



Westinghouse

numa-logic

4-CHANNEL DIGITAL-TO-ANALOG CONVERTER MODULE

(Voltage Output)

Catalog No. NL-751-H

PERFORMANCE DATA

Circuits Per Module	4
I/O Rack Positions	2 (Vertical Rack) 1 (Horizontal Rack)
Output Ranges	<ul style="list-style-type: none"> • 0 to 5 VDC • 0 to 10 VDC • -5 to +5 VDC • -10 to +10 VDC
Resolution	11 bits (10 bits + sign)
Differential Nonlinearity	$\pm 0.05\%$ of span
Thruput	500 μ s
Absolute Accuracy	$\pm 0.37\%$ at 0 to 60°C $\pm 0.15\%$ at 25°C
Zero Scale Error	± 2.5 mV (max)
Monotonicity	10 bits
Slewing Rate	0.05 V/ μ s
I/O Power Requirements:	
• Logic Supply	4 units
• Output Power Supply	1 unit
• External Supply Current	± 15.8 VDC @ 150 mA
Opto Isolation	1500 VDC (from Processor)
Temperature Rating	0° to 60°C
Humidity Rating	0 to 95% noncondensing
Zero Scale Symmetry	± 3.0 mV (max)
Full Range Bipolar Symmetry	0.03% of span (typ) 0.1% of span (max)
Output Loading	10 mA (max)

INTRODUCTION

The function of the Digital-to-Analog (D/A) Output Module is to convert four distinct binary numbers, received from four separate Processor output registers during the I/O scan, into four individual analog output voltages. Each analog output, referred to here as a "channel," is electrically isolated from the field connections; however,

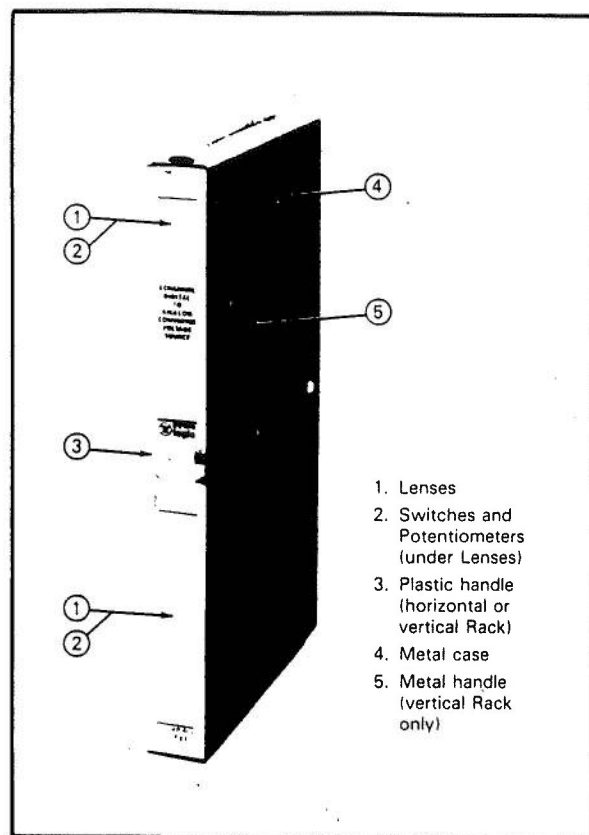


Figure 1 — 4-Channel Digital-to-Analog Output Module

each channel shares the same common, which is connected to the external power supply common. Addressing of the separate channels is determined by setting switch assemblies on the Module and on the I/O Rack.

One version of the NL-751 Module is available. The analog output voltage range for each channel can be set by a switch to either ± 5 V or ± 10 V.

The outputs vary in proportion to the binary input: the value range is from -1023 to $+1023$, and is produced by using 11 bits of a given output register (first 10 bits for magnitude; 16th bit for sign). Unipolar operation (0-5V, 0-10V) can be achieved by forcing the sign bit to the appropriate state. An additional feature allows the outputs to either go to zero or be held in their last state in the event of a Processor fault.

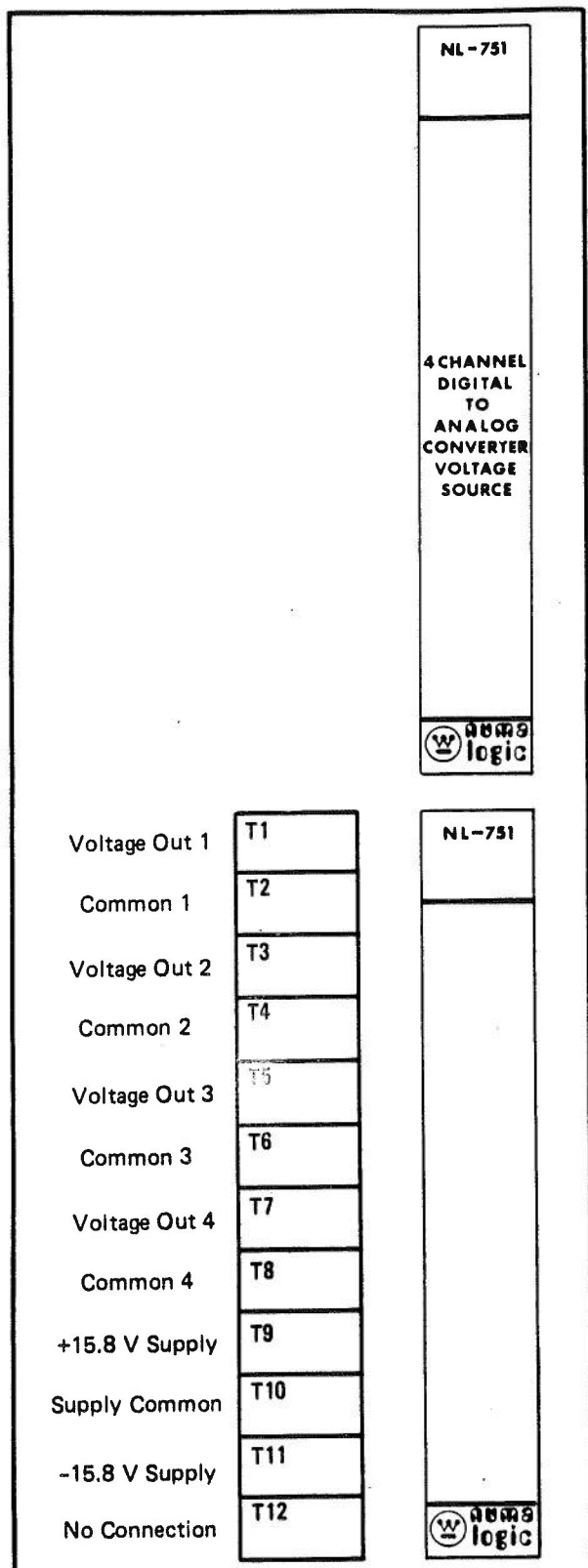


Figure 2 — Terminal Identification

The module is a double-height, single-width type. Field wiring to it is through terminals on the I/O Rack. Each channel is made up of two terminals:

- Voltage Output
- Common

An external ± 15.8 VDC power supply is required to operate the Module.

