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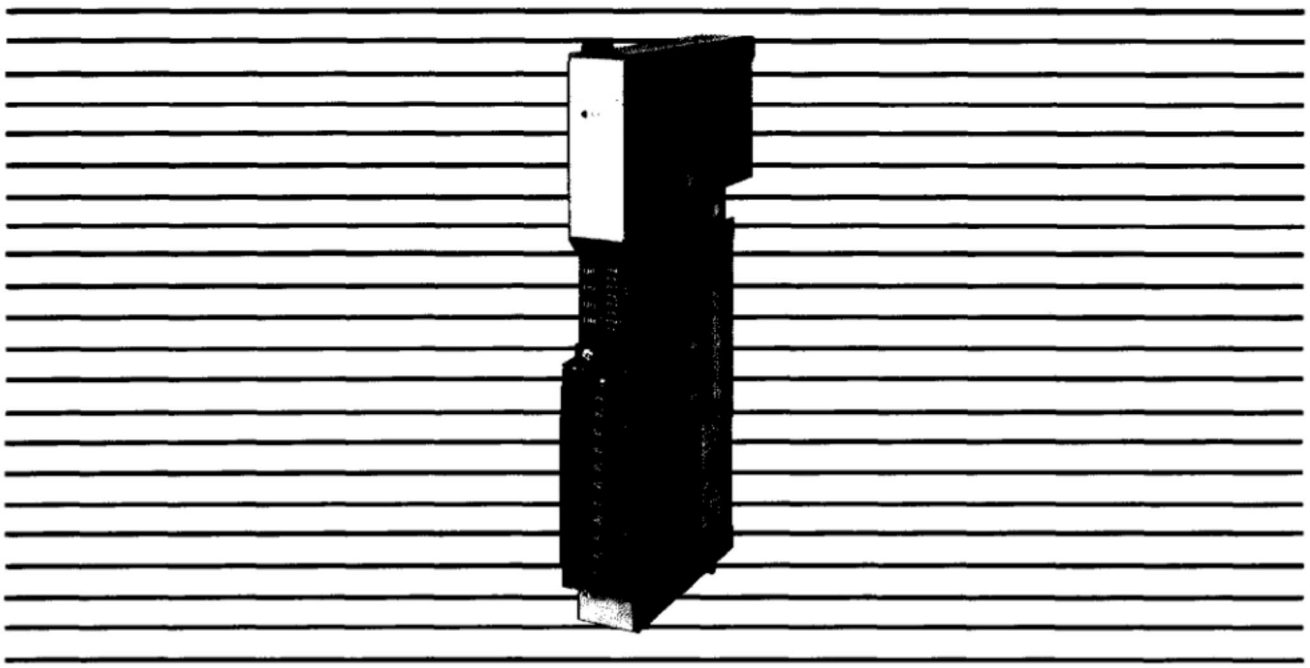
SQUARE D COMPANY

# Instruction Bulletin

SY/MAX®

## Class 8030 Type ROM121
## Analog Output Module

Bulletin # 30598-204-01B1
February 1990



*Dedicated to Growth*
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Supersedes 30598-204-01, September 1984

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# 1.0 DESCRIPTION OF SY/MAX FAMILY STANDARD ANALOG OUTPUT MODULE

## 1.1 Introduction

### 1.1.1 GENERAL DESCRIPTION

The Class 8030 Type ROM-121 Standard Analog Output Module provides the capability of generating 4 channels of analog output signals (4-20mA, 1-5VDC, 0-10VDC or ± 10VDC) for controlling adjustable frequency drives, positioning valves, dampers, etc. The module is compatible with any SY/MAX Processor which processes register I/O addressing capability. The module may be inserted into any slot of a register rack (except slot 1 of all RRK racks and the lower half of an RRK-300) or the register slot of a digital rack. Each module utilizes 4 registers in the system (1 register per channel) in which the analog current or voltage being output is stored as a value ranging from 0 to 9999. Simple programming techniques allow these storage register values to be scaled from engineering values prior to outputting, provided the processor being used has math capability. The module requires no external power supply to operate (drawing its power from the SY/MAX Power Supply connected to the rack) and requires no additional external components. Span and zero are adjustable while the module is operating, and must be initially calibrated for the selected range using a voltmeter. The outputs are short circuit protected, and the modules conform to industry standard ISA-S50.1. Upon HALTing of the associated processor, the output channels may be configured to either HOLD their last value or to RESET to the minimum value for the selected range, selectable by the user on the basis of the safest shutdown mode. A removable terminal strip facilitates quick replacement with no rewiring necessary.



Figure 1

### 1.1.2 GENERAL OPERATION

The Class 8030 Type ROM-121 module performs its tasks utilizing several subsystems. The digital to analog converter (D/AC) performs the actual conversion of the storage register value, and this signal is sent to the individual sample and hold circuitry of the respective output channels. The on-board microprocessor then performs the proper channel selection. Each channel references individual span and zero settings. The module also contains a DC-to-DC converter, along with signal and power isolation circuitry. For a block diagram of the operation, see Section 7.1.

## 1.2 Front of Module

The front of the module shows a RUN LED, SPAN and ZERO (or GAIN and OFFSET) adjustments for the 4 output channels, and a terminal strip.

The terminal strip contains 4 groups of 3 terminals; each group corresponds to 1 output signal or channel. One terminal exists for the positive wire to the output device, one terminal for the negative, and the third terminal for the shield wire. For field wiring considerations, see Section 3.4.

The SPAN and ZERO (or GAIN and OFFSET) adjustment potentiometers are used to calibrate the range of the individual channels. See Appendix A for proper calibration procedures.

The RUN LED indicates the on-board microprocessor is functioning properly.

## 1.3 Side of Module

Accessible by removing the two side cover plates are 8 DIP switches which allow the user to select the desired range setting and the HOLD or RESET option for the output channels in the event of the controlling processor going into HALT. See Section 3.3 for proper settings.

