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A Microprocessor-Controlled CAMAC Data Link Module

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A MICROPROCESSOR-CONTROLLED CAMAC DATA LINK MODULE

by

Jerry M. Potter

ABSTRACT

Communication between the central control computer and remote, satellite data-acquisition/control stations at the Clinton P. Anderson Meson Physics Facility (LAMPF) is presently accomplished through the use of CAMAC-based Data Link modules. With the advent of the microprocessor, a new philosophy for digital data communications has evolved. Data Link modules containing microprocessor controllers provide link management and communication network protocol through algorithms executed in the Data Link microprocessor.

I. PURPOSE

Communications between the central control computer and remote satellite data-acquisition/control stations at LAMPF have been effected through CAMAC-based Data Link modules located in CAMAC crates associated with each computing system. Control of the link, management of communications protocol, and message synchronization between two systems are under the control of algorithms residing in each controlling computer.

As the work load of the central control computer increased, it became evident that the system overhead created by the management of several Data Links would soon become intolerable.

The Data Link hardware, used in communications between the LAMPF central control computer and several satellite processing stations, was originally packaged in the CAMAC standard to make use of the computer independence associated with the CAMAC interface. A logical extension of the Data Link, and a solution to the overloading problem created by link management algorithms, lay in the appropriate use of microprocessor control within the Data Link.

II. DESCRIPTION

The system configuration, indicated in Fig. 1, is a radial coupling of satellite processor stations to the system controller (the central control computer).

Fig. 1. CAMAC/μ-processor data link system configuration.

The communications channel between two identical microprocessor Data Link modules (μp-DL) consists of a 23-pair cable for bidirectional data flow, error control, and request/priority handling. A parallel channel was originally chosen owing to the data transfer rates desired; thus, a parallel channel was also chosen for the μp-DL for compatibility and to maintain data through-put.

The communication control algorithms required for the μp-DL are split between the computer and its associated CAMAC-based link. Systems on either end of the communications channel must contain algorithms to load and initiate transfer of message, and to accept a received message. Figure 2 contains a simplified flow diagram for a computer and the associated μp-DL.

The system controller must determine if the μp-DL is busy, and if not, write the message to be transferred into a message buffer contained within the μp-DL. An instruction to initiate transfer is the only other action required by the controlling computer.

The transfer initiate instruction from the controlling computer causes the internal microprocessor in the Data Link module to be interrupted and begin the task of gaining control of the communications channel, synchronizing to the μp-DL at the other end, and sending the message stored in the message buffer. Error control in message transfer is handled by the two μp-DL modules. If an error occurs, as signified by ACK/NAK codes from a receiving μp-DL, the sending μp-DL will attempt a retransmission up to ten times before aborting and informing the controlling computer. In either case, the sending μp-DL will generate a LAM via the CAMAC interface to signify completion to the controlling computer.

During the synchronization and control process of a sending μp-DL, the receiving link microprocessor is signaled via an interrupt that a transfer is about to begin. Only after the successful receipt of a message does the receiving μp-DL signal the receiving computer (by LAM via the CAMAC interface) that a message is present in the message buffer for reading.

Fig. 2. CAMAC/ μ -processor data link simplified algorithm flow.

The LAM service routine for either sending-complete or received-message is identical in both computer systems at either end of the communication channel.

The block diagram of the μ -DL module is shown in Fig. 3. The central feature is the INTEL 8080 microprocessor interfaced to a two-bus structure, the RW Bus and the BRW Bus.

A set of CAMAC functions has been decoded for handling of the μ -DL by the CAMAC interface and controlling computer. LAM logic and a Control/Status Register (CSR) complete the necessary CAMAC connections.

Internal to the μ -DL, a coupled two-bus structure provides the required paths for data flow during loading of the message buffer, sending, and receiving of a message. The RW Bus connects the CAMAC write-lines, the message buffer, two 8-bit I/O ports from the 8080 (to make up a 16-bit internal word), the link receiver, and finally, a path to the BRW Bus. Gating of information onto the RW Bus is mutually exclusive and accomplished through tri-state logic.

Fig. 4. CAMAC/μ-processor data link communications channel transactions.

Front Panel

LEDs N Indicates that the μp-DL is being addressed
LE LAM ENABLE
LS LAM SOURCE
BUSY Indicates that the μp-DL is BUSY

CONNECTOR - J1-AMP #205211-1 (Data Link connector)

CONTROLS - There is a RESET pushbutton mounted below the Data Link connector. A RESET will reinitialize the μp-DL.

Power Requirements

μp-DL, Board No. 1

1 A at +6 V, 45 ma at -6 V, 115 ma at +24 V

μp-DL, Board No. 2

1.9 A at +6 V, 11 ma at -6 V

Physical Description

The μp-DL module resides in a two-wide CAMAC frame. The controlling station is the left-hand slot of the module.

The left-hand side of the μ P-DL module is made up of four pc boards. The board nearest the front is a DUAL PROGRAMMABLE PERIPHERAL INTERFACE BOARD (LAMPF Dwg. No. 63Y-125952). The second pc board from the front is the CENTRAL PROCESSING UNIT AND MEMORY BOARD (LAMPF Dwg. No. 63Y-125945). The third pc board from the front is the INTERRUPT STRUCTURE CARD (LAMPF Dwg. No. 63Y-149105.) The fourth pc board is the μ P-DL, Board No. 1 (LAMPF Dwg. No. 63Y-149106). The board connects to the CAMAC dataway and contains the CAMAC decode logic, LAM logic, and part of the Data Link control logic.

The right-hand side of the μ P-DL module contains one large pc board, μ P-DL, Board No. 2 (LAMPF Dwg. No. 63Y-149124). This pc board contains additional control logic, the Control Status Register (CSR), the RAM Message Buffer, the Memory Address Register (MAR), Bus Buffers, CAMAC Read/Write logic, LAM control logic, Data Link I/O logic, and the parity logic.

The drawings listed here are available from the author.

Software

Logical flow diagrams are provided in Appendix A. An assembly listing of the μ P-DL software is provided in Appendix B.

MICRO DATA LINK CAMAC COMMANDS

<u>Command</u>	<u>Mnemonic</u>	<u>Operation</u>
F(0)A(0)	RDR	*READ RAM (Message Buffer) and Increment the Memory Address Register on S2
F(0)A(1)	RCSR	Reads the Control Status Register
F(0)A(2)	RDMAR	Reads the Memory Address Register (R10-R1)
F(1)A(15)	RDI	Reads the Module Identifier (100g)
F(9)A(0)	CLR	Clear Registers and Restart the CPU
F(10)A(0)	CLM	Clear LAM Source
F(16)A(0)	WTR	*LOAD RAM (Message Buffer) and Increment the Memory Address Register on S2
F(16)A(1)	WCSR	Writes the Control Status Register
F(16)A(2)	WMAR	Writes the Memory Address Register (W10-W1). Must write the complement of the address desired.
F(25)A(0)	SEND	Send Data Link Message
F(25)A(1)	TRM	Test RAM (Message Buffer)
F(25)A(2)	DNLNLD	Execute a Down Line Load to a PDP-11 (PDP-11 DOS Load Mode Format)

All functions gated with Ni and S1 or S2 where appropriate.

X = 1 For all valid commands to module unless XI is set, which will cause the Dataway "X" response to be "0" on the next dataway cycle to the μ P-DL module.

Q = 0 For all commands to module.

Z-S2 Initialize - General Reset.

Power-Up - General Reset.

*The Data Link RAM (Message Buffer) is 512 x 16 or optional 1024 x 16.

