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A LOW POWER DATA ACQUISITION SYSTEM

by

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THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

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I. INTRODUCTION

The purpose of a data-acquisition system is to acquire and store information of interest in a number of analog signals for later evaluation. This is accomplished by sampling the signals at a sufficiently high rate to preserve the desired information, digitizing these samples, and storing the digital data (1).

The data-acquisition system in this report is designed primarily for wind prospecting at remote locations, as shown in Fig. I.1. It is based upon the RCA CDP18S020 Evaluation Kit (2) which uses the RCA CDP1802 COSMAC microprocessor (3). A Datel model ICT-WZ1 low-power, incremental-digital-cassette recorder is used for mass data storage. Power is supplied by a +12 volts automobile lead-acid storage battery driving a switching regulator that supplies ±12 volts and +5 volts D.C.

The system is designed to work with standard U.S. Weather Bureau Type F-420-C wind speed and wind direction transducers supplied by the Electric Speed Indicator Company. Temperature measurements are made by means of Analog Devices AD590 two-terminal temperature transducers.

The instruments are sampled at five times per second, 50 minutes out of each hour. The resulting data are stored on a standard digital cassette tape which will hold up to one week's data.

The system is initialized using the RCA COSMAC microterminal. After initialization, the system will operate indefinitely, requiring only the digital cassette tape to be changed once a week (4).

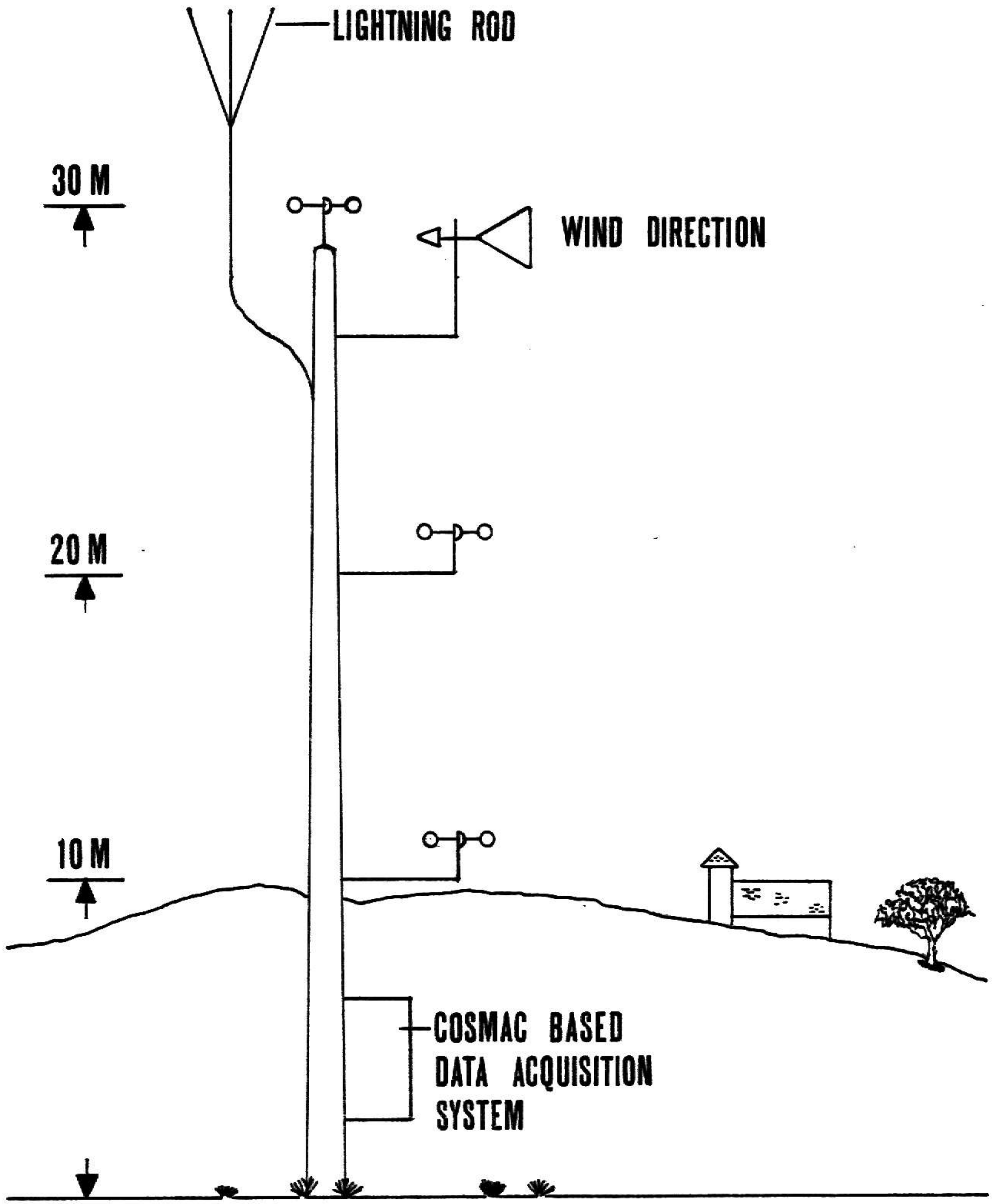


FIG. I.1 TYPICAL FIXED INSTALLATION FOR A WIND ENERGY INSTRUMENTATION SYSTEM

II. SYSTEM OPERATION

The system flow chart is shown in Fig. II.1. During the first 50 minutes of each hour, the analog multiplexer samples each anemometer and the wind direction indicator five times per second. Each analog reading is digitized and the 8-bit result shifted to leave a 7-bit binary number which forms the address to one of 128 sixteen-bit data bins. Each bin so addressed is incremented by one. In effect, histograms of the wind speed and wind direction measurements are constructed in data memory. A record is also kept of the differences between consecutive wind direction measurements. Figure II.2 shows how the bins are identified (1).

During the remaining ten minutes of each hour, if the internal temperature of the box is greater than -10°C, the internal temperature, external temperature, and barometric pressure are recorded on tape with each reading followed by a checksum. If the internal temperature is less than -10°C, no data are recorded. The individual transducer readings are then followed by the current real-time clock reading and the contents of the bins (1).

Information is written onto tape with the microprocessor driving both the stepper motor and the tape heads. The real-time software clock program is interleaved within the data acquisition and record programs and counts in minutes, hours, and days of the year (1).

Various data output formats have been used, but typically the current reading of the real-time clock is serially recorded on tape at the beginning of each write-on-tape period. This is followed by a checksum and a sixteen-bit file gap. Each set of 128 bins is

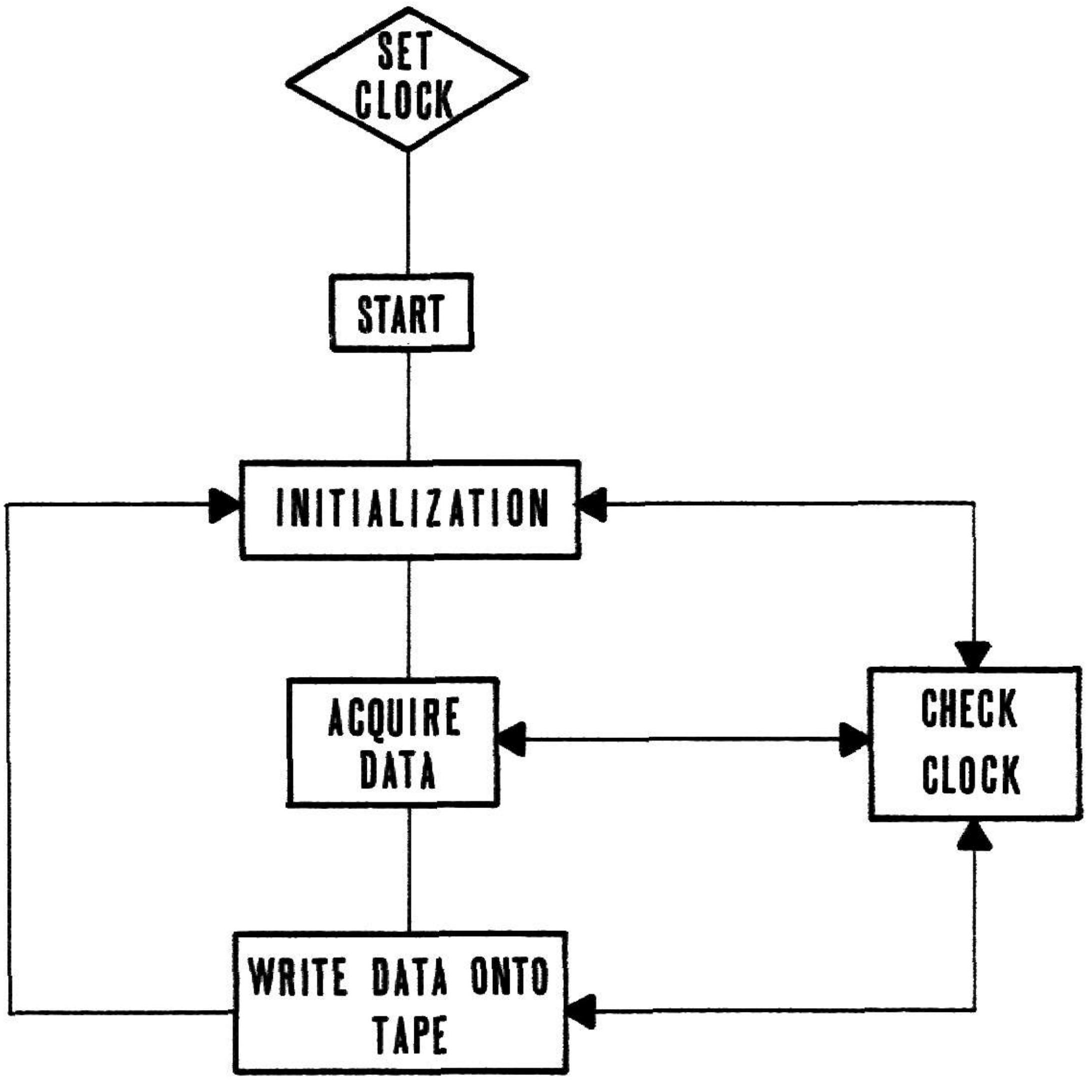


FIG. II.1 SYSTEM FLOW CHART

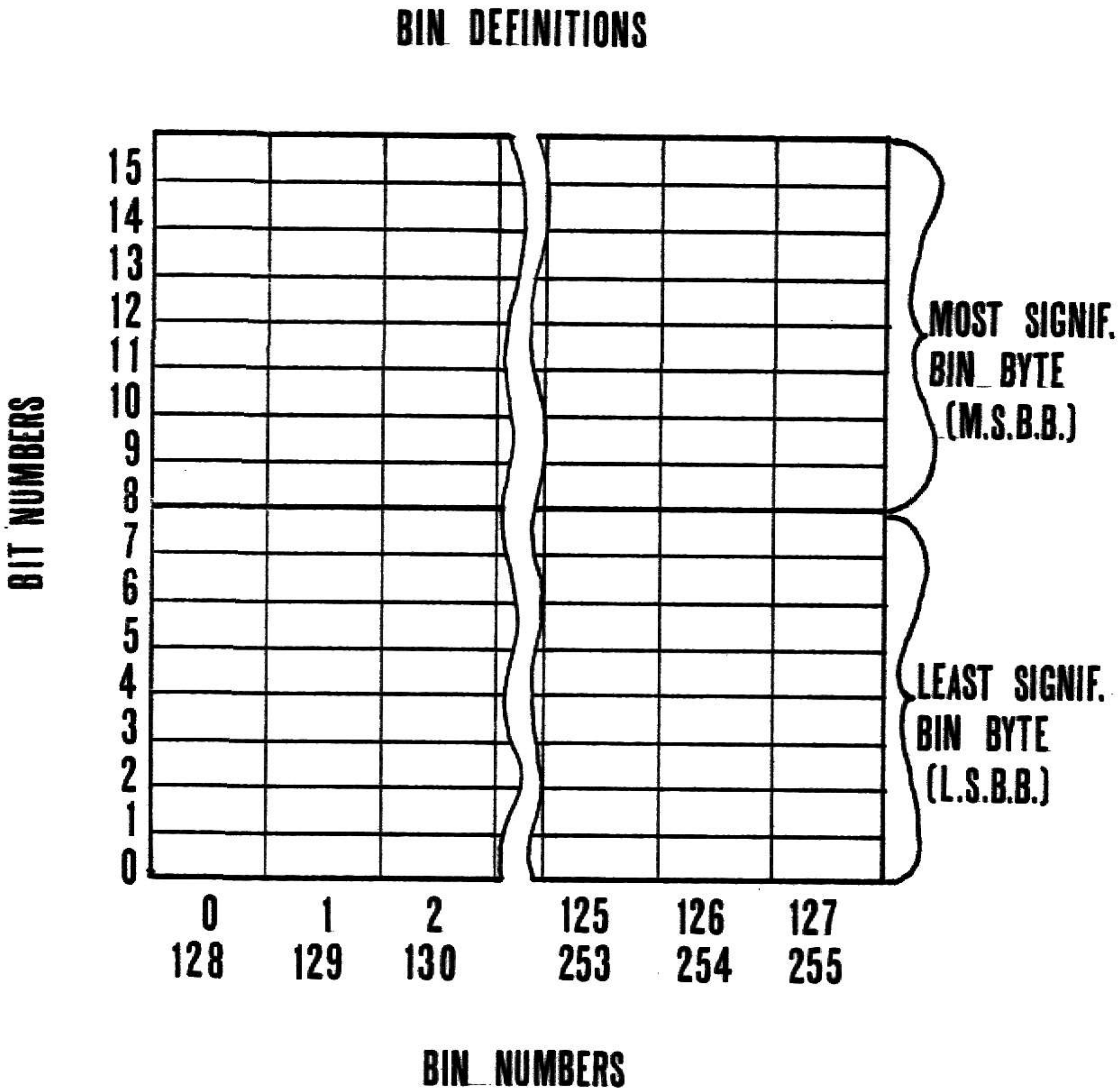
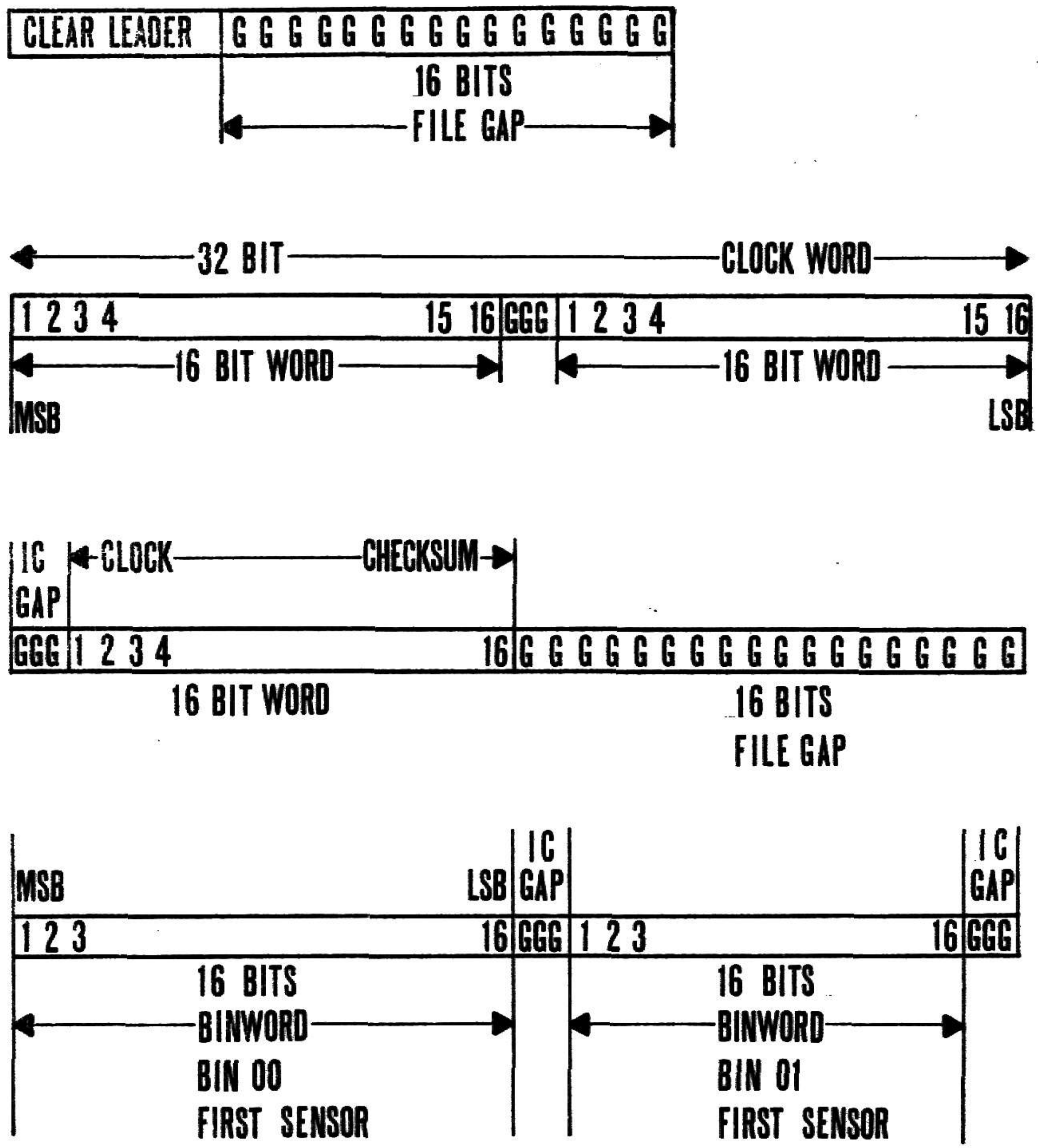


FIG. II.2 METHOD OF IDENTIFYING WIND DATA BINS followed by a checksum and another sixteen-bit file gap. Each sixteen-bit word is separated from its neighbor by a 3-bit intercharacter gap (IC). Each binword is recorded most significant bit (MSB) first. A typical output sequence is shown in Fig. II.3. With the procedure just described, the system will record data for at least one week on a standard certified-digital cassette tape (1,7).



