Electronic Associates, Inc., West Long Branch, New Jersey 07764

EAI 2000
ANALOG REFERENCE
HANDBOOK

ELECTRONIC ASSOCIATES, INC.

UNITED STATES OPERATIONS

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CONTENTS

CONTENTS (CONT)

CONTENTS (CONT)

CONTENTS (CONT)

CONTENTS (CONT)

CONTENTS (CONT)

ILLUSTRATIONS

Figure Number	Title	Page

ILLUSTRATIONS (CONT)

ILLUSTRATIONS (CONT)

ILLUSTRATIONS (CONT)

TABLES

CHAPTER 1

Table 1.1 Synopsis of EAI 2000 Publications

EAI Publ. Number	Title	Basic Content
00 800.2100-0	Hybrid Site Preparation	Site preparation data for EAI 2000 Hybrid Systems.
00 800.2101-0	EAI 2000 Systems Directory of Manuals	Topical index of manuals for the stand-alone EAI 2000 and the EAI 2000/P100 Hybrid and/or Digitally Controlled Systems. Also includes a descriptive list of manuals for EAI 2000/PDP-11 Systems.
00 800.2103-0	EAI 2000 System Functionals Manual	EAI 2000 System and Sub-system theory of operation. Uses system level functional diagrams with associated block text to illustrate and describe all major signal flow. The functionals define all related interconnections and, therefore, are useful as a troubleshooting tool.
00 800.2104-0	EAI 2000 Console System Information and Console Description	Provides quick reference data for maintenance technician. Locates and identifies all components of EAI 2000. Defines system power configurations. Contains cabling data, mnemonic lists, routine maintenance and recommended adjustment procedures.
*00 800.2105-0	EAI 2000 IC Data Handbook	A collection of integrated circuit element data for the various devices used in the EAI 2000.
*00 800.2106-0	EAI 2000 Replaceable Parts Volume	Replaceable Parts Lists for the fully expanded EAI 2000.
00 800.2107-0	EAI 2000 Analog Reference Handbook	Operating procedures, program patching, and applications for components of the EAI 2000.
*00 800.2108-0	EAI 2000 Drawings Volume	A complete set of reference drawings for the fully expanded EAI 2000.
00 800.2109-0	EAI 2000 Acceptance Test Handbook	Provides acceptance test procedures to be performed by EAI Installation Engineers. This manual is valuable to the Maintenance Technician for operational and performance checking.
00 800.2110-0	EAI 2000/PACER 100 Hybrid Acceptance Test Handbook	Similar to 00 800.2109-0. Includes software acceptance tests for EAI 2000/PACER 100 Hybrid Systems.
00 800.2111-0	EAI 2000/PDP11 Hybrid Acceptance Test Handbook	Similar to 00 800.2110-0. Includes software acceptance tests for EAI 2000/PDP11 Hybrid Systems.
*00 800.2113-0	EAI 2000 CSI Maintenance Manual.	Test methods and troubleshooting for the EAI 2000 Control and Setup Interface.
00 800.2114-0	EAI 2000 Multi-Console Expansions - Installation and Maintenance.	Defines the EAI 2000 Multi-Console Expansions. Provides Field Installation Data (Including retro-kit); and Maintenance Information for Multi-Console Systems.
*00 802.8013	M6800 Microcomputer System Design Data Manual (Motorola)	Defines the MC 6800 Microprocessor and the Asynchronous Communications Adapter (ACIA)
00 827.0082-0	EAI 2000 Hybrid Communication Library Manual	Software documentation for EAI 2000 Libraries (CSIL and SPIL).
00 827.0083-0	EAI 2000 Hybrid Diagnostics Manual	Software documentation for EAI 2000 Diagnostics (CSIT, SAT, SPIT, and DSFGT).

***Designates Optional Manuals**

INTRODUCTION TO THE EAI 2000

1.1 SCOPE OF REFERENCE HANDBOOK

The EAI 2000 Reference Handbook describes how to use the standard computer as an independent computational system. It provides an in-depth treatment of all the operational features and characteristics of the fully-expanded EAI 2000 Parallel Processor. Although the various chapters touch on operation of the EAI 2000 when used in conjunction with a digital computer, the EAI 2000 Hybrid Libraries Manual should be consulted for such system configurations. For reference, a complete list of EAI 2000 publications is provided in Table 1.1.

Subsequent paragraphs of this chapter very briefly highlight just a few of the many modern characteristics of the EAI 2000.

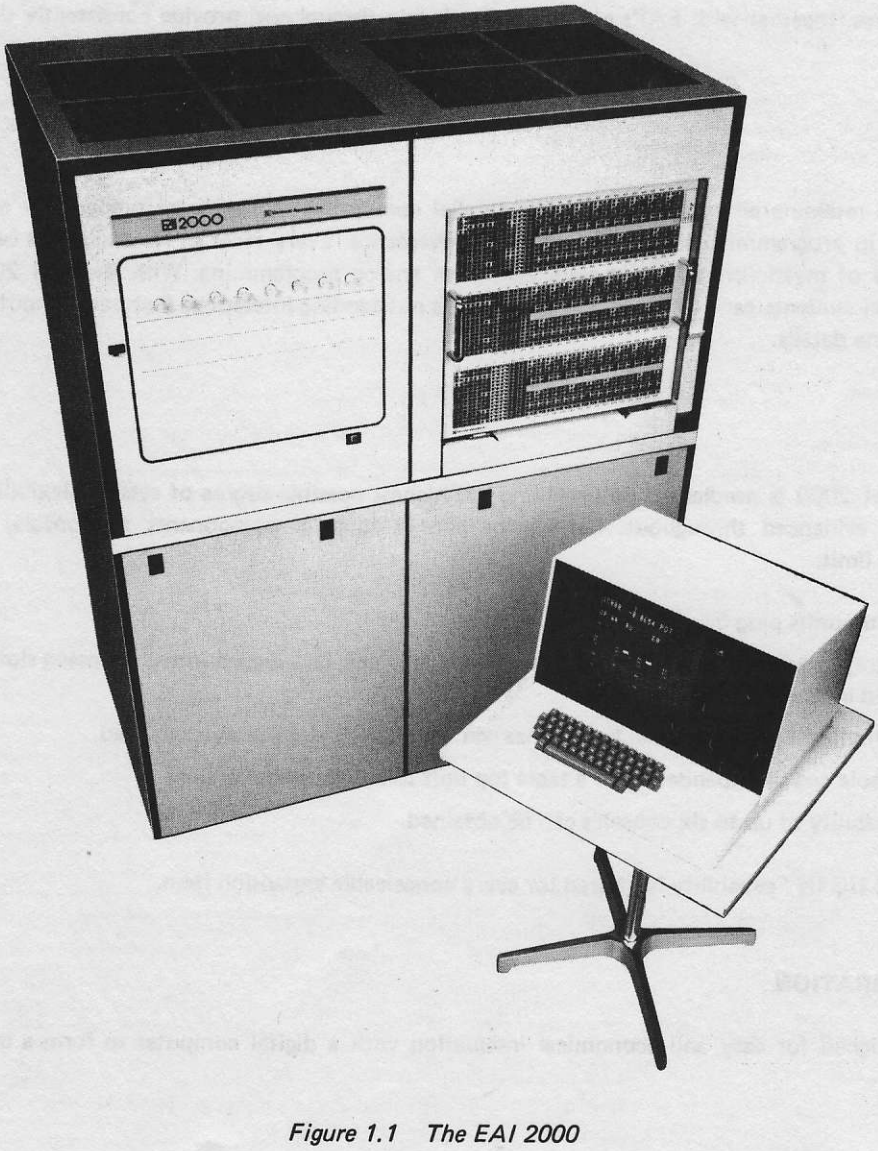


Figure 1.1 The EAI 2000

1.2 TECHNOLOGY

The EAI 2000 is based on contemporary technology. Its innovative design incorporates:

- Microprocessor Controls
- Video Terminal
- Wiring Plane Printer Interconnections
- Mass Termination Cabling
- State-of-the-art Integrated Circuits
- Solid State CMOS logic
- Monocoque Mechanical Construction

These advanced features, together with EAI's capable craftmanship throughout, provide consistently dependable performance.

1.3 CONVENIENCE

The EAI 2000, while retaining all of the high speed, parallel computing capability of predecessor analog systems, adds new dimensions in programming simplicity and user convenience. Every facet of its design has been scrutinized to remove the stigma of mysticism, so often associated with analog programming. With the EAI 2000, engineers, scientists, and technical students can readily apply the analog's outstanding interactive features without being diverted by interminable machine details.

1.4 FLEXIBILITY

The design of the EAI 2000 is predicated on providing the highest possible degree of system flexibility. The results of this criterion are evidenced throughout. Modularity permeates from components to console; universality is applied to its practical limit.

- Optional limiter units plug into component tray.
- Component trays plug into a back plane. Any analog tray can be plugged into any analog slot; any logic tray can be plugged into any logic slot.
- Computing amplifiers and additional backplanes can be added as expansion is required.
- Even the console can be expanded from a table top unit to a floor standing unit.
- A system capability of up to six consoles can be obtained.

In fact, "BOLT ON/PLUG IN" capability is offered for every conceivable expansion item.

1.5 SYSTEM INTEGRATION

The EAI 2000 is designed for easy and economical integration with a digital computer to form a complete hybrid computing system.

Two levels of system integration are available.

- A standard serial communications channel is available with micro-processor based control and set up interface to handle all nontime-critical communications. From the vantage of the digital, the EAI 2000 appears as simply another terminal: a terminal accessed with standard FORTRAN software. At this level, the digital computer can direct all of the control and monitoring functions required to setup, check out, and operate the parallel processor.

- For high speed time-critical communications, a Standard Parallel Interface may be added. Tailored to match the digital's I/O structure, it provides discrete logic lines, high speed mode control, priority interrupts, DAM (digital to analog multiplication) channels, and multiplexed ADC channels. Used together with the serial interface, this provides a unique synergetic system combining the advantages of both the digital computer and parallel analog processor.

CHAPTER

2

SYSTEM OVERVIEW

2.1 INTRODUCTION

This chapter serves as a system overview. A brief description is given of the system architecture, the major system modules, and the computing components. The emphasis is on organization and structure. Detailed operations are covered in subsequent chapters.

2.2 SYSTEM CONFIGURATIONS

2.2.1 GENERAL

The EAI 2000 is available in three standard system configurations:

Stand-alone parallel analog processor

Non-Time-Critical Hybrid via the serial communications interface

Time-Critical Hybrid via the Standard Parallel (Data Communication) Interface

Each configuration is illustrated in a simplified block diagram (Figures 2.1 - 2.3) and is described in the following subparagraphs.

2.2.2 STAND-ALONE ANALOG CONFIGURATION

Figure 2.1 depicts the stand-alone computer configuration with its characteristic parallel array of computing components. Individually, each component is capable of performing one or more well defined mathematical operations. Collectively, the components can be arranged to simulate physical phenomena or to model mathematical abstractions. The principals of operation, invoking the similarity to properties of nature, involves the representation of a mathematically described model by an analogous electrical model. The analog is formed by interconnecting the various computing components at the program panel. Continuous and discontinuous problem variables, represented by time-varying voltage signals, are processed in parallel. Graphical results are obtained on peripheral display devices. The overall program is interactively controlled and monitored from the user terminal. This interactive terminal is referred to as the Monitoring and Control Station (MACS). The MACS terminal operates in conjunction with the micro-processor based Control and Setup Interface (CSI).

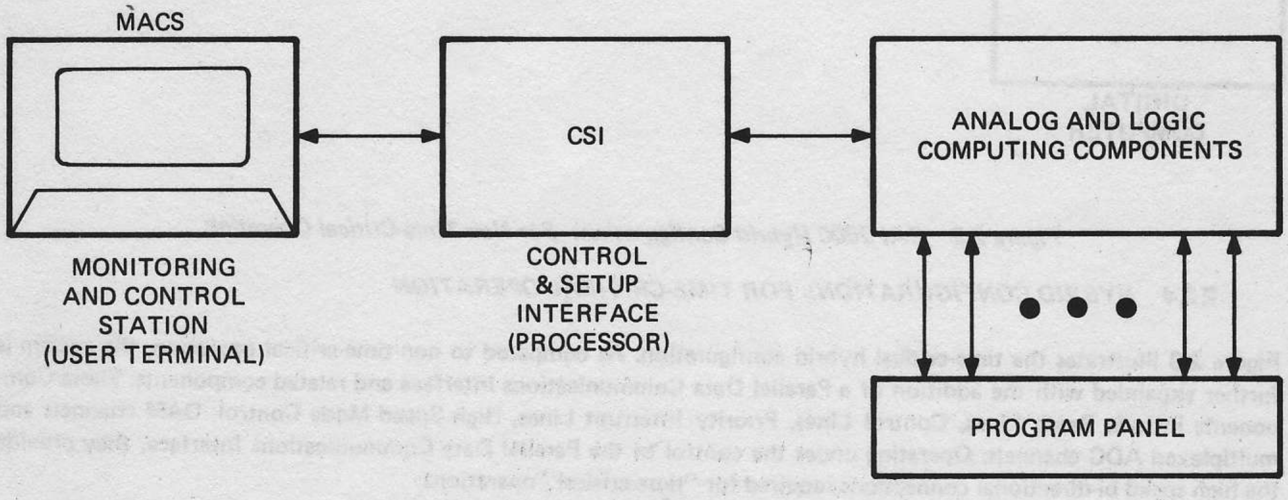


Figure 2.1 EAI 2000 Stand-Alone Configuration

2.2.3 *HYBRID CONFIGURATION: FOR NON-TIME-CRITICAL OPERATION*

Figure 2.2 illustrates the basic non-time-critical hybrid configuration. As compared to the non-time-critical hybrid stand-alone analog system, the parallel processor is enhanced by the addition of a general purpose digital computer; the basic structure remains unchanged. Communication with the digital processor is accomplished over an industry-standard, RS232C/CCITT compatible, Serial Communications Channel. The digital processor, with the advice and consent of the Control and Setup Interface (CSI), has access to all control and monitoring functions of the EAI 2000. Therefore, the digital processor can be programmed to automatically perform all procedural tasks (short of component interconnection) involved in the setup, checkout, and operation of the parallel processor. Bi-directional data flow in a Non-Time-Critical Hybrid Mode occurs at the fastest baud rate available with the particular digital processor. The CSI is capable of rates up to 9600 Bauds per second.

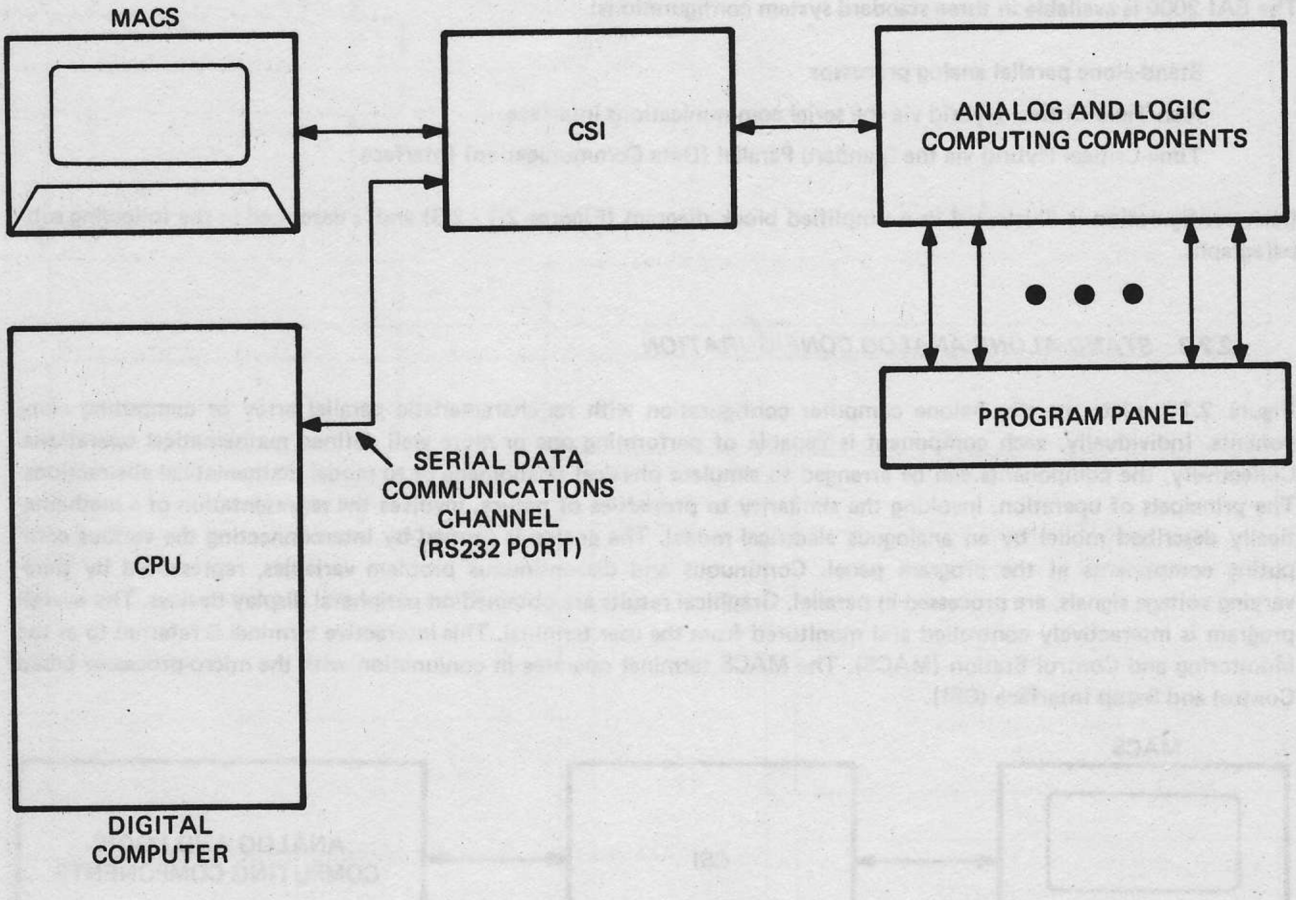


Figure 2.2 EAI 2000 Hybrid Configuration: For Non-Time-Critical Operation

2.2.4 *HYBRID CONFIGURATION: FOR TIME-CRITICAL OPERATION*

Figure 2.3 illustrates the time-critical hybrid configuration. As compared to non-time-critical operation, the system is further expanded with the addition of a Parallel Data Communications Interface and related components. These Components include Sense Lines, Control Lines, Priority Interrupt Lines, High Speed Mode Control, DAM channels and multiplexed ADC channels. Operating under the control of the Parallel Data Communications Interface, they provide the high speed bi-directional connections required for "time-critical" operations.

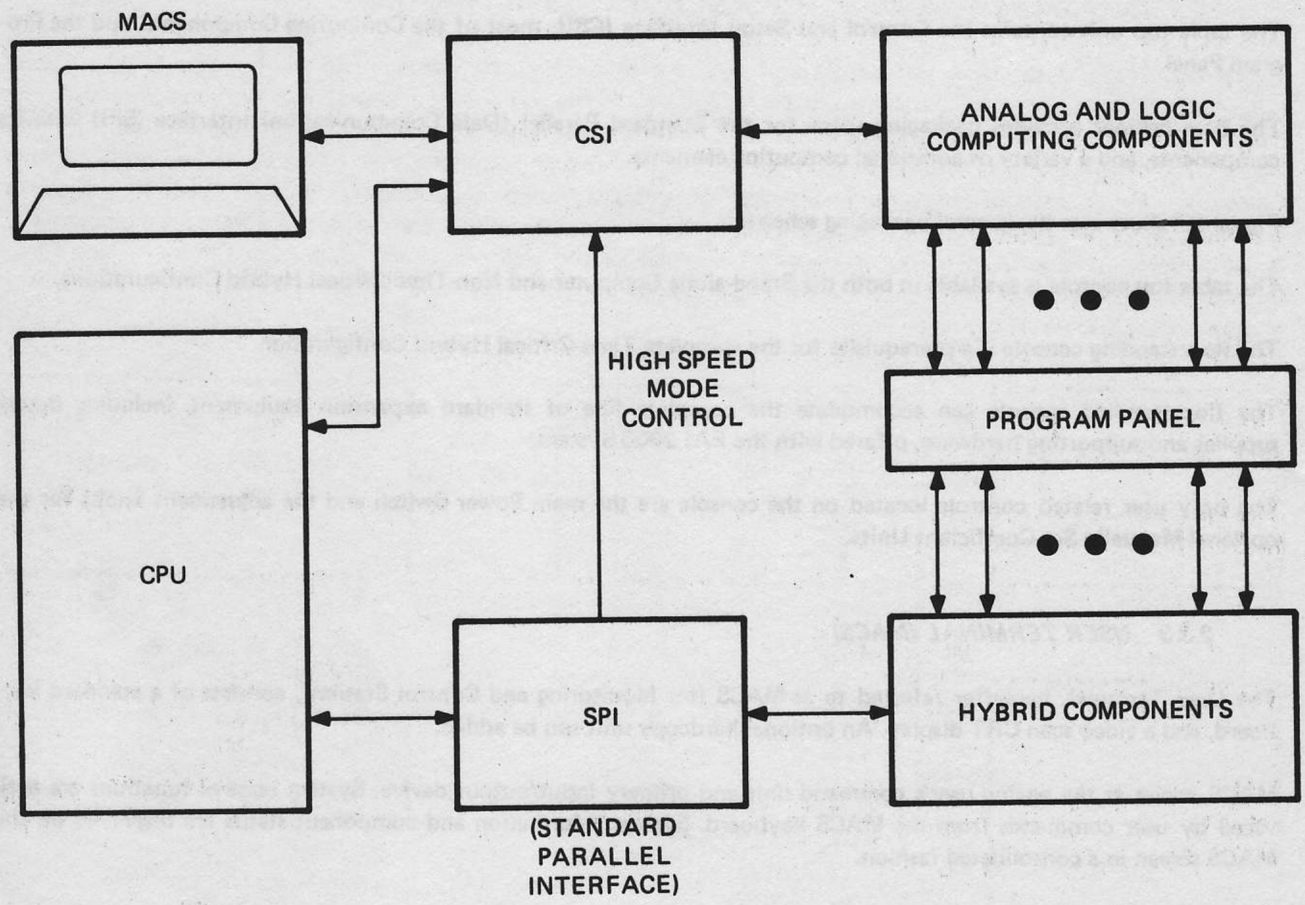


Figure 2.3 EAI 2000 Hybrid Configuration: For Time-Critical Operation

2.3 SUBSYSTEMS

2.3.1 INTRODUCTION

The major Subsystems comprising theEAI 2000 are listed below and are briefly described in the following text.

Console
User Terminal (MACS)
Control and Setup Interface (CSI)
Standard Parallel (DATA COMMUNICATION) Interface (SPI)

2.3.2 CONSOLE

The CONSOLE is available as either a table top unit or a floorstanding unit. The floorstanding unit is formed from the table top unit by adding a base cabinet.

The table top unit contains the Control and Setup Interface (CSI), most of the Computing Components, and the Program Panel.

The base cabinet provides packaging space for the Standard Parallel (Data Communication) Interface (SPI) with its components, and a variety of additional computing elements.

Figure 2.4 illustrates the general packaging scheme.

The table top console is available in both the Stand-alone Computer and Non-Time-Critical Hybrid Configurations.

The floorstanding console is a prerequisite for the complete Time-Critical Hybrid Configuration.

The floorstanding console can accomodate the complete line of standard expansion equipment, including power supplies and supporting hardware, offered with the EAI 2000 System.

The only user related controls located on the console are the main Power Switch and the adjustment knobs for the optional Manually Set Coefficient Units.

2.3.3 USER TERMINAL (MACS)

The User Terminal, hereafter referred to as MACS (for Monitoring and Control Station), consists of a standard keyboard, and a video scan CRT display. An optional hardcopy unit can be added.

MACS serves as the analog user's command unit and primary input/output device. System control functions are activated by user commands from the MACS keyboard. System information and component status are displayed on the MACS screen in a consolidated fashion.

The hybrid user has the option of accessing the system from either the digital processor or from MACS.

2.3.4 CONTROL AND SETUP INTERFACE (CSI)

The Control and Setup Interface is a microprocessor based, intelligent controller that supervises the overall system operation. Basically, the CSI performs the following tasks:

- Accepts Commands
- Interprets Commands
- Executes Commands
- Verifies Valid Execution
- Reports Error Conditions
- Generates the MACS Display

The Control and Setup Interface handles all the "non-time-critical" operations. Communications between Control and Setup Interface and the digital processor are transmitted over a Serial Data Communications Channel. Individual memory buffers are associated with each channel to ensure system integrity. Digital connection can be enabled and disabled, (by user command) from MACS. Once enabled, commands emanating from either MACS or the digital processor are accepted and executed on a "first-come-first-served" basis.

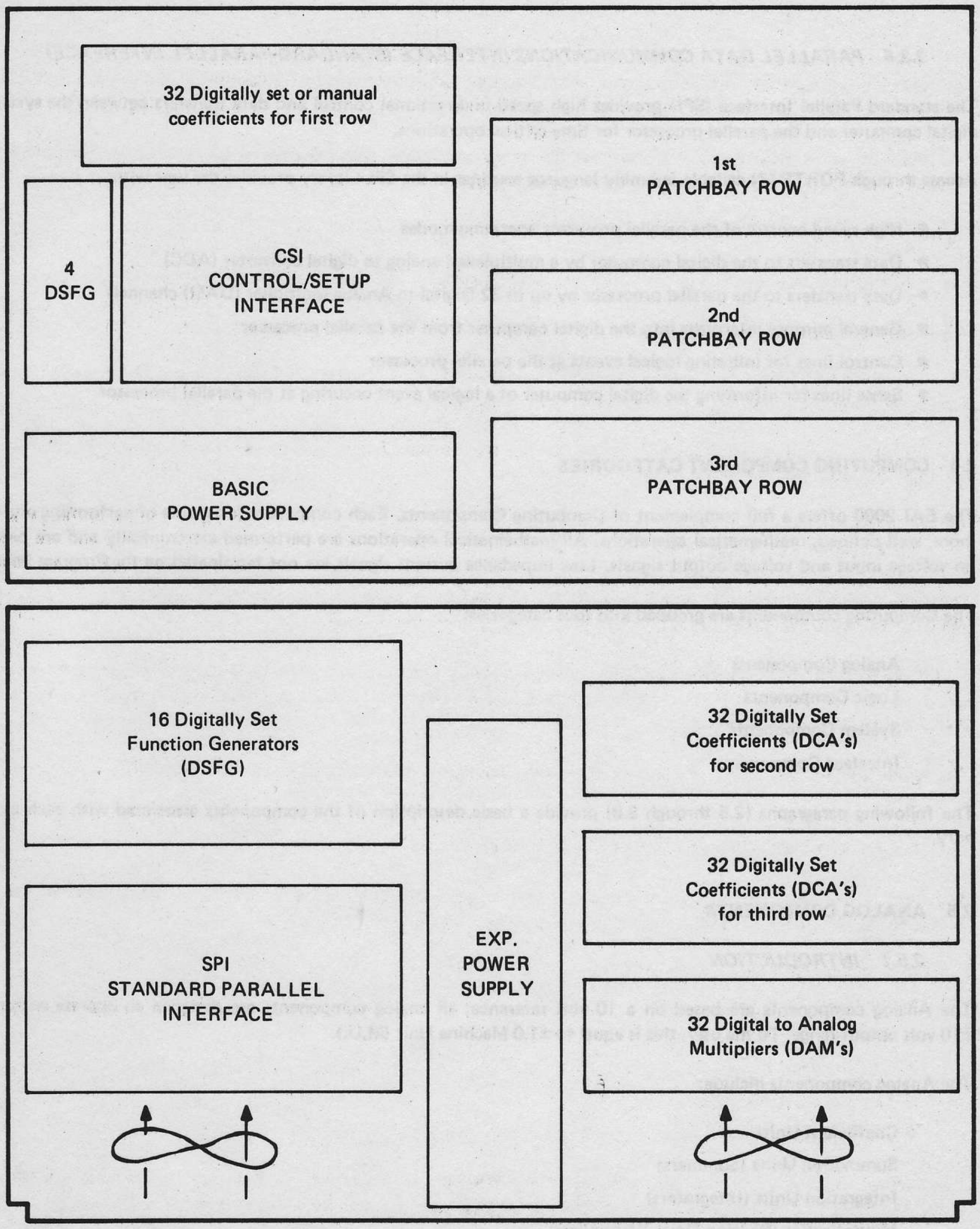


Figure 2.4 EAI 2000 System Console

2.3.5 PARALLEL DATA COMMUNICATIONS INTERFACE (STANDARD PARALLEL INTERFACE)

The standard Parallel Interface (SPI) provides high speed bi-directional control and data transfers between the system digital computer and the parallel processor for time-critical operations.

Access through FORTRAN callable assembly language routines in the SPI Library provides the user with:

- High speed control of the parallel processor operating modes
- Data transfers to the digital computer by a multiplexed analog to digital converter (ADC)
- Data transfers to the parallel processor by up to 32 Digital-to-Analog-Multiplier (DAM) channels
- General purpose interrupts into the digital computer from the parallel processor
- Control lines for initiating logical events at the parallel processor
- Sense lines for informing the digital computer of a logical event occuring at the parallel processor

2.4 COMPUTING COMPONENT CATEGORIES

The EAI 2000 offers a full complement of Computing Components. Each component is capable of performing one or more, well defined, mathematical operations. All mathematical operations are performed electronically and are based on voltage input and voltage output signals. Low impedance current signals are not terminated on the Program Panel.

The Computing components are grouped into four categories:

Analog Components
Logic Components
System Components
Interface Components

The following paragraphs (2.5 through 2.8) provide a basic description of the components associated with each category.

2.5 ANALOG COMPONENTS

2.5.1 INTRODUCTION

The Analog components are based on a 10 volt reference; all analog components are designed to operate within a ±10 volt output range. To the user, this is equal to ±1.0 Machine Unit (M.U.).

The Analog components include:

Coefficient Units
Summation Units (Summers)
Integration Units (Integrators)
Multiplication/Division Units (Multipliers)
Track-Store Units

Selector Switches

Limiters

Trigonometric Function Generators

Digitally Set Function Generators

Each Analog Component is briefly described in the following paragraphs. Detailed descriptions together with pertinent user information are presented in chapter 4.

2.5.2 COEFFICIENT UNITS

Two types of Coefficient Units are offered:

Digitally Set Coefficient Units (DCA's)

Manually Set Coefficient Units (POT's)

Both devices perform continuous multiplication of an analog variable times a constant coefficient. The coefficient can be assigned positive or negative values.

Digitally Set Coefficient Units are set by command from the MACS or the digital processor.

Manually Set Coefficient Units, as the name implies, are hand-adjusted by the user. The adjustment knobs are located on the front panel of the EAI 2000 Console.

2.5.3 SUMMER

The Summer comes in three versions:

4 Input Summer (Model 0.72.0051 TS/Σ Tray only)

6 Input Summer

7 Input Summer

Except for the number of inputs, all Summers are functionally equivalent. They perform continuous algebraic summation of several analog variables.

As an optional feature, the 4-Input and the 7-Input Summer can be equipped with a committed Variable Limiter.

2.5.4 INTEGRATOR

The Integrator performs continuous integration of an analog variable, with respect to time.

Operational modes of the Integrator can be selected at a Master level or a Local level. At the Local level, each integrator can be controlled separately.

The Integrator has 6 Time Scales arranged in decades from 1 through 100,000. The Time Scales can be selected at a Master level or a Local level. At the Local level, each Integrator can be controlled separately. Additionally, the local Time Scale can be selected on an absolute basis or a relative basis.

As an optional feature, the Integrator can also be equipped with a committed Variable Limiter.

2.5.5 MULTIPLIER

The Multiplier can be used as an operator or as a function generator. As an operator: the Multiplier performs continuous Multiplication or Division of two analog variables.

As a function generator: the Multiplier generates the Square or Square Root of an analog variable.

2.5.6 TRACK-STORE UNIT

The Track-Store Unit serves as a basic analog memory device capable of storing a single point of analog data.

In terms of a Sampled Data System, the Track-Store Unit performs the combined operations of a Summer, A Sampler, and a Zero Order Hold. Sampling and initialization are controlled by patched logic signals.

When not being used for sampling applications, the Track-Store Unit can be used as a 5 input Summer.

As an optional feature the Track-Store Unit (specifically, Model 0.72.0051-1) can be equipped with a committed Variable Limiter.

2.5.7 SELECTOR SWITCH

The Selector Switch is a basic analog signal switching device.

The Selector Switch, while functionally resembling a single pole-double throw relay, is completely electronic in operation. The Switch output is selected (under logic control) from a choice of two analog inputs.

2.5.8 TRIGONOMETRIC FUNCTION GENERATOR

The Trigonometric Function Generator can be used to generate any of the following functions of an analog variable:

Sine

Cosine

Arc Sine

2.5.9 DIGITALLY SET FUNCTION GENERATOR

The Digitally Set Function Generator (DSFG) is used to generate an arbitrary function of an analog variable.

The desired function is approximated in a piece-wise linear manner. Forty linear segments, specified by endpoint co-ordinates, are available. Function values, corresponding to fixed argument values, are entered from MACS or the digital processor. The endpoint coordinates are stored in a local memory; linear interpolation is automatically provided between the segment end points.

2.6 LOGIC COMPONENTS

2.6.1 GENERAL

The Logic Components are based on a 10 volt positive logic system. In a Boolean sense: a logic "0" corresponds to 0 volts and a logic "1" corresponds to 10 volts.

The logic components include:

- Gates
- Flip Flops
- Differentiators
- Registers
- Counters
- Comparators

Except for the Gates, all of the Logic Components are synchronized with the System Clock (See Paragraph 2.7.2).

Each Logic Component is briefly described in the following text. Detailed descriptions together with pertinent user information are presented in Chapter 5.

2.6.2 GATE

There are 2 Input Gates and 3 Input Gates.

A logical inverter is assigned to the output of each gate.

Individual Gates can be used to perform any of the following logic operations:

- AND
- OR
- NOT
- NAND
- NOR

Collectively, the Gates are used to generate combined logic functions.

The Gate output is essentially an instantaneous function of its inputs.

2.6.3 FLIP FLOP

The Flip Flop serves as the basic logic memory device.

The Flip Flop, as terminated on the Program Panel, can be used as a:

- Set Reset Flip Flop
- Trigger Flip Flop
- Delay Flip Flop

The Flip Flop can be manipulated and interrogated by command from MACS or the digital processor.

2.6.4 DIFFERENTIATOR

The Differentiator is an elementary logic device consisting of a gate and a flip flop. It is packaged as a component for user convenience.

The Differentiator is used to detect the state transition of a given logic signal. When its input undergoes a positive transition, the differentiator generates a pulse output.

2.6.5 REGISTER

The Register is an 8-Bit, General Purpose Register that can be used in any of the following roles:

- 8-Bit Binary Up Counter
- 8-Stage Shift Register
- 8-Individual Flip Flops

Using patched logic, the Register contents can be incremented, shifted, cleared, updated and decoded. The Register can also be loaded and decoded by command from MACS or the digital processor.

2.6.6 COUNTER

The Counter is a 15-Bit Digital Counter that is arranged to conveniently handle counting and timing operations.

The Counter includes a buffer register that can be preset by command from MACS or the digital processor.

Using patched logic, the Counter contents can be initialized or decremented.

Logic outputs indicate when counting is in progress and when counting is completed.

The Counter can be decoded by command from MACS or the digital processor.

2.6.7 COMPARATOR

The Comparator serves as the basic Analog-Logic interface device. It accepts two analog inputs and yields a logic output dependent on the difference of the inputs.

Classification of the Comparator as a logic component is a convenient arbitrary decision and is based on packaging details.

2.7 SYSTEM COMPONENTS

2.7.1 GENERAL

As previously described, the Analog and Logic Components are used as the elementary building blocks in the development of a desired analog model. In contrast, the System Components are used more generally to control or otherwise sustain the overall system operation.

The System Components include:

- **System Clock**
- **Pulse Train Outputs**
- **Rep-Op Timer**
- **Keyboard Pulses**
- **Trunk Lines**

Each System Component is briefly described in the following text. Detailed descriptions together with pertinent user information are presented in Chapter 6.

2.7.2 SYSTEM CLOCK

The System Clock is a crystal controlled oscillator operating at a frequency of 1MHz.

System Clock serves as the primary timing reference for the system. It is used internally to synchronize the operation of all sequential logic components.

The System Clock is not terminated on the Program panel.

2.7.3 PULSE TRAIN OUTPUTS

Six pulse trains (derived from the System Clock) are terminated on the Program Panel.

One of these pulse trains (TS) has a frequency that is proportional to the selected Master Time Scale. The other five, have fixed frequencies ranging by decades from 10^1 pps through 10^5 pps.

These pulse trains serve as timing references and may be used for a variety of applications.

2.7.4 REP-OP TIMER

The Rep-Op Timer is a 3 stage digital timer.

The Rep-Op Timer is primarily used to cycle the analog processor through a series of repetitive operations. It can also be used as a general purpose component.

The Rep-Op Timer is fully supported by the Control and Setup Interface. A set of commands is available for convenience of operation. The Rep-Op Timer includes a variety of Program Panel terminations to enhance its versatility.

The timing interval associated with each stage can be preset by command from MACS or the digital processor.

2.7.5 KEYBOARD PULSES

The user can generate a logic pulse on the Program Panel by issuing an appropriate command from MACS. Four such Keyboard Pulse outputs are terminated. These outputs provide the user with the ability to manually interact with a logic program.

2.7.6 OVERLOAD INDICATOR

An Analog component that is being operated in a manner that adversely affects its defined performance is said to be "overloaded." An overload is most commonly caused by a component output exceeding its operating range. The occurrence of an overload condition is indicated on the MACS display and on the Program Panel. The MACS display includes both; a Master Overload indication, and individual component overload indications. The Program Panel includes a logic termination (OVD) that goes high while an overload condition exists.

2.7.7 TRUNK LINES

Trunk lines electrically connect terminals on the Program Panel with connectors in the rear of the console. Using these trunk lines, peripheral devices can be conveniently cabled into the system complex.

Three types of Trunk lines are offered:

Analog

Logic

Display

The Analog Trunk lines are general purpose, bi-directional, feedthrough lines. A fully expanded system can accommodte a total of 96 Analog Trunk Lines.

The Logic Trunk lines are general purpose, uni-directional, buffered lines. There are 8 incoming lines and 8 outgoing lines.

The Display Trunk Lines are special purpose lines arranged to handle a variety of standard display devices. There are 16 Display Trunk Lines.

2.8 INTERFACE COMPONENTS

2.8.1 GENERAL

The Interface Components constitute the working elements of the Standard Parallel Interface (SPI). They provide the time-critical logical and data connections between the EAI 2000 and a digital computer. Terminations at the parallel processor appear on the program panel. At the digital computer, access is via the SPI Library.

The Interface Components include:

- High Speed Mode Control
- Control Lines
- Sense Lines
- Interrupts
- Analog to Digital Conversion (ADC) Channels
- Digital to Analog Multiplication (DAM) Channels

Each Interface Component is briefly described in the following text. Detailed descriptions together with pertinent user information are presented in Chapter 7.

2.8.2 HIGH SPEED MODE CONTROL

High Speed Mode Control permits operation of the time-critical analog and logic component modes directly through the SPI. Control is from the digital computer via a software subroutine.

2.8.3 CONTROL LINES

Control Lines are used to initiate logical events at the parallel processor from the system digital computer.

Up to 16 Control Line logical outputs can be terminated on the program panel.

Control lines can be set or reset individually or as a parallel 16 bit word from the digital computer via software subroutines.

Individual reset capability at the parallel processor program panel is also provided.

Control Line outputs are displayed on the MACS.

2.8.4 SENSE LINES

Sense Lines provide a means to indicate to the digital computer the occurrence of a logical event at the parallel processor.

Up to 16 Sense Line logical inputs can be terminated on the program panel.

Sense Lines can be read individually or as a parallel 16 bit word from the digital computer via software subroutines.

Sense line inputs are displayed on the MACS.

2.8.5 INTERRUPTS

General Purpose Interrupts permit the EAI 2000 to interrupt (in an orderly manner) the current operation of the digital computer and cause it to jump to a previously defined user subroutine.

Eight logical Interrupt inputs are terminated on the program panel.

The SPI Library contains a number of subroutines for Interrupt management.

Interrupt inputs are displayed on the MACS.

2.8.6 ANALOG TO DIGITAL CONVERSION (ADC) CHANNELS

The ADC is a high speed device for converting analog values into binary form for use by the digital computer.

Sixteen (multiplexed) inputs are terminated on the program panel of the EAI 2000.

The converted binary representation of the inputs can be read from the digital computer (via software subroutines), either singly or in contiguous blocks.

Synchronization inputs and outputs terminate on the program panel.

2.8.7 DIGITAL TO ANALOG MULTIPLICATION (DAM) CHANNELS

The DAM multiplies an analog value by a binary digital value to produce an analog output.

Up to 32 DAM Channels can be added to the system with their inputs and outputs terminated on the program panel.

A number of software subroutines are available for loading the digital multiplier values of DAM Channels, either singly or in contiguous blocks.

Synchronization inputs and outputs terminate on the program panel.

2.9 COMPONENT PACKAGING

2.9.1 GENERAL

The Components described in the previous paragraphs are functionally independent. However, practical considerations preclude packaging these components as individual items. Instead, the components are packaged in judiciously selected groups. The major ingredients involved in this packaging scheme are listed below and are briefly described in the following sub-paragraphs:

Component Trays

Special Purpose Trays

Component Bay

Program Panel

2.9.2 COMPONENT TRAYS

2.9.2.1 General

The Computing Components, except for the Coefficient Units and the Digitally Set Function Generators, are packaged in trays; each tray contains several components. The analog/logic distinction, noted for the components, is continued in the tray structure: Analog Components are packaged in Analog trays; Logic Components in Logic trays.

2.9.2.2 Analog Trays

There are 4 distinct analog Component Trays and one Coefficient Feedthrough tray. These trays are identified in Table 2.1. Each Analog tray contains 2 major Analog Components, a Selector Switch, and feedthrough wiring for 2 Coefficient Units. The major Analog Components included in a particular tray, are discerned from the tray name. The Coefficient Feedthrough tray is available as an option if additional DCA's are desired without adding Analog Component trays. As in the case of the Analog Component tray, the Coefficient Feedthrough trays provides feedthrough wiring for 2 Coefficient Units.

Table 2.1 Analog Component Trays

Tray Name	Tray Symbol
Integrator/Summer	$\int/\Sigma$
Multiplier/Summer	MUL/Σ
Track-Store/Summer	TS/Σ
Trig Function/Summer	SIN/Σ
Coefficient Feedthrough	—

2.9.2.3 Logic Trays

There are 3 distinct Logic Trays. These trays are identified in Table 2.2

The General Purpose Logic Tray contains:

- 2 Flip Flops
- 3 Gates
- 1 Differentiator
- 1 Counter

The contents of the other two trays are obvious from their names, refer to table 2.2.

Table 2.2 Logic Trays

Tray Name	Tray Symbol
General Purpose Logic	GPL
General Purpose Register	GPR
Comparator, 6 Pack	CMP

2.9.3 SPECIAL PURPOSE MODULES AND TRAYS

Because of size or other physical constraints the System Components, the Interface Components, and the Digitally Set Function Generators, are not packaged in trays. Instead, these components are packaged in separate modules contained within the System Console. These components are electrically terminated in Special Purpose Trays. The Special Purpose Trays provide the feedthrough wiring that connects the components to the Program Panel.

There are 7 distinct Special Purpose Trays. These trays are identified in Table 2.3.

The Readout Tray is a dual purpose tray that can be used for both the Digitally Set Function Generators and the Analog Trunks.

The Feedthrough Trays are used for the DAM channels and, optionally, for Analog Trunk Lines.

Table 2.3 Special Purpose Trays

Tray Name	Tray Symbol
Control	RT
Output	OUTPUT
Keyboard Pulse/Logic Trunk	$\sqcap\sqcup$/LT
Sense Line/Control Line	SL/CL
Interrupt Line/ADC	IL/ADC
Function Generators	F––
Feedthrough DAM Analog Trunk	 DA–– T––

2.9.4 COMPONENT BAY

The Component Trays and the Special Purpose Trays are contained in the Console directly behind the Program Panel. The structure in which the trays are mounted is referred to as the Component Bay.

The Component Bay can accomodate a total of 72 trays with a maximum complement of:

48 Analog Trays

12 Logic Trays

12 Special Purpose Trays

The Component Bay consists of a mechanical housing and wiring backplane.

The housing is arranged with 3 rows; each row has mounting slots for 24 trays.

The backplane is divided into three indepent segments; each segment provides wiring for one complete row.

The first backplane segment, corresponding to the top row, is basic to the system. The other two segments are individual expansion items.

Section 3 indicates the slot assignments for the analog, logic and special purpose system trays. Assuming the backplane segments have been installed, any analog tray can be plugged into any analog slot. Likewise, any logic tray can be plugged into any logic slot.

The Special Purpose trays, however, are committed to specific slots.

2.9.5 PROGRAM PANEL

The Program Panel serves as an interface between the computing components and the user.

The components, terminated on the Program Panel, are clearly identified; a simple addressing scheme is employed. The terminals are labeled and color coded.

The user interconnects the components by inserting patch cords into appropriate Program Panel terminals. Patching can be performed ON-LINE or OFF-LINE. The Program Panel, made of lightweight aluminum, is easily removed and installed.

The Program Panel markings are initially lithographed for a fully expanded, standard configuration. This standard configuration provides for a well balanced complement of computing components. Specialized configurations, however, can be readily accomodated. Pressure sensitive adhesive backed overlays are available for each Analog and Logic Tray. The overlays can be applied to modify the standard program panel markings.

CHAPTER

3

CHAPTER 3

THE PROGRAM PANEL

3.1 OVERVIEW

The Program Panel is the interface between the computing components and the user. All components have their input(s), output(s) and, where applicable, controls terminated in clearly identified areas of the panel. The user implements a program by interconnecting the computing blocks using stackable patch cords. As the panel is made of lightweight aluminum, it can be easily removed from the panel area of the EAI 2000 and stored, thus retaining the program for use at another time.

It is suggested that an actual Program Panel be referred to while reading this chapter for the first time.

The panel is divided into three nearly identical rows.

First Component Row

LOGIC	SPECIAL	ANALOG	
0-3	PURPOSE	0-17	20-37

Second Component Row

LOGIC	SPECIAL	ANALOG	
4-7	PURPOSE	40-57	60-77

Third Component Row

LOGIC	SPECIAL	ANALOG	
10-13	PURPOSE	100-117	120-137

The panel is supplied with lithographed markings for a fully-expanded EAI 2000 standard complement and configuration. Pressure sensitive overlays can be used to customize the program panel to match the complement and configuration the user selects. This manual considers the most general program panel — the one supplied without overlays. The program panel drawing and a summary of all available tray types are included at the end of this chapter. (See Figures 3.7 and 3.8).

Each row is divided into three fields, from left to right as follows:

Logic field is four trays wide.

Special-purpose field is also four trays wide.

Analog field is sixteen trays wide.

The trays are aligned vertically, each tray having 32 holes (terminations) arrayed 2 wide by 16 high. The components within a tray are clearly distinguished by the Program Panel markings. Color coding, as indicated in Table 3.1, further clarifies the function of each termination.

Table 3.1 Program Panel Color Codes

COLOR	ANALOG	LOGIC
GREEN	INPUT	INPUT
RED	OUTPUT + REFERENCE	SYNCHRONOUS
ORANGE	REFERENCE	ASYNCHRONOUS
YELLOW	COEFFICIENT UNIT LIMITER	----------------------------
BLACK	GROUND	----------------------------
WHITE	CONFIGURATION	CONTROL LOGIC "1"
GREY	UNUSED	----------------------------
RED/WHITE	+ TEST REFERENCE	----------------------------
ORANGE/WHITE	– TEST REFERENCE	----------------------------

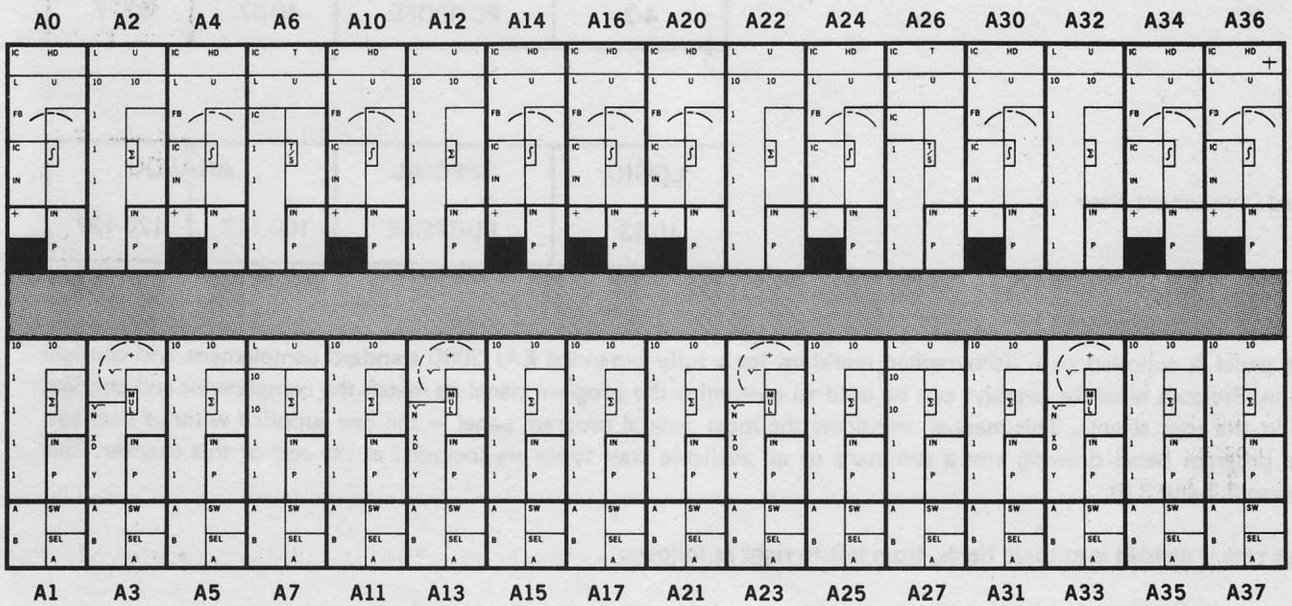


Figure 3.1 The Analog Field of The First Component Row

3.2 THE ANALOG FIELDS

Each analog field (Figure 3.1) can contain up to sixteen analog trays; each tray terminates two major components, the functions of which are indicated symbolically in black on a white background. For example, the first analog tray has a $\int$ and a Σ. In addition, every analog tray contains one (1) selector switch and provides terminations for two (2) coefficient units.

For the purpose of labeling (identifying and addressing) a computing component, letters and numbers are assigned to each component in each tray. The letter abbreviation key is:

A = Analog: any component having its function designated in black on a white background on the panel (∫, Σ, T/S, MUL, SIN)

C = Coefficient unit

Consider the first analog tray (Figure 3.2) as an example of addressing and identification.

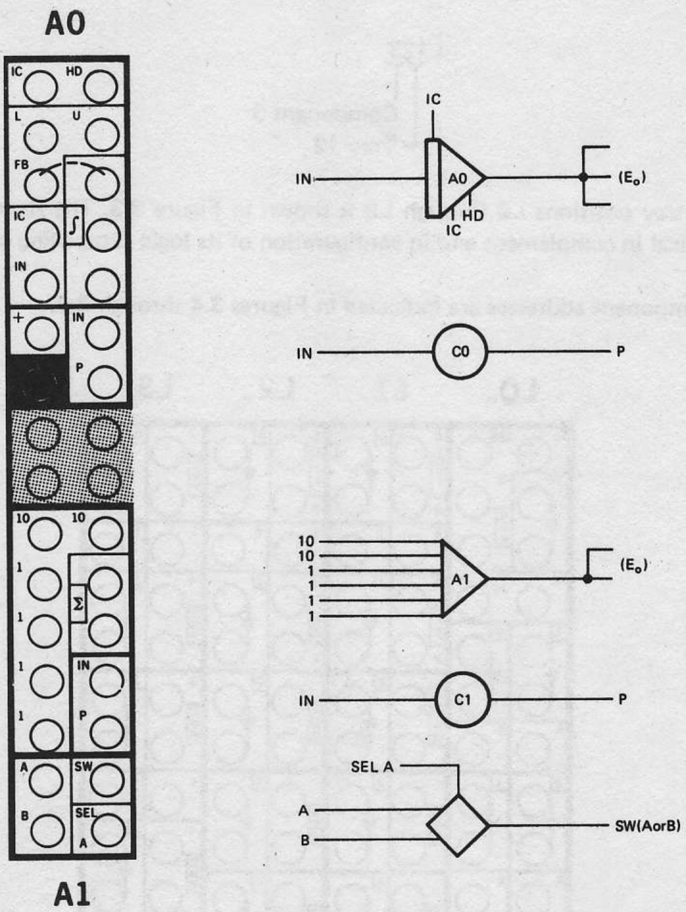


Figure 3.2 Example of Analog Tray Addresses at the Program Panel

The elements in the top half (AØ) are addressed AØ and CØ, while those in the bottom half (A1) are addressed A1, C1 and SW1.

As illustrated in Figure 3.1, components in the first component row are numbered Ø to 7, 1Ø to 17, 2Ø to 27 and 3Ø to 37. The address of a component in the second component row is 4Ø greater than that of the corresponding component in the first row. In the third component row, component addresses are 1ØØ greater than those in the top. This numbering scheme is based on the octal (base 8) numbering system. This same numbering scheme is used for reading the outputs of the various components, using the MACS Command Set. Refer to Chapters 9 and 10. Refer to Chapter 8 for MACS Display definitions.

3.3 THE LOGIC FIELDS

There are 12 positions available for logic trays, 4 in each logic field. These positions are identified on the Program Panel by headings with the prefix letter L (for logic) followed by a numerical designation. The numerical designations are based on the octal numbering system, hence the tray designations are Ø, 1, 2, 3, 4, 5, 6, 7, 10, 11, 12, and 13.

The Logic Components within a tray are also given numerical designations. Each tray can have up to 8 unique components (0-7). These designations are labeled in small white boxes within the tray outline. The Program Panel address for a logic component consists of the tray designation followed by the component designation.

L123

Component 3

Tray 12

The logic field containing tray positions LØ through L3 is shown in Figure 3.3. The standard program panel has three logic fields which are identical in complement and in configuration of its logic computing components.

As examples, individual component addresses are indicated in Figures 3.4 through 3.6.

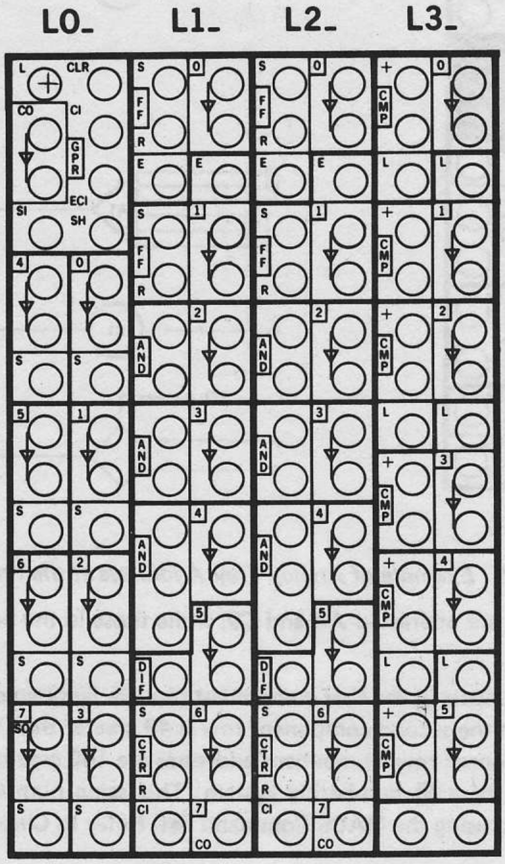
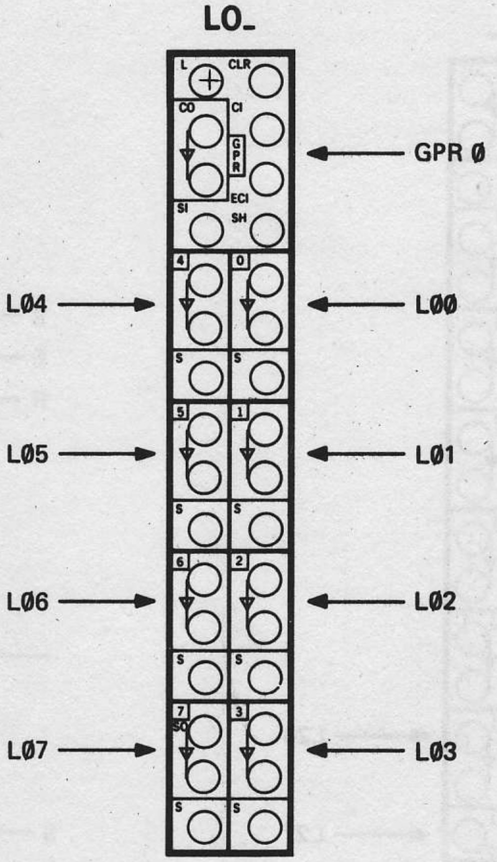


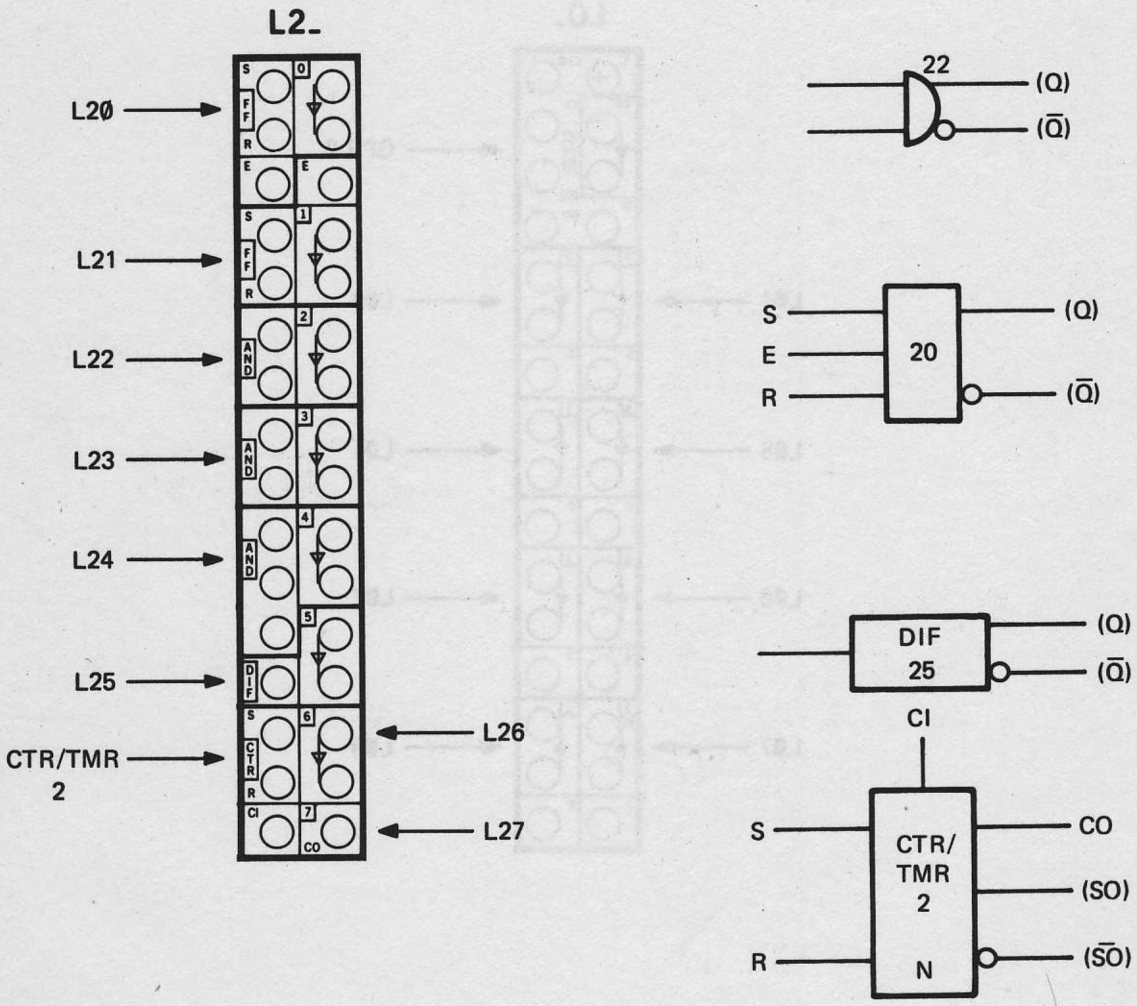
Figure 3.3 The Logic Field Of The First Component Row



NOTE

See Chapter 9, MACS Commands, for instructions on reading the decimal contents of a GPR.

Figure 3.4 General-Purpose Register (GPR) Tray Addresses



NOTE

1) *L1__ and L2__ are identical in the standard program panel configuration.*
2) *See Chapter 9, MACS Commands, for reading the decimal contents of the counter/timer (CTR/TMR)*

Figure 3.5 General-Purpose Logic (GPL) Tray Addresses

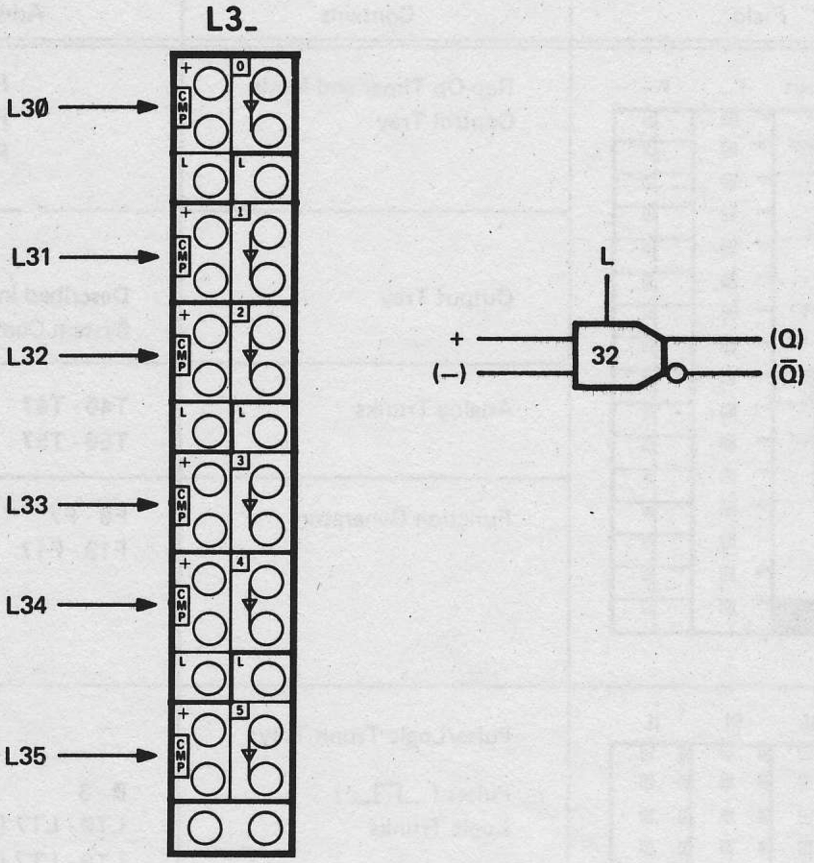


Figure 3.6 Comparator Tray Addresses

3.4 SPECIAL PURPOSE FIELDS

Each Special Purpose Field (first, second and third rows) has a different configuration. Table 3.2 illustrates and describes the addressing scheme for the Special Purpose Fields.

Table 3.2 Special Purpose Fields (Identification and Addressing)

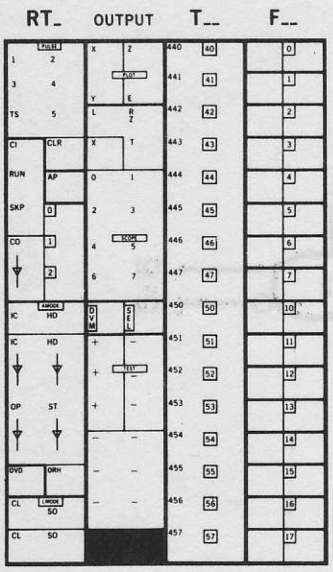
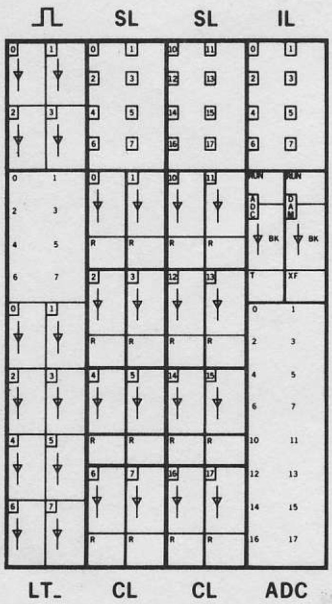
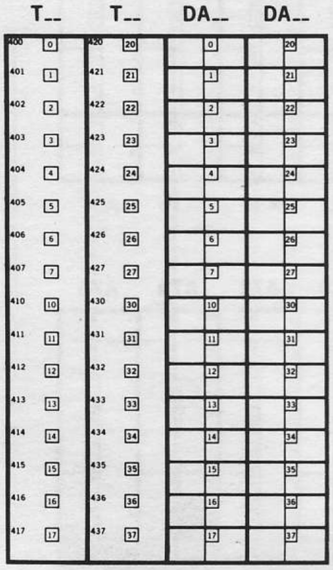
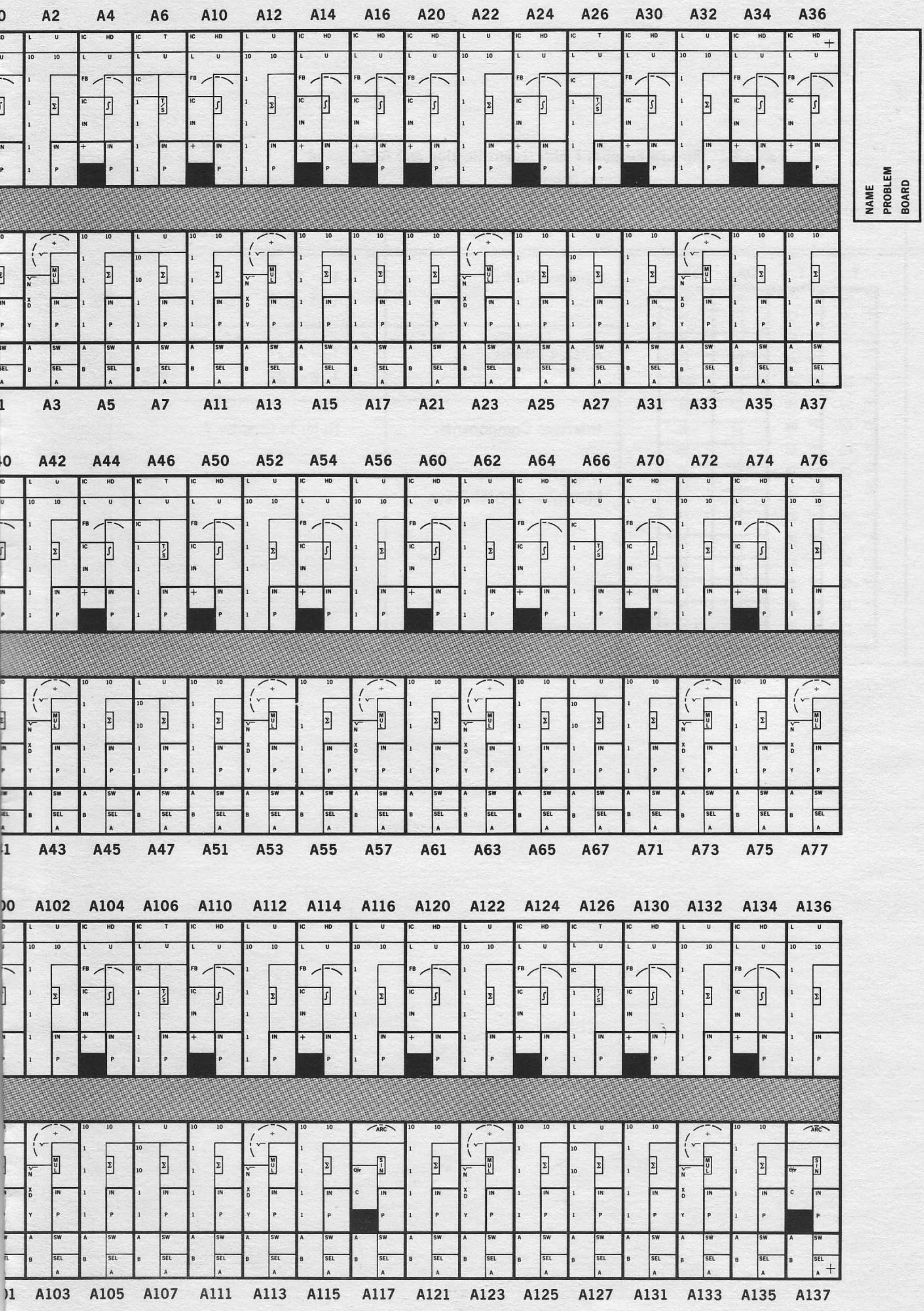
Row	Field	Contains	Addressing
1.		Rep-Op Timer and Mode Control Tray	RTØ RT1 RT2
		Output Tray	Described in Chapter 6, System Components
		Analog Trunks	T4Ø - T47 T5Ø - T57
		Function Generators	FØ - F7 F1Ø - F17
2.		Pulse/Logic Trunk Tray: Pulses (⎍) Logic Trunks	 Ø - 3 LTØ - LT7 (In) LTØ - LT7 (Out)
		Interface Components: Sense Line/Control Line Trays (SL/CL) Interrupt Line/ADC Tray (IL/ADC)	Refer to Chapter 7

Table 3.2 **Special Purpose Fields (Identification and Addressing) (Cont'd)**

Row	Field	Contains	Addressing
3.		Analog Trunks	TØ - T7 T1Ø - T17
		Analog Trunks	T2Ø - T27 T3Ø - T37
		Interface Components: Digital to Analog Multiplier (DAM) Trays	Refer to Chapter 7

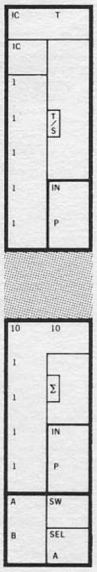

A2 A4 A6 A10 A12 A14 A16 A20 A22 A24 A26 A30 A32 A34 A36
A3 A5 A7 A11 A13 A15 A17 A21 A23 A25 A27 A31 A33 A35 A37
A42 A44 A46 A50 A52 A54 A56 A60 A62 A64 A66 A70 A72 A74 A76
A43 A45 A47 A51 A53 A55 A57 A61 A63 A65 A67 A71 A73 A75 A77
A102 A104 A106 A110 A112 A114 A116 A120 A122 A124 A126 A130 A132 A134 A136
A103 A105 A107 A111 A113 A115 A117 A121 A123 A125 A127 A131 A133 A135 A137
NAME
PROBLEM
BOARD

NOTE

The Standard Program Panel has recently been changed (as illustrated) to accomodate Track-Store/Summer Trays with Optional Limiters, and to eliminate two Dual Log Units which have been discontinued. Two Summer/Sine Units were also eliminated. These changes have increased the standard Integrator/Summer Complement by two and the standard Summer/Multiplier Complement by two. The following information is provided to define the earlier Program Panel Configuration.

1. Track-Store/Summer (T-S/Σ) without Limiter option (Model Number 0.72.0049). See Chapter 4, paragraphs 4.3 and 4.8 for description. This configuration formerly occupied locations:

   Row 1 = A6/A7, A26/A27
   Row 2 = A46/A47, A66/A67
   Row 3 = A106/A107, A126/A127



2. Summer/Sine (Σ/SIN) Units formerly occupied the following locations:

   Row 1 = A16/A17, A36, A37
   Row 2 = A56/A57
   Row 3 = A116/A117, A136, A137

3. Dual Log Units (LN/LN) would have occupied the following locations:

   Row 2 = A56/A57 and A76/A77

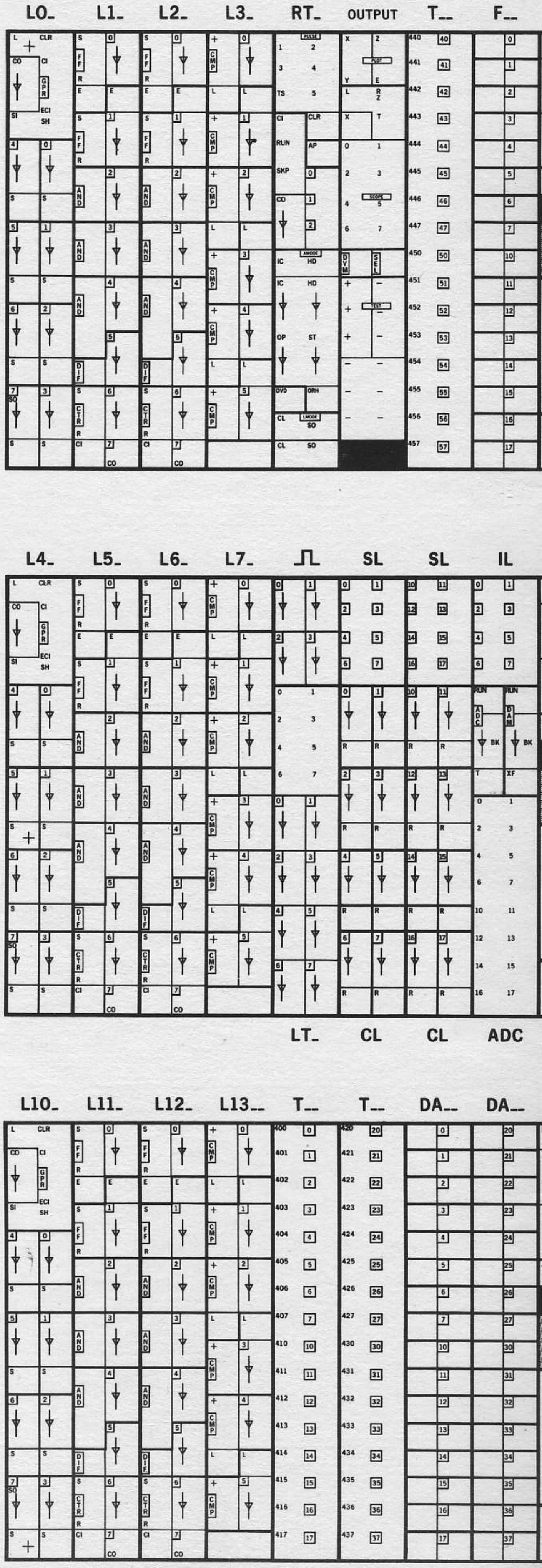


Figure 3.7 Program Panel Layout

Electronic Associates, Inc.