MICRO DATA LINK RESET SIGNALS

PWR-UP: Resets the Dual Programmable Peripheral Interface Board

Z + PWR-UP: Generates a RESET Signal
Clears LAM Enable
Clears the Memory Address Register

RESET = Z + PWR-UP + F(9)A(0)·DS1 + Manual Reset

RESET: Restarts the 8080 CPU at location zero
Clears LAM Source
Clears XI (X-IN from other Data Link)
Sets Data Link Busy

CL1: Clears LAM Source
Clears XI (X-IN from other Data Link)
Clears Data Link Busy

CL1 + Z + PWR-UP: Clears Receive Enable
Clears Send Enable
Clears RO - Request Out
Clears XOC - X-OUT-Control
Clears LCI - LAM Control In
Clears PAIN - Parity Accept In
Clears BEIN - Block Error In
Clears All Interrupts

F(10)A(0): Clears LAM Source

RMAR: Clears the Memory Address Register

CL1 and RMAR are generated only from the 8080 CPU.

MICRO DATA LINK - I/O ADDRESSING

Isolated I/O (Linear Select)

Address Bits A0 and A1 are Port Selects for the 8255 A Programmable Peripheral Interface Units.

Address Bits A2 through A7 are used for Device Select. Each Bit is assigned as the exclusive enable for a specific I/O device and is Active Low.

A0	Port Selects	
A1	of the 8255 A	
A2	Device "0" Select (8255A)	
A3	Device "1" Select (8255A)	
A4	Memory Address Register - Bits A7 - A0 (LO-Byte)	^a
A5	Memory Address Register - Bit *A9 - A8 (HI-Byte)	
A6	Not used	
A7	Interrupt Mask Register	

*The Data Link RAM is 512 x 16, or 1024 x 16 is optional.

^aWhen writing the MAR, one must write the low-order byte first and then the high-order byte; otherwise, the high byte may be incremented.

Device "0": CONTROL ADDRESS = FBH
CSRA ADDRESS = F8H
CSRB ADDRESS = B9H
CSRC ADDRESS = FAH

Device "1": CONTROL ADDRESS = F7H
DATA L ADDRESS = F4H
DATA H ADDRESS = F5H
DATA C ADDRESS = F6H

MICROPROCESSOR RAM = 3D00 THROUGH 3DFF.

MICRO DATA LINK INTERRUPT STRUCTURE

INTR 7	Not used	HIGHEST PRIORITY
INTR 6	XI	*
INTR 5	Down-Line Load	F(25)A(2)
INTR 4	Send DL Msg.	F(25)A(0)
INTR 3	Test RAM	F(25)A(1)
INTR 2	Write CSR	F(16)A(1)
INTR 1	RI	
INTR 0	Not used	LOWEST PRIORITY

*Will cause the Dataway "X" response to be "0" on the next dataway cycle to the μ p-DL module.

INTERRUPT MASK:

The INTERRUPT MASK REGISTER ADDRESS = 7FH.

A logical "1" written into the MASK REGISTER will MASK OFF the corresponding interrupt line.

<u>MASK BIT</u>	<u>INTERRUPT</u>
D7	INTR7
D6	INTR6
D5	INTR5
D4	INTR4
D3	INTR3
D2	INTR2
D1	INTR1
D0	INTR0

MICRO DATA LINK CAMAC CONTROL STATUS REGISTER

CAMAC COMMAND

F(16)A(1) WRITES THE CSR

F(0)A(1) READS THE CSR

	<u>Mnemonic</u>	<u>Operation</u>	
R/W1:	LE	LAM ENABLE	WRITE/READ
R/W2:	RO	REQUEST OUT	WRITE/READ ^a
R/W3:	XOC	X-OUT CONTROL	WRITE/READ ^b
R4:	PA	PARITY ACCEPT	READ ONLY
R5:	LAM	LAM STATUS	READ ONLY
R6:	RI	REQUEST IN	READ ONLY
R7:	XI	X-IN	READ ONLY
R8:	BSY	BUSY	READ ONLY
R9:	PE	PARITY ERROR	READ ONLY

^a Once RO has been written via the Dataway, the microcontroller takes over control of the RO line and then it can only be read and not cleared or set via the Dataway.

^b XOC: X-Out Control will send X-control = 0 to be detected on the next cycle in the other module.

MICRO DATA LINK CONTROL STATUS REGISTER

PROGRAMMABLE PERIPHERAL INTERFACE: 8255A - DEVICE 0

CONTROL WORD FOR CSR I/O (91H)

CONTROL ADDRESS = FBH

D7	D6	D5	D4	D3	D2	D1	D0
1	0	0	1	0	0	0	1

D0 = 1 Port C (Lower) - INPUT
D1 = 0 Port B - OUTPUT
D2 = 0 Group B - MODE "0"
D3 = 0 Port C (Upper) - OUTPUT
D4 = 1 Port A - INPUT
D5 = 0 Group A - MODE "0"
D6 = 0
D7 = 1 Mode Set Flag - Active

PROGRAMMABLE PERIPHERAL INTERFACE: 8255A - DEVICE 0

INPUT CSR

POC3	POC2	POC1	POC0	POA7	POA6	POA5	POA4	POA3	POA2	POA1	POA0
			BE	BSY	XI	RI	LCI	PAIN	XOC	RO	LE

POA0: LE LAM ENABLE
 POA1: RO REQUEST OUT
 POA2: XOC X-OUT-CONTROL
 POA3: PAIN PARITY ACCEPT IN
 POA4: LCI LAM CONTROL IN
 POA5: RI REQUEST IN
 POA6: XI X-IN
 POA7: BSY BUSY
 POC0: BE BLOCK ERROR

CSRA ADDRESS = F8
 CSRC ADDRESS = FA

OUTPUT CSR

POC7	POC6	POC5	POC4	POB7	POB6	POB5	POB4	POB3	POB2	POB1	POB0
I/O FLAG		PE	ROC		CL1	RMAR	IMAR	LAMO	LCO	PA	XO

POB0: XO X-OUT
 POB1: PA PARITY ACCEPT
 POB2: LCO LAM CONTROL OUT
 POB3: LAMO LAM OUT
 POB4: IMAR INC THE MAR
 POB5: RMAR RESET THE MAR
 POB6: CL1 CLEAR 1
 POC4: ROC REQUEST OUT CONTROL
 POC5: PE PARITY ERROR
 POC7: IOF I/O FLAG

CSRB ADDRESS = F9
 CSRC ADDRESS = FA

MICRO DATA LINK MEMORY I/O

PROGRAMMABLE PERIPHERAL INTERFACE: 8255A - DEVICE 1

CONTROL WORD FOR A READ OPERATION (9BH)

CONTROL ADDRESS = F7H

D7	D6	D5	D4	D3	D2	D1	D0
1	0	0	1	1	0	1	1

D0 = 1 Port C (Lower) - INPUT
D1 = 1 Port B - INPUT
D2 = 0 Group B - MODE "0"
D3 = 1 Port C (Upper) - INPUT
D4 = 1 Port A - INPUT
D5 = 0 Group A - MODE "0"
D6 = 0
D7 = 1 Mode Set Flag - Active

PROGRAMMABLE PERIPHERAL INTERFACE: 8255A - DEVICE 1

CONTROL WORD FOR A WRITE OPERATION (A4H)

CONTROL ADDRESS = F7H

D7	D6	D5	D4	D3	D2	D1	D0
1	0	1	0	0	1	0	X

D0 = X Don't Care
 D1 = 0 Port B - OUTPUT
 D2 = 1 Group B - MODE "1"
 D3 = 0 Port C4,5 - OUTPUT
 D4 = 0 Port A - OUTPUT
 D5 = 1 Group A - MODE "1"
 D6 = 0
 D7 = 1 Mode Set Flag - Active

- Software ACK Bit PIC4 is inverted and tied to PIC6 $\overline{ACK}_A$ and PIC2 $\overline{ACK}_B$ and is controlled via a Bit Set/Reset Command.
- PIC5 is tied to Output Disable ($\overline{OD}$) of the Data Link RAM.

