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SQUARE D

Instruction Bulletin

SY/MAX®

Class 8030 Type RIM125 16 Channel Analog Input Module

Bulletin #30598-209-01B1
June 1995



Replaces 30598-209-01A4
Dated May, 1991

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⚠ CAUTION

EQUIPMENT DAMAGE HAZARD

To avoid improper handling of equipment:

1. **Never remove this device while power is ON. Turn power supply switch to OFF and wait until all indicating lights are off before removing.**
2. **Do not subject to static discharge. This module contains electronic components that are very susceptible to damage from electrostatic discharge.**

Failure to observe this precaution can result in equipment damage.

⚠ WARNING

HAZARDOUS VOLTAGE

Do not touch the terminal block or the circuit board while power input wiring is connected.

Failure to observe this precaution can result in severe personal injury or death.

PLEASE NOTE

Electrical equipment should be serviced only by qualified electrical maintenance personnel, and this document should not be viewed as sufficient instruction for those who are not otherwise qualified to operate, service or maintain the equipment discussed. Although reasonable care has been taken to provide accurate and authoritative information in this document, no responsibility is assumed by Square D for any consequences arising out of the use of this material.

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1 DESCRIPTION OF THE TYPE RIM125 MODULE

1.1 Introduction

The Class 8030 Type RIM125 SY/MAX 16-Channel Analog Input Module provides the capability for inputting 16 channels of high-level analog input signals (0-20 mA, 4-20 mA, 0-5 VDC, 1-5 VDC, 0-10 VDC, +/-5 VDC, +/-10 VDC) to SY/MAX Programmable Controllers which have register I/O addressing capability, or to the SY/MAX PID Loop Controller (Process Control Module). This instruction bulletin describes the installation, programming, operation, and troubleshooting of the analog input module.

The analog module can be inserted into any slot of a register rack (except slot 1) or the register slot of a digital rack. Each module utilizes 16 registers in the system, one register per channel, in which the analog current or voltage being measured is converted to a value ranging from 0 to 9998 in increments of 1. This provides a register value in percent of full scale, with accuracy to 2 decimal places. Simple programming techniques allow these input readings to be scaled to engineering values, provided the processor being used has math capability.

The module requires no external power supply to operate because it draws its power from the SY/MAX power supply connected to the rack and requires no additional components, such as current loop resistors. No user adjustment of the span and zero is required, as automatic calibration is performed by one of the two on-board microprocessors. Two removable terminal strips facilitate quick replacement and eliminate the need for rewiring.

1.2 General Operation

The module performs its tasks utilizing several subsystems. The analog-to-digital converter (ADC) performs the actual conversion of the selected input channel, while the multiplexor (MUX) , under the control of one of the on-board microprocessors, performs the channel selection. The auto-calibration system (ACS) includes zero and reference voltage. The module also contains a DC-to-DC converter, and signal and power isolation circuitry. (See Section 7.1 for a block diagram of the operation.)

1.3 Front Panel Features

Figure 1-1 shows the module's front panel, with two terminal strips and a RUN LED (green). The two terminal strips each contain eight groups of two terminals with two additional terminals at the bottom; each group corresponds to one input signal or channel. One terminal exists for the positive wire of the signal source, one terminal for the negative and the shield wire. Section 3.4 discusses field wiring considerations.

The green RUN LED indicates that the digital logic circuitry in the module is functioning properly. See Section 6 for more information about interpreting LED operation.

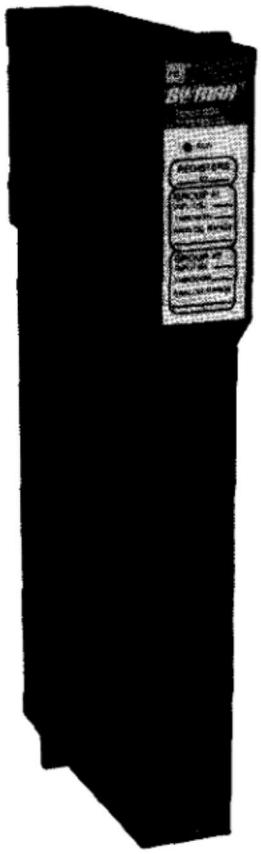


Figure 1-1 RIM125 Front Panel

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1.4 Side of Module

Four sets of DIP switches, accessible by removing the side cover plate (see Figure 1-2), allow users to select the desired address borders, range settings, and software averaging. Up to two different range settings can be selected on the module at the same time (one on group 1 and one on group 2) with the additional selection of the border (1 - 16) between groups 1 and 2. See Section 3.3 for locations of DIP switches and proper settings.

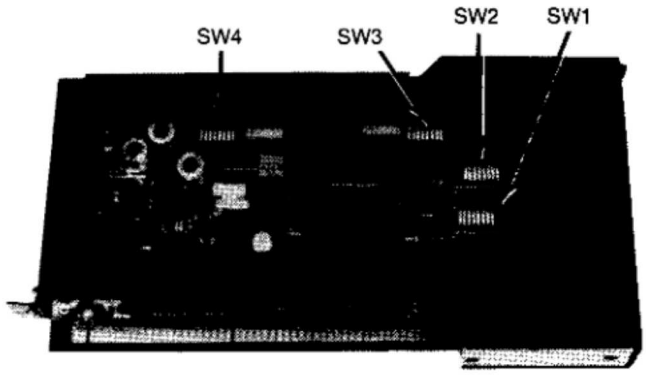


Figure 1-2 Side of Module, Cover Removed

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2 SPECIFICATIONS

2.1 Electrical

Inputs per module . . . . . 16 (two user-defined groups)

Ranges. . . . . 0-5 VDC, 1-5 VDC, 0-10 VDC, +/-5 VDC, +/-10 VDC, 0-20 mA, 4-20 mA

Accuracy . . . . . +/-0.05% (of full scale) at 25° C +/-0.25% over 0-60° C range

Resolution . . . . . 13.5 bits, one part in 10,000 (full scale range in the storage register of 0-9998, in increments of 1)

Under-range indication. . . . . Converted to -0001 for the 1-5 VDC and 4-20 mA inputs at signals less than 0.9 VDC and 3.6 mA respectively. All other unipolar and bipolar voltage ranges are converted to 0000.

