Westinghouse

numa-logic

8-CHANNEL ANALOG-TO-DIGITAL INPUT CONVERTER

Catalog No. NL-742-H (A through E)

PERFORMANCE DATA

Circuits per Module	8
I/O Rack Positions	2 (Vertical Rack) 1 (Horizontal Rack)
Input Ranges	• A 0 to 5 VDC • B 0 to 10 VDC • C ±5 VDC • D ±10 VDC • E 1 to 5 VDC
Input Protection	Inputs will withstand 40 VDC or 40 VAC RMS continuous
Input Impedance (1)	10 megohms
A/D Converter Type	Successive approximation
Resolution	10 bits over the span
Conversion Rate (1)	110 μs/channel
Absolute Accuracy (2)	0.3% (A, B, C, D) 0.5% (E)
Common Mode Rejection Ratio RTI (1)	70 dB
Gain Temperature Coefficient (1)	70 ppm/°C
Offset Temperature Coefficient (1)	0.3mV/°C (A, B, C, D) 0.6mV/°C (E)
External Power Requirements (1)	+15.8 @ 190mA −15.8 @ 20mA
I/O Power Requirements	9 units, Logic Power
Max. Common Mode Voltage (3)	2.0 V
Temperature Rating	0 to 60°C
Humidity Rating	0 to 95% noncondensing

(1) Typical

(2) Includes temperature, gain, and offset errors

(3) No input terminal should exceed ±12 V from Power Supply Common

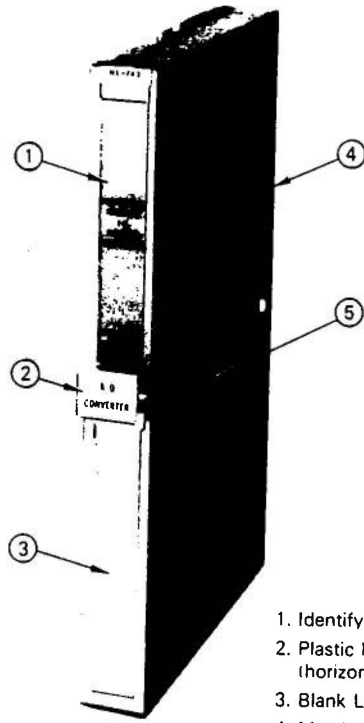

Figure 1 — Analog-to-Digital Input Module

INTRODUCTION

The function of the Analog-to-Digital (A/D) Input Module (Figure 1) is to convert 8 unipolar or bipolar analog input voltages into binary numbers which are transferred into separate input registers in the Processor during the I/O scan. Eight nonisolated analog inputs, referred to here as "channels", are each capable of converting voltage levels into binary numbers from 0 to 1023 for unipolar inputs, and −511 to +511 for bipolar inputs. Addressing of the eight channels is determined by setting the group select switch on the I/O rack.