PROGRAM PERIPHERAL INTERFACE: 8255A - DEVICE 1

READ OR WRITE DATA:

P1A7 P1A6 P1A5 P1A4 P1A3 P1A2 P1A1 P1A0

RW8	RW7	RW6	RW5	RW4	RW3	RW2	RW1
-----	-----	-----	-----	-----	-----	-----	-----

DATAL (PORT A) ADDRESS = F4H

P1B7 P1B6 P1B5 P1B4 P1B3 P1B2 P1B1 P1B0

RW16	RW15	RW14	RW13	RW12	RW11	RW10	RW9
------	------	------	------	------	------	------	-----

DATAH (PORT B) ADDRESS = F5H

SINGLE BIT SET/RESET FEATURE OF THE 8255A

Any of the eight bits of Port C can be Set or Reset using a single OUTPUT instruction.

CONTROL WORD

D7	D6	D5	D4	D3	D2	D1	D0
0	X	X	X	1-0	1-0	1-0	1-0

D0 = 1 Bit Set

D0 = 0 Bit Reset

D1 = 1-0

D2 = 1-0

D3 = 1-0

} Bit Select

D7 = 0 Bit Set/Reset Flag - Active

μp-DL, J1 PIN ASSIGNMENTS

<u>J1</u>		<u>Signal</u>	<u>J1</u>		<u>Signal</u>
1	} tw. pr.	D16A	24	} twisted pair (tw. pr.)	D5A
2		D16N	25		D5N
3	} tw. pr.	D15A	26	} tw. pr.	D4A
4		D15N	27		D4N
5	} tw. pr.	D14A	28	} tw. pr.	D3A
6		D14N	29		D3N
7	} tw. pr.	D13A	30	} tw. pr.	D2A
8		D13N	31		D2N
9	} tw. pr.	D12A	32	} tw. pr.	D1A
10		D12N	33		D1N
11	} tw. pr.	D11A	34	} tw. pr.	PAA
12		D11N	35		PAN
13	} tw. pr.	D10A	36	} tw. pr.	PRA
14		D10N	37		PRN
15	} tw. pr.	D9A	38	} tw. pr.	XOA
16		D9N	39		XON
18	} tw. pr.	D8A	40	} tw. pr.	LA
19		D8N	41		LN
20	} tw. pr.	D7A	42	} tw. pr.	ROA
21		D7N	43		RON
22	} tw. pr.	D6A	44	} tw. pr.	RIA
23		D6N	45		RIN
			46	} tw. pr.	XIA
			47		XIN

LAMPF DATA LINK CABLE WIRING

AMP, 50 contact connectors No. 205212-1

AMP, Connector Shield and Cable Clamp Assembly No. 205732-1

AMP, Pins No. 205310-8 for No. 26 twisted-pair wires

AMP, Pins No. 205202-4 for No. 22 twisted-pair wires

BELDEN, 23-pair Cable No. 9749

<u>Signal</u>	<u>Connector</u>	<u>To</u>	<u>Connector</u>	
D16A	Pin 1 BN	"	Pin 1	
D16N	2 BK	"	2	tw. pr.
D15A	3 RD	"	3	
D15N	4 OR	"	4	tw. pr.
D14A	5 YE	"	5	
D14N	6 GN	"	6	tw. pr.
D13A	7 RD	"	7	
D13N	8 BN	"	8	tw. pr.
D12A	9 RD	"	9	
D12N	10 BK	"	10	tw. pr.
D11A	11 BK	"	11	
D11N	12 OR	"	12	tw. pr.
D10A	13 BU	"	13	
D10N	14 GN	"	14	tw. pr.
D9A	15 RD	"	15	
D9N	16 WH	"	16	tw. pr.
D8A	18 GN	"	18	
D8N	19 WH	"	19	tw. pr.
D7A	20 YE	"	20	
D7N	21 BU	"	21	tw. pr.
D6A	22 OR	"	22	
D6N	23 WH	"	23	tw. pr.
D5A	24 BN	"	24	
D5N	25 WH	"	25	tw. pr.
D4A	26 BK	"	26	
D4N	27 YE	"	27	tw. pr.
D3A	28 RD	"	28	
D3N	29 GN	"	29	tw. pr.
D2A	30 GN	"	30	
D2N	31 BN	"	31	tw. pr.
D1A	32 OR	"	32	
D1N	33 GN	"	33	tw. pr.
PAA	34 YE	"	34	
PAN	35 WH	"	35	tw. pr.
PRA	36 RD	"	36	
PRN	37 BU	"	37	tw. pr.
XOA	38 GN	"	46	Signal
XON	39 BK	"	47	XIA
LA	40 BU	"	40	XIN
LN	41 BK	"	41	
ROA	42 WH	"	44	tw. pr.
RON	43 BK	"	45	
RIA	44 YE	"	42	tw. pr.
RIN	45 RD	"	43	
XIA	46 BU	"	38	
XIN	47 WH	"	39	tw. pr.

APPENDIX A

LOGICAL FLOW DIAGRAMS

CONTROL COMPUTER RECEIVE

840 CONTROL COMPUTER SEND DOWN-LINE LOAD TO PDP-11 VIA μ P-DL

10-DL RESTART

μP-DL INTERRUPT TO WRITE THE CONTROL STATUS REGISTER

UP-DL SEND

*The MAR is incremented on trailing edge of LCP IN-RD

μP-DL RECEIVE

*Data strobed into RAM when L.C. pulse is received

μP-DL INTERRUPT TO TEST RAM

APPENDIX B

PROGRAM LISTING

```

LINE  ADDR  B1 B2 B3 B4 ERROR  MICRO DATA LINK:  JERRY M. POTTER  1-DEC-77

3      LIST 5
4      ;
5      ;EQUIVALENCES:
6      ;
7      3E 00      STK      EQU      3E00H      ;STACK SET UP
8      3D 00      NTT      EQU      3D00H      ;NTT ADDRESS
9      3D 01      LCKSUM    EQU      3D01H      ;L-BYTE CKSUM
10     3D 02      HCKSUM    EQU      3D02H      ;H-BYTE CKSUM
11     00 FB      DEV0      EQU      0FBH      ;8255A DEVICE 0
12     00 F7      DEV1      EQU      0F7H      ;8255A DEVICE 1
13     00 F4      DATAL     EQU      0F4H      ;DATA LOW BYTE
14     00 F5      DATAH    EQU      0F5H      ;DATA HIGH BYTE
15     00 91      CONT1     EQU      91H      ;8255A CONTROL WORD 1
16     00 9B      CONT2     EQU      9BH      ;8255A CONTROL WORD 2
17     00 A4      CONT3     EQU      0A4H      ;8255A CONTROL WORD 3
18     00 FB      CSRA      EQU      0FBH      ;CSR INPUT
19     00 F9      CSRB      EQU      0F9H      ;CSR OUTPUT
20     00 FA      CSRC      EQU      0FAH      ;CSR PORT C I/O
21     00 80      FLAG      EQU      80H      ;CSR I/O FLAG
22     00 7F      INTMSK    EQU      7FH      ;INTERRUPT MASK ADDRESS
23     00 81      MSK1      EQU      81H      ;FALLS INT-1 THRU 6
24     00 BF      MSK2      EQU      0BFH      ;ALLOW ONLY INT-6
25     00 08      PAIRN     EQU      8H      ;PARITY ACCEPT IN BIT
26     00 06      PALCO     EQU      6      ;PARITY ACCEPT & LCO BITS
27     00 01      LE        EQU      1      ;LAM ENABLE BIT
28     00 20      RI        EQU      20H      ;REQUEST IN
29     00 02      RO        EQU      2      ;REQUEST OUT BIT
30     00 40      XI        EQU      40H      ;XI BIT
31     00 05      XLC0      EQU      5      ;X & LAM CONTROL OUT
32     00 01      XO        EQU      1      ;X-OUT BIT
33     00 04      XOC        EQU      4      ;X-CONTROL BIT
34     00 02      PA        EQU      2      ;PARITY ACCEPT BIT
35     00 01      BE        EQU      1      ;BLOCK ERROR BIT
36     00 10      LCI        EQU      10H      ;LAM CONTROL IN
37     00 04      LCO        EQU      4      ;LAM CONTROL BIT
38     00 08      LAM0       EQU      8H      ;CAMAC LAM BIT
39     00 0A      LAMPA      EQU      0AH      ;LAM OUT & PARITY ACCEPT
40     00 20      RMAR       EQU      20H      ;MAR RESET BIT
41     00 10      IMAR       EQU      10H      ;INC THE MAR
42     00 40      CL1        EQU      40H      ;CLEAR BIT
43     00 60      CLIMAR     EQU      60H      ;CLEAR & MARR BITS
44     00 00      INT7       EQU      0      ;NOT USED
45     00 08      INT6       EQU      8H      ;X-CONTROL
46     00 10      INT5       EQU      10H      ;DOWN LINE LOAD
47     00 18      INT4       EQU      18H      ;SEND MESSAGE
48     00 20      INT3       EQU      20H      ;TEST RAM
49     00 28      INT2       EQU      28H      ;WRITE CSR
50     00 30      INT1       EQU      30H      ;REQUEST IN
51     00 38      INTO       EQU      38H      ;NOT USED
52     ;
53     ;POWER-UP OR RESTART
54     ;
55     ORG      INT7
56     0000  31 00 3E      LXI      SP,STK      ;INITIALIZE SP

