1.1 INTRODUCTION

The Harvard Model 13-4615-47, Temperature Amplifier, Figure 1-1, is designed to give very accurate temperature readings in fractions of a degree over an extremely wide range temperature, by using several different values of RTD's and Thermistor Probes.

This versatile amplifier is capable of handling four different basic RTD values of 100, 200, 500 and 1000Ω, by simply installing a jumper in the appropriate position. Contacts E-25 and E-26 are provided to extend the rang of RTD resistance values An internal switch is provided to adapt the amplifier to Thermistor operation.

A front panel switch is provided so that s specific temperature can be read in Farenheit as well as Celsius For ease of setup, the attenuator switch is presented in Degrees Full Scale, form 1000 Degrees to as little as 2 Degrees Full Scale. The sensitivity control permits stepless adjustment of from 1 to 2.5 times the Full Scale reading.

The amplifier would not be complete without the Degrees Suppression Switch. This switch allows you the extreme versatility that is promised. You are able to suppress 999 Degrees of temperature either plus or minus.

The Harvard Temperature amplifier is compatible with Harvard 200 and 2000 Series Direct Writing Recorders. It may be used independently or with other recording systems when installed in an optional portable or rack mounted case with a built-in power supply.

1.2 SPECIFICATIONS

Measurement Range	-240° to 1200°F, -150° to 650°C
Attenuator Steps	2, 5, 10, 25, 50, 100, 250, 500, 1000 degrees F.S. plus OFF
Attenuator Inaccuracy	±0.25% of calibrated step
Sensitivity Vernier minimum	Multiplies full scale sensitivity by a of 2.5 times
Input Configuration	Differential/Floating from case
Input Impedance	1 MΩ minimum for DC to 10 Hz

Common Mode Rejection (w/350Ω unbalanced)	DC greater than 140dB on most sens. range 60 Hz greater than 120 dB on most sens. range
Maximum Allowable Input Voltage without Damage	260 volts RMS across input signal terminals 500 volts DC or Peak AC from common to chassis

Zero Line Instability (After 15 minute warm-up)

With Time	±.05°C for 24 hrs
With Temperature	±.04 degrees/°C ambient change
With Line	±.2% of full scale for ±10% line voltage change

Gain Stability

With Time	±.05% of reading/24 hrs
With Temperature	±.03 of reading/°C
With Line	±.1% of reading for ±10% line voltage change

Output Voltage	±5V into 2 kΩ or greater in parallel with .02µ f or less
Output Impedance	< 5 Ω
Output Noise	< .2% of Full Scale P-P DC to 100 Hz on most sens. range, decreasing on less sensitive ranges
Non-Linearity	±.55°C or 1°F, or .2% whichever is greater over linearized range (for 100Ω RTD)
Frequency Response	3 dB down at 10 Hz ±20% (lower with plug-in capacitors not supplied)
Filter Roll-Off	18dB/octave or 60dB/decade
Digital Panel Meter Output	10mV/°F or °C-1000 degrees maximum

	100mV/°F or °C-100 degrees maximum
Calibrated Zero Suppression	Practical ration of suppression setting to attenuator setting 100:1, usable to 500:1
Range	0 to ±999 degrees
Resolution	1 degree F or C
Non-Linearity	±.2% at suppression reading ±.05°
Inaccuracy (at 25°C, nominal line)	±.2% at suppression reading ±.05°
Stability (After 15 minute warm-up)	
With Time	±.015% of suppression range/24 hrs
With Temperature	±.0125 of suppression range/°C
With Line	±.01% of suppression range for ±10% line voltage change
Noise	±.02% PTP from DC to 100Hz
Operating Temperature	0°C to 50°C (+32°F to +122°F)
Operating Humidity	95%
Storage Temperature	-40°C to +70°C (-40°F to +158°F)
Power Input	
Voltage DC	+ and -15Vdc at 100ma
Line/Load Regulation	±5%
Ripple	5 millivolts RMS maximum
RTD Current Excitation	
Steps	2ma at 100Ω, 0.4 ma at 500 Ω, 0.2 ma at 1000 Ω (all at 0°C)

Copper RTD Operation

Range	-75°C to +150°C
Linearity	Within ±2°C from -75°C to +150°C

Nickel RTD Operation

Range	-60° to +180°C
Linearity	Within ±2°C from -6°C to +180°C

Thermistor Probe Operation
(internal switch selectable)

Range	0° to 42°C
Linearity	Within ±.5°C from +4°C to 40°C, within 1°C from 0°C to 42°C
Excitation	Approximately 765 millivolts DC, supplied internally

1.3 SUPPLIES AND ACCESSORIES

Parts Supplied with the Preamplifier

Input Connector (Male)

Plug-in Resistors:

R-42 4.5 KΩ	R1-288308-45000
R-46 100 KΩ	R1-288308-10002
R-50 225 KΩ	R1-288308-22502

Optional Accessories

Extender Card and Cable Assembly	887291

Connector Adapter – Adapt Phone Plug for YSI Thermistors	11-5407-54
Recalibrating Kit Assembly (see Paragraph 2.7.3)	696167

SECTION 11
INSTALLATION

2.1 GENERAL

This section describes the checks and inspections that should be made upon receiving the Harvard Temperature Amplifier, Model 13-4615-47 with a Temperature Amplifier, Model 13-4615-47 with a 2000 series unit. It covers installation procedures, signal input connections, and outline dimensions.

