INLAND MOTOR

KOLLMORGEN CORPORATION

FILTER CONTROL UNIT

(FCU)

USER'S MANUAL

MN-33

REVISION: B

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1.0 PRODUCT DESCRIPTION

The Filter Control Unit (FCU) Series is a dual output, application specific power supply designed to interface with the Inland Motor line of Servo Amplifiers. The FCU converts AC input voltages to: 1) an unregulated DC voltage, and 2) a regulated 28 VDC at 1.6 amps continuous. The FCU is designed to meet the following requirements:

--- HIGH POWER INPUT FREQUENCY RANGE: 47 to 63 Hz.

--- LOW POWER INPUT: 115 VAC 50/60 Hz Line Voltage at 0.5 amps RMS continuous with 1.5 amps RMS peak.

--- LOW POWER OUTPUT: Regulated 28 VDC, 1.6 Amps continuous, 3 Amps peak.

--- PACKAGING: 7.30 in. H. x 8.12 in. W x 11.5 in. L. package; weight 16 lbs.

--- TEMPERATURE RANGE (Ambient): 0 to +40 degrees C.

--- CIRCUIT PROTECTION: Input and Output fuses; Clamping of High Power Bus "pump-up" during deceleration of motors.

The High Power input requirements and output capabilities for the FCU Series are dictated in the Model Number. The Model Number FCU-VVV-AA contains the voltage and current rating, where VVV is maximum operating voltage level and AA is the maximum continous current rating. The FCU Models available are shown in Table 1.

Shown in Figure 1 is an outline drawing of the FCU. I/O connections to the unit are provided by screw terminal connectors on the front of the unit. Proper connection to these terminals is necessary before reliable operation of the FCU can be expected.

Further explanation of these connections and their functions is detailed in the sections on INSTALLATION and OPERATION. Please read these sections carefully before attempting to operate the unit or possible damage may result.

Table 1. FCU Series Models

Model Number	FCU-100-15	FCU-110-12	FCU-90-30 FCU-100-30	FCU-160-15	FCU-160-20	FCU-200-20	FCU-270-20
DC Output Voltage Maximum	100 VDC	110 VDC	100 VDC	160 VDC	160 VDC	200 VDC	270 VDC
DC Output Voltage Minimum	34 VDC	34 VDC	34 VDC	34 VDC	34 VDC	34 VDC	112 VDC
Continous DC Output Current Maximum	15 amps	12 amps	30 amps	15 amps	20 amps	20 amps	20 amps
Output Ripple Maximum	6%	6%	7%	6%	7%	7%	8%
AC Bus Input Voltage Range	25 to 70 VAC	25 to 78 VAC	25 to 70 VAC	25 to 114 VAC	25 to 114	25 to 142	80 to 192
AC Bus Input Current Maximum	15 amps RMS	12 amps RMS	30 amps RMS	20 amps RMS	20 amps RMS	20 amps RMS	20 amps RMS
Load Clamp Threshold	125 VDC	130 VDC	125 VDC	185 VDC	185 VDC	230 VDC	310 VDC
Load Clamp Window	115 VDC	120 VDC	115 VDC	170 VDC	170 VDC	210 VDC	285 VDC

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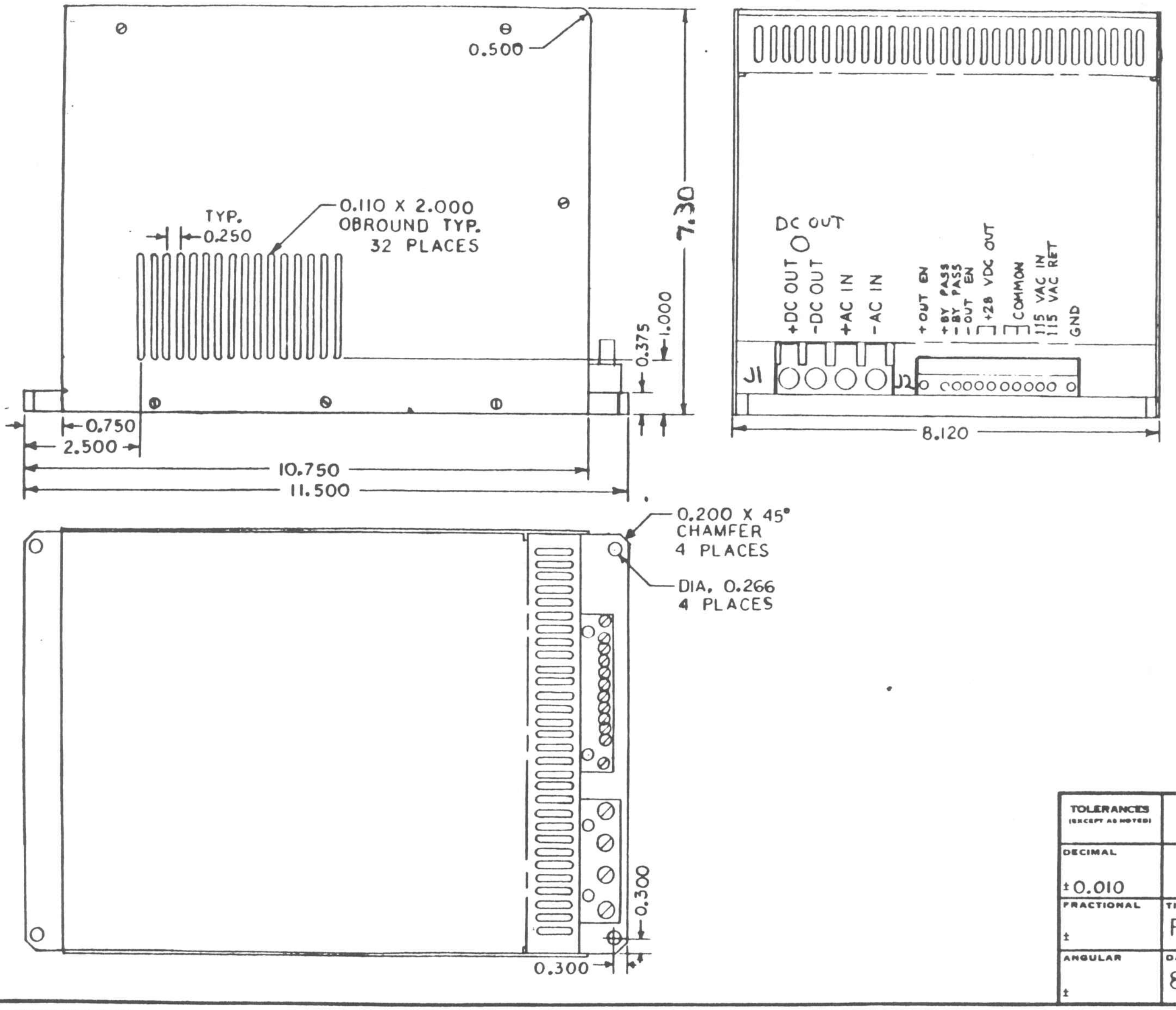


