Westinghouse

numa·logic

DIGITAL-to-ANALOG OUTPUT MODULE

Catalog No. NL-750

PERFORMANCE DATA

Circuits per Module	2 uni-polar
I/O Rack Positions Req'd.	2
Output Ranges ①	• 0 to 5 VDC 4 to 20 mA • 0 to 10 VDC 4 to 20 mA • 0 to 10 VDC 10 to 50 mA
Resolution	1 part in 4096
Differential Linearity	±0.012% of full-scale reading
Input from Processor	12 bits (binary value)
Thruput	1.1 ms delay (excluding scan time)
Absolute Accuracy ②	±0.4% of span (current output) ±0.25% of span (voltage output)
Temperature Coefficient	• 40 ppm of span/°C (current output) (typical) • 10 ppm of span/°C (voltage output) (typical)
Output Loading Current: Voltage:	 600 ohms (max.) 5 mA (max.)
I/O Power Requirements: • Logic Supply	 NL-750A 180 units (typ.) 240 units (max.) NL-750B 190 units (typ.) 250 units (max.) NL-750C 290 units (typ.) 350 units (max.)
• Output Power Supply	0.5 units (min./max.)
Opto Isolation	2500 V (for Processor)
Temperature Rating	0° to 60°C 32° to 140°F

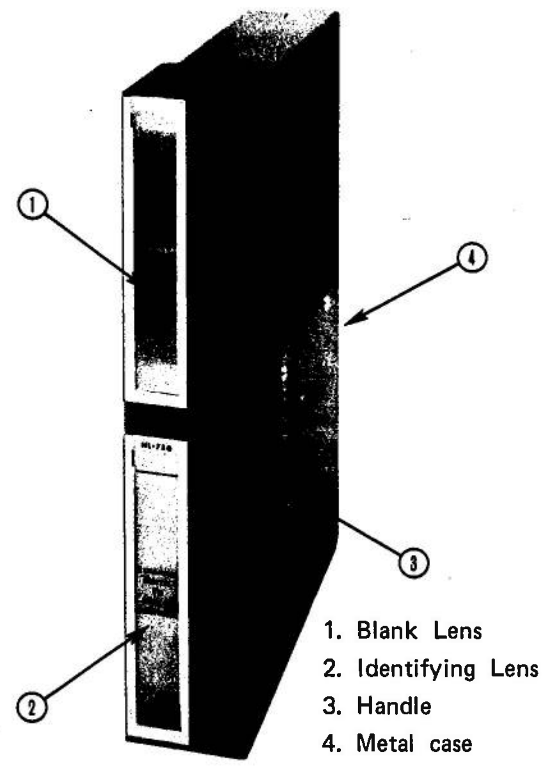


Figure 1 — Digital-to-Analog Output Module

INTRODUCTION

The function of the Digital-to-Analog (D/A) Output Module is to convert 2 distinct binary numbers, received from two separate Processor output registers during the

Humidity Rating	0 to 95% noncondensing
Keying Slots NL-750A, B, C	Between pins: 11 and 13 21 and 23

① Separate current and voltage terminals

② Includes temperature, gain and offset errors

I/O scan, into 2 individual analog output voltages or currents. Each analog output, referred to here as a "channel," is electrically isolated from the field connections.

Addressing of the separate channels is determined by settings on 2 switch assemblies located on both the Module and the I/O Rack.

Three versions of the Catalog No. NL-750 Module are available. They are distinguished by the analog output voltage and current range each outputs. (See Table A.) These outputs vary in proportion to the binary input: the value range is from 0 to 4095 and is produced by using 12 bits of a given output register.

The Module is a double-height, double-width type. Field wiring to it is through terminals on the I/O Rack. Each channel is made up of 2 groupings of terminals:

- Current outputs
- Voltage outputs

Voltage and current outputs can be used simultaneously, if desired. An external power supply is not required.

The Module includes 2 Lenses; the upper is blank, the lower identifies the Module.

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.)

Channel	Group	Function	Terminal
Top channel		Do not use.	T1
	Current outputs	Low-voltage return (−15 VDC)	T2
	Current outputs	Current source output	T3
	Current outputs	High-voltage return (−50 VDC)	T4
	Voltage outputs	+Voltage output	T5
	Voltage outputs	DC COM (0 VDC)	T6
Bottom channel	Current outputs	Low-voltage return (−15 VDC)	T7
	Current outputs	Current source output	T8
	Current outputs	High-voltage return (−50 VDC)	T9
	Voltage outputs	+Voltage output	T10
	Voltage outputs	DC COM (0 VDC)	T11
		Do not use.	T12

Figure 2 – Terminal Identification

Table A

MODULE VERSIONS

Catalog No.	Output Voltage (VDC)	Output Current (mA)
NL-750A	0 to 5	4 to 20
NL-750B	0 to 10	4 to 20
NL-750C	0 to 10	10 to 50

INSTALLATION

Physical Placement – Refer to the system drawings and determine the exact I/O Rack Positions in which the Module will be placed. (See Figure 5 for an explanation of "position.") Use a screwdriver to remove the terminal block adjacent to the top half of the Module to allow for its width. (See Figure 3.) Field wiring connects only to the lower terminals. Follow system wiring diagrams and carefully observe the type of conductor specified. A typical connection diagram is shown in Figure 4.

