DEC-11-HAAC-D

AA11-D
D/A subsystem manual

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FOREWORD

This manual contains instructions for installing, operating, and maintaining the AA11-D D/A Conversion Subsystem and the AA11-A, -B, and -C Display Options. The manual is divided into the following chapters:

Chapter 1 – provides a brief functional and physical description of the system including pertinent system parameters and specifications.

Chapter 2 – contains control and status word format and several AA11 programming examples.

Chapter 3 – provides theory of operation and applicable module information.

Chapter 4 – contains installation and adjustment procedures.

Chapter 5 – provides preventive and corrective maintenance procedures.

Chapter 6 – lists subsystem logic schematics, timing diagrams, flow diagrams, and circuit schematics.

Throughout this manual it is assumed that the reader has access to and is familiar with the following list of documents that relate to the AA11-D Subsystem.

Applicable Documents

Title	Number	Coverage
Unibus Interface Manual Second Edition	DEC-11-HIAB-D	Provides detailed theory, flow, and logic descriptions of the Unibus(TM) and external device logic. Includes detailed discussions of the following modules used in the TC11 Controller: M105 Address Selector M782 Interrupt Control M783 Unibus Transmitter M784 Unibus Receiver M795 Word Count & Bus Address Register M796 Unibus Master Control M798 Unibus Drivers
PDP-11/20 System (7-volume series)	DEC-11-HR1A-D through DEC-11-HR7A-D	Provides detailed theory of operation, flow, logic diagrams, operation, installation, and maintenance for components of the PDP-11 System including processor, memory, console, and power supply.
PDP-11 Handbook	Second Edition, 1970	A general handbook that provides discussions of addressing modes, the overall PDP-11 System, and the basic instruction set from a programming point of view. Includes some interface and installation information.
Logic Handbook	DEC, 1970	Presents functions and specifications of the M-Series logic modules, accessories, and connectors used in the AA11-D D/A Conversion Subsystem. Includes other types of logic produced by DEC but not used with PDP-11 devices.
Paper-Tape Software Programming Handbook	DEC-11-GGPA-D	Provides a detailed discussion of the PDP-11 software system used to load, dump, edit, assemble, and debug PDP-11 programs; input/output programming; and the floating point and math package.
VR12 Point Plot Display Maintenance Manual	DEC-CR-H6AA-D	Provides detailed installation, operation, theory of operation, and maintenance information for the VR12 display equipment.
Type RM503 Oscilloscope Instruction Manual	Tektronix	Provides operation, theory of operation, and maintenance information for the RM503 oscilloscope.
Type 611 Storage Display Unit Instruction Manual	Tektronix	Provides operation, theory of operation, and maintenance information for the Type 611 Storage Display Unit.

Modules used in this subsystem (with the exception of special-purpose modules) are described in the *DEC Logic Handbook*. Special-purpose modules are described in Chapter 3.

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CHAPTER 1
GENERAL INFORMATION

1.1 PURPOSE OF THE AA11-D

The AA11-D is a low-cost, high-performance, multichannel digital-to-analog (D/A) conversion subsystem designed for use with the PDP-11 Computers. Storage scope, display scope, and light pen control options are available for the AA11-D. These options provide Z-axis blanking for intensity control and require two digital-to-analog converters (DACs) for X- and Y-trace coordinates.

Typical applications of the AA11-D and its scope options include plotting points, setting of temperature set point controllers for process control systems, or driving the X- and Y-coordinate axis of a display. The system provides a bipolar analog voltage output, with absolute maximum voltage of ±10V. The output voltage is trimpot adjustable for full-scale output in two ranges: ±5V to ±10V and ±1V to ±5V.

1.2 SYSTEM DESCRIPTION

The AA11-D is a D/A conversion subsystem capable of converting up to four 12-bit digital words to an analog equivalent. Conversion is accomplished by A614 DAC modules; each module contains its own output amplifier and voltage reference source. Operating voltages are obtained from a common H704 Analog Power Supply. The DAC modules are uniquely addressed by an M105 Address Selector Module (see *PDP-11 Unibus Interface Manual* for a detailed description of this module). The 12-bit digital data words are applied to the DAC modules via a series of bus receivers (see Figure 1-1).

If the user desires display applications, in addition to the analog outputs, he can purchase a display option whereby two of the existing DAC modules are used to drive the X- and Y-axis of a display. The DAC 0 module drives the X-axis and the DAC 1 module drives the Y-axis. The display option includes an M105 C Address Selector Module that is used to address a control and status register in the scope option; an M782 Interrupt Control Module; an M799 Scope Control Module; and a display cable. Three types of display options are available: AA11-A, AA11-B, and AA11-C. These options are described in Paragraphs 1.2.2 through 1.2.4.

To use the scope option, a control word is loaded into the scope CSR (control and status register) to determine the type of intensification. Three types of intensification are available:

a. Intensify on loading X-axis
b. Intensify on loading Y-axis
c. Intensify a preselected display point.

In addition to the above, other functions performed by the control word include selection of high or low intensity, store or non-store, erase, etc. These functions are described in Chapter 3.

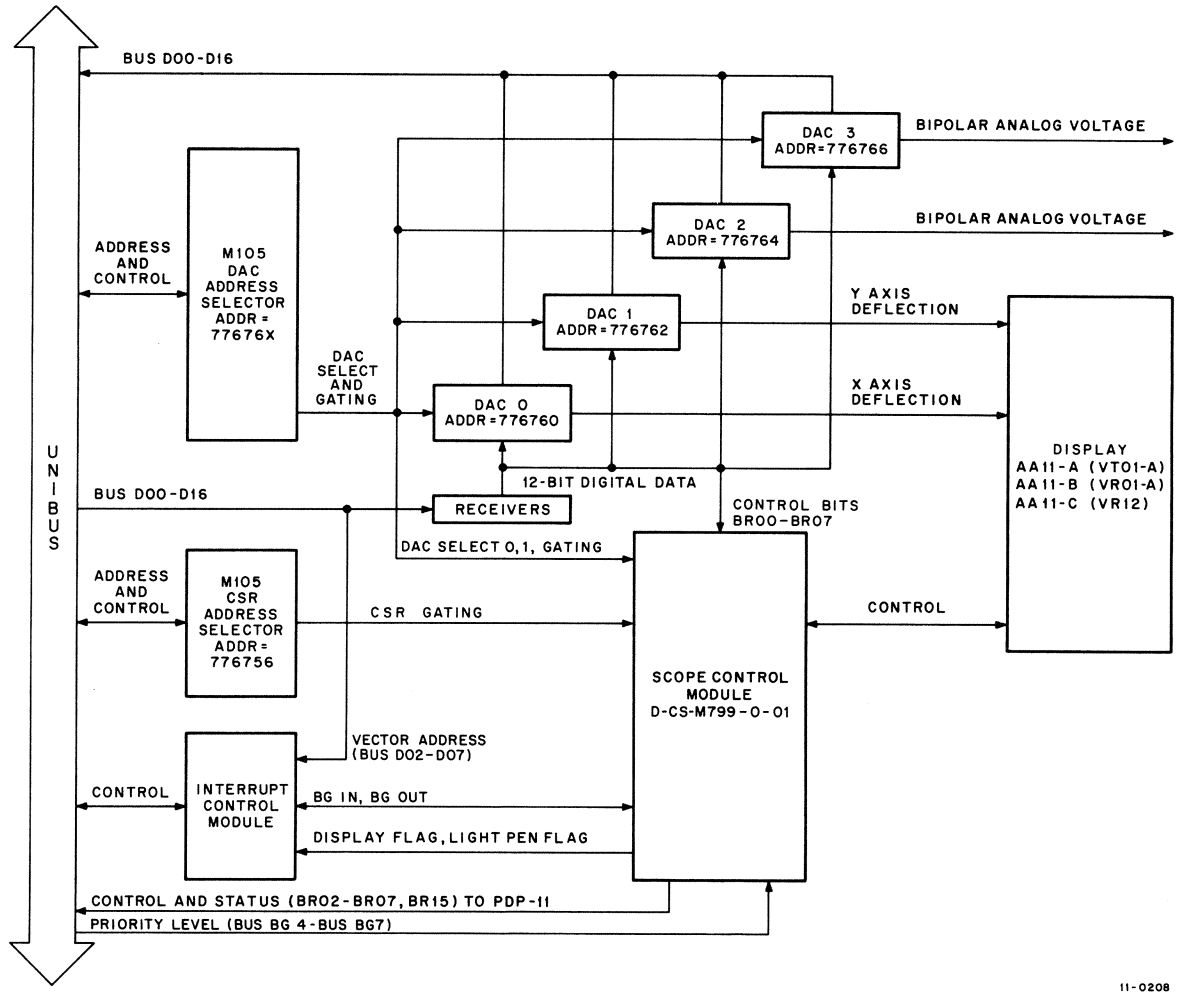


Figure 1-1 AA11 Subsystem Simplified Block Diagram

The interrupt control module allows the AA11 subsystem to initiate a program interrupt under the following two conditions:

a. When a display flag is raised indicating that the display is ready to be serviced.

b. When a light pen flag is raised (if a light pen option is installed). The raising of the light pen flag indicates that a light pen is ready to be serviced.

The light pen is assigned to priority level 5 and the display to priority level 4.

1.2.1 AA11-D Subsystem

Table 1-1 lists the equipment supplied with each AA11-D subsystem. The DAC modules (A614) are not included in the system and must be purchased separately. Three display options are available to the user. The options and equipment supplied with each are listed in Table 1-2. Note that each option requires a different display cable and each uses the same M799 Scope Control Module. Since each display type possesses different characteristics, a different set of jumper connections is needed on the scope control module for each option.

NOTE
The jumper connections are not wired on the scope control module itself, but are wired on the back plane of the receptacle which houses the module. See Paragraph 3.4 for a detailed description of the scope control module.

Table 1-1
AA11-D Subsystem Equipment Complement

Quantity	Nomenclature	Location	Module No./Part No.
1	Analog Power Supply	–	H704-C (H704-H)
1	Unibus Connector	A1, B1	M920
1	Digital Power Connector	A3	G772
1	Analog Power Cable	B3	7007116-0-0
1	DAC Address Selector	E1	M105
1	Bus Receiver	F1	M784

Note: The A614 DAC modules are not included with the equipment and are purchased separately. They plug into slots C1 D1, C2 D2, C3 D3, and C4 D4. Refer to module utilization drawing D-MU-AD11-D-06. Module receptacles A4B4 connect the AA11-D to the next device on the Unibus, via an existing Unibus cable. If the AA11-D is the last device on line, module receptacles A4B4 will be terminated.

1.2.2 AA11-A Display Option

The AA11-A Display option is used with the VT01-A Storage Display Unit (Tektronix Type 611) or equivalent. The control provides intensifying signals in both storage and non-storage modes. Erase signals are included in the logic; the setting of a flag indicates the end of an erase period and the readiness of the display for use. A control and status register (CSR) is also incorporated in the scope control for such functions as selecting modes of operation and monitoring display status. The DAC modules used to drive the VT01-A display are adjusted to give full-scale deflection of ±1V.

