

# HARVARD

A P P A R A T U S

Manual for Catalog No.  
60-0125

**User's Manual For:  
Harvard's Research DC Signal Conditioner  
With Zero Suppression  
Catalog No. 60-0125**

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**Harvard Apparatus Inc.**

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3rd Printing

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## SAFETY SUMMARY

The general safety information is for both user and service personnel. Specific WARNINGS and CAUTIONS will be found throughout the manual where they apply.

### *Terms in this Manual*

**CAUTION** statements identify conditions or practices that could result in damage to the equipment or other property. They will appear in boldfaced capital letters.

**WARNING** statements identify conditions or practices that could result in personal injury or loss of life. They will appear in boldfaced capital letters.

### *Symbols in this Manual*



This symbol indicates where cautionary information is to be found.

### *Terms as Marked on Equipment*

**CAUTION indicates a personal injury hazard** not immediately accessible as one reads the marking, or a hazard to property, including the equipment itself.

**DANGER** indicates a personal injury hazard immediately accessible as one reads the marking.

### *Symbols as Marked on Equipment*



DANGER – High Voltage



Protective ground (earth) terminal



ATTENTION – Refer to manual

## **SAFETY SUMMARY**

**(Continued)**

### **Power Source**

This instrument is intended to operate from a power source that does not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential.

### **Grounding the Instrument**

This instrument is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

### **Danger Arising From Loss of Ground**

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electric shock.

### **Use the Proper Power Cord**

Use only the power cord and connector specified for your instrument. Use only a power cord that is in good condition. For detailed information on power cords and connections see Section 2, Installation, in the User's Manual.

### **Use the Proper Fuse**

To avoid fire hazard, use only a fuse of the correct type, voltage rating and current rating as specified in the parts list for your instrument.

### **Do Not Operate Without Covers and Panels Installed**

To avoid personal injury and equipment damage, the user should disconnect power before removing covers, panels or any grounding straps. Reinstall covers, panels, and any grounding straps *before* reconnecting power.

### **WARNINGS For Authorized Service Personnel**

Do not perform internal service or adjustment of this instrument unless another person capable of rendering first aid and resuscitation is present.

Dangerous voltages exist at several points in this instrument. To avoid personal injury, do not touch exposed connections or components while power is on.

Disconnect power before removing protective panels, soldering, or replacing components.

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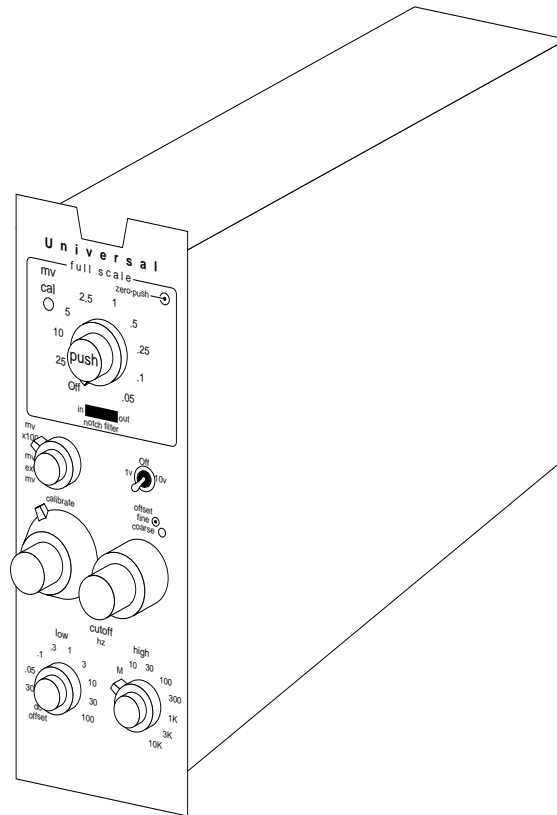
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## 1.1 Introduction

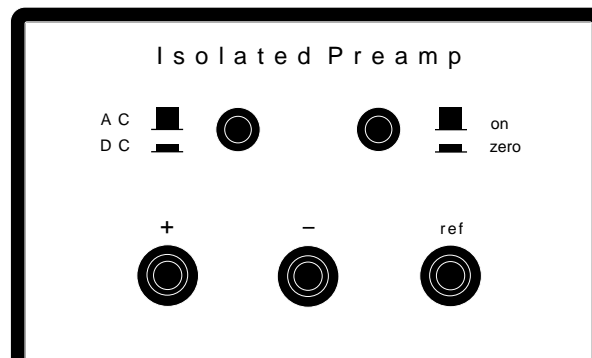
### 1.1.1 Universal Amplifier, Model 13-4615-58

The performance of the Harvard Universal Amplifier, shown in Figure 1-1, truly lives up to its name universal. The unit acts as an excellent differential amplifier or provides the capabilities of a top grade biophysical amplifier when utilized along with an Isolated Preamplifier, Model 11-5407-58. High input impedance, wide bandwidth, low noise, low-drift and transducer excitation are all incorporated to produce the finest signal conditioning available in any single amplifier module.



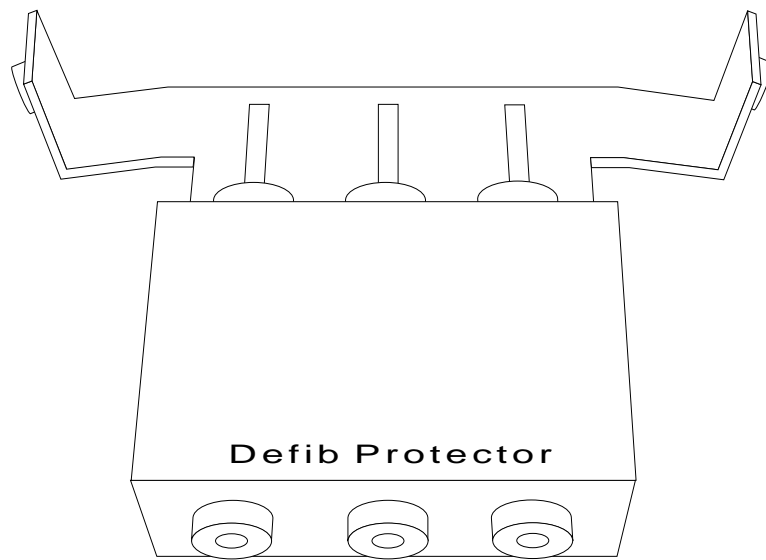
### 1.1.2 Isolated Preamplifier, Model 13-5407-58

Harvard's Isolated Preamplifier, shown in Figure 1-2 enhances the performance of the Universal Amplifier by providing signal isolation between the signal source and the measuring equipment. Since the Isolated Preamplifier is intended to be physically placed near the signal source, the small biophysical signals are conditioned before they can be degraded by noise pickup or the capacitance of long signal cables. The Isolated Preamplifier was designed solely for use with the Universal Amplifier.



### 1.1.3 Defibrillator Protector, Model 11-5407-59

The Harvard Plug-in Defibrillator Protector is shown in Figure 1-3. This unit provides input protection for the Isolated Preamplifier when usage of a defibrillator or other stimulators is anticipated.



## 1.2 Specifications

### 1.2.1 Model 13-4615-58

#### Amplifier Input:

##### Circuit Configuration:

DC	Differential and balanced to chassis
AC	Differential and balanced to chassis

##### Impedance:

"mv" and "mvX100" Range	100 m $\Omega$ each input to chassis
Input Current	< 100 pA either input at 25°C

##### Measurement Range:

"mVX100"	2.5 mV full scale to 10 V full scale
"mV" or "ext mV"	25 $\mu$ V scale to 250 mV full scale

Attenuation	0.05, 0.1, 0.25, 0.5, 1, 2.5, 5, 10, 25, full scale and OFF, "mV X100/mV/ext mV" switch and "calibrate" vernier dial
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Maximum Safe Voltage	120 V RMS; each input to common
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Internal Calibration	mV, ext mV: Selectable between
DC Signal Source	50 $\mu$ V and 1 mV with in $\pm$ 1% at 25°C $\pm$ 5 $\mu$ V/°C
	"mVX100": Selectable between 5 mV and 100 mV within $\pm$ 1% at 25°C

Attenuator Inaccuracy	$\pm$ 0.5% of calibrated step
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Non-linearity	$\pm$ 0.1% of full scale
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Instability:	(after 30 minute warm-up)
--------------	---------------------------

##### DC Mode, 500 $\mu$ V full scale:

Zero with Time	$\pm$ 4% of full scale/8 hrs
Zero with Line	$\pm$ 0.1% of full scale for a 10% line change
Zero with Temp	$\pm$ 2% of full scale/°C $\pm$ 10%
Gain with Time	$\pm$ 0.02%/24 hrs
Gain with Line	$\pm$ 0.02 for $\pm$ 10% line change
Gain with Temp	$\pm$ 0.03%/°C

##### AC Mode, 50 $\mu$ V full scale (by design):

Zero with Time	$\pm$ 1% of full scale/24 hrs
Zero with Line	$\pm$ 0.4% of full scale for a 10% line change
Zero with Temp	$\pm$ 1% of full scale/°C
Gain with Time	$\pm$ 0.02%/24 hrs
Gain with Line	$\pm$ 0.02 for $\pm$ 10% line change
Gain with Temp	$\pm$ 0.03%/°C

