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Voltammetric Analysis of Ordnance Materials

Part 2. A Portable Digital Voltammeter for Use With a Silver Wire Working Electrode

by
Dwight A. Fine
Research Department
and
David A. Reeve
Robert A. Dickus
Weapons Department

DECEMBER 1984

NAVAL WEAPONS CENTER
CHINA LAKE, CA 93555-6001



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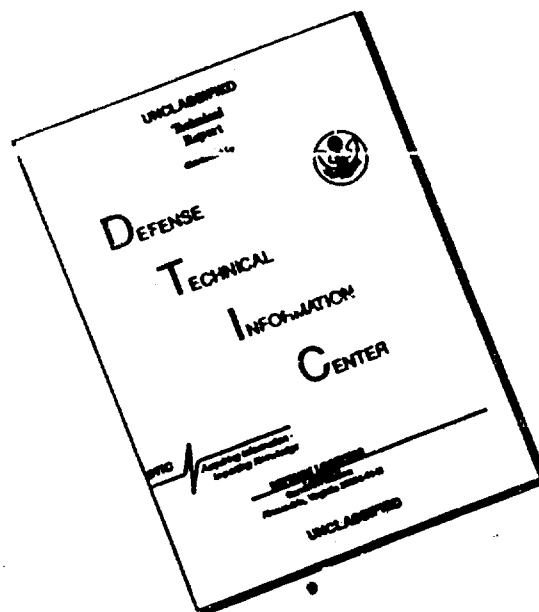
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FOREWORD

This report summarizes efforts to find suitable voltammetric methods for analysis of nitrate esters and aromatic nitro compounds and is presented in two parts under the general title, "Voltammetric Analysis of Ordnance Materials." Part 1 (NWC TP 6505, published in April 1984) is "Detection and Quantitation of Nitrate Esters and Various Nitro Compounds in Water by Voltammetry," and this report is Part 2. We have included some material published previously in October 1981 as NWC TM 4684 and have incorporated updates to that material.

The work described in this report was performed as part of a general program of electrochemical analysis of ordnance materials. The work was sponsored by the Naval Sea Systems Command, Task Area Number WF65559, Program Element 62565N; by the U.S. Army Toxic and Hazardous Materials Agency, Task R904.10.0163; and by the Naval Underwater Systems Center, WPN Source AA17X492.3790.

This report has been reviewed for technical accuracy by George McManis.

Approved by
E. B. ROYCE, Head
Research Department
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Under authority of
K. A. DICKERSON
Capt., USN
Commander

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(U) Voltammetric Analysis of Ordnance Materials.
Part 2. A Portable Digital Voltammeter for Use With a Silver Wire Working Electrode, by Dwight A. Fine, David A. Reeve and Robert A. Dickus. China Lake, Calif., Naval Weapons Center, December 1984. 52 pp. (NWC TP 6577, publication UNCLASSIFIED.)

(U) An inexpensive, portable, digital voltammeter has been designed and built at NWC. The instrument is intended for use with a silver wire working electrode. The voltammeter was built in response to a need on the part of Navy facilities for the monitoring of effluent water from the carbon column cleanup process used to remove propyleneglycoldinitrate from Otto fuel waste water. The instrument may also be used for the monitoring of contaminants such as nitroglycerin, dinitrotoluene, trinitrotoluene and nitroguanidine. This report describes in detail the construction, circuitry, software and operational features of the instrument.

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INTRODUCTION

A silver wire electrode has been found to be an effective working electrode for the voltammetric determination of nitrate esters and aromatic nitro compounds in water (Reference 1). The search for such an electrode was prompted by interest on the part of ordnance facilities in the monitoring of effluent waters for contamination by materials such as propyleneglycoldinitrate (PGDN), nitroglycerin (NG), dinitrotoluene (DNT), and trinitrotoluene (TNT). Commercially available voltammeters are too expensive and complex for purposes of bench or field testing, and a portable digital voltammeter has been developed at the Naval Weapons Center (NWC). The voltammeter was built by the Electronics Systems Branch at the request of the Instrumental Chemical Analysis Branch. This report describes the construction, circuitry, software, and operation of the instrument.

GENERAL DESCRIPTION

The voltammeter is designed to operate in conjunction with a silver wire working electrode, a platinum wire counter electrode and a standard calomel electrode (SCE) or silver/silver chloride reference electrode. A diagram of the system is shown in Figure 1.

The control unit was designed to meet the following criteria:

1. Portable. Housed in aluminum instrument case. Size: 18 x 13 x 5 inches (45 x 32.5 x 12.5 cm).
2. Semiautomatic. For simple operation by field personnel. Powered by conventional 115 V AC.
3. Drive solid electrodes with slow varying voltage ramps.
4. Take measurements of electrode currents for signal processing.
5. Calculate the contamination level in parts per million (ppm) and provide this value on hard copy printout.

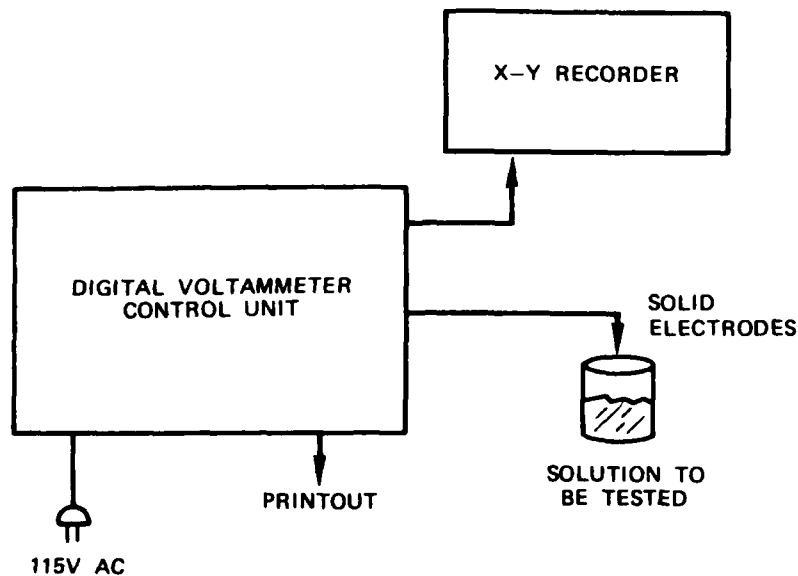


FIGURE 1. Diagram of the Voltammeter.

Expected levels of contamination to be measured by the instrument are in the range of 0.1 to 10 ppm. Although designed specifically to measure contamination by PGDN, it can be used to measure contamination by other nitrate esters and nitro compounds which have similar voltammograms, e.g., NG, DNT, and TNT.

The equipment setup for performing the digital voltammeter test consists of the electronic control unit and the test solution chamber with solid electrodes. The test chamber apparatus will consist of the test solution in the chamber, with means to support three electrodes in the solution. A cable connects the control unit to the top of the solid electrodes. The electronic control unit will sit on a workbench and plug into 115 V AC for power. Three analog test points are provided on the front panel to drive an X-Y recorder. Use of an X-Y recorder is not necessary for normal use of this system.

A connector on the front panel mates the cable to the test chamber. The cable has color-coded clips that readily attach to the electrodes. A brief outline follows which describes basic operation of a single testing of a test solution.

1. Prepare the test chamber.
2. Power on.
3. Run in BLANK mode.

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4. Prepare the chamber. Run in CAL (calibration) mode.
5. Prepare the chamber. Run in TEST mode.
6. Printer supplies hard copy of results.
7. Power off.

Each "run" will take a little less than 4 minutes to complete.

The system provides a slow varying voltage ramp to the electrodes. As the ramp voltage increases in absolute value, the chamber solution reacts chemically, characterized by a varying electric current in the working electrode, which is proportional to the amount of chemical contamination in the solution. This varying electric current is amplified, measured, and stored internally. The heart of the electronics system is the Intel 8085 microprocessor. Under software control, the system subtracts the background current from the current due to the contaminant, then the system calculates the concentration of contaminant (range: 0.1 to 10.0 ppm) by comparison with the current obtained from a known standard solution. The calculated concentration in ppm is displayed and printed out on hard copy.

