MINC-11

Book 7: Working with MINC Devices

November 1978

This document describes the physical and electrical characteristics of MINC systems and provides information about making laboratory/MINC connections, system reconfiguration, and troubleshooting.

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INTRODUCTION

USE OF THIS MANUAL

MINC is an integrated system for manipulating data and for monitoring and controlling complex external apparatus. Although computer-based, it is designed not to require detailed knowledge on your part regarding traditional computer hardware and software distinctions. Only at two points does this design principal not fully apply: when electrical connections are made between the MINC system and the outside world, and when system malfunction or operator error makes it necessary to isolate physical system components for scrutiny.

This manual is for users who must approach MINC as a physical and electrical object. It is organized in two parts. Part 1 concerns those questions likely to be asked by anyone who wishes to use MINC as a data transfer device—that is, to acquire data from or transmit data or control information to apparatus outside of the system. This section defines the electrical and mechanical preconditions for running the data transfer routines described in *Book 6: MINC Lab Module Programming.* Part 2 contains information pertinent to troubleshooting and diagnosing problems generated by the physical system or by operator error. It also contains recommendations for configuring systems with multiple MINC modules, setting up the system terminal, confirming data transfer connections, and reducing noise pickup.

Relationship to Other MINC Documents. This manual is not intended to be used alone, but to be read in conjunction with other MINC documents. The most important of these is *Book 6: MINC Lab Module Programming*, which describes the routines

SYSTEM HARDWARE

The physical components of a MINC system can be grouped into two categories: items common to all MINC systems, and those that can be purchased as options, either when the system is first acquired or at some later time as add-ons. See Part 2 for detailed specifications of all components.

All MINC systems include the following standard items:

- MINC cart, which provides support and transport for:
  - Dual diskette drive (RX02M)
  - MINC chassis (MNCBA) with power supply, containing:
    - LSI-11 processor (KD11-NA)
    - 32,768 words (65,536 8-bit bytes) of memory (MSV11-DD)
    - Diskette drive interface (RXV21)
    - Four-channel serial ASCII interface (DLV11-J)
    - IEEE bus interface (IBV11-A)
    - Bus terminator/diagnostic/bootstrap module (BDV11-AA)
  - Terminal with built-in graphics capability (VT105)

MINC systems can include some or all of the following lab modules:

- Analog-to-digital converter (MNCAD)
- Preamplifier (MNCAG)
- Dual multiplexer (MNCAM)
- Clock (MNCKW)
- Digital-to-analog converter (MNCAA)
- Digital input unit (MNCDI)
- Digital output unit (MNCDO)

MINC systems can also include:

- Dot-matrix printer (LA35)
- Isolation transformer (MNCIT)
- 110 baud, 20 mA serial line interface (DLV11-KC)

that control the MINC lab modules and also provides a general framework for approaching control programming problems. Although *Working with MINC Devices* identifies the data transfer routines pertinent to each lab module, its coverage of these routines is cursory and is written on the assumption that the reader either has already read relevant portions of *Book 6* or will go to *Book 6* for the necessary background and specific details.

Similarly, Chapter 6 gives information about the IEEE instrument bus that will be essential to you if you use the routines described in *Book 5: MINC IEEE Bus Programming*. Chapter 9 gives information about the MINC terminal that will be of general use in all system operations and of specific use when you are writing routines of the sort described in *Book 4: MINC Graphic Programming*.

Glossary Flags (*). Most technical terms used in this manual are defined when they are used. Definitions for a few terms, however, must be lengthy to be meaningful. These definitions are given in the Glossary at the end of the manual. When terms included in this Glossary are first used in the manual, they are followed by an asterisk (*). If, when you encounter the asterisk, detailed knowledge of the word's meaning seems necessary to you, you can go to the Glossary definition. If you are reading a section for the first time, however, you will probably decide that you don't wish to be distracted by detail and choose to continue reading.

Detailed understanding of all terms used in this manual will ultimately help maximize your ability to exploit the MINC system's very considerable resources. However, the system lets you accomplish a great deal long before you have achieved such understanding. This system attribute, in fact, lies at the heart of the MINC design. It doesn't hurt to be an expert, but you don't have to be one to do a large amount of constructive work with the system.

Record Keeping Aids. Part 2 contains a section (Mapping Data Transfer Connections) designed to assist you in the essential act of keeping records of what is connected to what in the applications you implement with MINC. You will soon discover that, as you develop more complex applications, clear and precise connection records are not only convenient, they are imperative.

PART 1

DATA AQUISITION AND CONTROL

CHAPTER 1

THE MINC DATA TRANSFER SYSTEM

Each MINC laboratory module (see Figure 1) consists of a metal-encased printed-circuit board with attached front panel and data transfer connector fingers along the top. These modules plug into a special MINC chassis which houses a power supply and a connector network. At the right end of the chassis, the connectors of this network accommodate processor-related modules not accessible to the user. Connectors in the central portion of the chassis accept up to eight MINC laboratory modules and are wired to make appropriate communications links with the processor when you plug a module into the chassis. The wiring also provides connections that permit modules to communicate with one another. A module can generate a signal for its own use or for use by neighboring modules. It can also use a signal originating in a neighboring module and pass it on to the next module or block further transmission. The result is an interconnection network defined by the particular modules plugged into the chassis at any given time.

MODULE PLACEMENT

The interconnections described above permit any given MINC module to communicate with its neighbor when plugged into any of the eight available chassis slots. However, placement of certain modules with respect to one another is restricted by a keying arrangement on the module front panels that prevents modules from being installed in ways that might cause component damage. In general, the analog-to-digital (A/D) converter, wherever it is located, becomes the focal point of most of the interconnection lines. These lines require that the dual multiplexers and preamplifiers be placed on the left of the A/D converter for analog channel expansion. The interconnection lines also require that the digital to-analog (D/A) converter and the digital modules (clock, digital input, and digital output) be installed to the right of the A/D converter. Any unused slots in a finished configuration must occur to the left of the leftmost module; there can be no empty module slots to the right of any module. See Chapter 9, System Configuration Procedures, for more detail.

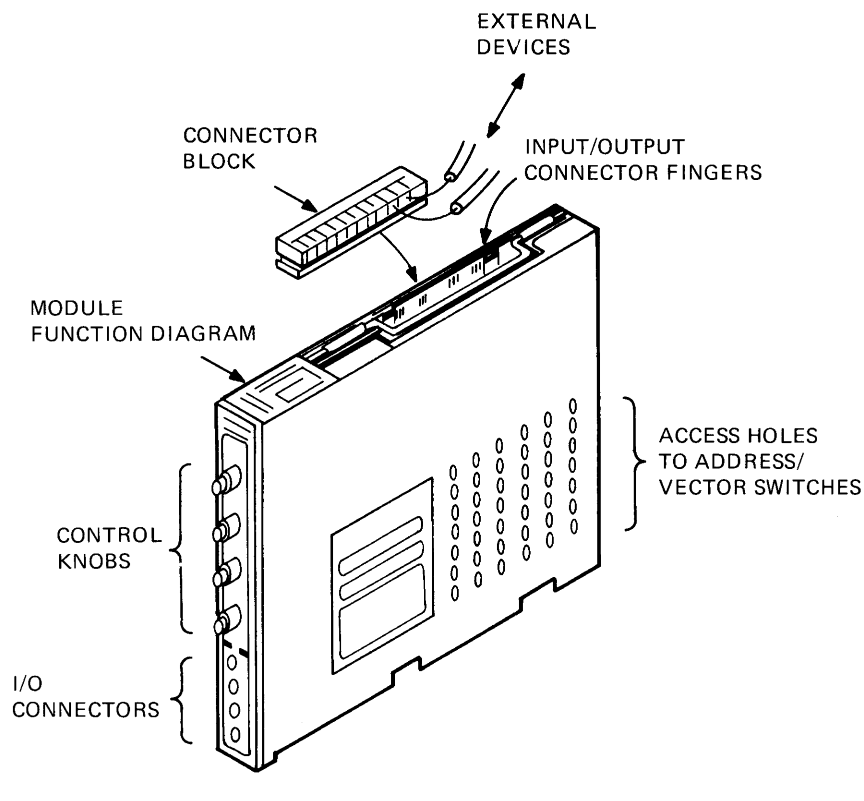


Figure 1. MINC Laboratory Module (A/D Converter)

MINC FUNCTION DIAGRAMS

Each MINC module is provided with a top panel function diagram that symbolically represents the module's function and its principal interconnection lines to other modules. When modules are installed in the MINC chassis, these diagrams build a map of system functions and communications paths (see Figure 2).

Figure 2 shows the map created by the function diagrams on a typical system. Note that certain modules pass on signals that originate in neighboring modules. The digital input, digital output, and D/A converter, for example, pass clock signals to the A/D converter — and the preamplifier and multiplexer modules pass on signals from other modules situated to the left.

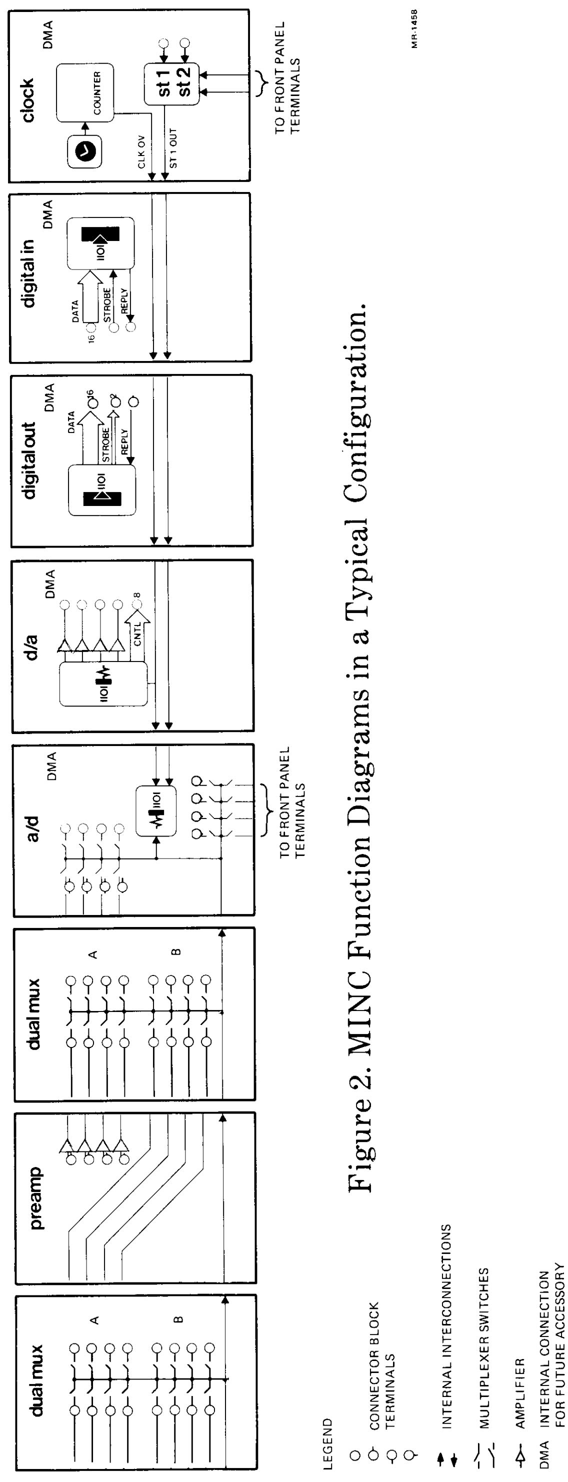


Figure 2. MINC Function Diagrams in a Typical Configuration.

MINC CONNECTOR BLOCKS

Except for the four single-ended channels accessed via the front-panel connectors on the A/D converter module, all MINC lab module connections can be made by means of the MINC connector blocks, illustrated in Figure 3.

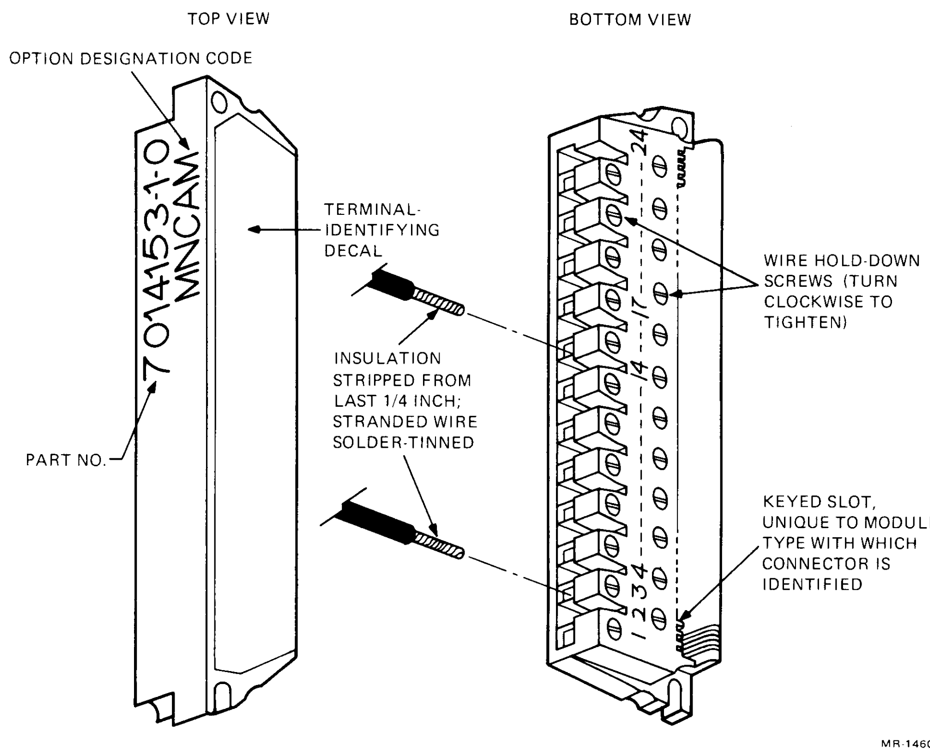


Figure 3. MINC Connector Block

These connector blocks mate with the connector fingers accessible through the top of all MINC modules and permit up to 24 wires from external apparatus to be securely connected to those fingers. Wires are secured initially by means of the hold-down screws integral to the block. Once wires are installed, the connector can quickly be plugged onto the module and equally quickly replaced by a like connector associated with different apparatus. Note that connectors not only carry an identifying option designation code and a screw-terminal identifying label, but also are mechanically keyed to prevent an A/D connector, say, from being plugged onto a digital out or clock module. Connector blocks are identified by option designation codes, which are listed in Table 1. See Chapter 10, Connections to External Apparatus, for information about using MINC connector blocks.

Table 1. MINC Module Option Designation Codes

Option Designation Code	*Module*
MNCAD	A/D converter
MNCAG	Preamplifier
MNCAM	Dual multiplexer
MNCKW	clock
MNCAA	D/A converter
MNCDI	Digital input unit
MNCDO	Digital output unit

CHAPTER 2 ANALOG-TO-DIGITAL CONVERSION

A/D conversions can involve up to four different kinds of MINC modules: the A/D converter itself, the preamplifier, the dual multiplexer, and the clock. These modules are referred to in this manual as the A/D group.

APPLICABLE LAB MODULE ROUTINES

MINC A/D functions are invoked by the following BASIC routines (see *Book 6* for full details):

AIN	Collect analog input data
AIN_HIST	Generate frequency histogram using analog input
AIN_SUM	Sum data from multiple analog sweeps
SET_GAIN	Set Preamplifier gain
TEST_GAIN	Check current gain and operating mode of A/D channel

ANALOG-TO-DIGITAL CONVERTER

The MINC A/D converter (see Figure 4) is a successive approximation* type analog-to-digital converter that translates the instantaneous value of a voltage applied to one of its inputs into a 12-bit binary value accessible to the system computer. The unit uses a patented auto-zeroing* circuit that makes possible A/D conversions of unusually high stability and accuracy. It can operate in differential* and/or single-ended* mode and, through its own multiplexer, can accept data on as many as 16 channels. Assisted by MINC multiplexer modules, the A/D converter can accommodate up to 64 input channels. The unit's first four channels (0-3) receive their inputs via connectors on the front panel;

the remaining inputs must be routed to the A/D connector block (see Figures 4 and 5).

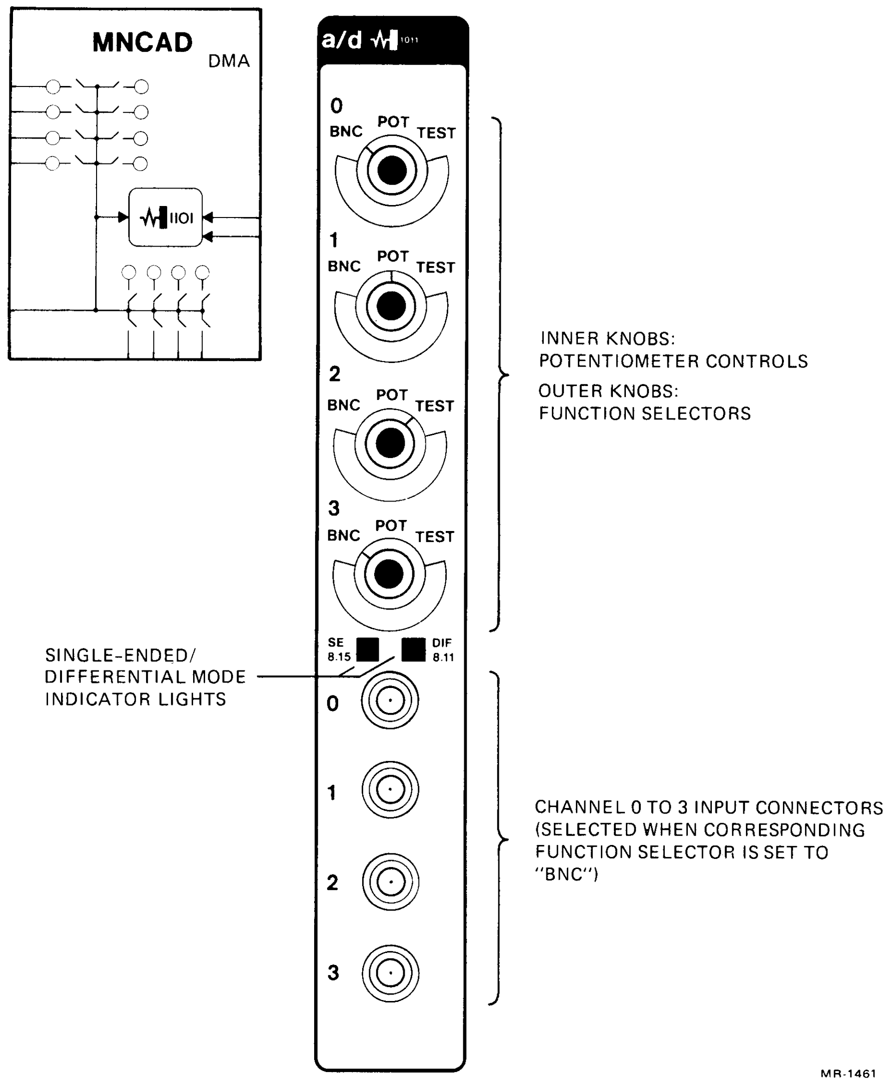


Figure 4. MINC A/D Converter

Front Panel Controls. Four sets of dual concentric knobs on the front panel provide control of three input conditions for each channel from 0 through 3; knob 0 determines input to channel 0, 1 to 1, and so on. The outer knob of each pair has three positions:

BNC: selects as A/D input whatever signal is connected to the associated front-panel connector.

POT: selects as A/D input an internally supplied reference that can be varied between −5.12 V and +5.12 V by the inner control knob.

TEST: selects as A/D input one of four test conditions, depending on the channel involved:

Channel 0: input connected to ground (0 volts)

Channel 1: input connected to an internally supplied 4.5 V level

Channel 2: input connected to an internally supplied -4.5 V level

Channel 3: input connected to an internally generated triangular wave with a frequency of approximately 9.5 Hz and an amplitude of approximately ±6 V.

These test signals provide definable input conditions that are useful in confirming proper operation of the A/D Converter. See Chapter 12.

Mode Indicators. The MINC A/D accommodates two groups of inputs. The first group (lines 0-7, channels 0-7) always operates in single-ended* (s.e.) mode. You can set the second group (by means of a ground connection to the s.e. terminal of the A/D connector block) to operate as eight single-ended channels (lines 8-15, channels 8-15). If the s.e. connection is absent or if a preamplifier occupies an adjacent slot to the left of the A/D converter, the second group operates as four differential* channels (lines 8-15, channels 8-11). The mode indicator lights on the front panel visually identify which condition prevails for lines 8 to 15 at any time.

Expansion. The A/D converter is capable of supporting up to 64 single-ended or up to 56 differential and 8 single-ended input channels. Expansion beyond the 12 or 16 channels supported by the converter alone is accomplished by adding dual multiplexer modules to the left of the A/D converter (see The MINC Dual Multiplexer, below). The A/D communicates with and fully controls the multiplexers via prewired system interconnections.

Preamplified Inputs. If you install a MINC preamplifier to the immediate left of the A/D or to the left of an associated multiplexer, input signals can be amplified by either manually selected or program-selected amounts. The preamplifier automatically identifies itself to the A/D, and the A/D automatically sets itself to differential operation for its second group of channels whenever a conversion through the preamplifier is involved. If the preamplifier is to the immediate left of a multiplexer, the multiplexer automatically sets itself to differential operation for the affected group of channels. See The MINC Preamplifer, below.

Initiation of A/D Conversions. The A/D can initiate conversions immediately upon execution of a program statement, or in response to an external signal (see *Book 6*).

Connector Block Labeling. Two of the 24 terminals on the A/D connector block (15T and -15T) are test points that you can ignore. The remaining 22 terminals provide input and ground connections as defined in Figure 5. Note that certain terminals have dual identity — one for single-ended operation and one for differential operation. The terminal immediately above "ch 8," for example, is labeled "ch 12/rt8." If single-ended operation is selected ("8-15" s.e. connected to ground), this terminal is single-ended channel 12. If single-ended operation is not selected ("8-15" s.e. *not* connected to ground), this terminal is the differential return line for channel 8. And so it goes for the remaining dual-identity terminals on the A/D.

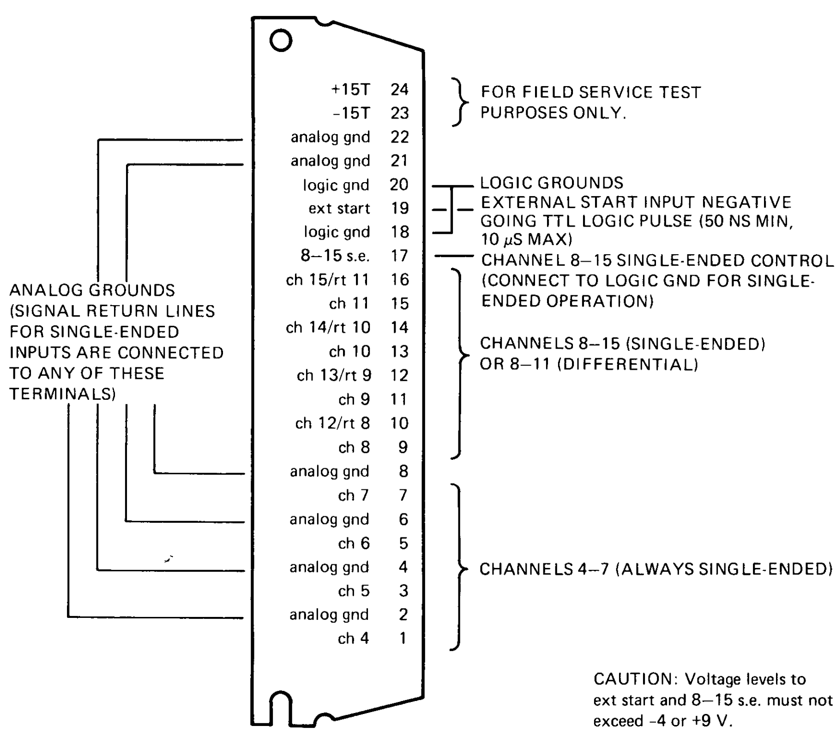


Figure 5. MINC A/D Connector Block

PREAMPLIFIER

The MINC preamplifier provides instrumentation-quality differential* amplification or attenuation of signals on four input channels (see Figure 6). It permits gain to be controlled either by means of front panel knobs or by program argument, and it can be set to respond to resistance (kilohms) or current (milliamps) as well as voltage.

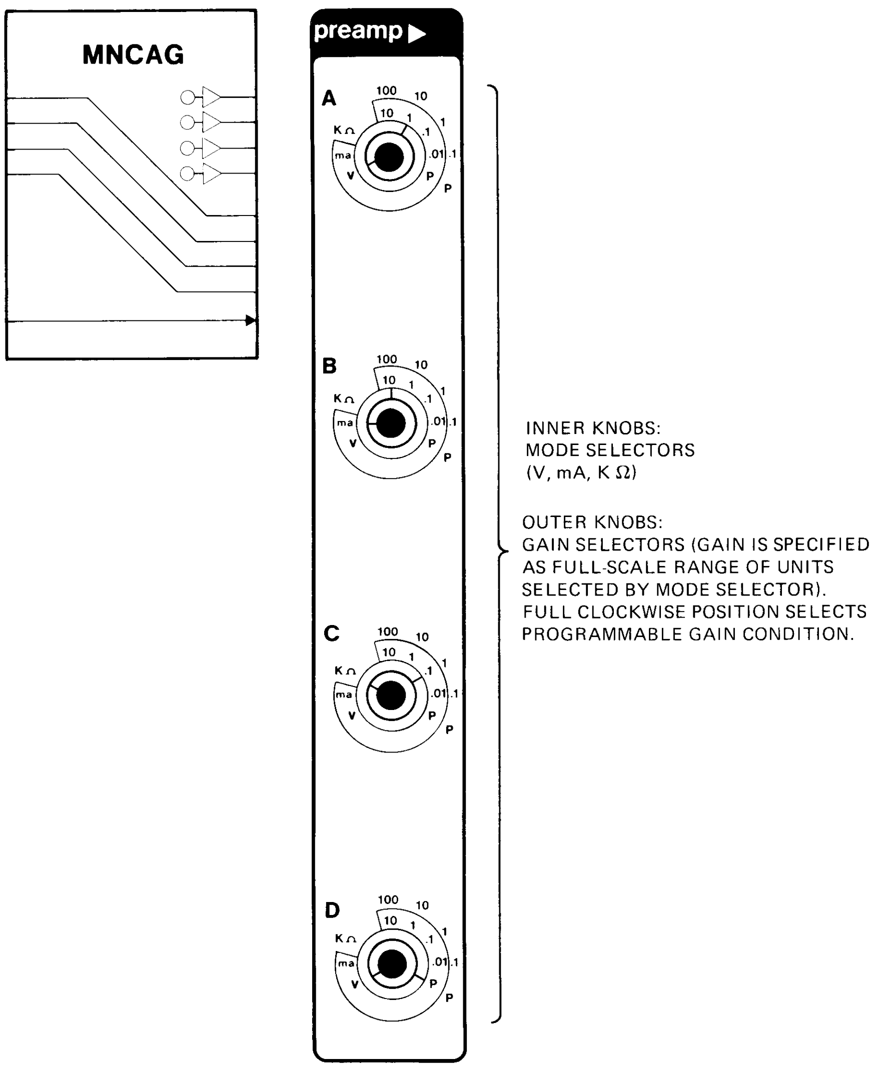


Figure 6. MINC Preamplifier

Front Panel Controls. The preamplifier front panel provides one set of dual concentric controls for each of the four channels. The inner knob in each set selects operating mode — voltage, current, or resistance. The outer knob selects the range for the chosen mode. Mode/range relationships are given in Table 2.

Table 2. Preamplifier Mode/Range Relationships

Mode		*Gain*			
		500	*50*	*5*	*0.5*
Voltage	Setting	±0.01	±0.1	±1.0	±10
	Range (V)	−0.01012 to +0.01012	−0.1012 to +0.012	−1.012 to +1.012	−10.12 to +10.12
Current	Setting	±0.01	±0.1	±1.0	±10
	Range (mA)	−0.01012 to +0.01012	−0.1012 to +0.1012	−1.012 to +1.012	−10.12 to +10.12
Resistance	Setting	0.1	1.0	10	100
	Range (kΩ)	0 to 0.1	0 to 1.0	0 to 10	0 to 100

The outer knob in each set is provided with a fifth position, P, which sets the preamplifier to a mode that permits the program to control gain. The knob must be in this position for the SET_GAIN command to operate. See *Book 6* for more details.

Configuration with A/D or Multiplexer. The preamplifier is designed to communicate with an A/D converter or multiplexer situated to its immediate right. All necessary interconnections are made automatically when preamplifiers are installed in locations adjacent to dual multiplexers or A/Ds; no external connections between modules are required. When a preamplifier is installed to the immediate left of the A/D converter, the single-ended mode selection jumper, if installed, is defeated, and the preamplifier is automatically assigned to the differential four-channel group involving channels 8 through 11 (see Figure 7). Since the preamplifier now occupies channels 8-11, you can no longer use lines 8-15 on the A/D connector block. Doing so will interfere with proper transmission of preamplifier signals and may damage the equipment involved.

When a preamplifier is installed to the immediate left of a dual multiplexer, the preamplifier is assigned to the differential four-channel group involving multiplexer A, channels a through d. If two preamplifiers are so installed, they are assigned to the two contiguous differential four-channel groups provided by multiplexer A and multiplexer B (see Figure 8). Note that you cannot use dual multiplexer connector block lines Aa to Ah when one preamplifier is installed to the immediate left of a dual multiplexer. When two preamplifiers are installed to the immediate left of a dual multiplexer, you can use none of that multiplexer's connector block lines.

Channel codes and dual multiplexer/preamplifier configuration are further discussed under The MINC Dual Multiplexer, below.

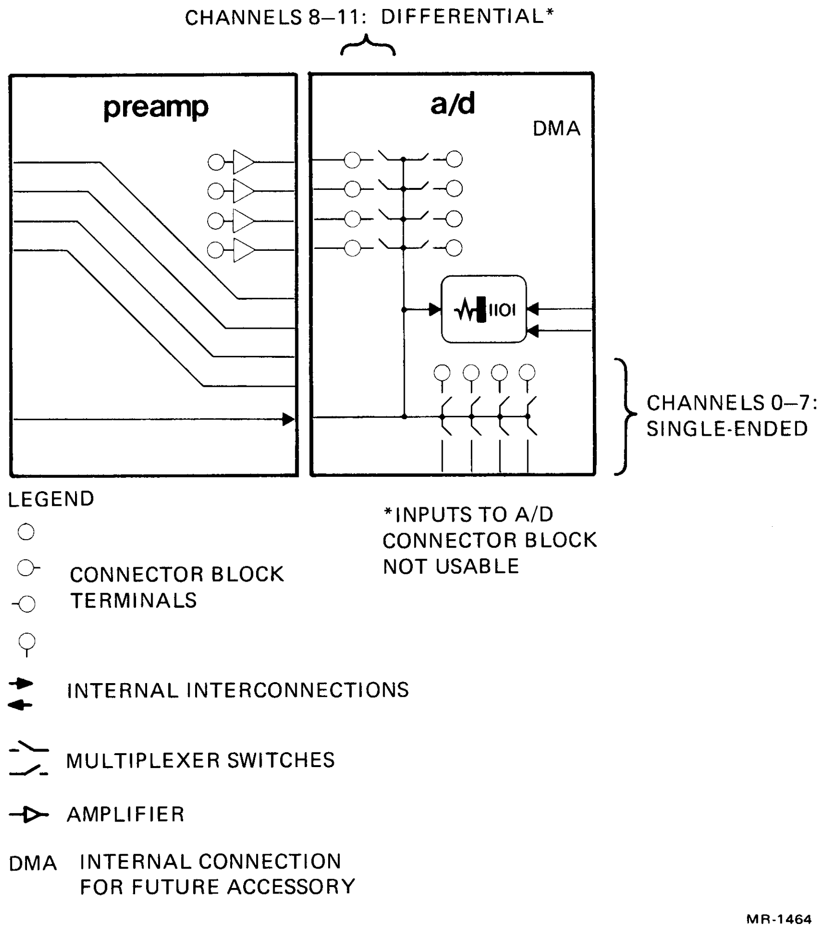


Figure 7. Signal Routing — Preamplifier to A/D

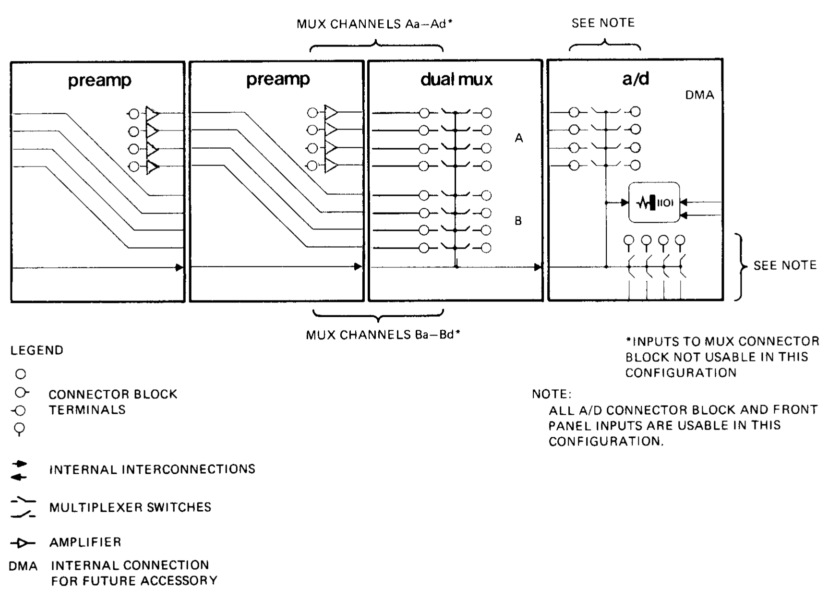


Figure 8. Signal Routing — Preamplifier to Multiplexer

When a Preamplifier Is Required. The most obvious situation requiring a preamplifier is that in which output from a monitored instrument is too low for adequate resolution by the A/D converter. The A/D responds to levels as low as 2.5 mV, but since it measures in 2.5 mV increments, input levels must be at least 50 or 100 mV if these quantum steps are not to introduce significant measurement errors. See Glossary, "Quantizing error."

Other situations requiring a preamplifier might include the following:

> Changes in resistance or current (as from a temperature sensor, strain gauge, or photo-resistor) must be measured and input to the computer for storage or manipulation.
>
> Output from a monitored instrument exceeds the ±5 V range of the A/D and must be attenuated.
>
> Output from a monitored instrument fluctuates widely and requires automatic gain setting (see SET_GAIN command in *Book 6*).
>
> Common mode* rejection of the unpreamplified A/D converter is inadequate for the requirements of the application. In differential mode, A/D rejection of noise common to both differential inputs is very high for frequencies approaching DC, but diminishes as the frequency of that noise increases. The common-mode rejection of the preamplifier, however, is very high at all frequencies. (See Chapter 8 for further information.)

Connector Block Labeling. The MINC preamplifier connector block accommodates instrument connections as defined in Figure 9.

DUAL MULTIPLEXER

The MINC dual multiplexer (see Figure 10) consists of two multiplexers, A and B, each of which permits transfer of a program-selected analog signal on any of eight single-ended or four differential channels to a single transfer line on the MINC chassis connectors. From this point the selected signal travels via the chassis connector wiring and any intervening preamplifiers and multiplexers to the MINC A/D converter installed to the right. Each of the two multiplexers can be independently configured to operate as four differential* or eight single-ended* channels.

Front Panel Indicators. The dual multiplexer front panel contains 20 monitor lights that indicate which channel is currently selected and which mode (single-ended or differential) the channel is set to.

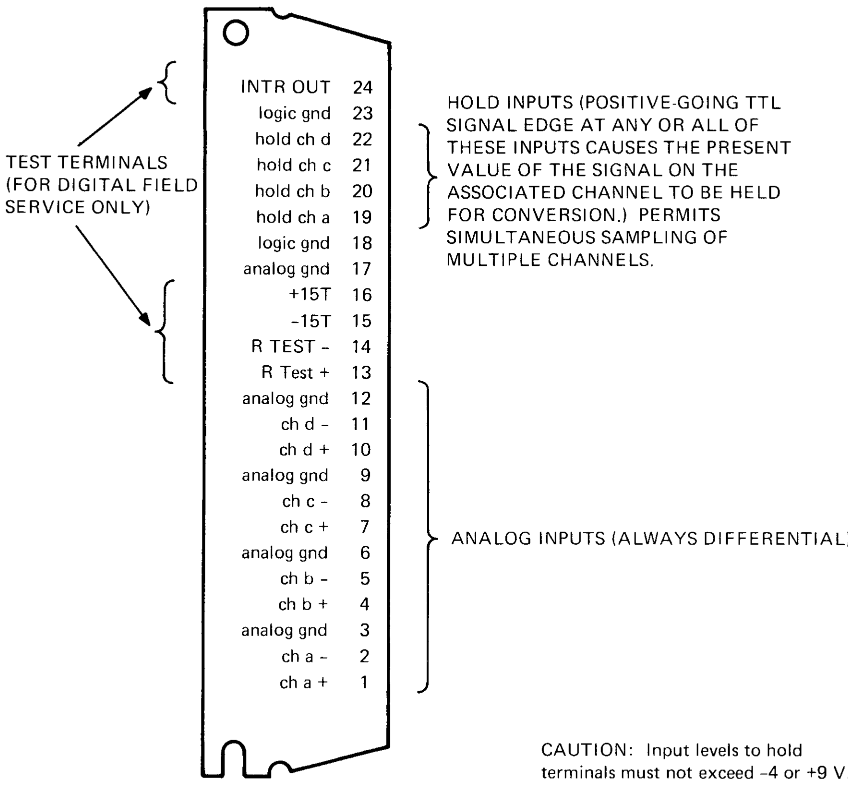


Figure 9. MINC Preamplifier Connector Block

Configuration with A/D and Preamplifier. The dual multiplexer is designed to communicate with an A/D converter situated on its right, and with one or two preamplifiers situated on its immediate left. Both multiplexers and preamplifiers are designed to relay signals to the A/D converter from other multiplexers situated to the left. The result is that an A/D converter can be expanded to accommodate up to 64 single-ended or up to 56 differential plus 8 single-ended channels. Maximum expansions are illustrated in Figures 11, 12, and 13. Table 3 indicates the number of dual multiplexers required for any combination of single-ended and differential inputs.

When Multiplexers Are Required. A dual multiplexer is necessary whenever more A/D input channels are required than can be connected to the A/D converter alone. Remember that, although both the A/D converter and the multiplexer accommodate 16 input lines, the A/D requires that eight of these lines (channels 0-7) always be single-ended. This means that only four differential channels can be accommodated on the lines that remain. Each dual multiplexer, however, can be configured when necessary to accommodate eight differential channels as well as four differential and eight single-ended. Note that MINC assigns channel numbers above 11 or 15 to inputs to dual multiplexers. This means that all inputs to the A/D connector block and front panel are available for connection to external signals even though one or more fully loaded multiplexers are installed in the system.

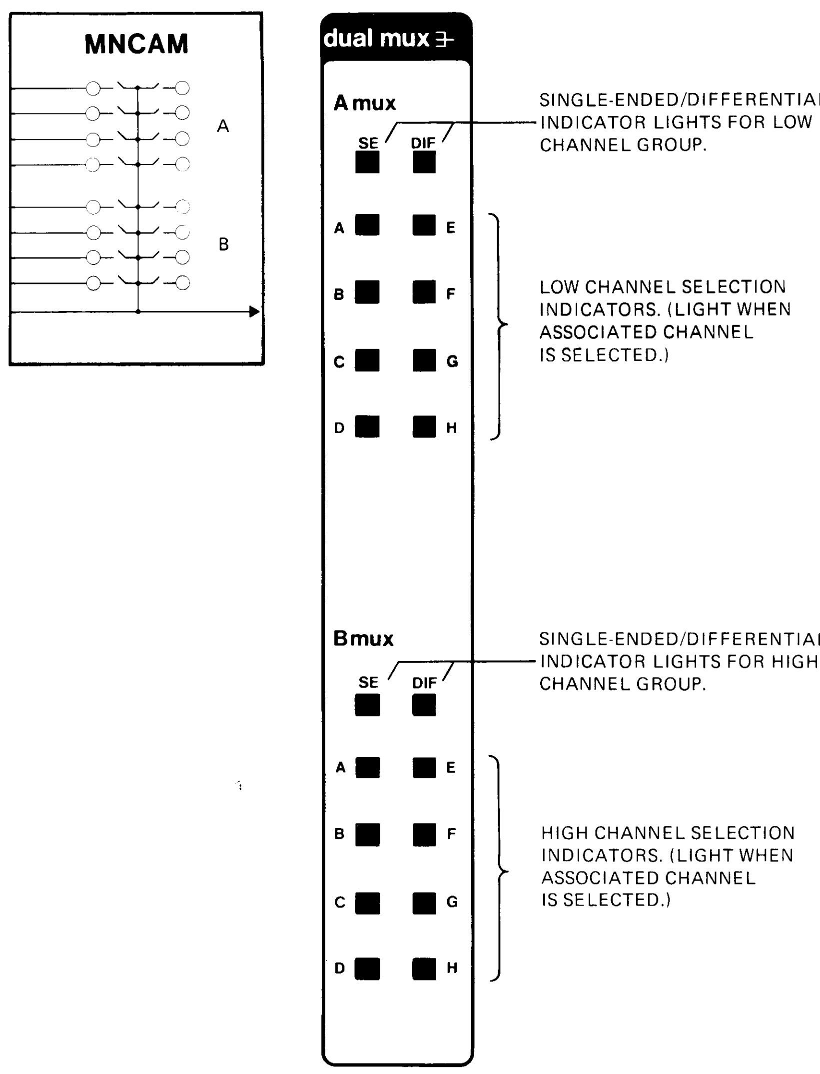


Figure 10. The MINC Dual Multiplexer

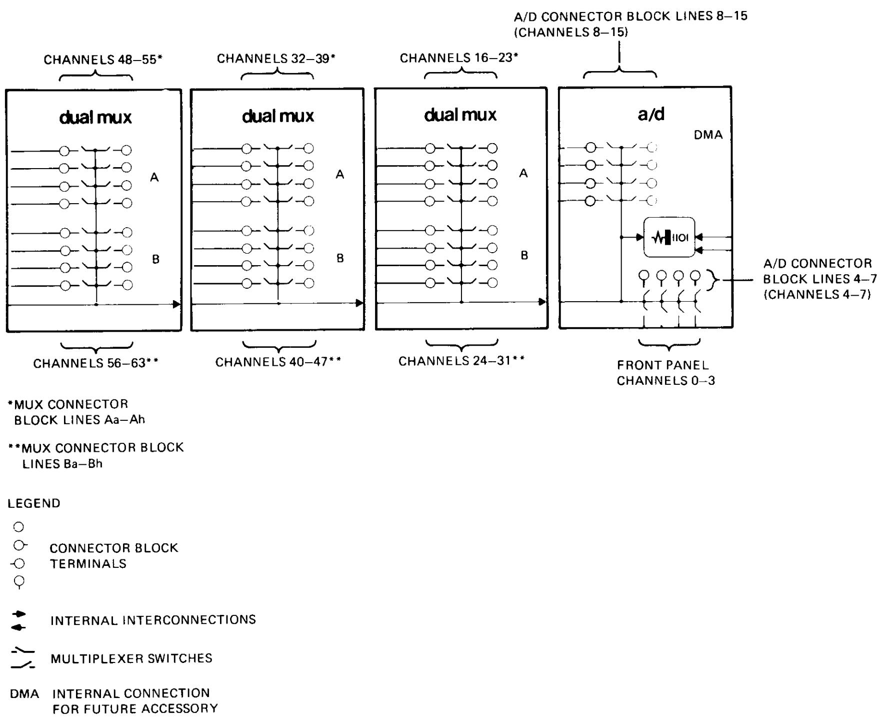


Figure 11. Maximum Expansion of Single-Ended A/D Channels

Connector Block Labeling. The multiplexer connector block accommodates 24 input, control, and ground connections to the multiplexer module. These connections are defined in Figure 14.