Table 1-2
Display Option Equipment Complement

Quantity	Nomenclature	Location	Module No./Part No.
	AA11-A Option		
1	Address Selector Module (CSR)	E2	M105
1	Interrupt Control Module	F2	M782
1	Display Cable	E3	7007138-0-0
1	Scope Control Module	E4, F4	M799
	AA11-B Option		
1	Address Selector Module (CSR)	E2	M105
1	Interrupt Control Module	F2	M782
1	Display Cable	E3	7007139-0-0
1	Scope Control Module	E4, F4	M799
	AA11-C Option		
1	Address Selector Module (CSR)	E2	M105
1	Interrupt Control Module	F2	M782
1	Display Cable	E3	7007122-0-0
1	Scope Control Module	E4, F4	M799

Note: The A614 DAC modules and the AA11-D must be ordered in addition to the display option. Two A614 DAC modules are required to drive the X- and Y-axis of the selected display.

There are no coarse adjustments on the VT01-A to provide full-scale deflection; however, two switches are available to determine the point of origin. The origin can be at any of the four corners or at the scope center. For values that are near 0, where full-scale deflection is not desired, the origin is usually selected at the center. The following statements depict where the origin should be selected depending on the deflection desired:

a. Positive full-scale deflection for X- and Y-axis – origin at lower left
b. Positive full-scale deflection for X-axis, negative for Y-axis – origin at upper left
c. Negative full-scale deflection for X-axis, positive for Y-axis – origin at lower right
d. Negative full-scale deflection for X- and Y-axis – origin at upper right.

Data is presented on an 11-in. storage cathode ray tube in the VT01-A in the aspect ratio of a conventional typewritten page (3/4 scale). For additional information on the VT01-A, refer to the *Tektronix Type 611 Storage Display Unit Instruction Manual.*

1.2.3 AA11-B Display Option

The AA11-B Display option provides the deflection delay and beam intensification for such displays as the VR01-A. Two levels of intensification (high and low intensity) are provided by the scope control module. Light pen input and status are provided for a light pen option. A CSR in the scope control is used to select modes of operation, monitor status, etc.

The VR01-A is a low-frequency, high-sensitivity display that provides accurate measurements up to 450 kHz. The display can be used for accurate curve plotting in the X-Y mode of operation. The DAC modules used to drive the VR01-A display are adjusted for ±10V full-scale deflection. For additional information on the VR01-A, refer to the *Tektronix Type RM503 Oscilloscope Instruction Manual.*

1.2.4 AA11-C Display Option

The AA11-C Display option provides the necessary deflection delay and beam intensification for scopes such as the VR12 Point Plot Display. The scope control provides both high- and low-level intensification. Light pen input and status are provided for a light pen option. The scope control contains a CSR to select modes of operation, monitor status, etc.

The VR12 Point Plot Display is a compact, solid-state device with a 6.75-in. x 9-in. viewing area that provides high-speed plotting capability at low power consumption levels. The DAC modules used to drive the display are adjusted to provide full-scale deflection of ±5V. For additional information on the VR12, refer to the *VR12 Point Plot Display Instruction Manual.*

1.3 AA11-D PHYSICAL DESCRIPTION

The AA11-D (and the display option, if ordered) consists of one system unit that is actually three H803 Connector Blocks strapped together (see *DEC Logic Handbook*). Each H803 Connector Block has receptacles to house eight single-height, single-width modules. Module utilization drawing D-MU-AA11-D-06 shows the modules used and their respective locations.

The AA11-D is located in a BA11 Mounting Box, which houses an H720 Digital Power Supply and can accommodate up to six system units. The H704-C, -H Analog Power Supply is mounted at the bottom of the cabinet. A cable, supplied with the AA11-D, connects the analog supply to the AA11-D.

Computer interface connections are made using the Unibus connector. Connections between modules are made via pins on the front of the connector blocks using wire-wrap. A connector on the side of each DAC module is supplied for customer connection of DAC outputs. A two-conductor twisted and shielded cable should be used to connect each DAC output to its load; DEC 90-07701, Belden No. 8762, or equivalent, is recommended.

1.3.1 H704-C/H704-H Analog Power Supply

Two types of power supplies are available with the AA11-D: the H704-C or the H704-H. The H704-C operates from 115V primary power; the H704-H operates from 230V primary power. Both models operate in the 47 to 420 Hz frequency range. Each supply produces +15V and -15V potentials for operation of analog circuits in the DAC modules. Primary power is fused by a 1/2 ampere fuse for the H704-C or a 1/4 ampere fuse for the H704-H.

1.3.2 H720 Power Supply

The H720 Power Supply provides +5V and -15V regulated potentials for logic circuit operation. There are two types of H720 Power Supplies: the H720-A and H720-B. The H720-A operates at 120V, ±10 percent; the H720-B operates at 240V, ±10 percent. Both models operate in the 47 to 63 Hz frequency range. For additional information on the H720 Power Supplies, refer to the *PDP-11 Unibus Interface Manual.*

1.4 SYSTEM EXPANSION

The AA11-D subsystem, consisting of one system unit, can accommodate up to four DAC modules. Four additional AA11-D system units can be added to the system.

Each additional AA11-D system unit increases the system capability by four DAC modules, or by two DAC modules and a display option, since the option requires two DAC modules for operation. Consequently, the total system can accommodate 20 DAC modules or 10 DAC modules and five display options (using the remaining 10 DACs). Other system combinations are also possible, such as 14 DAC modules and three display options (which require six DAC modules).

Table 1-3 lists the complete system capability and the DAC address assignments; also, the DACs associated with the display options are defined. For example, DAC 4 and DAC 5 are associated with a second display option; if a second display option is not desired, DAC 4 and DAC 5 will be used simply to provide bipolar analog ouputs and not to drive a display.

Table 1-3
DAC Address Assignments

DAC	System Unit	DAC Addresses
DAC 0	No. 1	776760 (X-Axis)
DAC 1		776762 (Y-Axis)
DAC 2		776764
DAC 3		776766
DAC 4	No. 2	776410 (X-Axis)
DAC 5		776412 (Y-Axis)
DAC 6		776414
DAC 7		776416
DAC 8	No. 3	776430 (X-Axis)
DAC 9		776432 (Y-Axis)
DAC 10		776434
DAC 11		776436
DAC 12	No. 4	776450 (X-Axis)
DAC 13		776452 (Y-Axis)
DAC 14		776454
DAC 15		776456
DAC 16	No. 5	776470 (X-Axis)
DAC 17		776472 (Y-Axis)
DAC 18		776474
DAC 19		776476
Display		**Display Addresses**
0		776756
1		776406
2		776426
3		776446
4		776466

1.5 SPECIFICATIONS

Table 1-4 lists pertinent specifications for the AA11-D and associated display options.

Table 1-4
Equipment Specifications

Physical Specifications	
Size (AA11-D)	1-5/8 in. in front of mounting surface 8-1/2 in. in back of mounting surface 2-3/8 in. high 16-1/2 in. wide
Weight (AA11-D)	10 pounds max.

Table 1-4 (Cont)
Equipment Specifications

Physical Specifications (Cont)

Size (H704-C, -H)	5-1/4 in. high 19 in. wide 6-3/4 in. deep
Weight (H704-C, -H)	10 pounds max.

Environmental Specifications

Temperature Range (operating)	+10°C to 50°C
Humidity (without condensation)	20 to 95%
Heat Dissipation	
AA11-A	15.7 Btu/hr
AA11-B	15.7 Btu/hr
AA11-C	15.7 Btu/hr
AA11-D	47.7 Btu/hr
A614	13.3 Btu/hr

Power Specifications

Input ac Voltage	
H704-C	105 Vac – 125 Vac
H704-H	210 Vac – 250 Vac
Input Current	less than 0.5A
Frequency	47 to 420 Hz
Input dc Voltage	
+ 5V	2.9A (max.)
-15V	180 mA (max.)
Power Dissipation	
AA11-A	4.6W (max.)
AA11-B	4.6W (max.)
AA11-C	4.6W (max.)
AA11-D	14.0W (max.)
A614	3.9W (max.)

DAC Module Performance Specification

Number of channels	1 to 4
Resolution	One part in 2048 of full scale (4096 of full range)
Digital input	Single buffered, 11 bits plus sign in 2's complement form 3777 = +Full Scale Output 0000 = 0 4000 = -Full Scale Output

For 0V to +Full Scale Output, all negative numbers are ignored. For 0V to -Full Scale Output, all positive numbers are ignored except 0V, which is considered positive in 2's complement arithmetic.

Table 1-4 (Cont)
Equipment Specifications

DAC Module Performance Specification (Cont)

Logic levels	TTL compatible, positive logic
At input side of bus receivers	0V = logic 1 +3V = logic 0
At output of bus receivers	0V = logic 0 +3V = logic 1

Analog Output
Range 1 – continuous from ±1V to ±5V at 10 mA.
Range 2 – continuous from ±5V to ±10V at 10 mA.

Each range has a 10 percent adjustment (approximate) beyond its limits at each end.

Gain Accuracy	±0.025% of full scale at 25°C or 1 mV, whichever is greater
Zero Offset	Adjustable to zero
Setting Time	20 μs maximum to within ±1/2 LSB for full scale step, 0V to 10V (measured at the output connector with no capacitive loading).
Linearity	±1/2 LSB or 1 mV, whichever is greater
Output Impedance	Less than 1Ω
System Noise	⩽500 μV peak-to-peak, dc to 1 kHz ⩽10 mV peak-to-peak, 1 kHz to 1 MHz
Capacitive Loading	0.1 μF at the output connector will not cause instability but will degrade the setting time.
Warm-up Time	5 min.
Temperature Coefficient	
Zero	±50 μV/°C
Gain	±0.002%/°C

Scope Option Performance Specifications

AA11-A (VT01-A Storage Display Unit)

Display Rate/Point	10 kHz max.
Display Time	
Storage Mode	80-μs deflection time 20-μs intensification time
Non-Storage Mode	80-μs deflection time 2-μs intensification time
Erase Time	0.5s

AA11-B (VR01-A Display Unit)

Display Rate/Point	45 kHz max. 50 Hz min.
Display Time	20-μs deflection time 2-μs intensification time

Table 1-4 (Cont)
Equipment Specifications

Scope Option Performance Specifications (Cont)	
Intensification Levels	2
Light Pen Input Rate	1 kHz max.
AA11-C (VR12 Point Plot Display)	
Display Rate/Point	45 kHz max. 50 Hz min.
Display Time	20-μs deflection time 2-μs intensification time
Intensification Levels	2
Light Pen Input Rate	1 kHz max.

CHAPTER 2
OPERATION AND PROGRAMMING

2.1 AA11-D OPERATION

The AA11-D Subsystem is an automatic device that does not require operator intervention. Ensure that primary power is applied and allow a five-minute warm-up before beginning operation.

2.2 CONTROL AND STATUS WORD

The AA11-D Subsystem operates under software control of the PDP-11. The control and status register (CSR) is addressed at 776756. Bits 00 and 01 (BR00 and BR01) of the control word are Write only; bits 02 through 06 are Read and Write; bits 7 and 15 are Read only. The format and description of each bit in the control word is shown in Figure 2-1.

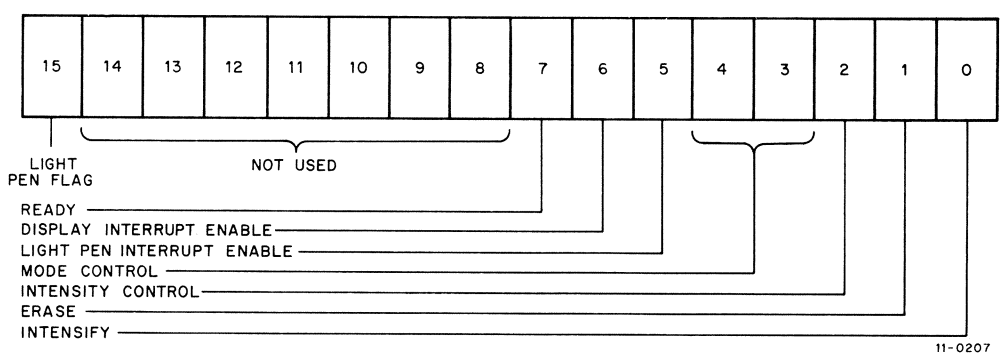


Figure 2-1 Control and Status Word Format

Bit 15 (Light Pen (LP) Flag) – This bit, when set, indicates that a signal has been received from the light pen. The flag is cleared by INIT (Read only).