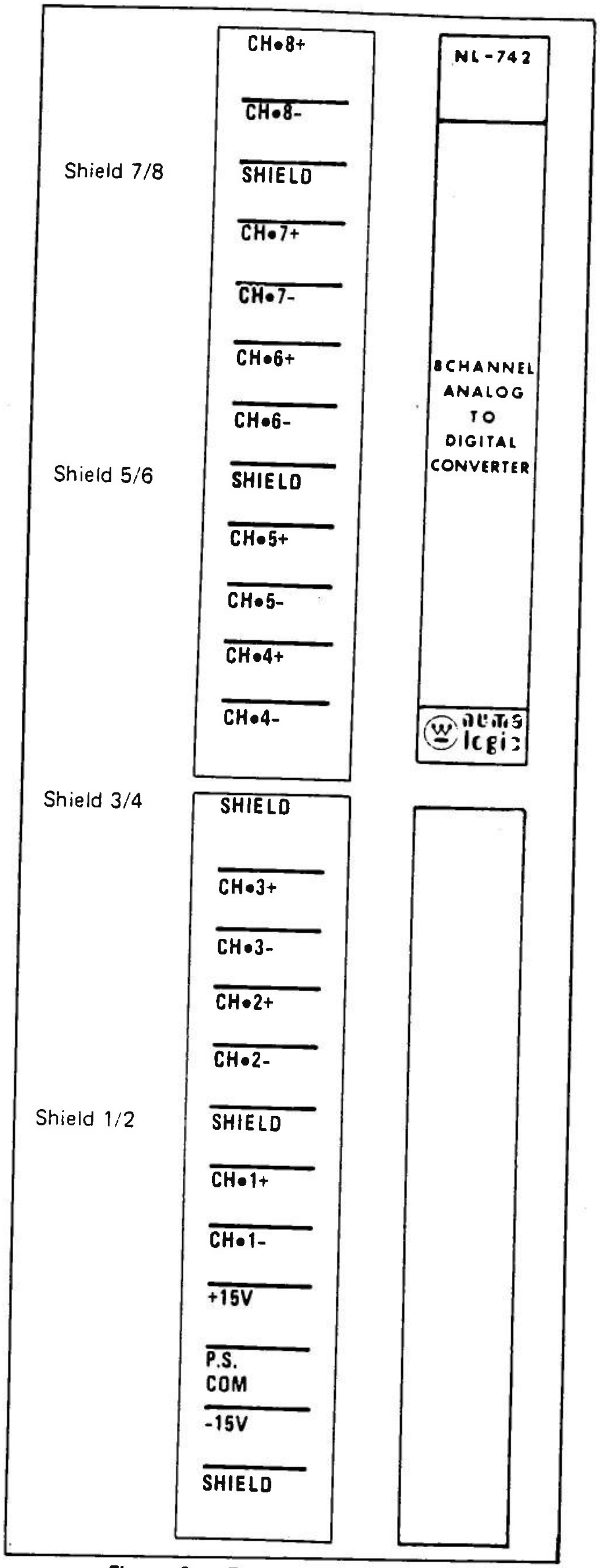

Figure 2 — Terminal Identification

Five versions of the Catalog No. NL-742-H Module are available. They are distinguished by the analog input voltage range each accepts:

- A 0 to 5V
- B 0 to 10V
- C ±5V
- D ±10V
- E 1 to 5V

The Module can accept analog current inputs if user-supplied resistors are added to convert the current input to a voltage. (See Application Note 5.)

In addition, the Module automatically checks for a number of power supply malfunctions, and upon detecting one, outputs a signal that sets to Logic "1" bit 15 of the input-registers associated with each channel of the Module. This can be detected by the program and appropriate action can be taken.

The Module is a double-height, single-width type. Field wiring to it is through terminals on the I/O Rack. Each channel uses three terminals:

- + Analog In
- − Analog In
- Shield

For proper operation of the Module, an external power supply is required. (See Application Note 6.)

The Module includes two pictorial Lenses, only one of which is marked. (See Figure 2.) A blank Lens may be substituted upon request. Optionally, an individualized Lens is available with user-specified JIC symbols.

Also supplied with the Module are two Terminal Identification Strips, which are to be filled in with wire numbers and applied to the I/O Rack next to the terminals.

MODULE SETUP

Handle — The Module is shipped with a metal handle and mounting screws, as well as a plastic handle and color-coded label. If the Module is to be installed in a vertical Rack (NLR-704) install the metal handle and/or the plastic handle as shown in Figure 1. For horizontal, high-density Rack (NLRH-704/708) installation, **do not** install the metal handle; install only the plastic handle. Fix the adhesive label to the front of the plastic handle as shown in Figure 1.

Group Select — Because there are eight analog input channels on the Module and eight input registers in an I/O group, register selection switching is not required on the Module. Table A shows the relation between rack group select switch settings and input register assignments for each channel.

Table A

GROUP SELECT (RACK) SWITCH SETTINGS

Channel	Group Select Switch Settings			
	1	2	3	4
1	IR0001	IR0009	IR0017	IR0025
2	IR0002	IR0010	IR0018	IR0026
3	IR0003	IR0011	IR0019	IR0027
4	IR0004	IR0012	IR0020	IR0028
5	IR0005	IR0013	IR0021	IR0029
6	IR0006	IR0014	IR0022	IR0030
7	IR0007	IR0015	IR0023	IR0031
8	IR0008	IR0016	IR0024	IR0032

Channel Inhibit — Channels 1 and 2 of the Module are always active. Channels 3 through 8 can be selectively inhibited by positioning the six switches on the Module as shown in Figure 3.

CAUTION

All other adjustments are done at the factory; do not attempt any other adjustments of the Module.

EXTERNAL WIRING

Cables — Figure 4 shows proper Module connections of shielded, twisted-pair channel cables and shielded, 3-wire power supply cable.

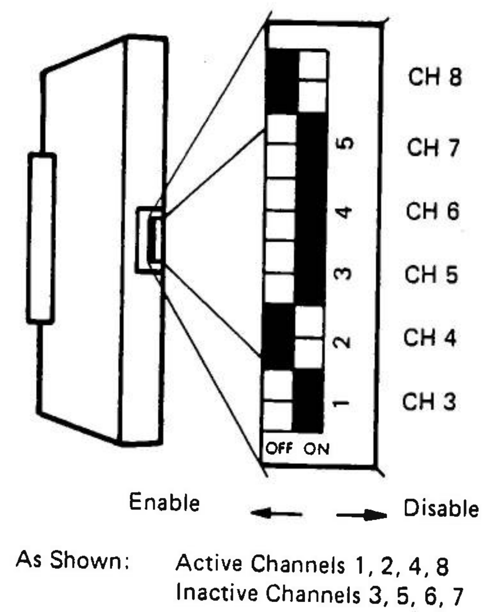

Figure 3 — Channel Inhibit Switches

Grounding/Shielding — Figure 5 shows recommended grounding and shielding techniques for cables used with the Module.

INSTALLATION - VERTICAL RACK

Physical Placement - Connect all field wiring to the Veritical Rack's terminals. Follow the typical connection diagrams in Figures 4 and 5. Installing the Module is a simple process: slide it into two of four positions on an I/O Rack. To do so, follow these steps:

Step 1 - Refer to system drawings and determine in which I/O Rack and in which positions in the Rack the Module will be placed. (Although a Module can be placed in either the upper two Positions or lower two Positions, it must not straddle Positions B and C. See Figure 6.)

