



**USER'S MANUAL**

**The 3B Series  
Signal Conditioning  
I/O Subsystem**

**AC1346**

**Three Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.  
Tel.: (617) 329-4700**



Errata  
Agency Certification  
3B series products  
Effective 7/01/2009

ADI will no longer carry the Factory Mutual (FM) approval Certification for the 3B series of products. All other certifications for the 3B series products will remain in place.

The decision to remove the FM approval Certification is an effort to control rising costs. Our decision to remove the FM approval Certification is not a result of any changes to these products.



**USER'S MANUAL  
3B SERIES**

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One Technology Way  
P.O. Box 9106  
Norwood, Massachusetts 02062-9106

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**REVISION RECORD**

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4.01	Modified 3B45/46 Gain setting Relation
4.02	Corrected 3B17 Calibration calibration section (2/13)



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# CHAPTER 1

## INTRODUCTION — SCOPE OF THE MANUAL

The intent of this manual is to serve as a guide to the proper configuration and operation of the 3B Series Subsystem as well as present the functional theory and specifications. A separate section is devoted to custom calibration and interfaces to user equipment. Appendices are included which contain accessories and custom ranging information.

### 1.1 GENERAL DESCRIPTION

The 3B Series Signal Conditioning I/O Subsystem provides a low cost, versatile method of interconnecting real-world analog signals to a data acquisition, monitoring or control system. It is designed to interface directly to sensor or analog signals such as thermocouple, RTD, strain gage, frequency inputs, wideband mV and V, LVDT or AD590/AC2626 solid state temperature sensor outputs or millivolt or process current signals and convert the inputs to standardized analog outputs compatible with high level analog I/O subsystems.

The 3B Series Subsystem consists of a 19" relay rack compatible universal mounting backplane and a family of plug in (up to 16 per rack) input and output signal conditioning modules. Eight and four channel backplanes are also available. Each backplane incorporates screw terminals for sensor inputs and current outputs and tracks for high level single ended outputs to the connector which interfaces with the user's equipment.

The high performance of the 3B Series Subsystem is assured by high quality signal conditioning featuring 130V or 220V rms input protection, galvanic isolation, high common mode rejection, filtering, low drift, rugged packaging, and, when required, sensor excitation. A wide zero suppression capability and easy field calibration are available with a unique plug-on ranging card.

The input and output modules are offered in both isolated ( $\pm 1500V$  peak) and nonisolated versions. The input modules feature complete signal conditioning circuitry optimized for specific sensors or analog signals and provide high level analog output. Each input module provides two simultaneous outputs: 0 to + 10V (or  $\pm 10V$ ) to the system connector and 4-20mA (or 0-20mA) to the output screw terminals. Output modules accept high level single ended voltage signals and provide an isolated or nonisolated 4-20mA (or 0-20mA) process signal. All modules feature a universal pin-out and may be readily "mixed and matched" and interchanged without disrupting field wiring.

Each backplane contains the provision for a subsystem power supply. The 3B Series Subsystem can be powered either from a common dc/dc or ac power supply mounted on each backplane or from an externally provided dc power supply. Two LEDs are used to indicate that power is being applied.

#### 1.1.1 FM APPROVAL/THE 3B SERIES

The 3B Series Signal Conditioning Subsystem is approved by Factory Mutual for use in Class I, Division 2, Groups A, B, C and D locations. This approval certifies that the 3B Series is suitable for use in locations where a hazardous concentration of flammable gas exists only under unlikely conditions of operation. Equipment of this type is called "nonincendive" and needs no special enclosure or other physical safeguards. For additional information on the 3B Series FM Approval, see Appendix D.

### 1.2 APPLICATIONS

The Analog Devices' 3B Series Signal Conditioning Subsystem is designed to provide an easy and convenient solution to signal conditioning problems in measurement and control applications. Some typical uses are in mini- and microcomputer based systems, standard data acquisition systems, programmable controllers, analog recorders, dedicated control systems, and other applications where monitoring and control of temperature, pressure, flow, position and analog signals are required. Since each input module features two simultaneous outputs, the voltage output can be used to provide an input to a microprocessor based data acquisition and control system while the current output can be used for analog transmission, operator interface, or an analog backup system. Figure 1.2.1 is a functional diagram of the 3B Series Subsystem.

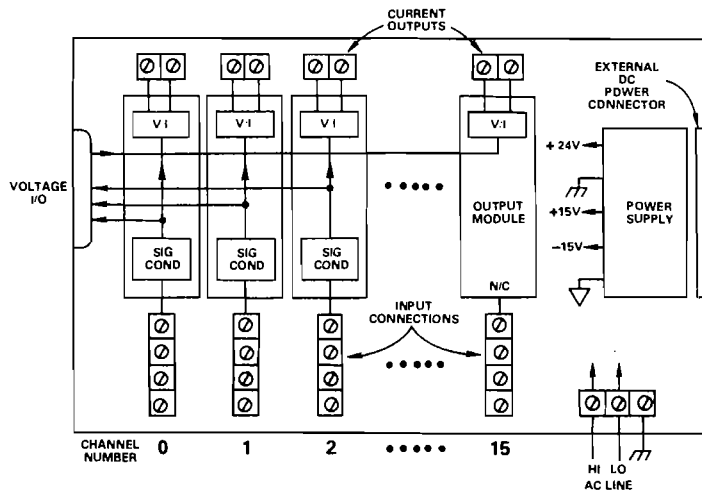


Figure 1.2.1 3B Series System Functional Block Diagram

### 1.3 DESCRIPTION OF 3B MODULES

The 3B input modules are single channel analog input conditioners that plug into sockets on the backplane. The choice of a specific 3B module depends on the type of input signal and also whether an isolated or nonisolated interface is required (refer to Table 1.3.1). The choice of the 3B output module depends on whether an isolated or nonisolated process current signal is required. Each module is identical in size (3.150" x 0.775" x 3.395") and has the same pin out. The transfer function provided by each input module is:

Input — specified sensor measurement range

Output — 0 to + 10V or  $\pm 10V$  dc

4-20mA or 0-20mA, nonisolated with respect to voltage output

The transfer function provided by each output module is:

Input — 0 to + 10V or  $\pm 10V$

Output — 4-20mA or 0-20mA

All modules include a printed circuit board incorporating electronic circuitry housed in a protective plastic shell. The shell contains provisions for securing each module to the backplane.

Input Type/Span	INPUT MODULES			
	Voltage Output	Current Output	Nonisolated Modules	Isolated Modules
dc, $\pm 10mV$ , $\pm 50mV$ , $\pm 100mV$	$\pm 10V$	4-20mA/0-20mA	3B10	3B30, 3B40
dc, $\pm 1V$ , $\pm 5V$	$\pm 10V$	4-20mA/0-20mA	3B10	3B31, 3B41
dc, $\pm 10V$	$\pm 10V$	4-20mA/0-20mA	3B11	3B31, 3B41
dc, 4-20mA, 0-20mA	0-10V	4-20mA/0-20mA	3B12	3B32
Thermocouple Types J, K, T, E, R, S, B	0-10V	4-20mA/0-20mA		3B37, 3B47
100 $\Omega$ Platinum RTD, 2, 3, 4 wire $\alpha = 0.00385$ (linearized)	0-10V	4-20mA/0-20mA	3B14	3B34
100 $\Omega$ Platinum RTD, Kelvin 4-wire $\alpha = 0.00385$ (linearized)	0-10V	4-20mA/0-20mA	3B15	
10 $\Omega$ Copper RTD, 2 or 3 wire	0-10V	4-20mA/0-20mA		3B34-C
120 $\Omega$ Nickel RTD, 2, 3, or 4 wire	0-10V	4-20mA/0-20mA		3B34-N
Strain Gage $\pm 30mV$ , $\pm 100mV$	$\pm 10V$	4-20mA/0-20mA	3B16, 3B18	
LVDT 4, 5, 6 wire or RVDT 4, 5, 6 wire	$\pm 10V$	4-20mA/0-20mA	3B17	
AD590/AC2626 Solid State Temperature Transducer	0-10V	4-20mA/0-20mA	3B13	
ac, 0-50mV rms, 0-100mV rms	0-10V	4-20mA/0-20mA		3B42
ac, 0-10V rms	0-10V	4-20mA/0-20mA		3B43
ac, 0-150V rms, 0-250V rms	0-10V	4-20mA/0-20mA		3B44
Frequency 0-25Hz, 0-300Hz	0-10V	4-20mA/0-20mA		3B45
Frequency 0-1500Hz, 0-3000Hz, 0-25kHz	0-10V	4-20mA/0-20mA		3B46

Table 1.3.1 Module Selection Table

The modules are available in several factory calibrated input ranges. Each input module includes separate screwdriver adjustable zero and span potentiometers for both the voltage output and the current output which can be used for fine calibration within the chosen range. The voltage and current adjustments are independent and noninteractive which allows for precise calibration of both outputs. Each output module has two adjustable zero and span potentiometers for fine calibration of the output current. Each potentiometer has an adjustment range of  $\pm 5\%$  span.

#### 1.4 WIDE ZERO SUPPRESSION CAPABILITY

A wide zero suppression capability and easy field recalibration are available with a unique plug-on ranging card (AC1310). If a special input range is desired, it can be provided by ordering the externally programmable version of the desired module (i.e., 3B32-00) and the plug-on ranging card, AC1310. This card houses user supplied resistors that determine the zero and span of the desired range. The RTD modules accept an additional resistor that is used for linearization of the input signal, while the thermocouple module uses an additional resistor to set the cold junction compensation level. This feature allows the user to provide zero suppression of up to and beyond 100% of the input range and provide a wide range of span modification. The capability allows the user to map any portion of the input signal to the full output span. For example, a user who wants to measure temperature with a thermocouple in the range of 800-900°C can use this ranging card for greater system resolution in that 100°C temperature span. This tremendous flexibility should satisfy virtually any requirement. The resistor values are determined by equations defined for each module. See the appropriate data page for each module within the User's Manual for further details. Special ranges can also be factory configured. Analog Devices will provide the function when a model 3B\_\_ - CUSTOM is ordered with the desired range.

#### 1.5 APPLICATION EXAMPLE

An example of how the 3B Series Subsystem might be used with an analog I/O subsystem in a measurement and control application is diagrammed in Figure 1.5.1. The sensor, which could be a thermocouple, is connected directly to the input screw terminals. The high level voltage output of the input module is compatible with any high level multiplexer or analog-to-digital converter which converts the data to the digital form that the microprocessor requires. The digital output of the microprocessor is connected to a digital-to-analog converter which provides a high level voltage output. The output module converts this high level voltage output to a process current which can be used to drive an actuator or any other control element.

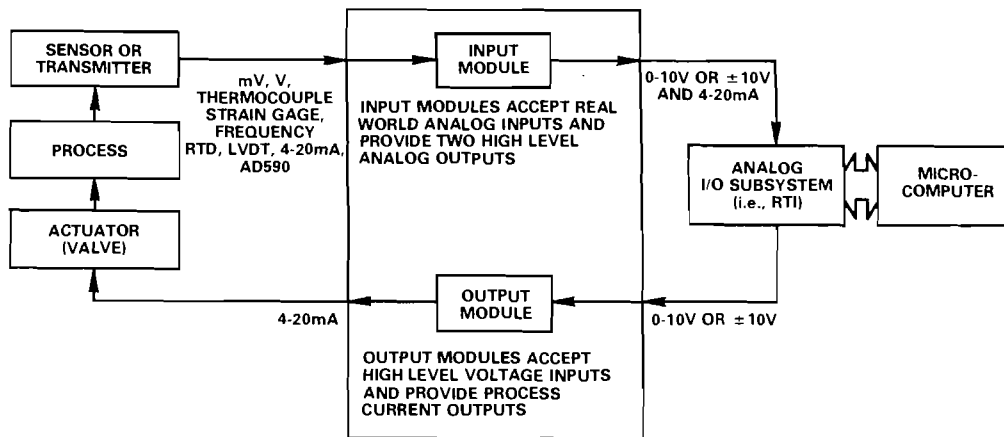


Figure 1.5.1 Function Block Diagram of a Typical Measurement and Control Application Using the 3B Series Subsystem

## **1.6 BACKPLANE FUNCTIONAL DESCRIPTION**

The three backplane models: 3B01, 3B02, and 3B03 are designed for sixteen, eight, and four channels respectively which offers users the flexibility to match the size of a system to specific applications. The sixteen channel backplane can be mounted in a 19" x 5.25" panel space while all backplanes can be surface mounted or mounted in a NEMA enclosure.

## **1.7 POWER SUPPLY**

The 3B Series Subsystem can operate from a common ac power supply or dc/dc (+ 24V input) power supply mounted in the subsystem or an externally provided  $\pm 15V$  or + 24V supply. The power supply is bussed to all signal conditioners in the system. Several power supplies are available to satisfy various current requirements.

## CHAPTER 2

### GENERAL INPUT MODULE SPECIFICATIONS

#### FEATURES

**Complete Signal Conditioning Function Per Module**

**Wide Variety of Sensor Inputs**

Thermocouples, RTDs, Strain Gages, Frequency Inputs, LVDT, AD590/AC2626

**Dual High Level Outputs**

Voltage: 0 to +10V or  $\pm 10V$

Current: 4-20mA/0-20mA

**Mix and Match Input Capability**

Sensor Signals, mV, V, 4-20mA, 0-20mA

**High Accuracy:  $\pm 0.1\%$**

**Low Drift:  $\pm 1\mu V/^{\circ}C$**

**Reliable Transformer Isolation:**

$\pm 1500V$  CMV

160dB CMR

Meets IEEE-STD 472: Transient Protection (SWC)

**Input Protection: 130V or 220V rms Continuous**

**Reliable Pin and Socket Connections**

**Low Cost Per Channel**

#### 2.1 INPUT MODULE

Each input module is a single channel signal conditioner that plugs into a socket on the backplane and accepts its signal from the input screw terminals. All input modules provide input protection, amplification and filtering of the input signal, accuracy of  $\pm 0.1\%$ , low drift of  $1\mu V/^{\circ}C$ , and feature two high level analog outputs that are compatible with most process instrumentation. The isolated input modules also provide  $\pm 1500V$  of CMV isolation.

The choice of a specific 3B module depends on the type of input signal and also whether an isolated or nonisolated interface is required. Input modules are available to accept millivolt, volt, process current, thermocouple, RTD, strain gage, frequency, LVDT and AD590 inputs. The voltage output of each module is available from the voltage I/O connector while the current output is available on the output screw terminals.

The transfer function provided by each input module is:

Input – specified sensor measurement range

Output – 0 to +10V dc or  $\pm 10V$

4-20mA, nonisolated with respect to voltage output

(0-20mA output programmed by a jumper option on the module)

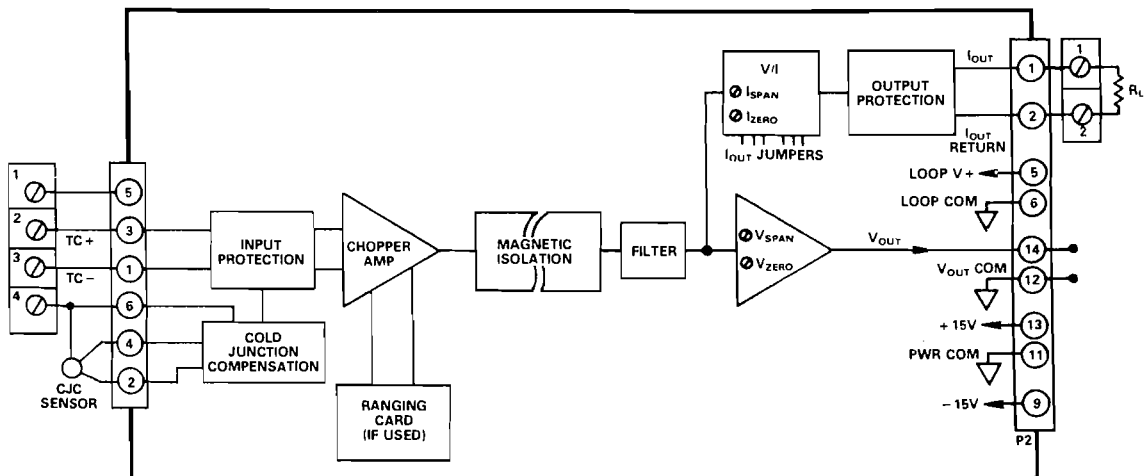


Figure 2.1.1 Model 3B37 Functional Block Diagram

For example, Figure 2.1.1 shows a functional diagram for the Model 3B37 isolated thermocouple signal conditioner. The input signal is filtered, amplified and has cold junction compensation applied before the isolation barrier. Reliable magnetic isolation is used to provide isolation protection. The outputs of the module are isolated from the input (up to  $\pm 1500V$  peak) and calibrated for 0 to +10V (voltage output) and 4-20mA (current output) which corresponds to the specified input span.

## GENERAL INPUT MODULE SPECIFICATIONS

(typical @ +25°C and  $\pm 15V$ , +24V dc power)

Model	Isolated Modules	Nonisolated Modules
Inputs	Per Selection Table	*
Outputs <sup>1</sup>	0 to +10V @ 5mA or $\pm 10V$ @ $\pm 5mA$ 4-20mA or 0-20mA @ $R_L = 0$ to $850\Omega^2$	*
Accuracy <sup>3</sup>	$\pm 0.1\%$ span	*
Nonlinearity <sup>4</sup>	$\pm 0.01\%$ span	*
Stability vs. Ambient Temperature		
Voltage Output		
Zero	$\pm 1\mu V/^\circ C$ for $G > 100$ (RTI)	*
Span	$\pm 0.0025\%$ reading/ $^\circ C$	*
Current Output (w. r. t. Voltage Output)		
Zero	$\pm 0.0025\%$ span/ $^\circ C$	*
Span	$\pm 0.0025\%$ reading/ $^\circ C$	*
Common Mode Voltage, Input to Output	$\pm 1500V$ pk max	$\pm 6.5V^5$
Common Mode Rejection @ 50Hz or 60Hz		
1k $\Omega$ Source Unbalance <sup>6</sup>	160dB	90dB <sup>5</sup>
Normal Mode Rejection @ 50Hz or 60Hz <sup>7</sup>	60dB	60dB
Differential Input Protection <sup>8</sup>	220V rms, cont.	130V rms, cont.
Voltage Output Protection	Continuous Short to Ground	*
Current Output Protection	130V rms, cont.	*
Zero and Span Adjustment Range <sup>9</sup>	$\pm 5\%$ of span	*
Input Transient Protection	Meets IEEE-STD 472 (SWC)	N/A
Input Resistance	15M $\Omega$	100M $\Omega$
Bandwidth <sup>10</sup>	3Hz (–3dB) or 10kHz (–3dB)	3Hz (–3dB) or 20kHz (–3dB)
Power Supply <sup>11</sup>	$\pm 15V$ dc, +24V dc	*
Size	3.150" $\times$ 0.775" $\times$ 3.395"	*
Environmental		
Temperature Range, Rated Performance	–25°C to +85°C	*
Storage Temperature Range	–55°C to +85°C	*
Relative Humidity Conforms to MIL Spec 202	0 to 95% @ 60°C noncondensing	*
RFI Susceptibility	$\pm 0.5\%$ span error, 5W @ 400MHz @ 3 ft.	*

### NOTES

<sup>1</sup>Voltage output range is determined by the module input range while the current output range is user selectable. Model 3B47 does not have a current output.

<sup>2</sup>For a 0-20mA range, a typical minimum output current is 10 $\mu A$ .

<sup>3</sup>Accuracy spec includes the combined effects of repeatability, hysteresis and linearity. Does not include sensor or signal source error. 3B42, 3B43 and 3B44 have a  $\pm 0.5\%$  accuracy. 3B17 has  $\pm 0.1\%$  accuracy when calibrated.

<sup>4</sup>RTD Models 3B14, 3B15, 3B34 and LVDT Model 3B17 have a linearization conformity error of  $\pm 0.05\%$ .

<sup>5</sup>Models 3B13, 3B14, 3B15, 3B16, and 3B17 each have the common mode voltage determined by the internal excitation circuitry.

<sup>6</sup>Only applies to units with 3Hz bandwidth. Models 3B18, 3B40, 3B41 have a CMR of 100dB.

<sup>7</sup>Only applies to units with 3Hz bandwidth.

<sup>8</sup>Includes excitation circuitry for models 3B13, 3B14, 3B15, 3B16, 3B17, 3B18 and 3B34.

<sup>9</sup>A wide range of zero suppression and custom calibration may be accomplished with a custom ranging card, AC1310. Model 3B17 has a gain adjustment range of 256:1 and an output referred zero suppression range of  $\pm 5V$ .

<sup>10</sup>Model 3B18 has a 20kHz bandwidth; models 3B40 and 3B41 have a 10kHz bandwidth; model 3B17 has a 100Hz bandwidth.

<sup>11</sup>+24V dc power is only needed for driving the current output at up to 850 $\Omega$ . If only voltage output is used, or a current output load of 400 $\Omega$  or less is desired,  $\pm 15V$  is all that is required.

\*Specifications same as isolated modules.

Specifications subject to change without notice.



If a special input range is desired, it can be provided with the externally programmable version of the desired module, the plug-on ranging card, and user supplied resistors. See the discussion of the module of interest within the User's Manual for further details.

Each input module has two user programmable jumper options. One option allows the user to program the current output to be proportional to either the 0 to +10V output or a -10V to +10V output. The second option allows the user to determine if the current output is 4-20mA or 0-20mA. All modules are shipped from the factory configured so that the current output is proportional to the 0 to +10V output and each current output is 4-20mA. If the push-on jumpers are changed, the zero and full scale points will shift by approximately 0.25% of span and will need to be recalibrated to remove this error.

The current output of all input modules requires a grounded return. The grounded return of the current output can only be used for the return of ONE MODULE. Two or more modules SHOULD NOT BE connected to the same RETURN terminal. If several current loops are to be returned with one ground, that connection should be made to the Loop Common on the DC POWER connector.

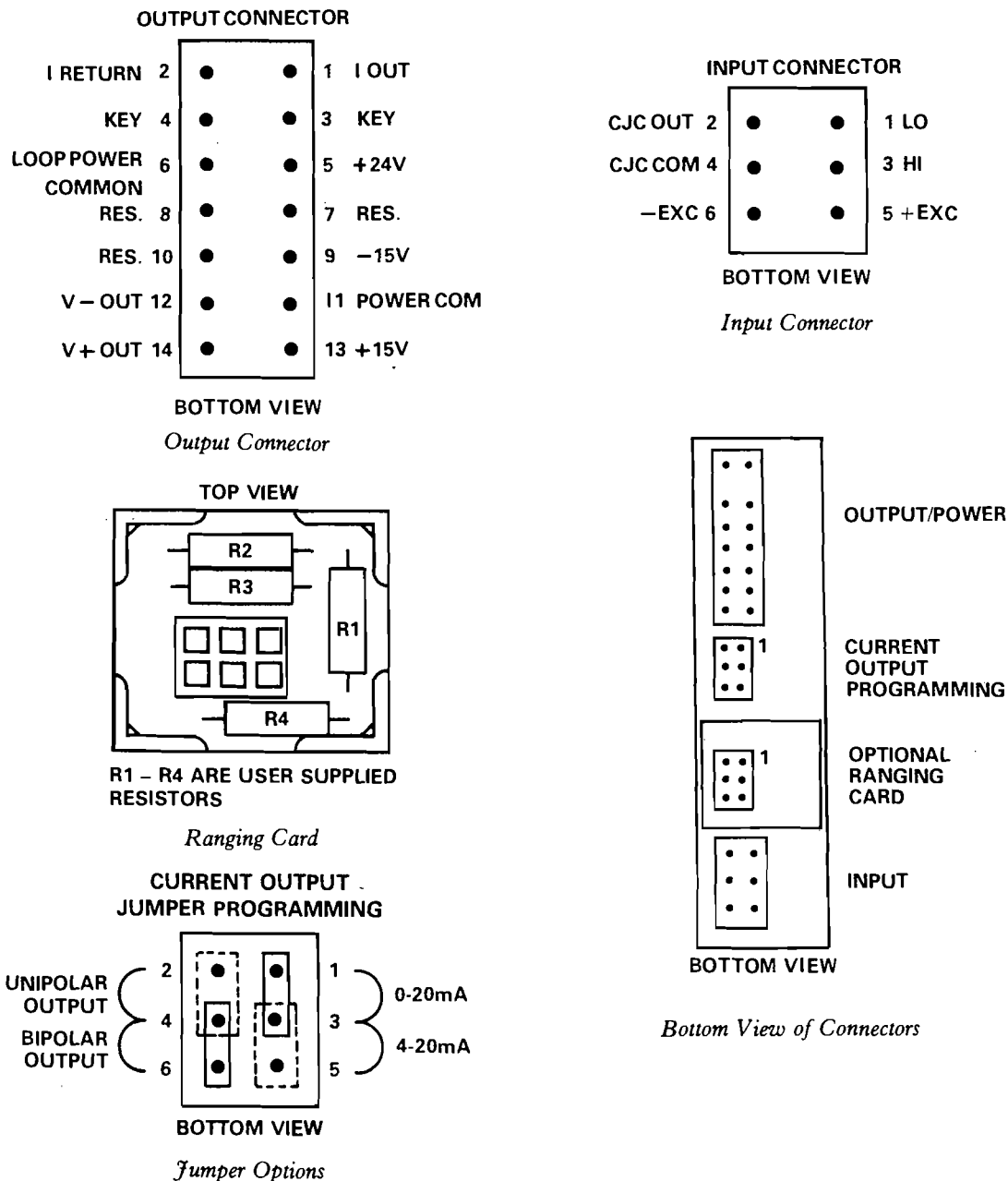


Figure 2.1.2 Input Module Connectors

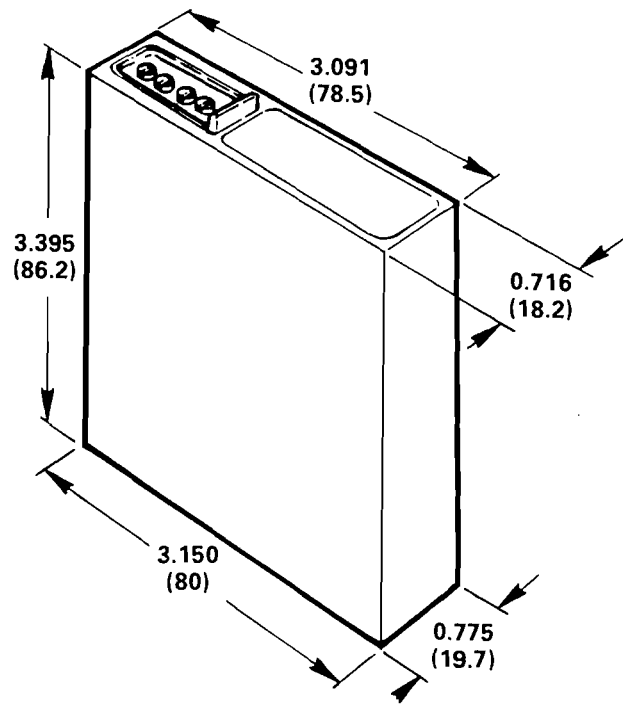
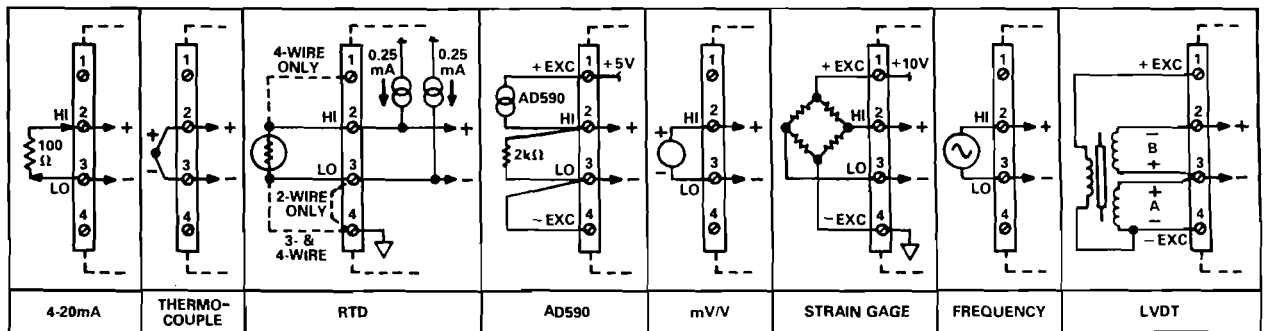


Figure 2.1.3 Module Outline Dimensions (Dimensions shown in inches and (mm)).



INPUT CONNECTIONS:  
ALL INPUT CONNECTIONS USE #6-32 SCREW TERMINALS,  
COMPATIBLE WITH 14 AWG WIRE.

Figure 2.1.4 Module Input Connections

### 2.1.1 MODELS 3B10 AND 3B11

#### FEATURES

**Accepts Millivolt and Volt Inputs**  
**3B10: ±10mV to ±5V**  
**3B11: ±10V**

#### FUNCTIONAL DESCRIPTION

Model 3B10 is a nonisolated voltage input device that is designed to accept a wide range of input voltages, ranging from ±10mV to ±5V. Model 3B11 is a nonisolated high level voltage input device that is designed to accept ±10V.

Figure 2.1.1.1 shows a functional diagram for models 3B10 and 3B11. Input protection of up to 130V is provided on the input screw terminals. The signal is then amplified and filtered to give the high level voltage output. Chopper based amplification is used to assure low drift and excellent long term stability. Both the voltage and current outputs can be independently adjusted over a ±5% span range for zero and span with the front panel accessible potentiometers. The current output, which has 130V output protection, interfaces with user equipment through screw terminal connections.

Both models 3B10 and 3B11 require a ground return for the input connections-to return the bias current to ground.

#### FINE CALIBRATION

Each model is factory calibrated for a specified range to provide zero and span accuracy of ±0.1% of span. User accessible zero and span trim potentiometers providing a ±5% adjustment range permit precise field calibration of both the voltage output and the current output. The two outputs are adjusted independently and are noninteractive. The following nonrecursive adjustment procedure is recommended:

1. Connect model 3B10(3B11) as shown in Figure 2.1.1.1 with  $R_L = 250\Omega$ .
2. Apply  $V_{IN} = 0$  volts, adjust  $V_Z$  for  $V_{OUT} = 0V \pm 10mV$  and  $I_Z$  for  $I_{OUT} = 4mA \pm 0.016mA$  or the measured voltage across  $R_L = +1V \pm 4mV$ .
3. Apply  $V_{IN} = +$  Full Scale, adjust  $V_S$  for  $V_{OUT} = +10V \pm 10mV$  and adjust  $I_S$  for  $I_{OUT} = 20mA \pm 0.016mA$  or the measured voltage across  $R_L = +5V \pm 4mV$ .

If a 0-20mA output is desired for a 0 to +10V output, adjust  $I_Z$  for  $I_{OUT} = 0mA \pm .020mA$  in Step 2 and  $I_S$  for  $I_{OUT} = 20mA \pm .020mA$  in Step 3. (A typical minimum output current is 10µA with 0-20mA operation).

If the current output is to be proportional to a -10V to +10V output instead of a 0 to +10V output,  $I_Z$  should be adjusted for a - Full Scale input in Step 2.

#### OPTIONAL ZERO SUPPRESSION/CUSTOM CALIBRATION

A wide zero suppression capability and easy field calibration are available with a plug-on ranging card, AC1310. If a special input range is desired, it can be provided by ordering the externally programmable version of the desired module (i.e., 3B10-00) and the AC1310 which houses user supplied resistors that determine the zero and span of the new range. A special range can also be factory configured. Consult the factory for details.

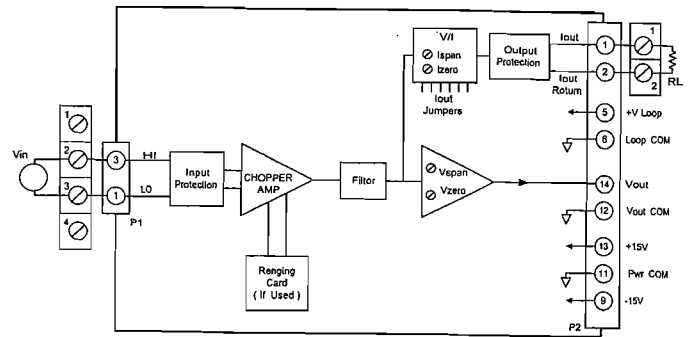


Figure 2.1.1.1. 3B10 and 3B11 Functional Block Diagram

The basic transfer function of both the 3B10 and 3B11 is:

$$V_O = G \times (V_{IN} - V_Z)$$

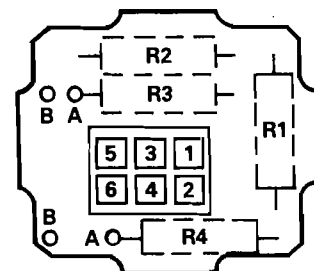
Where  
 $V_O$  = Output Voltage  
 $G$  = Gain  
 $V_{IN}$  = Input Voltage  
 $V_Z$  = Zero Suppression Voltage

#### GAIN SETTING RELATION

With the AC1310, the gain  $G$  is set by  $R_1$ , which forms part of an internal divider and is determined from the following relation:

$$\begin{array}{cc} \text{3B10} & \text{3B11} \\ R_1 = \frac{10k\Omega}{G-1} & R_1 = \frac{1k\Omega}{G-0.1} \end{array}$$

Gain  $G$  is a ratio of the change of output to the input change that produced it. Model 3B11 is a 3B10 with a 10× normal mode input attenuator. The attenuation is done before the zero suppression or gain, which causes a change in these relations. If there is to be no zero suppression,  $R_2$  should be a jumper and  $R_3$  should be left open. These resistors should be installed as indicated in Figure 2.1.1.2.



	GAIN SELECTION ONLY	GAIN AND ZERO SUPPRESSION
$R_1$	Gain Resistor	Gain Resistor
$R_2$	Jumper	Zero Suppression Resistor
$R_3$	Open	Zero Suppression Resistor
$R_4$	Open	Open

Figure 2.1.1.2 3B10 and 3B11 Custom Ranging

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24V dc power)

	3B10	3B11
Model	3B10	3B11
Inputs	±10mV to ±5V	±10V
Outputs	±10V (at 5mA) 4-20mA or 0-20mA (at R <sub>L</sub> = 0 to 850Ω) <sup>1</sup>	±10V
Maximum Current Output Range	0-31mA	*
Accuracy <sup>2</sup>	±0.1% span	*
Nonlinearity	±0.01% span	*
Stability vs. Ambient Temperature		
Voltage Output		30μV/°C
Zero	±1μV/°C <sup>3</sup>	*
Span	±0.0025% reading/°C	*
Current Output (w.r.t. Voltage Output)		
Zero	±0.0025% span/°C	*
Span	±0.0025% reading/°C	*
Common Mode Voltage, Input to Output	±6.5V	*
Common Mode Rejection (at 50Hz or 60Hz)		70dB
1kΩ Source Unbalance	90dB <sup>4</sup>	*
Normal Mode Rejection (at 50Hz or 60Hz)	60dB	*
Differential Input Protection	130V rms, cont.	*
Voltage Output Protection	Continuous Short to Ground	*
Current Output Protection	130V rms, cont.	*
Zero and Span Adjustment Range <sup>5</sup>	±5% of span	*
Response Time to 90% Span	0.2sec	*
Input Resistance	100MΩ	400kΩ
Input Bias Current	3nA	*
Input Noise	0.2μV rms at 10Hz bandwidth	*
Output Noise	50μV rms in 100kHz bandwidth	*
Bandwidth	3Hz (-3dB)	*
Power Supplies <sup>6</sup>		
±15V Input Supplies Range (Rated Operation)	±(11.5V to 16.5V)	*
Supply Rejection	±0.01% span/V	*
Supply Current	±10mA	*
+24V Loop Supply Range	+12V to +30V	*
Supply Rejection	0.0002% span/V	*
Supply Current	27mA (at +FS)	*
Size	3.150" × 0.775" × 3.395"	*
Environmental		
Temperature Range, Rated Performance	-25°C to +85°C	*
Storage Temperature Range	-55°C to +85°C	*
Relative Humidity Conforms to MIL Spec 202	0 to 95% (at 60°C noncondensing)	*
RFI Susceptibility	±0.5% span error, 5W (at 400MHz) (at 3 ft.)	*

## NOTES

- <sup>1</sup>For a 0-20mA range, a typical minimum output current is 10μA.
  - <sup>2</sup>Accuracy spec includes the combined effects of repeatability, hysteresis and linearity. Does not include sensor or signal source error.
  - <sup>3</sup>Models 3B10-04 and 3B10-05 have zero drift values of 3μV/°C and 15μV/°C respectively.
  - <sup>4</sup>Models 3B10-03, 3B10-04 and 3B10-05 have CMR values of 85dB, 80dB and 75dB respectively.
  - <sup>5</sup>A wide range of zero suppression and custom calibration may be accomplished with a custom ranging card, AC1310.
  - <sup>6</sup>+24V dc power is only needed for driving the current output at up to 850Ω. If only voltage output is used, or a current output load of 400Ω or less is desired, +15V is all that is required.
- \*Specifications same as 3B10.  
Specifications subject to change without notice.

## ORDERING INFORMATION

Input Range	Model Number
<b>Low Level,</b>	
Externally Programmable	3B10-00
±10mV	3B10-01
±50mV	3B10-02
±100mV	3B10-03
±1V	3B10-04
±5V	3B10-05
<b>High Level,</b>	
Externally Programmable	3B11-00
±10V	3B11-01

## ZERO SUPPRESSION VOLTAGE

For the 3B10, the zero suppression voltage,  $V_Z$ , can be set for any value between -6.35V and +6.35V through the use of  $R_2$  and  $R_3$  while  $V_Z$  can be set to any value from -63.5V to +63.5V for model 3B11.  $V_Z$  is determined from the following relations:

$$V_Z = 6.35V \times \frac{R_2}{R_2 + R_3} \quad V_Z = 63.5V \times \frac{R_2}{R_2 + R_3}$$

with the sign of  $V_Z$  determined by the choice of location A (positive) or location B (negative) for  $R_3$  (see Figure 2.1.1.3). The total resistance of ( $R_2 + R_3$ ) should be approximately 10kΩ to avoid taking excessive current from the voltage reference or self heating in the resistors. (For the 3B11, the 63.5V term is a function of the 10× attenuation of the input signal. The internal voltage reference is 6.35V and high watt resistors are not required for zero suppression). Using 10kΩ as the total value,  $R_2$  and  $R_3$  are determined from the following relations:

$$R_2 = \frac{V_Z}{6.35V} \times 10k\Omega \quad R_2 = \frac{V_Z}{63.5V} \times 10k\Omega$$

$$R_3 = 10k\Omega - R_2 \quad R_3 = 10k\Omega - R_2$$

REF:

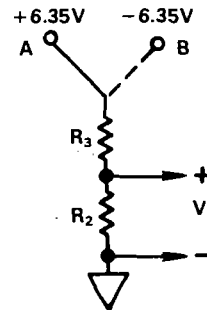


Figure 2.1.1.3 3B10 and 3B11 Zero Suppression Resistors

## LIMITS

The ranging card can be used to create a wide range of special transfer functions, but there are practical limits that must be observed. For the 3B10, the maximum input voltage for normal linear operation at either the HI or LO input terminal is ±6.6V with respect to output (system) common. For the 3B11, a similar relation applies after the input signal has been attenuated by a factor of 10. These relations are shown below:

$$3B10: V_{CM} + V_{NM} \leq 6.6$$

$$3B11: V_{CM} + \frac{V_{NM}}{10} \leq 6.6$$

The range of the module's voltage output adjustment is at least ±0.5V at the module output and can therefore correct any input offset error of less than 0.5V/Gain for the 3B10 and 5V/Gain for the 3B11. If possible the resistors used should be 1% tolerance, 10ppm. See Appendix A for a detailed discussion of limits, error contributions, and temperature effects of the ranging card.

## 2.1.2 MODELS 3B12 AND 3B32

### FEATURES

- Accepts Process Current Inputs (4-20mA or 0-20mA)
- Reliable Transformer Isolation (3B32)
- ± 1500V CMV
- 160dB CMR
- Meets IEEE-STD 472: Transient Protection (SWC)

### FUNCTIONAL DESCRIPTION

Model 3B32 is an isolated current input device that is designed to accept a process current (4-20mA or 0-20mA). The 3B12 offers a functionally equivalent design without input to output isolation.

Figure 2.1.2.1 shows a functional diagram for the model 3B32. The model 3B12 offers the same functional characteristics as the 3B32 but does not include isolation circuitry. A current sensing resistor, supplied with each module, is connected to screw terminals 2 and 3.

Input protection of up to 220V is provided for the 3B32 (130V for the 3B12) on the input screw terminals. The signal is then amplified and filtered to give the high level voltage output. Chopper based amplification is used to assure low drift and excellent long term stability. Transformer coupling is used to achieve stable, galvanic isolation between input and output. Both the voltage and current output can be independently adjusted over a ± 5% span range for zero and span with the front panel accessible potentiometers. The current output, which has 130V output protection, interfaces with user equipment through screw terminal connections.

Model 3B12 requires a ground return for the input connection to return the bias current to ground.

### FINE CALIBRATION

Each model is factory calibrated for a specified range to provide zero and span accuracy of ± 0.1% of span. User accessible zero and span trim potentiometers providing a ± 5% adjustment range permit precise field calibration of both the voltage output and the current output. The two outputs are adjusted independently and are noninteractive. The following nonrecursive adjustment procedure is recommended:

1. Connect model 3B12 (3B32) as shown in Figure 2.1.2.1 with  $R_L = 250\Omega$ .
2. Apply  $I_{IN} = 4mA$ , adjust  $V_Z$  for  $V_{OUT} = 0V \pm 10mV$  and  $I_Z$  for  $I_{OUT} = 4mA \pm 0.016mA$  or the measured voltage across  $R_L = +1V \pm 4mV$ .
3. Apply  $I_{IN} = 20mA$ , adjust  $V_S$  for  $V_{OUT} = +10V \pm 10mV$  and  $I_S$  for  $I_{OUT} = 20mA \pm 0.016mA$  or the measured voltage across  $R_L = +5V \pm 4mV$ .

If a 0-20mA input is used,  $I_{IN}$  should be 0mA in step 2. If a 0-20mA output is desired,  $I_Z$  should be adjusted for 0mA ± 0.020mA in step 2 and  $I_S$  should be adjusted for  $I_{OUT} = 20mA \pm 0.020mA$  in step 3 (a typical minimum output current is 10µA with 0-20mA operation).

### OPTIONAL ZERO SUPPRESSION/CUSTOM CALIBRATION

A wide zero suppression capability and easy field calibration are available with a plug-on ranging card, AC1310. If a special input range is desired, it can be provided by ordering the externally programmable version of the desired module (i.e. 3B32-00) and the AC1310 which houses user supplied resistors

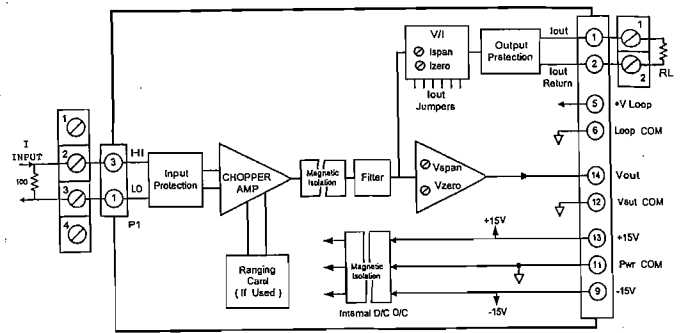


Figure 2.1.2.1 3B32 Functional Block Diagram

that determine the zero and span of the new range. A special range can also be factory configured. Consult the factory for details.

The basic transfer function of both the 3B12 and 3B32 is:

$$V_O = G(V_{IN} - V_Z)$$

Where

$$V_O = \text{Output Voltage}$$

$$G = \text{Gain}$$

$$V_{IN} = I_{IN}(100\Omega)$$

$$V_Z = I_Z(100\Omega)$$

$$I_{IN} = \text{Input Current}$$

$$I_Z = \text{Zero Suppression Current}$$

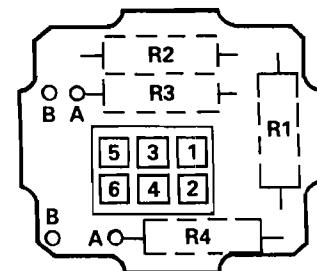
These relations assume the use of the 100Ω resistor supplied with each module.

### GAIN SETTING RELATION

With the AC1310, the gain G is set by  $R_1$ , which forms part of an internal divider and is determined from the following relation:

$$\begin{array}{cc} 3B12 & 3B32 \\ R_1 = \frac{10k\Omega}{G-1} & R_1 = \frac{40k\Omega}{G-2} \end{array}$$

Gain G is a ratio of the change of output to the input change that produced it. If there is to be no zero suppression,  $R_2$  should be a jumper and  $R_3$  should be left open. These resistors should be installed as indicated in Figure 2.1.2.2.