The Module includes two Lenses, converging adjustment switches and potentiometers. Only one of the Lenses is marked; another blank Lens may be substituted upon request. Optionally a custom Lens is available with user-specified JIC symbols.

Also supplied with the Module is a Terminal Identification Strip, which is to be filled in with wire numbers and applied to the I/O Rack next to the terminals. (See Figure 2.)

OUTPUT REGISTER SELECTION

The Module converts digital output register data to analog voltages. Select output registers per Table A, using the Register Selector Switch at the back of the Module (Figure 3) and the Group Select (GSEL) Switch on the horizontal or vertical I/O Rack (Figures 4 and 5). On a vertical Rack, set all unused TOP and BOT Switches to OFF.

VOLTAGE SELECTION

Each channel of the Module may be set independently to output either ± 5 V or ± 10 V by setting the selector switch under the top Lens of the Module (Figure 6). For each range, output register bits 0 to 10 (lower 10 bits) determine the magnitude of the output and bit 16 determines polarity (bit 16 = 1 = negative; bit 16 = 0 = positive).

NOTE

Unipolar operation (0-5V, 0-10V) is achieved by forcing bit 16 to off at all times.

All outputs are bipolar. An additional feature (switch 5) allows all four outputs to be held in their last states in the event of a Processor fault.

VOLTAGE ADJUSTMENT

The Module is factory set and adjusted in the 10V position on all channels. If a selector switch is changed, a gain adjustment may be required. Check as follows, using a Fluke 8050A, 4 1/2-digit multimeter (or equivalent):

Step 1. Set the output register value for the channel to 1023.

Step 2. Connect the multimeter to the appropriate output terminals (Figure 2). Check that output voltage conforms to Table B.

Table A

NL-751-H OUTPUT REGISTER SELECTION

Module Switches (Figure 3)				I/O Rack Group Select (GSEL) Switches (Figure 4 or 5)															
				Group 1				Group 2				Group 3				Group 4			
1	2	3	4	CH 1	CH 2	CH 3	CH 4	CH 1	CH 2	CH 3	CH 4	CH 1	CH 2	CH 3	CH 4	CH 1	CH 2	CH 3	CH 4
OFF	OFF	ON	OFF	1	2	3	4	9	10	11	12	17	18	19	20	25	26	27	28
OFF	OFF	OFF	ON	1	2	5	6	9	10	13	14	17	18	21	22	25	26	29	30
OFF	OFF	ON	ON	1	2	7	8	9	10	15	16	17	18	23	24	25	26	31	32
ON	OFF	OFF	OFF	3	4	1	2	11	12	9	10	19	20	17	18	27	28	25	26
ON	OFF	OFF	ON	3	4	5	6	11	12	13	14	19	20	21	22	27	28	29	30
ON	OFF	ON	ON	3	4	7	8	11	12	15	16	19	20	23	24	27	28	31	32
OFF	ON	OFF	OFF	5	6	1	2	13	14	9	10	21	22	17	18	29	30	25	26
OFF	ON	ON	OFF	5	6	3	4	13	14	11	12	21	22	19	20	29	30	27	28
OFF	ON	ON	ON	5	6	7	8	13	14	15	16	21	22	23	24	29	30	31	32
ON	ON	OFF	OFF	7	8	1	2	15	16	9	10	23	24	17	18	31	32	25	26
ON	ON	ON	OFF	7	8	3	4	15	16	11	12	23	24	19	20	31	32	27	28
ON	ON	OFF	ON	7	8	5	6	15	16	13	14	23	24	21	22	31	32	29	30
ON	OFF	OFF	OFF	3	4	1	2	11	12	9	10	19	20	17	18	27	28	25	26
OFF	ON	OFF	OFF	5	6	1	2	13	14	9	10	21	22	17	18	29	30	25	26
ON	ON	OFF	OFF	7	8	1	2	15	16	9	10	23	24	17	18	31	32	25	26
OFF	OFF	ON	OFF	1	2	3	4	9	10	11	12	17	18	19	20	25	26	27	28
OFF	ON	ON	OFF	5	6	3	4	13	14	11	12	21	22	19	20	29	30	27	28
ON	ON	ON	OFF	7	8	3	4	15	16	11	12	23	24	19	20	31	32	27	28
OFF	OFF	OFF	ON	1	2	5	6	9	10	13	14	17	18	21	22	25	26	29	30
ON	OFF	OFF	ON	3	4	5	6	11	12	13	14	19	20	21	22	27	28	29	30
ON	ON	OFF	ON	7	8	6	6	15	16	13	14	23	24	21	22	31	32	29	30
OFF	OFF	ON	ON	1	2	7	8	9	10	15	16	17	18	23	24	25	26	31	32
ON	OFF	ON	ON	3	4	7	8	11	12	15	16	19	20	23	24	27	28	31	32
OFF	ON	ON	ON	5	6	7	8	13	14	15	16	21	22	23	24	29	30	31	32

Do not set Module Switches such that the same registers are selected for different channels. For example, if all four of the Module Switches were set to OFF, then register 1 would be assigned to both Channels 1 and 3, and register 2 would be assigned to both Channels 2 and 4 --- an invalid arrangement.

Table B

OUTPUT VOLTAGE

Channel Range	Specification
5V	4.995V
10V	9.990V

Step 3. If the output voltage is out of spec, remove the Lens covering the channel's gain potentiometer (Figure 6).

Step 4. Adjust the voltage output per Table B.

Step 5. Lock the potentiometer in place with Glyptol (or equivalent) to minimize vibration drift.

WIRING AND SHIELDING

Figures 7 through 10 show wiring connections to the NL-751-H Module. Normally, shielding is tied to ground at the cable end away from the Module as shown in Figures 7 and 8. If this is not possible, use the alternate wiring schemes in Figures 9 and 10. Module terminals are shown in Figure 2; the lower terminal block is used for Module wiring.

CAUTION

All output commons are connected together internally. Therefore, users **cannot** connect output circuits to different common mode potentials without damage.