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 INSTALLATION

Preamplifier Model 13-4615-47 may be mounted in Harvard 2000 Recorder frames, Harvard portable case or rack mounted separately in a Harvard rack adapter kit.

1. Insertion

To install the preamplifier into its appropriate slot:

a. Slide the preamplifier into the enclosure until the rear output card edge connector is engaged. See Figure 2-1, REAR VIEW.

b. Tighten the rear retaining screw until the preamplifier front panel is flush with the edge of the enclosure. DO NOT OVERTIGHTEN. This locks the preamplifier into the enclosure.

c. Connect the 7 pin plastic input signal connector and secure it by turning the threaded plastic locking ring clockwise.

2. Removal

a. Disconnect the input connections with a counterclockwise turn to the connector and pull.

b. Loosen the rear retaining screw . The preamplifier will move forward about 1/8 of an inch.

c. Carefully slide the entire preamplifier out of the Harvard 2000 enclosure.

2.4 INPUT CONNECTIONS

Figure 2-2 shows the pin connections located at the rear of the Temperature Amplifier. For the convenience of the user, a mating guarded, multi-pin connector (Harvard Model 11-5407-50) is supplied.

For YSI Thermistor Probes use the Harvard Model 11-5407-54 connector.

2.6 PRELIMINARY SET-UP (PLATINUM)

a. Set switch S-2 (see Figure 3-2) to RTD mode. Make sure R-42 and R-46 (see Figure 2-6) are inserted into E9 + E10 and E11 + E12 respectively. A jumper must be installed into E7 + E8 for 100Ω RTD operation. For other probe resistances see Table 2-1. Jumper for E23- + E24 must be installed.

b. The probe should be hooked to the preamplifier as described in paragraph 2.4.

2.7 TYPICAL WIRING DIAGRAMS

The following diagrams typify the ease of wiring the Probes to the preamplifier. The pin numbers correspond to circled pin connections identified on Figure 2-2.

2.7.1 RTD Probes

After wiring per Figure 2-4 use the preliminary set-up procedure given in paragraph 2.6.a. These instructions and Table 2-2 should answer questions on the hookup and preliminary operation in the RTD mode.

2.7.2 Thermistor Probes

The amplifier is set up properly when S2 is in the Thermistor Mode, and R-42 and R-46 have been removed from their operating position and stored (see Figure 2-6). This amplifier has been calibrated at the factory for use with YSI 400 Thermistors so no adjustment should be necessary for proper operation. The YSI 400 Thermistor Probes (Harvard part numbers 369500-18010 thru 18026) are to be used with our connector Adapter 11-5407-47. For a fast test of your probe and amplifier operation you can try the following:

- Set-up the amplifier as in the preceding paragraph
- Degrees Suppression to 000
- F-C Switch C
- Place probe tip in Ice Water (distilled) 0°C
- Oscillograph to Zero Center with Degrees Full Scale at 0
- Degrees Full Scale to 2
- Adjust R-8, if necessary, to center of chart

For any further adjustment, refer to the section on Calibration.

2.7.3 Recalibration Kit Assembly

In order to operate this amplifier with other than Platinum Probes, some other resistors are necessary, as described in Table 2-2. By ordering part number 696167 (Kit Assembly) you will receive the following resistors and two jumper leads, all packaged together.

Symbol	Part	Description
	696167	Kit Assembly
R-42	R1-288308-965RO	Resistor, 965Ω
R-42	50-281851-67000	Resistor, 6.7 KΩ
R-46	50-281851-10402	Resistor, 104 KΩ

R-46	50-281851-11802	Resistor, 118 KΩ
R-103	50-281851-13001	Resistor, 13 KΩ
R-103	50-281851-665R0	Resistor, 665Ω
	267235	Jumper (2 in kit)

2.7.4 Recalibration

Copper 10 Ω RTD	Rtd Simulator Value Ω	Hi	Lo	Adjust	Voltage Reading	Tol ±mV
(See Table 2-2 Copper 10)	10	1	2	R1	50 mV	1
		4	3	R9	1.870 V	5
		5	3	R10	0 V	2
(Simulate 93.33 Deg. C)	13.93	5	3	R9	-.746 V	2
(Simulate 0 Deg. C)	10	5	3	R10	0 V	2

(Repeat last two steps until no further adjustment is necessary)

Copper 100 Ω RTD	Rtd Simulator Value Ω	Hi	Lo	Adjust	Voltage Reading	Tol ±mV
(See Table 2-2 Copper 100)	100	1	2	R1	50 mV	1
		4	3	R9	1.870 V	5
		5	3	R10	0 V	2
(Simulate 93.33 Deg. C)	139.3	5	3	R9	-.746 V	2
(Simulate 0 Deg. C)	100	5	3	R10	0 V	2

(Repeat last two steps until no further adjustment is necessary)

Rtd Simulator	Voltage	Tol

Copper 100 Ω RTD	Value Ω	Hi	Lo	Adjust	Reading	±mV

(See Table 2-2 Nickel 120) NOTE: Do not touch R4 (if it was tampered with see speci note.)