DESCRIPTION OF CONTROLS

Figure 2 is a diagram of the front panel of the voltammeter. A brief description of each part of the front panel is given.

Ammeter

Indicates current flow between working and counter electrodes.

Month/Day

Date is dialed manually by operator before start of the day's runs.

Light Emitting Diode (LED)

These four lights are illuminated in succession during a run to indicate the completion of the three fast voltage scans and the start of the slow scan.

Standard Concentration

Indicates concentration of solution used for standard. Correct value in ppm is dialed manually by operator before start of run.

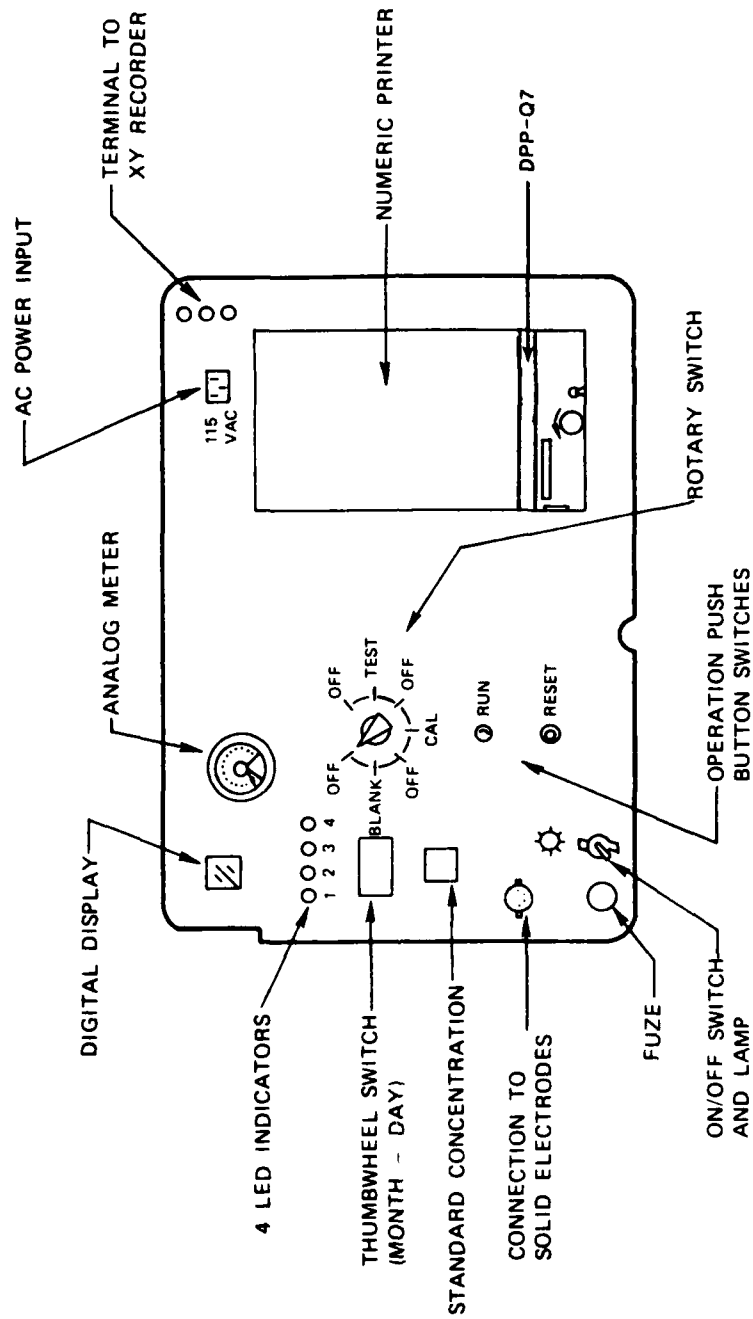


FIGURE 2. Diagram of the Front Panel of the Voltammeter.

Mode Switch

When this switch is set to BLANK, CAL, or TEST, the electrode cell is placed into the circuit and the resulting current flow shows on the ammeter.

Display (ppm)

Shows integral part of number which is printed by microprocessor.

Run

Pressing of this button actuates the sequence of three rapid voltage scans followed by one slow scan.

Reset

Pressing of this button aborts any run in progress. Results from previous runs are retained in memory.

SYSTEM DESCRIPTION

Figure 3 is a diagram of the entire system. The electrode current amplifier converts the electric current to a voltage, amplifies it, and scales it properly to drive the analog meter and the sample/hold amplifier. The analog meter is a real-time display of the relative amplitude of the electrode current (signal Y). The sample/hold amplifier is under software control and includes an analog-to-digital (A/D) conversion of the signal for the microprocessor. The scan generator circuits consist of a digital-to-analog (D/A) converter and scaling amplifiers.

Software controls the rate of both types of scans (fast: 50 mV/s; slow: 5 mV/s). The output labeled X is the voltage ramp, which is made available at an X-Y recorder terminal, and also goes to the counter electrode at the chamber. The reference electrode signal is brought into this circuit and added to the counter electrode signal to maintain a correct drive potential to the chamber.

Front panel control switches include a system RESET switch, RUN switch, and mode selection rotary switch. Their functions are detailed later. Front panel thumbwheel switches provide:

1. Setting in numbers which indicate month and day. These digits will be printed on the hard copy printout.
2. Standard solution concentration number (usually set at 1).

