SEMINAR OBJECTIVES

1. Learn the parts of a 2250 system and the acronyms associated with them.
2. Understand the principles of electrostatic discharge and demonstrate the ability to follow ESD prevention practices at all times.
3. Demonstrate the ability to use over 1/2 of the MCX and MCL commands.
4. Understand the correct wiring techniques and averaging routines to make good analog measurements.
5. Demonstrate the procedure to input and output digital signals to monitor and control an external device.
6. Develop the ability to recognize a correct self-test sequence and find the status of the 2250.
7. Develop proficiency in troubleshooting the 2250 using the diagnostic hardware and software.
8. Understand the procedures involved in installing a 2250 system.
9. Demonstrate the procedures to calibrate the analog boards in the 2250.
10. Acquire the ability to take a logical problem-solving approach to any 2250 problem.

HP-2250 TROUBLESHOOTING TECHNIQUES

1. Establish communications between the 2250 and the host computer. If the host cannot communicate with the 2250, check the cables and select codes. Replace the HP-IB board if needed.

2. If communications between the host and the 2250 is established, send a command to some of the 2250 function boards. If none of the boards operate, the MCI or the BIF boards should be replaced.

3. If all function boards operate except one, that board should be replaced. If the replacement board does not work, check the backplane and its connectors.

4. If digital function boards are not reading inputs or outputting correct voltages, check the programming. Some digital boards invert the input and output signals. If this does not correct the problem, replace the signal conditioning module on that channel.

5. If analog function boards are not reading inputs correctly, check the input signal. Insure that the signal is large enough to be sensed by the function card and low enough to prevent overflow. Also check the voltage for variance and common mode. If the signal is correct, replace the multiplexer function board. If this does not correct the problem, replace the ADC board.

6. If thermocouple measurements are not correct, verify that the thermocouple reference connector is receiving power from the function board. Insure that the thermocouple is outputting the correct voltage for that temperature. Read the reference temperature of the TRC. Double-check the programming. If all of these steps do not correct the problem, change the TRC. If this fails to correct the problem, change the function board.

7. Use the status registers to follow the operation of a task. Many "hardware failures" are actually a result of incorrect software. Always check the following items in addition to the hardware.

   Programming code (gains, interrupts, results storage,
   results format, status, etc)
   Function card configuration (read configuration registers)
   Incoming or outgoing signal at the function board
   Signal Conditioning Module application

THE STATUS LIGHTS ARE THE FIRST CLUE OF WHICH 2250 BOARD TO REPLACE. USE THE ENCLOSED TABLE TO TRACK HARDWARE FAILURES.

SCHED:WW:21 (831017.1921)

2250 HARDWARE MAINTENANCE SEMINAR

(October 24 - October 28)

		Morning 8:30-12:00		Afternoon 1:00-5:00
Day I		(7:30 A.M. - Breakfast)	MARK	ESD review
	Bill	Introductions System Introduction hardware familiarization system block diagram software overview	GRANT	Hardware configurations processor unit measurement & control unit
	MARK	Data Acquisition & Control Review thermocouples guarding/CMR analog-to-digital converters control techniques		
Day II	Bill	Software introduction MCX	Bill	Measurement & Control Lang
Day III	Bill	Measurement & Control Language with Fortran	Bill	Selftest Instrument Status
Day IV	Bill	Diagnostic Software	Bill	Warranty Policy DSP
Day V	GRANT	Installation Calibration	GRANT	Evaluation Service Notes
			Bill	Plant Tour (optional)

2250 SPECS CHANGES
September 1, 1983

Assembly	New Spec
25510A/B	*30VAC RMS isolation, channel/channel & channel/ground
25504A/B/C	*Maximum common mode 225VAC RMS, chan/chan & chan/gnd. For safety purposes, all connections to a single board must be considered as a single node. (Because of potential relay shorting.)
25514A/B	*250VAC RMS isolation, contacts/ground and between contact sets
25533B/C/D) E/F/G/H/J) 25537P/Q/R) S/T/U/V/W)	*250VAC RMS isolation, chan/chan and chan/gnd
25539A/E/) G/H/J)	250VAC RMS isolation, contacts/gnd and between contact sets.
25543N	*250VAC RMS isolation, chan/chan and chan/gnd
25545P	*250VAC RMS isolation, chan/chan and chan/gnd
25551A/B	Max common mode voltage determined by the card to which the assembly is connected. Not to exceed 250VAC.
25550A/B	Max common mode voltage determined by the SCM to which the assembly is connected. Not to exceed 250VAC.
25594A	Max common mode voltage determined by the card to which the assembly is connected. Not to exceed 250VAC.

*Specs which are explicitly published in the existing literature, as opposed to being implied by the system configuration.

LAB #2: LEARNING TO USE MCX

**** MEASUREMENT AND CONTROL PROCESSOR EXERCISER ****

PURPOSE: This lab is designed to familiarize you with MCX commands. MCX is probably the most powerful means of developing and debugging your application program. Without proper understanding of MCX's importance and flexibility, you may find the understanding of MCL/50 programming harder than it really is. MCX gives you the capability of interrogating your tasks that are running in the 2250. You can also simulate the interraction of the Host computer program gathering data and controlling the 2250. And, of course, you can use MCX as a virtual front panel to the 2250 so that analog and digital points can be tested after hookup.

EQUIPMENT REQUIRED:

2250 configured to use the demo consolete
HP 1000 or 9816/26/36 Desktop computer
MCX software disc for Desktop computer

OVERVIEW: Your instructor has provided you with both an MCX and MCL/50 Language Reference guide. Although the MCX Language Reference guide will be primarily used during this lab, you may find it useful to have the MCL/50 Lang. Ref. guide handy. This brings up a point. During the explanation of MCX commands, it will be necessary to use MCL/50 commands that have not been covered yet in your lecture. Don't be alarmed! This lab is structered such that the MCL/50 examples provide a stimulas or condition in the 2250 so that MCX can interrogate those conditions.

The MCX Lang. Ref. is essentially a printout of all the help file summaries available when running MCX. These summaries have been printed out and organized for your convenience. This is especially helpful if you have a terminal without much memory for displaying several commands at one time.

Please take the time right now to look over the MCX Lang. Ref so that you will be familiar with the location of command summaries during the rest of this lab.

I - Invoking MCX

Your instructor has assigned you to a particular 2250 and its associated Host computer. If you are using a desktop computer, you will have the HP-IB interface select code and the 2250 HP-IB address defined, and you will have a copy of MCX on disc which you will load in the following manner:

LOAD "MCX26"

If you are using the HP 1000, you will have a LOG-ON name given you with which to access the system, and you will be given the LU of the 2250. MCX will be available via the disc cartridge that has been allocated for you. Please LOG-ON at this time.

The next step for either user is to run MCX:

RU,MCX HP 1000

Press the RUN key. 9816/26/36

- you will be prompted to enter the LU(HP1000) or the HP-IB interface select code and instrument address. Do so at this time. Be sure the 2250 is turned ON and the HP-IB cables are properly installed is you have problems at this point.

II - MCX Help Summaries

As stated previously, the MCX program provides command summaries while it is running. Let's cause a couple of these summaries to be output to the screen.

NOTE

During the course of this lab, you will be asked to "enter in the following:". When asked this, simply type in the given text and press RETURN (HP1000) or ENTER (9816/26/36), unless otherwise told. Also note that you should enter in exactly what is given for each MCX command in this lab unless you are familiar with the abbreviations for MCX commands.

Please enter in the following:

? HELP (MCX command)

- a summary of MCX commands will be output to your screen just like the printout given in your MCX Lang. Ref. guide.

As you already have noticed, each command can also be summarized by using the "?" symbol and the command name. Enter in the following:

? READ (MCX command)

- a summary of the MCX command READ will be output to your screen.

Now see that you can also get summary descriptions of the different MCL/50 commands. Enter in the following:

? AI (MCX command)

- a command summary of the AI command will be given. This is very limited as far as important information being made avaiable. It is suggested that you use your MCL/50 Lang. Ref. instead so that special considerations when using commands together can be noted.

Try a few more commands if you so desire. All but the individual MCL command summaries are given in you MCX Lang. Ref. guide.

III - MCX Setup and Configuration Commands.

The LOG command is very useful when you need to get a hard copy of of all the lines entered and data results returned when running MCX. This can most important when developing your application programs or tasks because every input you make and every data result you get can be output to a disc file or printer. The default condition when MCX is invoked is no log device. Instead, every input you make and every result you get is already returned to the screen. Unless you have the cooperation of the other HP 1000 system users, it is best to leave the log mode as it is. Otherwise, there will be conflicts when more than one MCX program tries to use the only printer on the system. If you do need a hard copy, the LU of the printer is 6. For desktop users, the LOG ON address of the printer will be 700. You would enable logging to the printer in the following way:

LOG ON 6 - HP 1000 Users (MCX command)

LOG ON 700 - Desktop Users (MCX command)

Please check with everyone else first and don't leave your MCX program linked to the printer after your done...use the LOG OFF command.

What if you want to know what cards are present in your 2250. Enter in the following:

CARDS (MCX command)

- this will give you a list of the cards in each MCU present in your 2250. It may also inform you of cards that are not working properly. Also note that the cards are positioned such that analog cards start from slot 1 and move upwards in slot numbers; digital cards start at slot 8 and move downwards in slot numbers. This maintains isclation between the two different types of cards.

  If you desire, you can get a listing of the cards in your 2250 by using the LOG ON 6 command. But please turn logging OFF right away when others are on your system.

There are commands that set up the MCX program to read and display results in a cerain way. The following is a list of the SET command defaults for MCX:

A. SET RESULTS ON (Default condition; MCX command)

- All data output to the primary address (LU or HP-IB address) will be read immediately, if present, following the task terminator (!). This means that MCX issues a READ statement to the primary address of the 2250. For example, enter in the following:

  AI(1,1) ! MCL/50 Command

- This command informs the 2250 to make a voltage measurement on channel 1 of the ADC in slot 1 and return the result in millivolts. The result data was output to the primary address because no provisions were made to store the data locally in the 2250. With SET RESULTS ON, MCX picks up the result data immediately and displays it on the screen. If LOG ON 6 or LOG ON 700 is in effect, the result also goes to the printer.

B. SET POLLING ON 10 (Default condition, MCX commar

- This command informs MCX to poll the 2250 continuously to see if any data is available. If not, another MCX prompt is issued to the screen after 10 seconds. If polling is OFF and result data is read using the READ command when there is no data available, MCX will hang until the HP-IB times out.

C. SET MODE INTEGER (Default condition, MCX command)

- All data results returned from the 2250 are in integer format (-32768 to 32767).

D. SET STOP ON (Default condition, MCX command)

- If any run-time, CDA, or communication errors occur, MCX flags you of such and gives you the chance to abort the current operation. This is typically used when you are downloading an MCL/50 command file to the 2250 and a compile error has been found. Obviously, you would want to stop the transfer and correct the error before downloading the file again.

E. SET ECHO ON (Default condition, MCX comman

- When downloading an MCL/50 and/or MCX command file, all commands in the file are echoed to the screen which are found in the file.

All except the SET MODE command are typically left in their default state. The SET MODE command lets you display the received data in either Integer, Octal, or REAL format. For example, enter in the following:

AIR(1,1) ! (MCL/50 command)

example result: 16773 7682

- The result data is two integer words with SET MODE INTEGER. The data needs to be converted before you can understand the results. Enter in the following:

SET MODE REAL (MCX command)
AIR(1,1)! (MCL/50 command)

example result: 1.0274999

- The result data is now a single reading in REAL format. Note that this command is used with the AIR command only or when obtaining results from downloaded subroutines.

The other SET MODE command sets up the result data in octal format. This becomes useful when you write octal values to digital cards and would like to read octal values back instead integer format. For example, enter in the following:

```
SET MODE OCTAL          (MCX command)
FO (6,1) %17 !          (MCL/50 command)
RFO (6,1) !             (MCL/50 command)
```

result: 000017

- Note that the result is the same as the output value. If integer mode was still in effect, the result would have been: 15.

Now return MCX to SET MODE INTEGER before proceeding onto the next section.

IV - MCX Read, Write, and Status Commands

The READ, WRITE, and STATUS commands will be used more than any other commands in MCX. They provide you with stimulas (WRITE) and response (READ and STATUS) when analyzing tasks. The READ and WRITE are used most often to read/alter the values of variables or buffers that are present in a task. They can also be used to read the data present at the 2250 secondary addresses. The following is a printout of the secondary address assignments found in your MCX Lang. Ref.:

2250 Secondary addresses:

```
read  1:  system status
read  2:  main task status
write 3:  task to tell about
read  3:  resident task status
read  4:  interrupt status

write 5:  write buffers

write 6:  buffer, length to send back
read  6:  read buffers

write 7:  write variables

write 8:  variable, count to send back
read  8:  read variables

write 9:  download subroutines
read 11:  port A
read 12:  port B
read 13:  port C
read 14:  port D
```

The following examples will use pre-written MCL/50 tasks to illustrate the accessing of buffers, variable, ports, and secondary addresses. The INCLUDE command will be used to download the MCL tasks to the 2250. You are not expected to understand exactly how each task works. Only the fact that the task is changing the values of variables and buffers and whether or not the variables and buffers are to be output to the host is of your concern. Later, when you conduct further labs, you will remember the capabilities of these commands and will be able to use them to aid in program development.

Enter in the following:

INCLUDE LAB01 (MCX command)

- This tells MCX to access the file named LAB01 and download that file to the 2250. If no errors are found in compilation, the task will be executed as soon as it is compiled. The task LAB01 is listed below with a brief explanation of each MCL command:

```
* MCX LAB TASK #1
CLEAR    <-- MCX CLEAR command to get 2250's attention for MCL commands.
* The following are all MCL/50 commands
RESET!   <-- MCL RESET command which returns 2250 to turn on state.
DIMENSION (10,2,10,20) <-- Dimension 10 variables, V1 to V10, and 2 buffers
                           of 10 elements each.
V1=1               <-- Variable assignments.
V2=2                          "
V3=3                          "
V10=10                        "
B1(1)=10           <-- Buffer element assignments.
B1(2)=20                      "
B1(3)=30                      "
B1(10)=100                    "
IN(B2)             <-- Specify buffer B2 as an output buffer to store readings.
BLOCK AI(1,1,10)   <-- Set up 10 analog voltage readings to be taken on
                       channel 1.
RELEASE (B2,A)     <-- Send the data found in buffer B2 to Port A.  The
                       voltage readings will be output to Port A.
!                  <-- Terminate the task.
```

- Note that the text including and following the arrows is not a part of the LAB01 file. These were added to clarify the example.

Now let's use the READ command to look at the values of variables and buffer elements that have just been assigned. Enter in the following:

READ VARIABLE 1 10 (MCX command)

- this command specifies that starting with variable V1, read 10 consecutive variables (i.e. variables V1 to V10 will be displayed). You will note the first 3 elements are 1,2, and 3, corresponding to the assignments in the task. The elements V4 to V9 are garbage because they were not assigned in the task. V10 is 10.

These variables can also be read from secondary addresses. When using the secondary addressing, you are essentially simulating the operation of your FORTRAN or BASIC program statements. Enter in the following:

WRITE SECONDARY 8 2 1 10 (MCX command)

- This command specifies that 2 words (1 and 10) should be written to secondary address 8. MCX would transform this command into something similar to the following output commands from the particular Host you are using:

```
WRITE (LU2250:8) 1,10              FORTRAN 4X
                 - -
                 |  |__ Release 10 variables starting with V1.
                 |__ Starting with variable V1.

            or

OUTPUT 70508 USING "#,W";1,10      Series 200 BASIC
```

This is essentially saying that you want 10 variables released to secondary address 8 starting with variable 1.

When the following READ command is issued, the 10 variables starting with variable 1 will be output to the display:

```
READ SECONDARY 8                                 (MCX command)
```

These statements read 10 elements from secondary 8:

```
READ (LU2250:8) ITEM1,...,ITEM10            FORTRAN 4X

ENTER 70508 USING "%,W"; Item1,...,Item10   HP Series 200
```

You can also change the value of variables with either WRITE VARIABLE or WRITE SECONDARY. Enter in the following sequence of commands and note the results given:

```
WRITE VARIABLE 4 1 35               (MCX command)
READ VARIABLE 1 10                  (MCX command)
```

- The WRITE command will change the value of variable V4 to 35. The READ command then gives you all 10 variables for display. These commands are being transformed into Host computer statements in a similar manner to the following:

```
WRITE (LU2250:7) 4,1,35            FORTRAN 4X
WRITE (LU2250:8) 1,10
READ (LU2250:8) ITEM1,...,ITEM10

              or

OUTPUT 70507 USING "#,W";4,1,35    HP Series 200
OUTPUT 70508 USING "#,W";1,10
ENTER 70508 USING "%,W";Item1,...,Item10
```

- Notice that the same series of commands are necessary to fetch the variable values from secondary 8.

```
WRITE SECONDARY 7 3 4 1 40        (MCX command)
```

READ VARIABLE 1 10 (MCX command)

- This time variable V4 is given the value of 40. The WRITE command specifies secondary address 7 is to receive 3 words. When the 3 words are received, the 2250 knows that variable V4 and only V4 (according to the 1 specification) is to receive the value of 40.

Now, let's move on to the buffers. Similar results will occur. There are different secondary addresses and the sort. The following commands should be entered and the results noted:

READ BUFFER 1 10 (MCX command)

- This reads the values of elements 1 to 10 of buffer B1. You will note again that all elements not expressly assigned values will be garbage. Elements B1(1) to B1(3) are 10,20, and 30. B1(10) is 100. You can issue the same command from a Host computer by using the following commands:

```
WRITE (LU2250:6) 1,10                          FORTRAN 4X
READ (LU2250:6) ITEM1,...,ITEM10
```

or

```
OUTPUT 70506 USING "#,W";1,10
ENTER 70506 USING "%,W";Item1,...,Item10  HP Series 200
```

- In this case, you have to tell secondary address 6 which buffer you want to read from and how many elements, beginning with the first always, are to be released. The READ or ENTER statement then reads in as many values as were specified.

```
WRITE BUFFER 1 2 5 6          (MCX command)
READ BUFFER 1 10              (MCX command)
```

- This command sequence changes the values of B1(1) and B1(2) to 5 and 6. The 1 specifies buffer B1, the 2 specifies two consecutive elements, and the 5 and 6 are the values to be written.

```
WRITE SECONDARY 5 4 1 2 6 5    (MCX command)
WRITE SECONDARY 6 2 1 10       (MCX command)
READ SECONDARY 6               (MCX command)
```

- This set of commands performs the same function as the previous set except that the buffer elements B1(1) and B1(2) are 6 and 5, respectively. The first WRITE specifies secondary address 5, 4 words to be written, buffer B1 designated, 2 elements written to, and the values of 6 and 5 written. The second WRITE addresses secondary address 6 to inform the 2250 that it wants buffer B1 and 10 elements available. (The 2 specifies that 2 data elements follow.) Then, the READ specifies that all available elements at secondary address 6 should be read. These commands will be implemented in Host I/O commands in a similar manner to the following:

```
WRITE (LU2250:5) 1,2,6,5
                 - - - -
                 | | |_|__ Elements to be written
                 | |__ First two elements to be changed
                 |__ Buffer B1

WRITE (LU2250:6) 1,10
                 - -
                 | |__ Release first 10 elements
                 |__ Buffer B1

READ (LU2250:6) ITEM1,...,ITEM10

OUTPUT 70505 USING "#,W";1,2,6,5          HP Series 200
OUTPUT 70506 USING "#,W";1,10
ENTER 70506 USING "%,W";Item1,...,Item10
```

Now that buffer B1 has been read, it is a simple matter to read the the voltage readings from buffer B2. Enter in the following:

```
    READ BUFFER 2 10                      (MCX command)

         or

WRITE (LU2250:6) 2,10
READ (LU2250:6) ITEM1,...,ITEM10          FORTRAN 4X

         or

OUTPUT 70506 USING "#,W";2,10             HP Series 200
ENTER 70506 USING "%,W";Item1,...,Item10
```

- This gives the 10 voltage readings from channel 1 in slot 1.

```
READ PORT A                               MCX

         or

READ (LU2250:11) ITEM1,...,ITEM10         FORTRAN 4X

         or

ENTER 70511 USING "%,W";Item1,...,Item10  HP Series 200
```

- This also retrieves the 10 voltage readings that were released to Port A. Notice that the readings are identical to those just read. Also note that you can only do this once. Trying to read from Port A again will cause an HP-IB time-out. You can read from secondary 6 as often as you want. Also note that when using the READ or ENTER statements, you have to know how many items are to be read. Otherwise, you will hang on the input statments.

Now let's move on to the STATUS commands. Enter the following:

INCLUDE,LAB02

- This downloads the file LAB02 to the 2250 for compilation. If no errors are found, the series of tasks will be executed. The following is a commented version of LAB02:

```
* MCX TASK LAB #2
CLEAR      <-- Get the 2250's attention for more commands. (MCX command)
*   MCL/50 commands follow.
RESET      <-- Restore the 2250 to its power-on state.
!          <-- End of main task.
*
NTASKS(2,1)  <-- Specify 2 tasks and 1 will be interrupt scheduled.
DIMENSION (10,1,20) <-- 10 variables and 1 buffer with 20 elements.
!            <-- End of main task.
*
TASK(1,50)   <-- Task #1 with a priority of 50.
FCI(0)       <-- Disable function card interrupts.
SRQ(1)       <-- Send SRQ to Host.  Host can read value of 1 from secondary
                 address 4.
IN(B1)       <-- Declare buffer B1 as storage space for input commands.
REWIND (B1)  <-- Rewind the buffer pointer to the beginning of the buffer.
BLOCK AI(1,1,10) <-- Read 10 voltage readings from channel 1, slot 1.
RELEASE (B1,A)   <-- Release the 10 readings to Port A.
DO (6,16) 1      <-- Turn the Red pushbutton lamp ON to indicate data ready.
SKIP (B1,10)     <-- Buffer is rewound by RELEASE command.  Skip aheas 10
                     elements so data can again be released.
RELEASE (B1,A)   <-- Release the same data to same port again. This will
                     suspend the task until Port A is read once.
DO (6,16) 0      <-- After Port A is read, turn OFF the Red Lamp.
V1=1             <-- Flag set to indicate tnat task # 1 executed.
!            <-- End of Task #1.
*
TASK (2)     <-- Start of Task #2.  Default priority is 99.
REPEAT (0)   <-- Infinite REPEAT loop.
DO(6,1) 1    <-- Turn ON lamp # 1.
WNOW(0,0,50) <-- wait for 50 milliseconds.
DO(6,1)0     <-- Turn OFF lamp # 1.
CTIMER ; PTIMER(0,0,50)  <-- Clear timer.  Pause for 50 milliseconds.
                             During pause, let any higher priority tasks
                             run that are scheduled.  Task # 1 will be
                             scheduled when pressing switch # 1.
IF V1=1 THEN EXIT ENDIF <-- Check to see if task # 1 executed.  If V1
                            is 1, then exit loop.
NEXT         <-- End of loop.
!            <-- End of task # 2.
*
V1=0         <-- Set up a flag that can be used to see if task # 1 executed.
FCI(0)       <-- Disable function card interrupts.
INTERRUPT (6,1) 0  <-- Disable interrupts from point 1, slot 6.
ITASK     (6,1,1)  <-- Set up task # 1 to be scheduled on interrupt from
                       point 1, slot 6.
SENSE     (6,1) 1  <-- Allow a 0 to 1 transition to cause interrupts.
INTERRUPT (6,1) 1  <-- Enable interrupts from point 1, slot 6.
FCI(1)       <-- Enable function card interrupts.
START(2)     <-- Start task # 2.
!            <-- End main task.
```

Don't worry if you don't understand LAB02. It is considerably more advanced than LAB01. However, it does exercise the STATUS commands, which is our main concern right now. You will probably refer to this example later after some more labs and lectures.

LAB02 is now executing down in the 2250. It has configured the 2250 to generate an interrupt when you press the flashing switch, switch # 1.

** Please don't press the red button yet **

When the interrupt occurs, the 2250 will take 10 voltage readings from channel 1, slot 1, and release them to Port A. It will then turn ON the Red lamp indicating that the data is ready at Port A. The 2250 will then suspend the execution of the task until you read the data from Port A. When the data is read, the Red lamp will be turned off and task execution will terminate.

Before pressing the flashing switch, let's interrogate the 2250 with STATUS commands. Enter in the following:

```
STATUS SYSTEM                    (MCX command)
```

- The results should be that task #2 is executing and no data is present at any of the ports. Neither is there any interrupts pending. This MCX command is implemented similar to the following on your Host:

```
READ (LU2250:1) ISTAT1,...,ISTAT8       FORTRAN 4X

                or

ENTER 70501 USING "%,W";Item1,...,Item8 HP Series 200
```

- Data from secondary 1 will give you the following information:

Word   Decrtiption

1. Current running task
2. System error code
3. SRQ interrupt flag
4. Main result word count
5. Word count at port A
6. Word count at port B
7. Word count at port C
8. Word count at port D

```
STATUS INTERRUPTS          (MCX command)
```

- The results should be that no interrupts have occurred. This information comes from secondary address 4. Your Host would access this information in a similar manner to the following:

```
READ (LU2250:4) ITEM1,...,ITEM16        FORTRAN 4X

                or

ENTER 70504 USING "%,W";Item1,...,Item16   HP Series 200
```

- There are 16 words returned from secondary 4. If all are 0, there are no interrupts pending.

STATUS TASK 1 (MCX command)

- The results should be that task #1 is an the idle state. It will not run until an interrupt has occurred.

STATUS TASK 2 (MCX command)

- The results should indicate that task #2 is executing at some line at which the status check was intitiated. Task status can be found by accessing secondary 2 or 3. If you only want main task information, there are 8 words available from secondary 2. If you want status of a task other than a main task, you get that information from secondary 3 by first writing the task number and then reading the 8 status words. Here is how to read from secondary 3: (Secondary 2 is accessed just by reading, not by writing the task number also.)

```
WRITE (LU2250:3) 1                               FORTRAN 4X
READ (LU2250:3) ITEM1,...,ITEM8
```

or

```
OUTPUT 70503 USING "#,W";1                       HP Series 200
ENTER 70503 USING "%,W";Item1,...,Item8
```

- More specific error information is available from secondary 2 or 3. Refer to Appendix A of the Programmer's Reference Manual for more information on secondary 2 if you so desire.

Now press the flashing switch and enter in the following sequence of commands:

STATUS SYSTEM

- Now the status should read that task #1 is running and that interrupts are pending and data is available at Port A.

STATUS INTERRUPTS

- The results now should indicate that an interrupt has occurred on point 1, slot 6, and that an SRQ was initiated. The SRQ command issued a value of 1 to secondary address 4. When you invoke the STATUS INTERRUPTS command, secondary address data goes away. This means that reading secondary 4 clears interrupts.

READ PORT A

- Now the data at Port A will be displayed on the screen, and the 2250 tasks will terminate.

V - MCX Conclusion.

It is recommended that you spend as much time as necessary to fully understand MCX on your Host computer. Some of the MCX commands that were not covered in this lab will be covered later in labs when they seem more appropriate.

LAB 3--INTRODUCTION TO MCL COMMANDS

PURPOSE: The purpose of this lab is to gain experience in using the MCL commands presented in the lecture.

PROCEDURE: Run MCX on the host and use MCL commands to accomplish the following:

A. Place a short across channel 6, slot 1 on the FWA (field wiring assembly).

1. Calibrate the 25501 ADC board
2. Set the range on slot 1 channel 6 to 1 volt (Verify this by reading back the gain)
3. Read channel 6 on the ADC card using the various analog input commands(AI,AIM,AIR,AIC,AID)--the result should be near zero. In some cases it may be out of range--change the gain if needed. In other cases, it will be hard to decipher--change the mode if needed.
4. Read the channel 100 times at the free run speed--you should note a considerable variation in readings. THIS IS NOISE!!
5. Read the entire second field on the Digital input board. (There are two different ways to do this)
6. Light up switch #16 on the consolet.
7. Set meter #1 to 5 volts.
8. Light all of the lights on the consolet.
9. Set the mode to octal and read the value set on the thumbwheel switches.
10. Put a current through the pot and read the voltage across it. Verify by changing the pot position.

B. FOR THOSE OF YOU WHO ARE AMBITIOUS--Set up a task to take a temperature measurement. Follow the flow chart procedure listed in the seminar training manual.

LAB 4

WRITING MCL TASKS

PURPOSE: The purpose of this lab is to gain experience in writing MCL tasks using MCX include files.

PROCEDURE: Using EDIT on the 1000, create include files to do the following-

A. Take 20 temperature readings from one channel. Store the readings in buffer B2. Average the readings and store the result in variable V2.

Use the flowchart in the Seminar Training Manual to properly set up the temperature measurements.

Use pacing to minimize the noise in the readings.

Display the averaged result.

B. Write a task that lights the consolet lights one at a time in sequence at a rate of one light each half second. Note that only one light should be on at any time.

Place this task in an infinite loop. How can you interrupt this loop?

C. Using the above two tasks as resident tasks, write a main task that will start the task in A (task 1) if button #1 is pushed or start the task in B (task 2) if button #2 is pushed.

LAB 5--USING MCL WITH A FORTRAN PROGRAM

PURPOSE: The purpose of this lab is to send MCL commands to the 2250 and get back the results through a FORTRAN program in the host.

PROCEDURE:

A. Write an MCL task that will read a block of 100 readings from a shorted channel on the 2250. Use MCX to verify the program.

Place the MCL task in a FORTRAN program that will send this task to the 2250 and return the 100 readings to the terminal.

Compile the program, link this program, and run it. Verify the results with MCX.

B. FOR THOSE OF YOU WHO ARE AMBITIOUS---HOW ABOUT A DOWN-LOADED SUBROUTINE?

Follow the steps for down-loading a subroutine found in the training manual. Use the source file &SUB1 for the subroutine. Copy this file into file of your own. Compile it and run LINKR.

To down load the subroutine, use MCX. Before downloading, do a reset and clear out memory for the subroutine with the command NTASKS(0)!

Use the include file PRG1 to run a task that will call this subroutine.

SEMINAR HARDWARE CONFIGURATION RECORD

2251

slot	board	configuration
1	25501	no SCM's, no configuration
2	25502	no SCM's, no configuration
3	empty	
4	25510	channel 1 - unipolar voltage channel 2 - unipolar voltage channel 3 - unipolar current channel 4 - no matter
5	25511	25537R (25537-60003) SCM's on channels 1 - 12 no strobe SCM's
6	25516	25543N (25543-60001) SCM's on output channels 1 - 16 25537R (25537-60003) SCM's on input channels 1 - 16 no strobe SCM's
7	25513	25543N (25543-60001) SCM's on channels 1 - 12 no strobe SCM's
8	25514	no SCM's, no configuration

DESKTOP CONTROLLERS

The 2250 receives MCL commands in the form of ASCII strings sent to it by the controller. When using a desktop as a controller, you must suppress CR and LF because the 2250 does not recognize these as terminators. It expects an EOI at the end of each string and the "!" at the end of each 2250 task.

SENDING MCL COMMANDS TO THE 2250

To send a short main task to the 2250, use the following form.

```
OUTPUT 701 USING "#,K"; "DO(6,1,4) 1 1 1 1  AI(1,1)!" END
```

Where "#,K" suppresses CR,LF and outputs the string in compact form. "END" sends an EOI at the end of the string.

To send long strings to the 2250, set them up the commands in string variables.

```
DIM  DATA1$[100],DATA2$[100]
DATA1$="AI(1,1)  DO(6,1,4)1 1 1 1"
DATA2$="CPA(0,200) REP(10) WPA DO(6,16)1 WPA DO(6,16)0 !"
OUTPUT 701 USING "#,K";DATA1$ & DATA2$  END
```

RECEIVING DATA FROM THE 2250

To read back data from the 2250 main result buffer, you would use the 2250 primary address. It is best to designate the I/O path using an assign statement. Turn the format off. Allow time for any 2250 commands to compile and execute before you try to read the results. Remember, the first word that returns from the main result buffer is the condition code.

```
OPTION BASE 1
INTEGER  CODE,RSLT(100)
ASSIGN @B0 TO 701; FORMAT
ENTER @B0; CODE,RSLT(*)
```

The I/O path is assigned to 701 where 7 is the HPIB address and 01 is the primary address of the 2250. The condition code is put into the variable "code" and the results are put into an array "rslt". You can then print or display the results.

If you want to read another buffer, a 2250 variable, a port, or a status register; you must read these through a 2250 secondary address. For example, to read the status of a main task from secondary address 2; you can assign an I/O path to 70102 or use the following statement.

```
ENTER 70102 USING "%,W";ST(*)
```

The "%,W" demands two bytes 16-bit two's complement integer and an EOI causes an immediate termination. The results are put into the array "ST".

MCL LAB

ANALOG INPUT COMMANDS

There is an ADC board in slot 1. Take analog readings on channels 9-16 by typing in the following task in MCX.

```
AI(1,9,8) !
```

MCX automatically returns the results to your terminal screen. Since there are no connections to these channels, the results are noise in millivolts.

Measure the voltage on channels 1-10.

ANALOG OUTPUT COMMANDS

Send a voltage to meter #2 on the consolet. This meter is hooked up to the DAC in slot 4. You can send 5 volts to the meter with the following command.

```
VO(4,2) 5000 !
```

Return the meter to 1 volt.

DIGITAL INPUT COMMANDS

The multifunction board in slot 6 has 16 inputs and 16 outputs. The inputs are connected to the switches on the consolet. The following command reads the input value on all 16 input channels.

```
DI(6,1,16) !
```

The results should all be zero. If you hold down one or more buttons on the consolet and try the command again, you will see a result of "1" for each button you hold down.

DIGITAL OUTPUT COMMANDS

The 16 output channels of the multifunction board in slot 6 are connected to the light bulbs in the consolet. You can turn on light #1 by the following command.

```
DO (6,1) 1 !          (A "1" specifies "on")
```

You can turn the light off with the following command.

```
DO (6,1) 0 !          (A "0" specifies "off")
```

More than one light can be turned on with the following command.

```
DO (6,1,6) 1 0 1 0 1 1 !
```

ASKS & INCLUDE FILES

Up to this point, all commands sent to the 2250 by MCX have been main tasks. To send the 2250 a resident task, you must first reserve space in 2250 memory with the following commands.

```
NTASKS(3)           (This reserves memory for 3 tasks)
DIM(10,2,100) !     (This reserves memory for 10 variables
                      and two 100-word buffers)
```

If several commands or tasks are to be loaded into the 2250, it is best to use an include file. Create a file in the 1000 with the following command.

```
RU, EDIT
```

Type in the following resident tasks into an include file. Do not type in lines beginning with an "*". These lines are comment lines and are not executed in the 2250.

```
*  Task #1 is a resident task that will compile immediately but
*  it remains in memory until it is started by a main task.
*  The task sets a current through the potentiometer on
*  the consolet. (The DAC board in slot 4 is connected
*  to this pot.) It then reads the voltage generated
*  across this pot using channel 1 of the board in slot 1.
*  50 readings are taken and averaged. These readings are
*  stored in a 2250 buffer while the average is stored in
*  variable V1. Lights #1 and #2 are turned on when the
*  readings are finished.
*
TASK(1)
IN(B1)
REW(B1)
CO(4,3) 500
BLOCK
AI(1,1,50)
AAV(B1,50,V1)
DO(6,1,2)1 1!
*
*  The second task sets meter #1 to 8 volts and causes light #16
*  to flash.
*
TASK(2)
VO(4,1) 8000
PACE(0,200)
REP(20)
WPACE
DO(6,16) 1
WPACE
DO(6,16)
NEXT
VO(4,1) 0 !
```

```
*
*  The third task waits for button #1 to be pushed.  When this
*  occurs, the lights will sequence until button #2 is pushed.
*
TASK(3)
  IN(V5)
REP(0)
  DI(6,1)
  IF V5=1
  THEN
  GOTO (10)
  ENDIF
  PAUSE
  NEXT
LABEL (10)
  V7=1
  IN(V6)
  OUT(V7)
  CPACE(0,100)
  REP(0)
  WPACE
  FO(6,1)
  V7=V7 ROT 1
  DI(6,2)
  IF V6=1
  THEN
  GOTO (20)
  ENDIF
  PAUSE
  NEXT
LABEL (20)
  FO(6,1,2)0 0 !
```

When you are finished typing in this lab, do a control Q. After the / prompt type in the following.

EC,xxxxxx   (where xxxxxx is the file name)

To run this program, type in the following after the MCX prompt.

INCLUDE xxxxxxx

This does not start the tasks. To start one of the three tasks you must send a main task to the 2250 telling it which task to start. For example, START(1)! starts task #1. This does not read back the results. To get back the values in the buffer, you must type in the following MCX command.

READ BUFFER 1 50

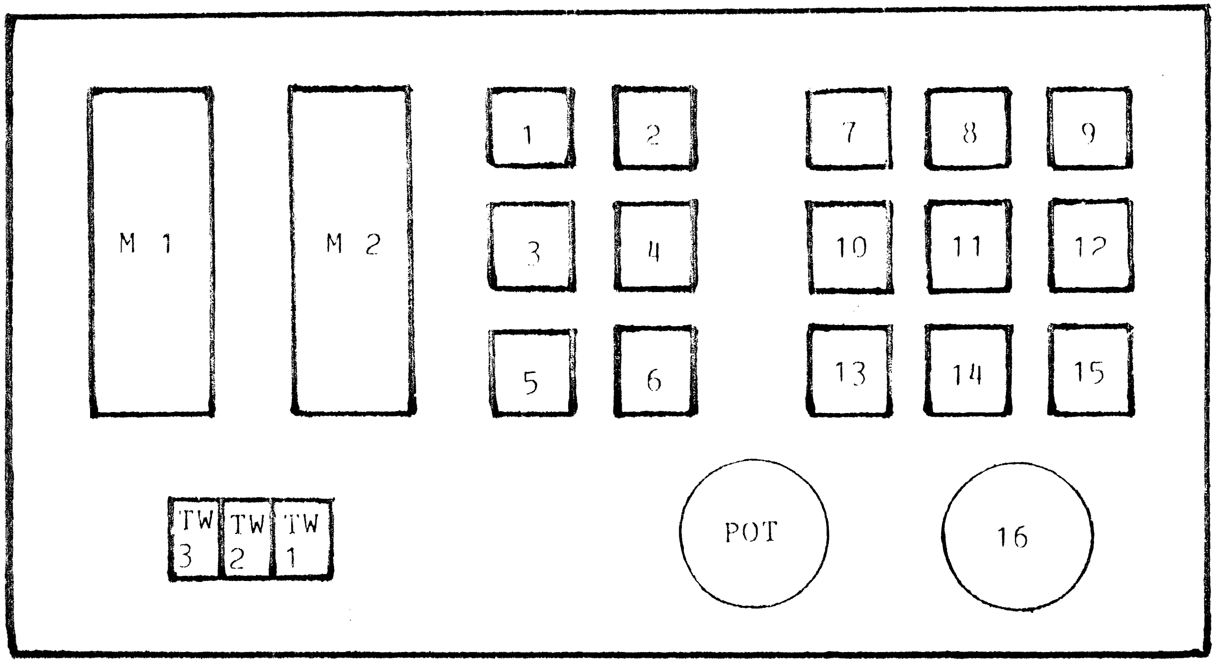
To get back the calculated average, you must send the following MCX command.

READ VARIABLE 1 1

To start the other tasks, type in START(2)! or START(3)! These tasks remain in memory until the 2250 is shut off or given a RESET! command. You may run them as often as you wish.

Bill Wakeham

8 Relay out 16
7 Dig... 32
6 ...
5 ... 16 16 4
4 DAC
... 32
1 High speed ADC 16



	SLOT		CHAN
M 1 -	4	-	1 VOLTS
M 2 -	4	-	2 VOLTS
TW 3 -	5	-	12, 11, 10, 9
TW 2 -	5	-	8, 7, 6, 5
TW 1 -	5	-	4, 3, 2, 1
POT	4	-	3 CURRENT
	1	-	1

SWITCH	SLOT		CHAN
S 1	6	-	1
S 2	6	-	2
S 3	6	-	3
S 4	6	-	4
S 5	6	-	5
S 6	6	-	6
S 7	6	-	7
S 8	6	-	8

SWITCH	SLOT		CHAN'
S 9	6	-	9
S 10	6	-	10
S 11	6	-	11
S 12	6	-	12
S 13	6	-	13
S 14	6	-	14
S 15	6	-	15
S 16	6	-	16

LIGHT	SLOT		CHAN
L 1	6	-	1
L 2	6	-	2
L 3	6	-	3
L 4	6	-	4
L 5	6	-	5
L 6	6	-	6
L 7U	6	-	7
L 8U	6	-	8

LIGHT	SLOT		CHAN
L 9U	6	-	9
L 10U	6	-	10
L 11U	6	-	11
L 12U	6	-	12
L 13U	6	-	13
L 14U	6	-	14
L 15U	6	-	15
L 16	6	-	16

LIGHT	SLOT		CHAN
L 7L	7	-	1
L 8L	7	-	2
L 9L	7	-	3
L 10L	7	-	4
L 11L	7	-	5
L 12L	7	-	6
L 13L	7	-	7
L 14L	7	-	8
L 15L	7	-	9

```
CONSOL T=00003 IS ON CR  00017 USING 00005 BLKS R=0000
                                              11:41 AM  WED.,  6  JUNE, 1984

*  CONSOL   - include file to test total functionality of consolette
*
*
clear
reset!
*
ntask(3)!
*
* potentiometer output on meter 2
task(1)
co(4,3)2000
rep(0)
    in(v1) out(v1)
    ai(1,1)
    if v1>10100 then goto(1) endif
    if v1<0 then goto(1) endif
    vo(4,2)
    label(1)
    pause
next
!
*
* light lights and indicate switch closure by turning off light
task(2)
fo(6,1,2)%177777,%777
rep(0)
    in(v3) out(v4)
    fi(6,1)
    v4=cmp v3
    v5=v4 rot -6
    fo(6,1,2)
*   if red button, then stop test
    if v3<0 then reset endif
    pause
next
!
*
* display TWS setting on meter 1
task(3)
rep(0)
    in(v1) out (v5)
    fi(5,1)
    v2=v1 and %17
    v2=v2 * 20
    v3=v1 rot -4
    v3=v3 and %17
    v3=v3 * 100
    v4=v1 rot -8
    v4=v4 and %17
    v4=v4 * 1000
    v5=v2 + v3
    v5=v5 + v4
    if v5 > 10000 then goto (1) endif
    if v5 < 0 then goto (1) endif
    vo(4,1)
    label(1)
    pause
next
!
*
```

```
0061  start(1) start(2) start(3)!
```

```
DEMO    T=00004 IS ON CR  00017 USING 00002 BLKS R=0000
                                      5:39 PM  WED.,  6  JUNE, 1984

CLEAR
RES!
NTASK(5,3)!
IN,Q1
IN,Q2
IN,Q3
IN,Q4
IN,Q5
FCI(1)
ITASK(6,16,4)
ITASK(6,5,1)
ITASK(6,11,2)
SENSE(6,16)1
SENSE(6,5)1
SENSE(6,11)1
SOVER(6,5)0
SOVER(6,16)0
SOVER(6,11)0
INTERRUPT(6,16)1
INTERRUPT(6,5)1
INTERRUPT(6,11)1
*START(1)
*START(2)
START(3)
*START(4)
START(5)
!
```

```
Q1      T=00004 IS ON CR  00017 USING 00006 BLKS R=0000
                                                    5:39 PM  WED.,  6  JUNE, 1984

TASK(1)
DIMENSION(50,5,100)
REP(5) DO(6,5) 1 CTI PTI(0,0,50) DO(6,5) 0 CTI PTI(0,0,50) NEXT
*V1=ANALOG INPUT VOLTAGE
*V2=ANALOG OUTPUT VOLTAGE
CTIMER
V1=0
V2=0
*REPEAT INDEFINITELY
REP(0)
*CURRENT OUTPUT,200 UAMPS
CO(4,3)200
*PUT THE ANALOG INPUT VOLTAGE FROM SLOT 1,CHANNEL 1 INTO VARIABLE V1
IN(V1)
AI(1,1)
REW(B1)
*PUT THE VALUE OF THE CLOCK INTO BUFFER B1. RCL(READ CLOCK) HAS 4 DATA
IN(B1)
*READ THE CLOCK
RTIMER
REW(B1)
V3=20-B1(2)
*COMPARISON;LOOK AT THE SECOND WORD IN BUFFER B2. THIS CONTAINS SECONDS
*IF THE VALUE IS < OR = 10,OUTPUT THE PRODUCT OF THE VALUE OF THE CLOCK
*TIMES THE VALUE OF THE VOLTAGE ACROSS THE POT. IF THE CLOCK IS >10,
*SUBTRACT THE VALUE OF THE CLOCK FROM 20, TO DECREMENT THE METER.
IF B1(2) <=10 THEN V2=V1*B1(2) ELSE V2=V1*V3 ENDIF
*IF THE VALUE TO BE OUTPUT TO THE METER IS GREATER THAN 10000 MVOLTS,MA
*EQUAL TO 10000 MVOLTS
IF V2>10000 THEN V2=10000 ENDIF
*IF V2<0 MAKE IT EQUAL TO 0 TO PREVENT BURNING OUT METER
IF V2<0 THEN V2=0 ENDIF
*FROM VARIABLE V2,OUTPUT VOLTAGE TO SLOT 4, CHANNEL 2(THE METER)
OUT(V2)
VO(4,2)
* WHEN THE CLOCK GETS TO 20 SEC RESET THE CLOCK TO 0
IF B1(2)=20 THEN CTIMER ENDIF
PAUSE
NEXT!
```

```
Q2      T=00004 IS ON CR  00017 USING 00006 BLKS R=0000
                                          5:39 PM  WED.,  6  JUNE, 1984
```

```
TASK(2)
ITASK(6,11,2)
DIM(50,5,100)
REP(1)
LABEL(100)
REW(B2)
*REPEAT 5 TIMES;DIGITAL OUTPUT SLOT 6 CHANNEL 11 1 CHANNEL DATA=1. ALSO
*DIG OUT TO SLOT 7 CHANNEL 5,1 CHANNEL DATA=1.WAIT
*0 HOURS,0 SEC,75 MSEC,THEN OUTPUT A 0 TO SAME CHANNELS,WAIT 75 MSEC,RE
REP(5); DO(6,11,1)1 (7,5,1)1;CTI;PTI(0,0,75);DO(6,11,1)0 (7,5,1)0;CTI;
PTI(0,0,75);NEXT
*PUT THE DATA FROM CHANNELS 1-12 OF THE DIG IN CARD IN SLOT 5 INTO BUFF
*B2 THIS IS THE DATA FROM THE THUMBWHEEL SWITCHES.REWIND THE BUFFER POI
*AFTER STORING THE DATA SO YOU CAN REFERENCE THAT BLOCK OF DATA JUST RE
*THE FOLLOWING IS A BCD(BINARY CODED DECIMAL) TO DECIMAL CONVERSION ROU
*SINCE THE DATA FROM THE THUMBWHEELS IS IN BCD FORMAT.
IN(B2);DI(5,1,12);REW(B2)
V11=1
V12=1
V13=0
REP(4)
IF B2(V11)=1 THEN V13=V13+V12 ENDIF
V11=V11+1
V12=V12*2
NEXT
V11=5
V12=1
V14=0
REP(4)
IF B2(V11)=1 THEN V14=V14+V12 ENDIF
V11=V11+1
V12=V12*2
NEXT
V11=9;V12=1;V15=0
REP(4)
IF B2(V11)=1 THEN V15=V15+V12 ENDIF
V11=V11+1
V12=V12*2
NEXT
V14=V14*10
V15=V15*100
V19=V13+V14
V16=V19+V15
V16=V16*10
*V16 IS THE RESULTING VALUE IN DECIMAL OF THE THUMBWHEEL SWITCHES. OUTP
*TO SLOT 4,CHANNEL1 OF THE DAC WHICH DISPLAYS THE VALUE ON THE LEFT MET
OUT(V16)
VO(4,1)
NEXT!
```

Q3   T=00004 IS ON CR 00017 USING 00004 BLKS R=0000

5:40 PM WED., 6 JUNE, 1984

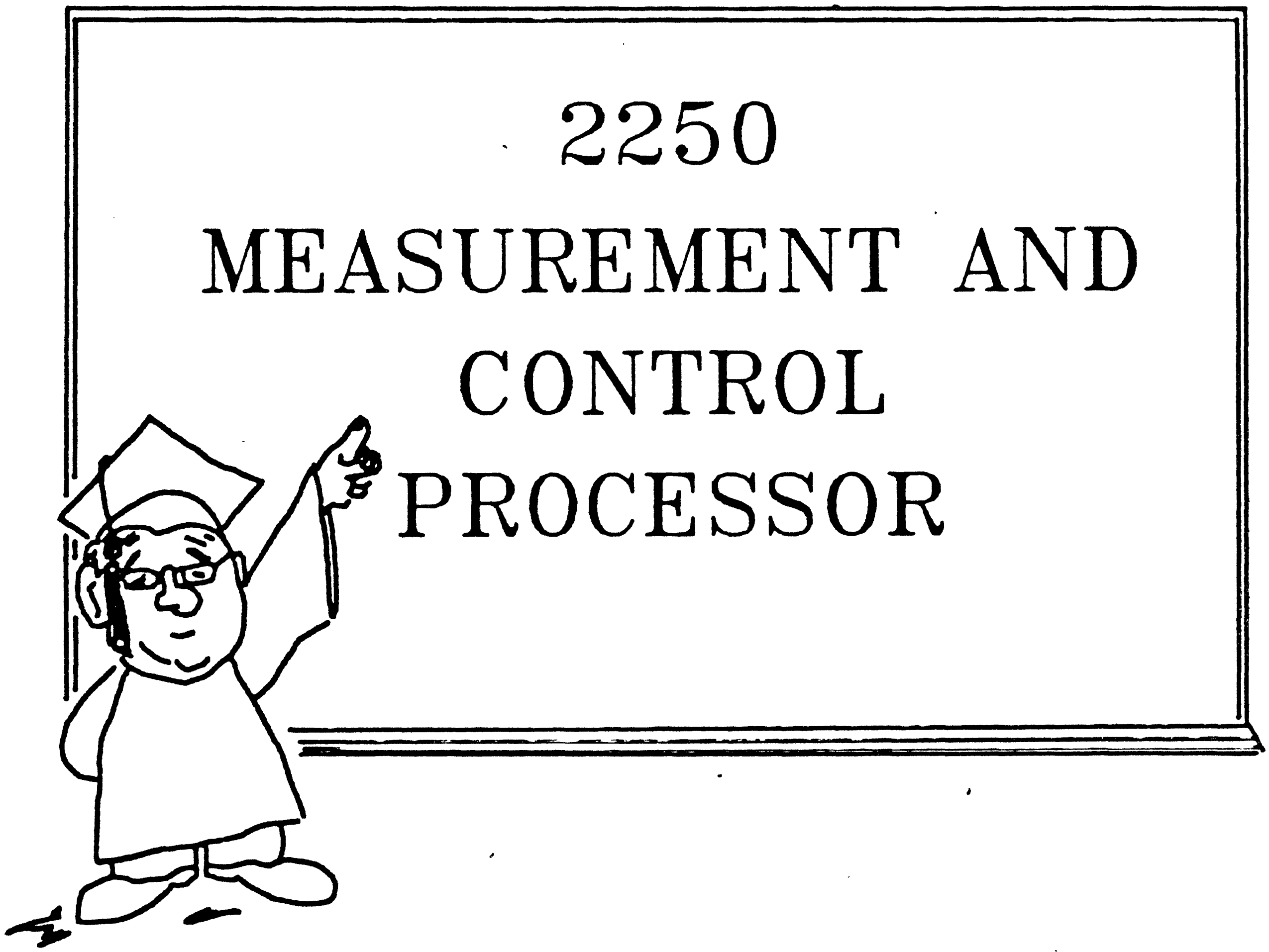
```
TASK(3)
DIMENSION (50,5,100)
V21=%000100
V23=%000001
V24=0
*REP(1)
LABEL(50)
PAUSE
IN(V40);DI(6,6)
IF V40=1 THEN DO(6,7,9)0 0 0 0 0 0 0 0 (7,1,9)0 0 0 0 0 0 0 0 ENDIF
IN(V29) RFO(6,1) IN(V28) RFO(7,1)
IN(V22); FI(6,1)
V26=V29 IOR V21
V27=V28 IOR V23
OUT(V26);FO(6,1);OUT(V27);FO(7,1)
IF V22()V21 GOTO (50) ENDIF
IF V24)=8 GOTO (60) ENDIF
LABEL(70);V24=V24+1
CASE V22 (%000100,100) (%000200,100) (%000400,200) (%004000,200)
CASE V22 (%040000,400) (%020000,400) (%010000,300) (%001000,300)
GOTO(50)
LABEL(60);V24=V24+1
IF V24=16 THEN V24=0 ENDIF
CASE V22 (%000100,200) (%000200,400) (%000400,400) (%004000,300)
CASE V22(%040000,300) (%020000,100) (%010000,100) (%001000,200)
GOTO(50)
LABEL(100);V21=V21ROT1,V23=V23ROT1
GOTO(50)
LABEL(200);V21=V21ROT3;V23=V23ROT3
GOTO(50)
LABEL(300);V21=V21ROT-3;V23=V23ROT-3
GOTO(50)
LABEL(400);V21=V21ROT-1;V23=V23ROT-1
GOTO (50)
!
```

Q4 T=00004 IS ON CR 00017 USING 00001 BLKS R=0000

5:40 PM WED., 6 JUNE, 1984

```
TASK(4,25)
STOP(5);STOP(2);STOP(1)
VO(4,1,2)0 0;FO(6,1)0 (7,1)0
REP(10);DO(6,16,1)1;WNOW(0,0,350);DO(6,16,1)0;WNOW(0,0,350)
START(5)
PAUSE
NEXT!
```

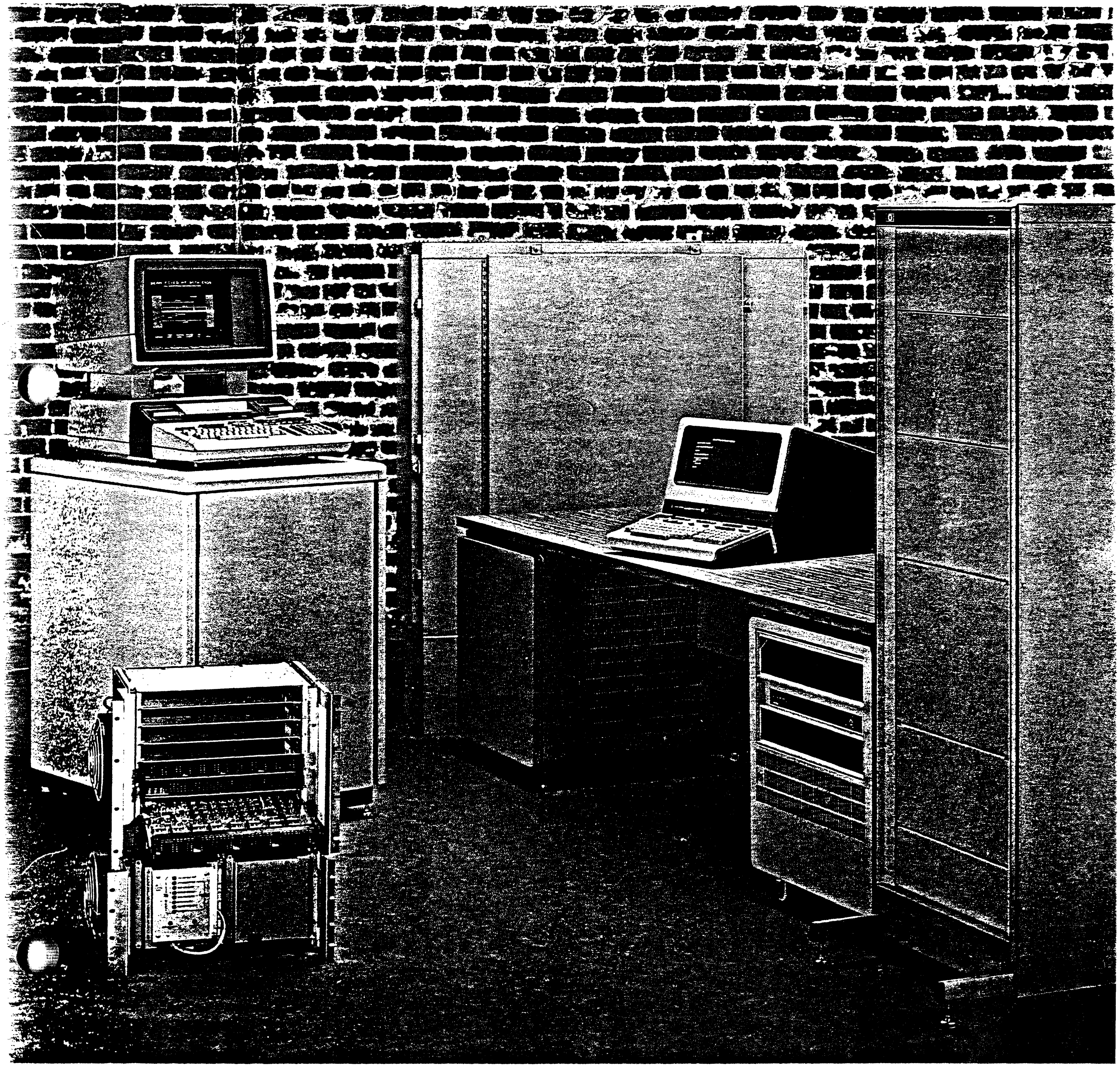
```
Q5      T=00004 IS ON CR  00017 USING 00001 BLKS R=0000
                                              5:40 PM  WED.,  6  JUNE, 1984

TASK(5)
REP(0);DO(6,3)1 (6,4)0 (6,1)0 (6,2)1
CTIMER PTIMER(0,0,350)
DO(6,3)0 (6,4)1 (6,1)1 (6,2)0
CTIMER PTIMER(0,0,350)
NEXT!
```


2250
MEASUREMENT AND
CONTROL
PROCESSOR

SYSTEM BLOCK

AN OVERVIEW
OF THE OPERATION
OF THE 2250 HARDWARE

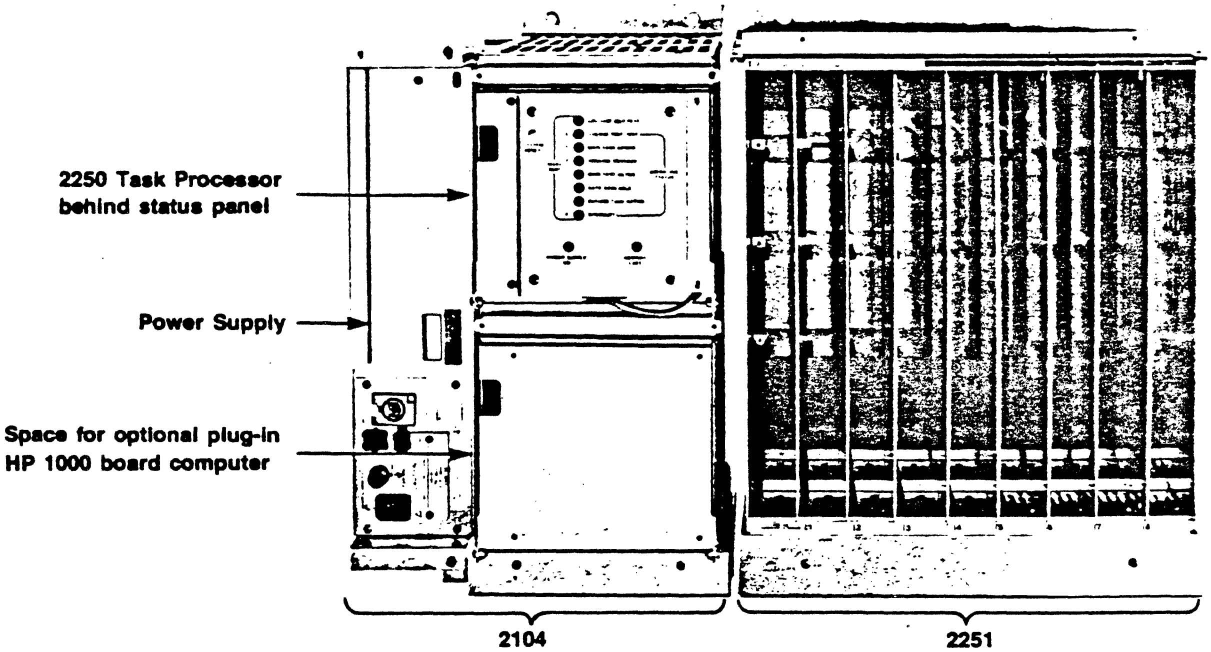
WHAT A 2250 CAN LOOK LIKE

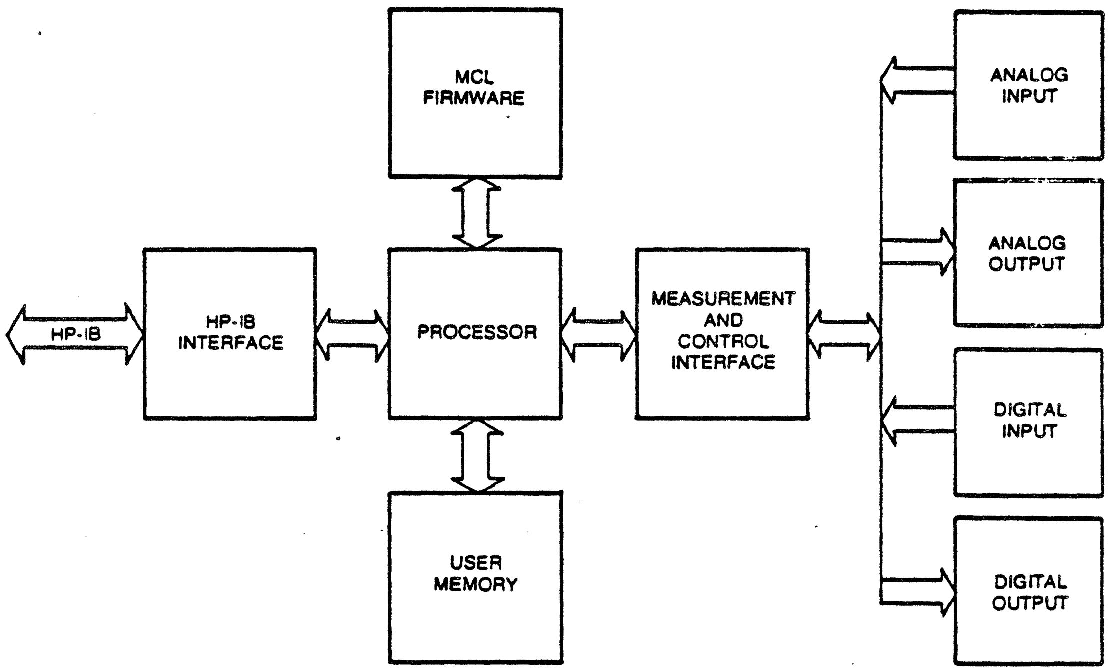


COMPONENTS OF THE 2250

- 2104 is an L-series computer with dedicated firmware
- 2250 has plug-in capabilities for another L series
- 9835, 9845 9826, 9836 software support available, as well as HP 1000
- HP-IB only
- capabilities of 7 additional MCU's

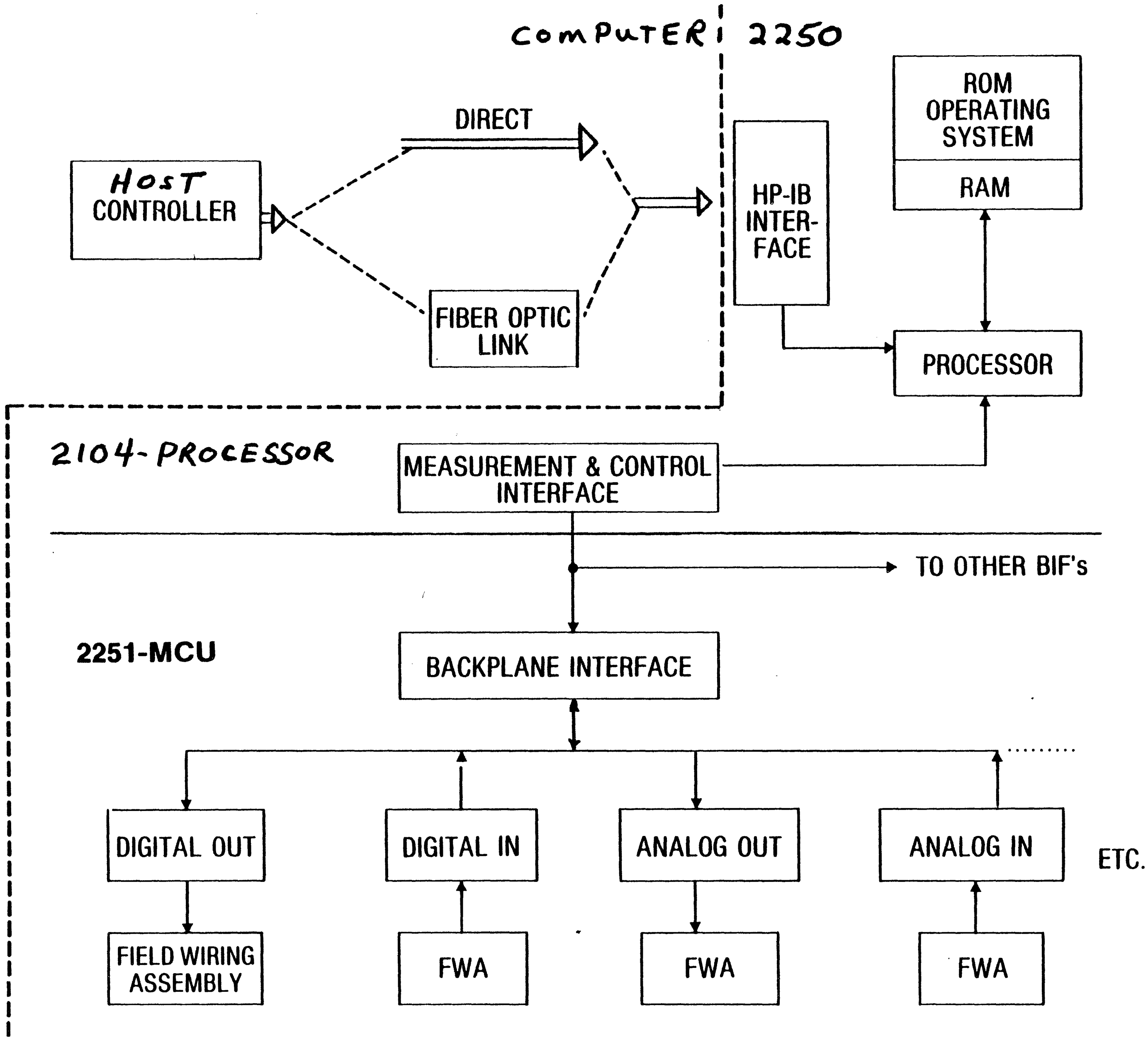
2250 COMPONENTS

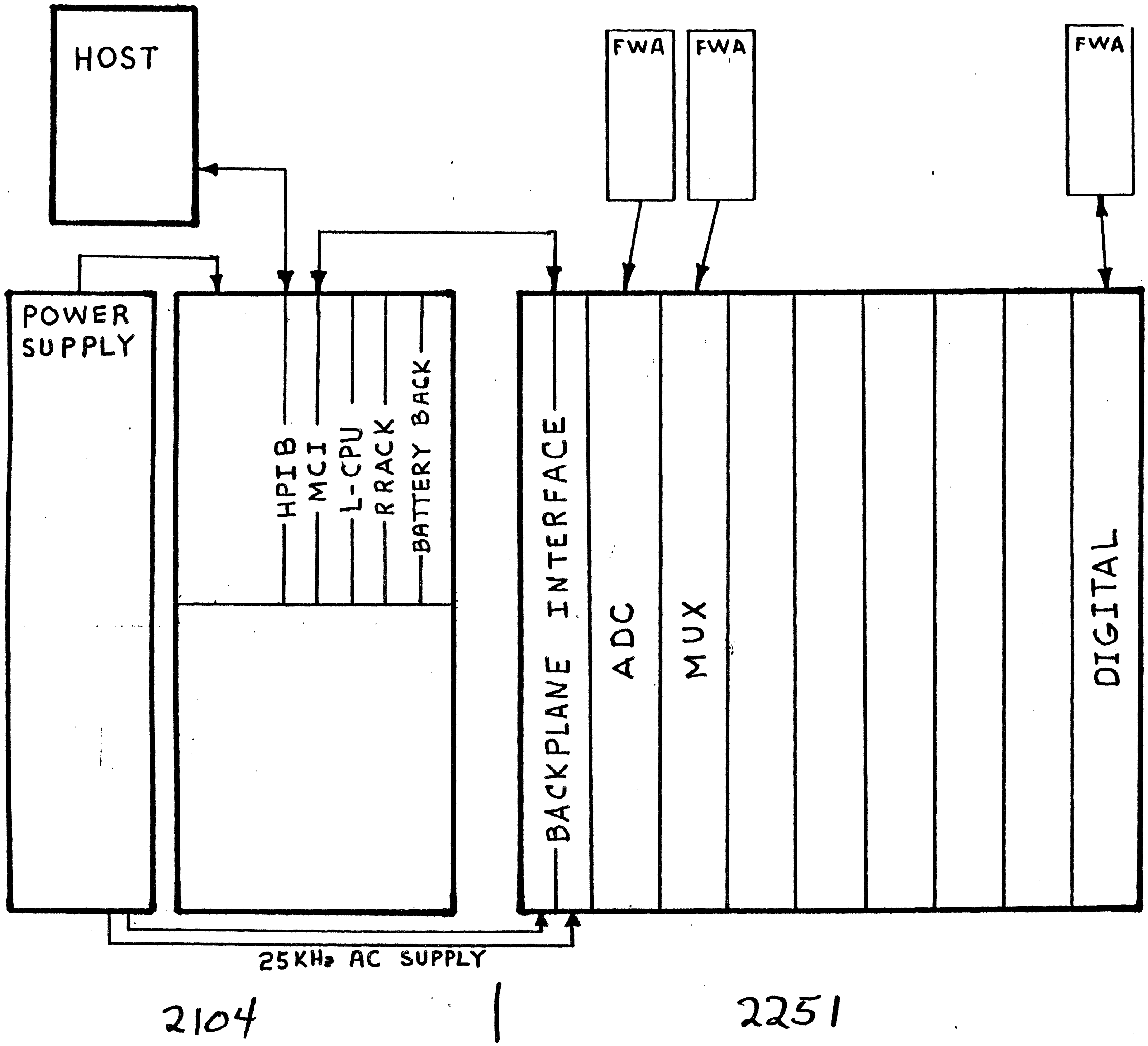




2250 GENERAL BLOCK

2250 BLOCK DIAGRAM

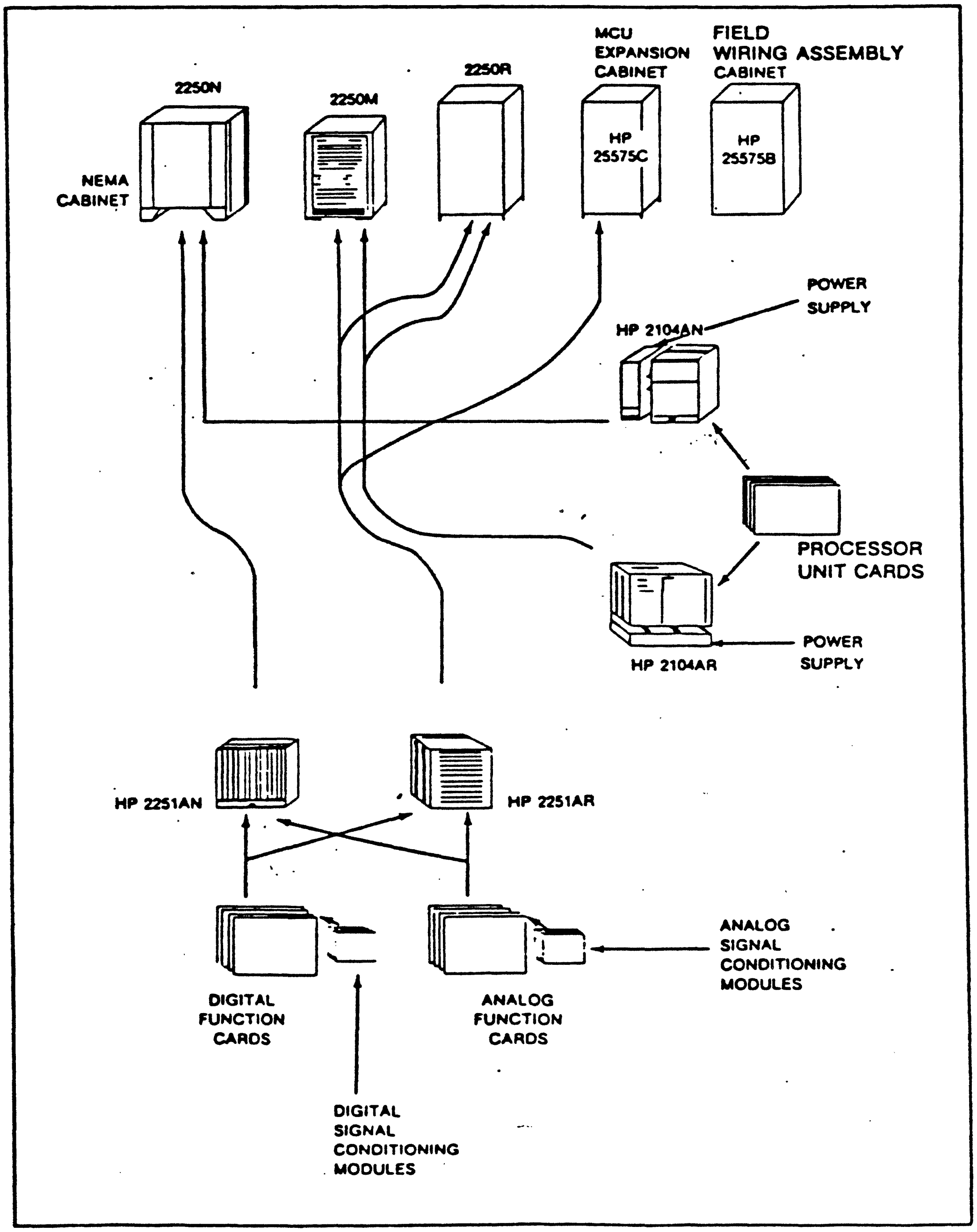




HOST
FWA
FWA
FWA
POWER SUPPLY
HPIB
MCI
L-CPU
RRACK
BATTERY BACK
BACKPLANE INTERFACE
ADC
MUX
DIGITAL
25KHz AC SUPPLY
2104
2251

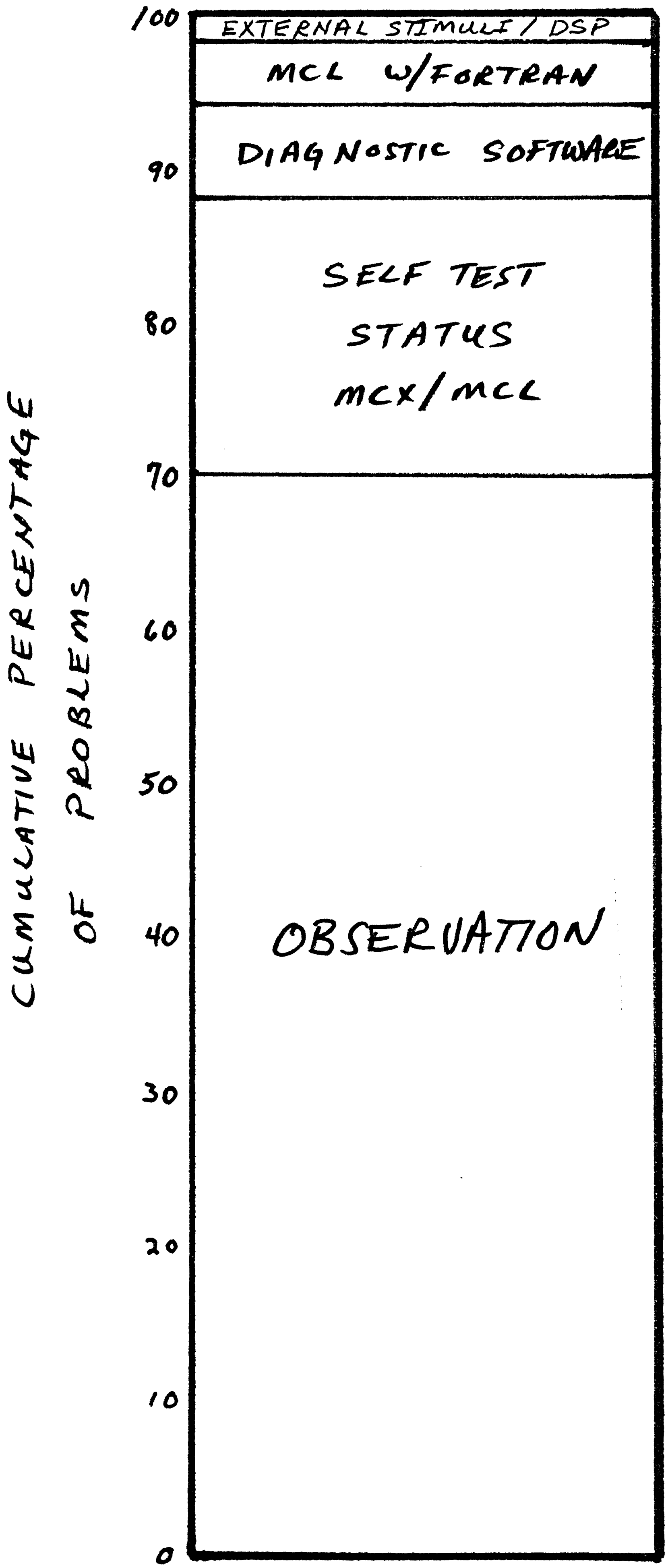
2250

CONFIGURATIONS



2250 ACRONYMS

BIF	Backplane Interface card - card plugged into the left most slot in a 2251 card cage. It buffers the communication between the MCI card in the 2104 processor unit and I/O cords in the 2251.
CDA	Continuous Data Acquisition - software that allows data transfer directly from I/O card to host computer disk memory at rates up to 50,000 samples per second. Part of the HP 1000 Automation Library.
CJC	Cold Junction Compensation - correcting thermocouple measurements for errors caused by joining the thermocouple wire to copper wire at the voltmeter. Can be done via hardware or software.
DDL	Diagnostic Design Language - a Basic-like computer language in which the 2250 diagnostics are written.
DSP	Diagnostic Support Package - a suitcase sized device, along with some software, a manual and some cables, that provides external stimuli for I/O card verifcation.
FWA	Field Wiring Assembly - a bundle of cables with a connector on one end and a terminal strip on the other. This is the part of a 2250 system that provides the interconnect between I/O cards and customer wiring.
MCI	Measurement and Control Interface card - card placed just to the left of the CPU card in the 2104 processor unit. This card serves as an interface between the CPU and the I/O cards. It also provides a clock for system measurement timing.
MCL	Measurement & Control Language - the language of the 2250 as opposed to Basic or FORTRAN. All commands to the 2250 must be written in MCL. MCL is a compiled language.
MCU	Measurement and Control Unit - the card cage that contains the I/O and BIF cards. Also called a 2251.
MCX	Measurement and Control Exerciser - a program, written in Basic or FORTRAN that runs on the host computer. This program provides interactive communication with the 2250 without having to write a complete application program. Part of the Automation Library.
PID	Proportional Integral Differential control - an advanced method of process control that utilizes an error signal, it's integral and it's derivative for dynamic system control.
SCM	Signal Conditioning Module - small printed circuit assemblies that mount on to I/O cards. These pca's transform customer signal levels to levels compatible with I/O card output circuitry.
TASK	term used to describe a sequence of operations to be performed by a 2250. Tasks are written in MCL and are downloaded from the host computer to the 2250 where they are compiled and executed. Tasks can be main tasks or resident tasks.
TRC	Thermocouple Reference Connector - a FWA with a special terminal blo for connecting thermocouples. The terminal block contains a temperat e measuring circuit that provides cold junction temperature information for software compensated thermocouple measurements.
VCP	Virtual Control Panel - an operational mode for L and A series computers where a terminal acts as a front panel. Used for executing 2250 diagnostics.