Bits 14 through 08 – Not used.

Bit 07 (READY) – This bit is a status bit read into the PDP-11 and represents the state of the DSP RDY flip-flop in the scope control. If the DSP RDY flip-flop is set, bit 07 indicates that the display is ready to be serviced. The flip-flop is initially set by an INIT from the PDP-11 and also by an INTENSIFY command (bit 00), an ERASE command (bit 01), or by intensifying on loading the X- or Y-axis. The flip-flop is cleared by starting a new display point (Read only).

Bit 06 (DISPLAY INTERRUPT ENABLE) – This bit is a control bit that, when present, allows the DSP FLAG to cause a program interrupt whenever intensification or erase has been completed. The bit is set under PDP-11 software control and is cleared by INIT (Read and Write).

Bit 05 (LIGHT PEN INTERRUPT ENABLE) – This bit is a control bit that, when present, allows the LIGHT PEN FLAG to cause a program interrupt as a result of a signal from a light pen source. Bit 05 is set under PDP-11 software control and is cleared by INIT (Read and Write).

Bits 04 and 03 (MODE CONTROL) – These two bits determine whether there will be intensification loading the X-axis, the Y-axis, or neither. If a plotter is installed with the system, bits 04 and 03 can also determine whether the plotter mode is in operation (Read and Write).

Bit 04	Bit 03	
0	0	neither mode
0	1	intensify on loading the X-axis
1	0	intensify on loading the Y-axis
1	1	plotter mode

Bit 02 (INTENSITY CONTROL) – For the VT01-A scope, this bit must be present for intensification in the Storage mode. For the VR01-A and VR12 scopes, this bit, when present, selects the high intensify mode and, when not present, selects the low intensify mode. If a plotter is available, this bit can also be used to lower the pen on the plotter (Read and Write).

Bit 01 (ERASE) – This bit is used to erase the VT01-A display. It drives an ERASE INTERVAL signal in the VT01-A low for 0.5s during which time the display is erased (Write only).

Bit 00 (INTENSIFY) – This bit, when present, initiates the deflection delay and intensify circuitry for all scopes and clears the DSP RDY flip-flop. The deflection delay allows time for the scope to deflect to its new coordinates. At the end of the delay, an intensify pulse is generated to intensify the new coordinates and to set the display ready flip-flop (Write only).

2.3 PROGRAMMING EXAMPLE OF DAC LOADING

This program will load a selected DAC with the value contained in bits 11-0 of the switch register. The program will continually monitor the switch register while the DAC will reflect the analog equivalent of the value contained in the switches. By knowing the digital input and the equivalent analog output, this program can be used to calibrate the DAC (refer to Table 4-1). The program can be loaded in any area of unused memory.

Symbolic	Octal	Comments
. = 1000		
LOOP: Mov @#SR, @#DAC0	1000/013737 1002/177570 1004/176760	;MOVE CONTENTS OF SR TO DAC 0
BR LOOP	1006/000774	;BRANCH TO BEGINNING

As a result of the first symbolic instruction, the assembler will assemble the octal coding in locations 1000, 1002, and 1004. These locations contain the instruction, source address, and destination address. The value in location 1004 points to the address of DAC 0. It can be modified to point to any of the other DAC addresses; for example, 176762 points to DAC 1.

The second symbolic instruction (octal coding in location 1006) returns the program to the starting point (Loop).

2.4 PROGRAMMING EXAMPLE FOR DRAWING HORIZONTAL LINE

This program illustrates a means of using the display to draw a horizontal line.

Symbolic	Octal	Comments
. = 1000		
LOOP: TSTB @#CSR	1000/105737 1002/176756	;IS READY BIT SET?
BPL LOOP	1004/100375	;NO, WAIT
ADD #X, @#DAC0	1006/062737 1010/000001 1012/176760	;ADD X TO DAC 0
INC @#CSR	1014/005237 1016/176756	;INTENSIFY POINT
BR LOOP	1020/000767	;DO AGAIN

In this program, the value X added to the DAC is equal to 1. In other words, every point on the display trace will be intensified. If, for example, the user desires to intensify every other point on the line, he simply changes the value in location 1010 to 000002. If the user wishes to intensify every third point, he changes the value in location 1010 to 000003 and so forth.

2.5 PROGRAMMING EXAMPLE FOR DRAWING VERTICAL LINE

To draw a vertical line on the display, the Y DAC must be addressed instead of the X DAC. This is accomplished by changing the value in location 1012 (Paragraph 2.4) from 176760 to 176762. As a result, the Y DAC is incremented to draw a vertical line.

CHAPTER 3
THEORY OF OPERATION

3.1 AA11-D FUNCTIONAL DESCRIPTION

Functionally, the AA11-D Subsystem consists of an M105 Address Selector Module, an M784 Bus Receiver Module, and an H704-C or H704-H Analog Power Supply. An H720 Digital Power Supply, used with the PDP-11, provides voltages for the digital circuits. The AA11-D Subsystem is not functional, however, until one to four DAC modules are provided (see Figure 3-1). The 12-bit digital input (11 bits plus sign) from the PDP-11 is applied to all DACs in parallel via the bus receivers. Only the DAC addressed will be enabled; this DAC will convert the digital input to a bipolar analog equivalent. The DAC modules are addressed by SELECT DAC 0, 2, 4, or 6 signals as shown in Figure 3-1. A detailed description of the address selector module may be found in the *PDP-11 Unibus Interface Manual.* The three gating signals from the address selector determine the direction of transfer; IN H DAC is a transfer to the PDP-11, OUT LOW H DAC is a low-order byte transfer to the AA11-D, and OUT HIGH H DAC is a high-order byte transfer to the AA11-D. These signals are derived from PDP-11 control bits C1, C0, and address bit 00.

3.2 DISPLAY OPTION (AA11-A, -B, or -C)

If a user desires the display option (AA11-A, -B, or -C) with the basic AA11-D Subsystem, he will receive an M105 Address Selector, an M782 Interrupt Control Module, an M799 Scope Control Module, and a display interface cable. With the display option, two of the DAC modules used in the AA11-D are used to drive the display, one for X-axis deflection and one for Y-axis deflection.

The CSR Address Selector is similar to the DAC Address Selector except for changes in signal names; note that the outputs are labelled CSR instead of DAC. This is because the CSR Address Selector addresses the CSR contained in the scope control module. The CSR Address Selector is configured for address 776756, the address assigned to the display option.

The Interrupt Control Module provides the logic required to make bus requests and to gain control of the bus. Logic to generate a program interrupt is also included. An interrupt may occur if the display or a light pen is ready to be serviced. BUS D02 – D07 determine the vector address of the interrupt. A more detailed description of this module can be found in the *PDP-11 Unibus Interface Manual.*

The Scope Control Module is used with any of the three display options. The module provides a two-state intensity control for the VR01-A and VR12 displays and provides erase, store, and non-store logic for the VT01-A storage display. The scope control module also provides the necessary delay for intensifying the dot until it has relocated to its new position. The delay is a function of the type of display employed.

The following paragraphs describe the A614 DAC Module and the M799 Scope Control Module in detail.

3.3 A614 DAC MODULE

The A614 DAC Module is a 12-bit, bipolar D/A converter that contains an input buffer register, a binary-weighted ladder and analog switches, a -10V reference source, a +10V reference source, and an output amplifier (see Figure 3-2). The circuits function as described below.

The 12-bit word (2^{-1} through 2^{-12}) is loaded into the input buffer register by an enable level and two pulse inputs. An OUT HIGH (H) DAC pulse with an enable level loads the higher order bits (2^{-1} through 2^{-4}) into the input register. An OUT LOW (H) DAC pulse with an enable level loads the lower order bits into the register.

The analog switches connect one end of the binary-weighted resistors of the ladder network to either ground or the -10V reference. The other end of all resistors is connected to the summing input of the output amplifier. The potential placed across a resistor causes a weighted current to flow through the resistor. In general, when an input register stage is set, its analog switch connects the weighted resistor to the negative reference. Similarly, when a register stage is reset, the resistor is connected to ground. However, when the MSB stage is set, the resistor is connected to ground; when the register stage is reset, the resistor is connected to the negative reference.

Current through all the ladder resistors is summed at the junction of the offset resistor and the output amplifier input, thus reflecting an analog value proportional to the value of the binary input. The analog output value, however, depends on the gain of the output amplifier. The gain range of the output amplifier is selected by connecting the proper feedback path to the amplifier's output. By connecting the LOW RANGE jumpers, an output voltage of from ±1V full scale up to ±5V full scale can be obtained, using the internal trimpot adjustments. When the HIGH RANGE jumpers are connected, an output voltage from ±5V full scale to ±10V full scale can be obtained, using the internal trimpots.

Trimpots are also included for reference Zener current adjustment, the negative reference voltage, output amplifier zero offset adjustment, and for the two MSB stages. The trimpots and their functions are listed in Table 3-1. See drawing D-CS-A614-0-1 for their circuit location.

Table 3-1
A614 DAC Module Adjustments

Trimpot Reference Designation	Function
R37	MSB adjustment
R39	2-nd MSB adjustment
R61	Coarse adjustment for negative reference

(continued on page 3-3)