Over-range indication . . Converted to 9999.

Conversion rate . . . . . 180 milliseconds for all 16 channels, 60 milliseconds for 4 channels

Worst case update time . . . . . Less than 360 milliseconds for all 16 channels, less than 120 milliseconds for 4 channels.

Isolation. . . . . 300 V channel to ground (or analog circuit to digital logic circuit) continuously applied. 1500 V fast transient burst isolation.

Maximum input overload. . . . . 30 mA (current), 50 VDC (voltage), applied continuously to the input terminals

Current loop resistors . . 250 Ohm +/-0.025%, 25 ppm/°C (resident in the module)

Power requirement . . . . 800 mA current draw from SY/MAX power supply connected to the rack

Input impedance . . . . . 0.1 µF in parallel with 100 megaOhms (voltage) or 250 Ohms (current)

Common mode rejection ratio . . . . . 84 dB

A/D converter type . . . . 14-bit high speed

Multiplexer type . . . . . Harris Type HI1-506A-7, 16 *channel, single-ended CMOS* MUX

Microprocessor type . . Two Intel QP80C31BH

RUN light . . . . . Indicates digital logic circuitry is functioning properly

Product certification . . UL, CSA, FM

2.2 Physical

Weight . . . . . 2.7 lbs (1.2 kg) approx..

Dimensions (WxHxD). . . 1.5 x 12.8 x 6.6 inches 3.8 x 32.5 x 16.8 cm

2.3 Environmental

Ambient temperature ratings:
Operational . . . . . 0 to 60°C
Storage . . . . . -40 to +100°C

Humidity rating . . . . . 5-95% RH, non-condensing

2.4 Compatibility with Racks

The following SY/MAX Class 8030 racks are compatible with the Type RIM125 module:

- RRK100, RRK200, RRK300 (except the first slot of all RRK racks and slots 17 & 18 of RRK300)
- HRK100, HRK150, HRK200 (register slots only)
- CRK210, CRK300 (register slot only)
- DRK210, DRK300 (register slot only)
- GRK110, GRK210 (register slot only)

2.5 Compatibility with Processors

The following SY/MAX Type SCP programmable controllers can be used with the Type RIM125 module:

- SCP311 and 312 (Series E and later)
- SCP323 and 344 (Series C and later)
- SCP313, 321, 322, 332, 333 (Series D and later)
- All Model 400, 450, 500, 600, 650 and 700 programmable controllers.

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3 INSTALLATION

3.1 Physical Inspection

3.1.1 New Module

The Type RIM125 module requires no additional components to function. The module is shipped set for the 0-10 volt range with all channels assigned to Group 1. Single (1) sample is also selected. The module requires no manual adjustments for setting zero and span. This is performed by the automatic calibration system. The user should not, however, plug the module into a rack before completing the following compatibility checks explained in their parenthetical references:

- The proper range for the application is available (Section 2.1)
- The proper range is selected (Section 3.3)
- The processor is compatible (Section 2.5)
- The rack and necessary slot are available (Section 2.4)
- The SY/MAX family power supply is adequately sized (Instruction Bulletin #30598-159)
- The rack is keyed properly (Section 3.2)
- Field wiring terminations are understood (Sections 3.4 and 5.2)
- The required programming, especially rack addressing, is understood (see appropriate programmer instruction bulletin).

Install the module by aligning the edge connector with the slot provided in the rack, and insert the card so that it snaps into place. Be sure to secure module to the rack with the captive fastening screw on the bottom.

⚠ CAUTION

EQUIPMENT DAMAGE

Do not insert or remove the RIM125 while the rack is powered up, or while wires carrying input signals are connected to the module. See Section 3.5 for general start-up procedures and Section 5.1 for application considerations regarding module insertion.

Failure to observe this precaution can result in equipment damage.

3.1.2 Replacing A Module

The RIM125 can be quickly and easily replaced with another module. There is no need to rewire the analog input points as the terminal strip (Part #30617-002-50) can be removed by simply pulling it straight off the face of the module (Figure 3-1). Be sure that the DIP switches in the replacement module have been properly coded for the desired range. No software reprogramming is necessary. See Section 5.1 for application considerations regarding module insertion and removal.

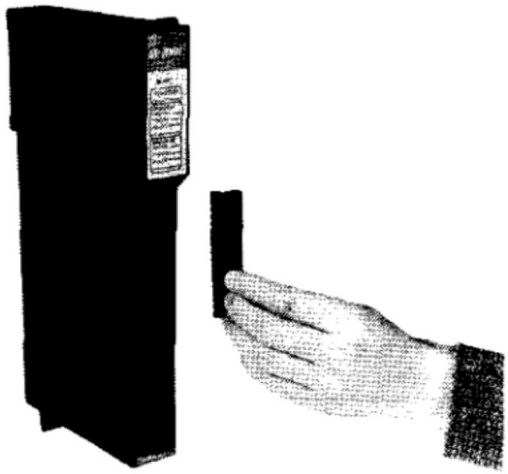


Figure 3-1 Terminal Strip Removal

3.2 Keying

It is possible to key a particular slot on the rack assembly so that only the Type RIM125 module can be inserted there. A keying pin kit, Class 8030 Type CBP104, may be used to insert a keying pin between pins 56 and 58 of the appropriate slot, as described in the register rack Instruction Bulletin, #30598-265. The same procedure also applies to the register slots of any digital rack.

The factory installed keying pin should not be removed from the register slots, as it ensures proper alignment between the slot pins and edge connector pads when the module is inserted or removed.