	GAIN SELECTION ONLY	GAIN AND ZERO SUPPRESSION
$R_1$	Gain Resistor	Gain Resistor
$R_2$	Jumper	Zero Suppression Resistor
$R_3$	Open	Zero Suppression Resistor
$R_4$	Open	Open

Figure 2.1.2.2 3B12 and 3B32 Custom Ranging

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24V dc power)

Model	3B32	3B12
Inputs	4-20mA, 0-20mA	*
Outputs	0 to +10V (α 5mA) 4-20mA or 0-20mA (α R <sub>L</sub> = 0 to 850Ω) <sup>1</sup>	*
Maximum Current Output Span	0-31mA	*
Accuracy <sup>2</sup>	±0.1% span	*
Nonlinearity	±0.01% span	*
Stability vs. Ambient Temperature		
Voltage Output		30μV/°C
Zero	±0.0025% span/°C	*
Span	±0.0025% reading/°C	*
Current Output (w.r.t. Voltage Output)		
Zero	±0.0025% span/°C	*
Span	±0.0025% reading/°C	*
Common Mode Voltage, Input to Output	±1500V pk max	±6.5V
Common Mode Rejection (α 50Hz or 60Hz)		
1kΩ Source Unbalance	160dB	90dB
Normal Mode Rejection (α 50Hz or 60Hz)	60dB	*
Differential Input Protection	220V rms, cont.	130V rms, cont.
Voltage Output Protection	Continuous Short to Ground	*
Current Output Protection	130V rms, cont.	*
Zero and Span Adjustment Range <sup>3</sup>	±5% of span	*
Response Time to 90% Span	0.2sec	*
Input Transient Protection	Meets IEEE-STD 472 (SWC)	N/A
Input Resistance	15MΩ	100MΩ
Input Bias Current	3nA	*
Input Noise	0.2μV rms at 10Hz bandwidth	*
Output Noise	50μV rms in 100kHz bandwidth	*
Bandwidth	3Hz (-3dB)	*
Power Supplies <sup>4</sup>		
±15V Input Supplies Range (Rated Operation)	±(11.5V to 16.5V)	*
Supply Rejection	±0.01% span/V	*
Supply Current	±10mA	*
+24V Loop Supply Range	+12V to +30V	*
Supply Rejection	0.0002% span/V	*
Supply Current	27mA (at +FS)	*
Size	3.150" × 0.775" × 3.395"	*
Environmental		
Temperature Range, Rated Performance	-25°C to +85°C	*
Storage Temperature Range	-55°C to +85°C	*
Relative Humidity Conforms to MIL Spec 202	0 to 95% (α 60°C noncondensing)	*
RF1 Susceptibility	±0.5% span error, 5W (α 400MHz α 3 ft.)	*

## NOTES

- <sup>1</sup>For a 0-20mA range, a typical minimum output current is 10μA.
  - <sup>2</sup>Accuracy spec includes the combined effects of repeatability, hysteresis and linearity. Does not include sensor or signal source error.
  - <sup>3</sup>A wide range of zero suppression and custom calibration may be accomplished with a custom ranging card, AC1310.
  - <sup>4</sup>+24V dc power is only needed for driving the current output at up to 850Ω. If only voltage output is used, or a current output load of 400Ω or less is desired, ±15V is all that is required.
- \*Specifications same as 3B32.  
Specifications subject to change without notice.

## ORDERING INFORMATION

Input Ranges	Model Number (Isolated)	Model Number (Nonisolated)
Externally Programmable	3B32-00	3B12-00
4-20mA	3B32-01	3B12-01
0-20mA	3B32-02	3B12-02

## ZERO SUPPRESSION VOLTAGE

For the 3B12, the zero suppression term,  $I_Z$ , can be set for any value between -63.5mA and +63.5mA through the use of  $R_2$  and  $R_3$  while  $I_Z$  can be set to any value from -31.75mA to +31.75mA for model 3B32.  $I_Z$  is determined from the following relations:

$$3B12: I_Z = 0.0635 \times \frac{R_2}{R_2 + R_3} \quad (I_Z \text{ in Amps})$$

$$3B32: I_Z = 0.03175 \times \frac{R_2}{R_2 + R_3} \quad (I_Z \text{ in Amps})$$

with the sign of  $I_Z$  determined by the choice of location A (positive) or location B (negative) for  $R_3$  (see Figure 2.1.2.3). The total resistance of ( $R_2 + R_3$ ) should be approximately 10kΩ to avoid taking excessive current from the voltage reference or self heating in the resistors. Using 10kΩ as the total value,  $R_2$  and  $R_3$  are determined from the following relations:

### 3B12

$$R_2 = \frac{100\Omega \cdot I_Z}{6.35V} \times 10k\Omega \quad (I_Z \text{ in Amps})$$

$$R_3 = 10k\Omega - R_2$$

### 3B32

$$R_2 = \frac{100\Omega \cdot I_Z}{3.175V} \times 10k\Omega \quad (I_Z \text{ in Amps})$$

$$R_3 = 10k\Omega - R_2$$

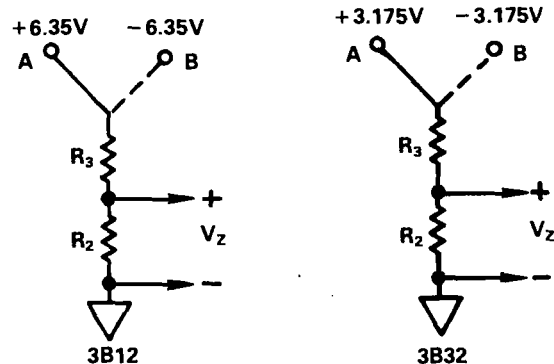


Figure 2.1.2.3 3B12 and 3B32 Zero Suppression Resistors

## LIMITS

The ranging card can be used to create a wide range of special transfer functions, but there are practical limits that must be observed. For the 3B12, the maximum input at either the HI or LO input terminal is ±6.6V with respect to output (system) common, which implies a 66mA current through the 100Ω resistor. The supplied resistor is 1/8W which means a higher watt resistor should be used if this much current is required. The maximum input current for the 3B12 is 30mA. The range of both module's voltage output adjustment is at least ±0.5V at the module output and can therefore correct any input offset error of less than 0.5V/Gain or 5mA/Gain with the 100Ω external resistor. If possible the resistors used should be 1% tolerance, 10ppm. See Appendix A for a detailed discussion of limits, error contributions, and temperature effects of the ranging card.

### 2.1.3 MODEL 3B13

#### FEATURES

Accepts AD590/AC2626 Input

#### FUNCTIONAL DESCRIPTION

The 3B13 is designed to interface with Analog Devices' AD590 temperature transducer. The 3B13 is a nonisolated device that accommodates the AD590 temperature measurement range of  $-55^{\circ}\text{C}$  to  $+130^{\circ}\text{C}$ .

Figure 2.1.3.1 shows a functional diagram for model 3B13. A current sensing resistor, supplied with each module, is connected to screw terminals 2 and 3. Sensor excitation of up to  $+6\text{V}$  is provided by the modules. Input protection of up to  $130\text{V}$  for the input and excitation screw terminals is provided in each device. The signal is then amplified and filtered to give the high level voltage output. Chopper based amplification is used to assure low drift and excellent long term stability. Both the voltage and current outputs can be independently adjusted over a  $\pm 5\%$  span range for zero and span with the front panel accessible potentiometers. The current output, which has  $130\text{V}$  input protection, interfaces with user equipment through screw terminal connections.

#### FINE CALIBRATION

The 3B13 is factory calibrated to operate over most of the full range of the AD590 ( $-55^{\circ}\text{C}$  to  $+130^{\circ}\text{C}$ ) and provides zero and span accuracy of  $\pm 0.1\%$  span. User accessible zero and span trim potentiometers providing a  $\pm 5\%$  adjustment range permit precise field calibration of both the voltage and current output. The two outputs are adjusted independently and are noninteractive. The following nonrecursive adjustment procedure is recommended:

1. Connect model 3B13 as shown in Figure 2.1.3.1 with  $R_L = 250\Omega$ .
2. Apply  $I_{IN} = 218.15\mu\text{A}$ , adjust  $V_Z$  for  $V_{OUT} = 0\text{V} \pm 10\text{mV}$  and  $I_Z$  for  $I_{OUT} = 4\text{mA} \pm 0.016\text{mA}$  or the measured voltage across  $R_L = +1\text{V} \pm 4\text{mV}$ .
3. Apply  $I_{IN} = 403.15\mu\text{A}$ , adjust  $V_S$  for  $V_{OUT} = +10\text{V} \pm 10\text{mV}$  and  $I_S$  for  $I_{OUT} = 20\text{mA} \pm 0.016\text{mA}$  or the measured voltage across  $R_L = +5\text{V} \pm 4\text{mV}$ .

If a 0-20mA output is desired,  $I_Z$  should be adjusted for  $0\text{mA} \pm 0.020\text{mA}$  in step 2 and  $I_S$  should be adjusted for  $I_{OUT} = 20\text{mA} \pm 0.020\text{mA}$  in step 3 (A typical minimum output current is  $10\mu\text{A}$  with 0-20mA operation).

The AD590 provides an output of  $1\mu\text{A}/^{\circ}\text{K}$  and the value of  $I_{IN}$  above is determined by the relation  $^{\circ}\text{K} = ^{\circ}\text{C} + 273.15$ . Thus for the AD590 range,  $-55^{\circ}\text{C} = 218.15^{\circ}\text{K}$  and  $+130^{\circ}\text{C} = 403.15^{\circ}\text{K}$ . The calibration is most readily accomplished with a current source and the AD590 could be used if it can be maintained at both reference temperatures.

The AD590 is available in many accuracy grades with calibration errors ranging from  $\pm 0.5^{\circ}\text{C}$  to  $\pm 10.0^{\circ}\text{C}$ . It is recommended that the higher quality grades be used (grades K, L or M) to assure that the 3B13 can be properly calibrated for system zero if desired. The accuracy of the 3B13 does not include sensor error.

#### OPTIONAL ZERO SUPPRESSION/CUSTOM CALIBRATION

A wide zero suppression capability and easy field calibration are available with a plug-on ranging card, AC1310. If a special input range is desired, it can be provided by ordering the

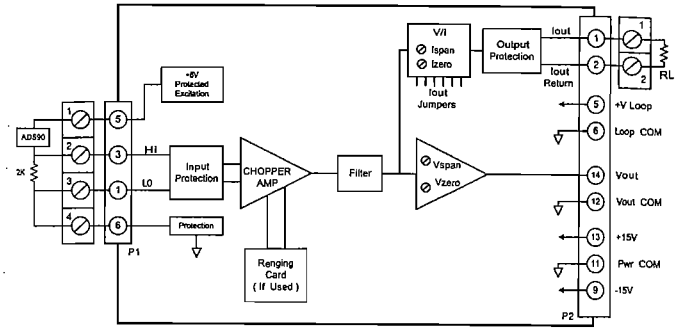


Figure 2.1.3.1 3B13 Functional Block Diagram

externally programmable version of the desired module (i.e., 3B13-00) and the AC1310 which houses user supplied resistors that determine the zero and span of the new range. A special range can also be factory configured. Consult the factory for details.

The 3B13 is designed for use with AD590/AC2626 temperature sensors, whose output is  $1\mu\text{A}$  per degree Kelvin. This current is converted to a voltage of  $2\text{mV}$  per  $^{\circ}\text{K}$  by a  $2\text{k}\Omega$  sensing resistor supplied with the 3B13. The 3B13 processes this signal exactly as would a 3B10, and the same rules for computing ranging components apply. However, it may be more convenient to work directly with the endpoint temperatures needed for an application. Use the following procedure:

1. Convert all temperatures to  $^{\circ}\text{K}$ .  
To convert from  $^{\circ}\text{C}$  to  $^{\circ}\text{K}$  add 273.  
To convert from  $^{\circ}\text{F}$  to  $^{\circ}\text{K}$ , multiply by  $5/9$  and add 255.2.  
To convert from  $^{\circ}\text{R}$  to  $^{\circ}\text{K}$ , multiply by  $5/9$
2. Compute the values for the gain setting resistors,  $R_1$  and the zero suppression resistors  $R_2$  and  $R_3A$ . If a  $0\text{V}$  to  $+10\text{V}$  output span is desired, the relations are:

$$\text{Gain Setting Resistor: } R_1 = \frac{\Delta T}{5000 - \Delta T} \times 10\text{k}\Omega$$

$$\text{Zero Suppression Resistors: } R_2 = T_{LO} \times 3.15\Omega$$

$$R_3A = 10\text{k}\Omega - R_2$$

Where  $T_{LO}$  is the Kelvin temperature that is to read  $0\text{V}_{OUT}$  and  $\Delta T$  is the total temperature from  $T_{LO}$  to the temperature that is to read  $+10\text{V}_{OUT}$ .

3. If an output range of other than 0 to  $+10\text{V}$  is desired, the following relations should be used:

$$\text{Gain Setting Resistor: } R_1 = \frac{\Delta T}{500\Delta V - \Delta T} \times 10\text{k}\Omega$$

$$\text{Zero Suppression Resistors: } R_2 = \frac{T_{LO} \Delta V - V_{LO} \Delta T}{\Delta V} \times 3.15\Omega$$

$$R_3A = 10\text{k}\Omega - R_2$$

Where  $T_{LO}$  is the Kelvin temperature at the low end of the measurement range that is to produce an output of  $V_{LO}$

$T_{HI}$  is the Kelvin temperature at the high end of the measurement range that is to produce an output of  $V_{HI}$ .

$\Delta T$  is the total temperature range ( $T_{HI} - T_{LO}$ )

$\Delta V$  is the total output span ( $V_{HI} - V_{LO}$ )

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24V dc power)

Model	3B13-01
Inputs	AD590 (-55°C to +130°C)
Outputs	0 to +10V (≈ 5mA) 4-20mA or 0-20mA (≈ R <sub>L</sub> = 0 to 850Ω <sup>1</sup> )
Maximum Current Output Span	0-31mA
Accuracy <sup>2</sup>	± 0.1% span
Nonlinearity	± 0.01% span
Stability vs. Ambient Temperature	
Voltage Output	
Zero	± 0.01 °C/°C
Span	± 0.0025% reading/°C
Current Output (w.r.t. Voltage Output)	
Zero	± 0.0025% span/°C
Span	± 0.0025% reading/°C
Normal Mode Rejection (@ 50Hz or 60Hz)	60dB
Differential Input Protection <sup>3</sup>	130V rms, cont.
Voltage Output Protection	Continuous Short to Ground
Current Output Protection	130V rms, cont.
Zero and Span Adjustment Range <sup>4</sup>	± 5% of span
Response Time to 90% Span	0.2sec
Input Resistance	100MΩ
Input Bias Current	3nA
Excitation Voltage	+6V
Input Noise	0.2μV rms at 10Hz bandwidth
Output Noise	50μV rms in 100kHz bandwidth
Bandwidth	3Hz (-3dB)
Power Supplies <sup>5</sup>	
± 15V Input Supplies Range	
(Rated Operation)	± (11.5V to 16.5V)
Supply Rejection	± 0.01% span/V
Supply Current	± 12mA
+ 24V Loop Supply Range	+ 12V to + 30V
Supply Rejection	0.0002% span/V
Supply Current	27mA (at + FS)
Size	3.150" × 0.775" × 3.395"
Environmental	
Temperature Range, Rated Performance	-25°C to +85°C
Storage Temperature Range	-55°C to +85°C
Relative Humidity Conforms to MIL Spec 202	0 to 95% (≈ 60°C noncondensing)
RFI Susceptibility	± 0.5% span error, 5W (≈ 400MHz (≈ 3 ft.

## NOTES

<sup>1</sup>For a 0-20mA range, a typical minimum output current is 10μA.

<sup>2</sup>Accuracy spec includes the combined effects of repeatability, hysteresis and linearity. Does not include sensor or signal source error.

<sup>3</sup>Includes excitation circuitry.

<sup>4</sup>A wide range of zero suppression and custom calibration may be accomplished with a custom ranging card, AC1310.

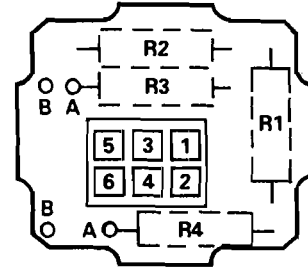
<sup>5</sup>+ 24V dc power is only needed for driving the current output at up to 850Ω. If only voltage output is used, or a current output load of 400Ω or less is desired, ± 15V is all that is required.

Specifications subject to change without notice.

## ORDERING INFORMATION

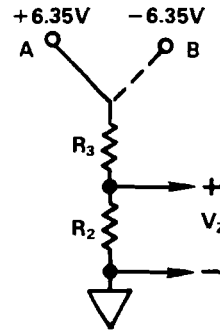
<b>Input Ranges</b>	<b>Model Number</b>
Externally Programmable	3B13-00
-55°C to +130°C	3B13-01
(-67°F to +266°F)	

4. R<sub>3</sub> should always go in location A. The total resistance of R<sub>2</sub> + R<sub>3</sub> should be approximately 10kΩ to avoid taking excessive current from the voltage reference or self heating in the resistors. If there is no zero suppression, (-273°K = 0V), R<sub>2</sub> should be a jumper and R<sub>3</sub> left open (see Figure 2.1.3.3.).



	GAIN SELECTION ONLY	GAIN AND ZERO SUPPRESSION
R <sub>1</sub>	Gain Resistor	Gain Resistor
R <sub>2</sub>	Jumper	Zero Suppression Resistor
R <sub>3A</sub>	Open	Zero Suppression Resistor
R <sub>4</sub>	Open	Open

Figure 2.1.3.2 3B13 Custom Ranging



R<sub>3</sub> should always go in location A.

Figure 2.1.3.3 3B13 Zero Suppression Resistors

## LIMITS

The ranging card can be used to create a wide range of special transfer functions, but there are practical limits that must be observed. For the 3B13, the maximum input at either the HI or LO input terminal is ± 6.6V with respect to output (system) common, which implies a 3.3mA current through the 2kΩ resistor. The range of the modules voltage output adjustment is at least ± 0.5V at the module output and can therefore correct any error less than 0.5V/Gain or 250μA/Gain with the 2kΩ external resistor.\* If possible, the resistors used should be 1% tolerance 10ppm. See Appendix A for a detailed discussion of limits, error contributions, and temperature effects of the ranging card.

\*With the AD590, there is 273°K of zero suppression for any range beginning at 0°C. This large amount of zero suppression limits the amount of gain that can be taken so that in general a practical temperature range may be 100°C.



## 2.1.4 MODELS 3B14 AND 3B15

### FEATURES

- Accepts RTD Inputs
- Linearized Outputs
- Sensor Excitation Provided
- Low Conformity Error
- Low Lead Resistance Effect

### FUNCTIONAL DESCRIPTION

The 3B14 and 3B15 are designed to accept a platinum RTD (Resistance Temperature Detector) input from the input screw terminals. The 3B14 accepts inputs from 2 or 3 wire RTDs while the 3B15 is specifically designed for 4 wire RTDs where high accuracy is required. The 3B14 provides automatic lead wire compensation to eliminate the effect of lead resistance from 3 wire sensors with an accuracy of  $\pm 0.02^\circ\text{C}/\Omega$ . The 3B15 provides automatic lead wire compensation for 4 wire sensors with an accuracy of  $\pm 0.00001^\circ\text{C}/\Omega$ . The RTD signal is internally linearized in each model to provide an output that is linear with temperature.

Figure 2.1.4.1 shows a functional diagram for models 3B14 and 3B15. A sensor excitation current of .25mA is provided by each module. Input protection of up to 130V for the input and excitation circuitry is provided. The signal is then amplified, linearized, and filtered to give the high level voltage output. Chopper based amplification is used to assure low drift and excellent long term stability. Both the voltage and current outputs can be independently adjusted over a  $\pm 5\%$  span range for zero and span with the front panel accessible potentiometers. The current output, which has 130V output protection, interfaces with user equipment through screw terminal connections.

### FINE CALIBRATION

Each model is factory calibrated for a specified range to provide zero and span accuracy of  $\pm 0.1\%$  of span. User accessible zero and span trim potentiometers providing a  $\pm 5\%$  adjustment range permit precise field calibration of both the voltage output and the current output. The two outputs are adjusted independently and are noninteractive. The following nonrecursive adjustment procedure is recommended:

1. Connect model 3B14 (3B15) as shown in Figure 2.1.4.1. with  $R_L = 250\Omega$ . Substitute a resistance standard for the RTD.
2. Determine the minimum and maximum resistance values of the platinum RTD from standard resistance/temperature tables. (For example, a measurement range of 0 to  $100^\circ\text{C}$  for a  $100\Omega$  platinum RTD corresponds to a resistance range of  $100.00\Omega$  to  $138.50\Omega$ .)
3. Connect the required minimum input resistance standard, adjust  $V_Z$  for  $V_{OUT} = 0V \pm 10\text{mV}$  and  $I_Z$  for  $I_{OUT} = 4\text{mA} \pm 0.016\text{mA}$  or the measured voltage across  $R_L = +1V \pm 4\text{mA}$ .
4. Connect the required maximum input resistance standard, adjust  $V_S$  for  $V_{OUT} = +10V \pm 20\text{mV}$  and  $I_S$  for  $I_{OUT} = 20\text{mA} \pm 0.016\text{mA}$  or the measured voltage across  $R_L = +5V \pm 4\text{mA}$ .

If a 0-20mA output is desired,  $I_Z$  should be adjusted for  $I_{OUT} = 0\text{mA} \pm 0.020\text{mA}$  in step 2 and  $I_S$  should be adjusted for  $I_{OUT} = 20\text{mA} \pm 0.020\text{mA}$  in step 3. (A typical minimum output current is  $10\mu\text{A}$  with 0-20mA operation).

### OPTIONAL ZERO SUPPRESSION/CUSTOM CALIBRATION

A wide zero suppression capability and easy field calibration are available with a plug-on ranging card, AC1310. If a special

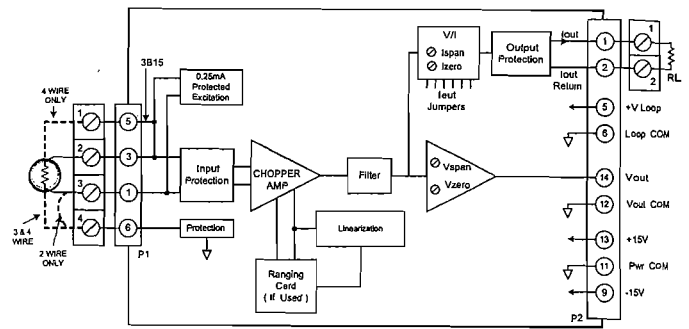


Figure 2.1.4.1 3B14 and 3B15 Functional Block Diagram

input range is desired, it can be provided by ordering the externally programmable version of the desired module (i.e., 3B14-00) and the AC1310 which houses user supplied resistors that determine the zero and span of the new range. A special range can also be factory configured. Consult the factory for details.

The ranging relations are identical for the 3B14 and 3B15. Ranging applications can be divided into two categories, depending on whether the module's internal linearizing circuit is used. If internal linearization is required, the following procedure applies:

1. The module's output voltage must always be positive since the linearizing circuit is active only for  $V_O > 0$ . The relations assume the use of a 0 to +10V output span. Other output ranges are possible, contact the factory for information on any other positive output range.
2. Any type of RTD can be used provided that its resistance does not exceed  $10\text{k}\Omega$  in the range of interest and its temperature characteristic is concave down. While virtually all RTDs have these properties, the conformity errors specified for these models apply specifically to  $100\Omega$  platinum RTDs following the European curve ( $\alpha = 0.00385$ ). Conformity errors for other RTD types can be supplied by the factory.
3. Ranging component values are found from:

$$\text{Gain Setting Resistor: } R_1 = \frac{20\text{k}\Omega}{G - 1}$$

$$\text{Zero Suppression Resistor: } 3\text{B15: } R_2 = R_Z \quad 3\text{B14: } R_3A = R_Z$$

$$\text{Linearization Resistor: } R_{4A} = \frac{Q - 1}{2 - Q} \times 20\text{k}\Omega$$

$$\text{Where Gain } G = 40\text{k}\Omega \times \left( \frac{1}{\Delta R_{MS}} - \frac{1}{\Delta R_{FS}} \right)$$

$R_Z$  = Resistance of the RTD at the temperature  $T_{MIN}$  that is to give  $V_O = 0V$

$$Q = \frac{\Delta R_{FS}}{\Delta R_{MS}} \quad (\text{a measure of nonlinearity})$$

$\Delta R_{FS}$  is the change in resistance from  $T_{MIN}$  to  $T_{MAX}$ , which will give  $V_O = +10V$

$\Delta R_{MS}$  is the change in resistance from  $T_{MIN}$  to  $T_{MID}$ , which will give  $V_O = +5V$

Figure 2.1.4.2 graphically shows the RTD values needed for ranging the 3B14 and 3B15 while Figure 2.1.4.3 depicts the mounting locations of the ranging resistors.

If internal linearization is not required, then the following procedure applies:

1. Output voltages at the endpoints of the span may be anywhere in the range of  $-10V$  to  $+10V$ .

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24V dc power)

Model	3B14	3B15
Inputs	100Ω Platinum RTD, 2 or 3 wire, α = 0.00385	100Ω Platinum RTD, 4 wire, α = 0.00385
Outputs	0 to +10V (α 5mA 4-20mA or 0-20mA (α R <sub>1</sub> = 0 to 850Ω <sup>1</sup> )	*
Maximum Current Output Range	0-31mA	*
Accuracy <sup>2</sup>	±0.1% span	*
Nonlinearity	±0.05% span	*
Stability vs. Ambient Temperature		
Voltage Output		
Zero	±0.005% °C/°C	*
Span	±0.0025% reading/°C	*
Current Output (w.r.t. Voltage Output)		
Zero	±0.0025% span/°C	*
Span	±0.0025% reading/°C	*
Lead Resistance Effect	±0.02°C/Ω	±0.00001 °C/Ω
Sensor Excitation Current	0.25mA	*
Normal Mode Rejection @ 50Hz or 60Hz	60dB	*
Differential Input Protection <sup>3</sup>	130V rms, cont.	*
Voltage Output Protection	Continuous Short to Ground	*
Current Output Protection	130V rms, cont.	*
Zero and Span Adjustment Range <sup>4</sup>	±5% of span	*
Response Time to 90% Span	0.2sec	*
Input Resistance	100MΩ	*
Input Bias Current	3nA	*
Input Noise	0.2μV rms at 10Hz bandwidth	*
Output Noise	50μV rms in 100kHz bandwidth	*
Bandwidth	3Hz(-3dB)	*
Power Supplies <sup>5</sup>		
±15V Input Supplies Range (Rated Operation)	±(11.5V to 16.5V)	*
Supply Rejection	±0.01% span/V	*
Supply Current	±20mA	*
+24V Loop Supply Range	+12V to +30V	*
Supply Rejection	0.0002% span/V	*
Supply Current	27mA (at +FS)	*
Size	3.150" × 0.775" × 3.395"	*
Environmental		
Temperature Range, Rated Performance	-25°C to +85°C	*
Storage Temperature Range	-55°C to +85°C	*
Relative Humidity Conforms to MIL Spec 202	0 to 95% (α 60°C noncondensing)	*
RFI Susceptibility	±0.5% span error, 5W (α 400MHz (α 3ft.	*

## NOTES

- <sup>1</sup>For a 0-20mA range, a typical minimum output current is 10μA.
  - <sup>2</sup>Accuracy spec includes the combined effects of repeatability, hysteresis and linearity. Does not include sensor or signal source error.
  - <sup>3</sup>Includes excitation circuitry.
  - <sup>4</sup>A wide range of zero suppression and custom calibration may be accomplished with a custom ranging card, AC1310.
  - <sup>5</sup>+24V dc power is only needed for driving the current output at up to 850Ω. If only voltage output is used, or a current output load of 400Ω or less is desired, ±15V is all that is required.
- \*Specifications same as 3B14.  
Specifications subject to change without notice.

## ORDERING INFORMATION

Range in °C	2 or 3 Wire RTD	4 Wire RTD
	α = 0.00385	α = 0.00385
Externally Programmable	3B14-00	3B15-00
-100 to +100	3B14-01	3B15-01
0 to +100	3B14-02	3B15-02
0 to +200	3B14-03	3B15-03
0 to +600	3B14-04	3B15-04

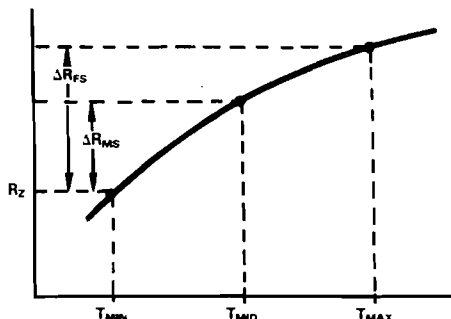
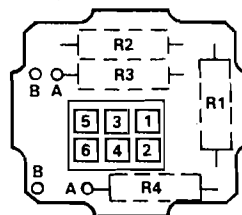


Figure 2.1.4.2 RTD Values Needed for Ranging Models 3B14 and 3B15



	GAIN SELECTION ONLY	GAIN AND ZERO SUPPRESSION	GAIN, ZERO SUPPRESSION AND LINEARIZATION
R <sub>1</sub>	Gain Resistor	Gain Resistor	Gain Resistor
R <sub>2</sub> *	Jumper	Zero Suppression Resistor	Zero Suppression Resistor
R <sub>3</sub>	Open	Open	Open
R <sub>4</sub>	Open	Open	Linearization Resistor

\*Zero Suppression for 3B14 Uses R<sub>4</sub>.

Figure 2.1.4.3 3B14 and 3B15 Custom Ranging

- Any type of RTD can be used provided that its resistance does not exceed 10kΩ in the measurement range of interest.
- Ranging components are computed from:

$$\text{Gain Setting Resistor: } R_1 = \frac{\Delta R_{FS}}{4000 V_{FS} - \Delta R_{FS}} \times 20k\Omega$$

$$\text{Zero Suppression Resistor: } 3B15: R_2 = R_Z \quad 3B14: R_3 = R_Z$$

Where  $R_Z$  = Resistance of the RTD at the temperature that is to give  $V_O = 0V$   
 $V_{FS}$  = Positive full scale output voltage desired  
 $\Delta R_{FS}$  = Change in RTD resistance from  $R_Z$  to the full scale temperature.

The fact that  $R_Z$  is set to the zero volt output point does not mean that negative outputs will not be meaningful; it just provides the simplest relation. Once  $R_1$  and  $R_Z$  are determined, the output voltage at any RTD temperature can be found, given the RTD's resistance at that temperature ( $R_{RTD}$ ), from the following relation:

$$V_O = (R_{RTD} - R_Z) \times 0.25mA \times G_V$$

$$\text{where } G_V = \frac{20k\Omega}{R_1} + 1$$

This relation is the general transfer function for the modules when linearization is not used.

## LIMITS

The ranging card can be used to create a wide range of special transfer functions, but there are practical limits that must be observed. The maximum RTD value that can be used with these modules is 10kΩ. The range of the module's voltage output adjustment is at least ±0.5V at the module output and can therefore correct any error less than 0.5V/Gain. If possible the ranging resistors used should be 1% tolerance, 10ppm while the linearization resistor can be a 50ppm part. See Appendix A for a detailed discussion of limits, error contributions, and temperature effects of the ranging card.

## 2.1.5 MODEL 3B16

### FEATURES

**Accepts Strain Gage Input  
Provides Bridge Excitation**

### FUNCTIONAL DESCRIPTION

The 3B16 is designed to accept inputs from full four arm bridge strain gage-type transducers on the input screw terminals. The 3B16 provides a constant +10V excitation and can be used with 300Ω to 1000Ω strain gage bridges. The module has a fixed 3Hz bandwidth to eliminate high frequency noise.

Figure 2.1.5.1 shows a functional diagram for the model 3B16. A constant bridge excitation voltage of +10V is provided on screw terminals 1 and 4. Input protection of up to 130V for the input and excitation circuitry is provided. The signal is then amplified and filtered to give the high level voltage output. Chopper based amplification is used to assure low drift and excellent long term stability. Both the voltage and current outputs can be independently adjusted over a ±5% span range for zero and span with the front panel accessible potentiometers. The current output, which has 130V output protection, interfaces with user equipment.

Model 3B16 requires a ground return for the input connection to return the bias current to ground.

### FINE CALIBRATION

The 3B16-01 is factory calibrated for a strain gage with a ±30mV span and provides a zero and span accuracy of ±0.1% of span. User accessible zero and span trim potentiometers providing a ±5% adjustment range permit precise field calibration of both the voltage output and the current output. The two outputs are adjusted independently and are noninteractive. The following nonrecursive procedure is recommended:

1. Connect model 3B16 as shown in Figure 2.1.5.1 with  $R_L = 250\Omega$ .
2. Apply  $V_{IN} = 0$  volts, adjust  $V_Z$  for  $V_{OUT} = 0V \pm 10mV$  and  $I_Z$  for  $I_{OUT} = 4mA \pm 0.016mA$  or the voltage measured across  $R_L = +1V \pm 4mV$ .
3. Apply  $V_{IN} = +30mV$ , adjust  $V_S$  for  $V_{OUT} = +10V \pm 10mV$  and  $I_S$  for  $I_{OUT} = 20mA \pm 0.016mA$  or the voltage measured across  $R_L = +5V \pm 4mV$ .

If a 0-20mA output is desired for a 0 to +10V output, adjust  $I_Z$  for  $I_{OUT} = 0mA \pm 0.020mA$  in step 2 and  $I_S$  for  $I_{OUT} = 20mA \pm 0.020mA$  in step 3. (A typical minimum output current is 10μA with 0-20mA operation).

If the current output is to be proportional to a -10V to +10V output instead of a 0 to +10V output,  $I_Z$  should be adjusted for a -30mV input in step 2.

### OPTIONAL ZERO SUPPRESSION/CUSTOM CALIBRATION

A wide zero suppression capability and easy field calibration are available with a plug-on ranging card, AC1310. If a special input range is desired, it can be provided by ordering the externally programmable version of the desired module (i.e., 3B10-00) and the AC1310 which houses user supplied resistors that determine the zero and span of the new range. A special range can also be factory configured. Consult the factory for details.

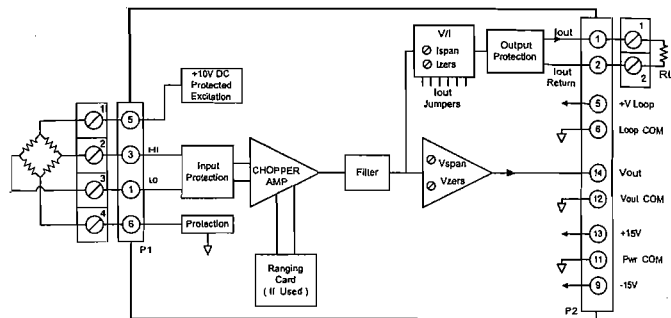


Figure 2.1.5.1 3B16 Functional Block Diagram

The basic transfer function of the 3B16:

$$V_O = G \times (V_{IN} - V_Z)$$

Where

$V_O$  = Output Voltage  
 $G$  = Gain  
 $V_{IN}$  = Input Voltage  
 $V_Z$  = Zero Suppression Voltage

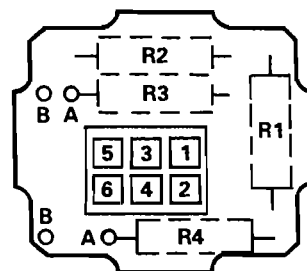
### GAIN SETTING RELATION

With the AC1310, the gain  $G$  is set by  $R_1$ , which forms part of an internal divider and is determined from the following relation:

3B16

$$R_1 = \frac{10k\Omega}{G - 1}$$

Gain  $G$  is a ratio of the change of output to the input change that produced it. If there is to be no zero suppression,  $R_2$  should be a jumper and  $R_3$  should be left open. These resistors should be installed as indicated in Figure 2.1.5.2.



	GAIN SELECTION ONLY	GAIN AND ZERO SUPPRESSION
$R_1$	Gain Resistor	Gain Resistor
$R_2$	Jumper	Zero Suppression Resistor
$R_3$	Open	Zero Suppression Resistor
$R_4$	Open	Open

Figure 2.1.5.2 3B16 Custom Ranging

### ZERO SUPPRESSION VOLTAGE

The zero suppression voltage,  $V_Z$ , can be set for any value between -6.35V and +6.35V through the use of  $R_2$  and  $R_3$  and is determined from the following relations:

$$V_Z = 6.35V \times \frac{R_2}{R_2 + R_3}$$

with the sign of  $V_Z$  determined by the choice of location A (positive) or location B (negative) for  $R_3$  (see Figure 2.1.5.3). The total resistance of ( $R_2 + R_3$ ) should be approximately

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24V dc power)

Model	3B16-01
Inputs	3mV/V
Outputs	±10V (α ±5mA) 4-20mA or 0-20mA (α R <sub>L</sub> = 0 to 850Ω <sup>1</sup> )
Maximum Current Output Range	0-31mA
Accuracy <sup>2</sup>	±0.1% span
Nonlinearity	±0.01% span
Stability vs. Ambient Temperature	
Voltage Output	
Zero	±1 μV/°C (RTI)
Span	±0.0030% reading/°C
Current Output (w. r. t. Voltage Output)	
Zero	±0.0025% span/°C
Span	±0.0025% reading/°C
Bridge Excitation	+10V
Bridge Resistance Range	300Ω to 1kΩ
Normal Mode Rejection (α 50Hz or 60Hz)	60dB
Differential Input Protection <sup>3</sup>	130V rms, cont.
Voltage Output Protection	Continuous Short to Ground
Current Output Protection	130V rms, cont.
Zero and Span Adjustment Range <sup>4</sup>	±5% of span
Response Time to 90% Span	0.2sec
Input Resistance	100MΩ
Input Bias Current	3nA
Input Noise	0.2μV rms at 10Hz bandwidth
Output Noise	50μV rms in 100kHz bandwidth
Bandwidth	3Hz (-3dB)
Power Supplies <sup>5</sup>	
±15V Input Supplies Range	
(Rated Operation)	±(12.7V to 16.5V)
Supply Rejection	±0.01% span/V
Supply Current	+45mA, -10mA
+24V Loop Supply Range	+12V to +30V
Supply Rejection	0.0002% span/V
Supply Current	27mA (at +FS)
Size	3.150" × 0.775" × 3.395"
Environmental	
Temperature Range, Rated Performance	-25°C to +85°C
Storage Temperature Range	-55°C to +85°C
Relative Humidity Conforms to MIL Spec 202	0 to 95% (α 60°C noncondensing)
RFI Susceptibility	±0.5% span error, 5W (α 400MHz (α 3ft.

## NOTES

<sup>1</sup>For a 0-20mA range, a typical minimum output current is 10μA.

<sup>2</sup>Accuracy spec includes the combined effects of repeatability, hysteresis and linearity. Does not include sensor or signal source error.

<sup>3</sup>Includes excitation circuitry.

<sup>4</sup>A wide range of zero suppression and custom calibration may be accomplished with a custom ranging card, AC1310.

<sup>5</sup>+24V dc power is only needed for driving the current output at up to 850Ω. If only voltage output is used, or a current output load of 400Ω or less is desired, ±15V is all that is required.

Specifications subject to change without notice.

## ORDERING INFORMATION

Input Ranges	Model Number
Externally Programmable	3B16-00
3mV/V	3B16-01

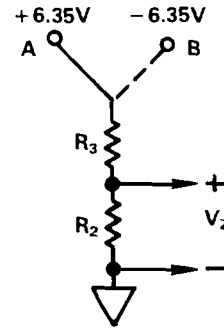


Figure 2.1.5.3 3B16 Zero Suppression Resistors

10kΩ to avoid taking excessive current from the voltage reference or self heating in the resistors. Using 10kΩ as the total value, R<sub>2</sub> and R<sub>3</sub> are determined from the following relations:

$$R_2 = \frac{V_Z}{6.35V} \times 10k\Omega$$

$$R_3 = 10k\Omega - R_2$$

## LIMITS

The ranging card can be used to create a wide range of special transfer functions, but there are practical limits that must be observed. The allowable input voltage for the 3B16 is 0 to +12V. The range of the module's voltage output adjustment is at least ±0.5V at the module output and can therefore correct any error less than 0.5V/Gain. If possible the resistors used should be 1% tolerance, 10ppm. See Appendix A for a detailed discussion of limits, error contributions, and temperature effects of the ranging card.

## 2.1.6 MODEL 3B17 FEATURES

**Accepts LVDT or RVDT Input**  
**Provides Complete LVDT Conditioning**  
**Provides 1kHz to 10kHz AC Excitation**  
**100Hz Bandwidth**  
**High Accuracy:  $\pm 0.1\%$**   
**Low Drift:  $\pm 0.01\%/^{\circ}\text{C}$**

### FUNCTIONAL DESCRIPTION

The 3B17 is a wideband input module that is designed to accept signals from 4, 5 or 6 wire LVDT or RVDT transducers. The 3B17 provides an ac excitation of 1-5V rms at frequencies ranging from 1kHz to 10kHz.

Figure 2.1.6.1 shows a block diagram for the 3B17. The ac excitation is provided on terminals 1 and 4. The amplitude and frequency of the ac excitation can be specified when ordered or can be configured externally with the AC1310 custom ranging card. Input protection of up to 130V is provided for the input and excitation circuitry. The signal is amplified to give the high level voltage output and automatically synchronously demodulated to correct for any phase shift errors from the primary to the secondaries of the LVDT, eliminating the need for a phase adjustment.

Unlike other 3B Series modules, all of the gain and zero suppression is accomplished with a screwdriver through the sliding door on top of the module. The gain adjustment has a 256:1 adjustment range which is accomplished with a combination of a digital gain set rotary switch for coarse adjustment and a fine trim potentiometer for precise calibration. The zero suppression is output referred and can adjust the output over  $\pm 5\text{V}$  from the center setting. After the voltage output is calibrated, the 130VAC protected current output can be independently adjusted over a  $\pm 5\%$  span range for zero and span with front panel accessible potentiometers. The current output is provided on screw terminal connections.

Historically, users of LVDTs have had to contend with various error terms. For example, quadrature voltages or null voltages are caused by interwinding capacitance and winding asymmetries. This error term is a residual ac voltage that appears at the differential output of the LVDT. It is called quadrature because it appears as a  $90^{\circ}$  out of phase voltage to the output signal. Another source of error is a fixed phase shift from the primary to the secondary of the LVDT. This error is often accounted for by synchronizing the demodulator on a phase shifted version of the excitation. In this approach the user must manually trim the phase of the demodulator and hope that the phase relationship does not shift with time or temperature.

The 3B17 uses a unique approach to compensate for these errors. The two secondary windings are identified as A and B in Figure 2.1.6.1, with the normal output being A - B. The function A + B is a voltage that is in phase with the secondaries and nearly invariant with the core displacement. Since this term is much larger than the quadrature voltage, it can be used to drive the demodulator directly. The 3B17 generates the A + B term by manipulating the A and A - B outputs. This approach automatically compensates for any phase error between the primary and secondaries of the LVDT and eliminates the need for a phase adjustment. It also rejects any residual quadrature voltages automatically. The 3B17 is the complete solution for your LVDT needs.

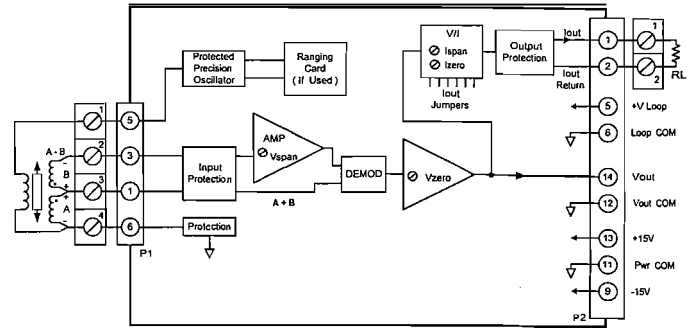


Figure 2.1.6.1 3B17 Functional Block Diagram

The 3B17 has the flexibility to address the broad array of LVDTs available with its extensive gain and zero adjustment range. The AC excitation is limited to a 20mA rms load which sets a lower circuit primary impedance of  $50\Omega$  for a 1V excitation and  $250\Omega$  for a 5V excitation. If the primary impedance of the LVDT is below  $50\Omega$ , the impedance of the LVDT can be increased by increasing the excitation frequency. This excitation capability addresses the vast majority of the LVDTs on the market.

### CALIBRATION

Each model, with the exception of the 3B17-00, is setup by the factory for a specified excitation voltage and frequency. The voltage output must be trimmed before the current output, because the large dynamic range of adjustment is accomplished in the voltage stage. Once the voltage output is calibrated, the current output can be independently adjusted. The following procedure is recommended:

1. Connect model 3B17 as shown in Figure 2.1.6.1 with  $R_L = 250\Omega$ , leaving the +EXC wire disconnected.
2. Adjust  $V_z$  for  $V_o = 0\text{V} \pm 10\text{mV}$
3. Connect the LVDT +EXC lead and adjust the mounting scheme so the voltage output is  $0\text{V} \pm 100\text{mV}$ . If minimal response to core position is noticed, first turn the rotary switch clockwise until full displacement of the core causes a change of several volts at the output. The dot is at minimum gain. Gain increases in the direction of the arrow on the face of the switch. This centers the LVDT core travel for maximum linearity.
4. Alternately position the core at both ends of travel and adjust the rotary switch to be close to the desired output span. Fine tune the span with the gain adjustment potentiometer. Each stop on the rotary switch represents a doubling of gain. Any gain in between two stops can be achieved by using the potentiometer.
5. Adjust  $V_z$  when the core position is at center to  $0\text{V} \pm 10\text{mV}$ . Adjust  $I_z = 4\text{mA} \pm 0.016\text{mA}$  or the voltage measured across  $R_L = 1\text{V} \pm 4\text{mV}$ .
6. Place the LVDT in the desired full scale output position and adjust  $I_s$  for  $I_{out} = 20\text{mA} \pm 0.016\text{mA}$  or the voltage measured occurs  $R_L = 5\text{V} \pm 4\text{mV}$ .

If a 0-20mA output is desired for a 0 to +10V output, adjust  $I_z$  for  $I_{out} = 0\text{mA} \pm 0.020\text{mA}$  in step 5 and  $I_s$  for  $I_{out} = 20\text{mA} \pm 0.020\text{mA}$  in step 6. A typical minimum output current is  $10\mu\text{A}$  with 0-20mA operation.