Turn R12 to full CW position (Amplifier OFF)	Ohmmeter	6	5	R11	Adjust to 22 kΩ ±1K	

SPECIAL NOTE: To adjust R4 remove jumper E27-28.

	120	1	2	R4	-240 mV	1

Re-install jumper at E27-28.

(Simulate 0 Deg. C)	120	5	3	R10	0 V	2
(Simulate 93.33 Deg. C)	200.14	5	3	R9	-.8 V	2
(Simulate 0 Deg. C)	280.82	5	3	R10	644 V	5

(Repeat steps in order until no further adjustment is necessary)

See Appendix A for Temperature-Resistance Tables covering Platinum, Nickel and Copper RTD probes.

Table 2-1
Jumper Placement

RTD Probes Platinum Type 385

Probe Resistance	Jumper
100 Ω	E7 + E8
200 Ω	E5 + E6
500 Ω	E3 + E4
1000 Ω	E1 + E2

TABLE 3-2
RESISTOR TABLE

RTD	PLUG-IN RESISTORS

Resistor	Place	Platinum	Nickel 120	Copper 10	Copper 100
R-42	E9 + E10	4.5 KΩ	6.7 KΩ	965 Ω	965 Ω
R-46	E11 + E12	98 KΩ	118 KΩ	104 KΩ	104 KΩ
R-50	E13 + E14	225 KΩ	Jumper	—	—
R-103	E25 + E26	—	—	665 Ω	13 KΩ
Short	E27 + E28	—	Jumper	—	—
Short	E23 + E24	Jumper	—	—	—
	E7 + E8	"See	Jumper	—	—
	E5 + E6	Table 2-1	—	—	—
	E3 + E4	for jumper	—	—	—
	E1 + E2	placement	—	Jumper	Jumper

Section III
OPERATION

3.1 GENERAL

This section illustrates and describes the controls of the Temperature Amplifier, Mo 13-4615-47, and provides complete operating instructions.

3.2 FRONT PANEL CONTROLS

Item numbers listed below refer to circled numbers in Figure 3-1.

Item	Control	Description
1	Attenuator	Selects full scale sensitivity.
2	F/C	Toggle switch, selects either °F or °C
3	Degrees Offset	Selects polarity of offset and steps 0 through 999 degrees in one degree steps. Thumbwheel switch.
4	Sensitivity	Single turn potentiometer with locking knob. Multiplies full scale sensitivity by a minimum of 2.
5	DPM Zero	Spring return toggle switch. Zeroes out the Digital Panel Meter.

3.3 INTERNAL CONTROLS

Item numbers listed below refer to numbers in Figure 3-2.

Item	Control	Description
R 1	RTD 1000	Sets current for 1000 Ω RTD probes
R 2	RTD 500	Sets current for 500 Ω RTD probes
R 3	RTD 200	Sets current for 200 Ω RTD probes
R 4	RTD 100	Sets current for 100 Ω RTD probes
R 5	4 Volt Reference	Sets 4.000 volts reference across TP-16 and TP-17
R 6	-10 Volt Reference	Sets -10 volt reference voltage
R 7	Therm. Excitation	Sets excitation voltage for thermistor
R 8	Zero-Thermistor	Sets bridge zero for thermistor operation
R9	Gain	Sets gain of input stage for RTD operation
R10	Zero-RTD	Sets zero for RTD operation

Item	Control	Description
R 11	Mid-Range	Used to adjust mid-range equalization for RTD operation
R 12	Hi End	Used to adjust high end equalization for RTD opera
R 13	F-Offset	Used to feed in the equivalent of +32 degrees durin the conversion of degrees C to degrees F
R 14	U2 Offset	Removes offset voltage from U2
R 15	U3 Offset	Removes offset voltage from U3
R 16	U5 Gain	Sets gain of output stage U5

R 17	U6 Offset	Removes offset voltage from U6
R 18	10 volt reference	Sets 10.000 volt reference voltage
S 2	RTD-Therm operation	Used to convert from RTD to Thermistor Probe
S 3	10mV-100mV	Used to select DPM output at 10mV/Degrees or 100mV/Degrees

3.4 PRELIMINARY OPERATION (RTD)

1. Set Deg. F.S. to OFF

2. Sensitivity to X1 Detent

3. F-C Switch to C

4. Degrees Suppression 000

5. Internal Controls:

a. RTD-Therm to RTD
b. Jumper across E7-E8 for 100 Ω RTD

3.5 OPERATION (RTD)

1. Install preamplifier

2. Hook-up test resistor (100 Ω ±.1%) or 100Ω RTD as shown in Figure 3-3. If you use an RTD put it in ice water

3. Turn on recorder

4. Adjust pen position to the right edge of the chart

5. Turn Deg. Full Scale to 100. Pen should remain on the right edge

6. Change input resistor to 138.5 Ω ±.1% (100°). Pen will move to left chart edge. Remove the probe from the ice water and let it hang in the room (assuming 68°F 20° room temperature). The pen should deflect 20 divisions to the left.