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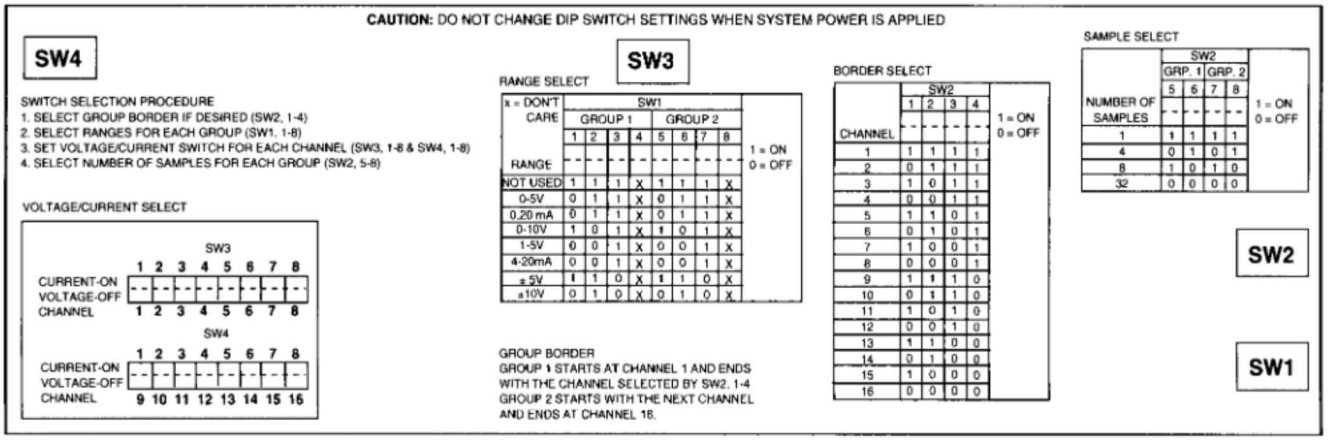


Figure 3-2 DIP Switch Summary

3.3 DIP Switch Settings

Removing the large cover plate on the side of the module provides access to four DIP switches for selecting a group address border, current or voltage ranges and software averaging (if needed). These settings should never be changed while the module is powered up. See Figure 3-2 and Sections 3.3.1 through 3.3.3 for the appropriate settings; note especially the labeling and orientation of the switches.

In this bulletin, individual switches are identified by a group number and a switch number. For example, 1-4 is switch 4 of DIP switch group 1.

⚠ CAUTION

EQUIPMENT DAMAGE

DIP switch settings should never be changed while power is applied to the module!

Failure to observe this precaution can result in equipment damage.

Notes:

- *Switches 1-4 and 1-8 are currently not used.*
- *If a range is not selected for a group (NOT USED) then these channels are not scanned by the module. This helps to decrease the overall update time of the module.*
- *One side of the first two switches of each DIP switch group is labeled "O" and "N" for ON. Press down on this side of the switches to set any of the switches ON.*

3.3.1 DIP Switch 1

DIP switch 1 is used to select the gain ranges for input groups number 1 and 2 as shown in Table 3-1. It is possible to select two ranges within a single group. This is done by selecting or deselecting the 250 Ohm shunt resistor.

⚠ CAUTION

EQUIPMENT DAMAGE

Switches should not be set in any combination other than that shown in Figure 3-2.

Failure to observe this precaution can result in equipment damage.

Table 3-1: DIP Switch 1 Selection

	Group 1			Group 2		
Switch	**1-1**	**1-2**	**1-3**	**1-5**	**1-6**	**1-7**
Range						
NOT USED	ON	ON	ON	ON	ON	ON
0-5V	OFF	ON	ON	OFF	ON	ON
0-20MA	OFF	ON	ON	OFF	ON	ON
0-10V	ON	OFF	ON	ON	OFF	ON
1-5V	OFF	OFF	ON	OFF	OFF	ON
4-20mA	OFF	OFF	ON	OFF	OFF	ON
+/-5V	ON	ON	OFF	ON	ON	OFF
+/-10V	OFF	ON	OFF	OFF	ON	OFF

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3.3.2 DIP Switch 2

DIP switch 2 indicates the last analog channel in group 1 (see Table 3-2) and also enables software averaging for groups 1 and 2 (see Table 3-3).

Table 3-2: Group 1 And 2 Delineation

Switch	2-1	2-2	2-3	2-4
Border				
1	ON	ON	ON	ON
2	OFF	ON	ON	ON
3	ON	OFF	ON	ON
4	OFF	OFF	ON	ON
5	ON	ON	OFF	ON
6	OFF	ON	OFF	ON
7	ON	OFF	OFF	ON
8	OFF	OFF	OFF	ON
9	ON	ON	ON	OFF
10	OFF	ON	ON	OFF
11	ON	OFF	ON	OFF
12	OFF	OFF	ON	OFF
13	ON	ON	OFF	OFF
14	OFF	ON	OFF	OFF
15	ON	OFF	OFF	OFF
16	OFF	OFF	OFF	OFF

DIP switches 2-5 through 2-8 are used to select the option for software averaging of the input signals on groups 1 and 2. Switches 5 and 6 and switches 7 and 8 are used for groups 1 and 2, respectively. The value is invalid for the first number of samples (the selected number of samples) after power-up. Each sample is placed in a stack and the average for the number of samples selected is provided to the processor.

Table 3-3: Software Averaging Selection

Group 1			Group 2		
Switch	**2-5**	**2-6**	**Switch**	**2-7**	**2-8**
No. of Samples			**No. of Samples**		
1	ON	ON	1	ON	ON
4	OFF	ON	4	OFF	ON
8	ON	OFF	8	ON	OFF
32	OFF	OFF	32	OFF	OFF

3.3.3 DIP Switches 3 and 4

These DIP switches are turned on to select a 250 Ohm shunt resistor for each input channel if the input signal for that channel is either 0-20 or 4-20 mA. DIP switches 3-1 through 3-8 are for input channels 1 through 8, and 4-1 through 4-8 are for input channels 9 through 16, respectively.

3.4 Field Wiring Terminations

Each analog input signal is wired to one pair of front input terminals (Part #30617-002-50). The numbered terminal accepts the positive input from the analog source. The "C" terminal is the common analog ground and accepts the negative input from the analog source as well as the shield wire.

It is recommended that the wiring used be a shielded twisted pair (Belden 8760 or equivalent), with the shield connected to the RIM125 module **only**. Note that all sixteen "C" terminals share a common analog ground. See Section 5.2 for more information on wiring.