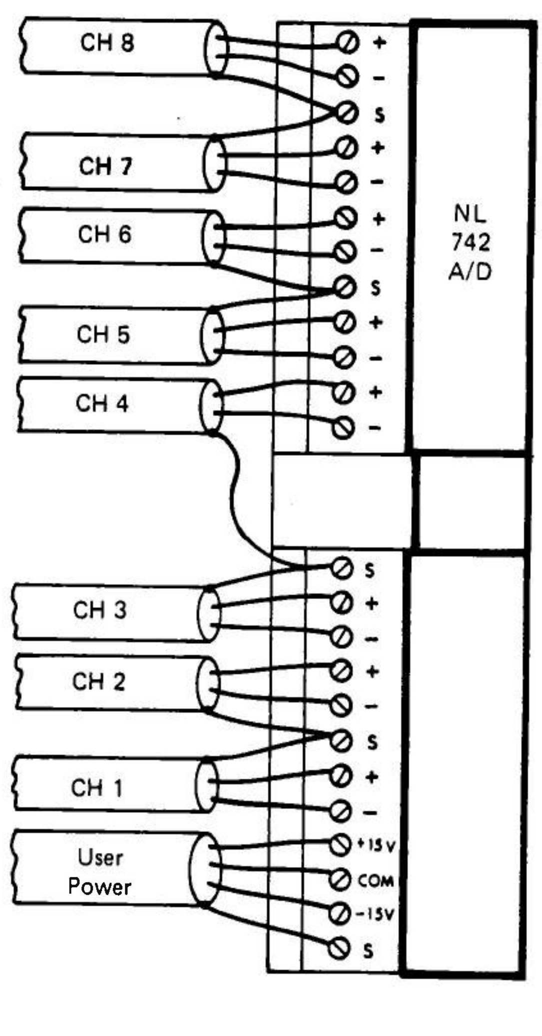

Figure 4 — NL-742-H Cable Connections

Step 2 - Set the Module's Channel Inhibit Switches (Figure 3).

Step 3 - Move the appropriate Locking Bars on the I/O Rack's built-in terminal blocks to the left to uncover the guide slots on the blocks (Figures 6 and 7).

Step 4 - Align the Module's guide pins with corresponding slots on the I/O Rack. Gently press the Module into the edge connectors on the Rack. Make sure the edge pins on the Module align and mate with the Rack connectors.

Step 5 - When the Module is properly seated, snap the Rack's Locking Bars over the Module's guide pins to hold it in place.

Step 6 - Apply the self-adhesive Terminal Identification strips, supplied with the Module, to the terminal block's face.

Step 7 - Write the wire number, or other identifying information, on the Terminal Identification Strips for subsequent use. Wiring practices to the terminals on the I/O Rack are described in the PC-900 and PC-700 Application Manuals.

Rack Switch Settings - Set the desired GSEL switch to ON (see Figure 6 for switch location and Table A for Rack Switch Settings). Set unused GSEL switches OFF.