```

LINE	ADDR	B1	B2	B3	B4	ERROR	MICRO DATA LINK: JERRY M. POTTER 1-DEC-77
57	0003	C3	40	00			JMP INIT ;START UP CODE
58							;
59							;INTERRUPT 6
60							;X-CONTROL
61							;
62							ORG INT6
63	0008	C3	A2	00			JMP XIN ;JMP TO X-IN ROUTINE
64							;
65							;INTERRUPT 5
66							;SEND DOWN-LINE-LOAD MESSAGE TO PDP-11
67							;PAPER TAPE FORMAT F(25)A(2)
68							;
69							ORG INT5
70	0010	C3	0C	01			JMP DNLNLD ;JMP TO DOWN LINE LOAD ROUTINE
71							;
72							;INTERRUPT 4
73							;SEND DL MESSAGE F(25)A(0)
74							;
75							ORG INT4
76	0018	C3	70	01			JMP SDMSG ;JMP TO SEND MESSAGE ROUTINE
77							;
78							;INTERRUPT 3
79							;TEST RAM F(25)A(1)
80							;
81							ORG INT3
82	0020	C3	AD	00			JMP TRAM ;JMP TO TEST RAM ROUTINE
83							;
84							;INTERRUPT 2
85							;WRITE CSR F(16)A(1)
86							;
87							ORG INT2
88	0028	C3	C8	00			JMP WCSR ;JMP TO WRITE CSR ROUTINE
89							;
90							;INTERRUPT 1
91							;REQUEST IN FROM OTHER DL
92							;
93							ORG INT1
94	0030	C3	67	02			JMP REGIN ;JMP RI ROUTINE
95							;
96							;INTERRUPT 0
97							;NOT USED
98							;
99							ORG INTO
100	0038	00					NOP
101	0039	C3	38	00			JMP \$-1 ;LOOP
102							;
103							ORG 40H
104	0040	DB	FA				IN CSRC ;TEST CSR I/O FLAG
105	0042	E6	80				ANI FLAG
106	0044	CA	4B	00			JZ SETRAM
107	0047	3E	91				MVI A,CONT1 ;GET CONTROL WORD 1
108	0049	D3	FB				OUT DEV0 ;SET-UP CSR I/O PORT
109							;
110	004B	3E	9B				SETRAM: MVI A,CONT2 ;GET CONTROL WORD 2

LINE	ADDR	B1	B2	B3	B4	ERROR	MICRO DATA LINK:	JERRY M. POTTER	1-DEC-77
111	004D	D3	F7				OUT	DEV1	;SET RAM PORT TO READ MODE
112	004F	DB	F8				IN	CSRA	;READ CSR
113	0051	47					MOV	B,A	;SAVE STATUS
114	0052	E6	40				ANI	XI	;TEST XI BIT
115	0054	C2	A2	00			JNZ	XIN	;JMP TO X-IN
116	0057	78					MOV	A,B	;GET STATUS
117	0058	E6	20				ANI	RI	;TEST RI BIT
118	005A	C2	7C	00			JNZ	ACKDL	;ACK TO SENDING DL
119									
120	005D	3E	60				CLR1:	MVI	A,CL1MAR
121	005F	D3	F9				OUT	CSRB	;CLEAR 1 & RESET MAR
122	0061	AF					XRA	A	;CLR A
123	0062	D3	F9				OUT	CSRB	;CLEAR CSR OUTPUT PORT
124	0064	D3	FA				OUT	CSRC	
125									
126	0066	DB	F8				TSTLE:	IN	CSRA
127	0068	E6	01				ANI	LE	;READ CSR
128	006A	C2	70	00			JNZ	ENAB	;TEST LE BIT
129	006D	C3	66	00			JMP	TSTLE	;JMP ON TEST LE
130									
131	0070	31	00	3E			ENAB:	LXI	SP,STK
132	0073	3E	B1				MVI	A,MSK1	;RESET SP
133	0075	D3	7F				OUT	INTMSK	;GET INT-MASK
134	0077	FB					EI		;ALLWS INT-1 THUR 6
135	0078	00					NOP		;ENABLE INTERRUPTS
136	0079	C3	78	00			JMP	\$-1	
137									;WAIT INT + RST
138	007C	3E	20				ACKDL:	MVI	A,RMAR
139	007E	D3	F9				OUT	CSRB	;RESET MAR
140	0080	AF					XRA	A	
141	0081	D3	F9				OUT	CSRB	;CLR A
142	0083	3E	A4				MVI	A,CONT3	
143	0085	D3	F7				OUT	DEV1	;GET CONTROL WORD 3
144	0087	AF					XRA	A	;SET RAM PORT TO WRITE MODE
145	0088	D3	F4				OUT	DATAL	;CLR A
146	008A	D3	F5				OUT	DATAH	;CLEAR WC L-BYTE
147	008C	3E	09				MVI	A,09H	;CLEAR WC H-BYTE
148	008E	D3	F7				OUT	DEV1	;BIT SET P1C4
149	0090	3E	08				MVI	A,08H	;RESETS 0BFA & 0BFB
150	0092	D3	F7				OUT	DEV1	;BIT RESET P1C4
151	0094	3E	9B				MVI	A,CONT2	
152	0096	D3	F7				OUT	DEV1	;GET CONTROL WORD 2
153	0098	3E	06				MVI	A,PALCO	;SET RAM PORT TO READ MODE
154	009A	D3	F9				OUT	CSRB	;SEND ACK
155	009C	AF					XRA	A	
156	009D	D3	F9				OUT	CSRB	;CLR A
157	009F	C3	5D	00			JMP	CLR1	
158									
159	00A2	3E	08				XIN:	MVI	A,LAMD
160	00A4	D3	F9				OUT	CSRB	;SET CAMAC LAM
161	00A6	AF					XRA	A	
162	00A7	D3	F9				OUT	CSRB	;CLR A
163	00A9	00					NOP		
164	00AA	C3	A9	00			JMP	\$-1	;WAIT FOR RST