If the current output is to be proportional to a -10V to +10V output instead of 0 to +10V output,  $I_z$  should be adjusted for a - Full Scale input in step 5.

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24V dc power)

<b>Model</b>	3B17
<b>Inputs</b>	20mV rms - 5V rms
<b>Outputs<sup>1</sup></b>	±10V (at ±5mA and 4-20mA or 0-20mA @ R <sub>L</sub> = 850Ω)
<b>Maximum Current Output for Input Overload</b>	40mA
<b>Accuracy, when Calibrated<sup>2</sup></b>	±0.1% Span
<b>Nonlinearity</b>	±0.05% Span
<b>Stability vs. Ambient Temperatures</b>	
<b>Voltage Output<sup>3</sup></b>	
Zero	±0.005% Span/°C
Span	±0.01% Span/°C
<b>Current Output (w.r.t. Voltage Output)</b>	
Zero	±0.0025% Span/°C
Span	±0.0025% Reading/°C
<b>LVDT Excitation</b>	
Excitation Voltage	1V rms - 5V rms
Excitation Tolerance	±10%
Excitation Frequency	1kHz - 10kHz ±15%
Excitation Drive	Up to 20mA rms min
Excitation Harmonic Distortion	<0.5%
<b>Differential Input Protection<sup>4</sup></b>	130V rms, Continuous
<b>Voltage Output Protection</b>	Continuous Short to Ground
<b>Current Output Protection</b>	130V rms, Continuous
<b>Voltage Zero Adjustment Range</b>	±5V
<b>Voltage Span Adjustment Range</b>	256:1
<b>Current Zero/Span Adjustment Range</b>	±5% of Span
<b>Bandwidth<sup>5</sup></b>	100Hz
<b>Response Time to 90% Span</b>	5ms
<b>Input Resistance</b>	100MΩ
<b>Input Bias Current</b>	1μA
<b>Power Supplies<sup>6</sup></b>	
±15V Input Supplies Range (Rated Operation)	±(13V to 18V)
Supply Rejection	±0.03% Span/V
Supply Current <sup>7</sup>	±65mA max plus LVDT Current
+24V Loop Supply Range	+13.5V to +30V
Supply Rejection	0.001% Span/V
Supply Current	27mA (at +F.S.)
<b>Size</b>	3.150" × 0.775" × 3.395"
<b>Environmental</b>	
Temperature Range, Rated Performance	-25°C to +85°C
Storage Temperature Range	-55°C to +85°C
Relative Humidity Conforms to MIL Spec 202	0 to 95% @ 60°C Noncondensing
RFI Susceptibility	±0.5% Span Error 5W @ 400MHz @ 3ft.

## NOTES

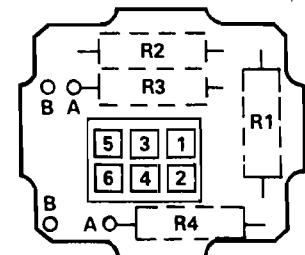
- <sup>1</sup>For a 0-20mA range, a typical minimum output current is 10μA.
  - <sup>2</sup>Accuracy spec includes the combined effects of repeatability, hysteresis and linearity. Does not include sensor error.
  - <sup>3</sup>Includes excitation drift.
  - <sup>4</sup>Includes excitation circuitry.
  - <sup>5</sup>Bandwidth can be set for up to 1/10 the excitation frequency when ordering a 3B17-CUSTOM.
  - <sup>6</sup>+24V dc power is only needed for driving the current output at up to 850Ω. If only voltage output is used, or a current output load of 400Ω or less is desired, ±15V is all that is required.
  - <sup>7</sup>Typical number is ±40mA per module plus ±5mA for LVDT drive current. Supply current requirements for LVDT current is 75% of the LVDT rms current.
- Specifications subject to change without notice.

## ORDERING INFORMATION

Excitation Voltage and Frequency	Model Number
Externally Programmable	3B17-00
3V rms @ 2.5kHz	3B17-01
5V rms @ 5kHz	3B17-02
5V rms @ 7.5kHz	3B17-03
1V rms @ 10kHz	3B17-04

The following models address differential coil applications.

Externally Programmable	3B17-D-00
3V rms @ 2.5kHz	3B17-D-01
5V rms @ 5kHz	3B17-D-02
5V rms @ 7.5kHz	3B17-D-03
1V rms @ 10kHz	3B17-D-04



### EXCITATION VOLTAGE AND FREQUENCY SELECTION

R <sub>1</sub>	Excitation Voltage
R <sub>2</sub>	Excitation Frequency
R <sub>3A</sub>	Excitation Frequency
R <sub>4A</sub>	Open

Figure 2.1.6.2 3B17 Custom Ranging

## MULTIPLE LVDT INSTALLATIONS

LVDTs are AC devices and have potential to cause interference between units. Careful installation may eliminate this in many cases. For a complete discussion of wiring practices in multiple LVDT installations, refer to Appendix B1.

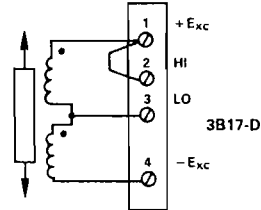
## SYNCHRONIZING MULTIPLE LVDTs

The 3B17 has the ability to synchronize its excitation with other 3B17s. For an extended discussion of that feature, please refer to Appendix B2.

## DIFFERENTIAL COIL CONDITIONING

The 3B17-D is a version of the 3B17 designed to address differential coil applications. The functional description and specifications are identical to the 3B17.

The 3B17-D must be connected as shown in the diagram below:



And, because the 3B17-D differential coil input module is intolerant of capacitive loads across the excitation terminal greater than 100pF, any capacitor across the entire differential coil must be removed.

## CUSTOM CONFIGURATION

A powerful custom-ranging capability is provided with a plug-on ranging card, AC1310. If a special excitation voltage or frequency is desired it can be provided by ordering the externally programmable version (3B17-00) and the AC1310 which houses the user supplied resistors that determine the excitation voltage and frequency of the new range. If possible, the excitation voltage resistor should be 1% tolerance, 10 ppm. The frequency resistors need only be 100 ppm. See Appendix A for a detailed discussion of limits of the ranging card. The excitation ranging flexibility and the wide calibration capability available with a standard 3B17 together provide the flexibility needed for the complete signal conditioning solution to virtually any LVDT requirement. The bandwidth of all standard 3B17s is 100Hz. A factory configured 3B17-CUSTOM can have a bandwidth that varies up to 1/10 the excitation frequency. A special range can also be factory configured with the excitation voltage settable between 1V and 5V and the excitation frequency can vary between 1kHz and 10kHz. Consult the factory for details.

## EXCITATION VOLTAGE SETTING RELATION

With the AC1310, the excitation voltage amplitude is set by R<sub>1</sub> which is determined from the following relation:

$$R_1 = \frac{10k\Omega \times V_{rms}}{7 - V_{rms}}$$

V rms is the desired rms amplitude of the oscillation, and it can be selected for any value between 1V and 5V. The accuracy of the excitation is ±10% with a harmonic distortion of less than 0.5%.

## EXCITATION FREQUENCY RELATION

The excitation frequency can be set for any value between 1kHz and 10kHz by resistors R<sub>2</sub> and R<sub>3A</sub>. These values are determined by the equation below:

$$R_2, R_{3A} = \frac{10^9}{f \times 6.3}$$

where f is the desired frequency of oscillation. These resistors should be installed as indicated in Figure 2.1.6.2.

### 2.1.7 MODEL 3B18

#### FEATURES

- Accepts Strain Gage Input
- 20kHz Bandwidth
- Provides Bridge Excitation
- Dual High Level Outputs
- Voltage:  $\pm 10V$
- Current: 4-20mA/0-20mA
- High Accuracy:  $\pm 0.1\%$
- Low Drift:  $\pm 3\mu V/^\circ C$
- Input Protection: 130V rms Continuous
- Reliable Pin and Socket Connections

#### FUNCTIONAL DESCRIPTION

The 3B18 is a wideband input module that is designed to accept signals from full four arm bridge strain gage-type transducers on the input screw terminals. The 3B18 provides a switch selectable excitation of +3.3V or +10.0V and can be used with 100 $\Omega$  to 10k $\Omega$  strain gage bridges. The module has a 20kHz bandwidth to interface to dynamic signals.

Figure 2.1.7.1 shows a block diagram for the model 3B18. A regulated bridge excitation of either +3.3V or +10.0V is provided on screw terminals 1 and 4. Input protection of up to 130V is provided for the input and excitation circuitry. The signal is amplified to give the high level voltage output. Both the voltage and current outputs can be independently adjusted over a  $\pm 5\%$  span range for zero and span with the front panel accessible potentiometers. The current output, which has 130V output protection, interfaces with user equipment through screw terminal connections.

Model 3B18 requires a ground return for the input connection to return the bias current to ground.

#### FINE CALIBRATION

Each model is factory calibrated for a specified range to provide zero and span accuracy of  $\pm 0.1\%$  of span. The excitation voltage should be used in the calibration setup since it has a  $\pm 2\%$  tolerance. User accessible zero and span trim potentiometers providing a  $\pm 5\%$  adjustment range permit precise field calibration of both the voltage output and the current output. The two outputs are adjusted independently and are noninteractive. The following nonrecursive procedure is recommended:

1. Connect model 3B18 as shown in Figure 2.1.7.1 with  $R_L = 250\Omega$ .
2. Apply  $V_{IN} = 0$  volts, adjust  $V_Z$  for  $V_{OUT} = 0V \pm 10mV$  and  $I_Z$  for  $I_{OUT} = 4mA \pm 0.016mA$  or the voltage measured across  $R_L = +1V \pm 4mV$ .
3. Apply  $V_{IN} = +$  Full Scale, adjust  $V_S$  for  $V_{OUT} = +10V \pm 10mV$  and  $I_S$  for  $I_{OUT} = 20mA \pm 0.016mA$  or the voltage measured across  $R_L = +5V \pm 4mV$ .

If a 0-20mA output is desired for a 0 to +10V output, adjust  $I_Z$  for  $I_{OUT} = 0mA \pm 0.020mA$  in step 2 and  $I_S$  for  $I_{OUT} = 20mA \pm 0.020mA$  in step 3. (A typical minimum output current is 10 $\mu A$  with 0-20mA operation).

If the current output is to be proportional to a -10V to +10V output instead of a 0 to +10V output,  $I_Z$  should be adjusted for a -Full Scale input in step 2.

#### CUSTOM CALIBRATION

A powerful custom ranging capability is provided with a plug-on ranging card, AC1310. If a special gain is desired, it

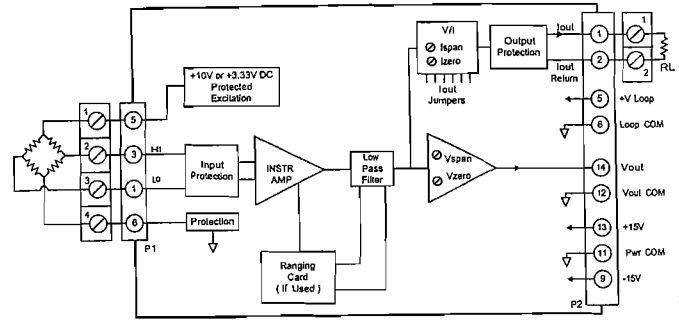


Figure 2.1.7.1 3B18 Functional Block Diagram

can be provided by ordering the externally programmable version of the desired module and the AC1310 which houses a user supplied resistor that determines the span of the new range. If desired, the 20kHz bandwidth can be reduced with user supplied capacitors installed in the AC1310. A special range can also be factory configured. Consult the factory for details.

The basic transfer function of the 3B18 is:

$$V_O = G \times V_{IN}$$

Where  $V_O =$  Output Voltage

$G =$  Gain

$V_{IN} =$  Input Voltage

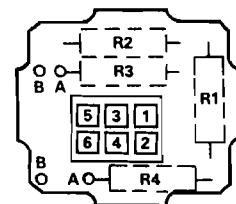
There is no provision for zero suppression beyond the  $\pm 5\%$  available with the zero potentiometers.

#### GAIN SETTING RELATION

With the AC1310, the gain  $G$  is set by  $R_{3A}$  which is determined from the following:

$$R_{3A} = \frac{200k\Omega}{G}$$

Gain  $G$  is a ratio of the change of output to the input change that produced it. If there is to be no bandwidth reduction,  $R_{4A}$  and  $R_1$  should be left open. The gain-setting resistor should be installed as indicated in Figure 2.1.7.2.



	GAIN SELECTION ONLY	GAIN SELECTION AND BANDWIDTH REDUCTION
$R_1$	Open	Filter Capacitor, $C_2$
$R_2$	Open	Open
$R_{3A}$	Gain Resistor	Gain Resistor
$R_{4A}$	Open	Filter Capacitor, $C_1$

Figure 2.1.7.2 3B18 Custom Ranging

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24V dc power)

<b>Model</b>	3B18
<b>Inputs</b>	
3B18-01	±30mV at 3mV/V Sensitivity
3B18-02	±10mV at 3mV/V Sensitivity
<b>Outputs</b>	±10V @ ±2mA
	4-20mA or 0-20mA @ R <sub>L</sub> = 0 to 850Ω <sup>1</sup>
<b>Maximum Current for Input Overload</b>	31mA
<b>Accuracy<sup>2</sup></b>	±0.1% span
<b>Nonlinearity</b>	±0.01% span
<b>Stability vs. Ambient Temperature</b>	
<b>Voltage Output</b>	
Zero	±3μV/°C (RTI)
Span	±0.0025% reading/°C
<b>Current Output (w.r.t. Voltage Output)</b>	
Zero	±0.0025% span/°C
Span	±0.0025% reading/°C
<b>Excitation Voltage</b>	±0.0015%/°C
<b>Bridge Excitation (User Selectable)</b>	+10V, +3.33V
<b>Excitation Tolerance</b>	±2%
<b>Bridge Resistance Range</b>	
@ V <sub>EXC</sub> = +10.0V	300Ω to 1kΩ
<b>Bridge Resistance Range</b>	
@ V <sub>EXC</sub> = +3.33V	100Ω to 10kΩ
<b>Common Mode Voltage, Input to Output</b>	±10V
<b>Common Mode Rejection @ 50Hz or 60Hz 1kΩ Source Unbalance</b>	100dB
<b>Differential Input Protection<sup>3</sup></b>	130V rms, Continuous
<b>Voltage Output Protection</b>	Continuous Short to Ground
<b>Current Output Protection</b>	130V rms, Continuous
<b>Zero and Span Adjustment Range<sup>4</sup></b>	±5% of span
<b>Bandwidth</b>	20kHz
<b>Response Time to 90% Span</b>	24μs
<b>Input Resistance</b>	100MΩ
<b>Input Bias Current</b>	25nA
<b>Power Supplies<sup>5</sup></b>	
±15V Input Supplies Range (Rated Operation)	±(13.5V to 16.5V)
Supply Rejection	±0.01% span/V
Supply Current	+50mA, -15mA
+24V Loop Supply Range	+13.5V to +30V
Supply Rejection	0.0002% span/V
Supply Current	27mA (at +FS)
<b>Size</b>	3.150" × 0.775" × 3.395"
<b>Environmental</b>	
<b>Temperature Range, Rated Performance</b>	-25°C to +85°C
<b>Storage Temperature Range</b>	-55°C to +85°C
<b>Relative Humidity Conforms to MIL Spec 202</b>	0 to 95% @ 60°C noncondensing
<b>RFI Susceptibility</b>	±0.5% span error, 5W @ 400MHz @ 3ft.

## NOTES

<sup>1</sup>For a 0-20mA range, a typical minimum output current is 10μA.

<sup>2</sup>Accuracy spec includes the combined effects of repeatability, hysteresis and linearity. Does not include sensor or signal source error.

<sup>3</sup>Includes excitation circuitry.

<sup>4</sup>Custom calibration may be accomplished with a custom ranging card, AC1310.

<sup>5</sup>+24V dc power is only needed for driving the current output at up to 850Ω. If only voltage output is used, or a current output load of 400Ω or less is desired, ±15V is all that is required.

Specifications subject to change without notice.

## ORDERING INFORMATION

Input Ranges	Model Number
Externally Programmable	3B18-00
±30mV, 3mV/V Sensitivity with 10V Excitation	3B18-01
±10mV, 3mV/V Sensitivity with 3.33V Excitation	3B18-02

## FREQUENCY RESPONSE

Model 3B18's standard bandwidth is 20kHz. The bandwidth can be set for any value less than 20kHz using the AC1310. The required capacitors, C<sub>1</sub> and C<sub>2</sub>, are determined from the following relations:

$$C_1 = 8.4 \mu\text{F}/F_C \quad \text{Note: For values of } C_1 \text{ below } 3\text{nF, reduce } C_1 \text{ by } 320\text{pF} \text{ and } C_2 \text{ by } 160\text{pF.}$$

$$C_2 = 4.2 \mu\text{F}/F_C$$

where F<sub>C</sub> is the desired cutoff frequency. Bipolar capacitors capable of withstanding ±10V should be used. The space limitations of the AC1310 must be considered when choosing the required capacitors. These capacitors are to be installed in the positions designated as R<sub>4A</sub> and R<sub>1</sub> respectively as indicated in Figure 2.1.7.2. The AC1310 can be used to reduce the bandwidth in factory ranged units.

## EXCITATION VOLTAGE SELECTION

The excitation voltage is selected by dip switches accessible behind the sliding door on the front of the module, just below the zero and span trim potentiometers. The switch settings for the excitation voltage are indicated in Table 2.1.7.1. No other combinations of switch settings are useful.

When the excitation terminals are open-circuited and the 3.33V excitation voltage is selected, the actual terminal voltage will rise to over 8V. This is not a harmful effect, but must be considered when the product is being tested. A load as small as 0.25mA will bring the voltage down to its specified value.

Excitation Voltage	Switch 1	Switch 2
10.0V	OFF	ON
3.33V	ON	OFF

Table 2.1.7.1 3B18 Excitation Voltage Switch Selections

## LIMITS

The ranging card can be used to create a wide range of special transfer functions, but there are practical limits that must be observed. The allowable input voltage for the 3B18 is ±10V. The range of the module's voltage output adjustment is at least +0.5V at the module output and can, therefore, correct any input offset error of less than 0.5V/Gain. If possible, the resistor should be 1% tolerance, 10ppm. See Appendix A for a detailed discussion of limits, error contributions, and temperature effects of the ranging card.



## Model 3B20

### FEATURES

**Accepts Strain Gage or Torque Transducer Inputs**  
**Provides Complete Strain Gage Conditioning**  
**Provides 1kHz to 10kHz AC Excitation**  
**Dual High Level Outputs**  
**Voltage:  $\pm 10V$**   
**Current: 4-20mA / 0-20mA**  
**High Accuracy:  $\pm 0.1\%$**   
**Low Drift:  $\pm 0.01\%/^{\circ}C$**   
**100Hz Bandwidth**

### FUNCTIONAL DESCRIPTION:

The 3B20 is a wideband input module that is designed to interface to four arm bridge transducers. The 3B20 provides an ac excitation of 2-10V rms at frequencies ranging from 1kHz to 10KHz. This module can accept inputs from 1.5mV rms to 150mV rms, accommodating most four arm bridge values.

Figure 1 is a functional block diagram for the 3B20. The ac excitation is provided on terminals 1 and 4. The amplitude and frequency of the ac excitation can be specified when ordered or can be configured externally with the AC1310 custom ranging card. Protection of up to 130V rms is provided for the input and the excitation circuitry. The signal is amplified to give the high level voltage output. The gain of the module can be a standard range, custom range or user configured with the AC1310. Both the current and voltage outputs can be adjusted by potentiometers for a minimum of 25% of the span range and  $\pm 1V$  for the zero adjustment. The current output, which has 130V output protection, interfaces with user equipment through screw terminal connections. In order to compensate for any phase shift between the excitation signal and the output signal from the transducer, a phase adjustment potentiometer is included in the front window of the module.

### 3B20 FINE CALIBRATION:

Each model, with the exception of the 3B20-00, is set up by the factory for a specified excitation voltage and frequency. The voltage and current outputs must be finely calibrated and the phase adjustment must be set for a specific transducer. The voltage output must be trimmed before the current output because the large dynamic range of adjustment is accomplished in the voltage stage. Once the voltage output is calibrated the current output can be

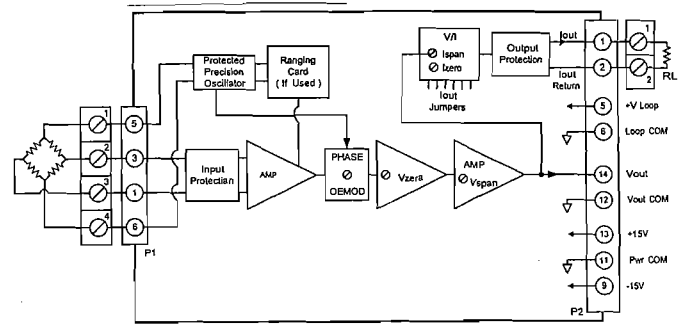


Figure 1 3B20 Functional Block Diagram

independently adjusted. The following procedure is recommended.

1. Connect the 3B20 as shown in the block diagram, with  $R_L = 250\Omega$ . Rotate the  $\emptyset$  adjustment counterclockwise until it clicks. This is zero phase adjustment. Apply a load or torque to the transducer that is at least 25% of full scale. Adjust  $\emptyset$  for the maximum  $V_{out}$ . This will compensate for any phase errors in the transducer.
2. Remove all load or torque from the transducer and adjust  $V_z$  for  $V_{out} = 0V \pm 10mV$ .
3. Connect a full load to the transducer and adjust  $V_s$  for  $V_{out} = 10.0V \pm 10mV$ .
4. Remove all load or torque from the transducer and adjust  $I_z$  for  $4mA \pm 0.016mA$  or the voltage measured across  $R_L = +1V \pm 4mV$ .
5. Connect a full load to the transducer and adjust  $I_s$  for  $I_{out} = 20mA \pm 0.16mA$  or the voltage measured across  $R_L = +5V \pm 4mV$ .

If a 0 - 20mA output is desired for a 0 to +10V output, adjust  $I_z$  for  $I_{out} = 0mA \pm 0.020mA$  in step 4 and  $I_s$  for  $I_{out} = 20mA \pm 0.020mA$  in step 5. A typical minimum output current is  $10\mu A$  with 0 - 20mA operation.

If the current output is to be proportional to a -10V to +10V output instead of a 0 to +10V output,  $I_z$  should be adjusted for a - Full Scale input in step 4.

### CUSTOM CONFIGURATION:

A powerful custom-ranging capability is provided with a plug-on ranging card, AC1310. If a special excitation voltage or frequency or module gain is desired it can be provided by ordering the externally programmable version (3B20-00) and the AC1310 which houses the user supplied resistors that determine the excitation voltage and frequency and the module's gain. The bandwidth of all standard 3B20's is 100Hz. A factory configured 3B20-CUSTOM can have a bandwidth that varies up to 1/10 the excitation frequency.

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24Vdc power)

<b>Model</b>	<b>3B20</b>
<b>Inputs</b>	1.5mV rms - 150mV rms
<b>Minimum Sensitivity</b>	.75mV/V
<b>Outputs<sup>1</sup></b>	±1.0V @ +5mA and 4-20mA or 0-20mA @ RL = 850Ω
<b>Maximum Current Output for Input Overload</b>	40mA
<b>Accuracy<sup>2</sup></b>	±0.1% Span
<b>Nonlinearity</b>	±0.05% Span
<b>Stability vs. Ambient Temperature</b>	
<b>Voltage Output<sup>3</sup></b>	
Zero	±0.005% Span/°C
Span	±0.01% Span/°C
<b>Current Output (wrt Voltage Output)</b>	
Zero	±0.0025% Span/°C
Span	±0.0025% Reading/°C
<b>Excitation</b>	
<b>Voltage</b>	2V rms - 10V rms
<b>Voltage Tolerance</b>	±2.5%
<b>Frequency</b>	1kHz - 10kHz
<b>Excitation Drive</b>	Up to 20mA rms min
<b>Excitation Harmonic Distortion</b>	<0.5%
<b>Differential Input Protection<sup>4</sup></b>	130V rms, Continuous
<b>Voltage Output Protection</b>	Continuous Short to Ground
<b>Current Output Protection</b>	130V rms, Continuous
<b>Span Adjustment<sup>5</sup></b>	±25% of span, minimum
<b>Zero Adjustment<sup>6</sup></b>	±1V, minimum
<b>Phase Adjustment Range</b>	0 - 4.25° min @ 1kHz 0 - 14° min @ 3.28kHz 0 - 37.25° min @ 10kHz
<b>Bandwidth<sup>7</sup></b>	100Hz
<b>Response Time to 90%</b>	5ms
<b>Input Resistance</b>	100MΩ
<b>Input Bias Current</b>	10nA
<b>Power Supplies<sup>8</sup></b>	
±15V Input Supply Range	±(13V to 18V)
Supply Rejection	±0.03% Span/V
Supply Current	±65mA max plus excitation current
+24V Loop Supply Range	+13.5V to +30V
Supply Rejection	0.001% Span/V
Supply Current	27mA (at +FS)
<b>Size</b>	3.150" x 0.775" x 3.395"
<b>Environmental</b>	
<b>Temperature Range, Rated</b>	-25°C to +85°C
<b>Storage Temperature</b>	-55°C to +85°C
<b>Relative Humidity</b>	0 to 95% @ 60°C Noncondensing
<b>RPI Susceptibility</b>	+0.5% Span Error 5W @ 400Hz @ 3ft.

## NOTES:

- Output open is 20 Volts
- For a 0-20mA range, a typical minimum output current is 10µA.
  - Accuracy spec includes the combined effects of repeatability, hysteresis and linearity.
  - Includes excitation distn.
  - Includes excitation circuitry.
  - Custom calibration may be accomplished with a custom ranging card, AC1318.
  - Bandwidth can be set for up to 1/10 the excitation frequency when ordering a 3B20-custom.
  - +24V dc power is only needed for driving the current output at up to 1.50Ω. If only voltage output is used, or a current output load of 400Ω or less is desired, ±15V is all that is required.

Specifications subject to change without notice.

## ORDERING INFORMATION

Model Number	Excitation and Sensitivity
3B20-00	Externally Programmable
3B20-01	5Vrms @ 3kHz, 2mV/V

## GAIN SETTING RELATION

The gain G is set by R4B which is determined from the following equation:

$$R4B = 20k * V_{rms} FS / (1.11 - V_{rms} FS)$$

(VrmsFS = Full Scale rms Input)

## EXCITATION VOLTAGE SETTING RELATION

With the AC1310, the excitation voltage amplitude is set by R1 which is determined from the relation:

$$R1 = (10k\Omega * V_{rms}) / (14.33V - V_{rms})$$

Vrms is the desired rms amplitude of the oscillation, and it can be selected for any value between 1V and 10V.

## EXCITATION FREQUENCY RELATION

The excitation frequency can be set for any value between 1kHz and 10kHz by resistors R2 and R3A. These values are determined by the equation below:

$$R2, R3A = 10^4 / (f * 6.3)$$

where f is the desired frequency of oscillation. These resistors should be installed as indicated in figure 2.

## LIMITS

The ranging card can be used to create a wide range of special transfer functions, but there are practical limits that must be observed. The allowable limit for the excitation voltage is 2Vrms to 10Vrms and 1kHz to 10kHz. The allowable input voltage for the 3B20 is ±150mV rms. The range of the module's voltage output adjustment is at least +0.5V at the module output and can, therefore, correct any input offset error of less than 0.5V/Gain for the 3B20. If possible the resistors used should be 1% tolerance, 10ppm. See Appendix A for a detailed discussion of limits, error contributions, and temperature effects of the ranging card.

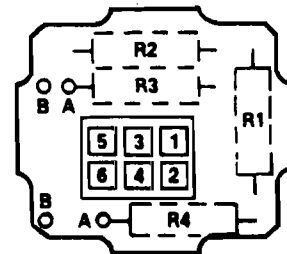


Figure 2 3B20 Custom Ranging

## Gain, Excitation Voltage and Frequency Selection

R1	Excitation Amplitude
R2	Excitation Frequency
R3A	Excitation Frequency
R4B	Gain

## 2.1.8 MODELS 3B30 AND 3B31

### FEATURES

#### Accepts Millivolt and Volt Inputs

3B30:  $\pm 10\text{mV}$  to  $\pm 100\text{mV}$

3B31:  $\pm 1\text{V}$  to  $\pm 10\text{V}$

#### Reliable Transformer Isolation

$\pm 1500\text{V}$  CMV

160dB CMR

Meets IEEE-STD 472: Transient Protection (SWC)

### FUNCTIONAL DESCRIPTION

Model 3B30 is an isolated millivolt input device that is designed to accept millivolt signals ranging from  $\pm 10\text{mV}$  to  $\pm 100\text{mV}$ . Model 3B31 is an isolated voltage input device that is designed to accept voltage signals ranging from  $\pm 1\text{V}$  to  $\pm 10\text{V}$ .

Figure 2.1.8.1 shows a functional diagram for models 3B30 and 3B31. Input protection of up to 220V is provided on the input screw terminals. The signal is then amplified and filtered to give the high level voltage output. Chopper based amplification is used to assure low drift and excellent long term stability. Transformer coupling is used to achieve stable, galvanic isolation between input and output. Both the voltage and current outputs can be independently adjusted over a  $\pm 5\%$  span range for zero and span with the front panel accessible potentiometers. The current output, which has a 130V output protection, interfaces with user equipment through screw terminal connections.

### FINE CALIBRATION

Each model is factory calibrated for a specified range to provide zero and span accuracy of  $\pm 0.1\%$  of span. User accessible zero and span trim potentiometers providing a  $\pm 5\%$  adjustment range permit precise field calibration of both the voltage output and the current output. The two outputs are adjusted independently and are noninteractive. The following nonrecursive adjustment procedure is recommended:

1. Connect model 3B30 (3B31) as shown in Figure 2.1.8.1 with  $R_L = 250\Omega$ .
2. Apply  $V_{IN} = 0$  volts, adjust  $V_Z$  for  $V_{OUT} = 0\text{V} \pm 10\text{mV}$  and  $I_Z$  for  $I_{OUT} = 4\text{mA} \pm 0.016\text{mA}$  or the measured voltage across  $R_L = +1\text{V} \pm 4\text{mV}$ .
3. Apply  $V_{IN} = +$  Full Scale adjust  $V_S$  for  $V_{OUT} = +10\text{V} \pm 10\text{mV}$  and  $I_S$  for  $I_{OUT} = 20\text{mA} \pm 0.016\text{mA}$  or the measured voltage across  $R_L = +5\text{V} \pm 4\text{mV}$ .

If a 0-20mA output is desired for a 0 to +10V output, adjust  $I_Z$  for  $I_{OUT} = 0\text{mA} \pm 0.020\text{mA}$  in step 2 and  $I_S$  for  $I_{OUT} = 20\text{mA} \pm 0.020\text{mA}$  in step 3. (A typical minimum output current is  $10\mu\text{A}$  with 0-20mA operation).

If the current output is to be proportional to a  $-10\text{V}$  to  $+10\text{V}$  output instead of a 0 to +10V output,  $I_Z$  should be adjusted for a  $-$  Full Scale input in step 2.

### OPTIONAL ZERO SUPPRESSION/CUSTOM CALIBRATION

A wide zero suppression capability and easy field calibration are available with a plug-on ranging card, AC1310. If a special input range is desired, it can be provided by ordering the externally programmable version of the desired module (i.e., 3B30-00) and the AC1310 which houses user supplied resistors that determine the zero and span of the new range. A special

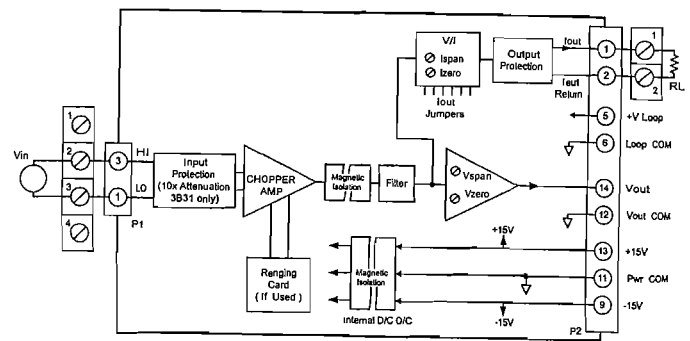


Figure 2.1.8.1 3B30 and 3B31 Functional Block Diagram

range can also be factory configured. Consult the factory for details.

The basic transfer function of both the 3B30 and 3B31 is:

$$V_O = G \times (V_{IN} - V_Z)$$

Where

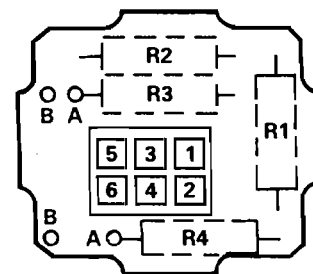
- $V_O$  = Output Voltage
- $G$  = Gain
- $V_{IN}$  = Input Voltage
- $V_Z$  = Zero Suppression Voltage

### GAIN SETTING RELATION

With the AC1310, the gain  $G$  is set by  $R_1$ , which forms part of an internal divider and is determined from the following relation:

$$\begin{array}{ll} \text{3B30} & \text{3B31} \\ R_1 = \frac{40\text{k}\Omega}{G-2} & R_1 = \frac{4\text{k}\Omega}{G-0.2} \end{array}$$

Gain  $G$  is a ratio of the change of output to the input change that produced it. Model 3B31 is a 3B30 with a  $10\times$  normal mode input attenuator. The attenuation is done before the zero suppression or gain, which causes a change in these relations. If there is to be no zero suppression,  $R_2$  should be a jumper and  $R_3$  should be left open. These resistors should be installed as indicated in Figure 2.1.8.2.



	GAIN SELECTION ONLY	GAIN AND ZERO SUPPRESSION
$R_1$	Gain Resistor	Gain Resistor
$R_2$	Jumper	Zero Suppression Resistor
$R_3$	Open	Zero Suppression Resistor
$R_4$	Open	Open

Figure 2.1.8.2 3B30 and 3B31 Custom Ranging

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24V dc power)

	3B30	3B31
Model	3B30	3B31
Inputs	±10mV to ±100mV	±1V to ±10V
Outputs	±10V @ ±5mA +20mA or 0-20mA @ R <sub>L</sub> = 0 to 850Ω <sup>1</sup>	*
Maximum Current Output Range	0-31mA	*
Accuracy <sup>2</sup>	±0.1% span	*
Nonlinearity	±0.01% span	*
Stability vs. Ambient Temperature		
Voltage Output		
Zero	±1μV/°C (RTI)	±0.0025% span/°C
Span	±0.0025% reading/°C	*
Current Output (w.r.t. Voltage Output)		
Zero	±0.0025% span/°C	*
Span	±0.0025% reading/°C	*
Common Mode Voltage, Input to Output	±1500V pk max	*
Common Mode Rejection @ 50Hz or 60Hz		
1kΩ Source Unbalance	160dB	160dB <sup>3</sup>
Normal Mode Rejection @ 50Hz or 60Hz	60dB	*
Differential Input Protection	220V rms, cont.	*
Voltage Output Protection	Continuous Short to Ground	*
Current Output Protection	130V rms, cont.	*
Zero and Span Adjustment Range <sup>4</sup>	±5% of span	*
Response Time to 90% Span	0.2sec	*
Input Transient Protection	Meets IEEE-STD 472 (SWC)	*
Input Resistance	15MΩ	650kΩ
Input Bias Current	3nA	*
Input Noise	0.2μV rms at 10Hz bandwidth	*
Output Noise	50μV rms in 100kHz bandwidth	*
Bandwidth	3Hz (-3dB)	*
Power Supplies <sup>5</sup>		
±15V Input Supplies Range (Rated Operation)	±(11.5V to 16.5V)	*
Supply Rejection	±0.01% span/V	*
Supply Current	±10mA	*
+24V Loop Supply Range	+12V to +30V	*
Supply Rejection	0.0002% span/V	*
Supply Current	27mA (at +FS)	*
Size	3.150" × 0.775" × 3.395"	*
Environmental		
Temperature Range, Rated Performance	-25°C to +85°C	*
Storage Temperature Range	-55°C to +85°C	*
Relative Humidity Conforms to MIL Spec 202	0 to 95% @ 60°C noncondensing	*
RFI Susceptibility	±0.5% span error, 5W @ 400MHz @ 3 ft.	*

## NOTES

- <sup>1</sup>For a 0-20mA range, a typical minimum output current is 10μA.
  - <sup>2</sup>Accuracy spec includes the combined effects of repeatability, hysteresis and linearity. Does not include sensor or signal source error.
  - <sup>3</sup>Models 3B31-02 and 3B31-03 have CMR values of 150dB and 145dB respectively.
  - <sup>4</sup>A wide range of zero suppression and custom calibration may be accomplished with a custom ranging card, AC1310.
  - <sup>5</sup>+24V dc power is only needed for driving the current output at up to 850Ω. If only voltage output is used, or a current output load of 400Ω or less is desired, -15V is all that is required.
- \*Specifications same as 3B30.  
Specifications subject to change without notice.

## ORDERING INFORMATION

Input Range	Model Number
Low Level,	
Externally Programmable	3B30-00
±10mV	3B30-01
±50mV	3B30-02
±100mV	3B30-03
High Level,	
Externally Programmable	3B31-00
±1V	3B31-01
±5V	3B31-02
±10V	3B31-03

## ZERO SUPPRESSION VOLTAGE

The zero suppression voltage,  $V_Z$ , can be set for any value between -3.175V and +3.175V for the 3B30 and -31.75V to +31.75V for the 3B31 through the use of  $R_2$  and  $R_3$  and is determined from the following relations:

$$V_Z = 3.175V \times \frac{R_2}{R_2 + R_3} \quad \text{3B30} \quad V_Z = 31.75V \times \frac{R_2}{R_2 + R_3} \quad \text{3B31}$$

with the sign of  $V_Z$  determined by the choice of location A (positive) or location B (negative) for  $R_3$  (see Figure 2.1.8.3). The total resistance of ( $R_2 + R_3$ ) should be approximately 10kΩ to avoid taking excessive current from the voltage reference or self heating in the resistors. (For the 3B31, the 31.75V term is a function of the 10× attenuation of the input signal. The internal voltage reference is 3.175V and high watt resistors are not required for zero suppression). Using 10kΩ as the total value,  $R_2$  and  $R_3$  are determined from the following relations:

$$R_2 = \frac{V_Z}{3.175V} \times 10k\Omega \quad \text{3B30} \quad R_2 = \frac{V_Z}{31.75V} \times 10k\Omega \quad \text{3B31}$$

$$R_3 = 10k\Omega - R_2 \quad \text{3B30} \quad R_3 = 10k\Omega - R_2 \quad \text{3B31}$$

REF:

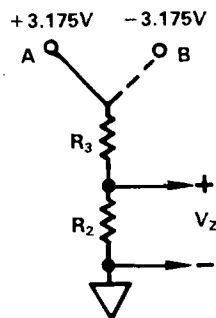


Figure 2.1.8.3 3B30 and 3B31 Zero Suppression Resistors

## LIMITS

The ranging card can be used to create a wide range of special transfer functions, but there are practical limits that must be observed. For the 3B30, the maximum differential input voltage for normal linear operation is ±1V. For the 3B31, the maximum differential input voltage for normal linear operation is ±20V. The range of the voltage output adjustment is at least ±0.5V at the module output and can therefore correct any input offset error of less than 0.5V/Gain for the 3B30 and 5V/Gain for the 3B31. If possible the resistors used should be 1% tolerance, 10ppm. See Appendix A for a detailed discussion of limits, error contributions, and temperature effects of the ranging card.

## 2.1.9 MODEL 3B34

### FEATURES

- Accepts RTD Inputs
- Linearized Outputs
- Sensor Excitation Provided
- Reliable Transformer Isolation
- ± 1500V CMV
- 160dB CMR
- Meets IEEE-STD 472: Transient Protection (SWC)
- Low Conformity Error
- Low Lead Resistance Effect

### FUNCTIONAL DESCRIPTION

The 3B34 provides 3 wire lead resistance compensation and can be connected to 2, 3, or 4 wire 100Ω platinum RTDs (Resistance Temperature Detectors), 2 or 3 wire 10Ω copper RTDs, and 2, 3, or 4 wire 120Ω nickel RTDs. The automatic lead wire compensation eliminates the effect of lead resistance from 3 wire sensors with an accuracy of ± 0.02°C/Ω. Platinum and nickel RTD signals are internally linearized. Copper RTDs are linear devices.

Figure 2.1.9.1 shows a functional diagram for model 3B34. A sensor excitation current is provided for each module: 0.25mA for platinum and nickel RTDs, 1.0mA for copper RTDs. Input protection of up to 220V for the input and excitation circuitry is provided. The signal is then amplified, linearized, and filtered to give the high level voltage output. Chopper based amplification is used to assure low drift and excellent long term stability. Transformer coupling is used to achieve stable galvanic isolation between input and output. Both the voltage and current outputs can be independently adjusted over a ± 5% span range for zero and span with the front panel accessible potentiometers. The current output, which has 130V output protection, interfaces with user equipment through screw terminal connections.

### FINE CALIBRATION

The 3B34 is factory calibrated for a specified range to provide zero and span accuracy of ± 0.1% of span. User accessible zero and span trim potentiometers providing a ± 5% adjustment range permit precise field calibration of both the voltage output and the current output. The two outputs are adjusted independently and are noninteractive. The following nonrecursive adjustment procedure is recommended:

1. Connect model 3B34 as shown in Figure 2.1.9.1 with  $R_L = 250\Omega$ . Substitute a resistance standard for the RTD.
2. Determine the minimum and maximum resistance values of the RTD from standard resistance/temperature tables. (For example, a measurement range of 0 to 100°C for a 100Ω platinum RTD corresponds to a resistance range of 100.00Ω to 138.50Ω.)
3. Connect the required minimum input resistance standard, adjust  $V_Z$  for  $V_{OUT} = 0V \pm 10mV$  and  $I_Z$  for  $I_{OUT} = 4mA \pm 0.016mA$  or the measured voltage across  $R_L = +1V \pm 4mV$ .
4. Connect the required maximum input resistance standard, adjust  $V_S$  for  $V_{OUT} = +10V \pm 10mV$  and  $I_S$  for  $I_{OUT} = 20mA \pm 0.016mA$  or the measured voltage across  $R_L = +5V \pm 4mV$ .

If a 0-20mA output is desired,  $I_Z$  should be adjusted for  $0mA \pm 0.020mA$  in step 2 and  $I_S$  should be adjusted for  $I_{OUT} = 20mA \pm 0.020mA$  in step 3. (A typical minimum output current is 10μA with 0-20mA operation).

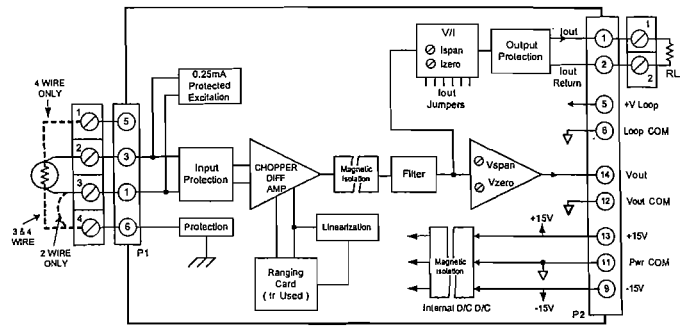


Figure 2.1.9.1 3B34 Functional Block Diagram

### OPTIONAL ZERO SUPPRESSION/CUSTOM CALIBRATION

A wide zero suppression capability and easy field calibration are available with a plug-on ranging card, AC1310. A special input range can be provided by ordering the externally programmable version of the desired module (i.e., 3B34-00) and the AC1310 which houses user supplied resistors that determine the new range. A special range can also be factory configured. Consult the factory for details.

For platinum and nickel RTD applications where internal linearization is required, the following relations determine the values of the custom ranging components. These relations assume the use of a 0 to +10V output span. Contact the factory for information on any other output range.

Linearization Resistor:

$$3B34-00 \quad R_4A = \left[ \frac{Q-1}{(2-Q) \times 1.7} - 1 \right] \times 25k\Omega$$

$$3B34-N-00 \quad R_4A = \left[ \frac{Q-1}{(Q-2) \times 1.85} - 1 \right] \times 28.3k\Omega$$

Gain Setting Resistor:  $R_1 = 20k\Omega \left( \frac{G}{1-G} \right)$

### Zero Suppression

Resistor:  $R_3A = R_Z$

Where  $Q = \frac{\Delta R_{FS}}{\Delta R_{MS}}$  (a measure of nonlinearity)

$R_Z$  = Resistance of the RTD at the temperature  $T_{MIN}$  that is to give  $V_O = 0V$

$$G = \frac{\Delta R_{FS}}{2 \times 10^4} \left( \frac{1}{Q-1} \right)$$

$\Delta R_{FS}$  is the change in resistance from  $T_{MIN}$  to  $T_{MAX}$ , which will give  $V_O = +10V$

$\Delta R_{MS}$  is the change in resistance from  $T_{MIN}$  to  $T_{MID}$ , which will give  $V_O = +5V$

Figure 2.1.9.2 graphically shows the RTD values needed for ranging the 3B34 while Figure 2.1.9.3 depicts the mounting locations of the ranging resistors.