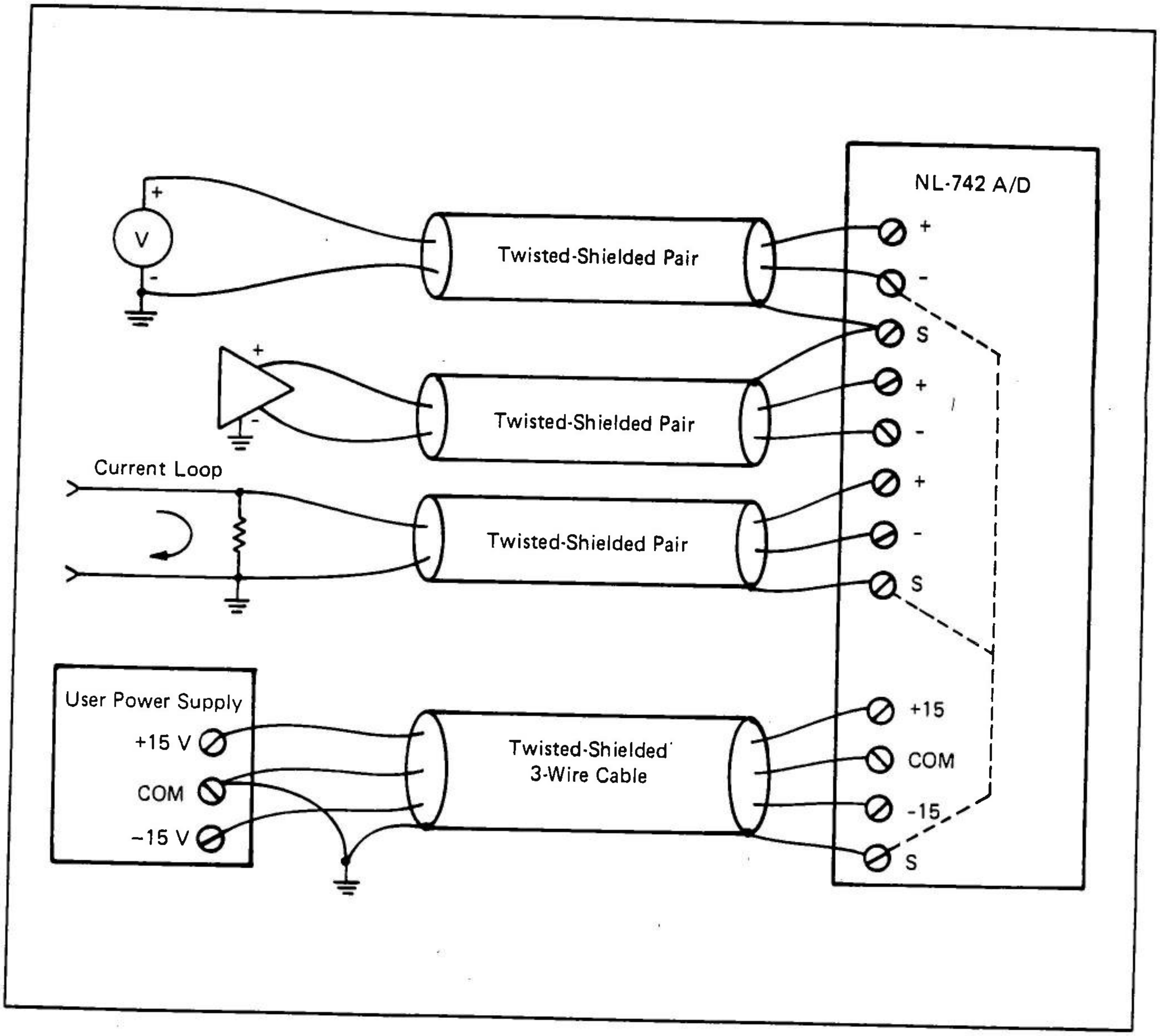

Figure 5 — NL-742-H Grounding and Shielding

CAUTION

Although two NL-742-H Modules may be physically accommodated by a vertical Rack, only one NL-742-H is permissible. This is because the GSEL switch specifies 8 input registers, and there are a corresponding 8 channels on one NL-742-H Module. The NL-742-H ignores the TOP and BOTT Rack Switch settings, allowing other Modules to be accommodated by the Rack.

INSTALLATION - HORIZONTAL RACK

NOTE

One NL-742-H Module may be placed in a 4-slot Horizontal Rack and two NL-742-H Modules may be placed in an 8-slot Horizontal Rack. Each Rack Group Select Switch matches the 8 input registers to be used with the 8 channels on one NL-742-H Module.

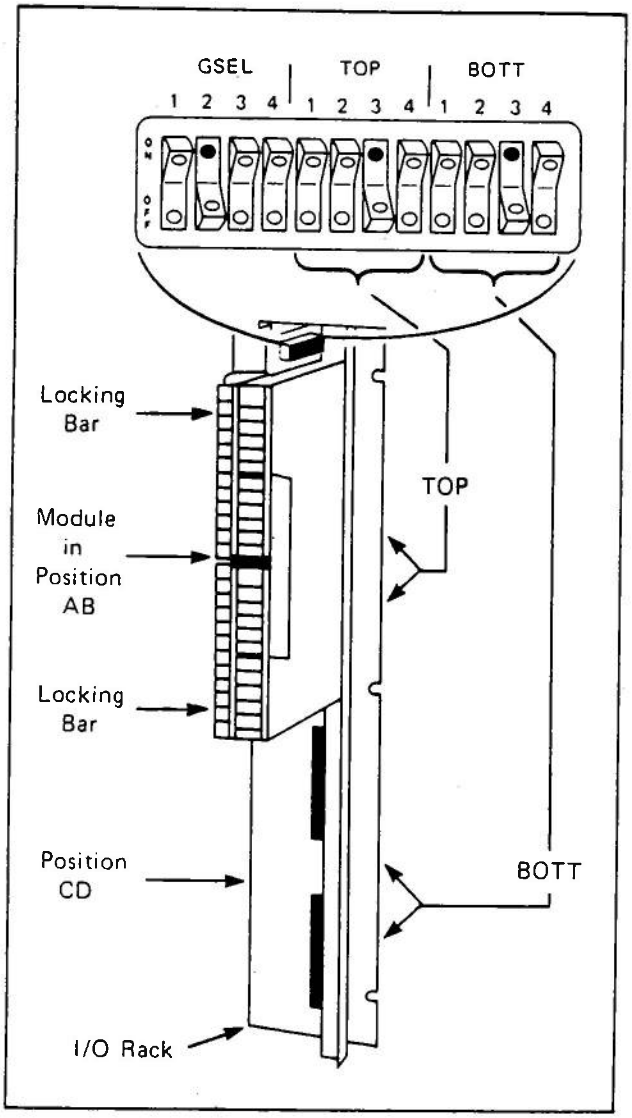

Figure 6 — Vertical Rack Switch Location

Physical Placement - Connect all field wiring to the Horizontal I/O Rack's terminals. Follow the typical connection diagrams in Figures 4 and 5. Installing the Module is a simple process: slide it into one of the four or eight Positions on a Horizontal Rack. To do so, follow these steps:

Step 1 - Refer to system drawings and determine in which Horizontal I/O Rack the Module is to be placed. Set the Group Select Switch, located on the inside surface of the Rack backplane (See Figure 8 and Table A for switch settings).

Step 2 - Pull the Terminal Raceway for the appropriate I/O Rack module slot forward until it stops; lock the Raceway in the extended position (Figure 9) using the top and bottom slide latches.

Step 3 - Refer to system drawings and set the Module Inhibit Switches (Figure 3) as required.