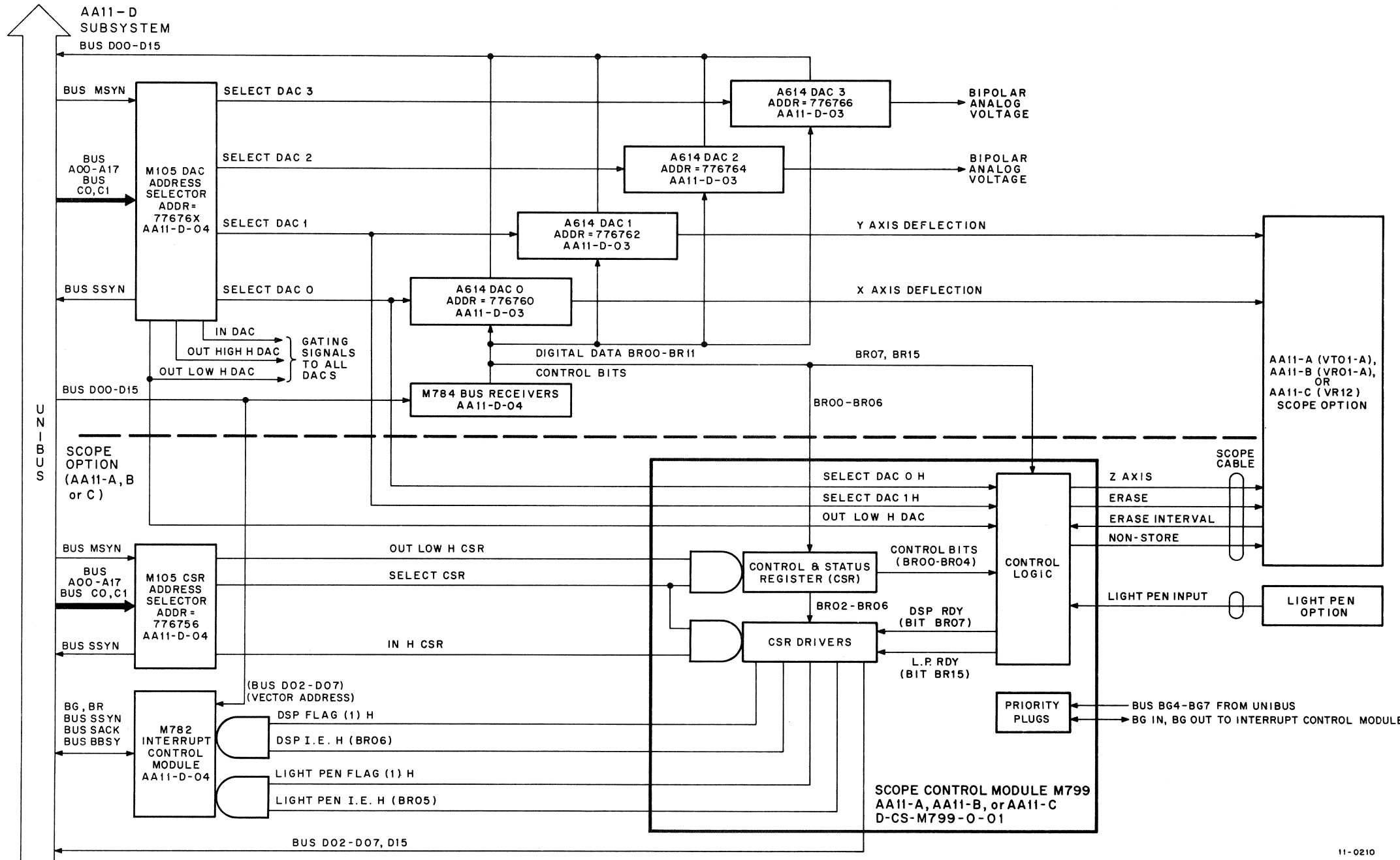


Figure 3-1 AA11 Subsystem Functional Block Diagram

Table 3-1 (Cont)
A614 DAC Module Adjustments

Trimpot Reference Designation	Function
R63	Fine adjustment for negative reference
R65	Establishes the proper operating current (7.5 mA) through the reference Zener
R77	Fine feedback adjustment for high-gain range
R78	Coarse feedback adjustment for high-gain range
R80	Fine feedback adjustment for low-gain range
R82	Coarse feedback adjustment for low-gain range
R92	Output amplifier zero-offset (balance) adjustment

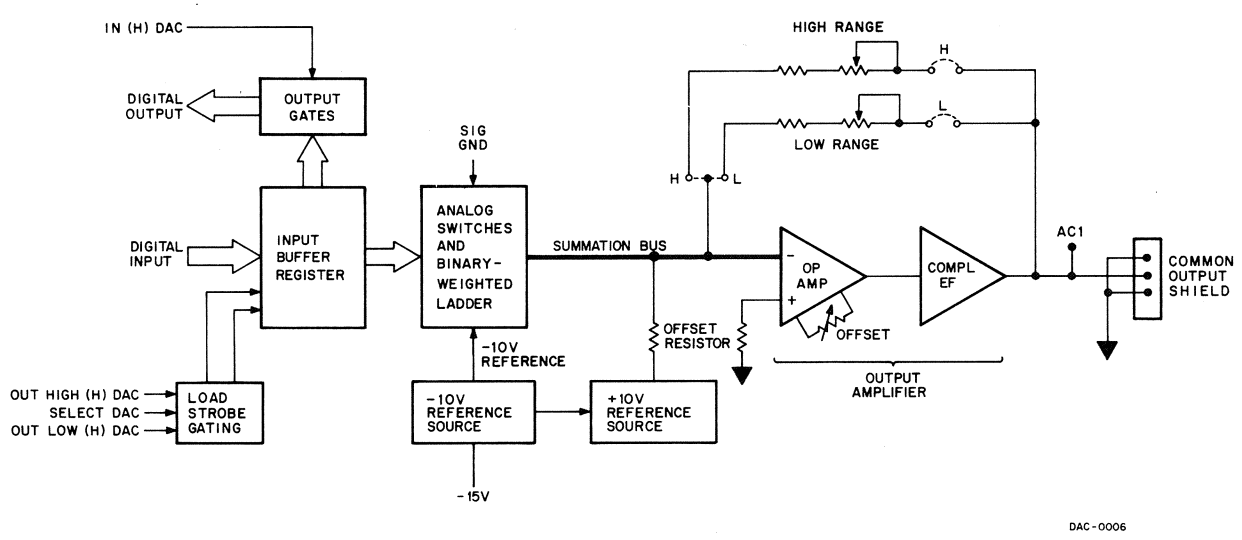


Figure 3-2 A614 DAC Module Functional Diagram

3.4 SCOPE CONTROL MODULE

The AA11 Subsystem employs an M799 Scope Control Module with the display option. The module is used with the VT01-A, VR01-A, or VR12 displays and is configured for a particular scope by a set of jumper wires. The following major functions are performed by the module:

a. Storage of control and status information
b. Intensification of a point upon loading the X-axis
c. Intensification of a point upon loading the Y-axis
d. Intensification of a preselected display point
e. Selection of high- or low-level intensification (not applicable to the VT01-A scope)
f. Selection of store or non-store mode (VT01-A only)
g. Display and light pen servicing

Figure 3-3 is a functional block diagram of the M799 Scope Control Module; drawing D-CS-M799-0-01 is the circuit schematic (refer to Chapter 5). The block diagram has the same relative arrangement as the schematic to provide ease of reference. Unless otherwise noted, the following paragraphs are applicable to all three displays.

3.4.1 Control and Status

PDP-11 control of the display option is accomplished by the control and status word (bits 00 through 06 (BR00 through BR06) and status bits Bus D07 and Bus D15). The action of the bits is described below.

NOTE
Control bits are loaded in a control and status register (CSR) and status bits are read out of the CSR. Bits 02 through 06 are applied to flip-flop inputs; all other bits are applied to gating networks.

Bit 00 is an INTENSIFY bit used to clear the DSP FLAG flip-flop and to initiate oscilloscope delay and intensification.

Bit 01 is an ERASE signal used to erase the VT01-A Storage Display. An ERASE INTERVAL signal in the VT01-A is normally high. When the ERASE signal is applied to the VT01-A via the scope control, the ERASE INTERVAL is forced low for 0.5s during which time the display is erased. At the end of this period, the ERASE INTERVAL signal returns to its former level and raises the display flag. Bits 02 through 06 are loaded into the CSR on receipt of SELECT CSR and OUT LOW H CSR signals; both signals originate at the CSR Address Selector Module. OUT LOW H CSR transfers a low-order byte to the AA11. These control bits can be read back to the PDP-11 on receipt of SELECT CSR and IN H CSR signals which also originate at the CSR Address Selector. IN H CSR is a full-byte AA11-to-PDP-11 transfer. The CSR is cleared by an INIT (Initialize) signal from the PDP-11, with the exception of bit 07. This bit is set indicating that the display is ready to be serviced.

Status Bits Bus D07 and Bus D15 are generated within the scope control and can be read back to the PDP-11. Bit D07 indicates the display is ready to be serviced; bit D15 indicates a light pen is ready.

3.4.2 Intensification of a Point Upon Loading X-Axis

In order to intensify a point upon loading the X-axis, the following requirements must be met (see zone C6 of the circuit schematic):

a. The CSR must be set to the correct mode-control bit; bit 04 must be a logic 0 and bit 03 a logic 1.
b. The external X DAC module (DAC 0) must be selected by the DAC Address Selector. This function is performed by the SELECT DAC 0 signal that is also applied to pin 12 of E6 to initiate intensification.
c. The OUT LOW H DAC signal (DATO bus sequence) from the DAC Address Selector must be present indicating a PDP-11-to-AA11 low-order byte transfer.

3.4.3 Intensification of a Point Upon Loading Y-Axis

In order to intensify a point upon loading the Y-axis, the following requirements must be met (see zone C6 of the circuit schematic):

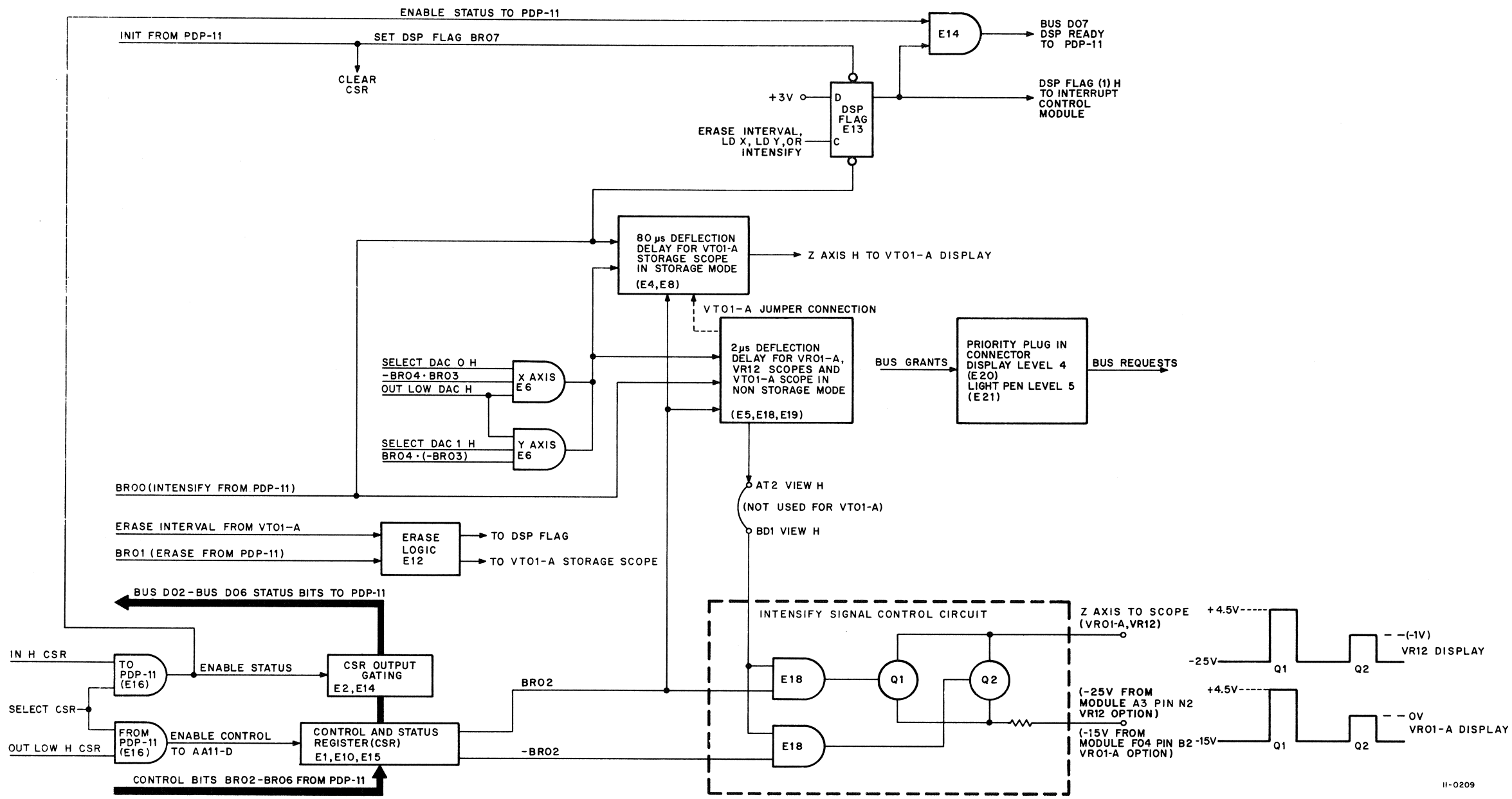


Figure 3-3 M799 Scope Control Module

a. The CSR must be set to the correct mode control bit. Bit 04 must be a logic 1 and bit 03 a logic 0.

b. The external Y DAC module (DAC 1) must be selected by the DAC Address Selector. This function is performed by the SELECT DAC 1 signal that is also applied to pin 12 of E6 to initiate intensification.

c. The OUT LOW H DAC signal (DATO bus sequence) from the DAC Address Selector must be present indicating a PDP-11-to-AA11 low-order byte transfer.