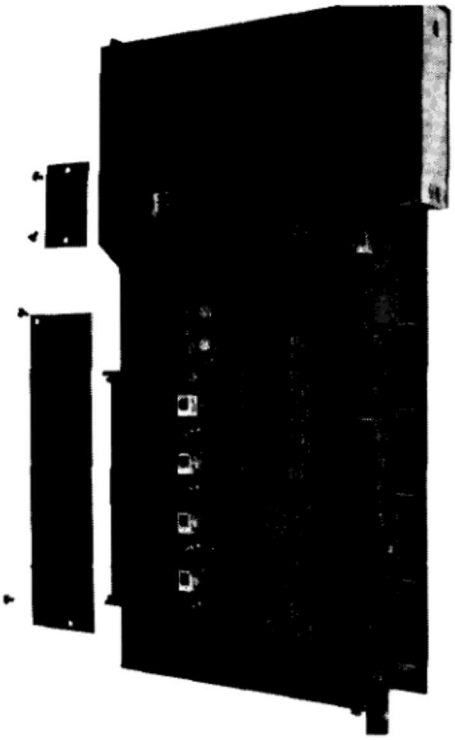


Figure 2

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# 2.0 SPECIFICATIONS

## 2.1 Electrical Specifications

| | |
|---|---|
| OUTPUTS PER MODULE: | 4 (selected range will apply to all 4 channels). |
| RANGES: | 1-5VDC, 0-10VDC, ± 10VDC, 4-20mA |
| ACCURACY: | ± 0.15% at 25°C, ± 0.5% (of full scale) over 0-60°C temperature range. Span and zero require initial user calibration. |
| RESOLUTION: | 11-bit, or 1 part in 2047 (full scale range in the storage register of 0-9999). Negative storage register values will correspond to the minimum output of the selected range; values in excess of 9999 will be represented as the maximum output for the selected range. |
| CONVERSION RATE: | Output channel reflects register value within 10 msec. of module receiving *updated information (40 msec. for all 4* channels). |
| ISOLATION: | 200V channel to ground (or analog output circuitry to digital logic circuitry) continuously applied, 1500V transient isolation. No analog channel-to-channel isolation. |
| DRIVE CAPABILITY: | 10mA (voltage settings), 600 ohms (current setting). |
| USER OUTPUT OPTIONS UPON CPU HALT: | HOLD (maintain the last value received while in RUN) or RESET (go to the minimum output for the selected range within 40 msec. of CPU HALT). |
| SHORT CIRCUIT PROTECTION: | Yes. |
| POWER REQUIREMENT: | 1500mA current draw from SY/MAX Family Power Supply connected to the rack. |
| D/A CONVERTER: | Analog Devices Type 7543 (CMOS 12-bit serial-in D/A converter). |
| MULTIPLEXER: | National Semiconductor Type LF398H, individual channel sample-and-hold. |
| MICROPROCESSOR: | Intel 8031 (controls the D/A converter, logic timing, and diagnostics). |
| RUN LIGHT: | Indicates digital logic circuitry is functioning properly. |

## 2.2 Physical Specifications

| | |
|---|---|
| WEIGHT: | 2.8 lbs. (approx.), 1.3 kg. |
| DIMENSIONS (WxHxD): | 1.5 x 12.8 x 6.6 (in)<br>3.8 x 32.5 x 16.8 (cm) |

## 2.3 Environmental Specifications

| | |
|---|---|
| AMBIENT TEMPERATURE: | 0-60°C (operational) |
| STORAGE TEMPERATURE: | −40 to +100°C |
| HUMIDITY RATING: | 5-95%, relative humidity (non-condensing) |

## 2.4 Compatibility with Racks

RRK-100, RRK-200, RRK-300 (except the first slot in any RRK rack, and any slot in the bottom half of an RRK-300)
HRK-100, HRK-200 (register slot only)
CRK-210, CRK-300 (register slot only)
DRK-210, DRK-300 (register slot only)
GRK-110, GRK-210 (register slot only)

## 2.5 Compatibility with Processors

*The following Class 8020 Type SCP programmable controllers:*
311 and 312 (series E and later)
323 and 344 (series C and later)
313, 321, 322, 332, 333 (series D and later)
All Model 400, 500, 600 & 650 Programmable Controllers
All Model 700 Programmable Controllers (ROM-121 must be series C or later if installed in the same rack as the processor. Any series may be used if the ROM-121 is used in a remote drop.)

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# 3.0 INSTALLATION

## 3.1 Physical Inspection

### 3.1.1 NEW MODULE

As packaged, the module requires no additional components to function. Individual channels do require calibration of SPAN and ZERO (or GAIN and OFFSET) settings. Refer to Appendix A for the proper procedure for the selected range. Before installing the module, the user should complete the following compatibility checks:

The proper range for the application is available (Section 2.1).

The proper range is selected (Section 3.3).

The desired CPU HALT output channel mode is selected (Section 3.3).

The processor is compatible (Section 2.5).

The rack and the necessary slot is available (Section 2.4).

They SY/MAX Family Power Supply is adequately sized (Instruction Bulletin 30598-159-XX or later).

The rack is not keyed to prevent module insertion (Section 3.2).

Field wiring terminations are understood (Sections 3.4 and 5.2).

The required programming, especially system addressing, is understood, refer to Instruction Bulletin 30598-174-XX or 30598-167-XX or SY/MATE programming Instruction Bulletin.

The module is installed by aligning the edge connector with the slots provided in the rack, and inserting the card so that it snaps into place. The module should then be secured to the rack with the captive fastening screw on the bottom.

CAUTION: The module should not be inserted or removed while the rack is powered up, or while wires are connected to an active output device. The user should insure that no signals are allowed to be transmitted to the output device until the operation of the module is understood. See Section 3.5.1 for general start-up procedures and Section 5.1 for application considerations regarding module insertion.

