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FAA TECHNICAL CENTER LETTER REPORT

REMOTE MAINTENANCE MONITORING SYSTEM-CONCENTRATOR
PROGRESS REPORT

by

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INTRODUCTION

Purpose.

The purpose of this report is to discuss enhancements made to the Remote Maintenance Monitoring System (RMMS) concentrator.

Background.

As part of Task 9 of 9550-AAF-501-78-002, the FAA Technical Center has designed and developed an RMMS concentrator. The purpose of the concentrator is to collect, store, and display maintenance/performance data obtained from remote site monitors and also to send the collected data to a Maintenance Processor Subsystem (MPS). The concentrator consists of a communications subsystem and a data subsystem. The communications subsystem transfers data to and from remote site monitors via serial data channels. Data collected by the communications subsystem is transferred to the data subsystem. The data subsystem stores and displays the collected data and also sends the data to the MPS. Figure 1 is a block diagram of the concentrator.

The first version of the concentrator was completed in November, 1981. It was designed to communicate with up to eleven remote site monitors. This initial concentrator design is described in letter reports CT-81-100-4LR (communications subsystem) and CT-82-100-8LR (data subsystem). In addition, devices were built to simulate ten remote site monitors. These devices are described in letter report CT-82-100-20LR.

After completion of the first concentrator, several tests were conducted to verify that the concentrator performed as required. Following the conclusion of the tests, the number of concentrator channels to remote monitors was increased to 35 and other enhancements to the concentrator were added. In addition, a device was developed that could simulate up to 24 remote site monitors. Another device was developed that could simulate communications with an MPS.

This letter report will discuss the enhancements made to the concentrator, the 24-channel remote site simulator, the MPS simulator, and the system testing performed on the expanded concentrator.

DISCUSSION

In this section, five topics will be discussed:

1. Channel expansion and other enhancements to the communications subsystem;

2. Enhancements to the data subsystem;

3. The design of the 24-channel simulator;

4. The design of an MPS simulator;

5. Test procedures for checking out the concentrator.

The basic principles of operation of the concentrator and detailed explanations of the hardware/software design will not be discussed here, since they have already been discussed in letter reports CT-81-100-4LR and CT-82-100-8LR. This report will discuss only the changes made to the first version of the concentrator.

1. Communications Subsystem

The following additions/enhancements were made to the communications subsystem:

a. The number of remote site channels that can be serviced by the subsystem was expanded from 11 channels to 35 channels. (Although 35 channels are available, 34 channels were used in testing, because only 34 remote site simulator channels are available.);

b. The periodic poll interval to each remote site can be varied from 1 to 99 hours, in 1-hour increments (a similar capability was also added to the data subsystem);

c. The general poll rate can be varied between one and nine seconds, in 1-second increments;

d. Date and time entries can be made at the local terminal;

e. Time is also synchronized to the data subsystem time;

f. Periodic polls now transmit time to all the remote sites;

g. In addition to notifying the data subsystem of a loss of communications, the communications subsystem now also notifies the data subsystem when communications is re-established.

In order to accomplish these additions, three Central Data Corporation B1018 serial communications boards and an Intel Corporation SBC 300 memory multimodule were added to the subsystem. Each B1018 board contains eight serial data communications channels. The SBC 300 multimodule attaches directly to the SBC 86/12A computer board and adds an additional 32K of random access memory (RAM) to the subsystem. To reduce the physical size of the subsystem, all the boards were transferred from the Intel Corporation ICS-80 chassis to the smaller Intel Corporation SBC-660 chassis.

The subsystem enhancements increased the executable code size from 7.5K bytes to 8.5K bytes of programmable read only memory (PROM). Also, the data storage buffers were increased from about 20K of RAM to over 40K of RAM.

The communications subsystem block diagram is shown in figure 2. User operations available via the local terminal are shown in figure 3.

2. Data Subsystem

The following enhancements to the data subsystem were made.

a. The capability of instituting periodic polls (in intervals from 1 to 9 hours) independently, on any channel was added to the data subsystem;

b. Real time clock values are now sent to the communications subsystem as part of the periodic poll messages;

c. All data acquired by the data subsystem is sent to an MPS simulator.

d. In addition to displaying a loss of communications messages on the local terminal, a message is also displayed when communications are resumed. The time that communications are lost and the time communications are resumed are also displayed (see figure 4);

e. An alarm warning message is sent to the local terminal as soon as the first alarm block is received (see figure 5);

f. When a technician, at one remote site, requests the data from a second remote site, the data subsystem acquires the data from the second site (via the communications subsystem). The data subsystem formats the data and transmits it (again via the communications subsystem) to the requesting site. Figure 6 is an example in which a technician at remote site G requests DME data from remote site 2 by typing "2D" (D for DME data). The information supplied contains status information, pulse spacing and pulse count information, transmitter power output, etc.