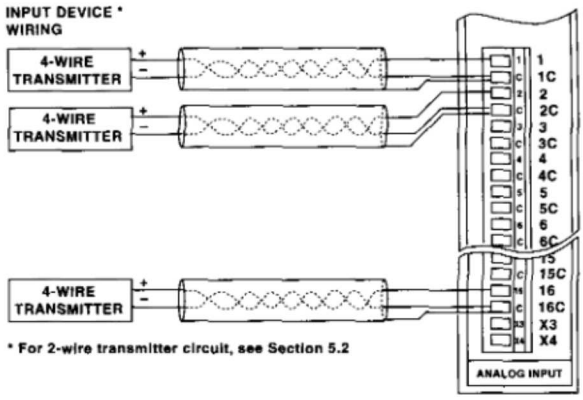


Figure 3-3 Typical Field Wiring

Note that terminals X1, X2, X3, and X4 are not used at this time.

3.5 RIM125 Start-Up

3.5.1 Necessary Processor Instructions

Before inserting the RIM125 into the rack, confirm that all DIP switches are correctly set (see Section 3.3).

The module may be inserted in the rack when

- the DIP switches are set
- rack addressing has been correctly assigned to recognize the module in that particular slot
- rack power is *off*
- no input signal is connected to the terminals of the module.

If the analog input module's microprocessors are functioning properly, at system power-up, bits 25 to 32 of the status field for the assigned registers reflect the following code:

11000001 (C1 Hex)

Bit 32 *Bit 25*

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HARDWARE CONFIGURATION

CRK, DRK, GRK or HRK Rack		
Register Slot (2)	**CPU Slot (1)**	**Digital I/O Slots**
RIM125	Model 400	

SYSTEM ADDRESSING
CPU Slot 0
Channel 0
Drop Number 0
Slot Number 1 96
Slot Number 2 112

COMMENTS
This will assign analog input channels 1 - 16 to registers 97 - 112 in the processor.

Example 1 — Model 400 in Digital I/O Rack With Register Slot

HARDWARE CONFIGURATION

RRK100 or RRK200 Rack			
Slot 1	**Slot 2**	**Slot 3**	**Empty Register Slots**
Model 400	CRM210	RIM125	

SYSTEM ADDRESSING
CPU Slot 0
Channel 0
Drop Number 0
Slot Number 1 —
Slot Number 2 96
Slot Number 3 112

COMMENTS
This will assign analog input channels 1 - 16 to registers 97 - 112 in the processor.

Example 2 — Model 400 in Register Rack

HARDWARE CONFIGURATION

RRK100 or RRK200 Rack			
Slot 1	**Slot 2**	**Slot 3**	**Empty Register Slots**
Model 500 (double width)		RIM125	

SYSTEM ADDRESSING
CPU Slot 0
Channel 0
Drop Number 0
Slot Number 1 460
Slot Number 2 —
Slot Number 3 476

COMMENTS
This will assign analog input channels 1 - 16 to registers 461 - 476.

Example 3 — Model 500 in Register Rack

If this bit pattern is not found in the expected registers, then either the system has been incorrectly rack-addressed or the module has failed its initialization sequence and is sending back an alternate bit pattern to describe the nature of the failure. See Table 4-1 for an explanation of the error codes. The module's RUN light may also fail to illuminate.

For a more systematic approach to checking out the operation of these modules, the test configuration and rack addressing assignments shown in the following examples can be used. These are only intended as examples of possible configurations which can be used for familiarization purposes. Final actual system layout depends on a user's proper understanding of the system definition or rack addressing as outlined in the Programmer instruction bulletin.

It is possible that non-zero values may be contained in the data field of those processor registers that are monitoring the analog input channels, even when those input channels have no input signal connected to them. This is not unusual when operating on any of the voltage range settings, due to the nature of high input impedance and CMOS multiplexing circuitry.

3.5.2 Indicator Light

Illumination of the green RUN light indicates that the RIM125's microprocessor is functioning properly, but does NOT necessarily mean that incoming analog signals are being properly converted.

If the RUN light is ON, but the RIM125 is not functioning properly, one of the following conditions may exist:

1. The slot in which the module is inserted may be misaddressed.
2. The user-defined border settings may be invalid.
3. The RIM125 may be set for a range that is not compatible with the input device.
4. The user-defined range settings may be invalid.
5. The RIM125 may be experiencing one of several miscellaneous non-fatal errors.

See Table 4-1 for possible error code conditions, and Section 6 for troubleshooting procedures.

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4 PROGRAMMING

4.1 Register Usage and Rack Addressing

Each analog input module occupies up to sixteen registers of the system. These sixteen registers should be assigned to the slot in which the module is inserted, and will exist *even if some of the channels remain unused.*

4.2 Status and Error Register Table

Table 4.1 contains the possible codes that may be found in bits 25 though 32 of the status field of the assigned registers, generated by one of the analog input module's on-board microprocessors.

Table 4-1 Status Bits

32	31	30	29	28	27	26	25	Description
1	1	0	0	0	0	0	1	Normal Operation
0	1	1	0	0	0	1	0	EPROM/RAM Failure
0	1	1	0	0	0	0	0	DC-DC Failure
0	1	0	1	0	0	1	1	Watchdog Failure
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	0	0	0	0	0	0	0	Slot not addressed

See Section 6.2 for a detailed explanation of these conditions.

4.3 Programming Equipment

Any series of the following types of Class 8010 programming devices can be used with the RIM125:

SY/MAX CRT Programmers	SPR250, SPR260, SPR300, SPR310
SY/MATE and SY/MATE Plus Personal Computer Software	SFI/SFW322, SFI/SFW323, SFI/SFW324, SFW 374/375, SFW472/473/474

The following listing summarizes the necessary series designation for other programming equipment.

Class 8010 Type:
SPR-100 Series D or later (Rev. 2.1)
SPR-200 Series H or later (Rev. 1.4)
SPR-201 Series D or later (Rev. 1.4)
SPR-210 Series H or later (Rev. 1.4)
SPR-211 Series D or later (Rev. 1.4)

4.4 Connection of Programming Equipment

Proper programming equipment needs to be connected to the processor controlling the slot in which the analog input module is inserted. The module cannot be interrogated separately.