Channel identification on the multiplexer connector block, unlike that on the A/D connector block, is symbolic rather than literal. The reason is that the A/D connector block is always involved with the lowest 12 or 16 channels associated with any given MINC system, and numerical channel identification is therefore definable. The dual multiplexer, however, may be one of as many as seven such units on a system, and the numerical identity of its channels depends on how many channels have been accommodated by multiplexers and the A/D converter to its right. Here as elsewhere you will need to maintain accurate records of interface connections. See Chapter 10, Connections to External Apparatus.

NOTE

Channel identification by the A/D converter is dynamic and automatically takes into account whether

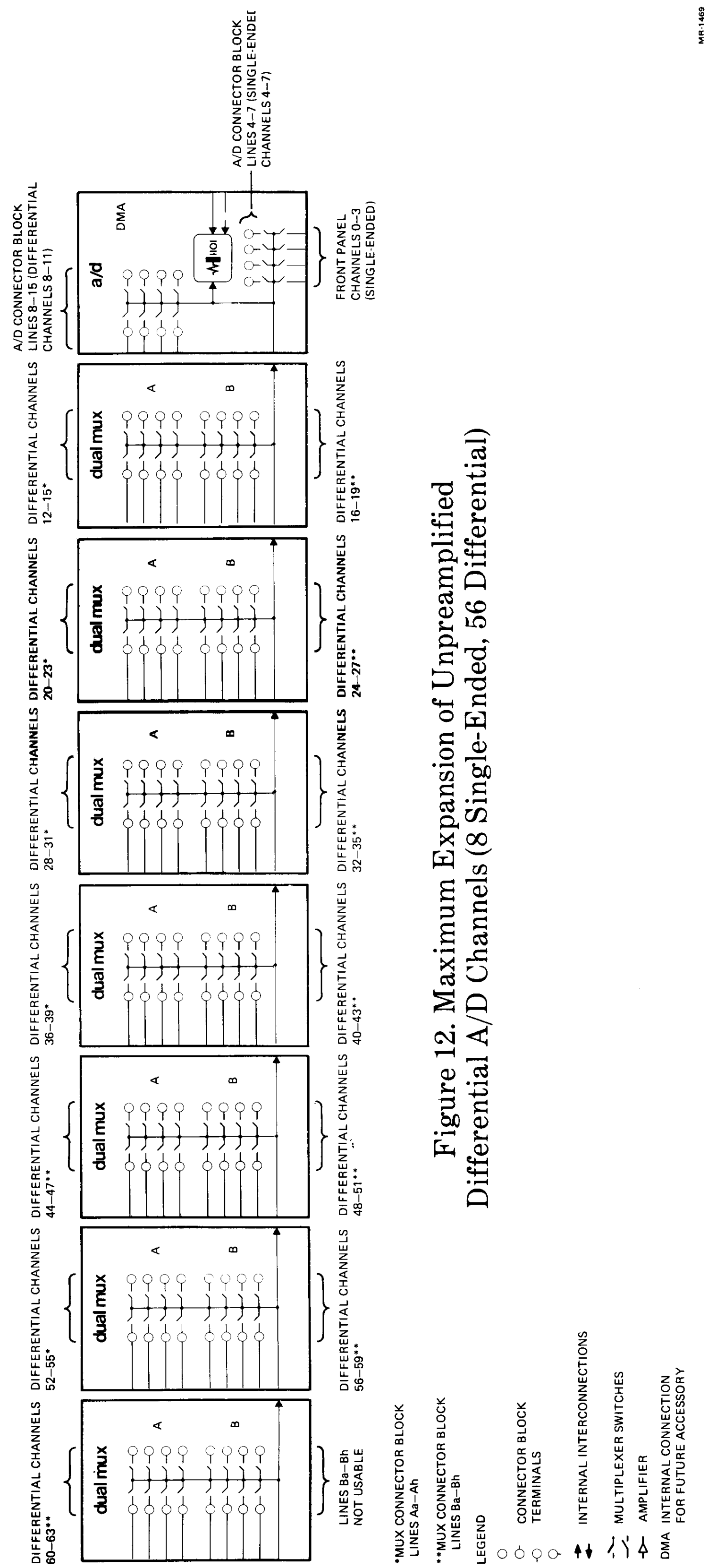


Figure 12. Maximum Expansion of Unpreamplified Differential A/D Channels (8 Single-Ended, 56 Differential)

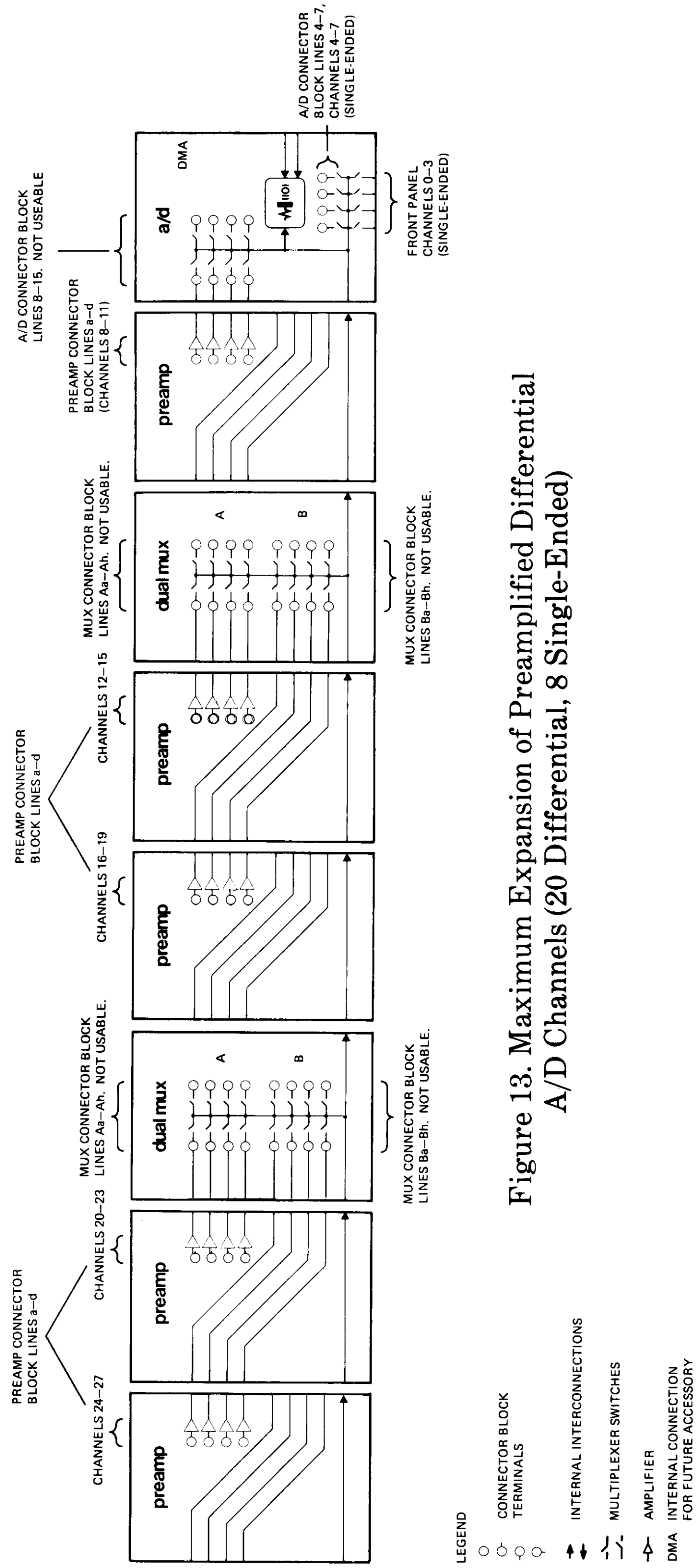


Figure 13. Maximum Expansion of Preamplified Differential A/D Channels (20 Differential, 8 Single-Ended)

Table 3. Multiplexers Required to Support One A/D with n Differential and x Single-ended Input Channels

SINGLE-ENDED CHANNELS \ DIFFERENTIAL CHANNELS	0	1-4	5-8	9-12	13-16	17-20	21-24	25-28	29-32	33-36	37-40	41-44	45-48	49-52	53-56
0		0	1	1	2	2	3	3	4	4	5	5	6	6	7*
1-8	0	0	1	1	2	2	3	3	4	4	5	5	6	6	7*
9-16	0	1	1	2	2	3	3	4	4	5	5	6	6		
17-24	1	1	2	2	3	3	4	4	5	5	6*				
25-32	1	2	2	3	3	4	4	5	5						
33-40	2	2	3	3	4	4	5*								
41-48	2	3	3	4	4										
49-56	3	3	4*												
57-64	3														

*LAST MUX ONLY PARTIALLY ADDRESSABLE

or not channel groups are set for single-ended or differential operating mode. This means that if operating mode is changed for a low group of channels, the numbers of all channels above that group are automatically changed to accommodate the fact that four channels have in effect been inserted or withdrawn at the lower end.

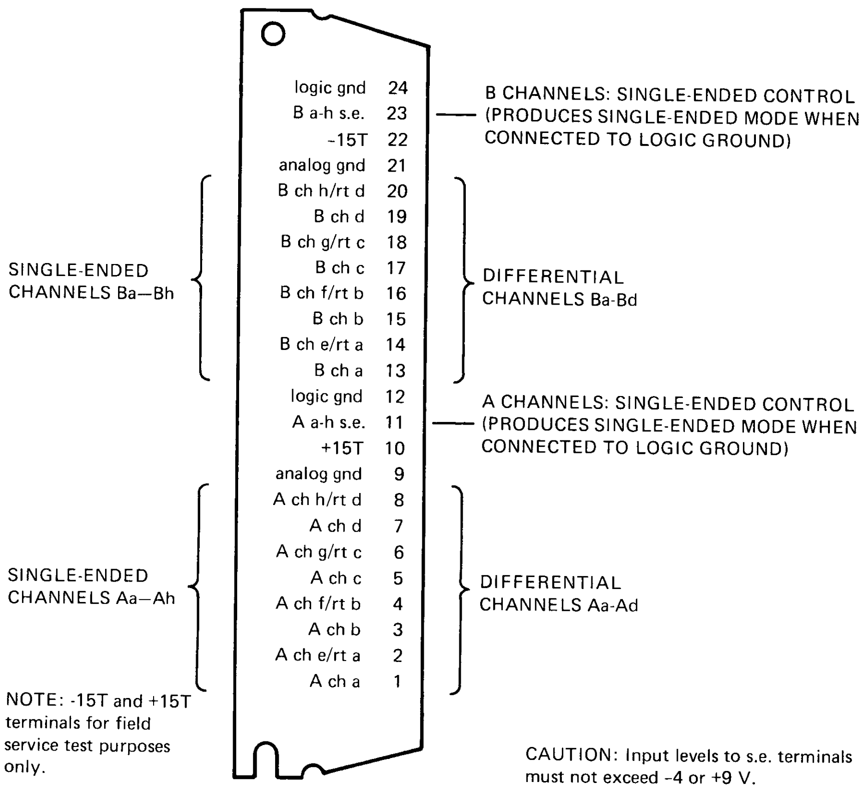


Figure 14. Dual Multiplexer Connector Block Labeling

Assume, for example, that a system with 1 A/D and 1 multiplexer is configured to accommodate 8 single-ended channels (0-7) and 12 differential channels (8-19). Any program requesting conversions on the highest channel in the group would contain an argument specifying channel 19.

If channels 8-11 (on the A/D converter) were now to be converted to single-ended mode, they would thereby become channels 8-15. This change would automatically cause the 8 differential channels associated with the multiplexer to be assigned identification numbers from 16 to 23. If the program arguments were not altered to accommodate these changes, all references to channels with numbers above 11 would be in error, and a call for a conversion on channel 19 would select the input previously associated with channel 15.

The simplest way of avoiding this confusion, and of precluding the need to rewrite large numbers of A/D statements, is to locate all analog inputs whose mode is subject to change at the high end of the channel sequence. If no channels exist that are higher than those whose mode has changed, then program arguments need be changed only for the changed channels. See also Random Channel Mode in *Book 6*.

CLOCK MODULE

To execute A/D conversions, not only must you identify appropriate channels and gain conditions, but you must also determine when and how often conversions are to occur. Lab module routines like AIN and AIN_SUM (see *Book 6*) provide arguments that permit you to designate what events will be used to specify these conditions. Some of those arguments involve using the clock (see Chapter 3, Time Interval Control and Sampling), either as a time-base generator communicating with the A/D via the clock overflow line, or as a transducer of external events communicating with the A/D via Schmitt trigger 1.

Configuration with A/D Converter. The signal transfer paths of the module interconnection system permit a clock to communicate with an A/D converter anywhere to its left as long as no second clock and no A/D-group module intervenes. The D/A converter, the digital output, and the digital input all pass the clock signals to the left without intervention (see Figure 2).

ANALOG INPUT CONNECTIONS

Connecting Grounded Apparatus. If the apparatus providing A/D input is grounded (that is, if its return terminal is connected to power line ground so that signal current can return thereby to the MINC System ground), make connections as illustrated in Figures 15 and 16. These figures show connections to the A/D connector block, but the principles illustrated apply equally well to preamplifier and multiplexer connections.

NOTE

It is good practice to label both ends of your lab module cables in a way similar to that suggested in the connection figures — that is, identifying at each end what is connected to the other. This facilitates confirmation of connections when installations grow complex.

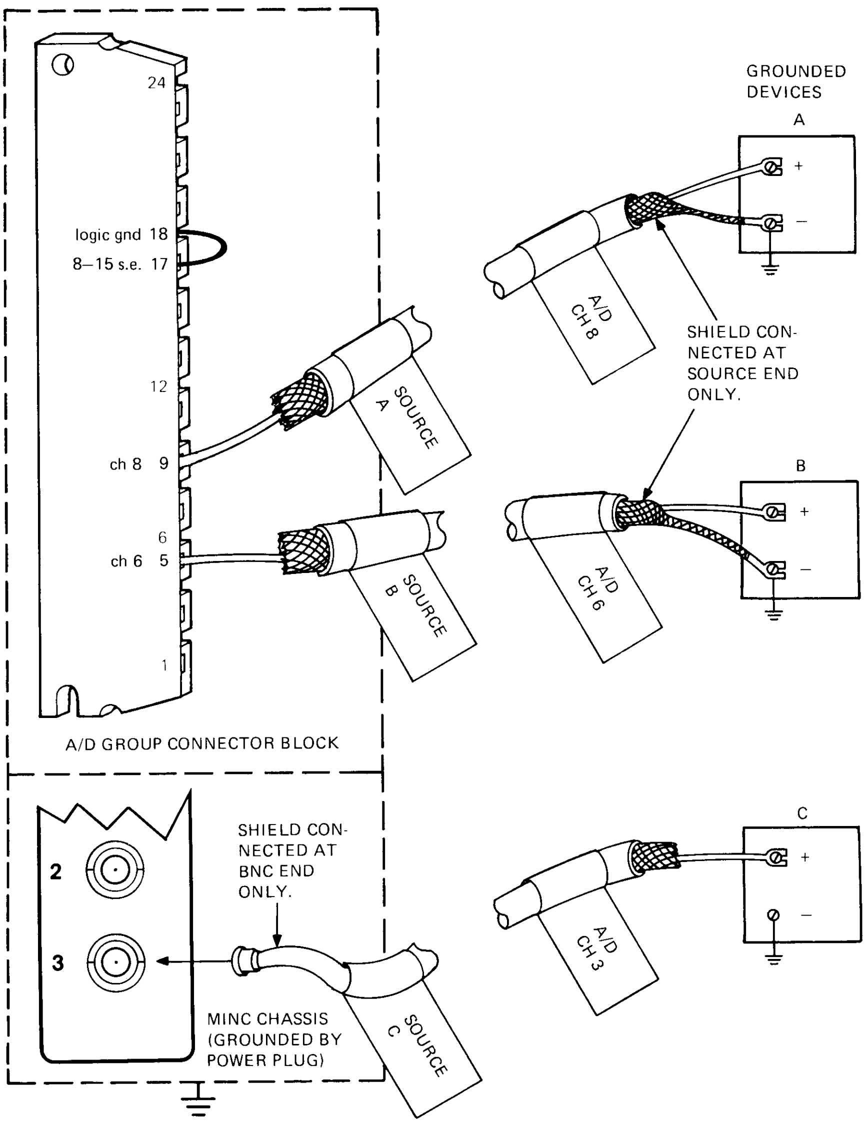


Figure 15. Single-Ended* Connections to MINC A/D Group from Grounded Sources

Connecting Floating Devices to the A/D Group. If the input device is floating (that is, if its return terminal is electrically isolated from power line ground as will be the case with most battery-operated, optically isolated, or transformer-coupled devices), make connections as illustrated in Figure 17. These figures show connections to the A/D connector block, but the principles illustrated apply equally well to preamplifier and multiplexer connections. Note that the A/D requires a ground reference connection, even when operating in differential mode. Note also that there is no advantage to operating in differential mode when the signal source is floating.

Single-ended Selection Straps. You can set channels 8-15 of the A/D converter and both sections of the dual multiplexer to

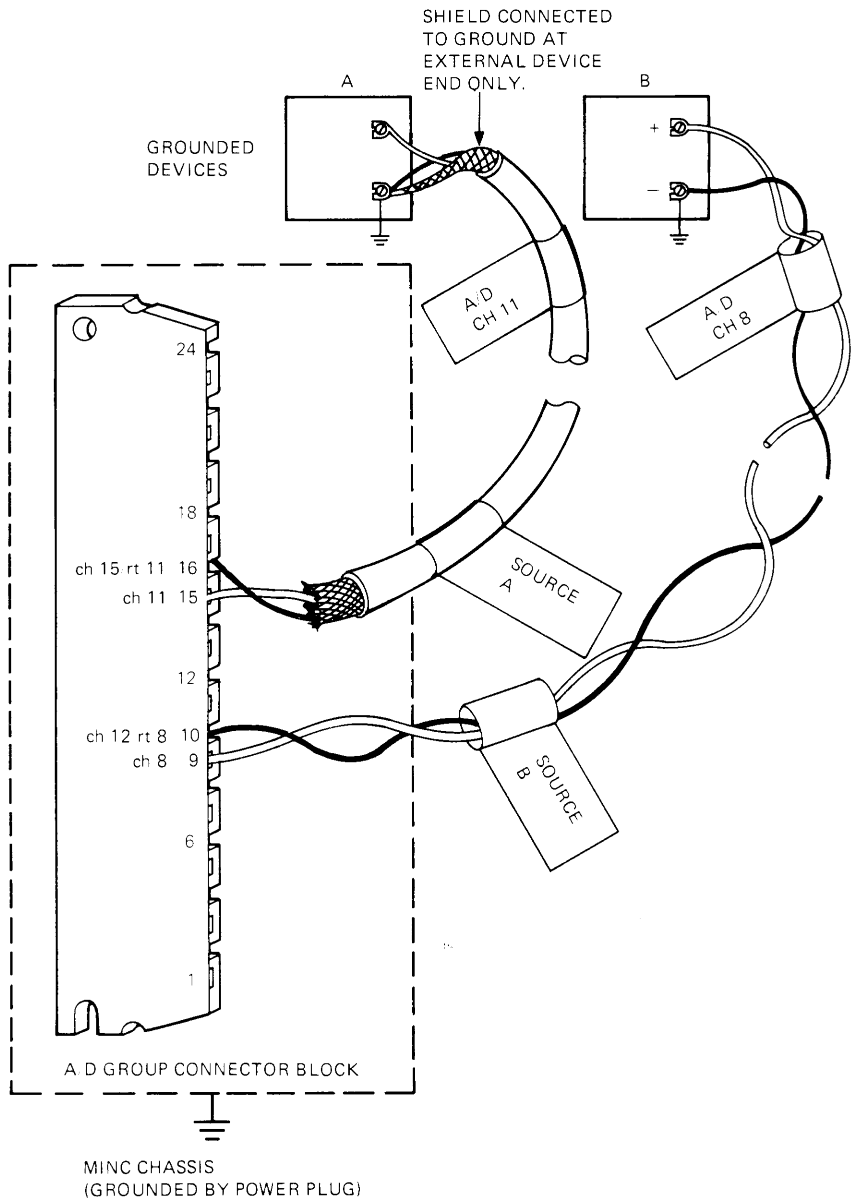


Figure 16. Differential* Connections to MINC A/D Group from Grounded Sources

operate in single-ended mode by installing connector block jumpers as illustrated in Figure 18.

Note that when you insert a preamplifier into a slot that communicates with a selected group of channels you cancel the effect of the single-ended selector straps. The preamplifier's presence is sensed by the A/D or multiplexer and conversions on the affected channels are made in differential mode whether or not the related single-ended strap is installed.

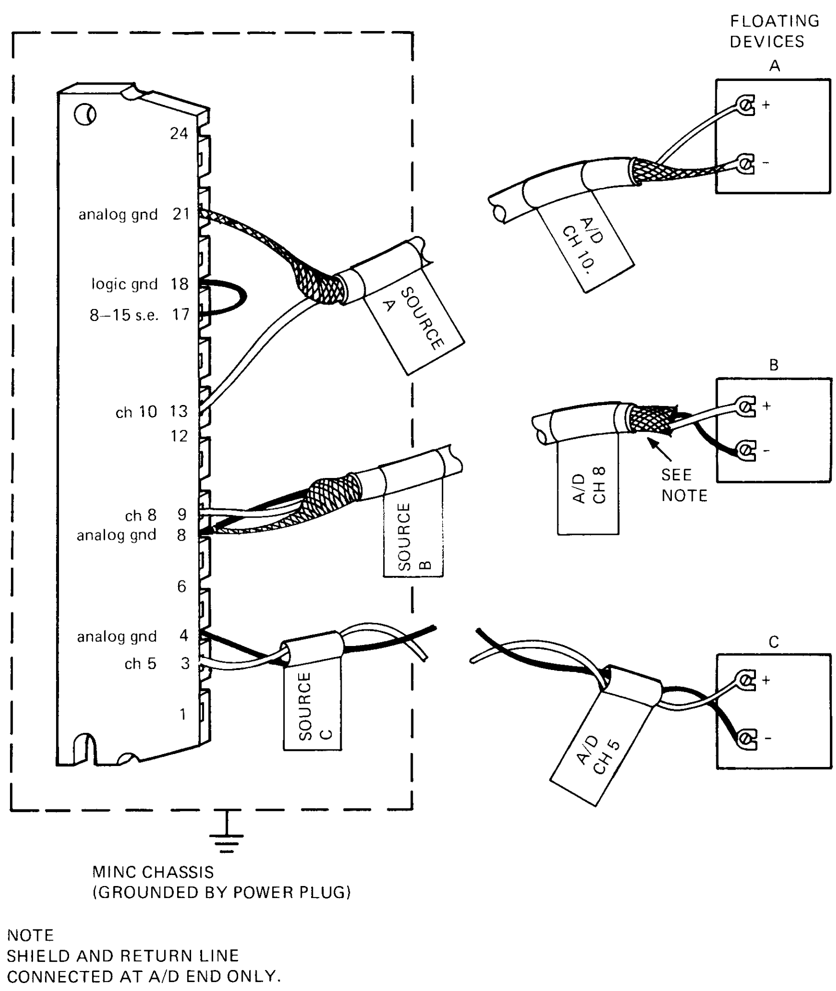


Figure 17. Single-Ended Connections to MINC A/D Group from Floating Sources

Input Selection (Channels 0-3). Input to channels 0-3 of the A/D is controlled by the larger of the two concentric knobs associated with each channel. To select signals connected to the associated front panel terminal set, the larger knob to the BNC position. To select an internally generated DC voltage that can be varied throughout the A/D converter's range by the smaller inner knob, set the larger knob to POT. The TEST position selects a test input that is different for each of the first four channels. See the description at the beginning of this chapter.

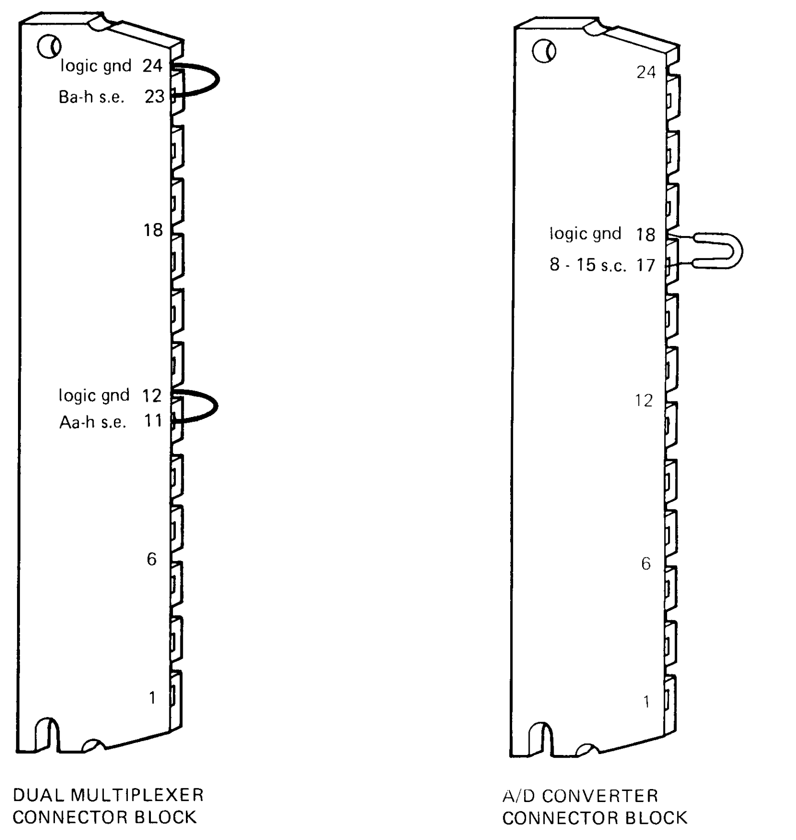


Figure 18. Single-Ended Selector Straps

CONTROL SETTINGS AND CONNECTIONS

Control settings and connections necessary to support A/D conversions in the MINC system are a function both of the program routines selected to implement the conversions and of the specific argument values chosen. Table 4 lists the routines that involve the A/D group and identifies those arguments that require specific front panel control settings or connector block connections. See *Book 6* for a full discussion of the listed routines.

Table 4. Connections and Control Settings for A/D Conversion Routines

Routine	*Argument*	*Supporting User Action*
AIN (Collect Analog Data)		
	mode ST2	Connect desired device to clock ST2 input and select appropriate slope and trigger conditions.
	mode X	Connect external frequency source to clock ST1 and select appropriate slope and trigger conditions.
	A/D-channel	Insure that all specified analog input channels are connected and that preamp gain/mode switches are properly set.
	rate=0	Connect sampling trigger line to A/D ext start.
AIN_HIST (Analog Histogram)		
	A/D-channel	Insure that the specified analog input channels are connected and the Preamp gain and mode switches are set as desired.
SET_GAIN	gain-code, A/D-channel	Insure that each channel specified is input to a preamplifier, and that the associated gain control is set as desired.
AIN_SUM (Accumulate Analog Sweeps)		A/D Connect apparatus specifying start of sweep to clock ST2 input.
	Mode=EXTERNAL	Connect frequency source to clock ST1 input and select desired slope and trigger conditions.
	rate=0	Connect apparatus providing sampling trigger to clock ST1 input or to ext start input of A/D.
	A/D-channel	Insure that each channel specified is input to a preamplifier, that the associated gain control is set to "P", and that the mode control is set as desired.

CHAPTER 3
TIME INTERVAL CONTROL AND SAMPLING

MINC TIME-KEEPING MODES

Many MINC control programs require time interval measurement and use one or another of two time-oriented mechanisms in the system. One of these is the system clock, which is present on all MINC systems and permits the computer to count line voltage cycles. Since power companies control line frequency with considerable precision, the system clock provides a precise timebase for some of the MINC routines. The SCHEDULE, PAUSE, and CIN routines use the system clock (see *Book 6*.)

All other time-dependent functions allowed by MINC program routines require one or two clock modules. These functions include not only the explicit elapsed-time and time-stamping routines (DIN, START_TIME, GET_TIME), but also those routines whose arguments specify sampling rate control, delays, or external timebase connections (for example, AIN, AOUT, DIN, DOUT, SCHMITT).

NOTE

If a system contains two clocks (clock 0 and clock 1), clock 0 must be to the left of clock 1. In such cases, clock-controlled data transfers and the SCHMITT routine use clock 0. The elapsed-time and time-stamping routines use clock 1. Clock 0 can be located anywhere to the left of clock 1 as long as it is not to the left of the A/D converter. Equipping a system with two clock modules permits simultaneous time measurement and clock- or Schmitt trigger-controlled data transfers. When a system contains only one clock, it is defined as clock 0 and requires that time-stamping and any routine invoking rate/delay parameters not be executed simultaneously. See Chapter 9 for information on configuring the second clock in a system.

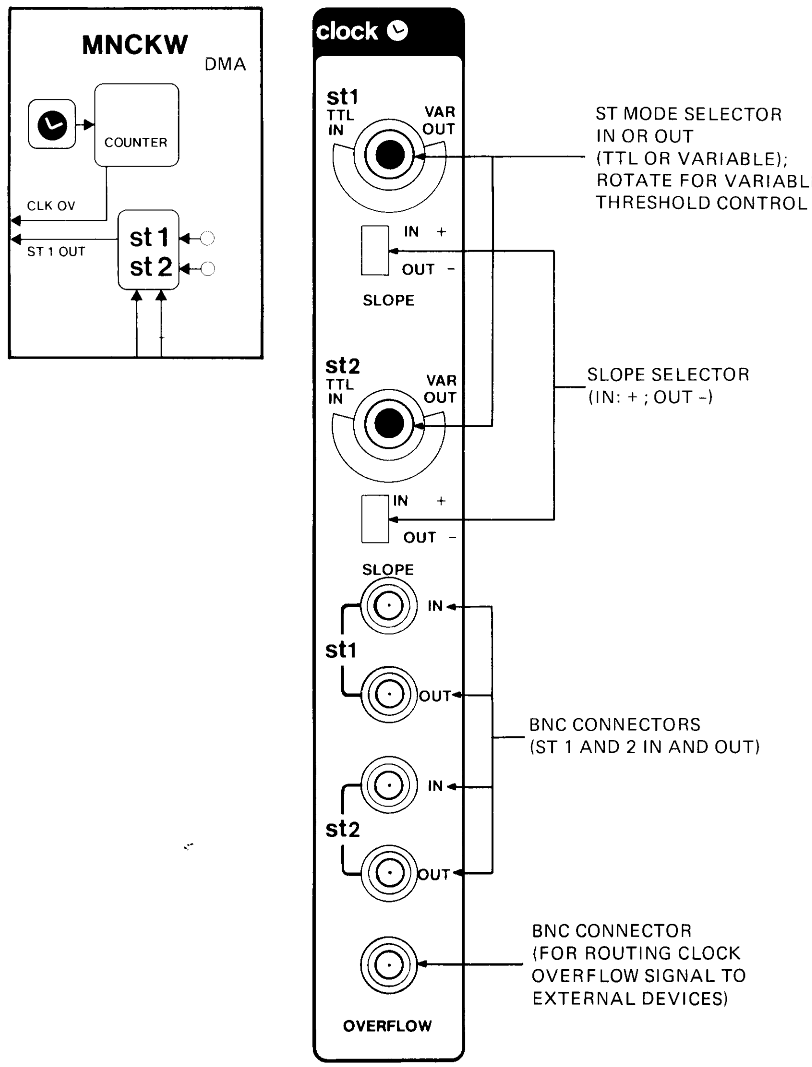


Figure 19. The MINC Clock

MINC CLOCK

The MINC clock (see Figure 19) is a programmable counter that can be driven by a variety of events occurring either inside or outside the MINC system. Internal to the unit is a crystal-controlled oscillator that provides signals at 1 MHz, 100 kHz, 10 kHz, 1 kHz, and 100 Hz. The MINC routines select an appropriate frequency from among these to drive the counter. Also available as counter-drivers are the power line frequency and an external input (ST1) that can accept regular or irregular rate signals. You can specify the line frequency and ST 1 inputs with lab module routine arguments (see *Book 6*).

Although for ease of use, the lab module routines conceal what actually happens from the user, these routines make use of the following attributes of the counter: 1) it can be read by the computer at any time; 2) it can be preset to any value within its range; and 3) it can signal the computer when it reaches its maximum count (overflows). The result is that under the control of the lab module routines, the computer/counter combination can identify the fact that any predetermined number of events has occurred. If these events have time significance, as in the case of the internally generated or power line frequencies, the unit becomes a clock. If the events do not have time significance — as in the case, say, of an organism response — the unit becomes an event totalizer or a predetermined counter.

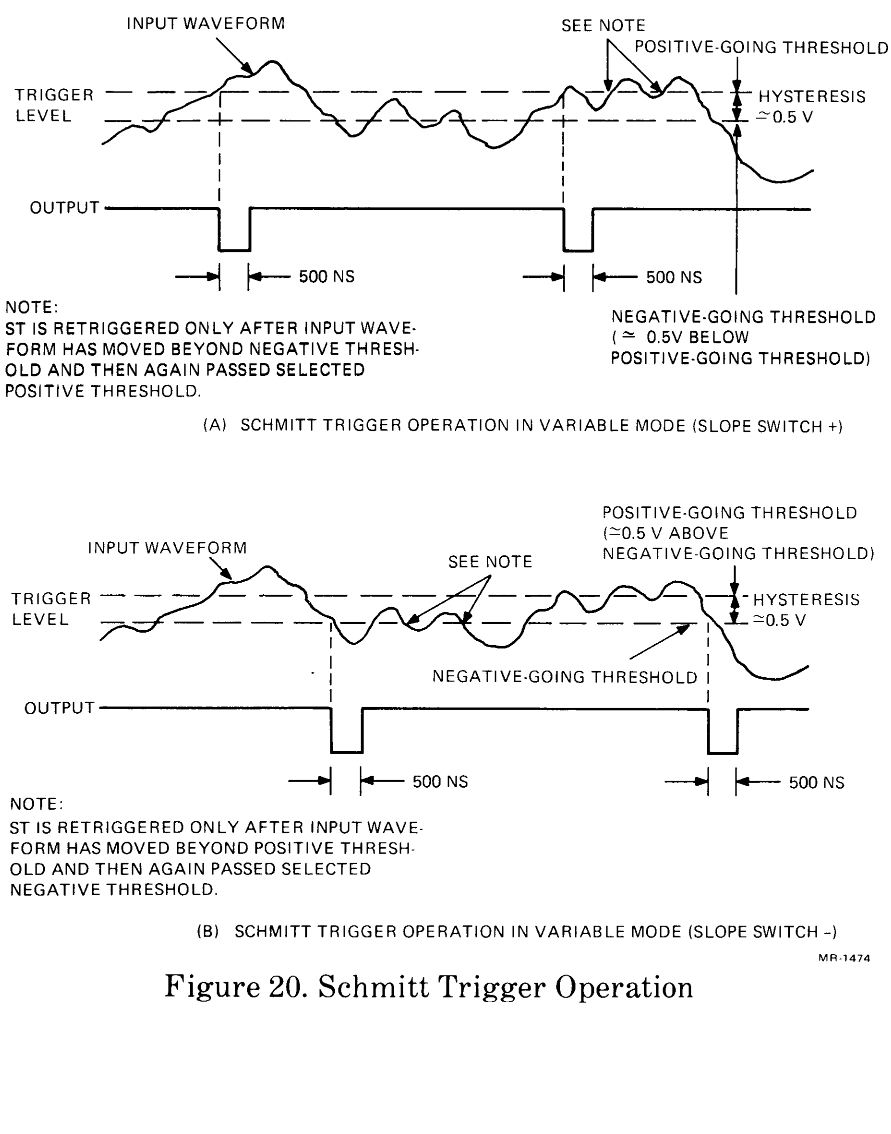


Figure 20. Schmitt Trigger Operation

Schmitt Triggers. The clock module provides two Schmitt triggers (ST1 and ST2), which can work interactively with or independently of the clock itself. When arguments involve Schmitt trigger 1, both the SCHMITT and AIN routines can count Schmitt trigger operations and initiate actions when selected criteria have been met (see *Book 6*). Broadly defined, Schmitt triggers function to convert analog signals into digital signals — not by creating a digital equivalent of the analog value, as does the A/D converter, but by outputting a single negative-going digital pulse (TTL* compatible) when a threshold value has been reached, as illustrated in Figure 20.

When the Schmitt trigger mode selector is set to VAR (variable mode), both the trigger threshold and the slope can be specified by front panel controls (see Figure 20). That is, each Schmitt trigger can be set to fire at a selected voltage point (controlled by the variable threshold knob) on either the positive-going or the negative-going slope of the waveform (controlled by the slope selector). In TTL mode (mode selector set to TTL), the trigger threshold is set automatically to a voltage point appropriate to integrated circuit logic levels and the SLOPE control determines whether firing will occur in response to a positive- or negative-going signal edge. Electrically, the only difference between Variable and TTL modes is that in the latter mode the threshold is fixed. See Figure 21.

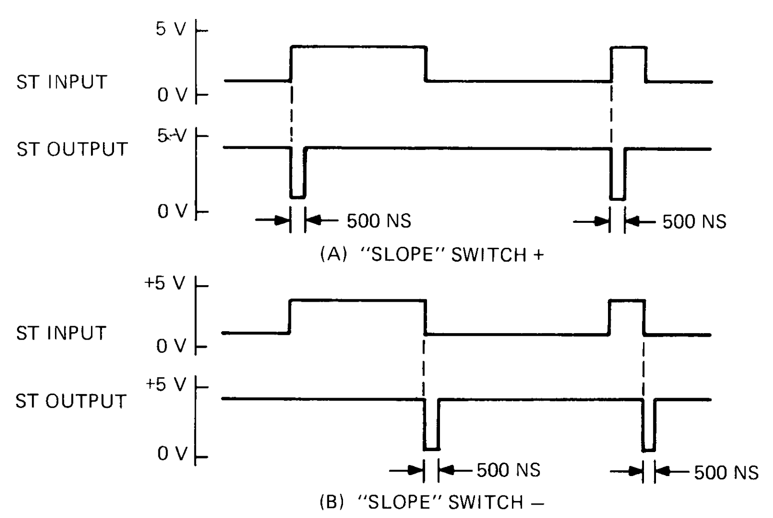


Figure 21. Schmitt Trigger Operation in TTL Mode

The MINC Clock Connector Block. Of the 20 connector block terminals, only terminals 1 to 8 are relevant for program control connections. The remaining terminals may be useful in complex applications, but no MINC routines either require or use them.

CAUTION

Alternate (and parallel) Schmitt trigger input and output terminals are provided both on the clock front panel and on the connector block. When connecting external apparatus to Schmitt trigger inputs or outputs, confirm that no connections have already been made on the alternate terminals. Failure to do so may result in damage to the external apparatus.

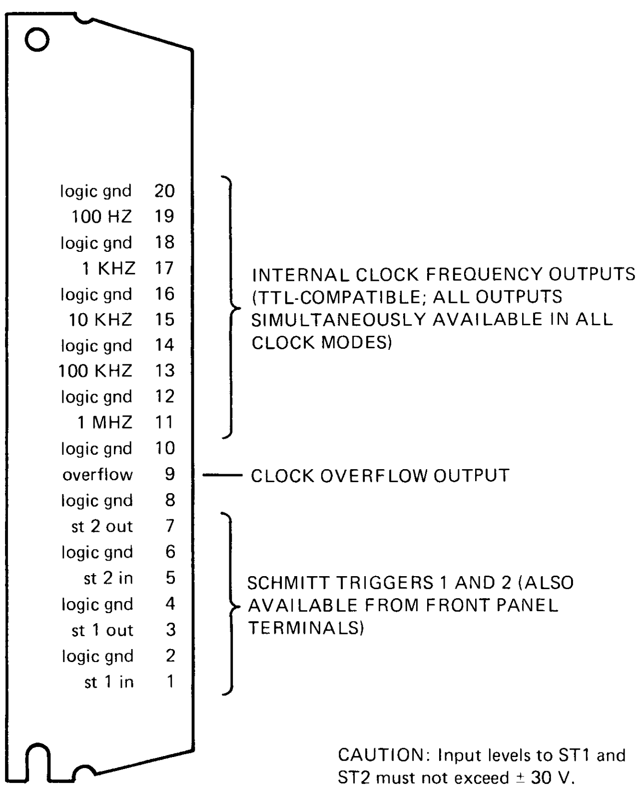


Figure 22. MINC Clock Connector Block

Control Settings and Connections. Most MINC routines use the clock in combination with other lab modules to control data transfer rates. The elapsed time routines, however, (START_TIME and GET_TIME) use the clock by itself to provide ongoing time-keeping capability with programmable resolution. No user connections are required for the elapsed time routines. The other lab module routines require connections to the clock only when the routine arguments invoke one or both of the clock's Schmitt triggers. Connections from external apparatus to Schmitt trigger inputs are made as illustrated in Figure 23.