##### Frequency Response:

Low Cut Off	"DC offset", "DC," .05, .1, .3, 1, 3, 10, 30, 100 Hz, -3 dB, $\pm$ 15% of indicated frequency, -6 dB/oct
High Cut Off	0.05, 10, 30, 100, 300, 1000, 3000, 10,000 Hz -3 dB, $\pm$ 15% of indicated frequency, -6dB/oct

Notch Filter	60 Hz reject filter, minimum -20 dB at 60 Hz, adjustable to 50 Hz
--------------	---



Noise ("mV" range, input shorted):

- 0.1 to 10 Hz < 4  $\mu$ V peak-to-peak, RTI
- 0.05 to 10 kHz < 50  $\mu$ V peak-to-peak, RTI

Common Mode Rejection > 90 dB at 60 Hz with 1 k $\Omega$  imbalance in "mV". > 70 dB in "mVX100"

Calibrated Vernier 10 turn vernier to multiply setting of attenuator or set transducer calibration from 0.5 to 10.5X

Overload Recovery Time: Low cutoff filter

- AC Manual via front panel "cal" switch or external gate control
- DC 10 msec compatible with time constant

**Offset Voltage** (uncalibrated):

- Range Up to  $\pm$ 500 mV in "mV" range; up to  $\pm$ 10 V in "mVX100" range
- Resolution  $\pm$ 2  $\mu$ V in "mV" range;  $\pm$ 200  $\mu$ V in "mVX100" range

**Stability:**

- After 30 minute warm up
- With Time  $\pm$ 0.02%/24 hrs
- With Temp  $\pm$ 0.05%/°C
- With Line  $\pm$ 0.02 for  $\pm$ 10% line change
- Noise  $\pm$ 50  $\mu$ V RTI on "mVX100" range;  $\pm$   $\mu$ V RTI on "mV" range

**Excitation Voltage:**

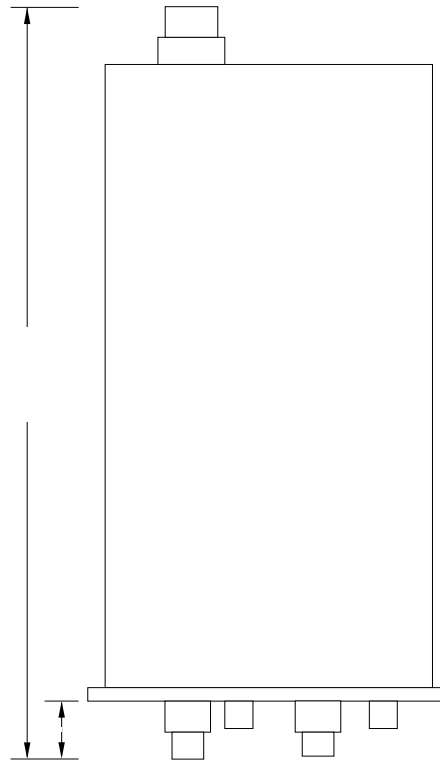
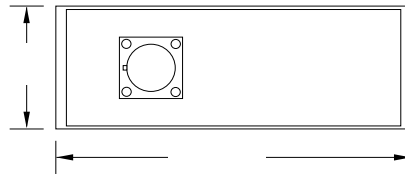
- Range 5.0 V  $\pm$ 5 mV ( $\pm$ 2.5 V nominal, balanced to chassis)
- Load Current 50 mA maximum (adjustable via plug-in resistor)
- Stability:
  - With Time  $\pm$ 0.05%/24 hrs
  - With Line  $\pm$ 0.02% for a  $\pm$ 10% change in line
  - With Temp  $\pm$ 0.05%/°C
- Noise 0.1% P-P from DC to 1kHz

**Power Requirements:**

- Voltage  $\pm$ 15 V,  $\pm$ 0.6 V, at 100 mZ
- Line and Load Regulation 0.5%
- Ripple 5 mV RMS maximum

**Physical:**

Exterior Dimensions, H x W x D (See Figure 1-4)



### 1.2.2 Catalog No. 60-0112

**Amplifier Input:**

- Circuit Configuration Differential and balanced to reference
- Impedance > 1000 m $\Omega$  shunted by < 30 pF in DC mode (100 m $\Omega$  and 30 pF in AC mode)
- Sink Rise Leakage Current < 10  $\mu$ A at 230 V RMS, 60 Hz input to chassis
- Noise (inputs shorted, "ext mV" only):
  - 0.05 to 10 Hz < 2  $\mu$  peak-to-peak RTI
  - 0.05 to 10 kHz < 12  $\mu$ V peak-to-peak RTI
- Input Current < 100 pA at 25°C either input

Instability: After 30 minute warm-up

Zero with Time  $\pm 4\%$  of full scale/8 hrs

Zero with Line  $\pm 0.1\%$  for a  $\pm 10\%$  line change

Zero with Temp  $\pm 2\%$  of full scale/ $^{\circ}\text{C}$

Gain with Time  $\pm 0.05\%/24$  hrs

Gain with Line  $\pm 0.05\%$  for a  $\pm 10\%$  line change

Gain with Temp  $\pm 0.05\%/^{\circ}\text{C}$

Maximum Safe Voltage 50 V peak input to reference; 500 V peak input to chassis

Maximum Common Mode:

Input to Chassis 100 dB at 60 Hz with  $1\text{k}\Omega$  resistive imbalance

Input to Reference 80 dB at 60 Hz with  $1\text{k}\Omega$  resistive imbalance

Gain Accuracy  $\pm 0.3\%$  of full scale

Linearity  $\pm 0.1\%$  of full scale in 25 mV full scale range; increasing to  $\pm 0.5\%$  in the 250 mV full scale range

Frequency Response: (-3 dB)

Small Signal, 25 mV

Input AC: 0.016 Hz to 10 kHz

DC: DC to 10 kHz

Full Power, 250 mV Input AC: 0.016 Hz to 10 kHz  $\pm 10\%$

DC: DC to 10 kHz  $\pm 10\%$

**Amplifier Output:**

Circuit Configuration Single ended to common

Voltage 0 to 5 VDC linear range

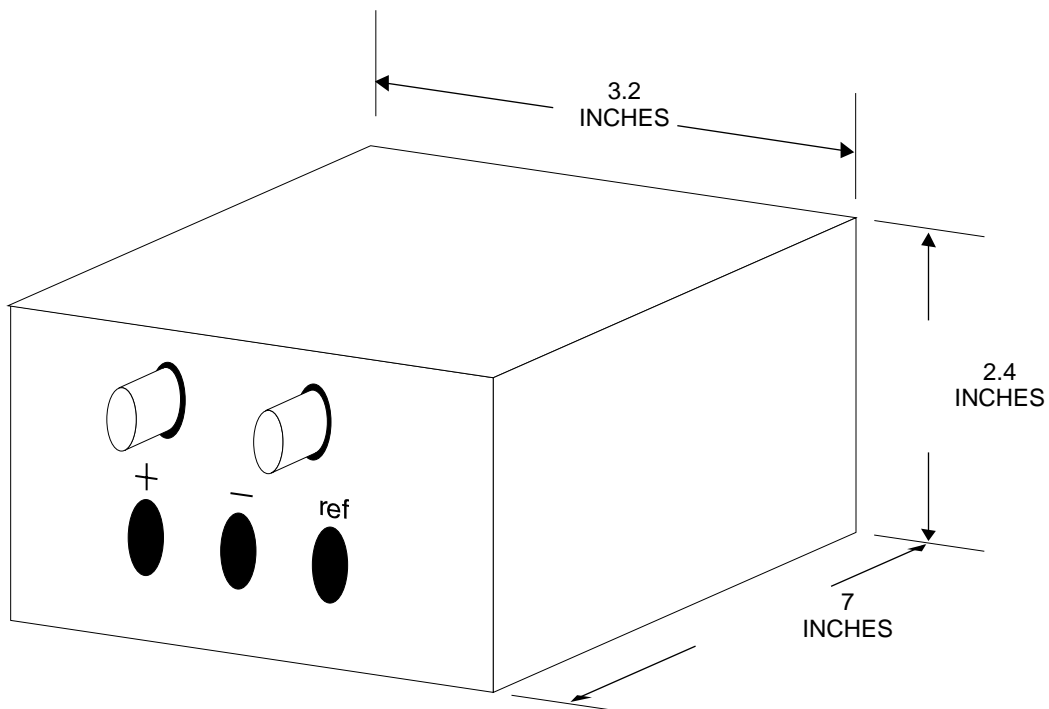
Impedance  $100\Omega$  nominal short-circuit proof

**Physical:**

Exterior Dimensions, H x W x D (See Figure 1-5)

6.1 x 8.1 x 18 cm (2.4 x 3.2 x 7 in)

(2.4 x 3.2 x 7 in)



### 1.2.3 Catalog No. 60-0013 Defibrillator Protector

Impedance:	DC to 60 Hz
Between Inputs	> 10 m $\Omega$ with common mode signals up to 2.5 V
Inputs to Chassis	> 50 m $\Omega$ each input to chassis
Leakage Current	The combined leakage of the Defibrillator Protector and the Isolated Preamplifier is < $\mu$ A with 230 V RMS, 60 Hz applied
Defibrillator Protection	The circuitry is designed to withstand up to 300 watt-seconds of defibrillator pulse energy

## 1.3 SUPPLIES AND ACCESSORIES

Catalog No.	Product
60-0109	Input Mating Connector (Male)
60-0225	Three Lead Non-Isolated Patient Cable Kit
60-0129	Adapter Cable, Deutsch to BNC
60-0280	Isolated Physiologic Pressure Transducer
60-0281	Miniature Isolated Physiologic Pressure Transducer
60-0114	Isotonic Muscle Transducer

## 2.1 GENERAL

This section describes the checks and inspections that should be made upon receiving the Harvard Universal Amplifier (Model 13-4615-58), Isolated Preamplifier (Model 11-5407-58) and the Defibrillator Protector (Model 11-5407-59). Installation procedures and typical signal input connections will also be discussed and diagrammed.