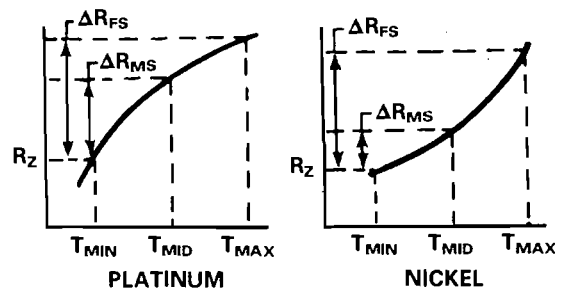


Figure 2.1.9.2 RTD Values Needed for Ranging Model 3B34

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24V dc power)

Model	3B34
Inputs	100Ω Platinum RTD, 2, 3, or 4 wire, α = 0.00385 10Ω Copper RTD,
2 or 3 Wire	120Ω Nickel RTD, 2, 3, or 4 Wire
Outputs	0 to +10V @ 5mA 4-20mA or 0-20mA @ R <sub>L</sub> = 0 to 850Ω <sup>1</sup> 0-31mA
Maximum Current Output Range	±0.1% span
Accuracy <sup>2</sup>	±0.05% span
Nonlinearity	
Stability vs. Ambient Temperature	
Voltage Output	
Zero	±0.02°C/°C
Span	±0.0025% reading/°C
Current Output (w.r.t. Voltage Output)	
Zero	±0.0025% span/°C
Span	±0.0025% reading/°C
Common Mode Voltage, Input to Output	±1500V pk max
Common Mode Rejection @ 50Hz or 60Hz	
1kΩ Source Unbalance	160dB
Normal Mode Rejection @ 50Hz or 60Hz	60dB
Sensor Excitation Current (100Ω Pt, 120Ω Ni)	0.25mA
(10Ω Cu)	1.0mA
Lead Resistance Effect (100Ω Pt, 120Ω Ni)	±0.02°C/Ω
(10Ω Cu)	±0.2°C/Ω
Differential Input Protection <sup>3</sup>	220V rms, cont.
Voltage Output Protection	Continuous Short to Ground
Current Output Protection	130V rms, cont.
Zero and Span Adjustment Range <sup>4</sup>	±5% of span
Response Time to 90% Span	0.2sec
Input Resistance	15MΩ
Input Bias Current	3nA
Input Noise	0.2μV rms at 10Hz bandwidth
Output Noise	50μV rms in 100kHz bandwidth
Bandwidth	3Hz (-3dB)
Power Supplies <sup>5</sup>	
±15V Input Supplies Range	
(Rated Operation)	±(11.5V to 16.5V)
Supply Rejection	±0.01% span/V
Supply Current	±10mA
+24V Loop Supply Range	+12V to +30V
Supply Rejection	0.0002% span/V
Supply Current	27mA (at +FS)
Size	3.150" × 0.775" × 3.395"
Environmental	
Temperature Range, Rated Performance	-25°C to +85°C
Storage Temperature Range	-55°C to +85°C
Relative Humidity Conforms to MIL Spec 202	0 to 95% @ 60°C noncondensing
RFI Susceptibility	±0.5% span error, 5W @ 400MHz @ 3 ft.

## NOTES

<sup>1</sup>For a 0-20mA range, a typical minimum output current is 10μA.

<sup>2</sup>Accuracy spec includes the combined effects of repeatability, hysteresis and linearity. Does not include sensor or signal source error.

<sup>3</sup>Includes excitation circuitry.

<sup>4</sup>A wide range of zero suppression and custom calibration may be accomplished with a custom ranging card, AC1310.

<sup>5</sup>+24V dc power is only needed for driving the current output at up to 850Ω. If only voltage output is used, or a current output load of 400Ω or less is desired, ±15V is all that is required.

Specifications subject to change without notice.

## ORDERING INFORMATION

<b>Range in °C</b> <b>100Ω Pt</b>	<b>2, 3 or 4 Wire RTD</b> <b>α = 0.00385</b>
Externally Programmable	3B34-00
-100 to +100	3B34-01
0 to +100	3B34-02
0 to +200	3B34-03
0 to +600	3B34-04
<b>Range in °C</b> <b>10Ω Copper</b>	<b>2 or 3 Wire RTD</b>
Externally Programmable	3B34-C-00
0 to 120 (10Ω @ 0°C)	3B34-C-01
0 to 120 (10Ω @ 25°C)	3B34-C-02
<b>Range in °C</b> <b>120Ω Nickel</b>	<b>2, 3, or 4 Wire RTD</b>
Externally Programmable	3B34-N-00
0 to +300	3B34-N-01

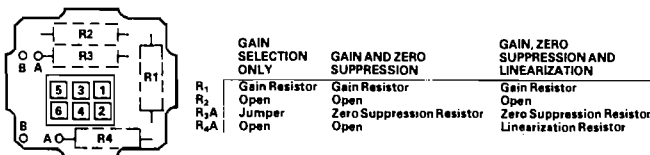


Figure 2.1.9.3 3B34 Custom Ranging

For copper RTDs, or for platinum or nickel RTD applications which do not require internal linearization, the following custom ranging procedure applies:

1. Output voltages at the endpoints of the span may be anywhere in the range of -10V to +10V.
2. Ranging components are computed from:

Gain Setting Resistor:

$$3B34-00, 3B34-N-00 \quad R_1 = \frac{\Delta R_{FS}}{2000 V_{FS} - \Delta R_{FS}} \times 20k\Omega$$

$$3B34-C-00 \quad R_1 = \frac{\Delta R_{FS}}{500 V_{FS} - \Delta R_{FS}} \times 20k\Omega$$

Zero Suppression Resistor:

$$R_{3A} = R_Z$$

Where  $R_Z$  = Resistance of the RTD at the temperature that is to give  $V_O = 0V$

$V_{FS}$  = Positive full scale output voltage desired

$\Delta R_{FS}$  = Change in RTD resistance from  $R_Z$  to the full scale temperature.

The fact that  $R_Z$  is set to the zero volt output point does not mean that negative outputs will not be meaningful; it just provides the simplest relation. Once  $R_1$  and  $R_Z$  are determined, the output voltage at any RTD temperature can be found, given the RTD's resistance at that temperature ( $R_{RTD}$ ), from the following relation for the 3B34-00 or the 3B34-N-00:

$$V_O = (R_{RTD} - R_Z) \times 0.25mA \times G_V$$

For the 3B34-C-00, the relation is:

$$V_O = (R_{RTD} - R_Z) \times 1.0mA \times G_V$$

$$\text{In both cases: } G_V = \left( \frac{20k\Omega}{R_1} + 1 \right) \times 2 = \frac{40k\Omega}{R_1} + 2$$

These relations are the general transfer functions for the modules when linearization is not used.

The ranging card can be used to create a wide variety of special transfer functions with virtually any type RTD. RTDs with a concave down temperature characteristic should be conditioned with the 3B34-00. RTDs with a concave up temperature characteristic should be conditioned with the 3B34-N-00. Any type RTD can be used with nonlinearized custom ranging.

## LIMITS

There are practical limits that must be observed when ranging the 3B34. The maximum RTD value in the measurement range of interest must not exceed 10kΩ for the 3B34-00 and 3B34-N-00 or 2.5kΩ for the 3B34-C-00. The range of the voltage output adjustment is at least ±0.5V at the module output and can therefore correct any error less than 0.5V/Gain. If possible the ranging resistors used should be 1% tolerance, 10ppm while the linearization resistor can be a 50ppm part. See Appendix A for a detailed discussion of limits, error contributions, and temperature effects of the ranging card.

## 2.1.10 MODEL 3B37

### FEATURES

- Accepts J,K,T,E,R,S or B Thermocouple Inputs
- Reliable Transformer Isolation
- ± 1500V CMV
- 160dB CMR
- Meets IEEE-STD 472: Transient Protection (SWC)
- Internal Cold Junction Compensation
- Open Thermocouple Detection

### FUNCTIONAL DESCRIPTION

The 3B37 accepts its signal from type J, K, T, E, R, S, and B thermocouples and provides two high level outputs that are proportional to the input signal.

Figure 2.1.10.1 shows a functional diagram for the model 3B37. Input protection of up to 220V is provided for the input circuitry. Cold Junction Compensation with an initial accuracy of ±0.5°C is performed in each unit with the external sensor provided on all channels of the 3B Series backplane. The signal is amplified and filtered to give the high level voltage outputs. Chopper based amplification is used to assure low drift and excellent long term stability. Transformer coupling is used to achieve stable galvanic isolation between input and output. Both the voltage and current outputs can be independently adjusted over a ±5% span range for zero and span with the front panel accessible potentiometers. The current output, which has 130V output protection, interfaces with user equipment through screw terminal connections.

### DOWNSCALE OPEN INPUT DETECTION

The 3B37 provides upscale open thermocouple detection when used under normal operation. Downscale open thermocouple detection can be provided by installing a 220MΩ resistor across screw terminals 2 and 4. This resistor could be a 0.25W carbon comp and need not be a tight tolerance (±20%). The addition of this resistor reverses the input bias current which provides downscale open input detection.

### FINE CALIBRATION

The 3B37 is factory calibrated for a specified range to provide zero and span accuracy of ±0.1% of span. Cold junction sensors, with an initial accuracy of ±0.5°C are provided on each backplane channel. If greater accuracy is desired, the modules should be calibrated in the actual backplane channel that they will be installed in. User accessible zero and span trim potentiometers providing a ±5% adjustment range permit precise field calibration of both the voltage output and the current output. The two outputs are adjusted independently and are noninteractive. The following nonrecursive adjustment procedure is recommended:

1. Make connections as shown in Figure 2.1.10.1 with  $R_L = 250\Omega$ . Use a precision millivolt source.
2. Measure the ambient temperature of the screw terminal block and determine the millivolt output for the thermocouple type being used from standard millivolt/temperature tables. This value will be inverted and added to the millivolt span of the thermocouple being simulated.
3. Determine the zero and full scale points for the measurement range from standard millivolt/temperature tables, and add to the number determined in step 2.

Example: Type J 0°C – 500°C

Zero and full scale values: 0mV to +27.388mV

Output at ambient temperature: 1.277mV (invert sign)

Corrected zero and span values: –1.277mV to +26.111mV

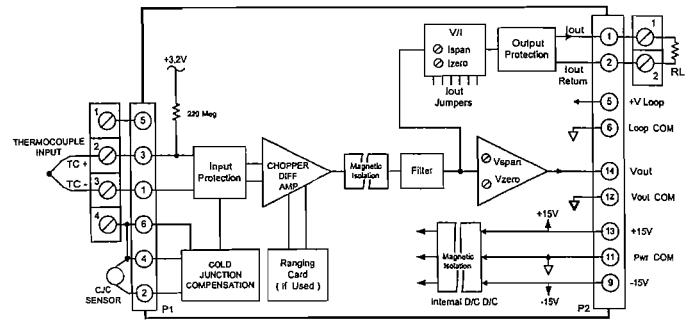


Figure 2.1.10.1 3B37 Functional Block Diagram

4. Apply  $V_{IN}$  for the minimum input signal (determined in step 3), adjust  $V_Z$  for  $V_{OUT} = 0V \pm 10mV$  and  $I_Z$  for  $I_{OUT} = 4mA \pm 0.016mA$  or the measured voltage across  $R_L = +1V \pm 4mV$ .
5. Apply  $V_{IN}$  for the maximum input signal (determined in step 3), adjust  $V_S$  for  $V_{OUT} = +10V \pm 10mV$  and  $I_S$  for  $I_{OUT} = 20mA \pm 0.016mA$  or the measured voltage across  $R_L = +5V \pm 4mV$ .

If a 0-20mA output is desired,  $I_Z$  should be adjusted for  $I_{OUT} = 0mA \pm 0.020mA$  in step 4 and  $I_S$  should be adjusted for  $I_{OUT} = 20mA \pm 0.020mA$  in step 5. (A typical minimum output current is 10μA with 0-20mA operation.)

The 3B37 might also be calibrated using an ice bath setup.

### OPTIONAL ZERO SUPPRESSION/CUSTOM CALIBRATION

A wide zero suppression capability and easy field calibration are available with a plug-on ranging card, AC1310. If a special input range is desired, it can be provided by ordering the externally programmable version of the desired module (i.e., 3B37-X-00) and the AC1310 which houses user supplied resistors that determine the zero and span of the new range. A special range can also be factory configured. Consult the factory for details.

The basic transfer function of the 3B37 can be expressed as:

$$V_O = G \times (V_{IN} - V_Z)$$

Where

- $V_O$  = Output Voltage
- $G$  = Gain
- $V_{IN}$  = Input Voltage
- $V_Z$  = Zero Suppression Voltage

The output voltages for a given temperature span and thermocouple type are available from standard tables, and these values should be substituted in the above equation.

### GAIN SETTING RELATION

With the AC1310, the gain  $G$  is set by  $R_1$ , which forms part of an internal divider and is determined from the following relation:

$$R_1 = \frac{40k\Omega}{G - 2}$$

Gain  $G$  is a ratio of the change of output to the input change that produced it. If there is to be no zero suppression, (i.e., 0°C = 0mV = 0V output) then  $R_2$  should be a jumper and  $R_3$  should be left open. Refer to the cold junction compensation section for the value for  $R_4$ . These resistors should be installed as indicated in Figure 2.1.10.2.

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24V dc power)

<b>Model</b>	<b>3B37</b>
<b>Inputs</b>	Thermocouple Types J, K, T, E, R, S, B
<b>Outputs</b>	0 to +10V @ 5mA 4-20mA or 0-20mA @ R <sub>1</sub> = 0 to 850Ω <sup>1</sup>
<b>Accuracy</b> <sup>2</sup>	± 0.1% span
<b>Nonlinearity</b>	± 0.01% span
<b>Stability vs. Ambient Temperature</b>	
<b>Voltage Output</b>	
Zero	± 0.02 °C/°C
Span	± 0.0025% reading/°C
<b>Current Output (w.r.t. Voltage Output)</b>	
Zero	± 0.0025% span/°C
Span	± 0.0025% reading/°C
<b>Common Mode Voltage, Input to Output</b>	± 1500V pk max
<b>Common Mode Rejection @ 50Hz or 60Hz</b>	
1kΩ Source Unbalance	160dB
<b>Normal Mode Rejection @ 50Hz or 60Hz</b>	60dB
<b>Differential Input Protection</b>	220V rms, cont.
<b>Voltage Output Protection</b>	Continuous Short to Ground
<b>Current Output Protection</b>	130V rms, cont.
<b>Zero and Span Adjustment Range</b> <sup>3</sup>	± 5% of span
<b>Response Time to 90% Span</b>	0.2sec
<b>Input Transient Protection</b>	Meets IEEE-STD 472 (SWC)
<b>Input Resistance</b>	15MΩ
<b>Input Bias Current</b>	15nA
<b>Input Noise</b>	0.2μV rms at 10Hz bandwidth
<b>Open Input Response</b>	Upscale
<b>Open Input Detection Time</b>	10sec
<b>Output Noise</b>	50μV rms in 100kHz bandwidth
<b>Bandwidth</b>	3Hz (-3dB)
<b>Cold Junction Compensation</b>	
<b>Initial Accuracy</b> <sup>4</sup>	± 0.5°C
<b>vs Temperature</b> <sup>5</sup> (+5°C to +45°C)	± 0.5°C
<b>Power Supplies</b> <sup>6</sup>	
± 15V Input Supplies Range (Rated Operation)	± (11.5V to 16.5V)
Supply Rejection	± 0.01% span/V
Supply Current	± 12mA
+ 24V Loop Supply Range	+ 12V to + 30V
Supply Rejection	0.0002% span/V
Supply Current	27mA (at + FS)
<b>Size</b>	3.150" × 0.775" × 3.395"
<b>Environmental</b>	
<b>Temperature Range, Rated Performance</b>	- 25°C to + 85°C
<b>Storage Temperature Range</b>	- 55°C to + 85°C
<b>Relative Humidity</b> Conforms to MIL Spec 202	0 to 95% @ 60°C noncondensing
<b>RFI Susceptibility</b>	± 0.5% span error, 5W @ 400MHz @ 3 ft.

**NOTES**

- <sup>1</sup>For a 0-20mA range, a typical minimum output current is 10μA.
  - <sup>2</sup>Accuracy spec includes the combined effects of repeatability, hysteresis and linearity. Does not include sensor or signal source error.
  - <sup>3</sup>A wide range of zero suppression and custom calibration may be accomplished with a custom ranging card, AC1310.
  - <sup>4</sup>When used with CJC sensor provided on 3B Series backplanes.
  - <sup>5</sup>Compensation error contributed by ambient temperature changes.
  - <sup>6</sup>+ 24V dc power is only needed for driving the current output at up to 850Ω. If only voltage output is used, or a current output load of 400Ω or less is desired, ± 15V is all that is required.
- Specifications subject to change without notice.

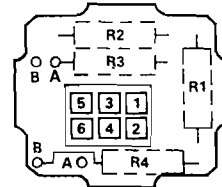
## ORDERING INFORMATION

**EXAMPLE MODEL 3B37 - K - 02**

Select Thermocouple Type  
J, K, T, E, R, S or B

Select Temperature Range  
01 through 06

Range in °C (°F)	TC Type	No.
- 100 to + 760	J	01
(- 148 to + 1400)		
- 100 to + 1350	K	02
(- 148 to + 2462)		
- 100 to + 400	T	03
(- 148 to + 752)		
0 to + 900	E	04
(32 to + 1652)		
0 to + 1750	R, S	05
(32 to + 3182)		
0 to + 1800	B	06
(32 to + 3272)		



	GAIN SELECTION ONLY	GAIN AND ZERO SUPPRESSION	GAIN, ZERO SUPPRESSION AND COLD JUNCTION COMPENSATION
R <sub>1</sub>	Gain Resistor	Gain Resistor	Gain Resistor
R <sub>2</sub>	Jumper	Zero Suppression Resistor	Zero Suppression Resistor
R <sub>3</sub>	Open	Zero Suppression Resistor	Zero Suppression Resistor
R <sub>4</sub> B	Open	Open	CJC Resistor

Figure 2.1.10.2 3B37 Custom Ranging

## ZERO SUPPRESSION VOLTAGE

The zero suppression voltage, V<sub>Z</sub>, can be set for any value between -3.175V and +3.175V through the use of R<sub>2</sub> and R<sub>3</sub> and is determined from the following relations:

$$V_Z = 3.175V \times \frac{R_2}{R_2 + R_3}$$

with the sign of V<sub>Z</sub> determined by the choice of location A (positive) or location B (negative) for R<sub>3</sub>, (see Figure 2.1.9.3). The total resistance of (R<sub>2</sub> + R<sub>3</sub>) should be approximately 10kΩ to avoid taking excessive current from the voltage reference or self heating in the resistors. Using 10kΩ as the total value, R<sub>2</sub> and R<sub>3</sub> are determined from the following relations:

$$R_2 = \frac{V_Z}{3.175V} \times 10k\Omega$$

$$R_3 = 10k\Omega - R_2$$

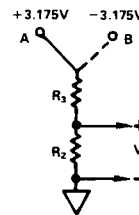


Figure 2.1.10.3 3B37 Zero Suppression Resistors

## COLD JUNCTION COMPENSATION SELECTION

The 3B37 incorporates internal cold junction compensation circuitry which is used with the external sensors incorporated in the 3B Series backplanes. The calibration of this circuitry is accomplished with a resistor installed in position R<sub>4</sub>B. The values for thermocouple types J, K, T, E, R, S and B are defined below; if another type is required, consult the factory for the required resistor value.

<b>TC Type</b>	<b>J</b>	<b>K</b>	<b>T</b>	<b>E</b>	<b>R</b>	<b>S</b>	<b>B</b>
<b>R<sub>4</sub>B</b>	210Ω	165Ω	165Ω	243Ω	23.7Ω	23.7Ω	Jumper (0Ω)

## LIMITS

The ranging card can be used to create a wide range of special transfer functions, but there are practical limits that must be observed. The maximum differential input voltage for normal linear operation is ±1V. The range of the voltage output adjustment is at least ±0.5V at the module output and can therefore correct any error of less than 0.5V/Gain. If possible the resistors used should be 1% tolerance, 10ppm. See Appendix A for a detailed discussion of limits, error contributions, and temperature effects of the ranging card.



### 2.1.11 MODELS 3B40 and 3B41

#### FEATURES

- Accepts Inputs from  $\pm 10\text{mV}$  to  $\pm 10\text{V}$  Inputs
- 10kHz Bandwidth
- Dual High Level Outputs
- Voltage:  $\pm 10\text{V}$
- Current: 4-20mA/0-20mA
- High Accuracy:  $\pm 0.1\%$
- Low Drift:  $\pm 2\mu\text{V}/^\circ\text{C}$
- Reliable Transformer Isolation
- $\pm 1500\text{V CMV}$ ,  $\text{CMR}=100\text{dB}$
- Meets IEEE-472: Transient Protection (SWC)
- Input Protection: 220V rms Continuous
- Reliable Pin and Socket Connections

#### FUNCTIONAL DESCRIPTION

The 3B40 is an isolated wideband millivolt input module that is designed to accept signals ranging from  $\pm 10\text{mV}$  to  $\pm 100\text{mV}$ . Model 3B41 is an isolated wideband voltage input module that is designed to accept voltage input signals ranging from  $\pm 1\text{V}$  to  $\pm 10\text{V}$ . Each model has a 10kHz bandwidth to interface to dynamic signals.

Figure 2.1.11.1 shows a functional diagram for models 3B40 and 3B41. Input protection of up to 220V rms is provided on the input screw terminals. Transformer coupling is used to achieve stable galvanic isolation between input and output. Both the voltage and current outputs can be independently adjusted over a  $\pm 5\%$  span range for zero and span with front panel accessible potentiometers. The current output, which has 130V rms output protection, interfaces with user equipment through screw terminal connections.

#### FINE CALIBRATION

Each model is factory calibrated for a specified range to provide zero and span accuracy of  $\pm 0.1\%$  of span. User accessible zero and span trim potentiometers providing a  $\pm 5\%$  adjustment range permit precise field calibration of both the voltage output and the current output. The two outputs are adjusted independently and are noninteractive. The following nonrecursive procedure is recommended:

1. Connect model 3B40 (3B41) as shown in Figure 2.1.11.1 with  $R_L = 250\Omega$ .
2. Apply  $V_{IN} = 0$  volts, adjust  $V_Z$  for  $V_{OUT} = 0\text{V} \pm 10\text{mV}$  and  $I_Z$  for  $I_{OUT} = 4\text{mA} \pm 0.016\text{mA}$  or the voltage measured across  $R_L = +1\text{V} \pm 4\text{mV}$ .
3. Apply  $V_{IN} = +\text{Full Scale}$ , adjust  $V_S$  for  $V_{OUT} = +10\text{V} \pm 10\text{mV}$  and  $I_S$  for  $I_{OUT} = 20\text{mA} \pm 0.016\text{mA}$  or the voltage measured across  $R_L = +5\text{V} \pm 4\text{mV}$ .

If a 0-20mA output is desired for a 0 to +10V output, adjust  $I_Z$  for  $I_{OUT} = 0\text{mA} \pm 0.020\text{mA}$  in step 2 and  $I_S$  for  $I_{OUT} = 20\text{mA} \pm 0.020\text{mA}$  in step 3. (A typical minimum output current is  $10\mu\text{A}$  with 0-20mA operation.)

If the current output is to be proportional to a  $-10\text{V}$  to  $+10\text{V}$  output instead of a 0 to +10V output,  $I_Z$  should be adjusted for a  $-$  Full Scale input in step 2.

#### CUSTOM CALIBRATION

A powerful custom ranging capability is provided with a plug-on ranging card, AC1310. If a special gain is desired, it can be provided by ordering the externally programmable version of the desired module and the AC1310 which houses

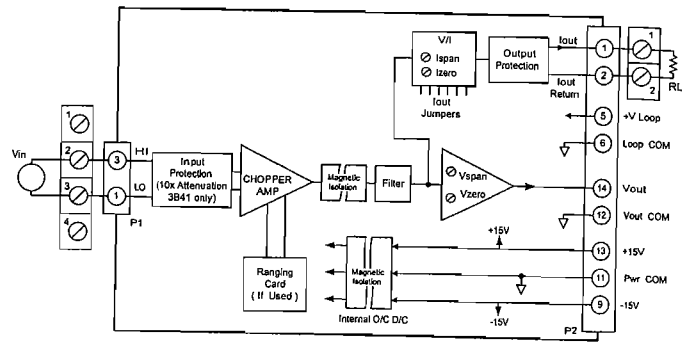


Figure 2.1.11.1 3B40 and 3B41 Functional Block Diagram

user supplied resistors that determine the zero and span of the new range. Special ranges can also be factory configured. Consult the factory for details.

The basic transfer function of both the 3B40 and 3B41 is:

$$V_O = G \times (V_{IN} - V_Z)$$

Where

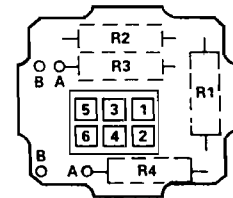
- $V_O$  = Output Voltage
- $G$  = Gain
- $V_{IN}$  = Input Voltage
- $V_Z$  = Zero Suppression Voltage

#### GAIN SETTING RELATION

With the AC1310, the gain  $G$  is set by  $R_1$ , which is determined from the following relations:

$$\begin{array}{ll} \text{3B40} & \text{3B41} \\ R_1 = \frac{400\text{k}\Omega}{G - 4} & R_1 = \frac{40\text{k}\Omega}{G - 0.4} \end{array}$$

Gain  $G$  is a ratio of the change of output to the input change that produced it. Model 3B41 is a 3B40 with a  $10\times$  normal mode input attenuator. The attenuation is done before the zero suppression and gain. If there is to be no zero suppression,  $R_2$  should be a jumper and  $R_3$  should be left open. These resistors should be installed as indicated in Figure 2.1.11.2.



GAIN SELECTION		GAIN AND ZERO SUPPRESSION	
$R_1$	Gain Resistor	$R_1$	Gain Resistor
$R_2$	Jumper	$R_2$	Zero Suppression Resistor
$R_3$	Open	$R_3$	Zero Suppression Resistor
$R_4$	Open	$R_4$	Open

Figure 2.1.11.2 3B40 and 3B41 Custom Ranging

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24V dc power)

Model	3B40	3B41
Inputs	±10mV to ±1V	±1V to ±10V
Outputs	±10V or ±2mA 4-20mA or 0-20mA or R <sub>1</sub> = 0 to 850Ω <sup>1</sup>	*
Accuracy <sup>2</sup>	±0.1% span	*
Nonlinearity	±0.02% span	*
Stability vs. Ambient Temperature		
Voltage Output		
Input Zero	±2μV/°C (RTI)	±10μV/°C
Output Zero	±25μV/°C	*
Span	±0.0025% reading/°C	*
Current Output (w.r.t. Voltage Output)		
Zero	±0.0025% span/°C	*
Span	±0.0025% reading/°C	*
Common Mode Voltage, Input to Output	±1500V pk max	*
Common Mode Rejection (at 50Hz or 60Hz)		
1kΩ Source Unbalance	100dB	85dB
Differential Input Protection	220V rms, cont.	*
Voltage Output Protection	Continuous Short to Ground	*
Current Output Protection	130V rms, cont.	*
Zero and Span Adjustment Range <sup>3</sup>	±5% of span	*
Bandwidth (-3dB)	10kHz	*
Response Time to 90%	55μs	*
Input Resistance	200MΩ	250kΩ
Input Bias Current	5nA	*
Input Noise		
(dc - 1MHz; R <sub>S</sub> = 10kΩ)	5μV rms	*
Output Ripple and Noise	25mV pk to pk	*
Power Supplies <sup>4</sup>		
±15V Input Supplies Range	±(12V to 16.5V)	*
Supply Rejection	±0.01% span/V	*
Supply Current	±10mA	*
+24V Loop Supply Range	+12V to +30V	*
Supply Rejection	0.0002% span/V	*
Supply Current	27mA (at +FS)	*
Size	3.150" × 0.775" × 3.395"	*
Environmental		
Temperature Range, Rated Performance	-25°C to +85°C	*
Storage Temperature Range	-55°C to +85°C	*
Relative Humidity Conforms to MIL Spec 202	0 to 95% or 40°C noncondensing	*
RFI Susceptibility	±0.5% span error, 5W or 400MHz or 3 ft.	*

## NOTES

- <sup>1</sup>For a 0-20mA range, a typical minimum output current is 10μA.
  - <sup>2</sup>Accuracy spec includes the combined effects of repeatability, hysteresis and linearity. Does not include sensor or signal source error.
  - <sup>3</sup>Custom calibration may be accomplished with a custom ranging card, AC1310.
  - <sup>4</sup>+24V dc power is only needed for driving the current output at up to 850Ω. If only voltage output is used, or a current output load of 400Ω or less is desired, +15V is all that is required.
- \*Specifications same as 3B40.  
Specifications subject to change without notice.

## ORDERING INFORMATION

Input Range	Model Number
Low Level,	
Externally Programmable	3B40-00
±10mV	3B40-01
±50mV	3B40-02
±100mV	3B40-03
High Level,	
Externally Programmable	3B41-00
±1V	3B41-01
±5V	3B41-02
±10V	3B41-03

## FREQUENCY RESPONSE

The standard bandwidth of the 3B40 and 3B41 is 10kHz. This frequency response is determined by a two pole filter. A third pole is available to reduce the frequency response of custom ranged units if desired. These modules can be configured at the factory with a 100Hz minimum bandwidth.

## ZERO SUPPRESSION VOLTAGE

The zero suppression voltage,  $V_Z$ , can be set for any value between -3.175V and +3.175V for the 3B40 and -31.75V to +31.75V for the 3B41 through the use of  $R_2$  and  $R_3$  and is determined from the following relations:

$$\begin{array}{cc} \text{3B40} & \text{3B41} \\ V_Z = 3.175V \times \frac{R_2}{R_2 + R_3} & V_Z = 31.75V \times \frac{R_2}{R_2 + R_3} \end{array}$$

with the sign of  $V_Z$  determined by the choice of location A (positive) or location B (negative) for  $R_3$  (see Figure 2.1.11.3). The total resistance of ( $R_2 + R_3$ ) should be approximately 10kΩ to avoid taking excessive current from the voltage reference or self heating in the resistors. (For the 3B41, the 31.75V term is a function of the 10× attenuation of the input signal. The internal voltage reference is 3.175V so standard 100mW resistors are suitable for zero suppression.) Using 10kΩ as the total value,  $R_2$  and  $R_3$  are determined from the following relations:

$$\begin{array}{cc} \text{3B40} & \text{3B41} \\ R_2 = \frac{V_Z}{3.175V} \times 10k\Omega & R_2 = \frac{V_Z}{31.75V} \times 10k\Omega \\ R_3 = 10k\Omega - R_2 & R_3 = 10k\Omega - R_2 \end{array}$$

## REF:

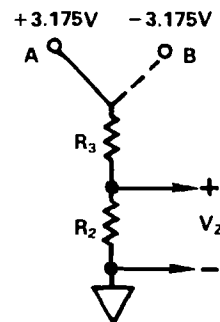


Figure 2.1.11.3 3B40 and 3B41 Zero Suppression Resistors

## LIMITS

The ranging card can be used to create a wide range of special transfer functions, but there are practical limits that must be observed. For the 3B40, the maximum differential input voltage for normal linear operation is ±2.5V. For the 3B41, the maximum differential input voltage for normal linear operation is ±25V. The range of the voltage output adjustment is at least ±0.5V at the module output and can therefore correct any input offset error of less than 0.5V/Gain for the 3B40 and 5V/Gain for the 3B41. If possible, the resistors used should be 1% tolerance, 10ppm. See Appendix A for a detailed discussion of limits, error contributions, and temperature effects of the ranging card.

## 2.1.12 MODELS 3B42, 3B43 AND 3B44

### FEATURES

Accepts 20mV to 550V ac inputs

Dual High Level Outputs

Voltage: 0 to +10V

Current: 4-20mA/0-20mA

High Accuracy:  $\pm 0.5\%$

Low Drift: 50ppm/ $^{\circ}$ C

Reliable Transformer Isolation

$\pm 1500V$  CMV, CMR=100dB

Meets IEEE-472: Transient Protection (SWC)

Input Protection: 220V rms Continuous (550V rms for 3B44)

Reliable Pin and Socket Connections

### FUNCTIONAL DESCRIPTION

Models 3B42, 3B43 and 3B44 are designed to accept ac sine-wave input signals. Model 3B42 accepts signals ranging from 20mV to 1V rms, model 3B43 accepts signals ranging from 1V to 50V rms and model 3B44 accepts inputs ranging from 50V rms to 550V rms.

Figure 2.1.12.1 shows a functional block diagram for models 3B42, 3B43 and 3B44. Input protection of up to 220V rms (550V rms for model 3B44) is provided on the input screw terminals. Each module uses an ac averaging technique. The input signal is rectified, filtered and scaled to give an rms reading for a sine-wave input. This scaling is not accurate for other input waveforms. Transformer coupling is used to achieve stable, galvanic isolation between input and output. Both the voltage and current outputs can be independently adjusted over a  $\pm 5\%$  span range for zero and span with front panel accessible potentiometers. The current output, which has 130V rms output protection, interfaces with user equipment through screw terminal connections.

### FINE CALIBRATION

Each model is factory calibrated for a specified range to provide zero and span accuracy of  $\pm 0.5\%$  of span. User accessible zero and span trim potentiometers providing a  $\pm 5\%$  adjustment range permit precise field calibration of both the voltage output and the current output. The two outputs are adjusted independently and are noninteractive. The following nonrecursive procedure is recommended:

1. Connect the unit as shown in Figure 2.1.12.1 with  $R_L = 250\Omega$ .
2. Apply  $V_{IN} = 0$  volts, adjust  $V_Z$  for  $V_{OUT} = 0V \pm 10mV$  and  $I_Z$  for  $I_{OUT} = 4mA \pm 0.016mA$  or the measured voltage across  $R_L = +1V \pm 4mV$ .
3. Apply  $V_{IN} = +$ Field Scale, adjust  $V_S$  for  $V_{OUT} = +10V \pm 10mV$  and  $I_S$  for  $I_{OUT} = 20mA \pm 0.016mA$  or the voltage measured across  $R_L = +5V \pm 4mV$ .

If a 0-20mA output is desired for a 0 to +10V output, adjust  $I_Z$  for  $I_{OUT} = 0mA \pm 0.020mA$  in Step 2 and  $I_S$  for  $I_{OUT} = 20mA \pm 0.020mA$  in Step 3. (A typical minimum output current is  $10\mu A$  with 0-20mA operation.)

### OPTIONAL ZERO SUPPRESSION/CUSTOM CALIBRATION

A powerful custom ranging capability is provided with a plug-on ranging card, AC1310. If a special range is desired, it can be provided by ordering the externally rangable version of the desired module (i.e., 3B42-00) and the AC1310 which

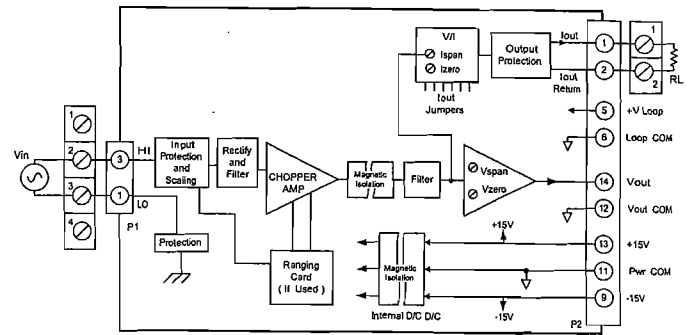


Figure 2.1.12.1 3B42, 3B43 and 3B44 Functional Block Diagram

houses user supplied resistors that determine the zero and span of the new range. Special ranges can also be factory configured. Consult the factory for details.

The basic transfer function of the 3B42, 3B43 and 3B44 is:

$$V_O = G(V_{IN} - V_Z)$$

where  $V_O$  = Output Voltage

$G$  = Gain

$V_{IN}$  = Input Voltage (rms)

$V_Z$  = Zero Suppression Voltage (rms)

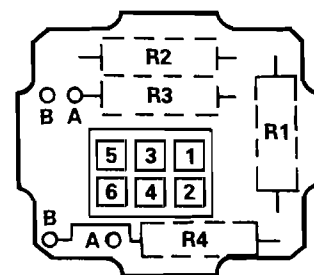
Gain  $G$  is the ratio of the change of output to the input change that produced it.

### SCALING RELATIONS

With the AC1310, the gain is set by  $R_1$  and  $R_4B$ .  $R_1$  is used to control the scaling of input in each of these three models while  $R_4B$  determines the gain from the rectifier on.  $R_1$  is determined from the following relations:

$$R_1 = \frac{20k\Omega}{\frac{1}{KV_m} - 1} \quad R_1 = \frac{20k\Omega}{\frac{50}{KV_m} - 1} \quad R_1 = \frac{20k\Omega}{\frac{550}{KV_m} - 1}$$

Where  $K = V_{av}/V_{rms} = 0.900$  for sinusoids  
 $V_m$  = full scale rms input voltage



	SCALING SELECTION ONLY	SCALING AND ZERO SUPPRESSION
$R_1$	Input Scaling Resistor	Input Scaling Resistor
$R_2$	Jumper	Zero Suppression Resistor
$R_3$	Open	Open
$R_4B$	Output Scaling Resistor	Output Scaling Resistor

Figure 2.1.12.2 3B42, 3B43 and 3B44 Custom Ranging

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24V dc power)

Model	3B42	3B43	3B44
Inputs, 50Hz-400Hz	20mV to 1V	1V to 50V	50V to 550V
Outputs	0-10V @ 5mA 4-20mA or 0-20mA @R <sub>L</sub> = 0 to 850Ω <sup>1</sup>	*	*
Accuracy <sup>2</sup>	±0.5% span	*	*
Stability vs. Ambient Temperature			
Voltage Output			
Zero	±0.005% span/°C	*	*
Span	±0.005% reading/°C	*	*
Current Output (wrt Voltage Output)			
Zero	±0.0025% span/°C	*	*
Span	±0.0025% reading/°C	*	*
Common-Mode Voltage			
Input to Output	±1500V peak max	*	*
Common-Mode Rejection			
@ 50Hz or 60Hz, 1kΩ source unbalance	100dB	*	*
Differential Input Protection	220V rms, continuous	*	550V rms, continuous
Voltage Output Protection	Continuous Short to Ground	*	*
Current Output Protection	130V rms, continuous	*	*
Zero and Span Adjustment Range <sup>3</sup>	±5% of span	*	*
Bandwidth <sup>4</sup>	3Hz	*	*
Response Time to 90% Span	0.2 sec	*	*
Input Transient Protection	Meets IEEE-STD-472(SWC)	*	*
Input Resistance	100MΩ	250kΩ	1MΩ
Input Bias Current	1nA	5nA	3nA
Output Noise	50μV rms on 100kHz Bandwidth	*	*
Power Supplies <sup>5</sup>			
±15V Input Supplies Range (Rated Operation)	±(11.5V to 16.5V)	*	*
Supply Rejection	±0.01% span/V	*	*
Supply Current	+10mA, -10mA	*	*
+24V Loop Supply	+12V to +30V	*	*
Supply Rejection	0.002% span/V	*	*
Supply Current	27mA (at +FS)	*	*
Size	3.150" × 0.775" × 3.395"	*	*
Environmental			
Temperature Range, Rated Performance	-25°C to +85°C	*	*
Storage Temperature Range	-55°C to +85°C	*	*
Relative Humidity Conforms to MIL Spec 202	0 to 95% @ 60°C Noncondensing	*	*
RFI Susceptibility	0.5% span error 5W @ 400MHz @ 3 feet	*	*

## NOTES

<sup>1</sup>For a 0-20mA range, a typical minimum output current is 10μA.

<sup>2</sup>Accuracy spec includes the combined effects of repeatability, hysteresis, ripple and linearity. Does not include sensor or signal source error.

<sup>3</sup>Custom calibration may be accomplished with a custom ranging card, AC1310.

<sup>4</sup>Bandwidth represents a response to a change in amplitude.

<sup>5</sup>+24V dc power is only needed for driving the current output at up to 850Ω. If only voltage output is used, or a current output load of 400Ω or less is desired, ±15V is all that is required.

\*Specifications same as 3B42.

Specifications subject to change without notice.

The difference between these three models is in the input scaling. The scaling is done before the zero suppression or gain so that the maximum value presented to the rectifier is 1V rms. The signal is processed the same from this point on in each of the three models. R<sub>4B</sub> is determined from the following relation, which is the same for all models:

$$R_{4B} = \frac{40k\Omega}{G1-2} \quad \text{where } G1 = \frac{10V}{1 - \frac{V_z}{V_m}}$$

(10V represents the module's output span.)

If there is to be no zero suppression, R<sub>2</sub> should be a jumper. These resistors should be installed as indicated in Figure 2.1.12.2.

## ZERO SUPPRESSION VOLTAGE

The zero suppression voltage, V<sub>Z</sub>, can be set for any value between 0 and 1.23V. Since the signal varies from 0 to 1V dc at the amplifier input, a zero suppression voltage of 0 to 1V dc corresponds linearly to a 0-100% of full scale zero suppression.

The zero suppression resistor, R<sub>2</sub>, is determined from the following relations for all three models:

$$R_2 = \frac{10k\Omega (V_z/V_m)}{1.23 - V_z/V_m}$$

R<sub>2</sub> should be installed as indicated in Figure 2.1.12.2.

## LIMITS

The ranging card can be used to create a wide range of special transfer functions, but there are practical limits that must be observed. The allowable input voltages are 20mV-1V rms for the 3B42, 1-50V rms for the 3B43, and 50-550V rms for the 3B44. The range of the modules voltage output adjustment is at least ±0.5V at the module output and can, therefore, correct any input offset error of less than 0.5V/Gain for the 3B42, 25V/Gain for the 3B43, and 275V/Gain for the 3B44. If possible, the resistors should be a 1% tolerance, 10ppm. See Appendix A for a detailed discussion of limits, error contributions, and temperature effects of the ranging card.

## ORDERING INFORMATION

Input Range	Model Number
Low Level ac (20mV - 1V rms), Externally Programmable	3B42-00
0 - 50mV rms	3B42-01
0 - 100mV rms	3B42-02
Volt ac (1V - 50V rms), Externally Programmable	3B43-00
0 - 10V rms	3B43-01
Volt ac (50V - 550V rms), Externally Programmable	3B44-00
0 - 150V rms	3B44-01
0 - 250V rms	3B44-02

### 2.1.13 MODELS 3B45 AND 3B46

#### FEATURES

- Accepts Frequency Inputs**
- Dual High Level Outputs**
- Voltage: 0 to +10V**
- Current: 4-20mA/0-20mA**
- High Accuracy: ±0.1%**
- Low Drift: ±500µV/°C**
- Reliable Transformer Isolation**
- ±1500V CMV**
- Meets IEEE-472: Transient Protection (SWC)**
- Input Protection: 220V rms Continuous**
- Reliable Pin and Socket Connections**

#### FUNCTIONAL DESCRIPTION

Model 3B45 is an isolated frequency input module that is designed to accept full scale frequency signals ranging from 25Hz to 1100Hz. Model 3B46 is an isolated frequency input module that is designed to accept full scale frequency signals ranging from 520Hz to 25kHz. The 3B45 has a 15ms debounce option that is factory installed for ranges less than 30Hz. Both modules have a user selectable threshold of either 0V or 1.6V, and an internal pull-up resistor for use with switch closure inputs.

Figure 2.1.13.1 shows a functional block diagram for models 3B45 and 3B46. Input protection of up to 220V rms is provided on the four input screw terminals. The input signal is compared to the selected threshold and hysteresis and the comparator's output frequency is converted to a voltage. The signal is then amplified and filtered to give the high level voltage output. Chopper based amplification is used to assure low drift and excellent long term stability. Transformer coupling is used to achieve stable, galvanic isolation between input and output. Both the voltage and current outputs can be independently adjusted over a ±5% span range from zero and span with the front panel accessible potentiometers. The current output which has 130V output protection interfaces with user equipment through screw terminal connections.

#### FINE CALIBRATION

Each model is factory calibrated for a specified range to provide zero and span accuracy of ±0.1% of span. User accessible zero and span trim potentiometers providing a ±5% adjustment range permit precise field calibration of both the voltage and current output. The two outputs are adjusted independently and are noninteractive. The following nonrecursive procedure is recommended:

1. Connect model 3B45 (3B46) as shown in Figure 2.1.13.1 with  $R_L = 250\Omega$ .
2. Apply  $F_{IN} = 0\text{Hz}$ , adjust  $V_Z$  for  $V_{OUT} = 0\text{V} \pm 10\text{mV}$  and  $I_Z$  for  $I_{OUT} = 4\text{mA} \pm 0.016\text{mA}$  or the measured voltage across  $R_L = +1\text{V} \pm 4\text{mV}$ .
3. Apply  $F_{IN} = \text{Full Scale}$ , adjust  $V_S$  for  $V_{OUT} = +10\text{V} \pm 10\text{mV}$  and  $I_S$  for  $I_{OUT} = 20\text{mA} \pm 0.016\text{mA}$  on the measured voltage across  $R_L = +5\text{V} \pm 4\text{mV}$ .

If a 0-20mA output is desired, adjust  $I_Z$  for  $I_{OUT} = 0\text{mA} \pm 0.020\text{mA}$  in Step 2 and  $I_S$  for  $I_{OUT} = 20\text{mA} \pm 0.020\text{mA}$  in Step 3. (A typical minimum output current is 10µA with 0-20mA operation).