STANDARD TYPES OF EAI 2000 TRAYS

ANALOG TRAY TYPES

AT1 = Integrator & Summer Tray
AT2 = Multiplier & Summer Tray
AT3 = Track/Store & Summer Tray
AT4 = SIN/COS & Summer Tray
AT5 = Test Tray

NOTE: *Any mixture of analog trays up to 48 total.*

LOGIC TRAY TYPES

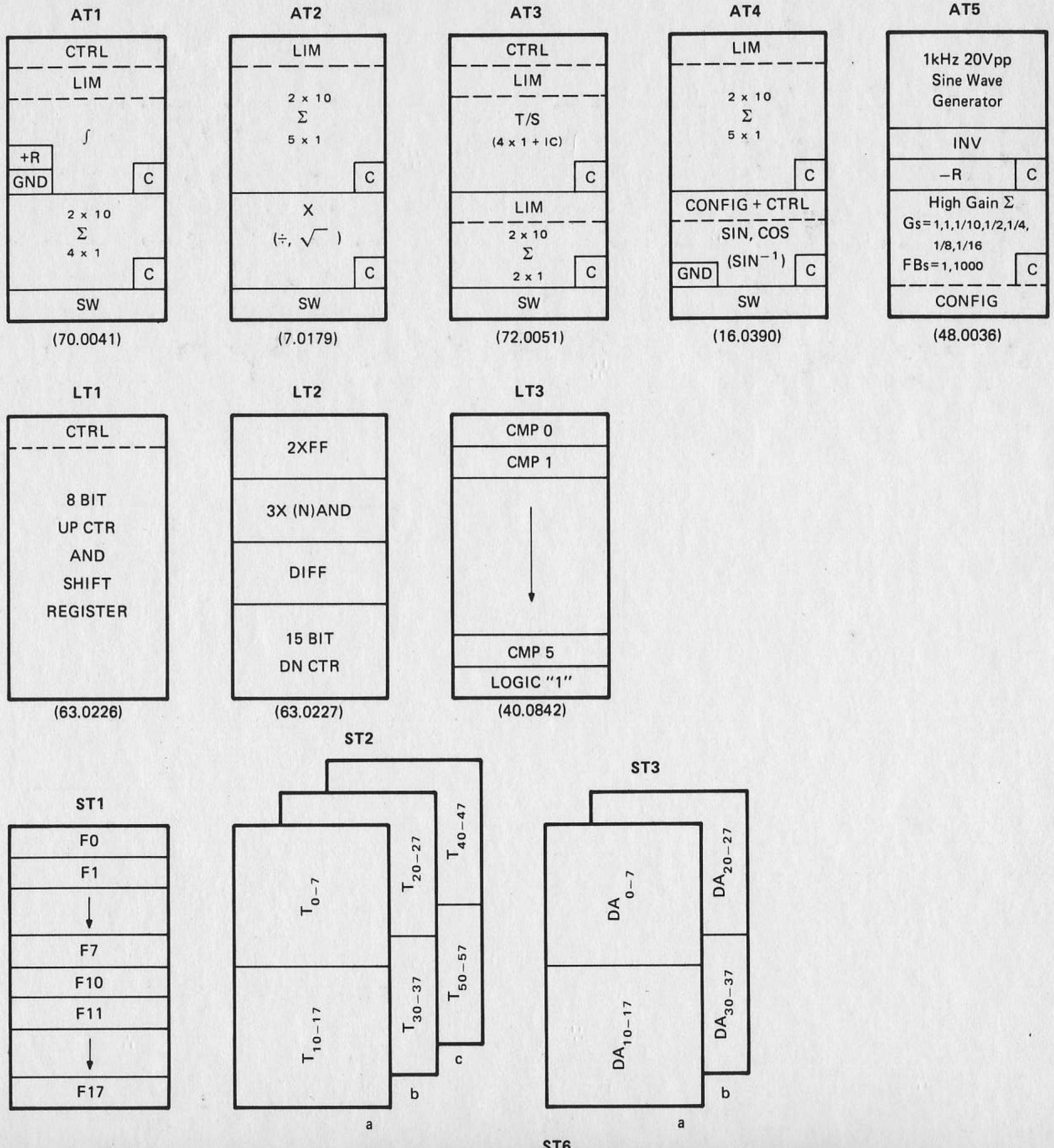
LT1 = GPR Tray
LT2 = GPL Tray
LT3 = CMP Tray

NOTE: *Any mixture of logic trays up to 12 total.*

SYSTEM TRAY TYPES

ST1 = Function Generator Tray
ST2 = Analog Trunk Tray
ST3 = DAM Tray

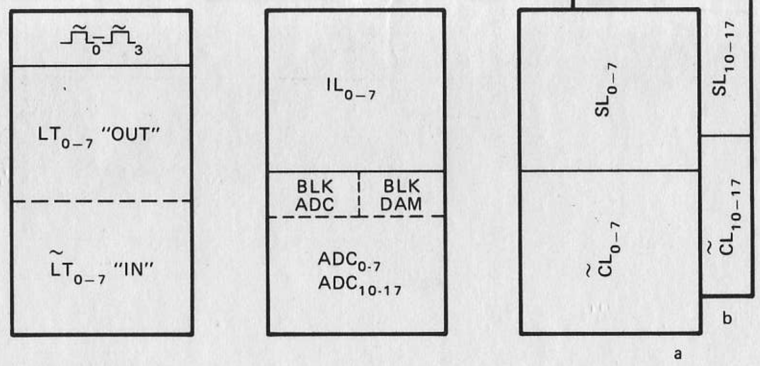
NOTE:
- Terminations for 16 FGs max in ST1
- Terminations for 16 DAMs in ST3
- ST2c in first row
- ST2a and b in third row
- ST3a and b in third row
- 16 optionally readable analog trunks and 16 non-readable analog trunks per one ST2 tray (one rear panel connector for each set of 16 trunks)



ST4 = BLIPS + Logic Trunks Tray

ST5 = Interrupt Lines + ADC Tray

ST6 = Sense and Control Lines Tray

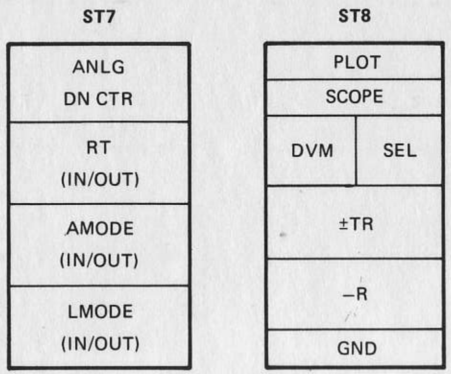


NOTE:
- *ST4, 5 and 6 in second row*
- *CLs have individual reset holes*
- *Buffered Logic Trunks (one rear panel connector for both "IN" and "OUT" trunks)*

ST7 = RT Tray

ST8 = Output Tray

NOTE: *ST7 and 8 come with the basic console*



LEGEND:

AT – Analog Tray
BLK – Block
C – Coefficient
CMP – Comparator (Differential)
CONFIG – Configuration Patching
CTR – Counter
CTRL – Control Inputs
DAM – Digital-to-Analog Multiplier
DIFF – Logic Differentiator
DN – Down
FBs – Feedback
FF – Flip-Flop
GPL – General Purpose Logic
GPR – General Purpose Register
Gs – Input Gains

IC – Initial Cond. Input
∫ – Integrator
INV – Inverter
LIM – Limiter (Dedicated)
LT – Logic Tray
(N) AND – AND/NAND Gate
R – Reference
RT – Rep-Op Timer
ST – System Tray
SW – Switch
TR – Test Reference
T/S – Track/Store Summer
$\tilde{X}$ – X and $\overline{X}$ available
$\overset{n \times 10}{\underset{m \times 1}{\Sigma}}$ – Summer with "m" gains of 1 and "n" gains of 10

	LOGIC	SYSTEM	ANALOG	
	4	4	16	1st Row
	4	4	16	2nd Row
	4	4	16	3rd Row
Total:	12 LTs	12 STs	48 ATs	

Rev. 1.1 – 9/7/78
Z.V.Ilic'

Figure 3.8 Standard Tray Types

CHAPTER 4

CHAPTER 4

ANALOG COMPUTING COMPONENTS

4.1 SCOPE OF CHAPTER

4.1.1 GENERAL

Each and every type of analog computing component available for the EAI 2000 is individually described in this chapter. The descriptions are from standpoints of functional operation; application; and as applicable, mode control commands.

4.1.2 FORMAT

For quick reference, each type of component is described in a separate and distinct main paragraph. Numbered subparagraphs are not used. Instead all component descriptions are formatted with a definition set of headings that are essentially the same for each component and appear in the same sequence. If a heading does not apply to a given component, the heading is simply ommitted.

The following description defines the format used throughout this chapter for describing individual components.

Format Description

4.n COMPONENT NAME

Main paragraph heading naming the component.

FUNCTION:

Defines basic function of the subject component.

OPTIONS: Wahlfunktionen

As applicable, defines the options associated with the component such as the availability of an optional limiter.

DESIGNATIONS: Bezeichnungen

Defines the program panel identification marks and/or other commonly used identifiers for the subject component.

PROGRAM SYMBOLS:

Illustrates and defines the basic program symbols associated with the subject component.

CHARACTERISTICS:

As applicable, illustrates unique characteristics associated with the subject component.

PROGRAM PANEL:

Illustrates and defines the program panel terminations, and provides basic patching information for the subject component.

TYPICAL COMMANDS:

As applicable, provides general examples of typical MACS Commands pertaining to the operation of the component.

XX CONTROLS:

As applicable, defines the various controls associated with the device, such as Integrator Mode and Time Scale.

APPLICATION NOTES:

These notes (listed in ascending numerical order) illustrate and define the basic applications, special features and constraints associated with the subject component.

4.1.3 FLAGS

As another means of quick reference, the upper corner (near the outer edge) of each page contains a flag (or flags) identifying the component type(s) described on that page. The following flags are used:

Coefficient Device	=	COEFF
Summer	=	SUM
Integrator	=	INT
Multiplier	=	MULT
Divider	=	DIV
Square Root Generator	=	SQ RT
Track/Store Unit	=	T/S
Selector Switch	=	SW
Sine Generator	=	SIN
Cosine Generator	=	COS
Arcsine Generator	=	ARC
Digitally Set Function Generator	=	FG
Limiter	=	LIM

4.2 COEFFICIENT UNIT

FUNCTION:

Continuous multiplication of an analog variable times a constant coefficient.

DESIGNATIONS:

DCA – Digitally Controlled Attenuator or Digitally Set Coefficient Unit
POT – Manually Set Coefficient Unit

SYMBOL:

As shown in Figure 4.1

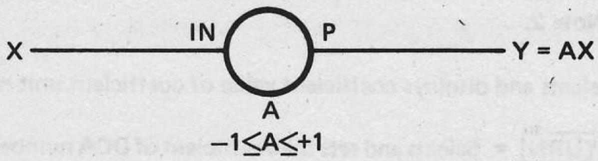


Figure 4.1 Coefficient Unit: Typical Programming Symbol

PROGRAM PANEL:

Coefficient Units are terminated in analog trays; each tray can terminate two Coefficient Units.

Digitally Set Coefficient Units can be terminated in any tray position. Manually Set Coefficient Units are restricted to trays in the first (top) row.

The Program Panel terminations are identical for both units; typical terminations are indicated in Figure 4.2.

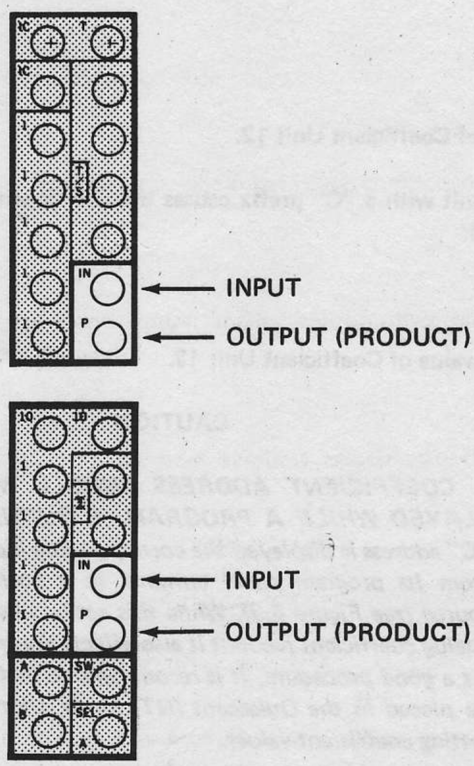


Figure 4.2 Coefficient Unit: Program Panel Terminations

TYPICAL COMMANDS:

MACS Commands are fully described in Chapters 9 and 10. The following illustrates some typical commands associated with DCA's. Refer to the Application Notes (as specified) for additional information and specific examples.

[P] [x] [RETURN] = Selects and displays output (product) value of coefficient unit number x. See Application Note 2.

[C] [x] [RETURN] = Selects and displays coefficient value of coefficient unit number x. See Application Note 3.

[C] [x] [=] [·] [n] [RETURN] = Selects and sets the coefficient of DCA number x to the value · n. See Application Notes 4 and 5.

[C] [x] [>] = Increments (slews) DCA number x one step. See Application Notes 6 and 7.

[C] [x] [<] = Decrements (slews) DCA number x one step. See Application Notes 6 and 7.

APPLICATION NOTES:

1. The Coefficient Unit is a two terminal device. An analog variable is patched into the input terminal (IN); the product of the input times a preset coefficient is obtained at the output terminal (P). The coefficient can be set, with a 4 decimal place precision, to a value within the interval −1.0 to +1.0.

2. Addressing a Coefficient Unit with a "P" prefix causes the product value to be displayed on the MACS screen. For example, the command:

   [P] [1] [2] [RETURN]

   displays the product value of Coefficient Unit 12.

3. Addressing a Coefficient Unit with a "C" prefix causes the coefficient value to be displayed on the MACS screen. For example, the command:

   [C] [1] [2] [RETURN]

   will display the coefficient value of Coefficient Unit 12.

CAUTION

A COEFFICIENT ADDRESS SHOULD NOT BE DISPLAYED WHILE A PROGRAM IS RUNNING. When a "C" address is displayed the corresponding input is switched from its program panel terminal to a positive reference source (see Figure 4.3). While this action yields the desired analog coefficient readout it also affects the product output. As a good procedure, it is recommended that the processor be placed in the Quiescent (QT) Mode prior to reading or setting coefficient values.

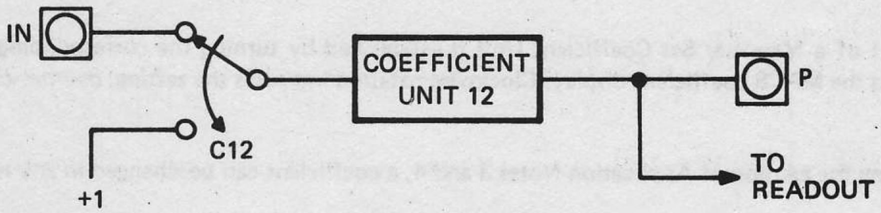


Figure 4.3 Coefficient Setting Scheme

4. **The coefficient value of a Digitally Set Coefficient Unit is established by command from MACS. For example, the command:**

   [C] [5] [6] [=] [·] [7] [5] [3] [1] [RETURN] (C56 = .7531)

   sets the coefficient of Coefficient Unit 56 to the value 0.7531.

   If the Coefficient Unit to be set is already displayed, the address may be omitted:

   [=] [·] [7] [5] [3] [1] [RETURN] (= .7531)

   In specifying the coefficient value, the following conventions should be observed:

   - **A positive sign (+) is optional; unsigned values are assumed positive.**
   - **Insignificant zeroes are optional.**
   - **A decimal point is always required.**

   Several example commands are indicated below:

   [C] [5] [7] [=] [–] [·] [9] [1] [2] [RETURN]
   [C] [7] [0] [=] [+] [·] [8] [7] [RETURN]
   [C] [7] [1] [=] [1] [·] [RETURN]
   [C] [7] [2] [=] [–] [1] [·] [RETURN]
   [C] [7] [3] [=] [0] [·] [RETURN]

CAUTION

DCA 1000 THRU 137 CANNOT BE LOADED DURING THE INTERVAL WHEN A DAM TRANSFER IS PENDING. This interval will occur only in the Hybrid environment when the DAM's have been loaded through the SPI but not yet transferred. An attempt to load these DCA's during this interval will result in the "SPI CONFLICT" error message being displayed on the MACS. Refer to MACS Error Messages, Table 8.2.

5. The coefficient of a Manually Set Coefficient Unit is established by turning the corresponding adjustment knob while observing the MACS coefficient display. Clockwise rotation increases the setting; counter-clockwise decreases the setting.

6. Notwithstanding the caution of Application Notes 3 and 4, a coefficient can be changed in any mode.

   In fact, the ability to modify parameters during problem execution constitutes one of the major benefits of analog processing. This is particularly true when the program is being run in high speed repetitive operation with one or more problem variables being graphically displayed. Typically, a user will alter a coefficient value while observing its qualitative effects on a variable. Once a particular phenomenon has been observed (such as; maximum overshoot, minimum miss distance, etc.) the processor can be placed in the Quiescent (QT) mode and then, the corresponding coefficient value can be displayed.

   A Digitally Set Coefficient can be changed, without displaying its "C" address, by using the step command as described in note 7. A Manually Set Coefficient is changed simply by turning its adjustment knob.

7. The coefficient of a Digitally Set Coefficient Unit can be incremented or decremented in steps by command from MACS. The basic step size is 2^{-7} ($\approx$.008); multiples of the basic step can also be commanded.

   For example, the command:

   [C] [7] [0] [>]

   will increment the coefficient of Coefficient Unit 70 by one step.

   Similarly, the command:

   [C] [7] [0] [<] [<]

   will decrement that coefficient by two steps.

   However, if the Coefficient Unit to be stepped is already displayed (by a previous select command) the address may be omitted. For example, the command:

   [>] [>]

   will increment the displayed coefficient by two steps.

   After entering a coefficient step command, as indicated above, the command can be re-executed simply by typing a Carriage Return command:

   [RETURN]

   This action can be repeated as long as the original command remains in the input buffer. Further, the command can be repetitively executed by depressing both the [RETURN] and [REPEAT] keys.

4.3 SUMMER

FUNCTION:

Continuous summation of several analog variables.

OPTIONS:

As an optional feature, the 4-input and the 7-input Summer can be equipped with a variable limiter. The limiter is described in Paragraph 4.14. Note that earlier versions of the EAI 2000 are not equipped with a 4-input Summer and its optional Limiter.

DESIGNATIONS:

SUM, Σ

SYMBOL:

As shown in Figure 4.4

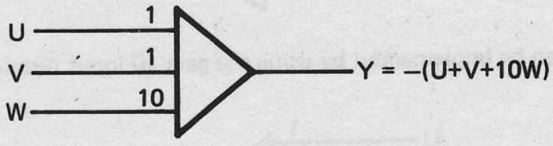


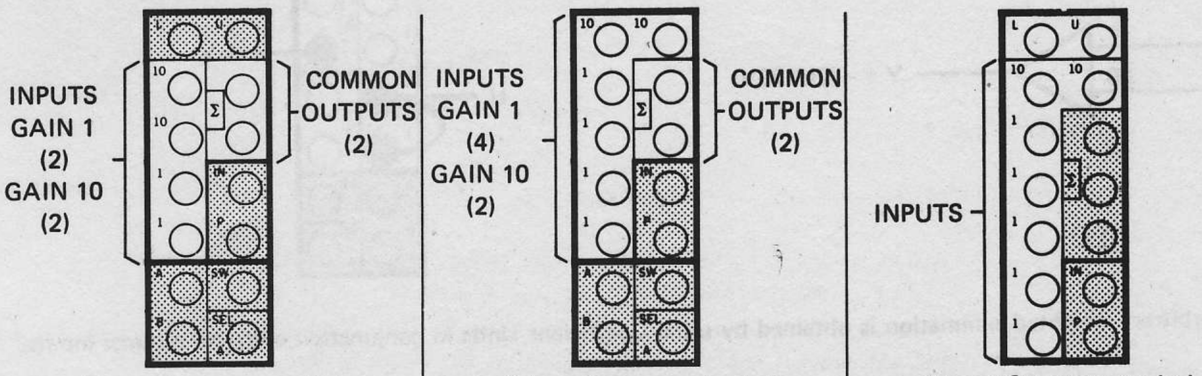
Figure 4.4 Summer: Typical Programming Symbol

PROGRAM PANEL:

Later versions of the TS/Σ Tray (Model No. 0.72.0051) contain a four input Summer as shown in Figure 4.5a.

A six input Summer (Figure 4.5b) is included in the ∫/Σ tray and in earlier versions (Model No. 0.72.0049) of the TS/Σ tray.

Seven input Summers (Figure 4.5c) are included in the MUL/Σ and SINE/Σ trays.



a. 4-input Summer: typical for later versions of TS/Σ

b. 6-input Summer: typical for ∫/Σ and earlier versions of TS/Σ

c. 7-input Summer: typical for MULT/Σ and SIN/Σ

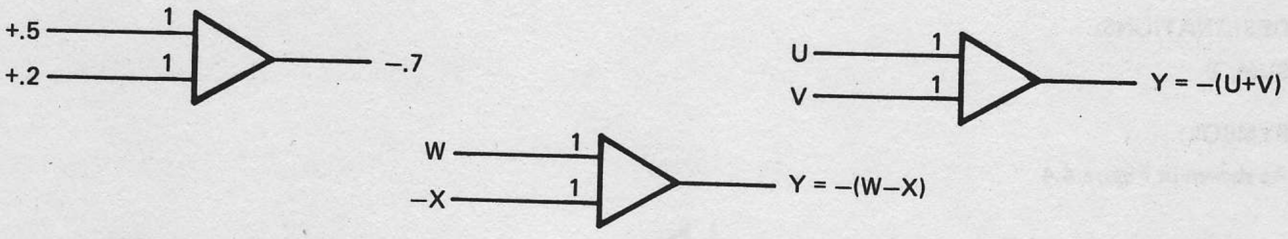
Figure 4.5 Summer: Program Panel Terminations

TYPICAL COMMANDS:

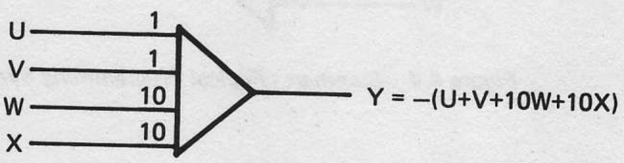
[A] [x] [RETURN] = Selects Summer number x for display. x is an even address for summers in Σ/MUL trays and Σ/SIN trays. x is an odd address for summers in $\int/\Sigma$ and TS/Σ trays.

APPLICATION NOTES:

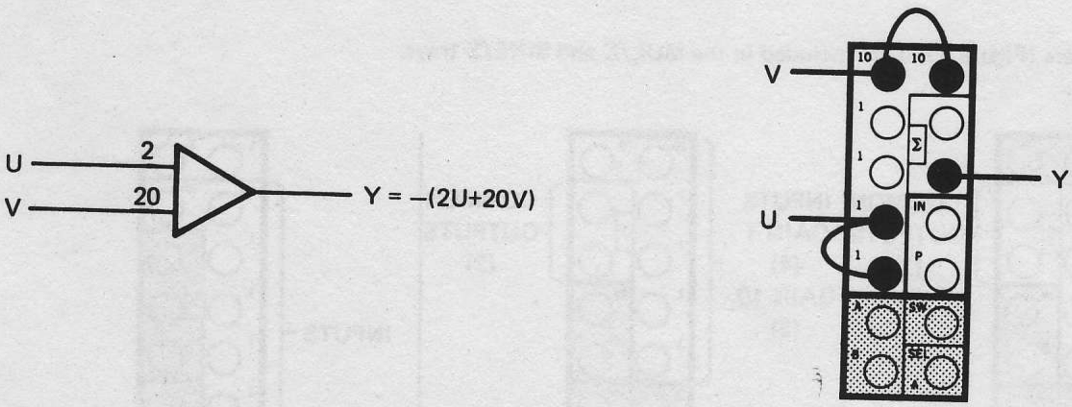
1. An unpatched input is equivalent to a constant zero; patching to ground is not required.
2. The Summer inverts; the output is the negative sum of the inputs.



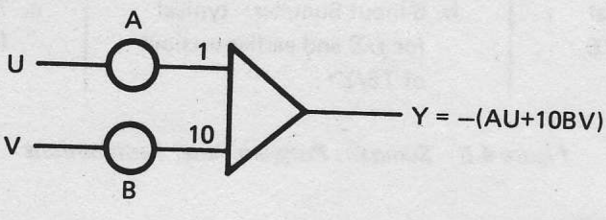
3. A weighted summation can be implemented by using the gain 10 input terminals.



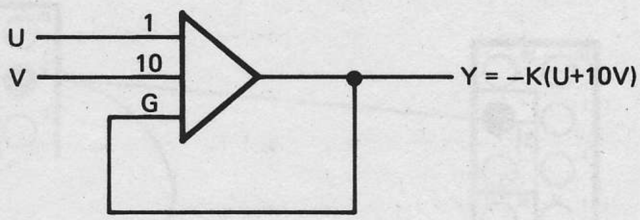
4. Input gains are additive; paralleling several inputs results in an effective gain equal to the sum of the individual gains.



5. An arbitrary weighted summation is obtained by using Coefficient Units in conjunction with the summer inputs.



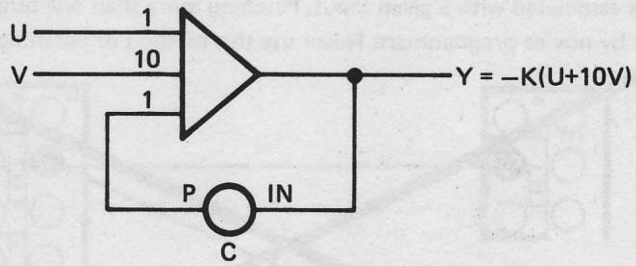
6. A common factor, multiplying the overall summation, can be achieved by using a local feedback connection.



Where: $K = \frac{1}{1+G}$

and G is any value that can be obtained with a single gain (1,10) or a parallel combination of gains (2, 20, etc.).

7. The common factor scheme of example 6 can be extended by including a coefficient unit in the feedback path.



Where: $K = \frac{1}{1+C}$

alternately, the coefficient C can be expressed as

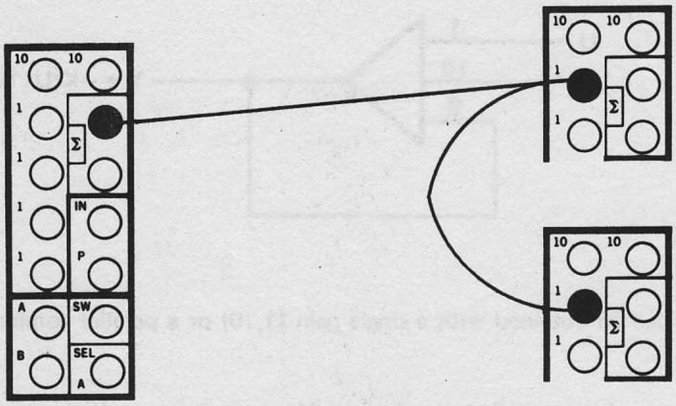
$$C = -\frac{K-1}{K}.$$

The following table indicates commonly used values:

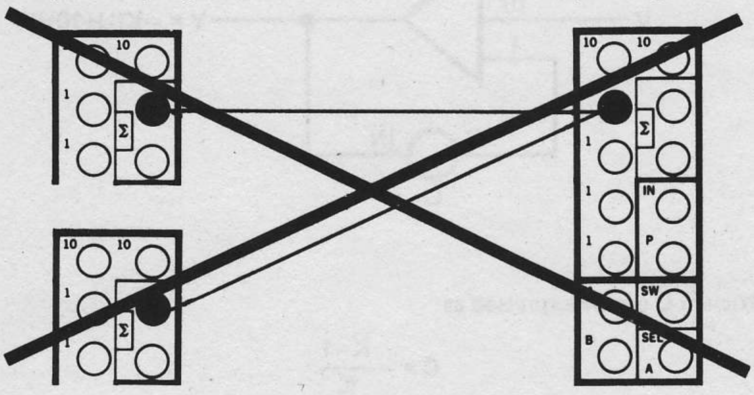
K	C
.5	1.
1	0.
2	–.50
4	–.75
5	–.80
10	–.90

This scheme should not be used with a feedback amplifier gain greater than unity. If the product of the amplifier gain times the coefficient (in the feedback path) is greater than unity, the combination may be unstable in which case the summer output will exhibit high frequency oscillations. Actually, values in excess of 3 have been tested successfully. However, to avoid the possibility of an error, the unity gain restriction is recommended.

8. Using the stackable patch cords, it is often convenient to "daisy chain" a single output to several different inputs. This practice makes it somewhat difficult to debug the program patching but is otherwise correct.



9. Only one output can be associated with a given input. Patching more than one output to a single input is a common mistake made by novice programmers. Never use this method of patching.



4.4 INTEGRATOR

FUNCTION:

Continuous integration, with respect to time, of an analog variable.

OPTIONS:

As an optional feature, the Integrator can be equipped with a variable limiter. The limiter is described in Paragraph 4.14.

SYMBOL:

As shown in Figure 4.6.

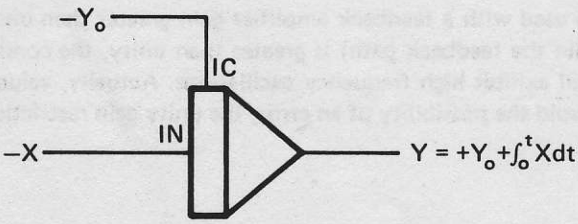


Figure 4.6 Integrator: Typical Programming Symbol

PROGRAM PANEL:

An Integrator, as shown in Figure 4.7, is included in the ∫/Σ tray.

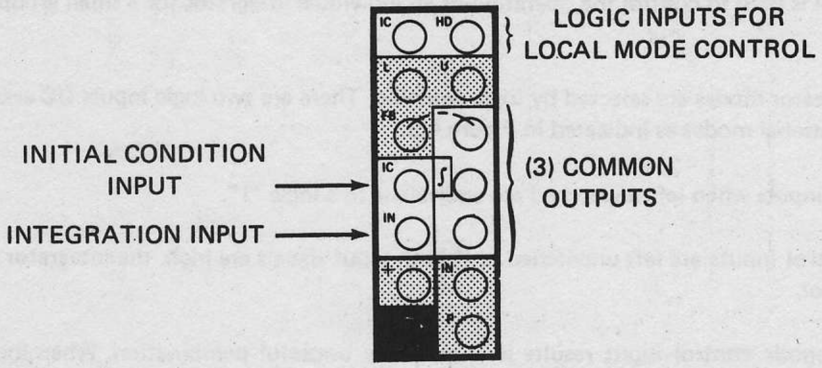


Figure 4.7 Integrator: Program Panel Terminations

TYPICAL COMMANDS:

MACS Commands are fully described in Chapters 9 and 10. The following examples illustrate typical commands pertinent to the operation of a given Integrator. For these examples, it is assumed that A1Ø is a valid integrator address.

COMMAND	FUNCTION
[A] [1] [Ø] [RETURN]	Display output
[D] [1] [Ø] [RETURN]	Display Derivative (Input)
[I] [1] [Ø] [RETURN]	Display Local Time Scale and Integrator output
[I] [1] [Ø] [=] [E] [2] [RETURN]	Select Absolute Local Time Scale of 10^2 (100)
[I] [1] [Ø] [=] [E] [+] [2] [RETURN]	Select Relative Local Time Scale of 10^2 (100) RTS = MTS x 10^2
[I] [1] [Ø] [=] [E] [–] [2] [RETURN]	Select Relative Local Time Scale 10^{-2} (.01) RTS = MTS x 10^{-2}
[I] [1] [Ø] [=] [E] [+] [Ø] [RETURN]	Select Relative Local Time Scale 10^0 (1) RTS = MTS

MODE CONTROL:

The Integrator has three modes of operation:

- IC Initial Condition
- OP Operate
- HD Hold

In the IC mode: the starting value of (Y_0) of the Integrator is established.

In the OP mode: integration proceeds with respect to time.

In the HD mode: the process of integration is suspended and the Integrator output is held constant.

These integrator control modes can be selected at a Master level or at a Local level.

Master level mode control, as described in Chapter 9, is typically used to control the overall operation of a program.

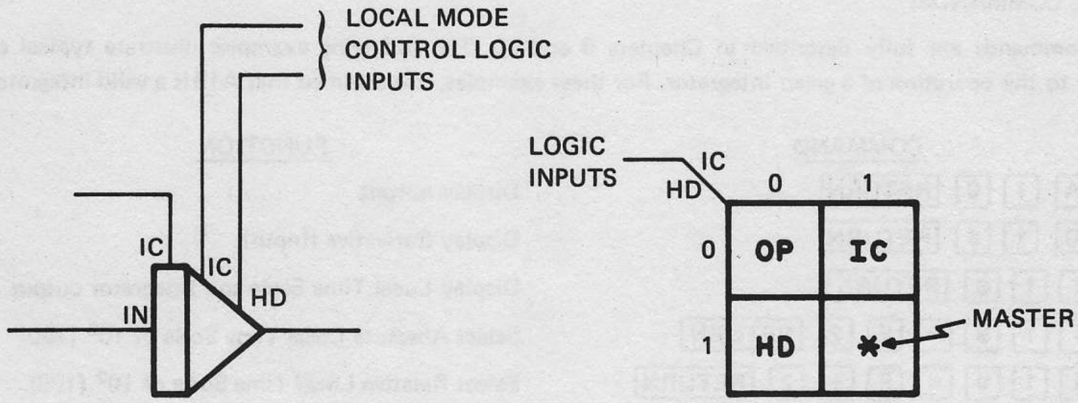
Local level mode control is used to control the operation of an individual integrator (or a small group of integrators) for specialized applications.

At the local level, integrator modes are selected by logic patching. There are two logic inputs (IC and HD) that are used to select the three operational modes as indicated in Figure 4.8.

The local mode control inputs when left unpatched are equivalent to a logic "1".

If both local mode control inputs are left unpatched or if both input signals are high, the integrator will respond to the Master level mode control.

Patching only a single mode control input results in a generally unuseful combination. When local mode control is required, both inputs must be patched with appropriate logic signals.



a. Symbol *b. Local Mode Control Logic*

Figure 4.8 Programming Symbol: Integrator With Local Mode Control

TIME SCALE CONTROL:

The INTEGRATOR has six time scales ranging by decades from 1 through 100,000.

Time Scales can be selected at a Master level or at a local level. Both the Master level and the local level Time Scale selection are accomplished by command from MACS.

Master level Time Scale selection, as described in Chapter 9, is typically used to control the overall solution speed.

Local level Time Scale selection is used to control the speed of an individual integrator (or a small group of integrators) for specialized applications.

At the local level, the Time Scale of an Integrator can be selected on a Relative basis or on an Absolute basis.

Relative Time Scale selection implies that the time scale for an individual integrator is proportional to the Master Time Scale. Individual Integrator Time Scale (or gain factor) is equal to the Selected Relative Time Scale multiplied by the Selected Master Time Scale.

Absolute Time Scale selection implies that the time scale for an individual integrator is fixed and independent of the Master Time Scale.

An exponential notation is used to simplify the time scale command entry. The notations and entries used for absolute time scales are shown in Table 4.1; relative time scales are shown in Table 4.2.

Table 4.1 Notations and Values for Absolute Time Scales

Exponential Notation	Time Scale Value (Gain)
EØ	1
E1	10
E2	100
E3	1,000
E4	10,000
E5	100,000

Table 4.2 Notations and Values for Relative Time Scales

Exponential Notation	Time Scale Value (Gain) RTS = MTS x E $\pm^{N}$
E + 0	RTS = MTS x 1
E + 1	RTS = MTS x 10
E + 2	RTS = MTS x 100
E + 3	RTS = MTS x 1,000
E + 4	RTS = MTS x 10,000
E + 5	RTS = MTS x 100,000
E –0	RTS = MTS x 1
E – 1	RTS = MTS x .1
E – 2	RTS = MTS x .01
E – 3	RTS = MTS x .001
E – 4	RTS = MTS x .0001
E – 5	RTS = MTS x .00001
RTS = Relative Time Scale MTS = Master Time Scale	

APPLICATION NOTES:

1. The Integrator inverts; this applies to both the IN and the IC analog input paths. See Figure 4.6.

2. An unpatched IC analog input is equivalent to a constant zero.

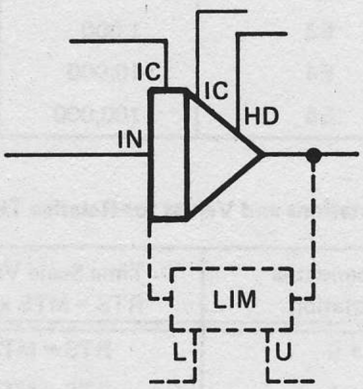
3. When drawing the programming symbol for an integrator, the terminal labels are sometimes omitted. By convention:

   a. The input to be integrated is drawn on the long side of the rectangle.

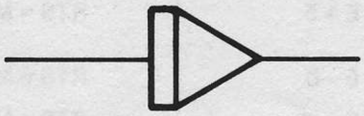
   b. The IC analog input is drawn on the short side of the rectangle.

   c. The local level mode control inputs (when used) are drawn on the sloping edge of the triangle. The IC logic input is assumed to be closest to the IC analog input.

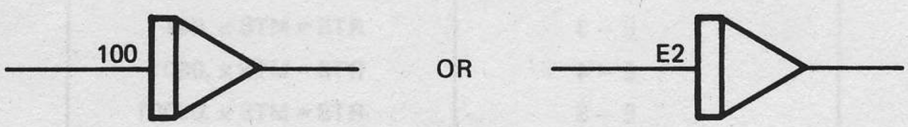
   d. The Integrator can be equipped with an optional Limiter. See Paragraph 4.14 for Integrator Limiter applications.



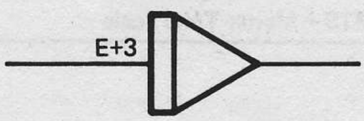
4. When drawing the programming symbol for an integrator, the time scale is indicated on the analog IN path. The omission of a value indicates that the integrator is under direct master control (E+0). Absolute time scales can be indicated with positional or exponential notation. Relative values (other than E+0) are always indicated with exponential notation.



MASTER TIME SCALE



ABSOLUTE TIME SCALE



RELATIVE TIME SCALE

5. When using the relative time scales, the following points should be noted:
   a. The Integrator has only 6 independent time scales.
   b. The local time scale is equal to the product of the Master Time Scale multiplied by the selected relative factor.
   c. The resulting local time scale must lie within the range from 1 through 100,000. Values outside this range will produce a Time Scale Error indication.
6. The fastest time scale (E5) is provided for specialized applications; it is not intended for general problem solutions. This time scale can be selected at the local level, but is not available at the Master level.

4.5 MULTIPLIER

FUNCTION:

Continuous multiplication of two analog variables.

DESIGNATIONS:

MUL

SYMBOL:

As shown in Figure 4.9.

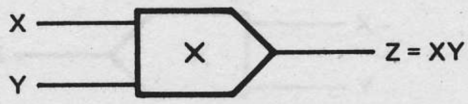


Figure 4.9 Multiplier: Typical Programming Symbol

PROGRAM PANEL:

A MULTIPLIER, as shown in Figure 4.10, is included in the MUL/Σ tray.

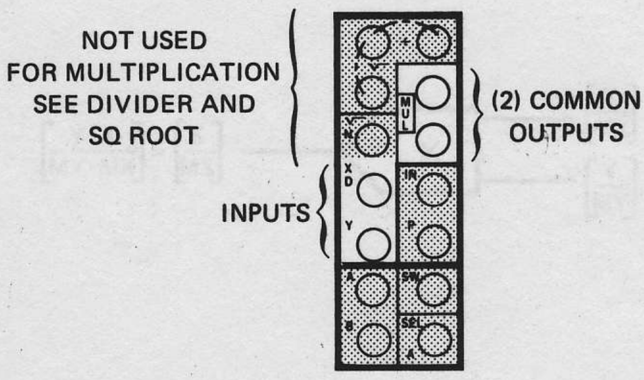
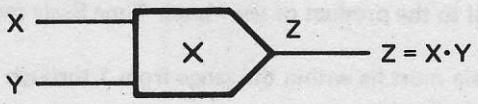
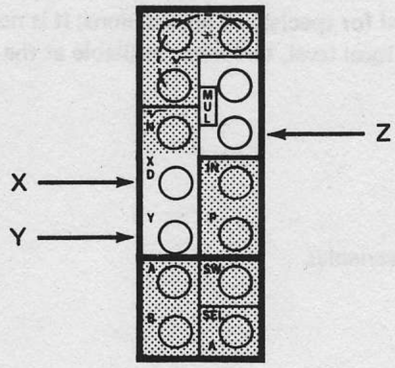


Figure 4.10 Multiplier: Program Panel Terminations

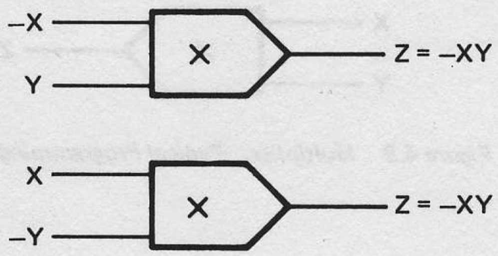
APPLICATION NOTES:

1. **Using a multiplier simply involves patching the desired inputs and outputs. The output is the product of the inputs; there is no sign inversion.**

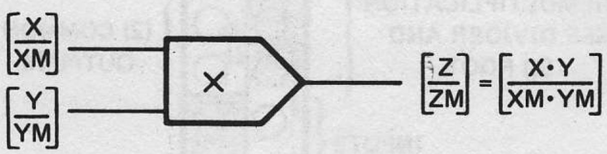




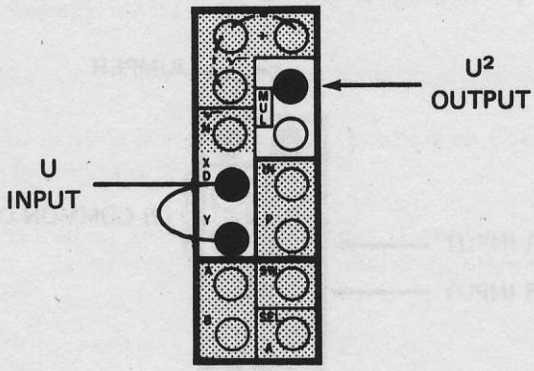
2. **Changing the sign of one input variable will effectively change the sign of the output.**



3. **Amplitude scaling of a multiplier is automatic. The output scale factor is the product of the input scale factors.**



4. **The Multiplier can be used to generate the Square of an analog variable. The variable is simply multiplied by itself.**



The square operation is conventionally indicated by the following simplified programming symbol:

The Digitally Set Function Generator can also be used to generate the square of a function, in the event a multiplier is not available. See paragraph 4.13.

4.6 DIVIDER

FUNCTION:
Continuous division of one analog variable by another analog variable.

DESIGNATION: ÷

SYMBOL:
As shown in Figure 4.11.

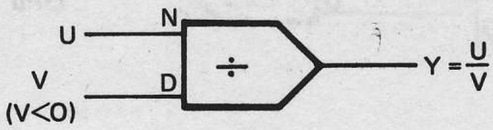


Figure 4.11 Divider: Typical Programming Symbol

PROGRAM PANEL:

The DIVIDER is configured from a Multiplier by inserting a jumper between the two horizontal control terminals as indicated in Figure 4.12.

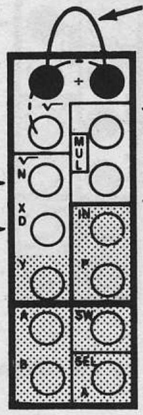


Figure 4.12 Divider: Program Panel Terminations

APPLICATION NOTES:

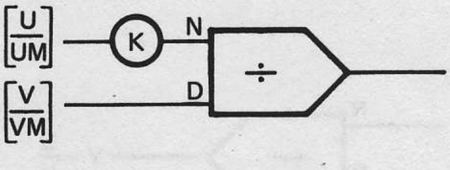
1. The Denominator input value must be negative. Non-negative values will yield an overload error condition. For practical reasons, the following restriction is also recommended; smaller magnitudes will result in an inaccurate Quotient.

$$D \leq -.01$$

2. The Numerator input is unrestricted with regard to sign, it may be positive, negative or zero. However, since the Quotient output must lie within the interval (−1, +1) it follows that:

$$|N| \leq |D|$$

3. To satisfy the scaling requirements specified in Note 2, it is often necessary to attenuate the numerator input.



$$\left[\frac{Y}{YM}\right] = \left[\frac{U/V}{UM/K \cdot VM}\right]$$

Further, with

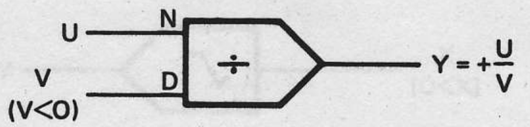
$$VMIN \leq |V| < VM$$

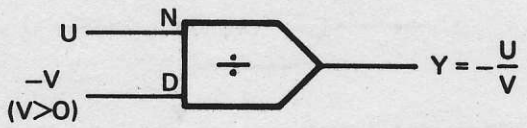
and assuming the extreme case, where a maximum numerator occurs simultaneously with a minimum denominator, we can write

$$YM = \frac{UM}{VMIN}$$

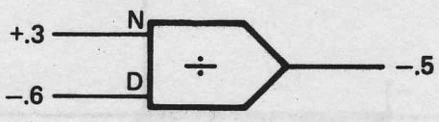
Hence $$K = \frac{VMIN}{VM}$$

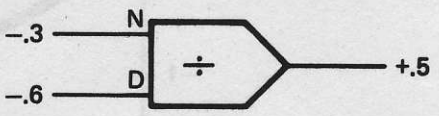
4. The sign associated with the output variable depends on the convention (selected by the user) for the names of the input variables.





5. Regardless of the variable name convention, the output value will always be opposite in sign to the numerator value.





4.7 SQUARE ROOT GENERATOR

FUNCTION:

Generate the Square Root of an analog variable.

DESIGNATION: $\sqrt{\ }$

SYMBOL:

As shown in Figure 4.13.

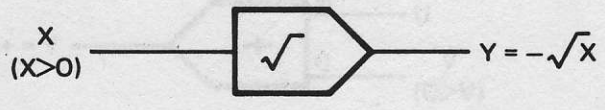


Figure 4.13 Square Root Generator: Programming Symbol

CHARACTERISTIC:

As shown in Figure 4.14.

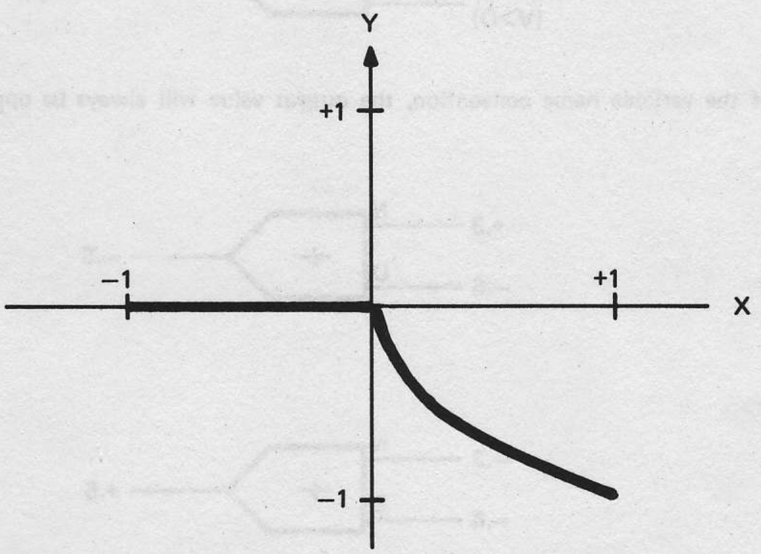


Figure 4.14 Square Root Generator: Input-Output Characteristic

PROGRAM PANEL:

The Square Root Generator is configured from a Multiplier by inserting a jumper between the two vertical control terminals as indicated in Figure 4.15.

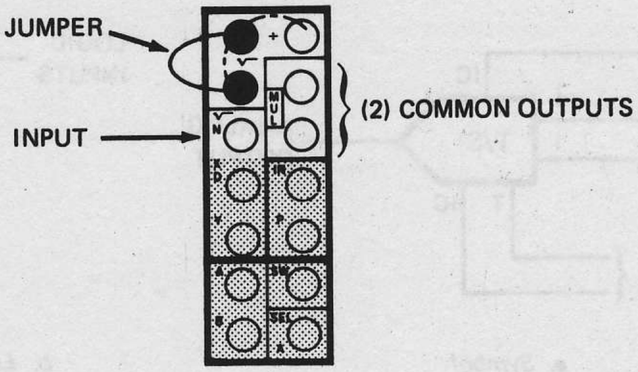


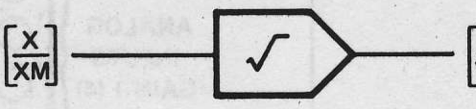
Figure 4.15 Square Root Generator: Program Panel Terminations

APPLICATION NOTES:

1. The input to a Square Root Generator is restricted to positive values. Non-positive input values will yield a zero (or near zero) output.

2. The Square Root Generator inverts; the output is the negative Square Root of the input. See Figures 4.13 and 4.14.

3. Amplitude scaling is automatic; the output scale factor is the square root of the input scale factor.



$$\left[\frac{Y}{YM}\right] = -\sqrt{\frac{X}{XM}}$$

4. A Digitally Set Function Generator can also be used to generate the square root of a function; should a Multiplier not be available. See Paragraph 4.13.

4.8 TRACK-STORE UNIT

FUNCTION:

Store an analog value.

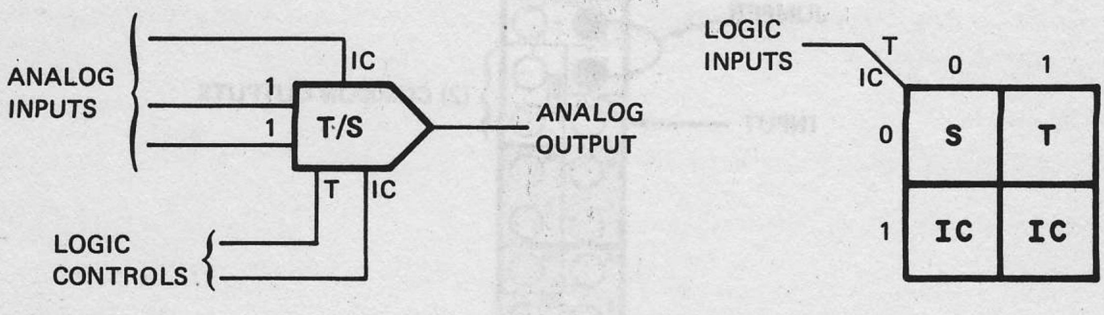
OPTIONS:

As an optional feature, later versions of the TS/Σ tray (Model Number 0.72.0051-1) contain a Limiter that is associated with the Track-Store Unit. The Limiter is described in Paragraph 4.14. The earlier versions (Model Number 0.72.0049) TS/Σ tray does not have this option.

DESIGNATIONS: T/S

SYMBOL:

As shown in Figure 4.16.

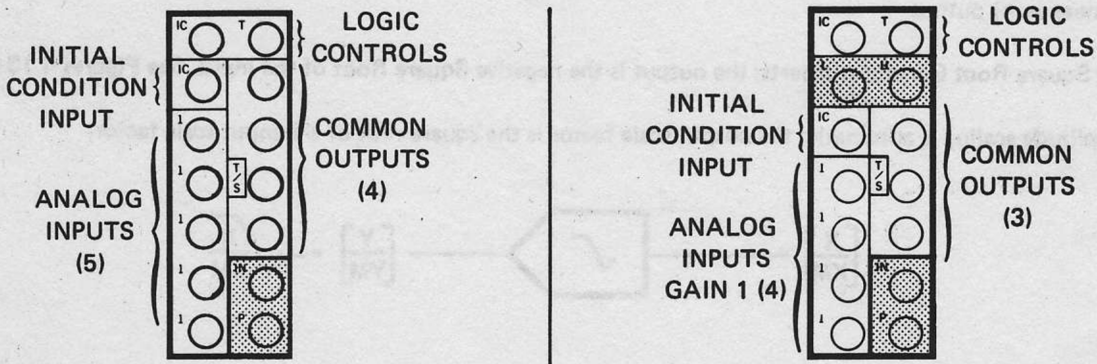


a. Symbol *b. Logic Mode Control*

Figure 4.16 Track-Store Unit: Programming Symbol

PROGRAM PANEL:

A Track-Store Unit, as shown in Figure 4.17, is included in the TS/Σ tray.



a. Earlier Versions (Model 0.72.0049) b. Later Versions (Model 0.72.0051-0/1)

Figure 4.17 Track-Store Unit: Program Panel Terminations

MODE CONTROL:

The Track-Store Unit has three modes of operation:

IC	Initial Condition
T	Track
S	Store

In the IC Mode: the starting value of the Track-Store Unit is established.

In the Track Mode: the Track-Store Unit behaves like a summer; the output is the negative sum of the inputs.

In the Store Mode: the output of the Track-Store Unit is held constant.

These modes are controlled by local logic patching. Two logic inputs (IC and T) are used to select the three operational modes as indicated in Figure 4.16.

APPLICATION NOTES:

1. The Track-Store unit inverts. This applies to both the analog IC input and the summing inputs.

2. Unpatched analog inputs are equivalent to the constant zero.

3. When not being used for sampling applications, the Track-Store Unit can be used as a 5 Input Summer. No logic patching is required. The logic control inputs are normally arranged for this purpose. When left unpatched:

   T = "1"

   IC = "0"

4. Figure 4.18 illustrates basic Track-Store operation. An analog input signal (x) is initially tracked and then stored. The track and store modes are controlled by the logic signal L. Transition from the track mode to the store mode is accomplished in approximately 1 microsecond.

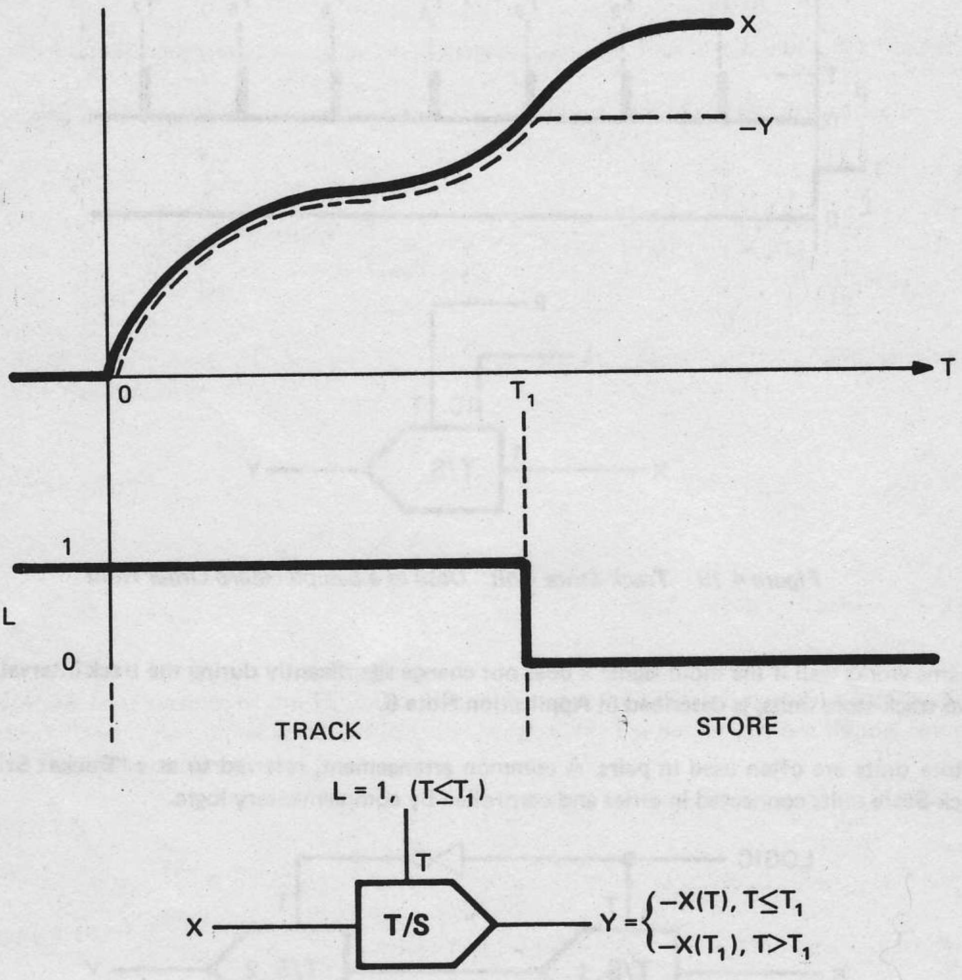


Figure 4.18 Basic Track-Store Application

5. A sampled data application is shown in Figure 4.19. The Track-Store unit serves as a combined Sampler and Zero Order Hold to generate a quantized version of the input signal.

   The Track-Store unit is initialized to zero by the logic signal L and the sampling is controlled by the logic pulse train P.

   In Figure 4.19, the output transition appears to occur instantaneously. In practice, a finite time (10-15 microseconds) is necessary to acquire the new data. The pulse width must be arranged to provide an appropriate tracking interval.

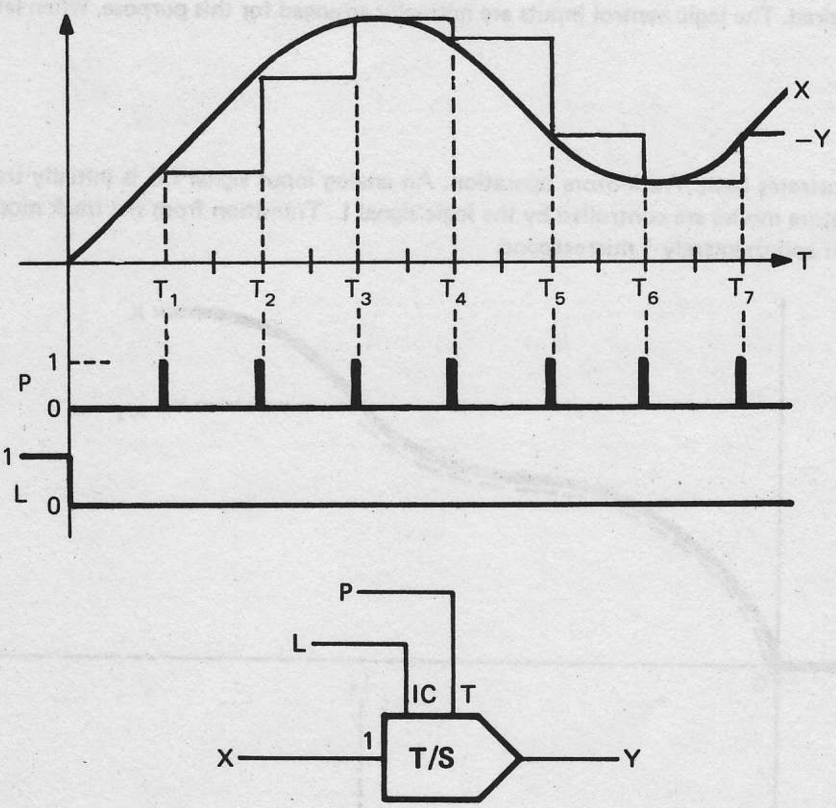


Figure 4.19 Track-Store Unit: Used as a Sampler/Zero Order Hold

This scheme works well if the input signal x does not change significantly during the track interval. A better scheme, using two track-store units, is described in Application Note 6.

6. Track-Store units are often used in pairs. A common arrangement, referred to as a "Bucket Brigade" consists of two Track-Store units connected in series and controlled by complementary logic.

When the logic signal is high: the first unit tracks the dynamic input signal x while the second unit stores the previous value.

When the logic signal goes low: the first unit stores the input value and the second unit tracks the stored value. Value changes of the input signal during the update interval are not reflected at the output.

Figure 4.20 shows the "Bucket Brigade" implementation of the sampled data application described in Note 5.

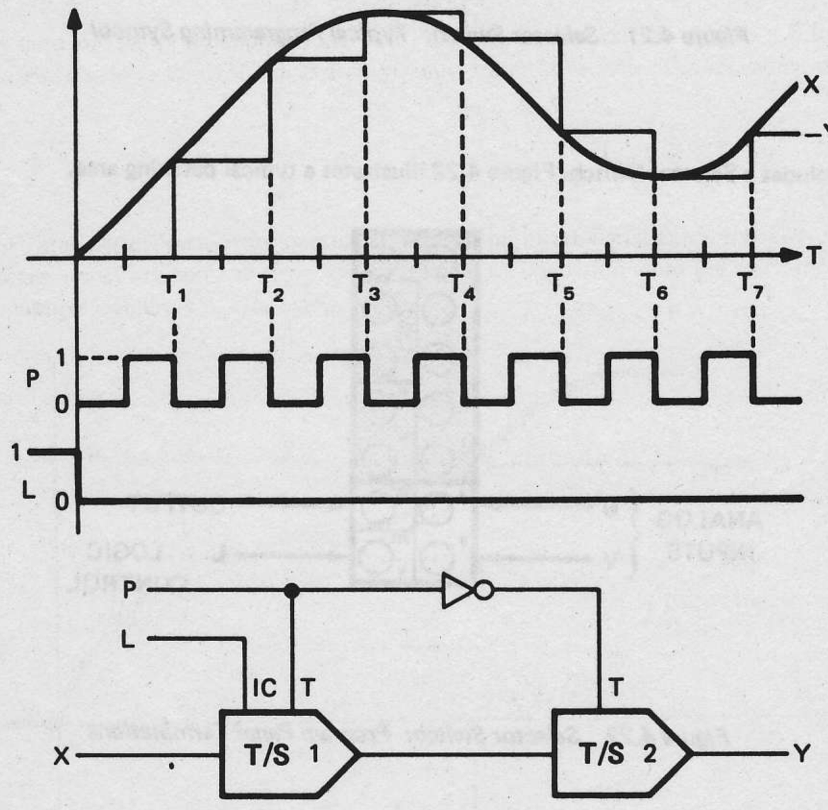


Figure 4.20 Bucket Brigade Track-Store: Used as a Sampler/Zero Order Hold

Schalter

4.9 SELECTOR SWITCH

FUNCTION:

Analog Signal Switching

DESIGNATION: SW

SYMBOL:

As shown in Figure 4.21.

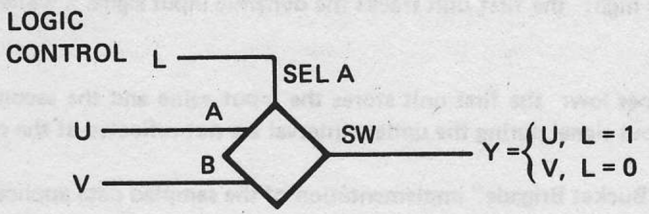


Figure 4.21 Selector Switch: Typical Programming Symbol

PROGRAM PANEL:

Every Analog Tray includes a Selector Switch. Figure 4.22 illustrates a typical patching area.

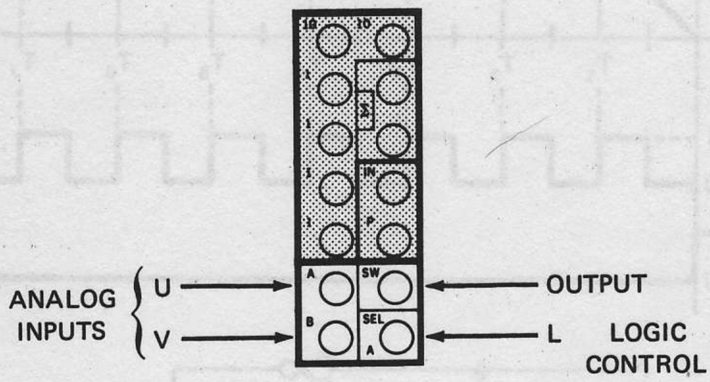


Figure 4.22 Selector Switch: Program Panel Terminations

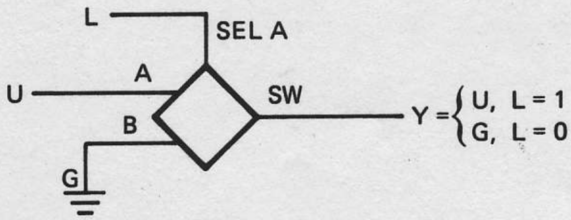
APPLICATION NOTES:

1. The Selector Switch output (SW) is selected from one of the two analog inputs (A or B). The selection depends on the logic control input (SEL A); a logic "1" selects A and a logic "0" selects B. The output is not inverted.

2. The logic control (SEL A) is normally a logic "1". If SEL A is left unpatched, the A input is connected to the output.

3. The switching operation is completely electronic; switching time is approximately 5 microseconds.

4. A zero analog input is best achieved by grounding the desired input. Grounding pins are provided for this purpose. Alternately, the input can be patched to ground (any black terminal).



5. The Selector Switch is the only analog component that cannot be directly displayed on the MACS Screen. In most situations, the switching effects can be observed on a downstream component. When this is inappropriate, the Switch output (SW) can be also patched to an unused Summer, Trunk, or readout terminal (DVM) and then displayed.

4.10 SINE GENERATOR

FUNCTION:

Generate the Sine of an analog variable.

DESIGNATION: SIN

SYMBOL:

As shown in Figure 4.23.

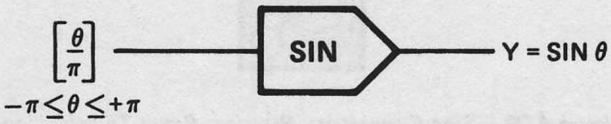


Figure 4.23 Sine Generator: Typical Programming Symbol

CHARACTERISTIC:

As shown in Figure 4.24.

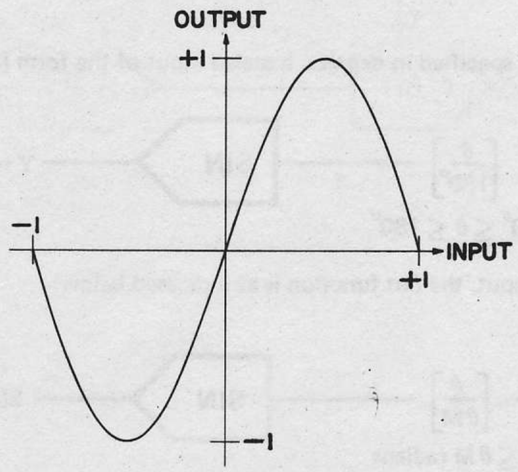


Figure 4.24 Sine Generator: Input-Output Characteristic

PROGRAM PANEL:

The Sine function is one of the three functions that can be generated with the Trigonometric Function Generator (See paragraphs 4.11 and 4.12).

The Trigonometric Function Generator is included in the SIN/Σ tray. The Program Panel terminations are indicated in Figure 4.25.

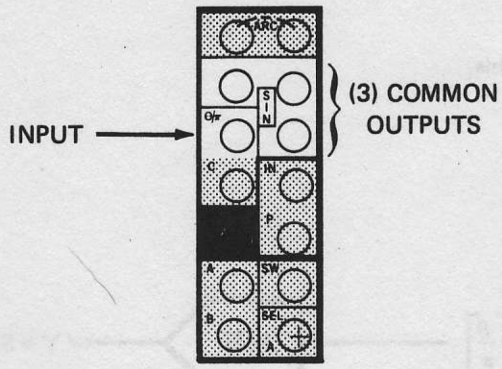


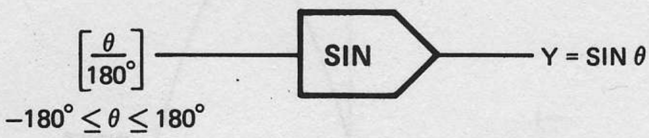
Figure 4.25 Sine Generator: Program Panel Terminations

APPLICATION NOTES:

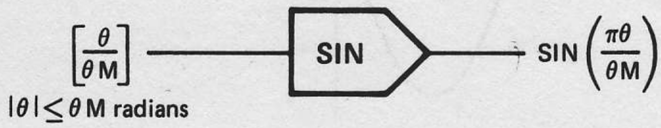
1. The Sine Generator has a preset sinusoidal function that covers one complete cycle. See Figure 4.24. The user is required to provide an appropriately scaled input.

2. If the unscaled argument is specified in radians, a scaled input of the form $[\theta/\pi]$ yields the desired Sin θ function. See Figure 4.23.

3. If the unscaled argument is specified in degrees, a scaled input of the form $[\theta/180^\circ]$ yields the desired Sin θ output.



4. With an arbitrarily scaled input, the out function is as indicated below:



5. The Sine function is an odd function. Therefore, a sign inversion in the input yields a sign inversion in the output.

4.11 COSINE GENERATOR

FUNCTION:

Generate the Cosine of an analog variable.

DESIGNATION: COS

SYMBOL:

As shown in Figure 4.26.

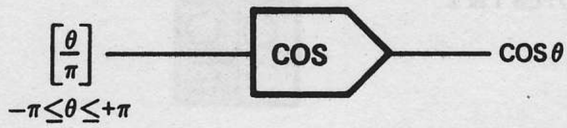


Figure 4.26 Cosine Generator: Typical Programming Symbol

CHARACTERISTIC:

As shown in Figure 4.27.

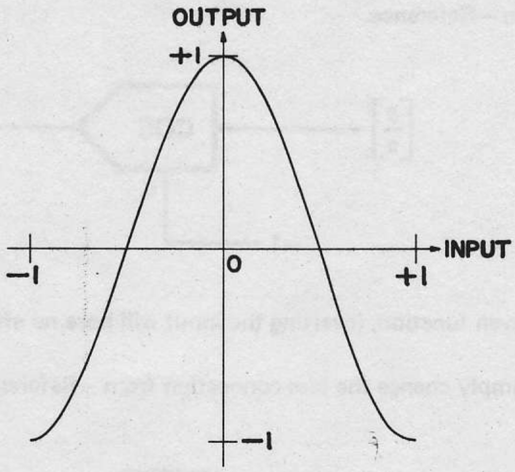


Figure 4.27 Cosine Generator: Input-Output Characteristic

PROGRAM PANEL:

The Cosine function is the second of three functions that can be generated with the Trigonometric Function Generator. See paragraphs 4.10 and 4.12.

The Trigonometric Function Generator is included in the SIN/Σ tray. The Program Panel terminations for the Cosine Function are illustrated in Figure.4.28.

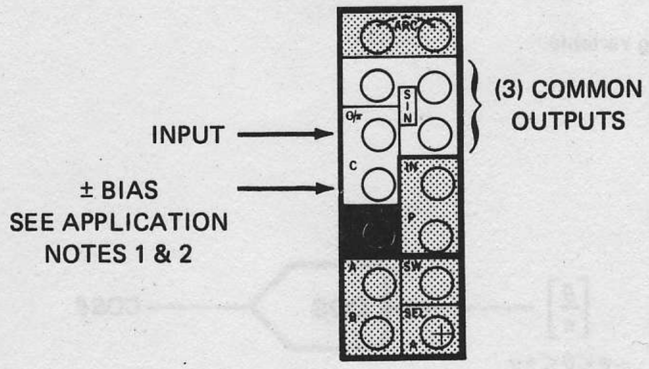
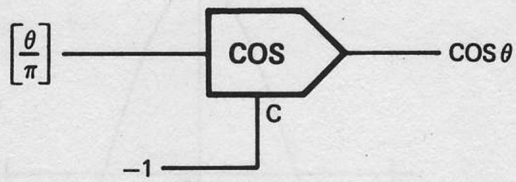


Figure 4.28 Cosine Generator: Program Panel Terminations

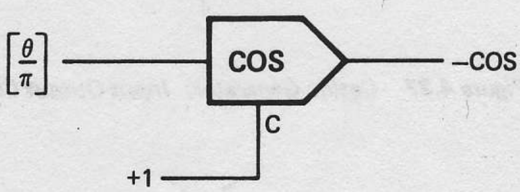
APPLICATION NOTES:

1. The Cosine function is formed from the basic Sine function by adding a constant bias to the input signal. The bias effectively shifts the sine function by 90° to produce the Cosine function. This bias is introduced by patching the terminal labelled "C" to −Reference.

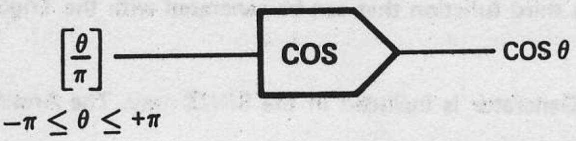


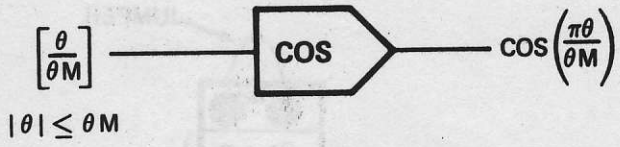
2. Since the Cosine is an even function, inverting the input will have no effect on the output.

   To invert the output, simply change the bias connection from −Reference to +Reference.



3. The input scaling described for the Sine function (paragraph 4.10) also applies to the Cosine function.





4.12 ARCSINE GENERATOR

FUNCTION:

Generate the ARCSINE of an analog variable.

DESIGNATIONS:

ARCSIN, SIN^{-1}

SYMBOL:

As shown in Figure 4.29.

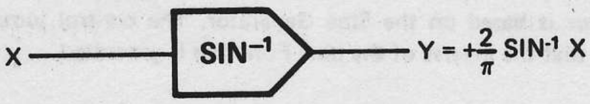


Figure 4.29 Arcsine Generator: Typical Programming Symbol

CHARACTERISTIC:

As shown in Figure 4.30.

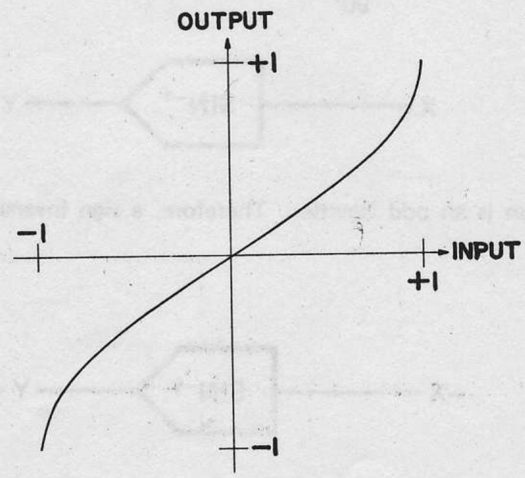


Figure 4.30 Arcsine Generator: Input/Output Characteristic

PROGRAM PANEL:

The ARCSINE function is the third function that can be generated with the Trigonometric Function Generator. See paragraphs 4.10 and 4.11.

The Trigonometric Function Generator is included in the SIN/Σ tray. The Arcsine Program Panel Terminations are illustrated in Figure 4.31.

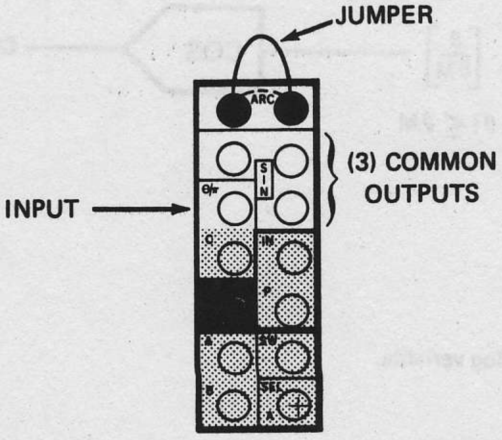


Figure 4.31 Arcsine Generator: Program Panel Terminations

APPLICATION NOTES:

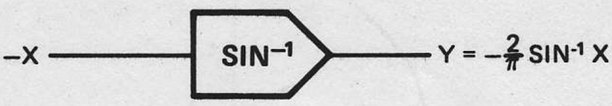
1. The ARCSINE Generator is based on the Sine Generator. The control jumper (Figure 4.31) effects an integral configuration change so that the inverse of the Sine Function is generated.

2. The ARCSINE Generator has an implicit scale factor associated with its output.

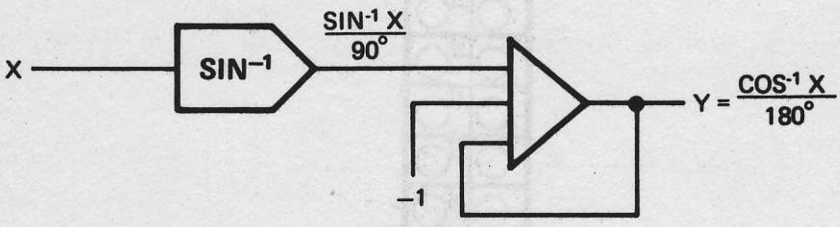
   In terms of radians, the scale factor is $\frac{2}{\pi}$. See Figure 4.29.

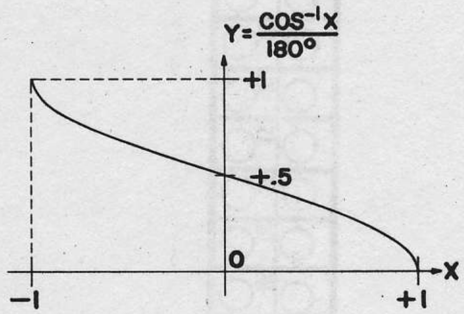
   In terms of degrees, the scale factor is $\frac{1}{90^\circ}$

3. The ARCSINE function is an odd function. Therefore, a sign inversion at the input will yield a sign inversion at the output.



4. The Arc-cosine cannot be generated directly with the Trigonometric Function Generator. The "C" input has no effect when the ARC jumper is instlalled. The Arc-cosine function can be generated with an Arcsine Generator and a Summer. The implementation, based on the identity Sin (90°–θ) = Cos θ, is shown below:





4.13 DIGITALLY SET FUNCTION GENERATOR (DSFG)

FUNCTION:

Generate an arbitrary function of an analog variable.

DESIGNATIONS: FG, DSFG

SYMBOL:

As shown in Figure 4.32.

Figure 4.32 Digitally Set Function Generator: Typical Programming Symbol

PROGRAM PANEL:

A fully expanded system can accomodate 16 independent Digitally Set Function Generators ($0\text{-}17_8$). These function generators are terminated in a Special Purpose tray that is located in the 8th position of the top component row. The Program Panel terminations are in Figure 4.33.

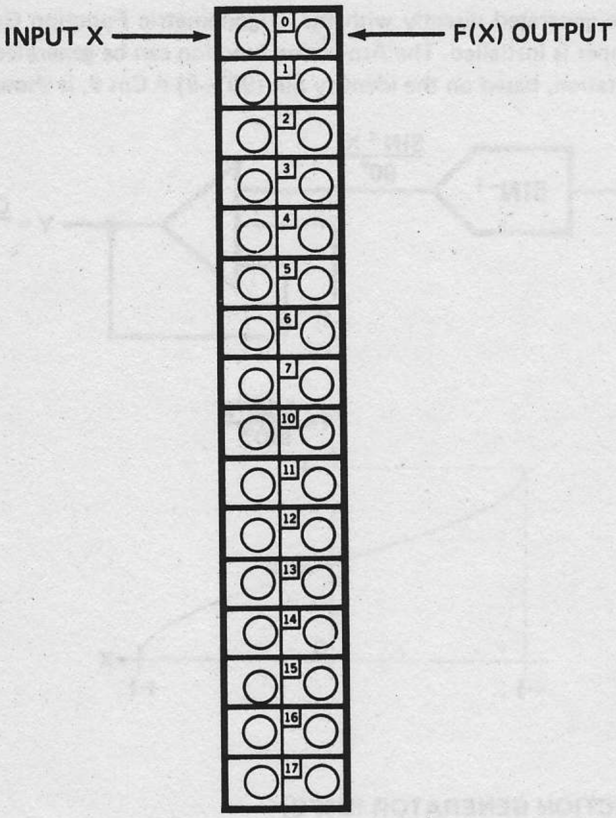


Figure 4.33 Digitally Set Function Generator: Program Panel Terminations

TYPICAL COMMANDS:

MACS Commands are fully described in Chapters 9 and 10. The following illustrates some typical commands associated with an individual Function Generator. Refer to Application Notes 5 through 11 for additional commands, information, and specific examples.

COMMAND	FUNCTION
[F] [n] [RETURN]	Selects Function Generator number x (0-17_8) for display and/or setup purposes. A given DSFG must be addressed and displayed before that DSFG can respond to any other individual commands. See Application Notes 5 and 9.
[CTRL] [F] or [L] [I] [;] [RETURN]	Displays the present function values of the currently addressed DSFG. See Application Notes 6 and 9.
[B] [=] [n] [RETURN]	Initialized the currently addressed DSFG for setting a 21 or a 41 breakpoint function. Where n = the value 21 or 41. See Application Notes 7 and 9.