Step 4 - Insert the Module into the Rack, to the right of the extended Terminal Raceway. Ensure that the board edge tabs at the top and bottom of the Module mate with the slots in the I/O Rack. Use the Module pull handle to seat the two sets of board edge pins at the back of the Module into the two edge-connectors in the back wall of the I/O Rack.

Step 5 - Unlock the slide latches and push in the Terminal Raceway; ensure that the slots in the terminal block mate with the four pins extending from the left side of the Module board. Lock the Terminal Raceway in with the slide latches.

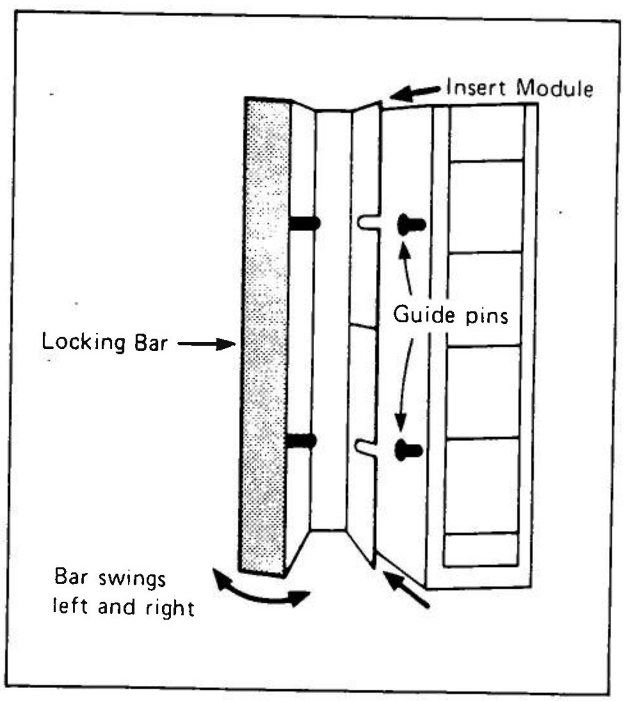

Figure 7 — Guide Slots

APPLICATION NOTES

1. The NL-742 A, B and E versions produce a 10-bit binary result which is placed in the low order 10 bits of an Input Register. The lowest voltage of the range will result in a zero count, the highest in a 1023 count; e.g., a 1-volt input results in a 0 count, a 5-volt input results in a 1023 count when using NL-742 E.
2. The NL-742 C and D versions produce a sign bit and 9 magnitude bits as a result of conversions. The 9-bit magnitude occupies the 9 low order bits in the Input Register. The sign bit (negative = 1) is located in the most significant location (bit 16) of the Input Register. A full-scale negative voltage produces a sign bit of 1 and a magnitude of 511. A full-scale positive voltage produces a sign of 0 and a magnitude of 511. A voltage of 0 produces a 0, but a voltage slightly less produces a −0 (0 magnitude and 1 sign bit).
3. All inputs have the same internal ground. Therefore, users cannot connect the inputs to circuits with different common mode voltages.
4. All inputs must have the voltages referenced to the Power Supply Common (0 V common mode). In addition, the Power Supply Common should be connected to earth.
5. Any channel on the Module can accept an analog current input if user-supplied resistors are added to convert the current input to a voltage. Select the correct resistance value from Table B. Install the resistor across the + Analog In and − Analog In terminals of the channel(s) to be converted (Figure 10). All resistors should be 0.1%, 1/2 watt precision types with low-temperature coefficient (less than ± 20 ppm).
6. The recommended power supply to be used with this module is POWER PAC, EPD7H-15-0V. This is a 0.75 A (60° C), ± 15 VDC (± 5% minimum adjustability), with overvoltage protection and a shielded transformer. This supply has foldback current limiting.

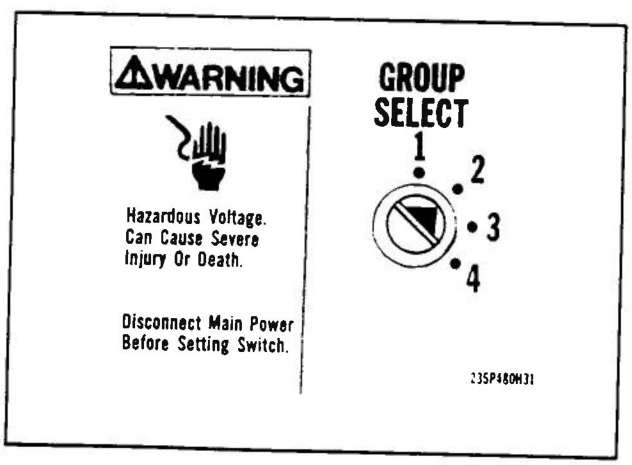

Figure 8 — Group Select Switch

Table B

CURRENT RANGE RESISTOR VALUES

For Current Range (mA)	Use Module	Add Resistor Value (ohms)	To Convert to VDC Range of
0 to 20	NL-742A	250	0 to 5
0 to 50	NL-742A	100	0 to 5
1 to 5	NL-742E	1000	1 to 5
4 to 20	NL-742E	250	1 to 5
10 to 50	NL-742E	100	1 to 5

7. A power-sense circuit is included on the board to detect dips in the + 15 or − 15 volt supply. Bit #15 will turn on (changes to 1) when power goes bad.
8. If any input exceeds ± 12 V from the Power Supply Common, invalid readings will occur on all channels contained on the Module. Software or hardware measures should be taken to prevent this from occurring.