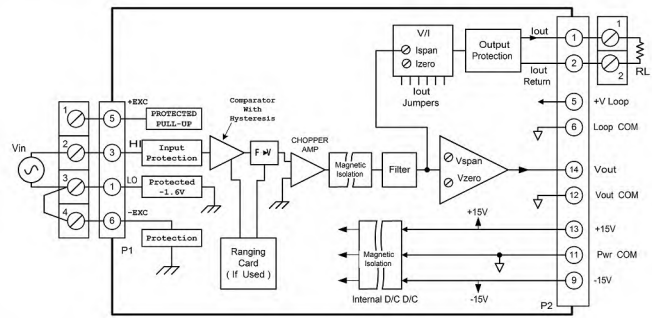


Figure 2.1.13.1 3B45 and 3B46 Functional Block Diagram

#### OPTIONAL ZERO SUPPRESSION/CUSTOM CALIBRATION

A wide zero suppression capability and easy field calibration are available with a plug-on ranging card, AC1310. If a special input range is desired, it can be provided by ordering the externally programmable version of the desired module (e.g., 3B45-00) and the AC1310 which houses user supplied resistors that determine the zero, span and hysteresis of the new range. A special range can also be factory configured. Analog Devices will provide the function when a model 3B\_\_-CUSTOM is ordered with the desired range.

The basic transfer function of both the 3B45 and 3B46 is:

$$V_O = G \times (F_{IN} - F_Z)$$

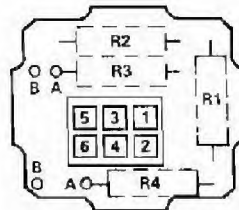
- When
- $V_O$  = Output Voltage
  - $G$  = Gain (V/Hz)
  - $F_{IN}$  = Input Frequency
  - $F_Z$  = Zero Suppression Frequency

#### GAIN SETTING RELATION

With the AC1310, the gain  $G$  is set by  $R_1$  which is determined from the following relation:

$$\begin{matrix} 3B45 & & 3B46 \\ R_1 = G \times 1.20 \times 10^6 & & R_1 = G \times 2.65 \times 10^7 \end{matrix}$$

Gain  $G$  is a ratio of the change of output to the input change that produced it. If there is to be no zero suppression,  $R_2$  should be left open. If a hysteresis of 4V is acceptable,  $R_4A$  should be left open. If no hysteresis is desired, install a jumper in  $R_4A$ . The gain resistor  $R_1$  should be installed as indicated in Figure 2.1.13.2.



	GAIN SELECTION	GAIN AND ZERO SUPPRESSION	GAIN, ZERO SUPPRESSION AND HYSTERESIS
$R_1$	Gain Resistor	Gain Resistor	Gain Resistor
$R_2$	Open	Zero Suppression Jumper	Zero Suppression Resistor
$R_3$	Open	Open	Open
$R_4A$	Jumper	Jumper	Hysteresis Resistor.

Figure 2.1.13.2 3B45 and 3B46 Custom Ranging

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24V dc power)

	3B45	3B46
Model	3B45	3B46
Inputs (Min and Max Span)	25Hz-1100Hz	520Hz-25kHz
Input Voltage Level	10mV-220V rms	*
Outputs	0-10V @ 5mA 4-20mA or 0-20mA @ R <sub>L</sub> = 0 to 850Ω <sup>1</sup>	*
Maximum Current Output for Input Overload	31mA	*
Accuracy <sup>2</sup>	±0.1% span	*
Nonlinearity	±0.02% span	*
Stability vs. Ambient Temperature		
Voltage Output		
Zero	500μV/°C	*
Span	±0.0050% reading/°C	*
Current Output (w.r.t. Voltage Output)		
Zero	±0.0025% span/°C	*
Span	±0.0025% reading/°C	*
Common-Mode Voltage, Input to Output	±1500V peak max	*
Differential Input Protection	220V rms continuous	*
Voltage Output Protection	Continuous Short to Ground	*
Current Output Protection	130V rms continuous	*
Zero and Span Adjustment Range <sup>3</sup>	±5% span	*
Input Transient Protection	Meets IEEE-STD 472 (SWC)	*
Input Resistance		
(Small Signal)	15MΩ	*
(Large Signal, V <sub>IN</sub> >4V)	82kΩ	*
Input Bias Current	3nA	*
Output Ripple	10mV rms @ 10% span max	*
Output Noise	75μV rms at 100kHz	*
Power Supplies <sup>4</sup>		
±15V Input Supplies Range (Rated Operation)	±(11.5V to 16.5V)	*
Supply Rejection	±0.01% span/V	*
Supply Current	±16mA	±19mA
+24V Loop Supply Range	+13.5V to +30V	*
Supply Rejection	0.0002% span/V	*
Supply Range	27mA (at +FS)	*
Size	3.150" × 0.775" × 3.395"	*
Environmental		
Temperature Range, Rated Performance	-25°C to +85°C	*
Storage Temperature Range	-55°C to +85°C	*
Relative Humidity Conforms to MIL Spec 202	0 to 95% @ 60°C noncondensing	*
RFI Susceptibility	±0.5% span error, 5W @ 400MHz @ 3 ft.	*

## NOTES

- <sup>1</sup>For a 0-20mA range, a typical minimum output current is 10μA.
- <sup>2</sup>Accuracy spec includes the combined effects of repeatability, hysteresis and linearity. Does not include sensor or signal source error.
- <sup>3</sup>Custom calibration may be accomplished with a custom ranging card, AC1310.
- <sup>4</sup>+24V dc power is only needed for driving the current output at up to 850Ω. If only voltage output is used, or a current output load of 400Ω or less is desired, ±15V is all that is required.
- \*Specifications same as 3B45.
- \*Specifications subject to change without notice.

## ORDERING INFORMATION

Input Range	Model Number
Frequency Input	
Externally Programmable	
(Min Span: 25Hz, Max Span: 1100Hz)	3B45-00
0-25Hz	3B45-01
0-300Hz	3B45-02
Frequency Input	
Externally Programmable	
(Min Span: 520Hz, Max Span: 25kHz)	3B46-00
0-1.5kHz	3B46-01
0-3kHz	3B46-02
0-25kHz	3B46-03

## ZERO SUPPRESSION FREQUENCY

The zero suppression frequency, F<sub>Z</sub>, can be set for any value up to 80% of the desired input span through the use of R<sub>2</sub>. Zero suppression is limited by temperature drift. Values larger than 80% of the input span will have a larger amount of temperature drift. The value for R<sub>2</sub> is determined from the following relations:

$$R_2 = \frac{1.52 \times 10^7}{F_Z} \quad R_2 = \frac{3.33 \times 10^8}{F_Z}$$

## HYSTERESIS SELECTION

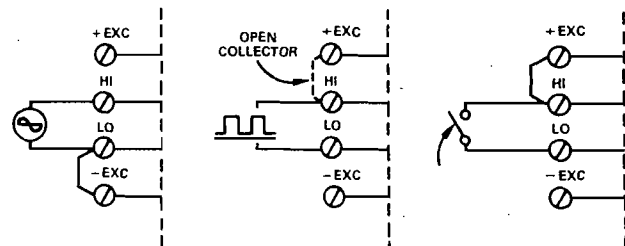
A standard 3B45 or 3B46 is shipped with zero hysteresis since a jumper is installed on the range carrier pins. If the jumper is removed, there will be nominally ±4V (±20%) of hysteresis. If less hysteresis is desired, it can be accomplished with the following equation:

$$R_4 A = \frac{10^6 \times V_H}{4 - V_H} \quad R_4 A = \frac{10^6 \times V_H}{4 - V_H}$$

where V<sub>H</sub> is the desired hysteresis. V<sub>H</sub> can be set for any value between 0 and 4V with a ±20% tolerance.

## THRESHOLD SELECTION

The threshold is determined by user wiring on the input screw terminals. If the input signal is a zero crossing voltage input, the LO input screw terminal must be tied to the -EXC screw terminal to implement a 0V threshold (see Figure 2.1.13.3a). When the LO input is not connected to the -EXC terminal (as in Figure 2.1.13.3b), the threshold is 1.6V which is useful for TTL level inputs. For open collector outputs, an internal pull-up resistor is provided at the +EXC screw terminal. The pull-up resistor, and 1.6V threshold are used with switch closure inputs (Figure 2.1.13.3c).



a. Zero Crossing Threshold    b. 1.6V Threshold    c. 1.6V Threshold with Contact Excitation

Figure 2.1.13.3 Threshold Selection

## RESPONSE TIME

Response time is a function of the frequency range. The table below indicates the time required to reach 90% of the output span for a step change input to the minimum and maximum ranges of the 3B45 and 3B46. Other ranges will have response times in between these extremes.

Model	Range	Response Time
3B45	0-25Hz	1.6sec
3B45	0-1.1kHz	0.6sec
3B46	0-520Hz	0.07sec
3B46	0-25kHz	0.03sec

## LIMITS

The ranging card can be used to create a wide range of special transfer functions, but there are practical limits to be observed. The 3B46 can accept ranges between 25kHz and 50kHz with a gradual decrease in linearity. A 0 to 30kHz range has 0.02% nonlinearity, 0-40kHz has 0.12% nonlinearity and a 0-50kHz range has 0.5% nonlinearity. The 3B45 and 3B46 offer input protection up to 220V and will operate normally up to that value. However, the user may want to externally attenuate large signals to reduce the noise level below the available hysteresis. The range of the module's output adjustment is at least ±0.5V at the module output and can, therefore, correct any error of less than 0.5V/Gain. If possible, the resistors should be 1% tolerance 10ppm. See Appendix A for a detailed discussion of limits, error contributions, and temperature effects of the ranging card.

## 2.1.14 MODEL 3B47

### FEATURES

Accepts J, K, T, E, R, S or B Thermocouple Inputs

Provides Linearized 0-10V Output

Reliable Transformer Isolation

$\pm 1500V$  CMV

160dB CMR

Meets IEEE-STD-472: Transient Protection (SWC)

Internal Cold Junction Compensation

Open Thermocouple Detection

### FUNCTIONAL DESCRIPTION

The 3B47 accepts its signal from type J, K, T, E, R, S, and B thermocouples and provides a 0 to +10V output. The input signal is internally linearized to provide an output which is linear with temperature. Figure 2.1.14.1 shows a functional diagram for the model 3B47. Input protection of up to 220V is provided for the input circuitry. Cold Junction Compensation with an initial accuracy of  $\pm 0.5^\circ C$  is performed in each unit with the external sensor provided on all channels of the 3B Series backplane. The signal is amplified and filtered to give the high level voltage output. Chopper based amplification is used to assure low drift and excellent long term stability. Transformer coupling is used to achieve stable galvanic isolation between input and output. The voltage output can be adjusted over a  $\pm 5\%$  span range for zero and span with the front panel accessible potentiometers.

### DOWNSCALE OPEN INPUT DETECTION

The 3B47 provides upscale open thermocouple detection when used under normal operation. Downscale open thermocouple detection can be provided by installing a  $220M\Omega$  resistor across screw terminals 2 and 4. This resistor could be 0.25W carbon comp and need not be a tight tolerance ( $\pm 20\%$ ). The addition of this resistor reverses the input bias current which provides downscale open input detection.

### FINE CALIBRATION

The 3B47 is factory calibrated for a specified range to provide zero and span accuracy of  $\pm 0.1\%$  of span. Cold junction sensors, with an initial accuracy of  $\pm 0.5^\circ C$ , are provided on each backplane channel. If greater accuracy is desired, the modules should be calibrated in the actual backplane channel that they will be installed in. User accessible zero and span trim potentiometers providing a  $\pm 5\%$  adjustment range permit precise field calibration of the voltage output. The following nonrecursive adjustment procedure is recommended:

1. Make connections as shown in Figure 2.1.14.1. Use a precision millivolt source.
2. Measure the ambient temperature of the screw terminal block and determine the millivolt output for millivolt/temperature tables. This value will be inverted and added to the millivolt span of the thermocouple being simulated.
3. Determine the zero and full scale points for the measurement range from standard millivolt/temperature tables, and add to the number determined in step 2.

Example: Type J 0-500 $^\circ C$

Zero and full scale values: 0mV to +27.388mV

Output at ambient temperature: 1.277mV (invert sign)

Corrected zero and span values: -1.277mV to +26.111mV

4. Apply  $V_{IN}$  for the minimum input signal (determined in step 3), adjust  $V_Z$  for  $V_{OUT} = 0V \pm 10mV$ .
5. Apply  $V_{IN}$  for the maximum input signal (determined in step 3), adjust  $V_S$  for  $V_{OUT} = +10V \pm 10mV$ .

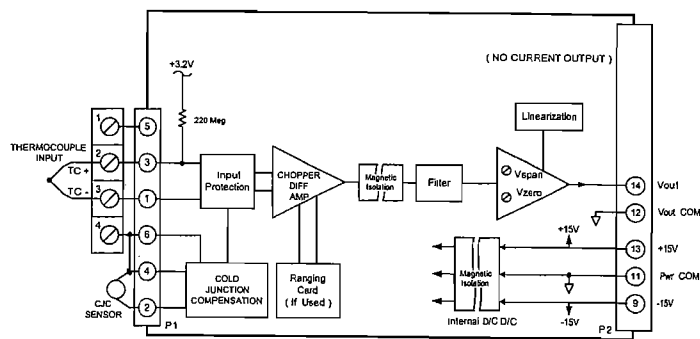


Figure 2.1.14.1 3B47 Functional Block Diagram

5. Apply  $V_{IN}$  for the maximum input signal (determined in step 3), adjust  $V_S$  for  $V_{OUT} = +10V \pm 10mV$ .

The 3B47 may also be calibrated using an ice bath setup.

### OPTIONAL ZERO SUPPRESSION/ CUSTOM CALIBRATION

The 3B47-CUSTOM is recommended for the user needing a 3B47 with special ranging. This is a factory configured unit in which the factory will install the resistors needed for zero, span, and cold junction compensation as well as the fifteen separate components needed for linearization. (Consult the factory for details.)

### OPTIONAL CURRENT OUTPUT

A current output can be provided for the 3B47 by installing a 3B19 or 3B39 in an adjacent channel and installing a jumper on the backplane that connects the 3B47 output to the Current Output Module's (either 3B19 or 3B39) input. If utilizing this feature with the 3B19 Non-Isolated Current Output Module, the 3B47 will have a current output capability comparable to that of the 3B37 Thermocouple Module. If, on the other hand, the 3B39 Isolated Current Output Module is used, the user would be provided with two levels of  $\pm 1500$  CMV isolation: an isolated current output from an isolated input module.

If the Optional Current Output feature is desired, it is implemented by using wire wraps or jumpers on the appropriate pins of the jumper posts located near the voltage I/O connectors. Figure 2.1.14.2 defines the channel pairs that can have this feature.

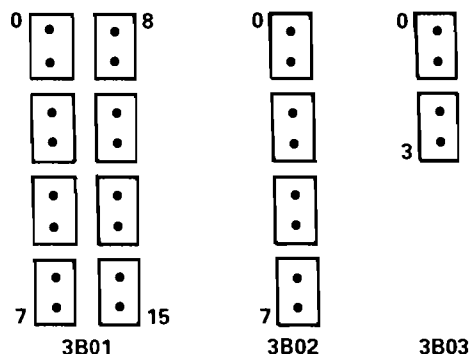


Figure 2.1.14.2 Adjacent Channels That Can Be Connected

# SPECIFICATIONS

(typical @ +25°C and ±15V, +24V dc power)

<b>Model</b>	<b>3B47</b>
<b>Inputs</b>	Thermocouple Types J, K, T, E, R, S, B
<b>Outputs</b>	0 to +10V @ 5mA
<b>Accuracy<sup>1</sup></b>	See ordering information
<b>Stability vs. Ambient Temperature</b>	
<b>Voltage Output</b>	
Zero	±0.02 °C/°C
Span	±0.0025% reading/°C
<b>Common Mode Voltage, Input to Output</b>	±1500V pk max
<b>Common Mode Rejection @ 50Hz or 60Hz</b>	
1k Source Unbalance	160dB
Normal Mode Rejection @ 50Hz or 60Hz	60dB
<b>Differential Input Protection</b>	220V rms, cont.
<b>Voltage Output Protection</b>	Continuous Short to Ground
<b>Zero and Span Adjustment Range<sup>2</sup></b>	±5% of span
<b>Response Time to 90% Span</b>	0.2sec
<b>Input Transient Protection</b>	Meets IEEE-STD 472 (SWC)
<b>Input Resistance</b>	15MΩ
<b>Input Bias Current</b>	15nA
<b>Input Noise</b>	0.2μV rms at 10Hz bandwidth
<b>Open Input Response</b>	Upscale
<b>Open Input Detection Time</b>	10sec
<b>Output Noise</b>	100μV rms in 100kHz bandwidth
<b>Bandwidth</b>	3Hz(-3dB)
<b>Cold Junction Compensation</b>	
<b>Initial Accuracy<sup>3</sup></b>	±0.5°C
<b>vs Temperature<sup>4</sup> (+5°C to +45°C)</b>	±0.5°C
<b>Power Supplies</b>	
±15V Input Supplies Range	
(Rated Operation)	±(11.5V to 16.5V)
Supply Rejection	±0.01% span/V
Supply Current	+16mA, -14mA
<b>Size</b>	3.150" × 0.775" × 3.395"
<b>Environmental</b>	
<b>Temperature Range, Rated Performance</b>	-25°C to +85°C
<b>Storage Temperature Range</b>	-55°C to +85°C
<b>Relative Humidity Conforms to MIL Spec 202</b>	0 to 95% @ 60°C noncondensing
<b>RFI Susceptibility</b>	±0.5% span error, 5W @ 400MHz @ 3 ft.

## NOTES

<sup>1</sup>Accuracy spec includes the combined effects of repeatability, hysteresis and linearity. Does not include sensor or signal source error.

<sup>2</sup>A wide range of zero suppression and custom calibration may be accomplished with a custom ranging card, AC1310.

<sup>3</sup>When used with CJC sensor provided on 3B Series backplanes.

<sup>4</sup>Compensation error contributed by ambient temperature changes.

Specifications subject to change without notice.

## ORDERING INFORMATION

EXAMPLE MODEL 3B47 - J - 01

Select Thermocouple Type  
(J,K,T,E,R,S or B) and Range

Range in °C (°F)	TC		
	Type	No.	Accuracy
0 to +760 (32 to +1400)	J	01	0.76°C
-100 to +300 (-148 to +572)	J	02	0.4°C
0 to +500 (32 to +932)	J	03	0.36°C
0 to +1000 (32 to +1832)	K	04	1.0°C
0 to +500 (32 to +932)	K	05	0.38°C
-100 to +400 (-148 to +752)	T	06	1.1°C
0 to +200 (32 to +392)	T	07	0.3°C
0 to +1000 (32 to +1832)	E	08	1.5°C
500 to +1750 (932 to +3182)	R	09	1.6°C
500 to +1750 (932 to +3182)	S	10	1.5°C
500 to +1800 (932 to +3272)	B	11	3.3°C



## 2.2 OUTPUT MODULES

### FEATURES

High Level Voltage Input (0-10V,  $\pm 10V$ )  
Process Current Output (4-20mA/0-20mA)  
High Accuracy:  $\pm 0.1\%$   
Reliable Transformer Isolation  
 $\pm 1500V$  CMV  
90dB CMR  
Meets IEEE-STD.472: Transient Protection (SWC)  
Output Protection: 130V or 220V rms Continuous  
Reliable Pin and Socket Connections  
Low Cost per Channel

### APPLICATIONS

Process Control, Factory Automation, Energy Management,  
Data Acquisition, and Control Systems.

### OUTPUT MODULE

#### General Description

Each output module accepts a high level analog signal from the Voltage I/O Connector and provides a current output on the output screw terminals. The output modules can be powered from an external +24V with a load of up to 850 $\Omega$ . If desired, +15V can be used to power the output modules with a smaller load (up to 400 $\Omega$ ). Each output module features high accuracy of  $\pm 0.1\%$ . If isolation is required, the 3B39 provides  $\pm 1500V$  peak of common mode voltage isolation protection.

The transfer function provided by each output module is:

Input: 0 to +10V or  $\pm 10V$   
Output: 4 to 20mA/0-20mA

Figure 2.2.1 shows a functional diagram for the model 3B39 isolated voltage to current converter. Each unit is plugged into a 3B Series backplane, which provides the power for each module. The input signal drives a voltage to current converter through the isolation barrier. Transformer coupling is used to achieve stable galvanic isolation. The current output can be adjusted over a  $\pm 5\%$  span range for zero and span with front panel accessible potentiometers. Output protection of up to 220V (130V for the 3B19) is provided for the current outputs.

Model 3B39 has been specifically designed for high accuracy applications in process control and monitoring systems to offer complete galvanic isolation and protection against damage from transients and fault voltage in transmitting information between subsystems or separated system elements. It provides total ground isolation and transient protection when interfacing D/A converters to standard 4-20mA current loops. This requirement is common in microcomputer-based control systems.

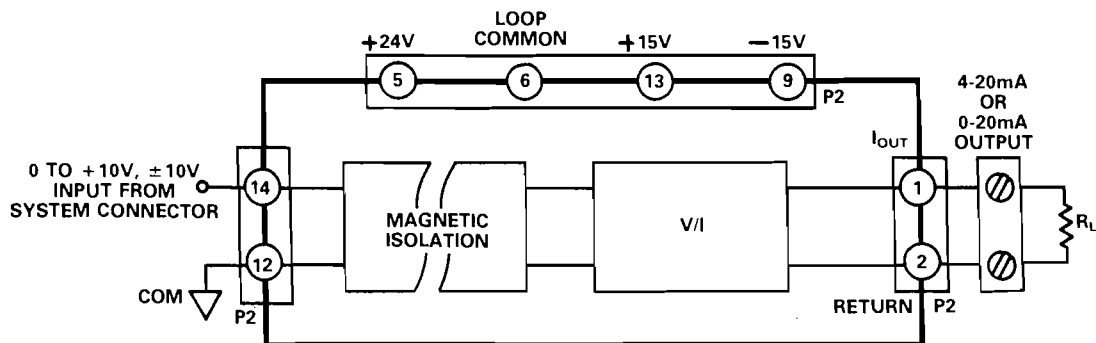


Figure 2.2.1 Model 3B39 Isolated Voltage to Current Converter Functional Block Diagram

Each output module has two user programmable jumper options. One option allows the user to program the current output to be proportional to either a 0 to +10V span input or a -10V to +10V input.

The second option allows the user to set the current output to 4-20mA or 0-20mA. All output modules are shipped from the factory so that the current output is proportional to the 0 to +10V input and all current outputs are 4-20mA.

### FINE CALIBRATION

The 3B19 and 3B39 are factory calibrated to  $\pm 0.1\%$  of span for a 0 to +10V input. If field calibration is required, the following nonrecursive procedure is recommended:

1. Connect the 3B39 (3B19) as indicated in Figure 2.2.1 with  $R_L = 250\Omega$ .
2. Apply  $V_{IN} = 0V$  and adjust  $I_Z$  so that  $I_O = 4mA \pm 0.016mA$  or the voltage measured across  $R_L = 1V \pm 4mV$ .
3. Apply  $V_{IN} = +10V$  and adjust  $I_S$  so that  $I_O = 20mA \pm 0.016mA$  or the voltage measured across  $R_L = 5V \pm 4mV$ .

If a 0-20mA output is desired,  $I_O$  should be adjusted for  $0mA \pm 0.020mA$  in step 2 and  $20mA \pm 0.020mA$  in step 3 (a typical minimum output current is  $10\mu A$  with 0-20mA operation).

## GENERAL OUTPUT MODULE SPECIFICATIONS

(typical @ +25°C and  $\pm 15V$ , +24V dc power)

Model	3B39, Isolated	3B19, Nonisolated
Inputs	0 to +10V, $\pm 10V$	*
Outputs	4-20mA or 0-20mA @ $R_L = 0$ to $850\Omega$	*
Accuracy <sup>1</sup>	+ 0.1% span	*
Nonlinearity	$\pm 0.01\%$	*
Stability vs. Ambient Temperature		
Zero	$\pm 0.0025\%$ span/ $^{\circ}C$	*
Span	$\pm 0.002\%$ reading/ $^{\circ}C$	*
Common Mode Voltage, Output to		
Input and Power Supply	$\pm 1500V$ pk max	N/A
Common Mode Rejection	90dB	N/A
Normal Mode Output Protection	220V rms, Continuous	130V rms, Continuous
Zero and Span Adjustment Range	$\pm 5\%$ of span	*
Output Transient Protection	Meets IEEE-STD 472 (SWC)	N/A
Input Resistance	10k $\Omega$	*
Power Supply <sup>2</sup>	$\pm 15V$ dc, +24V dc	*
Maximum Input Voltage Without Damage	$\pm 20V$	*
Size	3.150" $\times$ 0.775" $\times$ 3.395"	*
Environmental		
Temperature Range, Rated Performance	-25 $^{\circ}C$ to +85 $^{\circ}C$	*
Storage Temperature Range	-55 $^{\circ}C$ to +85 $^{\circ}C$	*
Relative Humidity Conforms to		
MIL Spec 202	0 to 95% @ 60 $^{\circ}C$ , noncondensing	*
RFI Susceptibility	$\pm 0.5\%$ span error, 5W @ 400MHz @ 3 ft.	*

### NOTES

<sup>1</sup>Accuracy spec includes combined effects of repeatability, hysteresis and linearity.

<sup>2</sup>+24V dc supply is only needed for driving loads of up to  $850\Omega$ .

+15V dc can be used for driving a  $400\Omega$  maximum load.

\*Specifications same as 3B39.

Specifications subject to change without notice.

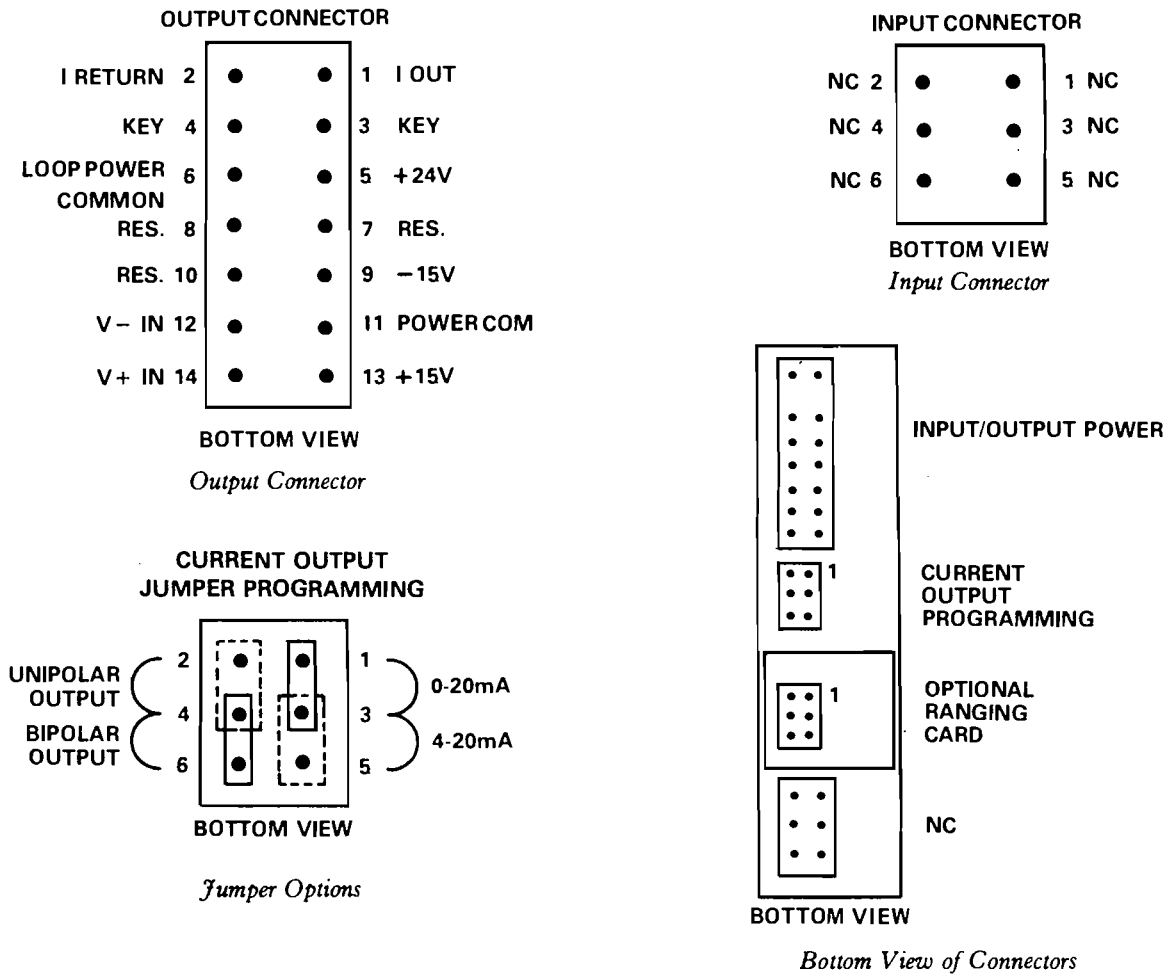


Figure 2.2.2 Output Module Connectors

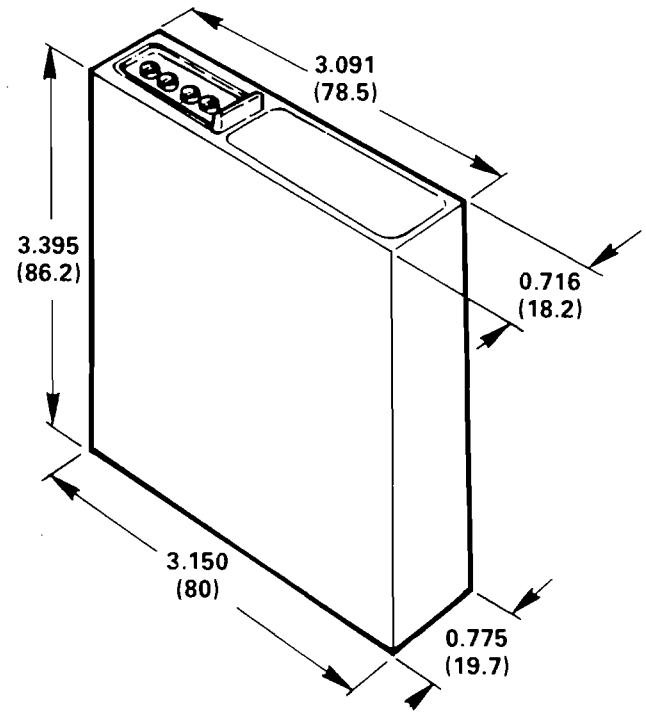


Figure 2.2.3 Output Module Dimensions  
Dimensions shown in inches and (mm).

### 2.3 BACKPLANE FUNCTIONAL DESCRIPTION

The 3B Series Signal Conditioning Subsystem consists of a family of backplanes, input modules, output modules and power supplies. The three backplane models, 3B01, 3B02 and 3B03 are designed for 16, 8 and 4 channels, respectively, to offer users the flexibility to match the size of a system to specific applications. The sixteen channel backplane can be mounted in a 19" × 5.25" panel space. Several mounting options are offered, including rack, surface, and NEMA enclosure mounting.

The 3B01 backplane can accommodate up to 16 signal conditioning modules. Modules can be mixed and matched in the backplane to provide the desired number of channels for a specific function. Each channel has four screw terminals for input connections. These connections satisfy all transducer inputs and provide transducer excitation when necessary. A cold junction sensor is supplied on each channel to accommodate thermocouple modules. Each channel has two screw terminals for the output connections for the 4-20mA output. Two 26-pin system connectors provide high level voltage I/O for all channels.

The 3B Series Subsystem offers high density packaging to conserve mounting space and can be easily tailored to fit the user's needs. All modules feature a universal pin out which assures interchangeability. The plug-in design allows easy reconfiguration.

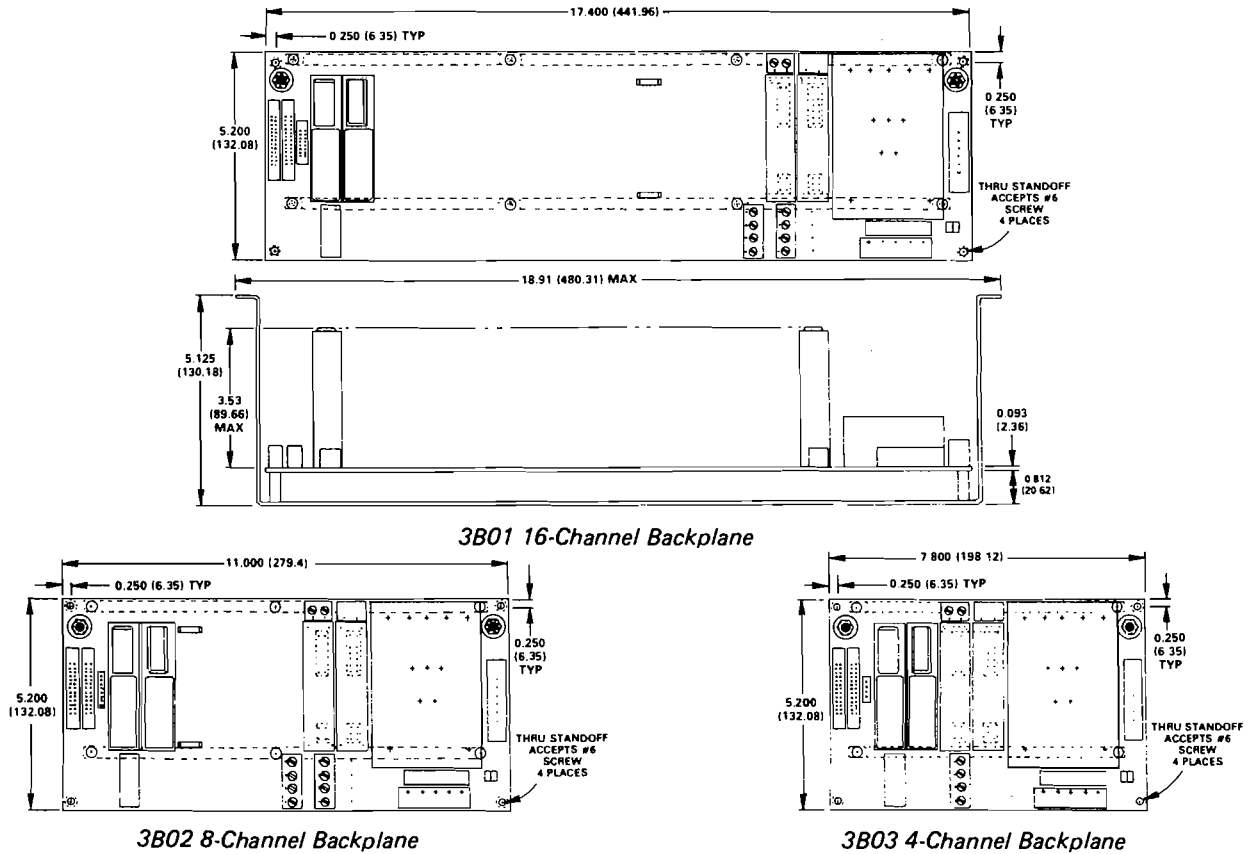


Figure 2.3.1 Backplane Outline Dimensions  
Dimensions shown in inches and (mm).

# BACKPLANE SPECIFICATIONS

Model	3B01	3B02	3B03
Channels	16	8	4
Power Supply Options <sup>1</sup>			
External Power Requirements	± 15V + 24V	*	*
AC Power Supply <sup>2</sup>	100, 115, 220, 240V ac	*	*
DC Power Supply <sup>3</sup>	+ 24V	*	*
Cold Junction Sensor	Provided on each Channel	*	*
Power Indicator	LEDs indicate ± 15V and + 24V power applied	*	*
Physical			
Size (with modules)	17.400" × 5.200" × 4.373"	11.000" × 5.200" × 4.373"	7.800" × 5.200" × 4.373"
Fuse	220V Fuse at 500mA (5mm × 20mm)	*	*

**NOTES**

<sup>1</sup>Actual Power Supply requirements are a function of the quantity and types of module used (see Table II)

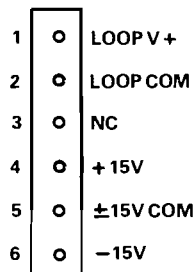
<sup>2</sup>AC Power Supplies include AC1300 and AC1301. Each is offered in one domestic and three foreign versions. Refer to Power Supply Specifications.

<sup>3</sup>AC1302 is an optional dc Power Supply

\*Specifications same as 3B01.

Specifications subject to change without notice.

**Power Connector  
DC Power**



TOP VIEW

**MATING**

**CONNECTOR:**

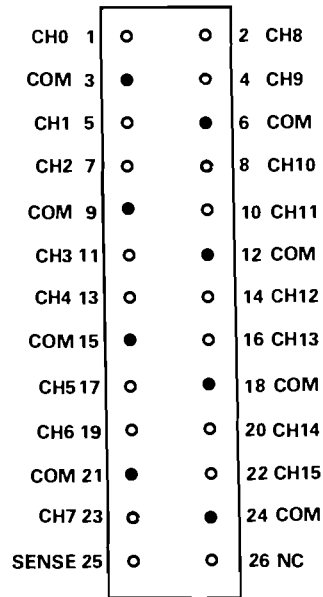
AMP P/N 202237-1 (6 PCS)

AMP P/N 207377-1 (1 PC)

OR EQUIVALENT

AC1352

**System Connector  
High Level Analog I/O**



TOP VIEW

● = GROUND

**MATING**

**CONNECTOR:**

AMP P/N 499958-6

OR EQUIVALENT

AC1312

Figure 2.3.2 Backplane Pin Designations  
(3B01, 3B02, 3B03)

## 2.4 POWER SUPPLY

The 3B Series Subsystem can operate from an ac power supply or dc/dc (+24V input) power supply mounted on the backplane or external  $\pm 15V$  and +24V supplies can be used. The power supply is bussed to all signal conditioners on the backplane. Supply current is a function of the modules that are actually used (see Table 2.4.1). The power supply outputs listed in the Specifications cover most cases. Each power supply operates over a  $-25^{\circ}C$  to  $+71^{\circ}C$  temperature range.

If the user wishes to use a +15V supply for current output, the +15V can be strapped to the loop power on connector P3 (see Figure 4.3.1). With this arrangement, the load resistance on current outputs is limited to  $400\Omega$  max.

If +24V is supplied from an external source, a dc/dc converter (ADI model AC1302) can be used to supply  $\pm 15V$  to the backplane. The current loop power is provided from the +24V source which must be capable of handling the desired number of current loop outputs.

If both +24V and  $\pm 15V$  are supplied from an external source, the power supply requirements must be satisfied for the desired number of modules.

Model	+15V dc Current	-15V dc Current	+24V dc Current
3B10	10mA	10mA	27mA
3B11	10mA	10mA	27mA
3B12	10mA	10mA	27mA
3B13	12mA	12mA	27mA
3B14	20mA	20mA	27mA
3B15	20mA	20mA	27mA
3B16	45mA	10mA	27mA
3B17	65mA*	65mA*	27mA
3B18	50mA	15mA	27mA
3B19	4mA	4mA	27mA
3B30	10mA	10mA	27mA
3B31	10mA	10mA	27mA
3B32	10mA	10mA	27mA
3B34	10mA	10mA	27mA
3B37	12mA	12mA	27mA
3B39	5mA	5mA	35mA
3B40	10mA	10mA	27mA
3B41	10mA	10mA	27mA
3B42	10mA	10mA	27mA
3B43	10mA	10mA	27mA
3B44	10mA	10mA	27mA
3B45	16mA	16mA	27mA
3B46	19mA	19mA	27mA
3B47	16mA	14mA	N/A

\*Typical number is 40mA per module plus  $\pm 5mA$  for LVDT drive current. Supply current requirements for LVDT current is 75% of the LVDT rms current.

Table 2.4.1 Module Power Requirements

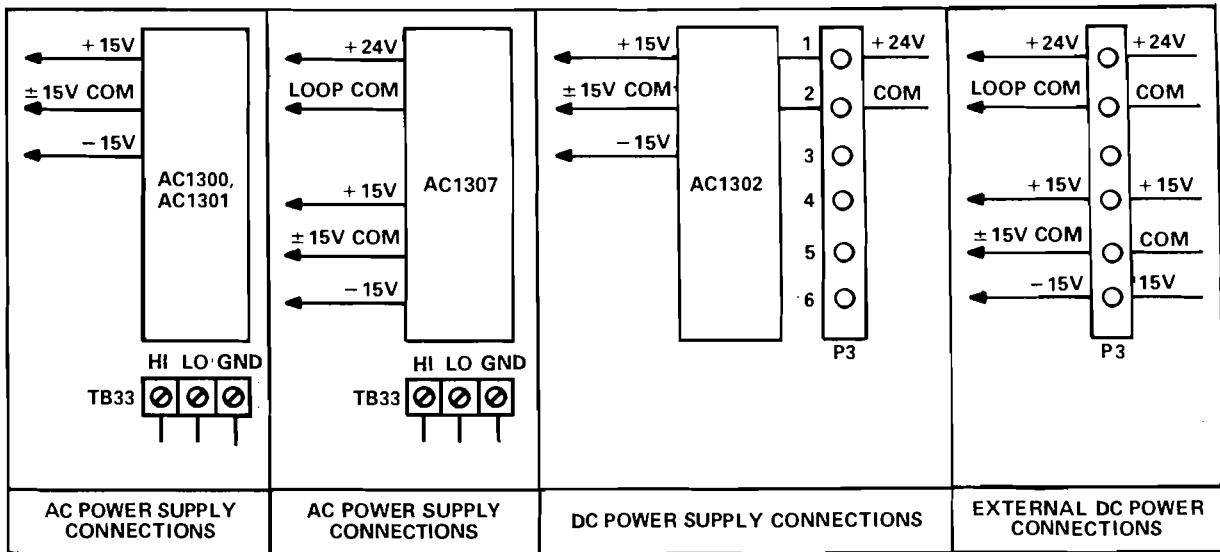


Figure 2.4.1 Power Supply Connections

## POWER SUPPLY SPECIFICATIONS

Model	AC1300	AC1301	AC1302	AC1307
Input Voltage	105-125V ac, 50Hz to 400Hz 205-240V ac, 50Hz to 400Hz (AC1300E) 90-110V ac, 50Hz to 400Hz (AC1300F) 220-260V ac, 50Hz to 400Hz (AC1300H)	105-125V ac, 50Hz to 400Hz 205-240V ac, 50Hz to 400Hz (AC1301E) 90-110V ac, 50Hz to 400Hz (AC1301F) 220-260V ac, 50Hz to 400Hz (AC1301H)	22.3V-26.4V	105-125V ac, 50Hz to 400Hz 205-240V ac, 50Hz to 400Hz (AC1307E)
Output Voltage	± 15V	± 15V	± 15V	+ 15V, - 15V, + 24V*
Output Current	± 200mA	± 350mA	± 190mA	+ 800mA, - 225mA, + 350mA
Operating Temperature	- 25°C to + 71°C	- 25°C to + 71°C	- 25°C to + 71°C	- 25°C to + 71°C
Storage Temperature	- 25°C to + 85°C	- 25°C to + 85°C	- 40°C to + 100°C	- 25°C to + 85°C
Dimensions (inches)	3.5 × 2.5 × 1.25	3.5 × 2.5 × 1.62	2.0 × 2.0 × 0.38	4.0 × 2.8 × 3.4

**NOTE**

\*The + 24V output is unregulated.

## CHAPTER 3

### INSTALLATION

The 3B Series Signal Conditioning I/O Subsystem is designed to be installed in any convenient location suitable for general purpose electronic equipment. Operating ambient temperature should be within  $-25^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  ( $-13^{\circ}\text{F}$  to  $+185^{\circ}\text{F}$ ) for satisfactory performance of the complete system. If the equipment is going to be used in a harsh or unfavorable environment, it may be necessary to install it inside a protective enclosure. It is recommended that the backplane be mounted and wired before the modules are installed. If a plug-in module requires calibration, refer to the calibration instructions for the particular module.

(PLEASE NOTE: The 3B Series is approved by Factory Mutual for use in Class I, Division 2, Groups A, B, C, and D locations when meeting the installment requirements shown in the drawing in Appendix C.)

#### 3.0 BACKPLANE MOUNTING

Four 6-32  $\times$  1" screws and through standoffs at the four corners of each backplane are provided for mounting purposes. Figure 3.0.1 shows the location of the mounting standoffs.

Securing the backplane with the four corner screws should be sufficient for most applications. If additional rigidity is required on the 3B01 and 3B02, they can also be secured with the through standoffs found on the center of each backplane (see Figure 3.0.1). The additional 6-32  $\times$  1" screws are provided with the 3B01 and 3B02.