CAUTION

Gain and offset adjustments for this Module are not user accessible and should not be adjusted. Attempting to modify the factory settings can cause damage which can result in improper Module operation.

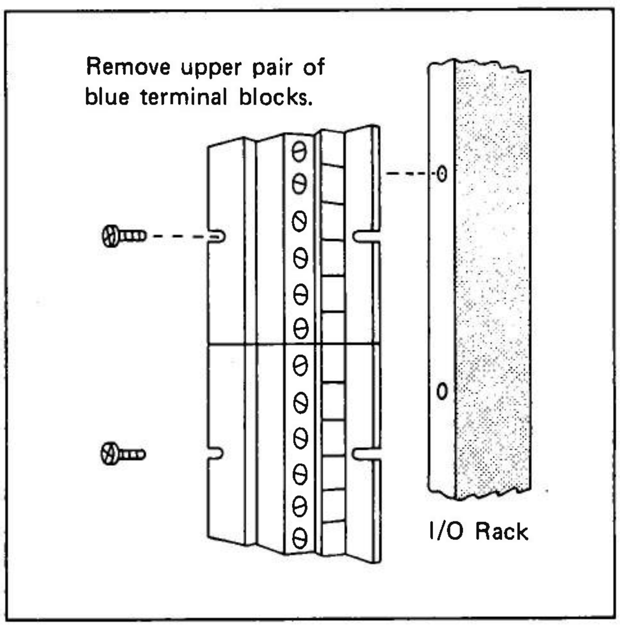
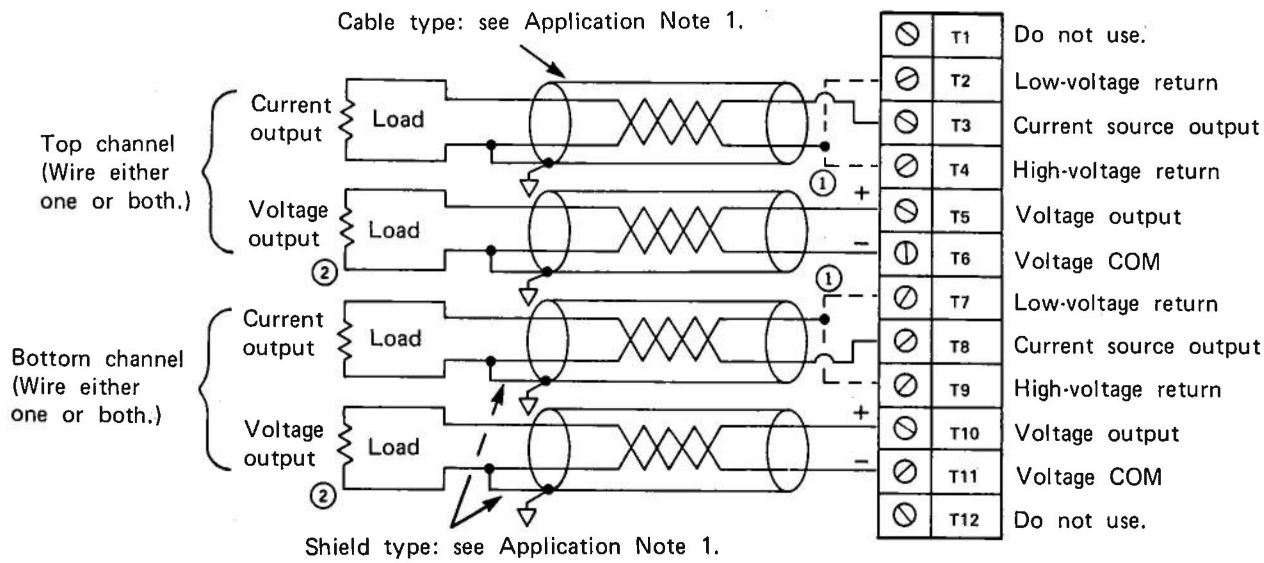


Figure 3 – Terminal Block Removal

Installing the Module is a simple process: slide it into 2 of 4 Positions on an I/O Rack. To do so, follow these steps:



(1) Current COM wires to terminal:

- T2/T7 low-voltage return for loads below 600 ohms (4 to 20 mA range)
- T4/T9 high-voltage return for loads below 600 ohms (10 to 50 mA range) or loads between 600 and 1500 ohms (4 to 20 mA range)

(2) Load must be greater than 2K ohms when used with the voltage outputs

Figure 4 – Connection Diagram (typical)

Step 1 – Place the Module in the selected Position. Although a Module can be placed in either the upper 2 Positions or the lower 2 Positions, it may not straddle Positions B and C. See Figure 5. Also, it is important that it be placed according to the user program Reference Number scheme.

