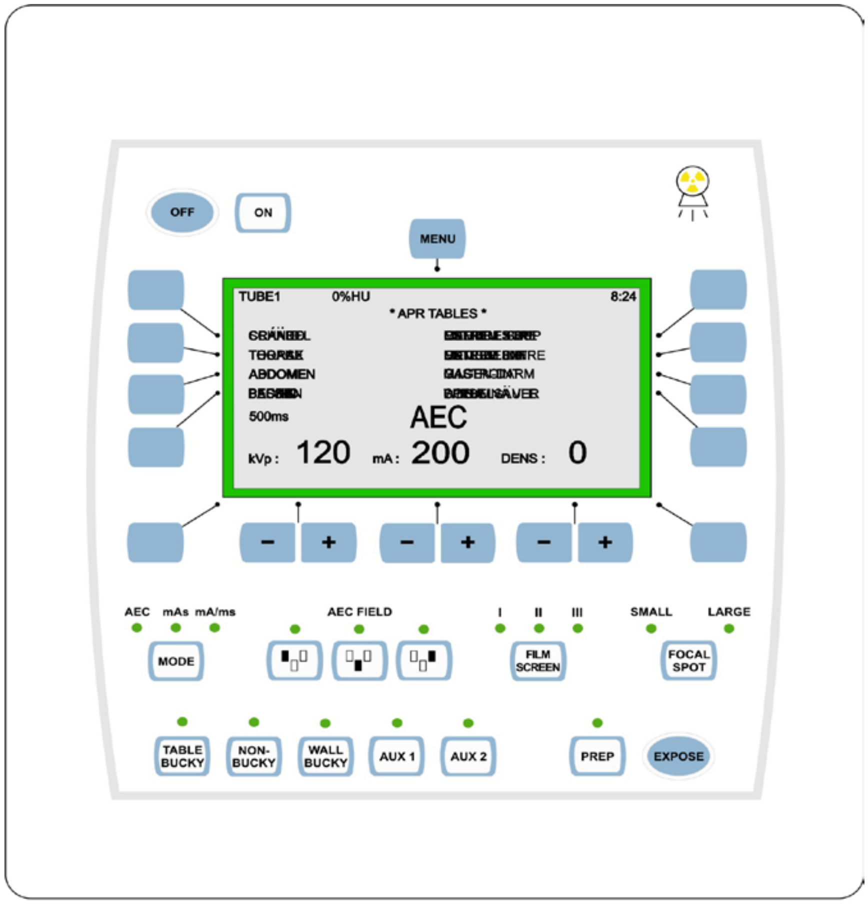
CMP 200® / CMP 200® DR SERIES
X-RAY GENERATOR



CMP200_001C.CDR

SERVICE MANUAL

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Chapter 1 Pre-Installation

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Introduction

This chapter summarizes the main features of the CMP 200® and CMP 200® DR X-ray generators (performance, regulatory and compatibility). Safety information is provided, along with environmental, room, and installation requirements. This chapter concludes with a pre-installation checklist and a diagram showing the major component layout.

The information in this chapter is provided in order for the installer to be able to plan the site layout prior to installation of the generator.

Terminology

Direct Radiography	Radiography in which the permanent recording is affected at an image reception area (i.e. film).
Indirect Radiography	Radiography in which the permanent recording is affected after transfer of the information obtained at an image reception area (i.e. digital imaging system).
Direct Radioscopy	Radioscopy in which the visible images are presented at the image reception area, or close to it, in the radiation beam (i.e. fluoroscope or image intensifier with a non-digital imaging system).
Indirect Radioscopy	Radioscopy in which the images are presented at a location outside the radiation beam after transfer of the information (i.e. digital imaging system with a flat-panel detector or with an image intensifier and a CCD camera).
Reference Air Kerma Rate	Air Kerma rate free in air in the primary X-ray beam measured under specific conditions and expressed at the patient-entrance reference point.
Patient Entrance Reference Point	Point intended to represent the intersection of the X-ray beam axis with the entrance surface of the patient.
Isocentre	In radiological equipment with several modes of movement of the reference axis around a common centre, the centre of the smallest sphere through which the radiation beam axis passes.
Entrance Field Size	Dimensions of the field in the entrance plane of an X-ray image receptor that can be used for the transmission of an X-ray pattern under specific conditions.
GenWare® Service Software (GenWare®)	It is a tool to configure the CPI X-ray generator.

Generator Description

The CMP 200® 100 kHz high frequency X-ray generator is a component for use in film-based stationary radiographic X-ray systems. The CMP 200® DR X-ray generator adds a digital interface for digital radiography (DR) equipment. The CMP 200® X-ray generator consists of a main power cabinet and an optional membrane control console. The CMP 200® DR X-ray generator consists of a main power cabinet and an optional membrane, touchscreen, mini-console, or mini-console with a pre wired hand switch or a foot switch (used with digital interface). The main power cabinet contains the High Voltage Module and control circuits, the filament drivers, a low speed starter (optional dual-speed starter on some models of CMP 200® DR), and interface connections to the room equipment.

The control console allows the operator to select the technique factors, image receptors, etc., and to initiate an X-ray exposure.

Features

The following are the main features of and the options available for the generator:

- Integral low speed starter, compatible with X-ray tubes with type “R” stator. Optional compatibility with GE 23/23 Ω equal impedance “E” stator
- Optional dual-speed starter on some models of CMP 200® DR (not available on 1-phase units and 208/230 VAC 3 –phase units), compatible with tube types listed in the X-ray Tube Stator Compatiblity Tables supplement, part number 74602600
- Capable of interfacing with various DR imaging systems (CMP 200® DR only)
- 24 VDC, 110, or 220 VAC power source for Buckys (fused at 0.8 amps)
- 24 VAC 150 watts power source for collimator lamp
- 24 VDC 45 watts power source for system locks
- Optional AEC
- Optional DAP (Dose-Area Product)
- Optional 24VDC, 75 Watts, regulated, unswitched 2.5 Amp DIN Rail mounted power supply (intended for use with LED collimators)
- Tomography

Radiographic Performance

Table 1-1A: Radiographic performance	
kVp range:	40 kV to 125 kV or 40 kV to 150 kV, depending on model
kVp steps:	variable in 1 kV steps
kVp accuracy:	± (5 % + 1 kV) measured 5 ms after the beginning of the exposure; ±2% between 70-80 kVp Measured between the 75% points of the kV waveform
Rise time (10%-90%):	<1.5 ms (typically < 1.0 ms) with 30 m (100 ft) Locaflex L3 or equivalent HV cables (4.4 µF ±10%)
Time range:	1.0 to 6300 milliseconds
Exposure time Steps:	Variable in 1 ms steps via protocol; Variable according to ISO 497 Series R'20 via CPI consoles
Exposure Time Accuracy:	± (2% + 0.5 ms) from 5 ms to 6300 ms and > 0.5 mAs ± (10% + 1 ms) for > 0.1 mAs and for < 5 ms or ≤ 0.5 mAs for 30 m (100 ft) HV cables Measured between the 75% points of the kV waveform
mAs range	0.1 to 500 mAs (32/40 kW) 0.1 to 630 mAs (50 kW) 0.1 to 800 mAs (65 kW) 0.1 to 1000 mAs (80 kW) Note for Minimum mAs: mAs Mode : 0.3 mAs (> 60 kV, 28 mA, 11 ms) mA, ms Mode: 0.3 mAs (> 60 kV, 10 mA, 30 ms) mAs or mA, ms Mode: 0.1 mAs (40 kV - 60 kV, 10 mA, 10 ms)
mAs accuracy:	± (10 % + 0.2 mAs) for > 0.5 mAs ± (10% + 0.05 mAs): 0.1 mAs – 0.5 mAs (preliminarily specified for the range beyond IEC standard)
mA range	10 to 400 mA (32 kW) 10 to 500 mA (40 kW) 10 to 630 mA (50 kW) 10 to 800 mA (65 kW) 10 to 1000 mA (80 kW)
mA steps:	Variable in 0.1 mA steps via protocol; Variable according to ISO 497 Series R'20 via CPI consoles (see Generator Exposure Tables in Appendix A of this manual)

Table 1-1A: Radiographic performance	
mA Accuracy (10 mA – 1000 mA):	± (5% +1 mA) for exposures ≥ 5 ms and > 0.5 mAs; measured 5 ms after the beginning of the exposure across a 10 Ω, 1% resistor at the HVM mA F/B terminals. ± (20%) mA for exposures > 0.1 mAs and for < 5 ms or ≤ 0.5 mAs; (0.1 – 0.25 mAs, mA ≥ 50 mA); measured between the 75% points of the kV waveform measured across a 1 Ω, 1% resistor at the HVM mA F/B terminals.
Coefficient of linearity:	⩽ 0.1 (Station to Station) for exposures ³ 25mA or 3.2ms
Coefficient of reproducibility:	⩽ 0.05 for a set of kV and mAs parameters
Duty Cycle:	Not to exceed 5 consecutive boosts, followed by a minimum 10 second wait period

Note: The product of kV and mA is constrained by the maximum power rating. The kV ripple is constrained by the minimum cable capacitance shown in the ***Minimum High Voltage Cable Requirements*** section of this chapter.

Audible Noise Specification

The audible noise is measured at a distance of 1 meter from the generator and 1 meter off the ground the **maximum Audible Noise Level is 62 dBA**.

Note: The audible noise is measured with the generator operating at worst-case scenario; fans running at high speed and tube spinning at high speed. The **average** audible noise level will be significantly lower since for the vast majority of exposures and clinical operating conditions the fans function at low speed and only increase to high speed as dictated by high power exposures, high duty-cycle exposures, and the generator thermal algorithm.

Output Parameter and Loading Factor

Table 1-1B: Output Parameter and Loading Factor		
Output Parameter	**Generator Series**	**Loading Factor**
Maximum X-ray tube voltage and highest X-ray tube current at that voltage	32 kW 40 kW 50 kW 65 kW 80 kW	125 kV, 250 mA / 150 kV, 200 mA 125 kV, 320 mA / 150 kV, 250 mA 150 kV, 320 mA 150 kV, 400 mA 150 kV, 500 mA
Maximum X-ray tube current and highest X-ray tube voltage at that current	32 kW 40 kW 50 kW 65 kW 80 kW	400 mA, 80 kV 500 mA, 80 kV 630 mA, 80 kV 800 mA, 81 kV 1000 mA, 80 kV
Combination of X-ray tube current and X-ray tube voltage resulting in highest output power	32 kW 40 kW 50 kW 65 kW 80 kW	320 mA, 100 kV 400 mA, 100 kV 500 mA, 100 kV 630 mA, 103 kV 800 mA, 100 kV
Highest constant output power at 100 kV, 0.1 sec	32 kW 40 kW 50 kW 65 kW 80 kW	320 mA, 100 kV, 0.1 s 400 mA, 100 kV, 0.1 s 500 mA, 100 kV, 0.1 s 630 mA, 100 kV, 0.1 s 800 mA,100 kV, 0.1 s
Nominal shortest irradiation time (AEC exposures)	All models (AEC control is available over the full kV and mA range)	< 2 ms with a dedicated or 3 of 5 field AEC board. AEC control is achieved by varying the ms of the exposure. The AEC ms range is 15 ms to an installer-programmable maximum not to exceed 600 mAs.

Environmental Specifications

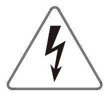
Table 1-2: Environmental Specifications	
OPERATING	
Ambient temperature range	10 to 40 °C (50 to 104 °F)
Relative humidity	20 to 80%, non-condensing
Atmospheric pressure range	1060 to 700 hPa (-400 to +3000 meters, 795 to 525 mm Hg); Reference: 1013 hPa nominal at sea level
TRANSPORT AND STORAGE	
Ambient temperature range	-20 to 70 °C (-4 to 158 °F)
Relative humidity	5 to 95%, non-condensing
Atmospheric pressure range	1060 to 700 hPa (-400 to +3000 meters, 795 to 525 mm Hg); Reference: 1013 hPa nominal at sea level

- Electrolytic capacitors contained within the equipment require less than +40 °C for long-term storage life.
- The membrane control console is limited to a minimum temperature of -20 °C, with a maximum duration of 48 hours at that temperature. Transport and storage is limited to a maximum duration of 120 hours between 50 and 70 °C, with an absolute humidity not to exceed the humidity of 85% RH at 50 °C.
- Touchscreen console temperatures below -20 °C and above +50 °C are limited to 10 days maximum duration, with a humidity not exceeding 50 % RH.

Safety

Safety and Warning Symbols

The following advisory symbols are used on the safety warning labels, and/or on circuit boards, and/or on the operator console.

	High voltage symbol used to indicate the presence of high voltage
	Warning symbol used to indicate a potential hazard to operators, service personnel or to the equipment
	This is a radiation exposure symbol used on operator console. Lights indicate that an exposure is in progress. This is accompanied by an audible tone from the console.
WARNING	This X-ray unit may be dangerous to patient and operator unless safe exposure factors, operating instructions and maintenance schedules are observed. Radiation warning label on operator console Never allow unqualified personnel to operate the X-ray generator.

Safety Notices and Warnings

Warnings:

- *This x-ray unit may be dangerous to patient and operator unless safe exposure factors, operating instructions and maintenance schedules are observed.*
- *Proper use and safe operating practices with respect to X-ray generators are the responsibility of users of such generators. CPI Canada Inc. (“The Manufacturer”) provides information on its products and associated hazards, but assumes no responsibilities for after-sale operating and safety practices.*
- *The Manufacturer accepts no responsibility for any generator not maintained or service according to this service and installation manual, or for any generator that has been modified in any way.*
- *The Manufacturer also assumes no responsibility for X-ray radiation overexposure of patients or personnel resulting from poor operating techniques or procedures.*
- *Do not modify this equipment without authorization of the Manufacture*

- *Hazardous voltages exist inside the generator whenever the main power disconnect is switched ON. These areas include, but are not limited to, the main fuse holder and associated circuits on the HV auxiliary board, the auxiliary transformer, and the main power contactor. LED DS1 ON the HV auxiliary board indicates the presence of the +24 VDC supply.*
- *The console ON/OFF switch DOES NOT disconnect the main power from the above areas inside the generator.*
- *The DC bus capacitors, located in the main cabinet present a safety hazard for at least 5 minutes after the power has been removed from the unit. Check that these capacitors are discharged before servicing the generator.*
- *An LED connected across the DC bus indicates the presence of high voltage. This LED is mounted on the EMC board (On some models, the EMC capacitor board DOES NOT contain any components other than the LED and the series resistors).*
- *Do not rely solely on bleeder circuits and high-voltage on indicators in the generator to protect you. Due to the possibility of component failure, it must never be assumed that an unlit LED ensures that no high voltage is present. Using a voltmeter, confirm that no high voltage is present before attempting any service.*
- *An arc flash is an electrical discharge of current that travels through the air and can produce temperatures approaching 20,000 degrees Celsius; This can cause severe burns to exposed skin and damage the eyes of the installer/service personnel. The mains input and generator capacitor bank are areas where a potential arc flash can occur. To minimize the risk of injuries from an arc flash, the installer/service personnel must wear the proper personal protective equipment (PPE) and work in accordance with the local regulations regarding arc flash hazards.*
- *Servicing the X-ray generator involves bending, being in an awkward position, reaching into hard to reach areas, and working at bottom position such as when routing wires, etc. Always take precautions and consider ergonomics to prevent hand scrapes and scratches, muscles strain or injuries when working on the generator.*
- *Installation of the generator must be done in accordance with the local regulations.*
- *Connection of the mains input cable must be done by a licensed electrician in accordance with the local electrical code.*

X-ray radiation exposure may be damaging to health, with some effects being cumulative and extending over periods of many months or even years. Operators and service personnel should avoid any exposure to the primary beam and take protective measures to safeguard against scatter radiation. Scatter radiation is caused by any object in the path of the primary beam and may be of equal or less intensity than the primary beam that exposes the film.

No practical design can incorporate complete protection for operators or service personnel who do not take adequate safety precautions. **Only authorized and properly trained service and operating personnel should be allowed to work with this X-ray generator equipment**. The appropriate personnel must be made aware of the inherent dangers associated with the servicing of high voltage equipment and the danger of excessive exposure to X-ray radiation during system operation.

Do not connect unapproved equipment to the rear of the console.

For the membrane console, J3 is for connection of an external hand switch, J4 is a serial port for use by an external computer, and J8 is for the interconnect cable to the main cabinet.

For the touchscreen console, COMM1 on the bottom of the touchscreen is for the interconnect cable to the generator, COMM2 is the serial port for use by the digital system, ETHERNET 1 and ETHERNET 2 are standard 10/100 Ethernet connections, the two USB ports for connection of external devices such as a DAP printer or a USB key.

Incorrect connections or use of unapproved equipment may result in injury or equipment damage.

Cautions:

- *Do not exceed the tube maximum operating limits. Intended life and reliability will not be obtained unless generators are operated within published specifications.*

Note:

- *The installer must provide a visual indication of the ON/OFF state of each external device that can prevent the generator from emitting radiation, or that can stop the generator from emitting radiation, or both.*
- *All electrical work performed during installation and service of this X-ray generator must be performed in accordance with CSA standard Z462 or equivalent.*

The following notes apply to the touchscreen console only.

Warnings:

- *The intended use of this touchscreen console is strictly for controlling the CPI generator and shoulc never be used for any unrelated or any other windows-based applications.*
- *The touchscreen console has no used serviceable parts. Do not attempt to open the touchscreen console.*
- *Ensure there is sufficient area around the venting slots of the touchscreen console to allow proper cooling of the internal components.*
- *Do not connect unapproved equipment to any part of the console.*
- *Peripheral devices should be IEC 60601-1 approved if located in the patient area.*
- *Use only the power supply provided with the console. Do not substitute the power supply provided with any other type.*
- *All components used for this touchscreen application are non-serviceable and must be replaced directly by CPI parts provided cannot be substituted.*
- *Incorrect connections, substituting of parts or use of unapproved equipment may result in injury or equipment damage.*
- *Routine maintenance suggests checking for loose console hardware, worn or defective cabling, and worn or loose tie wraps every 6 months.*
- *Never place liquid near the console.*
- *No practical design can incorporate complete protection for operators or service personnel who do not take adequate safety precautions.*
- *The touchscreen should be adjusted or positioned to avoid equipment damage or personal injury.*

Note:

- *Clean surface with a piece of non-abrasive material between the touchscreen and the surface.*
- *For wall mounted touchscreen consoles, ensure that the base is secured properly to a wall stub.*
- *Ensure the touchscreen console is resting on a flat and clean surface.*

Safety Warning Labels

This subsection defines the safety labels used inside and outside the generator cabinet.

Warnings:

- *Switch off the mains power disconnect and allow sufficient time for all capacitors to discharge before removing any covers.*
- *If any covers must be removed for service, take all required precautions with respect to the hazard(s) and immediately replace the covers when the need for removal is completed.*

Replace all fuses in this generator with the same type and rating

Refer to Table 9-2A and 9-2B of Information of Fuses (chapter 9: *Spares*) for fuse replacement information

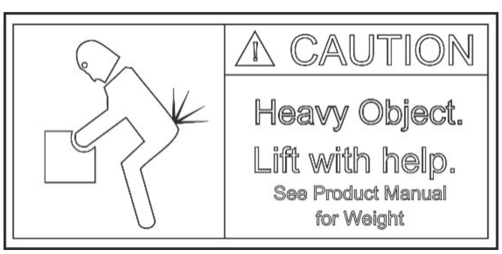
Refer to the Battery Replacement procedure (Chapter 6: Regular Maintenance)

This information is provided to help you establish safe operating conditions for both you and your X-ray generator. Do not operate this X-ray generator except in accordance with these instructions and any additional information provided by the X-ray generator manufacturer and / or competent safety authorities.

Note:

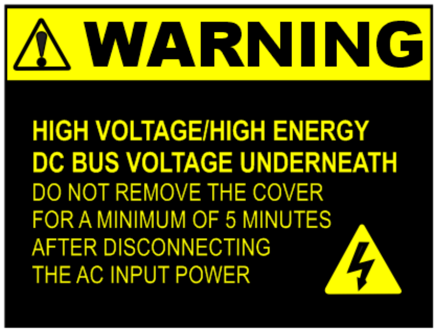
- *These labels and warnings are provided to alert service personnel that serious injury will result if the hazard identified is ignored.*

Weight Label



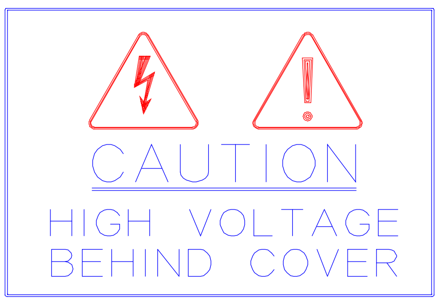
This label is attached to the main generator cabinet and to the High Voltage Module. Do not attempt to lift these items without proper assistance. The weight of the generator and the High Voltage Module is listed in the *Dimensions, Cable Entrance and Seismic Center Location* section of this chapter.

Caution HV/High Energy Warning Label



This label is attached to the generator cabinet and on the inside of the back cover above the High Voltage Module. The DC bus capacitors (approximately 300 to 670 VDC, depending on model) will remain charged for up to 5 minutes after the AC mains is disconnected or the console is switched off.

Caution HV Behind Cover Label

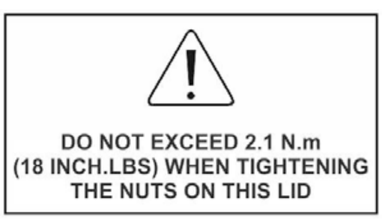


This label is attached to the outside of the generator cabinet, the cover over the inverter assembly, the cover over the DSS board and the fan cover. The Mains voltage is present inside the cabinet whenever the main disconnect is switched on. Additionally, the DC bus capacitors will remain charged for up to 5 minutes after the AC mains is disconnected or the console is switched off.

Warnings:

- *Wait a minimum of 5 minutes after the input mains power has been removed before removing any covers. Once the cover(s) are removed. Check that the voltage across the DC bus capacitors is near zero before servicing. If this voltage exceeds 50 VDC, qualified service personnel must manually discharge the capacitors.*

High Voltage Module - Transformer Terminals Notice

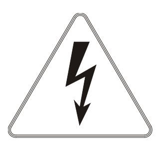


This notice is printed on the High Voltage Module lid and cautions against over-tightening the nuts on the transformer feedthrough terminals (for the primary of the HV transformers).

Danger High Voltage Notice

This notice is printed on the high voltage module lid. High voltage may be present at the primary terminals on the high voltage module lid board, at the output high voltage connectors, and at the mA/mAs measuring jacks if the shorting link is opened for mA/mAs measurements.

Auxiliary Transformer Labels



This label is fixed on the outer face of the auxiliary transformer to indicate the presence of high voltage taps on the primary of 120, 200, 240, 400 and 480 VAC. Ensure the main power disconnect is switched off and appropriate documentation is consulted before attempting to service this component.

HIGH VOLTAGE HAZARD: Be certain that you are aware of all potential high voltage locations and hazards as detailed in this section before removing any covers, or attempting any service on this X-ray generator.

HIGH VOLTAGE HAZARD: Approximately 400 VAC is present on the membrane console board in the area of T1, C36, and J5. This is a high voltage source for the fluorescent backlight on the LCD display.

HIGH VOLTAGE HAZARD: AC mains voltage and / or DC bus voltage (approximately 325 to 670 VDC, depending on model) is present on the H.V. auxiliary board whenever the AC mains is energized. Ensure that the AC mains is switched off and locked out before servicing this board. See the note below regarding the DC bus voltage.

HIGH VOLTAGE HAZARD: High voltage is present on all components connected to the AC mains (line fuses, auxiliary transformer, H.V. auxiliary board, main power contactor, etc) whenever the AC mains is switched on. Additionally, DC bus voltage is present on certain components (mains rectifier assembly, DC bus capacitors, inverter assembly, High Voltage Module, H.V. auxiliary board, etc) whenever the generator is switched on, and will remain on for up to 5 minutes after the console is switched off or the AC mains is switched off or disconnected.

HIGH VOLTAGE HAZARD: Approximately 600 VDC is present on the dual-speed starter board whenever the generator is switched on. This voltage is sourced from the DC bus capacitors in the generator, and therefore the high voltage hazard will remain for up to 5 minutes after the generator has been switched off.

High voltage (approximately 325 to 670 VDC, depending on model) is present on the inverter assembly and associated components whenever the AC mains is energized and the console is switched on, and for up to 5 minutes after the console is switched off or the AC mains is disconnected. **This combination of high voltage and high current is potentially lethal. Use extreme caution when servicing this unit.**

Preparing for Installation

Generator Heat Output

The maximum heat output of the main generator cabinet is less than 1000 BTU / hour in normal clinical use, with a maximum of 70 BTU / hour heat output for the console. The console is convection-cooled, and the main cabinet is fan cooled. The console and main cabinet should never be covered when the generator is switched on, as any covering may interfere with the cooling. The cooling vents must be unobstructed at all times.

Generator Power Requirements

The tables in this section show mains power requirements for various configurations of CMP 200® and CMP 200® DR X-ray generators. The installer must ensure that the generator is connected to the proper mains voltage as per the nameplate on the generator. **Notes** for all the **400** VAC line input voltages listed in this section**:**

Table 1-3A: Generator Power Requirements for 380/400 VAC line Input Voltage

<table>
<tr><td rowspan="5">380 VAC / 400 VAC Line Voltage:</td><td colspan="2">The generator may be operated with a line input voltage of 380 VAC -5% / +15%. If the generator must be installed with a line input voltage below 360 VAC (400 VAC -10% or 380 VAC -5%) then a 3-phase line matching auto-transformer may be used. The 3-phase line matching auto-transformer must meet the minimum requirements specified below:</td></tr>
<tr><td>Input</td><td>380 VAC 50 / 60 Hz</td></tr>
<tr><td>Output</td><td>400 VAC ±10%</td></tr>
<tr><td>Momentary Output Current</td><td>As specified below for each power level</td></tr>
<tr><td>Continuous Output Rating</td><td>Same as the Minimum Recommended Distribution Transformer Rating specified in Table 1-4</td></tr>
</table>

Table 1-3B: Generator Power Requirements for 32 kW Generator	
Line Voltage	208 VAC - 5% to 230 VAC + 10%, 1 phase 208 VAC - 5% to 230 VAC + 10%, 3 phase 400 VAC ± 10%, 3 phase 480 VAC ± 10%, 3 phase
Line Frequency	50/60 Hz.
Momentary Current	220 Amps at 208 VAC (1 phase) 120 Amps / phase at 208 VAC (3 phase) 200 Amps at 230 VAC (1 phase) 110 Amps / phase at 230 VAC (3 phase) 65 Amps / phase at 400 VAC 55 Amps / phase at 480 VAC
Nominal Current *	≤ 5 Amps
Momentary Power Consumption	See Table 1-4

Table 1-3C: Generator Power Requirements for 40 kW Generator	
Line Voltage	208 VAC - 5% to 230 VAC + 10%, 1 phase 208 VAC - 5% to 230 VAC + 10%, 3 phase. **400** VAC ± 10%, 3 phase 480 VAC ± 10%, 3 phase
Line Frequency	50 / 60 Hz
Momentary Current	275 Amps at 208 VAC (1 phase) 150 Amps / phase at 208 VAC (3 phase) 250 Amps at 230 VAC (1 phase) 135 Amps / phase at 230 VAC (3 phase) 80 Amps / phase at 400 VAC 65 Amps / phase at 480 VAC.
Nominal Current *	≤ 5 Amps
Momentary Power Consumption	See Table 1-4

Table 1-3D: Generator Power Requirements for 50 kW Generator	
Line Voltage	208 VAC - 5% to 230 VAC + 10%, 3 phase **400** VAC ± 10%, 3 phase 480 VAC ± 10%, 3 phase
Line Frequency	50/60 Hz
Momentary Current	185 Amps / phase at 208 VAC 170 Amps / phase at 230 VAC 100 Amps / phase at 400 VAC 80 Amps / phase at 480 VAC
Nominal Current *	≤ 5 Amps
Momentary Power Consumption	65 kVA

Table 1-3E: Generator Power Requirements for 65 kW Generator	
Line Voltage	400 VAC ± 10%, 3 phase 480 VAC ± 10%, 3 phase
Line Frequency	50/60 Hz
Momentary Current	125 Amps / phase at 400 VAC 105 Amps / phase at 480 VAC
Nominal Current *	≤ 5 Amps
Momentary Power Consumption	85 kVA

Table 1-3F: Generator Power Requirements for 80 kW Generator	
Line Voltage	400 VAC ± 10%, 3 phase 480 VAC ± 10%, 3 phase
Line Frequency	50/60 Hz
Momentary Current	155 Amps / phase at 400 VAC 130 Amps / phase at 480 VAC
Nominal Current *	≤ 5 Amps
Momentary Power Consumption	105 kVA

* Nominal Current = Generator standby current only. External or installer-supplied equipment connected to the generator may increase the nominal current beyond the values shown.

Table 1-10 defines the power line requirements for the generators.

Note:

- *Table 1-10 contains recommended values for the wire sizes between the mains disconnect and the generator. The actual values used at an installation are dependent on the quality of the input line (voltage level), the current requirements, and the length of the cable run, and must be confirmed by the installer.*
- *Final selection of generator input wire and disconnects as well as the cabling from the distribution transformer to the mains disconnect must meet the requirements of the local electrical codes, and is usually determined by hospital / contractor engineering.*
- *The ratings listed consider the generator requirements only. The installer must make the necessary compensation for additional load requirements.*
- *A poor quality input line may result in the installer having to de-rate the generator's maximum power.*

Table 1-4: Generator Power Line Requirements

Generator Series and Mains Voltage	Minimum Recommended Mains Disconnect to Generator (15 ft/5 m max)	Generator Momentary Line Current	Minimum Recommended Generator Service Rating	Minimum Recommended Distribution Transformer Rating	*Minimum Recommended Ground Wire Size	Apparent Mains Resistance
32 kW 208 VAC, 1p	#2 *** (33 mm^2)	220 A	120 A	45 kVa	#2 (33 mm^2)	0.045 Ω
32 kW 230 VAC, 1p	#2 *** (33 mm^2)	200 A	120 A	50 kVa	#2 (33 mm^2)	0.055 Ω
32 kW 208 VAC, 3p	#4 ** (21 mm^2)	120 A	100 A	45 kVa	#4 (21 mm^2)	0.07 Ω
32 kW 230 VAC, 3p	#4 ** (21 mm^2)	110 A	100 A	45 kVa	#4 (21 mm^2)	0.09 Ω
32 kW **400** VAC, 3p	#6 ** (13.3 mm^2)	65 A	100 A	45 kVa	#6 (13.3 mm^2)	0.27 Ω
32 kW 480 VAC, 3p	#6 ** (13.3 mm2)	55 A	100 A	45 kVa	#6 (13.3 mm2)	0.40 Ω
40 kW 208 VAC, 1p	#2 *** (33 mm2)	275 A	120 A	65 kVa	#2 (33 mm2)	0.035 Ω
40 kW 230 VAC, 1p	#2 *** (33 mm2)	250 A	120 A	65 kVa	#2 (33 mm2)	0.045 Ω
40 kW 208 VAC, 3p	#4 ** (21 mm2)	150 A	100 A	55 kVa	#4 (21 mm2)	0.055 Ω

Table 1-4: Generator Power Line Requirements						
Generator Series and Mains Voltage	Minimum Recommended Mains Disconnect to Generator (15 ft/5 m max)	Generator Momentary Line Current	Minimum Recommended Generator Service Rating	Minimum Recommended Distribution Transformer Rating	*Minimum Recommended Ground Wire Size	Apparent Mains Resistance
40 kW 230 VAC, 3p	#4 ** (21 mm2)	135A	100 A	55 kVa	#4 (21 mm2)	0.075 Ω
40 kW 400 VAC , 3p	#6 ** (13.3 mm2)	80 A	100 A	55 kVa	#6 (13.3 mm2)	0.22 Ω
40 kW 480 VAC, 3p	#6 ** (13.3 mm2)	65 A	100 A	55 kVa	#6 (13.3 mm2)	0.32 Ω
50 kW 208 VAC, 3p	#2 *** (33 mm2)	185 A	100 A	65 kVa	#2 (33 mm2)	0.045 Ω
50 kW 230 VAC, 3p	#2 *** (33 mm2)	170 A	100 A	65 kVa	#2 (33 mm2)	0.055 Ω
50 kW 400 VAC, 3p	#6 ** (13.3 mm2)	100 A	100 A	65 kVa	#6 (13.3 mm2)	0.17 Ω
50 kW 480 VAC, 3p.	#6 ** (13.3 mm2)	80 A	100 A	65 kVa	#6 (13.3 mm2)	0.24 Ω
65 kW 400 VAC, 3p	#6 *** (13.3 mm2)	125 A	100 A	85 kVa	#6 (13.3 mm2)	0.13 Ω
65 kW 480 VAC, 3p	#6 *** (13.3 mm2)	105 A	100 A	85 kVa	#6 (13.3 mm2)	0.19 Ω
80 kW 400 VAC, 3p	#6 *** (13.3 mm2)	155A	100A	105 kVa	#6 (13.3 mm2)	0.10 Ω
80 kW 480 VAC, 3p	#6 *** (13.3 mm2)	130A	100A	105 kVa	#6 (13.3 mm2)	0.15 Ω

* Refer to the *Generator Ground Requirements* section of this chapter for general grounding information. Maximum wire gauge is # 2 AWG Cu (33 mm²).

** Maximum wire gauge is # 4 AWG Cu (21 mm²).

*** Maximum wire gauge is # 2 AWG Cu (33 mm²).

Recommended Service Disconnect (as per Table 1-10):

All wiring and grounding should comply with the national electrical code or equivalent.

All wiring must be copper.

The disconnect switch shall be located within reach of the operator.

Generator Ground Requirements

A suitable ground must be connected from the disconnect switch to the main ground of the generator, located to the right of the main fuse block, on the sub-panel. The ground wire is typically part of the line cord, and the current capacity of the ground conductor must normally be equal to or greater than that of the line conductors.

A copper ground cable, #10 AWG (6 mm^2) or larger should be connected from the X-ray tube housing to the High Voltage Module ground stud (located at the top of the High Voltage Module).

If a neutral line is provided with the system, under no circumstances is it to be used for ground purposes. The ground must carry fault currents only.

Minimum High Voltage Cable Length Information

One of the properties of the generator high voltage cables is capacitance. This capacitance performs an important function in that it filters the generator output ripple. As a result the CMP 200® X-ray generators must be fitted with a minimum length (minimum capacitance) of high voltage cable. This minimum cable length is specified in Table 1-5:

Table 1-5: Mini High Voltage Length Information

kW/Line Voltage	Phase	Maximum kV Rating	Minimum Cable Capacitance	Minimum Cable Length [1]
80 kW, 400/480 VAC	3 p	150 kV	1540 pF	10.7 m (35 ft.)
65 kW, 400/480 VAC	3 p	150 kV	1320 pF	9.1 m (30 ft.)
50 kW, 400/480 VAC	3 p	150 kV	1320 pF	9.1 m (30 ft.)
50 kW, 208/230 VAC	3 p	150 kV	880 pF	6.1 m (20 ft.)
40 kW, 400/480 VAC	3 p	150 kV	880 pF	6.1 m (20 ft.)
32 kW, 400/480 VAC	3 p	150 kV	880 pF	6.1 m (20 ft.)
40 kW, 400/480 VAC	3 p	125 kV	1320 pF	9.1 m (30 ft.)
32 kW, 400/480 VAC	3 p	125 kV	1100 pF	7.6 m (25 ft.)
40 kW, 208/230 VAC	3 p	125 kV	1100 pF	7.6 m (25 ft.)
32 kW, 208/230 VAC	3 p	125 kV	880 pF	6.1 m (20 ft.)
40 kW, 208/240 VAC	1 p	125 kV	1100 pF	7.6 m (25 ft.)
32 kW, 208/240 VAC	1 p	125 kV	880 pF	6.1 m (20 ft.)

[1] Based on a cable capacitance of 145 pF/m (44 pF/ft.)

X-Ray Stator Drive Cable Requirements

The X-ray stator cable used with the starter assembly has to meet the following requirements:

The cable must be approved to at least 600 VAC if using a dual-speed starter and at least 300 VAC if using a low speed starter.

The cable must be shielded and the shield ground must be connected to the generator chassis ground and to the tube housing ground.

Note: For Metal Centre Section X-ray tubes, **DO NOT** connect the shield ground to the tube housing ground.

The maximum cable capacitance (from the inner conductors shorted together to the cable shield) **must be less than 5.1 µF**. For example, a cable, type 8618, made by Belden has a capacitance of 4.1 µF for 26 meters.

Note: If a longer cable is necessary with larger cable capacitance over 5.1 µF, consult the manufacturer.

Locating and Mounting the Generator

The main generator cabinet is self-standing and does not need to be supported. However, the installation should meet the following requirements:

- The floor must be flat and level.
- The generator installation area must be clean and free of dirt or debris.
- The installer must supply generator hold-down brackets, if required. Alternately, mounting holes have been provided in the base of the generator. The generator may then be anchored to the floor via these holes.
- Sufficient room must be provided to allow access to the rear and side of the generator for installation and service. See Figure 1-1 for recommended clearances.
- The main cabinet is fan cooled, therefore room-temperature air must be free to circulate around the cabinet. The cooling vents must be unobstructed at all times.
- A cable trough, conduit, or raceway (1 in; 2.5 mm, diameter) should be provided from the control console to the main cabinet to allow routing of the control cable if required.
- The control console is normally freestanding on a desk or shelf. It may be anchored if necessary.
- Do not place any objects regardless of size or weight on the generator.

•

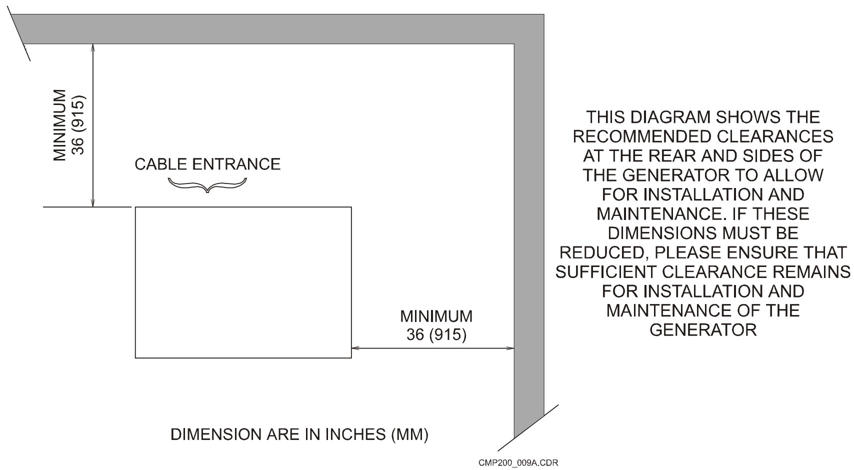


Figure 1-1: Generator clearances

Dimensions, Cable Entrance and Seismic Center Location

Figure 1-2 shows the dimensions of the generator cabinet, the locations of the cable access slots, the AC mains cable entry, and the seismic center location for the CMP 200® / CMP 200® DR X-ray generator.

The dimensions and weight of the generator and control console(s) are shown in Table 1-6.

Table 1-6: Dimensions and Weights of Generator and Control Consoles

ITEM	LENGTH	WIDTH	HEIGHT	WEIGHT
Main cabinet in shipping pack	30.5 (775)*	21.5 (546)*	38 (965)*	151 (68.6)
Main cabinet unpacked	25.7 (653)*	13.7 (348)*	24.3 (617)*	135 (61)
High Voltage Module		12.0 (305)	10.5 (267)	42 (19)
High Voltage Module		12.0 (305)	14.0 (356)	48 (22)
Membrane console	12.3 (313)**	10.9 (277)**	3.7 (94)**	6 (2.72)
Touchscreen control	See Figure 1-3			

* Refer to Figure 1-2

The above dimensions are inches (mm); weights are in pounds (kg).

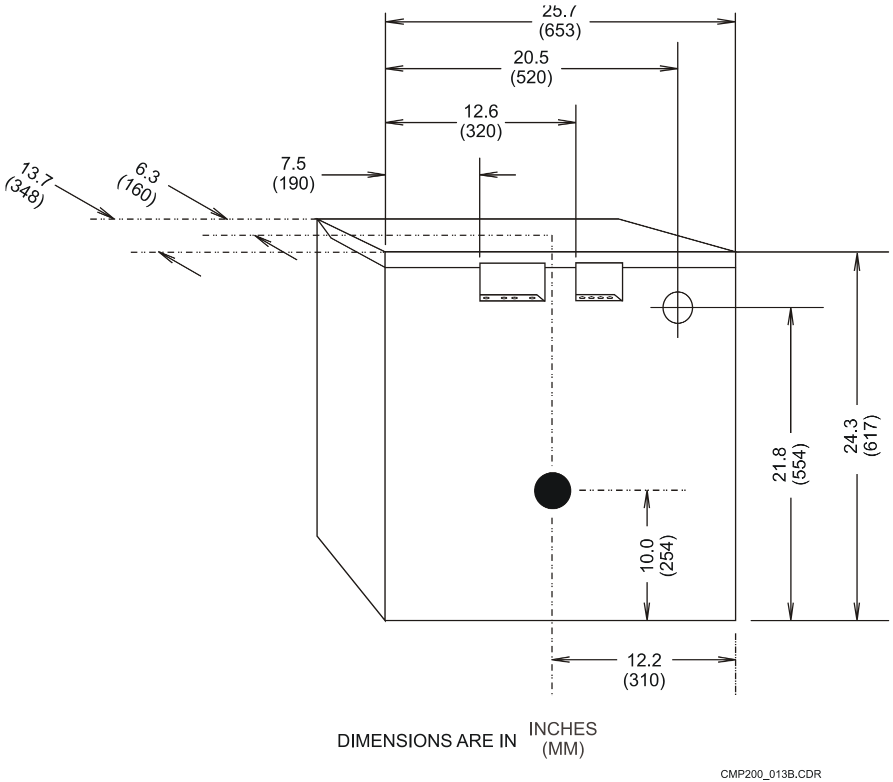


Figure 1-2: CMP 200® / CMP 200® DR cable entry locations and seismic center

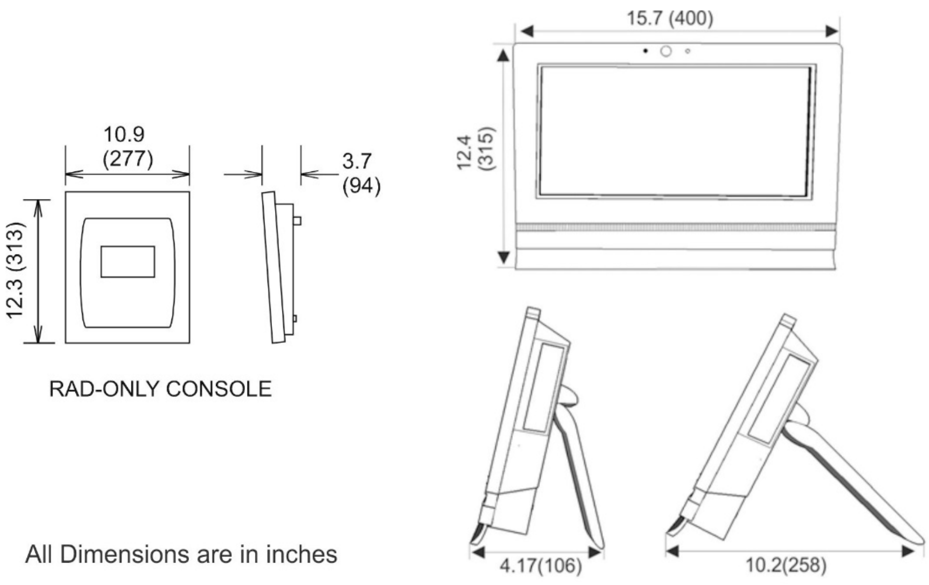


Figure 1-3: CMP 200® / CMP 200® DR operator console dimensions

Tools and Test Equipment Required

The following is a checklist of recommended tools and test equipment for installation and calibration of the generator.

CHECK √	DESCRIPTION
	General hand tools for installation: Wrenches, nut drivers, assortment of screwdrivers, pliers, etc.
	If the generator is to be anchored to the floor, suitable tools (i.e. drill, drill bits, etc.) and mounting hardware must be available.
	A supply of connectors for wiring: terminal lugs, caps, splices etc.
	A calibrated DVM that indicates true RMS voltages
	Dual trace memory oscilloscope with a minimum 20 MHz bandwidth; appropriate leads, probes, etc.
	Device for measuring true kVp, which may be a Dynalyzer equivalent or a non-invasive meter such as the Keithley TRIAD system
	A calibrated radiation meter with detectors that will allow for R/min and uR type measurements (or uGy and Gy/min)
	A suitable mA / mAs meter
	A strobe or reed type tachometer to verify that the anode is rotating up to speed
	A sufficient selection of absorbers to allow AEC calibration if this option is fitted: A suggested selection is Lexan in thickness of 5.0, 10.0, and 15.0 cm, or water in plastic containers of homogenous density in thickness of 5.0, 10.0, and 15.0 cm.
	Vapor proof compound for the HV terminations

Pre-Installation Checklist

Before starting the generator installation, review the following checklist.

CHECK √	DESCRIPTION
	Is there an unloading area to transport the generator from the delivery truck to the inside of the building?
	If the installation is not on the same floor as the delivery entrance, is there an elevator available?
	Is there a transport dolly or similar device to move the generator?
	Do any regulatory bodies need to be notified prior to installation?
	If movers are required, have arrangements for time and equipment been completed?
	Are lifting straps or some other suitable device available to lift the generator off the shipping pallet?

Generator Layout and Major Components

Figure 1-3 shows the external view and dimensions of the membrane and touchscreen operator's consoles. Figures 1-4 and 1-5 show the major components located inside the generator cabinet. Figure 1-6 is an internal view of the console, showing the major components and cabling. Figure 1-4 does not represent all models. This is meant to show major component layout only.

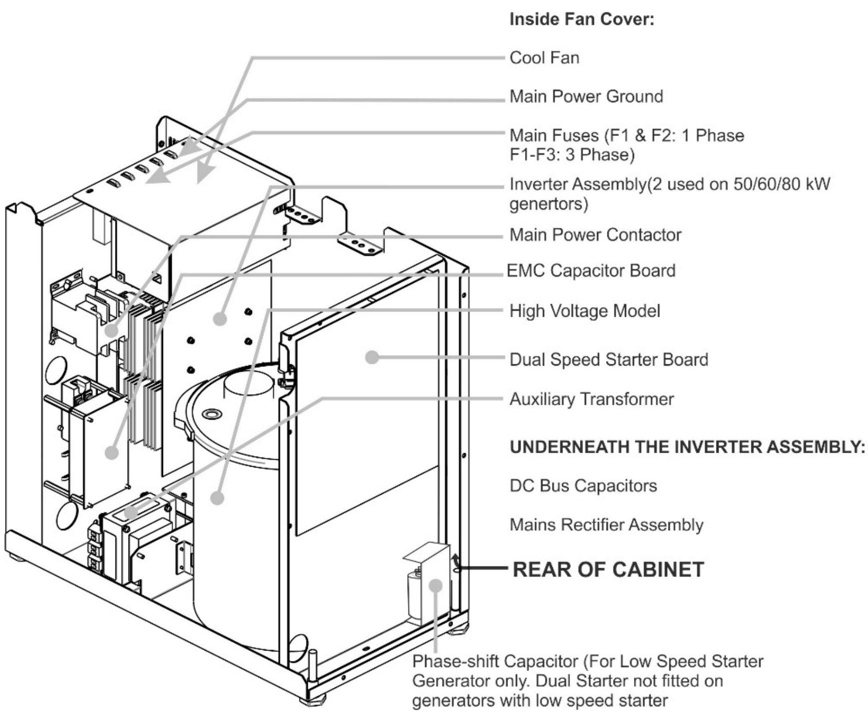


Figure 1-4: Major generator subassemblies view 1

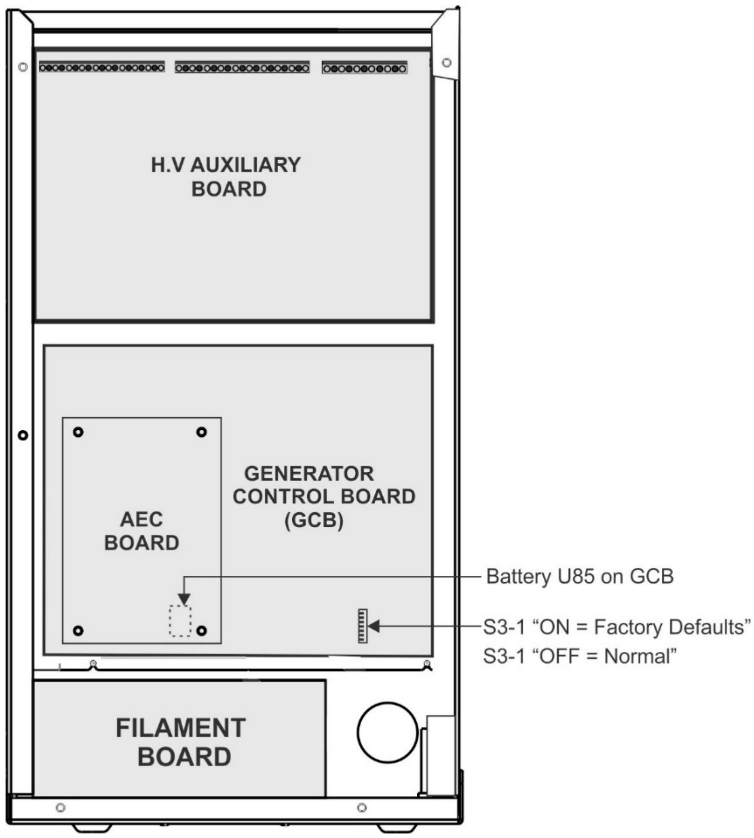


Figure 1-5: Major generator subassemblies view 2

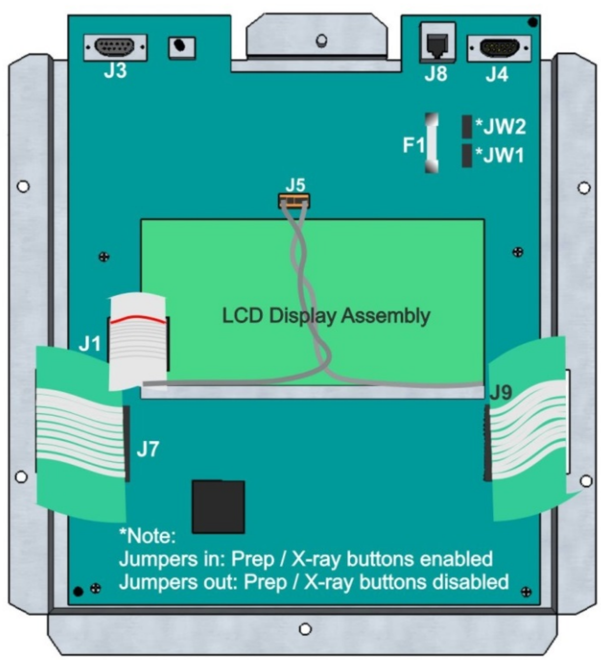


Figure 1-6: Console internal view

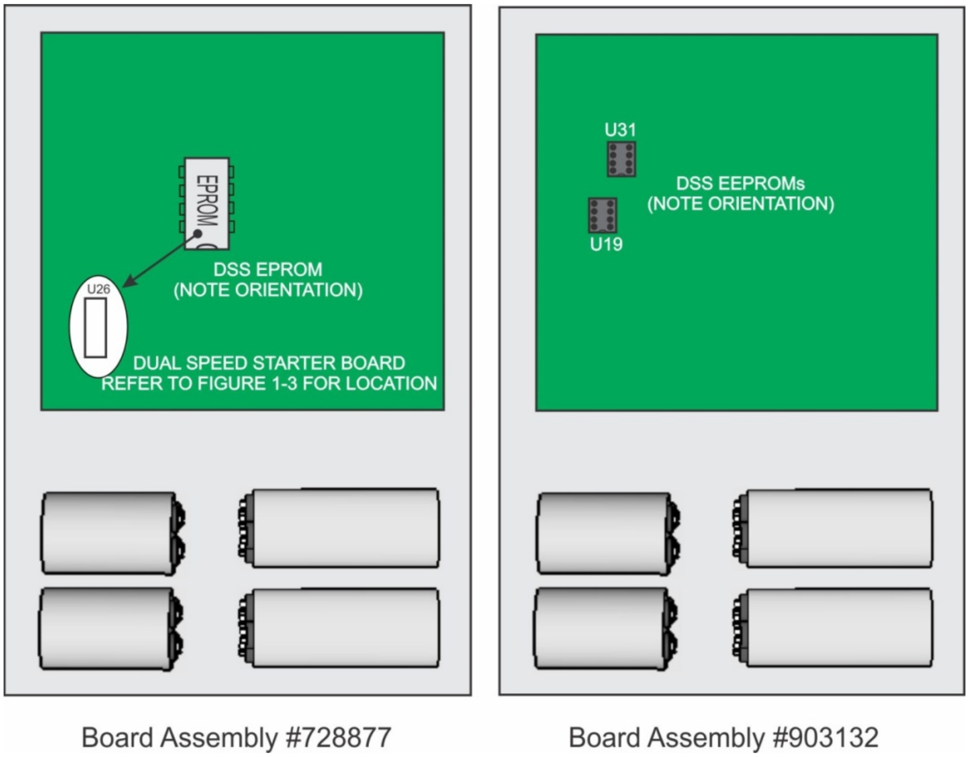


Figure 1-7: EPROM and EEPROM Locations

Compatibility Listing

This X-ray generator is compatible with the following equipment:

X-RAY TUBES:

Refer to the *X-ray Tube Stator Compatibility Tables* supplement (part number: 746026-00) and Chapter 2, *Installation*, of this manual.

Note:

- *Refer to the "Low Speed Starter Tube Compatibility" of the the* X-ray Tube Stator Compatibility Tables *supplement (part number: 746026-00) or the "Programming the Dual-Speed Starter" procedure in chapter 2, Installation, of this manual for further details.*

AEC DEVICES:

Refer to the Product Configuration / Compatibility Statement included in the document set.

DR INTERFACE:

Refer to the Product Configuration / Compatibility Statement included in the document set.

Runtime License Agreement (Touchscreen Console)

User / End User License Agreement

You should carefully read the following terms and conditions before using this product. It contains software (“Software”), the use of which is licensed by Communications & Power Industries Canada Inc. (“CPI”) to you, the original end user, for your use only as set forth below. If you do not agree to the terms and conditions of the agreement, do not use the software. If you use any part of the software, such use shall indicate that you accept these terms.

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Should you have questions regarding the use of the Software, please contact support@cmp.cpii.com.

Compatibility Statement

The compatibility statement for this generator is located at the front of this manual.

Open-Source License Agreement (Touchscreen Console)

The software included in the CPI product covered by this manual may contain copyrighted software programs that are licensed under the General Public License (GPL) V2. A copy of the GPL can be found on the GNU website, www.gnu.org. You may obtain the corresponding source code for a period of three years by forwarding your request to:

Satcom & Medical Products Division

45 River Drive

Georgetown, Ontario, L7G 2J4, Canada

Telephone:	(905) 877-0161	
Fax:	(905) 877-5327	
E-mail:	CANMarketing@cpii.com	Subject: Open Source Code

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Chapter 2 Installation

Contents

Introduction

This chapter contains instructions for unpacking and installing the CMP 200® and CMP 200® DR X-ray generators. This chapter also describes the basic wiring and setup of the generator (console, X-ray tube, AC mains, etc.), allowing for initial power-up of the generator. This is followed by tube seasoning and auto calibration.

Warning:

- *Installation and servicing is to be performed only by competent, trained personnel who are familiar with the potential hazards associated with the equipment.*
- *Ensure the AC input power is locked out for servicing. Verify the absence of voltage. Wait minimum of 5 minutes for capacitors to discharge before beginning any servicing.*
- *Do not place any objects regardless of size or weight on the generator.*
- *Do not allow any obstruction of the cooling vents.*

Unpacking

1. Inspect the shipping pack(s) for evidence of shipping damage.
   - The generator and the membrane control console (if applicable) are shipped in one pack.
   - The optional touchscreen console is shipped in a separate pack from the generator.

   If there is evidence of shipping damage, note this in the event that a damage claim is justified. Taking pictures of the damage is also recommended.

2. Remove the cardboard outer pack from the generator. See the cautionary note below before removing the pack.

   Caution: Open the cardboard pack(s) carefully. Sharp tools may damage the contents.

3. Set aside the cardboard pack.

   Warning: The generator mains cabinet (with HV Module) weighs approximately 135 pounds (61 kg). One person should not attempt to lift or move this assembly without proper equipment or assistance.

4. Remove and unpack the membrane control console, if included. This is strapped to the top of the generator. Then carefully lift the generator from the pallet.
5. Remove and unpack the optional hand switch, the optional mini-console orthe optional mini-console with a pre-wired hand switch or an IPX8 certifited foot switch, if included.
6. If applicable, unpack the optional touchscreen console along with the base and console cables.

7. Inspect all items for shipping damage, including loose hardware if applicable.
8. Unpack the manuals and any other paperwork that may be packed with the generator.
9. Keep the shipping packs. In case of shipping damage, place the unit(s) back in their shipping pack(s) and notify the carrier and the customer support department as described in chapter 1 of this manual.

Removing the Generator Cover

Warning:

- *Before performing next steps, you must use good judgment and work practices to avoid injury and damage to equipment.*

1. Remove and set aside the screws and washers securing the cover to the generator chassis.
2. Carefully lift the cover off the chassis.

Major Component Layout

Refer to the section *Generator Layout and Major Components* in Chapter 1, *Pre-installation* for major component identification and layout.

Equipment Placement

Main Cabinet

Place the generator cabinet in a location that will allow the following:

- Easy front and side access for service and sufficient clearance at the rear for room interface cables. Refer to Chapter 1, *Pre-installation*.
- Air circulation: The main cabinet is fan cooled, therefore room-temperature air must be free to circulate around the cabinet. The cooling slots in the cabinet must be unobstructed at all times.
- A stable footing
- Close proximity to service-disconnect boxes. Cables should not be on the floor where they could be stepped on or tripped over.
- Do not locate the X-ray generator within the patient environment of the X-ray room.

Control Console

Note:

- *Do not locate the control console where X-radiation may be present during setup / calibration or normal operation of the generator.*
- *You may choose to locate the console near the generator for initial programming and calibration temporarily. If so, complete the final console installation per this section when the generator installation is completed.*

Position the control console in its intended location and ensure that it is stable.

- The control console (membrane console, touchscreen console, mini-console, or mini-console with a pre-wired hand switch or foot switch) must be located inside an X-ray shielded control booth within the X-ray room, or outside the X-ray room.
- If the console is located on a shelf, supply index pins or equivalent hardware to the base of the console to prevent slipping.
- Ensure that the console is mounted at a height and angle to allow for easy viewing of the displays.
- If the optional CPI pedestal stand (membrane console) is to be used for the console mounting, follow the mounting instructions supplied with the stand.

Membrane Console

Note:

- *Some jurisdictions require that the console PREP and EXPOSE buttons be disabled if a hand switch is used. This is done by removing JW1 and JW2 from the console board as described below.*

1. Turn the console upside down and place it on a clean, non-abrasive surface.
2. Remove and set aside the screws securing the console base to the molded case, and the hardware from the console ground stud.
3. Remove the console base (the metal bottom panel with the feet attached).
4. Locate and then remove JW1 and JW2 from the console board. Refer to the appropriate Figure in Chapter 1, *Pre-instalation*, in the section *Generator Layout and Major Components*.
5. Do not discard the jumpers that were removed in the previous step. These will need to be reinstalled if the console PREP and EXPOSE buttons must be enabled in the future.
6. Reinstall the console base by reversing the previous steps.

Touchscreen Console

1. Carefully unpack the touchscreen console and the accessories and set the packaging aside. Verify that all components are undamaged.

2. Place the touchscreen console face down (see Figure 2-1) on a FLAT, CLEAN, NON-ABRASIVE surface.

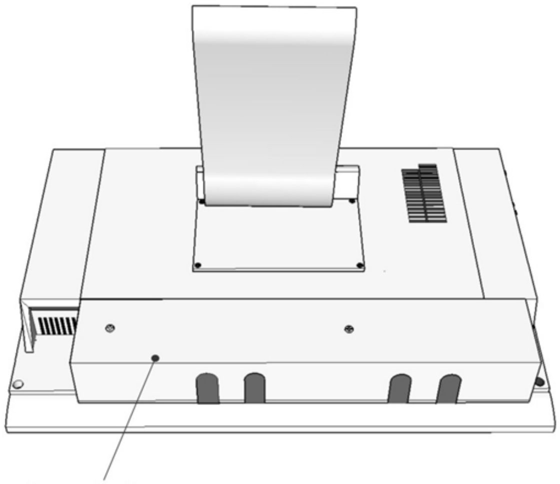


Figure 2-1: Rear of the touchscreen

Anchoring the Generator to the Floor

If it is desired to anchor the generator to the floor, refer to Chapter 1, *Pre-Installation*. This should not be done until all cable hookups to the generator are completed.

Wiring to the Generator

Unless specified otherwise, all cables (except AC mains) should be routed into the generator main cabinet through the cable access slots at the upper rear of the generator. The cables should be secured to the lip on the inside of the cable access slots using tie-wraps or equivalent fasteners. For connections that must be made to the H.V. auxiliary board, AEC board, or to the generator control board, route the cables over the top of the fan-mounting bracket and over the chassis divider panel. Tightly secure the signal cables to the fan assembly cover lances with cable ties or equivalent cable fasteners.

The AC mains cable is routed into the generator via the cable clamp on the rear of the generator, adjacent to the main fuses.

All cables should be kept away from high voltage areas in the cabinet, and dressed neatly in place. Cables should be cut to the correct length if possible, as excess cabling may contribute to EMI/RFI problems. For those cables that cannot be cut to the correct length (HV cables and console cables for example), try to minimize the area inside of any loops of excess cable, as these loops can create an antenna.

Ferrules should be used on the ends of all stranded wires that are connected to terminal connections in the generator. These must be supplied by the installer.

Note:

- *Excess lengths of cabling must never be bundled up and stored inside the generator.*

Warning:

- *To avoid the risk of electric shock, this equipment must only be connected to a mains supply with protective earth.*

Control Console

Membrane Console

Figure 2-2 shows the designations of the connectors on the rear panel of the membrane and touchscreen consoles.

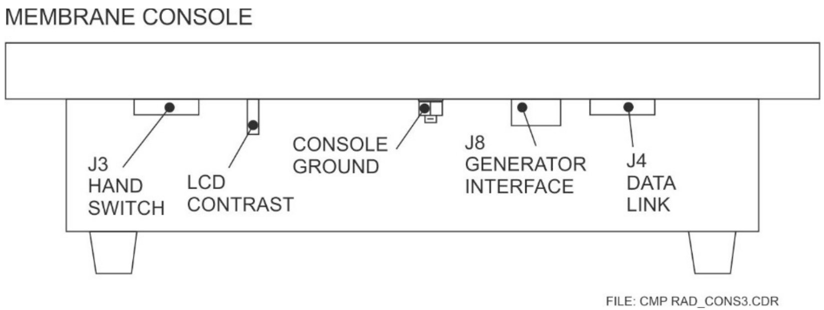


Figure 2-2: Interface of control console

1. Note the protective cover connected to the console cable. This is intended to protect the console cable connectors during shipping and while routing the console cable during installation. Disconnect the generator end of the cable (the end with the ferrite bead) from the protective cover, and then route the end of the cable with the protective cover attached as required. Remove and discard the protective cover when finished. After removing the protective cover, inspect the console cable connectors for any damage. Please see Figure 2-3 for an example of such damage.

   Route the generator end of the console cable into the generator cabinet via the cable access slot nearest to the generator control board. The cable must be routed as per Figure 2-5. Connect the generator end of the console cable to J3 on the generator control board.

Tightly secure the console cable to the fan assembly cover lance with a cable tie or an equivalent fastener. Secure console cable as shown in Figure 2-6.

Figure 2-3: A damage example of Console cable connector

2. Connect the free end of the console cable to J8 at the rear of the console. Leave sufficient slack in the cabling to the console to allow for future service and maintenance.
3. Two ferrite cores were added to the cable for the CPI membrane console to meet the Radiated Emission requirements. For units installed with an alternate console, similar ferrite cores may also be required. Contact Cusomter Support (contact information listed on the cover or the back of cover page) for additional details.

Touchscreen Console

The 15.6-inch touchscreen console is available in two support configurations: universal base and wall mount (optional). A special installation is required for the optional wall mount. The installation instruction, Touchscreen Console Installation Instruction for Wall Mount # 2990041300 P/N INS90589700, is provided with the wall mount kit.

Figure 2-4 illustrates the connectors and the covers of the 15.6-inch touchscreen console.

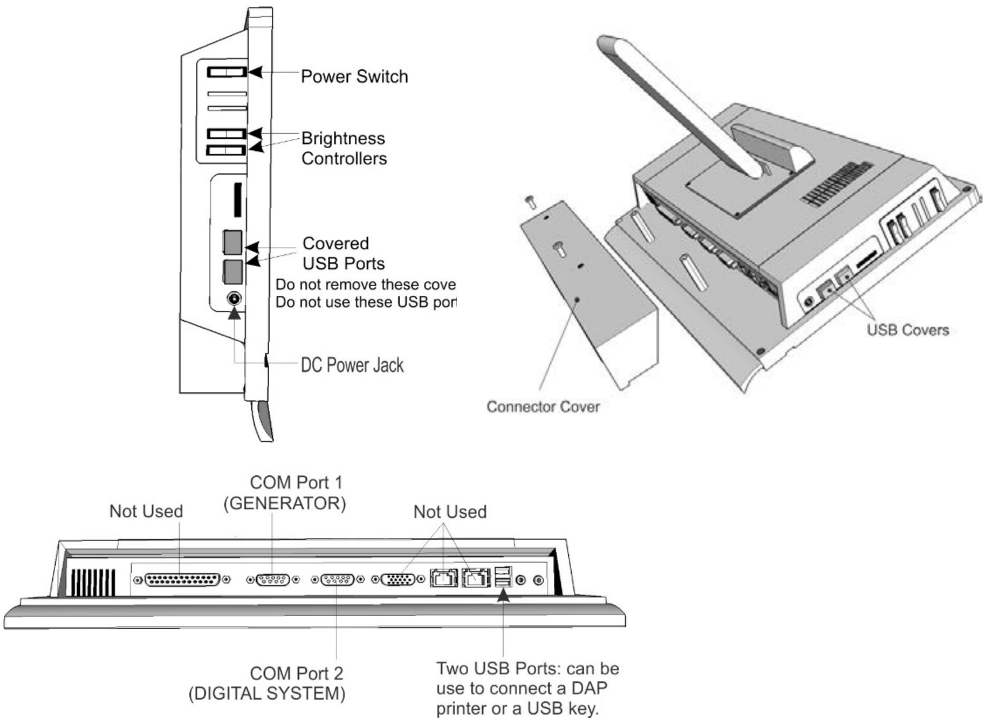


Figure 2-4 The cover of connectors of the touchscreen

1. Remove the two screws securing the Connector Cover to the touchscreen console (see Figure 2-4).
2. Remove the Connector Cover and place it and all hardware aside.
3. Route all the cables through the slots of the Connector Cover (see Figure 2-4).
4. Connect the console cable to the connector labeled AS “COMM1”.
5. Connect the digital imaging system cable (if required) to the connector labeled as “COMM2”.
6. Dress all the cables properly to avoid trip hazards, which may cause personal injury or console damage.
7. Tighten the two screws removed earlier to install the Connector Cover.
8. Route the generator end of the console cable (CPI part number: 90178000) and the digital imaging system cable into the generator cabinet via the cable access slot nearest to the generator control board. The cables must be routed as per Figure 2-5. Connect the generator end of the console cable to J3 and the digital imaging system cable to J25 (if required) on the generator control board.

   Warning: Connecting the touchscreen console cable to any connector other than J3 on the generator control board may cause damage to the generator. Verify that the console cable has been connected correctly prior to powering up the generator.

Note: Leave sufficient slack in the cabling to the touchscreen to allow for future service and maintenance.

9. Tighten the screw locks to secure the "D" connectors fully.
10. Connect the console power supply, part number 789-136-9300 to the DC Power Jack on the touchscreen console (see Figure 2-4).
11. Check the part number of the supplied power cord based on the following list before plugging in the cord into wall outlet.
    - 819-989-3500 (Europe)
    - 819-989-3100 (UK)
    - 819-989-3200 (North America)
    - 819-989-4100 (China)

    Note: The type of power cord supplied will depend on the region of generator shipment. If a power cord is required for a different region, contact CPI for inquiries.
12. Connect the power cord to the wall outlet.

    Note: Do not alter the power cord or power cord terminals in any way. Do not remove or disable the ground connections. Failure to follow these instructions may lead to personal injury and / or equipment damage.

Mini-Console (optional)

1. Install the fan assembly cover and confirm the connection of the fan assembly plug.
2. Connect the ferrite core end of the mini console cable to J19 on the generator control board. Gently move the mini console cable out of the way to tighten the screw locks fully. Avoid moving the ferrite core when tightening the two screw locks.

    Note: To maximize EMI performance, it is very important that the ferrite core is properly installed on the mini console cable.
3. Route the generator end of the mini console cable into the generator cabinet via the cable access slot nearest to the generator control board. The cable must be routed as per Figure 2-5.

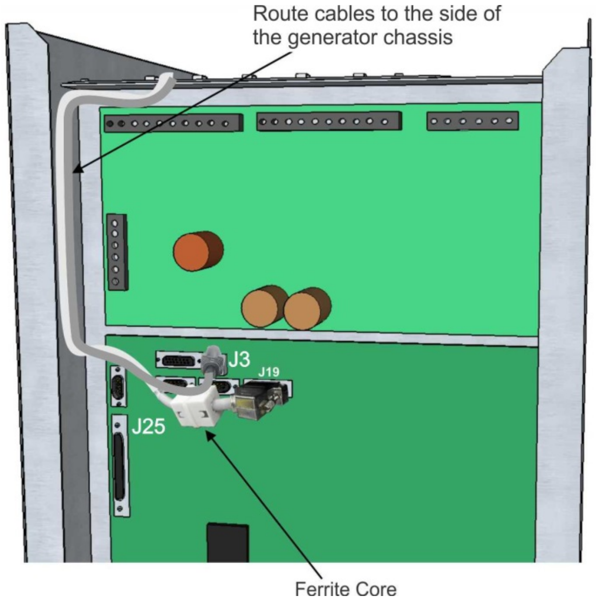


Figure 2-5: Mini Console cable routing

4. Secure the mini console cable to one of the lances on the fan assembly cover as shown in Figure 2-6. Use a cable tie or an equivalent fastener to secure the cable to the lance fully.

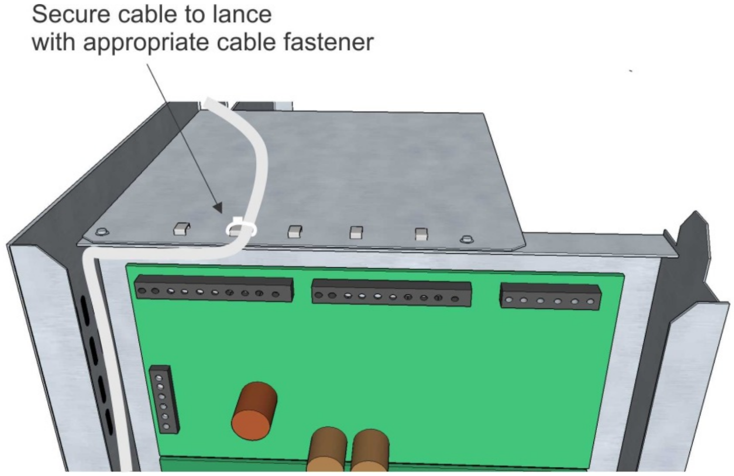


Figure 2-6: Mini console cable securing

Note: Verify that signal cables are tightly secured to the lances on the fan assembly cover and at the cable access slots at the back of the generator. Loosely secured signal cables may adversely affect the EMI performance of the generator.

5. Route the mini console cable through the cable access slot on the side of the generator chassis as shown in Figure 2-7. Keep the mini console cable and HV cables separated to maximize EMI performance.

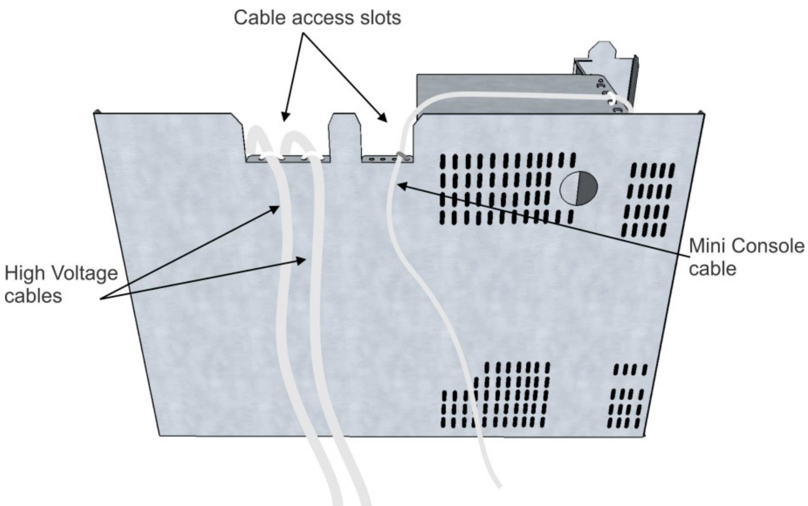


Figure 2-7: Cable routing

6. For the mini-console with a pre-wired IPX8 certified foot switch, there are 2 holes provided for rigid mounting to floor or equipment.

   Note: Connecting the mini console cable to any connector other than J19 on the generator control board may cause damage to the generator control board and mini console board. Verify that the console cable has been connected correctly prior to powering up the generator.

   Warning: When rounting the foot switch cable (5 meter), consider prevent of trip and fall hazards.

   Note: If the fan cover needs to be removed, always remember to secure cables with an appropriate cable fastener to lances after reinstalling the fan assembly cover.

Do not connect unapproved equipment to the rear of the console.

For the membrane console, J3 is for connection of an external hand switch, J4 is a serial port for use by an external computer, and J8 is for the interconnect cable to the generator main cabinet.

For the touchscreen console:

- COMM1 on the bottom of the touchscreen is for the interconnect cable to the generator.
- COMM2 is the serial port for use by the digital imaging system.
- ETHERNET 1 and ETHERNET 2 are standard 10/100 Ethernet connections, that should not be used.
- The two USB ports are for connection of external devices such as a DAP printer or a USB key.

For the mini-console, the short piece of console cable with the attached

15-pin “D” connector is for connection of the console cable that is connected to J19 on the generator control board.

Properly bundle signal cables together and tightly secure to the lances on the fan assembly cover to maximize the EMI performance.

Verify that signal cables are tightly secured to the lances on the fan assembly cover and at the cable access slots on the back on the generator. Loosely secured signal cables may adversely impact the EMI performance of the generator.

Two ferrite cores were added to the cable for the CPI membrane console to meet the Radiated Emission requirements. For units installed with an alternate console, similar ferrite cores may also be required. Consult Customer Support (contact information listed on the back of cover page) for additional details.

Incorrect connections or use of unapproved equipment may result in injury or equipment damage.

To Connect the DAP Printer:

Note:

- *The compatible DAP printer model is SLP-440 only.*

1. Refer to Figure 2-4.
2. Connect the DAP printer to the USB port (Figure 2-4) on the touchscreen console.
3. Perform the Installing the Connector Cover instruction described in this document before putting the console into service.

Hand Switch (Optional)

The optional hand switch, if ordered from CPI Canada Inc, is supplied pre-wired to a male 9-pin subminiature "D" connector. This connects to J3 on the membrane console. A male 9-pin subminiature "D" connector will need to be provided by the installer if the CPI supplied hand switch is not used.

Table 2-1: Pin Infromation of 9-Pin Subminiature "D" Connector

Pin Number	Pin Connections(J3 membrane console)
1	X-ray
2	No Connection
3	Prep
4	No Connection
5	Common (ground)
6	NOT USED
7	NOT USED
8	NOT USED
9	NOT USED

The optional Mini-console has a Hand Switch prewired to it.

X-ray Tube Stator Cable

The X-ray stator cable is the cable connecting between the X-ray generator and the X-ray tube. Although CPI does not supply this cable, **CPI requires the cable to meet the following requirements:**

1. The cable must be shielded.
2. The cable must meet 600 VAC-voltage rating.

The following two procedures will guide the connection of the X-ray stator cable for the low-speed starter and the dual-speed starter.

Connecting the X-ray Tube Stator Cable for Low-speed Starter

The J7 connector is designed for connecting the X-ray tube stator cable for the low-speed starter. It is located on the HV auxiliary board as shown in Figure 2-8.

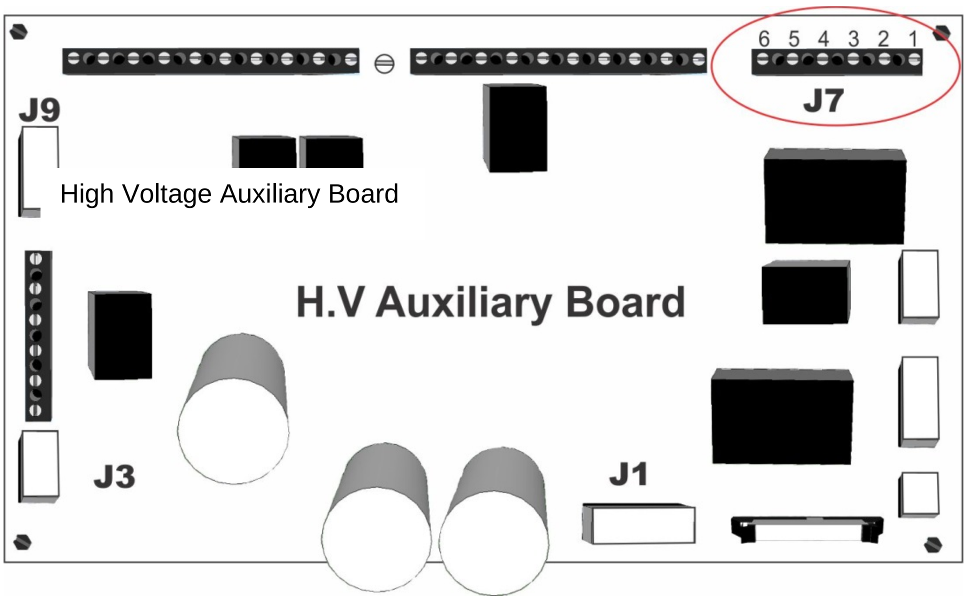


Figure 2-8: the connector of the X-ray tube stator cable for the low-speed starter

Table 2-2 shows the pin information of the J7 connector.

Table 2-2: Pin Information of J7 Connector on H.V Auxiliary Board	
Function	**Connect to**
SHIFT	J7-6
MAIN	J7-5
COMMON	J7-4
GROUND	J7-3
THERMAL SWITCH (Term 1)	J7-2
THERMAL SWITCH (Term 2)	J7-1

To connect the X-ray tube stator cable for the low-speed starter:

1. Route the X-ray tube stator cable towards the J7 connector on the HV auxiliary board as shown in Figure 2-8.

   Note: The shield for the stator cable must be grounded properly at both tube end and the generator end of the cable.

2. Connect the shield ground of the stator cable to J7-3 on the HV auxiliary board.
3. Connect the X-ray tube stator cable to J7 on the HV auxiliary board as per Table 2-2.
4. Perform the procedure, *checking the Connection of the X-ray Tube Stator Cable*, described in the following section.

Connecting the X-ray Tube Stator Cable for Dual-speed Starter

The connector is designed for connecting the X-ray stator cable for the dual-speed starter is located on the back of the DSS board mounting plate as shown in Figure 2-9.

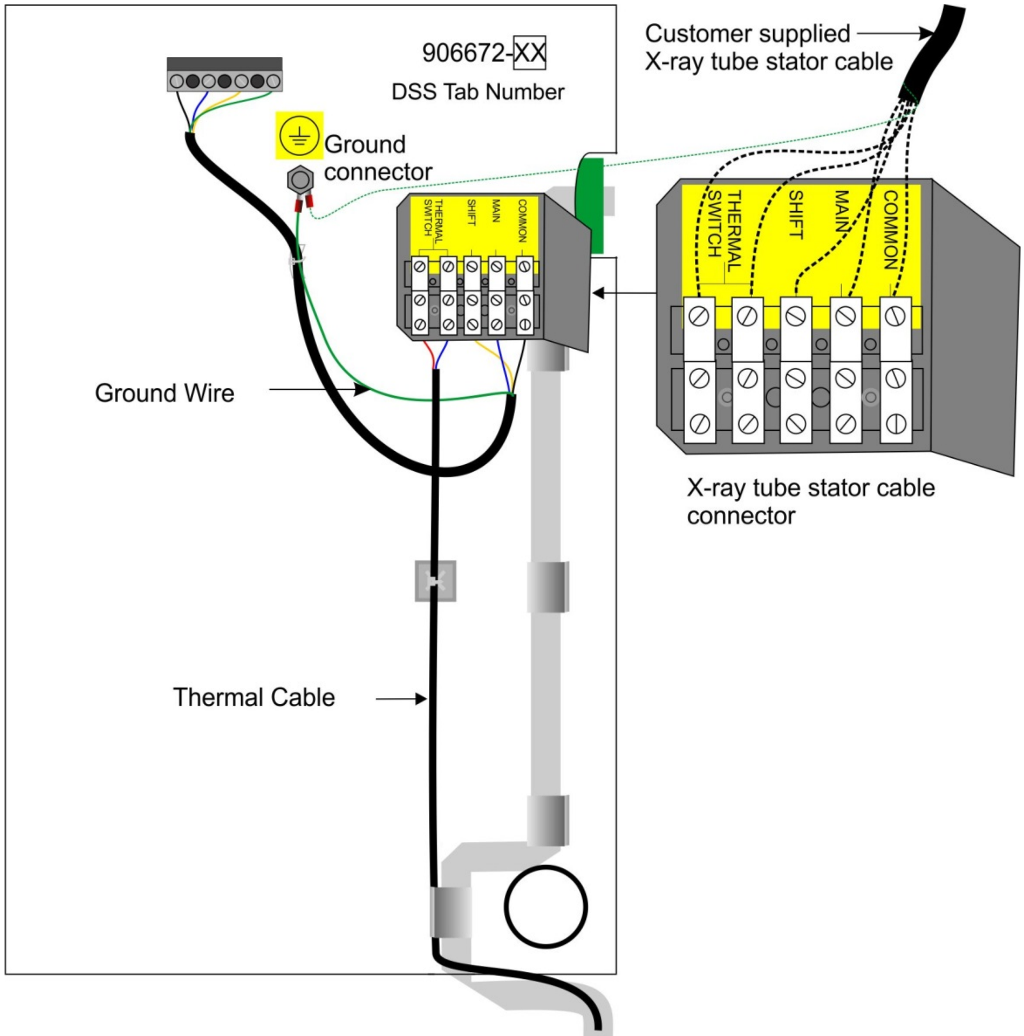


Figure 2-9: the connector of the X-ray stator cable for the dual-speed starter

1. Route the X-ray tube stator cable towards the X-ray stator cable connector on the back of the DSS board mounting plate. Refer to Figure 2-9.

   Note: The shield for the stator cable must be properly grounded at both tube end and the generator end of the cable.

2. Connect the shield ground of the stator cable to the ground connector on the mounting plate as shown in Figure 2-9.
3. Connect the X-ray tube stator cable to the X-ray stator cable connector as shown in Figure 2-9.
4. Secure the X-ray tube stator cable to the generator chassis using suitable tie-wraps or equivalent fasteners.
5. Perform the procedure, *checking the Connection of the X-ray Tube Stator Cable*, described in the following section.

Checking the Connection of the X-ray Tube Stator Cable

1. Check that the stator cable (SHIFT, MAIN, COMMON, GROUND, and THERMAL SWITCH) has been correctly connected and tightened as appropriate. Connection errors might cause X-ray generator or X-ray tube damage.
2. With an ohmmeter, measure the resistance between the Main, Common, and Shift connector pins for Tube. Record the results in Table 2-3.

Table 2-3: Example Stator Resistance Measurements

	Between Pins 1 & 2 (Common to Main)	Between Pins 1 & 3 (Common to Shift)	Between Pin 2 & 3 (Main to Shift)
Resistance, ohms			

3. Confirm that the results agree with the resistances documented in the tube stator datasheet provided by the X-ray tube manufacturer.

   Note: The sum of the resistance (Common to Main) and Resistance (Common to Shift) approximately equals to the resistance (Shift to Main). The smallest resistance should be the resistance (Common to Main).

Power Line Mains

Warning:

Connection of the mains input cable must be done by a licensed electrician in accordance with the local electrical code.

Warning:

To avoid electrical shock, ensure that the AC mains disconnect is locked in the OFF position, and that all mains cables are de-energized before connecting to the generator.

Refer to *Generator Power Requirements* of Chapter 1, *Pre-installation*, for generator power and power line requirements.