7. Change the F-C Switch to F

a. Using the resistor 100 Ω at the input = 32* lines deflection to the left (32° F)

With 114.67 Ω at input = 100 lines deflection to the left (100°F)

b. Using a 100 Ω RTD Probe in ice water = 32 lines deflection to the left (32°F)

With RTD Probe hanging in air = 68 lines deflection to the left (68°F)

*Assuming 100 lines/channel (divide by 2 for 50 lines/channel)

3.6 ZERO SUPPRESSION

After completion of paragraph 3.5 you can test the Zero Suppression by dialing in a negative temperature equivalent to the temperature that is then being recorded. Example: If you are recording 68° you would dial -68. The pen would then deflect t or the right edge. The recorder would then display 68 (attenuator setting +68).

3.7 PRELIMINARY OPERATION (THERMISTOR)

1. Set Deg. F.S. to OFF

2. Sensitivity to X1 Detent

3. F-C to C

4. Degrees Suppression 000

5. Internal Controls:

a. RTD-Therm Switch to Therm.

b. Remove R46 between E11-E12

c. Remove R42 between E9-E10

3.8 OPERATION (THERMISTOR)

1. Install preamplifier

2. Hook-up Thermistor Probe and put it in ice water as in Figure 3.4

3. Turn on recorder

4. Adjust the pen position to the right chart edge

5. Turn Degrees F.S. to 25. Pen should remain on right edge.

6. Remove Probe. Let it hang in air assuming 68°F (20°C). Pen should swing 80 *lin
to the left

7. Change the F-C switch to F and the Degrees F.S. switch to 100. With the Probe in water the deflection to the left should be 32* lines. With the Probe hanging in air (6 approximate deflection should be 68* lines.

*Assuming 100 lines/channel (divide by 2 for 50 lines/channel)

4.1 GENERAL

The Temperature preamplifier, 13-4615-47, is an amplifier primarily designed to g temperature readings to the fraction of a degree celsius utilizing as a transducer, a platinum type 385 RTD (Resistance Temperature Device) when wired to a "2000" Se Recorder or related equipment. The preamplifier will also accept other RTD Probes as "Platinum 392", copper, or nickel, or by internal switch, except Thermistors such the "YSI 400".

4.2 THE RTD

Platinum RTDs have highly stable characteristics and are outstandingly reproducible Their resistance is a function of temperature. However, the relationship of resistanc temperature is non-linear and necessitates careful design or linearization circuitry.

An RTD in its simplest form could be as follows:

It would be necessary to read the ohmmeter value and then refer to a chart to perc the correct temperature. The current flow through the RTD must be kept low to pr self-heating. Small deviations would be limited by the resolution of the meter.

We are capable of, in this RTD Temperature Amplifier, simplified reading of temper and extended resolution to 2 degrees (°F or °C) Full Scale, as seen by using our chart recorder as an indicating device.

This high resolution can be obtained up to 998 degrees plus or minus by using the Degrees OFF-SET switch. It can handle temperatures from -150° to 650° Centigrade (-238° to 1200° Fahrenheit). (See Figure 4-1, Block Diagram on Page 4.2).

The RTD is connected in a 4 wire configuration. In this way the length of the connec wires do not effect the accuracy, and the voltage developed across the RTD (by the v controlled current limiter) is fed directly into a high impedance instrument amplifie

4.3 BASIC INPUT CIRCUITRY (FIGURE 4-2)

The key feature of this circuitry is the Lin. A and Lin. B feedback components. Lin. A the main linearization path. Lin. B works only at the extremely high range when the associated diode barely comes into conduction. At high temperatures, Lin. A, and perhaps Lin. B, cause an increase in negative current that goes to the summing input the top amplifier. This causes an increase in the output of the top amplifier, which causes a corresponding increase in the current through the RTD resulting in Lineariz at the output.

Since the gain is less than 1, and the feedback positive, no oscillation occurs.

There is now, at TP-5, an output of -8mV/degree Celsius that represents the temperature of the RTD, linearized to better than .5 degrees throughout the desired range. Four basic ranges of RTD can be accommodated by simply switching in the p jumper. Small variations can be adjusted, ±5%, by the four single turn pots.

4.4 DEGREE CENTIGRADE TO DEGREE FAHRENHEIT CONVERTER (FIGURE 4-3)

At the flip of a switch you can convert from Centigrade to Fahrenheit. An operation amplifier converts the formula, Deg. Far. =9/5 Deg. Cent. +32, for this accomplishmen

Thirty-two (32) Degrees is injected in the circuit, at R-13, at the rate of 8 mV/degre The output, therefore, is equal to 32 x 8 = 256 mV = 32°F.

The output of the °C to °F Converter stage goes two ways. One is to a non-inverting that has a gain o 1.25 (10mV/°) or 12.5 (100mV/°). The output of this stage is used drive external panel meters or other devices at 10 or 100 mV/°. The second path is used to supply 8 mV/degree to the summing point of the suppression amplifier.

