WARRANTY

All TEKTRONIX instruments are warranted against defective materials and workmanship for one year. Any questions with respect to the warranty should be taken up with your TEKTRONIX Field Engineer or representative.

All requests for repairs and replacement parts should be directed to the TEKTRONIX Field Office or representative in your area. This will assure you the fastest possible service. Please include the instrument Type Number or Part Number and Serial Number with all requests for parts or service.

Specifications and price change privileges reserved.

U.S.A. and foreign Tektronix products covered by U.S. and foreign patents and/or patents pending.

TEKTRONIX is a registered trademark of Tektronix, Inc.

TEKTRONIX®

P7001
PROCESSOR

SERVICE

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077

Serial Number _____

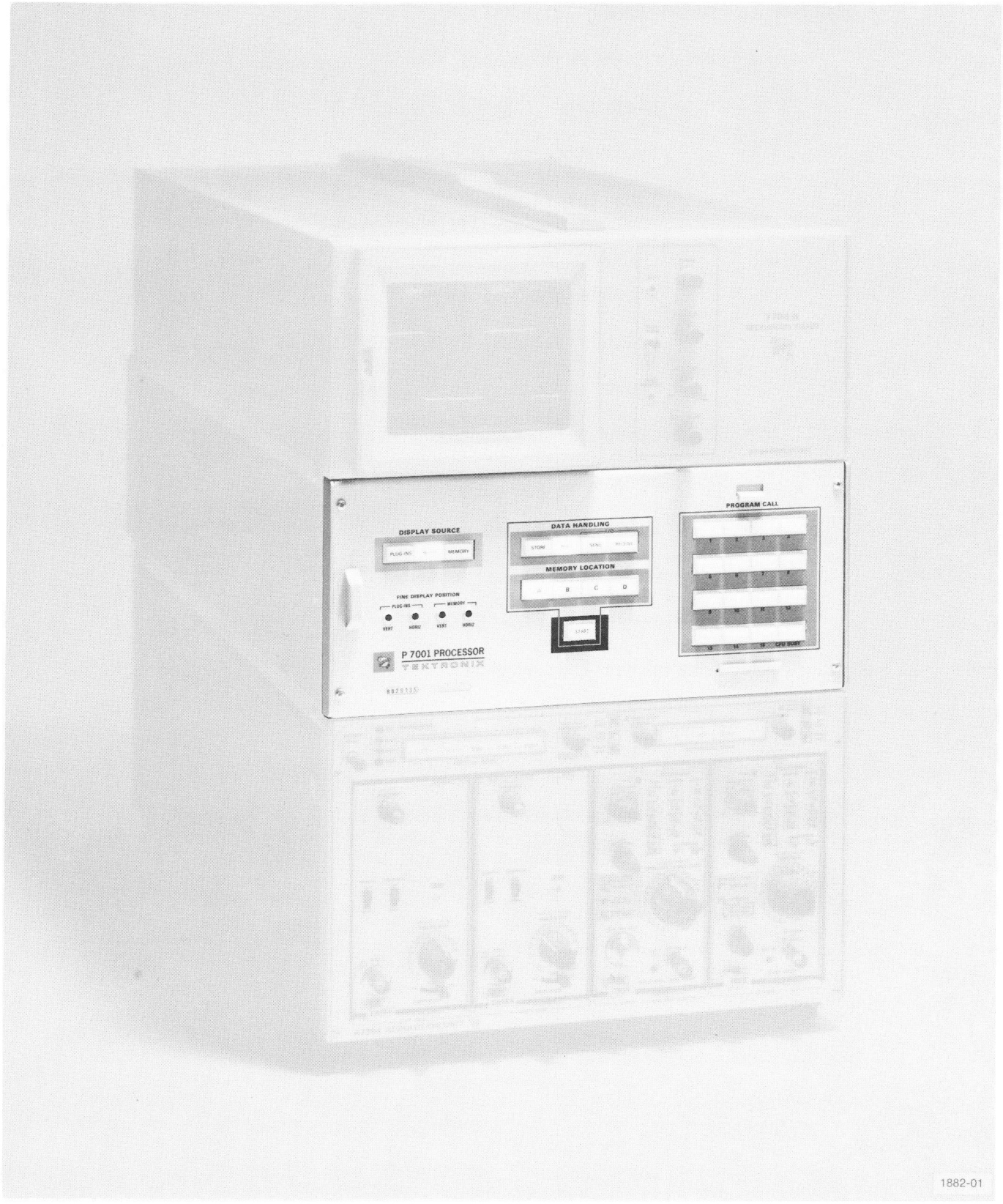
First Printing JAN 75

070-1882-00

TABLE OF CONTENTS

@

@



The P7001 Processor
as part of the Digital Processing Oscilloscope.

@

SECTION 1

CIRCUIT DESCRIPTION

The P7001 is essentially an interface between the 7704A Oscilloscope and a controller (minicomputer) or calculator. However, when the P7001 is not connected to a controller/calculator, it can operate alone and provide the 7704A with waveform storage capability. The circuit operation of the P7001 must be described while it is part of the DPO --- Digital Processing Oscilloscope.

Block Diagram

Block diagram #1 (pull-out at the rear of this manual) shows the complete DPO. The left side of the diagram is the A7704 Acquisition Unit. In the center is the P7001 Processor Unit. On the right is the D7704 Display Unit and, in the lower right corner is a block indicating the Controller or Calculator to which the DPO may be connected.

The information paths in the DPO can be divided loosely into three catagories: 1) the Analog Signal path, 2) Readout Information path, and 3) Communication path between cards in the processor.

Analog Signal Paths. If the front panel PLUG-INS button has been pressed, the vertical and horizontal analog information from the Plug-ins passes through the channel switches to the Display Unit for display. This information is also sampled by the Sample & Hold circuits and sent to the A-D Converter where it is digitized and discarded. If the Front Panel STORE and START buttons are

pressed, the digitized information is no longer discarded, but put into Memory.

The Display Generator converts digital information from memory into analog information and has it available at the channel switches. If the PLUG-INS button is pressed, the information does not get through the channel switches. However, if MEMORY or BOTH is pressed, the Display Generator sends the information through the channel switches to the Display Unit for display.

Readout Information. The second signal path is readout information. The analog row and column current steps from the Acquisition Unit readout system is monitored by the Readout Interface card. The Readout Interface Card converts this information into ASCII data and feeds it onto the P7001 Data Bus. At the same time, an address is fed onto the P7001 Address Bus which determines where in Memory the data will be stored.

If BOTH or MEMORY is pressed, the readout information is read out of the Memory by the Readout Interface Card. Here it is converted from ASCII data to row-and-column analog data and fed back to the Readout Board in the Acquisition Unit for display on the CRT through the normal Acquisition Unit-to-Display Unit readout signal paths.

Communication Between Circuit Cards. The third signal path is the communication that takes place between circuit cards. The discussion of this communication takes up the larger part of this circuit description. The Asynchronous Bus block shown on diagram #1 is the medium that the Processor uses for this between-card

@

communication (see Figure 1-1). There are 16 data lines, 13 address lines, and 10 control lines on the bus. Use of the bus is on a first-come, first-served basis with some priority determining logic in case two cards request the bus at the same time.

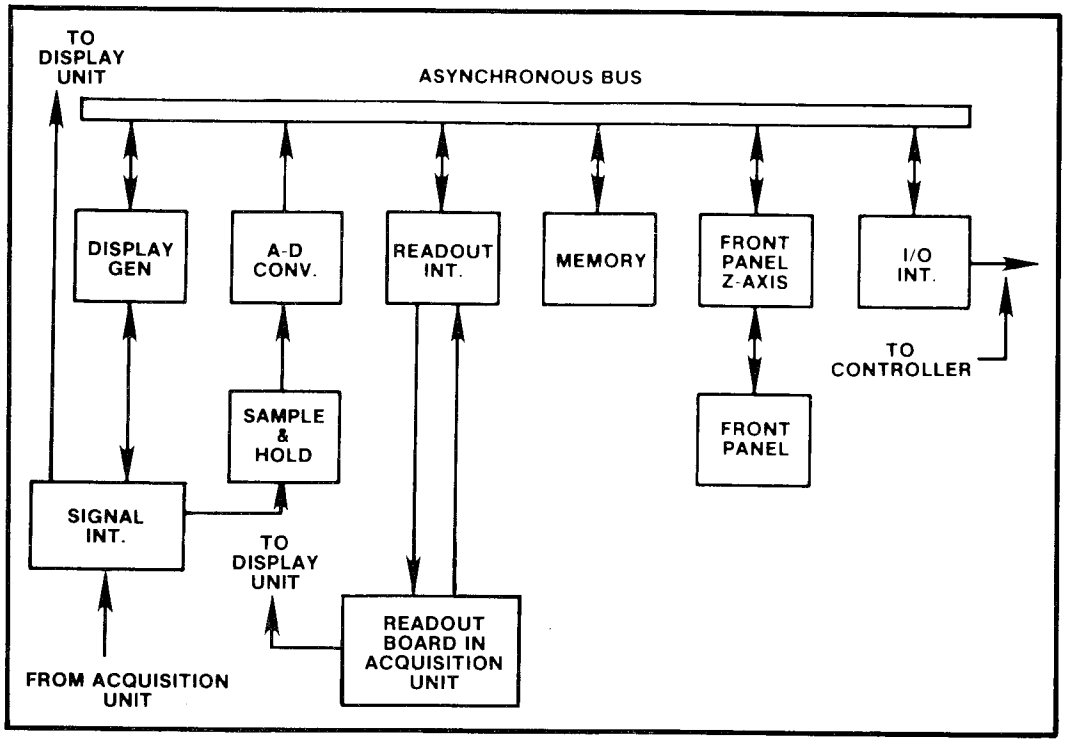


Figure 1-1. P7001 Block Diagram. 1882-02

The Processor reads from Memory, stores in Memory, feeds data to a Controller, receives data from the Controller, and provides readout conversion either from analog data to ASCII data or ASCII to analog data, all at essentially the same time, using the same Bus lines.

Information Transfer

Information transfer is accomplished by the timing of signals on the control lines. Each of the cards, with the exception of the Sample and Hold and Memory, has a bus controller whose job it is

to request the Bus and control it when that request is granted.

Timing. All cards work independent of one another in their operation and Bus request cycle. The Bus request and grant cycle is the main timing control. The Display Generator address counter steps at an eight microsecond clock cycle, unless stored readout information is being displayed. If readout is being displayed, the address counter steps after the completion of the readout cycle. The readout is timed by the time slots from the Acquisition Unit. The A-D Converter, on the other hand, must wait until its address registers are full. This depends upon the sampling rate, sweep speed, and signal repetition rate.

There are some functions that are occurring all the time that the instrument is on. "All the time" in this case means: time-shared with other functions. The Display Generator reads the Memory, and when MEMORY or BOTH is pressed, sends it to the CRT for display. The Sample & Hold card and the A-D Converter card are operating. However, this information is stored in Memory only if STORE and then START are pressed. Although the read from memory portion of the Readout Interface card is always functioning, readout information from the Plug-ins is stored in Memory only after STORE and START have been pressed. At this time the read from Memory stops functioning.

Sample and Hold. As soon as the instrument is turned on, the Sample & Hold circuit receives analog information from the plug-ins. It is sampled and fed to the A-D Converter at about a 150 KHz rate. Figure 1-2 shows a typical sinewave as it might appear on the CRT.

@

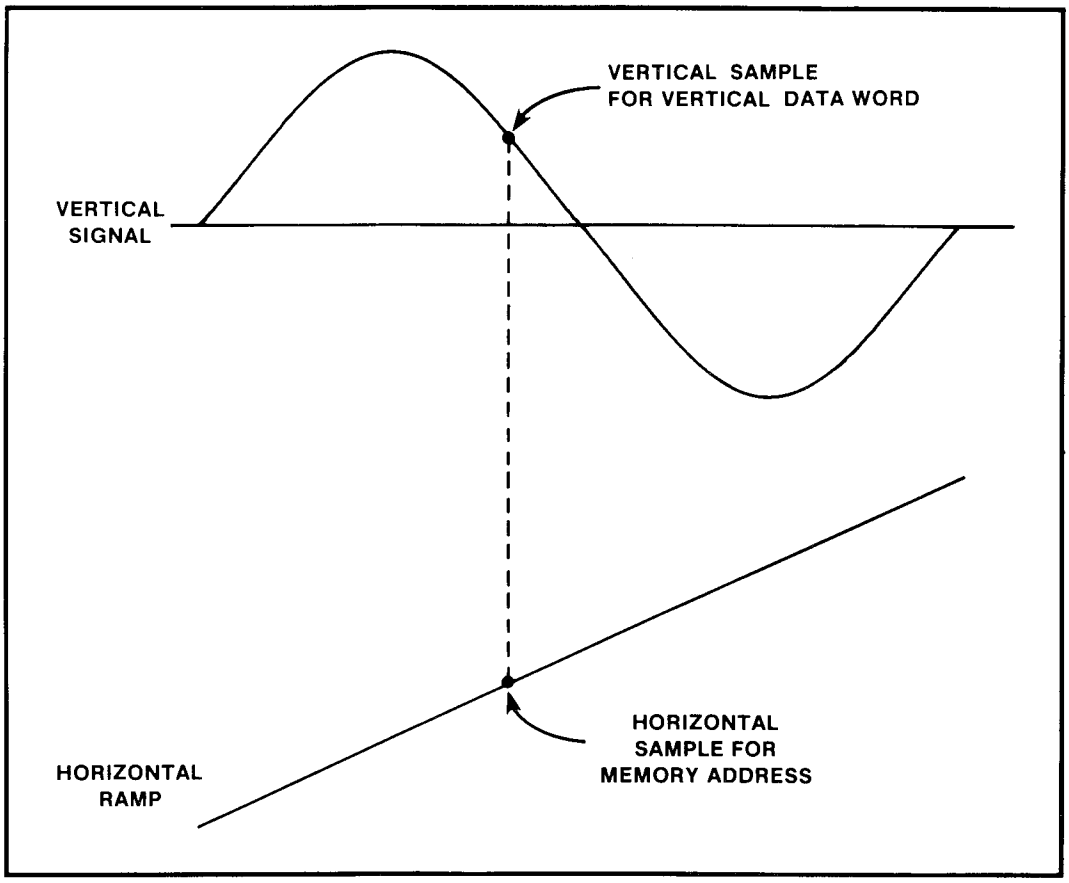
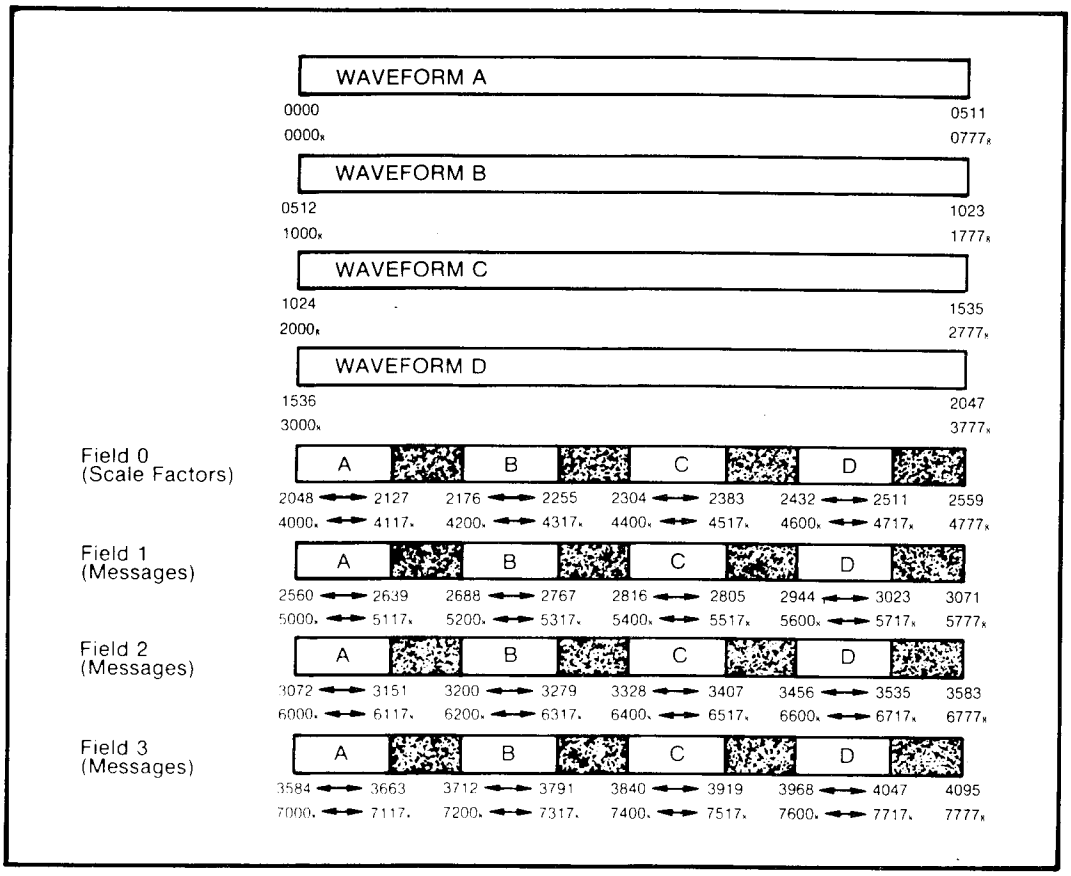


Figure 1-2. Sample Points.

Below it is a ramp representing the sweep waveform. A dot appears on the waveform and one appears below it on the ramp. These dots represent one sample of the vertical information and one sample of the horizontal information. Each time a vertical sample is taken, a horizontal sample is taken, but about 90 nanoseconds later. After the horizontal information is digitized, it becomes a Memory address. There are 512 horizontal Memory addresses for each waveform. The vertical sample, when digitized, becomes the vertical data bit in memory. There are up to 512 vertical data bits, each with a value of between Ø and 1023, for each waveform.

A-D Converter. Both the vertical and horizontal information from the Sample and Hold is digitized in the A-D Converter and

stored in a vertical buffer and a horizontal buffer to be written in Memory when STORE/START buttons are pressed or discarded (replaced by new data) when the HOLD button is pressed, or when Z-Axis is not valid.



1882-04

Figure 1-3. 4K Memory Map

Memory. The Memory map for a 4K Memory is shown in Figure 1-3. At the top of the figure are four blocks labeled waveform A, B, C, and D. These blocks represent the four waveform locations in Memory as selected from the Front Panel. In each of these blocks there is an address range of octal 777. Waveform A, for example, is $\emptyset\emptyset\emptyset\emptyset_8$ to $\emptyset777_8$. Converting 777_8 to decimal is equal to 511. $\emptyset\emptyset\emptyset\emptyset_8$ to $\emptyset777_8$ is $\emptyset$ to 511 in decimal. That's 512 address locations for each waveform. Below the waveform blocks in Figure 1-3, there

@

are four blocks indicating the four Field locations --- Field Ø, 1, 2, and 3. Field Ø contains the scale factor information for each corresponding waveform. For example, Field Ø, waveform A, contains addresses $4ØØØ_8$ to 4117_8, a range of 118_8 or, in decimal, 80 locations. This corresponds to the CRT screen which contains eight readout locations, 10 characters per location for a total of 80 possible characters.