AT END OF 128 BINWORDS FOR THE FIRST SENSOR THERE WILL BE A 16 BIT CHECKSUM FOLLOWED BY A 16 BIT FILE GAP.

FIG. II.3 TYPICAL TAPE RECORDING SEQUENCE

III. ELECTRONIC HARDWARE

A data flow diagram for the data-acquisition system is shown in Fig. III.1. Analog signals from the anemometers and wind direction indicator are connected via shielded cables and lightning protectors to matching networks. The matching networks are connected to the multiplexer inputs via one-pole RC filters, with half-power bandwidths of 20 Hz. Each filter is buffered by a TL061, JFET input, operational amplifier used as a voltage follower. A CMOS CD4051 multiplexer is used in conjunction with a Teledyne 8703 8-bit analog to digital converter. The AD590 temperature sensors are connected to the multiplexer via current divider circuits. A complete block diagram is shown in Fig. III.2.

The CPU, RAM, and Monitor ROM for the RCA microterminal are mounted on the CDP18S020 COSMAC evaluation board. The EPROM, multiplexer, analog to digital converter, input/output ports, and other support hardware, are mounted on the analog/digital interface board. The boards are innerconnected via a 24 pin ribbon connector, and one extra wire.

The Datel low-power, incremental, cassette transport is stepper motor driven and uses complementary non-return to zero (CNRZ) recording on two data tracks (5). It is connected to the CPU via four National CMOS DS3631 peripheral drivers wired to an output port on the A/D interface board. Two of the drivers feed the recording heads and the other two the stepper motor coils. The tape heads and the stepper motor operate from +12 volt D.C. During the time that the tape recorder is not being used, the peripheral drivers outputs are all set high in order to conserve power.

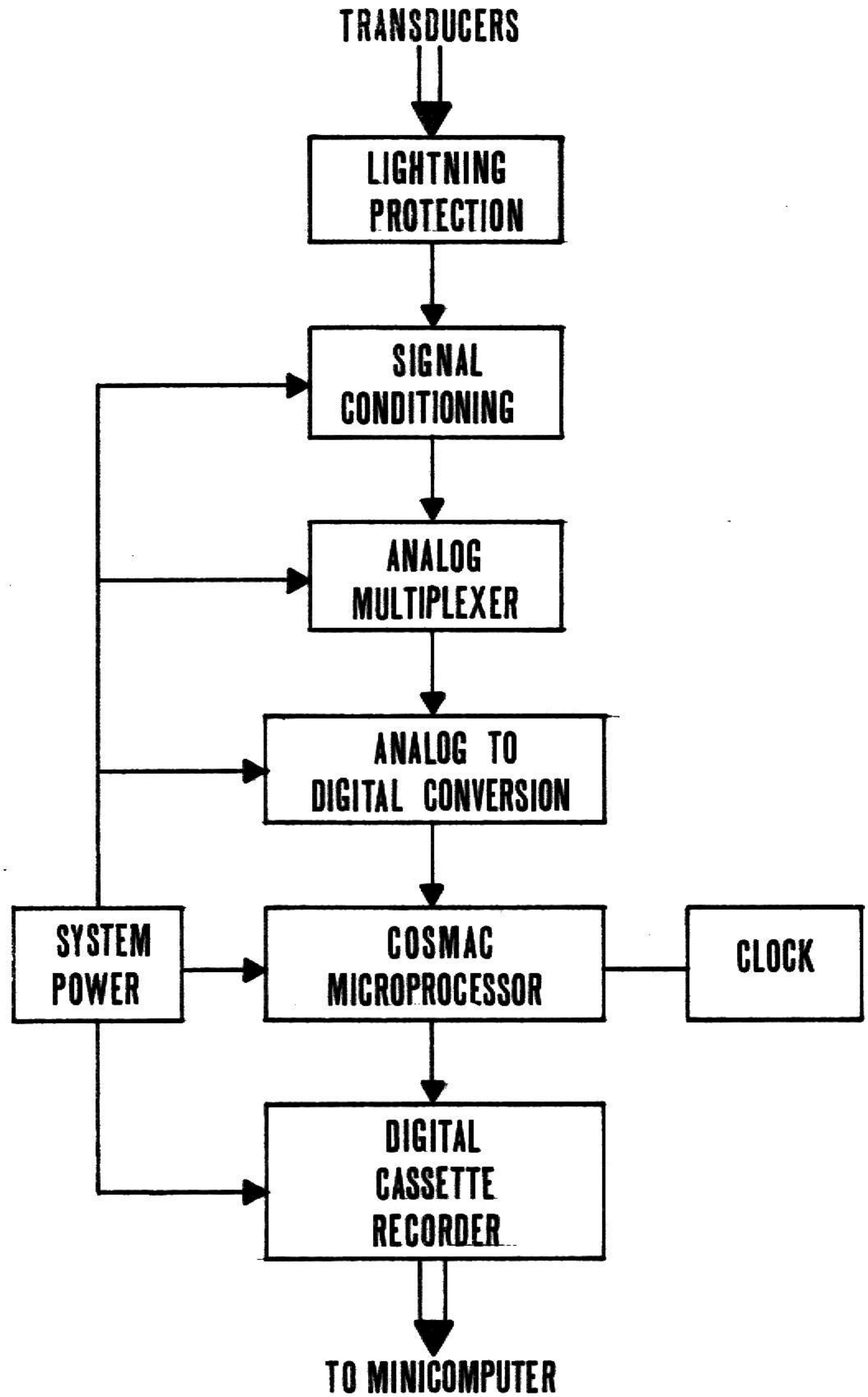


FIG. III.1 DATA FLOW DIAGRAM

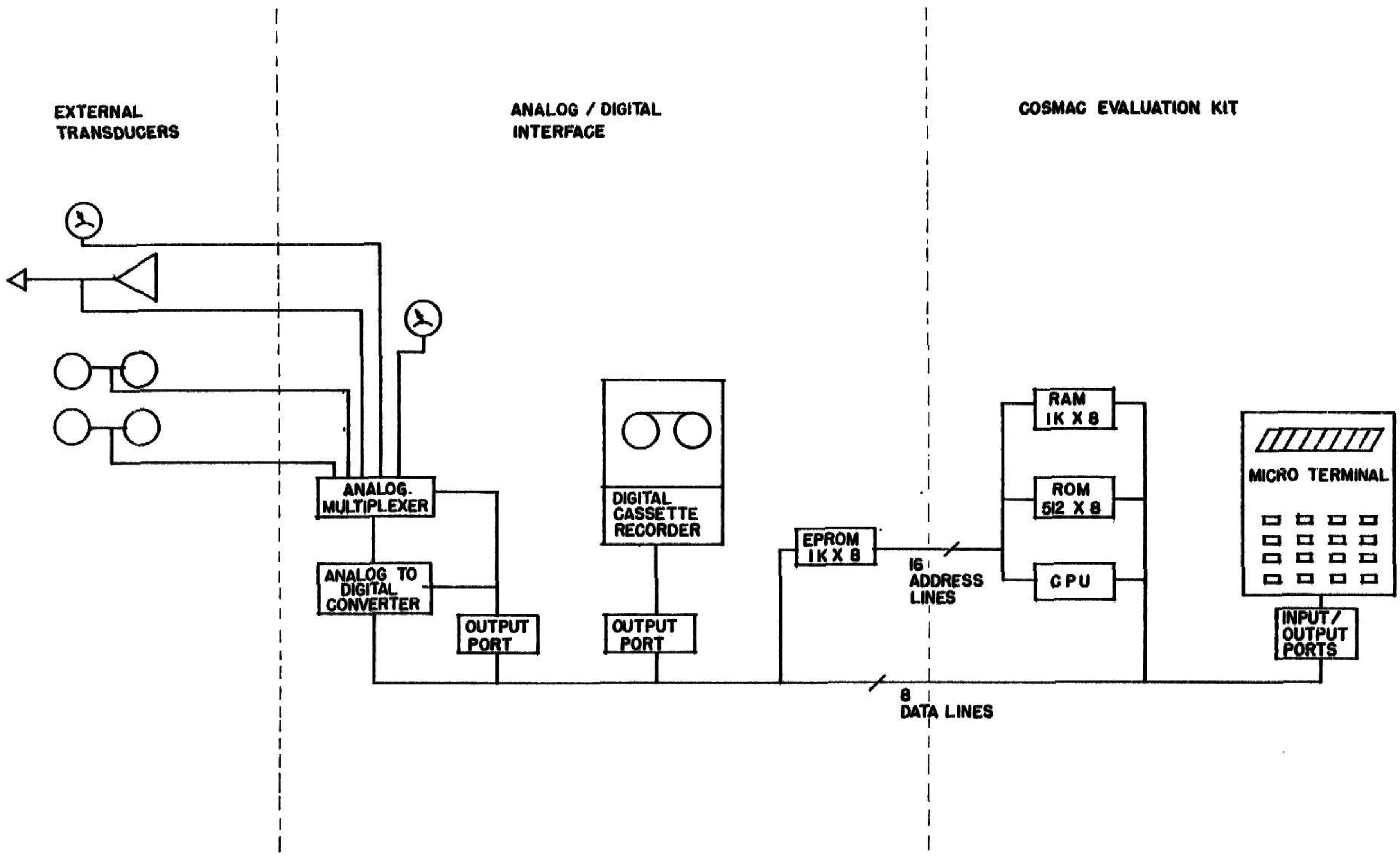


FIG. III.2 BLOCK DIAGRAM OF THE DATA ACQUISITION SYSTEM

The real-time clock is initialized and the system started by means of the RCA COSMAC handheld microterminal (4). This may also be used to run diagnostic programs stored with the main program in the Intersil IM6654 EPROMs (7).

The microterminal is disconnected from the COSMAC board once the system is running. This enables the microterminal to be used at a number of different sites (1).

Schematics of the RCA COSMAC Evaluation Board are at Figs. III.3 and 4 (2). Schematic of the Analog/Digital Interface Board are at Figs. III.5 and 6.

System power is derived from a +12v lead-acid storage cell running an external switching regulator which outputs ±12 volts and +5 volts. A -5 volt reference voltage is generated by a TL061 inverting amplifier on the analog board.