3.4.4 Intensification of a Preselected Point

In order to intensify a preselected point, an INTENSIFY (control bit 00) signal is supplied from the PDP-11. Any of the previously described types of intensification enables gate E7 in zone D5. The output of this gate is used to initiate a deflection delay and intensify pulse. The deflection delay provides sufficient delay of the intensify pulse until the dot can be repositioned on the display; the intensify pulse provides the actual scope intensification. The deflection delay and intensify pulse characteristics for each display are given in Table 3-2.

Table 3-2
Deflection Delay and Intensify Pulse Characteristics

Display	Deflection Delay (μs)	Intensify Pulse (μs)
VT01-A (Storage Mode)	80	20
VT01-A (Non-Storage Mode)	80	2
VR01-A	20	2
VR12	20	2

At the output of gate E7, circuitry differences begin to appear based on the particular display employed. Because of these circuitry differences, the deflection delay and intensify pulse for each display is described separately.

3.4.5 Scope Control Jumper Connections

When a particular display is to be used with the scope control, a pre-wired set of jumper connections is included on the back-plane wiring of the scope control module receptacle. To change to a new display, the existing set of jumpers must be removed and a new set of jumper wires installed. The back-plane designators have different designations than those shown on the schematic. The back-plane designations E04 and F04 correspond to A and B on the schematic, respectively. For example, E04S2 on the back-plane corresponds to AS2 on the schematic. Table 3-3 shows the jumper connections necessary for each type of display.

Table 3-3
Display Jumper Connections

VT01-A Jumpers	VR01-A Jumpers	VR12 Jumpers
E04R2 to E04C2 (AR2 to AC2)	E04R2 to E04C2 (AR2 to AC2)	E04R2 to E04C2 (AR2 to AC2)
E04K2 to E04C2 (AK2 to AC2)	E04K2 to E04C2 (AK2 to AC2)	E04K2 to E04C2 (AK2 to AC2)

Table 3-3 (Cont)
Display Jumper Connections

VT01-A Jumpers	VR01-A Jumpers	VR12 Jumpers
E04C1 to E04E2 (AC1 to AE2)	E04D1 to E04C2 (AD1 to AC2)	E04D1 to E04C2 (AD1 to AC2)
F04F1 to F04K1 (BF1 to BK1)	E04T2 to F04D1 (AT2 to BD1)	E04T2 to F04D1 (AT2 to BD1)
F04D2 to E04D1 (BD2 to AD1)	F04A1 to E04S2 (BA1 to AS2)	F04A1 to E04S2 (BA1 to AS2)
E04E1 to E03U2 (AE1 to E03U2)	F04S1 to E03U2 (BS1 to E03U2)	F04S1 to E03U2 (BS1 to E03U2)
E04D2 to E03E2 (AD2 to E03E2)	F04E2 to F04B2 (BE2 to -15V)	F04E2 to A03N2 (BE2 to -25V)
		F04D1 to E03H2 (BD1 to E03H2)

3.4.6 VT01-A Intensification (Storage Mode)

The deflection delay and intensify pulse circuitry for the VT01-A in the storage mode is shown in zones D6, D5, and D4 of the schematic. R3 and C22 form an RC network producing an 80-μs deflection delay, while R4 and C23 form an RC network producing a 20-μs intensify pulse. The output of this circuitry is called Z AXIS H and is applied via cable to the VT01-A scope.

3.4.7 VT01-A Intensification (Non-Storage Mode)

The deflection delay and intensify pulse circuitry for the VT01-A in the non-storage mode is shown in zones D4, D3, and D2 of the circuit schematic. The 80-μs deflection delay is produced across the parallel combination of capacitors C25 and C26 (BF1 is jumpered to BK1 for the VT01-A) and resistor R5. The 2-μs intensify pulse is developed across the RC network of R6 and C27. The intensify pulse output is coupled from NON STORE L (AC1) to NON STORE L (AE2) by a jumper wire and onto the display via the Z AXIS H line. During non-storage mode, the non-store output of pin AD2 grounds the non-store input to the scope. This point is not really at +10V during the storage mode.

NOTE
In order to develop the 2-μs intensify pulse, pin 5 of E18 must be high. In order to drive this point high, gate E17 must be enabled. E17 is enabled since control bit 02 must be a logic 0 for VT01-A non-storage mode.

3.4.8 VR01-A Display Intensification

The deflection delay and intensify pulse circuitry for the VR01-A is shown in zones D4, D3, and D2 of the schematic. The 20-μs deflection delay is developed across R5 and C26, while the 2-μs intensify pulse is developed across R6 and C27. This pulse is coupled from VIEW H (AT2) to VIEW H (BD1) via a jumper wire (zone C3) and is the input to a two-level intensity control circuit containing transistors Q1 and Q2. A second input to this circuit is control bit 02. If bit 02 is a logic 1, Q1 is turned on producing a high-intensify pulse of -15V to approximately +4.5V at Z AXIS (BS1). If bit 02 is a logic 0, Q2 is turned on producing a low-intensity pulse of -15V to

approximately 0V. A -15V reference at BE2 (zone B2) is supplied as a result of a jumper wire connecting BE2 to F04B2 on the back-plane.

NOTE

Pin 5 of E18 (zone C3) must be high (logic 1) in order to enable the intensify pulse circuit. This is accomplished by E17 going high. For the VR01-A, a jumper wire connects VIEW L (AS2) to VIEW L (BA1), which is the reset output of bit 02. As a result, both the set and reset output of bit 02 are applied to E17; no matter what state bit 02 is in, the output of E17 will be high.

3.4.9 VR12 Display Intensification

The deflection delay and intensify pulse circuitry for the VR12 is similar to that described for the VR01-A. One major exception is that the -V REFERENCE at BE2 is connected by jumper wire to A03N2 on the back-plane, providing a -25V reference instead of a -15V reference. A jumper wire connecting the reset output of bit 02 to the input to gate E17 is also provided for the VR12, just as for the VR01-A.

3.4.10 Scope Control Display and Light Pen Servicing

The scope control module contains a DSP RDY flip-flop which, when set, indicates that the display is ready to be serviced. The flip-flop is normally set by the INIT signal. When X- or Y-axis intensification or intensification of a preselected point is initiated, the flip-flop is reset as a result of the output of gate E7 (zone C4) going high. Pin 1 of E7 is the INTENSIFY command input, pin 13 is the X-axis intensification input, and pin 2 is the Y-axis intensification input. The DSP RDY flip-flop will then be clocked set by the trailing (positive-going) edge of the intensify pulse. The time from resetting the flip-flop to setting it is a function of the display used. For the VT01-A in storage mode, the flip-flop is reset for 100 μs; in non-storage mode, it is reset for 82 μs; for the VR01-A and VR12 scopes, the flip-flop is reset for 22 μs.

If control bit 06 is set as a result of the PDP-11 software and the DSP FLAG is raised, an interrupt will occur. This interrupt is due to bit 06 ANDed with the DSP FLAG (1) H at the input to the interrupt control module.

The scope control module also includes a light pen flag for a light pen option. If control bit 05 is set and the light pen flag is raised, an interrupt will occur. Light Pen Flag (1) H and bit 05 are also ANDed at the input to the interrupt control module.

3.4.11 Scope Control Priority Structure

Two integrated circuit plugs are provided on the M799 Scope Control Module to permit selection of priority levels for the display and for the light pen option, if included. The present configuration assigns the display to priority level 4 and the light pen to priority level 5. This can be changed simply by substituting a different plug in the plug-in receptacle on the module. The priority structure utilizes a request/grant scheme described in Chapter 2 of the *PDP-11 Interface Manual.*

CHAPTER 4
INSTALLATION AND ADJUSTMENTS

4.1 INSTALLATION PROCEDURES

The following paragraphs outline the recommended installation procedures for the AA11-D and scope option.

4.1.1 AA11-D Installation

Step	Procedure
1	Move the AA11-D into the installation area.
2	Unpack the AA11-D from shipping container and inspect the unit for damage. Any claims for damage should be made to the DEC district supervisor.
3	Remove tape and protective covering from modules and cables as required.
4	Mount the AA11-D system unit in the processor mounting box or in a BA11 expansion box; this will depend on system configuration. Install the system unit with screws provided.
5	Connect G772 digital power connector into AA11-D module receptacle A3.
6	If AA11-D is not the last device on the Unibus, connect M920 Unibus connector from receptacle A4B4 of previous device to receptacle A1B1 of the AA11-D. Continue Unibus from A4B4 of the AA11-D to receptacle A1B1 in the next device. **NOTE** **If AA11-D is to be last device on the Unibus, remove terminator from receptacle A4B4 of previous device and connect M920 Unibus connector from this point to A1B1 of the AA11-D. Also, install terminators in receptacle A4B4 of the AA11-D.**
7	Mount H704-C, -H Analog Power Supply Assembly in an available location at the bottom of the cabinet.
8	Connect the analog power supply cable (7007116-0-0) from the power supply to the AA11-D system unit. **NOTE** **The analog power supply cable can be identified by solderless connectors at one end of the cable.** The G767 connector at one end of the cable plugs into module receptacle B3 of the AA11-D system unit. The other end (solderless connectors) of the cable connects to the power supply in accordance with drawing D-UA-AA11-D-0 (Digital-to-Analog Control Assembly).

Step	Procedure
8 (continued)	**NOTE** **The analog power supply cable is 10-ft long. Therefore, if the analog power supply and AA11-D are located in different cabinets, they must be situated within approximately 10 ft of each other.**
9	Check to see that all modules are properly installed and located in accordance with module utilization drawing D-MU-AA11-0-MU.
10	Apply power and allow sufficient warm-up period. Using the precision voltage standard (see Table 5-2), perform the following checks and adjustments: *a.* Check that the voltage at pin A2 of module receptacle A3 is between +4.75 and +5.25V. *b.* Check that the voltage at pin B2 of module receptacle A3 is between -15.75 and -14.25V. *c.* Adjust the +15V analog voltage at pin D1 of module receptacle B3 so that it is between +14.99 and +15.01V. *d.* Adjust the -15 analog voltage at pin E1 of module receptacle B3 so that it is between -14.99 and -15.01V.
11	Load and run the AA11 DAC Calibration Diagnostic (MAINDEC-11-D6BA). Use a test oscilloscope for the square-wave test and connect the scope probe to the output of the DAC module (pin C1). Tie the return to pin F1 of the same module. Use short ground lead to minimize noise pickup. **NOTE** **The square-wave test is provided as a convenience for measuring settling time of the DAC. Most oscilloscopes do not provide a true measurement when viewing settling time to within 2.5 mV on a 10V step function. Therefore, this test need not be performed unless there is a doubt as to settling. If this test is made, a Tektronix 543A oscilloscope with a 1A5 preamp on the 10-mV scale (50V range) is recommended.**
12	Substitute the precision voltage standard (see Table 5-1) for the oscilloscope when performing the DAC calibration test. The standard should be in NULL METER mode. Verify readings in accordance with calibration sheets supplied with equipment. Readings should fall within ±0.025 percent of full-scale voltage. If readings are not within tolerance, refer to DAC module offset, gain, and calibration procedures (Paragraphs 4.2.2 through 4.2.4).