Figure 1-4 consists of four drawings of the CRT graticule showing the channel locations and the addresses for each waveform and its scalefactor. Waveform A's readout information from left vertical channel one starts at address $4ØØØ_8$. The right vertical channel one for Waveform A is address $4Ø12_8$ (Figure 1-4a). Waveform B's readout information from left vertical channel one is addressed starting at $42Ø0_8$ (Figure 1-4b), and so on. There is a total of 12_8 addresses (10 in decimal) for each channel. The conventional readout sequencing for the 7704A starts with the left vertical channel 2, goes to left vertical channel 1, right vertical channel 2, right vertical channel 1, and so on. However, in storing in memory, and reading from memory, the scale factor information is placed and located in a left to right sequence across the top of the CRT and then across the bottom or sequentially from channel Ø through channel 7.

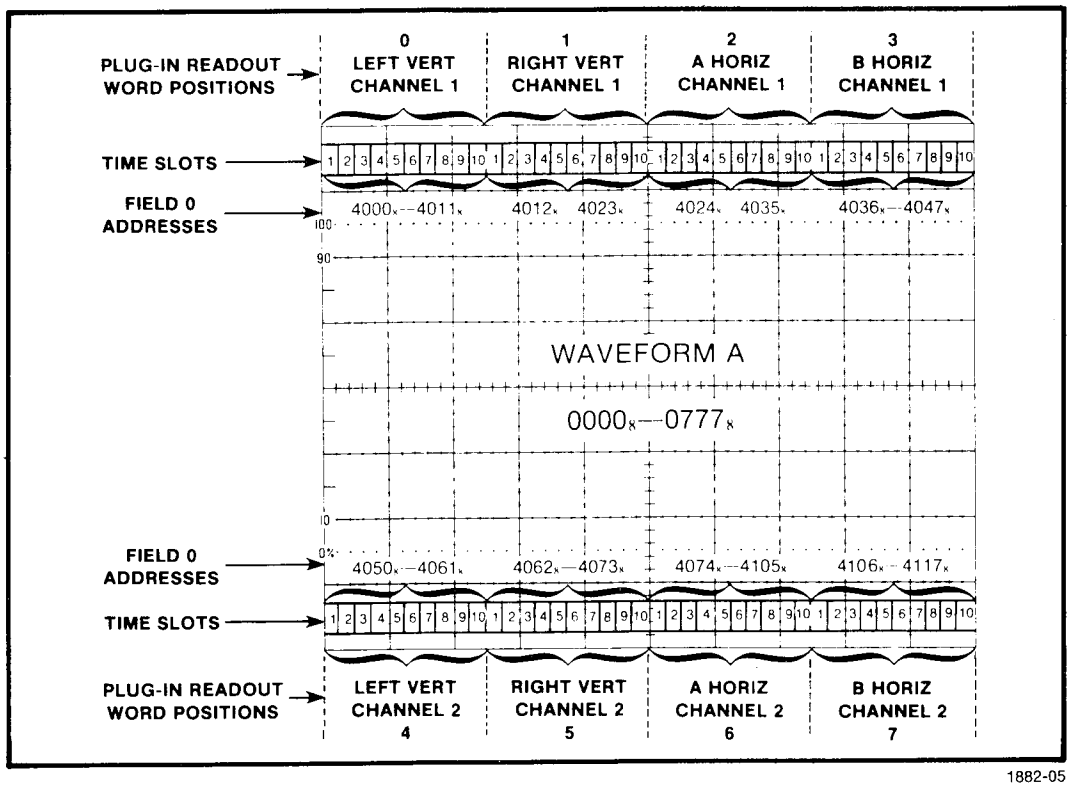


Figure 1-4 (a). Location of Readout Words & Characters (TIMESLOTS) and Field Ø Addresses for Waveform A.

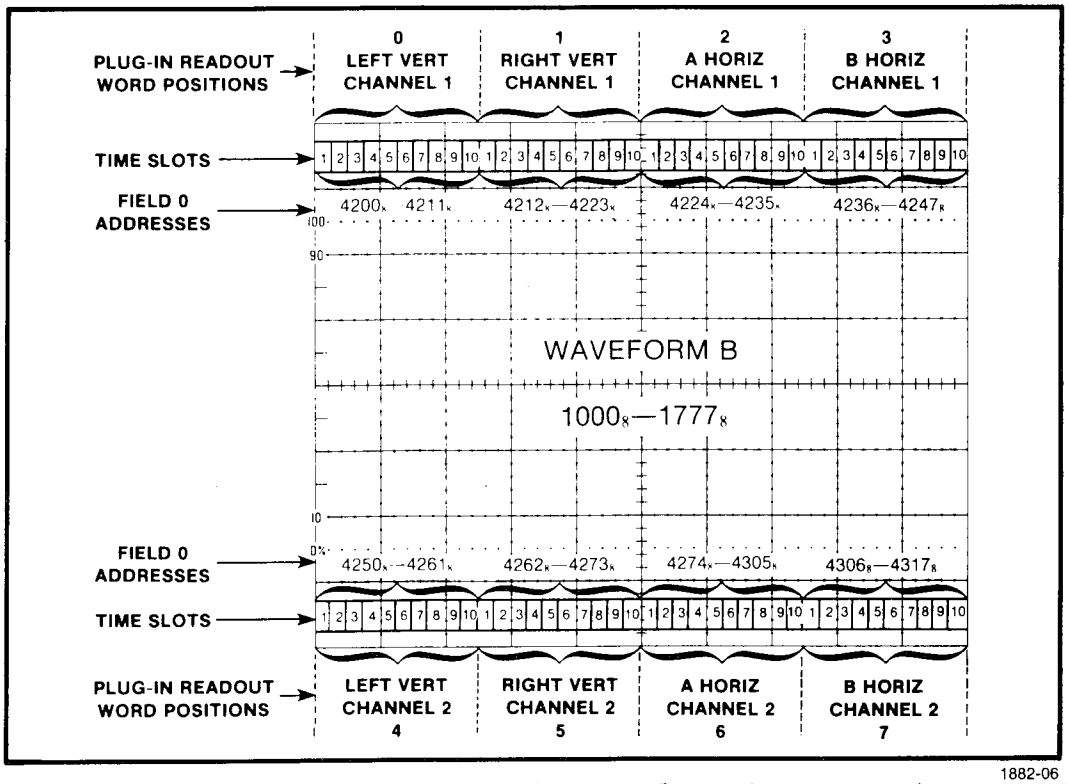


Figure 1-4 (b). Location of Readout Words & Characters (TIMESLOTS) and Field Ø Addresses for Waveform B.

@

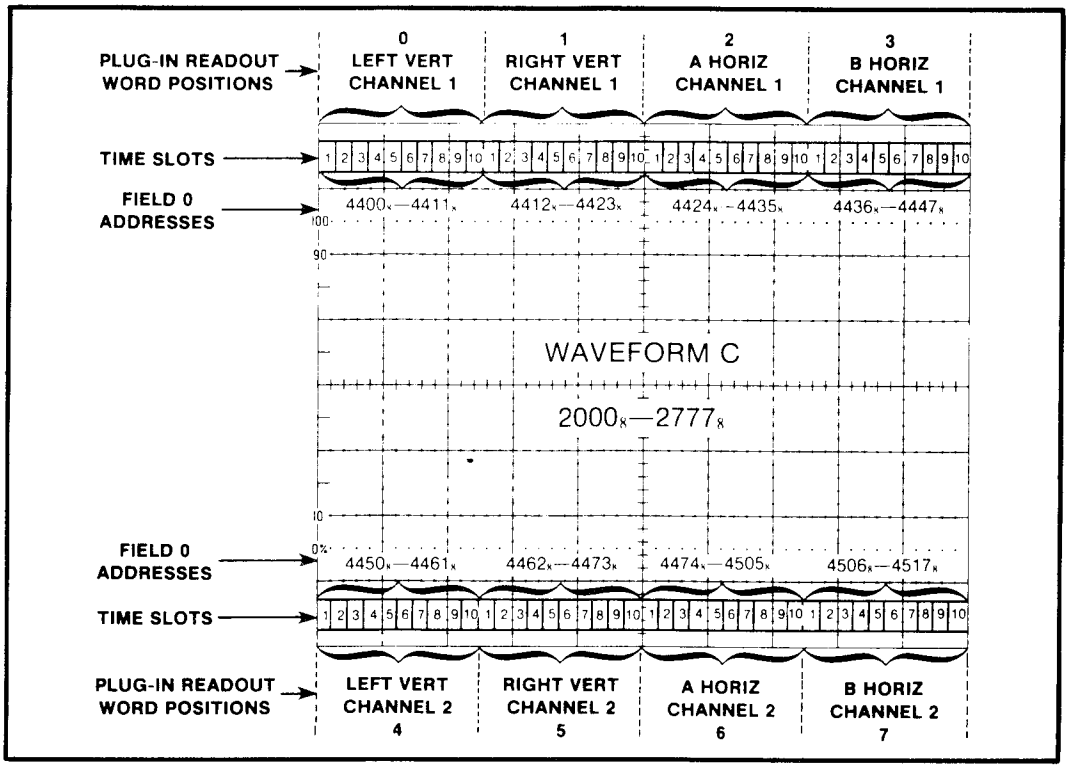


Figure 1-4 (c). Location of Readout Words & Characters (TIMESLOTS) and Field Ø Addresses for Waveform C.

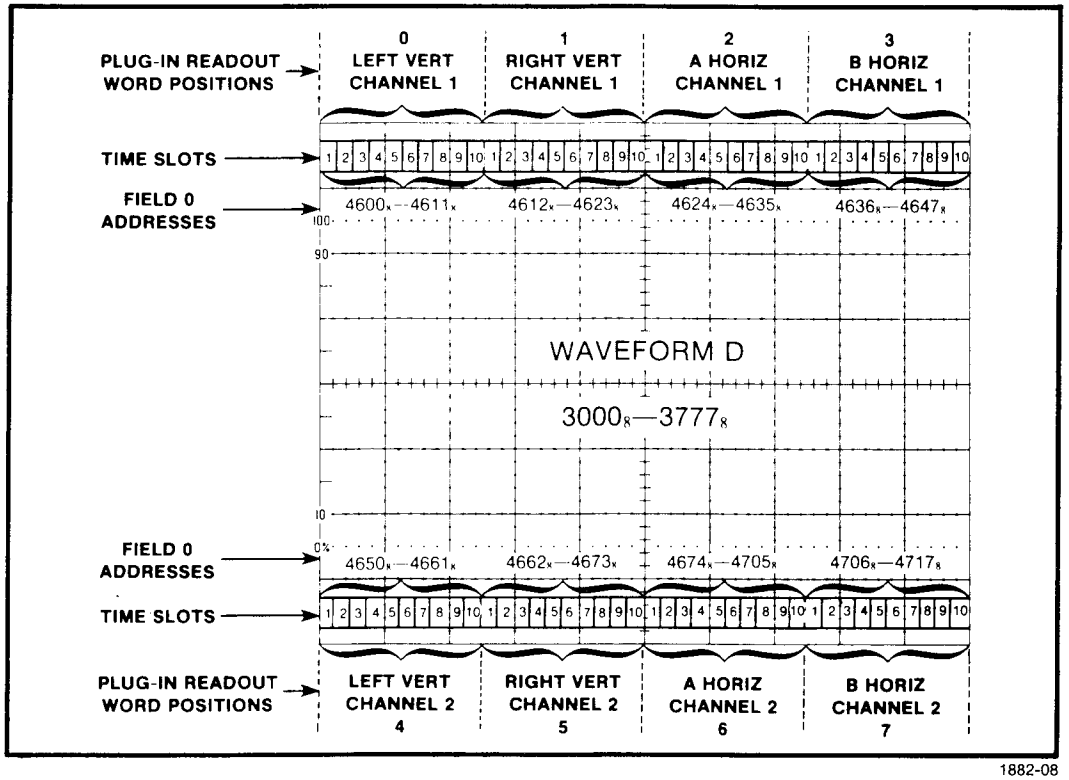
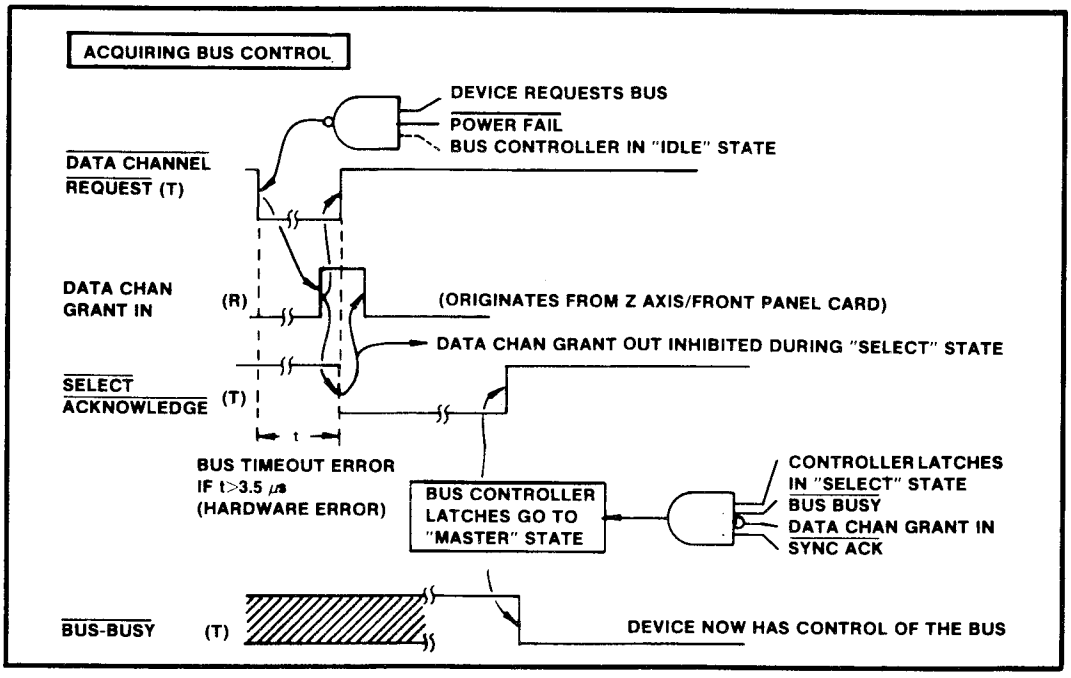


Figure 1-4 (d). Location of Readout Words & Characters (TIMESLOTS) and Field Ø Addresses for Waveform D.

Bus Control. Each card has a Bus controller circuit which is called the Card Controller. This circuit requests and maintains control of the Bus until the card is finished with its information transfer cycle. Communications between two or more cards is a Master-Slave relationship. During any Bus operation, one card has control of the Bus. This card's controller, the Master Card Controller, controls the bus when communicating with another card on the Bus, called the Slave. A typical example of this relationship is the A-D Converter, as Master, sending data to the Memory, as slave.

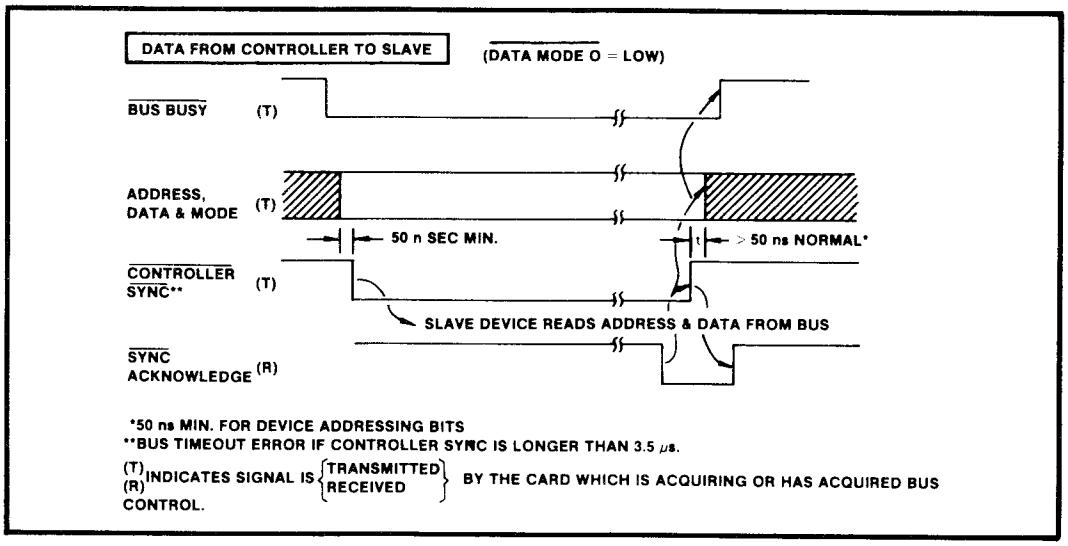
The sequence of events that occurs during information transfer --- bus acquisition, information request, and data transfer --- is what makes up Bus Control. Figure 1-5 depicts the sequence of events. Figure 1-5(a) shows the timing flow during bus acquisition.



1882-09

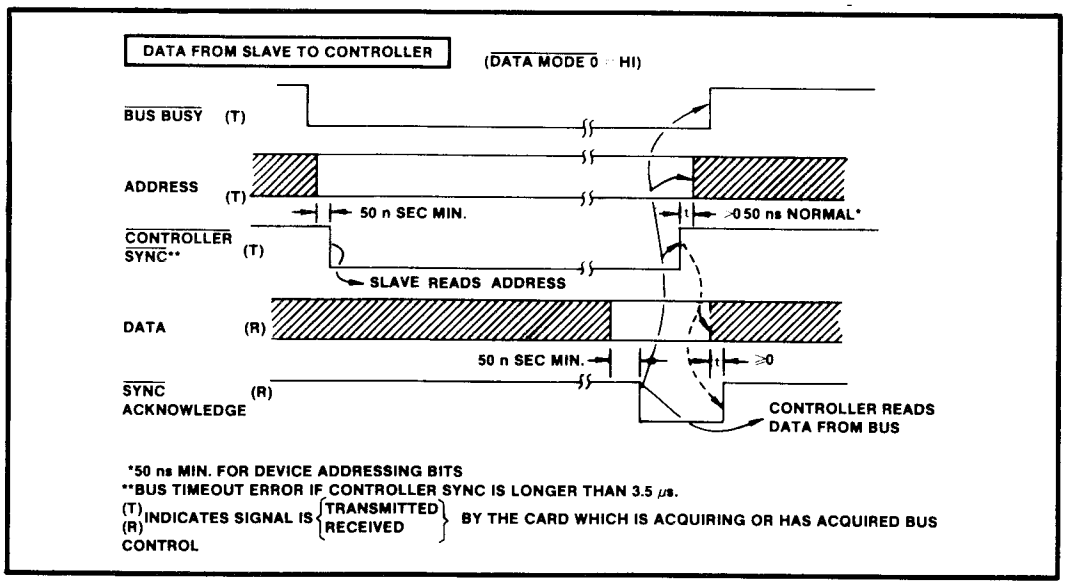
Figure 1-5(a). Bus Control (Acquisition)

@



1882-10

Figure 1-5(b). Bus Control (Controller-Slave).



1882-11

Figure 1-5(c). Bus Control (Slave-Controller).

Figure 1-5(b) describes the timing flow for transfer of information from the controlling card to the Slave. Figure 1-5(c) is the Slave's response back to the controlling card.