4.5 Program Steps

The values stored in the analog input registers may be utilized as would any storage register value (that is, in IFs, LETs, COMM statements, and so on). Valid data in the storage registers can range from 1 to 9998 in increments of 1. Thus, the value stored in the register reflects to two decimal places the percentage of the selected input signal being received. The values 0 and 9999 indicate under-range and over-range conditions, respectively, an indication that the signal being sent falls at the limits or outside the selected range.

4.6 Example Programs

In many cases, the incoming signal may need to be scaled to reflect the actual voltage or current values being received. Table 4.2 indicates the resolution being provided with the respective signal ranges, and demonstrates mathematically how the register values may be scaled or converted to their actual input values. The same technique is used to convert a register value to engineering units.

For the following examples assume register 109 contains the signal being measured by the analog input channel,

Table 4-2 Signal Range Resolutions

Range	Programming Rung	Result Read Register 100 in:	Resolution Provided by Analog Input Module
0-20mA	LET S100=S109x2	micro-amps	2 micro-amps per bit
4-20mA	LET S100=S109÷5x8+4000	micro-amps	1.6 micro-amps per bit
0-5VDC	LET S100=S109÷2	millivolts	0.5 millivolts per bit
1-5VDC	LET S100=S109÷5x2+1000	millivolts	0.4 millivolts per bit
0-10VDC	LET S100=S109	millivolts	1 millivolt per bit
+/-5VDC	LET S100=S109-5000	millivolts	1 millivolt per bit
+/-10VDC	LET S100=S109x2-10000	millivolts	2 millivolts per bit

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register 100 contains the mathematical result which has been scaled to reflect the actual voltage or current being input, and that these registers are used strictly for this purpose. Note that a value of 0 or 9999 in register 109 could be flagged as a limit or out-of-range condition.

When converting data, be aware of the computational limits of the processors. For example, the Models 300, 401 and 500 are restricted to integer math, whereas the Models 423, 424, 444, 631, 632, 452, 453, 654, 655 and 700 can do floating point calculations. Furthermore, the intermediate or final results of a Model 300 calculation cannot exceed +/-32,767, while in the Model 500 the intermediate result is a more liberal +/-2,147,483,647 but the final result must be within +/-32,767. Thus, when performing scaling on the REGISTER VALUE, it is prudent to observe the most stringent condition, that is, no intermediate or final result should exceed +/-32,767.

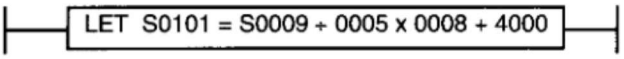
For example, assume we are monitoring a 4 to 20mA input with a register value of 5000. All variables to solve the transfer equation are provided and:

$$\text{INPUT SIGNAL} = \frac{5,000 \times 16}{10,000} + 4 = 12\text{mA}$$

Because the units being used will cost a great deal of precision, it is better to "think" in terms of micro-amps instead of milliamps and the equation now becomes:

$$\text{INPUT SIGNAL} = \frac{5,000 \times 16,000}{10,000} + 4,000 = 12,000\mu\text{A}$$

Assuming we are reading the REGISTER VALUE of 5,000 in register 9 and that register 101 is an unused storage register, the proper ladder rung to solve the transfer equation is:



which would result in S101 = 12,000 in the example. Note how judicious placement of the mathematical operators prevents the generation of an incorrect result. If the operation was first multiplied by 8, followed by the division by 5, an intermediate result greater than 32,767 would be generated and the calculation would fail in a Model 300. However, in all other processors this is *not* a problem and would be preferable (to multiply by 8 first) because it provides greater accuracy.

NOTE: All SY/MAX processors execute math operations strictly left-to-right.

4.7 Program Editing

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

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5 APPLICATION CONSIDERATIONS

5.1 Inserting and Removing the Module

⚠ CAUTION

EQUIPMENT DAMAGE

Do not insert or remove the module while the rack is powered up, or while wires carrying input signals are connected to the module. See Section 3.5 for general start-up procedures.

Failure to observe this precaution can result in equipment damage.

The rack must be powered down before the module is inserted. Insertion or removal of a module while the rack is under power may cause a bus error, causing the processor which is addressing the card to go to HALT, with the indication of an I/O error.

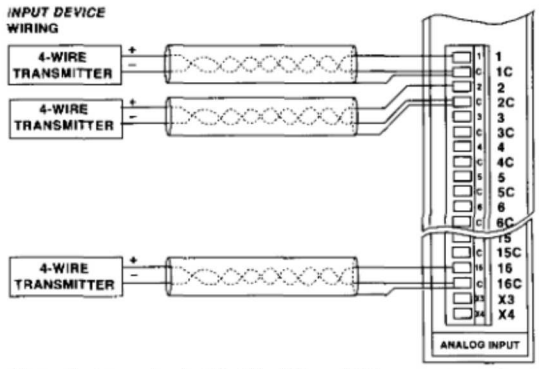
If the processor keyswitch is in RUN, the user should attempt to clear the error by toggling the processor keyswitch momentarily to HALT and then back to RUN. If this fails to clear the error, turn the keyswitch back to HALT and cycle power on the processor and the RIM125 module. If the error persists, remove power from the rack and attempt to re-seat the module. Similarly, when swapping modules, power should be removed from the rack to avoid the possibility of generating a bus error.

Factory installed keying pins should not be removed from the register slots, as they ensure proper alignment between the slot pins and the edge connector pads. Removal of the keying pins leaves open the possibility that the module may be inserted or removed at some angle other than straight on, resulting in a mismatch of slot pins and the edge connector pads.

5.2 Wiring

It is recommended that users connect the signal wires to input terminals of the module only when the transmitter or signal generating device is powered down. The analog circuitry of the module does not have the same ground reference as the digital circuitry, consequently, because the analog signals are allowed to "float," the actual potential difference existing between the module channels and local earth ground will depend on the system layout configuration. See Figure 7-2 for a simplified schematic of the module.

Always connect the transmitter or signal generator to the analog input module using shielded, twisted pair cable,



Note that terminals X1, X2, X3 and X4 are not used at this time.