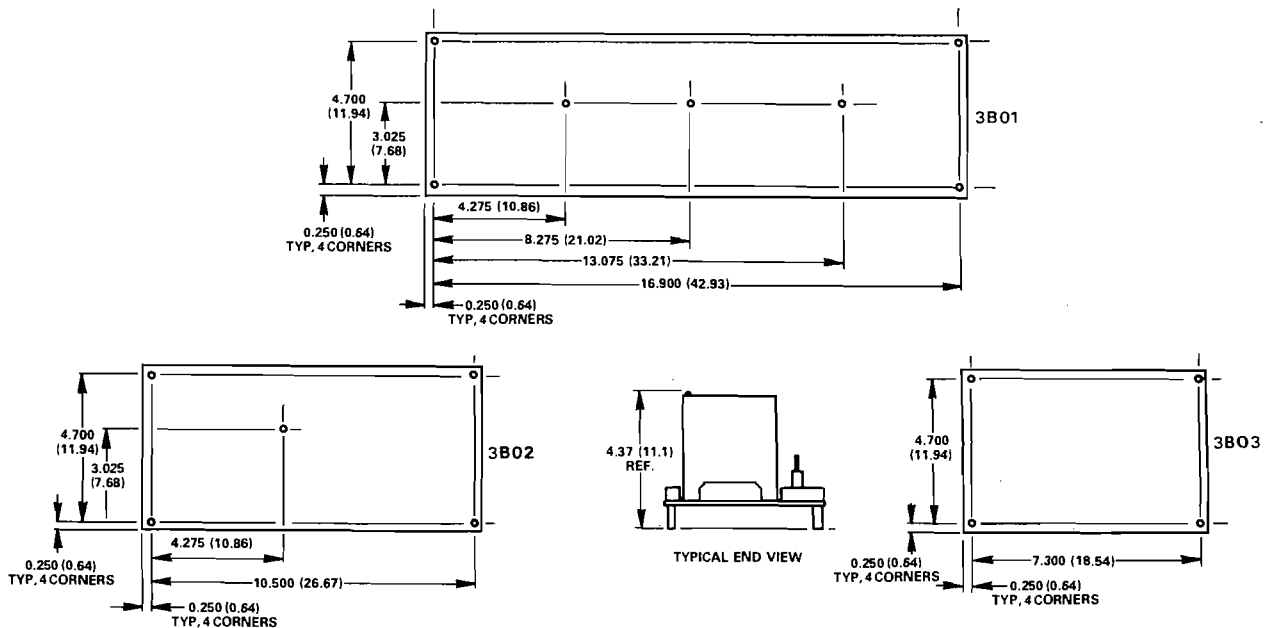


Figure 3.0.1 Backplane Mounting Dimensions

#### 3.1 19" RACK MOUNT KIT (AC1330)

The AC1330 includes a two piece metal device that is designed for mounting the 3B Series Subsystem in a 19" rack. The bottom plate has threaded inserts for mounting each of the three backplanes using the four screws (6-32  $\times$  1" long) that are shipped with each backplane. The top piece provides a rigid module holddown and is secured to the bottom piece with two quarter-turn fasteners. Figure 3.1.1 provides the location of the mounting holes on the bottom plate. Figure 3.1.2 is an assembly drawing for the AC1330 option. The backplane is readily fitted to the base plate by sliding it in from the side under the protruding metal used for stiffening. If a power supply is to be secured from the back of the backplane, it should be secured to the backplane before the backplane is mounted to the AC1330. If an interface board (i.e. AC1320) is to be mounted on the AC1330, it should be connected before the AC1330 is placed in a rack.



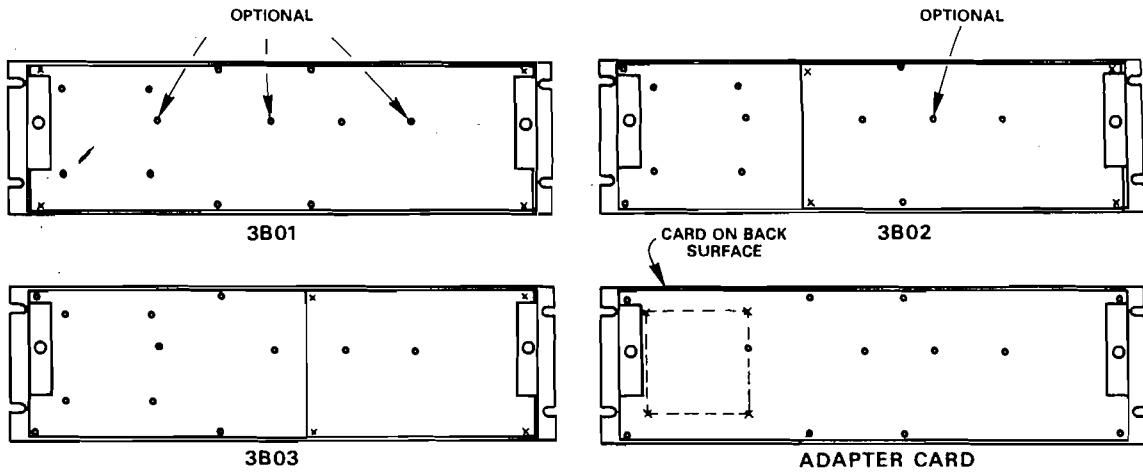


Figure 3.1.1 Rack Mount Options

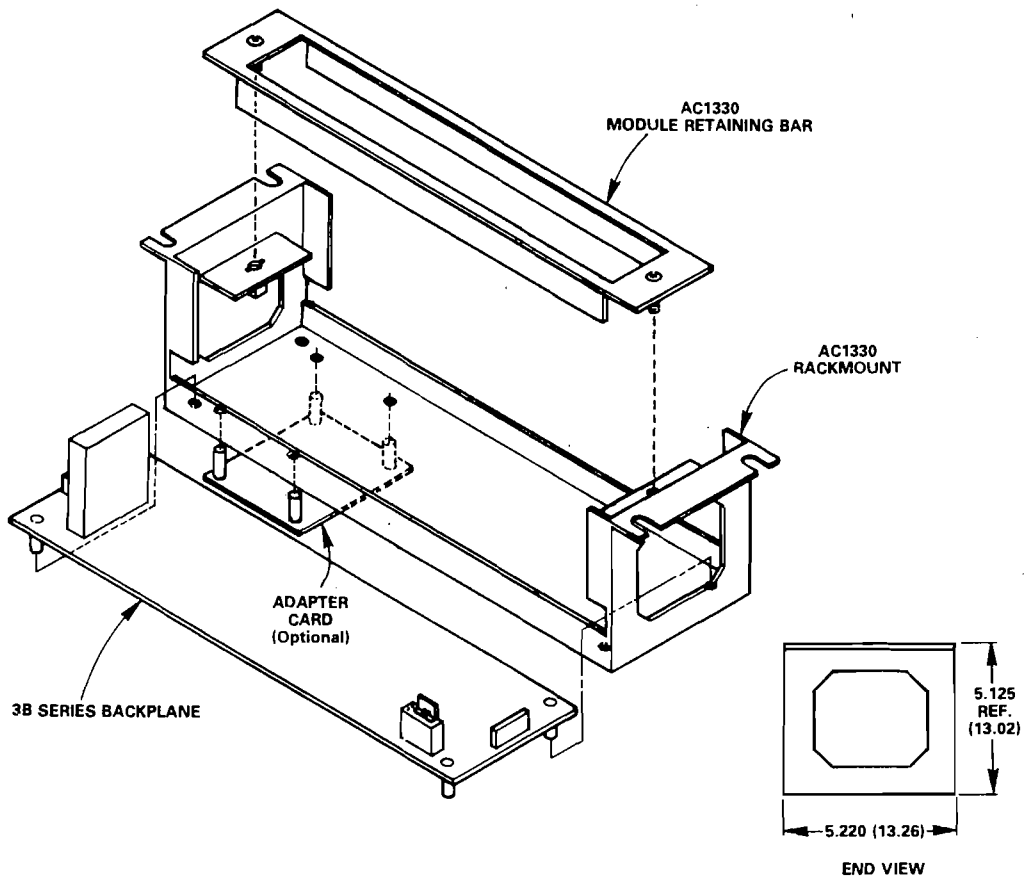


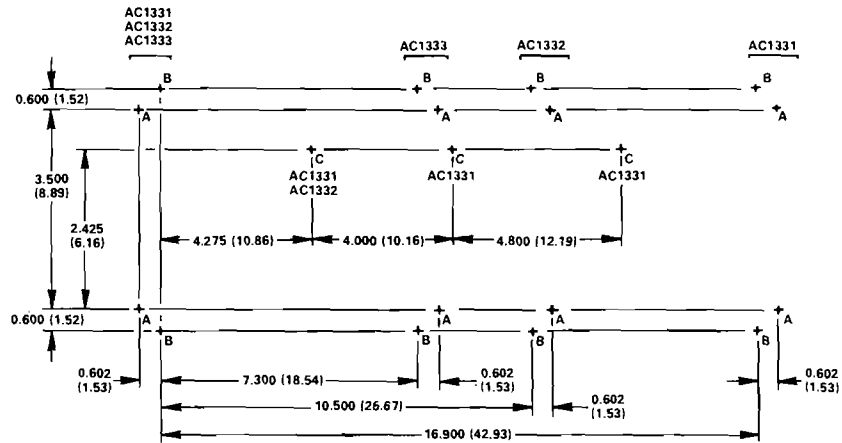
Figure 3.1.2 Rack Mount Assembly

### 3.2 3B SERIES SURFACE MOUNT KITS (AC1331, AC1332, AC1333)

The AC1331, AC1332, and AC1333 are surface mount kits that are designed for the sixteen (3B01), eight (3B02), and four (3B03) channel backplanes respectively. These accessories allow for easy panel and NEMA enclosure mounting. The AC1331 will mount the 3B01 in an 18.824" × 5.375" area. The AC1332 will mount the 3B02 in a 12.42" × 5.375" area, and the AC1333 will mount the 3B03 in a 9.22" × 5.375" area. A backplane and appropriate accessory are mounted to any surface by drilling and tapping the appropriate eight holes (four 6-32 and four 10-24). If additional rigidity is required on the 3B01 or 3B02, they can also be secured by drilling and tapping additional holes for 6-32 screws to pick up the through standoffs on the center of each backplane.

Figure 3.2.2 shows the mounting location for each of the three accessories, and Figure 3.2.3 shows an assembly drawing for the AC1331 surface mount option.

Mount the backplane first using four 6-32 × 1" screws provided. (On 3B01 and 3B02, additional screws may be inserted for additional rigidity.) Insert a module in the left-most position and the right-most position. Attach the module retaining bar to the two end brackets with the quarter turn fasteners as shown in Figure 3.2.3. Place the holddown assembly over the backplane so that the two modules fit up inside of the module retaining bar. Attach the end brackets to the mounting surface using the four 10-24 screws provided and flat washers. Remove the module retaining bar and install modules as desired.



1. Holes Marked "A" Are to Secure End Brackets. Drill and Tap for 10-24 Screw. Use Flat Washers Under the Screw Heads #25 Drill (0.1495 Inches) is Recommended for 10-24 Tap.
2. Holes Marked "B" Are for Securing Corner Standoffs of 3B Series Backplanes with 6-32 × 1" Screws Provided Drill and Tap for 6-32 Screw. #36 Drill (0.1065 Inches) is Recommended for 6-32 Tap.
3. Holes Marked "C" Are Optional Mounting for AC1331 and AC1332. Use 6-32 × 1" Screws Provided. Drill and Tap for 6-32 Screw. #36 Drill (0.1065 Inches) is Recommended for 6-32 Tap.

Figure 3.2.2 Surface Mount Dimensions

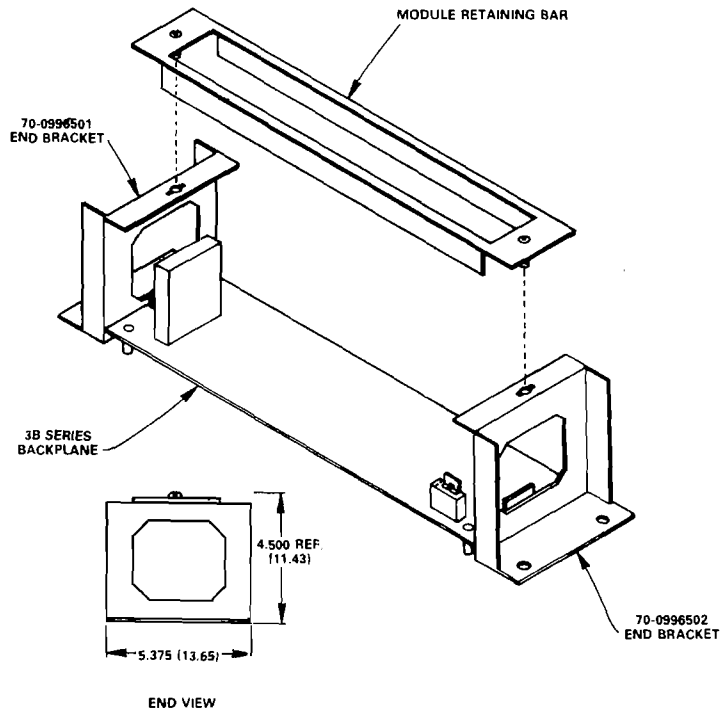


Figure 3.2.3 Surface Mount Assembly

### 3.3 POWER SUPPLY INSTALLATION

Each power supply comes with a retainer clip and required hardware that can be used to secure the power supply to any backplane. This feature allows each power supply to be removed from the backplane without disturbing the mounted backplane. If desired, the ac power supplies can be secured to the backplane from the back with #4 screws and a large diameter washer. The clip mounting is diagrammed in Figure 3.3.1.

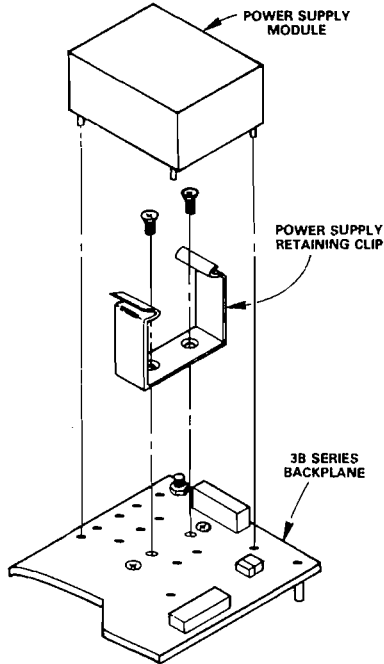


Figure 3.3.1 Power Supply Installation

### 3.4 ELECTRICAL CONNECTIONS

The wiring discussion is divided into three areas: power connections, field terminations, and user equipment termination.

**Power Connections:** The 3B Series Subsystem can operate from an ac power supply, a dc/dc power supply or an externally provided  $\pm 15V$  and  $+24V$  supply. If an ac power (i.e. AC1300, AC1301) is used, it should be secured to the backplane with the retainer clip or holddown screws as discussed in Section 3.3. The input wiring is connected to TB33 as indicated in Figure 3.4.1. The wiring of the ac power connector is most readily accomplished by removing the two corner screws that secure the yellow safety cover to the connector. This enables the cover to be easily removed so that the ac terminals are accessible.

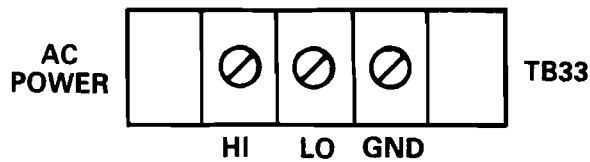


Figure 3.4.1 AC Power Connections

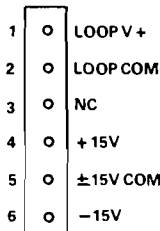
The AC1340-D power cord can be used with the ac connector and plugged into a standard wall outlet (the AC1340-C version is available for the European continental plug). If a different cable is used, proper wiring practice should be used so that no wiring is exposed.

It is recommended that the yellow safety cover be reinstalled after the ac power connector is wired so that no ac wiring is exposed.

If a dc/dc converter (AC1302) or external power is used, the wiring is brought to connector P3. This connector is compatible with an AMP mating connector or equivalent (see Figure 3.4.2). The AC1341 dc power cord can be used to interface the 3B Series to any external dc power source. If a user supplied cable is used, proper wiring practice should be employed to ensure that no wiring is exposed.

Note that if +15V is to be used to supply loop power, a jumper should be installed between pins 1 and 4 on the dc power connector (see Figure 4.3.1).

**Power Connector  
DC Power**



BOTTOM VIEW

**MATING  
CONNECTOR:**

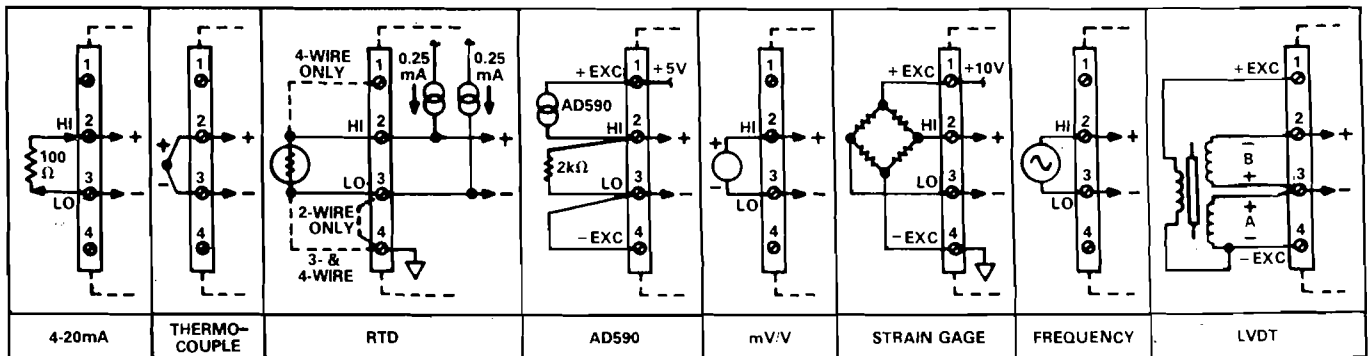
AMP P/N 202237-1 (6 PCS)

AMP P/N 207377-1 (1 PC)

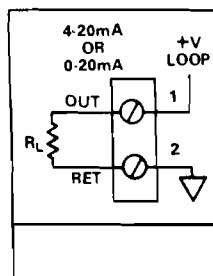
OR EQUIVALENT

AC1352

Figure 3.4.2 DC Power Connector



INPUT CONNECTIONS:  
ALL INPUT CONNECTIONS USE #6-32 SCREW TERMINALS.  
COMPATIBLE WITH 14 AWG WIRE.



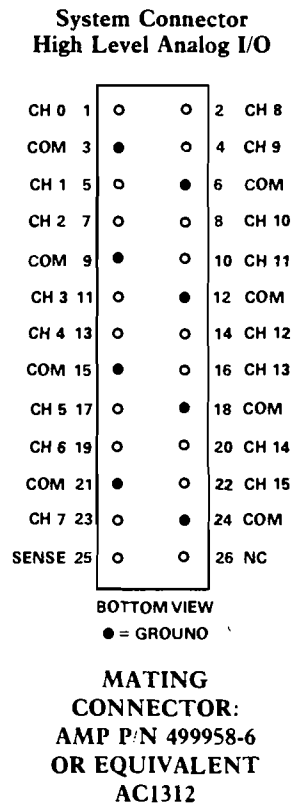
OUTPUT CONNECTIONS:  
ALL OUTPUT CONNECTIONS USE  
#6-32 SCREW TERMINALS.  
COMPATIBLE WITH 14 AWG WIRE.

Figure 3.4.3 Screw Terminal Connections

**Field Terminations:** All screw terminal connections are indicated in Figure 3.4.3. Input terminals numbered 1, 2, 3, and 4 correspond to the markings on each backplane. The output connectors each are marked 1 and 2 where 1 represents the current loop out and 2 represents the return. Calibration information may be found by referring to the instructions for the appropriate module. All input and output connections can accommodate 14-20 gauge wire.

Models 3B10, 3B11, 3B12, 3B16 and 3B18 (when used with external excitation) all require a ground return for the input connections to return the bias current to ground. The remaining nonisolated units do not require this since the input signal is grounded internal to the module. The isolated input modules do not require a return to ground since the input signal is floating.

**User Equipment Terminations:** All channels are single ended and share a common reference to all other channels and to the power supply common. The pinout of the system connector is shown in Figure 3.4.4. The 3B Series backplanes are readily interfaced to any user equipment by means of various interconnection boards. Four interface boards are available that interface directly with Analog Devices' Real Time Interface (RTI) Boards while there are two universal boards that are designed to satisfy most user interface needs. Five of these interface boards have identical mechanical dimension (5" x 4.5" with 3" x 3" mounting holes see Figure 3.4.5) while the AC1324 has smaller dimensions. (See Figure 4.2.2.1). There is also a selection of 3B to RTI Cable Assemblies (a cable assembly being defined as a cable with two connectors) that allow direct interface with many Analog Devices' RTI Boards.



*Figure 3.4.4 Voltage I/O Connector*

Figure 3.4.6 is a drill template that can be removed from the User's Manual and used for mounting any 5" x 4.5" interface board (see page following 3-7). Each board can be mounted on the back of the AC1330 Rack Mount Kit, the side of a cabinet, NEMA box, or any other convenient surface. The AC1315, a 2 foot, 26-pin cable that plugs into one of the system connectors and plugs into a 26-pin connector on the interface board, can be used with any interface board. The cable(s) from the interface board to the user equipment are also available as separate accessories.

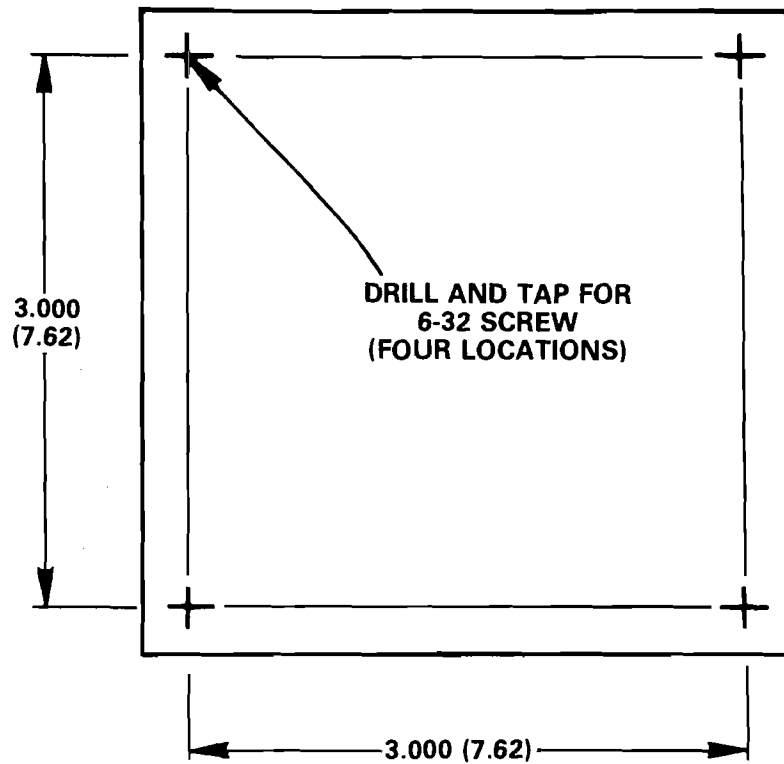
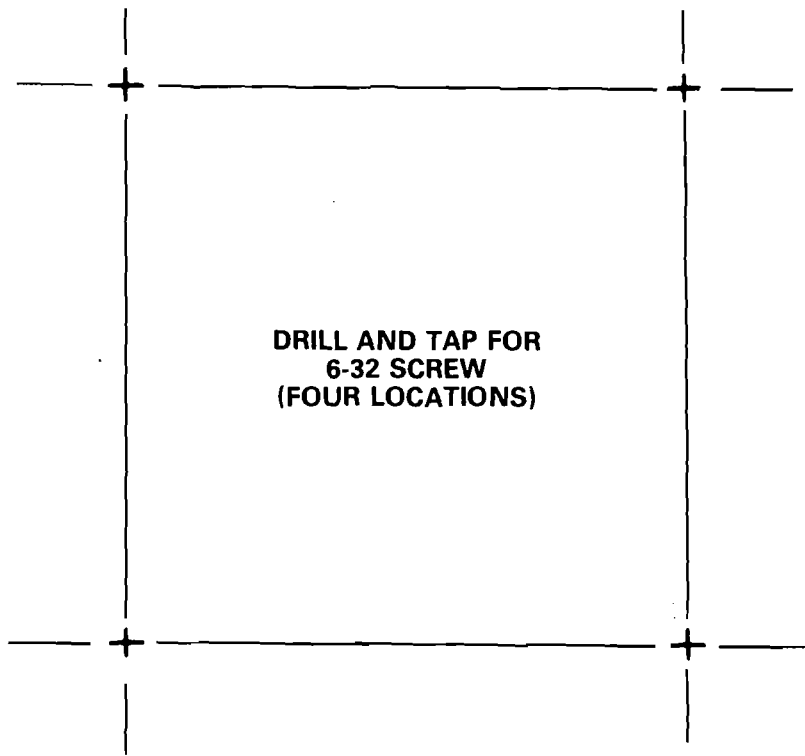


Figure 3.4.5 Interface Boards Surface Mount Dimensions

### 3.5 MODULE INSTALLATION

Before modules are installed, the proper jumper configuration must be chosen and the ranging card, AC1310, must be installed if used. Alignment marks are provided on the inside of the case skirt to aid the installation of the AC1310. When ready, the modules are plugged into the appropriate slot on the backplane. Each module and backplane is keyed to assure each module is plugged in properly. Each backplane location has two plastic clips that help align and retain the modules when they are plugged in. If a more rigid hold-down is desired, a rack mount (AC1330) or surface mount (AC1331, AC1332, AC1333) option may be used.



*Figure 3.4.6 Interface Boards Surface Mount Drill Template*

## CHAPTER 4

### OPERATION

This section discusses the various options available to the user with the 3B Series Subsystem. These features must be understood to assure that each system is properly configured.

#### 4.1 BACKPLANE JUMPER OPTIONS

Each backplane has a power supply jumper option that must be addressed. This jumper, marked W4, provides the capability of tying the  $\pm 15V$  power supply common to the +24V power supply common. If the +24V power supply is used, its common must be tied to the  $\pm 15V$  common. All backplanes are shipped with this jumper installed. If the two commons are connected externally, W4 should be disconnected on the backplane to help prevent ground loops.

Each backplane is configured with W2 installed for external voltage sensing (See Figure 5.1). This allows the 3B Series Subsystem to be used with Analog Devices' RTI boards measuring in a pseudo-differential mode to provide higher noise rejection. In this mode, pin 25 of connectors P1 and P2 is used as a common point for all voltage outputs. The common pins on P1 and P2 (See Figure 2.3.2) are connected to the  $\pm 15V$  power supply common on the 3B Series backplane and may be used as signal common in a single ended measurement system. Optionally, W1 and W3 can be installed and W2 removed to force pin 25 to power supply common.

A third option available to the user provides the capability of directing the voltage output of any input module to an adjacent output module. This feature could be used to provide an isolated current output from an isolated input module, which gives two levels of  $\pm 1500V$  CMV isolation. If this feature is desired, it is implemented by using wire wraps or jumpers on the appropriate pins of the jumper posts located near the voltage I/O connectors. Figure 4.1.1 defines the channel pairs that can have this feature.

Each backplane has been keyed to prevent modules from being improperly plugged in. The keys and plastic module retainer clips assure that all modules will be properly plugged in.

Each backplane contains two voltage I/O connectors that are identical electrically. Both connectors may be useful when using a 3B Series backplane for both analog input and analog output when the data acquisition system has separate input and output connectors.

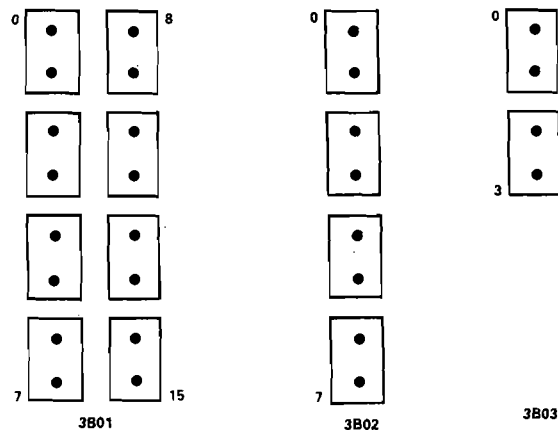


Figure 4.1.1 Adjacent Channels That Can Be Connected

#### 4.1.1 SURGE WITHSTAND CAPABILITY

The 3B Series isolated modules have been designed to meet the IEEE Standard for transient voltage protection (IEEE-STD 472). The Surge Withstand Capability can be tested with not less than 50 2.5KV bursts per second. A test duration of 2 seconds is widely accepted. A rise time of 20KV/ $\mu s$  is specified. Since  $I = C dv/dt$  and a typical module capacitance to ground is 10pF, each module could see 200mA of surge current. The 3B Series backplanes, which have been designed to accommodate up to 16 channels of this surge current, have a large ground plane and two large ground lugs that should be used with heavy cabling to return the surge current to earth ground in systems requiring surge withstand capability.



#### 4.1.2 ±15V AND +24V LOOP POWER COMMONS

The 3B Series backplanes are shipped with the ±15V common tied to the +24V loop common with jumper W4. If the commons of the two supplies are tied externally, this connection W4 should be disconnected to avoid ground loops within the subsystem. If it is desired that the commons of the ±15V and +24V loop supply be different, because of the existing hardware, the commons can vary by several volts and still operate. The precise relationship is defined in Figure 4.1.2.1 where the area between the limits defines the allowed differences between the power commons. The +15V supply can be used to power the current outputs if desired. The only limitation when using the +15V to power a current loop is that the output load must be 400Ω or less.

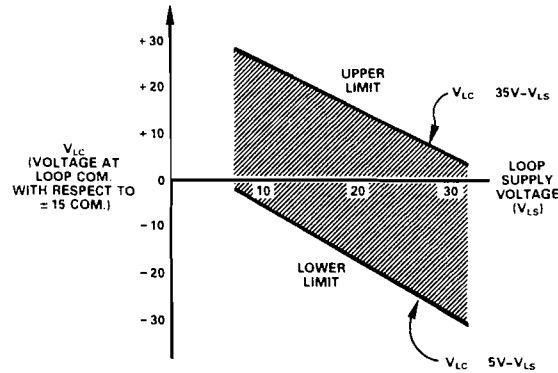


Figure 4.1.2.1 Relationship Between ±15V and Loop Power Supply Commons

#### 4.2 INTERFACE BOARDS

There are four adapter boards available to interface to specific Analog Devices' families of Real Time Interface (RTI) boards. These accessories provide a direct signal path to the appropriate RTI board. There are also two Universal Interface Boards that can be used for any interconnection needs. Each of these accessories can be mounted on the back of the AC1330 Rack Mount or on any flat surface. See Section 3.4 for mounting details.

##### 4.2.1 RTI INTERFACE BOARDS

AC1320-AC1323 provide a direct signal connection from the 3B Series to the analog inputs and/or outputs of Analog Devices' RTI boards. Refer to Table 4.2.1.1 to determine the correct accessory for the appropriate board. The 3B Series 26 pin connector(s) interfaces directly with the appropriate connector for each RTI board. All that is required to install the system is flat ribbon cables from the 3B Series backplane to the 26 pin connector on the board and a ribbon cable from the RTI connector to the RTI board. Each interface board is configured for all analog inputs and outputs to the appropriate RTI family.

Analog Devices' RTI products have a hardware settling time of at most 15μs which delays the start of an A/D conversion until the input amplifier has had time to settle after a MUX change. When 3B modules are selected from these RTI boards, the modules take approximately 50μs to settle to within ±1LSB (±0.02% FSR). The A/D conversion delay should be lengthened by increasing the hardware delay or by software changes to assure that accurate data is obtained.

ADIP/N	Description	Used With
AC1320	RTI-1225/26/60/62 Family Adapter Board	RTI-1225, RTI-1226, RTI-1260, RTI-1262
AC1321	RTI-1230/31/32 Family Adapter Board Also Supports Analog Inputs for RTI-1200, RTI-1250, RTI-1260, AIM03 and AIM100	RTI-1230, RTI-1231, RTI-1232 RTI-1200, RTI-1250, RTI-1260, AIM03, AIM100
AC1322	RTI-1240/41/42/43 Family Adapter Board	RTI-1240, RTI-1241, RTI-1242, RTI-1243
AC1323	RTI-711/24/32 Family Adapter Board	RTI-711, RTI-724, RTI-732
IOB120-01	RTI-800/815 Family Adapter Board with Cables	RTI-800, RTI-815

Table 4.2.1.1 Adapter Boards for Analog Devices RTI Products Board with Cables

The AC1320 interfaces the 3B Series to Analog Devices' analog I/O boards that are compatible with the STD Bus (see Figure 4.2.1.1). Connector J1 is used to interface one 3B Series backplane while connector J2 is available to interface a second 3B Series backplane (up to 32 analog inputs) to the RTI-1260 (connector J3 interfaces to the RTI-1260). Connector J4 provides a direct analog input for the RTI-1225. If the two analog outputs of the RTI-1225 are to be used, they are interfaced by installing two jumpers (W1 and W2) on the AC1320. This process connects the outputs to 3B channels 0 and 1. Connectors J5 and J6 provide direct analog output connections from 3B channels 0-3 and 4-7 respectively and can be used to interface to the RTI-1262. If more than eight analog outputs are required, up to two additional connectors can be installed in positions J7 and J8.

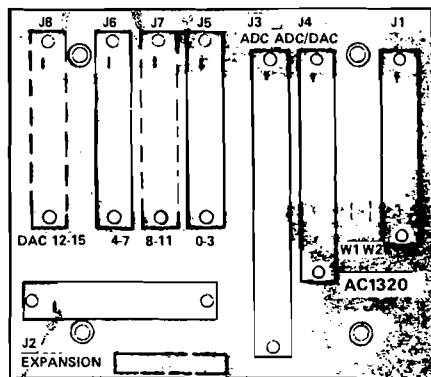


Figure 4.2.1.1 AC1320

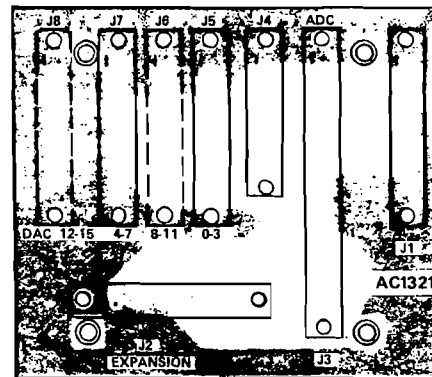


Figure 4.2.1.2 AC1321

The AC1321 interfaces the 3B Series to Analog Devices' Motorola Bus Analog I/O Boards (see Figure 4.2.1.2). Connectors J1 and J2 are used to interface up to two 3B Series backplanes (32 analog inputs) to the RTI-1230 and RTI-1231 with connector J3. If the two analog outputs of the RTI-1232 are to be used, they are interfaced with connector J4. Connectors J5 and J7 can be used to interface 3B channels 0-3 and 4-7 respectively to up to two RTI-1262 boards. If additional analog outputs are required, up to two additional connectors can be installed in position J6 and J8.

Connector J3 can also be used to interface analog inputs *only* to Analog Devices' RTI-1200, RTI-1250, RTI-1260, AIM03 and AIM100 Analog I/O products. Connectors J1 and J2 are used to interface from the 3B backplane (16 and 32 single ended inputs respectively) while connector J3 is used to interface to RTI or MACSYM products.

The AC1322 interfaces the 3B Series to Analog Devices' analog I/O boards that are compatible with Texas Instruments TM990 Bus (see Figure 4.2.1.3). Connectors J1 and J2 are used to interface up to two 3B Series backplanes (32 analog inputs) to the RTI-1240 and RTI-1241 with connector J3. If the two analog outputs of the RTI-1241 are to be used, they are interfaced with connector J4. Connector J5 is used to interface to the RTI-1242 and RTI-1243 analog output boards. If more than eight analog outputs are required, connector J6 can be used as the interface for an additional eight analog outputs.

The AC1323 interfaces the 3B Series to Analog Devices' analog I/O boards that are compatible with Intel's MULTIBUS (see Figure 4.2.1.4). Connector J1 is used to interface one 3B Series backplane (up to 16 channels) to the RTI-711 and RTI-732 with connector J2. Connectors J3-J6 are each used to interface four analog output channels to the RTI-724 and RTI-732. The AC1323 can be used to accommodate any mix of 16 inputs and outputs.

The IOB120-01 interfaces the 3B Series to Analog Devices' I/O boards that are compatible with the IBM-PC™, IBM-XT™ and IBM-AT™. J1 on the IOB120-01 provides direct 3B interface to the RTI-800, RTI-815, and MIO120-A via J1 and J3. W1 and W2 can either be jumpered to channels 14 and 15 of the 3B backplane for input or can be configured to provide analog output on channels 14 and 15. Terminal Block 2 (TB2) provides continuous analog output for the RTI-815 and MIO120-A only. TB1 provides the capability for external convert commands on all boards.

Cables and connectors are offered that interface with these accessories. These accessories are defined in Table 4.2.1.2.

#### 4.2.2 3B TO RTI/MACSYM CABLE ASSEMBLIES

In addition to the RTI Interface Boards, there are also several cable assemblies that provide direct connection to many of the RTI Series products as well as MACSYM products. A cable assembly is defined as a cable with two connectors.

See Table 4.2.1.2 for pertinent part numbers and descriptions.

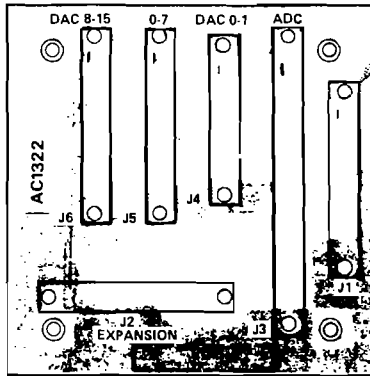


Figure 4.2.1.3 AC1322

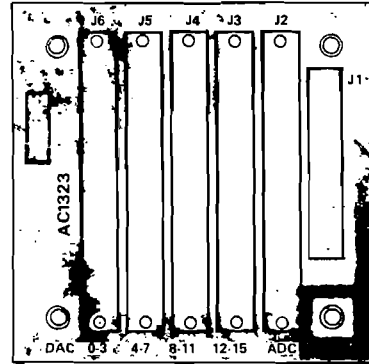


Figure 4.2.1.4 AC1323

#### Cables

ADIP/N	Description	Used With
AC1315	2' 26-Pin Cable Assembly*	3B01-3B03, AC1320-AC1325
AC1326	3B to RTI-1225/1226 Cable Assembly	3B01-3B03
AC1327	3B to RTI-711/732 Cable Assembly	3B01-3B03
AC1328	3B to RTI-724 Cable Assembly	3B01-3B03
AC1329	AC1323 to RTI-711/732 Cable Assembly	AC1323
AC1335	3B to MIO-120 Cable Assembly	3B01-3B03
AC1553	50-Pin Cable Connector with 3' Cable	AC1321-AC1323, AC1325
AC1554	26-Pin Cable Connector with 3' Cable	3B01-3B03, AC1320-AC1325
AC1555	20-Pin Cable Connector with 3' Cable	AC1321-AC1323, AC1325
AC1562	34-Pin Cable Connector with 3' Cable	AC1320, AC1325
AC1585-6	3B to RTI-1260 Cable Assembly	3B01-3B03
AC1585-7	3B to RTI-1262 Cable Assembly	3B01-3B03
CCA11	3B to MACSYM 150 Cable Assembly	3B01-3B03

#### Connectors

ADIP/N	Description	Used With
AC1311	20-Pin Female Mating Connector	AC1321-AC1323, AC1325
AC1312	26-Pin Female Mating Connector	3B01-3B03, AC1320-AC1325
AC1313	34-Pin Female Mating Connector	AC1320, AC1325
AC1314	50-Pin Female Mating Connector	AC1321-AC1323, AC1325
AC1316	20-Pin Board Mounted Male Connector	AC1325
AC1317	26-Pin Board Mounted Male Connector	AC1325
AC1318	34-Pin Board Mounted Male Connector	AC1325
AC1319	50-Pin Board Mounted Male Connector	AC1325
AC1352	6-Pin dc Power Female Mating Connector	3B01-03

\*A cable assembly is defined as a cable with two connectors.

Table 4.2.1.2 3B Series Cables and Connectors

### 4.2.3 UNIVERSAL INTERFACE BOARDS

Two universal interface boards are available to help satisfy any interconnection. The AC1324 accepts the 26 pin connector from the 3B Series Backplanes and provides 26 screw terminals for interconnecting to any analog I/O subsystem. This interface board might be used with programmable controllers and is diagrammed in Figure 4.2.2.1.

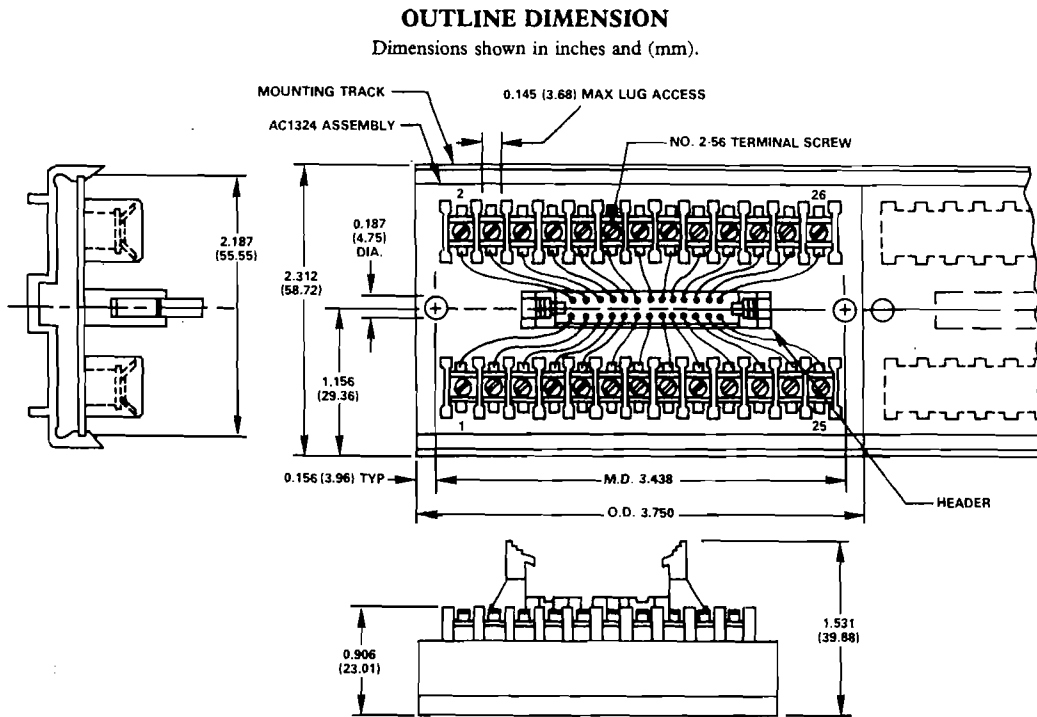


Figure 4.2.2.1 AC1324

The AC1324 can be mounted in snap track if desired or could be mounted to the back of the AC1330 Rack Mount Kit. Standoffs are included with the AC1324 and should be used if the AC1324 is to be mounted on the back of the AC1330 Rack Mounted Kit.

The AC1325 accepts up to two 26-pin connectors from 3B Series backplanes and has four patterns of holes that accommodate flat cable connectors of up to 50 pins each. The AC1325 (Figure 4.2.2.2) mates with the appropriate connectors required to interface with any user's equipment. The AC1325 will accept the AC1316-AC1319 board mount connectors or any standard flat cable connector with 0.1" spacing and has plated through holes for the necessary custom connections. Cables and connectors are offered to interface with the interface boards. These are defined in Table 4.2.1.2.

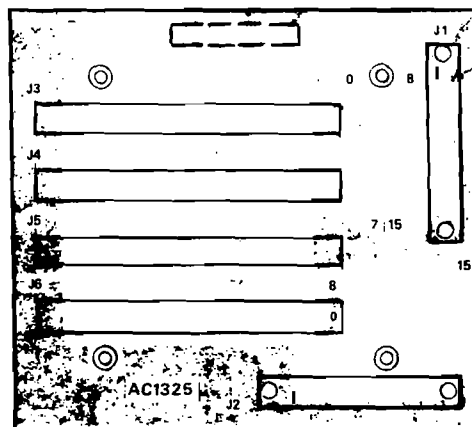


Figure 4.2.2.2 AC1325

### 4.3 CURRENT OUTPUT CONSIDERATIONS

#### 4.3.1 POWER CONSIDERATIONS

Loads of up to  $850\Omega$  can be used if an external +24V is supplied. If the user wishes to use a +15V supply for current output, the +15V can be strapped to the loop power on connector P3 (see Figure 4.3.1). With this arrangement, the load resistance on current outputs is limited to  $400\Omega$  max. Note also that this approach will require an additional 27mA per module from the backplane power supply.

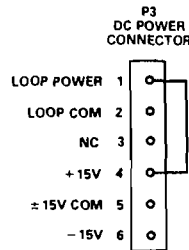


Figure 4.3.1 Jumper Strapping +15V Power to Loop Power

#### 4.3.2 CURRENT OUTPUT LOAD CONFIGURATION

The nonisolated current outputs (all modules except 3B39) are configured for a loop output and a grounded return. The typical configuration is shown in Figure 4.3.2 with the output dropped across the load resistor and connected to the RETURN screw terminal. Since the RETURN screw terminal is grounded, a perfectly acceptable connection would be to an external system ground (Figure 4.3.3). This connection will offer the user an additional 1V compliance. In most cases, the screw terminal connection will be the preferred connection.

The grounded return of the current output can only be used for the return of one module. Two or more modules should not be connected to the same RETURN terminal. If several current loops are to be returned with one ground, that connection should be made to the common on the Loop power connector.

The isolated current output module (3B39) should use the RETURN screw terminal since it is floating with respect to ground.

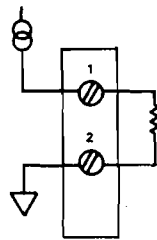


Figure 4.3.2 Preferred Current Output Load Connection

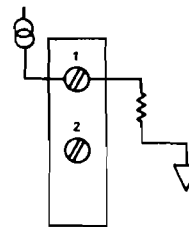


Figure 4.3.3 Optional Current Output Load Connection (nonisolated outputs only)

### 4.4 MODULE OPERATION

This section covers the options and features that are available with each module. The appropriate module section in Chapter 2 should also be reviewed.