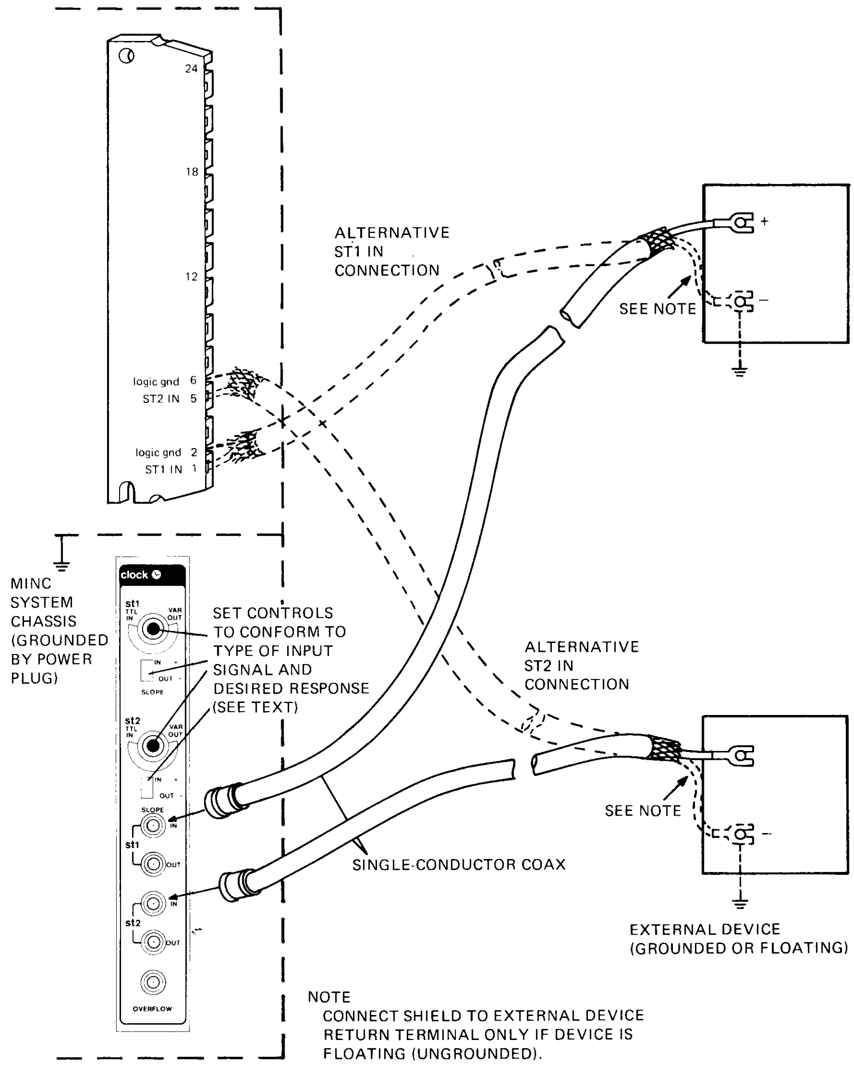


Figure 23. MINC Clock — ST1 and ST2 Connections and Control

Tables 5 and 6 list the routines that can use clock Schmitt triggers and identify those arguments that require specific front-panel control settings or connector block connections. See *Book 6* for a full discussion of the listed routines.

CAUTION

The clock Schmitt triggers can generate outputs in response to electrical noise when no device is connected to the input. To avoid such spurious responses from unused Schmitt triggers, set the mode selector to VAR and turn the associated potentiometer to either of its extreme settings.

Table 5. Connections and Control Settings for MINC Clock Routines

Routine	*Argument*	*Action Required*
AIN (Collect Analog Data)	mode=ST2	Connect external signal source to clock ST2 input and select desired slope and threshold conditions.
	mode=EXTERNAL	Connect external timebase source to clock ST1 input and select desired slope and threshold conditions.
	rate=0	Connect apparatus providing sampling trigger to clock ST1 input or to A/D ext start input.
AIN_HIST (Analog Histogram)		Connect apparatus providing sampling trigger to clock ST1 input or to A/D ext start input.
AIN_SUM (Accumulate Analog Sweeps)	mode=EXTERNAL	Connect external timebase source to ST1 input and select desired slope and threshold conditions.
	rate=0	Connect apparatus providing sampling trigger to clock ST1 input or to A/D ext start input.
AOUT (Send Analog Data)	mode=ST2	Connect external start signal source to clock ST2 input and select desired slope and threshold conditions.
	mode=EXTERNAL	Connect external timebase source to clock ST1 input and select desired slope and threshold conditions.
DOUT (Send Digital Output)	mode=ST2	Connect external start signal to clock ST2 input and select desired slope and threshold conditions.
	mode=EXTERNAL	Connect external timebase source to ST1 and select desired slope and threshold conditions.
	rate=0	Connect external apparatus reply line to DO reply terminal.
PST_HIST (Generate Post-Stimulus Histogram)		Connect source producing a signal at stimulus time to clock ST1; connect source producing a signal at response time to clock ST2. Set slope and threshold conditions as appropriate.
SCHMITT (Respond to Schmitt Trigger Input)	trigger=1	Connect source of signals that must elicit program responses to ST1 input and select desired slope and threshold conditions.
	trigger=2	Connect external start signal to clock ST2 input and select desired slope and threshold conditions.
TIME_HIST (Generate Time Interval Histogram)		Connect source of signals whose intervals are to be measured to clock ST2 input and select desired slope and threshold conditions.

DIN (Collect Digital Input)	mode=EXTERNAL	Connect external timebase source to clock ST1 input and select desired slope and threshold conditions.
	mode=ST2	Connect external signal source to clock ST2 input and select desired slope and threshold conditions.
	rate=0	Connect external apparatus generating sampling trigger to DI strobe (HB or LB STRB) terminal. For independent event sampling connect apparatus to D00 through D15.
START_TIME (Start Elapsed Time Counter)	mode=EXTERNAL	Connect external timebase source to clock ST1 input and select desired slope and threshold conditions.
	mode=ST2	Connect external start signal to clock ST2 input and select desired slope and threshold conditions.

Table 6. Connections and Control Settings for Timestamping and Elapsed Time Routines

Routine	*Argument*	*Action Required*
DIN	mode=TIMESTAMP	Insure either that Clock 1 is installed in addition to Clock 0 or that no other routine invokes Clock 0 while DIN is executing.
	mode=ST2	(See Note) Connect drive specifying DIN start to ST1 input and select desired slope and threshold conditions. (If mode ST2 and TIMESTAMP are invoked in the same routine, Clock 1 *must* be installed.)
	mode=EXTERNAL	Connect external frequency source to ST1 input and select desired slope and threshold conditions. (If EXTERNAL mode and TIMESTAMP are invoked in the same routine, Clock 1 *must* be installed.)
START_TIME GET_TIME		Insure either that Clock 1 is installed or that no other routine invokes Clock 0 during execution of timestamping command(s).

Note: The timestamp clock/elapsed time counter functions only in programmed mode; it will be stopped upon entry into immediate mode, and an error message will indicate that it has been running.

CHAPTER 4 DIGITAL-TO-ANALOG CONVERSION

Applicable program command:

AOUT (Send Analog Data)

See *Book 6* for complete description.

DIGITAL-TO-ANALOG CONVERTER

The MINC digital-to-analog (D/A) converter (see Figure 24) is a module housing four independent D/A converters (DACs), each of which is defined as a channel by the AOUT routine. The module receives numeric values from a program, preserves them in holding registers for each channel, and converts them to equivalent voltages at the associated output terminals. These voltages are sustained without further user involvement until new values arrive for those channels. The four DACs in the module accept data from the system via internal 12-bit binary registers. All DACs are therefore capable of a resolution of one part in 4096. Each DAC is provided with mode/range controls that permit user selection of unipolar* or bipolar* operation with a variety of output ranges (see D/A Input/Output Relationships, below).

All four DACs on each module are identical except for DAC 3, which routes the 4 least significant bits of its binary-encoded holding register to 8 user-accessible output terminals (4 normal and 4 inverted), as well as to the DAC 3 digital-to-analog converter circuit (see Figure 25). The result is that you can specify digital data to DAC 3 that will not only produce the desired analog output voltage but will also provide such control information as *intensify* (to storage oscilloscopes) or *raise pen* (to X-Y plotters). Forcing these bits to values other than those required by the conversion will affect conversion accuracy. However, these are the least significant four bits in the 12-bit data word that specifies the analog output voltage. They can therefore affect the DAC 3 output by less than 1% of its full-scale range.

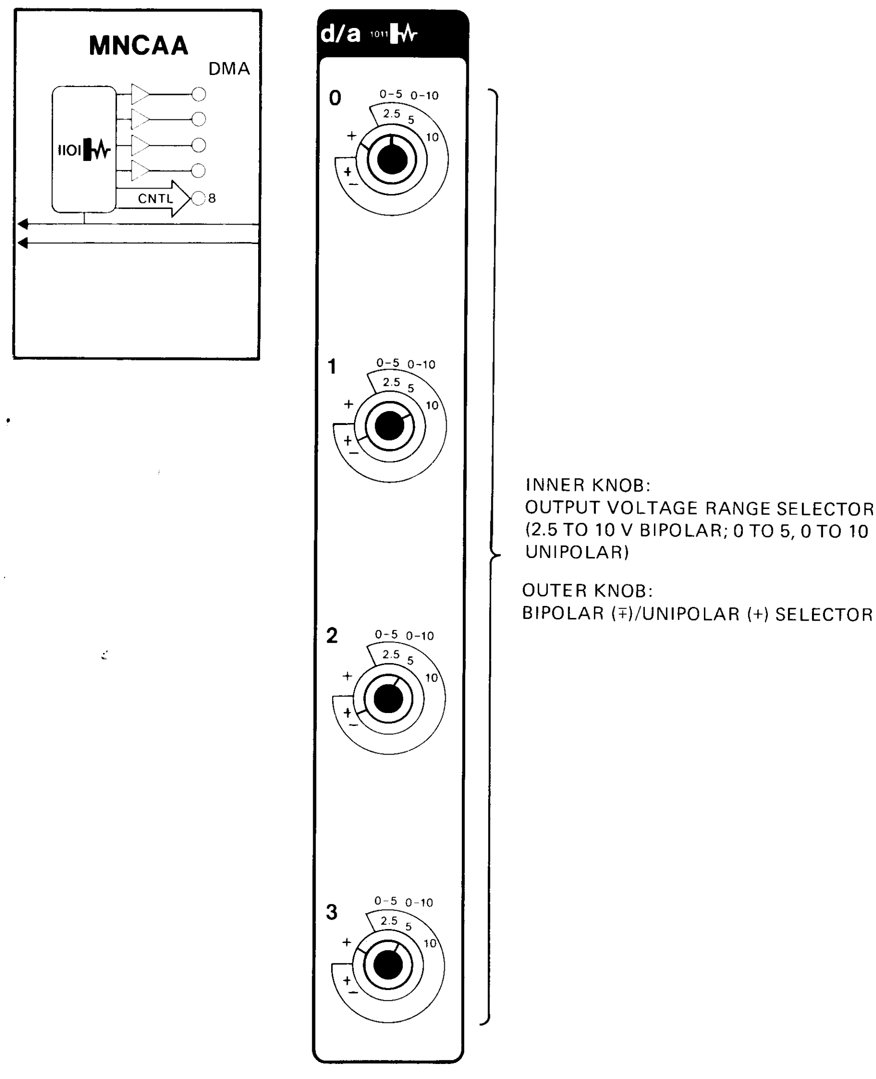


Figure 24. The MINC D/A Converter

D/A Input/Output Relationships. Two concentric knobs (see Figure 24) associated with each of the four channels on the MINC D/A converter permit you to select mode and range. Mode settings are unipolar (+) and bipolar (±); range settings are as follows:

Unipolar: 0-5 (0 to +5.11875 Volts)
0-10 (0 to +10.2375 Volts)

Bipolar: ∓2.5 (−2.56 to +2.55875 Volts)
∓5 (−5.12 to +5.1175 Volts)
∓10 (−10.24 to +10.235 Volts)

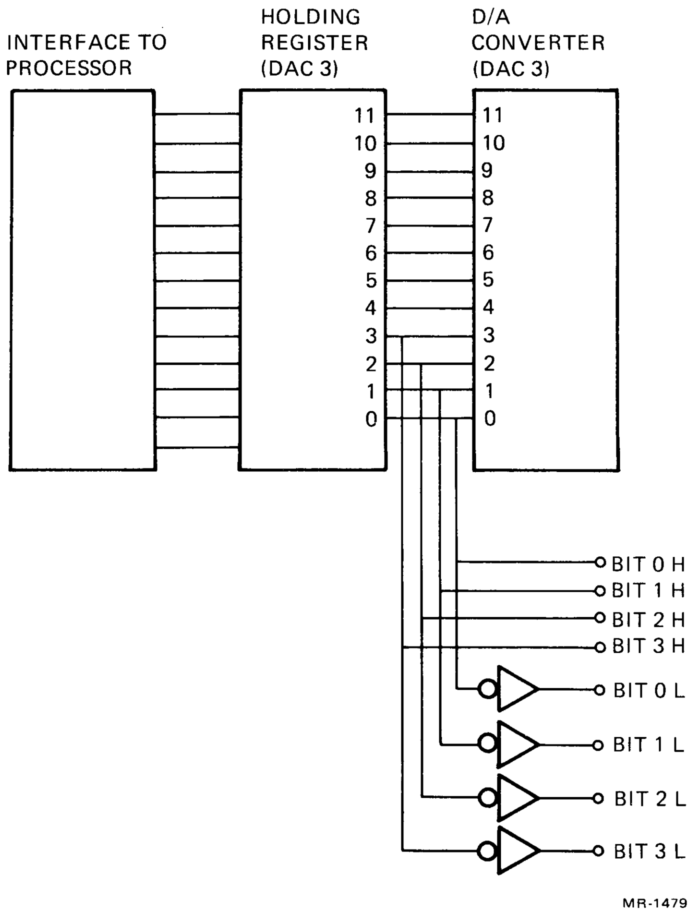


Figure 25. Channel 3 Control Bit Outputs

The AOUT routine (see *Book 6*) allows data in the range of -2048 to 2047. Because the condition of the control switches is not sensed by the system, it is up to you to set switches in a way that is consistent with your input data on the one hand and the device that receives the analog output voltage on the other. The relationship between data values made available to AOUT and voltages actually output is illustrated in Table 7.

Minimum Voltage Increments. If we exclude 0, the total number of distinct AOUT data values is 4095 (-2048 to 2047). This is so because 4095 is the largest number that can be represented by the 12-bit binary circuits that perform the conversions. Since these are integer values, the smallest change we can make on any DAC output voltage is that created by adding or subtracting

1 from the data value which generated that voltage. Conversely, the way to calculate what output voltage a DAC will produce in response to a given data value is to multiply the data value by the value of the smallest change, or minimum voltage increment.

Table 7. MINC D/A Data/Voltage Relationships

Input Value	OUTPUT (Bipolar)			OUTPUT (Unipolar)	
	±2.56V	±5.12V	-10.24V	0V to +5.12V	0V to +10.24V
-2048	-2.56	-5.12	-10.24	+0.0	+0.0
-2047	-2.55875	-5.1175	-10.235	+0.00125	+0.025
-0001	-0.00125	-0.0025	- 0.005	+2.55875	+5.1175
0000	-0.0	-0.0	- 0.0	+2.56	+5.12
+0001	+0.00125	+0.0025	+ 0.005	+2.56125	+5.1225
+2047	+2.55875	+5.1175	+10.235	+5.11875	+10.2375

Table 8 shows the minimum voltage increments associated with all MINC D/A modes and ranges. Notice that multiplying these values by -2048 and 2047 produces the full range values for bipolar operation given in Table 7. Multiplying these values by 4095 produces the full range values for unipolar operation given in Table 7.

Table 8. Minimum D/A Voltage Increments

Mode	Range	Minimum Increments	
Unipolar	0-10	.0025V	(2.5mV)
(+)	0-5	.00125V	(1.25mV)
Bipolar	10	.005V	(5mV)
(∓)	5	.0025V	(2.5mV)
	2.5	.00125V	(1.25mV)

To derive a data value that will produce a desired voltage under a given range condition, use one of the two equations below:

Unipolar: D = V/M - 2048
(PRINT V/M - 2048)
Bipolar: D = V/M
(PRINT V/M)

where D is an integer between -2048 and 2047, V is expressed in volts, and M is the minimum increment (in volts) associated with the selected range as given in Table 8.

Expansion. The MINC system supports up to four D/A converter modules (16 channels), provided that the address and vector switches are configured as indicated on the label affixed to the side of each module (see also Chapter 9, System Configuration Procedures). If only one MINC D/A converter exists in a system, it should be configured as unit 0. Subsequent units should be configured sequentially up to 3. No omissions can be tolerated in the sequence. If three D/A modules are configured as units 0,2, and 3, the system will not be able to detect the presence of units 2 and 3. If two units are configured as units 1 and 2, the system will permit no D/A conversion because it will detect no D/A modules.

From the point of view of the AOUT routine, channels are numbered sequentially from 0 to 15 (maximum), channels 0-3 occupying unit 0, 4-7 occupying unit 1, and so forth.

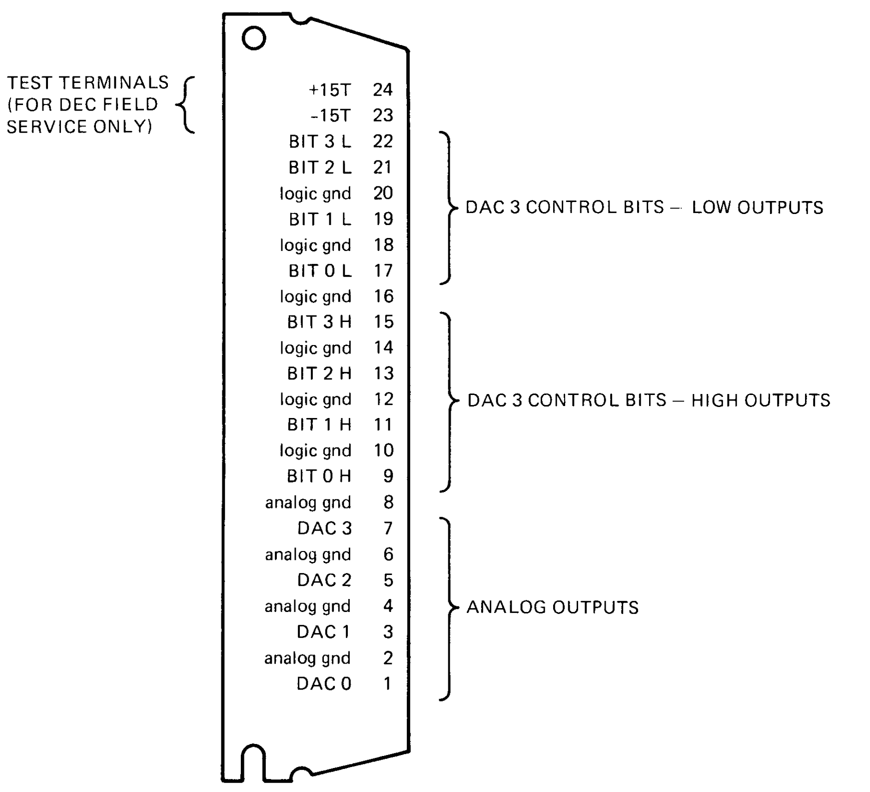


Figure 26. MINC D/A Connector Block

DAC 3 Resolution. The fourth DAC on each module (that is, channels 3, 7, 11, and 15 on systems with four D/A modules), provides user access to the four least significant bits of the holding register as described above. If these bits are unused on channels 7, 11, or 15, D/A conversions can be made with full accuracy. On channel 3, however, bit 0 is regularly used by the AOUT routine to specify intensify time to a possible oscilloscope. Its state is therefore unpredictable even when you are using none of the control bits on channel 3. This reduces the resolution of channel

3 to two parts in 4096 rather than one in 4096. Note that the full-scale accuracy of channel 3 is virtually unaffected by the indeterminate character of bit 0. Bit 0's uncertainty adds 1 minimum voltage increment (see Table 8) to the uncertainty of any channel 3 conversion. This amounts to less than .025% of any full-scale conversion.

Connector Block. The MINC D/A connector block, shown in Figure 26, provides terminals for connecting external apparatus to all four analog output channels (DAC 0 to DAC 3) and their grounds (analog gnd). Note that terminals for bits 0 to 3 allow you to choose between a high logic level* when the bit in

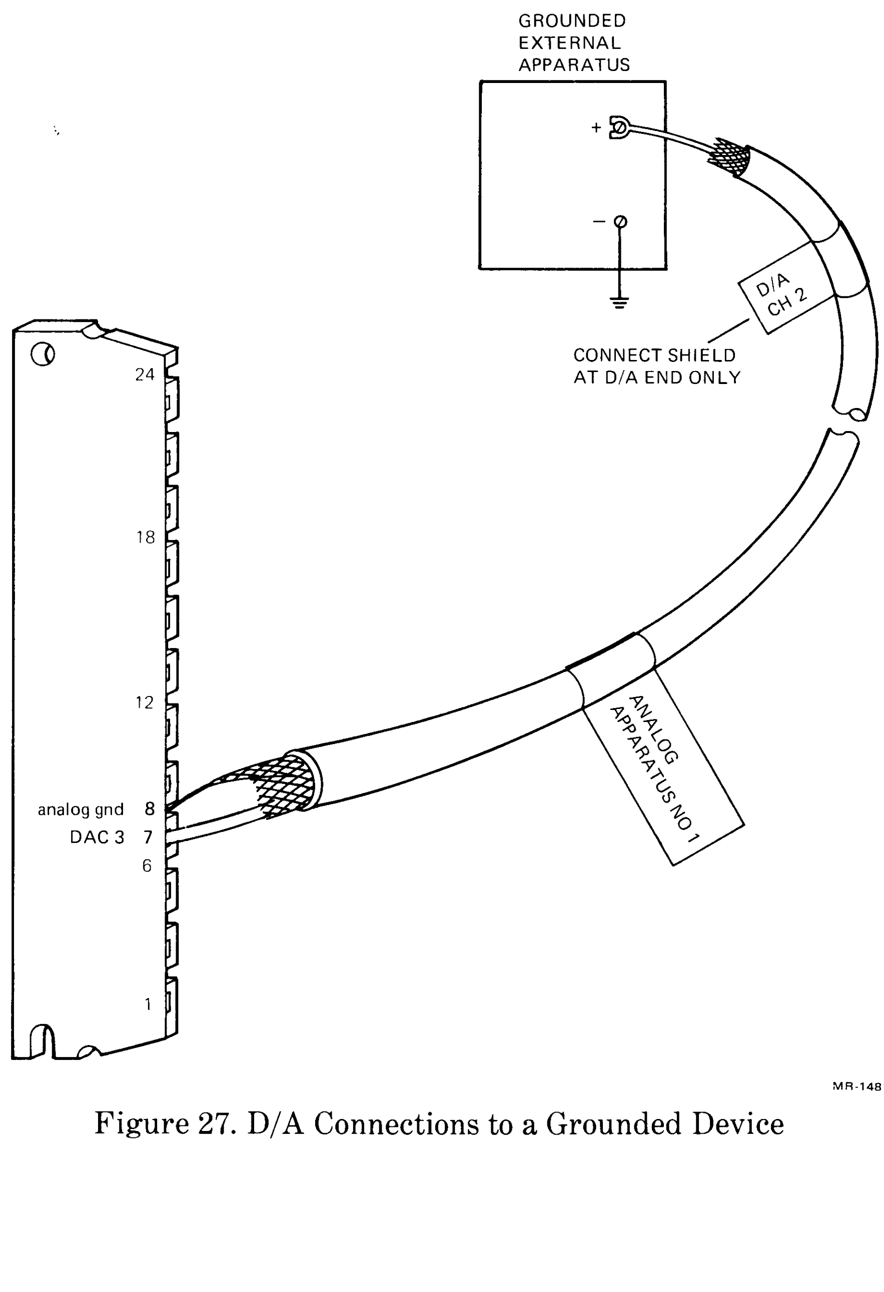


Figure 27. D/A Connections to a Grounded Device

question is set ("Bit n H") and a low logic level when that bit is set ("Bit n L"). This choice exists because some oscilloscopes and plotters require a high logic level to execute such functions as "intensify" and "raise pen," while others require a low logic level. Terminals 23 and 24 are test points for Digital Field Service personnel.

D/A CONNECTIONS TO EXTERNAL DEVICES

Grounded Devices. If you connect the signal return terminal of the device driven by the D/A converter to power line ground, you should not connect that terminal to any of the MINC D/A connector block grounds. Doing so may produce a ground loop that will adversely affect D/A and A/D results (see Chapter 11). Appropriate connections between D/A outputs and a grounded device are illustrated in Figure 27.

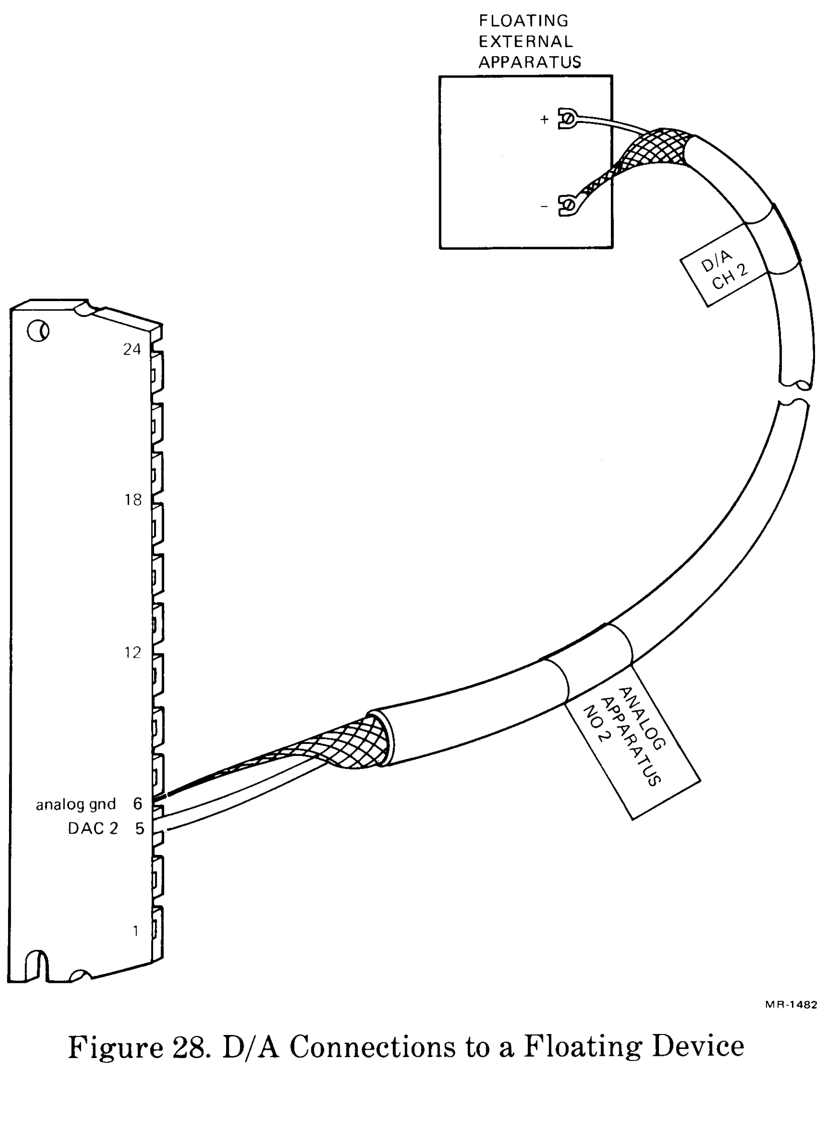


Figure 28. D/A Connections to a Floating Device

Floating Devices. If the external device has no connection between its signal return terminal and power line ground, connect the shield to ground at both ends. These connections are illustrated in Figure 28.

Oscilloscopes and X-Y Plotters. Connect oscilloscopes as illustrated in Figures 29 and 30. Note that channel 3 automatically asserts "Intensify" on bit 0 whenever a complete channel sequence has been output (see *Book 6*). This signal has a duration of approximately 10 microseconds. Its generation rests on the assumption that the D/A channel and number-of channel argu-

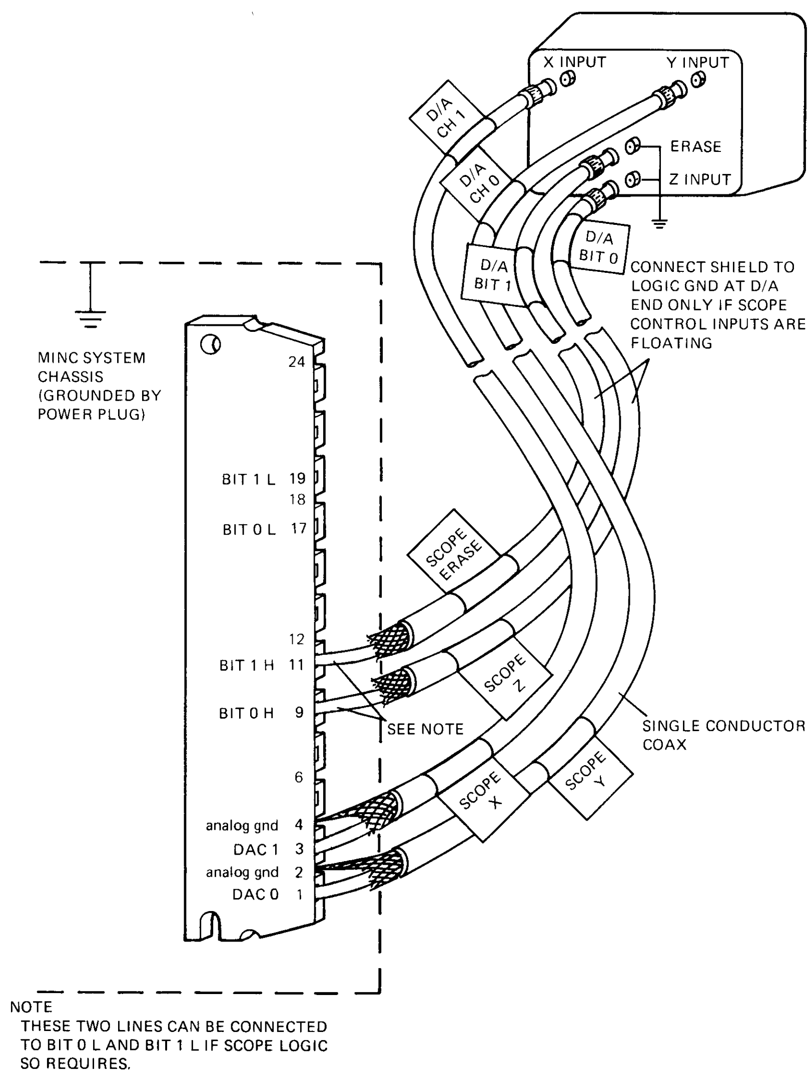


Figure 29. MINC D/A Connected to Scope with Differential X and Y Inputs

ments have previously loaded some channels (say, 0 and 1) with values appropriate to the scope X and Y axes. If bit 0 of DAC 3 is routed to the scope Z axis or Intensify input, the specified point will be displayed.

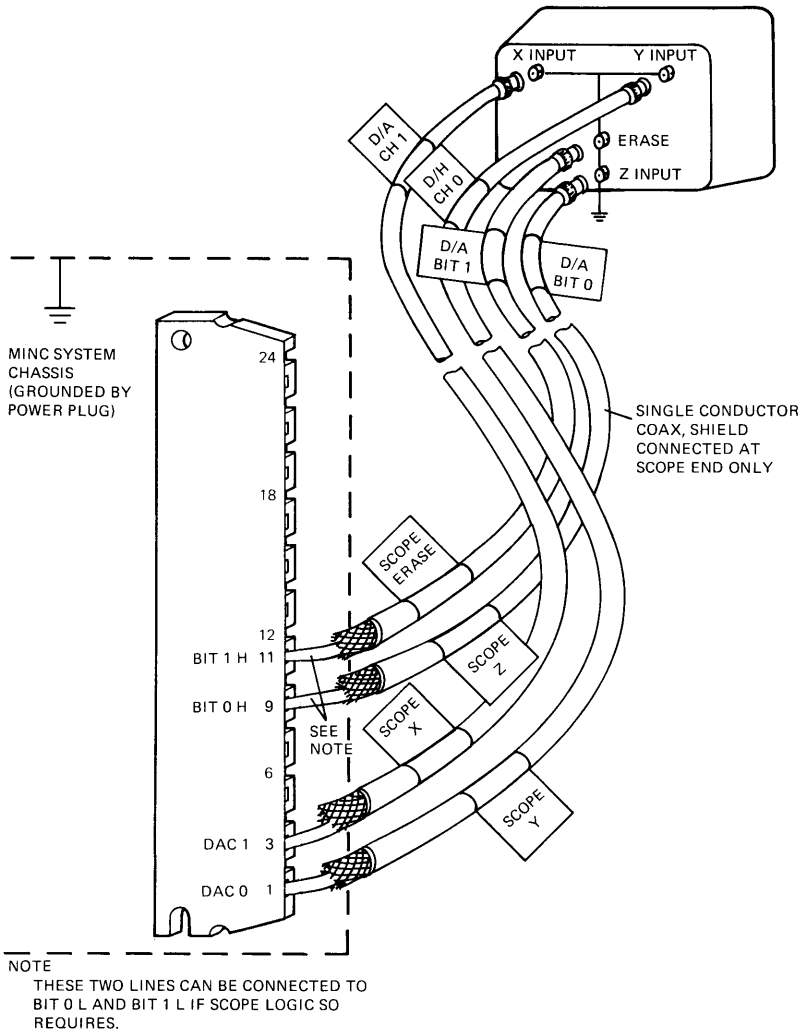


Figure 30. MINC D/A Connected to Scope with Grounded Single-Ended Inputs

Bits 0 through 3 are designed to be used as follows:

Bit 0: Intensify. Momentarily set by AOUT whenever a full sequence of output channels (as defined by the AOUT arguments) has been processed. Signal consists of a pulse with a duration of approximately 10 microseconds.

Bit 1: Indicates that the display is to be erased. Set only when the user outputs an analog value on channel 3 that involves this bit.

Bit 2: Not currently assigned. Set by user's analog value.

Bit 3: Pen up/down control. Set by user's analog output value.

Connect Plotters as illustrated in Figure 31.

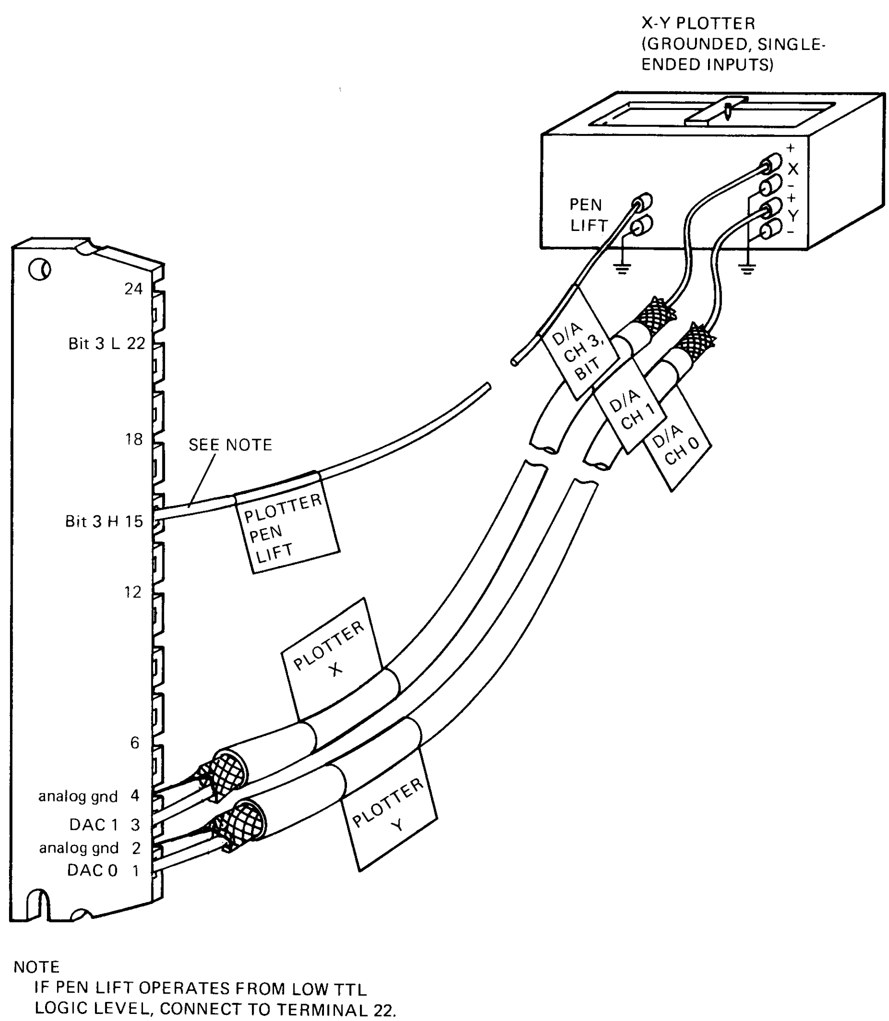


Figure 31. MINC D/A Connected to X-Y Plotter

CHAPTER 5
DIGITAL INPUT AND OUTPUT

THE MINC DIGITAL INPUT MODULE

Applicable Lab Module Routines (see *Book 6* for complete information):

DIN	Collect Digital Data
DIN_EVENT	Enable Independent Digital Input Lines
DIN_MASK	Specify Mask for Digital Input Unit
TEST_LINE	Test Condition of Digital Input Line

The MINC digital input unit accommodates 16 input lines and can be used to read binary data from external apparatus producing standard digital logic levels, analog voltages, or contact closures. All inputs are interfaced by Schmitt triggers* with inherent hysteresis* for increased noise immunity. A front panel DATA switch provides control of the polarity of the digital input unit's representation of the signal. The unit can collect data on command and is equipped with STROBE and REPLY terminals to facilitate communications with external instruments that transmit data on groups of up to 16 lines simultaneously. In addition, the unit supports an independent event mode of operation in which signals on selected input lines can initiate program operations (see *Book 6*).

Figure 32 shows the front panel of the digital input unit. The EVENT terminal is not required or used by any MINC routines. In independent event mode, a signal on any of the lines authorized by the DIN_EVENT arguments generates a TTL*-compatible output signal at the EVENT terminal. This signal will be a pulse of several microseconds duration and can be used to communicate with external apparatus.

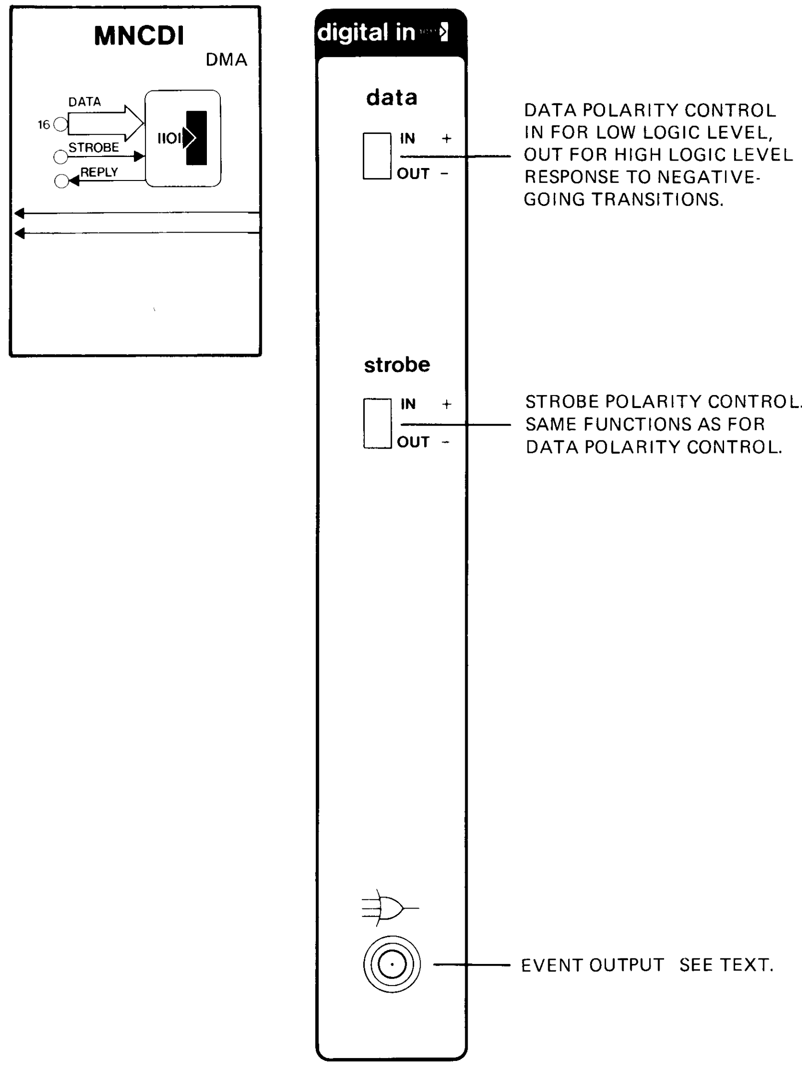


Figure 32. MINC Digital Input

Figure 33 shows the digital input connector block.