CAUTION: The ROM-121 cannot be used in the lower half of an RRK-300.

### 3.1.2 REPLACING A MODULE

A module may be quickly and easily replaced with another module. There is no need to require the analog output points as the terminal strip may be removed by simply loosening the screws which secure the strip. The user must be certain that the DIP switches are properly coded for the desired range and CPU HALT output channel setting. No software reprogramming is necessary. See Section 5.1 for application considerations regarding module insertion and removal.

## 3.2 Keying

A particular slot on the rack assembly may be keyed to accept only the ROM-121 module. A keying pin kit, Class 8030 Type CBP-104, may be used to insert the keying pin between pins 90 and 92 of the appropriate slot, as described in the register rack Instruction Bulletin 30598-265-XX. The same procedure also applies to the register slot of any digital rack.

CAUTION: When inserting or removing keying pins, use care to avoid touching the contact fingers within the connector. Improper insertion/removal may damage the connector.

## 3.3 DIP Switch Settings

Removing the two cover plates on the side of the module allows user access to six DIP switches for selecting the desired center or voltage range. There is also an exposed pair of DIP switches near the top of the edge connector in the rear of the module; one of the switches (S7) is used for range selection, the other switch (S8) is used for governing output channel response to a CPU HALT (HOLD or RESET). Both the selected range and the output channel response will be common to all four channels. These settings should never be changed while the module is powered up. See Figure 3 for the appropriate settings; note especially the labeling and orientation of the switches. See Section 5.3 for further discussion on the selection of the output channel HOLD or RESET response options.

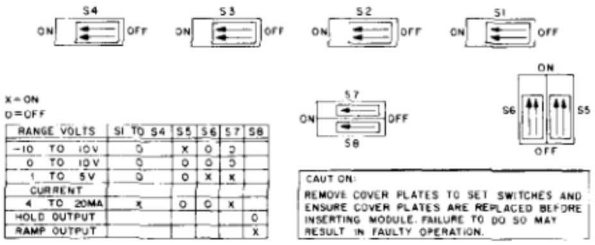



Figure 3

CAUTION: Do not change DIP switches while power is applied to the module.

## 3.4 Field Wiring Terminations

Each analog output signal is wired to a group of three front terminals. The plus and minus terminals for the respective channels indicate the polarity of the analog output signal. Each output channel should be wired as a signal source, with the capability of driving into a 600 ohm load on the 4-20mA range setting or 10mA on a voltage setting. The "S" terminal is provided for the shield wire of each analog output. It is recommended that the wiring used be shielded twisted pair (Belden 8760 or 8761 or equivalent) with the shield being connected at the analog output module only. The user should note that all four minus terminals share a common analog ground internally. See Section 5.2 for a discussion of wiring considerations.

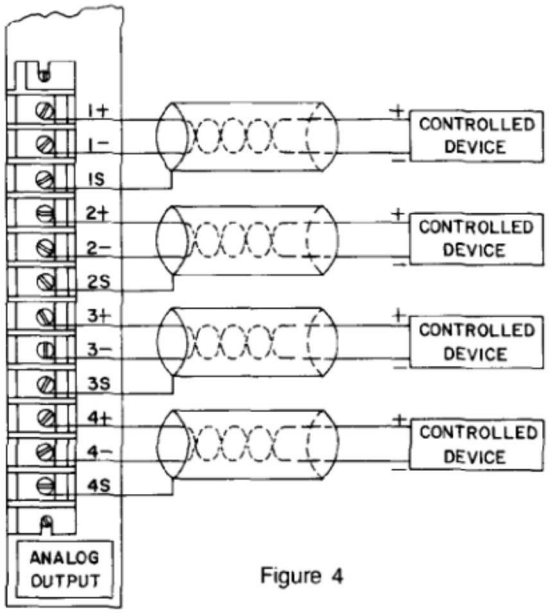


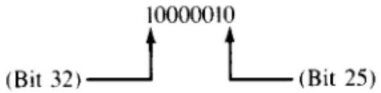

Figure 4

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## 3.5 Start-Up

### 3.5.1 NECESSARY PROCESSOR INSTRUCTIONS

After observing the conditions outlined in Section 3.1.1, with rack power off, and with no output signal wires connected to the terminals of the module, the module may now be inserted in the appropriate slot. If the systems addressing has been correctly assigned to recognize the module in that particular slot and if the analog output module's microprocessor is functioning properly, upon power-up bits 25 to 32 of the register status field for the assigned registers will reflect the following code:




If the above bit pattern is not found in the expected registers, then either the system has been misaddressed or the module has failed its initialization sequence and is sending back an alternate bit pattern to describe the nature of the failure. See Section 4.1.1 for an explanation of the error codes. The module's RUN light may also fail to illuminate.

The user should insure that each channel of the module is properly calibrated. Calibration should also occur any time the range of the module is altered, if the module is moved to a different rack, or if the rack power supply is changed. We recommend performing the calibration procedure (outlined in Appendix A) with the module at operating temperature.

Should the user wish to be more systematic about checking out the operation of these modules, the following test configurations and systems addressing assignments may be used. These are only intended as examples of possible configurations which may be used for familiarization purposes; final actual system layout is dependent upon the user's proper understanding of the system definition or rack addressing formats as outlined in Instruction Bulletin 30598-174-XX or 30598-167-XX or SY/MATE programming software.

**HARDWARE CONFIGURATION**

| CRK, DRK, GRK, or HRK Rack | | |
|---|---|---|
| ROM-121 | MODEL 300 | Digital I/O Slots |
| Register slot | CPU slot | |

**SYSTEM ADDRESSING**

CPU Slot 0
Channel 0
Drop Number 0
Slot Number 1 108
Slot Number 2 112

**COMMENTS**

This will assign analog output channels 1-4 to registers 109-112 in the processor.