No hardware changes were required to accommodate the above enhancements. However, the executable code increased from 13.5K bytes to almost 15K bytes and the data storage increased from 16K bytes to over 17K bytes. In the first data subsystem version, the executable code was loaded from the disk to RAM. In this version, the executable code resides in PROM to make more RAM available for expansion.

Figure 7 demonstrates the operations that can be performed via the data subsystem terminal keyboard.

3. Remote Site Monitor Simulator

To provide a means of testing the concentrator's communications capacity, a device that simulates 24 remote site monitors was developed. Added to the ten simulated channels already available, a total of 34 remote site channels can now be simulated.

Unlike the earlier simulators which used the Z-80 microprocessor, the 24-channel simulator uses the 8086 microprocessor. The device consists of the Intel SBC-86/12A computer board, and three 8-channel serial communications boards (B1018) from Central Data Corporation. The boards reside in an Intel ICS-80 multibus chassis. A portable CRT terminal from Applied Digital Data Systems (ADDS) is also used, however, any RS-232C compatible terminal is acceptable. A block diagram of the simulator is shown in figure 8.

Although this simulator uses different hardware, a different language (PLM-86), and has many more channels than the Z-80 based simulators, the principles of operation and software flowcharting are nearly identical to the Z-80 based simulators discussed in letter report CT-82-100-20LR. Therefore, a discussion of the operation and flowcharting will not be repeated here. Figure 9 demonstrates the operations that can be performed via the remote site simulator terminal keyboard.

4. Maintenance Processor Subsystem Simulator.

The MPS simulator was developed to demonstrate and test the data subsystem's ability to respond to a higher level processor's requests. No effort was made to make the simulator act like an MPS. It is simply a communication device designed to acquire data from and exchange messages with the data subsystem. It should be noted that the option also exists for an MPS to acquire data directly from the communications subsystem.

The MPS simulator is a Z-80 based device. It consists of an MCB computer board and a SIB serial communications board contained in an SCC-9 card cage. All these components are from Zilog. In addition, an RS-232C compatible terminal is required. The block diagram for the MPS simulator is shown in figure 10.

The principles of operation for the MPS simulator are as follows:

a. Under normal conditions, the simulator sends continuous general polls to the data subsystem every three seconds.

b. The data subsystem responds to the polls with an EOT (end of transmission) character, if the data subsystem has not received new data from the remote sites (this data is received via the communications subsystem);

c. If the data subsystem has received new data, it transmits it to the MPS simulator;

d. The MPS simulator receive routine performs error-checks on the incoming data. The MPS simulator transmit routine sends the appropriate ACK (acknowledgment) or NAK (negative acknowledgment) character to the data subsystem;

e. When a complete message is entered at the MPS simulator's local terminal, the message is sent to the data subsystem instead of the general poll;

f. The data subsystem sends the appropriate acknowledgment to the MPS simulator and prints the message on the data subsystem local terminal;

g. In a similar manner, messages can be sent from the data subsystem to the MPS simulator. However, the MPS simulator does not have the capability of displaying these messages or any of the data it receives.

5. System Testing

The configuration used to test the concentrator is shown in figure 11. Channel addresses begin with an ASCII "0" (equal to 30 hexadecimal) and end with an ASCII "S" (equal to 53 hexadecimal). The channel addresses are shown in table 1. Channel "3" was not used in these tests, but is operational. Most of the additions and enhancements made to the system were verified by making the appropriate keyboard entries at one of the local terminals, and then observing the results on the data subsystem local terminal and/or printer.

Since the MPS simulator was not designed to print received data, communications between the MPS simulator and the data subsystem was checked by inserting a Hewlett-Packard Model 1640A Serial Data Analyzer in the data link. The communications messages could then be verified on the data analyzer's CRT display.

Communications warning messages were checked by disconnecting one of the serial channels and observing a communications problem message displayed on the data subsystem terminal. The channel was then re-connected and a communications resumed message was displayed.

Once it was established that the concentrator was operating properly, the next step was to determine the concentrator's ability to handle unusually high communications loads.

To do this, the data rates on 32 remote channels were set to 1200 bits per second (bps). This is currently the highest data rate available in the concentrator software. The remaining two channels were set to 300 bps (these two simulators were programmed to operate only at 300 bps). The general polling rate was set to a 1-second interval.