Expansion. The MINC system supports up to four digital input modules. Each is identified in the digital input routines as a *unit* with an identifying number from 0 to 3. Unit 0 is the digital input module whose configuration switches have been set in accordance with the label on the side panel to define the module as unit 0. Unit 3 is the digital input module whose configuration switches define it as unit 3. Relative position of digital input modules is unimportant as long as all modules are inserted to the right of any A/D converter and to the left of clock 1, if it exists. (See Chapter 9, System Configuration Procedures.)

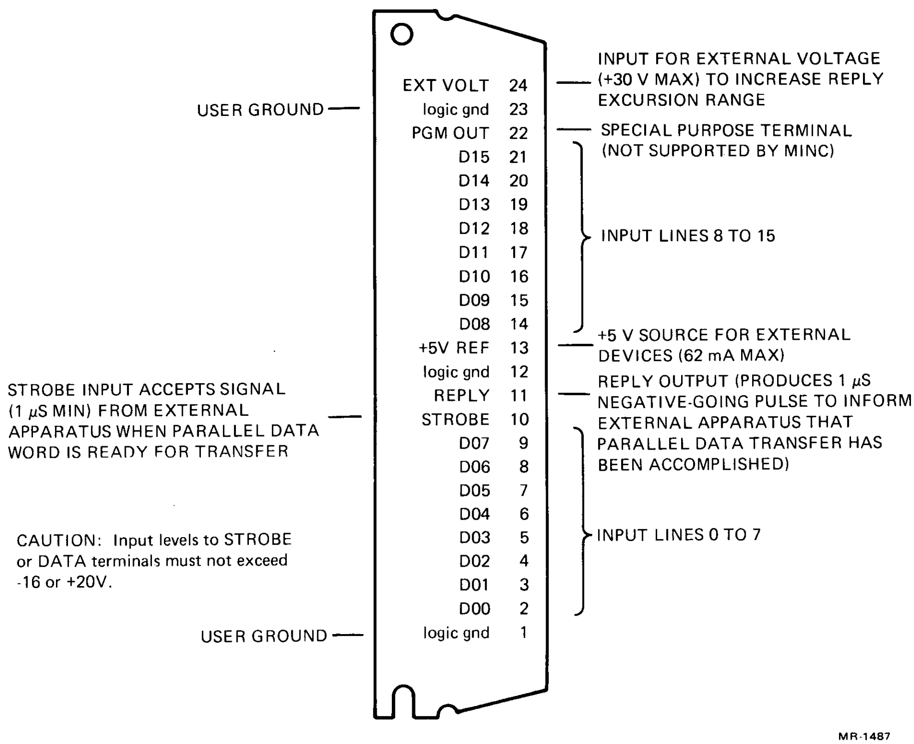


Figure 33. MINC Digital Input Connector Block

Connections to External Parallel Data Ports. Figure 34 shows connections between the digital input and an external instrument that transmits logic levels to the system on as many as 16 lines simultaneously. To expedite reliable data transfer, such instruments normally issue a signal to indicate that data is ready to be transferred. This signal must be connected to the STROBE terminal on the digital input connector block. Such instruments make no further transfers until signalled by the receiving device (MINC in this case) that the preceding transfer has been accepted. The digital input module issues this signal automatically from the REPLY terminal on the connector block. Figure 35 illustrates the timing relationships assumed by the digital input module when the DIN rate argument is 0.

Connect single unshielded wires between each data and control pin of the instrument connector and related terminals on the digital input connector block. See the user's manual for the instrument in question to ascertain how the instrument connector is wired. The relationship between instrument functions and digital input module terminals varies according to the instrument involved and your specific application and cannot be described more fully here. Make sure that at least one wire is connected between the external instrument ground and one of the three "logic gnd" (ground) terminals on the connector block.If more than one ground terminal is available at the instrument connector, it is good practice to connect a ground wire to each of the two user grounds on the digital input connector block.

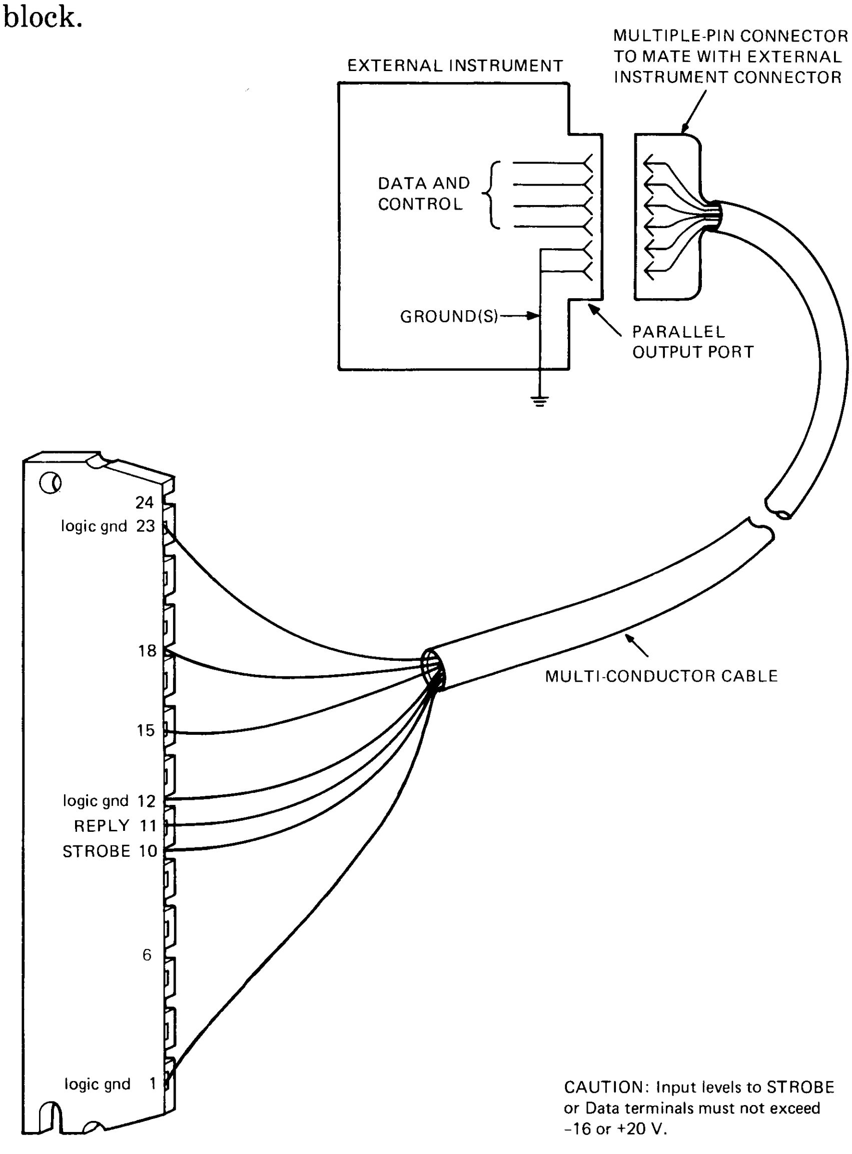


Figure 34. Connections Between Digital Input Unit and External Instrument with Parallel Output Port

NOTE

The REPLY signal issued by the digital input unit is a standard TTL* output. If the external device requires a higher voltage, an external voltage (+30 V maximum) may be introduced via terminal 24 (EXT VOLT). See The MINC Digital Output Module in this manual for details.

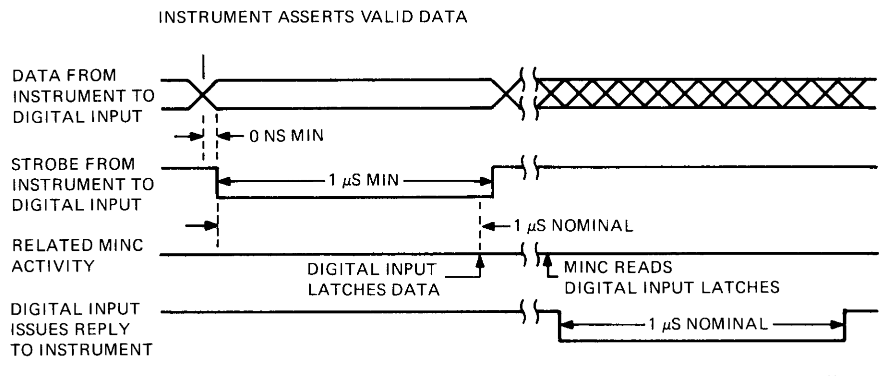


Figure 35. Timing Relationships for Data Transfer to Digital Input from External Parallel-transfer Instrument.

Data Latching and Polarity. The front panel DATA switch has two roles, depending on the nature of the DIN routines being run. In independent event operation (see *Book 6*), the DATA switch defines the polarity of the waveform that the unit will accept as an event. If the DATA switch is in (+), events on the input lines will be recognized when the waveform passes the positive-going threshold (about 2.3 volts). If the DATA switch is out (-), events will be recognized when the waveform passes the negative-going threshold (about 1.3 volts). In either case, the digital input's 16-bit binary data word will contain 1's for lines on which activity has occurred, and 0's for all other lines.

Under all other other operating conditions, the DATA switch reverses the polarity of the data word. If the DATA switch is set to "+", a high logic level* (or an absent connection) on any line will set the corresponding bit in the data word; a low logic level will clear the corresponding bit. If the DATA switch is set to "-", a high logic level (or an absent connection) on any line will clear, and a low logic level will set, the corresponding bit.

Digital Input Connections from External Switches. The primary problem in interfacing standard switch contact operations to MINC is that virtually all such switches exhibit contact bounce. At the moment of contact closure or opening, not one but several changes of state occur that can, depending on the switch and the program being run, manifest themselves as multiple rather than single events. This effect is diagrammed in Figure

36. As long as the switch remains closed, the +5 V bias voltage supplied by the Schmitt trigger input is shorted to ground, with the effect that the Schmitt trigger sees an input voltage of 0. When the switch condition is changed, multiple contact operations occur at the moment of transition, and each generates a response from the Schmitt trigger. The same thing occurs when the switch is closed again. If the duration of the contact bounce is great enough, the program may have time to read and clear the digital input unit before the switch-open bounce has subsided. In any case, such clearing will almost certainly have occurred by the time the switch is closed again. The result will be two or more program responses to each contact-open/contact-closed operation.

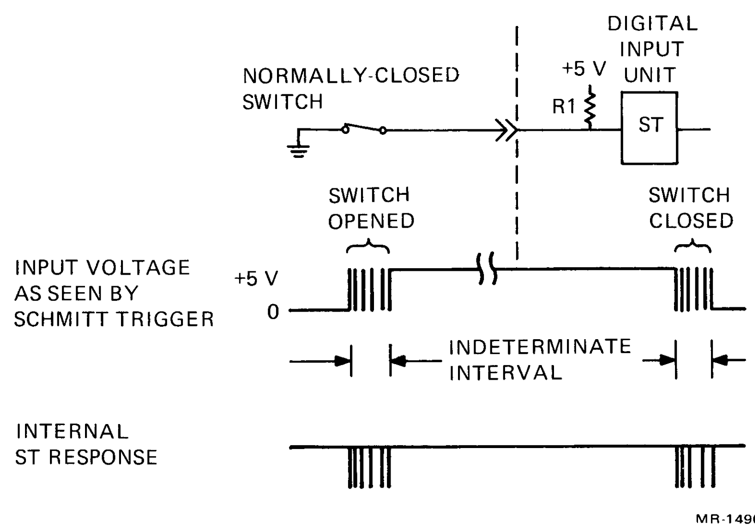


Figure 36. The Effects of Contact Bounce on a Digital In Schmitt Trigger

Figure 37 illustrates a user cure for the bounce problem. The input voltage is identical to that shown in Figure 36 except that a capacitor of an appropriate size is connected across the switch terminals. The switch bounces just as before when it is opened, but this time the capacitor, previously discharged by the closed contacts, absorbs the voltage transients created by the bounce, gradually charging through internal resistor R1 until the Schmitt trigger threshold voltage is reached. The result is one and only one response from the Schmitt trigger. A similar effect occurs when the switch is closed, the capacitor again absorbing the transients of the bounce and creating a steadily falling waveform that does not elicit a response from the positively set Schmitt trigger.

Table 9 provides a list of capacitance values that will delay Schmitt trigger operation by the indicated amounts. Connect capacitors directly across the switch terminals as shown in Figure 37. When large value polarized capacitors are involved, be sure to observe polarity (+end connected to the digital input side of the switch, other end connected to ground). Select, by trial and error, the smallest value that produces a delay sufficient to override the bounce characteristics of the switch in question.

Table 9. Delay Intervals for Debouncing Capacitors Connected as Shown in Figure 37.

DELAY INTERVAL	*MINIMUM C*
1 mS	.06 uF
10 mS	0.6 uF
20 mS	1.2 uF
40 mS	2.4 uF

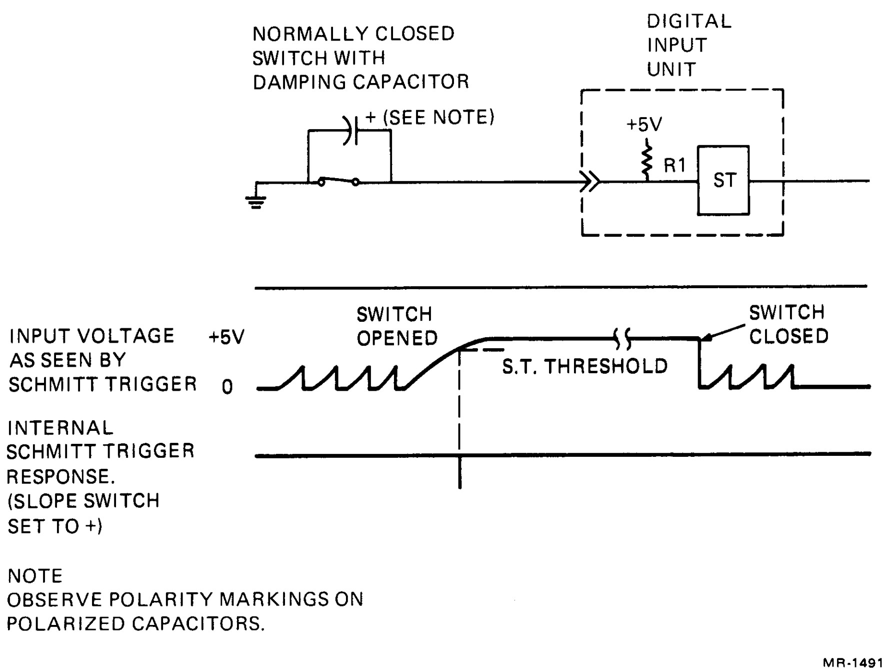


Figure 37. Capacitive Contact Debouncing for a Digital Input Unit Schmitt Trigger

Table 10 provides a summary of connections and control settings required by the DIN routine arguments. Unlisted arguments require no control setting or connective support from the user.

Table 10. Connections and Control Settings Required by the DIN Routine.

Routine	*Argument*	*Supporting User Action*
DIN	mode=TIMESTAMP	Confirm presence of required clock module(s).
	mode=ST2	Connect desired start signal line to ST2 input on clock.
	mode=EXTERNAL	Connect desired input to clock ST1.
	rate=0	Connect STROBE and REPLY to external apparatus and set STROBE polarity switch as required.
	rate=0	Connect sampling trigger line to DI strobe terminal or to any of terminals D00 to D15 for independent event operation.
	rate≥1	If EXTERNAL mode is specified, connect desired input to clock ST1.
	CHAN	Confirm that the specified channel(s) exist on the system.

THE MINC DIGITAL OUTPUT MODULE

Applicable Lab Module Routines (see *Book 6* for complete information):

DOUT	Send Digital Data
DOUT_MASK	Specify Mask for Digital Output
SET_LINE	Specify Condition of a Single Digital Output Line

The MINC digital output module (see Figure 38) permits program-controlled transfer of up to 16 bits of data or control information from the MINC system to external apparatus. The unit can output data on program command. Moreover, it is equipped with STROBE and REPLY terminals to facilitate communications with external instruments that accept data simultaneously on groups of as many as 16 lines. The unit can also drive up to 16 relays, lamps, or light-emitting diodes (see *Book 6* for details on use of SET_LINE commands for specifying discrete digital output lines).

Figure 39 shows the digital output connector block.

Expansion. The MINC system supports up to four digital output modules. Each is referenced in the digital output routines as a *unit* with an identifying number between 0 and 3. Unit 0 is the digital output module whose configuration switches have been set in accordance with the label on the side panel to define the module as unit 0. Unit 3 is the digital output module whose configuration switches define it as unit 3. Relative position of the digital output units is unimportant to the computer (though random placement may confuse the user) as long as all units are inserted to the right of any A/D converter and to the left of clock 1, if it exists (see Chapters 9 and 10).

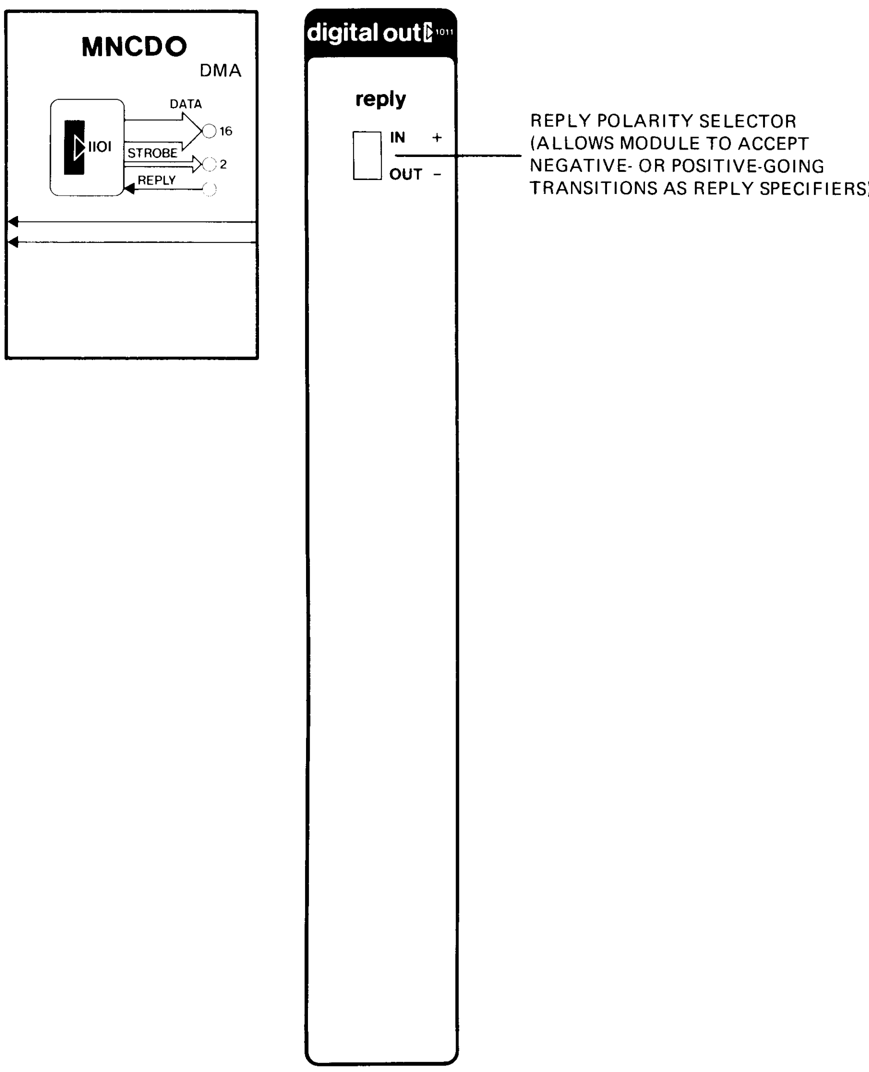


Figure 38. MINC Digital Output Module

Connections to External Parallel Data Port. Figure 40 illustrates connections between the digital output and an external instrument that accepts up to 16 parallel bits of digital information. To ensure reliable data transfer, such instruments often issue a "Data Accepted" signal when data has been received to inform the transmitting device that it can proceed to the next transfer. This signal line must be connected to the REPLY terminal on the digital output connector block. Such instruments wait to read new data until a "Data Ready" signal is received from the transmitting device. This signal line must be connected to either of the strobe terminals (HB STRB or LB STRB) on the connector block (the two are functionally identical for the MINC user). Figure 41 illustrates the timing relationships assumed by the digital output module.

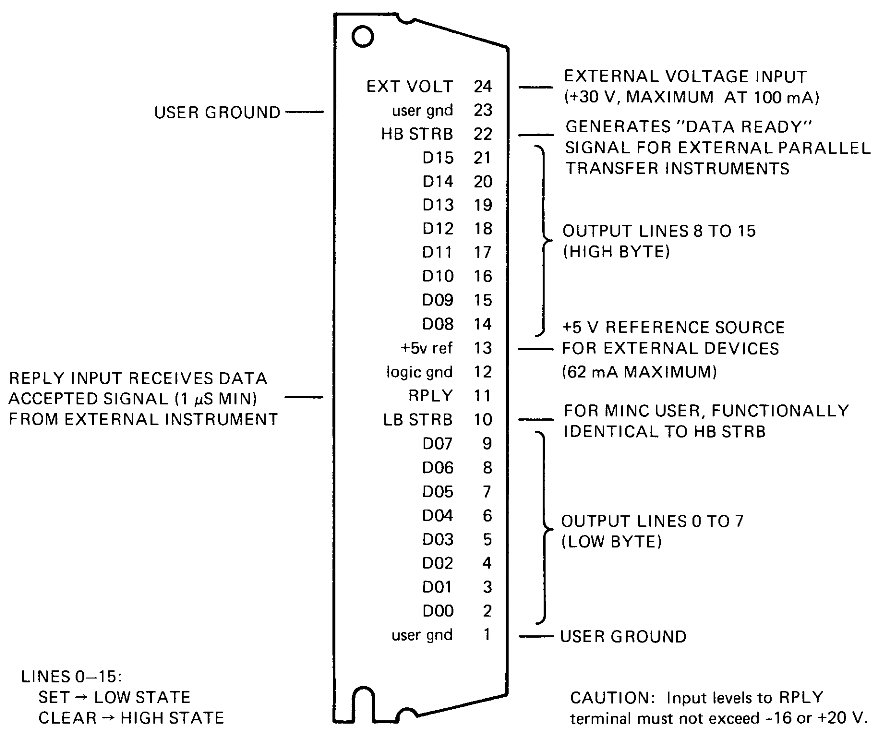


Figure 39. MINC Digital Output Connector Block.

Connect single unshielded wires between data and control pins of the instrument connector and related terminals on the digital output connector block. Make sure that at least one wire is connected between the external instrument ground and one of the two User Gnd terminals. If more than one ground terminal is available at the instrument connector, it is good practice to connect a ground wire to each user ground on the connector block.

Transfers Requiring Non-TTL* Voltages. The EXT VOLT terminal (pin 24) on the digital output connector block permits raising the data and STROBE high logic values from the TTL range to as high as +30 volts. Connect the external power supply as illustrated in Figure 42, and set the power supply to the level required by the external instrument.

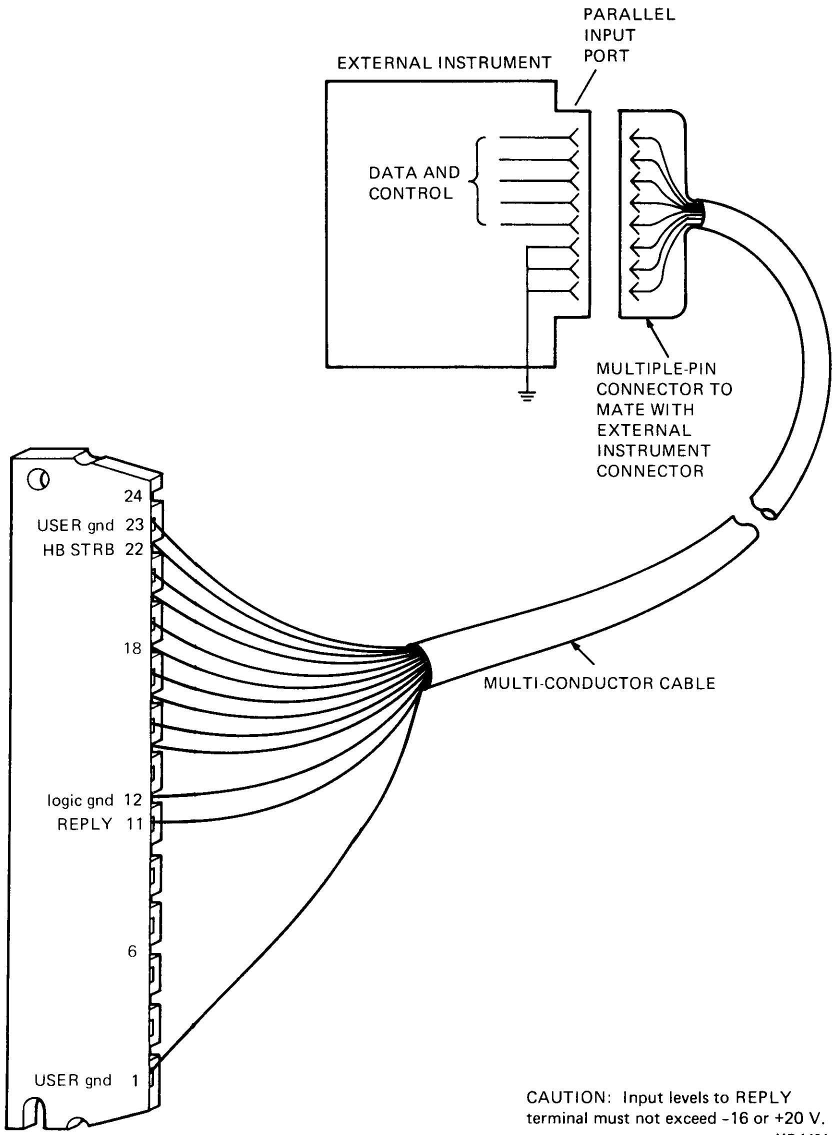


Figure 40. Connections to External Instrument with TTL-compatible Parallel Data Port

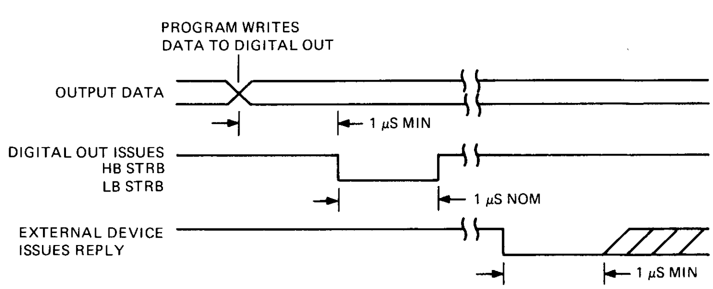


Figure 41. Timing of Parallel Data Transfer from the Digital Output to External Apparatus

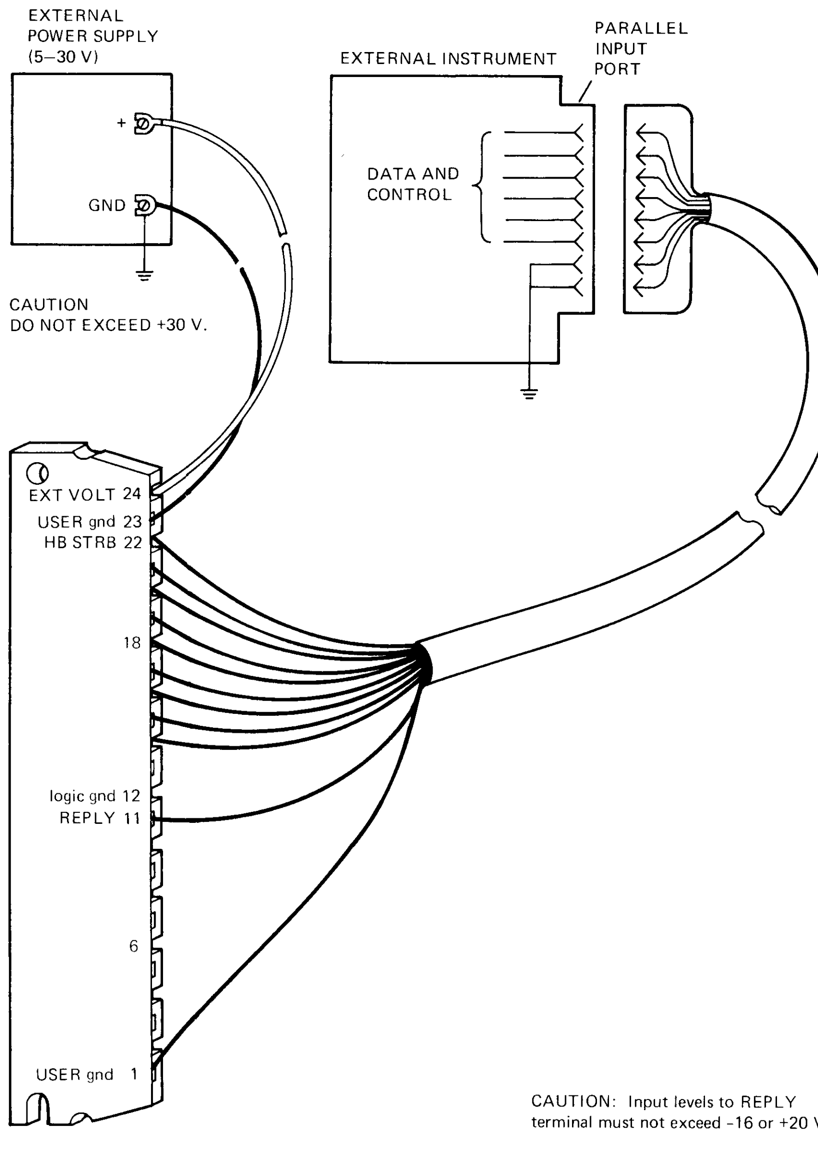


Figure 42. Use of the EXT VOLT Terminal

NOTE

Some instruments provide their own reference voltage terminal. In such cases you can dispense with the external power supply and make a connection between the instrument reference terminal and EXT VOLT on the digital output connector block.

Driving Power-consuming Devices. All output lines of the digital output unit (including the STROBE lines) are provided with drive transistors that can pass significant amounts of externally supplied current. For this reason, the digital output module can be used to drive a large variety of discrete external devices — light-emitting diodes, incandescent lamps, solid-state and electromechanical relays, small DC motors, and so forth. The main restrictions are that the external voltage not exceed +30 volts, that no more than 140 mA may be drawn from any single output, and that inductive devices such as electromechanical relays or motors be provided with suitable flyback clamp diodes. Connections to external devices are illustrated in Figure 43.

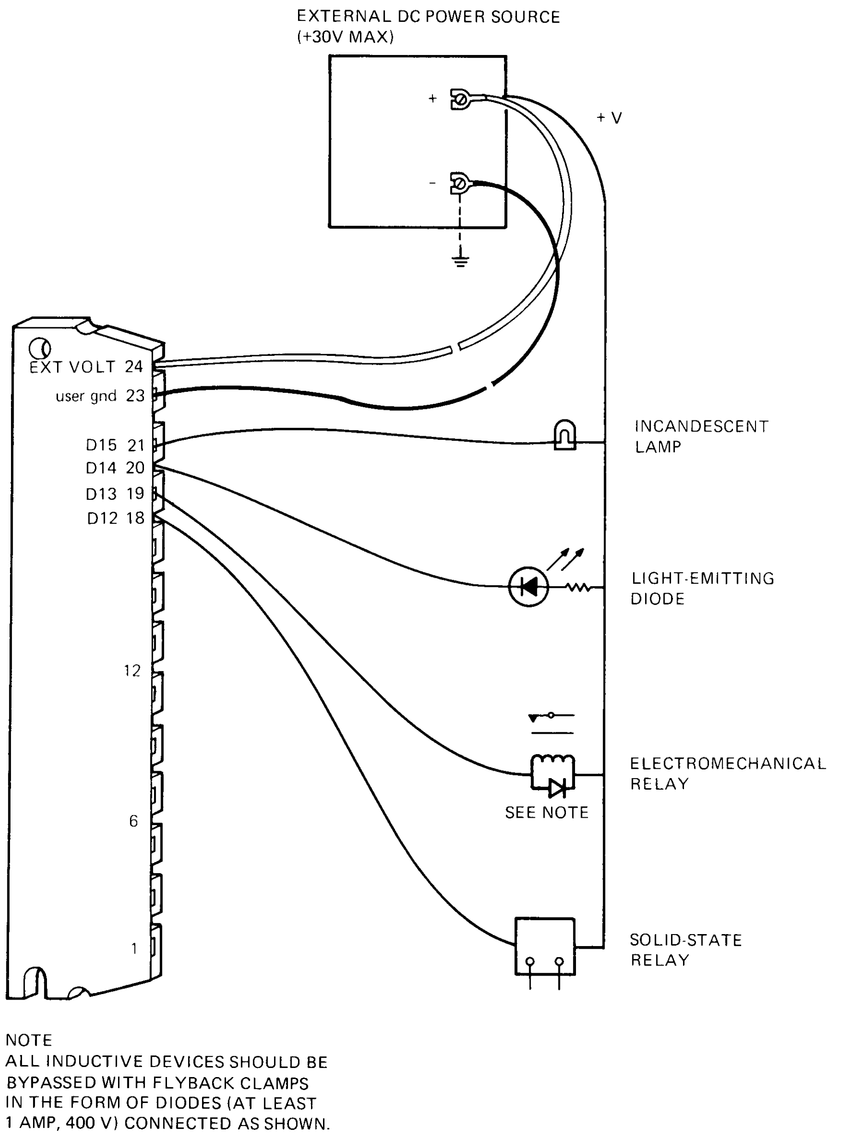


Figure 43. Connecting Discrete External Devices to the MINC Digital Output

Table 11 provides a summary of connections and control settings required by the DOUT routine. Unlisted arguments require no control setting or connective support from the user.

Table 11. Connections and Control Settings Required by the DOUT Routine

Routine	*Argument*	*Supporting User Action*
DOUT	mode=ST2	Connect desired input to clock ST2.
	mode=EXTERNAL	Connect desired input to ST1.
	rate=0	Connect HB STROBE or LB STROBE and REPLY to external apparatus and set Reply polarity switch as required.

CHAPTER 6
USING THE IEEE INSTRUMENT BUS

Housed in the processor section of the MINC chassis is the IEEE bus controller, a module that mediates between the MINC system and as many as 14 external IEEE-bus-compatible instruments. Communications with such instruments via this module are described in *Book 5*. What follows here describes the IEEE bus and provides information necessary to making connections between MINC and external instruments on the bus.

IEEE BUS

The IEEE Bus (defined in IEEE-488 General Purpose Instrument Bus Standard) consists of 16 data and control lines that are shared by all external IEEE instruments and which provide a communications path between those instruments and the MINC processor. Instruments are connected to the bus by multiple-conductor cables (see Figure 44). These cables terminate at both ends in combined male/female connectors that can be stacked one on another — thus permitting parallel connection of the MINC IEEE bus module and all the instruments on the bus.

BUS PROTOCOL

All instruments share the bus and could therefore interfere with one another if there were no restrictions on when and how instruments can send or receive information. For this reason, a bus communications protocol has been designed into the combined logic of the IEEE bus module and communicating instruments. This protocol allows bus instruments to operate under certain conditions (discussed below) as talkers, listeners, or controllers, or some combination of the three.

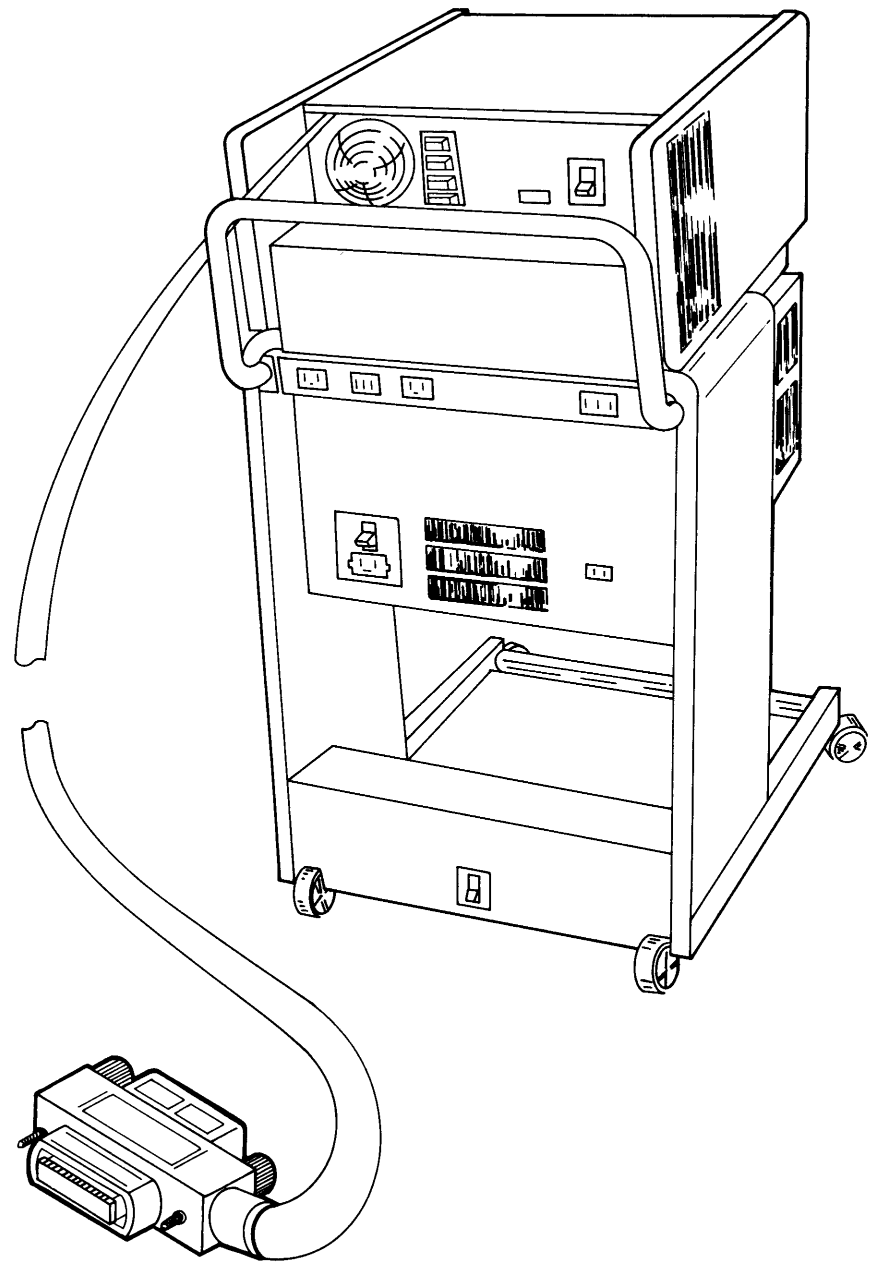


Figure 44. IEEE Bus Cable

Talkers. Any instrument that can output data to the bus is a potential talker. Digital voltmeters fall into this category, as do electronic counters, spectrum analyzers, and the interface bus controller itself. To prevent interference, bus protocol allows only one talker to be active at a time.

Listeners. Any instrument that can receive data from the bus is a potential listener. This includes the instrument bus controller itself as well as most instruments which can be controlled or receive data from the bus — digital voltmeters, electronic counters, spectrum analysers, plotters, line printers. Protocol allows any number of external instruments to be active listeners at the same time.

Controllers. Although a controller can be both a talker and a listener, it is distinguished by the fact that it oversees all activity on the bus. The controller can designate which instruments talk and which instruments listen and can thereby maintain an orderly flow of information along the bus. In the MINC world MINC itself is always the controller.

ADDRESSING

Talkers and listeners are converted from an inactive to an active role by being "addressed" to act in that role by the controller. Each instrument connected to and monitoring the bus is provided with one or more user-settable addresses, each specific to a talk and/or listen function within the instrument.

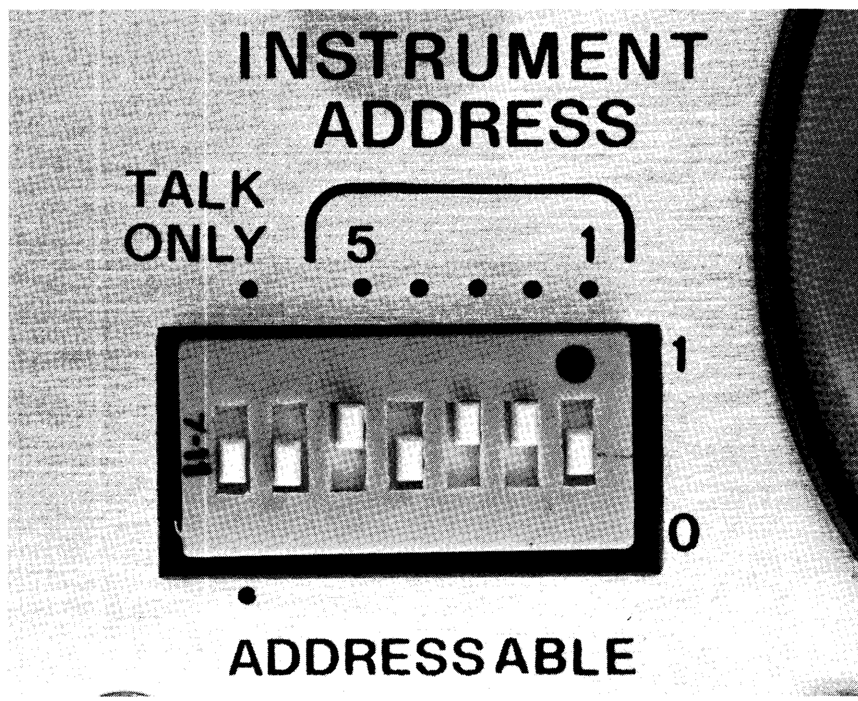
Note that a distinction must be made between the words "monitor" and "listen" in the world of the IEEE bus. All connected instruments *monitor* the bus continuously, whether in their listen mode or not. If they did not, they could not be directed even to "listen." *Listen,* however, denotes the act of waiting for messages.