INSTALLATION — VERTICAL RACK

Physical Placement — Remove the I/O Rack terminal block adjacent to the top half of the Module (Figure 11). Connect all field wiring to the I/O Rack's terminals adjacent to the lower half of the Module. Follow the typical connection diagrams in Figures 7 through 10. 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 — Screw the metal pull handle onto the side of the Module. If desired, the plastic pull handle may also be installed between the Module Lenses. Fix the color-coded adhesive label to the front of the plastic pull handle (See Figure 1.)

Step 2 — Refer to system drawings and determine in which I/O Rack and in which Position in the Rack the Module is to be placed. (Although a Module can be placed in either the upper two Positions or the lower two Positions, it may not straddle Positions B and C. (See Figure 5.)

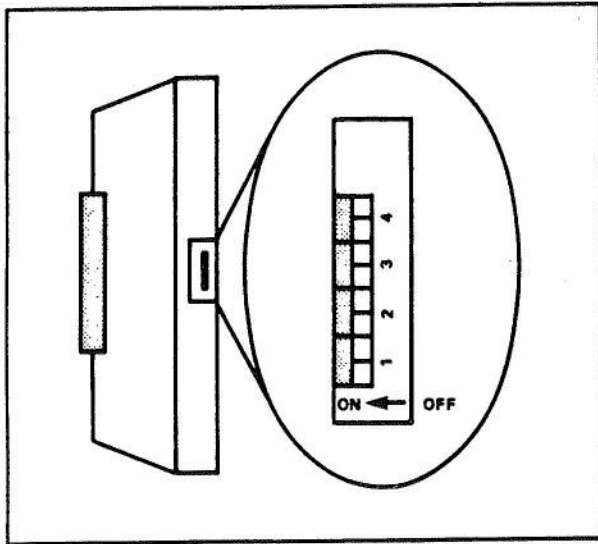


Figure 3 — Module's Register Selector Switch

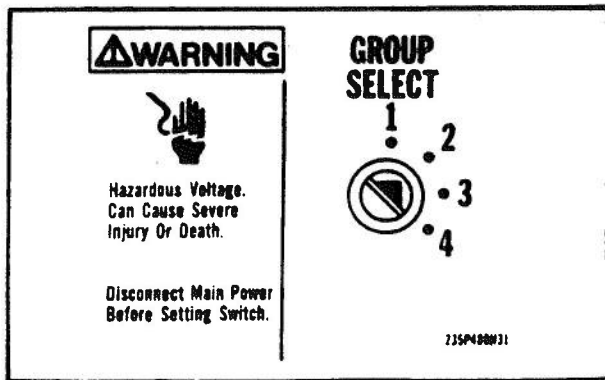


Figure 4 — Horizontal I/O Rack Group Select Switch

Step 3 — Set the output registers and voltage ranges per system drawings and the procedures described previously in Output Register Selection and Voltage Selection.

Step 4 — Move the appropriate Locking Bars on the I/O Rack's built-in terminal blocks to the left in order to uncover the guide slots on the blocks. (See Figures 5 and 12).

Step 5 — 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 6 — When the Module is properly seated, snap the Rack's Locking Bars over the Module's guide pins in order to hold it in place.

Step 7 — Apply the self-adhesive Terminal Identification Strips, supplied with the Module, to the terminal block's face.

