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ARMS LCU SOFTWARE TEST

LETTER OF FINDINGS

Richard VanSuetendael
Andrew Jeffery
Julie Riches

February 5, 1990

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1.0 INTRODUCTION

This report presents the results of ACN-230 testing performed on the Airport Remote Monitoring System (ARMS) Link Control Unit (LCU), at the Federal Aviation Administration (FAA) Technical Center. Previously conducted ARMS testing by ACN-230 at Red Bird, TX, Lafayette, LA and at Columbia, MO, had revealed problems with the LCU. The FAA Technical Center obtained an LCU from the FAA depot in Oklahoma City, OK, and testing was performed from October 1989 through January 1990. Two previously observed problems were the main focus of these tests. They included an inappropriate and excessive number of retries and errors during link level polling, and the loss of ARMS control during polling of stored alarms. For these tests, ACN-230 utilized their Maintenance Processor Subsystem (MPS) Testbed running TESTCOM software, Interim Monitor and Control Software (IMCS) and ACD-350 Synchronous MPS and RMS Communication Simulators.

2.0 PURPOSE

Testing of the ARMS LCU was conducted at the FAA Technical Center to analyze link errors, optimize configuration parameters to improve or eliminate MPS/LCU polling errors, and provide information needed to resolve these problems.

3.0 TEST PARTICIPANTS

Testing participants included:

- Richard VanSuetendael	ACN-230
- Ray Haines	ACN-230/CTA
- Andy Jeffery	ACN-230/CTA
- Julie Riches	ACN-230/CTA

4.0 TEST CONFIGURATIONS

Three test configurations were used to test LCU communications. Configuration #1 (Figure 1) connected the LCU to the MPS or MPS Simulator through Paradyne modems. Configuration #2 (Figure 2) was the same as Configuration #1, with the addition of an RMS Simulator connected to the LCU. Configuration #2 most closely resembles the field configuration. Configuration #3 (Figure 3) eliminates the modems and connects the MPS Simulator and RMS Simulator directly via null modem cables. Unless otherwise indicated, the LCU was configured with the "as delivered" system parameters. A list of test equipment, LCU PROMs and the "as delivered" parameters are presented in Appendix A.