#### 4.4.1 MODULE JUMPERS

Each module has two push-on jumper options. All modules are shipped from the factory configured for 4-20mA output and the current output is proportional to 0 to +10V output. If a 0-20mA output is desired and/or the current output is to be proportional to a -10V to +10V output, these parameters can be readily changed. If the push-on jumpers are changed, the zero and full scale points will shift by approximately 0.25% of span and will need to be recalibrated to remove this error. The details are defined in Section 2.1 for input modules and Section 2.2 for output modules.

#### 4.4.2 MODULE CALIBRATION

Each module has adjustment potentiometers that provide a  $\pm 5\%$  adjustment range. If fine calibration or minor range variations are desired, it can be accomplished by the calibration procedure defined for each module (see the calibration section of the appropriate module in Section 2). All units are shipped with a zero and span accuracy of  $\pm 0.1\%$  of span.

#### 4.4.3 CUSTOM RANGING (ZERO SUPPRESSION)

A wide zero suppression capability and easy field ranging are available with the AC1310 plug-on ranging card. If a special input range is desired, it can be provided by ordering the externally programmable version of the desired module (i.e. 3B32-00) and the AC1310 which houses user supplied resistors that determine the zero and span of the new range. This feature allows the user to provide zero suppression of up to and beyond 100% of the input range and provide a very wide range of span modification. The capability allows the user to map any portion of the input signal to the full output span. See the Custom Ranging section of the appropriate module in Section 2 to determine the required resistor values. The error contributions and temperature effects of custom ranging are discussed in Appendix A.

#### 4.4.4 MODULES COLOR CODING

The top labels of each module have been color coded to differentiate isolated units from nonisolated ones and input modules from output units. The colors of the labels are defined as:

ISOLATED INPUT – white lettering on a black background

NONISOLATED INPUT – black lettering on a white background

ISOLATED OUTPUT – white lettering on a red background

NONISOLATED OUTPUT – black lettering on a yellow background

#### 4.4.5 MODULE CONSTRUCTION

All module cases are made from a thermoplastic resin which has a fire retardent rating of 94V-0 and is designed for use from  $-55^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ . Each module's printed circuit board is 0.031 inch thick glass epoxy and the module's pins are gold plated contacts with a nickel undercoat.

#### 4.5 INDIVIDUAL MODULE MOUNTING KIT

The AC1345 individual module mounting kit is to be used when a user defined backplane is substituted for a 3B Series backplane. Figure 4.5.2 shows the outline of a 3B Series module when plugged into a 3B Series backplane, and gives the dimensions of the mating connectors and retaining clips and the spacing between them. 0.200" minimum spacing is required between the input conductors and 0.400" minimum spacing is used between input and output conductors. This spacing is required to maintain the 1500V CMV isolation provided by the isolated 3B modules. The dimensions of the figure should be considered when individual module mounting is desired.

The pinout of the input modules is defined in Section 2.1 and the pinout for the output modules is defined in Section 2.2.

Each AC1345 comes with a transistor-resistor pair that is to be used as a cold junction compensation sensor in thermocouple applications. This sensor is to be installed as indicated in Figure 4.5.1. The cold junction sensor will give an initial accuracy of  $\pm 0.5^{\circ}\text{C}$ .

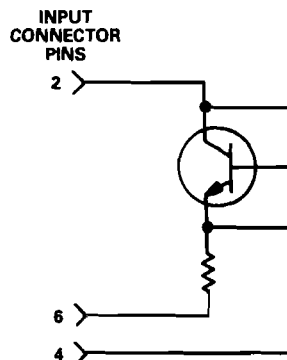


Figure 4.5.1 Cold Junction Compensation Connections

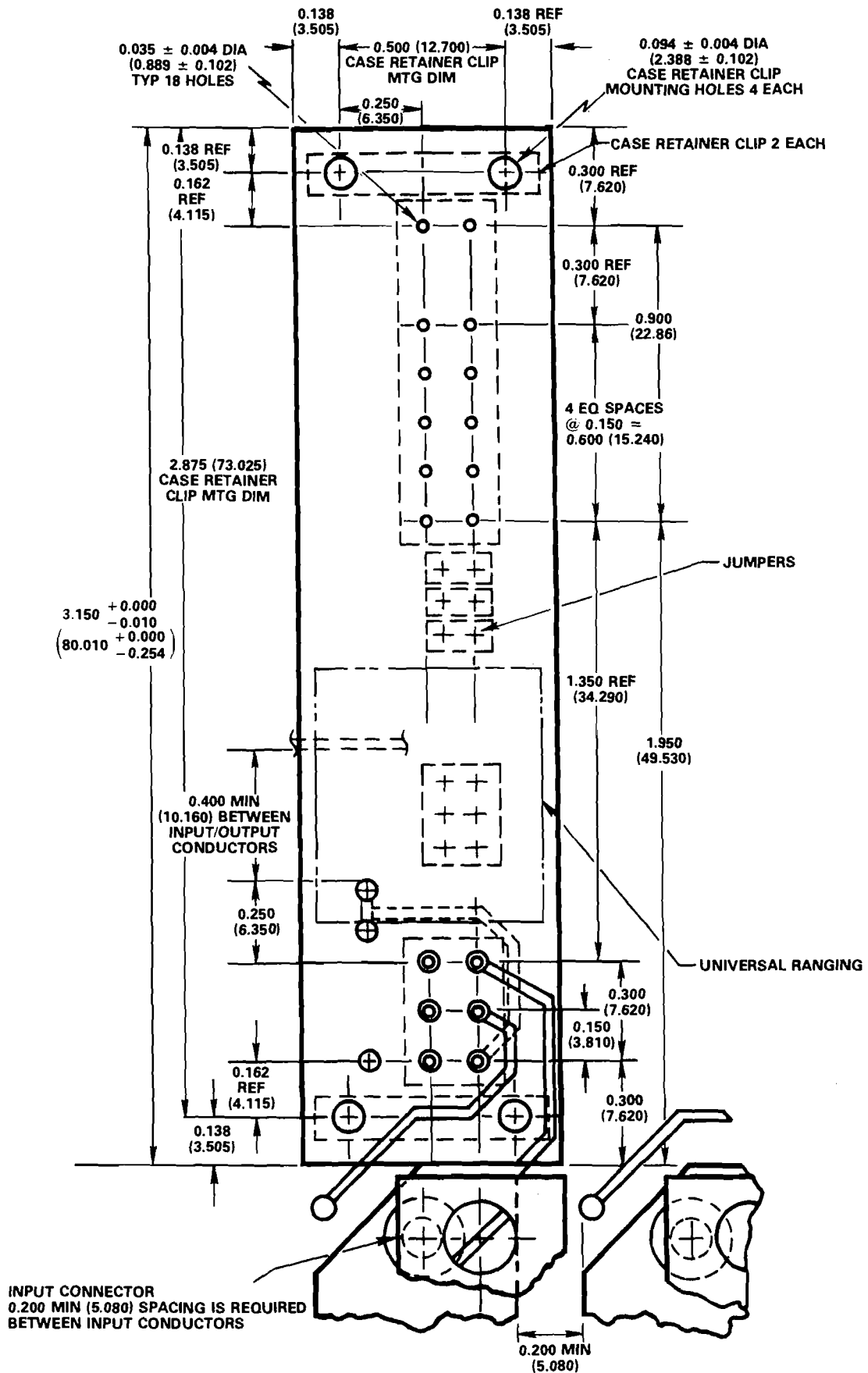


Figure 4.5.2 Individual Module Mounting Dimensions  
 Dimensions shown in inches and (mm).

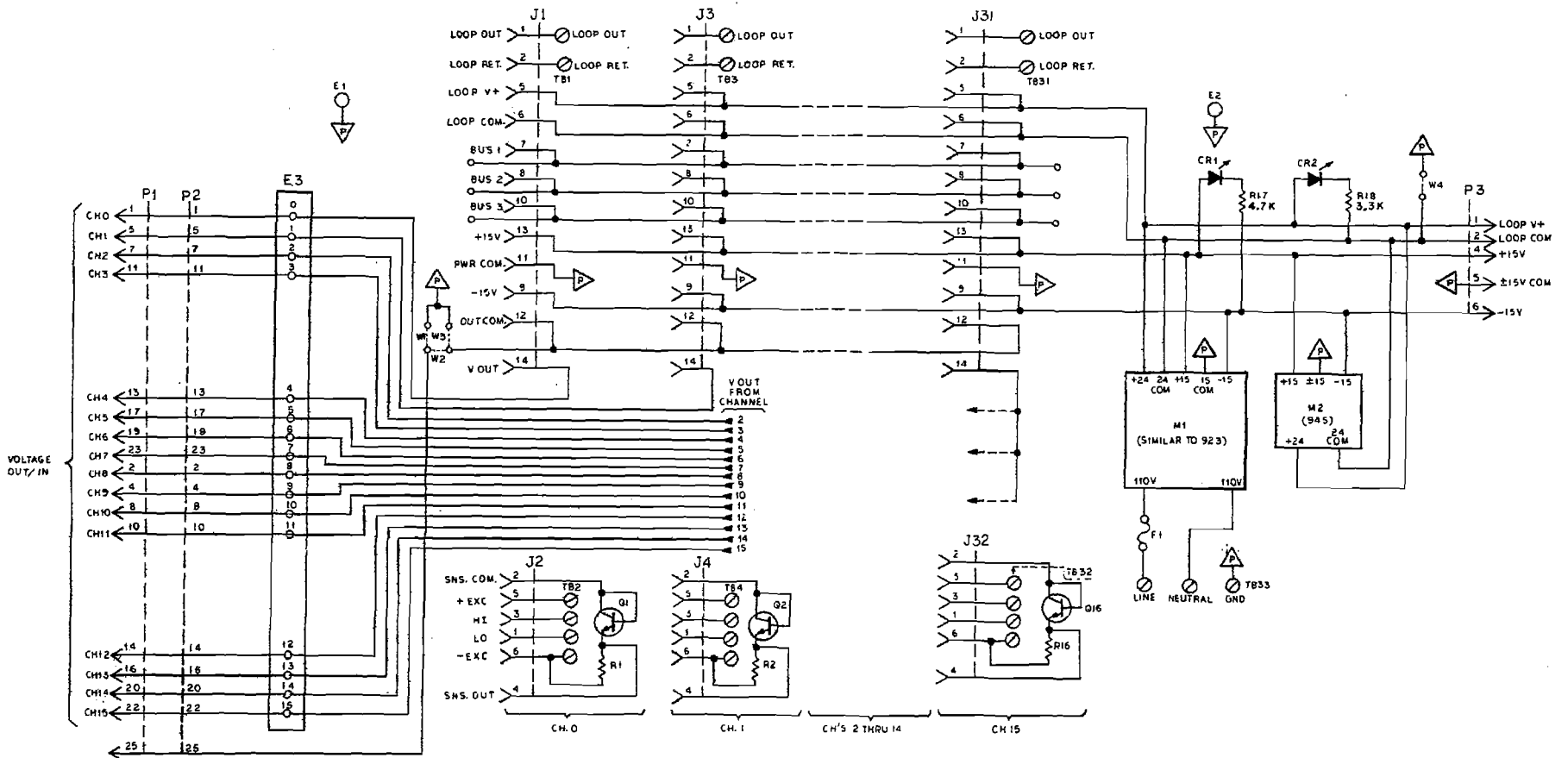


Figure 5.1 3B01 Schematic



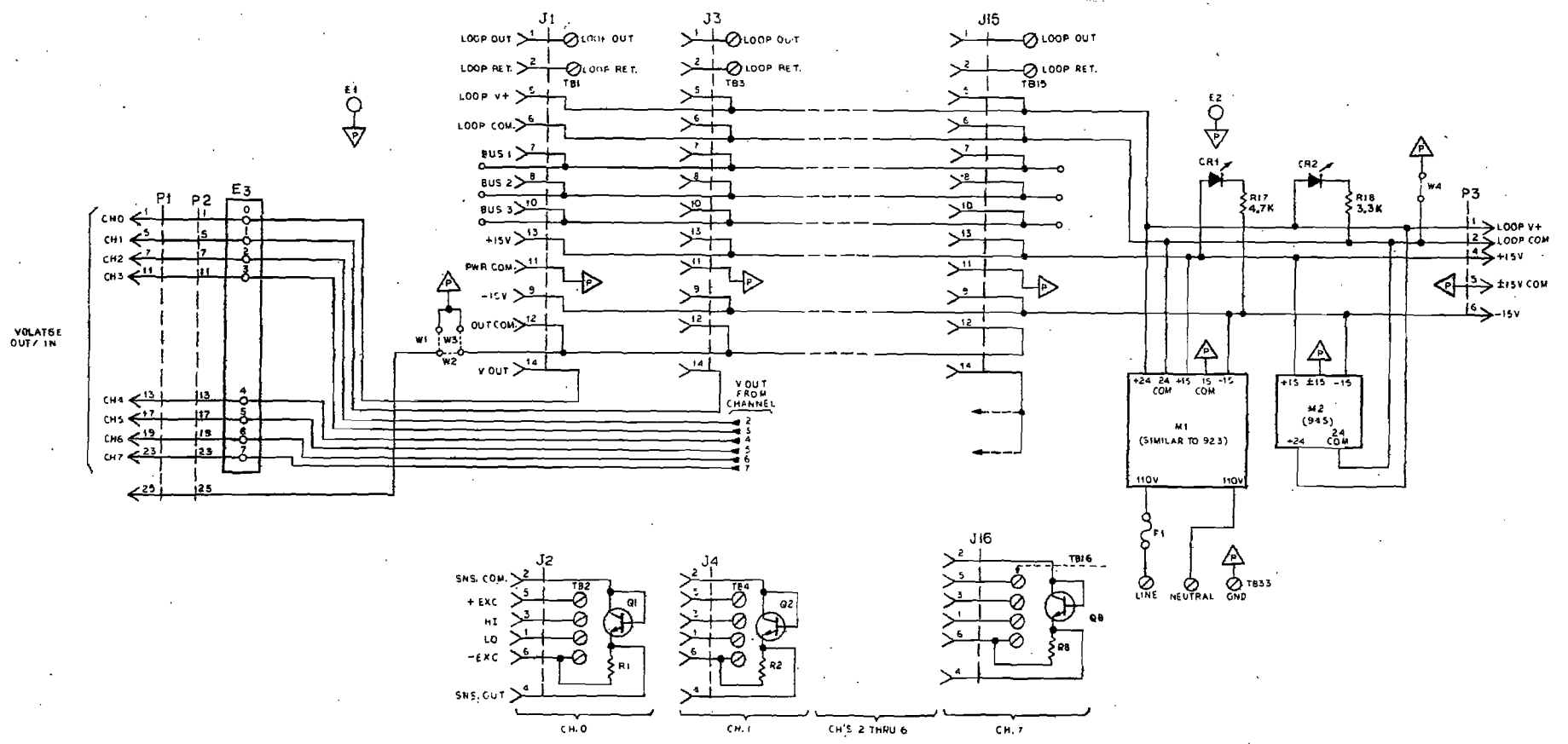


Figure 5.2 3B02 Schematic

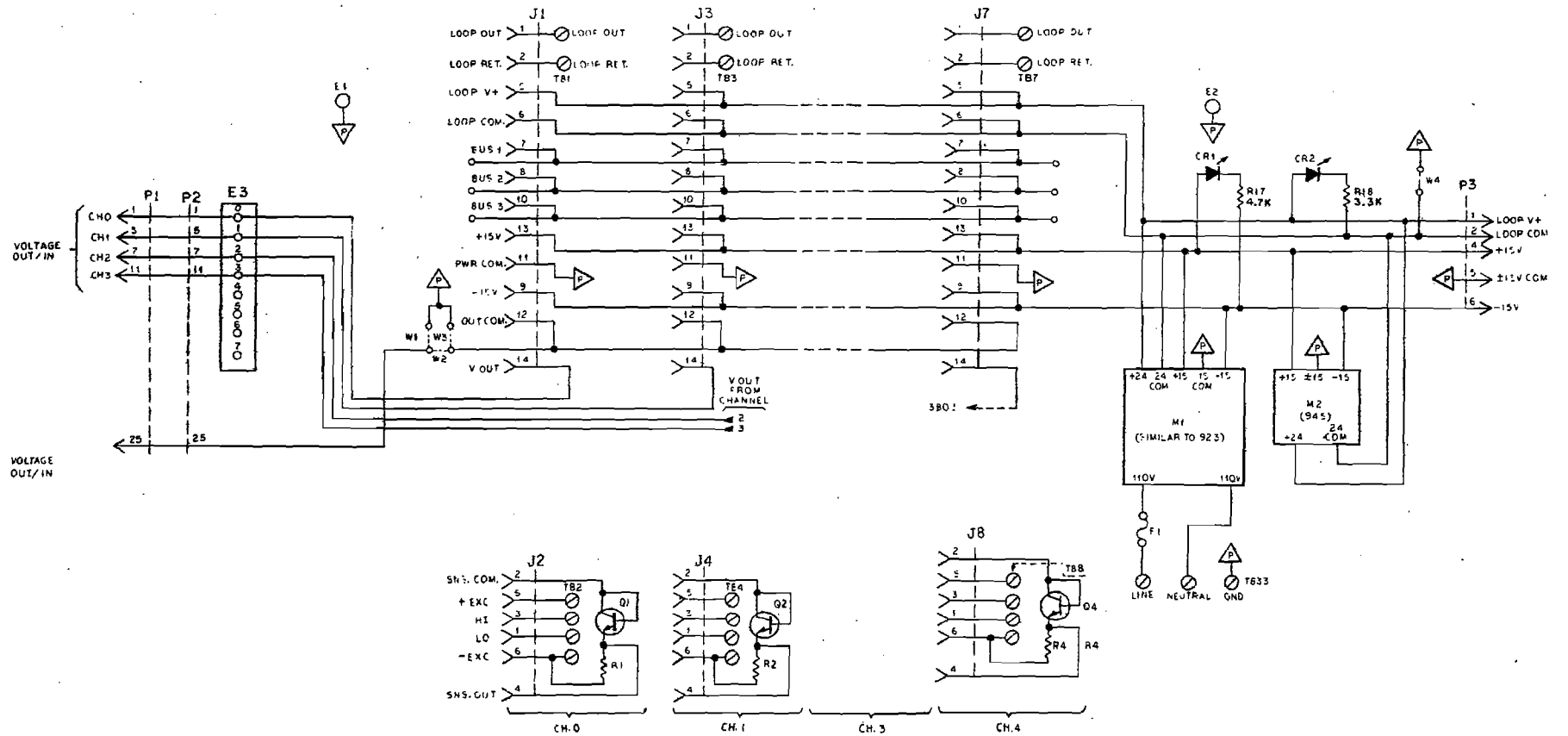


Figure 5.3 3B03 Schematic

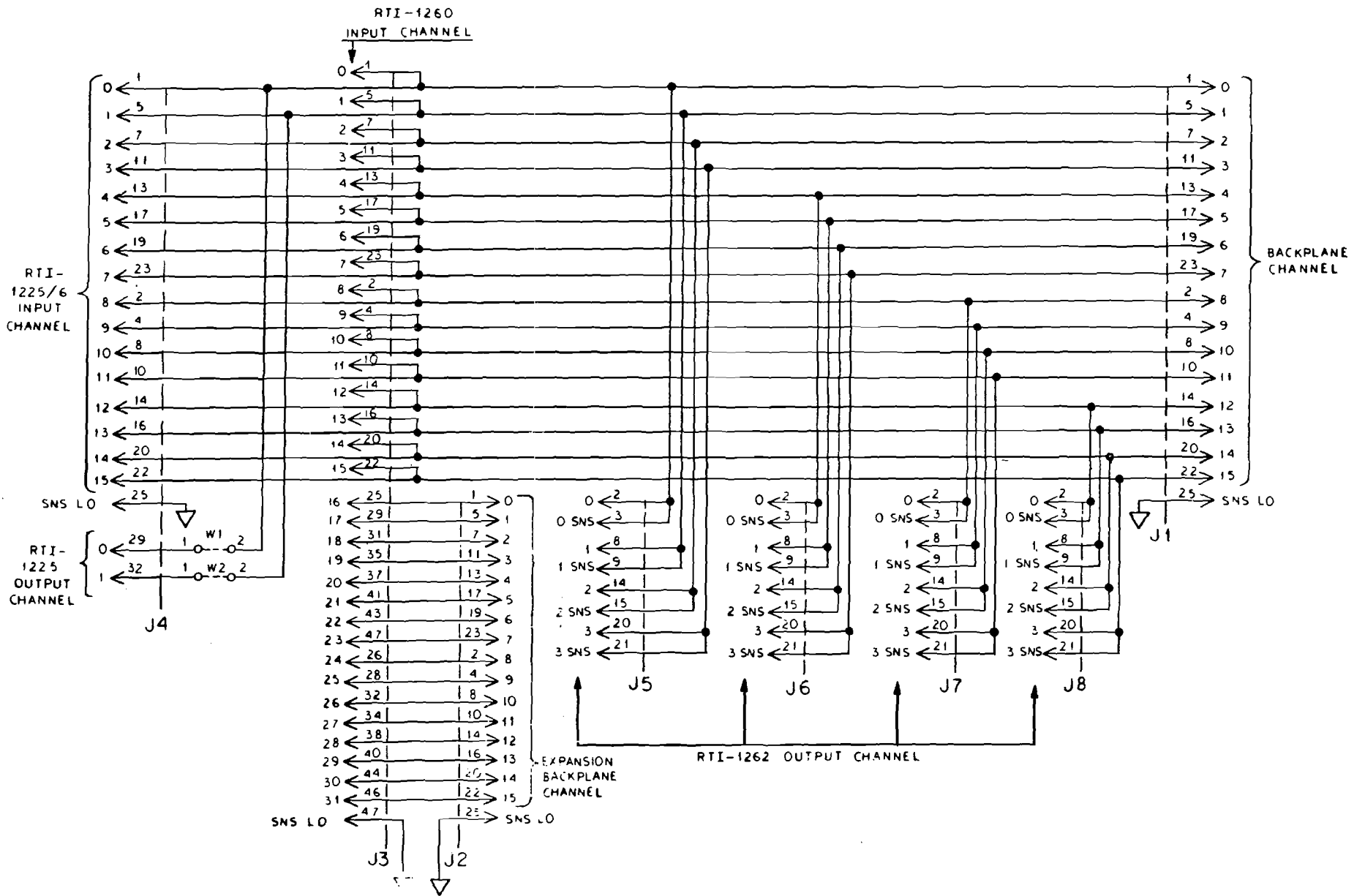


Figure 5.4 AC1320 Schematic

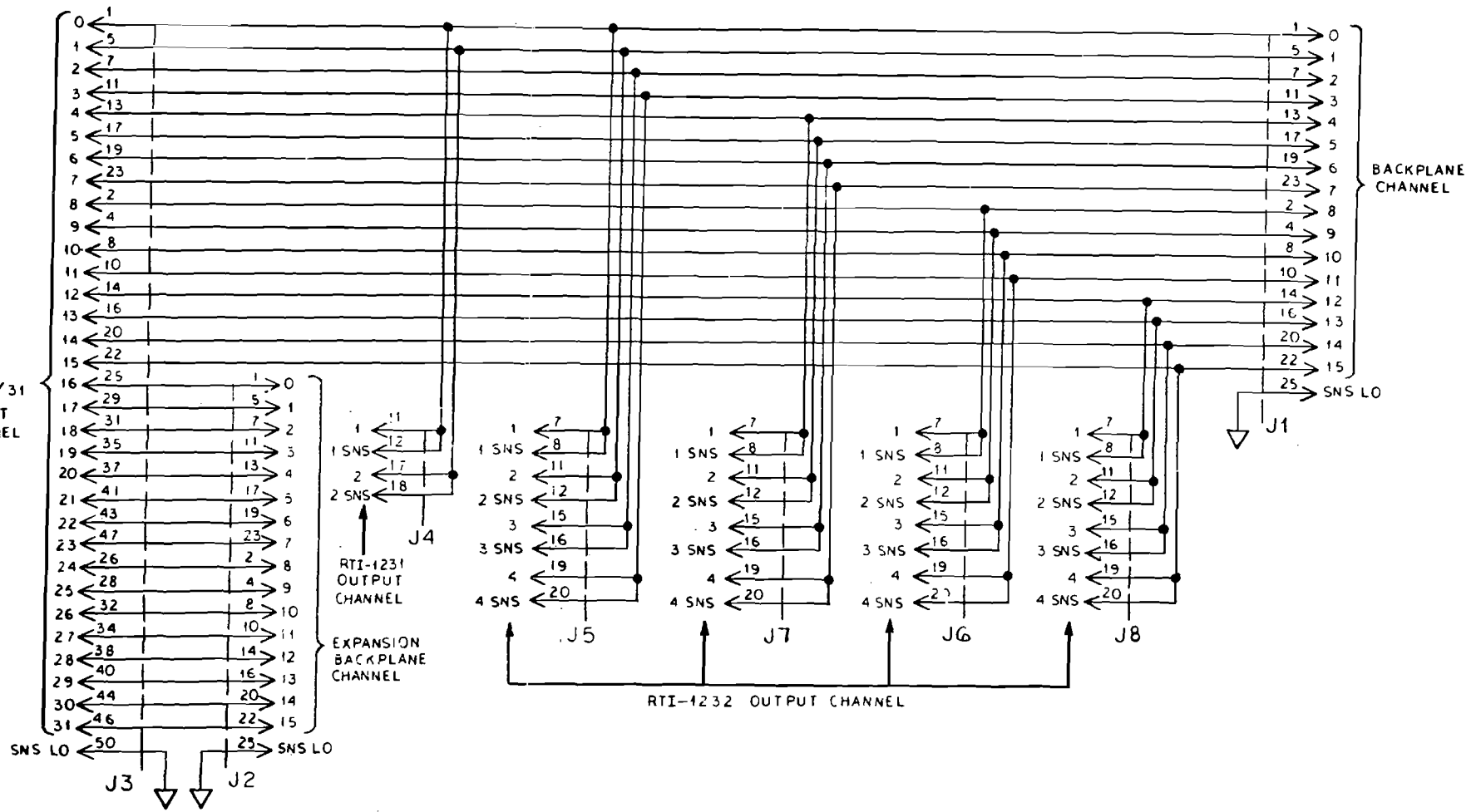


Figure 5.5 AC1321 Schematic

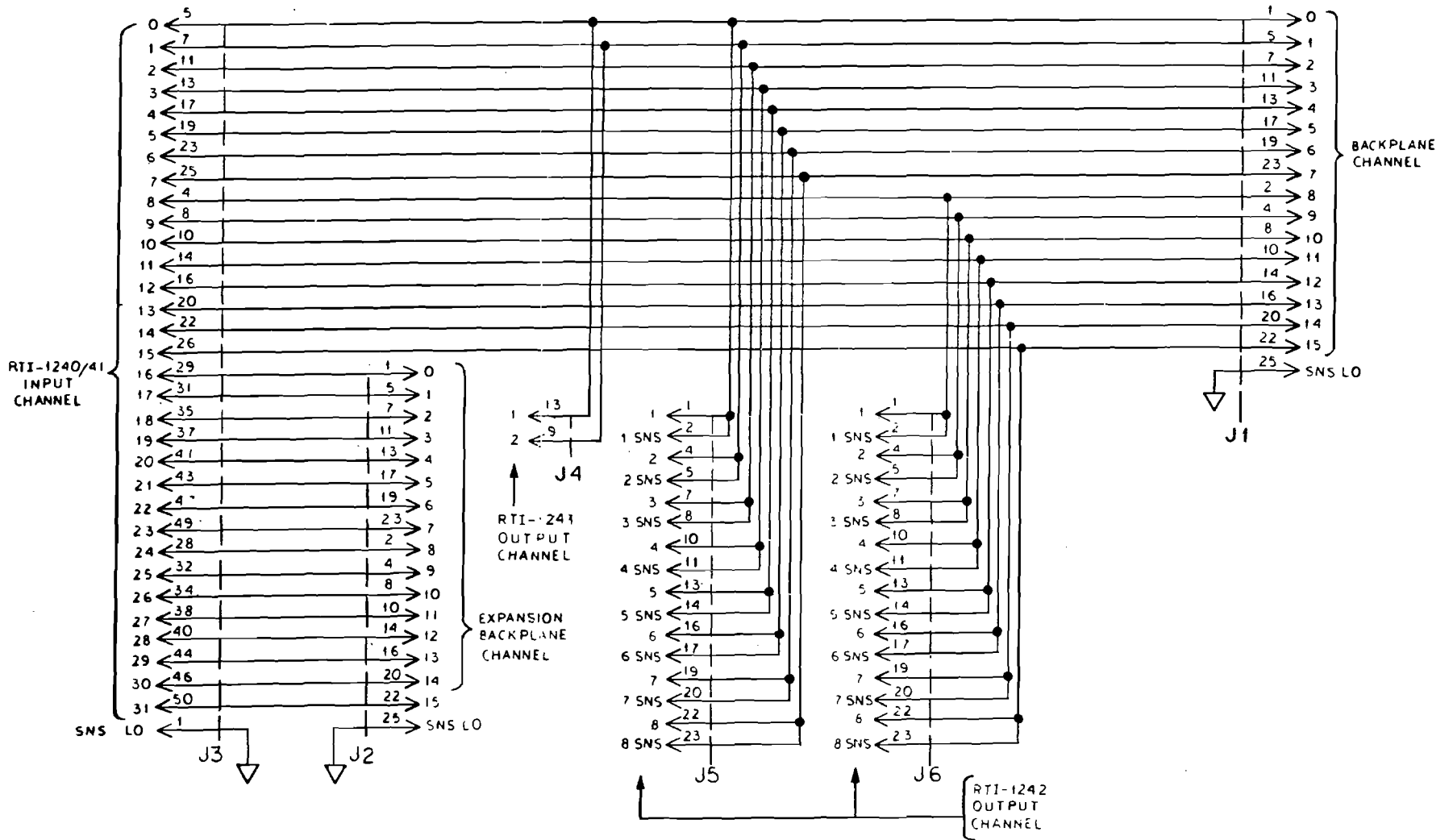


Figure 5.6 AC1322 Schematic

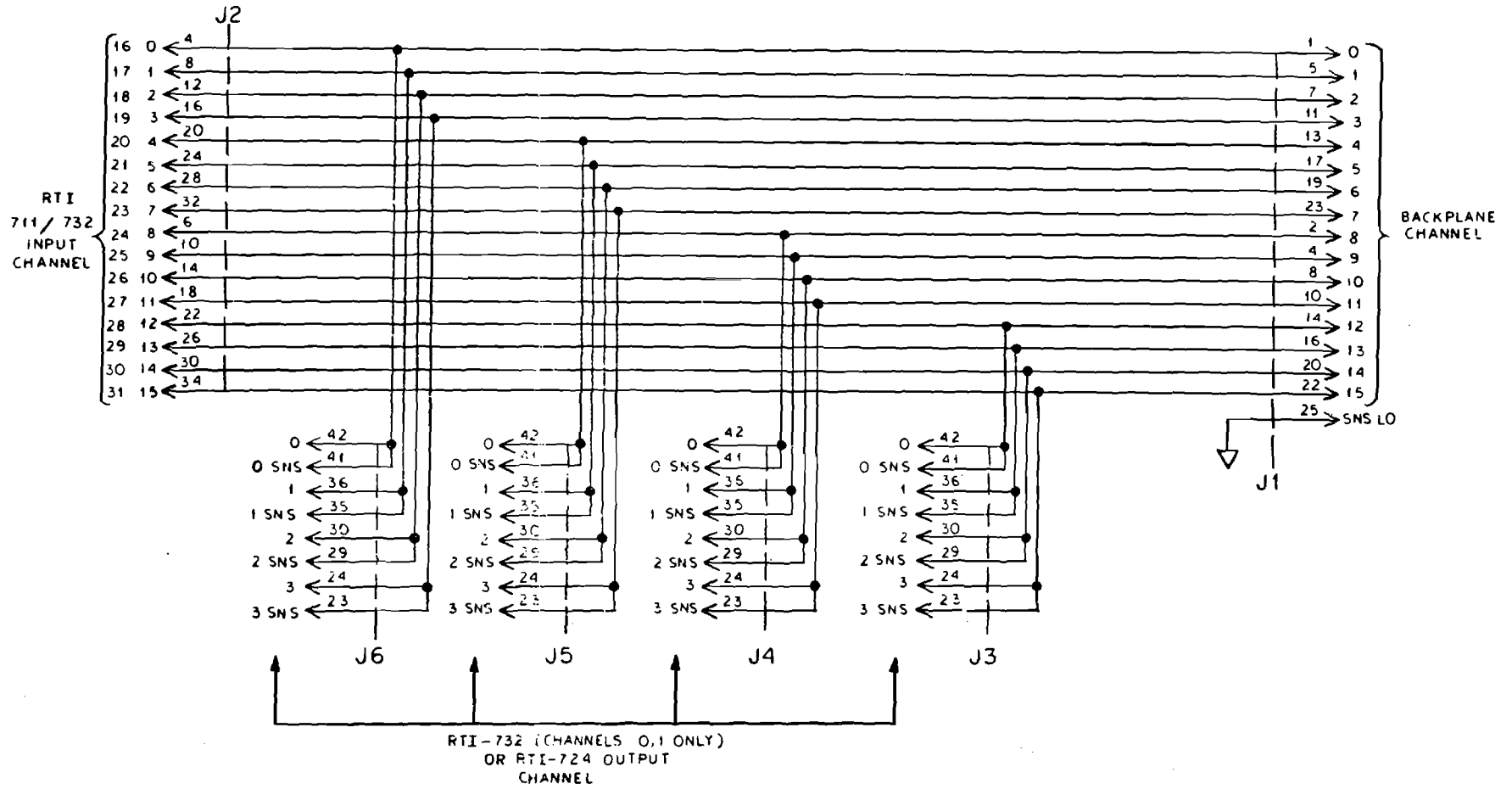


Figure 5.7 AC1323 Schematic

## APPENDIX A

### CUSTOM RANGING

Wide zero suppression and easy field ranging are available with the AC1310 plug-on ranging card and the externally programmable version of the desired input module (3B\_ \_00). The AC1310 houses user supplied resistors that determine the zero and span of the custom range. This section discusses custom ranging and its error contributions, temperature effects, and limitations.

### APPENDIX A1

#### CUSTOM RANGING mV, V, mA, THERMOCOUPLE, STRAIN GAGE, FREQUENCY AND AD590 MODELS

For the purposes of custom ranging, the 3B Series modules can be discussed in three categories; the RTD models, the LVDT model, and all others. The basic transfer function of all modules other than the RTD and LVDT modules can be characterized as:

$$V_O = G \times (V_{IN} - V_Z)$$

Where

$V_O$	=	Output Voltage
$G$	=	Gain
$V_{IN}$	=	Input Voltage
$V_Z$	=	Zero Suppression Voltage

This equation applies directly to millivolt and voltage input models (3B10, 3B11, 3B16, 3B18, 3B30, 3B31, 3B40, 3B41) and indirectly to the thermocouple input model (3B37) the current input models (3B12, 3B13, 3B32) and the ac input models (3B42, 3B43, 3B44). For the 3B37, the input temperature must be converted to a millivolt signal from standard tables. For the current input devices, the input current is converted to a voltage with an external sensing resistor. For the ac input devices, a scale factor must be considered.

The 3B47 cannot be externally custom ranged because of the complexity of the linearization circuitry. A 3B47-CUSTOM can be factory configured to satisfy a special range.

The transfer function for the frequency input models (3B45, 3B46) is:

$$V_O = G \times (F_{IN} - F_Z)$$

Where

$V_O$	=	Output Voltage
$G$	=	Gain (V/Hz)
$F_{IN}$	=	Input Voltage
$F_Z$	=	Zero Suppression Voltage

#### GAIN SETTING RELATIONS

With the AC1310, the gain  $G$  is set by  $R_1$  ( $R_{3A}$  for 3B18), which forms part of an internal divider and is determined from the following:

Models:	3B10, 3B12, 3B13, 3B16	3B11	3B30, 3B32, 3B37	3B31
Relations:	$R_1 = \frac{10k\Omega}{G - 1}$	$R_1 = \frac{1k\Omega}{G - 0.1}$	$R_1 = \frac{40k\Omega}{G - 2}$	$R_1 = \frac{4k\Omega}{G - 0.2}$
Models:	3B18	3B40	3B41	
Relations:	$R_{3A} = \frac{200k\Omega}{G}$	$R_1 = \frac{400k\Omega}{G - 4}$	$R_1 = \frac{40k\Omega}{G - 0.4}$	
Models:	3B45	3B46		
Relations:	$R_1 = G \times 1.18 \times 10^6$	$R_1 = G \times 2.60 \times 10^7$		

For the ac input modules, the gain is set by  $R_1$  and  $R_4B$ .  $R_1$  is used to control the scaling of input in each of these three models while  $R_4B$  determines the gain from the rectifier on.  $R_1$  is determined from the following relations:

3B42	3B43	3B44
$R_1 = \frac{20k\Omega}{\frac{1}{KV_m} - 1}$	$R_1 = \frac{20k\Omega}{\frac{50}{KV_m} - 1}$	$R_1 = \frac{20k\Omega}{\frac{550}{KV_m} - 1}$

Where  $K = V_{av}/V_{rms} = 0.900$  for sinusoids  
 $V_m =$  full scale rms input voltage

The difference between these three models is in the input scaling. The scaling is done before the zero suppression or gain so that the maximum value presented to the rectifier is 1V rms. The signal is processed the same from this point on in each of the three models.  $R_4B$  is determined from the following relation, which is the same for all models:

$$R_4B = \frac{40k\Omega}{G1-2} \quad \text{where } G1 = \frac{10V}{1 - \frac{V_z}{V_m}}$$

(10V represents the module's output span.)

### ZERO SUPPRESSION VOLTAGE

The zero suppression voltage,  $V_z$ , can be set for any value between  $-6.35V$  and  $+6.35V$  for nonisolated models ( $-63.5V$  to  $+63.5V$  for model 3B11) and  $-3.175V$  and  $+3.175V$  for isolated models ( $-31.75V$  to  $+31.75V$  for model 3B31 and 3B41). There is no zero suppression for the 3B18. The ac input modules are discussed separately at the end of this section. The relations for  $V_z$  are defined below:

Models:	3B10, 3B12, 3B13, 3B16	3B11	3B30, 3B32, 3B37, 3B40, 3B47
Relations:	$V_z = \frac{R_2}{R_2 + R_3} \times 6.35V$	$V_z = \frac{R_2}{R_2 + R_3} \times 63.5V$	$V_z = \frac{R_2}{R_2 + R_3} \times 3.175V$
Model:	3B31, 3B41		
Relations:	$V_z = \frac{R_2}{R_2 + R_3} \times 31.75V$		

The sign of  $V_z$  is defined by the mounting of  $R_3$  in location A (positive) or B (negative). The total resistance of  $R_2 + R_3$  should be approximately  $10k\Omega$  to avoid taking excessive current from the voltage reference or self heating of the resistors. (For the 3B11 and 3B31 (3B41), the 63.5V and 31.75V terms are functions of the  $10\times$  attenuation of the input signal. The internal references are 6.35V and 3.175V respectively, so ordinary 100mW resistors are suitable for zero suppression). Using  $10k\Omega$  as the total value,  $R_2$  and  $R_3$  are determined from the following:

Model:	3B10, 3B11, 3B13, 3B16	3B11	3B30, 3B32 3B37, 3B40, 3B47	3B31, 3B41
Relations:	$R_2 = \frac{V_z}{6.35V} \times 10k\Omega$	$R_2 = \frac{V_z}{63.5V} \times 10k\Omega$	$R_2 = \frac{V_z}{3.175V} \times 10k\Omega$	$R_2 = \frac{V_z}{31.75V} \times 10k\Omega$
	$R_3 = 10k\Omega - R_2$	$R_3 = 10k\Omega - R_2$	$R_3 = 10k\Omega - R_2$	$R_3 = 10k\Omega - R_2$

For the ac input modules, the zero suppression voltage,  $V_z$ , can be set for any value between 0 and 1.23V. Since the signal varies from 0 to 1V dc at the amplifier input, a zero suppression voltage of 0 to 1V dc corresponds linearly to a 0-100% of full scale zero suppression.

The zero suppression resistor,  $R_2$ , is determined from the following relations for all three models:

$$R_2 = \frac{10k\Omega (V_z/V_m)}{1.23 - V_z/V_m}$$



The zero suppression frequency,  $F_Z$ , can be set for any value up to 80% of the desired input span through the use of  $R_2$ . Zero suppression is limited by temperature drift. Values larger than 80% of the input span will have a larger amount of temperature drift. The value for  $R_2$  is determined from the following relations:

$$\begin{array}{cc} \text{3B45} & \text{3B46} \\ R_2 = \frac{1.52 \times 10^7}{F_Z} & R_2 = \frac{3.33 \times 10^8}{F_Z} \end{array}$$

#### ADDITIONAL CUSTOM RELATIONS

Model 3B18's standard bandwidth is 20kHz. The bandwidth can be set for any value less than 20kHz using the AC1310. The required capacitors,  $C_1$  and  $C_2$ , are determined from the following relations:

$$\begin{array}{cc} C_1 = 8.4\mu\text{F}/F_C & \text{Note: For values of } C_1 \text{ below } 3\text{nF,} \\ C_2 = 4.2\mu\text{F}/F_C & \text{reduce } C_1 \text{ by } 320\text{pF} \text{ and } C_2 \text{ by} \\ & 160\text{pF.} \end{array}$$

where  $F_C$  is the desired cutoff frequency. Bipolar capacitors capable of withstanding  $\pm 10\text{V}$  should be used. The space limitations of the AC1310 must be considered when choosing the required capacitors. These capacitors are to be installed in the positions designated as  $R_4A$  and  $R_1$  respectively. The AC1310 can be used to reduce the bandwidth in factory ranged units.

Model 3B37 and 3B47 requires an additional resistor to set the cold junction compensation for the appropriate thermocouple type. These values are defined in Section 2.1.9 (3B37) and Section 2.1.12 (3B47).

A standard 3B45 or 3B46 is shipped with zero hysteresis since a jumper is installed on the range carrier pins. If the jumper is removed, there will be nominally  $\pm 4\text{V}$  ( $\pm 20\%$ ) of hysteresis. If less hysteresis is desired, it can be accomplished with the following equation:

$$\begin{array}{cc} \text{3B45} & \text{3B46} \\ R_{4A} = \frac{10^6 \times V_H}{4 - V_H} & R_{4A} = \frac{10^6 \times V_H}{4 - V_H} \end{array}$$

where  $V_H$  is the desired hysteresis.  $V_H$  can be set for any value between 0 and 4V with a  $\pm 20\%$  tolerance.

### APPENDIX A1.1

#### ERROR CONTRIBUTIONS

The tolerance of the references (typically better than  $\pm 2\%$ ) will directly affect all nonzero values of  $V_Z$ . The contribution of the resistors used will be the total tolerance error of the two resistors multiplied by the fraction  $R_3/(R_2 + R_3)$ . In practical terms, this amounts to . . .

- . . . the total of the resistor tolerances for small  $V_Z$ .
- . . . half the total resistor tolerance at  $V_Z = 3\text{V}$ .
- . . . virtually no effect from resistors at  $V_Z = 6\text{V}$ .

Thus if  $V_Z$  is to be, for example, 100mV, the use of 1% tolerance resistors will result in a total possible error of  $\pm 4\%$  of  $V_Z$ , or  $\pm 4\text{mV}$  (assumes a 2% error in the reference voltage). This error is as seen at the module input, independent of gain.

For models 3B11 and 3B31, a  $10\times$  input attenuator is used to extend the input signal range of the basic amplifier in the 3B10 and 3B30 respectively. The tolerance of the attenuator (2% max) must be considered with custom ranging and is additive to the above terms.

The range of the module's voltage output ZERO ADJUST is at least  $\pm 0.5\text{V}$  at the module output, and it can therefore correct any input offset error of less than 0.5V/G. Thus the  $\pm 4\text{mV}$  input offset in the example above can be adjusted to zero for any gain less than 125. If more gain is to be taken, it will be necessary to use more accurate resistors at  $R_2$  and/or  $R_3$  to guarantee that the offset can be zeroed.

The tolerance of the gain-setting resistor,  $R_1$ , affects the accuracy of the selected gain directly. Since the module's SPAN ADJUST pots have at least a  $\pm 5\%$  adjustment range, the use of 1% tolerance resistors for  $R_1$  will be sufficient.

## APPENDIX A1.2

### TEMPERATURE EFFECTS

The temperature drift of the zero suppression voltage  $V_Z$  will depend upon the temperature coefficients of the resistors used in the same way that accuracy depends upon tolerance; that is, the total drift of  $R_2$  and  $R_3$  will be seen through a multiplier of  $R_3/(R_2 + R_3)$ . As before, the practical effect of this is that the total of the resistor temperature coefficients will be seen for small values of  $V_Z$ ; one-half the total will be seen for  $V_Z$  in the vicinity of 3V, and almost no drift will be contributed by the resistors for  $V_Z$  near 6V. Note that for the ac input modules, the top leg of the zero suppression divider ( $R_3$ ) is an internal resistor, with a value of  $10k\Omega$ , 1% tolerance, and a drift of  $10\text{ppm}/^\circ\text{C}$ .

The reference voltages supplied by the module have a typical drift of less than  $25\text{ppm}/^\circ\text{C}$ . This drift will add directly to the resistor drift for any value of  $V_Z$ . Thus, for  $V_Z = 100\text{mV}$  as in the example above, the use of a pair of  $50\text{ppm}/^\circ\text{C}$  resistors will result in a total drift of  $125\text{ppm}$  of  $V_Z$  per  $^\circ\text{C}$ , or  $12.5$  microvolts per  $^\circ\text{C}$ . This drift adds directly to the module's basic input offset drift. A lower value can, of course, be obtained by the use of better resistors for  $R_2$  and  $R_3$ .