## 2.2 Initial Inspection

Prior to attempting any electrical connections or operation, visually examine the unit for broken or loose knobs, dented or nicked panels and broken or chipped rear connectors.

## 2.3 Universal Amplifier Installation

The Universal Amplifier (Model 13-4615-58) may be mounted in any compatible Harvard Recorder of 4600 Amplifier Series cage.

**Caution: Power must be turned off when installing or removing amplifier modules.**

### 2.3.1 Insertion

To install the amplifier into its appropriate slot:

- a. Slide the amplifier into the enclosure until the rear output card edge connector is engaged.
- b. Tighten the rear retaining screw until the amplifier front panel is flush with the edge of the enclosure. **DO NOT OVERTIGHTEN.** This locks the preamplifier into the enclosure.
- c. The 12 pin Deutsch input cable connection at the rear of the amplifier module utilizes a locking ring which snaps into place as a securing device. Install the input signal cable by aligning the blue line on the locking ring on the cable connector with the polarizing key (See Figure 2-1) on the amplifier connector. Push the cable connector in until the locking ring snaps into place and/or the orange ring behind the locking ring on the connector shell becomes visible.

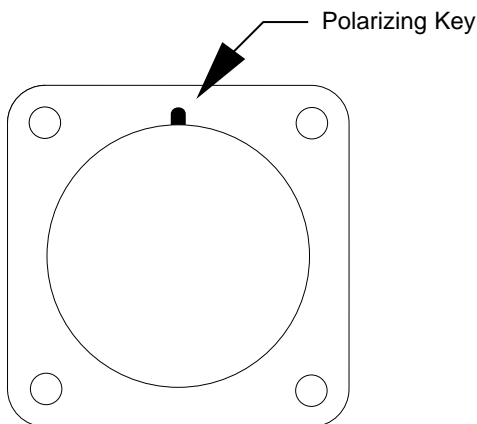
**Caution:** This type of connector (Deutsch) can be damaged beyond repair by attempting to twist or turn the locking ring. Do not attempt to tighten this connector by screwing or turning the locking ring. Hearing the ring snap and/or observing the orange ring behind the locking ring indicates total insertion has been attained.

### 2.3.2 Removal

- a. Disconnect the input connector by pulling back on the locking ring
- b. Loosen the rear retaining screw. The preamplifier will move forward 1/8 of an inch
- c. Carefully slide the entire amplifier out of the enclosure.

## 2.4 Universal Amplifier Input Connections

This amplifier unit may be used as a general purpose AC or DC amplifier, as a transducer amplifier or as a biophysical signal conditioner. Table 2.1 gives a complete input pin and signal listing and Table 2.2 indicates the connections for power and output signals available on the card edge connector. The amplifier cage may have spade lug terminals or push on terminals depending upon the model and manufacture date. Figure 2-2 gives a typical connector of the Universal Amplifier as a general purpose amplifier while Figure 2-3 shows a schematic for a transducer input. Use of Heart Sound Microphone (286700) and a Phone Jack/Deutsch Adapter Assembly (11-5407-57) with a Universal Amplifier is shown schematically in Figure 2-4.



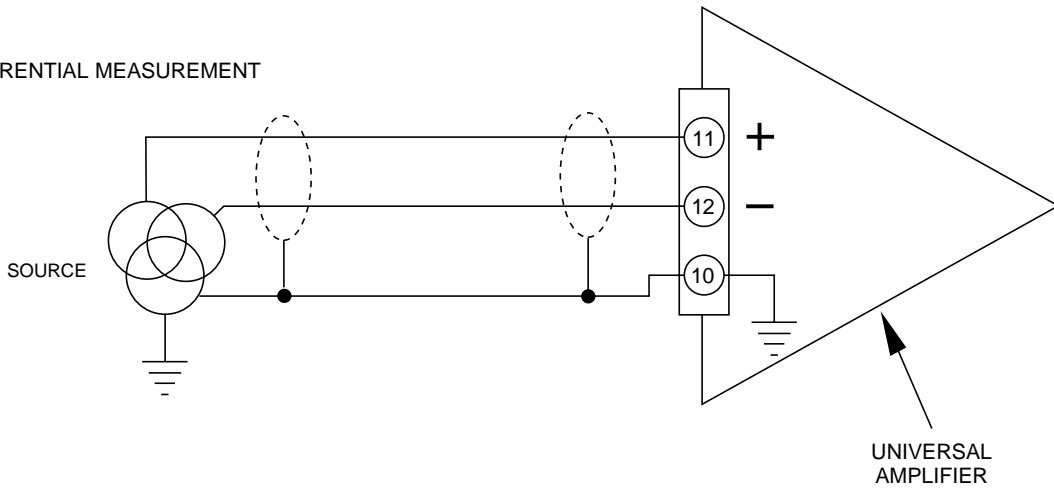
PIN	FUNCTION
1	NEC
2	NEC
3	NEC
4	NEC
5	NEC
6	(+) 15VDC
7	SHUNT CAL/(-) 15VDC
8	(-) EXC
9	(+) EXC
10	SHIELD
11	(+) SIG
12	(-) SIG

## 2.5 Isolated Preamplifier Installation

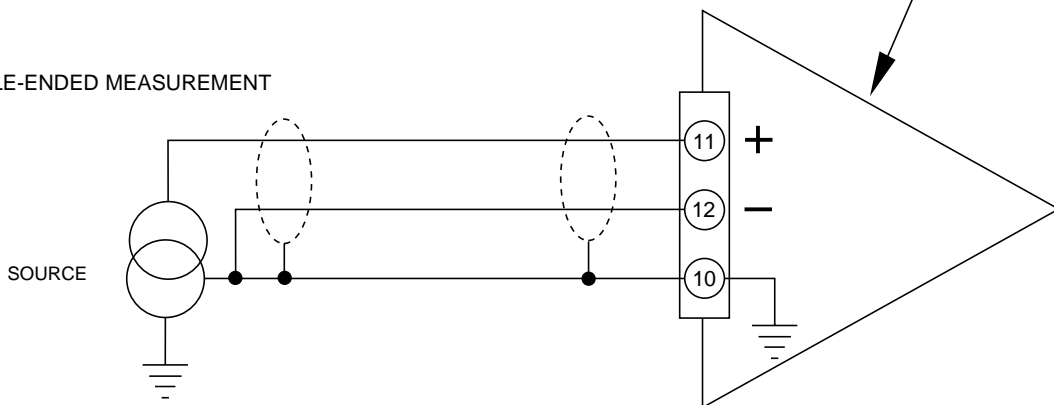
The Isolated Preamplifier (Model 11-5407-58) is a mobile unit which should be located as near the patient as possible without exceeding the interconnect cable length of fifteen (15) feet. The Deutsch connector on the Isolated Preamplifier cable is installed by aligning the blue line on the locking ring on the cable connector with the polarizing key on the amplifier connector (See Figure 2-1). Push the cable connector in until the locking ring snaps into place and/or the orange ring behind the locking ring on the connector shell becomes visible. Note the caution in Section 2.3 regarding the connector installation.