Example 1 — Model 300 in a Digital I/O Rack With Register Slot

**HARDWARE CONFIGURATION**

| RRK-100 or RRK-200 | | | |
|---|---|---|---|
| MODEL 300 | CRM-210 | ROM-121 | Empty Register slots |
| Slot 1 | Slot 2 | Slot 3 | |

**SYSTEM ADDRESSING**

CPU Slot 0
Channel 0
Drop Number 0
Slot Number 1 — —
†Slot Number 2 108
Slot Number 3 112

**COMMENTS**

This will assign analog output channels 1-4 to registers 109-112 in the processor.

Example 2 — Model 300 in a Register Rack

**HARDWARE CONFIGURATION**

| RRK-100 or RRK-200 | | | |
|---|---|---|---|
| MODEL 500 (double width) | | ROM-121 | Empty Register slots |
| Slot 1 | Slot 2 | Slot 3 | |

**SYSTEM ADDRESSING**

CPU Slot 0
Channel 0
Drop Number 0
Slot Number 1 460
Slot Number 2 — —
Slot Number 3 464

**COMMENTS**

This will assign analog output channels 1-4 to registers 461-464 in the processor.

Example 3 — Model 500 in a Register Pack

### 3.5.2 NORMAL INDICATING LIGHTS

Illumination of the green RUN light indicates the on-board microprocessor is functioning properly, but does not necessarily mean that analog output signals are being properly converted. Should the user suspect improper module operation despite the green RUN light, suggest examination of bits 25-32 of the analog output channel registers. See Section 4.1.1 for possible error code conditions, and Section 6 for troubleshooting procedures.

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# 4.0 PROGRAMMING

## 4.1 Register Usage for System Addressing

Each analog output module will occupy four registers of the system. These four registers should be assigned to the slot in which the module is inserted, and will exist even if some of the channels remain unused.

### 4.1.1 STATUS AND ERROR REGISTER TABLE

This section describes possible codes which may be found in bits 25-32 of the status field of the assigned registers, generated by the analog output module's on-board microprocessor.

**STATUS BITS**

| 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | Description |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | Normal Operation |
| 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | No card acknowledged in slot |
| 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | Diagnostics in progress |
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | EPROM failure |
| 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | DC-DC converter failure |
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | External RAM failure |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Slot not addressed |

See Section 6.2 for further explanation of these conditions.

## 4.2 Types of Programming Equipment

†Programming may be accomplished with any Series of Class 8010 Type SPR-25X, SPR-26X, SPR-30X or any series SY/MATE® software programming package.

The following listing summarizes the necessary series designation for other programming equipment. All are Class 8010.

Type SPR-200 Series H or later (Rev. 1.4)
Type SPR-201 Series D or later (Rev. 1.4)
Type SPR-210 Series H or later (Rev. 1.4)
Type SPR-211 Series D or later (Rev. 1.4)
Type SPR-250 All series
Type SPR-251 All series
Type SPR-260 All series
Type SPR-261 All series

## 4.3 Connection of Programming Equipment

Proper programming equipment is to be connected to the processor which controls the slot to which the analog output module is inserted. The module cannot be interrogated separately.

## 4.4 Program Steps

The values stored in the analog output registers may be utilized as would any storage register value, i.e. in IFs, LETs, COMMs statements, etc. Valid data as contained in the storage registers will range from 0 through 9999, with resolution of 1 part in 2047. Thus, the value stored in the register reflects to two decimal places the percentage of the selected range signal being output. The value 0 will correspond to the minimum output value, while 9999 will generate the maximum output value.

## 4.5 Example Programs

In many cases, the user will wish to enter a desired output current or voltage value; this must then be converted into a register value which the analog output module can interpret. The table below indicates the resolution provided with the respective signal ranges, and demonstrates mathematically how the actual current or voltage values may be scaled to properly represent output register values.

For the following examples, assume register 109 controls the analog output channel, and register 100 contains the actual voltage or current which the user desires to output. These are intended strictly as examples of conversions which the user may wish to make before outputting a value which the analog module is able to interpret. The user must have a fundamental understanding that storing or writing 0 in the register which controls the analog output channel will generate the minimum signal, 9999 will generate the maximum signal, and values in between will cause the signal to vary linearly throughout the range.

| Range | Value to be Converted | Program Rung | Resolution Provided by Analog Output Module |
|---|---|---|---|
| 4-20mA | Register 100 contains microamps | LET S109 = S100 ÷ 8x5 – 2500 | 7.81 microamps per bit |
| 1-5VDC | Register 100 contains millivolts | LET S109 = S100 ÷ 2x5 – 2500 | 1.95 millivolts per bit |
| 0-10VDC | Register 100 contains millivolts | LET S109 = S100 | 4.88 millivolts per bit |
| ± 10VDC | Register 100 contains millivolts | LET S109 = S100 ÷ 2 + 5000 | 9.77 millivolts per bit |

As an example, suppose the user wished to generate a 12 milliamp signal to an output device. Assuming the system has been properly configured, that channel one of the analog output module corresponds to register 109, and that the example program rung exists in the processor, entering a value of 12000 into register 100 will result in register 109 containing a value of 5000. This value, being midway between the available register range of 0-9999, corresponds to an output current of 12 milliamps, also in the middle of the desired output range. Similarly, if a value of 8 milliamps is desired to be output, entering the value 8000 into register 100 will result in a value of 2500 in register 109, generating an output signal of 8 milliamps. The user must become familiar with the full scale output signal being represented as 0-9999, reflecting to 2 decimal places the percentage of the selected signal range which is being output.

## 4.6 Program Editing

Ladder rung statements containing analog output registers may be edited as would any statement containing other storage registers.