CONFIGURATION #1
MPS/LCU WITH MODEMS

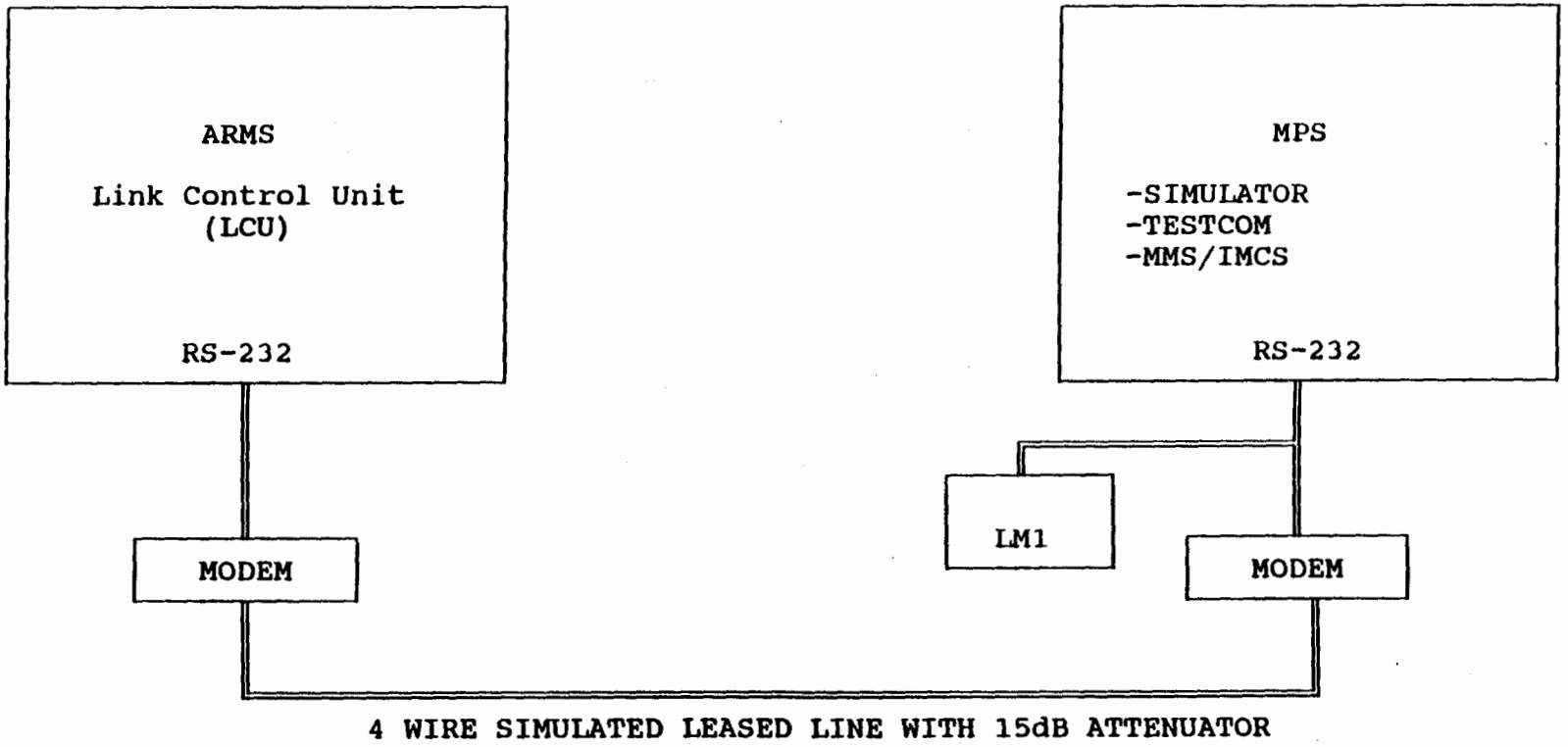


FIGURE 1

CONFIGURATION #2
MPS/LCU WITH MODEMS AND RMS SIMULATOR

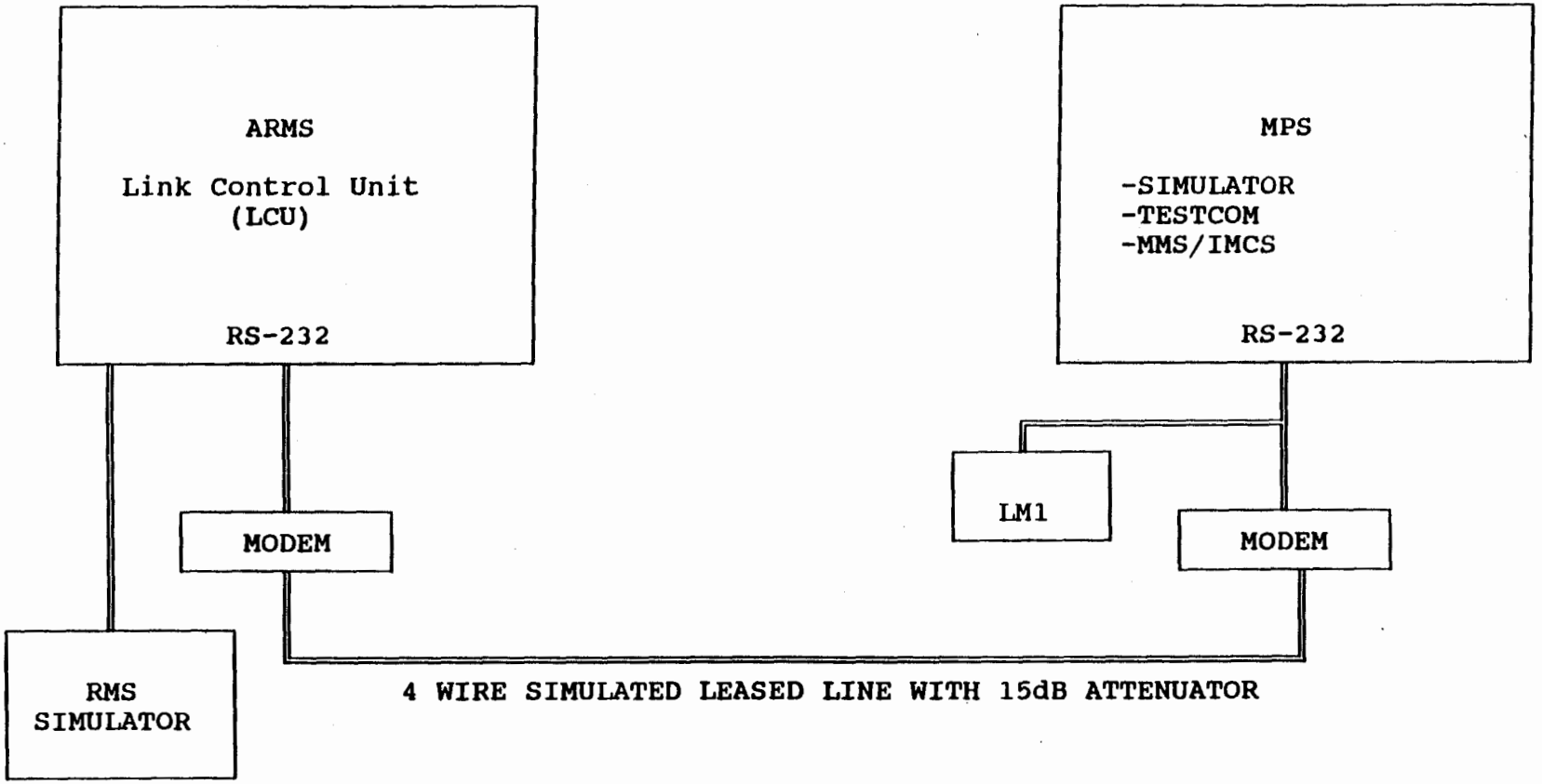


FIGURE 2

CONFIGURATION #3
MPS SIMULATOR/LCU DIRECT CONNECTION

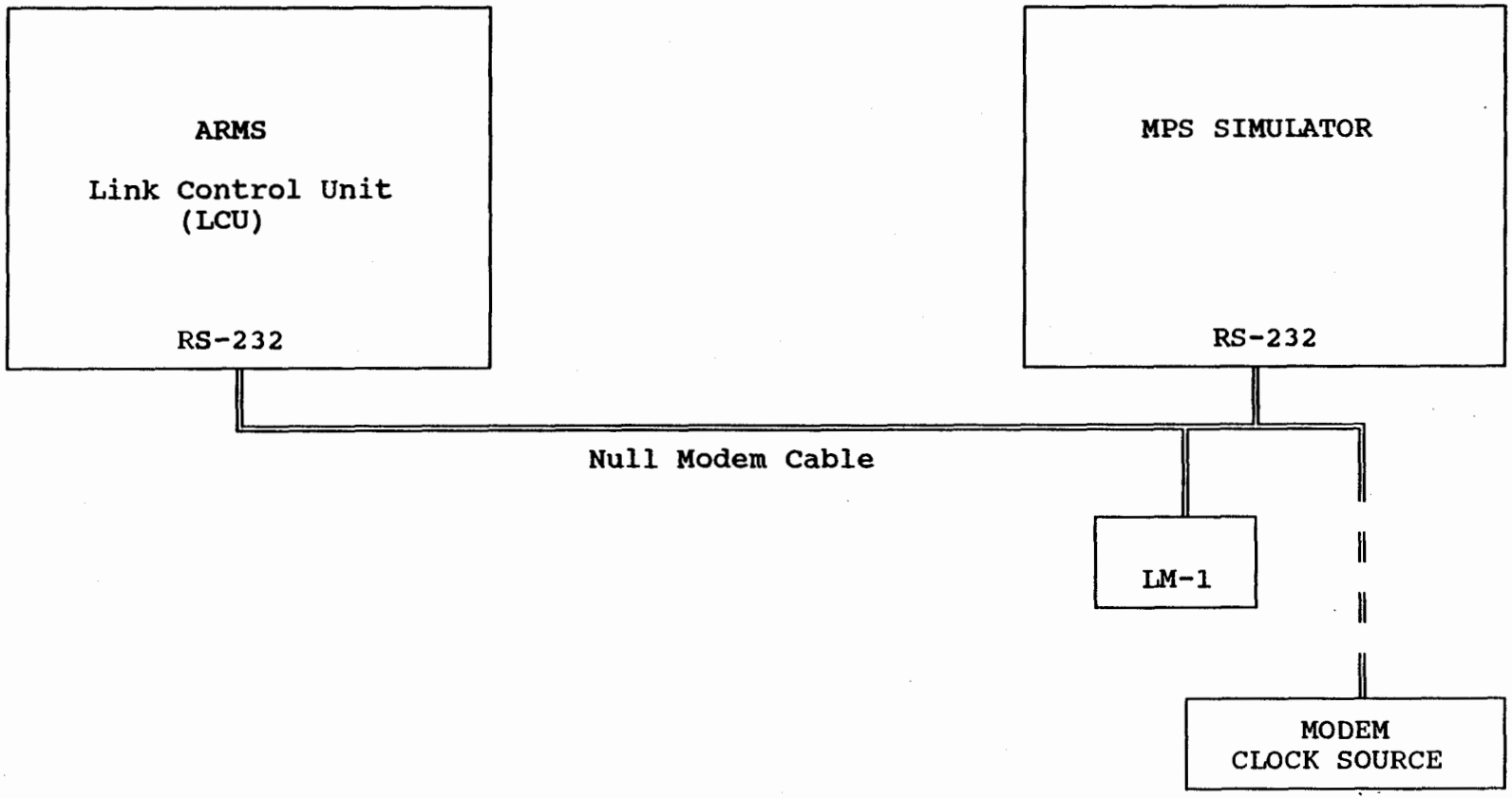


FIGURE 3

5.0 DISCUSSION AND RESULTS

Testing included monitoring of link level communications between the MPS or MPS simulator and LCU during continuous polling, while executing commands, and while priority messages/alarms were polled from the LCU buffer. Test results are discussed in this section. Graphs are presented with each discussion for comparison of results. Data sheets are presented in Appendix B for reference. Tests involving link level communication commands and polling of the LCU message buffer were observed and documented.

5.1 Continuous Polling

Configurations #1, #2 and #3 were each used to test the effect of LCU, Modem and MPS configuration parameters on link level continuous polling. For this series of tests, parameters such as clock sources, timing delays, and polling rates were varied and the resulting retries/errors were recorded. Typically, data was collected during 15-20 minute polling periods to obtain representative retry/error rate averages. No priority or command messages were found on the data link during these "steady state" tests. Four types of frame errors were encountered. There were Frame Rejects, Invalid Control Field, Exceed Maximum Frame Length, or Cyclic Redundancy Check (CRC) errors. The average number of polls per retry or frame error was calculated for each test configuration.

5.1.1 Clock Configuration Tests

Configuration #1 (Figure 1) was used during the Clock Configuration Tests to test the effect of different clock configurations on the MPS-LCU data link. The LCU and modem clock sources were varied and tested using the following settings:

	LCU Clock	LCU Modem Clock	MPS Modem Clock
A.	Internal	Internal	Internal
B.	Internal	External	Receive
C.	External	Internal	Receive

The MPS simulator was used with a 2 second polling rate. The LCU delay before sending any responses to the MPS was set "as delivered" to 20 x 10 millisecond (ms) units or 0.2 seconds. These two parameters were held constant throughout all clock configuration tests. Figure 4 graphically presents the results of these tests.

Clock Configuration Test

Average # of Polls per Retry

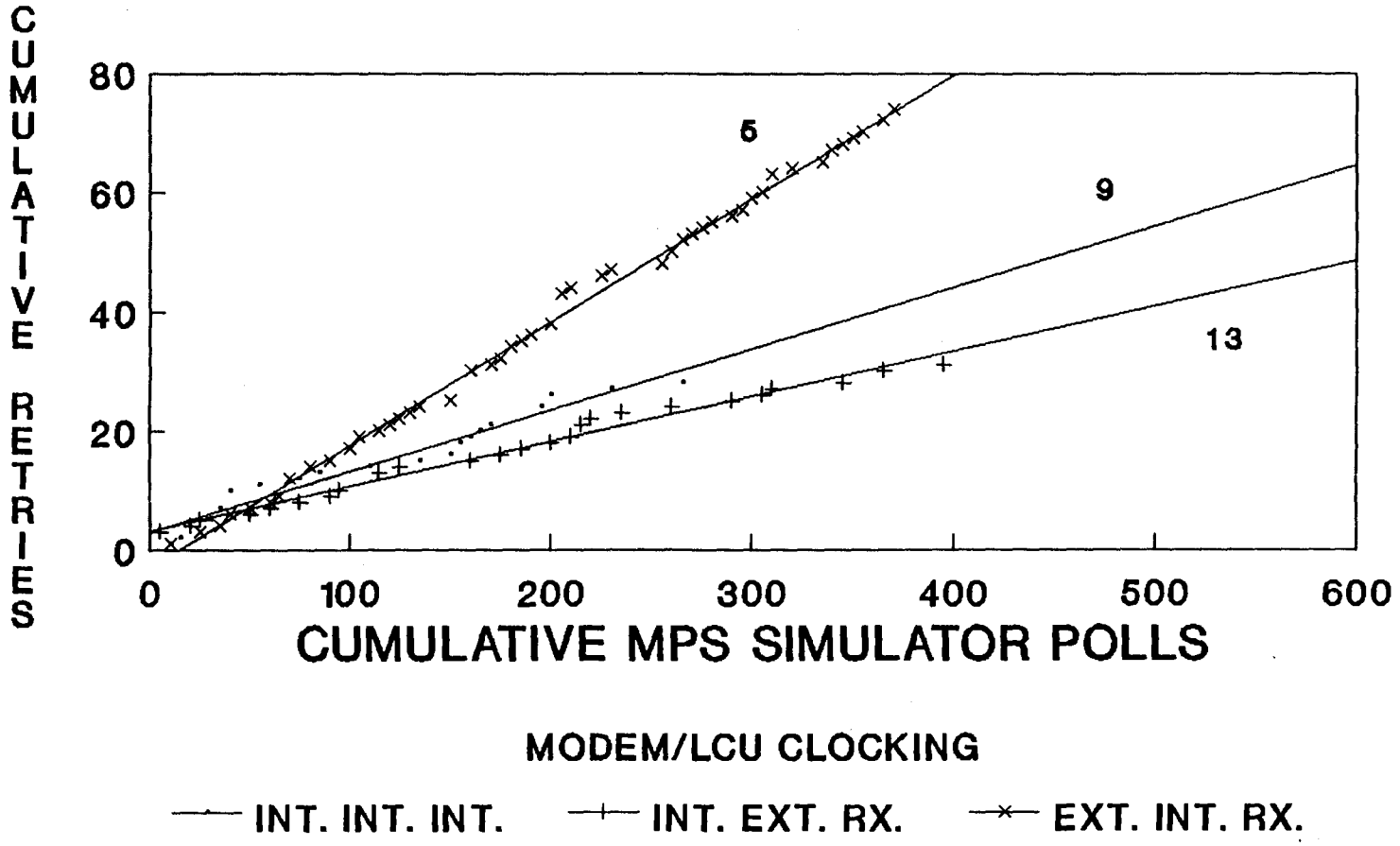


Figure 4

The results indicated that the worst clock configuration was the LCU configured for external clock source, the LCU modem configured with internal clock source, and the MPS modem utilizing the receive line clock source. This configuration averaged only five (5) successful polls before a retry or error occurred.

The best clock configuration averaged thirteen (13) successful polls per retry or error. This configuration utilized the internal LCU clock source, the external LCU modem clock source and the MPS modem configured to the receive line clock source. The data indicates that the LCU performs best with its own internal clock source.

To further investigate the clock source and error rate relationships, the LCU was tested using configuration #3 (Figure 3). The LCU was first tested while configured with the LCU internal clock and then tested with an external clock source. The modems were eliminated from the configuration to observe direct connect polling. While operating on its internal clock, the LCU and MPS simulator did not experience any retries or errors during the 15 minute test period. In the LCU external clock configuration, many retries and CRC errors were observed. Errors and retries averaged one every two or three polls.

The Columbia ARMS LCU was configured for an external clock source during the test in August 1989 (Letter of Findings, September 1989). Those retry and error rates were very similar to the rates observed in these tests.