COMMAND	FUNCTION
[V] [n] [=] [·] [n] [RETURN]	Sets the designated breakpoint number (x = 0-21 or 0-41) of the currently addressed DSFG to the Value • n. Where • n is a positive value less than one machine unit. This does not infer that breakpoints cannot be a +1.0 or −1.0. A minus sign ([−]) must be entered to achieve a negative breakpoint value. See Application Note 8 for other restrictions. Also refer to Application Note 9.

APPLICATION NOTES:

1. The Digitally Set Function Generator is a two terminal device. An analog variable is patched into its input terminal (IN) and a preset function of the input is obtained at the output terminal.

2. The Digitally Set Function Generator is used to generate a piecewise linear approximation of a continuous function. The domain and range of the generated function lies within the interval [−1, +1] Machine Units.

3. The user has the option of employing either 20 or 40 linear segments to produce a desired function. The linear segments are specified by endpoint coordinates.

   The x values of the endpoint coordinates are referred to as breakpoints. The y values are referred to as function values (f_x).

4. With 20 segments, there are 21 breakpoints evenly spaced at x axis intervals of 0.1 Machine Units. The first breakpoint is at −1.0, the second at −0.9 along the x axis, etc.

   With 40 segments, there are 41 breakpoints evenly spaced at x axis intervals of .05 Machine Units. The first breakpoint is at −1.0 along the x axis, the second at −0.95 along the x axis, etc.

5. A Digitally Set Function Generator is addressed with a prefix F, followed by the Program Panel numerical address and a Carriage Return. The DSFG address is restricted to one of 16 channels ($0\text{-}17_8$). For example the command:

   [F] [2] [RETURN]

   displays the output of Function Generator 2.

6. The array of function values can be displayed on the lower portion of the MACS screen. The command:

   [CTRL] [F]

   displays the function values for the currently addressed Function Generator. Note that a carriage return is not required when the control [CTRL] key is used.

7. The number of breakpoints (either 21 or 41) desired for a particular function is specified by command from MACS. There are only two applicable commands:

   [B] [=] [2] [1] [RETURN]
   or
   [B] [=] [4] [1] [RETURN]

   These commands initialize the currently addressed function generator for the specified number of breakpoints.

8. Function values are specified by command for MACS. For example, the command:

[V] [4] [=] [·] [8] [7] [6] [5]

sets the function value, corresponding to breakpoint No. 4, to the positive value .8765. This command applies to the currently addressed function generator.

9. Adjacent function values cannot differ by more than one Machine Unit.

$$|f_{n+1} - f_n| \leqslant 1.0$$

10. The overall setup procedure for a DSFG involves three basic steps and one optional step.

   a. Address (select) the Function Generator.

   b. Optional: Display the function values of the selected DSFG.

   c. Specify the desired number of breakpoints.

   d. Enter the function values.

The following example uses a hypothetical set of MACS Commands to demonstrate a typical sequence for setting up a 21 Breakpoint function. The use of a set-up table is recommended for references when setting up a DSFG function. See Appendix 5.

COMMAND	FUNCTION
[F] [2] [RETURN]	Select and display Function Generator 2.
[CTRL] [F]	Optional: Display Function Value Page for F2;
[B] [=] [2] [1] [RETURN]	Select 21 Breakpoint Mode for F2.

NOTE

The following V Commands set the value of each individual breakpoint at a specific X and Y (F_X) coordinate as follows:

	COORDINATE X	COORDINATE Y
[V] [1] [=] [–] [·] [5] [6] [RETURN]	–1.0	–0.560
[V] [2] [=] [·] [Ø] [RETURN]	–9.0	±0.000
[V] [3] [=] [·] [3] [4] [3] [RETURN]	–8.0	+0.343
•	•	•
•	•	•
•	•	•
[V] [1] [9] [=] [·] [1] [2] [5] [RETURN]	+0.8	+0.125
[V] [2] [Ø] [=] [–] [·] [3] [8] [RETURN]	+0.9	–0.380
[V] [2] [1] [=] [–] [·] [6] [3] [7] [RETURN]	+1.0	–0.637

11. A function previously set in one Function Generator can be copied into another Function Generator.

For example, executing the command:

[F] [2] [=] [7] [RETURN]

sets F2 with the same function that is currently set in F7.

F7 remains unchanged.

The Breakpoint Mode (B = 21 or B = 41) associated with F2 is automatically changed (when necessary) to agree with the new function.

12. Function values for the straight line functions Y = X and Y = –X are stored in a separate memory within the Control & Setup Interface. The Digitally Set Function Generators can be loaded with these functions using the identifiers specified in the following table. The intent is to provide a quick operational check of the function generators. The available test functions are indicated below:

Identifier	Breakpoints	Function
'100	21	Y = X
'101	21	Y = –X
'200	41	Y = X
'201	41	Y = –X

After correct operation has been verified, any previously set function can be easily re-established.

For example, executing the command:

[F] [5] [=] ['] [1] [Ø] [Ø] [RETURN]

sets F5 with the function values for the 21 breakpoint version of the function Y = X.

Then, executing the command:

[S] [;] [RETURN]

restores the previous user function. This command affects only the currently addressed function generator.

Further, executing the command:

[F] [7] [7] [=] ['] [1] [Ø] [Ø] [RETURN]

sets all function generators with the specified test function.

13. When the EAI 2000 is connected as a peripheral to a digital computer, or has an associated teletype compatible device; a predetermined library of functions can be automatically loaded into the Digitally Set Function Generators as required.

4.14 LIMITER

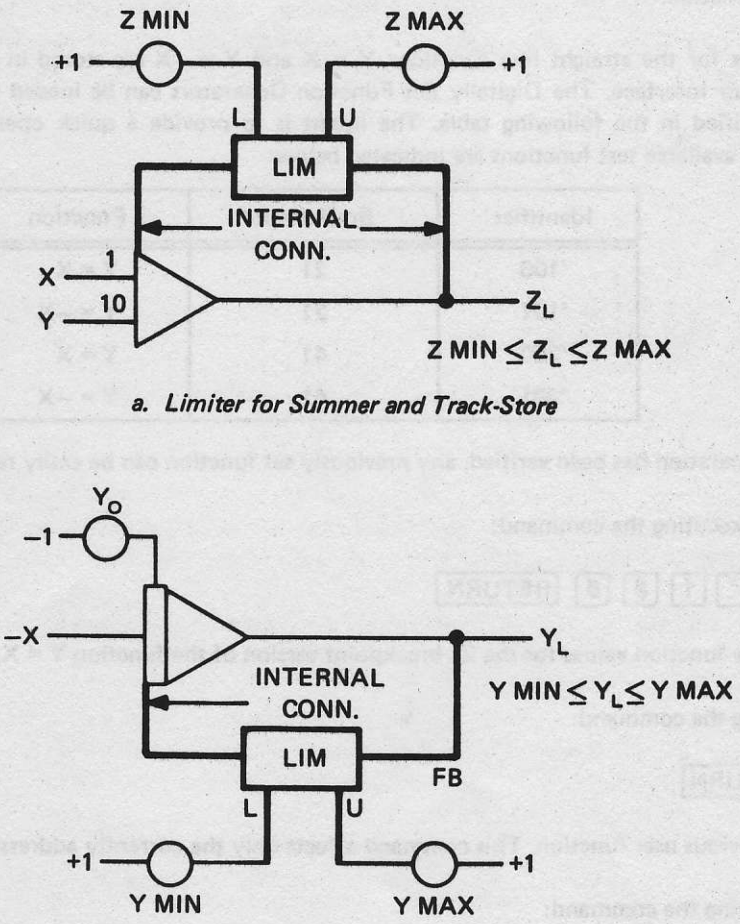
FUNCTION:

Limit output amplitude of Summer, Integrator, or Track-Store Units.

DESIGNATION: LIM

SYMBOL:

See Figure 4.34.



a. Limiter for Summer and Track-Store

b. Limiter for Integrator

Figure 4.34 Limiter: Typical Programming Symbols

PROGRAM PANEL:

The LIMITER, unlike the other analog components, is not an independent device; it is designed to function with a particular Summer, Track-Store Unit, or Integrator. The 4 and 7 Input Summer (paragraph 4.3), the Integrator (paragraph 4.4) and the Track-Store Unit (paragraph 4.8) can be optionally equipped with a LIMITER.

The Program Panel terminations for the Summer/Limiter are shown in Figure 4.35, a and b.

The Program Panel terminations for the Integrator/Limiter and the Track-Store Limiter are shown in Figure 4.35, c and d. Note that the Integrator/Limiter requires the insertion of a jumper from the Integrator output to the feedback terminal (FB) of the Limiter.

The Presence (or absence) of a Limiter cannot be determined by inspection of the Program Panel. To ascertain whether a Limiter is installed in a particular tray, simply address the corresponding component (Summer, Integrator, or Track-Store Unit). If a Limiter is present, the MACS display will indicate the letter "L" next to the Address readout.

APPLICATION NOTES:

1. The LIMITER is a high gain feedback element. Whenever the output of the associated Summer (or Integrator) exceeds the established limits, the LIMITER provides a compensating input signal to prevent any further output excursion.

2. The limits associated with a Limiter are established by patching appropriate analog inputs into the "L" provides the lower limit; "U" the upper the limit. There are no particular requirements on the polarity of either input; they may be positive, negative or zero. The only restriction is that

$$\boxed{L < U} \ .$$

3. For applications involving fixed limits, the "L" and "U" terminals are supplied with constant signals. Usually these signals are derived from Coefficient Units as indicated in Figure 4.34. However, it is permissable to directly supply a Reference signal (+1.0 MU or −1.0 MU) or to ground an input (for a zero limit).

4. For variable limits, the "L" and "U" terminals are legitimately supplied with time varying analog signals originating from other analog components (Integrator, Summer, DSFG, etc.).

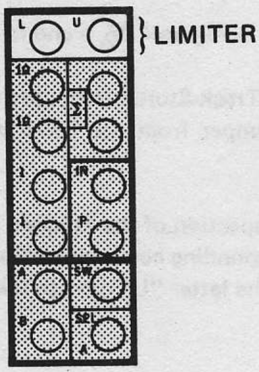
5. If the "L" terminal is left unpatched, the lower limit is set (by default) at approximately −1.2 MU. Likewise, the upper limit is set at approximately +1.2 MU. In both cases, the default limit is set beyond the overload indication threshold. If both the "L" and "U" terminals are left unpatched, the presence of the limiter has no effect on the normal operation of the associated component (Summer, Integrator, or Track-Store).

6. The output (z_L) of a summer/Limiter or Track-Store/Limiter (Figure 4.34a) is mathematically described as follows:

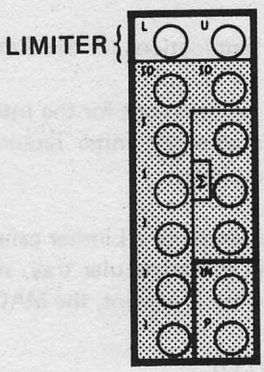
$$z_L = \begin{cases} \text{ZMAX}, & z \geq \text{ZMAX} \\ z, & \text{ZMIN} < z < \text{ZMAX} \\ \text{ZMIN}, & z \leq \text{ZMIN} \end{cases}$$

where (for this example)

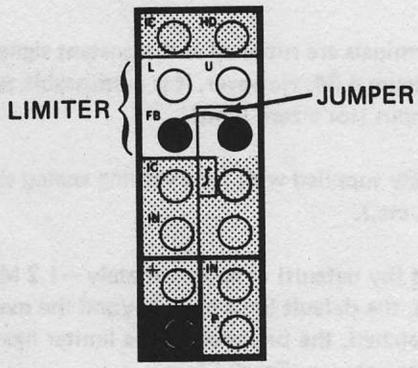
$$z = -(X + 10_y)$$



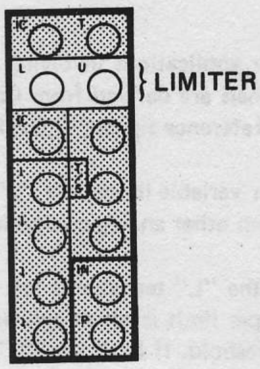
a. *4-Input Summer (0.72.0051-1 TS/Σ Tray Only)*



b. *7-Input Summer (Typical for Mult/Σ and SIN/Σ Trays)*



c. *Integrator (∫/Σ Tray)*



d. *Track-Store Unit (0.72.0051-1 TS/Σ Tray Only)*

Figure 4.35 Limiter: Program Panel Terminations

In general, z represents the output that would have occurred if the Summer had not been limited (i.e., the negative sum of the weighted inputs

The limit characteristic, relating z_L and z, is shown in Figure 4.36. A typical output of a Summer/Limiter is illustrated in Figure 4.37.

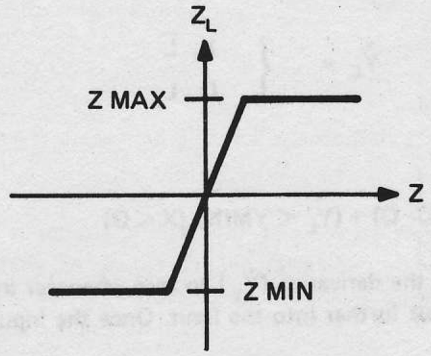


Figure 4.36 Summer/Limiter Characteristic

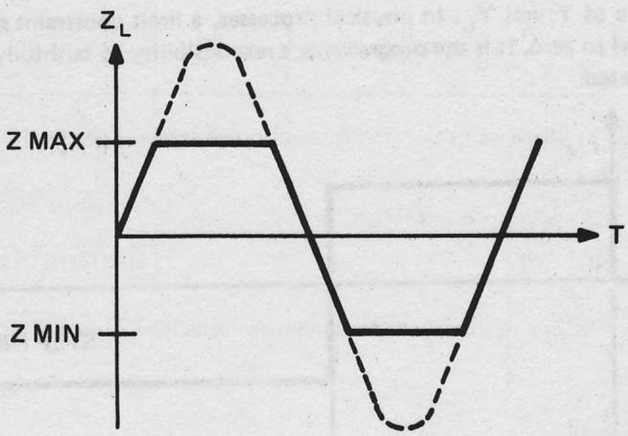


Figure 4.37 Typical Summer/Limiter Output

7. The mathematical description of the Integrator/Limiter is complicated because the limiting action affects the derivative of the signal being limited. With reference to Figure 4.34b, the output (Y_L) can be rigorously written as follows:

$$Y_L = Y_{oL} + \int_o^t \dot{Y}_L \, D_T$$

where, the initial condition

$$Y_{oL} = \begin{cases} YMAX, & Y_o \geq YMAX \\ Y_o, & YMIN < Y_o < YMAX \\ YMIN, & Y_o \leq YMIN \end{cases}$$

and, the derivative

$$\dot{Y}_L = \begin{cases} X, & \overline{L} \\ O, & L \end{cases}$$

with the logical condition

$$L = (YL > YMAX)\ (X > O) + (Y_L < YMIN)\ (X < O)$$

In words: the limiter will force the derivative ($\dot{Y}_L$) to zero whenever the output (Y_L) has reached a limit and the (X) is tending to push the output further into the limit. Once the input (X) changes direction, the output (Y_L) will come off the limit.

Figure 4.38 shows the response of an unlimited integrator and a limited integrator to a step input.

8. The limited Integrator is often mis-applied by novice programmers. It should be clear from figure 4.38, that the signal X is the derivative of Y; not Y_L. In physical processes, a limit constraint on a state variable implies that its derivative is being forced to zero. It is the programmer's responsibility to faithfully represent the physical phenomenon that is being simulated.

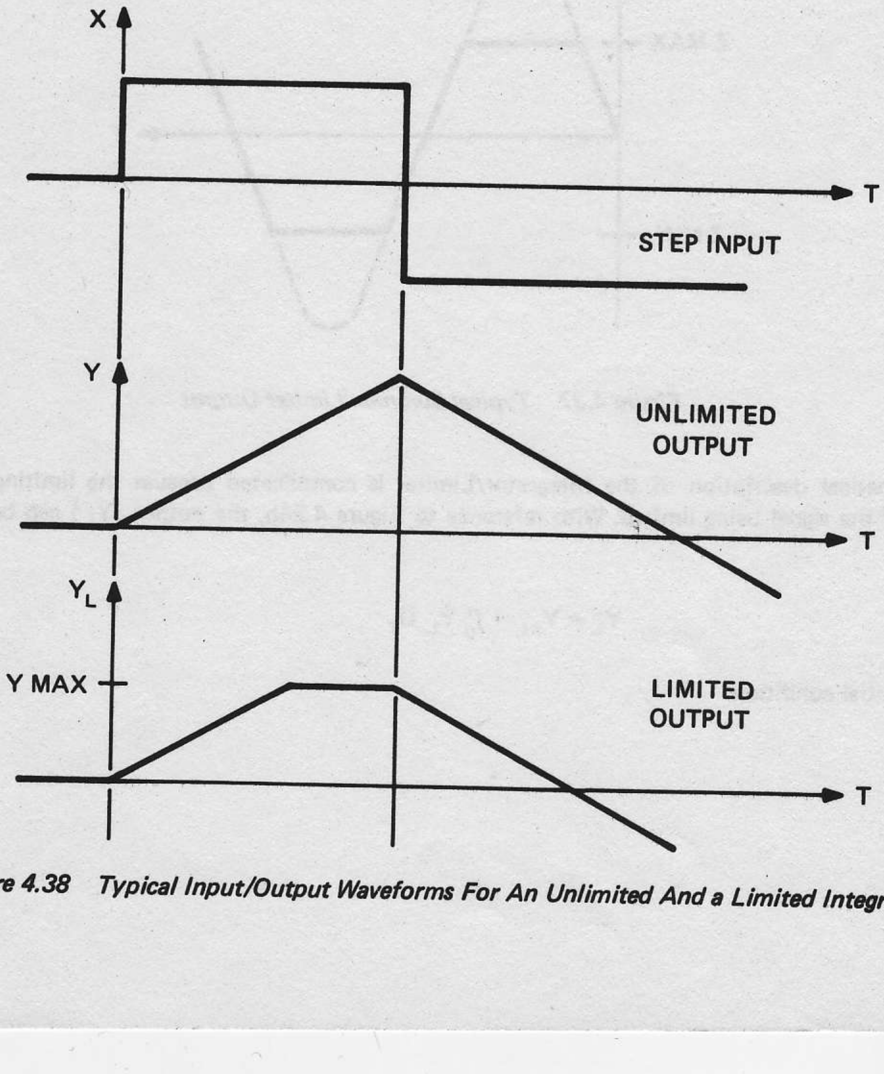


Figure 4.38 Typical Input/Output Waveforms For An Unlimited And a Limited Integrator

CHAPTER

5

LOGIC COMPUTING COMPONENTS

5.1 SCOPE OF CHAPTER

5.1.1 GENERAL

Each and every type of logic computing component available for the EAI 2000 is individually described in this chapter. The descriptions are from standpoints of functional operation and application.

5.1.2 FORMAT

For quick reference, each type of component is described in a separate and distinct main paragraph. Numbered subparagraphs are not used. Instead, all components are formatted with a definite set of headings that are essentially the same for each component and appear in the same sequence. If a heading does not apply to a given component, the heading is simply omitted.

The following description defines the format used throughout this chapter for describing individual logic components.

5.n COMPONENT NAME

Main paragraph heading naming the component.

FUNCTION:

Defines basic function of the subject component.

DESIGNATIONS:

Defines the program panel identification marks and/or other commonly used identifiers for the subject component.

SYMBOLS:

Illustrates and defines the basic program symbols associated with the subject component.

CHARACTERISTICS:

As applicable, illustrates unique characteristics associated with that component.

TYPICAL COMMANDS:

As applicable, provides general examples of typical MACS Commands pertaining to the operation of the component. MACS Commands are fully described in Chapters 9 and 10.

APPLICATION NOTES:

These notes (listed in ascending numerical order) illustrate and define the basic applications, special features, and constraints associated with the subject component.

5.1.3 FLAGS

As another means of quick reference, the upper corner (near the outer edge) of each page contains a flag (or flags) identifying the component type(s) described on that page. The following flags are used:

Logic Gate	=	GATE
Flip-Flop	=	FF
Logic Differentiator	=	DIF
Counter	=	CTR
General Purpose Register	=	GPR
Comparator	=	CMP

5.2 LOGIC GATE

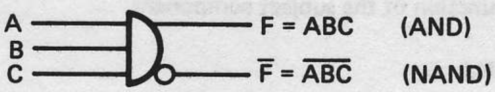
FUNCTION:

Combinational Logic Operations (AND/NAND; OR/NOR)

DESIGNATION: AND

SYMBOL:

As shown in Figure 5.1



A	B	C	F	$\overline{F}$
0	0	0	0	1
0	0	1	0	1
0	1	0	0	1
0	1	1	0	1
1	0	0	0	1
1	0	1	0	1
1	1	0	0	1
1	1	1	1	0

Figure 5.1 AND/NAND Logic Gate: Typical Programming Symbol/Truth Table

PROGRAM PANEL:

Logic Gates are included in the General Purpose Logic Tray. Each tray contains three logic gates as indicated in Figure 5.2.

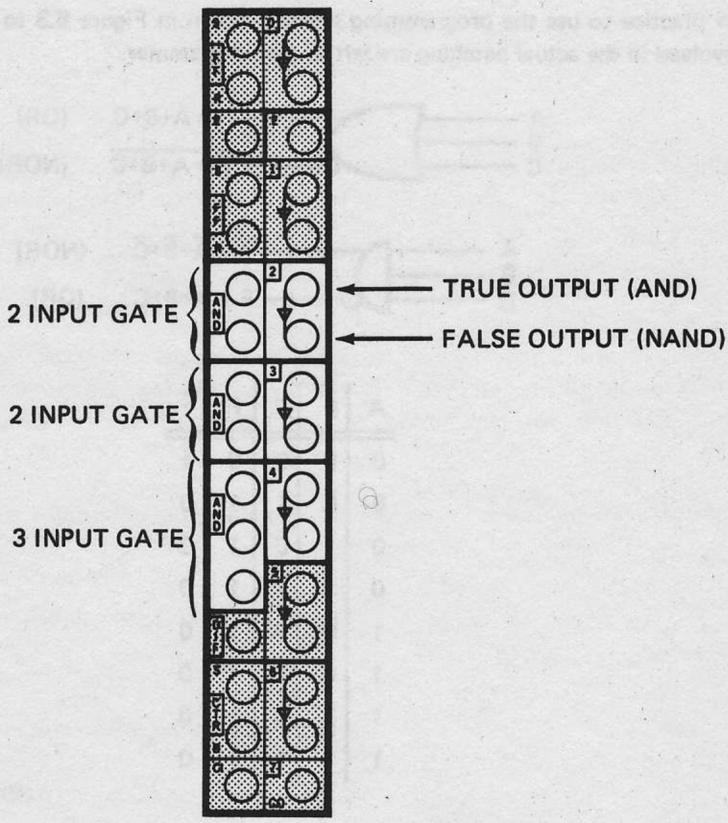


Figure 5.2 Logic Gates: Program Panel Terminations

TYPICAL COMMANDS:

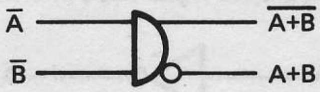
[L] [1] [2] [RETURN] = Selects and displays output state of AND Gate 2 in General Purpose Logic Tray One. In the Standard Program Panel Configuration, Gates are contained in Logic Trays L1, L2; L5, L6; and L11, L12. Individual Gates are numbered (addressed) 2 - 4.

APPLICATION NOTES:

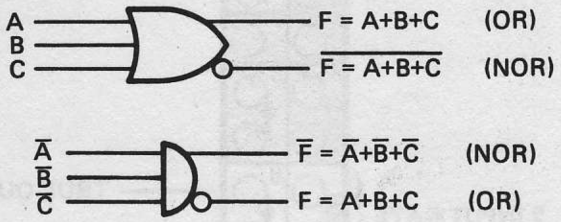
1. The Logic Gates are AND/NAND gates. This dual classification is justified because each gate has a built-in logic inverter; TRUE and FALSE outputs are terminated. The TRUE output yields the AND function; the FALSE output yields the NAND function. See Figures 5.1 and 5.2.

2. The logic components do not include OR/NOR gates. Instead, the OR/NOR function is obtained by using an AND/NAND gate with complementary inputs and outputs. This implementation is based on the identity:

$$A+B = \overline{\overline{A}\;\overline{B}}$$



3. It is common practice to use the programming symbol shown in Figure 5.3 to designate the OR/NOR function. The details involved in the actual patching are left to the programmer.

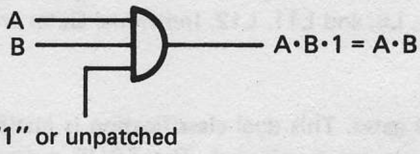


A	B	C	F	$\overline{F}$
0	0	0	0	1
0	0	1	1	0
0	1	0	1	0
0	1	1	1	0
1	0	0	1	0
1	0	1	1	0
1	1	0	1	0
1	1	1	1	0

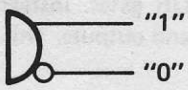
Figure 5.3 OR/NOR Logic Gate: Programming Symbols/Truth Table

4. Unpatched inputs are normally high (logic 1). This arrangement provides several user conveniences. See Application Notes 5, 6, and 7.

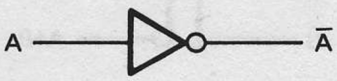
5. Unused inputs can be ignored.



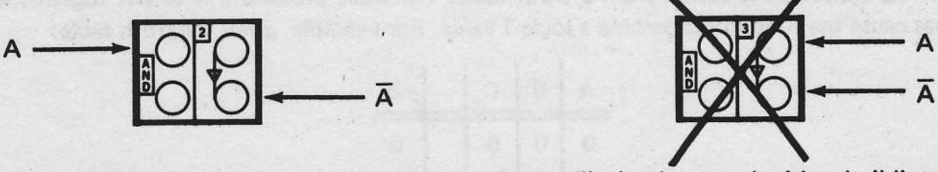
6. A logic gate with no inputs can be used as the source of logic constants.



7. A logic gate with a single input can be used as a NOT gate (logic inverter).



8. **DO NOT attempt to obtain the NOT function by patching an input to the AND output; it will not work.**

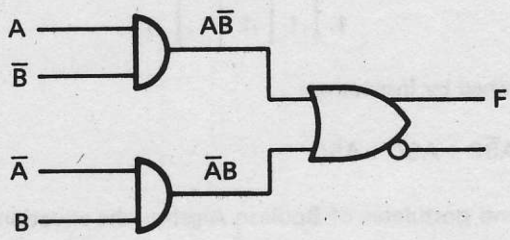


9. **A logic function, defined by an algebraic equation, can be readily implemented with a building block approach.**

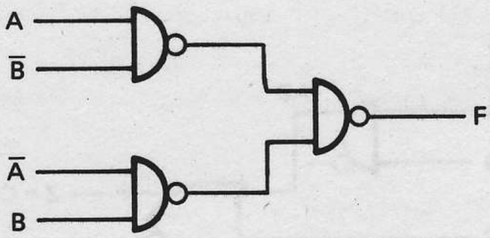
For example, the "EXCLUSIVE OR" function, defined as

$$F = A\bar{B} + \bar{A}B$$

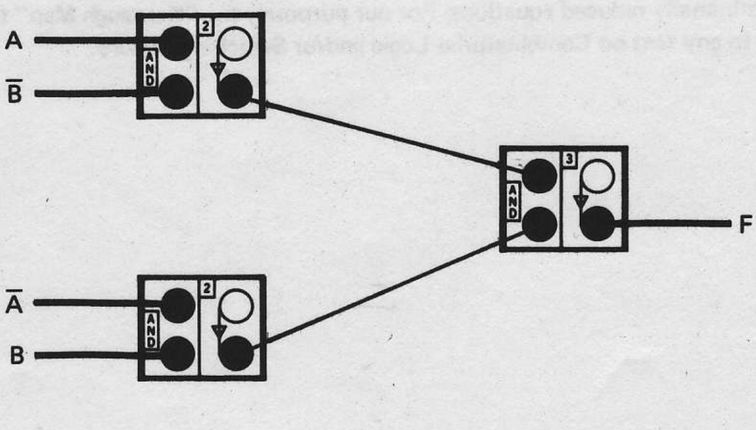
is diagramed as



implemented as



and patched as



10. In practice, logic functions are often defined by truth tables rather than by algebraic equations. It is a relatively simple task to formulate an equation from a truth table. The basic procedure is to OR together all of the input conditions that cause the function to assume a logic 1 value. For example, given the truth table:

A	B	C	Z
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

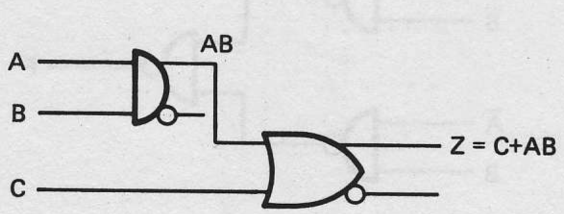
The following equation is obtained by inspection:

$$Z = \overline{A}\overline{B}C + \overline{A}BC + A\overline{B}C + AB\overline{C} + ABC$$

Then applying the theorems and postulates of Boolean Algebra, the equation is reduced to a minimal form. In our case:

$$Z = C + AB$$

The implementation is obvious:



The only difficulty in this process is obtaining the reduced equation. To this end, there are a variety of techniques that efficiently yield minimally reduced equations. For our purposes, the "Karnaugh Map" technique is well suited. The reader is referred to any text on Combinatorial Logic and/or Switching Theory.

5.3 FLIP-FLOP

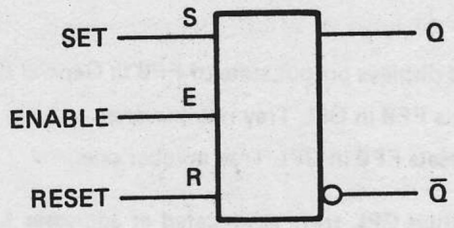
FUNCTION:

Store a Logic value.

DESIGNATION: FF

SYMBOL:

As shown in Figure 5.4.



Q_N	Q_{N+1}			
	SR = 00	01	10	11
0	0	0	1	1
1	1	0	1	0

Figure 5.4 General Purpose Flip-Flop: Typical Programming Symbol and State Transition Table

PROGRAM PANEL:

The General Purpose Flip-Flops are included in the General Purpose Logic (GPL) tray; each tray contains two flip-flops. The Program Panel terminations are shown in Figure 5.5.

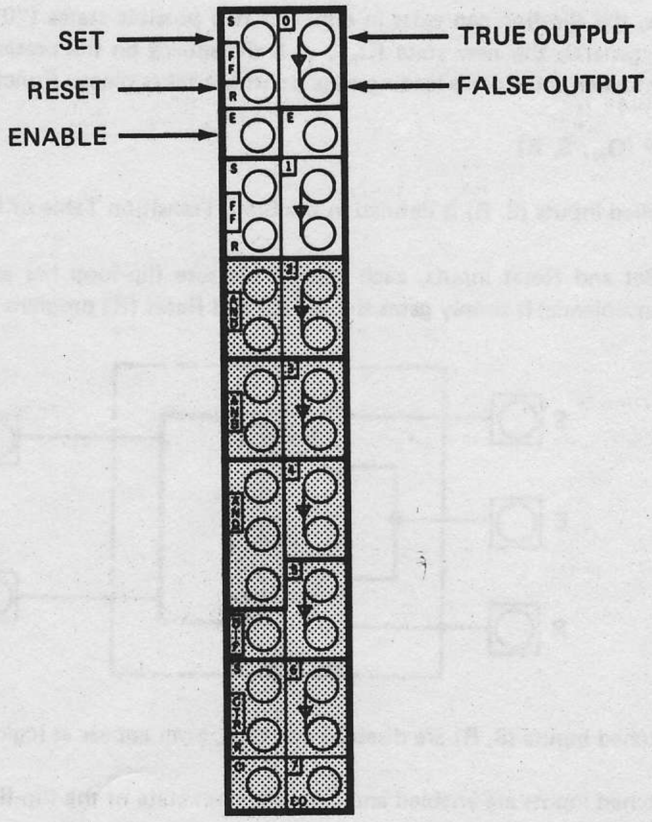


Figure 5.5 General Purpose Flip-Flops: Program Panel Terminations

TYPICAL COMMANDS:

[L] [1] [Ø] [RETURN] = Selects and displays output state of FFØ in General Purpose Logic Tray number one.

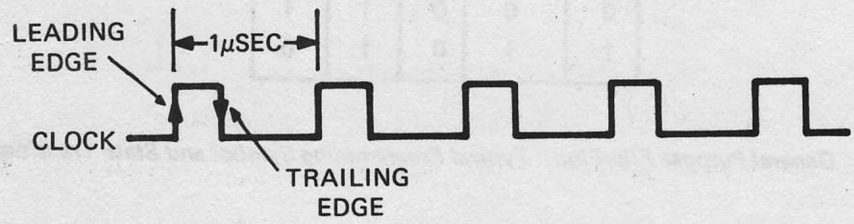
[L] [1] [Ø] [=] [1] [RETURN] = Sets FFØ in GPL Tray number one.

[L] [1] [Ø] [=] [Ø] [RETURN] = Resets FFØ in GPL Tray number one.

In the standard program panel configuration GPL trays are located at addresses L1, L2; L5, L6; and L11, L12. Individual flip-flops are numbered (addresses) Ø and 1.

APPLICATION NOTES:

1. Flip-Flops are symchronized with an internal clock. The clock signal is visualized as a pulse train.



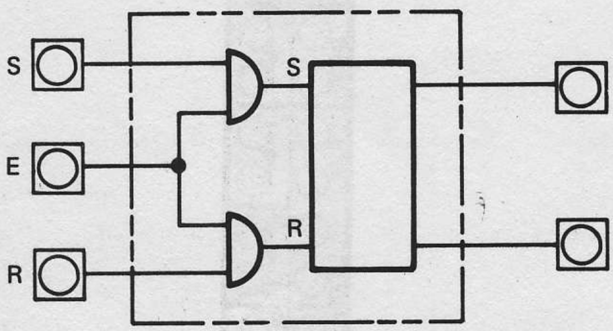
On the leading edge of a clock pulse: The S and R (Set and Reset) inputs are sampled. On the trailing edge: each flip-flop responds to its sampled inputs. No action is taken between clock pulses.

2. Between clock pulses, the flip-flop can exist in either of two possible states ("0" or "1"); the state is updated on each clock pulse. In general, the new state (Q_{N+1}) is dependent on the present state (Q_N) and on the applied inputs that are present when the clock's leading edge transition takes place. Functionally,

$$Q_N + 1 = F\,(Q_N,\ S,\ R)$$

The effect of the applied inputs (S, R) is defined in the State Transition Table of Figure 5.4.

3. In addition to the Set and Reset inputs, each general purpose flip-foop has an Enable (E) input. This input is provided as a user convenience; it simply gates the Set (S) and Reset (R) program panel inputs.

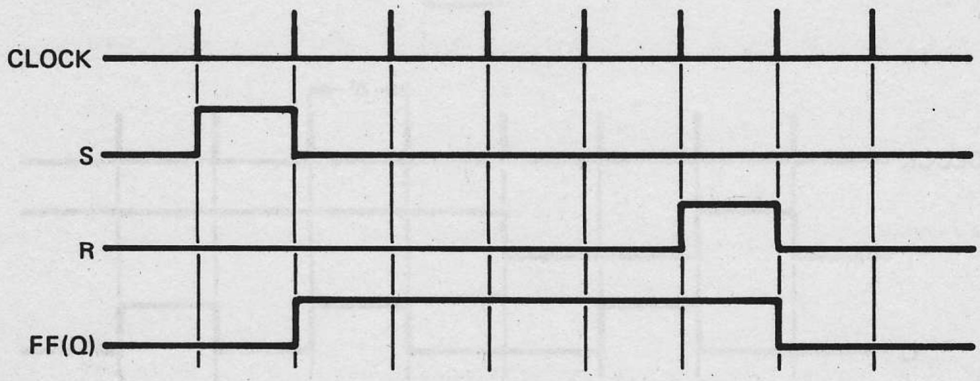


When E = 0: the patched inputs (S, R) are disabled and thus, both appear as logic 0.

When E = 1: the patched inputs are enabled and drive the next state of the flip-flop as indicated in Figure 5.4.

When left unpatched: the E input is normally high (logic 1). Therefore, when not required, this feature may be ignored. Unless explicitly shown, the E input is assumed to be a logic 1.

4. *Timing Diagram* - Synchronous logic circuits are often analyzed with the aid of a timing diagram. This diagram uses vertical lines to represent the clock pulses. It is understood that the inputs appearing just to the left of the vertical lines are the signals upon which the flip-flop action depends. State changes are shown on the vertical lines, but it must be understood that the actual transition takes place on the trailing edge of the clock pulse (or just to the right of the line). The following diagram illustrates a basic flip-flop responding to a pair of typical inputs. Unless otherwise specified, all flip-flops are assumed to be initially cleared (Q = 0).



5. *Delay Flip-Flop* - For the special case where a flip-flop is driven by complementary logic (S = D and R = $\overline{D}$), the new state depends only on the drive signal. Assuming the drive is synchronous, the flip-flop output follows the input with a one clock period delay. This configuration is referred to as a Delay (or simply D) Flip-Flop. See Figure 5.6.

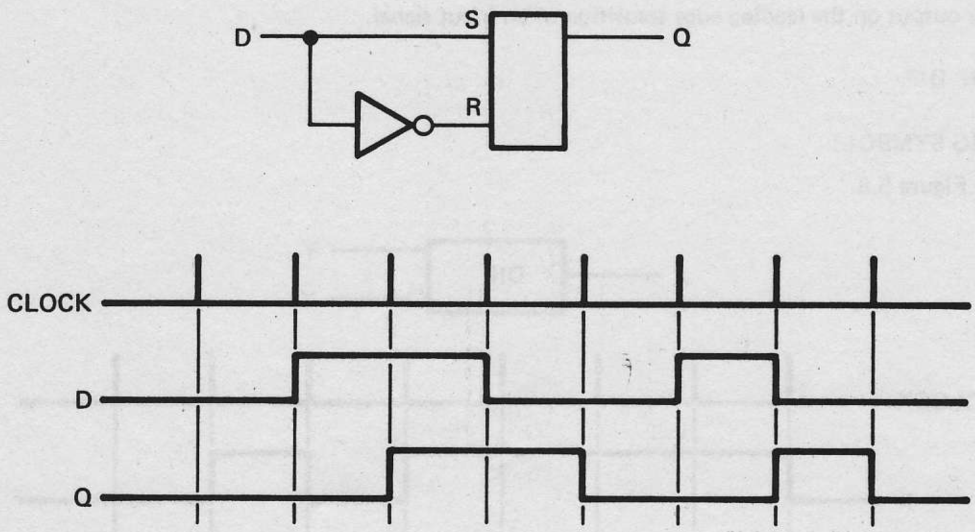


Figure 5.6 Delay Flip-Flop: Typical Programming Symbol and Timing Diagram

6. *Toggle Flip-Flop* - As another special case, consider a flip-flop driven by a single logic signal (S = R = T). The new state (Q_{N+1}) will either remain unchanged (T = 0) or will be complemented (T = 1). The state will change on each clock pulse as long as the input remains high. This configuration is referred to as a Toggle (or simply T) Flip-Flop. See Figure 5.7.

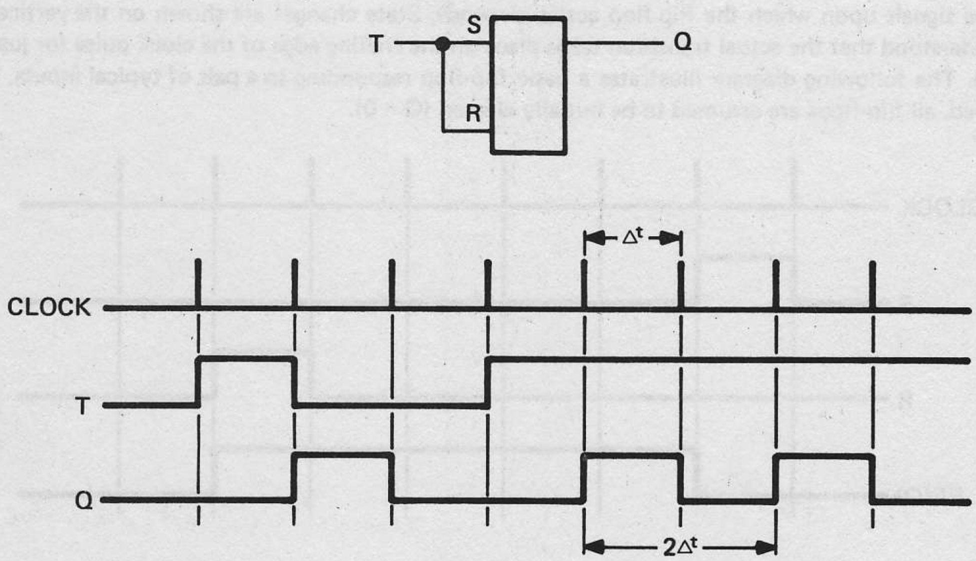


Figure 5.7 Toggle Flip-Flop: Typical Programming Symbol and Timing Diagram

5.4 LOGIC DIFFERENTIATOR

FUNCTION:

Generate a pulse output on the leading edge transition of an input signal.

DESIGNATION: DIF

PROGRAMMING SYMBOL:

As illustrated in Figure 5.8.

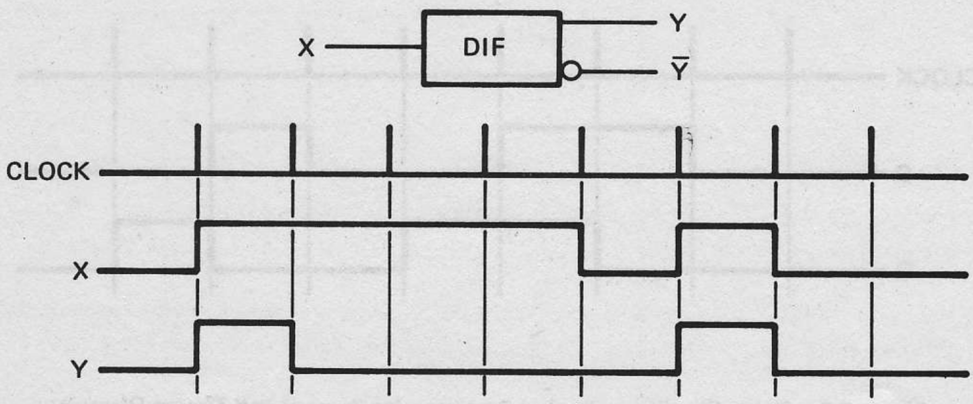


Figure 5.8 Logic Differentiator: Typical Programming Symbol and Timing Diagram

PROGRAM PANEL:

A logic Differentiator, as indicated in Figure 5.9, is included in each General Purpose Logic Tray.

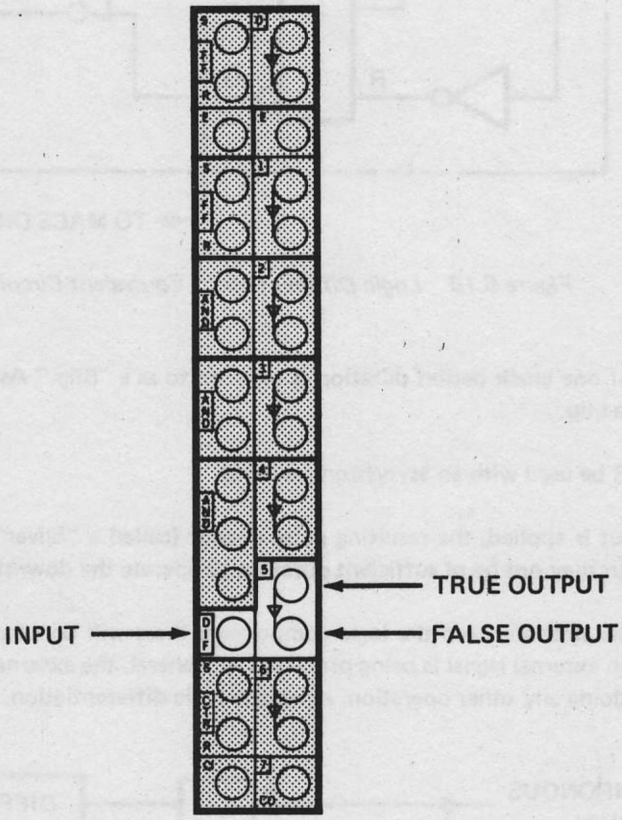


Figure 5.9 Logic Differentiator: Program Panel Terminations

TYPICAL COMMANDS:

[L] [1] [5] [RETURN] = Displays state of the DIF Flip-Flop (not its output) in GPL Tray number one.

[L] [1] [5] [=] [1] [RETURN] = Sets the DIF Flip-Flop (not its output) in GPL Tray number one.

[L] [1] [5] [=] [Ø] [RETURN] = Resets the DIF Flip-Flop (not its output) in GPL Tray number one.

GPL Trays are located at addresses L1, L2; L5, L6; and L11, L12. Each GPL Tray contains one DIF which has a 5 address.

APPLICATION NOTES:

1. The logic differentiator (DIF) generates a pulse whenever the input undergoes a "0" to "1" transition. The output goes high coincidentally with the input and then drops low on the next clock pulse. See Figure 5.8.

2. The Differentiator is provided as a user convenience because of the frequent requirement to generate pulse controls. If additional Differentiators are required they can be easily implemented, using a gate and a flip-flop, as indicated in Figure 5.10.

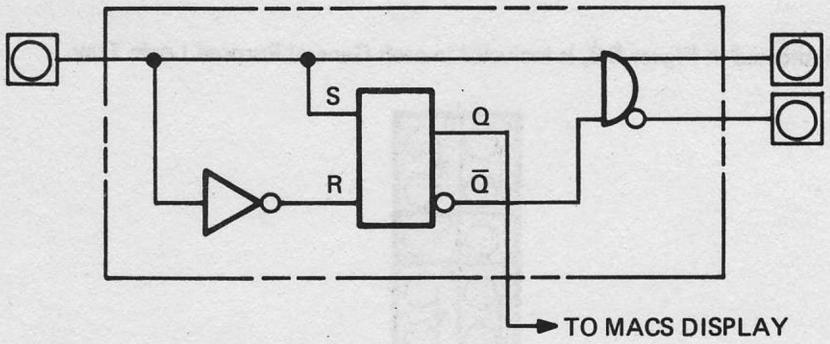


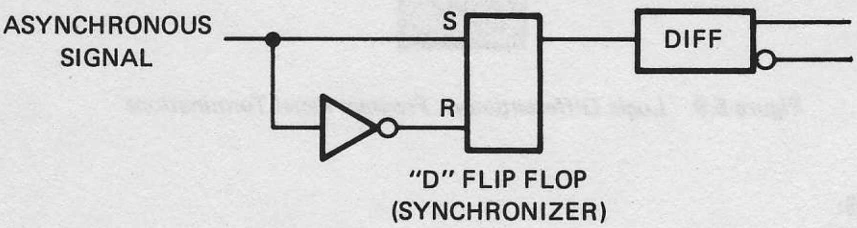
Figure 5.10 Logic Differentiator: Equivalent Circuit

3. A synchronized pulse of one clock period duration is referred to as a "Blip." Assuming the input is synchronized, the DIF output will be a blip.

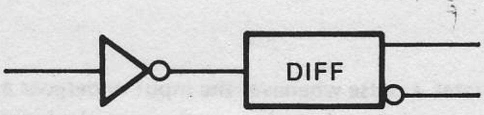
4. The DIF should NEVER be used with an asynchronous input.

   If an asynchronous input is applied, the resulting pulse output (called a "Sliver") is of shorter duration than one clock period. This output may not be of sufficient duration to operate the downstream components.

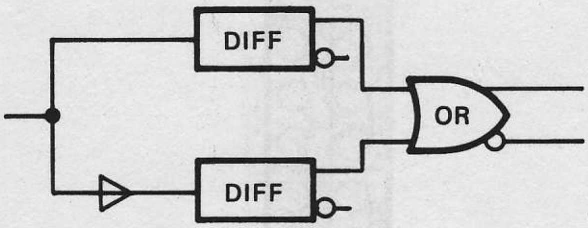
   If all of the logic signals emanate from the logic components there will be no problem in this regard. Typically, problems occur when an external signal is being processed. In general, the external signal should be buffered with a delay flip-flop prior to doing any other operation, especially logic differentiation.



5. The DIF, as packaged, is a leading edge differentiator. A trailing edge differentiator is obtained simply by applying the complementary input.



6. A bipolar differentiator, generating a pulse whenever the input changes can be implemented by ORing the outputs of a leading edge and a trailing edge differentiator.



7. The MACS display and readout for the DIF indicated the state of the internal flip-flop. The program panel output, because of its transitory nature, is not displayed. See Figure 5.10.

8. In general, the logic clear (CLR) mode forces all flip-flops to their "0" state. However, in the case of a DIF, the internal flip-flop is forced to its "1" state. This is done so that the DIF output in the CLR mode will be low regardless of the input.

5.5 COUNTER (15 BIT BINARY)

FUNCTION:

Counting and Timing.

DESIGNATION: CTR

SYMBOL:

As shown in Figure 5.11.

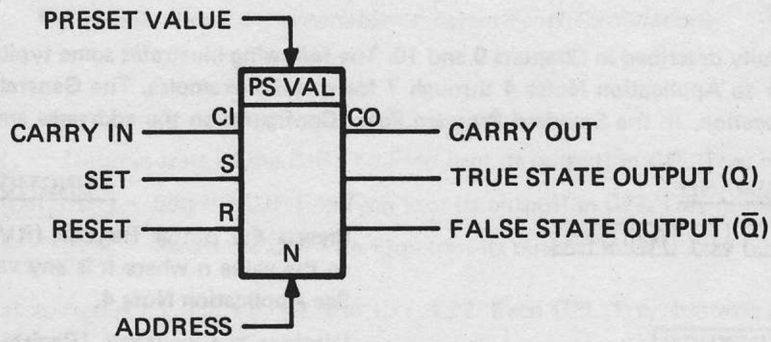


Figure 5.11 General Purpose Counter: Typical Programming Symbol

PROGRAM PANEL:

A COUNTER, as indicated in Figure 5.12, is included in each General Purpose Logic Tray.

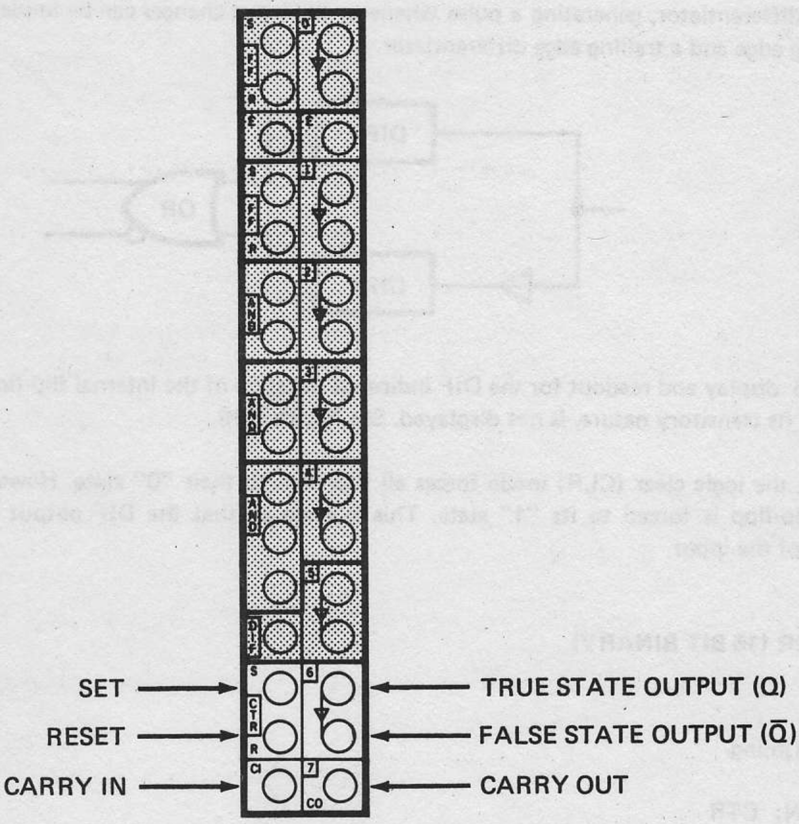


Figure 5.12 General Purpose Counter: Program Panel Terminations

TYPICAL COMMANDS:

MACS Commands are fully described in Chapters 9 and 10. The following illustrates some typical commands associated with a Counter . Refer to Application Notes 4 through 7 for specific examples. The General Purpose Counter is addressed using its tray location. In the Standard Program Panel Configuration the addresses are 1, 2; 5, 6; and 11, 12.

COMMAND	FUNCTION
[R] [V] [x] [=] [n] [RETURN]	Presets the Buffer Register (RV) of Counter Number x to the value n where n is any value from 1 - 326767_{10}. See Application Note 4.
[R] [V] [x] [RETURN]	Displays the contents (Register Value in decimal) of the selected Counter x. See Application Note 5.
[L] [x] [6] [RETURN]	Displays the output of the State Flip-Flop for Counter Number x. See Application Note 6.
[L] [x] [6] [=] [1] [RETURN]	Sets the State Flip-Flop (6) of Counter Number x. See Application Note 6.
[L] [x] [6] [=] [Ø] [RETURN]	Resets the State Flip-Flop (6) of Counter Number x. See Application Note 6.
[L] [x] [7] [RETURN]	Displays State of Carry out (7) for Counter Number x. See Application Note 7.

APPLICATION NOTES:

1. Basic Operation of the Counter, assuming the counter is initially reset, is described in the following steps (a - e). This description assumes that the Counter is initially reset. See Figure 5.13.

   a. A preset count is entered by user command from MACS. This initial value is stored in a buffer register.

   b. The initial value in the buffer register is automatically transferred to the counter register. The contents of the buffer register remain intact.

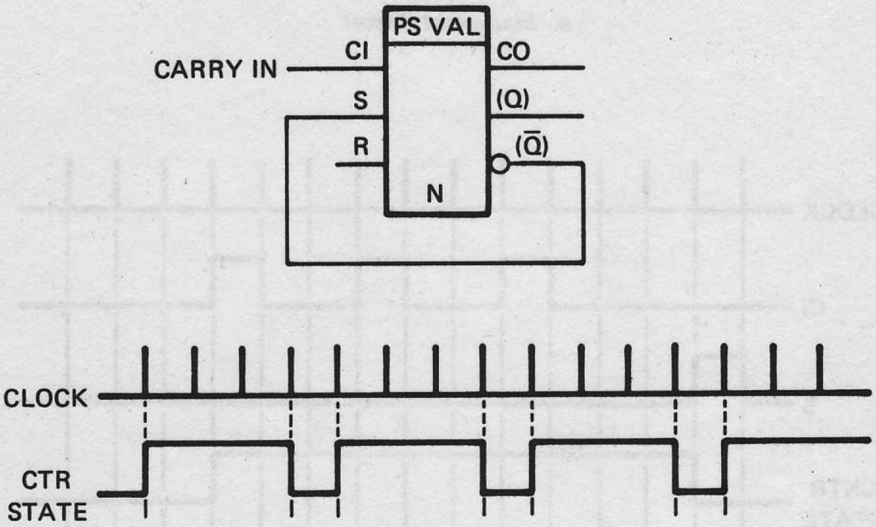
   c. A blip input applied to the Set (S) terminal enables the counter for counting and causes the state output to go high. The state output remains high until counting is completed, or is aborted by a Reset input.

   d. Once set, a Carry In (CI) blip will decrement the counter contents by one.

   e. Counting continues until the counter reaches "1". Then, coincidental with the next Carry In: a Carry Out (CO) blip is generated; the State output goes low; the counter is disabled; and the initial value in the buffer register is reloaded into the counter register.

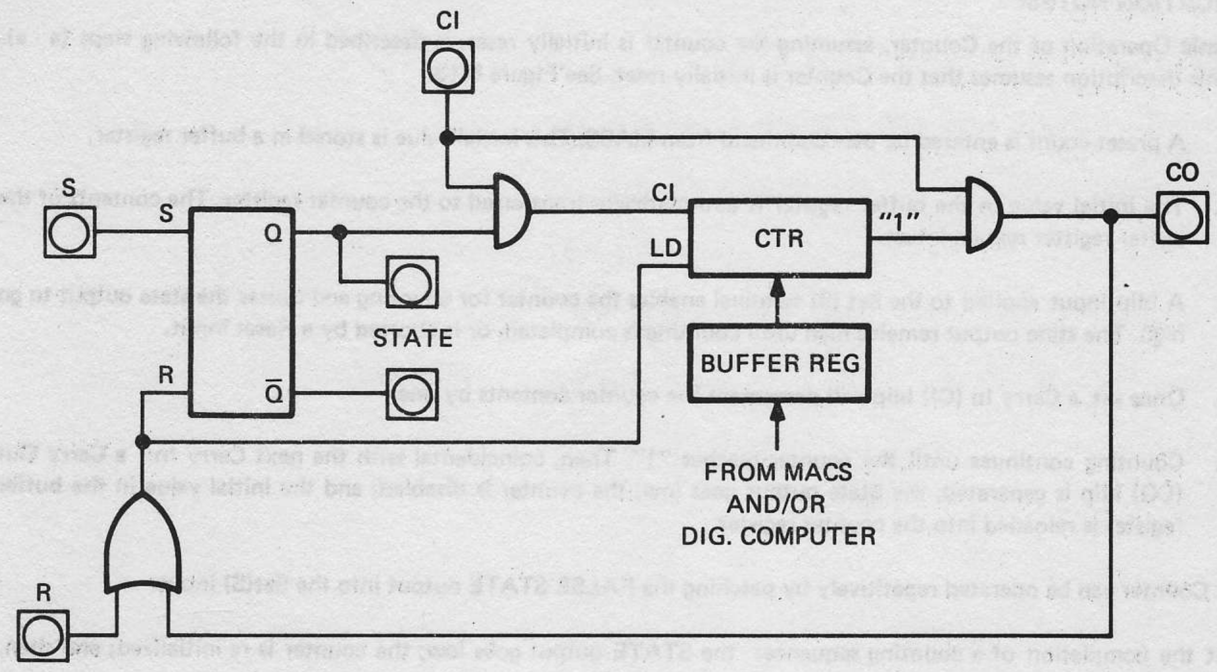
2. A Counter can be operated repetitively by patching the FALSE STATE output into the Set(S) input.

   At the completion of a counting sequence: the STATE output goes low; the counter is re-initialized; and then, on the next clock pulse, counting resumes.

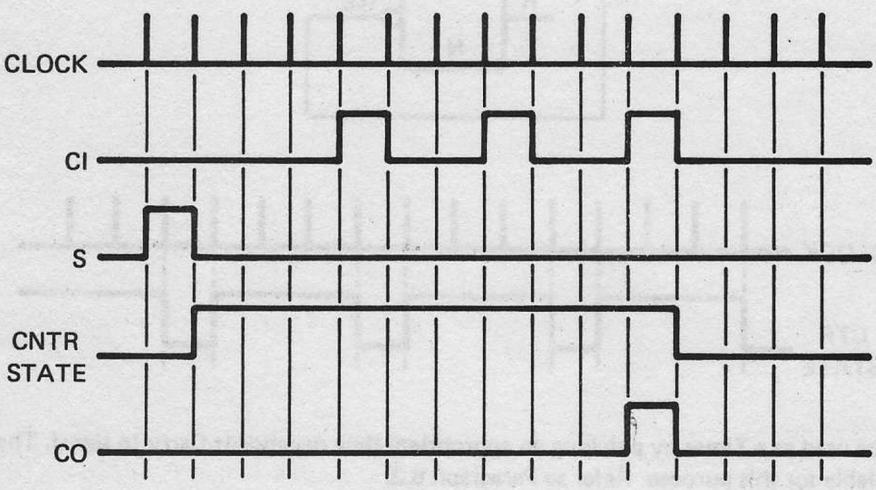


3. A Counter can be used as a Timer by patching an appropriate time dependent Carry In signal. There are a variety of pulse trains available for this purpose. Refer to Paragraph 6.3.

   If the Carry In is maintained at a logic 1, the Counter operates at clock frequency (10^6 counts/sec).



a. Equivalent Circuit



b. Typical Timing Diagram

Figure 5.13 General Purpose Counter: Equivalent Circuit and Timing

4. The preset value of the Counter is entered by user command from MACS. For example, the command

[R] [V] [2] [=] [3] [Ø] [RETURN]

initialized the corresponding buffer register to the value 30.

   a. The characters RV stand for "Register Value."

   b. The numerical address (2) refers to the tray location that is marked on the program panel (L2_).

   c. The value can be any positive integer from one to $32{,}767_{10}$.

The preset value can be loaded into the buffer register while counting is in progress.

5. The Counter contents can be displayed on the MACS Screen.

For example, the command

[R] [V] [2] [RETURN]

displays the decimal equivalent of the Register Value of the Counter in Logic Tray position 2 (L2_).

6. The Counter State flip-flop (Figure 5.12) is treated as a general purpose logic component. It can be displayed and manipulated by command from MACS. For example, the command

[L] [2] [6] [RETURN]

displays the state output for the Counter in tray location 2.

Similarly, the commands

[L] [2] [6] [=] [1] [RETURN]

and

[L] [2] [6] [=] [Ø] [RETURN]

serve to manually Set and Reset the Counter.

7. The Counter Carry Out gate (Figure 5.12) is treated as a general purpose logic component. It can be displayed by command from MACS. For example, the command

[L] [2] [7] [RETURN]

displays the Carry Out for the Counter in tray location 2. However, since the Carry Out is a blip during dynamic operation, this readout is only meaningful for Static Check purposes in the Logic Stop Mode.

5.6 GENERAL PURPOSE REGISTER

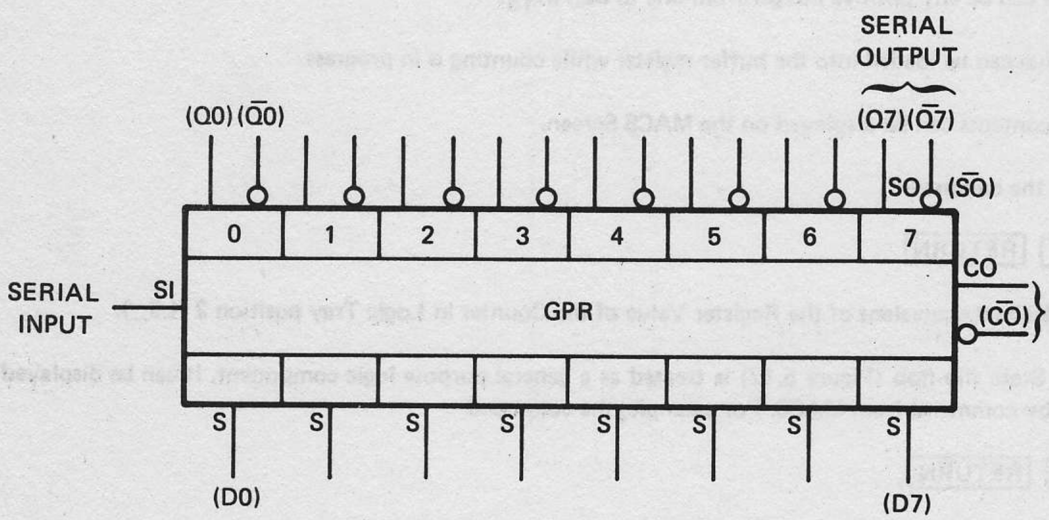
FUNCTION:

Sequential Logic Operations

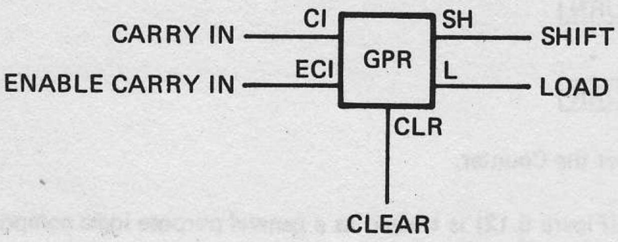
DESIGNATION: GPR

SYMBOLS:

See Figure 5.14.



a. Data



b. Control

Figure 5.14 General Purpose Register: Programming Symbols

PROGRAM PANEL:

The General Purpose Register (GPR) occupies an entire tray (the GPR tray). The Program Panel terminations are indicated in Figure 5.15.

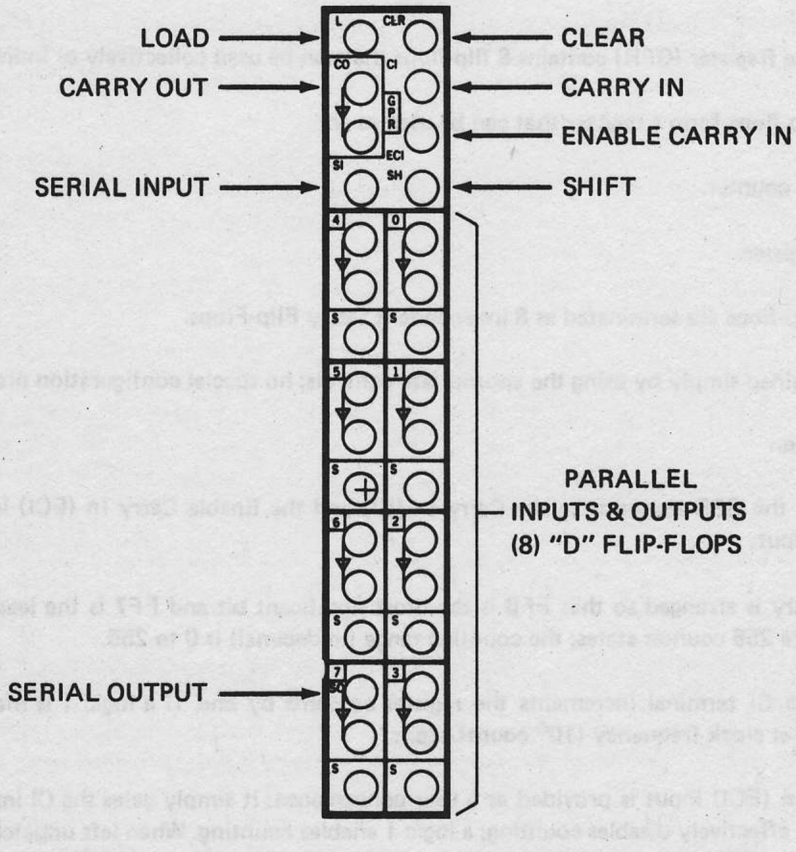


Figure 5.15 General Purpose Register: Program Panel Terminations

TYPICAL COMMANDS:

MACS Commands are fully described in Chapters 9 and 10. The following illustrates some typical commands associated with the GPR. The General Purpose Register (GPR) is addressed using its tray location. In Standard Program Panel Configurations the addresses are 1, 4, and 10. Refer to Application Notes 7 through 10 for specific examples.

COMMAND	FUNCTION
R V x RETURN	Displays the decimal value of the eight bit register located in tray position x. See Application Note 7.
R V x = n RETURN	Loads the decimal value n into the register in tray position x. Value n is limited to 255_{18}. See Application Note 8.
R V x = ' n RETURN	Loads the octal value n into the register in tray position x. 'n is limited to 377_8. See Application Notes 8 and 10.
L x n RETURN	Displays the state of individual flip-flop number n (FFn) of the GPR located in tray position x. See Application Note 9.

APPLICATION NOTES:

1. The General Purpose Register (GPR) contains 8 flip-flops that can be used collectively or individually.

   Collectively, the flip-flops form a register that can be used as an:

   a. 8-bit binary up counter.

   b. 8-stage shift register.

   Individually, the flip-flops are terminated as 8 independent Delay Flip-Flops.

   These roles are obtained simply by using the appropriate controls; no special configuration procedure is involved.

2. COUNTER Operation

   As a basic counter, the GPR responds to the Carry In (CI) and the Enable Carry In (ECI) inputs and produces a Carry Out (CO) output.

   The internal circuitry is arranged so that FFØ is the most significant bit and FF7 is the least significant bit. With 8 flip-flops, there are 256 counter states; the counting range (in decimal) is 0 to 255.

   A Blip input at the CI terminal increments the register contents by one. If a logic 1 is maintained, the register contents increment at clock frequency (10^6 counts/sec.).

   The Enable Carry In (ECI) input is provided as a user convenience; it simply gates the CI input. A logic Ø applied at the ECI terminal effectively disables counting; a logic 1 enables counting. When left unpatched, the ECI terminal is normally high. Thus, if this feature is not desired, it may be ignored.

   After all 8 flip-flops are set, the next Carry In produces a Carry Out. This output is formed as the AND of the 8 flip-flop states and the CI input. Assuming the CI input is synchronized, the Carry Out is a Blip.

   At the same time that a Carry Out is generated (assuming no other control is exercised) the register contents are automatically cleared. It should be noted that: starting from zero requires 256 CI blips before a CO blip is generated.

3. Shift Register Operation

   As a basic shift register, the GPR responds to the shift (SH) and the Serial Input (SI) inputs, and produces a Serial Out (SO) output.

   The internal circuitry is arranged so that shifting proceeds from left to right (from FFØ towards FF7).

   A Blip input at the SH terminal causes the register contents to be shifted one place. If a logic 1 is maintained, the register contents are shifted at clock frequency (10^6 shifts/sec).

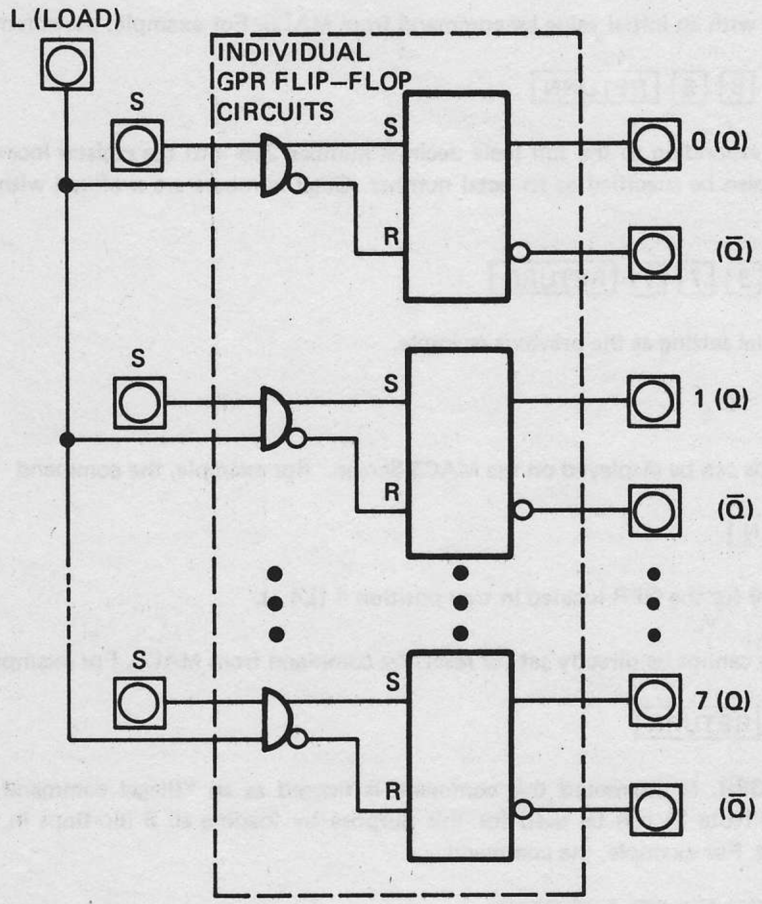
   When a shift is executed, the first flip-flop (FFØ) sets or resets depending on the Serial Input. If SI is high, FFØ will set; if SI is low or unpatched, FFØ will be reset. Effectively, the data at the Serial Input is shifted into the vacated bit Ø position.

   The Serial Output is merely the output of the last flip-flop in the line (FF7).

Combining the FF outputs with SI and feeding them back in an easy way to make a modulo n counter ($M<2^8-1$).

4. Independent Flip-Flops

When the GPR is not being used for counting or shifting operations, the 8 flip-flops can be used as independent Delay Flip-Flops. To enable these flip-flops for independent operation, it is necessary to patch a logic 1 into the load (L) terminal.



5. Parallel Load from Program Panel

The GPR can be loaded with an initial value from the program panel. The scheme is essentially the same as using the independent flip-flops (Application Note 4) except that the Load (L) control is supplied with a blip rather than a level. Effectively, all 8 register bits are loaded in parallel during one clock period. The bit pattern is determined by logic values patched into the individual set (S) inputs.

6. Parallel Clear from Program Panel

The Clear (CLR) input is used to clear the register contents to zero. A blip applied at the CLR terminal is sufficient to reset all 8 flip-flops in parallel during one clock period. If a logic 1 is maintained at the CLR terminal, the register remains cleared regardless of any other inputs.

7. The current contents of the GPR, expressed as a decimal number, can be displayed on the MACS Screen.

For example, the command

[R] [V] [4] [RETURN]

displays a decimal readout for the register located in tray position 4 (L4_) of the Logic Field.

8. The GPR can be loaded with an initial value by command from MACS. For example, the command

[R] [V] [4] [=] [2] [5] [5] [RETURN]

loads a bit pattern corresponding to the full scale decimal number 255 into the register located in tray position 4 (L4_). The value can also be specified as an octal number. Octal numbers are prefixed with an apostrophe. For example, the command

[R] [V] [4] [=] ['] [3] [7] [7] [RETURN]

will affect the same initial setting as the previous example.

$255_{10} = 377_8 = 11\ 111\ 111_2$

9. The individual Flip-Flops can be displayed on the MACS Screen. For example, the command

[L] [4] [Ø] [RETURN]

displays the state of FFØ for the GPR located in tray position 4 (L4_).

10. The individual flip-flops cannot be directly set (or reset) by command from MACS. For example, the command

[L] [4] [Ø] [=] [1] [RETURN]

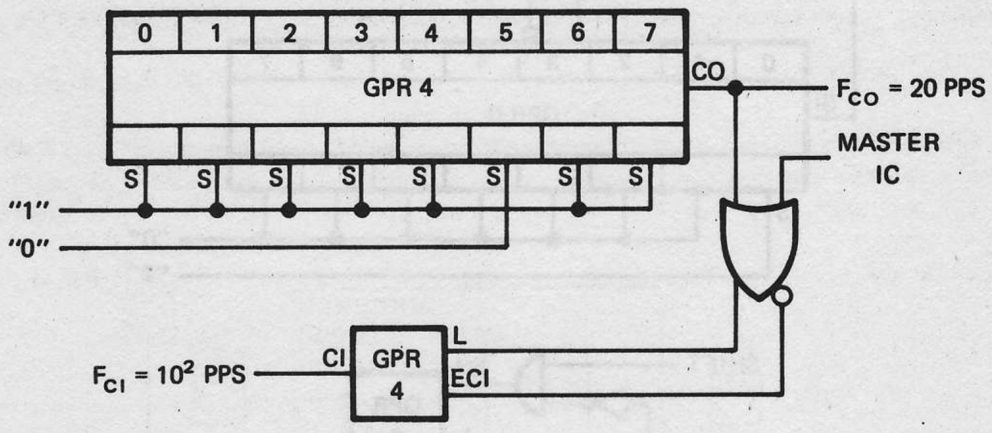
will not work with a GPR. If attempted this command is flagged as an "Illegal command." However, the RV command (Application Note 8) can be used for this purpose by loading all 8 flip-flops in such a manner as to obtain the desired result. For example, the command

[R] [V] [4] [=] ['] [2] [0] [0] [RETURN]

sets FFØ and resets all the other flip-flops associated with the GPR in tray location 4.

11. The GPR has four basic control functions: CLR, L, CI and SH. Of these controls, CLR is dominant; a logic 1 in the CLR terminal forces all 8 flip-flops low regardless of any other control activity. The order of the remaining controls, in decreasing priority, is SH, L, CI. It is the responsibility of the programmer to insure that the proper function is exercised at any given time.

12. As a basic application example, Figure 5.16 shows a GPR being used as a frequency divider. An input pulse train of 10^2 pulses/second is applied at the CI terminal and an output pulse train of 20 pulses/second is generated at the CO terminal.



SEE APPLICATION NOTE 12

Figure 5.16 General Purpose Register: Frequency Divider Application

The GPR is initially loaded during the IC period and is subsequently reloaded everytime a CO blip is generated. To ensure that there is not a control conflict, counting is disabled (via the ECI terminal) whenever the load signal is applied.

In general, for frequency divider applications, the decimal equivalent (N) of the bit pattern to be loaded into the register is given by

$$N = 256 - \frac{fCI}{fCO}$$

For our example

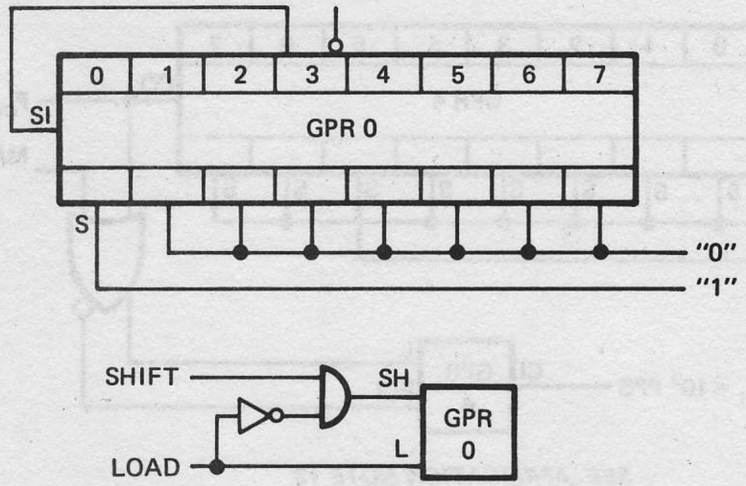
$$N = 256 - \frac{100}{20} = 251$$

and since

$$251_{10} = 373_8 = 11\ 111\ 011_2$$

the corresponding logic constants are applied at the individual Set(S) terminals.

13. Another basic application is illustrated in Figure 5.17. In this application, a GPR is used as a 4-Stage Ring Shift Register.