CUMULATIVE PERCENTAGE OF PROBLEMS
100
90
80
70
60
50
40
30
20
10
0
EXTERNAL STIMULI / DSP
MCL W/FORTRAN
DIAGNOSTIC SOFTWARE
SELF TEST
STATUS
MCX/MCL
OBSERVATION

2250 I.G.

I. What is it ?

A. Measurement and control box

1. Providing digital output
2. Providing digital input
3. Analog output
   a. -10 to + 10 volts dc
4. Analog input
   a. 0 to 230 volts
5. Can detect state change of a digital signal
6. Can provide relay closures

B. It is an instrument on the HPIB

1. Sold by 02 Sales
2. Sold by 01 sales
3. Repaired by 02 service
4. Calibrated on a time and materials basis by PT 11
5. Up to 14 on one HPIB

C. Microprocessor controlled device

1. Using L or XL processor boards

D. Device has own internal language and compiler

1. MCL/50
   a. Essentially a translator language

E. Uses Host software like MCX

a. needs Automation library in 1000 system

II. What sections does it have ?

A. 2104A processor/controller

B. Measurement Control Unit (MCU) 2251A

1. Box provides the digital points
2. Also provides the analog channels

III. General information about the processor (2104A)

A. Contained in a separate metal box

1. Especially made for the 2250
   a. Resembles a 2146 L system backplane
   b. Can also have a separate L for DS control

B. Uses the L power supply

1. Powers the processor cards
2. Powers the MCU
   a. Up to 2 MCUs with a 2104
   ~~b. Up to 3 MCUs without the 2104~~

C. Consists of 4 half sized cards for a minimum setup

1. I/O
   a. L HPIB card
   b. MCI card
      1). Measure and control interface
      2). Made by ~~Roseville~~ not DSD
2. L / XL processor card
3. RRack card
   a. ~~Roseville~~ memory card
   b. Has 16k of ROM
   c. Has 16k of RAM
   d. Implements the mapped stack architecture
4. For diagnostics must add other parts
   a. ASIC card
   b. Special modem cable
   c. All availible in PSP
5. For power fail backup of 2104 only add battery board
   a. Gives 30 minutes of backup for 2104 <u>only</u>

D. Communications with the external world

1. Talks HPIB to Host controller
   a. Host may be 1000 system
   b. Host may be desktop
      1). this configuration limits the data rate between host and 2250
      2) 2250 is ~~not~~ limited by this configuration
   c. Host may be Brand X
2. Talks out the 2104 to the MCUs via the MCI card
   a. Up to 8 total MCUs
3. Uses the lights on front status panel
   a. Shows the different modes while running
   b. Shows fatal and non fatal errors
      1). Fatal error is a parity error
      2). Non fatal type is a compiler error

E. Fits into 2 types of cabinets
   1. Standard HP 19" rack
   2. Nema 12 cabinet
F Has built in self test features

IV. Each part of the 2104A processor
   A. HPIB 12009A
      1. Standard L HPIB card
      2. Uses normal settling time for data transfers
      3. Main communication with the external world
   B. MCI 12070A
      1. Special I/O card for the 2250
      2. Provides data transfers to and from the MCUs
      3. Provides timing clocks for itself and software
         a. Time of day
         b. Watch dog timer
         c. Pacing
         d. Timeout interrupts
      4. Provides clock pulses to MCU
         a. 2 Mhz is the main clock
      5. Drives MCI bus
         a. Up to 8 total MCU
         b. Bus is ground true
         c. Bus runs at 100kHz
         d. Connects to the ~~Bus~~ Interface Function card (BIF)
         e. Multiplexes data and address on the same lines
         f. CMOS drivers for the MCI bus
            1). Electronically quiet
            2). Low power
   C. Processor card 12001 A/B
      1. Is an L / XL
      2. Provides the standard processor functions
         a. Instruction decode
         b. Backplane arbitration
         c. Volitile registers

D. RRack Card (ROM / RAM / Stack card)

1. Special memory card
2. Has 16k of RAM
   a. From 0k to 15k
3. Has 16k of ROM
4. Stack architecture implemented by this hardware
   a. Uses 0 - 377 octal for stacks
   b. Special RAM / ROM chips for stack
   c. Does special instruction decodes/maps for stack
   d. Converts some instructions to the equivalent of Pushs and Pops
5. Extends the memory cycle time be ½ when needed by the stack
8. Provides the ROM operating system
   a. Also contains tables for some measurement linearizations
   b. Thermocouples use the tables

E. Power supply

1. It is a 12035A
2. Standard L / XL as of 3/25/81
   a. Point is it may change
3. Provides 2104 power
   a. + 5 volts
   b. ± 12 volts
4. Supplies 27 volts at 25kHz chopped to the MCUs
   a. Isolated and converted by the BIFs
      1). Gives ± 9 volts AC for each card to convert to +5
      2). Gives ± 17 volts AC for each card to convert to 12 volts

V. MCU - 2251

A. Essentially a PC backplane

1. Has four busses
   a. Top is power
   b. Middle 2 are the data and digital control
   c. Bottom one is for analog

B. Requires a BIF card in the first slot

1. Buffers data
2. Makes 9 volts AC and 17 volts AC for distribution
3. Resynchronizes clocks for use within the MCUs ?

C. 8 maximum

D. Function cards are really the MCU

E. Function Cards

1. 16 channel analog in (ADC)
2. 32 channel high level multiplexer
3. 32 channel low level multiplexer
4. 16 point relay
5. 32 point digital input
6. 32 point digital output
7. 16 point multifunction
8. 4 channel counter
9. 4 channel pulse generator
10. 4 channel DAC

F. Function cards : generalized inputs and outputs where SCMs provide user interface
   1. Isolated in/out
      a. Digital
      b. Analog
   2. Non isolated
      a. Digital
      b. Analog

G. Can have different SCMs on the same card

H. Connects to the user wiring via FWAs (Field wiring assemblies)
   1. The goal is to isolate the sophisticated parts from non - adept users
   2. CE is responsibile for the FWA failures if they are HP provided

VI. Testing the 2250 (2104 - 2251)

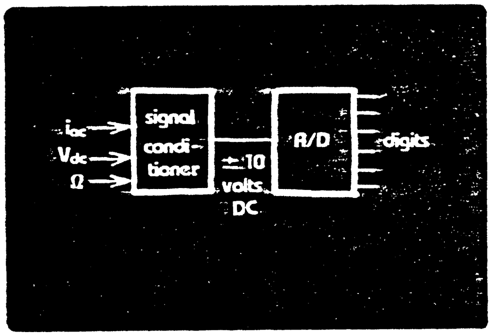
A. Processor
   1. Built in self tests
   2. Off line diagnostics
   3. Using MCX / MCL

B. MCU and processor
   1. Off line diagnostics
   2. The DSP ~~DIU~~ (~~Digital interface unit~~)
      a. Is a self contained stimulus response tool
      b. ~~Is 1/3 of the neede tools for a repair~~
         1). PSP
         2). FSI blue stripe parts
         3). ~~DIU~~

C. The SCMs are the users responsibility to replace and to stock.

86

Now, we will use an A to D (Analog to Digital) converter to change the analog dc level into digital information that can be used by a computer.



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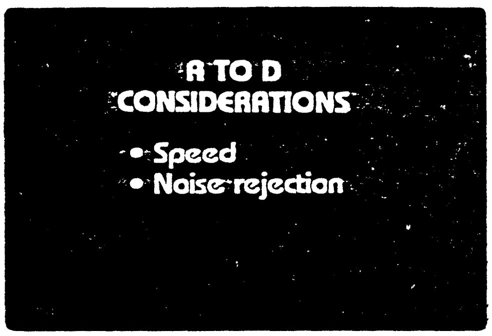
The A to D converter only operates over a single dc voltage range. The signal conditioner must therefore convert all signals to this range whether those signals are transducer signals or power supply voltages.



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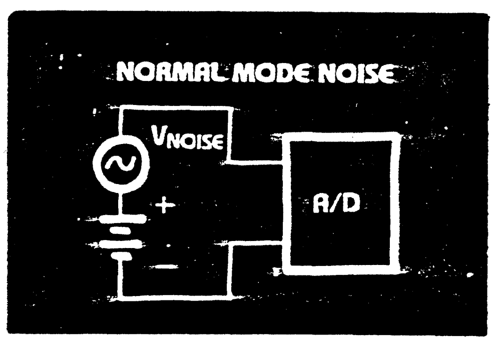
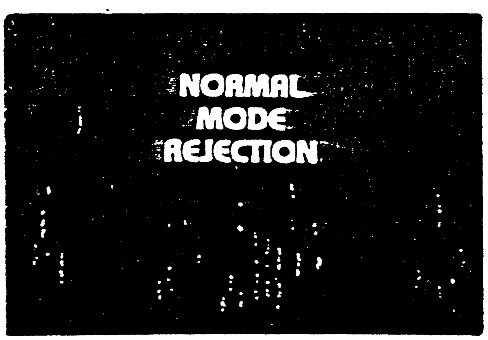
The speed of the measurement and the ability to reject noise are determined by the A to D converter section. Here you will see a speed vs. noise rejection tradeoff.



89

The noise we are concerned about is called Normal Mode Noise, It is typically ac noise, often power line related.

I'm trying to measure this battery. There's a noise voltage source in series with it. If the A/D has perfect noise rejection, all we will see on the display is a dc voltage reading. If the dispay changes constantly, we say the A/D has



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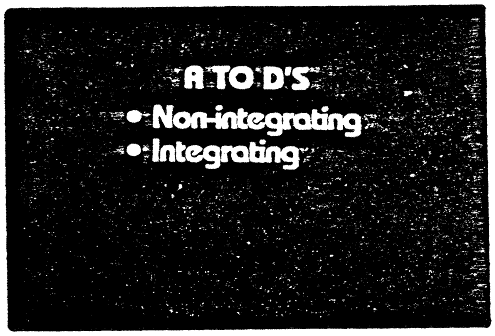
poor normal mode rejection; that is, it doesn't do a good job of suppressing the noise.

The way we do the A to D conversion has a signficant bearing upon how much noise we reject. From a noise standpoint, there



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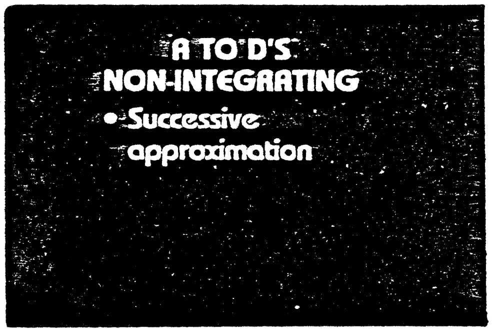
are two basic types of A to D: Integrating and non-integrating.

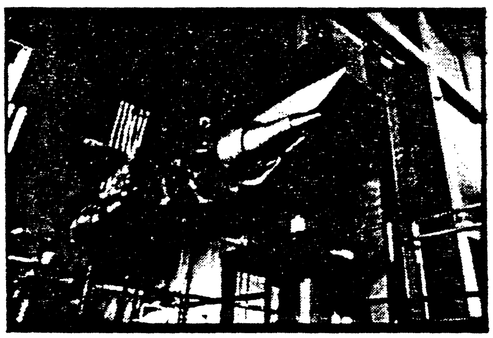
Generally, the application will dictate the type of A/D we choose.

Let's take a look at the most popular non-integrating technique.



92

Successive approximation is a digital A/D technique typically used for dynamic measurements.



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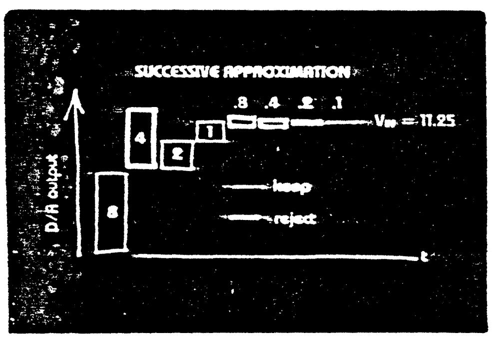
An example of a dynamic signal is the vibration on a jet engine.

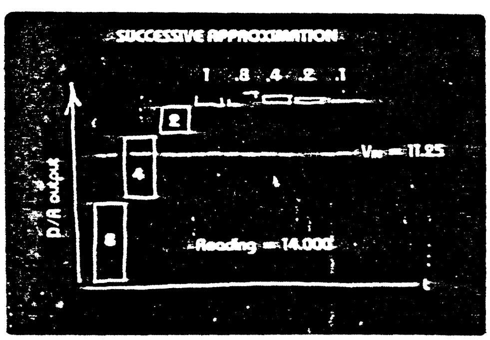
A strain gage signal is put through an amplifier and then into the successive Approximation A/D converter.



94

Successive Approximation works by comparing successively larger voltages to the input, one BCD bit at a time. Here just 4 tries and you have the first digit. At only 4 comparisons per digit, an S.A. A/D can go at Megahertz reading rates.

Typically, for 12 to 14 bit accuracy the number is closer to 50 KHz. But that's still very fast.

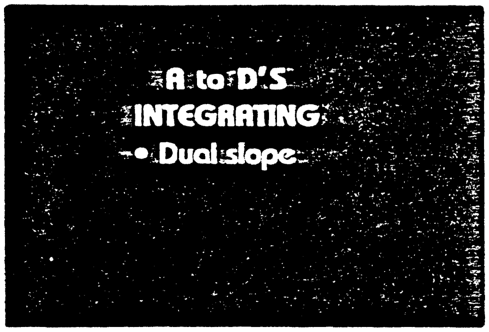


95

It's a very fast technique, but if there's any noise on the signal . . .

the noise will destroy the integrity of the reading.

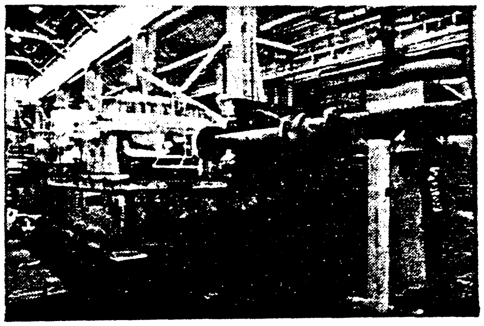
We must hold the input voltage constant before making the A/D conversion. That implies a good sample hold circuit in front of the A/D.



Now look at an A to D technique that has some built-in noise rejection, it's called dual slope and it is an integrating A to D technique.

An integrating A/D can help us get rid of the superimposed noise as long as the noise frequency is related to sample time.

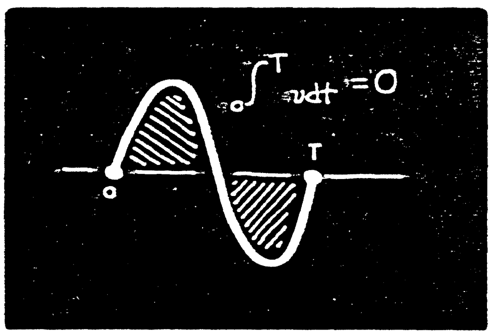
96



A great deal of the noise we encounter is related to the power distribution network, i.e., the line voltage.

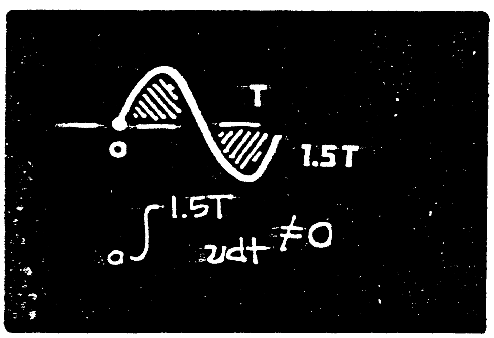
The integrating converter is useful in situations such as this where you need very high line-noise rejection.

97



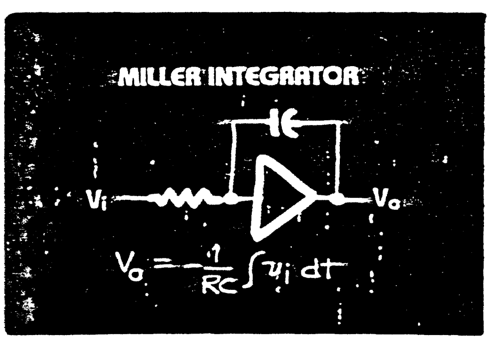
Here's a typical cycle of the AC line. Notice the top and bottom areas are equal. In other words, if we could integrate this noise, the effect of the noise would be totally eliminated.

98



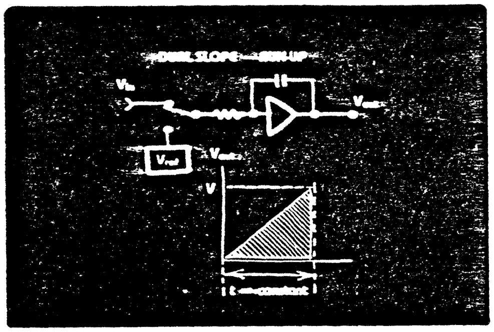
But we have to be careful to choose a whole number of cycles, otherwise the integration does no good.

99



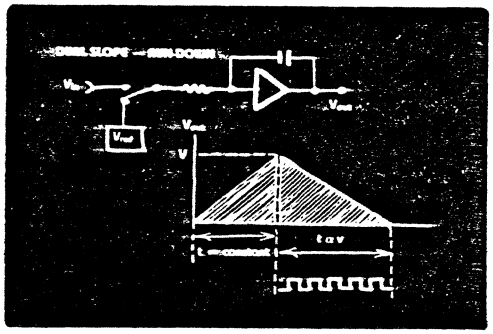
A very simple device called the Miller Integrator is used in most lower cost and pre-1980 dvms.

100



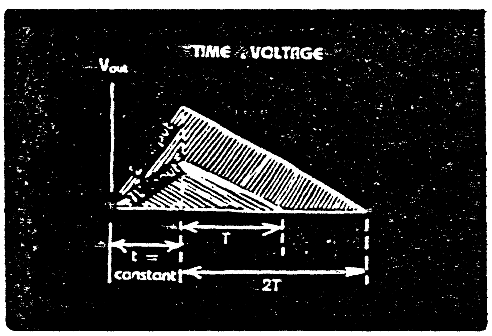
101

First, we'll charge the capacitor for a given time. That time will either be one line cycle or multiples of one line cycle.



102

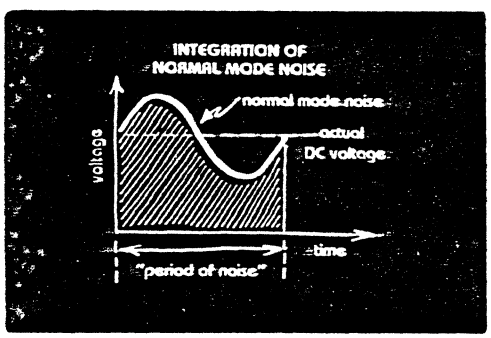
Then we'll discharge it using a reference current. As we start the discharge, we'll send clock pulses to a counter, stopping them when the voltage crosses zero. That gives us the reading.



103

Because the run-up slope changes with input voltage and because the run-down slope is constant, the run-down time is directly related to the input.

The dual slope converter is self-correcting in a lot of respects. The same clock determines all timing, so it need be only stable in the short term.

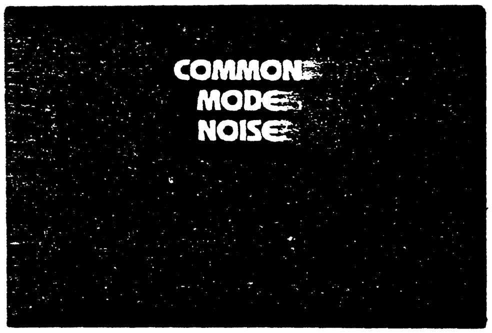


104

With the integration time equal to one period of the noise, dual slope speed is limited to a few readings/second because of a long run down time. but, you get infinite normal mode rejection at line frequencies.

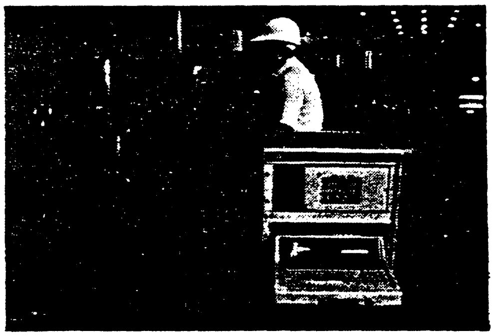
105

There's an improved technique called "multislope" that's faster than dual slope. Yet, you do not sacrifice noise rejection. All of our newer dvms use multislope.



There's another kind of noise that interferes with out measurement, but we can do something about it before it gets to the A/D.

121

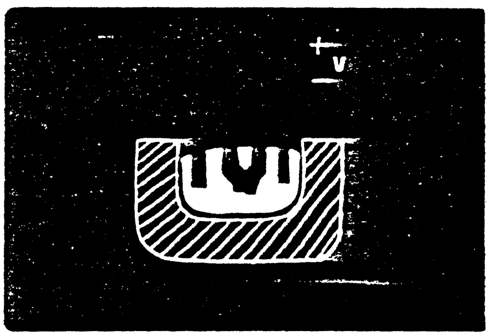


Suppose you're annealing the rotor in a jet engine.

The annealing furance might look like this:

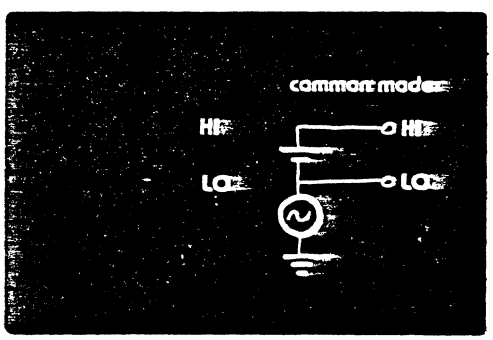
You want very accurate temperature measurement in the presence of a considerable noise voltage.

122



You try to measure the temperature at the center of the furnace. The furnace impresses a common mode voltage on the thermocouple.

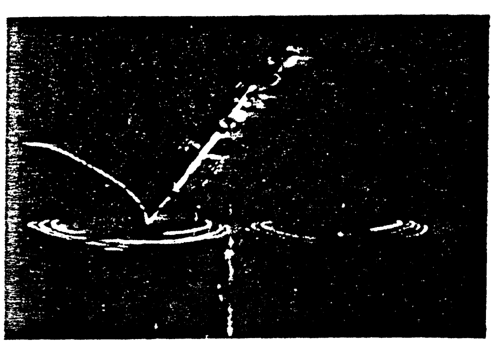
123



The common mode signal gets its name from the fact that it is in common with both the high and low terminals.

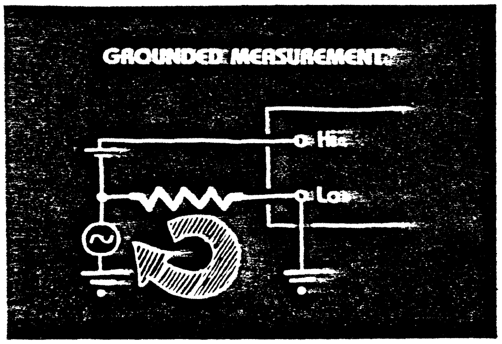
The normal mode signal is what we are actually trying to measure.

124



These two frogs are in "common mode."

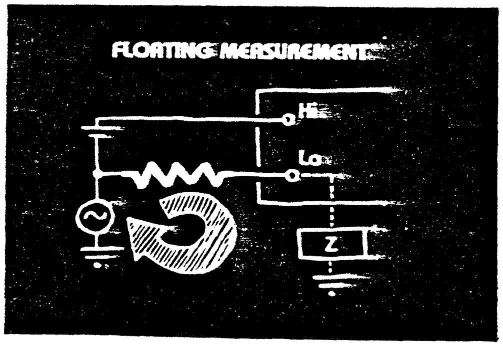
125



126

If we use a grounded A/D or voltmeter, we'll probably destroy the voltmeter as well as the thermocouple.

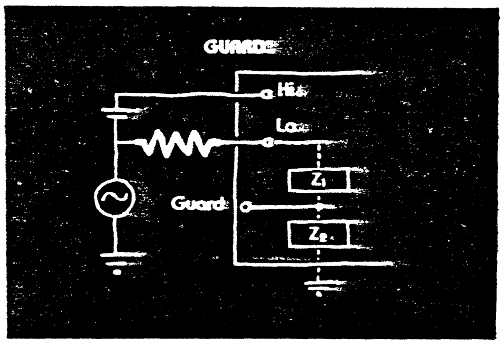
That large "ground current" makes a common mo voltage. Look at the voltmeter terminals. Wi are they measuring? That common mode noise h promptly turned into a normal mode noise, i.e it appears directly across the dvm input terminals.



127

A much better measurement can be made with a "floating" voltmeter which has a high impedan between low and earth ground.

The impedance acts as a voltage divider. If have a 100 volt source with 1KΩ lead resistan and Z is 10^{8} Ω then we have only 1mV of normal mode noise.



128

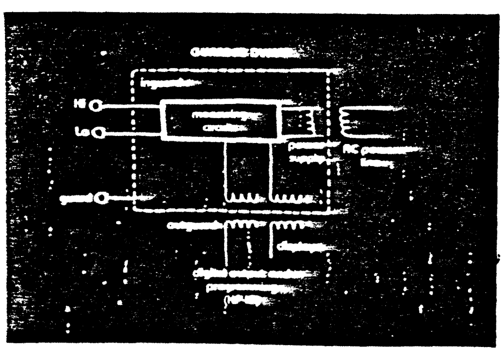
Now let's investigate another terminal called guard.

Many of our more expensive dvms and prec[illegible]on dvms have a guard terminal.

129

Physically, the guard is a sheet metal box th contains all of the analog circuits.

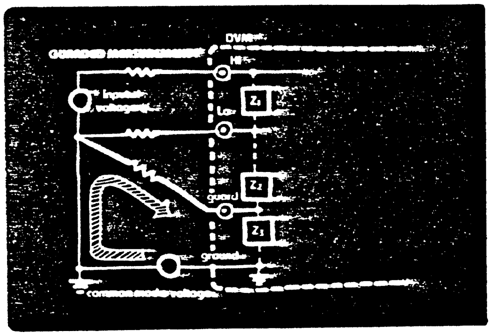
The guard is isolated from low and from chass ground of the instrument.



130

A guard is a relatively expensive technique t incorporate, because it involves isolated pow supplies and isolation of signals between inguard and outguard.

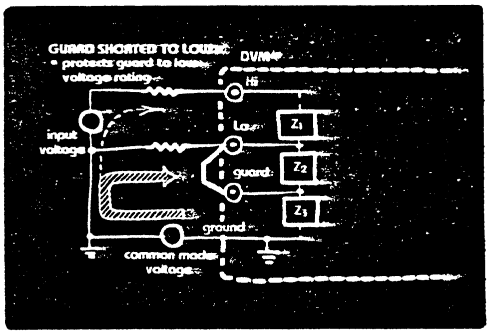
131



When connected in this fashion, the guard acts as a second voltage divider, giving us another two decades of noise rejection.

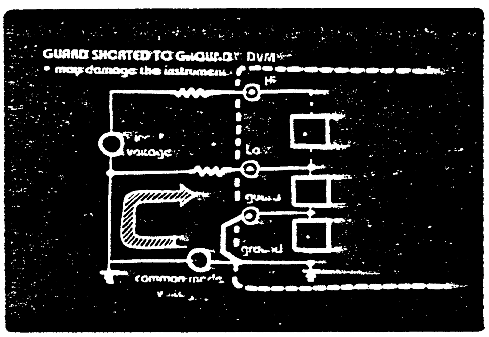
We have to be careful where we connect this third "guard" terminal.

132



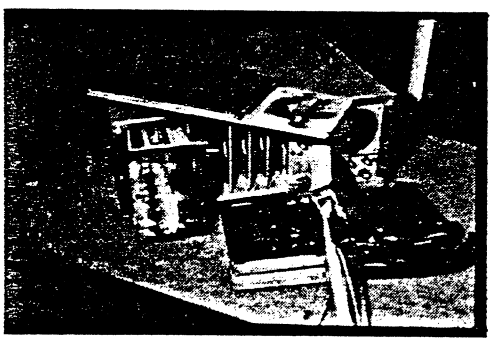
If we don't have a need for guard, we can simply connect it to low at the voltmeter. That's the same as having a floating voltmeter.

133



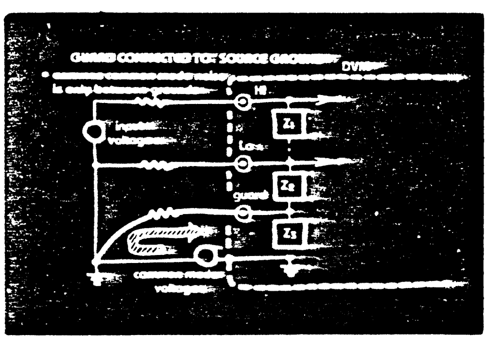
Here's something to avoid. The breakdown voltage from guard to earth is much higher than that from guard to low. So if you make this connection, you defeat the break-down protection of the box.

134

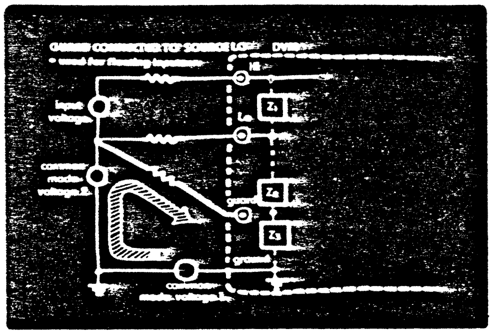


That connection may cause damage to the instrument.

135

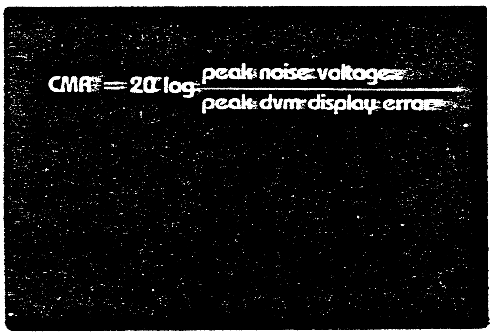


If you know exactly where the common mode source is, you can make this connection.



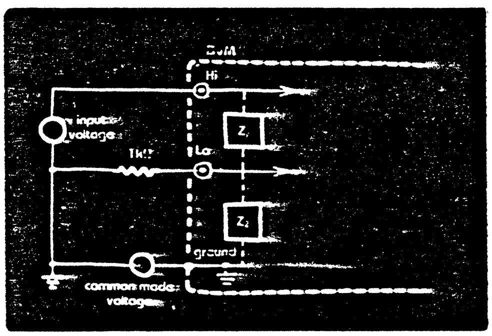
136

But if you don't, this is the safest and most noise-free connection.



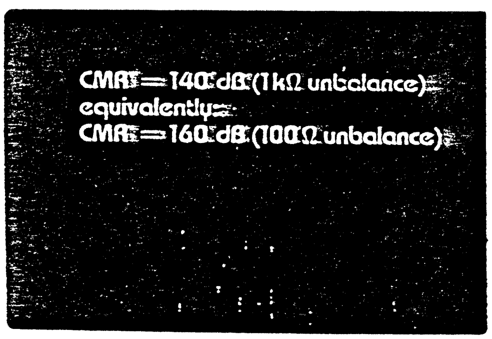
137

The result of all this is a specification known as common mode rejection. Notice both noise and error are specified in the same units: peak voltage.



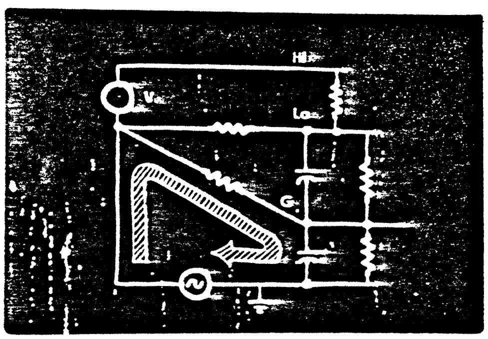
138

CMR is usually specified with a 1 KΩ resistor in the low lead. Since CMR is a function of the isolation resistance, it is also a function of the 1 KΩ resistor.



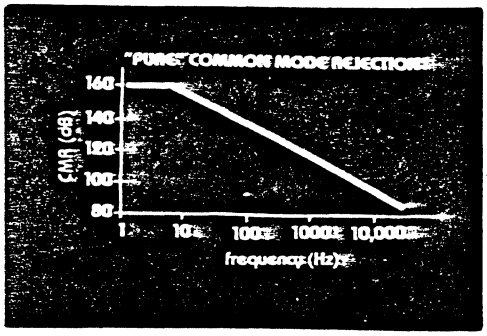
139

In fact, these two specifications are identical. Many A to D's are specified with 1 ohm of unbalance.



140

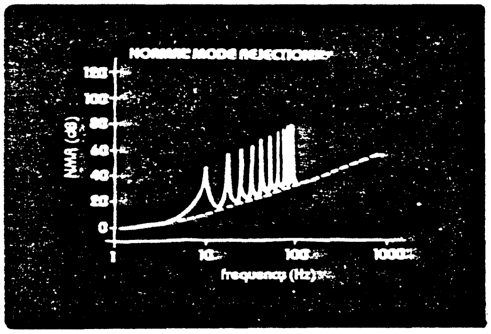
Remember the sheet metal box? It makes a fine capacitor. If the frequency of the noise source goes up, the capacitive impedance decreases, so CMR goes down.



141

Net result is a CMR that decreases with increasing frequency.

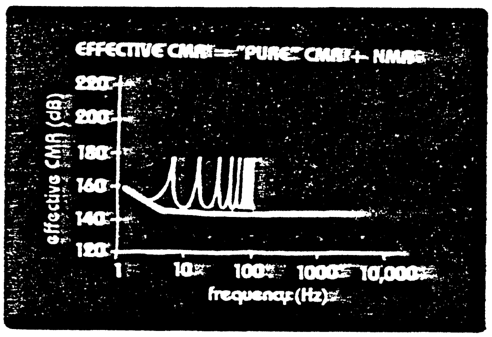
But remember that the common mode noise voltage is converted to a normal mode noise voltage and then read by the DVM.



142

So the normal mode rejection of the voltmeter helps get rid of this common mode error.

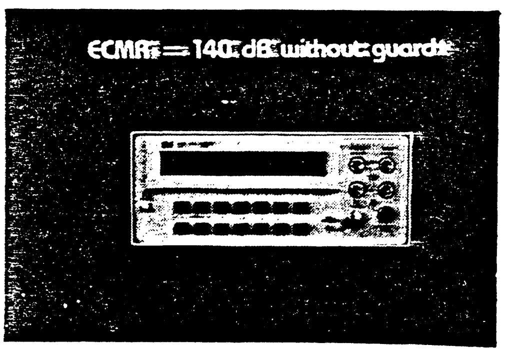
Here is the NMR plot for an integrating dvm.



143

The combination or the sum of the two effects is what we actually measure.

It's called <u>effective</u> common mode rejection.

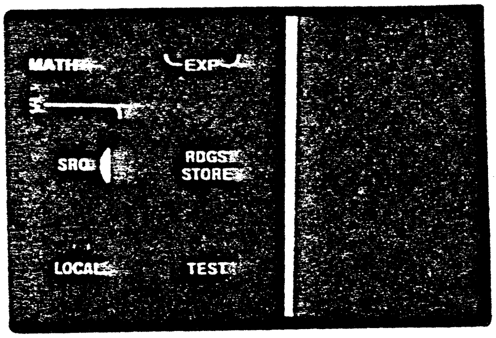


144

The 3478A has an excellent ECMR spec without the use of a guard terminal. For comparison, the 3456A has an ECMR of 150 dB and 160 dB with the filter. The guard provides extra noise rejection capability, but costs more money.

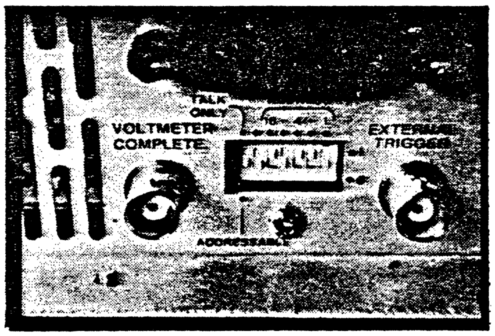
145

Now, we are going to cover some specifics of transducer measurements. Many of the techniques discussed in the basic measurement section will apply. Even though HP doesn't sell these transducer devices, you need to understand what customers are connecting to our equipment.



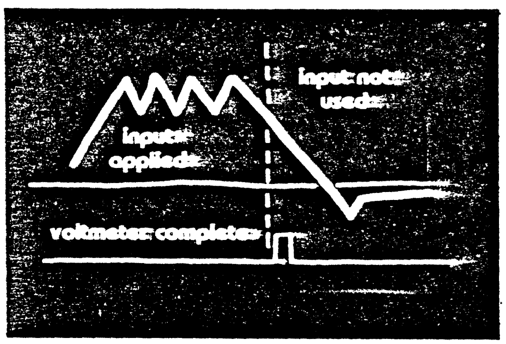
341

The 3456A dvm also has the capability to store up to 350 readings for this type of distributed processing. It also has the capability to store a program string in memory.



342

Many of our products have some hardware input/output signals that provide speed enhancements such as voltmeter complete outputs and external trigger inputs.

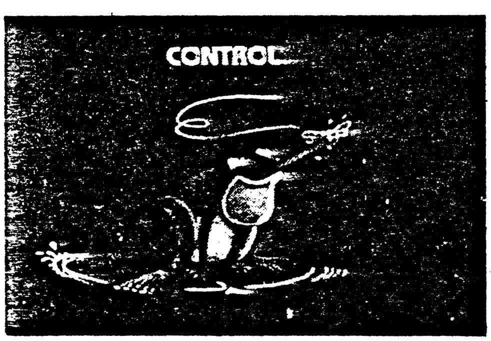


343

The voltmeter complete output is used to increment a scanner to the next channel without computer intervention. This signal comes after the reading is complete. The 3456A outputs VM complete before ramp down where-as the 3497A Option 001 VM outputs VM complete at the end ramp down. As a result, scanning can be done roughly twice as fast with the 3456A voltmeter.

344

Well, we're finally in control.

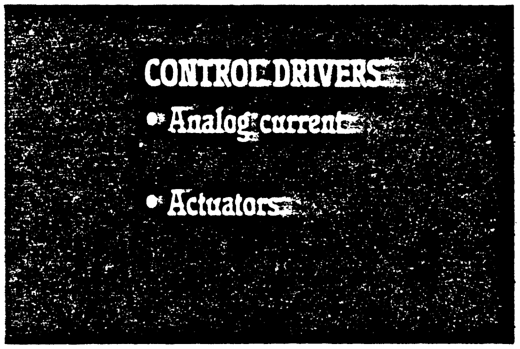


345

Control can be partitioned into the hardware used to do the actual control, the cards used to drive this hardware and the software logic to determine what control is needed.

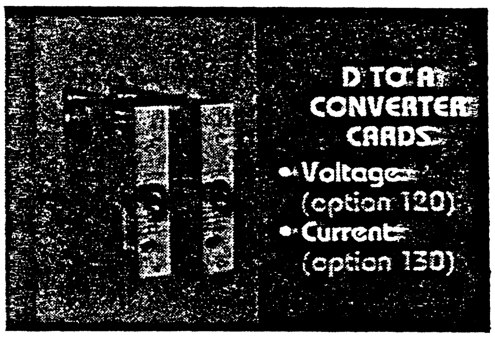
346

Many applications involve providing some control signals for a process.



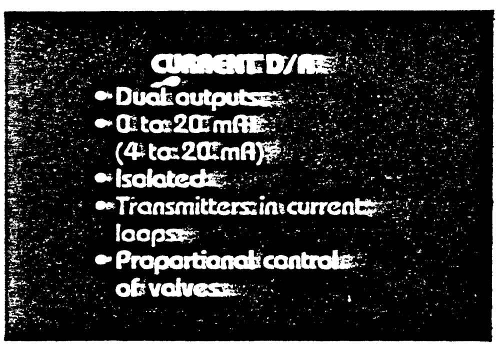
347

Our data acquisition and control units make several types of control possible. Included are: analog current or voltage outputs, switch closures and digital logic outputs.



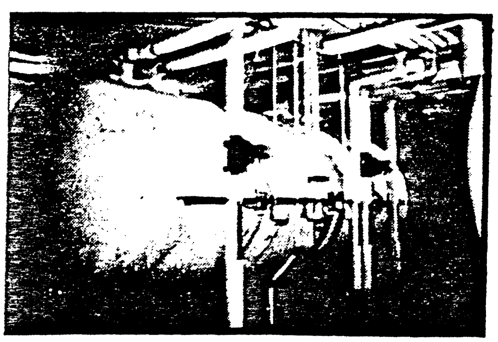
348

There are two choices for D/A's on the 3497A either a current card or a voltage card.



349

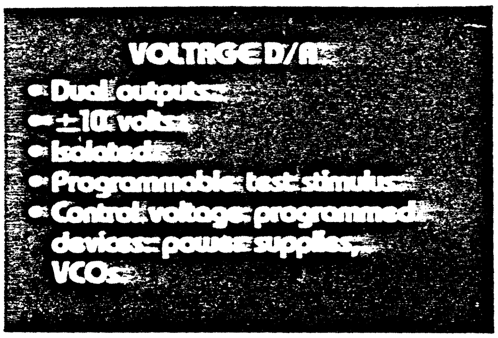
The current D/A card provides two outputs that can be configured for 0-20 or 4-20mA operation. They are isolated from one another and from ground, so you minimize ground loops. Typically, they are used to transmit control signals.



350

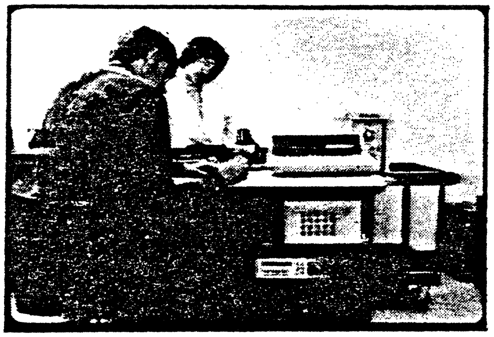
Valves and other devices operate on 20mA current loops. (The 4-20mA scheme lets you detect an open circuit which is 0mA).

You can use the current D/A to control this valve, for example.



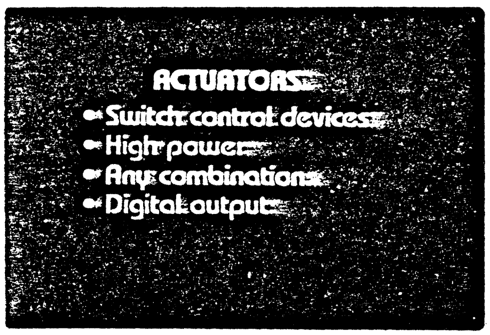
351

The voltage D/A card provides two individually programmable 0 to +10 Volt sources. They are isolated so you could stack them on each other to provide +20 volts. Typically, they are us as a test stimulus or to control voltage operated devices such as VCO's or power supplies.



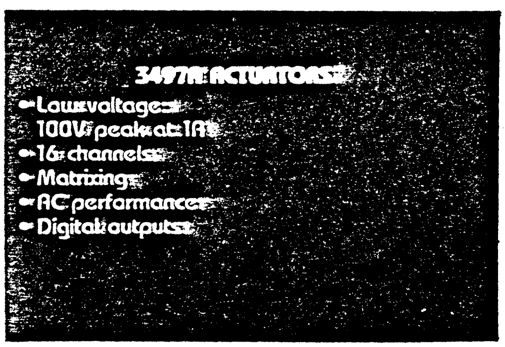
352

This card would be useful in production testing to supply power to a device under test.



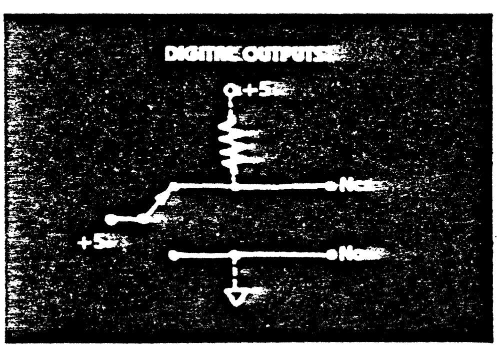
353

An actuator is nothing more than a relay. It typically can handle a great deal more current than a multiplexer relay. Its primary purpose is to switch control devices such as valves or alarms. It can switch relatively high currents, say 1 or 2 amps, and can be energized randomly Unlike the multiplexer switch, several actuat may be on at the same time. Sometimes, actuators are used as digital outputs.



354

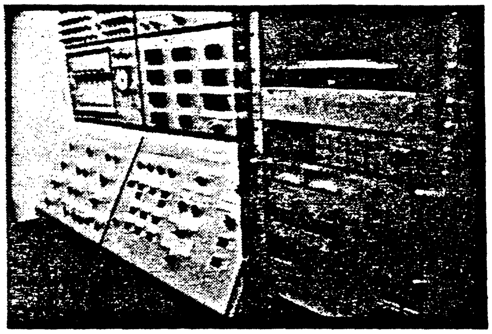
The 3497A has two different options for actuators. The lower voltage option has 16 channels/card and is useful for matrix switching, ac switching with quality and as digital outputs. The high voltage option will switch line voltage safely to small motors, alarm bells, lights and motor starters or solenoids.



355

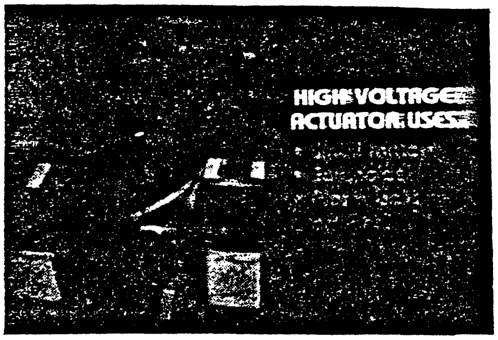
A resistive pull-up is connected from +5 to one actuator terminal, and the other terminal is grounded.

This can easily be done with the low voltage option with mercury-wetted relays, to insure no contact bounce.



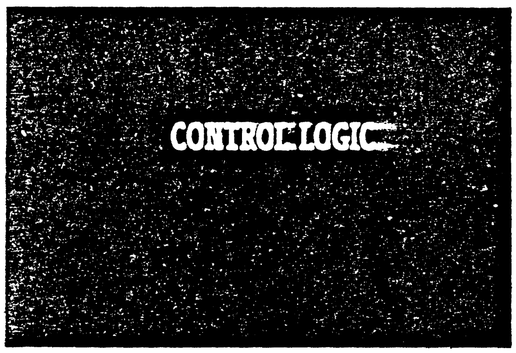
Digital outputs are used for programming non-standard interfaceable products. Handshake and flag lines are provided, also.

356



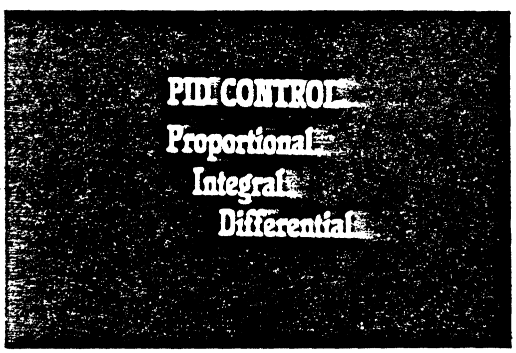
The high voltage actuator option is typically used for switching higher current devices such as motor starters, solenoids, bells and whistles.

357



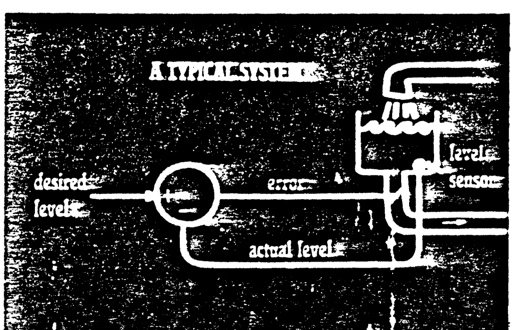
Having examined ways to drive control hardware, we will now look at logic techniques for determining what control is appropriate.

358



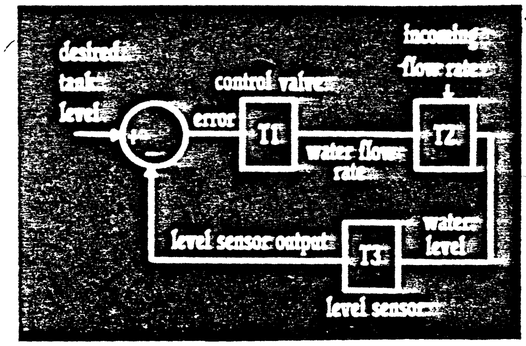
A popular and powerful control algorithm is called PID control. This stands for proportional-integral-differential control.

359



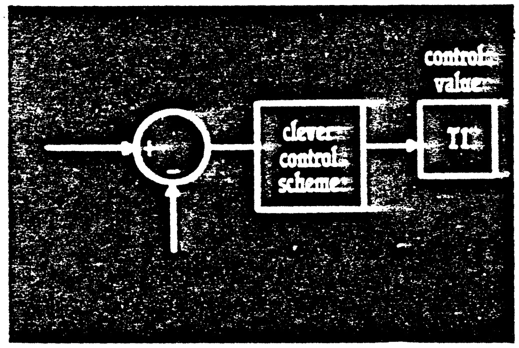
Let's examine a typical control system. If we want to control the level of liquid in a tank to some desired level, we might adjust the position of a control valve that allows liquid to leave the tank. The level is then measured and compared with the desired level to see if an error exists and further adjustment of the control valve is necessary.

360



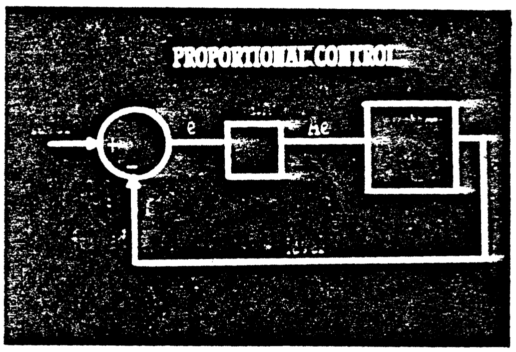
361

In terms of classical control theory, this is usually shown with a bunch of transfer functions.



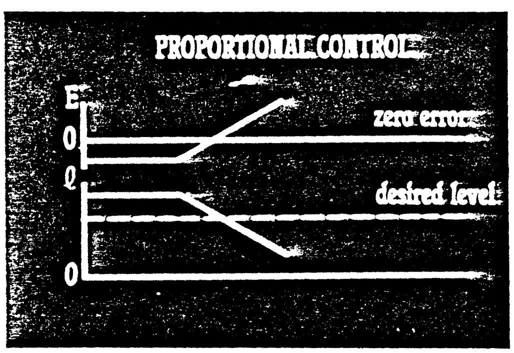
362

The error signal is often processed in some clever manner to improve the control of the valve. Let's look at some of these processes.



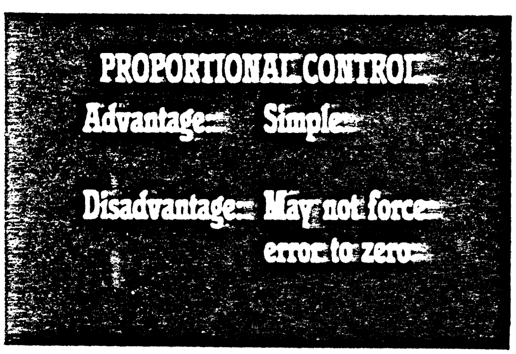
363

Proportional control is the simplest type of control. The error signal is scaled as necessary and then drives the control valve directly.



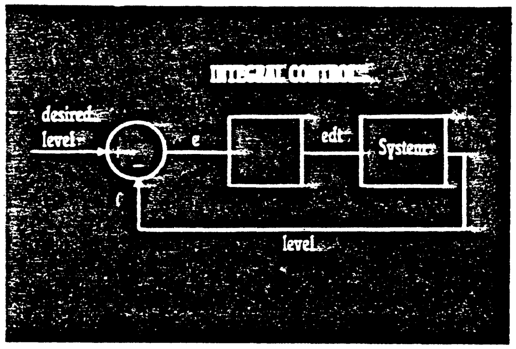
364

As shown, the error signal and the signal that drives the control valves are directly proportional.



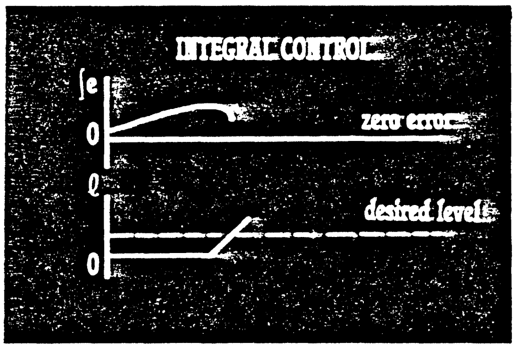
365

There is a disadvantage to proportional control. If there is a small residual error in the system (due perhaps to friction), the drive voltage will never be large enough to remove that error.



366

Integral control is another useful type of control. Here the error signal is integrated to develop the signal that drives the control valves.

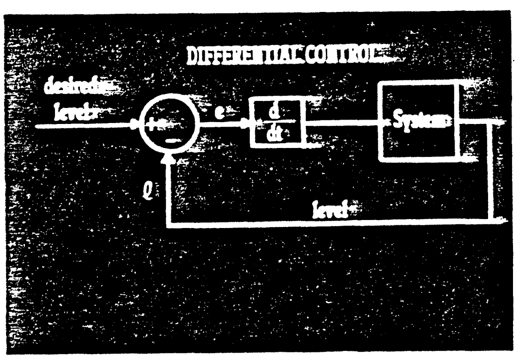


367

Integrating produces a control signal that is related to the area under the error curve, i.e., the longer an error has existed the larger the control signal will become.

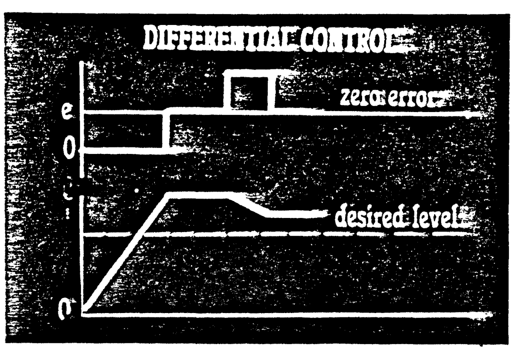
368

The advantage of integral control is that it will always force the error to zero. Its disadvantage is that it tends to produce oscillations. The correction signal may still be large when the error signal reaches zero, thus causing the error signal to pass right through zero.



369

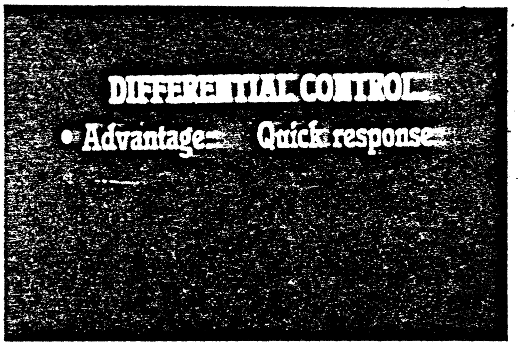
A third type of control is differential control. Here the control signal is the derivitive of the error signal.



370

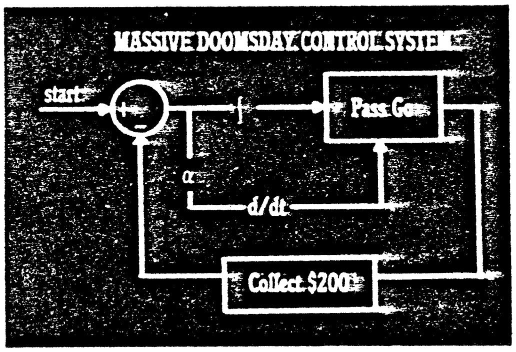
Differential control produces a control signal that follows the rate of change of the error. this allows very quick response to changes in tank level.

371



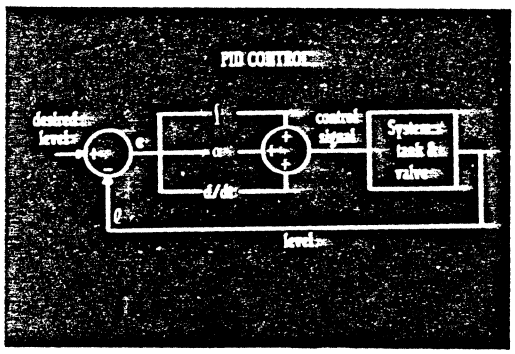
The advantage of differential control is its quick response to changes. It has a major disadvantage in that a steady state error will not be forced to zero.

372



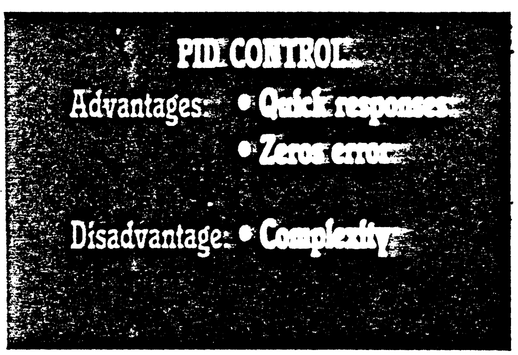
We have now examined three types of control. Put them together and what have we got? Dib-edy-dob-edy-glue!

373



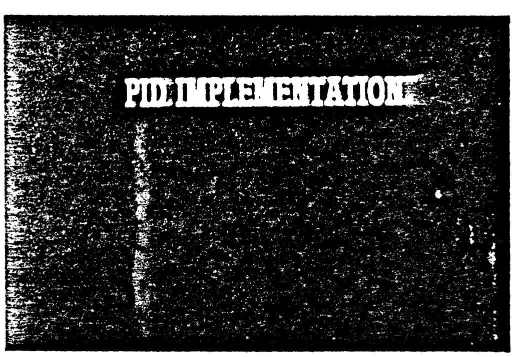
Let's try that again. If we use all three types of control and sum their outputs, we get some of the advantages of all three types. This is called PID control.

374



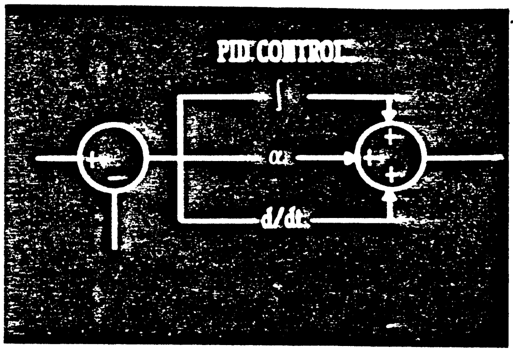
These advantages are: quick response to sudden changes and zero error in steady state conditions. The disadvantage is the system complexity.

375



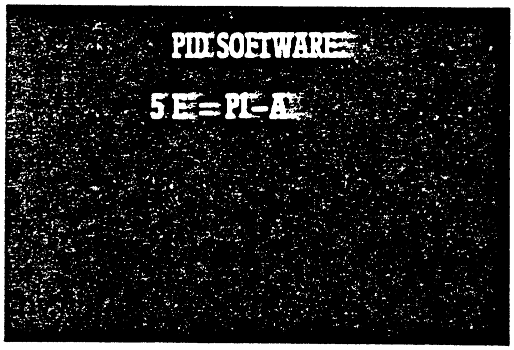
PID can be implemented in software or hardware. Software takes about 12 lines of BASIC code. Hardware loops are available for several hundred dollars each.

381



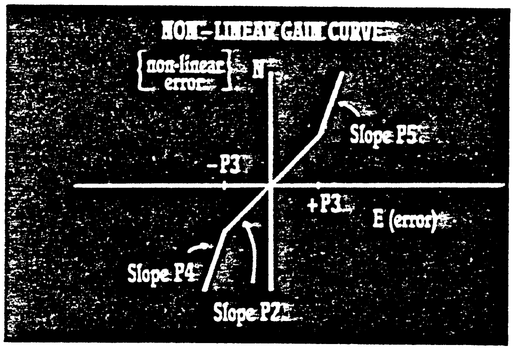
As mentioned earlier, this can be implemented in hardware or in software. The diagram we have seen represents a hardware implementation. Let's now examine a software implementation using BASIC.

382



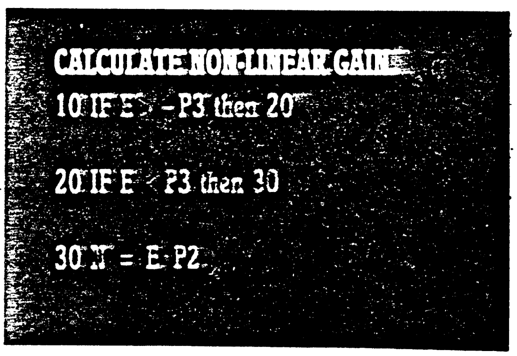
This line calculates the error by comparing the desired value with the signal received from a sensor, (the actual value). For example, think of a water tank with a desired and actual water level.

383



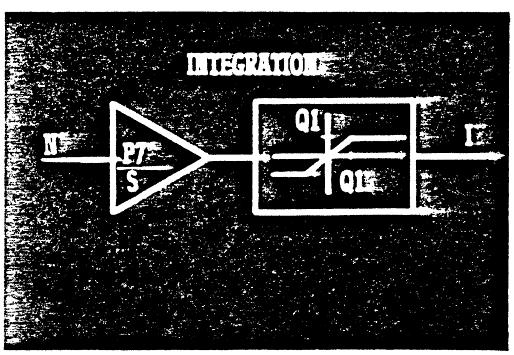
If the error becomes too large, we may want to increase its impact on the control device. This can be done using a non-linear gain curve.

384

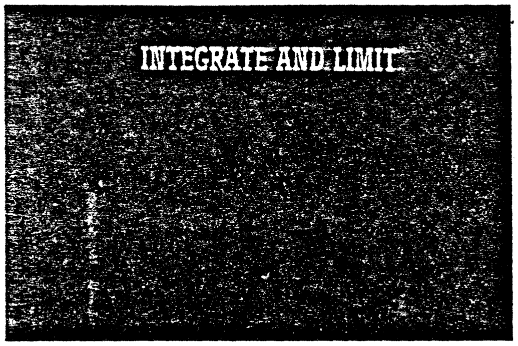


These 5 lines calculate the non-linear error (N) based upon the non-linear gain curve. If statements determine which segment of the curve is appropriate, then the correct straight line formula is used.

385

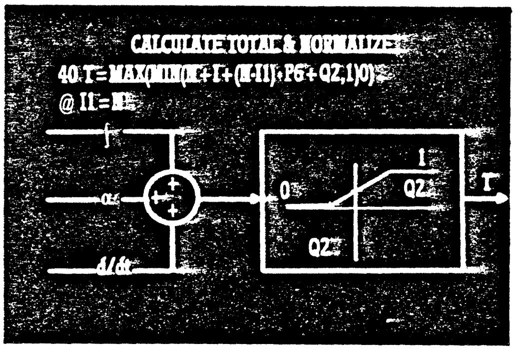


We can now calculate the integral part of the error. A constant, called Reset Limit (Q1), is used to keep the integral from getting infinitely large in cases where the error does not actually go to zero.



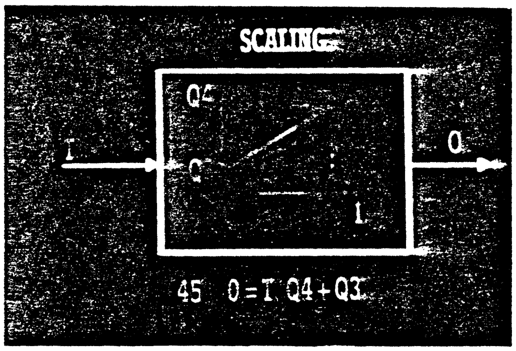
The integral is calculated and limited to the Reset Limit in one line of code. In the formula, N is the error, P7 is the time increment and P7*N is the area under the curve, the integral. This is added to I; the area under the curve up to this point in time.

386



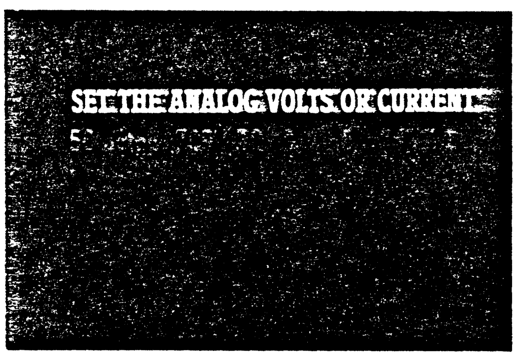
We now find the derivitive of the non-linear gain (N) and add it to the integral and proportional parts. This line also normalizes the result so that it falls between zero and one. Finally, the non-linear error (N) is saved for use the next time the derivitive is computed.

387



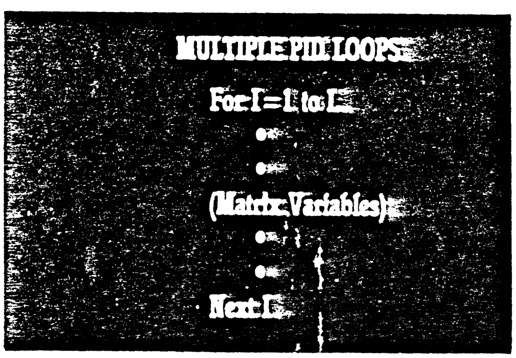
The PID signal is scaled to provide the proper output control signal magnitude. For example, if a 4-20mA current loop is used to drive the control device, the signal must be scaled into this range.

388



The actual control device is driven by an analog voltage or current. This line sets the 3497A D/A card in slot S and channel C to output the correct control voltage or current. (The 3497A has a dual voltage D/A card and a dual current D/A card).

389



That's it. If we want to control multiple PID loops we simply add a FOR-NEXT loop and use matrix variables.

390

ESD

ESD

WHAT IT IS and WHAT IT DOES

==>ESD is insidious and it is everywhere<==

==> To be effective, a prevention program must be universal<==

REVIEW OF FUNDAMENTALS

ESD GENERATOR MODELS

ESD FAILURE MODES

MODES and MODELS COMPARED

SOME MYTHS

REVIEW OF FUNDAMENTALS

* ESD (electrostatic discharge):

  · THE REDISTRIBUTION OF STATIONARY CHARGE

* CAPACITOR EQUATIONS:

capacitance	$Q=CV$	coulombs
energy in a capacitor	$W=1/2\ CV^2$	joules
capacitance of parallel plates	$C=\varepsilon a/d$	farads
current-voltage relationship	$I=Cdv/dt$	amperes

* METHODS OF CHARGE GENERATION

  piezoelectric - flexing certain materials

  inductive - charge induced from an electrostatic field

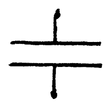
  capacitive - charged body movement

  triboelectric - rapidly separatinq two different materials

ESD GENERATOR MODELS

* FIELD INDUCED

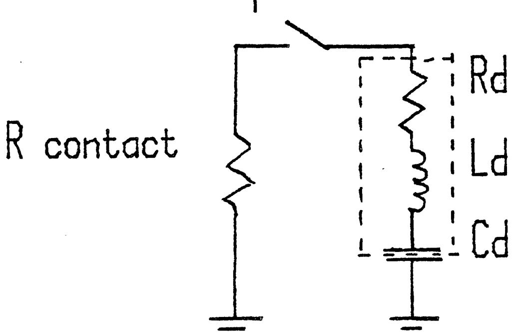
leadless



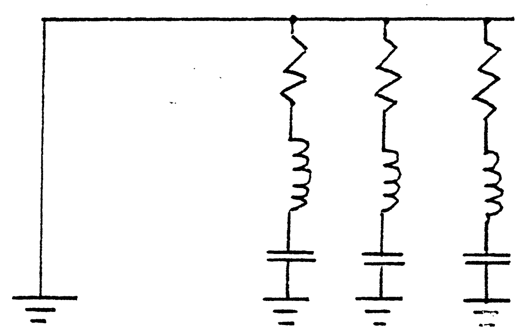
leaded

* CHARGED BODY

bipolar

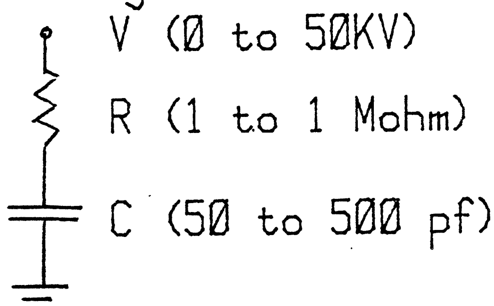


mos

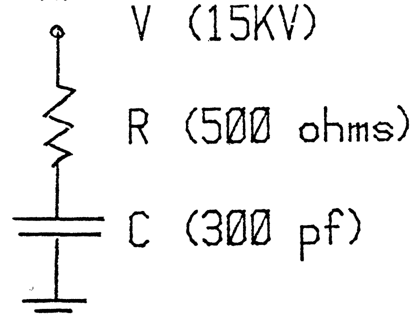


* HUMAN BODY

general



HP



* ESD STATISTICS

rise times	1 - 10 psec
peak voltages	10's KV
pulse widths	100's nsec
average power	10's KW
sensation	1 - 3 KV

common potentials	volts
walking on linoleum floor	250 - 12K
walking on carpeted floor	1.5K - 35K
working at bench	100 - 6K
sliding plastic box on carpeted bench	1.5K - 18K
solder remover	1K - 8K
freon circuit spray	5K - 15K
sliding on foam padded chair	1.5K - 18K

ESD FAILURE MODES

* GENERAL

voltage, current, energy, polarity
vaporization
melting
secondary breakdown
dielectric breakdown

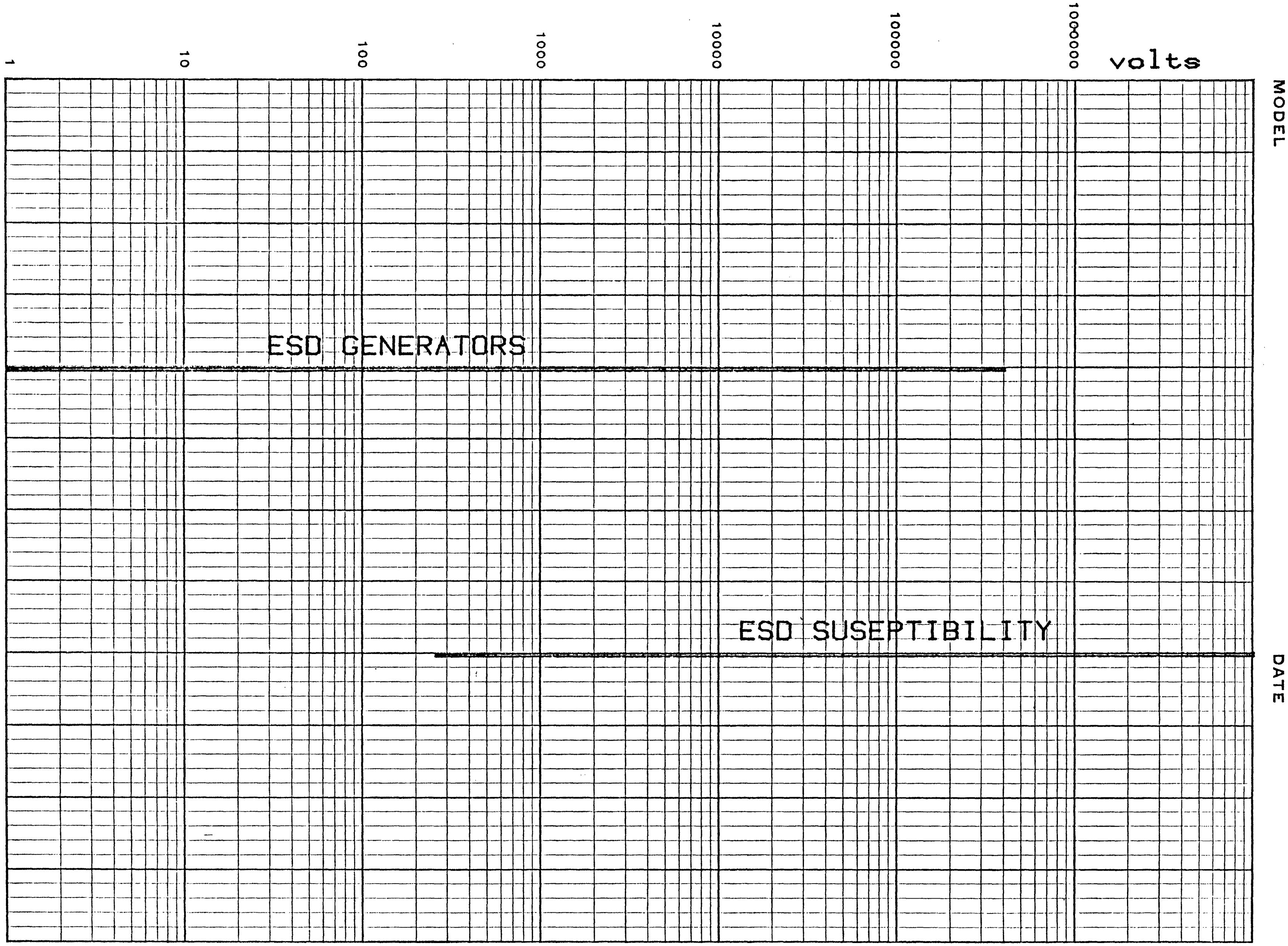
* ESD DAMAGE LEVELS

	volts
CMOS inverter (leakage current)	210
TTL inverter (leakage current)	700
STTL inverter (leakage current)	250
LSTTL inverter (leakage current)	350
ECL inverter (leakage current)	200
ECL RAM (leakage current)	135
NPN (beta shift)	400
PNP (beta shift)	450
JFET (pinch-off voltage)	400
Schottky diode (leakage current)	250

* NOTES

protection diodes are not always effective
CMOS and ECL are primarily voltage sensitive
TTL is primarily energy sensitive
degredation can be cumulative
1 ujoule is required to vaporize a 6 um creator in silicon
MOS dielectrics breakdown at 80 to 120 volts for 1000 Å thick
devices will only get more dense in the future

MODES and MODELS COMPARED



SOME MYTHS

1) only CMOS, MOS, and JFETS are suseptible to ESD

2) it won't happen to me

3) it didn't happen this time so it won't happen next time

4) it doesn't happen every time so it must not be ESD

5) I didn't see it or feel it so I didn't do it

6) it works now so it will work forever

7) if it's in a pc board, it's safe

9) it's OK as long as you don't touch it

9) using antistatic tools will prevent ESD damage

2250

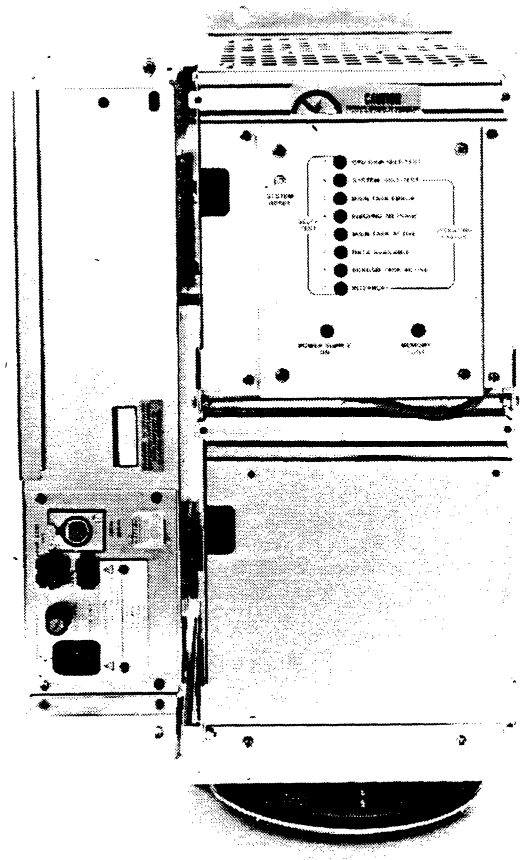
HARDWARE

2104 PROCESSOR UNIT

OR COAX
- HP-IB/fiber optic/link (37203 on a card)
- External pacing or triggering is done on MCI
- Status panel lights are copy of lights on CPU CARD

  NO LONGER USED – RFI EMISSIONS

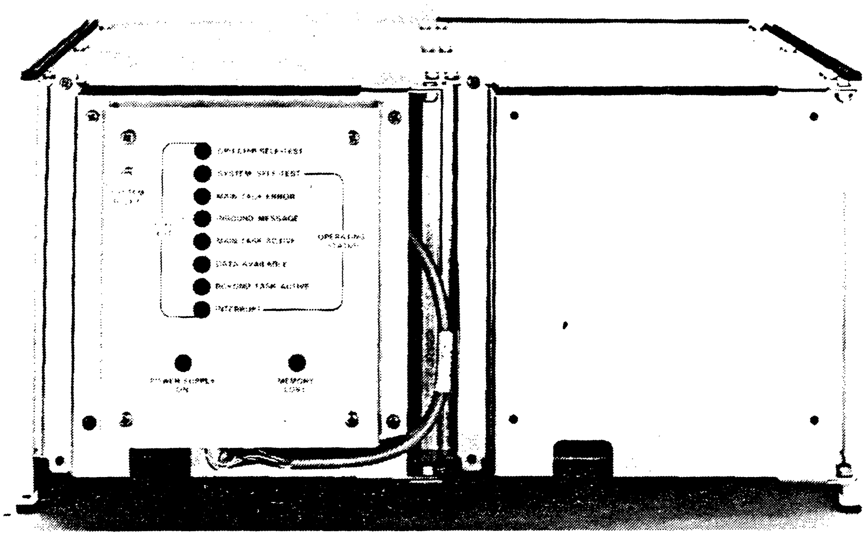
2104 PROCESSOR UNIT



52A-0612

HP 2104AN

(OLD [illegible])



52A-0613

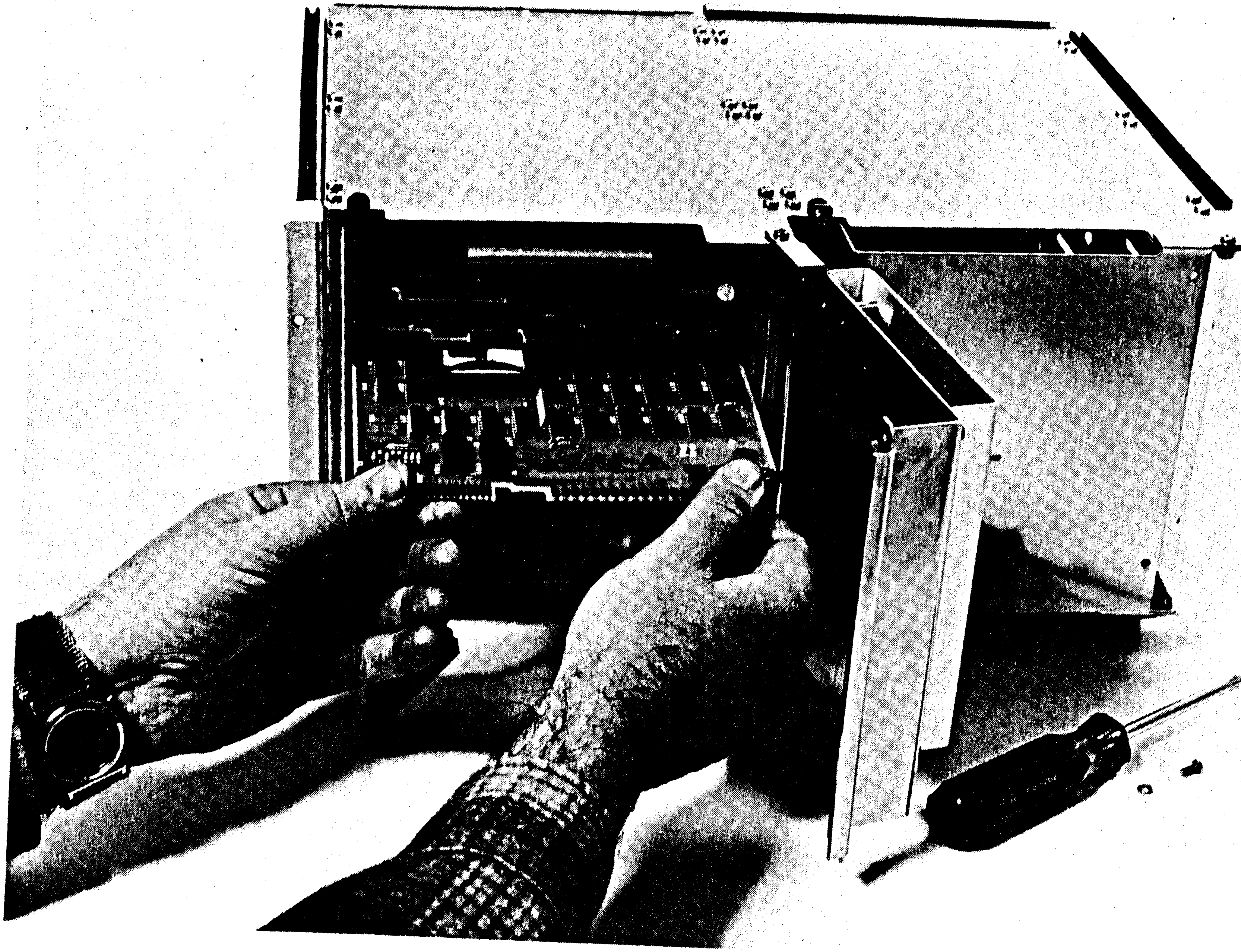
HP 2104AR

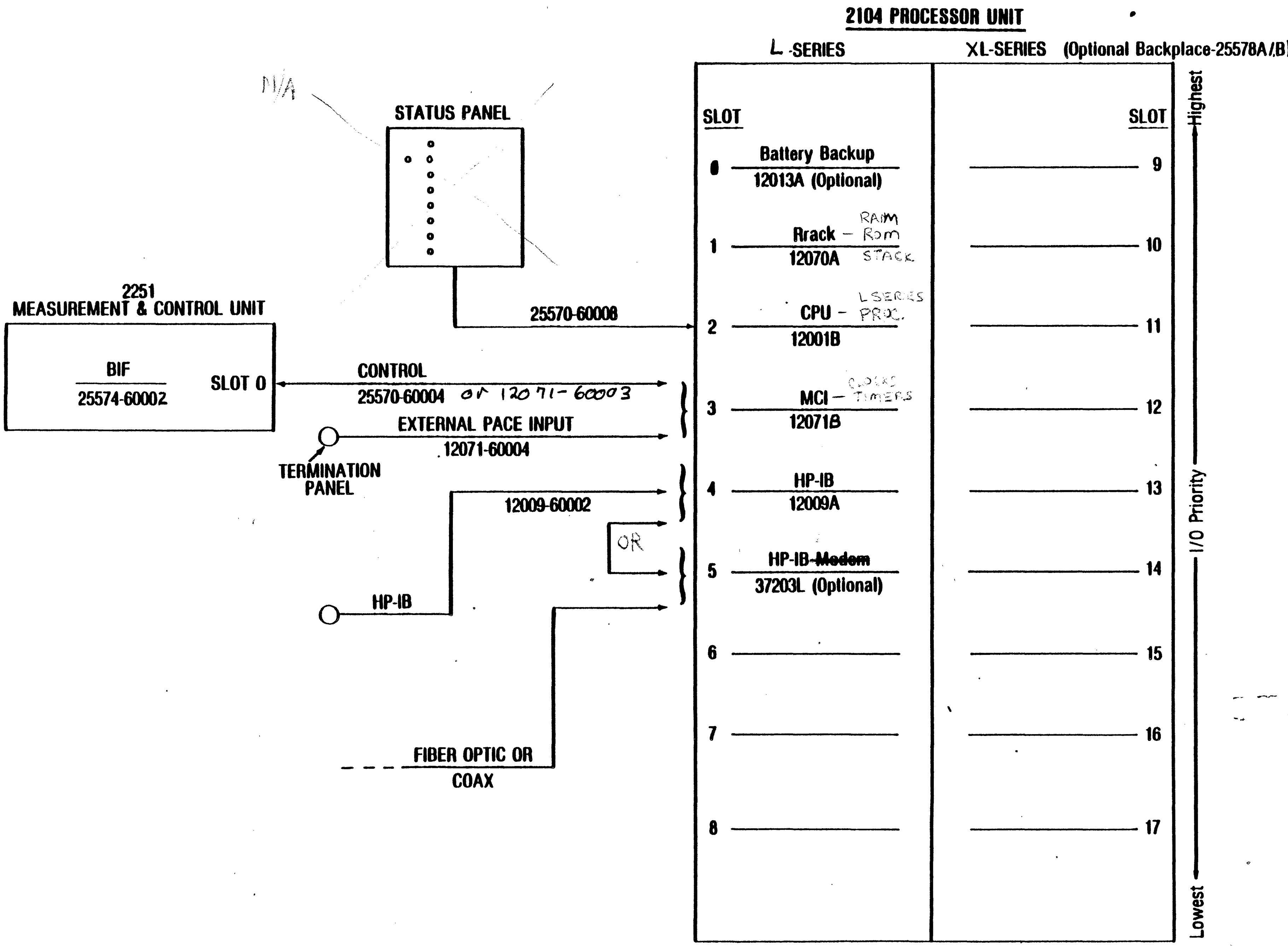
NEW CONFIGURATION
DOESN'T HAVE
LED PANEL

HP 2104AN and HP 2104AR Processor Units

WHAT IS WRONG HERE?