An important observation was made while attempting to configure the LCU clock source. Although the LCU terminal displayed a menu to change the clocking from internal to external, it was discovered that Jumper (J7) on the CPU Circuit Board also had to be changed in order to configure the LCU for external clocking.

The LCU and modem clocks were compared on an oscilloscope for similarity. Clock traces revealed that the frequencies were 2400 HZ. The voltage level on the LCU clock was 2.125 volts (max) and was slightly higher than the modem clock by 1 volt. These two clocks had similar characteristics. It could not be determined if a phase difference existed between the clocks. Figure 5 presents the LCU and modem clock comparison.

LCU AND PARADYNE LSI 24C MODEM

TRANSMIT CLOCK COMPARISON

LCU TRACE

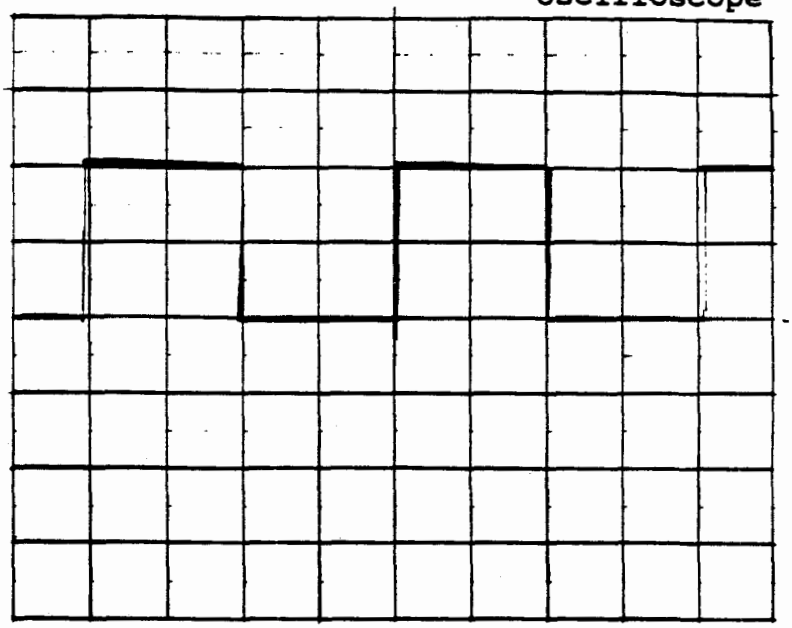
Oscilloscope

2.125 volts (max)

Period = 0.42 msec

Frequency = 2400 Hz

1 volt/div



0.1 msec/div

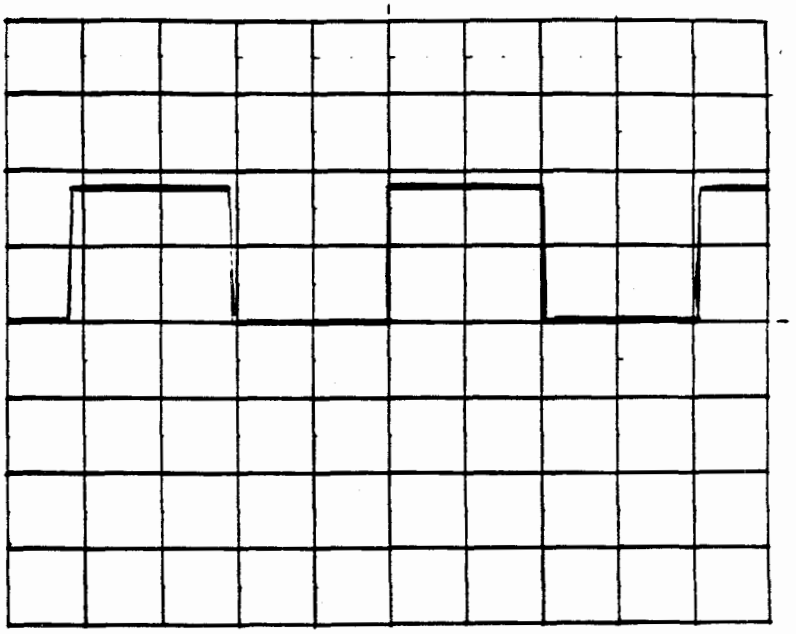
MODEM TRACE

1.625 volts (max)

Period = 0.42 msec

Frequency = 2400 Hz

1 volt/div



0.1 msec/div

Figure 5

5.1.2 MPS Polling Rate Tests

Configuration #1 (Figure 1) was used during the MPS Polling Rate Tests to test the effect of different MPS polling rates on the data link retries/errors. Tests were conducted using the MPS simulator, IMCS and TESTCOM on the MPS testbed at 1, 2, and 4 second polling intervals while the LCU delay before sending any responses to MPS was held constant at 20 x 10 ms units. The optimum clock configuration B (Section 5.1.1) was used for these tests. Results from these tests are presented in Figures 6 and 7. For these tests, the average number of polls per retry/error did not exhibit any trends. The highest average number of sequential polls without a retry was forty-nine (49). This was obtained with TESTCOM running at a 1 second polling rate. The worst retry rate was polling at 1 second intervals with the MPS simulator, which resulted with a retry every fifteen (15) polls.

5.1.3 LCU Response Delay Tests

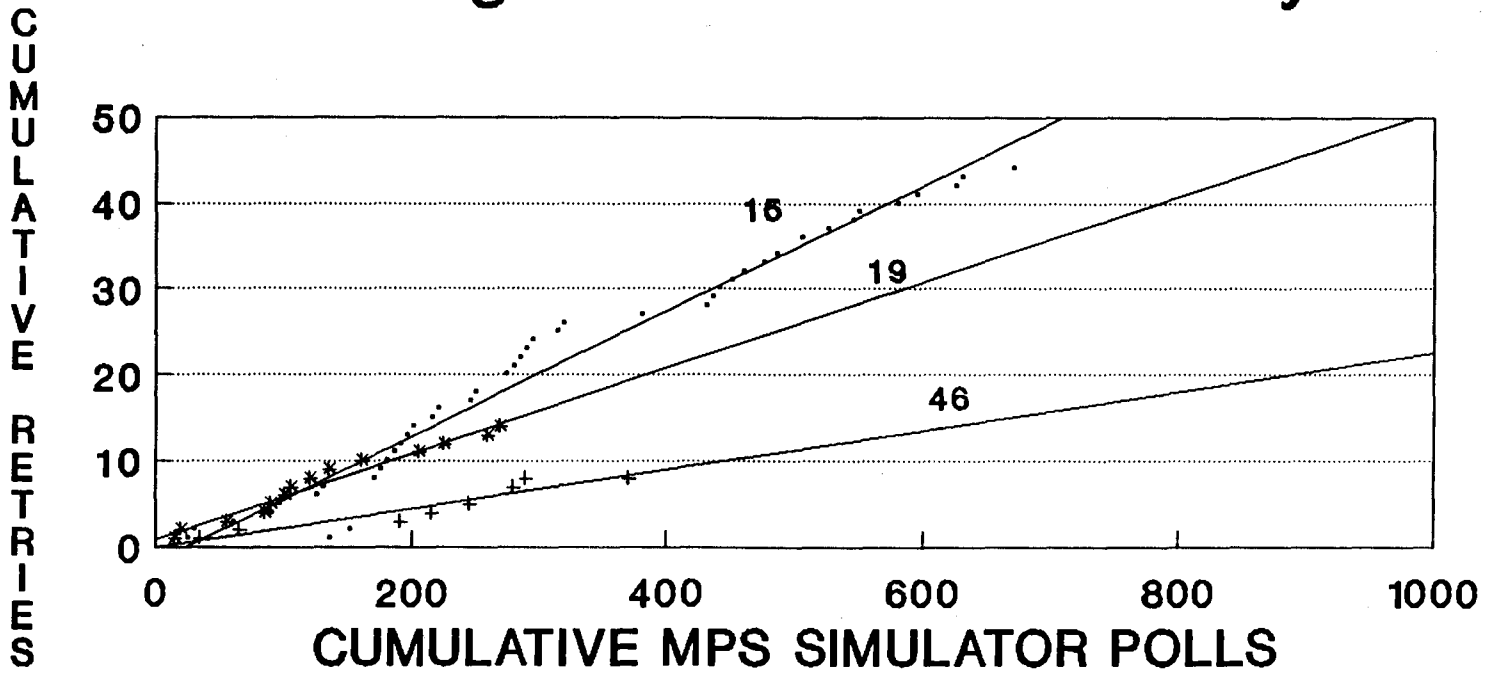
Configuration #1 (Figure 1) was used to test the effect of altering the delay before sending responses to MPS. LCU response delay times of 1 x 10 msec units (0.01 sec), 20 x 10 msec units (0.2 sec), and 60 x 10 msec units (0.6 sec) were tested. For each of these tests, the MPS polling rate was held constant at 2 seconds. Results of these tests are presented in Figures 8, 9 and 10. The MPS simulator results range from twelve (12) polls/retry at 1 x 10 msec unit, to forty-six (46) polls/retry at 20 x 10 msec units. TESTCOM results range from twenty seven (27) polls/retry at 1 x 10 msec unit, to eighty-two (82) polls/retry at 60 x 10 msec units. For IMCS polls, results range from nineteen (19) polls/retry at 1 x 10 msec unit, to twenty-four (24) polls/retry at 20 x 10 msec units. All three test series indicate that there is a greater retry rate at the 1 x 10 msec delay configuration. Table 1 presents this comparison.