4.1.2 Scope Option Installation

Step	Procedure
1	Unpack display from shipping container and inspect the unit for damage. Report any damage to DEC district supervisor.
2	Remove any tape or protective covering from display.
3	Mount the display in a convenient place. The VT01-A display is table-mounted, the VR01-A is rack-mounted; the VR12 can be table-mounted or rack-mounted. Connect the oscilloscope cable from the display to the AA11-D.

NOTE
The display must be located within 12 ft of the AA11-D because of the cable length (12 ft).

4	Plug ac power cord from display into an ac receptacle in the cabinet to reduce ripple and noise pickup.
5	Make sure that scope option modules are properly installed in accordance with module utilization drawing D-MU-AA11-0-MU.
6	Ensure that appropriate jumper connections have been made on back-plane of control module. See Table 3-3 for the jumper connections associated with each display.
7	DAC 0 is the module used to drive the X-axis of the display and DAC 1 is the module used to drive the Y-axis of the display. These DAC modules should be adjusted for full-scale deflection in accordance with the following:

Display	Full-Scale Deflection
AA11-A (VT01-A)	± 1V
AA11-B (VR01-A)	±10V
AA11-C (VR12)	± 5V

(Refer to A614 DAC module gain adjustment, Paragraph 4.2.3).

8	Load and run AA11-A, -B, -C Scope Control Test (MAINDEC-11-D6CA). Observe the various patterns and refer to the applicable display manuals for corrective maintenance.

4.2 ADJUSTMENT

4.2.1 H704-C/H704-H Power Supply Adjustment

Figure 4-1 shows the location of the +15V and -15V adjustment potentiometers. Adjust the +15V and -15V potentiometers on the power supply for +15 ±0.010V and -15 ±0.010V. Pins AD2 (+15V), AE2 (-15V), and AF2 (analog common) of any DAC module can be used as access points.

4.2.2 A614 DAC Module Offset Adjustment

The offset of each DAC module should be checked as required, using the AA11 DAC Calibration Diagnostic Program or a manually entered program (refer to Chapter 2 for a programming example to provide digital input). Allow a five-minute warm-up before attempting offset checks or adjustments.

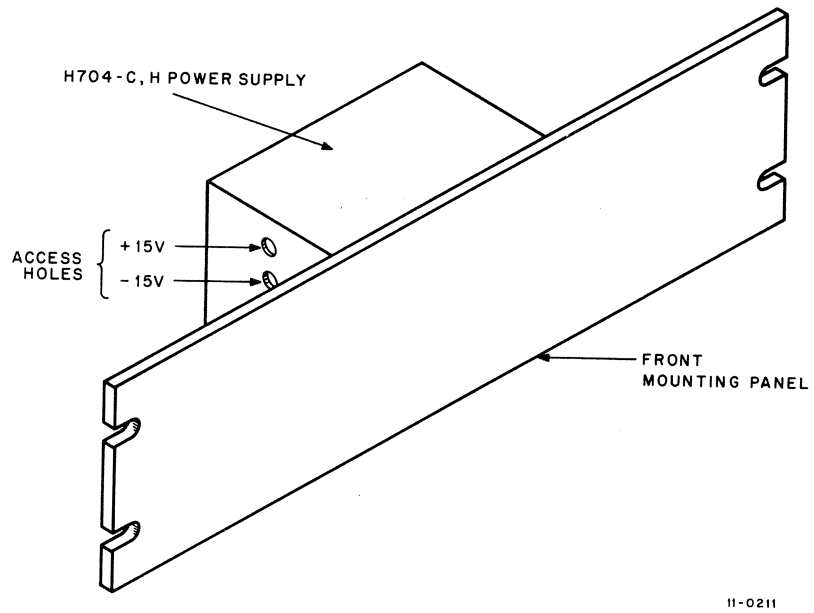


Figure 4-1 H704-C, -H Power Supply Assembly

To adjust offset:

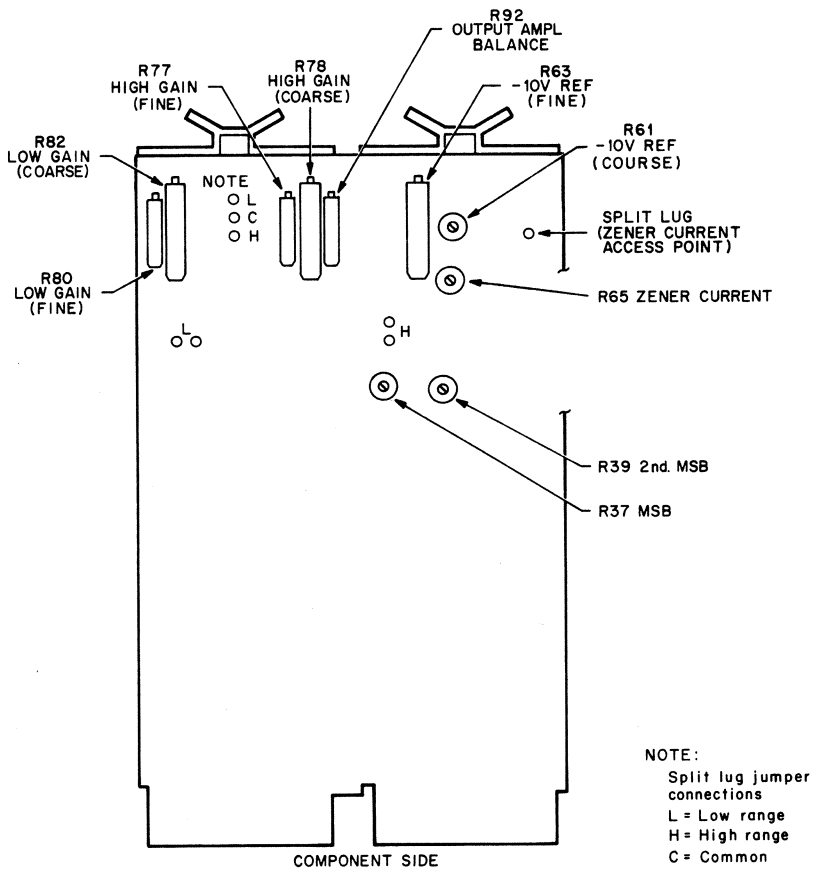
Step	Procedure
1	Connect null meter between AC1 of DAC module and analog common (AF2). This connection can also be made at the end of the output cable.
2	Provide a digital input 000000_8 to the DAC module. (Refer to Chapter 2 for a sample program or use diagnostic program.)
3	Adjust output amplifier balance potentiometer R92 (Figure 4-2) for an output of 0 ±0.025 percent of full-scale voltage, or 1 mV, whichever is greater.

4.2.3 A614 DAC Module Gain Adjustment

The gain of each DAC module should be checked daily before beginning normal operation and adjusted, if necessary, using the following procedure. Prerequisites for this adjustment are a five-minute warm-up and offset within tolerance. If the following adjustments cannot be made, perform the complete calibration procedure described in Paragraph 4.2.4.

To adjust gain for high range:

Step	Procedure
1	Connect null meter between analog output (AC1) and analog common (AF2). This connection can also be made at the end of the output cable.
2	Provide a digital input of 004000_8. (Refer to Chapter 2 for a sample program or use diagnostic program.)
3	Adjust coarse gain potentiometer R78 and fine gain potentiometer R77 (Figure 4-2) for an output of full-scale ±0.025 percent of full-scale voltage.



DAC-0008

Figure 4-2 A614 DAC Module Adjustment Locations

To adjust gain for low range:

Step	Procedure
1	Connect null meter between analog output (AC1) and analog common (AF2). This connection can also be made at the end of the output cable.
2	Provide a digital input of 004000_8. (Refer to Chapter 2 for a sample program or use diagnostic program.)
3	Adjust coarse gain potentiometer R82 and fine gain potentiometer R80 for an output of full-scale ±0.025 percent of full-scale voltage.

4.2.4 A614 DAC Module Calibration Procedure

The following procedure is recommended for complete calibration of a DAC module, such as may be required after a module repair. This procedure has been verified at the factory and should be followed as closely as possible for best results. Because of the interaction of some adjustments, certain steps may need to be repeated before proceeding as noted.

Step	Procedure
1	Allow a five-minute warm-up.
2	Verify that +15V and -15V outputs are within 10 mV of nominal value. If not, adjust these outputs. (Refer to Paragraph 4.2.1.)
3	Connect null meter between reference Zener test point (split lug, Figure 4-2) and analog common (AF2). Adjust reference Zener current potentiometer R65 for -6.625 ±0.001V.
4	Connect null meter between -10V reference (AH2) and analog common (AF2). Adjust -10V reference coarse potentiometer R61 and -10V reference fine potentiometer R63 for an output of -10 ±0.0005V.
5	Repeat steps 3 and 4 as required.
	NOTE **Steps 6 through 9 are used for high-gain range (±10V). If module is used for low-gain range (±5V), proceed with step 11.**
6	Connect null meter between analog output (AC1) and analog common (AF2). Provide a digital input of 005777_8. Adjust output amplifier balance potentiometer R92 (see Figure 4-2) for an output of -5.0049 ±0.0005V.
7	Provide a digital input of 004000_8. Adjust coarse gain potentiometer R78 and fine gain potentiometer R77 for an output of -10 ±0.0005V.
8	Provide a digital input of 006000_8. Adjust second MSB potentiometer R39 for an output of -5 ±0.0005V.
9	Provide a digital input of 000000_8. Adjust MSB potentiometer R37 for an output of 0 ±0.0005V.
10	Repeat steps 6 through 9 as required for optimum results.
	NOTE **Steps 11 through 15 are for low-gain range (±5V) usage only. If module is used for high-gain range (±10V), proceed with step 16.**
11	Connect null meter between analog output (AC1) and analog common (AF2). Provide a digital input of 005777_8. Adjust output amplifier balance potentiometer R92 (see Figure 4-2) for an output of -2.5024 ±0.0005V.
12	Provide a digital input of 004000_8. Adjust coarse gain potentiometer R82 and fine gain potentiometer R80 for an output of -5 ±0.0005V.
13	Provide a digital input of 006000_8. Adjust second MSB potentiometer R39 for an output of -2.5 ±0.0005V.
14	Provide a digital input of 000000_8. Adjust MSB potentiometer R37 for an output of 0 ±0.0005V.
15	Repeat steps 11 through 14 as required for optimum results.
16	Table 4-1 defines the theoretical analog outputs (both the high- and low-gain ranges) for significant digital inputs. Check these outputs as desired.