4.5 SUPPRESSION AMPLIFIER (FIGURE 4-4)

Twelve binary weighted resistors coupled with three decade Thumbwheel switches introduce a plus or minus offset in one degree steps from one to 999. The output of

stage is at -8 mV/degree. The output of this stage goes to the sensitivity control, th
the attenuator, which has 2° to 1000° Full Scale settings plus OFF.

4.6 OUTPUT STAGE (FIGURE 4-5)

The attenuator drives an Intersil IC L7650CPD Op-Amp. This device was chosen for excellent specifications as to offset voltage and temperature drift. Its output swing somewhat limited because of its ±8 volt supply.

Latch-up was a major problem. If the input voltage is allowed to increase over the supply voltage on either of its inputs – latch-up would occur. To take care of latch-u 20 KΩ resistor was installed in the input line. This limits the current to less than 1 thus preventing the latch-up.

We need a gain of 312.5 in this output segment. Because the Intersil Amp has limit output we lowered its gain to 156.75. At the same time adding a 741 IC to be used output amplifier with a gain of approximately 2. R-16 was provided so that the exa gain can be set.

NOTE: Most internal manipulations are handled at 8mV/degree. This level allows fo linear operation up to 1200°F which is 8 mV/° x 1200 or 9.6 Volts. This is well witl the range of op-amps using ±15 volt supplies.

The RTD Amplifier has a high frequency response that is down 3 dB at 10 Hz ±20%. Additional filtering to lower the upper limit even more can be had by plug-in capac (not supplied).

4.7 THERMISTOR OPERATION

An internal switch, RTD-Therm, is provided to convert from RTD to Thermistor oper using YSI Type 400 Thermistor Probes. For this mode the RTD-Therm Switch sets u bridge at the input. R-42 (input stage gain) and R-46 (input stage zero) are unplugg The Bridge Circuit is as follows: (See Figure 4-6)

Resistor R8 is used to adjust the low end of the desired range, and the voltage feedi the bridge is adjusted so that TP-5 output is 8 mV/°C. From this point the output is handled in the normal way as with RTDs.

SECTION V
CALIBRATION AND MAINTENANCE

5.1 MAINTENANCE

a. General

Maintenance on the preamplifier is limited to cleaning only.

CAUTION:

1. Before attempting to clean preamplifier, turn OFF power and remove from enclo

2. Avoid use of chemical cleaning agents which might damage plastic or printed surfaces. Do not use chemicals which contain toluene, Cellusolve, acetone or similar solvents.

EXTERIOR

Remove loose dust with a soft cloth or small paint brush. dirt which remains can be removed with a soft cloth dampened in a mild detergent and water solution. DO NO USE ABRASIVE CLEANERS.

INTERIOR

Dust in the interior should be removed occasionally due to its electrical conductivity under high humidity conditions. Blow off accumulated dust with dry low pressure a Remove any dirt which remains with a soft paint brush or a soft cloth dampened in mild detergent and water solution. A cotton-tipped applicator is useful for cleaning narrow spaces and/or printed circuit boards.

5.2 CALIBRATION

5.2.1 General

The Harvard Temperature Amplifier Model 13-4615-47 has been accurately calibra before shipment from the factory and should give long troublefree service. Should recalibration be required, it should be performed by qualified technical personnel o

CAUTION: CALIBRATION SHOULD NOT BE ATTEMPTED UNLESS SUITABLE, SPECIFIED TEST EQUIPMENT IS USED. SINCE SPECIAL, HIGH PRECISION EQUIPMENT IS REQUIRE IT IS RECOMMENDED THAT THIS MODEL BE RETURNED TO THE FACTORY FOR RECALIBRATION.

Note: Under normal conditions, complete calibration should be performed every 6 months. After repair of the unit or some other change in the electronics, it is neces only to recalibrate those circuits affected by the change.

5.2.2 Equipment Required

The following is a list of test equipment necessary for calibration.

a. Chart Recorder, Harvard 2000 Series

b. Oscilloscope, general purpose with filter cut-offs

c. D.C. Source, Digitec, Model 3110 or equivalent

d. D.C. Source, 500V (for over voltage checking)

e. A.C. Source, Wavetek, Model 142 or equivalent

f. A.C. Source 260V (Isolated)

g. DVM, Keithley 172 or equivalent

h. General Resistance RTD 100 Simulator

i. Decade Resistance Box DB-62 or equivalent

5.2.3 Preliminary Procedure

a. Set Front Panel controls as follows:

DEG FULL SCALE	OFF
°F-°C SWITCH	°C
SENSITIVITY	Detent (x1)

b. Set internal controls as follows:

Remove shorting plug from E23 and E24

Make sure shorting plug is on E7 and E8

Set RTD-Therm Switch to RTD

c. Connect the Amplifier to a 2000 Series Recorder or appropriate power source

d. Use a 2 KΩ resistor across the output when the preamplifier is not connected witl Harvard Recorder.

e. Use a 100 Ω precision resistor across the input. See Figure 5-1 for a reference.

f. Power ON – Warm-up approximately 10 minutes

5.2.4 Preliminary Adjustments and Checks

Follow the steps of Table 5-1, in order, after completing the following preliminary s up.