Alarms were then initiated on all channels simultaneously. The information received at the data subsystem terminal and printer indicated that the concentrator successfully handled this severe and unusual load.

According to a study conducted as part of the concentrator work (letter report CT-81-100-9-LR) it is unlikely that a concentrator in the field will require as many as 34 channels. Also, the data rates will probably not be as high as those used in this test. It is also unlikely that a condition will ever exist in which as many as 34 channels are transmitting data simultaneously. For these reasons, it can be concluded that this concentrator design is fast enough to handle any task that is required.

SUMMARY

This report has described concentrator enhancements, additional simulator devices, and test procedures to check out the concentrator.

The main concentrator enhancements can be summarized as follows:

1. The number of data channels has been expanded from 11 to 35.

2. The communications subsystem and remote site simulator real time clocks are now synchronized to the data subsystem clock.

3. Alarm status and additional communications status information are now available at the data subsystem local terminal.

4. The data subsystem now sends remote site monitor data to an MPS simulator.

5. Flexibility has been added in the selection of periodic poll and general poll rates.

6. Formatting procedures have been added to the data subsystem to allow a technician at one remote site to receive formatted data from another remote site.

The 24-channel remote site simulator and the MPS simulator were developed to provide more comprehensive testing of the concentrator. Using these devices, tests were conducted and the test results indicated the following:

1. All hardware and software additions and enhancements were operating correctly.

2. The concentrator can handle communications and alarm conditions that are probably more severe than those that will actually be encountered in the field.