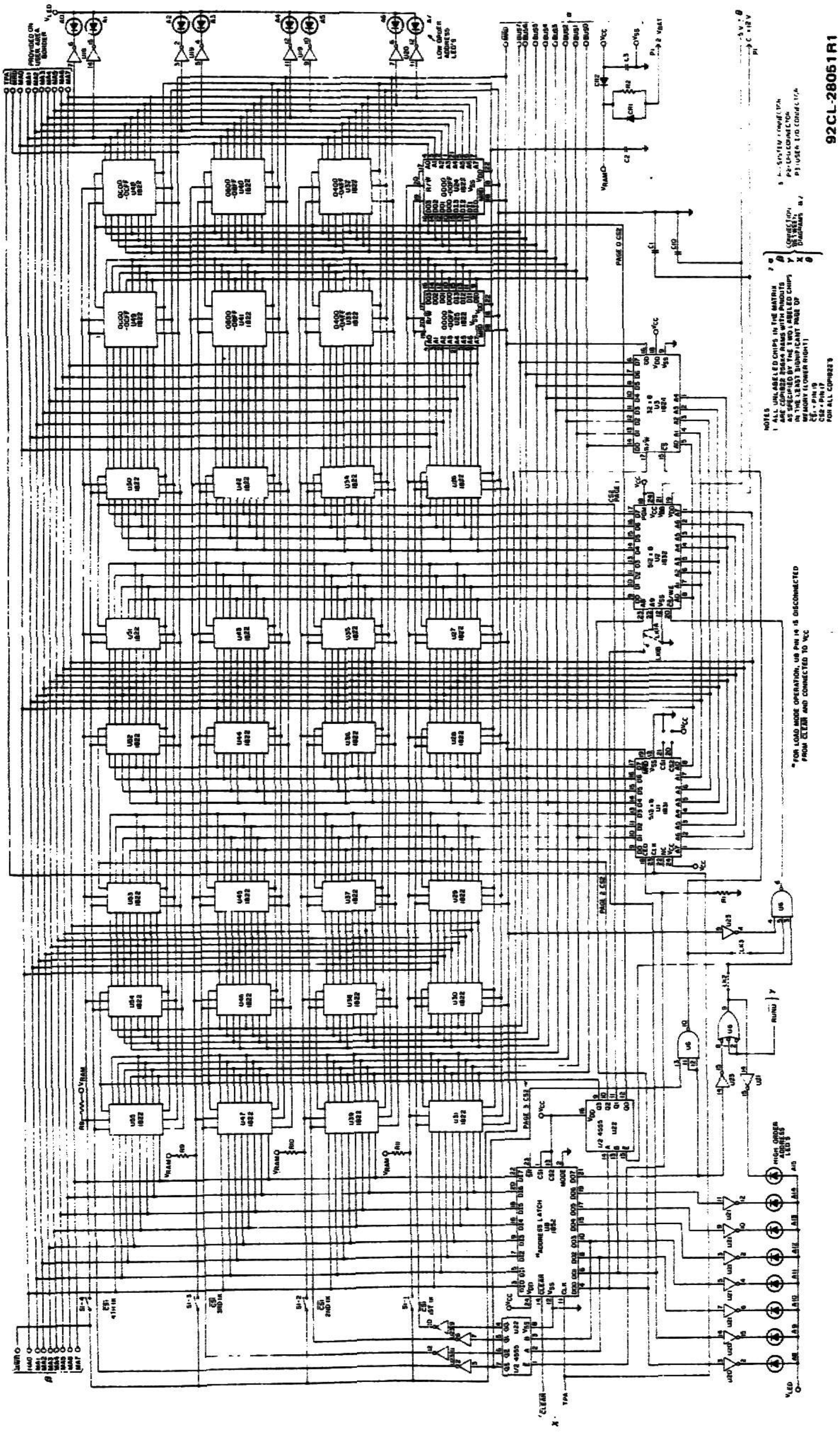


FIG. III.3 RCA COSMAC CPU, CONTROL AND I/O LOGIC SCHEMATIC

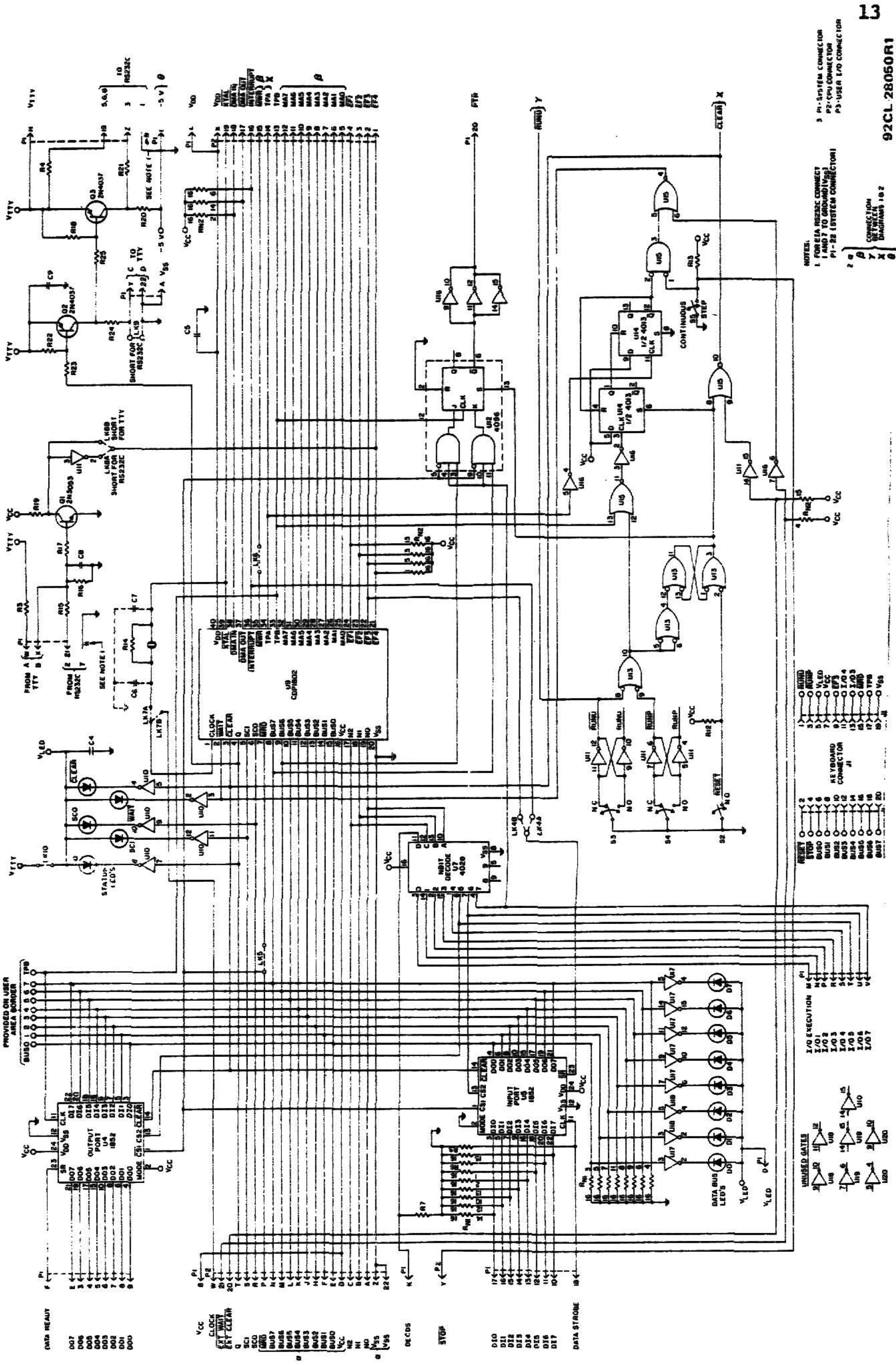


FIG. III.4 RCA COSMAC LOGIC DIAGRAM OF MEMORY ORGANIZATION

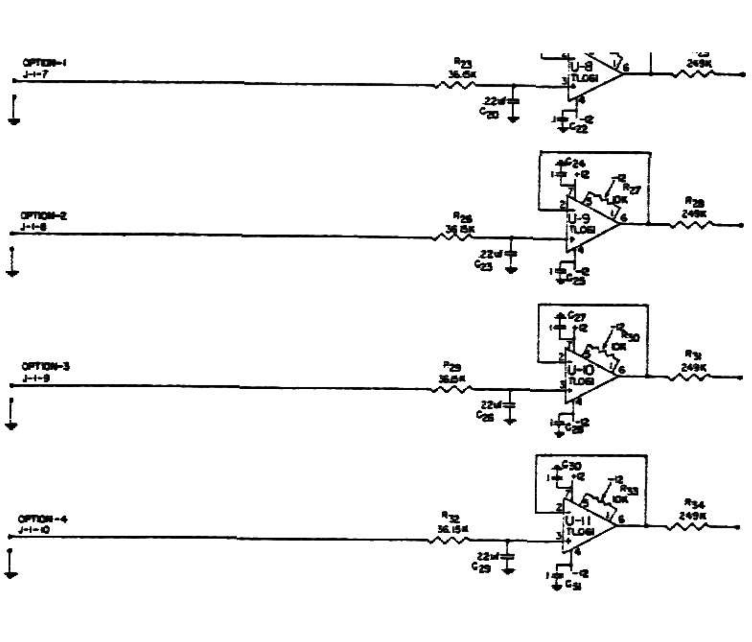


FIG. III-5 ANALOG INTERFACE BOARD SCHEMATIC

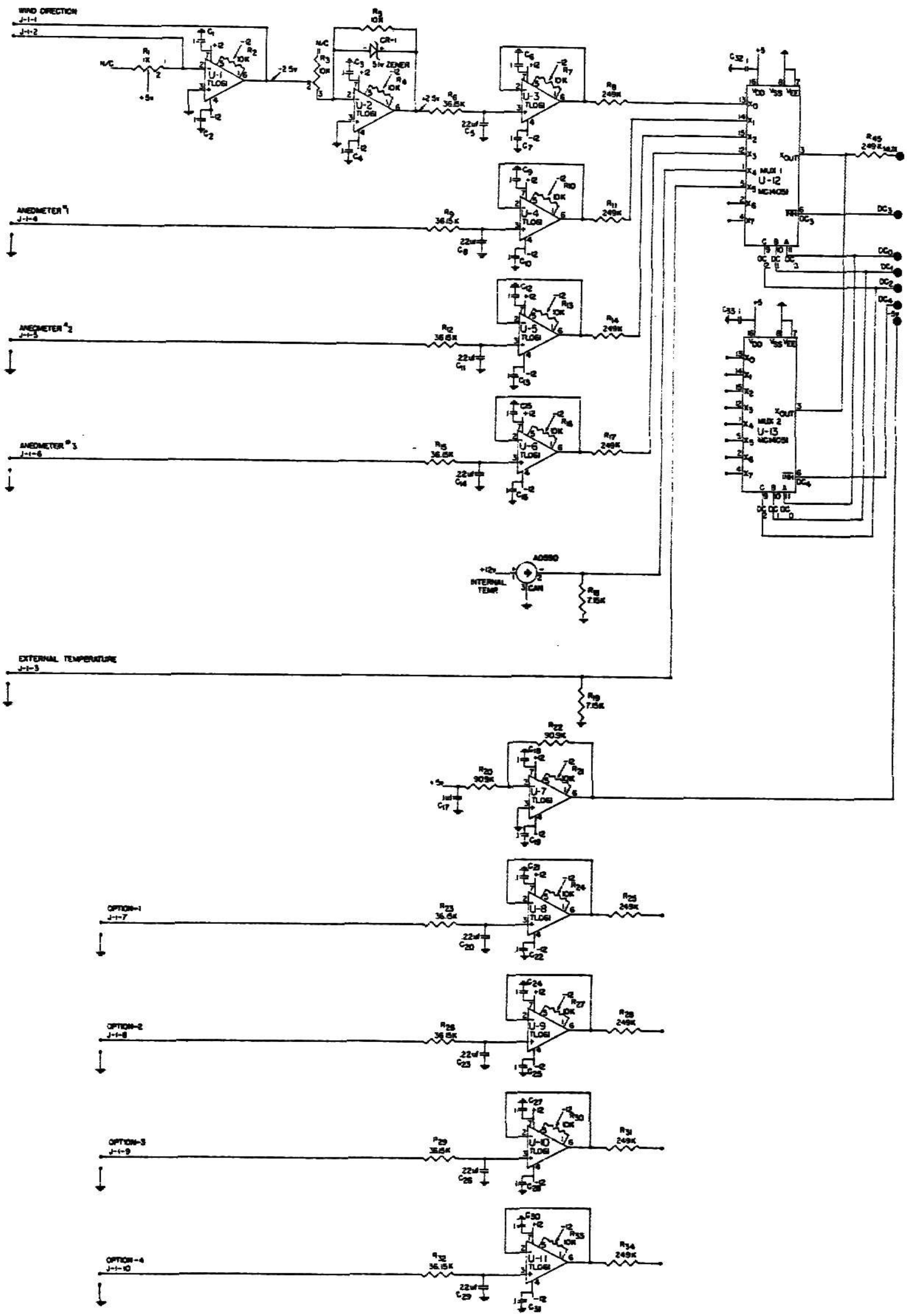


FIG. III-5 ANALOG INTERFACE BOARD SCHEMATIC

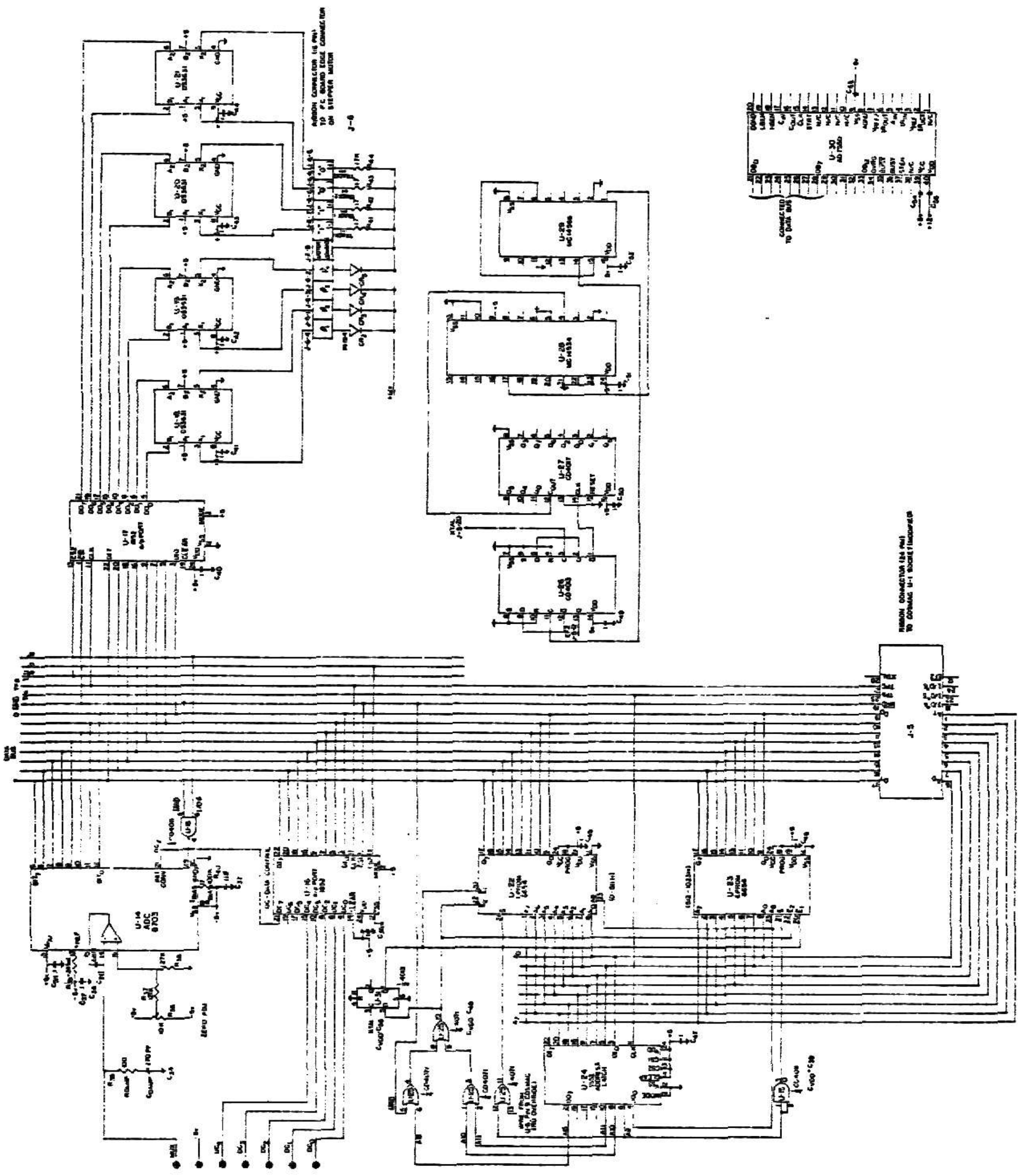


FIG. III-6 DIGITAL INTERFACE BOARD SCHEMATIC

IV. SYSTEM SOFTWARE

The total program is less than a kilo-byte and is divided into the following four main sections: (7)

1. Initialization
2. Data-acquisition and bin
3. Write-data-onto-tape
4. Real-time clock

The most complex section is the third which contains the stepper-motor drive routines, tape head drivers, parallel to serial conversions, and checksum calculations.

In the real-time clock program a digital divider circuit, on the A/D interface, provides a square wave input to the CPU's $\overline{\text{EF.2}}$ from the 2 MHz system clock. The square wave has a period of 2 minutes (1,7). The software clock program samples $\overline{\text{EF.2}}$ at frequent intervals and then maintains the updated values of minutes, hours, and days in registers R(7).0, R(7).1, R(8).0 and R(8).1. Register R6 is used as the program counter for the clock (7).

Data retrieval is achieved by means of a Datel LPR-16 cassette tape reader (6) which has been converted into a smart peripheral by the addition of an RCA COSMAC CDP18S020 Evaluation Board. The micro-processor converts the retrieved data into standard teletype format and communicates via 20mA current loops with a teletype or minicomputer. The data conversion program used in the COSMAC microprocessor is stored on paper tape if working to a teletype and floppy disk if working to a minicomputer (1,7).

V. APPLICATIONS

The battery-powered, CMOS, data-acquisition system described in this report was designed primarily for wind prospecting at remote locations using standard U.S. Weather Bureau wind direction and wind speed transducers. The use of a standard transducer enables realistic comparisons to be made with existing weather records, and if necessary, to wire the data-acquisition system into existing weather installations (1).

The system can easily be adapted to other applications requiring the collection of large amounts of data over a period of time, such as solar energy via a solar cell, or humidity and barometric pressure. It could also be adapted for use as a traffic counter to determine the traffic density and peak periods.

However, the system described in this report primary advantage over any other data-acquisition system available, is its ability to operate for an indefinite period of time on one standard inexpensive battery. This low power consumption feature is not found in other similar systems.

VI. CONCLUSIONS

A microprocessor based, low-power, data-acquisition system has been designed and built for taking large amounts of data reliably in remote areas. The system can be easily adapted to a wide variety of applications, and can be built at a reasonable cost.

VII. REFERENCES

1. Lucas, M.S.P., G. L. Johnson, "A Microprocessor Based, Low-Power, Data-Acquisition System," Conference Proceedings, Industrial and Control Applications of Microprocessors, March, 1979.

2. Evaluation Kit Manual for the RCA CDP1802 COSMAC Microprocessor, RCA, Solid State Division, Somerville, N.J. 08876, Copyright 1976.

3. User Manual for the CDP1802 COSMAC Microprocessor, RCA, Solid State Division, Somerville, N.J. 08876, Copyright 1977.

4. Instruction Manual for the RCA COSMAC Microterminal, RCA, Solid State Division, Somerville, N.J. 08876, Copyright 1977.

5. LPS-16 Cassette Data Logger Instruction Manual, Doc. No. LPSDMH 3705., Datel Systems, Inc., 1020 Turnpike Street, Canton, Mass. 02021, Copyright 1976.

6. LPR-16 Cassette Tape Reader System Instruction Manual, LPR-M0411, January 1975, Datel Systems, Inc., 1020 Turnpike Street, Canton, Mass. 02021.

7. Low-Power, Data-Acquisition, System Software Manual, M.S.P. Lucas, 1979. Pending Publication.

VIII. ACKNOWLEDGMENTS

The author would like to thank his major professor, Dr. Michael S. P. Lucas and Graduate Committee members, Dr. Gary L. Johnson and Dr. Corwin A. Bennett, for their support and guidance throughout this project. The author also thanks his family for their support and the United States Army for the opportunity and financial support to attend Graduate School.

APPENDIX I: USER MANUAL

AI.1 INTRODUCTION

The low-power, data-acquisition system, in its minimal form, allows the user to digitize six analog inputs for wind prospecting. However, with a minimum of additional hardware, the system can be expanded to utilize the ten additional analog inputs available. This allows the system to be used for many other applications.

This User Manual describes the assembly, alignment and operation of the low-power, data-acquisition system, in its minimal form.

The analog/digital interface assembly is divided into the analog board and digital board areas. The two boards are separate because of the nature of their functions. They are capable of independent operation, but for this application are interconnected by jumper wires.

The modifications required for the COSMAC Evaluation Board are then discussed. This is followed by a detailed system alignment procedure and operational check.

A detailed hardware description is given in Appendix AII.