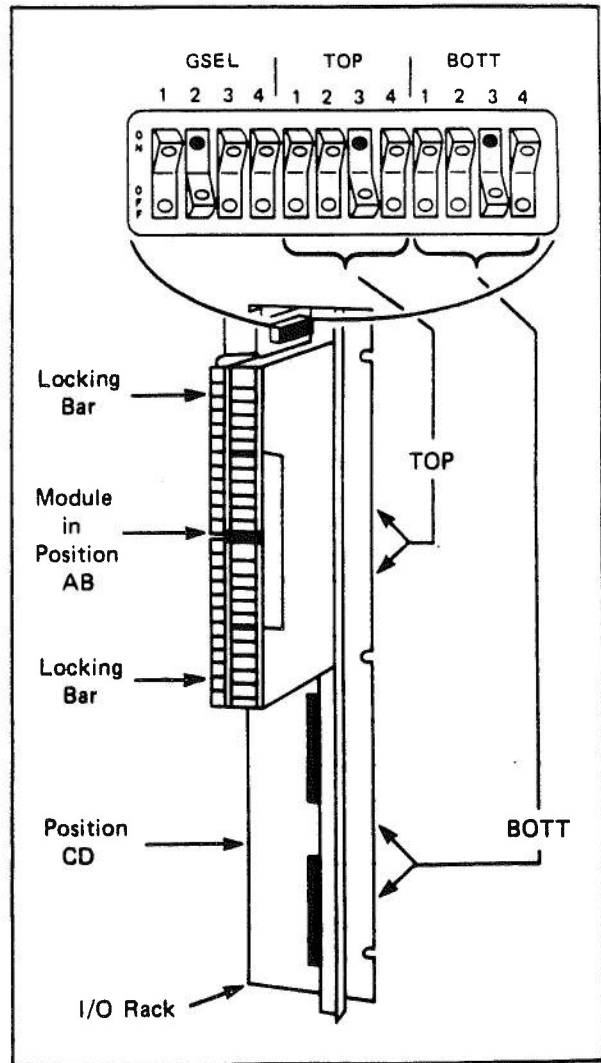


Figure 5 — Vertical I/O Rack Switches

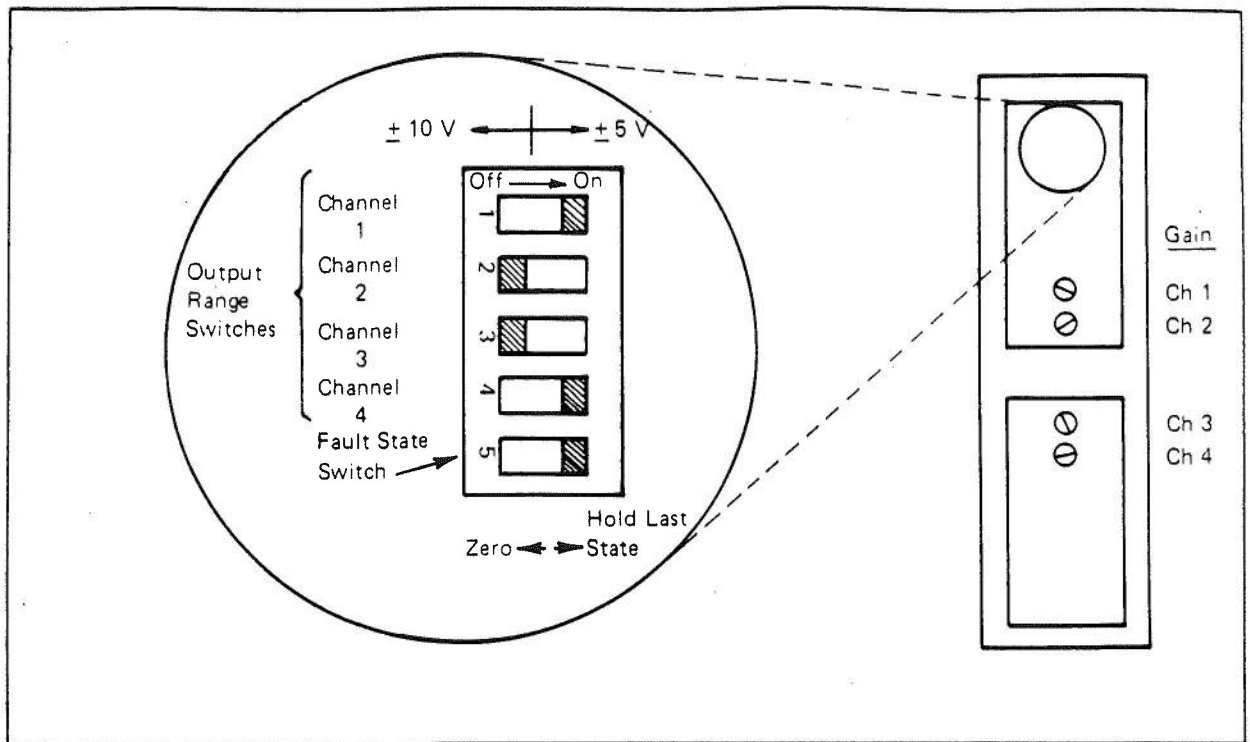


Figure 6 — Voltage Range Selector Switch and Gain Adjustments

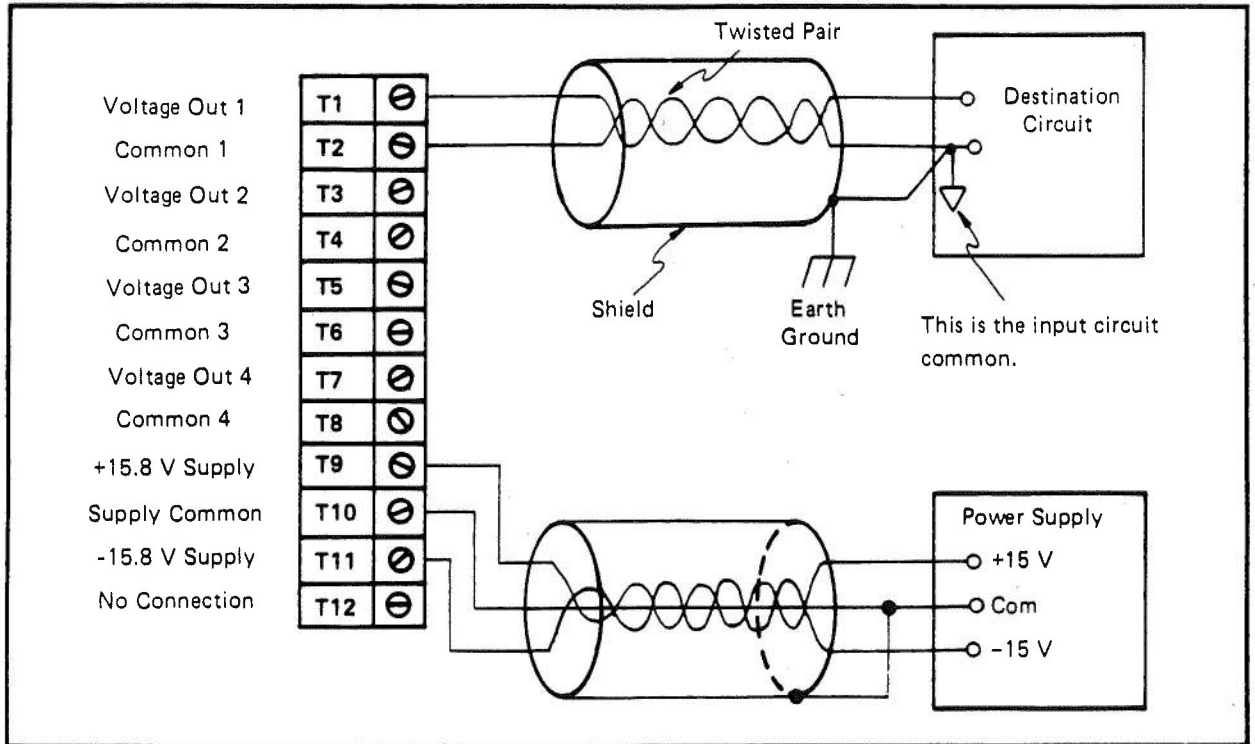


Figure 7 — Suggested Shield Wiring (Load Common Connected to Earth)