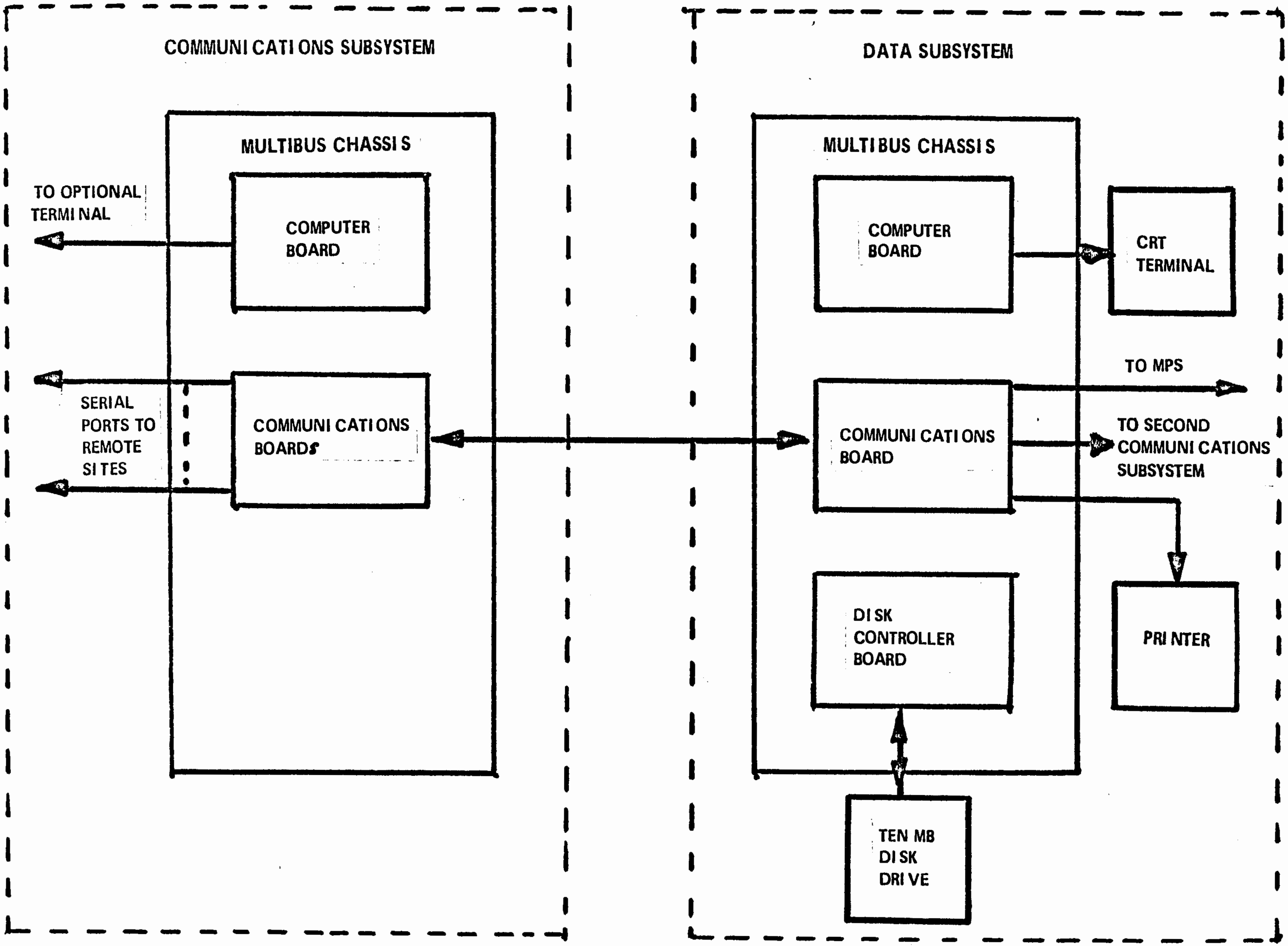

FIGURE 1 BASIC CONCENTRATOR CONFIGURATION

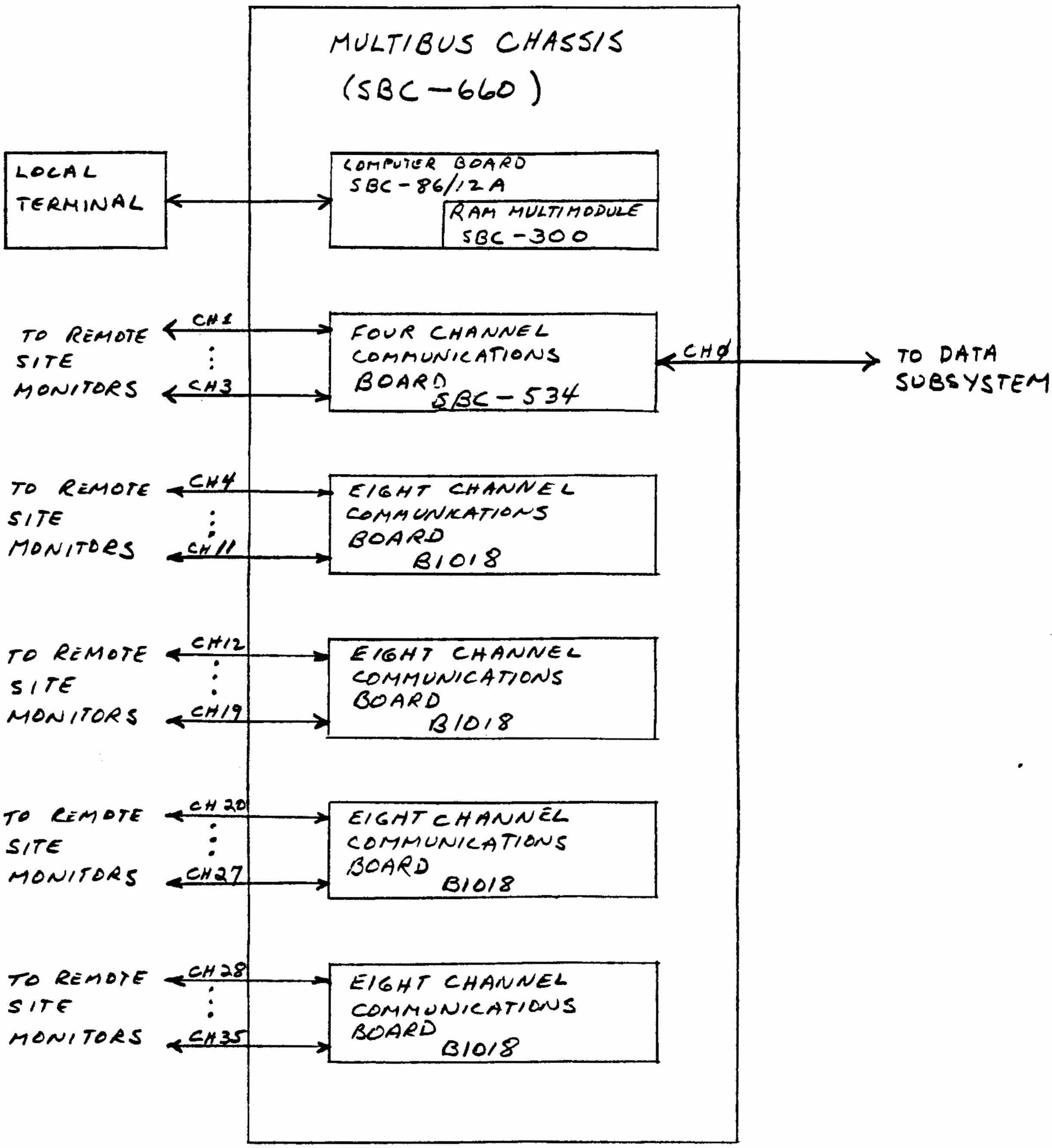

FIGURE 2 - COMMUNICATIONS SUBSYSTEM

```
H
TYPE ONE OF THE FOLLOWING:
B-SELECT BAUD RATE
C-SELECT NO. OF CHANNELS
D-SET DATE
G-SET GENERAL POLL TIMER
P-SET PERIODIC POLL TIMER
T-SET TIME


B WHICH CHANNEL?  7 TYPE 1 FOR 110, 2 FOR 300, 3 FOR 1200  2   OK


C ENTER LAST CHANNEL ADDRESS- S  OK


D ENTER DATE- 03/25/82.  OK


G ENTER GENERAL POLL TIMER IN SECONDS- 3  OK


P WHICH CHANNEL?  A ENTER PERIODIC POLL TIMER IN HOURS- 12.  OK


T ENTER TIME- 09:30:00.  OK
```

FIGURE 3 - COMMUNICATIONS SUBSYSTEM LOCAL TERMINAL COMMANDS
(USER ENTRIES ARE UNDERLINED)

COMMUNICATIONS PROBLEM ON CHANNEL- E 09:24:42

COMMUNICATIONS RESUMED ON CHANNEL- E 09:24:51

FIGURE 4 -COMMUNICATIONS MESSAGES ON DATA SUBSYSTEM LOCAL TERMINAL.

ALARM ON CHANNEL- C

ALARM ON CHANNEL- I

FIGURE 5 - ALARM MESSAGES ON DATA SUBSYSTEM LOCAL TERMINAL.

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B WHICH CHANNEL? G
ENTER TWO DIGIT DESTINATION ADDRESS- 2D  OK


FAC IDENT- 2

TIME: 09:30:29
DME:
LATEST
MON A /SYS DLY/PWR OUT/RPY EFF/PUL SPC/PUL CNT/ IDENT /BY-PASS/
         OFF      OFF      OFF      OFF      OFF      OFF      OFF