As a general note, insure that any unused CMOS I.C. input is connected to ground. A CMOS device will not function properly if an input is allowed to float.

When selecting discrete components, consideration should be given to the anticipated climatic extremes over which the system is expected to function.

AI.2 ANALOG BOARD

The main function of the analog board is to filter and buffer the analog input signals. Following signal conditioning, the signals are connected to the analog multiplexer for selection into the analog to digital converter located on the digital board.

The analog board also contains the -5 volt reference voltage for the analog to digital converter, and the internal temperature transducer. These functional areas are shown in Fig. AI.1.

The analog board assembly is relatively simple, however it is recommended that a little time be spent in becoming familiar with the parts placement and functional areas prior to assembly or use. The parts required for the minimal system analog board are in Table AI.1. These parts should be identified and located near the assembly area.

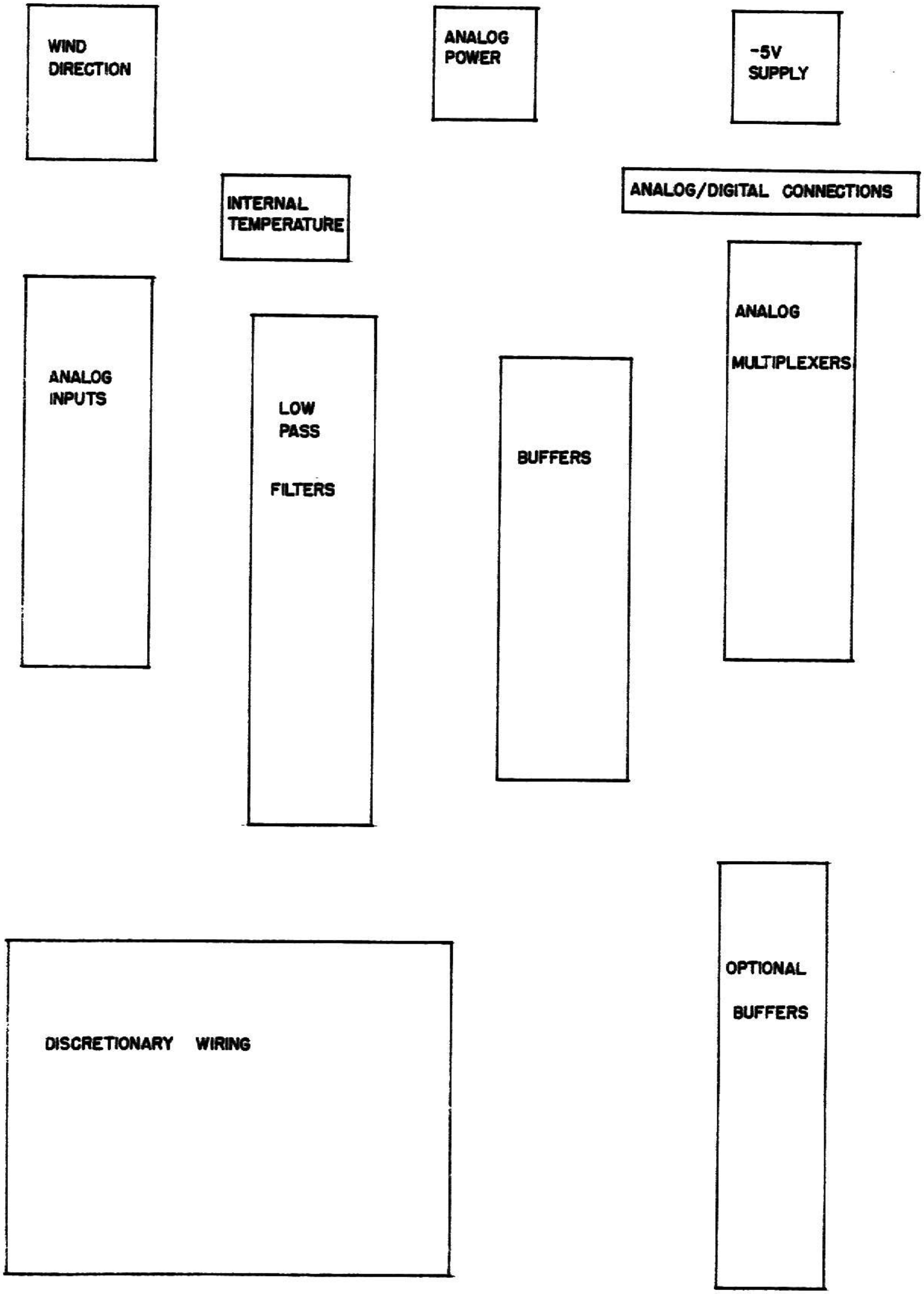


FIG. AI.1 ANALOG BOARD FUNCTIONAL AREAS

TABLE AI.1 ANALOG BOARD PARTS LIST - MINIMAL SYSTEM

Type Number	Analog ID#	Qty.	Description
--	--	1	Analog Printed Circuit Board, R.C.H., July 1979
TL061	U-1 thru U-7	7	JFET Operational Amplifier
CD4051	U-12	1	Analog Multiplexer
AD590	AD590	2	Two Terminal I.C. Temperature Transducer
--	C-1 thru C-4, C-6, C-7, C-9, C-10, C-12, C-13, C-15 thru C-19, C-32	16	.1 Microfarad, Ceramic Disc Capacitor
--	C-5, C-8, C-11, C-14	4	.22 Microfarad Mylar Capacitor
--	R-1	1	1K Ohm Trim Pot
--	R-2, R-3, R-4, R-7, R-10, R-13, R-16, R-21	8	10K Ohm Trim Pot
--	R-20, R-22	2	90.9K Ohm, 5%, 1/4 Watt Resistor
--	R-5	1	10K Ohm, 5%, 1/4 Watt Resistor
--	R-6, R-9, R-12, R-15	4	36.15K Ohm, 5%, 1/4 Watt Resistor
--	R-8, R-11, R-14, R-17, R-45	5	249K Ohm, 5%, 1/4 Watt Resistor
--	R-18, R-19	2	7.15K Ohm, 5%, 1/4 Watt Resistor
IN4733	CR-1	1	5.1v Zener Diode
308-AG39 D	For U-7	1	8-pin DIP Socket
316-AG39 D	For U-1/2, U-3/4, U-5/6, U-12	4	16-pin DIP Socket
324-AG39 D	J-2	1	24-pin DIP Socket
DB-25SF179	J-1	1	25-pin Cinch Socket
09-18-5063	J-3	1	6-pin Molex 1840-6 Series Connector

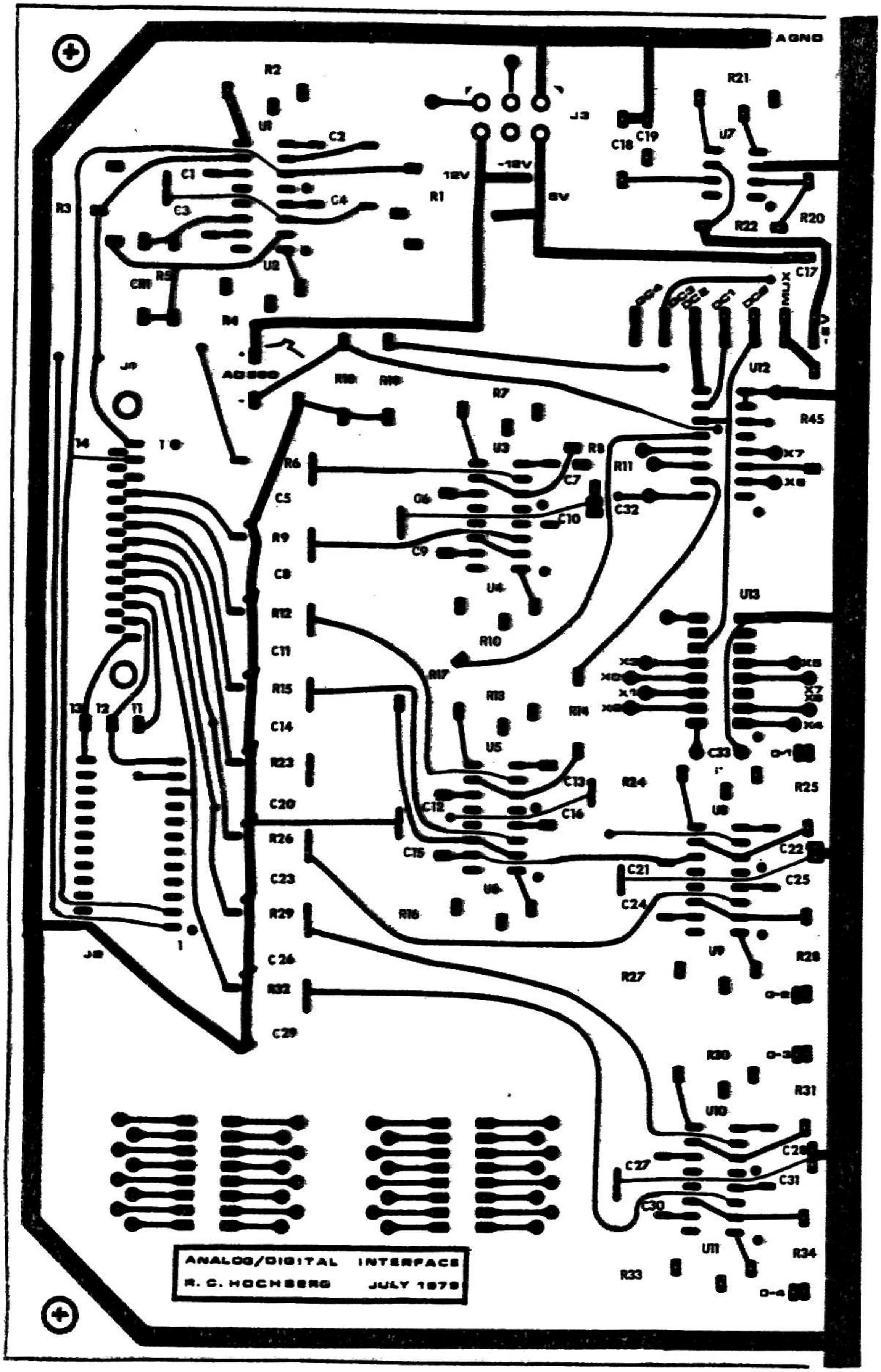


FIG. AI.2 ANALOG PRINTED CIRCUIT BOARD (TOP SIDE)

Table AI.2 shows the parts for optional user expansion. This will be covered later.

To assist the user in the assembly of the analog minimal system, a step by step procedure is given below:

1. Locate the analog printed circuit board and parts required in Table AI.1.
2. Orient the PC Board as shown in Fig. AI.2. This is the component side of the board. All soldering will be done on the reverse side.
3. Specific discrete component assembly instructions.
   a) Mount and solder the 8, 16, and 24 pin DIP sockets at locations U-7, U-1/2, U-3/4, U-5/6, U-12 and J-2, respectively.
   b) Mount and solder the 25 pin, DB-25 socket to J-1, and the 6-pin power socket to J-3, as indicated.
   c) Mount and solder trim pots. R-1 thru 4, R-7, R-10, R-13, R-16, and R-21, as indicated.
   d) Mount and solder resistors; R-5, R-6, R-8, R-9, R-11, R-12, R-14, R-15, R-17 thru 20, R-22 and R-45, as indicated.
   e) Mount and solder capacitors C-1 thru 19 and C-32, as indicated.
   f) Mount and solder the internal temperature transducer AD-590. Insure the tab is aligned as indicated.
   g) Mount and solder Diode CR-1. Insure the positive side (band) is toward the top of the board.
   h) Insert IC's U-1 thru 7 and U-12 as shown. Insure all pin 1's are located toward the lower right side of the board as indicated by the dots next to pin 1.

4. All unused CMOS device inputs must be connected to ground. In the minimal system, inputs 6 and 7 of U-12 are unused and must be jumper wired to ground.

<u>Alignment</u>

The Analog Board is now assembled and ready for power and alignment. The alignment consists of adjusting the wind direction input to compensate for different transducer impedances, and adjusting the operational amplifier offsets to a null value.

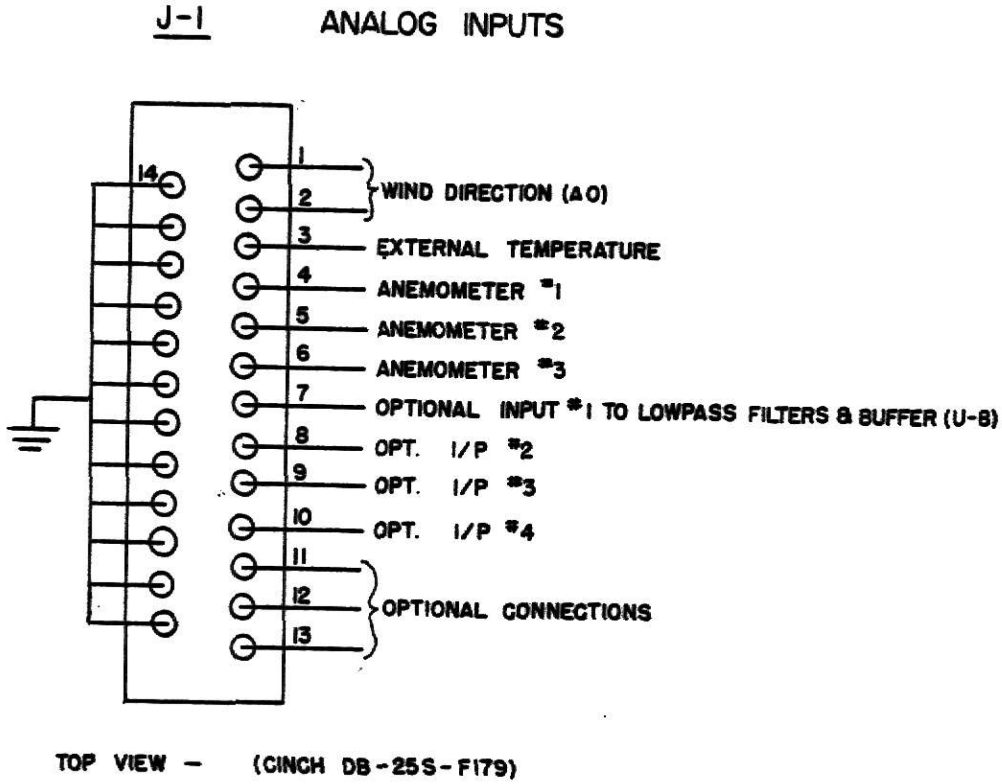
Make up a DB-25 connector. A 220 Ohm resistor should be connected across pins 1 and 2. This will simulate the maximum impedance of a wind direction indicator. Connect pins 3 thru 6 to ground. Insert this connector in J-1. See Fig. AI.3.

Now connect power to J-3 as shown in Fig. AI.4. Verify correct power to the ICS, referring to Fig. AI.5 as necessary.

Make the adjustments below in the sequence shown.

1. U-1/2, wind direction.
   a) Adjust R-1 and R-2 to give -2.5 v. on pin 6, U-1.
   b) Adjust R-3 and R-4 to give +2.5 v. on pin 6, U-2.
   c) Recheck pin 6, U-1.
2. U-3, wind direction buffer.
   a) Adjust R-7 to give +2.5 v. on pin 6, U-3.
   b) Ground pin 6, U-2 and verify 0 v. on pin 6, U-3.
3. U-4 thru 6, wind speed buffers.

   Adjust R-10, R-13, and R-16 to give 0 v. on pin 6 of U-4, U-5 and U-6, respectively.