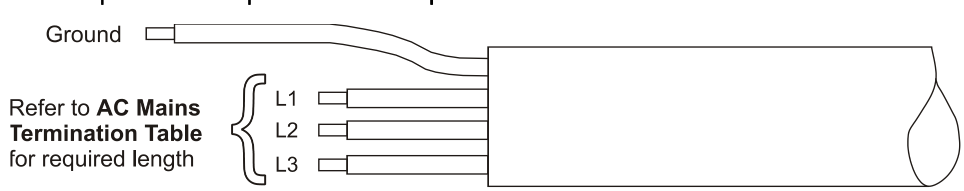


Figure 2-10: Termination of AC mains cable

Table 2-4: AC Mains Termination Table				
Generator Configuration	**Ground**	**L1**	**L2**	**L3**
65 kW and 80 kW, 400/480 VAC, 3P Configurations	7 (178)	3.25 (83)	3.25 (83)	4.25 (108)
50 kW 208/230 VAC, 3P Configurations	7 (178)	5 (127)	4.75 (121)	5 (127)
32 kW/40 kW/50kW 400/480 VAC, 3P Configurations	7 (178)	5.75 (146)	5.5 (140)	5.75 (146)
32 kW/ 40 kW, 208 /230 VAC, 1P Configurations	11 (280)	5.5 (140)	5.5 (140)	N/A

*Dimensions are in inches (mm)

1. Refer to Figure 2-11A and temporarily disconnect the fan by unplugging the fan power-connector and the EMC filter connector at the fan cover.

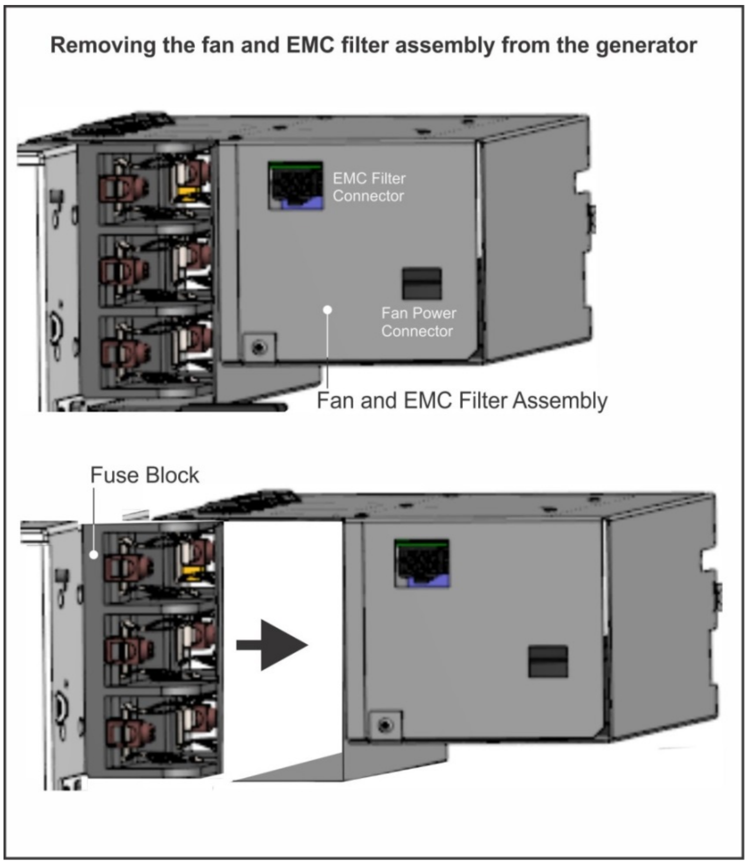


Figure 2-11A: Removing the fan and EMC filter assembly

2. Refer to Figure 2-11A. Remove and set aside the hardware securing the assembly to the generator. Then remove the assembly and set it aside.
3. Temporarily remove the safety cover from the main fuses (if fitted). This must be reinstalled after the AC mains connections are made, before reinstalling the fan and EMC filter assembly.
4. Prepare the AC mains cable as per Figure 2-10 and the **AC Mains Termination Table,** and then strip the ends of the leads to the required length.
5. Pass the AC mains cable through the cable clamp (see Figure 2-11B) at the upper rear of the generator cabinet, adjacent to the main fuses. Tighten the clamps to secure the cable.

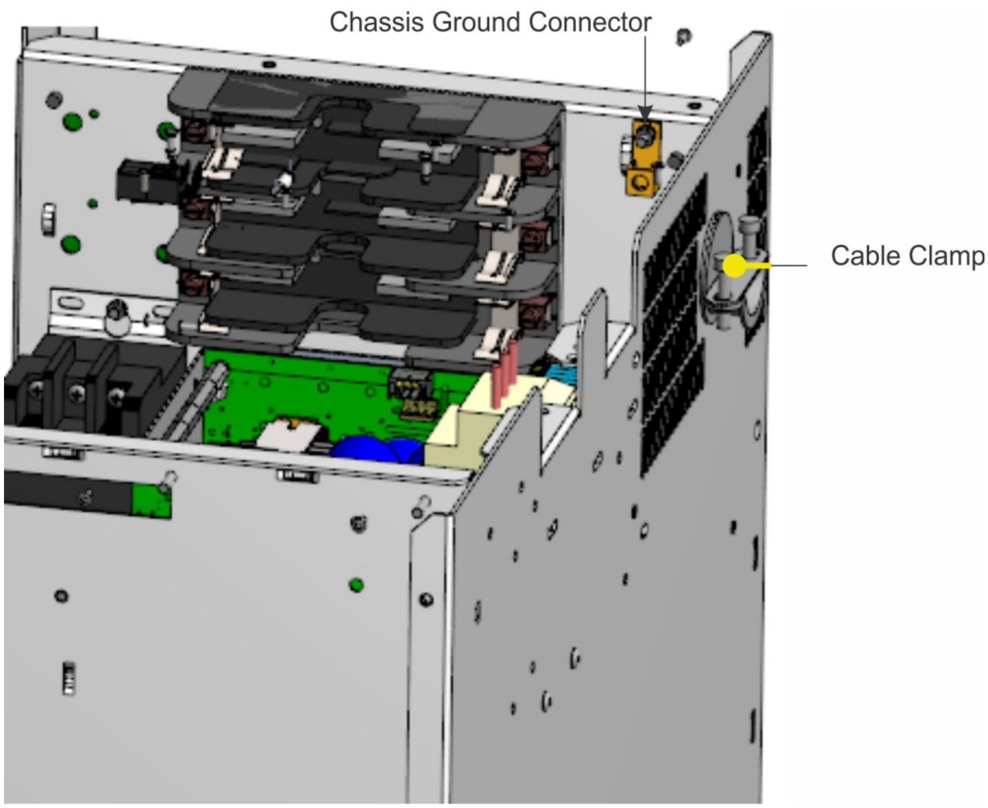


Figure 2-11B: The locations of the cable clamp and the chassis ground connector

6. Connecting the mains cable to the fuse holder
   - For 3-phase generators: Connect the ground wire of the mains power cable to the chassis ground connector (see Figure 2-11B), and connect the other wires to the terminals on the main fuse holder shown in Figure 2-11 C.
   - For single-phase generator: Route the three wires of the mains power cable through the two ferrites inside the ESD bag located above the HVM. Connect the ground wire to the ground connector and the other wires to the terminals on the mains fuse holder.

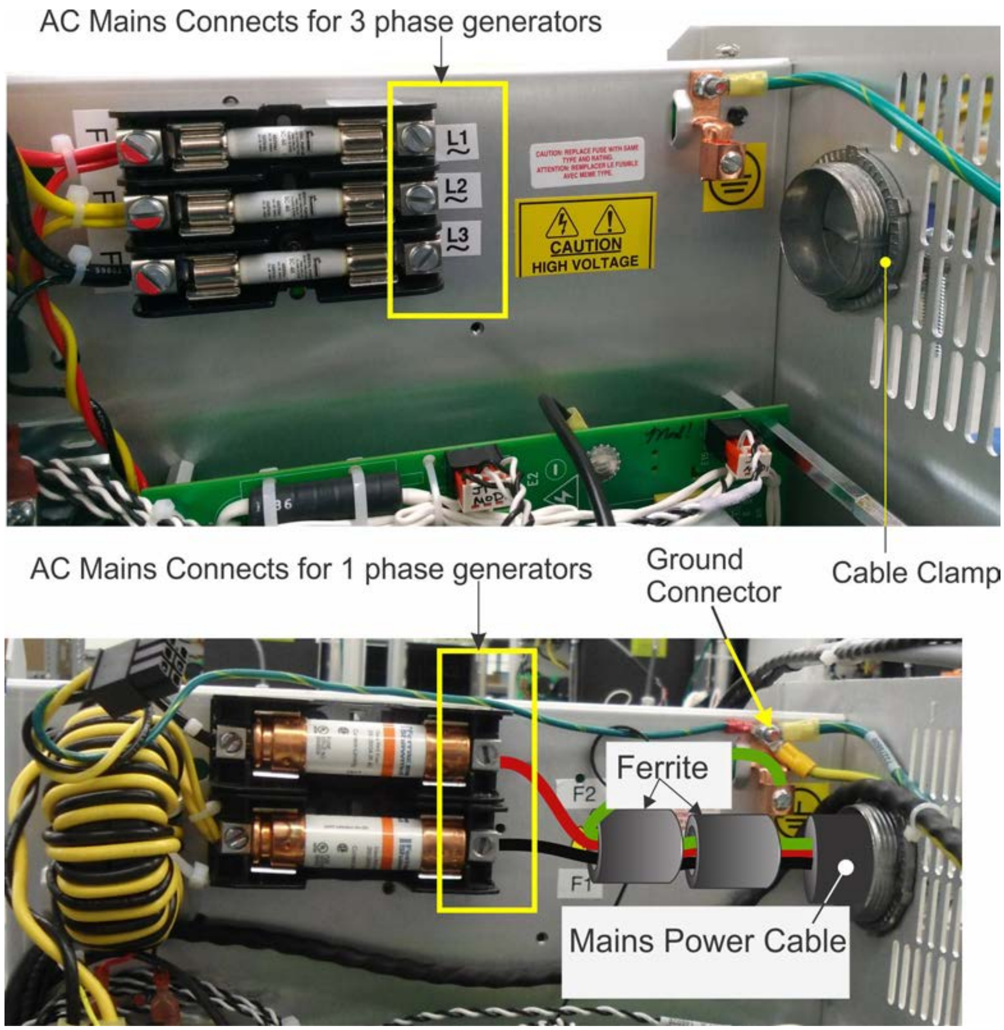


Figure 2-11C: Generator mains connection

1) Ferrules should be used on the ends of the AC mains wires. These must be supplied by the installer.
2) For China only, the power cable must be CCC approved.

7. Re-install the safety cover to the main fuses.
8. Refer to Figure 2-11D and gently reinstall the fan and EMC filter assembly to the generator. **Note**: There are cables and wires underneath the fuse block. When reinstalling the assembly, do not pinch cables or wires.

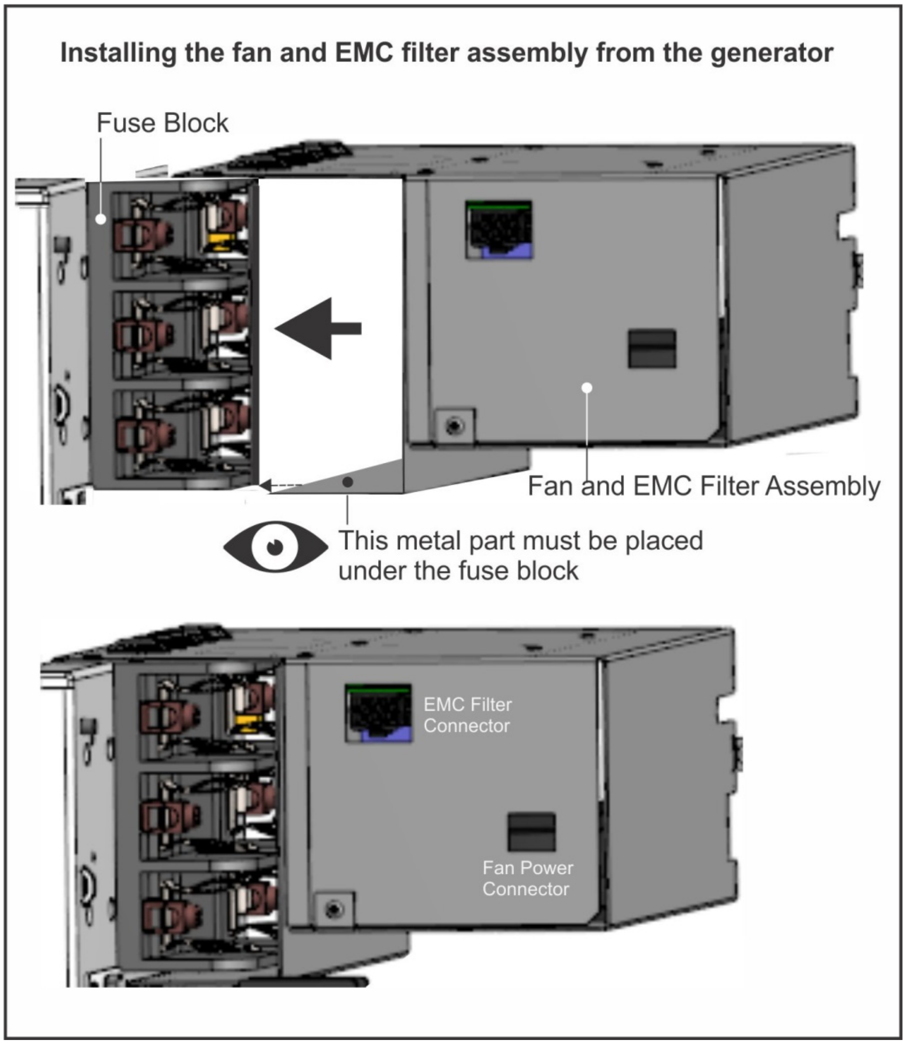


Figure 2-11D: Install the fan and EMC filter assembly

9. Secure the fan and EMC filter assembly to the chassis.
10. Reconnect the fan power cable to the fan power connector and the EMC filter cable to the EMC filter connector.

    Warning: The EMC filter installed inside the metal cover minimizes conducted and radiated emissions. This function will be disabled if the EMC filter cable is not reconnected to the EMC filter connector.

    Warning: The forced-air cooling fan is desiged to operate in an ambient temperature of expected degrees (Celsius or Fahrenheit) in order to maximize performance and reliability of the generator. Failure to reconnect the fan will result in generator malfunction and error messages.

11. Do not switch on mains power until requested to do so in a later step.

High Voltage Cables

The X-ray tube should be mounted in its normal fixture i.e. tube stand or other device. To connect the High Voltage Cables:

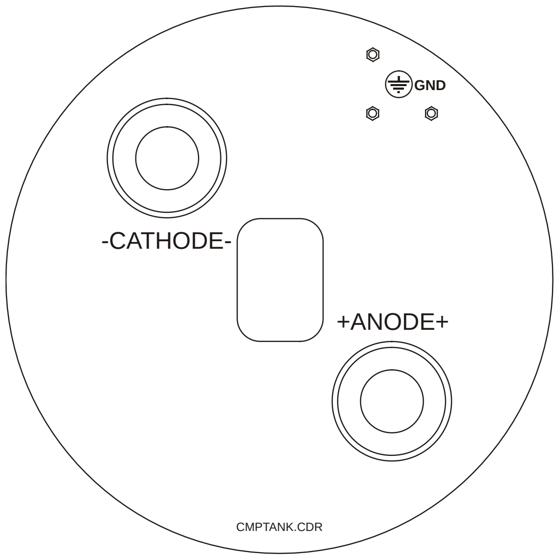


Figure 2-12A: HV connector identification

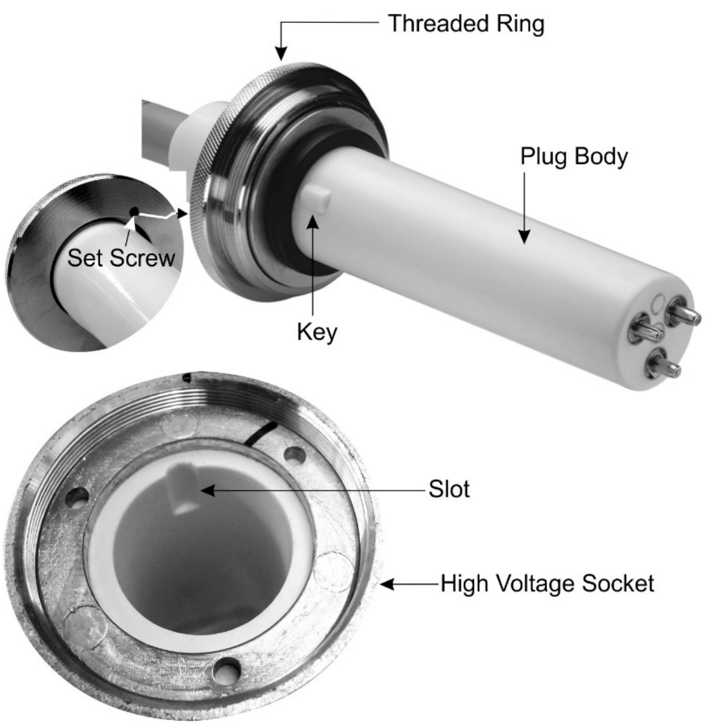


Figure 2-12B: HV cable and socket

Refer to Figure 2-12A and Figure 2-12B to install the HV cables:

1. Remove the dust caps that cover the HV (High Voltage) sockets on the HVM (high voltage module).
2. Check for debris inside the HV (**ANODE** and **CATHODE)** Sockets on the top of the HVM. If there is any debris found inside the sockets, it must be carefully removed.
3. Verify that the Plug Bodies are in good condition i.e., no cracks. The contact pins must be sufficiently opened to make good contact with the mating connectors inside the HV Socket.
4. Carefully clean the Plug Bodies of the HV cables by using dry lint-free paper towels.
5. Apply a thin coat of moisture-dissipating grease to each Plug Body.
6. Carefully clean the HV sockets by using dry lint-free paper towels.
7. Carefully observe the polarity (**ANODE** and **CATHODE**) for the HV Sockets and HV cables.
8. To connect the HV cables:
    1) In the ANODE (+) HV Socket, first identify the Slot in the socket and visually align it with the Key on the ANODE Plug Body as shown in Figure 12B. Then insert and push the Plug Body into the socket until it is firmly seated.
    2) In the CATHODE (-) HV Socket, first identify the Slot in the socket and visually align it with the Key on the CATHODE Plug Body as shown in Figure 12B. Then insert and push the Plug Body into the socket until it is firmly seated.

    Warning: The method, described in the next step, of how to tighten the threaded rings to the HV sockects must be performed by hand only. Usse of mechanical tools such as a wrench may result in over-tightening, which may rotate the HV socket. This rotation may seriously damage the high voltage module (HVM) or the X-ray generator.

9. Use the method described below to tighten the two Threaded Rings to the two HV Sockets.

    Note: A substantial amount of force is needed to secure the threaded ring of the HV connectors into the HVM interface. There is a risk of muscle strain. Avoid awkward posture and practice sound ergonomic procedures when performing this task.

    1) Tighten the Threaded Rings by hand only and ensure there is no gap between the Threaded Ring and the HV Socket, but do not over tighten.
    2) Using a hex key (1.5 mm), tighten the Set Screw, which will secure the Threaded Ring and ensure a good contact between the HV cable and the HVM.

10. After verifying normal X-ray generator operations, re-tighten the Threaded Rings connecting to the HV Sockets and the X-ray tube.

X-Ray Tube Housing Ground

In addition to the X-ray tube manufacturers recommended tube grounding procedure, a separate ground wire (10 AWG, $6mm^2$) must be connected from the X-ray tube housing to one of the ground studs on the HV module. Refer to Figure 2-12A for the location of these ground studs. These ground locations may have other ground wires already connected; ensure that these existing ground wires are not disconnected when making the X-ray tube ground connection.

Failure to make this ground connection may result in intermittent operation and/or exposure errors.

Room Equipment

Refer to Chapter 3, *Interface and Programming*, for connection of Buckys, interlocks, room lights, the DR imaging system (if applicable), DAP, collimator lamp and system locks power, and to Chapter 4, *AEC Calibration*, for installation and calibration of AEC. It is suggested that these items not be connected until the initial run-up of the generator is complete, and the tube auto calibration routine has been performed as described near the end of this chapter.

Emergency Power Off / Power Distribution Relay

To connect an external emergency power-off switch, disconnect the jumper from J2-1 to J2-2 on the generator control board. Then connect the emergency-off switch to J2-1 and J2-2. Refer to MD-0928 (System ON) in Chapter 10, *Functional Drawings*.

For installations where installer-supplied auxiliary power distribution circuits are added to the generator, 24 VDC is available on the high voltage auxiliary board to drive the coil of the power distribution relay. Connect the coil to J2-3 (+) and J2-4 (ground). Refer to MD-0927 (DC Bus and Power Distribution) in Chapter 10, *Functional Drawings*. **The maximum current available from this source is 100 mA.**

Warning:

- *The Emergency Power Off switch does not remove the AC mains input voltage. High voltages still exist inside the generator in the area of the auxiliary transformer and the HV auxiliary board. Ensure that the AC mains disconnect is locked out in the OFF position and all capacitors are discharged before servicing.*

Safety Interlocks

The room door-interlock switch must be wired to the generator as described in ***Inputs*** of Section Wiring to Inputs and Outputs in Chapter C before the generator is powered up. This switch must provide an open contact when the door is open.

Note:

- *The installer must provide a visual indication of the ON / OFF state of each external device that can prevent the generator from emitting radiation, or that can stop the generator from emitting radiation, or both.*

Jumper Settings on the HV Auxiliary Board

The jumpers on the HV Auxiliary board are used to configure the settings for a boost voltage for the Low Speed Starter and a Bucky supply voltage.

The Low Speed Starter is integrated into the HV Auxiliary board. The boost voltage for this starter based on the X-ray tube stator can be set to:

120 VAC / 240 VAC (factory default)

The Bucky supply voltage can be set to:

110 VAC / 230 VAC / +24 VDC

Warning:

- *High voltage is present on the HV auxiliary board at all times that the generator is switched on. Take appropriate precautions when servicing this board.*

Note:

- *The rotor boost time may be adjusted in the range of 0.9 second to 3.9 seconds. This should be set per the X-ray tube manufactures recommendation, or as required to ensure proper anode rotation at the end of the prep cycle.*
- *Refer to rotor boost, under generator limits in Chapter 3, Interface and Programming, for the procedure to set the rotor boost time.*
- *The low speed starter boost must not exceed 5 consecutive boosts, and must be allowed by a minimum 10-second wait period.*

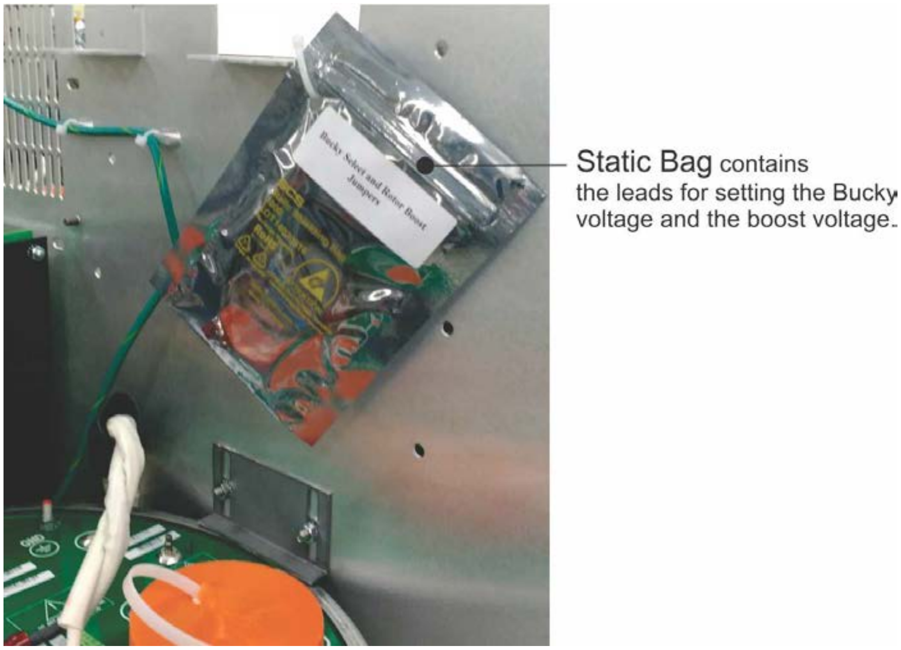
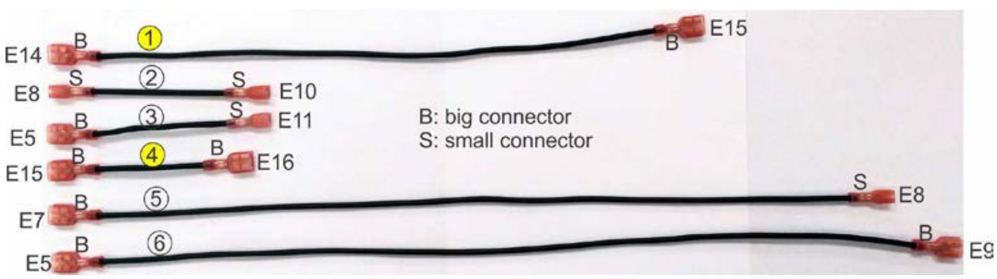


Figure 13: Bucky Select and Rotor Boost Jumpers

Settings the Bucky Voltage and the Boost Voltage on the HV Auxiliary Board



Note: The leads shown at left can be found on the HV Auxiliary board and inside the static bag (see Figure 13).

***Note**: Before continuing, refer to Table 1A, in the *X-ray Tube Stator Compatibility Tables* supplement (part number: 746026-00). Note the phase-shift capacitor value is compatible with your X-ray tube stator and determine the boost voltage for the desired X-ray tube. If the value of the phase-shift capacitor (See Figure 1-4) is **not** compatible with the desired X-ray tube stator type or the desire tube type cannot be found in Table 1A, contact CPI product support for assistance.

*Changing 120 V to 240 V Boost Voltage or vice versa: Remove lead 1 or 4 from the board and then		
Connect	To	To select
Lead 1	E14 and E15	120 V Boost Voltage
or		
Lead 4	E15 and E16	240 V Boost Voltage
Perform “Verify the Low Speed Stator” in the Acceptance Testing chapter of this manual.		

Changing 110 V / 230 V to +24 VDC Bucky Voltage: Remove leads 5 and 6 from the board and then		
Connect	To	To select
Lead 2	E8 and E10	Secondary Return
Lead 3	E5 and E11	+24 VDC Bucky Voltage
Changing +24 VDC to 110 V / 230 V Bucky Voltage: Remove leads 2 and 3 from the board and then		
Connect	To	To select
Lead 5	E7 and E8	Earth Ground
Lead 6	E5 and E9	110 V Bucky Voltage
	E5 and E12	230 V Bucky Voltage
Changing 110 V to 230 V Bucky Voltage or vice versa:		
Connect	To	To select
Lead 5	E7 and E8	Earth Ground
Lead 6	E5 and E9	110 V Bucky Voltage
	E5 and E12	230 V Bucky Voltage

Programming the Dual-Speed Starter

Caution:

- *Improper DIP-Switch settings will result in improper anode speed rotation which can cause overheating and / or damage to the X-ray tube.*

Warning:

- *Ensure programming the Dual-Speed Starter is fully understood and properly done before putting the generator in service.*

This section applies only to units fitted with a Dual-Speed Starter (DSS). Different settings apply depending on the DSS board number, and subassembly/tab number installed. Check the subassembly number and tab number (as shown in Figure 2-14A), and the board number (printed on the board) installed in your generator and follow the steps outlined in this section to program the DSS.

EPROM type / dual-speed starter - applies only to DSS Board #728877-06

1. The dual-speed starter EPROM is different for 400 V units and for 480 V units. If a 400 V unit is reconfigured for 480 V, or a 480 V unit is reconfigured for 400 V, the dual-speed starter EPROM will need to be changed. A spare EPROM (the complement of the EPROM that is in the dual-speed starter) is in a bag attached to the lip on the inside of the cable access slot above the HV module. Refer to Chapter 6, *Regular Maintenance*, for the EPROM (#7288770-06 DSS board) replacement procedure, and to Table 2-5 for the applicable EPROM part numbers.

Table 2-5: DSS Configuration			
400 VAC Configuration		480 VAC Configuration	
DSS part number	EPROM part #	DSS part number	EPROM part #
901297-02	733159-00	901298-02	735896-00
901297-12	739311-00	901298-12	739313-00
901297-13	733159-00	901298-13	735896-00
901297-15	733159-00	901298-15	735896-00
901297-16	739311-00	901298-16	739313-00

2. If you are making the conversion as per the previous step, use an indelible marker to change the part number of the dual-speed starter assembly (901297-XX to 901298-XX, or vice-versa). The dual-speed starter part number is printed on the opposite side of the board assembly, at the back of the mounting plate (see Figure 2-14A). Keeping the dual-speed starter part number current will maintain configuration control of the product.

Note: The DSS board #903132 uses EEPROM* NOT EPROM**. Table 2-5 only applies to the DSS board #728877-06. More information on upgrading the DSS board #903132 using EEPROM is found in Chapter 6, Regular Maintenance of this manual.

For the DSS subassemblies, the above configuration and EPROM part numbers only apply to subassemblies 901297-XX and 901298-XX.

EEPROM* - Electrically Erasable Programmable Read Only Memory

EPROM** - Electrically Programmable Read Only Memory

Figure 2-14A: DSS subassembly and tab number location

Tube type setting on DIP-Switch SW1 for DSS Boards #728877-06 and #903132-02

The dual-speed starter must be programmed for the X-ray tube type used at this site. This is done via DIP-switch SW1 on the dual-speed starter board.

The following tube functions are set with this switch:

- High-speed start and run voltages
- Low-speed start and run voltages
- Brake time and brake voltage
- Boost times
- Boost time increments. Boost time may be increased in 100 ms steps in the range of 100 to 700 ms.

⚠ DIP-switch SW1 on the dual-speed starter must be set correctly to match the X-ray tube in use. Failure to set this correctly may result in improper anode RPM and therefore may damage the X-ray tube.

1. Select the desired tube type from Table 2 of the *X-ray Tube Stator Compatibility Tables* supplement (part number: 746026-00). Record the tube type number (housing and insert) and the binary code as per the third column in the table. Please note that the tube compatibility applies only to the housing and inserts listed, i.e. for the specific manufacturer(s) shown.
2. If the desired tube type is not listed, please contact CPI product support for assistance.
3. The recommended dual-speed starter used in CMP 200® DR X-ray generators will be one of the following part numbers: 901297-**02**, **12**, **13**, **15** or **16** (400 VAC units), 901298-**02**, **12**, **13, 15** or **16** (480 VAC units), or 906664-21, 22, 23. Refer to the *X-ray Tube Stator Compatibility Tables* supplement (part number: 746026-00).

   The stated capacitor values are equivalent capacitor values, and are derived from several combinations of relay-selected series / parallel discrete capacitors, depending on the part number. Refer to MD-0924 (Dual Speed Starter) and MD-1069 (Dual Speed Starter 2) in Chapter 10, Functional Drawings, for details.

4. To determine if the dual-speed starter contained within your generator is compatible with the desired tube as selected in step 1, note the part number of the dual-speed starter in your generator. This is printed on the back of the mounting plate, opposite the board assembly (see Figure 2-14A). This part number must appear in the last column of Table 2 in the *X-ray Tube Stator Compatibility Tables* supplement (part number: 746026-00).

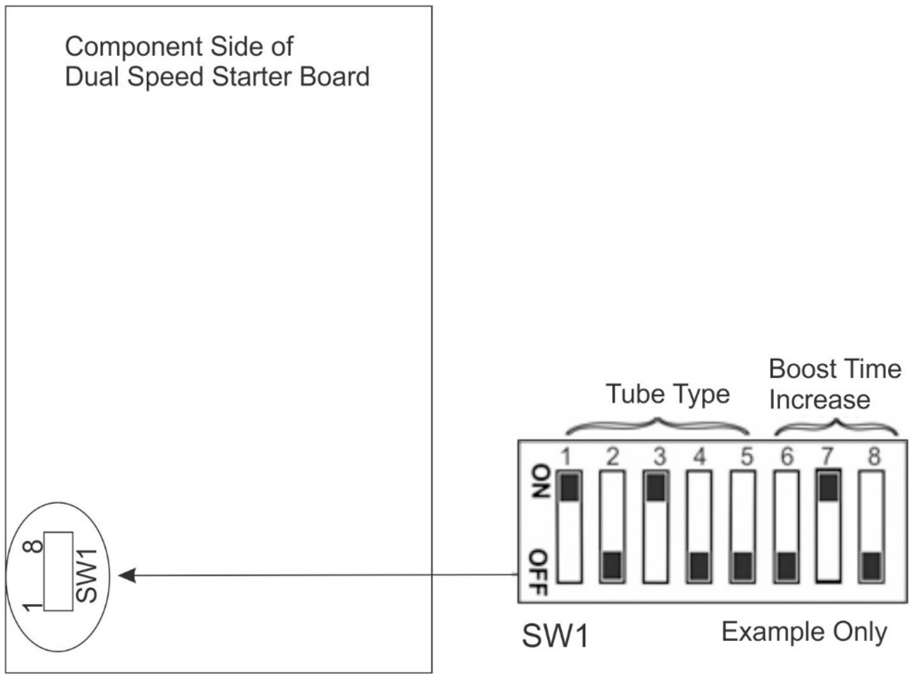


Figure 2-14B: Dual-Speed Starter DIP-switch SW1

5. Refer to Figure 2-14B. Set DIP-switch SW1 with the binary code for the selected tube. The binary code shown in the referenced Table 2 in the *X-ray Tube Stator Compatibility Tables* supplement (part number: 746026-00) programs the tube type (housing and insert), for example housing type Varian Sapphire with standard “R” stator and inserts per Table 2 requires SW1-1 to be set ON, SW1-2 OFF, SW1-3 ON, SW1-4 OFF and SW1-5 OFF. This programs the voltages, brake times, and boost times required.

   Additionally, SW1-6 to SW1-8 may be set to give incremental increases in boost time (0.1 to 0.7 second) over the preselected values (i.e. to run an older tube with worn bearings). For example, binary 000 gives zero increase, binary 001 gives 100 ms increase, binary 100 gives 400 ms increase, and binary 111 gives a 700 ms increase in boost time. SW1-6 represents bit 1, SW1-7 bit 2, and SW1-8 represents bit 3.

   EXAMPLE:

   Binary 100 = decimal 4 = 400 ms incremental boost time increase:

1	0	0
Bit 3	Bit 2	Bit 1
SW1-8	SW1-7	SW1-6

6. The DIP-switch setting shown in Figure 2-14B is for the example in step 5 with an incremental increase in boost time of 200 ms.
7. Follow the tube manufacturer's recommendation for verifying the anode speed. If the tube manufacturer does not supply recommendations or instructions to measure the anode speed, use a suitable tachometer that is capable of measuring the anode rotation speed.

   Note: It is critical that the tube anode speed meets the tube manufacturer's requirements. If the tube anode does not reach the required rotation speed, the tube may experience premature failure.

   Additionally, the following options may be available to some service personnel to verify the anode rotation speed:

   1) An accelerometer and a spectrum analyzer
   2) An accelerometer and an oscilloscope with Fast Fourier Transform (FFT) feature

   Note: For tubes where "Low speed operation only" is indicated, the dual-speed starter must be programmed for low speed only, and where "hig speed operation only" is indicated, the dual-speed starter must be programmed for high speed operation only. Refer to the *Tube Selection / Tube Setup* section in Chapter 3, *Interface and Programming*, for the procedure to do this.
   The DIP-switch shown in Figure 2-14B is representative of one style of switch only. Depending on manufacturer, your DIP-switch style may vary. Note the ON / OFF positions carefully for your unit.

Programming DIP-switch SW3 for DSS Board #903132-02

DIP-switch SW3 on the dual-speed starter must be set correctly. Failure to do this may result in improper anode RPM and therefore may damage the X-ray tube.

The dual-speed starter must be programmed to match the input voltage to the generator and the phase shift capacitors connected to the board. The phase-shift-capacitor configuration is identified by a label located on the back of the DSS panel. This programming is done by setting SW3.

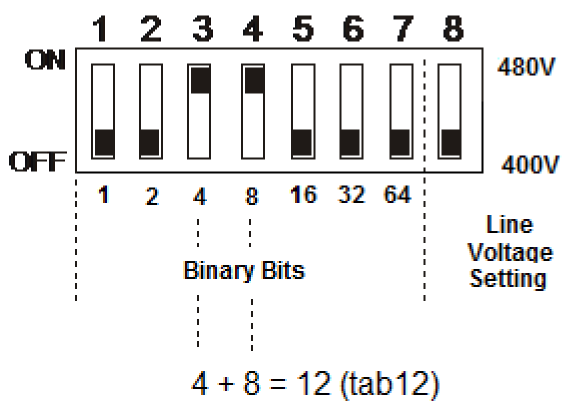
To Set Power Main Line Input:

Caution: Ensure that SW3-8 setting matches the line input voltage, which should match the Auxiliary Transformer Line Voltage Tap Selec*tion* instruction in the *Programming the Dual-Speed* Starter section of this manual.

- For generators with a mains input of **400 VAC** - **Set SW3 - 8 - OFF**
- For generators with a mains input of **480 VAC** - **Set SW3 - 8 - ON**

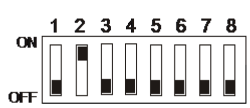
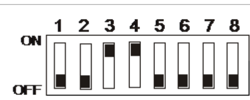
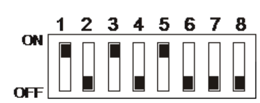
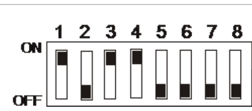
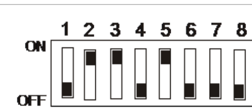
To Set Capacitor Configuration

1. Set SW3, switches 1 to 7 according to the subassembly tab number labeled on the back of the DSS panel (see Figure 2-14A).



Example above is configured for a panel assembly 9XXXXX-12, 400 V Line Input.

2. See the next two tables for a list of all the Tab numbers and their corresponding DIP-switch SW3 settings.

Table 2-6: Generator input Voltage: 400 VAC			
Tab Number	**SW3 Setting**	**Tab Number**	**SW3 Setting**
02		**16**	
12		**21**	
13		**22**	

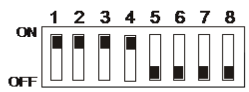
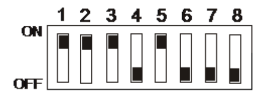
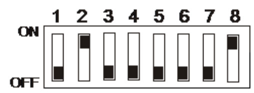
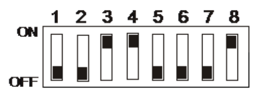
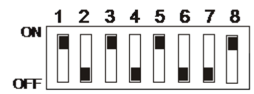
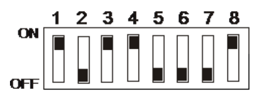
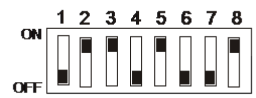
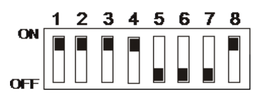
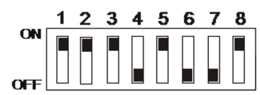
15		23	

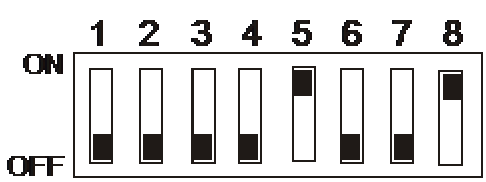
Table 2-7: Generator input Voltage: 480 VAC

Tab Number	SW3 Setting	Tab Number	SW3 Setting
02		16	
12		21	
13		22	
15		23	

Inspecting DIP-Switch SW8 setting for DSS Board #903132-02

DIP-Switch SW8 on the dual-speed starter must be set correctly. Failure to do this may result in damage to the X-ray tube or generator.

SW8 is set at the factory. Adjustment of this switch is not required. However, it is recommended to inspect the switch to verify that it is set properly before proceeding further. The settings are as follows:



SW8 factory switch settings

SW8 - switches 1,2,3,4,6,7 – **OFF**

SW8 - switches 5,8 – **ON**

Note: Only check the switch settings of DIP-Switch SW8. Making adjustments different from this setting will result in improper anode RPM, which can cause overheating and / or damage to the X-ray tube.

Configuring dual-speed starter 901297-15 / 901298-15

Dual-speed starter part number 901297-15 / 901298-15 is a special configuration in which the low-speed phase shift capacitors may be set to 15.5 uF or 28 uF. The 15.5 uF setting is intended for use in installations where low-speed operation of CGR (GE) Statorix tubes is required. The high-speed capacitance is automatically selected to either 3 uF or 6 uF according to the DIP-switch setting.

Refer to Figure 2-15. In configuration “A”, (28 uF) two leads are connected to the lower right capacitor. Thus, the capacitor is in-circuit in this configuration. Configuration “B” (15.5 uF) has one of the leads removed from the terminals of this capacitor, thus the capacitor is out of the circuit.

- To change from configuration “A” to “B”, disconnect the interconnecting lower lead from the lower left capacitor in Figure 2-15, and connect it to the same terminal on the lower right. This removes the lower right capacitor from the circuit.
- To change from configuration “B” to “A” in Figure 2-15, reconnect the lead between the two capacitors, as shown. This connects the capacitor into the circuit.

After the phase shift capacitors are correctly configured, set the DIP-switches as follows:

- Locate the desired tube in Table 2 of supplement 746026. With dual-speed starter 901297-15 / 901298-15 set to configuration “A”, this starter is compatible with all tubes requiring a 3 uF or 6 uF high-speed shift capacitor (unless indicated otherwise) and a 28, 30 or 31 uF low-speed shift capacitor. When set to configuration “B”, it is only compatible with tubes requiring a 3 uF or 6 uF high-speed shift capacitor (unless indicated otherwise) and a 15.5 uF low-speed shift capacitor.

  Note the DIP switch setting for the desired tube as per Table 2 of the X-ray Tube Stator Compatibility Tables supplement (part number: 746026-00).

- Set the DIP-switches as per *Tube Type Setting on DIP SWitch SW1 for DSS Board #728877-06 and #903132-02* in Chapter 2, *Installation*.

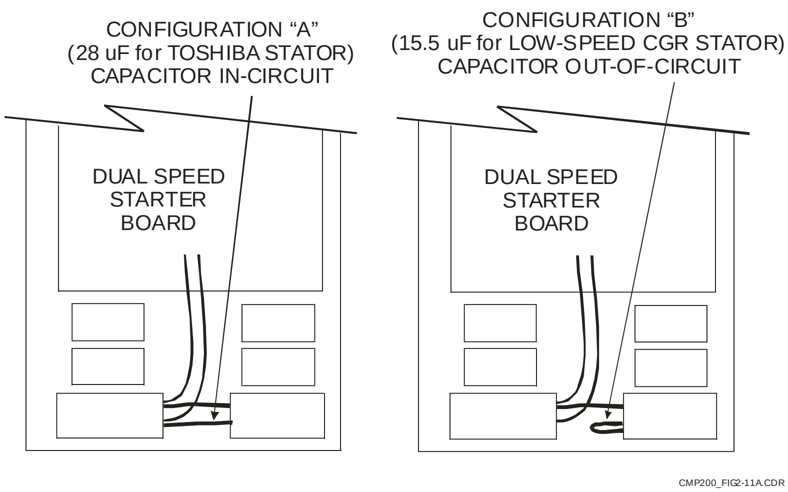


Figure 2-15: Selection of phase shift capacitance

Generator Control Board DIP-Switch Settings

Before continuing, verify the DIP-switch settings on the generator control board. These switches have been factory set but may have been readjusted, particularly if this generator is a re-install.

Generator Control Board:

Using Table 2-8 and verifying the settings on S3.

Table 2-8: S3 Settings

Generator Power	Maximum mA	S3-8	S3-7	S3-6	S3-5
32 kW	400 mA	OFF	OFF	OFF	ON
40 kW	500 mA	OFF	OFF	ON	OFF
50 kW	630 mA	OFF	OFF	ON	ON
65 kW	800 mA	OFF	ON	OFF	ON
80 kW	1000 mA	OFF	ON	ON	OFF

Note: SW3-1 when ON = Factory Defaults; OFF = Defaults Disabled; DIP-Switch S3-2, S3-3, S3-4 are not used. Refer to *Resetting Factory Defaults* in Chapter 6, *Regular Maintenance,* for details regarding the Factory Defaults setting.

Initial Run-up

This section describes the procedure for the tap selection of the auxiliary transformer line voltage, and for initial power-on of the generator after it has first been installed.

Observe the following points regarding the main distribution transformer

If using a distribution transformer with an isolated secondary, the secondary winding must be a wye (star) configuration with the center point ground-referenced. Do not use a delta-configured secondary, as there is no ground reference in this configuration.

If using an autotransformer-type distribution transformer, the AC input to the transformer must be ground-referenced.

Auxiliary Transformer Line Voltage Tap Selection

Warning:

- *The voltage tap selection describerd in this section does not apply to the generator configured for 50 kW output power and 400 VAC input mains power (the generator (50 kW and 400 VAC input)), which uses the single inverter board and can only be connected to the 400 VAC mains input. Connecting the 480 VAC mains input to the generator (50 kW and 400 VAC) input will cause in generator damage.*

For 208 / 230 V generators, the line voltage taps on the auxiliary transformer must be checked before powering up the generator.

For 400 / 480 V generators, the auxiliary transformer line-voltage tap is factory set to match the line voltage that was specified at the time of the order. If these units are to be operated from other than the rated line voltage (i.e. if a 400 V generator is to be operated from 480 V mains), the line voltage tap on the auxiliary transformer must be changed as described below.

For 208 / 230 VAC generators:

1. Verify that the mains voltage and current capacity is correct for the generator installation per *Generator Power Requirements* in Chapter 1, *Pre-insatllation*.
2. Locate the auxiliary transformer inside the generator cabinet. Refer to Figure 1-4 of Chapter 1, *Pre-insatllation*.
3. Note the line-voltage tap position on this transformer as determined by the location of the wire on the 208 V or the 240 V tap on the transformer primary. This is normally set to the 240 V tap. Refer to Figure 2-16.
4. Based on the nominal line voltage, set the transformer primary voltage tap as follows:

1) Loosen the clamping screws for the current line-voltage tap, and for the required line-voltage tap.
2) Connect to the 208 V tap if the line voltage is 215 VAC or less.
3) Connect to the 240 V tap if the line voltage is 216 VAC or higher.
4) Retighten both of the clamping screws.

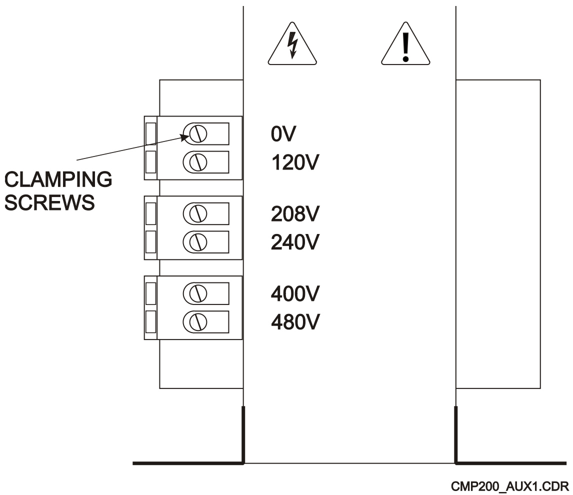


Figure 2-16: Auxiliary transformer, terminal view

For 400 / 480 VAC generators:

The 400 / 480 V tap setting only needs to be changed if a 400 V generator is to be operated from 480 V mains, or if a 480 V generator is to be operated from 400 V.

1. Verify that the mains voltage and current capacity is correct for the generator installation per *Generator Power Requirements* in Chapter 1, *Pre-insatllation*.
2. Locate the auxiliary transformer inside the generator cabinet. Refer to Figure 1-4 of Chapter 1, *Pre-insatllation*.
3. Note the line-voltage tap position on this transformer as determined by the location of the wire on the 400V or the 480V tap on the transformer primary. This is set to the 400 or 480V tap to match the line voltage specified at the time of the order. Refer to Figure 2-16.

   Caution: Ensure that DIP-switch SW3-8 setting on the dual-speed starter board (903132-02) is set according to the Programming DIP-switch SW3 for DSS Board #903132-02 procedure of Chapter 2, *Installation*, which should match the line voltage and the setting of the auxiliary transformer tap selected here.

4. Based on the nominal line voltage, set the transformer primary voltage tap as follows:
   1) Loosen the clamping screws for the current line-voltage tap, and for the required line-voltage tap.

2) Connect to the 400 V tap if the line voltage is nominally 400 VAC.
3) Connect to the 480 V tap if the line voltage is nominally 480 VAC.
4) Retighten both of the clamping screws.

Initial Voltage Measurements

1. If the mains supply is compatible with the generator, switch on the main breaker and / or the disconnect switch and check for the following voltages:

   Note: Do not switch the generator on at this time (only the AC mains to the generator is to be switched ON).

   Warning: Use extreme care in measuring these voltages. Accidental contact with mains voltages may cause serious injury or death. Mains voltage will be present inside the generator cabinet, even with the console switched off. The DC bus capacitors may present a safety hazard for a minimum of 5 minutes after the generator has been switched off. Check that these capacitors are discharged before touching any parts in the generator.

2. Measure and record the voltage across the main line fuses in the generator. Single-phase units will only use one set of voltage measurements.

   L1 phase to L2 phase: ______ VAC. L1 phase to ground: ______ VAC.

   L1 phase to L3 phase: ______ VAC. L2 phase to ground: ______ VAC.

   L2 phase to L3 phase: ______ VAC. L3 phase to ground: ______ VAC.

3. Are the line-to-line and line-to-ground voltages within specification for the unit? For single-phase 230 V units, the line to ground voltage should be 99 – 127 V. For 3 phase units, the phase to ground voltage should be 114 – 146 V for 208 / 230 V units, 230 V $\pm$ 10 % for 400 V units, and 277 V $\pm$ 10 % for 480 V units.

   ___ Check

4. Confirm that the auxiliary transformer line voltage taps are set to the appropriate position as per the measured line voltage.

   ___ Check

5. For units fitted with the optional dual-speed starter board 728877-06: if a 400 V unit is reconfigured for 480 V, or a 480 V unit is reconfigured for 400 V, the dual-speed starter EPROM will need to be changed by performing the EPROM (#7288770-06 DSS board)

6. replacement procedure

___ Check

For units fitted with the optional dual-speed starter board 903132-xx, the line input voltage is sensed automatically by the board and no component needs to be changed.

Tube mA Auto Calibration

It is recommended that the generator be tested at this point with only the X-ray tube and rotor / high-tension cables connected. The generator should be able to complete an X-ray tube seasoning and calibration cycle without other equipment connected to the generator (other than the basic interlocks as noted below). This will allow for easier fault isolation as each section of the system is connected and tested.

Before being able to make X-ray exposures, the room door interlock must be closed and the thermal switch must be closed. The interlocks cannot be deprogrammed during tube mA auto calibration.

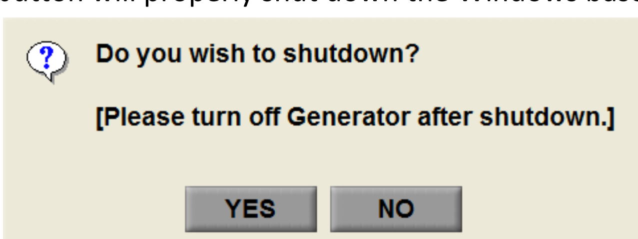
It is recommended that the tube be conditioned (seasoned) before beginning tube auto calibration, particularly if the tube has not been used for some time. Refer to *Tube Conditioning / Seasoning* in Chapter 6, *Regular Maintenance*.

Before beginning tube auto calibration, the tube used in this installation must be properly selected (*Tube Selection / Tube Setup*), and the generator limits should be programmed. Refer to Chapter 3, *Interface and Programming*.

Powering-up Touchscreen

The following messages may appear during the Power-up/initializing process:

- The message "**Generator Offline, please turn on Generator.**" displays if the console is switched ON, without switching the generator ON from the mini-console. If this is the case the message will disappear and the screen will refresh after the generator initializes.
- The message below displays when 'SYSTEM SHUT DOWN" has been selected in the **Main Menu**. This acts as a reminder to the user to also switch off the generator from the mini-console and avoid unnecessary idling. Tapping the **YES** button will properly shut down the Windows based software of the console.



There are two blue LED indicators on the 15.6-inch touchscreen console. They are located on the left side of the console. The top LED indicates the console is powered ON. The other indicates the hard drive status of the console.

Final Checks

The room interface connections may now be completed. These items are described in the *Room Equipment* section of this chapter.

1. When finished all wiring, check that all connections are tight and secure.
2. Check that all cables are dressed neatly inside the main cabinet, and secured as necessary.
3. Reconnect any grounds that have been removed from covers. Then reinstall all covers before placing the generator into service.
4. For units with the touchscreen console, perform *Touchscreen Calibration* in Chapter 3, *Interface and Programming*.
5. Re-install the generator cover. You must use good judgment and work practices to avoid injury and damage to equipment.

Note:

The installer should ensure that all cable connections to the generator are secure, and all cables external to the generator are adequately protected against accidental disconnection.

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Chapter 3 Interfacing and Programming

Contents

Introduction

This chapter describes the interfacing of the CMP 200® and CMP 200® DR X-ray generators to Bucky(s), interlocks, room lights, a DR imaging system (if applicable), DAP, collimator lamp and tube stand locks, and also describes the generator programming.

Wring to Inputs and Outputs

Note:

- *The installer must provide the necessary interfacing cables for wiring to the generator inputs and outputs described in this section.*

Warning:

- *Line voltage is present inside the generator at all times that the main disconnect is switched on. For safety, the main disconnect should be switched off and locked out while connecting room equipment.*

Inputs

The Bucky inputs, interlock 1 and interlock 2 / TOMO inputs, and room door interlock inputs are opto coupled. This means that a relay contact, transistor, or other low-impedance switching device (≤ 100 Ω, 10 mA current rating) must be connected across each of these inputs. Table 3-1 defines the pin outs, polarity at the terminals and the logic condition required for that input. If using a directional switching device, such as a transistor, the polarity of the voltage seen by the switching device must be observed. This is shown in Table 3-1.

Refer to Figure 3-1. This is a pictorial drawing of the J2, J4, and J11 inputs and outputs on the H.V. auxiliary board.

Refer to the section, *AEC Interconnect*, of Chapter 3, *Interface and Programming*, for details on AEC connections.

Warning:

- *Do not defeat the room door interlock or the interlock 1 and 2 inputs unless the corresponding device is not present. Consult the applicable regulations before disabling any exposure interlocks. Do not violate any regulations for X-ray safety. Never bypass the X-ray tube thermal switch interlock. Observe ionizing radiation personal protection at all times.*

Note:

- *The Bucky 1 and TOMO / Bucky 2 outputs may be installer programmed. Bucky 1 will normally be programmed to correspond to the table Bucky, and Bucky 2 will normally be programmed for the wall Bucky or for TOMO.*

Table 3-1: Generator Inputs on the HV Auxiliary Board

Connector Pins	Definition	
J2-5 (-) J2-6 (+)	B2: B1:	Bucky 1 ready. A contact closure from pin 5 to 6 indicates BUCKY 1 READY. *
J4-5 (-) J4-6 (+)	B2: B1:	Bucky 2 ready. A contact closure from pin 5 to 6 indicates BUCKY 2 READY.*
J4-9 (-) J4-10 (+)	Door interlock: A contact closure from pin 9 to 10 indicates that the room door is closed. *	
J2-1 (-) J2-2 (+)	Interlock 2. A contact closure from pin 1 to 2 indicates that interlock 2 is closed. * This is the tomo exposure input for any image receptor that is programmed for tomo operation. The tomo start / stop command is generated by the tomo system. The generator will only terminate the tomo exposure if the tomo backup time is exceeded. *	
J2-3 (-) J2-4 (+)	Interlock 1. A contact closure from pin 3 to 4 indicates that interlock 1 is closed. *	

*Note: These inputs are meant for dry contacts only. Do not apply any voltage source to these inputs.

Outputs

Table 3-2 shows the Bucky and auxiliary power outputs from the generator. Refer also to Figure 3-1.

Table 3-2: Generator Outputs on the HV Auxiliary Board

Connector Pins	Definition
J2-10	B4: Bucky 1 return
J2-9	B6: Ground (Bucky 1)
J2-8	B8: 24 VDC, 110 / 220 VAC out (Bucky 1). *See note below*
J2-7	B3: 24 VDC, 110 / 220 VAC out (Bucky 1 start). *See note below*
J4-4	B4: Tomo / Bucky 2 return
J4-3	B6: Ground (Tomo / Bucky 2)
J4-2	B8: 24 VDC, 110 / 220 VAC out (Tomo / Bucky 2). *See note below*
J4-1	B3: 24 VDC, 110 / 220 VAC out (Tomo / Bucky 2 start). *See note below*
J11-3 J11-4	Room lights. The generator supplies a dry contact closure when the room light is to be activated.
J11-5 J11-6	24 VAC @ 150 watts output for customer use
J11-1 (-) J11-2 (+)	24 VDC @ 45 watts output for customer use (not switched)

Note:

The Bucky outputs may be reconfigured to supply 24 VDC or 220 VAC if required, as described in chapter 10. Please confirm compatibility with the Buckys used in this installation before proceeding. For tomo operation, the applicable Bucky outputs must be programmed as necessary.

The BUCKY 1 START and TOMO / BUCKY 2 START relays K1 and K3 on the H.V. auxiliary board have provisions for R-C snubber circuits to be connected across these relays. For older Buckys that typically have relay inputs, the R-C snubber circuits usually need to be connected. These snubbers attenuate the dV/dT transients that are generated when the corresponding relay in the Bucky opens.

For newer Buckys with opto-coupler inputs, the R-C snubber circuits across relays K1 and K3 on the H.V. auxiliary board should remain disconnected, as the leakage current through the R-C snubber can be sufficient to energize the opto-couplers in the Bucky(s) when the corresponding relays on the H.V auxiliary board are open.

For older Buckys with relay inputs:

- Refer to Table 3-3 and to MD-0930 (Room Interface) in Chapter 10, *Functional Drawings*. The required resistors (R2, R15) must be installed to complete the R-C snubber circuit.

For newer Buckys with Opto-coupler inputs:

- No action required. Resistors R2 and R15 are NOT factory installed, therefore the R-C snubber is open-circuit. It is the responsibility of the installer to provide the proper interfacing circuits to the Opto-coupler(s) in these types of installations.

The resistors that must be installed to complete the R-C snubber circuits across K1 and K3 on the HV auxiliary board are shown below. Kits with these resistors are available from CPI Product Support. The kit part number is 90301600.

Table 3-3: Resistors for Bucky Relay

RELAY	RESISTOR	NOTE
K1	R2 (10 ohm 1/2 W carbon composition)	R2 is not factory-installed.
K3	R15 (10 ohm 1/2 W carbon composition)	R15 is not factory-installed.

Warning:

Do not exceed generator Bucky power 110 VAC 90 VA, 220 VAC 180 VA, 50 / 60 Hz, 0.8 amp fast blow fuse ($I^2 t \leq 0.15A^2 s$).

Inputs & Outputs (simplified schematic)

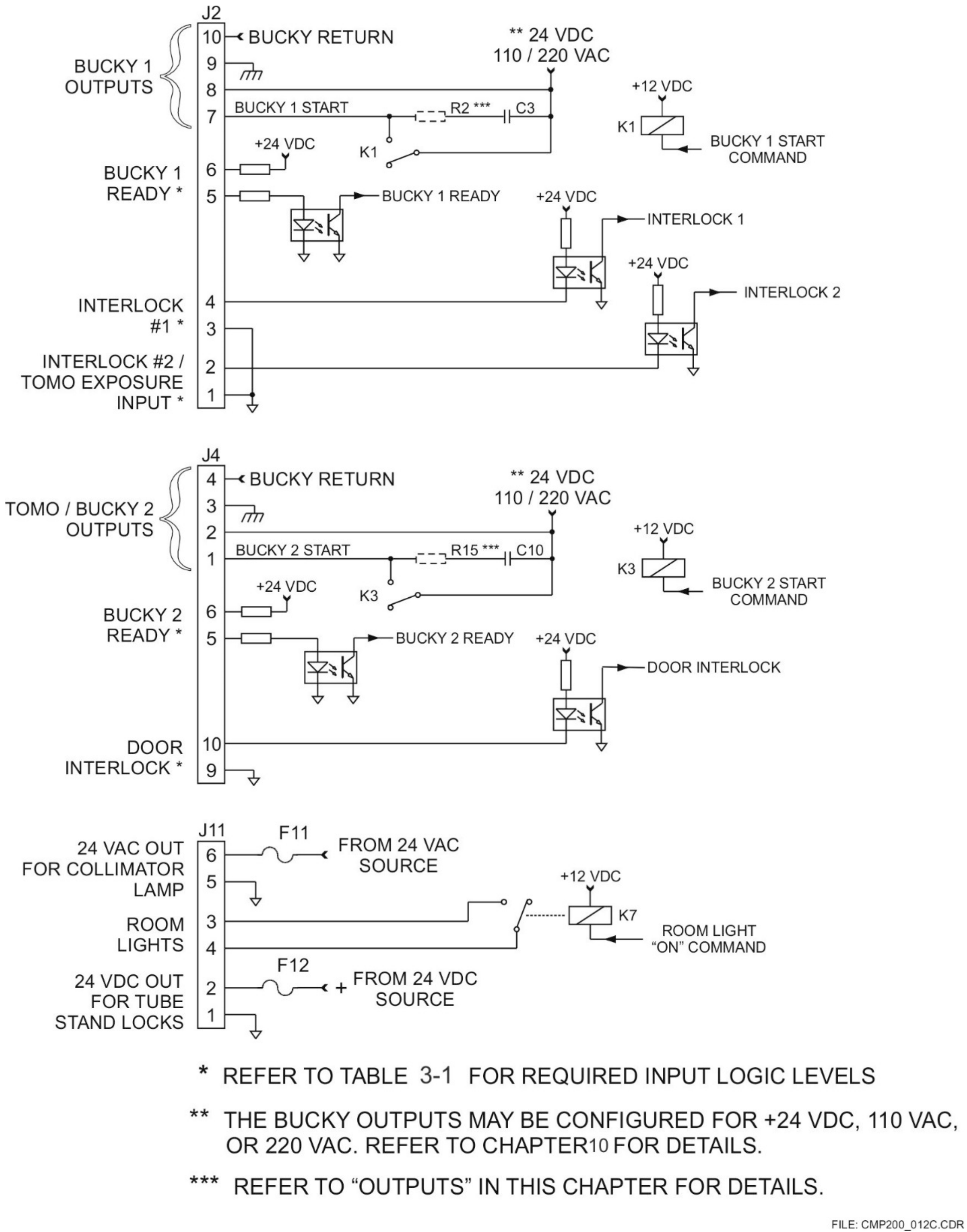


Figure 3-1: J2, J4, and J11 inputs and outputs (H.V. auxiliary board)

Interconnect

Refer to Chapter 4, *AEC Calibration*, for an overview of AEC theory, for AEC chamber connections, and for the AEC calibration procedure.

DR imaging system

CMP 200® DR X-ray generators are factory-configured to interface with one or more DR imaging systems. Refer to *Product Configuration / Compatibility Statement* to determine which with DR imaging system(s) this model of generator is compatible. The DR imaging system is connected to 37-pin “D” connector J25 on the generator control board. The corresponding digital imaging supplement will be included in the document set. Refer to that supplement for the installation and setup procedure of the DR imaging system.

Generator Programming via CPI Membrane Console and GenWare®

The generator maybe programmed and calibrated via the CPI membrane console or GenWare®. This section provides the instructions of how to program the generator via the membrane console and GenWare®.

When using the console for programming and calibration, all programming / calibration menus are displayed on the LCD display window on the console. The “soft key” buttons on the console are used to navigate through the programming screens and to select and enter values in this section.

Entering Into Programming Mode

To enter into the programming mode if using the membrane console, follow the steps below.

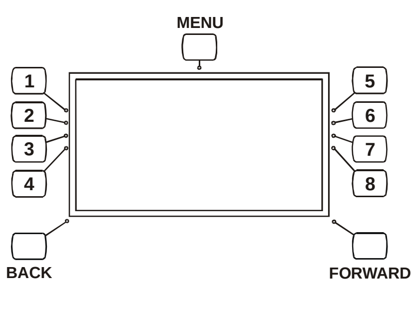


Figure 3-2: Programming / calibration mode reference

Opening GenWare® Installed in a Computer

This is used with the GenWare® (PC) utility software. This allows for data communication with a computer in order to download additional tube types, transfer APR data, edit APR text, perform setup and calibration functions, and for other minor functions. Further documentation is included with GenWare® (PC).

1. Refer to the instruction printed on the GenWare® CD to install GenWare®.
2. Connect the null-modem cable from a serial port on the computer with GenWare® installed to the *DATA LINK* connector on the rear of the control console. Refer to the Figure “Rear of control console” in chapter 2 for the location of this connector.
3. From the GENERATOR SETUP menu select DATA LINK, and then select CONNECT TO GENWARE. A DATA LINK submenu will open, indicating WAITING FOR DATA... PLEASE DO NOT TURN OFF POWER.
4. Switch on the computer and start GenWare®.
5. GenWare® is ready for use when communication is established with the generator.

If the data link connector is not available, i.e. on units without a CPI supplied console, J21 on the generator control board may be used.

Note:

GenWare® MP (PC) should be closed before exiting the data link function on the console. Failure to do so may require that the console be switched off and then on again in order to re-initialize communication with the generator.

Use these steps to access the **GENERATOR SETUP** menu (membrane console).

Action (membrane console)	Action (GenWare®)
1. Start with the generator switched OFF. 2. While pressing and holding the **MENU** button, press the power **ON** button on the console. The **MENU** button must be pressed until the console beeps. 3. Enter the password by pressing the button sequence: [**1**] - [**8**] - [**4**] - [**5**]. 4. The **GENERATOR SETUP** menu will be displayed next.	1. Start with the generator switched ON and then press the power switch to turn the touchscreen ON. 2. On the **Main Menu** window, press the **System Utilities** button. 3. Enter the password by pressing the button sequence: 1, 9, 7, 3 and then press the **Accept** button. 4. The **System Utilities** window displays. On this window, click the **Genware** button to enter the GenWare**®** application.

Generator Setup Menu

The **GENERATOR SETUP** menu for the membrane console is shown below.

* GENERATOR SETUP *	
UTILITY	APR EDITOR: DISABLED
DIAGNOSTICS	GEN CONFIGURATION
VALIDATE APR	DATA LINK
EXIT SETUP	

Table 3-4: Functions of the Generator Setup Menu		
Membrane Console		**GenWare®**
Menu	**Sub-menu**	Equivalent Function
UTILITY	SET TIME & DATE	Date and Time Control Window
	ERROR LOG	Error Log utility
	STATISTICS	Generator Statistics utility
	CONSOLE	N/A
APR EDITOR	Enables / disables changes to APR techniques.	N/A
DIAGNOSTICS	For factory use only	N/A
GEN CONFIGURATION	TUBE SELECTION	Tube Setup utility
	GENERATOR LIMITS	Generator Limits Setup utility
	RECEPTOR SETUP	Receptor Setup utility
	I/O CONFIGURATION	Receptor Setup utility
	AEC SETUP	AEC Setup and Calibration utility
	AEC CALIBRATION	AEC Setup and Calibration utility
	TUBE CALIBRATION	Tube Calibration utility
	DAP SETUP	DAP Setup utility
VALIDATE APR	Validates each APR entry to ensure that the APR's do not exceed the generator or tube limits	N/A
DATA LINK	CONNECT TO GENWARE® FIRMWARE UPDATE	Data Link: Allows communication with an external computer only.
	The function CONNECT TO GENWARE® is described in the section *DATA LINK (Connect to GenWare®)* later in this chapter. FIRMWARE UPDATE is described under *Console Firmware* in chapter 6 of this manual.	
EXIT SETUP	Returns to the normal operating mode (the non-setup / programming mode)	N/A

Utility Menu

The **UTILITY** menu presents the user with the options shown below.

```
                    * UTILITY *
SET TIME & DATE
ERROR LOG
STATISTICS
CONSOLE



EXIT
```

Setting Time and Date

This procedure allows the time and date to be set, or to be changed.

The **SET TIME & DATE** menu for the membrane console is shown below.

```
                 * SET TIME & DATE *
YEAR:     2002                          HOUR:   18
MONTH:       3                          MIN:    29
DAY:           30                                +
                                                 -



EXIT
```

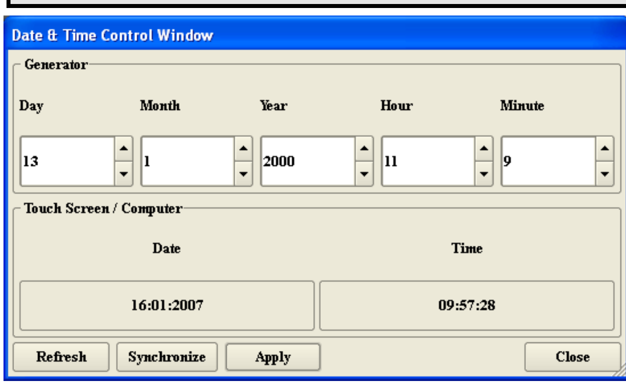


Figure 3-3: Date and Time Control Window

To set the time and date:

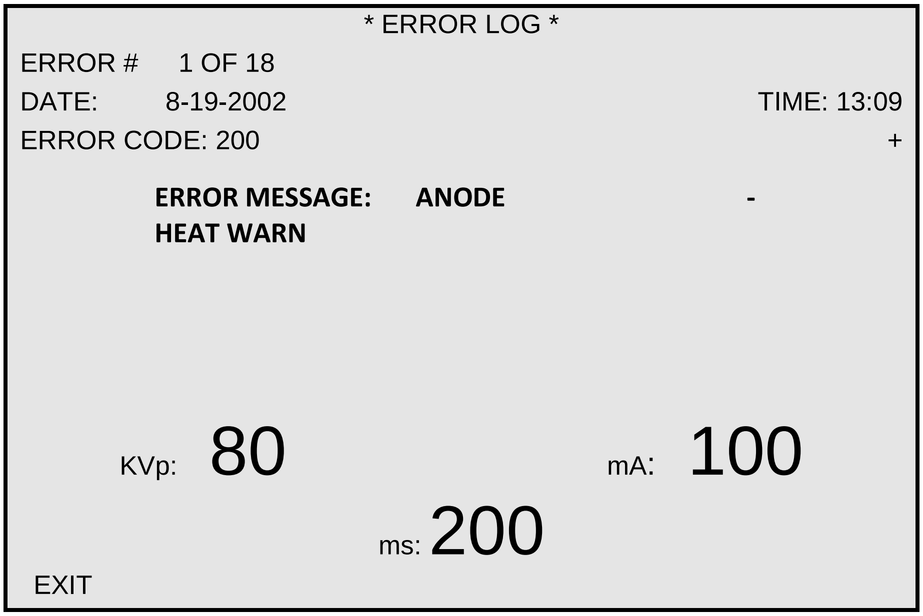
Action (membrane console)	Action (GenWare®)
1. From the **GENERATOR SETUP** menu, select the **UTILITY** menu. *2.* From the **UTILITY** menu, select the **SET TIME & DATE** menu. *3.* Select **YEAR**. Use the **+** or **–** buttons to set the year. *4.* Select **MONTH**. Use the **+** or **–** buttons to set the month. *5.* Select **DAY**. Use the **+** or **–** buttons to set the date. *6.* Select **HOUR**. Use the **+** or **–** buttons to set the hour (in 24 hour format). 7. Select **MIN**. Use the **+** or **–** buttons to set the minutes. 8. Press **EXIT** to return to the **UTILITY** menu.	1. Select the  button on the GenWare® toolbar to access the **Date & Time Control Window**. 2. The date and time may be set manually as described in steps 3 to 7 or the **Touch Screen / Computer** clock may be used to set the generator date and time as described in step 8. 3. Select the year via the **Year** dialog box. 4. Select the month via the **Month** dialog box. 5. Select the date via the **Day** dialog box. 6. Select the hour (in 24 hour format) via the **Hour** dialog box. 7. Select the minutes via the **Minute** dialog box. 8. To synchronize GenWare® to the clock in your computer (touchscreen), press the **Synchronize** button in the lower left corner of the **Date & Time Control Window**. Doing so will transfer the computer's (touchscreen computer's) time and date settings to the time and date dialog boxes in the upper half of the **Date and Time Control Window**. Pressing **Apply** will apply those settings to the generator's clock. 9. Press Close to exit the Date & Time Control Window.

Note: The time does not increment when in the SET TIME & DATE mode.

Error Log

This utility allows display of the error messages stored in the generator's error log. The error log storage limit is 200 messages, at which point the generator will replace the oldest with the most recent.

The **ERROR LOG** menu for the membrane console is shown below.



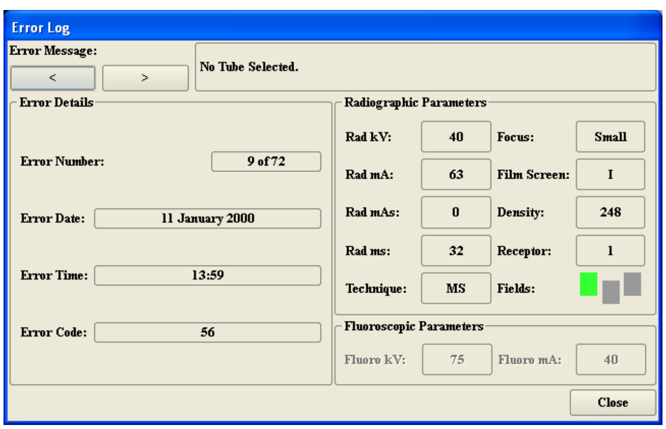
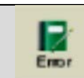


Figure 3-4: Error Log utility

To review the error log:

Action (membrane console)	Action (GenWare®)
1. From the **UTILITY** menu, select **ERROR LOG**. 2. Select **ERROR #** and use the **+** or **-** buttons to scroll through the error log. 3. The error code, error message, date and time of the error will be displayed in the LCD window, and the associated parameters will be displayed on the console displays *4.* Press **EXIT** to return to the **UTILITY** menu.	**1.** Select the **Error Log** button  on the GenWare® toolbar to access the error log utility 2. Press the **<** or **>** buttons on the **Error Log** window to scroll through the error log. The error message will be displayed to the right of the **< >** buttons on the **Error Log** window. The error code, date and time of the error, etc. will be displayed under **Error Details** on the left side of the **Error Log** window, and the associated parameters will be displayed under **Radiographic Parameters**. **3.** Select **Close** to exit the error log utility.

Statistics

This utility shows the tube exposure count and the accumulated generator exposure count. This also allows resetting of the tube 1 exposure counter.

The **STATISTICS** menu for the membrane console is shown below.

		* STATISTICS *	
TUBE 500	1	EXP:	RESET TUBE 1 EXP
TOTAL 1100		EXP:	
EXIT			

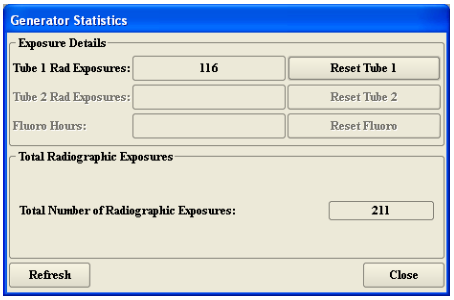


Figure 3-5: Generator Statistics utility

To view the generator statistics:

Action (membrane console)	Action (GenWare®)
1. From the **UTILITY** menu, select **STATISTICS**.	1. Select the statistics button  on the GenWare® toolbar to access the **Generator Statistics** window.
2. The **STATISTICS** menu displays exposure data, and allows the exposure counter to be reset as described below: • The **TUBE 1 EXP** counter displays the tube 1 exposure count made since this counter was last reset. • **TOTAL EXP** displays the total rad exposure count. This is not resettable ***** • Select **RESET TUBE 1 EXP** to reset the tube 1 exposure counter.	2. The **Generator Statistics** window displays exposure data, and allows the exposure counter to be reset as described below: • The Tube 1 Rad Exposures counter display the tube 1 exposure count made since this counter was last reset. • Total Number of Radiographic Exposures displays the total rad exposure count. This is not resettable *. • Select Reset Tube 1 to reset the tube 1 exposure counter.

**** Note: The subject exposure counter is reset when the factory defaults are reset. Therefore, the "total exposure" count should be recorded before resetting the factory defaults.***

3. Press **EXIT** to return to the **UTILITY** menu.	3. Select **Close** to exit the generator statistics utility.

Console (Membrane Console)

The **CONSOLE CONFIG** menus allow setting of specific console operating features to suit operator preferences, and allow resetting of the console parameters to the factory defaults.

CONSOLE CONFIG Screen 1

* CONSOLE CONFIG*

SLOW KEY REPEAT: 200MS LCD SCREEN

MED. KEY REPEAT: 150MS APR MODE: NO

FAST KEY REPEAT: 75MS +

SPEAKER VOLUME: 15 -

EXIT >>

CONSOLE CONFIG Screen 2

* CONSOLE CONFIG*

LOAD CONSOLE DEFAULTS?: NO

LOGO ON?: NO PASSWORD

LANGUAGE: ENGLISH

CM THICKNESS ON?: NO

<< >>

CONSOLE CONFIG Screen 3

* CONSOLE CONFIG*

DAP UNITS: $mGycm^2$

PED. SIZE: YES

<< RETURN

Since the **CONSOLE CONFIG** setup affects the membrane console only (setting of specific console operating features to suit operator preferences), no equivalent function is available in GenWare®.

Table 3-5 shows the definition of membrane console parameters as used in this section.

Table 3-5: Definition of Membrane Console Parameters

Function	Description
SLOW KEY REPEAT	Determines the speed at which displays change while the selected key is pressed for the first 5 counts.
MED. KEY REPEAT	Determines the speed at which displays change while the selected key is pressed for the next 5 counts.
FAST KEY REPEAT	Determines the speed at which displays change while the selected key is pressed after 10 counts.
SPEAKER VOLUME	Sets the speaker volume for the control console in the range 1 to 15
LCD SCREEN	Toggles between normal and reverse video for the LCD display.
APR MODE	NO allows the operator to select an APR view, and still have the ability to manually select receptors, focus, technique, film screen, AEC fields, etc. YES allows the operator to select all of the above EXCEPT the technique selection (AEC, mAs, mA/ms) i.e. this disables the ability to select AEC, mAs, mA/ms in APR mode. (AEC, mAs, mA/ms changes can only be made by selecting an APR technique that has been programmed to the desired technique).
LOAD CONSOLE DEFAULTS?	YES: Initializes the console CPU's NVRAM to the factory default settings when the generator is switched ON. This restores the factory defaults for the APR and the CONSOLE settings. NO: The NVRAM is not reset when the generator is switched on. The normal setting for this function is NO. Do not set to YES unless you intend to restore the console factory defaults. Doing so will cause all custom console and APR settings to be lost.
LOGO ON?	YES: The predefined logo is displayed briefly after the generator is switched on. NO: The logo is not displayed.
LANGUAGE	Selects the language for status and error messages as well as for the default APR text
CM THICKNESS ON?	YES: CM THICKNESS mode is enabled. NO: CM THICKNESS mode is disabled. If CM THICKNESS is enabled, the AEC BACKUP mode (under RECEPTOR SETUP) must be set to mAs for each image receptor. If this is not done, CM thickness will not be available in AEC mode.
PASSWORD	Allows the programming mode password to be changed

Table 3-5: Definition of Membrane Console Parameters	
Function	**Description**
DAP UNITS	µGym^2: The DAP value will display as. Standard resolution DAP chamber: 123456.7 µGym2. High resolution DAP chamber: 123456.78 µGym2. mGycm^2: The DAP value will display as. Standard resolution DAP chamber: 1234567 mGycm2. High resolution DAP chamber: 1234567.8 mGycm2. High resolution DAP measurements are only available if a high resolution DAP chamber is used and if it is properly selected as described in the section, *DAP Calibration Overview*, of this chapter.
PED. SIZE	**YES**: The pediatric patient size can be selected in APR mode within the normal operating mode and the APR validator will validate the data associated with the pediatric patient size. **NO**: The pediatric patient size cannot be selected in APR mode. In addition, the APR validator will disregard the pediatric patient size.

This function does not apply to GenWare®:

To set the membrane console parameters (Refer to the definitions in Table 3-5):

1. From the UTILITY menu select CONSOLE. This accesses CONSOLE CONFIG screen 1.
2. Select SLOW KEY REPEAT. Use the + or – buttons to set the “slow key repeat” time.
3. Select MED. KEY REPEAT. Use the + or – buttons to set the “med. key repeat” time.
4. Select FAST KEY REPEAT. Use the + or – buttons to set the “fast key repeat” time.
5. Select SPEAKER VOLUME. Use the + or – buttons to set the speaker loudness.
6. Select LCD SCREEN. Toggle the button to select normal or reverse video.
7. Select APR MODE. Toggle the button to select YES or NO.
8. Press >>.
9. Do not perform this step unless you intend to restore the console factory defaults.

   To restore the console factory default settings, select **LOAD CONSOLE DEFAULTS?** and then toggle the adjacent selection button to select **YES.**

In order for the changes to take effect, the generator must be switched OFF and then ON again. The console will prompt for a **YES** or **NO** to loading defaults when it is powered on again. Select **YES** to both prompts to reset both the console and APR defaults. Selecting **NO** will not update the defaults. Do not load the defaults for the console settings if you are changing the language. See **LANGUAGE**, below. The **LOAD CONSOLE DEFAULTS** setting automatically resets to **NO** the next time the generator is switched on.

10. Select **LOGO ON?.** Toggle the button to select **YES** or **NO**.
11. Select **LANGUAGE.** Toggle the selection button to select the desired language for status and error messages as well as for the default APR text.

    The console defaults (**APR MEMORY** only) must be loaded in order for the APR language changes to take effect.

    - Do not load the factory defaults for CONSOLE SETTINGS if you are changing the language, as this will reset the language back to English.
    - Loading the factory defaults for APR MEMORY will change the APR text to that of the selected language with the factory-default APR text. If the APR text has been customized using GenWare®, all customization will be lost if the factory defaults for APR MEMORY are loaded.
12. Select **CM THICKNESS ON?**. Toggle the button to select **YES** or **NO**.
13. Select **PASSWORD**. Enter and then re-enter a new password as prompted.

    BE SURE TO RECORD THE NEW PASSWORD BEFORE CHANGING THE DEFAULT PASSWORD. IF THE NEW PASSWORD IS SUBSEQUENTLY LOST, PLEASE CONSULT THE FACTORY.
14. Press **>>**.
15. Select **DAP UNITS**. Toggle the selection button to select **μGym^2** or **mGycm^2**.
16. Select **PED. SIZE**. Toggle the selection button to select **YES** or **NO**.
17. Select **<<** to return to the previous page in the CONSOLE CONFIG menus.
18. Select **RETURN** to return to CONSOLE CONFIG screen 1.
19. Select **EXIT** to return to the **UTILITY** menu.
20. Select **EXIT** again to return to the **GENERATOR SETUP** menu.

APR Editor (Membrane Console)

The **APR EDITOR** enables / disables the ability of the operator to make and then save changes to APR techniques.

* GENERATOR SETUP *	
UTILITY	APR EDITOR: DISABLED
DIAGNOSTICS	GEN CONFIGURATION
VALIDATE APR	DATA LINK
EXIT SETUP	

No equivalent function exists in GenWare®, as the **APR EDITOR** affects the console operation only.

Table 3-6: APR Editor (Membrane Console) Description

ENABLED:	Allows the operator to change the default APR technique(s), and then save the changes to memory. The APR will subsequently default to the changed technique.
DISABLED:	Allows temporary editing of APR technique(s), but does not allow the changes to be saved to memory. The APR will always default to the original technique when the generator is switched OFF and then ON again. **Note: *The generator saves the last APR EDITOR setting before being switched off. If the APR editor was previously ENABLED, APR changes may subsequently be made and then saved in normal operating mode without the need to manually set the APR editor to ENABLED. To disable APR technique changes, the APR editor must be set to DISABLED.***

Note:

- *APR text may be altered by using a computer running GenWare®. Further documentation regarding this function is included with GenWare® in the form of an ms word document. The default location for the word file is C:\CPI Canada\GenWare32\console\manual74089*.doc.*

This function does not apply to GenWare®.

To set the **APR EDITOR** (Refer to the definition in Table 3-6):

1. On the membrane console, from the **GENERATOR SETUP** menu, select **APR EDITOR**.
2. Toggle the button to select **ENABLED** or **DISABLED**

Generator Configuration

The **GEN CONFIGURATION** menu presents the user with the selections shown below. These are described in detail in this section.

* GEN CONFIGURATION *	
TUBE SELECTION	AEC SETUP
GENERATOR LIMITS	AEC CALIBRATION
RECEPTOR SETUP	TUBE CALIBRATION
I/O CONFIGURATION	DAP SETUP
EXIT	

Tube Selection / Tube Setup

The **TUBE SELECTION** function allows the desired tube type to be selected, and it allows setting of the default limits for the selected tube.

The CMP 200® consoles have a preloaded library of compatible X-ray tubes. In addition to the preloaded tube files, various user-selectable tubes can be uploaded to the console via the GenWare® console utilities.

- For the membrane console, if no user-selectable tube files have been uploaded, the first page of the tube selection screens will be titled **DEFAULT TUBE 1 SEL**. This page will list the first eight preloaded tubes. Additional preloaded tube types will be listed on subsequent pages.
- For the membrane console, if user-selectable tube files have been uploaded, the first page of the tube selection screens will be titled **USER TUBE 1 SELECT.** This page will contain a maximum of eight tubes, which is the maximum number of user-selectable tube files that can be uploaded to the console. Preloaded tube types will be listed on subsequent pages.
- If user-selectable tube file(s) are uploaded to the console and if these file(s) are of a newer revision than existing preloaded tube files, the latest user-uploaded files will not overwrite similar (possibly older) files on the **DEFAULT TUBE 1 SEL** pages.
- The actual tube file layout and the number of TUBE SELECTION screens may vary from the illustrations below.