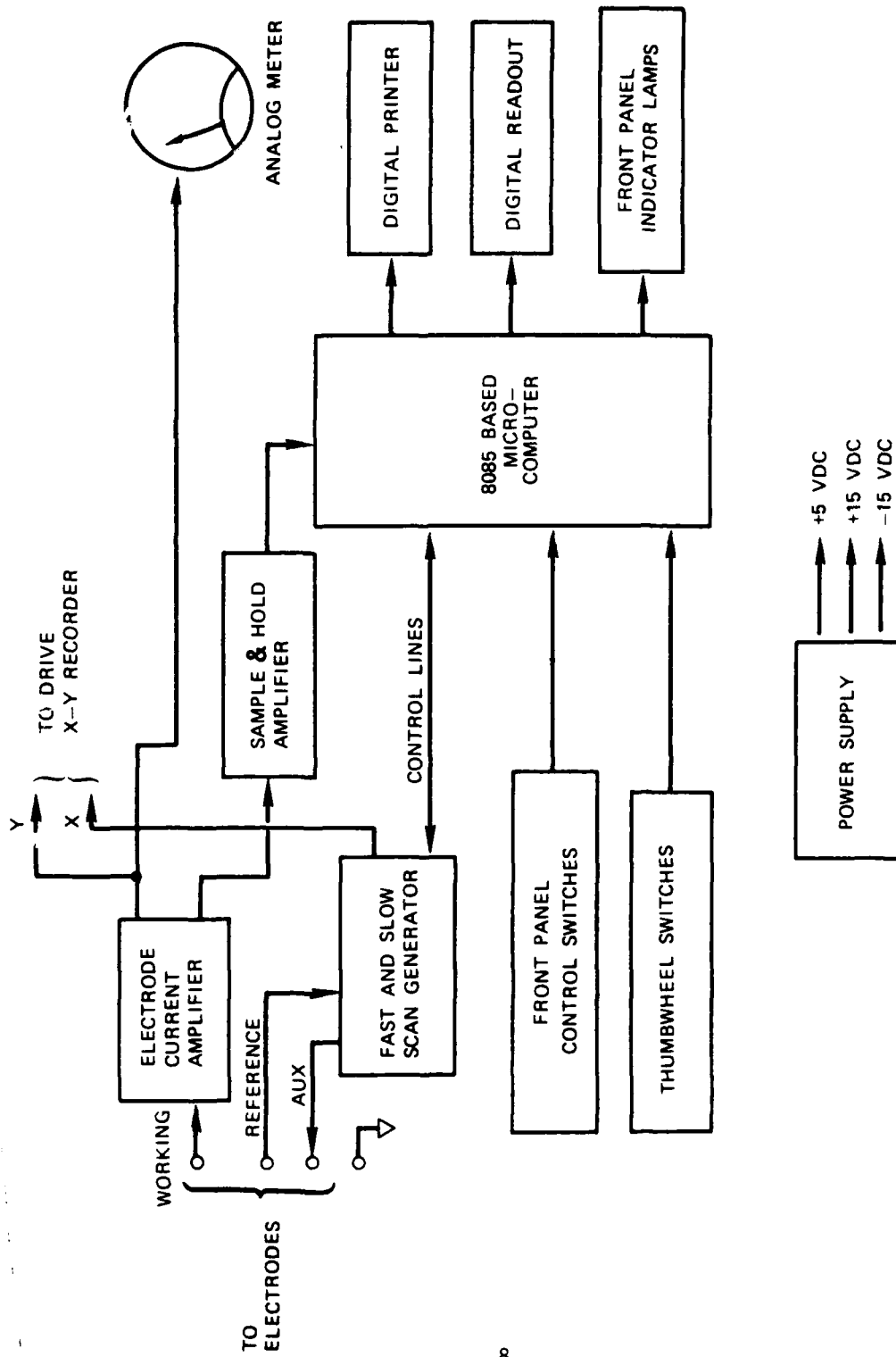


FIGURE 3. System Diagram, Voltammeter Electronic Unit.

The digital printer, DATEL DPP-Q7, is a self-contained numeric thermal printer. It is controlled by microprocessor software and will print the date and the resultant contamination level in ppm. The LED numeric digital display will indicate the test results in ppm and may be used for diagnostic tests on the system or display of intermediate results.

There is a set of four individual light-emitting diode lamps on the front panel that will indicate the progress in real time of a RUN sequence. The power supply for the unit is internal and is powered by 115 V AC. An on/off switch, fuze, and power-on lamp are on the front panel.

Figure 2 shows the front panel layout. The analog meter, scaled for 0 to 2 V DC, shows the relative magnitude of electric current coming from the working electrode during any scan (fast or slow--in any of the three modes) in real time. The rotary switch is used to select the mode of operation for a run operation. The off position means that no mode is selected and presents an off condition to the electrodes. An off condition for the electrodes is working electrode grounded, counter electrode open, and reference electrode--no change.

Figure 4 illustrates the basic circuit for operation of the electrodes in a run condition and in an off condition. The rotary switch is to be set to OFF when preparations are made to the test chamber. Just before pressing RUN to start a run sequence, the rotary switch is set to the desired mode. At the conclusion of a run (i.e., when all four lamps are on and a value is present on the digital display), the rotary switch is returned to off.

There are two momentary push button switches. The RUN switch, when activated, initiates active running of the software program. Once pressed, the system begins running and continues to completion of a cycle (just less than 4 minutes) unless reset. The RESET push button will interrupt any operation and set the system in a reset state awaiting a run command. Use of the reset switch would occur when it is necessary to halt the system operation and start over. Stored data from previously completed runs will be retained in memory when the system is reset.

The digital display of two digits will primarily be used to display final results of a test in ppm. During active operation and in the reset condition this display will be blank. The four LED lamps will show progression through a single test. They will light under the following conditions:

- LED 1 At conclusion of first FAST scan.
- LED 2 At conclusion of second FAST scan.

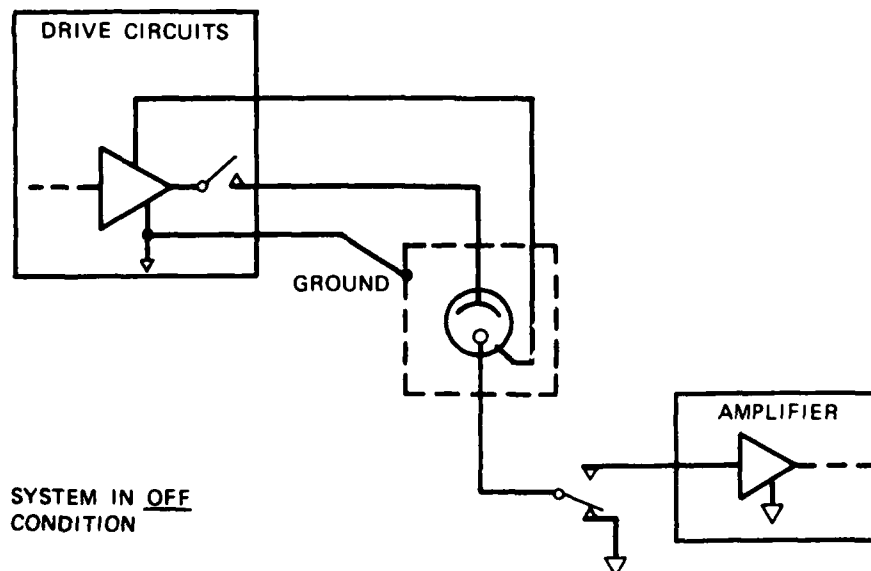
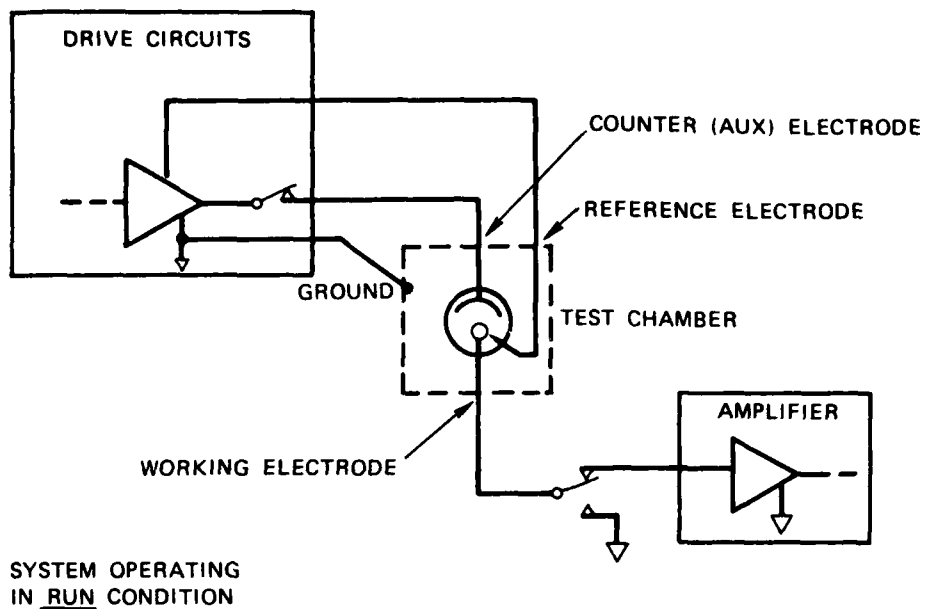


FIGURE 4. Basic Electrode Circuit.

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LED 3 At conclusion of third FAST scan.

LED 4 At conclusion of the 60-second pause.

All four LEDs lit at once indicate that the three preparation scans and the pause have been completed, and that the system will immediately begin a slow scan in the selected mode. At the end of a slow scan, the digital display will turn on with the resultant parameter for that mode. This concludes a "run." Pressing RUN or RESET will immediately turn the digital display and the four LEDs off.