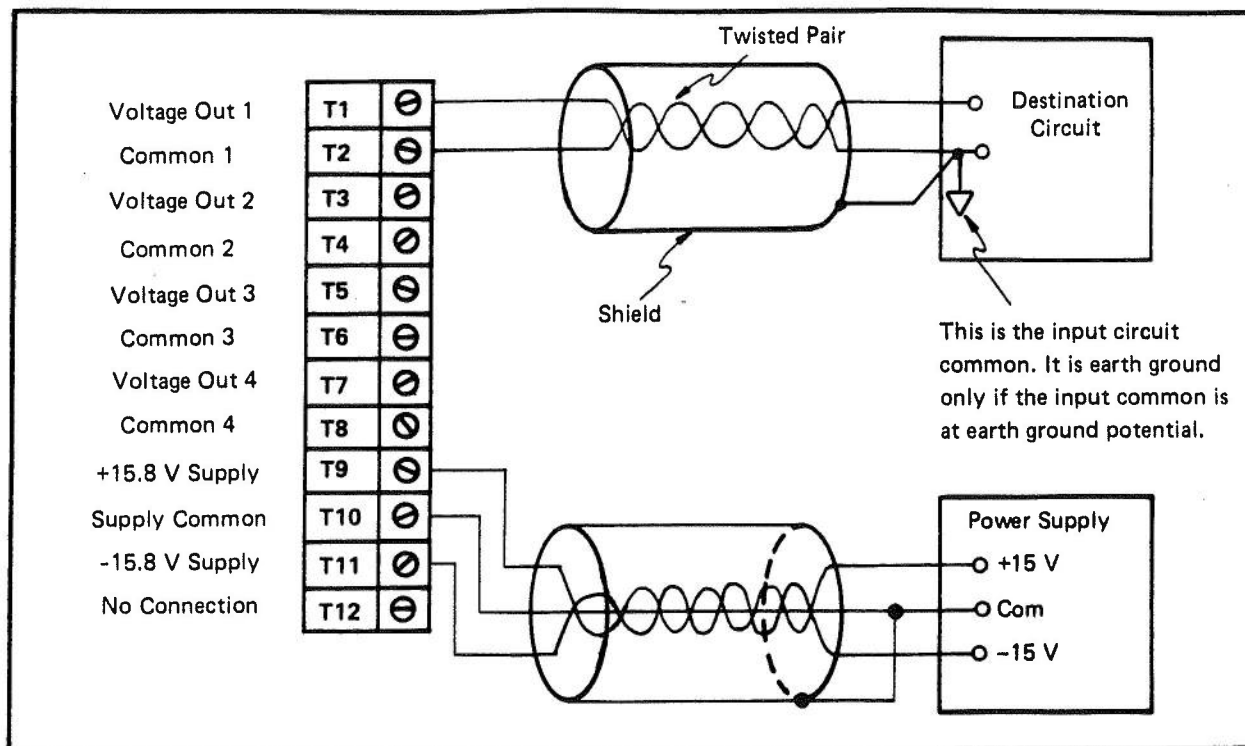


Figure 8 — Suggested Shield Wiring (Load Common Isolated from Earth)

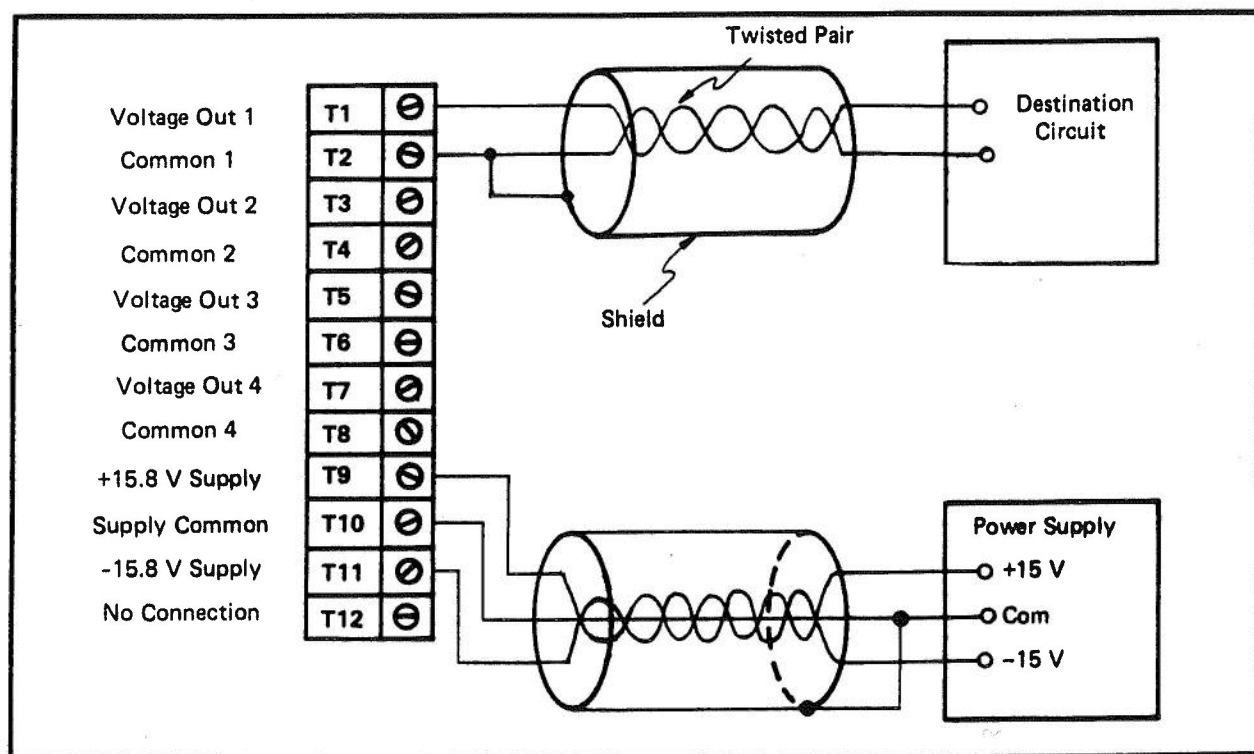


Figure 9 — Alternate Wiring (Isolated System)

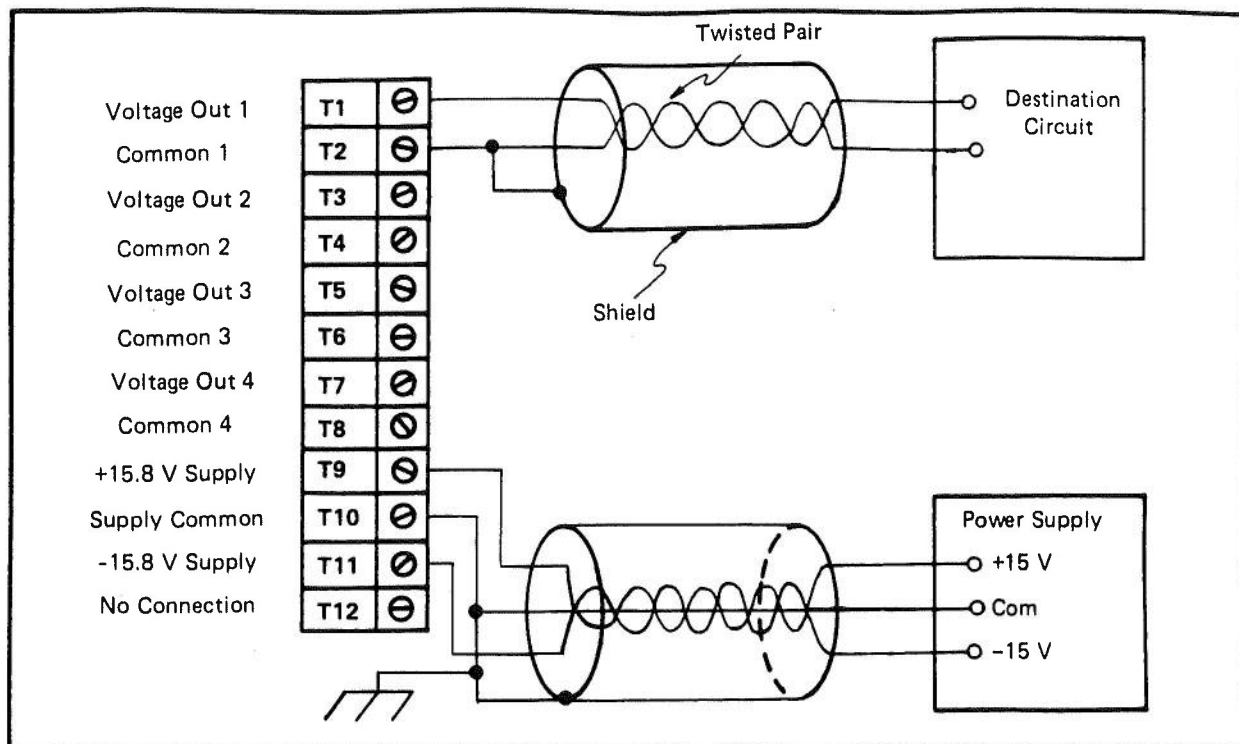


Figure 10 — Alternate Wiring (Earthed)

Step 8 — 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-700/900 Systems Manual.