TUBE SELECTION Screen 1 (this applies only if user-selectable tubes have been downloaded)**:**

* USER TUBE 1 SELECT *

THIS PAGE WILL DISPLAY ONE TO EIGHT USER-SELECTABLE
TUBES IF APPLICABLE
(IF DOWNLOADED FROM GenWare®)

EXIT >>

TUBE SELECTION screen 1 if no user-selectable tubes have been downloaded. This will be screen 2 if user-selectable tubes have been downloaded.

TUBE SELECTION Screen 2

* DEFAULT TUBE 1 SEL *

A192B 0.6/1.2	G256 0.6/1.0
A256 0.6/1.0	G292 0.6/1.2
A292 0.6/1.2	G1082 0.3/1.0
A272 0.3/0.6	RAD8 1.0/2.0

EXIT >>

TUBE SELECTION screen 2 (no user-selectable tubes) or screen 3 with user-selectable tubes

TUBE SELECTION Screen 3

* DEFAULT TUBE 1 SEL *

RAD13 1.0/2.0	RAD56 0.6/1.2
RAD14 0.6/1.2	RAD60 0.6/1.2
RAD21 0.6/1.2	RAD68 1.0/2.0
RAD44 1.0/2.0	RAD74 0.6/1.5

<< >>

TUBE SELECTION screen 3 (no user-selectable tubes) or screen 4 with user-selectable tubes

TUBE SELECTION Screen 4

```
                      * DEFAULT TUBE 1 SEL *
RAD92    0.6/1.2                    E7255X    0.6/1.2
E7239X   1.0/2.0                    MX75    1.0/2.0
E7242X   0.6/1.5                    MX100    0.6/1.25
E7252X   0.6/1.2                    RO1750    0.6/1.3



 <<                                                          >>
```

TUBE SELECTION screen 4 (no user-selectable tubes) or screen 5 with user-selectable tubes

TUBE SELECTION Screen 5

```
                      * DEFAULT TUBE 1 SEL *
PX1312   0.6/1.2                    X50AH    1.2/2.0
PX1429   0.6/1.2                    RTM78HS    0.6/1.2
PX1436   0.6/1.2                    RTM90HS    0.6/1.0
X40    1.0/2.0                      RTM90HS    0.6/1.2



 <<                                                          >>
```

TUBE SELECTION screen 5 (no user-selectable tubes) or screen 6 with user-selectable tubes

TUBE SELECTION Screen 6

```
                      * DEFAULT TUBE 1 SEL *
RTM90HS    0.6/1.5
RTM92HS    1.0/2.0
RTM101HS    .6/1.2
RTM101HS    .6/1.3



 <<                                                      RETURN
```

The next three menus show the default tube limits. These menus appear after a tube has been selected as per the following steps.

TUBE DEFAULTS Screen 1

*TUBE 1:	RAD60	0.6/1.2	12°
	REV 1.4*		
TUBE SPEED: LOW		MAX SF KW HS:	39.6
MAX SF KW LS: 21.3		MAX LF KW HS:	75.0
MAX LF KW LS: 58.9			+
MAX KV: 125			-
EXIT			>>

TUBE DEFAULTS Screen 2:

*TUBE 1:	RAD60	0.6/1.2	12°
	REV 1.4*		
SF STANDBY: 2.5A		FIL BOOST:	200MS
LF STANDBY: 2.5A		FIL PREHEAT:	800MS
SF MAX: 5.2A			+
LF MAX: 5.5A			-
<<			>>

TUBE DEFAULTS screen 3:

*TUBE 1:	RAD60	0.6/1.2	12°
	REV 1.4*		
MAX SF MA: 320			
ANODE HU WARNING: 80%			
ANODE HU LIMIT: 90%			+
			-
<<			RETURN

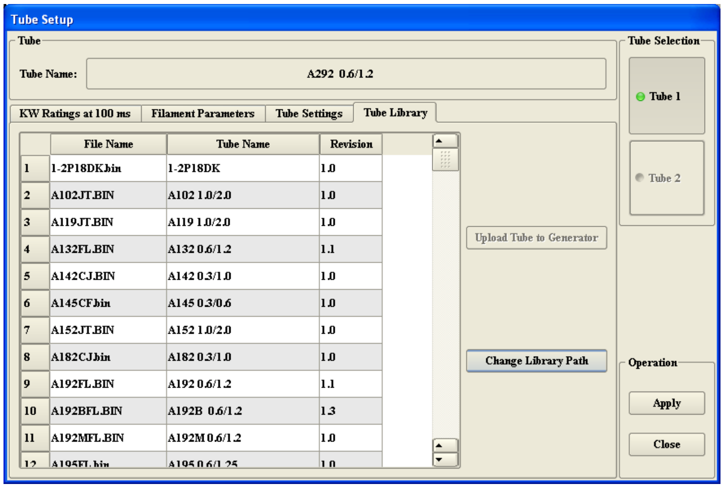


Figure 3-6: Tube Setup window, Tube Library tab

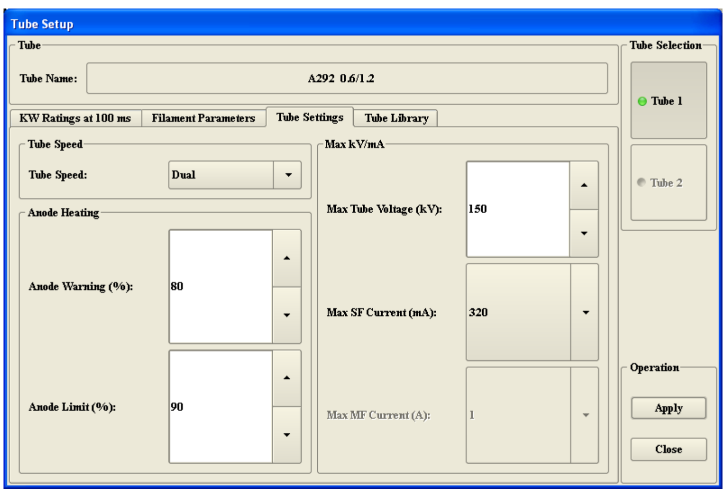


Figure 3-7: Tube Setup window, Tube Settings tab

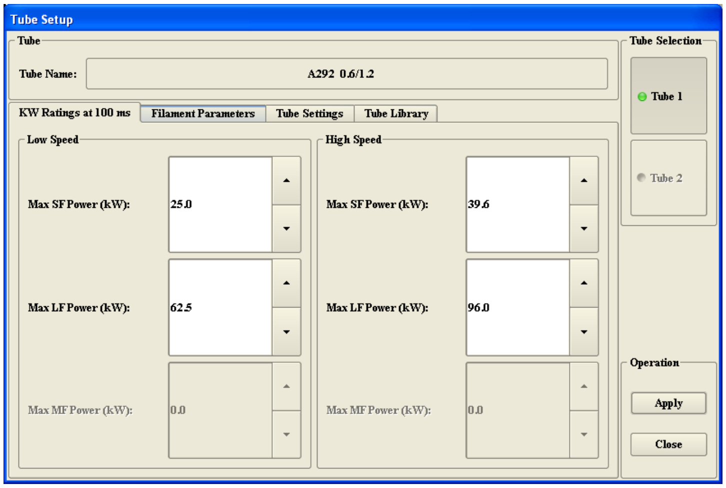


Figure 3-8: Tube Setup window, kW Ratings at 100 ms tab

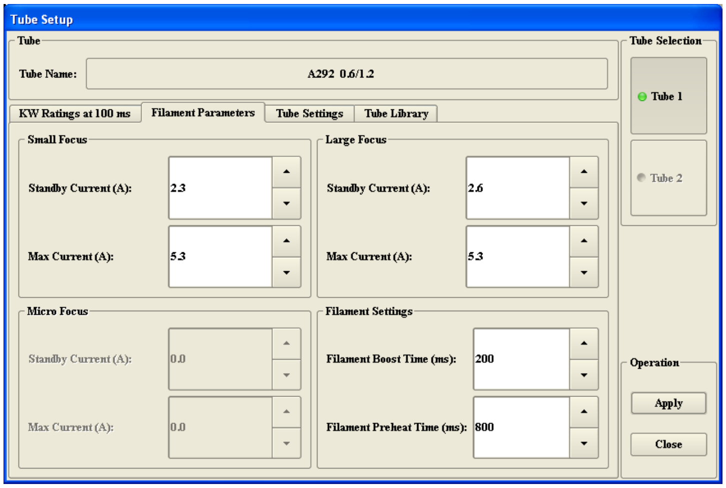


Figure 3-9: Tube Setup window, Filament Parameters tab

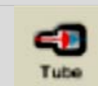
Table 3-7: Definitions of Tube Selection Menu Items

Function: Console	Function: GenWare®	Description	
TUBE SPEED	Tube Speed	**LOW:**	Low-speed mode only is enabled.
		HIGH:	High-speed mode only is enabled.
		DUAL:	Both low and high-speed modes are enabled. The generator will determine when to switch modes, based on exposure parameters and tube rating.
MAX SF KW LS	Low Speed: Max SF Power (kW)	Sets the maximum small focus low speed kW limit (@ 100 ms *)	
MAX LF KW LS	Low Speed: Max LF Power (kW)	Sets the maximum large focus low speed kW limit (@ 100 ms *).	
MAX KV	Max Tube Voltage (kV)	Sets the maximum kV allowed.	
MAX SF KW HS	High Speed: Max SF Power (kW)	Sets the maximum small focus high speed kW limit (@ 100 ms *)	
MAX LF KW HS	High Speed: Max LF Power (kW)	Sets the maximum large focus high speed kW limit (@ 100 ms *).	
SF STANDBY	Small Focus: Standby Current (A)	Sets the small focus standby filament current. The required value should be obtained from the X-ray tube data sheets.	
LF STANDBY	Large Focus: Standby Current (A)	As above but for large focus	
SF MAX	Small Focus: Max Current (A)	Sets the small focus maximum filament current	
LF MAX	Large Focus: Max Current (A)	As above but for large focus	
FIL BOOST	Filament Boost Time (ms)	Sets the filament rapid boost duration in order to quickly raise the filament temperature	
FIL PREHEAT	Filament Preheat Time (ms)	The time that the filament is held at the required emission level before an exposure is permitted.	
MAX SF MA	Max SF Current (mA)	Sets the maximum mA in small focus. This should be set as low as possible to prevent focal spot track wear and focal spot blooming.	
ANODE HU WARNING	Anode Warning (%)	Sets the limit at which the anode heat-warning message is displayed.	

Table 3-7: Definitions of Tube Selection Menu Items		
Function		**Description**
Console	**GenWare®**	
ANODE HU LIMIT	Anode Limit (%)	Sets the limit at which exposures will be inhibited. If the anode heating is currently under the limit, the next exposure will be inhibited if the generator calculates that the exposure will exceed the anode HU limit.

***** The stated maximum kW limits apply at the 100 ms point on the X-ray tube load ratings curve. Increasing or decreasing the kW limits will shift the entire curve up or down proportionately to the percentage kW change.

To select the desired tube type:

Action (membrane console)	Action (GenWare®)
1. From the GENERATOR SETUP menu, select GEN CONFIGURATION. *2.* From the GEN CONFIGURATION menu, select TUBE SELECTION. 3. Choose the desired tube type by pressing the button adjacent to the desired selection. Use the >> and << buttons to navigate through the tube selection menus if the desired tube is not displayed on the current page. Note that if a user-selectable tube is listed on the USER TUBE 1 SELECT page, it will not overwrite an existing (possibly older) tube file on one of the DEFAULT TUBE 1 SEL pages. In case of duplication, the tube file on the USER TUBE 1 SELECT page should normally be used. Additional tube types may be downloaded using the console utility in GenWare®, up to a limit of eight user-selectable tubes. *4.* Once the desired tube has been	1. Select the  button from the GenWare® toolbar to access the **Tube Setup** utility. 2. Select the **Tube Library** tab. 3. Choose the desired tube type from the tube library. Press Upload Tube to Generator to upload the selected tube to the generator. To select an alternate tube library, press Change Library Path: GenWare® via a PC: A Browse For Folder window will open. Browse to the drive / folder that contains the desired tube library, select the desired item and then select OK. The new tube library will replace the default tube library in the Tube Setup window. The desired tube may then be selected. Touchscreen GenWare®: A pop up window will open that points to the USB flash drive. Select the desired tube library on the USB drive and then select Open. The new tube library will replace the default tube library in the Tube Setup window. The desired tube may then be

Action (membrane console)	Action (GenWare®)
selected, parameters for that tube are displayed showing the default values. DO NOT adjust the default values at this time.	selected. For Touchscreen GenWare®, the desired tube library must be pre-loaded onto a USB flash drive.

Note: Ensure that the selected X-ray tube stator is compatible with the starter in the generator in use.

When the desired tube is selected, the default limits are displayed (membrane console). Please consult the X-ray tube data sheet(s) before making any changes.

The dual speed starter operates at 60 or 180 Hz (50 or 150 Hz for some tube types) independent of line frequency.

The low speed starter operates at 50 Hz for 50 Hz mains, or 60 Hz for 60 Hz mains. The generator samples the line frequency via a zero-crossing detector on the generator control board. Therefore, for units fitted with a low speed starter, the generator automatically derates the 60 Hz tube ratings for 50 Hz operation if required.

Note:

- *Do not change any defaults unless the impact of those changes is clearly understood. Initial calibration should be performed using the default values.*
- *Before changing X-ray tube default parameters, fill in the X-ray tube and generator parameter worksheet, Table 3-3. A blank form that should be photocopied is located at the end of this section. This allows recording of the default values and the new (changed) values.*

Use these steps to set the tube limits and the associated parameters. Refer to the definitions in Table 3-7.

Action (membrane console)	Action (GenWare®)
1. Select TUBE SPEED. Toggle the button to select DUAL, LOW, or HIGH. 2. Select MAX SF KW LS. Use the + or – buttons to set the low speed, small focus kW limit. 3. Select MAX LF KW LS. Use the + or – buttons to set the low speed, large focus kW limit. 4. Select MAX SF KW HS. Use the + or – buttons to set the high speed, small	1. Select the **Tube Settings** tab. 2. Select **Dual**, **Low**, or **High** via the **Tube Speed** dialog box. 3. Select the kW Ratings at 100 ms tab. 4. Set the low speed, small focus kW limit via the **Max SF Power (kW)** dialog box, under **Low Speed**. 5. Set the low speed, large focus kW limit via the **Max LF Power (kW)** dialog box, under **Low Speed**. **6.** Set the high speed, small focus kW

Action (membrane console)	Action (GenWare®)
focus kW limit. 5. Select MAX LF KW HS. Use the + or – buttons to set the high speed, large focus kW limit. 6. Select MAX KV. Use the + or – buttons to set the maximum allowable kV. 7. Press >>. 8. Select SF STANDBY. Use the + or – buttons to set the small focus filament standby current. 9. Select LF STANDBY. Use the + or – buttons to set the large focus filament standby current. 10. Select SF MAX. Use the + or – buttons to set the small focus maximum filament current. 11. Select LF MAX. Use the + or – buttons to set the large focus maximum filament current. 12. Select FIL BOOST. Use the + or – buttons to set the filament rapid boost duration. 13. Select FIL PREHEAT. Use the + or – buttons to set the filament preheat time. 14. Press >>. 15. Select MAX SF MA. Use the + or – buttons to set the maximum small focus mA. 16. Select ANODE HU WARNING. Use the + or – buttons to set desired anode HU warning %. 17. Select ANODE HU LIMIT. Use the + or – buttons to set desired anode HU limit %. 18. Press RETURN or alternatively << to exit to the Tube 1 Selection screen. 19. Press EXIT as required returning to	limit via the **Max SF Power (kW)** dialog box, under **High Speed**. 7. Set the high speed, large focus kW limit via the **Max LF Power (kW)** dialog box, under **High Speed**. 8. Select the **Tube Settings** tab. 9. Set the maximum allowable kV via the **Max Tube Voltage (kV)** dialog box. 10. Select the Filament Parameters tab. 11. Set the small focus filament-standby current via the **Standby Current (A)** dialog box, under **Small Focus**. 12. Set the large focus filament-standby current via the **Standby Current (A)** dialog box, under **Large Focus**. **13.** Set the small focus maximum filament current via the **Max Current (A)** dialog box, under **Small Focus**. **14.** Set the large focus maximum filament current via the **Max Current (A)** dialog box, under **Large Focus**. **15.** Set the filament rapid boost duration via the **Filament Boost Time (ms)** dialog box. **16.** Set the filament preheat time via the **Filament Preheat Time (ms)** dialog box. 17. Select the **Tube Settings** tab. **18.** Set the maximum small focus mA via the **Max SF Current (mA)** dialog box. **19.** Set the desired anode HU warning % via the **Anode Warning (%)** dialog box. 20. Set the desired anode HU limit % via the Anode Limit (%) dialog box.

Action (membrane console)	Action (GenWare®)
the GEN CONFIGURATION menu.	

Note:

Typically, the boost time should be between 200 and 250 msec, and the preheat time should be in the range of 700 - 800 ms.

If in doubt, monitor the filament feedback and be sure that there is no change in the signal level 5 ms. after the start of an exposure, and that the mA starts at the selected level.

Standby current must be below the emission point.

If the maximum filament current is increased, be careful not to exceed the tube manufacturer's specifications.

Table 3-8: X-ray Tube and Generator Parameter Worksheet

Tube Selection		Default	Selected	Tube Selection		Default	Selected
1	TUBE SELECTED			12	FIL BOOST		
2	TUBE SPEED			13	FIL PREHEAT		
3	MAX SF KW LS			14	MAX SF MA		
4	MAX LF KW LS			15	ANODE HU WARNING		
5	MAX KV			16	ANODE HU LIMIT		
6	MAX SF KW HS			17	GENERATOR LIMITS		
7	MAX LF KW HS			18	MAX KW		
8	SF STANDBY			19	MAX MA		
9	LF STANDBY			20	MIN MA		
10	SF MAX			21	MAX MAS		
11	LF MAX			22	ROTOR BOOST		

Generator Limits

The **GENERATOR LIMITS** function allows setting of the generator output limits defined below.

The **GENERATOR LIMITS** menu for the membrane console is shown below.

* GENERATOR LIMITS*			
MAX KW:	32	ROTOR BOOST:	1800 MS
MAX MA:	320		
MAX MAS	500		+
MIN MA:	10		-
EXIT			

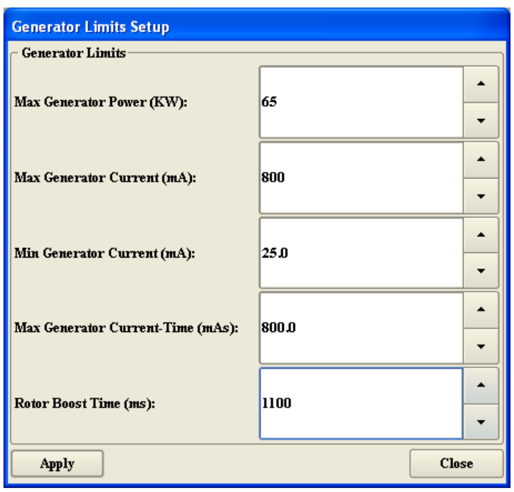


Figure 3-10: Generator Limits Setup window

Table 3-9: Definitions of Generator Limits Menu Items

Function		**Description**
Membrane Console	**GenWare®**	
MAX KW	Max Generator Power (kW)	Sets the maximum generator kW limit
MAX MA	Max Generator Current (mA)	Sets the maximum generator mA limit
MAX MAS	Max Generator Current-Time (mAs)	Sets the maximum generator mAs limit
MIN MA	Min Generator Current (mA)	Sets the minimum generator mA limit
ROTOR BOOST	Rotor Boost Time (ms)	Sets the low-speed-starter boost time, in milliseconds. The range is 900 ms (1 sec) to 3900 ms (4 sec), adjustable in 100 millisecond increments.

Note:

Before making any changes in this section, consult the X-ray tube data sheets to ensure that the proposed changes do not exceed the manufacturers recommended limits. The original generator limits should be recorded in a copy of Table 3-3 before continuing.

To set the generator limits (Refer to the definitions in Table 3-9):

Action (membrane console)	**Action (GenWare®)**
1. From the GEN CONFIGURATION menu, select GENERATOR LIMITS. 2. Select MAX KW. Use the + or – buttons to set the maximum kW. 3. Select MAX MA. Use the + or – buttons to set the maximum mA. 4. Select MIN MA. Use the + or – buttons to set the minimum mA. 5. Select MAX MAS. Use the + or	1. Select the  button to access the **Generator Limits Setup** utility. 2. Set the maximum kW via the **Max Generator Power (kW)** dialog box. **3.** Set the maximum mA via the **Max Generator Current (mA)** dialog box. **4.** Set the minimum mA via the **Min Generator Current (mA)** dialog box. **5.** Set the maximum mAs via the **Max Generator Current-Time (mAs)** dialog box. **6.** Set the desired rotor boost time via the **Rotor Boost Time (ms)** dialog box.

Action (membrane console)	Action (GenWare®)
– buttons to set the maximum mAs. 6. Select ROTOR BOOST. Use the + or – buttons to set the low speed starter boost time. 7. Press EXIT to return to the GEN CONFIGURATION menu.	7. Select **Apply** to save the new values to the generator. 8. Select **Close** to exit the generator limits setup utility.

Receptor Setup

The **RECEPTOR SETUP** function allows each of the image receptors to be programmed as defined in Table 3-10.

RECEPTOR SETUP Menu 1

```
                    * RECEPTOR   SETUP [sym] *
TUBE:       1                                  TOMO BUT:   2500 MS
RECEPTOR SYM: [sym]                            INTERFACE OPTS: 0
MEMORY: DEF                                                      +
TOMO:   NO                                                       -




EXIT                                                            >>
```

Note: The **INTERFACE OPTS** function is available only on the CMP200® DR generators.

RECEPTOR SETUP Menu 2

```
                    * RECEPTOR SETUP [sym]*
SF/LF SWITCH:   MAN                                       DEFAULTS
AEC BACKUP:     FIXED                            AEC CHANNEL:   1
AEC BACKUP MAS:   100                                            +
AEC BACKUP MS:   1000                                            -




<<                                                              >>
```

RECEPTOR SETUP Menu 3

* RECEPTOR SETUP [sym]*	
RAD HANG: 10 SEC	FUNCTIONAL OPTS:
	0
	+
	-
<<	RETURN

Note:

The defaults selection in MENU 2 is only available if memory in MENU 1 was set to DEF. Receptor MENUS 4 and 5 (following) are only accessible if defaults are enabled.

RECEPTOR SETUP Menu 4

* RECEPTOR SETUP [sym]*	
TECHNIQUE: AEC	LEFT FIELD: YES
FOCUS: SMALL	CENTER FIELD: YES
FILM SCREEN: 1	RIGHT FIELD: YES
<<	>>

RECEPTOR SETUP Menu 5

* RECEPTOR SETUP [sym]*	
KV: 75	DENSITY: 0
MA: 320	
MS: 50	+
	-
<<	

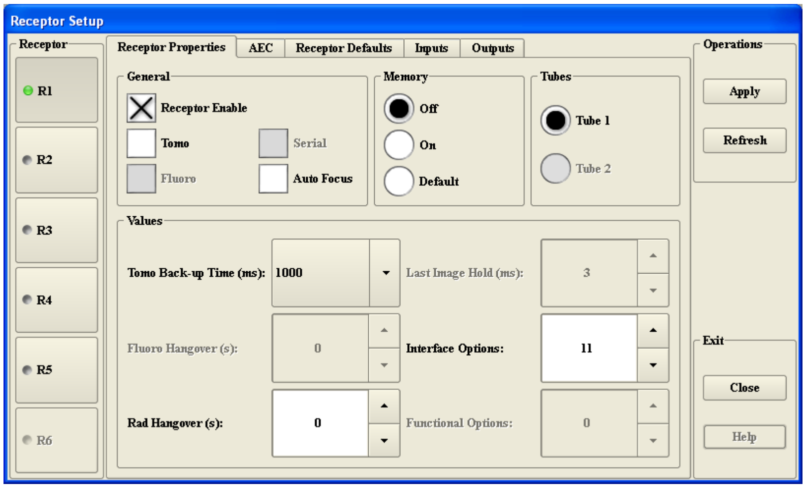


Figure 3-11: Receptor Setup window, Receptor Properties tab

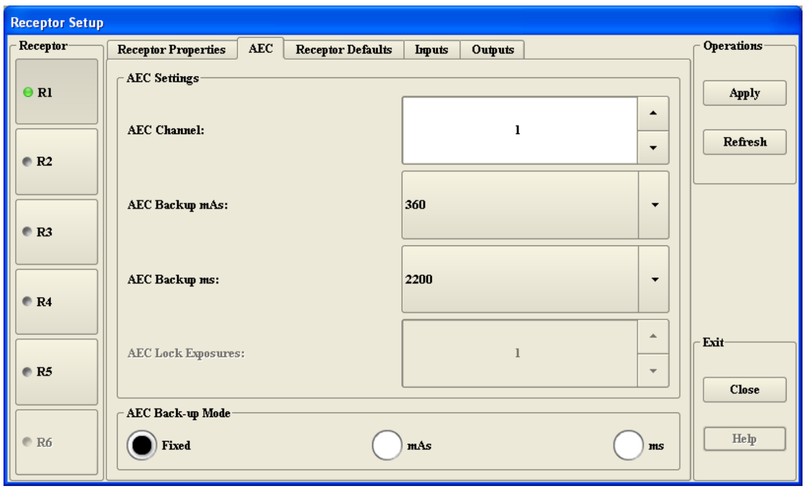


Figure 3-12: Receptor Setup window, AEC tab

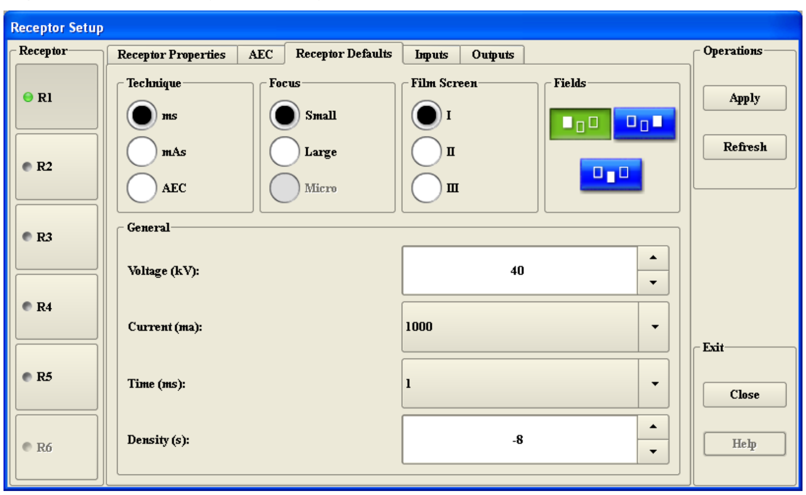


Figure 3-13: Receptor Setup window, Receptor Defaults tab

Definitions of **RECEPTOR SETUP** menu items:

Table 3-10: Definitions of Receptor Setup Menu Items

Function		**Description**
Membrane Console	**GenWare®**	
TUBE	Receptor Enable checkbox	This function allows the receptor to be disabled. **Membrane Console:** NONE: Disables the currently selected receptor 1: Enables the currently selected receptor **GenWare®:** Receptor Enable: Enables / disables the currently selected receptor
RECEPTOR SYM	N/A	Allows one of the predefined receptor symbols [sym] to be assigned to the selected receptor.
MEMORY	Memory	Defines the techniques that will be defaulted to when a receptor is selected. YES / on: The selected receptor will remember it’ last techniques such that those techniq are displayed when that receptor is re-selected. NO / off: The selected receptor will not rememb the last techniques used on that recept The techniques used will be the same a last used on the previous receptor. DEF / default: The techniques used for that receptor w be as programmed. See receptor setup menus 3 and 4 (membrane console) or t Receptor Defaults tab (GenWare®).
TOMO	Tomo	Enables or disables tomographic operation
TOMO BUT	Tomo Back-Up Time (ms)	Sets the tomo backup time
INTERFACE OPTS:	Interface Options:	Selects pre-defined digital interface options Refer to the digital imaging supplement in the front of this manual for the appropriate selection for this configuration
FUNCTIONA L OPTS:	Functional Options:	Selects pre-defined digital functional options. Refer to the digital imaging supplement in the front of this manual for the appropriate selection for this configuration

Table 3-10: Definitions of Receptor Setup Menu Items		
Function		**Description**
Membrane Console	**GenWare®**	
SF/LF SWITCH	This function is not available in GenWare®	Enables or disables the ability of the generator to automatically select the large or small focus AUTO: Small or large focus will automatically be selected by the generator. The small to lar (and vice-versa) switching will occur at the MAX SF MA set point. MAN: The operator must manually select small o large focus.
AEC BACKUP	AEC Back-up Mode	Defines the AEC backup mode to be used FIXED: The generator will determine the maximum AEC backup time, not to exceed preset AEC backup mAs/ms values or system limits. Th characters AEC will be displayed on the LCD display during AEC operation. MAS: Allows the operator to adjust the AEC back mAs, not to exceed preset AEC backup mAs/ms values or system limits. The mAs value will be displayed on the LCD display during AEC operation. MS: Allows the operator to adjust the AEC back ms, not to exceed preset AEC backup mAs/ values or system limits. The ms value will b displayed on the LCD display during AEC operation.
AEC BACKUP MAS	AEC Backup mAs	Sets the maximum AEC backup mAs, to a limit of 600 mAs
AEC BACKUP MS	AEC Backup ms	Sets the maximum AEC back-up ms
AEC CHANNEL	AEC Channel	Defines which AEC channel will be used by the selected receptor. This must be set to a valid AEC channel number, or to 0 as noted below. For example, if using an AEC board with only 3 input channels (channels 1 to 3), then selecting AEC channel 4 will cause an error. Selecting 0 disables AEC operation on that receptor.
RAD HANG	Rad Hangover (s):	Sets the time that the rotor will continue to spin after a rad exposure has terminated

Table 3-10: Definitions of Receptor Setup Menu Items		
Function		**Description**
Membrane Console	**GenWare®**	
The following selections are only available if defaults were enabled as previously described.		
TECHNIQUE	Technique	Defines which technique will be defaulted to when a receptor is selected. **Membrane Console :** mA: Defaults to mA/ms mode mAs: Defaults to mAs mode AEC: Defaults to AEC mode **GenWare®:** ms: Defaults to mA/ms mode mAs: Defaults to mAs mode AEC: Defaults to AEC mode
FOCUS	Focus	Defines which focus will be defaulted to when a receptor is selected. Options are SMALL or LARGE.
FILM SCREEN	Film Screen	Defines which film screen will be defaulted to when a receptor is selected and AEC enabled. Options are film screen 1, 2, or 3 (membrane console) or I, II, or III GenWare®.
LEFT FIELD CENTER FIELD RIGHT FIELD	Fields	Defines which field(s) will be defaulted to when a receptor is selected. **Membrane Console:** YES: The selected field will be selected. NO: The selected field will not be selected. **GenWare®:** Refer to the graphic under Fields: A blue field select rectangle = field not selected, a green field select rectangle = field selected
KV	Voltage (kV)	Selects the default kV
MA	Current (mA)	Selects the default mA
MS	Time (ms)	Selects the default ms
DENSITY	Density	Selects the default density

If the image receptor defaults are changed, please record the original defaults in a copy of Table 3-11:

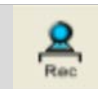
Table 3-11: Image Receptor Default Settings

Function	Receptor					
	1	2	3	5	5	6
TECHNIQUE						
FOCUS						
FILM SCREEN						
LEFT FIELD						
CENTER FIELD						
RIGHT FIELD						
KV						
MA						
MS						
DENSITY						

Note:

Do not switch off the generator while in *RECEPTOR SETUP DEFAULTS* MENUS 4 and 5. Doing so will cause the updated receptor setup parameters not to be saved. It is recommended that the first receptor programming be completed, the receptor setup menus be exited to the Gen Configuration menu, and then the receptor setup menu be reselected to program the next receptor. The above should be repeated until all receptors are programmed. This will ensure that the updated parameters are saved.

To set up the receptor parameters (Refer to the definitions in Table 3-11):

Action (Membrane Console)	**Action (GenWare®)**
1. From the GEN CONFIGURATION menu, select RECEPTOR SETUP. 2. Select the first receptor to be programmed. 3. Select TUBE. Toggle the button to select NONE or 1. 4. Select RECEPTOR SYM. Use the + or – buttons to select the desired receptor symbol. 5. Select MEMORY. Toggle the button to select NO, YES, or DEF. 6. Select TOMO. Toggle the button to select YES or NO. 7. Select TOMO BUT. Use the + or – buttons to select the desired tomo backup time. *8.* Select INTERFACE OPTS: Use the + or – buttons to select the desired interface option. 9. Press >>. 10. Select SF/LF SWITCH. Toggle the button to select AUTO or MAN. 11. Select AEC BACKUP. Toggle the button to select FIXED, MAS, or MS. 12. Select AEC BACKUP MAS. Use the + or – buttons to select the maximum backup mAs. 13. Select AEC BACKUP MS. Use the + or – buttons to select the maximum backup ms. 14. Select AEC CHANNEL. Use the + or – buttons to assign the desired AEC channel to the selected receptor, or to disable AEC operation on that receptor. 15. Press >>. 16. Select RAD HANG. Use the + or – buttons to select the desired rad hangover time. *17.* Select FUNCTIONAL OPTS: Use the + or –	1. Select the  button on the GenWare® toolbar to access the **Receptor Setup** utility. 2. Select the Receptor Properties tab. 3. Select the first receptor to be programmed. 4. Check the **Receptor Enable** checkbox to enable the selected receptor. 5. Under **Memory**, select **off, on**, or **default**. 6. Check the **Tomo** checkbox to enable tomographic operation. 7. Select the desired tomo backup time via the **Tomo Back-up Time (ms)** dialog box. 8. Select the desired interface option via the **Interface Options** dialog box. 9. Select the desired functional option via the **Functional Options** dialog box. 10. This function is not available in GenWare® 11. Select the **AEC** tab. 12. Under AEC Back-up Mode, select Fixed, mAs, or ms. 13. Select the maximum backup mAs via the **AEC Backup mAs** dialog box. 14. Select the maximum backup ms via the **AEC Backup ms** dialog box. 15. Select the AEC channel to be assigned to the selected receptor, or disable AEC operation on that receptor via the AEC Channel

Action (Membrane Console)	**Action (GenWare®)**
buttons to select the desired functional option.	dialog box. 16. Select the Receptor Properties tab. 17. Select the desired rad hangover time via the Rad Hangover (s) dialog box.
The following steps only apply if **MEMORY** in step 6 is set to **DEF** / **default**.	
1. Select **DEFAULTS**. This is on page 2 of the RECEPTOR SETUP menus. 2. Select **TECHNIQUE**. Toggle the button to select **MA, MAS,** or **AEC**. 3. Select **FOCUS**. Toggle the button to select **SMALL** or **LARGE**. 4. Select **FILM SCREEN**. Toggle the button to select **1, 2,** or **3.** 5. Select **LEFT FIELD**. Toggle the button to select **YES** or **NO**. 6. Repeat the previous step for the **CENTER** and **RIGHT** fields. 7. Press **>>**. 8. Select **KV, MA, MS,** and **DENSITY.** Use the **+** or **–** buttons to select the default kV, mA, ms, and density, respectively. 9. Press **<<** and **EXIT** as required to the **GEN CONFIGURATION** menu. 10. Repeat steps 1 to 29 for the remaining receptors. It is necessary to return to the **GEN CONFIGURATION** menu after programming each receptor to ensure that the updated parameters are saved to memory.	1. Select the Receptor Defaults tab. 2. Under Technique, select ms, mAs, or AEC. 3. Under Focus, select Small or Large. Micro focus is not available at this time. 4. Under Film Screen, select I, II, or III. 5. Select the left field on the graphic under Fields to select / deselect that field. Blue indicates that the field is not selected; green indicates that the field is selected. 6. Repeat the previous step for the center and right fields. 7. Select the default kV, mA, ms, and density via the Voltage (kV), Current (mA), Time (ms), and Density (s) dialog boxes, respectively.

I/O Configuration

The **I/O CONFIGURATION** function allows programming the states of the exposure for the inputs and the outputs on the room interface board.

The **I/O CONFIGURATION** menus for the membrane console are shown below.

```
                    * INPUTS [sym] *
TUBE THERMAL SW.                                  _ _ _ _
STANDBY STATE
DOOR ITLK:                     _ _ _ _

EXIT                                                   >>
```

```
                    * INPUTS [sym] *
INTERLOCK 1:                                      _ _ _ _
STANDBY STATE
INTERLOCK 2:                   _ _ _ _
BUCKY 1 RDY:                   _ _ _ _
BUCKY 2 RDY:                   _ _ _ _

<<                     ⇑                               >>
```

```
                    * OUTPUTS [sym] *
BUCKY 1 START:                                    _ _ _ _
STANDBY STATE
BUCKY 2 START:                 _ _ _ _
ROOM LIGHT:                    _ _ _ _

<<                     ⇑                               >>
```

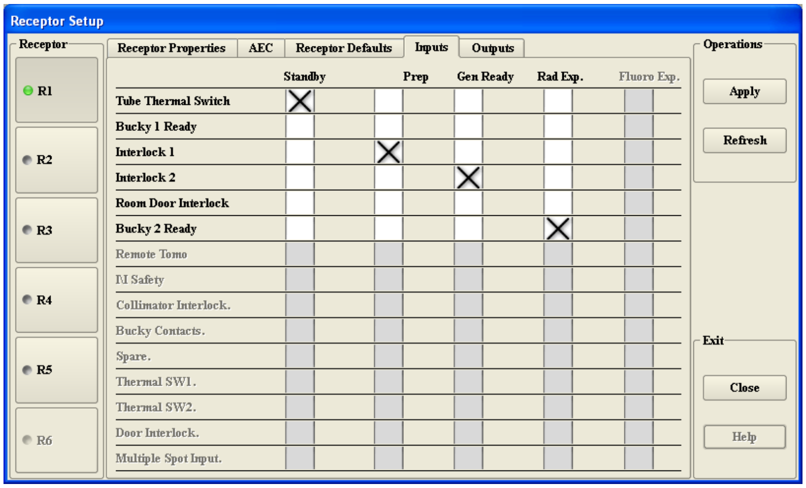


Figure 3-14: Receptor Setup window, Inputs tab

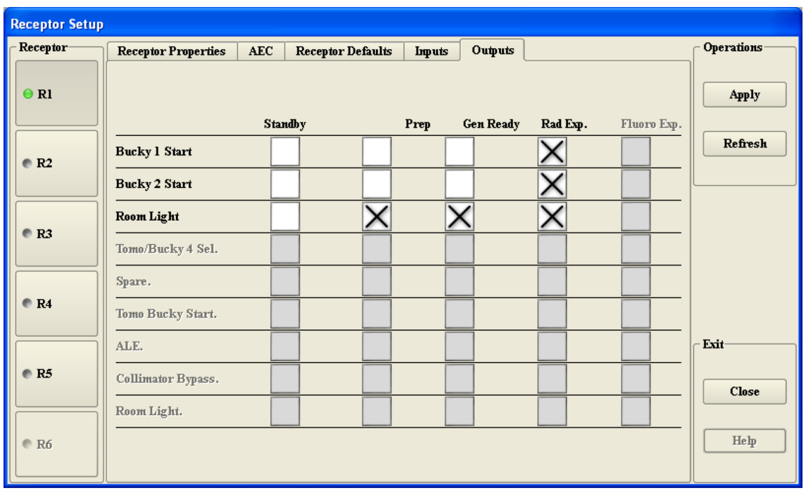


Figure 3-15: Receptor Setup window, Outputs tab

Table 3-12: Definitions of I/O Configuration Menu Items		
FUNCTION Membrane Console	**FUNCTION GenWare®**	**DESCRIPTION**
TUBE THERMAL SW	Tube Thermal Switch	Programs the thermal switch input at J7-1 and J7-2 on the HV auxiliary board
DOOR ITLK	Room Door Interlock	Programs the door interlock input at J4-9 and J4-10 on the HV auxiliary board
INTERLOCK 1	Interlock 1	Programs the interlock #1 input at J2-3 and J2-4 on the HV auxiliary board
INTERLOCK 2	Interlock 2	Programs the interlock #2 input at J2-1 and J2-2 on the HV auxiliary board. This is the tomo exposure input for any receptor that is assigned to tomo operation.
BUCKY 1 RDY	Bucky 1 Ready	Programs the Bucky 1 input at J2-5 and J2-6 on the HV auxiliary board
BUCKY 2 RDY	Bucky 2 Ready	Programs the Bucky 2 input at J4-5 and J4-6 on the HV auxiliary board
BKY 1 START	Bucky 1 Start	Programs the Bucky 1 “start” output at J2-7 on the HV auxiliary board
BKY 2 START	Bucky 2 Start	Programs the Bucky 2 “start” output at J4-1 on the HV auxiliary board. This is normally programmed as the tomo output.
ROOM LIGHT	Room Light	Programs the room light output at J11-3 and J11-4 on the HV auxiliary board

The inputs and outputs defined in Table 3-12 are programmable as follows:

- Inputs may be programmed such that the selected input is active or inactive during various states of the generator. Inactive inputs are ignored; unused inputs should normally be programmed to be inactive.
- Outputs may be programmed such that the relay connected to the selected output is energized or de-energized during various states of the generator. Unused outputs should normally be programmed to be de-energized.
- The inputs and outputs must be programmed separately for each receptor. Each receptor may have its own unique programming.

MEMBRANE CONSOLE

The **STATE** button on the upper right hand side of the menu selects the current state. The word **STATE** is preceded by the description of the state: for example, **STANDBY**.

The arrow in the lower middle area points to the current level for the selected state. Moving to the next state is accomplished by pressing the **STATE** button. The states are as follows:

STANDBY	Sets the state of the I/O when the generator is in standby or idle mode
PREP	Sets the state of the I/O when the generator enters PREP mode
GEN RDY	Sets the state of the I/O when the generator has completed PREP mode and is ready to expose
RAD EXP	Sets the state of the I/O when the generator starts a radiographic exposure

Pressing the button next to the selected input or output on the left of the display selects that function. The level of the selected state is changed by pressing the selection button again (low = off / inactive, high = on / active).

For inputs, setting the level “low” means that the input is ignored during that state. Setting the level “high” requires that the corresponding input is satisfied before the generator will advance to that state. For example, if the door interlock (DOOR ITLK) is set to logic “low” for all states, then an X-ray exposure may be made without a door interlock closure.

Setting an output level “low” causes the relay associated with that output to be de-energized during the selected state. Setting the level “high” will cause the associated relay to be energized during the selected state. For example, the Bucky 1 “start” output will be disabled if BKY 1 START is set to “low” for all states.

The example below shows a TYPICAL input configuration.

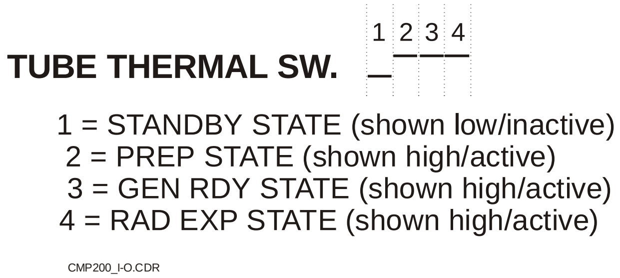


Figure 3-16: Example of input states

GenWare®

On the **Inputs** and **Outputs** tabs, the generator states are shown above the vertical grey / white bars. For inputs, grey indicates states where the input cannot be programmed. Only states that are shown in white can be changed. Outputs are programmable for each of the four generator states.

The logic level of the selected state is changed by clicking in the desired state column, to the right of the selected input or output (unchecked = off / inactive, checked = on / active).

For inputs, an unchecked state means that the input is ignored during that state. A checked state (marked with an **X**) requires that the corresponding input be satisfied before the generator will advance to that state.

For outputs, an unchecked state causes the relay associated with that output to be de-energized during the selected state. A checked state (marked with an **X**) will cause the associated relay to be energized during the selected state.

To program the I/O functions (Refer to the definitions in Table 3-12):

Action (membrane console)	Action (GenWare®)
1. From the GEN CONFIGURATION menu, select I/O CONFIGURATION. 2. Select the first receptor to be programmed. 3. Press the STATE button to select the first state that can be programmed for the TUBE THERMAL SW. input. This is the STANDBY state. Toggle the TUBE THERMAL SW. button to select the desired logic level (low or high) to disable or enable that input during the standby state. 4. Repeat the previous step for each state. 5. Repeat steps 3 and 4 for each input. Use the >> button to advance to INPUTS menu 2. 6. Press >> to select the OUTPUTS menu. 7. Repeat steps 3 and 4 to program each output. 8. When finished the I/O programming for the current receptor, exit to the GEN CONFIGURATION menu. 9. Reselect I/O CONFIGURATION, and then select the next receptor to be programmed. 10. Program all inputs and outputs for the selected receptor. 11. When finished programming all receptors, exit to the **GEN CONFIGURATION** menu.	1. From the **Receptor Setup** window, select the **Inputs** tab. 2. Select the first receptor to be programmed. Use the **Receptor** buttons on the **Receptor** window. 3. For the Tube Thermal Switch input, identify the first state that can be programmed. This is the Standby state. Enable or disable the Tube Thermal Switch input during the standby state by checking (with an X), or unchecking the Standby column to the right of Tube Thermal Switch. 4. Repeat the previous step for each state. 5. Repeat steps 3 and 4 for each input. 6. Select the Outputs tab. 7. Repeat steps 3 and 4 to program each output. An unchecked state causes the relay connected to that output to be de-energized during the selected state. A checked state (with an X) will result in the relay being energized during the selected state. 8. Select Apply to save the programming for the current receptor. 9. Select the next receptor to be programmed. Use the Receptor buttons on the Receptor Setup window. 10. Program all inputs and outputs for the selected receptor. 11. Select **Close** to exit the receptor setup utility.

The input and output programming should be recorded in a copy of Table 3-13. This will provide a record of the I/O configuration for future reference.

Table 3-13: Record of I/O Configuration Worksheet				
Inputs				
Functions	**STANDBY**	**PREP**	**GEN RDY**	**RAD EXP**
TUBE THERMAL SW				
DOOR ITLK				
INTERLOCK 1				
INTERLOCK 2				
BUCKY 1 RDY				
BUCKY 2 RDY				
Outputs				
Functions	**STANDBY**	**PREP**	**GEN RDY**	**RAD EXP**
BKY 1 START				
BKY 2 START				
ROOM LIGHT				

AEC Setup

The **AEC SETUP** menus allow programming of AEC parameters for each AEC channel.

AEC SETUP Menu 1

```
                          * AEC SETUP*
CHANNEL:        1                          CHAMBER TYPE:    ION
LEFT FIELD:           YES                FILM SCREEN   1  :  YES
CENTER FIELD:         YES                FILM SCREEN     2 :  YES
RIGHT FIELD:            YES               FILM SCREEN   3 :  YES




EXIT                                                          >>
```

AEC SETUP Menu 2 (Do not adjust these values at this time)

```
                    * AEC SETUP*
R FIELD COMP:        0
C FIELD COMP:        0
L FIELD COMP:        0                              +
                                                    -



<<
```

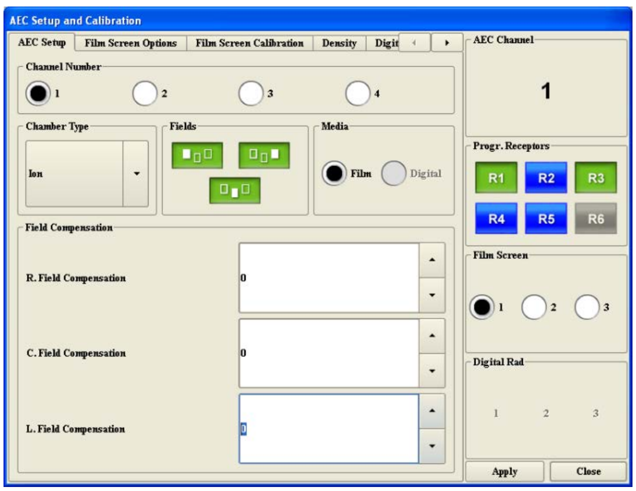


Figure 3-17: AEC Setup & Calibration window, AEC Setup tab

Note the following regarding GenWare® Figure 3-17:

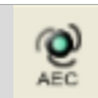
- The **AEC Channel** display in the top right corner of the **AEC Setup & Calibration** window shows the selected AEC channel.
- The **Progr. Receptors** display below the AEC channel display shows which receptors are programmed for the selected AEC channel.

Definitions of **AEC SETUP** menu items applicable to the initial AEC setup:

Table 3-14: Definitions of AEC Setup Menu Items

Function: Membrane Console	Function: GenWare®	DESCRIPTION
CHANNEL	Channel Number	Selects the AEC channel to be programmed
LEFT FIELD CENTER FIELD RIGHT FIELD	A graphic depicting the AEC chamber fields	Enables or disables the ability to select the left, center, or right AEC fields. **Membrane Console:** YES: The selected field is enabled. NO: The selected field is disabled. **GenWare®:** Refer to the graphic under Fields: A blue field select rectangle = field not selected, a green field select rectangle = field selected.
CHAMBER TYPE	Chamber Type	Selects the AEC chamber type **Membrane Console:** ION: Ion chamber S/S: Solid-state chamber APL: Apelem **GenWare®:** Ion: Ion chamber Solid State: Solid-state chamber Apelem: Apelem
FILM SCREEN 1 FILM SCREEN 2 FILM SCREEN 3	Film Screen Active	Enables or disables the ability to select film screen 1, film screen 2, or film screen 3 **Membrane console:** YES: The selected film screen is enabled. NO: The selected film screen is disabled. **GenWare®:** Checking 1, 2, or 3 under Film Screen Active enables that film screen.
R FIELD COMP C FIELD COMP L FIELD COMP	R. Field Comp C. Field Comp L. Field Comp	Allows left, center, and right field balance. This applies to solid-state AEC chambers only. The calibration procedure is described in the section, *AEC Calibration (Table Bucky)* in Chapter 4, *AEC Calibration*.

To perform the initial AEC setup (Refer to the definitions in Table 3-14):

Action (membrane console)	Action (GenWare®)
1. From the GEN CONFIGURATION menu, select AEC SETUP. 2. From **AEC SETUP** menu 1, select the AEC channel to be programmed. Pressing the **CHANNEL** button will scroll through the available AEC channels. *3.* Select **LEFT FIELD**. Toggle the button to select **YES** or **NO**. 4. Repeat the above for the **CENTER** and **RIGHT** fields. 5. Select **CHAMBER TYPE**. Use the **+** or **–** buttons to select the desired AEC chamber type.	1. Select the  button on the GenWare® toolbar to access the **AEC Setup and Calibration** utility. 2. Select the **AEC Setup** tab. 3. Under **Channel Number**, select the AEC channel that is to be programmed. 4. Select the left field on the graphic under **Fields** to enable / disable that field. Blue indicates that the selected field is disabled; green indicates that the selected field is enabled. 5. Repeat the above for the center and right fields. 6. Under **Chamber Type**, select the desired AEC chamber type.
Select ION if using solid state AEC board assembly 737992	
6. Select **FILM SCREEN 1**. Toggle the button to select **YES** or **NO**. 7. Repeat the above for **FILM SCREEN 2** and **FILM SCREEN 3**. 8. Press **>>**. 9. Select **R FIELD COMP**. Use the **+** or **–** buttons to enter the value **0**%. This may be optimized in a later step if using a solid-state AEC chamber. 10. Repeat the above for **C FIELD COMP** and **L FIELD COMP** 11. Repeat the applicable steps in this section for the remaining AEC channels. 12. Press << and EXIT as required to return to the GEN CONFIGURATION menu.	7. Select the Film Screen options tab. 8. Under Film Screen Active, select film screen 1. An X in the check box indicates that film screen 1 is enabled. 9. Repeat the above for film screen 2 and film screen 3. 10. Select the AEC setup tab. 11. Under Field Compensation, set the R. Field Comp value to 0. This may be optimized in a later step if using a solid-state AEC chamber. 12. Repeat the above for C. Field Comp and L. Field Comp. 13. Repeat the applicable steps in this section for the remaining AEC channels. 14. Select Apply to save programming changes to the generator. 15. Select Close to exit the AEC setup and calibration utility.

AEC Calibration

Refer to Chapter 4, *AEC Calibration*.

Tube Calibration

Before beginning tube auto calibration, the tube used in this installation must be properly selected, and the generator limits should be programmed, as described earlier in this chapter.

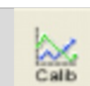
It is recommended that the tube be conditioned (seasoned) during tube auto calibration, particularly if the tube has not been used for some time. Refer to Tube Conditioning / Seasoning in Chapter 6, *Regular Maintenance*.

Warning:

The following procedures produce X-rays. Take all safety precautions to protect personnel from X-radiation.

Caution: Always verify the manufacturer of the tube insert. If the X-ray tube has been rebuilt. The tube insert and tube housing may be from different manufacturers.

Use these steps to perform the tube auto calibration.

Action (membrane console)	**Action (GenWare®)**
1. From the GENERATOR SETUP menu select GEN CONFIGURATION. 2. Select TUBE CALIBRATION. 3. Select FOCAL SPOT. Toggle the button to select the desired focal spot to calibrate (SMALL or LARGE). Start with SMALL. 4. Press and hold the X-RAY button (or use the optional hand switch) to begin the calibration procedure. 5. When finished calibrating the small focus, press RETURN and then repeat calibration on the large focal spot. 6. When auto-calibration is completed, press EXIT to return to the GENERATOR SETUP menu. 7. Press EXIT SETUP to exit out of the setup and calibration mode and return to the normal operation mode.	1. Select the  button on the GenWare toolbar to access the **Tube Calibration** utility. 2. Under **Focus,** select the desired focal spot to calibrate (**small** or **large)**. Start with **small**. 3. Press and hold the X-RAY button (or use the optional hand switch) to begin the calibration procedure. 4. Repeat the calibration on the large focal spot.

Note:

Should an error occur during auto calibration, an error message will be displayed. The generator will then limit the tubes operation to the range in which it was calibrated, thus allowing for partial operation of the generator.

Validate APR

The APR validator checks each APR entry to confirm that none of the requested parameters exceed the generator or tube limits. The APR validator will also check that the requested functions(s) within each APR are enabled. Invalid APR's may result due to GenWare® downloads - as APR's are not validated within GenWare® - or previously valid APR's may become invalid if generator limits or setup parameters are subsequently changed.

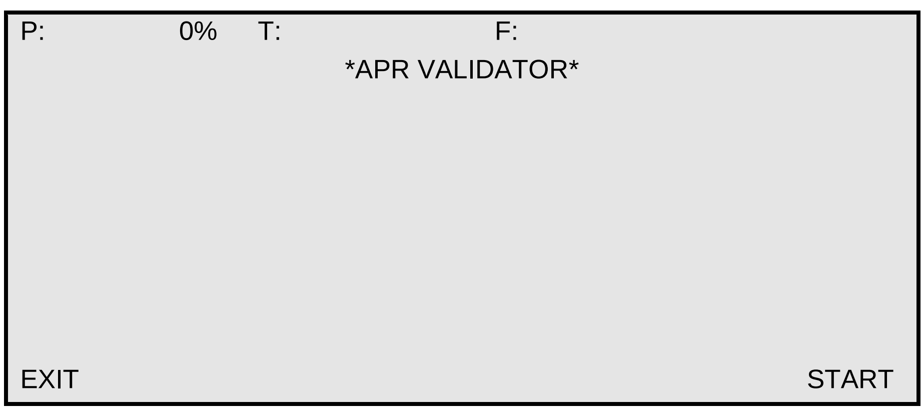
Invalid parameters and techniques may be corrected after the APR validator has completed its validation checks.

Note:

The APR validator is not available if CM Thickness mode is enabled. If the APR validator is selected with CM Thickness mode turned on, a message will be displayed indicating the APR validator does currently not support that CM Thickness mode.

This function does not apply to GenWare®.
To perform the APR validation:

1. From the **GENERATOR SETUP** menu, select **VALIDATE APR.** The APR VALIDATOR screen opens.



2. Pressing **EXIT** at any time that this button is available will return to the **GENERATOR SETUP** menu.
3. Press START to start the APR validator. The APR validation process will start.

While the APR validator is running:

- The name of each anatomical view being validated and the associated patient size will flash at the bottom of the APR validator screen along with its programmed parameters and techniques.
- The console LED's will light to indicate which image receptors and techniques are associated with the APR that is currently being validated.
- Failed APR's will be listed near the top of the APR validator screen. A maximum of four failed APR's will be displayed at one time.

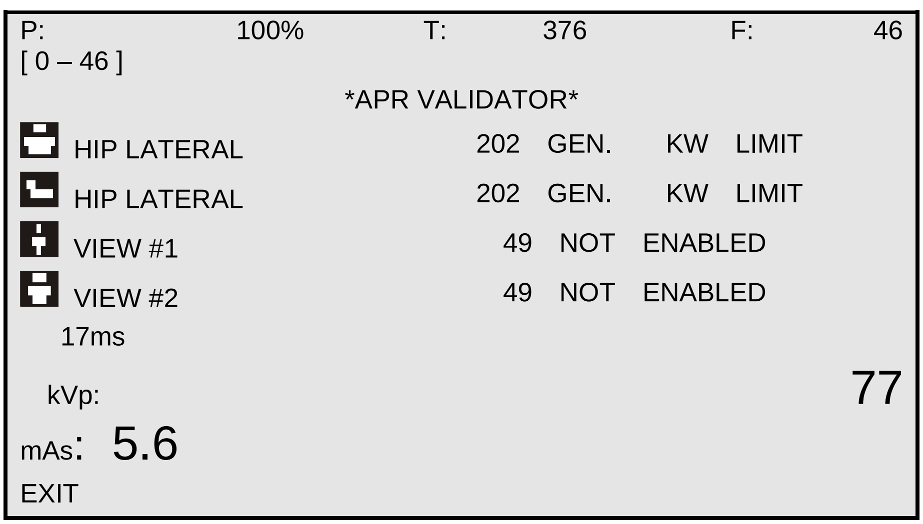
4. Pressing STOP while the APR validator is running will stop the APR validation.
5. While the APR validator is running or after it is finished or was stopped:

- P indicates percent completion. This will continuously update while the APR validator is running. The APR validation is finished when this indicates 100%.

If the APR validator is stopped before it has finished, this will display the percent completion at the time the APR validator was stopped.

- T shows the number of APR's that have been validated. This will continuously update while the APR validator is running. If the APR validator is stopped before it has finished, this will display the number of APR's that were validated at the time the APR validator was stopped.
- F shows the number of APR's that failed. This will continuously update while the APR validator is running. If the APR validator is stopped before it has finished, this will display the number of APR's that failed at the time the APR validator was stopped.

When the APR validator has finished running

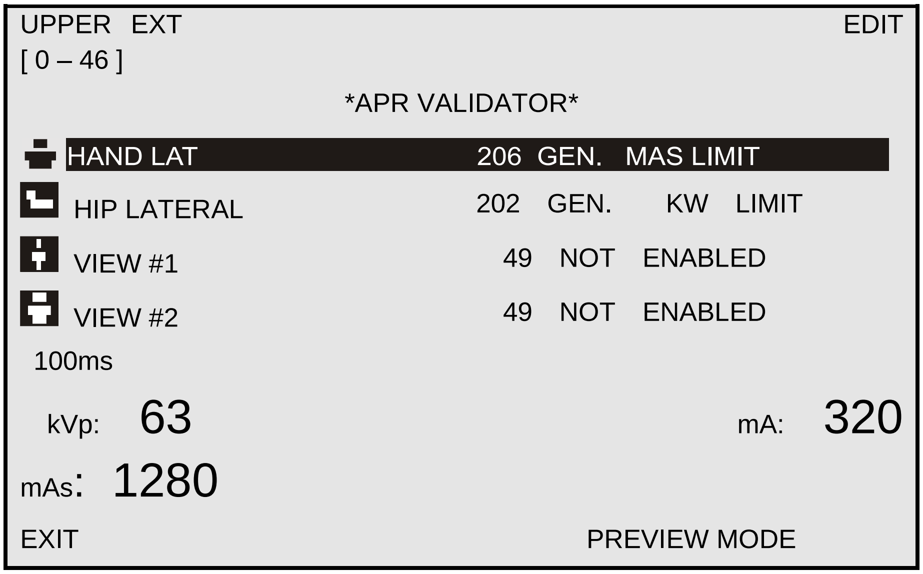


6. The view above shows the APR validator screen when the APR validator has finished running.

- The percent completion is shown as 100%.
- 376 APR's have been validated.
- 46 APR's have failed.

7. The console will first validate all APR's that use the large focus (receptor 1), then small focus (receptor 1). Next will be large focus (receptor 2), then small focus (receptor 2), etc until all APR's associated with all image receptors are exhausted.
8. The display at the top right of the LCD display (0 – 46 in the example) denotes the following:
   - The first number (0) indicates the number of APR items above the visible list on the current display. In the example above there are 0 items above the visible list, meaning that the list of failed APR's is at the top of the page.
   - The second number (46) refers to the number of failed APR's that are below the top of the page. In the example above 46 items are below the top of the list. Four failed APR's are shown, therefore there are another 42 listings that are not shown.

   Scrolling up or down as described in the next step will show the failed APR's that are not displayed in the current list.
9. To scroll up and down the list of failed APR's, if there are more than four items listed:
   - To scroll up in the list, press the soft key button [7].
   - To scroll down in the list, press the soft key button [8].
   - Refer to the Figure Programming / calibration mode reference near the front of this chapter for the location of the referenced buttons.
10. To edit a failed APR:
    - Select the APR to be edited using the adjacent soft key button [1] to [4] per the Figure Programming / calibration mode reference near the front of this chapter. The selected APR will be highlighted in PREVIEW MODE as per the Figure below.
    - The parameters and techniques that are currently requested by the selected APR will be shown (63 kV, 320 mA, 1280 mAs, 100 ms in the example below). The anatomical region that is the parent of the selected anatomical view is displayed at the top left of the LCD display.
    - Select EDIT to edit the selected APR.
    - To edit a failed APR



11. In the EDIT mode, (the console will be in EDIT mode after the EDIT button is pressed).
    - The console will attempt to change the value(s) that caused the APR validation to fail. For example, if the generator is set to maximum mA = 200 mA and the selected APR is requesting 360 mA, the console will then reduce the maximum mA to under 200 mA.
    - Another example of a failed APR is an anatomical view that is programmed for AEC. If the APR is programmed to select an image receptor that has AEC channel 0 assigned to it (no AEC), then the APR validator will display the error message 49 NOT ENABLED. In this case, either the selected receptor must be programmed for AEC or the APR must be reprogrammed such that it does not select AEC.
    - Select SAVE if the revised parameters and techniques are acceptable. The message SAVING APR DATA… will be briefly displayed. Do not turn the power off while the data is being saved, as doing so will corrupt the entire APR database.
    - APR's that have been fixed will be removed from the list of failed APR's.
    - The console will validate the remaining patient sizes within the same anatomical view after each save. These will also be removed from the list of failed APR's if applicable.
    - To exit the EDIT mode without making any changes, press one of the soft key buttons [1] to [4] that is associated with a failed APR.
12. Repeat steps 10 and 11 to edit the remaining APR's.

DAP Print Setup

1. Connect the DAP printer to the *DATA LINK* connector J4 on the rear of the console. Refer to the Figure "*Rear of control console*" in Chapter 2, *Installation*, of the CMP 200® service manual for the connector location.
2. Follow the procedure in the section, *DAP Setup Menu Items*, of this chapter to set up and test the DAP printer.

Note:

The generator must be configured for the specific printer (SEIKO instruments DPU-414 or SLP-200). The generator will be compatible only with the selected printer, therefore only that printer model must be used in this installation.

Note: The paper of labels used in the printer must meet all applicable regulations. Medical grade paper or labels, approved for medical records, must normally be used.

DAP Interfacing

DAP Compatibility

The CMP 200® series generator, when equipped with the DAP option, is compatible with the DAP devices listed in the table in the section, *DAP Setup Menu Items*. The correct DAP device must be selected in the DAP SETUP menu as described in the section, *DAP Setup Menu Items*, in order to ensure device compatibility.

The DAP chamber, when fitted with the proper interconnect cable, plugs directly into the generator control board in the generator. When ordering the DAP chamber from the DAP manufacturer, specify the CPI compatible interconnect cable, if available. This is a special cable terminated with a 9-pin male "D" connector that is designed to plug directly into the generator control board. If this cable is not available from the DAP device manufacturer, consult CPI product support for the required cable to connect the DAP chamber to the generator. Refer to Table 3-15 for the CPI cable assembly part numbers.

Table 3-15: Inforamtion of CPI DAP Device Cable

DAP Device	Interconnect Cable
PTW: PX-T11020	736145-00
Gammex-RMI: 841S	736146-00
VacuTec: VacuDAP 2004	Contact VacuTEC for this cable assembly
Scanditronix (IBA): 120-131, 120-131HS	736148-00

DAP Installation

1. Switch OFF the AC line voltage to the generator at the main disconnect switch. Allow sufficient time for all capacitors in the generator to discharge.
2. Install the DAP chamber as per the manufacturers instructions. The interconnect cable to the generator must be as per the section, *DAP Compatibility* of this chapter.
3. Route the DAP interconnect cable through one of the access slots at the upper rear of the generator, and then route the cables toward the generator control board. Secure the cable to the lip on the inside of the cable access slot using tie wraps or equivalent fasteners.
4. Plug the DAP cable into J4 on the generator control board. Tighten the screw locks on the connectors to secure the cables.
5. Set JW14 (near J4) on the generator control board as per the following table

Name	Scanditronix (IBA)	All Others
DAP Chamber	Jumper pins 1-2	Jumper pins 2-3

6. Proceed with DAP setup and calibration as per the remainder of this procedure.

DAP Setup

DAP Set up Menu

The **DAP SETUP** menus allow setup and calibration of the DAP device.

The **DAP SETUP** menus for the membrane console are shown below.

DAP SETUP Menu 1

	DAP * DAP SETUP *	
DAP: ON		TEST VALUE 1: 300
DEVICE TYPE 1: 7		+
CAL. VALUE 1: 1.00		-
0.0mGycm^2		
<<		>>

DAP SETUP Menu 2

DAP
* DAP SETUP *

ACC ALARM (mGycm²) +
2000
DAP PRINTER: DPU414 -

0.0mGycm²

<<

DAP SETUP Menu 3: DAP RESET / TEST / PRINT

EXIT
DAP = 0.0mGycm²

+
PRINT -

RESET TEST

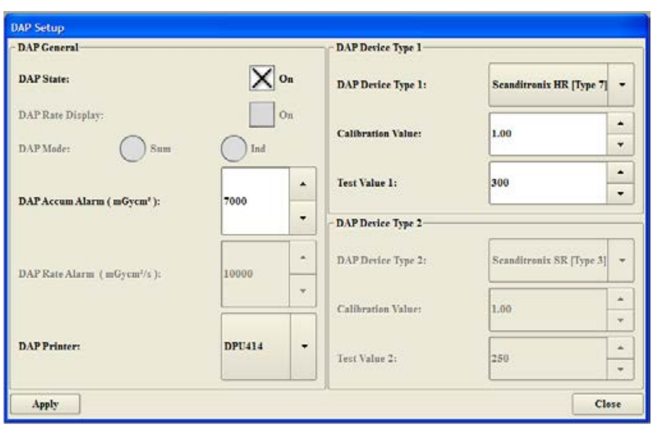


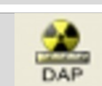
Figure 3-18: DAP Setup window

DAP Setup Menu Items

Table 3-16: Definitions of DAP Setup Menu Items		
Function		**Description**
Membrane	**GenWare®**	
DAP	DAP State checkbox	Enables or disables the DAP device **Membrane Console:** ON: The DAP function is enabled. OFF: The DAP function is disabled. **GenWare®:** The DAP function is enabled or disabled via the DAP State checkbox.
DEVICE TYPE 1	DAP Device Type 1	Selects the DAP device. Types 0 to 3 are standard resolution DAP chambers, and types 4 to 7 are high-resolution DAP chambers. 0 = PTW PX-T11020 1 = Gammex RMI 841S 2 = VacuTec VacuDAP 2004 3 = Scanditronix (IBA) 120-131 4 = Not assigned at this time 5 = Not assigned at this time 6 = Not assigned at this time 7 = Scanditronix (IBA) 120-131HS
CAL. VALUE 1	Calibration Value	Allows the DAP reading to be calibrated by adjusting this parameter
TEST VALUE 1	Test Value 1	A numeric value, supplied by the DAP device manufacturer, that represents the number of pulses generated by the DAP device during TEST mode. Typical terms used by DAP device manufacturers for this function are “Test Pulses”, “Test Value”, or “Test Count”, but other names may be used. The generator counts the number of pulses generated by the DAP device during TEST mode, and reports a DAP failure error message if the actual number of test pulses are not the same as the manufacturer-supplied test count, within an allowable margin of error.
ACC ALARM (mGycm^2)	DAP Accum Alarm (mGycm^2)	Sets the alarm level for accumulated DAP. The console will present an audible alarm and a visual warning via the LCD display when the accumulated dose exceeds this limit. This displays units of mGycm^2 regardless of the DAP UNITS setting in the CONSOLE utilities. A units

Table 3-16: Definitions of DAP Setup Menu Items		
Function		**Description**
Membrane	**GenWare®**	
		conversion will need to be done if DAP UNITS is set to display µGym^2, where 0.1 µGym^2 = 1 $mGycm^2$ i.e. 200 µGym^2 = 2000 $mGycm^2$.
DAP PRINTER	DAP Printer	Allows selection of the DAP printer type, or disabling of the DAP printer function. This is only available with the DAP printer option. OFF: Disables the DAP printer function DPU414: Selects the Seiko Instruments DPU-414 pr SLP200: Selects the Seiko Instruments SLP-200 pri
DAP	**Membrane Console** ***ONLY:*** Allows access to a submenu used to reset the DAP display, test the DAP device, and print a test label. This selection is available in the DAP SETUP menus when the DAP function is ON.	
PRINT	This function is not available in GenWare®	Prints a DAP label. The printer will print the date and time near the top of the label, and the accumulated Dose-Area Product (µGym^2 or $mGycm^2$) near the middle of the label. This information is retrieved from the generator at the time the label is printed. Several headings are also printed on the labels; the corresponding patient information must be manually entered.
RESET	Reset	Resets the DAP display to zero.
TEST	Test	Tests the DAP circuits by counting the number of test pulses (refer to TEST VALUE 1, above). A pass / fail message will be displayed after the DAP test and the actual number of test pulses counted will be also be displayed.

To set up the DAP device (DAP calibration is done after DAP setup):

Action (membrane console)	**Action (GenWare®)**
1. From the GEN CONFIGURATION menu, select DAP SETUP. 2. From **DAP SETUP** menu 1, select **DAP**. Toggle the button to select **ON** or **OFF**. The DAP device must be enabled if you want to continue.	1. Select the  button on the GenWare® toolbar to access the **DAP Setup** utility. 2. Check the **DAP State** checkbox to enable the DAP function.

Action (membrane console)	Action (GenWare®)
3. Select **DEVICE TYPE 1**. Use the **+** or **–** buttons to select the desired DAP device. 4. Select **TEST VALUE 1**. Use the **+** or **–** buttons to enter the test value for DAP device 1. 5. Press **>>**. 6. Select **DAP PRINTER**. Toggle the selection button to select **OFF, DPU414,** or **SLP200**. 7. Select ACC ALARM (mGycm2). Use the + or – buttons to set the maximum permissible accumulated DAP alarm point. 8. Press DAP to access the DAP RESET, TEST, and PRINT functions. 9. Press RESET to reset the DAP display to zero. 10. Press TEST to test the DAP system. This will test the DAP chamber and DAP circuits. 11. Press PRINT to print a DAP label. 12. Press EXIT to return to the DAP SETUP menu.	The DAP device must be enabled if you want to continue. 3. Select the desired DAP device via the **DAP Device Type 1** dialog box. 4. Select the test value for DAP device 1 via the **Test Value 1** dialog box. 5. Select the desired printer via the **DAP Printer** dialog box. 6. Select the maximum permissible accumulated DAP alarm point via the DAP Accum Alarm (mGycm2) dialog box. 7. When DAP is enabled, the accumulated DAP value will be displayed near the bottom of GenWare®, along with the Reset and Test buttons. 8. Select Reset to reset the DAP display to zero. 9. Select Test to test the DAP system. This will test the DAP chamber and DAP circuits.

DAP Calibration

The DAP device must be calibrated before use, and the calibration must be periodically checked as per the DAP device manufacturers requirements, or as per local regulations.

Equipment Required

The following equipment is required for DAP calibration.

- An X-ray cassette and film. The speed of the film / screen is not relevant, as the film is only used to determine the area that is irradiated at the dose-measurement plane.

- An X-ray cassette and film is the preferred method to measure the irradiated area, but if this is not readily available, for example if this is a digital only system, a procedure is given to determine the required area using the imaging system.
- A film processor to develop the film, if required.
- A calibrated dosimeter.
- A ruler or tape measure with centimeter markings. This will be needed to measure the exposed area of the film. If measuring in inches, use a calculator and multiply inches by 2.54 to obtain the measurement in centimeters.

DAP Calibration Overview

The first step involved in calibrating the DAP meter in the generator is to carefully make a dose measurement at a given distance from the X-ray source. The next step is to expose a test film at the same distance from the X-ray source as the dose measurement that was just made.

The dose-area product is calculated by multiplying the measured dose, in mGy, by the exposed area of the film, in cm^2. This gives the actual dose-area product, in $mGycm^2$.

After the reference dose-area product is determined as described above, it is compared to the DAP reading as measured by the generator. Adjustments are made to the **CAL. VALUE 1** parameter in the **DAP SETUP** menu such that the console's DAP display corresponds to the calculated dose-area product. This procedure may need to be repeated several times until the required accuracy is obtained.

The reason the DAP device (a specialized ion chamber) is able to accurately measure the dose-area product at its location at the bottom of the collimator is that although the radiation level falls off at a rate inversely proportional to the square of the distance from the source, the irradiated area increases as the square of the distance from the source. For example, by doubling the distance, the dose falls to $(½)^2$ = ¼ of the previous dose BUT the area increases to 2^2 = 4 times the area. Therefore, the dose-area product will remain constant at a given distance from the source. This is also the reason that care must be taken to ensure that the area measurement is done at the same distance from the X-ray source as the dose measurement.

DAP Calibration Procedure

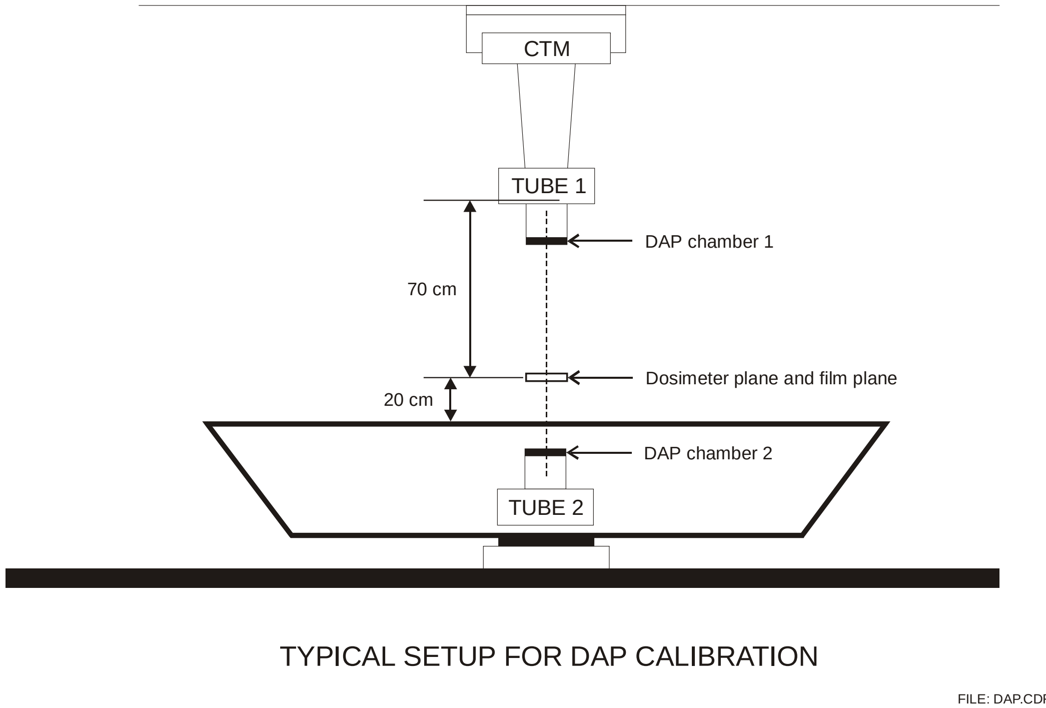


Figure 3-19: DAP setup

Use these steps to calibrate the DAP meter(s) in the generator.

1. Set up the dosimeter as per Figure 3-19. The probe should be centered relative to the central ray from the X-ray tube, and sufficiently far off the tabletop to minimize scatter radiation. ***Do not use any absorber during this procedure***.
2. Open the collimator such that the field size at the location of the probe is approximately 12 cm X 12 cm. Ensure that the probe is fully irradiated.
3. Enter the **DAP SETUP** menu.
4. Set the generator to 70 kV, 100 mA, 20 ms.
5. Press **DAP** to access the RESET / TEST /PRINT menu, then press **RESET** to reset the DAP display to zero. The DAP will reset to zero, then the generator will return to the **DAP SETUP** menu.
6. Make an X-ray exposure and note the dose per the dosimeter. Record the mR or mGy value in a copy of DAP Calibration Worksheet of this chapter. Convert the mR value to mGy, if necessary.
7. Note the DAP value as displayed on the console, and record the value in a copy of DAP Calibration Worksheet of this chapter.
8. Replace the dosimeter with an X-ray cassette and film if available. The film plane must be at the same location as the dosimeter was in step 8.

If using an image sensor such as an I.I., or flat panel, or other non-film image sensor, the image pickup plane must be at the same location as the dosimeter was in step 8.

Note:

The importance of this step cannot be overstated: the irradiated area measurement must be made at a point that is the same distance from the X-ray source as the dose was measured at.

9. Ensure that the collimator field at the measurement plane is smaller than the active area of the image pick-up device (film, I.I., or other). Refer to Figure 3-20.

Do not readjust the collimator from the setting that was used in step 8.

10. Make another exposure using the same settings as in step 6.

11. Develop the film (if used).

12. Measure the irradiated image area. For film, measure the length and width of the exposed area, and record the results in DAP Calibration Worksheet of this chapter. Refer to Figure 3-20.

    If using a digital imaging system, some systems have a cursor available that allows measurement of the length and width of the area in question. If the digital imaging system does not allow image size measurement, it is suggested that an X-ray opaque item of known dimensions be placed at the image plane. (A collimator test tool would be useful in this application). The length and width of the irradiated area can then be extrapolated by comparison to the size of the reference object. Record the length and width of the irradiated area at the measurement plane in DAP Calibration Worksheet of this chapter.

    Do not readjust the collimator from the setting that was used in step 8.

13. Calculate the irradiated image area, in cm^2. Use the length and width recorded in DAP Calibration Worksheet of this chapter.
14. Calculate the dose-area product by multiplying the area from DAP Calibration Worksheet of this chapter X the dose in mGy from DAP Calibration Worksheet of this chapter. Record the resulting value at step 3 in DAP Calibration Worksheet of this chapter.
15. Calculate the percentage error between the manually calculated DAP measurement (DAP Calibration Worksheet of this chapter, step 3) and the measured DAP value (DAP Calibration Worksheet of this chapter, step 4). Record the percentage error in step 5 of the table.

16. If the displayed DAP reading does not meet the required accuracy, increase or decrease **CAL. VALUE 1** (membrane console) or **Calibration Value (DAP Device Type 1)** for GenWare® by the same percentage as the percentage error.
17. Repeat steps 7 to 16 until the required accuracy is obtained. Make as many copies of DAP Calibration Worksheet of this chapter as required to record the results from all required iterations.

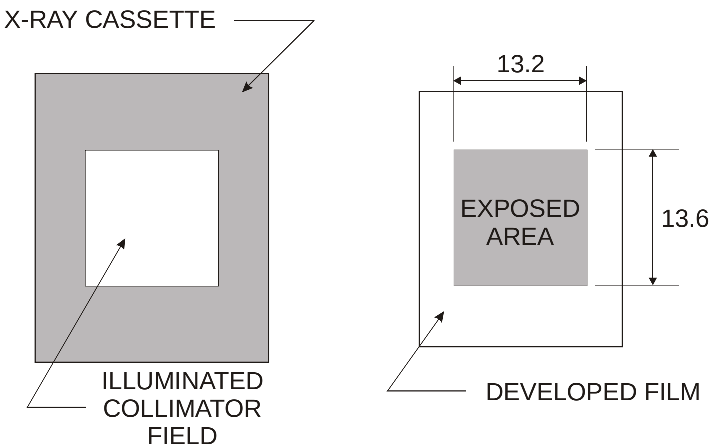


Figure 3C-20: Irradiated area vs. available image area

DAP Calculation Worksheet

1. Measured dose:

   Convert mR to mGy if necessary by multiplying mR X 0.00873. Example 23.3 mR X 0.00873 = 0.203 mGy.

   ______________ mR   ______________ mGy

2. Measure and record the exposed area of the film (Length X Width).

   Calculate the exposed area in cm^2 (length X width).

   ______________ Length (cm)   ______________ Width (cm)   ______________ Area (cm^2)

3. Multiply the dose in mGy (step 1) X the area in cm^2 (step 2). This will yield the actual dose-area product, in $mGycm^2$.

   ______________DAP ($mGycm^2$)

4. Record the DAP, in $mGycm^2$, as displayed on the console.

   ______________DAP ($mGycm^2$)

5. Calculate the percentage error: Refer to the example at the end of this section.

   ______________ % error

The second iteration of the DAP calibration procedure:

1. Measured dose:

   Convert mR to mGy if necessary by multiplying mR X 0.00873. Example 23.3 mR X 0.00873 = 0.203 mGy.

   _____________ mR _____________ mGy

2. Measure and record the exposed area of the film (Length X Width).

   Calculate the exposed area in cm^2 (length X width).

   _____________ Length (cm) _____________ Width (cm) _____________ Area (cm^2)

3. Multiply the dose in mGy (step 1) X the area in cm^2 (step 2). This will yield the actual dose-area product, in $mGycm^2$.

   _____________DAP ($mGycm^2$)

4. Record the DAP, in $mGycm^2$, as displayed on the console.

   _____________DAP ($mGycm^2$)

5. Calculate the percentage error: Refer to the example at the end of this section.

   _____________ % error

Refer to the sample DAP worksheet below:

1. Measured dose:

   Convert mR to mGy if necessary by multiplying mR X 0.00873. Example 23.3 mR X 0.00873 = 0.203 mGy.

   ____23.3_____ mR ____0.203____ mGy

2. Measure and record the exposed area of the film (Length X Width).

   Calculate the exposed area in cm^2 (length X width).

   ____13.6_____ Length (cm) ____13.2_____ Width (cm) ___179.52____ Area (cm^2)

3. Multiply the dose in mGy (step 1) X the area in cm^2 (step 2). This will yield the actual dose-area product, in $mGycm^2$.

   ____36.44____ DAP ($mGycm^2$)

4. Record the DAP, in $mGycm^2$, as displayed on the console.

   ____40_______ DAP ($mGycm^2$)

5. Calculate the percentage error: Refer to the example at the end of this section.

   ___-8.9______ % error

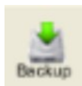
Sample percentage error calculation (step 5):

$$\frac{(36.44 - 40)}{40} \text{ X } 100 \;=\; \frac{-3.56}{40} \text{ X } 100 \;=\; -8.9\ \%$$

Generator Configuration Backup and Restore (GenWare®)

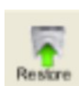
This is used with the GenWare® (PC) utility software. This allows the generator configuration (i.e. receptor setup, AEC setup and calibration, etc.) to be stored on a PC hard drive or other external memory device (ie. USB flash drive).

To back up the generator configuration

1. Launch the GenWare® MP (PC) utility software.
2. Select the 

button. This will open the standard Windows **Save As** window.
3. Enter a file name and select a location to save the file and click **Save**. A progress bar will indicate the percentage of the backup complete.
4. Record the file name and location for future reference or the event the generator configuration needs to be restored.

To restore a generator configuration

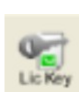
5. Launch the GenWare® (PC) utility software.
6. Select the 

button. This will open the standard Windows **Open** window.
7. Locate and select the desired backup file.
8. Select **Open**. A progress bar will show the percentage of the configuration file restored.

License Key Setup (GenWare®)

This is used with the CPI GenWare® utility software. This allows additional features to be activated in the generator software.

1. Launch the GenWare® utility software.

2. Select the 

button from the toolbar on the top of the screen.This will open the **Generator License Key Setup** window. Refer to Figure 3-21.
3. Note the System ID (this will be a sixteen-character string) and communicate it to CPI (via email or phone). The System ID will belong to the generator in which GenWare® MP is connected at the time the System ID is read.

4. CPI will provide a new license key (this will be a sixteen-character string). Enter this string into the dialog boxes to the right of **License Key**. The characters are not case-sensitive. For the PC version of GenWare®, uses a regular keyboard to enter the License key. For the touchscreen version of GenWare®, uses the on-screen keyboard to enter the License key.
5. Select **Apply** to program the new license key into the generator. Note: all characters MUST be entered to enable the **Apply** button.
6. Select **Close** to exit.