TOLERANCES
(EXCEPT AS NOTED)

DECIMAL
±0.010

FRACTIONAL
±

ANGULAR
±

SCALE
1:2

DRAWN BY

APPROVED BY

TITLE
FCU OUTLINE DRAWING, FIG. 1

DATE
8-29-85

DRAWING NUMBER

2.0 INSTALLATION

2.1 UNPACKING

Upon reciept, carefully check for any signs of shipping damage. Mishandling should be evident upon visual inspection of the shipping container. If damage is found during visual inspection, notify the appropriate carrier immediately.

2.2 MOUNTING ORIENTATION

The FCU can be mounted either horizontally or vertically provided that none of the ventilation slots are obstructed. Do not mount the FCU in a manner such that the 45 degree ventilation slots are in a horizontal plane. It is not recommended that the unit be mounted upside down.

2.3 DELETED

2.4 POWER INPUT

Power provided to the FCU needs to come from two separate AC voltages. The High Power AC input voltage is provided through the user's transformer. The Low Power AC input voltage is 115 VAC 50/60 Hz line voltage.

2.4.1 User's External Transformer

A power transformer is the interface between the user's available AC power and the High Power AC inputs of the FCU. The voltage supplied to inputs, +ACIN and -ACIN, must be in the input range of the FCU. Therefore, the transformer must be designed to accept the user's available AC power on the primary and step the secondary voltage to the FCU's range. The maximum transformer secondary current is dependent on the FCU Model used. This current is specified in Table 1 in the PRODUCT DESCRIPTION section as the AC BUS Input RMS Current Maximum. The transformer must be sized properly to handle the user's current levels.

2.4.2 High Power Bus Input

84V

The High Power Bus inputs, +ACIN and -ACIN, are connected to the secondary of the user's power transformer. The range of the AC voltage input on +ACIN and -ACIN is shown in Table 1 of the PRODUCT DESCRIPTION section. The frequency of the AC voltage input can range from 47 to 63 Hz. The input AC RMS current (user transformer secondary current) is approximately equal to DC Output current.

2.4.3 Low Power Bus Input

The Low Power Bus input, 115VACIN and 115VAC RETURN, provides the power to the FCU for the 28 VDC output and the internal small signal circuitry. The 115VACIN and 115VAC RETURN input requires 115 VAC 50/60 Hz voltage. The AC current required is 0.5 amp rms with 1.5 amps AC rms peak at power-up of the servo amplifier.

2.5 POWER OUTPUTS

The power outputs are DCOUT and 28VDCOUT. DCOUT is the high power bus output and 28VDCOUT is the low power bus output. These two power outputs are isolated from each other through an internal transformer. If common references are desirable, they can be connected together on the terminal block J1, or connected on the Small Signal circuit board by jumper J1.

2.5.1 DCOUT Output

The High Power Bus output, +DCOUT and -DCOUT, provides the power to the servo amplifier. The maximum and minimum High Power bus voltage is found in Table 1 of the PRODUCT DESCRIPTION Section. DCOUT is a function of the ACIN input and is approximated by

$$DCOUT = 1.4 X ACIN$$

The maximum DC output current and the output current ripple at full rated load is also found in Table 1.

2.5.2 28VDCOUT Output

The Low Power Output, +28VDCOUT and -28VDCOUT, is the regulated output which supplies the small signal circuitry of the servo amplifier. This output provides 28 VDC ± 5% at 1.6 amps continuous and 3 amps peak.

2.6 USER INPUTS

2.6.1 OUTEN Inputs

A positive voltage on +OUTEN referenced to -OUTEN, of +3.5 to +28 VDC will enable the DCOUT of the FCU. The OUTEN input current is approximately I = Vin/554 for Vin between 0 and 15 Volts, and I = (Vin - 5)/374 for Vin between 15 and 28 Volts. The DCOUT output is disabled if the +OUTEN input referenced to -OUTEN is +1.0 to -0.5 VDC, or open-circuited. The OUTEN input is connected through 554 ohms of resistance to a photodiode of an optocoupler. This input is electrically isolated from the FCU, and is protected from reverse polarity.

2.6.2 BYPASS Inputs

The +BYPASS and -BYPASS inputs allow for hardwire connections so that the FCU is always enabled. By simply connecting +BYPASS and -BYPASS together, the OUTEN input becomes non-functional and the FCU's DCOUT output does not depend on OUTEN.

2.7 SYSTEM WIRING CONNECTIONS

Figure 2 shows the system connections to the user's power transformer and servo amplifier. Review the figure before making connections.

2.7.1 High Power Connections

The high power connections are on the 4 contact Weidmuller MK6/4 6202.6 terminal block labeled J1. Table 2 shows the connections and the FCU chassis is labeled clearly to insure proper connection. The power connections should use at least 12 AWG size wire for rated loads.

WARNING

Do not connect +ACIN and -ACIN inputs to any power line without the use of an isolation transformer.

WARNING

Once +ACIN and -ACIN inputs, and 115VACIN and 115VAC RETURN inputs are supplied to the FCU, the +DCOUT output on connector J1 has dangerous voltage levels present. Do not make connections to Connector J1 unless all input power has been turned off. There is no ON/OFF switch on the FCU.