TABLE 1: LCU RESPONSE DELAY COMPARISON

MPS device	#10 ms Delay Units	#Polls/Retry
MPS Simulator	1	12
	20	46
	60	22
TESTCOM	1	27
	20	49
	60	82
IMCS	1	19
	20	24
	60	21

MPS Polling Rate Test

Average # of Polls Per Retry

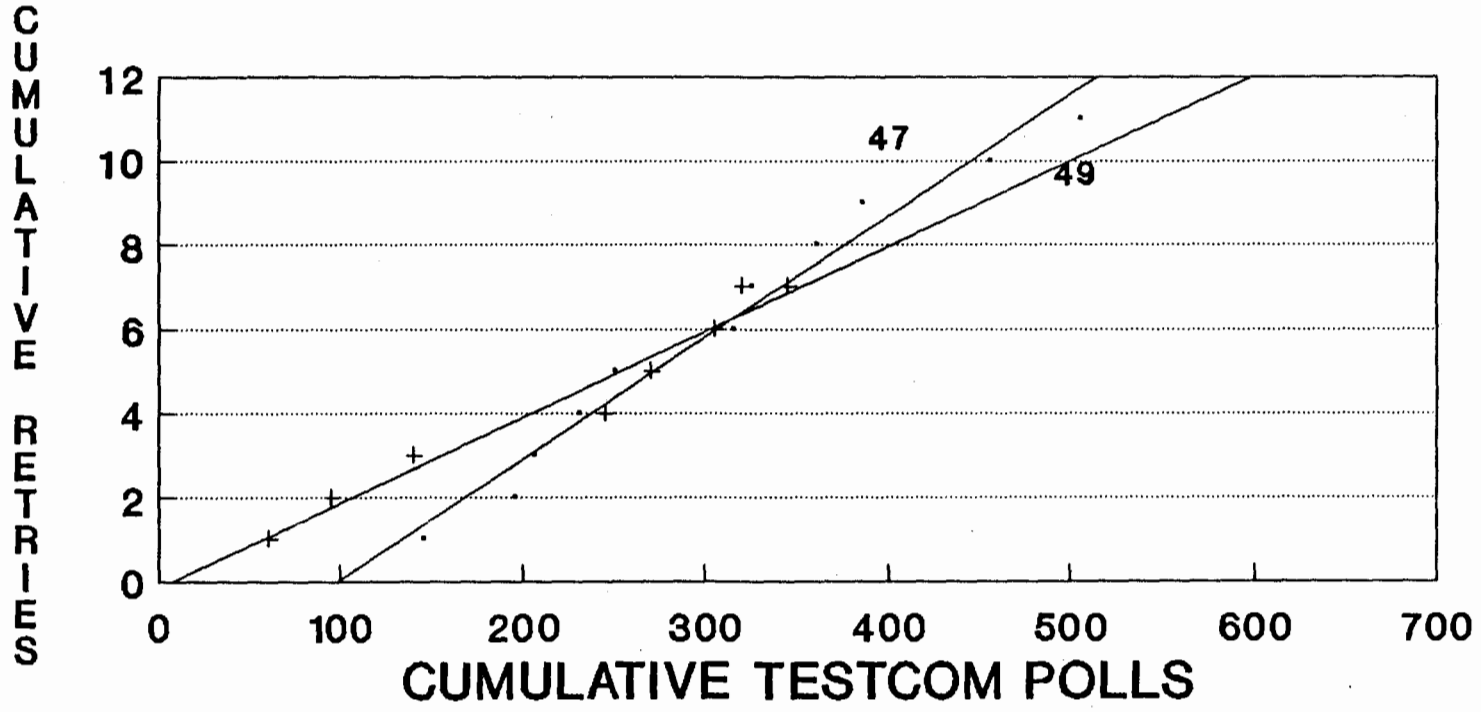


Constant LCU Delay/Varying Polling Rate

Figure 6

MPS Polling Rate Test

Average # of Polls Per Retry

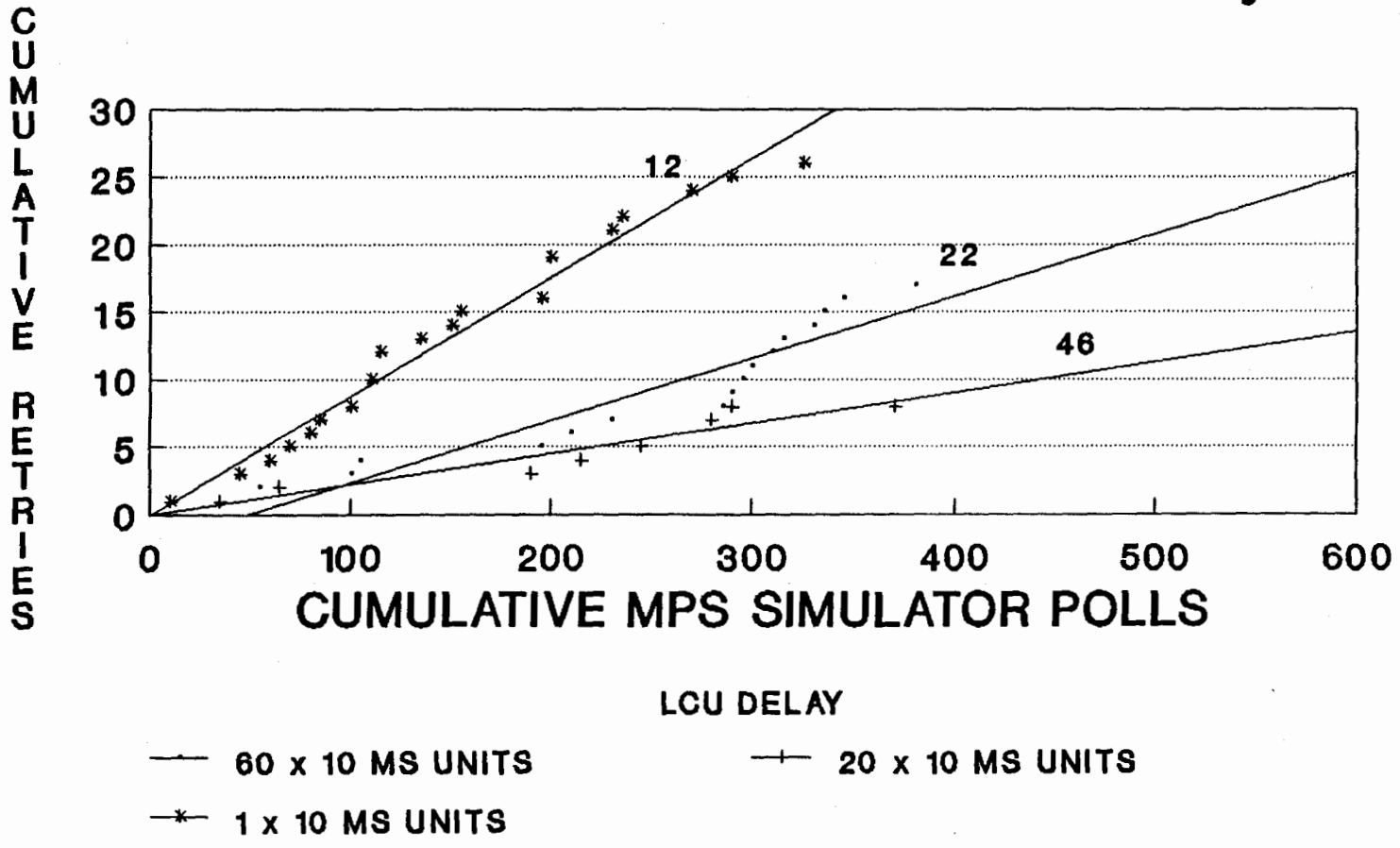


Constant LCU Delay/Varying Polling Rate

Figure 7

LCU Response Delay Test

AVERAGE # of Polls Per Retry

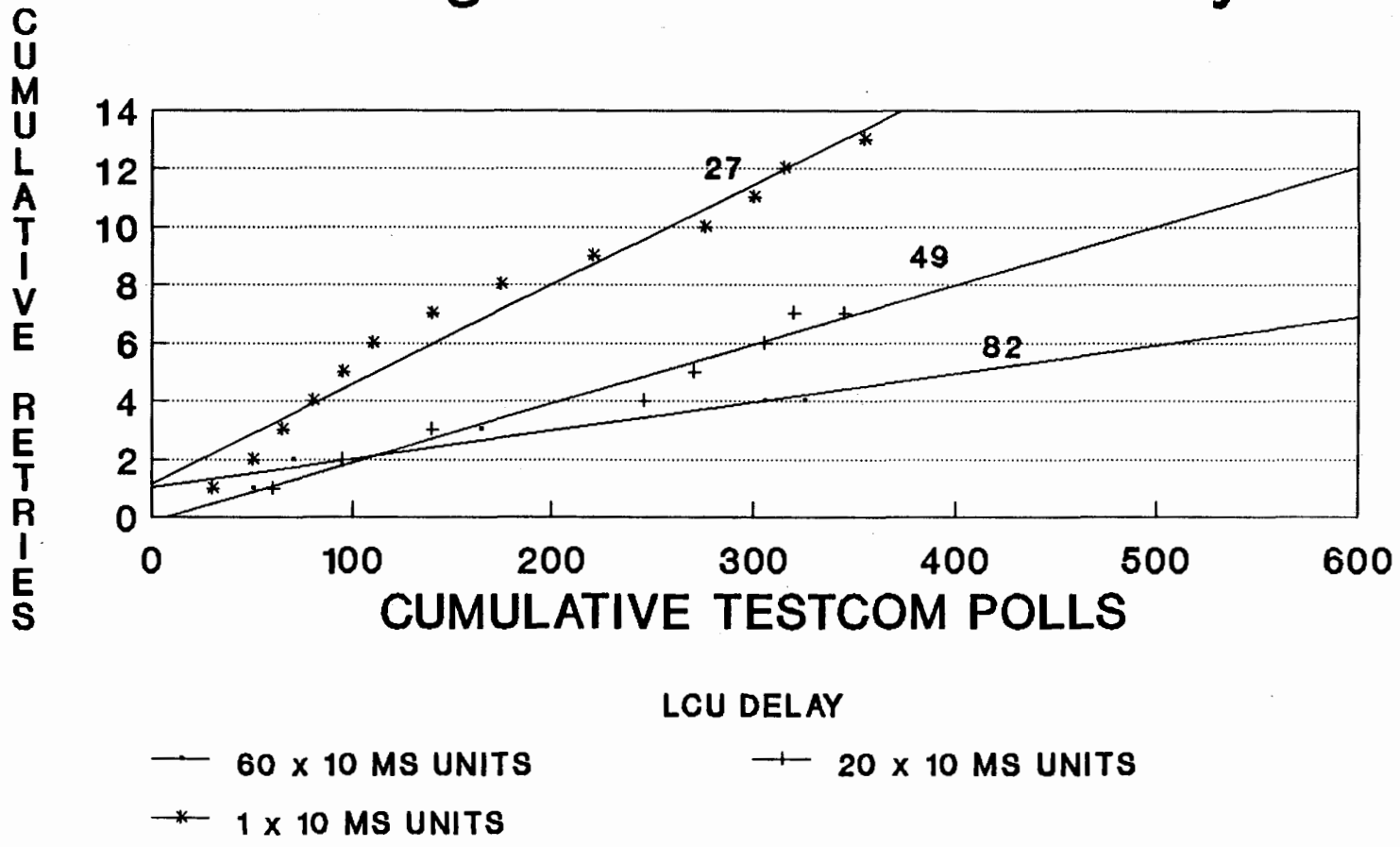


Constant Polling Rate/Varying LCU Delay

Figure 8

LCU Response Delay Test

Average # of Polls Per Retry

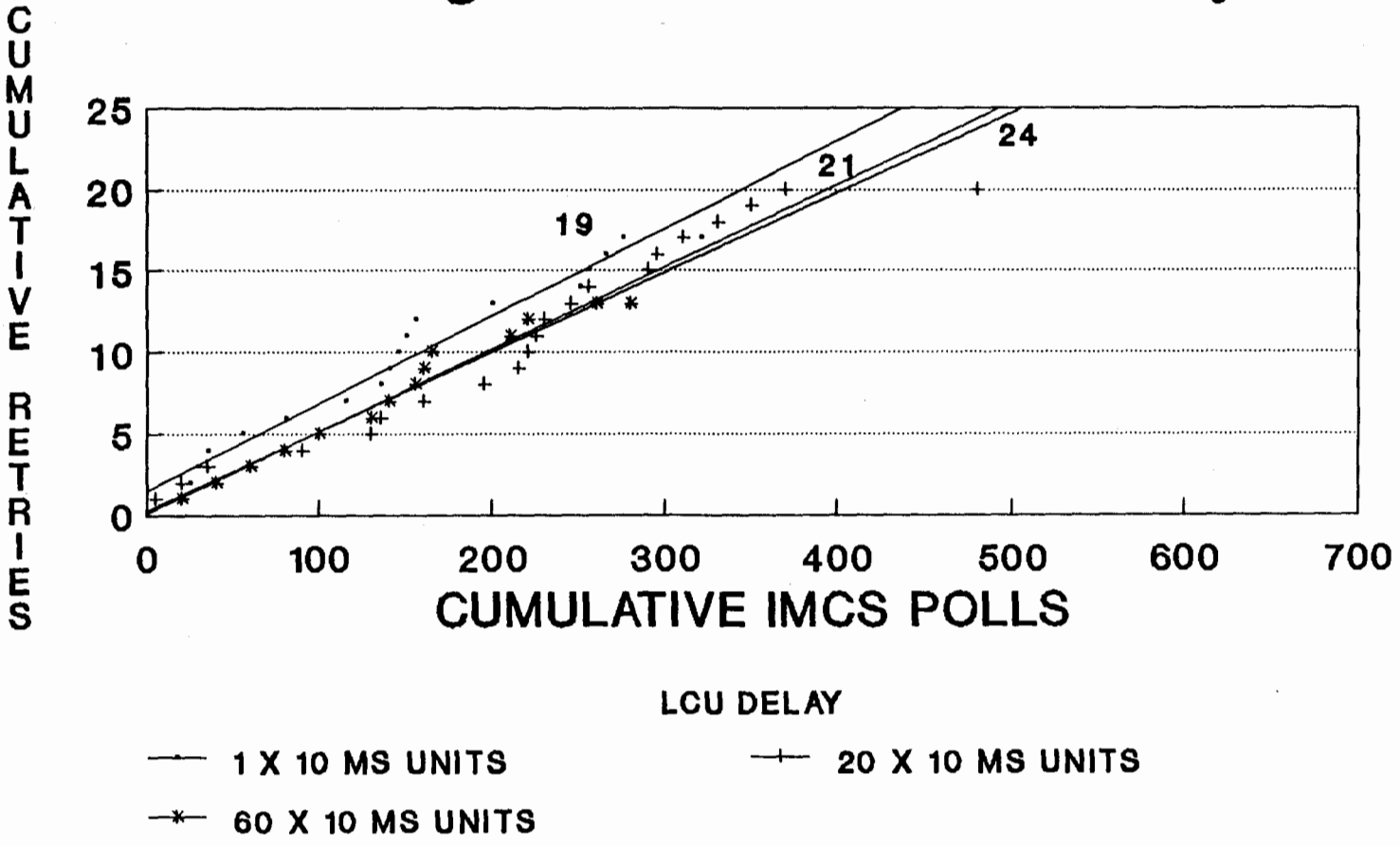


Constant Polling Rate/Varying LCU Delay

Figure 9

LCU Response Delay Test

Average # of Polls Per Retry



Constant Polling Rate/Varying LCU Delay

Figure 10

5.1.4 Optimum Configuration Parameters

Based on the clock source, MPS polling rate, and LCU response delay tests, an optimum test configuration was established to perform the buffer dump and link level command test. The optimum parameters used for these tests included:

Clock Sources:	Internal LCU Clock External LCU Modem Clock Receive Line MPS Modem Clock
MPS Polling Rate:	2 seconds
LCU Response Delay to MPS:	20 x 10 millisecond units

The basic problem encountered during continuous, normal polling (no priority messages) was that randomly, the LCU would not respond to an MPS poll. An MPS retry would follow after the 4 second retry interval, and the LCU would usually respond to the retry with a Receive Ready. Occasionally a second MPS retry would occur and the LCU would reply with a Receive Ready. Rarely did the LCU require three MPS retries.

Another problem encountered was the failure of the LCU to respond to a Continuous Poll when the MPS polled immediately after receiving a response from the LCU. This poll from MPS occurred before the specified polling rate interval. The LM-1 data revealed that the LCU did not respond to the MPSs quick poll and therefore the MPS reattempted to poll the LCU (after the 4 second retry interval). Upon receipt of the second poll, the LCU was able to respond.

5.2 LCU-MPS BUFFER DUMP TESTS (MPS Polling of Stored Messages)

Configurations #2 and #3 were each used to observe the results of LCU buffer dumps. The LCU was configured "as delivered" from the FAA depot, and the optimum clock sources were used from the previous test.

During this sequence of tests, continuous alarms were generated from the RMS simulator for 15 minutes. During this 15 minute interval, the LCU was not being polled by the MPS. This procedure filled the LCU buffer with alarms. When polling was started between the MPS and the LCU, the LCU buffer transmitted all stored alarms until it was empty. During the buffer dumps, reset commands were attempted from IMCS, TESTCOM and MPS simulator to clear the LCU buffer.

Previous ARMS testing at Columbia, MO revealed that commands were not usually executed by the LCU during a buffer dump. These tests recreated the scenario to study the problem further.

5.2.1 LCU-MPS Buffer Dump Using IMCS Test

Configuration #2 (Figure 2) was used to test whether or not an IMCS reset command could be sent to the LCU during an LCU buffer dump. The LCU buffer was filled with alarms and IMCS polling was initiated. During this procedure, the MPS-LCU communications line was monitored with the LM-1 protocol analyzer.

Prior to each reset command, a Receive Not Ready (RNR) was sent by the MPS. The LCU responded to the RNR by returning a Receive Ready (RR). In the next poll, the MPS sent the reset command. The LCU did not respond to this command. The MPS waited the retry period before attempting the command again. This sequence of events continued until the reset command timed out at MPS. The command was reattempted several times during the LCU alarm buffer dump, but each time the same results were observed. After the buffer dump was completed, the LCU accepted and executed the reset command.