Step 2 – Move the Locking Bar on the I/O Rack's built-in terminal block to the left in order to uncover the guide slots on the block. (See Figure 6.)

Step 3 – Align both of the Module's guide pins with corresponding slots on the I/O Rack. Gently press the Module into the edge connector on the Rack. Make sure the edge pins on the Module align and mate with the Rack connector. (Note: thumbwheel switches located at the rear of the Module will be set in a subsequent step.)

Step 4 – When the Module is properly seated, snap the Rack's Locking Bar over the Module's guide pins in order to hold it in place.

Step 5 – Apply the self-adhesive Terminal Identification Strip, supplied with the Module, to the terminal block's face.

Step 6 – Write the wire number, or other identifying information, on the Terminal Identification Strip for subsequent use. Wiring practices to the terminals on the I/O Rack are described in the PC-900 and PC-700 Application Manuals.

Switch Settings – In order to complete installation of the Output Module, it is necessary to physically set individual rocker and thumbwheel switches.

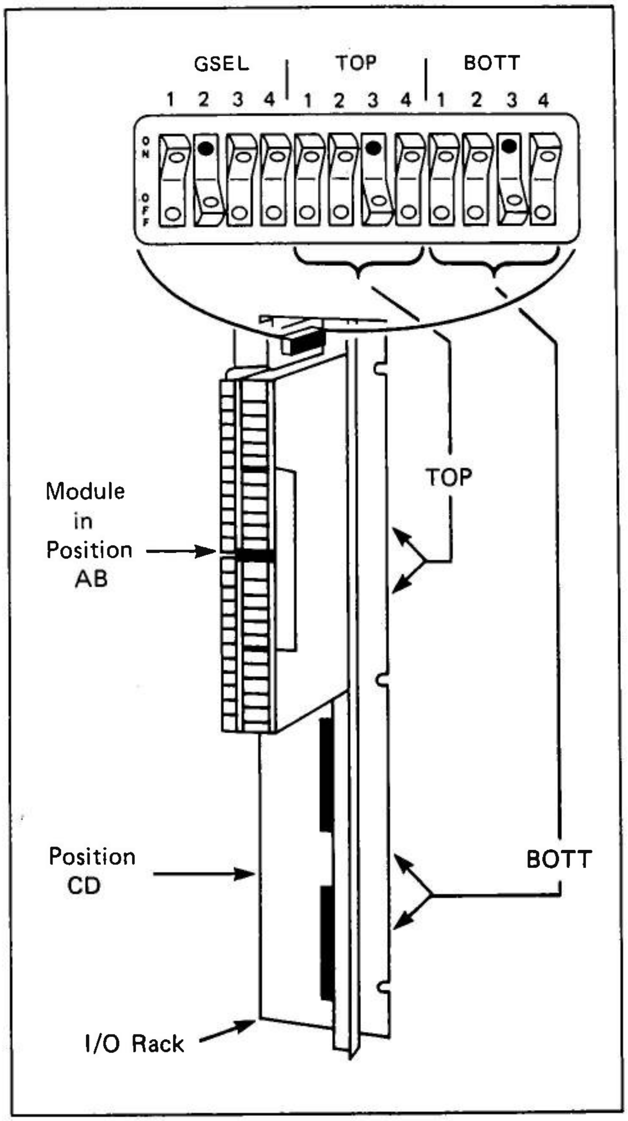


Figure 5 – Rack Switch Location

Their combined function is to electrically identify each terminal in the Rack with a Reference Number required for programming. This explanation is detailed only to the level required by the installation team. (For further details, see the PC-700 and PC-900 Application Manuals and Instruction Leaflet 15718.)

Step 1 – Locate the first-used D/A Output Module on the system drawings and on the I/O Rack. This may be anywhere in the layout and will probably be grouped together with other Output Modules of the same type.

Step 2 – Identify the Reference Number for the first output terminal on **that** Module. It will be a number like OR0001.

Step 3 – At the top right-hand side of **that** I/O Rack, locate the Rack Switch assembly. (See Figure 5.) Note that it is divided into 3 groups of 4 rocker switches each. Locate those that make up the GSEL area.