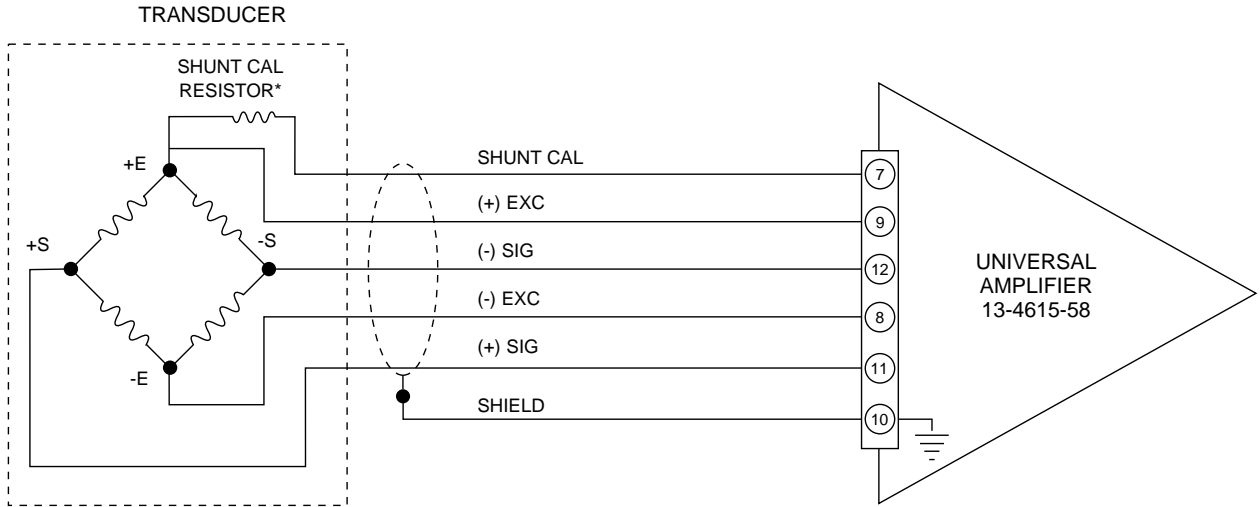
CARD EDGE PIN NO.	SPADE LUG TERMINALS	PUSH LUG TERMINALS	FUNCTION
1			PWR COM
2	9	1	REC OUT
3			(-) 15VDC
4			(+) 15VDC
5	8	3	SIG COM
6	6	13	NEC
7			NEC
8			NEC
A	12	6	NEC
B	11	5	MON OUT
C	10	7	REMOTE RESET
D	1	8	RESET COM
E	2	9	NEC
F	3	10	NEC
H	4	11	NEC
J	5	12	SCALED OUT

DIFFERENTIAL MEASUREMENT

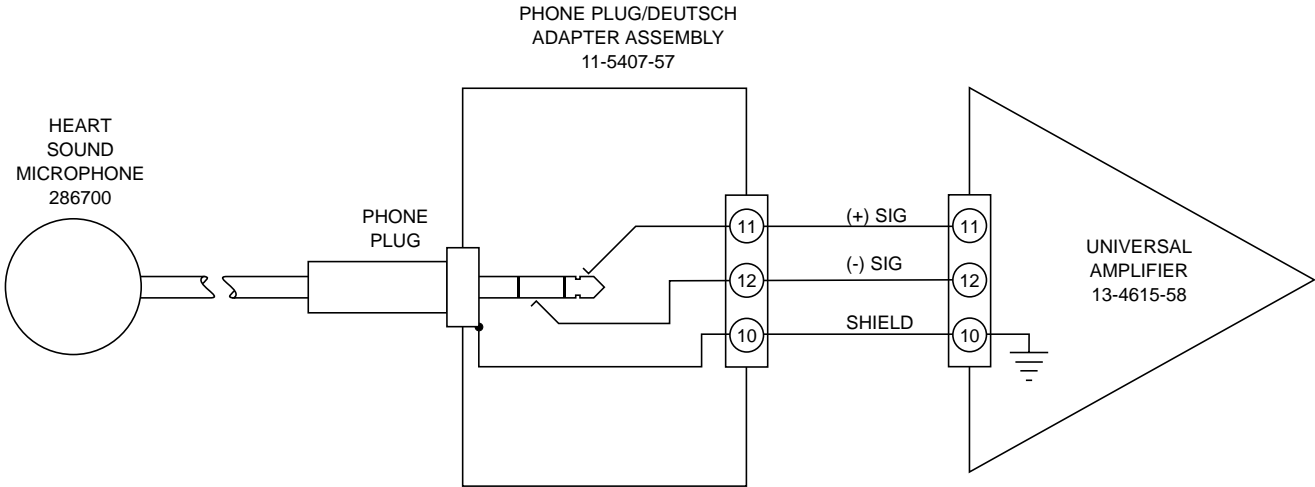


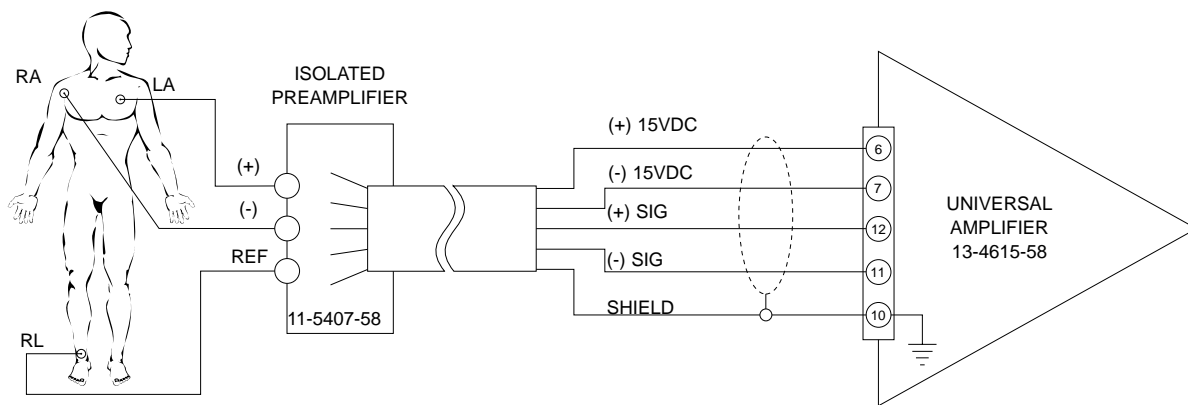
SINGLE-ENDED MEASUREMENT





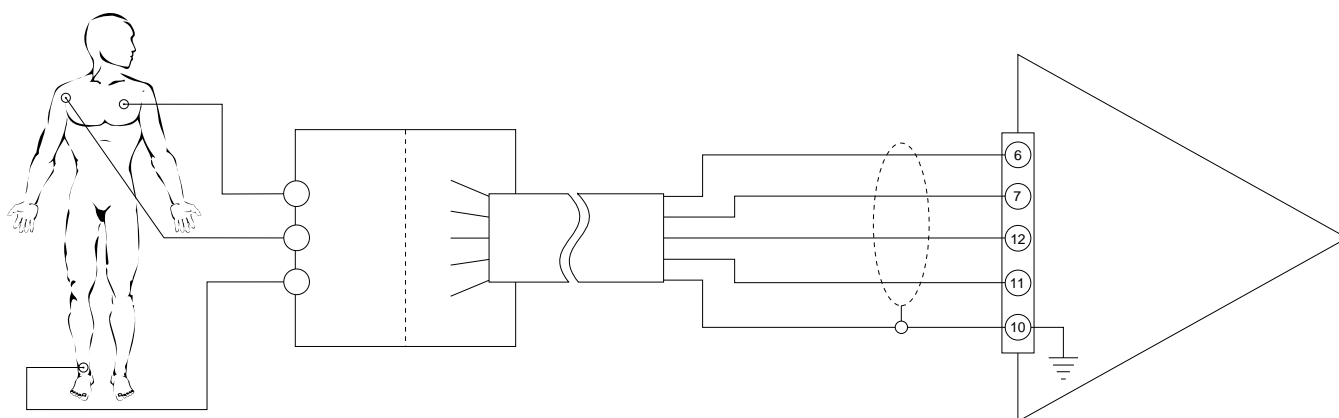
\*If a shunt calibration resistor is not installed within the transducer or its connector, install a jumper between pins 7 and 9 to allow installation of a shunt calibration resistor inside amplifier module.





## 2.6 Isolated Preamplifier Connections

Figure 2.5 demonstrates the method of connecting the Isolated Preamplifier inputs to a patient and outputs to a Universal Amplifier. Section 3.4.3 provide the instructions to insure the patient hookup is performed safely and properly.



## 2.7 Defibrillator Protector Installation

The Defibrillator Protector is designed for mounting directly to the Isolated Preamplifier. Proper installation is easily performed by following these steps:

1. Disconnect the Isolated Preamplifier interconnect cable from the Universal Amplifier.
2. Remove the front two cover screws from the Isolated Preamplifier
3. Insert the three output pins of the Defibrillator Protector into the input jacks of the Isolated Preamplifier
4. Align the mounting holes on the rear bracket of the Defibrillator Protector with the front two cover screw holes on the Isolated Preamplifier
5. Install the two screws to secure the Defibrillator Protector to the Isolated Preamplifier.

NOTE: These screws provide the ground connection for the Defibrillator Protector and must be installed.

## 2.8 Defibrillator Protector Connection

Installation of the input connections to the patient must be performed in accordance with Section 3.4.3. Figure 2.6 shows the input/output configuration using the Defibrillator Protector, Isolated Preamplifier, and the Universal Amplifier.