Setting Instrument Addresses. Most instruments that connect to the IEEE bus will be provided with one or more sets of switches or jumpers that permit you to set talk and/or listen address to appropriate values. The user's manual for the instrument in question should indicate where these switches or jumpers are located and how to utilize them to create the desired address codes. MINC accepts decimal addresses in the range of 0 to 30.

Primary Address Switch Arrays. Address facilities in most instruments will resemble those illustrated in Figure 45 and will permit user specification of five bits of address information. That is, a given instrument will provide five switches or five pairs of jumper posts that may be used to define a talk and/or listen address. Table 12 defines the conditions of the five least significant address bits necessary to specify each address from 0 to 30. A bit condition of 1 is normally created by an *on* switch setting or a jumper installed; 0 is created by an *off* switch setting or a jumper not installed.

Addressable Mode. Many instruments provide a switch that permits the user to select either addressable or independent operating modes. For programmed operation on the IEEE bus, this switch should be set to the addressable position.

Recording Instrument Addresses. It is good practice to record the addresses assigned to all instruments in the form of a table. This procedure not only helps prevent assigning duplicate addresses but is a useful reference for the person writing the control program who must use the specific instrument addresses.



9121-21

Figure 45. Typical Talk/Listen Address Switch

CONNECTING BUS CABLES

The final step in preparing an IEEE bus system is that of making connections between the IEEE bus controller cable and the instruments in the system. These connections are made by means of BN11A bus cables, available in 1-, 2-, and 4-meter lengths. Each cable is provided with stackable piggyback connectors that mate both with bus-compatible instrument connectors and with one another. Connections can be made in either star or linear configuration, as illustrated in Figure 46 — or in some combination of the two. Since the bus connects all instruments in parallel, there is no need to be concerned with physical instrument sequence along the bus.

Note that the maximum number of instruments that may be simultaneously connected to the IEEE bus is 15, with MINC itself counting as one instrument.

CAUTION

Although any number of instruments can be mechanically and electrically connected in star configuration, a practical constraint is imposed by the physical stress that a large stack of connectors exerts upon the instrument connector supporting them. In general, avoid building stacks more than three or four connectors high.

Table 12. Talk/Listen Address Switch Settings

Address Switch Settings (1 = Switch on)					*Talk/Listen Address (decimal)*
A5	*A4*	*A3*	*A2*	*A1*	
0	0	0	0	0	0
0	0	0	0	1	1
0	0	0	1	0	2
0	0	0	1	1	3
0	0	1	0	0	4
0	0	1	0	1	5
0	0	1	1	0	6
0	0	1	1	1	7
0	1	0	0	0	8
0	1	0	0	1	9
0	1	0	1	0	10
0	1	0	1	1	11
0	1	1	0	0	12
0	1	1	0	1	13
0	1	1	1	0	14
0	1	1	1	1	15
1	0	0	0	0	16
1	0	0	0	1	17
1	0	0	1	0	18
1	0	0	1	1	19
1	0	1	0	0	20
1	0	1	0	1	21
1	0	1	1	0	22
1	0	1	1	1	23
1	1	0	0	0	24
1	1	0	0	1	25
1	1	0	1	0	26
1	1	0	1	1	27
1	1	1	0	0	28
1	1	1	0	1	29
1	1	1	1	0	30
1	1	1	1	1	31 *

* Used for special purposes; not a valid device address.

Maximum System Cable Length. If a given system is to function properly, certain voltage levels and timing relationships must be maintained on the IEEE bus. Since these levels and times are affected by cable length and number of instruments connected to the bus, observe the following two constraints when you configure a system:

1. Total cable length for the system must be no greater than 20 meters (66 feet), including the 4-meter MINC IEEE cable.

2. Total cable length for the system must be no greater than 2 meters (6 feet) times the total number of instruments connected to the bus. MINC itself counts as one instrument in this calculation.

For example, if there are twelve instruments on your IEEE bus, rule 2 prevails, and the maximum cable length is (12+1)*2=26 meters — and 26 exceeds the 20-meter limit of rule 1. In this case, you will have to use shorter cables in such a way as to bring the total cable length down to 20 meters (66 feet).

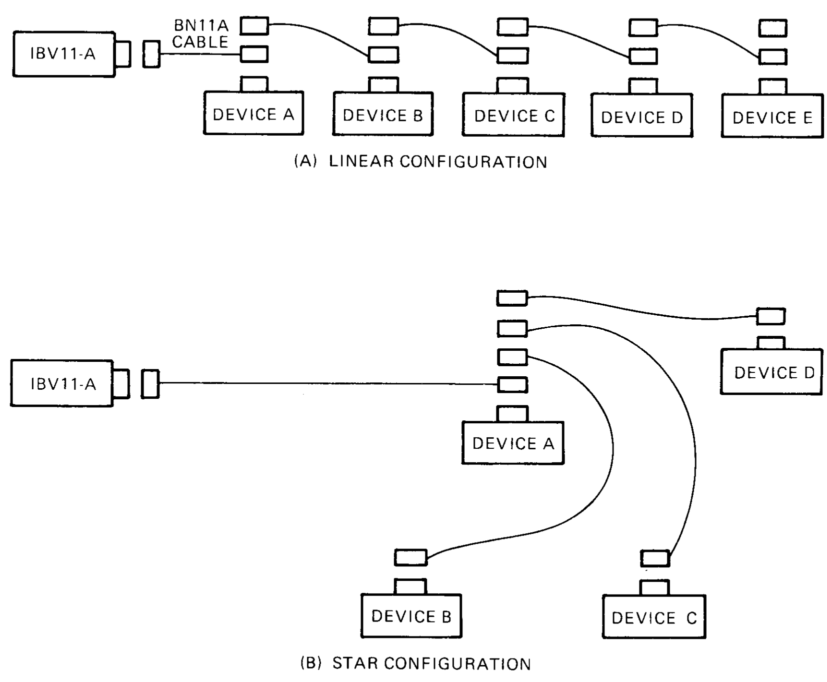


Figure 46. Bus Cable Connections

CHAPTER 7
CONNECTING SERIAL ASCII APPARATUS

Applicable Program Routines (see *Book 6* for complete information):

CIN	Characters In
COUT	Characters Out

Housed in the processor section of each MINC chassis is a serial ASCII transfer controller. This device contains three channels which are routed to the rear of the MINC chassis and identified as serial line units (SLU's). A fourth channel, also routed to the rear of the chassis, is identified with the term *CONSOLE* and is dedicated to the system terminal. These SLU's support serial* transfers of 8-bit ASCII code between the system and the terminal, a 30-character per second printer, and 2 other devices.

SLU2 is assigned to an optional 300-baud printer such as the Digital LA 35. SLU 0 and SLU 1 can be used with a variety of monitor and control instruments that can accept and send serial ASCII code. Table 13 shows the characteristics that each of the SLU's require from apparatus to which they are connected. Note that SLU's 0, 1, and 2 must have test connectors installed (as originally shipped) to run the MINC diagnostic chain (see Chapter 13).

Table 13. Input/Output Characteristics of SLU's 0, 1, and 2

Unit	*Baud Rate*	*Number of Data Bits*	*Number of Stop Bits*	*Mode*	*Parity*
SLU 0	9600	8	1	EIA	None
SLU 1	1200	8	1	EIA	None
SLU 2	300	8	1	EIA	None

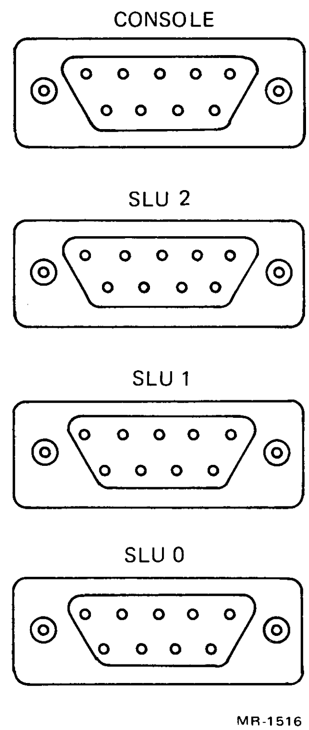
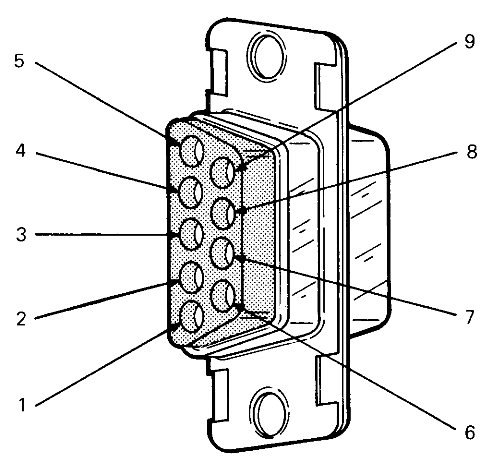


Figure 47. Serial Line Unit (SLU) Ports



PIN 6 – TRANSMIT/RECEIVE GROUND
PIN 7 – TRANSMIT (FROM EXTERNAL APPARATUS)
PIN 4 – RECEIVE (FROM MINC)
PIN 3 – SHIELD (IF ANY)

MR-1894

Figure 48. Wiring the SLU Connector

Unwired connectors that mate with the SLU ports are contained in the MINC interface kit. Figure 48 shows which pins are to be connected to which signal lines on the associated serial ASCII apparatus. Insert wire into the untapered end of the female connector pin and heat assembly with soldering iron until small drop of solder will flow into pin/wire interface. Use minimum solder required to provide a positive physical bond. When all pins are connected, insert each into the holes in the rear of the connector identified in Figure 48. Using a small screwdriver, apply pressure on the rear of each pin until it seats fully as indicated by an audible snap.

PART 2

SPECIFICATIONS, CONFIGURATION, TROUBLE-SHOOTING

CHAPTER 8
MINC SYSTEM SPECIFICATIONS

SYSTEM ENVIRONMENTAL REQUIREMENTS

The following requirements are imposed by the flexible diskettes, which must be within operating temperatures range before use. Note that diskettes exposed to a magnetic field strength of 50 oersteds or greater may lose data.

Temperature

- Operating: 15 to 32 degrees C (59 to 90 degrees F) ambient
- Nonoperating: -35 to +52 degrees C (-30 to +125 degrees F)

Relative humidity

- 25 degrees C (77 degrees F) maximum wet bulb; 2 degrees C (36 degrees F) minimum dew point; 20% to 80% relative humidity

DETAILED SPECIFICATIONS: STANDARD MINC ITEMS

The following specifications apply to the hardware items that make up the physical and electrical portion of the MINC system. These specifications often identify characteristics that are inaccessible or irrelevant to the user of the total hardware/software system. Nevertheless, such specifications may be of interest to MINC users, if only for comparative purposes. For this reason, and for the sake of completeness, they are included here.

MINC Cart, with standard MINC system components:

Size: 54.6 cm W × 110.5 cm H × 77.5 cm D (21.5″ × 43.5″ × 30.5″)

Weight: 125 kilos (275 lbs)

Dual Diskette Drive (RX02M)

Reliability (drive and diskette)

Minimum number of revolutions/track: 1 million (head loaded)

Seek error rate: 1 in 10^6 seeks

Soft read error rate: 1 in 10^9 bits read

Hard read error rate: 1 in 10^{12} bits read

NOTE

The above error rates apply to diskettes that are properly cared for. Seek error and soft read errors are usually caused by random effects in the head/diskette interface such as electrical noise, dirt, or dust. Both are called "soft" errors if the error can be recovered from in ten additional tries or less. "Hard" errors cannot be recovered from.

Drive Performance

Capacity:

Per diskette: 512,512 bytes

Per track: 6,656 bytes

Per sector: 256 bytes

Data transfer rate:

Diskette to controller buffer: 2μsec/data bit (500kbps)

Buffer to interface: 1 μsec/bit (1Mbps)

Interface to LSI-11 I/O bus: 9μs/8-bit byte (>100k bytes/sec)

Track-to-track move: 10/ms/track maximum

Head settle time: 20 ms maximum

Rotational speed: 360 rpm ± 2.5%

Recording surfaces/disk: 1

Tracks/disk: 77

Sectors/track: 26

Bit density: 6400 bpi at inner track

Track density: 48 tracks/in

Average access: 488 ms, computed as follows:

seek		settle		rotate		total
(77 tks/2)	×	10ms + 20ms	+	(166 ms/2)	=	488ms

MINC Chassis (MNCBA)

- Number of processor-related slots (4×36 terminals): 8
- Number of lab module slots (4×36 terminals): 8
- Power supply (+5 and +12 volts):

  +5V at 22A

  +12V at 11A

  Adequate to drive a MINC chassis filled with all standard plus the maximum number of optional modules.

Processor (KD11-HA)

The KD11-HA processor is built around a set of 5 N-channel metal oxide semiconductor (MOS) integrated circuit chips, which include control and data elements as well as two microcode read-only memories. The latter are programmed to emulate the PDP11/35,40 instruction set and include routines for on-line debugging (ODT), operator interfacing, and bootstrap loading. The processor also contains a 16-bit buffered parallel input/output bus, a line time clock input, priority interrupt control logic, power-fail/auto restart and other features to provide standalone operation. The entire processor, with all of the abovementioned features, is contained on one 22.8 by 13.2 cm printed circuit board.

Word length: 16 bits (two 8-bit bytes)

Memory address range: 32,768 words

Instruction set: more than 400 PDP-11/35,40 type instructions

IEEE Instrument Bus Interface (IBV11-A)

Interfaces between MINC and an IEEE bus (IEEE Standard 488-1975).

Input logic levels:

TTL logical low: 0.8 VDC max

TTL logical high: 2.0 VDC min

Output logic levels:

TTL logical low: 0.4 VDC max

TTL logical high: 2.4 VDC min

Memory (MSV11-DD)

* Type: Dynamic random-access MOS
* Logical size: 32,768 words (65,536 8-bit bytes)
* Refresh: internal
* Operating speed (assuming no I/O bus arbitration conflicts):

  Access time: 300 ns, typical; 350 ns max

  Cycle time: 650 ns typical; 750 ns max
* Physical size: 22.8 by 13.2 cm

Serial ASCII Interface (DLV11-J)

* Number of serial lines: 4
* Rates (jumper selectable): 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400
* Interface type: EIA
* Format: Jumper-selectable stop and data bit formats
* Architecture: compatible with LSI-11 bus and LSI-11 interrupt protocol
* Physical size: 22.8 × 13.2 cm

Diagnostic Bootstrap/Terminator (BDV11-AA)

Contains 120-ohm terminations for LSI-11 bus signal lines. Provides read-only memory programs that check the CPU, memory, and operator's console. Also contains start-up (bootstrap) programs for a number of LSI-11 compatible peripherals.

Diagnostic/bootstrap conditions are factory-selected by means of switch packs on the BDV11-AA module. When power is applied to the system or when the system is restarted, the selected diagnostics are executed, followed by the selected bootstrap. If hard errors occur during execution, the CPU halts and a diagnostic light display on the MDV11-AA defines the area of the failure. At the same time, the CPU, by entering Halt mode, causes the I/O address of the error to be presented on the operator's console.

The BDV11-AA is provided with two user-accessible switches — a halt/enable switch that allows the CPU to be forced into Halt mode, and a restart switch that enables the system to be restarted. It is also provided with five diagnostic lights (see Chapter 13 for details).

Keyboard/Monitor with Graphics Display (VT105)

Alphanumeric terminal characteristics

* Detached keyboard with plug-in coil cord
* Screen size: 80 columns by 24 lines or 132 columns by 14 lines
* Double-width, or double-height double-width characters, selectable on a line-by-line basis
* Selectable smooth or jump scrolling
* Blinking cursor, selectable as either underline or reverse video at cursor location
* Split screen capability
* 7 × 9 dot matrix characters with descenders
* Normal or reverse video
* Nonvolatile RAM storage of terminal operating characteristics
* Single character underline or reverse attributes accomplished on a whole-screen basis whereby all selected characters are given the same attribute. The cursor position is identified by blinking the selected attribute at the cursor location
* Composite video output — standard RS170 output for an auxiliary monitor (via BNC connector on rear of terminal)
* Built-in self-test
* P4 phosphor (white)

Size

* Keyboard: 45.7 cm W × 8.9 cm H × 20.3 cm D (18″ × 3.5″ × 8″)

* Monitor: 45.7 cm W × 36.8 cm H × 36.2 cm D (18″ × 14.5″ × 14.25″)

* Combined depth: 51.4 cm (20.25″)

Weight

* Keyboard: 2.3 kg; 5 lbs

* Monitor: 14 kg; 31 lbs

Video Connections

* Composite Video Output (external BNC connector): Provides EIA RS170-compatible output generated by combining the video signal with a composite sync signal.

* Output impedance: 75 ohms, DC coupled

* Sync level: 0 volts

* Black level: approx 0.3 volts with 75 ohm load

* White level: approx 1.0 volts with 75 ohm load

* Composite sync waveform: composed of 6 equalizing pulses, 6 vertical sync pulses, and 6 equalizing pulses

  Equalizing pulse width: 2.33 μsec ± 50 ns

  Vertical pulse width: 27.28μsec ± 200 ns

  Horizontal pulse width: 4.71μsec ± 50 ns

  Horizontal blank width:
  11.84μs ± 50 ns (80 column mode)

  12.34 μsec ± 50 ns (132 column mode)

* Front porch: 1.54 μsec ± 50 ns

* Video Input (external BNC connector):

  External video input signal is "OR'ed" with the internal video signal in such a way that the intensity of the beam at any point on the screen will correspond to the intensity of whichever signal would tend to make the beam brighter at that point.

  Input impedance: 75 ohms, DC coupled

  Black level: 0 volts

  White level: 1.0 volts

  Maximum continuous input: ± 2.0 volts

DETAILED SPECIFICATIONS: OPTIONAL MINC ITEMS

A/D Converter (at 25 degrees C unless otherwise noted)

* Input voltage range: ±5.12 V bipolar (full scale)
* Resolution*: 12 bits (1 part in 4096)
* Data acquisition time: 40 μsec typical; 43 μsec worst case (single channel)
* Sample and hold: aperture delay* = 200 nsec; aperture uncertainty* = 2 nsec
* Number of channels: 16 single-ended* or 8 single-ended and 4 quasi-differential*
* Input impedance: 100 megohms minimum
* Input bias current: 40nA maximum
  Effective input slew rate: 1.5 volts/microsecond
* Integral linearity*: ± 1 LSB* maximum (referenced to end points)
* Differential linearity*: ±1/2 LSB for 99% of states with no states missing or wider than 2 LSB
* Temperature stability: differential linearity = 2 ppm of full-scale range per degree C; offset = 7.5 ppm of full scale range per degree C; gain = 6 ppm per degree C.
* Analog input protection: fusible resistor guaranteed to open at ± 85 V within 6.25 seconds. Guaranteed not to open from -25 V to +20 V at the input. Overload affects no components other than the fusible resistor on the overloaded channel. No other channels will be affected.
* Logic input protection: fusible resistor guaranteed to open at ± 25 V within 6.25 seconds. Guaranteed not to open from -25 V to +20 V at the input.
* Test signals:

  Channel 0: 0 volts (ground potential)

  Channel 1: positive dc level, +4.4 V (±15%)

  Channel 2: negative dc level, -4.4 V (±15%)

  Channel 3: triangular wave, 9.5 Hz nominal (±15%)

MINC Preamplifier (MNCAG)

* Number of channels: 4

* Input impedance (voltage mode): 100 megohms, minimum
* Input leakage current (voltage mode): 40 nA, maximum
* Overvoltage protection (voltage mode): guaranteed to open at ±90V within 6.25 sec; guaranteed not to open from -25 to +25 V at input.
* Overcurrent protection (current mode): guaranteed to open at ±75mA within 6.25 sec; guaranteed not to open from -15 to +15 mA.
* DC accuracy: 0.015% at Gain=0.5; 0.02% at Gain=5; 0.04% at Gain=50; 0.05% at Gain=500.
* Output slew rate: 3 volts/microsecond
* Gain temperature coefficient: 3 ppm/degree C
* Analog input full scale ranges:

	Gain Factor			
Range	0.5	5	50	500
Volts	±-10	±1.0	±-0.1	±-0.01
Kilohms	100	10	1.0	0.1
Milliamps	±-10	±1.0	±-0.1	±0.01

MINC Dual Multiplexer (MNCAM)

* Gain: unity
* Interchannel settling error (in conjunction with A/D converter): 1 LSB* in 10 μsecs
* Interchannel crosstalk: 80 dB @ 1kHz
* Analog input full scale range: ±5.12 V
* Analog input bias current: ±100 nA
* Analog and logic protection: same as for MNCAD

MINC Clock (MNCKW)

* Counter resolution: 16 bits
* Programmable modes (4): single interval; repeated interval; external event (Schmitt trigger 2) timing; external event (Schmitt trigger 2) timing from zero base
* Clock rates (crystal controlled):

  1 MHz

100 KHz

10 KHz

1 KHz

100 Hz

Line frequency (50 or 60 Hz)

Schmitt trigger 1 (500 kHz maximum)

* Accuracy of time base: 0.01 % (crystal tolerances and temperature effects included)

* External inputs: 2 Schmitt triggers

  Input range (maximum limits): -30 V to +30 V

  Assertion level: dependent on condition of mode selector switch (TTL, variable), slope selector (+,-), and threshold level control; triggering range = -12 V to +12 V.

  Duration: Schmitt trigger inputs should remain asserted for a minimum of 1 microsecond and unasserted for a minimum of 1 microsecond.

* External outputs: Schmitt triggers 1 and 2

  Asserted level: low

  Destination: user device

  Duration: approximately 750 ns

  Characteristics: TTL open-collector driver with 470 ohm pull-up to +5 V

  Clock overflow: Same as Schmitt triggers 1 and 2

MINC D/A Converter (MNCAA)

* Resolution: 12 bits (1 part in 4096)

* Number of D/A converters: 4

* Digital input: 12 bits (binary encoded for unipolar mode; offset binary encoded for bipolar mode)

* Output voltage range (switch selected): ±2.56 V, ±5.12 V, ±10.24 V bipolar; 0 V to +5.12 V, 0 V to +10.24 V unipolar

* Gain temperature coefficient: 10 ppm per degree C, maximum

* Offset temperature coefficient: 20 ppm of full scale range per degree C, maximum
* Linearity*: ±1/2 LSB* maximum non-linearity
* Differential linearity*: ±1/2 LSB, monotonic
* Output impedance: 1 ohm maximum
* Drive capability: ±6 mA maximum (each converter)
* Slewing speed: 5 V/μsec
* Rise and settling time (to 0.1% of final value): 4 μsec (8 μsec with 5000 pF load in parallel with 1 Kohm)

MINC Digital Input Unit (MNCDI)

* Number of data inputs: 16
* Control input (1): STROBE
* Control output (1): REPLY
* Other outputs: PGM OUT (programmable output); DATA READY (front panel BNC connector)
* Input voltage levels: All inputs display hysteresis, are TTL* compatible, and are protected by fusible resistors. Input levels must not exceed -16 or +20V.
* Input sense: logic 1 may be defined as either a low voltage or a high voltage. Defined either by program or by a front panel switch.
* Output voltage levels: TTL compatible; may be redefined with an external power supply.
* Output current capabilities: 4mA max source, 150 mA max sink
* Programmable operating modes:

  Strobe (user initiated word transfer)

  Poll (computer initiated word transfer)

  Stimulus (individual bit recognition)
* Timing:

  REPLY: Data; 1μsec minimum transition low-going pulse output

  STROBE: 1 μsec minimum pulse width required (user must assert STROBE no sooner than the assertion of valid data)

MINC Digital Output Unit (MNCDO)

* Number of data outputs: 16
* Control outputs (2): LOW BYTE STROBE; HIGH BYTE STROBE
* Control input (1): REPLY
* Output voltage levels: TTL* compatible; may be redefined with an external power supply.
* Output current capabilities: 4 mA max source; 150 mA max sink.
* Input voltage levels: REPLY input is TTL compatible and fuse protected by fusible resistor. Levels must not exceed -16 or +20 V. Hysteresis is provided for increased noise immunity.
* Input sense: REPLY input assertion may be defined as either a positive or negative transition as selected by program or front panel switch.
* Timing:

  LOW BYTE STROBE: 1 μsec low-going pulse output

  HIGH BYTE STROBE: 1 μsec low-going pulse output

  DESKEW: interval between output data change and STROBE pulses = 1 μsec.

  REPLY: 1 μsec minimum pulse required.

CHAPTER 9
SYSTEM CONFIGURATION PROCEDURES

SYSTEM EXPANSION

From the point of view of system expansion, MINC modules fall into two categories: those that the system identifies by relative position with respect to other modules, and those that it identifies by means of unique switch settings on the modules themselves. Multiplexers and preamplifiers belong in the first category: as long as they are properly placed with respect to one another on the left of the A/D converter, the A/D converter will automatically assign a coherent channel identity to each input terminal (see Chapter 1, "The MINC Data Transfer System").

Clocks, digital input and output units, D/A converters, and the A/D converter belong in the second category: MINC identifies these modules by means of switch settings. The switches involved are mounted on the main printed-circuit board of the modules and are accessible through perforations in the right side plate. All units are set by the factory on the assumption that they will be the first of their kind on any given system. This assumption will be invalidated whenever multiple units are ordered initially with MINC or when modules must be added at some later date. In either case, these factory-set patterns must be changed to identify each unit as the second, third, or fourth of its kind in the system. The A/D is the only lab module that can share the MINC chassis with no other units of its own kind.

Switch patterns necessary to specify unit numbers are defined on the label attached to the right side cover of all modules. Note that units must be assigned sequential numerical identification: digital input units 0, 1, 2 — not 0, 2, 3. Switches can be set by ballpoint pen or other stylus-like tool inserted through the perforations in the side plate of the module, as shown in Figure 49.

Do *not* set switches with a pencil. Note that two sets of switches must be set for each module except the D/A, which has only one set.

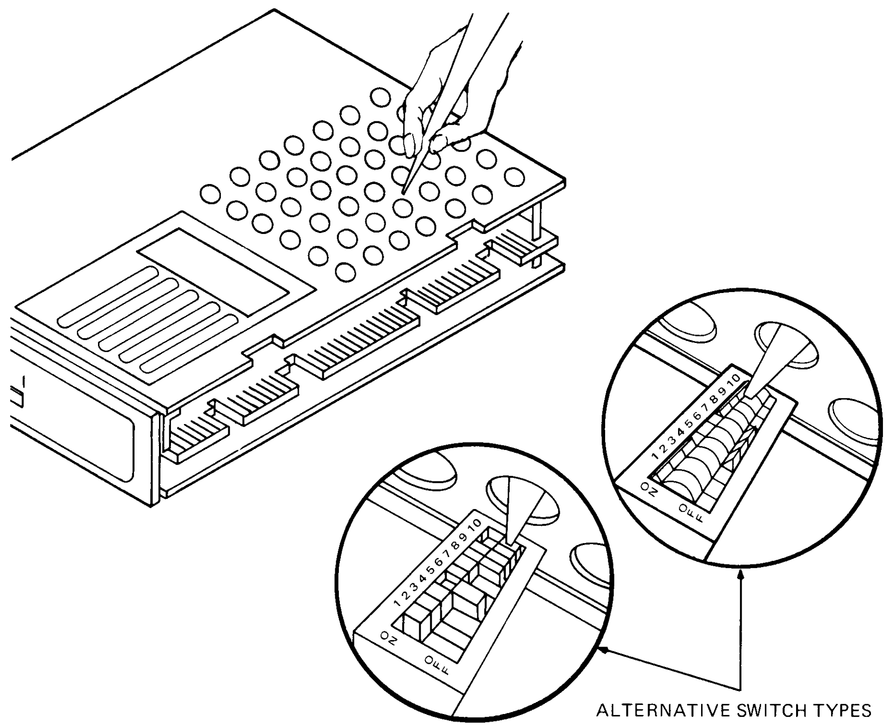


Figure 49. Setting Module I.D. Switches

Table 14 defines the maximum number of address switch equipped modules that the MINC system will permit. Note that MINC supports only one A/D converter. Limits on preamplifiers and multiplexers are established by the A/D's 64-channel capability or by physical space in the MINC chassis.

Table 14. Maximum Number of Addressable MINC Modules

Unit	*Maximum Units*
Clocks	2
Digital Input Units	4
Digital Output Units	4
D/A Converters	4
A/D Converter	1

Module Placement Sequence. Required placement sequence (right to left) is identified in Table 15.

Relative position of multiple modules of the same type is not critical as long as the group is installed in the proper position with respect to other modules of different types. It is, however, good practice — and will simplify the determination of appropriate programming routine arguments — to assign unit 0 of any group the rightmost position within the group, unit 1 the next position to the left, and so on. Module types can be omitted from the sequence defined in Table 15 as long as the sequence is preserved with the modules that do exist. *No empty slots are permitted between modules.*

NOTE

Module panels are keyed with respect to other panels to discourage wrong sequencing. However, it may be possible to force modules into their slots in incompatible ways. The last 5/8ths inch of module travel must insert the module connector fingers into the MINC chassis connectors and therefore requires some pressure. Up to this point, however, passage should be unimpeded and smooth. If you encounter resistance, do *not* force the module. Examine the keyways on the edges of the front panels involved. If they are incompatible, you are violating sequence requirements.

Table 15. MINC Module Placement Sequence

First Clock	(Clock 1)
Second Clock	(Clock 0)
First-Fourth Digital In	(Units 0-3)
First-Fourth Digital Out	(Units 0-3)
First-Fourth D/A	(Channels 0-15)
A/D	-----------
First Preamp	-----------
First Mux	-----------
Second Preamp	-----------
Third Preamp	-----------
Second Mux	-----------
Fourth Preamp	-----------
Fifth Preamp	-----------
Third-Seventh Dual Mux	-----------
Blanks	-----------

CHANGING OPERATING MODES ON THE MINC TERMINAL

The MINC terminal is a member of a new generation of computer-related devices that not only give their users a very large number of useful operating characteristics but also have a significant amount of built-in intelligence and memory. The latter two capabilites permit you to choose operating characteristics by keyboard command rather than by setting hardware switches. Setting these characteristics is accomplished in what is called setup mode.

It is intended that you read the following section with access to a MINC terminal so that you can execute the commands in question and get first-hand evidence of their effect.

How to Use Setup Mode. You can enter setup mode at any time by pressing the SETUP key at the upper left corner of the MINC keyboard. This causes the Setup A display to appear on the screen, as shown in Figure 50. There is also a secondary display, Setup B, which is discussed later in this section.

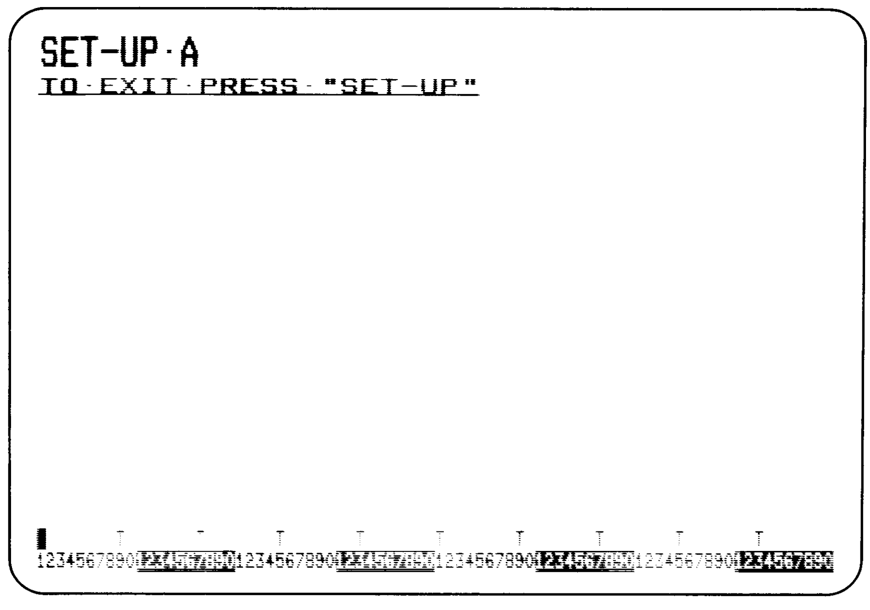


Figure 50. Setup A Display

You can leave setup mode at any time by pressing the SETUP key a second time. For the present, leave the setup A display on the screen.

NOTE

Entering setup mode does not erase your text from the character storage memory in the terminal but only replaces it temporarily on the screen with the setup displays. (Note that any graphics display details remain on the screen with the setup information.) When you press the SETUP key a second time to leave setup mode, your former text is restored. The only setup mode keys that DO erase the terminal character storage memory are the 9 key, the 0 key, and the SHIFT/R key. These keys are described in this section.

Setup A

* Screen contrast. The contrast of the screen is increased by the up-arrow key (↑) and decreased by the down-arrow key (↓).

Try holding down each of these keys and notice the change in the screen contrast.

* Tab stops.

NOTE

Tab stop settings on the terminal are ignored by the MINC system. The tab stop setting procedure is given here for completeness, but you should not expect those settings to affect text output by your MINC programs.

The tab stop setting can be changed with the 2 key. Tab stops are shown by the letter T, which appears at various points along the list of numbers (the Ruler) at the bottom of the primary display. This Ruler defines the number of columns on the screen. To change a tab stop, move the cursor to the position above the desired column and then press the 2 key. (The left- and right-arrow keys, the tab key, the return key, and the space bar all move the cursor without affecting setup conditions.) If there is already a tab stop at the column when you press the 2 key, that stop is cleared. If there is no previous tab in the column, a T appears, meaning that the tab stop is set. You can repeat this operation any number of times.

* Tab clear. See note under "Tab stops," above. To clear ALL tab stops, press the 3 key.

* Local mode. The MINC terminal can operate in two modes, local and remote. In the former, the screen image can be modified by operating the keyboard, but no data is transmitted to or received from the MINC system. In the latter, anything displayed on the screen (even the characters that you type) are received from a remote source — in this case, the MINC system. Since a terminal that will operate properly in local will normally operate properly in remote mode, local mode is useful for confirming that display problems are not the fault of the terminal.

To put the terminal in local mode, press the 4 key. This action will turn on the LOCAL lamp at the top of the keyboard. If you leave setup mode with the terminal set to local, the characters you type will appear on the screen but will not be sent to the MINC system.

The normal MINC terminal operating mode — allowing standard communication with the MINC system — is on-line. To return to on-line mode, press the 4 key again. This will cause the lamp to turn on.

* Screen width. The 9 key controls the width of the screen in columns. Press this key and observe that the ruler along the bottom of the screen changes. The screen is now 132 columns wide. Press the key again and the ruler reverts to its normal width of 80 columns. THE NORMAL 80-COLUMN WIDTH IS EXPECTED INITIALLY BY MINC GRAPHIC ROUTINES. Note that character data is lost from the character storage area when the 9 key is pressed.

* Terminal test. The 0 key starts a test procedure inside the MINC terminal which checks the keyboard and portions of the the terminal's memory. Pressing this key generates a rapid series of character displays on the screen. If the test is successful, it ends by restoring the permanent setup mode parameters (see the next item) and exiting from setup mode.

If the test fails, error information is generated on the keyboard lamps and the terminal screen. See Chapter 13 for more information.

NOTE

> Pressing the 0 key also erases any text that was in the terminal character storage memory before you entered setup mode.

* Saving Setup Conditions. The SHIFT/S key saves in the terminal's control memory whatever terminal conditions are currently specified. These parameters will remain in the control memory even when the terminal is turned off. Saved parameters are restored when the power is turned on again, at the completion of the terminal test, and when you press SHIFT/R in setup mode.

NOTE

> Be careful with the SHIFT/S key. Do not save setup mode parameters unless you are sure that they will not interfere with the needs of other users of the MINC system. See Figures 50 and 51 for standard MINC parameters.

* Restoring Previously Saved Setup Conditions. The SHIFT/R key RESTORES to control memory whatever operating parameters have been previously saved — in the case of a new machine

on which no variant parameters have been saved, those shown in Figures 50 and 51.

* Answer back message. SHIFT/A elicits "A=" from the terminal, after which the user of certain non-MINC systems may enter an answer back message for system use. This feature is *not* used by the MINC system. If you inadvertently type SHIFT/A, respond to "A=" with a carriage return.

Setup B

The remaining features of setup mode are accessed by means of Setup B, which you enter by pressing the 5 key. This causes the screen to display the pattern shown in Figure 51. You can restore the Setup A display by pressing the 5 key a second time, but leave the secondary display on the screen while you read the following.

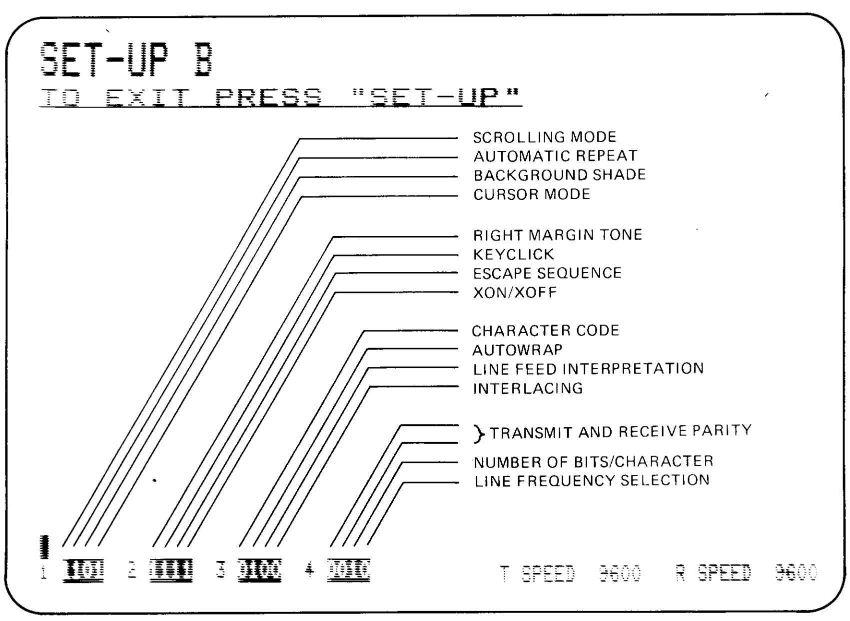


Figure 51. Setup B Display

NOTE

If you wish only to verify that your terminal is properly set up for MINC programming, compare the Setup B display on your screen with Figure 51, which shows a set of values that is compatible with all MINC routines.

If your screen reveals a different setup from that indicated in Figure 51, press SHIFT/R and then press the 5 key again. If your setup still differs from that defined in Figure 51 in some positions, reset these positions according to the instructions in this section.

Notice that, in setup B, the cursor is located at the left end of the groups of 0s and 1s at the bottom of the screen. Each of these digits represents what amounts to an on-off switch, with 0 signifying *off* and 1 signifying *on*. To control the remaining setup mode parameters, move the cursor until it is located over a digit you want to change; then press the 6 key. This action changes the number under the cursor either from 0 to 1 or from 1 to 0. Numbering of groups and digits within groups is from left to right and begins with 1.

The effect of each control digit in setup B is discussed below. Control digits are identified for quick reference in Figure 51.

* Scrolling mode. Digit 1 of group 1 controls scrolling mode. If the scrolling digit is 0, the terminal scrolls by jumping each line of characters up one line. If the scrolling digit is 1, the terminal scrolls with a smooth continuous movement of all affected lines. Set this digit to 1 on all MINC systems.

* Automatic repeat. Digit 2 of group 1 controls the automatic repeat feature for the terminal keys. If this digit is 1, keys will repeat automatically if you hold them down instead of depressing them momentarily. If this digit is 0, keys do not repeat. You may choose the setting that you find most convenient.

* Background shade of screen. Digit 3 of group 1 controls the figure-ground relationship of characters on the screen. If this digit is 0, the screen displays black characters on a white background. If the digit is 1 (the normal setting), the terminal displays white characters on a black background. MINC GRAPHIC ROUTINES INITIALLY EXPECT BLACK BACKGROUND SHADING.

* Cursor mode. Digit 4 of group 1 controls cursor mode. When this digit is 0, the cursor appears as a flashing underscore character. When this digit is 1, the cursor is a flashing white square on a black ground or vice versa. You can use either setting with MINC.

* Right margin tone. Digit 1 of group 2 controls the right margin tone. When this digit is 1, a tone sounds when your typed line comes within eight columns of the right margin. The tone does

not sound if this digit is 0. You can use either setting with MINC.

* Keyclick. Digit 2 of group 2 controls the "keyclick" feature of the terminal. If the digit is 1, any keystroke on the terminal produces an audible click. This click provides audible feedback for users who are accustomed to typewriters. If the digit is 0, all the keys are silent. You can use either setting with MINC.

* Escape sequence mode. Digit 3 of group 2 MUST be set to 1, to comply with the ANSI standard for escape sequences. THIS SETTING IS REQUIRED BY MINC. (If the digit is 0, the terminal emulates the escape sequences used by DIGITAL's VT52 terminal, and MINC routines will not function properly.)

* Automatic XON/XOFF. Digit 4 of group 2 MUST be set to 1, enabling this feature. REQUIRED FOR ALL MINC OPERATIONS. (With this feature enabled, the processor is automatically commanded to interrupt data transmission when the data handling speed of the terminal is exceeded. When the terminal catches up, the processor is automatically commanded to resume data transmission.)

* Character code selection. Digit 1 of group 3 MUST be set to 0, for ASCII code. REQUIRED FOR ALL MINC OPERATIONS. (A setting of 1 selects the United Kingdom code, which is incompatible with the MINC routines.)

* Autowrap feature. Digit 2 of group 3 MUST be set to 1, enabling this feature. (A setting of 1 causes all lines exceeding the width of the screen to "wrap around" to the following line and thus permits displaying lines whose length exceeds the selected screen width.)

* Interpretation of LINE FEED key. Digit 3 of group 3 MUST be set to 0. REQUIRED FOR ALL MINC OPERATIONS. (The 0 setting creates a single line feed character in response to a LINE FEED keystroke. A setting of 1 adds a carriage return character as well, causing the LINE FEED key to be interpreted as a "new line" function.)