Figure 5-1 Typical Field Wiring

Belden 8760 or equivalent. The shield protects the current carrying wires from noise, while the twisting of the wires helps to ensure that any noise which does penetrate to corrupt this signal influences both wires equally. In this way, the differential signal level between the two wires is maintained, and the signal is preserved due to the common-mode rejection designed into the module.

When wiring the RIM125 channels to the analog signal source or transmitter, proper configuration depends on the polarity and conventions followed by the manufacturer. The RIM125 should be treated as any load which is a part of the signal loop. Note that 2-wire and 4-wire transmitters are typically wired with different polarities. For instance, Figure 5-1 is applicable in cases where the signal generating device provides power to the loop, as with 4-wire transmitters.

A 2-wire transmitter, however, would be wired with the polarity opposite to that shown in Figure 5-1, because it acts as a load to the external power supply driving the loop. Figure 5-2 illustrates wiring of a 2-wire transmitter. Note that the 2-wire transmitter and RIM125 module are both loads on the external power supply; the power supply should be sized accordingly. Also see the transmitter manufacturer's wiring diagram for proper connections. **Do not mix 2-wire and 4-wire transmitters on one RIM125.**

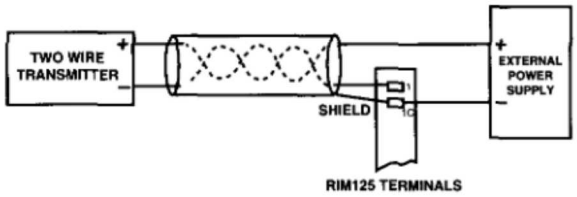


Figure 5-2 Two-Wire Transmitter Wiring

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Following are some other recommended practices:

- The shield must only be connected at one end—at the input module where the "C" terminal is provided for the shield of each pair of signal carrying wires. At the other end (near the transmitter) the shield should be peeled back and insulated from any contact with the other signal carrying wires and ground. This practice of using a single point for shield ground is especially applicable when a cable has been spliced or nicked; the user should exercise care to ensure that the shield is insulated along its entire length, and that it never comes in contact with any other surface.
- The unshielded portions of the wire run (such as the transmitter and at the analog input module) should be kept as short as practical.
- Wires carrying analog signals should be routed as much as possible away from potential sources of noise such as motors, transformers, or contactors. Be especially aware of any AC devices. As a rule of thumb, allow 6 inches (15.2 cm) of separation for every 120 volts. Analog signal wires must never share the same conduit with AC wiring. On those occasions where you must pass close to AC wiring, do so at right angles.
- Transmitters should not share the same signal return wire. Furthermore, because all 16 "C" (common) terminals on the module share the same analog ground, all transmitters connected to the module must reference the same ground at the other end. Failure to observe this practice will result in ground loops which will destroy the integrity of the individual signals. **Do not mix 2-wire and 4-wire transmitters on one RIM125.**
- When operating on a high-voltage range, the allowable length of the wire is limited by the capacitance build-up to a distance of approximately 50 feet (15.2 meters). The 0-20 and 4-20mA settings will have better noise immunity. Allowable distance on the current settings is limited by the drive capability of the transmitter (typically 600-1000 ohms) and the total loop resistance.
- The RIM125 is unable to properly interpret DC voltages below -13VDC (+/-10VDC range). DC voltages below this will result in incorrect data (value other than 0) present in the register assigned to that analog input point. No damage will result to the module up to +/-550VDC.
- Consult the bibliography at the end of this Instruction Bulletin for extensive information regarding considerations for analog signals.

5.3 Miscellaneous Considerations

All 16 channels are updated by the module every 180 milliseconds. This rate depends on the number of channels being scanned. See Section 5.4 for information on analog update times.

When using the analog input module in the same rack assembly as the Model 500 or 700, it is mandatory that 4, 8, 12 or 16 registers be assigned to each slot in which an analog input module is installed. When used with the Models 300, 400, 450, 600 and 650, it is possible to assign any number of registers from 1 to 16 if some channels will remain unused. In cases where not all of the channels on the module have been assigned registers, the input signal should be wired 1 through 16 in ascending order or they will not be accessible.

Due to the nature of CMOS multiplexing circuitry, non-zero values may appear across the plus and common terminals when operating on a voltage range, even with no wires connected to the terminals. This is an inherent characteristic of the high input impedance exhibited by solid state multiplexors, and is a normal condition which the user should be aware of.

DIP switch settings for the range should not be altered while the module is under power. These settings are read by the module on a routine basis and if changed may result in momentary incorrect readings.

Module "C" (common) inputs are not individually isolated. Connecting analog input signals with different ground references from each other to the same module could result in erroneous readings.

Analog values are inherently temperature sensitive. The specified accuracy of +/-0.25% of full scale range over the range of 0-60 °C improves to +/-0.05% at room temperature.

5.4 Conversion and Update Times

In certain applications, the user may wish to monitor rapidly changing analog signals which in turn may require faster update times by the analog module. Users may, by reducing the number of channels scanned, also reduce the update time of the analog module. To accomplish this, users would typically select the input range desired for input group number 1 and the number of inputs in that group (for example, a 10 VDC range for inputs 1 through 4). Next, users would select the NOT USED range for input group number 2 (see Table 3-1). By giving up the use of inputs 5 through 16, the module is no longer required to scan the unused channels and would convert the "four channel" module in 60 milliseconds.

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See Table 5-1 for complete information on conversion times versus the number of channels selected.

Conversion time is the time required to sample selected channels, convert them, and make then available to the processor. *Update time is the time required for a change* in the input to be available to the processor. Therefore, a change in the input that just missed being sampled (worst case) could take two times the conversion time before it is made available to the processor. Average update is roughly 35% greater than the conversion time.

Table 5-1: Conversion Rates vs. Channel Selection

No. of Used Channels	Conversion Time
1	30 ms
2	40 ms
3	50 ms
4	60 ms
5	70 ms
6	80 ms
7	90 ms
8	100 ms
9	110 ms
10	120 ms
11	130 ms
12	140 ms
13	150 ms
14	160 ms
15	170 ms
16	180 ms

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6 TROUBLESHOOTING

⚠ CAUTION

EQUIPMENT DAMAGE HAZARD

Never insert or remove the RIM125 module from the rack while it is under power. This principle must be observed when performing any troubleshooting.