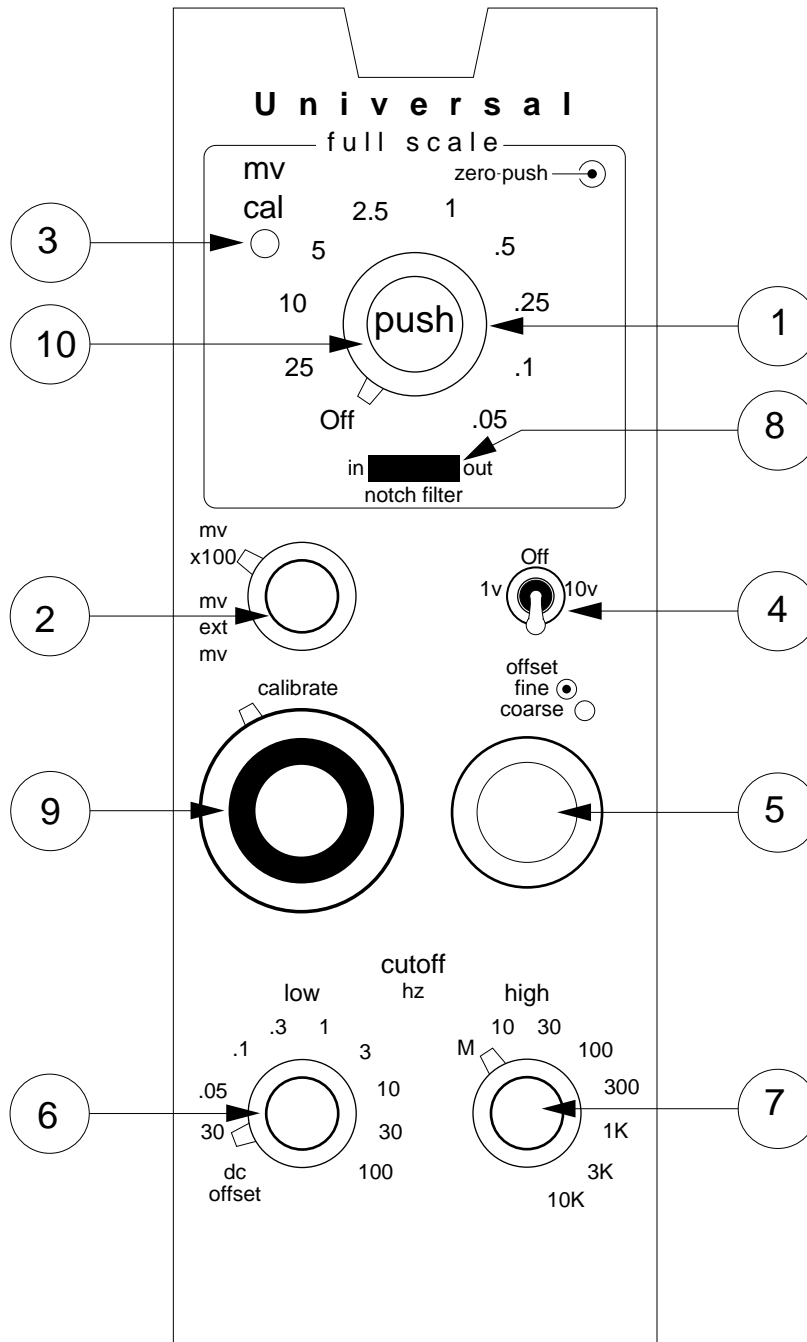


### 3.1 GENERAL

This section illustrates and describes the controls of the Universal Amplifier (Model 13-4615-58) and Isolated Preamplifier (Model 11-5407-58). Complete operating instructions are also provided.

### 3.2 UNIVERSAL AMPLIFIER FRONT PANEL CONTROLS

Item numbers listed below refer to circled numbers in Figure 3-.

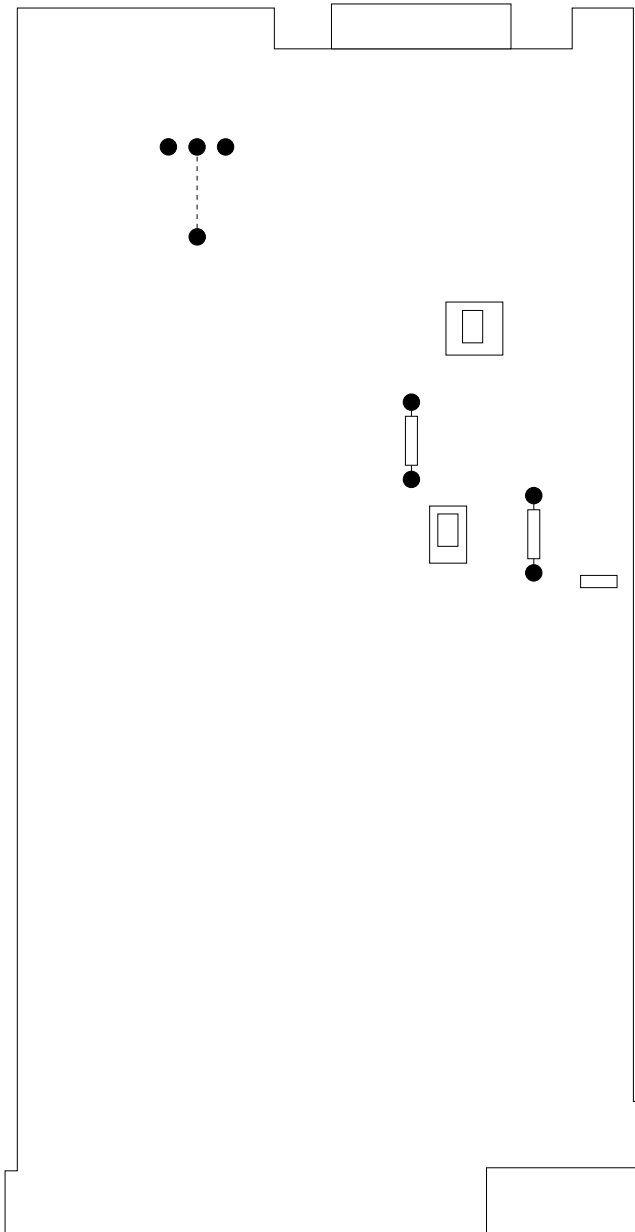


ITEM	CONTROL	DESCRIPTION
1	full scale	The step sensitivity control selects recorder and monitors full-scale outputs in millivolts and millivolts x100.
2	mvX100/mv/ext mv	The input signal encounters the internal 100 to 1 switch and then is multiplied by the "full scale" attenuator and the "calibrate" setting to obtain the overall sensitivity of the amplifier. Maximum measurement range is from 25 $\mu$ V to 10 V full scale. The "ext mv" position is used for operating with the optional Isolated Preamplifier.
3	mv bal	Amplifier DC zero shift balance control (see "zero-push").
4	cal (momentary)	The switch selects either DC or bridge transducer shunt calibration resistor (see Note 2). The "dc" position injects 1 mV or 100 mV 950 $\mu$ V or 5 mV, internally selectable) calibrate signal. The "dc" position also overload restores the amplifier, as well as defines the zero line when released.
5	offset (fine, coarse)	Concentric 10-turn controls for zero suppression or balancing bridge transducers (see "cutoff").
6-7	cutoff hz. (low, high)	The low and high switches select the bandpass of the amplifier for optimum signal characterization. The 'dc offset' position balances bridge transducer or provides zero suppression of unwanted DC signals. The "M" position limits the amplifier response to 0.08 Hz or 2.0 seconds time constant for mean pressure determination. (Time constant can be changed internally).
8	notch filter	The slide switch allows for 60 Hz noise rejection. The notch frequency can be adjusted internally for 60 or 50 Hz.
9	calibrate	A dial vernier sensitivity control that provides overlapping ranges with stepless adjustment from 0.5 to 10.5 times any setting of the "full scale" control (times "mvX100/mv/ext mv" switch). The dial vernier is also used for the calibration factor of strain gage transducers (See Note 1).
10	zero-push	This latching switch disconnects the signal source and shorts the amplifier inputs to ground. This allows for rapid determination of the amplifier zero balance when the low cutoff selector is in the "dc" position.
	NOTE 1	Example: A typical blood pressure transducer has a calibration factor of 50 $\mu$ V/V excitation /10 mmHg. Multiplying 50 $\mu$ V excitation times 5 volts times the full-scale load pressure of 100 mmHg equals 2.5 mv at 100 mmHG. Therefore, if you dial 2.5 on the "calibrate" control, select "mv" and set the "full scale" to the "1" position you will have 100mmHg full scale or 1 decimeter Hg full scale). A shorter method would be to divide the calibration factor by 20 and dial the number; for example: 50 - 20 = 2.5.
	NOTE 2	Harvard Statham Blood Pressure Transducers purchased from Harvard Recording Systems Division have shunt resistors installed equivalent to 100 mmHg (13.33 kilopascal).