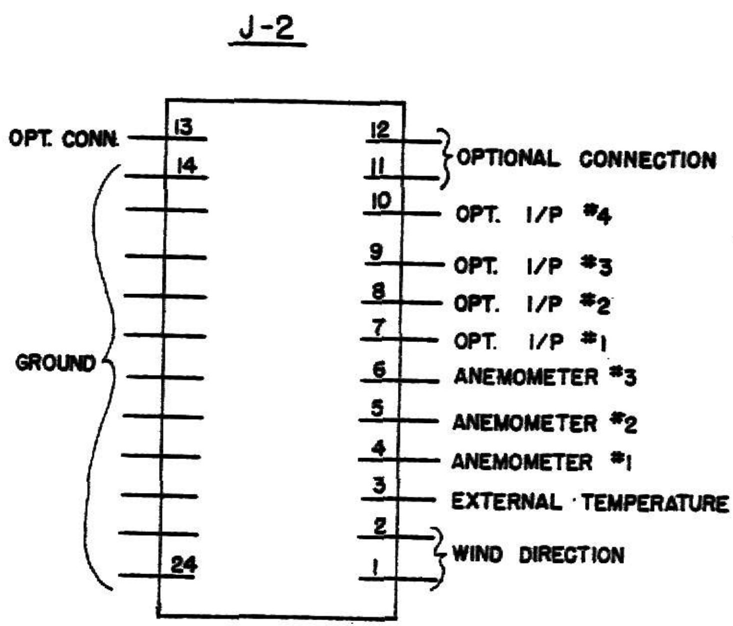
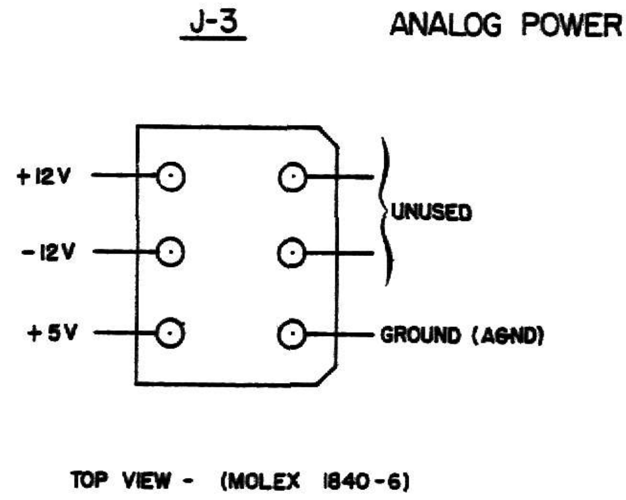


FIG. AI.3 ANALOG INPUT CONNECTIONS



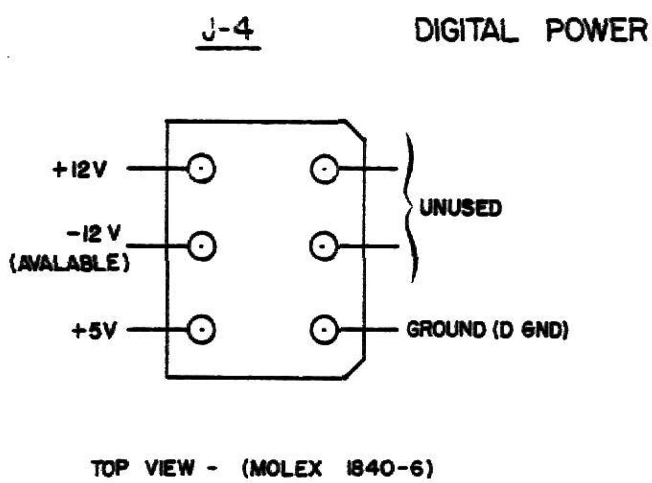


FIG. AI.4 ANALOG/DIGITAL INTERFACE POWER

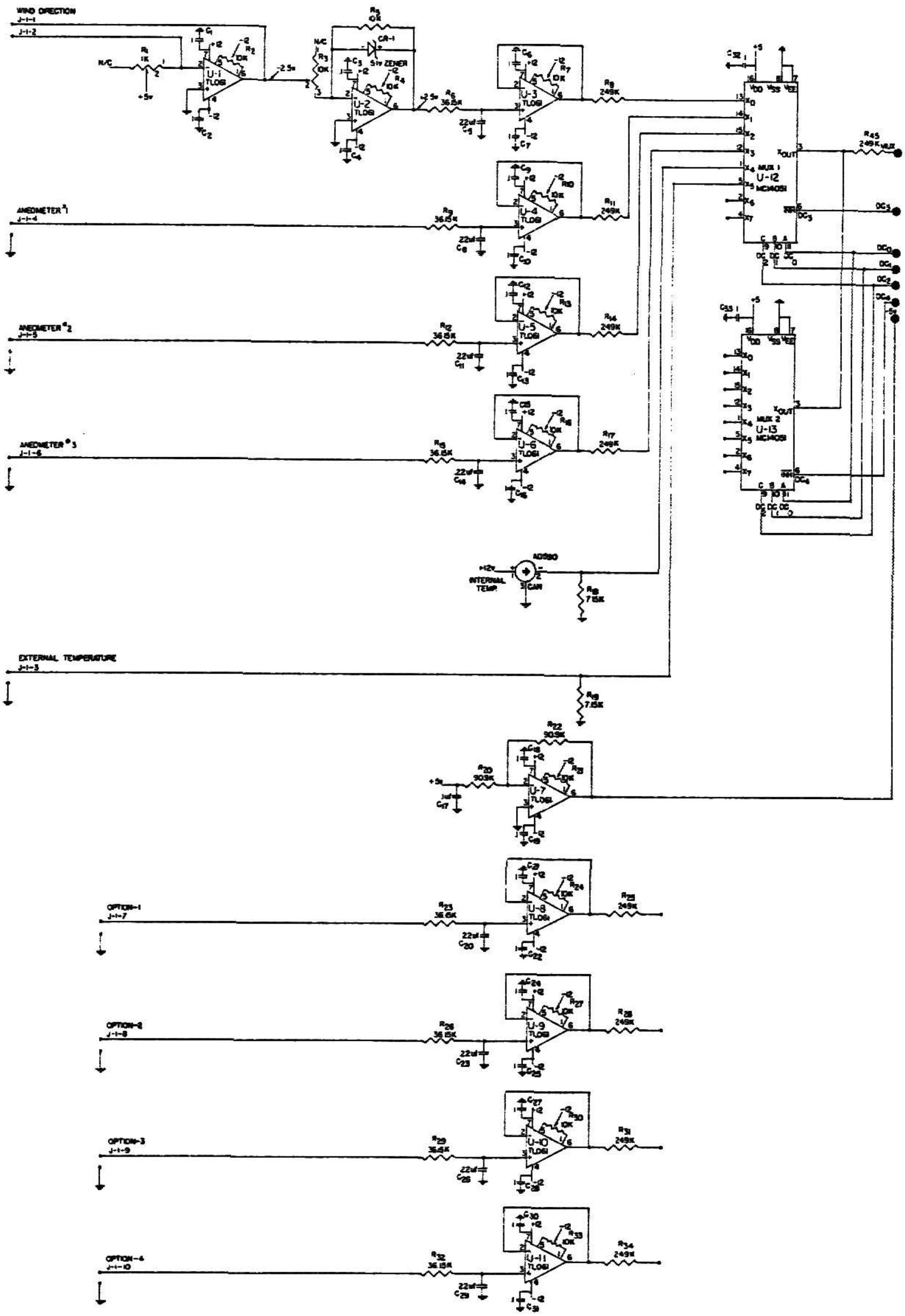


FIG. AI.5 ANALOG BOARD SCHEMATIC

4. U-7, -5 v. reference voltage.

   Adjust R-21 to give -5 v. at pin 6, U-7.

5. Verify approximately 2.14 volts on pin 1, U-12. This indicates the AD-590 is operating.

Optional Analog System Expansion

The Analog Board can be expanded to accept 4 additional prewired optional inputs with the parts listed in Table AI.2. Jumper wires need to be connected from the buffer outputs labeled 0-1 thru 4 to any of the unused multiplexer inputs labeled X-N. Once again, insure unused multiplexer inputs are grounded.

Pins 11 thru 13 on J-1 or J-2 are inputs also available to the user. A user discretionary wiring area is located at the bottom of the Analog Board.

TABLE AI.2 OPTIONAL ANALOG BOARD PARTS LIST

Type Number	Analog ID#	Qty.	Description
TL061	U-8 thru U-11	4	JFET Operational Amplifier
CD4051	U-13	1	Analog Multiplexer
--	C-21, C-22, C-24, C-25, C-27, C-28, C-30, C-31, C-33	9	.1 Microfarad Ceramic Disc Capacitor
--	C-20, C-23, C-26, C-29	4	.22 Microfarad Mylar Capacitor
--	R-24, R-27, R-30, R-33	4	10K Ohm Trim Pot
--	R-23, R-26, R-29, R-32	4	36.15K Ohm, 5%, 1/4 Watt Resistor
--	R-25, R-28, R-31, R-34	4	249K Ohm, 5%, 1/4 Watt Resistor
316-AG-390	For U-8/9, U-10/11, U-12	3	16-pin DIP Socket

AI.3 DIGITAL BOARD

The digital board is the main interface between the analog real world signals and the COSMAC microprocessor, via a 24 pin ribbon connector. The board contains the analog to digital converters, a clock divider chain for the real time clock, the digital cassette tape recorder control circuitry, and the EPROMS containing the system software. These functional areas are shown in Fig. AI.6.

The digital board has been designed to accommodate a 13 bit ADC for higher resolution if necessary. This will be discussed later.

The assembly of the digital board is quite easy and closely parallels the analog board. However, certain minor hardwiring changes are necessary. As with the analog board, it is recommended that a little time be spent becoming familiar with the parts and their placement prior to assembly or use. The parts required for the minimal system digital board are in Table AI.3. These parts should be identified and located near the assembly area. Table AI.4 identifies the parts for optional system expansion, and will be discussed later.

To assist the user in the assembly of the digital minimal system, a step by step procedure is given below:

1. Locate the digital printed circuit board and parts required in Table AI.3.
2. Orient the PC board as shown in Fig. AI.7. This is the component side of the board. All soldering will be done on the reverse side.
3. Specific discrete component assembly instructions.
   a) Mount and solder the 14 pin DIP sockets at locations U-15, U-25 and U-26.

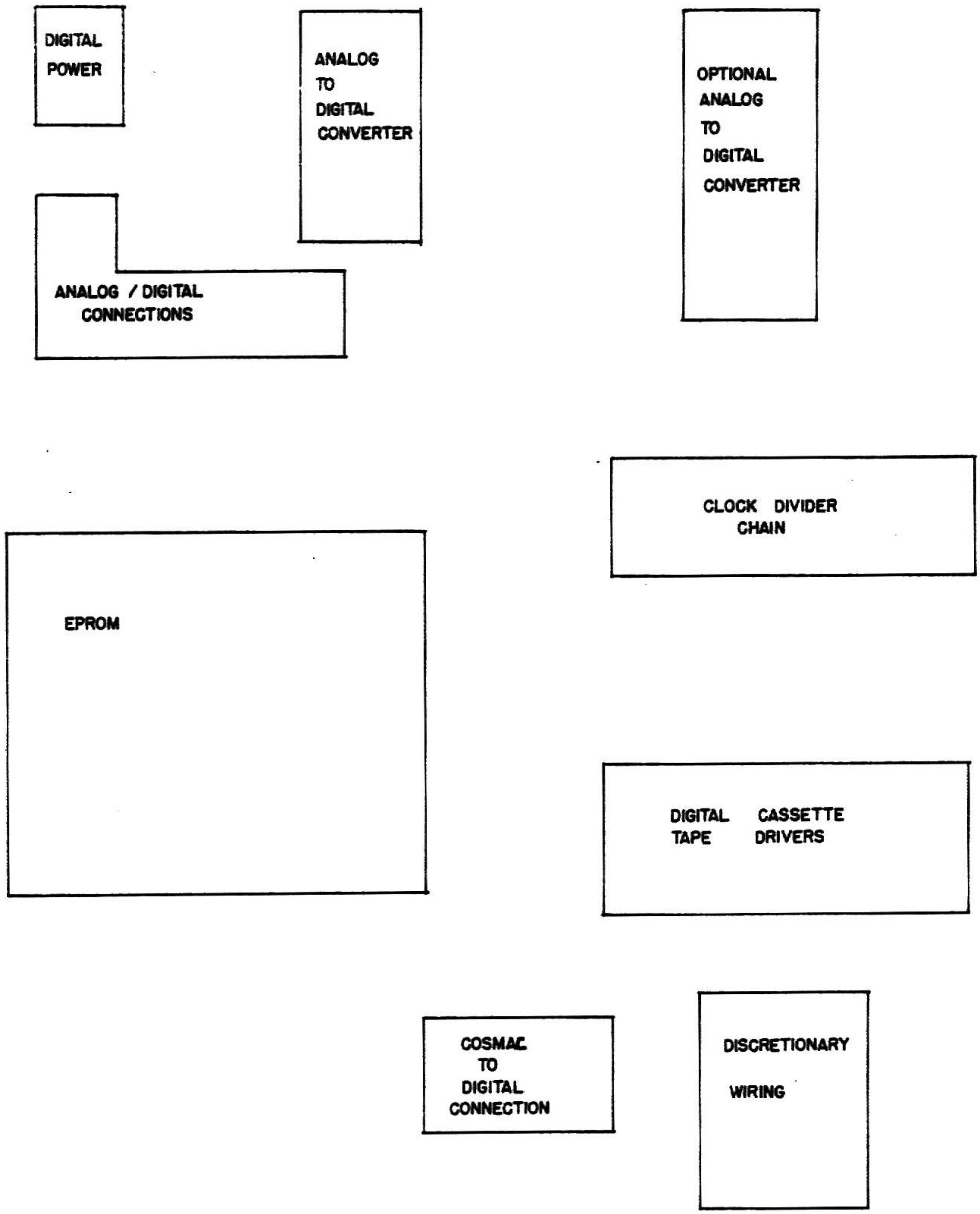


FIG. AI.6 DIGITAL BOARD FUNCTIONAL AREAS

TABLE AI.3 DIGITAL BOARD PARTS LIST - MINIMAL SYSTEM

Type Number	Digital ID#	Qty.	Description
--	--	1	Digital Printed Circuit Board, RCH, July 1979
Teledyne 8703	U-14	1	8-bit Analog to Digital Converter
CD 4011	U-15	1	Quad 2 Input Nand Gate
CDP 1852	U-16, U-17, U-24	3	8-bit Input/Output Port
DS 3631	U-18 thru U-21	4	Dual Peripheral Drivers
IM 6654	U-22, U-23	2	512x8 EPROM
CD 4013	U-26, U-31	2	Dual D Master-Slave Flip Flop
CD 4017	U-27	1	5 Stage Divide by 10 Johnson Counter
CD 4071	U-25	1	Quad 2 Input OR-Gate
MC 14534	U-28	1	Real Time 5-Decade Counter
MC 14566	U-29	1	Industrial Time Base Generator
--	C-35, C-37 thru C-52, C-56	18	.1 Microfarad Ceramic Disc Capacitor
--	C-34	1	270 Picofarad Ceramic Disc Capacitor
--	C-36	1	68 Picofarad Ceramic Disc Capacitor
--	R-36	1	10K Ohm, Trim Pot
--	R-39	1	249K Ohm, 5%, 1/4 Watt Resistor
--	R-35	1	100 Ohm, 5%, 1/4 Watt Resistor
--	R-40	1	100K Ohm, 5%, 1/4 Watt Resistor
--	R-38	1	1.27K Ohm, 5%, 1/4 Watt Resistor
--	R-37	1	121K Ohm, 5%, 1/4 Watt Resistor
--	R-41 thru R-44	4	1.7K Ohm, 5%, 1/4 Watt Resistor

TABLE AI.3 DIGITAL BOARD PARTS LIST - MINIMAL SYSTEM (continued)

Type Number	Digital ID#	Qty.	Description
IN914	CR-2 thru CR-5	4	Diode
314-AG39D	For U-15, U-25, U-26, U-31	4	14-pin DIP Socket
316-AG39D	For U-18/19, U-20/21, U-27, U-29, J-6	5	16-pin DIP Socket
324-AG39D	For U-14, U-16, U-17, U-22 thru 24, U-28, J-5	8	24-pin DIP Socket
09-18-5063	J-4	1	6-pin Molex 1840-6 Series Connector
--	Hole	1	Banana Plug Socket
ICTWZ1A1A	--	1	Datel Systems, Inc. Low-Power, Incremental-Cassette Transport
--	--	1	24-pin Ribbon Connector 18" long
--	--	1	16-pin Ribbon Connector 24" long