Table 2. High Power Connector J1

J1 CONNECTOR PIN	INPUT/OUTPUT	BUS NAME
1	OUTPUT	+DCOUT
2	OUTPUT	-DCOUT
3	INPUT	+ACIN
4	INPUT	-ACIN

2.7.2 Low Power Connections

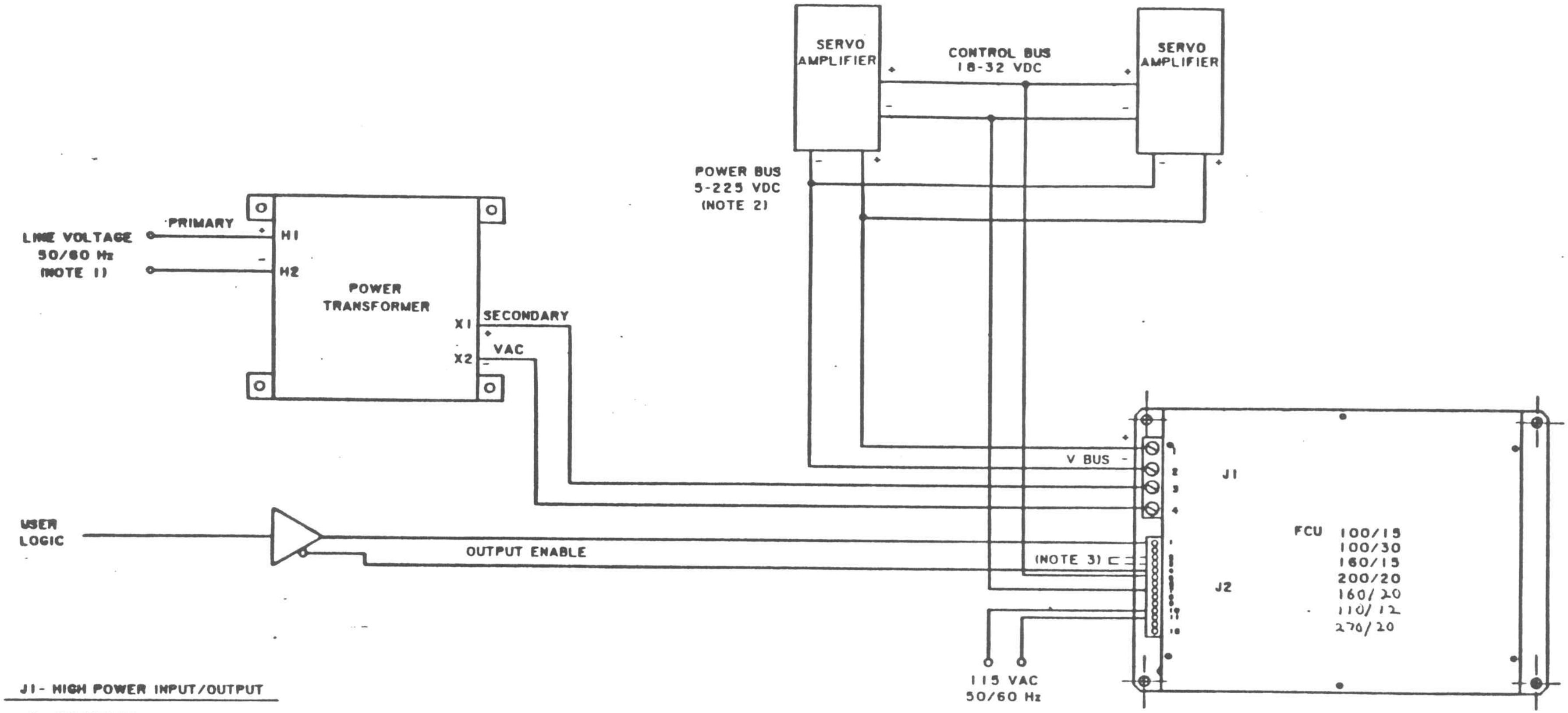
The low power and small signal connections are on the 12 contact Weidmuller MK2/12 2413.6 terminal block labeled J2. Table 3 shows the connections and the FCU chassis is labeled clearly to insure proper connection. The low power connections should use at least 20 AWG size wire.

Table 3. Low Power Connector J2

J2 CONNECTOR PIN	INPUT/OUTPUT	BUS or SIGNAL NAME
1	INPUT	+OUTEN
2	JUMPER	+BYPASS
3	JUMPER	-BYPASS
4	INPUT	-OUTEN
5	OUTPUT	+28VDCOUT
6	OUTPUT	+28VDCOUT
7	28V RETURN	COMMON
8	28V RETURN	COMMON
9	28V RETURN	COMMON
10	INPUT	115VACIN
11	INPUT	115VAC RETURN
12	CHASSIS GND	GND

2.7.3 Output Enable Connection Options

Figure 3 shows five options available for using OUTEN and BYPASS inputs. Option 1 will provide an ON/OFF switch for the FCU's DCOUT. Options 2 and 3 show interfaces to small signal voltages. Options 4 and 5 show hardwire enabling of the DCOUT bus. The BYPASS inputs are always open except for option 4.



J1- HIGH POWER INPUT/OUTPUT

1. DC OUT (+)
2. DC OUT (-)
3. AC IN (+)
4. AC IN (-)

J2- LOW POWER AND SIGNAL INPUT/OUTPUT

1. OUTPUT ENABLE (+)
2. ENABLE BYPASS (+)
3. ENABLE BYPASS (-)
4. OUTPUT ENABLE (-)
5. +28 VDC OUT
6. +28 VDC OUT
7. COMMON
8. COMMON
9. COMMON
10. 115 VAC IN, 50/60 Hz
11. 115 VAC RETURN
12. CHASSIS GROUND

NOTES:

1. LINE VOLTAGE FROM USER SUPPLIED INPUT CONTACTOR (RELAY).
2. POWER BUS DC VOLTAGE IS DETERMINED BY POWER TRANSFORMER SECONDARY VOLTAGE: V BUS ≅ 1.4 X VAC
3. WHEN OUTPUT ENABLE IS NOT USED, STRAP J2-2 TO J2-3.
4. THE FOLLOWING FCU INPUTS/OUTPUTS ARE INTERNALLY FUSED: AC IN, DC OUT, 115VAC IN, 28VDC OUT.