MON B /SYS DLY/PWR OUT/RPY EFF/PUL SPC/PUL CNT/ IDENT /BY-PASS/
         OFF      OFF      OFF      OFF      OFF      OFF      OFF
CONTRL/SYS DLY/PWR OUT/RPY EFF/PUL SPC/PUL CNT/ IDENT /
         OFF      OFF      OFF      OFF      OFF      OFF
CONTRL/  TX1   /  TX2   / ANT 1 / ANT 2 /BY-PASS/SHUTDWN/ ALARM /
          ON      OFF       ON      OFF      OFF      OFF      OFF
MON A /SYS DLY/PUL WTH/RPY EFF/PUL SPC/PUL CNT/ IDENT /
        49.40    3.501   65.87   12.00    2096.    1350.
MON B /SYS DLY/PUL WTH/RPY EFF/PUL SPC/PUL CNT/ IDENT /
        49.28    3.493   68.00   12.11    2095.    1350.
POWER /PK TX1 /PK TX2 /
        1000.    .0000
```

FIGURE 6 - REMOTE SITE G REQUESTS AND RECEIVES DME DATA FROM REMOTE SITE 2 VIA THE DATA SUBSYSTEM OF THE CONCENTRATOR. (USER ENTRIES ARE UNDERLINED)

```
TYPE H FOR HELP


H
TYPE ONE OF THE FOLLOWING:
B-TO POLL A REMOTE SITE
P-TO CREATE A PERIODIC POLL
S-TO SEND A MESSAGE TO A REMOTE SITE
T-TO ENTER TIME
CONTROL/D-TO ABORT ANY OPERATION


B ENTER ADDRESS- 2D  OK


P ENTER ADDRESS- 5
ENTER POLLING INTERVAL IN HOURS- 8  OK


S
ENTER THE DESTINATION ADDRESS 7 ENTER MESSAGE - TYPE CONTROL/C TO TERMINATE
This is a message from the concentrator to remote site #7.
  OK