Step	Description	Test Points Hi	Lo	Output Volts	Tol±	Resistan Adj.
1		123	0.0	10mV		None
2		143	10.0	1mV	R-18	
		153	-10.0	1mV	R-6	
3		1617		4.01 mV		R-5
4		1	2	.200	.05mV	R-4
	Remove jumper E7 + E8, install at	1	2	.100	.1mV	R-3
	Remove jumper E5 + E6, install at	1	2			
	Remove jumper E3 + E4, install at					
	Remove jumper E1 + E2, install at					
5		4	3			
6						
7						

5.2.5 Main RTD Calibration

Step	Description	Test Points Hi	Lo	Output VoltsTol±	Resista Adj.

5.3 INSPECTION CHECKS

5.3.1 Hi-Pot

1. Make sure R-42 and R-46 are in place.
   RTD jumper at E7+E8. RTD-Therm Switch to RTD.
   Jumper at E23+E24 in place.
   Power on. 5 minute warm-up.

2. Input 260 VRMS 60 Hz through isolation transformer to pins 1 and 2 for 30 seco
   Remove.

3. Input 500 VDC between pin 5 and case for 30 seconds.

4. A current flow of over 10 mA on either set-up indicates a balance.

   WARNING: HI VOLTAGE CAN KILL!

5.3.2 Common Mode Rejection

1. Use Figure 3 for proper set-up.
   Input 100 Ω.

2. Full Scale switch to 2°
   F°-C° switch to C°
   Thumbwheel to +000
   Sensitivity full CW.
   Short out 350 Ω resistor going to input pin 1.

3. Attach oscilloscope 2 (hi) 5 (lo) (Scope Cut-off 100 Hz) to Output (Card Edge).

4. Input 30 V p-p 60 Hz Frame (Lo) 5 (Hi).
   Oscilloscope should read < 90 mV p-p.

5. Short out 350 Ω resistor going to input pin 2 and open switch to pin 1.
   Output reading should be the same as in step 4.

6. Remove Generator and oscilloscope. Substitute DVM in place of Scope.
   Attach a 400 VDC supply in place of the oscillator. Frame (-) pin 5 (+).
   Use a 10 mA fuse for protection.
   Disregard initial voltage shift when first turned on.
   New reading should not vary more than 125 mV from initial reading.

7. Repeat step 6 shorting resistor in leg with pin 2 and opening the one with pin1.
   Remove voltage.
   Short both 350 Ω resistors.

5.3.3 RTD Zero

Set RTD box to 100.000 Ω (0°C).
Full Scale Switch to OFF, Output 0.0V ±10 mV.
Full Scale Switch to 100, Output O.OV ±15 mV.
Full Scale Switch to 2, Output O.OV ±1V.

5.3.4 Degrees Suppression Linearity and Accuracy

Monitor with DVM. TP-3 (Lo), TP-9 (Hi).
Set thumbwheel switch to +000.
Use Figure 5-1 for input. Adjust “R” standard for least error.
Follow the Table.

Thumbwheel Deg. Offset	DVM Reading (E = Error)	(±) Tolerance (mV) (Adjust)
+000	Error Reading	—
+001	8 mV + E	.416
+002	16 mV + E	.432
+003	24 mV + E	.448
+004	32 mV + E	.464
+005	40 mV + E	.480
+006	48 mV + E	.496
+007	56 mV + E	.512
+008	64 mV + E	.528
+009	72 mV + E	.544
+010	80 mV + E	.560
+020	160 mV + E	.720
+030	240 mV + E	.880
+040	320 mV +E	1.040
+050	400 mV + E	1.020
+060	480 mV + E	1.36
+070	560 mV + E	1.52
+080	640 mV + E	1.68
+090	720 mV + E	1.84
+100	800 mV + E	2.08
+200	1.6 V + E	3.6
+300	2.4 V + E	5.2
+400	3.2 V + E	6.8
+500	4.0 V + E	8.4
+600	4.8 V + E	10.0
+700	5.6 V + E	11.6

+800	6.4 V + E	13.2
+900	7.2 V + E	14.8
-010	-80 mV + E	.56
-100	-800 mV + E	2.08
-900	-7.2 V + E	14.8

5.3.5 Full Scale Accuracy

Connect DVM to edge connector pin 5 (Lo), pin 2 (Hi).
Check output in all Full Scale Positions per Table.

"R" Standard (ohms)	Full Scale	Output (Volts)	Tolerance (±) (Volts)
100.00 (0°)	2	0	1
100.78 (2°)	2	5	1
101.95 (5°)	5	5	.5
103.90 (10°)	10	5	.25
109.73 (25°)	25	5	.1
119.40 (50°)	50	5	.05
138.50 (100°)	100	5	.04
194.08 (250°)	250	5	.02
280.93 (500°)	500	5	.02
329.57	1000	3.25	.02

5.3.6 Variable Sensitivity – Linearity

Set the Full Scale Switch to 100.
Set the "R" Standard to 138.50 Ω.
Output should be 5 volts ±40 mV.
Turn the variable sensitivity CCW.
Output drops to below 2V.
Adjust variable sensitivity control so that the output is 2V ±1 mV.
Change the "R" Standard to 194.08 Ω.
Output now reads 5 volts ±20 mV.
Adjust variable sensitivity for an output of 5 volts ±1 mV.