Figure 2

INLAND MOTOR DIVISION
KOLLMORGEN CORPORATION
501 FIRST STREET
RADFORD, VIRGINIA

CONNECTION DIAGRAM
FCU SERIES

2	31454 T.COVEY	9-11 85	
T.COVEY	7-30 85		
BY	7-31 85		
BV	7-31 85		

C 3SK-10100 2

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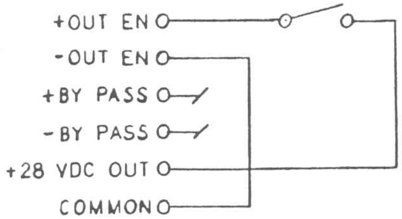

FIG. 3.1: OPTION 1

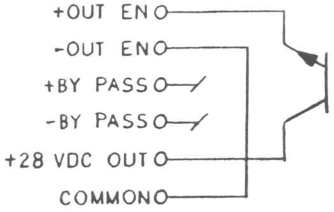

FIG. 3.2: OPTION 2

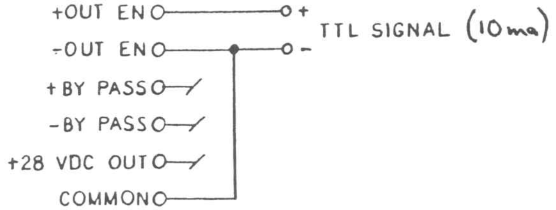

FIG. 3.3: OPTION 3

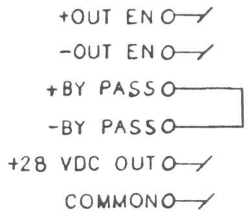

FIG. 3.4: OPTION 4

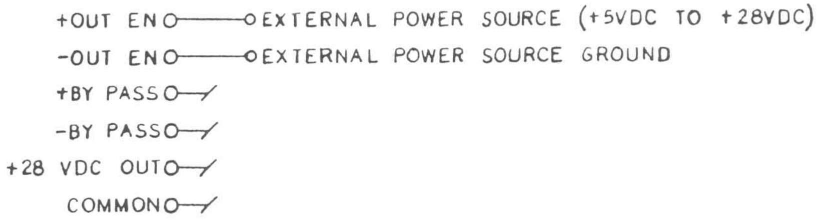

FIG. 3.5: OPTION 5

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FRACTIONAL ±	TITLE OPTION DIAGRAM, FIG. 3		
ANGULAR ±	DATE 8-29-85	DRAWING NUMBER	

2.8 FCU INPUT/OUTPUT SUMMARY

Pin	Signal	Description
J1-1	+DCOUT	This terminal is the positive output connection of the FCU high power bus. It is usually connected to +Power Input of the accompanying servo amplifier.
J1-2	-DCOUT	This terminal is the negative output connection of the FCU high power bus. It is usually connected to -Power Input of the accompanying servo amplifier.
J1-3	+ACIN	This terminal is connected to one side of the secondary of the user's transformer. CAUTION: DO NOT ATTEMPT TO CONNECT THIS TERMINAL DIRECTLY TO ANY POWER LINE WITHOUT THE USE OF AN ISOLATION TRANSFORMER.
J1-4	-ACIN	This terminal is connected to one side of the secondary of the user's transformer. CAUTION: DO NOT ATTEMPT TO CONNECT THIS TERMINAL DIRECTLY TO ANY POWER LINE WITHOUT THE USE OF AN ISOLATION TRANSFORMER.
J2-1	+OUTEN	This terminal is the positive input (optically isolated) to enable/disable the high power bus.
J2-2	+BYPASS	This terminal, connected to -BYPASS, allows the user to by-pass the OUTEN function.
J2-3	-BYPASS	This terminal, connected to +BYPASS, allows the user to by-pass the OUTEN function.

Pin	Signal	Description
J2-4	-OUTEN	This terminal is the negative input (optically isolated) to enable/disable the high power bus.
J2-5	+28VDCOUT	This terminal is the positive output of the 28 volt regulated supply.
J2-6	+28VDCOUT	Identical to terminal J2-5.
J2-7	COMMON	This terminal is the negative connection of the +28 volt regulated supply and the internal small signal ground.
J2-8	COMMON	Identical to terminal J2-7.
J2-9	COMMON	Identical to terminal J2-7.
J2-10	115VACIN	This terminal is the "Hot" connection to the 115 volt line. (Note: No isolation transformer is necessary.)
J2-11	115VAC Return	This terminal is the "Neutral" connection to the 115 volt line. (Note: No isolation transformer is necessary.)
J2-12	GND	This is a Chassis Ground intended for grounding the case/housing to an Earth Ground. This is not and SHOULD NOT be connected to any of the COMMON connections or -DCOUT.

3.0 OPERATION

3.1 POWER-UP SEQUENCING

The FCU powers-up with the low power output first and then the high power output. This allows the servo amplifier to be in control when the high voltage becomes present. The FCU is operational in less than 100 milliseconds after the 115 VAC 50/60 Hz line voltage is applied to inputs 115VACIN and 115VAC RETURN. However, only the 28 VDC output will be available that quickly. The high power DCOUT will be available 3 seconds after power-up of the 28 VDC output. The FCU has no AC power ON/OFF switch. Once input power is applied and the chassis mounted LED is illuminated, both voltages are present. The LED illuminates when the high power output voltage is present on DCOUT.

At power-up of the FCU, two input current surges will occur. These surges are due to the charging up of the internal bus capacitors. The 115VAC input will draw a surge current of 1.5 amps AC rms occuring at turn-on of this power. The ACIN input can draw a surge current of up to 150 amps depending on the DC output voltage. This surge occurs at the 3 second delay. These surges are very short, on the order of 10 milliseconds.