Figure 5 is a diagram of the electronics system. The Intel 8085 microprocessor is the controller for the system. It is wired on the PLS-858 card, a standard microcomputer card from Pro-Log Corporation, which includes system memory circuits. The software program in machine language is stored in two erasable programmable read-only memory (EPROM) devices. These memory devices were programmed with the Tektronix 8002 Microcomputer Development System. The analog circuits card was built and designed at NWC and contains integrated circuit amplifiers and data converters to process signals for the first prototype and was replaced with a printed circuit (PC) Board in the second unit that was built. The thumbwheel switches circuit is contained on a PC board and is now readily reproducible. The digital display board is presently wire wrap and could be replaced with a PC board directly. The printer interface is also in wire wrap and could be replaced by a PC board, or may completely be eliminated by replacing the numeric printer with a more complex alphanumeric serial input printer. Such a printer could provide lettering on the printout as an added clarity feature and would interface more directly with the microprocessor. This alphanumeric printer costs half again as much as the numeric printer. The rest of the wiring is point-to-point wiring and has been designed to be kept to a minimum (many signals are transferred serially instead of as 8-bit parallel information).

The analog meter is a rugged, watertight, sealed unit, built to withstand the rigors of travel and abuse which the system may encounter in normal usage. It is of much higher quality than standard meters and is scaled to be driven by 0 to 2 V DC signals. It will display electric current variations through the working electrode. The thumbwheel switches circuit and the digital display board were wrapped for the first prototype and were replaced with PC boards in the second unit. The power supplies are standard modules to convert 115 V AC to +5 V DC and to ± 15 V DC. This entire electronics system is mounted to the back of the front panel so that it will lift out of the case easily for servicing and modifying.

Appendix A shows detailed schematics, chassis wiring diagrams, and component layouts.

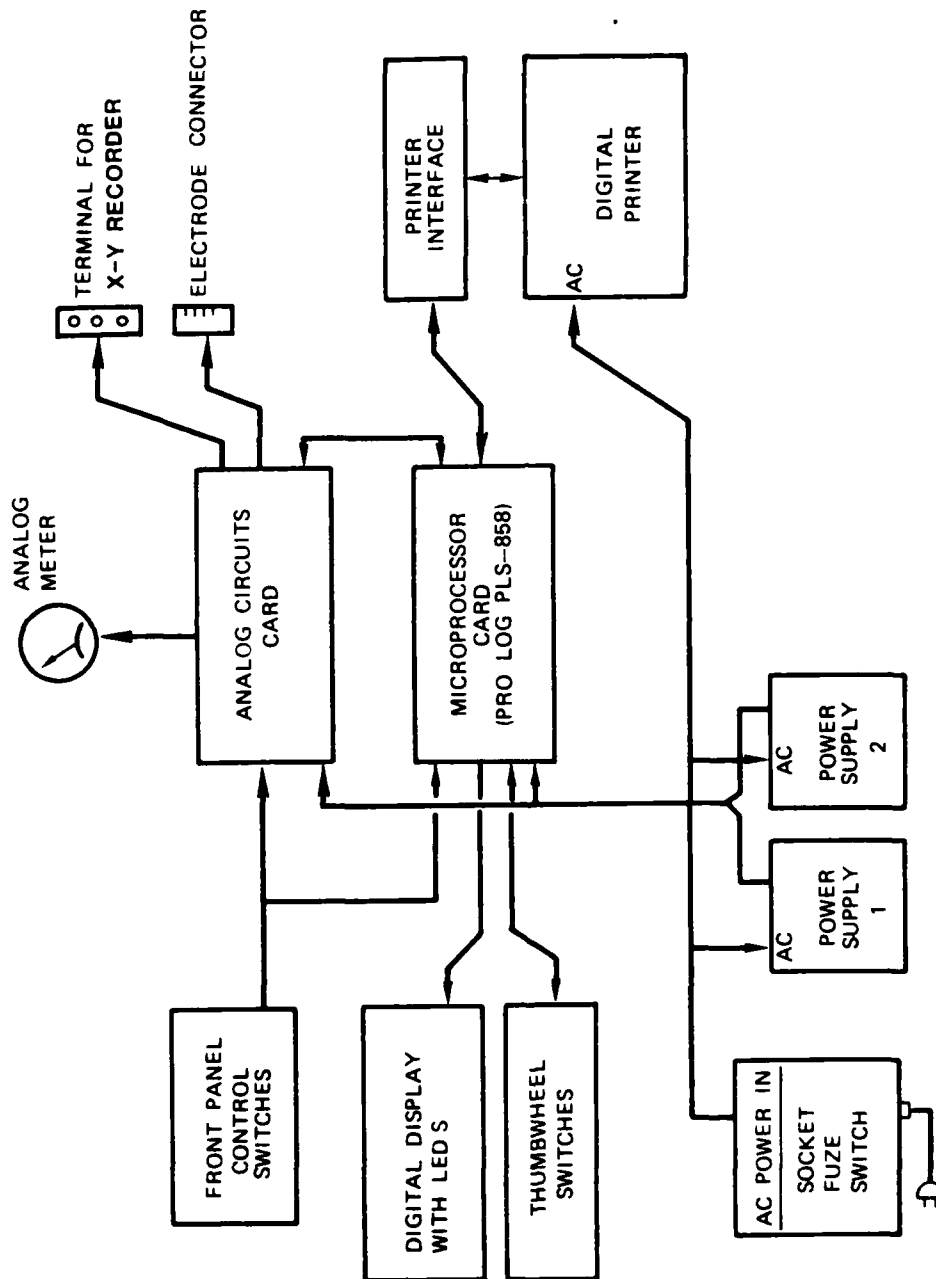


FIGURE 5. Electronic System Diagram.

SPECIFICATIONS

Following is a list of specifications for the voltammeter.

1. Provide FAST and SLOW scans
FAST defined as 50 mV/s
SLOW defined as 5 mV/s
2. Voltage range of linear DC ramps during a scan
FAST scans from -0.30 to -1.20 V
SLOW scans from -0.30 to -0.80 V

These potential limits are adjustable by changing parameter values in software.

3. The rotary switch will determine the mode of operation
OFF
BLANK, pure solution in the chamber
CAL (calibration), with 1 ppm standard
TEST, for testing the unknown
4. Pressing the RUN button will cause the following
Preparation scan 1 FAST
Preparation scan 2 FAST
Preparation scan 3 FAST
60-second pause
Measuring scan SLOW
5. It will be understood by the operator that the three FAST scans will prepare the electrodes, and that during the one SLOW scan the electrode current will be measured, processed, and recorded.
6. Provide digital readout--two numeric digits will show ppm levels of contamination.
7. Provide outputs capable of driving an X-Y recorder.
8. Provide thumbwheel switch to select ppm level of the standard solution (usually 1 ppm).
9. An electrical connector on the front panel will mate with cables from the electrodes.

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10. It is estimated that a 1 ppm contamination level causes a change in electrode current of 0.35 to 0.55 μA . During a CAL run this much current difference should be observed. The software design could be modified to test for this condition. A test failure would indicate a faulty electrode, an incorrect solution mixture, or some similar fault.

11. The printer will provide a hard copy printout of final results in ppm of contaminant.

12. The analog meter will display the relative magnitude of electrode current in real time.

13. During the SLOW scan, a sample window will exist from which the microprocessor will take samples of the electrode current. The microprocessor will record each sample, select the peak sample, and store this peak value as the electric current level for that scan.

14. The sample window is defined as the time during which the electrode potential varies from -0.45 to -0.65 V, during a SLOW scan.

15. The sample and hold amplifier circuit includes an A/D converter. Measured electric current through the working electrode of 40 μA will set the sample and hold amplifier to 9.99 V, which is its limit of measurement. Electric currents exceeding 40 μA will saturate the amplifier and give false results from the system.

16. Table 1 shows the basic parameters to be measured and/or manipulated by the system, and lists their expected limits.

TABLE 1. Basic Parameters and Expected Limits.