POWER ON. When the DPO is first turned on, $\overline{\text{POWER FAIL}}$ comes on low, stays there for about 0.1 second, and then goes high (see Figure 1-6). During the low period, all of the Card Controllers on all of the boards are set to their idle state. $\overline{\text{POWER FAIL}}$ also clears various flip flops and various status registers. $\overline{\text{POWER FAIL}}$ goes to the Display Generator, the A-D Converter, the Readout interface, the Memory, the Front Panel, the Front Panel priority logic, and the I/O Interface (see Figure 1-7).

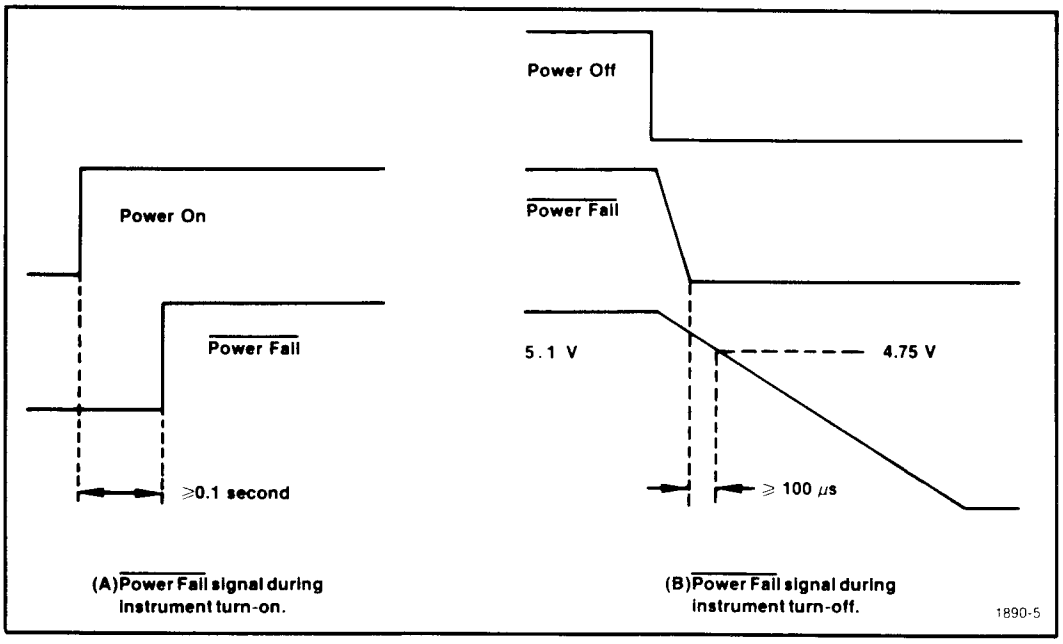
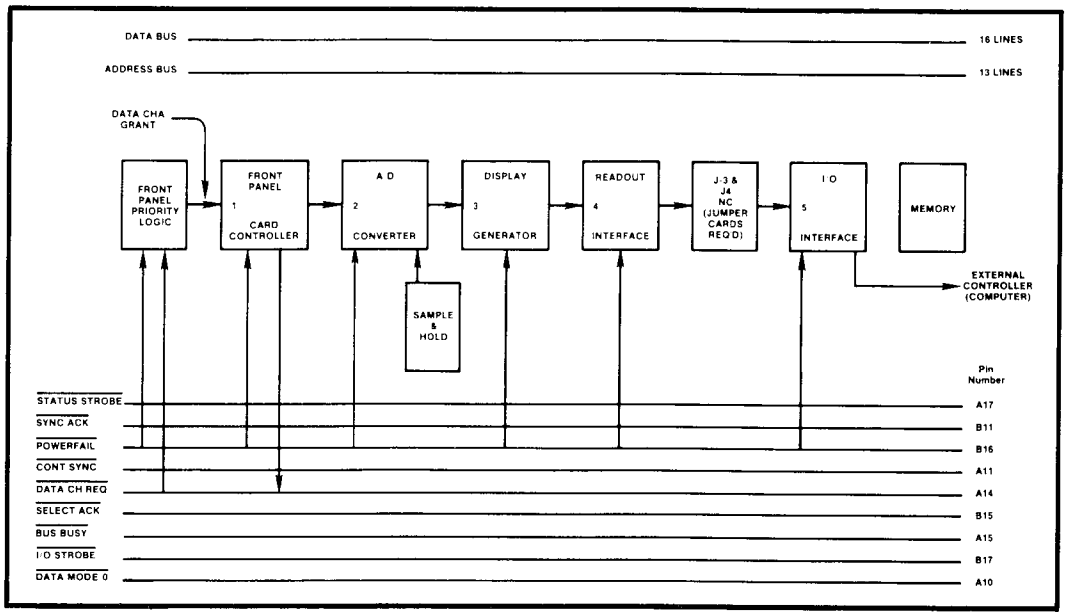


Figure 1-6. $\overline{\text{POWER FAIL}}$ Signal During Instrument Turn-on and Turn-off.

MASTER INTERRUPT. Master Interrupt is generated when the DPO is first turned on or when STORE, SEND or RECEIVE then START push buttons are pressed. It is also generated when any one of the PROGRAM CALL push buttons are pressed. MASTER INTERRUPT is not shown in Figure 1-7, but it starts the Front Panel Card Controller into its bus request cycle. The Front Panel sends out $\overline{\text{DATA CH REQ}}$. This signal is received by the Front Panel priority logic. It



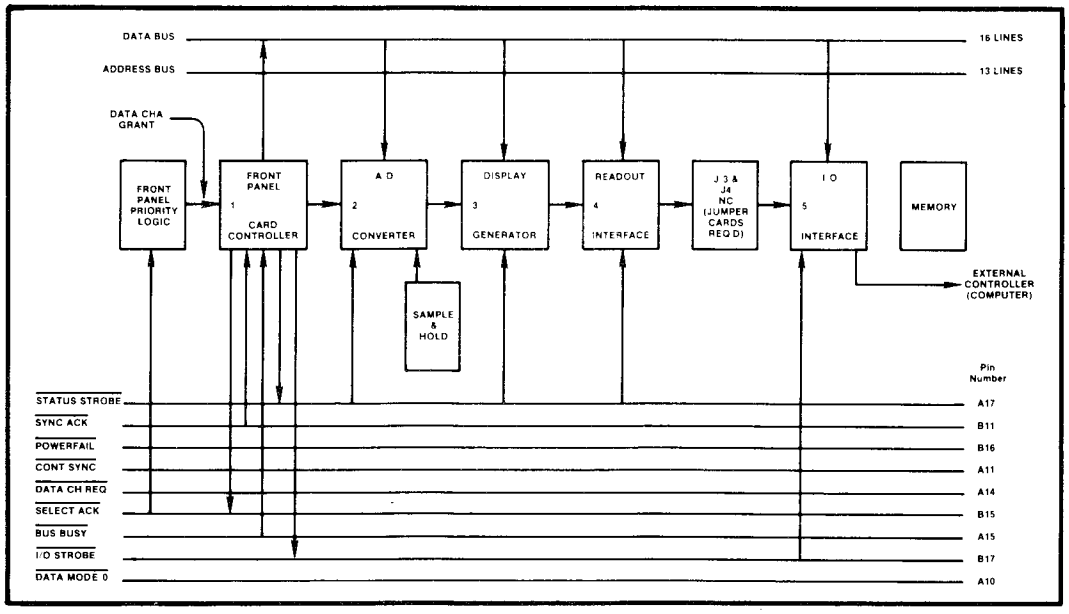
1882-12

Figure 1-7. $\overline{\text{POWER ON}}$ Bus Action.

checks to make sure that no other card has a request pending and that the POWER FAIL has completed its 0.1 second low. If everything is all right, it will generate DATA CH GRANT.

DATA CHANNEL GRANT PRIORITY. DATA CH GRANT goes through each card in series as shown between the blocks of Figure 1-7. It is generated by the Front Panel Priority Logic. DATA CH GRANT goes to the Front Panel Controller, from there to the A-D Converter, etc. forming a Daisy Chain. When any one of the controllers on any of the cards wants to use the bus and receives DATA CH GRANT, it immediately opens the line so that DATA CH GRANT does not go through. This establishes the bus use priority for the P7001.

FRONT PANEL CARD CONTROLLER. When the Front Panel Card Controller stops DATA CH GRANT, it immediately sends out $\overline{\text{SELECT ACK}}$



1882-13

Figure 1-8. Front Panel Controller Bus Action.

(see figure 1-8). $\overline{\text{SELECT ACK}}$ is then picked up by the Front Panel Priority Logic and terminates DATA CH GRANT. The termination of DATA CH GRANT allows the controller to look at $\overline{\text{BUS BUSY}}$. It also looks at $\overline{\text{SYNC ACK}}$. If both of these lines are high, it knows that no other card has control of the bus. The Front Panel Controller then goes to its Master state. Within the Front Panel circuit, the Master state will gate the data that was in the status latches onto the data bus. The condition of the status latches is a function of what has been selected at the Front Panel. If STORE has been selected, for example, along with waveform locations A, B, C, or D, these conditions are latched into the status latches.

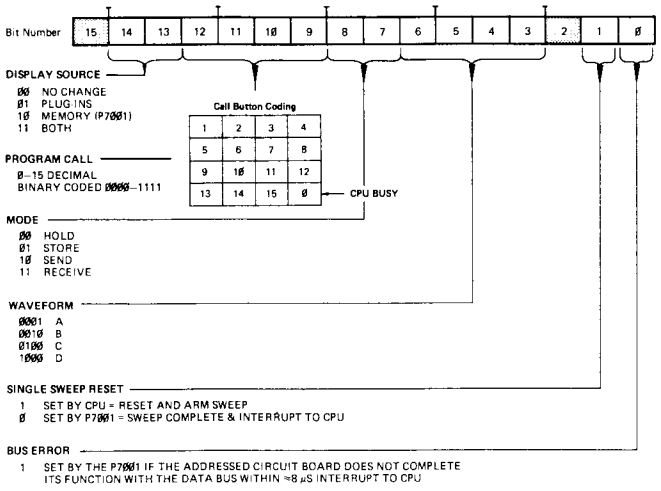
The Front Panel Controller sends out $\overline{\text{STATUS STROBE}}$ and $\overline{\text{I/O STROBE}}$. $\overline{\text{STATUS STROBE}}$ goes to the A-D Converter, the Readout Interface, and the Display Generator. $\overline{\text{I/O STROBE}}$ goes to the I/O

Interface card. The $\overline{\text{STATUS STROBE}}$ will latch into the status registers, on each of these cards, whatever status word was placed on the data bus. All four of these cards will now respond with $\overline{\text{SYNC ACK}}$. The first one to answer to the Front Panel will terminate the status word generated by the Front Panel.

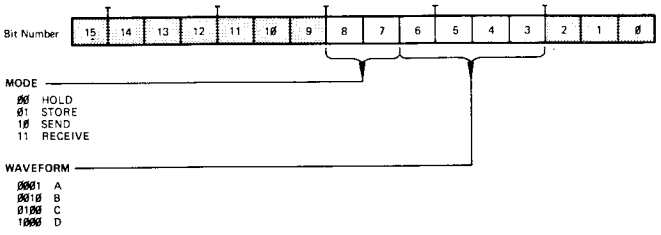
Any time that the condition of the Front Panel is changed, Master Interrupt will be generated. The cards will go through the same routine that has just been discussed. The difference would be that there would be a new status word fed to the cards for their action.

Word Formats. There are four types of signals used in information transfer: 1) those used for communication on the Control Lines, 2) Status words, 3) Address words, and 4) Data words. Control Lines are those we previously described under Bus Control. Now the other three types of signals will be described. It is important to note that Status Words and Data Words are both sent on the Data Bus lines, but at different times.

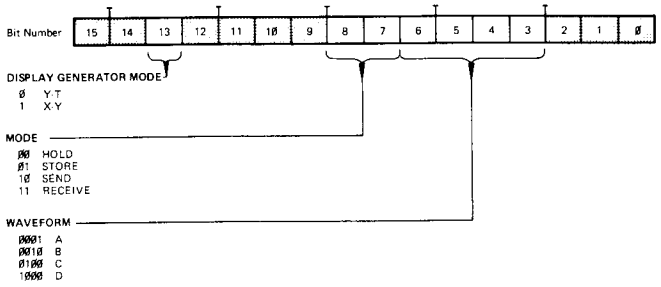
STATUS WORDS. When the Front Panel push buttons are changed, a new Status word is generated. This Status word reflects the status of the Front Panel and is sent to all circuit cards. Once the Front Panel Controller has control of the bus, it will send out $\overline{\text{STATUS STROBE}}$ which will latch the new Status word into each card's status latches. The format of each card's Status Word is shown in Figure 1-9.



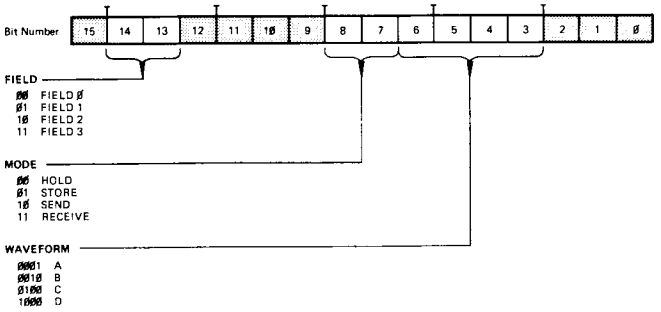
(a). Front Panel Status Word Format.



(b). A/D Converter Status Word Format.



(c). Display Generator Status Word Format.



(d). Readout Interface Status Word Format.

1882-14

Figure 1-9. Status Word Formats.

@

In each Status Word, Bits 3 through 6 determine the P7001 Memory location (A, B, C, or D) and Bits 7 and 8 determine the Mode (HOLD, STORE, SEND, or RECEIVE). Bits 9 through 12 are not used within the P7001, but are sent to an external controller (computer or calculator) to indicate which one of the 16 PROGRAM CALL buttons on the Front Panel have been pressed. All other bits are set only by an external Controller (computer or calculator). For example: Bits 13 and 14 in the Readout Interface Status Word are both normally "zero" indicating that readout stored by the P7001 will go only to Field Ø. Readout information for display on the DPO CRT is sent to any one of the other three fields by the Controller (computer or calculator). Changing bits 13 and/or 14 of the Readout Interface Status Word will cause it to display these messages.

A-D CONVERTER-DATA AND ADDRESS WORDS. Vertical waveform analog information which is converted to digital information by the A-D Converter Card consists of a 10 bit binary word for each vertical sample (see Figure 1-10). There are up to 512 data words per waveform, each with a value between the range of Ø to 1023. The vertical data word is the vertical (Y) information for each data point of the waveform. The LSB (Least Significant Bit) is placed in bit location 5 of the 16 bit word on the Data Bus.

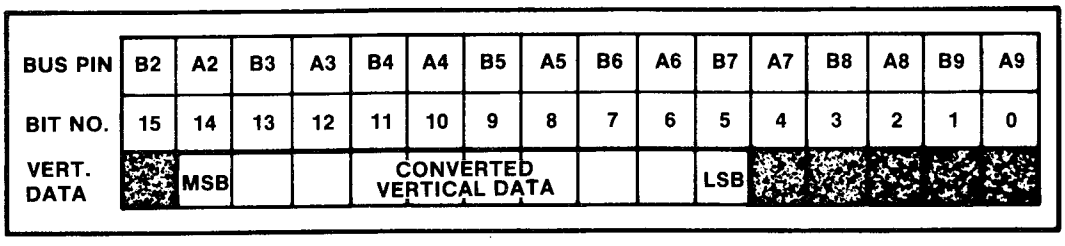


Figure 1-10. A-D Converter-Data Bus Format.

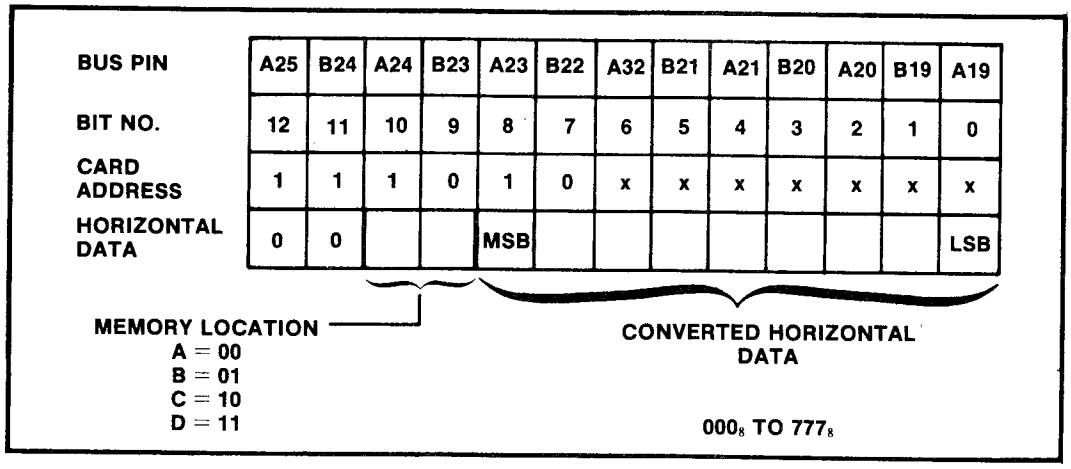


Figure 1-11. A-D Converter-Address Bus Format.

Horizontal waveform information which is converted by the A-D Converter, consists of a 9 bit binary word for each horizontal sample (see Figure 1-11). This word becomes the address in Memory where the vertical data word is stored. There are 512 address words per waveform.

DISPLAY GENERATOR -- DATA AND ADDRESS WORDS. The Display Generator Card reads the value of each horizontal location out of Memory as its address counter is stepped from Ø through 511 for each waveform.

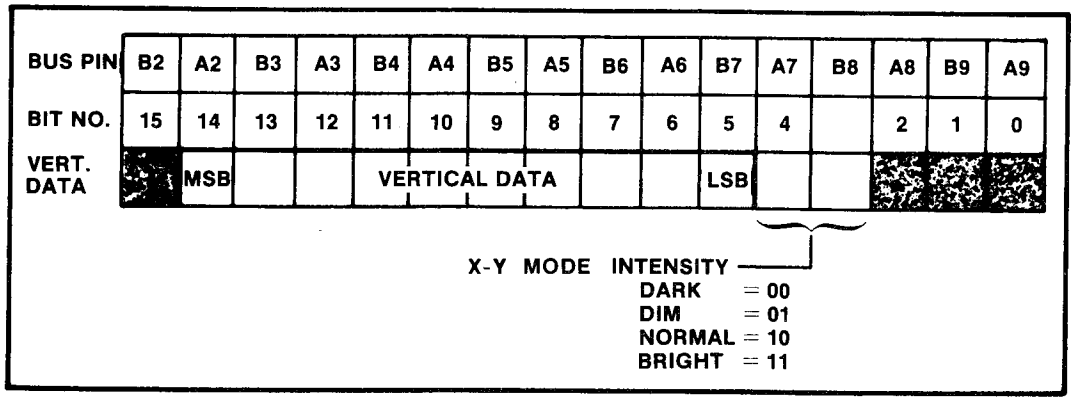


Figure 1-12. Display Generator - Data Bus Format.

@

The Display Generator first sends an address to the Memory in the same format as the A-D Converter used to put the information in Memory (Figure 1-10 and 1-12). The Display Generator then reads out the vertical data word from Memory that is at that address. Bits 3 and 4 can only be set by an external Controller to Display X-Y intensity information. Done by addressing the Display Generator in the X-Y mode with software. Figure 1-13 is the format for both X-Y and Y-T addresses. Memory Location in the X-Y mode is not applicable since the Controller sends data to the Display Generator only and not to the Memory.