SHIFT NO.	FF STATES: 0	1	2	3
–	1	0	0	0
1	0	1	0	0
2	0	0	1	0
3	0	0	0	1
4	1	0	0	0

SEE APPLICATION NOTE 13

Figure 5.17 General Purpose Register: 4-Stage Ring Shift Register

The GPR is initialized by a Load signal so that bit Ø is set and all the other bits are reset; an unpatched set input is equivalent to a logic Ø. Further, the complement of the Load signal is gated with the Shift signal thereby disabling the shifting operation while loading is in process.

With each Shift blip input, the "1" is shifted to the adjacent position. The connection between FF3 and the Serial Input (SI) provides a feedback path so that bit 3 is shifted back into bit Ø.

The unused flip-flops in positions 4 through 7 are affected by the shifting operation. Therefore, they are not available for independent operation.

5.7 COMPARATOR

FUNCTION:

Analog to Logic Interface

DESIGNATION: CMP

SYMBOL:

As illustrated in Figure 5.18.

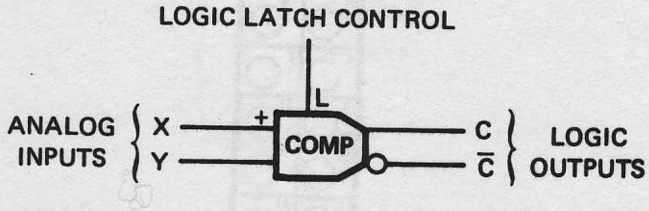


Figure 5.18 Comparator: Typical Programming Symbol

CHARACTERISTIC:

The switching characteristics of the Comparator are illustrated in Figure 5.19.

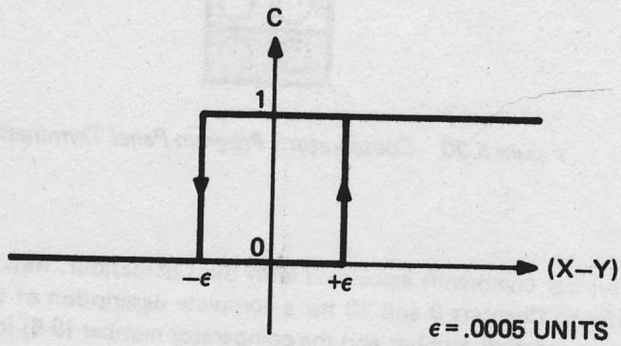


Figure 5.19 Comparator: Switching Characteristic

PROGRAM PANEL:

Six Comparators are contained in the Comparator (CMP) Tray. Program Panel terminations are indicated in Figure 5.20.

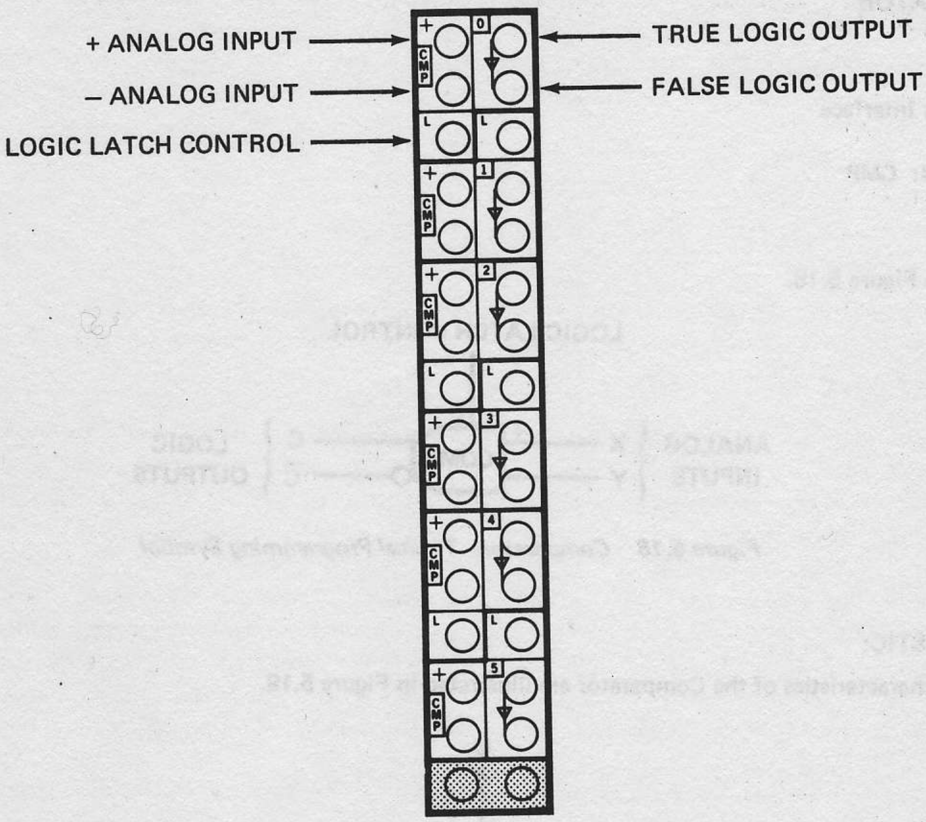


Figure 5.20 Comparator: Program Panel Terminations

TYPICAL COMMANDS:

The following illustrates typical commands associated with the Comparator. Refer to Application Notes 7 and 8 for specific examples. Also refer to Chapters 9 and 10 for a complete description of the MACS Commands. Comparators are addressed using their tray location number and the comparator number (Ø-5) in that tray. In the Standard Program Panel Configuration, Comparator Tray addresses are 3, 7 and 13.

COMMAND	FUNCTION
[L] [x] [n] [RETURN]	Selects and displays the state of Comparator Number n in Comparator tray position x of the Logic Field. See Application Note 7.
[L] [x] [n] [=] [1] [RETURN]	Selects and Sets Comparator Number n in tray position x of the Logic Field. See Application Note 8.
[L] [x] [n] [=] [Ø] [RETURN]	Selects and Resets Comparator Number n in tray position x of the Logic Field. See Application Note 8.

APPLICATION NOTES:

1. The Comparator is the basic Analog to Logic interface component. It accepts two analog inputs and provides a logic output, depending on the difference of the inputs.

2. The analog inputs are differential. The positive input is marked with a + sign; the negative input is unmarked.

3. With reference to Figure 5.18, the logic output (C) indicates whether the difference (X-Y) is positive or negative. The following expression described the Comparator output:

$$C = \begin{cases} 1, & X\text{-}Y>0 \\ 0, & X\text{-}Y<0 \end{cases}$$

4. To prevent "Chatter" when the input difference is near zero (within ϵ), a hysteresis band, as indicated in Figure 5.19, is incorporated into the Comparator design. In most practical situations, the hysteresis is sufficiently small so that it can be ignored.

5. The Comparator output is synchronized; the output will only change in coincidence with the trailing edge of System Clock. They synchronizing action introduces a delay in Comparator response; the maximum delay is one clock period (1 microsecond). For most practical applications, this delay (relative to the analog signal frequencies) is negligible and can be ignored.

6. The Comparator has a Logic Latch (L) Control input. When L is maintained at a logic 1 level, the Comparator response to the analog inputs is inhibited. Therefore, the Comparator output (when latched) remains at the prior level (state). When the Latch Control is returned to a logic Ø, the Comparator responds to the analog inputs in the normal manner. When L is left unpatched, the Latch Control is low (logic Ø), and the latching feature is inhibited. Therefore, if the latching feature is not required for a given application, simply leave the L termination unpatched.

7. The output of a Comparator can be displayed by command from MACS. For example, the command

   [L] [3] [5] [RETURN]

   displays the output of Comparator 35 (Comparator 5 in tray position 3).

8. A Comparator can be set or Reset by command from MACS. For example, the command

   [L] [3] [5] [=] [1] [RETURN]

   sets Comparator 35, and the command

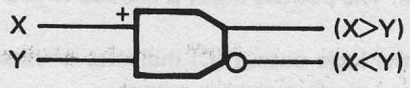
   [L] [3] [5] [=] [Ø] [RETURN]

   resets Comparator 35.

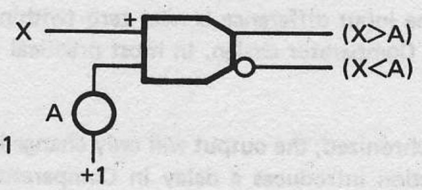
   These commands are in effect for only one clock period. On the next clock, the output again responds to the inputs.

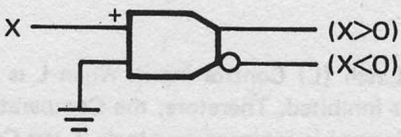
   These commands override the logic latch control. For example, if the Comparator is latched in a "Ø" state when a Set command is issued, the Comparator sets to the "1" state and remains latched in that state.

9. It is common practice to label the output of a Comparator with the input condition that causes the output to go high.

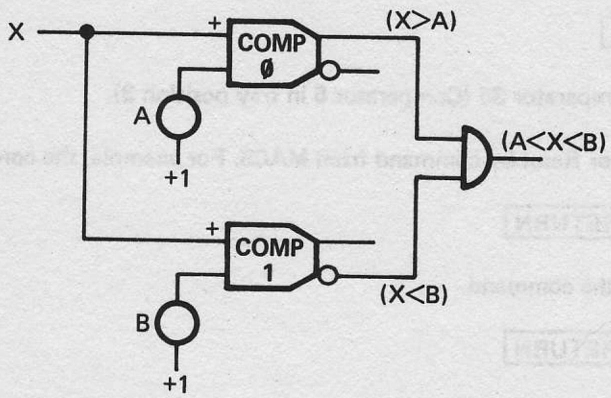


10. **The Comparator is often used to detect the occurence of an analog variable (X) crossing a fixed threshold. Typically, the fixed threshold value is introduced by patching a Coefficient Unit into the negative (–) input of the Comparator. If the desired threshold value is zero, the threshold input can be patched to ground (any black terminal). The input should not be left unpatched to obtain a threshold of zero.**





11. **The limit detection circuit is an extension of the example in Application Note 10. Two Comparators and an AND gate are used to detect the occurence of an analog variable within a specified band.**



12. **Comparators are often used in conjunction with Selector Switches (Paragraph 4.9). An absolute value circuit (one application of this) is illustrated in Figure 5.21.**

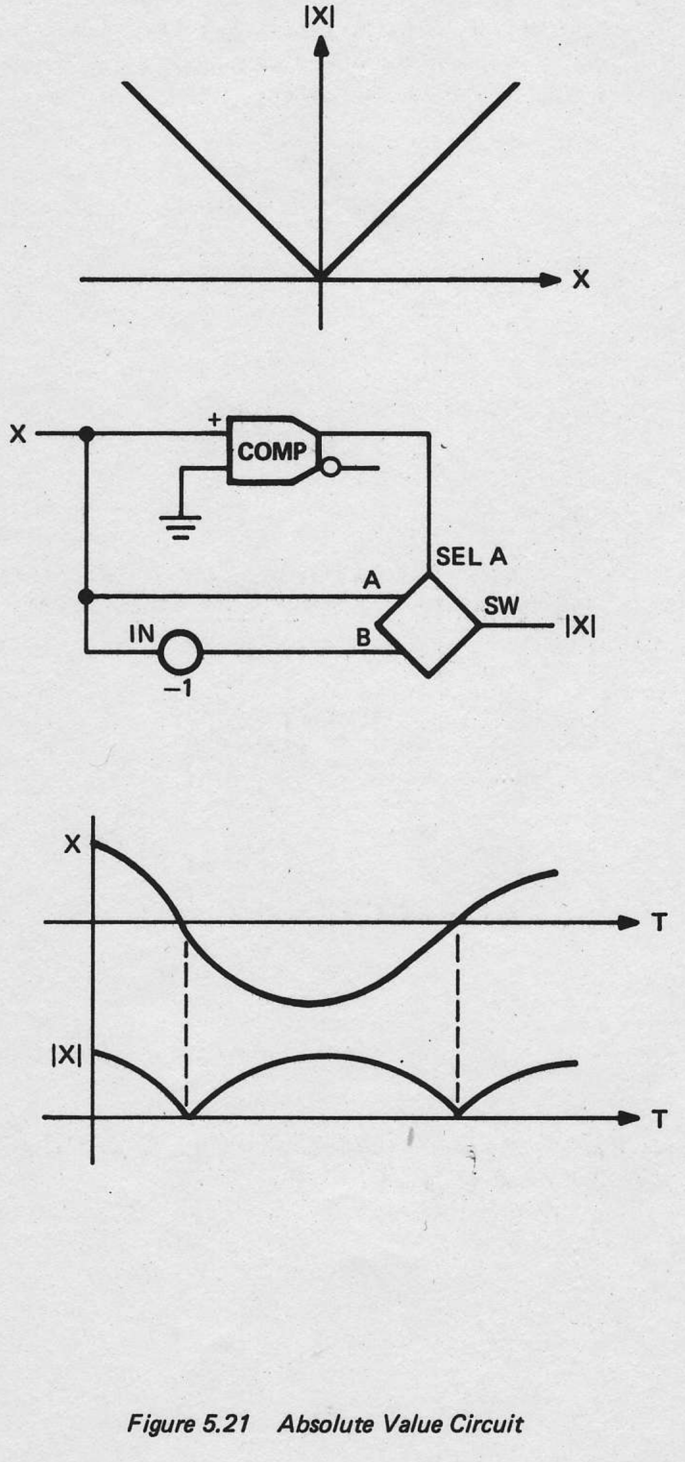


Figure 5.21 Absolute Value Circuit

CHAPTER

6

6.1 INTRODUCTION

This chapter is devoted to programming and application of those devices which in one or more ways are used in the EAI 2000 for operation as a system.

The system components include:

- System Clock
- Pulse Train Outputs
- Rep-Op Timer
- Keyboard Pulses
- Logic Trunks
- Analog Trunks
- Program Panel Mode Control
- Readout and Display Tray

6.2 SYSTEM CLOCK

FUNCTION:

Synchronization of Sequential Logic Components

DESIGNATION: CLOCK

SYMBOL:

The System Clock is not indicated on programming diagrams; its presence is implicitly assumed.

PROGRAM PANEL:

The System Clock is not terminated on the Program Panel.

APPLICATION NOTES:

1. The System Clock is a crystal controlled oscillator operating at a frequency of 1MHz.

2. The System Clock serves as the logic system's primary timing reference. It is used internally to synchronize the operation of all sequential logic components as described in Paragraph 5.3.

6.3 PULSE TRAIN OUTPUTS

FUNCTION:

Timing References

DESIGNATION: PULSE

SYMBOL:

As shown in Figure 6.1

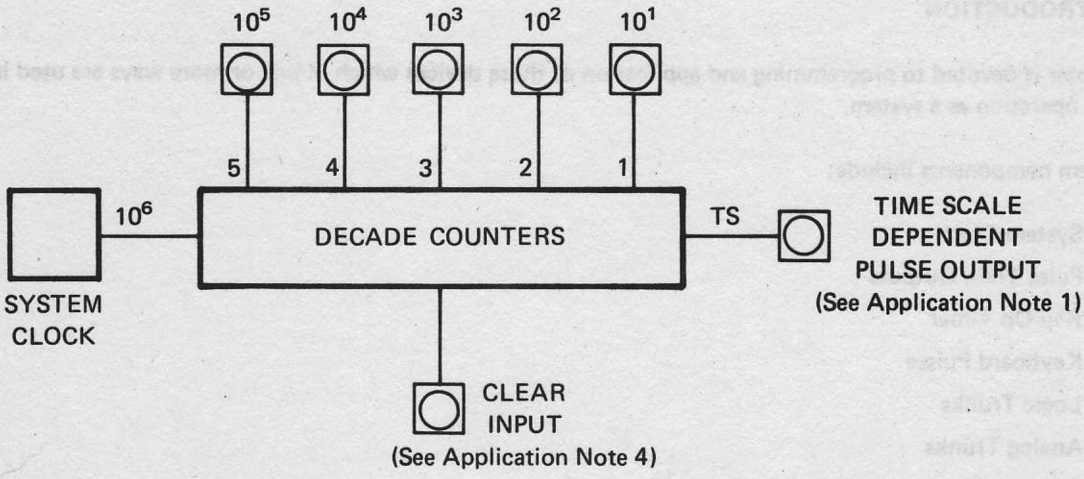


Figure 6.1 Pulse Train Outputs: Symbol and System Arrangement

PROGRAM PANEL:

Six Pulse Train Outputs and an associated Clear (CLR) control input are terminated in the Special Purpose Control tray. See Figure 6.2.

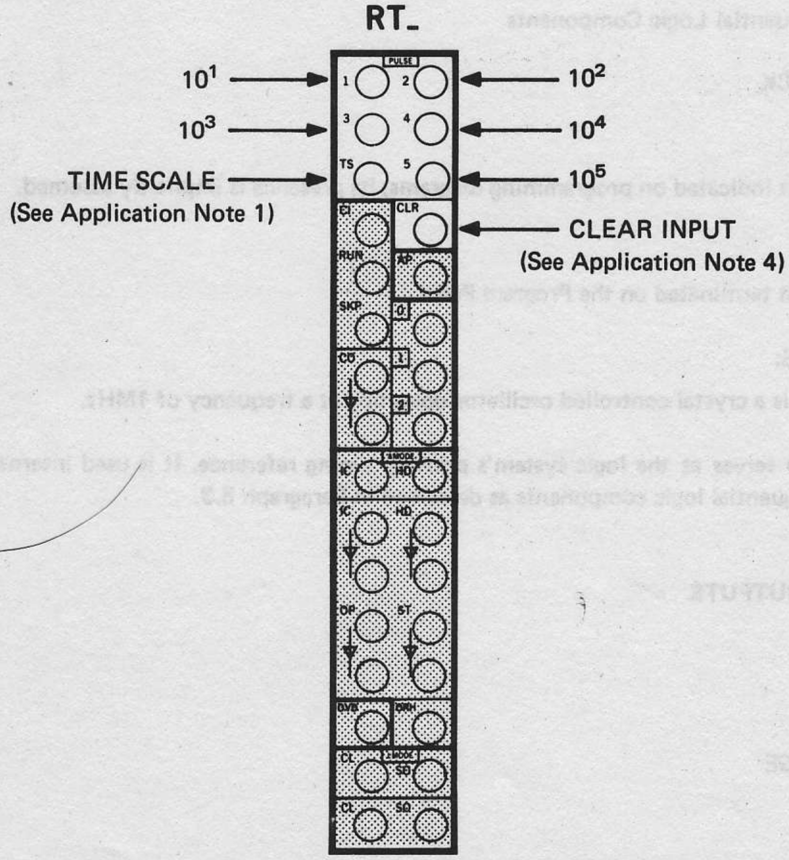


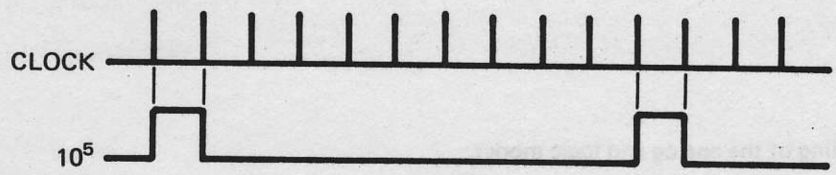
Figure 6.2 Pulse Train Outputs: Program Panel Terminations

APPLICATION NOTES:

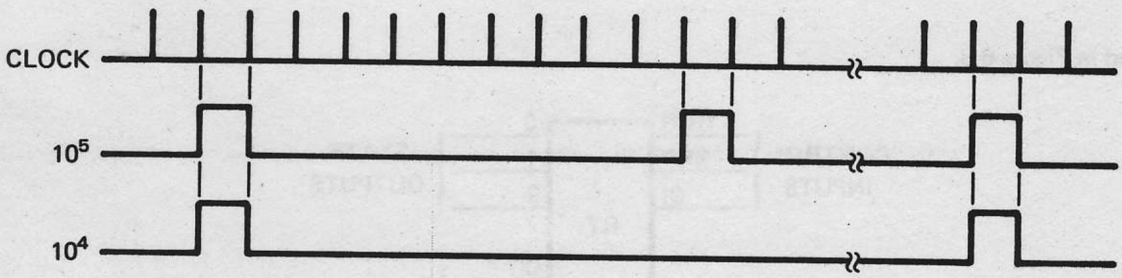
1. Six pulse trains, derived from the system clock are terminated on the program panel. Five of these have fixed. frequencies. One of them (labelled "TS") has a frequency proportional to the selected Master Time Scale as indicated below:

MASTER TIME SCALE	"TS" Frequency (pulses/sec.)
E0	10^2
E1	10^3
E2	10^4
E3	10^5
E4	Constant Logic "1"

2. The pulse outputs are blips; each pulse is one clock period in duration and is synchronized with the system clock.



3. The pulse trains are in phase with each other; corresponding pulse outputs occur during the same clock interval.



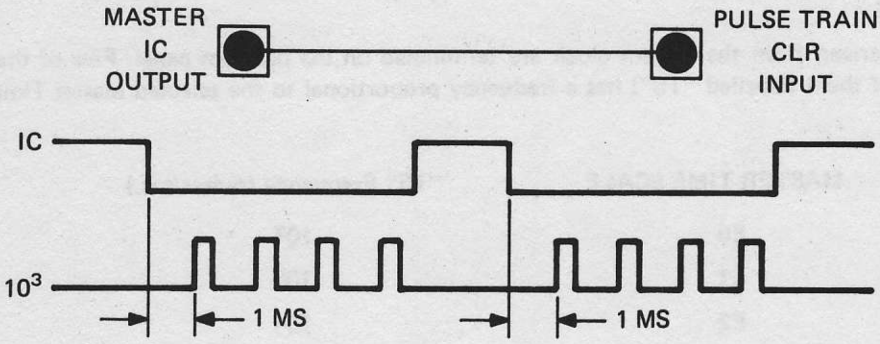
4. The pulse train outputs, as indicated in Figure 6.1, are generated by a series of five decade counters. These counters have a common Clear (CLR) input.

   When CLR is high: pulse generation is suspended and all five counters are re-initialized.

   When CLR is low: pulse generation proceeds as described in the previous notes.

   Left unpatched, the CLR input is normally low. If the Clear feature is not required, the CLR input can be ignored.

5. The CLR input is often used to synchronize the pulse train outputs with the start of an analog run. For example, patching the Master IC output to the pulse train CLR will insure a repeatable pulse pattern to within 1 microsecond, during successive Operate periods.



6. The pulse train outputs are unaffected by the logic mode control. Pulse outputs are generated regardless of any controls except for the local CLR input.

6.4 REP-OP TIMER

FUNCTION:

Control the repetitive cycling of the analog and logic modes.

DESIGNATION: RT

SYMBOL:

As illustrated in Figure 6.3.

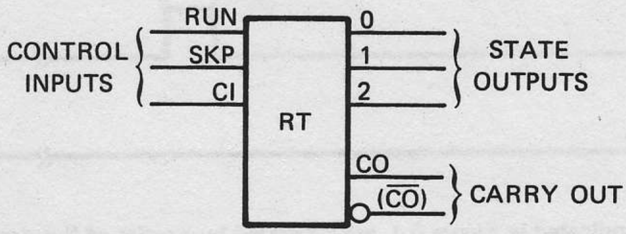


Figure 6.3 Rep-Op Timer: Typical Programming Symbol

PROGRAM PANEL:

The Rep-Op Timer is terminated in the special purpose CONTROL tray as indicated in Figure 6.4.

The Rep-Op Timer is a 3 stage counter; the stages are designed RT0, RT1 and RT2.

Each stage is preset with an initial count (time interval) from MACS. The preset values are stored in buffer registers.

Counting begins in the RT0 stage, proceeds to the RT1 stage, and then to the RT2 stage. When RT2 is completed, the cycle is repeated.

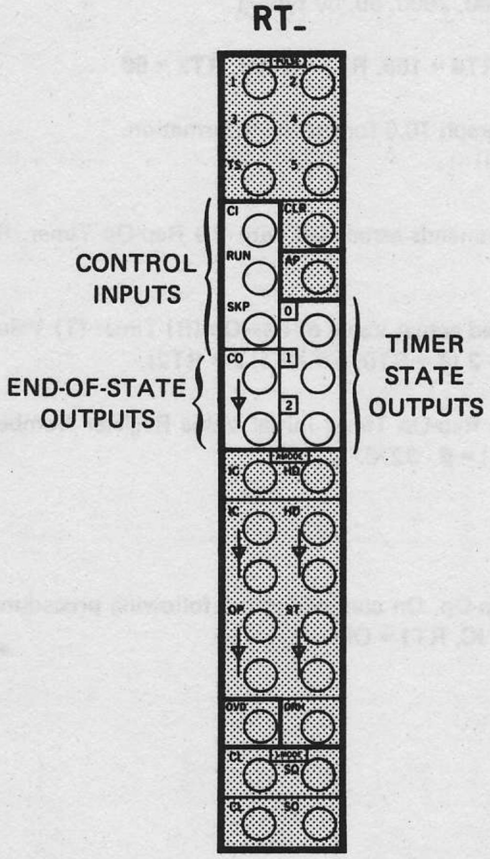


Figure 6.4 Rep-Op Timer: Program Panel Terminations

A state output is provided for each stage. The state output for a given stage is high while counting is in process in that stage.

The RUN input is used to enable (and disable) the counting process. It is normally high when unpatched.

The CI input controls the duration that counting is in process for each stage. It is normally low when not in use.

The SKP input provides a means to abort the balance of an interval based on some program event. It is normally low when not used.

The CO produces a pulse at the end of each interval. It is high for the last clock period of each interval.

Rep-Op Timer states 0, 1, 2 are mutually exclusive: one and only one of them has a high output at any instant of time. When the timer RUN input is low, the timer is held in the Ø-state. When RUN comes high, the timer remains in Ø for the preset time interval, then goes into the 1-state for that preset time interval, then into the 2-state for that preset time interval, then back into Ø for another repetitive cycle. The time intervals are set, in one of the two ways. The MACS initializing command [J] [;] [RETURN] sets the timer states to 500, 5000, 0 (states Ø, 1, 2; respectively).

Or, for example, one can set the states to 150, 2000, 50, by typing

RTØ = 15Ø, RT1 = 2ØØØ, RT2 = 5Ø

and pressing RETURN . Refer to Paragraph 10.6 for further information.

TYPICAL COMMANDS:

The following illustrates some typical commands associated with the Rep-Op Timer. Refer to Chapters 9 and 10 for more detailed information.

R T x RETURN = Select and read actual Value of Rep-Op (R) Timer (T) Value Register Number x. Where x = Ø - 2 (Ø = RT0; 1 = RT1; 2 = RT2).

R T x = i RETURN = Sets Rep-Op Timer Initial Value Register Number x to Value i. Where x = Ø - 2 and i = Ø - 32767_{10}.

APPLICATION NOTES:

1. Normal Rep-Op

No patching is needed for normal Rep-Op. On completing the following procedure the analog elements will cycle between the IC and OP modes (RT0 = IC, RT1 = OP).

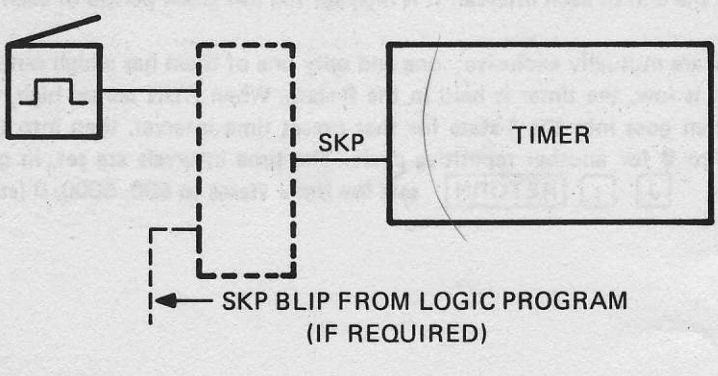
a. choose the time intervals
b. choose the master time scale
c. choose the logic mode
d. type AR and press RETURN

The time period for each stage is determined by the preset number of counts divided by the frequency of the CI pulse train. When the AR mode is selected, the CI pulse train is automatically connected to the TS pulse output (Paragraph 6.3). For example: Operating with a Master Time Scale of EØ yields a CI frequency of 100 counts/second. Thus, a preset count of 5000 corresponds to 50 seconds.

a. If RT2 is set to a value other than zero, the timer becomes a three-mode timer, with

RT0 = IC
RT1 = OP
RT2 = HOLD

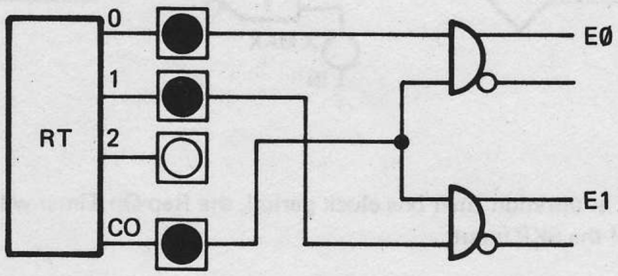
b. When the user selects any other analog mode by typing an appropriate command on the keyboard, the Rep-Op Timer will halt. It will not return automatically to the Ø-state. A pulse applied to the SKP input will cause the timer to advance to the next interval.

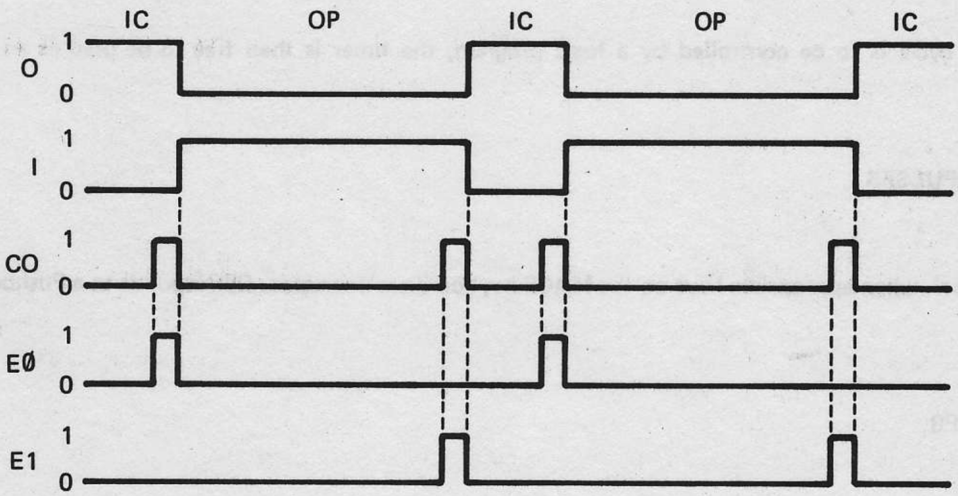


A blip ⎍ (patched through an OR-gate, if required) allows the user to advance the timer from 1 or 2 to 0, manually.

2. End-of-State Output

CO, the end-of-state output, can be gated with any state output to give a blip at the end of the cycle for that state.

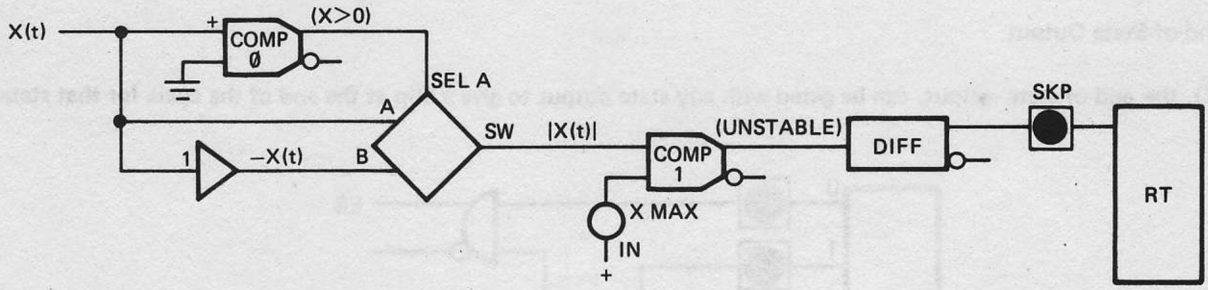




3. Skipping States

Ocassionally, a user will run a program having an OP-interval long enough to suit a "worst case" requirement. For example, suppose one is simulating a system to investigate its instabilities. The desired result is the YES-NO answer to the question: "for these values of the parameters, is the system unstable?" Generally, the definition of instability includes something like, "the system output has grown to K times the steady-state value (or some other arbitrary amplitude) within T seconds." This kind of problem will undoubtedly be run in Rep-Op at high speed so that hundreds of solutions will be generated per second. Thus, the Rep-Op 1 interval will be chosen long enough so that it represents, in scale, T seconds. But, suppose the system goes unstable in 0.1T for 20% of the parametric combinations, in .2T for another 20% in .5T for another 20% and in .8T for another 30%. This means that the full T seconds is needed only 10% of the time; the rest of the time is useless since the simulation has already delivered the desired answer and is marking time until the 1-interval has ended. Using the numbers and percents given, one sees that the complete run (N combinations of parametric values can be done in NT/2 instead of NT seconds; a 50% savings in time.

To obtain the savings one needs merely to input a blip at the SKP input. The timer will respond with a CO blip and abort the balance of this interval. The blip can be derived from the stabilizing test circuit.



If the input to SKP is longer in duration than one clock period, the Rep-Op Timer will skip states at one state per clock pulse for the duration of the SKP input.

4. General-Purpose Use

If the Rep-Op cycle is to be controlled by a logic program, the timer is then free to be used as an additional counter/timer.

6.5 KEYBOARD PULSES

FUNCTION:

Provides a blip (pulse), when appropriate keys on the MACS keyboard are depressed. Corresponds to a Pushbutton Flip-Flop.

DESIGNATIONS:

⎍ , BLIP, MAN PB

SYMBOLS:

As shown in Figure 6.5

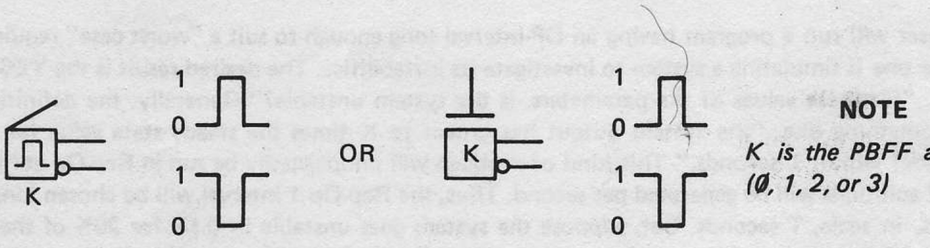


Figure 6.5 Keyboard Pulses: Programming Symbols

PROGRAM PANEL:

As shown in Figure 6.6

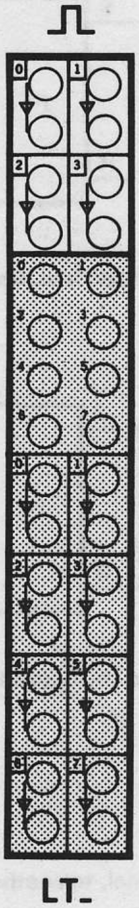


Figure 6.6 Keyboard Pulses: Program Panel Terminations

TYPICAL COMMANDS:

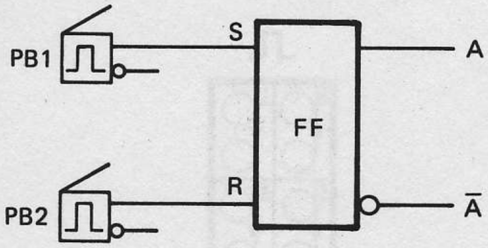
COMMAND	FUNCTION
[BLIP] [x]	Generates a pulse at the corresponding Program Panel Termination designated ⎍ x. Where x = Ø - 3.

APPLICATION NOTES:

1. The true output (⎍) is low until, with the MACS [BLIP] key held down, the address of the PB (Ø, 1, 2 or 3) is pressed. Simultaneously, the inverted (FALSE) output is high.

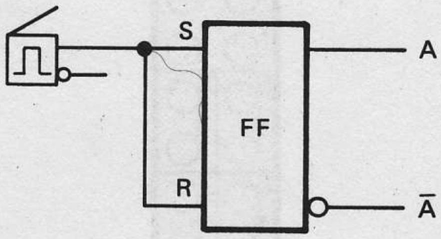
   When the [BLIP] and numeric address keys are pressed, the output (⎍) goes high for one clock period. Blips can be used to change a logic condition manually increment a counter, or set and reset a flip-flop. Blips are usually used for a Single-Step check of sequential logic circuit(s).

2. To obtain a manually-controlled level (high or low), patch two PB's as shown below:



Alternately keying PBØ and PB1 causes A to go high and low, respectively.

3. Another implementation uses one PB:



Each time the blip is generated, the output toggles to the opposite state.

6.6 LOGIC TRUNKS

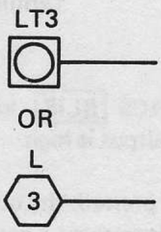
FUNCTION:

1. Provide paths for logic singals from the program panel, to another EAI 2000 console or compatible external digital circuitry. See Application Note 2.

2. Provide paths for logic signals originating at external devices, to the program panel.

DESIGNATION: LT

SYMBOLS:



PROGRAM PANEL:

As shown in Figure 6.7

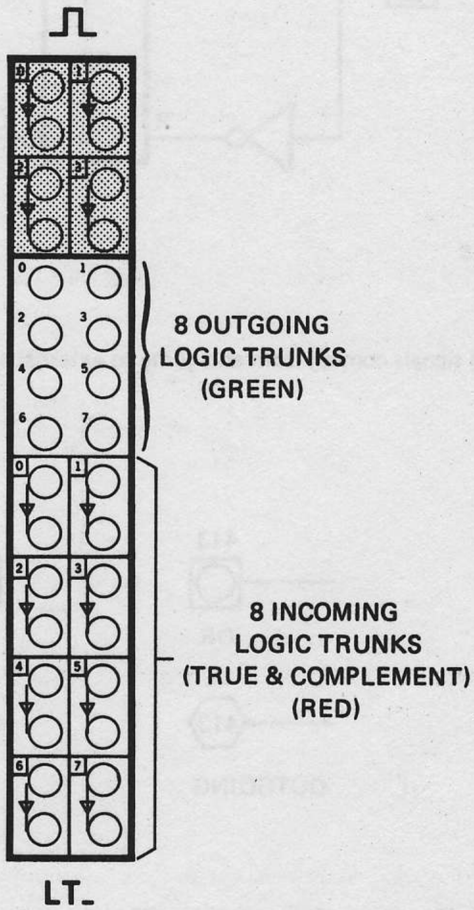


Figure 6.7 Logic Trunks: Program Panel Terminations

APPLICATION NOTES:

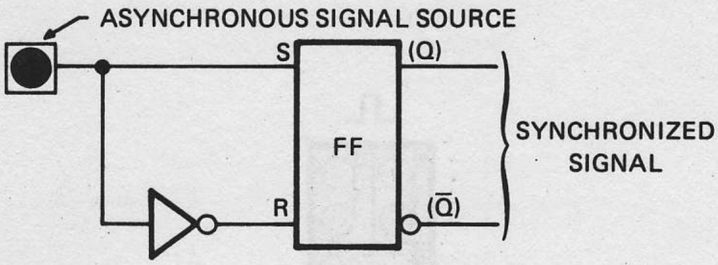
1. The programming symbol for a logic trunk does not explicitly indicate whether a trunk is incoming or outgoing. This should be obvious from the context; incoming trunks (color-coded red) are connected to inputs, outgoing (green) to outputs.

2. External logic trunk signal requirements are +5 volts for logic TRUE and zero volts for logic FALSE. The Logic Trunks are fully compatible with standard TTL logic.

   Circuitry within the logic trunk tray interfaces these TTL levels to the program panel (See Paragraph 2.6).

3. Signals emanating from external sources are asynchronous with respect to the EAI 2000 System Clock.

   If these signals are to be used with synchronous components, it is generally good practice to synchronize them with a D flip-flop before any other processing takes place.



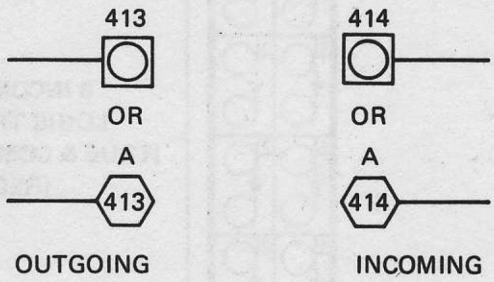
6.7 ANALOG TRUNKS

FUNCTION:

Provides paths for analog signals coming from and going to external analog devices.

DESIGNATIONS: AT

SYMBOLS:



PROGRAM PANEL:

Each of the three possible T__ trays (Figure 6.8) has 32 bidirectional, analog trunks.

The trunks on the left-hand side of the tray have three-digit numbers: 400-407, 410-417 on the first block (Row 3); 420-427, 430-437 on the second (Row 3); and 440-447, 450-457 (Row 1) on the third. Further, the trunks on the right-hand side are numbered correspondingly but with a two-digit number. The two-digit number is an address. Therefore, MACS can display the analog value of any of the right-hand trunks.

To read the value of the signal on trunk 41, for example, enter [T] [4] [1] [RETURN] from MACS.

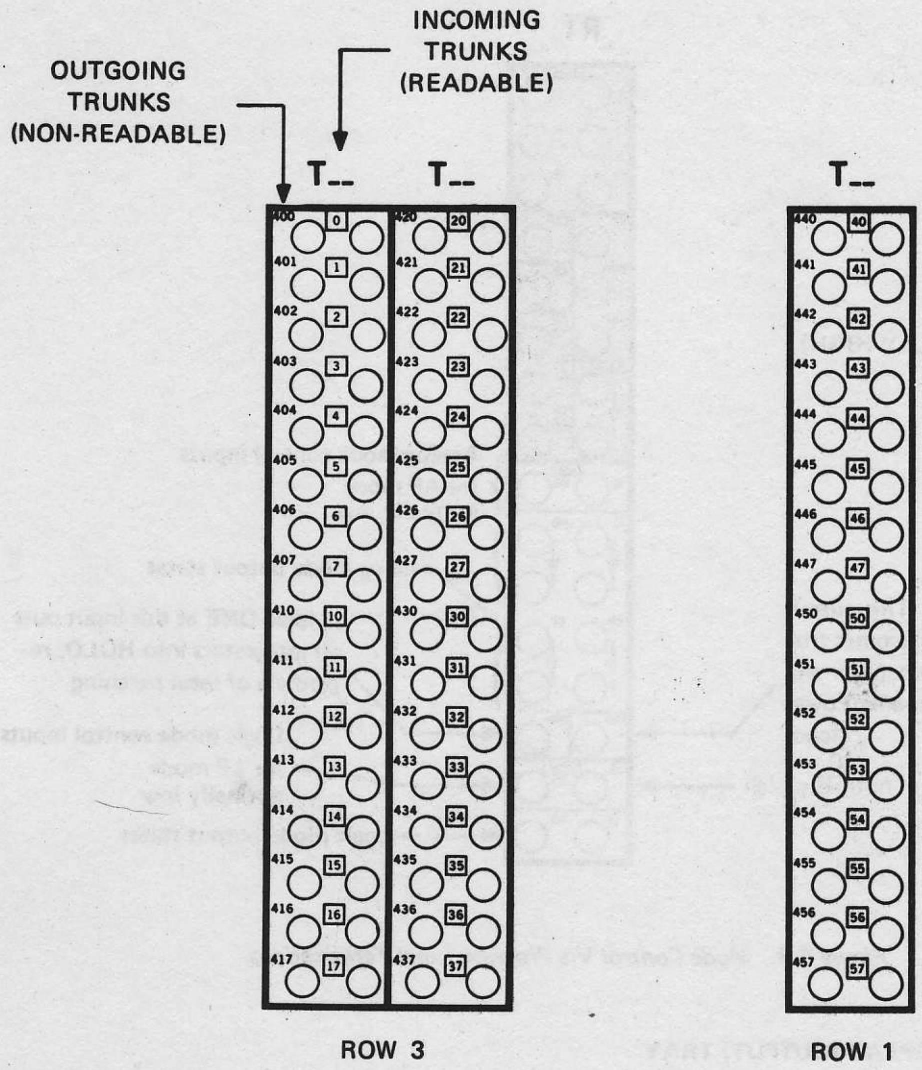


Figure 6.8 Analog Trunks: Program Panel Terminations

6.8 PROGRAM PANEL MODE CONTROL

FUNCTION:

Provide the means for mode changing under program control when involved in time-critical applications.

PROGRAM PANEL:

As defined in Figure 6.9.

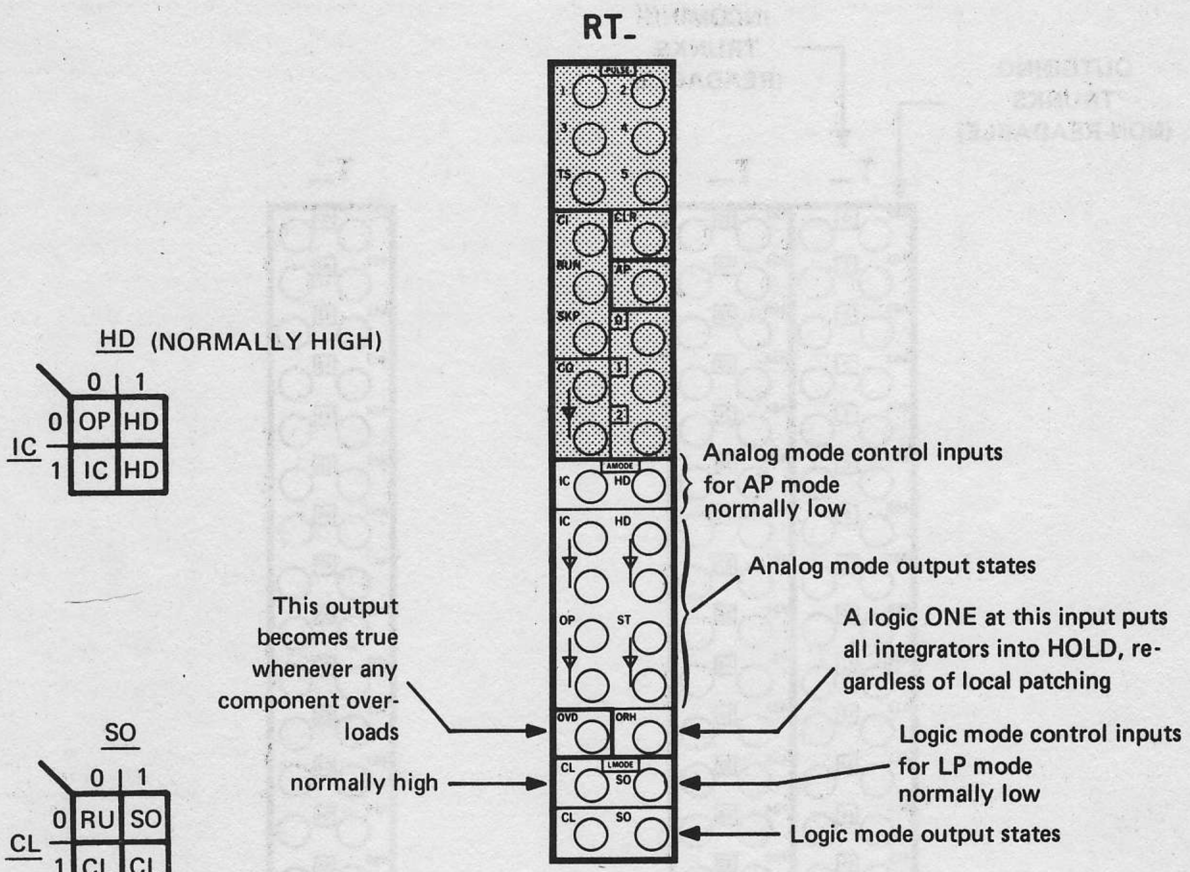


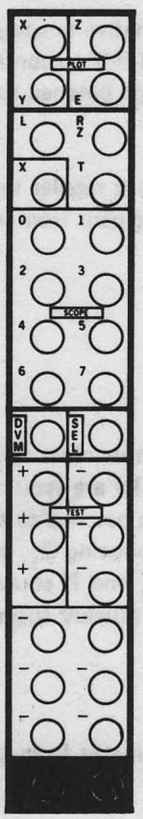
Figure 6.9 Mode Control Via Program Panel Terminations

6.9 READOUT AND DISPLAY (OUTPUT) TRAY

6.9.1 GENERAL

Included in every EAI 2000 and located in the special-purpose tray area of the first component row, is the Readout and Display Tray. Terminations on this tray offer a convenient interface between signals available at the program panel, and peripheral equipment as illustrated in Figure 6.10. Several types of recording and display devices can be used as accessories. The function of some of the patching terminations will differ depending on the specific devices chosen. For this reason, the following descriptions of terminal functions are grouped by peripheral device.

OUTPUT



Program Panel Output Tray	REAR PANEL CONNECTOR T00 Recorder	T01 Plotter	T02 Graphic Port	T03 Scope
X		X	X	
Y		Y	Y	
Z		Pen Dn	Beam On	
E			Erase	
X				X
0	Y0			Y0
1	Y1			Y1
2	Y2			Y2
3	Y3			Y3
4	Y4			
5	Y5			
6	Y6			
7	Y7			
L	Left Mkr			
R/Z	Right Mkr			Beam On
T	Chart On			Trigger

control signals
analog signals

Figure 6.10 Readout and Display (Output) Tray: Program Panel Terminations and Peripheral Signal Distribution

6.9.2 X-Y PLOTTER

The terminations for an X-Y plotter are at the top of the Readout and Display Tray and are labelled X, Y, and Z. The X and Y inputs are self-explanatory; a time-base signal or program variable may be patched to X. Z is used as a pen lift control; a low logic signal patched to Z raises the pen.

6.9.3 FOUR-CHANNEL DISPLAY SCOPE

Seven terminations on the Readout and Display Tray provide access to a four-channel display scope. These are labelled R/Z, X, T, and Ø through 3. R/Z may be used as a blanking control for the display, if required. T is a trigger input to the time-base built into the display. Both R/Z and T are normally driven by logic signals; a low patched to R/Z blanks the display, while a lot-to-high transition at T initiates a time-base sweep. X may be used, if desired, to provide a cross-plot signal (independent variable) to the horizontal axis in lieu of the time-base signal. Ø through 3 are inputs which allow simultaneous display of up to four independent variables.

6.9.4 EIGHT-CHANNEL RECORDER

Eleven terminations on the Readout and Display Tray may be used for an eight-channel recorder (alternative to using a display scope). These are labelled T, L, R/Z, and Ø through 7. Logic signals may be patched to T, L and R/Z to control chart speed and the left and right event markers, respectively, if available with the recorder. A logic high patched to T will turn on the chart motor.

The event markers are two-position pens at the edges of the recorder paper which may be used to mark regular time intervals (if driven by a constant frequency), or significant events. Ø through 7 are inputs for the analog pens from left to right, respectively.

6.9.5 COMPUTER READOUT TERMINATIONS

SEL

The output labelled SEL is driven by any analog signal currently selected for MACS readout. As an example of its application, consider the relatively common situation where plots of several variables (say, Q_1, Q_2, and R) are required against a common time-base. The time-base (generated by a simple integrator circuit on the computer) is patched to the X terminal, and SEL is patched to Y. The programmer may now select (via MACS) the component producing Q_1, and this signal will be connected to the Y axis of the plotter for the first run. Repeat runs with the Q_2 and R sources selected will then produce the composite plot without repatching. Other uses for this terminal will quickly suggest themselves to the reader.

DVM

The input labelled DVM provides the user with a general-purpose input to the EAI 2000 Digital Voltmeter from the program panel. The value of the input can be monitored from MACS by addressing the DVM at MACS.

Type:

[D] [V] [RETURN]

6.9.6 STATIC TEST REFERENCE

Computer Reference, ±10 volts = ±1.0 Machine Unit (M.U.) is available in various trays, however TEST Reference is only available from the OUTPUT Tray. TEST Reference is shaded terminations indicated by plus and minus signs.

When the user has selected the Static Test (ST) mode, plus and minus one M.U. will be available. In all other computer modes these terminations are inactive. This allows the user to patch ±1.0 M.U. to the initial condition inputs of all integrators which normally do not have a program initial condition. The user can then make a complete static check of his program (using ST mode) and avoid the inconvenience of patching and unpatching. He simply exists from the ST mode and unintended program initial conditions are removed automatically.

CHAPTER 7

INTERFACE COMPONENTS

7.1 INTRODUCTION

This chapter treats elements of the Standard Parallel Interface (SPI) in terms of their operation at the program panel. Handling these devices from a digital computer via software library routines is treated in the EAI 2000 Hybrid Communications Library Manual (See Table 1.1).

The SPI has program panel terminations at three types of the Special Purpose Trays:

1 ea. ADC/Control Tray (Designated IL)

2 ea. DAM Feedthrough Trays (Designated DA)

2 ea. Sense Line/Control Line Trays (Designated SL)

The IL and SL trays are located in the second component row of the program panel; the DA trays are in the third row.

7.2 THE IL TRAY (FIGURE 7.1)

7.2.1 GENERAL

The IL Tray provides terminations for:

8 ea. General-Purpose Interrupt Lines

16 ea. Analog-to-Digital Multiplexed Inputs

1 ea. Set of ADC Controls

1 ea. Set of DAM Controls

7.2.2 GENERAL PURPOSE INTERRUPT (GPI) LINES

There are 8 program panel terminations related to the GPI's. These are labeled Ø - 7. Each interrupt request line has an associated internal GPI Interrupt request flip-flop. Whenever an IL is brought high, its GPI flip-flop sets. If the interrupt enables are also set from the digital computer, an interrupt sequence is started by the digital. Note that there are several levels of interrupt enables.

The GPI line priorities are as follows: ILØ> IL1> . . . . >IL7.

When more than one of these lines is raised at the same time, they are serviced one at a time, and in order of priority.

The GPI flip-flops are cleared only from the digital computer. They are cleared individually as they are serviced by the Interrupt Service Routine of the digital computer. All 8 may be cleared as a group by the "Clear All Pending Interrupts" instruction sent by the digital to the SPI.

The unpatched value of these terminations is normally low.

Essentially the GPI flip-flops are triggered on the positive edge of Clock. A GPI FF is set on the next active edge of the 1MHz System Clock that occurs after the IL has been brought high.

To request another interrupt on this line (after the GPI has been cleared), the line must be brought low for a minimum of 1 μsec and then brought high. Interrupt inputs are monitored (for static checking) on the MACS display.

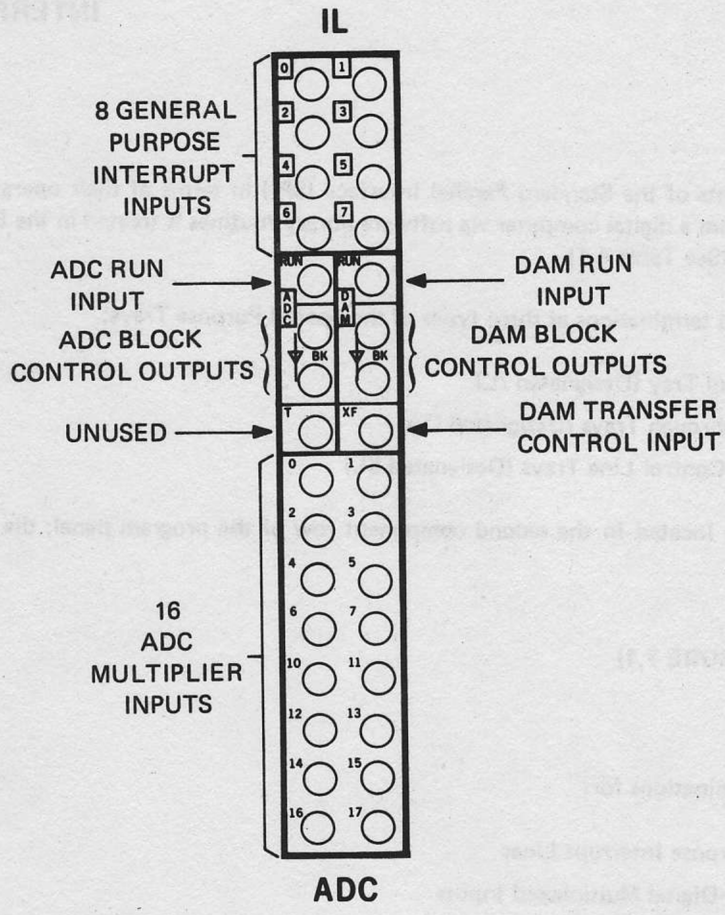


Figure 7.1 ADC/DAM Control and IL Tray: Program Panel Terminations

7.2.3 ADC ANALOG INPUTS

These 16 program panel terminations (Figure 7.1) are inputs to the multiplexer of an Analog-to-Digital Converter (ADC). The ADC analog inputs may be patched to any voltage in the range.

$$10V \geq Vin \geq -10V (1.0 \text{ machine unit})$$

7.2.4 ADC CONTROL TERMINATIONS

RUN:

The ADC RUN termination (Figure 7.1) is a logic input that allows program panel control of the ADC conversion rate. When RUN is high it allows conversions to occur provided that the ADC controller has been set up with First and Last channel addresses. RUN is normally high if unpatched. There are two basic modes of operation using RUN – pulse mode and level mode.

Pulse Mode – Each time RUN is pulsed (min/max pulse width is 1 μsec in Pulse Mode) a conversion will occur. This pulse rate must always be slower than the combined hardware/software rate of the ADC system. This mode is most useful when it is desired to synchronize a particular conversion to some external event. Assuming the ADC controller has its first and last address registers loaded and the multiplexer settling time delay of 2 μsec has elapsed the conversion begins about 1.5 μsec after the RUN is brought high, and continues for 10 μsec.

Level Mode — This mode allows the ADC to convert at the maximum combined hardware/software rate. Here again the first conversion begins about 1.5 μsec after RUN has been brought high. The second conversion begins in about 13 μsec after the first. The conversion rate of the 3rd and all subsequent channels is dependent on the rate that the digital program can read and dispose of the converted values. The upper limit is the hardware limit of about 13 μsec per conversion (about 80kHz). Since the ADC controller has a wraparound multiplexer address circuit, conversions can go on indefinitely. Minimum pulse width, high or low is 1 μsec in the Level Mode.

BLOCK (labeled BK):

A 1 μsec pulse is generated at the ADC BK (Figure 7.1) termination whenever the last conversion in a block of conversions has been completed. A block may be any length from 1 to 16 channels, ($0\text{-}17_8$) inclusive.

If the conversions are being made in the leve mode (RUN left high) the programmer may elect to terminate the conversions by using the block (BK) pulse to clear the high level input to the RUN termination.

The logical complement of BK is also available as an output.

T Termination (Figure 7.1):

T has no function at present. It is available for future utilization.

7.2.5 DAM CONTROL TERMINATIONS

There are 4 terminations on the ADC/Control tray (Figure 7.1) that are associated with the DAM system.

DAM RUN Termination:

The operation of this signal is similar to the ADC RUN signal. When RUN is low the DAM controller is inhibited from loading a DAM (either JAM loading or loading the 1st rank register, only). It will be normally high if it is not patched.

RUN may be used in the pulse or level mode. The minimum pulse width is 1 μsec.

The maximum rate that run may be pulsed must be less than and is dependent on the software/hardware rate of the DAM system.

DAM BLOCK (BK):

These operate in an identical fashion to the ADC Block terminations (See 7.2.4), indicating that a block of DAM's has been loaded.

DAM TRANSFER (XF):

This input allows a DAM transfer sequence to be initiated from the program panel. When a positive going edge is applied, a transfer sequence is begun causing all previously loaded DAM's to transfer. This sequence will take 3 to 4 μsec to complete.

The sequence should not be initiated when the DAM controller is actively loading DAM's. The DAM block pulse can be used as an indication that the controller is no longer active.

The minimum pulse width (high or low) is 1 μsec.

7.3 THE DA TRAY

The DA Tray (Figure 7.2) provides terminations for 16 ea. channels of Digital-to-Analog Multiplication (DAM). Two of the trays may be included, allowing a total of up to 32 DAM channels. Each DAM is a two terminal device, one termination is multiplying input, the second is the analog output. DAM controls are described in Paragraph 7.2.5.

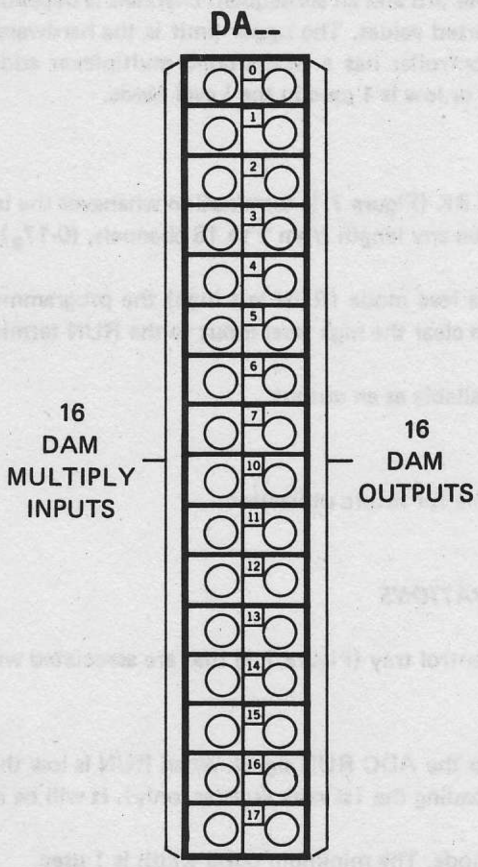


Figure 7.2 DAM Feedthrough (DA) Tray: Program Panel Terminations

7.4 SENSE LINE/CONTROL LINE (SL/CL) TRAY

7.4.1 GENERAL

The SL/CL Tray (Figure 7.3) provides terminations for 8 ea. Control Line (CL) Outputs and 8 ea. Sense Lines (SL) Inputs. Two of these trays may be included.

7.4.2 SENSE LINE INPUTS

These inputs are low when not patched. A minimum pulse width of 1 μsec is required to set the history value flip-flop associated with each line. Sense line inputs are monitored on the MACS display.

7.4.3 CONTROL LINE OUTPUTS

These outputs are synchronous with the clock, and are set and reset by the digital computer. True and Complementary outputs are available.

The Control Lines may be run in the Pulse Mode by patching a CL output (high true) into its control line reset termination. When set, the control line goes active for exactly one period of the clock (1 μsec) and then resets.

The pulse mode can also be achieved by simply patching the reset termination to a logic high. Control line outputs are monitored on the MACS display.

7.4.4 CONTROL LINE RESET (R) TERMINATIONS

When active, the Reset terminations clear the respective Control Lines. The minimum width of a reset pulse is 1 μsec. The control line resets on the next active edge of System Clock following the assertion of the reset pulse. Note that if reset remains active (high), and the control line is again set by the digital, the control line will pulse for 1 μsec (Pulse Mode). Therefore, holding reset active can not be used to inhibit the setting of a control line output.

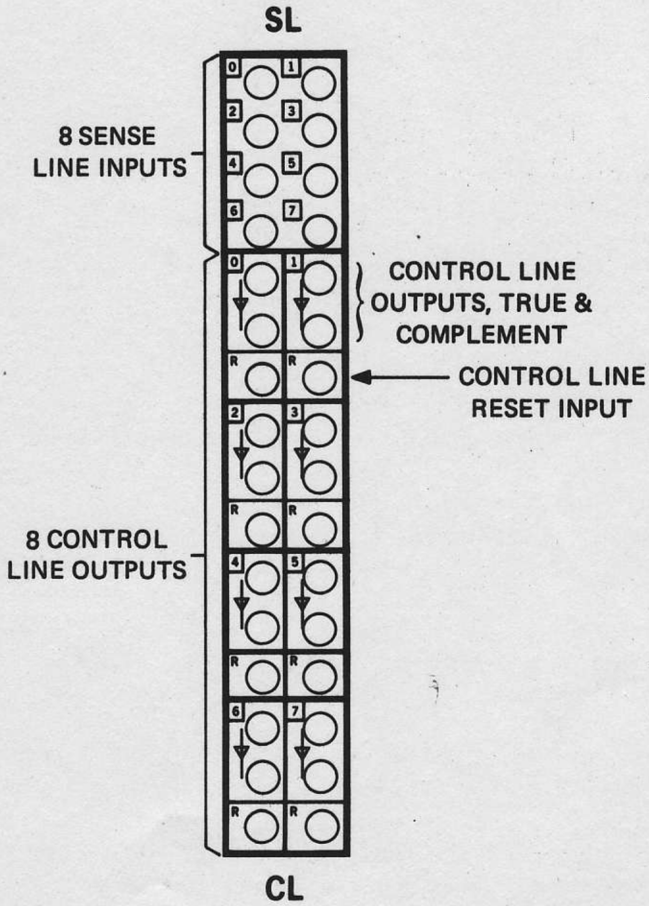


Figure 7.3 Sense Line/Control Line (SL/CL) Tray: Program Panel Terminations

CHAPTER

8

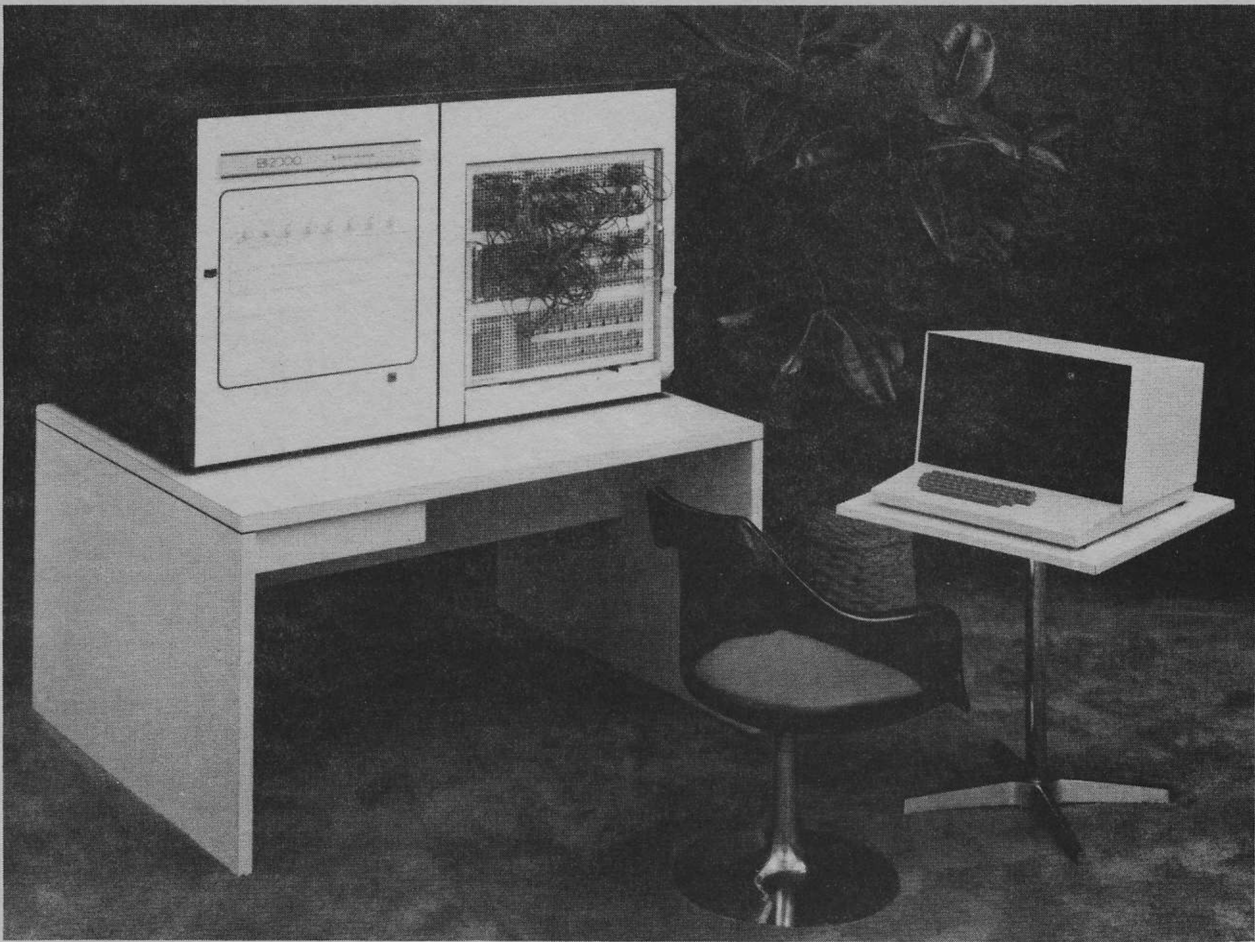


Figure 8.1 The EAI 2000 Console and MACS

UNDERSTANDING AND USING THE MACS DISPLAY

8.1 INTRODUCTION

The Monitoring and Control Station (MACS) is the basic two-way information interface between the user and the EAI 2000 Console (Figure 8.1). The information exchange occurs through the MACS Keyboard and the specially formatted CRT display. An extensive set of MACS keyboard commands are provided for user communication with the console. This command language is translated by the CSI hardware/firmware into the 2000 machine language, which is transparent to the user. The MACS CRT is a video display of the user command actions as well as the status of the 2000.

In order to operate the MACS, the user should understand the format and significance of the MACS display and its video information. Therefore, this chapter is dedicated to that purpose. The MACS keyboard commands are introduced and summarized in Chapter 9. Detailed command descriptions are provided in Chapter 10.

8.2 GENERAL DISPLAY AREAS

Essentially, the MACS display is divided into seven areas as illustrated in Figure 8.2. The following areas of the MACS display include Fixed Headings as follows:

1. Component Information:

   ADDRESS VALUE TYPE

2. System Information:

   A MODE L MODE SCALE

3. System Indicators:

   TS BA OV

   LD HY MC

Except for the System Indicators, pertinent alpha-numeric data for each heading appears directly below that heading. Data associated with the System Indicators appears directly below these headings as a rectangular light, or contrast inverted letters.

The Information Page Area also includes fixed headings under which data is displayed. However, the specific headings that appear are dependent on page/component selection.

Page Headings are as follows:

1. Logic (L) Page:

   GENERAL PURPOSE LOGIC

   SENSE LINES CONTROL LINES

   INPUT TRUNKS INTERRUPTS TIMER

2. Function Value (F) Page:

   DSFG XX DSFG number xx ($0\text{-}17_8$)

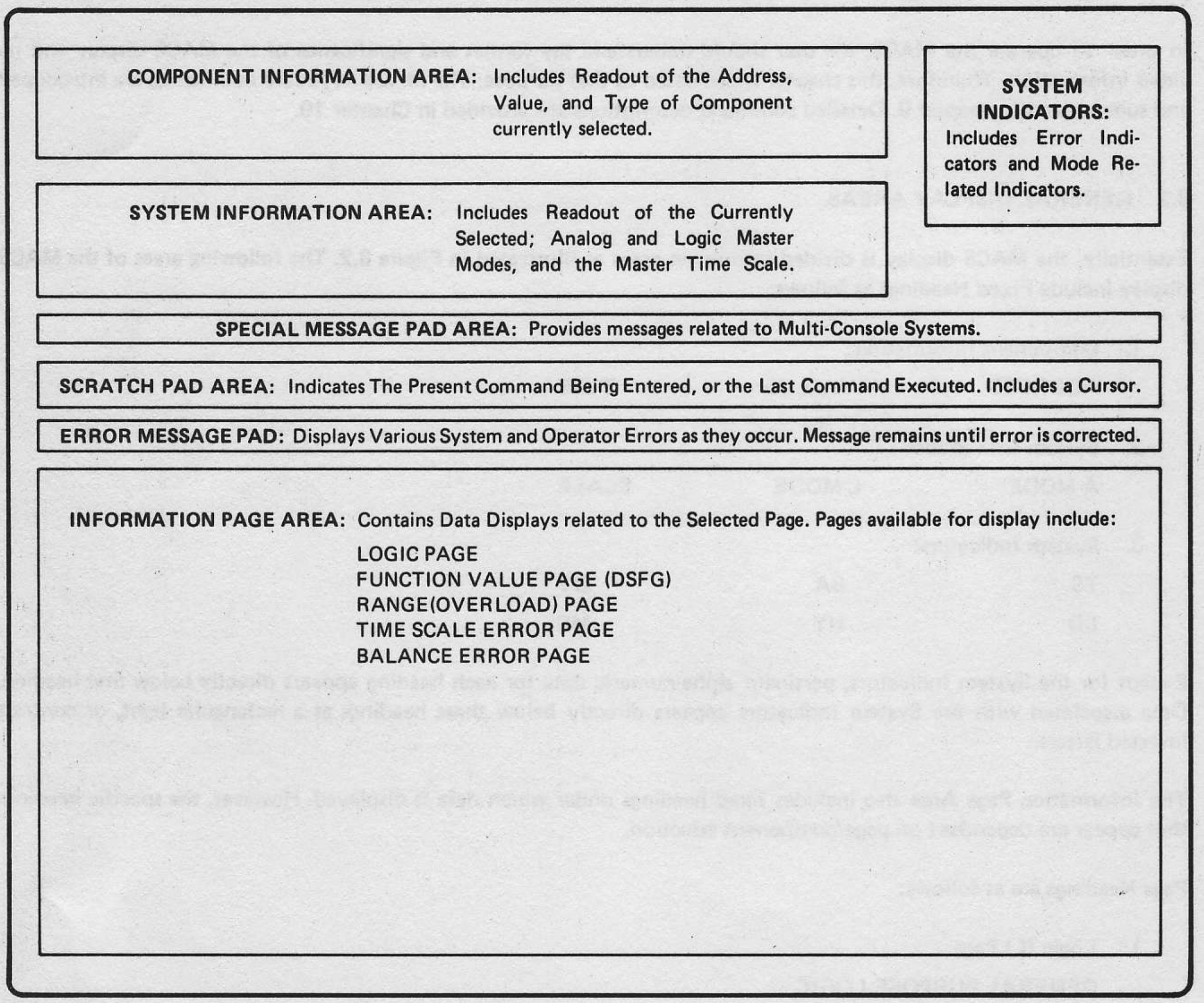


Figure 8.2 MACS General Display Areas

3. Range (R) Page:

   OVERLOADS

   FUNCTION GENERATOR

4. Time Scale Error (T) Page:

   TS ERRORS

5. Balance Error (BA) Page:

   AMPL BALANCE ERRORS

The Special Message Pad, Scratch Pad, and Error Message Pad areas do not have headings, only related data is displayed. Figure 8.3 illustrates a typical MACS display for a system that has just been initialized. The following Paragraphs (8.3 - 8.7) provide detailed descriptions of each area of the display and the types of data that may appear under each heading.

8.3 COMPONENT INFORMATION DISPLAY

8.3.1 ADDRESS FIELD

ADDRESS

1AØØØL 2LØ1Ø 1RVØ1 1DC37 3DVM	Data displayed under this heading is up to six characters long, the first of which is a numeric character representing a console prefix. (Console 1-6). The second character refers to the component type (A, C, P, D, I, L, F, and T). Some components require two characters for component identification (RV, RT, DC and DA), and occupy the second and third characters of the ADDRESS field. The very last character (sixth) is either a half bright L, indicating the presence of an optional limiter, or a blank, which indicates that a limiter is not present. There is only one device which is three alpha characters long, the DVM (Digital Voltmeter). Note, too, that for a one-console system, the user need not specify (enter) the console prefix 1. The displayed console prefix number will be 1 if the Mult-Console option is not exercised. If the Mult-Console option is exercised, the displayed console prefix will be determined by the setting (1 - 6) of the Console Switch- Leading zeros of a component address are displayed, but need not be entered at the keyboard.

8.3.2 VALUE FIELD

VALUE

+Ø.ØØØ1 −1.Ø828 32767 255 1 Ø INVALID	Data displayed under this heading is of variable format depending upon the type of component addressed. When an analog component is addressed (A, C, P, D, I, F, T, DC, DA or DV), the displayed data under the VALUE heading is seven characters long (first reserved for sign, third for decimal point, and others for decimal digits). When the displayed ADDRESS data is RV or RT (corresponding to addressing a General Purpose Register, Counter/Timer or Interval Timer), the data displayed under the VALUE heading is a decimal integer (Ø to 255_{10} for the GPR, and Ø to 32767_{10} for the Counter/Timer and Interval Timer).