Failure to observe this precaution can result in equipment damage.

6.1 Diagnostic Light

The RUN LED indicates that the on-board microprocessor which controls the communication to the SY/MAX processor is functioning properly. Section 3.5.2 lists some of the situations in which the RUN LED may be ON, but the analog signals are not being converted properly. Hence, while an illuminated light does not always indicate proper operation, one can assume that a light which fails to come on indicates a definite problem.

Failures experienced by the analog input module are classified as *fatal* or *non-fatal*. Fatal errors are indicated by the RUN LED remaining OFF. Recovery (when possible) can only be accomplished by cycling power to the rack in which the module is located.

In the case of a non-fatal error, the RUN LED illuminates but the processor (or drop) may refuse to go into RUN. Simple toggling of the processor keyswitch to HALT and back to RUN may be sufficient to clear the error. Distinctions between fatal and non-fatal errors are handled in this fashion because under certain "cold-start" conditions, module circuitry may require a brief warm-up period. Such a condition is not a true module error, but rather a physical circuitry limitation which clears itself after a brief period of time. In these cases, toggling the processor keyswitch is sufficient to allow the system to recover.

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 itself is producing power.

If the RUN LED flashed briefly upon the application of power, this indicates that the module failed to complete its power-up sequence of checks and is indicating a fatal error. Once again, this does not necessarily indicate a defective analog input module. The DC power being provided may be inadequate to sustain operation. This also occurs if there is no processor or remote interface module located in the same rack, because the module's microprocessor can sense that there is no device present with which to communicate.

If the RUN LED on an analog input module refuses to light, therefore, it might be wise to try the module in a configuration in which these possibilities can be ruled out. See Section 3.5.1 for examples of sample trial layouts. If the module is proven to be defective, register status bits will identify the reason.

6.2 Using Programming Equipment

Assuming the RUN LED is ON, the user should now check the controlling processor to verify that communication has been established. This is best done by using the programming equipment in the DATA mode to examine the storage registers which the user believes to be reading the analog input channels. Status bits 25 through 32 of the respective registers reveal a wealth of information. Table 4-1 on page 4-1 is a list of the status bits describing conditions associated with the analog module. Failure of *any* of the listed codes to appear most likely indicates a rack addressing problem. Refer also to Instruction Bulletins #30598-165 or #30598-167.

The codes listed in Table 4-1 may be interpreted as follows:

- **Normal Operation** – All *digital* circuitry is functioning reliably. The application of a signal within the intended operating range should cause changes in the assigned storage register to reflect the changing input. If this does not occur, suspect either the signal generating device or the analog circuit portion of the analog input module. Note that it is possible for the multiplexor or the analog-to-digital converter chip to malfunction and still give the indication of normal operation with RUN LED illumination.
- **EPROM Failure** – The module is defective and must be replaced.
- **DC-DC 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 input module. The module should be replaced.
- **Watchdog Failure** – This indicates a failure of the on-board microprocessor to keep the watchdog circuit from timing out. If this condition occurs, power down the rack in which the module resides and then re-apply power. If the module comes up in Normal

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Operation mode, the condition which caused the fault has been eliminated. If, however, the module comes up with the same error code, the unit 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 seated* properly. Check rack slot addressing for proper allocation of registers and slots.
- **Slot Not Addressed** – The system is not properly configured.

6.3 Erratic Operation

One cause of erratic operation is improper grounding and routing of signal wires. Ensure that the programmable controller system is grounded according to the instructions in the *Planning and Installation Guide* (#30598-175). Also, ensure that the shield of each analog signal wire is connected to the "C" terminal of the module and that the other end is *not* grounded. See Section 5.2 for other wiring considerations.

If there is still uncertainty as to which element in the system may be causing a problem, try the hardware configuration of one of the examples in Section 3.5.1. By virtue of the simplicity of the examples, numerous factors are eliminated to help narrow down the source of the problem.