BUS PIN	A25	B24	A25	B23	A23	B22	A22	B21	A21	B20	A20	B19	A19
BIT NO.	12	11	10	9	8	7	6	5	4	3	2	1	0
CARD ADDRESS	1	1	1	0	0	0	x	x	x	x	x	x	x
X-Y MODE DATA	1	1	1	1	MSB		HORIZONTAL DATA						LSB
HORIZONTAL DATA	0	0			MSB		HORIZONTAL DATA						LSB

MEMORY LOCATION
A = 00
B = 01
C = 10
D = 11

0_8 TO 777_8

1882-18

Figure 1-13. Display Generator - Address Bus Format.

READOUT INTERFACE -- DATA AND ADDRESS WORDS. The Readout Interface Card will store alpha-numeric information (ASCII Coded) for waveform scale factors by first sending an address to the Memory. The Memory then stores the ASCII Coded information from the Data Bus. To read from Memory, the Readout Card sends an address to the Memory and the Memory places the ASCII coded information, it has at that address, on the Data Bus. Figure 1-14 and 1-15 show the Readout Data and Address Bus formats.

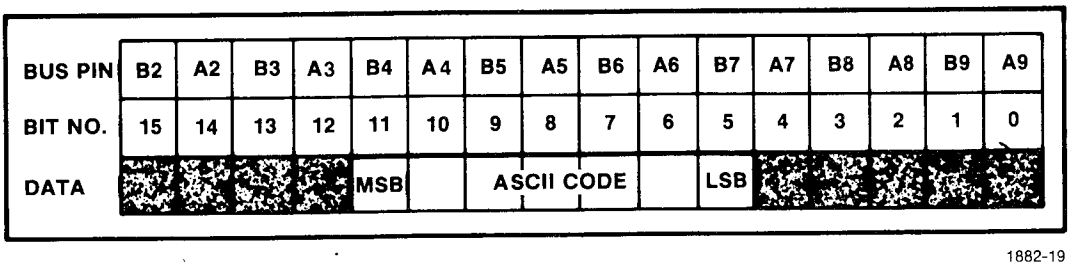


Figure 1-14. Readout Interface - Data Bus Format.

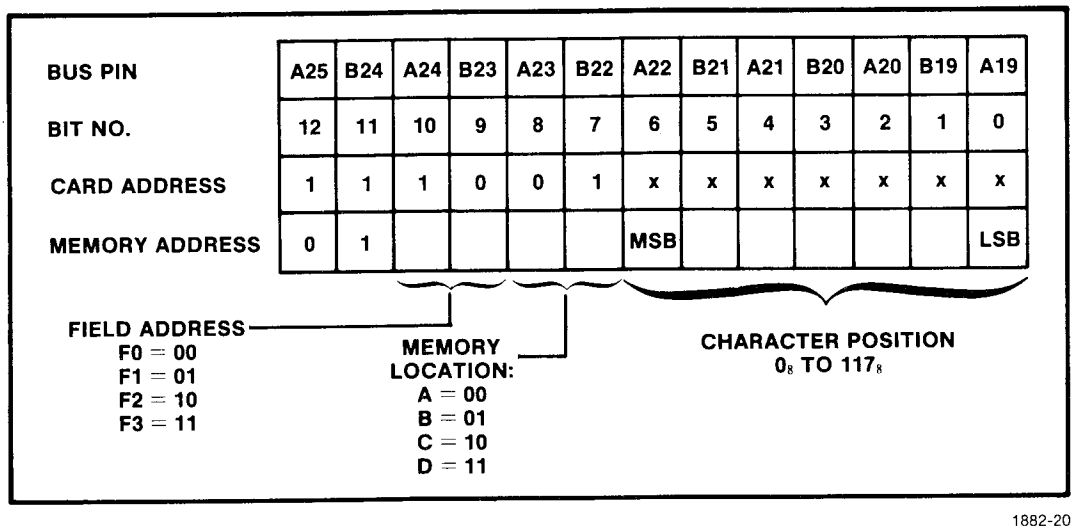


Figure 1-15. Readout Interface - Address Bus Format.

CARD ADDRESS WORDS. Each circuit card has an address by which it may be contacted by an external device such as a Controller (computer or calculator). Using the proper software, the Controller can address a card, set its status with a status word, and transfer data to or from the card as desired. Note in Figure 1-16b that for all cards except Memory and Sample & Hold, there is an address range of 177_8 (128 in decimal). In reality, all addresses will work because the low order bits are decoded as "don't cares". However, for standardization, only one of these addresses should be used, and the others reserved for specific future uses. Thus, the lowest address for any card is recommended for standardization. For example:

@

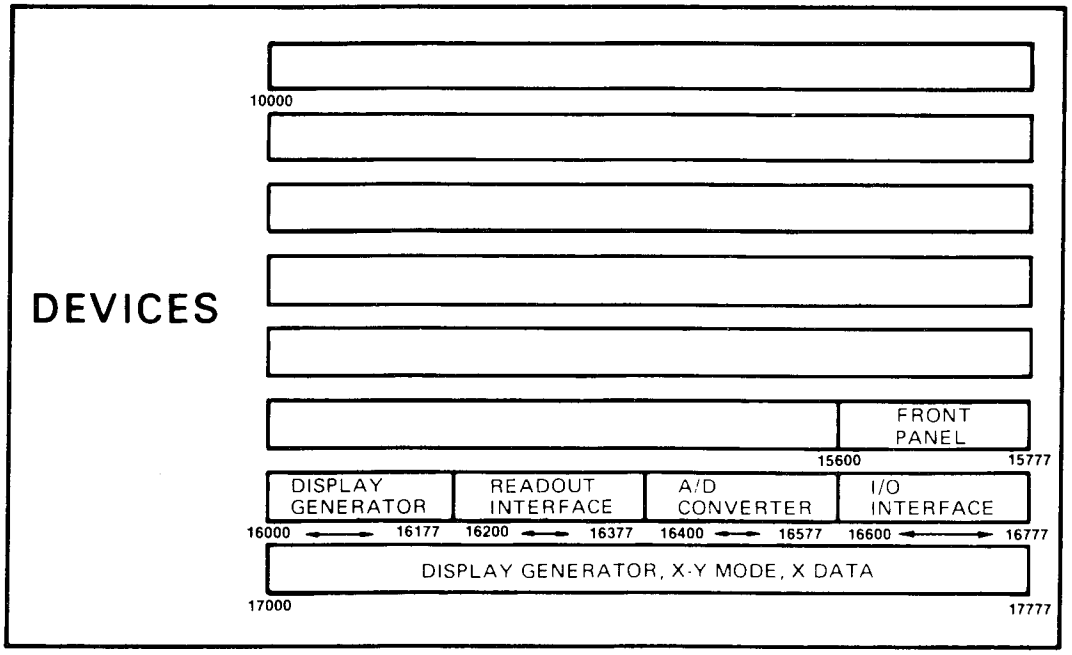
the Readout Interface Card would be addressed 16200_8 and the others 16201_8 to 16377_8 will not make any difference to the Readout Interface Card if used.

Figure 1-16a lists the address words with the "don't cares" shown as "x". The card addresses shown in Figure 1-16 are located above the 4K Memory addresses (see Figure 1-3). The addresses

PIN NUMBER	A25	B24	A24	B23	A23	B22	A22	B21	A21	B20	A20	B19	A19
ADDRESS BIT	12	11	10	9	8	7	6	5	4	3	2	1	0
A-D CONVERTER	1	1	1	0	1	0	x	x	x	x	x	x	x
READOUT INTERFACE	1	1	1	0	0	1	x	x	x	x	x	x	x
DISPLAY GENERATOR	1	1	1	0	0	0	x	x	x	x	x	x	x
FRONT PANEL	1	1	0	1	1	1	x	x	x	x	x	x	x
I/O INTERFACE	1	1	1	0	1	1	x	x	x	x	x	x	x
DISPLAY GENERATOR X-Y MODE	1	1	1	1	MSB ← HORIZONTAL DATA →								LSB

1882-21

Figure 1-16(a). P7001 Address Word Format.



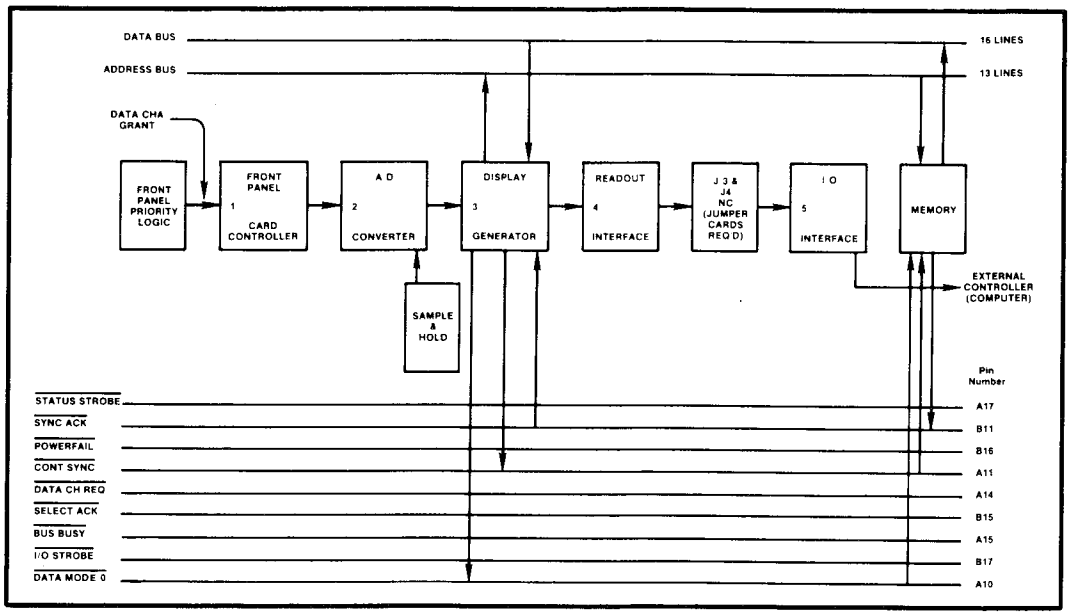
1882-22

Figure 1-16(b). P7001 Card Address Map.

between 10000_8 and 15600_8 are reserved for future use. New cards designed and installed in the spare card locations of the P7001 will be assigned an address in this range.

Operating Modes

There are two operating modes which should be discussed; HOLD and STORE. The key cards and their operation will now be described in each of these modes. Each card becomes Master using the same Bus request-Bus grant cycle as the Front Panel used in a previous paragraph titled "Bus Control".



1882-23

Figure 1-17. Display Generator - Hold Mode.

Display Generator - HOLD Mode. As soon as the Display Generator has become Master and its status is HOLD A, it places address (ØØØ) on the address bus. It then asserts $\overline{\text{DATA MODE Ø}}$ in a high condition (Figure 1-17). This indicates to the memory that this is a read cycle. The Display Generator then generates $\overline{\text{CONT SYNC}}$.

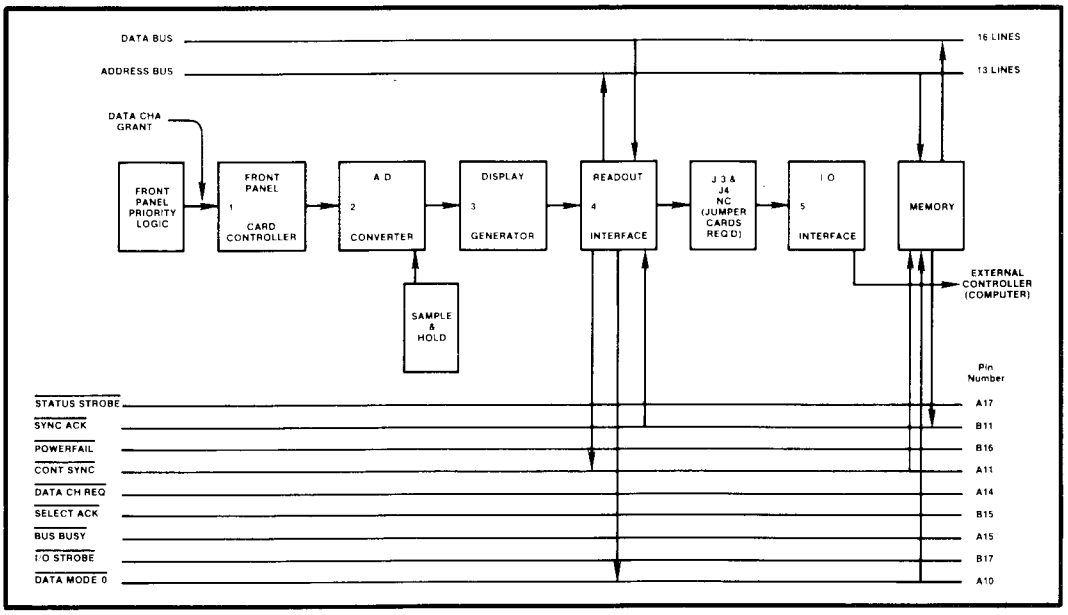
There is a 50 nanosecond delay between $\overline{\text{DATA MODE Ø}}$ and $\overline{\text{CONT SYNC}}$ to allow address settling time. $\overline{\text{CONT SYNC}}$ is now picked up by the Memory. The Memory checks $\overline{\text{DATA MODE Ø}}$, sees that it is in the read mode, looks at the address on the Address Bus, and reads data from Memory at that address. It then places this data on the Data Bus. The Display Generator picks up that data, which is in binary form, and converts it to vertical analog information. It also picks up the output of the address counter and converts it to horizontal analog information. It then sends this vertical and horizontal information through the display switch, if the Front Panel display switch is in MEMORY or BOTH, on to the CRT for display, in either a Dot or Vector format. The Display Generator address counter now steps to the next address as soon as the Memory circuit has completed its cycle and generates $\overline{\text{SYNC ACK}}$. $\overline{\text{SYNC ACK}}$ comes back to the Display Generator, which then returns to the idle state. As soon as the Display Generator has stepped to its next address, it will request the use of the bus again.

As mentioned earlier, the data to be stored in Memory is sampled at a random rate. It is placed in Memory in a random sequence. However, it's taken out in a logical sequence by the address counter in the Display Generator, such that a waveform is drawn from left to right in the conventional manner.

The Display Generator counter steps through 2Ø48 addresses. It requests data from Memory only when its address counter matches the address range of the selected waveform (A, B, C, or D). That means that it is only Master during the selected waveform. Total cycle time is 2048 X 8 microseconds (16.5 milliseconds), provided

@

all data is non-zero and all waveforms have been selected. 8 microseconds are required for displaying non-zero data and 2 microseconds for zero data during a selected waveform. 2 microseconds are required for the counter to step during non-selected waveforms for all data (zero and non-zero).



1882-24

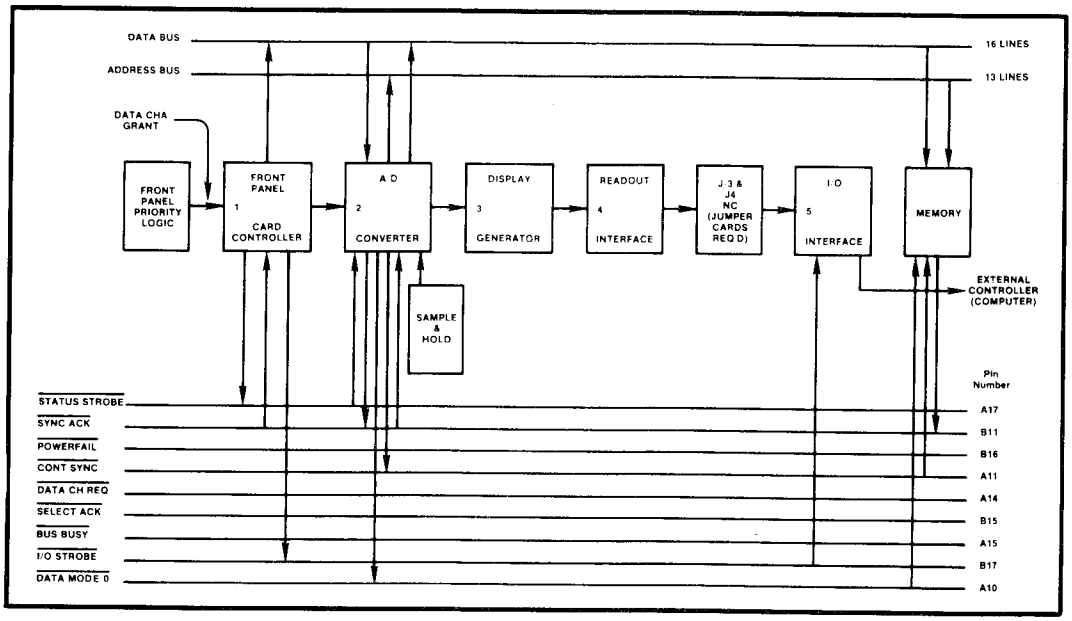
Figure 1-18. Readout Interface - Hold Mode.

Readout Interface - HOLD Mode. The Readout Interface Card receives $\overline{\text{STATUS STROBE}}$ at the same time as the Display Generator. The Readout Interface Card latches the status information into a status latch. When the Display Generator goes to the idle state and lifts $\overline{\text{BUS BUSY}}$, the Readout card may request the bus (Figure 1-18). If it is granted the use of the bus, it will then generate an address dictated by the time slots from the Acquisition Unit readout circuit. Part of the readout address is the selection of

waveform locations A, B, C, or D, which had been latched in the status register on the Readout card. The Readout also generates $\overline{\text{CONT SYNC}}$ low and $\overline{\text{DATA MODE 0}}$ high, which are picked up by the Memory. Having the address and the read command, the Memory sends the information at that address to the Readout Interface Card on the Data Bus. The data is in ASCII code. The Readout card converts it to row and column analog current and sends it to the Acquisition Unit readout board for conversion to characters for display, if the Front Panel Display Source is MEMORY or BOTH. When the Memory is finished sending the data it sends back $\overline{\text{SYNC ACK}}$ to the Readout Interface Card, which returns it to its idle state where it must request the Bus again.

As soon as the readout cycle is completed, the Display Generator has been waiting to request the bus again to display information at address ØØ1. This cycle of waveform/readout information display continues until there is some change in status.

A-D Converter - STORE Mode. The Front Panel starts the Bus request cycle again when a Master interrupt is generated. When granted, it feeds the status word on the data bus. It sends out $\overline{\text{STATUS STROBE}}$ and $\overline{\text{I/O STROBE}}$ (see Figure 1-19). The Display Generator, the A-D Converter, and the Readout Interface look at the status word with the arrival of $\overline{\text{STATUS STROBE}}$. They then latch that status word into the status latches. Whichever card reacts first sends back $\overline{\text{SYNC ACK}}$ to the Front Panel, terminating the Front Panel Control cycle. The Front Panel then lifts the status word from the data bus. With the arrival of $\overline{\text{STATUS STROBE}}$, which



1882-25

Figure 1-19. A-D Converter - STORE Mode.

latched the status word into all the latches, all four cards will request the bus. If STORE has been selected, the A-D Converter will get control of the bus, since it has first priority.