Table 4-1
A614 DAC Module Outputs for Significant Digital Inputs

Digital Input (octal)	Analog Output	
	±5V	±10V
000000	0.0000	0.0000
000001	0.0024	0.0049
000002	0.0049	0.0098
000004	0.0098	0.0195
000010	0.0195	0.0391
000020	0.0391	0.0781
000040	0.0781	0.1562
000100	0.1562	0.3125
000200	0.3125	0.6250
000400	0.6250	1.2500
001000	1.2500	2.5000
002000	2.5000	5.0000
003777	4.9976	9.9951
004000	-5.0000	-10.0000
006000	-2.5000	-5.0000
007000	-1.2500	-2.5000
007400	-0.6250	-1.2500
007600	-0.3125	-0.6250
007770	-0.0195	-0.3125
007774	-0.0098	-0.0195
007776	-0.0049	-0.0098
007777	0.0024	0.0049

CHAPTER 5
MAINTENANCE

5.1 PREVENTIVE MAINTENANCE

A systematic preventive maintenance program can be a useful tool to prevent system failures. Proper application of a preventive maintenance program is an aid to both serviceman and user, because detection and prevention of probable failures can substantially reduce maintenance and downtime.

Scheduling of computer usage should always include time for maintenance. Careful diagnostic testing can indicate problems which may only occur intermittently during on-line operation.

Weekly program checks and thorough preventive maintenance should be followed, based on the following criteria:

electrical: 1000 hours
mechanical: 500 hours

or at least quarterly.

5.1.1 Preventive Maintenance Tasks

The following tasks should be performed quarterly:

Step	Procedure
1	Clean the exterior and interior of the equipment cabinet using a vacuum cleaner, air blower, or a brush with long soft bristles, and/or cloths moistened in nonflammable solvent. If an air hose is used for cleaning, do not disturb components or wiring.
2	Lubricate hinges, slide mechanisms, and caster, with a light machine oil. Wipe off excess oil.
3	Visually inspect equipment for general condition.
4	Inspect all wiring and cables for cuts, breaks, fraying, wear, deterioration, kinks, strains, and mechanical security. Tape, solder, or replace any defective wiring or cable covering.
5	Inspect the following for mechanical security: switches, control knobs, lamps, connectors, transformers, fans, capacitors, etc. Tighten or replace as required.
6	Inspect all module mounting panels to ensure that each module is securely seated in its connector. Remove and clean any module that may have collected dirt or dust due to improper air filter servicing.
7	Inspect power supply components for leaky capacitors, overheated resistors, etc. Replace any defective components.
8	Check the output voltages (+15V and -15V) and ripple content of the H704-C, -H analog power supply as specified in the logic handbook for the H704 Supply. Use a multimeter to make these measurements without disconnecting the load. Use an oscilloscope to measure p–p ripple on all dc outputs of the supply. The outputs of the supplies are adjustable; therefore, if any output voltages are not within the specified tolerance, readjust the output voltages. If the desired output voltages are not attainable, initiate power supply maintenance. If ripple content is not within specifications, the supply is considered defective and corrective maintenance should be performed.
9	Run AA11 DAC calibration and scope control diagnostic programs to verify proper equipment operation.
10	Enter preventive maintenance results in a log book.

5.2 CORRECTIVE MAINTENANCE

When performing maintenance on the AA11-D system and scope options, ensure that the input conditions required to produce a specified output are met; otherwise, erroneous output readings may result indicating a nonexistent fault.

Two MAINDEC diagnostic programs are provided for system checkout – the AA11 DAC Calibration Diagnostic (MAINDEC-11-D6BA) and the AA11-A, -B, -C Scope Control Test (MAINDEC-11-D6CA).

5.2.1 AA11 DAC Calibration Diagnostic Program

The AA11 Calibration Diagnostic Program assists in the testing and calibration of up to four DAC modules, using a PDP-11 Computer. The diagnostic is subdivided into the following four main tests:

a. DAC Test – This test is used to determine if the DAC output is correct with respect to the input. Extended sign bits (15 through 12) are checked to ensure they retain the same value as bit 11 (sign bit).

b. Calibration Test – This test checks the accuracy of the DAC by feeding a known value into the DAC and verifying that the output is the analog equivalent of the input (refer to Table 4-1). The input is loaded from PDP-11 switches 11 through 0. Switches 14 through 12 specify the DAC to be tested.

c. Ramp Test – The DAC selected by switches 14 through 12 is cleared and incremented (or decremented) at a rate controlled by PDP-11 switches 7 through 0 until the maximum value is reached.

d. Square-Wave Test – The DAC selected by switches 14 through 12 is set to 0 and +full scale (-full scale of polarity negative) at a rate controlled by switches 7 through 0.

5.2.2 AA11-A, -B, -C Scope Control Diagnostic

The Scope Control Diagnostic is used to checkout the scope control module. The diagnostic is subdivided into the following tests.

a. Control and Status Register (CSR) Test – This test determines that all bits capable of being loaded into the CSR are loaded properly and that all bits that can be read out of the CSR are read out properly.

b. Interrupt Test – This test checks whether the display will cause an interrupt with the processor at priority level 3. An interrupt should occur since the display is of higher priority. The test also checks whether the display will cause an interrupt with the processor at priority level 4. In this case, an interrupt should not occur.

c. Display Test – The display is tested by creating various patterns (horizontal line, vertical line, square, x, character set). High and low intensity are also checked by displaying a line in both high and low intensification.

d. Erase Test – The erase test consists of filling the display tube with points in storage mode and then issuing an ERASE command to determine if the whole screen is erased.

5.3 RECOMMENDED SPARE PARTS

Most of the modules used in the AA11-D and scope options are also used in the PDP-11. Two exceptions are the A614 DAC Module and the M799 Scope Control Module. The spare parts inventory should be established with these exceptions in mind.

5.4 TEST EQUIPMENT

Table 5-1 lists the test equipment recommended for maintenance of the AA11-D and scope options.

Table 5-1
Recommended Test Equipment

Nomenclature	Manufacturer
Oscilloscope	Tektronix 453 (or equivalent)
Precision DC Voltage Standard	Electronic Development Corporation VS-11N (or equivalent)
Multimeter	Tripplett (or equivalent) (10,000 Ω/volts)

CHAPTER 6
ENGINEERING DRAWINGS

Engineering drawings pertinent to the AA11-D D/A Subsystem are listed in Table 6-1 and included in the print set and in a separate manual entitled *AA11-D D/A Subsystem, Engineering Drawings.*

6.1 DRAWING CODES

Digital Equipment Corporation's engineering drawings are coded to designate drawing type, major assembly, and series. A drawing number such as D-BS-AA11-D-01 contains the following information:

D	Size
BS	Type (Block Schematic)
AA11	Equipment designation
D	Manufacturing variation
01	The drawing number of a series

The drawing type codes are designated as follows:

AD	Assembly Drawing
BS	Block Schematic
DI	Drawing Index
IC	Interconnecting Cabling
MU	Module Utilization Drawing
FD	Flow Diagram
ML	Master Drawing List
SP	Specification
UA	Unit Assembly

6.2 WIRE LIST

The wire list supplements the logic drawings and discussions. It lists those module pins under common signal name that are wired together, and allows a signal to be traced from its source to all inputs. It is also possible to trace from inputs to source, but this is more easily accomplished by using the print prefix of the signal name.

Each signal name entry in the wire list notes: the signal name (RUN NAME and A/P); the module pin for this entry (PIN NAME); the order in which the pin is wire wrapped (BAY ORDER); the level at which the wrap is made (Z); the incorporation of the wire into a cable (C in column Q); the the drawing(s) upon which the module pin appears (DRAW). The manufacturing process ensures that specific module pins are interconnected; the order or level of interconnection is not tested or guaranteed.

Table 6-1
List of A11 Drawings

Drawing Number	Title
D-UA-AA11-D-0	Digital to Analog Control Assy.
D-IC-AA11-D02	Option Cables
D-BS-AA11-D-03	D-A Converters
D-BS-AA11-D-04	Interface
D-IC-AA11-D-05	AA11-D Bus & Power Connections
K-WL-AA11-D-WL	Wire List
D-BS-AA11-E-3	Color Control
D-MU-AA11-0-MU	Module Utilization
D-CS-A614-0-1	12 Bit Polar D/A Connector
B-CS-G772	Digital Power Connector
D-UA-H704-C-0	H704-C Power Supply
C-CS-M105	Address Selector
D-CS-M782	Interrupt Control Module
B-CS-M784	Unibus Receiver
D-CS-M799-0-01	Display Control
C-CS-M920	Internal Bus Connector
D-CS-M7990-0-1	LAB-11 Color Control
D-IA-7007116-0-0	Cable, Power Supply
D-IA-7007122-0-0	Cable Control VR12
D-IA-7007138-0-0	Cable Assy. VT01-A
D-IA-7007139-0-0	Cable Scope RM503
D-IA-7008550-0-0	Display Cable (AA11-E)

APPENDIX A
AA11-E VR20 COLOR DISPLAY CONTROL

A.1 INTRODUCTION

The AA11-E Display Control is one of several display options that can be used with the AA11-D subsystem. The AA11-E is actually an AA11-C Display Control that has been modified by the addition of an M7990 color control module and by certain wiring changes.

The AA11-E consists of the following modules:

M105	Address Selector
M782	Interrupt Control
M799	Display Control
M7990	Color Control

The general specifications for the AA11-E are:

Display Time	Green	18 μs deflection time per point 1 μs intensify time
	Red	14 μs deflection time per point 5 μs intensify time
Color Switching Time	Red to Green	1.6 ms
	Green to Red	0.3 ms
Maximum Cable Length		100 ft of Belden 8778 cable or equivalent

A.2 PROGRAMMING

The AA11-E operates under software control from the PDP-11. The control and status register is the same one shared by all AA11-D subsystem options. Figure A-1 shows the register bits pertinent to the AA11-E option.

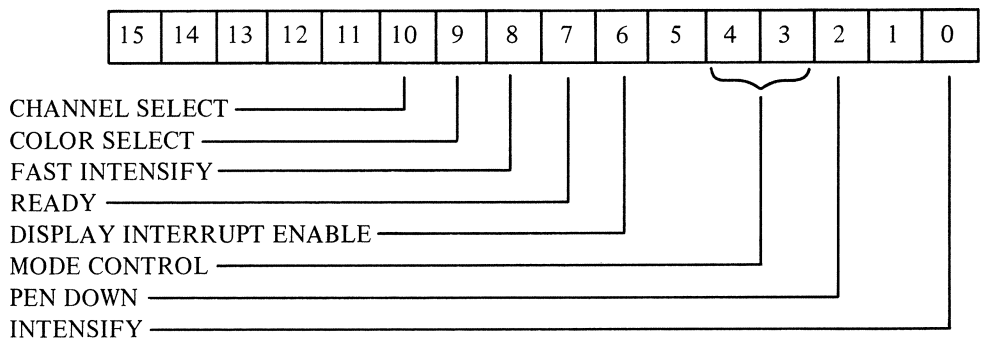


Figure A-1 Register Bits

Bit 10 (CHANNEL SELECT) – This bit selects the channel on which the dot will be displayed (Read and Write).

Bit 10 = 0 Channel 1
Bit 10 = 1 Channel 2

Bit 09 (COLOR SELECT) – This bit determines the intensification color of a dot. Initialize sets the green mode (Read and Write).

Bit 09 = 0 Green
Bit 09 = 1 Red

Bit 08 (FAST INTENSIFY) – This bit, when set, intensifies a dot in 1 μs and sets the DSP RDY flag (Write only).

Bit 07 (READY) – This is a status bit which represents the state of the DSP RDY flip-flop in the scope control. If set, it indicates the display has completed an intensification or a color change (Read only).

Bit 06 (DISPLAY INTERRUPT ENABLE) – This bit is a control bit that, when present, allows the DSP RDY flag to cause a program interrupt whenever intensification or color change has been completed. The bit is set under PDP-11 software control and is cleared by INIT (Read and Write).