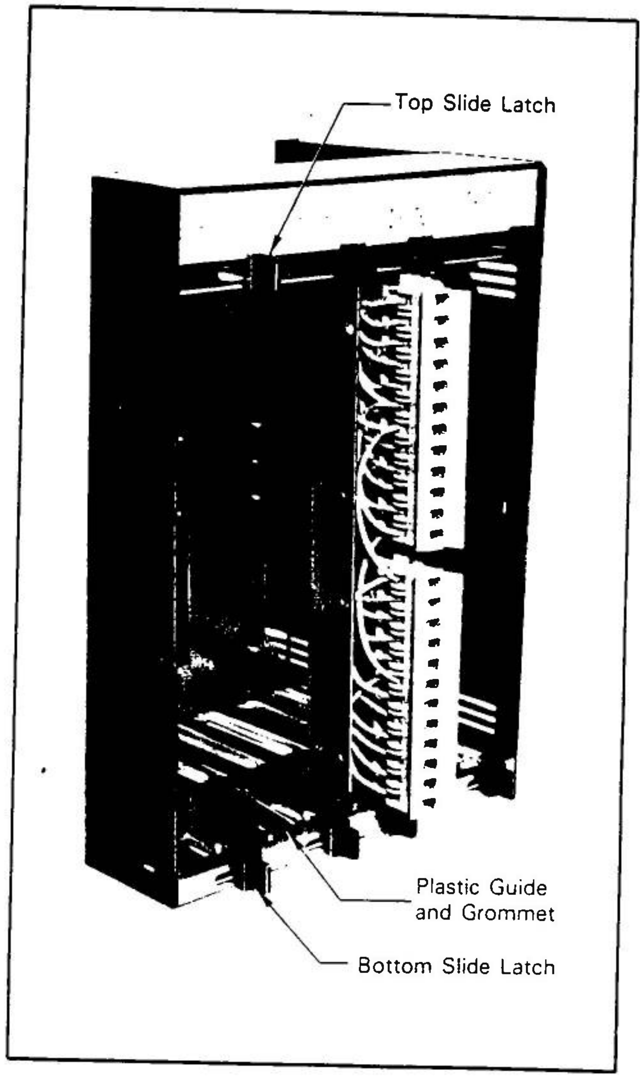

Figure 9 — Horizontal I/O Rack with Terminal Raceway in Extended Position

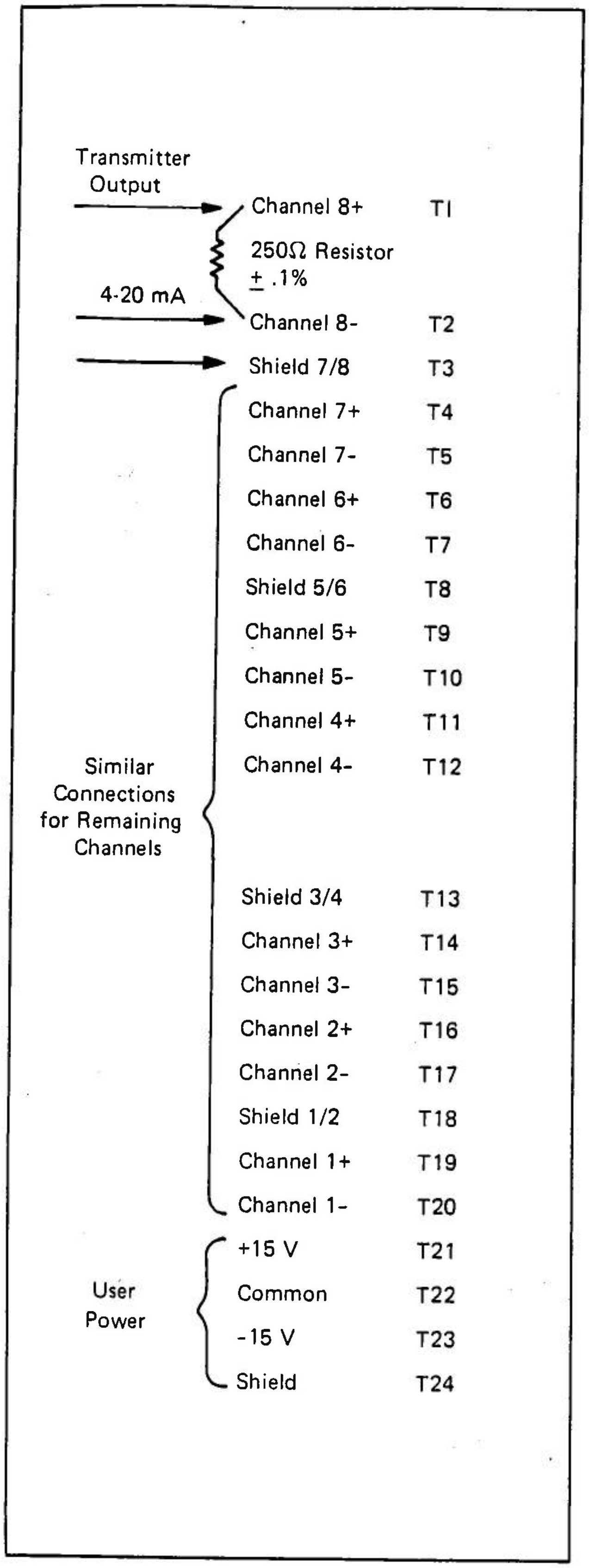

Figure 10 — Current Input Resistor Connections

9. The supply voltages should be set to +15.80 V and −15.80 V, respectively, to ensure proper operation.

10. Blocking diodes protect Module supply inputs from reverse wiring of supply voltages.

PROGRAMMING NOTES

1. If either an over- or under-range status condition is needed in a user program, use Input Register values 0000 and 1023 for unipolar inputs, or −511 or +511 for bipolar inputs, as under- and over-range signals, respectively. An input voltage above the full-scale rating for the Module results in a value of 1023 (unipolar) or +511 (bipolar), the identical value for a full-scale input. An input voltage of 0 VDC (unipolar) or −5VDC or -10VDC (bipolar), or less, results in an input register value of 0000 (unipolar) or −511 (bipolar).

2. The binary data from the A/D Input Module can be scaled by the user program via the special math functions. The resulting value will be a range of numbers from 0 to some number less than 1023. The following formula may be used to perform scaling:

$$\text{Scaled value} = \frac{\text{Input Register contents x desired full-scale number}}{1023}$$

Example: 0 to 10 VDC analog input originating from a 200.0 mm length gauge can be calibrated to indicate a range from 0 to 2000.0. (Here 0 VDC = 000.0 mm and 10 VDC = 200.0 mm.) Applying the formula, the user program would multiply the Input Register value by 2000 and then divide the result by 1023. The final value could be used directly by an output device such as a printer or LED display. It may also be used in the program itself.

3. System response time is, to a certain extent, a variable. (System response is defined as the amount of time required after a change of an input voltage's state at a field terminal, for a corresponding change of state within the Processor.) Since the A/D converter response time is faster than the Processor scan, the response time is limited by the Processor.

4. As a result of on-board malfunction detection circuitry, the Module can output a signal to the Processor that sets, to a Logic "1" (high), bit 15 of the Input Registers associated with the data channels. The setting of the malfunction bit creates an artificial value. This causes the Processor to operate incorrectly since the A/D input value will always be greater during a "greater than" comparison. To prevent this situation, the user program must be written to detect the setting of bit 15 and to initiate precautions in the program such as holding outputs ON or entering an emergency stop condition.

FUNCTIONAL THEORY

The Module contains 8 multiplexed channels fed into an A/D converter, along with associated storage output latches. Analog inputs are converted to binary numbers ranging from 0 to 1023 for unipolar inputs and −511 to +511 for bipolar inputs; the numbers are then stored in output latches. The Processor accesses the values in the latches during the I/O scan, thereby transferring the contents to the Input Registers assigned to the 8 channels of the Module. The Processor can then access the registers to perform further program functions.