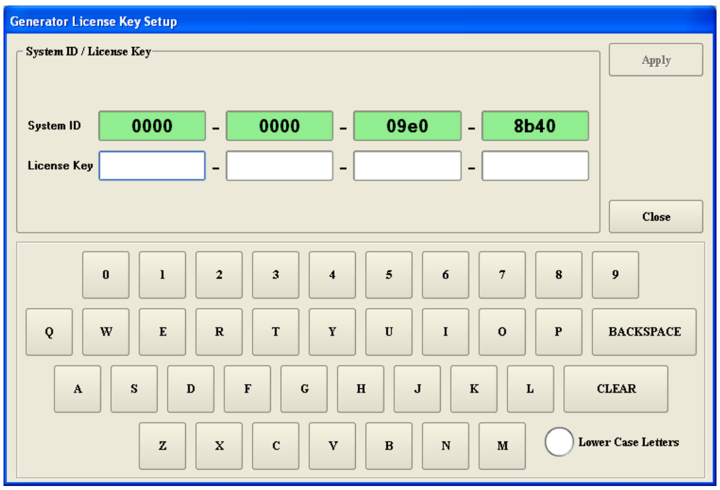


Figure 3-21: Generator License Key Setup window

Monochrome Display (GenWare®)

This is used with the CPI GenWare® (PC) utility software. This allows the display to be toggled between monochrome and full color.

1. Launch the GenWare® (PC) utility software.

2. Select the  button from the toolbar on the top of the screen. This will open the **Display Options** window. Refer to Figure 3-22.
3. Select the **Monochrome Display** radio button

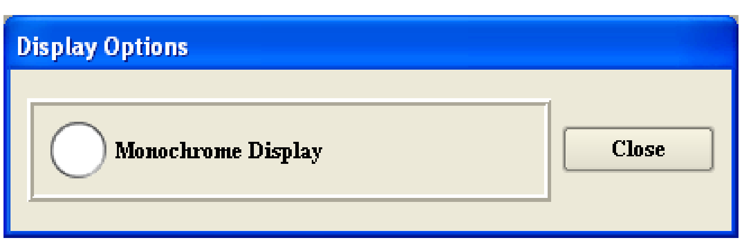


Figure 3-22: Display Options window

Generator Programming via CPI Touchscreen Console

This section provides the instructions of how to program the generator via the CPI touchscreen console.

Touchscreen System Utilities

This section describes the **System Untilities** function.

Opening GenWare® Installed in CPI Touchscreen

1. Click the Genware button to access to the GenWare® (touchscreen) utility software.

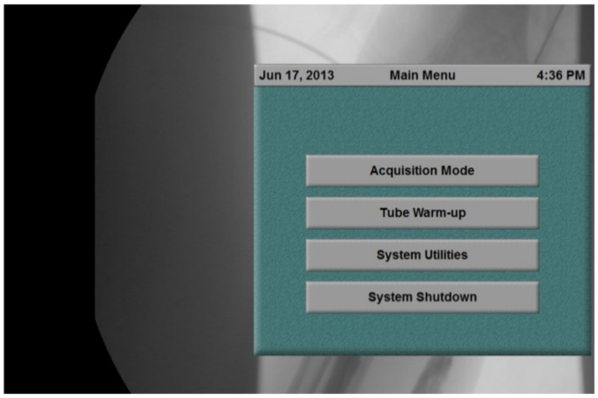


Figure 3-23: Main Menu

2. Some settings require to use the on-screen keyboard. The on-screen keyboard hides from the screen after the CPI application software is opened. To allow the on-screen keyboard displaying on the screen, follow the next steps.
3. On the **Main Menu** screen, using a stylus or the tip of your finger, tap the top left corner of the screen. The partial keyboard displays on the screen.

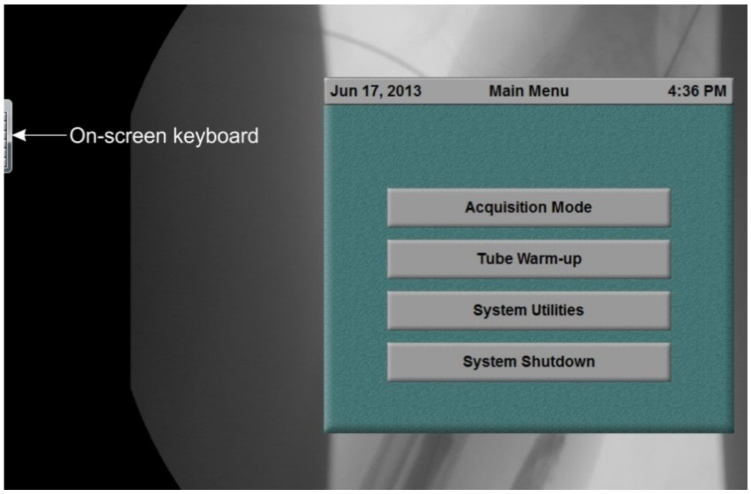


Figure 3-24: On-Screen Keyboard Hiden

4. Double-tap the partial on-screen keyboard (see the screenshot above). The full keyboard appears on the center of the screen.

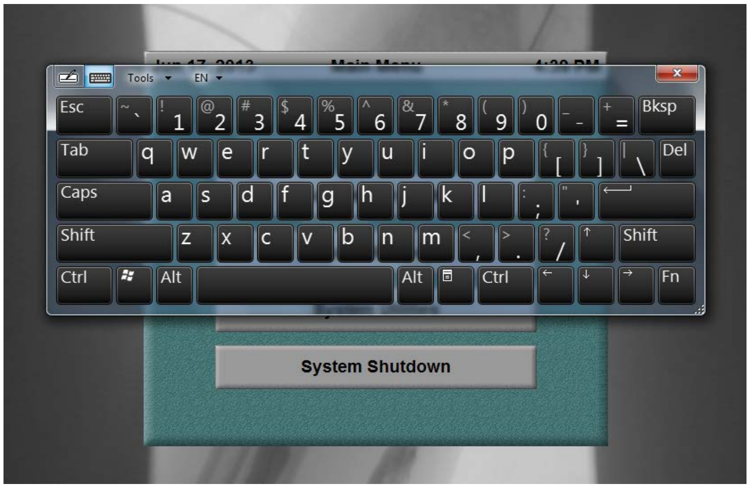


Figure 3-25: On-Screen Keyboard

Table 3-17: Functions of System Utilities Menu	
Function	**Description**
APR Editor	Allows the APR to be edited. Changes may be saved to memory.
APR Backup / Restore	Allows the APR data to be backed up, and backed-up APR data to be restored. The factory-default APR is available in several languages. This also allows APR files to be saved to a USB flash drive or laptop, and saved APR files to be downloaded from a USB flash drive or laptop.
Date / Time Setup	Allows the touchscreen's date and time to be set or changed
Receptor Symbols	Allows predefined receptor symbols to be assigned to each image receptor button. Also, allow receptor symbols to be saved to a USB flash drive and to be downloaded from a USB flash drive.
Genware®	Allows access to the GenWare® (touchscreen) utility software

Table 3-17: Functions of System Utilities Menu

Function	Description
Touch Screen Setup	1. Allows for the setting of specific console operating parameters 2. Sets up the serial communication ports on the touchscreen console 3. Sets the specific customer code for graphical user interfaces (skin) 4. Sets the screen saver interval 5. Allows adjustment of the General Volume, the Exposure Volume, and the LCD Brightness 6. Enables / disables compatible equipment (i.e. Infirmed digital interface). 7. Allows the operator and service passwords to be changed
Configuration Backup / Restore	Allows the receptor symbols and auto-positioner data, if applicable, to be backed up, and backed-up receptor symbols and auto-positioner data, if applicable, to be restored.
Main Menu	Press to return to the main console menu

Accessing the Utilities Menu

Use these steps to access the systems utilities functions.

1. From the main console menu (Figure 3-26), press **System Utilities**. A pop-up window will be displayed (Figure 3-27), requesting a password.
2. Press **1**, **9**, **7**, **3** in sequence to continue. This is the factory-default service password, and allows access to all of the functions listed above.
   - Press **Clear** to cancel an incorrect password.
   - Press **Cancel** to return to the main menu.
   - Press **Accept** to access the system utilities menu. After a brief delay, the system utilities menu (Figure 3-28) will be displayed. The message, "**Access Denied"** indicates that a password was incorrect. ***A service engineer as described later in this supplement may change the factory-default password. If the service engineer did changes the password, the password defined above will be not valid for the system utilities menu.***

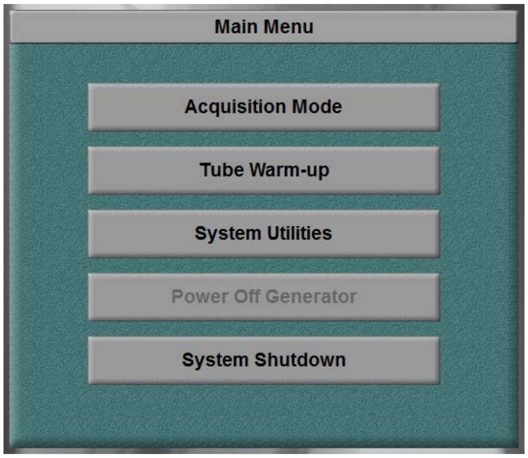


Figure 3-26: Main Menu

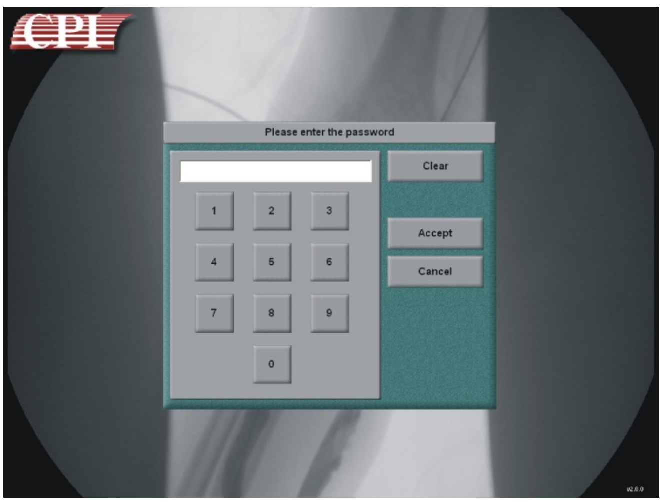


Figure 3-27: Password Window

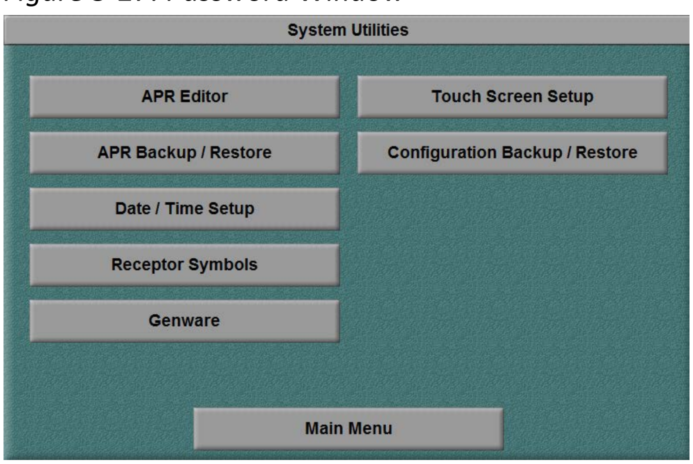


Figure 3-28: System Utilities Menu

APR Editor

It is strongly suggested that you review the section ANATOMICAL PROGRAMMING SELECTOR in the operator's manual before proceeding. A good understanding of the terminology and APR menu structures is needed to make APR changes.

Use these steps to access the APR editor function.

1. From the system utilities menu (Figure 3-28), press **APR Editor.** A screen similar in appearance to the normal operating screen will be displayed (Figure 3-29). However, as a reminder that you are in APR editor mode, the word **APR EDITOR** will be displayed in the APR window.

2. Refer to the applicable subsections (following) for the procedures to change parameters and technique for existing APR items, and to edit, add, or delete APR, procedural, or menu items.

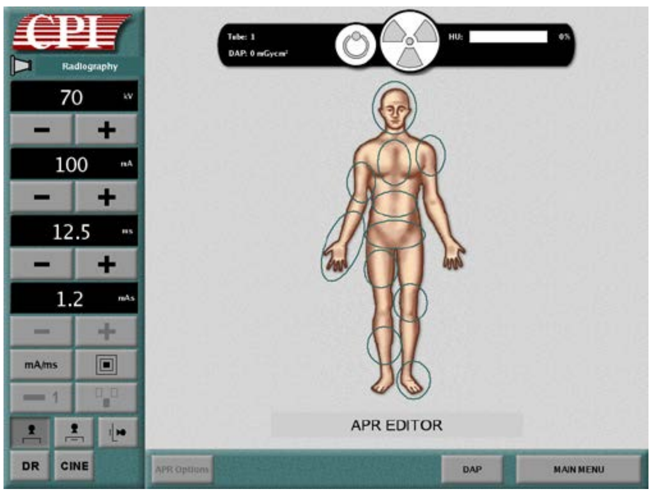


Figure 3-29: APR Editor Window

Note:

The display on your system may vary depending on generator type, and on programming and technique selections. Minor variations may exist in color scheme and graphic styles (SKINS) to suit specific customer requirements.

Note: When a region of interest (i.e. Skull) is selected, a pop-up menu wo;; appear similar to that in normal APR mode. In addition to "NEW" <ADD>, <EDIT>, and <DELETE> buttons, the <MOVE UP> and <MOVE DOWN> buttons will be displayed. The <MOVE UP> and <MOVE DOWN> buttons allow the items in a menu or submenu to be rearranged. To do this, select the item to be moved. This will highlight the item. Press <MOVE UP> to move the selected item up in the list, and <MOVE DOWN> to move the selected item down in the list.

To change parameters or techniques for an existing APR item:

1. Select the APR item to be changed. If the APR item is in a submenu of a menu or procedural item, select the parent menu item or procedural item, and then press **Open Sub-Menu**. It may be necessary to drill down through several submenus to find the desired APR item.
2. When the selected APR item is highlighted, select the patient size. The desired parameters / technique may be changed for that patient size (kV and mA, mAs, ms, density, AEC / mA/ms / mAs, focal spot, film screen, AEC fields, image receptor). Repeat for all patient sizes for that APR item as required. The highlight will change to red when the programmed APR has been altered.
3. Repeat steps 1 and 2 for other APR items within that menu or submenu, if applicable.
4. Press **BACK** when finished changing APR items in that menu / submenu. This may need to be done more than once to return to the top APR menu for the selected region of interest. A pop-up window will display asking if you wish to save the changes. Press **YES** to save the changes; **CANCEL** cancels the changes.

Note: When editing or adding an APR item, menu item, or procedural item, an English keyboard will pop put at the bottom of the screen. A partial keyboard with international symbols corresponding to the installer-selected language may be displayed at the top of the screen. Characters may then be entered via either keyboard. An ID code window may be siaplayed to the right of the window for the item text. The ID code is used by some imaging systems, and use of kthe proper code synchronizes the APR's between the touchscreen console and the imaging system. Refer to the appropriate imaging system documentation for valid ID codes. Touching the ID code window will move the cursor inot that window, allowing entry of the ID code. The ID code is not available on all software configurations of the touchscreen.

To edit (change the name of) an APR item:

1. Select the APR item as per step 1 under **"To change parameters or technique for an existing APR item".** The selection will be highlighted.
2. Press **Edit**. Keyboard(s) will display on the screen as described above, with the current name of the APR item highlighted.
   - Press **CANCEL** on the lower keyboard to exit without changing the name.
   - Press **DEL** to delete the highlighted name on the keyboard.
   - Type in the new name for that APR item. Use the **BACKSPACE** key to back space if corrections are needed.
   - Add / edit the ID code if desired (if displayed).
   - Press **ENTER** when finished.

To delete an APR item:

1. Select the APR item to be deleted. The selection will be highlighted.
2. Press **Delete**. A pop-up window will display asking if you are sure, you want to delete this item. Press **YES** to delete the item; **NO** cancels the deletion.

To add an APR item:

1. Select the appropriate location to add the APR item. An APR item may be added directly to a main APR menu, or may be added to a submenu of another menu or procedural item.

   If the APR item is to be added to a submenu of a menu or procedural item, select the parent menu item or procedural item, then press **Open Sub-Menu**. It may be necessary to drill down through several submenus to find the desired location for the new APR item.

2. Press **Add**. A pop-up window will display allowing you to select three item types to be added. Select **APR Item** (this is the default selection and the only available selection if adding to a procedural menu).
3. Press **OK** to continue. **Cancel** will cancel this action.
4. Keyboard(s) will display on the screen as described previously.
   - Type in the name of the new APR item.
   - Add the ID code if desired (if displayed).
   - Press **ENTER** when finished.
   - The new APR item will appear on the selected menu or submenu.
   - Change the parameters and technique as per the subsection **"To change parameters or technique for an existing APR item".**

To add, edit, or delete a procedural item:

Note:

A procedural item has only one submenu, which may only contain APR items. A procedure item will automatically select the next APR item on its list when the Prep or Expose buttomes are released.

Note:

A menu item has one or more submenus, which may include other menu items, procedural items and / or APR items. APR items contained within a menu must be selected manually.

1. To delete a procedural item, follow the steps in **"To delete an APR item".** Doing so will also delete the submenu associated with that procedural item.

2. To edit a procedural item, follow the steps in **"To edit (change the name of) an APR item".**
3. To add a procedural item, follow steps 1 to 3 in **"To add an APR item",** except select **APR Procedure** in step 2**.**
4. Keyboard(s) will display on the screen as described previously.
   - Type in the name of the new procedural item.
   - Add / edit the ID code if desired (if displayed).
   - Press ENTER when finished.
   - The new procedural item will appear on the selected menu or submenu.
   - Select the newly added procedural item. The selection will be highlighted.
   - Press Open Sub-Menu. A "generic" APR item named FIRST ITEM has been automatically inserted in that submenu.
   - You may now edit the name and change the parameters and technique for that APR item, and add additional APR items for that procedural item as per previous steps.

To add, edit, or delete a menu item:

1. To delete a menu item, follow the steps in **"To delete an APR item".** Doing so will also delete the submenu associated with that menu item.
2. To edit a menu item, follow the steps in **"To edit (change the name of) an APR item".**
3. To add a menu item, follow steps 1 to 3 in **"To add an APR item",** except select **APR Menu** in step 2**.**
4. Keyboard(s) will display on the screen as described previously.
   - Type in the name of the new menu item.
   - Add / edit the ID code if desired (if displayed).
   - Press **ENTER** when finished.
   - The new menu item will appear on the selected menu or submenu.
   - Select the newly added menu item. The selection will be highlighted.
   - Press **Open Sub-Menu**. A "generic" APR item named **FIRST ITEM** has been automatically inserted in that submenu.
   - You may now edit the name and change the parameters and technique for that APR item, and add additional APR items for that menu item as per previous steps.

APR Backup / Restore

To access the APR backup / restore function:

1. From the system utilities menu, press **APR Backup / Restore.** A pop-up window (Figure 3-30) will display showing the available backup files and the factory-default APR files in various languages. Pressing **Close** will exit the backup and restore menu.

2. Refer to the applicable subsections (following) for the procedures to back-up the current APR data, to restore saved APR data, and to upload and download APR files to and from a USB flash drive. The entire APR (parameters and techniques, APR text, menu structures, etc.) is backed up.

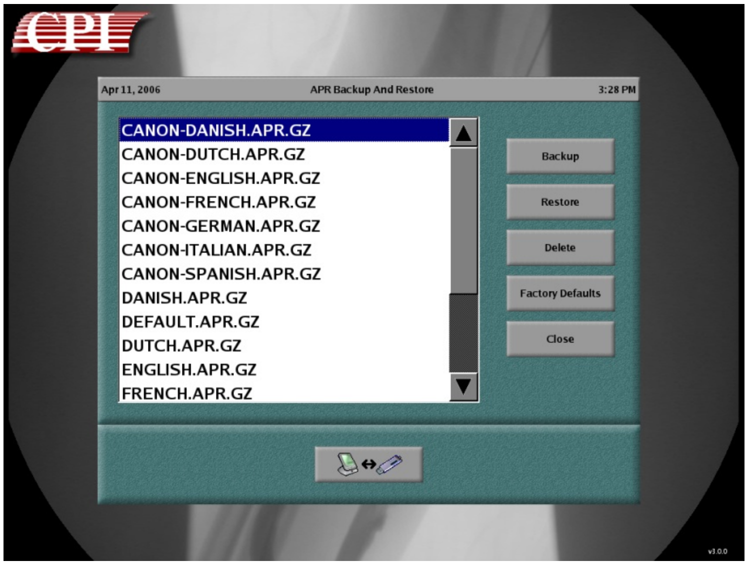


Figure 3-30: APR Back-up and Restore Window

To back-up current APR data:

1. Press **Backup**.
2. Keyboard(s) will display on the screen as described previously.
   - Type in the name of the new backup file.
   - Press **ENTER** when finished. The console will return to the APR backup / restore menu.
   - A pop-up window will display indicating that the backup was successful. Press **OK** to continue.

To restore backed-up APR data:

1. Select the APR data file to be restored. The selection will be highlighted.
2. Press **Restore**.
3. After a brief delay, a pop-up window will display indicating that restore was successful. Press **OK**.

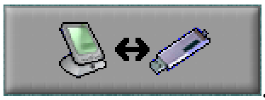
To delete an APR data file:

1. Select the APR data file to be deleted. The selection will be highlighted.
2. Press **Delete**. A pop-up window will display asking if you are sure you want to delete this file. Press **YES** to delete the file; **NO** cancels the deletion.

To restore the factory default APR data:

1. Press Factory Defaults.
2. After a brief delay, a pop-up window will display indicating that restore was successful. Press OK.

USB file transfer utility:

1. The USB file transfer utility allows APR files on the touchscreen to be saved to a USB flash drive, or saved APR files on a USB flash drive to be downloaded to the touchscreen.
2. In order to use this feature a USB flash drive is required. Connect the USB flash drive to **USBA** on the rear of the touchscreen console and press . After a brief auto-detection sequence where the touchscreen looks for the USB flash drive, the **USB File Transfer Utility** window (Figure 3-31) will open.

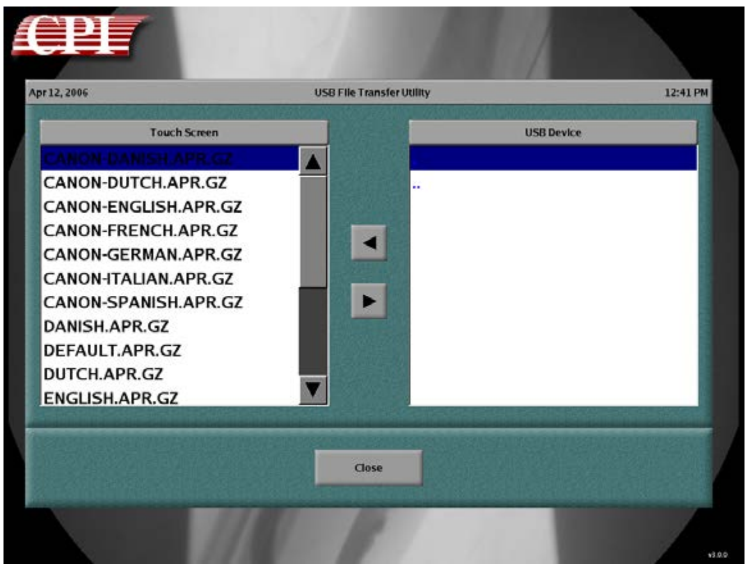


Figure 3-31: USB File Transfer Utility Window

3. To copy an APR file from the touchscreen to the USB flash drive select the desired file from the Touch Screen window and press . Once the file is copied successfully it will appear in the USB Device window of the USB File Transfer Utility.
4. To copy an APR file from a USB flash drive to the touchscreen select the desired file from the USB Device window and press . Once the file is copied successfully it will appear in the Touch Screen window of the USB File Transfer Utility.

5. When finished, press Close to exit.

Date / Time Setup

To perform the date and time setup:

1. From the system utilities menu, press **Date / Time Setup.** A pop-up window that allows setting of the date and time will display (Figure 3-32).
2. TO SET THE YEAR:

   Press the up or down arrows adjacent to ***Year*** to select the desired year. The selected year will display to the left of the up / down selection buttons.
3. TO SET THE MONTH:

   Press the up or down arrows adjacent to ***Month*** to select the desired month. The selected month will display to the left of the up / down selection buttons.
4. TO SET THE DATE:

   Press to select the desired date on the calendar that is displayed.
5. TO SET THE HOUR

   Press the up or down arrows to the right of ***Hour*** to select the desired hour. The selected hour will display to the left of the up / down selection buttons. This must be selected in 24-hour format, i.e. 2 PM would be entered as hour 14.
6. TO SET THE MINUTE

   Press the up or down arrows to the right of ***Minute*** to select the desired minute. The selected minute will display to the left of the up / down selection buttons. The current time will be displayed under ***Current Time.***
7. Press **Apply** to apply the current date and time settings without exiting the date and time menu. Pressing **OK** will apply the current settings and return to the system utilities menu. **Cancel** returns to the system utilities menu without applying changes to the time or date.

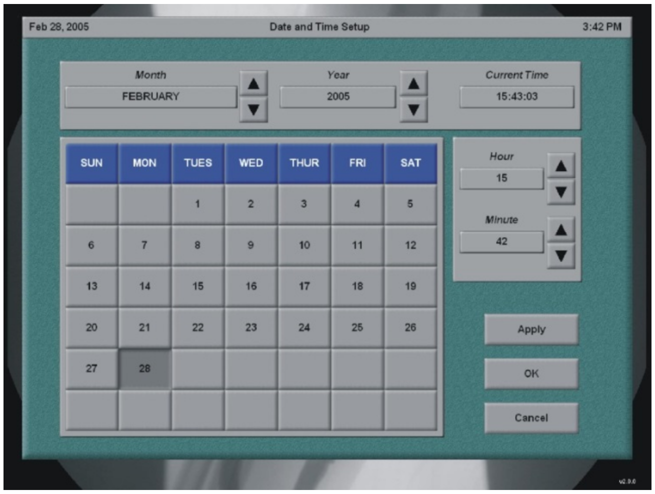


Figure 3-32: Date and Time Setup Window

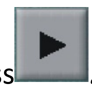
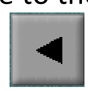
Receptor Symbols

The current image receptor symbols may be replaced with predefined symbols chosen from the receptor symbols library or downloaded from an external device.

Each image receptor button will always select a predefined image receptor (i.e. table Bucky, wall Bucky, DR, etc.). Before changing the image receptor symbols, it must be clearly understood which image receptors are selected by each image receptor button. Each image receptor button should then have a logical and intuitive symbol assigned to that position.

To change the receptor symbols:

1. From the system utilities menu, press **Receptor Symbols**.
2. A pop-up window (Figure 3-33) will open showing the image receptor buttons with the currently assigned symbols near the right side of the receptor symbols window, and the library of available receptor symbols near the left side of the window.
3. Select the image receptor button for which the symbol is to be changed. The receptor numbers in Figure 3-34 correspond to the receptor numbers in GenWare®, and are shown for reference only. For the CMP 200® series, only receptors 1 to 5 are available.
4. Select an appropriate symbol for the selected receptor from the symbols library. The selected symbol will be highlighted.
5. Press  to assign the selected symbol to the selected image receptor button.
6. Repeat steps 3 to 5 for each image receptor whose symbol is to be changed.

7. Press **OK** to continue or **CANCEL** to return to the system utilities menu without making any changes. If **OK** was pressed, a pop-up window will display asking if you wish to save the changes. Press **YES** to save the changes. Press **NO** to return to the system utilities menu; **CANCEL** cancels the changes.
8. To delete unused symbols from the receptor symbols library, select the symbol to be deleted. The selected symbol will be highlighted.
   - Press .
   - A pop-up window will display asking if you wish to delete the selected item. Press **YES** to delete the item; **NO** cancels the deletion.
   - DO NOT DELETE SYMBOLS YOU MAY WANT TO USE IN THE FUTURE.
9. To copy receptor symbol files to and from a USB flash drive press  to access the **USB File Transfer Utility**
10. To copy a receptor symbol file from the touchscreen to a USB flash drive select the desired file from the **Touch Screen** window and press . Once the file has been successfully copied it will appear in the **USB Device** window.
11. To copy receptor symbol files from a USB flash drive to the touchscreen select the desired file from the **USB Device** and press the . Once the file has been successfully copied it will appear in the **Touch Screen** window.
12. When finished press **Close** to exit.

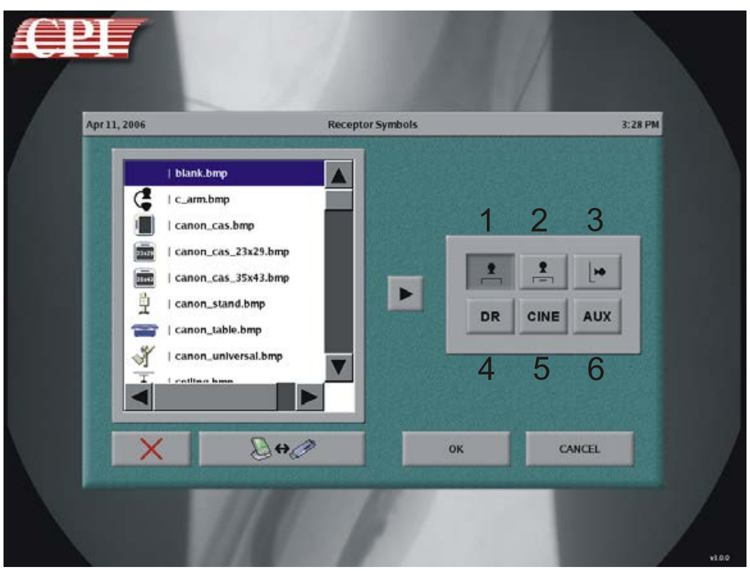


Figure 3-33: Receptor Symbols Window

Touchscreen Setup

The touchscreen setup menu accesses submenus that allow the service engineer to perform the following functions:

- Enable or disable certain console functions (audible generator ready indication).
- Enable or disable optional digital features.
- Set up serial communication ports COM 1 and COM 2 on the touchscreen console.
- Select the language for operator and error messages and graphics (i.e. on buttons, etc.).
- Select the generator type.
- Select the screen saver interval.
- Select the general and exposure volumes.
- Select the LCD brightness
- Change the operator and service password.
- Set the customer code.

To access the touchscreen setup menu:

1. From the system utilities menu, press Touch Screen Setup.
2. The touchscreen setup window will be displayed (Figure 3-34). This has three tabs, SETTINGS 1, SETTINGS 2, FEATURES and PASSWORDS that will be discussed in sequence.

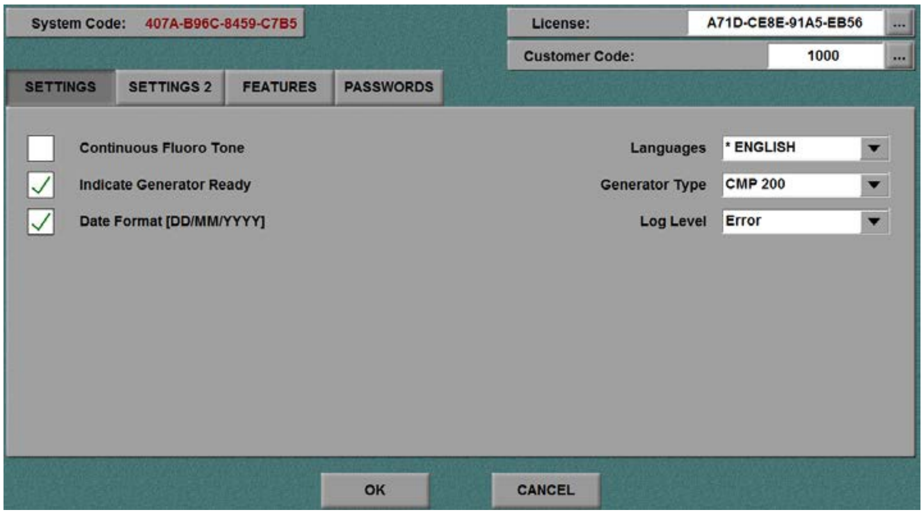


Figure 3-34: Touchscreen Setup Window, Settings Tab

- The **System Code** is a unique code assigned to each touchscreen on which the software is installed.
- The **License** is a code specifically assigned to each touchscreen. This enables options in the features tab. Please consult the factory to obtain a new license code if it is desired to enable new features, or to reinstall the existing license should the license code be accidentally overwritten.

- The **Customer Code** is a unique code assigned to each customer and selects the color scheme and graphic style (skin) to be displayed on the touchscreen console.

Settings

The functions near the left side of the settings window are enabled when checked (√).

Table 3-18: Functions of Touchscreen Setting Tab

Function	Description
Continuous Fluoro Tone	Not applicable
Indicate Generator Ready	Enables / disables the audible generator ready sounds (voice and / or tone). On (√): A tone will sound when the generator is ready to make an exposure (while pressing the PREP button, or briefly before making an exposure while the X-RAY button is pressed). Off: A tone will not sound when the generator is ready to make a exposure. A text message only will be presented.
Date Format [DD/MM/YYYY]	This setting is for the DAP printer only. Check: The date formatted DD/MM/YYY will be printed on the DAP label. Uncheck: The date formatted MM/DD/YYYY will be printed on the label.

To change the parameters on the Setting 1 tab:

1. Program the **Languages**. This selects the language for operator and error messages, and for text on the buttons, etc. Languages indicated with the prefix * will have all on-screen text fully translated into that language. Languages that are not indicated with the prefix * will have all on-screen text remain in English. However, the international keyboards will allow entry of the selected language.
2. Select the **Generator Type**. The touchscreen will not properly communicate with the generator unless this is set correctly.
3. Select the **Log Level**: **Error** or **Debug**
4. Press **OK** to continue or **CANCEL** to return to the system utilities menu without making any changes. If **OK** was pressed, a pop-up window will display asking if you wish to save the changes. Press **YES** to save the changes. Press **NO** to return to the system utilities menu; **CANCEL** cancels the changes.

Features

To select the digital functions:

1. From the touchscreen setup window, select **FEATURES**. Available digital interfaces will be shown on this screen. Refer to Figure 3-35.

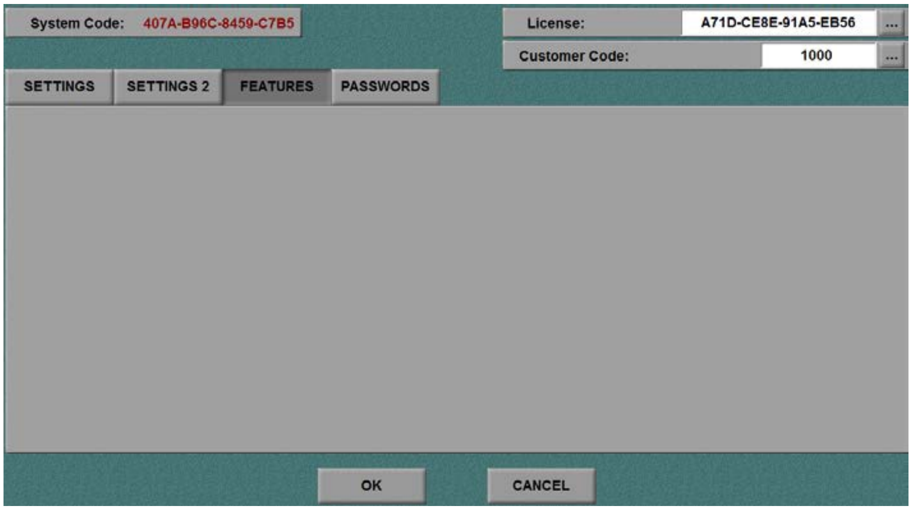


Figure 3-35: Touchscreen Setup Window, Features Tab

2. Check the applicable item to enable that function.
3. Press **OK** to continue or **CANCEL** to return to the system utilities menu without making any changes. If **OK** was pressed, a pop-up window will display asking if you wish to save the changes. Press **YES** to save the changes. Press **NO** to return to the system utilities menu; **CANCEL** cancels the changes.

Passwords

To change the current operator and service passwords:

1. From the touchscreen setup window, select **PASSWORDS**. Refer to Figure 3-36.
2. To change the operator password, press the **…** button to the right of the top operator password line. A password window will pop up. Enter the new password.
   - Press **Clear** to cancel an incorrect entry.
   - Press **Cancel** to close the password pop-up window.
   - Press **Accept** to accept the new password.
3. Repeat the previous step to enter the new password on the second operator password line.

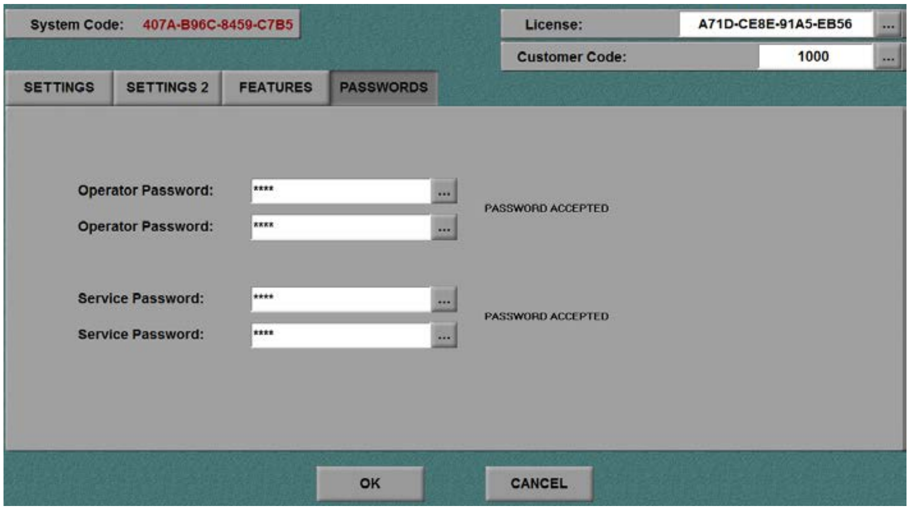


Figure 3-36: Touchscreen Setup Window, Passwords Tab

4. Press **OK** to continue; **CANCEL** cancels the changes.
5. A pop-up window will display asking if you wish to save the changes. Press **YES** to save the changes. Press **NO** to return to the system utilities menu; **CANCEL** cancels the changes.

   Note:

   Be sure to record the new service password before changing the factory-default password. If the new password is subsequently lost, consult the factory or re-install the touchscreen software in order to restore the factory-default service password.

6. To change the service password, press the **…** button to the right of the top service password line. A password window will pop up. Enter the new password.
   - Press **Clear** to cancel an incorrect entry.
   - Press **Cancel** to close the password pop-up window.
   - Press **Accept** to accept the new password.
7. Repeat the previous step to enter the new password on the second service password line.
8. Press **OK** to continue; **CANCEL** cancels the changes.
9. A pop-up window will display asking if you wish to save the changes. Press **YES** to save the changes. Press **NO** to return to the system utilities menu; **CANCEL** cancels the changes.

Tube Warm-Up Reminder Setup

A new tube warm up reminder feature has been added to the CPI Touch Screen software that can be configured to alert the operator to perform a Tube Warm up procedure when the selected X-ray tube has not been used for a programmable period.

The new tube warm-up reminder is factory defaulted to be disabled but can be activated and configured in the Touch Screen Setup menu.

To access the touchscreen setup menu:

1. From the system utilities menu, press Touch Screen Setup.
2. The touchscreen setup window will be displayed below. This has four tabs SETTINGS, SETTINGS 2, FEATURES and PASSWORDS that will be discussed in sequence.

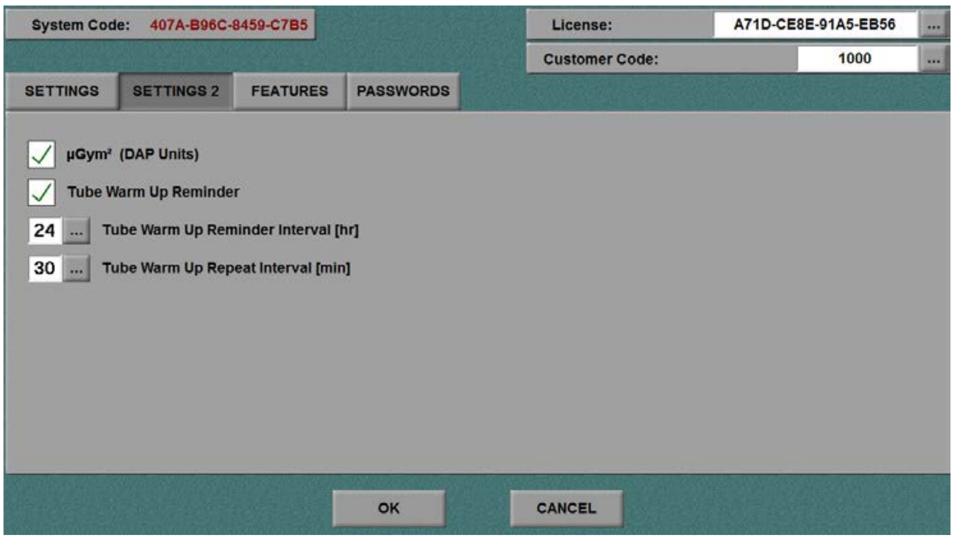


Figure 3-37: Touchscreen Setup Window, Setting 2 Tab

Settings 2

Table 3-19: Functions of Touchscreen Setting 2 Tab	
Function	**Description**
Tube Warm Up Reminder	Enables / disables the tube warm up reminder. On (√): The tube warm up reminder will be enabled. Off: The tube warm up reminder will be disabled.

Table 3-19: Functions of Touchscreen Setting 2 Tab

Function	Description
Tube Warm Up Reminder Interval [hr]	Selects the tube warm up reminder interval. This is the time since the last exposure, i.e. setting this to 12 hours means that a tube warm up reminder will be displayed 12 hours after the last radiographic exposure. For two-tube generators, the tube warm up reminder interval for each tube is tracked separately. The tube warm up reminder message applies to the tube currently in use. The tube warm up timer will be active when the generator is switched off. The tube warm up reminder message will be displayed when the generator is switched on if the tube warm up reminder limit is reached while the generator is switched off.
Tube warm Up Repeat Interval [min]	This sets the time, in minutes, since the last tube warm up reminder message was dismissed. This timer will be active when the generator is switched off. The tube warm up repeat reminder message will be displayed when the generator is switched on if the tube warm up repeat limit is reached while the generator is switched off.

To change the parameters on the settings 2 tab:

1. Enable or disable the tube warm up reminder via the **Tube Warm Up Reminder** checkbox.
2. Set the tube warm up reminder interval by pressing the **…** button to the left of **Tube Warm Up Reminder Interval [hr].** A numeric keypad will open. Enter the desired tube warm up reminder interval, in hours. The acceptable range is 1 to 24 hours.
   - Press **Clear** to cancel an incorrect entry.
   - Press **Cancel** to return to the settings 2 tab.
   - Press **Apply** to accept the changes.
3. Set the tube warm up repeat interval by pressing the **…** button to the left of **Tube warm Up Repeat Interval [min].** A numeric keypad will open. Enter the desired tube warm up repeat interval, in minutes. The acceptable range is 1 to 30 minutes.
   - Press **Clear** to cancel an incorrect entry.
   - Press **Cancel** to return to the settings 2 tab.
   - Press **Apply** to accept the changes.

Touchscreen Calibration

The touchscreen calibration function should be performed if touching the center of a buttons does not activate that function, i.e. if the touch-sensitive area appears displaced from the center of the corresponding icon.

To calibrate the touchscreen:

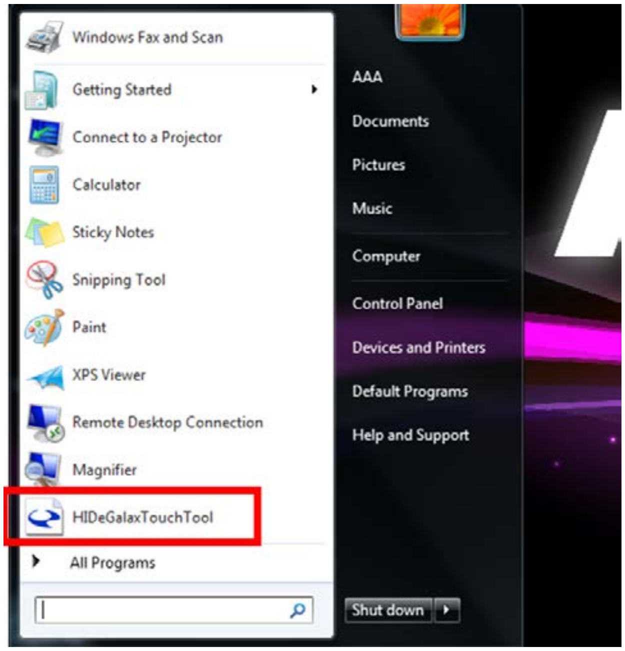


Figure 3-38: Location of HIDeGalaxTouchTool

1. From the Start menu, click the HIDeGalaxTouchTool icon.

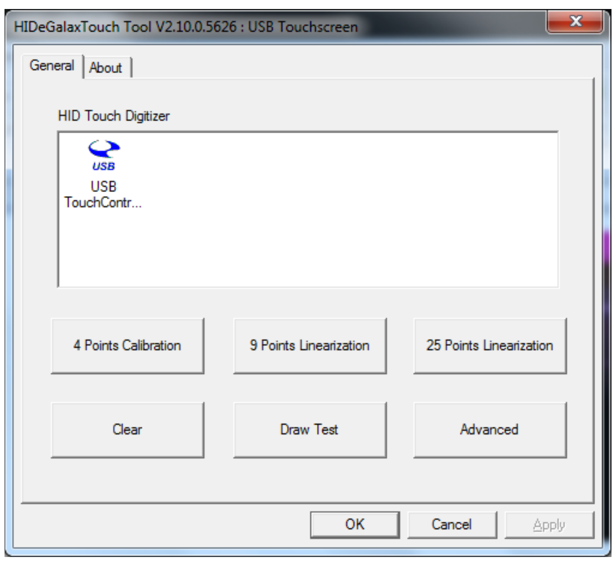


Figure 3-39: HIDeGalaxTouchTool Window

2. On the HIDeGalazTouchTool window, click the 25 Points Lineariztion button.

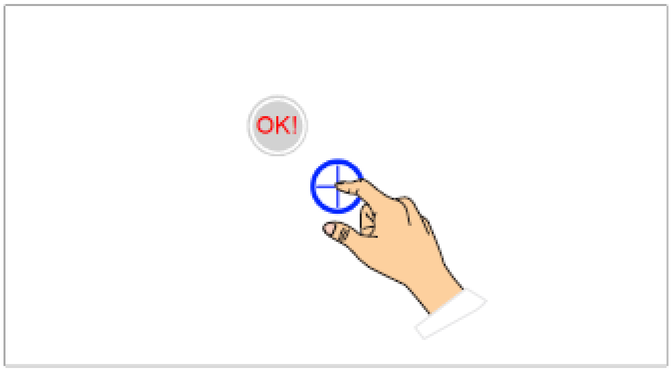


Figure 3-40: 25-Point Lineariztion Button

3. On the touch calibration screen, touch each of the cross hairs within the time specified.

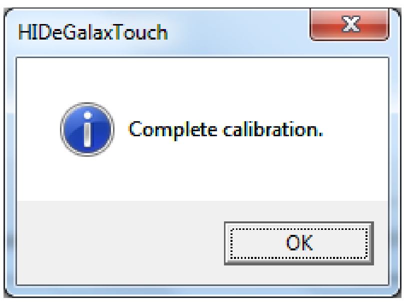
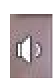


Figure 3-41: Complete Calibration Window

4. On the HIDeGalazTouch screen, click the OK button to confirm the completetion of the calibration.
5. Close all windows.

Adjusting Volume

1. Perform the *Opening the On-Screen Keyboard* instruction described in this document.
2. On the On-screen keyboard, double-tap the Windows key  .
3. On the Microsoft Window desktop, press the speaker icon  and move the slide button up or down to adjust the volume.

Configuration Backup / Restore

Use these steps to access the Configuration Backup and Restore function. This function backs up and restores the image receptor symbol assignment (Receptor Symbols) and the auto-positioner symbol assignment (Auto Position Symbols) if applicable.

1. From the system utilities menu, press **Configuration Backup / Restore.** A pop-up window (Figure 3-42) will display showing the available backup files that are stored on the touchscreen console's internal CompactFlash card.
2. Pressing **Close** will exit the backup and restore menu.
3. Refer to the applicable subsections (following) for the procedures to back-up the current receptor / auto-position symbols, to restore the current receptor / auto-position symbols, and to upload and download receptor / auto-position symbols to and from a USB flash drive.

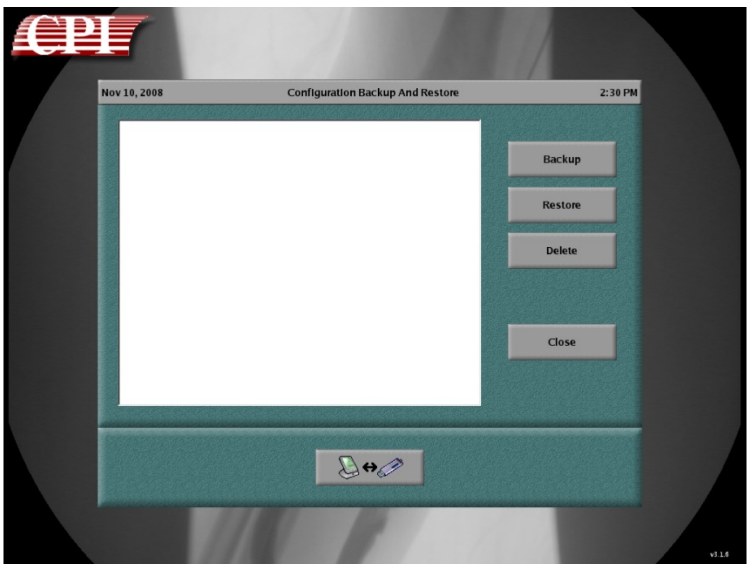


Figure 3-42: Configuration Back-up and Restore Window

To back-up current receptor / auto-position symbols:

1. Press **Backup**.
2. Type in the name of the new backup file.
3. Press **ENTER** when finished. The console will return to the configuration backup / restore menu, and the backed up file will be displayed in the **Configuration Backup And Restore** window.

To restore backed-up receptor / auto-position symbols:

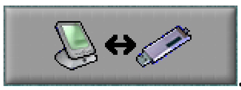
1. Select the desired backup file from the configuration backup and restore menu. The selection will be highlighted.
2. Press **Restore**.

3. A pop-up window will briefly display indicating the file-restoration status. The file restoration is finished when the pop-up window closes.

To delete a receptor / auto-position symbols file:

1. Select the backup file to be deleted. The selection will be highlighted.
2. Press **Delete**. A pop-up window will display asking if you are sure you want to delete this file. Press **YES** to delete the file; **NO** cancels the deletion.

USB file transfer utility

1. The USB file transfer utility allows the configuration files on the touchscreen to be saved to a USB flash drive, or saved configuration files on a USB flash drive to be downloaded to the touchscreen.
2. In order to use this feature a USB flash drive is required. Connect the USB flash drive to **USBA** on the rear of the touchscreen console and press . After a brief auto-detection sequence where the touchscreen looks for the USB flash drive, the **USB File Transfer Utility** window will open.

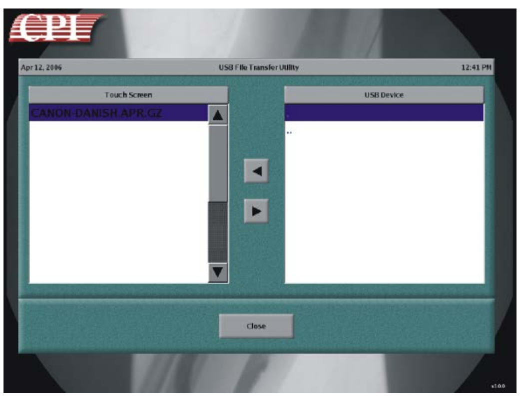


Figure 3-43: USB File Transfer Utility Window

3. To copy a configuration file from the touchscreen to the USB flash drive, select the desired file from the Touch Screen window and press . Once the file is copied successfully it will appear in the USB Device window of the USB File Transfer Utility.
4. To copy a configuration file from a USB flash drive to the touchscreen select the desired file from the USB Device window and press . Once the file is copied successfully it will appear in the Touch Screen window of the USB File Transfer Utility.
5. When finished, press Close to exit.

Touchscreen Console Firmware Upgrade / Restore

The USB key that comes with this manual can be used if the software becomes corrupted, or if the software boot sequence is not recoverable.

Note:

This instruction requires removing the connector cover from the touchscreen console to insert the USB key. The connector cover must be re-installed after removing the USB key. Refer to the removing and installing the connector cover instructions to remove and install the connector cover.

Backing up the APR Data:

1. The console firmware upgrade and recovery procedure will restore the APR parameters to their factory default values.
2. To save the customer APR data:
3. Perform the procedure **Backing up the APR Data** described earlier in this chapter.

Preparing for the Firmware Upgrade:

1. Turn the touchscreen off, based on the following procedures:

   If the the current touchscreen console state is on the Windows desktop,

   1) On the bottom left corner of the screen, press **Start**.
   2) Press **Shut down**.
   3) Press the power off button on the mini-console to turn off the generator.

   Or

   If the current touchscreen console state is on the CPI software Application,

   4) On the Main Menu, press System Shutdown
   5) Follow all on-screen procedures to turn off the generator.

2. Do <u>**not**</u> turn on the X-ray generator. Turn on the touchscreen console.
3. Make a note of the current software revision number displayed at the lower right hand corner of the CPI touchscreen console Software Application **Main Menu** for later comparison.
4. Perform the *Opening the On-Screen Keyboard* instruction described in this document.
5. Press the **ESC** key on the on-screen keyboard to exit from the CPI software Application **Main Menu** and to enter the window desktop.

Uninstalling the Old Firmware:

1. On the bottom left corner of the screen, press **Start** and then press **Control Panel**.
2. On the Control Panel window, double-tap on Programs and Features.
3. In the **Name** column, double-tap on **StarQ Console**.
4. On the pop-up window, press **Uninstall**.
5. Follow the steps of the wizard.
6. Close the **Control Panel** window.

Installing the New Firmware:

1. Insert the USB key containing the console firmware into one of the USB ports as shown in Figure 2-4.
2. On the **AutoPlay** window, press “Open folder to view files”.
3. Double-tap on the **Setup.exe** file.
4. Follow and complete the steps of the **StarQ Console** wizard.
5. Close all the windows.

After Console Firmware Installation:

1. Select the USB drive form the USB devices icon in the system tray.
2. Press **Eject** to safely remove the USB key.
3. Store the USB key in a safe place.
4. Press **Start** .
5. Press **Shut down** to turn off the touchscreen console.
6. Turn on the touchscreen console.
7. Verify the revision of the firmware. The revision should be higher than the old revision.

Restoring the APR Data:

- Perform the procedure **Restoring the APR Data** described in earlier this document.

Chapter 4 AEC Calibration

Contents

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Introduction

This chapter describes interfacing and setup / calibration of the various AEC board assemblies that are used in CMP200® and CMP200® DR X-ray generators.

This X-ray generator is factory configured to be compatible with specific AEC device(s). Refer to the Product Configuration / Compatibility Statement included in the document set for the factory configured AEC compatibility of this generator.

A set of AEC compatibility matrixes is included in the document set. Each AEC board has a corresponding AEC compatibility matrix, i.e. for AEC board 734614-XX, use AEC compatibility matrix SUP73461400.

The AEC compatibility matrixes list the AEC chambers / preamplifiers that each version of AEC board is compatible with, and they show the I/O pin connections and their functions, as well as related notes.

This chapter contains background information that is relevant to AEC operation. This is located at the back of this chapter, and should be understood before beginning AEC calibration.

Wiring the AEC Pickup Device to the Generator

1. Note the part number that is printed on the AEC board in the generator.
2. Connect the AEC device to the AEC board as per AEC boards specified in this section.

AEC Board (Solid State Chambers)

The AEC board shown below is compatible with various makes / models of solid-state chambers as per AEC compatibility matrix SUP73799200.

This board will be fitted with 6-pin circular connectors (J1 to J4) or with 7-pin in-line connectors (J11 to J14), depending on the application.

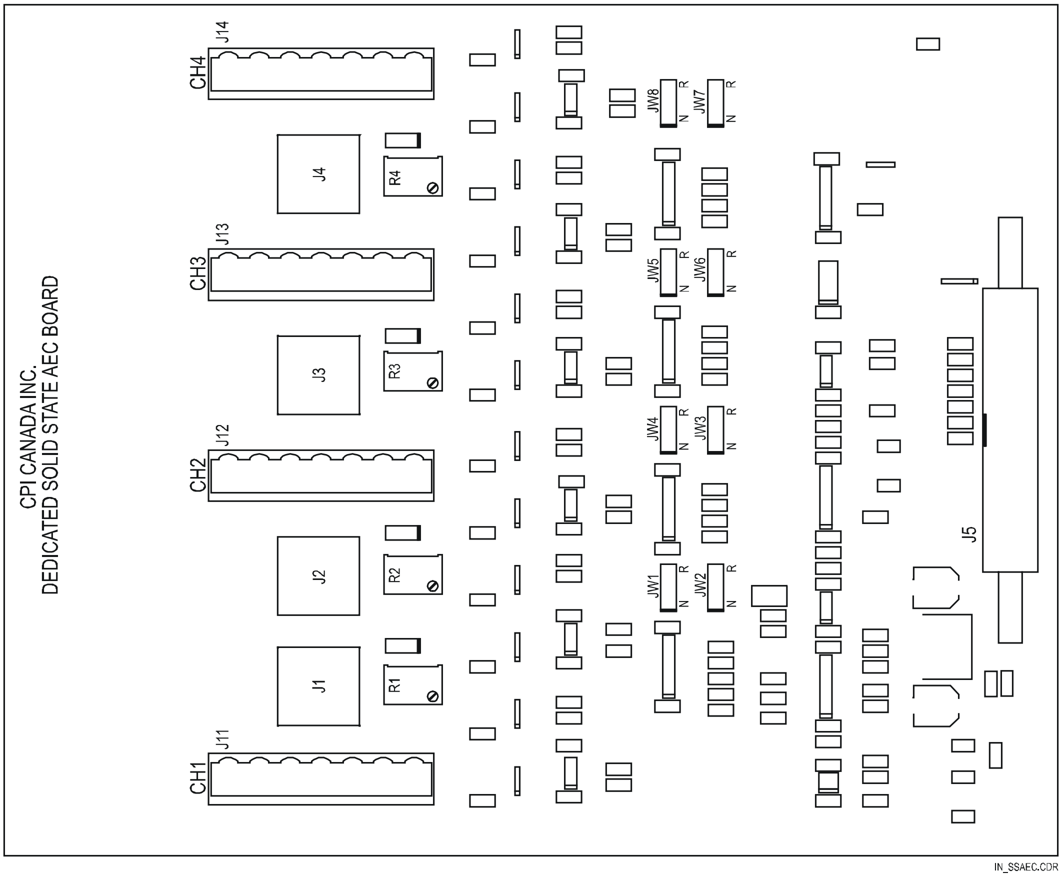

Figure 4-1: Dedicated solid-state AEC board (assembly 737992)

Note:

- *The chamber type must be set to ION for this board when performing the initial AEC setup (Chapter 3, Interfacing and Programming).*

AEC board input assignment (examples only, actual receptor assignments may vary):

- Ch 1 = J1 / J11 - Table Radiographic Bucky.
- Ch 2 = J2 / J12 - Vertical Wall Bucky.
- Ch 3 = J3 / J13 - Spot Film Device.
- Ch 4 = J4 / J14 - Aux. (Extra Bucky, Digital Acquisition, etc).

The following potentiometers are used for AEC gain adjustment:

- R1 is used for channel 1 gain adjustment.
- R2 is used for channel 2 gain adjustment.
- R3 is used for channel 3 gain adjustment.
- R4 is used for channel 4 gain adjustment.

Table 4-1A and Table 4-1B show the pin outs for both the 6-pin circular connectors and for the 7-pin in-line connectors on the AEC board in Figure 4-1.

Table 4-1A: Pin outs for 6-Pin Circular Connector J1 to J4

Function	Pin
Anode, right (refer to note below)	3
Cathode, right (refer to note below)	4
Anode, middle	1
Cathode, middle	6
Anode, left (refer to note below)	2
Cathode, left (refer to note below)	5
Ground	Connector shell

Table 4-1B: Pin outs for 7-pin in-line connector J11 to J14

Function	Pin
Anode, right (refer to note below)	1
Cathode, right (refer to note below)	2
Anode, middle	3
Cathode, middle	4
Anode, left (refer to note below)	5
Cathode, left (refer to note below)	6
Ground	7

Note: Jumpers JW1 to JW8 swap the left and right fields from J1 to J4 and J11 to J14 as per Table 4-2.

Table 4-2: Supplements for Tables 4-1A and 4-1B

Channel	Left / Right Fields as Per Tables 4-1A, 4-1B	Left / Right Fields Swapped Relative to Tables 4-1A, 4-1B
1	Jumper JW1, JW2 pins 1-2 (N)	Jumper JW1, JW2 pins 2-3 (R)
2	Jumper JW3, JW4 pins 1-2 (N)	Jumper JW3, JW4 pins 2-3 (R)
3	Jumper JW5, JW6 pins 1-2 (N)	Jumper JW5, JW6 pins 2-3 (R)
4	Jumper JW7, JW8 pins 1-2 (N)	Jumper JW7, JW8 pins 2-3 (R)

AEC Board (Ion Chambers)

The AEC board shown below is compatible with various makes / models of ion chambers as per AEC compatibility matrix SUP73461400.

This board will be fitted with 9-pin D connectors (J11 to J14), or with 12-pin in-line connectors (J1 to J4), depending on the application.

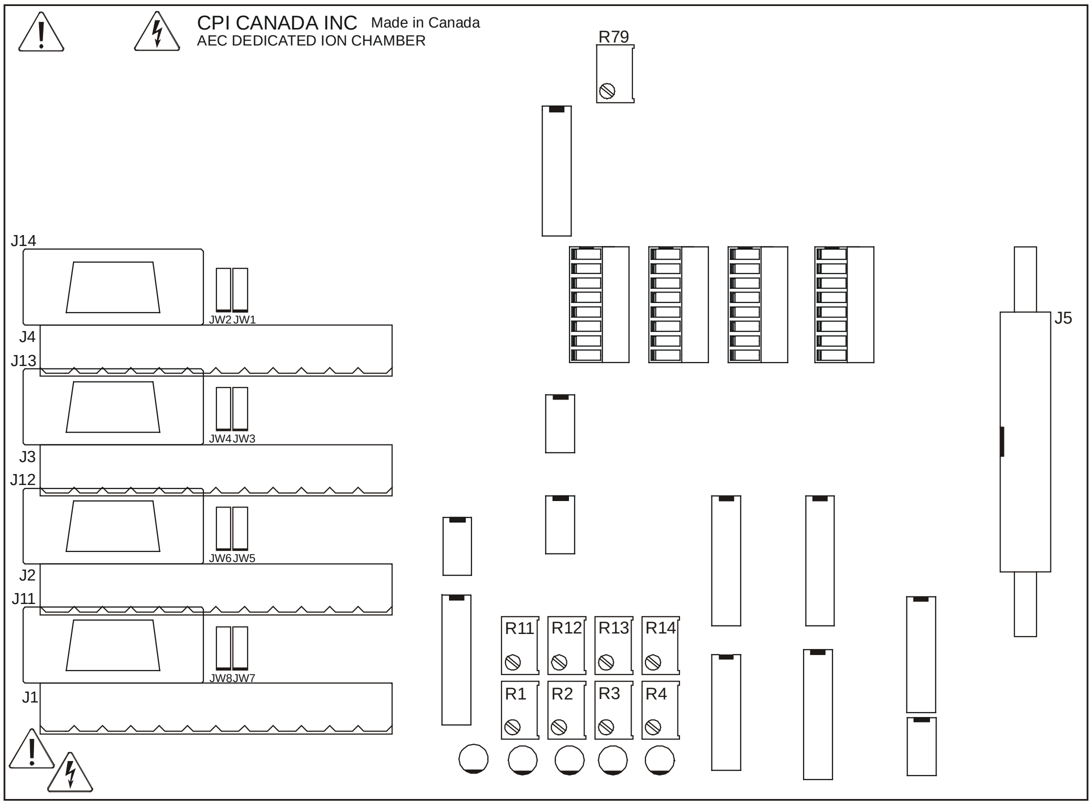

Figure 4-2: Dedicated ion chamber AEC board (assembly 734614)

AEC board input assignment (examples only, actual receptor assignments may vary):

- Ch 1 = J1 / J11 - Table Radiographic Bucky
- Ch 2 = J2 / J12 - Vertical Wall Bucky
- Ch 3 = J3 / J13 - Spot Film Device
- Ch 4 = J4 / J14 – Aux (Extra Bucky, Digital Acquisition, etc)

The following potentiometers are used for AEC gain adjustment:

- R1 is used for channel 1 gain adjustment.
- R2 is used for channel 2 gain adjustment.
- R3 is used for channel 3 gain adjustment.
- R4 is used for channel 4 gain adjustment.

The following potentiometers are used for short AEC exposure time compensation:

- R11 is used for channel 1 short exposure time compensation.
- R12 is used for channel 2 short exposure time compensation.
- R13 is used for channel 3 short exposure time compensation.
- R14 is used for channel 4 short exposure time compensation.

The resistor R79 adjusts the output of the high voltage bias supply. This is only fitted on versions of this board intended for use with ion chambers that require a separate high voltage bias supply. R79 adjusts the value of the +300 / +500 VDC, and the +45 VDC outputs, and should be set as per the ion chamber manufacturer specifications.

Table 4-3A and Table 4-4 show the pin outs for both the 9-pin D connectors and for the 12 pin in-line connectors on the AEC board in Figure 4-2. The 9-pin connectors are compatible with most models of AID ionization chambers. However, the installer should verify compatibility of the pin outs with the chamber(s) being used.

Table 4-3A: Pin outs for 9-pin D connector (J11 to J14)

FUNCTION	PIN
+300 VDC output Note: Only provided on configurations of this board requires the +300 VDC output.	1
Left field select (refer to note below)	2
Middle field select	3
Reset / start	4
Chamber output	5
Right field select (refer to note below)	6
-12 VDC output	7
+12 VDC output	8
Ground	9

Note: **Jumpers JW1 to JW8 swap the left and right fields on J11 to J14 as per Table 4-3B.**

Table 4-3B: Supplements for Table 4-3A		
Channel	**Left / Right Fields as Per Table 4-3A**	**Left / Right Fields Swapped Relative to Table 4-3A**
1	Jumper JW7, JW8 pins 1-2	Jumper JW7, JW8 pins 2-3
2	Jumper JW5, JW6 pins 1-2	Jumper JW5, JW6 pins 2-3
3	Jumper JW3, JW4 pins 1-2	Jumper JW3, JW4 pins 2-3
4	Jumper JW1, JW2 pins 1-2	Jumper JW1, JW2 pins 2-3

Table 4-4: Pin outs for 12-pin In-line Connector (J1 to J4)		
Function	**Pin**	**Note**
+500 VDC output	1	The +500, + or -300, and +45 VDC outputs are only provided on configurations of this board designed to interface to ion chambers requiring these voltage outputs. +12, -12, -24 VDC outputs are typically used as the DC supply for a pre-amplifier, often part of the ion chamber. -24 VDC is not available on CMP 200
+ or - 300 VDC output	2	
+45 VDC output	3	
+12 VDC output	4	
-12 VDC output	5	
-24 VDC output	6	
Ground	7	
Reset / start	8	
Right field select	9	
Middle field select	10	
Left field select	11	
Chamber output	12	

AEC Board (Ion Chambers)

The AEC board shown below is compatible with various models of ion chambers as per AEC compatibility matrix SUP73799800.

This board is fitted with 9-pin D connectors J1 to J4.

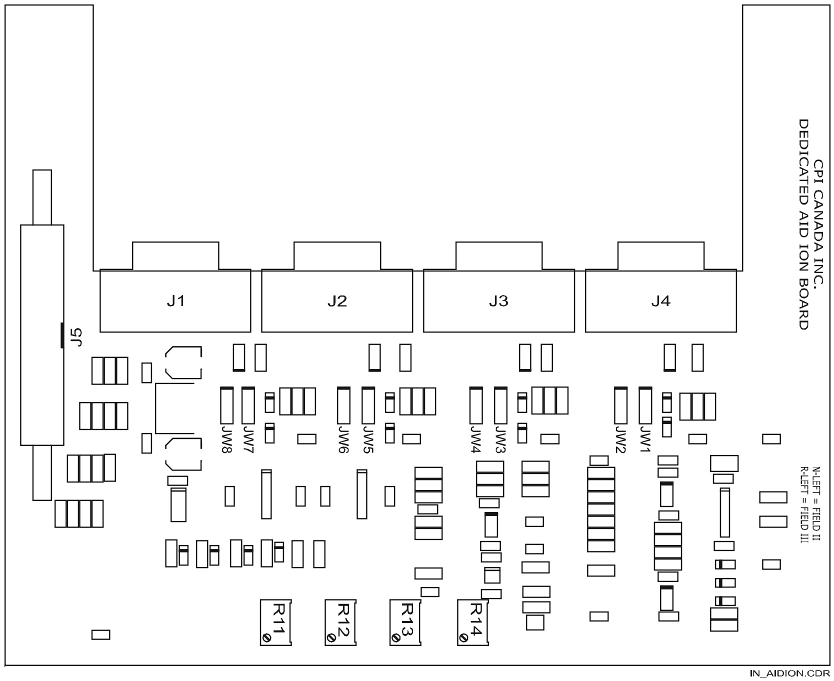

Figure 4-3: Dedicated ion chamber AEC board (assembly 737998)

AEC board input assignment (examples only, actual receptor assignments may vary):

- Ch 1 = J1 - Table Radiographic Bucky.
- Ch 2 = J2 - Vertical Wall Bucky.
- Ch 3 = J3 - Spot Film Device.
- Ch 4 = J4 - Aux. (Extra Bucky, Digital Acquisition, etc).

The following potentiometers are used for AEC gain adjustment:

- R11 is used for channel 1 gain adjustment.
- R12 is used for channel 2 gain adjustment.
- R13 is used for channel 3 gain adjustment.
- R14 is used for channel 4 gain adjustment.

Table 4-5A shows the pin outs for the 9-pin D connectors on the AEC board in Figure 4-3. The 9-pin connectors are compatible with most models of AID ionization chambers. However, the installer should verify compatibility of the pin outs with the chamber(s) being used.

Table 4-5A: Pin outs for 9-pin D Connector (J1 to J4)	
FUNCTION	**PIN**
Not used	1
Left field select (refer to note below)	2
Middle field select	3
Reset / start	4
Chamber output	5
Right field select (refer to note below)	6
-12 VDC output	7
+12 VDC output	8
Ground	9

Note: Jumpers JW1 to JW8 swap the left and right fields on J1 to J4 as per Table 4-5B.

Table 4-5B: Supplements for Table 4-5A		
CHANNEL	**Left / Right Fields as Per Table 4-5A**	**Left / Right Fields Swapped Relative to Table 4-5A**
1	Jumper JW7, JW8 pins 1-2 (N)	Jumper JW7, JW8 pins 2-3 (R)
2	Jumper JW5, JW6 pins 1-2 (N)	Jumper JW5, JW6 pins 2-3 (R)
3	Jumper JW3, JW4 pins 1-2 (N)	Jumper JW3, JW4 pins 2-3 (R)
4	Jumper JW1, JW2 pins 1-2 (N)	Jumper JW1, JW2 pins 2-3 (R)

AEC Board (5-Field Ion Chambers)

The AEC board shown below is designed for use with various three-of-five-field ion chambers as per AEC compatibility matrix SUP73938900.

This board is fitted with 15-pin D connectors J1 and J2.

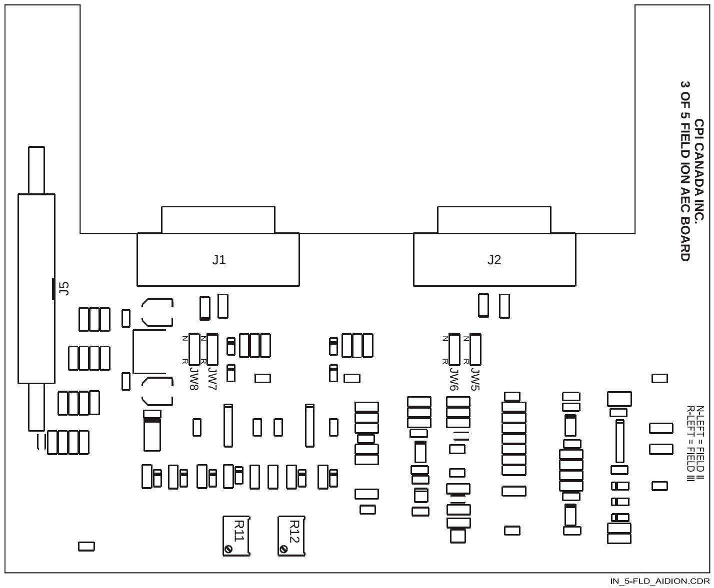

Figure 4-4: Three-of-five-field ion chamber AEC board (assembly 739389)

AEC board input assignment:

- Ch 1 = J1
- Ch 2 = J2

The following potentiometers are used for AEC gain adjustment:

- R11 is used for channel 1 gain adjustment.
- R12 is used for channel 2 gain adjustment.

Table 4-6A shows the pin outs for the 15-pin D connectors on the AEC board in Figure 4-4. The 15-pin connectors are compatible with some models of three-of-five-field AID ion chambers.

Table 4-6A: Pin outs for 15-Pin D Connector (J1 and J2)

FUNCTION	PIN
Not used	1
Left field select (refer to note below)	2
Middle field select	3
Reset / start	4
Chamber output	5
Right field select (refer to note below)	6
-12 VDC output	7
+12 VDC output	8

Table 4-6A: Pin outs for 15-Pin D Connector (J1 and J2)	
Ground	9
Not used	10
$\overline{\text{Portrait}}$	11
Not used	12
$\overline{\text{Inverted}}$	13
Not used	14
Not used	15

Note: Jumpers JW5 to JW8 swap the left and right fields on J1 and J2 as per Table 4-6A.

Table 4-6B: Supplements for Table 4-6A		
Channel	**Left / Right Fields as Per Table 4-6**	**Left / Right Fields Swapped Relative to Table 4-6**
1	Jumper JW7, JW8 pins 1-2 (N)	Jumper JW7, JW8 pins 2-3 (R)
2	Jumper JW5, JW6 pins 1-2 (N)	Jumper JW5, JW6 pins 2-3 (R)

Note: The filed compensation values (R FIELD COMP, C FIELD COMP, L FIELD COMP) in AEC setup menu 2 must all be set to 0. The AEC field balance must be done as per A.I.D's recommended procedure.

Pre-calibration Notes

Please note the following points before beginning AEC calibration.

Caution: The procedures in these sections require X-ray exposures. Take all safety precautions to protect personnel from X-radiation.

Should an improper technique be selected or an AEC fault occurs causing no AEC feedback signal to the generator. The exposure will terminated and an "AEC" device err / AEC feedback error message will be displayed if the ramp voltage fails to reach 4% of the expected ramp voltage when the exposure time reaches 20% of the selected backup time.

- When using a photo diode for AEC, there is normally no need to iterate all the kV breakpoints during AEC calibration. It will usually suffice to use the breakpoint at 75 kV calibration value at all kV breakpoints. If doing this, the calibration values should be confirmed at all kV breakpoints using the acquired digital images.
- For DR applications, the AEC calibration procedure uses the same potentiometers and menus as described for film in the following sections. However, the imaging system manufacturers literature should be consulted to determine the required dose / image brightness.
- The generator must be known to be calibrated before beginning AEC calibration.
- All components (X-ray tubes, collimators, AEC chambers, etc) used during AEC calibration must be those that will be used during procedures, and must be positioned as they will be in actual use of the X-ray room.
- During AEC calibration, always ensure that the central ray is centered relative to the image receptor.
- Before placing the absorbers, ensure that the collimator is opened sufficiently to irradiate ALL fields on the AEC pickup device.
- Ensure that the absorber is positioned to fully cover the X-ray field. The absorber must extend a minimum of 3/8 in. (10 mm) beyond the X-ray field.
- During AEC calibration, all AEC exposures should be done using mA values such that the exposures are in the 30 to 100 ms range UNLESS STATED OTHERWISE.
- The recommended absorber is water. This should be in a plastic container of uniform thickness. Lexan of a similar thickness is also a suitable absorber.
- Care must be exercised when using table Buckys with low kV values because most tabletops and grids absorb considerable radiation in the 60 – 65 kV range. This will adversely affect AEC operation.
- During AEC calibration, if exposure times do not change if the mA is varied, it may be that the input signal level to the AEC board is too high. If this is experienced, check the ramp voltage at the output of the first gain stage (the first operational amplifier output) on the AEC board for the subject AEC channel. This voltage must never exceed 10 V. If this voltage does exceed 10 V, reduce the input signal level as required.

Required Test Equipment

The following test equipment is required for AEC calibration.

- Lexan or equivalent (or water) absorbers in various thicknesses. Water should be in a plastic container of uniform thickness.
- Radiation dosimeter for digital applications.
- A supply of film in each film speed that will be calibrated.
- A cassette with intensifying screen in each speed that will be calibrated.

AEC Calibration (Table Bucky)

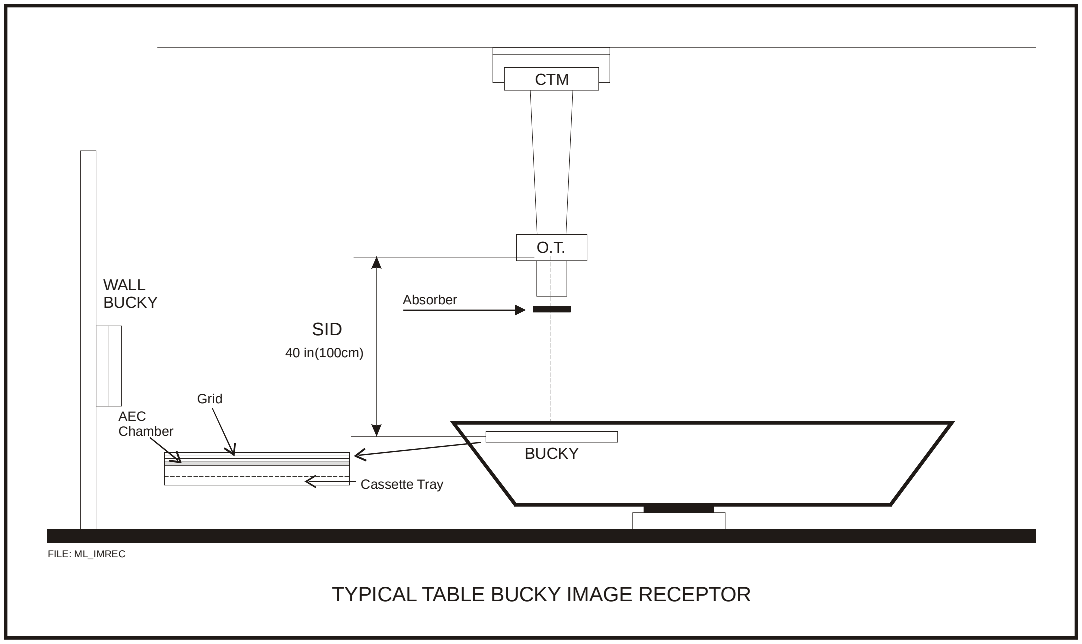

Figure 4-5: Equipment setup for table Bucky AEC calibration

The **AEC CALIBRATION** menus that relate to kV breakpoint calibration for the membrane console are shown below.

* AEC CALIBRATION *	
FILM SCREEN 1	DENSITY SETUP
FILM SCREEN 2	
FILM SCREEN 3	
EXIT	

* AEC CAL, F/S1 *			
50KV:	84.0	85KV:	42.8
55KV:	78.0	95KV:	38.0
65KV:	66.0		+
75KV:	54.0		-
<<			>>

* AEC CAL, F/S1 *		
110KV:	34.0	
130KV:	28.0	
		+
		-
<<		

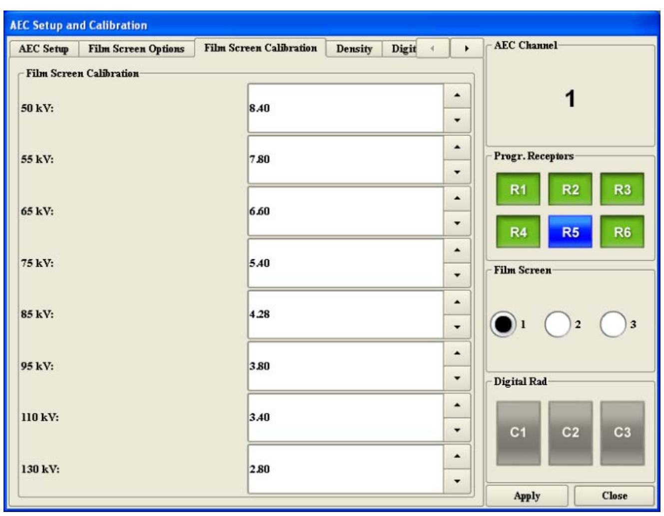

Figure 4-6: AEC Setup & Calibration window, Film Screen Calibration tab

To calibrate the table Bucky AEC:

Note:

If the AEC board being calibrated has short AEC time compensation potentiometers, the short exposure time compensation must first be disabled. To do this, adjust all short AEC exposure-time compensation pots to zero by turning each of these potentiometers clockwise fully. These are multi-turn potentiometers, and must be turned by as much as 25 turns to reach the zero-ohms limit.

Failure to pre-set these pots will result in difficulty in performing AEC calibration.

1. Set up the X-ray tube stand as shown in Figure 4-5.
2. Align the tube stand and table Bucky such that the central ray is centered relative to the image receptor.
3. Open up the collimator to expose all three fields of the AEC pickup. Ensure that the central ray remains centered relative to the image receptor.
4. Place the absorber (with thickness selected for 75 kV per Table 4-8) in the X-ray field, ensuring that the radiation is COMPLETELY blocked by the absorber.

Action (membrane console)	Action (GenWare®)
1. Ensure that in the **RECEPTOR SETUP** menu, each receptor has the desired AEC channel assigned to it. Refer to ***RECEPTOR SETUP*** in Chapter 3, *Interfacing and Programming*.	1. Ensure that in the **Receptor Setup** window, each receptor has the desired AEC channel assigned to it. Refer to ***RECEPTOR SETUP*** in Chapter 3, *Interfacing and Programming*.
2. In the **RECEPTOR SETUP** menu, set **MEMORY** to **NO** for each image receptor. This will ensure that the next receptor being calibrated will not remember the techniques from the previous receptor. The MEMORY function may be reset as desired after AEC calibration is completed.	2. In the **Receptor Setup** window, under the **Receptor Properties** tab, set **Memory** to **off** for each image receptor. This will ensure that the next receptor being calibrated will not remember the techniques from the previous receptor. The Memory function may be reset as desired after AEC calibration is completed.
3. In the **RECEPTOR SETUP** menu, ensure that the **AEC BACKUP MAS** and **AEC BACKUP MS** are set sufficiently high that the generator backup timer will not terminate the exposure.	3. In the **Receptor Setup** window, under the **AEC** tab, ensure that the **AEC Back-Up mAs** and **AEC Back-Up ms** are set sufficiently high that the generator backup timer will not terminate the exposure

Note: The purpose of the AEC backup timer is to prevent excessive patient radiation in the event, there is a failure of the AEC system, operator error, or patient positioning error. When selecting the AEC backup time mAs and/or ms values, ensure that the settings meet the following requirements:

- The AEC exposure will not be terminated prematurely, thus creating an underexposed image.
- The backup timer settings will limit the patient over exposure to the dose values specified in any applicable regulations and will not result in a reportable over exposure.

Action (membrane console)	Action (GenWare®)
4. From the GEN CONFIGURATION menu, select AEC CALIBRATION.	4. Select the AEC Setup and Calibration window.
5. From the **AEC CALIBRATION** menu, select **FILM SCREEN 1** (the slowest film screen combination).	5. On the main **AEC Calibration** window, select **Film Screen 1** (the slowest film screen combination).

Caution: During the following calibration procedure, be sure that the selected techniques will not overload the X-ray tube. Use caution when repeating exposures as this may quickly overload the X-ray tube. Most X-ray tube manufacturers recommend no more than two high-speed starts per minute.

Note: Be sure to use the same cassette for each exposure at that film speed.

Table 4-7: Film Speed vs. mAs @ 75 kV

Film Speed	mAs @ 75 kV
100	16
200	8
400	4
800	2

The mAs values noted in the above table represent the approximate desired mAs at an SID of 40 in. (100 cm), using a grid with a 12:1 ratio. All measurements were done with HVL = 3 mm Al @ 75 kV.

1. Select the table Bucky image receptor.

Action (membrane console)	Action (GenWare®)
2. N/A	Select the Film Screen Calibration tab.
3. Select the breakpoint at **75 KV**. Use the + or – buttons to enter the value **45**.	Enter the value 4.5 into the 75 kV dialog box, under Film Screen Calibration.

4. Select the appropriate mA for the first film speed being calibrated per Table 4-8, *remembering that the slowest film screen used in that installation must be calibrated first* (example 320 mA for 100-speed film). Select large focus, center field.
5. Make an exposure and note the mAs.
6. Referring to Table 4-7, select the target mAs required for the film speed being calibrated i.e. approximately 16 mAs at 75 kV for 100-speed film.
7. Adjust the required gain potentiometer on the AEC board while taking exposures until the mAs noted in the previous step is obtained.
8. Load a test cassette with fresh film and install it in the image receptor. Using the same technique as in the previous step, expose the film and develop it.
9. Measure the optical density. The desired value should have been previously recorded in a copy of Table 4-11.
10. If the measured O.D. is not within the desired value, adjust the gain pot to increase or decrease the density, and then repeat the previous two steps.
11. Once the desired film density is achieved, record the mAs, calibration number, and O.D. in a copy of Table 4-9.
12. Vary the absorber thickness, and confirm that the mAs changes accordingly.