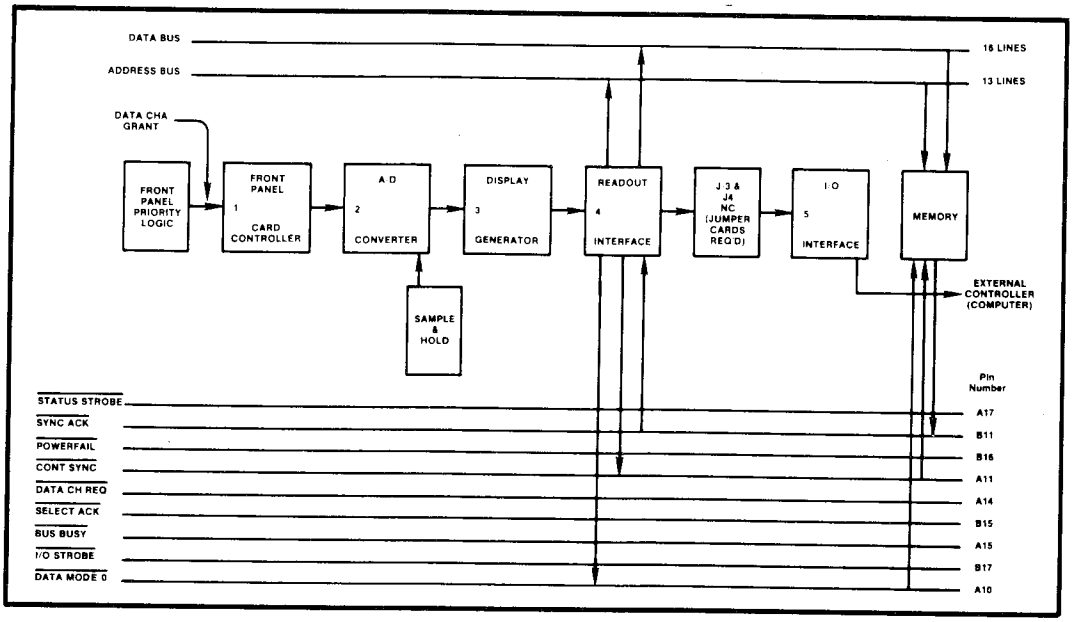
The A-D Converter has been digitizing the vertical and horizontal data continuously and placing both vertical and horizontal digital data in buffers. As soon as these buffers are full and the A-D Converter has control of the Bus via the same Bus request cycle as described previously, the card will become Master. It will place data on the bus along with its address. It will assert $\overline{\text{DATA MODE Ø}}$ low, which tells the Memory that this is a write cycle, and generates $\overline{\text{CONT SYNC}}$.

The Memory picks up $\overline{\text{CONT SYNC}}$ and $\overline{\text{DATA MODE Ø}}$, then latches

the address into the address register. Any data on the data bus will be stored in Memory at that address. As soon as Memory has the data, it sends back $\overline{\text{SYNC ACK}}$ which is picked up by the A-D Converter. This terminates that cycle and sets the A-D Converter to its idle state. In the meantime, the A-D Converter is digitizing another batch of vertical and horizontal information and as soon as the latches are full, it will request the bus again. This cycle will continue until the HOLD button is pressed.

NOTE

When any card sends data to be stored, the Memory will latch data and assert $\overline{\text{SYNC ACK}}$. The Memory will then proceed to store and not answer with $\overline{\text{SYNC ACK}}$ if another request is pending for 1.5 microseconds (Memory cycle time).



1882-26

Figure 1-20. Readout Interface - STORE Mode.

Readout Interface - STORE Mode. In the meantime, however, the Readout information has to get stored into memory. After the Readout card has the status word in its latches, it will request the use of the bus. However, because of its lower priority, it will have to wait. After the A-D Converter relinquishes control, and the Display Generator has had its turn, the Readout Card will take over and become Master. The row and column analog data from the Acquisition Unit has been previously digitized and converted to ASCII data by the Readout Interface Card. The Readout address word has been made up from encoded channels and timeslot information along with status information in its status latches. As soon as the Readout goes Master, it asserts $\overline{\text{DATA MODE Ø}}$ low, places an address and data on the bus, and sends out $\overline{\text{CONT SYNC}}$ (see Figure 1-20). This information is picked up by the Memory along with $\overline{\text{DATA MODE Ø}}$. The Memory will then place the data on the Data bus at the address that is on the Address bus. As soon as it has completed its cycle it will send out $\overline{\text{SYNC ACK}}$. This will terminate the readout cycle and the Readout card will relinquish control of the bus.

I/O Interface

Master State. An external Controller (computer or calculator) addresses the DPO through the I/O Interface (Figure 1-21). The I/O Interface then requests the bus by sending out $\overline{\text{DATA CH REQ}}$. The Front Panel priority logic replies with DATA CH GRANT, provided that another card isn't in control of the bus. As soon as the I/O Interface receives DATA CH GRANT, it sends out $\overline{\text{SELECT ACK}}$. This

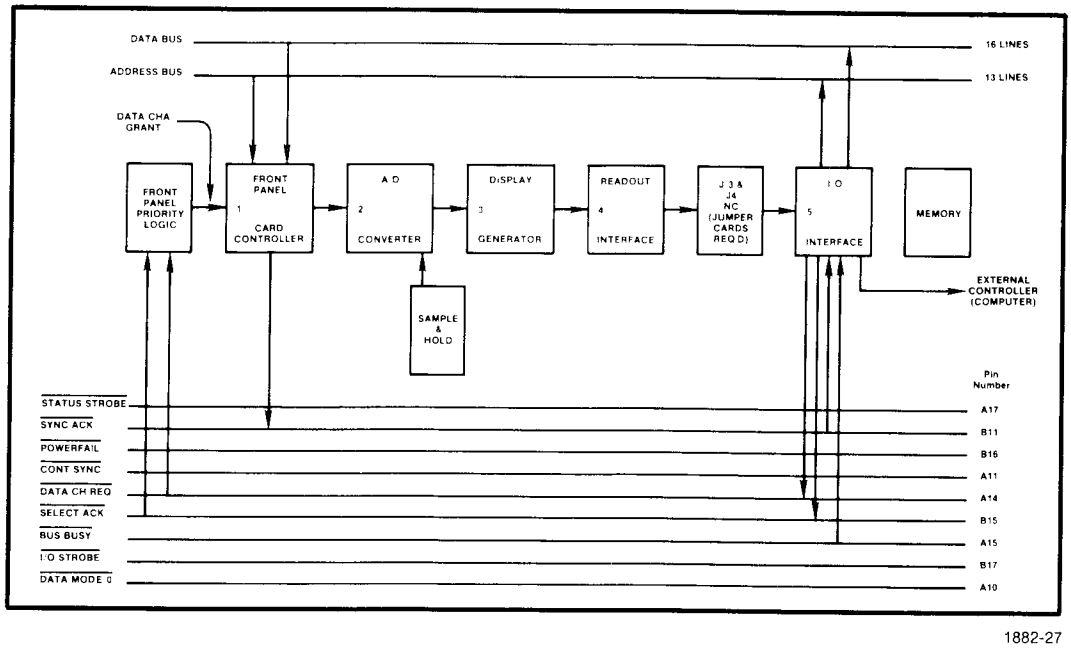


Figure 1-21. I/O Interface - Master State.

returns to the Front Panel priority logic and terminates DATA CH GRANT. Then the I/O Interface checks to make sure that $\overline{\text{SYNC ACK}}$ and $\overline{\text{BUS BUSY}}$ are not present. The I/O Interface goes to the Master state. It sends an address on the Address Bus and a status word on the Data Bus to the addressed card. The address is picked up by the addressed card's circuits. If, for example, the addressing is to the Front Panel, it will be disconnected so that it can not again be interrupted by the external Controller for 500 milliseconds. The status word is latched into the Front Panel latches. This in turn, lights the appropriate Front Panel pushbutton lights. The Front Panel then sends back $\overline{\text{SYNC ACK}}$ to the I/O Interface. That returns the I/O Interface to its idle state and terminates $\overline{\text{BUS BUSY}}$, the address word, and the status word.

@

For example, when an external ontroller that is programmed with TEK BASIC software gets control of the bus through the I/O Interface, it must address the Front Panel first and light the appropriate lights on the Front Panel. The external Controller then may address the A-D Converter to tell it to store in Memory any information coming from the Acquisition Unit. It may address the Display Generator to tell it to read from Memory. It may address the Memory directly to tell it to store in memory, data that comes from the Controller at an address also coming from the Controller. In each case, the Controller controls the sequence of addressing and the sequence of action from the various cards, usually matching the addressing of cards with the original setting of the Front Panel lights. Some statements in TEK BASIC are general, that is, one statement will cause the software to accomplish the above steps, HOLD PA, for example. There are specific statements in TEK BASIC which will only address one card. For example, HOLD PA,ME;FP will only change the lights on the Front Panel. Refer to the appropriate software manual for a further explanation.

Program Call Buttons. If the Program Call buttons are pushed, an $\overline{\text{I/O STROBE}}$ is generated, but not $\overline{\text{STATUS STROBE}}$. Only the I/O Interface is contacted. It, in turn, sends an interrupt to an external Controller. If the external Controller has TEK BASIC software, for example, it will look back at this device address, acknowledge receipt of the interrupt, and ask for data by way of the I/O Interface. Then the status word, which is stored in the Front Panel status latches, is fed onto the data bus where it's received by the external Controller. It then acts on that status

word to begin sending to the P7001 cards a series of commands. This series of commands would be where the Controller would address the various cards in proper sequence to perform specific functions. These functions depend upon the program entered into the Controller. In TEK BASIC for example, each PROGRAM CALL button starts execution of a user written program at a line number equal to 100 times the value of the button pressed. For example, if button number 1 is pressed, then the program will begin execution at line number 1ØØ.

Detailed Circuit Card Circuit Descriptions

This concludes the general circuit description of the P7001. For a more detailed circuit description of each card, refer to the individual circuit card service manual. See Section 5 of this manual for a listing of card manuals.

SECTION 2

PERFORMANCE CHARACTERISTICS

This section lists performance characteristics to be found in a normally operating P7001. They are provided as a guide to troubleshooting and as a summary of P7001 operation. For specifications of the Digital Processing Oscilloscope (DPO), refer to DPO Specification and Calibration Manual (070-1600-00).

Information Transfer

The P7001 Processor circuit cards use an asyncronous bus for information transfer. The bus allows the cards to work independently of each other and provides each card with parallel access to power supplies and address, data, and control lines. Section 1 described the action of the common lines on the bus, i.e., DATA, ADDRESS, and CONTROL lines. This section will describe the dedicated pins for each card. Figure 2-1 lists the performance time of the transfer actions.

Characteristic	Performance
Master Device	Time between the assertion of bus information (Mode, Address, and/or Data) to the assertion of $\overline{\text{CONT SYNC}}$ is 50 nanoseconds Minimum. Time from the removal of $\overline{\text{CONT SYNC}}$ to the removal of bus information is 50 nanoseconds Minimum.
Slave Device	Time from the assertion of data to the assertion of $\overline{\text{SYNC ACK}}$ is 50 nanoseconds Minimum.
Status Strobe	150 nanoseconds duration Minimum.
I/O Strobe	150 nanoseconds duration Minimum.

Figure 2-1. Transfer Characteristics.

Characteristic	Performance
CTRL SYNC Timeout Error	A low is produced on B11 (Data bit) within 5 microseconds after A11 (CONT SYNC) goes low, if no other card has generated the low. Sets Bit Ø of the Front Panel/Z-Axis Status Word when the above condition exists.
Data Channel Grant Timeout Error	After A13 (DATA CH GRANT OUT) on the Front Panel/ Z-Axis card goes high, it is pulled low within 5µS if no other card has pulled B15 (SELECT ACK) low. A13 cycles to a high state within 200 nS and a new timeout begins. Set Bit Ø of the Status Word when the above condition exists.
CPU Busy	Indicator button lights when PROGRAM CALL button bits are non-zero.
Bus Priority	1

Figure 2-2. Front Panel/Z-Axis Characteristics.

Dedicated Pins	Signal Command	Characteristics or Application
A35	Z AXIS (ACQ)	Analog current from Acquisition Unit of 1 mA to 4 mA, is recognized as an unblanked crt.
B35	DISPLAY GEN Z AXIS	Analog current from Display Generator.
B1	$\overline{\text{REMOTE RESET}}$	Level: Ø V = Reset Acquisition Unit Time Bases.
A28	DISPLAY PLUG-INS	Controls the signals displayed on the CRT of the Display Unit.
B29	$\overline{\text{PLUG IN}}$	Level: TTL Low = Display Source is Plug-ins.
A33	Z AXIS OUT(DISPLAY)	Analog current to Z-Axis amplifier of the Display Unit (0 mA to 4 mA).
B33	$\overline{\text{Z AXIS}}$	Level: TTL Low = Z Axis blanked High = Z Axis unblanked

Figure 2-3. Front Panel/Z-Axis Dedicated Pins.

Functions of the Front Panel/Z-Axis card.

Figures 2-2 and 2-3 show the performance characteristics and the application of the dedicated pins for the Front Panel/Z-Axis cards. They perform the following functions:

1) Issue a Status Word, when appropriate Front Panel buttons are pressed, to all circuit cards via the bus. (Changes to the Front Panel status that are produced by addressing it through the I/O Interface via the data bus will not generate a new Status Word.)

2) Indicates the operations modes to the operator, when the P7001 is programmed by either the operator or an external Controller (computer or calculator).

3) Processes Z-Axis data to the Display Unit and provides Z-Axis validation to the A-D Converter.

4) Controls the transfer of information via the data bus.

5) Provides a remote reset signal to the Acquisition Time Base Plug-in Units that are under program control, and signals the external Controller when the sweep is complete.

6) Informs the external Controller when a time-out error has occured.

7) Provides status information on the error light that is mounted on the card.

8) Pressing the Front Panel DATA HANDLING, MEMORY LOCATION, and START buttons causes $\overline{\text{STATUS STROBE}}$ and $\overline{\text{I/O STROBE}}$ to be generated. PROGRAM CALL buttons 1 to 16 generate $\overline{\text{I/O STROBE}}$ only. Pressing DISPLAY SOURCE buttons does not generate $\overline{\text{STATUS STROBE}}$ or $\overline{\text{I/O STROBE}}$.

9) When the Power is first turned on, the positive transition of $\overline{\text{Power Fail}}$ causes the Front Panel to send a Status Word which sets the Front Panel status to PLUG-INS, HOLD, and Memory Location A.

Dedicated Pin	Signal Command	Characteristic or Application
B1	DISPLAY PLUG-INS	Level: TTL Low= CRT will display Memory Information High= CRT will display Plug-ins.
A33	V-H INHIBIT	Readout vertical and horizontal inhibit. Level: TTL Low= non-readout High= readout
B33	SAMPLE COMMAND	1.4 microseconds pulse from A-D Converter. Used to trigger vertical and horizontal Sample.
A35	HORIZ SELECT	From A-D Converter. Used to switch Sample and Hold output stage from vertical to horizontal.
B35	SAMPLE ACK	Occurs 90 nanoseconds after SAMPLE COMMAND. Used to tell the A-D Converter that SAMPLE COMMAND has been received by both vertical and horizontal avalanche trigger circuits.

Figure 2-4. Sample and Hold Dedicated Pins.

Sample and Hold

The Sample and Hold circuit card consists of a vertical sampler, horizontal sampler, and a display switching circuit. The samplers generate replicas of the input vertical and horizontal signals from the Acquisition plug-in units and time multiplex them at the

sampling repetition rate for conversion to digital data by the A-D Converter. Sampling repetition rate is determined by the A-D Converter and is typically 150 kHz ± 30 kHz. The display switching section determines which waveform (real time or stored) is sent to the Display Unit for presentation. Figure 2-4 is a list of the dedicated pins on the Sample and Hold card and their application.

Analog to Digital Converter

The A-D Converter uses a successive approximation technique to digitize sampled vertical and horizontal information. The vertical resolution is 10 bits or 1 part in 1024 points; the horizontal is 9 bits or 1 part in 512 points. The vertical and horizontal samples are digitized to 10 bits; the horizontal sample is then truncated to 9 bits and used to address the P7001 memory. The vertical information is then stored in the selected address. The validity of the samples is also determined by the A-D converter before they are stored, by data received from the Front Panel/Z-Axis circuit cards. Conversion period for a vertical plus horizontal sample, is 6.5 µs ± 0.4 µs. Figure 2-5 is a list of the dedicated pins for use by the A-D Converter card.

Display Generator

The Display Generator converts X and Y data points to analog information for the Display Unit by: 1) Generating an analog signal from address information to provide the horizontal deflection voltage, and 2) converts binary information from either P7001 memory or an external Controller to analog data for the vertical deflection.

Dedicated Pins	Signal Command	Characteristics
B28	MAINFRAM CH SW SIG	Right Vert = +0.5V to +1.0V Left Vert = -0.5V to -1.0V
B29	CHOP DRIVE	Ch 1 = -0.5V to -1.0V Ch 2 = +0.5V to +1.0V
A33	$\overline{\text{Z AXIS}}$	TTL High = Z Axis blanked TTL Low = Z Axis unblanked
B35	SAMPLE ACK	TTL input
A36	$\overline{\text{EXT START}}$	TTL input, must be low at least 50 nanoseconds but no longer than 6.2 microseconds.
B1	LOAD HORIZ	TTL High = A-D Converter is the source of data on the bus.
A16	$\overline{\text{HUSH}}$	TTL, precedes SAMPLE COMMAND by 100 nanoseconds.
B33	SAMPLE COMMAND	1.4 microseconds pulse on positive transition sent to the Sample and Hold card.
A35	HORIZ SEL	TTL
Priority		2

Figure 2-5. A-D Converter Dedicated Pins.

The displays thus generated from the Memory locations that are selected by the Front Panel, are continuously refreshed (updated) to provide a flicker free presentation on the CRT.

Displays from Memory are limited to single valued functions (Y-T MODE). Multiple valued functions (X-Y MODE) can be displayed when the generator is provided continuous data from an external Controller. Figure 2-6 is a list of Display Generator dedicated pins and their use.

Dedicated Pin	Signal Command	Application
A33	READOUT TRIGGER	Trigger from Acquisition Unit readout board.
B35	DIS GEN Z AXIS	Z-Axis information to Front Panel/ Z-Axis card.
A36	$\overline{\text{DISPLAY SKIP}}$	Skip display information from Acquisition Unit readout board.
Priority		3

Figure 2-6. Display Generator Dedicated Pins.