NO WRIST STRAP





NOTE: There are no common signals between the L -Series and XL Series backplanes other than power supply signals and power.

MCI CARD FEATURES

ANALOG RATE LIMITED 50K 2 WORDS/ANALOG READING

- 100K Words/Second Maximum Transfer Rate. MCI TO BIF
- Scanning sequence and special card control information is controlled by self-configuring DMA transfers. NO SOFTWARE COMMANDS
  DOES NOT GO THRU PROCESSOR
  BIF → MCI → RRACK
  NO CPU
- Hardware time of day clock.
- Watchdog interrupt for Watchdog Timer. → STARTS A TASK IF HOST IS NOT HEARD FROM
- Timeout interrupt for function card transfers. →
- Hardware pacing timer.

POWER SUPPLY

Each power supply has the capability of running 3 units

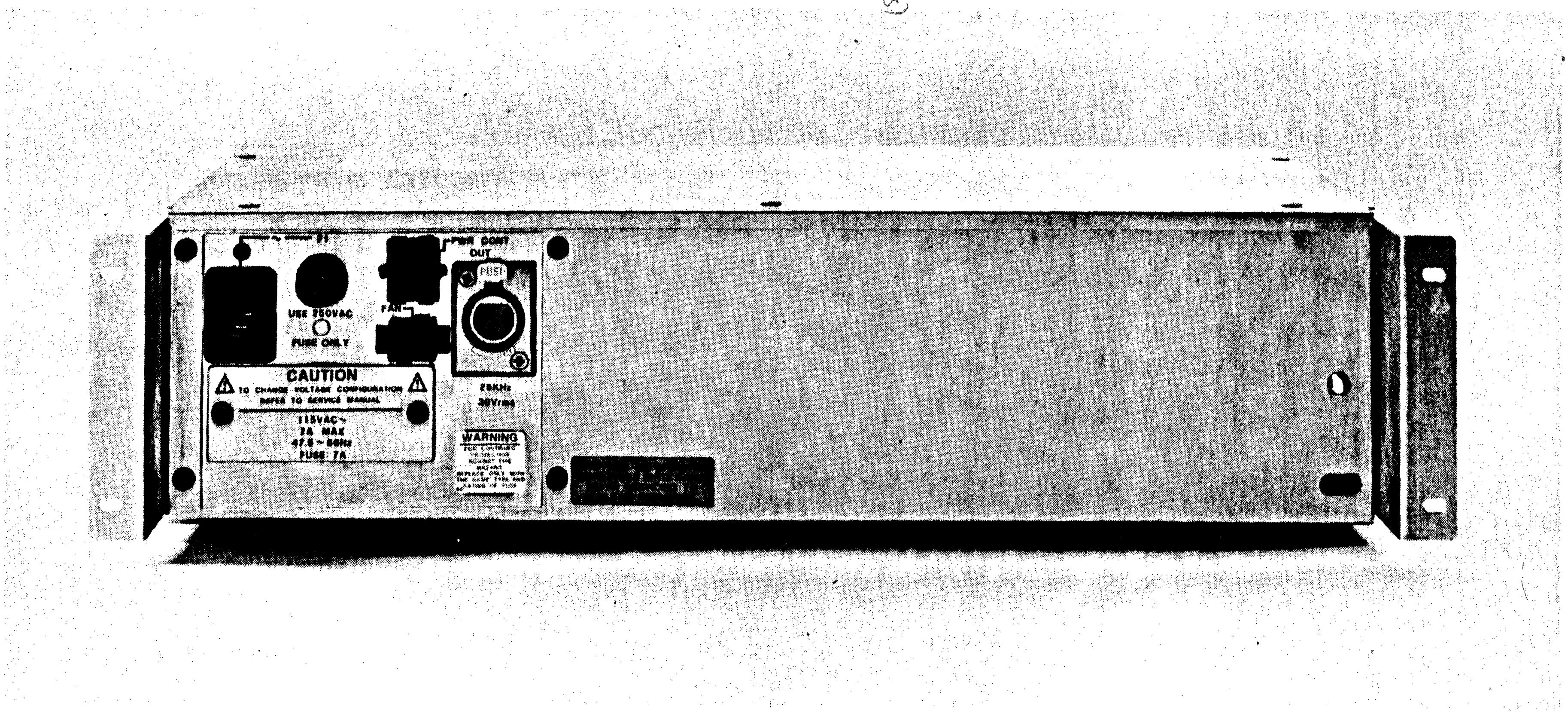
The first power supply runs the ~~CPU~~ 2104, and two 2251 MCU's

Add one supply for each additional pair of MCU's

BATTERY B/U — GOOD FOR LOSS OF POWER
BUT NOT BROWNOUTS

86-126 VAC

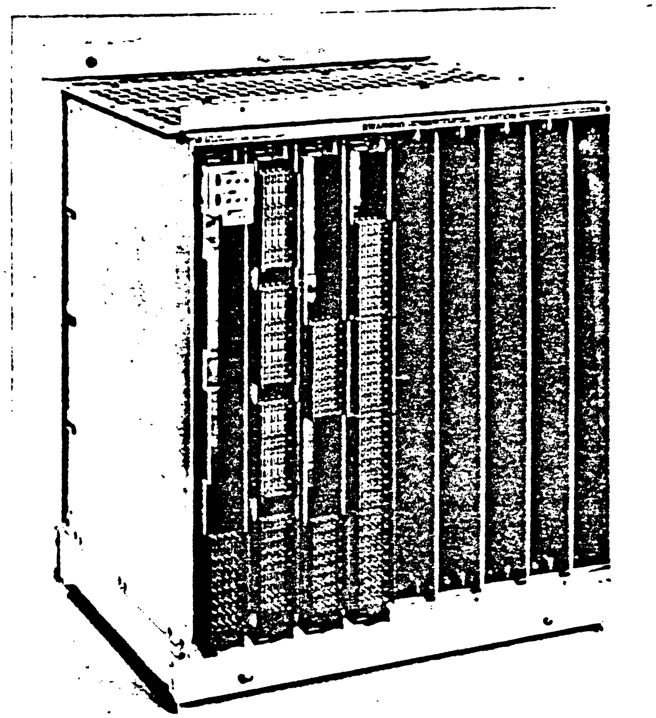
25kHz (14Vrms)
±12v
+5v



MCU

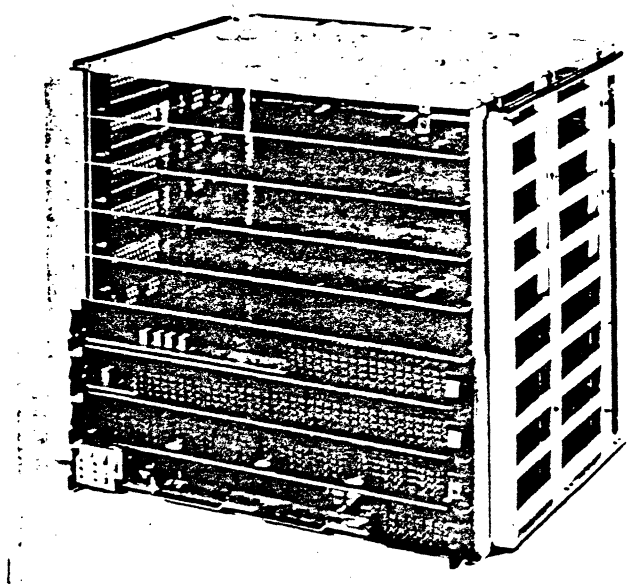
HP 2251 MEASUREMENT AND CONTROL UNIT
(Rack and Panel Mount)

Product Number 2251AR/AN



SLOTS COUNTED

0 - - - 8



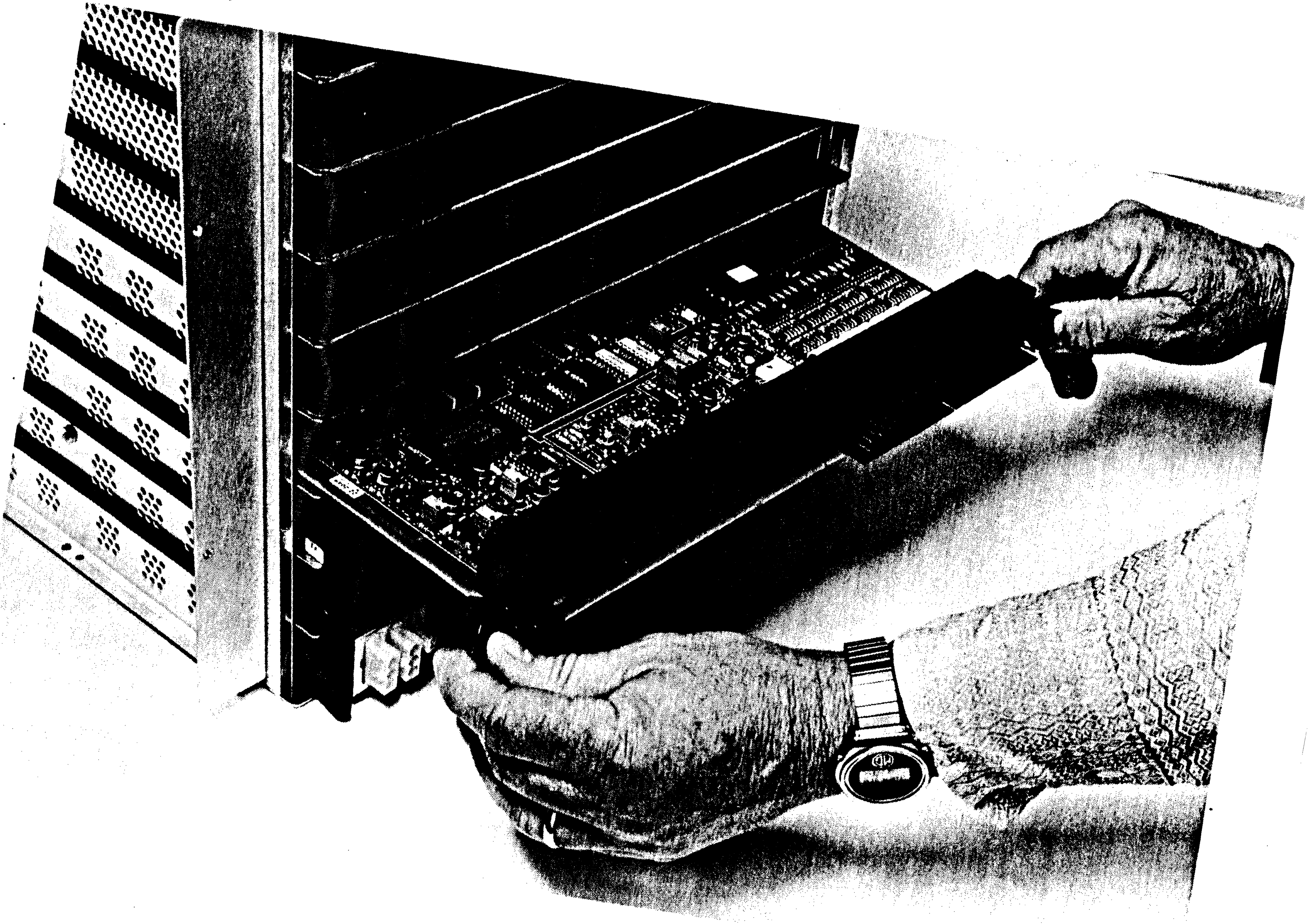
BOTTOM TO TOP 8

0

WARNING!

Do not touch the back of MCI or BIF cards. They have CMOS drivers and are **sensitive.**

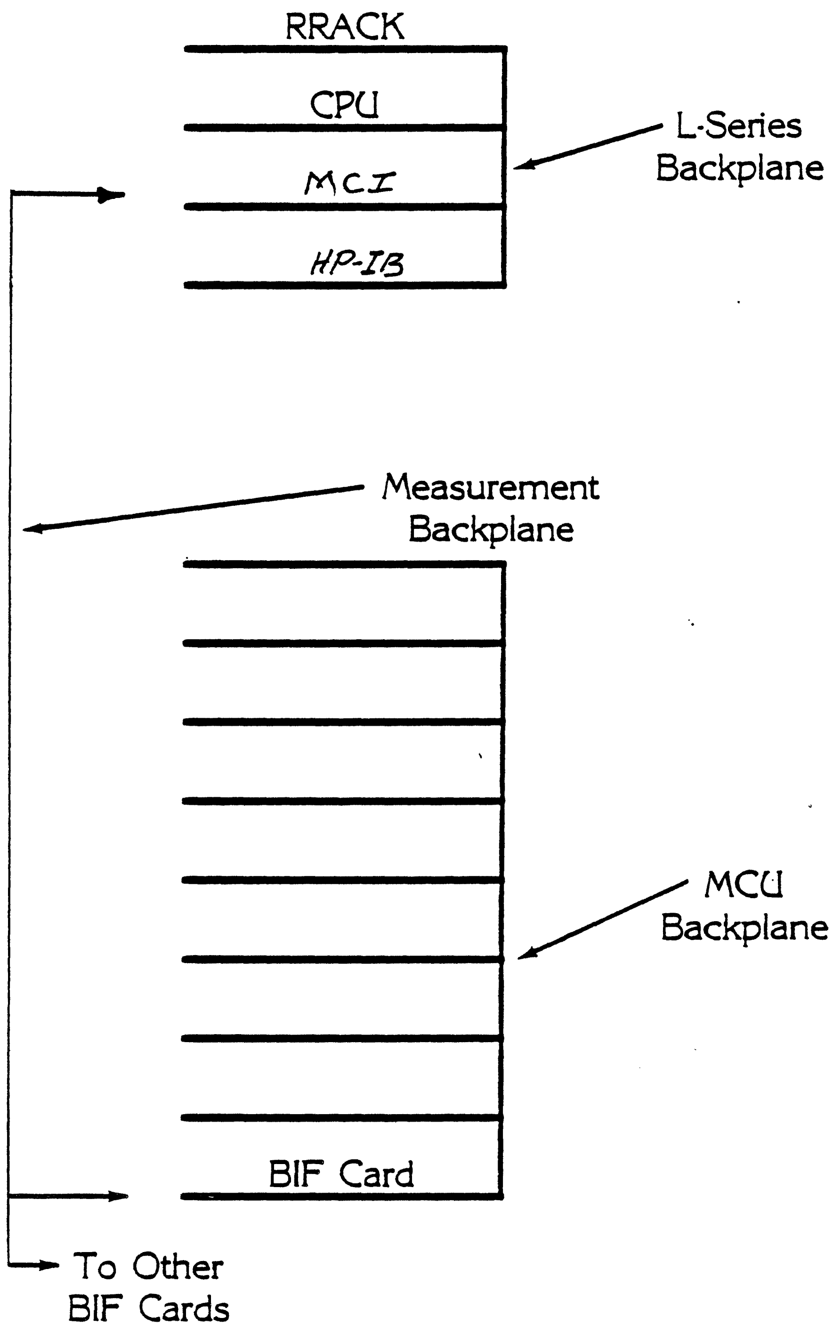
ALWAYS WEAR A GROUNDED WRIST STRAP WHEN HANDLING ANY 2250 PC BOARD ASSEMBLY!



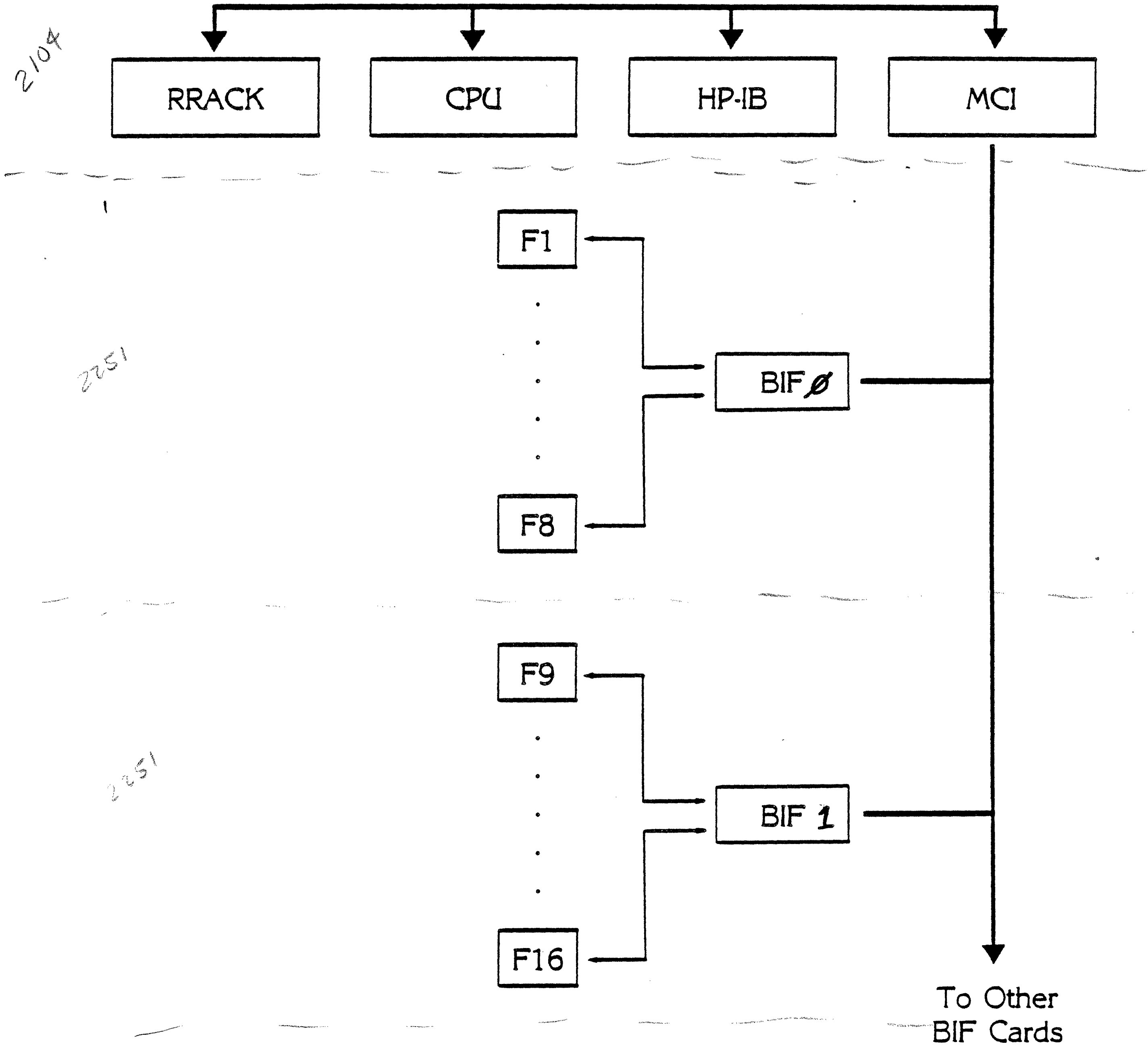
BIF CARD FEATURES

- Demultiplexes addresses and data on MCI bus.
- Decodes MCU and slot portion of the address information.
- Contains an interrupt register that can be polled to determine if any function cards in the MCU have interrupted.
- Converts 27 volts RMS, 25 khz power to ~~15~~, ~~12~~, 5~~VDC~~ 21, 17, 9 VAC for the MCU backplane. p. 3-25 HRM

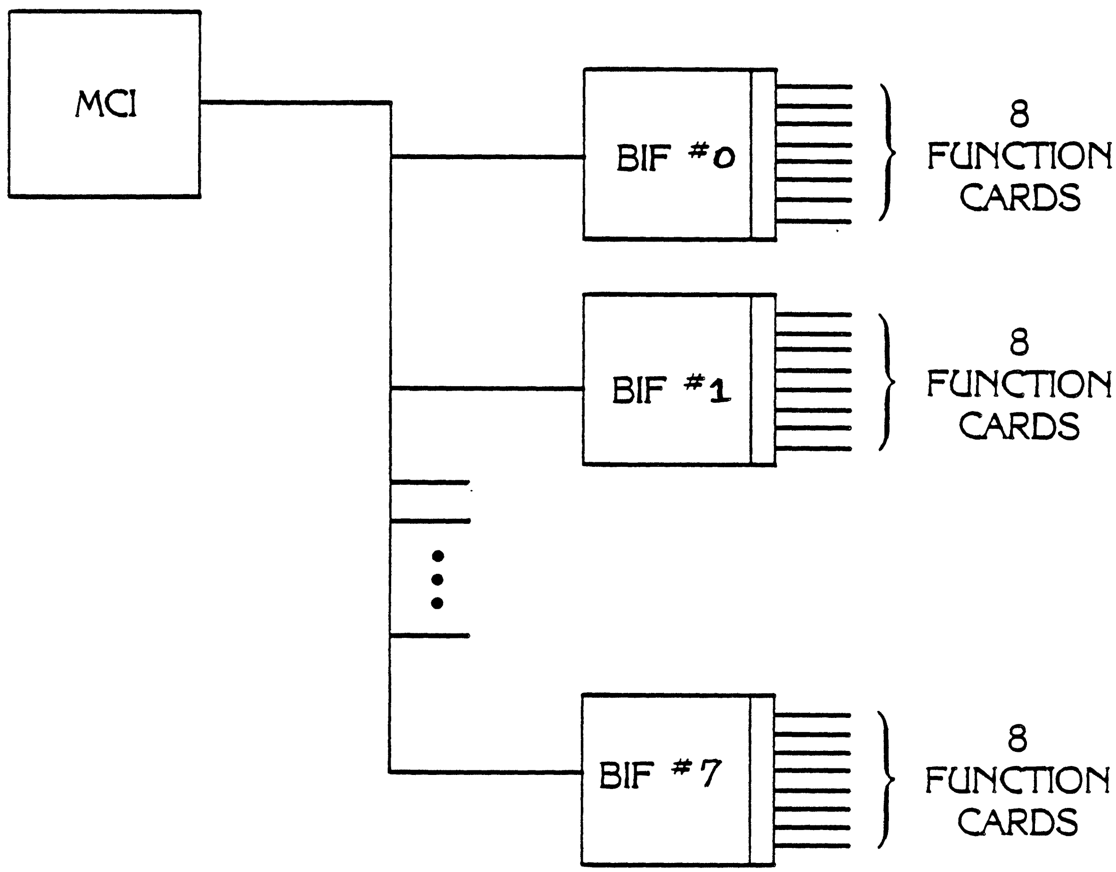
EACH FUNCTION CARD HAS ITS OWN POWER SUPPLY
CONVERTS 21, 17, 9 VAC TO ±12VDC, ±5VDC ON EACH BOARD



Card to Card Communication in the 2250 (Physical Configuration)



Card to Card Communication in the 2250
(Electrical Configuration)

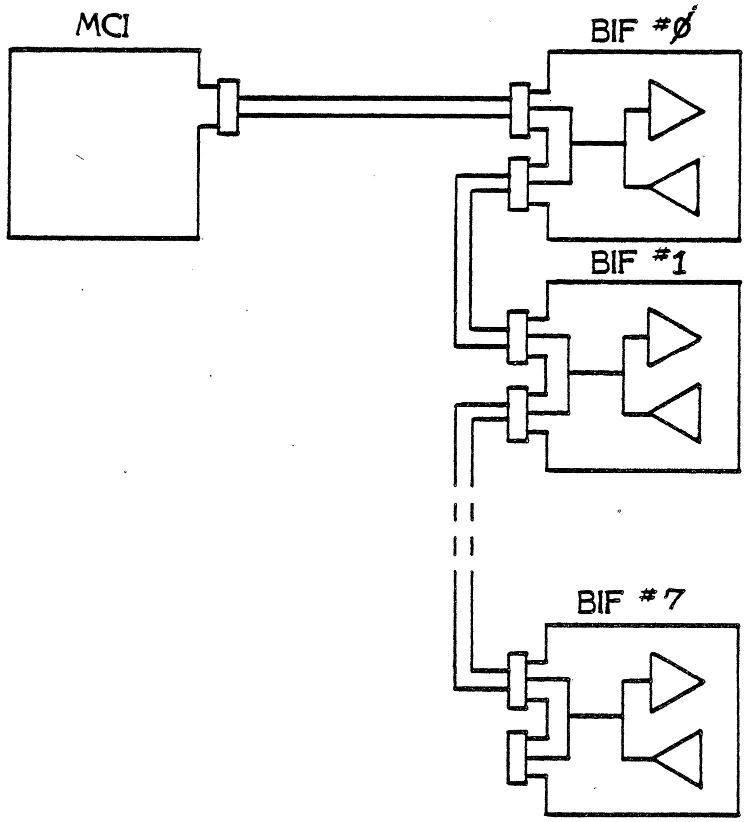


FUNCTION CARD BACKPLANE

The MCI and the function cards cannot drive 64 other cards on the same bus.

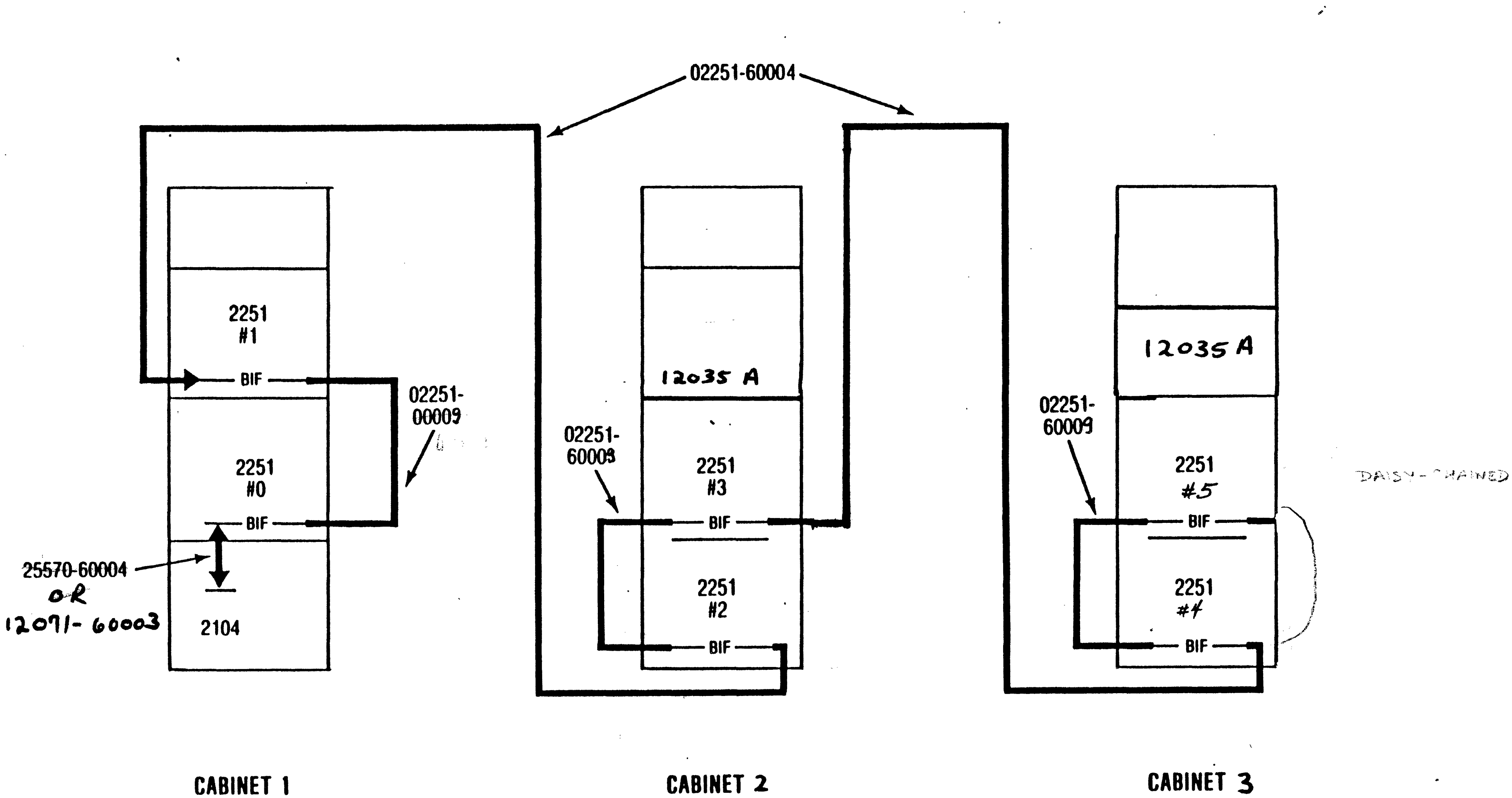
The backplane interface card (BIF) was introduced to provide additional buffering. No card of any type drives more than 8 other cards.

The printed circuit assembly which interconnects the BIF and 8 function cards is called the Measurement and Control Unit (MCU) backplane.



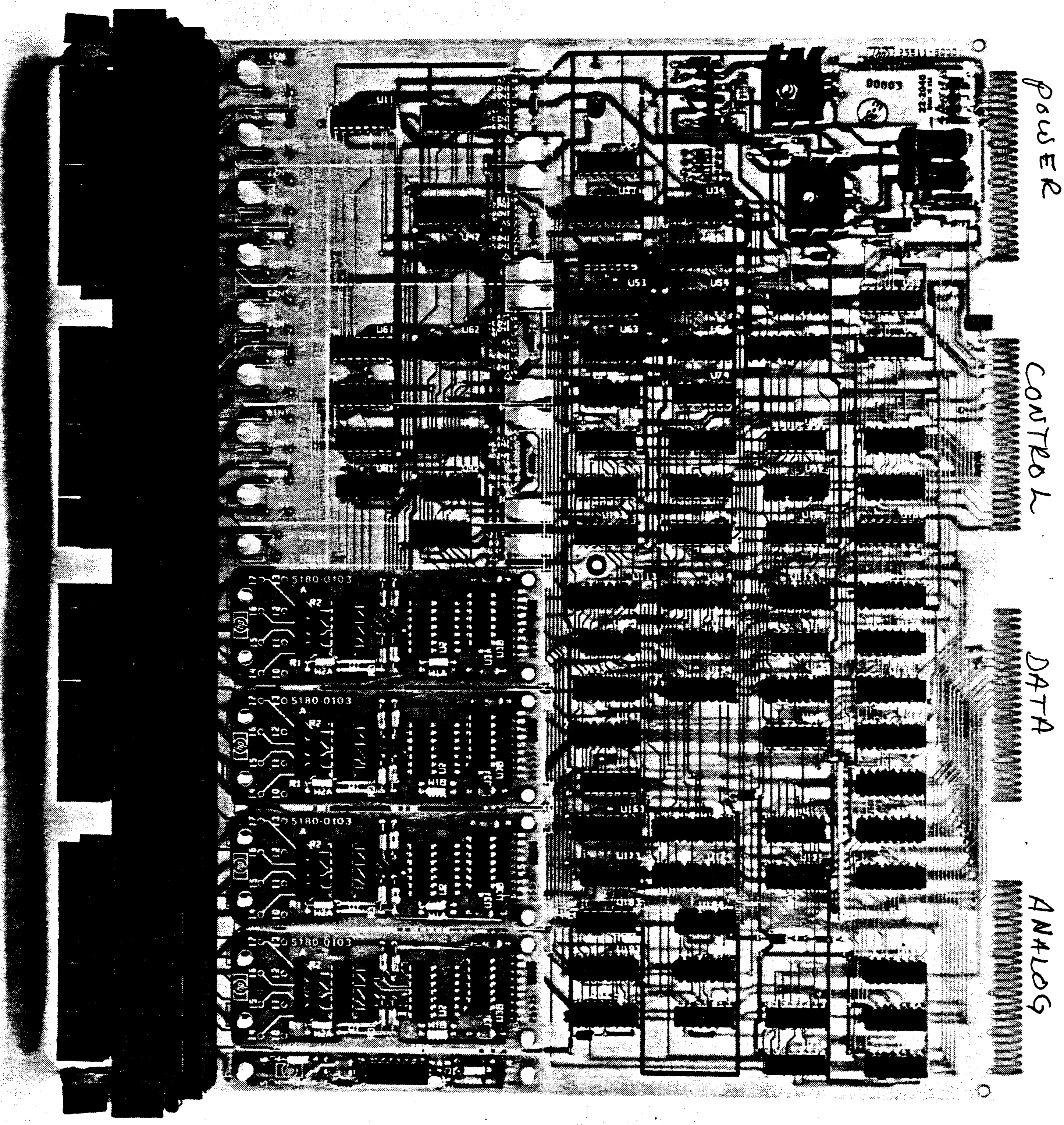
A daisy chain connection is used between BIFS so that no BIF sees any additional propagation delay due to the buffering on other BIFS.

This daisy chain connection is called the MCI bus.



02251-60004
2251
#1
BIF
02251-
00009
2251
#0
BIF
25570-60004
OR
12071-60003
2104
12035 A
02251-
60009
2251
#3
BIF
2251
#2
BIF
12035 A
02251-
60009
2251
#5
BIF
2251
#4
BIF
DAISY-CHAINED
CABINET 1
CABINET 2
CABINET 3

FUNCTION CARDS



25511 A

ANALOG FUNCTION CARDS

INPUT CARDS	DESCRIPTION
HP 25501A	16-Channel High-Speed Analog Input Card (ADC)
HP 25502A	32-Channel High-Level Multiplexer Card (HLMUX) SOLID STATE MULTIPLEXER CHIPS
HP 25503A	32-Channel Low-Level Multiplexer Card (LLMUX)
HP 25504A	16-Channel Relay Multiplexer Card (RELMUX)

HP 2250 DIGITAL FUNCTION CARDS

PRODUCT	DESCRIPTION
25510A	4-Channel V/I Analog Output
25511A	32-Point Digital Input
25512A	4-Channel Counter Input
25513A	32-Point Digital Output
25514A	16-Point Relay Output
25515A	4-Channel Pulse Output
25516A	16-Point In/16-Point Digital Multifunction

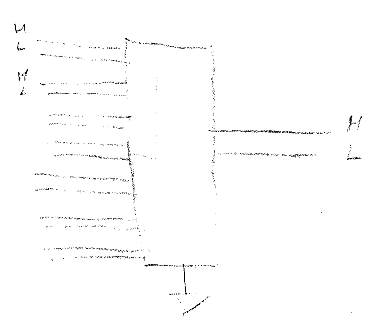
25501A
16-CHANNEL HIGH SPEED ANALOG INPUT

- 16 addressable input channels
- Max 240 channels via multiplexer cards (32 CH. EACH 7 MUX CARDS) + 16 ON ADC
- Max 50 KHz pacing
- auto ranging capability
- 14 bit resolution 12 BIT A/D
- Input range ±1.25V to ±10V

COMMON MODE + DIFF. MODE INPUT TO ADC MUST BE <= 10V.

GAIN	RANGE
1	10V
2	5
4	2.5
8	1.25V

*- AUTORANGING CAUSES LOSS OF 1 SIGNIFICANT BIT OF RESOLUTION



25502A
32-CHANNEL HIGH-LEVEL MULTIPLEXER

- Unity gain → GOES INTO ADC TO CONVERT
- Sampling Rate is 50 KHz either scanning or single channel
- Common mode rejection 80 dB
- Range ±1.25V to ±10V
- Different input signal conditioning available
  ANALOG FILTERING, CURRENT LOOP, ETC.
- Data register associated with each channel
  FOR CALIBRATE COMMAND, AND OTHERS

* PUTTING DIGITAL CARDS BETWEEN ADC AND MUX CARDS
ADDS NOISE TO SYSTEM — DON'T DO IT

25503A
32-CHANNEL LOW-LEVEL MULTIPLEXER

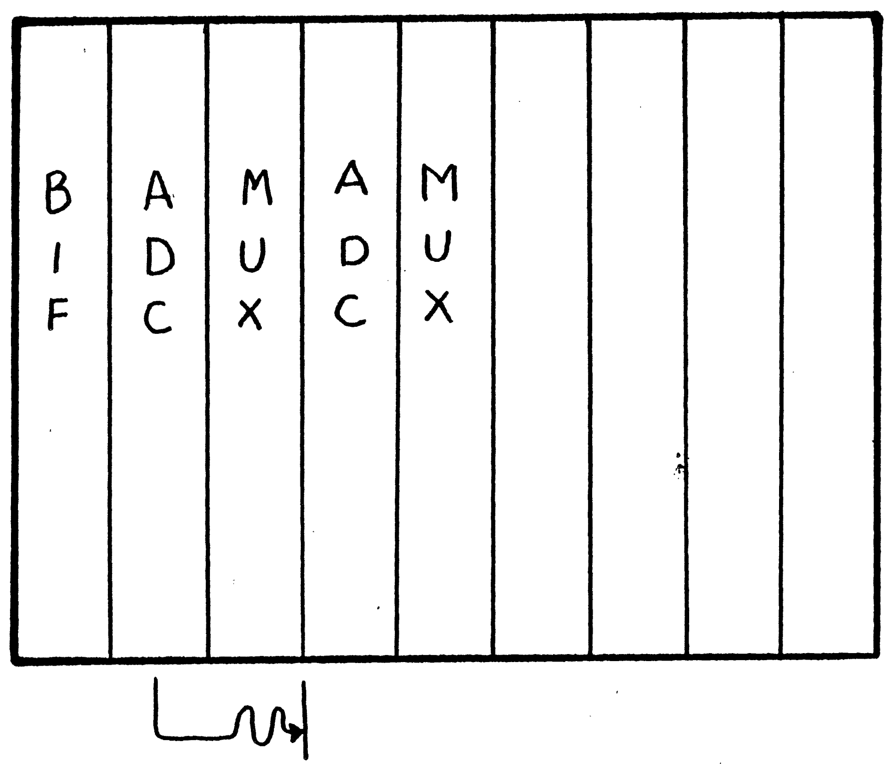
- Range ±12.5 mV to ±10V
- Signal conditioning modules
- Sampling rate of 50 KHz on a single channel or 20 KHz scanning on multiple channels
  DUE TO SETTLING TIMES NEEDED BECAUSE OF SLEW RATES USED AT HIGH GAINS
- Programmable gains: 1
  10
  100 x 8 = MAX GAIN OF 800
  ADC 1
  2
  4
  8

25504A
16 CHANNEL RELAY MUX

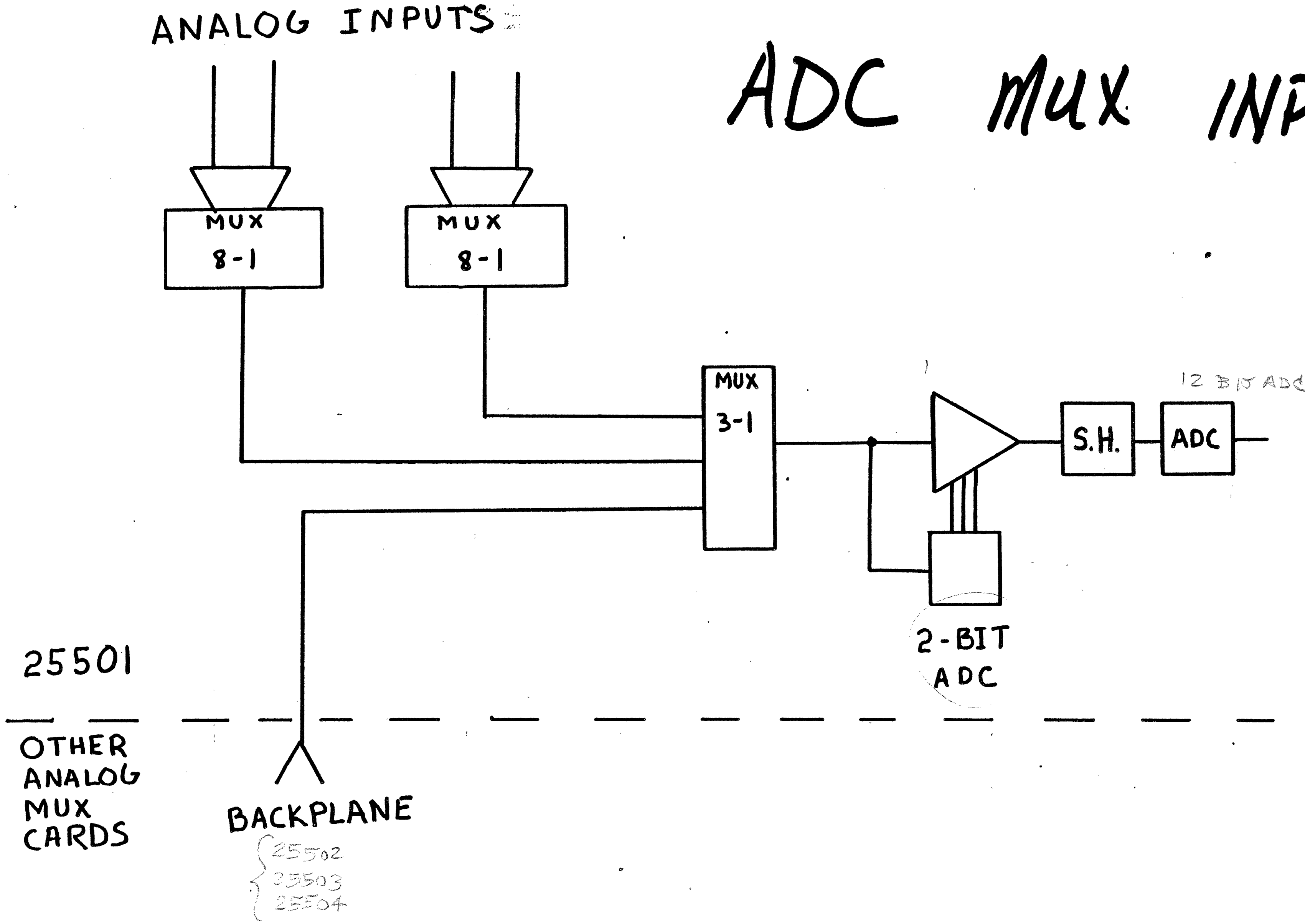
* RANGE ± 12.5MV TO ± 100V
* ± ~~350~~ 225 Vrms volt common mode range
  110 db rejection
* Programmable open sensor detect
* 14 bit resolution
* Sampling rate of 500 Hz scanning
  or single channel AT 10KHZ
* Programmable Gains: .1 (x ADC GAIN = .1, .2, .4, .8)
  1
  10
  100

SEE SERVICE NOTE FOR
FILTERING ABOVE 10V RANGE
(REMOVE CAPS.) (SN 2250-12)

ADC/MUX INTERFACE



ADC MUX INPUT



25510A
4-CHANNEL VOLTAGE/CURRENT ANALOG OUTPUT

- 12-bit resolution
- Range Voltage — Bipolar ±10V @ 20mA / Unipolar 0 to 10 @ 20 mA — + OR − VOLTAGE ONLY + V[illegible]

  Current 0 to 20mA @ 20V
- Max data rate is 32KHz
- Settling time (worst case) — SPECS

  Voltage Mode ~~200~~ 100 μsec

  Current Mode ~~1 msec~~ 300 μsec

CAL (ADJ.) — CAN ADJUST [illegible]

	OFFSET	GAIN
UNIPOLAR	0V	+10.237
BIPOLAR	−10.240V	+10.235V
CURRENT	0mA	20.475 ma

25511A
32-POINT DIGITAL INPUT

32 - POINTS

- Two 16-point fields
- Interrupt detection (NOT REALTIME) FUNCTION CARD INTERRUPT PROCESSOR MUST NOTICE
- Min pulse width 16 μsec
- Max speed 24K points/field~~s~~ OR per second ?
- Status, field and point register (sense, sense overide, unmasked, interrupt register)

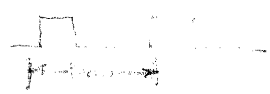
  DIRECTIONS OF EVENT CAUSES INTERRUPT

  SELECTS POINTS THAT CAN CAUSE AN INTERRUPT

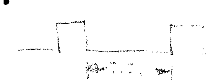
  RECORDS WHICH UNMASKED POINTS HAD AN EVENT
- Internal or external strobe

25512A
4-CHANNEL COUNTER

- 400 KHz maximum input rate
- 2 inputs per channel A B
- Totalize (2 DIFFERENT counts per channel) CH A CH B
- Extended totalize (0 to 4×10^9) CH A ONLY
  4,294,967,295
- Up-down count
  +32767
  -32768
- Period
  TIME BETWEEN PULSES



- Time interval
  PARTS OF A PULSE



- Frequency
  16 BITS
- Ratio A IS COUNTED
- 5 programmable interrupts per channel

25513A
32-POINT DIGITAL OUTPUT

- Signal conditioning modules available
- External strobe
- Maximum sequential speed is 32 KHz
- Field register
  - Status, Configuration
  - Read
  - Write

A "ONE" OUTPUT = ZERO OHMS (CLOSED SWITCH)

25514A
16-POINT RELAY OUTPUT

- C relay output (SPDT)
- Rated for switching
  250 VAC 1.5a
  125VAC 3.0a
  30VDC 2.0a
- External strobe
- SCM available, but NOT REQUIRED
- Maximum digital update rate from buffer
  24µs/write MOVE DATA FROM BACKPLANE TO OUTPUT [illegible]
- Maximum operate time 15msec CLOSE RELAY
  "1" — [illegible]
  [illegible]
- 100 uV thermal offset
- MAX OPERATING SPEED — 30 HZ

25515A
4-CHANNEL PULSE OUTPUT

(USED MAINLY WITH STEPPER MOTORS)

- (4) Independent output channels
- Programmable pulses (0 to 32767)
  - Pulse rate
  - Acceleration
  - Final pulse rate
  - Pulse width
- External limit switch inputs
- (2) Output lines per channel
- Input and output SCMs available

25516A
16-POINT DIGITAL MULTIFUNCTION

- 16 digital input
- 16 digital output
- 2 STROBES
- Two ranks of storage IN OUT
- Event counter (8 bit counter per point)
- Minimum detectable input
  Pulse width (external strobe) 1μsec
  Pulse width (other inputs) 16μsec
- Event detection register

RECOMMENDED FUNCTION CARD POSITIONS

SLOT #	PREFERRED POSITION	DIGITAL CARD
8	Highest	25514A 16-Channel Relay Output
7		25513A 32-Channel Digital Output
6		25516A 16-Channel Digital Mult.
5		25511A 32-Channel Digital Input
4		25512A 4-Channel Counter
3		25515A 4-Channel Pulse Output
2	Lowest	25510A 4-Channel V/I Analog Output

SLOT #	PREFERRED POSITION	ANALOG CARD
1	Highest	25501A 16-Channel HS Analog Input
2		32-Channel Low-Level MUX
3		16-Channel Relay MUX
4	Lowest	32-Channel High-Level MUX

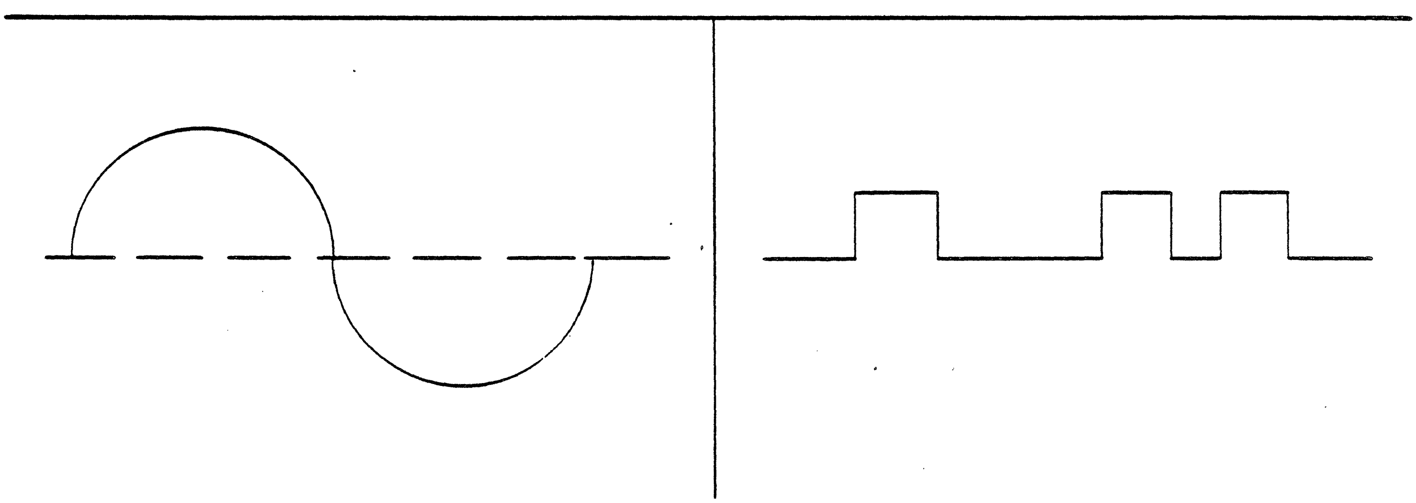
SCM

and

Interfacing

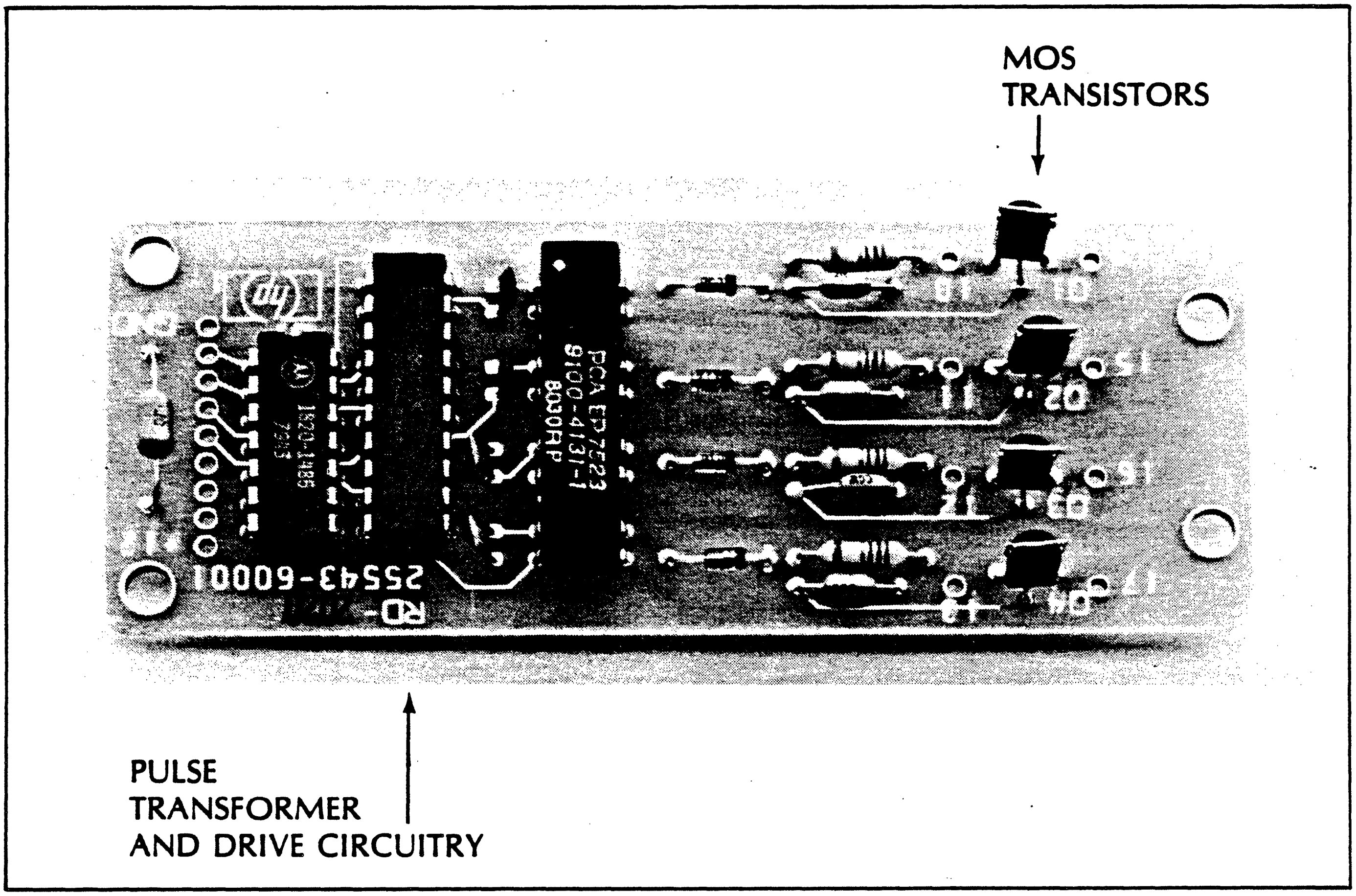
OVERVIEW

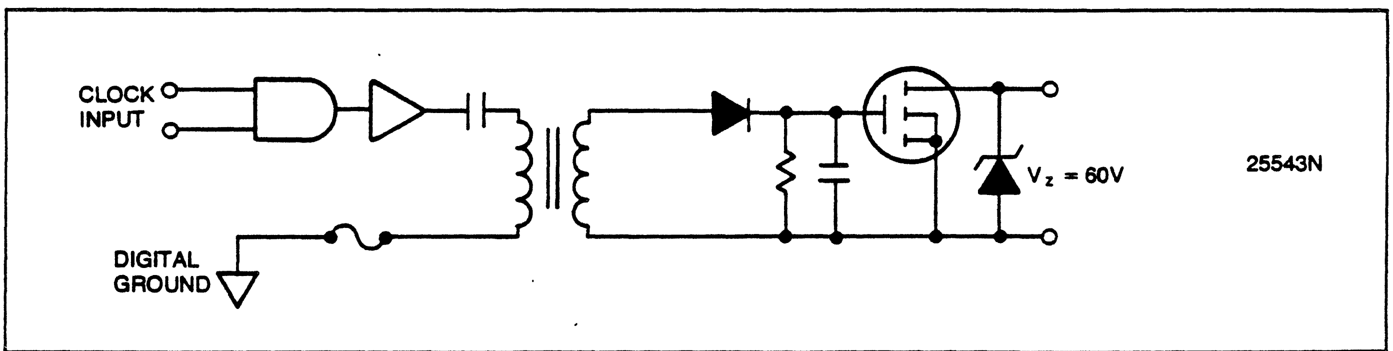
Signal Conditioning Modules are provided for both the Analog & Digital Function Cards.



4 CHANNEL ISOLATED OUTPUT SCM

Product number 25543N





ANALOG SCM's

INPUT

FOUR DIFFERENT TYPES OF ANALOG SCM's ARE PROVIDED:

25540A

1. Blank SCM — To be used by customer for custom designs.

25540B

2. Filter SCM — Provides two pole filter for use with high or low level multiplex cards.

25540C

3. Current Loop termination — Provides standard termination for 4 - 20 mA loops.

25540D

4. Filter and current loop SCM — Provides functions 2 and 3.

COMBINATION

ANALOG INPUT CARD SIGNAL CONDITIONING MODULES

ANALOG CARD	SCM	DESCRIPTION
HP 25501A	None	ADC Card (signal conditioning components can be added to the card).
HP 25502A	A,B,C,D*	HLMUX Card
HP 25503A	A,B,C,D*	LLMUX Card
HP 25504A	None	RELMUX Card (capacitors can be added to the plug-in relay circuits to provide input signal conditioning)

*A,B,C, and D are the SCM suffixes relating to the SCM NUMBER listed below.

SCM NUMBER	CHANNELS PER SCM	DESCRIPTION
25540A	8	Blank (User supplies components)
25540B	8	Passive Filter Network Capacitors
25540C	8	Passive Filter Network Current-Loop Resistors
25540D	8	Passive Filter Network Current-Loop Resistors and Filter Capacitors

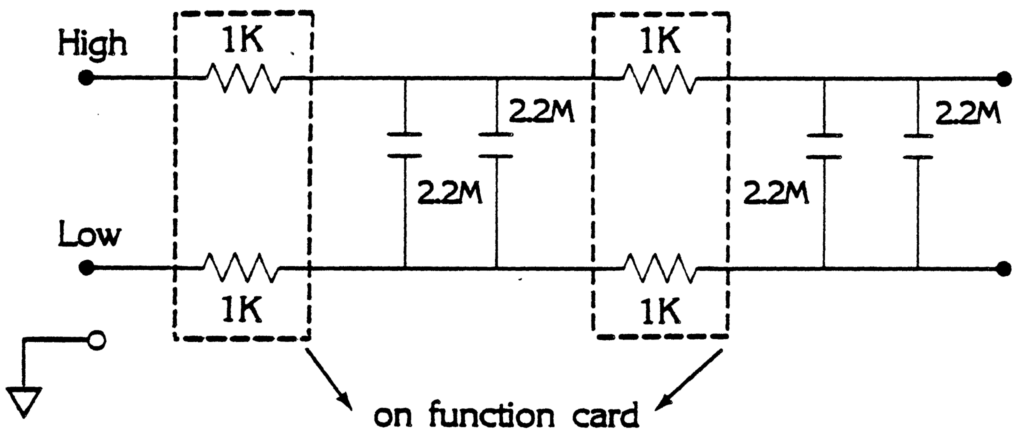
ANALOG FILTER SCM's

PROVIDE TWO POLE RESPONSE

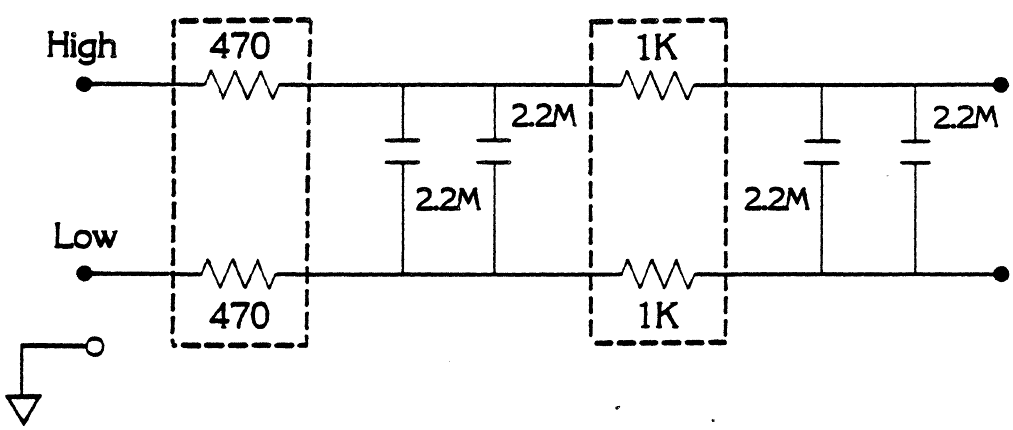
- Pole frequency varies according to the card used
- Lowest pole frequencies are 6.9 and 47 Hz with high level MUX
- High pole frequencies are 11 and 64 Hz with low level MUX

Analog SCM's Circuitry Diagram

(without protection)



High Level MUX



Low Level MUX

DIGITAL SCM SELECTION GUIDE

PRODUCT REFERENCE		
FUNCTION CARD	CROSS REFERENCE SCM NUMBER	DESCRIPTION
25511A	1 & 2*, 3 & 4	32-Point Digital Input
25512A	3 and 4	4-Channel Counter Input
25513A	1 & 2*, 5,6,7	32-Point Digital Output
25514A	1 & 2*, 8	16-Channel Relay Output
25515A	XXXX	4-Channel Pulse Output
25516A	1 & 2*, 3,4,7	32-Point Multifunction

*Single Channel SCM for External Strobe Input

SCM CROSS REFERENCE GUIDE			
SCM NO.	PRODUCT NO.	CHANNELS	DESCRIPTION
1	25531-Series	1	Non-Isolated Digital Input
	25531B		5 VDC Range
	25531C		12 VDC Range
	25531D		24 VDC Range
	25531E		48 VDC Range
	25531K		5 VDC Range, Sink Inputs
	25531L		12 VDC Range, Sink Inputs

DIGITAL SCM SELECTION GUIDE

(continued)

SCM CROSS REFERENCE GUIDE			
SCM NO.	**PRODUCT NO.**	**CHANNELS**	**DESCRIPTION**
2	25533-Series	1	Isolated Digital Input
	25533B		5 VDC Range
	25533C		12 VDC Range
	25533D		24 VDC (16 VAC) Range
	25533E		48 VDC Range
	25533F		72 VDC Range
	25533G		120 VDC (72VAC) Range
	25533H		115 VAC Range
	25533I		230 VAC Range
3	25535-Series	4	Non-Isolated Digital Input
	25535B		5 VDC Range
	25535C		12 VDC Range
	25535D		24 VDC Range
	25535E		48 VDC Range
	25535K		5 VDC Range, Sink Inputs
	25535L		12 VDC Range, Sink Inputs
4	25537-Series	4	Isolated Digital Input
	25537B		5 VDC Range
	25537C		12 VDC Range
	25537D		24 VDC (16 VAC) Range
	25537E		48 VDC Range
	25537F		78 VDC Range
	25537G		120 VDC (72VAC) Range
	25537H		115 VAC Range
	25537I		230 VAC Range
5	25543A	4	Isolated Digital Output, VMOS Solid-State Circuit.
6	25544-Series	4	Non-Isolated Digital Output
	25544A		Open Drain Circuit
	25544B		5 VDC Range
	25544C		12 VDC Range
7	25545A	2	Solid-State Relay Output (Reduces usable points by 2).

DIGITAL SCM SELECTION GUIDE

(continued)

SCM CROSS REFERENCE GUIDE			
SCM NO.	PRODUCT NO.	CHANNELS	DESCRIPTION
8	25539-Series 25539A 25539B 25539G 25539H 25539I	4	Arc Suppression Circuits For user added components 0 to 30 VDC Range 24 VAC Range 115 VAC Range 230 VAC Range

2250 SCM CROSS REFERENCE GUIDE

25531B	25531-60001	1 chan, 5vdc, non-isolated strobe,source	25511B (2
25531C	25531-60002	1 chan,12vdc "	25513B (2
25531D	25531-60003	1 chan,24vdc "	25514B (1
25531E	25531-60004	1 chan,48vdc "	25516B (1
25531K	25531-60005	1 chan, 5vdc, non-isolated strobe,sink	
25531L	25531-60006	1 chan,12vdc "	
25533B	25533-60001	1 chan, 5vdc, isolated strobe,source	
25533C	25533-60002	1 chan,12vdc, "	
25533D	25533-60003	1 chan,24vdc, "	
25533E	25533-60004	1 chan,48vdc, "	
25533F	25533-60005	1 chan,72vdc, "	
25533G	25533-60006	1 chan,120vdc/72vac, "	
25533H	25533-60007	1 chan,115vac, "	
25533J	25533-60008	1 chan,230vac, "	

****

25535B	25535-60001	4 chan, 5vdc, non-isolated input,source	25511B (8)
25535C	25535-60002	4 chan,12vdc, "	25512B (2)
25535D	25535-60003	4 chan,24vdc, "	25515B (2)
25535E	25535-60004	4 chan,48vdc, "	25516B (4)
25535K	25535-60005	4 chan, 5vdc, non-isolated input,sink	
25535L	25535-60006	4 chan,12vdc, "	
25536B	25536-60001	4 chan, 5vdc, non-isolated input,source	
25536K	25536-60005	4 chan, 5vdc, non-isolated input,sink	
25537P	25537-60001	4 chan, 5vdc, isolated input,source	
25537Q	25537-60002	4 chan, 12vdc, "	
25537R	25537-60003	4 chan, 24vdc, "	
25537S	25537-60004	4 chan, 48vdc, "	
25537T	25537-60005	4 chan, 72vdc, "	
25537U	25537-60006	4 chan,120vdc, "	
25537V	25537-60007	4 chan,115vac, "	
25537W	25537-60008	4 chan,230vac, "	

****

25539A	25539-80001	4 chan, blank, relay arc supression	25514B (4)
25539E	25539-60005	4 chan, 30vdc, "	
25539G	25539-60007	4 chan, 24vac, "	
25539H	25539-60008	4 chan,115vac, "	
25539J	25539-60009	4 chan,230vac, "	
25540A	5081-0106	8 chan,blank, analog input	25502B (4)
25540B	25540-60001	8 chan,filter, "	25503B (4)
25540C	25540-60002	8 chan,loop, "	25503C (4)
25540D	25540-60003	8 chan,loop&filter, "	

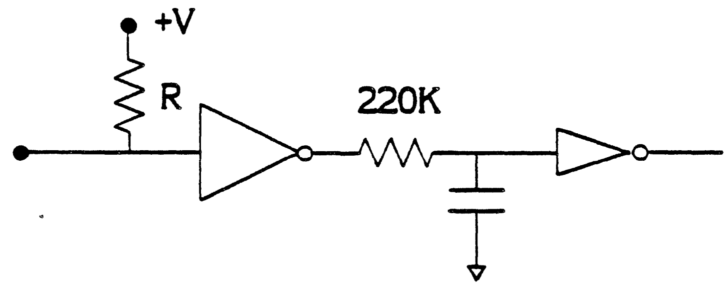
****

25543N	25543-60001	4 chan, 60vdc, open drain isolated output	25513B (8
			25515B (2
25544A	25544-60001	4 chan,open drain,non-isolated output	25516B (4
25544B	25544-60002	4 chan, 5 vdc, "	
25544C	25544-60003	4 chan, 12vdc, "	
25545P	25545-60001	2 chan,115vac, isolated output	
25546B	25546-60001	4 chan, 5vdc, non-isolated output	

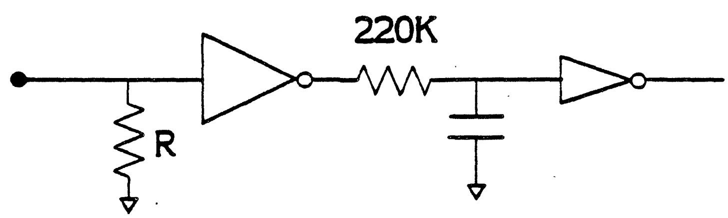
Digital Input SCM's

- Non-isolated – NO ISOLATION FROM INTERFACE CARD

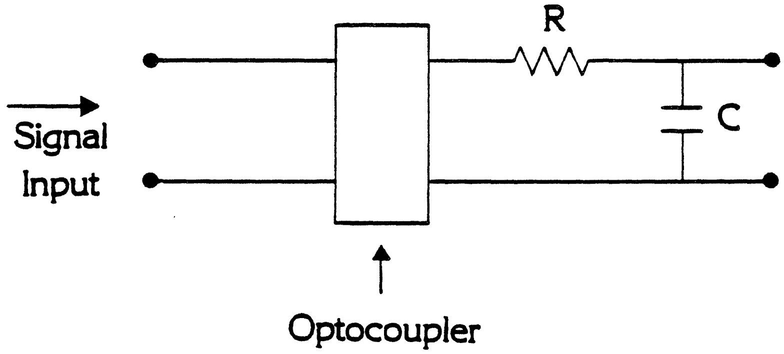
Sink-type – CUSTOMER SINKS CURRENT
2250 SUPPLIES CURRENT



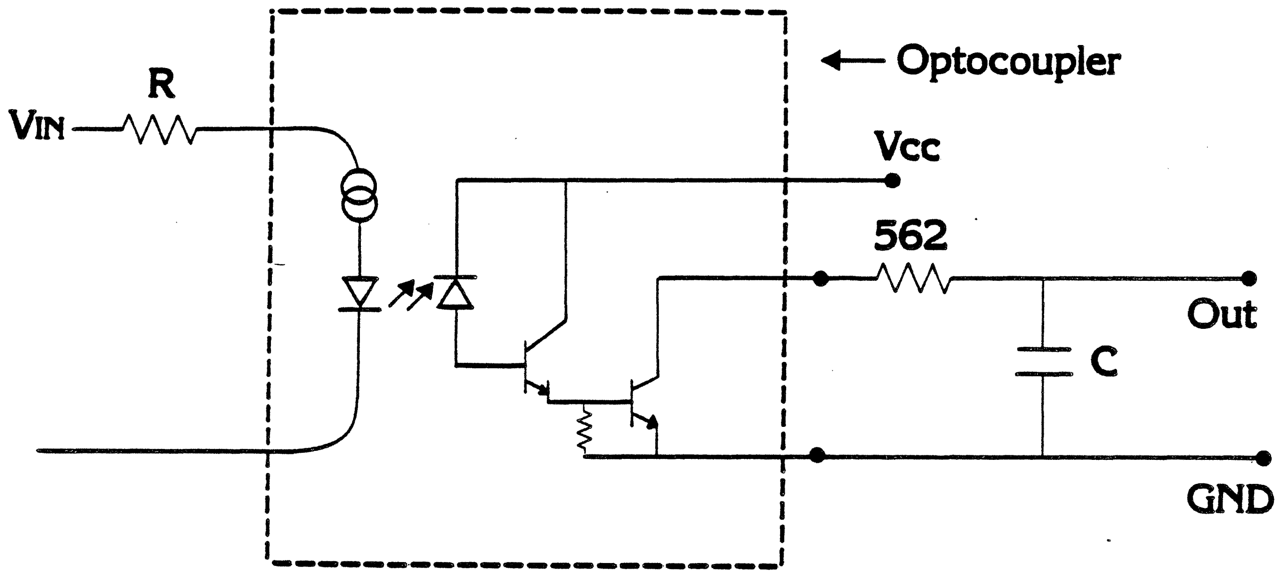
Source Type – CUSTOMER SUPPLIES CURRENT



- Isolated



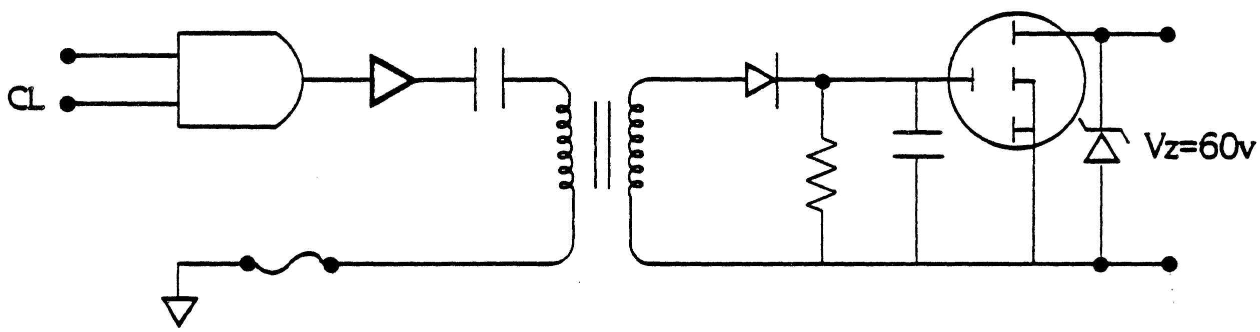
Problems with Isolated Input SCM's



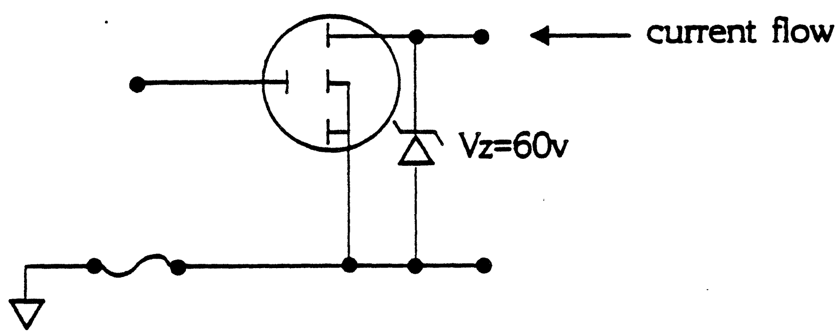
- Isolated Input SCM's cannot be used for switch closure applications, unless an external power supply is provided.
- Isolated power is not provided by the card.
- Speed is restricted by the opto-isolator.
- Debounce capacitor must be removed to increase speed.
- Need up to 4 mA current input to operate coupler.