### 3.3 UNIVERSAL AMPLIFIER USER CONTROLS

Item numbers listed below refer to Figure 3-2

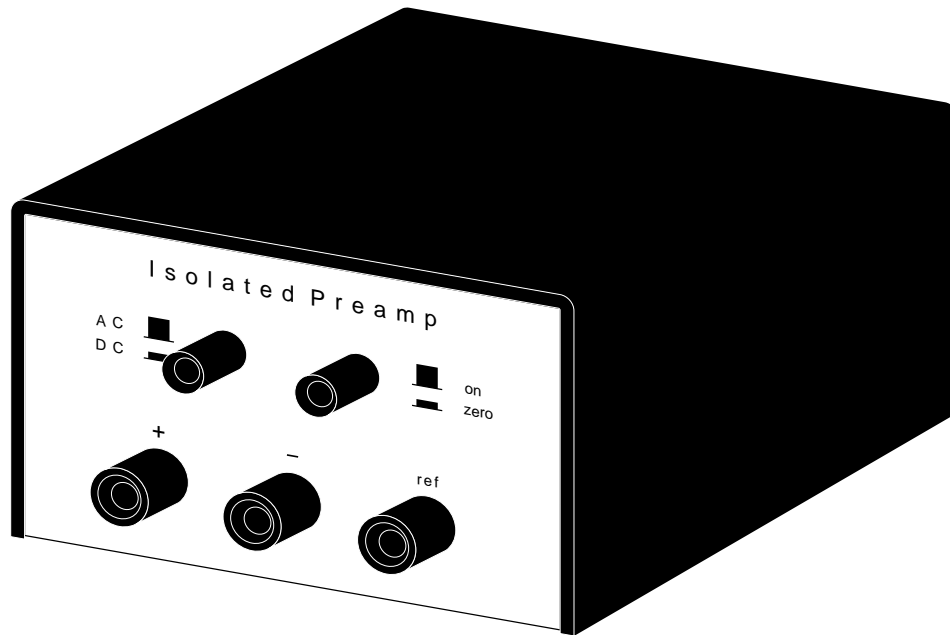
- |                |   |
|----------------|---|
| E1, E2, E3, E8 | Jacks for selecting (+) or (-) shunt calibration resistors. Jacks may be used to installed desired calibration resistor is none supplied. |
| E4, E5         | Jacks for setting excitation voltage to 5.0 V or 10.0 V   |
| E6, E7         | Jacks for setting mean output scale factor  |
| S-2            | Calibration Voltage selected at either 50 $\mu$ V or 1 mV   |
| S-3            | Excitation Polarity Select – normal or reverse  |
| J9             | Provides direct output with cable assy. CL-612311 between TP-F and J9. Provides mean output with shorting plug connector, 296520-1, on J9 |



### 3.4 ISOLATED PREAMPLIFIER FRONT PANEL CONTROLS

Item numbers listed below refer to circled numbers in Figure 3-3.

ITEM	CONTROL	DESCRIPTION
1	AC/DC	This latching pushbutton selects AC or DC coupling of the Isolated Preamplifier. AC response is from 0.016 Hz (-3 dB). Best common mode is achieved in "dc" position
2	zero/on	This latching pushbutton disconnects the input source signal and shorts the input to ground. In AC mode, an overload can be restored by placing the switch in "zero" position



### 3.5 DESIGN FEATURE

The 13-4615-58 Universal Amplifier is designed to be three amplifiers in one. It operates extraordinarily as a general all-purpose AC or DC Amplifier. It also accepts signals from pressure, force and strain gage displacement transducers directly in units of measure. When used with the addition of the 11-5407-58 Isolated Preamplifier, it is capable of measuring high frequency nerve potentials as well as DC coupled eye potentials, and nearly any other signal in the bioelectric field.

#### 3.5.1 GENERAL PURPOSE

As an example, assume a positive DC input of 1mv maximum is to be fed into the Universal Amplifier with the signal to be recorded on a chart recorder. The following setup procedures will prepare the system for operation:

1. Install the amplifier module and connect the input cable
2. Place "full scale" control to "off"
3. Adjust "calibrate" dial vernier to 1.0 reading
4. Select "dc" position on "low cutoff" switch
5. Start recorder and adjust trace for chart center
6. Set "mvX100/mv/ext mv" switch to "mv"
7. Depress the "zero-push" switch to "zero"
8. Place "full scale" control to "1"
9. Release "zero-push" switch from "zero"
10. Adjust trace to right chart edge
11. Set "mvX100/mv/ext mv" switch to "mvX100"
12. Input 1 mVDC signal and pen should move to left chart edge.

(Refer to Section 2.4 for interconnection information. Accessories to assist in making necessary circuit connections are listed in Section 1.3)

### 3.5.2. DC BRIDGE AMPLIFIER

When utilizing a DC Bridge or transducer input, the following steps will balance the system for proper operation:

1. Install the amplifier module and connect the input cable
2. Place "full scale" control to "off"
3. Adjust "calibrate" dial vernier to 1.0 reading
4. Select "dc" position on "low cutoff" switch
5. Put "high cutoff" switch in "1k" position
6. Start recorder and adjust trace for chart center
7. Set "mvX100/mv/ext mv" switch to "mv"
8. Depress "zero-push" switch to "zero"
9. Place "full scale" control to "1"
10. Adjust "mv bal" potentiometer to center trace
11. Select "10" position with "full scale" control
12. Release "zero-push" switch from "zero"
13. Place "low cutoff" switch to "dc offset" position
14. Using the "coarse offset" and "fine offset" controls, position the trace to chart center
15. While changing the "full scale" control to higher sensitivity positions, insure the tracing remains at chart center by adjusting the offset controls. Now the amplifier balance has been completed.

Four Transducers are sold through Harvard for the medical field:

P23ID Harvard-Statham Isolated Blood Pressure 369500-8916

P50 Harvard Statham Miniature Isolated Blood Pressure 369500-8904

UC2 Harvard Statham Bidirectional Isometric Force 369500-8640

Harvard Metripak Isotonic Muscle Transducer 793341-04042

## UL5 Microscale Accessory for the UC2 Transducer 369500-8621

(Other transducers that use a 5 VDC excitation voltage and have outputs 25  $\mu$ V full scale can be used)

### 3.5.3 WITH THE ISOLATED PREAMPLIFIER

#### A. Preliminary Set up

The following steps are used to balance the system prior to installing patient leads:

1. Install the Universal Amplifier and connect the Isolated Preamplifier interconnect cable. (If the Isolated Preamplifier will be concurrently used with stimulators, electrocauteries or defibrillators, insure a Defibrillator Protector is installed before the balancing procedure is performed.)

2. Set the Universal Amplifier switches to these positions:

full scale	off
calibrate	1.0
low cutoff	dc
high cutoff	1 k

3. Start recorder and adjust trace to chart center

4. Place "mvX100/mv/ext mv" to "mv"

5. Depress "zero-push" button to "zero"

6. Put "full scale" control to "10"

7. Adjust "mv bal" potentiometer to position trace at chart center

8. Release "zero/push"

9. Place "mvX100/mv/ext mv" to "ext mv"

10. Depress "zero-on" switch on Isolated Preamplifier to "zero"

11. Check to insure the trace is at chart center. If not adjust "mv bal" to center trace

12. Release "zero/on" switch to "on" position

13. Input 5 mVDC into the Isolated Preamplifier. The pen should deflect to the left or right side of the chart depending upon the signal polarity.

#### B. Patient Lead Connection

The following steps should be completed to protect against possible microshock hazards when placing patient leads.

1. Depress "zero/on" switch on the Isolated Preamplifier to "zero" position
2. Insure "mvX100/mv/ext mv" switch is in "ext mv"
3. Only after all leads and/or electrodes are connected should any attempt be made to monitor biophysical signals.
4. Release "zero/on" switch to "on" position
5. Before disconnecting or rearranging any leads or electrodes, depress the "zero/on" switch to "zero" position on Isolated Preamplifier

## SECTION IV

### DESCRIPTION OF OPERATION

#### 4.1 GENERAL

The Universal Amplifier (Model 13-4615-58) is a remarkable device because of the high input impedance, wide bandwidth, low noise and low drift capabilities. As evidence to its built-in versatility, the Universal Amplifier can be used for general purpose AC or DC signal conditioning, measurement of bioelectric phenomena, or strain gage transducer applications. This amplifier module can be combined with the Isolated Preamplifier (Model 11-5407-58) and Defibrillator Protector (Model 11-5407-59) to perform high quality ECG or EEG monitoring without experiencing signal loss and noise while still being protected against defibrillator damage.