T
ENTER TIME- 08:30:00  OK
```

FIGURE 7 - DATA SUBSYSTEM LOCAL TERMINAL COMMANDS
(USER ENTRIES ARE UNDERLINED)

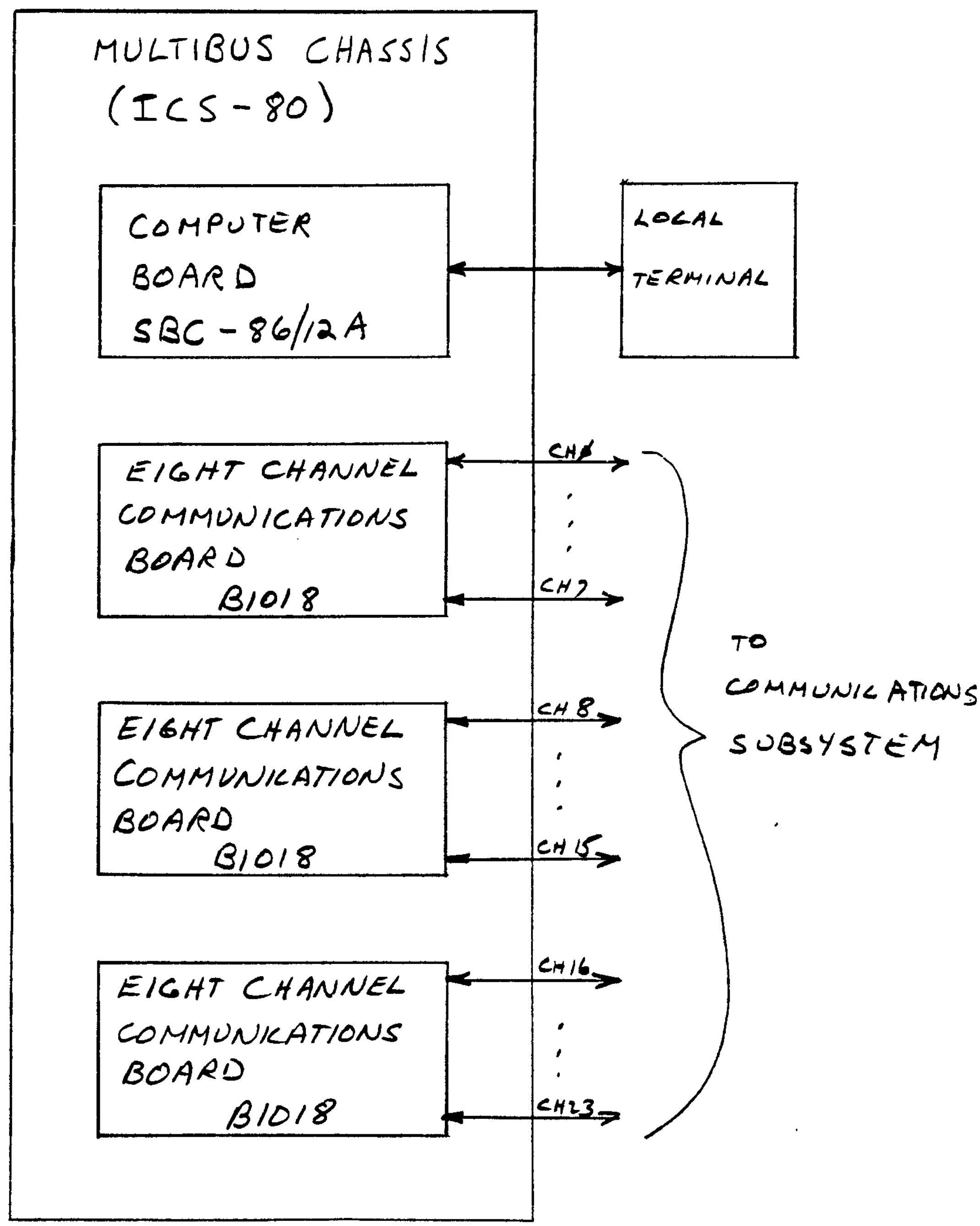

FIGURE 8- TWENTY-FOUR CHANNEL REMOTE SITE MONITOR SIMULATOR

```
H
TYPE ONE OF THE FOLLOWING:
A-TO CREATE AN ALARM
B-TO REQUEST DATA
D-TO ENTER THE DATE
R-TO CHANGE BAUD RATES
S-TO SEND A MESSAGE
T-TO ENTER TIME


A WHICH CHANNEL? A   OK


B WHICH CHANNEL? C
ENTER TWO DIGIT DESTINATION ADDRESS- 50   OK


FAC IDENT- 5

TIME: 08:59:12
DATE: 03/25/82
INNER MARKER
LATEST
/   MAIN / STDBY /   OFF   /ABN MON/ ABN PE/   PERF /
    ON      OFF      OFF      OFF      OFF      OFF