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# 5.0 APPLICATION CONSIDERATIONS

## 5.1 Module Insertion and Removal

As noted in Section 3.5.1, the rack MUST be powered down prior to module insertion. Insertion or removal of a module while the rack is under power will induce a bus error, causing the processor which is addressing the card to go into HALT, with the indication of an I/O error. If such an error is incurred, the user should first place the processor keyswitch in HALT, and cycle power on the processor. The processor keyswitch should then be turned back to RUN. If the I/O error persists, return the processor keyswitch to HALT, remove power from the rack, and attempt to reseat the module. Similarly, when swapping modules, power MUST be removed from the rack to avoid generating a bus error. We also recommend that the user connect the output signal wires from the device being controlled to the terminals of the analog output module only when the device and the analog module are without power. The user must insure that when these devices are brought on-line, the value in the register which controls the analog output channel is known, so that the device does not begin operation without the user's understanding. Furthermore, the analog output circuitry of the module does not have the same ground reference as the digital circuitry. The output signals are allowed to ''float'', and are therefore referenced to the device being controlled. See Section 7.3 for a simplified schematic of the module.

## 5.2 Wiring

The device to be controlled should always be connected to the analog output module via shielded, twisted-pair cable such as Belden 8760 or 8761. The shield serves to protect the signal-carrying wires from noise, while the twisting of the wires helps to insure that any noise which does penetrate to corrupt the signal influences both wires equally, maintaining the differential signal level.

When wiring the ROM-121 channels to the controlled device, the user should check the device manufacturer for wiring and loading considerations. The ROM-121 should be wired as a source which is driving into the load represented by the controlled device. Channel source limitations of the analog output module are 10 milliamp when operated on a voltage range setting, or 600 ohms when operated on the current range setting.

The following is a list of other recommended practices:

1. The shield must only be connected at one end. We recommend connection at the output module, where a terminal is provided for the shield of each pair of signal-carrying wires. At the other end (i.e. near the controlled device), the shield should be peeled back and insulated from any contact with the signal-carrying wires. This practice of ''singly grounding the shield'' is especially applicable when a cable has been spliced or nicked; the user should exercise care to insure that the shield is insulated along its entire length, and that it never comes in contact with any other electrical surface.

   Referring to Section 7.3, the user will note that the shield terminal is connected internally to the analog ground of the module. It is left to the user's discretion to determine whether connecting the shield at this point will provide the best noise immunity.

2. The unshielded portions of the wire run (such as at the controlled device and at the analog output module) should be kept as short as practical.

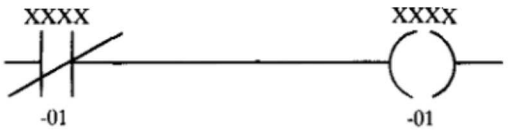
3. Wires carrying analog signals should be routed as much as possible away from potential sources of noise such as motors, transformers, contactors, etc. Be especially suspicious of any AC devices. Analog signal wires should NEVER share the same conduit with AC wiring. On those occasions where you must pass close by to AC wiring, do so at right angles.

4. Multiple devices which are controlled by the same analog output module should not share the same signal return wire. Furthermore, since all 4 minus terminals on the module share the same analog ground (see simplified schematic, Section 7.3), all controlled devices connected to the same module must reference the same ground at the other end. Failure to observe this practice may result in ground loops which could destroy the integrity of the signals being output to each controlled device.

5. The 4-20mA setting will have better noise immunity. When operating on a voltage range, the allowable length of the wire is limited by the capacitance build-up to a distance of approximately 50 feet. Allowable distance on the current setting is limited by the drive capability of the analog output module (600 ohms) and the total loop resistance.

6. Consult bibliography at the end of this instruction bulletin for extensive information regarding wiring considerations for analog signals.

7. When the ROM-121 is used in a remote drop of an LTI/RTI system a ladder rung which has the following form must be included in the control program.




Where: XXXX is the address of each register of the ROM-121 which resides in the remote (RTI) drop.

> WARNING: Since the analog ground is allowed to float, its actual potential with respect to true earth ground will depend on user layout. The user must be aware of this potentially significant difference between the module's analog ground (typically referenced to the controlled device) and digital ground.

## 5.3 Control of Output Channel Signal

In order to properly apply the ROM-121, the user must be aware of how the analog output channels respond to various processor operating modes (HALT, RUN & DISABLE OUTPUTS) based on the module's user-selected HOLD or RESET shutdown options. DIP switch S8 allows the user to select either shutdown option. See Section 3.3 for proper DIP switch settings.

### 5.3.1 CONTROL IN RUN

When the processor is in RUN, the output channel values will be under control of the associated storage register.

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### 5.3.2 CONTROL IN DISABLE OUTPUTS

When the controlling processor is in DISABLE OUTPUTS, the storage register values continue to change as the processor continues to execute the ladder program. The output channel values, however, WILL NOT REFLECT these changes, but will be based on the user-selected RESET or HOLD option. In the case of the RESET option, this implies that the output channel signal will remain at its *minimum* value, (4mA, -10VDC, 0VDC, etc.) regardless of the storage register value. *In the case of the HOLD option, the output channel signal will* be *frozen* at the last value generated by the user program while in RUN, and again will be independent of the changing storage register value.

### 5.3.3 CONTROL IN HALT

When the controlling processor is in HALT, the output channel and its associated register will be set to known user-defined state, the exact value depending on whether the user selected the RESET or HOLD shutdown option.

Selection of the RESET option will cause all of the analog output channels to output the minimum value of the selected range whenever the controlling processor goes to HALT. If the controlling processor goes from DISABLE OUTPUTS to HALT, the output channel signal will remain at minimum.

When the output channel HOLD option is selected, the output channel will remain at the last value generated by the user program at the time the controlling processor went into HALT. If the controlling processor was previously in DISABLE OUTPUTS and went into HALT, the actual output channel signal would have been established when the processor was switched out of the RUN mode. (Since while in DISABLE OUTPUTS the storage register value does not control the actual output channel signal.) See the DISABLE OUTPUTS *discussion under Section 5.3.2.*

In the event a fault in the ROM-121 causes the processor HALT condition, the output channels will reflect the minimum values for the selected range, regardless of the shutdown option. Refer to Table 5.1 for a summary of output channel and register operation for various RUN/HALT/DISABLE OUTPUT conditions.