LINE ADDR B1 B2 B3 B4 ERROR MICRO DATA LINK: JERRY M. POTTER 1-DEC-77

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165
166 00AD 3E BF      ;
167 00AF D3 7F      TRAM: MVI A,MSK2      ;GET INT-MASK
168 00B1 FB         OUT INTMSK      ;ALLOW ONLY INT-6
169 00B2 DB FB         EI           ;ENABLE INTERRUPTS
170 00B4 E6 02        IN CSRA       ;READ CSR
171 00B6 CA C3 00      ANI RD       ;TEST FOR RD
172 00B9 3E 20        JZ WRST
173 00BB D3 F9        MVI A,RMAR    ;RESET MAR
174 00BD AF          OUT CSRB
175 00BE D3 F9        XRA A         ;CLR A
176 00C0 C3 3E 02      OUT CSRB
177                    JMP ACKCOM+3  ;ACK SENDING COMPUTER
178 00C3 3E 81      ;
179 00C5 D3 7F      WRST: MVI A,MSK1  ;GET INT-MASK
180 00C7 C9         OUT INTMSK      ;ALLWS INT-1 THUR 6
181                    RET          ;WAIT FOR INT + RST
182 00C8 3E BF      ;
183 00CA D3 7F      WCSR: MVI A,MSK2  ;GET INT-MASK
184 00CC FB         OUT INTMSK      ;ALLOW ONLY INT-6
185 00CD DB FB         EI           ;ENABLE INTERRUPTS
186 00CF 47         IN CSRA       ;READ CSR
187 00D0 E6 04      MOV B,A        ;SAVE STATUS
188 00D2 C2 E0 00    ANI X0C       ;TEST X0 BIT
189 00D5 7B         JNZ SDX0       ;JMP TO SEND X0
190 00D6 E6 02      MOV A,B        ;GET STATUS
191 00D8 C2 EC 00    ANI RD       ;TEST RD BIT
192 00DB 3E 81      JNZ SETRO      ;SET RD
193 00DD D3 7F      MVI A,MSK1     ;GET INT-MASK
194 00DF C9         OUT INTMSK      ;ALLWS INT-1 THUR 6
195                    RET
196 00E0 3E 05      ;
197 00E2 D3 F9      SDX0: MVI A,XLCO  ;X & LAM CONTROL OUT
198 00E4 AF         OUT CSRB
199 00E5 D3 F9      XRA A         ;CLR A
200 00E7 3E 81      OUT CSRB
201 00E9 D3 7F      MVI A,MSK1     ;GET INT-MASK
202 00EB C9         OUT INTMSK      ;ALLWS INT-1 THUR 6
203                    RET          ;WAIT FOR INT + RST
204 00EC 3E 09      ;
205 00EE D3 FB      SETRO: MVI A,09H  ;BIT SET RD
206 00F0 DB FB      OUT DEV0
207 00F2 E6 20      IN CSRA       ;READ CSR
208 00F4 C2 FC 00    ANI RI       ;TEST FOR TIE
209 00F7 3E 81      JNZ TIE
210 00F9 D3 7F      MVI A,MSK1     ;GET INT-MASK
211 00FB C9         OUT INTMSK      ;ALLWS INT-1 THUR 6
212                    RET          ;WAIT FOR INT + RST
213 00FC 3E 40      ;
214 00FE D3 F9      TIE: MVI A,CL1   ;CLR1
215 0100 AF         OUT CSRB
216 0101 D3 F9      XRA A         ;CLR A
217 0103 3E 08      OUT CSRB
218 0105 D3 FB      MVI A,08H     ;BIT RESET RD
                OUT DEV0

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LINE	ADDR	B1	B2	B3	B4	ERROR	MICRO DATA LINK:	JERRY M. POTTER	1-DEC-77
219	0107	3E	81				MVI	A,MSK1	#GET INT-MASK
220	0109	D3	7F				OUT	INTMSK	#ALLOWS INT-1 THUR 6
221	010B	C9					RET		#WAIT FOR INT + RST
222									
223	010C	3E	BF				BNLNLB:	MVI	A,MSK2
224	010E	D3	7F					OUT	INTMSK
225	0110	FB						EI	#ENABLE INTERRUPTS
226	0111	DB	F8					IN	CSRA
227	0113	E6	02					ANI	RO
228	0115	CA	4E	02				JZ	NAKCOM+3
229	0118	3E	20					MVI	A,RMAR
230	011A	D3	F9					OUT	CSRB
231	011C	AF						XRA	A
232	011D	D3	F9						
233	011F	DB	F4					IN	DATAL
234	0121	5F						MOV	E,A
235	0122	DB	F5					IN	DATAL
236	0124	57						MOV	D,A
237	0125	E6	FE					ANI	OFEH
238	0127	FE	FE					CPI	OFEH
239	0129	C2	4E	02				JNZ	NAKCOM+3
240	012C	13						INX	D
241	012D	3E	10					MVI	A,IMAR
242	012F	D3	F9					OUT	CSRB
243	0131	AF						XRA	A
244	0132	D3	F9					OUT	CSRB
245									
246	0134	3E	04				DATA:	MVI	A,LCU
247	0136	D3	F9					OUT	CSRB
248	0138	AF						XRA	A
249	0139	D3	F9					OUT	CSRB
250									
251									
252									
253	013B	D5						PUSH	D
254	013C	16	10					MVI	D,LCI
255	013E	CD	F0	02				CALL	TIME
256	0141	E6	10					ANI	LCI
257	0143	C2	55	01				JNZ	TSTWC
258	0146	3E	20					MVI	A,RMAR
259	0148	D3	F9					OUT	CSRB
260	014A	AF						XRA	A
261	014B	D3	F9					OUT	CSRB
262	014D	3E	08					MVI	A,LAMD
263	014F	D3	F9					OUT	CSRB
264	0151	AF						XRA	A
265	0152	C3	70	00				JMP	ENAB
266									
267	0155	D1					TSTWC:	POP	D
268	0156	13						INX	D
269	0157	7A						MOV	A,D
270	0158	B3						ORA	E
271	0159	C2	34	01				JNZ	DATA
272	015C	3E	20					MVI	A,RMAR