The first time the user powers-up the FCU, proper output DC voltages should be verified before connecting to the servo amplifier. The 115VACIN input should be applied first and the +28VDCOUT verified before power is applied to ACIN. The 28VDCOUT and the DCOUT voltages should be measured with no load applied. This will verify proper input power connections. The PRODUCT DESCRIPTION section of this manual should be consulted to determine the proper output voltages. See the INSTALLATION section for proper input power connections if proper output voltages are not present.

After verification of the unloaded output voltages, the FCU can be powered off and then connected to the user's servo amplifier. Careful attention should be given to making proper connections. +DCOUT should be connected to the +INPUT input on the Inland Motor servo amplifier and -DCOUT should be connected to -INPUT. Output voltages should be checked again with the servo amplifer connected. Improper output voltages here indicates either improper amplifier connections or open fuses.

3.2 OPERATIONAL CHARACTERISTICS

3.2.1 High Power Output

The high power DCOUT output voltage is unregulated and dependent on the full-wave rectification of the ACIN input voltage. The load is typically the servo amplifier's inverter which delivers current to the motor. This output becomes active 3 seconds after the 28VDCOUT output becomes active. However, when the 28VDCOUT output becomes 22 VDC or less or the 115VACIN is turned off, the high power output is turned off and shunted to ground through power resistors by the FCU. Approximately 10% of the rated DCOUT bus voltage will remain on the DCOUT output after the shunting. The LED on the chassis is illuminated when DCOUT is active with high voltage.

3.2.2 LED Indicator

The LED visible from the chassis front is illuminated when the high power DCOUT output is present. The LED indicator and DCOUT DC voltage will be off, given any of the following conditions: 1) low power and high power AC inputs have not been provided, 2) the 3 second delay from power-up of the 28VDCOUT output has not expired, 3) the OUTEN input is not provided by the user or if OUTEN is not used, the BYPASS inputs have not been strapped together, 4) fuse F1, F2, F3, and/or PCB F1 has been blown, 5) the 28VDCOUT output is 22 VDC or less, or 6) the DCOUT voltage is below the rated minimum.

WARNING

> Blown fuses or low output voltages can indicate excessive current conditions such as short circuits or operation of FCU in excess of rated currents. Check connections and load current if these conditions exist. Check that the DCOUT voltage is as expected and see Load Clamp in this section and in the THEORY OF OPERATION section if an active load clamp is suspected.

3.2.3 Low Power Output

The low power 28VDCOUT output is a regulated 28 VDC output with capability of sourcing 1.6 amps continuous with 3 amp peaks. This output becomes active immediately when the 115VACIN input is supplied and will slowly discharge at turn off unless 28VDCOUT is connected to a load.

3.2.4 Load Clamp

Anytime a motor is being controlled by a servo amplifier and the motor is commanded to decelerate, the DCOUT bus can be "pumped-up" due the motor's back electromotive force (EMF). The motor becomes effectively a generator, and excessive generated energy must be dissipated. This energy is dissipated in a resistive load mounted internal to the FCU, and is activated when DCOUT is "pumped-up" to the load clamp threshold found in Table 1. At this voltage, the resistor bank is applied across the bus until the bus voltage drops back to the load clamp window voltage. The load clamp is rated at 200 Watts continuous maximum.

3.2.5 FCU Enable

OUTEN inputs are provided to allow small signal enable/disable control of the high power DCOUT output. The DCOUT output turns on immediately upon enabling, if the 28VDCOUT has been present for 3 or more seconds. This input is electrically isolated from the FCU so that the user can use the voltage levels already available in his system. See the INSTALLATION section for electrical specifications. The BYPASS inputs are provided to allow convenient and constant enabling of the FCU.

3.2.6 Fuses

Four fuses exist in the FCU to protect from short circuits and excess currents. A fuse is in-line with the high power +ACIN input, the high power +DCOUT output, the 115VACIN input, and the +28VDCOUT output. Refer to the MAINTENANCE section of this manual for fuse replacement.

4.0 THEORY OF OPERATION

4.1 System Overview

The FCU provides two output power sources, a high power DC output and a low power DC output. The high power DCOUT is derived from the secondary of the user's isolation transformer. This power transformer secondary is input into the FCU, and switched on and off internally in the FCU, based on the protection circuitry, the delay circuitry, and the OUTEN circuitry. When enabled, the high power AC input is full-wave rectified and filtered, to produce the unregulated DCOUT output. Fuse protection is provided in the high power AC input and the high power DCOUT output. A Load Clamp circuit protects the DCOUT output from excessive voltage caused by a decelerating motor. The low power 28VDCOUT output is derived from the 115VACIN input by the FCU's internal transformer, rectifier, single-chip regulator, output filter, and protective output fuse.

Two circuit boards are present in the FCU, the Power board and the Small Signal board. The Power board carries high voltage components used with the DCOUT bus such as the load clamp transistors, the transzorb, and the LED illumination circuit. The Small Signal board carries the low voltage circuitry such as the 28 Volt circuit, the undervoltage detection circuit, the delay circuit, and the load clamp comparator circuit.

4.2 DCOUT VOLTAGE

The DCOUT Voltage output provides the DC power bus to the servo amplifier. This power output is proportional to and is generated from the ACIN input voltage from the user's power transformer. The ACIN input is labeled +ACIN and -ACIN and these inputs are interchangable due to the AC signal. This input is first fed into fuse F1 and an AC solid state relay. The relay allows the load clamp circuitry, the undervoltage circuitry, the delay circuitry, and the OUTEN circuitry to switch off the high power input when appropriate. The AC output of the relay is then rectified by a full-wave bridge and capacitor filtered. The capacitor has a discharging resistor across it. Fuse F2 is wired in between the filter capacitor and the output terminal block.

The output side of fuse F2 also connects to the load clamp power resistors. The other side of the resistor connects to the Power board at P1 pin 9 and 10, which connects to the load clamp transistors.

4.3 POWER BOARD

The DCOUT output connects directly to the Power board P1 pin 6, to provide power for the LED illumination circuit R1 and CR3, the zener shunt regulator resistor R2, and the bus monitoring voltage divider resistor R3. This board also contains DC transzorb CR2 and DC bus noise filtering capacitors C1 and C2. Either CR1 or R7 will be populated, but never both.