5.2.2 LCU-MPS Buffer Dump Using TESTCOM Test

Configuration #2 (Figure 2) was used to test if a TESTCOM reset command could be sent to the LCU during an LCU buffer dump. The procedures for this test were the same as for the IMCS tests. The reset command was not executed by the LCU during the buffer dump.

5.2.3 LCU-MPS Buffer Dump Using MPS Simulator Test

Configuration #3 (Figure 3) was used to perform the LCU buffer dump tests using an MPS simulator. The LCU buffer was filled using the same procedure which was used during the IMCS and TESTCOM tests. When a reset command was sent from the MPS simulator, the command was immediately executed at the LCU. The reset command would clear the LCU buffer of alarms and after the 1 minute LCU diagnostics cycle, the LCU would return to normal operation. This test was repeated and the same results were observed.

There is a significant difference between sending commands from the MPS simulator (Version 4.00, March 1988) and sending commands from TESTCOM or IMCS. The MPS simulator polling cycle is halted whenever a command function key is used. Polling from a real MPS is continuous during commands initiated from the MPS terminal. Apparently, a command received by the LCU after a halt in polling is accepted.

5.3 LINK LEVEL COMMAND TESTS

Configuration #3 (Figure 3) was used to test the effect of transmitting link level commands. Several commands such as Disconnect and Frame Rejects, Type I, Type II and Type III were executed from the MPS simulator. Some problems were observed while executing these commands and events were recorded.

5.3.1 Frame Reject Command Test

With the LCU local terminal keyboard timed out, a Type I Frame Reject (FRMR) message (CONTROL FIELD INVALID) was sent and the LCU responded with a Frame Reject, as expected. A Type II FRMR message (I FIELD NOT PERMITTED) was then sent and a proper response was also returned. However, when a Type III FRMR message (I-FRAME EXCEEDS MAX. SIZE) was sent, the MPS-LCU link went into a Retry 1 situation from which it could not recover. This only occurs when the Type III FRMR message is sent to the LCU when the local terminal has timed out. Note that the local terminal should not effect link level communications except when changing parameters.

To create this problem, the following steps were performed:

- Allow the LCU local terminal keyboard to time out
- Since the MPS simulator sequentially sends first a Type I, second a Type II and then a Type III FRMR, send three consecutive FRMR messages from the MPS simulator to the LCU. Observe the response from the Type III message.

Data analysis revealed that a terminal message was sent to the LCU local terminal in response to the Type III FRMR. Because the LCU terminal had timed out, the terminal message remained in the buffer unable to be sent. Logging the terminal back on did not bring operations back on-line. The only way to clear this problem was to reset the LCU manually.

MPS Polling rate and LCU parameter changes had no affect on this problem.

5.3.2 LCU Disconnect Mode (DM)

When the LCU is put in Disconnect Mode (DM) and a second Disconnect command is sent to the LCU, an Unnumbered Acknowledgement (UA) is returned. According to NAS-MD-790 the response to a Disconnect command, when the LCU is in Disconnect Mode is a DM.

To recreate this problem, the following steps must be performed:

- Continuous poll for 1 minute to ensure proper responses are received for each poll.
- Send the LCU a Disconnect Mode (DM) command.
- Send a second disconnect command and observe the results.