LINE	ADDR	B1	B2	B3	B4	ERROR	MICRO DATA LINK: JERRY M. POTTER 1-DEC-77
273	015E	D3	F9				OUT CSRB
274	0160	AF					XRA A ;CLR A
275	0161	D3	F9				OUT CSRB
276	0163	3E	0A				MVI A,LAMPA ;LAMP & PARITY ACCEPT
277	0165	D3	F9				OUT CSRB
278	0167	3E	02				MVI A,PA ;LEAVE PA ON
279	0169	D3	F9				OUT CSRB
280	016B	3E	81				MVI A,MSK1 ;GET INT-MASK
281	016D	D3	7F				OUT INTMSK ;ALLOWS INT-1 THUR 6
282	016F	C9					RET ;WAIT FOR INT + RST
283							;
284	0170	3E	BF				SDMSG: MVI A,MSK ;GET INT-MASK
285	0172	D3	7F				OUT INTMSK ;ALLOW ONLY INT-6
286	0174	FB					EI ;ENABLE INTERRUPTS
287	0175	DB	F8				IN CSRA ;READ CSR
288	0177	E6	02				ANI RO ;TEST RO
289	0179	CA	4E	02			JZ NAKCOM+3 ;NAK SENDING COMPUTER
290	017C	21	00	3D			LXI H,NTT ;LOAD NTT ADDRESS
291	017F	36	00				MVI M,0 ;SET NTT=0
292	0181	3E	20				MVI A,RMAR ;RESET MAR
293	0183	D3	F9				OUT CSRB
294	0185	AF					XRA A ;CLR A
295	0186	D3	F9				OUT CSRB
296							;
297	0188	21	02	3D			RETRY: LXI H,HCKSUM ;LOAD HCKSUM ADDRESS
298	018B	DB	F5				IN DATAH ;READ H-BYTE
299	018D	77					MOV M,A ;SAVE HCKSUM
300	018E	57					MOV D,A ;MOV HB-WC TO REG-D
301	018F	E6	FE				ANI OFEH ;MASK BIT 8
302	0191	FE	FE				CPI OFEH ;TEST HB-WC
303	0193	C2	4E	02			JNZ NAKCOM+3 ;WC NON VALID
304	0196	2B					DCX H ;GET LCKSUM ADDRESS
305	0197	DB	F4				IN DATAL ;READ L-BYTE
306	0199	5F					MOV E,A ;MOV LB-WC TO REG-E
307	019A	3E	A4				MVI A,CONT3 ;GET CONTROL WORD 3
308	019C	D3	F7				OUT DEV1 ;SET RAM PORT TO WRITE MODE
309	019E	7B					MOV A,E ;GET L-BYTE WC
310	019F	3D					DCR A ;ADD -1 TO ORG WC
311	01A0	77					MOV M,A ;SAVE LCKSUM
312	01A1	D3	F4				OUT DATAL ;MODIFY RAM WC
313	01A3	3E	09				MVI A,09H ;BIT SET P1C4
314	01A5	D3	F7				OUT DEV1 ;RESET OBFA
315	01A7	3E	08				MVI A,08H ;BIT RESET P1C4
316	01A9	D3	F7				OUT DEV1
317	01AB	3E	9B				MVI A,CONT2 ;GET CONTROL WORD 2
318	01AD	D3	F7				OUT DEV1 ;SET RAM PORT TO READ MODE
319	01AF	23					INX H ;GET HCKSUM ADDRESS
320							;
321	01B0	3E	04				DRAM: MVI A,LCO ;OUTPUT RAM
322	01B2	D3	F9				OUT CSRB
323	01B4	AF					XRA A ;CLR A
324	01B5	D3	F9				OUT CSRB
325							;
326							;TEST LAM CONTROL IN:

LINE	ADDR	B1	B2	B3	B4	ERROR	MICRO DATA LINK:	JERRY M. POTTER	1-DEC-77
327									
328	01B7	D5					PUSH	D	#SAVE DE ON STACK
329	01B8	16	10				MVI	D,LCI	#GET LCI BIT IN D
330	01BA	CD	F0	02			CALL	TIME	#TEST BIT & TIME OUT ROUTINE
331	01BD	E6	10				ANI	LCI	#TESTFOR LCI
332	01BF	C2	C5	01			JNZ	Y1	
333	01C2	CD	FE	02			CALL	TOUT2	#TIME OUT 2
334									
335	01C5	D1					POP	D	#GET DE FROM STACK
336	01C6	13					INX	D	#INC WC, DE-RP
337	01C7	7A					MOV	A,D	#TEST WC=0
338	01C8	B3					ORA	E	
339	01C9	C2	5A	02			JNZ	RRAM	#GET NEXT WORD
340	01CC	D3	FA				OUT	CSRC	#DROP RO
341	01CE	2B					DCX	H	#GET LCKSUM ADDRESS
342	01CF	96					SUB	M	#NEGATE 16 BIT CKSUM
343	01D0	77					MOV	M,A	#SAVE LCKSUM
344	01D1	23					INX	H	#LOAD HCKSUM ADDRESS
345	01D2	3E	00				MVI	A,0	#CLR A
346	01D4	9E					SBB	M	
347	01D5	77					MOV	M,A	#SAVE HCKSUM
348	01D6	3E	A4				MVI	A,CONT3	#GET CONTROL WORD 3
349	01D8	D3	F7				OUT	DEV1	#SET RAM PORT TO WRITE MODE
350	01DA	3A	01	3D			LDA	LCKSUM	#LCKSUM TO A
351	01DD	D3	F4				OUT	DATAL	
352	01DF	3E	09				MVI	A,09H	#BIT SET P1C4
353	01E1	D3	F7				OUT	DEV1	#RESET OBFA
354	01E3	3E	08				MVI	A,08H	#BIT RESET P1C4
355	01E5	D3	F7				OUT	DEV1	
356	01E7	3A	02	3D			LDA	HCKSUM	#HCKSUM TO A
357	01EA	D3	F5				OUT	DATAL	
358	01EC	3E	09				MVI	A,09H	#BIT SET P1C4
359	01EE	D3	F7				OUT	DEV1	#RESET OBFB
360	01F0	3E	08				MVI	A,08H	#BIT RESET P1C4
361	01F2	D3	F7				OUT	DEV1	
362	01F4	3E	9B				MVI	A,CONT2	#GET CONTROL WORD 2
363	01F6	D3	F7				OUT	DEV1	#SET RAM PORT TO READ MODE
364	01F8	3E	04				MVI	A,LC0	#OUTPUT CKSUM
365	01FA	D3	F9				OUT	CSRB	
366	01FC	AF					XRA	A	#CLR A
367	01FD	D3	F9				OUT	CSRB	
368									
369									
370									
371	01FF	16	10				MVI	D,LCI	#GET LCI BIT IN D
372	0201	CD	F0	02			CALL	TIME	#TEST BIT & TIME OUT ROUTINE
373	0204	E6	10				ANI	LCI	#TEST FOR LCI
374	0206	C2	0C	02			JNZ	Y2	
375	0209	CD	FE	02			CALL	TOUT2	#TIME OUT 2
376									
377	020C	3E	4C				MVI	A,CL1	#ISSUE A CL1 TO
378	020E	D3	F9				OUT	CSRB	#CLR LCI FF
379	0210	AF					XRA	A	#CLR A
380	0211	D3	F9				OUT	CSRB	

LINE	ADDR	B1	B2	B3	B4	ERROR	MICRO DATA LINK:	JERRY M. POTTER	1-DEC-77
381	0213	3E	09				MVI	A,09H	#BIT SET RD
382	0215	D3	FB				OUT	DEV0	
383									
384									
385									
386	0217	16	10				MVI	D,LCI	#GET LCI BIT IN D
387	0219	CD	F0	02			CALL	TIME	#TEST BIT & TIME OUT ROUTINE
388	021C	E6	10				ANI	LCI	#TEST FOR LCI
389	021E	C2	24	02			JNZ	Y3	
390	0221	CD	FE	02			CALL	TOUT2	#TIME OUT 2
391									
392	0224	DB	F8				IN	CSRA	#READ CSR
393	0226	E6	08				ANI	PAIN	#TEST PA
394	0228	C2	3B	02			JNZ	ACKCOM	#ACK SENDING COMP
395	022B	21	00	3D			LXI	H,NTT	#LOAD NTT ADDRESS
396	022E	34					INR	M	#INC NTT
397	022F	3E	0A				MVI	A,0AH	
398	0231	BE					CMP	M	
399	0232	CA	4B	02			JZ	NAKCOM	#NTT = 10.
400	0235	CD	0B	03			CALL	RESTOR	#RESTORE ORIGINAL WC
401	0238	C3	8B	01			JMP	RETRY	#NTT < 10.
402									
403	023B	CD	0B	03			ACKCOM:	CALL	RESTOR
404	023E	3E	0A				MVI	A,LAMPA	#RESTORE ORIGINAL WC
405	0240	D3	F9				OUT	CSR8	#LAMP & PARITY ACCEPT
406	0242	3E	02				MVI	A,PA	#LEAVE PA ON
407	0244	D3	F9				OUT	CSR8	
408	0246	3E	B1				MVI	A,MSK1	#GET INT-MASK
409	0248	D3	7F				OUT	INTMSK	#ALLOWS INT-1 THUR 6
410	024A	C9					RET		#WAIT FOR INT + RST
411									
412	024B	CD	0B	03			NAKCOM:	CALL	RESTOR
413	024E	3E	0B				MVI	A,LAMP	#RESTORE ORIGINAL WC
414	0250	D3	F9				OUT	CSR8	#NAK SENDING COMP
415	0252	AF					XRA	A	#CLR A
416	0253	D3	F9				OUT	CSR8	
417	0255	3E	B1				MVI	A,MSK1	#GET INT-MASK
418	0257	D3	7F				OUT	INTMSK	#ALLOWS INT-1 THUR 6
419	0259	C9					RET		#WAIT FOR INT + RST
420									
421	025A	2B					RRAM:	DCX	H
422	025B	DB	F4				IN	DATAL	#GET LCKSUM ADDRESS
423									#READ L-BYTE OF
424	025D	86					ADD	M	#NEXT DATA WORD
425	025E	77					MOV	M,A	#UP-DATE CKSUM
426	025F	23					INX	H	#GET HCKSUM ADDRESS
427	0260	DB	F5				IN	DATAL	#READ H-BYTE OF
428									#NEXT DATA WORD
429	0262	8E					ADC	M	
430	0263	77					MOV	M,A	#UP-DATE CKSUM
431	0264	C3	B0	01			JMP	ORAM	
432									
433	0267	3E	BF				REQIN:	MVI	A,MSK2
434	0269	D3	7F				OUT	INTMSK	#GET INT-MASK
									#ALLOW ONLY INT-6