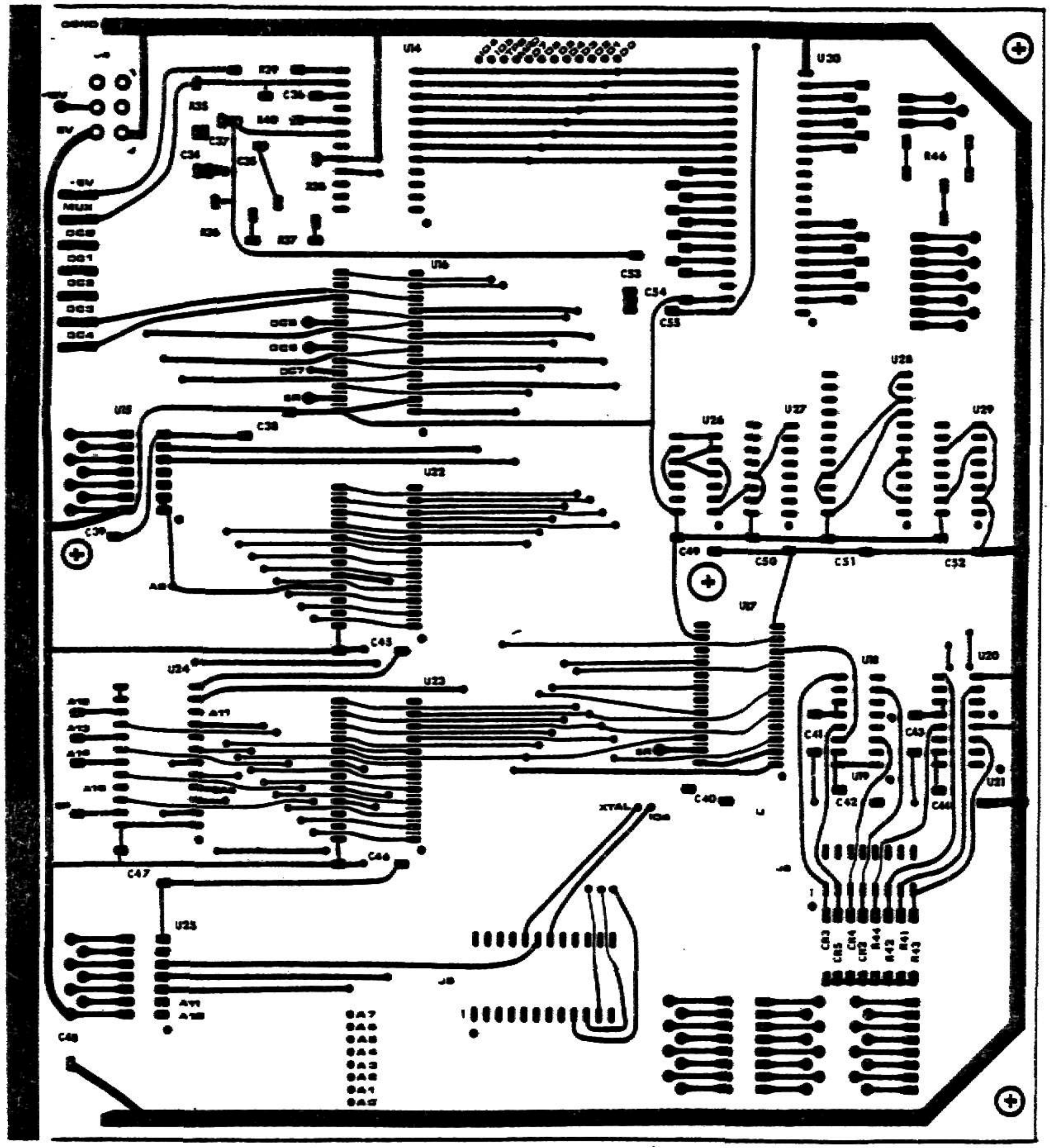


FIG. AI.7 DIGITAL PRINTED CIRCUIT BOARD (TOP SIDE)

b) Mount and solder the 16 pin DIP sockets at locations U-18/19, U-20/21, U-27, U-29, and J-6.

c) Mount and solder the 24 pin DIP sockets at locations U-14, U-16, U-17, U-22 thru 24, U-28 and J-5.

d) Mount and solder the 6-pin power socket to J-4.

e) Mount and solder resistors R-35 thru 45, as indicated.

f) Mount and solder capacitors C-34 thru 52, as indicated.

g) Mount and solder diodes CR-2 thru 5, as indicated. Insure the positive side (band) is to the bottom of the board.

4. The following modifications to the digital board are necessary to accommodate the unique chip select requirements of the Intell 6654 EPROMS used. If a different EPROM is used, these procedures will have to be modified. A more detailed discussion is in Appendix AII. Refer to the digital schematic Figure AI.8 as necessary.

a) Mount and solder a 14 pin DIP socket in the upper 14 holes in the discretionary wiring area. Insert capacitor C-56 in the lower holes. This IC will be referred to as U-31.

b) Jumper wire +5 volts to U-31, pin 14 and one side of C-56.

c) Jumper wire DGND to the other side of C-56, and U-31, pins 4, 6, 7, 8, 9, 10, and 11.

d) Jumper wire the signal XTAL to U-31, pin 3.

e) Jumper wire U-25, pin 10 to U-31, pin 5, and U-23, pin 22.

f) Jumper wire U-23, pin 20 to U-31, pin 1.

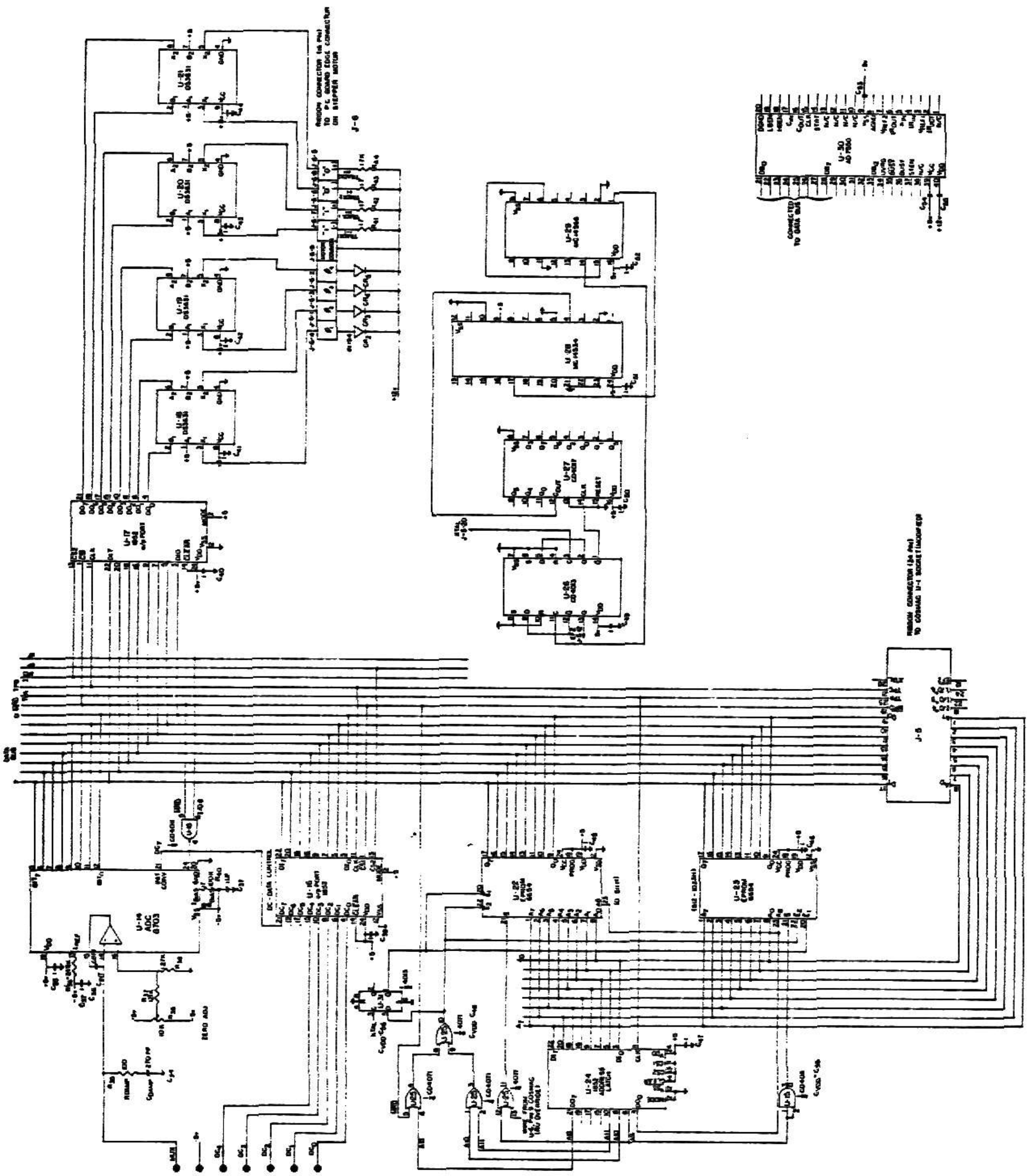


FIG. AI.8 DIGITAL BOARD SCHEMATIC

g) Cut the printed circuit trace on the top side of the board at U-25, pins 3 and 4, and U-22, pin 21.

h) Jumper wire U-24, pin 6 to U-25, pin 12.

i) Jumper wire U-25, pin 11 to U-22, pin 21.

j) Jumper wire U-25, pin 3 to U-25, pin 9 and U-25, pin 4 to U-25, pin 8.

k) Insert a banana plug socket in the hole between U-17 and U-26.

l) Jumper wire U-25, pin 13 to the socket.

5. Insert IC's U-14 thru 29 and U-31 as indicated. Insure all pin 1's are oriented toward the lower right side of the board as indicated by the dots next to pin 1.

6. Insure any unused CMOS device inputs are tied to ground in the minimal system, U-15, pins 8, 9, 12, 13 must be tied to DGND.

7. Wire the 16 pin ribbon connector to the cassette tape recorder edge connector, as shown in Figure AI.9 and Table AI.3.1.

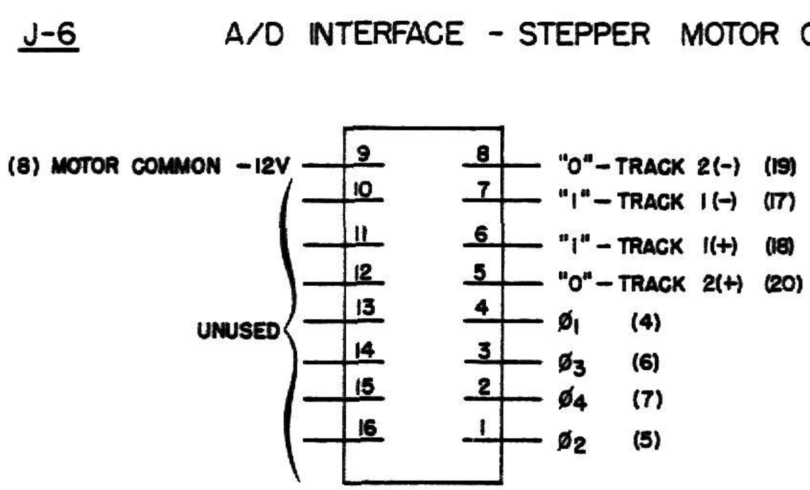


FIG. AI.9 CONNECTION FROM DIGITAL BOARD J-6 TO CASSETTE RECORDER EDGE CONNECTOR

TABLE AI.3.1 CONNECTION SUMMARY OF DIGITAL BOARD J-6 TO CASSETTE RECORDER EDGE CONNECTOR

J-6	Edge Connector
Pin 1	Pin 5
2	7
3	6
4	4
5	20
6	18
7	17
8	19
9	8

Alignment

The only alignment required on the digital board is to locate the zero end of the analog to digital converter. However, prior to this the analog and digital boards must be placed side by side as shown in Fig. AI.10. Jumper wires must now be added across the ground plane to connect -5 v, MUX, DC0, DC1, DC2, DC3, and DC4. The analog/digital interface will remain in this configuration for use.

Now connect power to J-4 as shown in Fig. AI.4. Verify correct power to the IC's, referring to Fig. AI.8 as necessary.

1. Insure ribbon connector to J-5 is removed.
2. Aligning the ADC
   a) Set initiate conversion high, U-14, pin 21.
   b) Set output enable low, U-14, pin 24.
   c) Apply +5 volts at U-12, pin 3.
   d) Check data lines D0 thru D7 are high.
   e) Apply .01 volts at U-12, pin 3.

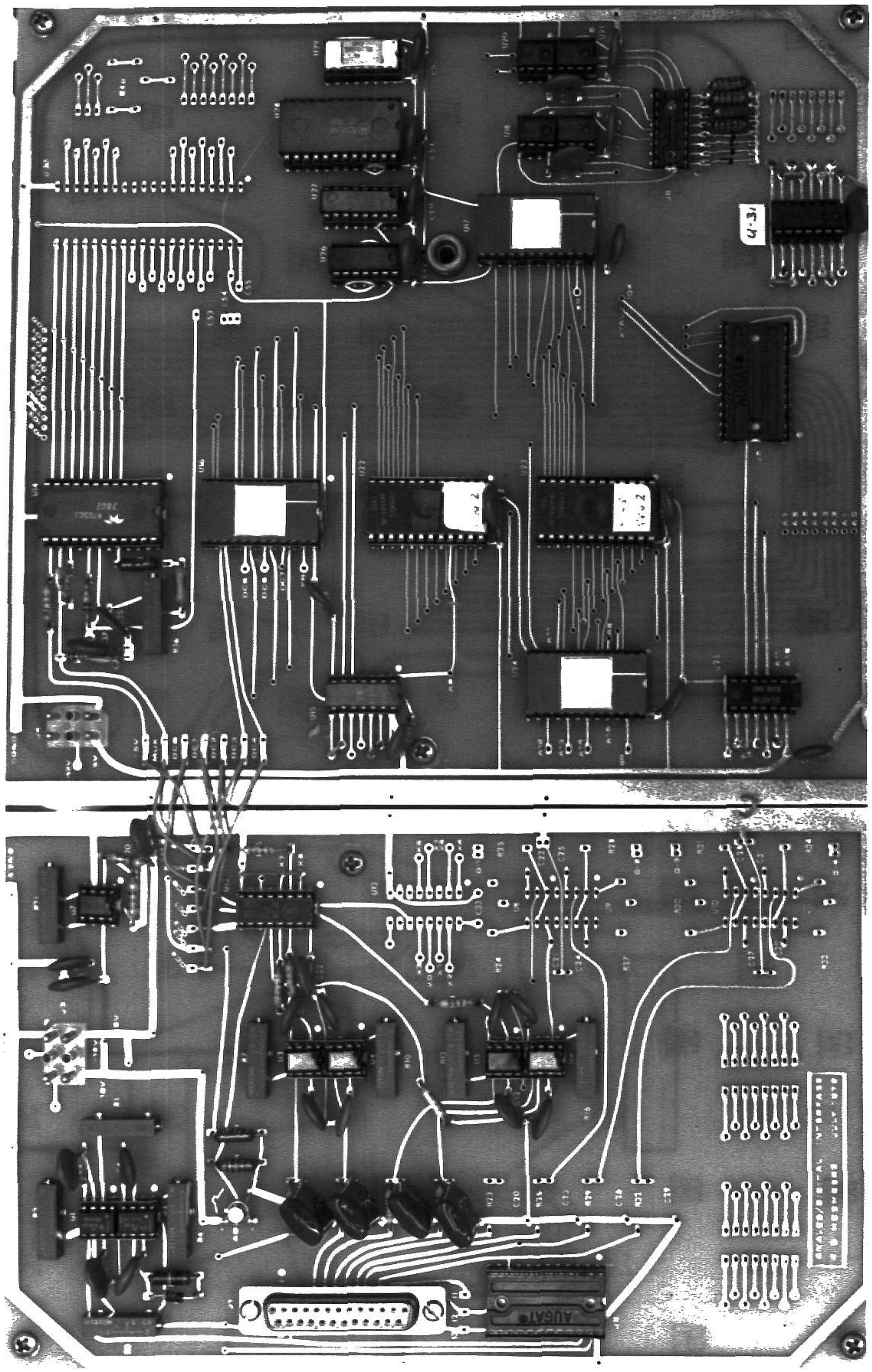


FIG. AI.10 OVERALL ANALOG/DIGITAL INTERFACE (TOP SIDE)

f) Adjust R-36 until D0 transitions from low to high. D1 thru D7 should also be low.

g) The ADC is now aligned.

Optional Digital System Expansion

The analog to digital conversion accuracy can be expanded from 8 bits to 13 bits by the use of an analog devices AD7550, 13 bit ADC in lieu of U-14. The required parts are listed at Table AI.4.

Details of the installation of the AD7550 can be found in the AD7550 applications bulletin. Sufficient discretionary wiring is available in the upper right corner of the board (U-30 area) to configure the ADC to specific user requirements.

TABLE AI.4 OPTIONAL DIGITAL BOARD PARTS LIST

Type Number	Digital ID#	Qty.	Description
AD7550	U-30	1	13 bit analog to digital converter
	C-53 thru C-55	3	.1 Microfarad Ceramic Disc Capilator
	R-46	1	10K Ohm Trim Pot
340-A639D	For U-30	1	40-pin DIP Socket

AI.4 COSMAC EVALUATION KIT, MODIFICATIONS REQUIRED AND SYSTEM CHECK

The RCA 18S020 COSMAC Evaluation Kit should be assembled according to its enclosed instructions. It will be used essentially as it is with only a few minor modifications. Table AI.5 contains the additional parts required. These parts should be identified and located near the assembly area.