Power Up — The logic of the Module is powered entirely by the +15.8 and −15.8 VDC external power supplies. Assuming that the external supplies and Processor are powered by the same AC source, the A/D conversion results will be available to the Processor when it completes its power-up cycle. (This assumes that the external supply voltages are operational within 750 ms, the nominal period with the recommended Westinghouse supplies.)

Power Down — When either a power-down failure or a power failure occurs, the following happens, in this order:

1. Bit #15 of all Input Registers assigned to the analog input channels will change from 0 to 1.
2. The values stored in the Input Registers assigned to the analog input channels will become invalid.
3. The Module will stop functioning.

Module Operation — Analog input voltages are converted to binary numbers ranging from 0 to 1023 or −511 to +511 at a 12.5 KHz rate. During the I/O scan, the Processor accesses the Input Register independently (that is, asynchronously) of the A/D converter's operation.

CIRCUIT DESCRIPTION

This description provides a quick overview of the Module's major circuit components and their functions. It is not necessary to read this information in order to install or use the unit.

The NL-742-H 8-channel analog to digital converter multiplexes from 2 to 8 input analog channels into a single A/D converter. All channels are differential and handle the same input voltage range. A conceptual diagram of the A/D converter is shown in Figure 11. Each block is briefly described here.

1. **Analog Input MUX** — All 8 channels enter the board at the receivers and pass through a passive filter and protection network before going to the Analog Input MUX. The MUX then selects one of the 8 channels according to the address that is applied to it.

2. **Analog Amplifiers** — The analog voltage that is selected by the MUX is buffered and passes to initial scaling and offset addition amplifiers. The initial scaling amplifier is programmed to have a particular gain, depending on the analog input voltage range used. In addition, the initial scaling amplifier acts as an active filter to remove high frequency noise. The analog voltage then passes to the offset addition amplifier, which is also programmed, depending on the analog input range.

3. **A/D Converter** — The A/D conversion is performed with a single chip which converts an input voltage to a binary value. The A/D conversion requires a total of 110 µs to complete the conversion and store the results in the RAM.

4. **Timing and Control** — The timing and control circuitry generates the signals needed for the analog-to-digital conversion process. The timing and control is based on a 125-KHz clock (for a 110 µs conversion rate) which allows generation of address signals to coordinate the operation of the analog input MUX, A/D converter, and RAM storage.