Digital Output SCM's

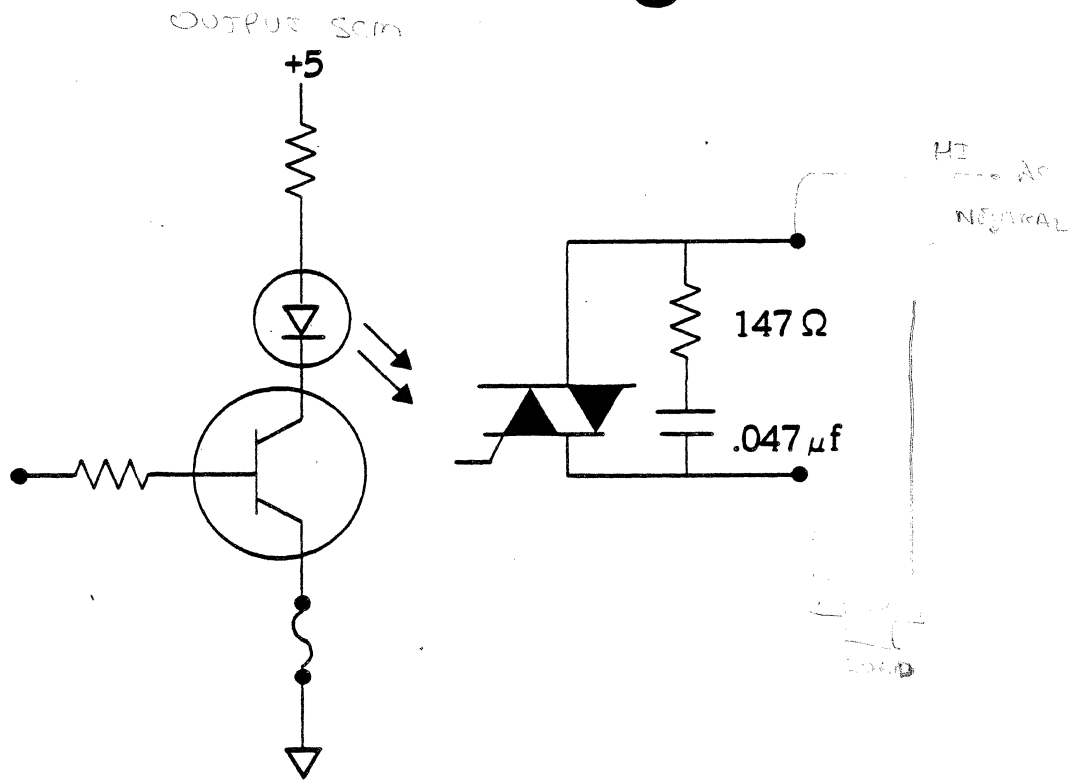
- Isolated



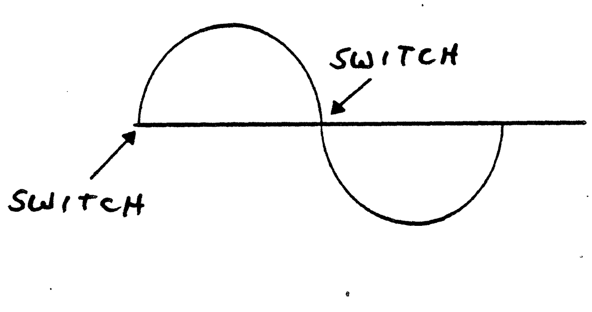
- Non-Isolated



AC Switching



- Triac Switch
- Conducts on positive and negative going slopes
- Zero crossing reduces EMI and RFI



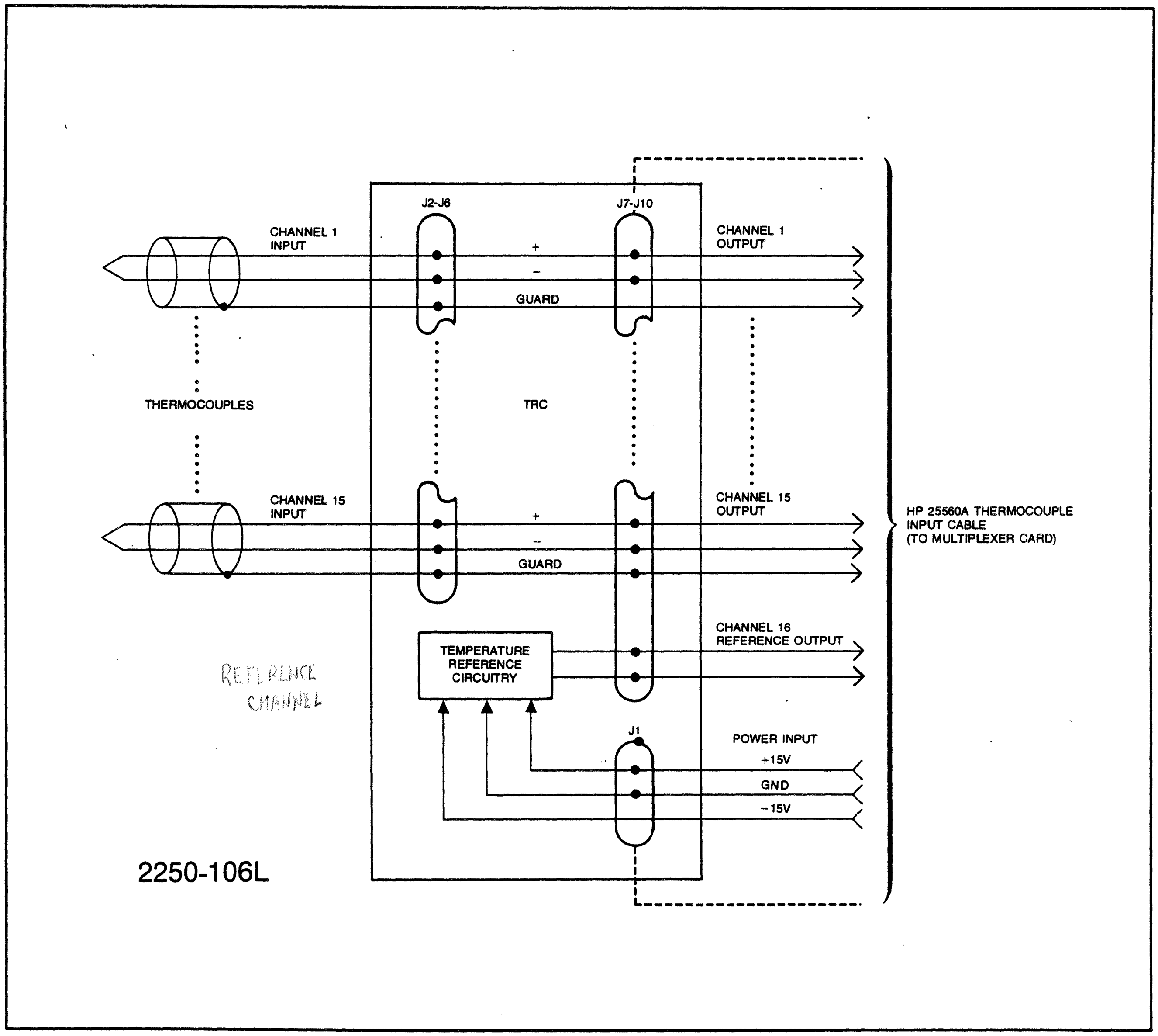
25594A
THERMOCOUPLE REFERENCE CONNECTOR

- 15 thermocouple connection J, K, T, E, R, S, B (MIXED)
- Reference output provides 10mv/°C (channel 16)
- Accuracy of Reference Output

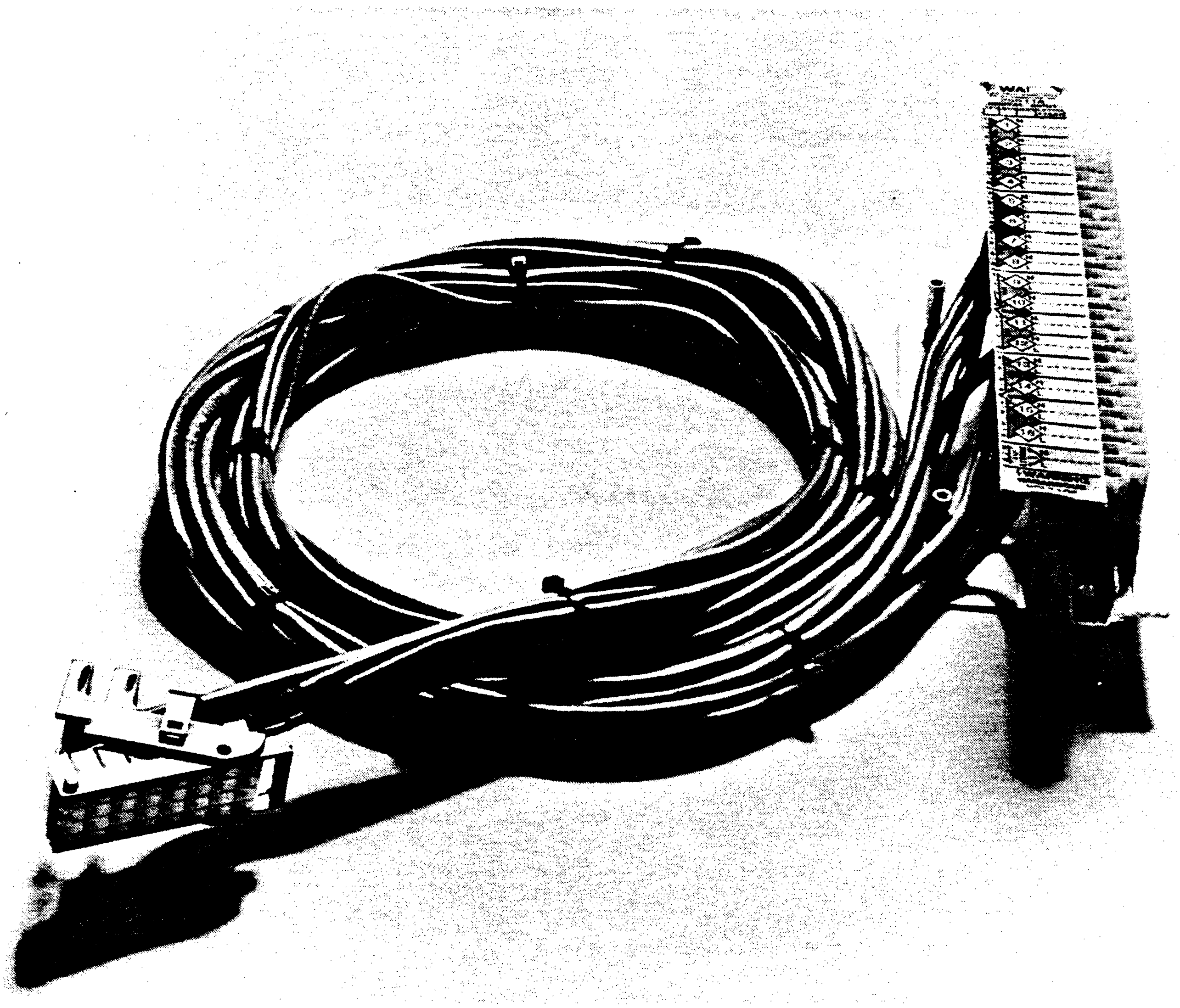
0 to 70 °C	±0.35 °C
0 to 50 °C	±o.25 °C

- 15 input channels per TRC

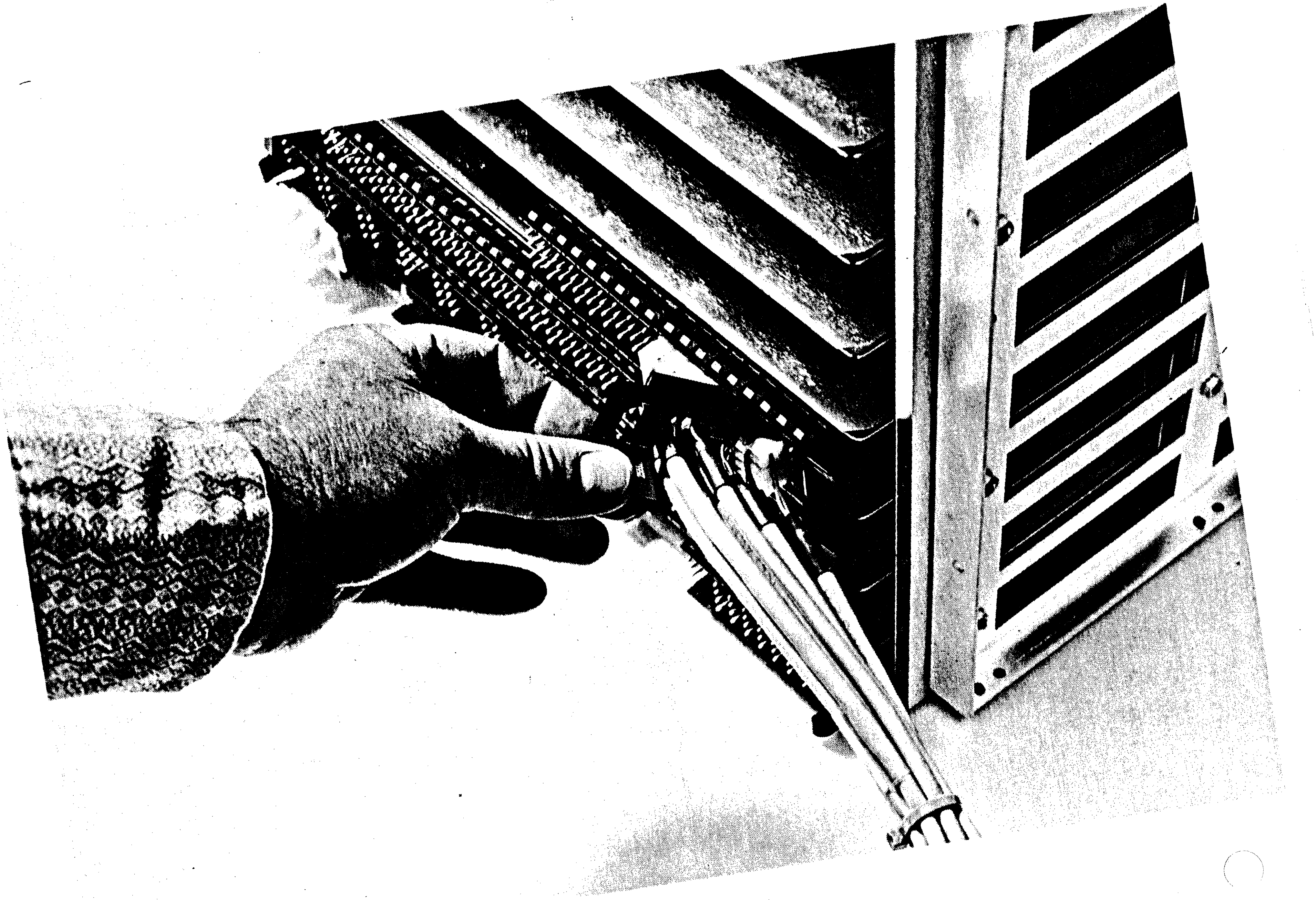
25594A
Functional Block Diagram



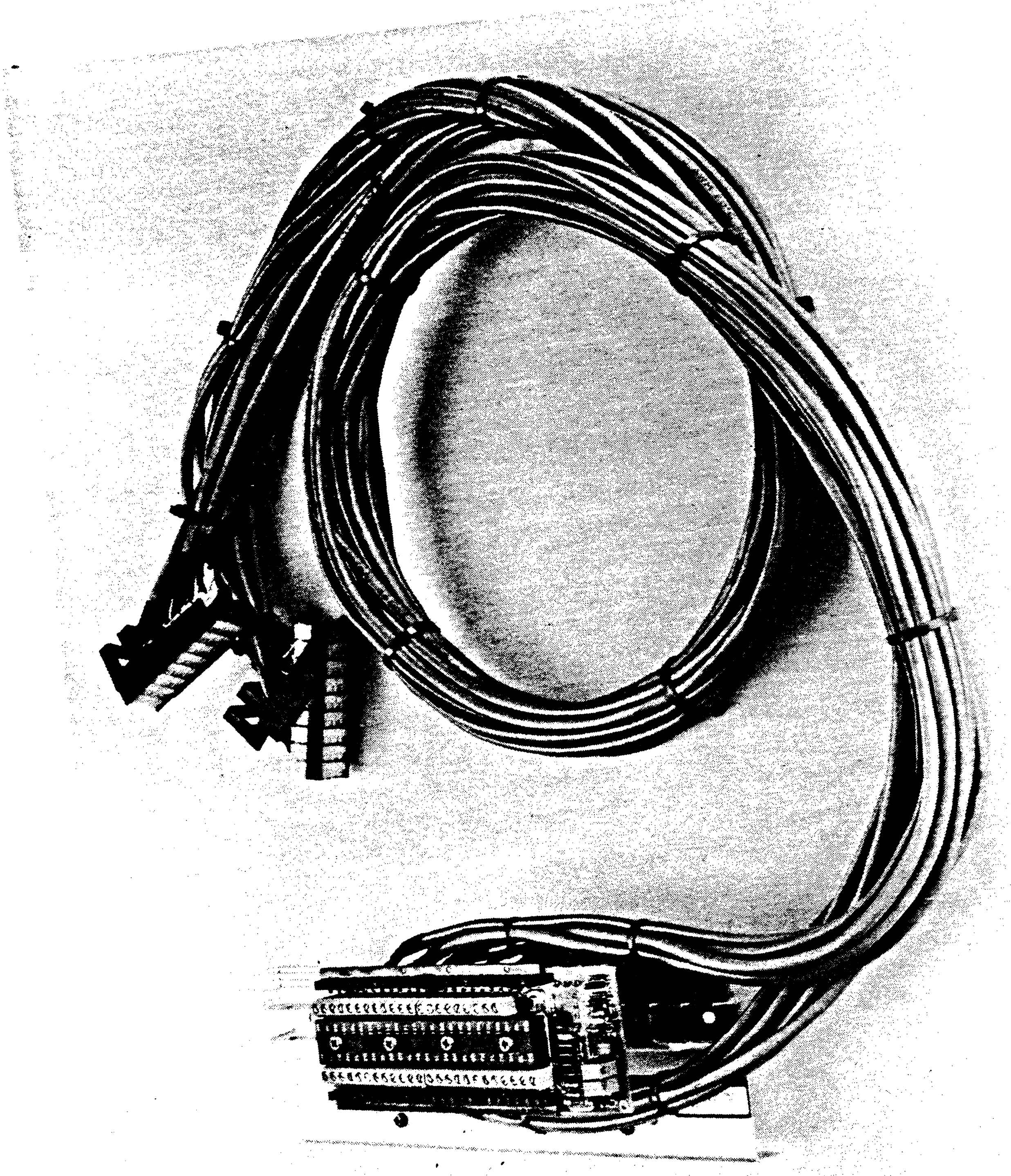
FWA's

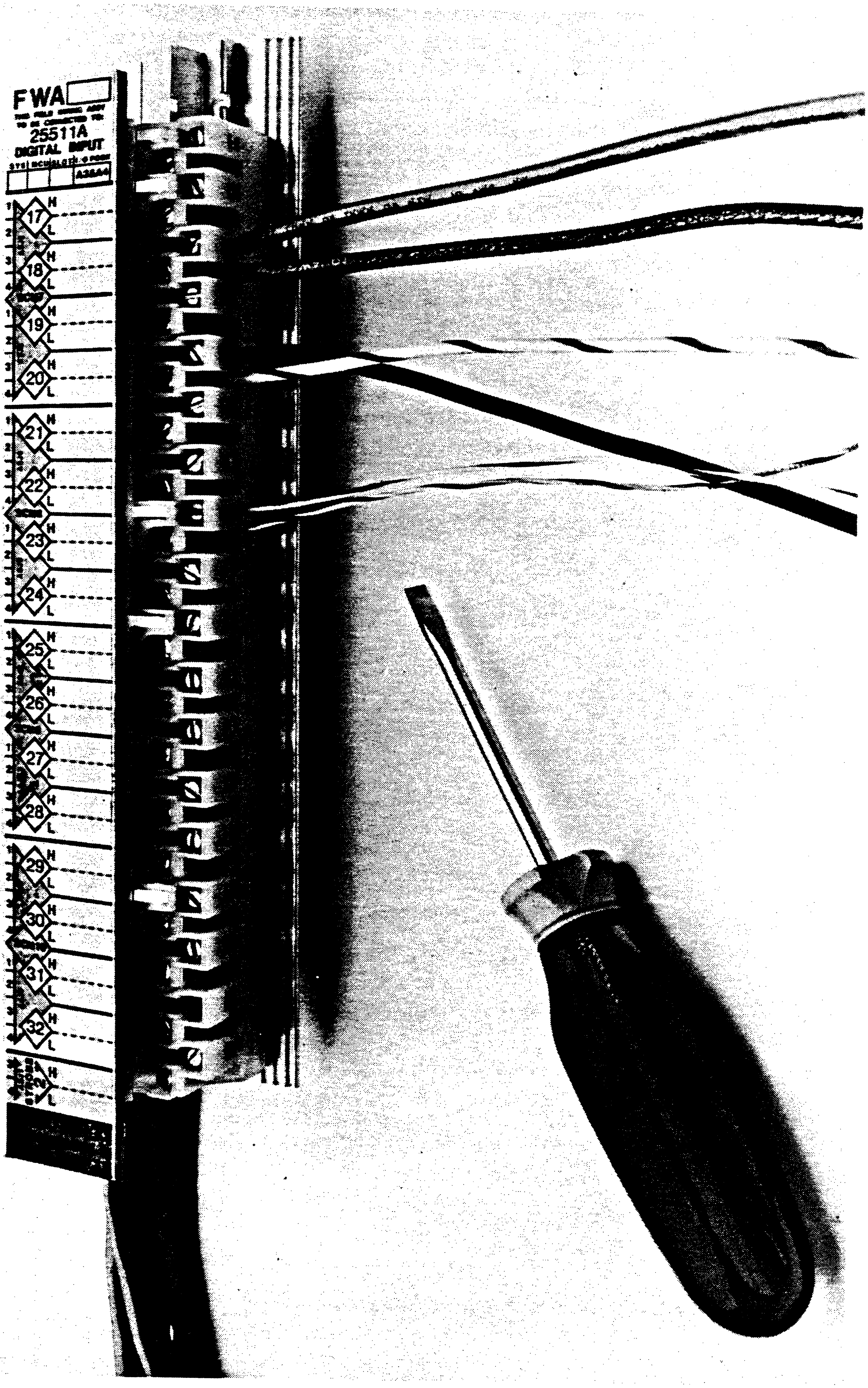


CABLING AND FIELD WIRING ASSEMBLY



THERMOCOUPLE REFERENCE CONNECTOR (TRC)




FWA
25511A
DIGITAL INPUT
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2250 SUMMARY

The 2250 is composed of an HP 2104 processor unit, from one to eight HP 2251 Measurement and Control units, and up to 64 I/O or function cards which send and receive measurement and control signals to external sensors and actuators. The function cards are wired to the external process through field wiring assemblies (FWA's). There can be up to 210 FWA's.

2250 PHYSICAL DESCRIPTION

The HP 1000 Measurement and Control processor (2250) consists of an HP 2104 processor and at least one HP 2251 Measurement and Control Unit (MCU). There can be up to 8 MCU's each having space for eight function cards. The type of enclosure is identified by model number, and the automation requirements of your own application determine what function cards are included.

2250 CONTROLLER

The 2250 controller includes four half-size cards that supply HP-IB interface, measurement and control processing and memory.

The HP 2250 measurement and control processor is a programmable interface between a computer and an external measurement and control system. The 2250 can service thousands of sensors and actuators in an external system with little participation on the part of the computer.

The external system is typically a factory process or laboratory experiment.

The function of the computer is mainly to send instructions to the 2250, and to send and receive data. As a result no particular computer or programming language is specified for communications with the 2250.

Control of all function cards is handled completely by the 2250 programming language, MCL/50.

The analog and digital input and output measurement and control functions are implemented by the function cards that are installed in any particular system.

The HP-IB interface is the communication path to the computer.

The measurement and control interface translates between processor protocol and function-card protocol.

The 2250 firmware is stored in read only memory (ROM) on the memory card. There is also read and write memory on the memory card. This RAM is for storing the instructions that implement a particular measurement and control system, and for storing data resulting from the instructions.

The HP 25572A/B power supply consists of an HP 12035A power supply and the mounting hardware required to install it. The HP 25572A is for the rack mounting and the HP 25572B is for panel mounting. The power supply provides the processor unit backplane with DC voltages and a 25 kHz voltage source to the MCU's via the backplane interface (BIF) card.

The HP 2251 Measurement and Control Unit (MCU) contains a card frame which holds the backplane interface card and up to eight function cards. There can be up to eight MCU's in an HP 2250 system.

HP 12013A BATTERY BACKUP CARD

The 12013A battery backup card protects memory contents up to 30 minutes if power fails.

The HP 12001A processor compiles and executes requests from the HP-IB bus and converts measurement and control data resulting from these requests.

The processor card operates from programs running in an external computer, and provides control of the HP 2250 and its function cards by executing instruction sets stored in the memory card ROM. The processor card also controls data transfers (including DMA), processes I/O interrupts, provides self-test instructions, and performs all necessary computations. The major component on the processor card is a 64-pin SOS integrated circuit which contains much of the processor logic. This IC is called the CPU chip.

THE INTERFACE BUS

The HP-IB is a standard method of communication for HP computers and HP-IB bus compatible instruments. Since the HP 2250 is a HP-IB bus compatible instrument, we use the HP-IB method of communication.

The interface bus consists of an HP-IB interface card (I/O Card) in the computer and a cable connecting the computer interface card with the 2250. This arrangement takes care of devices that are within a few meters of each other. For longer distances between the 2250 and the computer, an optical or coaxial HP-IB replaces the standard cable.

The HP-IB transfers data according to a standard protocol, and provides addressing and interrupt-handling facilities so devices can operate in parallel on the bus without interference. Thus, more than one 2250 can be connected to the bus, and other devices, such as printers, can be included. If other devices are on the bus, the computer can communicate with them, since each device has its own unique bus address.

HP 37203L HP-IB LINK

.he 37203A HP-IB link extends the transmission distance of the HP-IB bus to remote locations via coaxial cable or fibre optic cable. The maximum distance is 1000 metres (3280 feet).

HP 12009A HP-IB INTERFACE CARD

There are two DIP switches on the HP-IB card.

The select-code switch (U1) is on the front of the card, and must be set to octal 130 when the card is used in the 2250 controller section.

The HP-IB address switch (U16) is on the left side of the card. This switch determines HP-IB address of the 2250, related by system tables, in the host computer, to the logical unit number you use when writing programs for the HP 1000 computer. The HP-IB address can be set to any number below octal 37.

The 12009A HP-IB interface card connects to an HP-IB cable which carries control signals and data to and from a host computer (controller). Up to 15 other HP-IB devices can also be connected to the HP-IB bus cable to the HP-IB devices or system controller which may or may not be a HP computer. To the processor unit, this card is an I/O card and is under the processor card's control at all times.

The HP-IB card has the capability of handling its own DMA and of ecoding its own instructions from the processor unit. These features are performed by an I/O master chip located on the HP-IB card.

All interfaces to the processor unit backplane and to the HP-IB devices are provided by two integrated circuit chips. The first chip, the I/O processor (IOP) chip, manages all I/O functions of the backplane. The second chip, the PHI (Processor to HP-IB Interface) chip performs all data and control signal interactions with the HP-IB devices. Thru the use of these two chips, the HP 12009A interface relieves the processor of most of the HP-IB protocol processing.

In the case of the 2250, the external computer is the system controller. The HP-IB card plugs into a single slot of the processor unit card frame and is assigned only one select code. The HP-IB card is connected by cable to the HP-IB devices or system controller which may or may not be a HP computer. To the processor unit, this card is an I/O card and is under the processor card's control at all times.

The HP 12070A memory contains read only memory (ROM) chips, and Random Access Memory (RAM) chips. The HP 2250 firmware is stored on the ROM chips. The RAM chips contain user memory, which is used to store instructions that implement a particular measurement and control function, and to store the data resulting from the instructions.

The firmware also includes utility routines: engineering-unit onversion, thermocouple linearization, and a fail-safe "Watchdog" imer that can initiate special actions if the 2250 does not hear from the computer for a designated length of time. The ROM integrated circuits that contain the firmware are inserted into sockets in the memory card.

The RAM storage area is temporary memory, lost when power is off, unless the 2250 has a battery backup card. This area of memory essentially belongs to the MCL tasks you write. The processor reserves about 2K words for storing its own management data. The actual number of words used depends on the number and type of function cards in the system. This leaves about 14K words for compiled tasks and data, including down-loaded subroutines as well as input and output data in transit to or from the computer.

The memory card provides ROM memory for the HP 2250 firmware and RAM user memory for application programs. The ROM word size is 16 bits and the RAM memory is 17 bits (it has an additional bit for parity). The 16-bit wide memory corresponds with the HP 12001A processor requirements. The parity bit provides a means to maintain integrity of data in the RAMs.

The HP12071A Measurement and Control Interface (MCI) provides interface between the processor unit backplane and the Measurement and Control Unit (MCU) backplane. The MCU backplane connects to the function cards which provide the input/output capability for measurement and control.

The HP 12071A Measurement and Control Interface (MCI) card performs the following function:

Generates address words with address control signals which are used to select or scan input or output channels or points on the function cards.

Provides timing. The MCI card has internal timers for various measurement pacing modes. The internal timers are supplemented by an external pacing line to precisely control the rate at which measurement and control events occur, independently of processor timing. Internal and external pacing assures that the proper data passes thru the card's data register at the right time, transferring between the MCU and processor backplanes.

anages its own controller backplane I/O, responding to its firmware instructions, and from these it provides the required MCU backplane control signals to the function cards. It also receives function card handshake signals, function card interrupts, and function card data from the MCU backplane.

Interprets processor control instructions eg. DMA word transfers.

An I/O master chip on the MCI card processes I/O instructions and DMA operations independently for that card, relieving the computer of this function. This arrangement eliminates restrictions on the number or the type of devices or interfaces using DMA.

The I/O master detects the card's select code in address words from the computer independently of the card's position in the backplane. This is possible because the card's address is stored in a global register contained in the I/O master. The select code is entered via a set of switches on the card.

Priority of I/O interrupts and DMA backplane access is established by the I/O card's position in the processor unit. The slot next to the processor card has the highest I/O priority. From this slot the I/O interrupt priority numbers successfully increase (less priority) as the slot numbers increment. Therefore, due to the MCI card's location, it has the highest I/O card priority of the controller section.

The addressing circuits on the card consist of an address latch for the upper-eight address word bits, an address counter latch for the lower-eight address word bits, an address decoder for MCI card internal registers, and an address buffer for channel or point addresses to be transferred onto the MCU bus.

Input and output data transfers are passed through a bidirectional data register.

MCU DESCRIPTION

The Measurement and Control Interface (MCI) bus connects the MCI to one or more BIF's, depending on the number of the MCU's in the HP 2250 (each MCU contains one BIF). The BIF's connect to the function cards thru a backplane.

The card frame containing a BIF and the function cards it serves also contains the function card backplane. Together these items (card frame, BIF function cards, and function card backplane) comprise an MCU. Nine card slots in the card frame have physical designations from 0 thru 8.

The BIF is always in the first slot (Slot 0) of the MCU. The mainframe card group (function cards and BIF) is physically "MCU 1". The first additional MCU is usually "MCU 2" etc. The MCU address is set by a thumbwheel switch on the front edge of the BIF. MCU addresses do not have to agree with the physical location of the MCU. The BIF can communicate with up to 8 MCU's for a maximum of 64 function cards.

The last BIF must be terminated by a terminator connector.

pair of LED indicators on each BIF shows various conditions. One LED is green and indicates that the BIF has power and is connected to the MCI bus and the 25 kHz supply bus. The other LED is red and indicates abnormal operation which is most likely one of the following conditions:

A. 25 kHz power is not connected to the BIF but the control cable is connected and the MCI power is on.

B. The "Daisy Chain" of the control cable is broken somewhere between the BIF and the MCI, but 25 kHz power is connected to the BIF.

C. +12V supply on the BIF is not operating correctly.

D. Clock circuits on the BIF are not operating correctly.

E. Clock circuits on the MCI are not operating correctly.

If both indicators are off, then either the system power is off, or both the power cable and the 50-line control cable to the BIF are disconnected at some point in the chain.

The HP 25574A backplane interface (BIF) provides the function cards with signal buffering, partial address decoding, interrupt masking, and 25 kHz power. In a system consisting of more than one MCU, each MCU contains one BIF card, and the MCI bus connects through each BIF to the succeeding (or "downstream") MCU's in a daisy chain fashion.

The thumbwheel switch on the BIF card selects the slot addresses of the function cards within the card frame. Normal procedure is to set the switch on the card in the mainframe to "0", and to set the switches in each MCU to sequential numbers. Take care that no two BIF switches are set to the same number. The 2250 cannot detect this error, therefore it produces unpredictable results.

If your 2250 has only one Measurement and Control Unit (MCU), and the BIF selector switch in that MCU is set to zero, then the slot numbers are 1 thru 8, with slot 1 nearest the BIF card. If there is more than one MCU, the slot numbers are the sum of the BIF switch setting multiplied by eight, plus the slot number within the MCU (1 thru 8).

System slot number = BIF number x 8 + MCU slot number

The function cards can be plugged into any slot but the recommended placement is: analog cards start at slot one and digital cards start t slot eight and decrease in order. This is because the analog ighest priority slot is one and the digital highest priority slot is eight.

The power supply on the BIF is energized from 17 VRMs/25kHz which comes from a small transformer on the card. The transformer is powered from the 27 VRMs/25kHz lines originating in the HP 12035A power supply. The 25 kHz power connects to the BIF on J12, and thru it to downstream BIFs on J13 (or the opposite order of J13 and J12). A full-wave rectifier circuit is used in the BIF supply, providing a DC input to an IC regulator giving an output of +12V.

A line designated MDPWR on the MCI bus carries 12 VDC continuously. If the BIF supply fails, the voltage (called DPR on the BIF) maintains power on the BIF clock resynchronizer and data bus drivers. MDPWR becomes DPWR in the BIF and connects thru P2 to the function card backplane to enerfizes the function card bus drivers of any cards having a power supply failure.

The power for the BIF cards is distributed as an AC voltage of 27 VRMs 25kHz from the HP 12035A power supply or from an additional power supply if additional MCUs are added to the system. The high frequency allows the use of small sized components to provide DC voltage for the card circuitry. the 27 VRMs enters each BIF of J12 or J13 thru a 3-conductor cable, and is "Daisy-chained" to the next BIF thru another cable connected to J13 or J12.

Several DC voltages of 15V, 12V, and 5V are required on the function cards, the BIF originates AC voltages for distribution on the function card MCI bus to the function card rectifier/filter/regulator circuits on the cards. A BIF supply transformer provides the following AC voltages to give the DC requirements; 21 VRMs center-tapped, 17 VRMs center-tapped, and 9 VRMs center-tapped all at 25 kHz. The 25 kHz voltages connect to the function card to the function card MCI bus thru P1.

Function cards match the type of sensor or actuator in the external process. The principal function card type are analog input, analog output, digital input, digital output, counter, pulse output, and multiplexer cards (which allow several input/output cards to be connected to the same set of internal lines and "multiplex" the signals for these cards).

A function card can accomodate up to 32 external points (depending on card type) and occupies one slot in the MCU card frame.

HP 22501A 16-CHANNEL HIGH-SPEED ANALOG INPUT

The high-speed analog input card provides the 2250 with basic analog-to-digital conversion capability. This card converts readings at a 50 kHz rate with 14-bit resolution, equivalent to one part in 16,383, or approximately 0.006% resolution.

The HP 25501A has 16 differential input channels with full-scale ranges of 1.25, 2.5, 5 and 10 volts, positive or negative. Your MCL program can select the range, or select autoranging across the four ranges. Autoranging means that the analog input card can select its own gain by powers of 2 (within a 1 to 8 range) based on the signal input level. There is no~~w~~ speed penalty for using autoranging.

The number of input channels using a single 25501A card, can be expanded up to 240, buy using up to 7 ~~14~~ multiplexer function cards. The multiplexer cards connect through the multiplexer backplane to a special differential input on the Hp 25501A, so that none of the differential input channels is used for connecting multiplexers.

HP 25502A 32-CHANNEL HIGH-LEVEL MULTIPLEXER

The HP 25502A function card is a high-level solid-state analog signal multiplexer, providing 32 channels of differential analog input multiplexed to one differential channel, which connects to a special input on the analog input card. The HP 25502A has unity gain therefore, used with the 25501A analog input card, signal gain and autoranging characteristics are the same as thosde of the 25501A. The sampling rate is 50 kHz.

HP 25503A 32-CHANNEL LOW-LEVEL MULTIPLEXER

The HP 25503A provides low-level input and channel expansion for the HP 25501A analog input card, down to 12.5 millivolts full scale. Used with the HP 25501A, there are 12 programmable ranges, with the 25501A autoranging over four ranges. The sampling rate is 30 kHz.

HP 25504A 16-CHANNEL RELAY MULTIPLEXER

The relay multiplexer function card provides fully isolated channel expansion for the HP 25501A analog input card, with 16 differential input channels per multiplexer card. There are 16 programmable ranges, from 12.5 millivolts to 100 volts, with 25501A autoranging over four ranges. The sampling rate is ~~1 kHz~~.
500 Hz

HP 25510A 4-CHANNEL VOLTAGE/CURRENT ANALOG OUTPUT

The HP 25510A provides digital-to-analog output capability for the 2250, with 12-bit resolution and voltage or current output. The voltage range is 10 volts, positive or negative. The current range is 20 milliamperes, with 20-volt compliance. The maximum analog output rate is 37 kHz.

HP 25511A 32-POINT DIGITAL INPUT

The HP 25511A digital input card provides 32 digital input points to the 2250. Signal conditioning options interface with a wide range of AC and DC voltages. You can read the input state of any individual point or of a field of 16 points.

You can program individual point to interrupt either the 2250 or the computer. Event interrupt enable and transition direction are programmable. Also, the card can be programmed for strobed input, permitting an external strobe signal to determine when the point or field read shall take place.

HP 25513A 32-POINT DIGITAL OUTPUT

The HP 25513A digital output card provides solid-state switching to 32 output points. Signal conditioning options interface with a variety of AC and DC control actuators.

You can program the output points independently or as two 16-point fields. Data in the output registers is maintained until new data is programmed to the card or until an external strobe signal is received by the card from the external system. The card can be programmed to change outputs upon receipts of either an internal 2250 control signal or an external strobe signal.

HP 25514A 16-POINT RELAY OUTPUT

The HP 22514A card provides Form C relay output. The 16 channels can be programmed as independent points or a 16-point field. The card can be programmed to change outputs upon receipt of either an internal 2250 control signal or an external strobe signal.

HP 25515A 4-CHANNEL PULSE OUTPUT

The HP 25515A pulse output card generates a programmable number of pulses independently on each of four channels. The initial pulse rate, acceleration, final pulse rate, and the pulse width are also programmable. Alternatively, you can put the card in frequency-generator mode to provide pulses for an indefinte length of time. Two limit inputs can be programmed to stop the train of pulses when, for example, a mechanical stop switch is reached.

HP 25516A 16/16 POINT DIGITAL MULTIFUNCTION

The HP 25516A multifunction card provides 16 channel digital input points and 16 digital output points for the 2250.

Each input point on the multifunction card has a presettable event counter with a maximum count of 255. Each counter can be programmed to prescale (automatically repeat counting upwards from the preset value) or to totalize (automatically continue counting from zero after the preset number of counts).

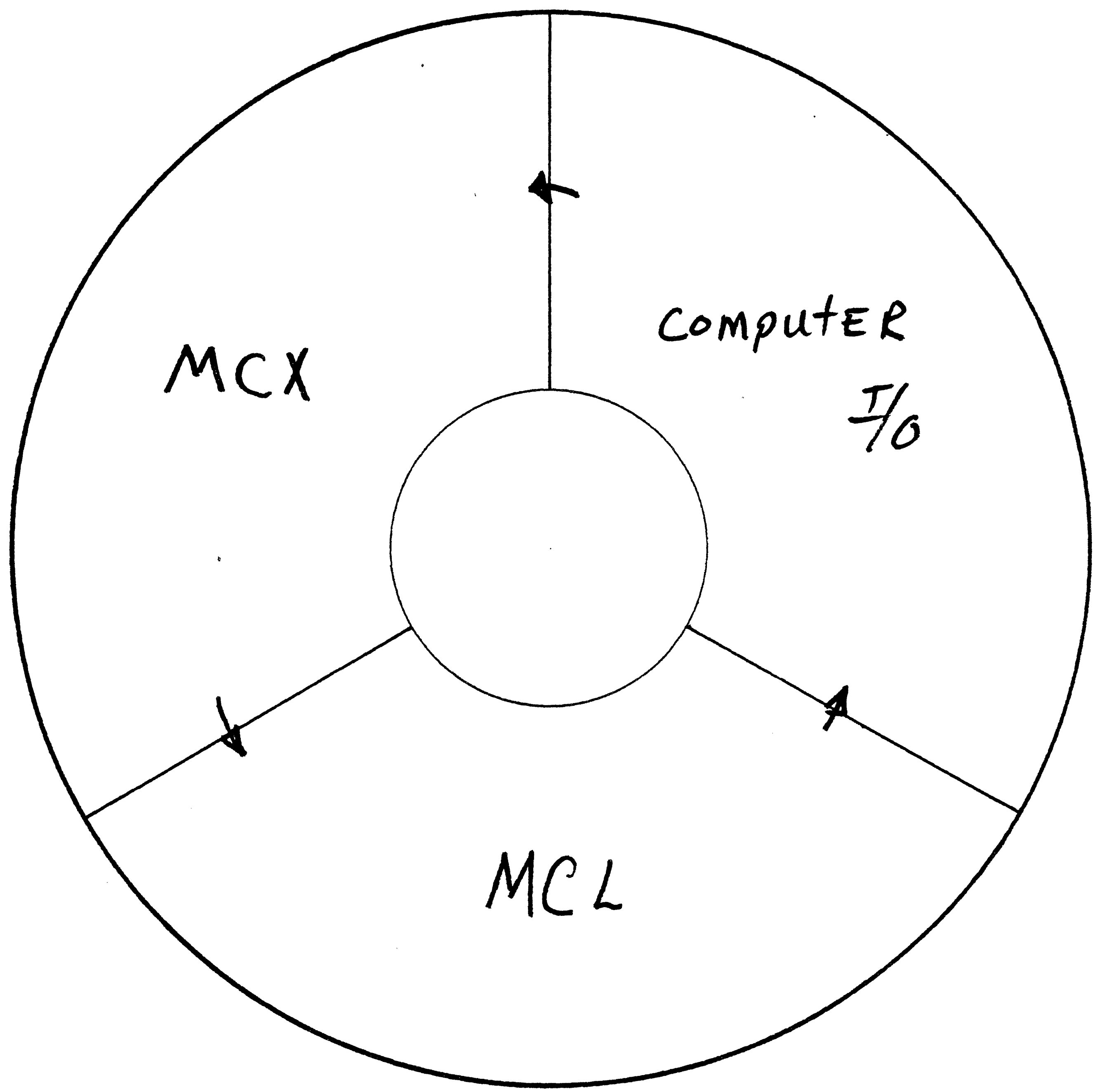
An event is defined for each point by enabling the point to interrupt, and programming the sense and sense override, which specify the desired direction of transition.

2250

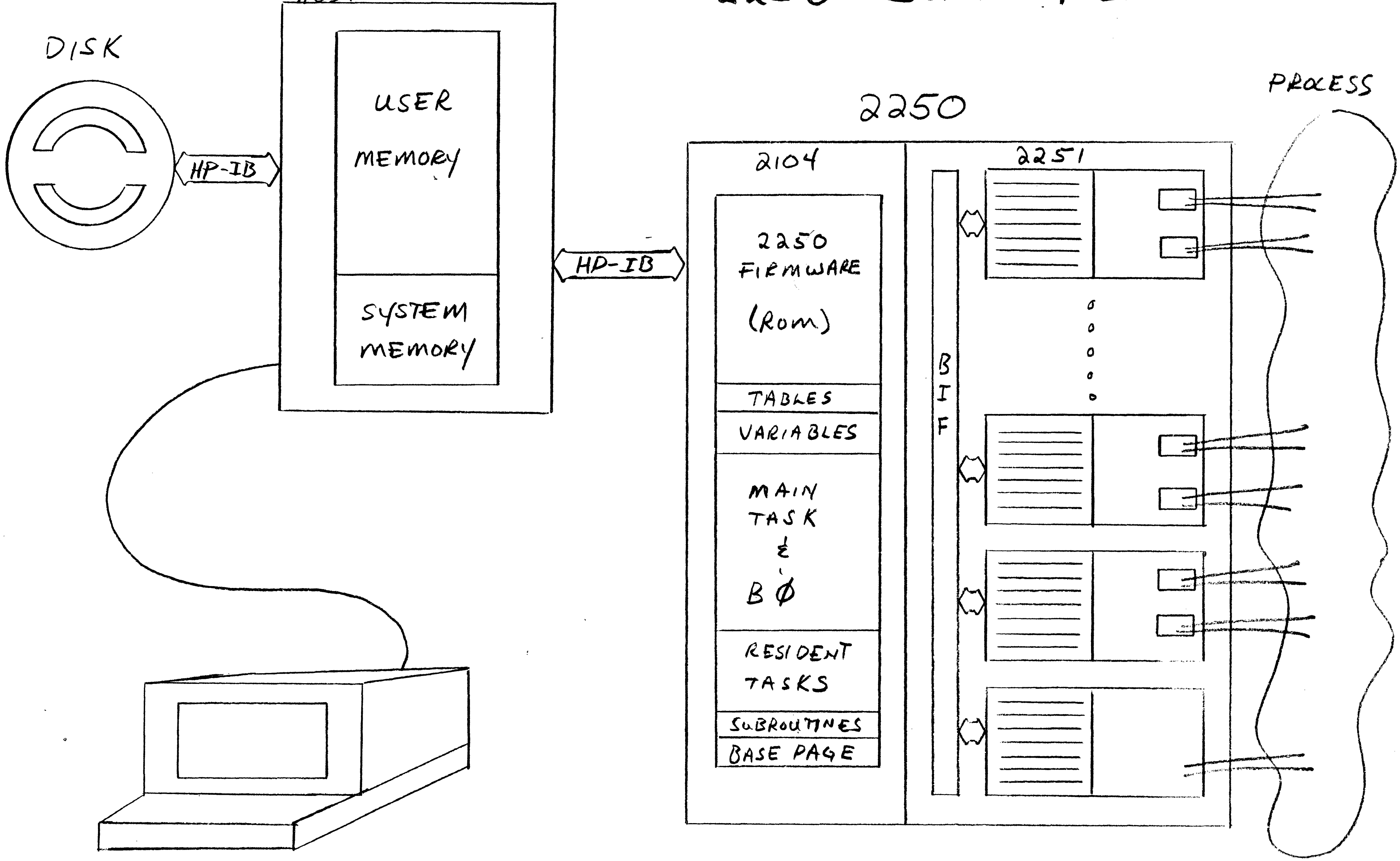
SOFTWARE

2250

SOFTWARE UNDERSTANDING



2250 SOFTWARE



HOST PROGRAMS

- RESIDE IN HOST COMPUTER MEMORY
- WRITTEN IN COMMON COMPUTER LANGUAGE LIKE FORTRAN OR BASIC
- CONTAINS MCL IMBEDDED IN WRITE STATEMENTS

MAIN TASK

- DOWNLOADED FROM HOST TO 2250
- ENTIRELY MCL
- COMPILES AND EXECUTES IMMEDIATELY

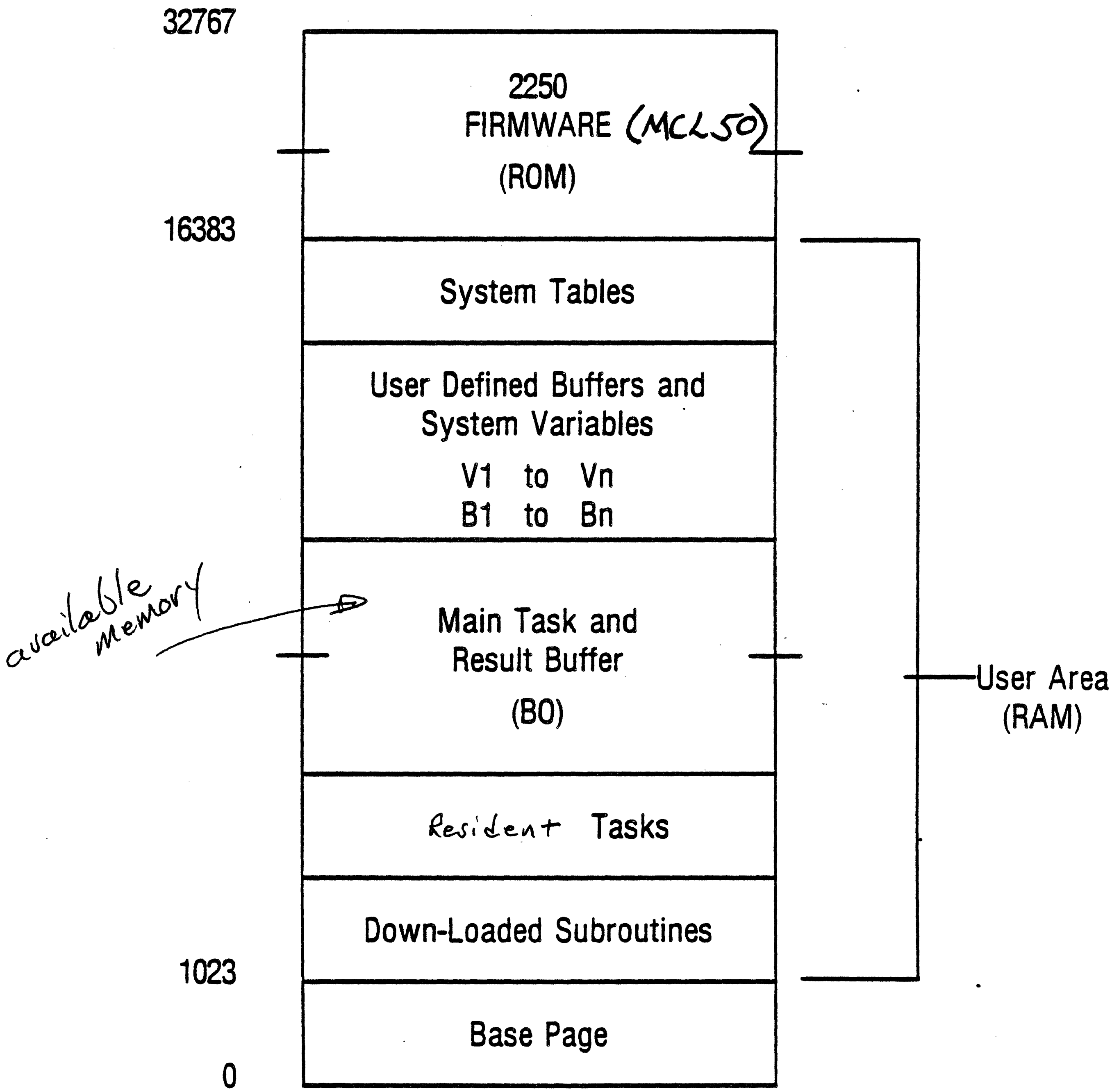
RESIDENT TASK

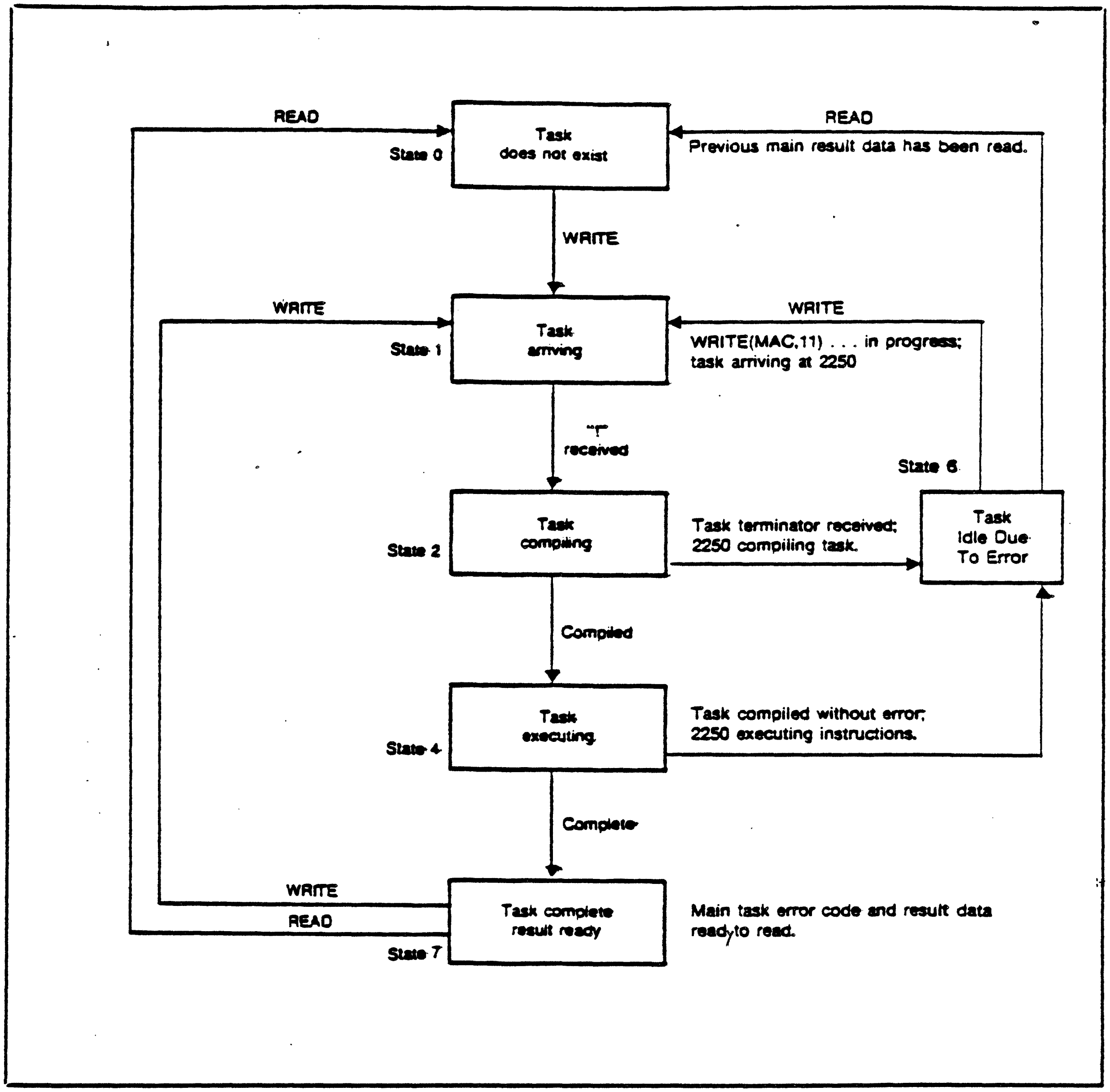
- DOWNLOADED FROM HOST TO 2250
- ENTIRELY MCL
- COMPILES IMMEDIATELY
- EXECUTION DELAYED

DOWNLOADED SUBROUTINE

- DOWNLOADED FROM HOST TO 2250
- ABSOLUTE COMPILED FORTRAN
- CONTAINS NO I/O
- CALLED FROM MAIN OR RESIDENT TASK

2250 MEMORY MAP



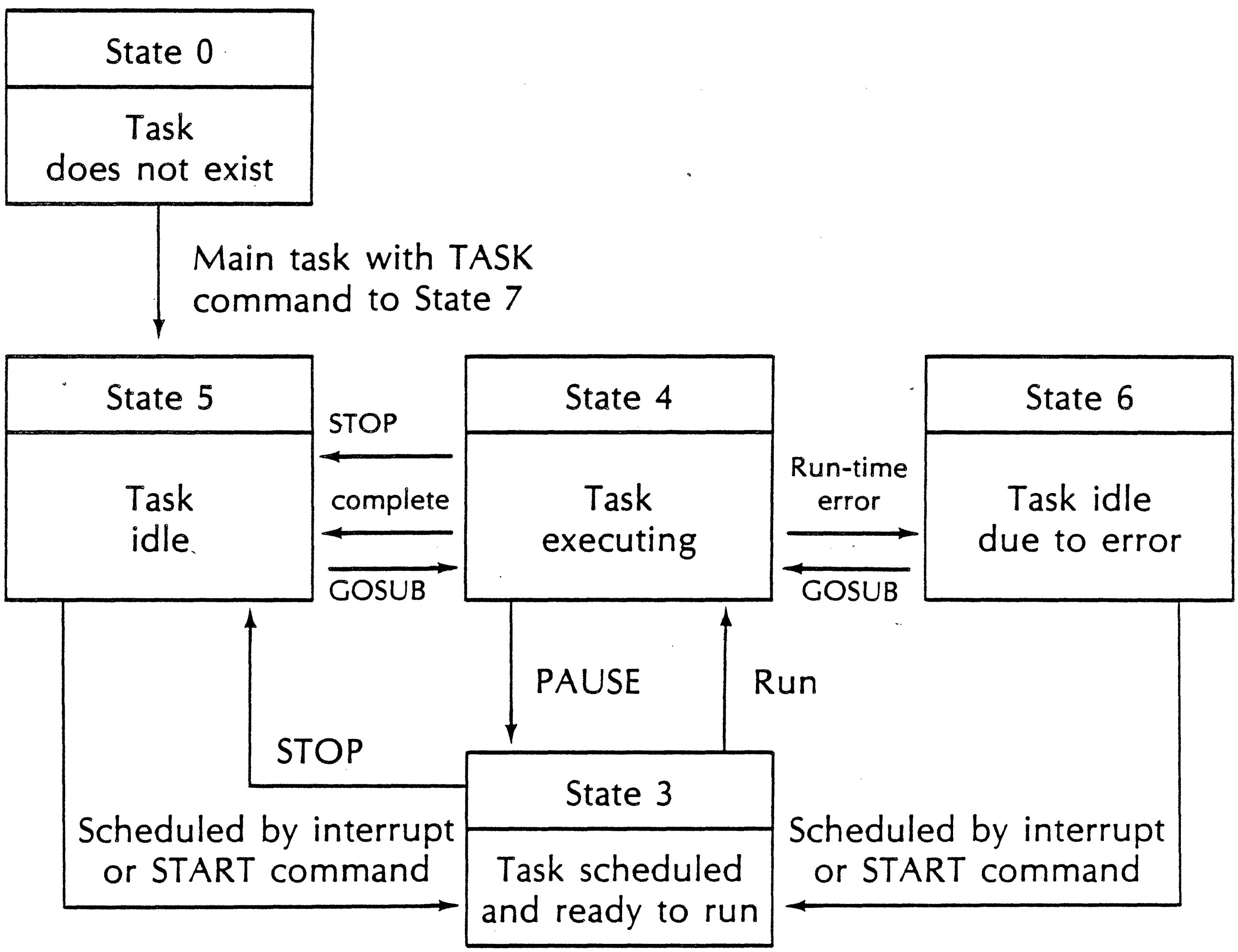


MAIN TASK STATE DIAGRAM

In the state diagram, the paths from State 7 to State 0 labeled READ and WRITE refer to the fact that either a READ or a WRITE addressed to the 2250 deletes all existing result data and the main task error code from the main result buffer.

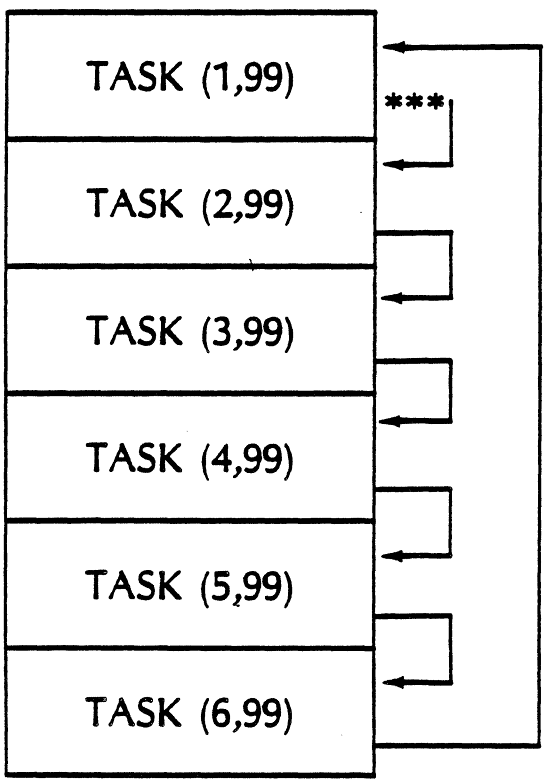
NOTE: RESET! WON'T CLEAR A MAIN TASK BECAUSE IT IS A TASK ITSELF. USE HP-IB 'CLEAR'

RESIDENT TASK STATUS

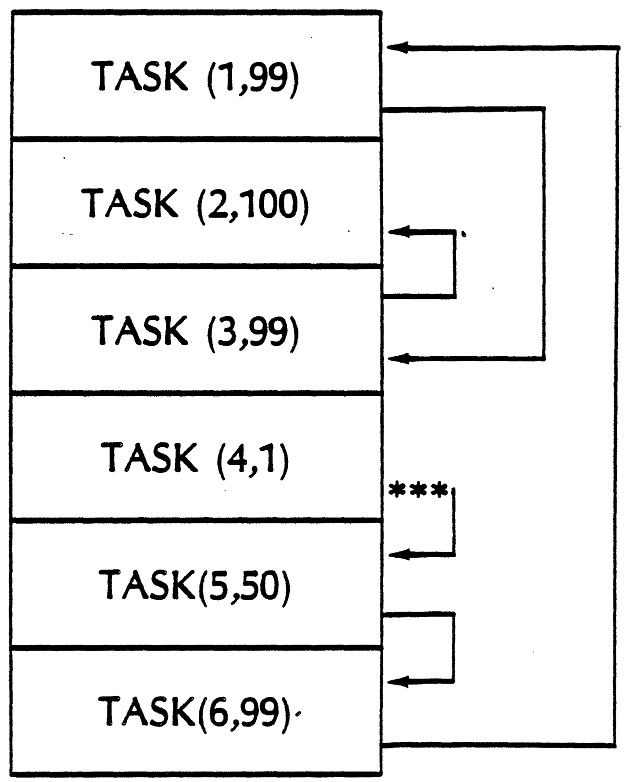


WHO EXECUTES NEXT?

If tasks of equal priority:



If tasks of different priority:



Assume a main task of:

START (1), START (2), START (3), START (4),
START (5), START (6)!

RULES TO REMEMBER

1) The MAIN task *always* has the highest priority.

2) A task (MAIN or RESIDENT) *cannot* execute until the currently executing task completes or pauses or is aborted!
   (Therefore, not multitasking)

3) Round-robin execution applies to tasks of equal priority *only*.

4) Resources such as buffers and variables for resident tasks are shared. (Except B0)

5) A resident task cannot store results into the main task result buffer (B0).

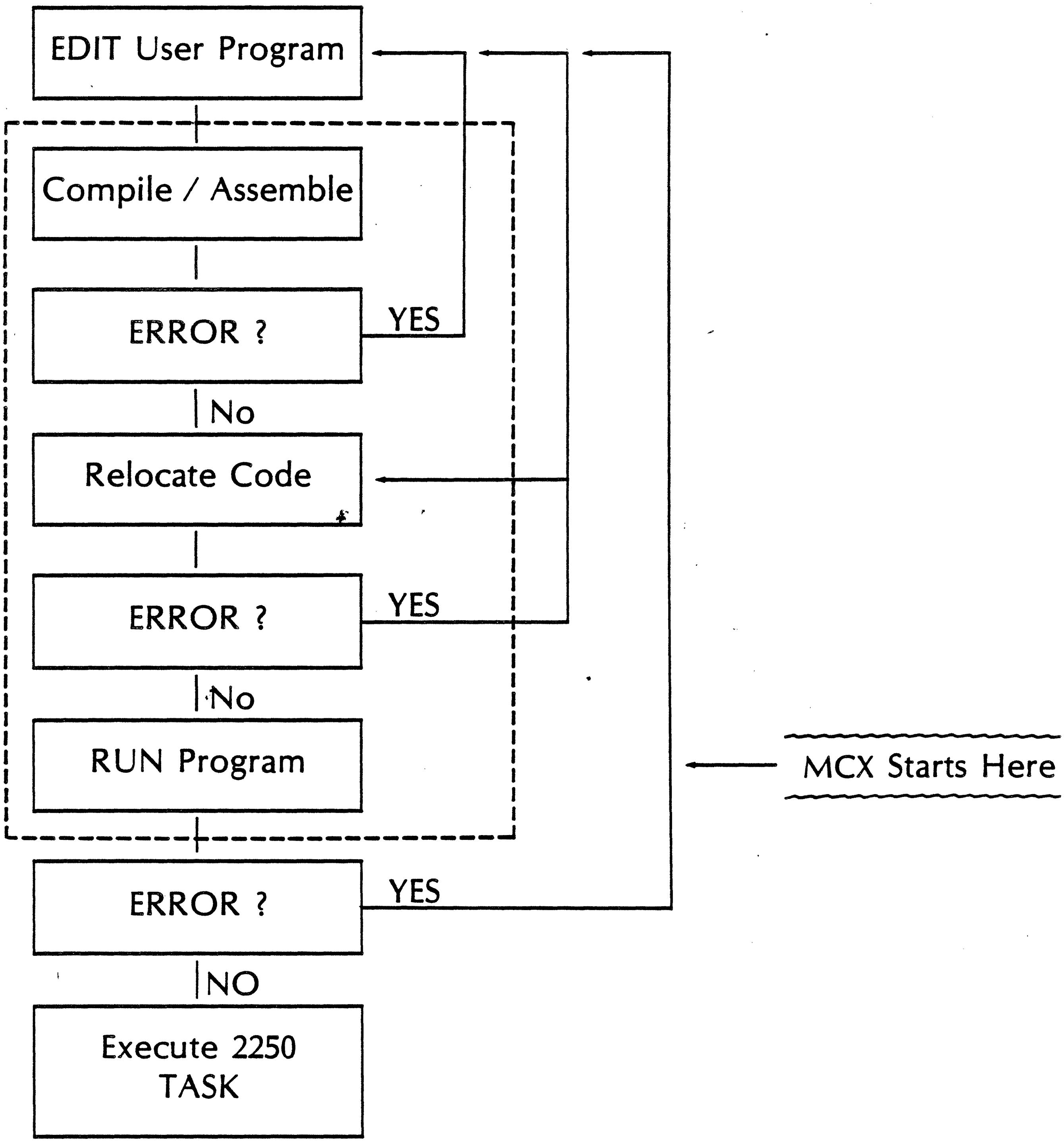
6) Before a main task executes there is an implicit IN (B0) OUT(B0) executed.

7) A resident task must assume that IN and OUT may have been altered by another task during a pause.

USING THE HP MEASUREMENT & CONTROL EXERCISOR

MCX

USER SOFTWARE INTERFACE TO THE 2250 AND THE MCL/50 FIRMWARE



TO INVOKE MCX

:RU, MCX [,lu] [,infile]

lu = 2250 logical unit number

infile = file NAMR of file containing MCL and/or MCX commands to be executed by MCX.

MCX PROGRAM COMMANDS

Command Type	MCX Command			
Read Commands	READ			
	READ BUFFER	buffer count		
	READ MEMORY	START ADD, Numwords		
	READ PORT	portname		
	READ REVISION			
	READ SECONDARY	address		
	READ VARIABLES	startvar numvar		
Write Commands	WRITE VARIABLES	startvar	numvar	data1 . . . dataN
	WRITE BUFFER	buffer	count	data1 . . . dataN
	WRITE SECONDARY	address		data1 . . . dataN
	WRITE SUBROUTINE	subfile		
Status Commands	STATUS SYSTEM			
	STATUS MAIN			
	STATUS TASK	number		
	STATUS INTERRUPTS			
Set Commands	SET RESULTS ON	SET ECHO		
	SET RESULTS OFF	SET STOP		
	SET MODE INTEGER			
	SET MODE OCTAL			
	SET MODE REAL			
	SET POLLING ON	time		
	SET POLLING OFF			
File Commands	INCLUDE	file namr		repeat count
	LOG ON	file namr		
	LOG OFF			
HP-IB Commands	CLEAR			
	TRIGGER			
System Configuration	CARDS			
Misc.	*			
	HELP or ??	? GE		LU
	QUIT	? SEC		LOCK UNLOCK
	/			RUn,[program,[data]]

Notes on MCX Syntax Rules

Commands are entered after the MCX prompt MCX:

Either MCX or MCL commands can be entered after the prompt. Upper or lower case is allowed, or a mixture of both.

MCX commands can be abridged to any length, down to one letter per word, as long as all the words in the command are represented.

EXAMPLE:

SYSTEM STATUS = SYS STAT = S S = s,s

Blanks or commas are legal delimiters.

READ COMMANDS

READ

Reads the main result buffer from the 2250 primary address.

READ BUFFER buffer count

Reads data from elements in the designated *buffer,* starting with the first element and continuing for *count.*

READ MEMORY startadd numwords

Reads the 2250 memory starting at address *startadd* and will read *numwords* words. If startadd is less than 400B, an error results.

READ PORT portname

Reads data from the desigated port *portname.* All words, up to 500, will be read from the port (A, B, C, or D).

READ REVISION

Displays the current firmware and MCX revision dates to the current log device or file.

MCX READ COMMANDS
(continued)

READ SECONDARY address

Reads from the specified secondary *address*. Secondaries 1 - 15 are allowed, and if address is ommited, secondary 1 will be read.

READ VARIABLES startvar numvar

Reads 2250 variables from the designated variables starting with *startvar* and reading for *numvar*.

MCX Read Examples

1) Read the result at the primary address after a main task of RAM!

```
MCX : READ

No error: result data:
   1:      14019
           14909
```

2) Read variables 10 through 20.

```
MCX : READ VAR 10 11

Variables     10 to    20
  10:    14540    14541    14542    14543    14544    14545    14546    14547
  18:    14548    14549    14550
```

3) Read first 50 words of buffer 5.

```
MCX : R BUFFER 5,50

Buffer data, buffer  5
   1:      0       1       1       1       2       2       3       3
   9:      4       4       4       5       5       6       6       7
  17:      7       7       8       8       9       9      10      10
  25:     10      11      11      12      12      13      13      13
  33:     14      14      15      15      16      16      16      17
  41:     17      18      18      19      19      19      20      20
  49:     21      21
```

MCX READ Examples Continued

4) Read port B that should contain 36 words.

```
MCX : READ PORT B

Data from port B
   1:      0      1      1      1      2      2      3      3
   9:      4      4      4      5      5      6      6      7
  17:      7      7      8      8      9      9     10     10
  25:     10     11     11     12     12     13     13     13
  33:     14     14     15     15
```

5) Read secondary 1 (system status),

```
MCX : R SEC 1

   1:     -1      0      1      0      0      0      0      0
```

6) Read secondary 4 (interrupt status).

```
MCX : READ SEC 4

   1:    1      5     24     33     44     56     84     87
   9:   99    127      0      0      0      0      0      0
```

7) Read secondary 2 (main task status).

```
MCX : R S 2

   1:    7      0      0      0      0      0      0      4
```

MCX READ Examples Continued

8) Reads words 256 through 270 of 2250 memory.

```
MCX : read mem 256 15

000400/  000400     256.
000401/  000401     257.
000402/  000402     258.
000403/  000403     259.
000404/  000404     260.
000405/  000405     261.
000406/  000406     262.
000407/  000407     263.
000410/  000410     264.
000411/  000411     265.
000412/  000412     266.
000413/  000413     267.
000414/  000414     268.
000415/  000415     269.
000416/  000416     270.
```

9) Read 10 words of 2250 memory starting at word 2000B.

```
MCX : Read memory 1024,10

002000/  002000    1024.
002001/  002001    1025.
002002/  002002    1026.
002003/  002003    1027.
002004/  002004    1028.
002005/  002005    1029.
002006/  002006    1030.
002007/  002007    1031.
002010/  002010    1032.
002011/  002011    1033.
```

10) Read the 2250 firmware and the MCX revision codes.

MCX : READ REVISION
Firmware rev. ~~2113~~ 2108, MCX rev. 2113

WRITE COMMANDS

WRITE VARIABLES startvar numvar data1 . . . dataN

Sends data *(data1 . . . dataN)* to the specified variables starting with *startvar* and writing for *numvar.*

WRITE BUFFER buffer count data1 . . . dataN

Sends data to elements in the designated *buffer,* starting with the first element and continuing until *data1* to *dataN* have been written.

WRITE SECONDARY address data1 . . . dataN

Sends data *(data 1 . . . dataN)* to the designated secondary *address.*

WRITE SUBROUTINE subfile

Writes a subroutine file *(subfile)* that has been generated by LINKR to the 2250, through secondary 9.

MCX Write Examples

1) Write digital data to variables 1 - 16.

MCX : WRITE VAR 1 16
Enter 16 data items: 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0
~~Status code is ok~~.
Data Written.

2) Write voltages in mvolts to elements 1 - 20 of buffer 1.

MCX : W B 1 20
Enter 20 data items: 500 500 500 500 400 400 500 500 500 200 200 200
Enter 8 data items: 100 100 100 100 120 120
Enter 2 data items: 120 120
~~Status code is ok~~.
Data written

3) Write to secondary 6 to set up secondary 6 read to read buffer elements from buffer 3.

MCX: write secondary 613

4) Send limit checking FORTRAN subroutine, LIMIT to the 2250.

MCX : WRITE SUBROUTINE LIMIT:AH:AH
Done

```
MCX: W V
Start variable number? 1
Number of variable? 5
Enter     5 data items: 1,2,3,4,5
 Data written.

MCX: R V
Start variable number? 1
Number of variables? 5

Variables       1 to       5

   1:      1      2      3      4      5

MCX: W B
Buffer number? 1
Number of items? 3
Enter     3 data items: 1,2,3
Communications error     42:     invalid buffer bounds

MCX: DIM(10,1,10)!

No error; no results returned.

MCX: W B
Buffer number? 1
Number of items? 3
Enter     3 data items: 1,2,3
 Data written.

R B 1 3

Buffer data: buffer #      1 first      3 items:

   1:      1      2      3
```

MCX STATUS COMMANDS

STATUS SYSTEM

Interprets the system status that is obtained from secondary address 1 and returns a system status message.

STATUS MAIN

Interprets the status of the main task by reading secondary address 2, and returns a main task status message.

STATUS TASK tasknum

Interprets the status of a resident task by reading secondary address 3, and returns a resident task status message.

STATUS INTERRUPT

Interprets the status of interrupts that have occurred in the 2250 by reading secondary address 4, and returns an interrupt status message.

<u>MCX Status Command Examples</u>

1) Obtain the 2250 system status.

```
MCX: STATUS SYSTEM

System status:
Task number    1 is running:
Port data is available:  A:   0   B:   0   C:   0   D:   10.
```

2) Obtain the main task status.

```
MCX: S MAIN

Main task status:
The task is undefined.
```

3) Obtain the status of task number 1.

```
MCX : STAT TASK 1

Task    1 status:
The task is running at command   2.
```

4) Obtain the interrupt status of the 2250.

```
MCX : STATUS INTERRUPT

Interrupt status:
Programmed srq   1
Programmed srq  30
Programmed srq 127
```

MCX SET COMMANDS

SET RESULTS ON / OFF

Used to determine when MCX will read results from the 2250. *ON* specifies read results immediately, while *OFF* disables reading of the main task result.

SET POLLING OFF / ON time

Used to determine if results are available before MCX attempts to read from the primary address. When *ON*, MCX will poll the 2250 for length of *time* to determine if result is available. *OFF* disables polling.

SET MODE INTEGER / OCTAL / REAL

Determines the output format of the results returned from main result buffer, secondaries, variables, buffers, and ports.

FILE COMMANDS

INCLUDE infile

Specifies that the MCX program is to take its input from a disc file rather than from the terminal. Either MCL/50 or MCX commands can be included in the *infile*.

LOG ON

Used to specify that all output sent to the log device will be copied to a disc file. The *logfile* will include all lines sent to the 2250, as well as all results and messages. *OFF* disables the logging feature.

MCX File Command Examples

1) Include MCX file NUMBER to be shipped to the 2250.

```
   MCX : INCLUDE NUMBER::AH

V1 = %22 ROT 8
V2 = %75 ROT 8
V3 = %67 ROT 8
V4 = %123 ROT 8
V5 = %147 ROT 8
!

No error; no results returned.
```

2) Log all input to file LOGFIL:AH:AH. Resulting logfile is as follows:

```
log on LOGFIL:AH:AH

CLEAR

IN TASK1

TASK(1)
OUT(V1) FO(8,1)
REPEAT (256)
  DO(7,1) 1
  WNOW (0,0,50)
  DO(7,1) 0
  WNOW(0,0,50)
NEXT
!

Run-time error 33 (task not ready to run) occurred at
command 1.

S S

System status:
Task number    1 is running;
Port data is available A:   0   B:   0   C:   0   D:   10

QUIT
```

BUS CONTROL COMMANDS

CLEAR
Sends the clear message to the HP-IB aborting all 2250 processing.

TRIGGER
Sets the HP-IB bus trigger flag (BT) in the 2250 to "1".

SYSTEM CONFIGURATION
CARDS

Request: CARDS

Box 0

Slot	Card	In	Out
8	Relay output		16
7	Digital output		32
6	Multifunction	16	16
5	— — — — —		
4	DAC		4
3	— — — — —		
2	— — — — —		
1	High speed ADC	16	

Box 1

Slot	Card	In	Out
16	Relay output		16
15	Digital output		32
14	Multifunction	16	16
13	Digital input	32	
12	DAC		4
11	— — — — —		
10	Multifunction	16	16
9	— — — — —		

Box 7

Slot	Card	In	Out
64	— — — — —		
63	— — — — —		
62	— — — — —		
61	— — — — —		
60	— — — — —		
59	Lowlevel mux	32	
58	Lowlevel mux	32	
57	High speed ADC	16	

Notes on the CARDS Command

The CARDS command sends an ID (1,128) ! to the Model 2250.

Only card types 1 through 16 and empty slots will be interpreted by MCX.

2250 Systems with several 2251 MCUs (more than 4) may not be able to include their total card configuration into the terminal memory. In this case, you should use the LOG command to log the configuration into a file.

MISCELLANEOUS MCX COMMANDS

HELP OR?

Prints the list of commands and their parameters to the log device.

QUIT

Exit from MCX.

* (Asterisk)

Denotes a comment to follow, and ignore the line. Used mainly for including comments in include files.

/ (Slash)

Causes the last 10 commands entered to MCX to be displayed on the screen for editing of one line and resending of that line.

RUN [program [program parameters]]
Allows user to run a program with out exiting MCX. Useful for editing include files and reviewing LOG files.

MCX Command Stack Examples

1) Display the last 10 commands entered to MCX and position cursor below the last line displayed.

```
   MCX : /

---Requests---
Set mode octal
Set results off
BLOCK AI (1,1,160) !
READ
INCLUDE BEGIN:AH:AH
SYS STAT
READ
\READ (5,1,177) !
READ
Set re on
_                 << Cursor positioned at this line
```

2) Display the last line entered only and position the cursor at that line.

```
   MCX : //

---Requests---
SET RE ON
_                 << Cursor positioned at this line
```

MCX Command Stack Examples Continued

3) Display the last 5 lines entered to MCX, and position the cursor at the first line displayed.