> CAUTION: When using the analog output module to control critical drive or process applications, a clear understanding of the output channel response to various modes under *which the processor may operate is required. In the event of* a processor HALT, the preferred selection of either the HOLD or RESET option is left to the user. If power to the analog module's rack is lost, the above statement does not apply, since all affected output channels will no longer generate a signal. When power is cycled to the module's rack (OFF to ON), the output channels will always reflect *the minimum value for the selected range until processor* RUN status is achieved. This is a function initiated by the on-board circuitry. This applies in those instances when both the processor and analog output module lose power simultaneously, i.e., they are both in the same rack. Consult the Local and Remote Interface Bulletin (30598-247-XX) for drop failure mode operation when the analog output *module is located in a remote rack.*

**Table 5.1 ROM-121 Output Shutdown Modes**

| Processor/Operation Step | RESET MODE | | HOLD MODE | |
|---|---|---|---|---|
| | Register Contents | Output | Register Contents | Output |
| **Model 300, 400, 500, 600, 700 Processors with the ROM-121 in a LOCAL & REMOTE Configuration** | | | | |
| 1. *RUN to HALT by Keyswitch or Control Bit (8176-3)* | *0000* | *Minimum* | *Freeze per Last CPU Update** | Hold |
| 2. RUN to DISABLE OUTPUTS by Keyswitch or Control Bit (8176-2) | Updates per Program | Minimum | Updates per Program | Hold |
| 3. DISABLE OUTPUTS to HALT by Keyswitch or Control Bit (8176-3) | 0000 | Minimum | Freeze per Last CPU Update* | Hold |

* For Remote System Configuration (LI/RI) the ROM-121 register contents may not reflect what is indicated in the above table; however, the analog output will operate as specified.

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## 5.4 Miscellaneous Considerations

1. The update time between the reception of a storage register value and its reflection to the output channel signal is 10 milliseconds. With 4 registers per module, each channel will therefore require at least 40 miliseconds for updating. Actual throughput time may be longer than this, and is dependent upon processor scan time and system configuration. When fast update times are required, the user optimizes throughput speed by locating the output module in the same rack with the processor.
2. The user should assign four registers to the slot in which the analog output module is inserted regardless of whether or not the user will wire output devices to all four channels. The user should be aware that these channels are live even if their associated registers contain a value of zero. Depending on the selected range, a register value of zero MAY NOT correspond to a signal value of zero.
3. DIP switch settings for the range and output channel CPU HALT option should not be altered while the module is under power. These settings are read by the module only during its power-up sequence.
4. Module "minus" outputs are not individually isolated, Connecting output devices with different ground referenced from each other to the same module may result in erroneous readings. The 200 volts of isolation between the module's analog ground and digital ground does not provide channel-to-channel isolation.
5. Analog values exhibit a small temperature drift; the specified accuracy of 0.5% of full scale range over 0-60°C range improves to 0.15% at room temperature. The user should note that high bit resolution can easily be swamped by the accuracy constraints under which any analog module must operate.

# 6.0 TROUBLESHOOTING

## 6.1 Diagnostic Light

The RUN LED indicates the on-board microprocessor is functioning properly. The possibility exists that this light may be ON, but the analog signals are not being converted as expected by the user. Thus, while an illuminated light may not indicate proper operation, a light which fails to come on indicates a definite problem.

If the light fails to come on at all, the module is not receiving DC power; check to see that the rack is connected to a properly sized SY/MAX Power Supply which is itself producing power. If the RUN light flashes briefly upon the application of power, this indicates that the module has failed to complete its power-up sequence of checks. Once again, this does not necessarily indicate a defective analog output module. The DC power being provided may be inadequate to sustain operation, or the module may not be seated properly in the register slots.

When confronted with an analog output module whose RUN light refuses to illuminate, the user would therefore do well to try the module in a configuration in which these possibilities can be ruled out. See Section 3.5.1 for examples of simple trial layouts.

> CAUTION: The analog output module must never be inserted or removed from the rack while under power. This principle must be observed when performing any troubleshooting.

## 6.2 Using Programming Equipment

Assuming the RUN light is ON, the user should now check the controlling processor to verify that communication has been established. This is best done by using a CRT programmer in the DATA mode to examine the storage registers which the user believed to be controlling the analog output channels. Status bits 25-32 of the respective registers will contain one of several status codes which can be used to pinpoint the operation of the module. Section 4.1.1 contains a table of the status bits describing the conditions associated with the analog output module; failure of any of the listed codes to appear most likely indicates a rack slot addressing problem. See Instruction Bulletin 30598-167-XX or 30598-174-XX or SY/MATE Manual.

The codes of Section 4.1.1 may be interpreted as follows:

NORMAL OPERATION — All digital circuitry is functioning reliably. Any changes to the storage register values controlling their assigned output channels should be reflected as changing output signals, provided the controlling processor is in RUN. If this is not occurring, suspect either the analog circuit portion of the analog output module or the device being controlled to be faulty. Suggest removing the controlled device from the analog output module and checking for proper signal conversion with either a voltage or current meter.

EPROM FAILURE — The module is defective and must be replaced.

DC-DC CONVERTER FAILURE — The DC power being supplied to the digital circuitry of the module is insufficient for reliable operation. If the SY/MAX Power Supply powering the rack is functioning properly, the fault lies with the DC-to-DC converter in the analog output module. The module should be replaced.

EXTERNAL RAM FAILURE — The module is defective and must be replaced.

NO CARD ACKNOWLEDGED IN SLOT — The processor is not recognizing the presence of the module. Try reinserting the module to make sure that it is properly seated. Check rack slot addressing for proper allocation of registers in slots. Be sure to remove power when reseating the module.