MPS polling rate changes and LCU parameter changes had no affect on this problem.

6.0 Conclusions

Although there are some correlations between error rates and the configurations tested, generally the occurrence of errors and retries appear to be random. The primary conclusion is that even under ideal laboratory conditions, the fielded configuration (similar to configuration #2) generates excessive link level errors. Because the modems in the configuration are widely used communication devices and there are no apparent incompatibility problems with LCU clock, the LCU is the probable cause of the excessive errors.

The strongest correlation between LCU/MPS configurations and error rates are the clock configuration tests. These clock configuration tests show error rates increase when the LCU operates with an external clock source. In the internal clock source mode, LCU/MPS communications can be further improved by configuring the LCU and MPS modems to external and receive clock sources, respectively.

When changing the LCU clock source from the local PC, there needs to be a message in the menu notifying users to properly change Jumper J7 on the CPU circuit board to the correct position.

The LCU alarm buffer dump problem observed in previous ARMS testing was reproduced during FAA Technical Center testing. This problem must be corrected to allow command execution during an LCU buffer dump. At this time it cannot be determined if correcting the link level error problem will affect the buffer dump problem.

Some problems such as buffer dumping and the polling errors were not present when using the MPS simulator. The LCU was not developed on a real MPS, and was developed using a simulator. These problems may have resulted from differences between the simulator and the real MPS.

Sending link level commands such as Disconnect and Frame Rejects reveals timing problems and some possible compliance violations to NAS-MD-790.

Recommendations:

1. Direct the LCU contractor to correct and eliminate the link level error problem. This should be accomplished on a real MPS. If the buffer dump problem still exists, the contractor should determine the cause and correct the problem, if appropriated. The contractor should also verify NAS-MD-790 compliance.

2. Retest the LCU at the FAATC when the contractor has corrected the link level error problems and test the LCU buffer dump problem.

3. Conduct NAS integration testing of ARMS after the polling error and buffer dump problems are eliminated. Include testing for NAS-SS-1000, NAS-MD-790 and performance requirements in the integration testing.

APPENDIX A

TEST EQUIPMENT

TEST EQUIPMENT

	Equipment	Part or Serial Number
1.	ACN-230 MPS Testbed	
2.	MMS Version 0302	
3.	IMCS Version 0703	
4.	LM-1/Compact II Protocol Analyzer	11905
5.	RMS/MPS/Compact II Simulators	23145
6.	Paradyne LSI 24C Modem	853-6040-0011
7.	Paradyne LSI 24C Modem	853-6040-0011
8.	Tektronix 465 Oscilloscope	91741
9.	Link Control Unit CPU Board Proms: Rev. G DLC Board Proms: Rev. C	311

DEFAULT LCU PARAMETERS

LCU SYSTEM SETUP:

1. LCU general
2. Portable terminal port
3. MPS communications port
   (NOTE: RMS communication circuit card #1 ALWAYS present!)
4. Card #1: common communication parameters
5. Card #1: RMS specific communication parameters
6. RMS communication circuit card #2 present [no]

LCU GENERAL SETUP:

1.	LCU label	[LCU]
2.	Terminal message "enter" mode label	[SEND]
3.	Terminal message "exit mode label	[EXIT]
4.	ASCII mode RMS command response timeout	[30 sec]

PORTABLE TERMINAL PORT SETUP:
NOTE: Changed terminal parameters have NO effect until AFTER log off !!

1.	Keyboard auto log off timeout	[10 min]
2.	Autobaud mode	[OFF/FIXED]
3.	Terminal type	[non-ANSI CRT]
4.	Baud rate	[2400 baud]
5.	Number of data bits	[8]
6.	Parity	[NONE]

MPS COMMUNICATIONS PORT SETUP

1.	Hex link address	[31]
2.	Baud rate	[2400 baud]
3.	Baud clock source	[internal]
4.	Consecutive retries for link auto-reset	[5]
5.	delay before sending any responses to MPS	[20 10 ms units]

DEFAULT LCU PARAMETERS (con't)

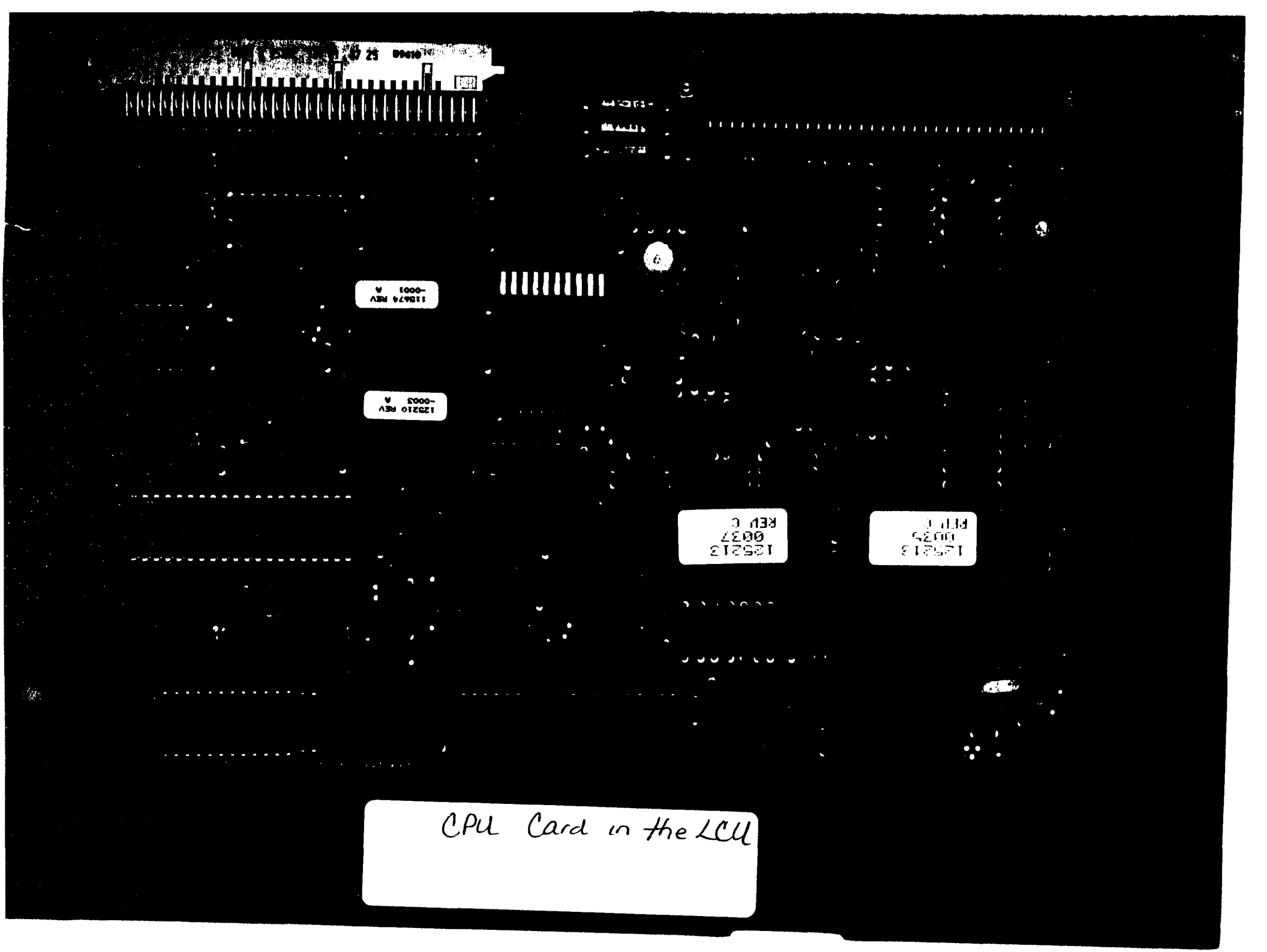
```
RMS COMMUNICATIONS COMMON PARAMETERS
     CIRCUIT CARD #1 SETUP:

1.  RMS interpoll delay                                    [50 10 ms
                                                            units]
2.  Consecutive retries for link auto-reset                [5]
3.  Consecutive connect failures for auto-disconnect       [5]
4.  Auto-disconnect to link restore delay                  [60 sec]
5.  ASCII mode consecutive RMS priority polls              [5]
6.  ASCII mode RMS priority interpoll delay                [25 10 ms
                                                            units]

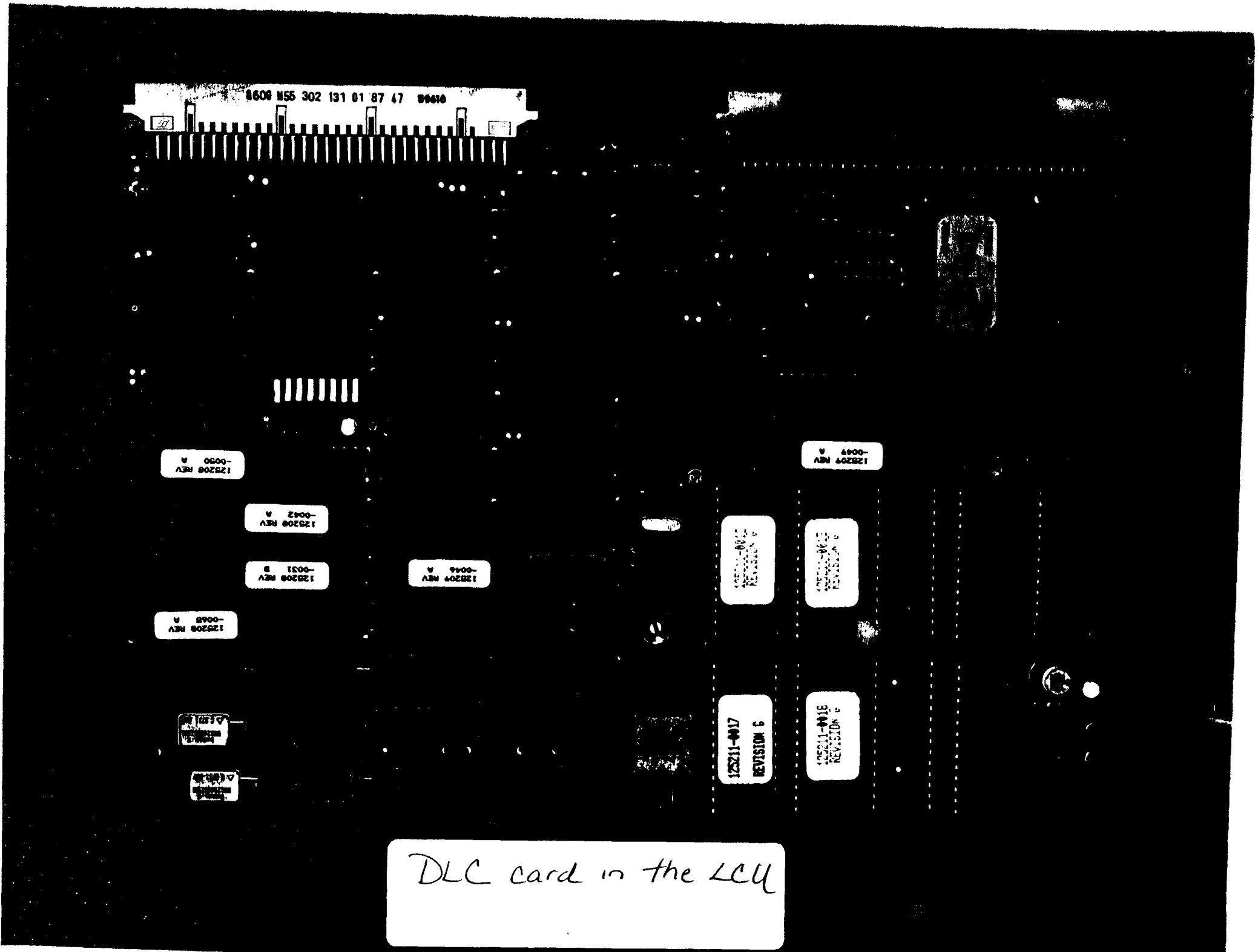
Enter desired selection (1..6) [exit] ?


RMS SPECIFIC COMMUNICATION PARAMETERS SETUP:
     WARNING:  Setting item 1 to "END" DESELECTS THIS and ALL
     HIGHER RMS slots!

1.  RMS label                                              [gs]
2.  Hex link address                                       [41]
3.  ASCII mode repeated-character companding               [yes]
4.  Respond Opportunity timeout                            [10 100 ms
                                                            units]
5.  Respond Opportunity timeout auto-retries               [3]
6.  Port assignment                                        [RS232C/
                                                            ext modem]
7.  Baud rate                                              [2400 baud]
8.  Baud clock source                                      [internal]
```