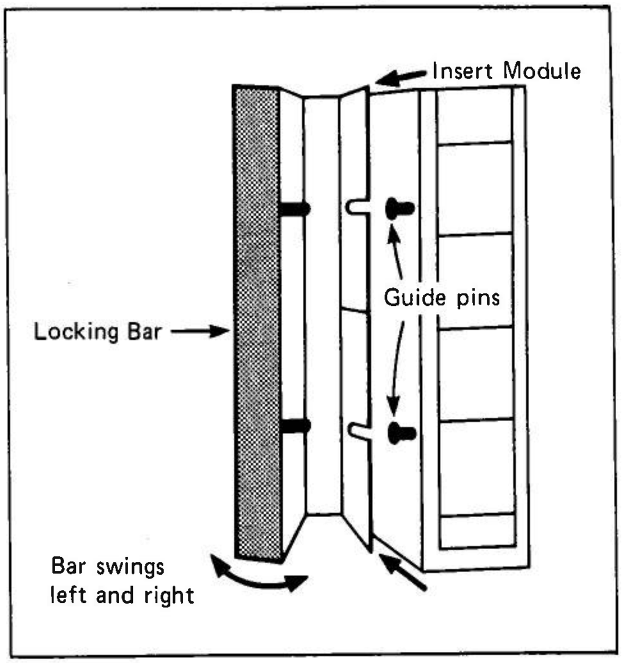


Figure 6 – Guide Slots

It is necessary to set 1 of the 4 switches to ON according to the specific Reference Number. Relate the Number to Table B for the first Module and for all other Output Modules of this type in subsequent I/O Racks.

Step 4 – As indicated on Table B's right column, set the proper switch to the ON position.

Table B

RACK SWITCH GSEL SETTING

If the Reference Number is:	Press ON GSEL Switch:
OR0001 thru 0008	1
OR0009 thru 0016	2
OR0017 thru 0024	3
OR0025 thru 0032	4

Step 5 – Set the remaining 3 switches in GSEL to the OFF position. (The 4 switches may be thought of as a type of selector switch.)

Step 6 – Set the remaining 8 rocker switches in the TOP and BOTT areas to the OFF position.

Step 7 – Two thumbwheel switches are located near the rear edge of the Module. (See Figure 7.) Both of these must be set to a specific digit in relation to the Reference Numbers assigned to the Module's 2 channels. Read Application Note 9 and refer to Table C. Also use the list described earlier in this publication at "Switch Settings."

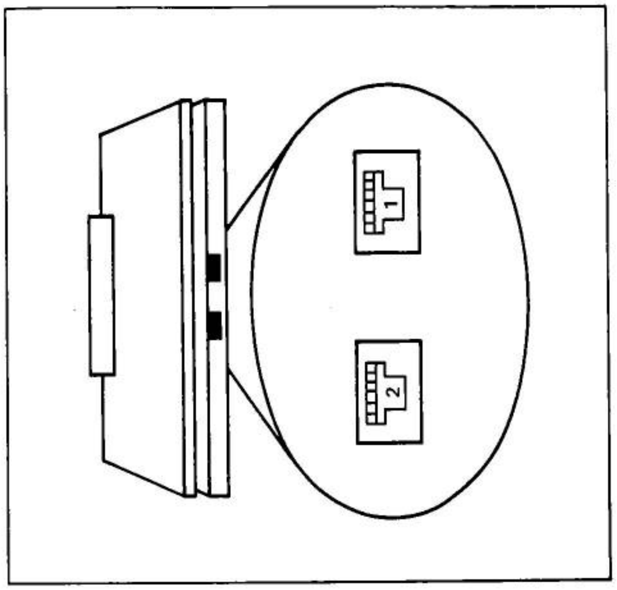


Figure 7 — Thumbwheel Switch Location

Example: The top channel is OR0017 and the bottom channel is OR0018. Answer: Set the top thumbwheel to 1, and the bottom thumbwheel to 2. Only GSEL switch 3 is ON.

Step 8 — As indicated in Table C, set the thumbwheels to the proper digits.

Step 9 — As an aid to future troubleshooting, mark the rocker switch settings on a piece of tape and place it near the assembly.

Table C

THUMBWHEEL SETTINGS ①

If the Reference Number is:	Turn thumbwheel to this digit:
OR0001, 0009, 0017, 0025	1
OR0002, 0010, 0018, 0026	2
OR0003, 0011, 0019, 0027	3
OR0004, 0012, 0020, 0028	4
OR0005, 0013, 0021, 0029	5
OR0006, 0014, 0022, 0030	6
OR0007, 0015, 0023, 0031	7
OR0008, 0016, 0024, 0032	8

① Do not use 0 or 9.