To assist the user in the systematic modification and checkout of the COSMAC Evaluation Kit, a step by step procedure is given below:

1. Assemble the COSMAC Evaluation Kit according to its instructions, however, make these changes:
   a) Modify U-8 for load mode.
   b) Insert a 16 pin DIP socket for U-11.
   c) Insert 24 pin DIP sockets for U-4 and U-5.
2. Connect the COSMAC for teletype operation and run the diagnostic programs in the manual.
3. After TTY check out, modify the COSMAC for microterminal operation.
   a) Insert J-1 microterminal connector.
   b) Replace ROM UT-4 with ROM UT-5 containing the microterminal program.
   c) Modify U-11, pins 4, 6, 10, 12 for no connection.
   d) Remove LK10, if inserted, and disconnect power to V_{TTY} at P-1-H.
   e) Run the microterminal diagnostic program.
4. After microterminal checkout, add these components:
   a) 22 pin - DIP sockets in RAM locations U-32 thru 41.
   b) XTAL frequency stabilizing capacitors C-6, 7.

TABLE AI.5 CDP18S020 COSMAC EVALUATION KIT MODIFICATION PARTS LIST FOR DATA ACQUISITION SYSTEM (Minimal System)

Type Number	COSMAC ID#	Qty.	Description
316-AG39D	For U-11	1	16-pin DIP Socket
322-AG39D	For U-32 thru U-41	10	22-pin DIP Socket
324-AG39D	For U-1	1	24-pin DIP Socket
3M 3428-1002	J-1	1	20-pin Header for Microterminal
CDP-R-522D	U-2	1	512x8 Static ROM (UT-5) Containing Utility Program for Microterminal
CDP-1822	U-32 thru 41	10	256x4 Static RAM
--	--	1	Banana Plug
--	--	5	Stand Offs - 2 1/2"
--	C-6, C-7	2	20 Picofarad Ceramic Disc Capacitor

c) Insert 256x4 static RAMS in sockets U-32 thru 41.

d) Verify read/write operation of the new RAM.

5. Unused COSMAC IC location U-1 will now be modified and used to interconnect the COSMAC Evaluation Kit with the analog/digital interface board.

a) Refer to Fig. AI.11. Cut the printed circuit trace at U-1, pins 12, 18, and 24 as shown on the top side of the COSMAC board.

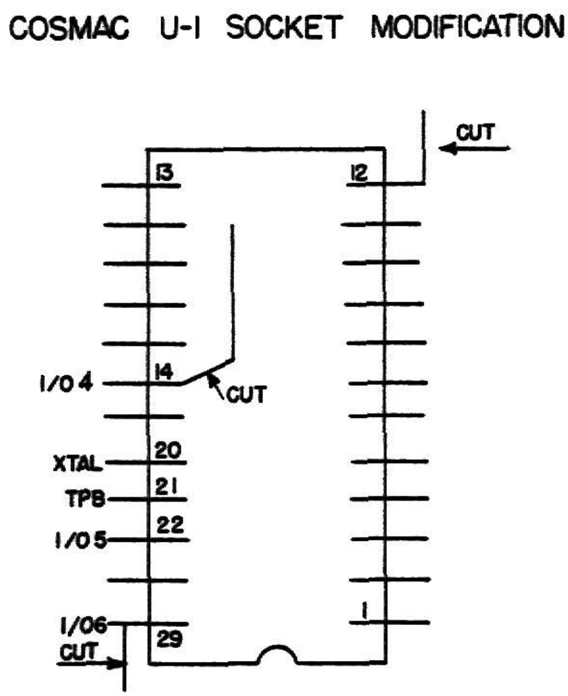


FIG. AI.11 COSMAC EVALUATION KIT U-1 SOCKET MODIFICATION

b) Cut the printed circuit trace at U-1, pin 18 on the solder side of the COSMAC board.

c) Solder a jumper wire from R-1 to the other side of U-1, pin 18 on the solder side of the board. This will insure R-1 remains in the circuit for proper operation.

d) Insert a 24 pin, DIP socket in location U-2.

e) Connect jumper wires as shown in Table AI.5 on the solder side of the COSMAC board.

Signal	From COSMAC Connector	To U-1 Pin Number
I/O 4	P-1-S	18
I/O 5	P-1-T	22
I/O 6	P-1-U	24
$\overline{EF2}$	P-2-3	12
TPB	P-2-13	21
XTAL	P-2-19	20

TABLE AI.6 COSMAC EVALUATION KIT U-1 SOCKET MODIFICATIONS

f) Connect a 24-pin ribbon connector from COSMAC U-1, modified to the system connector J-5 on the A/D interface. Verify the signal connections shown in Fig. AI.12 at J-5, with an Ohm meter.

J-5 COSMAC - A/D INTERFACE CONNECTION

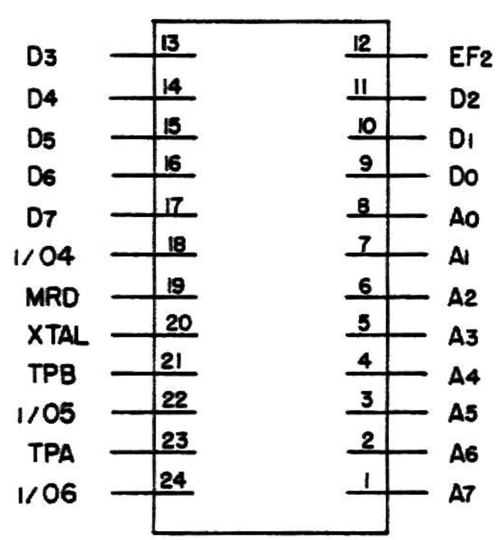


FIG. AI.12 A/D INTERFACE TO COSMAC SYSTEM INTERCONNECTION

6. The overall system is now ready for final assembly and check out.

   a) Solder a jumper wire from COSMAC U-6, pin 9 (use LK-2 location) to a banana plug. Insert the banana plug in the socket on the digital board.

   b) Remove COSMAC RAM from U-24, and U-25. RAM should only be in locations U-32 thru 41.

   c) Remove COSMAC U-4 and U-5. If U-5 has been soldered in, the chip must be disabled or no data can be read from the ADC. Cut the printed circuit trace at U-5, pin 1 on the solder side of the COSMAC board. Jumper wire U-5, pin 1 to U-5, pin 2.

   d) The 44 pin edge connector supplying power to the COSMAC Evaluation Kit should be configured as shown in Table AI.7 to the voltage switching regulator.

System Edge Connector Number	Function	Voltage Switching Regulator Point
P-1-A	Ground	D GND
P-1-B	V_{cc}	+5 volts
P-1-D	V_{LED}	V_{LED} Switch
P-1-L	V_{DD}	+5 volts

TABLE AI.7 COSMAC EVALUATION KIT POWER CONNECTIONS

7. Apply power to the A/D interface and the COSMAC Evaluation Kit.

   a) Verify reset and run utility on microterminal.

   b) Read EPROM memory.

c) Turn off/on LED power to verify proper operation.

d) Verify signals to J-5.

8. The low-power, data-acquisition system is now ready for initial check out.

a) Insure all connections are made and that the cassette tape recorder is connected to J-6.

b) Depress reset and run utility on microterminal.

c) Insert the number 48D in memory location 0400H.

d) Depress reset and start program on microterminal. The microterminal display will go blank; address LED A-8 on the COSMAC Evaluation Kit will be blinking.

e) Within 2 minutes, the cassette tape recorder motor will start to run for approximately 100 seconds.

f) If the system fails any of the above steps, the trouble needs to be located.

g) Mount the A/D interface board on top of the COSMAC board using the standoffs.

9. System operational check of the low-power, data-acquisition system.

a) Verify all connections are made.

b) Insert the analog alignment plug in J-1.

c) Insert an unused certified digital cassette tape in the recorder. Insure the tape is advanced past the leader.

d) Apply power. Depress reset and run utility on the microterminal.

e) Insert the minutes of the hour in MA 0400H, the hour in MA 0401H, the day of the year in MA 0402H and 0403H.

f) Depress reset and start program on the microterminal. Verify LED A-8 is blinking.

g) Turn off LED power.

h) After two or more hours, remove the cassette and read it to verify the data.

i) The system is now ready to go to the field.

APPENDIX II: DETAILED ANALOG/DIGITAL INTERFACE HARDWARE DOCUMENTATION

AII.1 GENERAL COMMENTS

The analog/digital interface hardware can be broken into the broad areas of analog and digital, as are the printed circuit boards. The analog section is used mainly for interfacing with the real world, while the digital section is used for control and data transfer.

In the following sections, each of the integrated circuits will be discussed in detail. This will help the user understand the hardware design considerations used and allow him to configure the system to his application. The format follows the sequential I.C. numbers and functional areas described earlier in this report.

AII.2 ANALOG BOARD

U-1, U-2 WIND DIRECTION

Description

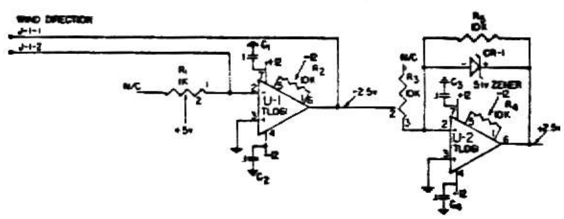
U-1 and U-2 are TL061 operational amplifiers used to compensate for various maximum instrument impedances in National Bureau of Standards (NBS) wind direction indicators (WDI).

The WDI operates as a variable resistor from 0 to 220 Ohms, for example. North is indicated by 0 Ohms and the other directions located by an increasing resistance in a clockwise direction to a maximum impedance for the WDI instrument.

Operation

U-1 is used as a divide-by-2 inverting amplifier. The WDI is used as a variable feedback resistor. A +5 v. reference voltage is input thru R-1 to the inverting input of U-1. The output then varies from 0 to -2.5 v. depending upon the impedance of the wind direction indicator (Z_{WDI}).

$$V_{out_{max}} = \frac{-V_{IN} R_F}{R_{IN}} = \frac{-5v(Z_{WDI})}{2 Z_{WDI}} = -2.5 \text{ v.}$$



NOTE: R_3 is adjusted to = R_5

FIG. AII.1 WIND DIRECTION

U-2 is used as a unity gain inverting amplifier. A 5.1 v. zener diode is incorporated in the feedback circuit to limit any voltage spikes caused by a poor contact in the WDI which would increase Z_{WDI} at that point to greater than the nominal maximum impedance, causing possible breakdown of the multiplexer.

Alignment

1. Determine the maximum impedance of the WDI instrument (Z_{WDI}).
2. Insert a resistor equal to Z_{WDI} across the WDI input of U-1 (J-1 or J-2 pins 1 and 2).
3. Adjust R_1, and offset null R_2 as necessary, to obtain -2.5 v. at pin 6 of U-1.
4. Adjust R_3, and offset null R_4 as necessary, to obtain +2.5 v. at pin 6 of U-2.
5. Recheck U-1 pin 6 and U-2 pin 6.

U-3 (LPF AND BUFFER FOR WIND DIRECTION INPUT)

Description

Incoming analog signals require signal conditioning and current limiting prior to input to an analog multiplexer. This is accomplished by a simple 1 pole R.C. low pass filter, an operational amplifier configured as a unity gain buffer with high input impedance, and a series current limiting resistor.

Operation

The 1 pole R.C. low pass filter has a 20 Hz 1/2 power bandwidth using a .22µf mylar capacitor and a 36.15K Ohm resistor.

U-3 is a TL061 operational amplifier configured for unity gain. In this mode, it has a high input impediance and a low output impediance.

Input current to the multiplexer is limited by a 249K Ohm resistor

$$I_{max} = \frac{5\ v.}{249K} = \sim 20\mu A$$

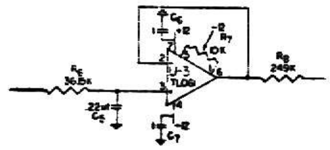


FIG. AII.2 LOW PASS FILTER AND BUFFER

Alignment

1. Ground U-2 pin 6.

2. Adjust R_7 to obtain 0 v. at U-3 pin 6.

U-4, U-5, U-6 LPF AND BUFFER FOR WIND SPEED INDICATORS

Description

U-4, U-5, U-6 are used in a similar fashion as U-3 for signal conditioning and current limiting the N.B.S. wind speed indicators.

The N.B.S. wind speed indicators are electrical generators and send out a variable 0 to 5 volts analog signal corresponding to the wind velocity. (The appropriate matching resistors are in the lightning protection box.)

Operation

U-4, U-5, U-6 functions and circuits are identical to U-3.

Alignment

U-4

1. Ground J-1 or J-2 pin 4 (Anemometer #1)

2. Adjust R-10 to obtain 0 v. at U-4 pin 6.

U-5

1. Ground J-1 or J-2 pin 5 (Anemometer #2).

2. Adjust R-13 to obtain 0 v. at U-5 pin 6.

U-6

1. Ground J-1 or J-2 pin 6 (Anemometer #3).

2. Adjust R-16 to obtain 0 v. at U-6 pin 6.

U-7 -5 VOLT SOURCE

Description

U-7 is an operational amplifier configured as a unity gain inverting amplifier. It converts +5 v. to -5 v. for use as a reference voltage for the Teledyne 8703 analog to digital converter, U-14.

Operation

U-7 is set up as shown. The resistors minimize any errors introduced by input bias currents.

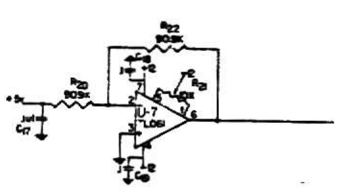


FIG. AII.3 -5 VOLT SOURCE

Alignment

1. Verify +5 v. at U-7 pin 2.

2. Adjust R-21 to obtain -5 v. at U-7 pin 6.

U-8, U-9, U-10, U-11 OPTIONAL LPF AND BUFFER

Description

U-8 thru 11 are set up to be used in a similar way as U-3, to provide low pass filtering, buffering, and current limiting. Their inputs are connected to J-1, J-2 to allow for up to four optional inputs, providing for system expansion and versatility. The outputs are not connected and must be jumper wired to a specific multiplexer input at the user's discretion.

Operation

U-8, U-9, U-10, U-11 functions are identical to U-3. Their outputs labeled 0-1, 0-2, 0-3, 0-4, respectively must be jumper wired to an unused multiplier input.

Alignment

U-8

1. Ground J-1 or J-2 pin 7 (optional input #1)
2. Adjust R-24 to obtain 0 v. at U-8 pin 6.

U-9

1. Ground J-1 or J-2 pin 8 (optional input #2)
2. Adjust R-27 to obtain 0 v. at U-9 pin 6

U-10, U-11

1. Ground J-1 or J-2 pin 9 or 10 (optional input #3 or #4)
2. Adjust R-30 or R-33 as appropriate to obtain 0 v. at U-10 or U-11 pin 6.

AD590 INTERNAL AND EXTERNAL TEMPERATURE

Description

Internal and external temperature measurements are made using an Analog Devices AD590 two terminal, IC temperature transducer, which produces an output current proportional to absolute temperature passing 1µA/°K. The circuit is as shown for both temperature devices.

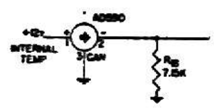


FIG. AII.4 TEMPERATURE TRANSDUCER

The internal temperature AD590 is mounted on the analog board and the external temperature AD590 is mounted outside the enclosure.

To provide current limiting into the ADC (U-14), the value of R (7.15K) is determined as follows:

The maximum input current into the ADC is 10µA. The maximum likely temperature to be measured is 50°C or ≈ 350µA.

$$R = 249K \times \frac{10 \text{ A}}{350 \text{ A}} = 7.11K \text{ Ohms} \approx 7.15K \text{ Ohms}$$

For ADC 8703: (U-14)

$$\text{Digital count out} = I_{IN} \times 528 \times \frac{R_{REF}}{V_{REF}} = I_{IN} \times 528 \times \frac{249K}{5v}$$

$$= I_{IN} \times 26294.4$$

Thus,

Temperature in °K = 1.368 x ADC count

Temperature in °C = (1.368 x ADC count) -273

Operation

The AD590s function as described.

Internal temperature is obtained from the AD590 mounted on the analog board. Current limiting is by R-18 (7.15K).

External temperature is obtained from the AD590 externally mounted. The (-) side (pin 2) is inputed to J-1 or J-2 pin 3, and current limited by R-19 (7.15K)

Alignment

None required.