DIAGNOSTICS IN PROGRESS — The module has not completed its power up checks. Since these checks require less than one second, should this code appear for an extended period of time the module is defective and must be replaced.

SLOT NOT ADDRESSED — Check rack addressing or system definition register assignments.

## 6.3 Erratic Operation

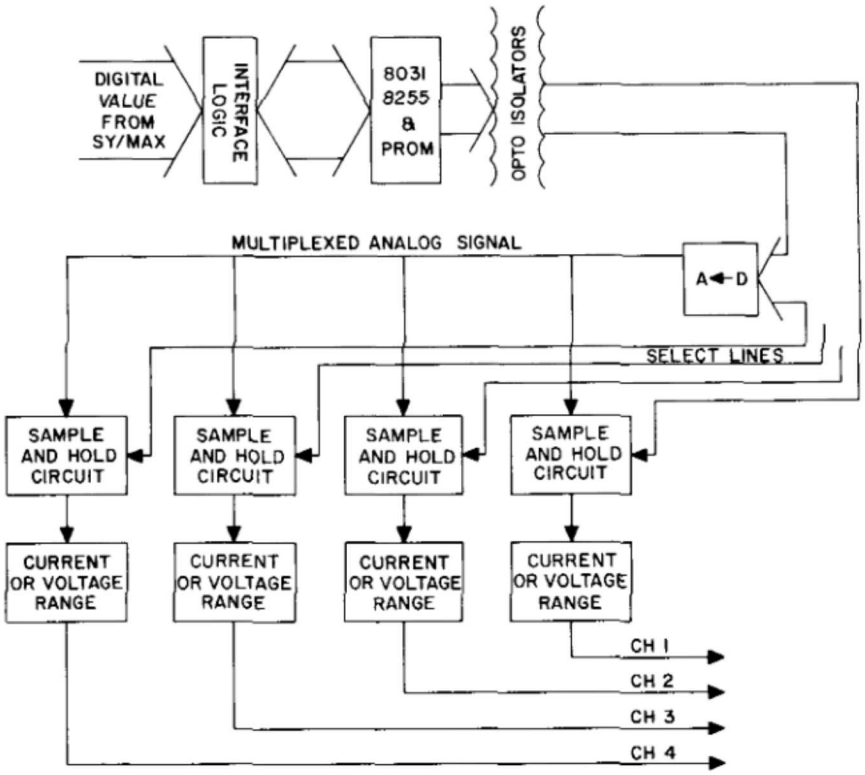
The module is not able to recognize invalid range switch settings. Thus, if the user has selected a range other than what was expected, or is operating on some completely invalid combination of DIP switch settings, results will be erratic. The user must insure that these switches are properly set.

If the user remains uncertain as to which element in the system may be causing a problem, suggest trying the hardware configuration of one of the examples of Section 3.5.1. By virtue of its simplicity, numerous factors are eliminated to help narrow down the source of the problem.

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# 7.0 THEORY OF OPERATION

## 7.1 Block Diagram




## 7.2 Detailed Description

This section describes the subsystems shown in Section 7.1.

The analog output module has its own DC/DC power supply, converting the 5 VDC from the SY/MAX power supply next to the rack to the ± 15 VDC level required by the analog circuitry. This regulated ± 15 VDC is used to source the output signal for each channel. Signal accuracy is maintained by the Analog Devices Type 584 Precision Voltage Reference.

The module employs the Analog Devices Type 7543 12-bit serial input digital-to-analog converter (D/AC). The signal being furnished by the D/AC is sent to the sample and hold circuitry for each respective output channel. The appropriate channel is then enabled by the logic circuitry, and this signal is converted either into a voltage or current output, depending on the mode selected. Operational amplifiers control output channel voltage ranges, while Darlington pair transistors are employed in the current range settings.

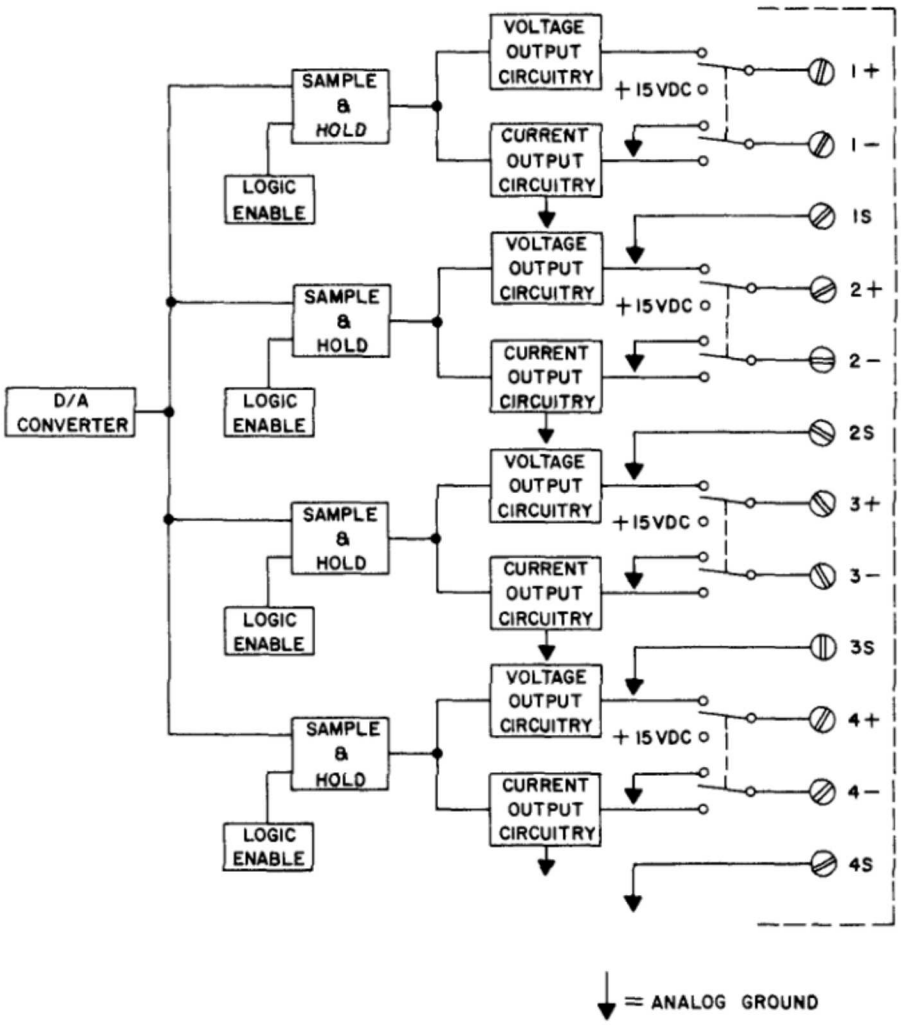
Output span and zero settings must be manually calibrated in order to establish parameters for the precision voltage reference. Calibration is required whenever the module is moved to a different rack, the power supply is changed, a new range is selected, or whenever the user suspects the accuracy has exceeded the specified tolerance of ± 0.5%.