* Interlacing. Digit 4 of group 3 controls the number of scan lines on the screen. If you look closely at characters on the screen, you can see the scan lines running through them. If this digit is 0, there are 240 scan lines between the top and bottom of the screen. If this digit is 1, an additional 240 lines are interlaced between the normal lines. If you set digit 4 to 1, you can see that interlacing makes characters look smoother, since more lines

are being used to make characters of the same size. However, interlacing may cause a slight jittering of the screen image; this is a normal property of interlacing. Interlacing is useful when you are photographing the screen, since it effectively reduces the amount of undefined space within each character and thereby increases character definition. You can use either setting with MINC.

* Transmission and reception parity. Set both digits 1 and 2 of group 4 to 0. REQUIRED FOR ALL MINC OPERATIONS.

* Number of bits per character. Digit 3 of group 4 MUST be set to 1 to indicate that the character code is 8 bits long. REQUIRED FOR ALL MINC OPERATIONS.

* Line frequency selection. Setting digit 4 of group 4 to 0 configures the terminal appropriately for a 60-Hz AC line; setting this bit to 1 configures the terminal for a 50-Hz line. American users should set this digit to 0.

* Transmission speed of terminal (T SPEED). If you hold the 7 key down,T SPEED displays a range of baud rates from 50 to 19,200. T SPEED MUST be set to 9600. REQUIRED FOR ALL MINC OPERATIONS.

* Reception speed of terminal (R SPEED). Controlled similarly to T SPEED, but with the 8 key. R SPEED MUST be set to 9600. REQUIRED FOR ALL MINC OPERATIONS.

Now return your terminal to normal operation by pressing the SETUP key again. Be sure that you have left all the setup mode parameters in their required states (see Figures 50 and 51).

CHAPTER 10
CONNECTIONS TO EXTERNAL APPARATUS

USING THE MINC CONNECTOR BLOCKS

Each MINC connector block accommodates up to 24 connections between any given laboratory module and external apparatus. Connector blocks are keyed to prevent attachment to modules not of their own type.

Wire Preparation. Stranded and insulated 22 gauge wire is generally best for MINC connections, although the connector blocks will accommodate larger and smaller gauges. Strip approximately 1/4 inch (6.5 mm) of insulation off the end of each wire to be connected, twist the exposed strands tightly together, and tin the exposed portion with resin-core solder (see Figure 52).

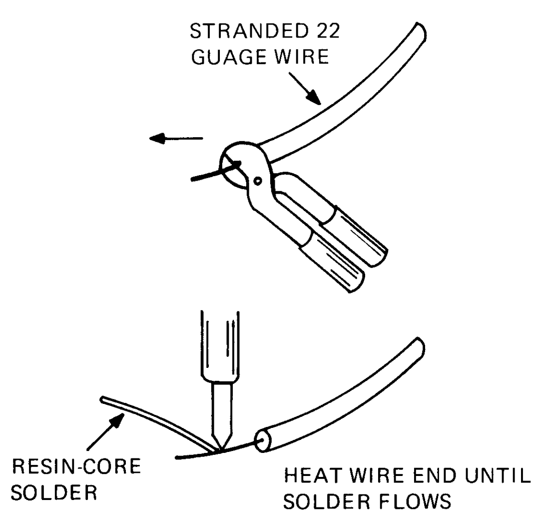


Figure 52. Preparing Wire for MINC Connector Blocks

Note that several ground wires must often share a single ground terminal. When such sharing can be anticipated, do not tin these wires until all wires destined to share a ground are available. Then strip approximately 1/2 inch (13 mm) of insulation from each wire, twist wires together to form a single tip, and tin the tip with solder.

Wire Installation. Select appropriate terminal (embossed numbers on bottom of connector block match terminal numbers on the top decal) and turn holding screw counterclockwise until bare wire portion can be fully inserted beneath screw. Insert wire end and turn down holding screw until tight. See Figure 53.

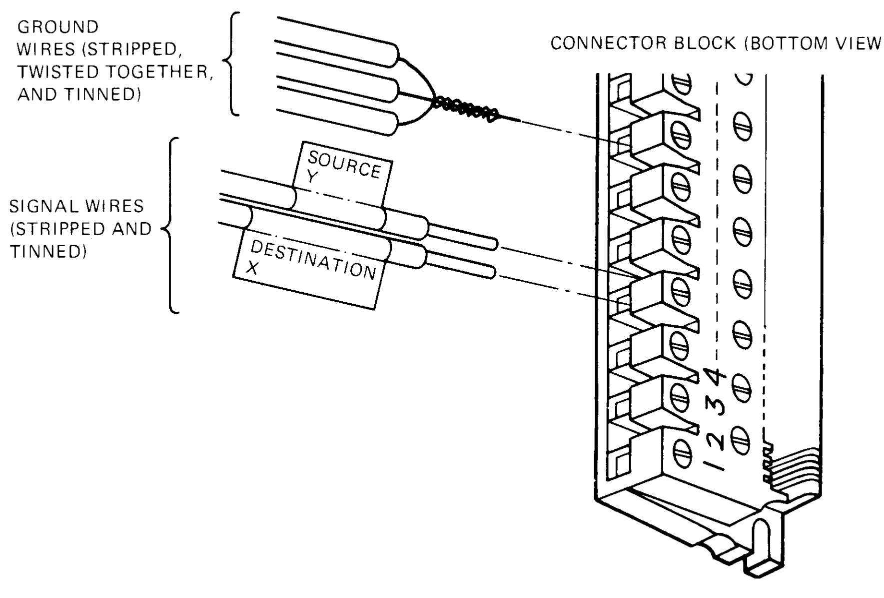


Figure 53. Installing Wires in MINC Connector Block

Strain Relief. When all wires are connected, dress wires toward the rear of the connector block and install tie wrap (supplied in the Interface Kit) as shown in Figure 54. Cut off excess tie wrap tail.

CONFIRMING DATA TRANSFER CONNECTIONS

Test equipment required:

- Function generator with sine and square wave outputs, output range to at least 5 V, frequency range 1/2 to 100 Hz.

- Volt-ohm meter or equivalent with DC range capable of clearly indicating 2.5 volts.

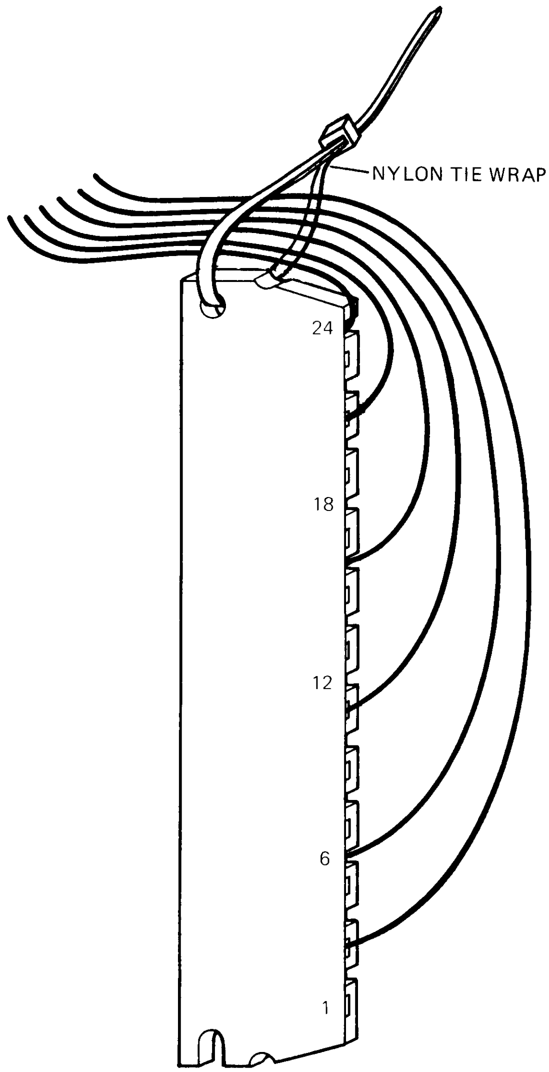


Figure 54. Strain Relief on the MINC Connector Block

The two biggest sources of confusion in the setting up and maintenance of complex interactive MINC/laboratory systems lie in the possibility of defective electrical connections and in the user's losing track of the destination or origin of wires attached to the MINC system. You can minimize the likelihood of the second problem by careful labeling of input/output wires and by careful record keeping as recommended in "Mapping Lab Module Connections" in this chapter. As systems grow complex, however, you will encounter situations in which there is some question about what external instrument is connected to what MINC device and about whether or not appropriate signals are being generated or received by the MINC system.

The procedures that follow are designed to permit you to isolate any input or output line on a MINC system and derive unambiguous information about MINC's relationship to that line. If the program described in each procedure does not produce the indicated results, four explanations are possible:

1. You are not connected to the line you think you are connected to.
2. Connections at one or both ends of the line in question are bad.
3. The line itself is broken or intermittent.
4. The MINC module involved is malfunctioning.

Do not jump prematurely to the conclusion that alternative 4 is the case. First, eliminate the uncertainties introduced by long cabling by making short, direct connections to the terminal in question and executing the procedure again. Only when this too fails should you assume that there may be a problem with the MINC hardware. See Chapter 13 for information dealing with hardware problems.

Running Connection Confirmation Programs

Turn off the system and make connections as described below. Then, insert a MINC demonstration diskette into SY0: and start the system as described in *Book 3*, Start Procedures. After the sytem displays READY, run the selected program by typing "RUN filespec."

A/D Group Inputs

1. Select wire or cable suitable for the intended source and connect one end to the relevant A/D group connector block (see Chapter 2 for a review of A/D inputs; see Chapter 11 for information affecting the choice of wire and cable.) Do not connect the other end to its intended destination at this time. Instead, connect to the function generator as shown in Figure 55.

2. Set function generator as shown in Figure 55 and install single-ended strap (if required) in the connector block involved.

3. If input is to a preamplifier, set mode control to "V" and gain control to "10."

4. Run A/D connection confirmation program (A/DCON) as

described in "Running Connection Confirmation Programs" above, and answer questions as appropriate. After the last question has been answered, you should see a waveform similar to that shown in Figure 56 scrolling from right to left across the terminal screen.

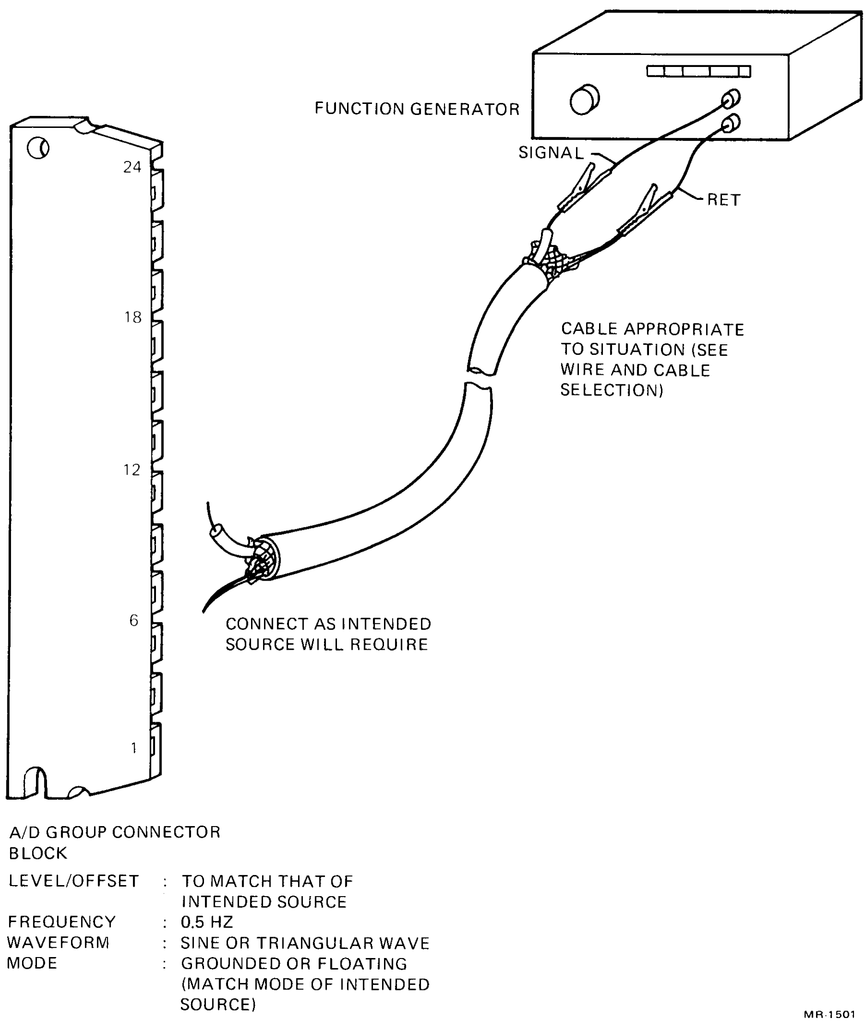


Figure 55. Confirming A/D-group Inputs

If this procedure fails to produce an appropriate waveform image, the fault most probably lies in faulty connections. You may want to review appropriate sections of Part 1, particularly those dealing with A/D group connector block labeling. If all else fails, see Chapter 13.

5. When you have satisfactorily confirmed connection to and operation of the selected channel, halt the program by typing CTRL/C twice, disconnect the function generator, and connect the intended apparatus. Then repeat steps 1 to 4 with any remaining channels. To avoid confusing interactions, make sure that all external apparatus except the function generator is turned off until you have finished confirming lab module connections.

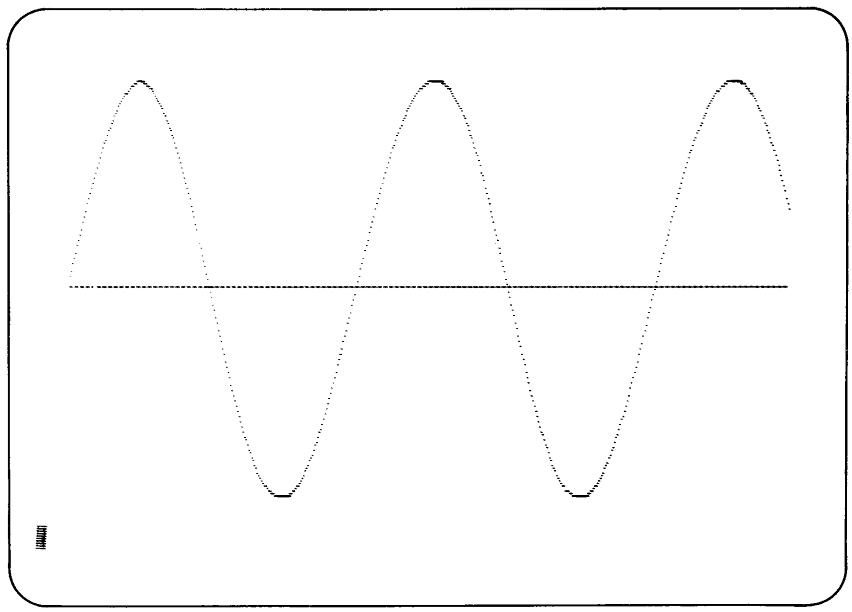


Figure 56. ADCON Display

Clock Schmitt Trigger Inputs

1. Select a wire pair of sufficient length to reach the intended source and connect one end to the selected Schmitt trigger input on the clock connector block. Do not connect the other end to its intended destination at this time. Instead, connect it to the function generator as shown in Figure 57. Make sure there are no connections to the front panel Schmitt trigger terminals. If you intend to make Schmitt trigger connections via the front panel connectors rather than the connector block, make sure that no conflicting connections are made to the Schmitt trigger terminals on the connector block.

2. Set the function generator as shown in Figure 57.

3. Set the selected Schmitt trigger to TTL (slope polarity does not matter).

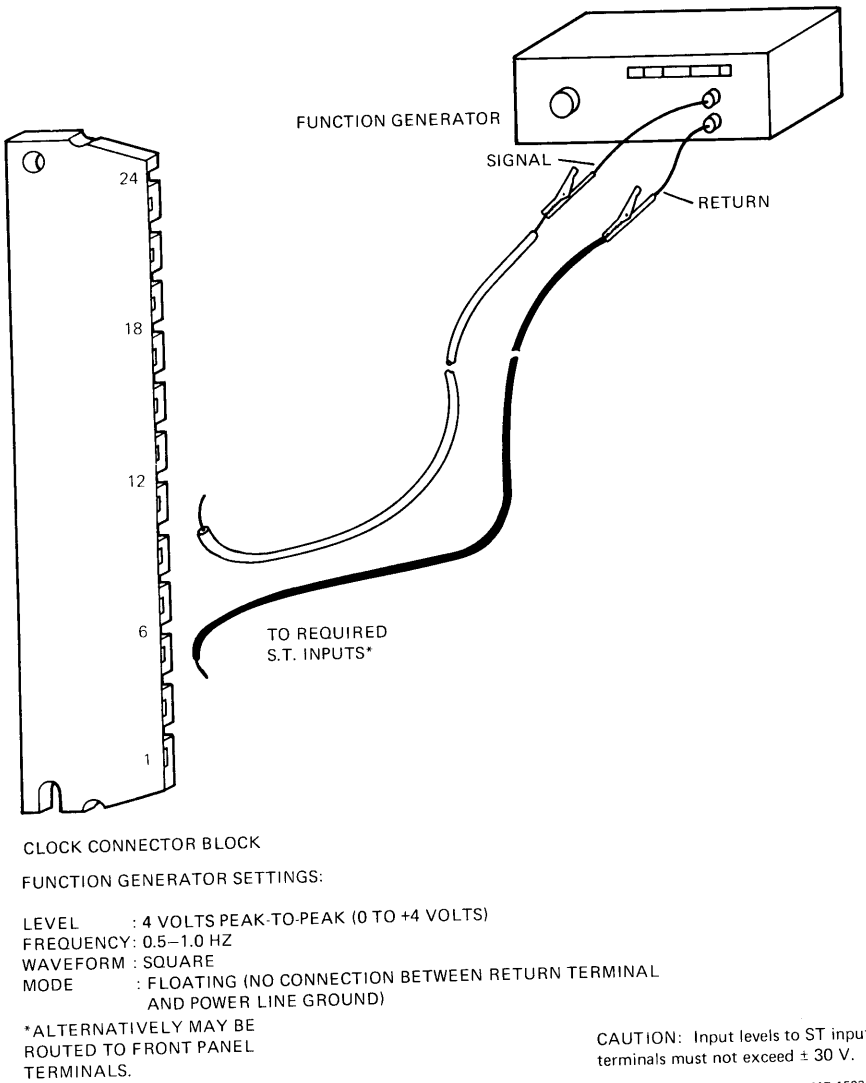


Figure 57. Confirming Schmitt Trigger Inputs

4. Run the Schmitt trigger input confirmation test (STCON) as described in "Running Connection Confirmation Programs," above. The system should print "Schmitt trigger n" on the terminal screen with each cycle from the function generator. If this does not occur, recheck your connections and control settings. If all else fails, see Chapter 13.

When you have satisfactorily confirmed connection to and operation of the selected Schmitt trigger, halt the program by typing CTRL/C twice, disconnect the function generator, and connect the intended apparatus. Then repeat Steps 1 to 4 with the remaining Schmitt trigger if that is necessary. To avoid confusing interactions, make sure that all external apparatus except the function generator is turned off until you have finished confirming lab module connections.

D/A Outputs

1. Select wire or cable suitable for the intended application and connect one end to the D/A connector block as illustrated in Figure 58 (see Chapter 4 for review of D/A outputs; see Chapter 11 for information affecting the choice of wire and cable). Do not connect the other end to its intended destination at this time. Instead, connect it to the voltmeter as shown in Figure 58.

2. Set VOM as indicated in Figure 58.

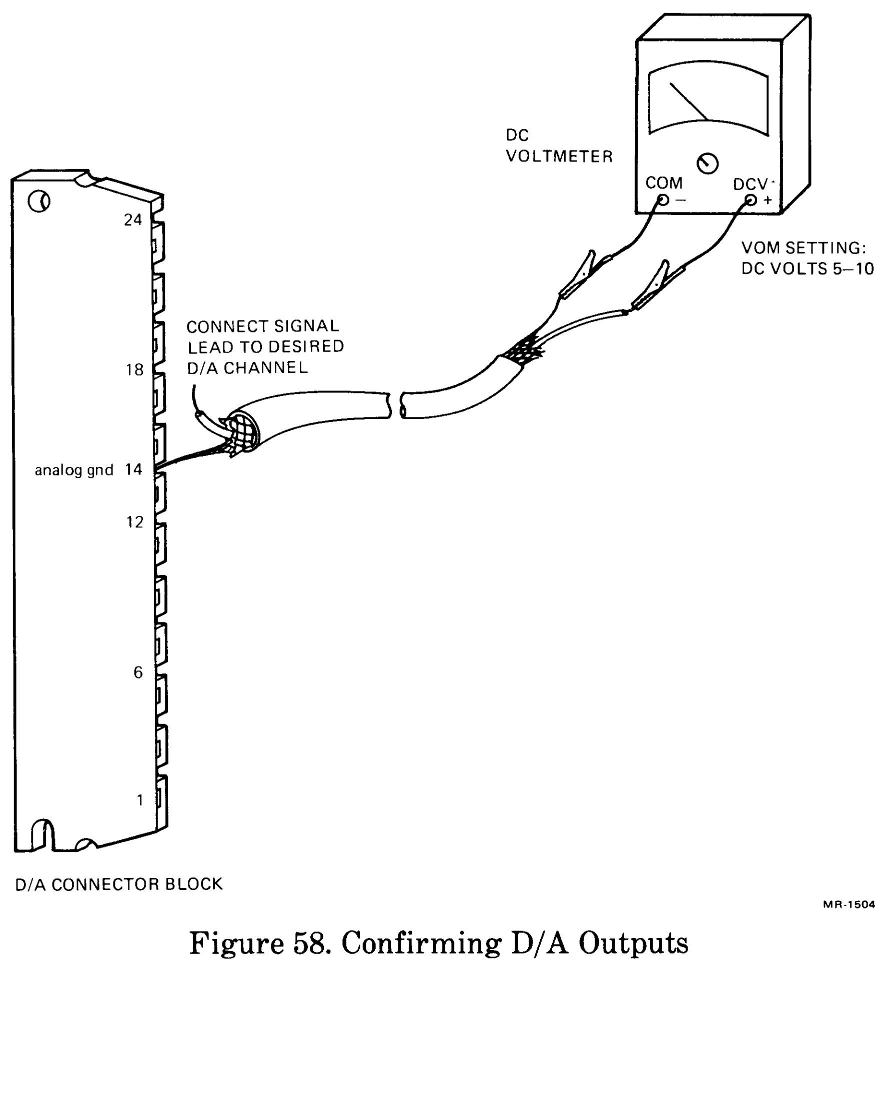


Figure 58. Confirming D/A Outputs

3. Set selected D/A converter channel to unipolar 0-5 volts.

4. Run the D/A connection confirmation program (DACON) as described in Running Connection Confirmation Programs, above. Answer questions as required until program enters its D/A outputting segment. If connections are properly made, the VOM indicator needle will move between 0 and approximately +5 volts once every second. If it does not, recheck your connections and control settings. If you are unclear about D/A channel allocation or control settings, review Chapter 4. If all else fails, see Chapter 13.

   When you have satisfactorily confirmed connection to and operation of the selected channel, halt the program by typing CTRL/C twice, disconnect the VOM, and make connections to the intended apparatus. Then repeat Steps 1 to 4 with any remaining channels. To avoid confusing interactions, make sure that all external apparatus is turned off until you have finished confirming lab module connections.

Signals to Digital Input Units

1. Select wire pair of sufficient length to reach the intended external instrument, and connect one end to a selected line logic gnd terminal on the digital input connector block. Connect the other ends to the function generator, as shown in Figure 59. (See Chapter 5 for review of digital input unit functions; see Chapter 11 for information affecting the choice of wire and cable.)

2. Set function generator as indicated in Figure 59.

3. Run digital input connection confirmation program (DICON) as described in Running Connection Confirmation Programs, above, and answer its questions about desired unit and line number.

   If connections are properly made, the phrase "transition detected" should be displayed on the terminal screen with each cycle from the function generator. If this does not occur, review your connections and control settings. You may wish to review the portion of Chapter 5 dealing with the digital input unit. If all else fails, see Chapter 13.

4. When you have satisfactorily confirmed connections to the selected input terminal, halt the program by typing

CTRL/C twice, disconnect the signal generator and connect to the intended apparatus. Then repeat Steps 1 to 4 for any remaining digital input connections. To avoid confusing interactions, make sure that all external apparatus is turned off until you have finished confirming lab module connections.

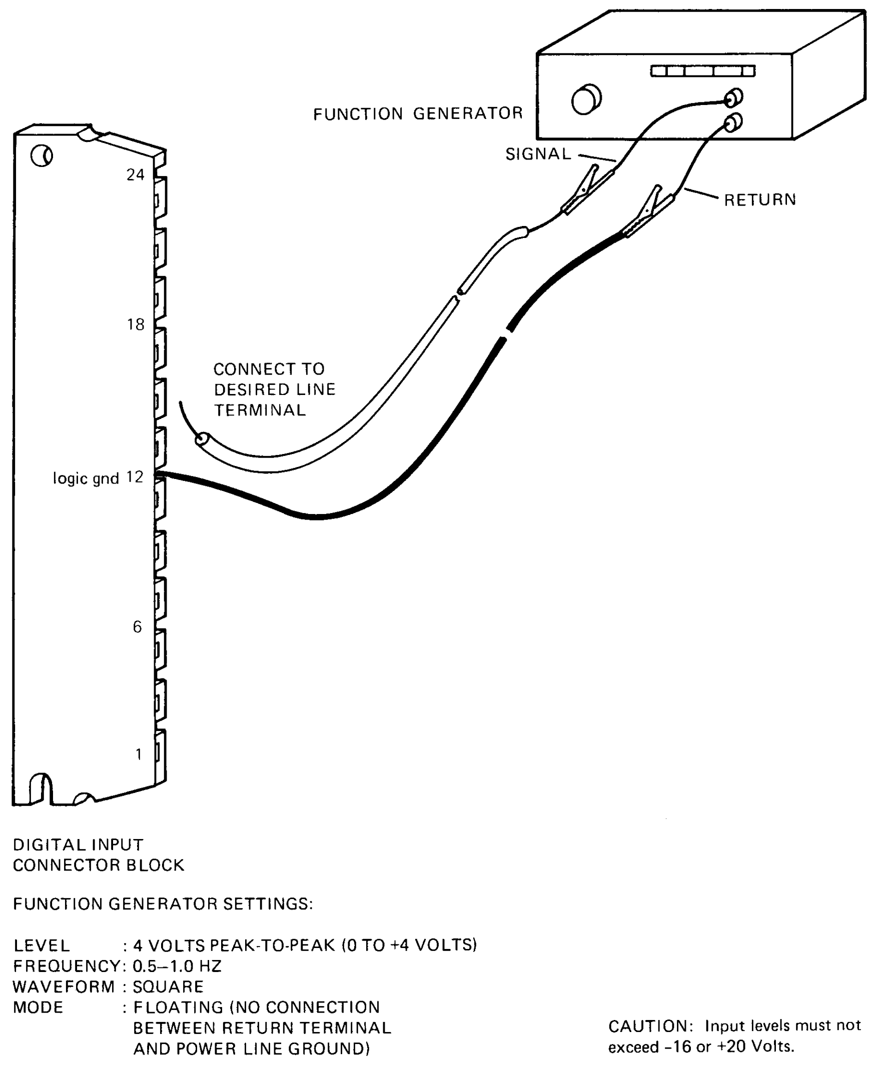


Figure 59. Confirming Digital Input Connections

Signals from Digital Output Units

1. Select a wire pair of sufficient length to reach the intended external apparatus. Connect one end of the pair to a user ground terminal and a selected output line terminal on the

chosen digital output connector block. Connect the other ends to the VOM, as shown in Figure 60. (See also the portion of Chapter 5 dealing with the digital output unit.)

2. Set VOM as indicated in Figure 60.

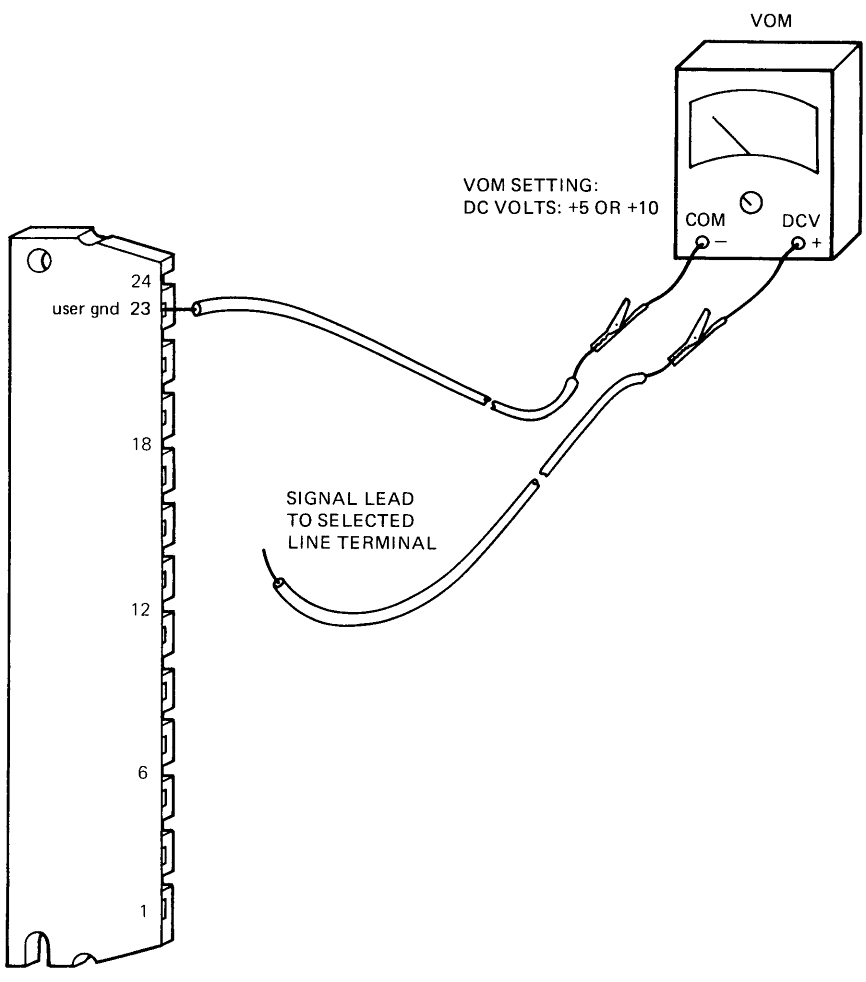


Figure 60. Confirming Digital Output Connections

3. Run the digital output connection confirmation program (DOCON) as described in Running Connection Confirmation Programs, above, and answer questions about desired unit and line numbers. If you have made the proper connections, the VOM indicator needle will deflect to approximately 4 volts once a second. If this does not occur, review your connections, control settings, and responses to test program questions. If all else fails, see Chapter 13.

4. When you have satisfactorily confirmed connections to the selected output terminal, halt the program by typing CTRL/C twice, disconnect the VOM and connect the intended apparatus. Then repeat steps 1 to 4 for any remaining digital output connections. To avoid confusing interactions, make sure that all external apparatus is turned off until you have finished confirming lab module connections.

MAPPING LAB MODULE CONNECTIONS

Each MINC laboratory module can accept as many as 24 wires from external apparatus, and MINC systems can accommodate as many as 8 modules. The result is that a MINC system can become the focal point for a formidable array of wires and cables — and can therefore become an open invitation to chaos in the absence of orderly record keeping.

One aid to maintaining clarity about specific connections is that of labeling cables and wires to indicate at each end what is connected at the other. This procedure helps to eliminate erroneous connections, but it does not assist the user who must write programs for a given system — particularly if this must be done at a site remote from the system itself.

For this reason the following pages contain reproducible configuration record forms that permit you to build a complete map of system data transfer connections and control settings. A limited number of these forms, perforated for easy detachment, is bound in the back of this manual. Remove one of these forms for each module in your system, tape the forms together in the same sequence as that of the modules in the MINC chassis, and fill all appropriate blanks and boxes. The resulting assembly can be accordian-folded for easy storage, but will allow quick access to information about any module.

Application ____________________________

____

Program Name ____________________________

Date ____________________________

MINC System Configuration Record

Using System Configuration Forms:

Tear out one record form for each lab module in the system and tape forms together in the same sequence as that of the modules in the MINC chassis. Fill out all appropriate blanks to identify system interconnections, and check all appropriate boxes to identify required switch settings. Accordion-fold the map thus constructed with this sheet serving as a cover.

PREAMPLIFIER

UNIT NO__________

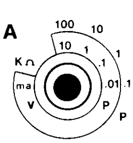
CONNECTOR BLOCK

Term No	Function	Connected to
24	INTR OUT	
23	logic gnd	
22	hold ch d	
21	hold ch c	
20	hold ch b	
19	hold ch a	
18	logic gnd	
17	analog gnd	
16	+15T	
15	−15T	
14	R TEST −	
13	R TEST +	
12	analog gnd	
11	ch d −	
10	ch d +	
9	analog gnd	
8	ch c −	
7	ch c +	
6	analog gnd	
5	ch b −	
4	ch b +	
3	analog gnd	
2	ch a −	
1	ch a +	

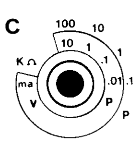
FRONT PANEL

(indicate selected switch settings)

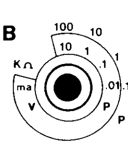
A



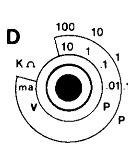
C



B



D



DUAL MULTIPLEXER

UNIT NO________

CONNECTOR BLOCK

Term No	Function	Connected to
24	logic gnd	
23	Ba-h s.e.	
22	−15T	
21	analog gnd	
20	B ch h/rt d	
19	B ch d	
18	B ch g/rt c	
17	B ch c	
16	B ch f/rt b	
15	B ch b	
14	B ch e/rt a	
13	B ch a	
12	logic gnd	
11	A a-h s.e.	
10	+15T	
9	analog gnd	
8	A ch h/rt d	
7	A ch d	
6	A ch g/rt c	
5	A ch c	
4	A ch f/rt b	
3	A ch b	
2	A ch e/rt a	
1	A ch a	

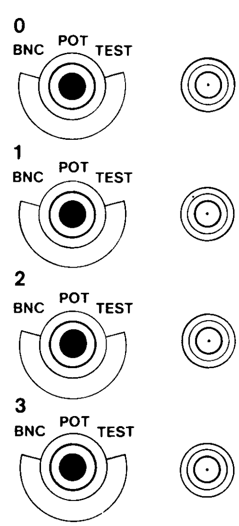
A/D CONVERTER

UNIT NO________

CONNECTOR BLOCK

Term No	Function	Connected to
24	+15T	
23	−15T	
22	analog gnd	
21	analog gnd	
20	logic gnd	
19	ext start	
18	logic gnd	
17	8–15 s.e.	
16	ch 15/rt 11	
15	ch 11	
14	ch 14/rt 10	
13	ch 10	
12	ch 13/rt 9	
11	ch 9	
10	ch 12/rt 8	
9	ch 8	
8	analog gnd	
7	ch 7	
6	analog gnd	
5	ch 6	
4	analog gnd	
3	ch 5	
2	analog gnd	
1	ch 4	

FRONT PANEL
(indicate selected switch settings)



D/A CONVERTER

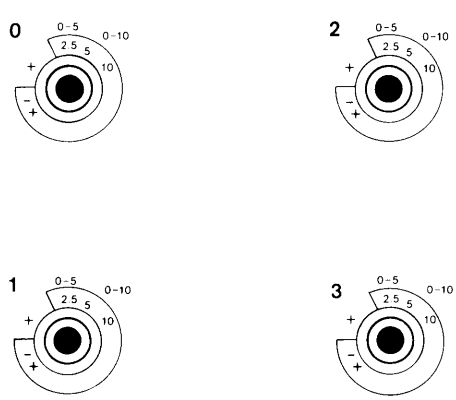
UNIT NO________

CONNECTOR BLOCK

Term No	Function	Connected to
24	+15T	
23	−15T	
22	BIT 3 L	
21	BIT 2 L	
20	logic gnd	
19	BIT 1 L	
18	logic gnd	
17	BIT 0 L	
16	logic gnd	
15	BIT 3 H	
14	logic gnd	
13	BIT 2 H	
12	logic gnd	
11	BIT 1 H	
10	logic gnd	
9	BIT 0 H	
8	analog gnd	
7	DAC 3	
6	analog gnd	
5	DAC 2	
4	analog gnd	
3	DAC 1	
2	analog gnd	
1	DAC 0	

FRONT PANEL

(indicate selected switch settings)



DIGITAL OUTPUT

UNIT NO________

CONNECTOR BLOCK

Term No	Function	Connected to
24	EXT VOLT	
23	user gnd	
22	HB STRB	
21	D15	
20	D14	
19	D13	
18	D12	
17	D11	
16	D10	
15	D09	
14	D08	
13	+5 V ref	
12	logic gnd	
11	RPLY	
10	LB STRB	
9	D07	
8	D06	
7	D05	
6	D04	
5	D03	
4	D02	
3	D01	
2	D00	
1	user gnd	

FRONT PANEL

(indicate selected switch settings)

reply

☐ +

☐ −

DIGITAL INPUT

UNIT NO ________

CONNECTOR BLOCK

Term No	Function	Connected to
24	EXT VOLT	
23	logic gnd	
22	PGM OUT	
21	D15	
20	D14	
19	D13	
18	D12	
17	D11	
16	D10	
15	D09	
14	D08	
13	+5 V REF	
12	logic gnd	
11	REPLY	
10	STROBE	
9	D07	
8	D06	
7	D05	
6	D04	
5	D03	
4	D02	
3	D01	
2	D00	
1	logic gnd	

FRONT PANEL
(indicate selected switch settings)

data

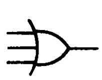
☐ +

☐ -

strobe

☐ +

☐ -



◎ ________

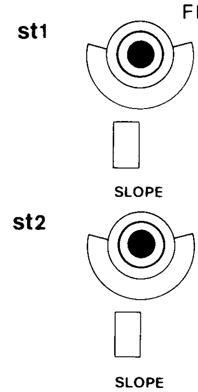
CLOCK

UNIT NO ________

CONNECTOR BLOCK

Term No	Function	Connected to
20	logic gnd	
19	100 Hz	
18	logic gnd	
17	1 KHz	
16	logic gnd	
15	10 KHz	
14	logic gnd	
13	100 KHz	
12	logic gnd	
11	1 MHz	
10	logic gnd	
9	overflow	
8	logic gnd	
7	ST2 OUT	
6	logic gnd	
5	ST2 IN	
4	logic gnd	
3	ST1 OUT	
2	logic gnd	
1	ST1 IN	

FRONT PANEL



st1: ☐ TTL ☐ VAR ☐ Slope + ☐ Slope –

st2: ☐ TTL ☐ VAR ☐ Slope + ☐ Slope –

st1 ◎ ________

st1 ◎ ________

st2 ◎ ________

st2 ◎ ________

OVERFLOW ◎ ________

CHAPTER 11
NOISE IN ANALOG TRANSMISSIONS

From the point of view of MINC data transfer, noise is any electrical manifestation that interferes with the accuracy or reliability of data or control transmissions. Digital transmissions are in general much less prone to noise problems than are analog because digital transmission levels are relatively high, impedances are low, and digital devices by design have a relatively high tolerance for noise. Analog transmissions, however, often require high precision or occur at low voltage levels. Moreover, source impedances on external analog apparatus are often relatively high and associated circuits display a correspondingly increased susceptibility to noise pickup.

In general, electrical noise problems are increased in proportion to the distance over which signals are transmitted. One of the reasons that MINC was designed as a roll-around system was to enable users to situate the system close to the devices with which it must communicate. "Close" in this case means 7.5 meters or less. The discussion that follows assumes that all connections to external analog and digital apparatus involve no more than 7.5 meters of wire or cable. Under these conditions, digital transmissions should be free from noise pickup without special shielding precautions in all but the most extreme cases. Analog transmissions, particularly inputs to the A/D group, may require attention as described below.

For the purposes of the MINC user, electrical noise can be classified into six categories: electrostatic, magnetic, common-mode (ground-loop), crosstalk, multiplexer, and residual.