    Steps 13 to 16 apply to solid-state AEC chambers only

13. Measure the mAs with the center AEC field only selected. Record this value.
14. Select the left field, and measure the mAs. Compare this value to the value noted for the center field.
15. If the field balance is not acceptable, adjust the left field compensation value up or down as described in the section ***AEC Setup*** in Chapter 3, *Interfacing and Programming* such that the left field matches the center field.

    Do not adjust the center field (C) compensation value.

16. Repeat steps 14 and 15 for the right field.

    Each breakpoint in the remainder of this section starts with the approximate mAs as per Table 4-8. After that mAs is achieved, a film must be exposed and the O.D. verified. If the O.D. is not the desired values, further iterations may be required to achieve the desired optical desity.

    Do not readjust the AEC board gain pot after the breakpoint at 75 kV is calibrated. Further desity adjustments will only be made by adjusting the calibration values for the other kV breakpoints.

17. Change the absorber thickness as specified for the breakpoint at 55 kV in Table 4-8. As before, ensure that the absorber fully blocks the X-ray field.

Action (membrane console)	Action (GenWare®)
18. In the following steps, you will need to scroll back and forth between **AEC CAL** menu 1 and **AEC CAL** menu 2 using the **>>** and **<<** buttons in order to access the required breakpoints.	N/A
19. Select the breakpoint at **55 KV**.	Select the 55 kV up or down buttons under **Film Screen Calibration**. This will set the generator kV demand to 55 kV.
20. Make an exposure and note the mAs. Use mA values as specified for the breakpoint at **55 KV** in Table 4-8.	Make an exposure and note the mAs. Use mA values as specified for the breakpoint at **55 KV** in Table 4-8.
21. Adjust the 55 kV calibration number using the **+** or **-** buttons such that the actual mAs is equal to the target mAs at 55 kV as per Table 4-8.	Adjust the 55 kV calibration number such that the actual mAs is equal to the target mAs at 55 kV as per Table 4-8.

Do not readjust the AEC board gain pot.

22. Load the test cassette with fresh film and install it in the image receptor. Using the same technique, expose the film and develop it.
23. Measure the optical density. The optical density should be as per step 18.
24. If the measured O.D. is not the desired value, readjust the 55 kV calibration number, then repeat the previous two steps.

Do not readjust the AEC board gain pot.

25. Once the desired film density is achieved, record the required values in a copy of Table 4-9.

Table 4-8: Target breakpoint calibration factors
100 speed film screen

Break point	Absorber	mAs	Generator mA	Generator BUT mAs
75 kV knee pt.	20 cm H_2O	16 mAs	320 mA	320 mAs (MAX)
55 kV	15 cm H_2O	25 mAs	320 mA	320 mAs (MAX)
50 kV	15 cm H_2O	40 mAs	320 mA	320 mAs (MAX)
65 kV	15 cm H_2O	10 mAs	320 mA	320 mAs (MAX)
110 kV	25 cm H_2O	6.3 mAs	200 mA	320 mAs (MAX)
130 kV	25 cm H_2O	5 mAs	200 mA	320 mAs (MAX)
85 kV	20 cm H_2O	10 mAs	320 mA	320 mAs (MAX)

95 kV	20 cm H_2O	5 mAs	320 mA	320 mAs (MAX)

200 speed film screen				
Break point	**Absorber**	**mAs**	**Generator mA**	**Generator BUT mAs**
75 kVp knee pt.	20 cm H_2O	8 mAs	250 mA	250 mAs (MAX)
55 kVp	15 cm H_2O	12.5 mAs	250 mA	250 mAs (MAX)
50 kVp	15 cm H_2O	20 mAs	250 mA	250 mAs (MAX)
65 kVp	15 cm H_2O	5 mAs	250 mA	250 mAs (MAX)
110 kVp	25 cm H_2O	3.2 mAs	250 mA	250 mAs (MAX)
130 kVp	25 cm H_2O	2.5 mAs	250 mA	250 mAs (MAX)
85 kVp	20 cm H_2O	5 mAs	250 mA	250 mAs (MAX)
95 kVp	20 cm H_2O	2.5 mAs	250 mA	250 mAs (MAX)

400 speed film screen				
Break Point	**Absorber**	**mAs**	**Generator mA**	**Generator BUT mAs**
75 kVp knee pt.	20 cm H_2O	4 mAs	200 mA	200 mAs (MAX)
55 kVp	15 cm H_2O	6.3 mAs	200 mA	200 mAs (MAX)
50 kVp	15 cm H_2O	10 mAs	200 mA	200 mAs (MAX)
65 kVp	15 cm H_2O	2.5 mAs	200 mA	200 mAs (MAX)
110 kVp	25 cm H_2O	1.6 mAs	200 mA	200 mAs (MAX)
130 kVp	25 cm H_2O	1.25 mAs	200 mA	200 mAs (MAX)
85 kVp	20 cm H_2O	2.5 mAs	200 mA	200 mAs (MAX)
95 kVp	20 cm H_2O	1.25 mAs	200 mA	200 mAs (MAX)

800 speed film screen				
Break Point	**Absorber**	**mAs**	**Generator mA**	**Generator BUT mAs**
75 kVp knee pt.	20 cm H_2O	2 mAs	100 mA	120 mAs (MAX)
55 kVp	15 cm H_2O	3.2 mAs	100 mA	120 mAs (MAX)
50 kVp	15 cm H_2O	5 mAs	100 mA	120 mAs (MAX)
65 kVp	15 cm H_2O	1.25 mAs	100 mA	120 mAs (MAX)
110 kVp	25 cm H_2O	0.8 mAs	100 mA	120 mAs (MAX)
130 kVp	25 cm H_2O	0.63 mAs	100 mA	120 mAs (MAX)
85 kVp	20 cm H_2O	1.25 mAs	100 mA	120 mAs (MAX)
95 kVp	20 cm H_2O	0.63 mAs	100 mA	120 mAs (MAX)

Note: For SID's other than 40 in. (100 cm) multiply the mAs by the factor [new SID / 40 in. (100 cm)]^2.

Record the final measurements in a copy of Table 4-9. The final measurements are those obtained AFTER films have been developed to verify the correct O.D. at each breakpoint.

Table 4-9: Breakpoint calibration worksheet			
FILM SCREEN 1	**SPEED =**		
#1 BK. POINT = 75 kV	mAs =	CAL. NO. =	O.D. =
#2 BK. POINT = 55 kV	mAs =	CAL. NO. =	O.D. =
#3 BK. POINT = 50 kV	mAs =	CAL. NO. =	O.D. =
#4 BK. POINT = 65 kV	mAs =	CAL. NO. =	O.D. =
#5 BK. POINT = 110 kV	mAs =	CAL. NO. =	O.D. =
#6 BK. POINT = 130 kV	mAs =	CAL. NO. =	O.D. =
#7 BK. POINT = 85 kV	mAs =	CAL. NO. =	O.D. =
#8 BK. POINT = 95 kV	mAs =	CAL. NO. =	O.D. =
FILM SCREEN 1	**SPEED =**		
#1 BK. POINT = 75 kV	mAs =	CAL. NO. =	O.D. =
#2 BK. POINT = 55 kV	mAs =	CAL. NO. =	O.D. =
#3 BK. POINT = 50 kV	mAs =	CAL. NO. =	O.D. =
#4 BK. POINT = 65 kV	mAs =	CAL. NO. =	O.D. =
#5 BK. POINT = 110 kV	mAs =	CAL. NO. =	O.D. =
#6 BK. POINT = 130 kV	mAs =	CAL. NO. =	O.D. =
#7 BK. POINT = 85 kV	mAs =	CAL. NO. =	O.D. =
#8 BK. POINT = 95 kV	mAs =	CAL. NO. =	O.D. =
FILM SCREEN 1	**SPEED =**		
#1 BK. POINT = 75 kV	mAs =	CAL. NO. =	O.D. =
#2 BK. POINT = 55 kV	mAs =	CAL. NO. =	O.D. =
#3 BK. POINT = 50 kV	mAs =	CAL. NO. =	O.D. =
#4 BK. POINT = 65 kV	mAs =	CAL. NO. =	O.D. =
#5 BK. POINT = 110 kV	mAs =	CAL. NO. =	O.D. =
#6 BK. POINT = 130 kV	mAs =	CAL. NO. =	O.D. =
#7 BK. POINT = 85 kV	mAs =	CAL. NO. =	O.D. =
#8 BK. POINT = 95 kV	mAs =	CAL. NO. =	O.D. =

26. Repeat steps 26 to 34 for the remaining breakpoints at: 50 kV, 65 kV, 110 kV, 130 kV, 85 kV, and 95 kV. Do the breakpoint calibration in the stated order.

    The 50 kV and 130 kV breakpoints only need to be calibrated if these kV ranges are used with AEC. Refer to the comments below.

    50 kV: At approximately 50 kV and under, the film screen sensitivity becomes too low for practical AEC operation when used with a Bucky. Unless special techniques are used which require the 50 kV range, simply enter the 55 kV calibration number into the breakpoint at 50 kV.

    130 kV: Unless special high kV techniques are used which require the 130 kV range, simply enter the 110 kV calibration number into the breakpoint at 130 kV.

27. Repeat steps 9 to 35 for **FILM SCREEN 2**, except:
    a. Film screen 2 must be the next highest film speed after film screen 1.
    b. When calibrating the breakpoint at 75 kV for film screen 2, DO NOT adjust the AEC board gain pot. Dose adjustments for film screen 2 at 75 kV must only be made by varying the breakpoint at 75 kV calibration numbers.
28. Repeat steps 9 to 35 for **FILM SCREEN 3**, except:
    a. Film screen 3 must be the highest film speed.
    b. When calibrating the breakpoint at 75 kV for film screen 3, DO NOT adjust the AEC board gain pot. Dose adjustments for film screen 3 at 75 kV must only be made by varying the breakpoint at 75 kV calibration numbers.

Action (membrane console)	Action (GenWare®)
29. Select **<<** to return to the **AEC CALIBRATION** menu.	N/A

Short AEC Time Compensation

Use these steps to perform the short AEC exposure time compensation.

These steps only apply if AEC exposures less than approximately 15 ms are required and the AEC board has short AEC time adjustment potentiometers.

1. Select the image receptor to be short AEC-time compensated, i.e. table Bucky.
2. Select the highest film speed used on the selected receptor, and then select **75** kV.
3. Set the mA per Table 4-8 for the film speed being used. Reinstall the absorber as per Table 4-8 for the breakpoint at 75 kV.
4. Make an exposure and confirm the mAs readings as previously recorded in Table 4-9.
5. Increase the mA such as to decrease the AEC exposure time to approximately 10 ms.

6. Adjust the short AEC time compensation pot for the AEC channel being calibrated such that the mAs is approximately the same as previously recorded (step 4).
7. Increase the mA again such as to decrease the AEC exposure time to approximately 6 ms (but not less).
8. Adjust the short AEC time compensation pot for the AEC channel being calibrated such that the mAs is approximately the same as it was in step 6.
9. The short AEC-time compensation adjustments affect the AEC calibration at longer exposure times. Therefore, it may now be necessary to readjust the gain pot (at 75 kV) for the AEC channel being calibrated to restore the mAs values to the values previously recorded in Table 4-9. Ensure that the absorber thickness and mA values are as per Table 4-8 when readjusting the AEC gain pot.
10. Using 75 kV exposures, films should be exposed and developed, and the O.D. checked at AEC exposure times of approximately 6 ms and approximately 100 ms. If the film density is not acceptable at both short and long AEC exposure times, it will be necessary to iterate the adjustments of both the short AEC time compensation pot and the AEC gain pot by repeating steps 3 to 8.
11. Repeat steps 1 to 10 for each image receptor (AEC channel) to be short AEC time compensated.

AEC Density Calibration

The **DENS SETUP** menus for the membrane console are shown below.

```
                    * DENS. SETUP *
-8:   ---
-7:   ---
-6:   ---                                        +
-5:   62%                                        -



EXIT                                            >>
```

```
* DENS. SETUP *
-4:   50%
-3:   37%
-2:   25%                                  +
-1:   12%                                  -



<<                                        >>
```

```
* DENS. SETUP *
+1:   12%
+2:   25%
+3:   37%                                  +
+4:   50%                                  -



<<                                        >>
```

```
* DENS. SETUP *
+5:   62%
+6:   ---
+7:   ---                                  +
+8:   ---                                  -



<<                                        >>
```

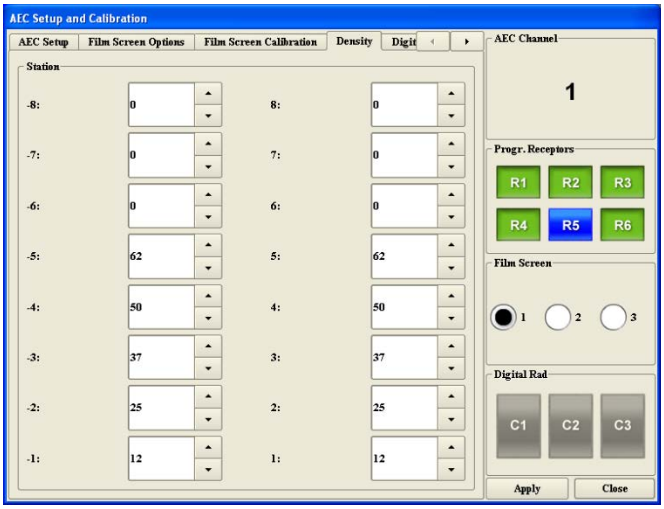

Figure 4-7: AEC Setup & Calibration window, Density tab

Please note the following points regarding density calibration:

- Up to eight density plus and eight density minus steps are available. If ± 8 density steps are not required, the unwanted density steps may be deprogrammed per the procedure below. For example, if only ± 5 density steps are desired, then density steps ± 6, 7, and 8 may be deprogrammed.
- Once the desired number of ± density steps are known, the relative minimum and maximum mAs values must be determined. Typically, the minimum density step will result in half (50%) of the nominal mAs (dose) and the maximum density step will typically give double (100% increase) the nominal mAs (dose). The nominal mAs is the value that was recorded at 0 density in Table 4-9.
- The relative mAs change per density step must be determined next. To do this, note the relative minimum and maximum mAs as determined above (i.e. 50% at min density and 100% increase at max density), then calculate the number of - density steps and the number of + density steps that will be required.

  The relative mAs change between density steps will then be the minimum density (i.e. 50) divided by the number of density minus steps or the maximum density (i.e. 100) divided by the number of density plus steps. This will yield the required mAs increment for each density minus step and for each density plus step respectively.

  For ± 8 density steps, this gives a mAs decrease of 6.25% per density minus step (8 steps x 6.25% per step = 50% mAs at -8 density) or a mAs increase of 12.5% per density plus step (8 steps x 12.5% per step = 100% mAs increase at +8 density).

Refer to Table 4-10 for two typical examples of density steps vs. calibration numbers. For 8 minus density steps the mAs decrease is 6.25% per step, and for 8 + density steps the mAs increase is 12.5% per step as per the example calculation above.

For 5 minus density steps the mAs decrease is 10% per step, and for 5 + density steps the mAs increase is 20% per step.

Table 4-10: Example density values			
Density Step	**Calibration Number (- 8 Density = Half the Dose, +8 Density = Double the Dose)**	**Density Step**	**Calibration Number (- 5 Density = Half the Dose, +5 Density = Double the Dose)**
-8	50		
-7	44		
-6	38		
-5	31	-5	50
-4	25	-4	40
-3	19	-3	30
-2	13	-2	20
-1	6	-1	10
0 DENSITY: SHOWN FOR REFERENCE ONLY.			
+1	13	+1	20
+2	25	+2	40
+3	38	+3	60
+4	50	+4	80
+5	63	+5	99
+6	75		
+7	88		
+8	99		

Use these steps to perform AEC density calibration.

1. Place the absorber (with thickness selected for 75 kV per Table 4-8 in the X-ray field, ensuring that the radiation is COMPLETELY blocked by the absorber.

Action (membrane console)	Action (GenWare®)
2. Select DENSITY SETUP.	Select the **Density** tab
3. Select **75** kV via the console.	Select **75** kV via GenWare®.
4. Referring to Table 4-9, note the mAs at 75 kV for film screen 1. This is the mAs required to achieve 0 density.	Referring to Table 4-9, note the mAs at 75 kV for film screen 1. This is the mAs required to achieve 0 density.

5. Determine the highest density minus step to be used. If there will be unused density steps, i.e. **–8**, **-7**, **-6**, these density steps must be disabled by setting them to **--**. This is done by using the **–** button to scroll down until the **--** symbol is displayed.	Determine the highest density minus step to be used. If there will be unused density steps, i.e. **–8**, **-7**, **-6**, these density steps must be disabled by setting them to **0**.
6. Select the highest density minus step that will be used, i.e. **–5**. Use the **+** or **–** buttons to set the calibration number for that step to the desired relative density value (example **50,** this will give approximately 1/2 the density).	For the highest density minus step that will be used, i.e. **–5**, enter the desired relative density value (example **50,** this will give approximately 1/2 the density).

7. Make an exposure and confirm that the measured mAs is approximately the desired value.
8. If the measured mAs is not as expected, adjust the calibration number and repeat the previous step.

Action (membrane console)	**Action (GenWare®)**
9. In the following steps, you will need to scroll back and forth between the **DENS. SETUP** menus using the **>>** and **<<** buttons in order to access the required density steps.	N/A

10. Select the next density step (i.e. **- 4**) and enter the appropriate calibration number for that step. Then repeat steps 7 and 8.
11. Repeat the previous step for each remaining density minus step.

Action (membrane console)	**Action (GenWare®)**
12. Determine the highest density plus step to be used. If there will be unused density steps, i.e. **+8**, **+7**, **+6**, these density steps must be disabled by setting them to **--**. This is done by using the **–** button to scroll down until the **--** symbol is displayed.	Determine the highest density plus step to be used. If there will be unused density steps, i.e. **+8**, **+7**, **+6**, these density steps must be disabled by setting them to **0**.

13. Select the highest density plus step that will be used, i.e. **+5**. Use the **+** or **–** buttons to set the calibration number for that step to the desired relative density value (example **99,** this will give approximately double the density).	For the highest density plus step that will be used, i.e. **+5**, enter the desired relative density value (example **99,** this will give approximately double the density).

14. Make an exposure and confirm that the measured mAs is approximately the desired value.
15. If the measured mAs is not as expected, adjust the calibration number and repeat the previous step.
16. Select the next lowest density step (i.e. **+4**) and enter the appropriate calibration number for that step. Then repeat steps 14 and 15.
17. Repeat the previous step for each remaining density plus step.

Action (membrane console)	Action (GenWare®)
18. Press **<<** or **RETURN** as required to return to the **AEC CALIBRATION** menu.	N/A

AEC Calibration (Wall Bucky)

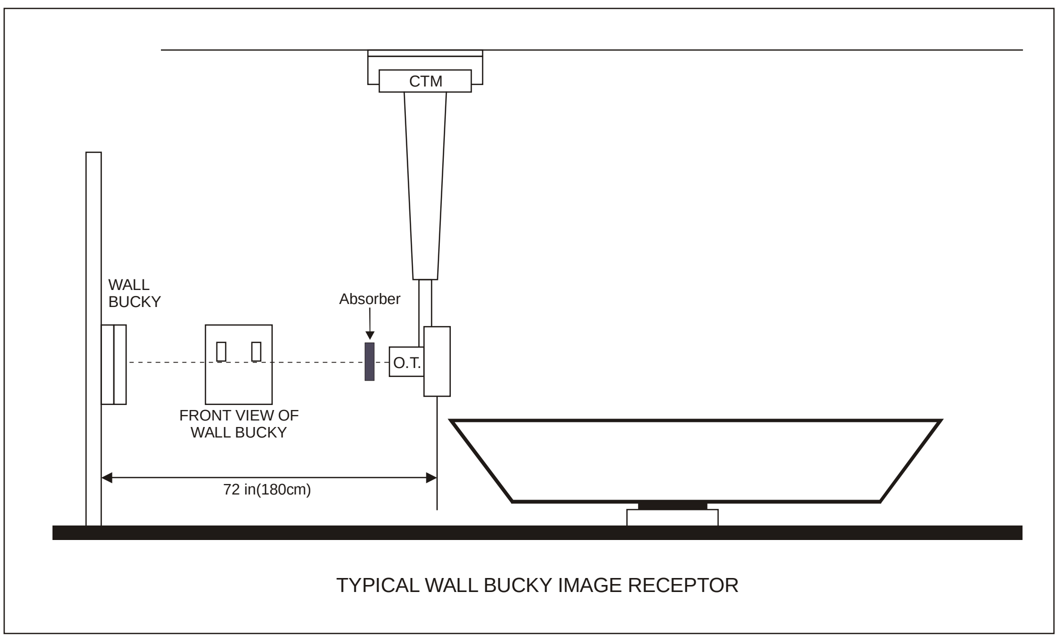

Figure 4-8: Equipment setup for wall Bucky AEC calibration

Please note the following points regarding wall Bucky calibration:

- If the wall Bucky is dedicated to chest radiography, a focused grid with a 10:1 or 12:1 ratio should be used along with an SID of 72 in. (180 cm).
- If the wall Bucky will be used for conventional as well as chest radiography, then two grids should ideally be used. See the note on the next page.

A reasonable compromise if a single grid must be used is a 10:1 ratio, 60 in. (150 cm) grid.

Note:

- *Since most wall Buckys are used at 40 and 72 in. (100 and 180 cm) SID. The grid must be chosen with care with respect to cut-off.*
- *A typical grid will have an 8:1 ratio, with 85 line pair / inch or 10:1 ratio with 150 line pair / inch pair / inch (stationary).*
- *Typically, 400-speed film screen will be used with 90 second processing.*

Grid Absorption

The following information may aid in selecting a grid and / or estimating mAs if required: The percentages listed are approximate.

A 10:1 ratio 60 in. (150 cm) focused grid will exhibit the following absorption when measured 5 in. (13 cm) from center:

At 72 in. (180 cm) absorption = 18%

At 40 in. (100 cm) absorption = 40%

A 12:1 ratio 60 in. (150 cm) focused grid will exhibit the following absorption when measured 5 in. (13 cm) from center:

At 72 in. (180 cm) absorption = 20%

At 40 in. (100 cm) absorption = 50%

A 10:1 ratio 72 in. (180 cm) focused grid will exhibit the following absorption when measured 5 in. (13 cm) from center:

At 40 in. (100 cm) absorption = 65%

A 12:1 ratio 72 in. (180 cm) focused grid will exhibit the following absorption when measured 5 in. (13 cm) from center:

At 40 in. (100 cm) absorption = 75%

A 10:1 ratio 40 in. (100 cm) focused grid will exhibit the following absorption when measured

5 in. (13 cm) from center:

At 72 in. (180 cm) absorption = 65%

A 12:1 ratio 40 in. (100 cm) focused grid will exhibit the following absorption when measured 5 in. (13 cm) from center:

At 72 in. (180 cm) absorption = 75%

Note: Breakpoint calibrations may previously have been done for all three film screen combinations during table Bucky AEC calibration. If so, the remaining image receptors must use the calibration curves previously established for those film screens.

If a spare film screen combination is available for wall Bucky use, it is suggested that two receptor selector buttons on the console be assigned to select the wall Bucky. The first wall Bucky selector should be used for 40 in. (100 cm) SID with the appropriate previously calibrated film screen. The second wall Bucky selector should then be used with the spare film screen at 72 in. (180 cm) SID.

This method will allow the grid to be optimized for each SID, as a separate dedicated film screen with its own calibration curve can be assigned to the 72 in. (180) SID.

Use these steps to perform the wall Bucky AEC calibration.

Steps 1 to 15 apply only if using one receptor select button for both SID's, using previously calibrated film screens.

1. Set up the X-ray tube stand as shown in Figure 4-8.
2. Align the tube stand and wall Bucky such that the central ray is centered relative to the image receptor.
3. Open up the collimator to expose all three fields of the AEC pickup. Ensure that the central ray remains centered relative to the image receptor.
4. Place the absorber (with thickness selected for 75 kV per Table 4-8) in the X-ray field, ensuring that the radiation is COMPLETELY blocked by the absorber.
5. Select the wall-Bucky image receptor.
6. Select the slowest film screen used for the wall Bucky, and then select the appropriate mA for that film screen per Table 4-8 (example 320 mA for 100 speed film). Select 75 kV, large focus, center field.
7. Make an exposure and note the mAs.
8. Referring to Table 4-9, note the previously established mAs at the breakpoint at 75 kV for the film speed being calibrated.

9. Adjust the gain potentiometer on the AEC board for the channel that is connected to the wall Bucky while taking exposures until the mAs noted in the previous step is obtained.

   Do not readjust the gain pot for any previously calibrated channels.

10. Load the test cassette with fresh film and install it in the image receptor. Using the same technique as in the previous step, expose the film and develop it.
11. Measure the O.D. The desired value should have been previously recorded in a copy of Table 4-11.
12. If the measured O.D. is not the desired value, adjust the gain pot to increase or decrease the density, and then repeat the previous two steps. Do not readjust the kV breakpoints that were previously calibrated.
13. Change the SID to 40 in. (100 cm) and repeat steps 10 to 12. Adjust the gain pot if necessary to achieve an acceptable compromise between both SID's.
14. Verify the O.D. at a range of different kV's.
15. Press **<<** as required to return to the **GEN CONFIGURATION** menu (membrane console).

    Steps 16 to 21 apply only if using two receptor select buttons (one for each SID), using one previously calibrated film screen and one uncalibrated film screen.

16. Select the wall Bucky image receptor via the selector configured for the 40 in. (100 cm) SID.
17. Repeat steps 1 to 12 at the 40 in. (100 cm) SID position using the appropriate previously calibrated film screen.
18. Verify the O.D. at a range of different kV's.
19. Select the wall Bucky image receptor via the selector configured for the 72 in. (180 cm) SID.
20. Calibrate the film screen assigned to this SID as per the table Bucky procedure. The AEC calibration pot must not be readjusted, as it was calibrated at the 40 in. (100 cm) SID. All breakpoints, including the breakpoint at 75 kV, are to be calibrated by adjusting the calibration numbers ONLY.
21. Press **<<** and **EXIT** as required to return to the **GEN CONFIGURATION** menu (membrane console).

AEC Calibration (MISC)

The remaining image receptors are calibrated in a similar manner to the table Bucky receptor. Only the gain pot for the active channel is to be adjusted at the slowest film screen used on the selected receptor.

Do not readjust the gain pot for previously calibrated receptors, and do not readjust the calibration values in the AEC calibration menu for previously calibrated film screens.

The memory function that was temporarily changed to OFF earlier in this chapter may now be reset to the desired value.

AEC Overview and Background Information

AEC exposures should normally be kept well under one second. When X-ray techniques that result in longer exposures are used, the film density will not be correct because of failure of reciprocity of the film.

Care must be exercised when using low kV values with table Buckys because most tabletops and grids absorb considerable radiation in the range of 60 – 65 kV. This will adversely affect AEC operation.

Film / Screen Response vs. kV

Film screen response to kV is not linear. Therefore, compensation must be provided in order to maintain constant film density as kV is changed for different anatomical studies. By selecting and calibrating various kV breakpoints, the overall system response will be compensated such as to yield a constant film density.

Up to eight breakpoints per film screen combination are available. The eight breakpoints are spread over three kV ranges as shown below:

- Low kV: 50, 55, 65 kV.
- Knee kV: 75 kV.
- High kV: 85, 95, 110, 130 kV.

Refer to Figure 4-9.

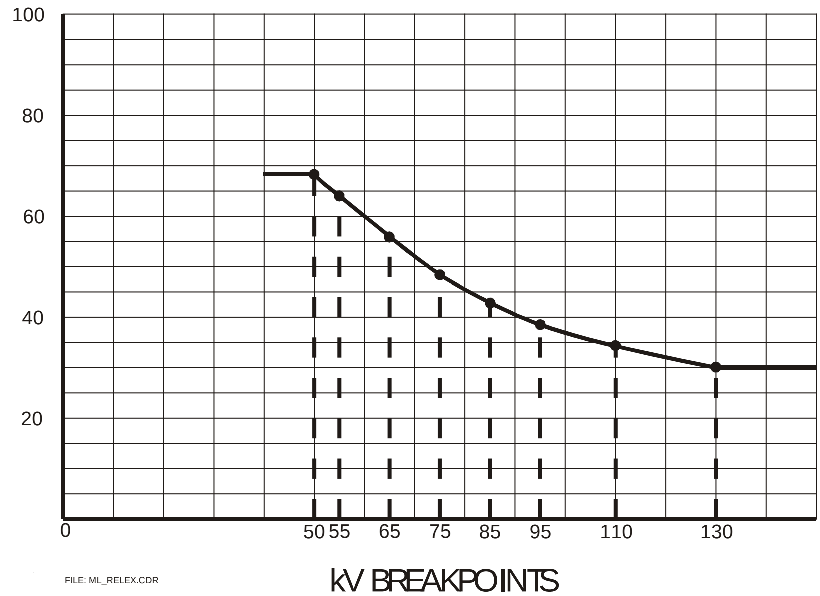

Figure 4-9: kV vs. relative density

AEC Calibration Range

Since the CMP 200® family of X-ray generators allows up to three separate film screen combinations to be calibrated, the following points must be considered:

- The AEC board allows for a zero to a maximum of 10-volt ramp at the comparator input. All AEC signals must fit within this range (for all film / screens, densities, and techniques).
- Most X-ray film-based applications require the use of two or more different film screen combinations, all of which will require different exposure doses.
- Using the slowest film screen combination, the required film input dose will be determined.
- Once this value is determined (during AEC calibration), the density calibration is performed to allow 100% (double the dose) and 50% (half the dose) values. These are typical values, and will determine the maximum required range of the AEC reference voltage (the output from the D/A converter).
- Figure 4-10 illustrates the different windows required for various film screen combinations.

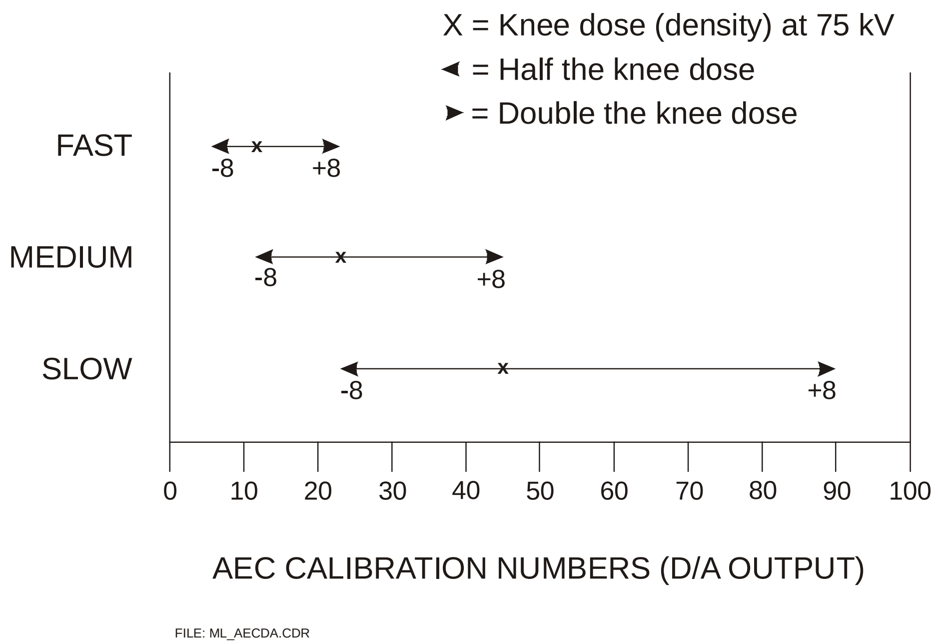

Figure 4-10: Film/screen speed vs. D/A output

Pre-calibration Setup

AEC Setup Worksheet

Before continuing, it is suggested that a copy of Table 4-11 be filled in with all required information. Refer to the example AEC setup worksheet on the next page.

Table 4-11: AEC setup worksheet

Function		**Receptor 1**	**Receptor 2**	**Receptor 3**
Film/Screen	1.			
	2.			
	3.			
Nominal optical density:				
Grid ratio/SID:				
Min - max kV range:				
± Density steps				
Density mAs (dose) change	+%:			
(per step)	-%:			
Chamber type:				
Regulatory AEC dose requirements?				

Table 4-11: AEC setup worksheet			
Function	**Receptor 1**	**Receptor 2**	**Receptor 3**
Is film processing maintained?			
Assigned receptor name:			
Are all cassettes similar?			
Additional notes:			
Additional notes:			

All receptors must have the same number of density steps and the same density dose change per step (density settings are common to all film screens and receptors).

Note: The example below is supplied for reference only. It does not represent an actual installation.

Table 4-12: Sample AEC setup worksheet				
Function		**Receptor 1**	**Receptor 2**	**Receptor 3**
Film/Screen	1.	Lanex/reg	Lanex/reg	Lanex/reg
	2.	Lanex/med	Lanex/chest	
	3.			
Nominal optical density:		1.2	1.1	1.4
Grid ratio/SID:		12:1	8:1	10:1
Min - max kVp range:		60 - 120	65 - 140	80 - 110
± Density steps		± 8	± 8	± 8
Density mAs (dose) change	+%:	12.5	12.5	12.5
(per step)	-%:	6.25	6.25	6.25
Chamber type:		Ion	Solid state	Ion
Regulatory AEC dose requirements?		Yes	Yes	Yes
Is film processing maintained?		Yes	Yes	Yes
Assigned receptor name:		Table	Wall	Aux
Are all cassettes similar?		Yes	Yes	Yes
Additional notes:				
Additional notes:				

AEC Pre-calibration Checks

It is recommended that a copy of the form below be filled in with the required information before attempting AEC calibration.

Table 4-13: Pre-calibration checklist

1. Verify that the AEC chambers are mounted correctly in the Bucky. Note that some chamber types must be physically isolated from equipment ground, refer to Figure 4-11 as an example.	CHECK:
2. Verify that each AEC chamber / pickup is properly connected to its intended input channel on the AEC board.	CHECK:
3. Make and type of AEC chamber/pickup: 4.	AEC Ch 1________________________________ AEC Ch 2________________________________ AEC Ch 3________________________________
5. Verify signal grounding for the AEC chamber. The only electrical ground should be at the AEC board in the generator. This applies to the ground braid (shield) for the AEC signal cable and to the ground return conductor(s) in the AEC signal cable.	CHECK:
6. Before calibrating, verify that the AEC system is functioning. This includes the AEC chambers / devices and the AEC circuits in the generator. Each of the fields on the AEC device must be able to terminate the exposure.	CHECK:
7. Radiographic techniques to be performed with the equipment (high kV chest, G.I. studies etc)?	
8. Does the suctomer use normal exposure factors (typical mAs / kV range)?	

AEC Chamber Installation

Figure 4-11 shows an installed AEC chamber. Note particularly the use of a suitable insulating material to isolate the body of the chamber from the receptor ground. This is required for non-insulated AEC chambers.

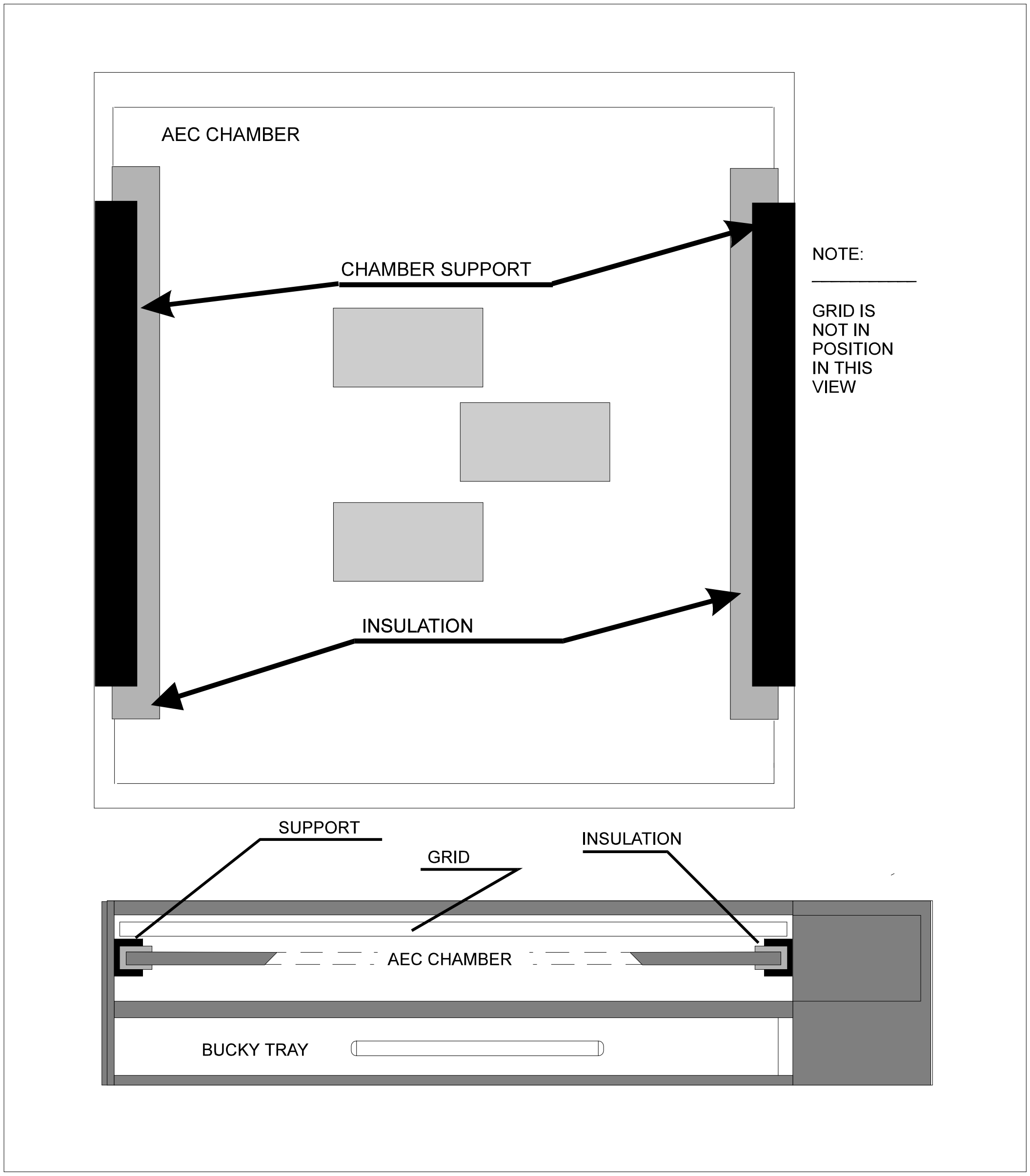

Figure 4-11: AEC chamber installation

Chapter 5 Acceptance Testing

Contents

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Introduction

This section details acceptance testing, this verifies that the generator is performing within its limits. This must be done at initial installation of the generator and as required by local regulations.

The applicable sections of this chapter should be performed when the generator is reconfigured or critical component(s) are replaced. Examples of such components are the X-ray tube, High Voltage Module, console board, generator control board, filament supply board, and the AEC board.

Acceptance test procedures may be defined by local regulations or by some hospitals / clinics / end users. Local or site-specific acceptance test procedures should be used as required to supercede all or part of the acceptance test procedures in this chapter.

Warning:

- *Use extreme care in measuring high voltages. Accidental contact may cause injury or death.*
- *Even with the generator switched off at the console, mains voltage is still present inside the generator cabinet. This voltage is extremely dangerous; use extreme caution.*
- *The DC Bus capacitors located beside the high voltage module has been switched off. Verify that of 5 minutes after the power has been switched off. Verify that theses capacitors are discharged before servicing or touching any parts.*
- *Do not adjust any potentiometers within the X-ray generator unless otherwise instructed. Ignoring this warning could result in damage to the X-ray tube, high voltage cables, and high voltage module, or increase the risk of patient over exposure.*
- *When verifying kV accuracy, use of an invasive meter is recommended. However, if this is not possible, a non-invasive meter may be acceptable. The use of non-invasive meter requires extra precautions in order to read accurate kV. For more information, refer to application note for using nor-invasive meter in kV measurement, MAN906930.*
- *The procedures in this chapter require the production of X-rays. Take all safety precautions to protect personnel from X-radiation.*
- *Always ensure that the equipment under test and all associated test equipment is properly grounded.*
- *Ensure that the high voltage cables are intact / undamaged and properly connected before attempting exposures.*

Ensure that the following items are completed prior to performing the acceptance testing:

- The generator is interfaced to compatible room equipment as noted on the product configuration \ compatibility statement at the front of this manual.
- The tube auto calibration has been done as per Chapter 3, *Interfacing and Programming*.

- The receptors have been programmed as per Chapter 3, *Interfacing and Programming*.
- If the installation has AEC, verify that all receptors have been calibrated as per Chapter 4, *AEC Calibration*.
- If the installation has DAP, verify that the DAP chambers have been calibrated as per *DAP Calibration Procedure* in Chapter 3, *Interfacing and Programming*.
- Acceptance testing shall only be started after the installation is complete i.e. with the generator in the final position and installed as per the previous chapters of this manual.

Test Equipment

- An invasive meter is recommended, however if a non-invasive meter must be used, refer to the warnings described in the "Introduction" section in this chapter.
- Storage oscilloscope.
- mA / mAs meter.
- Radiation meter 0-10 mGy (0-1000 mR).
- Lead diaphragm or equivalent to collimate the beam.
- General purpose DVM.
- Current probe 0 to 20 amps AC.
- A set of HVL filters.
- Calculator.
- Strobe or reed tachometer to measure anode speed.

Acceptance Tests (Basic Functions)

Console Tests

For the touchscreen console, check the console functionality by pressing the equivalent switch position on the touchscreen for the functions described in Section, *Console Tests* and *Low-Speed Starter Verification*, Verify the correct response on the touchscreen console for each function that is tested.

Action	Result	Check
1. Press the power ON then power OFF buttons on the console.	Unit is truned off.	
Note: Steps 2 and 3 apply only if a customer supplied external Emergency Power Off switch is connected. If no Emergency Power Off switch has been connected proceed to step 4.		

Action	Result	Check
2. Press the Emergency Power Off switch (if installed) and then the power ON button on the console.	Unit will remain unpowered.	
3. Reset the Emergency Power Off switch	N/A	
4. Press the power ON button again to switch the unit on.	Unit switches on.	
5. Press each of the receptor buttons that are active (those that have been enabled during generator configuration).	Verify that the adjacent LED lights for each receptor.	

Note: The technique select button used to select AEC / mAs / mA/ms in steps 6, 7, 8 will only be functional if APR MODE has been disabled during generator configuration (the technique select function is disabled if APR MODE is enabled). This function is described in Chapter 3, Interfacing and Programming, in the section UTILITY MENU, under CONSOLE.

6. Select an active radiographic receptor that has AEC programmed. Press the technique select button to select **AEC**. Verify the results:	A: The AEC LED lights. B: kV value is displayed. C: mA value is displayed. D: Density value is displayed.	
7. Press the technique select button to select **mAs.** Verify the results:	A: The mAs LED lights. B: kV value is displayed. C: mAs value is displayed.	
8. Press the technique select button to select **mA/ms.** Verify the results:	A: The mA/ms LED lights. B: kV value is displayed. C: mA value is displayed. D: ms value is displayed.	
9. Press the kV **+/-** buttons.	kV increases if kV **+** is pressed. kV decreases if kV **-** is pressed.	
10. Ensure that three-point operation is selected (**mA/ms**). Press the mA **+/-** buttons.	mA increases if mA **+** is pressed. mA decreases if mA **-** is pressed.	

Action	Result	Check
11. Ensure that three-point operation is selected (**mA/ms**). Press the ms **+/-** buttons.	ms increases if ms **+** is pressed. ms decreases if ms **-** is pressed.	
12. Press the focus select button.	The large and small focal spot LED's alternately light as the switch is pressed.	
13. Ensure that AEC is selected. Press the film-screen select button.	The three film-screen LED's (I, II, III) alternately light as the switch is pressed.	
14. Select 60 kV, 50 mA, 100 ms. Press the PREP button.	The LED adjacent to the prep button lights.	
15. Press the X-ray button.	The X-ray warning indicator lights during an X-ray exposure, and an audible tone is heard from the console.	
16. Ensure that **AEC** is selected. Press the individual AEC field select buttons in sequence.	The LEFT, CENTER, and RIGHT field selection LED's should light as each field is selected.	
17. Press the power OFF button on the console.	The unit switches off.	

Low-Speed Starter Verification

Note:

- *The generator is limited to a maximum of 5 consecutive low-speed boosts, followed by a minimum 10 second wait period.*
- *The X-ray tube data sheets should be consulted to confirm the tube manufacturer's maximum number of low-speed boosts.*

Action	Result	Check
1. Connect a current probe to the common lead of the X-ray tube stator. Switch ON the console. Press and hold the PREP button.	A 60 Hz waveform dropping to less than half amplitude after prep is complete.	
2. Measure the rotor boost time.	The result should be as set in chapter 3C.	
3. Use a strobe or reed tachometer and	Speed ≥ 3300 RPM.	

Action	Result	Check
verify that the tube reaches operating speed at the end of boost.		
4. Switch OFF the console.		

Dual-Speed Starter (DSS) (Optional) Verification

The generator must be programmed for dual-speed starter operation in order to be able to verify both modes of operation in this section. Do not program dual-speed operations if the tube used cannot operate at both low and high speed.

Note: The X-ray tube data sheets should be consulted to confirm the manufacturer's maximum allowable number of boosts per minute for the tube (low and high speed).

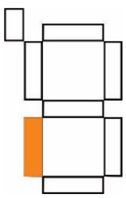
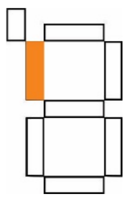
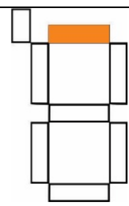
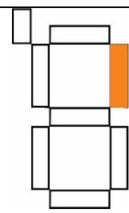
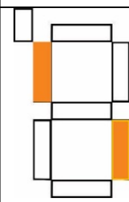
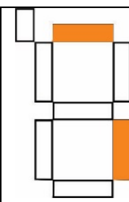
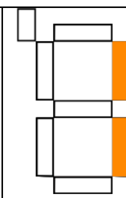
Action	Result	Check
1. Connect a current probe to the common lead of the X-ray tube stator. Switch ON the console. Select 70 kV, minimum mA, 50 ms. Press and hold the PREP button.	A low speed waveform dropping to less than half amplitude after prep complete	
2. Measure the rotor boost time	Should agree with the value in the dual-speed starter table of the *X-ray Tube Stator Compatibility Tables* supplement (part number: 746026-00).	
3. Select 100 kV, maximum mA, 50 ms, small focus. Press and hold the PREP button.	A high speed waveform dropping to less than half amplitude after prep complete.	
4. Measure the rotor boost time	Waveform frequency should agree with the value in the dual-speed starter table at the end of Chapter 2, *Installation*.	
5. Use a strobe or reed tachometer and verify that the tube(s) reach operating speed at end of boost. Use the techniques in steps 1 and 3 to select low and high-speed modes respectively.	Low Speed $\geq$ 3300 RPM. High Speed $\geq$ 9500 RPM.	

6. After a high-speed prep, verify that the dynamic brake is applied.	Will hear the X-ray tube slow down to 60 Hz.	

Indicators for Modes of Operation - Applies to DSS Board Number 903132-02

The DSS board, number 903132-02, includes a 7-segment display to indicate the mode of operation the DSS is running in. The checks below are included to verify the DSS functionality.**DS5 (heartbeat) should be flashing at 1 Hz (0.5 sec on, 0.5 sec off) indicating that the DSS is operational.**

Yellow indicates LEDs on
White indicates LEDs off

Standby	Low-Speed			High-Speed		
 *(DS2B is ON)*	 **BOOST** (DS2C is ON)	 **RUN** (DS2D is ON)	 **LOW SPEED BRAKING** **(WHERE APPLICABLE)** (DS2E is ON)	 BOOST (DS2C and DS2F are ON)	 RUN (DS2D and DS2F are ON)	 BRAKING (DS2E and DS2F are ON)

Acceptance Tests (kV, ms, mA and mAs)

Generator Rad Tests

- Use of an invasive meter is recommended, however if a non-invasive meter must be used, refer to the warnings described in the “Introduction” section in this chapter.
- mA / mAs measurements must be made by connecting a mA / mAs meter to the mA measurement jacks on the High Voltage Module.
- Measure ms at 75% of the peak kV value, i.e. from the time that the kV rises to 75% of its peak value until it drops below the same value.
- All test equipment must be calibrated and the measurement tolerances of the equipment must be known.

Note:

- *A Dynalyzer is not recommended for mA measurements with this X-ray generator. Bandwidth limitations of the Dynalyzer will result in inaccurate mA measurements must be made with a mA / mAs meter connected to the ma test jacks on the high voltage module.*
- *The result column in the following section shows the acceptable generator limits for kV, mA, mAs, and ms. Test and measurement tolerances must be accounted for in all measurements.*

Warning:

- *Take all appropriate precautions when connecting the mA /mAs meter to the high voltage module. Ensure mains power is switched off and all capacitors are discharged before connecting the meter. Use the same precautions when disconnecting the meter. The mA shorting link must be in place on the high voltage module at all times except when an approved mA / mAs meter is connected.*

Caution:

- *The following tests require the production of X-radiation. Use appropriate safety precautions to protect personnel.*

For each step in the tables below, confirm the expected result. The measurement range shown in the ***Result*** column includes the generator tolerances only. ***Test and measurement tolerances must be accounted for in all measurements.***

Action	Result	Check
1. Set up the measuring devices to measure kV, mA/ mAs and ms as per the manufacturer instructions.	N/A	
If high kV exposures are not allowed in the following steps, check the maximum kV setting that has been programmed. Refer to "*Tube Selection / Tube Setup*" in Chapter 3, *Interfacing and Programming*.		
2. Switch ON the generator and after initialization select the following parameters: kV = 100, mA = 100, time = 100 ms	N/A	
For reference, the specified kV, mA, mAs and ms accuracy is: kV: ±(5% + 1) kV, ±2 % from 70 to 85 kV mA: ±(5% + 1) mA mAs: ±(10% + 0.2) mAs ms: ±(2% + 0.5) ms ≥ 5 ms, ±(10% + 1) ms from 1 to 4 ms In the following steps, except for step 7, the results column shows upper and lower limits based on the specified tolerances.		

Action	Result	Check
3. Make an exposure and verify the results.	Gen kV = 94-106 kV Gen mA = 94-106 mA Gen ms = 97.5-102.5 ms	
4. Repeat the previous step but set the values to kV = 65, mA = 200	Gen kV = 61-69 kV Gen mA = 189-211 mA Gen ms = 97.5-102.5 ms	
5. Repeat the previous step but set the values to kV = 125	Gen kV = 118-132 kV Gen mA = 189-211 mA Gen ms = 97.5-102.5 ms	
6. Select 75 kV, 200 mA Select the exposure times shown below (3 point operation). Verify the mAs shown. A: 10 ms; B: 20 ms; C: 63 ms; D: 100 ms	A: Gen mAs = 1.6-2.4 mAs B: Gen mAs = 3.4-4.6 mAs C: Gen mAs = 11-14 mAs D: Gen mAs = 17.8-22.2 mAs	
7. Select 75 kV. Select the mAs shown below (2-point operation). Measure ms at 75% of the peak kV waveform A: 2 mAs; B: 8 mAs; C: 25 mAs D: 63 mAs	NOTE: The time associated with each mAs setting may vary depending on generator configuration. Use the ms displayed on the console as the reference for the measurements below. Gen ms per console	
In the above step, note the ms for the pending exposure. Then take the exposure and confirm that the actual ms = the demanded ms within the allowed tolerance: The ms accuracy of the generator is: • $\pm$ (2% + 0.5) ms for ms $\geq$ 5 ms • $\pm$ (10% +1) ms from 1 to 4 ms		
8. Select 200 mA, 100 ms (3-point operation). Select the kV values shown below. A: 50 kV; B: 60 kV; C: 80 kV D: 100 kV; E: 125 kV	A: Gen kV = 46.5-53.5 kV B: Gen kV = 56-64 kV C: Gen kV = 78.4-81.6 kV D: Gen kV = 94-106 kV E: Gen kV = 118-132 kV	

Action	Result	Check
9. Select 100 kV, 100 ms (3-point operation). Select the mA values shown below. Measure mA at 75% of the peak kV waveform A: 50 mA; B: 100 mA; C: 200 mA D: 400 mA; E: 500 mA; F: 630 mA G: 800 mA	A: Gen mA = 46.5-53.5 mA B: Gen mA = 94-106 mA C: Gen mA = 189-211 mA D: Gen mA = 379-421 mA E: Gen mA = 474-526 mA F: Gen mA = 598-662 mA G: Gen mA = 759-841 mA	

***Note:* The higher mA values will not be available on all generator models and / or programmed tube types.**

Acceptance Tests (AEC)

For generators with AEC:

1. Review section 4: AEC Calibration.
2. Recheck the mAs, dose and O.D. as recorded during initial installation. Follow the appropriate steps in chapter 4 to verify the AEC calibration.
3. CMP 200® / CMP 200® DR X-ray generators have a circuit that checks that the AEC ramp is at least 5% of the AEC reference voltage within 20% of the AEC backup time. This step confirms that this circuit is working, and that electrical noise on the AEC input does not exceed the 5% threshold.
    1) Close the collimator and point the X-ray tube away from the image receptor that has AEC channel 1 assigned to it. Alternately, close the collimator and cover the image receptor with a lead apron. Then select this image receptor via the console.
    2) Select the AEC mode of operation and 100 mA.
    3) Select the maximum kV used on that receptor and minimum density. Select the fastest film screen if available.
    4) Make an AEC exposure and verify that an AEC DEVICE ERROR message is displayed.
        - An AEC DEVICE ERROR message indicates that the selected AEC channel has passed this test. Repeat step 3 for the remaining AEC channels by selecting an image receptor that has the desired AEC channel assigned to it.
        - Go to step 3 (e) if an AEC DEVICE ERROR message is not displayed when testing the current AEC channel.

5) If the generator runs into backup ms or backup mAs, i.e. if an AEC DEVICE ERROR message is not displayed, some troubleshooting is required to determine the reason the "5% / 20%" circuit is not terminating the AEC exposure. Some troubleshooting tips:

   - Repeat steps 3 (a) to 3 (d) but select the minimum kV used on the current receptor, maximum density and the slowest film screen, if available. If an AEC DEVICE ERROR message results with these settings, this almost certainly indicates that there is sufficient noise on the AEC input to exceed 5% of the AEC reference voltage under the test conditions in step 3 (c), where the AEC reference voltage is at its minimum. The cause of excessive noise on the AEC input now needs to be found.
   - Measure the AEC reference voltage (PT reference). Then check that noise at the output of the AEC board (PT ramp) does not exceed approximately 2% of the AEC reference voltage.
   - Is the AEC cable routed along with other "noisy" cables i.e. stator cables?
   - Are the stator cables shielded and properly grounded? Shielded cable is recommended for the low speed starter and required for the dual-speed starter. The shield must be grounded at the tube end and at the generator end of the cable(s).
   - Is the AEC cable shielded? The shield should only be grounded at the AEC board in the generator.
   - Is the AEC chamber isolated from chassis ground? Some chamber types must be isolated from equipment ground.
   - If the generator runs into backup ms or backup mAs under both sets of test conditions (maximum kV, minimum density, fastest film screen AND minimum kV, maximum density, slowest film screen):
   - Recheck the troubleshooting steps in 3 (e).
   - Check the PT ramp at TP11 on the generator interface board.

6) Repeat the previous steps for the remaining AEC channels by selecting an image receptor that has the desired AEC channel assigned to it.

Refer to the section **AEC Calibration Range** in chapter 4 for background information on film screen speed vs. D/A output (reference voltage).

Acceptance Tests (DR Interface)

For CMP 200® DR X-ray generators with a DR imaging system, follow the system manufacturer's recommendations for system test to verify the DR interface.

Acceptance Tests (DAP)

Recheck the appropriate steps in Chapter 3, *Interfacing and Programming*, to verify the DAP calibration.

Acceptance Tests (HVL, Linearity and Reproducibility)

The procedure for performing reproducibility, linearity and HVL testing is contained in the supplement “Reproducibility, Linearity, & HVL Testing,” part number 740917.

Required Verification testing for spares

Table 4-1 lists the spare parts and the tests that are required after part replacements. Only perform the test(s) indicated by the “X” mark for each spare part.

Table 4-1: Test Matrix for Spare Parts

Part Names	DSS Verification	Generator RAD Test	Linearity and Reproducibility Tests
Filament Supply Board		x	x
HV Auxiliary Board		x	
Inverter Board		x	
Thermal Sensor Board	x	x	
EMC CAP Board		x	
Generator Control Board		x	x
DSS Board or DSS Assembly	x		
Console Connector Board		x	
High Voltage Module	x	x	x
DSS 2 Software Upgrade Kit	x		
Hand Switch Kit		x	
Battery: Panasonic, CR2032, L/BN, or equivalent		x	

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Chapter 6 Regular Maintenance

Contents

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Introduction

This chapter provides a recommended schedule for periodic maintenance of the CMP 200® series and the CMP 200® DR series of X-ray generators.

The initial installation date and location, and all service performed on the generator, should be recorded in Table 6-1. The record should be as thorough as possible, detailing the scope and type of work that was performed (all service and a record of all replacement parts that were installed). Additionally, the person performing the work should date and sign the record.

This information will be invaluable in the future for traceability and ensure continued compatibility of the generator.

If a major component (such as the HV module or a major circuit board) is replaced, recalibration will be needed. A separate procedure will be included with the spare in those cases, detailing the required calibration procedure. The acceptance test procedure per Chapter 5, *Acceptance Testing*, should then be performed prior to placing the generator back into service.

Warning:

- *Maintenance is to be performed only by competent, trained personnel who are familiar with the potential hazards associated with this equipment.*
- *Ensure the AC input power is locked out for servicing.*
- *Always switch off mains power to the generator and wait a minimum of 5 minutes for capacitors to discharge before beginning any preventative maintenance, including cleaning.*
- *Do not place any objects regardless of size or weight on the generator.*
- *Do not allow any obstruction of the cooling vents.*

Note:

- *Maintenance schedule frequency may be dictated by certain regulatory requirements of the country or state in which the installation is located. Always check the local codes and regulations when setting the maintenance schedule.*

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Service Record

Table 6-1: Installation and Service Record		
INSTALLED BY: ___________________ DATE: _______________ LOCATION: ___________________________		
Service Date	Description of Service	Performed By

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Maintenance Schedule

<table>
<tr><th>Maintenance Frequency</th><th>Description of Preventative Maintenance</th></tr>
<tr><td>As governed by local regulations:</td><td>Mandatory:
1. Check and recalibrate the DAP meter in the generator per Chapter 3, Interfacing and Programming, (units with the DAP option).
2. Verify the calibration of the generator; refer to Chapter 5, Acceptance Testing, of this manual.
3. Perform any additional tests required by laws governing this installation.</td></tr>
<tr><td>Every 6 Months AND whenever a related certifiable X-ray component is replaced:</td><td>Mandatory:
1. Clean and re-grease the HV connections on the HV module if using vapour-proof compound. See note following this table.
2. Perform the X-ray tube auto-calibration in Chapter 3, Interfacing and Programming. This is required within 6 months of installing a new X-ray tube, and annually thereafter.
Recommended (but not mandatory):
1. Clean the control consoles, hand switch / foot switch, and main cabinet as needed. Refer to Clearning of this chapter before proceeding.
2. For units with the touch screen console, perform touch screen calibration in Chapter 3, Interfacing and Programming.
3. Remove accumulated dust from the fan housing, fan blades and from the inverter heat sinks, where possible. Vacuuming is recommended.
4. Check all visual displays (warning and status lights, technique displays, exposure indicators, etc) for normal operation.
5. Check all audible indicators for normal operation, and check that the loudness settings are adequate for the environment.
6. The 19 Vdc power supply cables for the touchscreen and console cable are not worn or defective. Insulation does not show signs of wear.</td></tr>
<tr><td>Every 12 months:</td><td>Mandatory:
1. Check the insulating oil in the high voltage output connectors on the HV module (if applicable). See note following this table.
2. Clean the control consoles, hand switch / foot switch, and the main cabinet as needed. Refer to Clearning of this chapter before</td></tr>
</table>

Maintenance Frequency	Description of Preventative Maintenance
	proceeding. 3. For units with the touch screen console, perform touch screen calibration in Chapter 3, *Interfacing and Programming*, for the calibration procedure. 4. Remove accumulated dust from the fan housing, fan blades and from the inverter heat sinks, where possible. Vacuuming is recommended. 5. Test the X-ray tube thermal switch circuits in the generator. Disconnect the tube thermal switch, and then verify the correct error message and that X-ray exposures are inhibited. 6. Examine the following for any visible damage and replace any damaged components: • The exterior of the control console including the membrane switch assembly. • The cable between the control console and the generator main cabinet. • The hand switch / foot switch (if used) and the cables connecting this to the console. 7. Check all visual displays (warning and status lights, technique displays, exposure indicators, etc) for normal operation. 8. Check all audible indicators for normal operation, and check that the loudness settings are adequate for the environment. 9. Open the generator cabinet and examine the unit for any visible damage: Missing or loose ground connections, oil leaks, damaged cables etc. 10. Ensure that there are no obstructions blocking any of the cooling slots on the generator cabinet.
Every 5 years:	**Mandatory:** 1. Replace the lithium battery on the generator control board. Refer to the spares list in chapter 8 for the required part number. Refer to 6.7.0 for the battery replacement procedure. 2. Replace the cooling fan in the generator. The airflow vs. static pressure must be considered when replacing the fan. The replacement fan must have performance characteristics similar to the original fan. Consult the factory if in doubt.

Note: The high voltage receptacles on the HV module must be filled with insulating oil (preferred) or the high voltage connectors at the HV module end must be coated with vapour-proof insulating compound. The method used at the X-ray tube's high voltage connectors is at the discretion of the installer / service engineer; however, it must be adequate to prevent arcs / flashover at the X-ray tube end as tube high voltage arcs will affect the generator's usability.

Oil Fill / Level Check

CMP 200® / CMP 200® DR X-ray generators use different styles of HV module, depending on model. Refer to Figure 6-1. For the HV module on the right side of Figure 6-1, field maintenance is neither necessary nor possible. The oil is factory-filled to the correct level and the HV module is then sealed. An air-filled "bladder" within the high voltage module will expand and contract as the oil volume changes with pressure and temperature changes.

Note:

- *For the HV module on the right side of Figure 6-1, ensure that the vent tube ("VENT" in Figure 6-1) is not blocked.*

For the HV module on the left side of Figure 6-1, the oil level in the HV module can be checked in the field and the oil can be topped up if necessary. Refer to the steps below.

The insulating oil level in the HV module does NOT require periodic checking under normal conditions. However, if there is evidence of possible oil loss, the procedure for checking the correct oil level follows.

1. Loosen the screw for the oil fill plug on the high voltage module lid.
2. With the screw sufficiently loosened, remove the rubber (neoprene) plug.
3. Use a **clean** ruler, strip of cardboard, or other equivalent material to determine the oil level, **measured always from the TOP surface of the lid of the HV module.**
    1) Normally the oil level should be between 0.88 - 1.25 inches (22 - 32 mm) from the top of the high voltage module lid.
    2) If the oil level is between 1.25 - 1.6 inches (32 - 41 mm) from the top of the high voltage module lid, then clean oil should be added as needed.
    3) If the oil level is greater than 1.6 inches (41 mm) below the top of the high voltage module lid, please consult the factory.

4. Use only fresh oil, type Shell DIALA AX or equivalent. It is critical that air is not added when topping up the oil. The following procedure is strongly recommended when adding oil.
   4) Use a new clean syringe to remove oil from the container. A 60 cc catheter tip syringe is recommended. Approximately 60 cc of oil is required to raise the oil level by one millimeter.
   5) Turn the syringe upright and expel any trapped air.
   6) Place the tip of the syringe through the oil-fill plug and into the oil, ensuring that it is below the surface of the oil.
   7) Gently eject the oil from the syringe into the HV module, while making sure that the tip of the syringe remains below the surface of the oil until all of the oil is emptied from the syringe.
   8) Repeat the previous steps until the required amount of oil has been added.
5. Replace the oil fill plug. Once the plug is installed and the screw is properly seated, tighten the screw 4 turns. This will secure the oil fill plug. Wipe up any spills. Dispose of soiled absorber in compliance with government requirements, and ensure conformity to local disposal regulations. THE OIL DOES NOT CONTAIN PCBs.

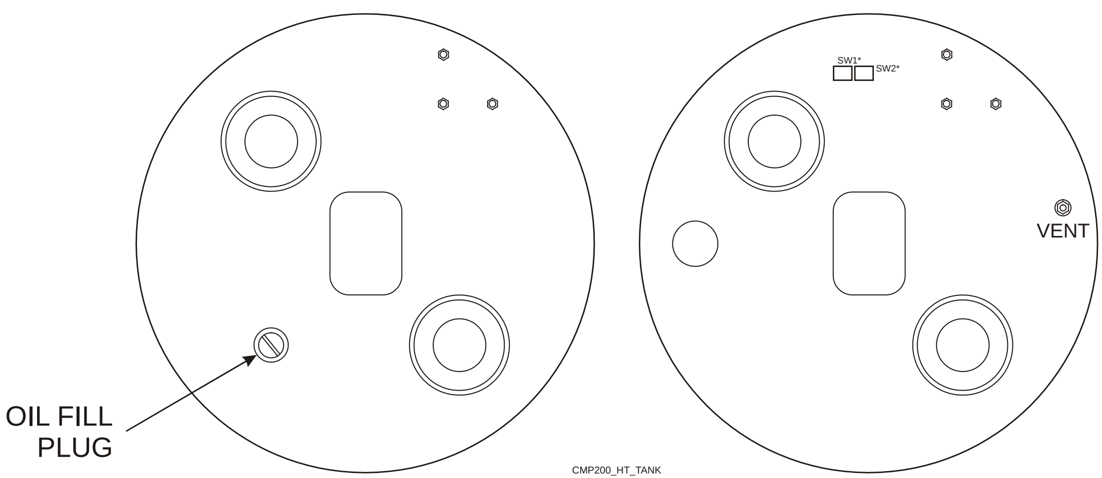


Figure 6-1: HV module oil fill

*** Do not adjust SW1 / SW2 on the HV module (not fitted on all models)**

Cleaning

- To clean the console surfaces (without disinfecting) use soap and water. This should be applied using a lint-free cloth as described below.
- If console surfaces need to be disinfected, use Actichlor or equivalent with a Hypochlorite concentration of 3 to 5%.
  - Dilute the disinfectant 50/50 with water.
  - Spray or dampen a lint-free cloth with the diluted disinfectant. The cloth must be damp only, not wet.
  - Gently wipe the console surfaces with the damp cloth.
- Never use any corrosive, solvent or abrasive detergents or polishes.
- Ensure that no water or other liquid can enter any equipment. This precaution prevents short circuits and corrosion forming on components.
- Methods of disinfection used must conform to legal regulations and guidelines regarding disinfection and explosion protection.
- If disinfectants are used which form explosive mixtures of gases, these gases must have dissipated before switching on the equipment again.
- Disinfection by spraying is not recommended because the disinfectant may enter the X-ray equipment.
- If room disinfection is done with an atomizer, it is recommended that the equipment be switched OFF, allowed to cool down and covered with a plastic sheet. When the disinfectant mist has subsided, the plastic sheet may be removed and the equipment be disinfected by wiping.

Firmware Upgrade

Warning:

- *Take appropriate electrostatic precautions at all times when handling the dual-speed starter EPROM.*

Caution:

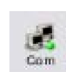
- *Applying power to the generator with the incorrect EPROM installed will damage the device. Always double-check for the proper orientation.*

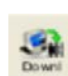
Note:

- *Proper IC installers / extractors should always be used when removing or installing the dual-speed starter EPROM.*

Console Firmware

1. Ensure that GenWare® (version 1.03 or later) is installed on the computer that will be used for the firmware upgrade. The CPI flash program utility is part of GenWare® MP.
2. Start with the console (generator) switched off.
3. Connect a null-modem cable from the serial port on the PC that will be used to do the firmware upgrade to the DATA LINK connector on the console.
4. Copy the updated software file onto the computer's hard drive. The updated software file may be distributed by various means including CD, e-mail, etc. There is only one file to be copied, in the format **123456A.cpm**. Note the folder to which this file has been copied.
5. Switch the console on.
6. Enter the **GENERATOR SETUP** menu. Select **DATA LINK,** and then select **CONNECT TO GENWARE**. Refer to chapter 3C. The LCD on the console will display **WAITING FOR DATA…. PLEASE DO NOT TURN OFF POWER**.
7. Start GenWare® on your PC. The LCD on the console will display **GENERATOR LINK ENABLED-PLEASE DO NOT TURN OFF POWER**. This indicates that GenWare® is communicating with the console.
8. If communication is not established, check the COM port setting in GenWare®.

    1) Select **Communications Setup**  on the GenWare® toolbar. The **Communication Setup** window will open.
    2) Under **COM Port Selection**, select the desired COM port, if known.
    3) Select **Apply**, and then **Close**.
    4) Exit GenWare®, and then restart GenWare® in order for the change to take effect.
    5) If the required COM port is not known, you may need to select consecutive COM ports by trial and error. Repeat the previous steps, using a different COM port for each trial.

9. Select **Firmware Updater**  on the GenWare® toolbar. The **CPI Generator Flash Program Utility** will open. Refer to Figure 6-2.
10. Select **EXIT** on the console to return to the **DATA LINK TYPE** menu.
11. Select **FIRMWARE UPDATE**. The LCD on the console will display **WAITING FOR UPDATE…PLEASE DO NOT TURN OFF POWER**.
12. On the **CPI Generator Flash Program Utility,** under **CPM Format**, ensure that **File** is selected. This is the default setting.

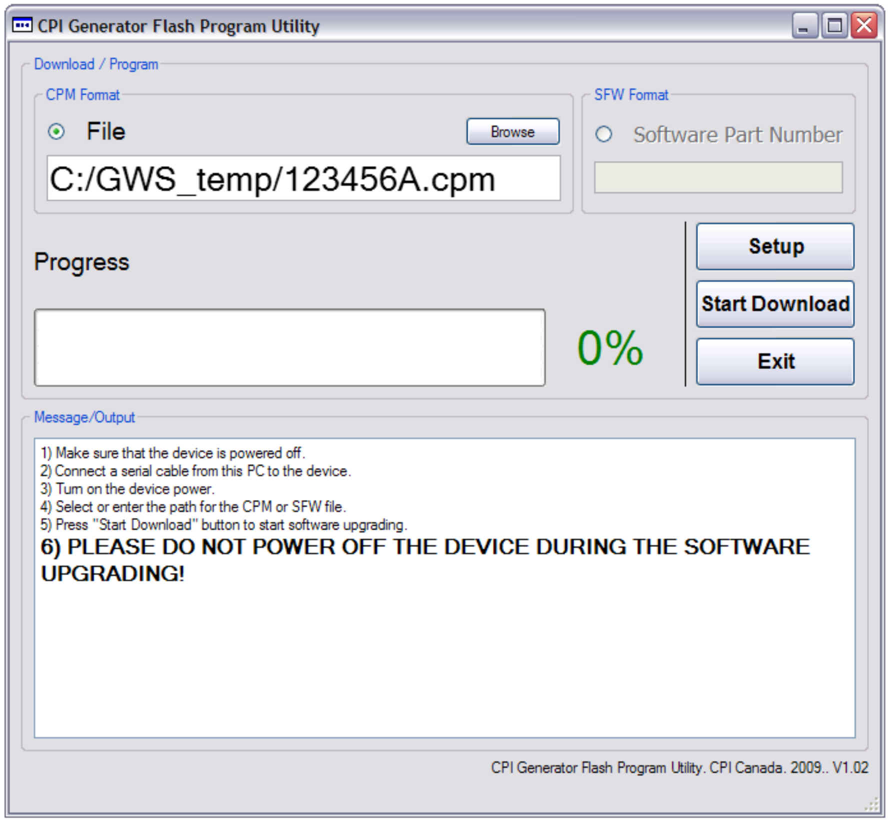


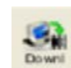
Figure 6-2: Console downloader utility

13. Select **Browse**. A dialog box will open asking you to **Choose a file to open**. Select the cpm file that was copied in step 4.
14. The file path and name will be copied into the text field under **CPM Format.**

    Warning: Do not switch off the generator during the next three steps. If power is lost during the upgrade process. The console will need to be returned to the factory to be reprogrammed.

15. Select **Start Download.**
16. If the updated software file is able to successfully download to the console, the **Progress** bar on the downloader utility window will indicate the progress, and the **%** indicator will show the percent completion. The console LCD will display **DOWNLOADING UPDATE… PLEASE DO NOT TURN OFF POWER** and it will also indicate the progress via a progress bar.
17. If the message **Console type is not matched!** is displayed, this indicates that the software file is not compatible with that console.
18. When the download is finished and the console's flash memory has been updated, the console will display **UPDATE SUCCESSFUL**. The console and computer may then be switched off, and the null-modem cable may be disconnected.

Generator Firmware

1. Ensure that GenWare® (version 1.03 or later) is installed on the computer that will be used for the firmware upgrade. The CPI flash program utility is part of GenWare®.
2. Start with the generator switched off.
3. Connect a null-modem cable from the serial port on the PC that will be used to do the firmware upgrade to J22 on the generator control board.
4. Copy the updated software file onto the computer's hard drive. The updated software file may be distributed by various means including CD, e-mail, etc. There is only one file to be copied, in the format 123456A.cpm. Note the folder to which this file has been copied.
5. Switch the generator on.
6. Start GenWare® on your PC. Then select Firmware Updater  on the GenWare® MP toolbar. The CPI Generator Flash Program Utility will open. Refer to Figure 6-2.
7. Switch the generator off. Do not switch off GenWare® or close the CPI Generator Flash Program Utility.
8. Locate jumper JW2 on the generator control board. Temporarily set this to the "upgrade" position (short across pins 2-3).
9. Switch the generator on again.
10. On the CPI Generator Flash Program Utility, under CPM Format, ensure that File is selected. This is the default setting.
11. Select Browse. A dialog box will open asking you to Choose a file to open. Select the cpm file that was copied in step 4.
12. The file path and name will be copied into the text field under CPM Format.

    Warning: Do not switch off the generator suring the next three steps. If power is lost during the upgrade procedd, the generator control board will need to be returned to the factory to be reprogrammed.

13. Select Start Download.
14. If the updated software file is able to successfully download to the generator, the Progress bar on the downloader utility window will indicate the progress, and the % indicator will show the percent completion.
15. If the computer is unable to communicate with the console, check the COM port setting. Select Setup, and then try a different Com Port.

16. When the download is finished and the generator's flash memory has been updated, the Progress bar and the % indicator on the downloader utility window will indicate 100%.
17. Switch the generator off. Set JW2 on the generator control board back to the "normal" position (short across pins 1-2).
18. Disconnect the null-modem cable and switch off the computer, if desired. The generator is now ready for use.

Dual-Speed Starter EPROM – For Board #728877-06

1. Switch the generator mains power OFF, and wait **5** minutes for the DC bus capacitors to fully discharged.
2. Locate and carefully remove the existing EPROM on the dual-speed starter board.
3. Carefully insert the replacement EPROM into the socket *observing the orientation per Figure 1-7 (see Chapter 1* - Pre-Installation*).*

Updating the Dual-Speed Starter Software – Board #903132-02

Updating the tube data on the 903132 DSS board is accomplished by inserting an EEPROM which contains the tube data files, into socket U31.

If there is a device present at U31 when the board is powered up, the board will update the stored data with the data from the EEPROM. The board will continue to operate with the stored data until an updated EEPROM is inserted at U31.

Follow the procedure below to update the tube data:

Warning:

- *Do not attempt to take exposures at any time while uploading software*
- *Ensure generator is off and de-energised before uploading software*

1. Insert the EEPROM* into U31 socket on the DSS Board. Verify that the EEPROM pin orientation is correct by checking its pin 1 location. **If the EEPROM orientation is wrong, it could get damaged and the generator could be damaged.**. Refer to Figure 1-7 *(see Chapter 1* - Pre-Installation of the CMP 200® DR Service and Installation Manual 901471*).*
2. Apply power to the DSS board by switching on the generator.
3. Ensure that HEARTBEAT LED DS5 is flashing at a very high speed, followed by *long on and short off* for a period of time.
4. Wait until the HEARTBEAT LED DS5 flashing rate changes to 1 Hz (0.5s on; 0.5s off).
5. Power off the generator.

6. The EEPROM at U31 can NOW be either removed from the socket or left in place.
7. Cycle the generator power OFF and then ON and observe that the HEARTBEAT LED DS5 is flashing as described in step 4.
8. Before placing the generator back into service, perform the Dual-Speed Starter Verification procedure found in the acceptance section of the service manual.

   ***EEPROM**- Electrically Erasable Programmable Read Only Memory

Resetting Factory Defaults

Resetting the factory defaults will restore the CPU's flash memory contents to their factory-default state. This will be required if a major firmware upgrade is done. Minor firmware upgrades, such as revision upgrades, do not require resetting of the factory defaults.

The factory defaults should not be reset casually as this will erase all custom programming made to the console or generator.

Note that there are separate procedures to reset the factory defaults for the console CPU and for the generator CPU.

CONSOLE CPU FACTORY DEFAULTS:

The procedure for loading console defaults is described in chapter 3C of this manual. Refer *to LOAD CONSOLE DEFAULTS*. This is described in the section *UTILITY MENU*, under *CONSOLE*.

To Set the Generator CPU Factory Defaults:

1. Switch the generator OFF at the console, and disconnect the mains voltage.
2. Remove the generator cover as described in chapter 2.
3. Locate S3 on the generator control board. Refer to the appropriate Figure in chapter 1, in the section *GENERATOR LAYOUT AND MAJOR COMPONENTS*.
4. Set S3-1 to the LOAD DEFAULTS (ON) position.
5. Switch ON the generator. After a brief period, the console will pause at the message **FACTORY DEFAULTS**.
6. Switch OFF the generator. Reset S3-1 back to the NORMAL (OFF) position.

   Note: Wait 5 minutes for the DC bus to discharge before powering up the generator.

7. Reprogram the tube selection to correspond to the connected tube as per *Tube Selection / Tube Setup* in Chapter 3, *Interfacing and Programming*. This information was initialized when the defaults were selected. This must be done before auto calibration is started, to prevent damage to the X-Ray tube.

8. Perform *Tube Auto Calibration* in Chapter 3, *Interfacing and Programming.* This must be done to ensure accuracy of the exposure parameters after the generator factory defaults have been loaded.

Note: The tube calibration sequence must be completed in full. If tube calibration is interrupted, the resulting mA / mAs values will be uncalibrated due to invalid calibration data.

This will initialize all generator data to the factory defaults [tube selection, generator limits (including anode boost time), receptor setup, I/O configuration, AEC setup, AEC calibration, tube calibration, time & date, error log, statistics and anode heat units].

Note: If the factory defaults have been set, critical parameters (i.e. anode boost time, etc.) must be manually re-programmed before operating the generator.

Dual-Speed Starter Compatibility Matrix

With the introduction of 903132-02 board, refer to this compatibility matrix when servicing the Dual-Speed Starter subassembly or the board assembly:

CMP 200® DR (all except DSS Assembly Tab -14)			
Sub (Plate) Assembly		**Board**	**Field Replacement / Upgrade Guide**
901297-02, 901297-12, 901297-13, 901297-15, 901297-16 (400VAC)	901298-02, 901298-12, 901298-13, 901298-15, 901298-16 (480VAC)	728877-06	Entire subassembly can be replaced by 906672 -21,-22,-23, in accordance with the latest revision of Stator Compatibility Tables 746026. Set SW3 (setting of line voltage and subassembly tab number) and SW8 (operating mode) accordingly. Board (only) can be replaced by 903132-02, but additional switches SW3 and SW8 must be configured as above. Subassembly tab remains the same.
906672-21, 906672-22, 906672-23		903132-02	Entire subassembly can be replaced by tabs of 901297 (400V) or 901298 (480V) in accordance with the latest revision of Stator Compatibility Tables 746026. Board (only) can be replaced by 903132-02. Board cannot be replaced by 728877-06 (board is not compatible with configurations of shift capacitors used).

CMP200DR (DSS Assembly Tab -14 only)		
Sub (Plate) Assembly	**Board**	**Field Replacement / Upgrade Guide**
902066-14,	728877-06 (EPROM 902072-00)	Entire subassembly can be replaced by 906672-14; caps are auto-switched and there is no need to configure the shift caps for "R" or "Q" stators manually. However, check the settings on SW3 (setting of "tab 14") and SW8 (operating mode). Board (only) can be replaced by 903132-02, but additional switches must be configured: SW3 (setting of "tab 14") and SW8 (operating mode). Subassembly number remains the same. Also check shift capacitor configuration for "R" or "Q" stators (capacitors must be manually configured, as before).
906672-14	903132-02	Entire subassembly can be replaced by 902066-14, but configure shift caps manually for "R" or "Q". Board (only) can be replaced by 903132-02. Board *cannot* be replaced by 728877-06 (board is not compatible with configuration of auto-switched shift capacitors used).

Note:

To avoid problems, CPI recommends using exactly the same subassembly or board assembly number.

SW1 **should always** be set according to 746026 and the Service manual 901471 (Installation chapter).

SW3 must always be set to the assembly Tab number (903132 boards only).

SW3-8 must also be set to the input line voltage (903132 boards only, **Tab -14 excluded and Tab -19 excluded**).

SW3-8 must also match the Auxiliary transformer line input voltage tap (400V or 480V) as set in the Installation chapter, section 2.10.1 of the Service Manual 901471.

Battery Replacement

Generator Control Board

The battery on the generator control board powers the Timekeeper SRAM chip U85 when the generator is switched off. This contains the real-time clock and the RAM memory that stores the tube heat-unit calculations. If the battery voltage drops below acceptable limits, the current date and time, along with the tube heat-unit calculations will be lost when the generator is switched off.

The AEC board will need to be temporarily removed to replace the battery, if the AEC option is fitted. Refer to 6.8.0 for the procedure to remove and replace the AEC board.

Insert the battery with the correct polarity as per the steps below. If the battery is inserted incorrectly, the CPU may report a low battery error message. If this occurs, remove and re-insert the battery with the correct polarity.

If the reversed polarity condition continues long enough, the battery may overheat causing leakage, rupture, fire or explosion and may cause personal injury.

Dispose of the old battery according to local regulations.

1. Perform the *Generator Configuration Backup* procedure in the *Interfacing and Programming* chapter of this manual. This will save the settings for the generator and the X-ray tube, the DAP calibration data, the AEC calibration data, the X-ray tube calibration data and so on.
2. Locate the battery on the generator control board. The battery is contained in a yellow plastic package that sits on top of the Timekeeper SRAM chip U85, near the middle of the generator control board.
3. Remove the battery by *GENTLY* prying between the battery and the generator control board. Be very careful not to damage the Timekeeper SRAM chip U85 that is directly under the battery.
4. Insert the replacement battery into the socket on U85. Orient the replacement battery such that the dot on the corner of the battery is near the dot on the generator control board (see Figure 6-3).

Figure 6-3: The orientation of the battery

5. If the error message "NVRAM ERR" (error code 03) is observed at initial turn-on after replacing the battery, perform the *Resetting Factory Defaults* procedure provided in this chapter. Otherwise, continue with step 6.
6. Perform the *Setting Time and Date* procedure in the *Interfacing and Programming* chapter of this manual.
7. Perform the *Generator Configuration Restore* procedure in the *Interfacing and Programming* chapter of this manual.
8. On the GenWare™ MP Toolbar, click the 

Report button to create the updated installation report.

AEC Board Removal and Installation

1. Switch the generator OFF at the console, and disconnect the mains voltage.
2. Disconnect the AEC chamber connections at the AEC board.
3. Disconnect the AEC control cable at J7 on the generator control board.
4. Locate the four nylon standoffs that secure the AEC board to the control board.
5. Turn the head of each plunger on the nylon standoffs approximately 90° counterclockwise.
6. Gently lift the AEC board off the nylon standoffs. Set the AEC board aside until the required components underneath are replaced. The AEC board should only be placed on a static-safe surface.
7. Reverse the above steps to replace the AEC board.

Tube Conditioning / Seasoning

Tube conditioning or "seasoning" is particularly important for new tubes or tubes that have not been used for several days. This should be performed on each X-ray tube before attempting auto calibration, as an unseasoned tube may not operate properly at higher kV values without arcing. Refer to the X-ray tube manufacturer's instructions, if available, for the tube conditioning or "seasoning" procedure. If the X-ray tube manufacturers instructions are not available, the following procedure may be used:

Tube Conditioning

The generator does X-ray tube auto calibration at 40 kV, 50 kV, 60 kV, 70 kV, 80 kV, 100 kV and 120 kV. The tube normally needs to be seasoned before it can be operated at the higher voltages encountered during auto calibration.

Tube seasoning is started by auto calibrating the kV stations up to and including part of the 70 kV station. The tube is then seasoned at 70 kV. Progressively higher kV stations are then auto calibrated and seasoned. Finally the entire kV and mA range is auto calibrated, then the tube is seasoned at the remaining high kV values.

Manually releasing the exposure button during auto calibration of a particular kV station in the following procedure prevents the generator from attempting operation beyond that kV/mA value.

Note: The tube manufacturer seasoning procedure recommended if available must always be used in place of the following procedure.

X-ray tubes that have not been used for more than 8 hours may suffer thermal shock if operated at high mA and kV without a warm-up procedure. A cold anode (Molybdenum) is very brittle and when suddenly heated over a small area may experience thermal cracking of the anode surface, eventually leading to permanent tube damage.

The procedure below is intended for seasoning an X-ray tube prior to attempting tube auto calibration. To season a tube that does not need to be calibrated, follow steps 2, 4, and 6.

X-ray tube seasoning should be done on LARGE focus in order to minimize tube wear.