D ENTER DATE- 03/25/82   OK


R WHICH CHANNEL? E TYPE 1 FOR 110, 2 FOR 300, 3 FOR 1200  2  OK


S WHICH CHANNEL? F
ENTER DESTINATION ADDRESS- 4
ENTER MESSAGE- TYPE CONTROL/C WHEN FINISHED
This is a message from remote site F to remote site 4.
  OK


T ENTER TIME- 09:00:00   OK
```

FIGURE 9- REMOTE SITE SIMULATOR LOCAL TERMINAL COMMANDS
(USER ENTRIES ARE UNDERLINED)

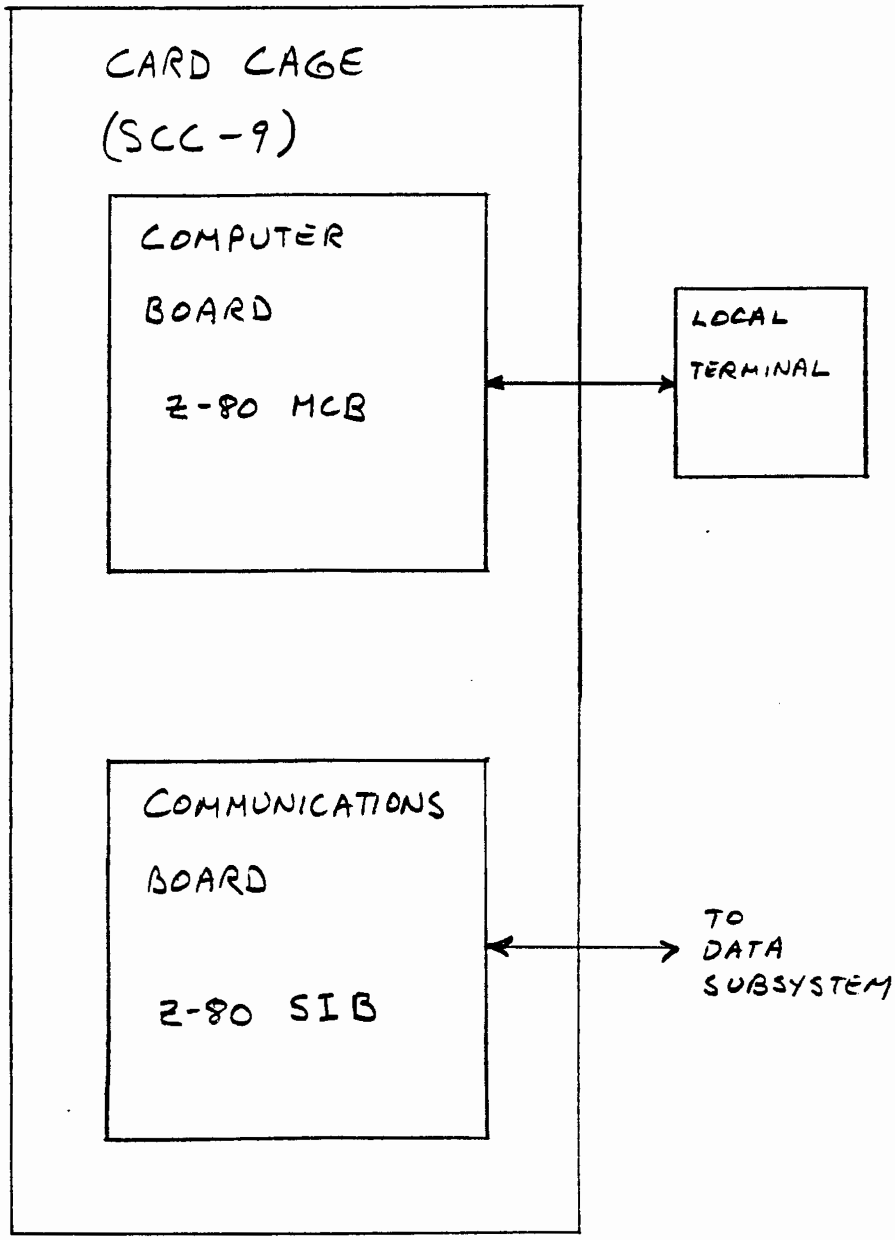

FIGURE 10 - MPS SIMULATOR