MCX : ////// or MCX: /5

```
---Requests---
SYS STAT              << Cursor positioned at this line
READ
READ (5,1,177) !
READ
SET RE ON
```

```
MCX: CLEAR
HP-IB device clear sent.

MCX: S S

System status:

No results or port data available.

MCX: DI(6,1,4)!

No error: result data:

   1:    0    0    0    0

MCX: DO(6,1,4) 1 1 1 1!

No error; no results returned.

MCX: RDO(6,1,4)!

No error; result data:

   1:    1    1    1    1

MCX: /

- - -Requests- - -
CLEAR
S S
DI(6,1,4)!
DO(6,1,4) 1 1 1 1!
RDO(6,1,4)!
```

MCX: RAM!

No Error; result data:

1: 14916

MCX: RAM
line sent

MCX: !

No error; result data:

1: 14916

MCX: ECHO(5) 1,2 3;4, , ,5!

No error; result data:

1: 1 2 3 4 5

MCX: CARDS

Box 0

Slot	Card	In	Out
8	Relay output		16
7	Digital output		32
6	Multifunction	16	16
5	Multifunction	16	16
4	DAC		4
3	Highlevel mux	32	
2	Lowlevel mux	32	
1	High speed ADC	16	

```
MCX: DIM(100,10,100)!

No error; no results returned.

MCX: IN(B1) ECHO(10) 1,2,3,4,5,6,7,8,9,10 !

No error; no results returned.

MCX: REW(B1) OUT(B1) IN(B0) ECHO(10)!

No error; result data:

 1:      1      2      3      4      5      6      7      8
 9:      9     10

MCX: V1=1 REP(10) B0(V1)=V1 V1=V1+1 NEXT !

No error; no results returned.

MCX: V1=1 REP(10) B0(V1)=V1 V1=V1+1 NEXT SKIP (B0,10)!

No error; result data:

 1:      1      2      3      4      5      6      7      8
 9:      9     10

MCX: RANGE(2,16)1000 CLB(2) REW(B1) IN(B1) AIT(2,16)!

No error; no results returned.

MCX R B 1 1

Buffer data: buffer #     1 first     1 items:

 1:    240
MCX: AIT(2,16)!

No error; result data:

 1:    240
```

MCL/50 and MCX INSTRUCTOR'S GUIDE

I. Introduction to MCL/50

A. What is MCL/50?

1. High-level command language/translater (see Data Sheet in handouts)

2. Communicates with 2250 (2104)

B. How MCL/50 is used

1. ASCII output from a program running in the host computer (See EXAMPLE Program in handouts)

2. Interactively using MCX (Measurement & Control Exerciser)

II. MCL/50

A. Getting started — SLIDE

see Quick Reference Guide for MCL/50

1. Command level 1

see handouts for each instruction

a. ECHO
b. ID
c. RAM
d. RESET
e. SYN
f. SCLOCK
g. RCLOCK

2. Command Syntax — SLIDE

see handouts for details

a. Command name
b. Command parameter group
c. Delimitor
d. In-line data
e. Extended command parameter group
f. ! (BANG) Task terminator

B. Basic digital commands — SLIDE

1. Points

a. DI - Digital input
b. DO - Digital output

2. Fields

a. FI - Field input
b. FO - Field output

3. Output registers — SLIDE

a. RDO - Read digital output
b. RFO - Read field output

4. Examples - slides SLIDE

C. Basic analog commands

1. Analog output see handouts

a. VO - Voltage output, in milliVolts
b. CO - Current output, in microAmperes

2. Analog input see handouts

a. Flowchart of events for Analog Input SLIDE and handout
b. Determine range of channel
c. Set gain
   1) Set RANGE (for MUX card); AON (optional for ADC)
OR 2) Set GAIN (use gain code table) for MUX or ADC
d. Calibrate using CLB command
e. Voltage Input
   1) AI- returns milliVolts

/ 2) AIM- returns microVolts
Optional / 3) AIR- returns HP 1000 real format
Material / 4) AIC- returns raw format, integer pairs
/ 5) AID- returns integer pairs,1st: 25 mVolt units
/ 2nd: 1 uVolt units

III. MCX Measurement & Control Exerciser SLIDE

A. Flow of events using Host computer program (not MCX) SLIDE

1. EDIT(R) user program (BASIC,ASMB,FTN4,FTN4X)

2. Program is compiled/assembled in host computer

3. Program object code is relocated using LOADR

4. Program is executed in host computer

a. Program outputs ASCII strings to 2250 lu.
   Strings are MCL/50 commands to 2250
b. Program accepts return codes and results from 2250 lu

B. Alternate Method - MCX

1. Invoke MCX

a. Use command string file from editor.(INFILE parameter)
b. Use interactively

2. EDIT command string

3. Transfer control to command file using INCLUDE command

C. MCX SLIDE

1. Invoking - see quick reference guide (handout)

2. Syntax

handout

a. Prompt (MCX:)

b. MCL/50 or MCX commands may be used
c. Commands may be abbreviated

3. Commands SLIDE

a. Cards - system configuration SLIDE,handout
b. Read SLIDE,handout
c. Write SLIDE,handout
d. Status SLIDE,handout
e. Set SLIDE
f. File SLIDE,handout
g. HP-IB SLIDE
h. Misc. SLIDE
i. Command Stack handout

** Three example handouts of well-documented MCX tasks.

Topics which may be encountered during discussion of MCX:

Variables, buffers, ports, secondary addresses, polling, result mode, and task states & diagrams

These topics may be further expounded upon at the discretion of the instructor, based on his perception of the interest level and competance of the students and the time remaining for discussion.

Time for actual hands-on use of MCL/50 and MCX should be allotted for the students to become more familiar with the subsystems.

Included here are some labs which may be used for this purpose. Some example MCX tasks, similar to the output desired of the labs, are provided as reference for the labs.

The consolette provided with the training system will make these labs much simpler to implement.

Digital output should be directed to slot 6 with a field of points from 1 to 16.

Analog output (Voltage Output) should be directed to slot 4, channnels 1 and/or 2 to monitor voltage output on the meters of the consolette.

INTRODUCTION

TO

HP-MCL/50

MEASUREMENT AND CONTROL LANGUAGE

HEWLETT PACKARD

HP-MCL/50 (Measurement and Control Language)

112 commands total
look at 56

Features

- Local intelligence with over 100 application-oriented commands
- Real-time operation decoupled from the computer to provide predictable performance
- Multi-task environment
  - local storage and execution of compiled tasks
  - tasks scheduled by external events or the host computer or time and time interval
- Built-in data reduction and decision making capabilities
  - data automatically converted to engineering units
  - thermocouple linearization and conversion to °C
  - arithmetic, boolean, logical operations on user data
  - decision making based on both analog and digital limit conditions
  - high-level control structures for program branching and looping
- Downloaded HP-1000 FORTRAN or Assembler subroutines for customized data reduction, filtering, and control algorithms
- Continuous data acquisition up to 50,000 samples per second, with local buffering
- Accurate, hardware-controlled synchronization and pacing of analog and digital inputs and outputs
- Built-in time-of-day clock and watchdog timer for system integrity
- History data acquisition up to 50,000 samples/second
- Flexible management of 28K bytes of user memory for tasks and data buffers
- Built-in processor self-test
- Computer independent programming for compatibility with a wide variety of computers

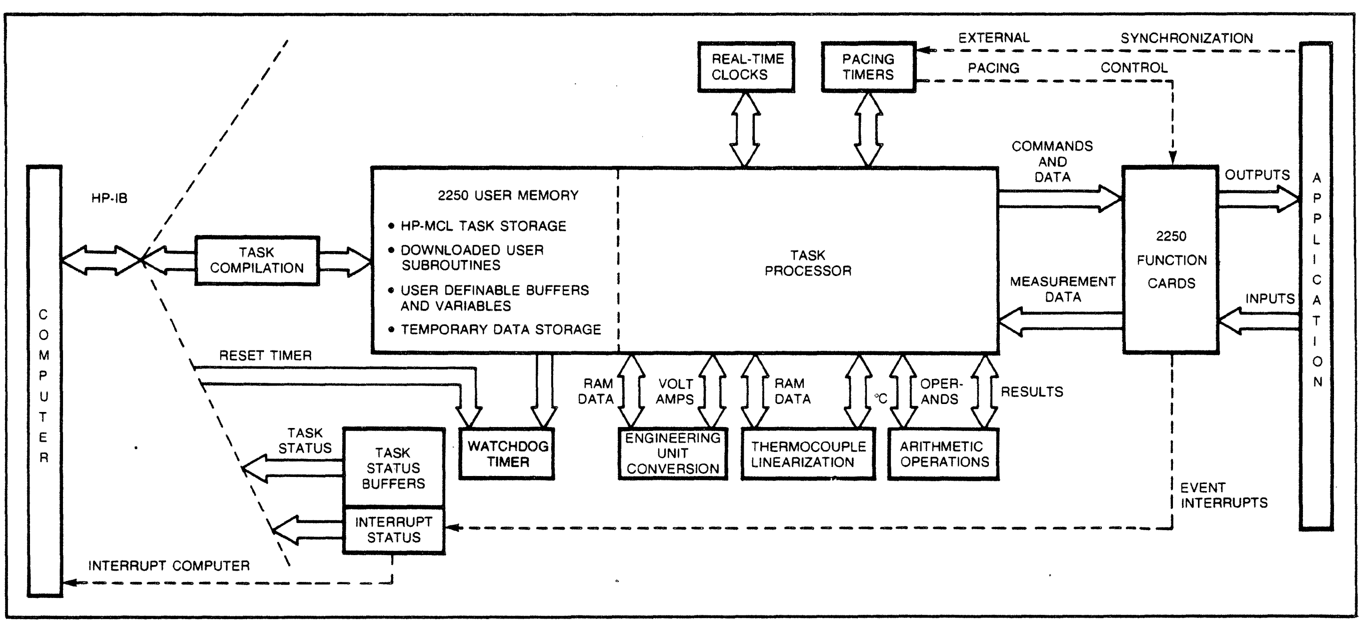
Applications

HP-MCL/50 allows the user to easily program the 2250 to perform the specific automation tasks required for an application. With HP-MCL/50, the timing of 2250 tasks can be completely decoupled from that of the computer. This leaves the host computer free to perform other operations, thus increasing total system throughput.

Description

HP-MCL/50 is a high level Measurement and Control Language designed for use with the 2250. With HP MCL/50, the 2250 is microprogrammed to accept complete tasks from the computer, compile the commands, and then execute those tasks in the real-time environment of the user's system. Tasks may include such functions as periodically gathering a group of measurements, converting the data to engineering units (volts, amps., °C), starting a control sequence at a specified time or time interval, and decision-making for closed-loop control. The 2250 is also capable of executing stored FORTRAN digital filtering or control algorithms that were previously compiled and prepared on an HP 1000 computer. All data is transferred in binary format.

The speed of measurements and control operations may be internally or externally paced on a scan or channel level. A high-speed, continuous acquisition mode allows simultane-



2250 FUNCTIONAL BLOCK DIAGRAM

ous buffered data gathering and transmission. Multiple tasks may be compiled and stored locally for later execution. Tasks may be scheduled upon interrupt from a function card or on command from another request or task. Other capabilities include history data acquisition, analog offset correction, time-of-day clock, and built-in processor self-test.

The firmware to implement HP-MCL/50 is stored in 16K words of ROM on the 2250 memory card.

Summary of HP-MCL/50 capabilities

- **Analog/digital I/O commands**
  - Easy to recognize, applications oriented
  - Separation of commands and data for convenient updating of output variables
  - Programmable analog gains
  - Parallel measurement and control operations
  - User selectable computer data formats

- **Synchronizing, timing, and pacing commands**
  - Time-of-day clock
  - Programmable internal pacing of all function cards
  - Synchronizaion with computer or external events

- **Built-in application utilities**
  - Automatic engineering unit conversions
  - Thermocouple linearization/conversion to °C (includes reference junction compensation)
  - Watchdog timer to determine system integrity

- **Application task development/control/ supervision commands**
  - Looping (REPEAT-NEXT)
  - IF...THEN...ELSE structures for decision making
  - Analog limit checking (> , <, etc.)
  - Flexible internal buffer management
  - Arithmetic capabilities: +, −, ×, ÷
  - Logical and Boolean operations AND, NOT, XOR, etc.
  - Bit manipulation routines

- **Multi-task capabilities**
  Local storage of compiled tasks task execution initiated by:
  - HP-MCL/50 GOSUB command
  - External interrupt (from function card or computer)
  - Automatic background task scheduling
  - Watchdog timer alarm

- **Optional execution of customized downloaded FORTRAN subroutines**
  - For data reduction, filtering and digital control algorithms
  - Callable from HP-MCL/50 task
  - Includes library calls such as SORT(X) and SIN(X)
  - FORTRAN or HP 1000 ASSEMBLY LANGUAGE
  - Computation using real numbers

- **System level control and data handling structures**
  - Optional user defined variables and buffers
  - Direct access to variables/buffers from the host computer, for updating control values without affecting the current task
  - Multiple communications ports for complex data handling applications (memory exchange)

- **Hardware configuration, status, control, test, and verification commands**

- **Flexible error handling and recovery**

Summary of HP-MCL/50 commands

Command	Description
• AAVERAGE	average analog buffer
ABORT	enable task abort
• AI	analog input
• AIC	analog input card format
• AID	double word analog input
• AIM	microvolt analog input
• AIR	real analog input
• AIT	read reference temperature
AND	bit masking operator
• AOFF	autorange off
• AON	autorange on
• BLOCK	permit multiple reading from one point
CALL	call subroutine
• CASE	multi-path branching
CBUFFER	declare CONVERT data source and destination
CCONTROL	counter card control
CFN	counter card configuration
• CLB	calibrate analog input
CLR	clear bit logical operator
CMP	logical bit complement operator
CNUM	set counter card average mode
• CO	output analog current
CONVERT	convert raw data to engineering units
COUNT	read multifunction card counter
• CPACE	set channel mode pacing
• CTIMER	clear task timer
CTL	write card configuration register
DCOUNT	read double word count
• DI	read digital input point
• DIMENSION	declare variables and buffers
• DO	digital point output
DREAD	double word read from register
DWRITE	double word write to register
EFCN	counter card configuration
• ECHO	verify communications
EOFF	disable immediate-execute mode
EON	resume normal execution of commands
EXECUTE	trigger delayed data transfer
• EXIT	exit a repeat loop
FCI	function card interrupt
• FI	read digital input field
• FO	digital field output
• GAIN	set analog gain
GOSUB	run subtask
• GOTO	unconditional branch
• ID	MCU and function card identification
• IF	relational branching
• IN	store define where input is to go
INTERRUPT	enable or disable function card interrupt
IOR	bit masking operator
ITASK	assign interrupt handling task
• LABEL	program control label
MOD	remaindering operator
• NTASKS	define number of tasks
ONERROR	go to LABEL upon error
• OUT	take output data from specified location
• PACE	set scan mode pacing
• PAUSE	suspend task
PCONTROL	pulse channel control
PNUMBER	set pulse number
POC	pulse channel configuration
PRATE	pulse rate configuration
PRESET	preset multifunction card counters
• PTIMER	pause for task timer
• RAM	read amount of available memory
• RANGE	set analog range

Command and Description	
RBIT	read card register bits
RCFN	read counter card configuration
• RCLOCK	read time of day clock
RCNUM	read counter card average
RCOUNT	read single word count with re-start
RCS	read card status
RDCOUNT	read double word count with re-start
• RDO	read digital output configuration
READ	single word read
• REF	read and set reference temperature
• RELEASE	release stored data to port
• REPEAT	repeat a sequence of commands
• RESET	system reset
• REWIND	rewind buffer
• RFO	read digital output field configuration
• RGAIN	read analog gain
RINTERRUPT	read interrupt configuration
ROLL	set multifunction counter rollover
ROT	logical rotate operator
RPRESET	read multifunction counter preset
RPREM	read number of remaining pulses
• RTIMER	read task timer
• SCLOCK	set clock
SENSE	define interrupt transition sense
SET	set bit logical operator
• SKIP	move buffer pointer
SOVERRIDE	override transition sense for interrupts
• SRQ	request service from computer
• START	schedule task
• STOP	stop task
• SYN	system normalize
• TASK	define resident task
• TTEMP	read thermocouples
TRANSFER	set up for input or output of unchanged data
• TREF	set thermocouple reference temperature
TSTAT	task status
• VO	output integer voltage
• WATCHDOG	set watchdog timer
WBIT	write card register bits
WEXT	wait for external strobe
• WNOW	wait now
• WPACE	wait for pace pulse
WPOINT	wait for digital input point
WRITE	single word write
• WTIMER	wait for task timer
XOR	bit masking operator

HP-MCL/50 Example

`PACE (1, 20,.0)`	Set Internal Pacer = 1.020000 sec.
`IN(B1)`	Place data in buffer B1.
`WEXT; AI(1,1,16)`	Synchronize with an external trigger, using a dummy READ.
`REPEAT (0)`	Repeat indefinitely.
`  REWIND (B1); IN(B1)`	Prepare buffer for data.
`  WPACE`	Wait for internal pace signal.
`  AI(1,1,16)`	Store 16 analog inputs (pressures) in B1.
`  IN(B2); JTEMP(1,17)`	Read temp. from J-type thermocouple and
`  RCLOCK`	Read time-of-day clock into Buffer B2.
`  CALL GRAD(B1,B2)`	Call downloaded FORTRAN pressure gradient routine and put coefficients into B2.
`  RELEASE(B2,A)`	Return temperature, time-of-day and gradient coefficients to the computer using 2250 Port A.
`  IF B2(1) < 2000 THEN`	
`    V2 = B2(1) - V1`	
`    V2 = V2/12`	Limit check temperature - if <200°then compute a new valve position and
`    OUT(V2); CO(5,1)`	output the current (mA.) stored in V2.
`  ELSE`	If > =200 then turn on 4 display lights. Alert the computer of the Alarm Condition
`    DO(6,1,4) 1,1,1,1`	by sending an interrupt #1.
`    SRQ(1)`	
`    GOTO(5)`	Goto Label (5).
`  ENDIF`	
`  IF V9=1 THEN EXIT`	Watch for computer to terminate the task by asynchronously setting V9 to 1. Then exit to LABEL(5).
`  ENDIF`	
`NEXT`	
`LABEL(5)`	
`GOSUB(3)`	Run shutdown task 3 immediately.
`START(4)!`	Schedule background monitoring task #4.

TASK CONTROL

SPECIFY NUMBER OF TASKS

NTASKS (maxnum ,maxlinks)

maxnum - number of resident tasks

maxlinks - number of interrupt tasks

DEFINE A RESIDENT TASK

TASK (task number[, priority[, type]])

task number	number that the task will be referenced with.
priority	determines the execution priority of the task. Lower the number the higher the priority. (default is 99)
type	0=no special characteristics. (default) 1=task will execute upon auto restart.

START (task number)
SCHEDULES A TASK FOR EXECUTION

STOP [(task number)]
unschedules a task

2250 COMMAND SYNTAX

AI (1,2,3); VO(5,3,2) 100,200 (5,3,2) 300,400 !

Terminator

Extended Command Parameter Group

In-Line Data

Delimator

Command Parameter Group

Command Name

Command Name

AI (1,2,3); VO (5,3,2) 100,200 (5,3,2) 300,400 !

All MCL commands start with a command name, with some commands consisting of the name and nothing else.

The 2250 accepts upper case or lower case letters, and requires only the first three of those letters.

Commands that are documented as having only two letters, however, must be written as specified (such as the DI and VO commands).

Legal Characters and Delimiters

A through Z	Legal characters: interchangeable with a through z
a through z	Legal characters: interchangeable with A through Z
0 through 9	Legal characters
+ - * /	Arithmetic operators
= # > <	Relational operators
-	Prefix to negative constant
+	Prefix to positive constant: not required
%	Prefix to octal constant
([{	Parameter delimiters: opening, interchangable
)] }	Parameter delimiters: closing, interchangable
.	Decimal point for floating-point constants
: , ; blank	General delimiters
!	End of task

Illegal Characters

" $ & ' ? @ \ ^ ` | ~

Nonprinting control characters (except CR and LF)

Numbers and Their Formats

Numbers sent to the 2250 primary address must be integer with character type ASCII.

Any fixed point numbers will be rounded to the nearest integer value (3.5 = 4 and 3.4 = 3) and floating point numbers (3.5E3) will not be accepted.

Numbers sent to any secondary addresses must be formatted in 2's compliment binary integer.

Numbers returned from the primary or secondary addresses are generally 2's compliment binary integer.

The AIR command will return HP 1000 real-formatted data. These values can be read from the primary or secondary addresses using unformatted FORTRAN READ statements into a real variable.

Command Parameters

AI (1,2,3); VO (5,3,2) 100,200 (5,3,2) 300,400 !

Command parameters can be, for example, the slot number, starting channel, and number of channels of an input or output command, or the hours, seconds and milliseconds of a timing command.

The command parameter string must follow the command name (except for extendable commands), and must be enclosed in parentheses, brackets, or braces.

Most command parameters must be constants except where the command description states differently.

Delimitors are required between parameters (commas are used for legibility).

Some parameters are optional and therefore may be ommitted. The command description will state the default value for the parameter.

Notes on Delimitors

AI (1,2,3); VO(5,3,2) 100,200 (5,3,2) 300,400 !

Legal delimeters are: ([{)] } * , ; blank

In most cases, multiple general purpose delimitors may be used any number of times, except between letters of command names or between digits of a data item. The 2250 will store the extra delimitors into the main task buffer, but will throw them out at compilation time.

Example:

Legal:

```
AI          (1,     2,     3)
AI (1,2,3):::::AI(2,1,2)
AI (1    2     3)
AI (1,,,,3:::::3)
```

Illegal:

```
A I (1,2,3)
AI ((1,2,3))
```

In-Line Command Data

AI (1,2,3); VO (5,3,2) 100,200 (5,3,2) 300,400 !

If a command directs the 2250 to put signals on output channels, the signal data can be sent in the form of in-line data items appended to the command.

Data items must have delimiters between them. Commas or blanks will do, but commas are more legible.

No delimiter is required after the parameter string (5,3,2) because the closing parenthesis is recognized as a delimiter.

Extendable Commands

AI (1,2,3); VO (5,3,2) 100,200 (5,3,2) 300,400 !

Many MCL commands are extendable, meaning that when a command is to be used again for a different slot or channel and they are not sequential, for example, the command parameter group and data can be specified without providing the command again.

The above example shows two voltages output to slot 5, channels 3 and 4. The first voltage output is 100 and 200 millivolts. The second voltage output is 300 and 400 millivolts.

The commands could have been provided as follows:

VO (5,3,2)100,200; VO (5,3,2) 300,400

Extendable commands can be extended indefinitely and there is no limit to the number of extensions acceptable after a command name, as long as no other command name intervenes.

Extendable commands are faster and occupy less memory; therefore, the extended form of the command is the preferred form.

Task Terminator

AI (1,2,3); VO (5,3,2) 100,200 (5,3,2) 300,400 !

The task terminator (sometimes referred to as "The BÀNG") marks the end of every task. The 2250 starts compiling the task as soon as it receives the terminator.

The BANG must be the last significant character of a task sent to the 2250. Blanks and control characters (CR and LF) are not significant. The EOI signal must be set true to indicate that the message has been completed.

The HP 1000 will assert the EOI line automatically. Desktop computers, however, must use the EOI command to direct the desktop to assert the EOI line after the 2250 message has been sent.

If there are two tasks with terminators in one data message, the 2250 will accept the entire message, but will compile and run only the task preceding the first terminator.

EXAMPLE:

```
AI (1,2,3); VO (5,3,2) 100, 200! VO (5,3,2) 300, 400!
                                                    ^
                                           EOI Asserted
```

Everything before the first BANG is compiled and executed, and everything between the first and last BANG will not be compiled at all.

COMMAND MODIFIERS

Command modifiers change the meaning of parameters or the manner in which a command executes.

EXAMPLE:

AI (1, 2, 3) reads channels 2, 3, and 4.

Number of sequential channels

Starting channel number

BLOCK: AI (1, 2, 3) reads channel 2, three times.

Number of readings for the channel

Channel number to read

EXAMPLE:

BLOCK: AI (1, 2, 12); AI (1, 4, 12) reads channel 2, twelve times & read channels 4 through 15.

TRANSMISSION TERMINATION

- ! "the Bang" marks the end of a task
- CR and LF are not significant
- EOI must be set true to indicate the completion of the message
- HP 1000 asserts EOI automatically
- Desktops must be programmed to assert the EOI command. This does not happen automatically.

GETTING STARTED WITH MCL

Use the ECHO command to verify communications on the interface bus.

ECHO (number of items) item1, item2, ... itemn

Use the command ID to verify what types of function cards are present in the 2250 system.

ID (starting slot [, number of slots])

Use command RAM to return the amount of user memory remaining for compiling tasks and storing tasks and data.

RAM

1) Power up
2) RESET!
3) SYN!
4) CHECK([illegible])
just stops task execution

Use the command RESET to initialize the 2250 by executing the self-test and resetting the state of the function cards to their power-on state.

RESET

Use the command SYN to deliver a normalize signal to all function cards, and therefore set all cards to their power-on condition.

SYN

Use the SCLOCK and RCLOCK commands to set and read the time of day clock.

SCLOCK (hours[, seconds[, milliseconds]])
RCLOCK

BASIC DIGITAL COMMANDS

Read sequential single point digital inputs.

DI (start slot, start point, [,number of points])

Write the least significant bit of output data to sequential single point digital outputs.

DO (start slot, start point, [,number of points])

Read sequential 16 point fields of digital input.

FI (start slot, start field [,number of fields])

Write sequential fields of 16 digital output data.

FO (start slot, start field [,number of fields])

BASIC DIGITAL COMMANDS

(Continued)

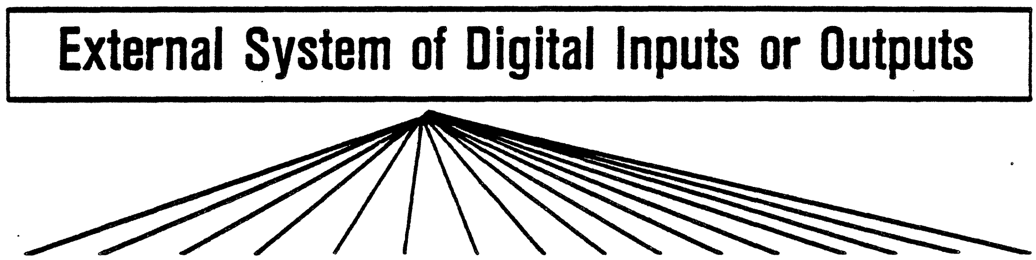
Read current output state of sequential points.

RDO (start slot, start point [,number of points])

Read current output state of sequential fields.

RFO (start slot, start field [,number of fields])

DIGITAL POINTS AND FIELDS



Point Number>	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Bit Number >	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

1 Field of 16 Points

BINARY

0 000 000 001 101 111

OCTAL

157

DECIMAL

111

2250 DIGITAL I/O EXAMPLES

1) To set points 1 and 16 in slot 6 of MCU ∅

DO (6,1) 1; DO(6,16) 1 !
or
DO (6, 1) 1 (6,16) 1 !
or
FO (6,1) %100001 !

octal

2) To determine the state of points 17-24 of a digital input card in slot 7 of MCU 1

DI (15, 17,8) !
or
FI (15,2) !

3) To read the state of digital points for the 25511A in slots 1-3 and for the 25516A in slot 4 of MCU 7

DI (57,1,112) ! (uses 112 words of memory)
or
FI (57,1,7) ! (uses 7 words of memory)

READ ANALOG INPUT

AI (start slot, start channel, [,# of channels])
Return voltages from the specified channels in millivolts.

AIM (start slot, start channel [,# of channels])
Return voltages from the specified channels in microvolts.

AIR (start slot, start channel [,# of channels])
Return voltages from the specified channels in HP 1000 Real Format.

AAV (firstword, numwords, average)
Computes the average of two or more single word input readings (AI, AIM, tTEMP, or AIT) and stores that average in the variable **average**.

READ ANALOG INPUT
(continued)

AID (start slot, start channel, [,# of channels])

(useful for high accuracy and large magnitude voltages)

Return voltages from the specified channels in integer pairs.

Word 1	Voltage in units of 25 millivolts
Word 2	Remainder in units of 1 microvolts

VOLTS = WORD 1 * 25000 + WORD 2 microvolts

READ ANALOG INPUT

(continued)

AIC (start slot, start channel [,# of channels])

Return voltages in raw card format from the specified channels in integer pairs.

(only 14 bits used)

Word 1		Most Significant Bits of Data	
	15		0

Bit 7 = 1 if out of range

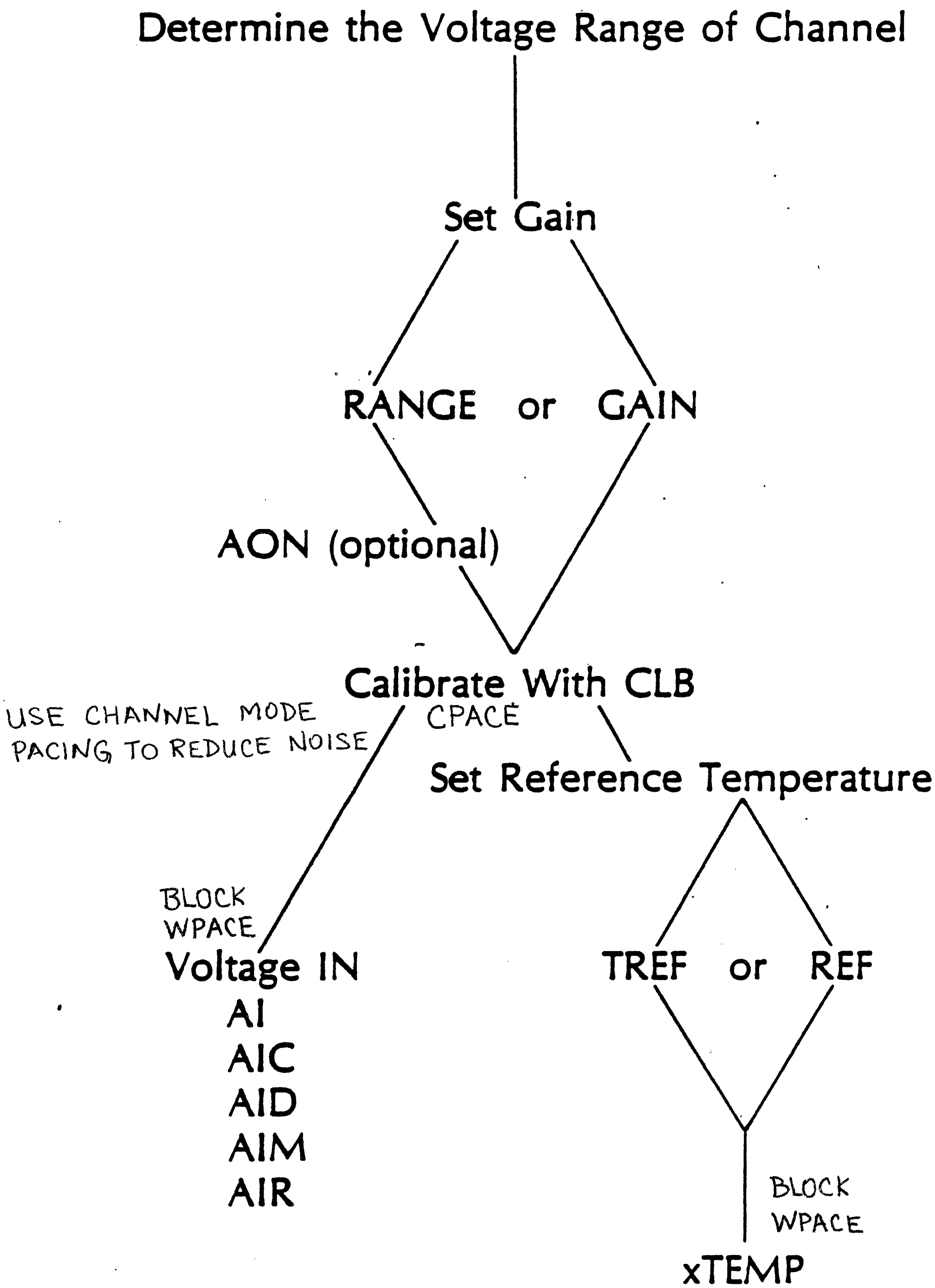
(reserved for future)

Word 2	LSB's of Data		ADC Gain	MUX GAIN
	15 8	7	6 3	2 0
			10	010

N = IAND (17B, ISHFT (Word2, -3)
M = IAND (7B, WORD2)

VOLTS = (WORD1* 256.0 + ISHFT(WORD2,-8)) * (0.5**(N+1)) * (0.1**M)

ANALOG INPUT



AVERAGE THE READINGS AAV ( )

SET ANALOG RANGE

EASIER

RANGE (start slot, start chan. [,# of channels]) range1 . . . rangen

Setting the range amounts to setting the range of each input channel (in millivolts) to the highest level you expect to encounter on that channel.

FASTER

GAIN (start slot, start chan. [,# of channels]) gaincode 1...gaincode n.

Setting analog input gain for a given input voltage range.

RGAIN (start slot, start chan. [,# of channels]) will read the current setting of analog gain.

"1250"

Analog Input Function Card	MUX Gain	Input Ranges (Volts)			
HP 22501A 16-Channel High-Speed ADC	—	1.25	2.5	5.0	10.0
HP 22502A 32-Channel High-Level MUX	1.0	1.25	2.5	5.0	10.0
HP 22503A 32-Channel Low-Level MUX	100.	0.0125	0.025	0.05	0.1
	10.	0.125	0.25	0.5	1.0
	1.0	1.25	2.5	5.0	10.0
HP 22504A 16-Channel Relay MUX	100.	0.0125	0.025	0.05	0.1
	10.	0.125	0.25	0.5	1.0
	1.0	1.25	2.5	5.0	10.0
	0.1	12.5	25.0	50.00	100.0
ADC gain for each range shown above		8	4	2	1

DIRECT ANALOG INPUT

GAIN (start slot, start channel, ⌊,# of channels⌋) gaincode1...gaincoden

Using the gain code allows you to directly program one or several channels to specified gain or to autorange one or several channels. This command applies to any MUX or ADC card.

The GAIN command is faster than the RANGE command and uses less memory than the RANGE command, but is not as convenient as the ANGE command from a programmers point of view.

All error checking is done for RANGE at compile time but not for the GAIN command.

ANALOG INPUT RANGES AND GAIN CODES

Function Cards	Range (volts)	Resolution	Gain	Octal Gain Codes			Decimal value
				ADC	MUX	value	
D	100.0*	12.5 mV	0.1	(1) 14	1	141	97
D	50.0*	6.3 mV	0.2	(2) 15	(.1) 1	151	105
D	25.0	3.1 mV	0.4	(4) 16	1	161	113
D	12.5	1.6 mV	0.8	(8) 17	1	171	121
A B C D	10.0	1.25 mV	1	14	2	142	98
A B C D	5.0	625 uV	2	15	(1) 2	152	106
A B C D	2.5	313 uV	4	16	2	162	114
A B C D	1.25	156 uV	8	17	2	172	122
C D	1.0	125 uV	10	14	3	143	99
C D	.5	63 uV	20	15	(10) 3	153	107
C D	.25	32 uV	40	16	3	163	115
C D	.125	16 uV	80	17	3	173	123
C D	.1	12.5 uV	100	14	4	144	100
C D	.05	6.4 uV	200	15	(100) 4	154	108
C D	.025	3.2 uV	400	16	4	164	116
C D	.0125	1.6 uV	800	17	4	174	124
Autoranging:							
D	100.0	Refer to lists		14	1	341	225
A B C D	10.0	above for the		14	2	342	226
C D	1.0	range selected		14	3	343	227
C D	0.1	by autoranging		14	4	344	228

Function Card Types:
A = HP 25501A 16-Channel High-Speed ADC
B = HP 25502A 32-Channel High-Level MUX
C = HP 25503A 32-Channel Low Level MUX
D = HP 25504A 16-Channel Relay MUX

*NOT UL APPROVED

CALIBRATE
ANALOG INPUT

also done at powerup and RESET!

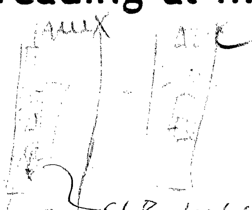
(0) - whole system

CLB (slot number of ADC or MUX card)

The calibrate command updates the correction factors for all input channels on the specified card and stores the calibration constants into 2250 memory.

CLB (0) will calibrate all analog input channels.

It is a good idea to issue the CLB command about every 15 minutes for high accuracy. Issue it immediately before taking a reading at maximum accuracy.



AUTORANGING

CLB looks at this zero input so input mux is [illegible] we're not checked

AON (slot number of ADC card)

Autorange all ADC channels on the ADC card and for any multiplexer that uses the ADC card, regardless of the programmed gain.

AON allows the ADC to change its gain to 1, 2, 4, or 8.

The RANGE command affects the gain of the ADC and MUX cards, while the AON command affects only the ADC gain, i.e. MUX cards don't autorange.

AOFF (slot number of ADC card) will cancel ADC autoranging.

power on condition is AOFF

ANALOG OUTPUT COMMANDS

Voltage Out

VO (start slot, start channel [,# channels]) mvolts1,...,mvoltsn

Current Out

CO (start slot, start channel [,# channels]) uamps1,...,uampsn

READING TEMPERATURES

Before using any of the thermocouple temperature reading commands, you must first establish a reference temperature with either the REF or TREF command.

REF (slot, channel)
Establishes the reference temperature for all thermocouples connected to the same isothermal block.

TREF (temperature in tenths of a degree Celcius)
If using a known reference temperature from an ice-bath or oven, use the TREF command to establish the temperature.

You may have to issue the REF command more than once, as each isothermal block has room for only 15 connections.

AIT (slot, channel)
Reads the TRC reference output in tenths of a degree Celcius.

READING TEMPERATURES
(continued)

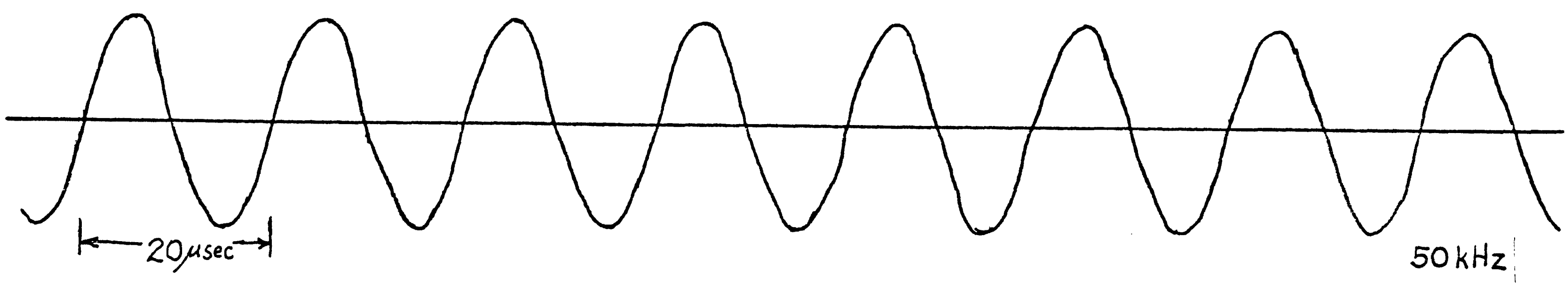
xTEMP (start slot, start channel [,# of channels])

x = B, E, J, K, R, S, or T

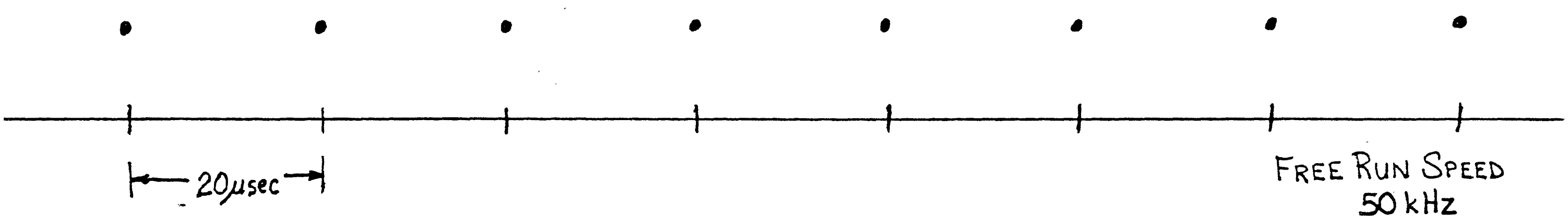
The commands perform linerarization of thermocouple readings, returning the temperatures in tenths of a degree Celcius.

The last temperature set with the REF or TREF command determines the reference temperature used by the linearization routines.

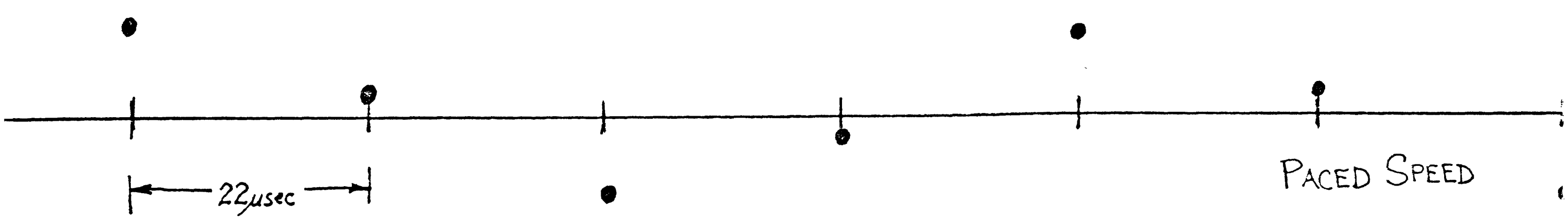
NOISE



READINGS WITH NO PACING



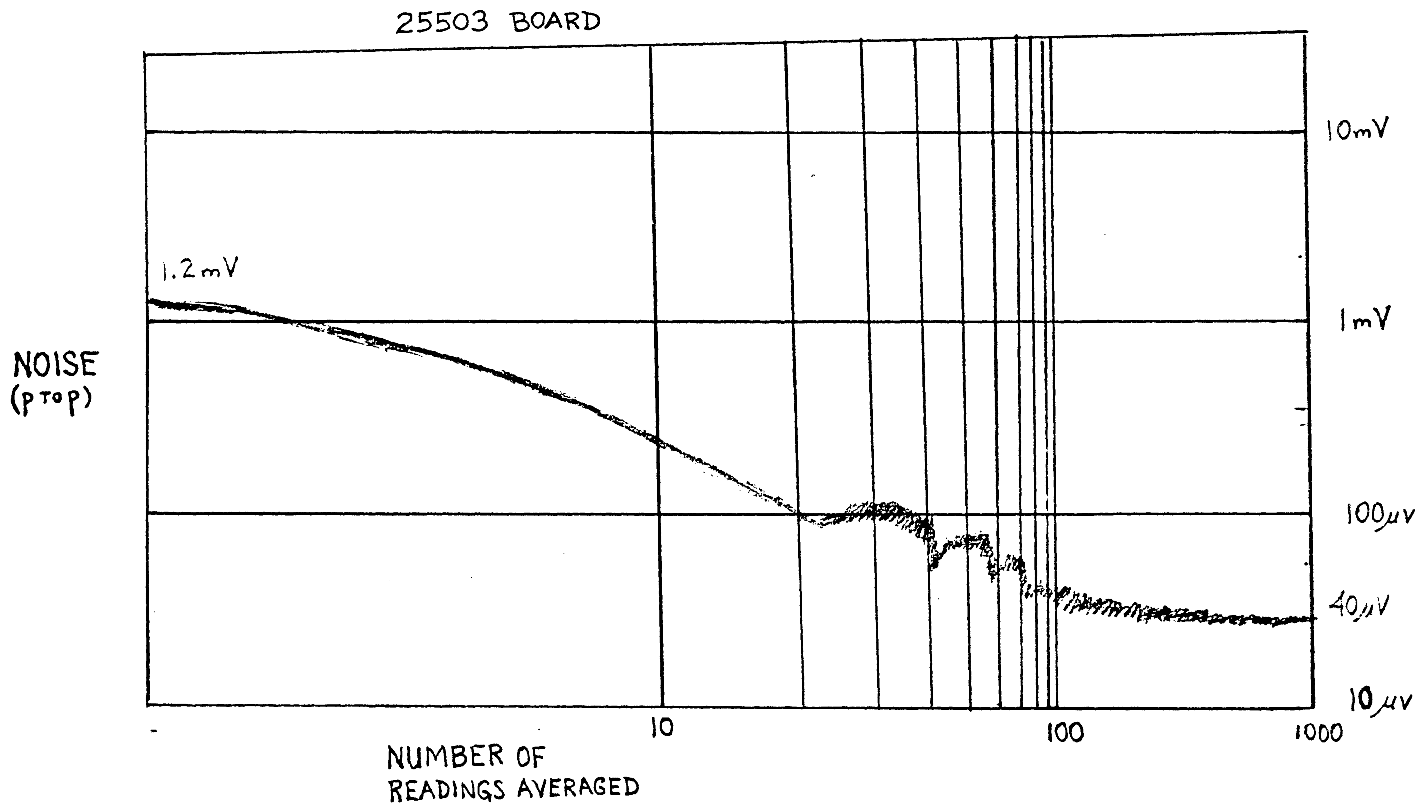
READINGS WITH PACING



NON-PACED READINGS → NOISE OFFSET

PACED READINGS → NOISE CAN BE AVERAGED OUT

AVERAGING



BY USING AVERAGING, NOISE IS REDUCED BY $1/\sqrt{N}$

WHERE N = NUMBER OF READINGS

[USE PACING WHEN AVERAGING READINGS]

VARIABLE AND BUFFER NAMES

Variable Names

Vn n = a number equal to or less than the number of variables declared in the DIM command.

Buffer Names

Bn n = a buffer number within the declared DIM command limit.

BVm Vm = an MCL variable containing the number n.

INITIALIZING BUFFERS AND VARIABLES DIMENSION COMMAND

DIM [(#variables, #buffers, buffer1 size [,,,buffern size])]

Clears and reconfigures user memory, sets the number of variables available, an declares the number of buffers and their size

VARIABLES ≥ 10

ECHO IS A GOOD WAY TO INITIALIZE BUFFERS

IN(B3) ECHO(5) 1, 2, 3, 4, 5 !

INITIALIZES THE FIRST FIVE WORDS OF B3 to 1, 2, 3, 4, 5 RESPECTIVELY

DIMENSION COMMAND EXAMPLES

1) **DIM !**

Define 10 variables and no buffers.

2) **DIM (20,10,100,100,10) !**

Allocates memory for 20 variables, and 10 buffers. Buffers 1 and 2 will be 100 words each, and buffers 3 through 10 will be 10 words each.

3) **DIM (5,10,10) !**

Will not compile and will return a compile error of 2. Why?

can't have < 10 variables

4) **DIM (0) !**

What will this task do?

compile error at ! can't have < 10 variables no way to find buff ptr. if loose track

BUFFER MANAGEMENT COMMANDS

REWIND Moves the current location pointer back to the start of the buffer (location zero). The buffer will not be cleared.

SKIP Moves the current location pointer past the specified number of words in the specified buffer.

RELEASE Releases the buffer contents to a port for transmission to the host computer.

IN Data for the following input commands will be read from the measurement cards and written into the specified buffer.

OUT Date for the following output commands will be read from the specified buffer and written to the addressed measurement cards, unless in-line data is appended to the command.

if IN or Out are being used in a loop w/pause good practice to have IN/Out inside loop cuz when pause main task can get in which will redefine IN/out to be BØ so when you go back to res. task loop, will try to access BØ which is illegal

BUFFER INDEXING

Bk(i)	i = a number which, when added to the position of the buffer IN/OUT pointer, references a buffer element within the bounds set by the DIM command.
BVk(i)	Vk = an MCL variable containing buffer number k.
Bk(Vj) or **BVk(Vj)**	Vj = a variable containing index number

BUFFER POINTERS AND INDEX NUMBERS

set to 0th element after DIM

—Pointer——→

Buffer n

Word 1	Bn(1)
Word 2	Bn(2)
Word 3	Bn(3)
Word 4	Bn(4)
Word 5	Bn(5)
•	•
•	•
•	•
Word n	Bn(n)

The pointer increments one count before each word IN or OUT

Buffer state after a DIM REWIND, or RELEASE command.

Buffer n

	Word 1	Bn(-3)
	Word 2	Bn(-2)
	Word 3	Bn(-1)
Pointer→	Word 4	Bn(0)
	Word 5	Bn(1)
	•	•
	•	•
	•	•
	Word n	Bn(n-4)

Buffer state after an IN or OUT of 4 words

Buffer index relative to buff. ptr.
buffer index can be < 0 if resulting location is > 0

BUFFER MANAGEMENT EXAMPLES

Assume DIM (10,10,100,10) for examples 1 through 4.

1)	REWIND (B1)	
	IN (B1) AI (6,1,16)	Read 16 voltages into buffer 1
	RELEASE (B1,A) !	Release the buffer to port A
2)	IN (V1)	Read 5 voltages into variables
	AI (6,1,5) !	1 through 5.
3)	IN (V5)	
	RCLOCK !	What will happen? OK since V5 + V6 ... 6 words
4)	REWIND (B2)	A run-time error of 27 will occur.
	IN (V1)	Why?
	AI (6,1,5)	
	B2(1) = V1	
	B2(2) = V2	
	B2(3) = V3	
	B2(4) = V4	need set P(B2+4)
	RELEASE (B2,D) !	

BUFFER "GOTTCHAS"

1. Buffer indexing is **relative to current buffer position.**

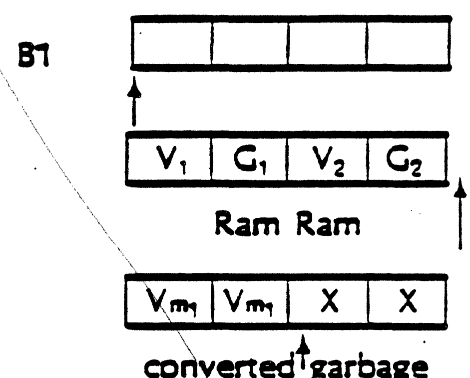
2. Be careful converting analog output from buffers.

```
OUT (B1)
VO (4,1,3)  <----------  converts data to internal format
                         before doing output
REWIND (B1)
VO (4,1,3)  <----------  gets error — data in wrong format

OUT (B1)
VO (4,1,3)
REWIND (B1)
TRANS VO (4,1,3) <-----  no conversion, so OK
```

3. Buffer must be twice as large to do an AI

```
IN (B1)
AI (1,1,2)
```



4. RCLOCK modifies 6 words in the buffer, although it returns 4 words.

ARITHMETIC AND LOGICAL OPERATIONS

In MCL tasks, arithmetic and logical operations can be performed on data contained in MCL variables or indexed buffer elements

Result = Operand1 operator Operand2

+	Add operand1 to operand2
−	Subtract operand2 from operand1
*	Multiply operand1 by operand2
/	Divide operand1 by operand2
AND	Bit-by-bit logical "and"
IOR	Bit-by-bit inclusive "or"
XOR	Bit-by-bit exclusive "or"
ROT	Rotate operand1 left or right by operand2 value — neg value - shift left / pos value - shift right
BIT	Obtain operand1 bit value specified by operand2
SET	Result becomes operand1 value with bit #operand2 set to 1
CLR	Result becomes operand2 value with bit #operand2 cleared to 0
CMP	Bit-by-bit logical complement of operand2 (16 bit 1's complement) XOR w/ -32,767
NOT	Complement of lsb in operand2 and set all other bits to 0
MOD	Remainder of integer divide of operand1 by operand2

CONTROL STRUCTURES

The MCL/50 firmware allows setting up control structures that branch (or loop) depending on arithmetic comparisons, a test for HP-IB trigger, or tests of external conditions.

IF operand1 relation operand2 [THEN] * [ELSE ***] ENDIF**

CASE operand (#, label) ... (#, label)

GOTO (label #)

LABEL (label #)

REPEAT (#times) * NEXT**

EXIT

CONTROL STRUCTURE
EXAMPLES

1) Copy buffer 2 to buffer 1

```
V1 = 1
REPEAT (100)
  B1(V1) = B2(V1)
  V1 = V1 + 1
NEXT
!
```

2) Constantly test the current state of digital input point 16 in slot 5. If set to 1, then set channels 1 through 8 of the digital output card in slot 7.

```
REPEAT(0)
    IN(V1) DI(5,16)
    IF V1 = 1
        THEN
        DO(7,1,8) 1 1 1 1 1 1 1 1
        GOTO (9999)
    ELSE
    ENDIF
NEXT
LABEL(9999)
!
```

CONTROL STRUCTURE

EXAMPLES (continued)

3) Assume variable 10 (V10) is a flag set by either the host computer or a previous task such that the value of the flag signifies what type operation should be performed by the task. V10 will be set as follows:

-1	Take no action
0	Wait for a value
1	Set bit 1 of digital output card in slot 7
2	Set bit 2 of digital output card in slot 7
3	Set bits 17-25 of digital out card in slot 7
>3	Error condition

```
LABEL (10)
IF V10 = 0
   THEN GOTO (10)
   ELSE
   IF V10 = -1
      THEN      GOTO (9999)
      ELSE
      IF V10 = 1
         THEN DO(7,1) 1      GOTO (9999)
         ELSE
         IF V10 = 2
            THEN DO (7,2) 1      GOTO (9999)
            ELSE
            IF V10 = 3
               THEN FO(7,2) %777      GOTO(9999)
               ELSE
               V1 = -1
            ENDIF
         ENDIF
      ENDIF
   ENDIF
ENDIF
LABEL(9999)
   V10 = 0
!
```

OR

CONTROL STRUCTURE
EXAMPLES (continued)

```
LABEL (10)
CASE V10 (0,10) (-1,9999) (1,100) (2,200) (3,300)
GOTO  (8888)
        LABEL (100) DO(7,1) 1     GOTO (9999)
        LABEL (200) DO(7,2) 1     GOTO (9999)
        LABEL (300) FO(7,2) %777 GOTO (9999)
LABEL (8888)
        V1 = -1
LABEL(9999)
      V10 = 0
!
```

NESTING OF CONTROL STRUCTURES

Nesting is allowed up to 10 levels and each control construct must completely contain any higher level nesting.

Legal Nesting

```
IF VI = V2 THEN REPEAT (10) ... NEXT ELSE REPEAT (10) ...NEXT ENDIF
                |<-Second Level->|      |<-Second Level->|
|<--------->|<--------First   Level------>|<----First   Level------->|
```

```
IF V1=V2 THEN IF V2=V3 THEN REPEAT (10) ... NEXT ENDIF ENDIF
                            |<-Third   Level->|
              |<------->|<--------Second Level-------->|
|<------>|<---------------------First   Level----------------->|
```

Illegal Nesting

```
IF V1=V2 THEN REPEAT (10) ... ELSE ... NEXT ENDIF
              |<-------Second Level-------->|
|<------->|<------First Level------>|<---------->|
```

```
REPEAT (5) ... IF V1=V2 THEN ... NEXT ... ENDIF
|<-----------FIRST LEVEL----------->|
               |<---------Second Level--------->|
```

BUS TRIGGER FLAG (BT)

The bus trigger flag BT is accessible for testing only by the IF command. The flag will read "1" if the host computer has sent a trigger message.

EXAMPLE:

```
LABEL (1)
    IF BT <> 1      Test if trigger sent from host computer.
    GOTO (1)        If not set, loop and test again.
    ENDIF
AI (1,1,16)!        When flag is set, take analog reading.
```

PACING

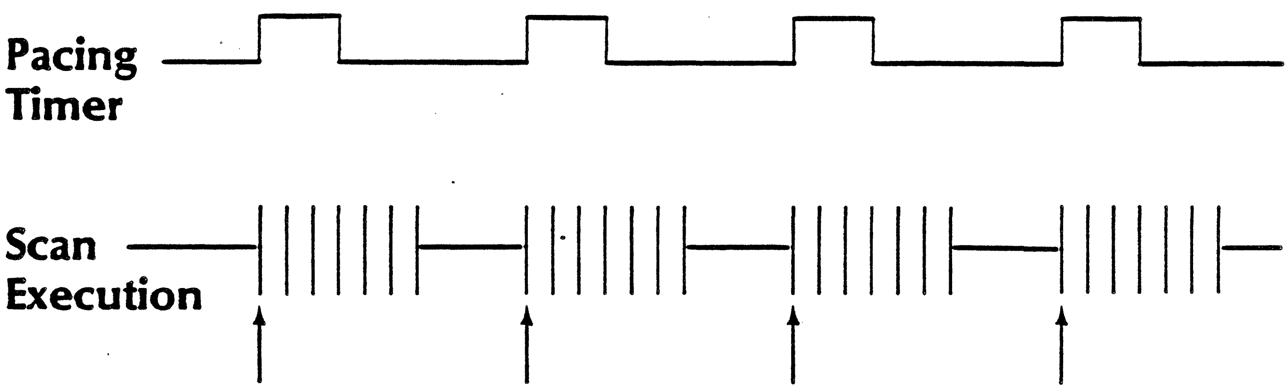
PACING

Pacing provides the user with a way to accurately space a series of I/O operations.

Pacing Interval	Pacing Timer Round Off Value
0 ms - 65.5 ms	2 us
65.5 ms - 327 ms	10 us
327 ms - 3.27 ms	100 us
3.27 s - 32.7 s	1 ms
32.7 s - 327 s	10 ms
327 s - 819 s	25 ms

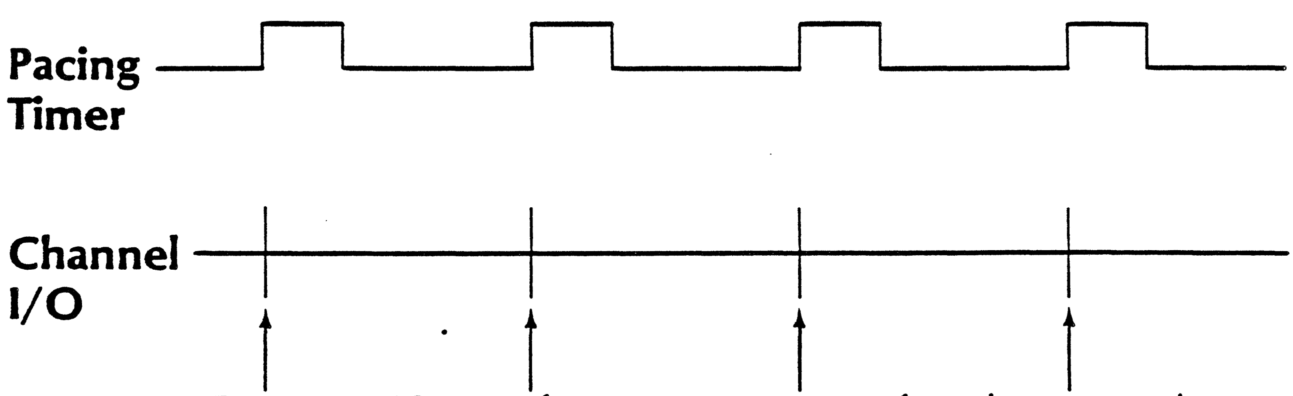
MODES OF PACING

SCAN MODE



Execute I/O at free run speed upon each pace pulse.

CHANNEL MODE



Execute I/O transfer on occurance of each pace pulse.

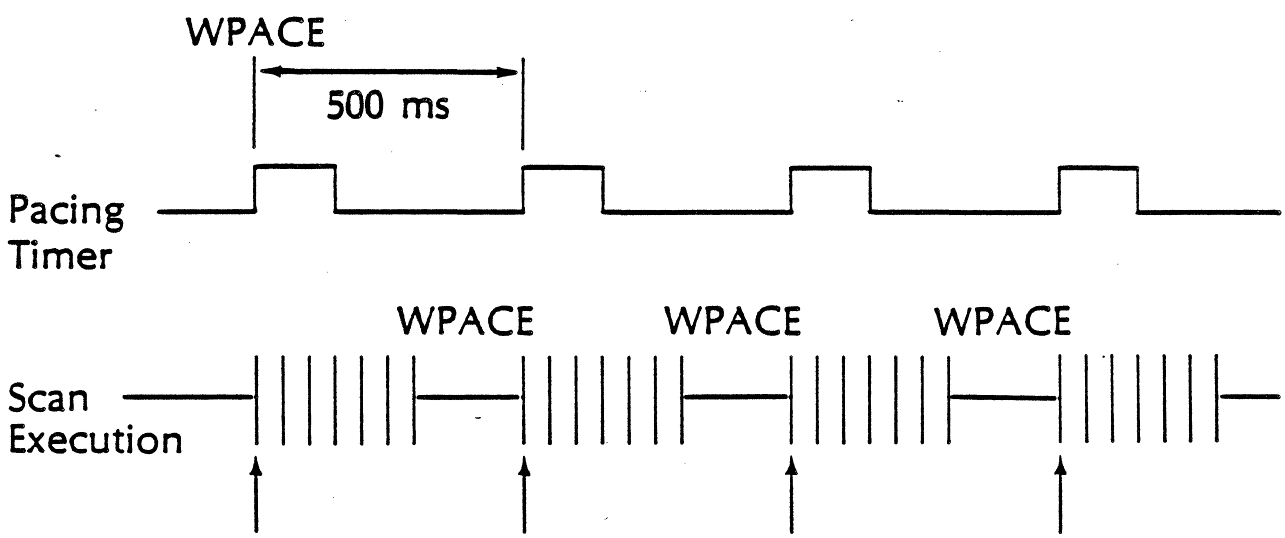
SET AND ACTIVATE SCAN MODE PACING PACE & WPACE

PACE (seconds [,milliseconds [,microseconds]])
WPACE

PACE sets up scan mode pacing, while **WPACE** (wait for pace) causes the next I/O operation to delay until pace pulse is encountered.

EXAMPLES OF SCAN MODE PACING

1)
```
TASK(1)
PACE (0,500,0)
REPEAT (5)
    WPACE
    AI (1,1,5)
NEXT
!
```



Read channels 1 - 5 upon each pace pulse at free run speed.

SET AND ACTIVATE CHANNEL MODE PACING CPACE & WPACE

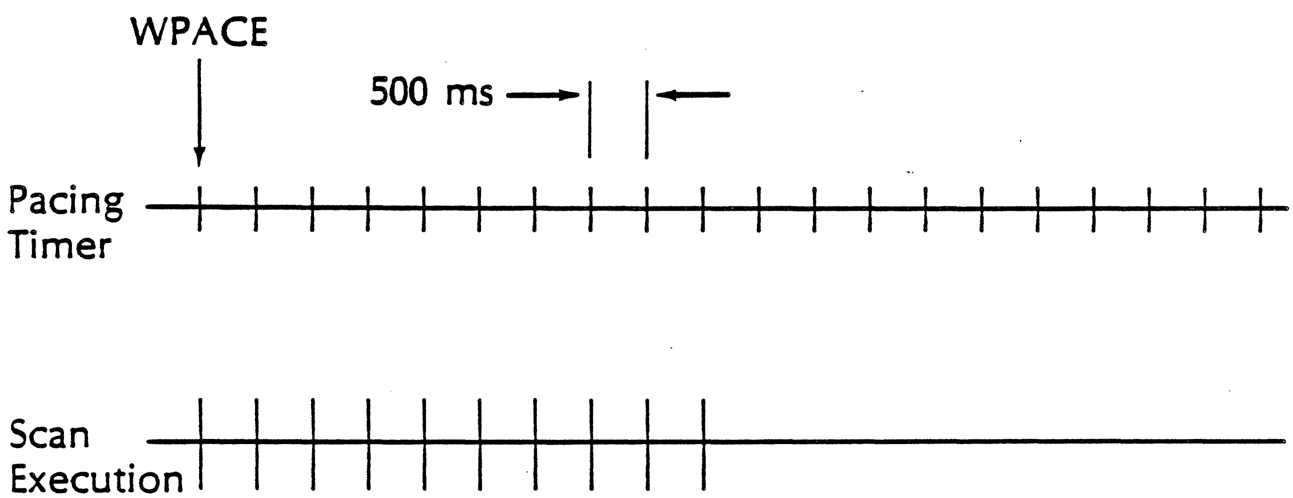
CPACE (seconds [,milliseconds [,microseconds]])
WPACE

CPACE and WPACE work just like scan mode pacing, except:

CPACE sets up pacing time for channel mode. Therefore, all I/O will execute on a pace pulse.

EXAMPLES OF CHANNEL MODE PACING

```
1) TASK (1)
   CPACE (0,500)
   BLOCK
   WPACE
   AI(1,1,10)
   !
```



Execute 10 analog readings at channel 1; each per pace pulse.

ANALOG INPUT

DIMENSION
IN( )
GAIN( )
CLB( )
CPACE( )
REF( )
WPACE
BLOCK; xTEMP( )•
AAV( )

This is a standard format for making analog inputs.

• Substitute an appropriate analog command here.

AVERAGING

SET GAIN
CALIBRATE
USE PACING
AVERAGE READINGS

EXAMPLE:

DIM (10,1,200)	DIMENSION 10 VARIABLES, 1 BUFFER
IN (B1)	DESIGNATE B1 AS INPUT BUFFER
GAIN (2,1) 124	SET GAIN TO LOWEST RANGE
CLB (2)	CALIBRATE LLMUX CARD
CPACE (0,0,22)	SET CHANNEL MODE PACING TO 22μ SECONDS
WPACE	WAIT FOR PACE PULSE
BLOCK AIM (2,1,100)	TAKE A BLOCK READING ON CHANNEL 1 (100 TIMES)
REW (B1)	REWIND THE BUFFER
AAV (B1, 100, V1)	TAKE THE AVERAGE OF 100 READINGS IN BUFFER 1. PLACE AVERAGE IN VARIABLE 1.

SYSTEM CLOCK

Precision	Maximum Interval
8 microseconds	3260 Hours

Commands That Use System Clock

CTIMER	RTIMER
PTIMER	SCLOCK
RCLOCK	WNOW
WTIMER	

SCLOCK (hours [,seconds[,milliseconds]])
Set time-of-day clock

RCLOCK
Read time-of-day clock

CTIMER
Clear resident task elapsed time timer

RTIMER
Read resident task elapsed time timer

WNOW (hours [,seconds,[milliseconds]])

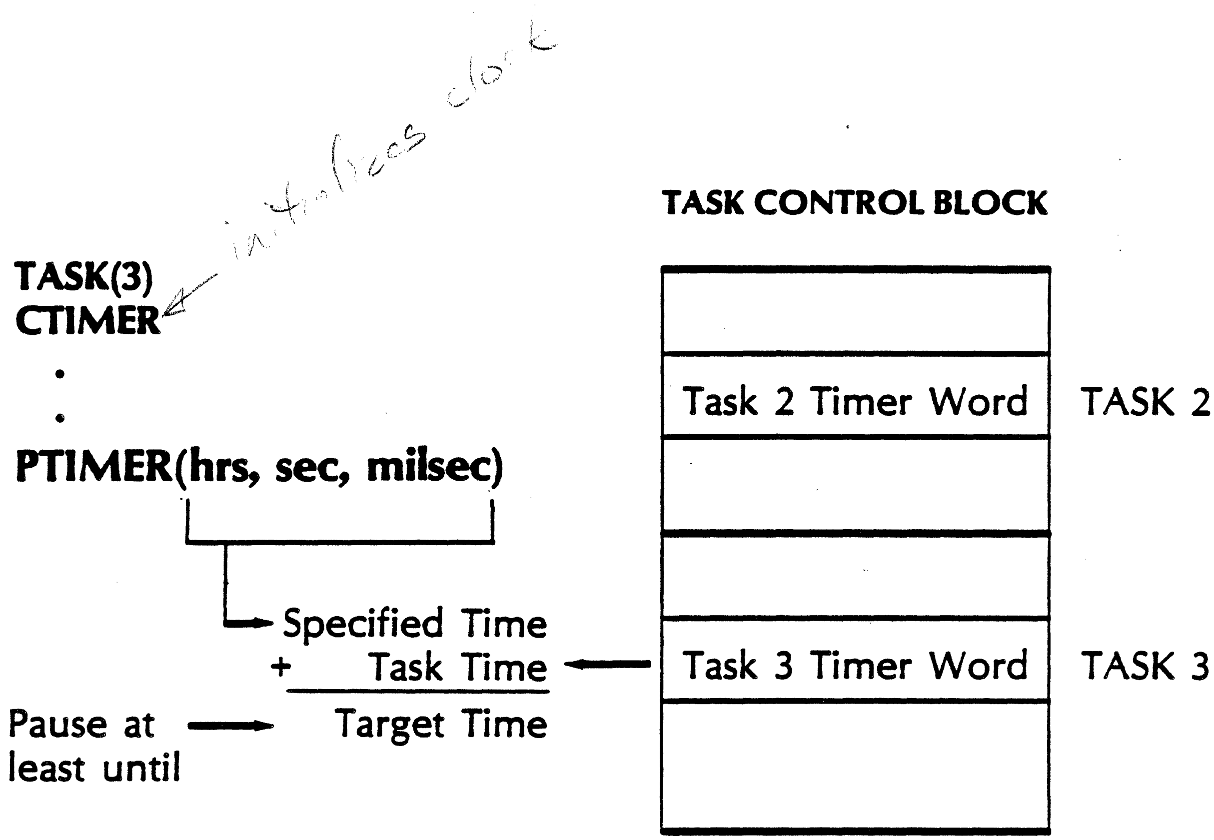
Wait the specified length of time.

PTIMER (hours [, seconds [, milliseconds]])
Pause with timer

WTIMER (hours [, Seconds [, milliseconds]])
Wait for task timer

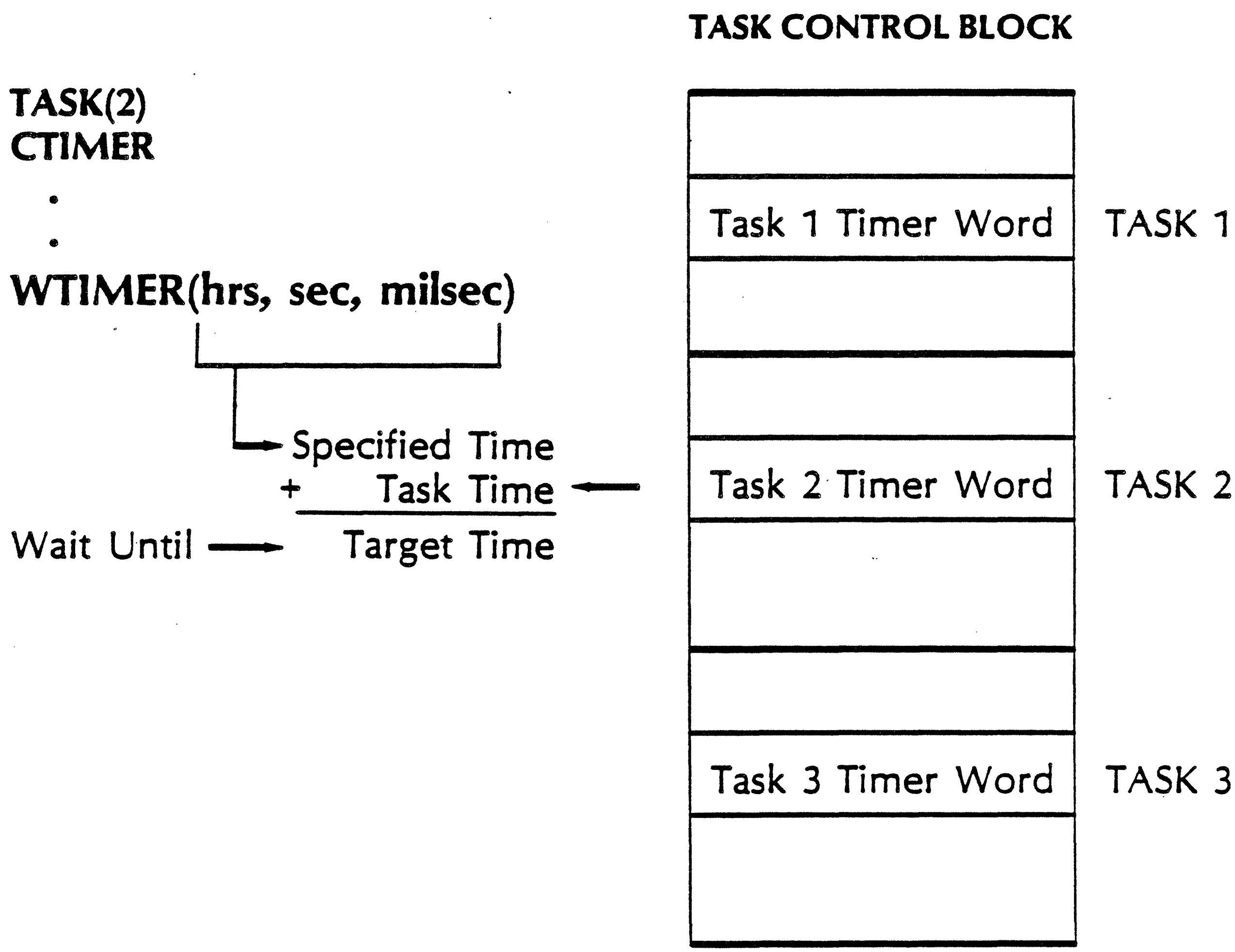
PAUSE WITH TIMER

PTIMER (hours [,seconds [,milliseconds]])



WAIT FOR TASK TIMER

WTIMER (hours [,seconds [,milliseconds]])



PAUSE COMMAND

PAUSE

Causes a backgroud task to be suspended if other background tasks of equal or higher priority are waiting to execute, or if a main task is waiting to be accepted by the 2250 at the primary address.

WATCHDOG TIMER

WATCHDOG (seconds, task number)

The watchdog timer allows you to set a maximum time that communications between the 2250 and the host computer is allowed not to exist.

Note: this merely "START's (schedules) the task, then normal scheduling rules apply before execution starts.

INTERRUPTS

The 2250 can signal the host computer with the SRQ message.

There are 2 ways of generating an SRQ.

- Programmatically, with the SRQ command
- In response to an external event, by configuring a function card to interrupt. (And not assigning a resident task to the interrupt.)

BE WARY

SRQ IS:

1) An MCL Command

2) A message sent from the 2250 to the host computer.

   and

3) The name of a subroutine, on the HP 1000, that assigns a service program to the SRQ message.

USING THE SRQ COMMAND

SRQ (SQR NUMBER)!

Will send a service request and put SRQ number in interrupt status.

0<SRQ number≤126

SRQ(0) will not affect interrupt status.
(The host is signaled)

USING THE SRQ COMMAND

SRQ (SQR NUMBER)!

Will send a service request and put SRQ number in interrupt status.

0<SRQ number≤126

SRQ(0) will not affect interrupt status.
(The host is signaled)

use SRQ for debug. set SRQ(1)
SRQ(2)
SRQ(3)
at various places in code to see how far it got (max. sec. 4)

can not tell how many times same interr. has occured.

but 2250 response to interrupt = 4 msec.

INTERRUPT STATUS

A read from secondary 4 will return 16 words of interrupt status information.

- The interrupt conditions are returned in ascending numerical order. If an interrupt occurred twice, it will still only be reported once.
- If all sixteen words are nonzero, then you should read interrupt status again. There are probably more interrupt conditions to report.
- Interrupt codes 127 and 128 are used to report fatal errors and card polling errors, respectively.
- Interrupt codes above 128 are used to report function card interrupts.

127 - interrupt from a card that isn't supposed to generate interrupts

128. if 1000 interrupts have been generated but not serviced

MCL w/FORTRAN

MCL

w/ FORTRAN

SENDING TASKS TO THE 2250

The main task is sent to the 2250 via the HP-IB primary address of the 2250 as an ASCII string

For example, using FORTRAN 4X

```
FTN4X,L
      PROGRAM PACNG
      MAC = 22
      WRITE (MAC,.100)
100   FORMAT (
C  SET SCAN MODE PACING, ONE SECOND
C  PACE INTERVAL
      *" PACE (1) "/
      *" IN (B2)   "/
C  REPEAT 100 TIMES, A SCANNED INPUT
C  TO 2250 BUFFER 2 OF
C  ANALOG AND DIGITAL DATA
      *" REPEAT (100)         "/
      *"     WPACE            "/
      *"     AI (1,3,10)      "/
      *"     DI (5,3,2,)      "/
      *" NEXT !               ")
       END
```

WRITE FORTRAN PROGRAM

SOURCE CODE &FILE1

RU, EDIT, &FILE1

COMPILE PROGRAM

RELOCATABLE CODE %FILE1

RU, FTN4X, &FILE1, , -

LINK LIBRARIES

EXECUTABLE CODE 'FILE1

RU, LOADR, , %FILE1

RUN PROGRAM

RU, PROG1

SEND MCL COMMANDS
READ MAIN RESULT BUFFER
WRITE OUT RESULTS

```
FTN4X,L
      PROGRAM RESLT
      INTEGER STATUS, DATA(16)
      LU=31
      WRITE (LU,10)
 10   FORMAT ("AI(1,1,16)!")
      READ(LU) STATUS, DATA
      WRITE(1,20) DATA
 20   FORMAT (8I7/,8I7)
      STOP
      END
```

SENDING TASKS TO THE 2250
(continued)

Main tasks, in the form of command strings can be constructed by any convenient method, as long as all constants and variables are type "character" so the 2250 receives an ASCII string.

```
FTN4X,L
      PROGRAM DIGIO
      INTEGER POINTS (5)
      CALL RMPAR (POINTS)
C   WRITE DIGITAL DATA TO POINTS 1 THROUGH 5.
      MAC = 22
      WRITE (MAC,100) POINTS
100   FORMAT (" DO (3,1,5)" 5I7 "!")
      •
      •
      •
      END
```

SENDING LONG TASKS

FORTRAN has a formatting buffer of 134 characters for storing the ASCII characters for a WRITE statement. Therefore, when you need to send long tasks to the 2250, you will have to adjust the formatting of the task in one of the following ways:

A) MULTIPLE WRITE AND FORMAT STATEMENTS

```
        WRITE (MAC,100)
        WRITE (MAC,200)
        WRITE (MAC,300)
        •
        •
        •
        WRITE (MAC,1000)
100     FORMAT(" TASK(1)")
200     FORMAT(" CLB(1)")
300     FORMAT(" REPEAT (1000)")
        •
        •
        •
1000    FORMAT(" NEXT! ")
```

SENDING LONG TASKS
(continued)

B) USING LINEFEED CHARACTER IN FORMAT STATEMENT

```
        WRITE (MAC,100)
100     FORMAT (
       *" TASK(1) "/
       *" CLB(1) "/
       *" REPEAT(1000) "/
        •
        •
        •
       *" NEXT ! ")
```

C) INCREASING THE FORMATTERS BUFFER SIZE

```
        INTEGER BUFFER (500)
        CALL LGBUF(BUFFER,500)
        WRITE (MAC,100)
100     FORMAT (
       *" TASK(1)
       *  CLB(1)
       *  REPEAT(1000)
          •
          •
          •
       * NEXT ! ")
```

OBTAINING RESULTS FROM THE MAIN TASK AND RESULT BUFFER

1) If an error occurred at the 2250:
   or
   If no error occurred, but no data to send back:

Host Computer ← CONDITION CODE ← 2250

2) If no error occurred and data to be sent back:

Host Computer ← CONDITION CODE, DATA1, DATA 2, . . . ,DATAn ← 2250

EOI will be asserted by the 2250 upon the last byte of data.