U-12 ANALOG MULTIPLEXER

Description

U-12 is an 8 channel analog multiplexer, CD4051. The multiplexer acts as a switch, switching the selected input to the output. The output is connected thru a current limiting resistor, R-45, to the ADC input. The input connections are as follows:

X_0 = wind direction (from U-3)

X_1 = wind speed #1 (from U-4)

X_2 = wind speed #2 (from U-5)

X_3 = wind speed #3 (from U-6)

X_4 = internal temperature (from internal AD590)

X_5 = external temperature (from external AD590)

X_6, X_7 } Unused but available on board (ground if not used)

The control lines A, B, C are connected to the "Data Control" lines from U-16 on the digital side (DC-0 thru DC-3).

DC-0	A
DC-1	B
DC-2	C
DC-3	$\overline{\text{Inhibit}}$

Operation

When the appropriate data control word is sensed, DC-3 = 0 (0XXX), the multiplexer is active, and the selected input is put on the output line.

Alignment

None required. However, insure any unused input is tied to AGND.

U-13 OPTIONAL MULTIPLEXER

Description

U-13 is an optional 8 channel analog multiplexer, CD4051, similar to U-12.

The output of U-13 is connected also thru R-45 to the ADC.

The inputs are not connected, but are labeled X_0 thru X_7 on the analog board.

The control lines A, B, C are connected to DC-0 thru DC-2, respectively, with $\overline{\text{inhibit}}$ connected to DC-4 for unique device selection.

Operation

Similar to U-12.

Alignment

None required. However, insure unused inputs tied to AGND.

TABLE AII.1 SUMMARY OF MULTIPLEXER AND ADC DATA CONTROL DECODING

Data Control Lines	MUX-1 (U-12)	MUX-2 (U-13)	ADC (U-14)
DC-0	A	A	
DC-1	B	B	
DC-2	C	C	
DC-3	$\overline{\text{Inhibit}}$		
DC-4		$\overline{\text{Inhibit}}$	
DC-5			
DC-6			
DC-7			Initiate Conversion

AII.3 DIGITAL BOARD

U-14 ANALOG TO DIGITAL CONVERTER

Description

U-14 is a Teledyne 8703 8 bit monolithic CMOS analog to digital converter. Conversion is performed by an incremental charge balancing technique. An internal operational amplifier integrates the sum of the unknown analog current (from the analog multiplexers U-12, U-13) and pulses of a reference current (from U-7). The number of pulses (charge increments) needed to maintain the amplifier summing junction near zero is counted at the end of conversion, the total count is latched into the digital outputs as an 8 bit binary word. The $\overline{\text{output enable}}$ control switches the outputs to a high impedance or off state when held high. The off state allows bus organized output connections.

Operation

U-14 is set up as shown in Fig. AII.5.

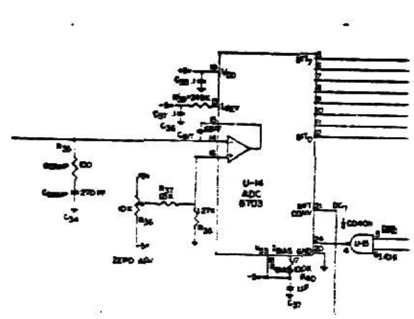


FIG. AII.5 ANALOG TO DIGITAL CONVERTER

A detailed explanation of the required discrete component values can be found in the Teledyne 8703 applications notes.

Digital data outputs are directly connected to the data bus on the digital board. The initiate conversion signal is obtained from the initiate conversion, data control word latched by U-16. Data output line 7, called data control 7 (DC-7), is connected to U-14 pin 21.

The output enable signal is obtained from U-15. $\overline{\text{Output enable}}$ is held high (not on) by U-15. The $\overline{\text{output enable}}$ will be driven low (turned on) when the I/06 signal is high and $\overline{\text{MRD}}$ is high as determined by the COSMAC CPU and program. (Note: I/06 is also used to select the input port U-5 on the COSMAC, however, U-5 is not used and will not affect this operation.)

$$\text{Digital Counts} = \frac{V_{IN} \times 528 \times 249K}{249K \times (-5v)}$$

The zero adjust circuit (R-36) is used during alignment to locate the zero end of the input to output relationship.

Alignment

1. Remove ribbon connector at J-6 (to eliminate any interference from COSMAC).
2. Apply power, verify voltages ±5 v.
3. Set initiate conversion (pin 21) high.
4. Set $\overline{\text{output enable}}$ (pin 24) low.
5. Apply ∿5 v. at pin 3, U-12.
6. Check data lines D_0-D_7, should be high indicating maximum input/output in free run operation.

7. Apply ∿.01 v. at pin 3, U-12 (½ LSB = $\frac{5\ v.}{51.2}$ ∿.01 v.)

8. Adjust R-36 to give a low to high transition on D_0 (0000 0000 → 0000 0001). This correctly locates the zero end for the ADC.

Note: Insure jumper wires from the analog to digital boards are in place prior to starting, i.e., -5 v., MUX, DC-0 - DC-4.

U-15 QUAD-2 INPUT NAND

Description

U-15 is a Quad 2-input NAND gate, CD4011. Two of the four gates are used, the remaining two gates are available for discretionary use.

Operation

Gate one is used as an inverter for U-23 (EPROM) output enable (pins 1, 2 in, 3 out).

Gate two is used to logic and the 1/06 and $\overline{MRD}$ signals required for U-14, pin 24 output enable (pins 5, 6 in, 4 out).

Gates three and four are unused.

Alignment

None required. However, any unused inputs <u>must</u> be connected to DGND or the gates will not function properly (i.e., pins 8, 9, 12, 13 to DGND).

U-16 DATA CONTROL LATCH

Description

U-16 is a RCA CDP1852, 8-bit input/output port. The mode control is used to program the device as an input port (mode = 0) or output port (mode = 1). In this configuration, U-16 is used as an output port to latch control words from the data bus. Data is strobed into the ports 8-bit register from the data bus when $\overline{CS1}$ · CS2 · clock = 1 ($\overline{MRD}$ · I/05 · TPB). The output remains enabled at all times and has been designated data control, i.e., DC-0 thru DC-7.

Operation

U-16 functions as a data output port (similar to COSMAC U-4), latching data on the I/05 command. The outputs, Data Control 0 to 7 are used as shown in Table AII.2.

Alignment

None

TABLE AII.2 SUMMARY OF DATA CONTROL LINE FUNCTIONS

Data Control Line	Function
DC-7	Initiate conversion U-14
DC-6	Not used, but available
DC-5	Not used, but available
DC-4	Inhibit signal for U-13
DC-3	Inhibit signal for U-12
DC-2, DC-1, DC-0	Multiplexer control word U-12/13 to select input

U-17 DATA OUTPUT LATCH

Description

U-17 is a RCA 1852, 8-bit input/output port configured as an output port (similar to U-16). U-17 latches a data word used to control the cassette tape recorder peripheral drivers (U-18 - 21). Data is strobed into the port's 8-bit register when $\overline{MRD} \cdot I/04 \cdot TPB = 1$.

Operation

U-17 functions as a data output port, latching data on the I/04 command during the hourly write on tape sequence.

The output data lines are connected to the 'A' inputs of U-18 to 21.

Alignment

None.

U-18, 19, 20, 21 PERIPHERAL DRIVERS

Description

U-18, 19, 20, 21 are DS 3631 dual CMOS peripheral drivers. U-18, 19 are used to drive the cassette recorder stepper motor. U-20, 21 record track 1 and track 0 data respectively. The 3631 has a high output voltage and current capability at low internal current drain.

Operation

U-18, 19, 20, 21 operate as described.

Resistors R_{41} - R_{44} were chosen to provide the typical required head write current of 7.5mA ($I = \frac{12\ v.}{1.7K} \approx 7.1mA$)

Diodes CR2-CR5 limit reverse current from the motor drive.

Alignment

None required.

J-6 is connected to the cassette recorder's edge connector.

U-22, U-23 EPROM

Description

U-22 and U-23 are Intersil, IM6654, 512x8, EPROMS with three-state outputs. The EPROMS are used for permanent storage of the data acquisition program. U-22 contains program 0000-01FF HEX and U-23 contains 0200-03FF HEX.

Operation

Strobe line $\overline{E_1}$ latches both the address lines and chip enable line $\overline{E_2}$. Chip select line $\overline{S}$ enables the three state outputs.

U-22 and U-23 are uniquely selected by $\overline{MRD} \cdot \overline{A\text{-}15} \cdot \overline{A\text{-}11} \cdot \overline{A\text{-}10} = 0$ in U-25. A-15 low insures the COSMAC UT-5 is not selected. Likewise, $\overline{A\text{-}10} \cdot \overline{A\text{-}11}$ does not select the RAM in 0400-07FF HEX. This signal is connected to $\overline{E_2}$.

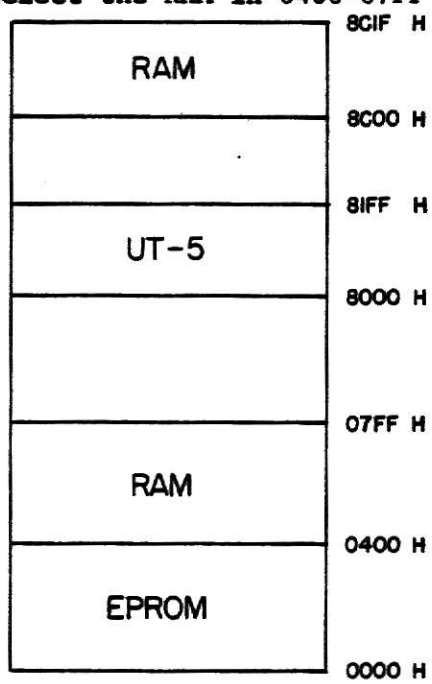


FIG. AII.6 MEMORY MAP

Address line A-9 is used to distinguish between U-22 and U-23 by connecting it to the chip select line $\overline{S}$.

Since in a typical read operation, the address lines are latched by a downward edge on $\overline{E_1}$, time must be given for the address to be valid from U-24 and for $\overline{E_2}$ to be driven low. This time delay is accomplished by a 'D' flip-flop, U-31, delaying the $\overline{E_2}$ signal approximately 2 clock cycles before a downward edge on $\overline{E_1}$ latches the address lines and $\overline{E_2}$.

An external line runs from the COSMAC U-6, pin 9 and is logic OR with address line A-9 into U-22's chip enable, $\overline{S}$. This is necessary to prevent U-22 from being addressed at the same time the COSMAC UT-5 ROM monitor program is started. On reset, the COSMAC CPU sets the address and data lines low, and surpresses TPA and TPB. Depressing the RU (run utility) button, drives A-15 high to select the ROM, UT-5. However, since A-15 is not latched high (TPA is supressed) then the U-22 chip select logic also selects U-22, thinking ROM UT-5 is not being addressed. Thus, the extra hard wire is necessary to avoid the ambiguity.

<u>Alignment</u>

None required. However, the EPROMS must be externally programmed.

<u>U-24 ADDRESS LATCH</u>

<u>Description</u>

U-24 is an RCA CDP 1852 8-bit input/output port used as an address latch, similar to the COSMAC U-8. The most significant byte is latched with TPA. The least significant byte is then multiplexed on the address lines by the CPU.

<u>Operation</u>

The addresses are used in the chip select process for the EPROMS U-22 and U-23.

Alignment

None required.

U-25 QUAD 2-INPUT OR GATE

Description

U-25 is a Quad 2-input OR gate, CD4071. All four of the gates are used in the chip select logic for U-22 and U-23.

Operation

Gate one is used to logic OR address lines A-10 and A-11. It's output is input to gate three.

Gate two is used to logic OR $\overline{MRD}$ and A-15. It's output is input to gate three.

Gate three logic OR's the outputs from gates one and two. The output is used to enable. Chip enable $\overline{E_2}$. ($\overline{A-15} \cdot \overline{MRD} \cdot \overline{A-10} \cdot \overline{A-11} = 0$)

Gate four is used to override the chip select line $\overline{S}$ into U-22 when the run utility button is pressed.

Alignment

None required. However, any unused input must be connected to DGND.

U-26, U-27, U-28, U-29 CLOCK DIVIDER CHAIN

Description

U-26, U-27, U-28 and U-29 are used to divide the COSMAC 2M Hz system clock down to a one minute on, one minute off signal that can be used to derive a software real time clock.

U-26 is a CD4013 dual D-flip flop, that is used as a divide by 2 mechanism.

U-27 is a CD4017 5-stage divide by 10 Johnson counter, that is used as a divide by 10 mechanism.

U-28 is a MC14534 real time 5-decade counter, that is used as a divide by 10^5 mechanism.

U-29 is a MC14566, industrial time base generator used as a divide by 60 mechanism.

Operation

The clock divider chain functions as shown in Fig. AII.7 dividing the 2M Hz input frequency down to a 1 minute on/off pulse, period 120 sec. f = .0833 Hz.

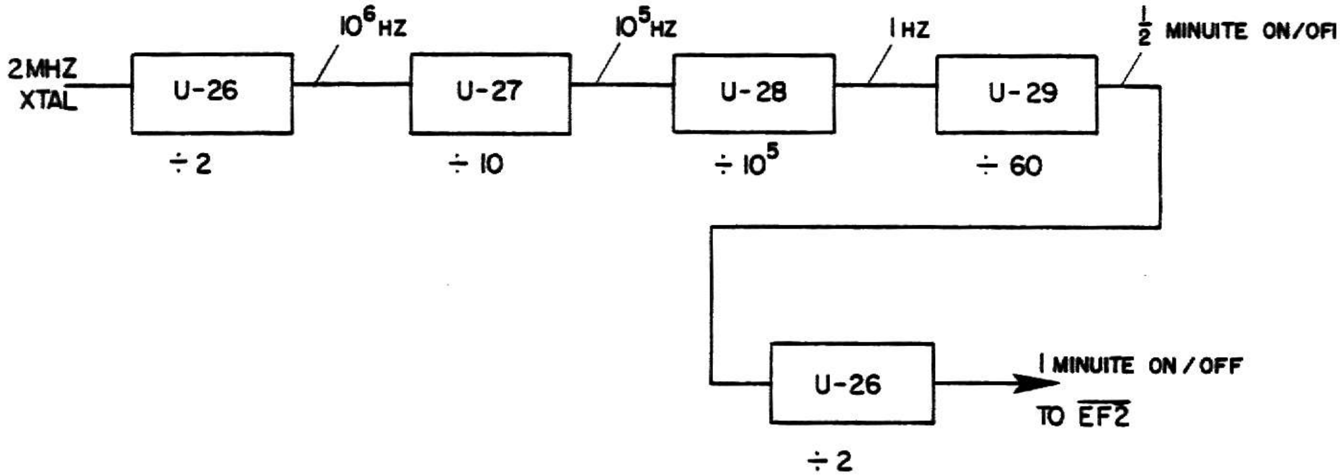


FIG. AII.7 CLOCK DIVIDER CHAIN

The output is connected to $\overline{EF2}$ on the CPU, and is sampled high or low by the system software.

Alignment

None required.

U-30 OPTIONAL ANALOG TO DIGITAL CONVERTER

Description

U-30 is an optional analog to digital converter location designed to accommodate an analog devices AD 7550 13 bit analog to digital converter for higher resolution if necessary.

Operation

Power and data connections have been made on the digital board. The other connections required for operations are left to the user's discretion, for his requirements.

Alignment

To be determined by user.

U-31 DUAL D-FLIP FLOP

Description

U-31 is a CD4013, dual D-flip flop, that is used as a delay element for the strobe line, $\overline{E_1}$, input to the EPROMS U-22 and U-23 to allow time for a complete valid address.

Operation

U-31 delays the signal from U-25 by dividing it by 2 in the flip flop, effectively delaying the $\overline{E_1}$ strobe signal by 2 clock cycles. This allows time for a valid address to reach the EPROM.

Alignment

None required. However, all unused inputs must be tied to DGND.

A LOW-POWER, DATA-ACQUISITION SYSTEM

by

RICHARD CLIFFORD HOCHBERG

B.S., Kansas State University, 1970

AN ABSTRACT OF A MASTER'S REPORT

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requirements for the degree

MASTER OF SCIENCE

Department of Electrical Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

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ABSTRACT

This report describes the design, construction, and operation of a low-power, data-acquisition system for use in wind prospecting at remote locations. A RCA COSMAC evaluation board and an Analog/Digital interface board are used in conjunction with a Datel low-power, incremental, digital cassette-recorder. The system monitors three anemometers, a wind direction indicator and two temperature sensors in its minimal configuration. It can be readily expanded to accept up to seven additional analog inputs. A standard digital-cassette tape will record data resulting from sampling for one week at five samples a second per input for 50 minutes out of each hour.