4.4 SMALL SIGNAL BOARD

The Small Signal board carries all the logic and small signal circuitry as well as the AC to 28 VDC conversion circuitry.

4.5 LOW POWER VOLTAGE

The low power 115VACIN is first input into fuse F3, which is connected to the primary of the internal transformer. The transformer secondary output connected to the Small Signal board at P2 pin 1 and 2, is full-wave rectified by CR11 to produce an approximate 35 VDC output. A 10,000 uF capacitor filters this output before the voltage enters the voltage regulator IC. A LM338 is used to regulate the approximate 35 VDC to the 28 volt 28VDCOUT. This output is filtered by two 470 uF capacitors and fed through circuit board mountable fuse F1 before terminal block J2. COMMON is the negative of the full-wave rectifier and regulator reference.

4.6 PROTECTION AND CONTROL CIRCUITRY

4.6.1 Internal Power Supplies

The internal power supply which provides power to the Small Signal board's internal analog circuitry is a LM78L12 regulator. This regulator is input the 28 VDC from the LM338 and regulates the +12 VDC internal supply. The undervoltage protection circuitry and the delay circuitry operate at this +12 VDC.

The load clamp circuitry on the Small Signal board is powered by +15 VDC. This power comes from a zener shunt regulation of the DCOUT output. A 15V zener diode, CR9, is in series with resistor R2 (R2 is on the power board). The +15 VDC power supply is tapped off the cathode of CR9. Eighty per cent of the DCOUT maximum voltage is required to generate the +15 VDC. The +15 VDC is isolated from the +12 VDC regulated voltage.

4.6.2 Load Clamp Circuitry

The load clamp circuit on the Small Signal board consist of an op amp which compares a reference set by voltage reference CR7, to a voltage divider circuit comprised of R20 and R3 (R3 is on the power board). The voltage divider is sourced by DCOUT and is filtered by voltage follower. When DCOUT causes the voltage across R20 to exceed the voltage reference set by CR7, then the voltage comparator turns on the power MOSFETs. Power MOSFETs, Q1 and Q2 of the Power board, is the switch which controls the load clamp. When the MOSFETs are on, the DCOUT bus is shunted through the load clamp power resistors mounted on the base plate. The solid state relay is off when the load clamp is on.

The load clamp turns off when the DCOUT voltage divider drops to the reference voltage with the hystersis being set by R21.

4.6.3 Undervoltage Circuitry

The undervoltage circuitry on the Small Signal board monitors the output of the 28 volt regulator on the output side of fuse F1. This output is voltage divided by R3 and R4 and compared, through voltage comparator U3, to the reference set by R5 and CR3. When the voltage across R4 drops below the voltage reference, the undervoltage circuitry turns off the solid state relay and actives the load clamp. This protects the servo amplifier by discharging the DCOUT bus when loss of 28 VDC is detected. When the 28VDCOUT voltage recovers to at least 24 VDC, the undervoltage circuitry allows the DCOUT output voltage to return after a delay of 3 seconds.

4.6.4 Delay Circuitry

The delay circuitry exist on the Small Signal board. The delay circuit voltage comparator U3 compares a RC network consisting of R8 and C11 to a voltage reference. When the 115VACIN input is applied, capacitor C11 begins to charge up. The delay circuitry holds the load clamp on and the solid state relay off until C11 charges to the reference voltage. The delay is activated every time the undervoltage circuit detects an undervoltage and the 28VDCOUT output recovers to the proper voltage range.

4.6.5 OUTEN Inputs

The high power DCOUT output can be enabled and disabled from a small signal voltage by the +OUTEN and -OUTEN inputs. The 28VDCOUT output will not be affected. The input requirements for the OUTEN inputs are given in the INSTALLATION section. +OUTEN and -OUTEN are the inputs to an optocoupler circuit which is an MOC5008 optocoupler photodiode in series with 555 ohms resistance. A 1N5231 zener diode, in parallel and opposite orientation of the photodiode, is included for reverse polarity protection and current limiting. This optocoupler U6, allows isolation and control between the user's hardware and the servo system. The optocoupler controls the switching of the solid state relay and the load clamp.

4.6.6 BYPASS Inputs

+BYPASS is the open-collector output of the optocoupler U6. -BYPASS is connected to COMMON. When +BYPASS and -BYPASS are strapped together, the optocoupler output is logic low, and the OUTEN function is removed. The DCOUT output only depends on undervoltage, delay, and load clamp circuitry when the BYPASS inputs are used.

5.0 MAINTENANCE

Under normal operating conditions the FCU needs no maintenance or adjustments. The FCU Series is designed for trouble-free operation at the rated loads. It is recognized that set-up problems can occur and components can be destroyed when misapplied. This section is provided to allow the user to make judgements on the serverity of any damage and to allow options for restoration. This section of the manual contains maintenance information for use in interior access, preventive maintenance, corrective maintenance, and troubleshooting of the FCU.

5.1 PRELIMINARY INFORMATION

5.1.1 Interior Access

Disconnect all power to the FCU before removing the chassis cover. The interior of the chassis is accessed by removing the 7 small screws holding the cover top (side with LED) in place. Three of these screws are located at the top on each side with one remaining screw located at the top rear. Carefully lift off top cover. To lift off the side cover, remove the three screws at the bottom of each side and remove the four screws holding the two fuseholders to the side. Reverse this procedure to replace the covers.

WARNING

> Dangerous potentials exist at several points throughout this unit. When the FCU is operated with the interior exposed, do not touch exposed connections or components. Some transistors have voltages present on their cases. Disconnect power before cleaning the unit or replacing parts. Verify that the large capacitors internal to the unit have discharged to safe voltage levels.

5.2 PREVENTIVE MAINTENANCE

Preventive maintenance consists of cleaning, visual inspection, etc. Preventive maintenance performed on a regular basis may prevent FCU breakdown and prolong its life. The severity of the environment to which the FCU is subjected determines the frequency of maintenance.

5.2.1 Cleaning

The FCU should be cleaned as often as operating conditions require. Accumulation of dirt in the FCU can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides an electrical conduction path which may result in FCU failure.