INSTALLATION — HORIZONTAL RACK

Physical Placement — Remove the Terminal Raceway from the I/O Rack (Figure 13). Loosen the two screws and remove the top terminal block from the Terminal Raceway (Figure 11). Connect all field wiring to the bottom terminal block. Follow the typical connection diagrams in Figures 7 through 10. Installing the Module is a simple process: slide it into one of the four or eight Positions on an I/O Rack. To do so, follow these steps:

Step 1 — Slide the plastic pull handle into the slot between the Lenses on the front of the Module. Fix the color-coded adhesive label to the front of the plastic pull handle. (Do not install the metal pull handle — it is designed for use with the Vertical I/O Rack only.) See Figure 1.

Step 2 — Refer to system drawings and determine in which I/O Rack the Module is to be installed.

Step 3 — Set the output registers and voltage ranges per system drawings and the procedures described previously in Output Register Selection and Voltage Selection.

Step 4 — Pull the Terminal Raceway for the appropriate I/O Rack module slot forward until it stops; lock the Raceway in the extended position (Figure 13) using the top and bottom slide latches.

Step 5 — 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 6 — Unlock the slide latches and push in the Terminal Raceway; ensure that the slots in the terminal block mate with the pins extending from the left side of the Module board. Lock the Terminal Raceway in with the slide latches.

APPLICATION NOTES

1. Maximum output voltages are adjusted to 4.995V for the 5V range; 9.990V for the 10V range (Table B).
2. An output register value of 1023 corresponds to the maximum voltage output. Any value larger than 1023 (excluding bit 16) will produce a full output.
3. Since the polarity control is signi magnitude, two values exist for zero (+0.000 and -0.000).