1. Start the tube auto calibration sequence, and manually terminate the exposure at 70 kV and 250 mA.

2. Season the tube at 70 kV by taking approximately 10 exposures of 200 mA and 100 ms. These exposures should be taken at the rate of approximately one every 15 seconds.
3. Restart the auto calibration sequence and manually terminate the exposure at 100 kV and 250 mA.
4. Season the tube at 100 kV by taking approximately 5 exposures of 200 mA and 100 ms. These exposures should be taken at the rate of approximately one every 15 seconds.
5. Restart the auto calibration sequence and manually terminate the exposure at 120 kV and 160 mA.
6. Season the tube at 120 kV by taking approximately 5 exposures of 160 mA and 100 ms. These exposures should be taken at the rate of approximately one every 15 seconds.
7. Restart the auto calibration sequence and allow the auto calibration sequence to complete.

End of Product Life

The generator's useful life has been estimated at 10 years from point of sale.This will vary depending on use and environmental conditions. If the generator has completed its useful service life, local environmental regulations must be complied with concerning disposal of possible hazardous materials used in the construction of the generator.

In order to assist with this determination, the noteworthy materials used in the construction of this generator are itemized below:

Item:

- Electrical insulating oil in HV module. This is a mineral oil with trace additives (25 Litre (6.5 U.S. gal)
- Solder (lead/tin).
- Epoxy fiberglass circuit board materials, tracks are solder on copper.
- Wire, tinned copper. Insulated with PVC, tefzel, or silicone.
- Steel and / or aluminum (generator cabinet and console chassis).
- Plastic (console enclosure and console membrane).
- Electrical and electronic components: IC's, transistors, diodes, resistors, capacitors, etc.

Warning:

- *Do not disassemble, incinerate, or short-circuit the battery(s) in this product. Do not put it in trash that is disposed of in landfills; Dispose of it as required by local ordinances.*

- *The fluorescent lamp in the LCD display contains mercury. Do not put it in trash that is disposed of in landfills; Dispose of it as required by local ordinances.*
- *The LCD is made of glass. If the LCD breaks due to rough handing or dropping, and the internal fluid gets in your eyes or on your hands, immediately wash the affected areas with water for at least 15 minutes. Seek medical attention if any symptoms are present after washing.*

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Chapter 7 Theory of Operation

Contents

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Introduction

This chapter contains the theory of operation for the CMP 200®and CMP 200® DR X-ray generators. The theory of operation is organized by functional blocks as per the functional drawings in Chapter 10, *Functional Drawings*.

Functional Theory of Operation

Refer to the appropriate functional block diagram in Chapter 10 in conjunction with the theory of operation in this chapter. Waveforms and voltages at the pertinent test points are typically shown on the last page of each functional drawing.

System ON (MD-0928)

The generator control board on the CMP 200® series of X-ray generators includes power ON and power OFF switches S1 and S2 that may be used to switch the generator on and off locally while working on the equipment. These switches are connected in parallel with the generator ON and OFF switches that are located on the consoles.

Pressing any of the Power-ON switches turns on Q5 on the generator control board. This turns on Q6, holding the collector of Q6 low. This latches Q5 in the “on” state by holding the base of Q5 low when the ON switch is released.

The collector of Q6 is connected to K1 on the generator control board (MD-0927). K1 will be energized when the generator is switched on, supplying +24 V to the console.

With Q6 turned on, the base of Q7 is held low, turning Q7 off. The collector of Q7 is connected to the ON / OFF control pins on the +5 V, +12 V, and +15 V switching regulators on the generator control board (MD-0927). With Q7 turned off, the regulator control pins will be pulled to a logic high state, enabling the low-voltage supplies on the generator control board (MD-0927).

In normal operation, a wire jumper is connected between J2-1 and J2-2 on the generator control board. An emergency-off switch may be connected to the generator by removing the jumper between J2-1 and J2-2, and then wiring the emergency-off switch to J2-1 and J2-2. If the connection between J2-1 and J2-2 is open-circuit (i.e. no jumper or an open emergency-off switch), K2 will be de-energized as shown. This holds the base of Q6 low, preventing Q6 from turning on.

A supervisory circuit (not shown) monitors the +1.2 V, +3.3 V, and +5 V DC supplies on the generator control board. The supervisory circuit releases the CPU reset line when these low voltage DC supplies are detected at start-up. This causes the CPU to enter its startup sequence. The CPU will initialize itself, perform its startup diagnostics, and then output a command via U86 and U83 on the generator control board to energize soft-start contactor K2 on the H.V auxiliary board. The CPU will then wait for approximately 10 seconds for the output of opto-coupler U5 on the H.V auxiliary board to ramp high, indicating that the DC bus capacitors are charged. If U5 indicates proper DC bus capacitor charging within the allotted time, the CPU will output a command to U86 and the driver consisting of Q28, Q29, etc to energize the main power contactor via the H.V auxiliary board. Soft-start contactor K2 will be de-energized after a maximum of 10 seconds, as the soft-start circuit is not needed once the DC bus capacitors are charged.

If opto-coupler U5 on the H.V auxiliary board does not indicate normal DC bus capacitor charge within the allowed time limit, an error message will be presented and the turn-on sequence will be aborted.

Pressing any of the power-OFF switches turns on Q4 on the generator control board. This turns off Q5, turning off Q6. This will de-energize K1 on the generator control board, removing the +24 V supply from the console. With Q6 turned off, Q7 will turn on, taking the ON / OFF control lines on the +5 V, +12 V, and +15 V regulators low. This disables the switching regulators, shutting down the generator control functions. The main power contactor will open, removing the AC input to the mains rectifier assembly.

DC Bus & Power Distribution (MD-0927)

Sheet 1 applies to single-phase generators:

Assuming that the AC mains is connected and switched on, line voltage is applied to the primary of the auxiliary transformer via F8 and F9 on the H.V auxiliary board. This will establish the +/-35 V supplies via F1 and D1, and the +24 V supply via F2 and F3, and D3 / D4.

When the generator is switched on as described in the section, *System ON*, +24 V is supplied to the consoles via K1 and F2 on the generator control board. For the membrane console, the +24 V supply is regulated to +5 V and -20 V on the console board (page 4). The touchscreen console is powered from the +24 V supply; on-board regulators step this down as required by the internal circuits. The low voltage DC supplies on the generator control board are also established when the generator is switched on, as per the section, *System ON*.

K2 on the H.V. auxiliary board will be energized when the soft-start command is received from the CPU. This will pre-charge the DC bus capacitors via F4 and F5, K2, D5 and series current limiting resistors. The DC bus charging current flows through R17, developing sufficient voltage drop to energize U5. At the start of DC bus capacitor charging, current through R17 is at its maximum. U5 will be on at all times except near the zero crossing of the AC current waveform. The output of U5 will as per Figure 1 on page 5 of MD-0927 (early charging). As the bus capacitors approach a fully charged state, the current in R17 will approach zero. U5 will only be on near the peaks of the AC current waveform, and the output of U5 will as per “nearly finished charging” in Figure 1 on page 5 of MD-0927. When the CPU detects the “nearly finished charging” state via U5, the main power contactor and the cooling fan will be energized. The chassis-mounted mains rectifier assembly to produce approximately 320 VDC for 230 VAC input then rectifies the line voltage. The inverter board to produce the drive for the primary of the HV transformer as described in the section, *kV Control and Feedback (MD-0932)* switches the DC bus voltage.

LED DS1 on the H.V. auxiliary board confirms the presence of the +24 VDC supply, and DS1 on the EMC capacitor board indicates that the DC bus is charged.

The *BUCKY DRIVE* output may be configured for +24 VDC, 110 VAC, or 220 VAC. Connecting E11 to E5 and E7 to E8 supplies +24 VDC, wiring E9 to E5 and E7 to E8 supplies 110 VAC, and jumpering E12 to E5 and E7 to E8 outputs 220 VAC.

K6 on the H.V. auxiliary board will be energized when the +12 V supply on the generator control board is present, supplying +24 VDC, 120 VAC, or 240 VAC to the Bucky drive circuits (section, *Room Interface*).

The low-speed starter boost voltage is jumper selectable to be 120 or 240 VAC. Connecting E16 to E15 selects 240 V boost, and jumpering E14 to E15 selects 120 V boost.

As described in the section, *System ON*, the +5 V, +12 V, and +15 V switching regulators become operational when the generator is switched on. The –12 V, +1.2 V, and +3.3 V supplies are derived from the +12 V and +5 V supplies, respectively.

Sheet 2 applies to three phase 208 / 230 V generators:

With respect to MD-0927, the operation of three phase 208 / 230 V generators is similar to that described above for single-phase generators.

Sheet 3 applies to three phase 400 / 480 V generators:

With respect to MD-0927, the operation of three phase 400 / 480 V generators is similar to that described for single-phase generators.

The rectified DC bus voltage for 400 VAC units will be approximately 560 VDC, or approximately 670 VDC for 480 VAC units.

Refer to MD-0927, sheet 4:

Sheet 4 applies to all units. For the membrane console, the +24 V supply is regulated to +5 V, +3.3 V, +1.2 V, and -20 V via F1 on the console board. The console board contains a 300 VAC (approximately) power supply that drives the cold-cathode fluorescent lamp in the LCD display assembly. This power supply is driven from the +5 VDC supply.

The touchscreen console is powered from the generator's +24 V supply; on-board regulators step this down via F3 on the touch-screen board as required by the internal circuits.

Sheet 4 also shows the low-voltage DC power supply connections to the filament board and to the AEC board.

Room Interface (MD-0930)

+24 VDC, 120 VAC, or 240 VAC for the *BUCKY DRIVE* is available when K6 on the H.V. auxiliary board is closed as described in the section, *DC Bus & Power Distribution (MD-0927)*. The 24 VAC and 24 VDC supplies are present at all times that the AC mains is energized. The 24 VAC supply is fused by F11 and brought out at J11-6 and J11-5 on the H.V. auxiliary board (maximum 150 watts for collimator use), and the 24 VDC supply is fused by F12 and made available at J11-2 and J11-1 for system locks use (maximum 45 watts).

Bucky relays K1 and K3 on the H.V. auxiliary board are driven by U83 and U86 on the generator control board. When K1 or K3 is energized, +24 VDC, 120 VAC, or 240 VAC is provided at J2-7 or J4-1 on the H.V. auxiliary board to start Bucky 1 or Bucky 2.

The Bucky 1 or Bucky 2 ready signal (a contact closure is needed) will energize opto coupler U2 or U6 respectively. The Bucky-ready status from U2 / U6 is conveyed to the CPU via data buffer U89, where it is processed to determine if the Buckys are ready to make an X-ray exposure.

During an X-ray exposure, the base of Q31 on the generator control board is pulled high via U19. This will turn on Q31, energizing K7 on the H.V. auxiliary board. K7 provides a dry contact closure when energized, which may be used to control the room light.

The H.V. auxiliary board also contains 4 interlock inputs. These include interlocks 1 and 2, the door interlock, and the X-ray tube thermal switch interlock. Each of these interlock inputs requires a contact closure to indicate a normal condition, with a closed interlock energizing the associated opto coupler U1, U3, U4, or U9 respectively. The CPU via data buffer U89 on the generator control board reads the outputs of the opto-couplers, where the information is used to determine the readiness of the associated input.

X-ray Exposure (MD-0931)

Refer to MD-0931, sheet 1:

The PREP and X-RAY switches on the membrane console are connected in parallel with the console-mounted hand switch, as shown on drawing MD-0931. The PREP and X-RAY switches on the touchscreen console, the X-ray mini-console, and on their associated hand switches are connected to the inputs of U8 and U9 on the generator control board, respectively.

Pressing PREP on the membrane console will energize opto coupler U16 on the console board. If U16 is energized, or one of the PREP switches on the touchscreen console, X-ray mini-console, or on the associated hand switch is pressed, U8 on the generator control board will be energized. The console CPU (FPGA) reads the output of U16 on the console board, and the generator CPU via data buffer U71 reads the output of U8 on the generator control board. A prep request will be recognized if the output of U16 on the console board (membrane console only) and / or U8 on the generator control board is low. DS5 on the generator control board will light to indicate that a prep request has been made.

Pressing X-RAY on the membrane console will energize U17 on the console board. If U17 is energized, or one of the X-RAY switches on the touchscreen console, X-ray mini-console, or on the associated hand switches is pressed, U9 and U7 on the generator control board will be energized. The console CPU reads the output of U17 on the console board, and the generator CPU via data buffer U71 reads the output of U7 on the generator control board. An X-ray request will be recognized if the output of U17 on the console board (membrane console only) and / or U7 on the generator control board is low. When the generator CPU receives an X-ray request, the emitter of U9 on the generator control board will be pulled low via U86 and driver U83, assuming that there are no errors that would prevent an exposure. With U9 on the generator control board energized, and its emitter held low, the collector of U9 will be held low.

Jumpers JW1 and JW2 on the console board (membrane consoles) may be removed to disable the console PREP and X-RAY buttons. If these jumpers are removed, PREP and X-RAY requests may be made via a hand switch connected to J3 on the membrane console.

Refer to MD-0931, sheet 2:

The collector of opto-coupler U9 on the generator control board (page 1) is OR'ed with several other signals on the generator control board, all of which must be at the correct logic level in order to be able to make an X-ray exposure.

- The base of Q27 on the generator control board must be held low to allow an exposure. This requires the following conditions:
  - The output of U65 must be low, indicating that the CPU has detected no fault.
  - The ***X-RAY ENABLE*** command from U9 (page 1) or U11 (MD-0926) must be low.
  - The HV module must be connected, holding the line connected to TP17 low.
- The base of Q26 must be held low by U67, indicating a valid X-ray request.

With the base of Q26 and Q27 held low, Q26 and Q27 will be off. The line connected to TP16 on the generator CPU board will then be pulled high via R91, pulling the control inputs on AND gates U26A and U26B on the generator control board high, as described in 7.2.5.

Lastly, with the output of U67 on the generator control board low, the collector of Q21 will be high. This turns Q22 off, isolating Q22 from the kV demand circuit, part of the section, *kV Control and Feedback (MD-0932)*.

kV Control and Feedback (MD-0932)

Refer to MD-0932, sheet 1:

When there is no X-ray request by the CPU, the ***RAD INHIBIT*** line from MD-0931 will be pulled high. This circuit is described in the section, *X-ray Exposure (MD-0931)*. When the ***RAD INHIBIT*** line is high, the junction of R131 / R123 on the generator control board will be held high (+12 V). This ensures that the error amplifier cannot generate any kV demand.

When a valid X-ray request is received, the ***RAD INHIBIT*** command is removed and the D/A converter U43 will produce the required kV reference voltage. The kV reference voltage is buffered by U38A, inverted by U48A, and then summed with the positive going kV feedback signal from U51B at the input of error amplifier U25A. Error amplifier U25A will regulate the kV by producing a DC output that is proportional to the difference between the kV reference voltage and the kV feedback voltage.

The kV demand signal and the kV feedback signals are also processed by U72A, U72B, and Q25. The result is an ***HV ON*** signal at the output of Q25 that is high when the actual kV is greater than approximately 75% of the demanded kV.

The HV primary current is sampled by T2 and rectified by D33, D36, D38, and D42 to produce a current limit signal (a negative voltage proportional to the primary current). This is applied to the input of U25B, where it will limit the kV demand if the primary current exceeds safe limits. This current limit signal is also fed to comparator U69, which generates a fault pulse if excessive primary current is sensed. This fault pulse is fed to the CPU via U78, immediately causing the gate drive to be inhibited, preventing inverter damage due to the over-current condition.

The output of U25B swings increasingly negative for increased kV demand. This kV demand voltage is buffered and inverted by U33A, and then applied to the VCO (voltage controlled oscillator).

The VCO generates complementary output pulses that vary in frequency. The frequency of these pulses is inversely proportional to demanded generator output power. The current sense feedback from T1 synchronizes the start of the pulses.

The gate-drive pulses from the VCO are fed to AND gates U26A and U26B. The control inputs of U26A and U26B are held high if all logic conditions to allow an X-ray exposure are satisfied. The drive pulses are inverted and level shifted by U27A and U27B, and then applied to the gates of the MOSFET inverter consisting of Q16, Q17, Q19, and Q20 on the generator control board. These MOSFETS form a full bridge inverter circuit that outputs high frequency gate pulses to the power MOSFETS on the inverter board(s) via J5 and / or J13 on the generator control board.

The differential kV feedback voltage from the HV module is brought to J9 on the generator control board. This is applied to the inputs of U51A and U56B, where the kV feedback scaling is precisely set by R218. The differential feedback signals are then summed by U51B. The output of U51B supplies a kV feedback signal to error amplifier U25A as described earlier in this section. The kV feedback signal is also supplied to the CPU via A/D converter U45, which monitors the output voltage during an exposure. Lastly, the kV feedback signal is fed to the kV over-voltage comparator U55, which will send a fault pulse to the CPU via U78 if a kV over-voltage condition is detected.

The generator control board also contains circuits that guard against an inverter “shoot-through” fault. If a shoot through fault is detected, T3 and / or T4 on the generator control board will supply a current pulse that is detected by comparator circuits U70 and U75. The relevant comparator will then generate a fault pulse that is passed to the CPU via U78, causing the gate drive to be inhibited immediately, thus preventing inverter damage due to this fault.

Refer to MD-0932, sheet 2 and 3:

The inverter board(s) produce the high power drive for the HV transformers (32 and 40 kW generators use one inverter board, 50 kW and 65 kW units use two inverter boards). The output of the inverter board(s) drive the primaries of the HV transformers via the resonant / sharing inductors and the resonant capacitor and a current transformer that samples the HV primary current.

The HV module has similar anode and cathode sections. The cathode and anode sections each have their own high voltage transformer and high voltage multiplier board. The anode section generates the anode voltage, 0 to 62.5 or 75 kV. The cathode section generates the cathode voltage, 0 to -62.5 or -75 kV. The anode and cathode sections contain voltage dividers that supply kV anode and cathode feedback voltages. The kV feedback from the HV module is brought to J9 on the generator control board as described earlier in this section.

The HV module is not field-repairable. Defective HV modules must be replaced as a complete unit with the factory-specified replacement.

Filament Drive and mA Control (MD-0934)

Refer to MD-0934, sheet 1:

D/A converter U42 on the generator control board will produce the filament reference voltage (1 volt = 1 amp of filament current) when the CPU receives a valid Prep command. This is buffered by U32B and then routed to the filament supply board via J14 on the generator control board.

The filament reference voltage is fed to U4B on the filament supply board. The output of U4B is summed with the output of current limit clamp U4A. The filament current limit is set at 5.5 or 6.5 amps via JW2-11&12; it is shown set to limit at 5.5 amps on MD-0934 (the jumper is not connected).

Next, the filament reference voltage is summed with the filament feedback voltage at the input of error amplifier U5A. When the reference voltage is greater than the feedback voltage, the output of U5A rises, causing the pulse width at the output of U3 to increase.

PWM (pulse-width modulator) U3 drives MOSFETS Q4, Q5, Q6, and Q7, which form a full bridge inverter. The MOSFETS convert the + and - 35 V supplies to high frequency AC to drive the primary of the filament transformers at the filament switching frequency, approximately 42.5 kHz, via C70, the primary of T1, large / small filament select relay K1, J5 on the filament supply board, and J4 on the high voltage module lid board. The Oscillator Frequence Setting circuit determines the value (42.5 kHz) of filament switch frequency. When JW1-1&2 as shown in the drawing is connected, the value of the frequency is set to 42.5 kHz.

The secondary of the filament transformers provides high voltage isolation, and drive the filaments via the filament mounting board and the cathode high voltage connector as shown.

The output of filament current sense transformer T1 on the filament supply board is rectified by D11, D12, D13, and D14, and fed to RMS converter circuit consisting of U7,U8 and associated components. The output of the RMS converter drives U5B, which is a variable gain amplifier. The filament current feedback is calibrated such that 1 volt = 1 amp of filament current. The calibrated filament feedback voltage (representing actual filament current) appears at the input of buffer U6A, at the summing input of error amplifier U5A as described earlier in this section, and at the input of comparator U6B.

The output of U6A is brought to J2-2 on the filament supply board. The filament current feedback signal is then converted to a digital signal by A/D converter U45 on the generator control board in order that the filament current can be monitored by the CPU.

The output of U6B will be low if a filament fault is present, i.e. filament current less than approximately 1.8 amps. This will turn Q9 on the filament supply off, taking its collector high. The output of Q9 is taken to the CPU via U78 on the generator control board. If low filament current is detected, X-ray exposures will not be possible, and a filament fault message will be displayed.

Refer to MD-0934, sheet 2:

When an exposure is in process, X-ray tube current flows through series resistors on the HV anode and cathode boards. The voltage developed across these resistors, which is proportional to the X-ray tube current, is taken to J9 on the generator control board. Transient protectors on the high voltage boards clamp the voltage across the series resistors during high voltage arcs.

The grounded mid-secondary circuit in the HV module is connected to the mA test jacks E17 / E18 on the high voltage module lid board. Transient protectors on the high voltage module lid board clamp the voltage across the mA measuring device during high voltage arcs, and prevent the voltage at E17 and E18 from rising above approximately 15 volts if the ma test jack is removed and no measuring device is connected.

The anode mA feedback that appears at J9-1 and J9-2 on the generator control board is scaled approximately 0.4 volts = 100 mA of anode current, and is applied to the input of differential amplifier U68B.

The output of U68B is taken to comparator U47, which detects high anode mA. U47 will send a fault pulse to the CPU via U78 if an anode over-current condition is detected, causing the kV output to be inhibited immediately, thus preventing generator damage due to the over-current fault.

The output of U68B is also fed to the input of U68A, which provides a scaled mA feedback voltage. The mA is calibrated by R160 such that 1 volt = 100 mA at the output of U68A. The output of U68A is taken to the data bus via A/D converter U45, and also to voltage amplifier U74A, which provides a better quality (higher gain) feedback signal at low anode currents. The CPU to regulate the X-ray tube mA and to perform mA monitoring functions during exposures uses the mA feedback information.

The cathode mA feedback at J9-4 and J9-3 on the generator control board is used for cathode over-current detection only. The cathode mA feedback is fed to the input of differential amplifier U56A. The output of U56A is taken to comparator U50, which detects high cathode mA. U50 will send a fault pulse to the CPU via U78 if a cathode over-current condition is detected, inhibiting the X-ray exposure, thus preventing generator damage due to the over-current fault.

Low-Speed Starter (MD-0935)

120 or 240 VAC is supplied to the low-speed starter via F6 and F7 on the H.V. auxiliary board. This voltage is jumper-selectable on the H.V. auxiliary board; refer to MD-0927 for details.

The coil of K4 on the H.V auxiliary board is connected in parallel with the main power contactor, and therefore is energized when the main power contactor is energized after completion of the generator power-on sequence. This is described in the section, *System ON*.

When a Prep request is made, the CPU via U86 and driver U83 on the generator control board energizes K5 on the H.V. auxiliary board for the **ROTOR BOOST** duration that was selected in the **GENERATOR LIMITS** menu (chapter 3) in order to boost the rotor. The rotor is allowed to coast briefly, and then boosted again for approximately 500 milliseconds every 5 seconds during Prep in order to maintain normal anode rotation. During the boost cycles (when K5 is energized), 120 or 240 VAC is applied directly to the main winding and to the shift winding on the stator via the chassis-mounted phase shift capacitor.

The main and shift currents flow through R20 and R19 on the H.V. auxiliary board, respectively, energizing opto couplers U7 and U8 if there is sufficient stator current. Normally, the opto couplers will only conduct during the peaks of the stator current. This is reflected in the output waveform of the opto couplers at TP8 and TP7 as shown on page 2 of MD-0935. If there is low (or no) stator current, U8 and / or U7 will not be energized. The output of the opto couplers at TP8 / TP7 will then be pulled high (+5 V). This steady-state condition (+5 V) is detected by the CPU via U89 on the generator control board, where it is recognized as a rotor fault.

Dual-Speed Starter - Board Number 728877-06 (MD-0924)

The generator CPU decides whether the pending exposure should be made at low-speed or high-speed operation. Based on this determination, the CPU will output the high-speed / low-speed command via U86 and U83 on the generator control board. The output of U83 lights DS10 on the generator control board, and energizes U12 on the dual-speed starter board. The dual-speed starter CPU monitors the output of U12, and sets low or high-speed operation based on the state of U12.

The prep command is also output by the generator CPU and latched by U86. Driver U83 lights DS11 on the generator control board, and energizes U13 on the dual-speed starter board. The dual-speed starter CPU monitors the output of U13, and starts the boost cycle when the output of this opto coupler is low.

K1 on the dual-speed starter board will close at the start of the prep cycle. K4 will close at the same time that K1 is energized. This ensures that the high voltage is isolated from the stator terminals at all times except during normal operation of the dual-speed starter.

The dual-speed starter contains an inverter, Q1 to Q4, which produces the required stator current at 50, 60, 150, or 180 Hz by precisely switching the 560 / 650 volt DC bus. The dual-speed starter CPU controls the switching of the inverter via the driver circuit consisting of U1-U9 and T1-T4, etc. The setting of DIP switch SW1 determines all stator drive parameters (boost voltage and boost time, run voltage, brake voltage and brake time, etc).

The modulated output from the inverter is fed to the common stator terminal via one leg of the inverter and via K4. The shift and main currents are taken from the other leg of the inverter via K5 and K6. K1-A switches the main current, and K1-B switches the shift current.

The following description applies to dual-speed starters 901297-12, 13, 16 and 901298-12, 13, 16 only. Relay K3 is held open for high-speed operation and closed for low-speed operation. The dual-speed starter will automatically set K7 open or closed based on the setting of DIP switch SW1, selecting one-of-two possible capacitor values. The available capacitor values are shown in the tables on MD-0924.

The operation of dual-speed starter 901297-15 and 901298-15 is similar, except that relay K7 is always held open during low-speed operation, providing 28μF of low-speed capacitance. It is also possible to configure this starter to provide 15.5μF of low-speed capacitance by removal of one of the low speed capacitors. One-of-two possible value of high-speed capacitance is automatically selected using K7.

The operation of dual-speed starter 901297-02 and 901298-02 is similar, except that K7 is not used, resulting in only one value each of low-speed capacitance (60μF) and high-speed capacitance (20μF).

The DC bus current is monitored by a circuit consisting of CS1, U10, U11, etc. If a problem such as a ground fault in the stator circuit is detected, a latch in the inverter fault detector circuit will be set. This will light DS1 and inhibit the drive pulses for the inverter Q1 to Q4.

The contacts of current sense relays K5 and K6 will be closed when the main and shift currents are above preset limits. With K5 and K6 closed, Q5 on the dual-speed starter board is supplied with base current. This will turn on Q5, whose output is monitored by the dual-speed starter CPU. If normal stator current is detected, the CPU will output a logic low signal at J1-10 on the dual-speed starter board. This stator-ready signal drives opto-coupler U88 on the generator control board, turning U88 on in the normal (no stator-current fault) state. DS9 will be on at prep in low speed mode, and on after prep is finished in high-speed mode. The generator CPU reads the output of U88 via U87 on the generator control board. A stator fault condition will immediately remove the generator ready and drive-enable signals, inhibiting kV output. Additionally, the dual-speed starter CPU will open K1 and K4 on the dual-speed starter board, removing the stator drive.

Dual-Speed Starter (DSS 2, New Version) – Board Number 903132-02 (MD-1069)

Power is supplied from J18 of the generator control board to J1 of the dual-speed starter board. This 12VDC is used to supply the circuits that drive gates and relays and is also converted to power the low voltage logic circuits requiring 5VDC (linear regulator)and 3.3VDC (switching regulator).

The setting of DIP switch SW1 determines the tube type, all stator drive parameters, i.e., boost voltage and boost time, run voltage, brake voltage and brake time, etc. The Microcontroller will read its setting during PREP to determine the configuration and operating mode of the dual-speed starter board. It will use this information to decide which relays to drive, as well as the drive parameters used for a particular tube. These parameters are stored within the DSS microcontroller.

The dual-speed starter board will operate in legacy mode when installed in a CMP200DR. In legacy mode, the generator CPU will determine whether the pending exposure should be made at low-speed or high-speed operation.

The generator CPU will output the Prep command and the high-speed / low-speed signals to the DSS. The Microcontroller on the dual-speed starter board via J1 and the Opto-isolators will receive the signals. Indicator DS7 will light while the PREP signal is active. DS8 will also light while the High Speed signal is active.

The Microcontroller will start the boost cycle in low or high-speed operation based on the state of the signals.

The DSS ready command is sent to the main CPU through J1 on the dual-speed starter board to J3 on the generator control board. When the dual-speed starter is ready, DS9 on the generator control board lights up.

DC bus voltage used to power the inverter is brought from E10 and E11 of the EMC Board to E9 and E10 of the dual-speed starter board and is measured by the Current Sensors. The outputs of the Current Sensors are sent to comparators. If the current is too high, the Flip-flop will latch into a state that shuts down the gate drive circuits preventing damage. At the same time during this state, the Microcontroller receives this status with the Bridge Inverter shut down, DS1 will be lit, indicating an inverter fault, inhibiting further operation until the error is cleared through a generator restart.

The dual-speed starter contains an inverter, IGBT Switches, which produces the required stator current at 50, 60, 100, 120, 150 or 180 Hz by precisely switching the 560 / 680 volt DC bus. The Microcontroller on the dual-speed starter board controls the switching of the inverter via the FET Driver Circuit.

To drive the anode of the X-ray tube, the DC bus voltage is modulated to produce a sinusoidal voltage, the value of which is calculated by the Microcontroller using pulse width modulation to provide the tube the right amount of drive, via gate drive lines Driver 1 and Driver 2. These drive signals are *ANDed* with the *Enable* signal, whose state is determined by the Microcontroller depending on the status of the generator. Furthermore, if one of the drive signals is locked up at a wrong state or the 12V supply to the DSS is too low, the FET driver circuit and fault current circuit will latch a value disabling the *Enable* signal. The Enable signal informs the Microcontroller the status of the gate drives whether the gate drives are enabled or disabled.

The main and shift currents of the tube are also measured. These values are sent to the microcontroller for monitoring. If the values are outside of their normal range, the *Enable* signal is disabled, the Microcontroller on the dual-speed starter board sends the error status and error message to the generator CPU board, and consequently inhibiting further generator operation.

K1 on the dual-speed starter board will close at the start of the prep cycle. K4 will close at the same time that K1 is energized. Both K1 and K4 will be open in standby state. This ensures that the high voltage is isolated from the stator terminals at all times except during normal operation of the dual-speed starter.

The modulated output from the inverter is fed to the common stator terminal via one leg of the inverter and via K4. The main current is taken from the other leg of the inverter passing the current sensor into K1-B for tube 1. The main current branches off to the shift capacitors whose output is measured by current sensor and into K1-A for tube 1.

The Shift Capacitor Selection Circuit relays determine the shift capacitance, which is required by the X-ray tube stator windings.

- Push button Switches SW4 and SW5 may be used to test the dual-speed starter circuits for tube 1 in both low and high-speed modes. These inputs go directly to the microcontroller.
- DS5 will flash at a 1 Hz rate to indicate that the Microcontroller is operational.
- The settings for SW1 are described in chapter 2 of this manual.
- The 7-segment display made by DS 2A-2G and DS2DP will display error codes. For the details of the error information, see troubleshooting section, chapter 5 of this manual.

Automatic Expsore Control (AEC), MD-0936

Refer to MD-0936, sheet 1:

Sheet 1 shows the circuits on the generator control board that provide the interface between the generator CPU and the AEC board. Eight lines supply the AEC chamber select signals, the start signal, and the field select signals to the AEC board via U90 and driver U91. The AEC ramp (*PT RAMP*) from the AEC board is voltage-amplified by a factor of approximately 20 by U66B and compared to the AEC reference voltage by U73. The output of U73 is normally high, switching low when the magnitude of the AEC ramp is approximately 5% of the AEC reference voltage. This step change at the output of U73 is detected by the CPU via U71, and is used by the CPU to generate an error message if the trajectory of the AEC ramp is such that the AEC exposure will exceed the AEC backup time.

The AEC reference voltage is generated by D/A converter U44, buffered by U38B, and fed to comparator U73 and to the AEC board via J7-10. The magnitude of the AEC reference voltage is determined by the CPU (based on the upcoming exposure), and will be a value between 0 and 10 volts.

The PT stop signal is generated by the AEC board when the magnitude of the AEC ramp is equal to the AEC reference voltage, and indicates that the desired AEC exposure should be terminated. The PT stop signal is routed via U71 to the CPU, where it will terminate the AEC exposure immediately when this signal is received.

Refer to MD-0936, sheet 2:

This is the functional schematic of AEC assembly 734614, used with various ionization type AEC chambers. The AEC chambers are connected to J1/J11, J2/J12, J3/J13, and / or J4/J14. The AEC board will either be fitted with 12-pin in-line connectors, or 15-pin 'D' connectors, depending on the application. The AEC signal from the AEC chamber(s) is routed to the input of analog switches S1A to S1D on the AEC board. These analog switches are controlled by the chamber-select signals.

The chamber-select signals originate on the generator control board as per sheet 1. Only one chamber may be active at one time, and DS1 to DS4 on the AEC board indicate which channel is active. The chamber-select signals are inverted by U3B, U3C, U3D, and U3F; and connected to the control inputs of the analog switches described in the previous paragraph. The analog switch corresponding to the selected AEC input channel will be closed when that channel is selected, thus connecting the AEC signal to preamplifier U1A, which provides voltage gain. The input of U1A will be configured such that U1A is a non-inverting amplifier for use with AEC chambers that have a positive going output, and as an inverting amplifier for use with chambers with a negative voltage output.

The start signal also originates on the generator control board. This signal, when active, will light DS5 on the AEC board. The start signal is buffered and inverted by U3E and U3A, and will be logic low at the output of U3A when the start signal is active. This opens the analog switch that is part of the sample and hold circuit at the input of U2A during an AEC exposure. This analog switch is closed at all other times. The sample and hold circuit will sample any electrical noise at the output of U1A during standby operation, and subtract this noise from the AEC signal during an AEC exposure. This ensures that the output of U2A is proportional to the AEC chamber output voltage only, and is not influenced by noise.

The output of U2A connects to the common inputs of analog switches S2A to S2D. These analog switches are controlled by the chamber-select signal, and the switch corresponding to the active channel will be closed. This connects the output of U2A to the AEC gain adjustment potentiometer R1 to R4 corresponding to the active channel. The AEC signal, which will be either a ramp or a DC voltage depending on AEC chamber type, is now fed to the input of U2B. This will be factory configured as an integrating amplifier by connecting C4 into the circuit for use with AEC chambers that output a DC output voltage, or U2B will be configured as a linear amplifier by connecting R32 into the circuit for use with AEC chambers that provide a ramp voltage. The start signal also connects to analog switch S4. This switch opens when an AEC exposure starts, allowing U2B to start integrating or amplifying the AEC signal.

The output of U2B will be a positive going ramp regardless of the AEC chamber type in use. This ramp voltage is processed by U4A and U4B, and also fed to the short AEC exposure time compensation circuit consisting of R11 to R14, S3A to S3D, R53 and C11. Analog switches S3A to S3D are controlled by the chamber-select signal. The switch corresponding to the active channel will be closed, connecting the phase-lead network C11 / R53 to the wiper of the AEC short-time adjustment potentiometer. This circuit is disabled when the wipers of R11 to R14 are at the ground end of the potentiometers, and maximum short-time compensation is provided when the wipers are set to the end of the potentiometers connected to U2B.

The AEC ramp from U4B is taken to the generator control board where it is processed as described earlier in this section, and also fed to comparator U6 on the AEC board where it is compared to the AEC reference voltage. The output of U6 is normally high, switching low when the magnitude of the AEC ramp equals the reference voltage. This PT stop signal is further processed on the generator control board.

The START, and LEFT, MIDDLE, and RIGHT field select signals are brought to the AEC chambers via J1/J11, J2/J12, J3/J13, and J4/J14. The AEC board will be factory configured to directly output the active low signal from the generator control board to the AEC chamber if required, or to output +12 V or +24 V if the chamber requires active high signals. For AEC chambers that require active high outputs, the start, right, middle, or left field select signal is taken from the collector of Q1 to Q4, respectively. The active low signals from the generator control board turn on Q1 to Q4, outputting either +12 V or +24V (depending on factory configuration) at the collector when active.

Jumpers JW1 to JW8 swap the left and right fields on J11 to J14. Jumpering pins 2-3 of the field selector jumpers (JW7 / JW8 for channel 1, JW5 / JW6 for channel 2, JW3 / JW4 for channel 3, JW1 / JW2 for channel 4) connects the left field select signal to pin 6 and the right field select signal to pin 2. Jumpering pins 1-2 of the field selector jumpers connects the left field select signal to pin 2 and the right field select signal to pin 6.

The AEC board also contains a DC to DC converter that produces +45 V, + or - 300 V, and +500 VDC. The converter circuit consists of U7, T1, output voltage adjustment potentiometer R79, and associated components. The +45 V output is hard wired to all of the AEC chamber connectors, and + or - 300 V is permanently connected to J1 to J4. Additionally, the AEC board will be factory configured to supply either + or - 300 V or +500 V to J11 to J13, and to a second pin on J1 to J4 (in addition to the + or - 300 V fixed output).

Refer to MD-0936, sheet 3:

This page shows the input circuits for AEC board assembly 737992. This board is used with solid-state AEC chambers. The AEC chamber outputs are connected to the anode and cathode inputs of J1/J11, J2/J12, J3/J13, and / or J4/J14. The AEC board will be fitted either with 7-pin in-line connectors, or with circular style connectors, depending on the application. U2A, U2B, U8A, U8B, U16A, U16B, U3A, U3B, U9A, U9B, U17A, and U17B are extremely high gain preamplifiers that convert the current output from the AEC diodes (several hundred pico amps, typically) to a useable voltage.

The output of each preamplifier is connected to an analog switch used for field selection. Selecting the desired field closes the corresponding analog switch, connecting the output of that preamplifier to the summing node at the junction of R69, R9, R22 for channel 1, R40, R47, R55 for channel 2, R70, R11, R23 for channel 3, and R41, R49, R56 for channel 4.

JW1 to JW8 swap the left and right fields. Jumpering pins 1-2 of the field selector jumpers (JW1, JW2 for channel 1, JW3, JW4 for channel 2, JW5, JW6 for channel 3, JW7, JW8 for channel 4) selects the normal left-right orientation, and jumpering pins 2-3 of the field selector jumpers reverses the left-right field selection.

Selecting an active AEC channel closes U4D for channel 1, U14D for channel 2, U5D for channel 3, and U15D for channel 4. The output from the selected AEC channel will then be passed on to the signal processing circuits as shown on the next sheet of MD-0936.

Refer to MD-0936, sheet 4:

This shows the signal processing circuits for AEC board assembly 737992. The AEC channel 1 to channel 4 outputs are connected to the inverting input on U12A, which is a variable gain amplifier where the gain of this stage depends on the number of AEC fields that are selected. With one field selected, the gain of this stage will be at its maximum; and with three fields selected, the gain of this stage will be divided by three. The variable gain of U12A compensates for the variable voltage output of the input preamplifiers, thus keeping the signal output from U12A constant relative to the number of fields that are selected.

The output of U12A feeds the inverting input of U11B. A sample and hold circuit is connected to the non-inverting input on U11B. This circuit samples any electrical noise at the output of U12A during standby operation, and subtracts this noise from the AEC signal during an AEC exposure. This ensures that the output of U11B is proportional to the AEC chamber output only, and is not influenced by noise.

The output of U11B is connected to the input of U11A via the gain adjustment pots R1 to R4 and the analog switches for channels 1 to 4.

U11A is an integrating amplifier where C31 starts to integrate the AEC voltage when the AEC exposure starts. This is accomplished by opening the analog switches that are in series with R35, R38, R42, and R59 at the start of the exposure. This produces a ramp whose slope is proportional to the input voltage at U11A.

The AEC ramp is taken to the generator control board where it is processed as described earlier in this section, and fed to comparator U10 on the AEC board where it is compared to the AEC reference voltage. The output of U10 is normally high, switching low when the magnitude of the AEC ramp equals the reference voltage. This PT stop signal is further processed on the generator control board.

The chamber-select signals exit on the generator control board as per sheet 1. Only one chamber may be active at one time, and the active channel is indicated by DS1 to DS4 on the AEC board. The chamber-select signals are inverted by U6, and then connected to the control inputs on analog switches U4D, U14D, U5D, and U15D (sheet 3) for AEC channel selection and to the analog switches in series with R1 to R4 to select the required gain pot.

The field select signals from the generator control board are also active low. These signals are inverted by U6, and then connected to the analog switches in the feedback loop of U12A, and to the analog switches that select the fields on the previous sheet.

The start signal from the generator control board is inverted by U6 on the AEC board, and then inverted again by Q2. The output of Q2 is connected to the analog switches in the feedback loop of U11A. The extra inversion provided by Q2 is required to open those analog switches during an exposure.

Refer to MD-0936, sheet 5:

This is the functional schematic of AEC assembly 737998, used with ionization AEC chambers. The AEC chambers are connected to J1 to J4. The AEC signal from the AEC chamber(s) is routed to the input of analog switches U1A to U1D on the AEC board. These analog switches are controlled by the chamber-select signals.

The chamber-select signals exit on the generator control board as per sheet 1. Only one chamber may be active at one time, and the active channel is indicated by DS1 to DS4 on the AEC board. The chamber-select signals are inverted by U6, and connected to the control inputs of the analog switches described in the previous paragraph. The analog switch corresponding to the selected AEC channel will be closed when that channel is selected, thus connecting the AEC signal to the input of U7A.

The start signal also exits from the generator control board. This is inverted by U6, and then inverted again by Q4 and Q5. The output of Q5, when active, opens the analog switch that is part of the sample and hold circuit at the input of U8A during an AEC exposure. This analog switch is closed at all other times. The sample and hold circuit will sample any electrical noise at the output of U7A during standby operation, and subtract this noise from the AEC signal during an AEC exposure. This ensures that the output of U8A is proportional to the AEC chamber output voltage only, and is not influenced by noise.

The output of U8A connects to the common inputs of the analog switches that are in series with gain pots R11 to R14. These analog switches are controlled by the chamber-select signal, and the switch corresponding to the active channel will be closed. This connects the output of U8A to the AEC gain adjustment potentiometer R11 to R14 corresponding to the active channel. The AEC signal, which will be a ramp, is now fed to the input of U8B. The analog switch in the feedback loop of U8B is opened during an exposure, allowing the AEC ramp to appear at the outputs of U4A and U4B.

The AEC ramp output from U4B is taken to the generator control board where it is processed as described earlier in this section, and fed to comparator U9 on the AEC board where it is compared to the AEC reference voltage. The output of U9 is normally high, switching low when the magnitude of the AEC ramp equals the reference voltage. This PT stop signal is further processed on the generator control board.

The START signal from Q4, and the LEFT, MIDDLE, and RIGHT field select signals from Q1, Q2, Q3 respectively are brought to the AEC chambers via J1 to J4.

Jumpers JW1 to JW8 swap the left and right fields on J1 to J4. Jumpering pins 2-3 of the field selector jumpers (JW7 / JW8 for channel 1, JW5 / JW6 for channel 2, JW3 / JW4 for channel 3, JW1 / JW2 for channel 4) connects the left field select signal to pin 6 and the right field select signal to pin 2. Jumpering pins 1-2 of the field selector jumpers connects the left field select signal to pin 2 and the right field select signal to pin 6.

Refer to MD-0936, sheet 6:

This is the functional schematic of AEC assembly 739389, used with various 3-of-5-field ion chambers. The AEC chambers are connected to J1 and J2. The AEC signal from the AEC chamber(s) is routed to the input of analog switches U1C and U1D on the AEC board. These analog switches are controlled by the chamber-select signals.

The chamber-select signals originate on the generator control board as per sheet 1. Only one chamber may be active at one time, and the active channel is indicated by DS1 and DS2 on the AEC board. The chamber-select signals are inverted by U6. The signals CH 1 and CH 2 are connected to the control inputs of the analog switches described in the previous paragraph. The analog switch corresponding to the selected AEC channel will be closed when that channel is selected, thus connecting the AEC signal to the input of U7A.

The channel 3 and channel 4 select lines from U6 are inverted by Q6 and Q7. The outputs of Q6 and Q7 are redesignated as the PORTRAIT and INVERTED signals, respectively. These signals select four different combinations of the L-M-R fields from the five available fields on the AEC chamber.

The start signal also exits from the generator control board. This is inverted by U6, and then inverted again by Q4 and Q5. The output of Q5, when active, opens the analog switch that is part of the sample and hold circuit at the input of U8A during an AEC exposure. This analog switch is closed at all other times. The sample and hold circuit will sample any electrical noise at the output of U7A during standby operation, and subtract this noise from the AEC signal during an AEC exposure. This ensures that the output of U8A is proportional to the AEC chamber output voltage only, and is not influenced by noise.

The output of U8A connects to the common inputs of the analog switches that are in series with gain pots R11 and R12. These analog switches are controlled by the chamber-select signal, and the switch corresponding to the active channel will be closed. This connects the output of U8A to the AEC gain adjustment potentiometer R11 or R12 corresponding to the active channel. The AEC signal, which will be a ramp, is now fed to the input of U8B. The analog switch in the feedback loop of U8B is opened during an exposure, allowing the AEC ramp to appear at the input of U4A via a phase-lead network that provides short time compensation.

The AEC ramp from U4A is again inverted by U4B and taken to the generator control board where it is processed as described earlier in this section, and fed to comparator U9 on the AEC board where it is compared to the AEC reference voltage. The output of U9 is normally high, switching low when the magnitude of the AEC ramp equals the reference voltage. This PT stop signal is further processed on the generator control board.

Serial Communications (MD-0937)

When the generator is switched on and the start-up diagnostics are finished, the console will attempt to communicate with the generator. The console will send data to the generator, and then wait for a response from the generator. If the console receives a response, communication may continue. If the console CPU does not receive a response from the generator CPU, a communication error message will be displayed.

When the membrane console is sending data to the generator, DS2 on the console board will flash. DS3 on the generator control board will flash when data is being received by the generator control board from the membrane console or the touchscreen console. DS2 on the generator control board and DS3 on the membrane console board (if applicable) will flash to indicate that the generator control board is sending data to the console.

U11 on the console board (membrane consoles) is a RS-232 driver that drives serial port J4. DS5 and DS4 on the console board will flash to indicate that data is being sent to, and received from the serial port.

The generator control board includes two serial communications ports. These include J21, which is an RS-232 communications port, and J22, which is used for optional features.

DS1 on the console board (membrane consoles) and on the generator control board will flash at a consistent 1 Hz rate if the related CPU is operational.

DAP (MD-0938)

The DAP circuits consist of switching circuits to control the outputs at J4, and circuits to feed the DAP pulses back to the CPU. Data latch U19 and driver U20 switch the +5 V and +15 V supplies via Q2, Q3, and Q1 as required to control and test the DAP chamber. For DAP chambers with differential outputs, JW14 is jumpered from pins 2-3, thus connecting the differential output from the DAP chamber directly to the input of U1. For DAP chambers with a single-ended output, JW14 must be jumpered on pins 1-2. This connects the output of the DAP chamber to the input of opto-coupler U94. This provides increased noise immunity for single-ended DAP chambers, as the signal must be greater than approximately 2 V in order to turn on the opto-coupler. The single-ended output of U94 is then connected to the input of U1.

The RS-485 driver, U1, sends single-ended (not differential) pulses to the CPU via U78. The DAP pulses are counted by, and the related calculations are performed by the generator CPU.

Digital interface (MD-0926)

Refer to MD-0926, sheet 1:

Sheet 1 shows the digital outputs on the generator control board that drive the digital imaging system and the optional X-ray mini-console. Data latch U5 latches the output data for the imaging system. One of the outputs from U5 is an EXPOSURE ENABLE signal that is taken low if the generator has recognized a valid exposure request. The remaining outputs from U5 are fed to driver U4, where three of the outputs are connected directly to J25 and to inverters Q9, Q10, and Q11. The next two outputs from U4 are connected to inverters Q12 and Q14 only. The outputs of inverters Q9, Q10, Q11, Q12, and Q14 drive five of the outputs on J25.

Four of the single-ended outputs from U5 also drive differential drivers U21, U28, U30, and U35. These differential drivers drive four of the outputs on J25.

The ***HV ON*** signal from MD-0932 is taken to the input of U37D on MD-0926. Monostable timer U40 is triggered at the start of the ***HV ON*** signal, generating a 13-millisecond pulse. This ensures that the output of U37C stays on for a minimum of 13 milliseconds for very short exposures, while having no effect on longer exposures. The resulting “exposure on” signal from U37C is taken to J25 via driver U4, and is inverted by Q15. The output of U37C is also taken to differential driver U31 for imaging systems that need a differential “exposure on” signal.

Lastly, U19 latches the commands to drive the prep / exposure indicators and LS1 and LS2 in the mini-console. These signals are fed to driver U20, which provides the required current gain.

Refer to MD-0926, sheet 2:

Sheet 2 shows the digital inputs from the digital imaging system. One input is a differential input that is fed to the data bus via U46 and U18, and six inputs are opto-coupled via U12, U16, U17, U22, U23, and U36. The digital imaging system must pull J25-11 high to enable an X-ray exposure. When this line is high, turning on U29 and U11, and the *EXPOSURE ENABLE* line is low, the *X-RAY ENABLE* command will be low. This allows the *DRIVE ENABLE* signal on MD-0931 to be pulled high, enabling the gate drive pulses on MD-0932.

Temp Sensor / Programming Jumpers (MD-0925)

The inverter temperature sensor is mounted on a thermal sensor board that is mounted on one of the inverter heat sinks. The output of the inverter temperature sensor is connected to J17-2 on the generator control board. The temperature sensor, which has an output of 10mV / °C, is connected to the input of U79A. The output of U79A is scaled 100mV / °C; this is divided by R162 / R163 to bring the signal within the useable range of A to D converter U45. The generator CPU, which will inhibit further exposures if it calculates that the next exposure will exceed a safe inverter temperature, reads the digital output of U45.

The output of U79A is also connected to a fan voltage circuit controlled by voltage comparator U97. When the voltage at TP34 is less than 3.5V, the output of U97 is high. The logic high is fed into the fan voltage regulator circuit putting the voltage at J26-1 between 6.5 and 7 volts (driving the cooling fan at low speed).

If the voltage at TP34 reaches 3.5V (approx. 35°), the output of U97 goes low. The logic low is fed into the fan voltage regulator circuit, which will drive the voltage at J26-1 to approximately 12.5 volts (driving the cooling fan at high speed).

MD-0925 also shows programming jumpers JW12, JW2, and JW13. JW12 tells the CPU if the generator has a cooling fan. JW-12 should be jumpered from pins 2-3 for generators with fans, and pins 1-2 if a new-style generator control board is used to upgrade or repair older generators without fans. Note that if the jumper is in position 1-2 (no fan), the generator duty cycle will be reduced.

JW2 is used to upgrade the generator firmware. This is set to JW2 pins 1-2 for normal operation, and pins 2-3 to upgrade the firmware. JW13 is factory-set, and should not be reconfigured in the field.

Interconnect Diagram (MD-0939)

This drawing shows the cabling between the major subassemblies in the CMP 200® X-ray generator. Where applicable, this document references the appropriate functional schematics and sections of the service manual for details on the area of interest.

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Chapter 8 Troubleshooting

Contents

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Introduction

The CMP 200® / CMP 200® DR series operator's console will display status messages on the LCD display during normal and abnormal operation of the generator. This chapter contains tables of those messages and suggests actions to be taken by service personnel to correct any malfunctions that may occur.

Warning:

- *Installation and servicing is to be performed only by competent, trained personnel who are familiar with the potential hazards associated with equipment.*
- *Ensure the AC input power is locked out for servicing. Verify the absence of voltage. Wait minimum of 5 minutes for capacitors to discharge before beginning any servicing.*
- *Do not place any objects regardless of size or weight on the generator.*
- *Do not allow any obstruction of the cooling vents.*

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Status and Error Codes

Operator Messages

These messages indicate the status of the generator.

Message (Membrane Console)	Message (Touchscreen Console)	Description
ERROR – The Power Generator connected to this console is not a CPI CMP 200® family device. Unable to continue…		This could mean that the console is configured to operate with the incorrect family of generator or that there is a problem with the serial communication between the generator and the console. 1. Ensure that the console cable is properly connected to the console. 2. Consult your service representative for further instructions.
DAP NOT READY	DAP not ready	The optional DAP is in its “warm up” state, and not ready to make DAP measurements.
INITIALIZATION		Displayed during power up sequence
SPINNING ROTOR		Displayed when prep state is active
X-RAY ON		Displayed during an X-ray exposure
X-RAY READY	Generator Ready	Indicates that the generator is ready to make an exposure
	Generator offline…	1. Indicates that the console is unable to communicate with the generator 2. Ensure that the generator is switched on, and that the console cable is properly connected to the console. 3. Consult your service representative if this does not solve the problem.

Limit Messages

These messages indicate that an exposure has been requested that exceeds one or more limits.

Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
AEC DENSITY LIM	Generator AEC density limit	Requested density not programmed	Select another density or program requested density step
ANODE HEAT WARN	Anode warning level exceeded	Anode has exceeded programmed warning level.	Wait for anode to cool
CAL LIMIT	Calibration limit: selected parameter not calibrated	Requested parameter not calibrated	Recalibrate X-ray tube or select a calibrated parameter
DAP ACCUM. WARN	DAP accumulation Warning.	The accumulated DAP value exceeds the programmed DAP limit.	Reset the DAP
GEN DUTY WARNING	Generator duty cycle limit	The X-ray generator has reached its duty cycle warning limit.	1. Re-evaluate technique factors. 2. Allow generator to cool if possible. If exposures are continued, serious generator damage may result due to overheating.
GEN. JOULE LIMIT	Generator Joule Limit	The requested exposure will exceed the generators kilo joule heat limit.	Allow the generator to cool sufficiently to allow the requested exposure
GEN. KV LIMIT	Generator kV limit	Requested kV not allowed as generator kV limit has been reached.	Check technique if this is seen when APR is used
GEN. KW LIMIT	Generator kW limit	Requested parameter not allowed as generator kW limit has been reached.	Check technique if this is seen when APR is used

Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
GEN. MA LIMIT	Generator mA limit	Requested mA not allowed as generator mA limit has been reached.	Check technique if this is seen when APR is used
GEN. MAS LIMIT	Generator mAs limit	Requested mAs not allowed as the generator mAs limit has been reached	Check technique if this is seen when APR is used
GEN. MS LIMIT	Generator ms limit	Requested ms not allowed as the generator ms limit has been reached	Check technique if this is seen when APR is used
INVALID PARAM.	Invalid communication parameter	Generator detected invalid parameter within received message, message ignored.	Select valid parameter
	Parameter limit	The selected parameter has exceeded its limits.	None
TUBE KV LIMIT	Tube kV limit	Requested kV not allowed as tube kV limit has been reached	Release the KV + button
TUBE KW LIMIT	Tube kW limit	Requested parameter not allowed as tube kW limit has been reached	Release the KV + or the mA + buttons
TUBE MA LIMIT	Tube mA limit	Requested mA not allowed as tube mA limit has been reached	Release the mA + button
TUBE MAS LIMIT	Tube mAs limit	Requested mAs not allowed as tube mAs limit has been reached	Release the mA + or ms + buttons

Error Messages

These messages indicate that an error has occurred. The errors are logged in the error log; previous errors should be reviewed by service personnel before taking further action.

*Note: An invasive meter is recommended, however if this is not possible, a non-invasive meter may be acceptable. The use of non-invasive meter requires extra precautions in order to read accurate kV. For more information, refer to Application Note for Using Non-invasive Meter in kV Measurement, 906930.

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
	APR MEMORY ERROR		APR data has been corrupted.	See note 1 near end of this section
		The license you entered does not appear to be valid. Please re-enter your license key	The touchscreen software license key has been entered incorrectly.	Verify and re-enter the license key
E003	GEN NVRAM ERR.	Generator CPU NVRAM error	Generator CPU NVRAM data has been corrupted.	Re-initialize generator CPU NVRAM using generator factory defaults
E004	GEN RTC ERROR	Generator CPU Real Time Clock error	Generator CPU real time clock is not functioning.	Reset time and date
E005	PS CONTACT ERR	Main Contactor Error	Unit did not detect proper charging up of 600V bus caps. Main contactor will not be closed if bus is not charged.	1. Measure 600V bus and determine reason for not charging. 2. Check fuses and charging resistors on the power input board.
E006	ROTOR FAULT	Rotor Fault	In the generator standby phase for the low-speed starter, the generator main	**For low-speed starter:** 1. Check if the X-ray stator

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
			CPU detects the voltage reading (> 0 and < 5 V) at the test point TP8 or TP7 on the HV auxiliary board). In the tube preparation phase, current relays in main and shift circuits were not energized.	cable properly connects to the J7 connector on the High Voltage Auxiliary board. 2. Refer to the functional drawing (MD-0935) and check TP6, TP7, and TP9, on the High Voltage Auxiliary board. 3. Check F6, F7, and F8 on the High Voltage Auxiliary board. 4. Check the connection for the X-ray tube end. **For dual-speed starter:** 1. Check if the X-ray stator cable properly connects to the connector located at the back of the DSS board mounting plate (see Figure 2-6 in Chapter 2) 2. Check DS 1 on the DSS board. If it lits, there is a breakdown in the starter or stator circuits. 3. Disconnect stator and retry it, which will isolate

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
				where the fault occurred. 4. Refer to the "Installation" chapter. Verify the DIP-switch settings on the DSS board. They should be set according to the type of tube being used. 5. Check the connection for the X-ray tube end.
E007	FILAMENT FAULT	Filament Fault	Generator has detected filament current <2 amps.	1. Check for open filament in X-ray tube. 2. Check for poor connections in the cathode cable. 3. Check fuses on filament board(s).
E008	KV/MA FAULT	kV / mA Fault	The generator has detected a fault in the kV or mA output during an exposure and immediately terminated the exposure. This may be caused by arcing in the X-ray tube, arcing of the HV cables, or HV Module.	1. If arcing of the X-ray tube is suspected, check condition of tube. The X-ray tube may be damaged or simply require "seasoning". Refer to chapter 6 for tube seasoning procedure. 2. If failure of HV Module is suspected, contact product support

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
E009	PS NOT READY	Power Supply Not Ready	The generator is not ready to make an exposure.	1. Retry exposure. 2. If error happens again, wait for inverter to cool. 3. Check +/- 12 V lines in power supply section.
E011	HIGH MA FAULT	mA During Exposure Too High	The generator CPU detected mA greater than allowed tolerance.	1. Check for actual exposure mA. Do not attempt calibration until satisfied that generator is exposing properly. 2. Recalibrate X-ray tube. *
E012	LOW MA FAULT	mA During Exposure Too Low	The generator CPU detected mA less than allowed tolerance.	
E013	MANUAL TERMIN	Manually Terminated Exposure	Operator released exposure switch during exposure.	1. Re-take exposure if necessary. 2. Check for faulty switch contacts or wiring.
E014	AEC BUT ERROR	AEC Back-up Timer - Exposure Terminated	The programmed AEC Back-Up Time limit was reached and the exposure was terminated by the generator.	1. Check that the exposure technique settings are clinically valid. 2. Verify that the correct AEC chamber is energized during the AEC exposure.

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
			When the FIXED AEC Back-Up mode is selected, an AEC BUT Error may also be reported if the X-ray Tube or Generator kW or HU limit is reached during an AEC exposure	1. Check that the AEC exposure has not reached the X-ray tube kW or HU limit. 2. Check that the AEC exposure has not reached the generator kW or HU limit.
E016	TOMO BUT ERROR	Tomo Back-up Timer – Exposure Terminated	Tomo exposure exceeded backup time	1. Check exposure technique settings. 2. Increase tomo backup time, if necessary.
E017	NOT CALIBRATED	Uncalibrated Exposure Parameter	Selected mA not calibrated for selected kV	Recalibrate X-ray tube
E018	PREP TIMEOUT	Preparation Timeout	Generator has been in prep state too long.	Reduce length of time in prep state
E019	ANODE HEAT LIMIT	Anode Heat Limit	Selected parameters will cause X-ray tube to exceed its programmed anode heat limit.	Reduce parameters or wait for tube to cool
E020	THERMAL INT #1	Thermal Switch Interlock #1 Error	X-ray tube # 1 too hot and its thermal switch has opened.	Wait for X-ray tube # 1 to cool
E022	DOOR INTERLOCK	Door Interlock Error	Door is open.	1. Close door. 2. Check J4, pins 9 and 10 on the HV auxiliary board.
E028	PREP SW CLOSED	Prep Input Active During Initialization Phase	Prep input active during power on initialization phase	Check prep switch and input for short circuit.

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
E029	X-RAY SW CLOSED	X-ray Input Active During Initialization Phase	X-ray input active during power on initialization phase	Check X-ray switch and input for short circuit.
E032	CONSOLE COMM ERR	Console Communication Error	The generator has detected error in communication to console.	1. Check console cable for damage and proper connection 2. Turn power off and then on to reset generator
E033	GEN BATTERY LOW	Warning Lithium Battery Voltage Low	The generator detects lithium battery voltage is low.	Replace lithium battery
E034	+12VDC ERROR	+12 V DC Error	The +12VDC rail is out of tolerance.	Check the +12VDC rail on the generator control board
E035	-12VDC ERROR	-12 V DC Error	The -12VDC rail is out of tolerance.	Check the -12VDC rail on the generator control board
E038	CAL DATA ERROR	Calibration Data Corrupt Error	The generator detects corrupt calibration data.	Re-calibrate X-ray tube(s), if the error repeats, contact Cusomter Support (contact information listed on the cover page and back of cover page) . or If this error occurs during auto-calibration at 100 kV, re-do the auto calibration. If the error persists, change the HV cables and then re-do the calibration. If the error still persists, contact CPI Customer Support

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
E039	AEC DATA ERROR	AEC data corrupt	The generator detects corrupt AEC data.	Reprogram AEC data or set factory defaults
E041	REC DATA ERROR	Receptor data corrupt	The generator detects corrupt receptor data.	Reprogram receptor data or set factory defaults
E042	TUBE DATA ERR.	Tube data corrupt	The generator detects corrupt tube data.	Reprogram tube data or set factory defaults
E043	KV ERROR	High voltage error - kV detected in non X-ray state	kV detected in non X-ray state (This can be seen at the end of an exposure if the generator is connected to long, high capacitance HV cables. They may have a charge when the generator expects KV to be 0.)	Switch OFF generator. Prevent further use of generator. Call product support.
E044	COMM ERROR	Invalid communication message	Received communication message not valid and ignored	Reset error
E045	NOT SUPPORTED	Communication message not supported	Received message is valid, but not supported by this system	Reset error
E046	MODE INHIBITED	Mode Inhibited	Received message is valid, but not allowed during present state	1. Reset error. An APR technique may be asking for something that is disabled in the generator setup. 2. Check the APR programming.

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
E049	NOT ENABLED	Not enabled	Requested function not programmed to be enabled	Reprogram to enable function or change APR not to select a function
E050	GEN DATA ERROR	Generator limit data corrupt	The generator detects corrupt generator limit data.	Reprogram the generator limit data or set factory defaults
E051	AEC DEVICE ERR	AEC feedback error (no feedback signal detected)	The generator has detected no, or insufficient, feedback signal from the AEC device.	1. Check that X-ray tube is pointing at correct AEC device. 2. Check AEC cable for damage and proper connection.
E052	HIGH SF CURRENT	High small focus filament current error in standby	The generator detects small focus filament current greater than limits in standby mode.	1. Check filament reference and feedback signals. Substitute tube cathode with external load before testing. 2. Check filament board.
E053	HIGH LF CURRENT	High large focus filament current error in standby	The generator detects large focus filament current greater than limits in standby mode.	1. Check filament reference and feedback signals. Substitute tube cathode with external load before testing. 2. Check filament board.
E054	AEC OUT OF RANGE	AEC reference out of range	The AEC reference has reached a maximum or minimum limit.	Re-adjust AEC calibration including density to operate within AEC range (0 to 10 VDC).

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
E055	NO FIELDS ACTIVE	No fields selected in AEC mode	AEC enabled but no fields are selected.	Select AEC field(s)
E056	NO TUBE SELECTED	Receptor Disabled	All Receptors have no X-ray tube programmed.	Program receptor(s) with tube number
E057	AEC STOP ERROR	AEC stop signal In wrong state	The AEC stop signal (P.T. stop signal) is active low indicating exposure is finished during prep state.	1. Check that the P.T. ramp does not exceed the P.T. reference during prep state. 2. Check AEC device for proper operation.
E058	CONSOLE BUT ERR.	Console back-up timer	Console has detected exposure exceeded backup time and terminated exposure. This error can happen if the console communication is corrupted during an exposure.	1. Check routing of the console cable, route it away from noise sources. 2. Call product support.
E060	EXP. KV HIGH	High kV error	kV exceeds high kV tolerance level.	1. Check the output of the kV reference DAC on the generator CPU board. 2. Measure the output of the generator with a kV measurement device* (see Note described in the beginning of this section).

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
E061	EXP. KV LOW	Low kV error	kV exceeds low kV tolerance level.	1. Check the output of the kV reference DAC on the generator CPU board. 2. Measure the output of the generator with a kV measurement device* (see Note described in the beginning of this section).
E063	FACTORY DEFAULTS	Factory defaults set	S3-1 on the generator control board is set to the LOAD DEFAULTS position.	Set S3-1 to the NORMAL position. The generator will not exit the initialization phase until this is done.
E065	TOMO DEVICE ERR.	Tomo device error.	The tomo start signal was not received within 30 seconds of pressing the X-ray switch on the generator.	1. Check the tomo connections to the generator. 2. Check the tomo system.
E067	PS DUTY LIMIT	Power supply duty cycle limit exceeded	Power supply duty-cycle limit exceeded	1. Re-evaluate technique factors. 2. Allow generator to cool if possible. Exposures are inhibited until the generator has cooled sufficiently.
E071	DAP DOSE OVERFLW	DAP overflow error	The accumulated DAP value exceeds the display limit.	Reset the DAP

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
E072	DAP DEVICE ERR.	DAP device error	The DAP device is not functional.	1. Check the DAP wiring. 2. Check the DAP interface board.
E073	DAP DATA ERROR	DAP data error	The DAP configuration data is corrupted.	Reset factory defaults.

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
74	INVERTER 1 ERROR	Inverter 1 Error	Highest probability – Tube arcing; Less likely – Power circuit, HV Module, or Inverter	1. Attempt a new exposure at lower KV (40kV, 10mA, 20ms) a. If E74 is reported again, refrain from additional exposures and inform CPI Coustomer Support of the failure. b. If does not re-occur, there is a high probability of an arc event in the system. Go to step 2. 2. Attempt a few more exposures while gradually increasing KV (40kV, 10mA, 20ms; 50kV, 10mA, 20ms; 60kV, 10mA, 20ms). 3. Season the tube as per manufacturer's spec or replace if necessary. 4. Check HV cables / connectors for signs of arcing – reapply die-electric grease if necessary or replace cables. 5. If issue not solved by steps above, call Product Support.

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
E075	INVERTER 2 ERROR	Inverter 2 Error	Highest probability – Tube arcing; Less likely – Power circuit, HV Module, or Inverter	1. Attempt a new exposure at lower KV (40kV, 10mA, 20ms) a. If E75 is reported again, refrain from additional exposures and inform Product Support of the failure. b. If does not re-occur, there is a high probability of an arc event in the system. Go to step 2. 2. Attempt a few more exposures while gradually increasing KV (40kV, 10mA, 20ms; 50kV, 10mA, 20ms; 60kV, 10mA, 20ms). 3. Season the tube as per manufacturer's spec or replace if necessary. 4. Check HV cables / connectors for signs of arcing – reapply die-electric grease if necessary or replace cables. 5. If issue not solved by steps above, call Cusomter

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
				Support (contact information listed on the back of cover page) .
E077	RES. CIRCUIT ERR	Resonant Circuit Error	HV primary over-current detected.	1. Check for arcing of the X-ray tube. 2. Check for arcing in the HV Module; if failure of HV Module is suspected, contact product support.
E078	BUCKY1 INTERLOCK	Bucky 1 Interlock error	Indicates that Bucky 1 is not ready	Check Bucky 1
E079	BUCKY2 INTERLOCK	Bucky 2 Interlock error	Indicates that Bucky 2 is not ready	Check Bucky 2
E080	INTERLOCK 1 OPEN	Interlock 1 Open	Indicates that the interlock 1 is open	1. Check the circuits connected to interlock 1. 2. Refer to *Inputs* in Chapter 3, Interfaceing and Programming.
E081	INTERLOCK 2 OPEN	Interlock 2 Open	Indicates that the interlock 2 is open	1. Check the circuits connected to interlock 2. 2. Refer to *Inputs* in Chapter 3, Interfaceing and Programming.
E082	KV OVER VOLTAGE	kV Over Voltage	The output kV exceeded the maximum allowed kV limit.	1. Auto-calibrate tube (per *Tube Calibration* in Chapter 3) * 2. Consult product support.

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
E083	ANODE MA FAULT	Anode mA Fault	The anode current exceeded the maximum allowed limit.	1. Check for arcing of the X-ray tube. 2. Check for arcing in the HV Module; if failure of HV Module is suspected, contact product support.
E084	CATHODE MA FAULT	Cathode mA Fault	The cathode current exceeded the maximum allowed limit.	1. Check for arcing of the X-ray tube. 2. Check for arcing in the HV Module; if failure of HV Module is suspected, contact product support.
E085	ROTOR MAIN FAULT	Rotor Main Fault	Indicates that insufficient current was sensed in the stator main winding.	1. Check the X-ray tube stator wiring. 2. Check the rotor board.
E086	ROTOR SHFT FAULT	Rotor Shift Fault	Indicates that insufficient current was sensed in the stator shift winding.	1. Check the X-ray tube stator wiring. 2. Check the rotor board.
E087	GEN DUTY WARNING	Generator duty cycle limit	Indicates a potential fault with the inverter thermal sensor	1. Check the J17 connection on the control board. 2. Check the thermal sensor connection. 3. Replace the thermal sensor cable, thermal sensor board or control board as necessary.

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
E088	GEN DUTY WARNING	Generator duty cycle limit	Indicates the inverter has overheated.	1. Allow generator to cool if possible. 2. Check that the inverter cooling fan is connected. 3. Replace the thermal sensor cable, thermal sensor board or control board as necessary.
E100	CAL-MAX MA ERR.	Calibration error – maximum mA exceeded	Maximum mA has been exceeded during auto calibration.	Repeat auto calibration and/or decrease standby current.
E101	CAL-DATA LIMIT	Calibration error – calibration data table exceeded	Auto calibration has exceeded data table length due to an excessive number of exposures.	1. Check to see if the filament standby current is too low. 2. Retry auto calibration.
E102	CAL-MAX FIL ERR	Calibration error – maximum filament current exceeded	Maximum filament current for the selected focus has been reached.	Confirm if exposures are accurate. If so raise maximum filament current or lower maximum mA.
E103	CAL-MAN. TERM.	Calibration error – manually terminated	Operator released exposure button during auto calibration.	Retry auto Calibration.
E104	CAL-NO MA	Calibration error – no mA	No mA feedback detected during auto calibration.	1. Check to see if generator is exposing. 2. Call product support.
E105	CAL-MIN MA ERR.	Calibration error – minimum mA not calibrated	Minimum generator mA was exceeded at start of calibration.	Reduce filament standby current on primary and/or secondary filament.

Error Code	Message (Membrane Console)	Message (Touchscreen Console)	Description	Action
E150	TABLE COMM ERR	Table communication error	A communication error has occurred with the table.	1. Ensure that the table is powered on. 2. Check the serial communication cable, connectors, etc.
E152		Table error	The table has sent a table error message to the generator.	Refer to the table manufacturer's documentation
E154		Table emergency stop	The table emergency stop has been activated.	Reset the table emergency stop
E230	DAP NOT READY		The optional DAP is in its "warm up" state, and not ready to make DAP measurements.	Allow the DAP chamber sufficient time to warm up
E240	OUT OF LABELS		The printer is out of labels.	Load more labels
E241	LABEL JAMMED		The labels are jammed.	Clear the paper jam
E242	PRINTER ERROR		The printer self-diagnostics have reported a printer problem.	Refer to the printer manual
E243	PRINTER COMM ERR		The printer has reported a communication error.	Try printing again
E244	PLATEN OPEN		The paper platen is not positioned properly.	Check the platen position
E245	PRINTER OFF-LINE		The printer is off-line.	Put the printer on-line

* The generator purges the existing X-ray tube auto calibration data before starting the auto calibration routine and saving new calibration data. Therefore, auto calibration should be a last resort during general troubleshooting, and should only be done to recalibrate the tube. For example, if a low mA fault is presented, you should ensure that the generator is fully functional, and actually needs recalibration. If calibration is attempted on a partially functional generator, the auto calibration routine may be aborted before any calibration is done, and the generator will inhibit further exposures until the selected mA is calibrated for the selected kV.

1. For an APR MEMORY ERROR fault, the console factory defaults must be restored or the APR must be restored via GenWare®. The procedure for resetting console factory defaults is described in Chapter 6, *Regular Maintenance*.

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Miscellaneous Faults

Erratic Console Faults

SYMPTOM: In some environments that are "electrically noisy", the console may exhibit erratic faults i.e. RAM data error, intermittent loss of communication, or random fault messages may be displayed.

SOLUTION: Connect a separate ground wire, #14 AWG (2.3 mm2) or larger from the ground stud on the rear of the console (marked CONSOLE GROUND in Figure "Interface of control console" in Chapter 2, *Installation*) to the ground stud located beside the main input fuse block. This is marked GROUND CONNECTION in the Figure "Generator mains connection" in Chapter 2, *Installation*.

SYMPTOM: In some situations the touchscreen console may appear "frozen" i.e. cannot activate any of the buttons on the touch sensitive screen. This may be a case of the touchscreen calibration being significantly out of alignment.

SOLUTION: Refer to *Touchscreen Calibration* on Chapter 3, *Interfacing and Programming* of this manual for the procedure to complete the 25-point linearization calibration of the Touchscreen Console.

LED Indicators

The following table describes the normal states and functions of the status and diagnostic LEDs on the circuit boards in the generator.

A change in the state of an LED may be for a brief duration, especially during a fault or an exposure.

Dual-Speed Starter (DSS) - Board No. 728877-06 and 903132-02

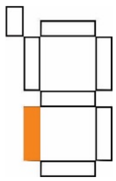
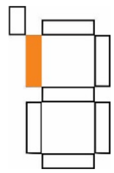
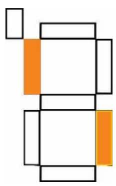
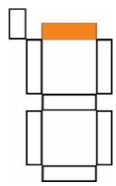
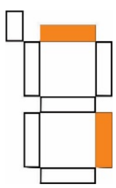
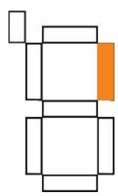
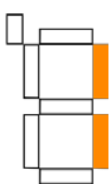
LED	NORMAL STATE	FUNCTION
DS1	Off	If it lits, indicates that excessive current has been drawn from the DC Bus. This indicates a DSS fault, if lit without a tube stator connected.

Dual-Speed Starter (DSS) - Board No. 903132-02 only

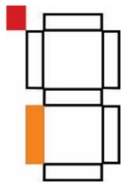
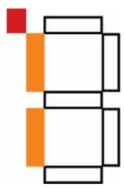
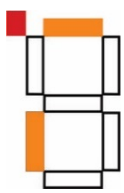
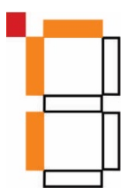
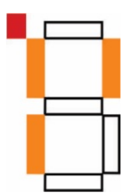
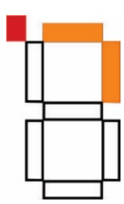
The following display patterns indicate the modes of operation on DSS Board # 903132-02. The LEDs can be found on the DSS board and is arranged similar to a 7-segment LED display.

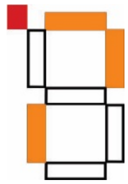
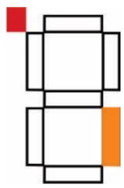
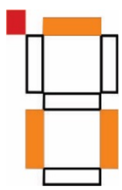
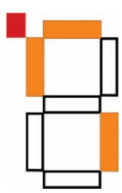
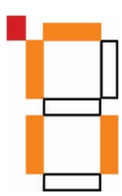
Orange indicates LEDs on

White indicates LEDs off

 DSS is in IDLE state	 DSS is in low speed BOOST state
 DSS is in high speed BOOST state	 DSS is in low speed RUN state
 DSS is in high speed RUN state	 DSS is in low speed BRAKE state
 DSS is in high speed BRAKE state	 **Flashing Red LED will indicate an error**  **Flashing Orange LEDs will indicate the type of error** Note: Read the Orange LED pattern only when the Red LED flashes ON. Ignore the Orange LED pattern when the Red LED is OFF.

Identify the errors on DSS Board # 903132-02 using the display patterns and the corresponding problem as listed in this table. The LED is found on the DSS board, arranged similar to a 7-segment LED display.

Segment	**Problem**	**Action**
	Low speed not supported	1. Check that SW1 is set according to the X-ray tube connected to the generator (refer to the *Programming the Dual-Speed Starter* section, in Chapter 2, *Installation*, of this maual). 2. Check that SW3 is set according to the tab number marked on the back of the DSS panel
	High speed not supported	1. Check that SW1 is set according to the X-ray tube connected to the generator ((refer to the *Programming the Dual-Speed Starter* section, in Chapter 2, *Installation*, of this maual). 2. Check that SW3 is set according to the tab number marked on the back of the DSS panel
	IMAIN is less than a threshold	Check for open circuit in MAIN rotor connection
	ISHIFT is less than threshold	Check for open circuit in SHIFT rotor connection
	INVTRIP is detected	If lit, indicates that excessive current has been drawn from the DC Bus.
	VBUS input is less than 400V	1. Check for low AC mains line input. 2. Check main contactor is closed.

Segment	Problem	Action
	Capacitance not found	1. Check that SW1 is set according to the x-ray tube connected to the generator (refer to the *X-ray Tube Stator Compatibility Tables* supplement (part number: 746026-00). 2. Check that SW3 is set according to the tab number marked on the back of the DSS panel
	Tube 1 and board tab type mismatch	1. Check that SW1 is set according to the x-ray tube connected to the generator (refer to the *X-ray Tube Stator Compatibility Tables* supplement (part number: 746026-00). 2. Check that SW3 is set according to the tab number marked on the back of the DSS panel 3. Insect the setting of SW8 for the following settings: Switches 5 and 8 = **ON** All other switches = **OFF**
	Communication mode wrong	Check the switch settings of SW8: Switches 5 and 8 = **ON** All other switches = **OFF**
	Voltage table is corrupted	Power cycle the board.
	Tubes are not all configured	1. Check that SW1 is set according to the x-ray tube connected to the generator (refer to the *X-ray Tube Stator Compatibility Tables* supplement (part number: 746026-00). 2. Check that SW3 is set according to the tab number marked on the back of the DSS panel 3. Insect the setting of SW8 for the following settings: Switches 5 and 8 = **ON** All other switches = **OFF**

Generator Control Board

LED	Silk Screen	Normal State	Function
DS1	HEARTBEAT	Flashing	Flashing at 1 Hz to indicate the generator CPU is functioning.
DS2	TXD	Flashing	Flashes to indicate that the generator control board is sending data to the console
DS3	RXD	Flashing	Flashes when data is being sent to the generator control board by the console
DS4	AUX2 TXD	Flashing	Flashes to indicate that the generator control board is sending data to the COM port J21
DS5	PREP	Off	Lit when in PREP state
DS6	XRAY	Off	Lit when in XRAY state
DS7	AUX TXD	Flashing	Flashes to indicate that the generator control board is sending data to J22 on the generator control board
DS8	AUX RXD	Flashing	Flashes when data is being received from J22 on the generator control board.
DS9	READY	Off	Indicates rotor ready (sufficient stator current) In low speed mode DS9 is on at prep. In high speed mode DS9 is on after prep completed.
DS10	HS	Off	If lit, indicates rotor is in high - speed operation.
DS11	PREP	Off	Lit when in Prep state.
DS12	AUX1 RXD	Flashing	Flashes when data is being received from COM port J21 on the generator control board.

HV Auxiliary Board

LED	Normal State	Function
DS1	On	Indicates presence of the +24 VDC supply

EMC Capacitor Board

LED	Normal State	Function
DS1	On	Indicates the DC bus capacitors are charged.

AEC Board

LED	Normal State	Function
AEC Board 734614		
DS1	Off	Indicates channel 1 is selected.
DS2	Off	Indicates channel 2 is selected.
DS3	Off	Indicates channel 3 is selected.
DS4	Off	Indicates channel 4 is selected.
DS5	Off	Indicates reset / start signal is present.
AEC Board 737992		
DS1	Off	Indicates channel 4 is selected.
DS2	Off	Indicates channel 3 is selected.
DS3	Off	Indicates channel 2 is selected.
DS4	Off	Indicates channel 1 is selected.

LED	Silk Screen	Normal State	Function
AEC Board 737998			
DS1	CH1	Off	Indicates channel 1 is selected.
DS2	CH2	Off	Indicates channel 2 is selected.
DS3	CH3	Off	Indicates channel 3 is selected.
DS4	CH4	Off	Indicates channel 4 is selected.
AEC Board 739389			
DS1	CH1	Off	Indicates channel 1 is selected.
DS2	CH2	Off	Indicates channel 2 is selected.

Chapter 9 Spares

Contents

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Introduction

This chapter contains the list of spare parts for the CMP 200® series and CMP 200® DR series of X-ray generators.

Spare Part List

Tables 9-1, 9-2A, and 9-2B show the recommended spare parts for the CMP 200® and CMP 200® DR family of X-ray generators.

Table 9-1: Spare Information

Description	Number
HV Auxiliary Board	See Note 1
Generator Control Board	Consult factory (see Note 4)
Filament Board	SP73140700CMP SP90543100 (SMT)
Inverter Board	Consult factory
Console Board (see Note 5)	SP95024400
AEC Board (see Note 2)	73799200 (Solid State Chambers)
	73799201 (Solid State Chambers)
	73799202 (Dedicated Solid State Chambers)
	73799800 (Ion Chambers)
	73938900 (5-Field Ion Chambers)
	734614-02 (Ion Dedicated Chambers)
	734614-03 (Ion Dedicated Chambers)
	734614-05 (Ion Dedicated Chambers)
	734614-08 (Ion Dedicated Chambers)
	734614-12 (Ion Dedicated Chambers)
	734614-13 (Ion Dedicated Chambers)
DC Bus Capacitor Assembly	See the DC Bus Capacitor Assembly Kit table at the end of this table
Rectifier Assembly, Mains	SP6623071100CMP
Transformer, Auxiliary	SP90340900
Fan Assembly	SP73940100
Fan and EMC filter assembly for 3-phase generators	SP95040400

Table 9-1: Spare Information		
Description	**Number**	
Fan and EMC filter assembly for single-phase generators	SP95040401	
HV Module Assembly	Consult factory	
Dual-Speed Starter Board (DSS 2, new version)	SP90313202CMP	
Dual-Speed Starter Subassembly	See Note 3	
Battery, Timekeeper SRAM	See Note 6	
AC Main Contactor	SP95065800 (It is compatible with the generator control board, part number 90792600)	
DC Main Contactor	SP95068000 (It is compatible with the generator control board, part numbers 90114600 and 736763-XX)	
Thermal Sensor Board	SP90153100CMP	
EMC Capacitor Board	SP90187908CMP (for 32/40 kW, 125 kV, 1-phase generators) SP90187909CMP (for 3-phase generators) SP90187910	
LED Collimator Power Supply	SP95003400	
LSS Capacitor Assembly	SP903836-00	LSS Shift Capacitor, 30 µF
	SP903836-01	LSS Shift Capacitor, 40 µF
	SP903836-02	LSS Shift Capacitor, 20 µF
902634-XX	Mini-Console with a Hand Swtich Kit	
950245-XX	Mini-Console Kit	
15.6” touchscreen console	SP95041800	
Power Cord for the 15.6” console (Power cord is region specific; when ordering, use the specific part number for tha region)		
Europe	SP8199893500	
UK	SP8199893100	
China	SP8199894100	
North America	SP8199893200	
CPI Wall mount (The touchscreen consoles can be wall mounted depending on the requirement)	SP2990041200	

Table 9-1: Spare Information	
Description	**Number**
Software upgrade -15.6” touchscreen console (Order this part if a software upgrade is needed. The software comes in a USB flash drive)	SP90741700TS

DC Bus Capacitor Assembly Kit

Spare Part No.	Apply to:		
	CMP200® /DR	CMP200®EA	Configurations of X-ray Generators
SP907097-00CMP	✓	✓	32/40 kW, 208/230 VAC, 1-Phase, 125 kV
SP907097-01CMP	✓	✗	32/40 kW, 400/480 VAC, 3-Phase, 125 kV 50/65 kW, 400/480 VAC, 3-Phase, 150 kV
SP907097-02CMP	✓	✗	32/40 kW, 400/480 VAC, 3-Phase, 150 kV
SP907097-03CMP	✓	✓	32/40 kW, 208/230 VAC, 3-Phase, 125 kV 50 kW, 208/230 VAC, 3-Phase, 150 kV 50 kW, 208/230 VAC, 1-Phase, 150 kV

Table 1 details all the fuse information. This information will guide the fuse replacement. Replacement fuses should be of the same type, rating and specifications to that of the original fuse.