Temperature drift in the value of the gain-setting resistor,  $R_1$ , will directly affect the module's gain drift. Note, however, that the basic drift specifications for the modules include the effect of a gain-setting resistor drift of  $\pm 10\text{ppm}/^\circ\text{C}$ ; rated performance will be obtained if the drift of  $R_1$  is less than or equal to this value.

## APPENDIX A2

### CUSTOM RANGING RTD MODELS

RTD Ranging applications can be divided into two categories, depending on whether the module's internal linearizing circuit is used. If internal linearization is required, the following procedure applies:

1. For models 3B14 and 3B15, the module's output voltage must always be positive since the linearizing circuit is active only for  $V_O > 0$ . The relations assume the use of a 0 to +10V output span. Other output ranges are possible, contact the factory for information on any other positive output range.
2. Any type of RTD can be used provided that its resistance does not exceed  $10k\Omega$  in the range of interest and its temperature characteristic is concave down. While virtually all RTDs have these properties, the conformity errors specified for these models apply specifically to  $100\Omega$  platinum RTDs following the European curve ( $\alpha = 0.00385$ ). Conformity errors for other RTD types can be supplied by the factory.
3. Ranging component values are found from:

3B14, 3B15

$$\text{Gain Setting Resistor: } R_1 = \frac{20k\Omega}{G - 1}$$

Zero Suppression

$$\text{Resistors: } \quad 3B14: R_3A = R_Z \quad 3B15: R_2 = R_Z$$

$$\text{Linearization Resistor: } R_4A = \frac{Q - 1}{2 - Q} \times 20k\Omega$$

$$\text{Where Gain } G = 40k\Omega \times \left( \frac{1}{\Delta R_{MS}} - \frac{1}{\Delta R_{FS}} \right)$$

3B34-00, 3B34-N-00\*

$$R_1 = 20k\Omega \left( \frac{G}{1 - G} \right)$$

$$R_3A = R_Z$$

$$3B34-00 R_4A = \left[ \frac{Q - 1}{(2 - Q) \times 1.7} - 1 \right] \times 25k\Omega$$

$$3B34-N-00 R_4A = \left[ \frac{Q - 1}{(Q - 2) \times 1.85} \right] \times 28.3k\Omega$$

$$G = \frac{\Delta R_{FS}}{2 \times 10^4} \left( \frac{1}{Q - 1} \right)$$

$R_Z$  = Resistance of the RTD at the temperature  $T_{MIN}$  that is to give  $V_O = 0V$

$$Q = \frac{\Delta R_{FS}}{\Delta R_{MS}} \text{ (a measure of nonlinearity)}$$

\*Since copper RTDs are linear devices, the 3B34-C-00 does not need a linearization resistor.

$\Delta R_{FS}$  is the change in resistance from  $T_{MIN}$  to  $T_{MAX}$ , which will give  $V_O = +10V$   
 $\Delta R_{MS}$  is the change in resistance from  $T_{MIN}$  to  $T_{MID}$ , which will give  $V_O = +5V$

If internal linearization is not required, then the following procedure applies:

1. Output voltages at the endpoints of the span may be anywhere in the range of  $-10V$  to  $+10V$ .
2. Any type of RTD can be used provided that its resistance does not exceed  $10k\Omega$  in the measurement range of interest.
3. Ranging components are computed from:

3B14, 3B15	3B34-00, 3B34-N-00
Gain Setting Resistor: $R_1 = \frac{\Delta R_{FS}}{4000 V_{FS} - \Delta R_{FS}} \times 20k\Omega$	$R_1 = \frac{\Delta R_{FS}}{2000 V_{FS} - \Delta R_{FS}} \times 20k\Omega$
	3B34-C-00
	$R_1 = \frac{\Delta R_{FS}}{500 V_{FS} - \Delta R_{FS}} \times 20k\Omega$

Zero Suppression

Resistors:	3B14: $R_{3A} = R_Z$	3B34: $R_{3A} = R_Z$
	3B15: $R_2 = R_Z$	

Where  $R_Z$  = Resistance of the RTD at the temperature that is to give  $V_O = 0V$   
 $V_{FS}$  = Positive full scale output voltage desired  
 $\Delta R_{FS}$  = Change in RTD resistance from  $R_Z$  to the full scale temperature.

The fact that  $R_Z$  is set to the zero volt output point does not mean that negative outputs will not be meaningful; it just provides the simplest relation. Once  $R_1$  and  $R_2$  are determined, the output voltage at any RTD temperature can be found, given the RTDs resistance at that temperature ( $R_{RTD}$ ), from the following relations:

3B14, 3B15, 3B34-00, 3B34-N-00

$$V_O = (R_{RTD} - R_Z) \times 0.25mA \times G_V$$

3B34-C-00

$$V_O = (R_{RTD} - R_Z) \times 1.0mA \times G_V$$

where  $G_V = \frac{20k\Omega}{R_1} + 1$  for 3B14 and 3B15 and  $G_V = \frac{40k\Omega}{R_1} + 2$  for 3B34.

## APPENDIX A2.1

### ERROR CONTRIBUTIONS

The tolerance of the resistor chosen for zero suppression and the mismatch of the current sources (typically 0.2%) define the error introduced with zero suppression. As an example, if when using the 3B34-00 the low end of a range is to be  $100^\circ C$  (which gives  $R_Z = 175.84\Omega$  from standard tables), the use of a 1% tolerance resistor will result in a total possible error of  $\pm 1.2\%$  or  $\pm 2.1\Omega$ . This error is seen at the module input, independent of gain.

The range of the module's voltage output zero adjust is at least  $\pm 5.0\%$  of the output span. Thus, the  $\pm 2.1\Omega$  input offset in the example above can be adjusted to zero for any output span greater than  $42\Omega$  (approximately  $110^\circ C$ ). If a smaller output span is desired, it will be necessary to use a more accurate resistor at  $R_2$  to guarantee that the offset can be zeroed.

The tolerance of the gain-setting resistor,  $R_1$ , affects the accuracy of the selected gain directly. Since the modules SPAN ADJUST have at least a  $\pm 5\%$  adjustment range, the use of 1% tolerance resistors for  $R_1$  will be sufficient.

## APPENDIX A2.2

### TEMPERATURE EFFECTS

The temperature drift of the zero suppression resistor  $R_Z$  directly affects the module's input offset drift. Thus, if a 50ppm/°C resistor is used, the drift should be added directly to a module's input offset drift. A lower value can of course be obtained by the use of a better resistor.

Temperature drift in the value of the gain setting resistor,  $R_1$ , will directly affect the module's gain drift. Note, however, that the basic drift specification for the modules includes the effect of a gain-setting resistor drift of  $\pm 10\text{ppm}/^\circ\text{C}$ . Rated performance will be obtained if the drift of  $R_1$  is less than or equal to this value.

## APPENDIX A3

### CUSTOM RANGING LVDT MODULE

The excitation voltage amplitude of the 3B17 LVDT input module is set by  $R_1$  which is determined from the following relation:

$$R_1 = \frac{10\text{k}\Omega \times V_{\text{rms}}}{7 - V_{\text{rms}}}$$

$V_{\text{rms}}$  is the desired rms amplitude of the oscillation, and it can be selected for any value between 1V and 5V. The accuracy of the excitation is  $\pm 10\%$  with a harmonic distortion of less than 0.5%.

Using resistors  $R_2$  and  $R_3A$ , the excitation frequency can be set for any value between 1kHz and 10kHz. These values are determined by the equation below:

$$R_2, R_3A = \frac{10^9}{f \times 6.3}$$

where  $f$  is the desired frequency of oscillation.

Since the excitation voltage resistor is used to set the amplitude of the excitation, its drift is reflected directly in the output of the module. Therefore, the excitation voltage resistor should be 1% tolerance, 10ppm. The frequency setting resistors on the other hand need only be 100ppm, since the module is insensitive to changes in frequency.

## APPENDIX A4

### RANGING LIMITS

The range carrier can be used effectively to create a very wide range of special transfer functions, but there are practical limits which must be observed. The limits are of three fundamental types:

- a. Module input restrictions. Independent of the amount of gain or zero suppression taken, the maximum voltage for normal, linear operation at either the HI or LO input terminal for the nonisolated units is:

3B10, 3B12, 3B13	$\pm 6.6\text{V}$ with respect to output (system) common
3B16	0 to +12V with respect to output (system) common
3B17*	$\pm 10\text{V}$ peak with respect to output (system) common
3B18	$\pm 11\text{V}$ with respect to output (system) common

For isolated units, the maximum differential voltage input is:

3B30, 3B37, 3B47	$\pm 1\text{V}$ differential input
3B31	$\pm 20\text{V}$ differential input
3B32	$\pm 2\text{V}$ differential input
3B40	$\pm 2.5\text{V}$ differential input
3B41	$\pm 25\text{V}$ differential input

\*The 3B17 requires no zero or gain setting resistors.

For isolated ac input modules, the maximum ac voltage input is:

3B42	1V rms
3B43	50 V rms
3B44	550V rms

Model 3B11 has a  $10\times$  input attenuator that affects its restriction. For this product, the sum of common mode voltage plus one tenth the normal mode voltage must be less than 6.6V. The RTD models (3B14, 3B15, 3B34) will work for any RTD value less than  $10k\Omega$  ( $2.5k\Omega$  for Copper RTDs).

Frequency Input Models 3B45 and 3B46 offer input protection up to 220V and will operate normally up to that value. The 3B46 can accept ranges between 25kHz and 50kHz with a gradual decrease in linearity. A 0–30kHz range has 0.02% nonlinearity and a 0–50kHz range has 0.5% nonlinearity.

- b. Adjustability of offset. As was mentioned above, the range of the voltage output ZERO pot is  $\pm 0.5$  volts at the module output. Equivalently, it can correct for INPUT offsets of up to  $\pm 0.5V/G$ . The errors in  $V_Z$  can limit the maximum gain when zero suppression is used. When  $V_Z$  is zero (no zero suppression), the offset adjustment need only cover the module's input offset voltage (typically less than  $\pm 50$  microvolts), so that gains up to 10000 are practical in many cases. Some exceptions are: the 3B37 and 3B47, where CJC errors limit gain to about 4000; the 3B18, whose larger input offset implies a gain limit of 5000; and the 3B40, where oscillation may occur for gains above 5000.
- c. Noise. At the higher gains (beyond 1000) all of the noise seen at the module output is a reflection of the module's input noise seen through the chosen gain. Although the noise does not rise in proportion to gain (due to a gradual decrease in module bandwidth beyond  $G = 1000$ ) there may well be a point beyond which system resolution is limited by noise rather than by the resolution of the data converter. There is, in general, no benefit in increasing gain beyond that point.

## APPENDIX B1

### MULTIPLE LVDT INSTALLATIONS

When multiple LVDTs are used in the same installation, good wiring practice is recommended to minimize interference between channels. This interference, which can occur when the difference in the LVDT excitation frequencies is smaller than the bandwidth of the module, can be virtually eliminated by keeping the wires from each LVDT as far apart as possible. It is best to use shielded cable, tying the shield to backplane common, and keeping the LVDT leads as short as possible.

Interference may still occur if the bodies of the LVDTs must be in close proximity to each other. To eliminate any interference, the oscillator of one 3B17 can be used to excite several LVDTs. The primary leads of all the LVDTs are connected in parallel to screws 1 and 4 of the module whose oscillator is to be used. The secondary leads are connected in the normal manner to their respective 3B17s. A jumper, AC1344, must be installed between pins 1 and 3 of the optional ranging card connector of the modules whose excitation circuits are not being used to turn off those modules' oscillators (see Figure below). This technique is limited in that the sum of the primary currents of all the LVDTs connected to one 3B17 must not exceed 20mA rms.

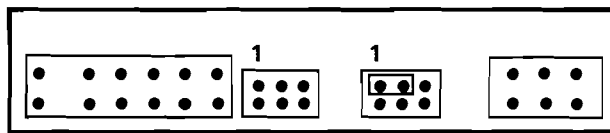


Figure B1. 3B17 Module . . . Bottom View of Connectors

## APPENDIX B2

### SYNCHRONIZING MULTIPLE LVDTs

It is possible to synchronize the oscillators of any number of 3B17s on the same backplane. All of the 3B17s to be synchronized must have the same nominal excitation voltage and frequency. An AC1310 with a jumper soldered into position R3B (see Figure below) is placed on the ranging connector of each 3B17 to be synchronized. This connects a control node of the excitation oscillator to Bus 3 on the 3B01, 3B02, 3B03 (16, 8, and 4 channel backplanes). Other 3B modules may still be used on the same backplane, but only 3B17s with identical nominal excitation voltages and frequencies may be connected to the synchronization bus. User programmed units (i.e., 3B17-00s) cannot be synchronized because the AC1310 custom ranging card is required to provide the connection to the synchronization bus. The synchronization capability is available only on 3B17s with a date code of 8646 or higher.

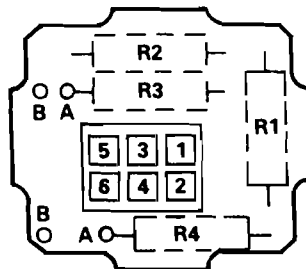


Figure B2. To Synchronize Like 3B17s Solder Jumper in Position R3B

## APPENDIX C

### ACCESSORIES

#### Custom Ranging Card

ADIP/N	Description	Used With
AC1310	Plug-on Card Requiring Customer Supplied Resistors	Any 3B Input Module

#### Power Supply Kits

ADIP/N	Input Voltage	Output Voltage	Output Current*	Description
AC1300**	115V ac	± 15V	± 200mA	AC Power Supply and Hold Down
AC1301**	115V ac	± 15V	± 350mA	AC Power Supply and Hold Down
AC1302	24V dc	± 15V	± 190mA	DC/DC Converter and Hold Down
AC1307	115V ac	± 15V + 24V***	+ 800mA, - 225mA + 350mA	AC Power Supply and Hold Down

\*Power supply current is a function of the actual modules used. See Table II in the 3B Series data sheet for current requirements.  
 \*\*Add "E", "F" or "H" suffix to model number for 220V ac, 100V ac or 240V ac input voltages, respectively.  
 \*\*\*The +24V output is unregulated.

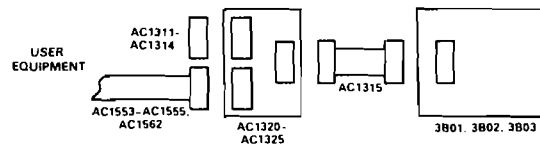
#### Power Cords

ADIP/N	Description	Used With
AC1340-D	7 ft. Domestic Power Cord	3B01, 3B02, 3B03
AC1340-C	7 ft. Continental Power Cord	3B01, 3B02, 3B03
AC1341	6 ft. dc Power Cable	3B01, 3B02, 3B03

#### Mounting Kits

ADIP/N	Description	Used With
AC1330	19" Rack Mount Kit	3B01, 3B02, 3B03
AC1331	16-Channel Surface Mount Kit	3B01
AC1332	8-Channel Surface Mount Kit	3B02
AC1333	4-Channel Surface Mount Kit	3B03

### INTERCONNECTION ACCESSORIES



This diagram depicts how the 3B Series may be interfaced to the user's equipment. The AC1315 ribbon cable provides a direct electrical connection to all adapter boards. Four adapter boards (AC1320-AC1323) are designed for specific Analog Devices' RTI boards and two (AC1324-AC1325) are designed for universal connections. All adapter boards accept either connectors or ribbon cables that can interface with the user's equipment.

## Cables

<b>ADIP/N</b>	<b>Description</b>	<b>Used With</b>
AC1315	2' 26-Pin Cable Assembly*	3B01-3B03, AC1320-AC1325
AC1326	3B to RTI-1225/1226 Cable Assembly	3B01-3B03
AC1327	3B to RTI-711/732 Cable Assembly	3B01-3B03
AC1328	3B to RTI-724 Cable Assembly	3B01-3B03
AC1329	AC1323 to RTI-711/732 Cable Assembly	AC1323
AC1335	3B to MIO-120 (or RTI-800/815) Cable Assembly	3B01-3B03
AC1553	50-Pin Cable Connector with 3' Cable	AC1321-AC1323, AC1325
AC1554	26-Pin Cable Connector with 3' Cable	3B01-3B03, AC1320-AC1325
AC1555	20-Pin Cable Connector with 3' Cable	AC1321-AC1323, AC1325
AC1562	34-Pin Cable Connector with 3' Cable	AC1320, AC1325
AC1585-6	3B to RTI-1260 Cable Assembly	3B01-3B03
AC1585-7	3B to RTI-1262 Cable Assembly	3B01-3B03
CCA11	3B to MACSYM 150 Cable Assembly	3B01-3B03

## Connectors

<b>ADIP/N</b>	<b>Description</b>	<b>Used With</b>
AC1311	20-Pin Female Mating Connector	AC1321-AC1323, AC1325
AC1312	26-Pin Female Mating Connector	3B01-3B03, AC1320-AC1325
AC1313	34-Pin Female Mating Connector	AC1320, AC1325
AC1314	50-Pin Female Mating Connector	AC1321-AC1323, AC1325
AC1316	20-Pin Board Mounted Male Connector	AC1325
AC1317	26-Pin Board Mounted Male Connector	AC1325
AC1318	34-Pin Board Mounted Male Connector	AC1325
AC1319	50-Pin Board Mounted Male Connector	AC1325
AC1352	6-Pin dc Power Female Mating Connector	3B01-03

## Miscellaneous

<b>ADIP/N</b>	<b>Description</b>	<b>Used With</b>
AC1342	100 $\Omega$ Current Sense Resistor (Spare)	3B12, 3B32
AC1343	2k $\Omega$ Current Sense Resistor (Spare)	3B13
AC1344	10 Jumpers (Spare)	Any 3B Module
AC1345	Individual Module Mounting Kit with CJC Sensor	Any 3B Module
AC1346	3B Series Manual	
AC1350	Blank Module (Includes PC Board, Case and Connector)	Custom Function with 3B Series
AC1351	Blank Module (Includes Case and Connector only)	Custom Function with 3B Series

## Adapter Boards for Analog Devices RTI Products

<b>ADIP/N</b>	<b>Description</b>	<b>Used With</b>
AC1320	RTI-1225/26/60/62 Family Adapter Board	RTI-1225, RTI-1226, RTI-1260, RTI-1262
AC1321	RTI-1230/31/32 Family Adapter Board  Also Supports Analog Input for RTI-1200, RTI-1250, RTI-1260, AIM03, and AIM100	RTI-1230, RTI-1232 RTI-1232 RTI-1200, RTI-1250, RTI-1260, AIM03, AIM100
AC1322	RTI-1240/41/42/43 Family Adapter Board	RTI-1240, RTI-1241 RTI-1242, RTI-1243
AC1323	RTI-711/24/32 Family Adapter Board	RTI-711, RTI-724, RTI-732
IOB120-01	RTI-800/815 Family Adapter Board with Cables	RTI-800, RTI-815

\*A Cable Assembly is defined as a cable with two connectors.



## UNIVERSAL ADAPTER BOARDS

The universal adapter boards are intended to provide connections to any external equipment. The AC1324 has a 26-pin connector which accepts the high level voltage I.O from a 3B Series backplane (the AC1315 might be used for this purpose). User connections are then made to screw terminals on the AC1324, which allows the 3B Series to interface to any equipment with just a screw

driver. The AC1325 has two 26-pin connectors that can interface with two 3B Series backplanes and has 4 patterns of holes that accommodate flat cable connectors of up to 50 pins each. The AC1325 mates with the appropriate connectors required to interface with the users' equipment. The AC1325 will accept the AC1316-AC1319 board mount connectors or any standard flat cable connector with 0.1" spacing.

ADIP/N	Description
AC1324	Universal Adapter with 26-Pin Connector in/ 26 Screw Terminals out
AC1325	Universal Adapter with two 26-Pin Connectors in/ 4 patterns of 50 sockets out. Accommodates the necessary connectors for each application

APPENDIX D

NOT to be distributed outside the FACTORY MUTUAL SYSTEM, except by CLIENT.

MODELS 3B01, 3B02, 3B03 SIGNAL CONDITIONING

SUBSYSTEM

for

HAZARDOUS LOCATIONS

from

ANALOG DEVICES INC.

ROUTE 1 INDUSTRIAL PARK

NORWOOD, MASS. 02062

J. I. OK5A8.AX  
(3611)

DECEMBER 26, 1984



**Factory Mutual Research**

1151 Boston-Providence Turnpike  
P.O. Box 688  
Norwood, Massachusetts 02062



# Factory Mutual Research

1151 Boston-Providence Turnpike  
P.O. Box 688  
Norwood, Massachusetts 02062

OK5A8.AX  
(3611)

December 26, 1984

MODELS 3B01, 3B02, 3B03 SIGNAL CONDITIONING  
I/O SUBSYSTEM  
for  
HAZARDOUS LOCATIONS

from

ANALOG DEVICES INC.  
ROUTE 1 INDUSTRIAL PARK  
NORWOOD, MASS. 02062

## I INTRODUCTION

1.1 Analog Devices Inc. requested approval of the apparatus listed in Section 1.2 to be in compliance with the applicable requirements of the following standards:

<u>Title</u>	<u>No.</u>	<u>Issue Date</u>
Electrical Equipment for Use in Class I, Division 2 Hazardous (Classified) Locations	ISA dS12.12 (Draft 12)	1983
Electrical Utilization Equipment	Class No. 3820	September 1979

1.2 The following apparatus is nonincendive, with nonincendive circuit field wiring for Class I, Division 2, Groups A, B, C and D hazardous locations in accordance with Drawing 03-0952800, Rev. A and will appear in the Approval Guide as follows:

ANI/I/2/ABCD - 03-0952800/A\*

\*See Dwg. 03-0952800 for nonincendive circuit field wiring parameters

Signal Conditioning Subsystem. Models 3B01, 3B02, 3B03

## II DESCRIPTION

2.1 The attached documents describe the major functions and operation of the signal conditioning subsystem. The manufacturer has made available all necessary component information, system specification, and test procedures which have been examined. Installation and operation manuals are available which thoroughly describe each major assembly, initial installation, testing, periodic adjustments and trouble shooting techniques.

3.3 There are no relays, switches, or contacts in any of the plug-in modules, power supplies, or backplane of the 3B Series Subsystem. Therefore, no arcing or sparking contacts.

3.4 Modules 3B30, 3B31, 3B32, 3B34, and 3B37 each contain two small signal isolation transformers. The maximum inductance was measured as 0.9H. The circuits using these transformers were examined to determine if any hazardous stored energy could reach the nonincendive circuit field wiring terminals under normal conditions. Analysis and tests determined that the energy was prevented from reaching these terminals by the following components.

<u>Component</u>	<u>Type</u>
R46	2.2M ohms
R47	20K ohms
R48	100K ohms
R49	100K ohms
R28	470K ohms

### 3.5 Nonincendive circuit field wiring parameters.

3.5.1 Nonincendive circuit field wiring parameters for Terminals 1 and 2 of TB1-TB31 (odd numbered only) and Terminal 1 of TB2-TB32 (even numbered only) are as follows:

$$\begin{array}{ll} V_{oc} = 30 \text{ V} & L_a = 50 \text{ mH} \\ I_{sc} = 30 \text{ mA} & C_a = 0.2 \text{ } \mu\text{fd} \end{array}$$

3.5.2 Nonincendive circuit field wiring parameters for Terminals 2, 3, and 4 of TB2-TB32 (even number only).

$$\begin{array}{ll} V_{max} = 30 \text{ V} & L_i = 0 \\ I_{max} = 30 \text{ mA} & C_i = 0 \end{array}$$

3.5.3 Nonincendive circuit field wiring parameters for all pins on Connector P1, and P2, except when 3B19 or 3B39 output modules are used.

$$\begin{array}{ll} V_{oc} = 15 \text{ V} & L_a = 300 \text{ mH} \\ I_{sc} = 10 \text{ mA} & C_a = 1 \text{ } \mu\text{fd} \end{array}$$

3.5.4 Nonincendive circuit field wiring parameters for all pins on Connector P1, and P2 using 3B19 or 3B39 output modules.

$$\begin{array}{ll} V_{max} = 30 \text{ V} & L_i = 0 \\ I_{max} = 30 \text{ mA} & C_i = 0 \end{array}$$

### 3.6 Electrical Utilization Examination

3.6.1 Power supplies AC1300 and AC1301, representative of the power supplies described in Paragraph 2.4, were tested under fault conditions by separately shorting each DC output. Under these conditions, the maximum temperature measured on the case was 75° (Referenced to 40°C).

4.3 Marking on the individual plug-in modules displays the following information:

- a. Model number
- b. Manufacturer's name
- c. Input and output parameters

#### V REMARKS

5.1 Installation, use and maintenance should be in accordance with the manufacturer's documents and the National Electrical Code.

5.2 Tampering or replacement with nonfactory components may adversely affect the safe use of the system.

#### VI CONCLUSION

The apparatus described in Section 1.2 meets Factory Mutual requirements. Approval is effective when the Approval Agreement is signed and returned to Factory Mutual.

#### VII DOCUMENTATION FILE

The following documentation is applicable to this approval and is on file at Factory Mutual. No changes of any nature shall be made unless notice of the proposed change has been given and written authorization obtained from Factory Mutual. The Approved Product - Revision Report, FMRC Form 797 shall be forwarded to Factory Mutual as notice of proposed changes.

<u>Document No.</u>	<u>Revision</u>	<u>Title</u>
03-0952800	A	3B Series Noncendive Installation Diagram
75-1123200	A	3B Series FM Approval
02-0951500	E	Schematic Drawing Model 3B10
02-0951600	E	Schematic Drawing Model 3B11
02-0951700	E	Schematic Drawing Model 3B12
02-0951800	F	Schematic Drawing Model 3B13
02-0951900	F	Schematic Drawing Model 3B14
02-0952000	F	Schematic Drawing Model 3B15
02-0951200	E	Schematic Drawing Model 3B16
02-0952200	D	Schematic Drawing Model 3B19
02-0952300	C	Schematic Drawing Model 3B30
02-0952400	C	Schematic Drawing Model 3B31
02-0952500	C	Schematic Drawing Model 3B32
02-1006100	B	Schematic Drawing Model 3B34
02-0952600	D	Schematic Drawing Model 3B37
02-0952700	B	Schematic Drawing Model 3B39
02-0951300	B	Schematic Diag. Manifold Type 3 Board
02-0953000	A	Schematic Diag. Manifold 4 Channel Backplane
02-0952900	A	Schematic Diag. Manifold 8 channel backplane

**APPROVED PRODUCT – REVISION REPORT  
OR ADDRESS/CONTACT CHANGE REPORT**



**SENDER:** Forward original and one (1) copy with updated drawings or other appropriate change information to the attention of the Approvals Division. Original will be returned showing course of action taken.

Additional forms may be requested by writing to the attention of the Factory Mutual Stockroom.

**FORWARD TO:**

**FACTORY MUTUAL RESEARCH**  
1151 Boston-Providence Turnpike  
P.O. Box 688  
Norwood MA 02062

Please type below your Company Name, Address, City, State & Zip Code.

Attention: **R. T. Burke**

Analog Devices, Inc.  
P. O. Box 280  
Norwood, MA 02062

DATE May 20, 1986
FORWARDED BY A. Scannell
TITLE Q.A. Engineer
MODEL(S) AFFECTED 3B01, 3B02, 3B03
INDICATE FACTORY MUTUAL JOB IDENTIFICATION(S) AFFECTED OK5A8.AX

PRODUCT(S)  
I/O Subsystems

IS A FACTORY MUTUAL LISTED MODEL/TYPE NO. REVISED BY THIS CHANGE? IF YES, EXPLAIN (USE SEPARATE SHEET IF REQUIRED):  YES  NO

HAS THE MANUFACTURING LOCATION, LISTING ADDRESS, TELEPHONE NUMBER OR CONTACT PERSON CHANGED? IF YES, EXPLAIN BELOW:  YES  NO

REVISION DETAILS

DWG NO. AFFECTED

NEW DWG. NO.

Analog Devices requests additional modules to be added to the 3B01, 3B02 and 3B03 signal conditioning subsystem approved nonincendive as described in FM J.I. OK5A8.AX. There are ten new plug-in signal modules and two new plug-in power supplies as listed below:

Signal Module

Input Type

3B17	Linear Variable Differential Transformer
3B18	Wideband Strain Gage Inputs
3B40, 3B41	Wideband Isolated mV and V inputs
3B42, 3B43, 3B44	Isolated AC mV and V inputs
3B45, 3B46	Isolated Frequency inputs
3B47	Isolated Linearized Thermocouple input

<u>Power Supply Model</u>	<u>Input Voltage</u>	<u>Output (Both Models)</u>
AC1307	105 Vac to 125 Vac	+15 Vdc @ 800 mA -15 Vdc @ 225 mA
AC1307E	205 Vac to 240 Vac	+24 Vdc @ 350 mA

The plug-in signal modules contain circuits that are very similar to the modules examined as described in FM J.I. OK5A8.AX.

**BELOW FOR FACTORY MUTUAL USE**

COMMENTS:	REVISION REPORT J.I. 1M4A0.AX		REVISION NOTICE NO. N/A	
	FORWARD APPROVAL AGREEMENT <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO		FILE 3611	
	<input checked="" type="checkbox"/> REVISION(S) AUTHORIZED		<input type="checkbox"/> NOT AUTHORIZED	
	REVISION REVIEWED <i>[Signature]</i>	DATE 6/10/86	REVISION APPROVED <i>[Signature]</i>	DATE 6-10-86

There are no relays, switches or contacts in any of the new plug-in modules. Therefore, no arcing or sparking contacts. Temperature tests were conducted on one of the new power supplies. The maximum temperature measured on Model AC1307 power supply was 95°C at an ambient of 40°C. Model AC1307E has a 240 ac power input and both have the same regulating circuitry. Analysis indicates Model AC1307E would produce the same maximum temperature on the 15 volt regulator transistor.

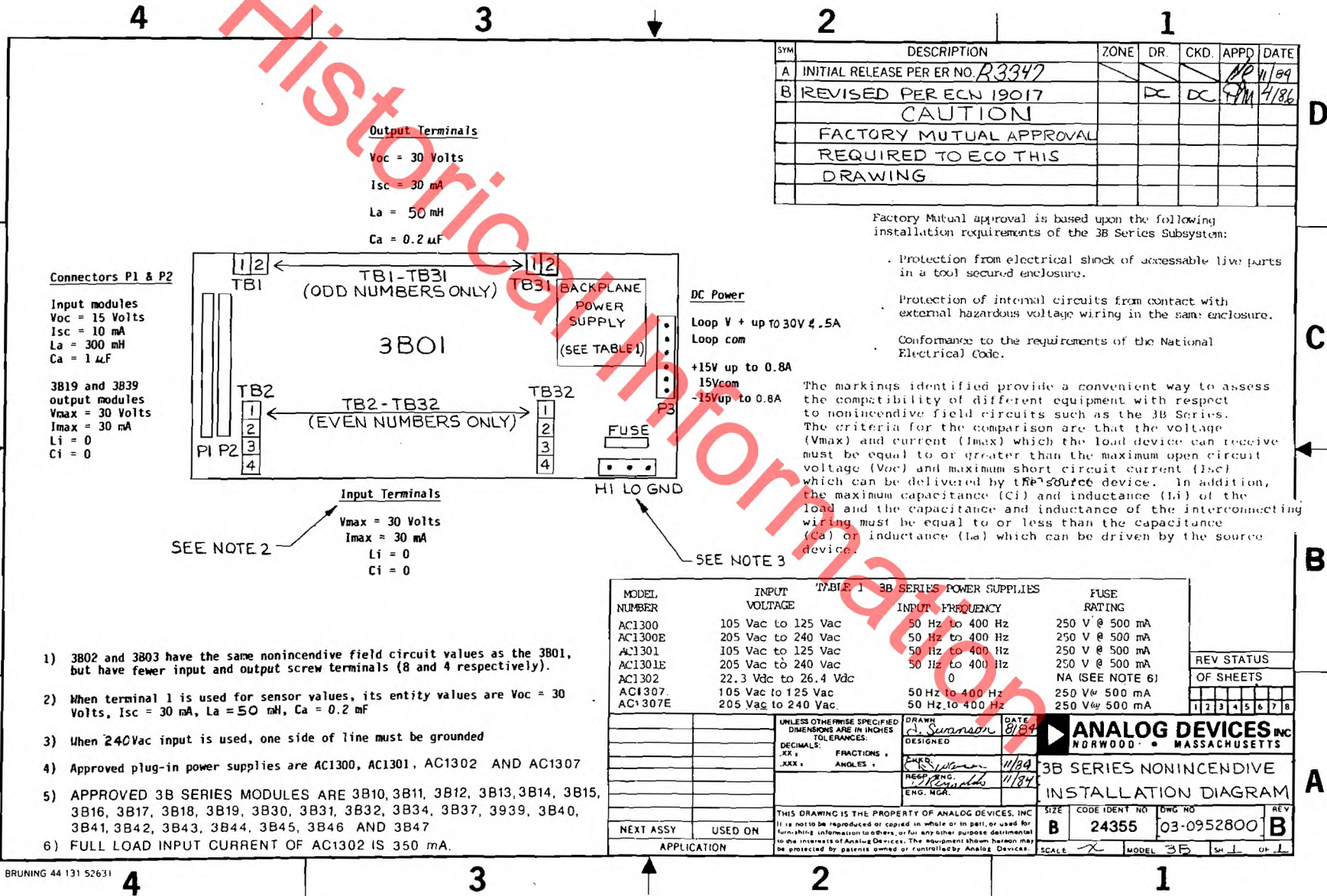
Report J.I. OK5A8.AX identified a maximum temperature of 107°C, referenced to 40°C, on Signal Module 3B16. Analysis of the new signal module circuitry points to the same maximum temperature. Therefore, the existing temperature rating of T4A for the 3B subsystem remains unchanged with this report.

The power transformer in supplies AC1307 and AC1307E are identical, and both have a primary fuse of 0.5 amps. A sample transformer was tested under fault conditions by separately shorting each secondary winding and applying rated primary voltage. In all cases, the 0.5 amp primary fuse opened within 5 seconds. Test results were satisfactory. Sections 3.6.2, 3.6.3 and 3.6.4 of the original Report OK5A8.AX also apply to this revision report. These sections cover Hypot Testing and electrical shock protection, as specified in FM Standard No. 3820.

The nonincendive field wiring parameters remain the same as listed on System Drawing 03-0952800/B and the listing guide will be changed to Revision B.

<u>Document No.</u>	<u>Documentation File</u>	
	<u>Revision</u>	<u>Title</u>
91-1174400	C	Specification Control Drawing AC1307
02-1182100	A	Schematic Diagram (3B17)
02-1J45800	A	Schematic Diagram (3B18)
02-1056200	B	Schematic Diagram (3B40/41)
02-1047300	B	Schematic Diagram (3B42, 3B43, 3B44)
02-1080100	B	Schematic Diagram (3B45, 3B46)
02-1105800	A	Schematic diagram (3B47)
03-0952800	B	3B Series Nonincendive Instal. Diag.

*Robert A. Brink 6/10/02*



SYM	DESCRIPTION	ZONE	DR.	CKD.	APPD.	DATE
A	INITIAL RELEASE PER ER NO. R3347					11/1/89
B	REVISED PER ECN 19017		DC	DC		4/18/86
<b>CAUTION</b>						
FACTORY MUTUAL APPROVAL						
REQUIRED TO ECO THIS						
DRAWING						

Factory Mutual approval is based upon the following installation requirements of the 3B Series Subsystem:

- Protection from electrical shock of accessible live parts in a tool secured enclosure.
- Protection of internal circuits from contact with external hazardous voltage wiring in the same enclosure.
- Conformance to the requirements of the National Electrical Code.

The markings identified provide a convenient way to assess the compatibility of different equipment with respect to nonincendive field circuits such as the 3B Series. The criteria for the comparison are that the voltage (Vmax) and current (Imax) which the load device can receive must be equal to or greater than the maximum open circuit voltage (Voc) and maximum short circuit current (Isc) which can be delivered by the source device. In addition, the maximum capacitance (Ci) and inductance (Li) of the load and the capacitance and inductance of the interconnecting wiring must be equal to or less than the capacitance (Ca) or inductance (La) which can be driven by the source device.

**Connectors P1 & P2**  
 Input modules  
 Voc = 15 Volts  
 Isc = 10 mA  
 La = 300 mH  
 Ca = 1 μF

**3B19 and 3B39 output modules**  
 Vmax = 30 Volts  
 Imax = 30 mA  
 Li = 0  
 Ci = 0

**Output Terminals**  
 Voc = 30 Volts  
 Isc = 30 mA  
 La = 50 mH  
 Ca = 0.2 μF

**DC Power**  
 Loop V + up to 30V @ .5A  
 Loop com  
 +15V up to 0.8A  
 15Vcom  
 -15V up to 0.8A

**Input Terminals**  
 Vmax = 30 Volts  
 Imax = 30 mA  
 Li = 0  
 Ci = 0

SEE NOTE 2

SEE NOTE 3

- 3B02 and 3B03 have the same nonincendive field circuit values as the 3B01, but have fewer input and output screw terminals (8 and 4 respectively).
- When terminal 1 is used for sensor values, its entity values are Voc = 30 Volts, Isc = 30 mA, La = 50 mH, Ca = 0.2 μF
- When 240Vac input is used, one side of line must be grounded
- Approved plug-in power supplies are AC1300, AC1301, AC1302 AND AC1307
- APPROVED 3B SERIES MODULES ARE 3B10, 3B11, 3B12, 3B13, 3B14, 3B15, 3B16, 3B17, 3B18, 3B19, 3B30, 3B31, 3B32, 3B34, 3B37, 3B39, 3B40, 3B41, 3B42, 3B43, 3B44, 3B45, 3B46 AND 3B47
- FULL LOAD INPUT CURRENT OF AC1302 IS 350 mA.

MODEL NUMBER	INPUT VOLTAGE	INPUT FREQUENCY	FUSE RATING
AC1300	105 Vac to 125 Vac	50 Hz to 400 Hz	250 V @ 500 mA
AC1300E	205 Vac to 240 Vac	50 Hz to 400 Hz	250 V @ 500 mA
AC1301	105 Vac to 125 Vac	50 Hz to 400 Hz	250 V @ 500 mA
AC1301E	205 Vac to 240 Vac	50 Hz to 400 Hz	250 V @ 500 mA
AC1302	22.3 Vdc to 26.4 Vdc	0	NA (SEE NOTE 6)
AC1307	105 Vac to 125 Vac	50 Hz to 400 Hz	250 V @ 500 mA
AC1307E	205 Vac to 240 Vac	50 Hz to 400 Hz	250 V @ 500 mA

REV STATUS							
OF SHEETS							
1	2	3	4	5	6	7	8

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES		DRAWN: A. Sumner DESIGNED: [Signature] CHECKED: [Signature] REVISIONS: [Signature] ENG. MGR.: [Signature]	DATE: 8/84 11/84 11/84	<b>ANALOG DEVICES INC</b> NORWOOD • MASSACHUSETTS
THIS DRAWING IS THE PROPERTY OF ANALOG DEVICES, INC. It is not to be reproduced or copied in whole or in part, or used for furnishing information to others, or for any other purpose detrimental to the interests of Analog Devices. The equipment shown herein may be protected by patents owned or controlled by Analog Devices.				SIZE: B CODE IDENT NO: 24355 DWG NO: 03-0952800 REV: B
NEXT ASSY	USED ON	APPLICATION	SCALE: X	MODEL: 3B SH. 1 of 1



**APPENDIX E**  
**THE 3B SERIES SUBSYSTEM:**  
**COMMONLY ASKED QUESTIONS**

- Q. Is the 4-to-20mA output of the the 3B39 isolated from loop power?
- A. Yes, the current output is isolated from the input and from the loop power.
- Q. On the 3B system, where do I get the 24V for current output?
- A. Up to 400Ω max load per module can be supplied from the ±15V power supply mounted on the backplane (within the power supply current output specification). This is obtained by strapping pins 1 and 4 on P3. Or the 24V can be supplied externally through P3 (see page 4–6).
- Q. Are the outputs from a 3B37 thermocouple module linearized?
- A. No. A common practice is to use a “poly” statement via software in the user’s system. The transfer function of the 3B37 is in the 3B Users’ Manual. A 3B47 thermocouple module does provide a linearized output.
- Q. How can I isolate an input signal and also isolate the output from the power supply ground?
- A. Use an output module in conjunction with an input module, i.e., a 3B31 and a 3B39. The output of the 3B31 is the input to the 3B39. (This is known as 3-port isolation.)
- Q. I have a 3B16 strain gage module, but I need bandwidth of 1kHz. Can I cut out the filter inside the module?
- A. No. It’s not that simple. What you need ia a 3B18 module!
- Q. How do I correspond my desired 4-20mA output with –10V to +10V or 0 to +10V output?
- A. All modules are shipped 4-20mA corresponding to 0 to +10V output. For a –10V to +10V proportion, the user would select by a jumper on the bottom of the module. A jumper also exists for 0-20mA output.
- Q. When I plug my “-00” 3B module into the backplane, I get –10 volts out. What should I do?
- A. Plug the configured AC1310 onto the module.
- Q. On our 3B RTD modules, how do we linearize? Do we use two endpoints, worst case or what?
- A. We use  $T_{min}$ ,  $T_{mid}$  and  $T_{max}$  – three (3) points!
- Q. I’m using a 3B39 (output module) and have 0 to +10V input going to my screw terminals #2 and #3, but I can’t get 4-20mA output?
- A. Input (0 to +10V, –10V to +10V) is to go through P1 or P2 26-pin connector, not screw terminals.
- Q. I have a 3B18 module. How do I zero suppress? It’s not in the manual.
- A. There is no zero suppression available on the 3B18.
- Q. Do you have an isolated input strain gage module?
- A. Not at this time, the output from the 3816/18 could be put into a 3B31 though.
- Q. Why can’t the 3B16 strain gage module handle 100Ω load cells?
- A. The 3B16 provides +10V of excitation with approximately 35mA driving capability. With a 100Ω strain gage requiring 10V excitation, there would be a need for 100mA driving capability. If using the 3B18 with the 3.3V excitation, only 33mA is required.
- Q. Do I have to return the 20mA output from 3B modules back into the same module or can I use a common return path for all my 3B outputs?
- A. With nonisolated modules you may use the loop power supply return for all the modules. You will of course lose the overvoltage protection that each module offers on its current return.

## NOTES

## Addendum to the 3B Series User's Manual

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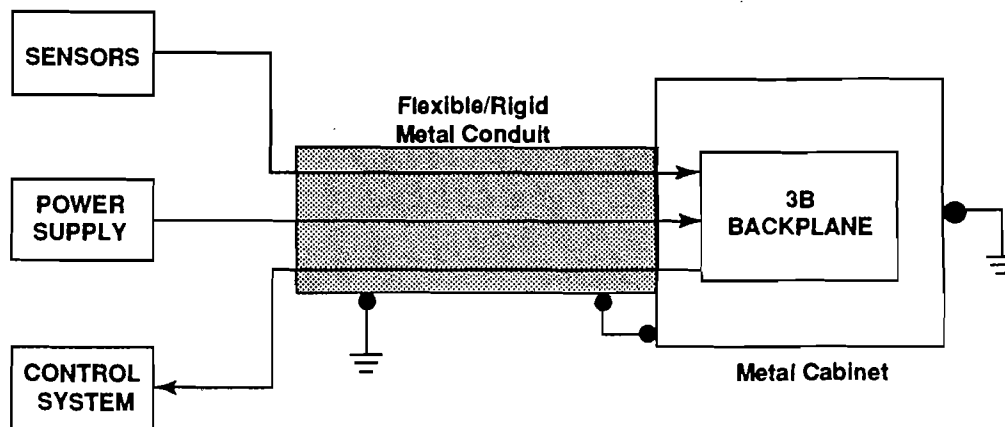
### Important Information

for use of the  
3B Series Signal Conditioning Subsystems  
in RFI/EMI fields.

The 3B Series Modular Signal Conditioners has been tested and passed the stringent "heavy industrial" requirements of the European Union's electromagnetic compatibility (EMC) directive. The 3B Series modules have the CE (Communauté Européenne) mark on their label indicating their approval. Only products that comply with these directives can have the CE mark affixed. Only CE marked products can be sold in the EU starting on January 1, 1996.

In order to comply with the European Standards in a typical heavy industrial application we recommend the following setup:

1. The modules must be mounted on a standard **iomation** 3B backplane.
2. The 3B backplane must be mounted inside a standard metal cabinet which fully encloses the modules on all sides. The cabinet must be earth grounded at a convenient point and good electrical contact between all side panels must be assured.
3. All wiring must be routed through a metal conduit or wire chase (flexible or rigid).
4. The conduit must be earth grounded and electrically connected to the cabinet.
5. Due to the low input levels, it is recommended that all input, output and power lines be shielded. The wiring must be connected as described in Chapter 3 of this manual.



**General Wiring Configuration**

## **CE CERTIFICATION TESTS**

The 3B Series modules have been tested and certified according to the rigorous electromagnetic constraints of the EN50082-2 and EN50081-2 European Standards.

The tests performed in accordance with these standards were:

- Radiated RF Immunity - 80 MHz to 1000 MHz.
- Pulsed RF Immunity - 900 MHz, 50% Duty Cycle, 200 Hz.
- Conducted RF Immunity - 150 KHz to 80 MHz.
- Magnetic Field Immunity - 50 Hz.
- Fast Transient Immunity.
- ESD Immunity, Contact Method.
- ESD Immunity, Air Discharge Method.
- Voltage Surge Immunity.
- Emissions.

When used according to these installation directions, any errors caused by EMI/RFI interference will be less than 0.1% of the full scale 3B measurement range (typical @ 25°C), for field strengths up to 10 V/M and frequencies up to 1 GHz.