APPLICATION NOTES

1. In order to minimize the effects of electrical noise, all field wiring must conform to the following guidelines:

- Use single-pair, twisted, shielded cable, AWG No. 22, or larger conductors, for each analog output channel.
- Connect all cable shields to the common (voltage output) or return (current output) connection to the load **only** at the load end in order to prevent ground loops. (See Figure 4.)
- Maintain a minimum spacing of 12 in. (30.5 cm) from inductive devices such as isolation transformers, motors and starters.
- Keep analog cable runs as short as possible, and route them away from AC conductors as much as possible.

2. When driving an SCR motor speed control (that is, a DC drive), it is desirable to isolate the Module's D/A output common from the SCR bridge's common. If this practice is not followed, electrical noise produced by the bridge can be coupled into the Module, thus causing its output voltage or current to be at an incorrect level. Since most SCR bridge circuits are generally isolated from control circuits with transformers or optical isolators, it is necessary only to perform proper wiring in order to eliminate this problem. (See Figure 8.)

3. All power requirements for the Module are supplied by either the supplies in the Processor or, at times, the I/O Expander Supply. Exact needs vary with the Module version, as listed in Table D.

Table D

POWER REQUIREMENTS

Function	Logic Power Supply (units)	Output Power Supply (units)
Basic Module	184	0.5
Each 4 to 20 mA channel	33	0
Each 10 to 50 mA channel	83	0

Example: What is the total Logic Power Supply requirement for a Module with a single 4 to 20 mA low-voltage return and a separate 0 to 10 VDC channel? Answer: basic Module = 184 units; 4 to 20 mA channel = 33 units; total Logic Power Supply = 217 units. Total Output Power Supply requirement = 0.5 units.

4. In order to calculate the values of the voltage or current, as represented by the binary numbers from 0 to 4095, available from the Module, use Table E.

Example: What is the output of a 4 to 20 mA D/A output channel when a binary value of 2000 is sent from the output register? Answer: 11.8144 mA, or:

$$2000 \times 0.0039072 = 7.8144 \text{ mA} + 4.0 = 11.8144 \text{ mA}$$

Table E

VALUE CONVERSIONS

If Output Range is:	Multiply input value by:
0 to 5 VDC	0.0012210
0 to 10 VDC	0.0024420
4 to 20 mA	0.0039072 Then add 4.0
10 to 50 mA	0.0097680 Then add 10.0

5. When operating a channel as a current source, the maximum load resistances must conform to those listed in Table F.

6. Under certain conditions, a D/A output channel switches to 0 VDC or minimum current (4 or 10 mA). These conditions are: when a system fault occurs or when the Processor key switch is turned to the "program" position.

7. Low-level/high-frequency noise superimposed on the analog output of each channel originates from the switching-type power supply contained on the Module. The noise is 0.1 V, peak-to-peak, at 1 mHz; since most field devices do not respond to such high frequencies, this output is generally not a problem. For those applications where it causes difficulty, use a R-C low-pass filter to eliminate the noise.

8. The Module requires the exclusive use of 2 Processor output registers. Note that it is possible to configure an application that requires more registers than are available in a specific Processor. Before designing a system, refer to the Series 700 and 900 Application Manuals for specific Processor register capability.

Also note that it is important to choose output registers that are numbered sequentially **and** within the same GSEL grouping as outlined in Table B. In other words, it would be unacceptable to use the Reference Numbers OR0008 and OR0009 to identify the 2 channels of this Module.

Table F

LOAD RESISTANCES (MAX.)

Load return connection (VDC)	4 to 20 mA: ohms (max.)	10 to 50 mA: ohms (max.)
-15	600	200
-50	1500	600

9. Thumbwheels near the rear edge of the Module identify each circuit with respect to a specific Reference Number and output register. When looking at the Module so that the label is readable, the lower thumbwheel identifies the bottom channel; the higher thumbwheel identifies the top channel. See Figure 7 and Table C. Exact settings must be supplied on system drawings to aid installation teams.