Bits 04 and 03 (MODE CONTROL) – These two bits determine whether there will be intensification loading the X-axis, the Y-axis, or neither (Read and Write).

Bit 04	Bit 03	
0	0	neither mode
0	1	intensify on loading the X-axis
1	0	intensify on loading the Y-axis
1	1	plotter mode

Bit 02 (PEN DOWN) – This bit provides an output to a plotter for up-down pen control (Read and Write).

Bit 02 = 0 Low (0V) output to plotter
Bit 02 = 1 High (+3V) output to plotter

Bit 00 (INTENSIFY) – This bit, when present, initiates the deflection delay and intensify circuitry, and clears the DSP RDY flip-flop. The deflection delay allows time for the CRT beam to deflect to its new coordinates. At the end of the delay, which varies as follows, an intensify pulse is generated to intensify a point at the new coordinates and to set the DSP RDY flip-flop (Write only).

a. Changing from red to green 1.6 ms
b. Changing from green to red 0.3 ms
c. No change in color 19 μs

A.2.1 Programming Example

The following sample program displays two dots on the VR20. One dot will be displayed in green on channel 1 and another in red on channel 2.

	Symbolic	Address Contents	Comments
	.=1000		
LOOP:	TSTB @ # CSR	1000/105737	
		1002/176756	; display ready?
	BPL LOOP	1004/100375	; no; wait
	CLR @ # DAC0	1006/5037	; set X coord = 0
		1010/176760	; DAC X status address
	CLR @ # DACY	1012/5037	; set Y coord = 0
		1014/176762	; DAC Y status address
	MOV # 1, @ # CSR	1016/12737	; intensify a point,
		1020/0001	; on chan 1,
		1022/176756	; in green.
LOOP 1:	TSTB @ # CSR	1024/105737	
		1026/176756	; display ready?
	BPL LOOP 1	1030/100375	; no: wait
	MOV #3001, @ # CSR	1032/12737	; intensify a point,
		1034/3001	; on chan 2,
		1036/176756	; in red
	BR LOOP	1040/757	; do it again

NOTE: 1. **If the channel or color is changed before the display flag is set the intensify pulse may be inhibited.**

2. **Unlike the AA11-C bit 2 is not used for HI/LO intensify.**

A.3 DETAILED DESCRIPTION

The logic control for the AA11-E consists of the M799 and M7990 modules. The following discussion refers only to the M7990 module. A description of the M799 module is covered in Paragraph 3.4 of this manual.

A.3.1 Intensifying Point – No Color Change

Dots may be intensified at the rate of 19 μs per dot. When the program issues an intensify command, the signal is delayed 14 μs in the M799 module. This delayed signal (NON-STORE L) is fed to pin S1 (M7990). If the color flip-flop (E2-M7990) is in the green mode (pin 6 high), then NON-STORE L is delayed an additional 4 μs (pin 6, E8-M7990). A 2-microsecond pulse (COL NON-STORE) is developed (pin 11, E8-M7990 and pin 4 E7-M7990) and sets the display flag. This flag is DISP FLAG (1) H on the M799. At the same time, COL NON-STORE is ANDed with pin 5, E9-M7990 and an INTENSIFY pulse (+4V to -2V) is produced by transistors Q1, Q2, and Q3 at pin R1 (Z input).

A.3.2 Intensifying Point – Color Change

Normally the program displays all green dots, then switches colors to display all red dots. The delay circuit that operates between color changes operates as follows.

The signal SELECT CSR 6 H (pin A1, M7990) and the signal OUT HIGH CSR (pin B1, M7990) are ANDed at E1 and the resultant signal clocks pin 3 of E2. The change of state at pin 6 of E2 either triggers one-shot E4 or one-shot E11. For a change to green, pin 6 of E11 goes low for 1.6 μs. During this period, the DISP FLAG READY signal (pin E1) and COL NON-STORE (pin V1) are inhibited. This means that the DONE flag (bit 07 of the CSR) cannot be set and no intensifying takes place. At the end of this delay, pin 6 of E11 goes high to produce COL NON-STORE (pin V1). The COL NON-STORE sets the DONE flag and intensifies a point provided bit 0 of the CSR has been set.

A.3.3 Channel Selection

The M7990 module also selects the VR20 channel that is to be used for displaying the point. A channel is selected by means of bit 10 in the CSR. Issuing any command to the upper byte of the CSR produces SELECT CSR 6 H and OUT HIGH H CSR. These two signals clock the channel select flip-flop (E2) to one of two states depending on the condition of BR10 H (pin F1).

A.3.4 Speaker Driver

The speaker control on the M7990 module consists of three flip-flops and a driver transistor. Byte bit 0 (BUS A00 H) is applied to a divide-by-8 circuit (E6 and E9) which turns Q4 on or off. The collector of Q4 switches -15V to a speaker volume control potentiometer. The volume control is not part of the M7990 but is connected to module pins P2 and F2.

A.4 FIELD INSTALLATION

The AA11-D subsystem can be used with a number of display options and normally is shipped with a pre-wired set of jumpers for the AA11-E display control option. If a field change is required, it is necessary to modify the existing display option so that it becomes an AA11-E. Table A-1 lists the set of jumpers that must be added. Table 3-3 lists the jumpers to be deleted, depending on which of the options has been installed previously.

Table A-1
VR20 Connections

Signal Name	Connection	Remarks
PEN DONE H	E04K2 to E03C2	Add
DISP FLAG (1) H	E04L1 to F02U1	Delete
NON-STORE L	F03S1 to E04C1	Add
COL NON-STORE L	F03V1 to E04E2	Add
DISP FLAG (1) H	E04L1 to F03D1	Add
DISP FLAG (1) H	F03E1 to F02U1	Add
STORE H	E04D1 to E04T1	Add
VIEW L	F04A1 to E04S2	Add
LTC L	A03P2 to E03U2	Add
BR08 H	F03D2 to F01U1	Add

After the wiring changes are completed, plug the modules into the AA11-D as shown in Table A-2.

Table A-2
Module Locations

Module	Slot
M105	E02 (Cut Jumpers for address 176756)
M782	F02 (Cut Jumpers for vector 140)
M957 (cable)	E03
M7990	F03
M799	EF04

A.4.1 Color Delay Adjustment

The adjustments provided in the following procedure are on the M7990 module which is located in slot F03.

Step	Procedure
1	Turn off the VR20 display.
2	Perform the color delay adjustment test which is part of MainDEC-11-D6FA.
3	Adjust the green to red delay as follows: *a.* Attach a scope probe (Tektronix Model 453 oscilloscope or equivalent) to TP2 which is next to the left potentiometer on the M7990 module. *b.* Set the oscilloscope at 50 μs/cm and 2 V/cm. *c.* Adjust the potentiometer for a negative-going pulse width of 300 μs (see Figure A-2).
4	Adjust the red to green delay as follows: *a.* Attach the scope probe to TP3 which is next to the right potentiometer on the M7990 module. *b.* Set the oscilloscope at 0.5 ms/cm and 2 V/cm. *c.* Adjust the potentiometer for a negative-going pulse width of 1.6 ms (see Figure A-2).

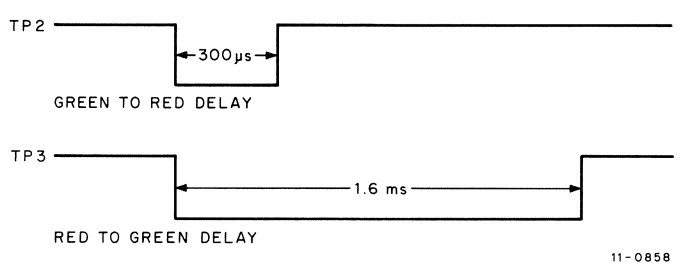


Figure A-2 Color Delay Adjustment Waveforms

A.4.2 Amplifier Calibration

Do not turn on the VR20 with the signal cable connected until the following adjustment has been completed. A blown fuse may result if the amplifier is not calibrated.

Step	Procedure
1	Remove the BC12A signal cable from the rear of the VR20 Display.
2	Attach oscilloscope probes at pins A02A (X deflection) and A03A (Y deflection) of the VR20. These pins are located on the R series connector block which is at the left side of the unit. Set both oscilloscope channels to 1V/cm dc.
3	Adjust the position pots for 0 volts. These pots are located on top of each A225 module.
4	Replace the signal cable.
5	Display the rectangle which is part of MainDEC-11-D6FA. Using the gain potentiometer on the A225 modules, adjust the rectangle for 6-3/4 inch vertical and 9-inch horizontal lines.

A.4.3 Acceptance Test

Run MainDEC-11-D6FA program. Requirements for acceptable operation are given in Table A-3.

Table A-3
Acceptance Requirements

Test Description	Requirements
Command and status register test. Displays blinking dot at center of screen.	Must run for two minutes. Rings bell every 100 pulses.
Display horizontal line.	Line must be free of oscillation and ripple.
Display vertical line.	Line must be free of oscillation and ripple.
Display rectangle	Lines must be free of oscillation and ripple. Can be used to calibrate X and Y gain on VR20.
Display X	Must be free of oscillation and ripple.
Display alphanumeric characters across center of screen	Characters must be clearly defined with no dots out of line by more than two dot distances.
Display channel 1 and channel 2 at center of the screen	Switch the VR20 to CHANNEL 1. Channel 2 display should disappear. Switch to CHANNEL 2. Channel 1 display should disappear.
Display rectangle and a small x	Switch to CHANNEL 1; the display should be green. Switch to CHANNEL 2; the display should be red. With the VR20 set to CHANNEL 1 & 2, the displays (red and green) should overlay and be off by no more than one dot position.
Display diagonal line	This test checks the control settling time. The line must be linear with no dot smear.

A.5 TROUBLESHOOTING

A troubleshooting chart is provided in Table A-4.

Table A-4
Troubleshooting Chart

Problem	Probable Cause
Fails command and status register test	M799 module. The diagnostic listing explains the cause of the error.
Horizontal line test is non-linear or noisy	DAC0 is not calibrated or is failing. Faulty display cable or AA11-FA.
Vertical line test is non-linear or noisy	DAC1 is not calibrated or is failing. Faulty display cable or AA11-FA.
Display X test is smearing at extremities	Signal COL NON-STORE L is not being delayed 15 μs in M799 module (E2 or E5).
Display CHANNEL 1 & 2 test fails	M7990 module.
Speaker doesn't sound in display alpha-numeric characters speaker test	Speaker driver circuits on M7990 module.
Failures of display rectangle and small x test:	
1. Displays green only	COL RED L signal not present on M7990 module.
2. Displays red only	Color bit grounded in display cable or AA11-FA. Signal COL RED L is always low.
3. Display is not overlaid over whole screen	Red and/or green time delays are not long enough. E4 or E11 on M7990 module is failing.
4. Dot smear in green only	Signal COL NON-STORE L is not delayed 4 μs from signal NON-STORE L on M7990 module. Red to green time delay is not 1.6 ms. E11 on M7990 is failing.
5. Dot smear in red only	Green to red time delay is not 300 μs on M7990 module. E4 on M7990 is failing.
6. Dots are overlayed at outer edges of the screen but are more than two dot distances apart in center. (It is normal for dots to be better overlayed in center of screen.)	G839 module in VR20 is not calibrated correctly. Refer to VR20 User's Manual DEC-12-HRSA-D.

NOTE
The AA11-FA front panel normally isolates the line clock signal (LTCL) from the VR20. If the display cable is plugged directly into the VR20, this line clock signal is fed into the Z direct input. No harm results, but 60 Hz ripple may appear in the display.