Parameter	Software mnemonic	Electric current from electrode	Analog voltage range	Range of values in software
BLANK solution ^a	IBLNK	0-10.80 μA	0-2.70 V	00-45 ₁₆
CAL solution ^a	IMCAL	0-14.40 μA	0-3.60 V	00-5C ₁₆
TEST solution ^a	IMTST	0-36.00 μA	0-8.99 V	00-E5 ₁₆
Calibration standard	CS			usually 1
Dilution factor	DF			1, 2, 3, or 4

^a Measured electric current.

MICROPROCESSOR PROGRAM

The Intel 8085 microcomputer software program was developed in assembly language with the use of the Tektronix 8002 Microcomputer Development System. The machine language program was derived from the assembly language listing and stored on EPROMs to be used as hardware for the Digital Voltammeter System. Figure 6 is a general flowchart of the program. Appendix B includes the detailed flowcharts and the list code printout for the entire software program.

CALCULATIONS

Table 2 shows the sequence of calculations of the digital voltammeter. The terms used in the equations are defined in Table 1 and on page 17. The following definitions apply to the parameters used by the software program. A mnemonic is assigned to each parameter.

TABLE 2. Sequence of Calculations of the Digital Voltammeter.

Function	Mode		
	BLANK	CAL	TEST
Parameter (peak of 20)	IBLNK	IMCAL	IMTST
Calculations	None	$ICAL = \frac{(IMCAL - IBLNK)}{CS}$ CS usually = 1	$IMBTST = IMTST - IBLNK$ DF = 1, 2, 3, or 4 $IPPMDF = (IPPM)(DF)$ $= \frac{(IMBTST)(DF)}{ICAL}$
Marker	1	2	3
Results	IBLNK	ICAL	IPPMDF

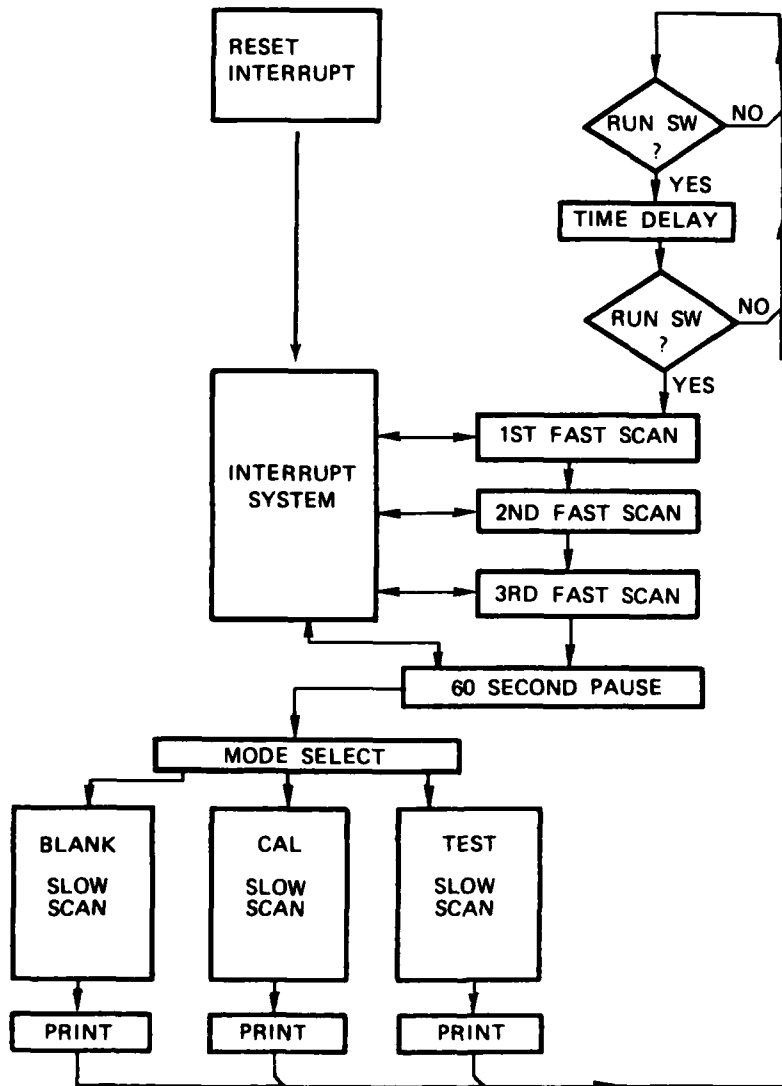


FIGURE 6. General Flow Chart.

INPUT PARAMETERS

- IBLNK The peak value of 20 samples of measured electrode current in the BLANK solution. A measured quantity scaled for software use.
- IMCAL The peak value of 20 samples of measured electrode current in the CAL solution. A measured quantity scaled for software use.
- IMTST The peak value of 20 samples of measured electrode current in the TEST solution. A measured quantity scaled for software use.
- CS Calibration factor; represents the concentration level in the CAL solution. Usually equal to 1 ppm. Set as a factor in software or dialed in by the front panel ppm switch.
- DF Dilution factor; the factor applied to the calculated concentration level in TEST solution assuming no dilution effects when preparing the solution. Set as a factor in software. Usually equal to 1, 2, 3, or 4.

CALCULATED PARAMETERS

- ICAL Value proportional to the differential amount of electric current equivalent to 1 ppm.
- IMBTST Value proportional to the differential amount of current from TEST solution compared to BLANK solution.
- IPPM Contaminant concentration in TEST solution, not considering a dilution factor.
- IPPMDF Contaminant concentration in TEST solution including the dilution factor. The final result.

EQUATIONS TO BE PROCESSED

Given parameters (measured values and scale factors) = IBLNK, IMCAL, IMTST, CS, and DF.

$$ICAL = \frac{(IMCAL - IBLNK)}{CS} \quad (1)$$

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$$\text{IMBTST} = \text{IMTST} - \text{IBLNK} \quad (2)$$

$$\text{IPPM} = \frac{\text{IMBTST}}{\text{ICAL}} \quad (3)$$

$$\text{IPPMDF} = (\text{IPPM})(\text{DF}) \quad (4)$$

$$= \frac{(\text{IMBTST})(\text{DF})}{\text{ICAL}} \quad (5)$$

OPERATING PROCEDURE

1. Plug power cable into panel (upper right) and connect to 115V AC.
2. Connect electrode cable to panel (lower left). With electrodes inserted into cell, connect leads to electrodes as follows:
 - a. WKG lead to working electrode.
 - b. AUX lead to auxiliary (counter) electrode.
 - c. REF lead to reference electrode.

The GND lead need not be connected, but should be grounded for optimum results.

3. Set mode switch to the uppermost OFF position.
4. Dial thumbwheel switches to correct date (month/day).
5. Set STANDARD dial to concentration in ppm that will be used for a standard.
6. Turn power ON.
7. Measure blank solution (distilled water + salt + buffer) into cell. Deaerate for about 20 minutes.
8. Set mode switch on BLANK.
9. When ammeter needle is steady, press RUN. Observe three fast preparatory scans, 60-second pause, and one slow measuring scan. The four small lights to the left of the ammeter will light up in succession at the end of each fast scan and at the end of the 60-second pause. At end of run, the printer will print date and the display will show a random number.

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10. Turn mode switch counterclockwise to next OFF setting.
11. Add standard PGDN (or other analyte) to blank to yield final concentration equal to setting on STANDARD. Deaerate for about 50 seconds.
12. Turn mode switch to CAL.
13. When ammeter needle is steady, press RUN. Observe three preparatory scans, 60-second pause, and one slow measuring scan. Printer will advance without printing any number.
14. Turn mode switch counterclockwise to next OFF setting.
15. Add salt/buffer to unknown solution, measure solution into cell, and deaerate for about 20 minutes.
16. Turn mode switch to TEST.
17. When ammeter needle is steady, press RUN. Observe three preparatory scans, 60-second pause, and one slow measuring scan. Printer will print unknown concentration in ppm (to one decimal figure). Display will show whole number part of concentration.
18. Turn mode switch to next OFF setting.
19. For any additional unknown solutions, repeat steps 15-18.
20. To abort a run, press RESET. Printer will then print random number.
21. For use in conjunction with an X-Y recorder, make the following connections:
 - a. X on voltammeter to (+) input of X on recorder.
 - b. Y on voltammeter to (+) input of Y on recorder.
 - c. GND on voltammeter to (-) input of Y on recorder.
 - d. (-) input of X to (-) input of Y on recorder.