CPU Card in the LCU



DLC card in the LCU

APPENDIX B

DATA SHEETS

LCU DATA SHEET

TEST NO. DEC20 #5 DATE 12-20-89

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	5	5	3	3	
2.	15	20	1	4	
3.	2	22	1	5	
4.	25	47	1	6	
5.	12	59	1	7	CRC
6.	15	74	1	8	
7.	15	89	1	9	
8.	4	93	1	10	Frame CRC
9.	19	112	2	12	Frame CRC
10.	1	113	1	13	Max Frame
11.	10	123	1	14	Frame CRC
12.	35	158	1	15	
13.	14	172	1	16	Frame CRC
14.	10	182	1	17	Max Frame
15.	15	197	1	18	Frame CRC
16.	13	210	1	19	Frame CRC
17.	4	214	2	21	
18.	5	219	1	22	
19.	14	233	1	23	Max Frame
20.	25	258	1	24	Frame CRC
21.	29	287	1	25	Frame CRC
22.	17	304	1	26	
23.	3	307	1	27	Max Frame
24.	37	344	1	28	Max Frame

LCU DATA SHEET

TEST NO. DEC20 #5 DATE 12-20-89

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	18	362	1	29	
2.	1	363	1	30	Max Frame
3.	31	394	1	31	Max Frame
4.					
5.		Average No. Polls per Retry = 13			
6.		Sample Time = 15 min			
7.		MPS Polling Rate = 2 sec			
8.		LCU Delay to MPS = 20 - 10 ms units			
9.		Clock configuration			
10.		LCU - Internal			
11.		LCU Modem External			
12.		MPS Modem Rx			
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					

(Figure 4)

LCU DATA SHEET

TEST NO. DEC20#3 DATE 12-20-89

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	10	10	1	1	
2.	11	21	1	2	Frame CRC Error
3.	3	24	1	3	Frame CRC Error
4.	11	35	1	4	Frame CRC Error
5.	2	37	1	5	
6.	2	39	1	6	Frame CRC Error
7.	9	48	1	7	
8.	10	58	1	8	
9.	3	61	1	9	
10.	7	68	3	12	Frame CRC, Max Fram
11.	11	79	2	14	Frame CRC
12.	10	89	1	15	
13.	10	99	1	16	Frame CRC
14.	1	100	1	17	
15.	4	104	2	19	Max Frame
16.	9	113	1	20	Max Frame
17.	4	117	1	21	Frame CRC
18.	7	124	1	22	
19.	2	126	1	23	
20.	5	131	1	24	Frame CRC
21.	15	146	1	25	
22.	11	157	1	26	Frame CRC
23.	1	158	4	30	4 Frame CRC
24.	11	169	1	31	Frame CRC

LCU DATA SHEET

TEST NO. DEC20 #3 DATE 12-20-89

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	4	173	1	32	Max Frame
2.	3	176	1	33	Frame CRC
3.	0	176	1	34	
4.	5	181	1	35	Max Frame
5.	5	186	1	36	Max Frame
6.	12	198	2	38	Frame CRC
7.	4	202	1	39	Frame CRC
8.	1	203	3	42	Max Frame
9.	1	204	1	43	
10.	2	206	1	44	Frame CRC
11.	15	221	2	46	(2) Frame CRC
12.	6	227	1	47	
13.	25	252	1	48	Control Field Invalid
14.	5	257	1	49	Frame CRC
15.	2	259	1	50	
16.	2	261	1	51	Frame CRC
17.	4	265	1	52	Frame CRC
18.	3	268	1	53	
19.	7	275	1	54	Frame CRC
20.	1	276	1	55	Frame CRC
21.	14	290	1	56	Frame CRC
22.	5	295	1	57	Max Length Exceed
23.	2	297	1	58	
24.	3	300	1	59	

LCU DATA SHEET

TEST NO. DEC20 #3 DATE 12-20-89

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	2	302	1	60	
2.	4	306	2	62	
3.	3	309	1	63	Frame CRC
4.	9	318	1	64	Invalid NCR)
5.	16	334	1	65	
6.	5	339	1	66	Frame CRC
7.	1	340	1	67	Frame CRC
8.	1	341	1	68	Frame CRC
9.	8	349	1	69	
10.	6	355	1	70	Frame CRC
11.	7	362	1	71	
12.	1	363	1	72	
13.	4	367	1	73	Control field invalid
14.	3	370	1	74	
15.					
16.	Average No. Polls per Retry = 5				
17.	Sample time = 15 min				
18.	MPS Polling Rate = 2 sec				
19.	LCU Delay to MPS = 20 - 10 ms units				
20.	Clock configuration:				
21.	LCU External				
22.	LCU Modem Internal				
23.	MPS Modem Rx				
24.					

(PC-4)

#1

LCU DATA SHEET

TEST NO. 1.2.B DATE 12-11-89

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	8	8	1	1	
2.	3	11	1	2	
3.	15	26	1	3	FRAME REJECT
4.	1	27	1	4	
5.	1	28	1	5	FRAME REJECT
6.	3	31	2	7	
7.	5	36	2	9	
8.	2	38	1	10	
9.	16	54	1	11	
10.	20	74	1	12	
11.	7	81	1	13	
12.	26	107	1	14	
13.	25	132	1	15	
14.	18	150	1	16	
15.	3	153	1	17	
16.	1	154	1	18	
17.	3	157	1	19	
18.	4	161	1	20	
19.	7	168	1	21	
20.	24	192	1	22	
21.	1	193	1	23	
22.	1	194	1	24	
23.	4	198	1	25	
24.	1	199	1	26	

LCU DATA SHEET

TEST NO. 1.2.B (cont.) DATE 12-11-89

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	30	229	1	27	
2.	36	265	1	28	FRAME REJECT
3.					
4.		AVERAGE NO. POLLS PER RETRY = 9			
5.		SAMPLE TIME = 15 MIN.			
6.		MPS POLLING RATE = 2 SEC			
7.		LCU DELAY TO MPS = 20 - 10 msec UNITS (0.2 sec)			
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					

LCU DATA SHEET

TEST NO. DEC21 4 DATE 12/21/89

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	56	56	2	2	
2.	46	102	1	3	Frame CRC error
3.	5	107	1	4	
4.	88	195	1	5	
5.	14	209	1	6	
6.	20	229	1	7	
7.	55	284	1	8	
8.	3	287	1	9	
9.	6	293	1	10	
10.	8	301	1	11	
11.	8	309	1	12	Frame CRC error
12.	2	311	1	13	
13.	18	329	1	14	Frame CRC error
14.	6	335	1	15	Max Frame Exceeded
15.	8	343	1	16	
16.	39	382	1	17	Frame CRC error
17.					
18.		Average No. Polls per Retry = 22			
19.		Sample Time = 15 min			
20.		MPS polling rate 2 sec			
21.		LCU Delay To MPS = 60 - 10ms units			
22.		Clock configuration:			
23.		LCU internal			
24.		LCU Modem External			
		MPS modem Rx			

Figure 5)

LCU DATA SHEET

TEST NO. DEC21 5 DATE 12/21/89

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	9	9	1	1	
2.	38	47	2	3	
3.	11	58	1	4	
4.	12	70	1	5	Frame CRC Error
5.	10	80	1	6	Max Frame Exceed
6.	1	81	1	7	
7.	20	101	1	8	
8.	8	109	2	10	Frame CRC Error
9.	8	117	2	12	CRC, Max Frame
10.	18	135	1	13	CRC
11.	13	148	1	14	
12.	5	153	1	15	Max Frame
13.	41	194	1	16	
14.	8	202	3	19	2 CRC's, Max Frame
15.	28	230	2	21	Max Frame
16.	7	237	1	22	
17.	33	270	2	24	Max Frame, CRC
18.	18	288	1	25	CRC
19.	36	324	1	26	
20.					
21.	Average No. Polls Per Retry = 12				
22.	Sample Time = 15 min				
23.	MPS Polling Rate 2 sec				
24.	LCU Delay to MPS 1-10 ms unit				