PROGRAMMING NOTES

1. The Processor is capable of outputting binary data above the value 4095, but such condition should be avoided.

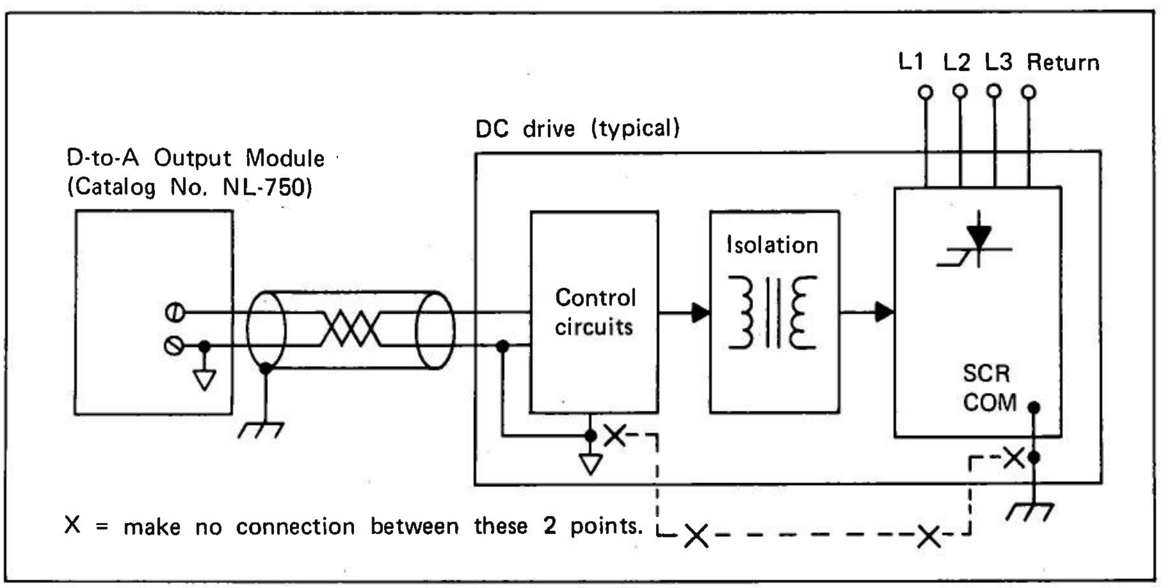


Figure 8 — DC Drive Connections

Although the maximum value of 4095 requires only 12 binary digits, each output register is made up of 16 bits. Thus the output value could be larger than 4095. In fact, 4096 (13 binary digits) produces a "roll over" output of 0; 4097 produces a 1. Even though these conditions are predictable, they should be avoided to maintain operating simplicity.

2. Data sent from the Processor to the D/A converter must be in binary form. Zero must correspond to the **lowest** voltage or current output from each D/A channel; 4095 must correspond to the highest voltage or current.

3. The 2 channels of a single Module cannot be assigned the same Reference Number. If a "twin-output" arrangement is required, use one of the following techniques:

- 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.
- Use a single channel of entirely **different** Modules and assign identical Reference Numbers to both. The most simple arrangement is to place two D/A Modules in the same I/O Rack. All channels on both Modules must then have Reference Numbers that correspond to a **single** grouping of Table B.

4. The output register values from the Processor are retentive. For example, when AC power is removed and restored, whatever output value previously present will be restored. (This assumes the output register's value was **not** modified by the user program in the meantime.) Precautions—such as an operator reset device—may be necessary to eliminate undesirable movements caused by the retentive characteristics.

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

$$\text{scaled value} = \frac{\text{value to scale}}{\text{maximum value}} \times 4095$$

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 weight gauge outputs a BCD number varying from 0 to 2000 pounds. (The given value is transmitted to a Register Input Module which passes it into an input register.) To provide an output varying from 0 to 10 VDC in direct proportion to the input 0 to 2000 range, perform the following:

- Convert the BCD value to binary and store it in a holding register.
- Divide the holding register's contents by 2000. Multiply the result by 4095. This gives the scaled value.
- Load the scaled value in the appropriate output register associated with the D/A channel.

FUNCTIONAL THEORY

The Digital-to-Analog Output Module contains 2 separate D/A converters referred to as the top and bottom channels. Each channel is electrically isolated both from the Processor and the other channel. A binary number, ranging from 0 to 4095, is sent from separate output registers to storage latches on the Module for eventual use by the D/A converters. The converters' outputs are an analog voltage or current directly proportional to the binary value input to the Module.

Power Up – The Module receives all its operating power from the Processor. When AC power is applied to the Processor, the Logic Power Supply is energized. After about 100 msec it is operational, and both the Processor and Module begin normal operation. Immediately after the Logic Supply is enabled, the D/A output will be 0 volts, and the current output will supply the minimal current. Both D/A channels are at the minimum output level until after the power-up routine and the first user program scan are completed.

After about 2 seconds the normal I/O updating begins, and the retentive characteristics of the Processor are in effect. (See Programming Note 4.)

Power Down – When AC line power is removed, the Processor initiates its power-down routine. One of the first tasks is to clear the D/A outputs. As the supply voltages continue to decay, a non-zero output may occur for a few seconds since the D/A converter may not respond correctly during the decay period.

Module Operation – Binary numbers from 0 to 4095 are input to each channel from the Processor's output registers. Within 1 msec a voltage or current proportional to the binary value input is available from each channel. The double-buffered converter design provides a non-zero transition between I/O scans. 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

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. (See Figure 9.)