Recorder settings:

- a. X = 100 mV/min
- b. Y = 1 V/inch for fast scan,
100 mV/inch for slow scan when concentrations greater than 3 ppm,
10 mV/min for slow scan when concentrations less than 3 ppm.

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REFERENCES

1. Naval Weapons Center. Voltammetric Analysis of Ordnance Materials. Part 1. Detection and Quantitation of Nitrate Esters and Various Nitro Compounds in Water by Voltammetry, by Dwight A. Fine and Melvin H. Miles, China Lake, Calif., NWC, April 1984. 24 pp. (NWC TP 6505, publication UNCLASSIFIED.)

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Appendix A
HARDWARE DOCUMENTATION

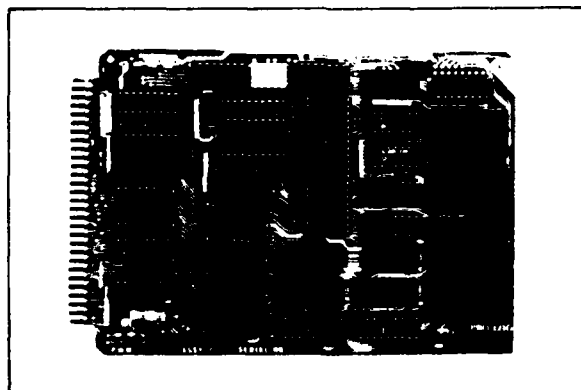
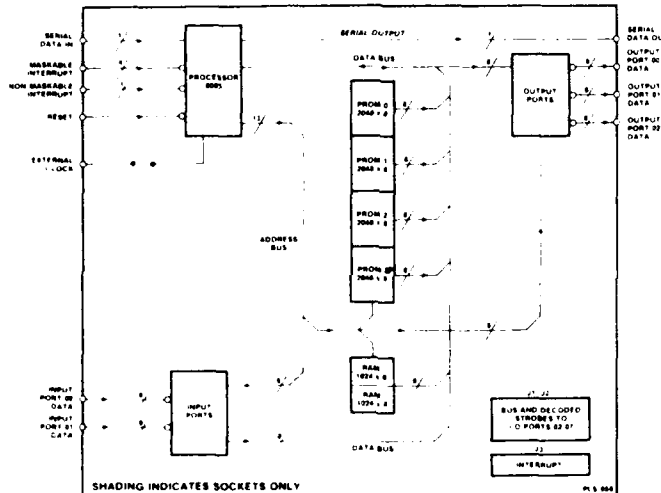


8085 EDGE CARD SYSTEMS PLS-858 ONE CARD SYSTEM

The PLS-858 is a complete 8085 microprocessor system on one 4 1/2" x 6 1/2" circuit card. The system provides a 56-pin card edge connector that is similar to the existing Pro-Log PLS-881 microprocessors. The PLS-858 incorporates all the elements of the highly popular PLS-881 and PLS-888 and expands on them. The PLS-858 offers the capability of expanding program memory to 8192 bytes using 2048 byte D2002 PROM (2716 or equivalent). The PLS-858 also comes with 1024 bytes of read/write memory and can be expanded to 2048 bytes simply by plugging in two additional D1004 RAMs (2114 or equivalent). Like the companion PLS cards, the more powerful PLS-858 includes three output ports and two input ports at the card edge, however, I/O can be expanded to eight input and eight output ports with a simple ribbon cable expansion system that accesses the data bus and I/O decoder strobe. The PLS-858 offers 5 external interrupts, a serial input line and a serial output line, 320 nanosecond time states, and single +5V supply operation. To utilize the full power of the 8085 and add versatility to the PLS-858, an interrupt expansion connector is provided.

FEATURES

- 8085 Processor
- 2K Byte RAM capacity with 1K Included
- Sockets for 8K Bytes 2716 EPROM
- Crystal Clock
- 320 Nanosecond State Time
- Power-on and External Reset
- Three 8-Bit Output Ports
- Two 8-Bit Input Ports
- External Port Expansion to 16 ports
- Five Interrupts
- 1 Each Serial Input and Output Lines
- Program Compatible with 8080 Systems
- Single +5V Supply



PLS-858 ONE CARD SYSTEM

FIGURE A-1. One Card System Description.

PLS-858 ONE CARD SYSTEM

SPECIFICATIONS

CARD DIMENSIONS

- 4.50 in (11.43 cm) high by 6.50 in (16.51 cm) long
- 0.48 in (1.22 cm) maximum profile thickness
- 0.062 in (0.16 cm) printed circuit board thickness

CARD INCLUDES

- Card ejector
- One 8085 Processor
- 1K 8-bit bytes 2114 RAM and sockets for second 1K bytes
- Four ROM sockets for 2716 PROMs
- Crystal clock circuit and provisions for external clock
- Power-on and external reset
- 2 Input ports (8-bit)
- 3 Output ports (8-bit)

INSTRUCTION EXECUTION CAPABILITY

- Executes all of the 8085 Processor instructions
- 0.32 microseconds time state cycle $\pm 0.05\%$ at $25^{\circ}\text{C} \pm 0.1\%$ $0-55^{\circ}\text{C}$
- Instructions require from 4 to 8 time states

MEMORY

- Maximum Access Time 0.450 microseconds
- PROM 2716 or equivalent
- RAM 2114 or equivalent

INPUTS (Active low except where noted, loading 1 LSTTL load)

- 16 Data Lines (2 Input Ports)
- Port Expansion Data Bus (J1, active high)
- 5 Interrupt Requests (J3, three at card edge)
- 1 Serial Input Line (active high)
- 1 Reset Control Line
- 1 RDY (active high)

OUTPUTS (Active low except where noted, drive 5 TTL loads)

- 24 Latched Output Data Lines (3 output ports)
- Port Expansion Data Bus (J1, active high)
- 2 System Reset (J2 and card edge)
- 1 Clock Signal
- 1 Serial Output Data (J3, active high)
- 6 Input Port Strobes (J2)
- 5 Output Port Strobes (J2)

POWER REQUIREMENTS

- VCC: +5 volts $\pm 5\%$ at 1.2 A max, fully loaded (100 mA per ROM, 100 mA per RAM)
- GND: 0 volts