Clock configuration:
LCU - internal
LCU modem External

(Figure 5)

LCU DATA SHEET

TEST NO. DEC21 2 DATE 12-21-89

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	27	27	1	1	
2.	3	30	1	2	
3.	28	58	1	3	
4.	30	88	1	4	
5.	8	96	1	5	
6.	31	127	1	6	Frame CRC error
7.	5	132	1	7	Frame CRC
8.	37	169	1	8	Max Frame
9.	4	173	1	9	Max Frame
10.	8	181	1	10	Max Frame
11.	2	183	1	11	
12.	2	185	1	12	
13.	6	191	1	13	
14.	2	193	1	14	
15.	21	214	1	15	Frame CRC Error
16.	5	219	1	16	Max Frame
17.	25	244	1	17	
18.	7	251	1	18	
19.	25	276	2	20	
20.	1	277	1	21	Max Frame
21.	3	280	1	22	Max Frame
22.	6	286	1	23	Max Frame
23.	5	291	1	24	
24.	22	313	1	25	Frame CRC

(cont)

LCU DATA SHEET

TEST NO. DEC21 2 DATE 12-21-89

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	2	315	1	26	
2.	63	378	1	27	
3.	50	428	1	28	Frame CRC
4.	7	435	1	29	
5.	7	442	1	30	
6.	9	451	1	31	
7.	9	460	1	32	
8.	14	474	1	33	
9.	13	487	1	34	
10.	18	505	2	36	Frame CRC
11.	19	524	1	37	
12.	20	544	1	38	Frame CRC
13.	7	551	1	39	
14.	31	582	1	40	Frame CRC
15.	11	593	1	41	
16.	32	625	1	42	Frame CRC
17.	3	628	1	43	
18.	43	671	1	44	
19.					
20.	Average No. Polls Per Retry = 15				
21.	Sample Time = 20 min.				
22.	MPS Polling Rate = 1S				
23.	LCU Delay to MPS = 20-10ms				
24.	Clock configuration:				

LCU internal
LCU Modem External
MPS Modem Rx

re 5)

LCU DATA SHEET

TEST NO. DEC213 DATE 12-21-89

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	13	13	1	1	
2.	6	19	1	2	
3.	36	55	1	3	Frame CRC
4.	29	84	1	4	
5.	2	86	1	5	Frame CRC
6.	16	102	1	6	Frame CRC
7.	3	105	1	7	
8.	16	121	1	8	
9.	14	135	1	9	Frame CRC
10.	24	159	1	10	
11.	45	204	1	11	Frame CRC
12.	22	226	1	12	
13.	32	258	1	13	
14.	12	270	1	14	
15.					
16.	Average No. Polls per Retry = .19				
17.	Sample Time = 15 minutes				
18.	MPS polling rate = 4 sec				
19.	LCU Delay to MPS = 20-10 ms				
20.	Clock configuration:				
21.	LCU internal				
22.	LCU modem external				
23.	MPS modem Rx				
24.					

e 5)

LCU DATA SHEET

TEST NO. DEC217 DATE 12-21-89

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	34	34	1	1	
2.	32	66	1	2	
3.	126	192	1	3	
4.	23	215	1	4	
5.	30	245	1	5	
6.	35	280	2	7	
7.	10	290	1	8	
8.	80	370	0	8	
9.					
10.					
11.	Average No. Polls per Retry = 46				
12.	Sample Time = 15 min				
13.	MPS polling rate = 2 sec				
14.	LCU Delay to MPS 20 - 10 ms units				
15.	Clock configuration:				
16.	LCU internal				
17.	LCU modem External				
18.	MPS modem Rx				
19.					
20.					
21.					
22.					
23.					
24.					

(pg 5)

LCU DATA SHEET

TEST NO. TANDEM 1 DATE 7-2-90

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	51	51	1	1	
2.	18	69	1	2	
3.	97	166	1	3	
4.	139	305	1	4	
5.	23	328	0	4	
6.					
7.					
8.	Average No. Polls per Retry = 82				
9.	Sample Time = 15 min				
10.	MPS (Tandem) polling rate = 2 sec				
11.	LCU delay to MPS = 60 - 10ms units				
12.	Clock configuration:				
13.	LCU Internal				
14.	LCU Modem External				
15.	MPS Modem Rx				
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					

(Figure 6)

LCU DATA SHEET

TEST NO. Tandem 2 DATE 1-2-90

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	61	61	1	1	
2.	35	96	1	2	
3.	45	141	1	3	
4.	105	246	1	4	
5.	26	272	1	5	
6.	35	307	1	6	
7.	14	321	1	7	
8.	25	346	0	7	
9.					
10.	Average No. Polls per Retry = 49				
11.	Sample Time = 15 min				
12.	MPS(Tandem) polling rate = 2sec				
13.	LCU delay to MPS = 20 - 10ms units				
14.	Clock configuration				
15.	LCU - Internal				
16.	LCU Modem External				
17.	MPS Modem Rx				
18.					
19.					
20.					
21.					
22.					
23.					
24.					

Figure 6)

LCU DATA SHEET

TEST NO. TANDEM3 DATE 1-9-90

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	31	31	1	1	
2.	20	51	1	2	
3.	14	65	1	3	
4.	10	75	1	4	
5.	19	94	1	5	FRMT
6.	15	109	1	6	
7.	29	138	1	7	
8.	35	173	1	8	
9.	46	219	1	9	
10.	55	274	1	10	FRMJ
11.	27	301	1	11	
12.	12	313	1	12	
13.	42	355	1	13	
14.					
15.	Average No. Polls Per Retry = 27				
16.	Sample Time = 15 min				
17.	MPS (Tandem) polling rate = 2 sec				
18.	LCU delay to MPS = 1-10ms unit				
19.	Clock configuration				
20.	LCU Internal				
21.	LCU Modem External				
22.	MPS Modem Rx				
23.					
24.					

igure 6)

LCU DATA SHEET

TEST NO. Tandem 4 DATE 1-9-90

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	147	147	1	1	
2.	49	196	1	2	
3.	9	205	1	3	
4.	25	230	1	4	
5.	19	249	1	5	
6.	65	314	1	6	
7.	9	323	1	7	
8.	37	360	1	8	
9.	26	386	1	9	
10.	69	455	1	10	
11.	70	525	1	11	FRMJ
12.					
13.	Average No. Polls per Retry = 47				
14.	Sample time = 15 min				
15.	MPS Polling Rate = 1 sec				
16.	LCU Delay to MPS = 20 x 10ms units				
17.	Clock configuration				
18.	LCU internal				
19.	LCU Modem External				
20.	MPS Modem Rx				
21.					
22.					
23.					
24.					

LCU DATA SHEET

TEST NO. Tandem 5 DATE 12-90

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	71	71	1	1	
2.	25	96	1	2	
3.	2	98	1	3	
4.	130	228	0	3	
5.					
6.					
7.		Average No. Polls Per Retry = 76			
8.		Sample Time = 15 min			
9.		MPS Polling Rate = 4 sec			
10.		LCU Delay to MPS = 20 - 10ms units			
11.		Clock configuration			
12.		LCU Internal			
13.		LCU Modem External/			
14.		MPS Modem Rx			
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					

FIGURE 6)

LCU DATA SHEET

TEST NO. TMCS2 DATE 1-9-90

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	3	3	1	1	
2.	19	22	1	2	
3.	12	34	1	3	
4.	59	93	1	4	
5.	37	130	1	5	
6.	4	134	1	6	
7.	26	160	1	7	
8.	34	194	1	8	
9.	19	213	1	9	
10.	4	217	1	10	
11.	2	219	1	11	
12.	10	229	1	12	
13.	18	247	1	13	
14.	6	253	1	14	
15.	35	288	1	15	
16.	2	290	1	16	
17.	20	310	1	17	
18.	18	328	1	18	
19.	24	352	1	19	
20.	16	368	1	20	
21.	113	481	0	20	
22.					
23.					
24.					

re 7)

LCU DATA SHEET

TEST NO. IMCS2 DATE 1-9-90

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.					
2.		Average No Polls Per Retry = 24			
3.		Sample Time = 15 minutes			
4.		IMCS Polling Rate = 2 seconds			
5.		LCU Delay to MPS = 20-10ms units			
6.		Clock configuration:			
7.		LCU Internal			
8.		LCU Modem External			
9.		MPS Modem Rx			
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					

ure 7)

LCU DATA SHEET

TEST NO. IMCS 3 DATE 1-9-90

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	20	20	1	1	
2.	1	21	1	2	
3.	1	22	1	3	Frame Reject
4.	15	37	1	4	
5.	19	56	1	5	
6.	24	80	1	6	
7.	33	113	1	7	
8.	19	132	1	8	
9.	9	141	1	9	
10.	3	144	1	10	
11.	4	148	1	11	
12.	1	149	1	12	
13.	52	201	1	13	
14.	47	248	1	14	
15.	4	252	1	15	
16.	11	263	1	16	
17.	12	275	1	17	
18.	44	319	0	17	
19.					
20.	Average No Polls Per Retry = 19				
21.	Sample Time = 15 minuts				
22.	IMCS Polling Rate = 2sec				
23.	LCU Delay to MPS = 1-10ms unit				
24.	Clock configuration.				

LCU Internal
LCU Modem External
MPS Modem 0

LCU DATA SHEET

TEST NO. TMCS1 DATE 1-11-90

	CONSECUTIVE MPS POLLS	CUMULATIVE MPS POLLS	RETRIES	CUMULATIVE RETRIES	ERRORS
1.	20	20	1	1	
2.	20	40	1	2	REJ
3.	17	57	1	3	
4.	26	83	1	4	
5.	15	98	1	5	
6.	32	130	1	6	
7.	9	139	1	7	REJ
8.	19	158	1	8	
9.	1	159	1	9	REJ
10.	2	161	1	10	
11.	49	210	1	11	
12.	11	221	1	12	
13.	38	259	1	13	REJ
14.	18	277	0	13	
15.					
16.		Average No. Polls Per Retry = 21			
17.		Sample Time = 15 min			
18.		MDS Polling Rate = 2 sec			
19.		LCU Delay to MDS 6.0 - 10ms units			
20.		Clock configuration:			
21.		LCU Internal			
22.		LCU Modem External			
23.		MDS Modem Rx			
24.					