5.2.1.1 Exterior

Dirt and dust accumulation on the base plate should be kept clean since the ability of the FCU to dissipate heat can be greatly reduced. The base plate is the thermal path to the user supplied heat sink and dirt and dust on the base plate or user supplied surface will act as an insulator and create a high thermal resistance. This will eventually cause excessive heating and can lead to failure of power components. Dust on the outside of the FCU can be removed with a soft cloth or small brush. The brush is particularly useful for dislodging dirt on and around the connectors. Dirt which remains can be removed with a soft cloth dampened in a mild detergent and water solution. Abrasive cleaners should not be used.

5.2.1.2 Interior

If visible dust is in the interior of the FCU, the dust should be removed due to its electrical conductivity under high-humidity conditions. The best way to clean the interior is to blow off the accumulated dust with dry, low-pressure air. Remove any dirt which remains with a soft brush. A cotton-tipped applicator is useful for cleaning in narrow spaces or for cleaning circuit boards.

5.2.2 Visual Inspection

The FCU should be inspected occasionally for such defects as blown fuses, broken connections, improperly seated semiconductors, damaged or improperly installed components, and heat damaged parts. The corrective procedure for most visible defects is obvious, however, particular care must be taken if heat-damaged components are found.

Overheating usually indicates other trouble in the FCU; therefore, it is important that the cause of overheating be corrected to prevent recurrence of the damage.

5.2.3 Fuses

If the fuses need replacement, remove all power from the FCU and remove the top of the case. Replace the fuse with the same or equivlent fuse as shown in Table 4.

The FCU contains four fuses. High power fuses F1 and F2 are mounted in fuse holders on the sides of the chassis. Low power fuse F3 is mounted on the base plate behind the J2 terminal block. Small signal fuse F1 on the Small Signal board is in a PCB mounted fuse holder. If the ACIN input is present and the +DCOUT voltage output is non-existant, then the high current fuses F1 and F2 should be checked, if none of the other disable conditions exists which are listed in the LED Indicator section of INSTALLATION. If the 115VACIN input is present and the +28VDCOUT is non-existant then fuses F3 and PCB F1 should be checked.

5.2.4 Semiconductor Checks

Periodic checks of the semiconductors in the FCU are not recommended. The best check of semiconductor performance is actual operation in the unit. More details on checking semiconductor operation are given under TROUBLESHOOTING.

Table 4. Recommended Fuses

Component	Input/Output	Model	Fuse Type
F1	+ACIN	FCU-100-15	25 Amp Slow, Bussman FRN-R-25
		FCU-110-12	25 Amp Slow, Bussman FRN-R-25
		FCU-100-30	45 Amp Slow, Bussman FRN-R-45
		FCU-160-15	25 Amp Slow, Bussman FRN-R-25
		FCU-160-20	35 Amp Slow, Bussman FRN-R-35
		FCU-200-20	35 Amp Slow, Bussman FRN-R-35
		FCU-270-20	35 Amp Slow, Bussman FRN-R-35
F2	+DCOUT	FCU-100-15	15 Amp Fast, Littlefuse KLK-15
		FCU-110-12	15 Amp Fast, Littlefuse KLK-15
		FCU-100-30	30 Amp Fast, Littlefuse KLK-30
		FCU-160-15	15 Amp Fast, Littlefuse KLK-15
		FCU-160-20	20 Amp Fast, Littlefuse KLK-20
		FCU-200-20	20 Amp Fast, Littlefuse KLK-20
		FCU-270-20	20 Amp Fast, Littlefuse KLK-20
F1 on PCB	+28VDCOUT	All Models	4 Amp Fast, Bussman AGC-4
F3	115VACIN	All Models	2 Amp Slow, Bussman MDA-2

5.3 TROUBLESHOOTING

The FCU is designed to provide a long life of trouble-free operation. Should repairs ever be required though, it is recommended that the unit be returned to INLAND MOTOR. Only someone familiar with electronics servicing should attempt repairs since potentially dangerous electrical voltages exist within the unit when it is energized.

The following information is provided to facilitate troubleshooting of the FCU. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component. An understanding of the circuit operation is very helpful in locating troubles, particularly where integrated circuits are used. See the Theory of Operation section for additional information.

5.3.1 Troubleshooting Equipment

The following equipment is useful for troubleshooting the FCU.

5.3.1.1 Oscilloscope

Description: Frequency, dc to 5 megahertz; deflection factor, from 10 millivolts to 50 volts/division. A 10X probe should be used in high voltage sections.
Purpose: To check operating waveforms in the unit.

5.3.1.2 Current Probe and Amplifier

Description: TEKTRONIX P6303 Current Probe and AM 503 Current Probe Amplifier or equivalent. Frequency response, dc to 5 megahertz; capable of measuring currents of 20 amps or greater.
Purpose: To monitor input, output, and ripple currents for correct characteristics.

5.3.1.3 Multimeter

Description: SIMPSON 260 VOM or equivalent.
Purpose: To test the semiconductors used in the FCU and for general troubleshooting.

5.3.1.4 AC Power Supply

Description: 50-60 Hz, AC power supply, variac, or transformer, with voltage adjustable to the maximum rated input AC voltage rms of the FCU; current-limited with minimum 10 amp capacity;
Purpose: To provide a low voltage current-protected input to the ACIN inputs for safe testing of the FCU.

5.3.2 Troubleshooting Techniques

This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks assure proper connection and operation. If the trouble is not located by these checks, the remaining steps aid in locating the defective component.

When the defective component is located, it should be replaced following the replacement procedures given under corrective maintenance.

5.3.2.1 Check Connections

Incorrect or loose connections can indicate a problem that is easily repaired. If there is any question about the correct function of inputs and/or their correct wiring, see the INSTALLATION and OPERATION sections.

5.3.2.2 Check Associated Equipment

Before proceeding with troubleshooting of the FCU, check that the equipment used with this FCU is operating correctly. Check that the input power source is properly connected and that the interconnecting cables are not defective. Also, check the power source for the proper voltages.