@

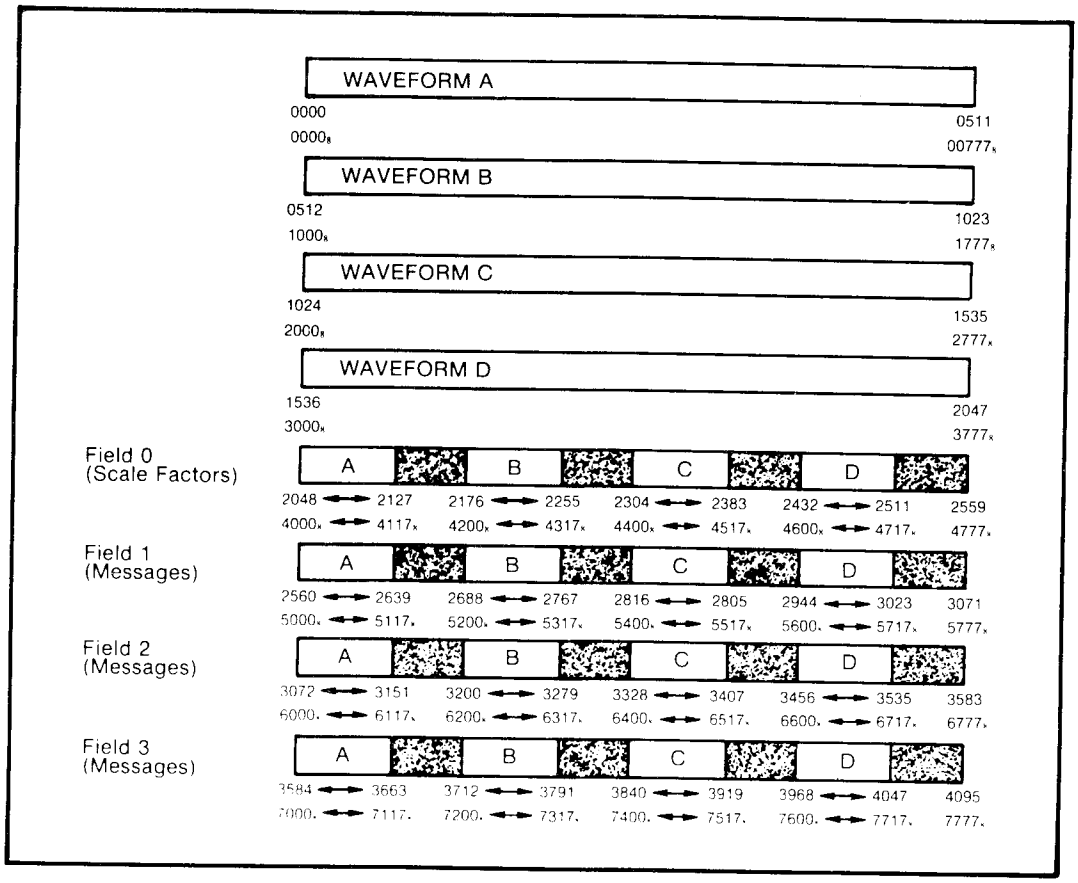


Figure 2-7. Readout Interface Memory Allocation.

Dedicated Pin	Signal Command	Application
B1	READOUT INTENSITY	Disables Readout Card when Display Unit readout intensity control is off.
A27 A28 B28	$\overline{\text{CH ADD 2}}$ $\overline{\text{CH ADD 1}}$ CH ADD 4	Channel location; information from Acquisition Unit readout board.
B29	$\overline{\text{PLUG-IN}}$	TTL from Front Panel/Z-Axis card. Low when Display Source is Plug-ins.
A33	READOUT TRIGGER	Timing trigger from Acquisition Unit readout board.
A35	$\overline{\text{PLUG-IN RO DISABLE}}$	Turns off readout information from Plug-ins.
A36	DISPLAY SKIP	From Acquisition Unit readout board. Used to skip display between readout words.
B33 B34	COLUMN DATA ROW DATA	Sends information to Acquisition Unit Readout Board during read from Memory. Receives information from Acquisition Unit Plug-ins during STORE mode.
B34	(B33 and B34 shield, raised to +15V)	Common shield tie point. Used to carry +15V reference from Acquisition Unit Readout oard.

Figure 2-8. Readout Interface Card Dedicated Pins.

Readout Interface

The Readout Interface circuit card channels readout information, via the data bus, from the Acquisition Plug-In Units to the P7001 Memory for storage during the STORE mode. The Readout card determines the memory address from Front Panel information.

The Readout card channels stored information into the readout circuit in the Acquisition Unit for display during the HOLD mode while BOTH or MEMORY is selected. When two or more stored waveforms are selected, the displayed readout applies to the waveform nearest location A. Under program control, one of the twelve additional stored messages in memory is displayed.

Message size is 80 characters with 40 displayed across the top and 40 displayed across the bottom of the CRT. There are three message fields of four messages each and a fourth field which is normally used to store readout information for waveforms A, B, C and D.

The number of addresses that can be displayed on the DPO CRT is 120_8 (P7001 memory addresses begin at the locations indicated in Figure 2-7). Figure 2-8 is a list of Readout Interface Card dedicated pins and their use.

Core Memory

The P7001 Core Memory contains a fully decoded, random access memory with a 4096 word capacity each 10 bits long. Storage media is a planar stack of cores that are woven in a double herringbone, 3D-3 wire pattern.

Characteristic	Performance
Access Time	450 nanoseconds or less
Cycle Time	1.25 nanoseconds to 1.45 microseconds.
Modes	Read/Restore, Clear/Write, Read/Modify/Write
Voltage	Set by adjusting the resistance between Test Pt "V" and the junction of R101 and R105, (with R103) to 4.34 kΩ at 25°C ± 60 Ω/°C from 20°C to 30°C.
Strobe Timing	180 nanoseconds ± 5 nanoseconds after READ command goes low.

Figure 2-9. Core Memory Characteristics.

Dedicated Pin	Signal Command	Application
A36	V MEM SENSE	Provides no current reference potential back to Power Supply for voltage regulation.
A34 B34	V MEM	Provides regulated voltage for core current.
B28	$\overline{\text{INHIBIT}}$	Used for between board communication in the P7001 core memory assembly.
A28	$\overline{\text{LOAD MDR}}$	
B29	$\overline{\text{STROBE}}$	
B33	SYNC DRIVE	
A33	$\overline{\text{GATE DATE}}$	
A35	CLEAR MDR	
Note: The above pins are not used with Semiconductor Memory.		

Figure 2-10. Core Memory (J8-J9) Dedicated Pins.

Semiconductor Memory

There are two versions of the Semiconductor Memory, one containing 1024 words of 10 bits each and the other containing 2048 words of 10 bits each. By using multiples of the basic 1K and 2K memories, four memory combinations are attainable: A 1024 word memory (1K), a 2048 word memory (2K), a 3072 word memory (3K), and a 4096 word memory (4K).

The 1K and 2K Semiconductor Memories have exactly the same characteristics and differ only in the number of memory cells added to the etched circuit card. The Semiconductor Memory has no dedicated pins.

Characteristic	Performance
Cycle Time	1300 nanoseconds
Modes	Clear/Write, Read/Restore
Address Settling Time (TP1)	450 nanoseconds
Write Pulse (TP2)	800 nanoseconds

Figure 2-11. Semiconductor Memory Characteristics.

@

Power Supply

The P7001 Power Supply is designed to provide considerable savings in volume, weight, and power consumption. This high effeciency supply provides the voltages shown in Table 2-13 within the tolerances listed. Table 2-12 lists the input voltage specifications and minimum load required.

Characteristic	Performance
Min Load Required	50 watts input
Maximum Line Voltage Input	250 V RMS
Line Voltage Regulation (Selected by a rear panel Selector Assembly)	115 V nominal: Operates between 90 V to 132 V RMS 230 V nominal: Operates between 180 V to 264 V RMS
Line Frequency	48 Hz to 440 Hz
Power Consumption (Max) from 60 Hz, 115 V RMS line	120 watts, 1.5 A

Figure 2-12. Power Supply Characteristics.

Tolerance for DC Supplies			
Supply	Tolerance	Ripple[1]	Supplemental Information
-50V	Within 1%	3 mV	Foldback limiting for all supplies except +50V
-15V	Within 1.2%	2 mV	
-5V	Within 2%	2 mV	
+5V	Within 2%	2 mV	
+5.1V	Within 5%	10 mV	Over voltage protection for 5.1V supply
+15V	Within 2%	2 mV	
+Memory Volts (temp comp - see core memory manual)		2 mV	
+50V	Within 5%	5 mV	

[1]Ripple is measured with an oscilloscope with bandwidth of 1 MHz ± 10%.

Figure 2-13. Power Supply Tolerances.

SECTION 3

MAINTENANCE INFORMATION

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance, or troubleshooting of the P7001.

WARNING

Dangerous potentials exist at several points throughout the DPO. When the instrument is operated with the covers removed, do not touch exposed connections or components. Some transistors have voltages present on their cases. Disconnect power before cleaning the instrument or replacing parts.

Preventive Maintenance

Preventive maintenance consists of cleaning, visual inspection, lubrication, etc. Preventive maintenance which is performed on a regular basis may prevent instrument breakdown and will improve its reliability. The severity of the environment to which the P7001 is subjected determines the frequency of maintenance. A convenient time to perform preventive maintenance is preceding recalibration.

Cleaning. The P7001 should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts

as an insulating blanket and prevents efficient heat dissipation. It also privides an electrical conduction path which may result in instrument failure.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. In particular, avoid chemicals which contain benzene, toluene, xylene, acetone, or similar solvents.

Exterior. Loose dust accumulated on the outside of the P7001 can be removed with a soft cloth or small brush. The brush is particularly useful for dislodging dirt on and around the front panel controls. Dirt which remains can be removed with a soft cloth dampened in a mild detergent and water solution. Abrasive cleaners should not be used.

CRT. Clean the plastic light filter, faceplate protector, and the CRT face with a soft, lint-free cloth dampened with denatured alcohol.

Interior. Dust in the interior of the instrument should be removed occasionally due to its electrical conductivity under high humidity conditions. The best way to clean the interior is to blow off the accumulated dust with dry, low-pressure air. Remove any dirt which remains with a soft paint brush or a cloth dampened with a mild detergent and water solution. A cotton-tipped applicator is

useful for cleaning in narrow spaces or for cleaning plastic and ceramic parts and circuit cards.

Visual Inspection. The P7001 should be inspected occasionally for such defects as broken connections, improperly seated cable connectors, improperly seated semiconductors, damaged or improperly installed circuit boards and cards, and heat-damaged parts.

The corrective procedure for most visible defects is obvious. However, particular care must be taken if heat-damaged components are found. Overheating usually indicates other trouble in the instrument. Therefore, it is important that the cause of overheating be corrected to prevent recurrence of the damage.

Semiconductor Checks. Periodic checks of the semiconductors in the P7001 are not recommended. The best check of semiconductor performance is actual operation in the circuit. More details on checking semiconductor operation are given under troubleshooting.

Recalibration. To assure accurate measurements, check the calibration of this instrument after each 1000 hours of operation or every six months if used infrequently. In addition, replacement of components may necessitate recalibration of the affected circuits. The calibration procedures can also be helpful in localizing certain troubles in the instrument. In some cases, minor troubles may be revealed and/or corrected by recalibration.

Troubleshooting

The following information is provided to facilitate troubleshooting of the P7001. Information contained in other sections of this manual and the card manuals should be used along with the following information to aid in locating the defective component. An understanding of the circuit operation is very helpful in locating troubles, particularly where integrated circuits are used. See the Circuit Description section of this manual and each card manual for complete information.

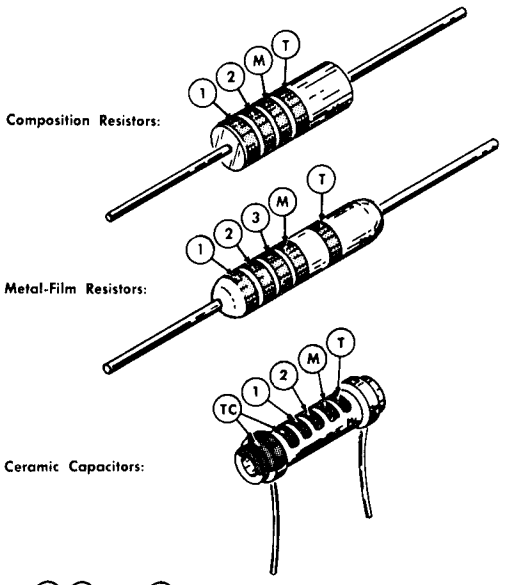
Troubleshooting Aids:

DIAGRAMS. Complete circuit diagrams are given on fold-out pages in each card manual. These diagrams are numbered serially from 1, in this manual, through 12, in the Power Supply manual. The component number and electrical value of each component in this instrument are shown on the diagrams. See Section 4 of this manual for a definition of the reference designators used to identify components on each circuit card. The portions of the circuit mounted on circuit cards are enclosed with shaded blue or grey lines.

RESISTOR COLOR-CODE. In addition to the brown composition resistors, some metal-film resistors and some wire-wound resistors are used in the P7001. The resistance values are printed on the body of the component. The resistance values of composition resistors and metal-film resistors are color-coded on the components with EIA Color-code (some metal-film resistors may have the value printed on the body). The color-code is read starting with the

@

stripe nearest the end of the resistor. Composition resistors have four stripes which consist of two significant figures, a multiplier, and a tolerance value (see Figure 3-1). Metal-film resistors have five stripes consisting of three significant figures, a multiplier, and a tolerance value.



Resistor and Capacitor Color Code

Color	Significant Figures	Multiplier: Resistors	Multiplier: Capacitors	Tolerance: Resistors	Tolerance: Capacitors
Silver	---	10^{-2}	---	±10%	---
Gold	---	10^{-1}	---	±5%	---
Black	0	1	1	---	±20% or 2 pF*
Brown	1	10	10	±1%	±1% or 0.1 pF*
Red	2	10^{2}	10^{2}	±2%	±2%
Orange	3	10^{3}	10^{3}	±3%	±3%
Yellow	4	10^{4}	10^{4}	±4%	+100% −0%
Green	5	10^{5}	10^{5}	±0.5%	±5% or 0.5 pF*
Blue	6	10^{6}	10^{6}	---	---
Violet	7	---	---	---	---
Gray	8	---	10^{-2}	---	+80% −20% or 0.25 pF*
White	9	---	10^{-1}	---	±10% or 1 pF*
(none)	---	---	---	±20%	±10% or 1 pF*

*For capacitance of 10 pF or less.

NOTE: T and/or TC color code for capacitors depends upon manufacturer and capacitor type. May not be present in some cases.

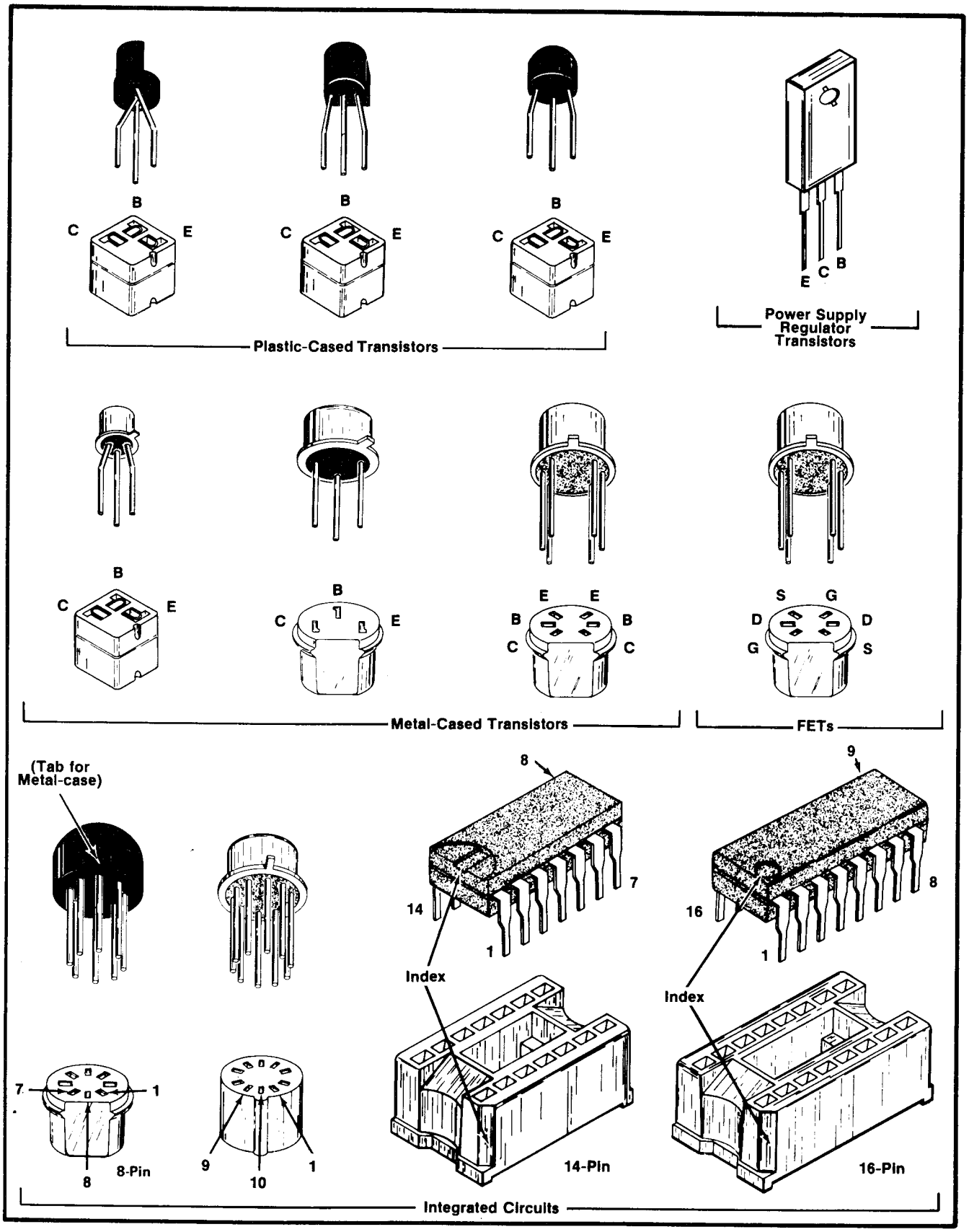
1882-29

Figure 3-1. Color-code for Resistors and Ceramic Capacitors.

CAPACITOR MARKING. The capacitance values of common disc capacitors and small electrolytics are marked in microfarads on the side of the component body. The white ceramic capacitors used in the P7001 are color-coded in picofarads using a modified EIA code (see Figure 3-1).

DIODE COLOR-CODE. The cathode end of each glass-encased diode is indicated by a stripe, a series of stripes, or a dot. For most silicon or germanium diodes with a series of stripes, the color-code identifies the three significant digits of the Tektronix Part Number using the resistor color-code system (e.g., a diode color-coded pink-, or blue-, brown-grey-green indicates Tektronix Part Number 052-0185-00). The cathode and anode ends of metal-encased diodes can be identified by the diode symbol marked on the body.

SEMICONDUCTOR LEAD CONFIGURATION. Figure 3-2 shows the lead configuration for the semiconductors used in this instrument. This view is as seen from the bottom of the semiconductors.



1882-30

Figure 3-2. Electrode Configuration for Semiconductors.

Troubleshooting Equipment. The following equipment is useful for troubleshooting the P7001:

1. Transistor Tester

Description: Dynamic-type tester. Must be capable of measuring reverse breakdown voltages of at least 400 volts.

Purpose: To test the semiconductors used in this instrument.

Recommended type: Tektronix Type 577 Transistor-Curve Tracer.

2. Multimeter

Description: VTVM, 10 megohm input impedance and 0 to 500 volts range, AC and DC; ohmmeter, 0 to 50 megohms. Accuracy, within 3%. Test probes must be insulated to prevent accidental shorting.

Purpose: To check voltages and for general trouble-shooting in this instrument.

NOTE

A 20,000 ohms/volt VOM can be used to check the voltages in this instrument if allowances are made for the circuit loading of the VOM at high-impedance points.

3. Test Oscilloscope

Description: Frequency response, DC to 50 megahertz minimum; deflection factor, 5 millivolts to 5 volts/division and 1 milliampere to 1 ampere/division. A 10X, 10-megohm voltage probe should be used to reduce circuit loading for voltage measurements.