LINE	ADDR	B1	B2	B3	B4	ERROR	MICRO DATA LINK:	JERRY M. POTTER	1-DEC-77	
435	026B	FB					EI		#ENABLE INTERRUPTS	
436	026C	DB F8					IN	CSRA	#READ CSR	
437	026E	E6 02					ANI	RD	#TEST RD	
438	0270	C2 5D 00					JNZ	CLR1	#TIE, JMP TO CLR1	
439	0273	21 02 3D					LXI	H, HCKSUM	#LOAD HCKSUM ADDRESS	
440	0276	AF					XRA	A	#CLR A	
441	0277	77					MOV	M, A	#CLR HCKSUM	
442	0278	2B					DCX	H	#GET LCKSUM ADDRESS	
443	0279	77					MOV	M, A	#CLR LCKSUM	
444										
445									#TEST LAM CONTROL IN:	
446										
447	027A	16 10					RDATA:	MVI	D, LCI	#GET LCI BIT IN D
448	027C	CD F0 02						CALL	TIME	#TEST BIT & TIME OUT ROUTINE
449	027F	E6 10						ANI	LCI	#TEST FOR LCI
450	0281	C2 87 02						JNZ	NDATA	
451	0284	C3 5D 00						JMP	CLR1	#TIME OUT ENTRY 1
452										
453	0287	DB F8					NDATA:	IN	CSRA	#READ CSR
454	0289	E6 20						ANI	RI	#TEST RI
455	028B	CA A2 02						JZ	RCKSUM	#READ CKSUM
456	028E	DB F4						IN	DATAL	#READ L-BYTE
457	0290	86						ADD	M	
458	0291	77						MOV	M, A	#UP-DATE CKSUM
459	0292	23						INX	H	#LOAD HCKSUM ADDRESS
460	0293	DB F5						IN	DATAL	#READ H-BYTE
461	0295	8E						ADC	M	
462	0296	77						MOV	M, A	#UP-DATE CKSUM
463	0297	2B						DCX	H	#LOAD LCKSUM ADDRESS
464	0298	3E 04						MVI	A, LCO	#LAM CONTROL OUT
465	029A	D3 F9						OUT	CSRB	
466	029C	AF						XRA	A	#CLR A
467	029D	D3 F9						OUT	CSRB	
468	029F	C3 7A 02						JMP	RDATA	#READ DATA
469										
470	02A2	DB F4					RCKSUM:	IN	DATAL	#READ L-BYTE
471	02A4	86						ADD	M	
472	02A5	77						MOV	M, A	#UP-DATE CKSUM
473	02A6	23						INX	H	#LOAD HCKSUM ADDRESS
474	02A7	DB F5						IN	DATAL	#READ H-BYTE
475	02A9	8E						ADC	M	
476	02AA	77						MOV	M, A	#UP-DATE CKSUM
477	02AB	3E 04						MVI	A, LCO	#LAM CONTROL OUT
478	02AD	D3 F9						OUT	CSRB	
479	02AF	AF						XRA	A	#CLR A
480	02B0	D3 F9						OUT	CSRB	
481										
482										#TEST REQUEST IN:
483										
484	02B2	16 20						MVI	D, RI	#GET RI BIT IN D
485	02B4	CD F0 02						CALL	TIME	#TEST BIT & TIME OUT ROUTINE
486	02B7	E6 20						ANI	RI	#TEST FOR RI
487	02B9	C2 BF 02						JNZ	READY	#OTHER DL RDY FOR AK + NAK
488	02BC	C3 5D 00						JMP	CLR1	#TIME OUT ENTRY 1

```

LINE  ADDR  B1 B2 B3 B4 ERROR  MICRO DATA LINK:  JERRY M. POTTER  1-DEC-77

489
490 02BF 3E 20      ;
491 02C1 D3 F9      READY:  MVI  A,RMAR      ;RESET MAR
492 02C3 AF          OUT  CSRB
493 02C4 D3 F9      XRA  A          ;CLR A
494 02C6 BE          OUT  CSRB
495 02C7 C2 E1 02    CMP  M
496 02CA 2B          JNZ  NAKDL      ;NAK TO DATA LINK
497 02CB BE          DCX  H          ;LOAD LCKSUM ADDRESS
498 02CC C2 E1 02    CMP  M
499 02CF DB FA      JNZ  NAKDL      ;NAK TO DATA LINK
500 02D1 E6 01      IN   CSRC      ;READ CSR
501 02D3 C2 E1 02    ANI  BE        ;TEST BE
502 02D6 3E 08      JNZ  NAKDL      ;NAK TO DATA LINK
503 02D8 D3 F9      MVI  A,LAMG     ;CAMACH
504 02DA AF          OUT  CSRB
505 02DB D3 F9      XRA  A          ;CLR A
506 02DD 00          OUT  CSRB
507 02DE C3 DD 02    NOP
508                JMP  $-1         ;WNT + RST
509 02E1 3E 0B      ;
510 02E3 D3 FB      NAKDL:  MVI  A,0BH     ;BIT SET PE
511 02E5 3E 04      OUT  DEVO
512 02E7 D3 F9      MVI  A,LCD      ;LAM CONTROL OUT
513 02E9 AF          OUT  CSRB
514 02EA D3 F9      XRA  A          ;CLR A
515 02EC 00          OUT  CSRB
516 02ED C3 EC 02    NOP
517                JMP  $-1         ;WAIT FOR INT + RST
518                ;
519                ;SUBROUTINES:
520                ;
521                ;TEST BIT & TIME OUT SUBROUTINE:
522 02F0 01 C5 38    TIME:  LXI  B,38C5H     ;WAIT COUNT = 256MSEC MAX
523                ;COUNT = 17.615082 USEC/BIT
524                ;
525 02F3 DB F8      TSTBIT:  IN   CSRA      ;READ CSR
526 02F5 A2          ANA  D          ;TEST BIT
527 02F6 C0          RNZ          ;BIT TESTED = 1
528 02F7 0B          DCX  B          ;BUMP COUNT
529 02F8 7B          MOV  A,B
530 02F9 B1          ORA  C
531 02FA C2 F3 02    JNZ  TSTBIT      ;TEST BIT
532 02FD C9          RET             ;BIT TESTED = 0
533                ;
534                ;TIME OUT 2 SUBROUTINE:
535                ;
536 02FE CD 0B 03    TOUT2:  CALL  RESTOR     ;RESTORE ORIGINAL WC
537 0301 3E 08      MVI  A,LAMG     ;NAK SENDING COMPUTER
538 0303 D3 F9      OUT  CSRB
539 0305 AF          XRA  A          ;CLR A
540 0306 D3 F9      OUT  CSRB
541 030B C3 70 00    JMP  ENAB      ;TIMED OUT ENTRY 2
542                ;