5. **Offset Binary to Signed Magnitude Converter** — The A/D chip produces a 10-bit absolute binary number (offset binary). When the Module is programmed for a unipolar mode, the binary number passes through without being altered. However, when programmed for a bipolar mode, the binary number is converted to a 9-bit magnitude and 1-sign bit.

6. **User Power Interface** — The user power interface produces the various voltage levels needed by the module and provides a user power O.K. signal for the Processor.

7. **Opto Isolators** — The opto isolators provide the electrical isolation between the field wiring and the Processor.

8. **Digital Power** — This produces the regulated +5 volts that is needed by the digital circuitry.

9. **RAM Storage** — The 10-bit binary values from the A/D conversions are stored in the first eight addresses of RAM. The RAM is dual-port, which allows the A/D converter logic to write into one data port and the Processor to

read from a second data port. The address bus, however, must be shared by the A/D and the Processor. When the Processor wants to read a value, it gets immediate priority of the RAM and the A/D is locked out. All the values generated by the A/D during this locked-out condition are thrown away. This is not a problem since the A/D is much faster than the Processor and is always able to have new data stored in RAM at the time of lockout.

10. **Bus Arbitration** – The bus arbitration logic controls the use of RAM by the A/D circuitry and the Processor. When the Processor is not attempting to read the RAM, a buffer is enabled, allowing the write and address signals from the A/D to be sent to the RAM. When the Processor is attempting to read the RAM, a buffer is enabled, which enables the address signals from the Processor.

11. **I/O Bus Interface** – This interface is used to place the binary values from the RAM onto the I/O data lines.

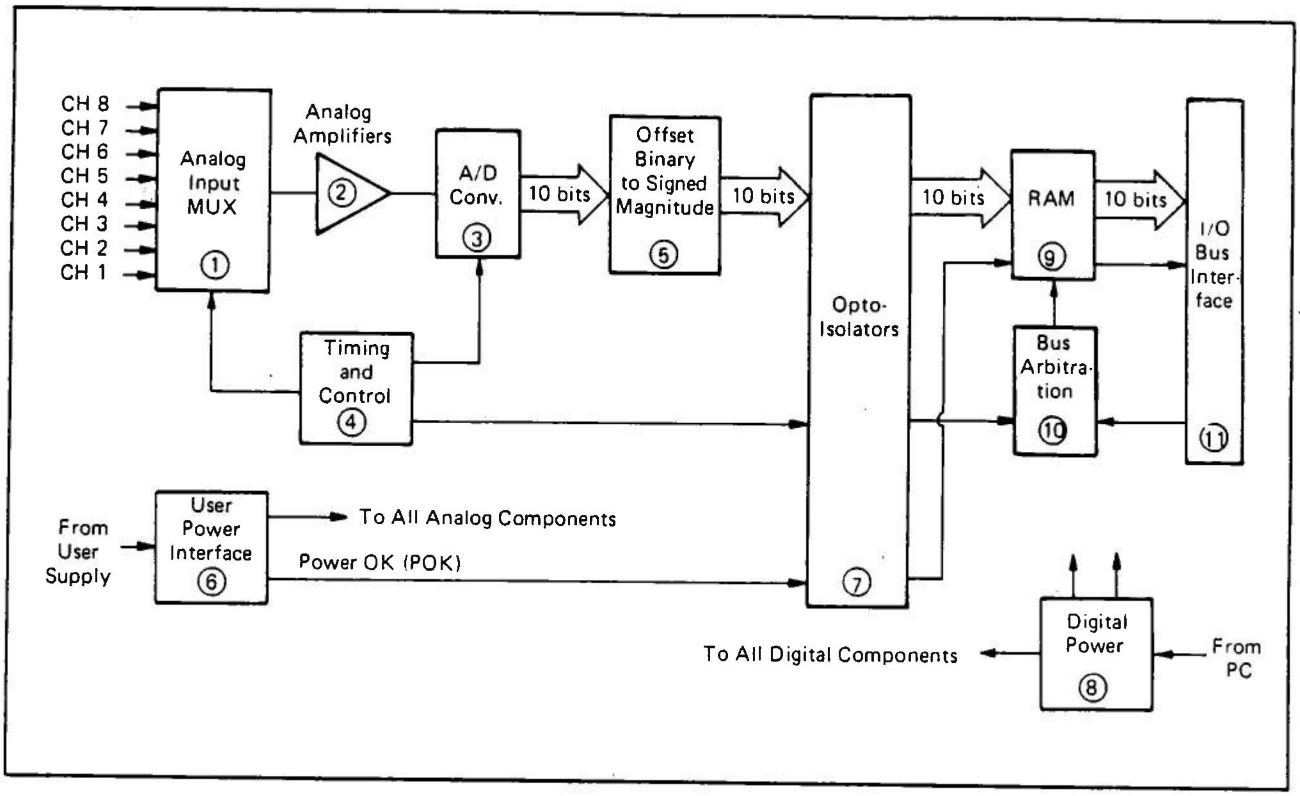

Figure 11 – NL-742-H Conceptual Block Diagram

Instruction Leaflet 15729
October, 1982

Westinghouse Electric Corporation
Industry Electronics Division
Madison Heights, Michigan 48071