READING THE MAIN RESULT

Using FORTRAN 4X, the result can be read as follows:

```
FTN4X,L
          PROGRAM RESLT
          INTEGER CCODE,DATA(3)


C  SEND TASK TO 2250 TO INPUT DIGITAL DATA FROM SLOT 3,
C  CHANNELS 1, 3 AND 5

          MAC = 22
          WRITE (MAC,100)
100       FORMAT (" DI(3,1) (3,3) (3,5)!")

C  READ THE CONDITION CODE AND THE INTEGER RESULT FROM THE
C  PRIMARY ADDRESS USING AN UNFORMATTED READ.

          READ (MAC,IOSTAT = ERROR) CCODE,DATA

C  CHECK FOR FORTRAN READ ERROR

          IF(ERROR.NE.0.AND.ERROR.NE.496) GOTO 9000

C  CHECK FOR 2250 ERROR

          IF(CCODE.NE.0) THEN
                WRITE(1,200)  CCODE
200             FORMAT(" ERROR —— CONDITION CODE = " I7)
                STOP 1
          ELSE
                WRITE (1,300) DATA
300             FORMAT(" DIGITAL POINTS 1, 3, & 5 = " 3I7)
                STOP 0
          ENDIF

C  DETERMINE FORTRAN READ ERROR

9000      •
          •
          •
          END
```

HP 1000
FORTRAN IV OR IVX

Reading Results:

```
CALL EXEC (1, MAC, IBUF,IBUFL)
CALL ABREG (ISTAT, ILOG)
```

IBUF — Integer buffer where data will be put. First word will be in 2250 status.

IBUFL — Length of IBUF in words. Should be at least as large as the maximum data you are expecting.

ISTAT — DVR37 status. Ignore this.

ILOG — Actual number of words returned to you in IBUF.

SECONDARY ADDRESSES

ADDRESS	TYPE
0	MAIN RESULT BUFFER
1	SYSTEM STATUS WORDS
2	MAIN TASK STATUS
3	RESIDENT TASK STATUS
4	INTERRUPT STATUS WORDS
5	WRITE TO BUFFERS
6	READ BUFFERS
7	WRITE TO VARIABLES
8	READ VARIABLES
9	DOWN-LOADED SUBROUTINES
10	-------
11-14	READ PORTS A-D

USING SECONDARY ADDRESSING WITH THE 2250

How to read or write secondary information:

FORTRAN 4X

READ (2250lu : secondary address) data buffer

WRITE(2250lu : secondary address) data buffer

FORTRAN IV

CALL SECR (2250lu, secondary address, data buffer, length)

CALL SECW (2250lu, secondary address, data buffer, length)

HP 1000 BASIC

Call SECR (2250lu, secondary address, data buffer, length)

CALL SECRR (2250lu, secondary address, data buffer, length)

CALL SECW (2250lu, secondary address, data buffer, length)

2250 Secondary Addresses and Data Transferred

Address	Function	Data Transferred
0	Read	Main result buffer
1	Read	System status
2	Read	Main task status
3	Write Read	Task number Resident task status
4	Read	Interrupt status
5	Write	Buffer number, number of data items, data items
6	Write Read	Buffer number, number of data items Data items
7	Write	Starting variable, number of variables, data items
8	Write Read	Starting variable, number of variables Data items
9	Write	Down-loaded subroutines
10	---	Not assigned
11 - 14	Read	Ports A through D

SECONDARY ADDRESSING

Writing to Buffers—Secondary Address 5

Word 1	Buffer number
Word 2	Number of data items to be written to buffer
Word 3	Data item for the first buffer element
Word 4	Data item for the second buffer element
•	
•	
•	
Word n+2	Data for the nth buffer element

SECONDARY ADDRESSING WITH BUFFERS AND VARIABLES

EXAMPLES

Assume a FORTRAN integer buffer VAR(100) with values initially of 1 through 20 in words 1 through 20.

1) Write words 1-20 of buffer VAR to 2250 variables 1 through 20.
   WRITE (MAC:7, IOSTAT = ERROR) 1,20,VAR

2) Write VAR(1) through VAR (10) to 2250 variables 10 through 20.
   WRITE (MAC:7, IOSTAT = ERROR) 10,10,VAR

3) Write the buffer VAR to 2250 buffer 3 that is dimensioned to 100 words
   WRITE (MAC:5, IOSTAT = ERROR) 3,100,VAR

SECONDARY ADDRESSING

Reading From Buffers—Secondary Address 6

Write	Word 1	Buffer number to access.
	Word 2	Number of data items to read.
Read	Word 1	Contents of first buffer element.
	Word 2	Contents of second buffer element.
	•	
	•	
	•	
	Word n	Contents of last buffer element.

SECONDARY ADDRESSING WITH BUFFERS AND VARIABLES

EXAMPLES
(continued)

Assume 2250 variables 1 through 20 contain digital data, and buffer 4 (dimensioned to 100 words) contains analog data as a result of an AIR (6,1,50) command

4) Read variables 1 through 20 into VAR(1) through VAR(20).
   WRITE(MAC:8) 1,20 READ (MAC:8,IOSTAT=ERROR) VAR

5) Read 2250 variables 10 through 20 into VAR(1) through VAR(10).
   WRITE(MAC:8) 10,10 READ (MAC:8,IOSTAT=ERROR) VAR

6) Read, using BASIC, the real analog data in buffer 4.
   I(1) = 4
   I(2) = 100
   CALL SECW (MAC,6,I,2)
   CALL SECRR (MAC,6,BUFFER,100)

SECONDARY ADDRESSING FOR TRANSFERRING DATA TO AND FROM THE 2250

Writing to Variables-Secondary Address 7

Word 1 Starting variable number to receive first data item

Word 2 Number of sequential variables to receive data

Word 3 First data item for the first variable described by word 1

•

•

•

Word n+2 nth data item for the last variable

SECONDARY ADDRESSING FOR TRANSFERRING DATA

Reading From Variables-Secondary Address 8

Write	Word 1	Starting variable number
	Word 2	Number of sequential variables
Read	Word 1	Contents of first variable
	Word 2	Contents of second variable
	•	
	•	
	•	
	Word n	Contents of last variable

ACCESSING PORT DATA SECONDARIES

11 THROUGH 14

The RELEASE command makes buffer data available at a port. As soon as the task executes the command, your computer program can find out how many words are available and can read the data.

EXAMPLE:

To release the data to a port:

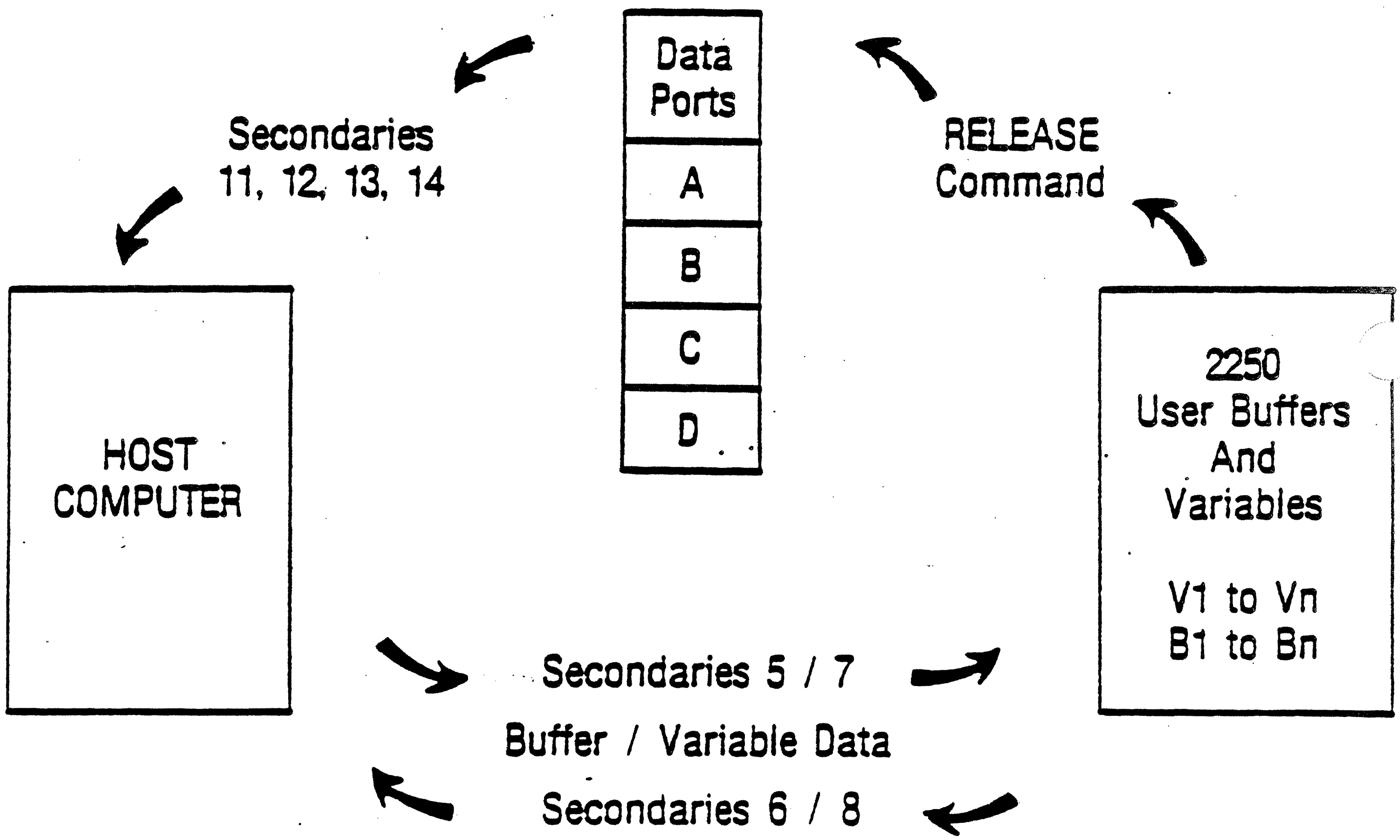
```
IN (B1); DI(2,1,10); RELEASE (B1,A)
IN (B2); DI(3,1,16); RELEASE (B2,B)
```

To receive the data in a computer program

```
INTEGER DATA1(100), DATA2(100)

READ (MAC:11, IOSTAT=ERROR) DATA1
READ (MAC:12, IOSTAT=ERROR) DATA2
```

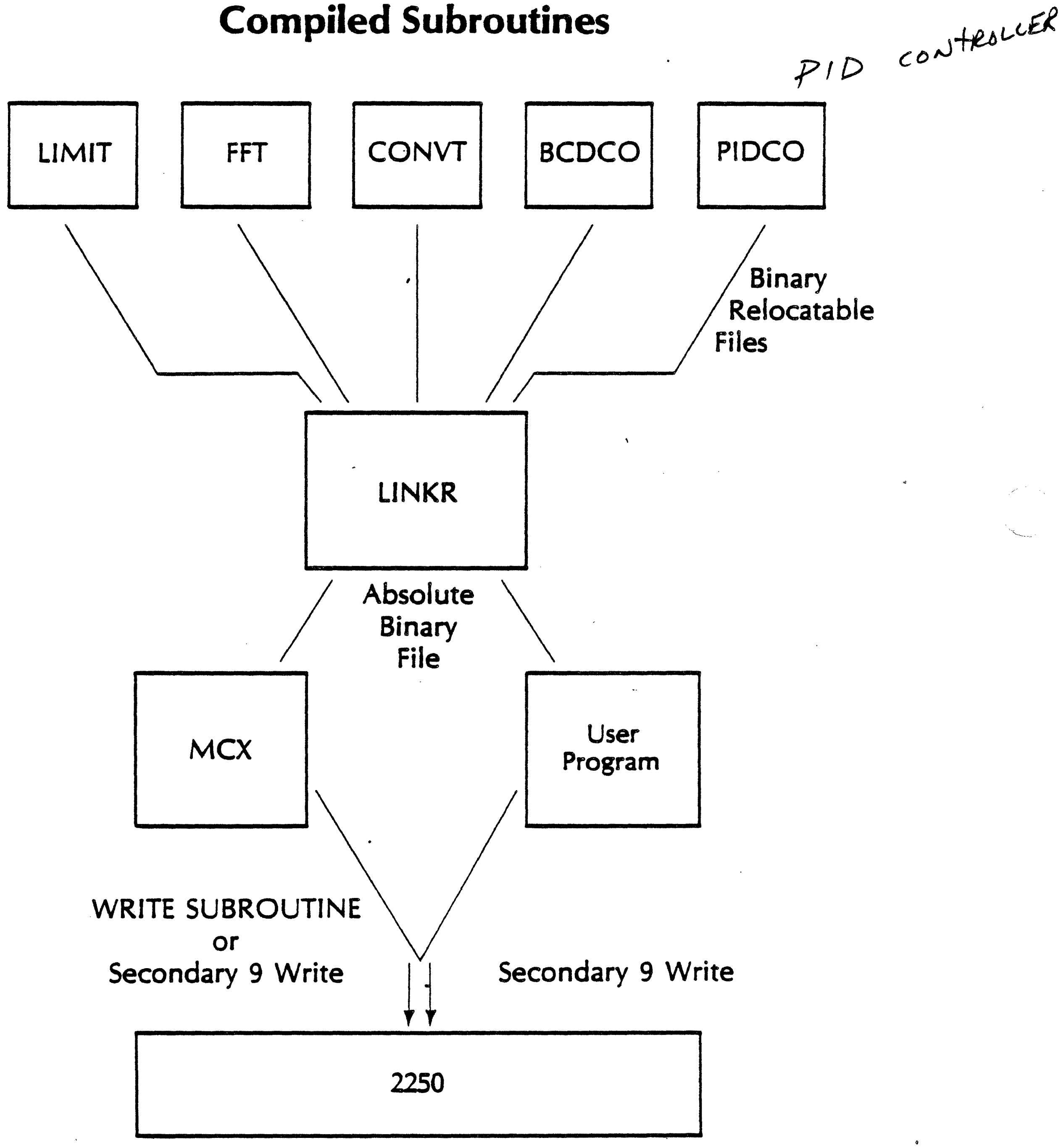
HOST COMPUTER / 2250 VARIABLE AND BUFFER FLOW



DOWNLOADED SUBROUTINES

DOWNLOADING SUBROUTINES PROCESS OVERVIEW

Compiled Subroutines



LINKR COMMANDS

LINKR COMMAND	COMMAND MEANING
ABORT	Clean up and abort immediately.
DISPLAY	Display any unsatisfied externals.
END	End, if all externals can be satisfied, and create output file.
HELP	Display a command summary.
LIBRARY, *filenamr*	*Search filenamr* (multiple passes if needed) when first MCL command is given.
MCL, sub name	Make this *sub*routine *name* accessible to the MCL/50 CALL command.
MSEARCH, *filenamr*	Perform multiple searches of *filenamr* to satisfy any undefined externals.
NEED, *sub name*	When a library is searched, the subroutine called *sub*routine *name* will be relocated automatically from the library. Good for relocating a subroutine out of a file, instead of relocating the entire file.
RELOC, *filenamr*	Link the specified *filenamr.*
SEARCH, *filenamr*	Perform a single search of *filenamr* to satisfy undefined externals.

RULES TO FOLLOW WHEN PROGRAMMING

- Subroutine names must be alpha-numeric with first character alphabetic.
- NAM record must declare SUBROUTINE; Not PROGRAM or FUNCTION.
- STOP or PAUSE statements not allowed. Must return control to point of call.
- EXEC calls not allowed, and therefore FORTRAN READ and WRITE statements not allowed.
- Named COMMON allowed but not SYSTEM COMMON.
- Maximum number of parameters allowed to be passed to or from subroutine is 20.
- When using library functions like SQRT, a 2250 subroutine must be written and linked that performs the actual call to SQRT.

```
FTN4X,L
      SUBROUTINE CHKLM (BUFFIN, SIZE, LOW, HIGH, BUFOUT, ERRCHT)

C  ROUTINE TO CHECK THE LIMITS OF VALUES IN A BUFFER OF
C  UNKNOWN SIZE.
C
C  BUFFIN     = NAME OF BUFFER CONTAINING VALUES.
C  SIZE       = SIZE OF BUFFER IN WORDS.
C  LOW        = LOWER LIMIT VALUE.
C  HIGH       = HIGH LIMIT VALUE.
C  BUFOUT     = BUFFER TO STORE LIMIT INDICATION.
C               -1 = BELOW LOWER LIMIT.
C                0 = WITHIN LIMITS.
C                1 = ABOVE HIGHER LIMIT.
C  ERRCNT     = VARIABLE CONTAINING NUMBER OF BAD LIMIT VALUES.

      INTEGER BUFFIN (SIZE),
     *        BUFOUT (SIZE),
     *        ERRCNT,
     *        LOW,
     *        HIGH,
     *        SIZE

      ERRCNT = 0

      DO 100 I = 1,SIZE
         IF (BUFFIN (I).LT.LOW) THEN
            BUFOUT(I) = -1
            ERRCNT = ERRCNT + 1

            ELSE
            IF (BUFFIN (I).GT.HIGH) THEN
               BUFOUT(I) = 1
               ERRCNT = ERRCNT + 1

            ELSE
            BUFOUT(I) = 0

            ENDIF
         ENDIF
100   CONTINUE

      RETURN
      END
```

PROCEDURE TO DOWNLOAD A SUBROUTINE TO THE 2250

1. WRITE A FORTRAN SUBROUTINE

```
FTN 4X, L
      SUBROUTINE  CHKLM (PARM1, PARM2 . . )
          :
      RETURN
      END
```

2. COMPILE THE SOURCE FILE

```
RU, FTN4X, &CHECK, ,-
```

3. CONVERT TO OLD FORMAT (RTE-A ONLY)

```
RU, OLDRE, %CHECK
```

4. RUN LINKR ROUTINE TO LINK LIBRARIES TO THE COMPILED FILE

```
RU, LINKR,  , !CHECK, "CHECK

LINKR:  LIB, $QLIB
        LIB, $MLIB1
        LIB, $MLIB2
        LIB, $MLIB3
        REL, %CHECK
        MCL, CHKLM
        END
```

5. DOWNLOAD INTO THE 2250 (USE FORTRAN OR MCX)

```
MCX:  WR SUB !CHECK
```

6. CALL SUBROUTINE IN A 2250 TASK

```
  :
CALL  CHKLM ( PARM1, PARM2, ...)
  :
  !
```

HP2250 AUTOMATION LIBRARY

* **MCX--MEASUREMENT AND CONTROL EXERCISER**

  EXECUTES ON HOST
  RELOCATABLE FILE

* **LINKR--SUBROUTINE LINKER**

  EXECUTES ON HOST
  RELOCATABLE FILE

* **MCLIO--I/O FROM SUBROUTINES**

  EXECUTES ON 2250
  FILE IN GLIB-MUST BE LINKR'D

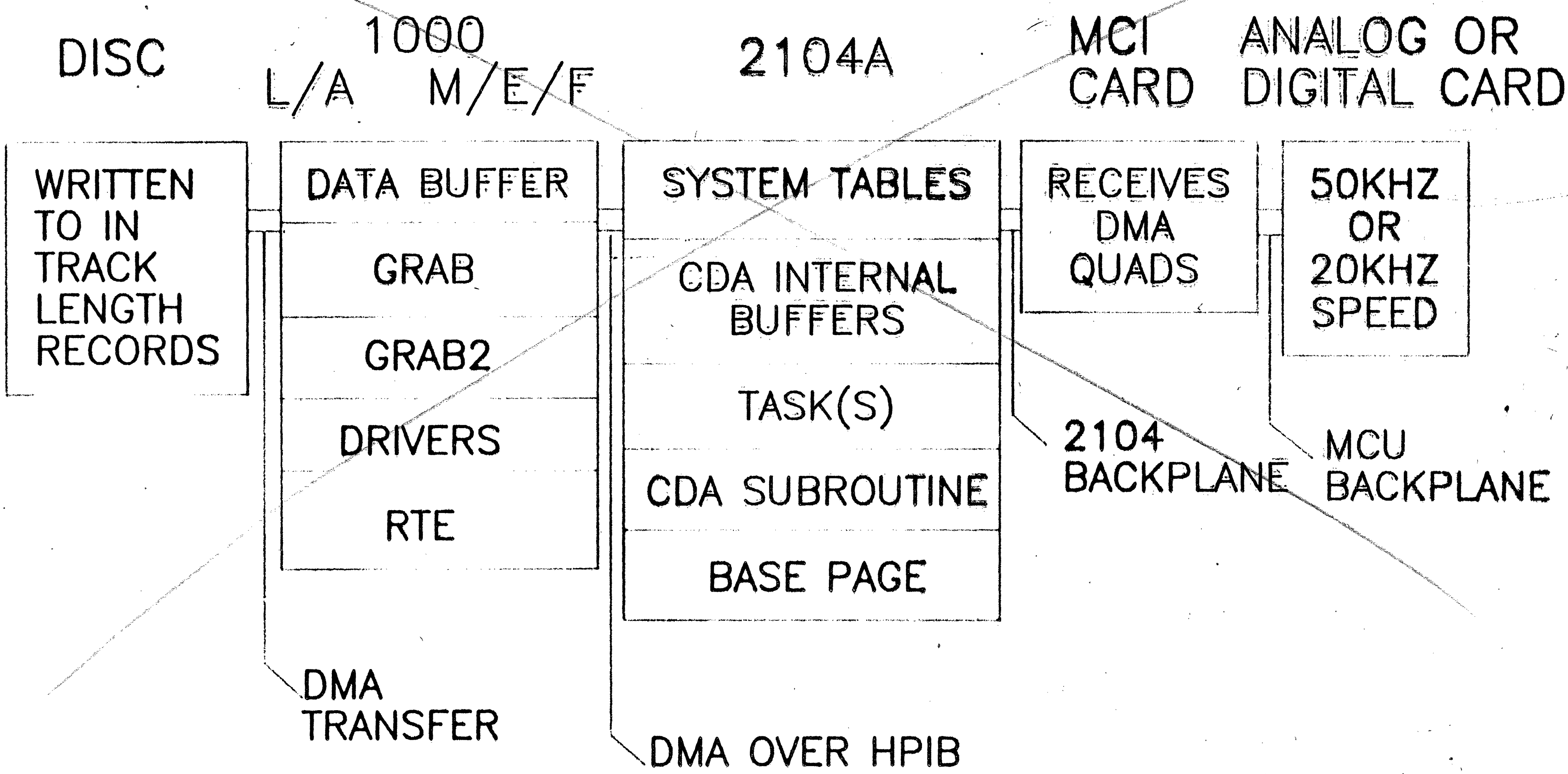
* **CDA--CONTINUOUS DATA ACQUISITION**

  EXECUTES ON 2250
  TYPE 7 FILE

* **GRAB AND GRAB2--WORK WITH CDA**

  EXECUTE ON HOST
  RELOCATABLE FILES

CDA DATA FLOW



CDA:RI

SUMMARY OF AVAILABLE STATUS INFORMATION

Main Task Error Code (word #2)

A one word item that tells what kind of error the main task has experienced.

Status Secondary 1 (System Status)

8 words of data that tell you:

- Which task is executing
- What communication or system error has occurred
- How much data is available at main address and at ports A-D

Status Secondary 2 (main task) and 3 (other tasks)

8 words of data that tell you:

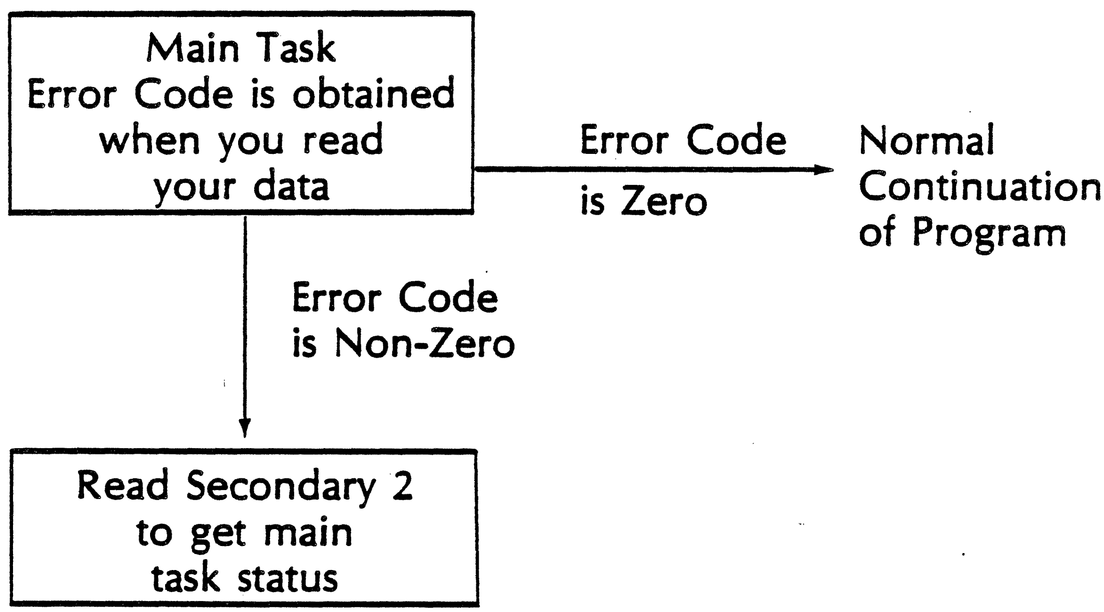
- The current state of the task
- What kind of error occurred
- Where the error occurred

Status Secondary 4 (interrupt status)

16 words of data that tell you:

- What programmed interrupts have occurred
- Which function cards have interrupted

WHAT HAPPENED TO THE TASK I SENT?



MCX STATUS COMMANDS

STATUS SYSTEM

Interprets the system status that is obtained from secondary address 1 and returns a system status message.

STATUS MAIN

Interprets the status of the main task by reading secondary address 2, and returns a main task status message.

STATUS TASK tasknum

Interprets the status of a resident task by reading secondary address 3, and returns a resident task status message.

STATUS INTERRUPT

Interprets the status of interrupts that have occurred in the 2250 by reading secondary address 4, and returns an interrupt status message.

MCX Status Command Examples

1) Obtain the 2250 system status.

```
MCX: STATUS SYSTEM

System status:
Task number    1 is running:
Port data is available:  A:   0   B:   0   C:   0   D:   10.
```

2) Obtain the main task status.

```
MCX : S MAIN

Main task status:
The task is undefined.
```

3) Obtain the status of task number 1.

```
MCX: STAT TASK 1

Task    1 status:
The task is running at command   2.
```

4) Obtain the interrupt status of the 2250.

```
MCX : STATUS INTERRUPT

Interrupt status:
Programmed srq   1
Programmed srq  30
Programmed srq 127
```

SYSTEM STATUS

System status, available through secondary address 1, contains status information not related to a particular task. The meaning of each status word is as follows:

2250 System Status Secondary Address 1

Word Number	Meaning
1	Current running task number (-1 if no task executing)
2	System error code
3	SRQ interrupt flag
4	Main result word count (includes condition code)
5	Word count at port A
6	Word count at port B
7	Word count at port C
8	Word count at port D

System Error Codes Word 2 of System Status (40-59)

Code	Meaning
40	Invalid secondary address given
41	Secondary transaction aborted
42	Non-existent buffer referenced (secondary 5 or 6)
43	Non-existent variable referenced (secondary 7 or 8)
44	Checksum error on downloaded subroutine (secondary 9)
45	Attempted download on occupied memory (secondary 9)
46	Attempted download to insufficient memory (secondary 9)
47-49	Undefined
50-54	Are defined as fatal errors
55-59	Undefined

MAIN TASK STATUS

The main task status provides the current state of the main task and the nature of any error condition that may exist.

Main Task Status — Secondary Address 2

Word Number	Meaning
1	Task state
2	Task error code (same as condition code)
3	Command number of error
4	Slot or task number of error
5	Parameter group or command number
6	Item number of error
7	Task number (always zero for main task)
8	Status lights (copy of 2104 status panel lights)

For Words 4,5,6;

slot number parameter group item number	Corresponds to a compile time (word 2 $\leq$ 19) error
task number command number 0	Corresponds to a run time error

TASK STATE

Task State: Secondary Address 2 —— Word 1

Code	State	Conditions
0	Task does not exist	
1	Task is arriving on the interface bus	main task only
2	Task is compiling	main task only
3	Task is queued, ready to run	resident tasks only
4	Task is executing	
5	Task is idle	resident tasks only
6	Task is idle due to an error	
7	Task is complete with result ready	main task only

MAIN TASK ERROR CODE (CONDITION CODE)

Main Task Error Code: Compiler Errors (1-19)

SECONDARY ADDRESS 2 WORD 2

Code	Meaning
1	Illegal command keyword
2	Illegal command parameter
3	Illegal in-line data
4	Illegal control structure syntax
5	Command illegal for first slot in sequence
6	Command illegal for slot after first in sequence
7	Empty slot included in sequence
8	Memory overflow
9	CALL command refers to non-existent subroutine
10	Reference to undefined label
11	Illegal use of modifying command
12-19	Undefined

Main Task Error Code: Run-Time Errors (20-39)

SECONDARY ADDRESS 2 WORD 2

Code	Meaning
20	Undefined
21	Parameter invalid or out of range
22	Output data invalid or out of range
23	A non-existent variable was referenced
24	A non-existent buffer was referenced
25	Buffer overflow or index out of range
26	Insufficient memory to complete command
27	Operation on empty buffer
28	Card configuration error
29	Function card 1/0 error
30	Undefined
31	Illegal task number
32	Task recursion
33	Illegal use of task
34-49	Undefined

Main Task Error Code: CDA Errors (60-63)

SECONDARY ADDRESS 2 WORD 2

Code	Meaning
60	CDA terminated due to memory overflow
61	CDA terminated due to function card interrupt
62	CDA terminated due to HP-IB bus trigger
63	CDA terminated because of firmware error (Contact SE)

STATUS LIGHTS

Status Lights: Secondary Address 2 —— Word 8

Bit Number	Meaning When Lit
0	SRQ interrupt(s) pending (check secondary address 4)
1	Resident task running (task number at sec. 1, word1)
2	Main result available from the primary address
3	Main task executing
4	Inbound task arriving at primary address
5	Main task error has occurred
6	Clear for successful self-test
7	Clear for successful self-test

INTERRUPT STATUS

A read from secondary 4 will return 16 words of interrupt status information.

- The interrupt conditions are returned in ascending numerical order. If an interrupt occurred twice, it will still only be reported once.
- If all sixteen words are nonzero, then you should read interrupt status again. There are probably more interrupt conditions to report.
- Interrupt codes 127 and 128 are used to report fatal errors and card polling errors, respectively.
- Interrupt codes above 128 are used to report function card interrupts.

FUNCTION CARD REGISTERS

To the 2250 firmware, a function card appears as a set of registers.

- Any input operation is implimented by reading a function card register. (Ditto for output operations.)
- To perform a configuration opeation like changing the gain of an analog multiplexer, a write to a special register is performed.
- To get function card status, a read from a certain register is performed.

PRIMITIVE MCL COMMANDS

(not in Programmer's Reference Manual)

READ (start slot, start register[,#of registers])
Read single word function card registers

DREAD (start slot, start register[,#of registers])
Read double word function card registers

WRITE (start slot,start register[,# of registers])data1,...datan
Write single word data to function card registers

DWRITE (start slot,start register[,#of registers])data1,...data2n
Write double word data to function card registers
(counter only)

RBIT (slot,register, start bit[,#of bits])
Read bits from function card register

WBIT (slot, register, start bit[,#of bits])data1,...datan
Write bits to function card register

ANALOG INPUT CARDS
REGISTER ASSIGNMENTS
BANK 1

	Page 1	
1	DATA1	GAIN1
2	DATA2	GAIN2
3	DATA3	GAIN3
4	DATA4	GAIN4
5	DATA5	GAIN5
6	DATA6	GAIN6
7	DATA7	GAIN7
8	DATA8	GAIN8
9	DATA9	GAIN9
10	DATA10	GAIN10
11	DATA11	GAIN11
12	DATA12	GAIN12
13	DATA13	GAIN13
14	DATA14	GAIN14
15	DATA15	GAIN15
16	DATA16	GAIN16

	Page 2	
17	DATA17	GAIN17
18	DATA18	GAIN18
19	DATA19	GAIN19
20	DATA20	GAIN20
21	DATA21	GAIN21
22	DATA22	GAIN22
23	DATA23	GAIN23
24	DATA24	GAIN24
25	DATA25	GAIN25
26	DATA26	GAIN26
27	DATA27	GAIN27
28	DATA28	GAIN28
29	DATA29	GAIN29
30	DATA30	GAIN30
31	DATA31	GAIN31
32	DATA32	GAIN32

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ANALOG INPUT CARDS
REGISTER ASSIGNMENTS
BANK 2

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ANALOG INPUT CARDS
REGISTER ASSIGNMENTS
BANK 3

	Page 9	
129	ZERO1	GAIN1
130	ZERO2	GAIN2
131	ZERO3	GAIN3
132	ZERO4	GAIN4
133	ZERO5	GAIN5
134	ZERO6	GAIN6
135	ZERO7	GAIN7
136	ZERO8	GAIN8
137	ZERO9	GAIN9
138	ZERO10	GAIN10
139	ZERO11	GAIN11
140	ZERO12	GAIN12
141	ZERO13	GAIN13
142	ZERO14	GAIN14
143	ZERO15	GAIN15
144	ZERO16	GAIN16

	Page 10	
145	ZERO17	GAIN17
146	ZERO18	GAIN18
147	ZERO19	GAIN19
148	ZERO20	GAIN20
149	ZERO21	GAIN21
150	ZERO22	GAIN22
151	ZERO23	GAIN23
152	ZERO24	GAIN24
153	ZERO25	GAIN25
154	ZERO26	GAIN26
155	ZERO27	GAIN27
156	ZERO28	GAIN28
157	ZERO29	GAIN29
158	ZERO30	GAIN30
159	ZERO31	GAIN31
160	ZERO32	GAIN32

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ANALOG INPUT CARDS
REGISTER ASSIGNMENTS
BANK 4

	Page 13
193	GAIN1
194	GAIN2
195	GAIN3
196	GAIN4
197	GAIN5
198	GAIN6
199	GAIN7
200	GAIN8
201	GAIN9
202	GAIN10
203	GAIN11
204	GAIN12
205	GAIN13
206	GAIN14
207	GAIN15
208	GAIN16

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209	GAIN17
210	GAIN18
211	GAIN19
212	GAIN20
213	GAIN21
214	GAIN22
215	GAIN23
216	GAIN24
217	GAIN25
218	GAIN26
219	GAIN27
220	GAIN28
221	GAIN29
222	GAIN30
223	GAIN31
224	GAIN32

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249	CARD CONFIGURA.
250	0
251	CARD STATUS
252	0
253	CARD ID REGISTER
254	0
255	0
256	BIF

DIGITAL INPUT CARDS
REGISTER ASSIGNMENTS
BANK 1

	Page 1
1	POINT1
2	POINT2
3	POINT3
4	POINT4
5	POINT5
6	POINT6
7	POINT7
8	POINT8
9	POINT9
10	POINT10
11	POINT11
12	POINT12
13	POINT13
14	POINT14
15	POINT15
16	POINT16

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17	POINT17
18	POINT18
19	POINT19
20	POINT20
21	POINT21
22	POINT22
23	POINT23
24	POINT24
25	POINT25
26	POINT26
27	POINT27
28	POINT28
29	POINT29
30	POINT30
31	POINT31
32	POINT32

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DIGITAL INPUT CARDS
REGISTER ASSIGNMENTS
BANK 2

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DIGITAL INPUT CARDS
REGISTER ASSIGNMENTS
BANK 3

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161	FIELD 1
162	FIELD 2
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DIGITAL INPUT CARDS
REGISTER ASSIGNMENTS
BANK 4

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	Page 14
209	SENSE FIELD 1
210	SENSE FILED 2
211	OVERRIDE FIELD 1
212	OVERRIDE FIELD 2
213	
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	Page 15
225	UN MACK 1
226	UN MACK 2
227	
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	Page 16
241	INTERRUPTS 1
242	INTERRUPTS 2
243	
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249	CARD CONFIGURA.
250	0
251	CARD STATUS
252	0
253	CARD ID REGISTER
254	0
255	0
256	BIF

SELF TEST

SELF TEST

- Executed on power on or pressing reset button on status panel
- Errors in Appendix A (attached)

L PROCESSOR SELF TEST

- Address and data lines
  (data path check, 1st LED off if pass)
- Basic instruction set
  of CPU
- Processor card
  interrupt flag, timebase generator, LIA/B instructions & global register flag
- RAM memory
  non destructive; if no back up, RAM is cleared
- I/O Data transfer and DMA
  of each I/O IC

2250 SELF TEST

- Executes automatically after successful completion of processor self test
- RAM test (16 K words) destructive; skipped if memory backed up
- Base register and stack (skipped if memory backed up)
- ROM checksum and position (checksum on each 4K)
- SYSTEM CONFIGURATION - select codes, interrupts, stacks cleared
- MCI, BIF and HPIB configuration check.

  MCI - internal timers, registers & DMA transfers
  BIF - interrupt status and data registers checked
  HP-IB - PHI chip, card control registers & DMA transfers

- FIRMWARE INITIALIZATION
- 2nd LED OFF

APPENDIX A
SELF TEST ERROR MESSAGES

lsb at bottom of panel

Table A-1. Self-Test Error Codes

LED Error Code lsb	DESCRIPION (1 = ON, 0 = OFF)
11111111	Data Path Check
	Pretest
01111111	CPU Test Failure
01111110	Processor Test Failure -- This pattern may alternate with the select code of the illegally interrupting I/O card. (The select code is displayed in inverted logic: lit LED is logic 0, unlit LED is logic 1.)
01111101	Memory Test Failure
01111100	I/O Test Failure -- This pattern may alternate with any of the following patterns: 00111111 = No chips detected. At least one I/O card must be installed. 00111110 = Two or more I/O cards are configured for virtual control panel (VCP) interfacing (not allowed). 00111101 = I/O priority chain broken. Vacant slots between plug-in cards not allowed. 00111100 = Two or more I/O cards are set for the same select code (not allowed). 00111011 = An I/O card is set for a select code less than 20 (not allowed). 00111010 = The I/O card set for VCP interfacing has the wrong select code.

Table A-1. Self-Test Error Codes (continued)

LED Error Code	DESCRIPTION (1 = ON, 0 = OFF)
01111100	00xxxxxx = None of the above. This is the select code of an I/O card that failed. (The select code is displayed in inverted logic: lit LED is logic 0, unlit LED is logic 1.)
01111011	Executing Loader
01111010	Loader Error
01111001	Loader Error
01111000	Executing Virtual Control Panel (VCP)
	Self-Test, RAM Tests
01110011	Fill RAM With Post-Inc Base Register Function
01110010	Test RAM With Pre-Dec Base Register Function
01110001	Fill Base Register Offset Table
01110000	Test Base Register Offsets
	Self-Test, ROM Tests
01101111	Position Check, ROM Locations 40000 thru 47777
01101110	Checksum Test, ROM Locations 40000 thru 47777
01101101	Position Check, ROM Locations 50000 thru 57777
01101100	Checksum Test, ROM Locations 50000 thru 57777
01101011	Position Check, ROM Locations 60000 thru 67777
01101010	Checksum Test, ROM Locations 60000 thru 67777
01101001	Position Check, ROM Locations 70000 thru 77777
01101000	Checksum Test, ROM Locations 70000 thru 77777
	Self-Test, Configuration and MCI Tests
01100111	No MCI Card Found
01100110	No HP-IB Card Found
01100101	Trap Cells
	continued

Table A-1. Self-Test Error Codes (Continued)

LED Error Code	DESCRIPTION (1 = ON, 0 = OFF)
	Self-Test, MCI Errors
01100100	Initialize and Last Control Word Interrupt
01100011	MCI Internal Registers
01100010	Time of Day Clock
01100001	Watchdog Timer
01100000	Timeout Interrupt
	Self-Test, BIF Tests
01011111	Box 0
01011110	Box 1
01011101	Box 2
01011100	Box 3
01011011	Box 4
01011010	Box 5
01011001	Box 6
01011000	Box 7
01010111	Box 8
01010110	Box 9
01010101	Box 10
01010100	Box 11
01010011	Box 12
01010010	Box 13
01010001	Box 14
01010000	Box 15
	Self-Test, HP-IB Tests
01001111	HP-IB Initialization, Clear
01001110	HP-IB Data Bus
01001101	PHI Initialize, Flush FIFOS
01001100	Output Data Transfer, Interrupts
01001011	Input data Transfer
01000000	Firmware initialization
00xxxxxx	Self-Test Passed (xxxxxx = don't care)

DIAGNOSTIC SOFTWARE

2250 DIAGNOSTIC OVERVIEW

A SELF TEST

B KERNEL

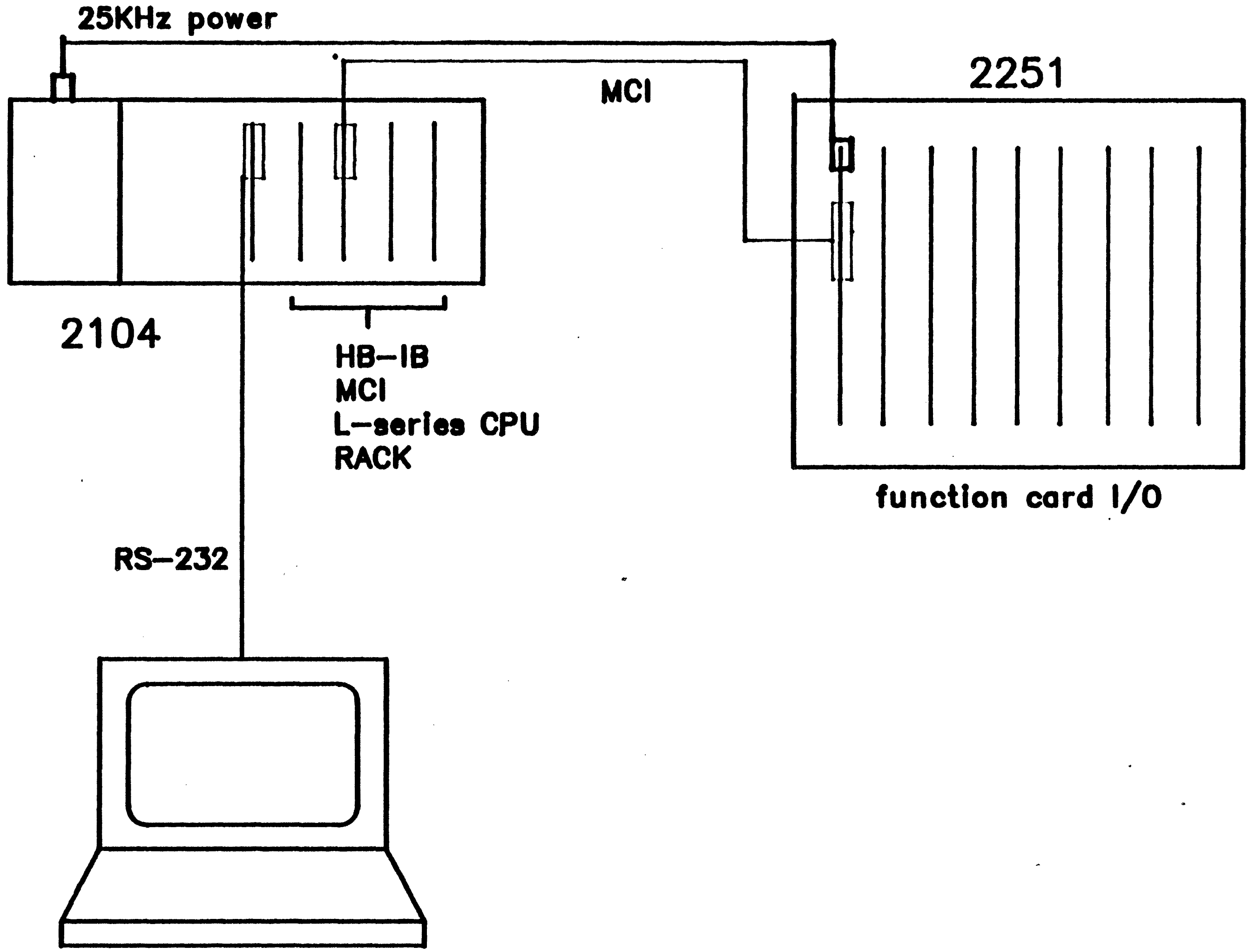
C RRACK

D MCI/B.IF

E HP-IB

F FUNCTION CARDS LEVEL 1

HP 2250 Test Configuration



HP 264x or HP 85 (emulation)

LEVEL I DIAGNOSTICS

DIAGNOSTICS

- Are available on mini-cartridge only
- Presently used with 264X AND HP 85

KERNEL

- Standard L series stand-alone diagnostic
- Tests CPU, RAM and I/O

MCI/BIF

- Checks MCI registers, timers and state machine.
- Checks BIF cards, interrupt circuitry

RRACK

- Checks base registers, stack, RAM and ROM.

HP-IB DIAGNOSTIC

- Requires DDL to be loaded
- Tests PHI chip, DMA circuitry and data paths.

FUNCTION CARD LEVEL 1

- Tests 85% of digital cards and 35% of analog cards
- Requires DDL to be loaded in memory
- To be run on installation
- Can be set to loop
- Are not interactive
- Error messages in Appendix B.

DSP

Overview of Diagnostic Service Package

Operation of Level II Software Diagnostics

D.S.P. Hardware

DIAGNOSTIC OPERATION

Menu Driven

Uniform Operation

Real Time Displays

Data in Engineering Units

A-SERIES COMPATABILITY

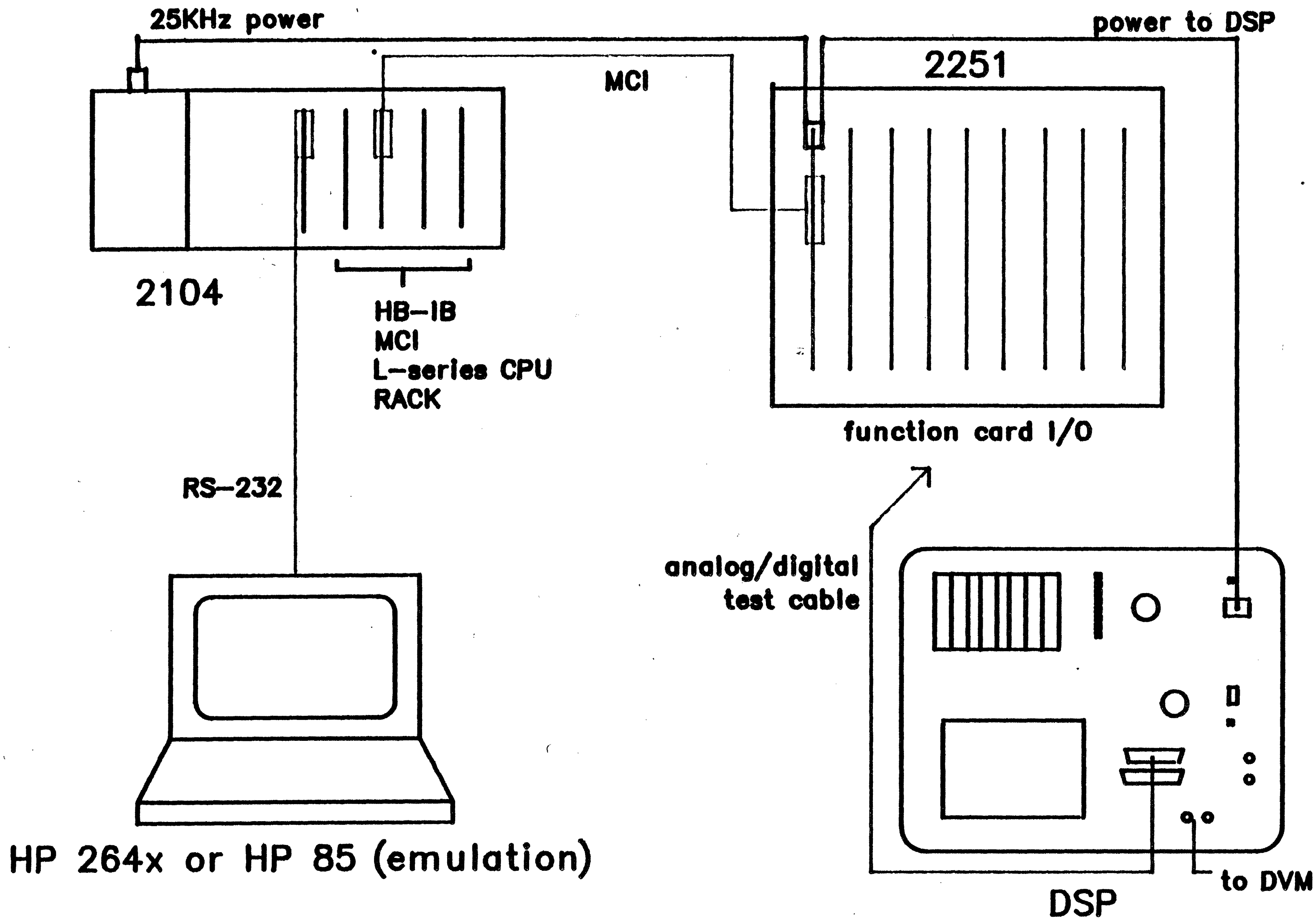
source code compatable

HP 2250 cannot use A-series DDL interpreter (with DCS)

uses too much memory [illegible])

current L-series DDL must be supported for HP 2250

HP 2250 Test Configuration



LEVEL II DIAGNOSTICS

DIAGNOSTIC SERVICE PACKAGE

Level II Software

7 diagnostic programs

written in DDL

750–1600 lines of code (each)

designed to operate with
HP 85 or HP 264x terminal

provide I/O testing of all
255xx M&C function cards

Software requires 1 to 4½ minutes to load
for each card type. Must be reloaded
if 2250 powered down (if no battery backup)

Always note card type configurations
Before powering up the 2250 for diagnostics.

EXECUTING A DIAGNOSTIC
(example)

```
LEVEL II Analog Input Diagnostic
Do you wish to test all cards
Enter Y or N
```

If response is Y, then the diagnostic automatically selects a function card for testing. If response is N, then the diagnostic will prompt for a slot number.

Enter slot number of test card

<response>

Select channels to be tested

1. Channels 1 to 8
2. Channels 9 to 16
3. Channels 17 to 24
4. Channels 25 to 32

Enter 1,2,3,4, or return to select new card.

<response>

Select type of test

A. Input test

B. Autorange test

C. Delayed Execution test

D. Alignment test

E. Open sensor detect

Enter A,B,C,D,E,

or return to select new chan.

Attach analog test fixture
to channels 1 through 8
Press return when ready

SLOT 2 25503 LOW LEVEL MUX

Input Test

Channel	Mvolts	Errs
1	1252	0
2	.007	0
3	1249	0
4	.010	0
5	50	0
6	−10001	0
7	49	0
8	−9998	0

Autoranging OFF

Press space bar for next menu

Digital Output SCM's
4–pt: 25543(s),25544(s), 25545(s),25546(s)

SCM type	Product No. Suffix(s)	Part No. Suffix(s)
internally pulled up	25544B	60002
	25544C	60003
	25546B	60001
open drain	25543N	60001
	25544A	60001
solid state	25545P	60001

Strobe Input SCM's
1–pt: 25531(s),25533(s)

SCM type	Product No. Suffix(s)	Part No. Suffix(s)
Isolated	33(B–H,J)	60001–60008
Source	31(B–E)	60001–60004
Sink	31(K,L)	60005,60006

*** DISABLE VOLTAGE SOURCE ***
Set CARD TYPE to DIGITAL OUT
Select MODE2 to test pts. 5–8
If strobe input SCM's are
mounted on card being tested,
set correct STROBE SCM type.
Set OUTPUT SCM type.
*** ENABLE VOLTAGE SOURCE ***
Attach digital out test module
to points 5 through 8
using digital card cables.
Press return when ready

SLOT 5 25513 DIGITAL OUTPUT

Output Test

Point	State	Errs
1	Low (0)	0
2	High (1)	0
3	Low (0)	0
4	High (1)	0

Press 1,2,3,4 to change state
Press 0 to change all states
Press space bar for next menu

SERVICE NOTES

IF YOU ARE USING INPUT SIGNALS GREATER THAN 10 VOLTS

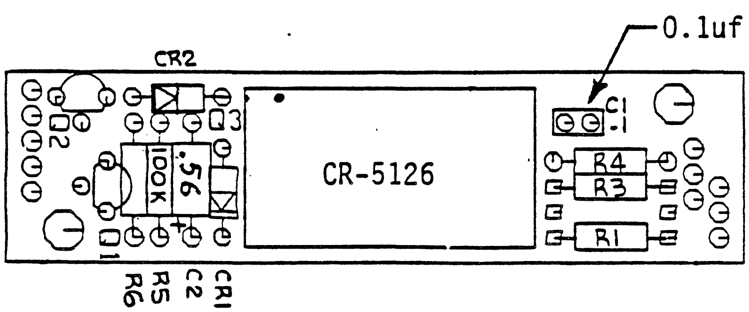
READ THE FOLLOWING NOTE

If you are using the Relay Mux (22504) to measure input signals greater than 10 volts the 0.1uf input filter capacitor must be removed.

The Relay Mux (25504A) has relay modules (25504-60002) mounted on the board. These relay modules contain the reed relays that switch or multiplex the input signals to the gain amplifier on the Relay Mux. The relay modules also have a 0.1uf filter capacitor tied between the differential inputs to reduce noise induced on the input. This filter capacitor has a voltage rating compatible to the 10v voltage range or less. When a voltage greater than 14v is applied across the capacitor it shorts out causing a low resistance load on the 100 ohm input resistors. The input resistors wattage rating is then exceeded due to the high current flow and the resistors burn out.

The 0.1uf input capacitor should be removed on those channels where the 10 volt range will be exceeded. Removing this capacitor will eliminate the over-voltage input shorting problem and increase the lifetime of the relays when switching input voltages greater than 10v.

The input capacitor can be identified using the diagram below. The removal of this capacitor is also described in the Hardware Reference Manual (02250-90001) page 7-17.



25504—60002

SERVICE NOTE

Supersedes:

APPLIES TO:	All Units ☒	Only Units on Agreement ☐
PERFORM:	Immediately ☒ On Failure ☐	At PM/Normal Call ☐ Information Only ☐

WARRANTY:	**EXTENDED**	**NORMAL**	**NONE**
LABOR:	.5 Hr		
PARTS:	X		
TRAVEL:	X		

SERVICE INVENTORY	Return for update ☐ Return for salvage ☐	Use as is ☒ See text ☐

WARRANTY EXTENDED UNTIL: July 1, 1982

2250N/R
Backplane Problem

A problem has been discovered with the backplane of the 2251AN/AR unit associated with 2250 M & C System. Stresses applied to the backplane can cause failure of the unit. A brace, Part No. 02251-60008, has been designed to eliminate these stresses. All units, shipped prior to 01 July 81, must be retrofied with the brace immediately.

Warranty will be extended for one year to cover travel and 1/2 hour of labor. Orders for the brace can be placed by calling Roseville Division order processing.

Dave Pratt
(916) 786-2001

Instructions for installation are included with the part.

PCO No. 52-0190

Bill Kind

8/81-52

HEWLETT PACKARD

2250-02

SERVICE NOTE

Supersedes:

APPLIES TO:	All Units ☐	Only Units on Agreement ☐
PERFORM:	Immediately ☐ On Failure ☐	At PM Normal Call ☐ Information Only X

WARRANTY:	**EXTENDED**	**NORMAL**	**NONE**
LABOR:			X
PARTS:			X
TRAVEL:			X

SERVICE INVENTORY	N/A	Return for update ☐ Return for salvage ☐	Use as is ☐ See text ☐
WARRANTY EXTENDED UNTIL:	N/A		

PDU WIRING DIAGRAM

(INFORMATION ONLY)

PROBLEM: The PDU wiring diagram in the Hardware Reference Manual (02250-90001 pg. vi March 1982 update) and Installation and Start-up Manual (02250-90012 pg. vi March 1982 update) is incorrect. The diagram shows the on/off switch shorts out the high and neutral lines when turned on.

CORRECTION: Note the following diagram, it reflects the correct configuration of the PDU. This corrected diagram will be included in the next set of manual updates in July 1982.

PCO; N/A

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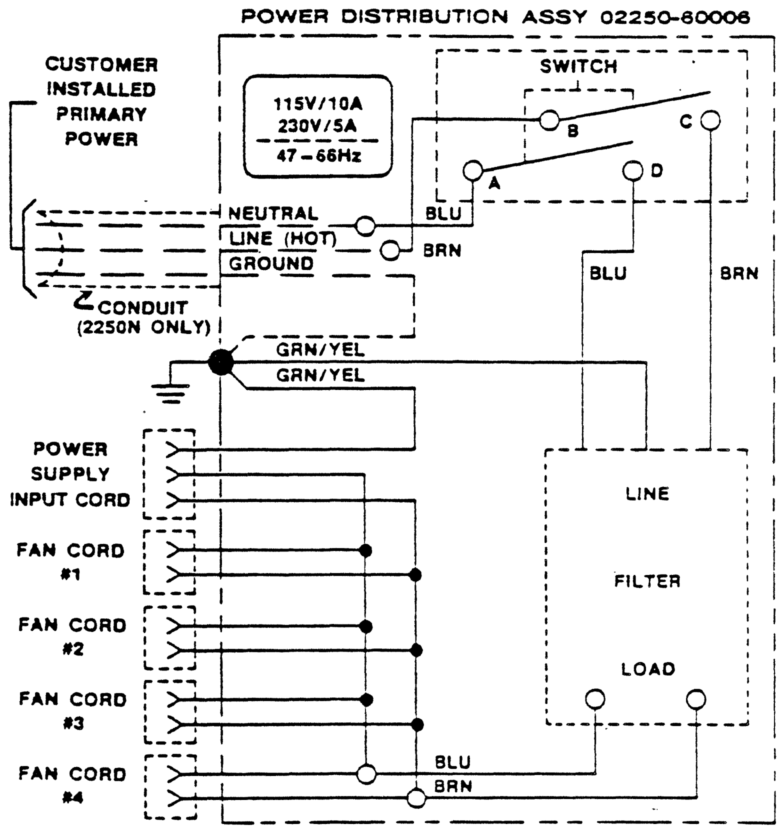

POWER DISTRIBUTION ASSY 02250-60006
CUSTOMER INSTALLED PRIMARY POWER
115V/10A
230V/5A
47 - 66Hz
SWITCH
B
C
A
D
NEUTRAL
LINE (HOT)
GROUND
BLU
BRN
BLU
BRN
CONDUIT (2250N ONLY)
GRN/YEL
GRN/YEL
POWER SUPPLY INPUT CORD
FAN CORD #1
FAN CORD #2
FAN CORD #3
FAN CORD #4
LINE
FILTER
LOAD
BLU
BRN

Noise Histograms
for Analog Input
Cards on 2250

We have had several requests from the field regarding noise and how to evaluate if a particular 2250 system is exhibiting excessive noise on it's analog input cards. We have made available to the field via DSD "SEAS" a program called HIST that will provide a statistical analysis or histogram of readings taken on an individual channel. HIST provides the user with the spread, average, standard deviation, etc. on a finite number of readings taken "on channel". The information gathered can help determine whether a system is within specification or not. To use this program first gain access to DSD "SEAS" and retrieve &HIST. Load &HIST onto the host 1000 of the 2250 under test. Compile it using the Fortran compiler in the system. It requires a large background (LB) option. Once compiled and loaded use MCX to set the gain of the channel to be scanned to 800. Now run HIST. Follow the sample below. User inputs are underlined.

Sample session	Comments
:MCX,43 Using LU 43 as the 2250 LU.	Run MCX to LU of the 2250 you are working on.
== : MCX - HP2250 M & C Processor Exerciser : == Use ? for help, Quit to exit.	
MCX: GAIN(2,30)124! No error; no results returned.	Set gain of the slot and channel of the LLMUX being tested. "124"=gain of 800
MCX: Q :HIST1 LU OF THE 2250? 43	Quit MCX Run HIST
SLOT IN QUESTION? 2 CHANNEL OF OPERATION? 30	Respond to prompts.
HISTOGRAM SPECIFICATIONS HOW MANY READINGS? 1000	
MILLI-SECONDS BETWEEN READINGS? 0 MICRO SECONDS BETWEEN READINGS? 20 PACE1= 0 PACE2= 20	"0"ms and "20"us
BUCKET WIDTH (VOLTS RTO)? .00001	Bucket widthes should be 10uv (.00001) Distribution of readings
VALUE NUMBER OF READINGS -.0000250 17 -.0000150 385 -.0000050 570 .0000050 28	
Average value is -.0000087 Top= .00001 Bottom= -.00002 The spread of the readings is .0000312 Standard deviation is .0000051	Spread should be less than 70.0uv Standard deviation should be less than 10.0uv NOTE: The above readings are 31.2uv spread and 5.1uv S.D.
WHAT NEXT ? REPEAT..............................NULL REPEAT WITH NEW HISTOGRAM SPECS.........1 REPEAT WITH NEW CARD AND CHANNEL SPECS..2 HALT PROGRAM...........................3	

The above data was retrieved while shorting the input on slot 2 channel 30 with a shorting block (25595-60010). The shorting block will short eight (8) channels at a time and can be found in the DIU package (02250-67801) or ordered from CPC.

If you determine that the noise specification is not met by the 2250 being tested refer to Service Notes 2250-04 and 2250-05. If these Service Notes are properly executed the noise in the 2250 should be reduced with-in the specification.

NOTE: The HIST program will only run on a 1000 that has a large background partition. HIST can be run on other systems with modification. If you are working on a Desktop Computer or require help in modifying the program call Roseville Division for help.

SN 2250-04

SERVICE NOTE

Supersedes:

APPLIES TO:	All Units ☐	Only Units on Agreement ☒
PERFORM:	Immediately ☐ On Failure ☐	At PM/Normal Call ☒ Information Only ☐

WARRANTY:	EXTENDED	NORMAL	NONE
LABOR:		X	
PARTS:		X	
TRAVEL:		X	

SERVICE INVENTORY	Return for update ☐ Return for salvage ☐	Use as is ☐ See text ☒

WARRANTY EXTENDED UNTIL: n/a

12035/2250
LLMUX Noise

Problem: The 25503 LLMUX may exhibit high levels of noise. This noise can be exhibited by shorting the input to the LLMUX, setting the LLMUX gain to 800, and taking a number of readings. The spread of the readings "on channel" should be less than 70 microvolts(uv).The standard deviation of those readings should be less than 10uv.*

Cause: The 12035 power supply provides 25kHz, 30volt power to the Measurement and Control Unit (2251 MCU). The Backplane Interface Card (BIF) receives this power through a front connector, steps the 30 volts down to several voltages and distributes the lower voltages onto the backplane to power the function cards. The BIF provides a 100kHz sync signal to the 12035 power supply. The 12035 divides the 100kHz signal by four (4) to provide a 25kHz sync signal to lock on to. This is important, as the sync signal locks the power supply frequency to the system clock on the MCI card. The power supply's phase lock loop (PLL) is designed to only lock onto frequencies greater than it's own center frequency. If the PLL center frequency is greater than the 25kHz sync signal (ie. 26.5kHz) then the sync signal will be ignored and the power supply frequency will free run at it's own center frequency (26.5kHz in this case). All power supplies tested to date on systems or 2104's shipped before July 1982 have exhibited center frequencies greater than 25kHz. Those power supplies that are set above 25 kHz are free running at frequencies greater than 25kHz and are not synchronized to the 2250 system.

Solution: The/ center frequency of the power supply requires adjustment to 23.75kHz. This setting will allow the 100kHz sync signal (divided by four) to synchronize and lock the 12035 power supply frequency to the 2250 system clock.

REQUIRED EQUIPMENT: Frequency counter
Shorting block 25590-60010 (in PS kit)
Program HIST *

PROCEED AS FOLLOWS

HEWLETT PACKARD

1) Check the frequency of the power supply at pins 1 and 2 of the 25kHz 30 volt output.
   a) Check with the 100kHz sync signal plugged in.
      Should be 25kHz plus or minus 10-15Hz
   b) Check with the 100kHz sync signal disconnected.
      (small 2 pin connector on front of BIF or small 9 pin connector on front of 12035 power supply)
      Should be less than 24,700Hz

If reading 1b is not less than 24,700Hz proceed to step 2 to adjust power supply center frequency.
If 1b is OK and 1a is not then you may have a defective power supply, power cable (12035-BIF), BIF, or MCI card.

If the power supply requires adjustment proceed as follows:

2) REMOVE POWER
3) Remove 12035 from 2104 or rack.
4) Remove top cover (eight screws)
   WARNING HIGH VOLTAGE MAY BE PRESENT
5) Locate center frequency pot (see diagram)
   Secondary plug in card closest to center of power supply
   pot on edge of card

```
 ______________________________________________
|                                              |
|        Center                                |
|        frequency ------->o o_________________|
|        pot               o___________________|
|______________________________________________|
```

Top view of 12035 power supply with cover off.

6) Plug in power cord   WARNING HIGH VOLTAGE PRESENT
7) Reconnect frequency counter to 25kHz output of power supply pins 1 and 2.
8) Adjust pot CCW to reduce frequency to 23,750Hz.
9) Power OFF.
10) Reassemble power supply and reinstall.
11) Check 25kHz 30volt output with sync line plugged in. Frequency should be 25kHz plus or minus 10-15Hz.
12) Check if noise has been reduced below 70uv spread and 10uv standard deviation.* If there are more than two (2) MCU's in the system there will be more than one (1) 12035 power supply. All power supplies must be adjusted in the system.
13) If the noise has not been reduced below the spec the BIF card may require replacement.**

NOTE: This adjustment should only be made on conplaint of the customer. The manifestation of this noise problem is seen only on the 25503 LLMUX and when that card's gain is set to 800. Therefore it affects only a small number of systems. FSI should be checked and adjusted locally. All new and exchange 12035's shipped after 1 July 1982 have been readjusted. No part number change or date code change is required since this is an adjustment.

* A noise histogram program is available to automatically determine the spread, average, and standard deviation of a finite number of readings taken 'on channel'. &HIST is available at DSD on "SEAS". Refer to SN 2250-03 for more information on HIST.

** Refer to SN 2250-05 for more information on BIF/25503 noise problems.

SN 2250-05

SERVICE NOTE

Supersedes:

APPLIES TO:	All Units ☐	Only Units on Agreement ☒
PERFORM:	Immediately ☐ On Failure ☒	At PM/Normal Call ☐ Information Only ☐

WARRANTY:	**EXTENDED**	**NORMAL**	**NONE**
LABOR:		X	
PARTS:		X	
TRAVEL:		X	

SERVICE INVENTORY	Return for update ☒ Return for salvage ☐	Use as is ☐ See text ☐

WARRANTY EXTENDED UNTIL: 15 August 1983

BIF/LLMUX
Noise

Problem: The 25503 LLMUX may exhibit high levels of noise. This noise can be exhibited by shorting the input of the LLMUX, setting the LLMUX gain to 800, and taking a number of readings. The spread of the readings "on channel" should be less than 70 microvolts(uv). The standard deviation should be less than 10uv.*

NOTE: SN 2250-04 must be performed before proceeding with this service note.

Cause: The 12035 power supply provides 25kHz, 30 volt power to the Measurement and Control Unit (2251 MCU). The Backplane Interface Card (BIF) receives this power through a front connector, steps the 30 volts down to several voltages and distributes the lower voltages onto the backplane to power the function cards. The two (2) transformers on the BIF must have their primary windings wound opposite of each other, otherwise the Electromagnetic radiation (EMI) emmitted by the two (2) transformers is increased considerably, causing excessive noise on the LLMUX.

Solution: The only effective way to test for excessive noise is to run HIST.* If there is excessive noise replace the BIF. The spread should be less than 70uv and the standard deviation should be less than 10uv.

All 25574-69001 boards in field inventory should be retuned to CSD for credit. A 25574-69002 will be the replacement for the 25574-69001. If a noisy BIF is found at a customer site, replace the 255746x001 with a 25574-69002. All 25574-6x002 boards are known good boards with matched transformers and tested for noise.

OLD BIF 25574-6x001 NEW BIF 25574-6x002

NOTE: This board exchange should only be made on customer complaint. The manifestation of this noise problem is seen only on the 25503 LLMUX and when that cards gain is set to 800. Therefore it affects only a small number of customers. Less than one third (1/3) of all BIF's shipped have miss matched transformers, so not all customers with LLMUX's will even have this problem.

* A noise histogram program "Hist" is available to automatically determine the spead, average, and standard deviation of a finite number of readings taken 'on channel'. &HIST is available at DSD on "SEAS". Refer to SN 2250-03 for more information on HIST.

SN 2250-06

S E R V I C E N O T

Supersedes:

APPLIES TO:	All Units ☐	Only Units on Agreement ☒	
PERFORM:	Immediately ☐ / On Failure ☒	At PM/Normal Call ☐ / Information Only	
WARRANTY:	EXTENDED	NORMAL	NONE
LABOR:		X	
PARTS:		X	
TRAVEL:		X	
SERVICE INVENTORY	Return for update ☒ / Return for salvage ☐	Use as is ☐ / See text ☐	
WARRANTY EXTENDED UNTIL:	1 Nov. 1983		

Noise on the

25503 LLMUX

Problem: The 25503-6X001 has exibited a high level of noise when it is set at a gain of 800. After executing the two previous service notes 2250-04 (12035/2250 LLMUX Noise) and 2250-05 (Bif/LLMUX Noise) the noise exibited on those LLMUX's in slots 2 and 3 in the MCU may be as high as 90uv of spread (SP) and 15uv of standard deviation (SD)on some cards. The specifications call for a maximum of 70uv SP and 10uv SD.

Cause: There are two problems that need to be addressed. First is the spread (SP) being out of specification. The problem is a first reading offset caused by an unstable driven ground power supply. The manifestation of the problem is that when a new channel is addressed, the floating ground of the amplifier strip oscillates during the first one or two readings on that channel. The oscillation of the driven or floating ground causes the input signal to look different than it actually is (ie. it is offset by 30-50uv). The feedback loop in the driven ground amplifier circuit was modified to eliminate the oscillation problem.

The second problem of the SD being out of specification was caused by the 25kHz power distributed to the function cards being coupled into the first stage amplifier on the LLMUX. This coupled noise was then amplified by a gain of 100 on the LLMUX and caused the the distribution of the readings taken on channel to be excessively wide. Shields were added above and below the amplifier strip on the LLMUX to reduce the amount of 25kHz noise coupled into the input.

Solution: The 25503-6X001 has been replaced by the 25503-6X002. The new board includes the power supply change and the shields. The specifications of 70uv SP and 10uv SD will be met by the 25503 at any pacing rate when using 'HIST' *.

All boards in field service inventory should be returned to CSD for credit. A 25503-69002 will be the replacement for the 25503-60001. Replace or fix on failure only.

OLD LLMUX 25503-6X001 NEW LLMUX 25503-6X002

NOTE: Contact RVD Tech Marketing to obtain the proper ordering and billing information. Orders greater than two (2) cards will not be accepted without prior authorization from RVD.

Service notes 2250-04 and 2250-05 must be implemented either prior to or concurrent to this service note.

* HIST is available on SEAS. A description on the use and operation is provided in service note 2250-03.

HEWLETT PACKARD

SN 2250-07

SERVICE NOTE

Supersedes:

APPLIES TO:	All Units ☐	Only Units on Agreement ☒
PERFORM:	Immediately ☐ On Failure ☐	At PM/Normal Call ☐ Information Only ☒

WARRANTY:	EXTENDED	NORMAL	NONE
LABOR:		X	
PARTS:		X	
TRAVEL:		X	

SERVICE INVENTORY	Return for update ☒ Return for salvage ☐	Use as is ☐ See text ☐
WARRANTY EXTENDED UNTIL: N/A		

25504 Relay Mux
Input Over-voltage
Latch-up

Problem: When an input voltage is 110% or greater than the specified range set up via software, the 25504 Relay Mux latches up into a nonrecoverable state. The only way to recover is to power the MCU down and power it back up again.

Cause: The Relay Mux will latch-up if the input voltage exceeds 110% of the programmed range. If the card was set to a gain of .1 or a range of 100 volts and the input exceeded 110 volts differential mode (ie.across the high and low inputs) the card will latch-up. The over-voltage flip-flop would set causing all the input relays to open and protect the card. The only way to reset the flip-flop was to remove the suspect input signal and power the Relay Mux down.

Solution: The over voltage flip-flop configuration was changed to reset every time the card changes from channel to channel to eliminate this problem. The new date code that reflects this change is 2230. FSI should be updated with the new date code. Customer boards should be replaced on failure only since this is an enhancement to the product.

Note: This service note is for information only and no warranty is available since it only latches-up due to customer error (over voltage on the input for the programmed range).

SN 2250-08

SERVICE NOTE

Supersedes:

APPLIES TO:	All Units ☐	Only Units on Agreement X
PERFORM:	Immediately ☐ On Failure X	At PM/Normal Call ☐ Information Only ☐

WARRANTY:	EXTENDED	NORMAL	NONE
LABOR:	0.5 hours		
PARTS:		X	
TRAVEL:	Standard		

SERVICE INVENTORY	Return for update ☐ Return for salvage ☐	Use as is ☐ See text X
WARRANTY EXTENDED UNTIL:	1 November 1983	

25594B Relay Mux
TRC power cable
miswired

Problem: The power cable portion of the Relay Mux TRC cable was miswired. The TRC will not return the proper ambient temperature of the TRC isothermal block.

Cause: The +12 volt and common wires on the TRC end of the cable were reversed causing the TRC to malfunction.

Solution: The two wires should be reversed so that the TRC is powered correctly. The +12 volt wire (red) should be connected to pin 3, the -12 volt wire (green or white) should be connected to pin 2, and the common or ground wire (black) should be connected to pin 1. This can be accomplished by removing the red wire from pin 1 and the black wire from pin 3. To remove the pins from the plastic connecter use a small blade screw driver to depress the retaining clip on the pin and slide the pin out. To replace the pins just slide the pin with the red wire into position 3 of the plastic connecter and the pin with the black wire into position 1 of the plastic connecter (ie. just swap pins 1 and 3).

GND BLACK	PIN 1	TRC END OF CABLE
-12v GRN or WHT	PIN 2	
+12v RED	PIN 3	

Do not check unless there is a customer complaint. The above modification should only be made if the TRC does not return the proper ambient temperature.

This repair can be performed on the customer site. One half (0.5) hour is provided to perform the fix ,and standard travel. There is no FSI to update or replace.

SERVICE NOTE

Supersedes:

APPLIES TO:	All Units ☐	Only Units on Agreement X
PERFORM:	Immediately ☐ / On Failure ☐	At PM/Normal Call X / Information Only ☐

WARRANTY:	EXTENDED	NORMAL	NONE
LABOR:	2 hours		
PARTS:		X	
TRAVEL:			X

SERVICE INVENTORY	Return for update ☐ / Return for salvage ☐	Use as is ☐ / See text X

WARRANTY EXTENDED UNTIL: 1 Nov. 1983

2162 Upgrade For 2250'N'

Problem: When the 2250 systems were originally introduced the sales liturature indicated that a system could be upgraded to a 2162 Automaton Processor if the customer chose to do so after taking delivery of the 2250 system. Some addtional engineering was required to maintain the high reliability expected of the product, and 2250'N' systems with a date code less than 2210 can not be upgraded to a 2162 without modification in the field.

Cause: All 2250'N' systems with a date code less than '2210' require an additional fan assembly (02250-60011) (110v) or (02250-60012) (220v) for additional cooling, and a new power distribution unit (PDU) (02250-60006) to reduce radiated emmisions onto the power line.

Solution: The fan assembly needs to be attached to the top of the 2104AN and the old PDU needs to be replaced with the new PDU (02250-60006) which includes a line filter.

Fan assembly (110volt)	02250-60011 \	One or the other
	X	is required, not
Fan assembly (220volt)	02250-60012 /	both.
Power distribution unit	02250-60007	

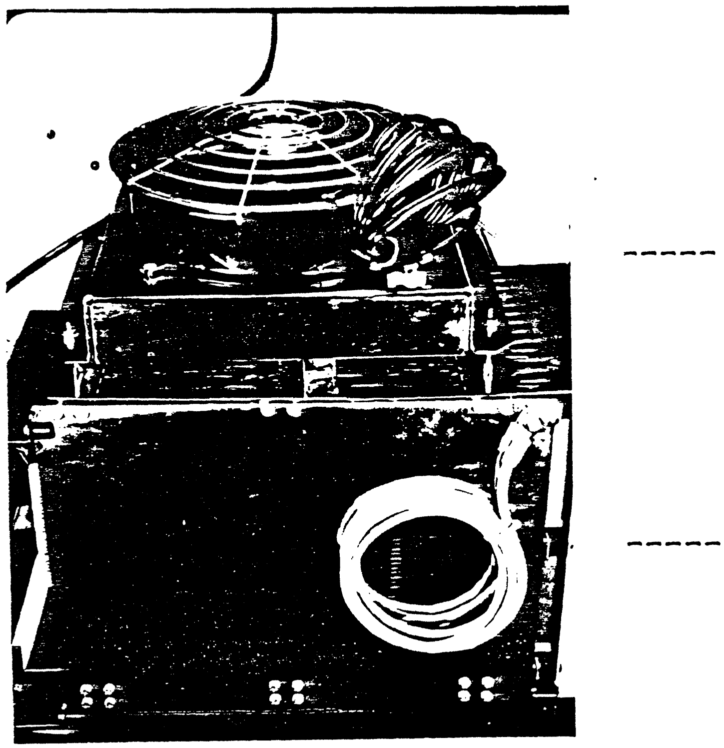
Order the above parts from CPC. Two (2) hours of installation is provided plus parts mentioned above. No travel is included as this upgrade should be done concurrent to the 2162 upgrade. The sales order of the "L"series used to upgrade the 2250 system to a 2162 must accompany any billing for this service note.

NOTE: Any 2250'N' with a date code of '2210' or greater may be upgraded by just adding the necessary "L"series cards into the lower card cage of the 2104AN. Those units that are not upgraded to a 2162 do not reqire the modifications described in this service note.

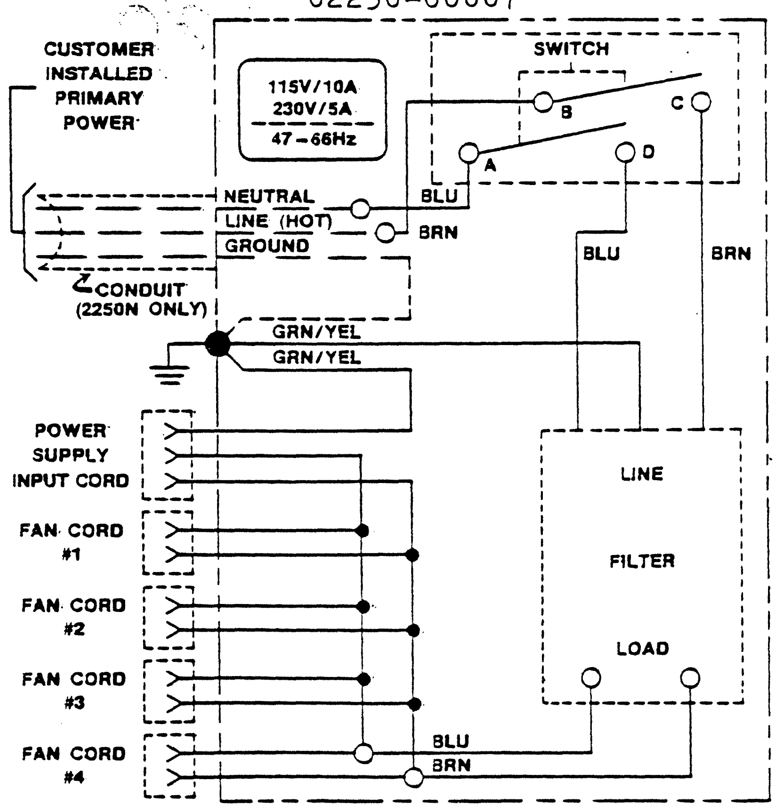
CAUTION: Presently none of the 'standard' 2250 systems or components provide for upgrading with any "A"series processor or component.