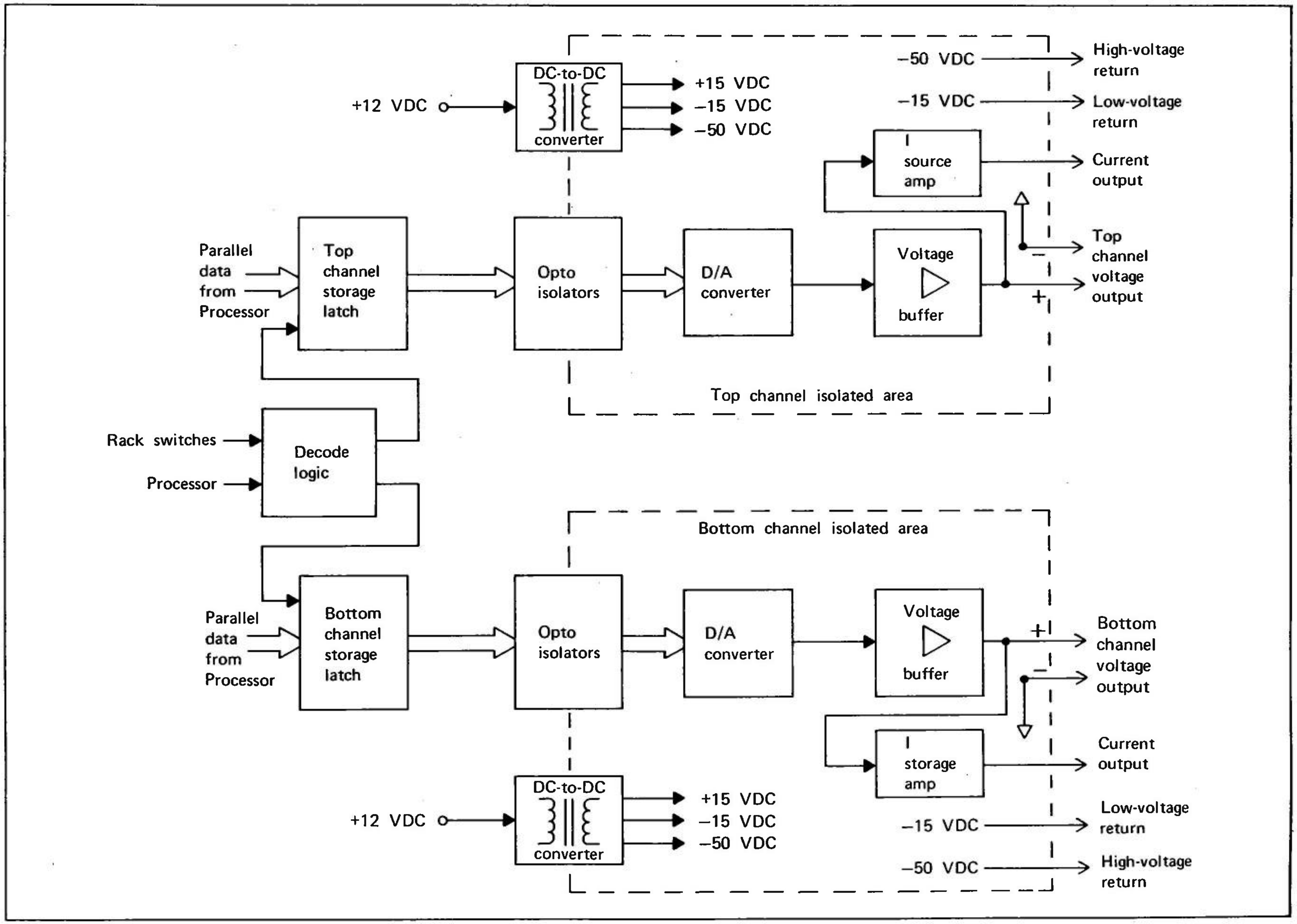


Figure 9 – D/A Module: Conceptual Block

The Digital-to-Analog Module supports 2 separate D/A channels, described here as the top and bottom. These channels each converts a separate 12-bit binary number into an analog voltage or current. A conceptual block diagram of the D/A converter is shown in Figure 9. Each block is briefly described here.

DC-to-DC Converters — Two separate supplies each receive a +12 VDC from the Logic Power Supply in the Processor and produce the +15, -15 and -50 VDC isolated outputs. The inverter, or chopper-type supply, contains a transformer that provides the electrical isolation for each channel.

Storage Latches — These devices receive binary data from the Processor's output registers during the I/O update scan and holds the data for use by the D/A converters.

Opto Isolators — Transfers and electrically isolates the 12-bit binary number sent in parallel from the storage latch to the D/A converter. Complete isolation of each channel is obtained with the isolators and, also, with the isolated +15 and -15 VDC supplies from the DC-to-DC converters.