Purpose: To check operating waveforms in this instrument.

Recommended type: Tektronix 7704A or 7603 Oscilloscope with 7A16 Amplifier, 7A14 Current Probe Amplifier, and 7B70 or 7B71 Time Base plug-in units. Use a P6053 10X probe and a P6021 Current Probe.

4. Isolation Transformer

Description: 1:1 turns ratio, 500 volt-amperes minimum rating, 50-60 cycle. Must have three-wire power cord, plug, and receptacle with ground connection carried through from input to output.

Purpose: To isolate the P7001 from the line potential when troubleshooting in the power supply.

Recommended type: Stancore #P6298 (for 115-volt line only) Modified to include three-wire power cord, plug, and receptacle.

5. Variable Autotransformer

Description: Output variable from 0 to 140 volts, 10

amperes minimum rating. Must have three-wire power cord, plug, and receptacle.

Purpose: To vary the input line voltage when troubleshooting in the power supply.

Recommended type: General Radio W10MT3W Metered Variac Autotransformer.

Troubleshooting Techniques. This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks assure proper connection, operation, and calibration. If the trouble is not located by these checks, the remaining steps aid in locating the defective component. When the defective component is located, it should be replaced following the replacement procedures given under Corrective Maintenance.

1. Check Control Settings. Incorrect control settings can indicate a trouble that does not exist. If there is any question about the correct function or operation of any control, see the DPO Operators Manual and the 7704A Operators Manual.

2. Check Associated Equipment. Before proceeding with troubleshooting of the P7001, check that the equipment used with it is operating correctly. Check that the signal is properly connected and that the interconnecting cables are not defective. Also, check the power source. The 7704A and the Plug-in Units should be checked. The

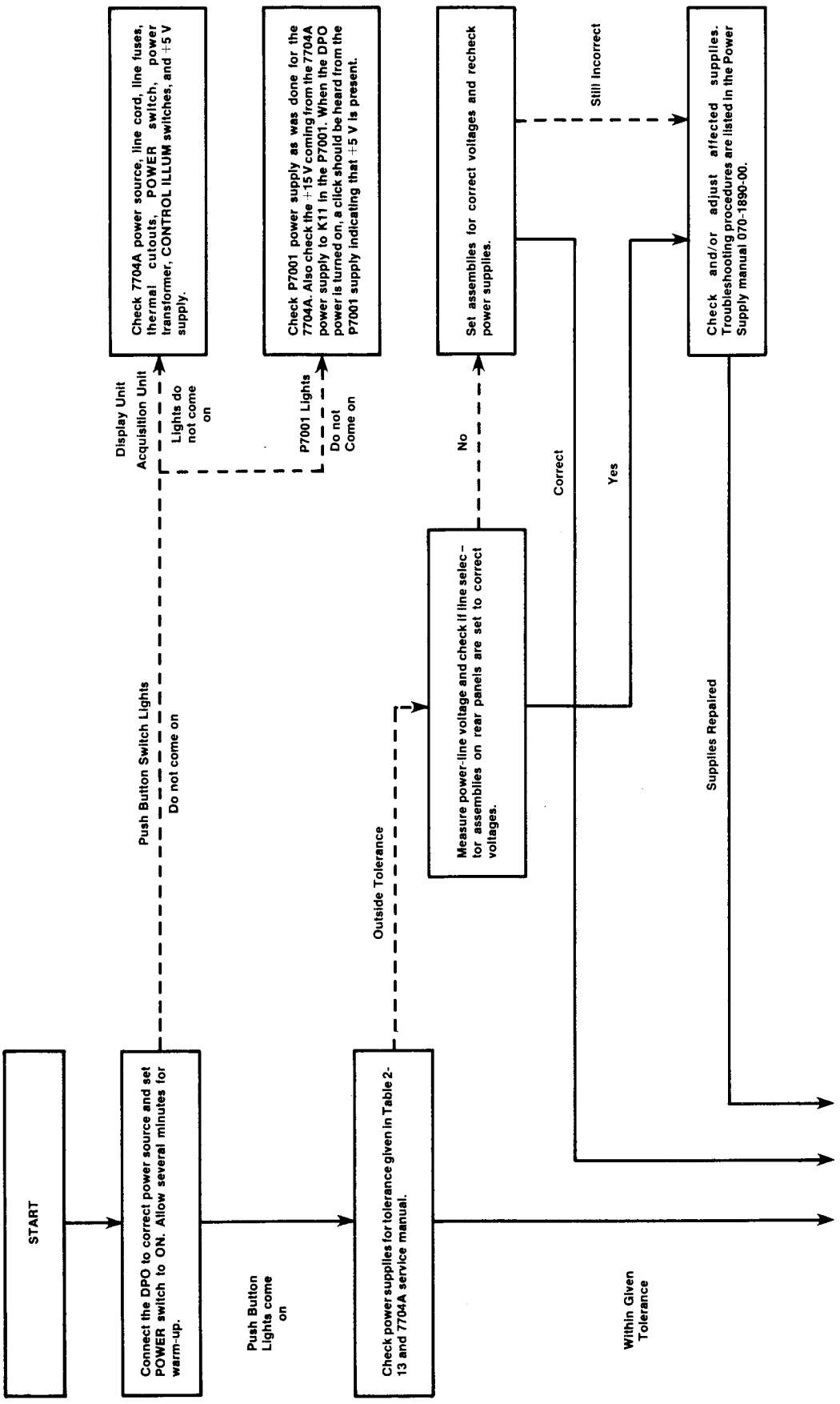
plug-in units can be checked for proper operation by substituting other units which are known to be operating properly (preferably of the same type). If the trouble persists after substitution, the P7001 is probably at fault.

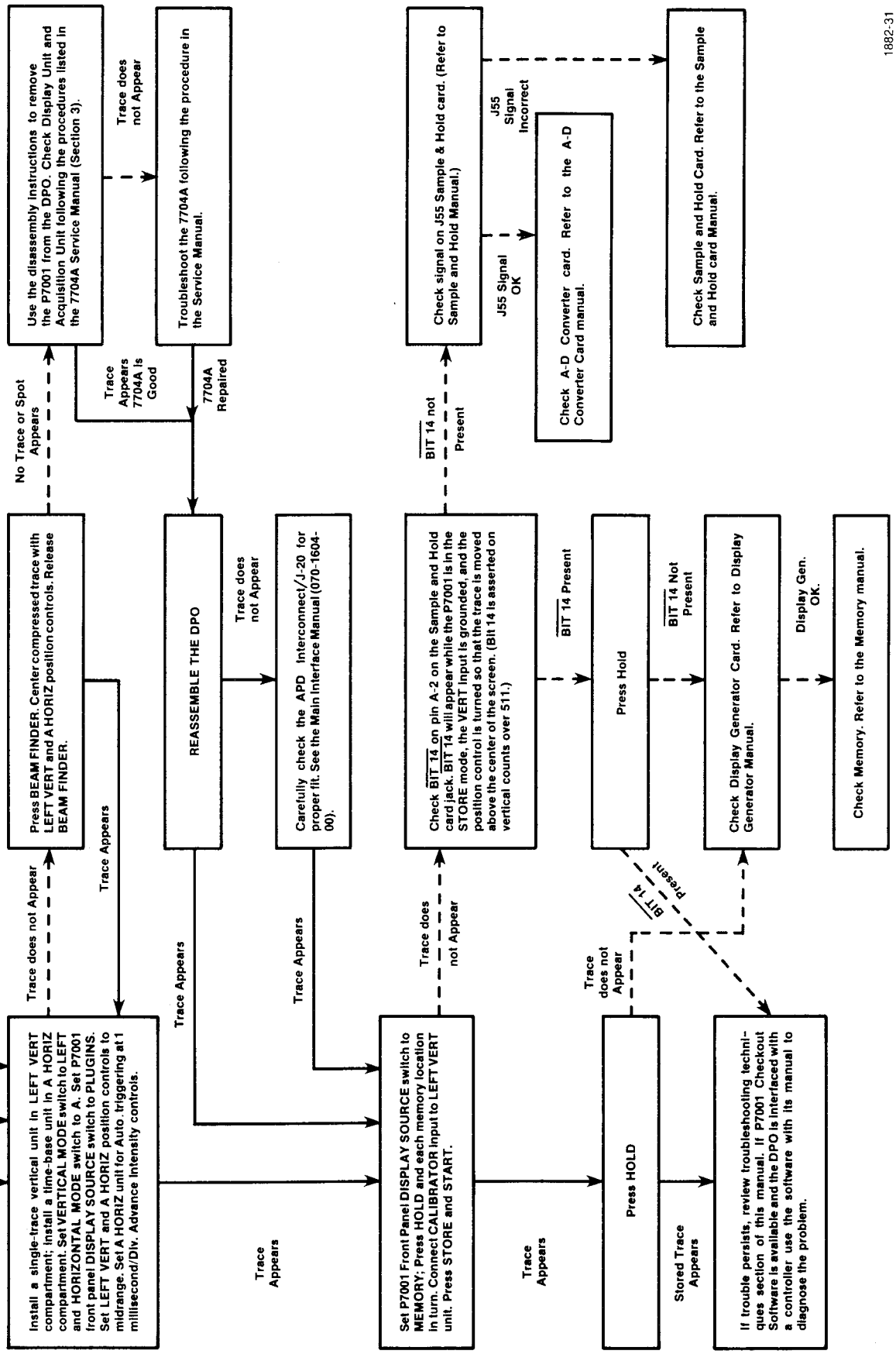
3. Visual Check. Visually check the portion of the instrument in which the trouble is located. Many troubles can be found by visual indications such as unsoldered connections, broken wires, damaged circuit boards, damaged components, etc.

4. Check Instrument Calibration. Check the calibration of the P7001 as part of the DPO, or the affected circuit if the trouble appears in one circuit. The apparent trouble may only be a result of misadjustment or may be corrected by calibration. Complete calibration instructions are given in the DPO Specification and Calibration Manual.

5. Isolate Trouble to a Circuit Card. To isolate trouble to a particular circuit card, note the trouble symptom. The symptom often identifies the card on which the trouble is located. Figure 3-3, Circuit Isolation Troubleshooting Chart, gives procedures to use in isolating the problem to a particular circuit card of the P7001/DPO. Start from the top of the chart and perform the given checks on the left side of the page until a step is found which does not produce the indicated results.

Fig. 3-3. CIRCUIT ISOLATION TROUBLESHOOTING CHART




Install a single-trace vertical unit in LEFT VERT compartment; install a time-base unit in A HORIZ compartment. Set VERTICAL MODE switch to LEFT and HORIZONTAL MODE switch to A. Set P7001 front panel DISPLAY SOURCE switch to PLUGINS. Set LEFT VERT and A HORIZ position controls to midrange. Set A HORIZ unit for Auto. triggering at 1 millisecond/Div. Advance intensity controls.
Trace does not Appear
Trace Appears
Press BEAM FINDER. Center compressed trace with LEFT VERT and A HORIZ position controls. Release BEAM FINDER.
No Trace or Spot Appears
Use the disassembly instructions to remove the P7001 from the DPO. Check Display Unit and Acquisition Unit following the procedures listed in the 7704A Service Manual (Section 3).
Trace does not Appear
Trace Appears 7704A Is Good
Troubleshoot the 7704A following the procedure in the Service Manual.
7704A Repaired
REASSEMBLE THE DPO
Trace does not Appear
Carefully check the APD Interconnect/J-20 for proper fit. See the Main Interface Manual (070-1604-00).
Trace Appears
Trace Appears
Set P7001 Front Panel DISPLAY SOURCE switch to MEMORY. Press HOLD and each memory location in turn. Connect CALIBRATOR input to LEFT VERT unit. Press STORE and START.
Trace does not Appear
Check BIT 14 on pin A-2 on the Sample and Hold card jack. BIT 14 will appear while the P7001 is in the STORE mode, the VERT input is grounded, and the position control is turned so that the trace is moved above the center of the screen. (Bit 14 is asserted on vertical counts over 511.)
BIT 14 not Present
Check signal on J55 Sample & Hold card. (Refer to Sample and Hold Manual.)
J55 Signal OK
J55 Signal Incorrect
Check A-D Converter card. Refer to the A-D Converter Card manual.
Check Sample and Hold Card. Refer to the Sample and Hold card Manual.
BIT 14 Present
Press Hold
BIT 14 Not Present
Check Display Generator Card. Refer to Display Generator Manual.
Display Gen. OK.
Check Memory. Refer to the Memory manual.
Trace does not Appear
BIT 14 present
Trace Appears
Press HOLD
Stored Trace Appears
If trouble persists, review troubleshooting techniques section of this manual. If P7001 Checkout Software is available and the DPO is interfaced with a controller use the software with its manual to diagnose the problem.
1882-31

@

Further checks and/or the circuit card in which the trouble is probably located are listed to the right of this step. After the defective circuit card has been located, refer to the particular card manual for further troubleshooting information. It is recommended that the nearest TEKTRONIX Field Office be contacted about card repair.

6. Check Power Supply Voltages. Incorrect operation of all circuit cards often indicates trouble in the power supply. Check first for correct voltage of the individual supplies. However, a defective component elsewhere in the instrument can appear as a power supply trouble and may also affect the operation of other circuits. See the P7001 Power Supply Manual for detailed troubleshooting information.

Corrective Maintenance

Corrective maintenance consists of component replacement and instrument repair. Special techniques required to replace components in this instrument are given here.

Obtaining Replacement Parts.

STANDARD PARTS. All electrical and mechanical part replacements for the P7001 can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, check the parts lists for value, tolerance, rating, and description.

NOTE

When selecting replacement parts, it is important to remember that the physical size and shape of a component may affect its performance in the instrument, particularly at high frequencies. All replacement parts should be direct replacements unless it is known that a different component will not adversely affect instrument performance.

SPECIAL PARTS. In addition to the standard electronic components, some special components are used in the P7001. These components are manufactured or selected by Tektronix, Inc. to meet specific performance requirements, or are manufactured for Tektronix, Inc. in accordance with our specifications. These special components are indicated in the Electrical Parts List by an asterisk preceding the part number. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. Order all special parts directly from your local Tektronix Field Office or representative.

ORDERING PARTS. When ordering replacement parts from Tektronix, Inc., include the following information:

1. Instrument type.

2. Instrument serial number.

3. A description of the part (if electrical, include circuit number).

4. Tektronix Part Number.

Soldering Techniques.

WARNING

Disconnect the instrument from the power source before soldering.

The reliability and accuracy of this instrument can be maintained only if proper soldering techniques are used when repairing or replacing parts. General soldering techniques which apply to maintenance of any precision electronic equipment should be used when working on this instrument. Use only 60/40 rosin-core, electronic-grade solder. The choice of soldering iron is determined by the repair to be made. When soldering on circuit boards, use a 35- to 40-watt pencil-type soldering iron with a 1/8-inch wide, wedge-shaped tip. Keep the tip properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the wiring from the base material. Avoid excessive heat; apply only enough heat to remove the component or to make a good solder joint. Also, apply only enough solder to make a firm solder joint; do not apply too much solder.

For metal terminals (e.g., switch terminals, potentiometers, etc.) a higher wattage-rating soldering iron may be required. Match the soldering iron to the work being done. For example, if the component is connected to the chassis or other large heat-radiating

surface, it will require a 75-watt or larger soldering iron. The pencil-type soldering iron used on the circuit board can be used for soldering to switch terminals, potentiometers, or metal terminals mounted in plastic holders.

Component Replacement.

WARNING

Disconnect the instrument from the power source before replacing components.

GENERAL. The exploded-view drawings associated with the Mechanical Parts List (located in each card manual) may be helpful in the removal or disassembly of individual components or sub-assemblies.

INTERFACE CONNECTORS. The individual connectors on the Main Interface can be replaced. However, it is recommended that the entire Main Interface board be replaced if a large number of the contacts are damaged. An alternative solution is to refer the maintenance of the damaged Main Interface board to your local Tektronix Field Office or representative.

SEMICONDUCTOR REPLACEMENT. Semiconductors should not be replaced unless actually defective. If removed from their sockets during routine maintenance, return them to their original sockets. Unnecessary replacement of semiconductors may affect the calibration of this instrument. When semiconductors are replaced, check the operation of the part of the instrument which may be affected.

CAUTION

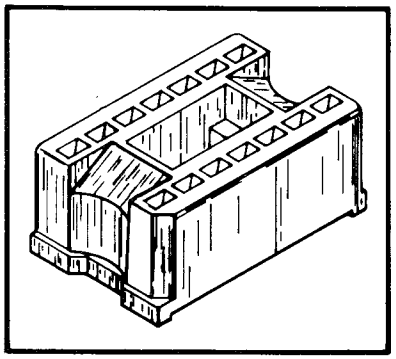
POWER switch must be turned off before removing or replacing semiconductors.

Replacement semiconductors should be of the original type or a direct replacement. Figure 3-2 shows the lead configuration of the semiconductors used in this instrument. Some plastic case transistors have lead configurations which do not agree with those shown here. If a replacement transistor is made by a different manufacturer than the original, check the manufacturer's basing diagram for correct basing. All transistor sockets in this instrument are wired for the standard basing as used for metal-cased transistors. Power Supply transistors which are mounted on the chassis use silicone grease to increase heat transfer. Replace the silicone grease when replacing these transistors.

WARNING

Handle silicone grease with care. Avoid getting silicone grease in eyes. Wash hands thoroughly after use.

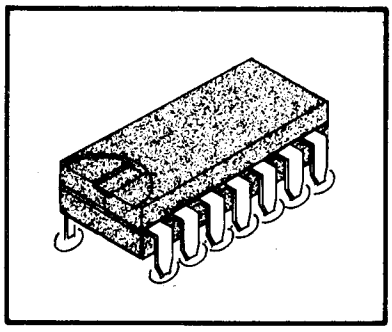
An extracting tool should be used to remove the 14- and 16-pin integrated circuits that are mounted in sockets to prevent damage to the pins. This tool is available from Tektronix, Inc. Order Tektronix Part No. 003-0619-00. If an extracting tool is not available when removing one of these integrated circuits, pull slowly and evenly on both ends of the device. Try to avoid



1882-32

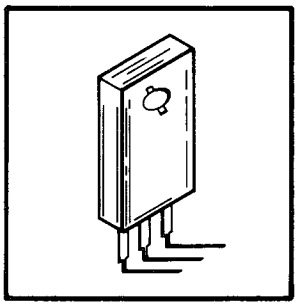
having one end of the integrated circuit pins disengage from the socket before the other, as this may damage the pins.

To remove integrated circuits which are soldered to the circuit card, first unsolder each of the pins (using a vacuum-type de-soldering tool or other device to remove excess solder). Then straighten the pins and using an extracting tool, remove the integrated circuit from the holes. Place the new IC into the holes and solder the pins to the back side of the card.