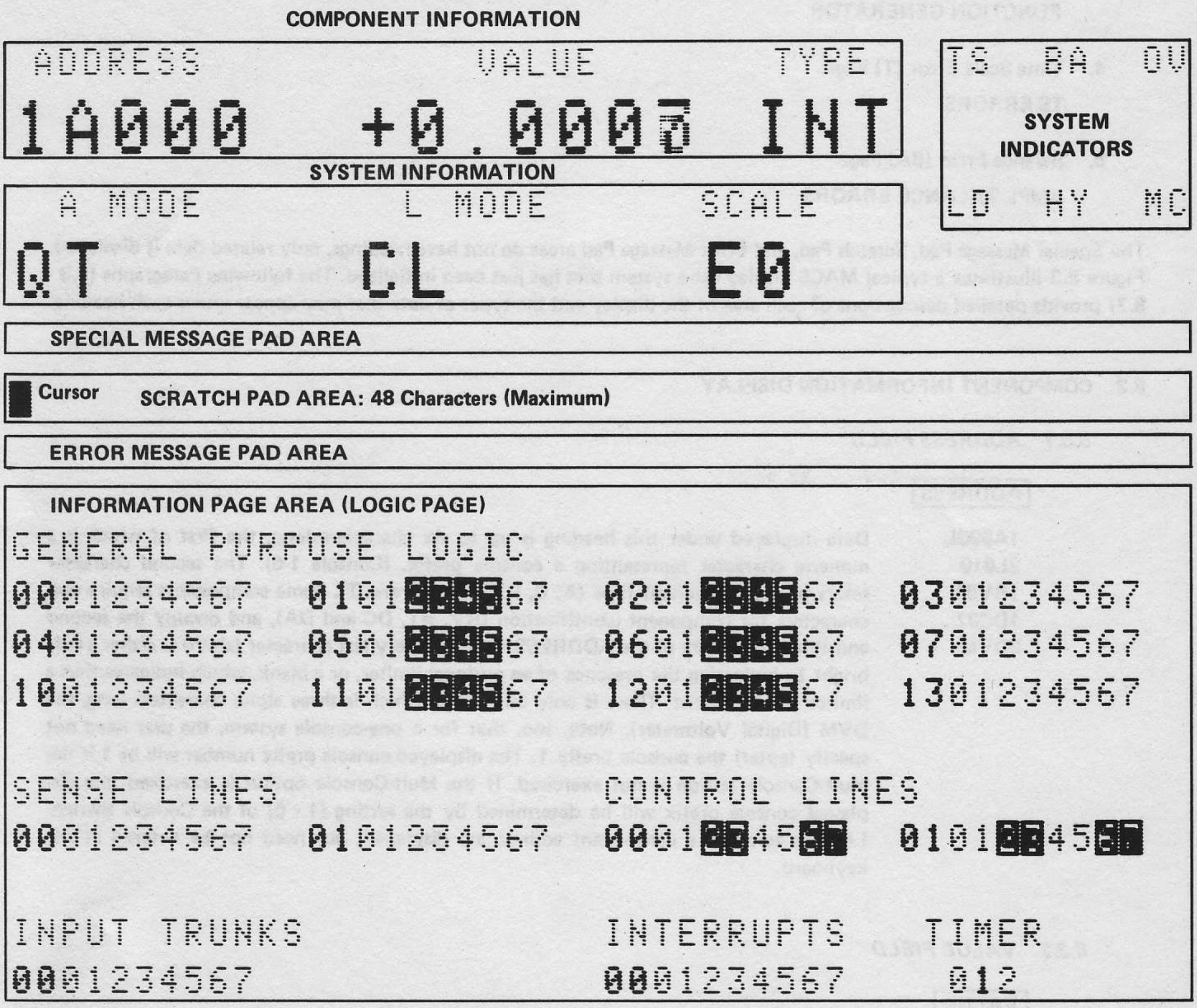


Figure 8.3 Typical MACS Display After System Initialization

When addressing a logic component (Lx is displayed under the ADDRESS heading), there are only two possible data displays under the VALUE heading: 1 or Ø (representing high and low states, respectively, of the addressed logic component).

If, a non-existent component is addressed (either an illegal address, or missing component at a legal address), the word INVALID is flashed repeatedly under the VALUE heading.

8.3.3 COMPONENT/TRAY TYPE FIELD

| TYPE |

SUM
FG
INT
GPL
EØ
E+2
TST

The readout under this heading is alphabetic, identifying mnemonically the type of analog component addressed, or the type of logic tray in which the addressed logic component is located. An alphanumeric readout appears only when an integrator is addressed using the I symbol, in which case the readout under the TYPE heading contains the information on the gain of the selected integrator.

Component TYPE Data Displays:

SUM	Summer
INT	Integrator
MUL	Multiplier (even if used for Division or Square Root Extraction)
SIN	Sin/Cos (even if used as Cosin or Arcsin)
FG	Function Generator
T/S	Track/Store Summer (even if used as a regular summer)
TST	Test Tray Summer
INV	Test Tray Inverter
TK	Trunk

Tray TYPE Data Displays:

GPR	General Purpose Register Tray
GPL	General Purpose Logic Tray
CMP	Comparator Tray

Individual Integrator Gain TYPE Data Display:

En	Specifies 10^n for the absolute gain of the addressed integrator.
E+n	Specifies 10^n times greater gain than the gain called for by the SCALE display.
E–n	Specifies 10^{-n} times smaller gain than the gaincalled for by the SCALE display. (i.e., 10^{-n} times "greater" gain).

Examples:

1. EØ under the TYPE heading specifies gain of one ($10^\circ = 1$) for the selected Integrator, regardless of the SCALE value.

2. E+Ø specifies 10^{0} = 1 "greater" gain than the gain called for by the SCALE display. In this case, the gain of the selected Integrator will be the gain specified under the SCALE heading.

3. E–3 specifies 10^{-3} "greater" gain than the one called for by the SCALE display. Consequently, if SCALE calls for E3 (= 10^{3}), the effective gain of the selected Integrator will be 10^{3} times smaller, or equal to a gain of one as:
$10^{3} \times 10^{-3} = 10^{3-3} = 10^{0} = 1$

4. In general, if "m" is the specified exponent for the Master Time Scale, and "±n" is the specified exponent for the gain of the individual Integrator, the resulting gain (RG) is computed as:
$RG = 10^{m \pm n}$

8.4 SYSTEM INFORMATION DISPLAY

8.4.1 ANALOG MODE FIELD

A MODE

XX YY — There are provisions for two sub-data displays under this heading:

XX identifies the current Analog Mode, and YY identifies the Mode Control Source.

The YY sub-entry is blank if a control source is not used. There are two mode control sources within the EAI 2000 console:

1. Rep-Op Timer, used to repetitively cycle between time critical modes.
2. Program Panel, for Analog Mode control through special A MODE Control inputs.

Instructions from the MACS keyboard and digital computer can directly control all modes, as well as enabling the other sources for control of the time critical modes.

In a multi-console environment, a "Master Console" can be a third mode control source whereby, Modes (both analog and logic) of "Shared Consoles" are controlled by the Mode of the Master Console.

XX	Interpretation	
IC	Initial Condition	Time Critical Modes
OP	Operate	
HD	Hold	
ST	Static Test	Setup Modes
QT	Quiescent	
BA	Balance	

Note that A MODE does not display HD when the Hold Mode is selected by the ORH input at the Program Panel.

YY	Interpretation
AR	Analog Rep-Op: Analog Master Mode under the control of Rep-Op timer
AP	Analog Program Panel: Analog Master Mode under Program Panel Control.
SL	Slave: A time critical Analog Master Mode is slaved to the Analog Modes of the Master Console.

Note that when YY contains data (not blank), the displayed data for XX can only be IC, OP or HD and, when YY = AP with no signal in the IC and HD Program Panel control inputs, the displayed data for XX is IC (based on the unpatched "values" of the mode control signals).

8.4.2 *LOGIC MODE FIELD*

L MODE

XX YY — This heading also has provision for two sub-data displays. As with the A MODE heading, the XX identifies the current Logic Mode, and YY identifies the Control Source.

The Control Sources are the same as for the Analog Mode.

XX	Interpretation	
CL	Logic Clear	Time Critical Modes
RU	Logic Run	Time Critical Modes
SO	Logic Stop	Time Critical Modes

YY	Interpretation
LR	Logic Rep-Op: Logic Mode under the control of Rep-Op timer.
LP	Logic Program Panel: Logic Mode under Program Panel Control
SL	Slave: A time critical Logic Master Mode is slaved to the Logic Modes of the Master Console.

YY is not displayed if a Control Source is not selected.

8.4.3 *MASTER TIME SCALE FIELD*

SCALE

E∅
E1
E2
E3
E4

The displayed data under this heading specifies the Master Time Scale which sets the base (Master) gain for all integrators having relative individual gain.

A display of Em under the SCALE heading indicates that the base gain is set to 10^m (where m = ∅-4) as detailed in the following Table:

SCALE Display	Interpretation
EØ	Base gain set to $10^{\emptyset} = 1$
E1	Base gain set to $10^1 = 10$
E2	Base gain set to $10^2 = 100$
E3	Base gain set to $10^3 = 1000$
E4	Base gain set to $10^4 = 10000$

If individual integrator x has its own relative gain set to $10^{\pm n}$ (its TYPE display contains E±n when Ix is addressed), the desired effective gain is 10 (m±n). The only realizable (built-in) integrator gains are 1, 10, 100, 1000, 10,000 and 100,000, which restricts (m±n) such that

$$0 \leq (m + n) \leq 5$$

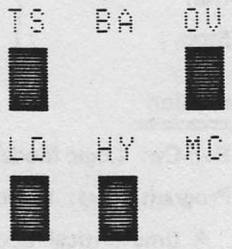
If this inequality is not satisfied, the firmware turns on the Time Scale Error indicator (Paragraph 8.5.2) and sets the gain to the closest extreme (10^0 or 10^5).

8.5 SYSTEM INDICATORS

8.5.1 GENERAL

There are a total of six System Indicators as follows:

- TS = Time Scale Error
- BA = Balance Error
- OV = Overload Error
- LD = Local Display
- HY = Hybrid
- MC = Multi Console



When lit (a rectangle appears) an active state is indicated. The first three (TS, BA, and OV) are error indicators and when lit, are accompanied by an audio error cue. The remaining three (LD, HY, and MC) are mode related indicators.

8.5.2 TIME SCALE ERROR – TS INDICATOR

When lit, this indicator denotes a Time Scale Error for one or more integrators as defined in the description of the SCALE heading (Paragraph 8.4.3). When TS lights, one would normally invoke a T (Time Scale Error) Page to determine which integrators in particular have a Time Scale Error, and then change: the Master Time Scale; or individual relative time scales; and/or settings of the coefficients feeding those integrators in error.

In a Multi-console environment, the display of a contrast inverted asterisk indicates a Time Scale Error on one or more of the other Consoles (other than the one whose video is currently on).

8.5.3 *BALANCE ERROR – BA INDICATOR*

BA

When the BA command (Paragraph 10.4) is executed, this indicator lights if one or more Summers (including Track/Stores) or Integrators are out of balance. An amplifier is out of balance if its output magnitude exceeds 0.0100 as shown under the VALUE heading (Paragraph 8.3.2) while the computer is in the Balance Mode. In the Balance Mode, a gain of 1000 is imposed on all summers and integrators and their programmed inputs are disabled. The output value therefore shows the offset error multiplied 1000 times. Consequently, considering the above conditions, the permissable error is effectively $<|\pm 10^{-5}|$ Machine Units, or 100μV.

Upon execution of the Job Command from the MACS Terminal (Paragraph 9.4.3 and 10.3), the system is momentarily placed in the BA mode and all summer and integrator outputs are read. If any units are out of balance, the BA indicator lights and the addresses of those units are stored for display on the Balance Page.

Note that upon executing the BA Command, the Balance Page (showing the balance status of all summers and integrators currently in the console) is automatically invoked, but its content is not continuously updated. If balance adjustments are required, refer to the EAI 2000 System Information and Console Description Manual (Publication No. 00 800 2104). When adjustments have been completed, the BA Command should be re-executed to update the Balance Page content to ensure all units are functioning properly. The BA indicator should turn off upon re-execution of the BA Command (if no more "out-of-balance" components are detected).

BA

In a Multi-Console environment a contrast inverted asterisk appearing under the BA heading indicates a Balance Error on one or more of the other Consoles (other than the currently selected console). The lit rectangle (described in the preceding paragraphs) in a Multi-Console environment indicates a BA error on the currently selected console (the console whose video is currently displayed).

8.5.4 *OVERLOAD – OV INDICATOR*

OV

When lit, OV indicates that one or more computing components (including function generators, but excluding coefficients) are operating outside their designed linear range. To find out which particular component(s) is overloaded, one has to invoke the Range Page (Paragraph 10.19). The overloaded state of a component used within a program invalidates simulation results. Consequently, when sensed, this state is transmitted immediately both to the MACS indicator and the OVD (overload) termination on the Program Panel. The OVD logic signal is available to freeze the solution enabling a user to determine the cause of the overload. Note that the OV MACS indicator and the OVD Program Panel signal promptly go off when the reason for overload disappears. Therefore to ease debugging, one has to utilize the OVD signal in conjunction with sequential logic in order to hold the effect of transient overloads (those which do not stay long enough to be seen on the OV indicator).

An overloaded component is one which is sensed (by internal circuits) to be operating in the non-linear range. The EAI 2000 components are designed to be linear in the range of (at least) ±1.05MU. However, a component can be overloaded due to current conditions even though its output is within the linear voltage range. The two most common reasons for a component to be overloaded are:

Incorrect patching

Incorrect scaling

OV The OV indicator displays a contrast inverted R to signify an overload condition in the Reference Power Supply (+REF, −REF, or both).

OV In a Multi-Console environment, the OV indicator displays a contrast inverted asterisk to signify an overload (OVD) occurance on a console other than the console whose video is currently displayed. This permits operator detection of an OV condition of all consoles from any MACS, even if the video information of the overloaded console is not currently displayed. The contrast inverted asterisk will appear only if the currently selected console is not itself in an overload condition. Therefore, to detect an OV error in another console, an OV condition in the currently selected console must be corrected first.

8.5.5 LOCAL/NORMAL DISPLAY – LD INDICATOR

LD When lit, LD indicates Local Display Mode of the Display CRT. When not lit, the Normal Display Mode is indicated.

Normally, when the serial port is active (driven by a TTY compatible device or digital computer) the displayed component ADDRESS, VALUE and TYPE is the last one selected for setup or readout purposes, whether from the MACS Keyboard or the Serial Port. When in Local Display, only the component selected at the MACS Keyboard is displayed. This permits component monitoring independently of commands from the Serial Port. While in this mode, any component-oriented command sent via the Serial Port without an identifying address will be executed upon the locally selected component. Note that other MACS Display functions (other than the component selection) are not affected by this Mode. For example, the current Analog Mode is based on the last Analog Mode command received, whether the command came from the Serial Port or the MACS Keyboard.

8.5.6 HYBRID – HY INDICATOR

HY When lit, indicates that both the Serial Port and the Parallel Port are enabled. This indicator must be lit in order to place the digital computer on-line and create a Hybrid environment. This indicator must also be lit if a teletype or teletype compatible device is to be enabled through the Serial Port. Refer to Paragraph 10.3 for a description of the On-Line Command.

Note that the capability to input and execute commands from the MACS keyboard is not lost while the Serial Port is enabled, as the firmware maintains two command buffers: one for commands coming from the MACS keyboard; and the other for commands coming through the Serial Port. These two data paths are completely parallel until the firmware detects a RETURN character from either of them. The port first sensed to contain a RETURN is then temporarily disabled until all of the commands accumulated within its buffer are executed. The second port meanwhile allows its command buffer to be loaded. When this port gets a RETURN, it will attempt to execute its content, and will succeed only if the first port has finished execution. This type of port setup enables parallel accumulation of port commands, and then serial execution.

8.5.7 MULTI-CONSOLE – MC INDICATOR

MC This Multi-Console Indicator lights with an inverted M when a particular console in a multi-console system is selected as the Master Console. Conversely, the MC indicator displays a contrast inverted S on all slaved consoles.

MC

8.6 SCRATCH PAD

The Scratch Pad Area of the Display (Figure 8.2) contains the last MACS Keyboard Command (or string of commands) executed, the current command(s) being entered and a Cursor, or only a Cursor.

For example, only the Cursor (contrast inverted rectangle) appears when the system is initialized. This occurs during the power-up phase or when the system is initialized by the Job Command. See Paragraphs 9.4.3 and 10.3.

The Cursor always appears when a command is being entered and moves to the right one space each time a new character is entered.

When a command is executed (RETURN key depressed), the Cursor disappears. Note that most commands have only a few characters. However, the Scratch Pad can handle up to 48 characters. This permits stringing a succession of commands separated by commas.

Refer to the various command exercises in Chapters 9 and 10 for further examples of Scratch Pad use.

8.7 SPECIAL MESSAGE PAD

The Special Message Pad is only active in a Multi-Console environment. During setup of a Multi-Console System (Selecting the MASTER and SLAVE consoles), the message **CONSOLE NOT SELECTED** will appear. The correct operator response is to select the console prefix number (1 - 6) on which the succeeding set of commands are to be performed. See Command Number 10.3 in Table 9.10 for further information.

8.8 ERROR MESSAGE PAD

The Error Message Pad displays a variety of error messages. Essentially, these messages are divided into five classes as defined in Table 8.1. The INVALID Error Message (Class 1, Message b) is displayed under the VALUE heading. All other messages flash in the Error Message Pad Area.

Table 8.1 Classification of MACS Error Messages

CLASS		MESSAGE	
1.	Common Operator Errors	a.	ILLEGAL COMMAND
		b.	INVALID
		c.	NUMBER OUT OF RANGE
		d.	NO DSFG SELECTED
		e.	NO SUCH CONSOLE
2.	DCA Error	a.	SELECTED DCA IS INVALID
3.	DVM Errors	a.	DVM OFFSET ERROR
		b.	DVM GAIN ERROR
		c.	DVM OFFSET AND GAIN ERROR
4.	Serial Port Errors	a.	SERIAL PORT NOT ON LINE
		b.	SERIAL PORT NOT READY
		c.	SERIAL PORT SYNTAX ERROR
		d.	LOST CONTACT WITH DIG COMPUTER
5.	Parallel Port Error		SPI-CONFLICT - - - RE-EXECUTE LAST COMMAND

These error messages are defined in the MACS Error List (Table 8.2) in the exact order listed in Table 8.1. Each definition includes the basic cause of the error message and the method of recovery.

Table 8.2 MACS Error Messages

CLASS OF ERROR	ERROR MESSAGE	CAUSE	RECOVERY
Common Operator Error	ILLEGAL COMMAND	Attempting to execute a non-defined command [ID].	Look up the correct command syntax.
		Attempting to execute a command that is not executable on selected component [A4 = Ø, CØ> where CØ = handset pot]	Look up the correct component address or check the command description and/or syntax.
		Attempting to execute a Multi-Console Command (Command Group 10) on a system which does not have a Multi-Console expansion.	Issue a legal command
		Attempting to select a component on a console whose number is outside the range 1 - 6. This error is only triggered in the Multi-Console environment.	Position the Console Select switch to a number between 1 and 6 and make sure that each console of a Slaved system has a different console number.
	INVALID NOTE The word INVALID flashes in the Component Information Display Area under VALUE. This message does not appear in the Error Message Pad.	Attempting to address a component that is not physically in the System (tray missing), but address value is within range of the system.	Re-execute the same command using a valid address.
	NUMBER OUT OF RANGE	The numeric part of a command (other than address) is in error. For example, commands such as; I8, A244, E5, V44, RTØ = 55000, etc. will cause this error message.	Look up the range of numeric entries for that command and then enter the correct value in that range.

Table 8.2 MACS Error Messages (Cont'd)

CLASS OF ERROR	ERROR MESSAGE	CAUSE	RECOVERY
Common Operator Error (cont.)	NO DSFG SELECTED	Attempting to execute a command that requires prior DSFG selection.	Select the desired DSFG and re-execute the command issued prior to Error Message.
	NO SUCH CONSOLE	Addressing a non-existant console.	Check setting of Console select switch.
		Not prefixing first command upon setting up a Slaved system, or not issuing Console Select Command before the first non-prefixed command.	Prefix the first command with a valid console number, or issue a Console Select Command.
DCA Error	SELECTED DCA IS INVALID	This message is displayed upon detection of an invalid DCA address while executing a DCA Slewing Command.	Re-execute the same command, but with only an existing DCA.
DVM Errors	DVM OFFSET ERROR	This error message is displayed when the DVM "ground" readout differs from zero by a predetermined amount. DVM offset to ground is digitally corrected by firmware.	This is a maintenance problem. Inform Service Technician.
	DVM GAIN ERROR	This error message is displayed when the DVM correction factor exceeds a predetermined range. DVM gain correction factor is determined by firmware, which compares the voltage being read against reference voltage of the same sign.	This is a maintenance problem. Inform Service Technician.
	DVM OFFSET AND GAIN ERROR	Both DVM errors have occurred in the process of reading one component value.	This is a maintenance problem. Inform a Service Technician.
Serial Port Errors	SERIAL PORT NOT ON LINE	The Port itself, or the device attached to it (teletype, digital computer, etc.) is not turned on.	Turn on the device and reissue the On Line Command. When ON, the Serial Port is checked (by Firmware) every 30 milliseconds for the On Line bit status.

Table 8.2 MACS Error Messages (Cont'd)

CLASS OF ERROR	ERROR MESSAGE	CAUSE	RECOVERY
Serial Port Errors (cont.)	SERIAL PORT NOT READY	Hardware problem with I/O device attached to the Serial Port or the port itself (ACIA; Asynchronous Communications Interface Adapter).	Inform Service Technician.
	SERIAL PORT SYNTAX ERROR	All inclusive syntax error for commands from the digital computer over the Serial Port.	A new (non-erroneous) command clears this message.
	LOST CONTACT WITH DIG COMPUTER	Firmware has timed out the required digital computer response (echo). NOTE The firmware allows several minutes for establishing the initial contact by sending a SPACE Character and waiting for the digital computer to send its echo back. Once the initial contact is established, 10 seconds are allowed for the digital to echo back every character (one at a time) sent to it by the Micro-processor within the 2000. This feature does not slow down Serial Port communications. It allows for digital Computer overhead when the 2000 is not the only "User" serviced.	Inform Service Technician. Any MACS Command will clear the message.
Parallel Port Error	SPI CONFLICT - - RE-EXECUTE LAST COMMAND	During the interval that a DAM transfer is pending (DAM's loaded but not yet transferred) that either of the following has occurred: a. A local attempt (at MACS) to set any DAM. b. A local attempt (at MACS) or a Hybrid attempt (thru Serial Port) to set any of the last 32 DCA's (DCA 100 thru 137).	Check with Digital Operator. If permissable, trigger the transfer from the Program Panel by pulsing the DAM-XF terminations of the IL/ADC Tray. Then, re-execute the last command.

8.9 INFORMATION PAGES

As indicated in Figure 8.2, there are five information pages available for display on the bottom portion of the CRT. Since specific Commands are required to select a page of information, the individual pages are described in Chapter 10 under Paging Commands (Paragraph 10.20). The individual pages are also illustrated in that chapter as follows:

Figure No.	Page
10.20	Function Page
10.21	Logic Page
10.22	Range (Overload) Page
10.23	Time Scale Error Page
10.24	Amplifier Balance Error Page

CHAPTER 9

UNDERSTANDING AND USING THE MACS KEYBOARD COMMAND SET

9.1 INTRODUCTION

This chapter provides information to familiarize the user with the characteristics of the MACS Keyboard and defines the MACS Command Set. Some basic command exercises are also provided to illustrate keyboard operation and the interactive characteristics of the MACS Display. More detailed command descriptions and command exercises are provided in Chapter 10.

9.2 THE MACS KEYBOARD

As shown in Figure 9.1, the MACS Keyboard is similar to a standard TTY type keyboard and contains all of the alphanumberic, punctuation, arithmetic keys, and three special purpose keys required to implement the EAI 2000 commands.

Figure 9.1 The MACS Keyboard

The following summarizes the functions of those keys requiring special consideration while operating the MACS Keyboard.

	[RETURN]	=	Carriage Return. Used to execute the previously entered command(s).
	[CTRL]	=	Used to initiate specific control commands. The control commands associated with this key do not require a carriage return. This key must be depressed and held until the remainder of the control command is entered.
	[RUB OUT]	=	Used for editing commands.
	[REPT]	=	Operated in conjunction with [RETURN] key to cause repeated (10 per second) execution of the command(s) displayed in the Scratch Pad.
Non-Std. Keys	[<] [>]	=	Used to Decrement ([<]) or Increment ([>]) a previously selected DCA.
	[BLIP]	=	Used to generate a pulse at the Program Panel.

NOTES

1. *All commands except those using the* BLIP *and* CTRL *keys must be terminated with a carriage return (* RETURN *key) for immediate interpretation and execution.*
2. *Repeated use of* RETURN *key (by itself or with* REPT *key) will cause repeated execution of the command(s) displayed in the Scratch Pad area.*
3. *Commands using the* BLIP *and* CTRL *keys can not be executed from the keyboard of a teletype or teletype compatible device connected through the Serial Port. Commands associated with these keys may only be executed at the MACS Keyboard.*
4. *Commands may be strung together using commas (* , *) as separators between each command up to the full Command Buffer length of 48 characters. A command string is interpreted and executed serially. Strung commands require a single* RETURN *after the last command of the string is entered. A command string in excess of 48 characters (spill over) will in no way affect the execution of other commands in the string. The partially spilled command(s) will simply not be executed. See Paragraph 9.4.2 for more information concerning strung commands.*

9.3 THE MACS COMMAND SET

The MACS Command set is used to control operations of the EAI 2000 from the MACS Keyboard. Each command has its own distinct format and syntax. For ease of command use and reference, these commands are presented in Tabular form and are divided into functional groups. Each functional command group is defined in a separate table as follows:

Group	Type of Commands	Inclusive Command Numbers	Table No.
1	Editing	1.1 - 1.3	9.1
2	Initialization	2.1 - 2.5	9.2
3	Master Mode Selection and Control	3.1 - 3.14	9.3
4	Integrator Time Scale Selection	4.1 - 4.3	9.4
5	Component Addressing and Readout	5.1 - 5.13	9.5
6	Component Setting (Analog and Logic)	6.1 - 6.13	9.6
7	Paging	7.1 - 7.5	9.7
*8	Program-Save-to-Restore	8.1 - 8.3	9.8
9	Miscellaneous	9.1 - 9.2	9.9
10	Multi-Console	10.1 - 10.4	9.10

*Entered from Remote TTY or TTY Compatible Terminal which is connected through the Serial Port.

The Table for each functional command group is formatted in the following manner:

Number	Format	Description	Para. Ref.

Number: Commands are numbered sequentially within a group for ease of identification and future reference. i.e., 1.1-1.3, 2.1-2.5, etc.

Format: This column illustrates the command format and syntax by showing the specific keys (labeled boxes) and the sequence in which they are to be operated. Numeric address and Value Variables are designated using lower case letters such as x, y, n, etc., and are enclosed in broken boxes.

Description: Described the operation(s) that occur when each sommand is executed. When an address list is specified in this column (as in Command 6.6, Table 9.6), the addresses are for the standard (typed) configuration.

Para. Ref.: This column specifies those paragraphs that contain additional (or related) information for each command.

It is strongly urged that the user become familiar with the MACS Command Set as presented in Tables 9.1 through 9.10 before attempting to operate the EAI 2000. Detailed command descriptions and additional exercises are provided in Chapter 10. As a cross reference, the MACS commands set is also listed in Table 9.11. This Table is presented in Alphabetic/Numeric command order by item number (in a format similar to Tables 9.1 through 9.10) and includes a command number column for cross-reference to the functional command groups. The user may also refer to the MACS COMMAND LIST as presented in Appendix 2. This Appendix contains an abbreviated set of commands with a full description and condensed set of notes. The MACS COMMAND LIST may be removed from the Appendix and placed near the MACS terminal to provide quick reference to most of the information necessary for day-to-day operations.

Table 9.1 Group 1 Commands: Editing

NO.	FORMAT	DESCRIPTION	PARA. REF.
1.1	[RUB OUT]	Deletes last <u>character</u> entered and moves cursor back one space.	10.2.1 9.4.2
1.2	[RUB OUT] [RETURN]	Clears both the Scratch and Message Pad areas (deletes last <u>line</u>) and initialized Censor in Scratch Pad area.	10.2.1
1.3	[CTRL] [S]	Aborts current command and clears the Scratch and Message Pads. Brings in Logic Page and places console in the Off-Line Mode, see Command 2.3. In a Multi-Console environment, [CTRL] [S] also unslaves the Multi-Console system. After execution of [CTRL] [S], each console displays its own video information and the Console prefix (first character of the ADDRESS field) mirrors the setting of the console select switch.	10.2.2

Table 9.2 Group 2 Commands: Initialization

NO.	FORMAT	DESCRIPTION	PARA. REF.
JOB COMMAND			
2.1	[n] [J] [;] [RETURN]	Job Command. Initializes Console Number n (n = 1 to 6) by setting the following conditions: 1. Momentarily places Console Number n in the Balance (BA) Mode to Check for balance errors. 2. Selects QT (Quiescent) <u>Mode</u>. See Command 3.6 for QT Mode description. 3. Logic Mode = CL 4. Master Time Scale = EØ 5. Individual Integrator Time Scale = E + Ø 6. Display Mode = Normal 7. AØ selected 8. Rep-Op Timer set to; RTØ = 5ØØ RT1 = 5ØØØ RT2 = Ø 9. All DSFG's set to Y = Ø with 21 Breakpoints 10. Logic Page Selected **NOTE** *The Console prefix number (n) may be omitted in single console systems. In a Multi-Console environment, if the prefix is omitted the Job Command will be executed on the last console selected, see Command 10.3 for related information.*	9.4.3 10.3
ON/OFF Line Control			
2.2	[O] [N] [RETURN]	Enables both the Serial and Parallel Ports. Initializes firmware with proper communications protocol.	10.3 8.5.6

Table 9.2 Group 2 Commands: Initialization (Cont.)

NO.	FORMAT	DESCRIPTION	PARA. REF.
2.3	[O] [F] [RETURN]	Disables both the Serial and Parallel Ports.	10.3 8.5.6
Display Control			
2.4	[N] [D] [RETURN]	Activates Normal Display Mode: MACS display is controlled with the last command from the MACS Keyboard, or from the Digital Computer if the Digital is On Line.	10.3 8.5.5
2.5	[L] [D] [RETURN]	Activates Local Display Mode: Enables independent local component selection and monitoring regardless of On Line digital computer selection.	10.3 8.5.5

Table 9.3 Group 3 Commands: Master Mode Control

NO.	FORMAT	DESCRIPTION	PARA. REF.
Analog Master Mode Selection			
3.1	[CTRL] [I] OR [I] [C] [RETURN]	Selects Initial Condition Mode. Sets the output of all Integrators to the programmed initial values. All other analog components are in the Operate Mode.	9.4.3 10.4
3.2	[CTRL] [O] OR [O] [P] [RETURN]	Selects Operate Mode. Placing the 2000 in this mode initiates the dynamic solution of a problem. The Integrators begin to integrate at the rate as determined by their operating input and effective gain.	10.4
3.3	[CTRL] [H] OR [H] [D] [RETURN]	Selects Hold Mode. The Hold Mode disconnects all Integrator inputs and holds (freezes) the Integrator outputs at their existing values. All other analog components remain in the Operate Mode.	10.4
3.4	[S] [T] [RETURN]	Selects Static Test Mode (IC Mode plus Test Reference Available at the Program Panel). See OUTPUT TRAY description (paragraph 6.9.6).	10.4 6.8.6
3.5 (7.5)	[B] [A] [RETURN]	Selects Balance Mode and Displays the Balance Page. All Integrator and Summer Gains = 1000 with inputs grounded. The BA indicator goes on if a balance error exists.	10.4 8.5.3
3.6	[Q] [T] [RETURN]	Selects Quiescent (QT) Mode (Like BA Mode, but no Balance Page). The QT Mode sets the following conditions: 1. Disconnects and grounds programmed inputs. 2. Sets gain of all Integrators and Summers to 1000.	9.4.3 10.4
Logic Master Mode Selection			
3.7	[C] [L] [RETURN]	Selects Clear Mode. Comparable to the Analog IC Mode. Used to initialize the logic elements.	9.4.3 10.5.1
3.8	[R] [U] [RETURN]	Selects Run Mode. Comparable to the Analog OP Mode. Applies system clock to all clocked components.	10.5.1

Table 9.3 Group 3 Commands: Master Mode Control (Cont.)

NO.	FORMAT	DESCRIPTION	PARA. REF.
3.9	[S] [O] [RETURN]	Selects Stop Mode. Comparable to the Analog HD Mode. Disconnects clock from all clocked components permitting them to hold the state attained at the time 0 is selected.	10.5.1
3.10	[S] [S] [RETURN]	Selects Single Step Mode. Places Logic in Stop Mode (If not already in Stop) and advances Logic one clock pulse (step) each time executed.	10.5.2
Master Mode Control Source Selection			
3.11	[A] [R] [RETURN]	Places Analog Master Mode Selection under control of the Rep-Op Timer as follows: IC → OP → HD → IC . . . . . if RT2 ≠ Ø IC → OP → IC . . . . . if RT2 = Ø	10.6.1
3.12	[L] [R] [RETURN]	Places Logic Master Mode Selection under control of the Rep-Op Timer as follows: CL → RU → SO → CL . . . . . if RT2 ≠ Ø CL → RU → CL . . . . . if RT2 = Ø	10.6.1
3.13	[A] [P] [RETURN]	Places Analog Master Mode Selection under Program Panel control of IC and HD inputs (A Mode Control Inputs). See Program Panel Mode Control (paragraph 6.8).	10.6.2 6.8
3.14	[L] [P] [RETURN]	Places Logic Panel Master Mode Selection under Control of the Program Panel CL and SO inputs (L Mode Control Inputs). See Program Panel Mode Control, paragraph 6.8.	10.6.2 6.8

NOTES

1. *To control only the Logic Master Mode with the Rep-Op Timer, patch a timing signal into the CI termination of the Rep-Op Timer and enter [L] [R] [RETURN].*
2. *When AR or LR (or both) are executed; the time spent in IC/CL, OP/RU, and HD/SO is proportional to the count stored in RTØ, RT1 and RT2 respectively; and is inversely proportional to the number of clock pulses during which the Rep-Op Timer Carry In (CI) input is high.*
3. *For synchronous control of both Logic and Analog Master Modes with the Rep-Op Timer, execute LR first and then AR. Patching is not required.*
4. *Selection of new Analog or Logic Master Mode, or a new Master Mode Control Source automatically de-selects the current Mode or Source.*
5. *In a Multi-Console environment, only the Rep-Op Timer or the A MODE and L MODE control inputs of the MASTER Console can be used to synchronously control the time critical modes of the Slaved system. Rep-Op Timers of SLAVE Consoles are free for use as counter/timers.*

Table 9.4 Group 4 Commands: Integrator Time Scale (Gain) Selection

NO.	FORMAT	DESCRIPTION	PARA. REF.
Master Time Scale Selection			
4.1	[E] [m] [RETURN]	Sets Master Time Scale Factor (Gain) to 10^m. Where m is an Exponent (E) value from Ø to 4 (10^0 - 10^4).	10.7 4.4
Relative Time Scale Selection (Individual Integrator)			
4.2	[I] [x] [=] [E] [+] [n] [RETURN] OR [I] [x] [=] [E] [–] [n] [RETURN]	Sets Integrators (I) Number Relative time scale Factor (Gain to 10 (m + n) where 0 m ± n 5). Examples for Gain Command Entry: [I] [4] [=] [E] [+] [3] (x = 4, n = 3) [I] [4] [4] [=] [E] [–] [4] (x = 44, n = 4) Examples of Effective Gain Calculation: Based on the Master Time Scale (MTS) and the commanded Relative Gain (RG), the desired effective gain is computed and set by firmware for each Integrator. The resultant gain must have one of the following values: 10^0, 10^1, 10^2, 10^3, 10^4, or 10^5. If this range is exceeded, the gain is set to the closest extreme, and the Time Scale Error Indicator (TSE) is turned on. The following Table shows seven typical in range selections and two erroneous selections.	10.7 4.4

MTS	RG	EFFECTIVE GAIN	NOTE
E0	E+0	$10^{0+0}=10^0=1$	Valid
	E+1	$10^{0+1}=10^1=10$	Valid
	E+2	$10^{0+2}=10^2=100$	Valid
	E+5	$10^{0+5}=10^5=100{,}000$	Valid for Individual Integrator
E1	E+0	$10^{1+0}=10^0=1$	Valid
	E+1	$10^{1+1}=10^2=100$	Valid
	E-1	$10^{1-1}=10^0=1$	Valid
	E-2	$10^{1-2}=10^{-1}=.1$	TSE, gain sets to 10^0
	E+5	$10^{1+5}=10^6=1{,}000{,}000$	TSE, gain sets to 10^5
E2, etc.	etc.	etc.	etc.

NO.	FORMAT	DESCRIPTION	PARA. REF.
Absolute Time Scale Selection			
4.3	[I] [x] [=] [E] [n] [RETURN]	Sets Integrator (I) Number x Absolute Time Scale Factor (Gain) to 10^n. Where n is an Exponent (E) with a value from Ø-5(10^0 - 10^5).	10.7 4.4

Table 9.5 Group 5 Commands: Component Addressing (Selection) and Readout

NO.	FORMAT	DESCRIPTION	PARA. REF.
Analog Component Selection			
5.1	[A] [x] [RETURN]	Selects and reads Type and Output of Analog Component Number x. Where x = Ø-137$_8$. Components with an A Address Include: SUM, INT, T-S, MUL, and SIN.	10.8.1 4,3-4.8 4.10 4.11
5.2	[C] [x] [RETURN]	Selects and reads type and Coefficient Value of Coefficient Device Number x. Where x = Ø-137$_8$ for DCAs and 0-37$_8$ for HSP's. The MACS component type displays POT (for Handset Coefficient Units) or DCA (for Digitally Controlled Coefficient Units). THIS COMMAND LEAVES THE PROGRAMMED ANALOG INPUT DISCONNECTED. To re-connect, select any other component.	10.8.3 4.2
5.3	[D] [x] [RETURN]	Selects and reads the Derivative (D) input value of Integrator Number x. Where x is an Integrator address (even number) in the range Ø-76$_8$.	10.8.2 4.4
5.4	[I] [x] [RETURN]	Selects and Reads the Time Scale setting and Output of Integrator (I) Number x. Where x is an Integrator address (even number) in the range Ø-76$_8$.	10.8.2 4.4 9.4.5
5.5	[P] [x] [RETURN]	Selects and reads Type and Output Value (Product) of Coefficient device Number x. Where x = Ø-137$_8$ for DCA's and Ø-37$_8$ for HSP's. The MACS Type display is POT for Handset units, and DCA for Digitally Controlled units.	10.8.3 4.2
5.6	[F] [x] [RETURN]	Selects and reads Output of DSFG Number x. Where x = Ø-17$_8$. This command must be executed prior to performing any other individual DSFG commands. See Group 6 Commands (6.8 - 6.12).	9.4.7 4.13
5.7	[T] [x] [RETURN]	Selects and reads the Output of Analog Trunk (T) Number x. Where x = Ø-57$_8$.	10.8.5
5.8	[L] [x] [y] [RETURN]	Selects and reads Logic (L) Tray Number x and the State of Logic Component Number y on that Tray. Where the Tray select x = Ø-13 and Logic component select y=Ø-7 (Ø-5 in the case of Comparators). The State of Logic Trunks, Sense Lines, Control Lines, and Interrupt Lines are read directly from the Logic Page. See Group 7 Commands (7.2). In the case of a Differentiator (DIF) this command selects and reads the State of its Flip-Flop. To find the Output Value of a DIF, patch its output into an AND gate and read the gate. This reads the DIF value indirectly. The Logic Page displays the status of the same flip-flop; not the DIF output.	10.9 5.5 5.6 5.7

Table 9.5 Group 5 Commands: Component Addressing (Selection) and Readout (Cont.)

NO.	FORMAT	DESCRIPTION	PARA. REF.
5.9	[R] [V] [x] [RETURN]	Selects and reads Value (V) of Register (R) Number x. Where in a standard configuration: x = Ø, 4, 1Ø$_8$ for GPR's; x = 1, 2, 5, 11, 12 for CTR's. The value is displayed in Decimal form. The binary equivalent of the GPR Value is displayed on the Logic Page. See Command Group 7 (7.2).	10.9 5.5 5.6 5.7
5.10	[R] [T] [x] [RETURN]	Selects and reads actual Value of Rep-Op (R) Timer (T) Value Register Number x. Where x = Ø-2 (Ø=RT0; 1=RT1; 2=RT2). The Value is displayed in decimal form. The current state of the Rep-Op Timer is displayed on the Logic Page. See Command Group 7 (7.2).	9.4.6 10.10 6.4
DAM (Digital-to-Analog Multiplier) Select			
5.11	[D] [C] [x] [RETURN]	Selects and reads Coefficient Value (C) of DAM (D) Number x. Where x = Ø-37$_8$.	10.10
5.12	[D] [A] [x] [RETURN]	Selects and reads Analog (A) Output Value of DAM (D) Number x. Where x = Ø-37$_8$.	10.10
Address Advance Command			
5.13	[CTRL] [A]	Updates the displayed address to the next sequential (and available) address of the currently selected address Type. If the currently selected component is the last available, the address cycles back (address wrap-around) to the first available component.	10.11 9.4.5 9.4.6

Table 9.6 Group 6 Commands: Component Setting

NO.	FORMAT	DESCRIPTION	PARA. REF.
Setting Digital Coefficient Attenuator (DCA)			
6.1	[C] [x] [=] [v] [RETURN]	Displays and sets digital Coefficient (C) Number x to the Value (V) in a range from -1.0 to +1.0. Where x = Ø-137$_8$; and v = a scaled fraction number consisting of an optional plus (+) sign, an optional Ø digit followed by a required decimal point (.), and up to five decimal digits. Values of +1.0 are also valid. Negative values must be preceded by a minus sign. If more than five decimal digits are entered for value, the DCA sets to a value rounded to five decimal digits.	10.12 4.2
Stepping (Slewing) DCA Coefficient Values			
6.2	[C] [x] [>] ··· [>] [RETURN]	Adds 2^{-7} (an increment of 0.008) to the current coefficient value of DCA number x (where x = Ø-137$_8$) for each [>] . Stops at ≈+1.0.	10.13 4.2

Table 9.6 Group 6 Commands: Component Setting (Cont.)

NO.	FORMAT	DESCRIPTION	PARA. REF.
6.3	[C] [x] [<] --- [<] [RETURN]	Subtracts 2^{-7} (a decrement of 0.008) from the current coefficient value of DCA number x (where x = $\emptyset$-137_8) for each [<]. Stops at ≈-1.0.	10.13 4.2
NOTES 1. *The Value of coefficient for DCA Number x is not displayed as a result of the Stepping commands, unless DCA Number x is already selected for readout by previous execution of Command 6.1.* 2. *This feature (Note 1) permits the selection of an arbitrary component (such as an Integrator) and slewing a particular DCA while simultaneously observing its effect on the selected component.*			
6.4	[D] [C] [x] [=] [v] [RETURN]	Displays and sets a Coefficient (C) of DAM (D) Number x to the digital Coefficient (C) Value (v) in a range from -1.0 to +1.0. Where x = $\emptyset$-37_8; and v = a scaled fraction number consisting of an optional $\emptyset$ digit followed by a required decimal point (.) and up to five digits. Negative values must be preceded by a minus (—) sign. If more than five decimal digits are entered for the coefficient values the DAM sets to a value rounded to five decimal digits.	10.14
Set Rep-Op Timer			
6.5	[R] [T] [x] [=] [i] [RETURN]	Sets Rep-Op Timer (RT) Initial Value Register Number x to value i. Where x = $\emptyset$-2 (RT$\emptyset$ - RT$\emptyset$2), and i = $\emptyset$-32767_{10}. Execute this command in any Logic Master Mode. The transfer of Initial Values occurs when the AR Command (which starts the Rep-Op Timer) is executed; when Timer RUN goes low, or SKP goes high, and on every Carry-Out Pulse.	10.15 6.4
Set General Purpose Registers (GPRs) and Counters (CTRs)			
6.6	[R] [V] [x] [=] [i] [RETURN]	Sets the Value (V) Register (R) of GPR or CTR Number x to value specified by i as follows: 1. GPR In a standard configuration x = $(\emptyset, 4, 1\emptyset)_8$; and i = $\emptyset$-377_8. The GPR has no Initial Value Register. Logic Clear (CL) resets all eight flip-flops to the zero state. Therefore, this command must be executed in a Logic Mode other than CL. The MACS Logic Page displays the actual GPR contents in a binary form (Bit 7 is the LSB). The decimal equivalent of the GPR content is displayed in the VALUE window.	10.16 5.5 5.6

Table 9.6 Group 6 Commands: Component Setting (Cont.)

NO.	FORMAT	DESCRIPTION	PARA. REF.
Set General Purpose Register (GPRs) and Counters (CTRs)			
6.6 (cont.)		2. CTR In a standard configuration $x=(1,2,5,6,11,12)_8$; and $i=\emptyset\text{-}32767_{10}$ or $\emptyset\text{-}77777_8$. This command loads the Initial Value Register of CTR x and can be executed in any Logic Master Mode. Transfer of the Initial Value to the CTR occurs in Logic CL; when CTR Reset (its R input set goes high), and automatically on every Carry Out Pulse. Patching is not required. The MACS Logic Page displays the condition of the CTR State Flip-Flop. The CTR content is displayed in decimal form in the VALUE window.	
Set Logic Components			
6.7	(to set): [L] [x] [y] [=] [1] [RETURN] (to reset): [L] [x] [y] [=] [Ø] [RETURN]	Sets/resets Logic Component Number y in Logic (L) Tray Number x to 1 or Ø. Where $x = \emptyset\text{-}13_8$ and $y = \emptyset\text{-}7_8$ (Ø-5 for Comparators). Set Flip-Flops, Differentiators, Counters, and Comparators while in the Logic Stop (SO) Mode. This overrides the effect of patched inputs. The Differentiator Flip-Flop may be Set/Reset, not the DIF output. This command cannot directly Set/Reset individual GPR Flip-Flops.	10.17 5.5 5.7
Setting DSFGs (Digitally Set Function Generators)			
6.8	[B] [=] [2] [1] [RETURN] OR [B] [=] [4] [1] [RETURN]	Initializes the previously selected DSFG (Command 5.6) for set up of a 21 or 41 Breakpoint (B) function.	10.18 9.4.7 4.13
6.9	[V] [x] [=] [f] [RETURN]	Enters (sets) Function Value f at Breakpoint Number x of the previously selected DSFG (Command 5.6). Where x = Ø-21 or Ø-41, and f is a function value in the range of -1.0 to +1.0. Also brings in the updated function page, if entered through the MACS keyboard. The value of F is a scaled fraction number consisting of an optional Ø digit followed by a required decimal point and up to five digits. Negative values must be preceded by a minus (–) sign. If more than five decimal digits are entered for a value f, the DSFG sets a value rounded for five decimal digits. The difference between two neighboring function values cannot exceed ±1.0 MU (i.e., $\lvert f_{n+1} - f_n \rvert \leq 1$).	10.18 4.13

Table 9.6 Group 6 Commands: Component Setting (Cont.)

NO.	FORMAT	DESCRIPTION	PARA. REF.
6.10	[S] [;] [RETURN]	Set (Restore) the selected DSFG (Command 5.6) to the values it had before it was set with a Test Function (Command 6.12). Also used to set a selected DSFG if the function values were entered from the Serial Port, and were not followed by the Set Command.	10.18 4.13
6.11	[F] [y] [=] [x] [RETURN]	Function Transfer. Sets DSFG Number y to the same function values as DSFG Number x and selects DSFG Number y. Where y and x = Ø–17_8.	10.18 4.13
6.12	[F] [x] [=] [′] [m] [RETURN]	Sets DSFG Number x with the test function specified by ′m. Where x = Ø–17_8. The Test Function Code for ′m is as follows: ′m — Resulting Test Function ′100 — 21BPT Function y = +X ′101 — 21BPT Function y = -X ′200 — 41BPT Function y = +X ′201 — 41BPT Function y = -X After test function is verified, Fx can be restored to its original value using Command 6.10.	10.18 4.13
6.13	[F] [7] [7] [=] [′] [m] [RETURN]	Sets all DSFGs (Ø–17_8) to the test function specified by ′m. The Restore Command (6.10) can also be used in conjunction with this command to reset all DSFGs to the Functions they were set to prior to issuing the test function command.	10.18 4.13

Table 9.7 Group 7 Commands: Paging

NO.	FORMAT	DESCRIPTION	PARA. REF.
7.1	[CTRL] [F] OR [L] [I] [;] [RETURN]	Brings in Function Page for the previously selected DSFG (Command 5.6). This page Lists the function values at each Breakpoint. Once executed, CTRL F is automatically re-executed upon selection of another DSFG, or upon entry of new function values.	10.19 9.4.7
7.2	[CTRL] [L]	Brings in Logic Display Page. Includes SL, CL, IL, and RT States, in addition to displaying states of General Purpose Logic Components and Trunks.	10.19
7.3	[CTRL] [R]	Brings in Range (Overload) Page which (with the exception of Coefficient devices), indicates all overloaded Analog Computing Components (Including DSFGs).	10.19
7.4	[CTRL] [T]	Brings in Time Scale Error Page. Indicates all Integrators having a Time Scale Error (TSE). See Command 4.2 for cause of TSE.	10.19

Table 9.7 Group 7 Commands: Paging (Cont.)

NO.	FORMAT	DESCRIPTION	PARA. REF.
7.5 (3.5)	[B] [A] [RETURN]	Executes BA Mode and brings in Balance Page. This Page indicates all out of balance amplifiers including T/S Summers and Integrators. This Command must be re-executed in order to update the contents of the Balance Page.	10.4 10.19

Table 9.8 Group 8 Commands: Program-Save-To-Restore

NO.	FORMAT	DESCRIPTION	PARA. REF.
8.1	[N] [$] [C] [:] [RETURN]	This command outputs analog program data of console number n to an external Teletype compatible device via the RS232 Port. The data is output in the same format as required for future re-setup. The program data includes: Coefficient values of Handset Pots, DCA's, DAM's; Integrator Time Scales; RV and RT Register Values; and all DSFG values. The list is headed with the current Master Time Scale and both Master Modes. This command must originate (be entered) at the external device. Upon read-in, this command restores the original problem settings: all coefficients (except Handset Pots); Integrator Time Scales; DSFGs; and all Initial Value Registers to the corresponding counters must be implemented by the user. The machine is restored to the same Master Modes and Time Scale that existed.	10.20
8.2	[n] [$] [V] [:] [RETURN]	Analog Program Value Save. This command outputs the values of all A, D, F, P, and readable T components of console number n to an external Teletype compatible device via the RS232 Port, and must be entered from the external device. The list is headed with the current Master Time Scale and both Master Modes.	10.20
8.3	[n] [$] [F] [:] [RETURN]	Outputs the function values of the selected (and used) DSFG for re-setup when read back. A "used" DSFG is defined as a DSFG upon which at least one function value has been set (Command 6.9). This command must be entered from the external device.	10.20

NOTES

1. *Connect the input/output device through the Serial Port, Select the proper Baud rate, select On-Line Mode (Command 2.2), and start the external device before using the above commands.*
2. *Read-in is initiated from the device, not at the MACS.*
3. *The RETURN character may have other designations (such as CARRIAGE RETURN, CR or ↲) as determined by the specific external device.*

Table 9.8 Group 8 Commands: Program-Save-To-Restore (Cont.)

NOTES (Cont.)

4. *$C and $F cassette or paper tapes can be produced Off-Line by simply keying the same command sequence one would enter from the MACS.*
5. *To abort the execution of the $ commands, execute Command 1.3 ([CTRL] [S]) at the MACS.*
6. *In single console systems, the console number (n) does not have to be specified. In a multi-Console environment, omitting the console number is equivalent to specifying the n of the last console selected.*

Table 9.9 Group 9 Commands: Miscellaneous

NO.	FORMAT	DESCRIPTION	PARA. REF.
Digital Value Monitoring			
9.1	[D] [V] [RETURN]	Selects the analog input termination at the program panel as the input to the DVM (Digital Volt Meter). Permits patching an analog signal to the DVM for conversion and readout on the MACS VALUE Display.	10.2.1
Generating BLIPs (Pushbutton Flip-Flop)			
9.2	[BLIP] [x]	Generates a BLIP at the corresponding Program Panel terminations designated ⎍ x. BLIP is one of the three special keys, and x = Ø–3.	10.2.1

Table 9.10 Group 10 Commands: Multi-Console

NO.	FORMAT	DESCRIPTION	PARA. REF.
Master Console			
10.1	[M] [C] [RETURN]	A console at which this command is executed is declared the MASTER Console as indicated by the display of a contrast inverted M under the MC Indicator heading. For predictable results, only one console of a multi-console system should be selected as MASTER. In a multi-console system, the time critical Analog and Logic Modes are changed synchronously. Master Time-Critical (analog and logic) Mode commands (MASTER or SLAVE) in the system. However, Synchronous Program Panel control of time-critical analog and logic modes may only be performed by patching at the MASTER Console. Similarly, the Rep-Op Timer of a MASTER Console only may be used to control the time-critical modes of a multi-console system.	8.4.1 8.4.2 8.5.7 8.7

Table 9.10 Group 10 Commands: Multi-Console (Cont.)

NO.	FORMAT	DESCRIPTION	PARA. REF.
10.1 (cont.)		**NOTE** *For proper execution; this command should be issued as a single command, or as the last command in a command string. If not, the ILLEGAL COMMAND error message will result. This same error message is output if the Multi-Console expansion is not present in the system.*	
Slave Console			
10.2	[S] [L] [RETURN]	This command selects the console at which it is issued as a SLAVE in a multi-console system. When Slaved, the time-critical modes change synchronously with the mode of operation of the MASTER console. The mode commands for the Slaved system can be issued at the keyboard of the MASTER console, or any one of the other SLAVE consoles. When the SLAVE command is executed, a contrast inverted S is displayed under the MC (Multi-Console) heading to indicate that the console is Slaved. When the master mode of a console is slaved, SL is displayed to the right of the current A and L MODE headings. **NOTE** *For proper execution; this command should be issued in a single command, or as the last command in a command string. If not, the ILLEGAL COMMAND error message will result. This same error message is output if the Multi-Console Expansion is not present in the system.*	8.4.1 8.4.2 8.5.7 8.7
Console Selection			
10.3	[n] [RETURN]	Display the video of the Selected Console on the display of the console at which the Select Command was issued. In a Multi-Console environment, this command presets a console prefix (n = 1-6) for all subsequent commands which may be issued without the prefix. Normally, Console Select is issued in response to the message **CONSOLE NOT SELECTED** (appearing in the Special Message Pad area of the display). Once the Multi-Console system is set up, and the console prefix is known to the system (by issuance of this command, or another command that included the console prefix), the video display of the selected console is switched to the display of the console at which the selection is made.	8.7

Table 9.10 Group 10 Commands: Multi-Console (Cont.)

NO.	FORMAT	DESCRIPTION	PARA. REF.
Console Selection (Cont.)			
10.3 (cont.)		If when issuing this command one asks for the video of a console that is not part of the Slaved System (not a MASTER ( ) or one of the SLAVE consoles), a NO SUCH CONSOLE error message will be displayed, and each console will display its own video with the **CONSOLE NOT SELECTED** message. **NOTE** *The Console Select Command is particularly useful during the debugging of a Multi-Console program. For example, should the OV indicator display a contrast-inverted asterisk, an overload condition exists in one or more of the other consoles (other than and/or in addition to the console whose video is currently on). Therefore, by systematically issuing the Console Select on each Console in the system in turn, and observing the state of the OV indicator, it is possible to determine precisely which consoles are in overload.*	
Unslaving (Normal) Command			
10.4	[n] [N] [O] [RETURN]	Places MASTER or SLAVE Console number n in the Unslaved Mode. In other words, Console n is no longer a MASTER or SLAVE, and may be operated independently of the rest of the Multi-Console system. The entry [n] must be the prefix of a console belonging to the Slaved system. If not the NO SUCH CONSOLE error message and the **CONSOLE NOT SELECTED** message will be displayed, and each console will display its own video. When the [n] selection is within range (is a part of the Slaved system), only the specified console (MASTER or SLAVE) will be removed from the Slaved system and the rest of the system will remain Slaved. If the MASTER console is deselected, another MASTER selection (Command 10.1) should be made for the Slaved system. To unslave the entire system use [CTRL] [S] (Command 1.3) instead of executing 1NO, 2NO, 3NO, etc.	8.7

Table 9.11 Alphabetic List of MACS Commands

Item	Command Format	Basic Function	Table Ref.	Command No.
1	[A] [P] [RETURN]	Select Program Panel as source for Analog Master Mode control.	9.3	3.13
2	[A] [R] [RETURN]	Select Rep-Op Timer as source for Analog Master Mode control.	9.3	3.11
3	[A] [x] [RETURN]	Address and Read an Analog component.	9.5	5.1
4	[B] [A] [RETURN]	Balance Mode Select.	9.3 (9.7)	3.5 (7.5)
5	[B] [=] [2] [1] [RETURN] Refer to Items 28 to 31 and 70 for related commands.	Initialize previously selected DSFG for set-up of a 21 Breakpoint Function.	9.6	6.8
6	[B] [=] [4] [1] [RETURN] Refer to Items 28 to 31 and 70 for related commands.	Initialize previously selected DSFG for set-up of a 41 Breakpoint Function.	9.6	6.8
7	[BLIP] [x]	Generate a Pulse (BLIP).	9.9	9.2
8	[C] [L] [RETURN]	Clear Mode Select.	9.3	3.7
9	[CTRL] [A]	Address Advance.	9.5	5.13
10	[CTRL] [F] See Item 40 for alternate command.	Display Function Page.	9.7	7.1
11	[CTRL] [H] See Item 32 for alternate command.	Hold Mode Select.	9.3	3.3
12	[CTRL] [I] See Item 33 for alternate command.	Initial Condition Mode Select.	9.3	3.1

14	[CTRL] [O] See Item 54 for alternate command.	Operate Mode Select.	9.3	3.2
15	[CTRL] [R]	Display Range Page.	9.7	7.3
16	[CTRL] [S]	Editing (Command Abort).	9.1	1.3
17	[CTRL] [T]	Display Time Scale Error Page.	9.7	7.4
18	[C] [x] [RETURN] See Items 19 to 22 for related commands.	Select and read Coefficient value of a Hand-set Pot or DCA.	9.5	5.2
19	[C] [x] [>] ··· [>] [RETURN] ([C] [x] [>]: This part of entry is not required if C x is already selected for display (Item 18).)	Increment (step) DCA Coefficient value.	9.6	6.2
20	[C] [x] [<] ··· [<] [RETURN] ([C] [x] [<]: This part of entry is not required if C x is already selected for display (Item 18).)	Decrement (step) DCA Coefficient value.	9.6	6.3
21	[C] [x] [=] [v] [RETURN] ([C] [x]: This part of entry is not required if C x is already selected for display (Item 18).)	Set DCA Coefficient value.	9.6	6.1
22	[D] [A] [x] [RETURN]	Select and read Output (product) of a DAM.	9.5	5.12
23	[D] [C] [x] [RETURN]	Select and read Coefficient of a DAM.	9.5	5.11
24	[D] [C] [x] [=] [v] [RETURN] ([D] [C] [x]: This part of entry is not required if DCx is already selected for display (Item 23).)	Set DAM Coefficient value.	9.6	6.4
25	[D] [V] [RETURN]	DVM in Select.	9.9	9.1
26	[D] [x] [RETURN]	Select and read Derivative (Input) of an Integrator.	9.5	5.3

37	[I] [x] [=] [–] [n] [RETURN] This part of entry is not required if I x is already selected for display (Item 34).	Selects Relative Local Time Scale of an Integrator (Negative).	9.4	4.2
38	[J] [;] [RETURN] See Item 50 for related command.	Console Initialization (Job).	9.2	2.1
39	[L] [D] [RETURN] See Item 48 for counter command.	Initialize Display in Local Mode.	9.2	2.5
40	[L] [I] [;] [RETURN] See Item 10 for alternate command.	Display Function Page.	9.7	7.1
41	[L] [P] [RETURN]	Select Program Panel as source for Logic Master Mode Control.	9.3	3.14
42	[L] [R] [RETURN]	Select Rep-Op Timer as source for Logic Master Mode Control.	9.3	3.12
43	[L] [R] [,] [A] [R] [RETURN]	Synchronize Rep-Op Timer Control of both Logic and Analog Master Modes.	9.3	3.11/3.12
44	[L] [x] [y] [RETURN]	Address and Read Logic Tray Type and the State of a Logic Component.	9.5	5.8
45	[L] [x] [y] [=] [1] [RETURN]	Set Logic Component.	9.6	6.7
46	[L] [x] [y] [=] [Ø] [RETURN] This part of entry is not required if L x y is already selected for display (Item 44).	Reset Logic Component.	9.6	6.7
47	[M] [C] [RETURN] See Items 49, 51, and 65 for related commands.	Master Console select (Multi-Console systems only).	9.10	10.1

Table 9.11 Alphabetic List of MACS Commands (Cont.)

Item	Command Format	Basic Function	Table Ref.	Command No.
27	[E] [m] [RETURN] See Items 34 thru 37 for related commands.	Set Master Time Scale Factor.	9.4	4.1
28	[F] [x] [RETURN] See Items 5, 6, 29-30 and 70 for related commands.	Select and read a DSFG output.	9.5	5.6
29	[F] [x] [=] ['] [m] [RETURN] ([F] [x] [=]: This part of entry is not required if F x is already selected for display (Item 28).)	Set a DSFG to a specified Test Function.	9.6	6.12
30	[F] [y] [=] [x] [RETURN]	DSFG Function Transfer.	9.6	6.11
31	[F] [7] [7] [=] ['] [m] [RETURN]	Set all DSFGs to a specified Test Function.	9.6	6.13
32	[H] [D] [RETURN] See Item 11 for alternate command.	Hold Mode Select.	9.3	3.3
33	[I] [C] [RETURN] See Item 12 for alternate command.	Initial Condition Mode Select.	9.3	3.1
34	[I] [x] [RETURN]	Address and read Time Scale and Output of an Integrator.	9.5	5.4
35	[I] [x] [=] [E] [n] [RETURN] ([I] [x] [=]: This part of entry is not required if I x is already selected for display (Item 34).)	Set Absolute Local Time Scale.	9.4	4.3
36	[I] [x] [=] [+] [n] [RETURN] ([I] [x] [=]: This part of entry is not required if I x is already selected for display (Item 34).)	Select Relative Local Time Scale of an Integrator (Positive).	9.4	4.2

Table 9.11 Alphabetic List of MACS Commands (Cont.)

Item	Command Format	Basic Function	Table Ref.	Command No.
48	[N] [D] [RETURN] See Item 39 for counter command.	Initialize Display in Normal Mode.	9.2	2.4
49	[n] [RETURN] See Items 47, 51, and 65 for related commands.	Console Select (Multi-Console systems only).	9.10	10.3
50	[n] [J] [;] [RETURN] See Item 38 for related command.	Console Initialization (Job).	9.2	2.1
51	[n] [N] [0] [RETURN] See Items 47, 49, and 65 for related commands.	Unslave Console (Multi-Console Systems only).	9.10	10.4
52	[O] [F] [RETURN]	Inhibit communications via Serial and Parallel Ports.	9.2	2.3
53	[O] [N] [RETURN]	Enable communications via Serial and Parallel Ports.	9.2	2.2
54	[O] [P] [RETURN] See Item 14 for alternate command.	Operate Mode Select.	9.3	3.2
55	[P] [x] [RETURN]	Select and Read output (product) of a Coefficient device.	9.5	5.5
56	[Q] [T] [RETURN]	Quiescent Mode Select.	9.3	3.6
57	[R] [T] [x] [RETURN]	Select and read Rep-Op Timer Initial Values.	9.5	5.10
58	[R] [T] [x] [=] [i] [RETURN] This part of entry is not required	Set Rep-Op Timer.	9.6	6.5

59	RUB OUT	Editing (delete a character).	9.1	1.1
60	RUB OUT RETURN	Editing (delete a line).	9.1	1.2
61	R U RETURN	Run Mode Select.	9.3	3.8
62	R V x RETURN	Select and Read Value of GPR and CTR Registers.	9.5	5.9
63	R V x = i RETURN (R V x) — This part of entry is not required if R V x is already selected for display (Item 62).	Set General Purpose Registers (GPR) and Counters (CTR).	9.6	6.6
64	S ; RETURN See Items 28 and 29 for related commands.	Set (restore) DSFG function after setting a Test Function.	9.6	6.10
65	S L RETURN See Items 47, 49, and 51 for related commands.	Slave Console select (Multi-Console systems only).	9.10	10.2
66	S O RETURN	Stop Mode Select.	9.3	3.9
67	S S RETURN	Single Step Mode Select.	9.3	3.10
68	S T RETURN	Static Test Mode Select.	9.3	3.4
69	T x RETURN	Select and Read an Addressable Analog Trunk.	9.5	5.7
70	V x = n RETURN See Items 5, 6, and 28 for related commands.	Set DSFG Function Value of the previously selected DSFG.	9.6	6.9
71	n $ C : RETURN	Program Save/Restore.	9.8	8.1
72	n $ F : RETURN	Function Value Save/Restore.	9.8	8.3
73	n $ V : RETURN	Analog Program Value Save.	9.8	8.2

9.4 TYPICAL COMMAND EXERCISES

9.4.1 INTRODUCTION

The following paragraphs provide some basic command information and some introductory exercises for user familiarization with MACS keyboard operation. The various exercises include illustrations of actual video frames taken from the MACS CRT Display.

9.4.2 ENTERING COMMANDS IN GENERAL

As each character of a command is entered (typed) at the MACS Keyboard, it is displayed in the Scratch Pad area of the MACS Display CRT. As described in Paragraph 8.6 the Cursor (contrast inverted blank) appears in the position that the next entered character will occupy. Once the entire command is entered, the Carriage Return Key ([RETURN]) must be depressed for command execution. The command is first analyzed (by the CSI firmware) for syntax errors, and is then executed. Most MACS Commands are only a few characters long, making them easy to remember, and reducing the probability of errors. If an error is detected, the appropriate error message is flashed in the Message Pad area (just below the Scratch Pad). To gain operator attention, the error message is followed by a discreet audio cue. Furthermore, the cursor is located immediately to the right of the first erroneous character detected by the firmware. The incorrect character is contrast inverted.

To correct a syntax error, simply re-enter the command properly. There is no need to erase ([RUB OUT]) the portion of the command that is in error.

If there is no error in either syntax or command execution, the Scratch Pad content remains intact, except that the cursor disappears. Therefore, the absence of the cursor indicates prior execution of the command(s). Commands displayed in the Scratch Pad may be re-executed by pressing [RETURN] again.

Several commands can be strung between commas ([,]) and when [RETURN] is pressed, the entire group of commands will be executed in the order each was entered. The processing of a string of commands stops with the first error detected. All commands beyond the detected point of error (beyond the cursor) are ignored. Commands with a colon ([:]) or semi-colon ([;]) as the last character do not require commas as command separators. See Paragraph 9.2, Note 4, for additional information.

Commands involving the equal sign ([=]) are typically used for setting component values (Table 9.6). If the component to be set is already selected (displayed in the ADDRESS window), only the value data (right hand side of the entry), along with the equal sign need be entered. For example, Command 6.1 specifies the entry [C] [x] [=] [v] to set a DCA Coefficient. Assume C4Ø is the DCA in question, has previously been selected and is now to be set to Ø.5. The ADDRESS windows would then have the following display:

ADDRESS
1CØ4Ø

Therefore, it is only necessary to enter the value data portion of the command

[=] [•] [5] [RETURN]

rather than the entire command

[C] [4] [Ø] [=] [·] [5] [RETURN]

In a Multi-Console Environment, all commands (except 10.1 and 10.2, Table 9.10) accept a console prefix number. If the prefix number is not entered, the command will affect the previously selected console.

9.4.3 INITIALIZING THE SYSTEM

When power is applied to the EAI 2000, the power up sequence takes place. This is a partial execution of the Job Command (See Table 9.2, Command 2.1) as the momentary BA Mode is skipped. The Job Command initializes the console by momentarily placing it in the Balance (BA) Mode. The following is the total effect of executing the Job Command (See Figure 9.2):

1. All analog inputs grounded.
2. Gain of all Integrators and Summers = 1000.
3. Master Time Scale = EØ
4. Logic Mode = CL
5. Individual Integrator Time Scale = E+Ø
6. Display Mode = Normal
7. AØ is selected.
8. REP-OP Timer set to:

   RTØ = 5ØØ

   RT1 = 5ØØØ

   RT2 = Ø
9. All DSFG's set to Y = Ø with 21 Breakpoints.
10. Logic Page selected.

The display state illustrated in Figure 9.2 occurs automatically during power-up, or with Keyboard execution of the Job Command (J;RETURN).

Observe the : selected amplifier 1AØØØ (the number 1 specifies Console 1); QT and CL Master Modes; EØ Master Time Scale Factor; the General Purpose Logic Page; and the cursor (bright rectangle in the scratch pad area). Also observe the last noisy digit of the VALUE display. This is the result of the high gain imposed on AØØ in the QT Mode and is typical. Also, note the off state of the six indicators in the upper right-hand corner. If a balance error had occured while the console was momentarily in the Balance Mode, the BA indicator would be lit.

```
 ADDRESS               VALUE          TYPE   TS  BA  OV
1A000    +0.0000  INT
  A MODE              L MODE         SCALE      LD   HY   MC
QT                    CL             E0

█




GENERAL PURPOSE LOGIC
0001234567   0101234567   0201234567   0301234567
0401234567   0501234567   0601234567   0701234567
1001234567   1101234567   1201234567   1301234567

SENSE LINES                CONTROL LINES
0001234567   0101234567   0001234567   0101234567

INPUT TRUNKS               INTERRUPTS    TIMER
0001234567                 0001234567    012
```

Figure 9.2 Typical MACS Display After Power-Up or Job Command Execution

9.4.4 EXERCISES IN MODE SELECTION

Let us place the EAI 2000 in the Initial Condition Mode. Quickly checking into the available commands for Master Mode Selection (Analog Master Mode Selection Group 3, Table 9.3), there are two ways to select the Initial Condition Mode using Command 3.1: one, by depressing the [CTRL] key and then the character [I] ; or, two, by typing in the characters [I] [C] followed by the Carriage Return character ([RETURN] key). If we choose to do it the second way, we first type in character [I] .

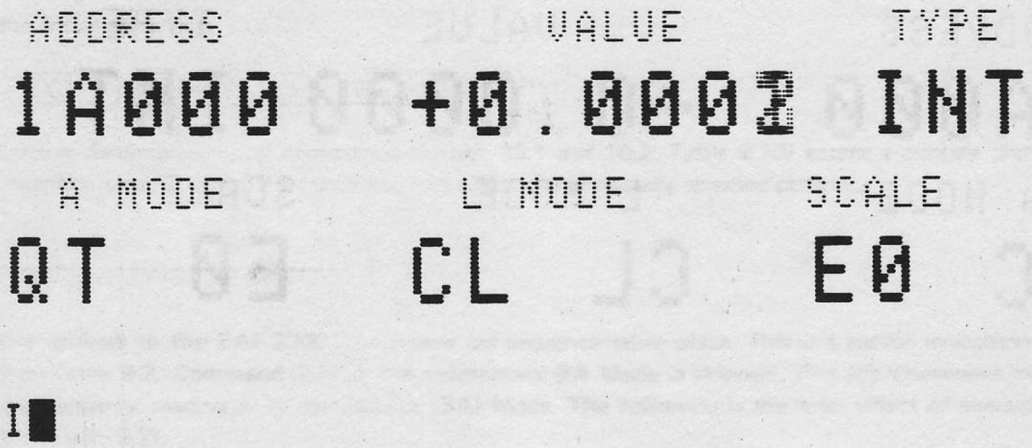


Figure 9.3 IC Mode Command (3.1), First Character

As a response, the system enters the same character into the Scratch Pad area and moves the cursor one character ahead as shown in Figure 9.3.

Next, we type in [C] and the process repeats, i.e., the character "C" is displayed in the Scratch Pad area (Figure 9.4) and the cursor moves to the next character position.

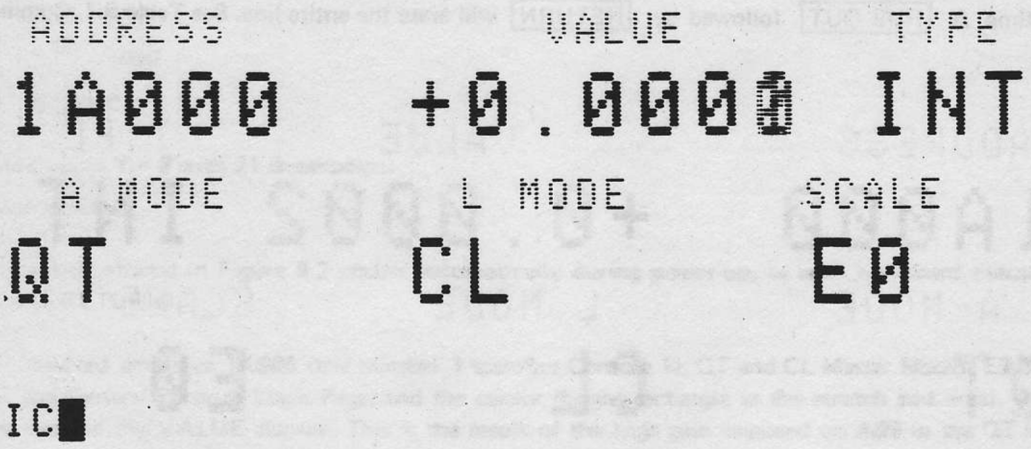


Figure 9.4 IC Mode Command (3.1), Second Character

Even though we have entered the command name, the command is not yet executed. The A MODE display still indicates the QT Mode. To execute the command, we press the [RETURN] key. [RETURN] signals the completion of the entry (End of Record) from the MACS keyboard and the firmware proceeds to execute the typed in command. Within a 30th of a second, the firmware has updated the Display (Figure 9.5 to show the new A MODE. Observe that the Cursor is no longer present.

```
ADDRESS          VALUE          TYPE
1A000   -0.0000   INT
A MODE          L MODE          SCALE
IC              CL              E0

IC
```

Figure 9.5 IC Mode Command (3.1) Executed

Note that the VALUE is now a solid zero since the gain through the IC input is one (1) and we did not patch anything into it (equivalent to patching the analog ground, zero).

Assume that we typed in the character [D] by mistake, and without looking into the Scratch Pad area tried to execute the ID command (Figure 9.6). Based on this entry, we would hear a single beep every time we tried to execute this erroneous command. Additionally, the firmware outputs the flashing ILLEGAL COMMAND message which is shown on the next display illustration. If we happen to notice the typing error, we can use the [RUB OUT] key to erase one character at a time. A [RUB OUT] followed by [RETURN] will erase the entire line. See Table 9.1, Commands 1.1 and 1.2.

```
ADDRESS          VALUE          TYPE
1A000   +0.0002   INT
A MODE          L MODE          SCALE
QT              CL              E0

ID█
ILLEGALCOMMAND
```

Figure 9.6 Illegal Mode Command

To enter the legal command after trying to execute an illegal one, we simply proceed by entering the correct commands. It is not necessary to erase the illegal command from the Scratch Pad area. Since this is an exercise, let's enter the legal IC command with the [CTRL] and [I] keys. Depressing the CTRL key and holding it down while typing in the [I] character, will automatically clear the Scratch Pad area and then echo the IC set of characters as if we typed them in ourselves. Note that there is no difference in the execution speed of the IC command regardless of how it is entered.

9.4.5 EXERCISES IN INTEGRATOR SELECTION

We shall now select a few integrators to verify the individual time scale of each. As a result of the Job Command (Paragraph 9.4.3), they should all be set to E+Ø.

The command format to select an Integrator for readout of its Time Scale is

[I] [x] [RETURN]

This is Command 5.4 from Table 9.5, Component Address Selection and Readout Group 5.

Therefore, we enter [I] [Ø] [RETURN] and observe that the time scale factor for integrator IØØØ is, in fact, E+Ø as displayed under the heading TYPE (Figure 9.7). Note that it is not necessary to enter leading zeros ([I] [Ø] [Ø] [Ø] or [I] [Ø] [Ø]). However, entering leading zeros is legal and will select the same component.

```
ADDRESS          VALUE          TYPE
1I000     -0.0000     E+0

  A MODE         L MODE         SCALE
IC               CL             E0


I0
```

Figure 9.7 Integrator Gain and Output Readout Command (5.4)

To check the gain of other integrators, we can use the [CTRL] [A] command (Address Advance Command 5.13).

This command advances the address toward the next available component of the same type (Ix). Observe that the content of the Scratch Pad (Figure 9.8) is left intact. The alternative to using the [CTRL] [A] command would be time consuming, since we would have to type an individual address for each integrator on a trial and error basis.

```
ADDRESS            VALUE          TYPE
1I004        -0.0000        E+0
  A MODE            L MODE         SCALE
IC                  CL             E0



I0
```

Figure 9.8   Advancing Address to Next Available Integrator (Command 5.13)

Advancing the address again with the same [CTRL] [A] command (Figure 9.9), identifies integrator 1Ø as the next available integrator. Note that the integrator gain is correctly set to E+Ø.

Observe the half bright L next to the address field. This signifies the existence of an optional limiter for the selected integrator. All Integrators have this option. Integrators for which the Limiter option is not exercised do not display the L. See Figures 9.7 and 9.8 for IØ and I4, respectively.

```
ADDRESS            VALUE          TYPE
1I010L       -0.0000        E+0
  A MODE            L MODE         SCALE
IC                  CL             E0



I0
```

Figure 9.9   Advancing Address (Command 5.13) to Integrator with Limiter Option Exercised

If integrators Ø, 4 and 1Ø were the only integrators within the system, the next execution of the [CTRL] [A] command would re-select integrator Ø. This is the address wrap-around feature.

The addressing scheme is octal. Therefore, if we attempt to address integrator 8, the firmware generates the error message, NUMBER OUT OF RANGE (Figure 9.10). Note how the Scratch Pad character 8 (the erroneous entry) is contrast-inverted.

ADDRESS VALUE TYPE

1A000 -0.0000 INT

A MODE L MODE SCALE

IC CL E0

I8

NUMBER OUT OF RANGE

Figure 9.10 Integrator Out of Range Error

9.4.6 EXERCISES FOR READING THE REP-OP TIMER

By addressing the Rep-Op Timer (Table 9.5, Command 5.10), we can read the initial values assigned to the timer registers by the JOB; command. We will first address the RTØ (Figure 9.11).

ADDRESS VALUE TYPE

1I010L -0.0000 E+0

A MODE L MODE SCALE

IC CL E0

RT0█

Figure 9.11 Selecting RTØ for Readout (Command 5.10)

Upon pressing the RETURN key (Figure 9.12), the ADDRESS window reflects the RTØ address, and the content of that initial value register is displayed as 500 in the VALUE window.

ADDRESS	VALUE	TYPE
1RTØ	500	
A MODE	**L MODE**	**SCALE**
IC	CL	EØ

RTØ

Figure 9.12 Execution of RTØ Readout

Now advancing the address with the [CTRL] [A] command will display the initial setting for the RT1 (=5000) and RT2 (=Ø) Rep-Op Timer Initial Value Registers as shown in Figure 9.13. Observe the unchanged content (RTØ) of the Scratch Pad area. This is true for all control key ([CTRL]) commands.