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7 THEORY OF OPERATION

7.1 Block Diagram

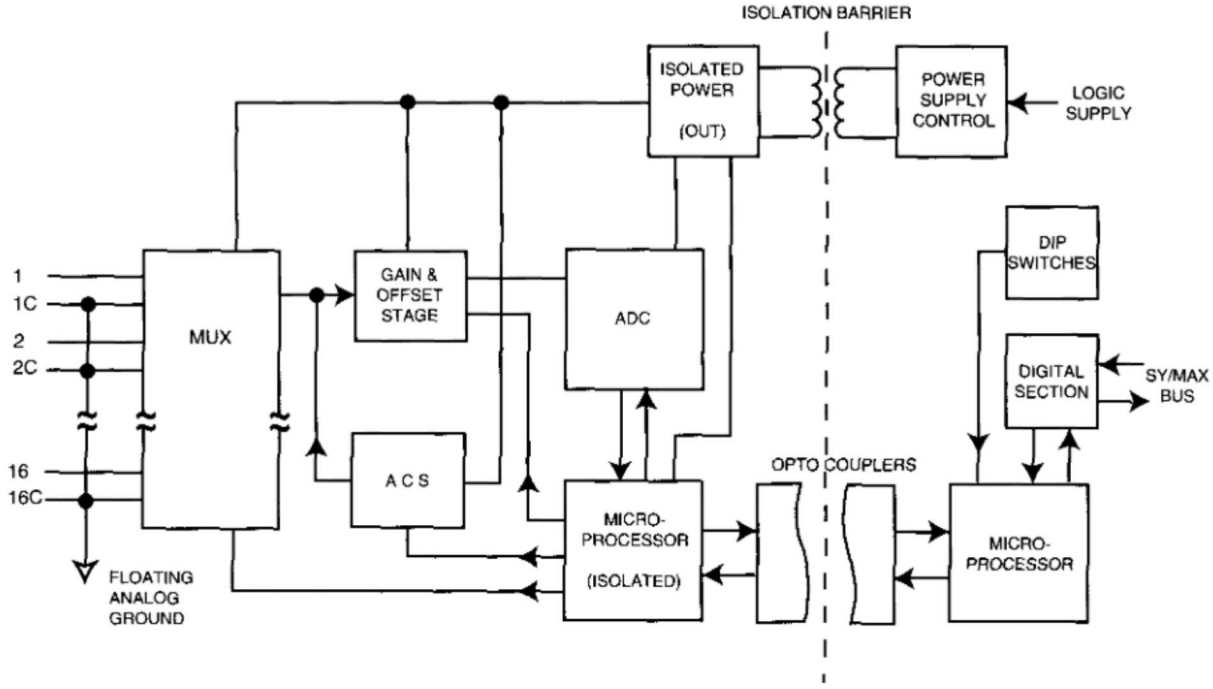


Figure 7-1 Block Diagram

7.2 Description

The analog input module has its own DC/DC power supply circuitry. It converts the 5 VDC from the SY/MAX power supply connected to the rack to the +/-15 VDC required by the analog circuitry as well as +/-5 VDC outputs to furnish power required by the balance of the analog and digital circuitry used in the isolated side of the module.

The module uses a 16-channel, single-ended CMOS multiplexor (Harris Type HI1-506-7) to switch, in turn, each of the 16 channels providing the input signals to the microprocessor controlled gain and offset stage.

The microprocessor which controls the analog subsystem selects an input channel through the analog multiplexor. It also selects the appropriate gain and offset stages (previously selected by the user through the DIP switches) for the input channel which feeds the signal to the analog-to-digital converter.

The module uses a 14-bit high speed analog-to-digital converter (ADC). The 14-bit resolution (1 in 16,384 parts) of the ADC is mathematically compressed to 1 in 10,000 parts by the microprocessor to provide the user with reliable data.

The analog circuitry of the module is designed to float at the potential of the analog input common. Power isolation is accomplished through the use of an isolated, forward flyback, half-wave rectified transformer running at 20K Hz with optical feedback. All communications across the isolation barrier are accomplished by means of HP optical couplers which provide a serial communications link between the two onboard microprocessor operating at 187K baud.

The automatic calibration subsystem (ACS), under the control of the isolated microprocessor, replaces the need for calibrated input signals to make adjustments to eliminate initial errors in system offset and gain. The ACS uses protected CMOS switches to apply both a precision voltage (5.0000 V) and analog ground (0.0000 V) signal to the ADC. These signals are fed through each gain and offset stage in current use by the module to provide a baseline. When subsequent conversions are performed on field analog input signals, the conversion circuitry errors

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are eliminated using a Y = mX+b software-algorithm, providing corrected digital information to the user. The key to accurate ACS operation is a function of the following points:

1. The initial accuracy of the 5V reference must be high; the RIM125 accuracy is 5.0000 V +/-0.0002 V (less than 1/4 of 1 bit worst case).
2. The long-term drift must be low; the RIM125 drift is 15 ppm/1000 hrs.
3. The temperature drift of the reference must be low; the RIM125 drift is 0.3 to 0.5 ppm/degree C typical.

The operation of the module is governed by two Intel 8031 microprocessors running at 12 MHz. One controls such tasks as power-up and operating diagnostic checks, monitoring of DIP switch selections, software signal averaging (when selected) as well as communications to the SY/MAX processor. The second microprocessor provides control of the multiplexor, gain and offset stage selections, ACS, and ADC subsystems.

7.3 Simplified Schematic (Input Circuitry)

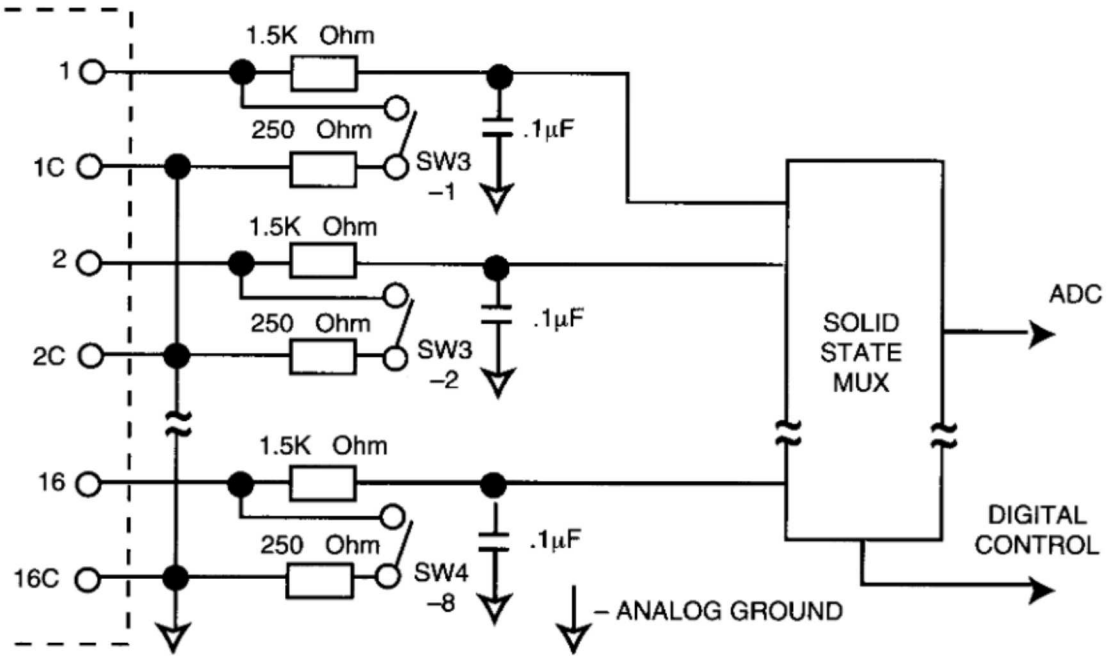


Figure 7-2 Input Schematic

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- IEEE Std 142-1982, *Recommended Practice for Grounding of Industrial and Commercial Power Systems.*
- Ott, Henry W. *Noise Reduction Techniques in Electronic Systems.* New York: Wiley-Interscience, 1976.

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