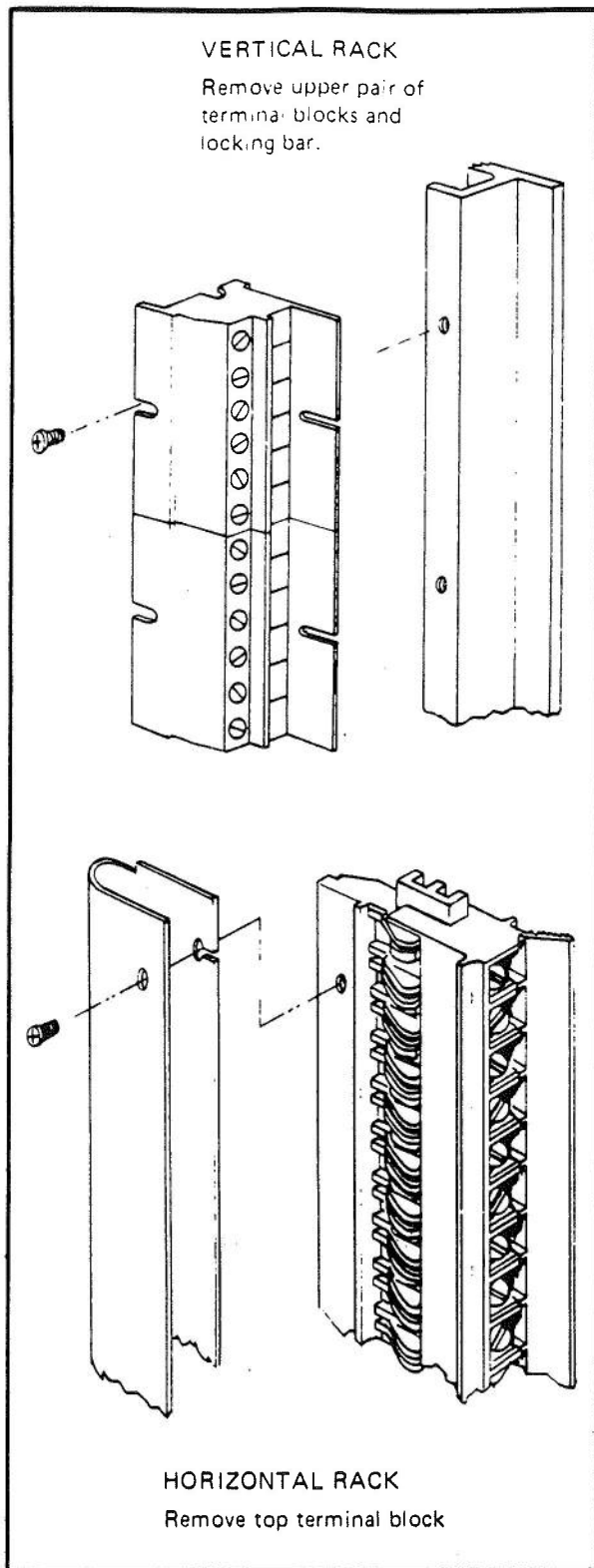


Figure 11 — Terminal Block Removal

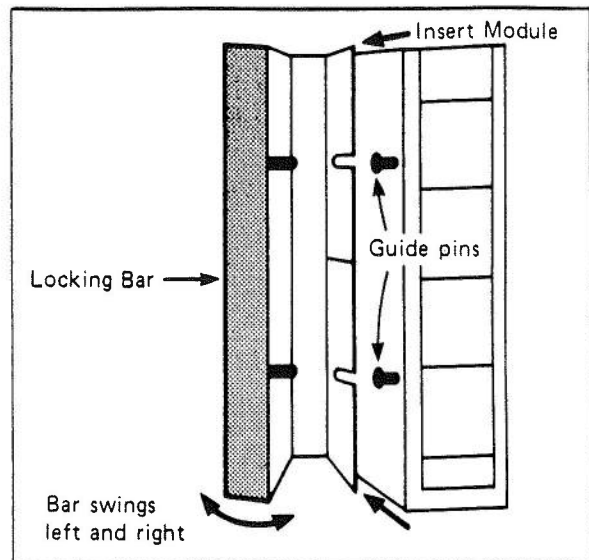


Figure 12 — Vertical Rack Guide Slots

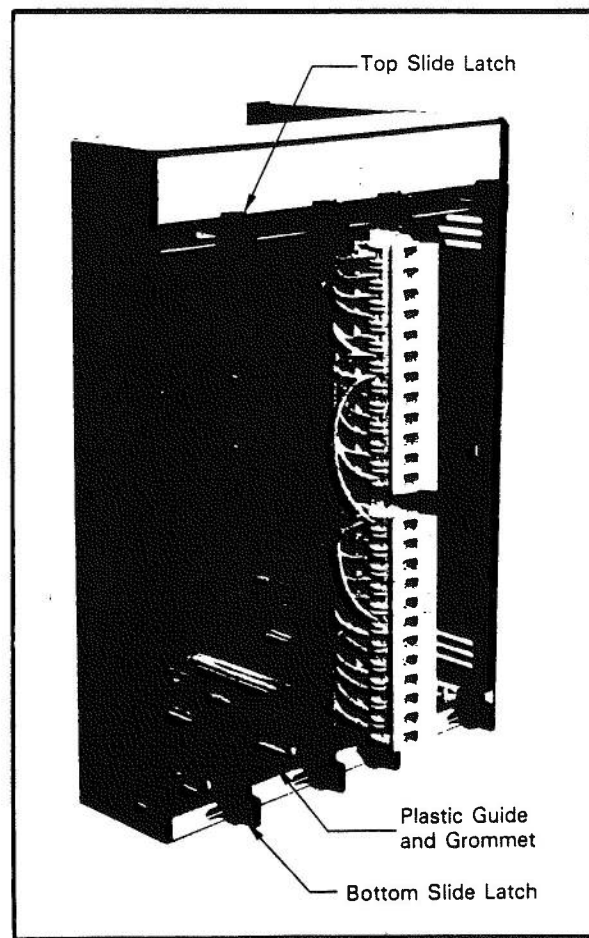


Figure 13 — Horizontal Rack with Terminal Raceway in Extended Position

4. All the output commons are internally connected together. Therefore, users cannot connect output circuits to different common mode potentials without damage. Any applications requiring this ability can use two different NL-751 Modules or else one NL-750 Module, which has isolation between channels.

5. The recommended power supply to be used with this module is POWER PAC, #EPD 7H-15-0V. This supply is rated at 0.75A (60°C), $\pm 15\text{VDC}$ ($\pm 5\%$ minimum adjustability), with overvoltage protection and a shielded transformer. It also has foldback current limiting.

6. The Processor and the power supply for the Module should be connected to the same power source so that they power-up simultaneously.

7. A reset circuit on the Module ensures that the output is zeroed on power-up. However, for a brief period on power-up and power-down, the output voltage may change to a nonzero value when the supply voltages are too low for the proper operation of the CMOS and analog circuitry on the Module. Therefore, from a systems viewpoint, power should first be applied to the Processor and the external supply and then to the field devices.

8. The supply voltages should be set to $+15.80\text{V}$ and -15.80V , respectively, to ensure proper operation.

9. Blocking diodes are used to protect Module supply inputs from reverse wiring of supply voltages.

10. Voltage outputs can be shorted to common indefinitely without damage.

11. Output register values of $+1023$ and -1023 will not differ in voltage values by more than 0.1% (maximum error).

PROGRAMMING NOTES

1. Each channel of the Module uses the first 10 bits and bit 16 of its assigned output register (OR) to produce the desired analog voltage output (bit 16 determines the sign). The lowest possible number contained in the 10 bits is 0; the highest is 1023. Any assigned output register whose contents are greater than 1023 (excluding the sign bit) will produce the high end of the Module's output range (either 5V or 10V).

2. Zero corresponds to the **lowest** output from each channel; 1023 corresponds to the highest voltage.

3. Each of the four channels of a Module must be assigned to different output registers (channels 1 and 3, or 2 and 4, cannot be assigned the same output register). The output registers used by a Module must also be in the same output register groups. If a "twin-output" arrangement is required, use the following technique: Use the move instruction to "copy" the contents of the output register (with the reference number that cannot be used twice) to a second output register. Both registers will then contain the same data, and channel outputs can be identical.

4. The output of each channel of the Module depends on the value it receives from its assigned output register (OR). If the Processor loses its AC power, the value present in the OR is saved. However, if the external supply for the Module is wired to the same AC source as the Processor, Module output will go to zero. If the external supply is on a separate AC supply (different from the Processor supply), the Module's Fault State Switch settings (Figure 6) determine the output state: the Module will maintain its outputs at the value present when the Processor loses power if the switch is set to ON; the outputs will go to zero if the switch is OFF. The last state/zero state settings also apply in the event of a Processor fault.

5. Binary data from the Processor can easily be scaled to provide full-scale use of an output channel. Use the following formula:

$$\text{scaled value} = \frac{\text{value to scale}}{\text{maximum value}} \times 1023$$

Where:

value to scale = binary value to be scaled: from an input or holding register

maximum value = maximum binary value of the "value to scale"

Example — A voltage output is needed in proportion to an input from an RPM transducer. The RPM transducer is available in BCD form, varying from 0 to 2000 RPM. To provide an output varying from 0 to 5V in direct proportion to the RPM input, perform the following:

- Convert the BCD value to binary and store it in holding register "A".
- Divide the contents of holding register "A" by 2000 and store in holding register "B".
- Multiply holding register "B" by 1023. This gives the scaled value. Store the result in the output register which the specified D/A channel is set to read. The value will be converted to a voltage which is proportional to the input RPM.

FUNCTIONAL THEORY

The Module contains four separate D/A converters, which are all referenced to the same DC common return. The four channels are not isolated from each other, and cannot be connected to loads which are not referenced to the same DC common or ground. Each channel is electrically isolated from the Processor. Numbers varying from 0 to 1023 (stored in specified output registers) are converted to binary numbers by the Processor and sent one at a time to the Module. The single value is stored in a latch and serially shifted to its corresponding D/A converter on the Module. The D/A converter output is an analog voltage which is directly proportional to the binary value that was input from the output register. Use of the 16th bit provides polarity: if bit 16 is set to 1, output is negative; if set to 0, output is positive.

NOTE

The output registers assigned to the NL-751 Module must be from the same output register group. Also, no two channels on the Module can be assigned to the same output register.

Power-Up — A reset circuit on the module ensures that the outputs are zeroed on power-up. However, for a brief period on power-up and power-down, the output voltage may change to a nonzero value when the supply voltages are too low for the CMOS and analog circuitry on the module to operate properly. Therefore, from a systems viewpoint, power should be applied first to the Processor and the Module's external supply and then to the field devices.