ADDRESS	VALUE	TYPE
1RT1	5000	
A MODE	**L MODE**	**SCALE**
IC	CL	EØ

RTØ

a. First CONTROL A

```
ADDRESS            VALUE        TYPE
1RT2                   0

  A MODE         L MODE        SCALE
IC               CL            E0

RT0
```

b. Second CONTROL A

Figure 9.13 Readout of RT1 and RT2 Using Address Advance (Command 5.13)

9.4.7 DSFG Exercises

Now let's check whether DSFG's (Digitally Set Function Generators) have been set to zero by the JOB; command. To do this, we simply enter the address of the first function generator (expected to be FØ) followed by RETURN. This particular EAI 2000 system (Figure 9.14) on which the above commands are exercised does have DSFG Ø.

```
ADDRESS            VALUE        TYPE
1F000        +0.0001            FG

  A MODE         L MODE        SCALE
IC               CL            E0

F0
```

Figure 9.14 Executing DSFG Select (Command 5.6)

Note the TYPE readout FG (Function Generator) and its output of almost zero. If the system did not have a DSFG at the address FØ, the VALUE entry would be flashing INVALID (as shown in Figure 9.15) when F5 is addressed. This system does not have a DSFG unit at the F5 address.

```
ADDRESS              VALUE          TYPE
1F005              INVALID

  A MODE            L MODE         SCALE
IC                  CL              E0


F5█
```

Figure 9.15 Invalid DSFG Selection

In order to see the table of functional values, we have to invoke the Function Page by entering the list command (LI; RETURN or CTRL F). See Table 9.7, Command 7.1. The bottom part of the screen (Figure 9.16) contains the full table titled with the DSFG ØØ (the one that is addressed). The left most column (displayed half bright) contains the cue.

```
ADDRESS           VALUE            TYPE     TS    BA    OV
1F000         +0.0001             FG

  A MODE          L MODE           SCALE    LD    HY    MC
IC                CL               E0


LI;


DSFG 00
(01) +0.0000, +0.0000, +0.0000, +0.0000, +0.0000
(06) +0.0000, +0.0000, +0.0000, +0.0000, +0.0000
(11) +0.0000, +0.0000, +0.0000, +0.0000, +0.0000
(16) +0.0000, +0.0000, +0.0000, +0.0000, +0.0000
(21) +0.0000
```

Figure 9.16 Execution of DSFG Function Page (Command 7.1)

Note that DSFG Ø (and all others present within the system at the time of power-up or execution of the JOB; command) is initiated with 21 breakpoints (B=21). We can easily change it into a 41 breakpoint function by entering B=41 [RETURN]. To confirm acceptance of the B=41 command entry, we can relist the function table.

Instead of executing the above commands separately, we can string them by entering them in the order we want them executed (separated by commas) and entering just one [RETURN] at the end of a string. See Figure 9.17.

```
ADDRESS            VALUE          TYPE   TS   BA   OV
1F000      +0.0001  FG

  A MODE          L MODE         SCALE    LD   HY   MC
IC            CL             E0

B=41,LI;


DSFG 00
(01) +0.0000, +0.0000, +0.0000, +0.0000, +0.0000
(06) +0.0000, +0.0000, +0.0000, +0.0000, +0.0000
(11) +0.0000, +0.0000, +0.0000, +0.0000, +0.0000
(16) +0.0000, +0.0000, +0.0000, +0.0000, +0.0000
(21) +0.0000, +0.0000, +0.0000, +0.0000, +0.0000
(26) +0.0000, +0.0000, +0.0000, +0.0000, +0.0000
(31) +0.0000, +0.0000, +0.0000, +0.0000, +0.0000
(36) +0.0000, +0.0000, +0.0000, +0.0000, +0.0000
(41) +0.0000
```

Figure 9.17 Selection of 41 Breakpoints and Function Page by Stringing Commands 6.8 and 7.1

CHAPTER 10

DETAILED MACS COMMANDS

10.1 INTRODUCTION

This chapter lists and describes all MACS commands. The descriptions are generally grouped by function, and in all cases appear in command number order. For user convenience, tabular data extracted from the MACS Command Set (Tables 8.1 – 8.10) precedes the various command descriptions. As applicable, exercises and samples of command execution (with the associated displayed data) are provided. Refer to Chapter 9 for other basic exercises and information. Also Refer to Chapter 8 for Display definitions.

10.2 EDITING COMMANDS (1.1 – 1.3)

NO.	FORMAT	DESCRIPTION	PARA. REF.
1.1	[RUB OUT]	Deletes last character entered and moves cursor back one space.	10.2.1 9.4.2
1.2	[RUB OUT] [RETURN]	Clears both the Scratch and Message Pad areas (deletes last line) and initialized Censor in Scratch Pad area.	10.2.1
1.3	[CTRL] [S]	Aborts current command and clears the Scratch and Message Pads. Brings in Logic Page and places console in the Off-Line Mode, see Command 2.3. In a Multi-Console environment, [CTRL] [S] also unslaves the Multi-Console system. After execution of [CTRL] [S], each console displays its own video information and the Console prefix (first character of the ADDRESS field) mirrors the setting of the console select switch.	10.2.2

10.2.1 USING RUBOUT AND RETURN

The [RUB OUT] and [RETURN] keys are used in combination to edit erroneous keyboard entries (as observed in the Scratch Pad area of the display) that have not yet been executed. Pressing [RUB OUT] immediately followed by [RETURN] executes Command 1.2, which deletes both the Scratch and Message Pads. This is only desirable if you wish to delete the entire entry. If you want to revise an entry, and then execute the contents of the corrected Scratch Pad: use [RUBOUT] as many times as necessary to delete the last valid character as well as the erroneous character(s); next re-enter the last valid character followed by the corrections (if any); and then press [RETURN].

The following example illustrates the method (and pitfalls) of editing an appended (extra) character entry.

1. Assume you have entered the following invalid information in the Scratch Pad.

```
A1234█
```

2. Actually you intended to address A123. Therefore, you press [RUB OUT] once to delete the character 4.

```
A123█
```

3. The character 4 is no longer displayed and the cursor has moved back one position. The entry appears ready for execution, and you press [RETURN] which clears the entire entry without selecting the component.

█

This is the result of an effective execution of Command 1.2 ([RUB OUT] followed by [RETURN]) which deletes the line.

4. The correct procedure (for this example) is to [RUB OUT] two characters: the invalid character and the last valid one.

A12█

5. Then enter the last valid character ([3]) followed by [RETURN] to properly execute the desired task.

ADDRESS

1A123

A123

10.2.2 USING [CTRL] [S]

This command (1.3) can be used to abort any currently executed command. For example, to abort the execution of externally generated $ Commands (See Paragraph 10.20), press [CTRL] immediately followed by [S]. The system will no longer respond to the external $ commands and the Logic Page is called in for display.

In a Multi-Console system, this command is also used to unslave the system which can include up to six consoles.

10.3 INITIALIZATION COMMANDS (2.1 – 2.5)

NO.	FORMAT	DESCRIPTION	PARA. REF.
JOB COMMAND			
2.1	[n] [J] [;] [RETURN]	Job Command. Initializes Console Number n (n = 1 to 6) by setting the following conditions: 1. Momentarily places Console Number n in the Balance (BA) Mode to Check for balance errors. 2. Selects QT (Quiescent) Mode. See Command 3.6 for QT Mode description. 3. Logic Mode = CL 4. Master Time Scale = EØ 5. Individual Integrator Time Scale = E + Ø 6. Display Mode = Normal 7. AØ selected 8. Rep-Op Timer set to; RTØ = 5ØØ RT1 = 5ØØØ RT2 = Ø 9. All DSFG's set to Y = Ø with 21 Breakpoints 10. Logic Page Selected **NOTE** *The Console prefix number (n) may be omitted in single console systems. In a Multi-Console environment, if the prefix is omitted the Job Command will be executed on the last console selected, see Command 10.3 for related information.*	9.4.3 10.3
ON/OFF Line Control			
2.2	[O] [N] [RETURN]	Enables both the Serial and Parallel Ports. Initializes firmware with proper communications protocol.	10.3 8.5.6
2.3	[O] [F] [RETURN]	Disables both the Serial and Parallel Ports.	10.3 8.5.6
Display Control			
2.4	[N] [D] [RETURN]	Activates Normal Display Mode: MACS display is controlled with the last command from the MACS Keyboard, or from the Digital Computer if the Digital is On Line.	10.3 8.5.5
2.5	[L] [D] [RETURN]	Activates Local Display Mode: Enables independent local component selection and monitoring regardless of On Line digital computer selection.	10.3 8.5.5

The use of Initialization Commands are straight forward. Therefore, no further description is provided. Refer to other Paragraphs specified in the Para. Ref. column for additional and/or related information.

10.4 ANALOG MASTER MODE COMMANDS (3.1 – 3.6)

NO.	FORMAT	DESCRIPTION	PARA. REF.
Analog Master Mode Selection			
3.1	[CTRL] [I] OR [I] [C] [RETURN]	Selects Initial Condition Mode. Sets the output of all Integrators to the programmed initial values. All other analog components are in the Operate Mode.	9.4.3 10.4
3.2	[CTRL] [O] OR [O] [P] [RETURN]	Selects Operate Mode. Placing the 2000 in this mode initiates the dynamic solution of a problem. The Integrators begin to integrate at the rate as determined by their operating input and effective gain.	10.4
3.3	[CTRL] [H] OR [H] [D] [RETURN]	Selects Hold Mode. The Hold Mode disconnects all Integrator inputs and holds (freezes) the Integrator outputs at their existing values. All other analog components remain in the Operate Mode.	10.4
3.4	[S] [T] [RETURN]	Selects Static Test Mode (IC Mode plus Test Reference Available at the Program Panel). See OUTPUT TRAY description (paragraph 6.9.6).	10.4 6.8.6
3.5 (7.5)	[B] [A] [RETURN]	Selects Balance Mode and Displays the Balance Page. All Integrator and Summer Gains = 1000 with inputs grounded. The BA indicator goes on if a balance error exists.	10.4 8.5.3
3.6	[Q] [T] [RETURN]	Selects Quiescent (QT) Mode (Like BA Mode, but no Balance Page). The QT Mode sets the following conditions: 1. Disconnects and grounds programmed inputs. 2. Sets gain of all Integrators and Summers to 1000.	9.4.3 10.4

Observe that the System Operating Modes (IC, OP, and HD) can be selected using the CTRL key and a single entry of I, C, or O. The System Setup Modes (ST, BA, and QT) do not have this capability. They must be selected using the Mode Designators (ST, BA, or QT) and the RETURN key.

The currently selected Analog Master Mode for the system is always displayed under the heading A MODE, regardless of how the mode was composed or commanded. See Paragraph 8.4.1 for a description of the display readout under the A MODE heading.

A MODE

IC

10.5 LOGIC MASTER MODE COMMANDS (3.7 – 3.10)

NO.	FORMAT	DESCRIPTION	PARA. REF.
Logic Master Mode Selection			
3.7	[C] [L] [RETURN]	Selects Clear Mode. Comparable to the Analog IC Mode. Used to initialize the logic elements.	9.4.3 10.5.1
3.8	[R] [U] [RETURN]	Selects Run Mode. Comparable to the Analog OP Mode. Applies system clock to all clocked components.	10.5.1
3.9	[S] [O] [RETURN]	Selects Stop Mode. Comparable to the Analog HD Mode. Disconnects clock from all clocked components permitting them to hold the state attained at the time 0 is selected.	10.5.1
3.10	[S] [S] [RETURN]	Selects Single Step Mode. Places Logic in Stop Mode (If not already in Stop) and advances Logic one clock pulse (step) each time executed.	10.5.2

10.5.1 GENERAL

The above commands (except for Single Step Mode) select the designated Logic Master Mode and display the respective code (CL, RU or SO) under the L MODE heading on the CRT. See Paragraph 8.4.2 for a description of the display readout under the L MODE heading. The Logic Single Step Mode has some unique characteristics and is described in the following paragraph.

L MODE

CL

10.5.2 USING THE SINGLE STEP COMMAND (3.10)

When the Single Step Command is executed ([S] [S] [RETURN]), the L MODE display is Logic Stop (SO) not Single Step (SS). See Figure 10.1.

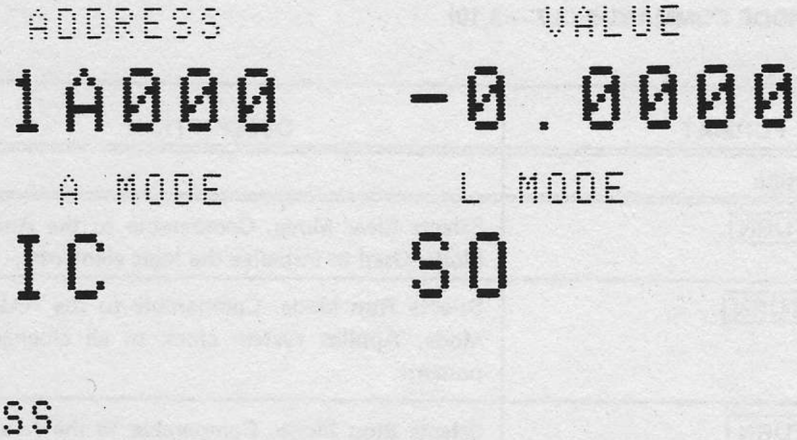


Figure 10.1 Execution of Logic Single Step (Command 3.10)

Re-executing the SS Mode effectively single steps the clock. To demonstrate this, a logic 1 is patched into the CI (Carry Input) of GPR Ø. Selecting component RVØ (Register Value of GPR Ø) and the Logic Clear Mode displays the information shown in Figure 10.2.

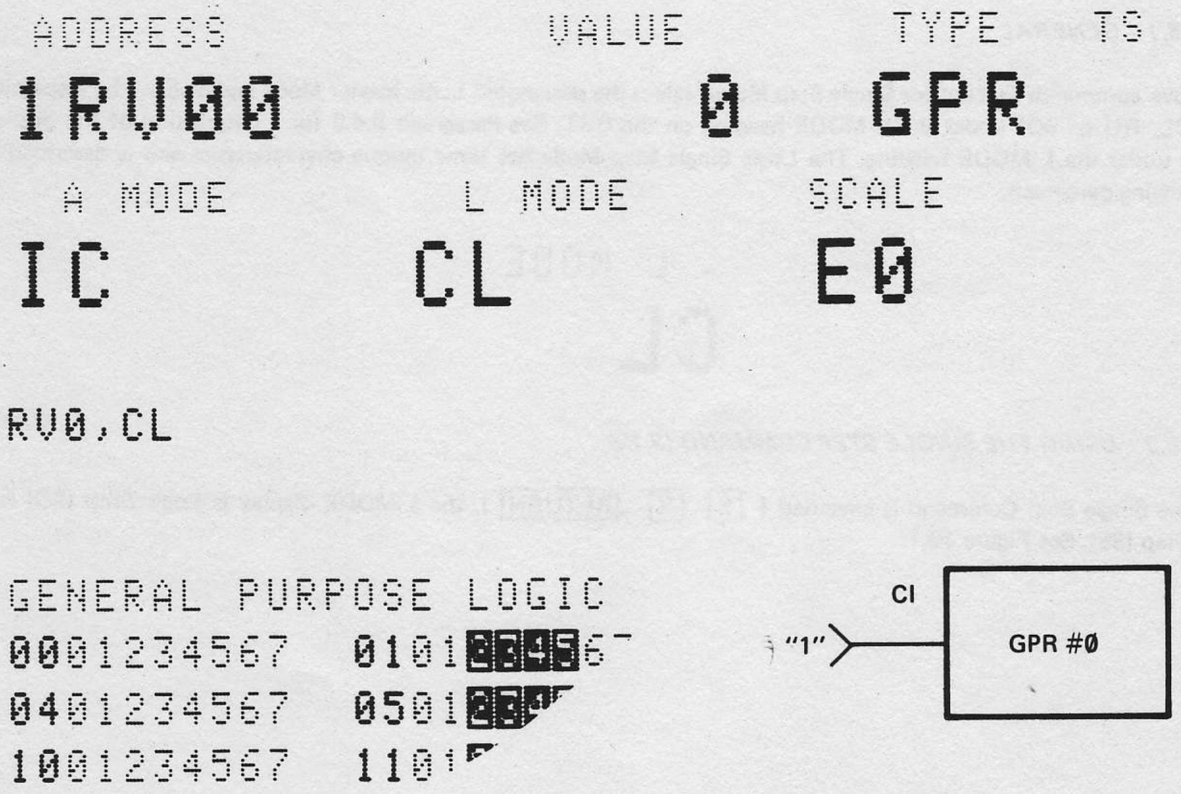


Figure 10.2 Setting GP Register Value and Selecting Logic Clear Mode by Stringing Commands 5.9 and 3.7

Note that the "cleared" value of RVØ is a decimal Ø under the "VALUE" heading, and Binary ØØØØØØØØ values on the General Purpose Logic Page for logic components LØØØ – LØØ7. These components represent the status of GPR Ø at the bit level (LØ = the Most Significant Bit, and L7 = the Least Significant Bit).

Upon entering the Single Step Mode and executing it once, the decimal and binary values are updated to show the count of one (Figure 10.3).

```
ADDRESS             VALUE      TYPE
1RV00                   1      GPR
  A MODE          L MODE     SCALE
IC            SO             E0


SS



GENERAL PURPOSE LOGIC
0001234567   01012345
0401234567   050'
1001234567
```

Figure 10.3 Effect of Single Step Command (3.10) as Observed on GPR VALUE Display

Pressing the [RETURN] key six more times, or stringing six SS commands and executing them with one RETURN, would add six more counts to GPR Ø, totaling seven as shown in Figure 10.4. Note the Logic 1 status of the bits LØØ5-LØØ7. This represents the decimal 7 displayed under the VALUE heading.

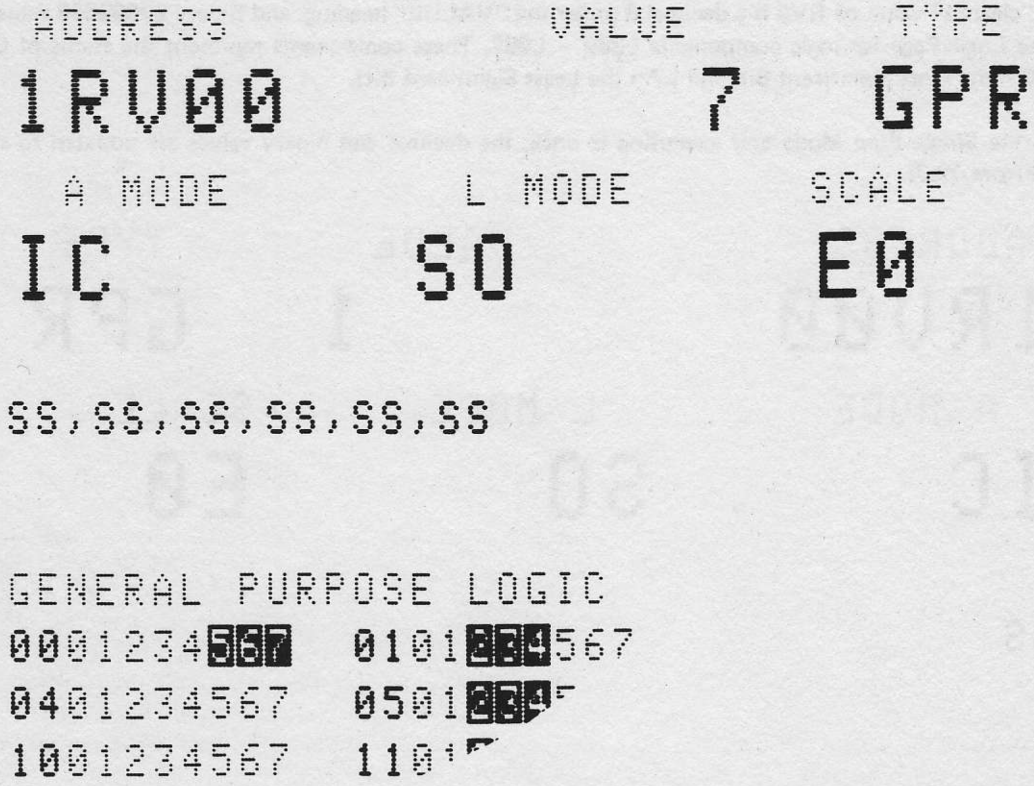


Figure 10.4 Effect on GPR VALUE Display when Stringing Single Step Commands (3.10)

10.6 MASTER MODE CONTROL SOURCE COMMANDS (3.11 – 3.14)

10.6.1 REP-OP TIMER AS MODE CONTROL SOURCE (3.11, 3.12)

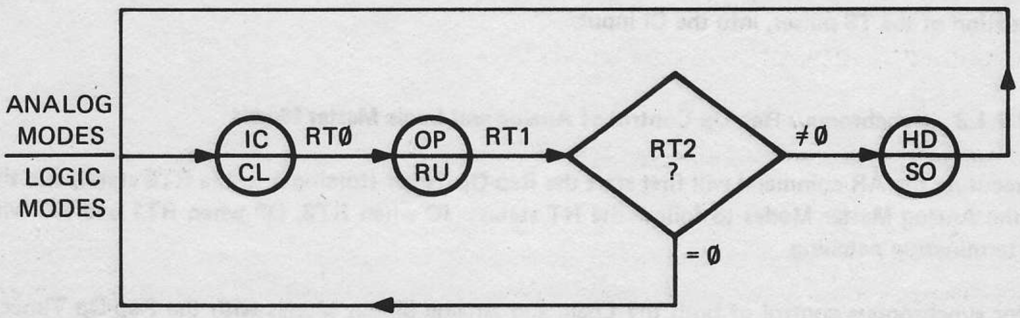
NO.	FORMAT	DESCRIPTION	PARA. REF.
Master Mode Control Source Selection			
3.11	[A] [R] [RETURN]	Places Analog Master Mode Selection under control of the Rep-Op Timer as follows: IC → OP → HD → IC . . . . . if RT2 ≠ Ø IC → OP → IC . . . . . if RT2 = Ø	10.6.1
3.12	[L] [R] [RETURN]	Places Logic Master Mode Selection under control of the Rep-Op Timer as follows: CL → RU → SO → CL . . . . . if RT2 ≠ Ø CL → RU → CL . . . . . if RT2 = Ø	10.6.1

NOTES

1. *To control only the Logic Master Mode with the Rep-Op Timer, patch a timing signal into the CI termination of the Rep-Op Timer and enter* [L] [R] [RETURN] .
2. *When AR or LR (or both) are executed; the time spent in IC/CL, OP/RU, and HD/SO is proportional to the count stored in RTØ, RT1 and RT2 respectively; and is inversely proportional to the number of clock pulses during which the Rep-Op Timer Carry In (CI) input is high.*
3. *For synchronous control of both Logic and Analog Master Modes with the Rep-Op Timer, execute LR first and then AR. Patching is not required.*
4. *Selection of new Analog or Logic Master Mode, or a new Master Mode Control Source automatically de-selects the current Mode or Source.*
5. *In a Multi-Console environment, only the Rep-Op Timer or the A MODE and L MODE control inputs of the MASTER Console can be used to synchronously control the time critical modes of the Slaved system. Rep-Op Timers of SLAVE Consoles are free for use as counter/timers.*

10.6.1.1 Analog Rep-Op (AR) Control

The AR and LR commands can cycle the Analog or Logic Master Modes under Rep-Op Timer control. When in the AR Mode, the Rep-Op Timer establishes the IC Mode for a duration which is proportional to the count stored in initial value register RTØ. The IC Mode is followed by the OP Mode for the duration of RT1. Then, based on the content of RT2, the HD Mode is entered (proportional to RT2); or the Mode reverts to IC if RT2 = Ø. The HD Mode (if entered: RT2 other than zero) is followed by the IC Mode. Similarly, when in the LR Mode, the Rep-Op Timer controls the cycling of the Logic Master Modes based on the following state flowchart:



To determine the actual time spent in each of the states, the signal patched into the CI input of the Rep-Op Timer must be checked. This is necessary as the RT (Rep-Op Timer) actually counts the number of clock pulses during which its CI input is high. When the CI input is unpatched and the AR Mode is selected, the effective input is high one clock pulse for every TS pulse (refer to RT Tray in Chapter 6). The frequency of TS pulses is proportional to the Master Time Scale in accordance with the following table:

Master Time Scale (MTS)	TS
EØ	10^2 pulses/sec
E1	10^3 pulses/sec
E2	10^4 pulses/sec
E3	10^5 pulses/sec
E4	10^6 pulses/sec effectively (actually logic 1)

For example, when RTØ = 500, RT1 = 5000 and RT2 = Ø the EAI 2000 will spend 5 sec, 50 sec and 0 sec in the IC, OP and HD modes, respectively; if the E0 Master Time Scale is selected, and the CI input of the Rep-Op Timer is unpatched:

$$\frac{RT\emptyset}{10^2} = \frac{500}{100} = 5 \text{ sec}$$

$$\frac{RT1}{10^2} = \frac{5000}{100} = 50 \text{ sec}$$

Consider the time in terms of units such that when MTS = EØ, a second is broken into 10^2 = 100 parts, 500 of which represent 5 seconds ($\frac{500}{100}$ = 5 sec). Similarly, the EAI 2000 will spend in OP only 5000/10^6 = 5ms (If MTS = E4) or only 5ms in IC when MTS = E3 (500/10^5 = 5ms).

In the case where the source of "PULSES" is patched to the Rep-Op Timer CI input, the duration of RT periods is not dependent upon MTS. Patching the "PULSES" source designated 3 into CI and keeping RTØ = 500 will account for the computer spending 500/10^3 = 0.5 sec in the IC mode, and similarly for other pulse sources (1, 2, 4 and 5).

Patching a signal into the CI of the Rep-Op Timer which stays high for more than one clock pulse will appropriately effect the Rep-Op Timing. For example, when a constant Logic 1 is patched into CI, counting will proceed at the frequency of the clock (10^6 pulses/sec). Note that Logic 1 automatically comes from TS when in the E4 Time Scale.

10.6.1.2 Logic Rep-Op (LR) Control

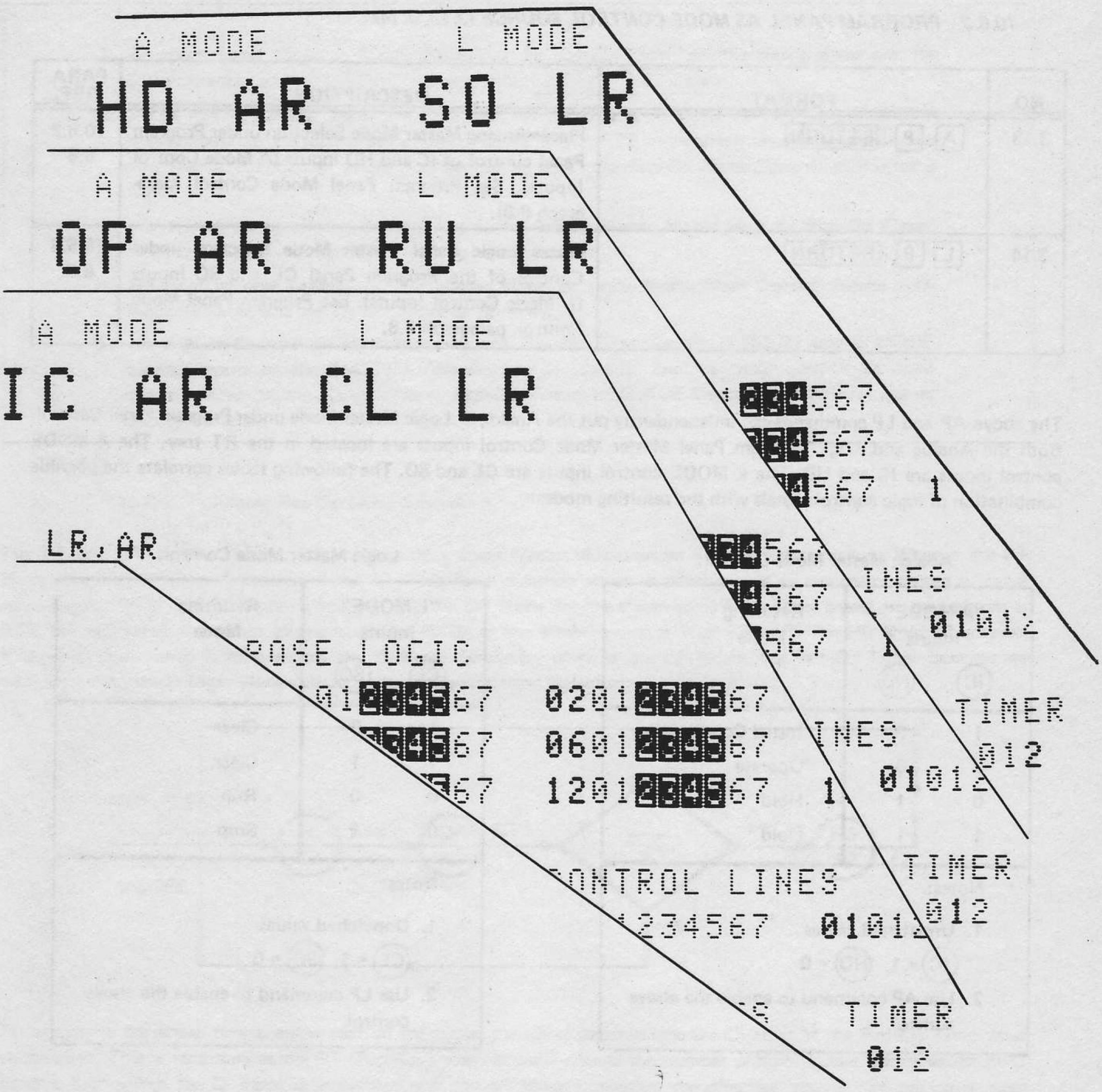
Entering and executing the LR command will establish the Logic Master Mode which corresponds to the current state of the Rep-Op Timer (CL if RTØ, RU if RT1 and SO if RT2), but will not start the Rep-Op Timer cycling unless there is an external signal patched into the termination of the Rep-Op Timer. In other words, the LR mode does not cause automatic connection of the TS pulses, into the CI input.

10.6.1.3 Synchronous Rep-Op Control of Analog and Logic Master Modes

Entering and executing the AR command will first start the Rep-Op Timer (forcing it to the RTØ state), and then cause the cycling of the Analog Master Modes to follow the RT states: IC when RTØ, OP when RT1 and HD when RT2, regardless of CI termination patching.

Consequently, for synchronous control of both the Logic and Analog Master Modes with the Rep-Op Timer, execute the LR, AR command string. See Figure 10.5. Note the correspondence of the RT states (bright digits under the TIMER heading) with the Master Modes:

	MODE	
TIMER	A	L
0	IC	CL
1	OP	RU
2	HD	SO



NOTE

Selecting a new Master Mode or new Master Mode Control Source automatically de-selects the previous one.

Figure 10.5 Synchronous Analog and Logic Rep-Op Mode Control (Stringing Commands 3.12 and 3.11)

10.6.2 PROGRAM PANEL AS MODE CONTROL SOURCE (3.13, 3.14)

NO.	FORMAT	DESCRIPTION	PARA. REF.
3.13	[A] [P] [RETURN]	Places Analog Master Mode Selection under Program Panel control of IC and HD inputs (A Mode Control Inputs). See Program Panel Mode Control (paragraph 6.8).	10.6.2 6.8
3.14	[L] [P] [RETURN]	Places Logic Panel Master Mode Selection under Control of the Program Panel CL and SO inputs (L Mode Control Inputs). See Program Panel Mode Control, paragraph 6.8.	10.6.2 6.8

The above AP and LP commands can independently put the Analog or Logic Master Mode under Program Panel Control. Both the Analog and Logic Program Panel Master Mode Control inputs are located in the RT tray. The A MODE control inputs are IC and HD. The L MODE control inputs are CL and SO. The following tables correlate the possible combination of logic control signals with the resulting modes:

Analog Master Mode Control:

"A MODE" Inputs (IC)	(HD)	Resulting Mode
1	0	Initial Condition
0	0	Operate
0	1	Hold
1	1	Hold

Notes:

1. Unpatched values (IC) = 1, (HD) = 0
2. Use AP command to enable the above control.

Logic Master Mode Control:

"L MODE" Inputs (CL)	(SO)	Resulting Mode
1	0	Clear
1	1	Clear
0	0	Run
0	1	Stop

Notes:

1. Unpatched values (CL) = 1, (SO) = 0
2. Use LP command to enable the above control.

10.7 INTEGRATOR TIME SCALE (GAIN) COMMANDS (4.1 – 4.3)

NO.	FORMAT	DESCRIPTION	PARA. REF.
Master Time Scale Selection			
4.1	[E] [m] [RETURN]	Sets Master Time Scale Factor (Gain) to 10^m. Where m is an Exponent (E) value from Ø to 4 (10^0 - 10^4).	10.7 4.4
Relative Time Scale Selection (Individual Integrator)			
4.2	[I] [x] [=] [E] [+] [n] [RETURN] OR [I] [x] [=] [E] [–] [n] [RETURN]	Sets Integrators (I) Number Relative time scale Factor (Gain to 10 (m + n) where 0 m ± n 5). Examples for Gain Command Entry: [I] [4] [=] [E] [+] [3] (x = 4, n = 3) [I] [4] [4] [=] [E] [–] [4] (x = 44, n = 4) Examples of Effective Gain Calculation: Based on the Master Time Scale (MTS) and the commanded Relative Gain (RG), the desired effective gain is computed and set by firmware for each Integrator. The resultant gain must have one of the following values: 10^0, 10^1, 10^2, 10^3, 10^4, or 10^5. If this range is exceeded, the gain is set to the closest extreme, and the Time Scale Error Indicator (TSE) is turned on. The following Table shows seven typical in range selections and two erroneous selections.	10.7 4.4

MTS	RG	EFFECTIVE GAIN	NOTE
E0	E+0	$10^{0+0}=10^0=1$	Valid
	E+1	$10^{0+1}=10^1=10$	Valid
	E+2	$10^{0+2}=10^2=100$	Valid
	E+5	$10^{0+5}=10^5=100{,}000$	Valid for Individual Integrator
E1	E+0	$10^{1+0}=10^0=1$	Valid
	E+1	$10^{1+1}=10^2=100$	Valid
	E-1	$10^{1-1}=10^0=1$	Valid
	E-2	$10^{1-2}=10^{-1}=.1$	TSE, gain sets to 10^0
	E+5	$10^{1+5}=10^6=1{,}000{,}000$	TSE, gain sets to 10^5
E2, etc.	etc.	etc.	etc.

NO.	FORMAT	DESCRIPTION	PARA. REF.
Absolute Time Scale Selection			
4.3	[I] [x] [=] [E] [n] [RETURN]	Sets Integrator (I) Number x Absolute Time Scale Factor (Gain) to 10^n. Where n is an Exponent (E) with a value from Ø-5(10^0 - 10^5).	10.7 4.4

The Master Time Scale Command (4.1) sets the base gain used by the firmware to compute the final gain for all the integrators whose time scale is set relative to this Master Time Scale (see description of TS heading in Paragraph 8.5.2 for more details).

Note that the realizable integrator gains are those which are built-in (10^0, 10^1, 10^2, 10^3, 10^4, 10^5), and that only the first five decades (10^0 to 10^4) are programmable with the Master Time Scale Command (Command 4.1). The highest gain (10^5) can be commanded only through commands 4.2 and 4.3. See description of SCALE heading in Paragraph 8.4.3 and the description of Individual Integrator Gain under the TYPE heading (Paragraph 8.3.3) for more information.

10.8 ANALOG COMPONENT ADDRESS AND READOUT COMMANDS (5.1 – 5.7)

NO.	FORMAT	DESCRIPTION	PARA. REF.
Analog Component Selection			
5.1	[A] [x] [RETURN]	Selects and reads Type and Output of Analog Component Number x. Where x = Ø-137_8. Components with an A Address Include: SUM, INT, T-S, MUL, and SIN.	10.8.1 4,3-4.8 4.10 4.11
5.2	[C] [x] [RETURN]	Selects and reads type and Coefficient Value of Coefficient Device Number x. Where x = Ø-137_8 for DCAs and 0-37_8 for HSP's. The MACS component type displays POT (for Handset Coefficient Units) or DCA (for Digitally Controlled Coefficient Units). THIS COMMAND LEAVES THE PROGRAMMED ANALOG INPUT DISCONNECTED. To re-connect, select any other component.	10.8.3 4.2
5.3	[D] [x] [RETURN]	Selects and reads the Derivative (D) input value of Integrator Number x. Where x is an Integrator address (even number) in the range Ø-76_8.	10.8.2 4.4
5.4	[I] [x] [RETURN]	Selects and Reads the Time Scale setting and Output of Integrator (I) Number x. Where x is an Integrator address (even number) in the range Ø-76_8.	10.8.2 4.4 9.4.5
5.5	[P] [x] [RETURN]	Selects and reads Type and Output Value (Product) of Coefficient device Number x. Where x = Ø-137_8 for DCA's and Ø-37_8 for HSP's. The MACS Type display is POT for Handset units, and DCA for Digitally Controlled units.	10.8.3 4.2
5.6	[F] [x] [RETURN]	Selects and reads Output of DSFG Number x. Where x = Ø-17_8. This command must be executed prior to performing any other individual DSFG commands. See Group 6 Commands (6.8 - 6.12).	9.4.7 4.13
5.7	[T] [x] [RETURN]	Selects and reads the Output of Analog Trunk (T) Number x. Where x = Ø-57_8.	10.8.5

10.8.1 *ADDRESSING GENERAL COMPONENTS (COMMAND 5.1)*

All EAI 2000 Components (except A/D Converters and D/A Switches) are directly readable through MACS. The A xxx command (5.1) is useful (not only to select and read a component type and value) but to determine what component type (SUM, INT, T-S, MUL or SIN) actually resides at any given address.

10.8.2 *ADDRESSING INTEGRATORS (COMMANDS 5.1, 5.3, and 5.4)*

The integrators can be addressed with three commands (5.1, 5.4 and 5.3). The first command for example [A] [4] [RETURN] will select Integrator A4, display its output under the VALUE heading, (Figure 10.6) and the INT code as the component TYPE. Note that INT appears only because there is an integrator at this address.

```
ADDRESS        VALUE       TYPE
1A004    +1.0000    INT
  A MODE        L MODE      SCALE
ST              S0          E0

A4
```

Figure 10.6 Using Address (A) Command (5.1) to Determine Component Type.

Now that we know that component A4 is an integrator, we can use command 5.4 ([I] [4] [RETURN]) to find out the selected integrator gain under the heading TYPE. See Figure 10.7.

```
ADDRESS        VALUE       TYPE
1I004+1.0000 E+0
  A MODE        L MODE      SCALE
ST              S0          E0

I4
```

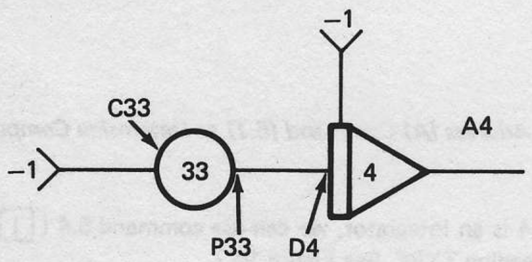
Figure 10.7 Using the Integrator (I) Command (5.4) to Determine Individual Integrator Gain and Output

To read the input (derivative) of the same integrator (Figure 10.8) enter D4 [RETURN] (Command 5.3).

```
ADDRESS          VALUE        TYPE
1D004      +0.2222   INT

  A MODE           L MODE         SCALE
ST            CL             E0


D4
```

Figure 10.8   Using the D Command (5.3) to Read Integrator Derivative

To correlate the results of the commands exercised in this paragraph, refer to the programming diagram in Figure 10.9. Before given values for D4 could be obtained Coefficient Device 33 had to be set to –.2222. Even though the commands to set coefficients are explained later, one of them is given here to enable you to exercise the commands given so far.

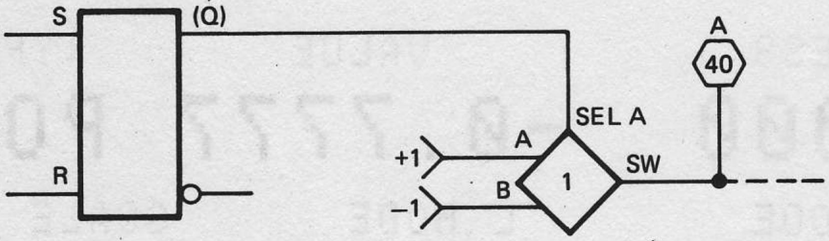



```
ADDRESS          VALUE        TYPE
1C033      -0.2222   DCA

  A MODE           L MODE         SCALE
ST            SO             E0


C33=-.2222
```

Figure 10.9   Using the C (Coefficient) Command (6.1) to Set Derivative Value

10.8.5 ADDRESSING ANALOG TRUNKS (COMMAND 5.7)

Readable trunks are optional and if the option is chosen, use Command 5.7 to read them. They are useful to monitor the signals coming from the external world, or for indirect reading of electronic switches:



Based on the above patching (Flip-Flop 10 controls the position of the switch arm; output of the switch SW connected to Trunk 40) and the use of a command to set the Flip-Flop to the desired state (1 or 0), we have the following VALUES for the switch output based on the logic value of the switch control input SEL A:

1. First, setting Flip-Flop 10 to logic 1 selects input A variable to pass through the switch and appear as the SW output. There is no SW command, so trunk 40 is read (Figure 10.12) to assess the value of the switch output. The input A is connected to positive reference and since there is no inversion within the switch, the VALUE display = +1.0.

```
ADDRESS        VALUE        TYPE
1T040      +1.0000     TK
A MODE      L MODE       SCALE
ST          SO           E0

L10=1,T40
```

Figure 10.12 Reading Analog Trunks (Command 5.7) and Using Trunk Lines to Read Selector Switches (A Input)

2. Similarly, the output of the SW 1 is indirectly read to be −1 (Figure 10.13) when Flip-Flop 10 is reset (= set to Ø state) which causes the switch control to pass the B input variable through the switch:

```
ADDRESS     VALUE     TYPE
1T040    -1.0000     TK

A MODE      L MODE    SCALE
ST          SO        E0

L10=0,T40
```

Figure 10.13 Reading Analog Trunks (Command 5.7) and Using Trunk Lines to Read Selector Switches (B Input)

10.9 LOGIC COMPONENT ADDRESS AND READOUT COMMANDS (5.8 – 5.10)

NO.	FORMAT	DESCRIPTION	PARA. REF.
5.8	[L] [x] [y] [RETURN]	Selects and reads Logic (L) Tray Number x and the State of Logic Component Number y on that Tray. Where the Tray select x = Ø–13 and Logic component select y=Ø–7 (Ø–5 in the case of Comparators). The State of Logic Trunks, Sense Lines, Control Lines, and Interrupt Lines are read directly from the Logic Page. See Group 7 Commands (7.2). In the case of a Differentiator (DIF) this command selects and reads the State of its Flip-Flop. To find the Output Value of a DIF, patch its output into an AND gate and read the gate. This reads the DIF value indirectly. The Logic Page displays the status of the same flip-flop; not the DIF output.	10.9 5.5 5.6 5.7
5.9	[R] [V] [x] [RETURN]	Selects and reads Value (V) of Register (R) Number x. Where in a standard configuration: x = Ø, 4, 1Ø$_8$ for GPR's; x = 1, 2, 5, 11, 12 for CTR's. The value is displayed in Decimal form. The binary equivalent of the GPR Value is displayed on the Logic Page. See Command Group 7 (7.2).	10.9 5.5 5.6 5.7
5.10	[R] [T] [x] [RETURN]	Selects and reads actual Value of Rep-Op (R) Timer (T) Value Register Number x. Where x = Ø–2 (Ø=RT0; 1=RT1; 2=RT2). The Value is displayed in decimal form. The current state of the Rep-Op Timer is displayed on the Logic Page. See Command Group 7 (7.2).	9.4.6 10.10 6.4

These commands select and read the state of the general purpose logic components, comparators, and the contents of the CNTR, GPR, and Rep-Op Timer. See those paragraphs specified in the Para. Ref. Column for additional information concerning these commands.

10.10 DAM ADDRESS AND READOUT COMMANDS (5.11, 5.12)

NO.	FORMAT	DESCRIPTION	PARA. REF.
DAM (Digital-to-Analog Multiplier) Select			
5.11	[D] [C] [x] [RETURN]	Selects and reads Coefficient Value (C) of DAM (D) Number x. Where x = Ø-37_8.	10.10
5.12	[D] [A] [x] [RETURN]	Selects and reads Analog (A) Output Value of DAM (D) Number x. Where x = Ø-37_8.	10.10

Like DCA's, Digital-to-Analog Multipliers (DAM's) can be selected to readout and display their coefficient value (Command 5.11); or their output value (Command 5.12), which is the product of the Coefficient value and the analog input value. Note that DAM's can be used as DCA's if they are installed in the DCA module, and in such cases may be readout using the Coefficient Device Address and Readout Commands (5.2 and 5.5). The TYPE Component display indicates DAM regardless of where the DAM is used.

10.11 ADDRESS ADVANCE COMMAND (5.13)

NO.	FORMAT	DESCRIPTION	PARA. REF.
Address Advance Command			
5.13	[CTRL] [A]	Updates the displayed address to the next sequential (and available) address of the currently selected address Type. If the currently selected component is the last available, the address cycles back (address wrap-around) to the first available component.	10.11 9.4.5 9.4.6

Each time CTRL A is executed, it advances the address register to the next valid address of the same type component. When CTRL A is executed after the last component of a type has been selected, the address register wraps-around to the first valid address for that type component. This address step command is useful for sequential address and value readout, sequential selection and setup of components (such as Coefficient units and registers), and simply for determining the valid addresses for any given type component.

10.12 SETTING DCA COEFFICIENT VALUES (6.1)

NO.	FORMAT	DESCRIPTION	PARA. REF.
Setting Digital Coefficient Attenuator (DCA)			
6.1	[C] [x] [=] [v] [RETURN]	Displays and sets digital Coefficient (C) Number x to the Value (V) in a range from -1.0 to +1.0. Where x = $\emptyset$–137_8; and v = a scaled fraction number consisting of an optional plus (+) sign, an optional Ø digit followed by a required decimal point (.), and up to five decimal digits. Values of +1.0 are also valid. Negative values must be preceded by a minus sign. If more than five decimal digits are entered for value, the DCA sets to a value rounded to five decimal digits.	10.12 4.2

10.12.1 THE DCA COEFFICIENT MODE

This command places the selected DCA (x) in the Coefficient (C) Mode and loads the value specified by the entry (v). The Coefficient Mode disconnects the analog input patched to the selected DCA in termination and applies +REF to the DCA. Therefore, to restore the programmed (patched) input after setting the coefficient, another component must be selected. This is especially important to remember if attempting to change a DCA value during a problem run. The Slew Command (See Paragraph 10.13) may be used to change a coefficient value during a problem run and does not disconnect the programmed input. The DCA coefficient setting command may also be used to set DAM's if they occupy a DCA location.

10.12.2 SETTING A BLOCK OF COEFFICIENTS

To set a block of coefficients to the same value:

a. Address the first DCA in the Coefficient Mode ([C] [x]).

b. Input the desired value ([v]) and press [RETURN].

c. Press [CTRL] followed by [A] to advance the address. Then press [RETURN] to load the second DCA.

d. Repeat Step C for each remaining DCA in the block.

10.12.3 COEFFICIENT VALUE ROUNDING

The Coefficient Value ([v]) is a scaled fraction number as specified in the tabular description for Command 6.1. The value entered at the MACS keyboard is in decimal format with up to four digits beyond the decimal point. If more than four decimal digits are entered, the fourth digit is automatically rounded-off as illustrated in Figure 10.14.

```
ADDRESS          VALUE        TYPE
1C022     +0.1235  DCA
   A MODE          L MODE        SCALE
ST              S0             E0

=.12349
```

a. Rounding Up

```
ADDRESS          VALUE        TYPE
1C022     +0.1234  DCA
   A MODE          L MODE        SCALE
ST              S0             E0

=.12341
```

b. Rounding Down

Figure 10.14 Automatic Rounding of Coefficient Values

10.13 SLEWING DCA COEFFICIENT VALUES (6.2, 6.3)

NO.	FORMAT	DESCRIPTION	PARA. REF.
Stepping (Slewing) DCA Coefficient Values			
6.2	[C] [x] [>] --- [>] [RETURN]	Adds 2^{-7} (an increment of 0.008) to the current coefficient value of DCA number x (where x = Ø-137_8) for each [>] . Stops at ≈+1.0.	10.13 4.2
6.3	[C] [x] [<] --- [<] [RETURN]	Subtracts 2^{-7} (a decrement of 0.008) from the current coefficient value of DCA number x (where x = Ø-137_8) for each [<] . Stops at ≈-1.0.	10.13 4.2

NOTES

1. *The Value of coefficient for DCA Number x is <u>not</u> displayed as a result of the Stepping commands, unless DCA Number x is already selected for readout by previous execution of Command 6.1.*
2. *This feature (Note 1) permits the selection of an arbitrary component (such as an Integrator) and slewing a particular DCA while simultaneously observing its effect on the selected component.*

10.13.1 SLEWING DCAs IN GENERAL

The above two commands add (subtract) approximately .008 to (from) the current coefficient value for every occurrence of the > (<) sign. If a series of signs (>> or <<<) are entered, the command is executed only once. However the step size value is the multiple of the single > (<) sign value.

These slewing commands are extremely valuable for parameter sensitivity studies, controller tuning or manual optimization studies. A particular coefficient corresponding to the parameter under study can be slewed up or down while simultaneously monitoring its effect on another component, such as the output of a selected integrator.

Note that slewing a DCA up or down is valid throughout the operating range of a coefficient (–1. to +1). Therefore, if you start with a coefficient value of –1 and repeatedly (ten times per second) execute the slew up command ([>] [RETURN] [REPT]), the full coefficient range will be covered in approximately 2/.008 or 25 seconds. More often, slewing is accomplished within the same sign. When a coefficient reaches approximately +1 (–1), the command to slew it up (down) is disregarded and the coefficient value is held at this point.

10.13.2 SLEW COMMAND EXERCISES

The following exercises are provided to illustrate the use of the Slew Commands.

Exercise 1.

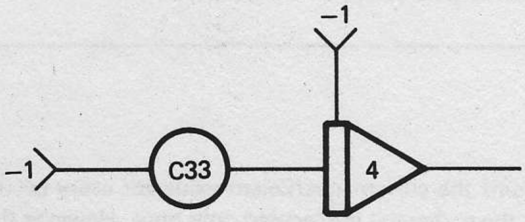
String Commands 6.1 (Paragraph 10.12) and 6.2 to select and set DCA 22 to Ø, and increment (slew up) that DCA by approximately .008 (one step) ([C] [2] [2] [=] [·] [Ø] [,] [>] [RETURN]). The display should appear as shown in Figure 10.15.

```
ADDRESS              VALUE        TYPE
1C022          +0.0079  DCA

A  MODE            L  MODE         SCALE
ST                 S0              E0

=.0,>
```

Figure 10.15 Setting and Slewing (Commands 6.1 and 6.2) a Selected DCA

Exercise 2.

1. Patch the following circuit.



2. String the necessary commands to:
   a. Select and set coefficient 33 to Ø
   b. Select D4 (Derivative input to Integrator 4)
   c. Slew C33 down approximately 0.040

3. The display should appear as shown in Figure 10.16.

```
ADDRESS              VALUE        TYPE
1D004          +0.0390  INT

A  MODE            L  MODE         SCALE
ST                 S0              E0

C33=.0,D4,C33<<<<<
```

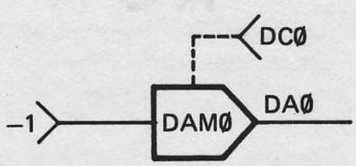
Figure 10.16 Selecting, Setting, and Slewing (Commands 5.6, 6.1 and 6.3) a DCA and Observing the Effect on a Derivative (Command 5.3)

10.14 SETTING DAM COEFFICIENT VALUES (6.4)

NO.	FORMAT	DESCRIPTION	PARA. REF.
6.4	[D] [C] [x] [=] [v] [RETURN]	Displays and sets a Coefficient (C) of DAM (D) Number x to the digital Coefficient (C) Value (v) in a range from -1.0 to +1.0. Where x = Ø-37_8; and v = a scaled fraction number consisting of an optional Ø digit followed by a required decimal point (.) and up to five digits. Negative values must be preceded by a minus (—) sign. If more than five decimal digits are entered for the coefficient values the DAM sets to a value rounded to five decimal digits.	10.14

The DAM coefficient value is set with the above (DC) Command. This command can not be used to set DAM's that are being used as DCA's that is, when the DAM occupies a DCA location, it must be selected and loaded using a (C) coefficient address (Command 6.1, Paragraph 10.12).

For example with the above command (6.4), we can set the coefficient of DAM Ø to +.5 and then read the output value (product) of the same DAM by executing the DA command (5.12). The DAM output (like a DCA) is a product of the applied analog input and the coefficient setting.



Note that there is no inversion at the output as can be observed on the display (Figure 10.17).

Normally, the DAM coefficient values are set from the digital computer via the EAI supplied Hybrid Communications Library. Setting DAM coefficients through the MACS keyboard is an added capability that is quite useful in debugging a hybrid program. Note that the same capability allows DAMs to be used as plain coefficients (use command 6.4 for setting the coefficient and command 5.12 to read the output).

Additionally, if located in the position of regular coefficients (DCAs), you must use the regular coefficient command 6.1 to set them and command 5.5 to read the output.

SET DAM COEFF

READ DAM PRODUCT

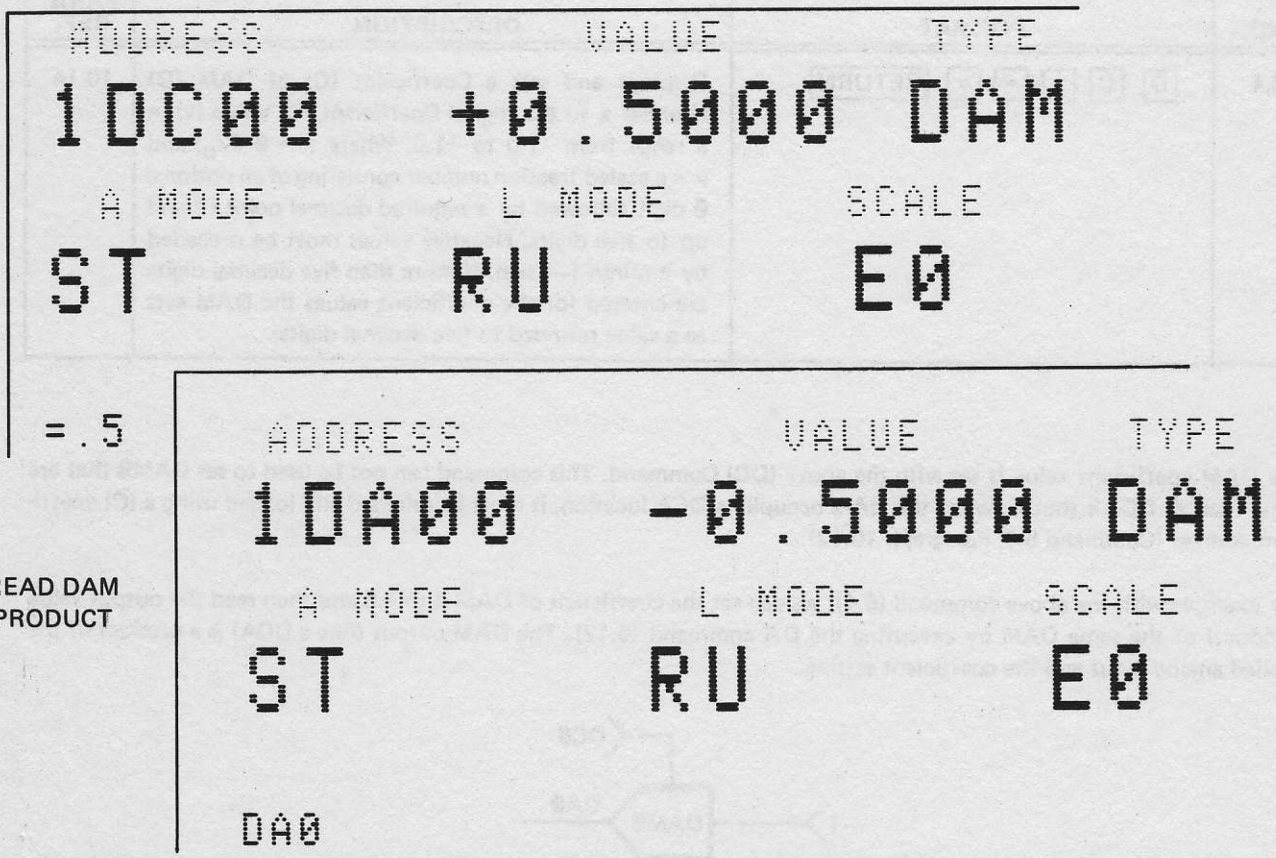


Figure 10.17 Setting a DAM Coefficient (Command 6.4) and Reading the DAM Product (Command 5.12)

10.15 SETTING THE REP-OP TIMER (6.5)

NO.	FORMAT	DESCRIPTION	PARA. REF.
Set Rep-Op Timer			
6.5	[R] [T] [x] [=] [i] [RETURN]	Sets Rep-Op Timer (RT) Initial Value Register Number x to value i. Where x = Ø-2 (RTØ - RTØ2), and i = Ø-32767$_{10}$. Execute this command in any Logic Master Mode. The transfer of Initial Values occurs when the AR Command (which starts the Rep-Op Timer) is executed; when Timer RUN goes low, or SKP goes high, and on every Carry-Out Pulse.	10.15 6.4

The above command is used to set the three Initial Value Registers of the Rep-Op Timer (RTØ, RT1 and RT2). Note that they are upon power up, or after the execution of a Job Command these registers are set to 500, 5000 and 0, respectively. The actual counter is not accessible through the MACS. The immediate state or the Rep-Op Timer is displayed (012) on the Logic Page under the heading TIMER.

The Initial Value Registers of the Rep-Op Timer can be loaded by the above command at any time. However, their values are not transferred to the actual counter until: the AR command (3.11) is executed; or the Rep-Op RUN termination goes low; or the SKP termination goes high; and on every Carry Out (CO) pulse. See comments under Commands 3.11 and 3.12 (Paragraph 10.6.1) for more details on the Rep-Op Timer.

10.16 SETTING GENERAL PURPOSE REGISTERS (GPRs) AND COUNTERS (CTRs) (6.6)

NO.	FORMAT	DESCRIPTION	PARA. REF.
Set General Purpose Registers (GPRs) and Counters (CTRs)			
6.6	[R] [V] [x] [=] [i] [RETURN]	Sets the Value (V) Register (R) of GPR or CTR Number x to value specified by i as follows: 1. GPR In a standard configuration x = $(Ø, 4, 1Ø)_8$; and i = $Ø\text{-}377_8$. The GPR has no Initial Value Register. Logic Clear (CL) resets all eight flip-flops to the zero state. Therefore, this command must be executed in a Logic Mode other than CL. The MACS Logic Page displays the actual GPR contents in a binary form (Bit 7 is the LSB). The decimal equivalent of the GPR content is displayed in the VALUE window. 2. CTR In a standard configuration x=$(1,2,5,6,11,12)_8$; and i=$Ø\text{-}32767_{10}$ or $Ø\text{-}77777_8$. This command loads the Initial Value Register of CTR x and can be executed in any Logic Master Mode. Transfer of the Initial Value to the CTR occurs in Logic CL; when CTR Reset (its R input set goes high), and automatically on every Carry Out Pulse. Patching is not required. The MACS Logic Page displays the condition of the CTR State Flip-Flop. The CTR content is displayed in decimal form in the VALUE window.	10.16 5.5 5.6

10.16.1 GENERAL GPR AND CTR ADDRESSING

This same command is (RVxxx = i - - i) is used to set the actual register of the GPR, and the Initial Value Register of the CTR. The distinction (GPR or CTR) is in the data entered for the address (xx). In standard systems, the GPR address assignments are Ø, 4 and 1Ø$_8$; and the CTR address assignments are 1, 2, 5, 6, 11 and 12$_8$. For clarity, the GPR and CTR are described in separate paragraphs (10.16.2 and 10.16.3, respectively).

10.16.2 SETTING THE GPRs

The GPRs are upcounters. Therefore, they are reset to zero in the Logic Clear (CL) Mode. A GPR can be set to any value (i) in the range Ø to 255. When a GPR is addressed for readout (Command 5.9, Paragraph 10.9), the MACS displays the contents of the actual register in decimal form. The binary to decimal conversion is accomplished by the firmware. The binary register content (State of all GPR Flip-Flops) is displayed on the Logic Page (Paragraph 10.19).

The following example (Figure 10.18) illustrates the MACS display for GPR Ø which has been set to the value 77_{10}.

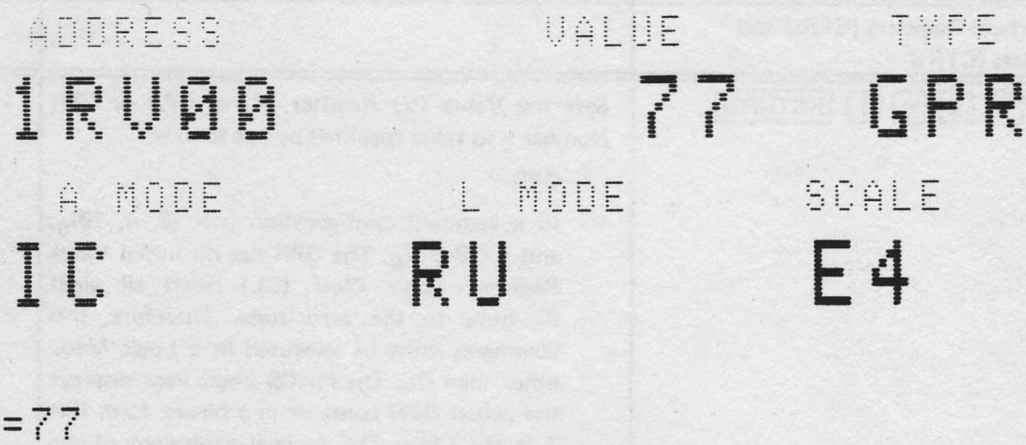


Figure 10.18 Setting the Value (Command 6.6) of a Selected GPR

Note that GPR Ø was previously selected using Command 5.9 (RVØ RETURN). Then, the Value Command (= 77 RETURN) was entered. If knowledge of the previous contents of GPR Ø was not desired, the GPR could have been selected and set to 77_{10} as follows:

[R] [V] [Ø] [=] [7] [7] [RETURN]

Also not that nothing has been patched into the GPR inputs. Therefore, the GPR is not counting.

The GPR can also be set with an octal value by preceding the value entry with the character ['] (prime). For example, GPR Ø could be set to octal 77 (63_{10}) as follows:

[=] ['] [7] [7]

The VALUE window will display decimal 63. However, the Logic Page displays the binary equivalent of the octal value. See Paragraph 10.5.2 for an exercise that illustrates the binary readout of GPR Ø on the Logic Page.

10.16.3 SETTING CTRs

The CTRs are down counters and require an Initial Value Register. The content of this register is transferred to the actual counter (CTR) during any one of the following conditions:

1. When Logic Clear (CL) Mode is selected.
2. When the Counter R (Reset) termination goes high.
3. On every Carry Out (CO) pulse.

A CTR can be set to any value (i) in the range Ø - 32767_{10}. When a GPR is addressed for readout (Command 5.9, Paragraph 10.9), the MACS displays the contents of the actual register in decimal form (binary to decimal conversion is done by firmware. The Logic Page (Paragraph 10.19) displays the CTR State Flip-Flop, not the register value.

The following example (Figure 10.19) illustrates the MACS display with the Initial Value Register loaded with 9999_{10} and transferred to the CTR using the Clear (CL) Mode.

```
ADDRESS          VALUE          TYPE
1RVØ1            9999           GPL
  A MODE           L MODE         SCALE
IC               CL             E4

RV1=9999,CL
```

Figure 10.19 Setting a Counter and Transferring the Value by Stringing Commands 6.6 (Counter Set) and 3.7 (Logic Clear Mode)

Note that a strung command (RV1 = 9999, CLR RETURN) was used. If the CTR set command (RV1 = 9999 RETURN) was used along, only the Initial Value Register would set and the display would indicate the previous value contained in the CTR. In this case, the Logic Clear Mode (CL) was selected to provide an immediate value transfer to the CTR and display that value.

10.17 SETTING LOGIC COMPONENTS (6.7)

NO.	FORMAT	DESCRIPTION	PARA. REF.
Set Logic Components			
6.7	(to set): [L] [x] [y] [=] [1] [RETURN] (to reset): [L] [x] [y] [=] [Ø] [RETURN]	Sets/resets Logic Component Number y in Logic (L) Tray Number x to 1 or Ø. Where x = Ø-13_8 and y = Ø-7_8 (Ø-5 for Comparators). Set Flip-Flops, Differentiators, Counters, and Comparators while in the Logic Stop (SO) Mode. This overrides the effect of patched inputs. The Differentiator Flip-Flop may be Set/Reset, not the DIF output. This command cannot directly Set/Reset individual GPR Flip-Flops.	10.17 5.5 5.7

The above commands may be used to set or reset the state of the following logic components on an individual basis.

1. GPL Tray
   a. Free Flip-Flops
   b. Differentiator State Flip-Flop
   c. State Flip-Flop of CTRs
2. GPR Tray
   None
3. CMP Tray
   The output Flip-Flop of all comparators.

The Logic Component Set Commands enable full state checkout of the logic program. Once the desired logic outputs of the above components are set, the Logic Component Read command (5.8) and/or the content of the Logic Page (Paragraph 10.9) may be implemented to confirm the state outputs of the combinatorial logic components.

If the prepatched logic forces a particular component into an undesired static state, the above command must be executed while in the Logic Stop (SO) Mode.

Note that, while the Logic is in the Stop Mode, the output of a Differentiator is an AND of its input and the NOT side of its Flip-Flop. Both the Logic Page and the VALUE readout display the state of the Differentiator internal Flip-Flop even though the address corresponds to the output termination of the Differentiator.

10.18 SETTING DSFGs (6.8 - 6.13)

NO.	FORMAT	DESCRIPTION	PARA. REF.
Setting DSFGs (Digitally Set Function Generators)			
6.8	[B] [=] [2] [1] [RETURN] OR [B] [=] [4] [1] [RETURN]	Initializes the previously selected DSFG (Command 5.6) for set up of a 21 or 41 Breakpoint (B) function.	10.18 9.4.7 4.13
6.9	[V] [x] [=] [f] [RETURN]	Enters (sets) Function Value f at Breakpoint Number x of the previously selected DSFG (Command 5.6). Where x = Ø-21 or Ø-41, and f is a function value in the range of -1.0 to +1.0. Also brings in the updated function page, if entered through the MACS keyboard. The value of F is a scaled fraction number consisting of an optional Ø digit followed by a required decimal point and up to five digits. Negative values must be preceded by a minus (–) sign. If more than five decimal digits are entered for a value f, the DSFG sets a value rounded for five decimal digits. The difference between two neighboring function values cannot exceed ±1.0 MU (i.e., $\lvert f_{n+1} - f_n \rvert \leq 1$).	10.18 4.13
6.10	[S] [;] [RETURN]	Set (Restore) the selected DSFG (Command 5.6) to the values it had before it was set with a Test Function (Command 6.12). Also used to set a selected DSFG if the function values were entered from the Serial Port, and were not followed by the Set Command.	10.18 4.13
6.11	[F] [y] [=] [x] [RETURN]	Function Transfer. Sets DSFG Number y to the same function values as DSFG Number x and selects DSFG Number y. Where y and x = Ø-17_8.	10.18 4.13
6.12	[F] [x] [=] [’] [m] [RETURN]	Sets DSFG Number x with the test function specified by ’m. Where x = Ø-17_8. The Test Function Code for ’m is as follows: ’m — Resulting Test Function ’100 — 21BPT Function y = +X ’101 — 21BPT Function y = -X ’200 — 41BPT Function y = +X ’201 — 41BPT Function y = -X After test function is verified, Fx can be restored to its original value using Command 6.10.	10.18 4.13
6.13	[F] [7] [7] [=] [’] [m] [RETURN]	Sets all DSFGs (Ø-17_8) to the test function specified by ’m. The Restore Command (6.10) can also be used in conjunction with this command to reset all DSFGs to the Functions they were set to prior to issuing the test function command.	10.18 4.13

To set a DSFG, one first accesses the desired DSFG with Select Command 5.6 (Paragraph 10.8).

Next, command 6.8 is used to choose the desired number of breakpoints, and then, the function values corresponding to each breakpoint have to be entered. The function is basically set with every execution (or a string) of Command 6.9. Stringing Command 6.9 enters function values immediately. To check the accumulated table of function values, one has to invoke the Function Page (See Paragraph 10.19).

Command 6.11 is used to copy a function from one DSFG unit to another and set it.

Special commands (6.12 and 6.13) enable setting DSFGs with EAI preprogrammed test functions while preserving the original function. One uses command 6.10 to restore the original function after using a test function.

A single command 6.13 sets all DSFG units present in the system to the desired test function.

Note that the test functions cannot be transferred with command 6.11. The DSFGs must be assigned to a test function individually.

Refer to Paragraph 9.4.7 and 4.13 for additional information concerning the DSFG Commands.

10.19 PAGING COMMANDS (7.1 - 7.5)

NO.	FORMAT	DESCRIPTION	PARA. REF.
7.1	[CTRL] [F] OR [L] [I] [;] [RETURN]	Brings in Function Page for the previously selected DSFG (Command 5.6). This page Lists the function values at each Breakpoint. Once executed, CTRL F is automatically re-executed upon selection of another DSFG, or upon entry of new function values.	10.19 9.4.7
7.2	[CTRL] [L]	Brings in Logic Display Page. Includes SL, CL, IL, and RT States, in addition to displaying states of General Purpose Logic Components and Trunks.	10.19
7.3	[CTRL] [R]	Brings in Range (Overload) Page which (with the exception of Coefficient devices), indicates all overloaded Analog Computing Components (Including DSFGs).	10.19
7.4	[CTRL] [T]	Brings in Time Scale Error Page. Indicates all Integrators having a Time Scale Error (TSE). See Command 4.2 for cause of TSE.	10.19
7.5 (3.5)	[B] [A] [RETURN]	Executes BA Mode and brings in Balance Page. This Page indicates all out of balance amplifiers including T/S Summers and Integrators. This Command must be re-executed in order to update the contents of the Balance Page.	10.4 10.19

There are five information pages that may be displayed on command. These are as follows:

1. CTRL F: Function Page (Figure 10.20)

   The Function Page lists the function value for every breakpoint of the currently selected DSFG.

2. CTRL L: Logic Page (Figure 10.21)

   The Logic Page displays the state of all Logic Components as well as the state of: Control Lines, Sense Lines, Logic Trunks and the Rep-Op Timer. This page is also called during the power up and when initializing the system using the Job Command (2.1).

3. CTRL R: Range Page (Figure 10.22)

   The Range Page indicates those amplifiers that are in overload (not operating in their linear range).

4. CTRL T: Time Scale Error Page (Figure 10.23)

   The Time Scale Error Page indicates those Integrators whose gains have been programmed in a manner that places them outside of the standard (non-existant values).

5. BA RETURN: Balance Error Page (Figure 10.24)

   The Balance Page indicates all unbalanced components. Note that the BA Command (7.5) is actually Mode Command (3.5). See Paragraphs 8.5.3 and 9.4.3 for related information.

```
DSFG 02
(01) -1.0000; -0.9000; -0.8000; -0.7000; -0.6000
(06) -0.5000; -0.4000; -0.3000; -0.2000; -0.1000
(11) +0.0000; +0.1000; +0.2000; +0.3000; +0.4000
(16) +0.5000; +0.6000; +0.7000; +0.8000; +0.9000
(21) +1.0000
```

Figure 10.20 Sample Function Page (Command 7.1)

```
GENERAL PURPOSE LOGIC
0001234567  0101234567  0201234567  0301234567
0401234567  0501234567  0601234567  0701234567
1001234567  1101234567  1201234567  1301234567

SENSE LINES                 CONTROL LINES
0001234567  0101234567      0001234567  0101234567

INPUT TRUNKS                INTERRUPTS    TIMER
0001234567                  0001234567     012
```

Figure 10.21   Sample Logic Page (Command 7.2)

```
OVERLOADS
0001234567  0101234567  0201234567  0301234567
0401234567  0501234567  0601234567  0701234567
1001234567  1101234567  1201234567  1301234567

FUNCTION GENERATOR
0001234567  0101234567
```

Figure 10.22   Sample Range (Overload) Page (Command 7.3)

```
TS ERRORS
0001234567  0101234567  0201234567  0301234567
0401234567  0501234567  0601234567  0701234567
1001234567  1101234567  1201234567  1301234567
```

Figure 10.23 Sample Time Scale Error Page (Command 7.4)

```
AMPL BALANCE ERRORS
00012 4567  01012 45    02012 4567  03012 45
04012 45    05012 45    06  2       07  2
10          11          12          13
```

Figure 10.24 Sample Amplifier Balance Error Page (Command 7.5/3.5)

10.20 PROGRAM SAVE AND RESTORE COMMANDS (8.1 – 8.3)

NO.	FORMAT	DESCRIPTION	PARA. REF.
8.1	[N] [$] [C] [:] [RETURN]	This command outputs analog program data of console number n to an external Teletype compatible device via the RS232 Port. The data is output in the same format as required for future re-setup. The program data includes: Coefficient values of Handset Pots, DCA's, DAM's; Integrator Time Scales; RV and RT Register Values; and all DSFG values. The list is headed with the current Master Time Scale and both Master Modes. This command must originate (be entered) at the external device. Upon read-in, this command restores the original problem settings: all coefficients (except Handset Pots); Integrator Time Scales; DSFGs; and all Initial Value Registers to the corresponding counters must be implemented by the user. The machine is restored to the same Master Modes and Time Scale that existed.	10.20
8.2	[n] [$] [V] [:] [RETURN]	Analog Program Value Save. This command outputs the values of all A, D, F, P, and readable T components of console number n to an external Teletype compatible device via the RS232 Port, and must be entered from the external device. The list is headed with the current Master Time Scale and both Master Modes.	10.20
8.3	[n] [$] [F] [:] [RETURN]	Outputs the function values of the selected (and used) DSFG for re-setup when read back. A "used" DSFG is defined as a DSFG upon which at least one function value has been set (Command 6.9). This command must be entered from the external device.	10.20

NOTES

1. *Connect the input/output device through the Serial Port, Select the proper Baud rate, select On-Line Mode (Command 2.2), and start the external device before using the above commands.*
2. *Read-in is initiated from the device, not at the MACS.*
3. *The RETURN character may have other designations (such as CARRIAGE RETURN, CR or ⮐) as determined by the specific external device.*
4. *$C and $F cassette or paper tapes can be produced Off-Line by simply keying the same command sequence one would enter from the MACS.*
5. *To abort the execution of the $ commands, execute Command 1.3 ([CTRL] [S]) at the MACS.*
6. *In single console systems, the console number (n) does not have to be specified. In a multi-Console environment, omitting the console number is equivalent to specifying the n of the last console selected.*

The preceding commands are used to save whole or partial EAI 2000 programs. The Save/Restore Commands cannot be executed from the MACS keyboard, but only from a teletype or teletype compatible device that is connected to the Serial Port, and can send the Specified ASCII character string (via the keyboard of the device). Observe all notes at the end of the preceding list.

10.21 MISCELLANEOUS COMMANDS (9.1, 9.2)

NO.	FORMAT	DESCRIPTION	PARA. REF.
Digital Value Monitoring			
9.1	[D] [V] [RETURN]	Selects the analog input termination at the program panel as the input to the DVM (Digital Volt Meter). Permits patching an analog signal to the DVM for conversion and readout on the MACS VALUE Display.	10.2.1
Generating BLIPs (Pushbutton Flip-Flop)			
9.2	[BLIP] [x]	Generates a BLIP at the corresponding Program Panel terminations designated ⎍ x. BLIP is one of the three special keys, and x = Ø–3.	10.2.1

The above commands are straight forward, and therefore further descriptions are not provided. See the referenced paragraphs for additional information.