5.3.2.3 Visual Check

Visually check the portion of the instrument in which the trouble is located. Many troubles can be located by visible indications such as unsoldered connections, broken wires, damaged circuit boards, damaged components, etc.

5.3.2.4 Isolate Trouble To a Circuit

To isolate trouble to a particular circuit, note the trouble symptom. The symptom often identifies the circuit in which the trouble is located. It is also advisable to troubleshoot from the outside in; interfaces are the first place to look for problems. Incorrect operation of all circuits often indicates trouble in the FCU internal power supplies. Check first for correct voltage of the input supply. A defective component elsewhere in the FCU can appear as power supply trouble and may also affect the operation of other circuits. Check that the 28VDCOUT maintains the rated voltage. If the 28VDCOUT voltage is within the listed tolerance and the internal +12V is proper, the internal supplies can be assumed to be working correctly.

5.3.2.5 Check Voltages and Waveforms

Often the defective component can be located by checking for the correct voltage or waveform in the circuit.

5.3.2.6 Check Individual Components

The following procedures describe methods of checking individual components in the FCU. Components which are soldered in place are best measured by first disconnecting one end. This isolates the measurement from the effects of surrounding circuitry.

5.3.2.6.1 Semiconductors

CAUTION

> Power must be disconnected before removing or replacing semiconductors.

A good check of semiconductor operation is actual performance under operating conditions. A transistor can most effectively be checked by substituting a new component for it (or one which has been checked previously). However, be sure that circuit conditions are not such that a replacement transistor might also be damaged. The Load Clamp MOSFETs can be checked safely by disconnecting the input power, removing the suspected transistor, and measuring resistance Gate-Source (Positive lead-Negative lead), Drain-Gate, and

Drain-Source with a VOM. The meter should be set on the RX100 scale and all readings should read Open-Circuit except for Source-Drain which will show the MOSFET internal diode. This test must be conducted with Power OFF; proper polarity is important.

Integrated circuits can be checked with an oscilloscope or by direct substitution. A good understanding of the circuit operation is essential to troubleshooting circuits using integrated circuits. In addition, a good understanding of signal flow and types of signals can be gained by referring back to the Theory of Operation section. Use care when checking around integrated circuits so adjacent leads are not shorted together. Wherever possible, consult manufacturer's data sheets for the IC in question.

5.3.2.6.2 Diodes

A diode can be checked for an open or for a short circuit by measuring the resistance between terminals with an ohmmeter set to the RX1 scale. The diode resistance should be very high in one direction and very low when the meter leads are reversed.

5.3.2.6.3 Resistors

Check the resistors with the ohmmeter. Resistors normally do not need to be replaced unless the measured value varies widely from the specified value.

5.3.2.6.4 Capacitors

A leaky or shorted capacitor can best be detected by checking resistance with an ohmmeter on the highest scale. Do not exceed the voltage rating of the capacitor. The resistance reading should be high after initial charge of the capacitor. An open capacitor can best be detected with a capacitance meter.

5.3.3 Testing after Repairs

After any repairs to the FCU are done, preliminary testing should be done before applying full input power. Before applying any input power to the FCU, an ohmmeter should be used to verify connections, particularly those which have been disconnected and reconnected.

5.3.3.1 Testing with Input Power

To allow low current and low power testing on a repaired FCU, an AC power supply which has a variable voltage and current control should be used for the ACIN input power to the FCU. Since the DCOUT is an unregulated power output, the output voltage will depend on the input voltage. Refer to the INSTALLATION section for proper ACIN and DCOUT voltage levels.

If a repair has been made in the low power circuitry, the 115VACIN input should be brought up to 115 VAC gradually to verify operation without excess current. Once the +28VDCOUT output and internal supply voltages have been verified, the DCOUT high power output can be checked by gradually applying the ACIN input voltage. Consult the THEORY OF OPERATION section for more detail.

5.4 CORRECTIVE MAINTENANCE

Corrective maintenance consists of component replacement and FCU repair. Special techniques required to replace components in this FCU are given here.

5.4.1 Obtaining Replacement Parts

5.4.1.1 Standard Parts

All electrical and mechanical part replacements for the FCU can be obtained through INLAND MOTOR. However, many of the electronic components can be obtained locally in less time than is required to order them from INLAND. Before purchasing or ordering replacement parts, check closely for value, tolerance, rating, and description.

5.4.1.2 Special Parts

Most of the mechanical parts used in the FCU have been manufactured by INLAND. Order all special parts directly from INLAND MOTOR.

5.4.1.3 Ordering Parts

When ordering replacement parts, include the following information:

1. Filter Control Unit Model No.
2. Filter Control Unit Serial No.
3. A description of the part and the location (if electrical, include circuit number).

5.4.2 Soldering Techniques

The reliability and accuracy of this FCU can be maintained only if proper soldering techniques are used when repairing or replacing parts.

<u>WARNING</u>

> Remember, disconnect the FCU from the power input source and wait for the bus capacitor to discharge before soldering.

General soldering techniques which apply to maintenance of any precision electronic equipment should be used when working on this instrument. Use only 60/40 rosin-core electronic-grade solder. After soldering is completed, clean the area around the solder connection with a flux-remover solvent.

5.4.3 Circuit Board Replacement

If a circuit board is damaged beyond repair, the entire assembly including all soldered-on components, can be replaced. The circuit boards in the FCU are easily accessible. Be sure and obtain an Return Autorization Number from INLAND before shipping.

5.4.4 Replacement of Chassis-Mounted Components

Most components can be removed by disconnecting connectors and removing mounting screws or bolts. Some components may require some desoldering.

5.4.5 Semiconductor Replacement

Semiconductors should not be replaced unless actually defective. Unnecessary replacement of semiconductors may affect calibration of some parts of the FCU. When semiconductors are replaced, check the operation of the part of the instrument which may be affected.

Replacement semiconductors should be of the original type or a direct replacement. Devices such as MOSFETs which have heat sinks, use isolation pads and silicone grease to increase heat transfer. Replace the isolation pads and silicone grease when replacing these components. Incorrectly mounted, these components can result in further damage by causing a direct short from the MOSFET to the heat sink (chassis ground).

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