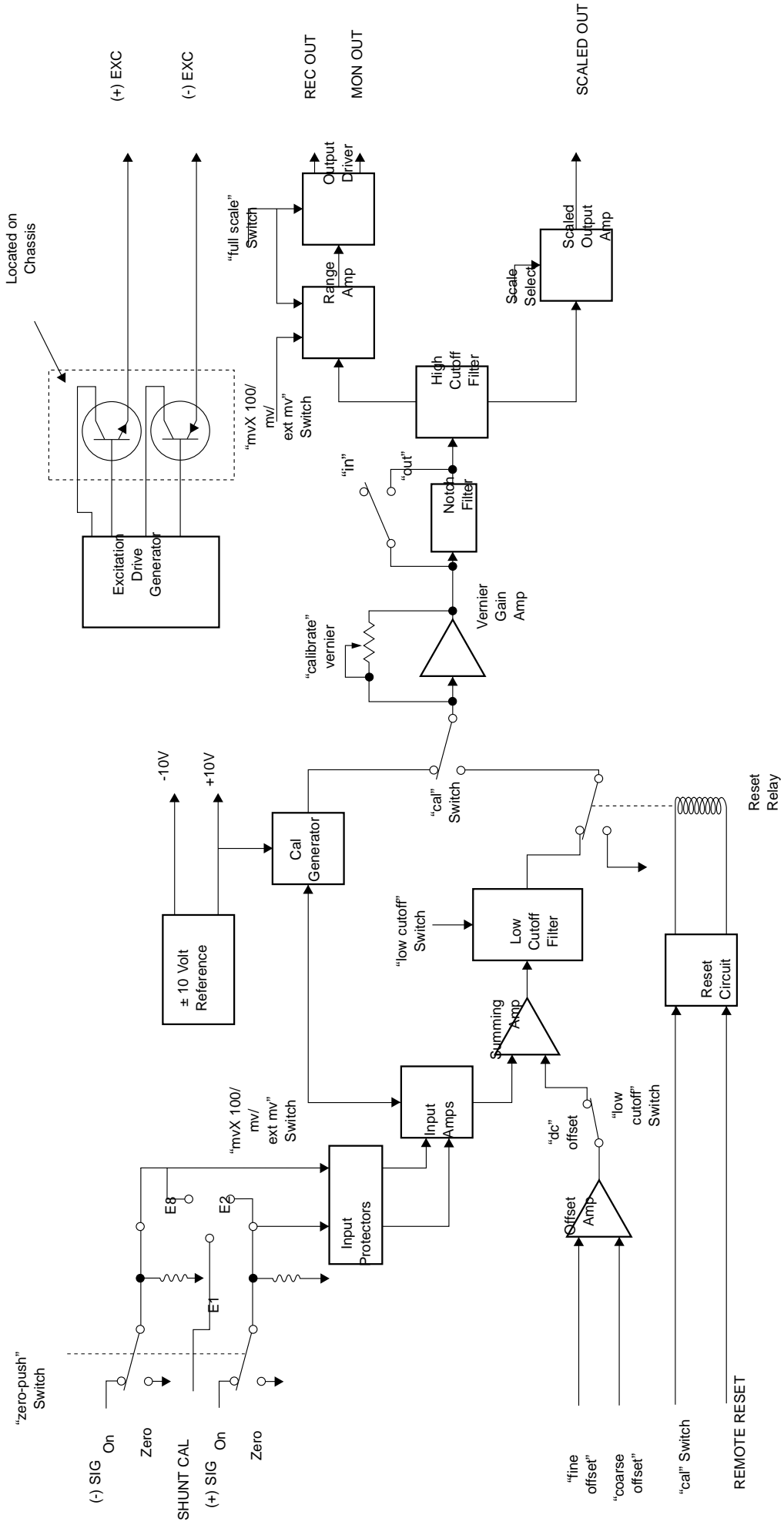
#### **4.2 UNIVERSAL AMPLIFIER (Model 13-4615-58)**

This discussion will follow a block diagram (Figure 4-1) and will cover not only the basic function of each block but also the unusual characteristics. Generally speaking, the direction of the presentation will proceed along the normal signal (data) path with ancillary blocks covered as their functions come into play.

##### 4.2.1 INPUT SIGNALS (SHUNT CAL.)

Normally the (+)SIG and (-)SIG input signals are routed through the "zero-push" switch to the input protectors. When the switch is depressed, the inputs to the amplifier are shorted to ground. These shorted inputs are very useful when the user is calibrating the unit or wanting to identify the reference or baseline.





The SHUNT CAL input signal is activated during a transducer application when the “cal” switch is held in the “shunt” position. A known value of resistance is connected across one arm of the transducer to provide a calibration voltage which offsets the amplifier’s output signal trace a prescribed amount.

Many medical transducers have a built-in shunt cal resistor and therefore a jumper must be installed between E1 and E2 for a positive calibration input or from E1 to E8 if a negative calibration is desired. (The jumper can be stored in E1 to E3 position if amplifier is not being used in a transducer application). When no shunt cal resistor is built into the transducer, I.e. strain gages, the Deutsch input connector can be jumpered between pins 7 and 9 to complete the SHUNT CAL signal path and a know value resistor is then installed between E1 and E2 for positive calibration or E1 to E8 for negative calibration.

The Value of such a shunt cal resistor can be calculated using the following formula:

$$R_{\text{shunt}} = \frac{1 \times 10^6}{4NF} - 0.5 R_o$$

- Where -
1. N = Desired calibration signal size
  2. F = Calibrator factor provides on the Transducer's certificate, i.e.,  $\mu\text{V}/\text{V}/\text{mmHg}$
  3.  $R_o$  = the output resistance of transducer as found on the transducer's certificate

Example:  
N = 10 cmHg  
F = 50 mV/V/cmHg  
 $R_o$  = 300 ohms

#### **4.2.2 INPUT PROTECTION**

The Universal Amplifier is equipped with protection circuitry which will limit the input signal to the input amplifiers. Back-to back diodes are placed on each input line to clip the signal level at  $\pm 15$  volts. This protection is capable of handling noise spikes or slight overvoltage signal but insufficient to prevent damage when a defibrillator is used. The maximum current specification for each of the diodes is 50 mA.

#### **4.2.3 INPUT AMPS**

The input amplifiers are basically voltage followers with a switch selectable gain possible. If the "mvX100/mv/ext mv" switch is in the "mvX100" or "ext mv" positions, the amplifiers have a unity gain. The selections of "mv" on the switch inserts R3 and R7 into the circuitry and provides a gain of approximately twenty through the input amplifiers.

The ability to balance the output of the positive and negative input amps is provided through R18 and R19. The "mvX100/mv/ext mv" switch selects the amount of common mode rejection to be inserted into the positive amplifier's output. When in "mv" position, R19 will supply proper compensation while R18 is active in "mvX100" and "ext mv". The common mode rejection (CMR) output is biased when the "low cutoff" switch is placed in "dc offset" selection.

#### **4.2.4 OFFSET AMPLIFIER**

The offset circuit is designed to reduce or eliminate a DC voltage component of an incoming signal. If the input signal varies between +5 mVDC and +10 mVDC, the area of interest does not include that below +5 mVDC. By interjecting a -5 mVDC offset, the area of interest can be expanded to give greater detail and a more useful output. The "fine offset" and "coarse offset" controls utilize the  $\pm 10$  VDC reference output to supply the offset amplifier with its input. The offset amp provides the desired signal correction through the CMR circuit when "dc offset" is selected on the "low cutoff" switch.

#### **4.2.5 SUMMING AMP**

The summing amplifier has the responsibility of combining the positive and negative input amplifier output signals. Although the negative input amplifier has no alteration made to its output, the positive input amplifier output will have common mode rejection correction inserted. This CMR signal can also be biased by the offset amplifier when "dc offset" mode is selected on the "low cutoff" switch.

#### **4.2.6 LOW CUTOFF FILTER**

The "low cutoff" switch controls the function and limits of the low cutoff filter. When "dc" or "dc offset" is selected the filter is disabled and the summing amp output is resistively coupled to the next stage. The remaining positions on the switch will provide capacitive coupling of the summing amp signal with -3 dB steps from .05 Hz and will establish the lower limit of the Universal Amplifier's bandpass.

#### **4.2.7 RESET CIRCUIT**

The output from the low cutoff filter passes through a set of contacts on the reset relay. The reset circuit which drives this relay can be activated two ways – by remote reset or by depressing "cal" switch to "dc".

The remote reset signal places a ground on the input of the reset circuit which turns on the relay drive transistor and charges a holding capacitor. Pulling in the relay causes the low cutoff filter output to open and the ground potential to be sent through the "cal" switch to the vernier gain amplifier. In this way, the amplifier can be reset and the zero baseline defined by a remote switch closure between card-edge pins C and D.

The second reset method is holding the "cal" switch in the "dc" position. The reset circuit will again be activated by turning on the relay drive transistor and charging the holding capacitor. In this reset mode,

the “cal” switch applies the cal generator output to the vernier gain amp. Upon release of the “cal” switch, the holding capacitor in the reset circuit keeps the reset relay energized for approximately 400 ms. Therefore, the output of the Universal Amplifier during a “dc” calibration sequence will be first at the cal level, followed by a 400 ms zero (ground) baseline, and then a return to a normal input-following signal.

#### **4.2.8 Cal Generator**

The cal generator utilizes the + 10 VDC reference voltage to produce a known calibration voltage. An internal switch, S2, permits selection of a 1 mV or 50 $\mu$ V output level. In addition two separate voltage divider networks are used to generate the outputs required for calibration when the “mvX100/mv/extmv” switch selects either “mv” or “mvX100” mode.

#### **4.2.9 VERNIER GAIN AMP**

The vernier gain amplifier is the only stage of the module which has the capability of the stepless front panel gain control. The “calibrate” vernier can vary the gain of the universal amplifier from 0.5 to 10.5 times the “full scale” setting. This adjustment also allows the operator to calibrate the system when used in a transducer application.