ELECTROSTATIC NOISE

AC voltage sources such as power lines, transformers, lightning, and digital logic components, to name only a few, can become capacitively coupled to signal leads to a degree determined directly by the combined areas of the radiating and receiving surfaces and inversely by the distance separating them. Whether the noise thus coupled to the signal line is objectionable or not depends on a number of factors. Among these are the level of the radiating signal, the impedance of the circuit involved, and the level defined as objectionable by the application. Other things being equal, a low-level electrostatic source has less influence than a high-level one; a low-impedance circuit is less influenced

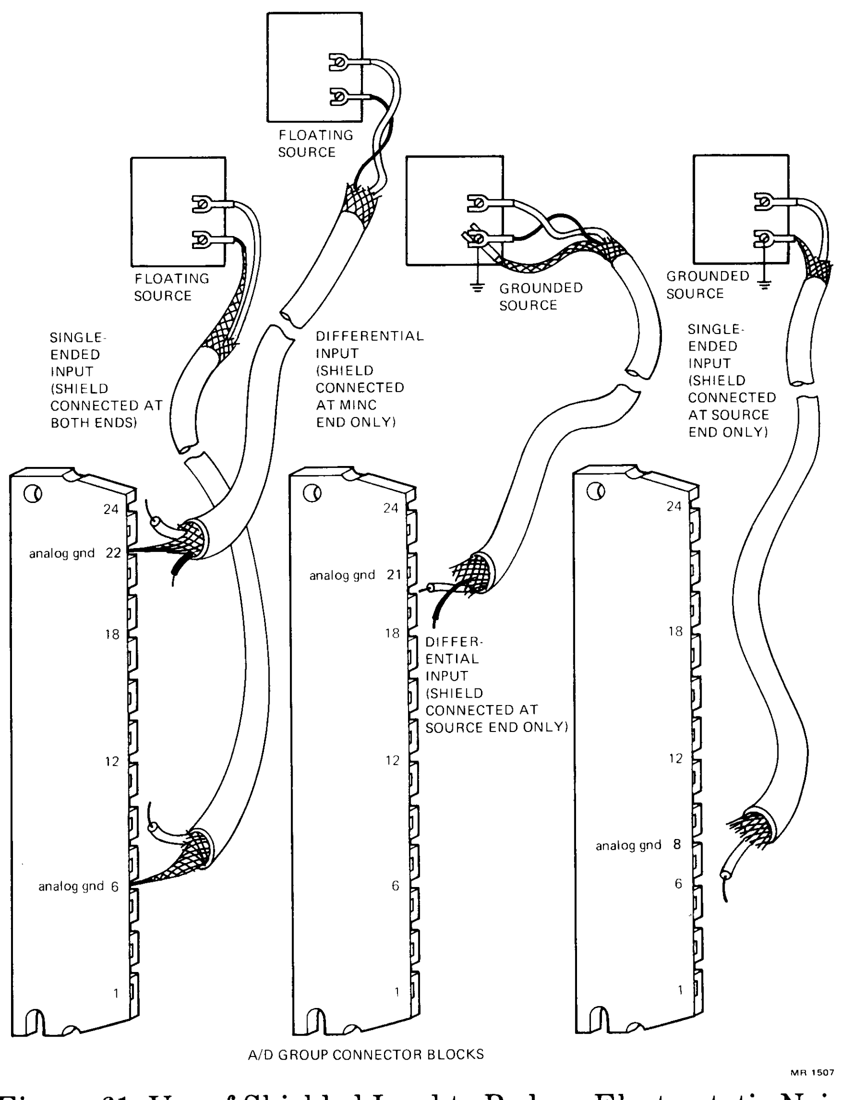


Figure 61. Use of Shielded Lead to Reduce Electrostatic Noise Pickup

by a given level of electrostatic interference than a high-impedance circuit; and an application attempting to make precise measurements of a 1-millivolt signal will be more troubled by electrostatic noise than one dealing with a 1-volt signal in the same noise environment.

The most effective way of reducing electrostatic noise pickup is to introduce a grounded barrier between the electrostatic source and the signal wire(s) involved. This is most conveniently done by means of shielded leads as shown in Figure 61. Such leads are commercially available in single and multiple conductor form, and employ braided or twisted wire or metal foil as shield material. Note that shielding is effective when grounded at only one end and that it is generally necessary to make such one-sided connections to avoid ground loops (see "Ground Loops," below). Only when the shield constitutes the only return path from or to a floating instrument is the shield connected at both ends.

MAGNETIC NOISE

Whenever an electric current passes through a conductor, it generates a magnetic field concentric with the conductor. The strength of this field is directly proportional to the magnitude of the current and inversely proportional to the distance between the conductor and any reference point. Electric motors, generators, solenoids, and the like generate magnetic fields of considerable strength.

When any portion of an analog signal wire lies in a magnetic field generated by an alternating current, the field induces an opposing alternating current in the wire. This current flows through the impedances of the circuits to which the wire is attached and generates noise voltages that are superimposed on whatever signal the circuit normally carries.

The sort of shielding that is effective against electrostatic noise has virtually no effect against magnetic noise. The most effective defense here is the use of commercially prepared twisted pair conductors. Twisting, illustrated in Figure 62, replaces the single loop created by the signal and return line with a series of small loops. The noise pickup of any given loop in the series tends to be cancelled out by the opposing pickup of neighboring loops. The net result is a significant overall reduction in magnetic noise pickup.

Note that both shielding and twisting can be used simultaneously when both electrostatic and magnetic influences contribute to noise problems. See Figure 16.

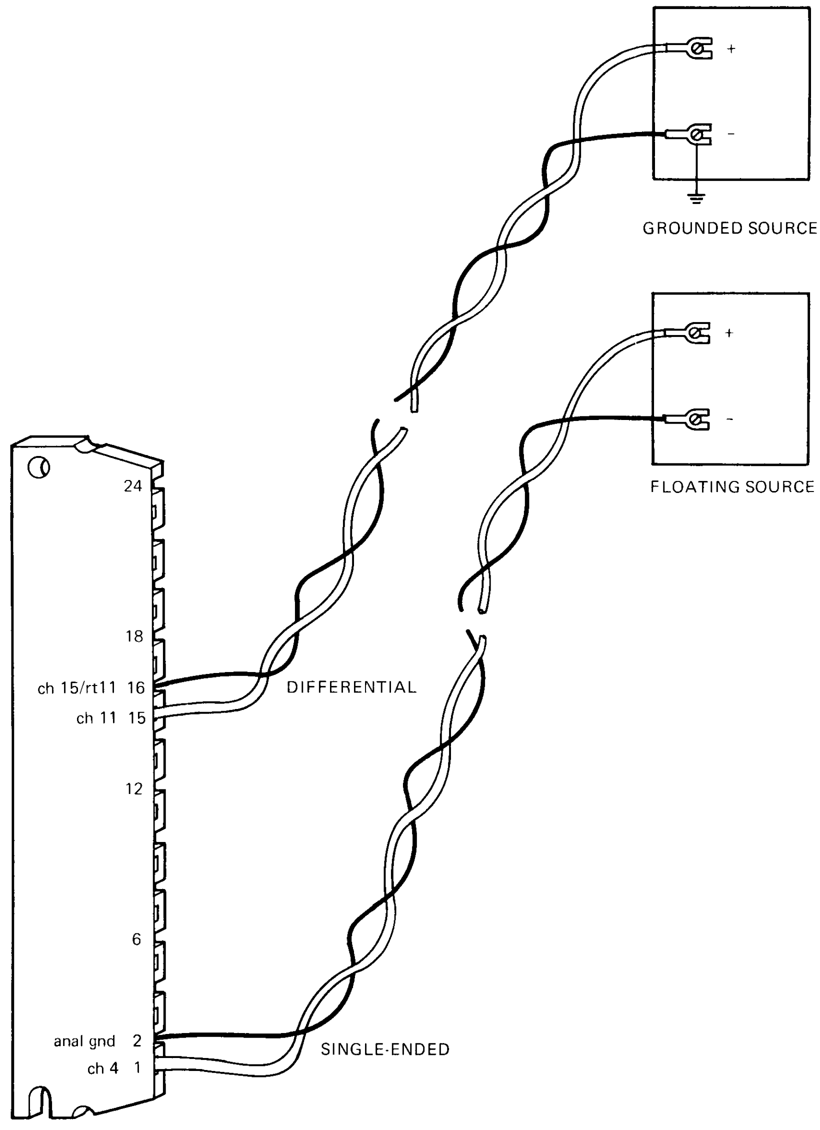


Figure 62. Use of Twisted Pair Leads to Reduce Magnetic Noise Pickup

COMMON MODE (GROUND LOOP) NOISE

We can say of most factory and laboratory line voltage grounds what someone has said of citizens in certain democracies: all are equal, but some are more equal than others. This problem is particularly marked when two line-powered devices are connected to outlets at some distance from one another. In these circumstances you may encounter differences in ground potential ranging from a few millivolts to several volts, depending on the character of the wiring and on the size of the loads sharing the power line ground system.

Such differences in ground potential can become significant even when high precision or low level signals are not an issue. Figure 63 illustrates the problem. The difference in ground potential between the two devices appears as a voltage generator whose output adds to that of the generating device. This noise component will occur predominantly at the line frequency, but may contain transients of almost any sort, depending on the equipment that generated the ground potential difference in the first place.

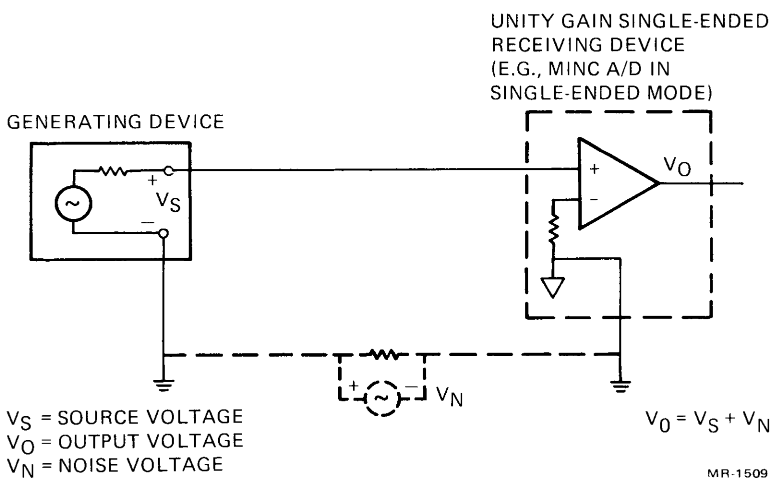


Figure 63. Common-Mode Noise Pickup

Clearly, the first step in reducing common mode noise of the kind described above is to connect the MINC system to an outlet as close as possible to that which supplies power to the peripheral instruments. This may not eliminate common mode noise problems altogether, but it should reduce them to the point where the next step will do so. The next step is differential operation as described later in this section.

Ground Loops. A variant on the case in which common mode noise is generated in power line grounds by devices unrelated to the MINC system may occur when two MINC data transfer circuits share a common local return path and thereby interfere with one another. A typical situation of this sort is shown in Figure 64. Here, return currents generated in one circuit develop voltages (commonly called ground loop voltages) across the residual impedances of the return path. These are picked up as common mode noise by the other circuit. Ground loop voltages of this sort become a problem when heavy-current and/or high-frequency devices (such as the digital out unit) share a common return path with high gain and/or high resolution devices such as preamplifiers and A/D converters.

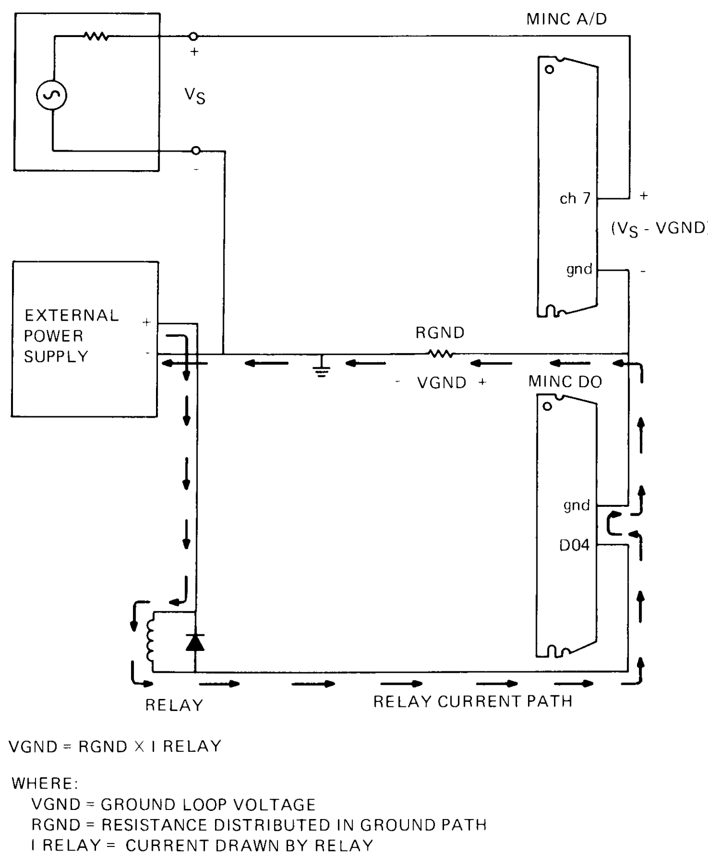


Figure 64. Typical Ground Loop Conditions

The primary cure for locally generated common mode noise is to eliminate or avoid shared return paths between analog and digital modules and their external apparatus. Where practicable, it is good practice to float external apparatus and use a dedicated wire for signal return rather than the power line ground, which may be carrying return currents of other apparatus. In situations that do not permit floating an external piece of apparatus, it sometimes helps to provide a dedicated signal return wire (as short and heavy as practicable) between the external apparatus and the related MINC connector block ground terminals.

The big gun in your arsenal of defense against common mode noise in A/D conversion is the differential capability of the MINC A/D group modules. Differential and single-ended input devices differ in several respects: a single-ended device has one active input terminal and responds to the instantaneous difference in potential between this input and ground. The differential device, however, has two active input terminals (+ and -), neither of which is connected to ground, and responds to the instantaneous difference in potential between the two terminals.

Figure 65 shows a differential input device such as a MINC A/D converter operating in the context of the same common mode voltages assumed in Figure 63.

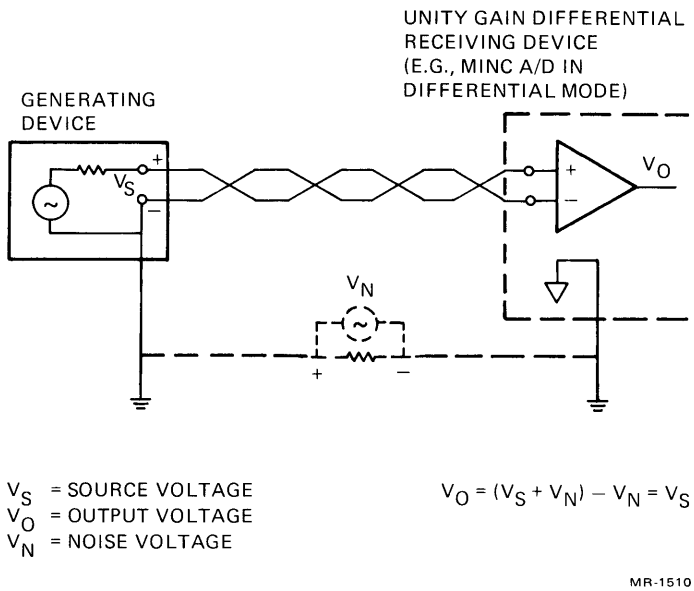


Figure 65. Common Mode Noise Voltages Input to a Differential Device

Since the noise in the power line ground system is common to both the + and the - terminals of the receiving device, and since, in differential mode, the receiving device responds only to voltage *differences* between these terminals, the ground system noise is canceled out.

The above discussion is accurate for true differential input devices such as the MINC preamplifier, but it somewhat oversimplifies the way in which the MINC A/D handles differential operations. For most cases in which the common mode noise consists mainly of line frequency artifacts, however, the above statements should not be seriously misleading. See Glossary, "Differential," for more details.

CROSSTALK NOISE

Crosstalk occurs when wires carrying unrelated signals lie within close proximity to one another (as happens when multiwire cable is used or when groups of wires are bundled together for some distance). In such circumstances, the signal in one wire will sometimes be coupled by electrostatic and/or magnetic effects into an adjacent wire and become mixed with the signal in the adjacent wire. Crosstalk most frequently occurs when a wire carrying a low-level and/or high-impedance signal lies close to a wire carrying a high-level and/or low-impedance signal.

Two cures for the crosstalk problem are like those for electrostatic and magnetic pickup; shielding and twisting either the radiating or the receiving wires — or in extreme cases, both. It is sometimes simpler to isolate sensitive wires (that is, those carrying low level and/or high impedance signals) from other wires in the interfacing connections — particularly from wires driving power-consuming devices such as relays or lamps.

MULTIPLEXER NOISE

All solid state multiplexers inject a small amount of charge into their input lines when changing channels, causing a transient error voltage that is discharged by the input signal's source impedance. MINC multiplexers manifest this characteristic, and also inject a small charge into the selected input line at the end of each conversion when the auto-zero* switch is turned off. After any channel change and after any conversion, the A/D's control logic allows approximately a 9-microsecond interval during which conversions cannot start without generating error conditions. Normally, this is sufficient time for the input transient to settle out. However, more time may be needed when the multiplexer is switching into an input channel with high source impedance, particularly when large amounts of shunt capacitance exist in the interconnecting cables. Source impedance/cable shunt capacitance products greater than 1 microsecond should be avoided whenever conversions are to be made in fast mode at maximum rate with maximum precision. This means that cable shunt capacitance for a 1000 ohm source should not exceed 1000 pF (10^3 ohms * 10^{-9} = 10^{-6} secs), that shunt capacitance for a 100 ohm source should not exceed 0.01 microfarad (10^2 ohms * 10^{-8} = 10^{-6} secs), and so on. Assuming twisted pair cable capacitance of 50 pF per foot, these constraints translate into a maximum run of 20 feet from a 1000 ohm source. Note that settling errors can be eliminated by increasing the time between conversions.

RESIDUAL NOISE IN A/D CONVERSIONS

At low levels, electrical activity of the sort that we call noise is an unavoidable characteristic of electron flow. Where electronic instruments are concerned, careful design can minimize the effects of noise, and its influence can be masked by operation at relatively high current levels, but there is always a level below which measurements are not accurately repeatable because of noise.

The effects of this residual noise in the MINC A/D converter contribute less than 1/2 a minimum voltage increment to any conversion value. This means that successive readings from a stable DC source (such as that selected by TEST on channels 0, 1, or 2) should not vary by more than one minimum voltage increment from conversion to conversion. The case is different, however, when a preamplifier set to relatively high gain is introduced between a stable DC source and the A/D converter. When a preamplifier is set to a gain of 500, a minimum voltage increment is equivalent to .000005 Volts ($5\mu V$). Even if external noise reduction procedures were to be perfectly implemented, Johnson and other noise sources within the preamplifier itself would cause successive conversions from a "stable" DC source to vary by several minimum voltage increments. Since few sources are stable in the microvolt range, and since noise reduction techniques are by nature imperfect, considerable variation can be regarded as normal when you are inputting to a preamplifier set to a gain of 500. Noise contributions will diminish from this high point as the gain of the preamplifier is reduced.

CHAPTER 12
PREVENTIVE MAINTENANCE

The MINC system is designed to work dependably in normal human environments without elaborate ongoing maintenance. You may want to clean external surfaces occasionally with a soft cloth dampened in a solution of mild detergent and water. Take care that no water runs into the keyboard or any other subassembly that houses electrical components.

Once a month, pull the system air filter out from behind the grill on the right end of the MINC chassis. If it is dirty, rinse it in warm water, allow it to dry, and replace it behind the grill. DO NOT ALLOW THE SYSTEM AIR FILTER TO BECOME CLOGGED.

CHAPTER 13 MINC SYSTEM TROUBLESHOOTING

Trouble, for a MINC user, is any system response that violates that user's expectations about how the system should behave. In order of probability, trouble tends to occur for the following reasons:

1. Programming errors. Much more often than not, trouble occurs because you have issued incompatible or inappropriate commands to the system. Assistance in identifying such errors is provided in Book 2, Chapter 16. Make sure you fully understand each command and routine that you use. Pay particular attention to the Restrictions section associated with the discussion of each data transfer routine in Book 6.

2. Data transfer connection errors. The next most likely source of trouble — particularly on systems with complex data transfer commitments — lies in connections that route inputs and outputs to locations that are different from what you assumed at the time you wrote the control program. The best cure for these troubles is to avoid them to start with by careful mapping of data transfer connections and control settings as recommended in Chapter 10 of this manual. When you doubt the viability of specific connections, follow the connection confirmation procedures, also described in Chapter 10.

3. Hardware trouble. This category can be reduced to two subcategories.

   a) Trouble caused by improper hardware configuration. If the MINC system is to operate correctly, all system interconnections must be appropriately and completely made, all circuit breakers and power switches must be on, all laboratory module address and vector switches must be set to the proper conditions, and all modules must occupy contiguous slots starting at the right side of the MINC chassis. Moreover, the system terminal must be set up with the proper operating parameters. See Chapter 9.

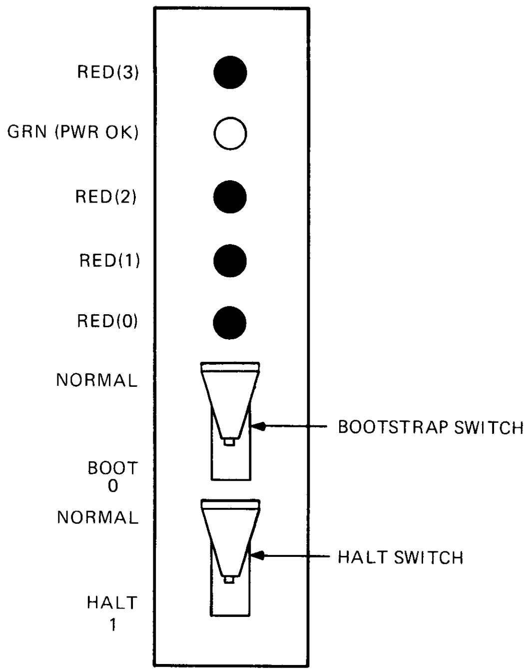
   b) Troubles caused by hardware malfunction. MINC systems are fabricated from high quality computer grade components, and all electrical subassemblies are operated under power for an extended period prior to final calibration and testing. This screens out the vast majority of potential failures before the system ever leaves the factory. However, no fault prevention procedure can be perfect, and, over a period of time, faults may develop. For that reason, a variety of testing and diagnostic aids are provided with the MINC system. These are discussed below.

AIDS TO HARDWARE FAULT DIAGNOSIS

1. The BDV11 bootstrap/diagnostic module. This module occupies the leftmost slot in the MINC chassis and contains a read-only memory program which, on powerup, automatically tests the processor and memory, and then tries to initiate system operation via the diskette drive (that is, it tries to "bootstrap" the system from the diskette drive). If the program fails in any of these efforts, it causes the diagnostic lamps on the top edge of the board to display a pattern that identifies the nature of the error. See Figure 66.

2. VT105 self-test. The Setup A 0 command (see Chapter 9) causes the terminal to check the keyboard and its own memory. Errors are indicated by the keyboard lamps. This permits you to identify most faults that might arise in the terminal.

3. System diagnostics. Each MINC system is shipped with a diagnostic diskette that permits you to cause the MINC processor to exercise every component in the system and issue error messages whenever a fault is found. These messages can be recorded and saved for DIGITAL field service personnel.



STATUS LAMPS

3	PWR OK	2	1	0	
X	OFF	X	X	X	NO POWER
ON	ON	ON	ON	ON	HALT SWITCH ON, OR SYSTEM HUNG
OFF	ON	OFF	OFF	ON	CPU ERROR
OFF	ON	OFF	ON	OFF	MEMORY ERROR
OFF	ON	ON	OFF	ON	DISK ERROR
OFF	ON	ON	ON	OFF	DISK LOAD ERROR (PROBABLE BAD OR NON-BOOTABLE DISK)

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Figure 66. BDV11 Diagnostic Lamps

TROUBLESHOOTING PROCEDURE

The following list enumerates the more common user-correctable sources of trouble with the MINC system. These should be checked first when the system fails to operate or operates in what appears to be a strange or sporadic fashion.

1. Main power cable is disconnected or loose.

2. Secondary power cables on the rear of the MINC cart are disconnected or loose (see Figure 67 for cable connection information).

3. One or more circuit breakers on the rear of the MINC cart are switched off (see Figure 68 for circuit breaker locations).

4. A fuse has blown on the terminal or the MINC chassis. To check for a blown fuse, disconnect the system power cord, remove the fuse holder and visually inspect the fuse. If a fuse has blown, replace it with a fuse of an *identical rating and type,* reconnect the power cord, and turn the system on. If the fuse blows again, call Digital Field Service.

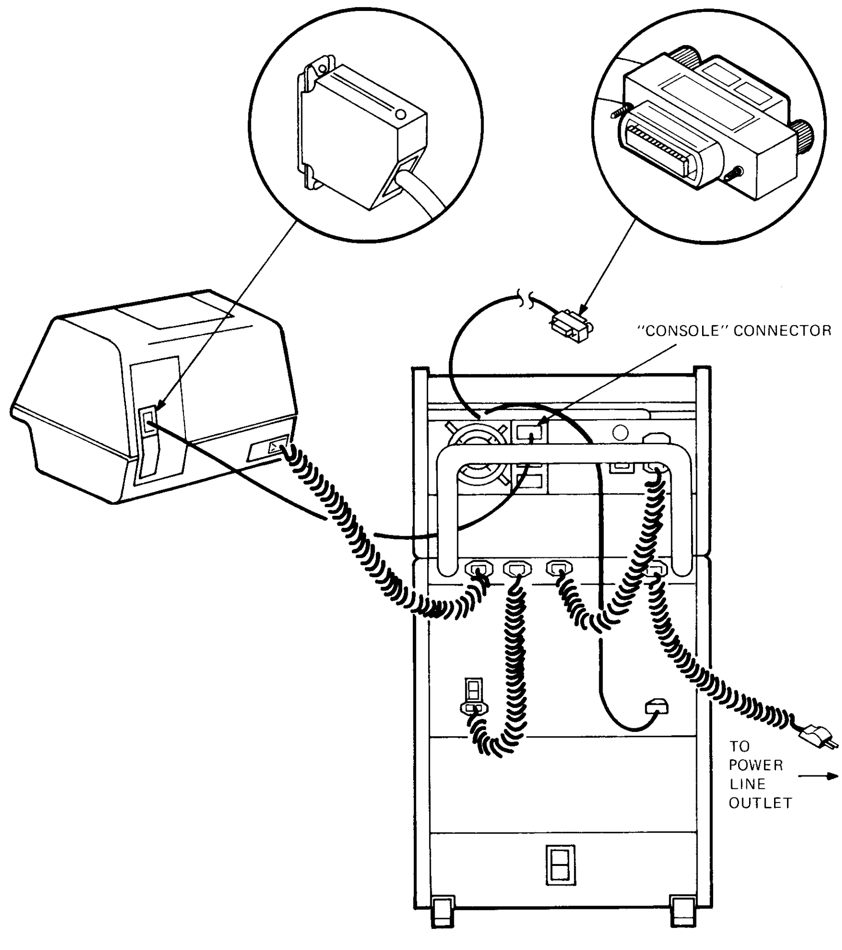

Figure 67. MINC Cable Connections

5. Signal cables are disconnected or loose (see Figure 67 for signal cable connection information).

6. Modules are improperly installed in the MINC chassis (see Chapter 9 for system configuration information).

7. Modules are configured with inappropriate address/vector switch settings (see Chaper 9 for further information).

8. Data transfer connector block(s) are not seated properly.

9. External apparatus is not operating according to expectation and is monopolizing or overrunning the system.

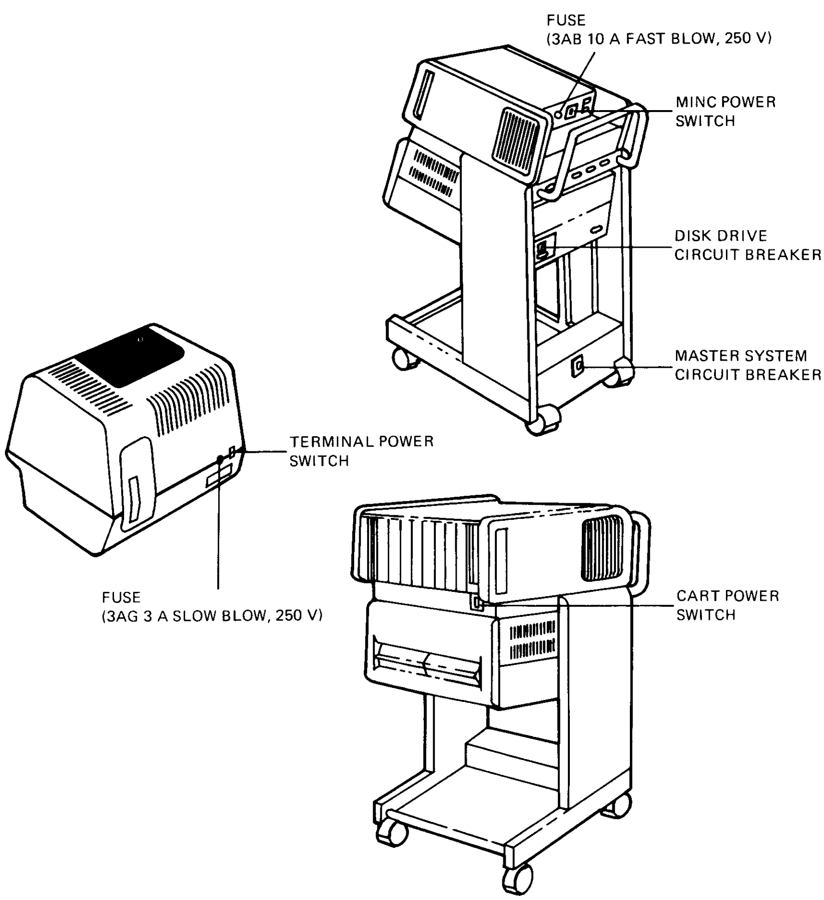

Figure 68. MINC Switches

10. Diskette is improperly inserted.

11. Wrong diskette has been inserted.

12. Bad diskette has been inserted.

13. System terminal has been set up with inappropriate parameters (see Chapter 9, "Changing Operating Modes on the MINC Terminal").

14. BREAK key on the system terminal has been pressed, causing the MINC processor to exit from the MINC operating mode and to enter the LSI-11 halt mode — identified by a display similar to that shown in Figure 69. Press SHIFT/P to recover if no other keystrokes have intervened since pressing the BREAK key. If this procedure is unsuccessful, it will be necessary to power down the system and restart.

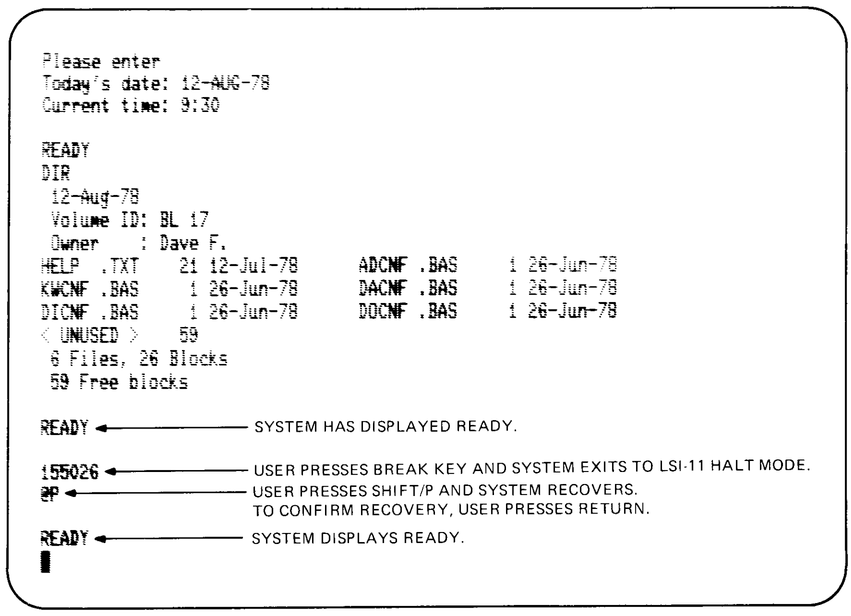

Figure 69. Terminal Response to "Break" Key Operation

RUNNING DIAGNOSTICS

To run the MINC system diagnostic chain, proceed as follows:

1. Remove diskettes from drives 0 and 1.
2. Power down the system.
3. Remove all connections from external equipment (MINC connector blocks, SLU's, IEEE bus, etc.).
4. Install SLU test connectors (shown in Figure 70) on SLU 0, SLU 1, and SLU 2.
5. Load diagnostic diskette into drive 0 (left hand drive).
6. Power up the system and wait for introductory messages to be presented on the terminal by the diagnostic program.

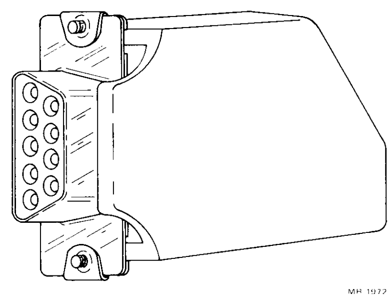

Figure 70. SLU Test Connector

These messages should look like those shown in Figure 71. (If no messages appear, refer to "Troubleshooting Procedure," above. If you can do nothing to establish communication with the system, record the condition of the diagnostic lamps on the BDV11 and call Digital Field Service.)

```
DZQU5-A 15-AUG-78 RYDP - XXDP RX02 MONITOR 28K
RESTART ADDR:152262
BOOTED VIA UNIT#:  0
TO ABORT THE FOLLOWING HELP MESSAGE TYPE CTRL C (^C)

TYPE:
F<CR> TO SET CONSOLE FILL COUNT
D<CR> FOR DIRECTORY ON CONSOLE, OR
D/F<CR> FOR SHORT DIRECTORY ON CONSOLE, OR
D/L<CR> FOR DIRECTORY ON LINE PRINTER, OR
D/L/F<CR> FOR SHORT DIRECTORY ON LINE PRINTER,
R COPY<CR> TO RUN COPY PROGRAM,
R FILENAME<CR> TO RUN ANY OTHER PROGRAM.
L FILENAME<CR> TO LOAD A PROGRAM ONLY
S<CR> TO START THE PROGRAM JUST LOADED,
S ADDR<CR> TO START THE PROGRAM AT SPECIFIC ADDRESS
C FILENAME<CR> TO RUN A CHAIN,
C FILENAME/QV<CR> TO RUN A CHAIN IN QUICK VERIFY MODE.
REFER TO XXDP USER MANUAL MD-11-DZQXA FOR ADDITIONAL HELP.
.
```

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Figure 71. Initial Display from the MINC Diagnostic Diskette

7. Press SETUP on the terminal keyboard, and press the 5 (Setup A/B) key to enter Setup B. If the first digit is a "1", change it to a "0" by pressing the space bar twice and typing the 6 (Toggle 1/0) key. Return to normal mode by pressing the SETUP key again.

8. Type C MINC11 followed by a return. The system will respond with a display like that shown in Figure 72.

```
S<CR> TO START THE PROGRAM JUST LOADED.
S ADDR<CR> TO START THE PROGRAM AT SPECIFIC ADDRESS
C FILENAME<CR> TO RUN A CHAIN.
C FILENAME/QV<CR> TO RUN A CHAIN IN QUICK VERIFY MODE.
REFER TO XXDP USER MANUAL MD-11-DZQXA FOR ADDITIONAL HELP.
.C MINC11

.R VMNF??/1

MD-11-DVMNF-A   MINC-11 OPTION SIZER PROGRAM


OPERATOR        -       PLEASE DO THE FOLLOWING:

REMOVE THE CUSTOMER CONNECTIONS FROM EACH "MINC-11" OPTION
MNCAD (A/D)             SET FRONT PANEL SWITCHES TO THE "TEST" POSITION
MNCKW (CLOCK)           PULL OUT "ST1" AND "ST2" SWITCHES
                        AND ROTATE FULLY CLOCKWISE
MNCDI (DIGITAL IN)      SET "DATA" SWITCH TO THE "-" POSITION
SLU 0                   INSTALL "SLU TEST CONNECTOR"
SLU 1                   INSTALL "SLU TEST CONNECTOR"
SLU 2                   INSTALL "SLU TEST CONNECTOR"

DEPRESS A KEY ON THE CONSOLE TERMINAL WHEN READY. █
```

MR 1974

Figure 72. Operating Instructions Issued by the Diagnostic Chain

9. Follow all applicable instructions in the display. When you are ready to proceed, press any key on the keyboard.

10. The system should then run the diagnostic programs listed and described in Table 16. Observe the screen closely. Errors will be identified either by the processor halting (in which case you should make note of the address presented on the screen) or by messages similar to those shown in Figure 73. If errors of the second type occur, press the BREAK key and make note of the error message. Then press SHIFT/P to allow the diagnostic program to continue.

Table 16. Diagnostic Programs in the MINC11 Chain.

Name (see note)	*Function*
VMNF??.BIC	Startup/Sizer
VKAA??.BIC	CPU Test
VKAB??.BIC	Extended Instruction Set Test
VKAC??.BIC	Floating Instruction Set Test
VKAL??.BIC	TRAPS Test
VIBB??.BIC	IBV 11 Test
VDLA??.BIC	DLV11-J Test
VMNC??.BIC	Clock Test
VMNB??.BIC	DI Test
VMNE??.BIC	DO Test
VMND??.BIC	D/A Test
VMNA??.BIC	A/D Test
ZVTN??.BIC	VT105 Test
VMNG??.BIC	Termination Program

Note: Question marks designate elements in the file name that may change. The monitor program accepts a question mark as a "wild card" substitute for any character.

```
PROGRAM DETECTED      2 MNCKW (CLOCK)'S
END PASS #     1
.R VMNB??/1

CVMNB-A MNCDI (DIGITAL IN) DIAGNOSTIC

PROGRAM DETECTED     0 MNCDI (DIGITAL IN)'S
END PASS #     1
.R VMNE??/1

CVMNE-A MNCDO (DIGIAL OUT) DIAGNOSTIC

PROGRAM DETECTED      1 MNCDO (DIGITAL OUT)'S
MNCDO (DIGITAL OUT) UNIT #     1
EXPECTED INTERRUPT AT 340 RECEIVED INTERRUPT AT 374
PLEASE CHECK VECTOR SWITCHES
       RESTARTING LOGIC TEST

END PASS #     1
.R VMND??/1

157252
@
```

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Figure 73. Typical Error Identification

Figure 74 shows a typical error-free run of the diagnostic chain up to but not including the terminal test, which puts up a variety of complex patterns on the terminal screen.

The terminal test is last in the diagnostic chain series. When it is done, the system will display a message indicating that the chain has finished. If errors were detected on the first pass through the chain, turn off the system and repeat Steps 6 through 10. Make sure that you follow all instructions given by the system when the diagnostic chain starts to run (Step 8). If the error(s) persist on the second pass, call Digital Field Service. If the errors do not persist, several explanations are possible:

1. Errors were generated on the first pass by improper lab module switch settings which you corrected before running the second pass.

2. Errors were generated by intermittent or thermally sensitive components in the system. If the operating history of the system confirms this hypothesis, contact Digital Field Service.

3. Errors were generated by static discharge in the vicinity of the system during the first run. This problem is most likely to occur during cold, dry weather and/or when operating on rug-covered floors.

Figure 74. Typical Error-free Run of the MINC11 Diagnostic Chain

```
DEPRESS A KEY ON THE CONSOLE TERMINAL WHEN READY.
  ;MNCAD AT ADDRESS = 171000   VECTOR = 400
  ;MNCKW AT ADDRESS = 171020   VECTOR = 440
  ;MNCKW AT ADDRESS = 171024   VECTOR = 450
  ;MNCAA AT ADDRESS = 171060   VECTOR =  **  DOES NOT EXIST **
  ;MNCDI  **  DOES NOT EXIST **
  ;MNCDO AT ADDRESS = 171260   VECTOR = 340
# OF   ;MNCAD 1  ;MNCKW  2  ;MNCAA  1  ;MNCDI  0  ;MNCDO  1
END PASS #      1
.R VKAA??/1

 END PASS
.R VKAB??/1

END PASS
.R VKAC??/1

END PASS
.R VKAD??/1

END OF PASS
.R VIBA??/1

MD11-DVIBA-A
*
END PASS #      1
.R VDLA??/1

CVDLAA0 DLV11-J TEST

WILL TEST:

MODULE 1  CHANNEL   0  1  2  3

END PASS #      1
.R VMNC??/1

CVMNC-B MNCKW (CLOCK) DIAGNOSTIC

PROGRAM DETECTED      2 MNCKW (CLOCK)'S
END PASS #      1
.R VMNB??/1

CVMNB-A MNCDI (DIGITAL IN) DIAGNOSTIC

PROGRAM DETECTED     0 MNCDI (DIGITAL IN)'S
END PASS #      1
.R VMNE??/1

CVMNE-A MNCDO (DIGIAL OUT) DIAGNOSTIC

PROGRAM DETECTED      1 MNCDO (DIGITAL OUT)'S
END PASS #      1
.R VMND??/1

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@P
CVMND-A  MNCAA (D/A) DIAGNOSTIC

PROGRAM DETECTED      1 MNCAA (D/A)'S
END PASS #      1
.R VMNA??/1

CVMNA-A MNCAD (A/D) DIAGNOSTIC

PROGRAM DETECTED      1 MNCAD (A/D)'S

END PASS #      1
.R ZVT???/1          <-------- TERMINAL TEST (NOT SHOWN) RUN AT THIS POINT.

END PASS #      1
.R VMNG??/1

CVMNG-A MINC-11 CHAIN TERMINATOR PROGRAM

OPERATOR  -    THE AUTOMATIC RUNNING OF THE DIAGNOSTICS HAS NOW BEEN COMPLETED
```

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If the diagnostic run indicates no errors and you are aware of no operating anomalies, assume that the system is fully operative. If the diagnostic run indicates no errors but you are aware of problems in running lab module programs, run the connection confirmation programs described in Chapter 10. These will permit checking all input lines for continuity and will detect blown fusible resistors on lab module inputs. The more information you can accumulate about a given problem, the more efficiently your Digital Field Service office will be able to diagnose and correct that problem.

GLOSSARY OF MINC TERMS

The following terms have meanings in the MINC context not likely to be covered in standard dictionaries. Most entries here have been flagged by an asterisk (*) elsewhere in this book. When definitions involve other terms included in the Glossary, those terms also are flagged with an asterisk.

Absolute Accuracy
The analog error of an A/D converter, expressed as a percentage of full scale, referenced to the National Bureau of Standards Volt.

Aperture delay
The time that elapses between the instant an external HOLD command is received and the instant the sampled signal is actually being held by the hold circuits. This time would ideally be zero but in actual practice amounts to approximately 200 nanoseconds.

Aperture uncertainty
The consistency with which the aperture delay* repeats from command to command. Consistency is important if conversions are to be equally spaced in time.

Auto-zeroing
A method of stabilizing offset drift in an A/D converter. In the patented process used by the MINC A/D, auto-zeroing occurs at that stage in an A/D conversion at which a previously obtained sample voltage is held and the A/D input circuits prepare to measure that voltage. If operation is in single-ended mode, the A/D input is switched to ground at this time, and the subsequent measurement is of the difference between the held sample and the ground potential at the A/D converter input. Since any ground potential differences between the A/D input and measurement circuits are common to both the sampled voltage and the auto-zero ground reference, these differences are effectively canceled out of the measurement.