10.22 MULTI-CONSOLE COMMANDS

NO.	FORMAT	DESCRIPTION	PARA. REF.
Master Console			
10.1	[M] [C] [RETURN]	A console at which this command is executed is declared the MASTER Console as indicated by the display of a contrast inverted M under the MC Indicator heading. For predictable results, only one console of a multi-console system should be selected as MASTER. In a multi-console system, the time critical Analog and Logic Modes are changed synchronously. Master Time-Critical (analog and logic) Mode commands (MASTER or SLAVE) in the system. However, Synchronous Program Panel control of time-critical analog and logic modes may only be performed by patching at the MASTER Console. Similarly, the Rep-Op Timer of a MASTER Console only may be used to control the time-critical modes of a multi-console system.	8.4.1 8.4.2 8.5.7 8.7

NO.	FORMAT	DESCRIPTION	PARA. REF.
10.1 (cont.)		**NOTE** *For proper execution; this command should be issued as a single command, or as the last command in a command string. If not, the ILLEGAL COMMAND error message will result. This same error message is output if the Multi-Console expansion is not present in the system.*	
Slave Console			
10.2	[S] [L] [RETURN]	This command selects the console at which it is issued as a SLAVE in a multi-console system. When Slaved, the time-critical modes change synchronously with the mode of operation of the MASTER console. The mode commands for the Slaved system can be issued at the keyboard of the MASTER console, or any one of the other SLAVE consoles. When the SLAVE command is executed, a contrast inverted S is displayed under the MC (Multi-Console) heading to indicate that the console is Slaved. When the master mode of a console is slaved, SL is displayed to the right of the current A and L MODE headings. **NOTE** *For proper execution; this command should be issued in a single command, or as the last command in a command string. If not, the ILLEGAL COMMAND error message will result. This same error message is output if the Multi-Console Expansion is not present in the system.*	8.4.1 8.4.2 8.5.7 8.7
Console Selection			
10.3	[n] [RETURN]	Display the video of the Selected Console on the display of the console at which the Select Command was issued. In a Multi-Console environment, this command presets a console prefix (n = 1-6) for all subsequent commands which may be issued without the prefix. Normally, Console Select is issued in response to the message **CONSOLE NOT SELECTED** (appearing in the Special Message Pad area of the display). Once the Multi-Console system is set up, and the console prefix is known to the system (by issuance of this command, or another command that included the console prefix), the video display of the selected console is switched to the display of the console at which the selection is made.	8.7

NO.	FORMAT	DESCRIPTION	PARA. REF.
Console Selection (Cont.)			
10.3 (cont.)		If when issuing this command one asks for the video of a console that is not part of the Slaved System (not a MASTER ( ) or one of the SLAVE consoles), a NO SUCH CONSOLE error message will be displayed, and each console will display its own video with the **CONSOLE NOT SELECTED** message. **NOTE** *The Console Select Command is particularly useful during the debugging of a Multi-Console program. For example, should the OV indicator display a contrast-inverted asterisk, an overload condition exists in one or more of the other consoles (other than and/or in addition to the console whose video is currently on). Therefore, by systematically issuing the Console Select on each Console in the system in turn, and observing the state of the OV indicator, it is possible to determine precisely which consoles are in overload.*	
Unslaving (Normal) Command			
10.4	[n] [N] [O] [RETURN]	Places MASTER or SLAVE Console number n in the Unslaved Mode. In other words, Console n is no longer a MASTER or SLAVE, and may be operated independently of the rest of the Multi-Console system. The entry [n] must be the prefix of a console belonging to the Slaved system. If not the NO SUCH CONSOLE error message and the **CONSOLE NOT SELECTED** message will be displayed, and each console will display its own video. When the [n] selection is within range (is a part of the Slaved system), only the specified console (MASTER or SLAVE) will be removed from the Slaved system and the rest of the system will remain Slaved. If the MASTER console is deselected, another MASTER selection (Command 10.1) should be made for the Slaved system. To unslave the entire system use [CTRL] [S] (Command 1.3) instead of executing 1NO, 2NO, 3NO, etc.	8.7

The Multi-Console commands are fully detailed in the above list and referenced paragraphs. Therefore, further descriptions are not provided.

APPENDIX

1

APPENDIX 1

TERMINOLOGY

A	Amplifier, Address, Analog Component, "A" input of the electronic switch
ADC	Analog to Digital Converter
AND	AND gate
AP	Analog Mode Program Panel Control
AR	Analog Mode Rep-Op Control
B	Number of Breakpoints (B = 21 or B = 41)
BA	Balance (Analog Mode); Balance Error Indicator
[BLIP]	Special key, used in conjunction with the Ø through 3 characters to create "blips"
C	Coefficient, Coefficient Value
CI	Carry In
CL	Clear (Logic Mode); Control Line
CLR	Clear
CMP	Comparator; Comparator Tray
CO	Carry Output
CSI	Control and Setup Interface
CTR	Counter
[CTRL]	Control key, used in conjunction with other keys to initiate execution of special functions
Cx	Coefficient # x, Value of Coefficient # x
D	Derivative
DAM	Digital to Analog Multiplier
DAx	Output of DAM # x (product of digital coefficient and analog input)
DCA	Digital Coefficient Attenuator
DCx	Coefficient of DAM # x
DIF	Differentiator (Logic)
DSFG	Digitally Set Function Generator
DV, DVM	Digital Value Monitoring, Digital Volt Meter
Dx	Derivative of Integrator # x
E	Enable; Erase
ϵ	"belongs to"
ECI	Enable Carry In
F	Function, Function Generator
FF	Flip-Flop
FG	Function Generator
Fx	Function Generator # x
GPI	General Purpose Interrupt
GPL	General Purpose Logic Tray General Purpose Logic Page

GPR	General Purpose Register Tray General Purpose Register
HD	Hold (Analog Mode)
HY	"Hybrid" (Serial and Parallel ports enabled)
I	Integrator
∫	Integrator
IC	Initial Condition (Analog Mode)
IL	Interrupt Line
IN	Input
INL	Integrator with Limiter
INT	Integrator
Ix	Integrator # x, Time Scales Factor of Integrator # x
J	Job
L	Logic; Lower, Lower Limit; Load; Left Event Marker
LD	Local Display
LP	Logic Mode Program Control
LR	Logic Mode Rep-Op Control
Lx	Logic Component # x
M	Master
m	Exponent of the Master Time Scale Factor
MC	Mult-Console
MUL	Multiplier
n	Breakpoint Number; exponent of the Integrator's Time Scale Factor; Console Number
ND	Normal Display
NO	Normal (Unslaved Mode)
OP	Operate (Analog Mode)
OV	Overload Indicator
P	Product; Output of coefficient (Product of the input to the Coefficient and its coefficient value)
POT	Manually-Set Coefficient Attenuator
Px	Output of coefficient # x
QT	Quiescent (Analog Mode)
R	Reset; Reference; Right event marker
r	Row
[REPT]	Repeat Key. When used with another key, the "other" key is effectively entered at the rate of ten per second for as long as both of them are depressed. Usually used with RETURN key to execute the contents of the Command Buffer (e.g., slewing command) at the above rate
[RETURN]	Carriage Return Key
RT	Rep-Op Timer, Rep-Op Tray

RTØ	Rep-Op Timer's Initial Condition Register Value; Interval zero Logic Output of the Rep-Op Timer
RT1	Rep-Op Timer's Operate Register Value; Interval one Logic Output of the Rep-Op Timer
RT2	Rep-Op Timer's Hold Register Value; Interval two Logic Output of the Rep-Op Timer
RU	Run (Logic Mode)
RV	Register Value
RVx	Register # x Value
S	Step; Set; Slave
S/C	Sine/Cosine, Sine/Cosine Tray
SEL A	Select A; Control Input of the switch
SI	Serial Input
SIN	Sine; Sine Tray
SL	Sense Line; Slave
SO	Stop (Logic Mode)
SPI	Standard Parallel Interface
SS	Single Step (Logic Mode)
ST	Static Test (Analog Mode)
SUM	Summer
Σ	Summer
SW	Switch; Output of the switch
T	Trunk; Trigger; Chart On
TS	Time Scale Error Indicator
T/S	Track/Store Summer
TST	Test, Test Tray
TTY	Teletype
Tx	Trunk # x
U	Upper; Upper Limit
v	Value
Vn	Function Value at breakpoint # n
x	Address
Z	Pen Down; Beam On

APPENDIX

2

MACS COMMAND LIST

CONTENTS

NOTE

Detailed command descriptions are contained in Chapters 9 and 10 of the Reference Manual. All references are to Tables in Chapter 9. Each table contains a Paragraph Reference for additional descriptions of specific commands.

MACS COMMAND LIST

INTRODUCTION:

All commands except those using [BLIP] and [CTRL] keys must be terminated with a Carriage/Return ([RETURN]) key for immediate interpretation and execution. Repeated use of [RETURN] key (by itself or with [REPT] key) will cause repeated execution of the command(s) entered into the Scratch Pad.
Commands using [BLIP] and [CTRL] keys can not be executed from the keyboard of a teletype or teletype compatible device connected through the Serial Port, but only through the MACS Keyboard.
See MACS Error List for interpretation, probable cause and suggested action based on a particular error message appearing in the Message Pad.
The underlined and/or capitalized characters *have* to be used.
Commands without underlined characters have to be entered in full.
Commands can be strung between commas (up to the full Command Buffer length of 48 characters) for serial interpretation and execution. Commas are not needed after the commands with a colon or semi-colon as the last character. "Strung" commands need only one [RETURN] after the last command.
The referenced component addresses are based on a "standard" configuration, but the EAI 2000 addressing scheme is totally flexible as it is aware of both the presence and the type of addressed component/tray.
See EAI 2000 Reference Manual (Chapters 8 and 9) for detail examples on how to use MACS Commands and how to interpret the status of EAI 2000 on the MACS Display.

1. EDITING:

1.1	RUB OUT	Deletes last character entered and moves cursor back one character
1.2	RUB OUT RETURN	Clears both the Scratch and Message Pad areas
1.3	CTRL S	Aborts current command and clears both the Scratch and Message Pads. Brings in Logic Page.

2. INITIALIZATION:

Job Command

2.1	n, Job; (for n ≠ 1) Job; (for n = 1)	Initializes Console #n (Momentarily into Balance Mode to check for Balance Errors, and then QT (all integrators and summers in X1000 Mode ready for Balancing; no Balance Page), Master Time Scale to E0, Logic to CL, all individual integrators to E+0, Normal Display, selected A000, RTO=500, RT1=5000, RT2=0, all DSFGs set to y=0 with 21 breakpoints.

ON/OFF Line Control

2.2	ON	Puts Digital Computer or teletype compatible device "On" line (enables both serial and parallel ports). Initiates firmware for proper communications protocol.
2.3	OFf	Puts Digital Computer "Off" line (disables both serial and parallel ports to/from digital computer).

Display Control

2.4	ND	Activates "Normal Display" (the MACS display controlled with the last command received from MACS keyboard or digital computer if "ON" line).
2.5	LD	Activates "Local Display" (enables component selection and monitoring independently of the "ON" line digital computer selection.)

3. MASTER MODE COMMANDS:

Analog Master Mode Selection

3.1	CTRL I	IC	Selects Analog Initial Condition
3.2	CTRL O	OP	Selects Analog Operate
3.3	CTRL H	HD	Selects Analog Hold
3.4	–	ST	Selects Analog Static Test (Test References present)
3.5	–	BA	Selects Analog Balance
3.6	–	QT	Selects Analog Quiescent (like BA but no Balance Page)

Logic Master Mode Selection

3.7	CL	Selects Logic Clear
3.8	RU	Selects Logic Run
3.9	SO	Selects Logic Stop
3.10	SS	Selects Logic Single Step

NOTE

SS will put Logic into SO Mode (unless the Logic was already in Stop) and advance Logic by one clock pulse for every execution of SS command.

Selecting Master Mode Control Source

3.11	AR	Puts Analog Master Mode under the Control of Rep-Op Timer: IC-OP-HD-IC . . . if RT2 ≠ 0, IC-OP-IC . . . if RT2 = 0
3.12	LR	Puts Logic Master Mode under the Control of Rep-Op Timer: CL-RU-SO-CL . . . if RT2 ≠ 0, CL-RU-CL . . . if RT2 = 0
3.13	AP	Puts Analog Master Mode under the Program Panel Control (IC and HD "AMODE" control inputs)
3.14	LP	Puts Logic Master Mode under the Program Panel Control (CL and SO "LMODE" control inputs)

NOTES

1. *To control only the Logic Master Mode with Rep-Op Timer, patch timing signal into the CI hole of Rep-Op Timer and enter LR.*
2. *When AR or LR or both are executed, the time spent in IC (CL), OP (RU) and HD (SO) is proportional to count stored in RTØ, RT1 and RT2 respectively, and inversely proportional to number of clock pulses during which the Rep-Op Timer's Carry In (CI) input is "high".*
3. *For synchronous control of both Logic and Analog Master Modes with Rep-Op Timer, enter LR first and then AR (no patching required).*
4. *Selecting new Analog or Logic Master Mode or new Master Mode Control Source automatically de-selects the current one(s).*

4. INTEGRATOR TIME SCALE (GAIN) COMMANDS:

Master Time Scale Selection

4.1	Em	Sets Master Time Scale Factor to 10^m where $m \in (0, 4)$

Relative Time Scale Selection

4.2	Ix = E ± n	Sets Integrator #x Time Scale Factor to $10^{(m \pm n)}$ where $0 \leqslant m \pm n \leqslant 5$
	= E ± n	If Ix already selected

Absolute Time Scale Selection

4.3	Ix = En	Sets Integrator #x Time Scale Factor to 10^n, $n \in (0, 5)$
	= En	If Ix already addressed

NOTE

Based on the Master Time Scale (MTS) and the commanded Relative Gain (RG), the desired effective gain is computed and set by firmware for each integrator. The resultant gain has to have one of the following values: 10^0, 10^1, 10^2, 10^3, 10^4, or 10^5. If range is exceeded, the gain is set to the closest extreme and the Time Scale Error Indicator (TSE) is turned on. The following table presents nine typical cases:

MTS	RG	Effective Gain	Note
EØ	E + Ø	$10^{0+0} = 10^0 = 1$	O.K.
	E + 1	$10^{0+1} = 10^1$	O.K.
	E + 2	$10^{0+2} = 10^2$	O.K.
	E + 5	$10^{0+5} = 10^5$	O.K. (See Manual)
E1	E + Ø	$10^{1+0} = 10^1$	O.K.
	E + 1	$10^{1+1} = 10^2$	O.K.
	E–1	$10^{1-1} = 10^0$	O.K.
	E–2	$10^{1-2} = 10^{-1}$	TSE, gain set to 10^0
	E + 5	$10^{1+5} = 10^6$	TSE, gain set to 10^5
etc.	etc.	etc.	etc.

5. COMPONENT ADDRESSING AND READOUT

Analog Component Addressing

5.1	Ax:	Selects and Reads Type and Output of Analog Component #x, $x \in (0, 137)_8$
5.2	Cx:	Selects and Reads Type and Value of Coefficient #x, $x \in (0, 137)_8$
5.3	Dx:	Selects and Reads Derivative #x (see note 3)
5.4	Ix:	Selects and Reads Time Scale and output of Integrator #x (see note 3)
5.5	Px:	Selects and Reads Type and Output of Coefficient #x, $x \in (0, 137)_8$
5.6	Fx:	Selects and Reads Output of DSFG #x, $x \in (0, 17)_8$
5.7	Tx:	Selects and Reads Analog Trunk #x, $x \in (0, 57)_8$

Logic Component Addressing

5.8	Lx:	Selects and Reads Tray Type and State of Logic Component #x
5.9	RVx:	Selects and Reads Actual Value of Register #x (the value is presented in decimal form) $x \in (0, 4, 10)_8$ for GPRs and $x \in (1, 2, 5, 11, 12)_8$ for CTRs. The binary equivalent of the GPR value is displayed on Logic Page.

Rep-Op Timer Command

5.10	RTx:	Selects and Reads Rep-Op Timer Initial Value Register #x, $x \in (0, 2)$ (the value is presented in decimal form). The current state (0, 1 or 2) of Rep-Op Timer is displayed on Logic Page.

DAM (Digital-to-Analog Multiplier) Commands

5.11	DCx:	Selects and Reads Coefficient of DAM #x, $x \in (0, 37)_8$
5.12	DAx:	Selects and Reads Output of DAM #x, $x \in (0, 37)_8$

Address Advance Command

5.13	CTRL A	Updates the displayed address to the next sequential and available address of the component type already selected. If the current component is the last available, cycles back to the first available.

NOTES

1. *Read Logic Trunks, Sense Lines, Control and Interrupt Lines directly from the Logic Page.*
2. *Patch output of the Electronic Switch into the analog trunk ("in" side) and read trunk to indirectly ascertain the value of the switch output.*
3. *Integrator (Derivative) Addressing:* $x = (x_0 + 4 + 4 + 4 + \ldots)_8$
   where $x_0 = 0$ *for 1st row integrators* $\therefore x_{1r} \in (0, 4, 10, \ldots, 34)_8$
   and $x_0 = 40$ *for 2nd row integrators* $\therefore x_{2r} \in (40, 44, 50, \ldots, 74)_8$
   and $x_0 = 100$ *for 3rd row integrators* $\therefore x_{3r} \in (100, 104, \ldots, 134)_8$
4. *In the case of a Differentiator, this command will select and read the state of its Flip-Flop. Patch output of a Differentiator into an AND gate and read the gate to indirectly find the value of the Differentiator's output. The Logic Page displays the status of the same Flip-Flop and* **not** *the output of a Differentiator.*

6. COMPONENT SETTING COMMANDS:

Setting DCA Coefficient Values

6.1	Cx = v	Displays and sets DCA #x to value v ϵ (−1., +1.)
	= v	If Cx already selected

NOTES

1. *Value v is a scaled fraction number consisting of an optional plus sign and an optional 0 digit followed by a required decimal point and up to five decimal digits or ±1.0.*

   If more than five decimal digits are entered for v, the DCA will be set to the value rounded to five decimal digits.

2. *Use this command to set coefficients during the problem set-up. Use special "Stepping" commands (see below) to change coefficient values during the problem run.*

Stepping DCA Coefficient Values ("Slewing")

6.2	Cx> (>>, >>> etc.)	Adds 2^{-7} (≈ .008) or its multiple (.016, .024 etc.) to the current coefficient value of DCA #x. Stops at +1. (See Notes)
	> (>>, >>> etc.)	If Cx already selected (displayed)
6.3	Cx< (<<, <<< etc.)	Subtracts 2^{-7} (≈ .008) or its multiple (.016, .024 etc.) to the current coefficient value of DCA #x. Stops at −1. (See Notes)
	< (<<, <<< etc.)	If Cx already selected (displayed)

NOTES

1. *The value of coefficient #x is not displayed as a result of using C stepping command unless DCA #x is already selected.*
2. *The above feature enables selecting an arbitrary component and slewing a particular DCA while simultaneously observing its effect on the "arbitrary" component.*

Setting DAM Coefficient Values

6.4	DCx = v	Sets DAM #x coefficient to value v ϵ (−1., +1.). See notes under "Setting DCA Coefficient Values"
	= v	If DCx already addressed

Set Rep-Op Timer

6.5	RTx = i	Sets Rep-Op Timer Initial Value Register #x, $x \in (0, 2)$ to value i, $i \in (0, 32767)_{10}$
	= i	If RTx already selected

NOTES

Execute the above loading command in any logic Master Mode. The transfer of Initial Values to the actual counter is done when AR command is executed (which starts the REP-OP Timer, too), when Timer RUN hole goes low or SKP hole goes high, and on every carry-out pulse.

Set General Purpose Registers (GPRs) and Counters (CTRs)

6.6	RVx = i	Sets Register #x to value i (see Notes)
	= i	If RVx already selected

NOTES

1. *GPRs: $x \in (0, 4, 10)_8$ and $i \in (0, 255)_{10}$*
   Execute the above loading command in other than Logic Clear mode as General Purpose Register has no Initial Value Register. Logic Clear clears the Register (sets all eight Flip-Flops to zero state).
2. *CTRs: $x \in (1, 2, 5, 6, 11, 12)_8$ and $i \in (0, 32767)_{10}$*
   The above command loads the Initial Value Register of Counter #x and can be executed in any Logic Master Mode. The transfer of Initial Value to the actual counter is done in Logic CL when CTR reset (R hole goes high), and automatically on every carry-out pulse (no patching required).
3. *MACS displays (in decimal form) the content of actual registers for both GPRs and CTRs. Its Logic Page displays the binary content of all GPRs, but only the state flip-flop for the CTRs.*
4. *Both GPR and CTR can be set with an octal value: ie$(\emptyset, 377)_8$ for the GPR and ie $(\emptyset, 77777)_8$ for CTR.*

Set Logic Components

6.7	Lx = 1 or 0	Sets Logic Component #x to Logic "1" or "0"
	= 1 or 0	If Lx already selected

NOTES

1. *To over-ride the conflicting effect of patched inputs, set the Flip-Flops, Differentiators, Counters and Comparators while in Logic Stop (SO) Mode.*
2. *Only the Differentiator's Flip-Flop (no Differentiator's output) is settable/resettable with the above command. (While in Logic Stop Mode, the output of a Differentiator is an AND of its input and $\overline{Q}$ of its Flip-Flop).*
3. *This command can not directly set/reset the individual Flip-Flops of a General Purpose Register (GPR).*

Setting DSFGs (Digitally Set Function Generators)

6.8	B = 21 or 41	Selects number of Breakpoints
6.9	Vn = f	Enters Function Value f ϵ (–1., +1.) @ Breakpoint #n ϵ (1, B), sets selected DSFG and brings in the updated Function Page if entered through the MACS Keyboard.
6.10	<u>S</u>et<u>;</u>	Sets Selected DSFG. Used to reset a selected DSFG to values it had before it was set with 'MMM functions and to set selected DSFG if function value(s) came through the Serial Port and were not followed by this command.
6.11	Fy = x	Sets DSFG #y to the same values as DSFG #x (function "transfer") and selects DSFG #y.
6.12	Fx = 'MMM = 'MMM	Sets DSFG #x to Function pointed by 'MMM If DSFG #x already selected
6.13	F77 = 'MMM	Sets all DSFGs to Function pointed by 'MMM

NOTES

1. *'MMM = '100 for 21 BPT Function y = +x (straight line going from -1 to +1 MU)*
   '101 for 21 BPT Function y = -x (straight line going from +1 to -1 MU)
   '200 for 41 BPT Function y = +x
   '201 for 41 BPT Function y = -x
2. $|f_{n+1} - f_n| max = 1$; *fn is a function valve at Breakpoint #n.*

7. PAGING COMMANDS:

7.1	CTRL F <u>L</u>ist<u>;</u>	Brings in Function Page for the selected DSFG (Lists Function Values at each Breakpoint). Once executed, it is automatically re-executed upon the selection of a new DSFG or upon entering new function value(s).
7.2	CTRL L	Brings in Logic Display Page (includes SL, CL, IL and RTx states)
7.3	CTRL R	Brings in Range (overload) Page. Indicates all overloaded analog computing components (including DSFGs) except coefficients.
7.4	CTRL T	Brings in Time Scale Error Page. Indicates all integrators with Time Scale Error.
7.5 (3.5)	BA	Executes BA Mode and brings in Balance Page indicating all out of balance summers (including T/S Summers) and integrators. This command has to be re-executed in order to update the contents of the Balance Page.

8. PROGRAM SAVE-TO-RESTORE COMMANDS:

8.1	$Coef:	This command will output addresses and coefficient values of all hand-set pots, DCAs, DAMs, Integrator Time Scales, RV and RT Register Values and DSFGs through the RS232 port to the teletype compatible device in the same format as required for future re-setup. Enter this command from the external device. Upon read-in, it will restore the original problem by setting integrator time scales, DSFGs, all coefficients (except the hand-set ones) and all initial value registers. Transfer of initial value registers to the corresponding counters is left to the user. The machine is placed in IC and SO Master Modes.
8.2	$Val:	This command will output the values of all A, D, F, P, and T components. Enter this command from the external device.
8.3	$Fun:	This command will output the function values of the selected and "used" DSFG ready for the re-setup when read back. Enter this command from the external device. A "used" DSFG is one upon which at least one command #6.9 has been executed.

NOTES

1. *Connect the input/output device through the serial port, select proper Baud rate, select "ON" Line mode and start the device before using the above commands.*
2. *Read-in is initiated from the device (everything else as in Note 1) without any MACS command.*
3. *$C and $F cassette or paper tapes can be produced manually and off-line by simply keying the same command sequence one would have to enter from the MACS.*
4. *Use [CTRL] S command from the MACS to abort the execution of above commands.*

9. MISCELLANEOUS COMMANDS:

Digital Value Monitoring

9.1	DVm	Selects "DVM" input on the Program Panel for manual input to VALUE display (address any addressable component to disable this input).

Creating "BLIPS"

9.2	[BLIP] x	Creates "BLIP" on the corresponding Program Panel hole labelled ⎍ x. [BLIP] is a special key and x ϵ (0, 3)

10. MULTI-CONSOLE COMMANDS:

Master Console

10.1	[M] [C] [RETURN]	A console at which this Command is executed is declared the MASTER Console as indicated by the display of a contrast inverted M under the MC Indicator heading. For predicable results, only one console of a multi-console system should be selected as MASTER. In a multi-console system, the time critical Analog and Logic Modes are changed synchronously. Master Time-Critical Mode commands (analog and logic) may be issued at the keyboard of any console (MASTER or SLAVE) in the system. However, synchronous Program Panel control of time-critical analog and logic modes may only be performed by patching at the MASTER console. Similarly, the Rep-Op Timer of a MASTER console only may be used to control the time critical modes of a multi-console system.

NOTE

For proper execution; this command should be issued as a single command, or as the last command in a command string. If not, the ILLEGAL Command error message will result. This same error message is output if the Multi-Console expansion is not present in the system.

Slave Console

10.2	[S] [L] [RETURN]	This command selects the console at which it is issued as a SLAVE in a multi-console system. When slaved, the time-critical modes change synchronously with the mode of operation of the MASTER console. The mode commands for the slaved system can be issued at the keyboard of the MASTER console, or any one of the other SLAVE consoles. When the SLAVE command is executed, a contrast inverted S is displayed under the MC (Multi-Console) heading to indicate that the console is Slaved. When the master mode of a console is slaved, SL is displayed to the right of the current A and L MODE headings.

NOTE

For proper execution; this command should be issued as a single command, or as the last command in a command string. If not, the ILLEGAL command error message will result. This same error message is output if the Multi-Console Expansion is not present in the system.

Console Selection

10.3	[n] [RETURN]	Displays the video of the Selected Console on the display of the Console at which the Select Command was issued. In a Multi-Console environment, this command presets a console prefix (n = 1 - 6) for all subsequent commands which may be issued without the prefix. Normally, Console Select is issued in response to the message **CONSOLE NOT SELECTED** (appearing in the Special Message Pad area of the display).

Console Selection

10.3 (cont.)		Once the Multi-Console system is set up and the console prefix is known to the system (by issuance of this command or another command that included the console prefix), the video display of the selected console is switched to the display of the console at which the selection was made. If when issuing this command one asks for the video of a console that is not part of the Slaved System (not a MASTER or one of the SLAVE consoles), a NO SUCH CONSOLE error message will be displayed and each console will display its own video with the **CONSOLE NOT SELECTED** message.

NOTE

The Console Select command is particularly useful during the de-bugging of a Multi-Console program. For example, should the OV indicator display a contrast-inverted asterisk, an overload condition exits in one or more of the other consoles (other than and/or in addition to the console whose video is currently on). Therefore, by systematically issuing the Console Select on each console in the system in turn and observing the state of the OV indicator, it is possible to determine precisely which consoles are in overload.

Unslaving (Normal) Command

10.4	[n] [N] [O] [RETURN]	Places MASTER or SLAVE Console number n in the Unslaved Mode. In other words Console n is no longer a MASTER or SLAVE and may be operated independently of the rest of the Multi-Console system. The entry n must be the prefix of a console belonging to the Slaved system. If not the NO SUCH CONSOLE error message and the **CONSOLE NOT SELECTED** message will be displayed, and each console will display its own video. When the [n] selection is within range (is a part of the Slaved system), only the specified console (MASTER or SLAVE) will be removed from the Slaved system and the rest of the system will remain Slaved. If the MASTER Console is de-selected, another MASTER selection (Command 10.1) should be made for the Slaved system. To Unslave the entire system use [CTRL] [S] (Command 1.3) instead of executing 1NO, 2NO, 3NO, etc.

APPENDIX

3

MACS ERROR LIST

Legend: ○ Cause
● Recovery

Common Operator Errors:

ILLEGAL COMMAND

- ○ Attempting to execute a non-defined command [ID]
- ● Look up the correct command syntax.
- ○ Attempting to execute a command that is not executable on selected component [A4 = Ø, CØ>] where CØ = handset pot.
- ● Look up the correct component address or check the command description and/or syntax.
- ○ Attempting to execute a Multi-Console Command on a system which does not have a Multi-Console Expansion.
- ● Issue a legal command.
- ○ Attempting to select a component on a console whose number is outside the range 1 - 6. This error is only triggered in the Multi-Console environment.
- ● Position the Console Select switch to a number between 1 and 6 and make sure that each console of a Slaved system has a different console number.

INVALID

NOTE

The word INVALID flashes in the Component Information Display Area under VALUE. This message does not appear in the Error Message Pad.

- ○ Attempting to address a component that is not physically in the system, but whose address value is within range of the system.
- ● Re-execute the same command using a valid address.

NUMBER OUT OF RANGE

- ○ The numeric part of a command is not within range of the system. For example commands such as I8, A244, E5, RTØ = 55000, etc will cause this error.
- ● Look up the range of numeric entries for that command and then enter the correct value in that range.

NO DSFG SELECTED

- ○ Attempting to execute a command that requires prior DSFG selection.
- ● Selects the desired DSFG and re-execute the command issued prior to Error Message.

NO SUCH CONSOLE

- ○ Addressing a non-existant console.
- ● Check setting of Console Select switch.

Common Operator Errors (Cont.)

- ○ Not prefixing first command upon setting up a Slaved system, or not issuing Console Select Command before the first non-prefixed command.
- ● Prefix the first command with a valid console number, or issue a Console Select Command.

DCA Error:

SELECTED DCA IS INVALID

- ○ This message is displayed upon detection of an invalid DCA Address while executing a DCA Slewing Command.
- ● Re-execute the same command, but with an existing (valid) DCA.

DVM Errors:

DVM OFFSET ERROR

- ○ This error message is displayed when the DVM "ground" readout differs from zero by a predetermined amount. DVM offset to ground is digitally corrected by firmware.
- ● This is a maintenance problem. Inform Service Technician.

DVM GAIN ERROR

- ○ This error message is displayed when the DVM gain correction factor exceeds a predetermined range.

  DVM gain correction factor is determined by firmware, which compares the voltage being read against reference voltage of the same sign.
- ● This is a maintenance problem. Inform Service Technician.

DVM OFFSET AND GAIN ERROR

- ○ Both DVM errors have occured in the process of reading one component value.
- ● This is a maintenance problem. Inform Service Technician.

Serial Port Errors:

SERIAL PORT NOT ON LINE

- ○ The Port itself, or the device attached to it (teletype, digital computer, etc.) is not turned on.
- ● Turn on the device and re-issue the On Line Command.

SERIAL PORT NOT READY

- ○ Hardware problem with I/O device attached to the Serial/Port or the Port itself (ACIA; Asynchronous Communications Interface Adapter.)
- ● Inform Service Technician.

SERIAL PORT SYNTAX ERROR

- ○ All inclusive syntax error for commands from the digital computer over the Serial Port.
- ● A new (non-erroneous) command clears this message.

LOST CONTACT WITH DIG COMPUTER

- o Firmware has timed out before the required digital computer response (echo).

NOTE

The firmware allows several minutes for establishing the initial contact by sending a Space Character and waiting for the digital computer to send its echo back. Once the initial contact is established, 10 seconds are allowed for the digital computer to echo back every character (one at a time) sent to it by the Micro-processor within the 2000. This feature does not slow down Serial Port Communicagions. It allows digital computer overhead when the 2000 is not the only "User" serviced.

- ● Inform the Service Technician. Any MACS Command will clear the message.

Parallel Port Error:

SPI PORT CONFLICT - - RE-EXECUTE LAST COMMAND

- o During the interval that a DAM transfer is pending (DAM's loaded but not yet transferred) that either of the following has occurred:

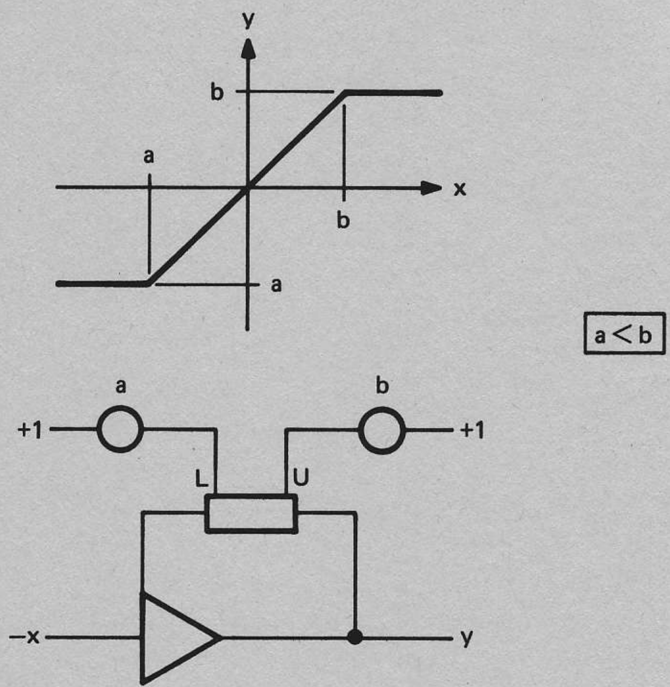
  a. A local attempt (at MACS) to set any DAM.

  b. A local attempt (at MACS) or a Hybrid attempt (thru Serial Port) to set any of the last 32 DCA's (DCA 100 thru 137).

- ● Check with the Digital Operator. If permissable, trigger the transfer from the Program Panel by pulsing the DAM-XF termination of the IL/ADC tray. Then, re-execute the last command.

APPENDIX 4

LIMITS



NOTE

For a=o, the coefficient unit may be omitted by patching the "L" terminal directly to ground.

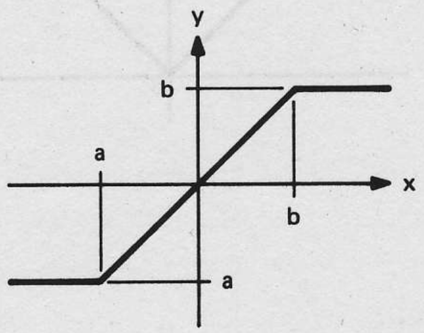
Likewise, for b=o, the "U" terminal may be grounded.

ANALOG/LOGIC CIRCUITS FOR SIMULATING NON-LINEAR CHARACTERISTICS

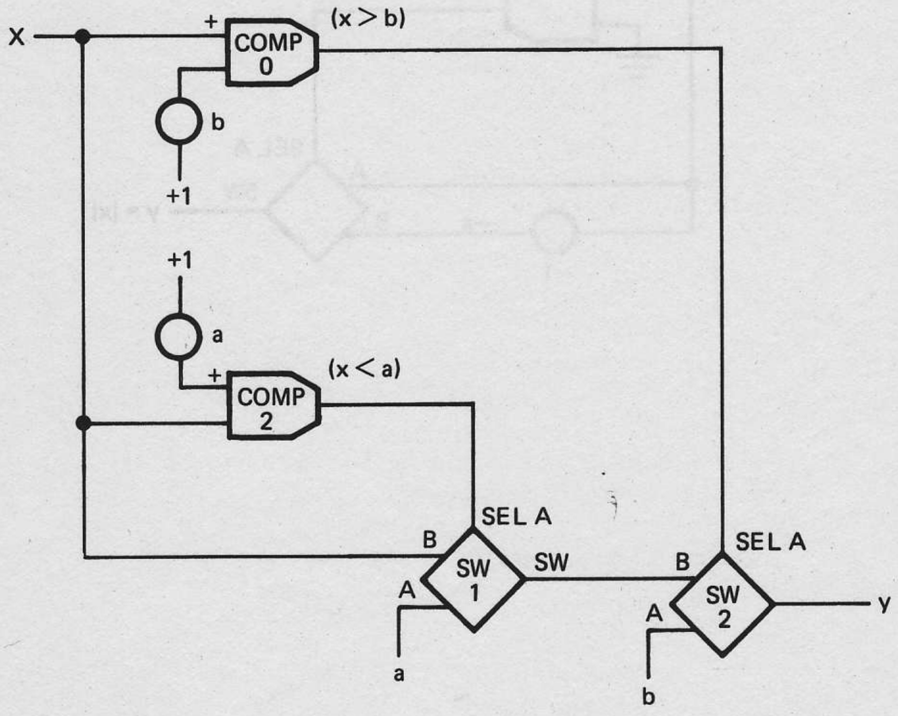
NON-LINEAR CHARACTERISTICS

This appendix provides a "COOKBOOK" of analog/logic circuits for simulating a variety of commonly encountered non-linear characteristics (i.e., limit, deadzone, etc.). In most cases, two alternate approaches are indicated: one using Limiters, the other using Logic. The two circuits, generally provide equivalent responses; the choice of one over the other is primarily a matter of component availability.

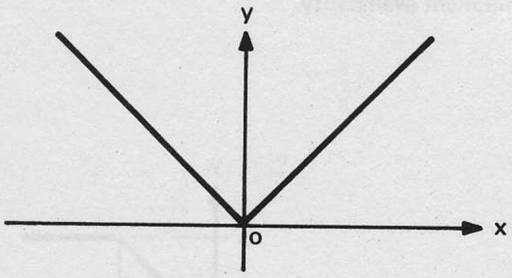
LIMITS

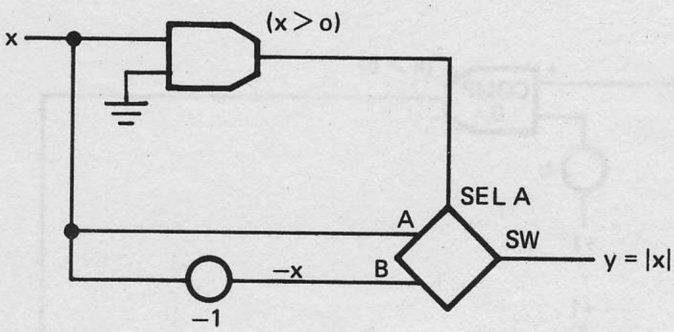


A<B

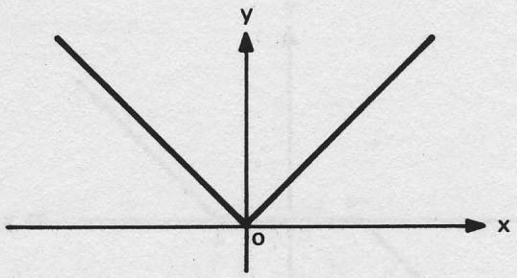


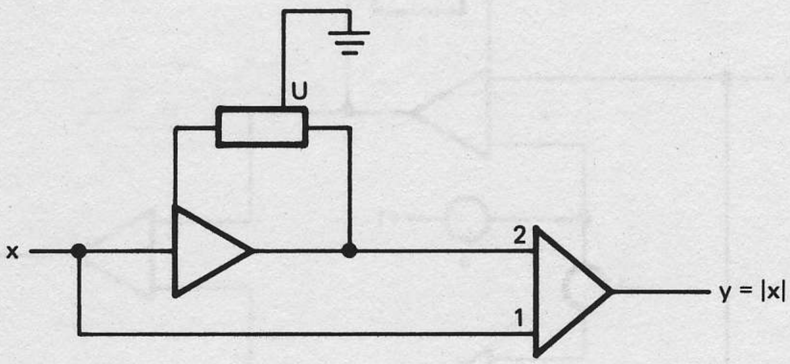
ABSOLUTE VALUE



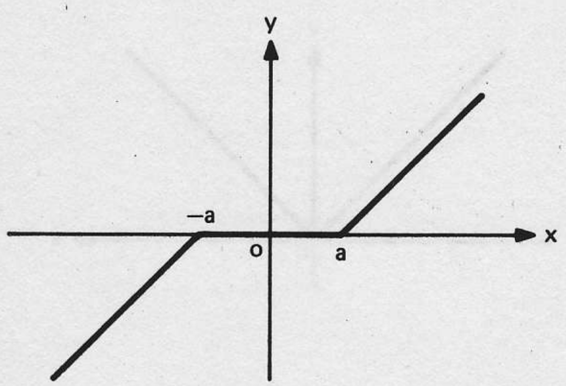


ABSOLUTE VALUE

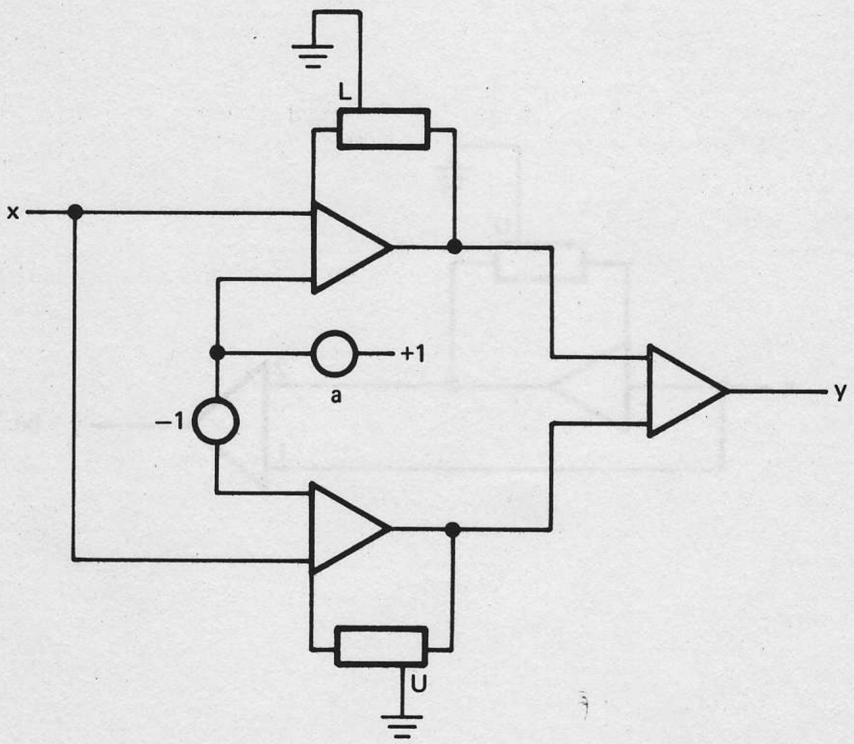




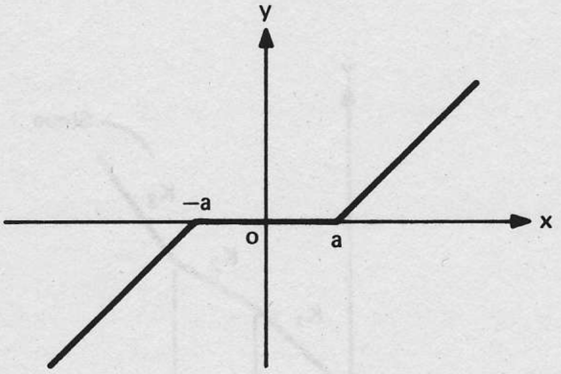
DEAD ZONE



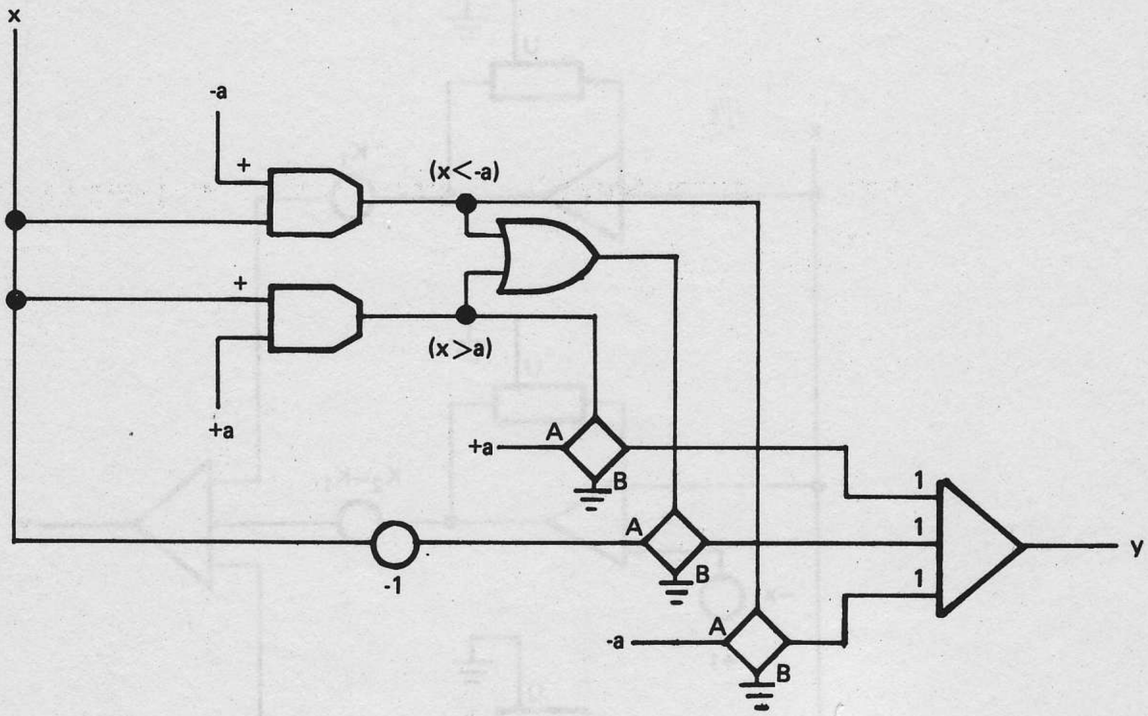
a > o

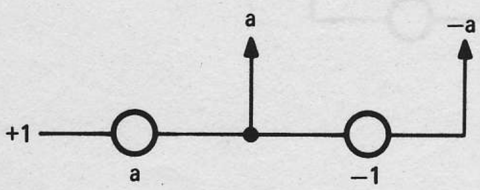


DEAD ZONE

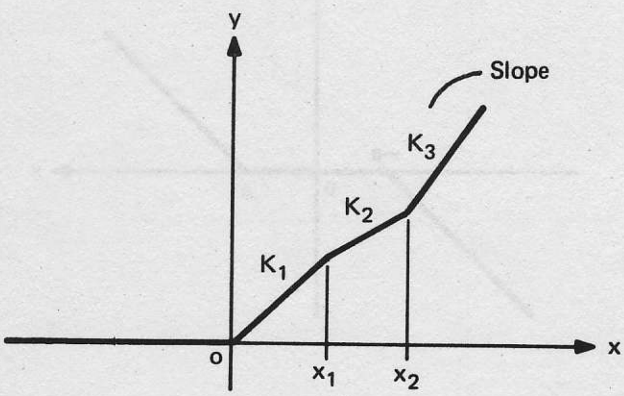


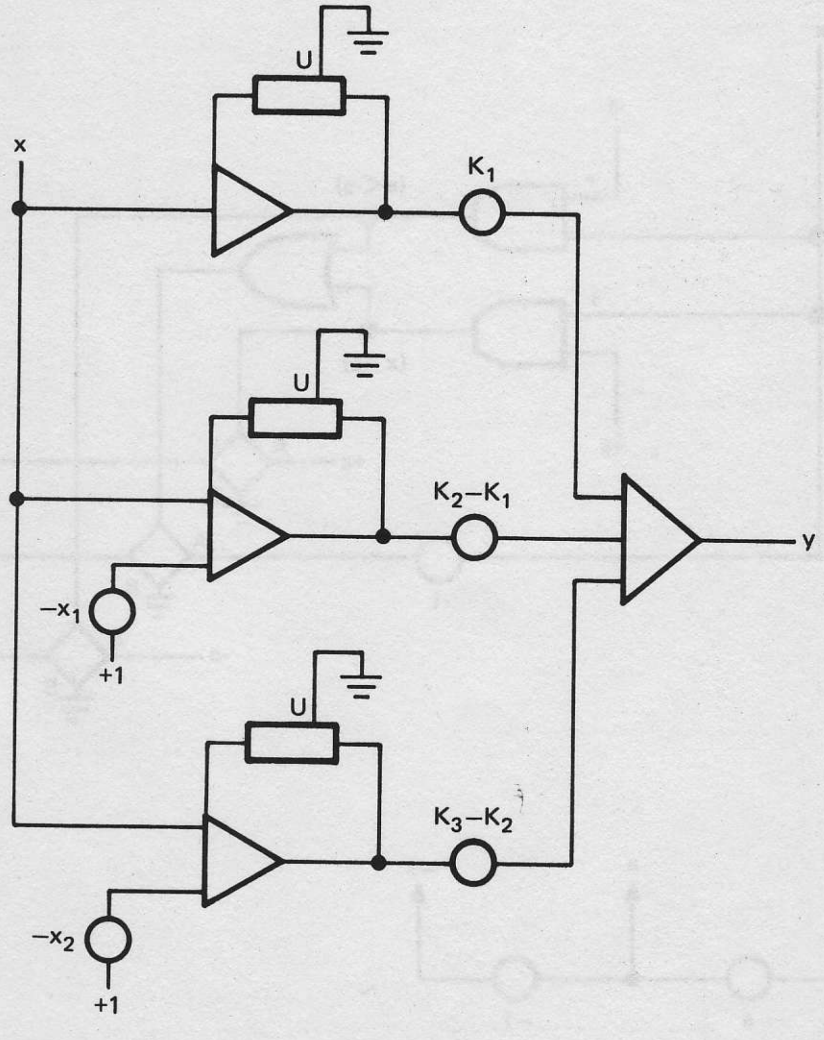
a > o



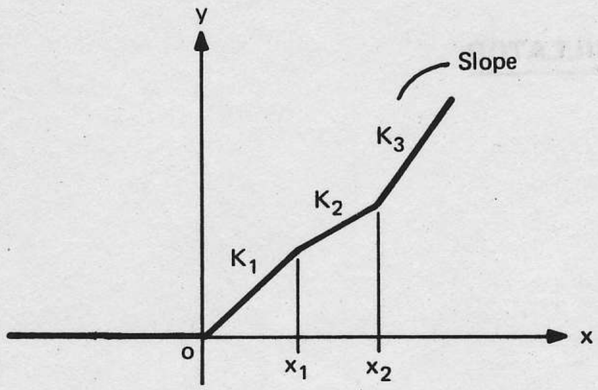


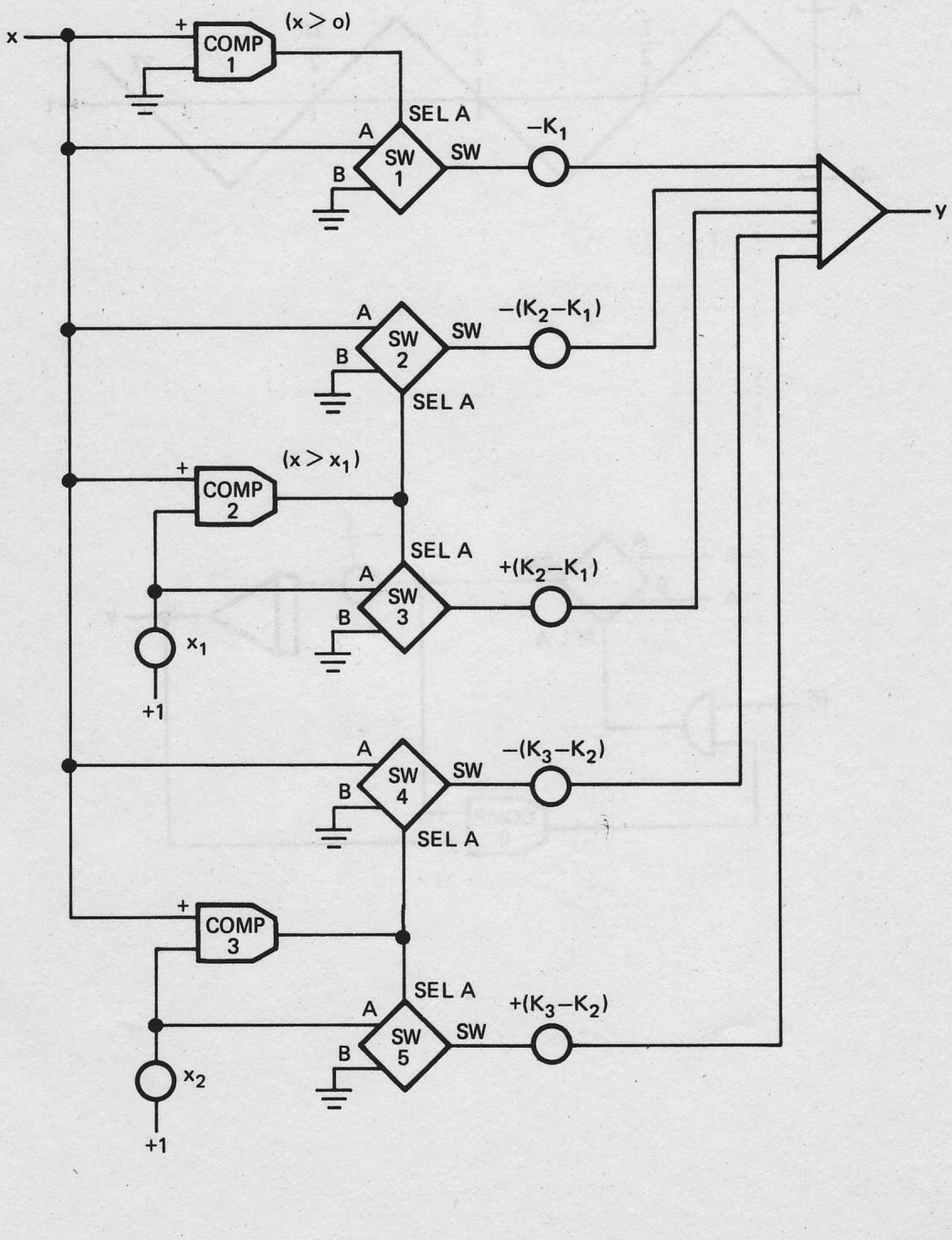
PIECEWISE LINEAR CHARACTERISTIC



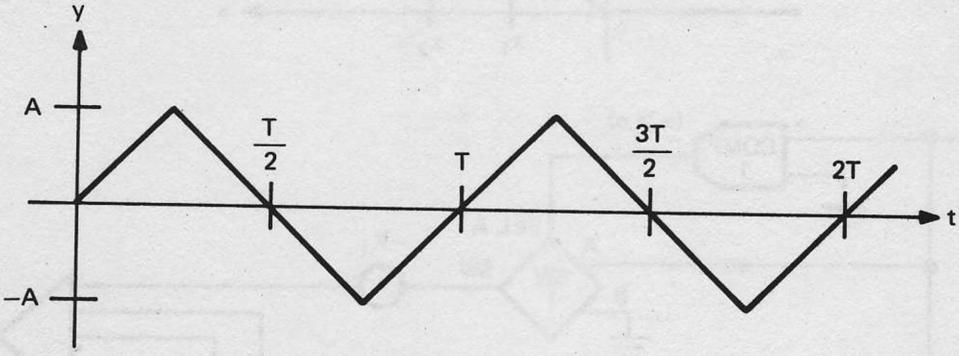


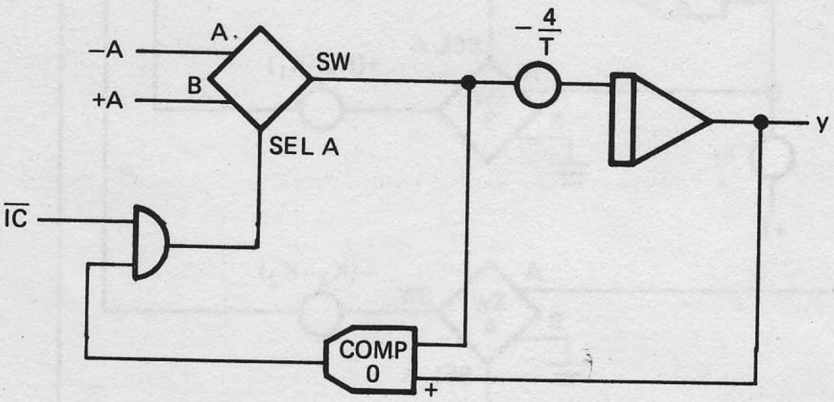
PIECEWISE LINEAR CHARACTERISTIC



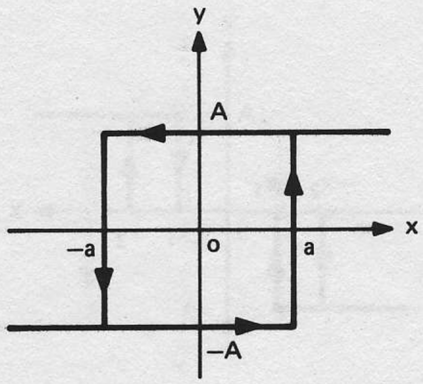


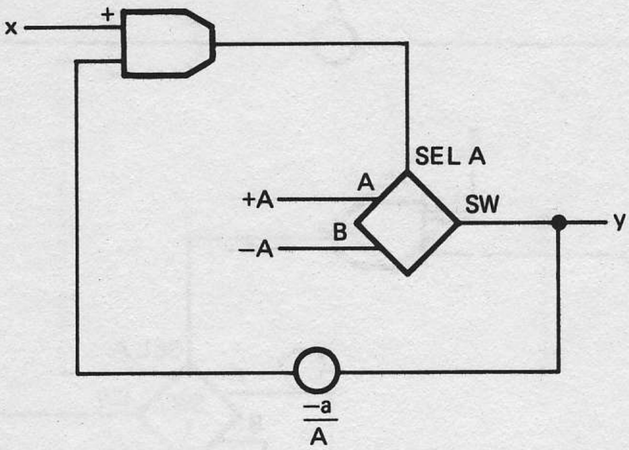
TRIANGULAR WAVE OSCILLATOR





BANG-BANG CHARACTERISTIC W/HYSTERESIS



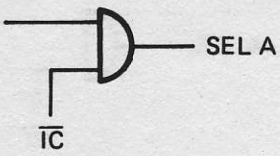


NOTE

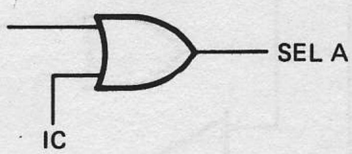
If |x(o)|<a

then, desired initial state is obtained by gating comparator output

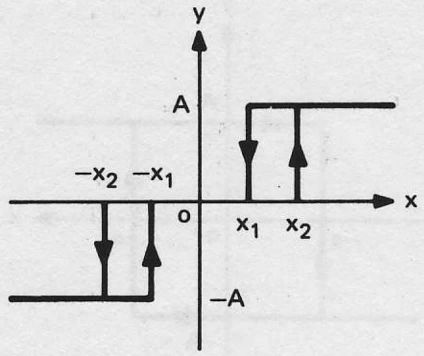
for y(o) = −A:

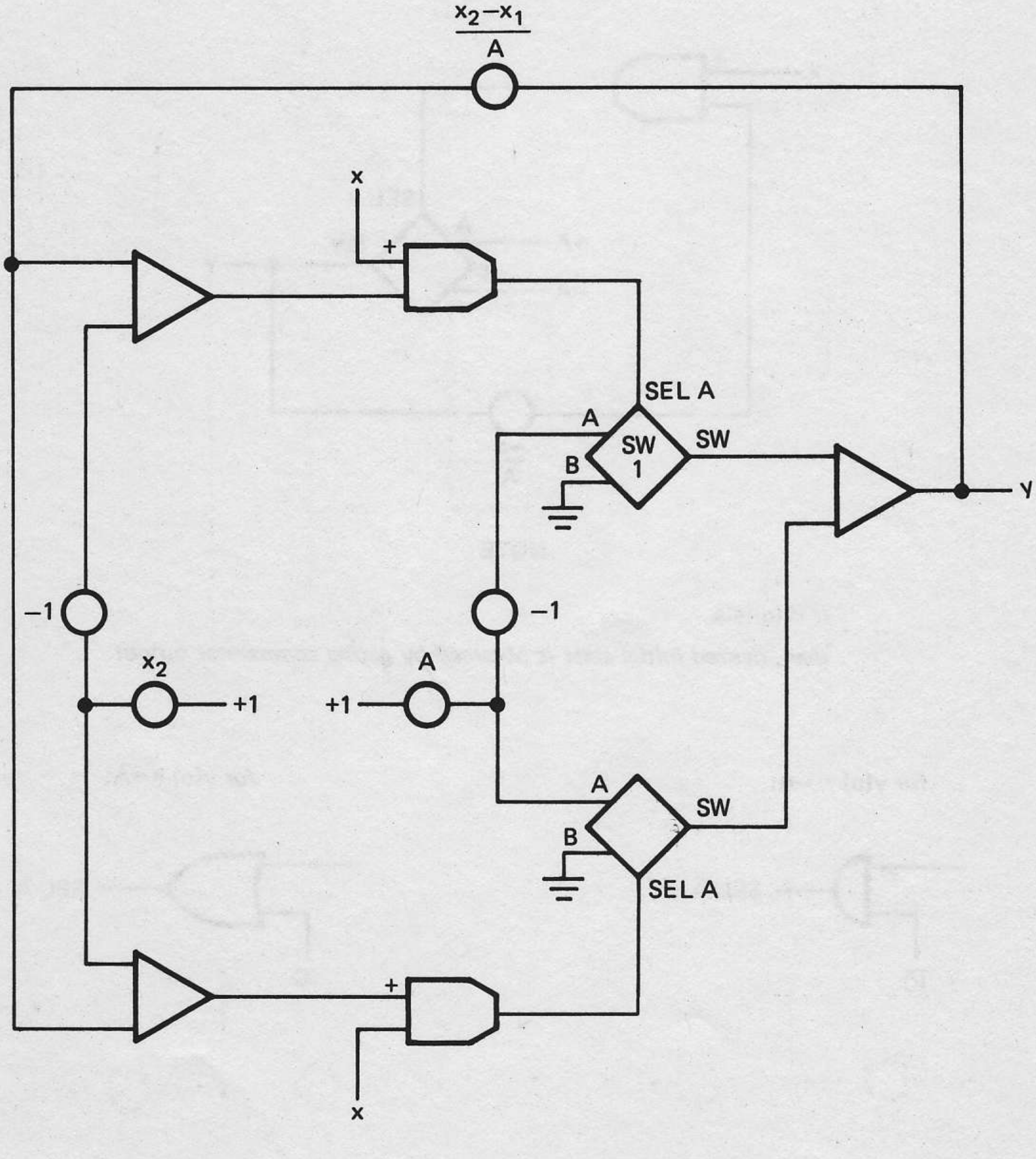


for y(o) = +A:

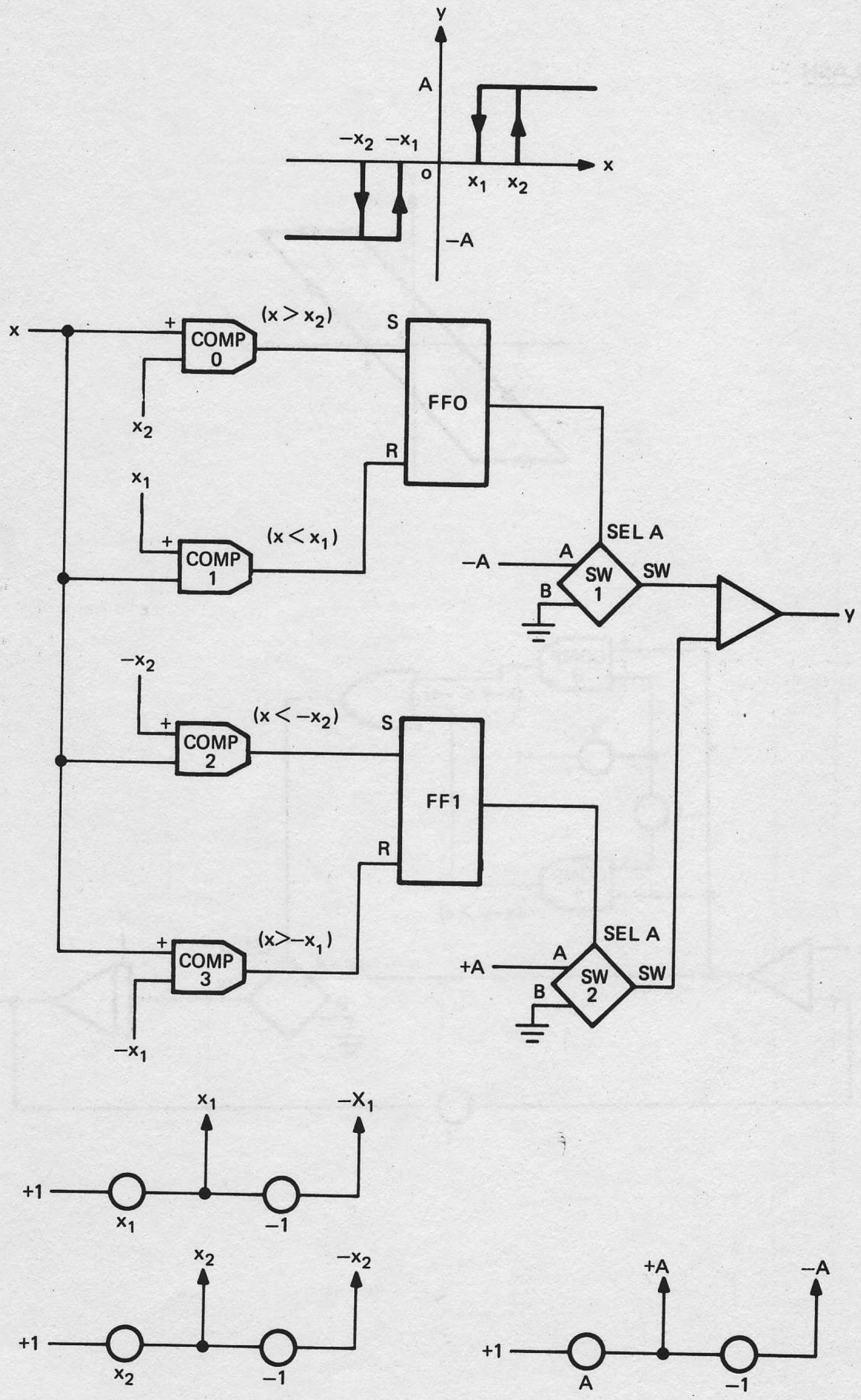


TRI-STABLE CHARACTERISTIC W/HYSTERESIS

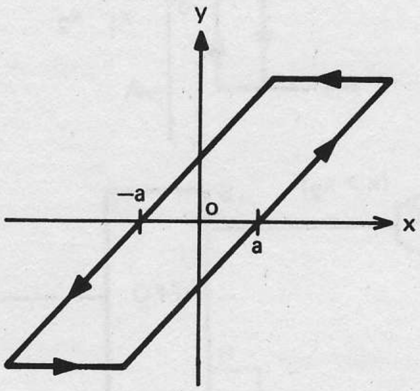


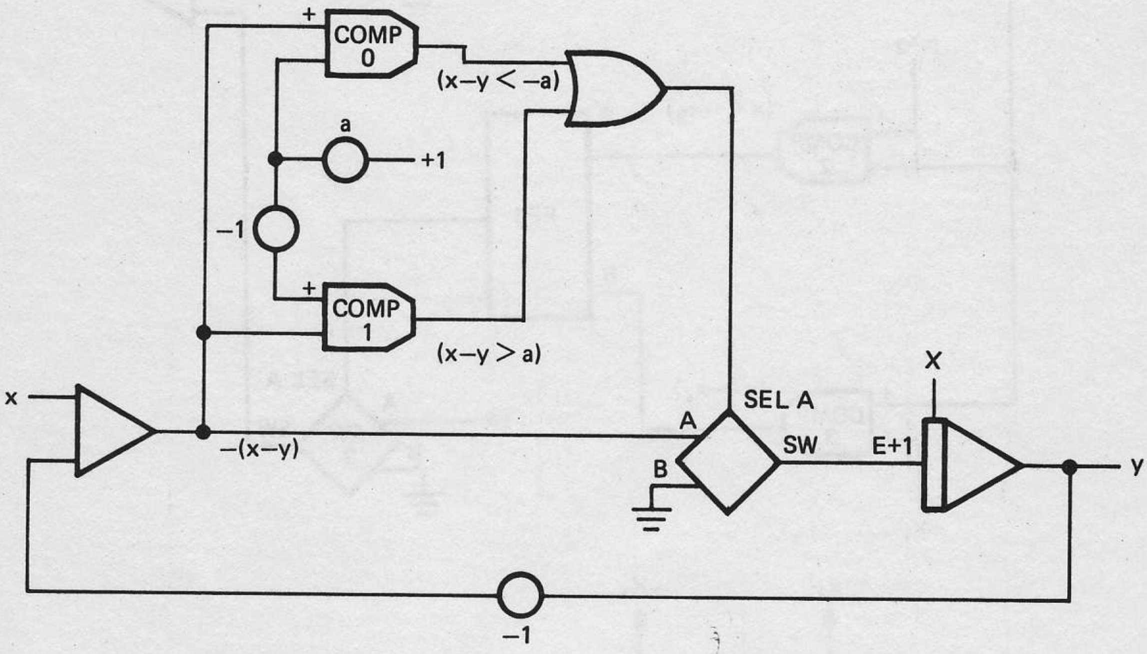


TRI-STABLE CHARACTERISTIC W/HYSTERESIS

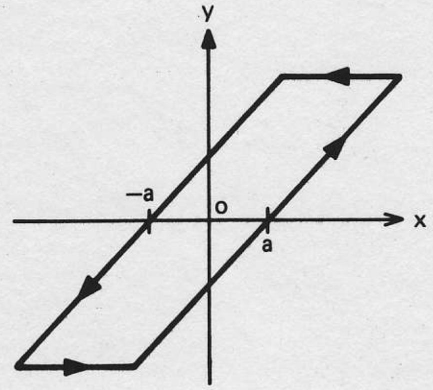


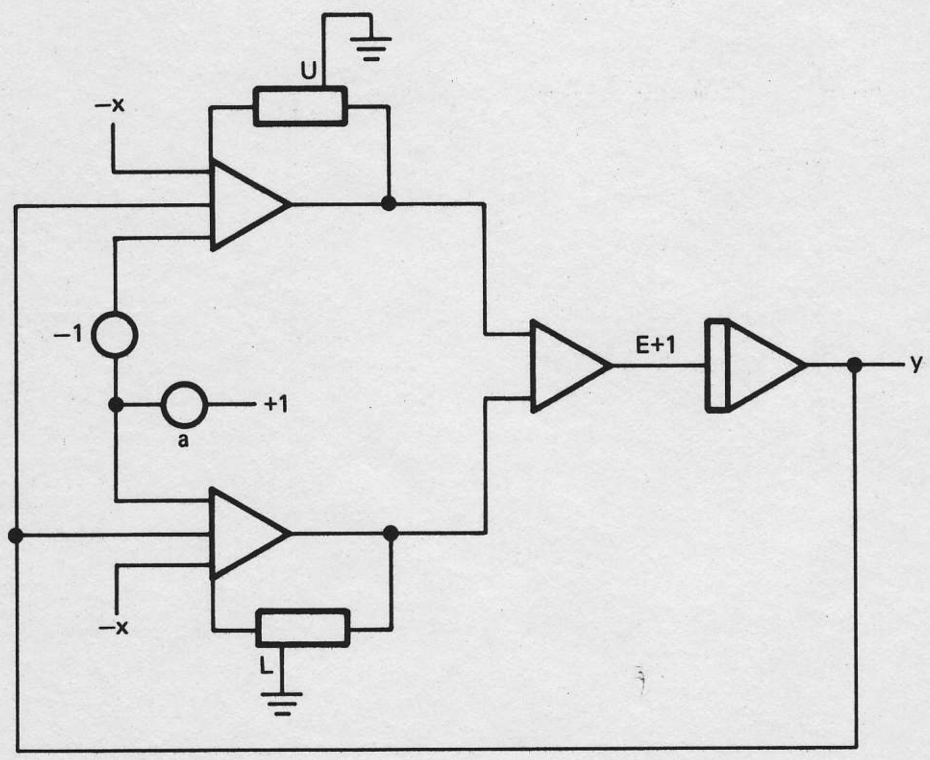
BACKLASH





BACKLASH



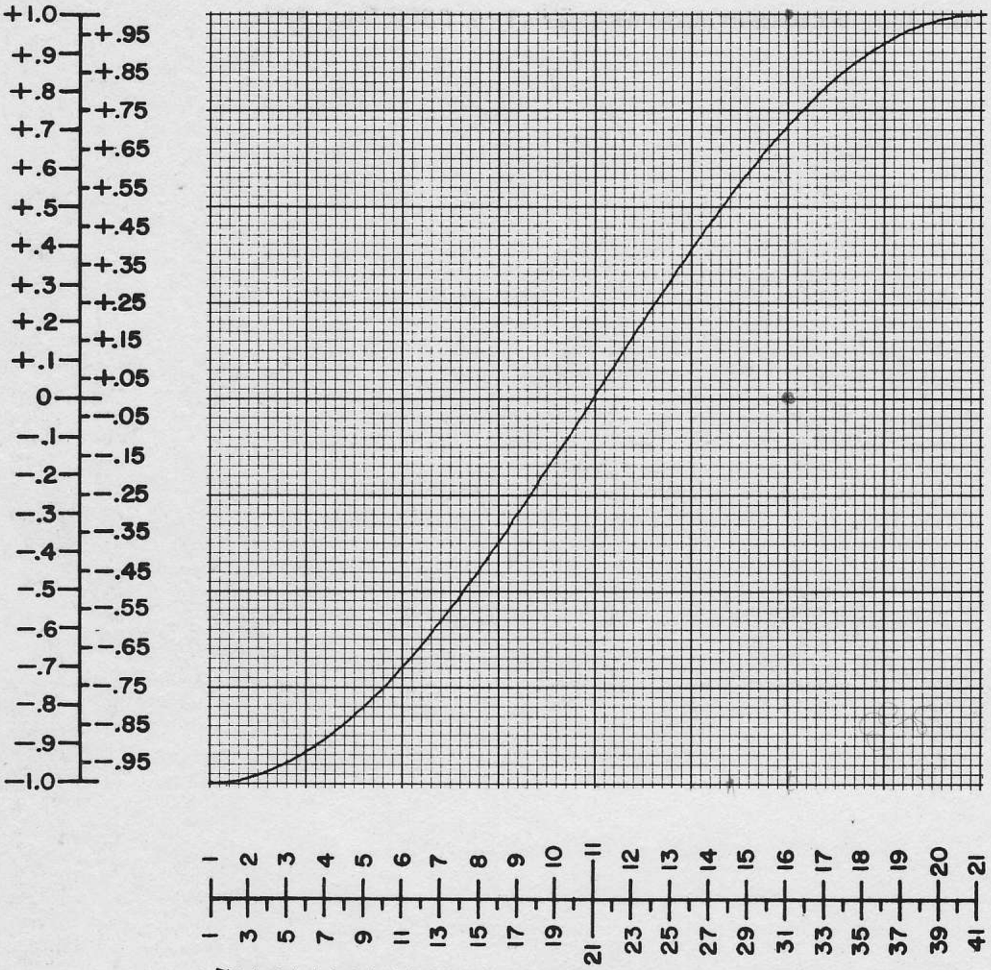


APPENDIX

5

DSFG SETUP TABLE

This Appendix contains recommendations for a DSFG Setup Table.