#### **4.2.10 NOTCH FILTER**

In some situations, a line frequency signal interferes with the true input and distorts the output beyond acceptance. The notch filter is designed to minimize this problem by filtering out the line frequency noise. The “notch filter” switch selects whether the filter circuit is used (“in”) or not (“out”). Internal potentiometer R50 adjusts the center of the notch filter to either a 50 Hz or 60 Hz line frequency.

**NOTE:** Universal Amplifiers that were built in early production lots used a 200 k $\Omega$  potentiometer for R50 and there was an insufficient range of adjustment for 50 Hz applications. The new 500 k $\Omega$  pot allows adjust for both 60 Hz and 50 Hz line frequencies.

#### **4.2.11 HIGH CUTOFF FILTER**

The rolloff frequency of the high cutoff filter is selected by the “high cutoff” switch and determines the upper limit of the Universal Amplifier bandpass response. The “M” switch position provides a mean or average output to the range amp and output driver. This “M” output is the same signal which is normally used by the scaled output amp.

#### **4.2.12 SCALED MEAN OUTPUT AMP**

The scaled mean output amplifier generates a continuous average output not affected by the “full scale” or “high cutoff” switches. The “M” output from the high cutoff filter is conditioned to produce a  $\pm 10$  VDC full scale output at card edge connector pin J. The gain of the scaled output amp is controlled by R79 (scale select resistor) which plugs into E6 and E7. The amplifier is shipped with a 5 k $\Omega$  resistor installed that give a scale factor of 10 but it can be replaced with other values to produce different full scale factors. The following formulas will aid in selecting the correct resistor value for a specific application:

#### **4.2.13 RANGE AMP.**

The range amplifier receives its signal input from the high cutoff filter and control inputs from the “mvX100/mv/ext mv” and “full scale” switches. The “mv” or “ext mv” selection boosts the amplifier gain five times while “mvX100” does not request an increase in gain. The “mv” position also, provided a gain of 20 in the input amp for a total of 100 times increase in sensitivity to this point while the “mvX100” selection has maintained unity gain throughout. An “ext mv” input received unity gain in the input amp and a five times increase in the range amp. To determine the overall system increase this far, the 20 times boost in the Isolated Preamplifier must be figured and this brings the total to 100 times.

#### **4.2.14 OUTPUT DRIVER**

The output drive supplies the REC OUT and MON OUT signals for hard copy printing. The signals from the range amp are received through an attenuator string which is switched by the “full scale” selections. This final stage then boosts the signal by a factor of 10 for sufficient output drive capabilities.

#### **4.2.15 EXCITATION DRIVE GENERATION**

The excitation drive generator utilizes the +10 VDC output of the  $\pm 10$  volt reference to derive the excitation voltage for transducer applications. The standard excitation output signal are  $\pm 2.5$ VDC with (+)EXC on card edge pin 9 and (-)EXC on pin 8. There is an internal switch (S3) which provides a method of reversing the two outputs. If the transducer being used requires a different excitation voltage, R89 should be removed by unplugging the present resistor from E4 and E5 (see Figure 3-2) and replaced with another value of resistance. The following formula will determine the necessary resistor in  $k\Omega$ .

### **4.3 ISOLATED PREAMPLIFIER (Model 11-5407-58)**

The purpose of the Harvard Isolated Preamplifier is to provide signal conditioning and amplification near the signal source. this reduces the problem of noise and cable capacity effects on very high impedance signal sources. The Isolated Preamplifier also provides electrical isolation between the signal source and the measurement equipment. The preamplifier is intended for use with and powered by the Harvard Universal Preamplifier.

#### **4.3.1 INPUT CIRCUIT**

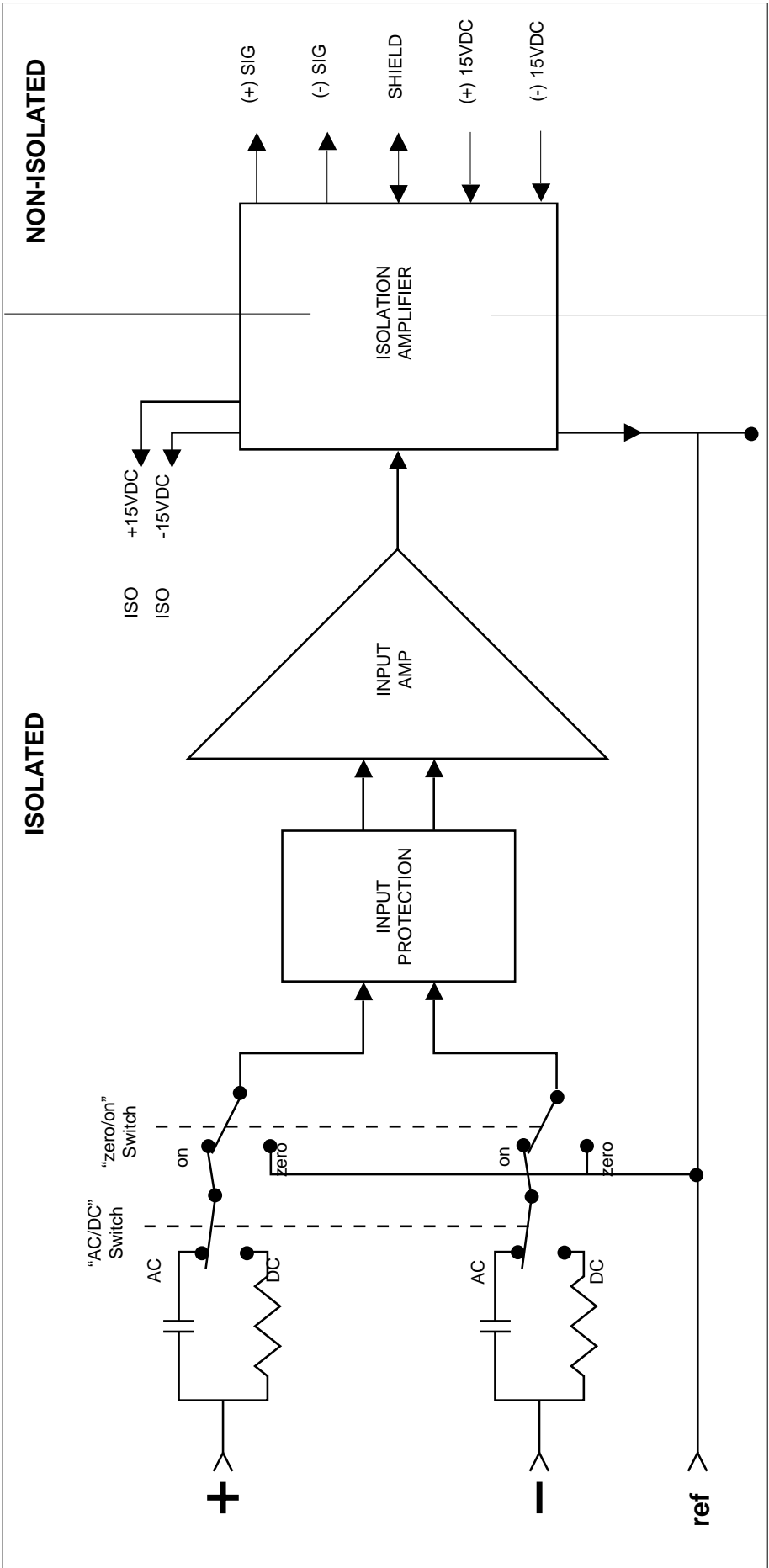
The input signals, (+) and (-), may be AC or DC coupled as selected on the AC/DC switch (see Figure 4-2). Once coupling is determined, the signals proceeds to the “zero/on” switch. When in the “zero” position (depressed), the input lines are opened and all three leads are shorted together to produce a zero base line. the “zero/on” switch should also be depressed during the connection of the input signal source (See Section 3.4.3B).

#### **4.3.2 INPUT PROTECTION**

Back-to-back diodes are connected to each of the signal input lines to provide protection against excessive inputs up to 40 volts RMS. Once a input signal surpasses 15 volts, the clipping diodes will be turned on and limit the signal strength.

#### **4.3.3 INPUT AMP**

The input amp consist of fully floating differential FET stages, a X20 gain amplifier for each signal and a summing amplifier. The FET circuits provide low noise while the gain amplifiers permit balancing of signals and adjustment of gain. After the signals are summed, the output of the input amp is sent to the isolation amplifier.



#### **4.3.4 ISOLATION AMPLIFIER**

The purpose of the isolation amplifier is to provide electrical isolation between the input and output of the Isolated Preamplifier. This is accomplished by modulating the input, passing it through a transformer and then demodulating the signal. This stage also isolates the (+) and (-) 15VDC and common lines coming from the Universal Amplifier for usage in the isolated portion of the preamplifier.

#### **4.4 DEFIBRILLATOR PROTECTOR (Model 11-5407-59)**

The Model 11-5407-59 Defibrillator Protector is designed specifically to protect the Model 11-5407-58 Isolated Preamplifier from defibrillator pulses with peak energy delivery up to 300 watt-sec.

The Defibrillator Protector reduces the high voltages in two stages. The first section consist of spark gaps which short out any voltages above 1000 volts. The second stage has clamping transzorbs which hold the maximum signal to 18.2 volts.