If operation is in differential* mode, auto-zeroing switches the A/D input to the return input of the selected channel, and the subsequent measurement is of the difference between the held sample and the voltage on the return input. Any DC voltage common to both the signal and return terminal is canceled out of the subsequent measurement.

Bipolar

Identifies an output condition in which voltages can swing to either side of ground as shown in Figures 75 and 76. MINC D/A converters allow selection of either *bipolar* or *unipolar** output modes.

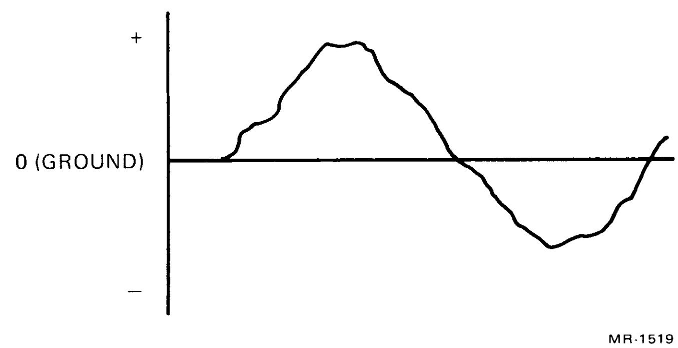

Figure 75. Bipolar Voltage Waveform

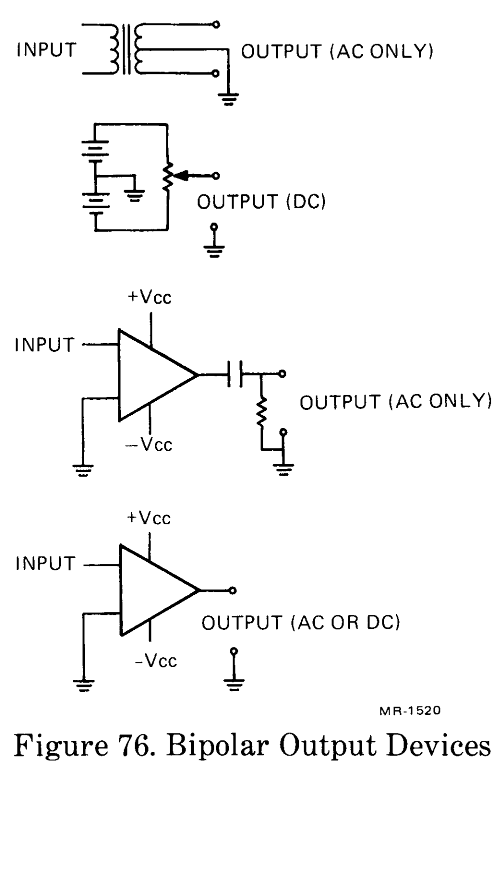

Figure 76. Bipolar Output Devices

Common Mode

As used in phrases like common mode rejection, common mode noise, and common mode interference, identifies an input condition in which a signal component is common to both the signal and return terminals of a measuring device such as an A/D converter. Since such signal components are not generated by the transmitting device, they constitute "noise" in the transmission and must often be reduced either by appropriate wiring procedures or by use of differential input mode, or both (see Chapter 11, Noise in Analog Signal Transmissions, and Glossary, *Differential*).

Differential

Contrasted with "single-ended."* Identifies an input mode of certain amplifiers in which the signal to be acted upon at any instant is defined as the instantaneous *difference* between an input and a return terminal. The advantage of differential operation is that signals common to both terminals (that is, common mode* signals) are not seen and are therefore effectively canceled.

The MINC preamplifier always operates in differential mode, whereas the A/D converter and any associated dual multiplexers provide the choice of single-ended or differential operation. Note that the differential common mode rejection of the preamplifier and A/D converter are identical with respect to DC common mode noise but not the same with respect to AC common mode noise. This difference occurs for the reasons discussed below.

In differential mode, the MINC A/D performs a conversion via the following steps (see Figure 77):

1. The associated multiplexer enables the selected channel by closing a normally open semiconductor switch in the primary input side of the channel (e.g., ch 13).

2. The A/D samples the signal at the primary input terminal.

3. The A/D prepares to start the actual conversion by a) holding the sampled signal and b) turning off the primary input switch and turning on a similar switch associated with the measured channel's return terminal (e.g., rt 13). Since this terminal is associated with ground, only common mode voltages will be present on it.

4. The A/D performs the conversion as described in this Glossary under *Successive Approximation* — subtracting the common mode contribution from the held sample.

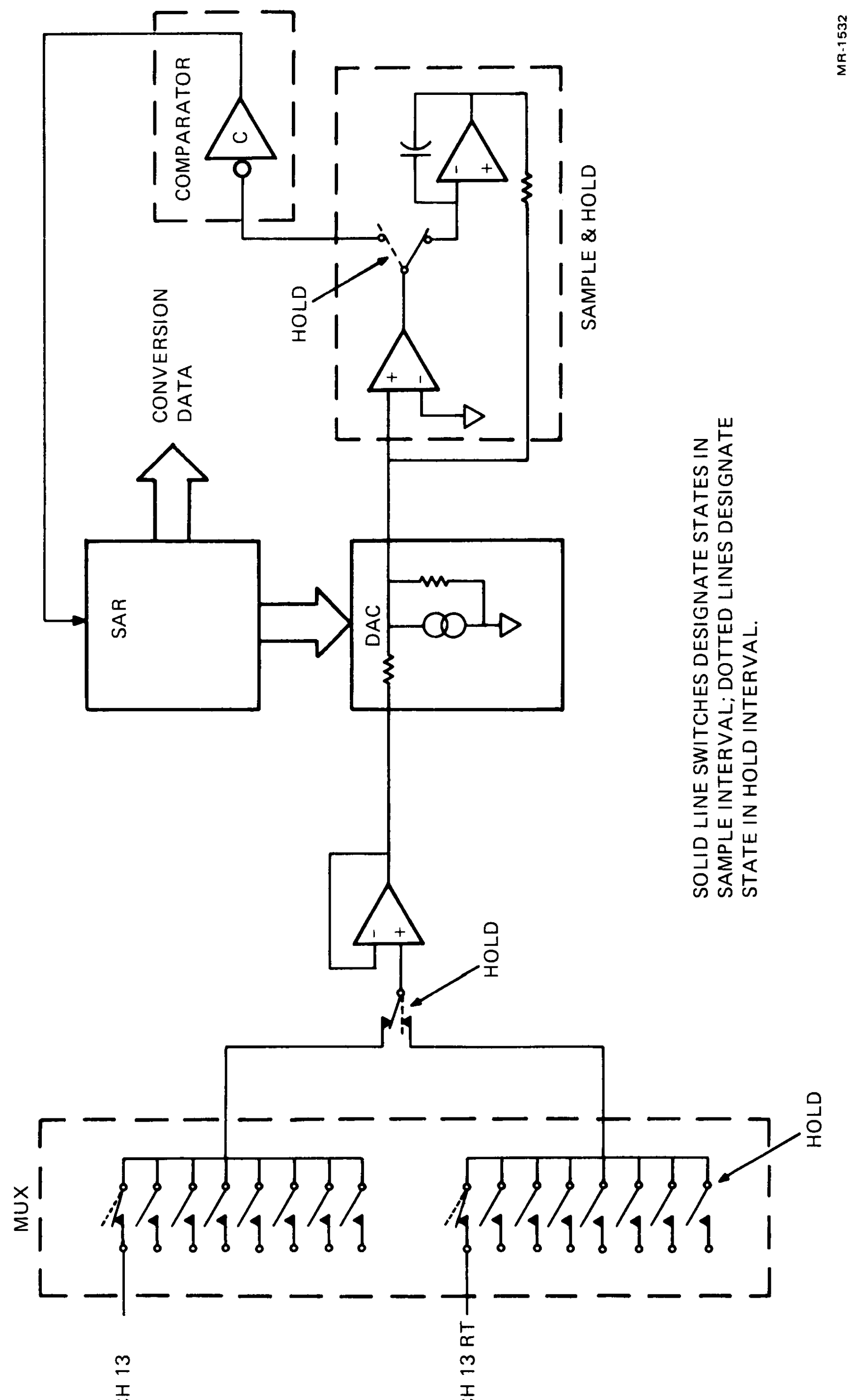

Figure 77. MINC A/D Converter (Differential Mode)

The successive approximation operation takes about 30 microseconds. Although the sampled voltage is held at its initial value throughout the conversion, any AC components in the common mode voltage may change before the conversion is finished and will affect the results by the extent to which they do so. The consequence is that, while the A/D's differential common mode rejection is very high at DC, it diminishes as a function of frequency (see Figure 78). DIGITAL has coined the name "quasi-differential" to identify the modified differential operation of the MINC A/D.

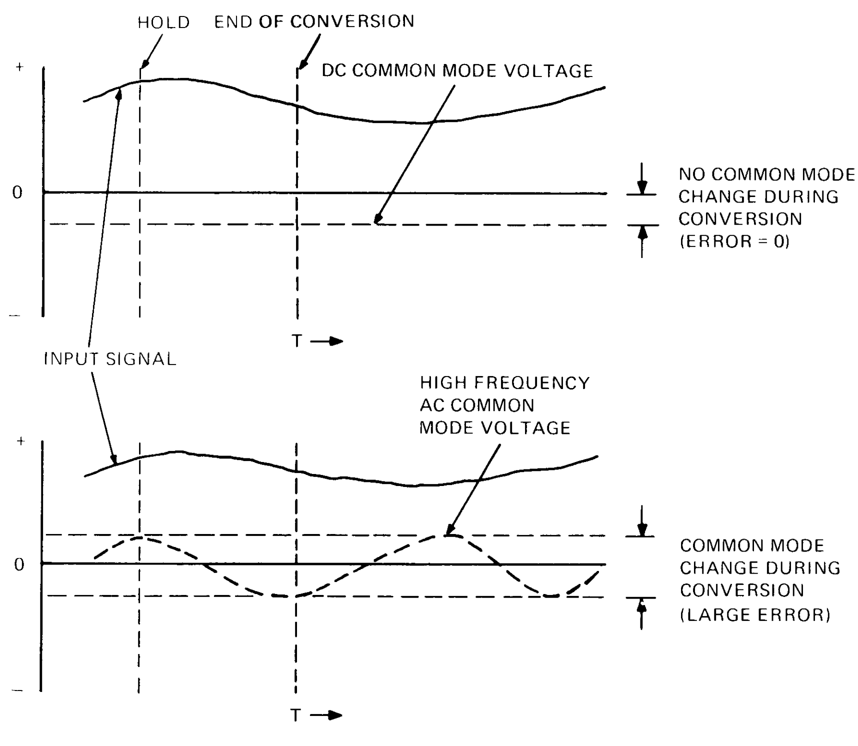

Figure 78. DC vs. AC Common Mode Voltages into the MINC A/D

The MINC preamplifier circumvents the above inaccuracies by holding not only the primary input terminal voltage but that on the return terminal as well. This means that when the A/D reaches Step 3, the common mode voltage is still what it was at the time the sample was taken, and common mode contributions, whether DC or AC, are cancelled out of the measurement.

Differential Linearity

A means of specifying the uniformity of state widths* in an A/D converter. Ideally, all state widths would be identical (1 LSB*), although in practice this goal is not completely attainable. The state widths of the MINC A/D converter will not be zero or greater than

2 LSB for any state. Moreover, 99 percent of all state widths will be between 1/2 and 1 1/2 LSB.

Gain Temperature Coefficient

The amount that the gain accuracy of a device changes with a change in temperature. Expressed in ppm/degree C or degree C/LSB* at full scale. If an A/D has a gain temperature coefficient of 20 degrees C/LSB at full scale, the converted value will be in error by 1 LSB at full scale if the temperature rises 20 degrees above 25 degrees C.

Hysteresis

The tendency of certain binary devices to manifest a different threshold when changing from 0 to 1 than when changing from 1 to 0. Specifically, *hysteresis* in this manual refers to the ability of clock and digital-input Schmitt triggers* to fire when their primary threshold is reached only if the input voltage has previously gone beyond a secondary threshold that is offset from the primary by a significant amount (see Figure 20). The ability to respond in the context of the history of a signal as well as its present state makes the Schmitt trigger extremely useful in dealing with noise and event definition problems. See Chapter 5, Digital Input Connections from External Switches.

Input Bias Current

The amount of current that flows between an A/D converter input and a source device output. Generated by DC bias conditions in the A/D itself.

Input Impedance (DC)

The resistance seen at the input of a given device.

Integral Linearity

See *linearity*, below.

Least Significant Bit

See *LSB*, below.

Linearity

The maximum deviation from a straight line drawn between the end points of the converter transfer function. Linearity may be expressed as a percentage of full scale or as a fraction of an LSB*.

Logic Level

Identifies the output state of binary electronic devices. TTL* components generate outputs in one of two states: low (approximately 0 to +0.4 V) and high (approximately +2.4 to +5 V). A TTL output of the first sort is often described as a low logic level; an output of the second sort is described as a high logic level.

LSB (Least Significant Bit)

In A/D conversions, the value associated with the last bit of the successive approximation* register. In a 12-bit A/D converter this value is 1/4096 of the full-scale range — which translates, in the case of the MINC A/D, to 2.5 mV. Equivalent to "minimum voltage increment" as used in Part 1 of this manual.

Multiplexer Settling Time

The maximum time required to reach a specified error region around the input value when switching channels. Channel switching generates transients that are stored in residual input cable capacitances and require time to decay to nonsignificant levels. The A/D converter allows approximately 9 microseconds for this process, but under unusual circumstances (where long, high capacitance cables carry high-impedance input signals or where preamplifiers set to gains of 50 to 500 are involved), FAST mode conversions may have to be slowed to speeds well under the maximum rate.

Parallel

As a computer term, *parallel* identifies a mode of data transmission in which the logical bits that compose data words each have a dedicated line and can thus be transmitted simultaneously (that is, in parallel) with one another. *Parallel* contrasts with *serial**.

The advantage of parallel over serial transmission is that it tends to be much faster. The disadvantage is that it requires as many lines as there are bits in the transmitted word.

Quantizing Error

A/D conversion errors arising from the fact that converted values must be expressed in quantum steps with a size of one LSB*. This means that any conversion that does not fall exactly at the midpoint between quantum boundaries will be skewed by as much as 1/2 an LSB.

Since a MINC A/D LSB is equal to 2.5 millivolts, any reading is likely to be in error by as much as 1.25 millivolts. When conversions are made on signals near the A/D full-scale level, the percentage of error due to quantizing is very small (less than .025 percent). However, as input signal levels are reduced, quantizing error makes a proportionally greater contribution. An analog level of 3.75 millivolts, for example, might be converted to 5 millivolts or to 2.5 millivolts — and now the error is 33 percent.

The most effective cure for objectionable quantizing errors is to increase the signal level with a preamplifier.

Relative Accuracy

The degree to which a D/A output uniformly reflects changes in digital input. Conversely, the degree to which an A/D digital output uniformly reflects changes in analog input. Expressed as a fraction of full scale with gain and offset errors adjusted to zero.

Resolution

In the context of A/D converters, resolution is defined as the smallest analog change that can be discriminated. Resolution is equivalent to the analog value of the least significant bit* of the successive approximation* register.

Schmitt Trigger

A logic device capable of responding to voltage *levels* rather than voltage *transitions*. Unlike Schmitt triggers, the most common TTL* logic devices require not only that input voltages change level but also that they change level in a very short time. These devices respond to the leading or trailing edge of a rapid voltage shift and are sometimes therefore called edge-triggered devices. If a slowly changing voltage is input to an edge-triggered device, that device produces indeterminate outputs while the input level dwells in the region between low and high (see Glossary, *Logic Level*, and *TTL*). Schmitt trigger devices, however, respond once and only once when a certain voltage threshold is reached. Moreover, they respond with hysteresis* so that minor perturbations in an ascending or descending voltage do not trigger additional responses.

Serial

As a computer term, *serial* identifies a mode of data transmission in which the logical bits that compose each data word are transmitted according to a prescribed protocol one after another (serially) along a single pair of lines from a sending to a receiving device. *Serial* contrasts with *parallel**.

The advantage of serial over parallel transmission is that it requires few lines. The disadvantage is that it tends to be slower.

Single-ended

Contrasted with *differential**. Identifies an input mode of certain amplifiers in which the signal to be acted upon at any instant is defined as the difference between an input terminal and ground. The main advantage of single-ended operation in the MINC world is that a single-ended input requires only one active terminal, and twice as many such channels can therefore be accommodated by a given multiplexer than could be accommodated in differential mode. The main disadvantage is that single-ended operation does not cancel common mode* interference.

Slew Rate

The ability of the input or output of an analog circuit to respond to or change its voltage in a given period of time. If an input slew rate is 7 volts per microsecond, the analog circuit can respond to a change of 7 volts in one microsecond. If the output slew rate is 7 volts per microsecond, the output can change 7 volts in one microsecond.

State Width

The range of input voltage which will produce a given digital result from an A/D converter. Ideally all state widths should be exactly 1 LSB*, although this goal is not fully attainable in practice. See Figure 79 and Glossary, *Differential Linearity*.

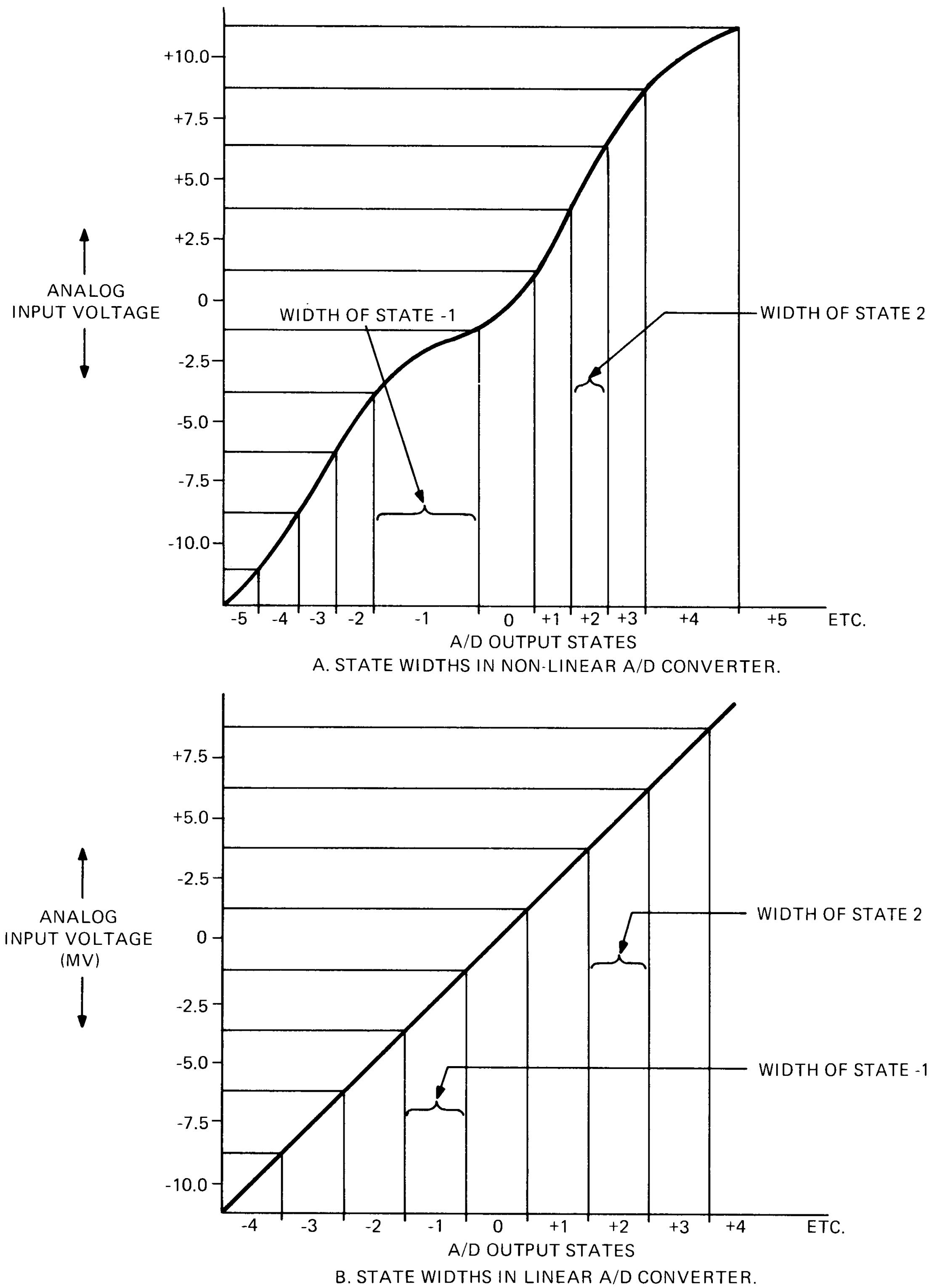

Figure 79. State Width in A/D Conversions

Successive Approximation

A method of converting an analog level into a digital equivalent by a series of approximations, each with twice the resolution of its predecessor. The MINC A/D implements its successive approximation by iterating the following algorithm 12 times, once for each bit in the successive approximation register (SAR). See Figure 80.

1. Set the most significant remaining bit of the SAR to 1 and with the output thus formed generate a comparison level in a precision digital-to-analog converter (DAC).

2. Compare this level with the held equivalent of the sampled signal.

3. If the comparison level is less than the held sample, leave the present bit set.

4. If the comparison voltage is greater than the held sample, set the present bit to 0.

5. Prepare to operate on the next most significant bit.

6. Go to step 1.

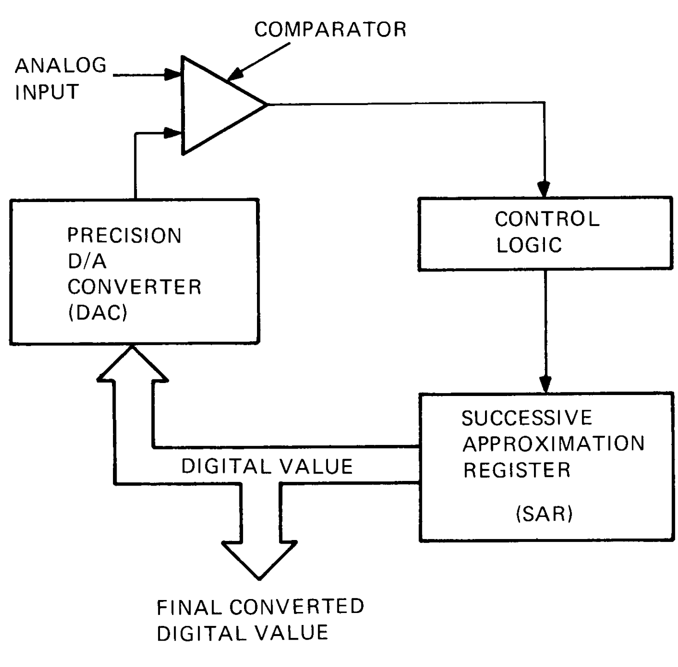

Figure 80. Successive Approximation Block Diagram

This operation involves the components illustrated in Figure 80 and will generate levels in the comparison DAC that resemble those illustrated in Figure 81. When all bits have been operated on, the control register will contain the digital equivalent of the sampled level. Resolution of the measurement is a function of the number of bits available in the control register. The 12 bits in the MINC A/D produce conversions with a resolution of one part in 4096.

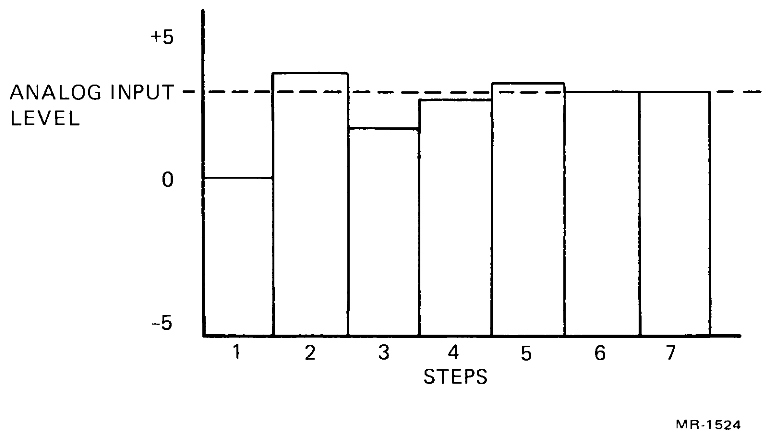

Figure 81. Progression of Levels in Successive Approximation DAC (7 bits only)

TTL

Initialism for *transistor-transistor logic* (sometimes referred to as T^2L). Defines the design and operating characteristics of the most common integrated circuit logic devices. TTL devices have the following approximate operating characteristics:

* Supply voltage: +5
* Input Voltages: low = 0.0 V to +0.7 V; high = +2.0 V to +5 V
* Input Currents: low = -6.8 mA at 0 V in; high = 1.3 mA at +5 V in
* Output Voltages: low = 0.0 V to +0.4 V; high = +2.4 V to +5 V
* Drive Capability: 10 inputs
* Typical Rise/Fall Times: less than 20 nanoseconds

Unipolar

Identifies an analog output condition in which voltages cannot swing past ground (see Figures 82 and 83). The MINC D/A converter allows selection of either unipolar or bipolar* output modes.

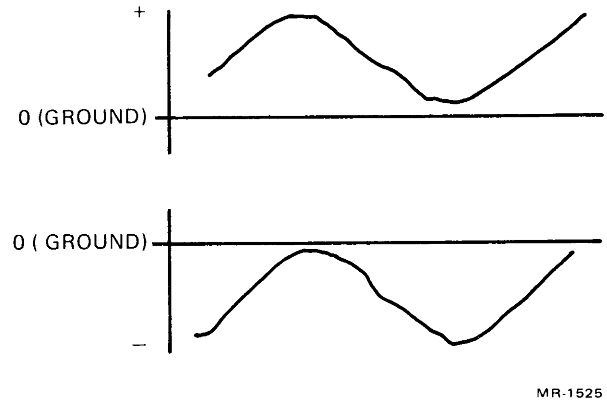

Figure 82. Unipolar Voltage Waveforms

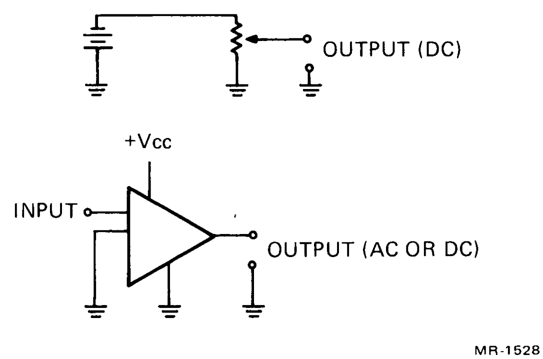

Figure 83. Unipolar Output Devices

INDEX

Application ______________________________

____

Program Name ______________________________

Date ______________________________

MINC System Configuration
Record

Using System Configuration Forms:

Tear out one record form for each lab module in the system and tape forms together in the same sequence as that of the modules in the MINC chassis. Fill out all appropriate blanks to identify system interconnections, and check all appropriate boxes to identify required switch settings. Accordion-fold the map thus constructed with this sheet serving as a cover.

PREAMPLIFIER

UNIT NO__________

CONNECTOR BLOCK

Term No	Function	Connected to
24	INTR OUT	
23	logic gnd	
22	hold ch d	
21	hold ch c	
20	hold ch b	
19	hold ch a	
18	logic gnd	
17	analog gnd	
16	+15T	
15	–15T	
14	R TEST –	
13	R TEST +	
12	analog gnd	
11	ch d –	
10	ch d +	
9	analog gnd	
8	ch c –	
7	ch c +	
6	analog gnd	
5	ch b –	
4	ch b +	
3	analog gnd	
2	ch a –	
1	ch a +	

FRONT PANEL
(indicate selected switch settings)

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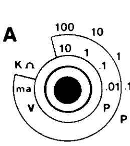

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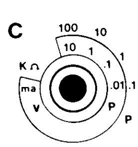

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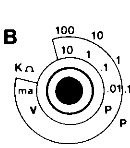

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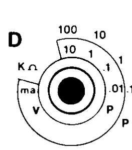


DUAL MULTIPLEXER

UNIT NO__________

CONNECTOR BLOCK

Term No	Function	Connected to
24	logic gnd	
23	Ba-h s.e.	
22	−15T	
21	analog gnd	
20	B ch h/rt d	
19	B ch d	
18	B ch g/rt c	
17	B ch c	
16	B ch f/rt b	
15	B ch b	
14	B ch e/rt a	
13	B ch a	
12	logic gnd	
11	A a-h s.e.	
10	+15T	
9	analog gnd	
8	A ch h/rt d	
7	A ch d	
6	A ch g/rt c	
5	A ch c	
4	A ch f/rt b	
3	A ch b	
2	A ch e/rt a	
1	A ch a	

A/D CONVERTER

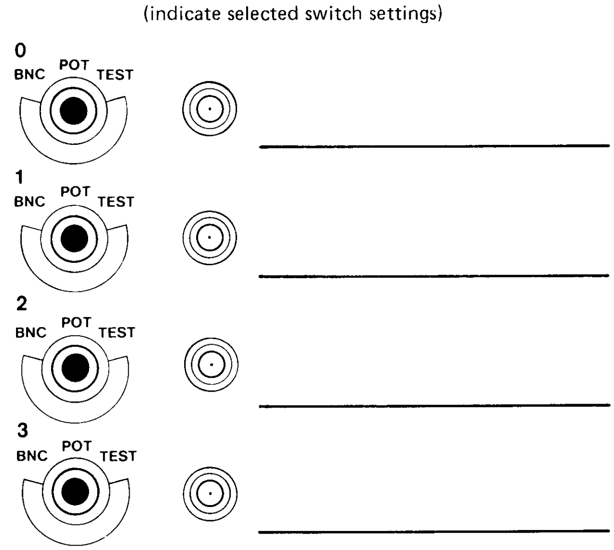
UNIT NO__________

CONNECTOR BLOCK

Term No	Function	Connected to
24	+15T	
23	−15T	
22	analog gnd	
21	analog gnd	
20	logic gnd	
19	ext start	
18	logic gnd	
17	8–15 s.e.	
16	ch 15/rt 11	
15	ch 11	
14	ch 14/rt 10	
13	ch 10	
12	ch 13/rt 9	
11	ch 9	
10	ch 12/rt 8	
9	ch 8	
8	analog gnd	
7	ch 7	
6	analog gnd	
5	ch 6	
4	analog gnd	
3	ch 5	
2	analog gnd	
1	ch 4	

FRONT PANEL

(indicate selected switch settings)



D/A CONVERTER

UNIT NO__________

CONNECTOR BLOCK

Term No	Function	Connected to
24	+15T	
23	-15T	
22	BIT 3 L	
21	BIT 2 L	
20	logic gnd	
19	BIT 1 L	
18	logic gnd	
17	BIT 0 L	
16	logic gnd	
15	BIT 3 H	
14	logic gnd	
13	BIT 2 H	
12	logic gnd	
11	BIT 1 H	
10	logic gnd	
9	BIT 0 H	
8	analog gnd	
7	DAC 3	
6	analog gnd	
5	DAC 2	
4	analog gnd	
3	DAC 1	
2	analog gnd	
1	DAC 0	

FRONT PANEL
(indicate selected switch settings)

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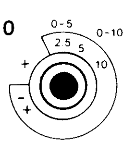

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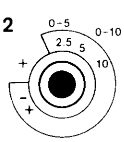

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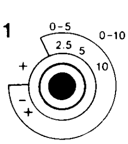

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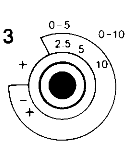

DIGITAL OUTPUT

UNIT NO__________

CONNECTOR BLOCK

Term No	Function	Connected to
24	EXT VOLT	
23	user gnd	
22	HB STRB	
21	D15	
20	D14	
19	D13	
18	D12	
17	D11	
16	D10	
15	D09	
14	D08	
13	+5 V ref	
12	logic gnd	
11	RPLY	
10	LB STRB	
9	D07	
8	D06	
7	D05	
6	D04	
5	D03	
4	D02	
3	D01	
2	D00	
1	user gnd	

FRONT PANEL
(indicate selected switch settings)

reply

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DIGITAL INPUT

UNIT NO ________

CONNECTOR BLOCK

Term No	Function	Connected to
24	EXT VOLT	
23	logic gnd	
22	PGM OUT	
21	D15	
20	D14	
19	D13	
18	D12	
17	D11	
16	D10	
15	D09	
14	D08	
13	+5 V REF	
12	logic gnd	
11	REPLY	
10	STROBE	
9	D07	
8	D06	
7	D05	
6	D04	
5	D03	
4	D02	
3	D01	
2	D00	
1	logic gnd	

FRONT PANEL
(indicate selected switch settings)

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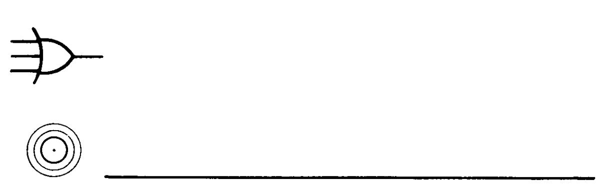


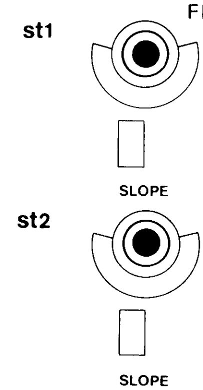
CLOCK

UNIT NO ________

CONNECTOR BLOCK

Term No	Function	Connected to
20	logic gnd	
19	100 Hz	
18	logic gnd	
17	1 KHz	
16	logic gnd	
15	10 KHz	
14	logic gnd	
13	100 KHz	
12	logic gnd	
11	1 MHz	
10	logic gnd	
9	overflow	
8	logic gnd	
7	ST2 OUT	
6	logic gnd	
5	ST2 IN	
4	logic gnd	
3	ST1 OUT	
2	logic gnd	
1	ST1 IN	

FRONT PANEL



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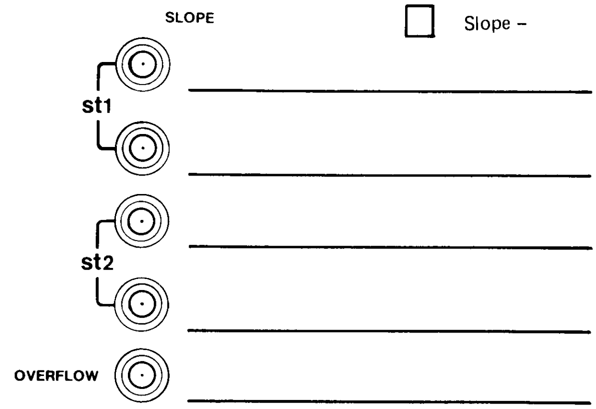

Application ____

____

Program Name ____

Date ____

MINC System Configuration Record

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PREAMPLIFIER

UNIT NO__________

CONNECTOR BLOCK

Term No	Function	Connected to
24	INTR OUT	
23	logic gnd	
22	hold ch d	
21	hold ch c	
20	hold ch b	
19	hold ch a	
18	logic gnd	
17	analog gnd	
16	+15T	
15	−15T	
14	R TEST −	
13	R TEST +	
12	analog gnd	
11	ch d −	
10	ch d +	
9	analog gnd	
8	ch c −	
7	ch c +	
6	analog gnd	
5	ch b −	
4	ch b +	
3	analog gnd	
2	ch a −	
1	ch a +	

FRONT PANEL
(indicate selected switch settings)

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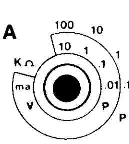

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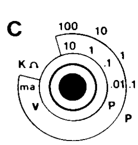

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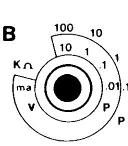

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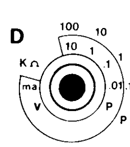


DUAL MULTIPLEXER

UNIT NO__________

CONNECTOR BLOCK

Term No	Function	Connected to
24	logic gnd	
23	Ba-h s.e.	
22	-15T	
21	analog gnd	
20	B ch h/rt d	
19	B ch d	
18	B ch g/rt c	
17	B ch c	
16	B ch f/rt b	
15	B ch b	
14	B ch e/rt a	
13	B ch a	
12	logic gnd	
11	A a-h s.e.	
10	+15T	
9	analog gnd	
8	A ch h/rt d	
7	A ch d	
6	A ch g/rt c	
5	A ch c	
4	A ch f/rt b	
3	A ch b	
2	A ch e/rt a	
1	A ch a	

A/D CONVERTER

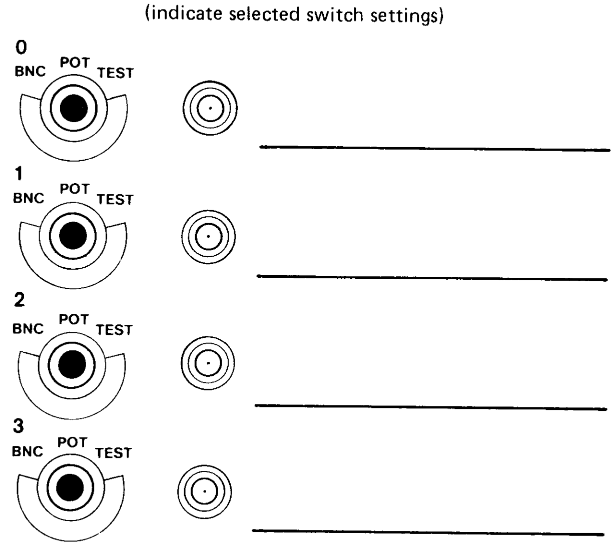
UNIT NO__________

CONNECTOR BLOCK

Term No	Function	Connected to
24	+15T	
23	-15T	
22	analog gnd	
21	analog gnd	
20	logic gnd	
19	ext start	
18	logic gnd	
17	8–15 s.e.	
16	ch 15/rt 11	
15	ch 11	
14	ch 14/rt 10	
13	ch 10	
12	ch 13/rt 9	
11	ch 9	
10	ch 12/rt 8	
9	ch 8	
8	analog gnd	
7	ch 7	
6	analog gnd	
5	ch 6	
4	analog gnd	
3	ch 5	
2	analog gnd	
1	ch 4	

FRONT PANEL

(indicate selected switch settings)



D/A CONVERTER

UNIT NO__________

CONNECTOR BLOCK

Term No	Function	Connected to
24	+15T	
23	−15T	
22	BIT 3 L	
21	BIT 2 L	
20	logic gnd	
19	BIT 1 L	
18	logic gnd	
17	BIT 0 L	
16	logic gnd	
15	BIT 3 H	
14	logic gnd	
13	BIT 2 H	
12	logic gnd	
11	BIT 1 H	
10	logic gnd	
9	BIT 0 H	
8	analog gnd	
7	DAC 3	
6	analog gnd	
5	DAC 2	
4	analog gnd	
3	DAC 1	
2	analog gnd	
1	DAC 0	

FRONT PANEL
(indicate selected switch settings)

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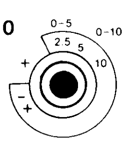

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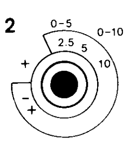

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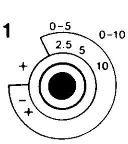

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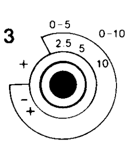

DIGITAL OUTPUT

UNIT NO__________

CONNECTOR BLOCK

Term No	Function	Connected to
24	EXT VOLT	
23	user gnd	
22	HB STRB	
21	D15	
20	D14	
19	D13	
18	D12	
17	D11	
16	D10	
15	D09	
14	D08	
13	+5 V ref	
12	logic gnd	
11	RPLY	
10	LB STRB	
9	D07	
8	D06	
7	D05	
6	D04	
5	D03	
4	D02	
3	D01	
2	D00	
1	user gnd	

FRONT PANEL
(indicate selected switch settings)

reply

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DIGITAL INPUT

UNIT NO ________

CONNECTOR BLOCK

Term No	Function	Connected to
24	EXT VOLT	
23	logic gnd	
22	PGM OUT	
21	D15	
20	D14	
19	D13	
18	D12	
17	D11	
16	D10	
15	D09	
14	D08	
13	+5 V REF	
12	logic gnd	
11	REPLY	
10	STROBE	
9	D07	
8	D06	
7	D05	
6	D04	
5	D03	
4	D02	
3	D01	
2	D00	
1	logic gnd	

FRONT PANEL

(indicate selected switch settings)

data

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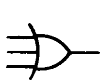
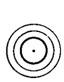


 ________

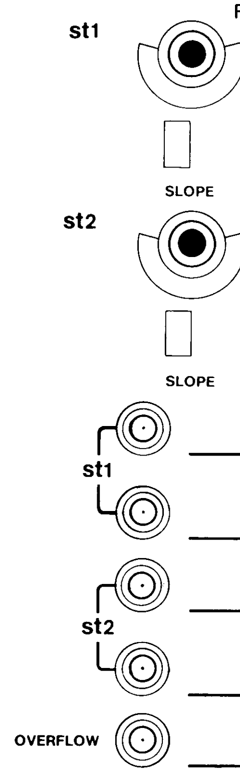
CLOCK

UNIT NO ________

CONNECTOR BLOCK

Term No	Function	Connected to
20	logic gnd	
19	100 Hz	
18	logic gnd	
17	1 KHz	
16	logic gnd	
15	10 KHz	
14	logic gnd	
13	100 KHz	
12	logic gnd	
11	1 MHz	
10	logic gnd	
9	overflow	
8	logic gnd	
7	ST2 OUT	
6	logic gnd	
5	ST2 IN	
4	logic gnd	
3	ST1 OUT	
2	logic gnd	
1	ST1 IN	

FRONT PANEL



☐ TTL

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☐ Slope –

☐ TTL

☐ VAR

☐ Slope +

☐ Slope –

Working with
MINC Devices
AA-D572A-TC

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Did you find this manual understandable, usable, and well-organized? Please make suggestions for improvement.

Did you find errors in this manual? If so, specify the error and the page number.

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- ☐ Higher-level language programmer
- ☐ Occasional programmer (experienced)
- ☐ User with little programming experience
- ☐ Student programmer
- ☐ Other (please specify)__________

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