D/A Converter — The 12-bit binary number from the opto isolators is sent to this device where an analog voltage is produced. A very accurate thin-film, nichrome, resistor R-2B network is used. Double buffering of the data allows the output to change value without resetting to zero. Soon after the Processor updates the R-2R storage latch, the D/A converter outputs the new value.

Voltage Buffer — This is a unity gain voltage follower that provides a high-impedance load for the D/A output. In addition, the stage contains LC filters that help protect the circuitry from the effects of electrical noise. (See Figure 10.)

I Source Amp — This amplifier produces a varying current proportional to the value of the voltage source. There are 2 returns: -15 and -50 VDC. These provide the ability to drive a range of load resistances, as described in Application Note 5. Inductors and capacitors provide surge protection for the output.

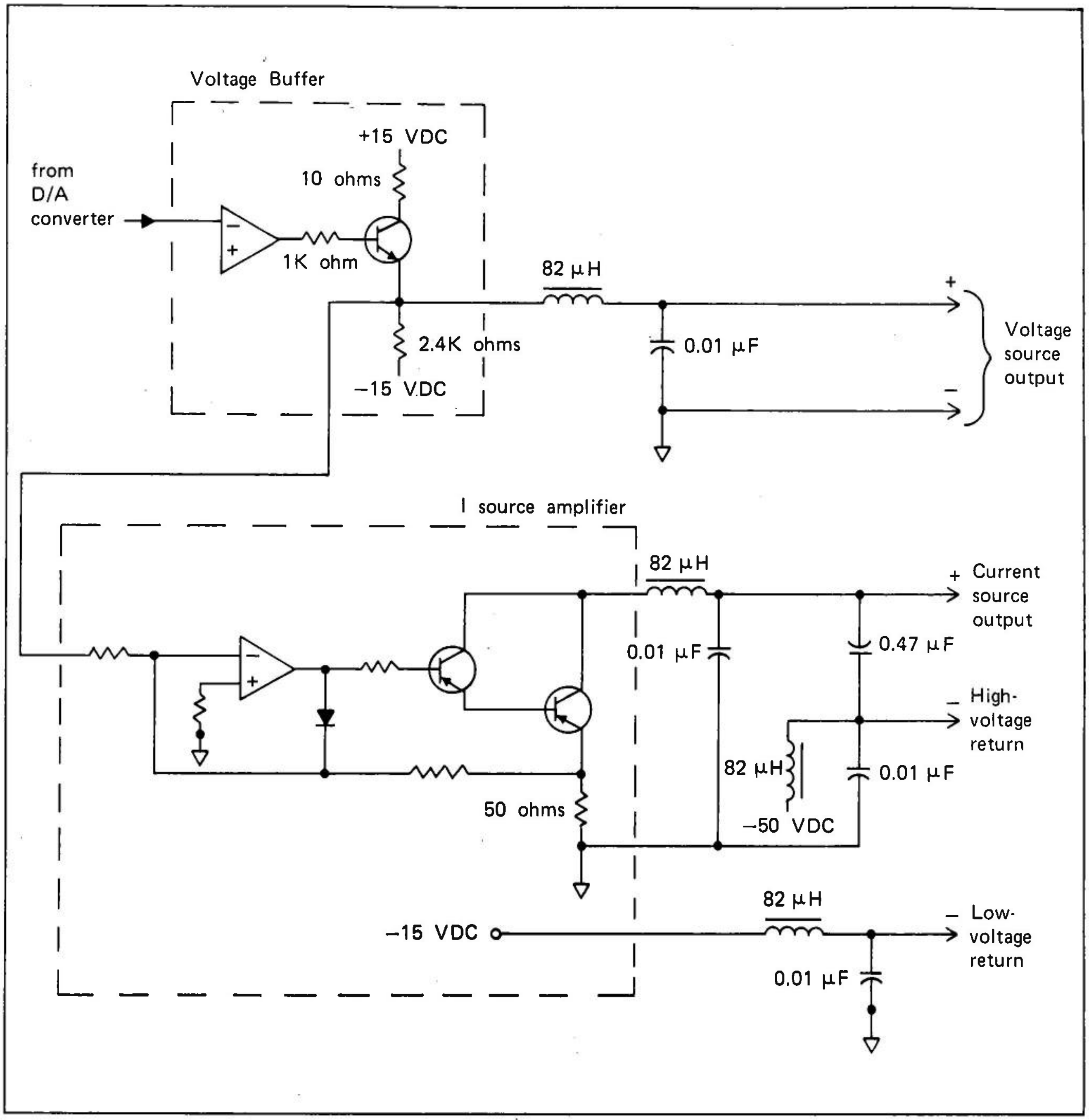


Figure 10 – D/A Top Channel Driver Circuits

Instruction Leaflet 15655
July, 1982

Westinghouse Electric Corporation
Industry Electronics Division
Madison Heights, Michigan 48071