Table 9-2A: Fuse Information			
Fuse Location	**Voltage Level (VAC)**		**Rating / Type**
	400 / 480	**208 / 230**	
Main Power Input		F1, F2 (1 phase, 32/40 kW)	T50A RK5 250VAC Time Delay CPI Part Number 5550031200
	F1, F2, F3 (50 kW)	F1, F2, F3 (3-phase 32/40 kW)	T60A G 480VAC Time Delay CPI Part number 6713837500
	F1, F2, F3 (32/40 kW)		T40A G 480VAC Time Delay CPI Part Number 6713837700
	F1, F2, F3 (65/80 kW)		F60A K5 600VAC, 50kA I.R. OTS-60 CPI Part Number 6800004300

Table 9-2A: Fuse Information			
Fuse Location	**Voltage Level (VAC)**		**Rating / Type**
	400 / 480	**208 / 230**	
		F1, F2, F3 (50 kW)	F60A K5 250VAC, 50kA I.R. CPI Part Number 6800000400
High Voltage Auxiliary Board	F1, F6, F7	F1, F6, F7	T8A L 250VAC Time Delay CPI Part Number 5550037500
	F2, F3	F2, F3	T5A L 250VAC Time Delay CPI Part Number 5570210570
	F10	F10	F0.8A L 250VAC Fast Acting CPI Part Number 5570211500
	F11	F11, F4, F5	T6.3A L 250VAC Time Delay CPI Part Number 5550033400
	F12	F12	T2A L 250VAC Time Delay CPI Part Number 6800003700
	F4, F5		T1A H 500VAC Time Delay CPI Part Number 6711905800
	F8, F9		T4A H 500VAC Time Delay CPI Part Number 6711906600
		F8, F9	T4A H 250VAC Time Delay CPI Part Number 5550033100
Filament Board		F1, F2	T4A L 250VAC Time Delay CPI Part Number 5550033100
Dual Speed Starter Board		F1, F2	F15A H 1000VDC Semiconductor Protection Fuse, Fast Acting CPI Part Number 6800004500

Table 9-2B: Fuse Kit Information				
Part Number	**Generator Configurations**	**Kit applies to**		**Kit Name and Items**
		CMP200/DR (VZW2556Rxx)	CMP200EA VZW2562ARxx)	
SP5550031200CMP	32/40KW,208/230V,1P	✓	✓	Mains Power Input Fuse Kit contains the mains power input fuses
SP6713837500CMP	32/40KW,208/230V,3P; 50KW,400/480,3P	✓	✘	
SP6713837700CMP	32/40KW,400/480V,3P; 12.5KW,480V,3P	✓	✘	
SP6800004300CMP	65/80KW,400/480V,3P	✓	✘	
SP6800000400CMP	50KW,400/480V,3P	✓	✓	

Table 9-2B: Fuse Kit Information				
Part Number	Generator Configurations	Kit applies to		Kit Name and Items
		CMP200/DR (VZW2556Rxx)	CMP200EA VZW2562ARxx)	
SP90661500CMP	All power level, 400/480V	✓	✘	Logic Fuse kit contains fuses used with different boards
SP90661501CMP	All power level, 208/230V	✓	✓	
SP90661400CMP	32/40kW,208/230V,1P	✓	✓	Master Fuse Kit Includes the Mains Power Input Fuse Kit and the Logic Fuse Kit
SP90661401CMP	32/40kW,208/230V,3P	✓	✘	
SP90661402CMP	32/40kW,400/480V,3P	✓	✘	
SP90661403CMP	50kW,208/230V,3P	✓	✓	
SP90661404CMP	50kW,400/480V,3P	✓	✘	
SP90661405CMP	65/80kW,400/480V,3P	✓	✘	

Note 1:

For X-ray generators with H.V auxiliary board part numbers 739445-00 / 739445-01 or 739442-00 / 739442-01 and serial numbers before CPD05500F09, refer to table 9-3.

Table 9-3: H.V Auxiliary Board Kit Numbers		
Stator Type	208 / 230 V Generators	400 / 480 V Generators
"R" type stator	SP73944500CMP	SP73944200CMP
GE 23/23 Ω stator	SP73944501CMP	SP73944201CMP

For X-ray generators with H.V auxiliary board part numbers 739445-00 / 739445-01 or 739442-00 / 739442-01 and serial number CPD05500F09 and higher:

If you want to upgrade the X-ray generator by using the LSS kit, refer to table 9-4.

Otherwise, refer to table 9-3.

Table 9-4: Low-Speed Starter Kit Information				
LSS Kit No	Capacitor Value	AC Mains Voltage	H.V Auxiliary Board No	Note
SP90369000	30 μF	400 / 480 V	739442-99	Includes Mounting Hardware
SP90369001	40 μF			
SP90369002	20 μF			
SP90369010	30 μF	208 / 230 V	739445-99	
SP90369011	40 μF			

SP90369012	20 μF			

For X-ray generators that contain a chassis-mounted phase-shift capacitor, refer to table 9-5.

Table 9-5: Capacitor Field Kit Information		
Field Capacitor Kit part Number	**Capacitor Value**	**Notes**
903836-00	30 μF	Includes Mounting Hardware
903836-01	40 μF	
903836-02	20 μF	

Units with the dual-speed starter option will be fitted with H.V. auxiliary board 739442-99.

Before installing a replacement H.V. auxiliary board, jumpers must be properly installed on this board in order to select the Bucky voltage (24 VDC, 110 VAC, or 220 VAC). After determining the Bucky-drive-voltage requirement, connect the appropriate pair of jumpers in accordance with table 9-6 *****.

The jumpers that select the Bucky voltage must be set per Table 9-6.

Table 9-6: Jumper Settings for Bucky Output Voltages	
BUCKY OUTPUT	**H.V. AUXILIARY BOARD JUMPERS (units with isolated 110 / 220 VAC, using auxiliary transformer 739446)**
24 VDC	E11-E5, E7-E8
110 VAC	E9-E5, E7-E8
220 VAC	E12-E5, E7-E8

After determining the required rotor boost voltage, connect a wire jumper (see Table 9-7) between the desired tabs on the boards *****.

Table 9-7: Jumper Settings for Rotor Boost Voltages	
Rotor Boost Voltage	**H.V. Auxiliary Board Jumpers**
120 VAC	E14-E15
240 VAC	E16-E15

***** A complete set of jumpers is shipped with each new generator. Three of the jumpers are installed on the H.V. auxiliary board, and the remaining jumpers are in a bag attached to the lip on the inside of the cable access slot above the HV module.

If the Bucky or low-speed starter boost voltage needs to be changed on an existing H.V. auxiliary board, use the existing jumper(s) if they are of the correct length and have the proper connector to fit the tab(s) on the board. Otherwise, select the shortest wires from the spare jumper set that will connect between the desired tabs on the board and that have the proper connectors on the jumpers. For spares boards, the jumpers will need to be removed from the “old” board and reused.

Additionally, JW1 must be set per Table 9-8 before installing a replacement H.V. auxiliary board.

Table 9-8 Jumper JW1 Configurations

UNIT TYPE	JW1 CONFIGURATION: H.V. AUXILIARY BOARD
1 phase	OPEN (jumper pins 2-3)
3 phase	CLOSED (jumper pins 1-2)

Note 2:

The AEC board in your generator was selected to be compatible with specific AEC devices. To maintain full compatibility, the original part number must be ordered as a replacement.

Note 3:

This applies to the dual-speed starter option only. Spares should be stocked accordingly. The part number shown for the dual-speed starter board is for the board only, without the phase-shift capacitors. For the complete dual-speed starter subassembly, several part numbers (which are tube-stator dependent) are used in CMP 200® DR 400 / 480 VAC generators. To determine which dual-speed starter subassembly is in your generator, note the DUAL-SPEED STARTER SUBASSEMBLY KIT part number. The label on a sticker is located at the opposite side of the board assembly on the back of the mounting plate. This will be the part number that must be ordered for spares usage. Examples of part numbers are 901297-XX, 901298-XX, 902066-XX, 906672-XX where XX is a two digit number designating the exact configuration.

Note 4:

This generator control board is jumper configurable. Refer to the Table 9-9A and Table 9-9B to configure the generator control board for your X-ray generator.

Warning: Do not attempt to reconfigure 125 kV maximum generators for 150 kV operations. Serious generator damage will occur.

Table 9-9A: Jumper Settings of the Generator Control Board		
Function	**Jumpers**	**Configuration**
Firmware Upgrading	JW2	PINS 1-2: Normal PINS 2-3: Upgrade
	JW4 and JW5	Set as per Table 9-5b below.
kV Overvoltage Trip	JW6	PINS: 1-2: 125 kV PINS: 2-3: 150 kV
	JW7	Not used.
Cooling Fan	JW12	PINS 1-2: No Fan PINS 2-3: Fan
Maximum kV	JW13	PINS 1-2: 125 kV (For 125 kV high voltage module) PINS 2-3: 150 kV (For 150 kV high voltage module)
DAP	JW14	Set as per *DAP Installation* in Chapter 3, *Interfacing and Programming*.
High voltage module Feedback Comp.	JW15	PINS 1-2: 125 kV PINS 2-3: 150 kV
KV Feedback Compensation	JW16	PINS 1-2: 125 kV PINS 2-3: 150 kV

Table 9-9B: JW4 and JW5 Settings of the Generator Control Board		
Module Configurations	**JW4**	**JW5**
32 / 40 kW, 400 / 480 VAC, 125 kV	Pins 1-2	Pins 1-2
50 kW, 400 / 480 VAC, 150 kV	Pins 2-3	Pins 1-2
32 / 40 kW, 208 / 230 VAC, 125 kV	Pins 2-3	Pins 2-3
32 / 40 kW, 400 / 480 VAC, 150 kV	Pins 1-2	Pins 1-2
50 kW, 208 / 230 VAC, 150 kV	Pins 2-3	Pins 2-3
65 / 80 kW, 400 / 480 VAC, 150 kV	Pins 2-3	Pins 2-3

Note 5:

These assemblies apply to generators equipped with a membrane console only.

Note 6:

CPI does not supply the Battery on the Generator Control board. Customer has to supply exactly the same battery (timekeeper SRAM, ST Micro Electronics “SNAPHAT” part number M4T32-BR12SH6)

Chapter 10 Functional Drawings

Contents

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Introduction

This chapter contains the functional schematics for the CMP 200® X-ray generator. Each functional schematic represents a major function in the generator. The functional schematics in this chapter represent all of the major functional blocks in the CMP 200® X-ray generators.

Functional Schematic Index

The following functional schematics are included in this chapter.

Table 10-1: CMP 200® Generator Functional Drawings

Description	Numbers	Revision
DC Bus and Power Distribution	MD-0927	H
System ON	MD-0928	D
Room Interface	MD-0930	D
X-Ray Exposure - Radiographic	MD-0931	C
kV Control and Feedback	MD-0932	C
Filament Drive and mA Control	MD-0934	B
Low-Speed Starter	MD-0935	E
Dual-Speed Starter	MD-0924	D
Dual-Speed Starter (DSS 2, new version)	MD-1069	B
Automatic Exposure Control (AEC)	MD-0936	B
Serial Communications	MD-0937	D
DAP	MD-0938	C
Digital Interface	MD-0926	B
Temp Sensor / Programming Jumpers	MD-0925	C
Interconnect Diagram	MD-0939	E

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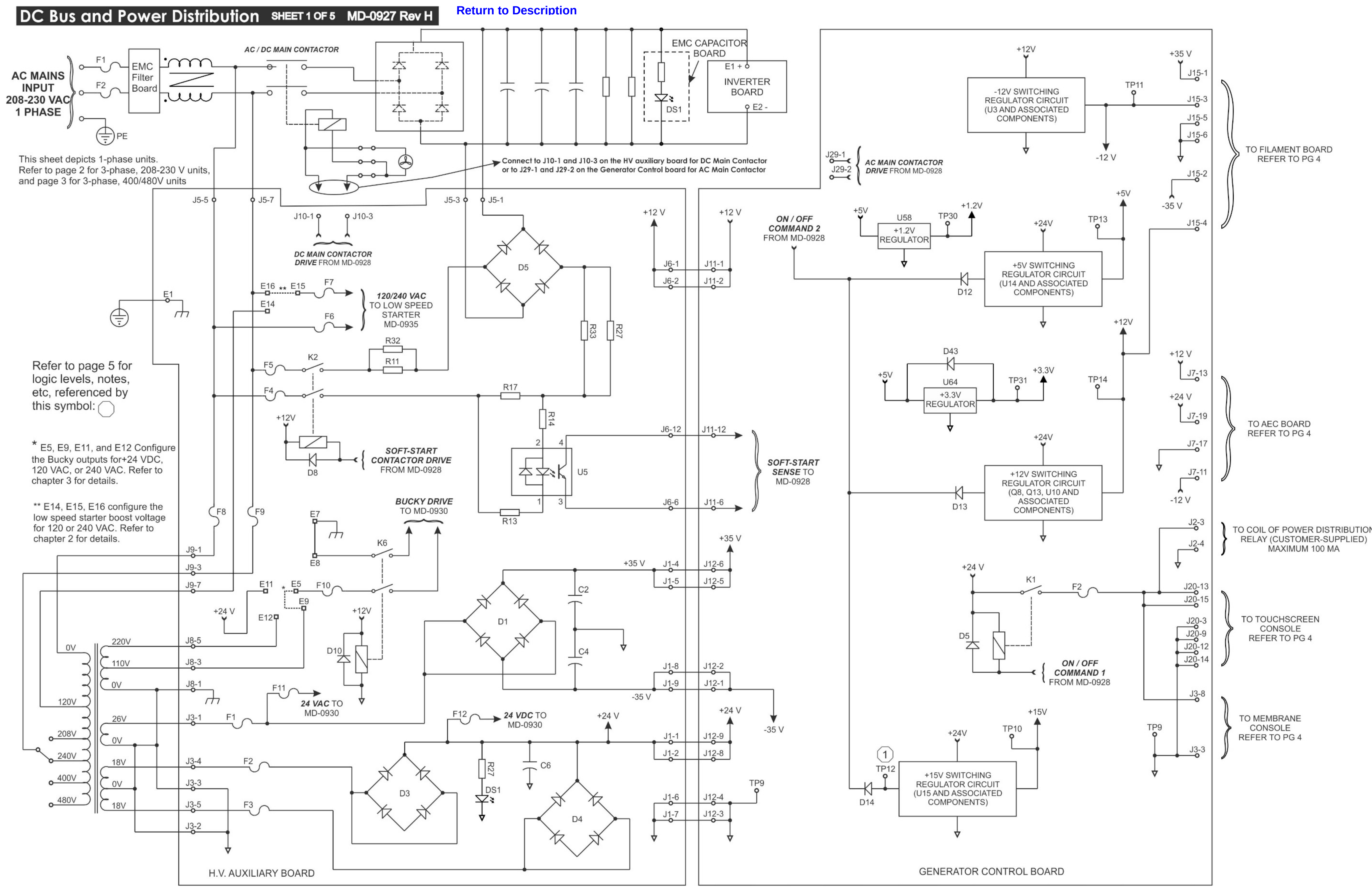
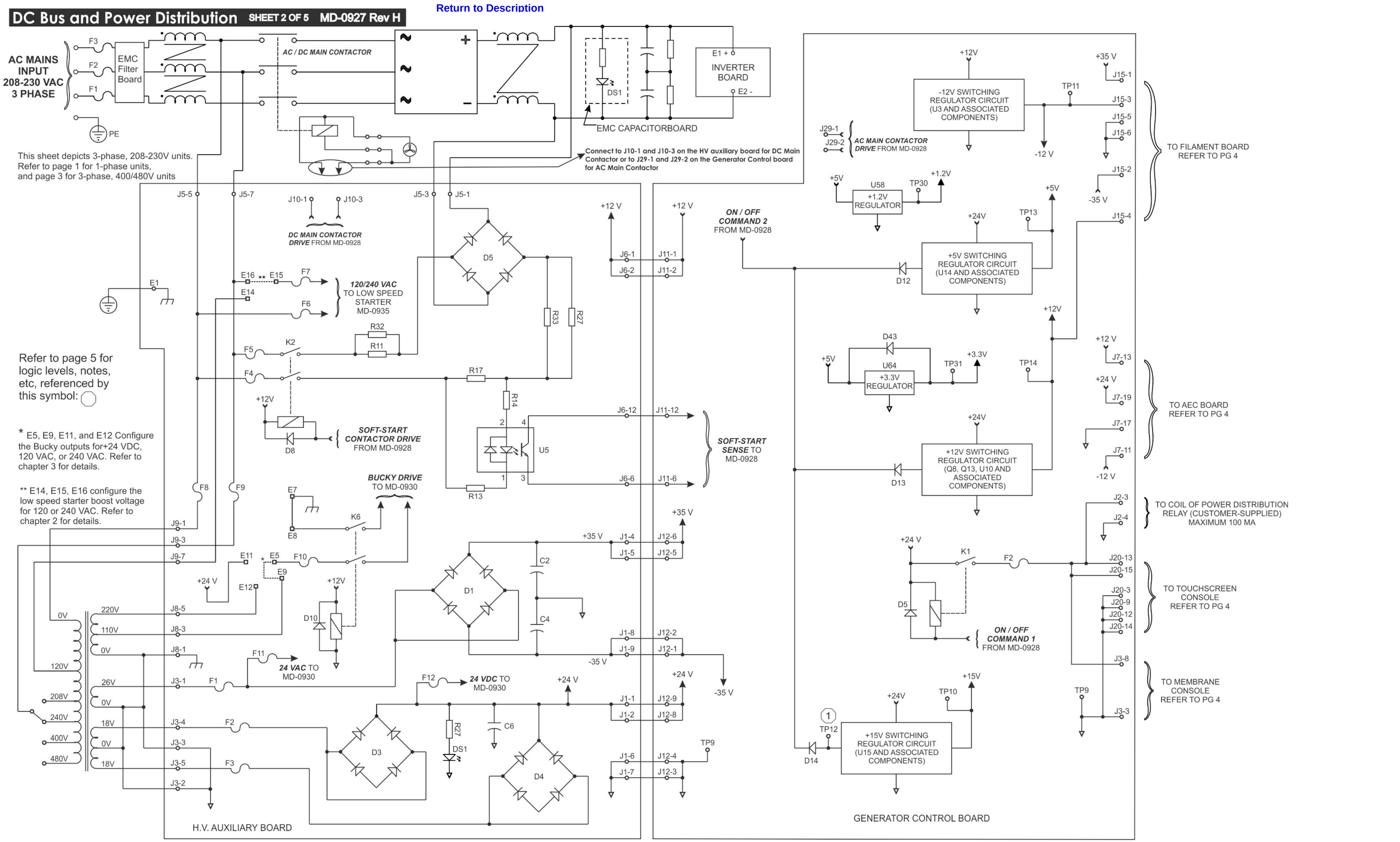
DC Bus and Power Distribution

Return to Description

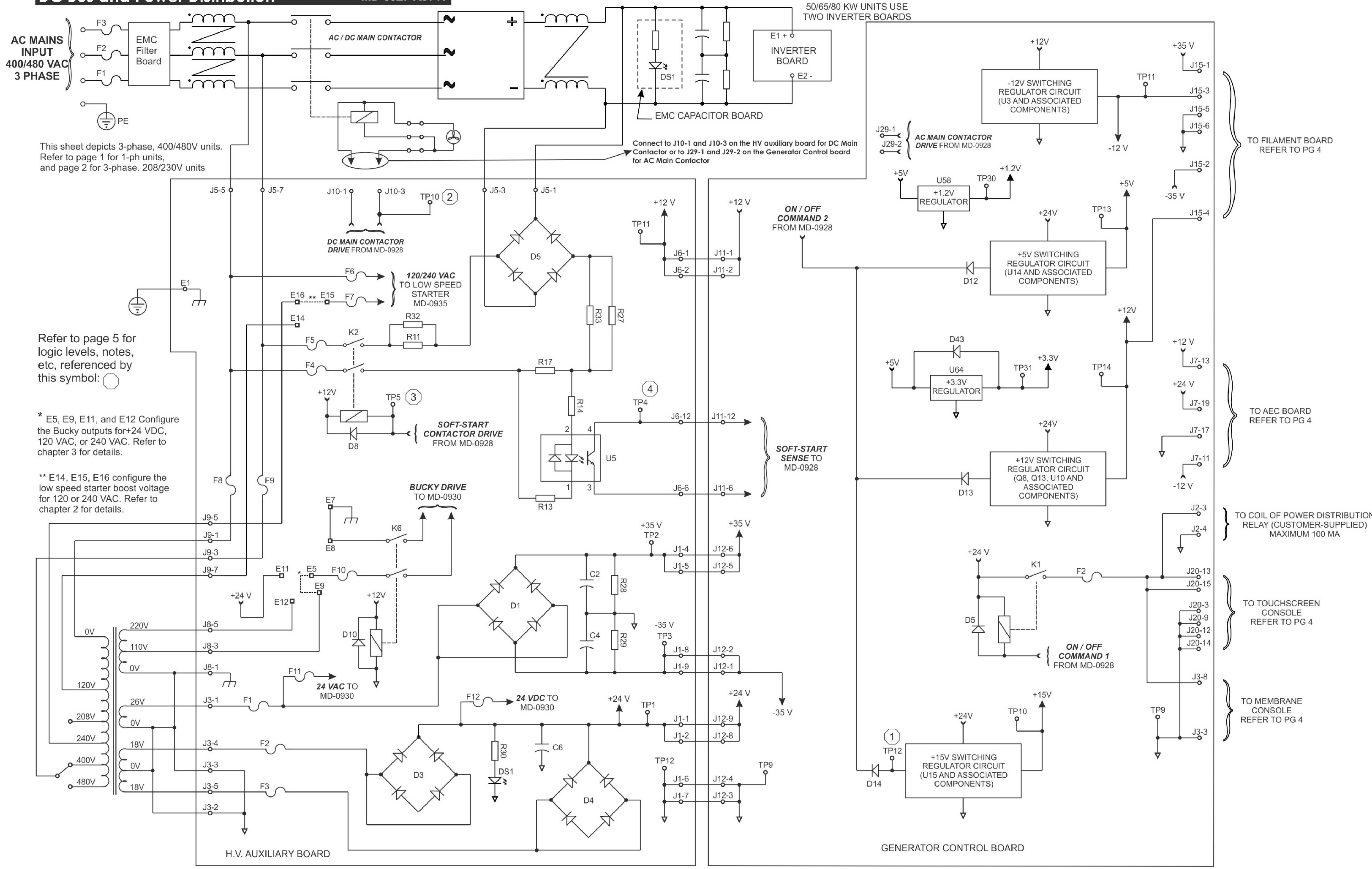


Return to Description



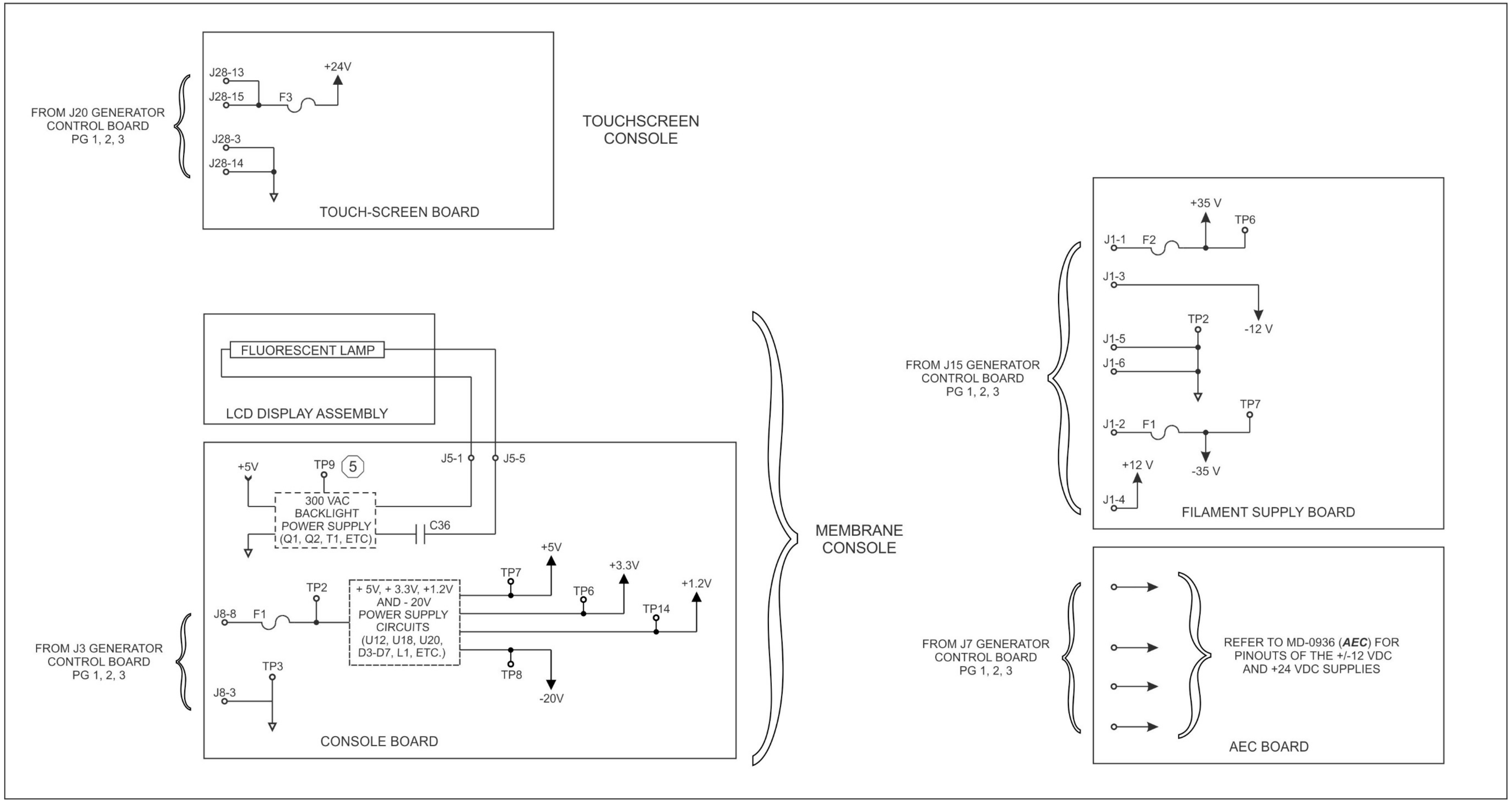
DC Bus and Power Distribution SHEET 3 OF 5 MD-0927 Rev H

Return to Description



DC Bus and Power Distribution SHEET 4 OF 5 MD-0927 Rev H

Return to Description



DC Bus and Power Distribution SHEET 5 OF 5 MD-0927 Rev H

NOTE REFERENCE	REMARKS
1	"LOW" (APPROXIMATELY 0 VDC) DISABLES THE +5V, +12V, AND +15V REGULATORS (GENERATOR SWITCHED OFF). "HIGH" (APPROXIMATELY 24V DC) ENABLES THESE REGULATORS (I.E. GENERATOR SWITCHED ON) .
2	"LOW" (APPROXIMATELY 0 VDC) ENERGIZES THE MAIN POWER CONTACTOR IN THE GENERATOR, ("HIGH", + 12V DC = NOT ENERGIZED). THIS CONTACTOR IS ENERGIZED AFTER THE MAIN BUS CAPACITORS ARE CHARGED, APPROXIMATELY 10 SECONDS AFTER POWER-ON. **(Test point available on 400 / 480V AC units only)**
3	"LOW" (APPROXIMATELY 0V DC) ENERGIZES THE SOFT START CONTACTOR K2 ON THE H.V. AUXILIARY BOARD, ("HIGH", + 12V DC = NOT ENERGIZED). THIS CONTACTOR IS ENERGIZED FOR A MAXIMUM OF APPROXIMATELY 10 SECONDS AFTER POWER-ON IN ORDER TO CHARGE THE DC BUS CAPACITORS. **(Test point available on 400 / 480V AC units only)**
4	THE VOLTAGE WAVEFORM AT THIS TEST POINT IS DEPICTED IN FIGURE 1 BELOW. **(Test point available on 400 / 480V AC units only)**
5	THE VOLTAGE WAVEFORM AT THIS TEST POINT IS DEPICTED IN FIGURE 2 BELOW.

FIGURE 1

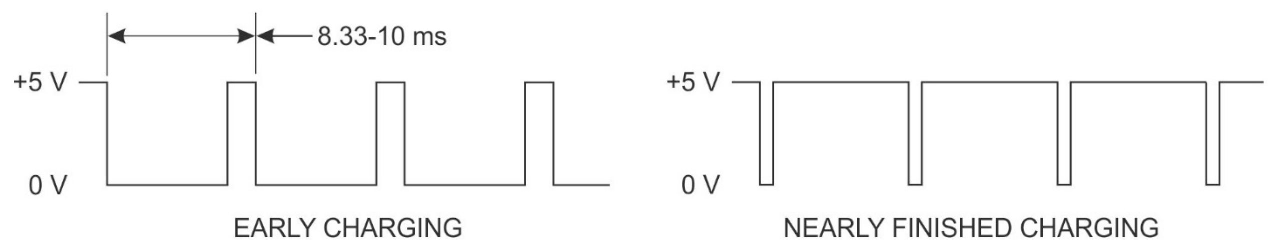
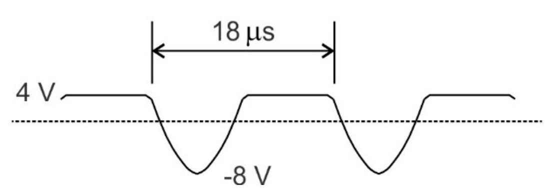
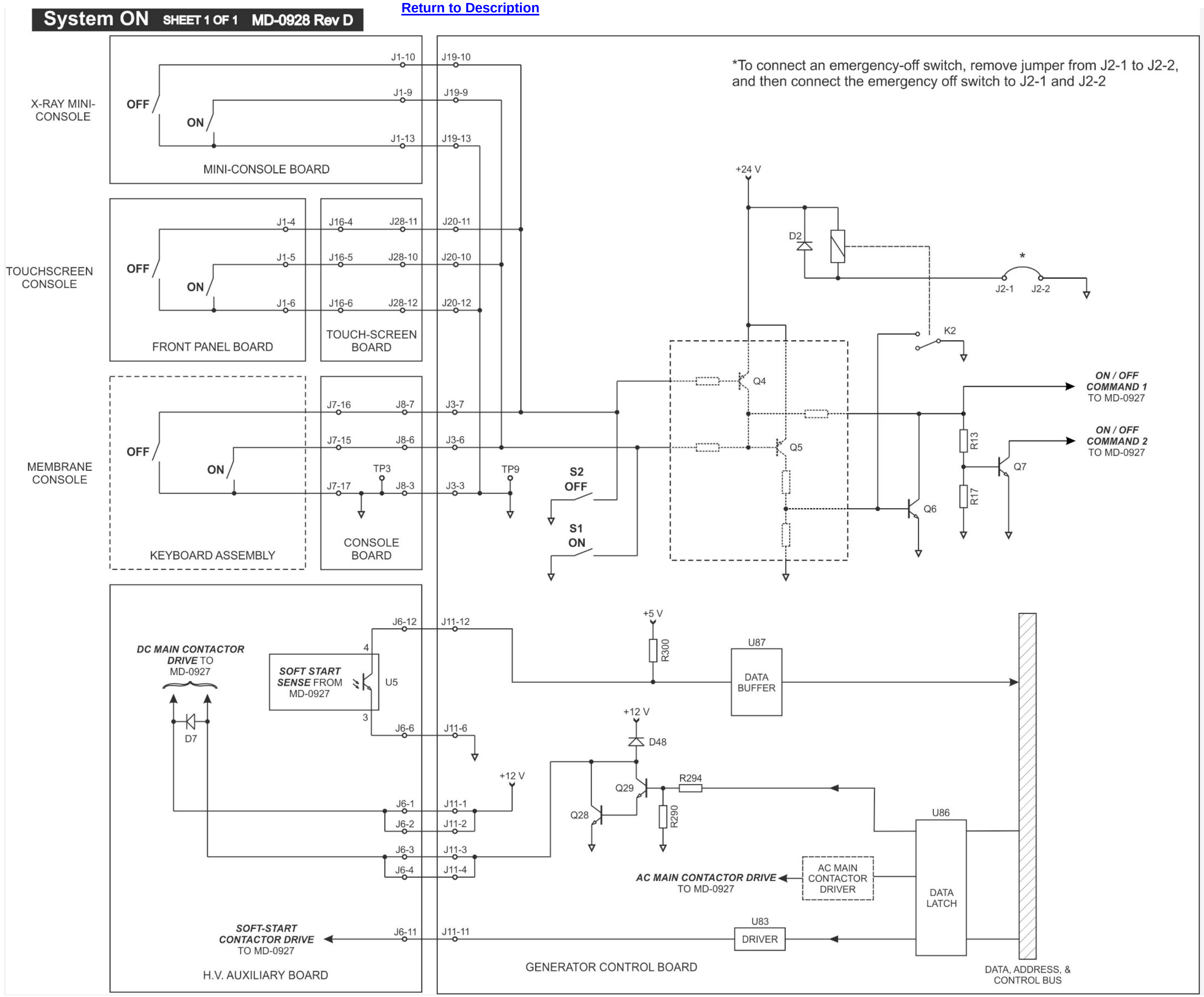


FIGURE 2

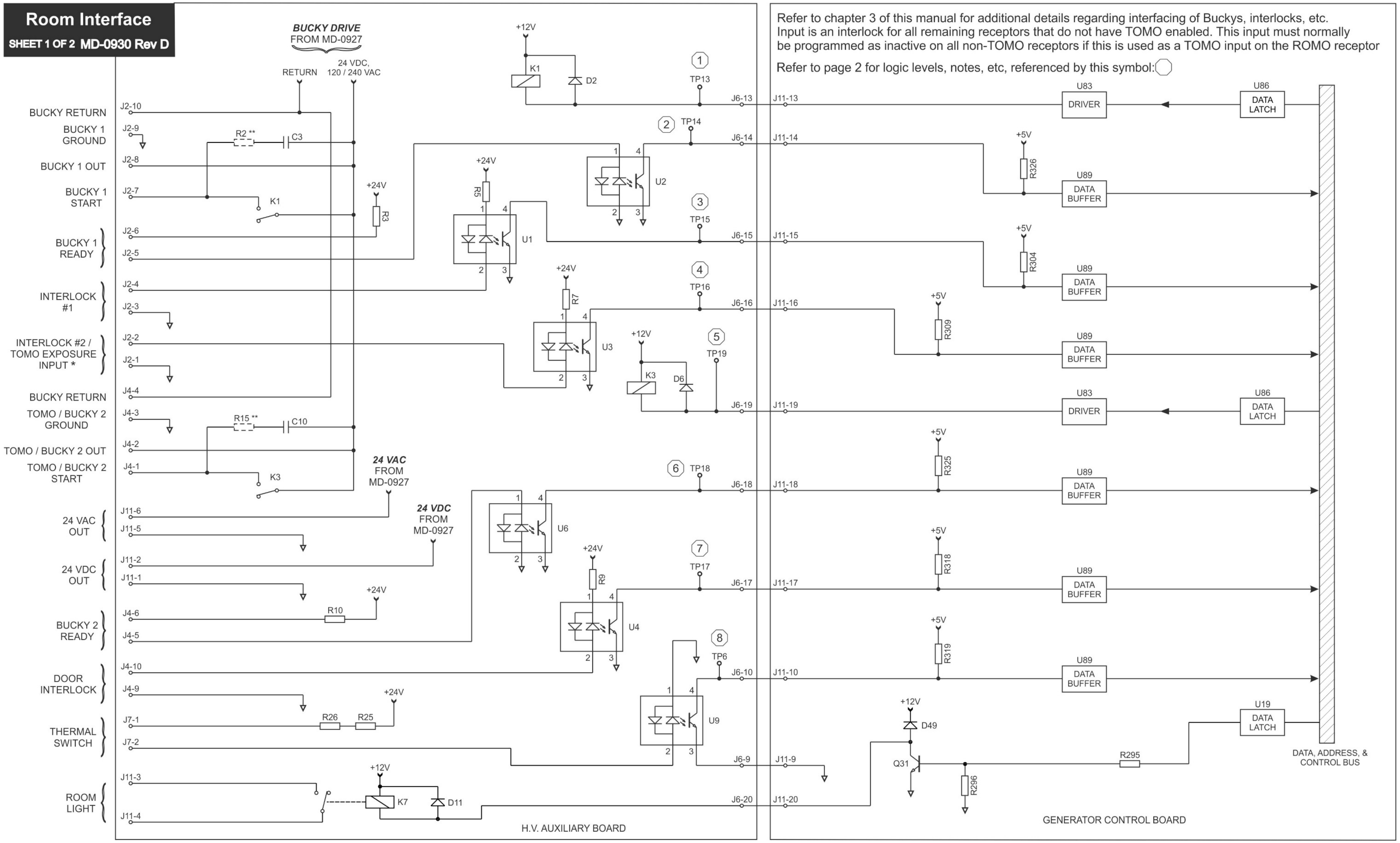


System ON


System ON SHEET 1 OF 1 MD-0928 Rev D
Return to Description
X-RAY MINI-CONSOLE
MINI-CONSOLE BOARD
TOUCHSCREEN CONSOLE
FRONT PANEL BOARD
TOUCH-SCREEN BOARD
MEMBRANE CONSOLE
KEYBOARD ASSEMBLY
CONSOLE BOARD
OFF
ON
S2 OFF
S1 ON
*To connect an emergency-off switch, remove jumper from J2-1 to J2-2, and then connect the emergency off switch to J2-1 and J2-2
+24 V
D2
K2
J2-1
J2-2
Q4
Q5
Q6
Q7
R13
R17
ON / OFF COMMAND 1 TO MD-0927
ON / OFF COMMAND 2 TO MD-0927
DC MAIN CONTACTOR DRIVE TO MD-0927
SOFT START SENSE FROM MD-0927
U5
D7
+5 V
R300
U87
DATA BUFFER
+12 V
D48
Q29
Q28
R294
R290
U86
DATA LATCH
AC MAIN CONTACTOR DRIVE TO MD-0927
AC MAIN CONTACTOR DRIVER
U83
DRIVER
SOFT-START CONTACTOR DRIVE TO MD-0927
H.V. AUXILIARY BOARD
GENERATOR CONTROL BOARD
DATA, ADDRESS, & CONTROL BUS

Room Interface

Return to Description



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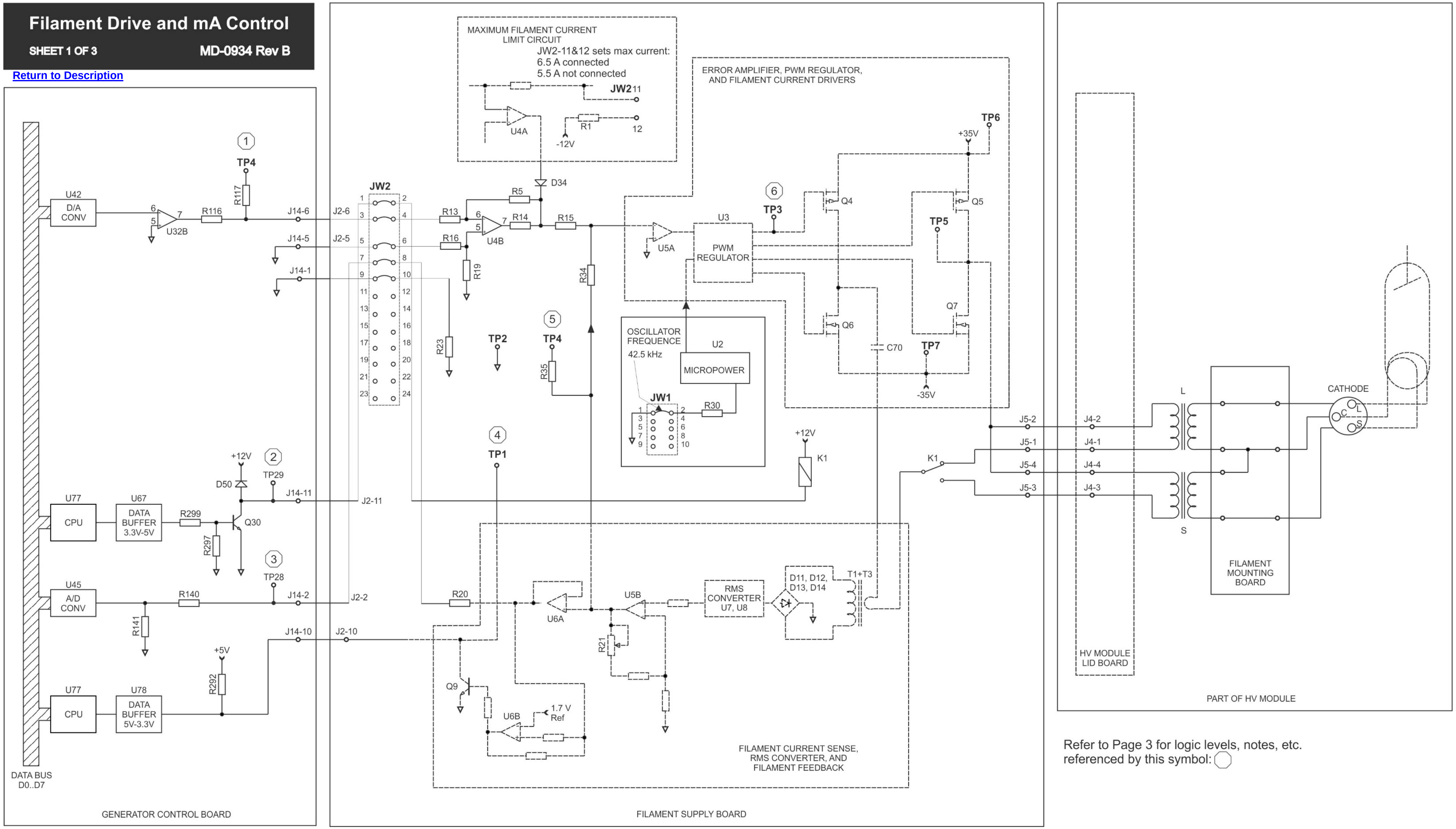
Room Interface SHEET 2 OF 2 MD-0930 Rev D

Room Interface

NOTE REFERENCE	REMARKS	
1	"LOW" (APPROXIMATELY 0 VDC) = BUCKY 1 START. "HIGH" (APPROXIMATELY +12 VDC) = BUCKY 1 NOT REQUESTED TO START.	**(Test point available on 400 / 480V AC units only)**
2	"LOW" (APPROXIMATELY 0 VDC) = BUCKY 1 READY. "HIGH" (APPROXIMATELY +5 VDC) = BUCKY 1 NOT READY.	**(Test point available on 400 / 480V AC units only)**
3	"LOW" (APPROXIMATELY 0 VDC) = 40" S.I.D. INTERLOCK CLOSED. "HIGH" (APPROXIMATELY +5 VDC) = 40" S.I.D. INTERLOCK OPEN.	**(Test point available on 400 / 480V AC units only)**
4	"LOW" (APPROXIMATELY 0 VDC) = 72" S.I.D. INTERLOCK CLOSED. "HIGH" (APPROXIMATELY +5 VDC) = 72" S.I.D. INTERLOCK OPEN.	**(Test point available on 400 / 480V AC units only)**
5	"LOW" (APPROXIMATELY 0 VDC) = BUCKY 2 START. "HIGH" (APPROXIMATELY +12 VDC) = BUCKY 2 NOT REQUESTED TO START.	**(Test point available on 400 / 480V AC units only)**
6	"LOW" (APPROXIMATELY 0 VDC) = BUCKY 2 READY. "HIGH" (APPROXIMATELY +5 VDC) = BUCKY 2 NOT READY.	**(Test point available on 400 / 480V AC units only)**
7	"LOW" (APPROXIMATELY 0 VDC) = DOOR INTERLOCK CLOSED. "HIGH" (APPROXIMATELY +5 VDC) = DOOR INTERLOCK OPEN.	**(Test point available on 400 / 480V AC units only)**
8	"LOW" (APPROXIMATELY 0 VDC) = THERMAL SWITCH CLOSED. "HIGH" (APPROXIMATELY +5 VDC) = THERMAL SWITCH OPEN.	**(Test point available on 400 / 480V AC units only)**

** These resistor may need to be installed in some applications. Refer to chapter 3 for details.

Filament Drive and mA Control

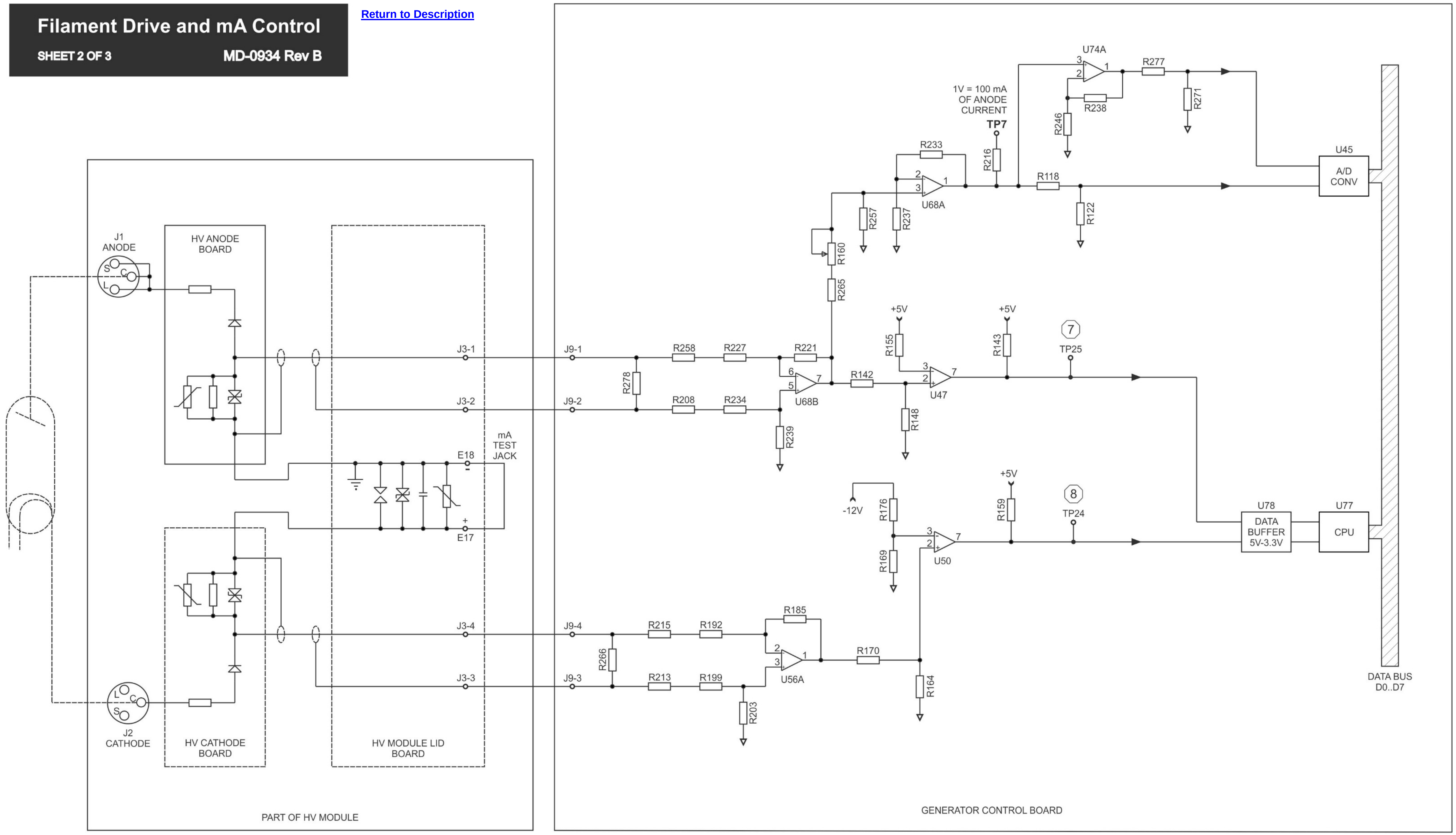


Refer to Page 3 for logic levels, notes, etc. referenced by this symbol: ⬡

Filament Drive and mA Control

SHEET 2 OF 3 MD-0934 Rev B

Return to Description



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Filament Drive and mA Control SHEET 3 OF 3 MD-0934 Rev B

NOTE REFERENCE	REMARKS
1	1 VOLT AT THIS TEST POINT = 1 AMP OF FILAMENT DEMAND.
2	"LOW" (APPROXIMATELY 0 VDC) ENERGIZES K1 ON THE FILAMENT SUPPLY BOARD (SMALL FILAMENT), "HIGH" (APPROXIMATELY +12 VDC) DE-ENERGIZES K1 (LARGE FILAMENT).
3	0.6 VOLT AT THIS TEST POINT = 1 AMP OF ACTUAL FILAMENT CURRENT.
4	"HIGH" (APPROXIMATELY 5 VDC) = FILAMENT FAULT (FILAMENT CURRENT < 1.8 A). "LOW" (APPROXIMATELY 0 VDC) = NO FILAMENT FAULT.
5	1 VOLT AT THIS TEST POINT = 1 AMP OF ACTUAL FILAMENT CURRENT.
6	PWM OUTPUT. THE WAVEFORM WILL BE AS PER FIGURE 1 FOR LOW AND HIGH FILAMENT CURRENT DEMAND.
7, 8	A NARROW PULSE WILL BE PRESENT AT THESE TEST POINTS DURING SEVERE ANODE OR CATHODE OVER CURRENTS (I.E. TUBE OR HV MODULE ARCS). REFER TO FIGURE 2. THESE PULSES MAY BE VERY DIFFICULT TO OBSERVE, AS THE HIGH VOLTAGE WILL SHUT DOWN WHEN A FAULT IS DETECTED, THUS REMOVING THE OVER CURRENT SITUATION.

FIGURE 1

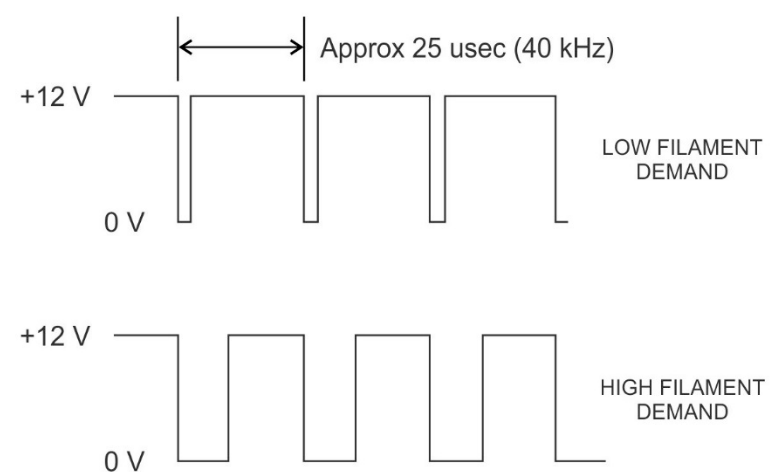
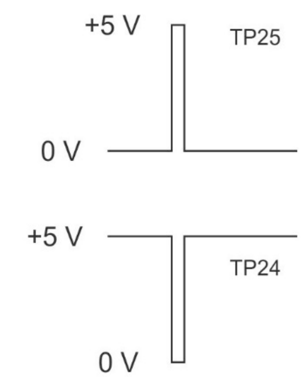
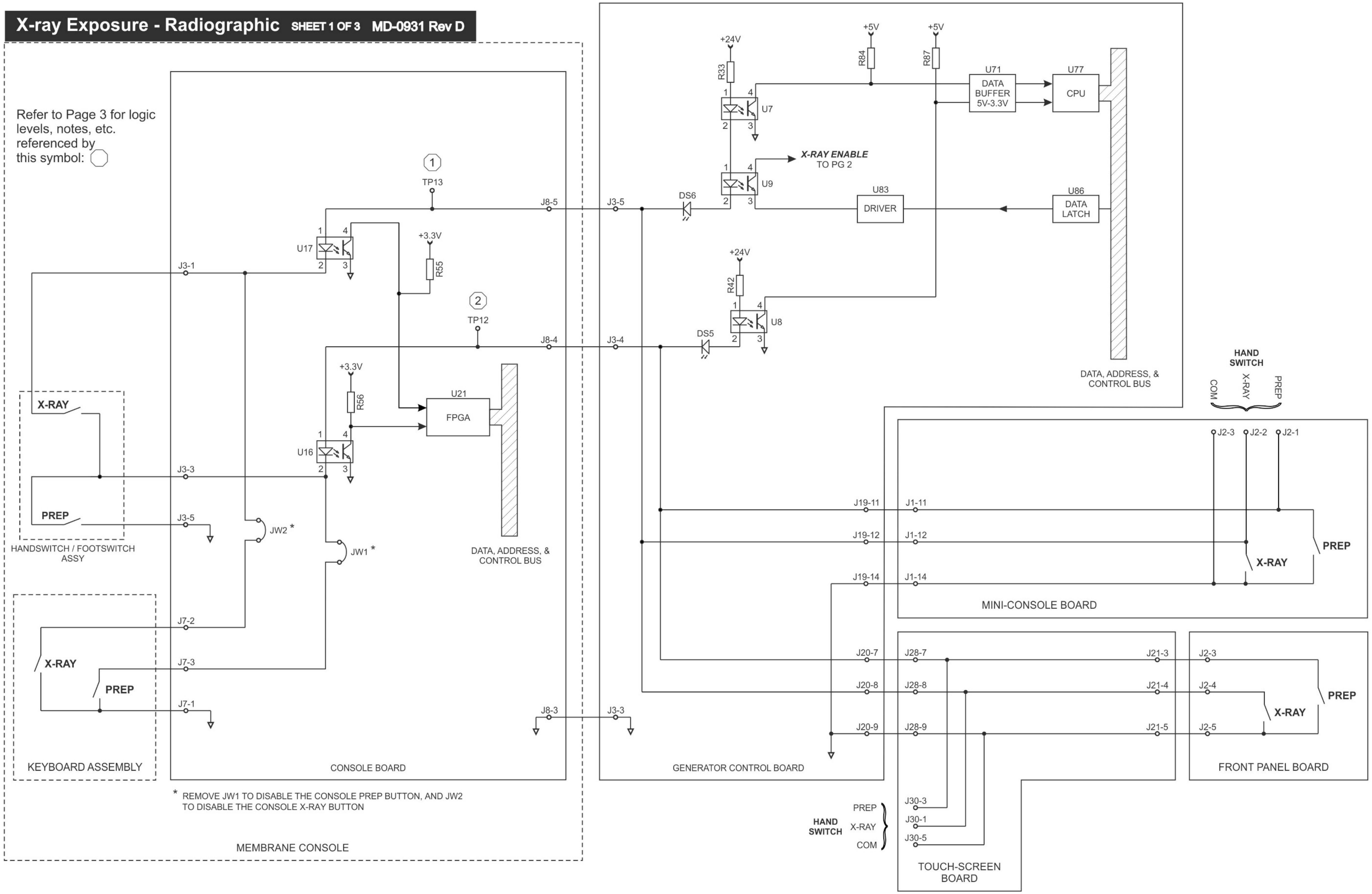


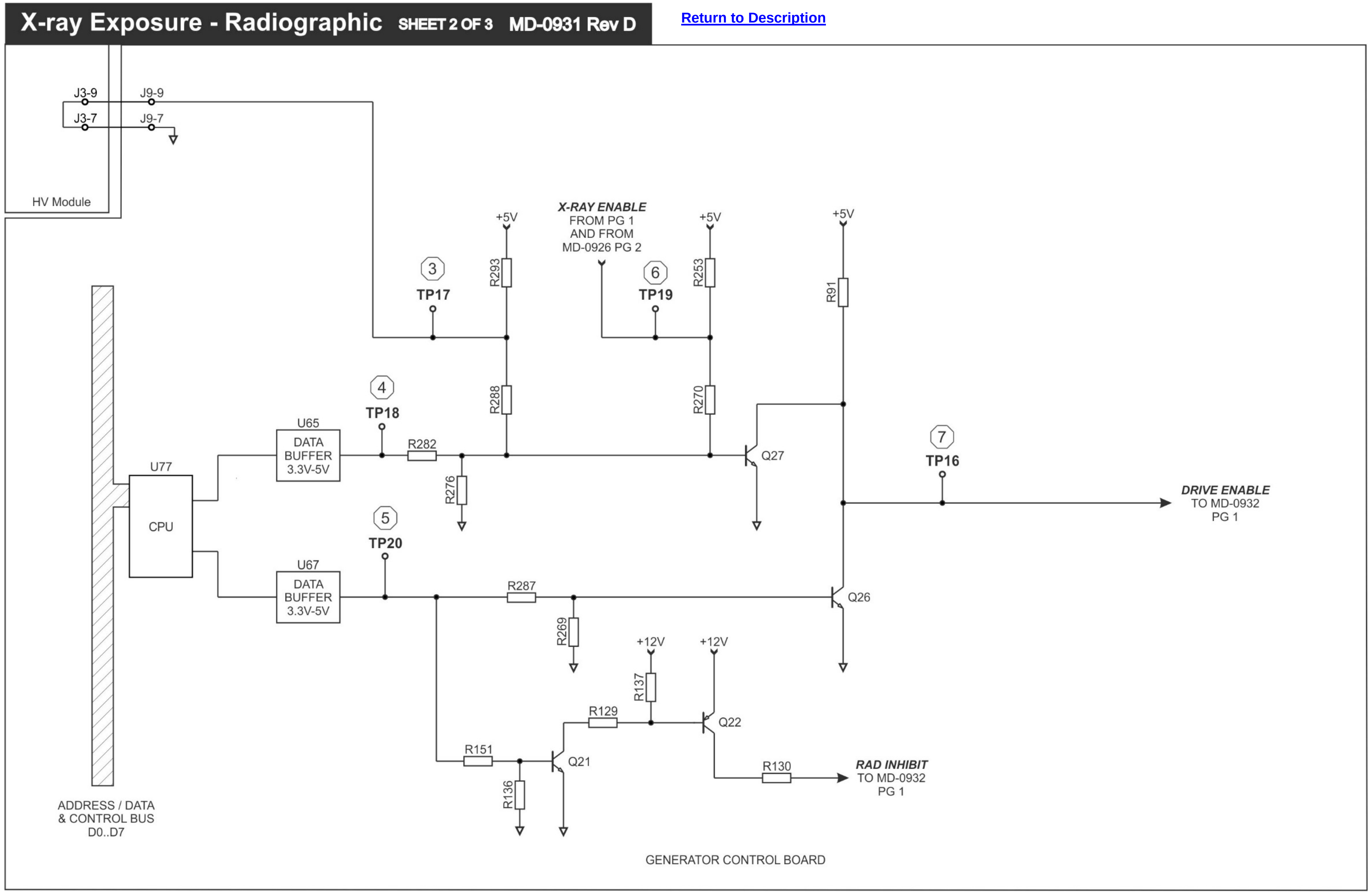
FIGURE 2



X-ray Exposure (Radiographic)

Return to Description



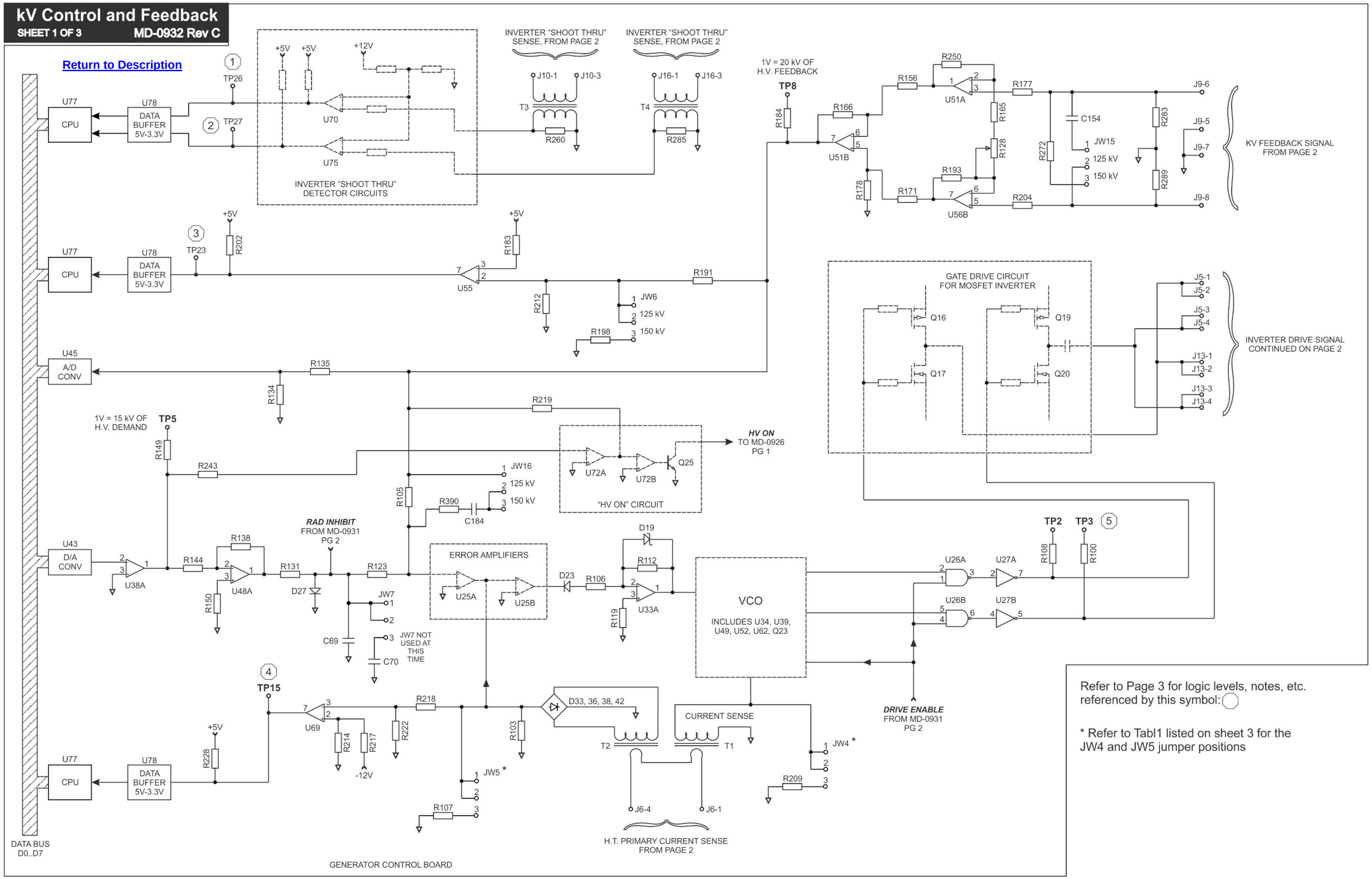


[Return to Description](#)

X-ray Exposure - Radiographic SHEET 3 OF 3 MD-0931 Rev D

NOTE REFERENCE	REMARKS
1	"LOW" (APPROXIMATELY 0V DC) = X-RAY REQUESTED. "HIGH" (APPROXIMATELY +24V DC) = X-RAY NOT REQUESTED.
2	"LOW" (APPROXIMATELY 0V DC) = PREP REQUESTED. "HIGH" (APPROXIMATELY +24V DC) = PREP NOT REQUESTED.
3	"LOW" (APPROXIMATELY 0V DC) = HV MODULE CONNECTED. "HIGH" (APPROXIMATELY +5V DC) = HV MODULE NOT CONNECTED.
4	"LOW" (APPROXIMATELY 0V DC) = NO FAULT PRESENT. "HIGH" (APPROXIMATELY +5V DC) = FAULT DETECTED, EXPOSURE INHIBITED.
5	"LOW" (APPROXIMATELY 0V DC) = X-RAY REQUESTED. "HIGH" (APPROXIMATELY +5V DC) = X-RAY NOT REQUESTED BY THE CPU.
6	"LOW" (APPROXIMATELY 0V DC) = EXPOSURE REQUESTED. "HIGH" (APPROXIMATELY +5V DC) = EXPOSURE NOT REQUESTED OR REQUEST NOT VALID.
7	"HIGH" (APPROXIMATELY +5V DC) = GATE DRIVE PULSES ENABLED. "LOW" (APPROXIMATELY 0V DC) = GATE DRIVE PULSES NOT ENABLED DUE TO A FAULT OR NO VALID EXPOSURE REQUEST.

KV Control and Feedback



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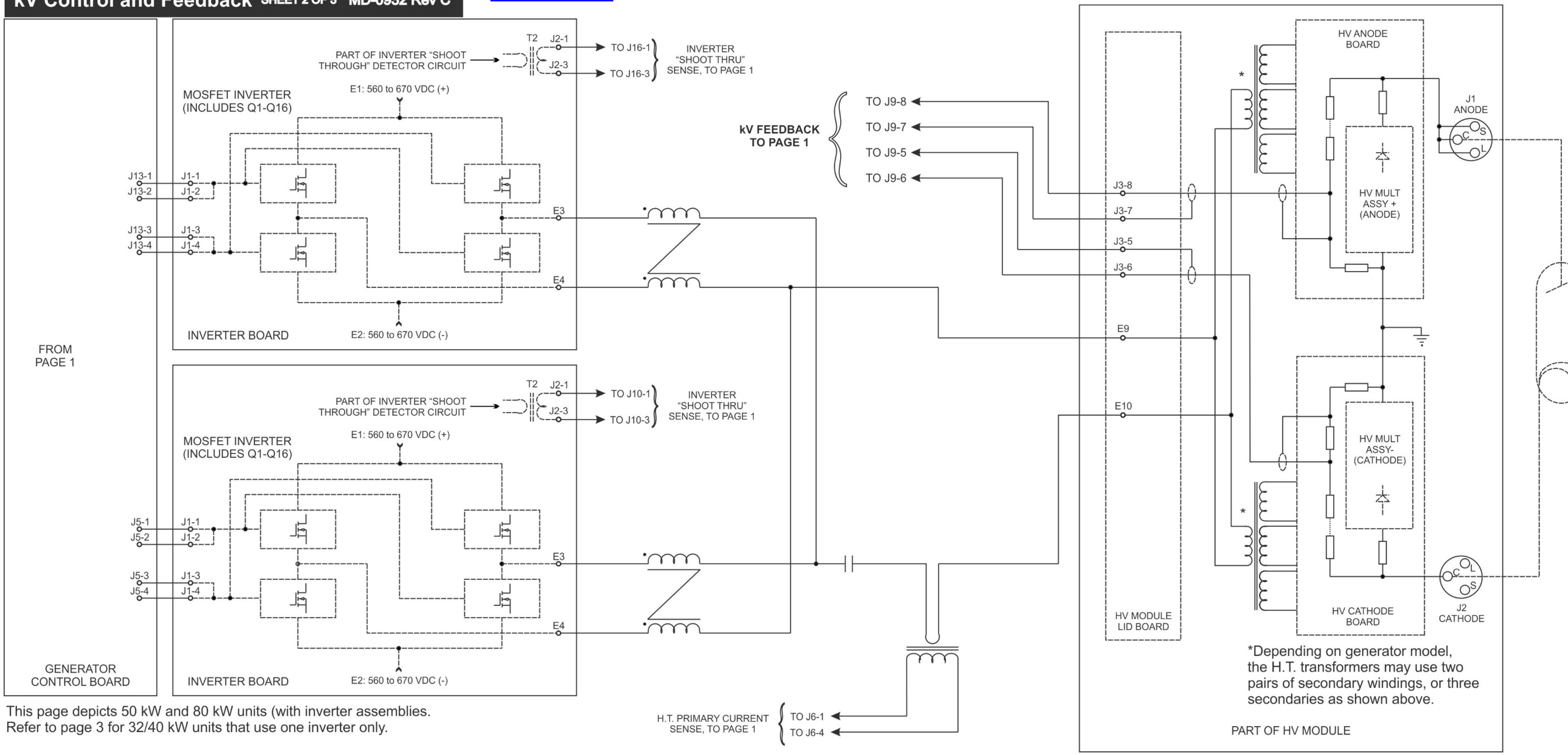
kV Control and Feedback SHEET 2 OF 3 MD-0932 Rev C

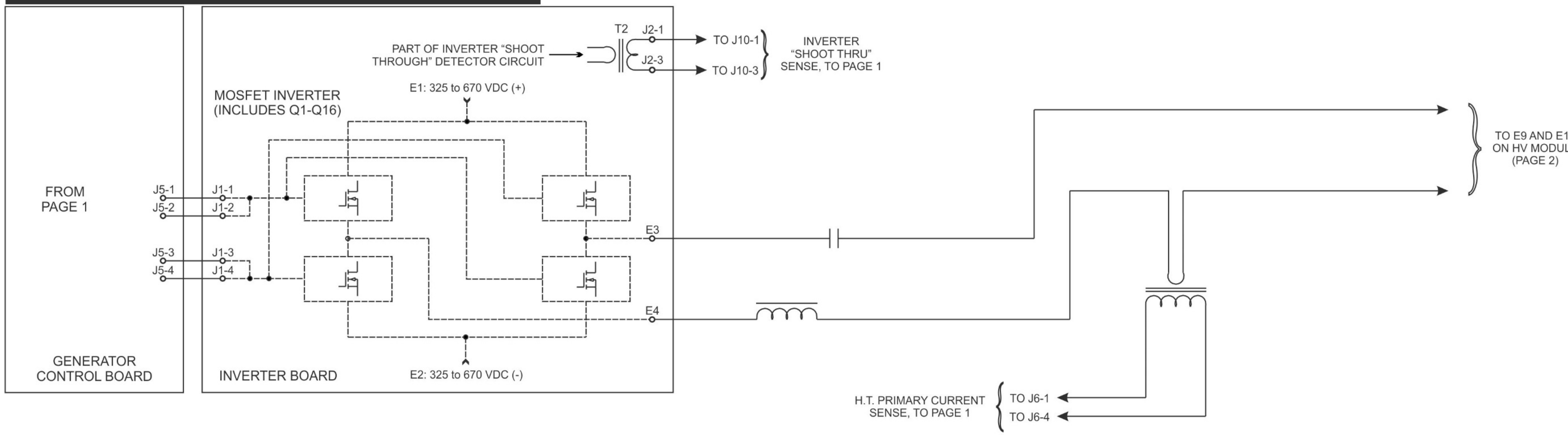
Return to Description



This page depicts 50 kW and 80 kW units (with inverter assemblies. Refer to page 3 for 32/40 kW units that use one inverter only.

kV Control and Feedback SHEET 3 OF 3 MD-0932 Rev C

Return to Description



NOTE REFERENCE	REMARKS
1	A NARROW PULSE WILL BE PRESENT AT THIS TEST POINT IF AN INVERTER "SHOOT THROUGH" HAS BEEN DETECTED. THE VOLTAGE WAVEFORM AT THIS TEST POINT IS DEPICTED IN FIGURE 1 BELOW. THIS PULSE MAY BE VERY DIFFICULT O DETECT, AS THE INVERTER DRIVE WILL BE SHUT DOWN WHEN A "SHOOT THROUGH" IS DETECTED, THUS REMOVING THE FAULT CONDITION.
2	AS PER # 1.
3	A NARROW PULSE WILL BE PRESENT AT THIS TEST POINT IF KV OVER VOLTAGE HAS BEEN DETECTED (130 KV FOR 125 KV UNITS, 163 KV FOR 150 KV UNITS). REFER TO FIGURE 1. THIS PULSE MAY BE VERY DIFFICULT TO DETECT, AS THE HIGH VOLTAGE WILL BE SHUT DOWN WHEN THE OVER VOLTAGE CONDITION IS DETECTED, THUS REMOVING THE FAULT CONDITION.
4	A NARROW PULSE WILL BE PRESENT AT THIS TEST POINT IF INVERTER OVER CURRENT HAS BEEN DETECTED. THE VOLTAGE WAVEFORM AT THIS TEST POINT IS DEPICTED IN FIGURE 1 BELOW. THIS PULSE MAY BE VERY DIFFICULT O DETECT, AS THE INVERTER DRIVE WILL BE SHUT DOWN WHEN AN OVER CURRENT CONDITION S DETECTED, THUS REMOVING THE FAULT CONDITION.
5	THE VOLTAGE AT TP2 AND TP3 SHOULD BE A 50% DUTY CYCLE SQUARE WAVE, RANGING IN FREQUENCY FROM APPROXIMATELY 80 kHz TO APPROXIMATELY 250 kHz, DEPENDING ON GENERATOR OUTPUT POWER. SEE FIGURE 2.

FIGURE 1

FIGURE 2

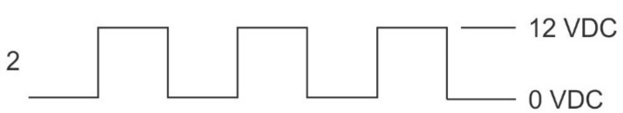


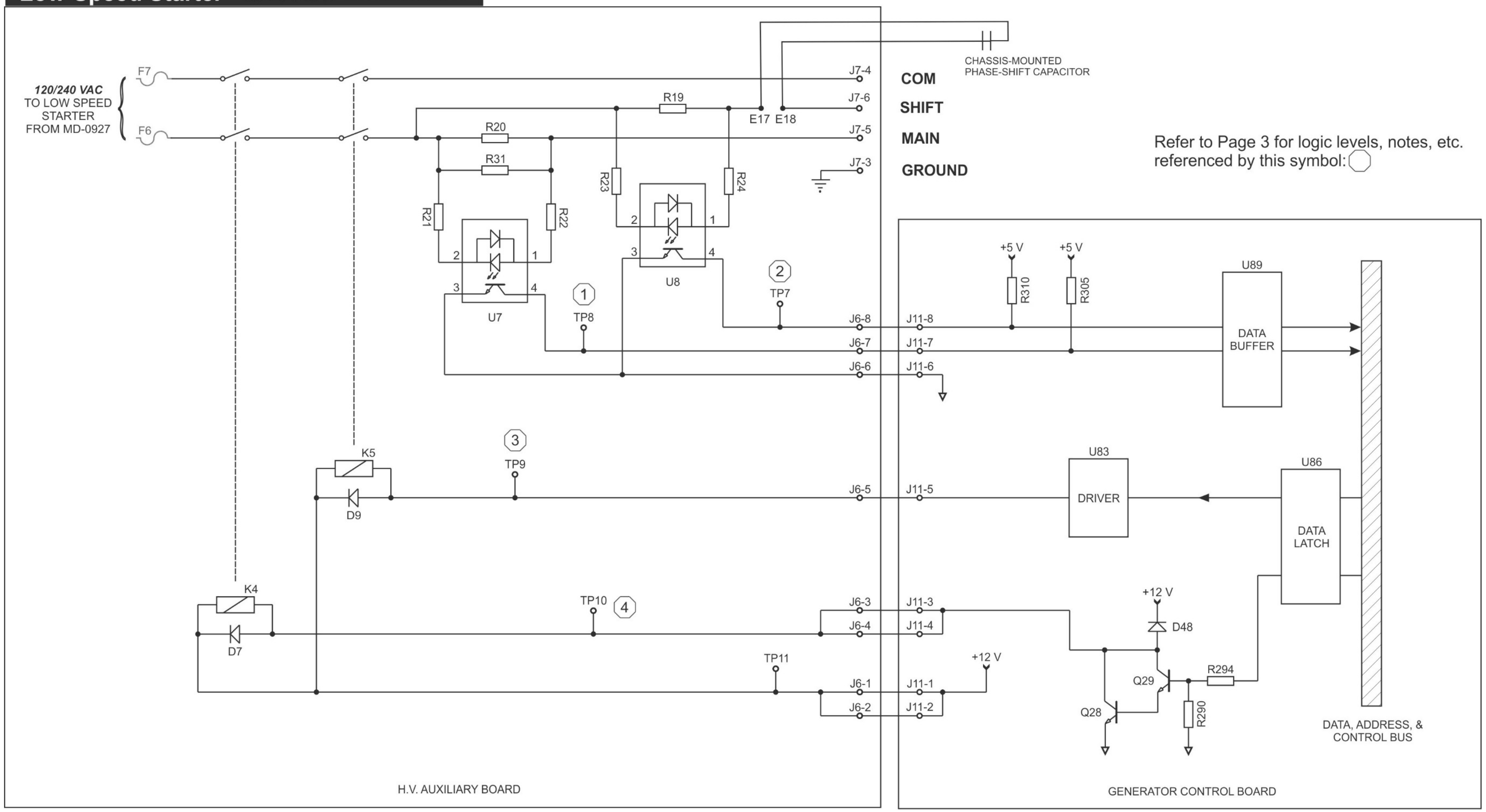
TABLE 1

	32/40 kW 400/480 VAC 125 kV	50 kW 400/480 VAC 150 kV	32/40 kW 208/230 VAC 125 kV	32/40 kW 400/480 VAC 150 kV	50 kW 208/230 VAC 150 kV	65/80 kW 400/480 VAC 150 kV
JW4	Pins 1-2	Pins 2-3	Pins 2-3	Pins 1-2	Pins 2-3	Pins 2-3
JW5	Pins 1-2	Pins 1-2	Pins 2-3	Pins 1-2	Pins 2-3	Pins 2-3

Low Speed Starter

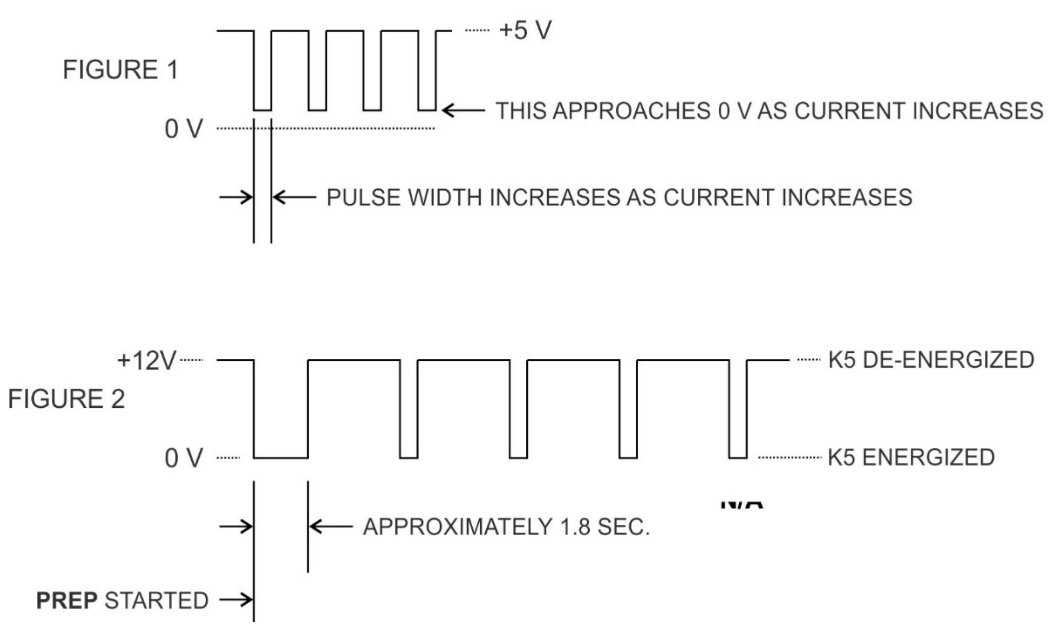
Low-Speed Starter SHEET 1 OF 2 MD-0935 Rev E

Return to Description

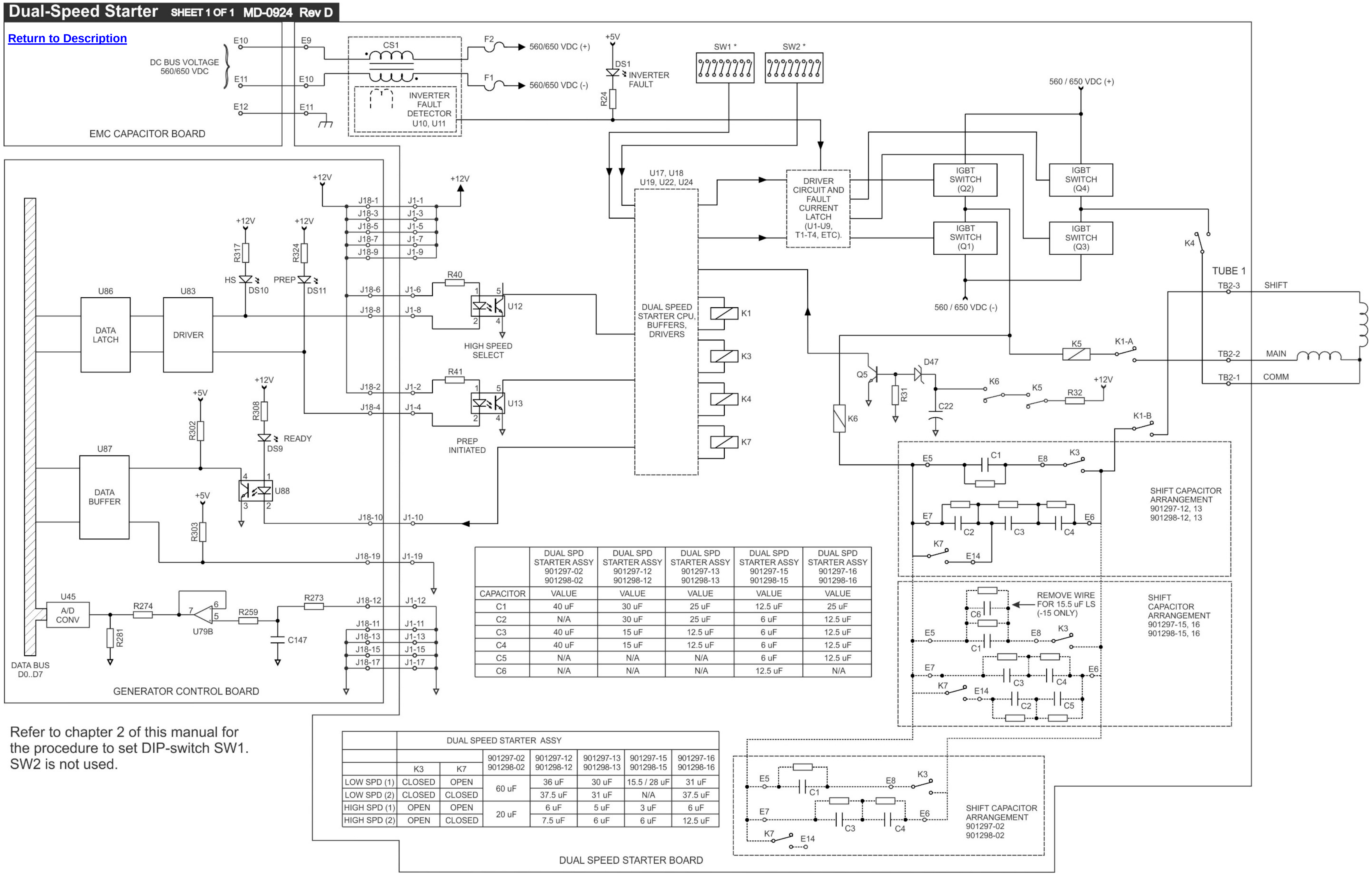


Low-Speed Starter SHEET 2 OF 2 MD-0935 Rev E

NOTE REFERENCE	REMARKS
1	MAIN STATOR CURRENT SENSE. IF MAIN CURRENT IS LOW, THIS WILL BE APPROXIMATELY +5V DC. PULSES AT 100 OR 120 HZ WILL BE PRESENT AS SHOWN IN FIGURE 1 AT NORMAL STATOR CURRENT.
2	PHASE-SHIFT STATOR CURRENT SENSE. IF SHIFT CURRENT IS LOW, THIS WILL BE APPROXIMATELY +5V DC. PULSES AT 120 HZ WILL BE PRESENT AS SHOWN IN FIGURE 1 AT NORMAL STATOR CURRENT.
3	"LOW" (APPROXIMATELY 0V DC) FOR APPROXIMATELY 1.8 SEC DURING PREP, THEN PULSED LOW FOR 500 MSEC EVERY 5 SECONDS DURING PREP. REFER TO FIGURE 2.
4	"LOW" (APPROXIMATELY 0V DC) ENERGIZES K4 ON THE H.V. AUXILIARY BOARD, ("HIGH", + 12V DC = NOT ENERGIZED). THIS RELAY IS ENERGIZED AFTER THE MAIN BUS CAPACITORS ARE CHARGED, APPROXIMATELY 10 SECONDS AFTER POWER-ON.