The analog circuitry of the module is designed to float at the potential of the analog output ground, typically established by the connection configuration to the device being controlled. Power isolation on the module is accomplished by the Analog Devices AD 940 DC-to-DC converter. Digital to analog circuit isolation is accomplished via HP optocouplers.

The module operation and control is governed by the Intel 8031 microprocessor, while the Intel 8255A *PPI* chip is used to regulate bus traffic.

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## 7.3 Simplified Schematic (Output Circuitry)




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# APPENDIX A
# STANDARD ANALOG OUTPUT MODULE CALIBRATION

A newly-installed module requires user calibration before operation. Calibration should also be performed if the module is moved to another rack, the range is changed, the power supply is changed, or the user suspects module accuracy is falling outside of the ± 0.5% specification. Each channel requires individual calibration using the respective ZERO and SPAN (OFFSET and GAIN) potentiometers on the front face of the module. By establishing the endpoints, the module's reference and linearizing circuitry will maintain accuracy over the entire range. Greater reliability will be achieved if calibration is performed at operating temperatures.

In addition to a processor, rack, and power supply, the user will also require a programmer or loader/monitor, cable (preferably shielded, twisted-pair) and a voltmeter. An analog input module may be used in place of the voltmeter, but calibration parameters will not be as precise. If the module will be operated on the current range, a precision 100 ohm resistor will be needed if the voltmeter *cannot be switched to current operation.* The selected range will apply to all 4 channels, which must be individually calibrated. Refer to the appropriate range calibration procedure below. The processor must be in RUN. When performing the calibration, it may be necessary to repeat the procedure several times. If the user is unsuccessful in making progress, we suggest turning both potentiometers counterclockwise until the channel output ceases to *change, then beginning the appropriate range calibration* procedure again.

### 0 to 10VDC Range

1) Set range DIP switches.
2) Set output channel register to 9999. Adjust SPAN (GAIN) potentiometer until 9.999 volts is displayed.
3) *Set output register to 0. Adjust ZERO (OFFSET) potentiometer* until 0.000 volts is displayed.
4) Repeat steps 2 and 3 to achieve the desired precision.
5) Repeat this procedure for the other three channels.

### −10 to 10VDC Range

1) Set range DIP switches.
2) *Turn the SPAN and ZERO (GAIN and OFFSET) potentiometers* counterclockwise until the channel output ceases to change.
3) Set output channel register to 9999. Adjust SPAN (GAIN) potentiometer until 9.999 volts is displayed. Call this voltage X.
4) Set output channel register to 0. Note displayed output, and call this voltage Y.
5) Calculate the desired minimum output Z thusly:

$$Z = Y - \frac{X + Y}{2}$$

6) Adjust ZERO (OFFSET) potentiometer until Z is displayed.
7) Set output channel register to 9999. Adjust SPAN (GAIN) potentiometer until 9.999 volts is displayed.
8) Adjust to desired precision either by repeating steps 3 through 7 or manually tweaking the potentiometers to achieve the desired precision.
9) Repeat the procedure for the other 3 channels.

EXAMPLE: $X = 9.999, Y = -9.676$

$$Z = -9.676 - \frac{9.999 - 9.676}{2} = -9.838$$

After adjusting the ZERO (OFFSET) potentiometer until output channel signal was −9.838 volts, the output channel register was set to 9999, and the SPAN (GAIN) potentiometer was adjusted until the output channel signal was 9.999 volts. Upon entering 0 into the output channel register, the signal was seen to be −9.988 *volts. More precision could be achieved by alternately tweaking* the potentiometers.

### 1 to 5VDC Range

1) Set range DIP switches.
2) Set output channel register to 9999. Adjust SPAN (GAIN) potentiometer until 4.999 volts is displayed.
3) *Set output channel register to 0. Adjust ZERO (OFFSET)* potentiometer until 1.000 volts is displayed.
4) Repeat steps 2 and 3 until desired precision is achieved.
5) Repeat the procedure for the other 3 channels.

### 4 to 20MA Range

1) Set range DIP switches.
2) *For calibration with voltmeter, connect 100 ohm resistor across* the channel "+" and "−" terminals.
3) Set output channel register to 9999. Adjust SPAN (GAIN) potentiometer until 1.999 volts is displayed.
4) Set output channel register to 0. Adjust ZERO (OFFSET) potentiometer until 0.400 volts is displayed.
5) Repeat steps 3 and 4 until desired precision is achieved.
6) *Repeat the procedure for the other 3 channels.*

Note: If an ammeter is used in place of a voltmeter, step 2 should be ignored, with outputs of 19.99 and 4.000 mA to be used for calibration with steps 3 and 4.

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