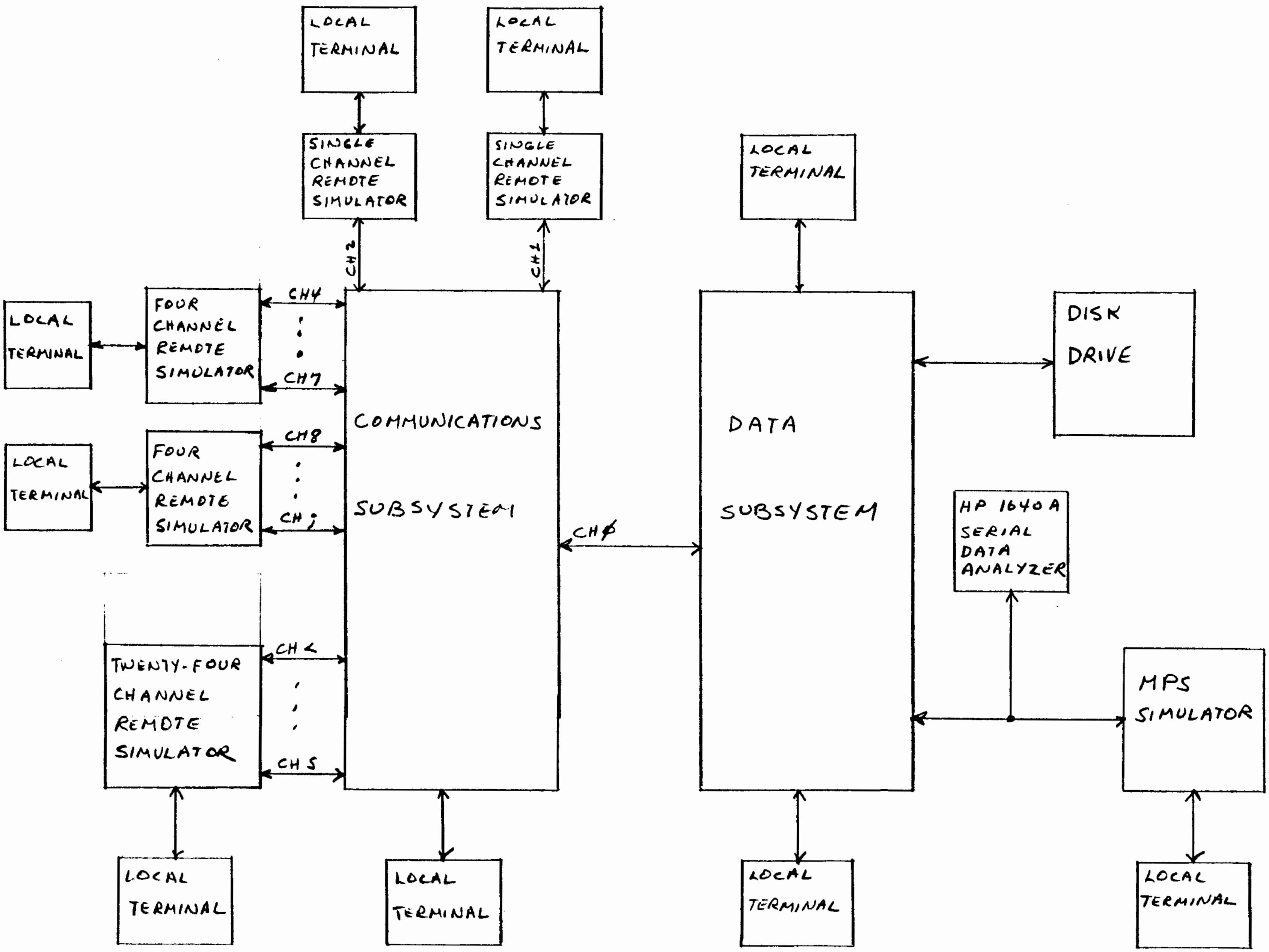

FIGURE 11 - CONCENTRATOR TEST CONFIGURATION

TABLE 1

Remote Site Channel Addresses

Channel	ASCII Identification	Hexadecimal Value
0 (data subsystem)	0	30
1	1	31
2	2	32
3	3	33
4	4	34
5	5	35
6	6	36
7	7	37
8	8	38
9	9	39
10	:	3A
11	;	3B
12	<	3C
13	=	3D
14	>	3E
15	?	3F
16	@	40
17	A	41
18	B	42
19	C	43
20	D	44
21	E	45
22	F	46
23	G	47
24	H	48
25	I	49
26	J	4A
27	K	4B
28	L	4C
29	M	4D
30	N	4E
31	O	4F
32	P	50
33	Q	51
34	R	52
35	S	53