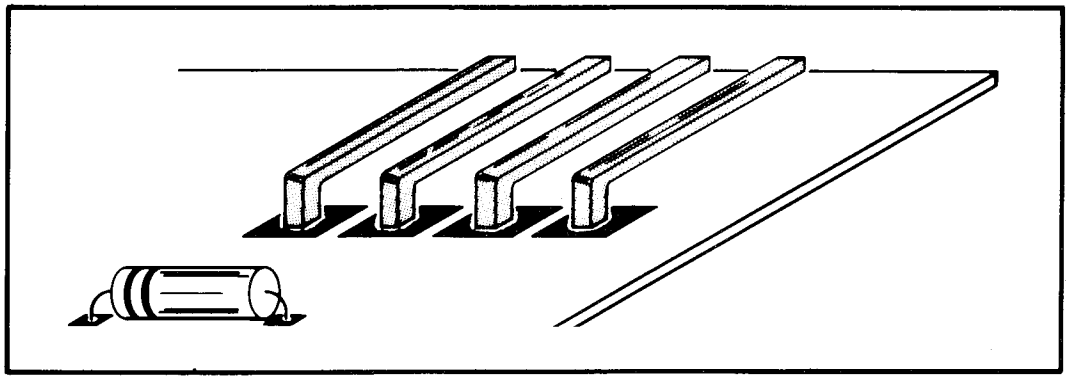
1882-33

To replace one of the power transistors mounted on the Power Supply Voltage Regulator Board; first unsolder the three transistor leads, then take out the mounting screws and remove the defective transistor. When replacing the transistor, tighten the mounting screws (use silicone grease as described previously). Then resolder the leads onto the voltage regulator board.



1882-34

INTERCONNECTING PIN REPLACEMENT. The type of interconnecting pin used in this instrument to interconnect the circuit cards with other components and cards is a pin or pins that is/are soldered into the card. If the mating connector is on the end of a lead, an end-lead pin connector is used which mates with the interconnecting pin.



1882-35

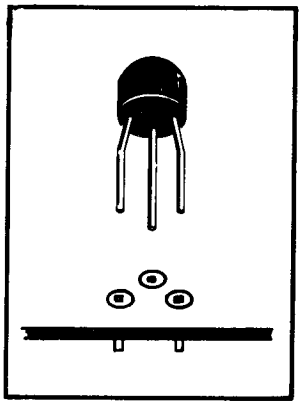
NOTE

A circuit-board pin replacement kit including necessary tools, instructions and replacement pins is available from Tektronix, Inc. Order Tektronix Part No. 040-0542-00.

To replace a pin which is mounted on a circuit card, first disconnect any pin connectors. Then, unsolder the damage pin and pull it out of the circuit board with a pair of pliers. Be careful not to damage the wiring on the card with too much heat. Ream out the holes in the circuit card with a 0.031-inch drill. Remove the ferrule from the new interconnecting pin and press the new pin into the hole in the circuit card. Position the pin in the same manner as the old pin. Then, solder the pin on both sides of the circuit card. If the old pin was bent at an angle to mate with a connector, bend the new pin to match the associated pins.

CIRCUIT CARD PIN SOCKETS. Pin Sockets are sometimes used on the circuit cards in place of transistor and Integrated Circuit sockets. To replace one of these sockets, first unsolder the pin

@

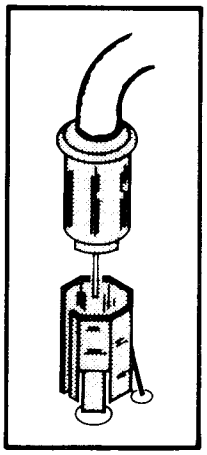

1882-36

on the back side of the card (use a vacuum-type desoldering tool or other device to remove excess solder). Then, straighten the tabs on the socket and remove it from the hole in the circuit card. Place the new socket in the circuit card hole and press the tabs down against the card. Solder the tabs of the socket to the circuit card; be careful not to get solder into the socket.

NOTE

The spring tension of the pin sockets ensures a good connection between the circuit card and the pin. This spring tension can be destroyed by using the pin sockets as a connecting point for spring-loaded probe tips, alligator clips, etc.

COAXIAL CONNECTORS. Replacement of the coaxial end-lead connectors requires special tools and techniques; only experienced maintenance personnel should attempt replacement of these connectors. It is recommended that the cable be replaced as a unit.

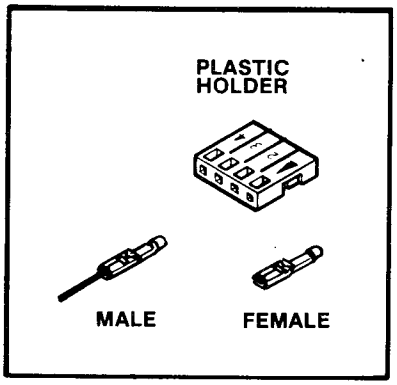

1882-37

The coaxial sockets can be removed by desoldering the tabs attached to the circuit card. Use a vacuum-type desoldering tool or other device.

END-LEAD PIN CONNECTORS. The pin connectors used to connect the wires to the interconnecting pins are clamped to the ends of

the associated leads. To replace damaged end-lead pin connectors, remove the old pin connector from the end of the lead and clamp the replacement connector to the lead.

Some of the pin connectors are grouped together and mounted in a plastic holder; the overall result is that these connectors are removed and installed as a multi-pin connector. To provide correct orientation of this multi-pin connector when it is replaced, an arrow is stamped on the circuit board or chassis and a matching arrow is molded into the plastic housing of the multi-pin connector. Be sure these arrows are aligned as the multi-pin connector is replaced. If the individual end-lead pin connectors are removed from the plastic holder, note the color of the individual wires for replacement.



1882-38

PUSHBUTTON SWITCH REPLACEMENT. The push button switches are not repairable and, if defective, may require replacement of the Front Panel circuit board. Components which are mounted on this board can be replaced using the normal replacement procedures.

Recalibration After Repair

After any electrical component has been replaced, the calibration of that particular circuit should be checked, as well as the calibration of other closely related circuits. Since the low-voltage supply affects all circuits, calibration of the entire instrument should be checked if work has been done in the low

voltage supply or if the power transformer has been replaced. The Performance Check procedure provides a quick and convenient means of checking instrument operation.

Instrument Repackaging

If this instrument is to be shipped for long distances by commercial means of transportation, it is recommended that it be repackaged in the original manner for maximum protection. The original shipping carton can be saved and used for this purpose. The Repackaging illustration in the Mechanical Parts List shows how to repackage the DPO and gives the part number for the packaging components. New shipping cartons can be obtained from Tektronix, Inc. Contact your local Tektronix Field Office or representative.

NOTE

The packaging material is not designed to protect the plug-ins if shipped installed in the plug-in compartments. The plug-ins should be shipped in their own shipping cartons.

SECTION 4

DIAGRAMS AND ILLUSTRATIONS

Symbols and Reference Designators

Electrical components shown on the diagrams located in each card manual are in the following units unless noted otherwise:

Capacitors = Values one or greater are in picofarads (pF).

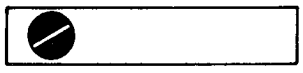
Values less than one are in microfarads (μF).

Resistors = Ohms (Ω)

Symbols used on the diagrams are based on USA Standard Y32.2-1967.

Logic symbology is based on MIL-STD-806B in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The following special symbols are used on the diagrams:

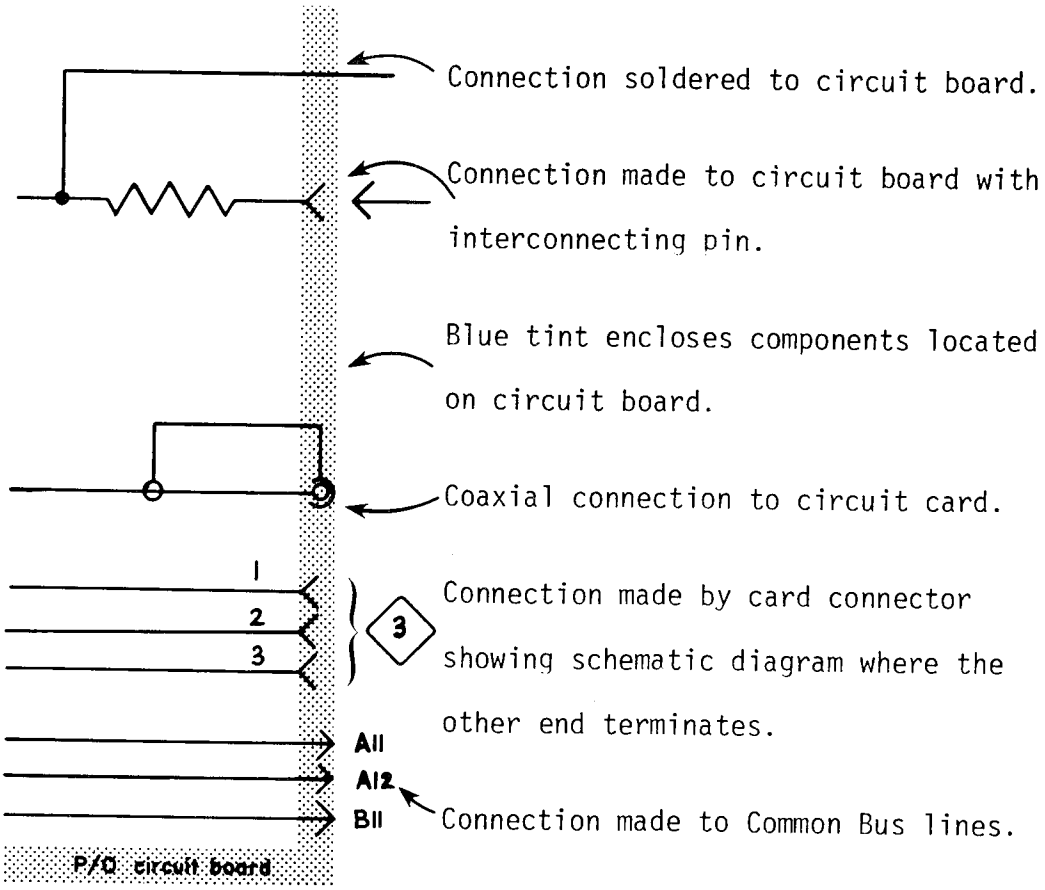


External Screwdriver adjustment

Refer to diagram number indicated in diamond.

Refer to waveform number indicated in hexagon.

@



The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

A	Assembly, separable or repairable
C	Capacitor, fixed or variable
CR	Diode, signal or rectifier
DL	Delay Line
DS	Indicating device (lamp)
F	Fuse
FL	Fliter
H	Heat dissipating device (heat sink, heat radiator, etc)
J	Connector, stationary portion
K	Relay
L	Inductor, fixed or variable
Q	Transistor or silicon-controlled rectifier

P	Connector, movable portion
R	Resistor, fixed or variable
RT	Thermistor
S	Switch
T	Transformer
TP	Testpoint
U	Assembly, inseparable or non-repairable (integrated circuit, etc.)
VR	Voltage regulator (zener diode, etc.)
Y	Crystal

@

SECTION 5

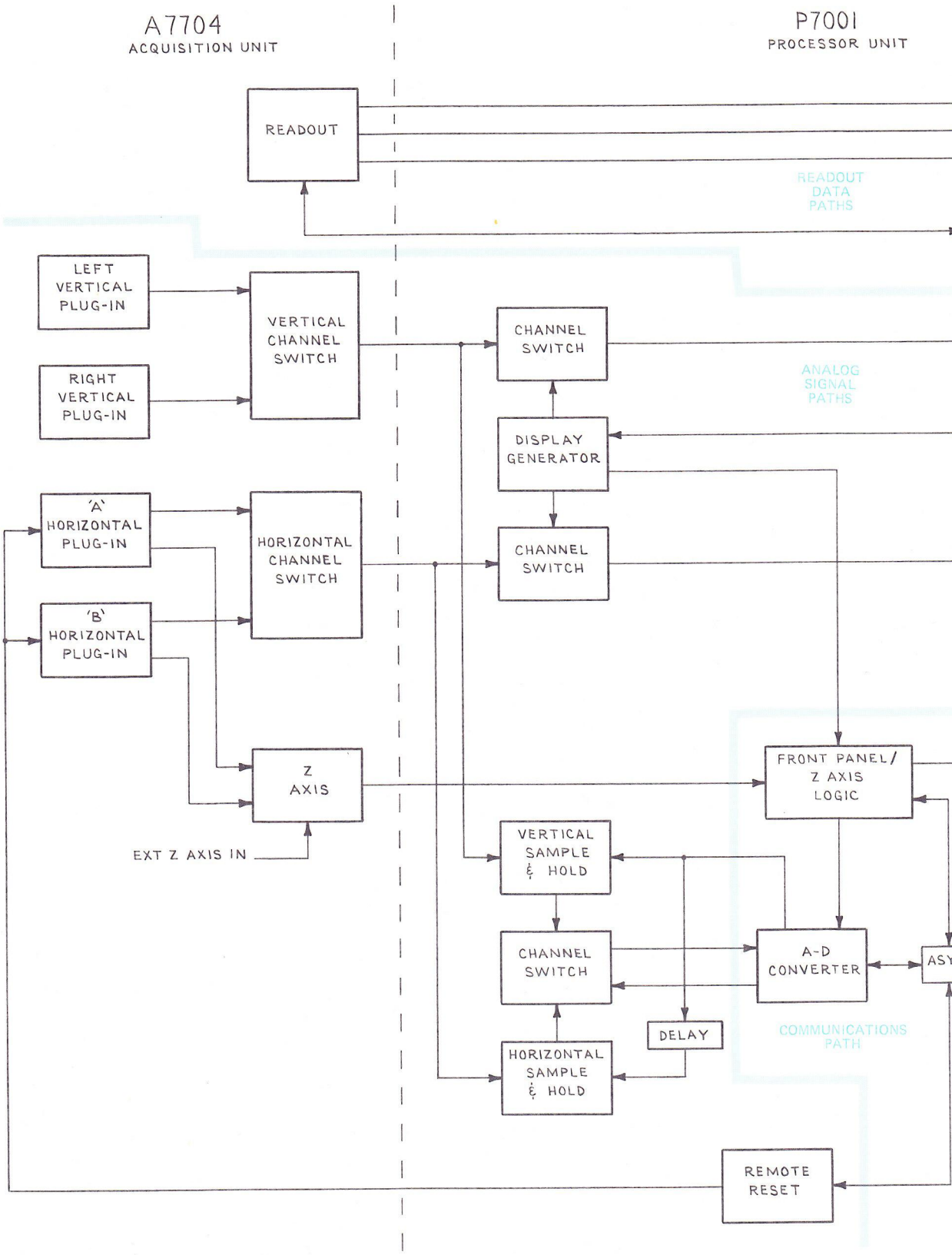
CARD SERVICE MANUALS

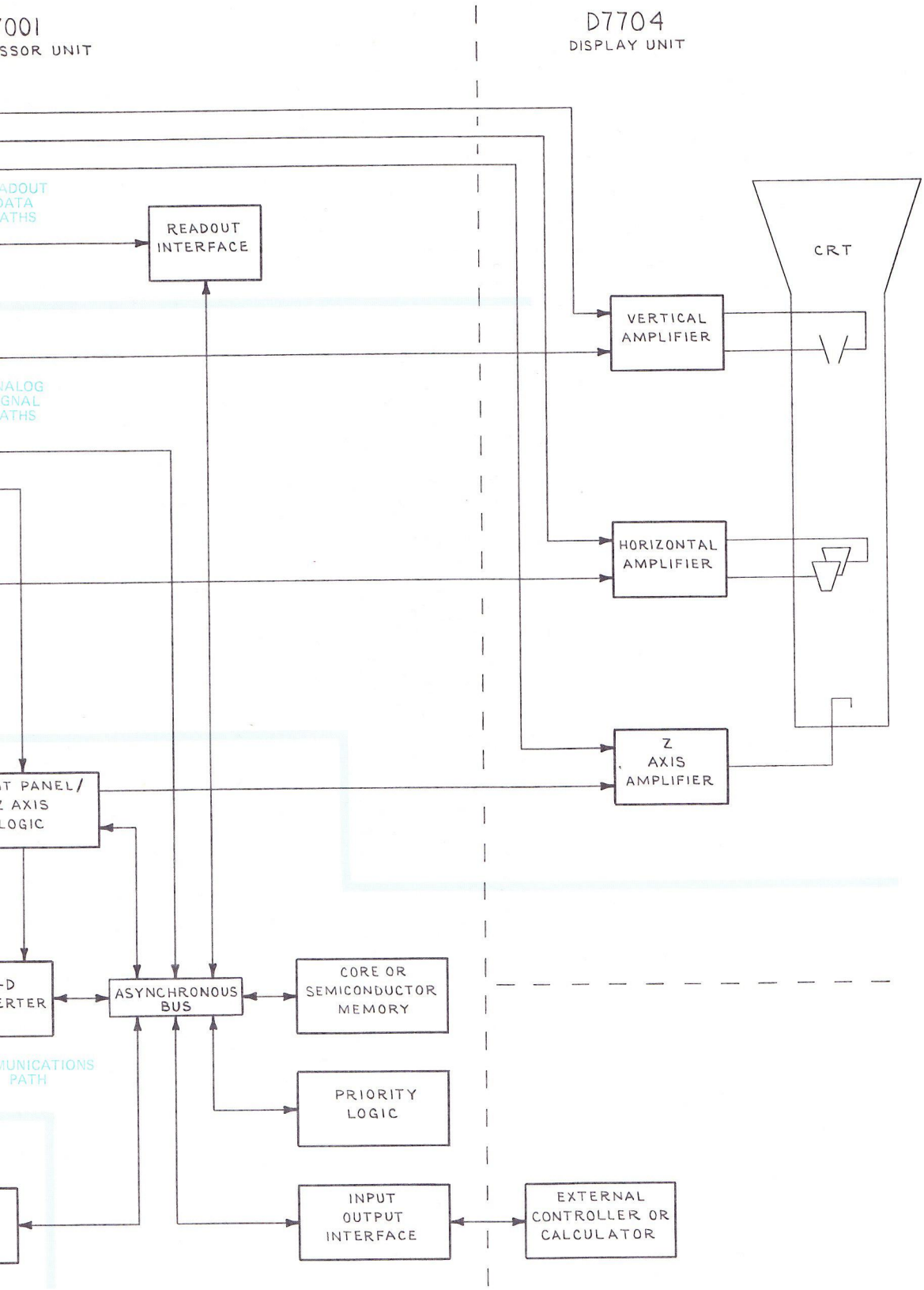
The following individual card service manuals are used in the P7001:

070-1604-00	Main Interface
070-1605-00	Core Memory
070-1606-00	Semiconductor Memory
070-1608-00	Display Generator
070-1609-00	Readout Interface
070-1610-00	Front Panel/Z-Axis
070-1809-00	A-D Converter
070-1810-00	Sample and Hold
070-1890-00	Power Supply

Each manual can be ordered separately and contains a detailed circuit description of the specific card, troubleshooting procedures, circuit diagrams, and parts lists.

To receive a copy of all the above listed manuals plus this manual (070-1882-00) order manual number 070-1925-00 --- P7001 Composite Service Manual.


A7704
ACQUISITION UNIT
P7001
PROCESSOR UNIT
READOUT
READOUT DATA PATHS
LEFT VERTICAL PLUG-IN
RIGHT VERTICAL PLUG-IN
VERTICAL CHANNEL SWITCH
CHANNEL SWITCH
ANALOG SIGNAL PATHS
DISPLAY GENERATOR
'A' HORIZONTAL PLUG-IN
'B' HORIZONTAL PLUG-IN
HORIZONTAL CHANNEL SWITCH
CHANNEL SWITCH
Z AXIS
EXT Z AXIS IN
FRONT PANEL/ Z AXIS LOGIC
VERTICAL SAMPLE & HOLD
CHANNEL SWITCH
A-D CONVERTER
DELAY
COMMUNICATIONS PATH
HORIZONTAL SAMPLE & HOLD
REMOTE RESET



DPO BLOCK DIAGRAM 1