(over for diagrams)

Fan Assembly
02250-60010 or 02250-60011



PDU
02250-60007



SN 2250-10

S E R V I C E   N O T E

Supersedes:

APPLIES TO:	All Units ☐	Only Units on Agreement X
PERFORM:	Immediately ☐ / On Failure ☐	At PM/Normal Call X / Information Only ☐

WARRANTY:	**EXTENDED**	**NORMAL**	**NONE**
LABOR:	2 hours		
PARTS:		X	
TRAVEL:			X

SERVICE INVENTORY	Return for update ☐ / Return for salvage ☐	Use as is ☐ / See text X

WARRANTY EXTENDED UNTIL: 1 Nov. 1983

2162 Upgrade For 2250'R'

When the 2250 systems were originally introduced the sales literature indicatd that a system could be upgraded to a 2162 Automation Processor if the customer chose to do so after taking delivery of the 2250 system. Some additional engineering changes were required to maintain the high reliability expected of the product.

Problem: 2250'R' systems with a date code less than 2210 can not be upgraded to a 2162 without modification in the field.

Cause: The 2250'R' with a date code less than 2210 requires a backplane power cable with larger gauge wire to provide greater current carrying capacity for the additional "L"series boards and a new power distribution unit with a line filter to reduce radiated emmisions onto the power lines.

Solution: Replace the present backplane power cable (25570-60009) with the new 'Y' type cable (25572-60004), and replace the old PDU with the new PDU with the line filter (02250-60007).

Backplane power cable	25572-60004
Power distribution unit	02250-60007

Order the above parts from CPC. Two (2) hours of installation is provided plus parts mentioned above. No travel is included as this upgrade should be done concurrent to the 2162 upgrade. The sales order of the "L"series used to upgrade the 2250 system to a 2162 must accompany any billing for this service note.

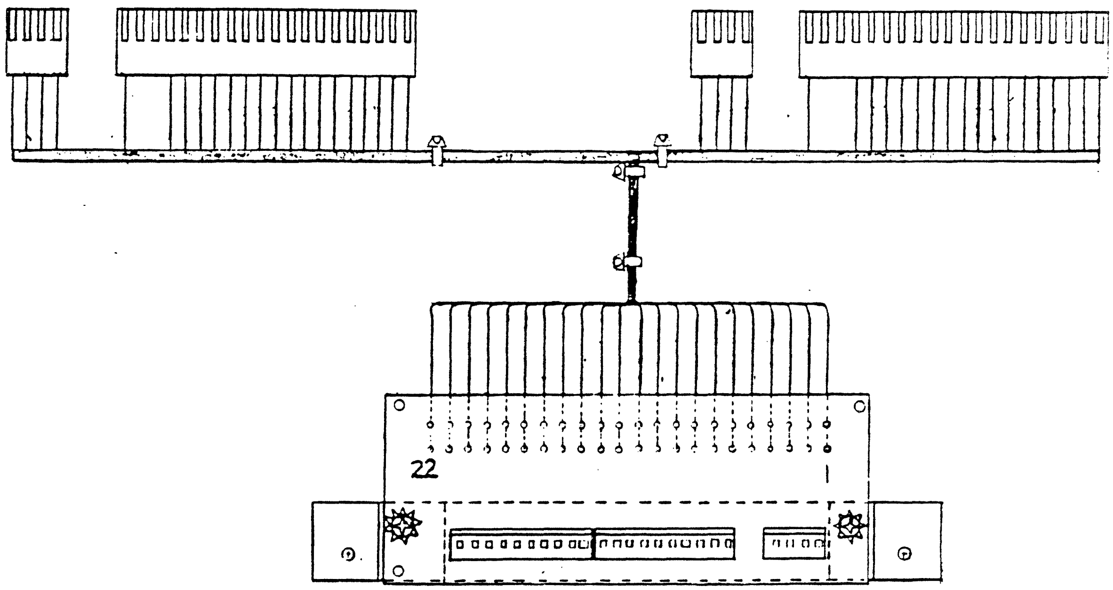
NOTE: Any 2250'R' with a date code of 2210 or greater may upgraded to a 2162 by just adding the necessary "L"series cards into the right side of the 2104AR card cage. Those units that are not upgraded to a 2162 do not require the modifications described in this service note.

CAUTION: Presently none of the 'standard' 2250 systems or components provide for upgrading with any "A"series processor or component.

(over for diagrams)

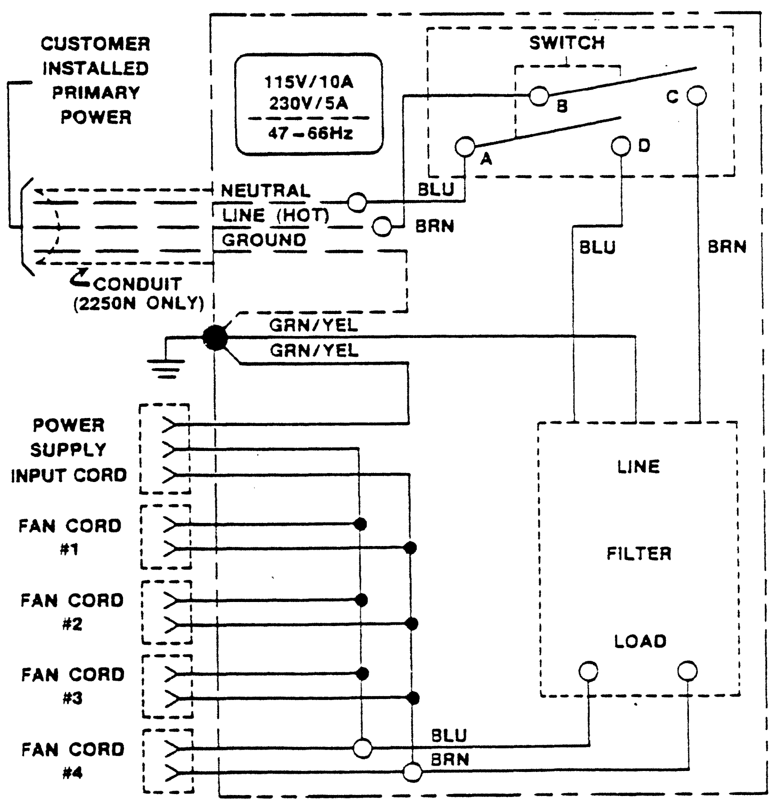
25572-60004 Backplane power cable

To 2250 backplane   To XL backplane



To back of 12035 power supply

Power Distribution Unit
02250-60007



SN 2250-11

SERVICE NOTE

Supersedes:

APPLIES TO:	All Units ☐	Only Units on Agreement ☒
PERFORM:	Immediately ☐ / On Failure ☐	At PM-Normal Call ☐ / Information Only ☒

WARRANTY:	EXTENDED	NORMAL	NONE
LABOR:			X
PARTS:			X
TRAVEL:			X

SERVICE INVENTORY	Return for update ☐ / Return for salvage ☐	Use as is ☒ / See text ☐

WARRANTY EXTENDED UNTIL: N/A

New MCI-BIF cable
for RFI requiements

The old MCI-BIF cable (25570-60004) flat ribbon cable contributed to the 2250 systems' radiated emmisions causing the 2250 to not meet RFI regulations.

The old flat ribbon cable (25570-60004) was not shielded and contributed to EMI emmisions of the product.

A new shielded MCI-BIF cable (12071-60003) has been created to reduce the radiated emmisions of the 2250 system.

New MCI-BIF cable	Old MCI-BIF cable flat ribbon type
12071-60003	25570-60004

This is an 'information only' service note, there are no suggested or required updates to be performed for this service note.

S E R V I C E N O T E

Supersedes:

APPLIES TO:	All Units ☐	Only Units on Agreement ☒
PERFORM:	Immediately ☐	At PM Normal Call ☐
	On Failure ☐	Information Only ☒

WARRANTY:	EXTENDED	NORMAL	NONE
LABOR:		X	
PARTS:		X	
TRAVEL:		X	

SERVICE INVENTORY	Return for update ☐	Use as is ☒
	Return for salvage ☐	See text ☐

WARRANTY EXTENDED UNTIL: N/A

Relay module shorting out with 15 volt differential input

Problem: When a voltage greater than 14 volts is input into the differential input of the Relay Mux (25504A), the input is becomes shorted after a short period of time. This causes the 100 ohm input resistors to burn up, and the 2250 to give erroneous readings. The Relay Mux is rated to handle inputs up to 100 volts.

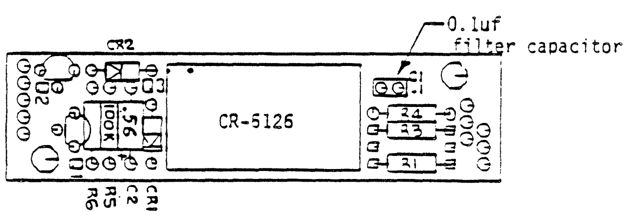
Cause: The Relay Mux (25504A) has relay modules (25504-60002) mounted on the board. These relay modules contain the reed relays that switch or multiplex the input signals to the gain amplifier on the Relay Mux. The relay modules also have a 0.1uf filter capacitor tied between the differential inputs to reduce noise induced on the input. This filter capacitor has a voltage rating compatible to the 10v voltage range or less. When a voltage greater than 14v is applied across the capacitor it shorts out causing a low resistance load on the 100 ohm input resistors. The input resistors wattage rating is then exceeded due to the high current flow and the resistors burn out.

Solution: The 0.1uf input capacitor should be removed on those channels where the 10 volt range will be exceeded. Removing this capacitor will eliminate the over-voltage input shorting problem and increase the lifetime of the relays when switching input voltages greater than 10v.

The input filter capacitor is provided for customer convenience and is not necessary for the operation of the Relay Mux card.

The input capacitor can be identified using the diagram below. The removal of this capacitor is also described in the Hardware Reference Manual (02250-90001) page 7-17.

This is an 'Information Only' service note and no warranty is included.



HEWLETT PACKARD

SERVICE NOTE

Supersedes:

APPLIES TO:	All Units ☐	Only Units on Agreement XX
PERFORM:	Immediately ☐ On Failure ☐	At PM Normal Call ☐ Information Only XX

WARRANTY:	EXTENDED	NORMAL	NONE
LABOR:			X
PARTS:			X
TRAVEL:			X

SERVICE INVENTORY	N/A	Return for update ☐ Return for salvage ☐	Use as is ☐ See text ☐

WARRANTY EXTENDED UNTIL:

Software Service Note

MCLIO Averaging Routine Bug

Problem: MCLIO is a 2250 downloaded subroutine which can be used to collect input data, average the data, and convert the average to engineering units. However, in the current revision (2101) of MCLIO, the averaging routine does not always return correct results.

Cause: The MCLIO averaging routine does not always use every sample read to compute the average, thus giving an invalid average result. Also, if the data collected and averaged by MCLIO does not all have the same gain code, MCLIO may use the wrong zero-offset factor to correct the average for drift.

Solution: These 2 bugs in the MCLIO averaging routine have been fixed, and the corrected version of $QLIB (which contains MCLIO) is now available. The new revision code is 2240, and the corrected version of $QLIB is available on SEAS at DSD. The new version of MCLIO should not be used with autoranging because if all the data to be averaged do not have the same gain code, MCLIO will return an out-of-range result as the average.

Note: In addition to fixing the averaging algorithm, the new version of MCLIO adds a new feature. Now MCLIO can be used to set up scan or channel mode pacing (equivalent to the PACE and CPACE commands in MCL/50). This will be documented in an update to the Automation Library Manual, part number 25581-90001.

SN 2250-15

SERVICE NOTE

Supersedes:

APPLIES TO:	All Units X	Only Units on Agreement ☐
PERFORM:	Immediately ☐ On Failure ☐	At PM/Normal Call ☐ Information Only X

WARRANTY:	EXTENDED	NORMAL	NONE
LABOR:			
PARTS:			
TRAVEL:			

SERVICE INVENTORY	Return for update ☐ Return for salvage ☐	Use as is ☐ See text ☐

WARRANTY EXTENDED UNTIL: n/a

25574-6x002 BIF card
Mis-matched transformers
(For information only, re: SN 2250-05)

Problem: Recently,it was discovered that mismatched transfomers on the 25574-60001 caused an increase in noise on the 25503-60001 LLMUX card;service note 2250-05 titled "BIF/LLMUX NOISE" described the possible problems and fix.The vendors were informed of the correct winding configuration for the transfomers with an assembly upgrade to 25574-60002.However, a part no.change to the transformers was never implemented.For reasons of traceability,we have now decided to change these part no.'s and revise the date code of the 25574-60002 assembly.

Cause: The original fix included 'red dots' painted-on the transformers to distinguish between those parts that were matched and those that were not,as opposed to changing the part no.'s. This caused problems in manufacturing the p.c. assembly;thus,new transformer part no.'s were implemented.

Solution:

Listed below are the old and new transformer part no.'s;the new numbers become effective as of p.c. assembly date code 2247.Any transformers before date code 2247 will have the 'red dots' painted-on.

old #	new #
9100-2637	9100-4294
9100-2681	9100-4295

There is no functional,physical or electrial change to the pca and thus requires no action in the field;the change was made for divisional traceability of the parts only.

This service note is for information only.

SN 2250-16
SERVICE NOTE

SUPERSEDES
NONE

APPLIES TO:	All Units ☒	Only Units on Agreement ☐
PERFORM:	Immediately ☐ On Failure ☒	At PM/Normal Call ☐ Information Only ☐

WARRANTY:	EXTENDED	NORMAL	NONE
LABOR:			X
PARTS:	X		
TRAVEL:			X

SERVICE INVENTORY	Return for update ☐ Return for salvage ☐	Use as is ☐ See text ☒

WARRANTY EXTENDED UNTIL: September 1984

HIGH "OFF" SIGNAL LEAKAGE CURRENT IN SIGNAL CONDITIONING MODULES (25543N, 25544A, 25544B, 25544C)

Problem: The 25543N, 25544A, 25544B, and 25544C Signal Conditioning Modules each contain four VMOS field-effect transistors (FET's) that are used as output switches. The FET's switch on and off normally. However, when switched off, some of these FET's have a leakage current that is greater than the 10 μamp specification. If the leakage current is large enough, it can cause the customer's circuitry to turn on. Often, the customer's external circuitry provides the only indication that the FET is malfunctioning.

Cause: FET's (P/N 1855-0431) with date codes 8113, 8120, and 8125 have a bad die that results in premature breakdown. This causes a high leakage current when the FET is off.

Solution: All FET's (P/N 1855-0431) with date codes of 8113, 8120, and 8125 have the bad die. New FET's will be used on the 25543N, 25544A, 25544B, and 25544C SCM's. These new FET's have had a die change which should prevent their early breakdown and eliminate their high leakage current.

Until September 1984, any existing 25543N, 25544A, 25544B and 25544C SCM's that have FET's (P/N 1855-0431) with date codes of 8113, 8120, and 8125 can be replaced under warranty IF THEY FAIL. The date code is a four-digit number that is labeled on the FET. New FET's have a dot between the first two digits and the last two (i.e. 82.37). Old FET's have the four-digit number with no dot.

GD/svs

09/83-09

Printed in U.S.A.

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The old SCM's should be discarded when they fail. They should be replaced with a new SCM that contains the new FET's. The SCM part numbers are as follows:

25543N	25543-60001
25544A	25544-60001
25544B	25544-60002
25544C	25544-60003

HP 2250
MEASUREMENT AND CONTROL PROCESSOR

Installation and Start Up

HP 2250

SITE ENVIRONMENTAL

MANUAL

MAY 1982

PRELIMINARY

H. P. CONFIDENTIAL

SECTION 1 INTRODUCTION GENERAL INFORMATION

This manual provides information regarding the environmental requirements of the Hewlett-Packard 2250. This includes operating and non-operating (storage, transport or power down) requirements. Section II provides a generic description of each environmental item. Appendix A contains the specific environmental requirements, operational specifications and operational characteristics for each specific HP 2250.

Note: This manual applies only to the HP 2250's listed in Appendix A.

USE A POWER & SITE PREP SPECIALIST

The environmental requirements cover both the actual physical location of the HP 2250 and the associated area. While Hewlett-Packard provides consultation on the site environment requirements, the scheduling, planning, preparation and verification of a site environment suitable for installation of a Hewlett-Packard 2250 is the customer's responsibility. Hewlett-Packard Sales and Support Personnel are available during the pre-installation period to assist the customer.

The information in this manual covers only the Hewlett-Packard 2250's and accessories. The customer is responsible for meeting the site environmental requirements for the rest of the system components. If the HP 2250 is to be installed on Hewlett-Packard computer equipment, appropriate site preparation documentation, including environmental requirements will be provided for each system component.

Environmental requirements are those items required to ensure that the HP 2250 will meet the published operational characteristics. Each environmental item has a specific measurable parameter or information that affects the operational characteristics of the HP 2250. Continual operation of the HP 2250 at the limits of the environmental requirements may result in degradation of HP 2250 operation. The following items are considered environmental requirements.

*Temperature	*Electromagnetic Susceptibility
*Humidity	*Contaminants
*Shock	*Cooling Requirements
*Vibration	*Altitude

Chemical contaminants that can corrode components are presently being researched by Hewlett-Packard. Operating a Hewlett-Packard 2250 in an environment known to contain significant amounts of the listed contaminants will lead to malfunctions requiring extensive servicing. Hewlett-Packard therefore recommends to our customers that HP components not be stored or operated in areas that contain the contaminants listed under corrosive contaminants.

SECTION II ENVIRONMENTAL REQUIREMENTS

Introduction

The quality and reliability of a product must be developed in the product design stage and carried through the manufacturing process. Hewlett-Packard seeks to design and build the finest quality into our products starting at the bread-board stage.

At each design stage, a randomly selected number of products are put through the environmental test sequence. This random selection of products is referred to as "type testing".

Due to the length of testing time and in some cases the increased stress levels applied to the product, it is not possible to test each and every product manufactured. In addition to the type of testing, certain tests are performed on each product as it is completes the manufacturing cycle. This testing further ensures that the product sold is as good as the product that was environmentally tested.

Effects of Climate

All HP 2250's can operate in an environment suitable for human occupancy as long as moisture will not condense within the environment and room air does not contain chemical contaminants which may degrade 2250 components. Along with the environment in which the 2250 operates, the effects of outside temperature, humidity, altitude and other regional characteristics must be taken into consideration. For instance:

* At higher altitudes, the efficency of a cooling fan decreases because of reduced air density. Consider keeping the 2250 enclosure at a lower temperature to compensate for the reduced air density at the 2250 air intake vents.

* In locations where extremes of temperature and humidity prevail, consider the effects of such conditions on the 2250 enclosure when the main power is shut down. For instance in northern regions, the effects of winter nighttime temperatures should be considered when the main power is shut off.

* In warm, humid regions, a fungus growth prevention program should be considered.

* In shoreline installations, the 2250 site may require special air conditioners, dehumidifiers, and other items to reduce high humidity and corrosive salt in the air.

Reliability is at its maximum when operated within the optimum temperature and humidity range. See temperature and relative humidity requirements in Appendix A.

Vibration and Shock

Vibration can cause slow degradation of mechanical parts and, when severe, can cause data errors hence it should be avoided or controlled. Also, mechanical connections such as PCA connectors, cable connectors, and processor backplane wiring may be affected. The best preventative measure is to build the site away from vibration-generating sources, such as heavy industrial machinery (stamp mills, etc.). Care in handling the 2250 will also avoid problems resulting from sudden shock. See vibration and shock requirements in Appendix A.

Altitude

Altitude must be considered for the conditions: operating and nonoperating. In the operating environment, the lack of adequate air density at extremely high altitudes may cause cooling problems. See altutude requirements in Appendix A.

Electromagnetic Susceptibility

Introduction

In order to establish and maintain the correct electromagnetic environment it may be necessary to take unique steps. This may include but not be limited to the following:

* Improved grounding techniques
* Placing the 2250 in a grounded screen enclosure
* Placing grounded copper screens on all windows.
* Placing the 2250 in a NEMA cabinet.

Radiated Interference Susceptibility

Electronic equipment, including 2250's, may exhibit unacceptable behavior if operation is attempted in environments where electromagnetic fields exist, such as near radio and TV transmitting towers, or near radar installations as found at airports. If radiated electromagnet fields are suspected, or verified (such as by direct measurement using spectrum analyzers or field strength meters), precautions should be taken to shield the HP products from the electromagnetic field.

Conducted Interference Susceptibility

Radio frequency noise may be introduced into a 2250 from the ac power line as wectric field. Power line conditioners and line filters are very effective in eliminating conducted radio frequency interference (RFI).

Electrostatic Discharge

Electrostatic discharge, commonly known as static electricity, may cause alteration of data, improper operation or electronic failure. Carpeting, low humidity, and leather-soled shoes may all contribute to unacceptable electrostatic fields. If static discharges are detected (as when touching door knobs, or metallic objects). humidifiers, anti-static mats and other anti-static procedures should be implemented.

Power Line Irregularities

In some geographic areas, available power that is used for the 2250 may experience excessive voltage sags, surges, transients, outages, or other irregularities that are unacceptable for reliable 2250 operation. Therefore, a power quality survey must be conducted. The results of the survey should be analyzed for correct voltage, current, phase, the absence of detrimental power line transients, and conducted interference that can cause a malfunction to occur as a 2250 out-of-specification operation. If any item does not meet HP 2250 requirements, corrective action must be taken to correct the situation. Power line irregularities may be divided into the following categories.

a. Line Dropout. The power distribution network may lose power for short periods of time. The HP 2250 will recover gracefully from short duration line dropouts. To insure that long duration power line dropouts will not not affect the constant operation of any electrical device, an uninteruptable power supply (UPS) would be required. Line conditioners and regulators will not help in this situation.

b. Over or Under Voltage. Fluctuations From the nominal line voltage are experienced as the result of equipment being turned on or off both within the immediate vicinity and also over the entire power network. A power failure many miles away may cause voltage fluctuations. In a worst case situation, "brown out" only a UPS will provide uninterupted power.

c. Line Transients. Just as radio frequency noise may be transmitted over the ac power line, electrical noise may also be experienced at the ac power outlet. Line transients may result in interupted operation, blown fuses, or electrical failure. The surge wave forms used to test the HP 2250 power line transient response are shown in figure 4. The waveforms are described in the IEEE "Guide on Surge Vin AC Circuits up to 600V Final Draft."

d. Neutral to Ground Noise. This is noise exibited between the neutral to ground lines.

e. Ground to Ground Noise. This is noise exhibited between the HP 2250 ground and earth ground.

f. Power Line Distortion. This is an undesired change in the original signal waveform that results in an unfaithful representation of the desired waveform. Waveform clipping is one example of this type of distortion. Noise in the form of extraneous signals superimposed on the desired waveform is not defined as distortion.

Power line conditioners may be helpful in regulating and conditioning (removing transients) ac power. Problems associated with power line irregularities are often very difficult to diagnose due to the unpredictable and intermittent nature of the problem.

Corrosive Contaminants

Corrosion is a complex form of material deterioration and is generally defined as the destruction of material by chemical or electrochemical reaction with its environment. Some effects of corrosion in HP 2250's are the deterioration of plastics used in the equipment and general degradation of conformal coatings on printed circuit assemblies (PCA's). Many common problems can be avoided by isolating the 2250 from contaminant producing machinery. Examples of this type are office copiers, milling machines, and equipment that produce corrosive vapors or particulates. However, in areas where the atmosphere contains large amounts of various corrosive contaminants, more drastic measures must be taken to ensure clean air in the environment where the 2250 is used. Most environments are corrosive to some degree. Examples are air and moisture; fresh, distilled, or salt water; urban and industrial atmospheres; steam and other gases such as chlorine, ammonia, hydrogen sulfide, sulfur dioxide, and fuel gases; mineral acids such as hydrochloric sulfuric, and nitric. In general, inorganic materials are more corrosive than organic. For example, corrosion in the petroleum industry is due more to sodium chloride, sulfur, hydrochloric and sulfuric acids, and water than to oil, naptha, or gasoline.

Modern chemical process industries utilize higher temperatures and pressures, making possible new processes to obtain better yields, greater speeds, or lower costs of production. However, these higher temperatures and pressures unfortunately involve more severe corrosive environments.

Corrosive environments such as that found in steel, acid, and paper manufacturing industries usually preclude the use of filtered ambient air for forced convection cooling. Corrosives generally connot be filtered out by normal filtration methods, and the techniques that must be used are complex and costly. In these cases, the 2250 must be enclosed in a highly controlled environment.

Although the term "environment" as used here refers only to atmospheric contaminants, there is a strong link between corrosion rates and temperature and humidity conditions. Many corrosion processes (film thickness buildup, etc.) accelerate rapidly at high humidities and temperatures. This means that corrosive environments that possess high temperatures and humidities should be of particular concern. The following are typical corrosive contaminants.

* Total Hydrocarbons. Hydrocarbon vapors are known to be very corrosive to precious metal contacts used in computer equipment. A typical example is the contacts on PCA's which employ gold in many instances.

* Sulfer Dioxide. Sulfur is generally considered the most corrosive of the contaminant gases. In combination with water, it forms sulfuric acid mist, an active and rapidly corrosive compound. It is known to produce molecular separation in polymers, and to cause spots on microfilm materials. This acid is found in industrial environments and causes deterioration of equipment surfaces.

* Oxides of Nitrogen. Oxides of nitrogen cause nitrate-stress cracking in electrical contacts, and the absorbed gases react to form nitric acid on component surfaces. Also, small amounts of nitrogen oxide causes deterioration in polymers.

* Total Oxidants. The presence of oxidizing gases in the atmosphere, particularly the ozone, is known to be potentially harmful to any organic material. The damaging effects most often encountered are the cross linking of elastomers, the cracking of stressed rubber, and the oxidation of silver.

* Hydrogen Sulfide. Hydrogen sulfide is a rapid corrosive agent, particularly to copper and silver. Hydrogen sulfide is a common atmospheric contaminant found near oil fields, sulfer springs, and marshy areas, and occasionally is emitted from industrial or sewage treatment activities.

* Ammonia. In sufficient concentrations, ammonia has been found to cause cracking of stressed brass, decrease insulation resistance, and increase loss factor in certain insulators.

* Halogens. Halogens are five chemical elements that form salts by direct union with metals. The five halogens are: fluorine, bromine, clorine, iodine and astatine. Halogens react strongly with metals and hydrogen to form halides. The metal halides are solid water-soluable salts such as table salt (sodium chloride). When hydrogen halides are in a water solution, they from strong acids such as hydrochloric acid. Halogens are both poisonous and corrosive and usually occur in salt deposits and sea water environments. Halogens (and their compounds) are widely used in medicine, photographic films, sanitation processes, disinfectants, insecticides, some textile processes, paints, bleaches and plastics.

Cooling Requirements

The fans on the 2250 provide adequate ventilation when the 2250 is operated in the appropriate environment. To obtain maximum efficiency, allow the required clearances between the front and rear of the 2250. Air conditioning may be required to maintain the correct temperature. Install required air conditioning before installation of a HP 2250. See temperature requirements in Appendix A.

Safety

Factory Mutual System approved. IEC 348 CSA (pending) VDE waived in W. Germany for 2250N

Power Characteristics

115 VAC (standard HP 2250) Range 86 to 127 Vrms 230 VAC (option -015) Range 195 to 253 Vrms at 47 to 66 Hz

Physical Characteristics

HP 2250M (MOBILE) Height: 94.6 cm (37.25 in.) Width: 62.2 cm (24.5 in.) Depth: 81.3 cm (32.0 in.) Weight: 100 kg (220 lbs) Packaging: Mounted in cabinet (similar to L-Series Lo-boy cabinet) on casters (system is mobile).

Power cord, connector plug, and receptacle are the customer's responsibility.

HP 2250N (NEMA) Height: 182.88 cm (72.0 in.) Width: 127.0 cm (50.0 in.) Depth: 53.3 cm (21.0 in.) Weight: 175.9 kg (387 lbs) Packaging: Mounted in a NEMA Type-12 moisture and dust resistant cabinet.

Power cord, connector plug, and receptacle are the customer's responsibility.

HP 2250R (RACK) Height: 163.2 cm (64.25 in.) Width: 53.3 cm (21.0 in.) Depth: 99.1 cm (30.0 in.) Weight: 130 kg (286 lbs) Packaging: Mounted in a standard 19-inch rack. System may be expanded with an HP 25575C Measurement and Control Expansion Cabinet and and HP 25575B Field Wiring Assembly Cabinet via options 001, 002, and 003 (001, 016, 017 for European power)

Power cord, connector plug, and receptacle are the customer's responsibility.

Ambient Temperature

HP 2250N (NEMA cabinet system) Operating: 0 to 50 degrees C (32 to 122 degrees F) Non-Operating: -40 to 75 degrees C (-40 to 167 degrees F)

HP 2250M and HP 2250 R (Mobile and Rack-mount systems) Operating: 0 to 40 degrees C (32 to 104 degrees F) Non-Operating: -40 to 75 degrees C (-40 to 167 degrees F)

Relative Humidity

5% to 95% at 40 degrees C (104 degrees F) without condensation.

Altitude Operating: -100 metres (-325 feet) to 4,600 metres (15,000 feet) Non-Operating:-100 metres (-325 feet) to 15,300 metres (50,000 feet)

Power Requirements

115 VAC (Standard HP 2250) Range 86 to 127 ~~Hz~~ Vrms 230 VAC (Option -015) Range 195 to 253 Vrms at 47 to 66 Hz

4. CLASS II

A general facility modified to support the operation of computer equipment. Typically associated with a designated or partitioned area of a lab, office or light industrial/manufacturing area.

- o Typically a small or medium size multi-user system or large measurement and control/data aquisition system with limited terminal and peripheral capability.
- o HP site preparation and installation visits.
- o Examples: HP 3000 series 40, 250 model 30 and 35, HP 1000 model 45 and 65, 2250K (1000 system based)

4.1 SPECIFICATIONS

Products installed in Class II environments shall exhibit sustained reliable operation over the following specification ranges.

4.1.1 Temperature

- o Optimum range: 15-30 deg C +/- 5 deg C (59-86 F)
- o Maximum range: 5-40 deg C +/- 10 deg C (41-104 F) up to 24 hours maximum but no more than 20% of the total operating time (no hardware or media damage)

4.1.2 Humidity

- o Optimum range: 30-70 % wet bulb < 26 deg C
- o Maximum range: 20-80 % wet bulb < 30 deg C up to 24 hours but no more than 20% of the total operating time (no hardware or media damage)

4.1.3 AC Power (same as class I)

Equipment shall continue or resume normal operation under the following conditions:

LIMITATIONS OF THE 12035A POWER SUPPLY

- o Voltage variation: 100, 120 volts nominal +/- 10 %
  200, 208, 220, 240 volts nominal +/- 10 %
- o Frequency variation: 50/60 Hz +/- 5 %
- o Total harmonic distortion: 5 % or less
- o Momentary power failure: 16 msec (1 cycle) or less

- Normal mode transient noise: (to be determined)
- Common mode transient noise: (to be determined)
- Voltage surge: (to be determined)

4.1.4 Electric field (same as class I)

- Radiated: 2.5 volts/meter (0.5-1000 Mhz)
- Conducted: (to be determined)

4.1.5 Magnetic field

- (to be determined)

4.1.6 Electrostatic discharge

- (to be determined)

4.1.7 Airborne particulates (dust) (same as class I)

- Optimum range: 100 micrograms/cubic meter or less
- Maximum range: 200 micrograms/cubic meter or less up to 48 hours maximum but no more than 30% of the total operating time (no hardware or media damage)

4.1.8 Corrosive gasses

- (to be determined)

4.1.9 Vibration and shock

- (to be determined)

4.2 SITE MODIFICATIONS

4.2.1 Required

Designing products to eliminate the following requirements has been determined unfeasible from a cost standpoint. Exceptions must be approved by the local HP service organization.

- Dedicated AC branch circuit for system processor and all peripherals.
- Isolated power ground for system processor and all peripherals.
- Temperature and humidity control for general area.

4.2.2 Optional

The following is encouraged to further ensure sustained relaible operation.

- o AC power conditioning unit for system and all peripherals.

- o Temperature activated 'shunt-trip' switch set to 45 deg C (110 deg F)

- o Temperature and humidity recording device installed permanently on site. See Section 2.6.1.

- o Removal of all carpet within 10 foot radius of the system. Anti-static mats (such as HP 92176 type) installed at all entrances (where carpet ends). See Section 7 for guidelines on carpeted facilities.

Facilities which exceed specifications for EMI, dust, airborne contamination and vibration require additional modifications to be evaluated by CSD.

5. CLASS III

A general facility without substantial modifications to support the operation of computer equipment. Typically installed in a home, lab, office, or light industrial/manufacturing facility.

- o Typically a single user desktop system or small measurement and control/data acquisition system.
- o Phone-in site preparation and customer installation.
- o Examples: HP 85, 9826, 9845, 250 model 20, 1000 model 5, 2250M (9845 system based)

5.1 SPECIFICATIONS

Products installed in Class III environments shall exhibit sustained reliable operation over the following specification ranges.

Note: Special attention must be given devices with sensitive media installed in Class III environments (see Section 2.4).

5.1.1 Temperature

- o Optimum range: 5-40 deg C +/- 10 deg C/hr (41-104 F)
- o Maximum range: 0-55 deg C +/- 15 deg C/hr (32-131 F) up to 12 hours maximum but no more than 10% of the total operating time (no hardware or media damage)

5.1.2 Humidity

- o Optimum range: 20-60 % wet bulb < 30 deg C
- o Maximum range: 10-90 % wet bulb < 30 deg C up to 12 hours maximum but no more that 10% of the total operating time (no hardware or media damage)

5.1.3 AC Power - MORE LENIENT/NOT AS CRITICAL

Equipment shall continue or resume normal operation under the following conditions:

- o Voltage variation: 100, 120 volts nominal +15/-20 %
  200, 208, 220, 240 volts nominal +15/-20 %
- o Frequency variation: 50/60 Hz +/- 5%
- o Total harmonic distortion: 10 % or less
- o Momentary power failure: 40 msec (2.4 cycles or less)
- o Normal mode transient noise: (to be determined)

- o Common mode transient noise: (to be determined)
- o Voltage surge: (to be determined)

5.1.4 Electric field

- o Radiated: 5.0 volts/meter or less (0.5-1000 Mhz)
- o Conducted: (to be determined)

5.1.5 Magnetic field

(to be determined)

5.1.6 Electrostatic discharge

(to be determined)

5.1.7 Airborne particulates (dust)

- o Optimum range: 200 micrograms/cubic meter or less
- o Maximum range: 300 micrograms/cubic meter or less up to 24 hours maximum but no more than 20% of the total operating time (no hardware or media damage)

5.1.8 Corrosive gasses

(to be determined)

5.1.9 Vibration and shock

(to be determined)

5.2 SITE MODIFICATIONS

5.2.1 Required

The only requirement for Class III products is a grounded, 3-prong electrical receptacle connected to a commercial or resdential grade power source.

5.2.2 Optional

The following is encouraged to further ensure sustained reliable operation.

- o AC power transient protection device

ESD IMPORTANT

- o If carpet within 10 feet install a grounded 'static control mat' (such as HP 92175) in front of system or device.

Facilities which exceed specifications for EMI, dust, air-borne contamination and vibration require additional modifications to be evaluated by CSD.

6. CLASS S

A severe environment with no major modifications to support the operation of computer equipment. Typically associated with heavy industrial or manufacturing area.

- o Typically a process and control/data acquisition system or data entry terminal packaged specifically for harsh environments.
- o HP installation of larger systems.
- o Examples: HP 2250N (Nema 12 cabinet)

6.1 SPECIFICATIONS

Products installed in Class S environments shall exhibit sustained reliable operation over the following specification ranges.

Note: Special attention must be given devices with sesitive media installed in Class S environments (see Section 2.4).

5.1.1 Temperature MORE VARIANCE

- o Optimum range: 0-55 deg C +/- 15 deg C/hr (32-131 F)
- o Maximum range: -15-70 deg C +/- 15 deg C/hr (5-158 F) up to 12 hours maximum but no more than 10% of the total operating time (no hardware or media damage)

5.1.2 Humidity

- o Optimum range: 10-90 % wet bulb < 30 deg C
- o Maximum range: 5-100 % wet bulb < 30 deg C up to 12 hours maximum but no more that 10% of the total operating time (no hardware or media damage)

5.1.3 AC Power (same as class III)

Equipment shall continue or resume normal operation under the following conditions:

- o Voltage variation: 100, 120 volts nominal +15/-20 %
  200, 208, 220, 240 volts nominal +15/-20 %
- o Frequency variation: 50/60 Hz +/- 5%
- o Total harmonic distortion: 10 % or less
- o Momentary power failure: 40 msec (2.4 cycles or less)

- Normal mode transient noise: (to be determined)
- Common mode transient noise: (to be determined)
- Voltage surge: (to be determined)

6.1.4 Electric field (same as class III)

- Radiated: 5.0 volts/meter or less (0.5-1000 Mhz)
- Conducted: (to be determined)

6.1.5 Magnetic field

(to be determined)

6.1.6 Electrostatic discharge

(to be determined)

6.1.7 Airborne particulates (dust)

- Optimum range: 350 micrograms/cubic meter or less
- Maximum range: 750 micrograms/cubic meter or less up to 12 hours maximum but no more than 10% of the total operating time (no hardware or media damage)

6.1.8 Corrosive gasses

(to be determined)

6.1.9 Vibration and shock

(to be determined)

6.2 SITE MODIFICATIONS

6.2.1 Required

The only requirement for Class S products is a grounded, 3-prong electrical receptacle connected to a commercial or residential grade power source.

6.2.2 Optional

The following is encouraged to further ensure sustained reliable operation.

- AC power transient protection device

Facilities which exceed specifications for EMI, dust, airborne contamination and vibration require additional modifications to be evaluated by CSD.

3.5 ELECTROSTATIC DISCHARGES

One of the most difficult classes of problems to deal with is system interruption due to electrostatic discharge. Such static induced failures can manifest itself in several ways. All digital circuits can err as a result of interpreting static induced voltages as valid signals. The result is erratic behavior.

Static charges are transferred to nonconductive surfaces as contact between two parts is broken. For example, as the print wires of a dot matrix printer (such as the HP 2631A) strike the paper, they transfer a charge to the paper. Since this happens thousands of times per sheet, a surprisingly high charge can be transferred to each sheet. In a low humidity area, it is easy to leave 500 volts on each sheet. As the sheets stack up, it is not uncommon to build up 20,000 volts on the paper stack. A high static charge may also build up on personnel as they walk around the room.

Static discharges typically affect digital circuits by inducing voltages on the signal lines. To avoid static induced failures, a device must either tolerate or prevent discharges. Preventing discharges is preferred since a static discharge may upset any component in the computer system. This solution is very difficult to implement. Hence, most solutions try to handle static both ways. TO PREVENTION — TWO METHODS

1. Static control involves providing some form of conductive path to ground so that charges cannot build up. There are several ways to provide a ground path. They include conductive mats, antistatic sprays, ionizers, humidifiers, tinsel strips (on printers), and corona discharge devices.

2. Static hardening of a device involves shielding the electronics from static discharge noise. This is typically done by enclosing the circuits in a grounded metal box. Such shielding can be defeated by attaching unshielded signal cables to the unit. An unshielded cable acts as an antenna to pick up noise and route it to the electronics.

Proper system ground is critical to preventing static discharges. Incorrectly wired wall sockets and improper grounds particularly aggravate static problems since there is no good path for electrostatic charges to be drained. Because of this, any site that continues to fail erratically should have a thorough power and ground analysis.

ELECTRICAL CONSIDERATIONS	CHAPTER 4

A qualified electrician must provide an adequate source of power for the computer system. The computer system will consist of one or more equipment bays (depending on the model and options purchased), plus a number of freestanding items such as terminals, discs, line printers, and magnetic tape units. Whether you modify existing electrical facilities or develop an entirely new facility, plan to:

- o Estimate total power requirements for the computer area.
- o Install the power distribution panels that will supply the new system.
- o Fabricate and connect the input power cable to the CPU Bay Power Control Module (50 Hz sites or multiple bay configurations).
- o Provide convenience outlets.
- o Plan for electrical safety.
- o Ensure that all wiring conforms to local codes.

As you plan and install electrical facilities, maintain close liaison with the Site Coordinator. Check with him if questions arise or you need assistance. He will either provide the help you need or contact an HP Customer Engineer for further assistance.

4.1 DETERMINING POWER REQUIREMENTS

To calculate the power requirements at your site, complete the Power Requirements Form provided in Table 4-1. Use the the following guidelines.

SYSTEM REQUIREMENTS

Refer to the System Component Table, available from the Site Coordinator, to calculate the current (in amps) required by the HP 1000 Computer System. If the HP 1000 Computer System is included as part of an HP Automatic Test System, add the current required by the instrumentation, switches and accessories to the system requirements. Note that the total current figure should include the equipment ordered for the initial system plus any additional equipment planned for future system expansion. Enter the total opposite the System Requirements heading in Table 4-1.

If the current requirements are not available for a particular device, the worst case maximum average current can be calculated from the maximum power (in watts) or maximum apparent power (in volt-amperes) as follows:

Max Current = (Max Power)(1.3)/(Rated Voltage)

Max Current = (Max Volt-Amperes)/(Rated Voltage)

SITE VARIABLES

To fully account for all requirements, calculate the total current (in amps) as follows:

- o Plan the current required by auxiliary equipment that is not part of the HP supplied system, such as modems, electric typewriters, and electronic instruments. For these values, consult the data sheets of each manufacturer. Enter the total current opposite the Interface/Auxiliary Equipment sub-heading in Table 4-1.

- o Estimate the current required for site illumination and enter the total opposite the Lights sub-heading in Table 4-1. Power for lighting should not be supplied from the computer system panel.

- o Confer with the environmental specialist to determine what equipment is planned. Calculate the amperes required and enter the value in Table 4-1. Note that power for these devices should not be taken from the dedicated power line to the computer system.

- o Make allowance for power used by items (other than HP equipment) that might be added to the computer area in the future. Enter the total current in the table.

- o Calculate any additional requirements not considered above. If any equipment is currently in use at the site, a clip-on ammeter can be used to determine its approximate current demand. Enter the value in the table.

TOTAL CURRENT REQUIREMENTS

Add the values in Table 4-1 and enter the sum.

TAKE INTO ACCOUNT
OTHER EQUIPMENT

2250 7A - SURGE @ TURN-ON
1 MCU 15A - STEADY
1 PROC
8 BOARDS

	AMPERES (at ___ volts, ___ Hz)
SYSTEM REQUIREMENTS	___
SITE VARIABLES	
Interface/Auxiliary Equipment	___
Lights	___
Environmental Conditioning Equipment . .	___
Future Expansion	___
Other Factors	___
TOTAL CURRENT REQUIREMENTS	___

Table 4-1. Current Requirements Form

4.2 SERVICE VOLTAGE

There are several acceptable configurations that may be used to supply AC power to the computer system. Proper layout of the system power mains is essential for proper and reliable operation of the system. Guidelines for recommended power circuit specifications are outlined below. They should be implemented in accordance with local electrical codes.

- Install the recommended isolated/insulated ground in accordance with Section 4.9.

- Install a dedicated power line for the computer system and associated peripheral devices. Ensure that the required voltages are available.
- Ensure that ground leakage current conforms to local electrical codes.

Figure 4-1 illustrates a typical building electrical distribution system. Figures 4-2, 4-3, 4-4, and 4-5 illustrate some typical system power layouts.

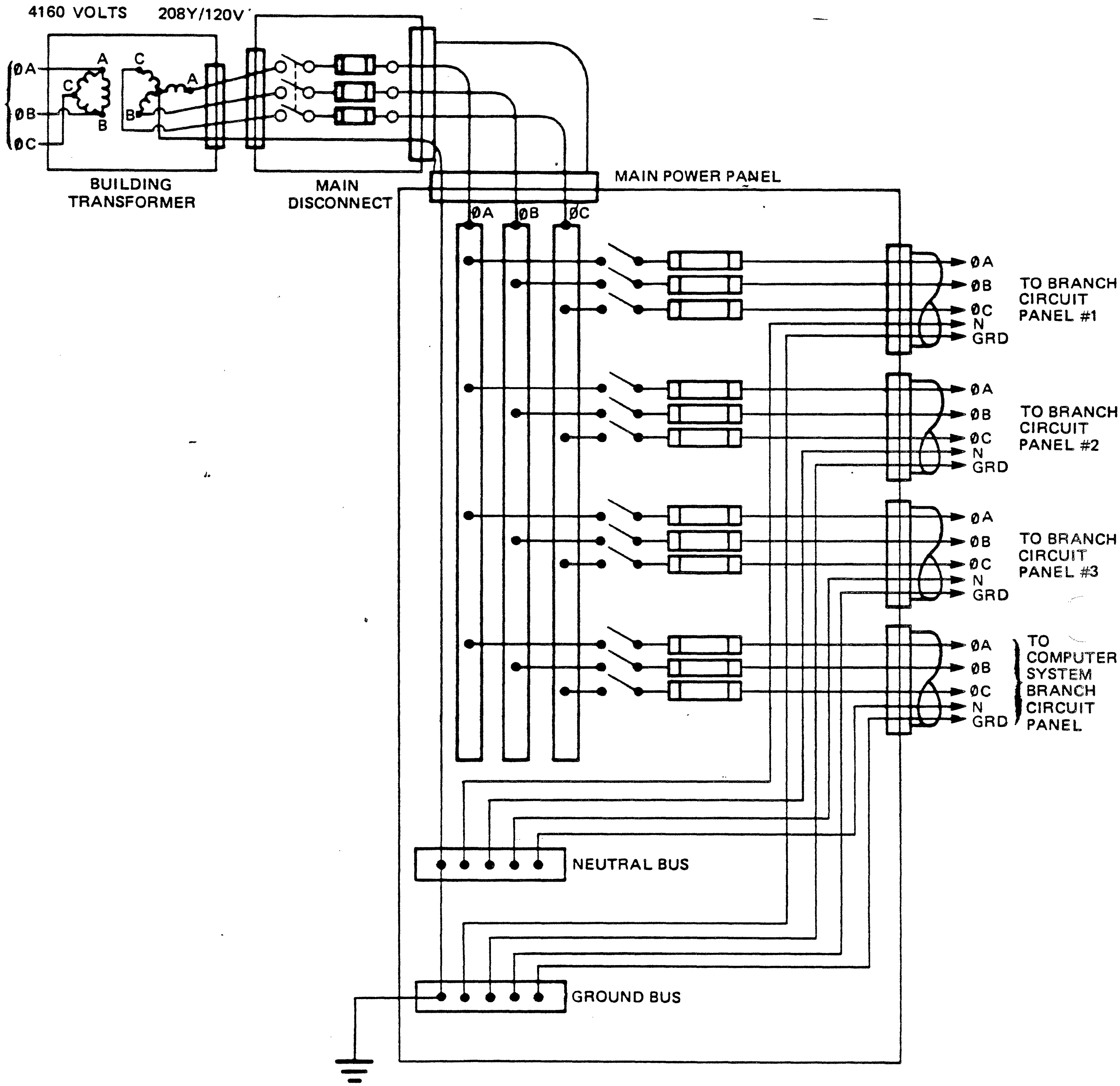


Figure 4-1 Typical Building Electrical Distribution System

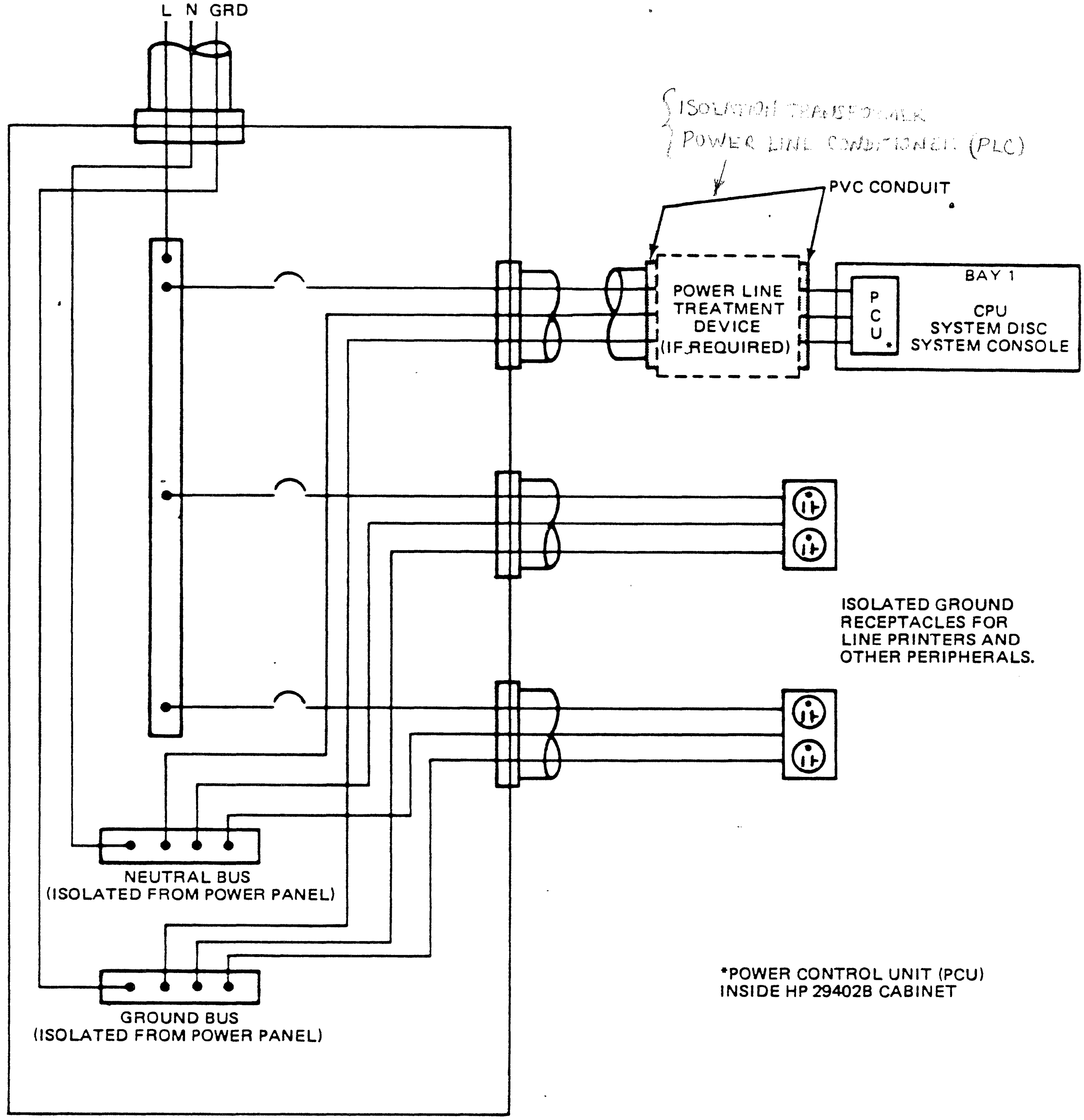


Figure 4-2 120 volt, 60 Hz, Single-phase Power Layout

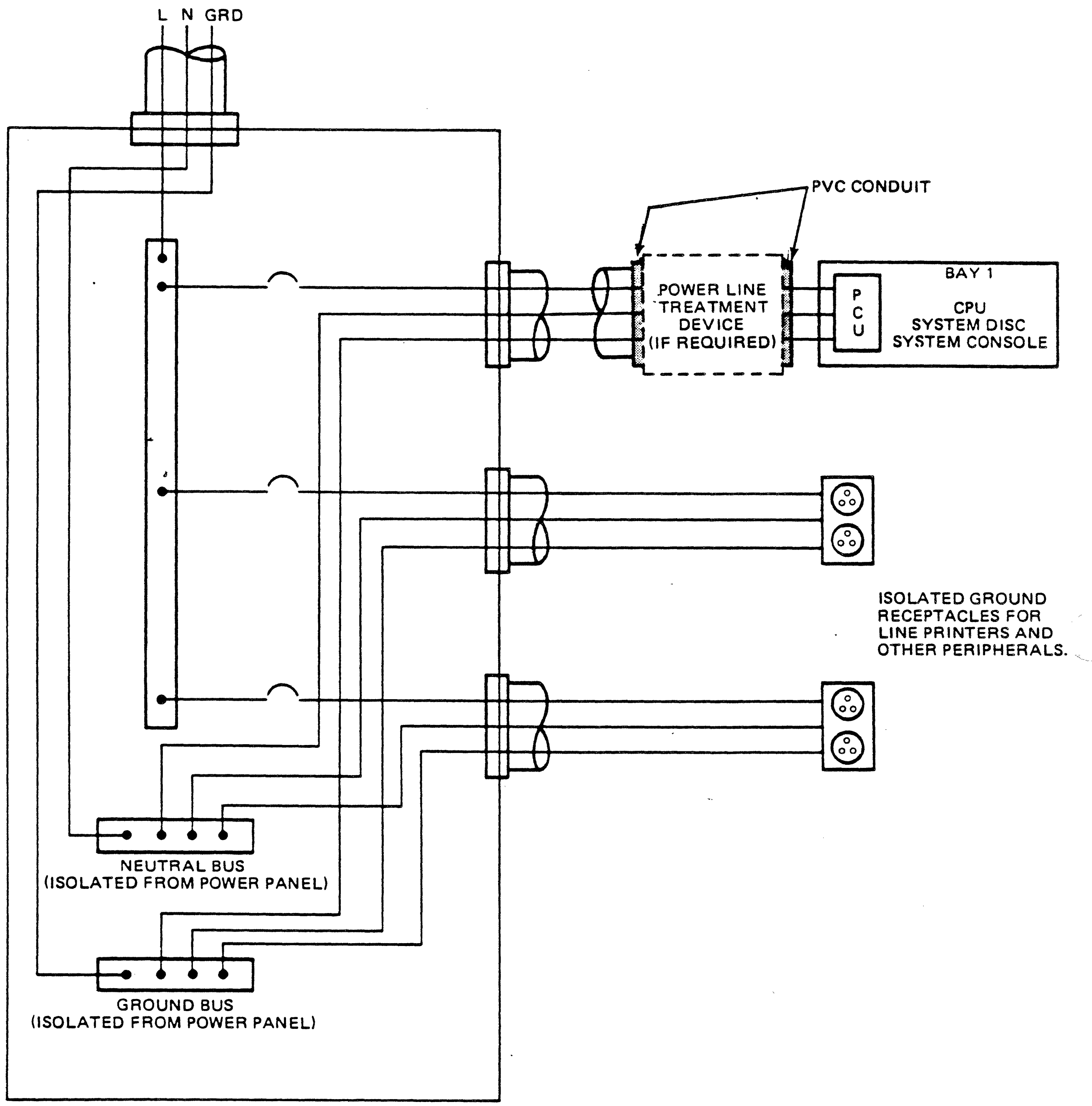


Figure 4-3 230 volt, 50 Hz, Single-phase Power Layout

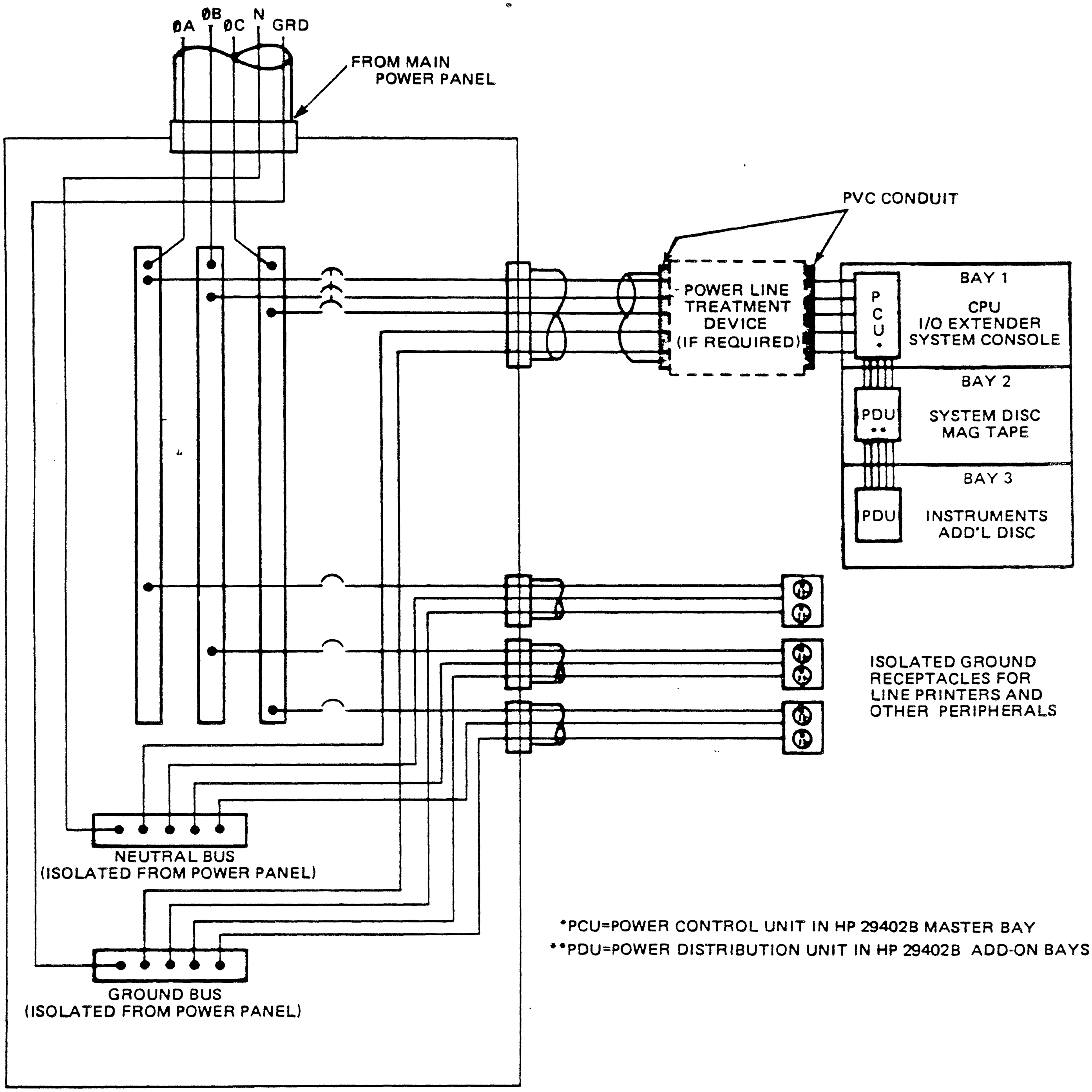


Figure 4-4 208Y/120 volt, 60 Hz, three-phase Power Layout

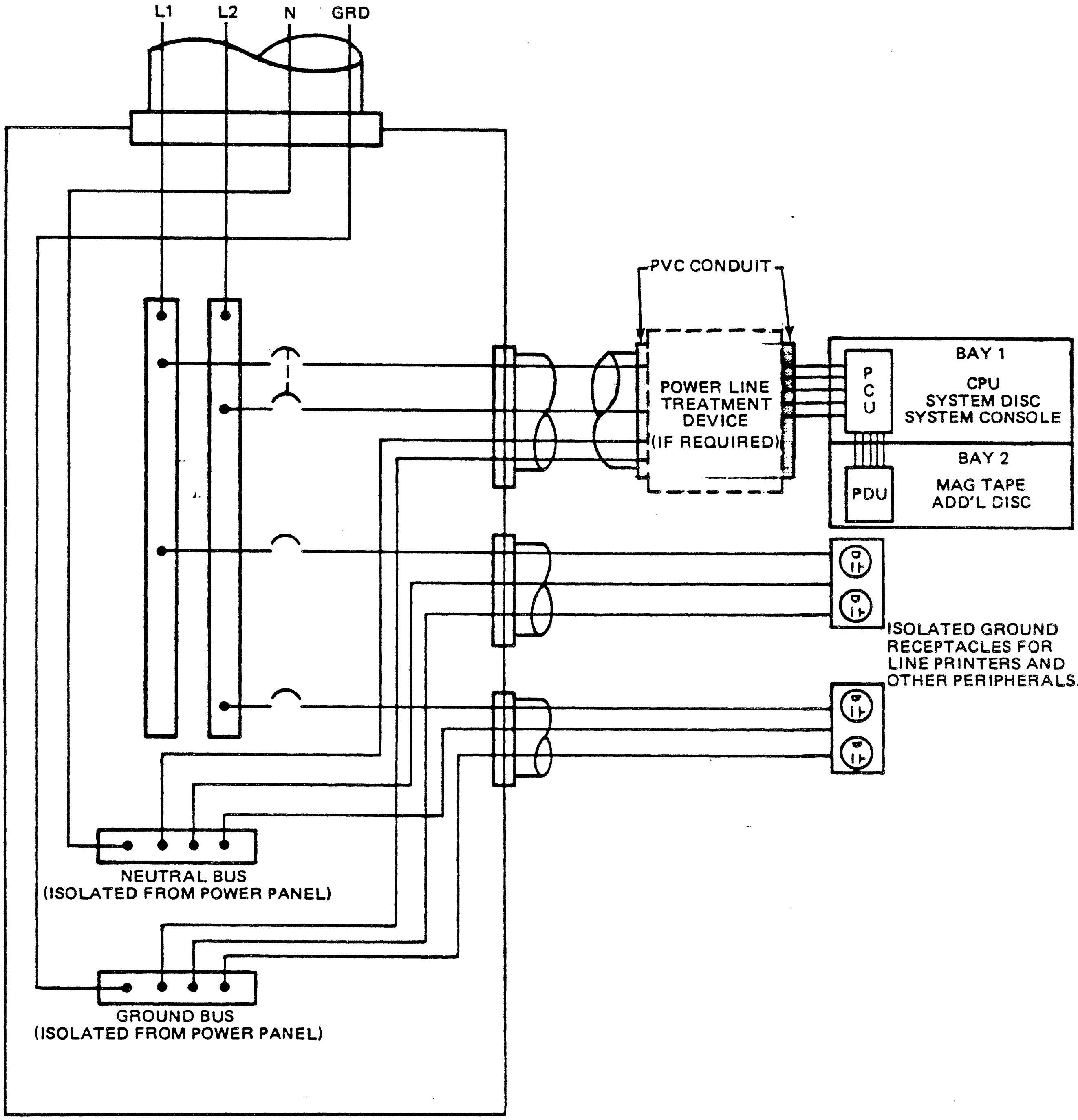


Figure 4-5 120/240 volt 60 Hz, Split-phase Power Layout

4.3 VOLTAGE LIMITS

At all sites, the steady-state line-to-neutral voltage should be maintained within +5 or -10 percent of the normal rated voltage as measured at the input power side of the computer system when it is powered on. For HP 1000 Computer Systems, the normal rated voltages are 120V, 240V, 220V, and 100V. However, some peripherals do not support all of these rated voltages. Consult the HP 1000 Site Planning Workbook.

The steady-state line-to-neutral voltage can be measured with a true RMS reading digital voltmeter. Power line specifications must ultimately be met as measured at the computer power supply terminals with the system powered on.

4.4 FREQUENCY LIMITS

The line frequency variation must be maintained at +/- 2.0% for both 50 and 60 Hertz sites as measured at the input power side of the computer when it is powered on.

4.5 HARMONIC CONTENT

The maximum total harmonic content of the computer system feeder should not exceed 5 percent as measured at the input power side of the computer system when it is powered-on.

4.6 POWER NOISE

HP 1000 Computer Systems have been designed to withstand a reasonable amount of input power noise. However, there are many electrical noise sources over which electric power utilities and HP have no control. The major source of this electrical noise is produced by other electrical equipment (e.g., motors, solenoids, SCRs, and X-ray machines) located near the computer site.

4.6.1 Noise Supression

To suppress electrical noise from existing or future electrical equipment, it is strongly recommended that a dedicated feeder between the main power panel and the computer system branch circuit panel be installed. If objectionable transients still exist after installation of a dedicated feeder, a device which will reduce input power noise may be required. Refer to Section 4.7 for information regarding power line treatment devices.

4.6.2 Power Line Disturbances

Input power noise which disturbs the output of power supplies or causes disturbances in signal lines in the computer system can cause computer system malfunctions. These input disturbances can be categorized as surges, sags, and impulses.

Surges and sags are sudden positive or negative changes in the level of the input voltage having a duration between 5 milliseconds and 5 seconds. Generally, a sag or surge should not exceed about +/- 15% of the normal rated voltage and should return to the steady-state condition within 1/2 second (within 3 cycles for disc based systems).

Transients are sudden positive or negative changes in the input voltage having a duration between 1 nanosecond and 5 milliseconds. A transient greater than 50% of the normal rated voltage (depending upon its energy content) may produce computer system malfunctions.

A power line disturbance monitor is useful in identifying poor quality input power and characterizing disturbances. Since power line disturbances can vary hourly, daily, and weekly, it is recommended that this monitor be connected for at least one week. Do not consider the results as absolute since disturbances can change seasonally.

4.7 POWER LINE TREATMENT DEVICES

If objectionable transients still exist after installation of a dedicated feeder and dedicated ground, the installation of a device which will reduce input power line disturbances may be required. There are basically four devices which can be utilized to accomplish this task. They are:

- o isolation transformer
- o line conditioner
- o motor-generator set
- o uninterruptible power system

The line treatment device should be sized according to present and future requirements. Hewlett-Packard recommends a minimum rating of 5 KVA to allow for present needs and future expansion.

4.7.1 Isolation Transformer

isolation transformers attenuate common-mode noise. They also attenuate differential (normal) mode noise to some degree. These noise voltages are measurable concurrently between the noise can be generated by lightning, motors, induction furnaces, SCRs, X-ray machines, and radio and TV stations. Proper installation of an isolation transformer can eliminate such input power problems. The isolation transformer should attenuate common-mode noise about 140 dB and have less than 0.001 pf of coupling capacitance.

4.7.2 Line Conditioner

A line conditioner can attenuate both common-mode noise and normal-mode noise. Normal-mode noise voltages are measurable between the hot line and neutral. They may be alleviated but cannot be eliminated by an isolation transformer. Such noise can be generated by devices in other equipment on the same circuit (such as SCRs, relays, and motors). Proper installation of a line conditioner can eliminate such input power problems and help regulate the line voltage. A ferroresonant line conditioner should attenuate common-mode noise and normal-mode noise about 140 dB with less than 0.001 pf of coupling capacitance. An electronic line conditioner with SCR tap switching should attenuate common-mode noise about 140 dB and normal-mode noise about 60 dB with less than 0.001 pf of coupling capacitance.

4.7.3 Motor-Generator Set

A motor-generator set consists of a synchronous AC motor connected to a synchronous AC generator, usually with a flywheel for energy storage. Both common-mode noise and normal-mode noise can be eliminated by this device. Voltage regulation is provided by automatic control of the generator. The flywheel can provide for limited loss of power (typically a few cycles) before the generator frequency drops below tolerance because of flywheel run down.

4.7.4 Uninterruptable Power System

An Uninterruptable Power System (UPS) protects against electrical noise, brown-outs (low voltage), and black-outs (loss of voltage). During normal operation, line power supplies power to the recitfier. The rectifier powers the inverter and keeps the batteries charged. The computer is connected to the output of the inverter. In the event of a brown out or blackout, the batteries will supply power to the inverter and keep the computer on line.

Unless the duration of a black-out exceeds the time that the batteries can supply power to the computer system, the computer will operate normally. Due to high cost, battery vault, and spare parts required, a UPS should be considered only for applications where black-outs, brown-outs, serious frequency variations, or severe transients could cause expensive downtime on a critical system. If the input power to the computer system does not include severe transients but suffers from brown-outs, a voltage regulator could provide a solution.

4.7.5 Reliability

Engineering judgements between installing a more expensive power line conditioning system and the resulting increase in system reliability must be made for each installation. A computer system operating at the extremes of its operating specifications is not as reliable as one operating under its typical design conditions.

4.8 POWER TURN-ON SURGE

The power supply circuit should be capable of handling a 400 percent over-current inrush when equipment is turned on. Select circuit breakers for the branch circuit power distribution panel that can withstand this surge current. Thermal-trip circuit breakers are recommended.

4.9 GROUNDING

Proper system ground connections are vitally important to the safe and reliable operation of the system. Generally, existing electrical ground lines are not adequate for proper computer system operation. In addition to conforming to local electrical codes, the computer system ground must also meet two additional requirements. First, it must serve as a current return path in case of a short circuit between the power line and the computer mainframe. Second, it must serve as a ground reference for the computer power system and data cables.

4.9.1 Dedicated Ground

HP strongly recommends installing a dedicated ground conductor between the main power panel and the computer system branch circuit panel along with the dedicated feeder. If installation of a dedicated feeder is not economically feasible, use another code approved method. A dedicated isolated/insulated ground should still be installed. Use of an isolated ground rod is not acceptable.

An isolated/insulated ground conductor should be bonded to the ground bus in the building main power panel, and run with the circuit conductors. This ground should pass through panelboards without being connected to the panelboard grounding terminal bar. An isolated ground bus constructed from a terminal block kit can be installed on the panelboards to connect the isolated ground conductor. To avoid connecting the isolated ground to the conduit at the power outlet, use an isolated ground recepticle such as a Hubble IG-5362 (See Figure 4-6). The isolated ground conductor is noted in the National Electrical Code, Section 250-74, Exception 4.

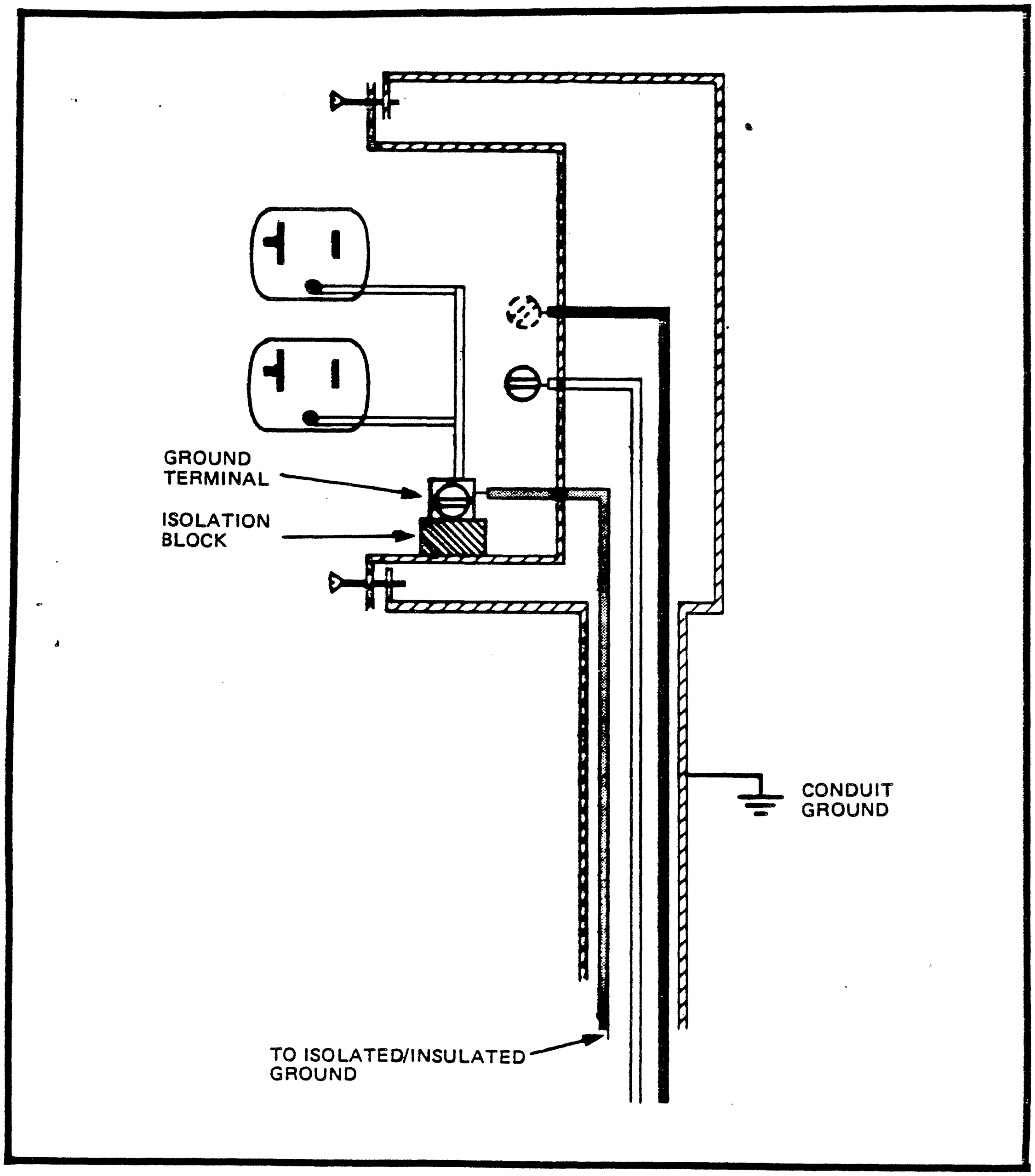


Figure 4-6 Isolated Ground Recepticle

In Section 250-51, the National Electrial Code states that the path to ground from circuits, equipment, and conductor enclosures shall (a) be permanent and continuous, (b) have capacity to conduct safely any fault current likely to be imposed on it, and (c) have sufficiently low impedance to limit the voltage to ground and facilitate the operation of the circuit protective devices in the circuit.

Satisfing this statement requires a resistance of 2.1 ohms or less. If the resistance is too high, several items should be investigated. If a line treatment device and dedicated ground are not being used, the neutral-to-ground (N-G) bonding at the building service main power panel should be checked. If a line treatment device is being used, the N-G bonding at the line treatment device secondary should be checked. If an existing N-G bond has been installed in an improper location, it should be removed and replaced since undesirable current in a portion of the grounding conductor can result.

When a line treatment device is installed in a multi-story building, it is necessary to connect the line treatment device case to the building structural steel for a low noise ground. One end of the ground wire should be bolted to the case of the line treatment device and the other welded to the nearest available vertical structural steel member. Connecting the ground to structural steel in a multi-story building is better than running a wire down to a separate ground rod in the basement. A water pipe should not be used as a ground. An isolated ground rod is never an acceptable ground.

4.9.2 Measuring Ground Quality

The following measurements can be made to determine the quality of a ground. With the power switched off at the computer system branch circuit panel, measure the resistance between the neutral and ground conductors at the computer input power terminals. This measurement should be made using a ground impedance tester. A reading greater than 2.1 ohms between neutral and ground indicates a dangerous situation.

The continuity of the grounding conductor should be verified. If the size of the grounding conductor is smaller than the circuit conductors or if the grounding conductor is uninsulated, the grounding conductor must be replaced with an insulated conductor equal in size to the circuit conductors.

Several specialized devices are commercially available for determining the quality of a grounding system. Ground check devices which induce current in the ground line for testing purposes and indicates ground quality (via lights or a scale calibrated in ohms) and an earth ground tester which measures earth resistance of ground rods and grid systems are among the devices available.

4.10 BALANCING ELECTRICAL LOADS

Balancing electrical loads in three-phase and split-phase systems is important because it:

- reduces the severity of externally generated sags and surges to equipment driven from a separate transformer.
- improves performance of isolation transformers.
- increases transformer lifetime.

Unbalanced loads will cause a voltage differential between neutral and ground. This voltage measurement can be used to verify proper load balancing.

A clip-on ammeter should be used to balance electrical loads. Measure the current in each phase, disconnect power from the computer system branch circuit panel, rearrange the loads, and repeat the meaurements. Repeat this procedure until the neutral current is minimized.

Measurement of the voltage differential between neutral and ground can also be used to verify proper load balancing. With the computer power on, measure the voltage differential between the neutral and ground conductors at the computer input power terminals using an oscilloscope. The ground clip attached to the oscilloscope probe should be as short as possible. Disconnect power from the computer system branch circuit panel, rearrange the loads, and repeat the measurements. Continue this procedure until the neutral-to-ground voltage is minimized.

The neutral-to-ground voltage may be further reduced by balancing other loads on the feeder or increasing the wire size of the feeder. If the neutral-to-ground voltage is too high at the computer system branch circuit panel, install a dedicated feeder from the main power panel.

Historically, computer systems with neutral-to-ground voltages greater than 5 volts peak-to-peak have experienced intermittent problems.

4.11 LIGHTNING PROTECTION

In areas where electrical storms pose a real danger, HP recommends that the customer install a lightning protection system to guard against damage to electronic equipment and to protect personnel. A primary site protection system is designed to prevent damage from direct lightning strikes and a resulting fire. The system consists of lightning masts or rods (air terminals) spaced on or around the facility. The rods should be connected by welded joints to a buried earth ground girdle. Alternately, overhead conductors may span the facility and connect to earth ground rods. In most commercial power distribution systems, line surge protection is normally provided, but secondary precautions at the site should not be overlooked. This is particularly true where primary power is supplied by overhead lines. Lightning protectors can be installed in the computer system primary power lines as protection against damage to electronic components and as a fire prevention measure for the system and building.

A secondary type of protection system is designed to prevent metal parts of the building or building contents from accumulating static electrical charges that can cause sparking. In particular, this may be necessary at high altitude locations or in dry climates. The system consists of a buried earth ground girdle to which all metal parts, including the reinforcing steel of the building, are connected. An interior grounding bus may be utilized for grounding building contents. The earth ground girdle can consist of a 2/0 AWG bare copper cable completely surrounding the facility with its ends connected to form a closed loop. It should be buried not less than 46 centimeters (about 18 inches) below grade outside the structural foundation. Electrical contractors in your area should be contacted to provide specific details.

The susceptibility of data lines to transients produced by lightning can be reduced by practicing simple cabling techniques. Burying shielded cables in conduit can eliminate 70% of the transients if the area does not experience a direct strike to the ground.

Routing data cables inside buildings must be performed as cautiously as outdoor routing. A data line running along an AC power line is susceptible to transients and crosstalk.

Many transient suppression devices have been developed for protecting data communication facilities. The most effective means of protection against transients has been the combination of a gas discharge tube and a special zener diode. During low-level transients, the special zener diode provides the necessary protection. As the limit of the zener is approached, the gas-tube fires and suppresses the transient. Such devises are marketed under the trade name of TransZorbs (TM).

Several cables which offer terminal protection from lightning-induced transients on data communications line are available from Hewlett-Packard. They are for hardwired applications only. The only signals carried by the cables are Data In, Data Out, and Ground. These cables are listed on Table 4-2.