OPERATING TEMPERATURE RANGE: $0-55^{\circ}\text{C}$

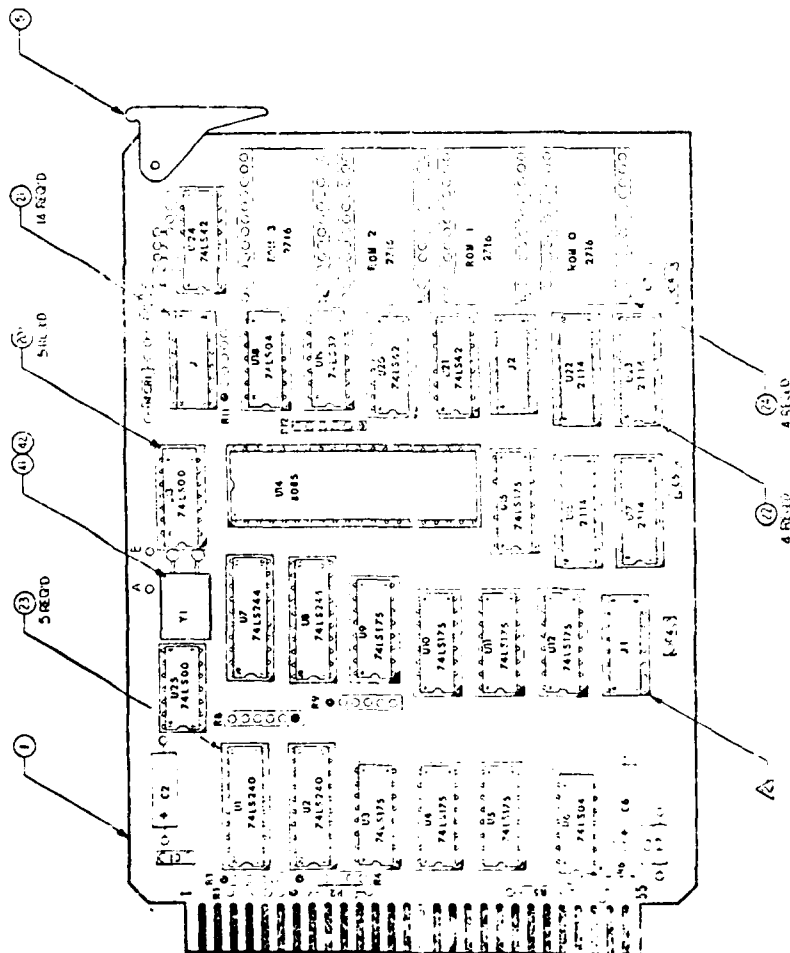
CONNECTOR REQUIREMENTS:

- 56 pin, 28 position dual-in-line on 0.125 in (0.318 cm) centers

PLS 858 EDGE CONNECTOR PIN LIST															
1	5 VOLTS	2	GROUND	3	SPARE	4	IN0 5	5	IN0 6	6	IN0 7	7	IN0 8	8	IN0 4
9	IN0 3	10	IN0 2	11	IN0 1	12	OUT0 1	13	OUT0 2	14	OUT0 3	15	OUT0 4	16	OUT1 1
17	OUT1 2	18	OUT1 3	19	OUT1 4	20	OUT2 1	21	OUT2 2	22	OUT2 3	23	OUT2 4	24	INTA
25	NMI	26	RST5	27	RST1	28	SIO	29	5 VOLTS	30	GROUND	31	SPARE	32	IN1 5
33	IN1 6	34	IN1 7	35	IN1 8	36	IN1 4	37	IN1 3	38	IN1 2	39	IN1 1	40	OUT0 5
41	OUT0 6	42	OUT0 7	43	OUT0 8	44	OUT1 5	45	OUT1 6	46	OUT1 7	47	OUT1 8	48	OUT2 5
49	OUT2 6	50	OUT2 7	51	OUT2 8	52	REQ	53	RDY	54	CLR	55	RST	56	SIO