"R" Standard (Ω)	Output (Volts)	(±Tol.) (mV)
194.08	5.00	1
175.84	4.00	15

157.32	3.00	15
138.50	2.00	20
119.40	1.00	20
120.00	0.00	25

Turn the Full Scale Switch to OFF.
Turn variable sensitivity control (CW) to detent position.

5.3.7 10 mV – 100 mV/Degree Check

Full Scale switch to OFF.
Adjust "R" Standard to 138.50 Ω.
Connect DVM to card edge connector pin 5 (Lo) pin J (Hi).
With the 10 mV – 100 mV switch in the 10 mV position output should read 1V ± mV.
With the 10 mV – 100 mV switch in the 100 mV position output should read 10V ±50 mV.
Hold the DVM Zero Switch in the Zero position.
Output should read 0.0 volts ±2.5 mV.

5.3.8 Degree Centigrade/Fahrenheit Conversion

Set the 10-100 mV switch in the 10 mV position.
Adjust "R" Standard per the following Table.
Monitor the edge connector pin 2 (Hi) pin 5 (Lo) as in the following Table.

"R" Standard (Ω)	Temp. (Degrees)	°F/°C Switch	Output (Volts)	(±) Tol. (mV)
39.65	-150	C	-1.50	5
39.65	-238	F	-2.38	10
84.21	-40	F	-.40	10
84.21	-40	C	-.40	5
100.00	0	C	0.00	5
100.00	32	F	.32	10
138.50	212	F	2.12	10
138.50	100	C	1.00	5
329.57	650	C	6.50	13
329.25	1200	F	12.00	25

5.3.9 Output Noise

1. Set Full Scale switch to 2.

2. Degrees F/C to C.

3. Set "R" Standard at 100.00 Ω.

4. Attach an oscilloscope (frequency response limited to 100 Hz) to the edge connec pin 2 (Hi), pin 5 (Lo).

5. Keep preamplifier away from strong AC fields.

6. Noise as read on the scope must be less than 10 mV p-p.

5.3.10 Output Oscillating Check

A. Switching Offset Control

1. Set as in steps 1-2-3 of Output Noise, above.

2. Attach a 2 KΩ resistor and a .02 μ fd capacitor across pins 5 and 2 of the edge connector. The scope Bandwidth should be 10 MHz and the input set at AC.

3. Switch the Degrees Offset between +100 and +000.

4. Observe the scope for evidence of oscillation.

5. Disregard switching transients.

B. Switching Resistance Box

1. Place the 2K resistor and the .02 μ fd capacitor across pins 5 and 2 of the edge connector.

2. Alternate the "R" Standard between 100.00 and 200.00 Ω.

3. There should be no evidence of oscillation.

4. Use both the 10 and 100 mV/Degree positions for this test.

5. Leave the switch in the 10 mV position.

5.3.11 Frequency Response

1. Attach the amplifier as in Figure 5-4.

2. Set Full Scale Switch to 10.

3. Set Degrees F/C to C.

4. Use an oscilloscope with a bandwidth of 1 KHz. Set Scope on AC.

5. Set the AC Generator to 1 Hz Sine Wave.

6. Adjust the amplitude of the generator to give a 5 Volt p-p response on the oscilloscope.

7. Raise the generator frequency until the amplitude on the scope drops to 3.5 V p Generator output amplitude must be held constant.

8. This frequency must fall between 8 and 12 Hz.

9. Change generator frequency to 100 Hz.

10. Shunt 250K resistor with 50K.

11. Adjust generator for a .5V p-p readout on the scope.

12. Readjust the generator frequency to 200 Hz. Generator output amplitude must held constant.

13. The scope reading should have dropped to < 50 mV p-p.

14. Remove all connections.

5.3.12 RTD Test 100-1000 Ω

1. Set the FS switch to 100.

2. Degrees F/C switch to C.

3. Offset to 000.

4. Install the 100.00 Ω resistor at the input. Use Figure 5-1 for reference.

5. Output should read 0.00 V ±15 mV.

6. Check Table for proper RTD jumper position to match the input resistance.

RTD Jumper	Input Resistance (Ohms)
E7-E8	100.00
E5-E6	200.00
E3-E4	500.00
E1-E2	1000.00

7. Re-install jumper at E7-E8.

5.3.13 Thermistor Test

1. Set-up input as in Figure 5-2.

2. Put RTD-Therm switch in Therm mode.

3. Unplug R-42 and R-46.

4. Connector DVM (Lo) to pin 5, (Hi) to pin 2 on edge connector.

5. Sensitivity at detent position.

6. Offset to 000.

7. Degrees F/C in C position.

8. Test per the following Table.

Therm. Sw Centigrade	Resistor Ohms	F.S. Sw.	Reading (Volts)	(±) Tol.
0°	7355	2	0	2.2 V
4°	6011	5	4	.5
10°	4483	10	5	.25
20°	2814	25	4	100 mV
30°	1815	25	6	100
38°	1301	50	3.8	50
42°	1108	50	4.2	100