PRODUCT NUMBER	PART NUMBER	RS-232C CONNECTOR	APPROPRIATE TERMINAL	HP 1000 COMPUTER SUBSYSTEM	LENGTH (m)
13222Y	13222-60005	Male	262X	MUX	5.0
13222Z	13222-60006	Female	262X	---	5.0
13232Y	02640-60218	Male	264X	MUX	4.5
13232Z	02640-60219	Female	264X	---	4.5

Table 4-2. HP Electromagnetic Pulse Protect Cables

4.12 PLANNING CABLE LAYOUT AND FABRICATION

The Electrical Specialist is responsible for fabricating and installing the following cables:

- o Cables that supply power to multi-bay system configurations.
- o Cables that supply power to additional disc drives. This is required for 50 Hertz operation only.
- o Cables that provide power to the freestanding peripheral devices. This is required for 50 Hertz operation only.
- o Wiring to supply power to convenience outlets.
- o Wiring for lights, heating, ventilating, and air conditioning equipment.

Cable fabrication should be discussed with the HP Customer Engineer at the Site Preparation meeting. Cable routing and receptacle placement should be sketched on the Site Floor Plan.

WARNING

Do not connect any devices to the main power source during site construction. Make this connection as the final step of system installation. This precaution minimizes the hazard created by accidentally closing the main power switch while work is being performed and injuring personnel or damaging the computer. Hewlett-Packard is not responsible for equipment damaged by applying power to the system before it is installed.

4.12.1 Equipment Connections

The power cables and plugs for all HP components are selected according to the country of origin of the sale. If it appears that a power cable and/or plug are not correct, contact your local HP Customer Engineer. Power plug configurations are listed in Figure 4-7.

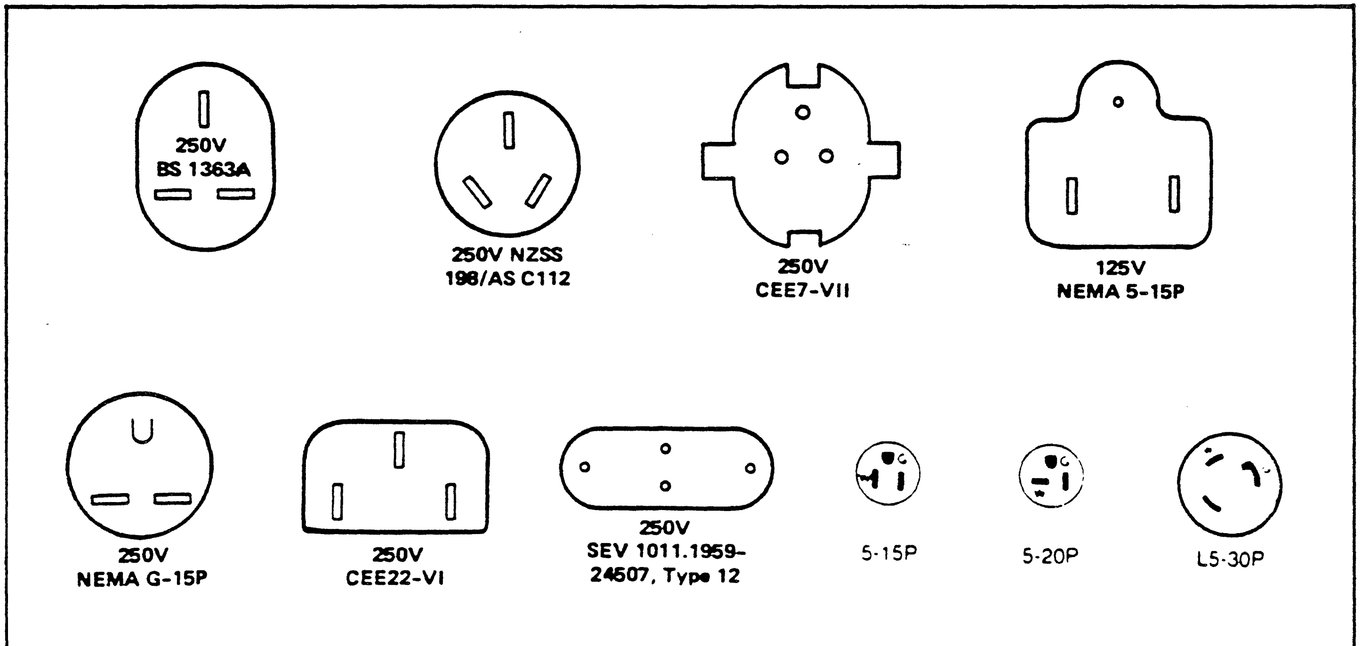


Figure 4-7 HP Power Cable Plugs

INSTALLING 2250 IN NEMA CABINET

Special tools needed:

9/16-inch universal socket with minimum of 18-inch extension.

2 ~~1~~. Place 2104 card cage on threaded studs in NEMA cabinet, aligning bottom first, then top. Secure to cabinet with washers and nuts on threaded studs.

1 ~~2~~. Install fan assembly on 2104 card cage. Connect AC line cord to fan. Install fan grille.

3. Align power supply with the rails at the left side of the 2104 card cage and slide rearward until the connector is just about to mate. Sight between the power supply and card cage to ensure that the male and female connectors are aligned before completing the rearward movement of the power supply.

4. Install 2 screws to secure the power supply to the card cage.

7 ~~5~~. Lift in the 2251 card cage and place on the four threaded studs. Align the holes first at the bottom, then at the top.

6. Secure the 2251 in place by placing a washer and nut on each of the four threaded studs.

5 ~~7~~. Install the fan assembly on the 2251. Connect the AC line cord to the fan. Install the fan grille.

8. Repeat steps 5 through 7, above, if a second 2251 is to be installed in the cabinet. Install the second 2251 on the upper four threaded studs.

9. If necessary, install cards in 2104 card cage.

10. If necessary, install Function cards in 2251. (BIF always in slot 0, ADC cards next, analog cards next, then digital cards.)

11. On either side of cabinet, install FWA (Field Wiring Assembly) for each card.

    a. Using labels provided, affix a label to each FWA card connector to identify 2251 box number, slot number, and connector number. For example, the lower 2251 is always box 0. A card in slot 4 of box 0 might have four connector assemblies. These assemblies would be marked 0-4-1, 0-4-2, 0-4-3, 0-4-4. Card connector assemblies are numbered from bottom to top.

    b. At field wiring end, affix a label on the cover of the FWA to identify the function card to which it is connected by type and location. Use the same marking sequence as indicated in e, above.

INSTALLING 2250 IN NEMA CABINET (Continued)

c. One at a time, route the cables through the cut-out on either side of the cabinet. Connect the card connector end to the appropriate card connector and install the screw terminal assembly on the mounting plate as follows:

   (1) At screw terminal end, align base of standoffs with the detents in the mounting plate and install 2 mounting screws to hold terminal assembly in place.

   (2) Install cover assembly, securing to standoffs with 2 screws.

12. Interconnect the processor and 2251 by installing the ~~flat ribbon cable~~ CABLE between the MCI card in the processor and the BIF card in 2251 Box 0. If a second 2251 is used, interconnect the 2251s.

13. Connect 25 kHz power cable between power supply and 2251 Box 0.

14. Connect ac line power to power supply and the fan assemblies for the processor and 2251 card cages. Self-test begins to operate at power-up.

15. Perform Level I and Level II Diagnostics procedures.

2104 REMOVAL (Continued)

5. Remove the fan grille.

6. Remove 2 screws and slide out the fan assembly. Disconnect the AC line cord from the fan assembly.

7. Remove nuts and washers from the two threaded studs which secure the bottom of the card cage to the cabinet.

8. Remove nuts and washers from the two threaded studs which secure the top of the card cage to the cabinet.

9. Slide the card cage forward off the threaded studs and lift out of the cabinet.

FIELD WIRING ASSEMBLIES

1. Remove 2 screws. Remove cover.

2. Remove 2 more screws. Remove FWA.

NOTES FOR THE CE

1. To change the fan on the 2104 card cage, the Power Supply must first be removed as in the above procedure.

2. The Power Supply must be removed to gain access to the transorbs.

REMOVAL OF 2250 FROM NEMA CABINET

Special tools needed:

9/16-inch universal socket with minimum 18-inch extension

2251 Removal

1. Disconnect field wiring cables from card connectors. Move cables toward side of cabinet to prevent damage during disassembly.

2. Disconnect any cables that interconnect the 2251 and other assemblies in the cabinet. (Processor, power supply, second 2251.)

3. Remove fan grille from fan.

4. Remove 2 screws and slide out fan assembly. Disconnect the AC line cord from the fan assembly.

5. Remove the 2 nuts and washers from the threaded studs at the bottom of the 2251 assembly.

6. Remove the 2 nuts and washers from the threaded studs at the top of the 2251 assembly.

7. Slide the 2251 forward off the threaded studs and lift out of cabinet.

2104 REMOVAL

1. If the 2104 is being removed along with the 2251, perform the steps above and then continue with this procedure. If the 2104 is being removed separately, first perform the following:

    a. Remove from the card connectors of the 2251 all field wiring cables that are routed to the left side of the cabinet. Position these cables to the side so that they will not interfere with the disassembly.

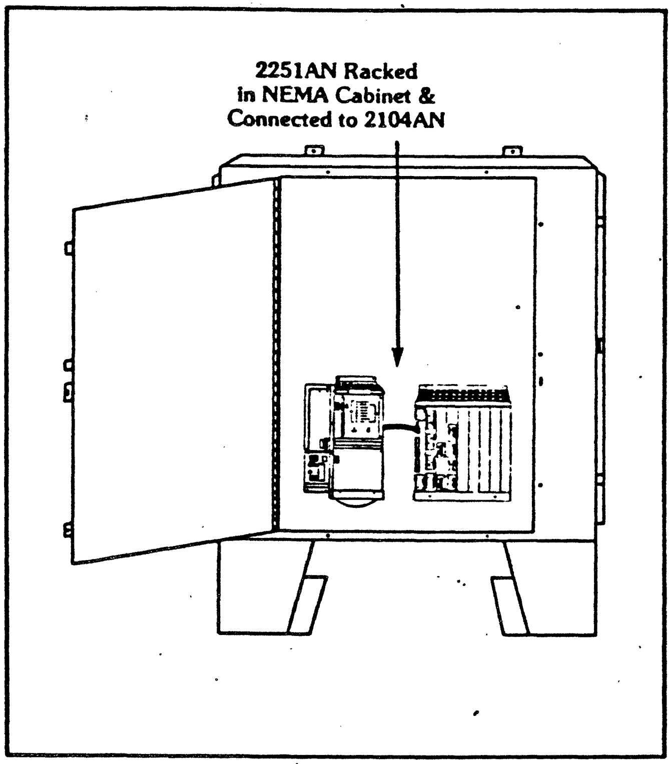
    b. Disconnect the cables that interconnects the 2104 MCI card and the BIF card in the 2251.

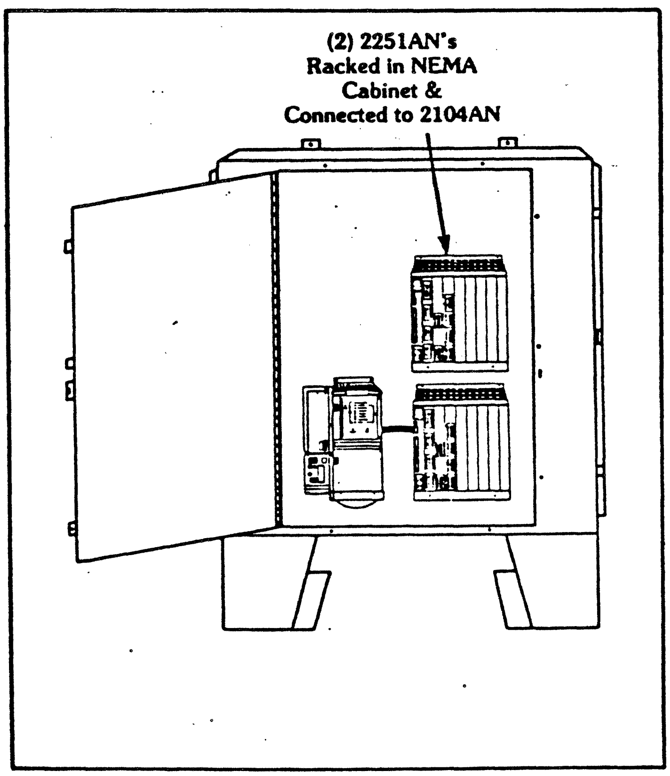
    c. Disconnect the 25 kKz power cable from the BIF card in the 2251.

2. Disconnect AC line cord from the power supply.

3. Remove 2 screws that secure the power supply to the card cage.

4. Remove the power supply by first sliding it forward until it is off its mounting rails, then lift it up, back, and out of the cabinet.

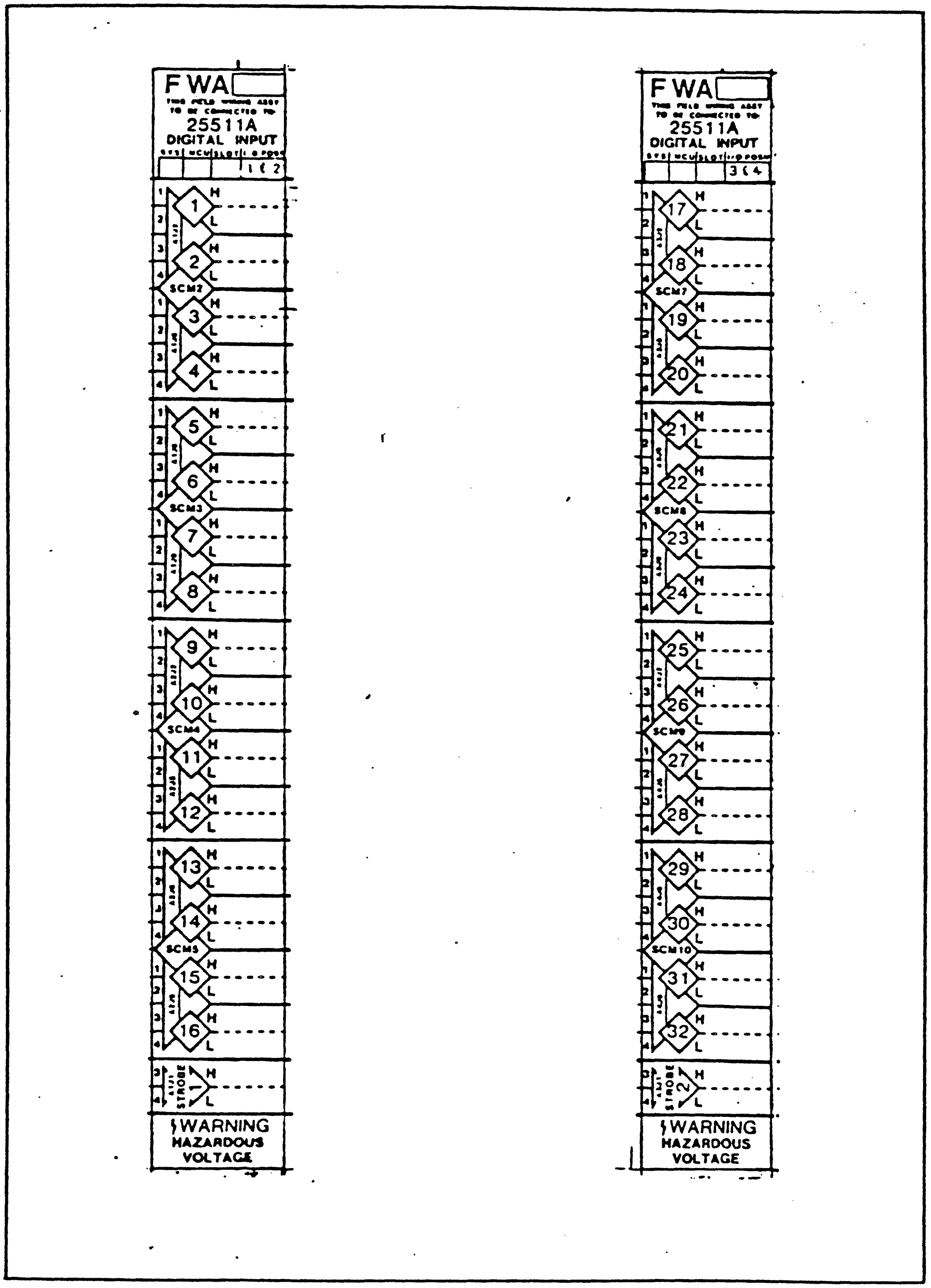

2251AN Racked
in NEMA Cabinet &
Connected to 2104AN


(2) 2251AN's
Racked in NEMA
Cabinet &
Connected to 2104AN

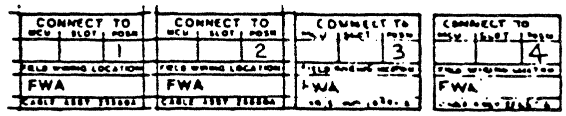
FWA LABELS

BOARD	# OF CHANNELS		LABELS	
25501B	16		H	
			L	
			GND	
			GD	
25502B	32		H	
			L	
			GND	
			GD	
25503B	32		H	
			L	
			GND	
			GD	
25503C	30		H	
			L	
			GD	
25504B	16		GD	
			H	
			L	
			GD	
25504C	15		H	
			L	
			GD	
25510B	4		H	OUTPUT
			L	
			H	REMOTE SENSE
			L	
25511B	32		H	
			L	
	2	STROBES	H	
		(SCM 1&6)	L	
25512B	4		H	A
			L	
			H	B
			L	
25513B	32		H	
			L	
	2	STROBES	H	
		(SCM 1&6)	L	
25514B	16		NO	
			C	
			NC	
			C	
	1	STROBE	H	
		(SCM 1)	L	
25515B	4	OUTPUT	H	A
			L	
			H	B
			L	
	4	INPUT	H	CW
			L	
			H	CCW
			L	
25516B	32		H	
			L	
	1	STROBE	H	
		(SCM 5)	L	

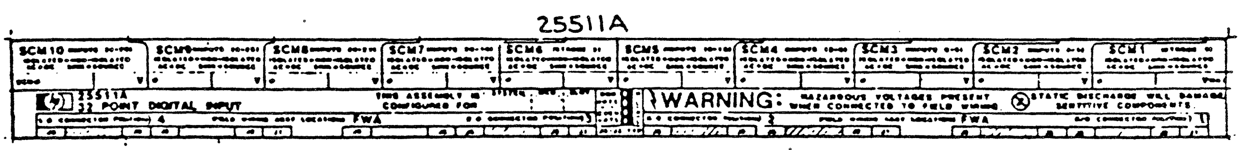
Termination Block Labels



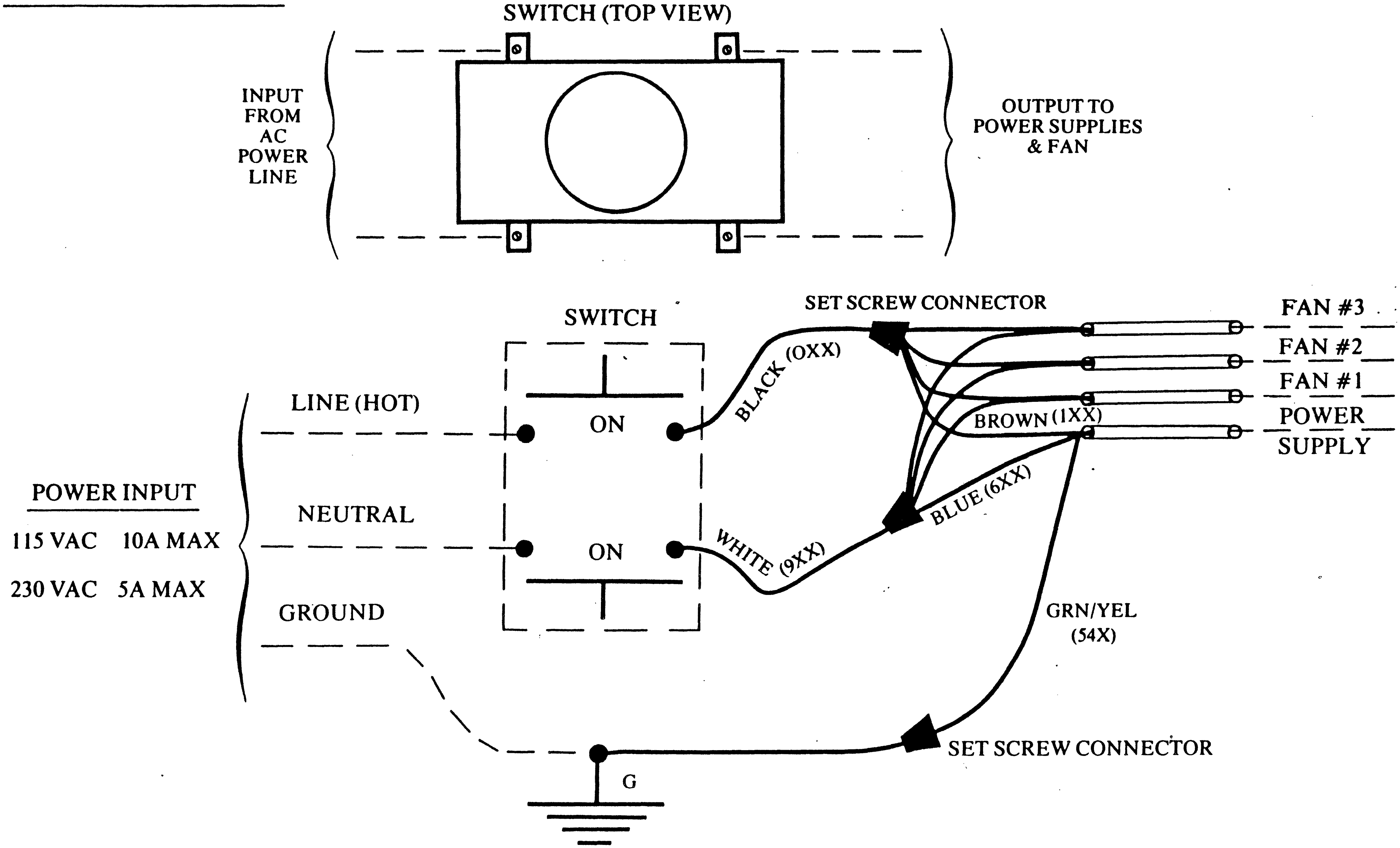
Cable Labels



Function Card Label

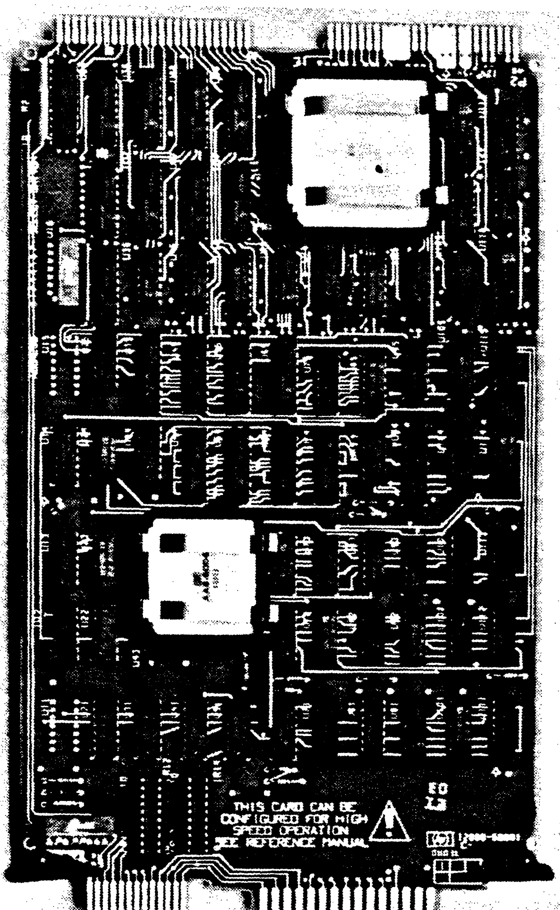


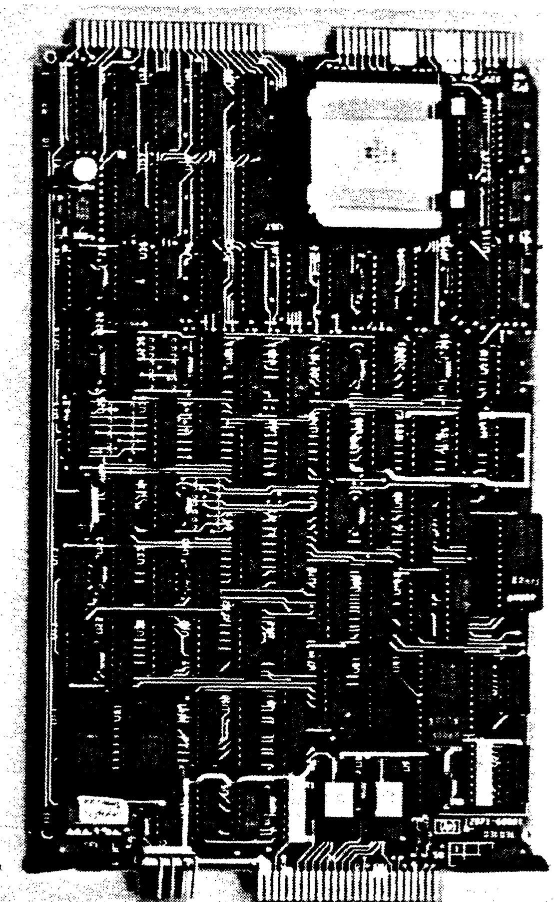
AC POWER WIRING



ALL WIRING IS #18 AWG

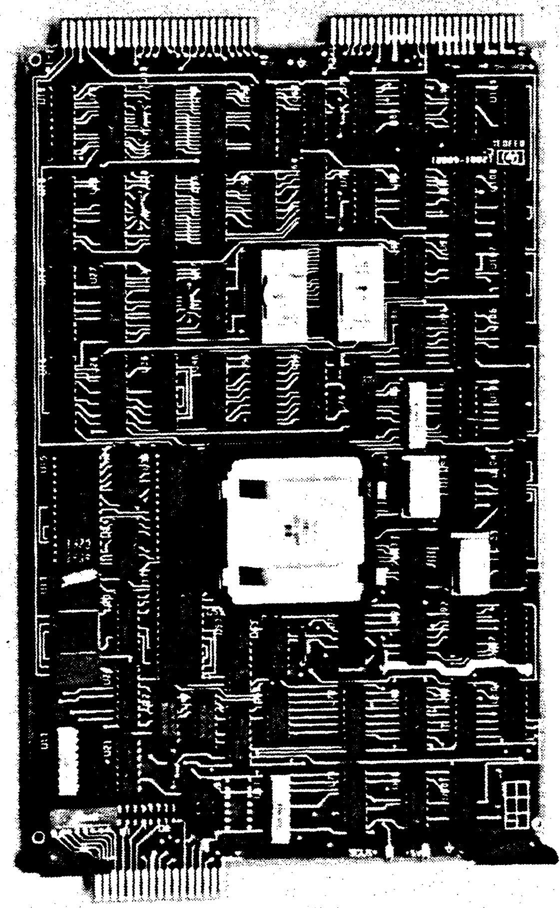
HP IB

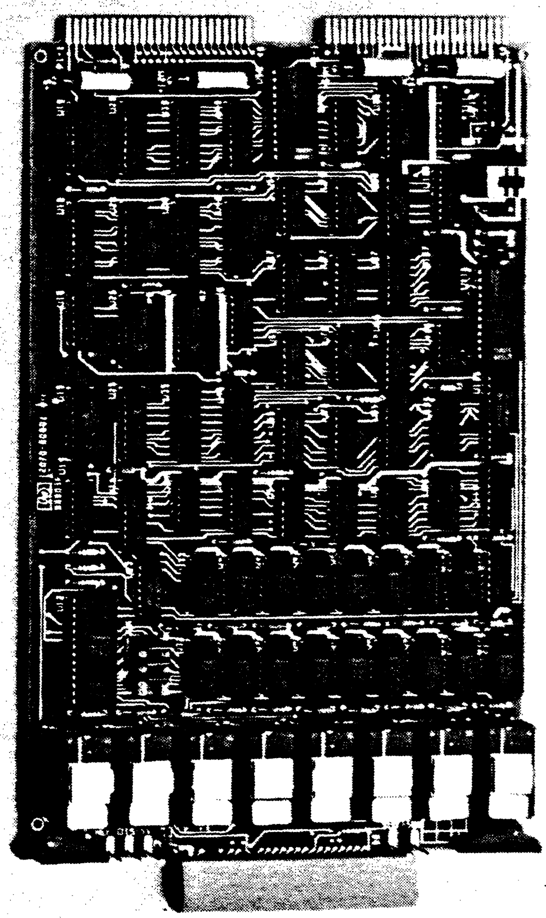




MCI

CPU

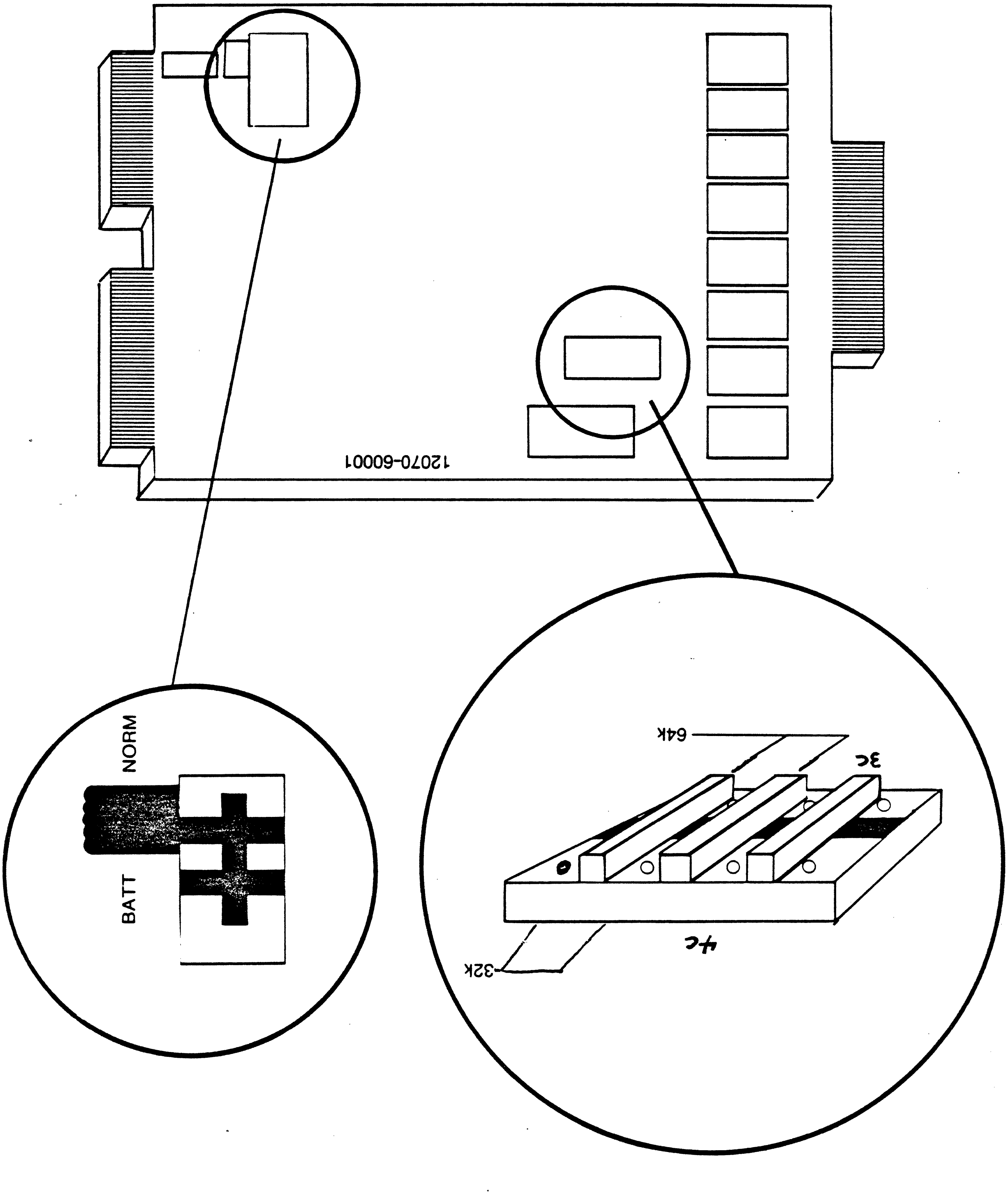




RRack

JUMPER CONFIGURATIONS

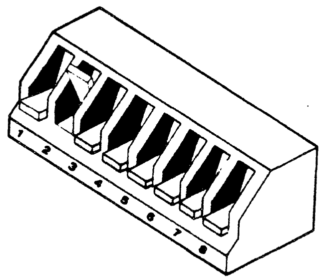
RRACK CARD 12070-60001



JUMPER CONFIGURATIONS

(continued)

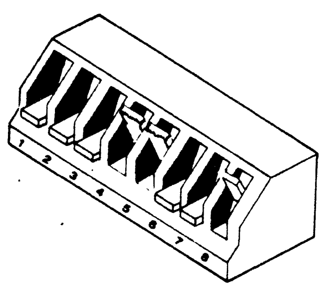
Procesor Card 12001-60001



100 Octal

U1 (front edge of card)
Set to 101 octal for VCP after break
for diagnostic use.
[SWITCH 8 WOULD BE UP FOR BATTERY BACKUP]

MCI Card 12071-60001

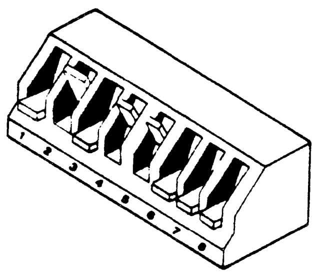


Select code 31

JUMPER CONFIGURATION

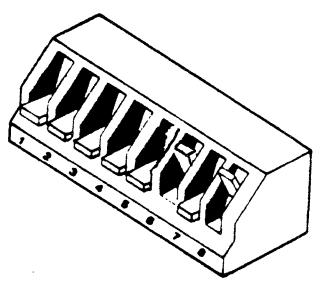
(continued)

H P I B CARD 12009-60001



Select code 130
SW 2 is open for
normal settling time.

U1 (front of card)



U 16 (left rear of card)
(shows address 5)
any address below 37B is ok)

JUMPER CONFIGURATIONS

(continued)

HP 12013A Battery Backup Card

Set as you would for L-Series **except** REMOTE is not used.

Power Supply

Verify that label plate matches what was ordered.
i.e. 115 VAC
7A MAX
47.5-66HZ
FUSE: 7A

BIF

Set thumbwheel switch to desired MCU #
(i.e. first MCU = 0)

WARNING!

Function cards may be damaged by static discharge.

Handle by edges only.

WEAR A GROUNDED
WRIST STRAP!

RECOMMENDED FUNCTION CARD POSITIONS

SLOT #	PREFERRED POSITION	DIGITAL CARD
8	Highest	25514A 16-Channel Relay Output
7		25513A 32-Channel Digital Output
6		25516A 16-Channel Digital Mult.
5		25511A 32-Channel Digital Input
4		25512A 4-Channel Counter
3		25515A 4-Channel Pulse Output
2	Lowest	25510A 4-Channel V/I Analog Output

SLOT #	PREFERRED POSITION	ANALOG CARD
1	Highest	25501A 16-Channel HS Analog Input
2		32-Channel Low-Level MUX
3		16-Channel Relay MUX
4	Lowest	32-Channel High-Level MUX

START UP PROCEDURE

1. Insure all cables and switches are properly installed and configured.
2. Apply line power
3. Observe power supply LED's. TWO green LED's for normal operation.
4. Observe self test status LED's on STATUS panel. Should end in "Data Available" state.
5. Green LED on RRACK card should remain on.
6. Perform Level I diagnostics.
7. USE mcx to do spot functional check.

ANALOG FUNCTION CARDS

INPUT CARDS	DESCRIPTION
HP 25501A	16-Channel High-Speed Analog Input Card (ADC)
HP 25502A	32-Channel High-Level Multiplexer Card (HLMUX)
HP 25503A	32-Channel Low-Level Multiplexer Card (LLMUX)
HP 25504A	16-Channel Relay Multiplexer Card (RELMUX)

HP 2250 DIGITAL FUNCTION CARDS

PRODUCT	DESCRIPTION
25510A	4-Channel Analog output
25511A	32-Point Digital Input
25512A	4-Channel Counter Input
25513A	32-Point Digital Output
25514A	16-Point Relay Output
25515A	4-Channel Pulse Output
25516A	16-Point In/16-Point Digital Multifunction
25517A	Breadboard (for user designed functions)

ANALOG INPUT CARD SIGNAL CONDITIONING MODULES

ANALOG CARD	SCM	DESCRIPTION
HP 25501A	None	ADC Card (signal conditioning components can be added to the card).
HP 25502A	A,B,C,D*	HLMUX Card
HP 25503A	A,B,C,D*	LLMUX Card
HP 25504A	None	RELMUX Card (capacitors can be added to the plug-in relay circuits to provide input signal conditioning)

*A,B,C, and D are the SCM suffixes relating to the SCM NUMBER listed below.

SCM NUMBER	CHANNELS PER SCM	DESCRIPTION
25540A	8	Blank (User supplies components)
255406	8	Passive Filter Network Capacitors
25540C	8	Passive Filter Network Current-Loop Resistors
25540D	8	Passive Filter Network Current-Loop Resistors and Filter Capacitors

DIGITAL SCM SELECTION GUIDE

PRODUCT REFERENCE		
FUNCTION CARD	CROSS REFERENCE SCM NUMBER	DESCRIPTION
25511A	1 & 2*, 3 & 4	32-Point Digital Input
25512A	3 and 4	4-Channel Counter Input
25513A	1 & 2*, 5,6,7	32-Point Digital Output
25514A	1 & 2*, 8	16-Channel Relay Output
25515A	XXXX	4-Channel Pulse Output
25516A	1 & 2*, 3,4,7	32-Point Multifunction

*Single Channel SCM for External Strobe Input

SCM CROSS REFERENCE GUIDE			
SCM NO.	PRODUCT NO.	CHANNELS	DESCRIPTION
1	25531-Series	1	Non-Isolated Digital Input
	25531B		5 VDC Range
	25531C		12 VDC Range
	25531D		24 VDC Range
	25531E		48 VDC Range
	25531K		5 VDC Range, Sink Inputs
	25531L		12 VDC Range, Sink Inputs

DIGITAL SCM SELECTION GUIDE

(continued)

SCM CROSS REFERENCE GUIDE

SCM NO.	PRODUCT NO.	CHANNELS	DESCRIPTION
2	25533-Series	1	Isolated Digital Input
	25533B		5 VDC Range
	25533C		12 VDC Range
	25533D		24 VDC (16 VAC) Range
	25533E		48 VDC Range
	25533F		72 VDC Range
	25533G		120 VDC (72VAC) Range
	25533H		115 VAC Range
	25533I		230 VAC Range
3	25535-Series	4	Non-Isolated Digital Input
	25535B		5 VDC Range
	25535C		12 VDC Range
	25535D		24 VDC Range
	25535E		48 VDC Range
	25535K		5 VDC Range, Sink Inputs
	25535L		12 VDC Range, Sink Inputs
4	25537-Series	4	Isolated Digital Input
	25537B		5 VDC Range
	25537C		12 VDC Range
	25537D		24 VDC (16 VAC) Range
	25537E		48 VDC Range
	25537F		78 VDC Range
	25537G		120 VDC (72VAC) Range
	25537H		115 VAC Range
	25537I		230 VAC Range
5	25543A	4	Isolated Digital Output, VMOX Solid-State Circuit.
6	25544-Series	4	Non-Isolated Digital Output
	25544A		Open Drain Circuit
	25544B		5 VDC Range
	25544C		12 VDC Range
7	25545A	2	Solid-State Relay Output (Reduces usable points by 2).

DIGITAL SCM SELECTION GUIDE

(continued)

SCM CROSS REFERENCE GUIDE			
SCM NO.	PRODUCT NO.	CHANNELS	DESCRIPTION
8	25539-Series 25539A 25539B 25539G 25539H 25539I	4	Arc Suppression Circuits For user added components 0 to 30 VDC Range 24 VAC Range 115 VAC Range 230 VAC Range

2250 SCM CROSS REFERENCE GUIDE

25531B	25531-60001	1 chan, 5vdc, non-isolated strobe,source	25511B (2)
25531C	25531-60002	1 chan,12vdc "	25513B (2)
25531D	25531-60003	1 chan,24vdc "	25514B (1)
25531E	25531-60004	1 chan,48vdc "	25516B (1)
25531K	25531-60005	1 chan, 5vdc, non-isolated strobe,sink	
25531L	25531-60006	1 chan,12vdc "	
25533B	25533-60001	1 chan, 5vdc, isolated strobe,source	
25533C	25533-60002	1 chan,12vdc, "	
25533D	25533-60003	1 chan,24vdc, "	
25533E	25533-60004	1 chan,48vdc, "	
25533F	25533-60005	1 chan,72vdc, "	
25533G	25533-60006	1 chan,120vdc/72vac, "	
25533H	25533-60007	1 chan,115vac, "	
25533J	25533-60008	1 chan,230vac, "	

****

25535B	25535-60001	4 chan, 5vdc, non-isolated input,source	25511B (8)
25535C	25535-60002	4 chan,12vdc, "	25512B (2)
25535D	25535-60003	4 chan,24vdc, "	25515B (2)
25535E	25535-60004	4 chan,48vdc, "	25516B (4)
25535K	25535-60005	4 chan, 5vdc, non-isolated input,sink	
25535L	25535-60006	4 chan,12vdc, "	
25536B	25536-60001	4 chan, 5vdc, non-isolated input,source	
25536K	25536-60005	4 chan, 5vdc, non-isolated input,sink	
25537P	25537-60001	4 chan, 5vdc, isolated input,source	
25537Q	25537-60002	4 chan, 12vdc, "	
25537R	25537-60003	4 chan, 24vdc, "	
25537S	25537-60004	4 chan, 48vdc, "	
25537T	25537-60005	4 chan, 72vdc, "	
25537U	25537-60006	4 chan,120vdc, "	
25537V	25537-60007	4 chan,115vac, "	
25537W	25537-60008	4 chan,230vac, "	

****

25539A	25539-80001	4 chan, blank, relay arc supression	25514B (4)
25539E	25539-60005	4 chan, 30vdc, "	
25539G	25539-60007	4 chan, 24vac, "	
25539H	25539-60008	4 chan,115vac, "	
25539J	25539-60009	4 chan,230vac, "	
25540A	5081-0106	8 chan,blank, analog input	25502B (4)
25540B	25540-60001	8 chan,filter, "	25503B (4)
25540C	25540-60002	8 chan,loop, "	25503C (4)
25540D	25540-60003	8 chan,loop&filter, "	

****

25543N	25543-60001	4 chan, 60vdc, isolated output	25513B (8)
			25515B (2)
25544A	25544-60001	4 chan,open drain,non-isolated output	25516B (4)
25544B	25544-60002	4 chan, 5 vdc, "	
25544C	25544-60003	4 chan, 12vdc, "	
25545P	25545-60001	2 chan,115vac, isolated output	
25546B	25546-60001	4 chan, 5vdc, non-isolated output	

INSTALLATION SECTION INSTRUCTORS GUIDE

!!! WILL MEAN GO TO NEW SLIDE.
THIS IG IS ONLY TO BE USED AS NOTES. YOU ARE EXPECTED TO EXPAND ON THE SLIDES YOURSELF.

!!!
THIS SECTION WILL DISCUSS THE CONFIGURATIONS AND INSTALLATION PROCEDURES

!!!
A) SYSTEM WILL COME IN EITHER NEMA OR STANDARD RACK
    1)RACK WILL HAVE SPECIAL POWER MODULE
    2)NO POWER STRIPS IN EITHER CABINET
    3)FWA ARE FOUND IN SIDES OF NEMA CABINET
    4)FWA ARE IN BACK OF RACK CAB. OR IN SECOND CAB IF USING RACKS.

!!!
A)POWER SUPPLY WILL RUN ONE 2104 AND TWO MCU'S OR ~~THREE~~ TWO MCU'S
    1)MAX OF TWO MCU'S IN ONE NEMA CABINET.
    2)NOTE CABINETS 2 AND 4 IN THE SLIDE WOULD BE FOR FWA'S.

!!!
A) MULTIPLE MCU'S ARE CONNECTED TOGETHER WITH DAISY CHAIN TYPE CABLES.
    1)FIRST CABLE WILL BE A SIX INCH ~~RIBBON~~ CABLE
    2)SUCCESIVE MCU'S WILL BE CONNECTED TOGETHER WITH A ROUND CABLE. MAX LENGTH OF ONE CABLE 11 FT. MAX LENGTH OF ENTIRE STRING 32 FT.
    3) TERMINATOR ON LAST BIF.?

!!!
A) SLIDE SHOWS FRONT EDGE CONNECTOR OF FUNCTION CARD
    1)SPECIAL BLOCK / CABLE / FWA ARE PROVIDED BY FACTORY.
    2) FWA MOUNTED IN BACK OF RACK OR SIDE OF NEMA AS APPROPRIATE
    3) CONNECTION TO CUSTOMER EQUIPMENT IS THE CUSTOMERS RESPONSIBILITY.

!!!
A) ILLUSTRATION OF FWA.

!!!
A) ILLUSTRATION OF THERMOCOUPLE BLOCK WHICH WILL BE FOUND ON CERTAIN CONFIGURATIONS.

!!!
A) WHEN YOU GET SYSTEM A CONFIGURATION CHART SIMILAR TO THE ONE SHOWN WILL BE SUPPLIED BY THE FACTORY.
    1) THIS CHART SHOWS CABLING CONFIG.
    2) DEMONSTRATE USE OF THE CHART.
        A-B-C = MCU # - SLOT # - BLOCK #

!!!
A) SLIDE SHOWS A FWA LABEL
1) THE LABEL IDENTIFIES WHAT THE CONNECTIONS ARE FOR EACH DATA POINT IN THE 2250.

!!!
A) THIS SLIDE ILLUSTRATES ORDER OF CARDS IN 2104 CONTROL UNIT.
1) ALSO NOTE EXTERNAL CONNECTIONS.

!!!
ILLUSTRATION OF 2104 STATUS PANEL.
1) THIS STATUS PANEL IS A MIRROR OF THE CPU STATUS LED'S.

!!!
ILLUSTRATION OF FOUR CARDS ALWAYS FOUND IN 2104 CARD FRAME.

!!!
RRACK CARD JUMPER CONFIGURATIONS

!!!
PROCESSOR CARD AND MCI CARD SWITCH CONFIGURATIONS.
MCI GETS SET TO SELECT CODE 31.

!!!
HPIB SWITCH CONFIGURATIONS.
NOTE THAT HPIB ADDRES CAN BE ANYTHING SINCE 2250 OP SYSTEM READS THE HPIB ADDRESS UPON POWER UP.

!!!
MORE CARD CONFIGURATIONS.
1) START BIF NUMBERING FROM 0 AND LEAVE NO BLANKS TO SAVE ON TABLE AREA IN 2250 MEMORY.

!!!
PRODUCT NUMBERS FOR VARIOUS FUNCTION CARDS.

!!!
ILLUSTRATION OF A VARIETY OF SCM'S

!!!
TABLE OF AVAILABLE ANALOG INPUT SCM'S

!!!
THE NEXT THREE SLIDES SHOW THE CHOICES OF SCM'S FOR DIGITAL FUCTION CARDS.

!!!
PREFERED SLOT ASSIGNMENTS FOR ANALOG AND DIGITAL FUNCTION CARDS.

!!!
START UP PROCEDURE TO BE FOLLOWED ON INSTALLATION.
1) LEVEL II DIAGNOSTICS NOT TO BE RUN ON DAY OF INSTALLATION SINCE CE WOULD HAVE TO DISCONNECT ALL CABLES AND IT IS THOUGHT THAT HE WOULD THEREBY CREATE MORE PROBLEMS.

!!!
WARNING ABOUT HANDLING OF FUNCTION CARDS BEFORE WE BREAK INTO LAB
AND DESTROY MACHINE.

ANY QUESTIONS FROM CE'S ON THIS SECTION OF LECTURE???

BREAK NOW FOR LAB ON DISSASEMBLY AND REASSEMBLY OF 2250.

FOLLOW THIS WITH DIAGNOSTIC SECTION TO SEE WHAT WE BROKE.

CALIBRATION

25501

4.8 CALIBRATION PROCEDURE

If the ADC card is not operating according to its specifications, calibration may be required. After calibration, the overall operation of the ADC card can be verified by performing the verification tests described in the HP 2250 Diagnostics and Verification Manual, part no. 25595-90001. Specific instructions for calibrating the ADC card are contained in the following paragraphs.

4.8.1 EQUIPMENT REQUIRED

The following is a list of equipment required for calibration:

EQUIPMENT	USE
HP 3455A Digital Voltmeter	Reference voltages, zero, and gain adjustments.
HP 3310A Function Generator	Common Mode Rejection adjustment.
HP 180A Oscilloscope, with HP 1806A Low-Frequency Differential Plug-In	Common Mode Rejection adjustment, and Sample to Hold pedestal adjustment.
Accurate DC voltage source. Electronic Development Corp. Model 501J, or equivalent	PGA Gain adjustment, and ADC calibration
Extender Card	Provides access to the HP 25501A

4.8.2 PRELIMINARY PROCEDURES

a. Turn the HP 2250 system power OFF.

CAUTION

The ADC card contains static-sensitive components. Be sure to use appropriate anti-static procedures when you handle the card. (The pages on "Safety Considerations" at the beginning of this manual describe the anti-static procedures that you should follow.) Failure to follow these procedures may result in damage to the card.

b. Using the appropriate anti-static procedures, remove the HP HP 25501 card from its slot and insert the extender card in its place. Then insert the HP 25501A card into the extender card.

c. Turn on power to the HP 2250 system and ensure that it passes self-test.

d. At the controller you are using (HP 1000, HP 9826, etc.), call the HP 2250 exerciser program (MCX, for example) and issue the command:

```
ID(1,n)!
```

where "n" is the number of function card slots in your HP 2250 system. The ID codes of the function cards installed in the HP 2250 system should be returned, and the ID code of 1 should be returned from the slot that the HP 25501A is in.

e. From the exerciser program, issue the following command:

```
AI(adc slot,1)!
```

f. Two items should be returned:

1. A condition code of 0, indicating that the command executed correctly.

2. The data from the conversion on channel 1, which should should be any integer between -32768 and + 32767. Because no data was put into the card, you can't expect to know what the the data should be. All that is being determined with the command is whether the card will perform a conversion.

g. If step f. was successful (an integer between -32768 and +32767 was returned), the calibration can be started.

4.8.3 COMMON MODE REJECTION ADJUSTMENT

Perform the following steps:

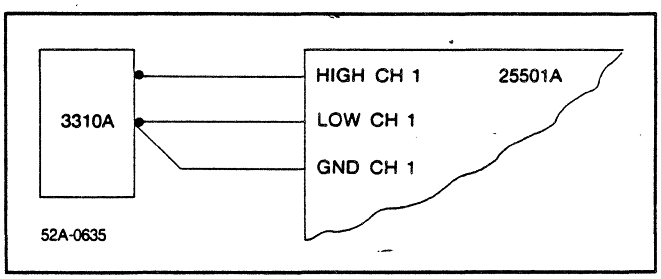
a. From the exerciser program, issue the command:

AI(adc slot,1)!

b. Set the output of the 3310A function generator to the following:

Frequency:	100 Hz
Function:	Sine wave
Amplitude:	10 volts peak (20 volts peak-to-peak)
DC offset:	Zero

c. Connect the function generator to the input of the HP 25501A as shown below:



d. Connect the + input of the HP 1806A CH A plug to the D/SE TEST POINT on the HP 25501A.

e. Connect the - input of the HP 1806A CH B plug to the PGA GND TEST POINT on the HP 25501A.

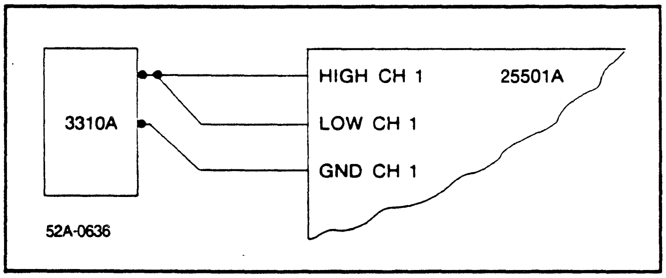
f. Connect the ground clips of both probes to the PGA GND TEST POINT on the HP 25501A.

g. Set the scope vertical sensitivity to 5V/div, the time base to 5msec/div, the trigger mode to internal, AC, and + slope. (Experiment to get a clear picture.)

h. Verify that there is a 20 volt peak-to-peak sine wave coming out of the D/SE amplifier (the test point that the + probe is connected to.

i. If there is a 20 v p-p sine wave at this point, then you are ready to perform the Common Mode Rejection adjustment. If the 20 v p-p sine wave is not present, the HP 25501A card is defective.

j. Connect the output of the 3310A to the input of the HP 255501A as shown below:



k. Increase the sensitivity of the scope to approximately 5mV/div. You should see a sine wave with an amplitude of from 1 mV p-p to 10 mV p-p.

l. Adjust R103 on the HP 25501A for a minimum output as viewed on the scope. (Anything below 1 mV p-p is acceptable, as this corresponds to > 80 db of common mode rejection.) Use the BANDWIDTH LIMIT switch on the scope, if necessary to eliminate noise on the display.

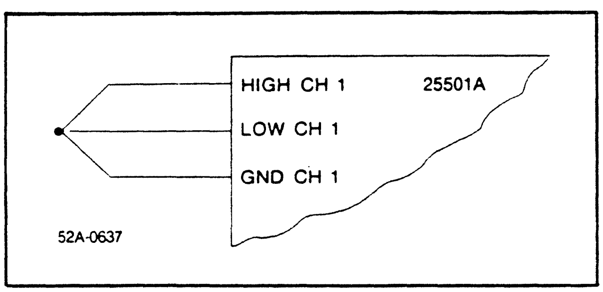
m. If the output cannot be adjusted for < 1 mV p-p, the HP 25501A card is defective.

4.8.4 SAMPLE-TO-HOLD DYNAMIC OFFSET ADJUSTMENT

Perform the following:

a. Disconnect the 3310A function generator from the HP 25501A.

b. Short the high and low inputs on the HP 25501A to its ground as shown below:



c. From the exerciser program, issue the following command:

```
REP(0);REW(B0);BLOCK READ(adc slot,1,10000);NEXT!
```

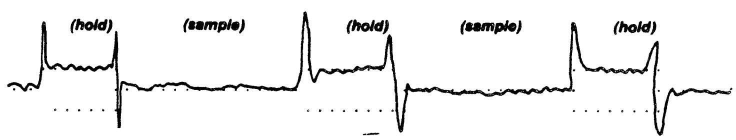
This command sets up a high speed AI loop; no data will be returned. The HP 25501A is taking readings with a short pause after every 10000 readings.

d. Move the + probe of the scope from the D/SE TEST POINT (from the previous test) to the S/H TEST POINT. Leave the - probe on the PGA GND TEST POINT.

e. Set the scope vertical sensitivity to 20 mV/div, AC coupled, and the time base to 5 usec/div.

f. A square, or similar, wave should appear on the scope. Adjust R66 (JUMP) on the HP 25501A so that the amplitude of the square wave decreases. Increase the scope sensitivity as necessary until it is in the 5 mV/div scale. MAKE SURE THAT THE BANDWIDTH LIMIT SWITCH IS IN THE 500 kHz POSITION FOR THIS TEST!

g. You should observe a waveform similar to that shown below:



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h. Continue to adjust R66 until the line between sample and hold is as straight as possible (< 1 mV).

i. The test is now complete. Remove the + and - scope probes and ground clips from their respective test points.

j. Issue the HPIB CLEAR message (CLEAR n on an HP 9826 desktop computer, where "n" is the interface number of the HP-IB interface, or CL from the MCX exerciser program on the HP 1000).

4.8.5 AUTORANGING REFERENCE VOLTAGE ADJUSTMENT

Perform the following:

a. Connect the digital voltmeter - lead to the PGA GND test point and the + lead to the + 10V TEST POINT on the HP 25501A.

b. Ensure that the digital voltmeter is in DC volts, autorange.

c. Adjust R92 (+10 REF) on the HP 25501A until the voltmeter reads +10.070 volts, plus or minus 2 mV.

d. Move the voltmeter + lead to the -10V TEST POINT.

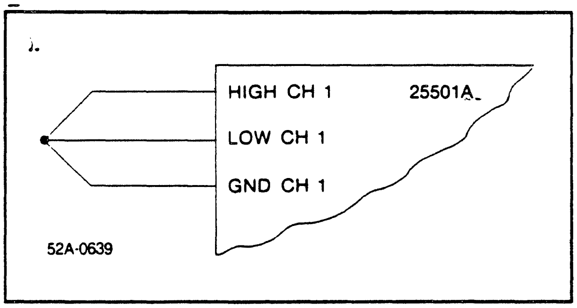
e. Adjust R98 (-10 REF) on the HP 25501A until the voltmeter reads -10.070 volts, plus or minus 2 mV.

4.8.6 PGA AND SUMMING AMPLIFIER OFFSET ADJUST

Perform the following:

a. Remove any test equipment still connected from the previous test.

b. Connect the input of the HP 25501A Channel 1 as shown below:



c. From the exerciser program, issue the following command:

GAIN(adc slot,1)122 DREAD(adc slot,1)!

Three data items should be returned:

1. A zero condition condition code.
2. Any value, which should be ignored.
3. 122, which is the gain code for a PGA gain of 8.

d. Connect the + lead of the digital voltmeter to the PGA TEST POINT, and the - lead to the PGA GND TEST POINT on the HP 25501A.

e. The digital voltmeter should read between +/- 100 mV.

f. Adjust R82 (PGA ZERO) on the HP 25501A until the voltmeter reads zero, plus or minus 0.4 mV.

g. From the exerciser program, issue the following command:

GAIN(adc slot,1)98 DREAD(adc slot,1)!

The first returned data item should be 0, ignore the second data item returned, and the third data item should be 98, which is the PGA gain code for unity gain.

h. Connect the + lead of the voltmeter to the ADC TEST POINT, and the - lead to the AGND TEST POINT on the HP 25501A.

i. Set SW1 (CALIB) as follows:

1 -- CLOSED

2 -- CLOSED

3 -- CLOSED

4 -- OPEN

j. The digital voltmeter should read between plus and minus 30 mV.

k. Adjust R37 (INO) on the HP 25501A until the voltmeter reads plus or minus 0.2 mV.

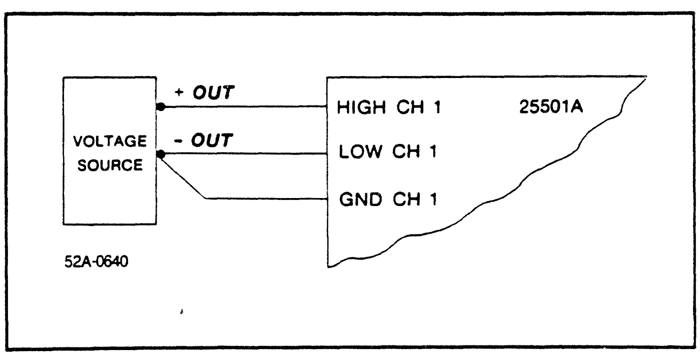
l. Set SW1 to OPEN, CLOSED, CLOSED, OPEN.

4.8.7 PGA GAIN ADJUST

Perform the following:

a. Remove any test equipment still connected from the previous test.

b. Connect the voltage source to the input of the HP 25501A as shown below:



c. Connect the + lead of the voltmeter to the PGA TEST POINT and the - lead to the PGA GND TEST POINT.

d. From the exerciser program, issue the following command:

GAIN(adc slot,1)98 AI(adc slot,1)!

e. Switch the voltage source between plus and minus 10 volts and verify that the digital voltmeter reads plus or minus 10 volts, respectively, with a tolerance of +/- 2 mV.

f. Set the voltage source to +5 volts, and then issue the following command:

GAIN(adc slot,1)106 AI(adc slot,1)!

This sets the PGA gain to 2.

g. Adjust R95 (G=2) on the HP 25501A until the voltmeter reads +10 volts, +/- 0.5 mV.

h. Set the voltage source to +2.5 volts, and issue the following command:

GAIN(adc slot,1)114 AI(adc slot,1)!

This sets the PGA gain to 4.

i. Adjust R90 (G=4) on the HP 25501A until the voltmeter reads +10 volts, +/- 0.5 mV.

j. Set the voltage source to +1.25 volts, and issue the following command:

GAIN(adc slot,1)122 AI(adc slot,1)!

This sets the PGA gain to 8.

k. Adjust R84 (G=8) on the HP 25501A until the voltmeter reads +10 volts, +/- 0.5 mV.

l. Issue the command RES! to complete this test.

4.8.8 ADC GAIN ADJUST

Perform the following:

a. Remove any test equipment still connected from the previous test.

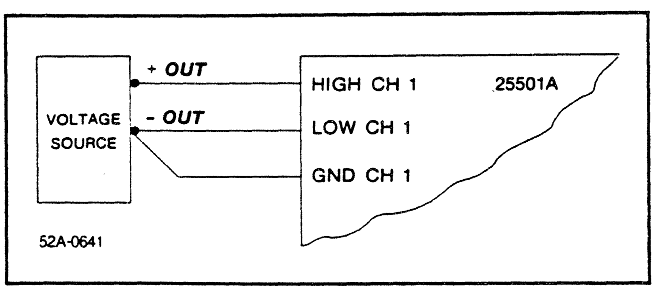
b. Issue the following command:

```
CPA(0,0,20);WPA;BLOCK AID(adc slot,1,50)!
```

This sets the HP 25501A to pace at 20 usec, and requests 50 analog double word readings. These readings should be processed as shown in the following example program:

```
      LUTERM=LOGLU(SLU)                              !Get terminal LU
      READ(LU2250) CC                                !Read condition code
      IF(CC .NE. 0)CALL ERROR                        !Go to error handler
                                                      if problem
      READ(LU2250) (V(I),I=1,100)                    !Gather the 100 data
                                                      items
      SUM = 0
      DO 10 I = 1,99,2                               !DO loop to sum the
                                                      50 readings
      SUM=SUM + (V(I)*0.025) + (V(I+1)*0.000001)
10    CONTINUE
      AVERGE = SUM/50                                !Calculate average of
                                                      50 readings
      WRITE(LUTERM,20) AVERGE
20    FORMAT("Average = "F9.5,"volts")               !Display average
      GOTO XXXX                                      !Repeat
```

c. Connect the voltage source to the input of the HP 25501A as shown below:



d. Set the value of the voltage source to 0 volts DC.

e. Set SW1 (CALIB) to CLOSED, CLOSED, CLOSED, OPEN.

f. Start the program running. You should observe a reading of approximately -0.06 volts.

g. Be sure power has been applied to the card for at least 5 minutes before proceeding.

h. On the HP 25501A, adjust the potentiometer marked ZERO until the display reads 0.00000, +/- 0.000500 volts. (An occasional noise jump outside the range may occur, this is normal.)

i. Set the voltage source to +5 volts.

j. On the HP 25501A, adjust the potentiometer marked +5VOLT until the display reads +5.00000, +/- 0.000500.

k. Set SW1 on the HP 25501A to OPEN, CLOSED, CLOSED, OPEN.

l. Set the voltage source to + 10 volts.

m. On the HP 25501A, adjust the potentiometer marked +10VOLT until the display reads +10.00000, +/- 0.000500.

n. Set the voltage source to -10 volts.

o. On the HP 255501A, adjust the potentiometer marked -10VOLT until the display reads -10.00000, +/- 0.000500.

p. Set the voltage source to +10, +5, 0, -5, and -10 and determine that the display corresponds with the above voltages plus or minus 1.25 mV. If not, recalibrate the card from step d.

25503

6.8 CALIBRATION

If the LLMUX card is not operating according to specifications, you may need to calibrate it. After calibration, you can verify the overall operation of the card by performing the tests described in the HP 2250 Measurement and Control Processor Diagnostic and Verification Manual, part number 25595-90001. The following paragraphs contain specific instructions for calibrating the LLMUX card.

6.8.1 EQUIPMENT REQUIRED

You will need the following equipment for calibrating the LLMUX card:

1) HP 3455A digital voltmeter.
2) Extender card, part number 25591-60001, as shown in figure 6-3.
3) Shorting connector, part number 25590-60010, as shown in figure 6-4.

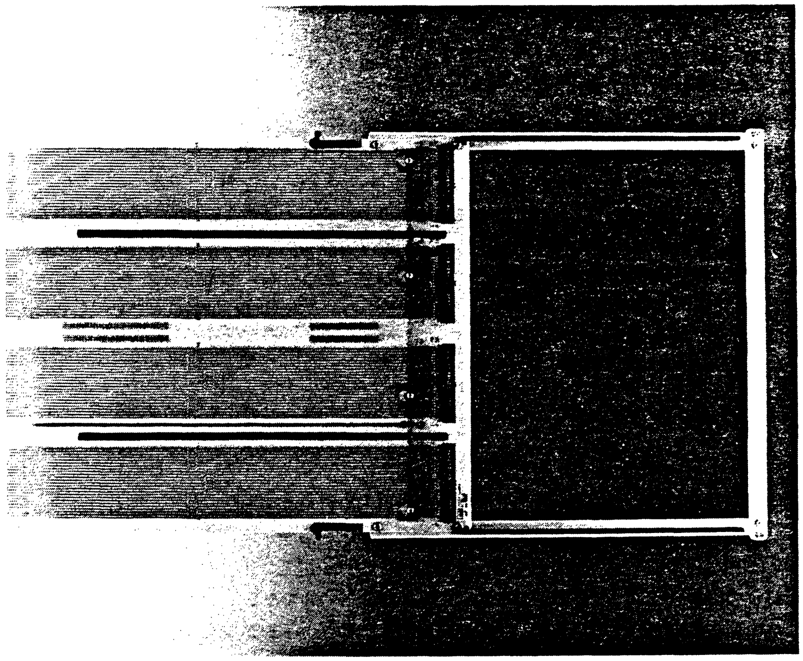

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Figure 6-3. Extender card

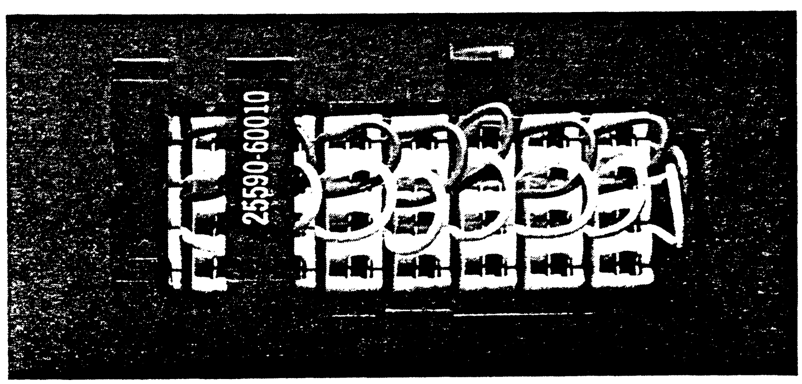

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Figure 6-4. Shorting connector

6.8.2 PRELIMINARY PROCEDURE

1) Turn the power to the HP 2250 system OFF.

2) Remove the field wiring assemblies (FWAs) from the HP 25503A LLMUX card.

3) Remove the LLMUX card from its slot and insert the extender card in its place. Insert the LLMUX card into the extender card. Leave the FWAs disconnected.

CAUTION

> The LLMUX card contains static-sensitive components. Be sure to use appropriate anti-static procedures when you handle the card. (The pages on "Safety Considerations" at the beginning of this manual describe the anti-static procedures that you should follow.) Failure to follow these procedures may result in damage to the card.

4) Turn power to the HP 2250 system ON and make sure that the system passes self-test.

5) Allow the LLMUX card to reach normal operating temperature. This warm-up period usually takes 15 minutes; if, however, the card was already at operating temperature before you turned the power off, and if the power was not off for more than 30 seconds, you can go ahead with the calibration procedure.

6) At the controller you are using (HP 1000, HP 9826, HP-85, etc.) issue the command

   ```
   ID(1,n)!
   ```

   to the HP 2250, where n is the number of function card slots in your HP 2250 system. (If you are using the MCX exerciser program, just type in "CARDS".) This will cause the ID codes of the function cards in your system to be returned, and an ID code of 3 should be returned for the slot that contains the HP 25503A LLMUX card.

7) Issue the following command from controller to the HP 2250:

   ```
   AI(slot,1)
   ```

where "slot" is the slot number of the LLMUX card. This will cause the HP 2250 to make an analog reading of channel 1 of the LLMUX card. Two values should be returned:

a) A condition code of 0, indicating that the command executed correctly.

b) The datum from the conversion on channel 1; this should be any integer in the range of -32768 to 32767. (Since channel 1 is not connected to a known voltage, there is no way of knowing what the "correct" reading should be. All that you are doing here is verifying that the card is able to take a reading.)

8) If step 7 was successful (that is, if an integer between -32768 and 32767 was returned), you are ready to proceed with the calibration.

6.8.3 OFFSET VOLTAGE ADJUSTMENT

There are three adjustments to be made in calibrating the HP 25503A LLMUX card; they are all adjustments of operational amplifier offset voltages. Do the following:

1) Short the inputs of the first channel of the LLMUX card. This involves connecting the HIGH, LOW, and GROUND pins of the channel. This is most easily done with the shorting connector (part number 25590-60010) shown in figure 6-4. Connect the shorting connector to the first block of eight channels on the card, just as though you were connecting a field wiring cable. (You don't have to use the shorting connector if you don't want to, but we have found that using the connector is easier than trying to run wires between all those little pins.)

CAUTION

> If you do try to connect the pins with individual wires, be careful not to make contact with the fourth row of pins. These pins carry power for the thermocouple reference connectors, and an accidental connection between these pins and the other pins could damage the card. We recommend that you use the shorting connector.

2) Issue the following command to the HP 2250:

   AI(slot,1)

   where "slot" is the number of the slot that contains the LLMUX card.

3) Set the voltmeter to the lowest voltage range and connect it between points A and C (shown in figure 6-5) on the LLMUX card.

4) Adjust potentiometer R601 (on the front edge of the card) until you get a reading of zero on the voltmeter.

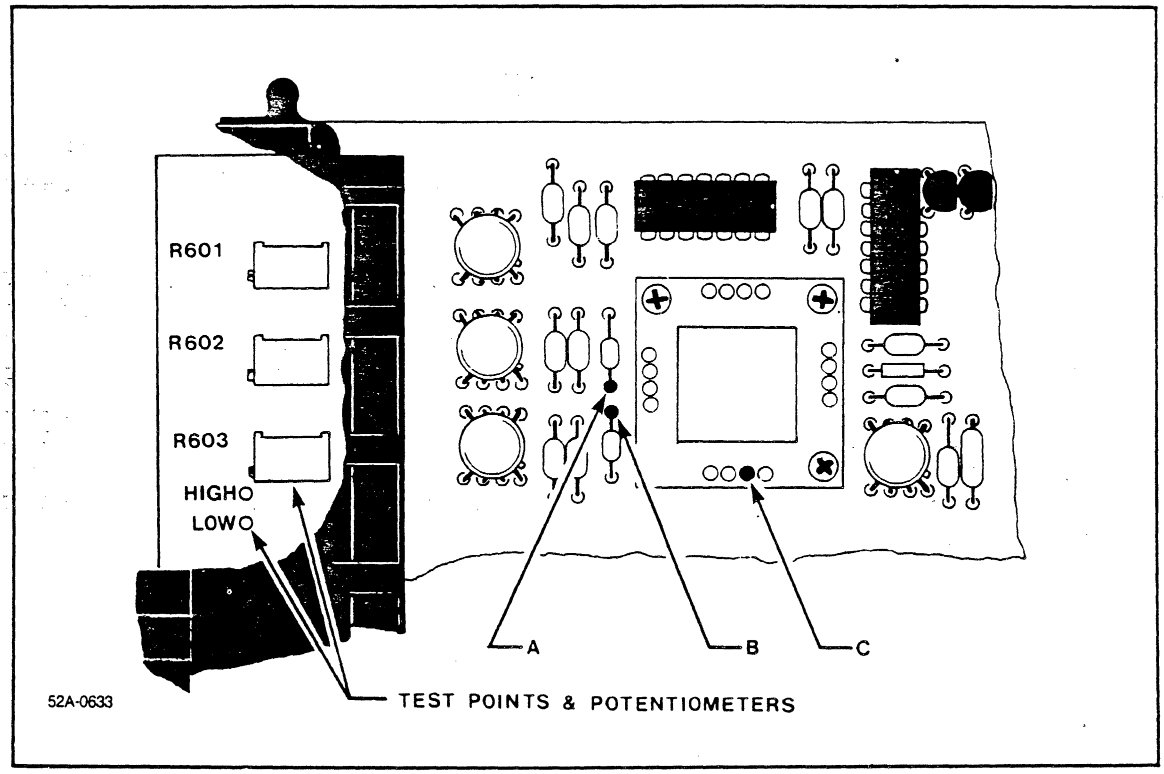

Figure 6-5. LLMUX Test Points and Adjustments

5) Connect the voltmeter between points B and C (shown in figure 6-5).

6) Adjust potentiometer R602 (on the front edge of the card) until you get a reading of zero on the voltmeter.

7) Connect the voltmeter between test points HIGH and LOW on the front edge of the card.

8) Adjust potentiometer R603 (on the front edge of the card) until you get a reading of zero on the voltmeter.

9) Calibration of the LLMUX card is now complete. To return to norma operation:

   a) Turn power to the HP 2250 system OFF.

   b) Remove the LLMUX card from the extender card.

CAUTION

> The LLMUX card contains static-sensitive components. Be sure to use appropriate anti-static procedures when you handle the card. (The pages on "Safety Considerations" at the beginning of this manual describe the anti-static procedures that you should follow.) Failure to follow these procedures may result in damage to the card.

   c) Remove the extender card from its slot and insert the LLMUX card in its place.

   d) Connect the FWAs to the LLMUX card.

   e) Turn power ON.

The HP 2250 system is now ready to go.

25510

8.7 CALIBRATION

The HP 25510 analog output card (DAC card) should be calibrated any time that you change the operating mode (unipolar voltage, bipolar voltage, or unipolar current output) of a channel, or after every nine months of operation under normal conditions. After calibration, you can verify the overall operation of the card by performing the tests described in the HP 2250 Measurement and Control Processor Diagnostic and Verification Manual, part number 25595-90001.

The following paragraphs contain specific instructions for calibrating the DAC card.

8.7.1 EQUIPMENT REQUIRED

To calibrate the DAC card you need the following equipment:

1) HP 3466A digital multimeter

   OR

2) a) HP 3455A digital voltmeter

   and

   b) a .25W 100 ohm resistor

The multimeter is slightly easier to use.

The following paragraphs contain specific instructions for calibrating the DAC card.

8.7.1 EQUIPMENT REQUIRED

To calibrate the DAC card you need the following equipment:

1) HP 3466A digital multimeter

   OR

2) a) HP 3455A digital voltmeter

   and

   b) a .25W 100 ohm resistor

The multimeter is slightly easier to use.

8.7.2 PRELIMINARY PROCEDURE

1) Turn the power to the HP 2250 system OFF.

2) Remove the field wiring assemblies (FWAs) from the HP 25510A DAC card.

3) Remove the DAC card from its slot in the backplane and set the mode switches for each DAC channel to the desired mode of operation (unipolar voltage, bipolar voltage, or unipolar current output). The mode switches (one pair per channel) are located near the front edge of the card.

   Note that bipolar current output is not a legal option, and that such a switch setting will prevent the card from identifying itself following a power ON cycle.

4) Insert the card into its slot and turn power to the HP 2250 system ON. Make sure that the system passes self-test.

5) Allow the card to reach normal operating temperature. This warm-up period is generally 15 minutes, but it can be shorter if the card was at operating temperature before you turned off the system power. If power was off for 30 seconds or less you don't need to allow any extra warm-up time.

6) At the controller you are using (HP 1000, HP 9826, HP-85, etc.) issue the command

   ID(1,n)!

   to the HP 2250, where n is the number of function card slots in your HP 2250 system. (If you are using the MCX exerciser program, you can enter "CARDS".) This will cause the ID codes of the function cards in your system to be returned, and an ID code of 10 should be returned for the slot that contains the HP 25510A DAC card.

7) Since a voltmeter can not measure current directly, you will have to make special arrangements if you are using a voltmeter (rather than a multimeter) and if any of your channels is set for current output. This can be done easily using a .25W 100 ohm shunt resistor and Ohm's Law.

Before you make any current measurements, set your voltmeter to measure ohms and measure the value of the resistor. For this measurement, connect the resistor directly across the ohms input; that way you will avoid including the resistance of the test leads in your measurement. We will refer to the measured resistance value as "R" in the tables below.

When you measure the current output from a DAC channel, set the voltmeter to measure volts and connect the resistor directly across the volts input. Connect the test leads to the current output. The test leads and the resistor thus become part of the circuit, and the voltmeter makes a direct reading of the voltage drop across the shunt resistor. This voltage drop is equal to the product of ~~the measured resistance and the current output; that is, E =~~ IR. (Clever, eh?) The tables below indicate acceptable ranges for the voltages being measured.

8.7.3 VOLTAGE AND CURRENT ADJUSTMENTS

Each channel of the DAC card needs to be adjusted according to the output mode selected for that channel. A zero adjustment and a full scale adjustment are made for each channel. Do the following:

1) Make the zero adjustment:

a) Set up the multimeter/voltmeter to measure voltage or current, as is appropriate to the output mode of the channel you are calibrating. Select a range compatible with the values in table 8-2, below. Attach the test leads of the meter to the appropriate output points.

b) Using the exerciser program (MCX, for example) issue the appropriate command to the DAC card, as listed in table 8-2.

c) Adjust the zero potentiometer for the channel until the meter reading is in the range specified by the table.

Table 8-2. Zero Calibration Values

Mode	MCL Command	Meter Reading
UV	VO(slot,channel)0!	-.001 V to +.001 V
BV	VO(slot,channel)-10240!	-10.242 V to -10.238 V
C	CO(slot,channel)5!	.003 mA to .007 mA or .003*R mV to .007*R mV

UV = unipolar voltage BV = bipolar voltage C = unipolar current	slot = slot number of DAC card channel = channel being calibrated

R = resistance of shunt resistor (see item 7, above)

2) Make the full scale adjustment:

a) Make sure that the multimeter/voltmeter is set to a range compatible with the values in table 8-3, below.

b) Using the exerciser program, issue the appropriate command, as listed in table 8-3.

c) Adjust the gain potentiometer until the meter reading is in the range specified in the table.

Table 8-3. Full Scale Calibration Values

Mode	MCL Command	Meter Reading
UV	VO(slot,channel)10238!	+10.237 V to +10.238 V
BV	VO(slot,channel)10235!	+10.233 V to +10.237 V
C	CO(slot,channel)20475!	20.473 mA to 20.477 mA or 20.473*R mV to 20.477*R mV

UV = unipolar voltage
BV = bipolar voltage
C = unipolar current

slot = slot number of DAC card
channel = channel being calibrated

R = resistance of shunt resistor (see item 7, above).

3) Repeat steps 1 and 2 for each channel.

4) After all channels have been calibrated, use the exerciser program to issue commands to set outputs for all channels at normal levels.

5) Reconnect the field wiring and resume normal operation.