```

LINE ADDR B1 B2 B3 B4 ERROR MICRO DATA LINK: JERRY M. POTTER 1-DEC-77

```

543                                     ;RESTORE ORIGINAL WC SUBROUTINE:
544                                     ;
545 030B 3E 20      RESTOR: MVI    A,RMAR      ;RESET RAM ADDRESS
546 030D D3 F9      OUT     CSRB
547 030F AF        XRA     A                ;CLR A
548 0310 D3 F9      OUT     CSRB
549 0312 DB F4      IN      DATAL          ;READ L-BYTE
550 0314 5F        MOV     E,A            ;SAVE L-BYTE WC
551 0315 3E A4      MVI     A,CONT3       ;GET CONTROL WORD 3
552 0317 D3 F7      OUT     DEV1          ;SET RAM PORT TO WRITE MODE
553 0319 7B        MOV     A,E            ;GET L-BYTE WC
554 031A 3C        INR     A              ;ADD +1 TO THE WC
555 031B D3 F4      OUT     DATAL
556 031D 3E 09      MVI     A,09H         ;BIT SET PIC4
557 031F D3 F7      OUT     DEV1          ;RESET OBFA
558 0321 3E 08      MVI     A,08H         ;BIT RESET PIC4
559 0323 D3 F7      OUT     DEV1
560 0325 3E 9E      MVI     A,CONT2       ;GET CONTROL WORD 2
561 0327 D3 F7      OUT     DEV1          ;SET RAM PORT TO READ MODE
562 0329 C9        RET
563 032A           END

```

TOTAL ASSEMBLER ERRORS = 0

MICRO DATA LINK: JERRY M. POTTER 1-DEC-77

SYMBOL TABLE

* 1

A	0007	ACKCOM	023B	ACKDL	007C	B	0000
BE	0001	C	0001	CL1	0040	CL1MAR	0060
CLR1	005D	CONT1	0091	CONT2	009B	CONT3	00A4
CSRA	00F8	CSRB	00F9	CSRC	00FA	D	0002
DATA	0134	DATAL	00F5	DATAL	00F4	DEVO	00FB
DEV1	00F7	DNLNLD	010C	E	0003	ENAB	0070
FLAG	0080	H	0004	HCKSUM	3D02	IMAR	0010
INIT	0040	INT0	0038	INT1	0030	INT2	0028
INT3	0020	INT4	0018	INT5	0010	INT6	0008
INT7	0000	INTMSK	007F	L	0005	LAM0	0008
LAMPA	000A	LCI	0010	LCKSUM	3D01	LCD	0004
LE	0001	M	0006	MSK1	0081	MSK2	00BF
NAKCOM	024B	NAKDL	02E1	NDA	0287	NTT	3D00
ORAM	01B0	PA	0002	PAIN	0008	PALCO	0006
PSW	0006	RCKSUM	02A2	RDATA	027A	READY	02BF
REGIN	0267	RESTOR	030B	RETRY	0188	RI	0020
RMAR	0020	RD	0002	RRAM	025A	SDMSG	0170
SIX0	00E0	SETRAM	004B	SETRO	00EC	SP	0006
STK	3E00	TIE	00FC	TIME	02F0	TOUT2	02FE
TRAM	00AD	TSTBIT	02F3	TSTLE	0066	TSTWC	0155
WCSR	00C8	WRST	00C3	XI	0040	XIN	00A2
XLCO	0005	X0	0001	XOC	0004	Y1	01C5
Y2	020C	Y3	022A				
STOP	--						

R PIP
*IT:DX1:UDL.OBJ

:0600000031003EC3400088
:03000800C3A20090
:03001000C30C011D
:03001800C37001B1
:03002000C3AD006D
:03002800C3C8004A
:03003000C36702A1
:04003800C33800C9
:1E004000DBFAE680CA4B003E91D3FB3E9BD3F7DBFB47E640C2A20078E620C27C003E74
:1E005E0060D3F9AFD3F9D3FADBF8E601C27000C36600310C3E3E81D37FFB00C3780045
:1E007C003E20D3F9AFD3F93EA4D3F7AFD3F4D3F53E09D3F73E08D3F73E9BD3F73E06CF
:1E009A00D3F9AFD3F9C35D003E08D3F9AFD3F900C3A9003E8FD37FFBDBF8E602CAC356
:1E00B8000003E20D3F9AFD3F9C33E023E81D37FC93EBFD37FFBDBF847E604C2E0007840
:1E00D600E602C2EC003E81D37FC93E05D3F9AFD3F93E81D37FC93E09D3FBDBF8E6204A
:1E00F400C2FC003E81D37FC93E40D3F9AFD3F93E08D3FB3E81D37FC93EBFD37FFBDB7E
:1E011200F8E602CA4E023E20D3F9AFD3F9DBF45FDBF557E6FEFEFEC24E02133E10D3B5
:1E013000F9AFD3F93E04D3F9AFD3F9D51610CDF002E610C255013E20D3F9AFD3F93E09
:1E014E0008D3F9AFC37000D1137AB3C234013E20D3F9AFD3F93E0AD3F93E02D3F93ED2
:1E016C0081D37FC93EBFD37FFBDBF8E602CA4E0221003D36003E20D3F9AFD3F921025E
:1E018A003DDBF57757E6FEFEFEC24E022BDBF45F3EA4D3F77B3D77D3F43E09D3F73E40
:1E01A80008D3F73E9BD3F7233E04D3F9AFD3F9D51610CDF002E610C2C501CDFE02D142
:1E01C600137AB3C25A02D3FA2B9677233E009E773EA4D3F73A013D03F43E09D3F73E08
:1E01E40008D3F73A023DD3F53E09D3F73E08D3F73E9BD3F73E04D3F9AFD3F91610C5AA
:1E020200F002E610C20C02CDFE023E40D3F9AFD3F93E09D3FB1610CDF002E610C224BE
:1E02200002CDFE02DBF8E608C23B0221003D343E0ABECA4B02CD0B03C38801CD0B0380
:1E023E003E0AD3F93E02D3F93E81D37FC9CD0B033E08D3F9AFD3F93E81D37FC92BDB60
:1E025C00F4867723DBF58E77C3B0013EBFD37FFBDBF8E602C25D0021023DAF772B77DB
:1E027A001610CDF002E610C28702C35D000D2F8E620CAA202DBF4867723DBF58E772BEA
:1E0298003E04D3F9AFD3F9C37A02DBF4867723DBF58E773E04D3F9AFD3F91620CDF040
:1E02B60002E620C2BF02C35D003E20D3F9AFD3F9BEC2E1022BREC2E102DBFAE601C26B
:1E02D400E1023E08D3F9AFD3F900C3D0023E0BD3FB3E04D3F9AFD3F900C3EC0201C5E3
:1E02F20038DBF8A2C00B78B1C2F302C9C00H033E08D3F9AFD3F9C370003E20D3F9AF59
:1A031000D3F9DBF45F3EA4D3F77B3CD3F43E09D3F73E08D3F73E9BD3F73E922
:0000000000

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