9. This completes inspection.

10. Restore R-42 and R-46 to their proper positions.

11. Rut RTD-Therm Switch in RTD mode.

Appendix A

Temperature Vs. Resistance Table
(Platinum 385 - 100 Ω @ 0°C)

℃	Ohm
-100	60.20
-95	62.23
-90	64.25
-85	66.27
-80	68.28
-75	70.29
-70	72.29
-65	74.29
-60	76.28
-55	78.27
-50	80.25
-45	82.23
-40	84.21
-35	86.19
-30	88.17
-25	90.15
-20	92.13
-15	94.10
-10	96.07
-5	98.04
0	100.00
+5	101.95
+10	103.90
+15	105.85
+20	107.79
+25	109.73
+30	111.67
+35	113.61
+40	115.54

+45	117.47
+50	119.40
+55	121.32
+60	123.24
+65	125.16
+70	127.07
+75	128.98
+80	130.89
+85	132.80
+90	134.70
+95	136.60
+100	138.50
+105	140.39
+110	142.28
+115	144.17
+120	146.06
+125	147.94
+130	149.82
+135	151.70
+140	153.57
+145	155.45
+150	157.32
+155	159.19
+160	161.05
+165	162.91
+170	164.76
+175	166.62
+180	168.47
+185	170.32
+190	172.16
+195	174.00
+200	175.84
+205	177.68
+210	179.51
+215	181.34
+220	183.17
+225	185.00
+230	186.82
+235	188.64
+240	190.46
+245	192.27
+250	194.08

+255	195.89
+260	197.70
+265	199.50
+270	201.30
+275	203.09
+280	204.88
+285	206.67
+290	208.46
+295	210.25
+300	212.03
+305	213.81
+310	215.58
+315	217.36
+320	219.13
+325	220.90
+330	222.66
+335	224.42
+340	226.18
+345	227.94
+350	229.69
+355	231.44
+360	233.19
+365	234.93
+370	236.67
+375	238.41
+380	240.15
+385	241.88
+390	243.61
+395	245.34
+400	247.06
+405	248.78
+410	250.50
+415	252.22
+420	253.93
+425	255.64
+430	257.34
+435	259.05
+440	260.75
+445	262.45
+450	264.14
+455	265.83
+460	267.52

+465	269.21
+470	270.89
+475	272.57
+480	274.25
+485	275.93
+490	277.60
+495	279.27
+500	280.93
+505	282.59
+510	284.25
+515	285.91
+520	287.57
+525	289.22
+530	290.87
+535	292.52
+540	294.16
+545	295.80
+550	297.43
+555	299.07
+560	300.70
+565	302.33
+570	303.95
+575	305.58
+580	307.20
+585	308.82
+590	310.43
+595	312.04
+600	313.65
+605	315.26
+610	316.86
+615	318.46
+620	320.05
+625	321.65
+630	323.24
+635	324.83
+640	326.41
+645	327.99
+650	329.57

Temperature ℃	Resistance of Element Ohms	Temperature ℃	Resistance of Element Ohms

-75	69.75	110	209.32
-70	72.90	115	214.00
-65	76.06	120	218.74
-60	79.26	125	223.54
-55	82.48	130	228.42
-50	85.73	135	233.35
-45	89.00	140	238.35
-40	92.32	145	243.41
-35	95.66	150	248.54
-30	99.03	155	253.75
-25	102.44	160	259.02
-20	105.88	165	264.36
-15	109.35	170	269.78
-10	112.86	175	275.26
-5	116.41	180	280.82
0	120.00	185	286.45
5	123.57	190	292.17
10	127.18	195	297.95
15	130.83	200	303.81
20	134.52	205	309.75
25	138.26	210	315.78
30	142.04	215	321.88
35	145.86	220	328.06
40	149.74	225	334.33
45	153.65	230	340.68
50	157.62	235	347.12
55	161.65	240	353.63
60	165.71	245	360.23
65	169.81	250	366.93
70	173.99	255	373.71
75	178.21	260	380.58
80	182.48	265	387.54
85	186.81	270	394.60
90	191.20	275	401.74
95	195.64	280	408.97
100	200.14	285	416.30
105	204.70	290	423.73

Temperature vs. Resistance Table
(Copper Probe 10 Ω @ 0°C)

°C	Ohm
-50	7.9
-40	8.32
-30	8.74
-20	9.16
-10	9.58
0	10.00
10	10.42
20	10.84
30	11.26
40	11.68
50	12.10
60	12.53
70	12.95
80	13.37
90	13.79
100	14.21
110	14.63
120	15.06
130	15.48
140	15.90
150	16.32
160	16.73

Appendix

Schematic Drawings

This section contains complete schematic drawings for this Harvard product. The schematics are arranged in numerical order by drawing number. All documents included in this section are listed below in alphanumeric order by title, along with t drawing numbers to help locate them. The part number of any PC board assembly be obtained by replacing the initial “2” in the schematic number with an “8”.

Alphabetical List of Schematics

Description of Assembly	Schematic Drawing Number & Revision I	
Preamplifier Assembly (13-4615-47)	295377	A-1

Board Assembly	295269	S-2
Preamplifier Assy. (13-4615-474029)	CL-212200	