Dual Speed Starter

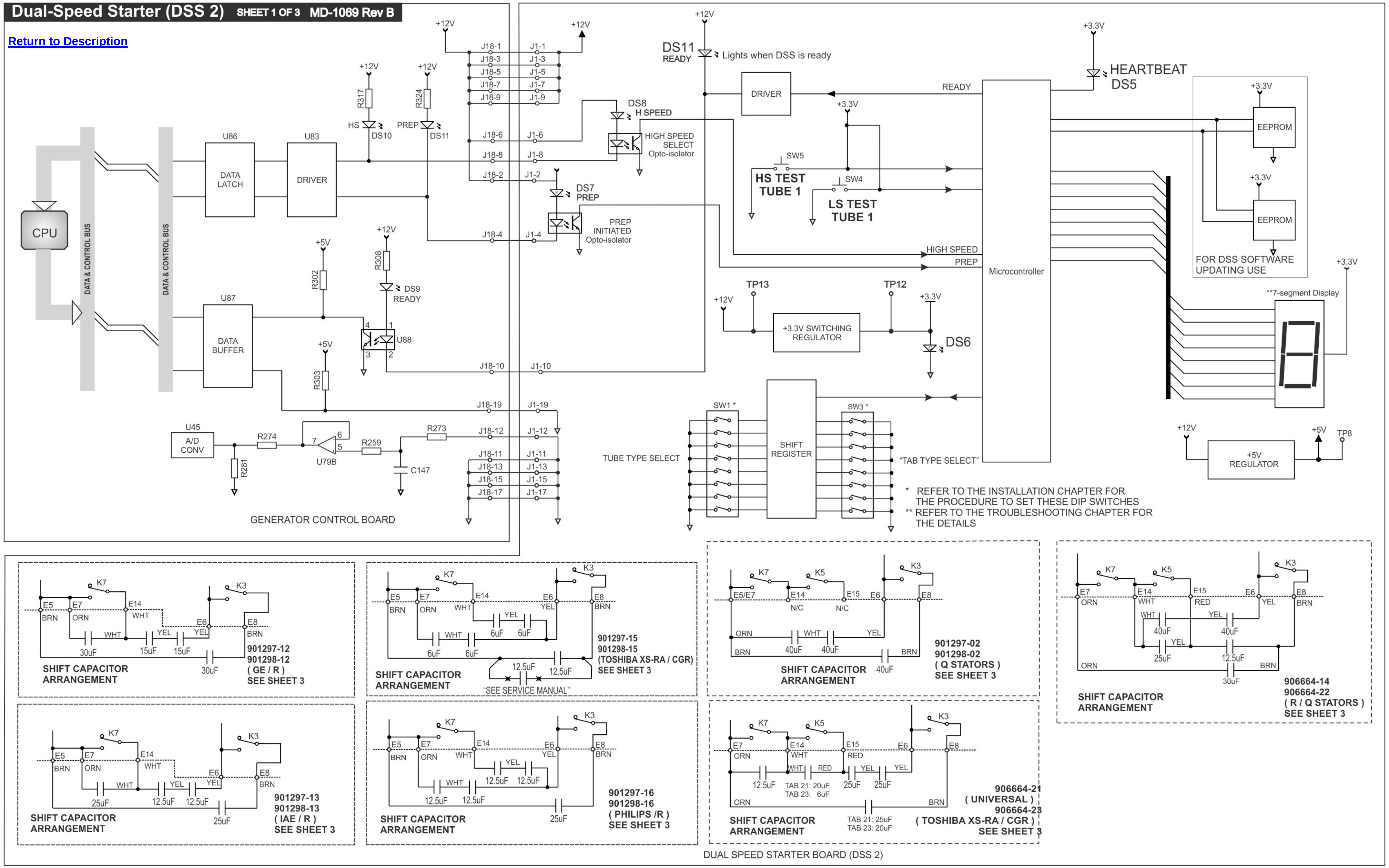


	DUAL SPD STARTER ASSY 901297-02 901298-02	DUAL SPD STARTER ASSY 901297-12 901298-12	DUAL SPD STARTER ASSY 901297-13 901298-13	DUAL SPD STARTER ASSY 901297-15 901298-15	DUAL SPD STARTER ASSY 901297-16 901298-16
CAPACITOR	VALUE	VALUE	VALUE	VALUE	VALUE
C1	40 uF	30 uF	25 uF	12.5 uF	25 uF
C2	N/A	30 uF	25 uF	6 uF	12.5 uF
C3	40 uF	15 uF	12.5 uF	6 uF	12.5 uF
C4	40 uF	15 uF	12.5 uF	6 uF	12.5 uF
C5	N/A	N/A	N/A	6 uF	12.5 uF
C6	N/A	N/A	N/A	12.5 uF	N/A

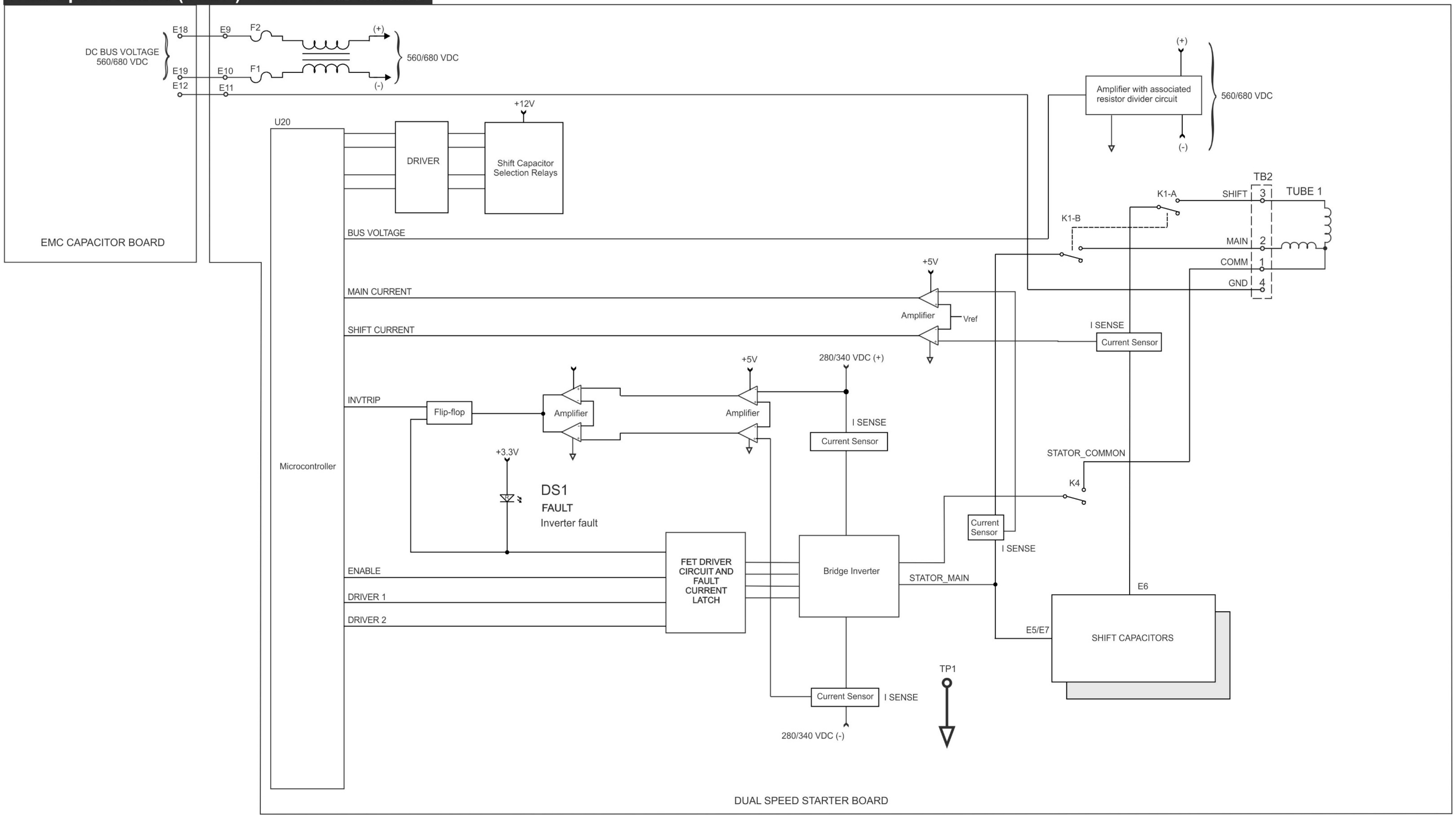
	DUAL SPEED STARTER ASSY						
	K3	K7	901297-02 901298-02	901297-12 901298-12	901297-13 901298-13	901297-15 901298-15	901297-16 901298-16
LOW SPD (1)	CLOSED	OPEN	60 uF	36 uF	30 uF	15.5 / 28 uF	31 uF
LOW SPD (2)	CLOSED	CLOSED		37.5 uF	31 uF	N/A	37.5 uF
HIGH SPD (1)	OPEN	OPEN	20 uF	6 uF	5 uF	3 uF	6 uF
HIGH SPD (2)	OPEN	CLOSED		7.5 uF	6 uF	6 uF	12.5 uF

Refer to chapter 2 of this manual for the procedure to set DIP-switch SW1. SW2 is not used.

Dual Speed Starter 2



Dual-Speed Starter (DSS 2) SHEET 2 OF 3 MD-1069 Rev B



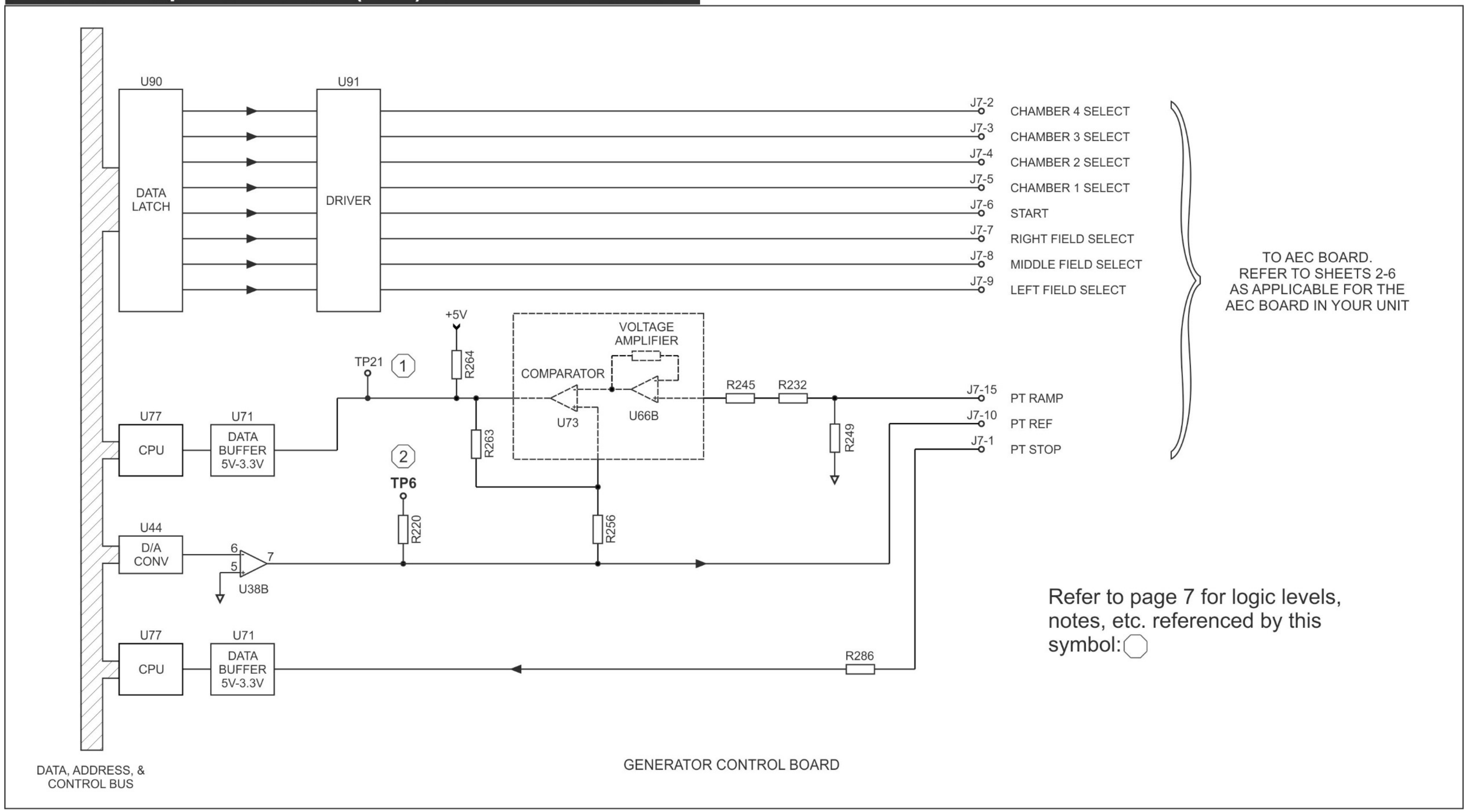
Dual-Speed Starter (DSS 2) SHEET 3 OF 3 MD-1069 Rev B

K3	K7	K5	901297-02 901298-02	901297-12 901298-12	901297-13 901298-13	901297-15 901298-15	901297-16 901298-16	906664-21	906664-14 906664-22	906664-23
OPEN	OPEN	OPEN	20uF	6uF	5uF	3uF	6uF	5uF	5uF	3uF
		CLOSED						6.3uF	6uF	6.3uF
OPEN	CLOSED	OPEN		7.5uF	6uF	6uF	12.5uF	7.5uF	20uF	4uF
		CLOSED						12.5uF		12.5uF
CLOSED	OPEN	OPEN	60uF	36uF	30uF	15.5uF / 28uF	31uF	30uF	30uF	23uF
		CLOSED						31uF		26uF
CLOSED	CLOSED	OPEN		37.5uF	31uF	18.5uF / 31uF	37.5uF	33uF	58uF	24uF
		CLOSED						37.5uF	62.5uF	32uF

AEC

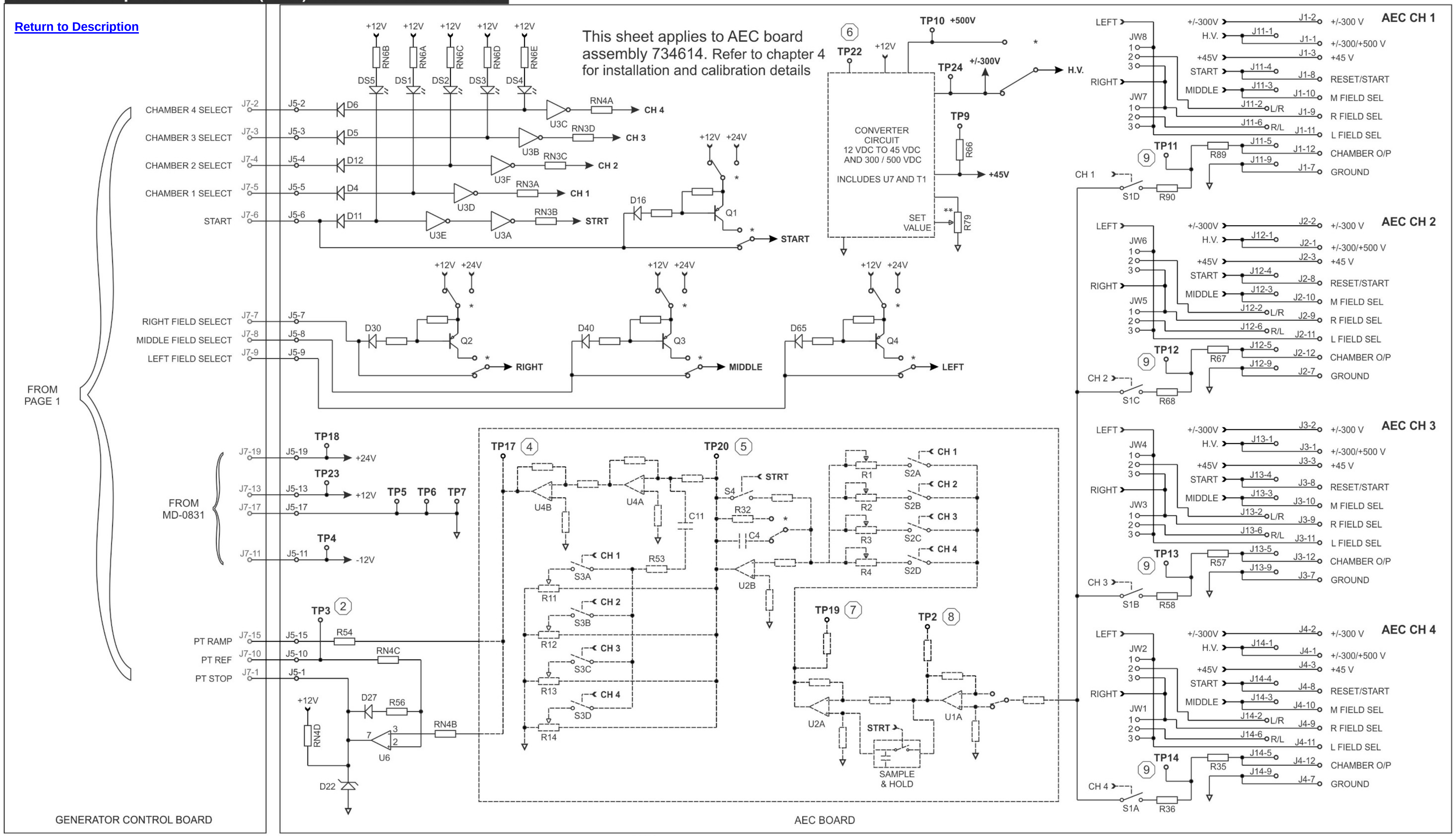
Automatic Exposure Control (AEC) SHEET 1 OF 7 MD-0936 Rev B

Return to Description



Automatic Exposure Control (AEC) SHEET 2 OF 7 MD-0936 Rev B

Return to Description



The +/- 12 V outputs on J1 to J4 and J11 to J14 are not shown on this diagram. These are detailed on the connector pin out tables in Chapter 4.

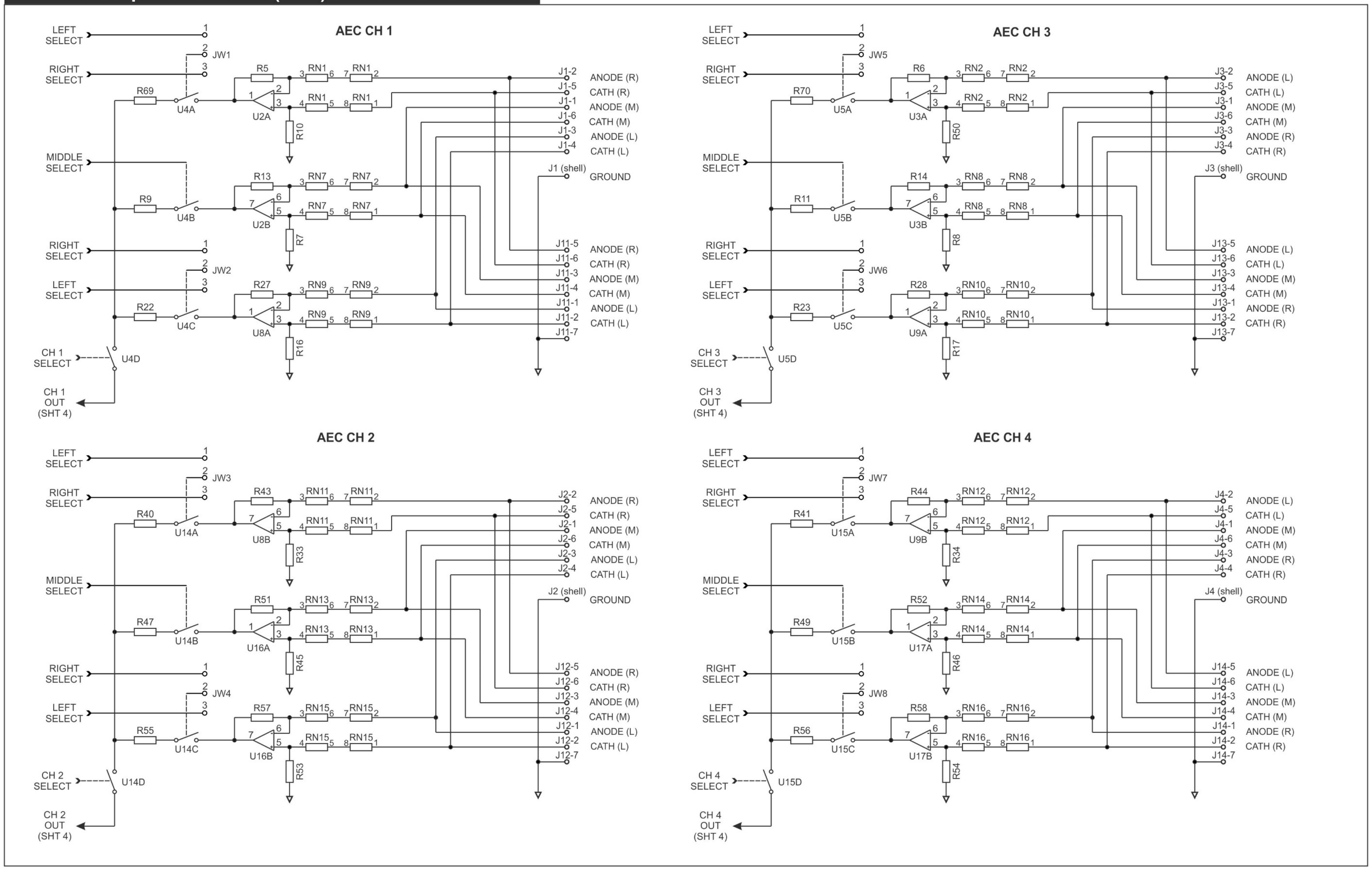
** R79 adjusts the +45 V, +300 V, and +500 V outputs from the DC to DC converter circuit. Refer to Chapter 4 for details.

Designates an analog switch. These are I.C. "switches" that are switched ON / OFF by applying the appropriate logic level.

* Designates a factory configured logic or signal level. AEC board are configured at the time of order to be compatible with the specified AEC chamber(s). Fo example, the START signal to the chamber may be factory configured to be ACTIVE LOW (0 V), ACTIVE HIGH (+12 V), or ACTIVE HIGH (+24 V).

Automatic Exposure Control (AEC) SHEET 3 OF 7 MD-0936 Rev B

Return to Description

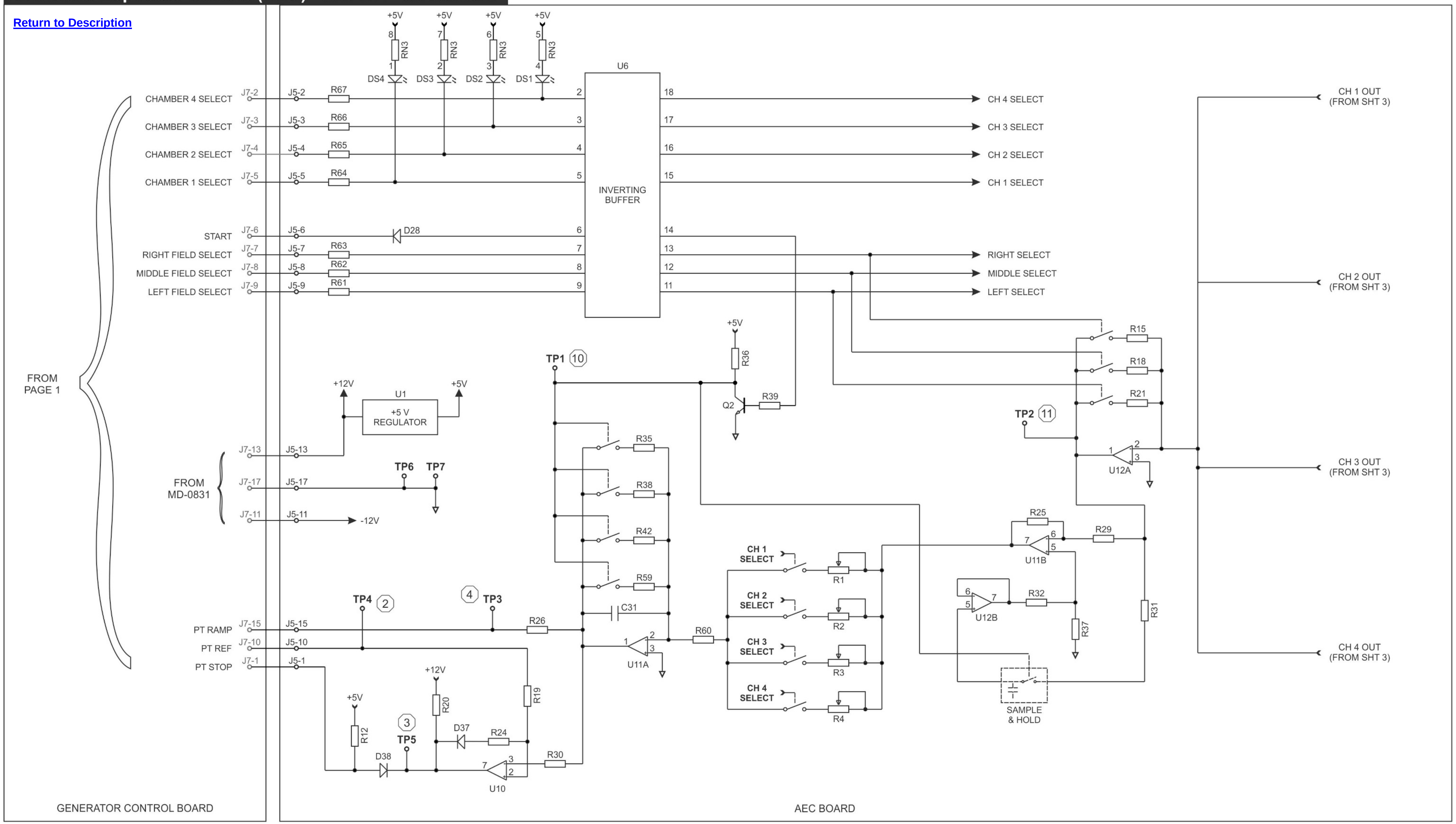


This sheet applies to AEC board assembly 737992. This page shows the input circuits; The signal processing circuits are continued on the next sheet. Refer to Chapter 4 for installation and calibration details.

Designates an analog switch. These are I.C. "switches" that are switched ON / OFF by applying to the appropriate logic level (0 V = OFF), 5 V = ON).

Automatic Exposure Control (AEC) SHEET 4 OF 7 MD-0936 Rev B

Return to Description

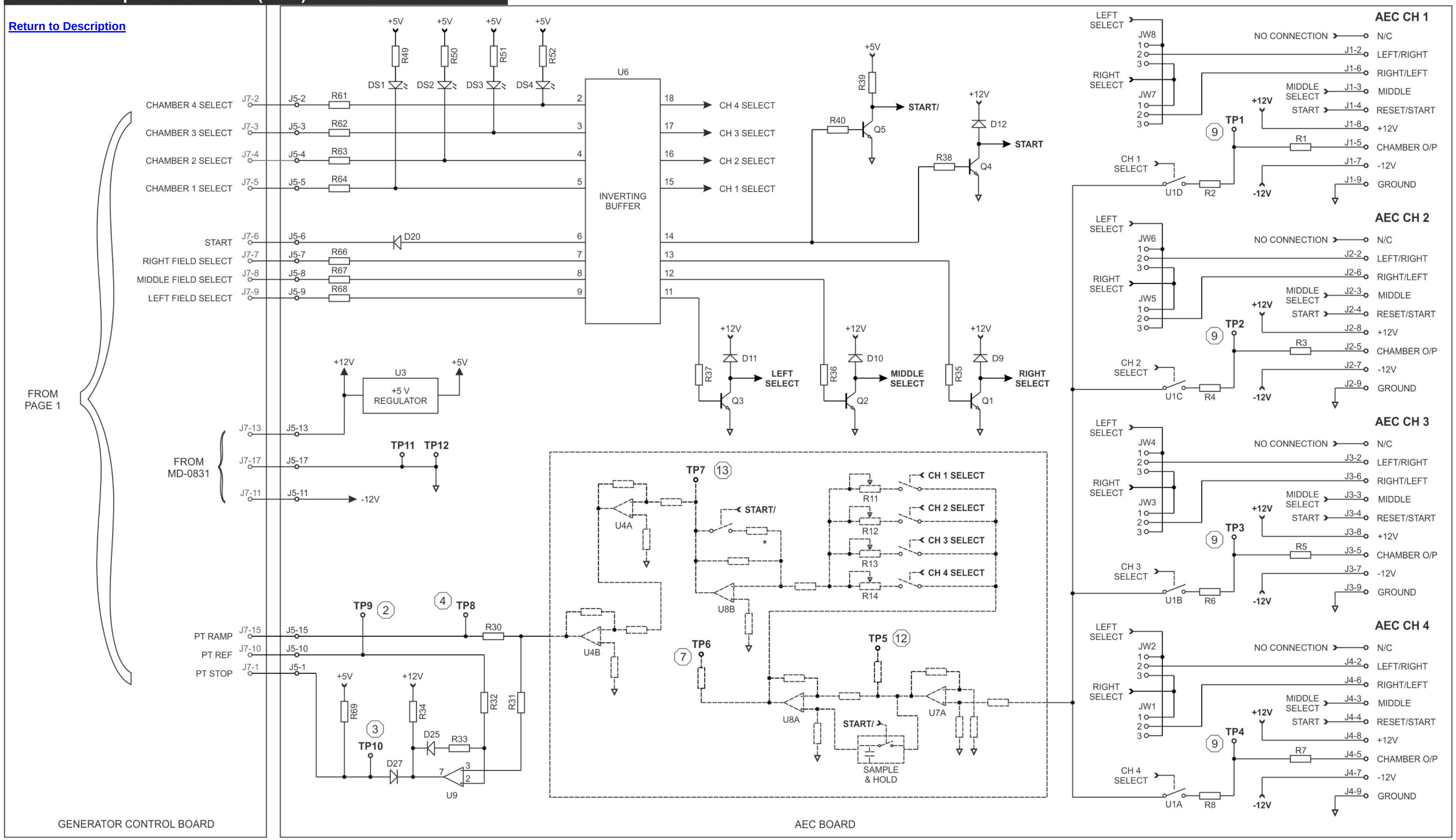


This sheet applies to AEC board assembly 737992. The sheet shows the signal processing circuits; the input circuits are shown on the previous sheet. Refer to Chapter 4 for installation and calibration details.

Designates an analog switch. These are I.C. "switches" that are switched ON / OFF by applying to the appropriate logic level (0 V = OFF), 5 V = ON).

Automatic Exposure Control (AEC) SHEET 5 OF 7 MD-0936 Rev B

Return to Description

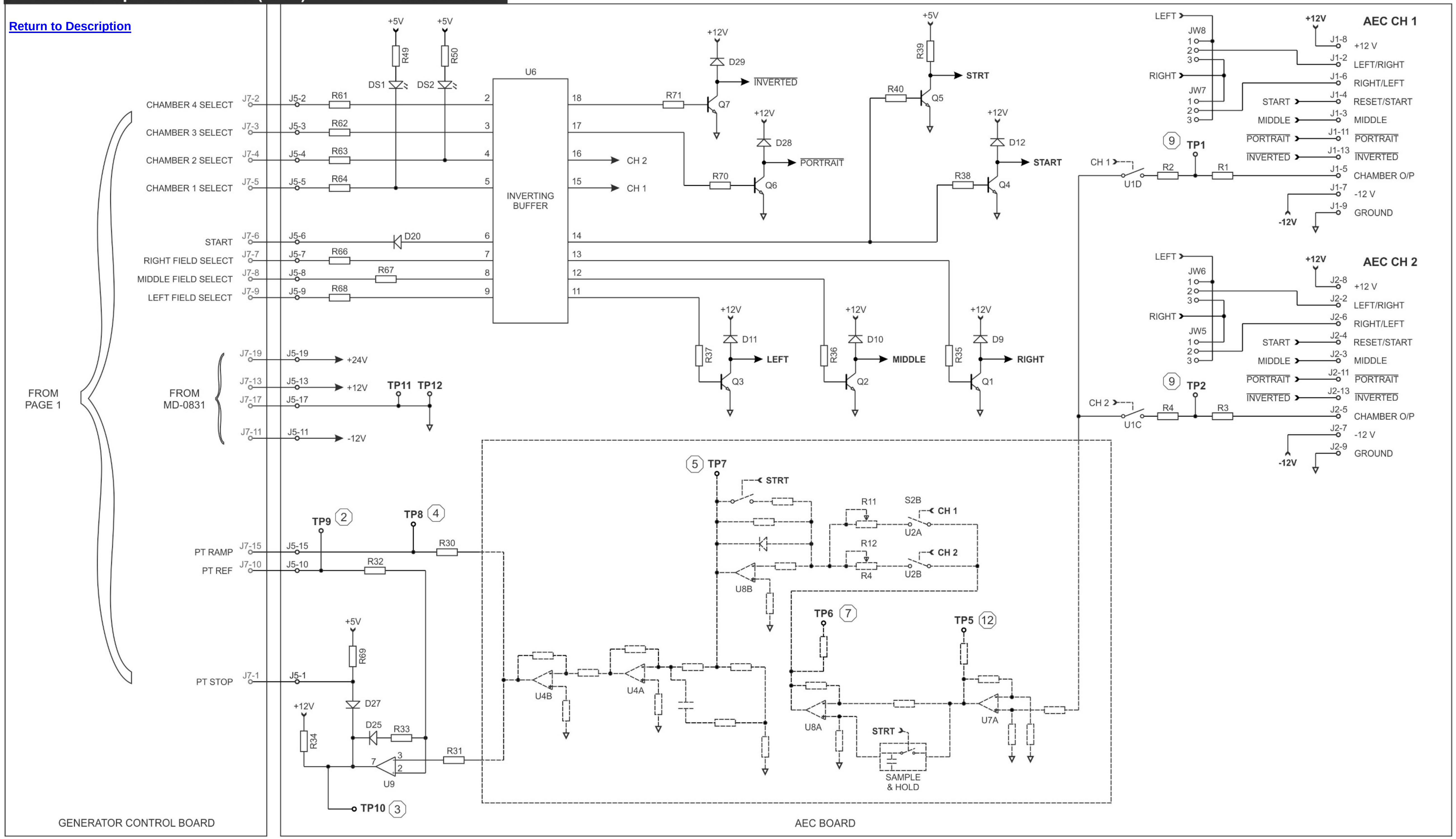


This sheet applies to AEC board assembly 737998. Refer to Chapter 4 for installation and calibration details.

Designates an analog switch. These are I.C. "switches" that are switched ON / OFF by applying to the appropriate logic level.

Automatic Exposure Control (AEC) SHEET 6 OF 7 MD-0936 Rev B

Return to Description



This sheet applies to AEC board assembly 739389. Refer to Chapter 4 for installation and calibration details.

Designates an analog switch. These are I.C. “switches” that are switched ON / OFF by applying to the appropriate logic level.

Automatic Exposure Control (AEC) SHEET 7 OF 7 MD-0936 Rev B

NOTE REFERENCE	REMARKS
1	GENERATES A PULSE PER FIGURE 1 WHEN THE AEC RAMP IS APPROXIMATELY 5 % OF THE AEC REFERENCE IF THE AEC RAMP IS ON THE CORRECT TRAJECTORY.
2	AEC REFERENCE VOLTAGE, 0 TO +10 VDC, DEPENDING ON AEC TECHNIQUE. THE LENGTH OF THE AEC EXPOSURE IS PROPORTIONAL TO THE AEC REFERENCE VOLTAGE.
3	AEC STOP (PT STOP) SIGNAL. THIS IS NORMALLY HIGH (APPROXIMATELY +5 VDC), SWITCHING LOW WHEN THE AEC RAMP = THE AEC REFERENCE VOLTAGE. REFER TO FIGURE 1.
4	AEC RAMP. THIS IS A SIGNAL RAMPING FROM 0 TOWARD +10 VDC, THE ACTUAL MAGNITUDE WILL DEPEND ON THE AEC TECHNIQUE. REFER TO FIGURE 2.
5	AS PER # 4.
6	PWM OUTPUT. THIS WILL BE VARIABLE WIDTH PULSES (PULSE WIDTH INCREASING AT INCREASING LOAD), UP TO A MAXIMUM OF 50% DUTY CYCLE. REFER TO FIGURE 4.
7	AEC RAMP OR DC VOLTAGE. THIS IS A RAMP OR DC VOLTAGE, DEPENDING ON AEC CHAMBER TYPE (INTEGRATING OR NON-INTEGRATING). REFER TO FIGURE 3.
8	AS PER # 7, EXCEPT THAT THE RAMP OR DC VOLTAGE WILL BE POSITIVE GOING AND NOT OF THE SAME MAGNITUDE.
9	THE VOLTAGE AT THIS TEST POINT IS THE OUTPUT OF THE AEC CHAMBER. REFER TO THE AEC CHAMBER MANUFACTURERS DOCUMENTATION FOR DETAILS.
10	THIS IS THE START SIGNAL. “HIGH” (5 VDC) = $\overline{\text{START}}$ = ANALOG SWITCHES CLOSED, “LOW” (0 VDC) = START = ANALOG SWITCHES OPEN.
11	THIS WILL BE A POSITIVE DC VOLTAGE. THE MAGNITUDE OF THE DC VOLTAGE IS DEPENDENT ON THE AEC TECHNIQUE IN USE.
12	AS PER # 7, EXCEPT THAT THE POLARITY WILL BE POSITIVE.
13	THE POLARITY AND MAGNITUDE OF THE RAMP AT THIS POINT SHOULD BE APPROXIMATELY THE SAME AS THE **PT RAMP** OUTPUT. NOTE REFERENCE 4.

FIGURE 1

FIGURE 2

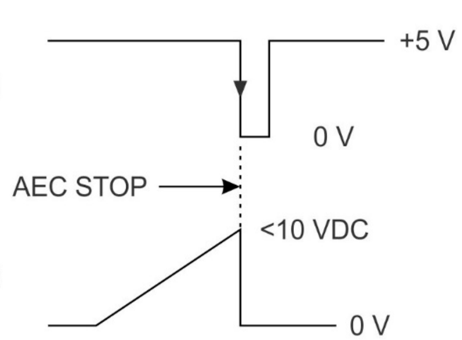


FIGURE 3

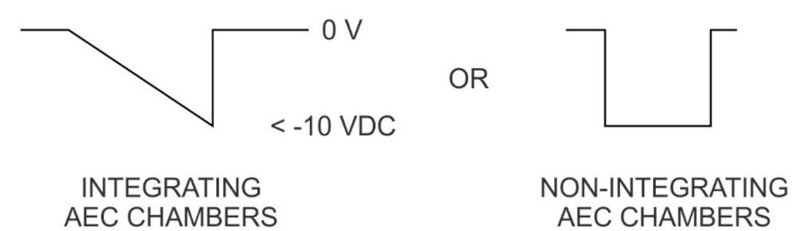
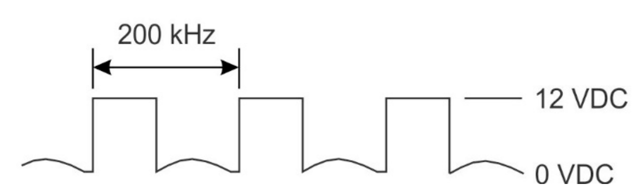
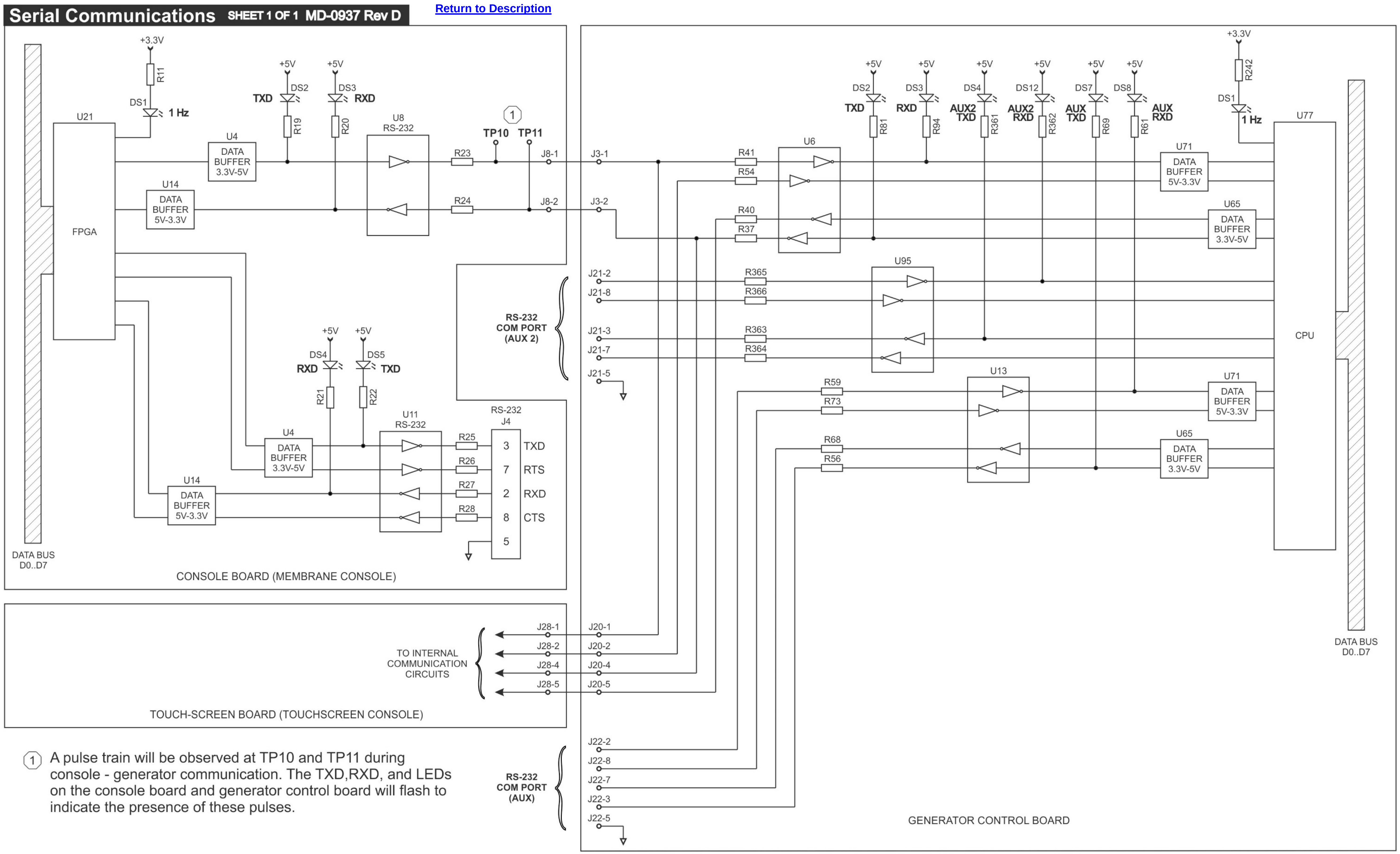


FIGURE 4

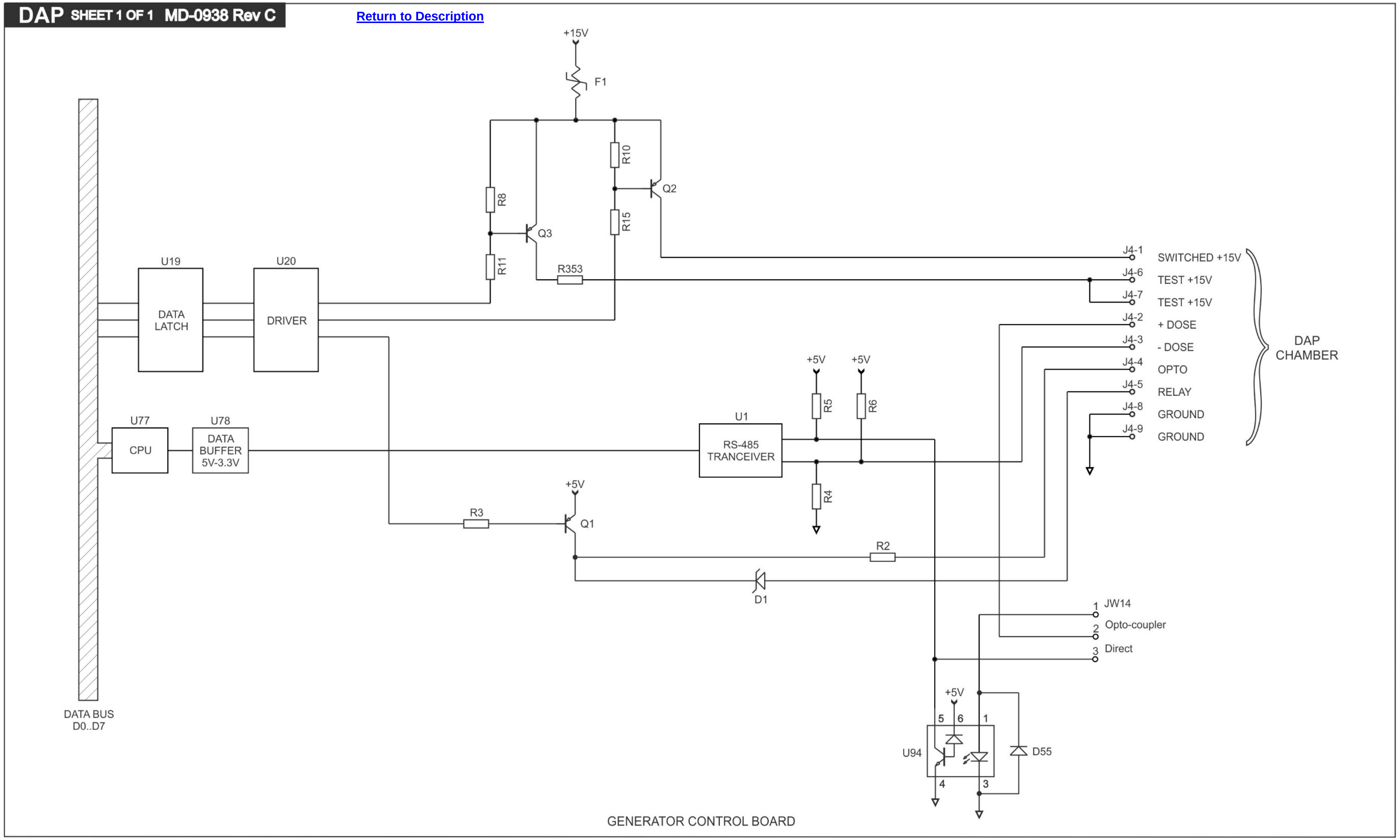


Serial Communications



1 A pulse train will be observed at TP10 and TP11 during console - generator communication. The TXD,RXD, and LEDs on the console board and generator control board will flash to indicate the presence of these pulses.

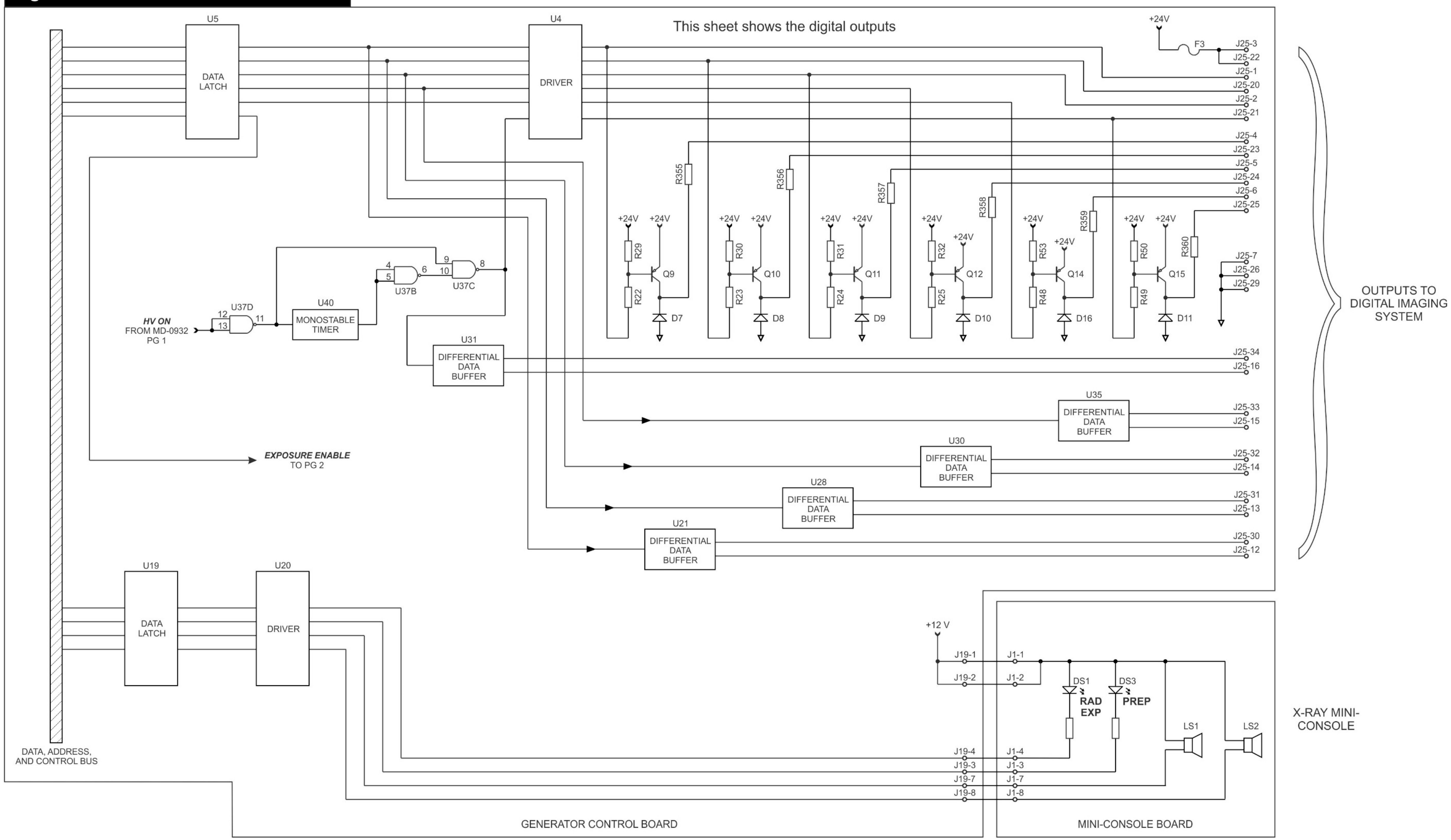
DAP


DAP SHEET 1 OF 1 MD-0938 Rev C
Return to Description
+15V
F1
R10
Q2
R8
Q3
R15
R11
R353
U19
U20
DATA LATCH
DRIVER
J4-1
SWITCHED +15V
J4-6
TEST +15V
J4-7
TEST +15V
J4-2
+ DOSE
J4-3
- DOSE
J4-4
OPTO
J4-5
RELAY
J4-8
GROUND
J4-9
GROUND
DAP CHAMBER
+5V
R5
R6
U1
RS-485 TRANCEIVER
U77
CPU
U78
DATA BUFFER 5V-3.3V
R4
R3
Q1
R2
D1
JW14
Opto-coupler
Direct
U94
D55
DATA BUS D0..D7
GENERATOR CONTROL BOARD

Digital Interface

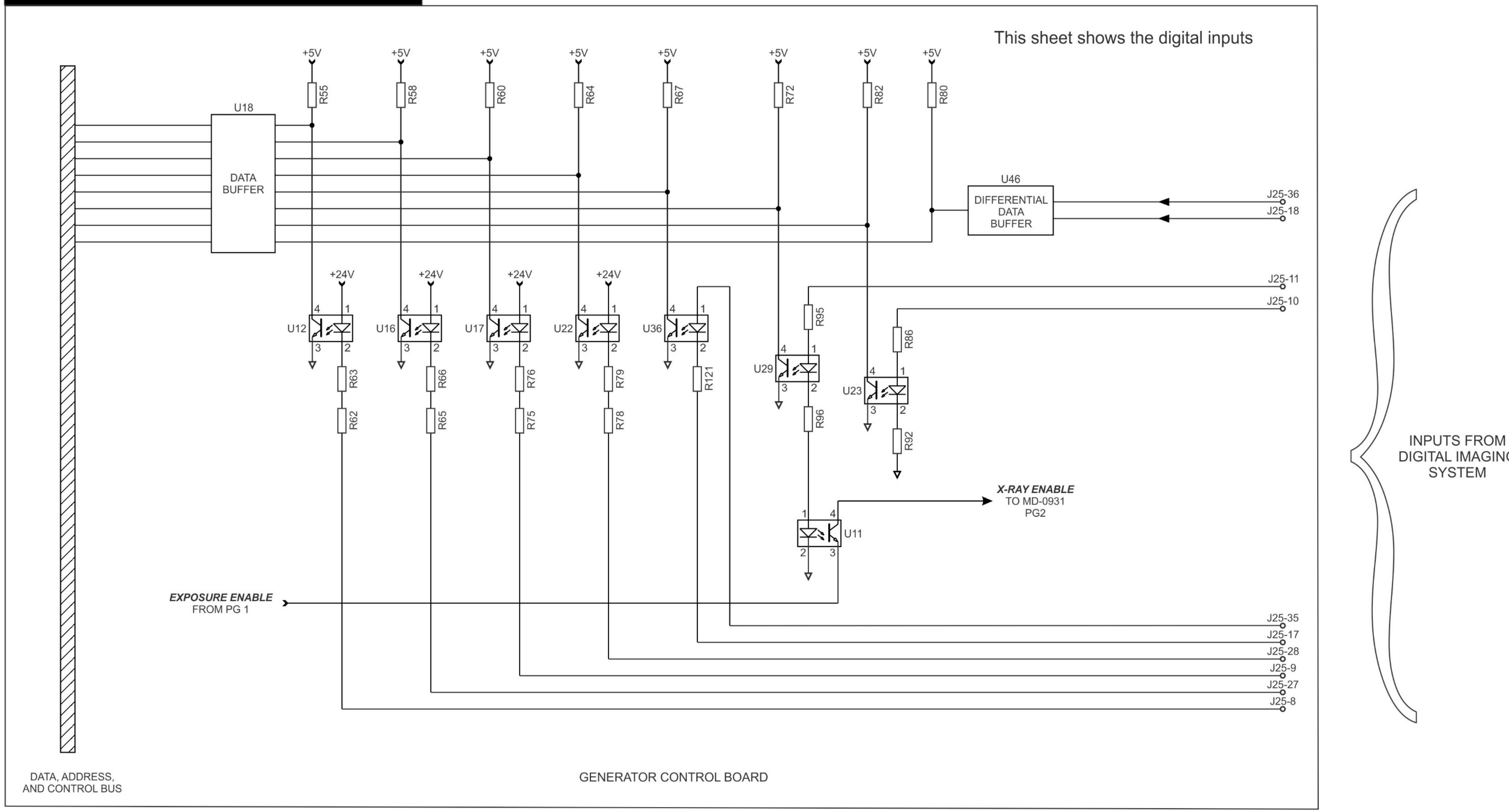
Digital Interface SHEET 1 OF 2 MD-0926 Rev B

Return to Description

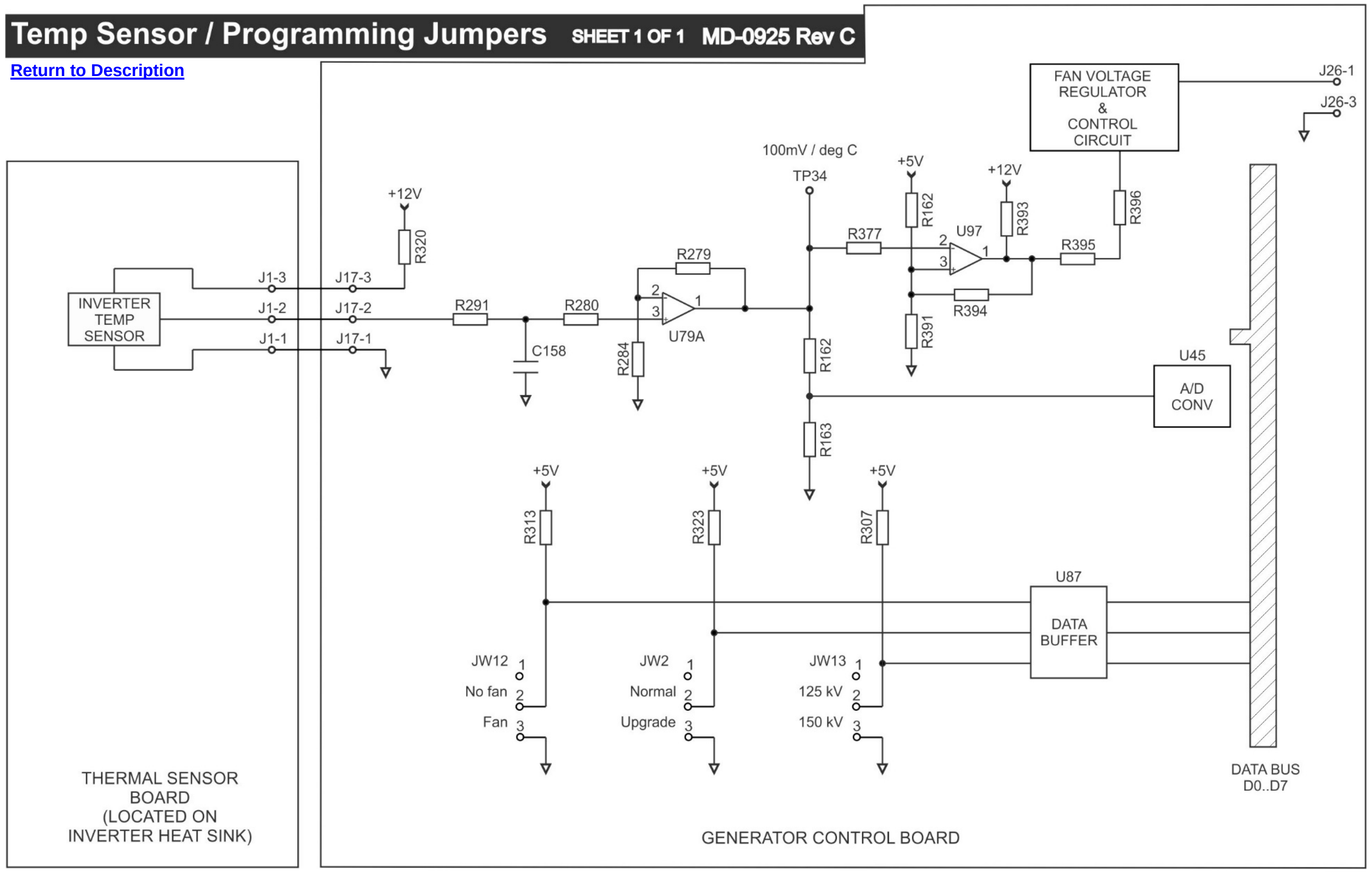


Digital Interface SHEET 2 OF 2 MD-0926 Rev B

Return to Description



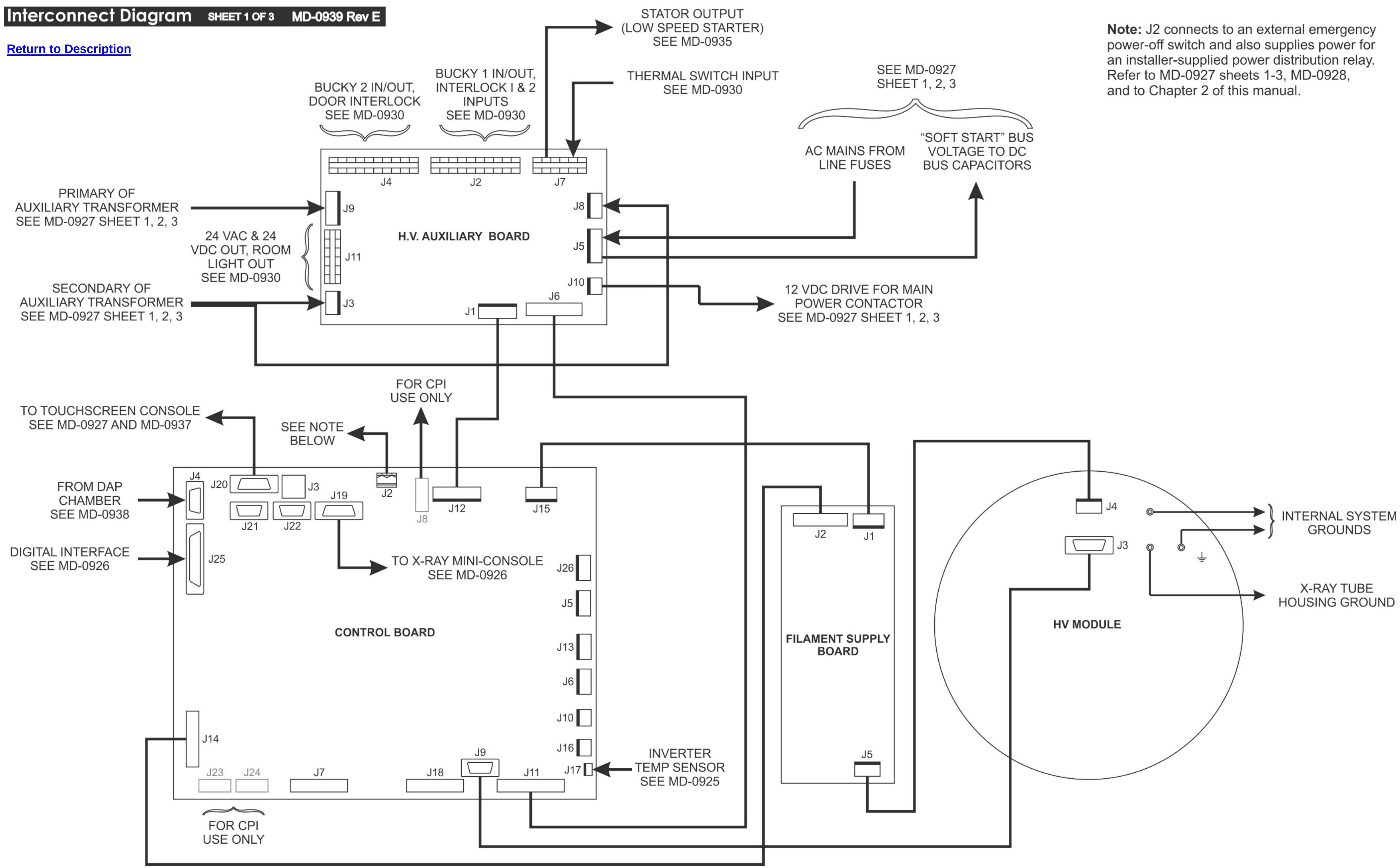
Temperture Sensor / Programm Jumpers

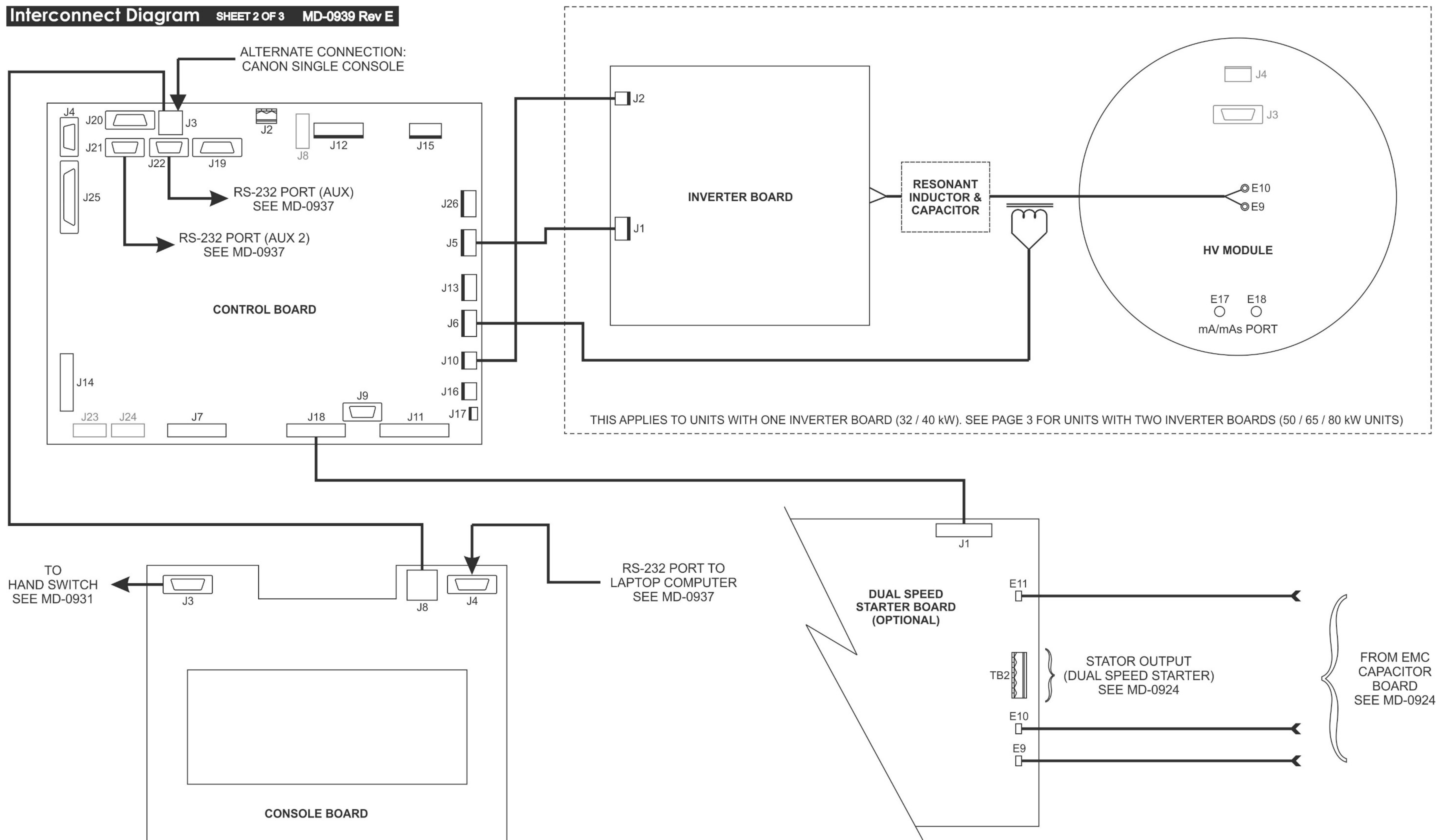


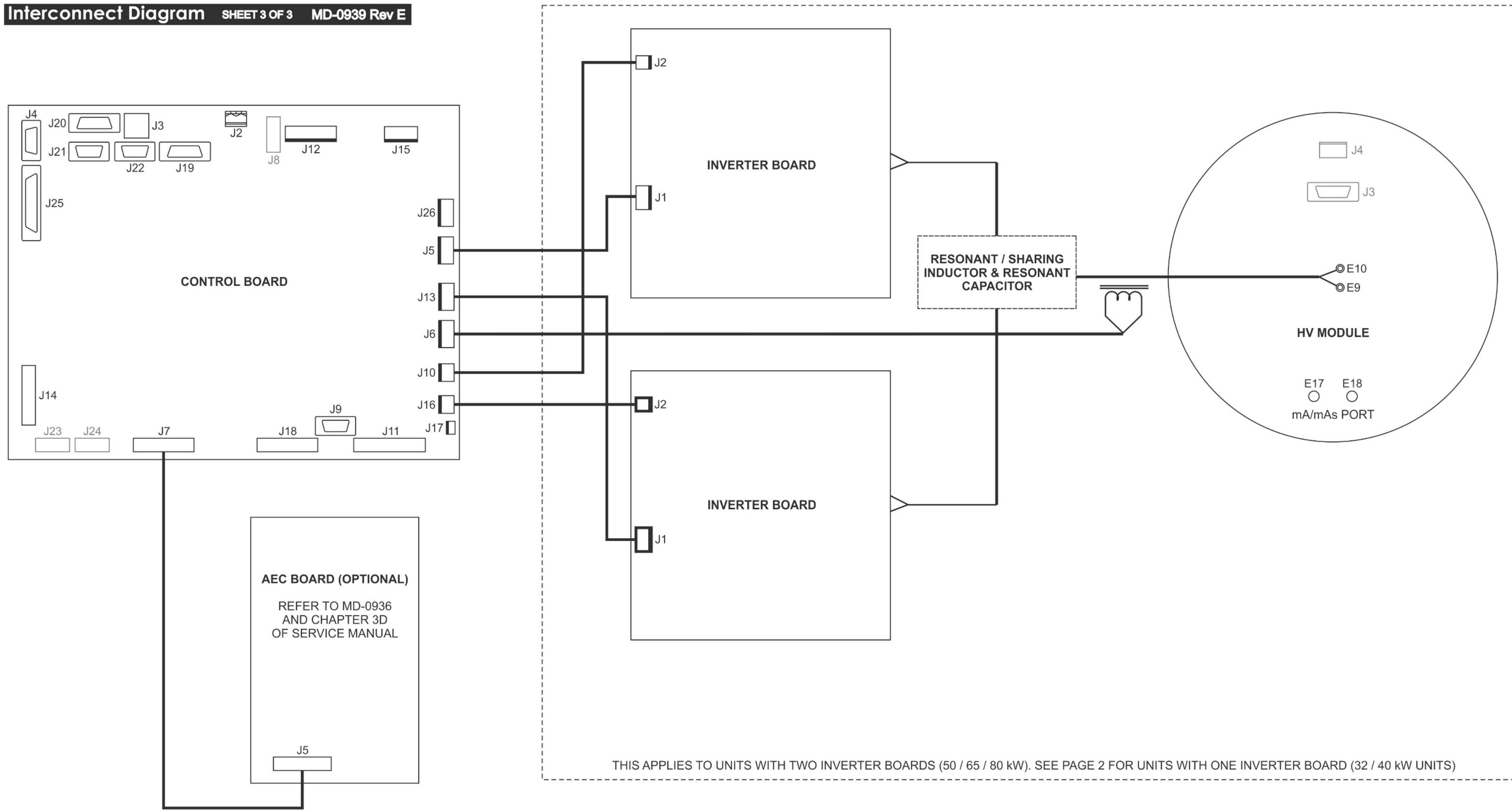
Interconnect

Interconnect Diagram SHEET 1 OF 3 MD-0939 Rev E

Return to Description




Interconnect Diagram SHEET 2 OF 3 MD-0939 Rev E
ALTERNATE CONNECTION:
CANON SINGLE CONSOLE
J4
J20
J3
J2
J12
J15
J21
J22
J19
J8
J25
RS-232 PORT (AUX)
SEE MD-0937
RS-232 PORT (AUX 2)
SEE MD-0937
J26
J5
J13
CONTROL BOARD
J6
J10
J16
J14
J9
J17
J23
J24
J7
J18
J11
J2
J1
INVERTER BOARD
RESONANT
INDUCTOR &
CAPACITOR
J4
J3
E10
E9
HV MODULE
E17
E18
mA/mAs PORT
THIS APPLIES TO UNITS WITH ONE INVERTER BOARD (32 / 40 kW). SEE PAGE 3 FOR UNITS WITH TWO INVERTER BOARDS (50 / 65 / 80 kW UNITS)
TO
HAND SWITCH
SEE MD-0931
J3
J8
J4
RS-232 PORT TO
LAPTOP COMPUTER
SEE MD-0937
CONSOLE BOARD
J1
DUAL SPEED
STARTER BOARD
(OPTIONAL)
E11
TB2
STATOR OUTPUT
(DUAL SPEED STARTER)
SEE MD-0924
E10
E9
FROM EMC
CAPACITOR
BOARD
SEE MD-0924


Interconnect Diagram SHEET 3 OF 3 MD-0939 Rev E
CONTROL BOARD
J4
J20
J3
J2
J8
J12
J15
J21
J22
J19
J25
J26
J5
J13
J6
J10
J16
J17
J14
J23
J24
J7
J9
J18
J11
INVERTER BOARD
J2
J1
INVERTER BOARD
J2
J1
RESONANT / SHARING INDUCTOR & RESONANT CAPACITOR
HV MODULE
J4
J3
E10
E9
E17
E18
mA/mAs PORT
AEC BOARD (OPTIONAL)
REFER TO MD-0936 AND CHAPTER 3D OF SERVICE MANUAL
J5
THIS APPLIES TO UNITS WITH TWO INVERTER BOARDS (50 / 65 / 80 kW). SEE PAGE 2 FOR UNITS WITH ONE INVERTER BOARD (32 / 40 kW UNITS)

Appendix A: Generator Exposure Tables

This chapter provides Table 1 that shows mAs values resulting from preselected mA and ms values (3-point operation). This table also shows the range and interrelation of these loading factors. For example, if in AEC operation it is known that the preset backup mAs limit is 50 mAs and 100 mA is chosen for that technique, then the maximum length of exposure possible (at which time the backup mAs limit is reached) is 500 ms.

In the above example, read down the 100 mA column to the 50 mAs value. Then read across to the left side of the page to the 500 ms value, this will be the maximum time allowed for the stated conditions.

Generator Technique Selection (3 Point Selection: mA/ms & mAs)

Table 1: mAs values vs. mA & time selected

Time	mA Selected																
(ms)	10	11	12.5	14	16	18	20	22	25	28	32	36	40	45	50	56	63
1.0																	
1.1																	
1.2																	
1.4																	
1.6																	0.10
1.8																0.10	0.11
2.0															0.10	0.11	0.125
2.2														0.10	0.11	0.125	0.14
2.5													0.10	0.11	0.125	0.14	0.16
2.8												0.10	0.11	0.125	0.14	0.16	0.18
3.2											0.10	0.11	0.125	0.14	0.16	0.18	0.20
3.6										0.10	0.11	0.125	0.14	0.16	0.18	0.20	0.22
4.0									0.10	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25
4.5								0.10	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28
5.0							0.10	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32
5.6						0.10	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36
6.3					0.10	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40
7.1				0.10	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45
8.0			0.10	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50
9.0		0.10	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56

Table 1: mAs values vs. mA & time selected																	
Time	mA Selected																
(ms)	10	11	12.5	14	16	18	20	22	25	28	32	36	40	45	50	56	63
10	0.10	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63
11	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71
12.5	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80
14	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90
16	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0
18	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1
20	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25
22	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4

Table 1: mAs values vs. mA & time selected (cont.)

Time (ms)	mA Selected 71	80	90	100	110	125	140	160	180	200	220	250	280	320	360	400	450
1.0				0.10	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45
1.1			0.10	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50
1.2		0.10	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56
1.4	0.10	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63
1.6	0.11	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71
1.8	0.125	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80
2.0	0.14	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90
2.2	0.16	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0
2.5	0.18	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1
2.8	0.20	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25
3.2	0.22	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4
3.6	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6
4.0	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8
4.5	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0
5.0	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2
5.6	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5
6.3	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8
7.1	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2
8.0	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6
9.0	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0
10	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5
11	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0

Table 1: mAs values vs. mA & time selected (cont.)																	
Time	mA Selected																
(ms)	71	80	90	100	110	125	140	160	180	200	220	250	280	320	360	400	450
12.5	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6
14	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3
16	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1
18	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0
20	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0
22	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10

Table 1: mAs values vs. mA & time selected (cont.)

Time (ms)	mA Selected																
	500	560	630	710	800	900	1000										
1.0	0.50	0.56	0.63	0.71	0.80	0.90	1.0										
1.1	0.56	0.63	0.71	0.80	0.90	1.0	1.1										
1.2	0.63	0.71	0.80	0.90	1.0	1.1	1.25										
1.4	0.71	0.80	0.90	1.0	1.1	1.25	1.4										
1.6	0.80	0.90	1.0	1.1	1.25	1.4	1.6										
1.8	0.90	1.0	1.1	1.25	1.4	1.6	1.8										
2.0	1.0	1.1	1.25	1.4	1.6	1.8	2.0										
2.2	1.1	1.25	1.4	1.6	1.8	2.0	2.2										
2.5	1.25	1.4	1.6	1.8	2.0	2.2	2.5										
2.8	1.4	1.6	1.8	2.0	2.2	2.5	2.8										
3.2	1.6	1.8	2.0	2.2	2.5	2.8	3.2										
3.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6										
4.0	2.0	2.2	2.5	2.8	3.2	3.6	4.0										
4.5	2.2	2.5	2.8	3.2	3.6	4.0	4.5										
5.0	2.5	2.8	3.2	3.6	4.0	4.5	5.0										
5.6	2.8	3.2	3.6	4.0	4.5	5.0	5.6										
6.3	3.2	3.6	4.0	4.5	5.0	5.6	6.3										
7.1	3.6	4.0	4.5	5.0	5.6	6.3	7.1										
8.0	4.0	4.5	5.0	5.6	6.3	7.1	8.0										
9.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0										
10	5.0	5.6	6.3	7.1	8.0	9.0	10										
11	5.6	6.3	7.1	8.0	9.0	10	11										

Table 1: mAs values vs. mA & time selected (cont.)																	
Time	mA Selected																
(ms)	500	560	630	710	800	900	1000										
12.5	6.3	7.1	8.0	9.0	10	11	12.5										
14	7.1	8.0	9.0	10	11	12.5	14										
16	8.0	9.0	10	11	12.5	14	16										
18	9.0	10	11	12.5	14	16	18										
20	10	11	12.5	14	16	18	20										
22	11	12.5	14	16	18	20	22										

Table 1: mAs values vs. mA & time selected (cont.)

Time (ms)	mA Selected																
	10	11	12.5	14	16	18	20	22	25	28	32	36	40	45	50	56	63
25	0.25	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6
28	0.28	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8
32	0.32	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0
36	0.36	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2
40	0.40	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5
45	0.45	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8
50	0.50	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2
56	0.56	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6
63	0.63	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0
71	0.71	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5
80	0.80	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0
90	0.90	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6
100	1.0	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3
110	1.1	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1
125	1.25	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0
140	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0
160	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10
180	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11
200	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5
220	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14
250	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16
280	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18

Table 1: mAs values vs. mA & time selected (cont.)																	
Time	mA Selected																
(ms)	10	11	12.5	14	16	18	20	22	25	28	32	36	40	45	50	56	63
320	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18	20
360	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18	20	22
400	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18	20	22	25
450	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18	20	22	25	28
500	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18	20	22	25	28	32

Table 1: mAs values vs. mA & time selected (cont.)																	
Time	mA Selected																
(ms)	71	80	90	100	110	125	140	160	180	200	220	250	280	320	360	400	450
25	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11
28	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5
32	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14
36	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16
40	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18
45	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18	20
50	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18	20	22
56	4.0	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18	20	22	25
63	4.5	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18	20	22	25	28
71	5.0	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18	20	22	25	28	32
80	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18	20	22	25	28	32	36
90	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18	20	22	25	28	32	36	40
100	7.1	8.0	9.0	10	11	12.5	14	16	18	20	22	25	28	32	36	40	45
110	8.0	9.0	10	11	12.5	14	16	18	20	22	25	28	32	36	40	45	50
125	9.0	10	11	12.5	14	16	18	20	22	25	28	32	36	40	45	50	56
140	10	11	12.5	14	16	18	20	22	25	28	32	36	40	45	50	56	63
160	11	12.5	14	16	18	20	22	25	28	32	36	40	45	50	56	63	71
180	12.5	14	16	18	20	22	25	28	32	36	40	45	50	56	63	71	80
200	14	16	18	20	22	25	28	32	36	40	45	50	56	63	71	80	90
220	16	18	20	22	25	28	32	36	40	45	50	56	63	71	80	90	100
250	18	20	22	25	28	32	36	40	45	50	56	63	71	80	90	100	110
280	20	22	25	28	32	36	40	45	50	56	63	71	80	90	100	110	125

Table 1: mAs values vs. mA & time selected (cont.)																	
Time	mA Selected																
(ms)	71	80	90	100	110	125	140	160	180	200	220	250	280	320	360	400	450
320	22	25	28	32	36	40	45	50	56	63	71	80	90	100	110	125	140
360	25	28	32	36	40	45	50	56	63	71	80	90	100	110	125	140	160
400	28	32	36	40	45	50	56	63	71	80	90	100	110	125	140	160	180
450	32	36	40	45	50	56	63	71	80	90	100	110	125	140	160	180	200
500	36	40	45	50	56	63	71	80	90	100	110	125	140	160	180	200	220

Table 1: mAs values vs. mA & time selected (cont.)

Time	mA Selected																
(ms)	500	560	630	710	800	900	1000										
25	12.5	14	16	18	20	22	25										
28	14	16	18	20	22	25	28										
32	16	18	20	22	25	28	32										
36	18	20	22	25	28	32	36										
40	20	22	25	28	32	36	40										
45	22	25	28	32	36	40	45										
50	25	28	32	36	40	45	50										
56	28	32	36	40	45	50	56										
63	32	36	40	45	50	56	63										
71	36	40	45	50	56	63	71										
80	40	45	50	56	63	71	80										
90	45	50	56	63	71	80	90										
100	50	56	63	71	80	90	100										
110	56	63	71	80	90	100	110										
125	63	71	80	90	100	110	125										
140	71	80	90	100	110	125	140										
160	80	90	100	110	125	140	160										
180	90	100	110	125	140	160	180										
200	100	110	125	140	160	180	200										
220	110	125	140	160	180	200	220										
250	125	140	160	180	200	220	250										
280	140	160	180	200	220	250	280										

Table 1: mAs values vs. mA & time selected (cont.)																	
Time	**mA Selected**																
(ms)	**500**	**560**	**630**	**710**	**800**	**900**	**1000**										
320	160	180	200	220	250	280	320										
360	180	200	220	250	280	320	360										
400	200	220	250	280	320	360	400										
450	225	250	280	320	360	400	450										
500	250	280	320	360	400	450	500										

Table 1: mAs values vs. mA & time selected (cont.)																	
Time	**mA Selected**																
(ms)	**10**	**11**	**12.5**	**14**	**16**	**18**	**20**	**22**	**25**	**28**	**32**	**36**	**40**	**45**	**50**	**56**	**63**
560	5.6	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18	20	22	25	28	32	36
630	6.3	7.1	8.0	9.0	10	11	12.5	14	16	18	20	22	25	28	32	36	40
710	7.1	8.0	9.0	10	11	12.5	14	16	18	20	22	25	28	32	36	40	45
800	8.0	9.0	10	11	12.5	14	16	18	20	22	25	28	32	36	40	45	50
900	9.0	10	11	12.5	14	16	18	20	22	25	28	32	36	40	45	50	56
1000	10	11	12.5	14	16	18	20	22	25	28	32	36	40	45	50	56	63
1100	11	12.5	14	16	18	20	22	25	28	32	36	40	45	50	56	63	71
1250	12.5	14	16	18	20	22	25	28	32.	36	40	45	50	56	63	71	80
1400	14	16	18	20	22	25	28	32	36	40	45	50	56	63	71	80	90
1600	16	18	20	22	25	28	32	36	40	45	50	56	63	71	80	90	100
1800	18	20	22	25	28	32	36	40	45	50	56	63	71	80	90	100	110
2000	20	22	25	28	32	36	40	45	50	56	63	71	80	90	100	110	125
2200	22	25	28	32	36	40	45	50	56	63	71	80	90	100	110	125	140
2500	25	28	32	36	40	45	50	56	63	71	80	90	100	110	125	140	160
2800	28	32	36	40	45	50	56	63	71	80	90	100	110	125	140	160	180
3200	32	36	40	45	50	56	63	71	80	90	100	110	125	140	160	180	200
3600	36	40	45	50	56	63	71	80	90	100	110	125	140	160	180	200	220
4000	40	45	50	56	63	71	80	90	100	110	125	140	160	180	200	220	250
4500	45	50	56	63	71	80	90	100	110	125	140	160	180	200	220	250	280
5000	50	56	63	71	80	90	100	110	125	140	160	180	200	220	250	280	320
5600	56	63	71	80	90	100	110	125	140	160	180	200	220	250	280	320	360
6300	63	71	80	90	100	110	125	140	160	180	200	220	250	280	320	360	400

Table 1: mAs values vs. mA & time selected (cont.)

Time	mA Selected																
(ms)	71	80	90	100	110	125	140	160	180	200	220	250	280	320	360	400	450
560	40	45	50	56	63	71	80	90	100	110	125	140	160	180	200	220	250
630	45	50	56	63	71	80	90	100	110	125	140	160	180	200	220	250	280
710	50	56	63	71	80	90	100	110	125	140	160	180	200	220	250	280	320
800	56	63	71	80	90	100	110	125	140	160	180	200	220	250	280	320	360
900	63	71	80	90	100	110	125	140	160	180	200	220	250	280	320	360	400
1000	71	80	90	100	110	125	140	160	180	200	220	250	280	320	360	400	450
1100	80	90	100	110	125	140	160	180	200	220	250	280	320	360	400	450	500
1250	90	100	110	125	140	160	180	200	220	250	280	320	360	400	450	500	560
1400	100	110	125	140	160	180	200	220	250	280	320	360	400	450	500	560	630
1600	110	125	140	160	180	200	220	250	280	320	360	400	450	500	560	630	710
1800	125	140	160	180	200	220	250	280	320	360	400	450	500	560	630	710	800
2000	140	160	180	200	220	250	280	320	360	400	450	500	560	630	710	800	900
2200	160	180	200	220	250	280	320	360	400	450	500	560	630	710	800	900	1000
2500	180	200	220	250	280	320	360	400	450	500	560	630	710	800	900	1000	
2800	200	220	250	280	320	360	400	450	500	560	630	710	800	900	1000		
3200	220	250	280	320	360	400	450	500	560	630	710	800	900	1000			
3600	250	280	320	360	400	450	500	560	630	710	800	900	1000				
4000	280	320	360	400	450	500	560	630	710	800	900	1000					
4500	320	360	400	450	500	560	630	710	800	900	1000						
5000	360	400	450	500	560	630	710	800	900	1000							
5600	400	450	500	560	630	710	800	900	1000								
6300	450	500	560	630	710	800	900	1000									

Table 1: mAs values vs. mA & time selected (cont.)

Time	mA Selected																
(ms)	500	560	630	710	800	900	1000										
560	280	320	360	400	450	500	560										
630	320	360	400	450	500	560	630										
710	360	400	450	500	560	630	710										
800	400	450	500	560	630	710	800										
900	450	500	560	630	710	800	900										
1000	500	560	630	710	800	900	1000										
1100	550	630	710	800	900	1000											
1250	630	710	800	900	1000												
1400	710	800	900	1000													
1600	800	900	1000														
1800	900	1000															
2000	1000																
2200																	
2500																	
2800																	
3200																	
3600																	
4000																	
4500																	
5000																	
5600																	
6300																	

Note 1:	22/32 kW Generators	Maximum mA = 400	Maximum mAs = 500
	40 kW Generators	Maximum mA = 500	Maximum mAs = 500
	50 kW Generators	Maximum mA = 630	Maximum mAs = 630
	65 kW Generators	Maximum mA = 800	Maximum mAs = 800
	80 kW Generators	Maximum mA = 1000	Maximum mAs = 1000

Note 2: mA/TIME values are tube rating dependent. For certain tubes, some mA/TIME selections are not available at higher kV selections.

Note 3: The maximum power output of this family of generators is 32 kW, 40 kW, 50 kW, 65 kW or 80 kW respectively. The generator software does not allow a kV and mA combination to be selected that exceeds these maximum values.

Note 4: mAs selection values also are limited by X-ray tube focal spot emission and anode thermal (HEAT) loading.

Appendix B: Revision History

Revision History		
Rev	**Description**	**Date**
AG	Update: Radiographic Performance, Generator Power Requirement, AEC Calibration, MD-0927 and MD-0928 (AC Main Contactor) Add: New console board spare kits, warnings for the installtiaon of the AC mains, and the AC main contactor spare kit Delete: Applicable Standards (replaced by Regulatory and Safety Compliance supplement, SUP95065600 Modify: The Interfacing and Programming chapter	04-16-2020

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