−1.0	V1	V1
−.95		V2
−.9	V2	V3
−.85		V4
−.8	V3	V5
−.75		V6
−.7	V4	V7
−.65		V8
−.6	V5	V9
−.55		V10
−.5	V6	V11
−.45		V12
−.4	V7	V13
−.35		V14
−.3	V8	V15
−.25		V16
−.2	V9	V17
−.15		V18
−.1	V10	V19
−.05		V20
.0	V11	V21
+.05		V22
+.1	V12	V23
+.15		V24
+.2	V13	V25
+.25		V26
+.3	V14	V27
+.35		V28
+.4	V15	V29
+.45		V30
+.5	V16	V31
+.55		V32
+.6	V17	V33
+.65		V34
+.7	V18	V35
+.75		V36
+.8	V19	V37
+.85		V38
+.9	V20	V39
+.95		V40
+1.0	V21	V41

EAI 2000

BY

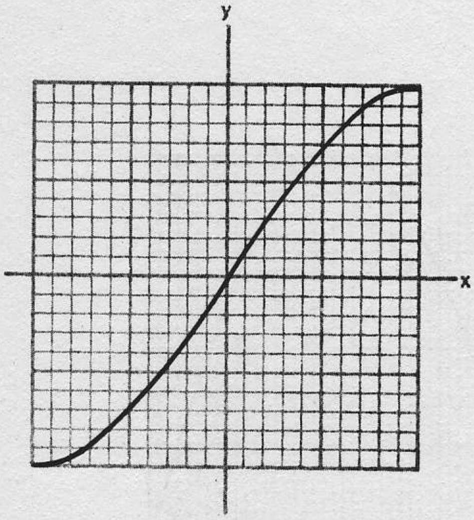
DATE

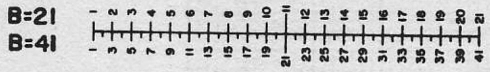
TITLE

y=Sin X

$-90° \leq X \leq +90°$

PAGE

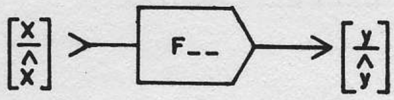




NOTE: $\left| \left[\frac{y}{\hat{y}}\right]_{n+1} - \left[\frac{y}{\hat{y}}\right]_{n} \right|_{MAX} = 1$

y=Sin x

$-90° \leq x \leq +90°$



$\hat{x} = 90°$

$\hat{y} = 1$

X[°]	Y	$\left[\frac{x}{\hat{x}}\right]$	B 21	B 41	$\left[\frac{y}{\hat{y}}\right]$
−90	−1.	−1.0	V1	V1	−1.
−85.5	−.9969	−.95		V2	−.9969
−81	−.9877	−.9	V2	V3	−.9877
−76.5	−.9724	−.85		V4	−.9724
−72	−.9511	−.8	V3	V5	−.9511
−67.5	−.9239	−.75		V6	−.9239
−63	−.8910	−.7	V4	V7	−.8910
−58.5	−.8526	−.65		V8	−.8526
−54	−.8090	−.6	V5	V9	−.8090
−49.5	−.7604	−.55		V10	−.7604
−45	−.7071	−.5	V6	V11	−.7071
−40.5	−.6494	−.45		V12	−.6494
−36	−.5878	−.4	V7	V13	−.5878
−31.5	−.5225	−.35		V14	−.5225
−27	−.4540	−.3	V8	V15	−.4540
−22.5	−.3827	−.25		V16	−.3827
−18	−.3090	−.2	V9	V17	−.3090
−13.5	−.2334	−.15		V18	−.2334
−9	−.1564	−.1	V10	V19	−.1564
−4.5	−.0785	−.05		V20	−.0785
0	0	.0	V11	V21	0
4.5	.0785	+.05		V22	.0785
9	.1564	+.1	V12	V23	.1564
13.5	.2334	+.15		V24	.2334
18	.3090	+.2	V13	V25	.3090
22.5	.3827	+.25		V26	.3827
27	.4540	+.3	V14	V27	.4540
31.5	.5225	+.35		V28	.5225
36	.5878	+.4	V15	V29	.5878
40.5	.6494	+.45		V30	.6494
45	.7071	+.5	V16	V31	.7071
49.5	.7604	+.55		V32	.7604
54	.8090	+.6	V17	V33	.8090
58.5	.8526	+.65		V34	.8526
63	.8910	+.7	V18	V35	.8910
67.5	.9239	+.75		V36	.9239
72	.9511	+.8	V19	V37	.9511
76.5	.9724	+.85		V38	.9724
81	.9877	+.9	V20	V39	.9877
85.5	.9969	+.95		V40	.9969
90	1	+1.0	V21	V41	1

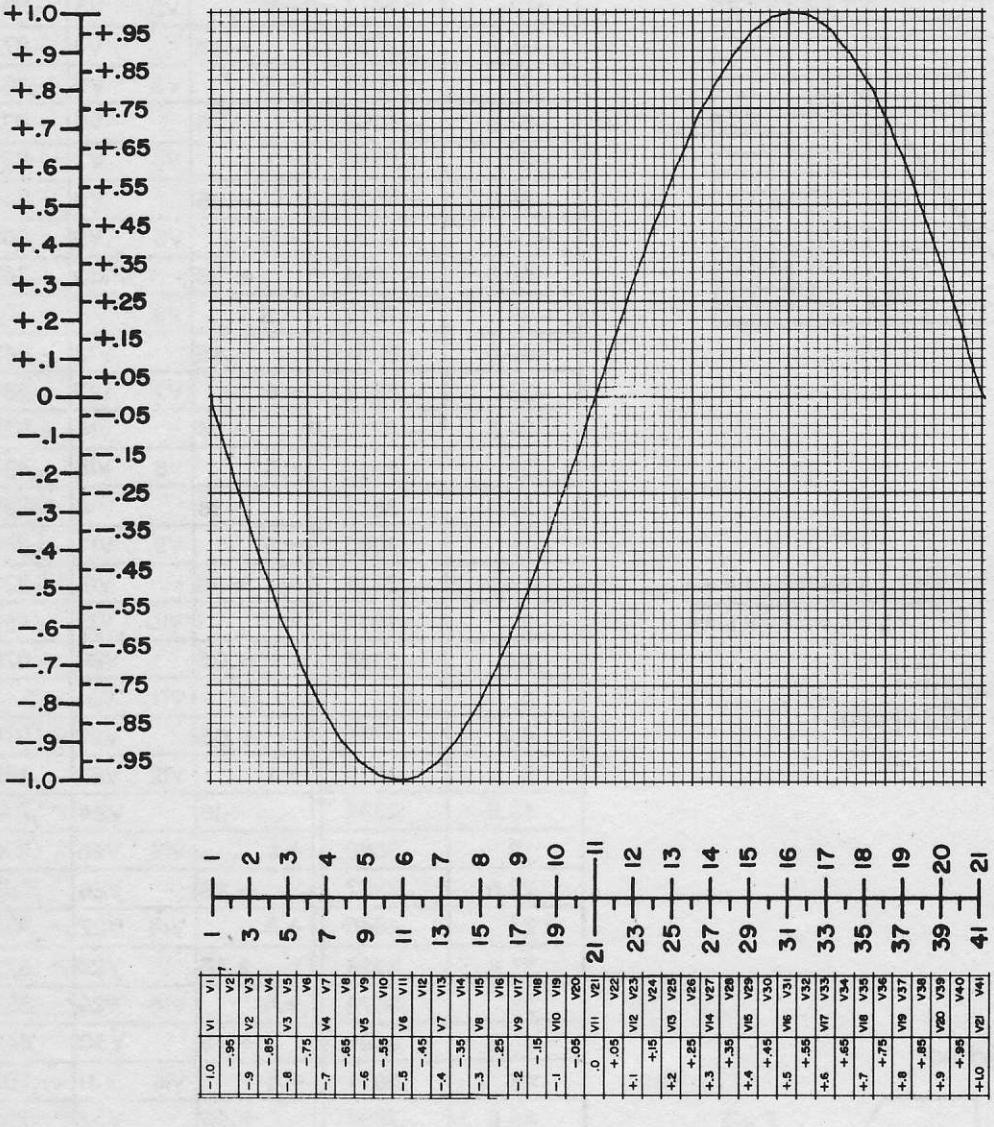
EAI 2000

BY

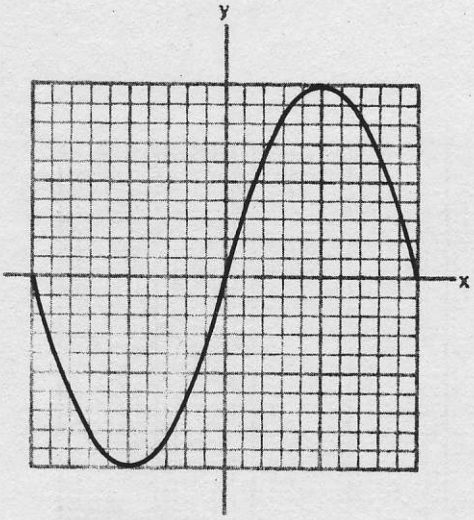
DATE

TITLE F__ SETUP TABLE y=Sin X

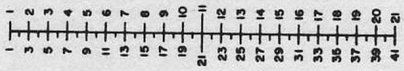
PAGE



EAI 2000	BY	TITLE	PAGE
	DATE	y=Sin X $-180^\circ \le X \le 180^\circ$	



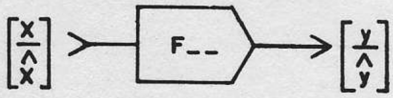
B=21
B=41



NOTE: $\left| \left[\frac{y}{\hat{y}}\right]_{n+1} - \left[\frac{y}{\hat{y}}\right]_n \right|_{MAX} = 1$

y= Sin x

$-180° \leq x \leq 180°$

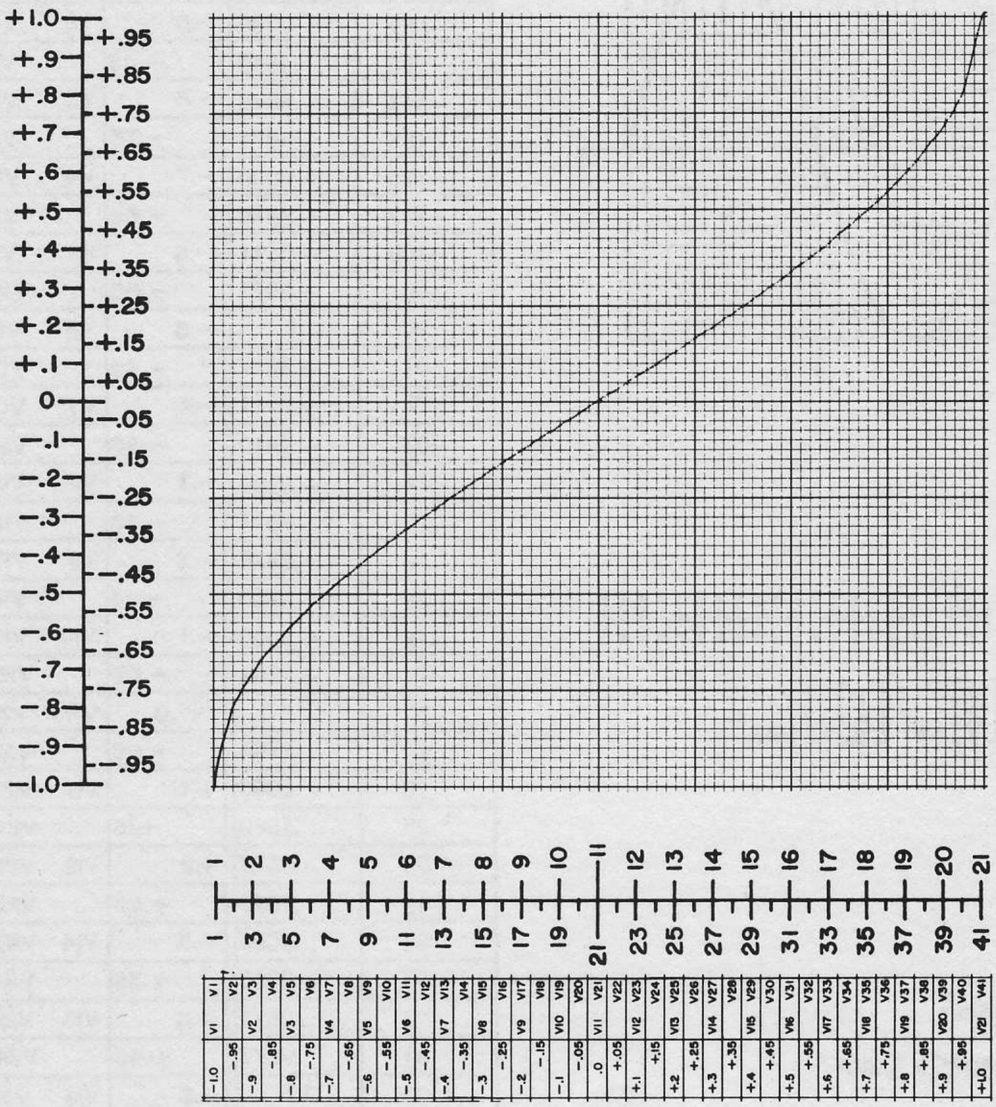


$\hat{x} = 180°$

$\hat{y} = 1$

x[°]	Y	$\left[\frac{x}{\hat{x}}\right]$	B 21	B 41	$\left[\frac{y}{\hat{y}}\right]$
–180	0	– 1.0	V1	V1	0.
–171	–.1564	–.95		V2	–.1564
–162	–.3090	–.9	V2	V3	–.3090
–153	–.4540	–.85		V4	–.4540
–144	–.5878	–.8	V3	V5	–.5878
–135	–.7071	–.75		V6	–.7071
–126	–.8090	–.7	V4	V7	–.8090
–117	–.8910	–.65		V8	–.8910
–108	–.9511	–.6	V5	V9	–.9511
–99	–.9877	–.55		V10	–.9877
–90	–1.	–.5	V6	V11	–1.
–81	–.9877	–.45		V12	–.9877
–72	–.9511	–.4	V7	V13	–.9511
–63	–.8910	–.35		V14	–.8910
–54	–.8090	–.3	V8	V15	–.8090
–45	–.7071	–.25		V16	–.7071
–36	–.5878	–.2	V9	V17	–.5878
–27	–.4540	–.15		V18	–.4540
–18	–.3090	–.1	V10	V19	–.3090
–9	–.1564	–.05		V20	–.1564
0	0	.0	V11	V21	0.
9	.1564	+.05		V22	.1564
18	.3090	+.1	V12	V23	.3090
27	.4540	+.15		V24	.4540
36	.5878	+.2	V13	V25	.5878
45	.7071	+.25		V26	–.7071
54	.8090	+.3	V14	V27	.8090
63	.8910	+.35		V28	.8910
72	.9511	+.4	V15	V29	.9511
81	.9877	+.45		V30	.9877
90	1.	+.5	V16	V31	1.
99	.9877	+.55		V32	.9877
108	.9511	+.6	V17	V33	.9511
117	.8910	+.65		V34	.8910
126	.8090	+.7	V18	V35	.8090
135	.7071	+.75		V36	.7071
144	.5878	+.8	V19	V37	.5878
153	.4540	+.85		V38	.4540
162	.3090	+.9	V20	V39	.3090
171	.1564	+.95		V40	.1564
180	0.	+1.0	V21	V41	0.

EAI 2000	BY	TITLE	PAGE
	DATE	F__ SETUP TABLE y=Sin X	



EAI 2000

BY

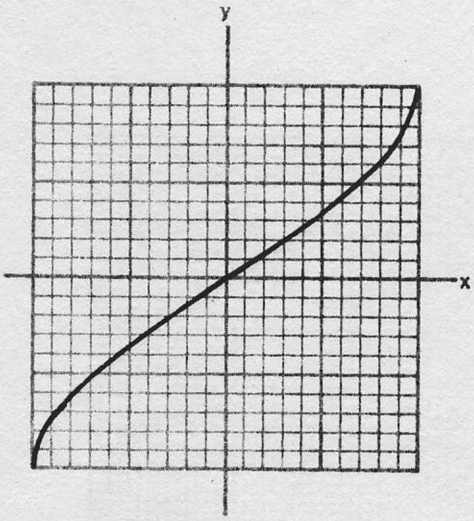
DATE

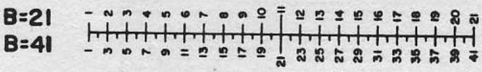
TITLE

$y = \sin^{-1} x$

$-1 \leq X \leq +1$

PAGE

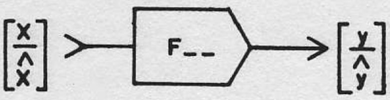




NOTE: $\left| \left[\frac{y}{\hat{y}}\right]_{n+1} - \left[\frac{y}{\hat{y}}\right]_{n} \right|_{MAX} = 1$

$y = \sin^{-1} x$

$-1 \leq x \leq +1$



$\hat{x} = 1$

$\hat{y} = 90°$

X	Y[°]	$\left[\frac{x}{\hat{x}}\right]$	B 21	B 41	$\left[\frac{y}{\hat{y}}\right]$
–1.	–90	–1.0	V1	V1	–1.
–.95	–71.8	–.95		V2	–.7978
–.9	–64.2	–.9	V2	V3	–.7129
–.85	–58.2	–.85		V4	–.6468
–.8	–53.1	–.8	V3	V5	–.5903
–.75	–48.6	–.75		V6	–.5399
–.7	–44.4	–.7	V4	V7	–.4936
–.65	–40.5	–.65		V8	–.4505
–.6	–36.9	–.6	V5	V9	–.4097
–.55	–33.4	–.55		V10	–.3707
–.5	–30	–.5	V6	V11	–.3333
–.45	–26.7	–.45		V12	–.2972
–.4	–23.6	–.4	V7	V13	–.2620
–.35	–20.5	–.35		V14	–.2276
–.3	–17.5	–.3	V8	V15	–.1940
–.25	–14.5	–.25		V16	–.1609
–.2	–11.5	–.2	V9	V17	–.1282
–.15	–8.6	–.15		V18	–.0959
–.1	–5.7	–.1	V10	V19	–.0638
–.05	–2.9	–.05		V20	– 0318
0	0	.0	V11	V21	0
.05	2.9	+.05		V22	.0318
.1	5.7	+.1	V12	V23	.0638
.15	8.6	+.15		V24	.0959
.2	11.5	+.2	V13	V25	.1282
.25	14.5	+.25		V26	.1609
.3	17.5	+.3	V14	V27	.1940
.35	20.5	+.35		V28	.2276
.4	23.6	+.4	V15	V29	.2620
.45	26.7	+.45		V30	.2972
.5	30	+.5	V16	V31	.3333
.55	33.4	+.55		V32	.3707
.6	36.9	+.6	V17	V33	.4097
.65	40.5	+.65		V34	.4505
.7	44.4	+.7	V18	V35	.4936
.75	48.6	+.75		V36	.5399
.8	53.1	+.8	V19	V37	.5903
.85	58.2	+.85		V38	.6468
.9	64.2	+.9	V20	V39	.7129
.95	71.8	+.95		V40	.7978
1.0	90	+1.0	V21	V41	1.

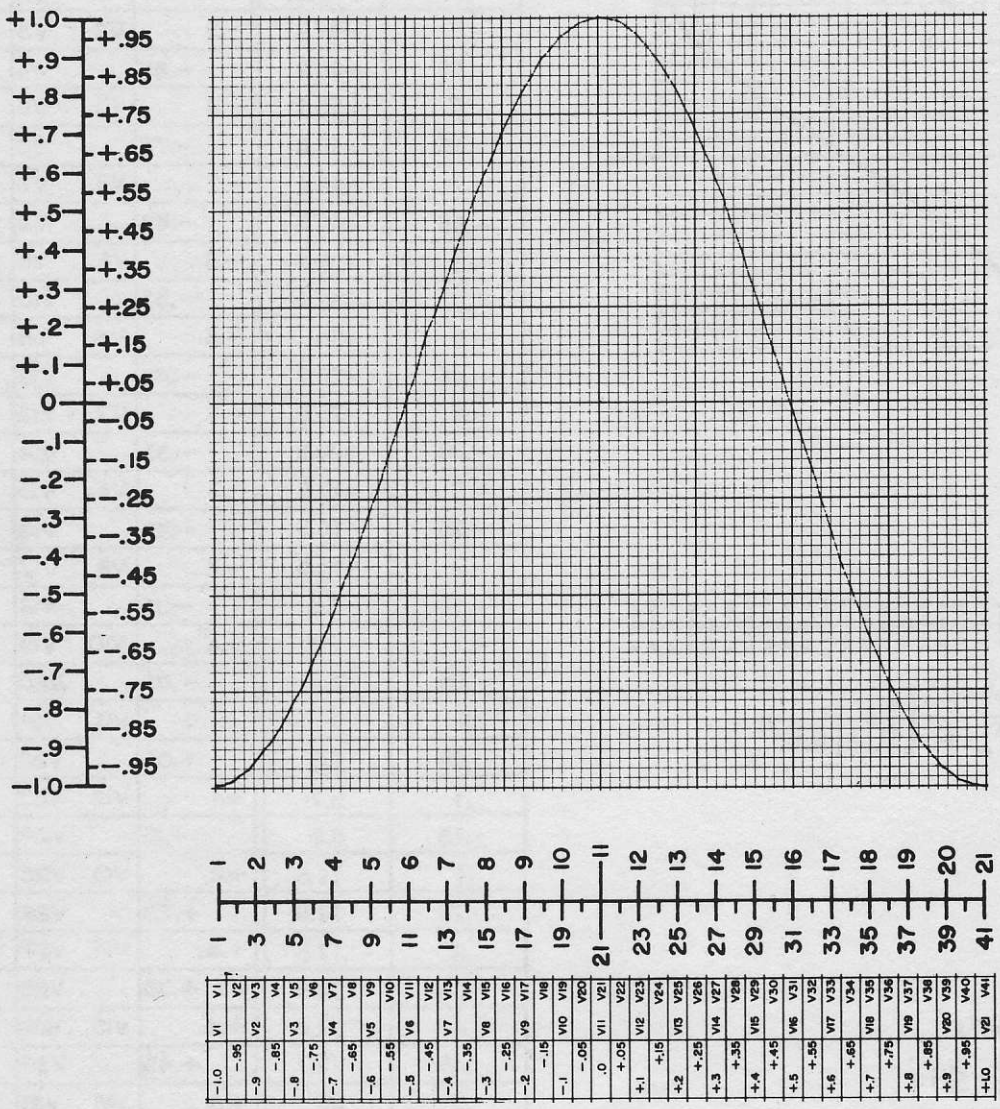
EAI 2000

BY

DATE

TITLE F__ SETUP TABLE $y = \sin^{-1} x$

PAGE



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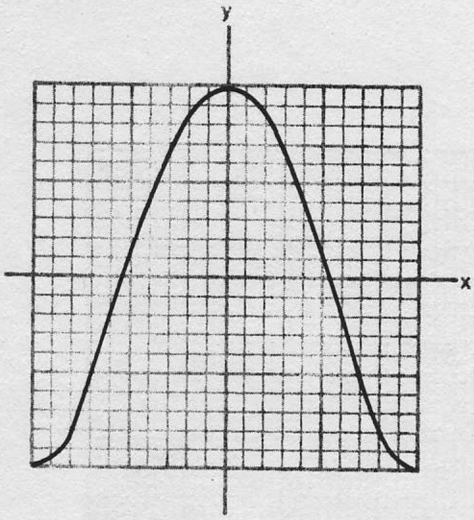
BY

DATE

TITLE y=Cos x
−180°≤X180°

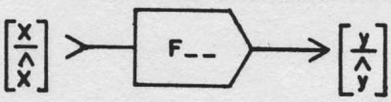
PAGE



NOTE: $\left|\left[\frac{y}{\hat{y}}\right]_{n+1} - \left[\frac{y}{\hat{y}}\right]_{n}\right|_{MAX} = 1$

y = Cos x

$-180° \leq x \leq 180°$



$\hat{x} = 180°$

$\hat{y} = 1$

x [°]	Y	$\left[\frac{x}{\hat{x}}\right]$	B 21	B 41	$\left[\frac{y}{\hat{y}}\right]$
−180	−1.	−1.0	V1	V1	−1.
−171	−.9877	−.95		V2	−.9877
−162	−.9511	−.9	V2	V3	−.9511
−153	−.8910	−.85		V4	−.8910
−144	−.8090	−.8	V3	V5	−.8090
−135	−.7071	−.75		V6	−.7071
−126	−.5878	−.7	V4	V7	−.5878
−117	−.4540	−.65		V8	−.4540
−108	−.3090	−.6	V5	V9	−.3090
−99	−.1564	−.55		V10	−.1564
−90	0.	−.5	V6	V11	0.
−81	.1564	−.45		V12	.1564
−72	.3090	−.4	V7	V13	.3090
−63	.4540	−.35		V14	.4540
−54	.5878	−.3	V8	V15	.5878
−45	.7071	−.25		V16	.7071
−36	.8090	−.2	V9	V17	.8090
−27	.8910	−.15		V18	.8910
−18	.9511	−.1	V10	V19	.9511
−9	.9877	−.05		V20	.9877
-0	1.	.0	V11	V21	1.
9	.9877	+.05		V22	.9877
18	.9511	+.1	V12	V23	.9511
27	.8910	+.15		V24	.8910
36	.8090	+.2	V13	V25	.8090
45	.7071	+.25		V26	.7071
54	.5878	+.3	V14	V27	.5878
63	.4540	+.35		V28	.4540
72	.3090	+.4	V15	V29	.3090
81	.1564	+.45		V30	.1564
90	0.	+.5	V16	V31	0.
99	−.1564	+.55		V32	−.1564
108	−.3090	+.6	V17	V33	−.3090
117	−.4540	+.65		V34	−.4540
126	−.5878	+.7	V18	V35	−.5878
135	−.7071	+.75		V36	−.7071
144	−.8090	+.8	V19	V37	−.8090
153	−.8910	+.85		V38	−.8910
162	−.9511	+.9	V20	V39	−.9511
171	−.9877	+.95		V40	−.9877
180	−1.	+1.0	V21	V41	−1.

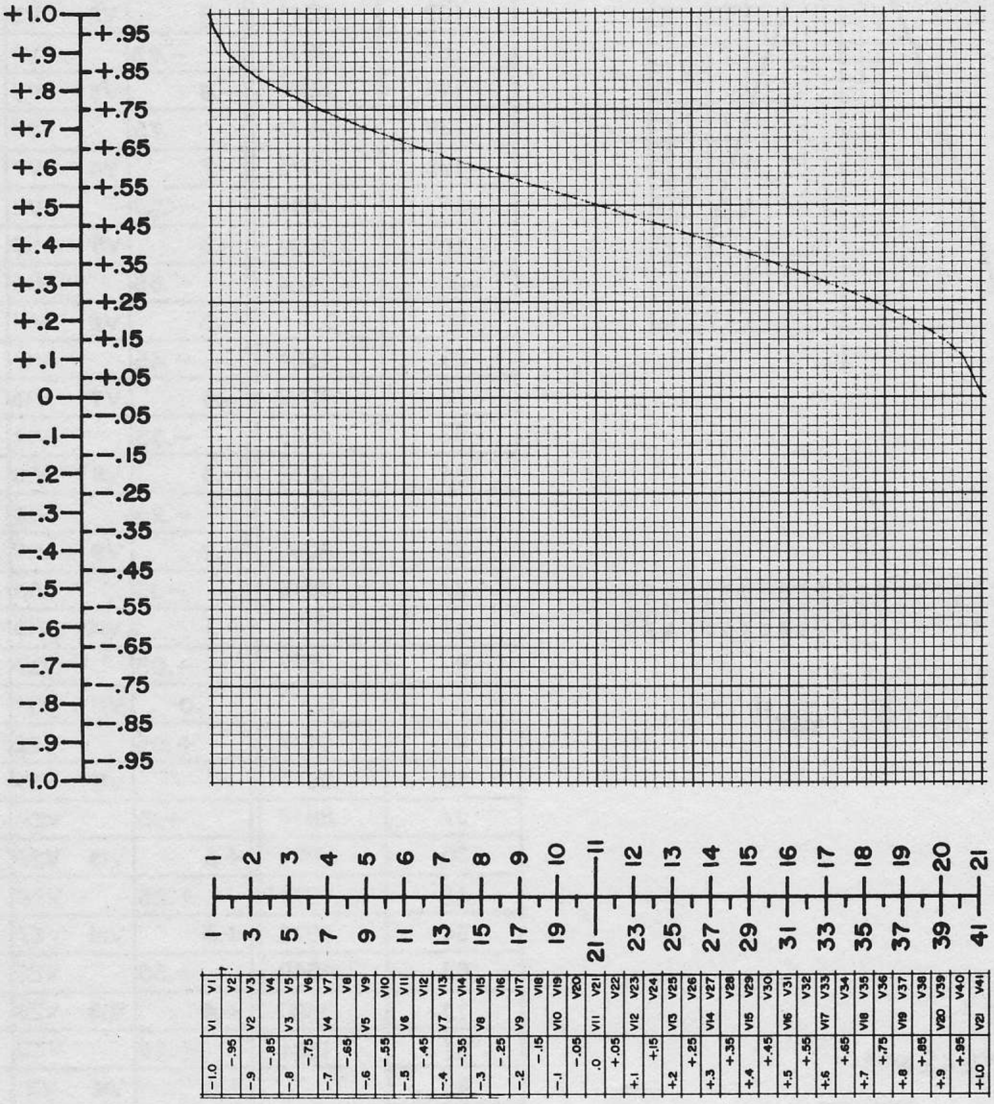
EAI 2000

BY

DATE

TITLE F__ SETUP TABLE y=Cos x

PAGE



EAI 2000

BY

DATE

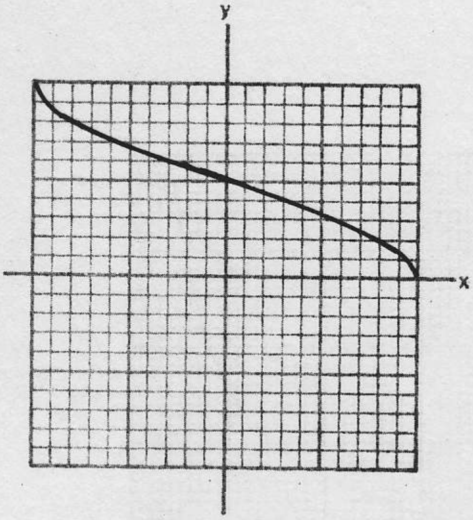
TITLE

$y = \cos^{-1} x$

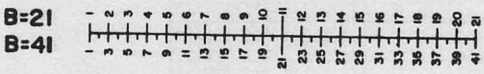
$-1 \leq X \leq +1$

PAGE

A5-10



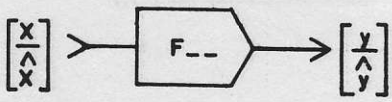
X	Y[°]	[X/X̂]	B 21	B 41	[y/ŷ]
−1.0	180	−1.0	V1	V1	1.
−.95	161.8	−.95		V2	.8989
−.9	154.2	−.9	V2	V3	.8564
−.85	148.2	−.85		V4	.8234
−.8	143.1	−.8	V3	V5	.7952
−.75	138.6	−.75		V6	.7699
−.7	134.4	−.7	V4	V7	.7468
−.65	130.5	−.65		V8	.7252
−.6	126.9	−.6	V5	V9	.7048
−.55	123.4	−.55		V10	.6854
−.5	120	−.5	V6	V11	.6666
−.45	116.7	−.45		V12	.6486
−.4	113.6	−.4	V7	V13	.6310
−.35	110.5	−.35		V14	.6138
−.3	107.5	−.3	V8	V15	.5970
−.25	104.5	−.25		V16	.5804
−.2	101.5	−.2	V9	V17	.5641
−.15	98.6	−.15		V18	.5479
−.1	95.7	−.1	V10	V19	.5319
−.05	92.9	−.05		V20	.5160
0	90	.0	V11	V21	.5
.05	87.1	+.05		V22	.4841
.1	84.3	+.1	V12	V23	.4681
.15	81.4	+.15		V24	.4521
.2	78.5	+.2	V13	V25	.4359
.25	75.5	+.25		V26	.4196
.3	72.5	+.3	V14	V27	.4030
.35	69.5	+.35		V28	.3862
.4	66.4	+.4	V15	V29	.3690
.45	63.3	+.45		V30	.3514
.5	60	+.5	V16	V31	.3333
.55	56.6	+.55		V32	.3146
.6	53.1	+.6	V17	V33	.2952
.65	49.5	+.65		V34	.2748
.7	45.6	+.7	V18	V35	.2532
.75	41.4	+.75		V36	.2301
.8	36.9	+.8	V19	V37	.2048
.85	31.8	+.85		V38	.1766
.9	25.8	+.9	V20	V39	.1436
.95	18.2	+.95		V40	.1011
1.0	0	+1.0	V21	V41	0



NOTE: $\left| \left[\frac{y}{\hat{y}}\right]_{n+1} - \left[\frac{y}{\hat{y}}\right]_{n} \right|_{MAX} = 1$

$y = \cos^{-1} x$

$-1 \leq x \leq +1$



$\hat{x} = 1$

$\hat{y} = 180°$

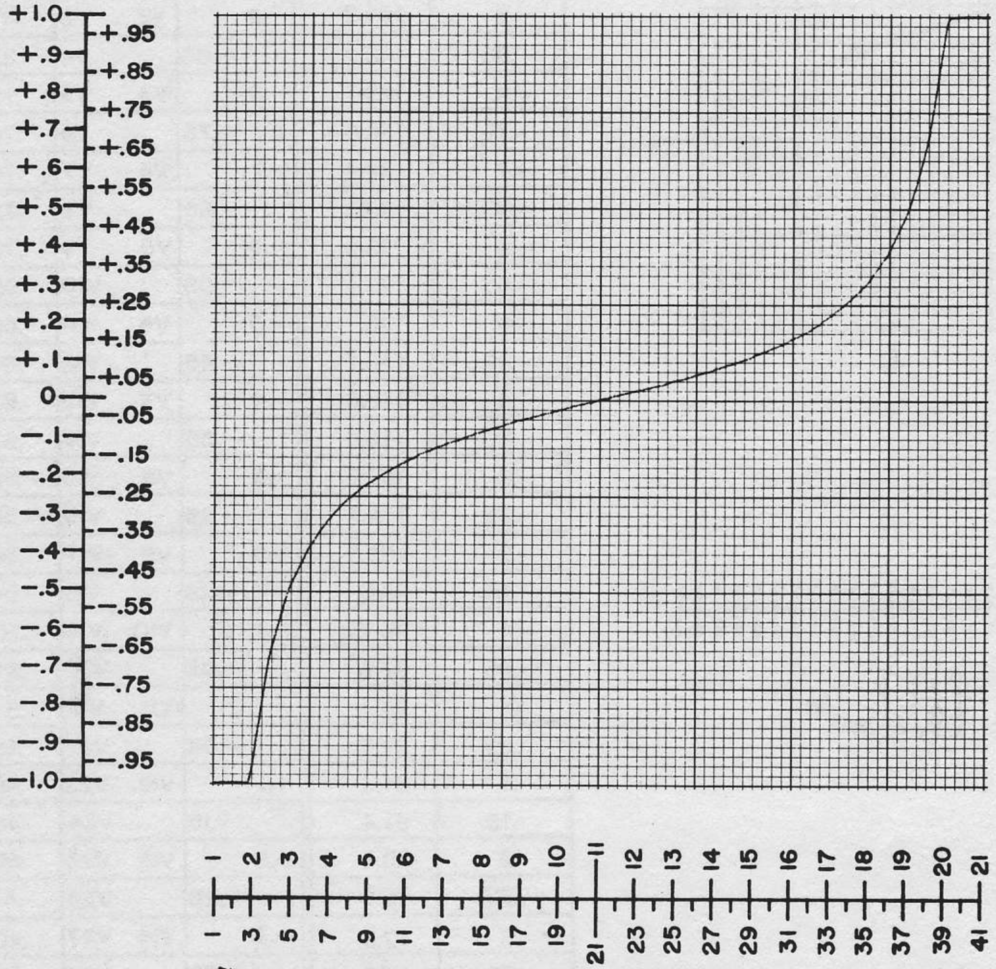
EAI 2000

BY

DATE

TITLE F__ SETUP TABLE $y = \cos^{-1} x$

PAGE



−1.0	V1	V1
−.95		V2
−.9	V2	V3
−.85		V4
−.8	V3	V5
−.75		V6
−.7	V4	V7
−.65		V8
−.6	V5	V9
−.55		V10
−.5	V6	V11
−.45		V12
−.4	V7	V13
−.35		V14
−.3	V8	V15
−.25		V16
−.2	V9	V17
−.15		V18
−.1	V10	V19
−.05		V20
.0	V11	V21
+.05		V22
+.1	V12	V23
+.15		V24
+.2	V13	V25
+.25		V26
+.3	V14	V27
+.35		V28
+.4	V15	V29
+.45		V30
+.5	V16	V31
+.55		V32
+.6	V17	V33
+.65		V34
+.7	V18	V35
+.75		V36
+.8	V19	V37
+.85		V38
+.9	V20	V39
+.95		V40
+1.0	V21	V41

EAI 2000

BY

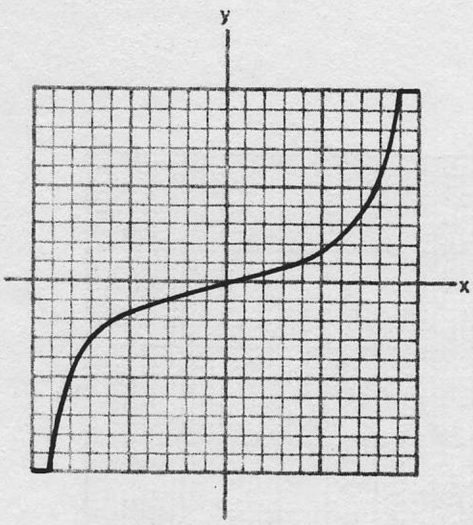
DATE

TITLE

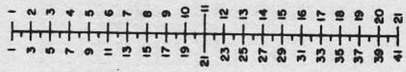
y=Tan x

$-81° \leq X \leq +81°$

PAGE



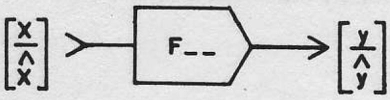
B=21
B=41



NOTE: $\left|\left[\frac{y}{\hat{y}}\right]_{n+1} - \left[\frac{y}{\hat{y}}\right]_{n}\right|_{MAX} = 1$

y = Tan x

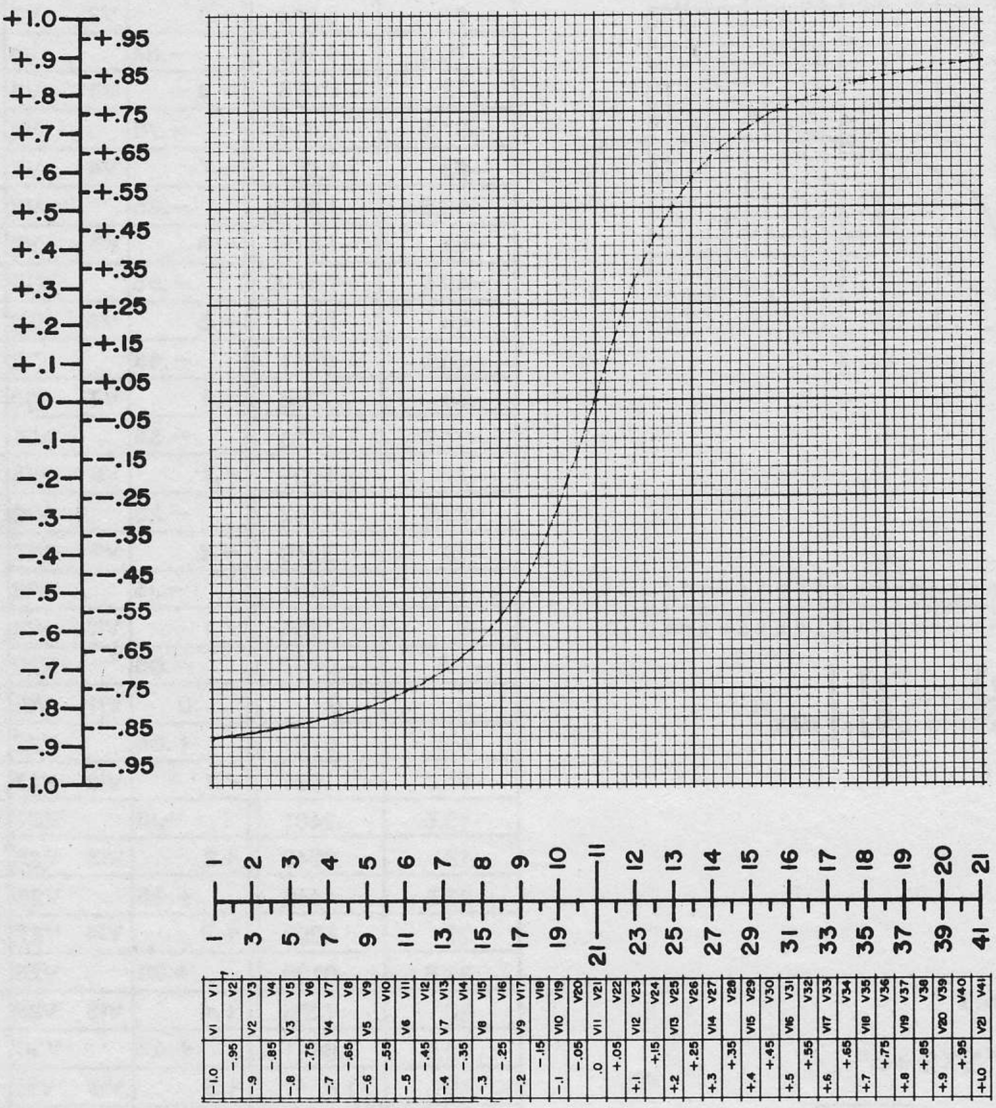
$-81^\circ \leq x \leq +81^\circ$



$\hat{x} = 90^\circ$

$\hat{y} = 6.314$

$x[^\circ]$	Y	$\left[\frac{x}{\hat{x}}\right]$	B 21	B 41	$\left[\frac{y}{\hat{y}}\right]$
−90	−6.314	−1.0	V1	V1	−1.
−85.5	−6.314	−.95		V2	−1.
−81	−6.314	−.9	V2	V3	−1.
−76.5	−4.165	−.85		V4	−.6596
−72	−3.078	−.8	V3	V5	−.4875
−67.5	−2.414	−.75		V6	−.3823
−63	−1.963	−.7	V4	V7	−.3109
−58.5	−1.6319	−.65		V8	−.2585
−54	−1.3764	−.6	V5	V9	−.2180
−49.5	−1.1708	−.55		V10	−.1854
−45	−1.0	−.5	V6	V11	−.1584
−40.5	−.8541	−.45		V12	−.1353
−36	−.7265	−.4	V7	V13	−.1151
−31.5	−.6128	−.35		V14	−.0971
−27	−.5095	−.3	V8	V15	−.0807
−22.5	−.4142	−.25		V16	−.0656
−18	−.3249	−.2	V9	V17	−.0515
−13.5	−.2401	−.15		V18	−.0380
−9	−.1584	−.1	V10	V19	−.0251
−4.5	−.0787	−.05		V20	−.0125
0	0	.0	V11	V21	0
4.5	.0787	+.05		V22	.0125
9	.1584	+.1	V12	V23	.0251
13.5	.2401	+.15		V24	.0380
18	.3249	+.2	V13	V25	.0515
22.5	.4142	+.25		V26	.0656
27	.5095	+.3	V14	V27	.0807
31.5	.6128	+.35		V28	.0971
36	.7265	+.4	V15	V29	.1151
40.5	.8541	+.45		V30	.1353
45	1.0	+.5	V16	V31	.1584
49.5	1.1708	+.55		V32	.1854
54	1.3764	+.6	V17	V33	.2180
58.5	1.6319	+.65		V34	.2585
63	1.963	+.7	V18	V35	.3109
67.5	2.414	+.75		V36	.3823
72	3.078	+.8	V19	V37	.4875
76.5	4.165	+.85		V38	.6596
81	6.314	+.9	V20	V39	1.
85.5	6.314	+.95		V40	1.
90	6.314	+1.0	V21	V41	1.



EAI 2000

BY

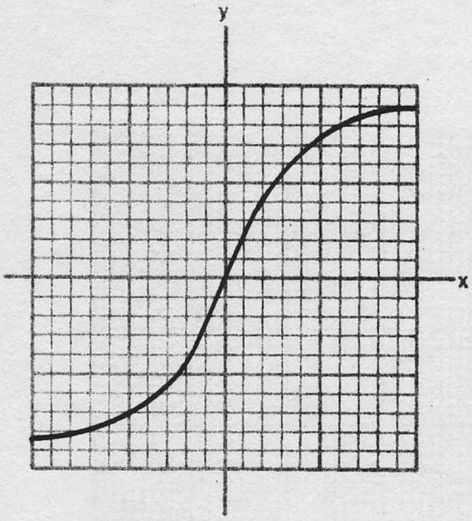
DATE

TITLE

$y = \mathrm{Tan}^{-1} x$

$-5 \leq X < +5$

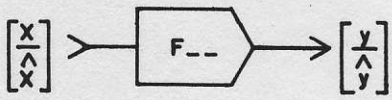
PAGE



NOTE: $\left| \left[\frac{y}{\hat{y}}\right]_{n+1} - \left[\frac{y}{\hat{y}}\right]_{n} \right|_{MAX} = 1$

$y = \tan^{-1} x$

$-5 \leq X \leq +5$

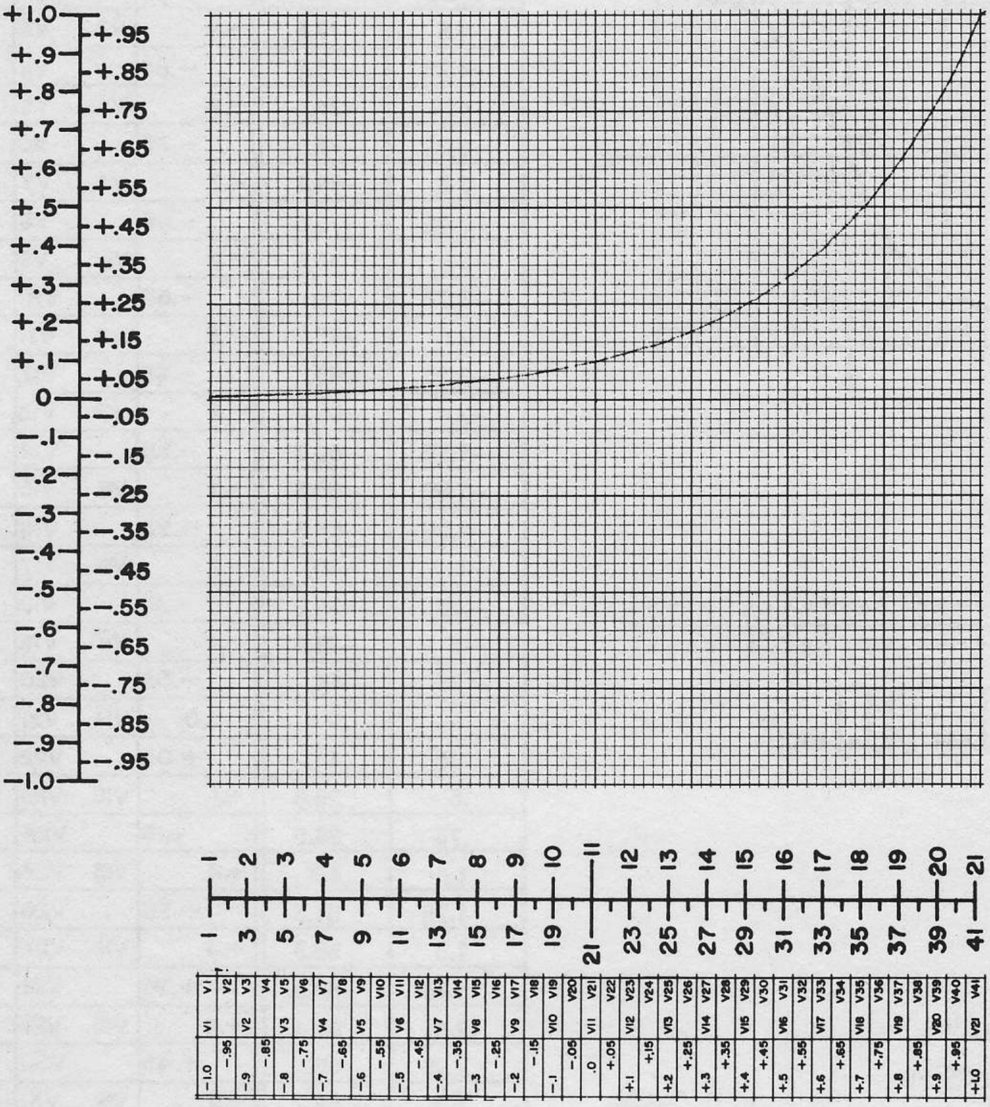


$\hat{x} = 5$

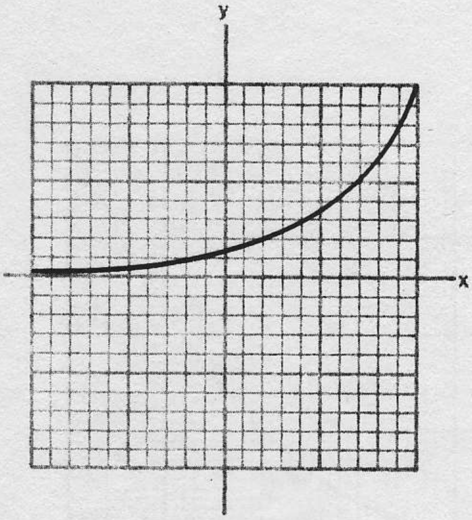
$\hat{y} = 90°$

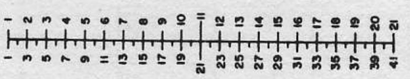
X	Y[°]	$\left[\frac{X}{\hat{X}}\right]$	B 21	B 41	$\left[\frac{y}{\hat{y}}\right]$
–5.	–78.7	–1.0	V1	V1	–.8743
–4.75	–78.1	–.95		V2	–.8680
–4.5	–77.5	–.9	V2	V3	–.8608
–4.25	–76.8	–.85		V4	–.8529
–4.	–76.	–.8	V3	V5	–.8440
–3.75	–75.1	–.75		V6	–.8341
–3.5	–74.1	–.7	V4	V7	–.8228
–3.25	–72.9	–.65		V8	–.8100
–3.	–71.6	–.6	V5	V9	–.7952
–2.75	–70.	–.55		V10	–.7780
–2.5	–68.2	–.5	V6	V11	–.7578
–2.25	–66.	–.45		V12	–.7338
–2.	–63.4	–.4	V7	V13	–.7048
–1.75	–60.3	–.35		V14	–.6695
–1.50	–56.3	–.3	V8	V15	–.6257
–1.25	–51.3	–.25		V16	–.5704
–1.	–45°	–.2	V9	V17	–.5
–.75	–36.9	–.15		V18	–.4097
–.5	–26.6	–.1	V10	V19	–.2952
–.25	–14	–.05		V20	–.1560
0	0	.0	V11	V21	0
.25	14.	+.05		V22	.1560
.5	26.6	+.1	V12	V23	.2952
.75	36.9	+.15		V24	.4097
1.0	45°	+.2	V13	V25	.5
1.25	51.3	+.25		V26	.5704
1.5	56.3	+.3	V14	V27	.6257
1.75	60.3	+.35		V28	.6695
2.0	63.4	+.4	V15	V29	.7048
2.25	66.	+.45		V30	.7338
2.5	68.2	+.5	V16	V31	.7578
2.75	70.	+.55		V32	.7780
3.0	71.6	+.6	V17	V33	.7952
3.25	72.9	+.65		V34	.8100
3.5	74.1	+.7	V18	V35	.8228
3.75	75.1	+.75		V36	.8341
4.0	76.	+.8	V19	V37	.8440
4.25	76.8	+.85		V38	.8529
4.5	77.5	+.9	V20	V39	.8608
4.75	78.1	+.95		V40	.8680
5.0	78.7	+1.0	V21	V41	.8743

EAI 2000 | BY | DATE | TITLE F__ SETUP TABLE $y = \tan^{-1} x$ | PAGE



EAI 2000	BY	TITLE	PAGE
	DATE	$y=10^x$ $-1 \le x \le 1$	

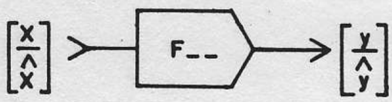




NOTE: $\left| \left[\frac{y}{\hat{y}}\right]_{n+1} - \left[\frac{y}{\hat{y}}\right]_{n} \right|_{MAX} = 1$

$y = 10^x$

$-1 \leq x \leq 1$



$\hat{x} = 1$

$\hat{y} = 10$

X	Y	$\left[\frac{x}{\hat{x}}\right]$	B 21	B 41	$\left[\frac{y}{\hat{y}}\right]$
−1.	.1	−1.0	V1	V1	.01
−.95	.112	−.95		V2	.0112
−.9	.126	−.9	V2	V3	.0126
−.85	.141	−.85		V4	.0141
−.8	.159	−.8	V3	V5	.0159
−.75	.178	−.75		V6	.0178
−.7	.200	−.7	V4	V7	.02
−.65	.224	−.65		V8	.0224
−.6	.251	−.6	V5	V9	.0251
−.55	.282	−.55		V10	.0282
−.5	.316	−.5	V6	V11	.0316
−.45	.355	−.45		V12	.0355
−.4	.398	−.4	V7	V13	.0398
−.35	.447	−.35		V14	.0447
−.3	.501	−.3	V8	V15	.0501
−.25	.562	−.25		V16	.0562
−.2	.631	−.2	V9	V17	.0631
−.15	.708	−.15		V18	.0708
−.1	.794	−.1	V10	V19	.0794
−.05	.891	−.05		V20	.0891
0	1.	.0	V11	V21	.1
.05	1.122	+.05		V22	.1122
.1	1.259	+.1	V12	V23	.1259
.15	1.413	+.15		V24	.1413
.2	1.585	+.2	V13	V25	.1585
.25	1.778	+.25		V26	.1778
.3	1.995	+.3	V14	V27	.1995
.35	2.239	+.35		V28	.2239
.4	2.512	+.4	V15	V29	.2512
.45	2.818	+.45		V30	.2818
.5	3.162	+.5	V16	V31	.3162
.55	3.548	+.55		V32	.3548
.6	3.981	+.6	V17	V33	.3981
.65	4.467	+.65		V34	.4467
.7	5.012	+.7	V18	V35	.5012
.75	5.623	+.75		V36	.5623
.8	6.310	+.8	V19	V37	.6310
.85	7.079	+.85		V38	.7079
.9	7.943	+.9	V20	V39	.7943
.95	8.913	+.95		V40	.8913
1.	10.	+1.0	V21	V41	1.

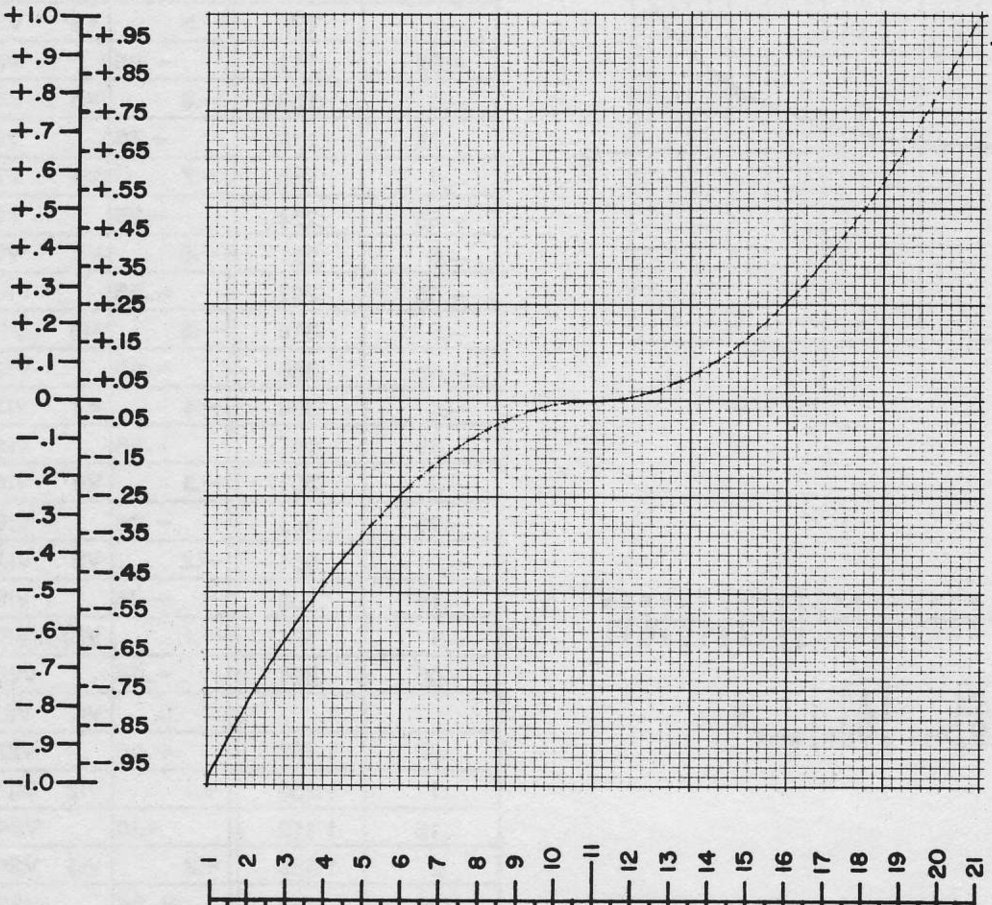
EAI 2000

BY

DATE

TITLE F__ SETUP TABLE $y=10^x$

PAGE



−1.0	V1	V1
−.95		V2
−.9	V2	V3
−.85		V4
−.8	V3	V5
−.75		V6
−.7	V4	V7
−.65		V8
−.6	V5	V9
−.55		V10
−.5	V6	V11
−.45		V12
−.4	V7	V13
−.35		V14
−.3	V8	V15
−.25		V16
−.2	V9	V17
−.15		V18
−.1	V10	V19
−.05		V20
.0	V11	V21
+.05		V22
+.1	V12	V23
+.15		V24
+.2	V13	V25
+.25		V26
+.3	V14	V27
+.35		V28
+.4	V15	V29
+.45		V30
+.5	V16	V31
+.55		V32
+.6	V17	V33
+.65		V34
+.7	V18	V35
+.75		V36
+.8	V19	V37
+.85		V38
+.9	V20	V39
+.95		V40
+1.0	V21	V41

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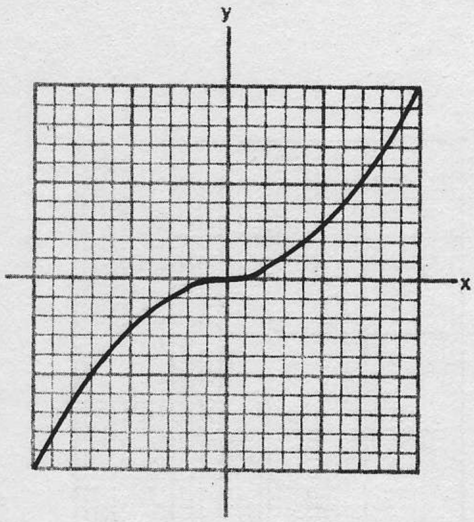
BY

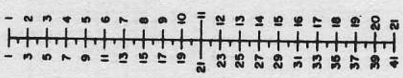
DATE

TITLE $y = x|x|$ $-1 \le X \le +1$

PAGE



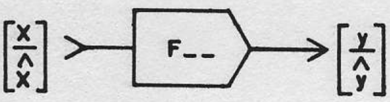
B=21
B=41



NOTE: $\left|\left[\frac{y}{\hat{y}}\right]_{n+1}-\left[\frac{y}{\hat{y}}\right]_{n}\right|_{MAX}=1$

$y = x|x|$

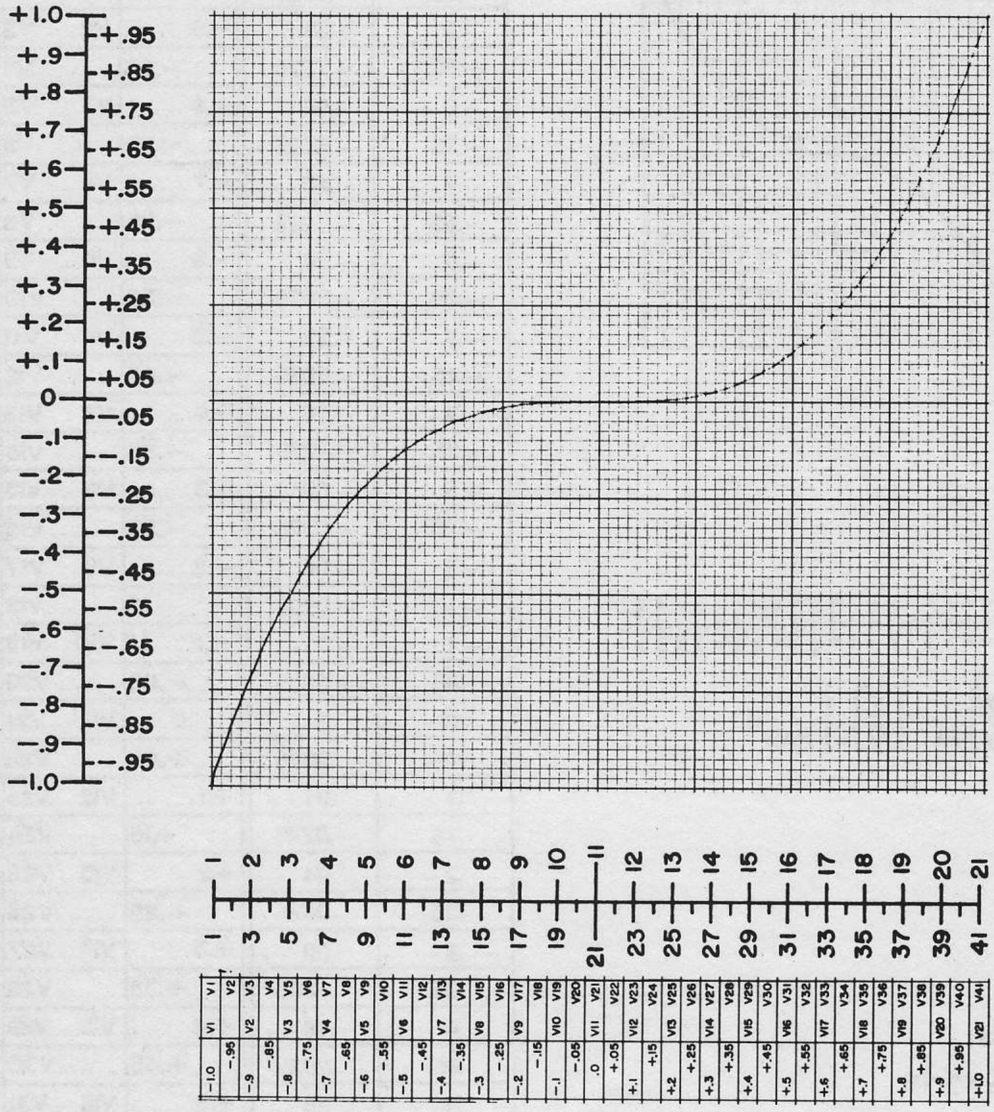
$-1 \leq x \leq +1$



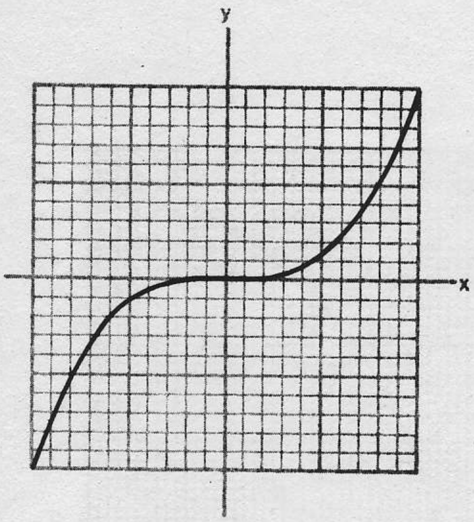
$\hat{x} = 1$

$\hat{y} = 1$

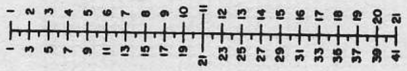
X	Y	$\left[\frac{x}{\hat{x}}\right]$	B 21	B 41	$\left[\frac{y}{\hat{y}}\right]$
−1.0	−1.	−1.0	V1	V1	−1.
−.95	−.9025	−.95		V2	−.9025
−.9	−.81	−.9	V2	V3	−.81
−.85	−.7225	−.85		V4	−.7225
−.8	−.64	−.8	V3	V5	−.64
−.75	−.5625	−.75		V6	−.5625
−.7	−.49	−.7	V4	V7	−.49
−.65	−.4225	−.65		V8	−.4225
−.6	−.36	−.6	V5	V9	−.36
−.55	−.3025	−.55		V10	−.3025
−.5	−.25	−.5	V6	V11	−.25
−.45	−.2025	−.45		V12	−.2025
−.4	−.16	−.4	V7	V13	−.16
−.35	−.1225	−.35		V14	−.1225
−.3	−.09	−.3	V8	V15	−.09
−.25	−.0625	−.25		V16	−.0625
−.2	−.04	−.2	V9	V17	−.04
−.15	−.0225	−.15		V18	−.0225
−.1	−.01	−.1	V10	V19	−.01
−.05	−.0025	−.05		V20	−.0025
0	0	.0	V11	V21	0
.05	.0025	+.05		V22	.0025
.1	.01	+.1	V12	V23	.01
.15	.0225	+.15		V24	.0225
.2	.04	+.2	V13	V25	.04
.25	.0625	+.25		V26	.0625
.3	.09	+.3	V14	V27	.09
.35	.1225	+.35		V28	.1225
.4	.16	+.4	V15	V29	.16
.45	.2025	+.45		V30	.2025
.5	.25	+.5	V16	V31	.25
.55	.3025	+.55		V32	.3025
.6	.36	+.6	V17	V33	.36
.65	.4225	+.65		V34	.4225
.7	.49	+.7	V18	V35	.49
.75	.5625	+.75		V36	.5625
.8	.64	+.8	V19	V37	.64
.85	.7225	+.85		V38	.7225
.9	.81	+.9	V20	V39	.81
.95	.9025	+.95		V40	.9025
1.	1.	+1.0	V21	V41	1.



EAI 2000	BY	TITLE	PAGE
	DATE	$y=x^3$ $-1 \leq X \leq +1$	



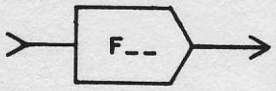
B=21
B=41



NOTE: $\left| \left[\frac{y}{\hat{y}}\right]_{n+1} - \left[\frac{y}{\hat{y}}\right]_{n} \right|_{MAX} = 1$

$y = x^3$

$-1 \leq x \leq +1$

$\left[\frac{x}{\hat{x}}\right]$  $\left[\frac{y}{\hat{y}}\right]$

$\hat{x} = 1$

$\hat{y} = 1$

X	Y	$\left[\frac{x}{\hat{x}}\right]$	B 21	B 41	$\left[\frac{y}{\hat{y}}\right]$
−1.	−1.	−1.0	V1	V1	−1.
−.95	−.8574	−.95		V2	−.8574
−.9	−.729	−.9	V2	V3	−.729
−.85	−.6141	−.85		V4	−.6141
−.8	−.512	−.8	V3	V5	−.512
−.75	−.4219	−.75		V6	−.4219
−.7	−.343	−.7	V4	V7	−.343
−.65	−.2746	−.65		V8	−.2746
−.6	−.216	−.6	V5	V9	−.216
−.55	−.1664	−.55		V10	−.1664
−.5	−.125	−.5	V6	V11	−.125
−.45	−.0911	−.45		V12	−.0911
−.4	−.064	−.4	V7	V13	−.064
−.35	−.0429	−.35		V14	−.0429
−.3	−.027	−.3	V8	V15	−.027
−.25	−.0156	−.25		V16	−.0156
−.2	−.008	−.2	V9	V17	−.008
−.15	−.0034	−.15		V18	−.0034
−.1	−.001	−.1	V10	V19	−.001
−.05	−.0001	−.05		V20	−.0001
.0	0	.0	V11	V21	0
.05	.0001	+.05		V22	.0001
.1	.001	+.1	V12	V23	.001
.15	.0034	+.15		V24	.0034
.2	.008	+.2	V13	V25	.008
.25	.0156	+.25		V26	.0156
.3	.027	+.3	V14	V27	.027
.35	.0429	+.35		V28	.0429
.4	.064	+.4	V15	V29	.064
.45	.0911	+.45		V30	.0911
.5	.125	+.5	V16	V31	.125
.55	.1664	+.55		V32	.1664
.6	.216	+.6	V17	V33	.216
.65	.2746	+.65		V34	.2746
.7	.343	+.7	V18	V35	.343
.75	.4219	+.75		V36	.4219
.8	.512	+.8	V19	V37	.512
.85	.6141	+.85		V38	.6141
.9	.729	+.9	V20	V39	.729
.95	.8574	+.95		V40	.8574
1.	1.	+1.0	V21	V41	1.

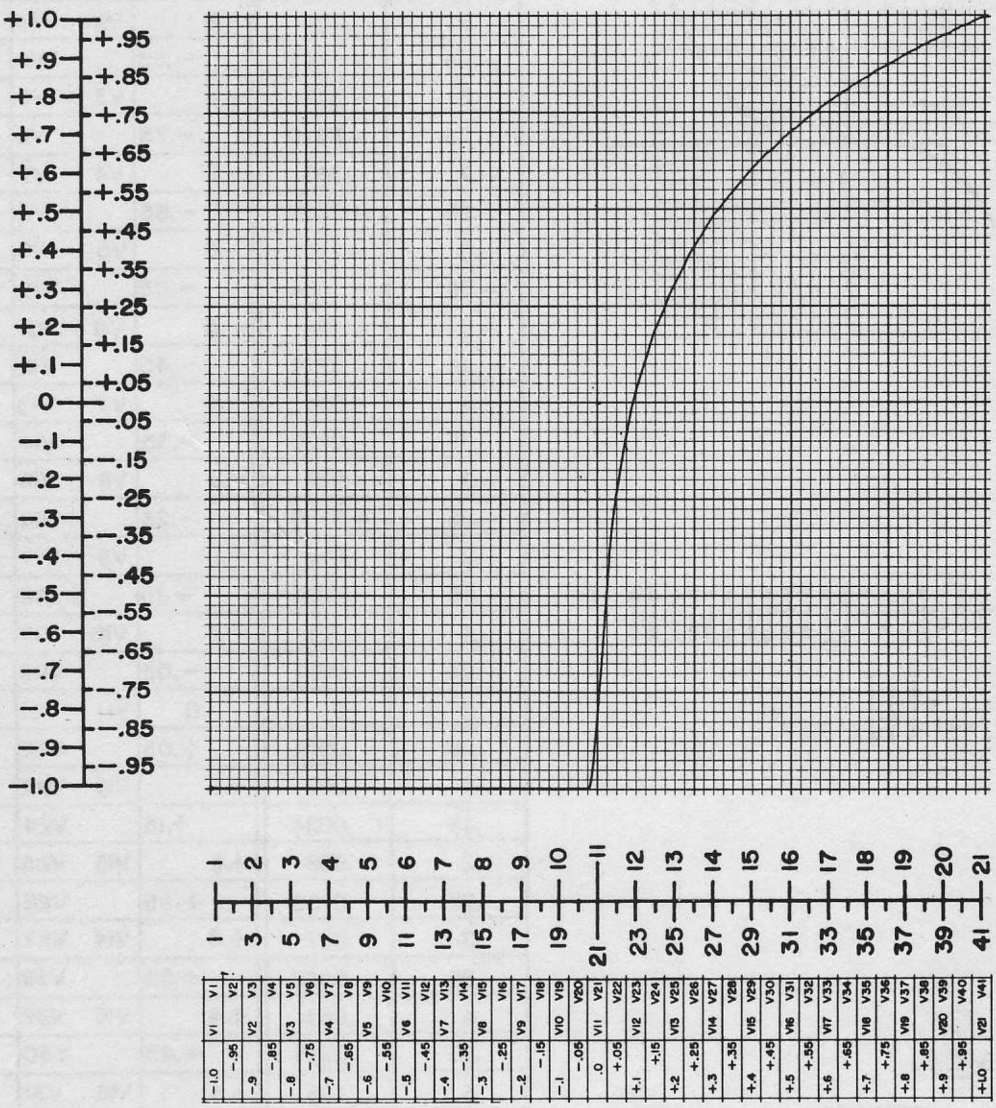
EAI 2000

BY

DATE

TITLE F__ SETUP TABLE $y = x^3$

PAGE



EAI 2000

BY

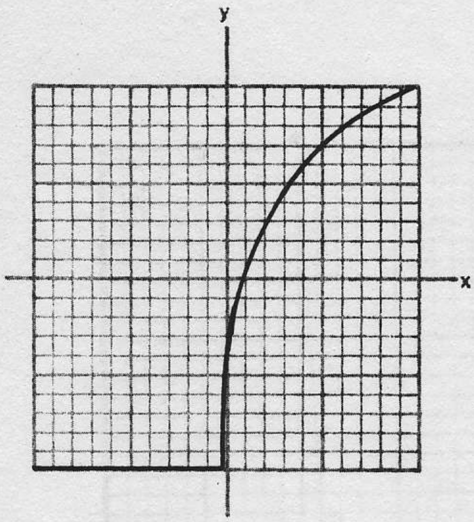
DATE

TITLE

y=Log (10X)

.05≤X≤1

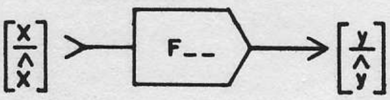
PAGE



NOTE: $\left| \left[\frac{y}{\hat{y}}\right]_{n+1} - \left[\frac{y}{\hat{y}}\right]_{n} \right|_{MAX} = 1$

y = Log (10X)

$.05 \leq X \leq 1$

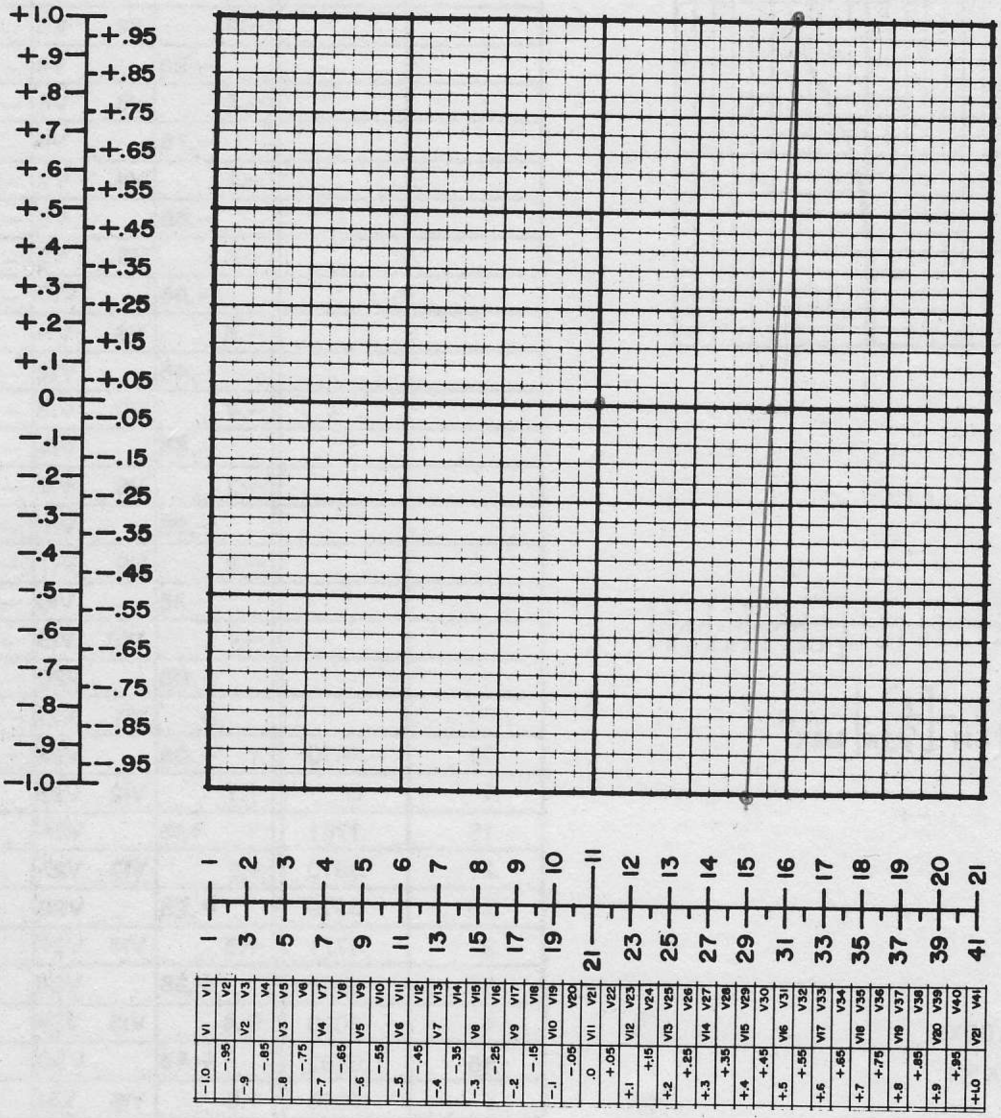


$\hat{x} = 1$

$\hat{y} = 1$

X	Y	$\left[\frac{X}{\hat{X}}\right]$	B 21	B 41	$\left[\frac{y}{\hat{y}}\right]$
		−1.0	V1	V1	−1.
		−.95		V2	−1.
		−.9	V2	V3	−1.
		−.85		V4	−1.
		−.8	V3	V5	−1.
		−.75		V6	−1.
		−.7	V4	V7	−1.
		−.65		V8	−1.
		−.6	V5	V9	−1.
		−.55		V10	−1.
		−.5	V6	V11	−1.
		−.45		V12	−1.
		−.4	V7	V13	−1.
		−.35		V14	−1.
		−.3	V8	V15	−1.
		−.25		V16	−1.
		−.2	V9	V17	−1.
		−.15		V18	−1.
		−.1	V10	V19	−1.
		−.05		V20	−1.
		.0	V11	V21	−1.
.05	−.3010	+.05		V22	−.3010
.1	0	+.1	V12	V23	0
.15	.1761	+.15		V24	.1761
.2	.3010	+.2	V13	V25	.3010
.25	.3979	+.25		V26	.3979
.3	.4771	+.3	V14	V27	.4771
.35	.5441	+.35		V28	.5441
.4	.6020	+.4	V15	V29	.6020
.45	.6532	+.45		V30	.6532
.5	.6990	+.5	V16	V31	.6990
.55	.7404	+.55		V32	.7404
.6	.7782	+.6	V17	V33	.7782
.65	.8129	+.65		V34	.8129
.7	.8451	+.7	V18	V35	.8451
.75	.8751	+.75		V36	.8751
.8	.9031	+.8	V19	V37	.9031
.85	.9294	+.85		V38	.9294
.9	.9542	+.9	V20	V39	.9542
.95	.9777	+.95		V40	.9777
1.	1.	+1.0	V21	V41	1.

EAI 2000 | BY | DATE | TITLE F__ SETUP TABLE y=Log (10X) | PAGE



EAI 2000

BY

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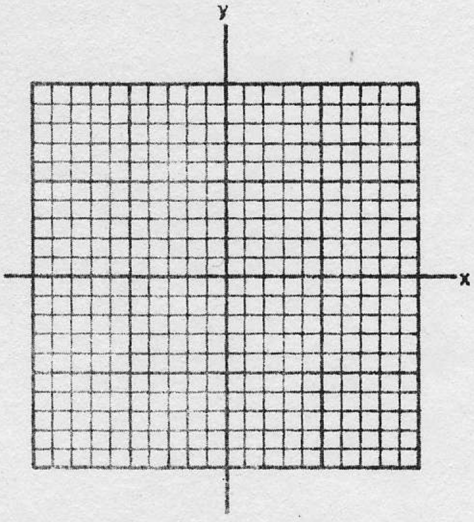
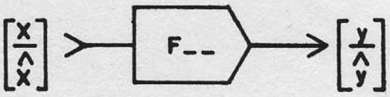
TITLE

PAGE



B=21
B=41

NOTE: $\left|\left[\frac{y}{\hat{y}}\right]_{n+1}-\left[\frac{y}{\hat{y}}\right]_{n}\right|_{MAX}=1$



$\hat{x}$ =

$\hat{y}$ =

X	Y	$\left[\frac{x}{\hat{x}}\right]$	B 21	41	$\left[\frac{y}{\hat{y}}\right]$
		−1.0	V1	V1	
		−.95		V2	
		−.9	V2	V3	
		−.85		V4	
		−.8	V3	V5	
		−.75		V6	
		−.7	V4	V7	
		−.65		V8	
		−.6	V5	V9	
		−.55		V10	
		−.5	V6	V11	
		−.45		V12	
		−.4	V7	V13	
		−.35		V14	
		−.3	V8	V15	
		−.25		V16	
		−.2	V9	V17	
		−.15		V18	
		−.1	V10	V19	
		−.05		V20	
		.0	V11	V21	
		+.05		V22	
		+.1	V12	V23	
		+.15		V24	
		+.2	V13	V25	
		+.25		V26	
		+.3	V14	V27	
		+.35		V28	
		+.4	V15	V29	
		+.45		V30	
		+.5	V16	V31	
		+.55		V32	
		+.6	V17	V33	
		+.65		V34	
		+.7	V18	V35	
		+.75		V36	
		+.8	V19	V37	
		+.85		V38	
		+.9	V20	V39	
		+.95		V40	
		+1.0	V21	V41	

EAI 2000

BY

DATE

TITLE F__ SETUP TABLE

PAGE

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