Power-Down — A reset circuit on the Module ensures that the outputs are zeroed on power-down. However, for a brief period on power-up and power-down, the output voltage may change to a nonzero value when the supply voltages are too low for the CMOS and analog circuitry on the Module to operate properly. If the Module voltage is supplied from a different AC source than the Processor and the Processor powers-down or goes into fault, the zero state/last state switch will determine what the outputs on the Module will do.

Module Operation — The Module reads its assigned output registers one at a time. The value in the output register may be any number from 0 to 1023 in binary form. This number is loaded into a 16-bit parallel-to-serial shift register, which shifts the binary number one bit at a time through an opto coupler to its appropriate D/A converter. If the number is greater than 1023 (excluding sign bit 16) there is an overrange circuit which will set the D/A to its full output voltage.

The D/A converts the binary number to a voltage directly proportional to the binary number within 500 μ s and sends it to a voltage control circuit which will send it to the load that the board is connected to.

This is done for each of the remaining three outputs. When the value of the Processor's output register changes, the associated D/A channel output increases or decreases from its current value without resetting to zero.

CIRCUIT DESCRIPTION

The following is a quick overview of the Module's major circuit components and their functions. It is not necessary to read this information to install or use the unit.

The Module supports four separate D/A channels which share an internal DC common. These four outputs must all be referenced to the same DC common or damage to the board will result.

Each channel converts a separate output register 10-bit binary (plus sign) number into an analog voltage. A conceptual block diagram of the D/A converter is shown in Figure 14. Each block is briefly described here.

1. Voltage Supplies — The Module uses the +12VDC and +VLED voltages supplied by the Processor to run its Processor bus-side logic up to the opto couplers. The external ± 15.8 VDC supply runs the D/A side and all output circuitry.

2. Parallel-to-Serial Shift Register — Receives binary data and serially shifts it to the proper D/A Module.

3. System Clock — Provides all timing signals for the Module.

4. Opto Couplers — Transfer and electrically isolate the Processor side signals from the analog-side signals.

5. Overrange Circuit — If bits 11, 12, 13, 14, or 15 are set to 1, the overrange circuit detects this and the D/A Module is set to full output voltage.

6. Zero State/Last State — This switch-selectable circuit will either set the outputs to zero or lock them at their last output.

7. D/A Converters — Each 10-bit binary number is serially loaded in conjunction with the start conversion signal from the decode logic. The D/A converts the number to an analog voltage and outputs it to the voltage amplifier.

8. Voltage Reference — A precision 5-volt reference for the D/A converter.

9. Voltage Amplifier — Circuitry to regulate output voltage to the load.

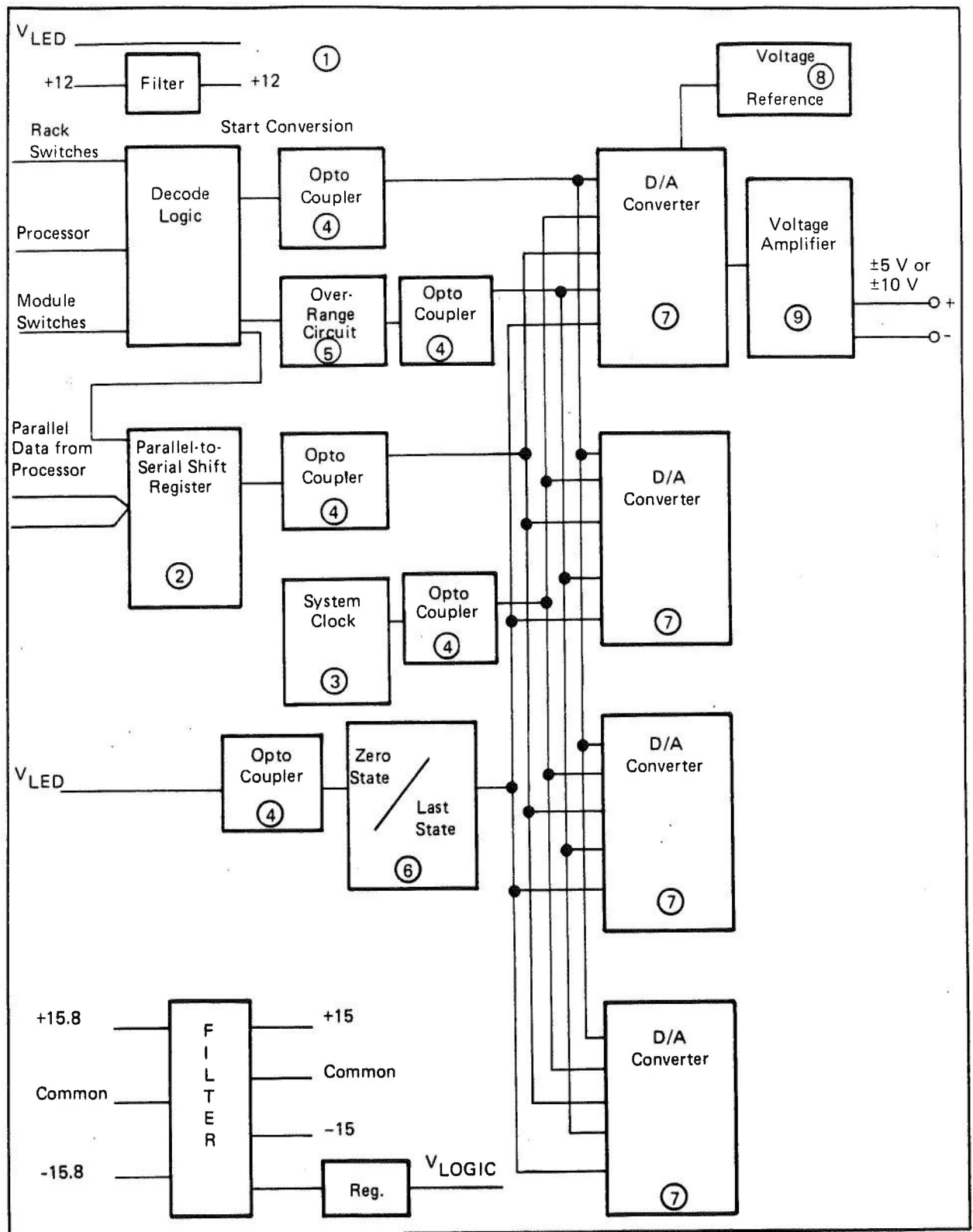


Figure 14 — D/A Module Conceptual Block Diagram

Instruction Leaflet 15726
December, 1982

Westinghouse Electric Corporation
Industry Electronics Division
Madison Heights, Michigan 48071