I/O PORT EXPANSION SOCKETS															
J1 DATA								J2 CONTROL AND POWER							
DATA 1-8				DATA 9-16				CONTROL FLOW				SIGNAL FLOW			
DATA 1-8				DATA 9-16				CONTROL FLOW				SIGNAL FLOW			
DI-4	N	TE	1	IN	DI-1	N	TE	1	IN	DI-1	N	TE	1	IN	DI-1
DO-2	N	TE	2	IN	DI-8	N	TE	2	IN	DI-8	N	TE	2	IN	DI-8
DO-4	N	TE	4	IN	DO-1	N	TE	1	IN	DO-1	N	TE	1	IN	DO-1
DO-1	N	TE	1	IN	DO-7	N	TE	7	IN	DO-7	N	TE	7	IN	DO-7
DI-7	N	TE	7	IN	DO-2	N	TE	2	IN	DO-2	N	TE	2	IN	DO-2
DO-5	N	TE	5	IN	DI-5	N	TE	5	IN	DI-5	N	TE	5	IN	DI-5
DO-8	N	TE	8	IN	DI-6	N	TE	6	IN	DI-6	N	TE	6	IN	DI-6
DI-3	N	TE	3	IN	DI-2	N	TE	2	IN	DI-2	N	TE	2	IN	DI-2
J3 INTERRUPTS AND MISC								J4 SIGNAL FLOW							
DATA 1-8				DATA 9-16				CONTROL FLOW				SIGNAL FLOW			
DATA 1-8				DATA 9-16				CONTROL FLOW				SIGNAL FLOW			
GH0	N	TE	1	IN	GH0	N	TE	1	IN	GH0	N	TE	1	IN	GH0
IS-2	N	TE	2	IN	BR5	N	TE	5	IN	BR5	N	TE	5	IN	BR5
IS-3	N	TE	3	IN	OS-3	N	TE	3	IN	OS-3	N	TE	3	IN	OS-3
IS-4	N	TE	4	IN	OS-4	N	TE	4	IN	OS-4	N	TE	4	IN	OS-4
IS-5	N	TE	5	IN	OS-5	N	TE	5	IN	OS-5	N	TE	5	IN	OS-5
IS-6	N	TE	6	IN	IS-7	N	TE	7	IN	IS-7	N	TE	7	IN	IS-7
OS-6	N	TE	6	IN	IS-5	N	TE	5	IN	IS-5	N	TE	5	IN	IS-5
OS-7	N	TE	7	IN	IS-6	N	TE	6	IN	IS-6	N	TE	6	IN	IS-6
IS-7	N	TE	7	IN	IS-4	N	TE	4	IN	IS-4	N	TE	4	IN	IS-4
IS-8	N	TE	8	IN	IS-3	N	TE	3	IN	IS-3	N	TE	3	IN	IS-3
IS-9	N	TE	9	IN	IS-2	N	TE	2	IN	IS-2	N	TE	2	IN	IS-2
IS-10	N	TE	10	IN	IS-1	N	TE	1	IN	IS-1	N	TE	1	IN	IS-1
IS-11	N	TE	11	IN	IS-0	N	TE	0	IN	IS-0	N	TE	0	IN	IS-0
IS-12	N	TE	12	IN	IS-15	N	TE	15	IN	IS-15	N	TE	15	IN	IS-15
IS-13	N	TE	13	IN	IS-14	N	TE	14	IN	IS-14	N	TE	14	IN	IS-14
IS-14	N	TE	14	IN	IS-13	N	TE	13	IN	IS-13	N	TE	13	IN	IS-13
IS-15	N	TE	15	IN	IS-12	N	TE	12	IN	IS-12	N	TE	12	IN	IS-12
IS-16	N	TE	16	IN	IS-11	N	TE	11	IN	IS-11	N	TE	11	IN	IS-11
IS-17	N	TE	17	IN	IS-10	N	TE	10	IN	IS-10	N	TE	10	IN	IS-10
IS-18	N	TE	18	IN	IS-9	N	TE	9	IN	IS-9	N	TE	9	IN	IS-9
IS-19	N	TE	19	IN	IS-8	N	TE	8	IN	IS-8	N	TE	8	IN	IS-8
IS-20	N	TE	20	IN	IS-7	N	TE	7	IN	IS-7	N	TE	7	IN	IS-7
IS-21	N	TE	21	IN	IS-6	N	TE	6	IN	IS-6	N	TE	6	IN	IS-6
IS-22	N	TE	22	IN	IS-5	N	TE	5	IN	IS-5	N	TE	5	IN	IS-5
IS-23	N	TE	23	IN	IS-4	N	TE	4	IN	IS-4	N	TE	4	IN	IS-4
IS-24	N	TE	24	IN	IS-3	N	TE	3	IN	IS-3	N	TE	3	IN	IS-3
IS-25	N	TE	25	IN	IS-2	N	TE	2	IN	IS-2	N	TE	2	IN	IS-2
IS-26	N	TE	26	IN	IS-1	N	TE	1	IN	IS-1	N	TE	1	IN	IS-1
IS-27	N	TE	27	IN	IS-0	N	TE	0	IN	IS-0	N	TE	0	IN	IS-0
IS-28	N	TE	28	IN	IS-15	N	TE	15	IN	IS-15	N	TE	15	IN	IS-15
IS-29	N	TE	29	IN	IS-14	N	TE	14	IN	IS-14	N	TE	14	IN	IS-14
IS-30	N	TE	30	IN	IS-13	N	TE	13	IN	IS-13	N	TE	13	IN	IS-13
IS-31	N	TE	31	IN	IS-12	N	TE	12	IN	IS-12	N	TE	12	IN	IS-12
IS-32	N	TE	32	IN	IS-11	N	TE	11	IN	IS-11	N	TE	11	IN	IS-11
IS-33	N	TE	33	IN	IS-10	N	TE	10	IN	IS-10	N	TE	10	IN	IS-10
IS-34	N	TE	34	IN	IS-9	N	TE	9	IN	IS-9	N	TE	9	IN	IS-9
IS-35	N	TE	35	IN	IS-8	N	TE	8	IN	IS-8	N	TE	8	IN	IS-8
IS-36	N	TE	36	IN	IS-7	N	TE	7	IN	IS-7	N	TE	7	IN	IS-7
IS-37	N	TE	37	IN	IS-6	N	TE	6	IN	IS-6	N	TE	6	IN	IS-6
IS-38	N	TE	38	IN	IS-5	N	TE	5	IN	IS-5	N	TE	5	IN	IS-5
IS-39	N	TE	39	IN	IS-4	N	TE	4	IN	IS-4	N	TE	4	IN	IS-4
IS-40	N	TE	40	IN	IS-3	N	TE	3	IN	IS-3	N	TE	3	IN	IS-3
IS-41	N	TE	41	IN	IS-2	N	TE	2	IN	IS-2	N	TE	2	IN	IS-2
IS-42	N	TE	42	IN	IS-1	N	TE	1	IN	IS-1	N	TE	1	IN	IS-1
IS-43	N	TE	43	IN	IS-0	N	TE	0	IN	IS-0	N	TE	0	IN	IS-0
IS-44	N	TE	44	IN	IS-15	N	TE	15	IN	IS-15	N	TE	15	IN	IS-15
IS-45	N	TE	45	IN	IS-14	N	TE	14	IN	IS-14	N	TE	14	IN	IS-14
IS-46	N	TE	46	IN	IS-13	N	TE	13	IN	IS-13	N	TE	13	IN	IS-13
IS-47	N	TE	47	IN	IS-12	N	TE	12	IN	IS-12	N	TE	12	IN	IS-12
IS-48	N	TE	48	IN	IS-11	N	TE	11	IN	IS-11	N	TE	11	IN	IS-11
IS-49	N	TE	49	IN	IS-10	N	TE	10	IN	IS-10	N	TE	10	IN	IS-10
IS-50	N	TE	50	IN	IS-9	N	TE	9	IN	IS-9	N	TE	9	IN	IS-9
IS-51	N	TE	51	IN	IS-8	N	TE	8	IN	IS-8	N	TE	8	IN	IS-8
IS-52	N	TE	52	IN	IS-7	N	TE	7	IN	IS-7	N	TE	7	IN	IS-7
IS-53	N	TE	53	IN	IS-6	N	TE	6	IN	IS-6	N	TE	6	IN	IS-6
IS-54	N	TE	54	IN	IS-5	N	TE	5	IN	IS-5	N	TE	5	IN	IS-5
IS-55	N	TE	55	IN	IS-4	N	TE	4	IN	IS-4	N	TE	4	IN	IS-4
IS-56	N	TE	56	IN	IS-3	N	TE	3	IN	IS-3	N	TE	3	IN	IS-3
IS-57	N	TE	57	IN	IS-2	N	TE	2	IN	IS-2	N	TE	2	IN	IS-2
IS-58	N	TE	58	IN	IS-1	N	TE	1	IN	IS-1	N	TE	1	IN	IS-1
IS-59	N	TE	59	IN	IS-0	N	TE	0	IN	IS-0	N	TE	0	IN	IS-0
IS-60	N	TE	60	IN	IS-15	N	TE	15	IN	IS-15	N	TE	15	IN	IS-15
IS-61	N	TE	61	IN	IS-14	N	TE	14	IN	IS-14	N	TE	14	IN	IS-14
IS-62	N	TE	62	IN	IS-13	N	TE	13	IN	IS-13	N	TE	13	IN	IS-13
IS-63	N	TE	63	IN	IS-12	N	TE	12	IN	IS-12	N	TE	12	IN	IS-12
IS-64	N	TE	64	IN	IS-11	N	TE	11	IN	IS-11	N	TE	11	IN	IS-11
IS-65	N	TE	65	IN	IS-10	N	TE	10	IN	IS-10	N	TE	10	IN	IS-10
IS-66	N	TE	66	IN	IS-9	N	TE	9	IN	IS-9	N	TE	9	IN	IS-9
IS-67	N	TE	67	IN	IS-8	N	TE	8	IN	IS-8	N	TE	8	IN	IS-8
IS-68	N	TE	68	IN	IS-7	N	TE	7	IN	IS-7	N	TE	7	IN	IS-7
IS-69	N	TE	69	IN	IS-6	N	TE	6	IN	IS-6	N	TE	6	IN	IS-6
IS-70	N	TE	70	IN	IS-5	N	TE	5	IN	IS-5	N	TE	5	IN	IS-5
IS-71	N	TE	71	IN	IS-4	N	TE	4	IN	IS-4	N	TE	4	IN	IS-4
IS-72	N	TE	72	IN	IS-3	N	TE	3	IN	IS-3	N	TE	3	IN	IS-3
IS-73	N	TE	73	IN	IS-2	N	TE	2	IN	IS-2	N	TE	2	IN	IS-2
IS-74	N	TE	74	IN	IS-1	N	TE	1	IN	IS-1	N	TE	1	IN	IS-1
IS-75	N	TE	75	IN	IS-0	N	TE	0	IN	IS-0	N	TE	0	IN	IS-0
IS-76	N	TE	76	IN	IS-15	N	TE	15	IN	IS-15	N	TE	15	IN	IS-15
IS-77	N	TE	77	IN	IS-14	N	TE	14	IN	IS-14	N	TE	14	IN	IS-14
IS-78	N	TE	78	IN	IS-13	N	TE	13	IN	IS-13	N	TE	13	IN	IS-13
IS-79	N	TE	79	IN	IS-12	N	TE	12	IN	IS-12	N	TE	12	IN	IS-12
IS-80	N	TE	80	IN	IS-11	N	TE	11	IN	IS-11	N	TE	11	IN	IS-11
IS-81	N	TE	81	IN	IS-10	N	TE	10	IN	IS-10	N	TE	10	IN	IS-10
IS-82	N	TE	82	IN	IS-9	N	TE	9	IN	IS-9	N	TE	9	IN	IS-9
IS-83	N	TE	83	IN	IS-8	N	TE	8	IN	IS-8	N	TE	8	IN	IS-8
IS-84	N	TE	84	IN	IS-7	N	TE	7	IN	IS-7	N	TE	7	IN	IS-7
IS-85	N	TE	85	IN	IS-6	N	TE	6	IN	IS-6	N	TE	6	IN	IS-6
IS-86	N	TE	86	IN	IS-5	N	TE	5	IN	IS-5	N	TE	5	IN	IS-5
IS-87	N	TE	87	IN	IS-4	N	TE	4	IN	IS-4	N	TE	4	IN	IS-4
IS-88	N	TE	88	IN	IS-3	N	TE	3	IN	IS-3	N	TE	3	IN	IS-3
IS-89	N	TE	89	IN	IS-2	N	TE	2	IN	IS-2	N	TE	2	IN	IS-2
IS-90	N	TE	90	IN	IS-1	N	TE	1	IN	IS-1	N	TE	1	IN	IS-1
IS-91	N	TE	91	IN	IS-0	N	TE	0	IN	IS-0	N	TE	0	IN	IS-0
IS-92	N	TE	92	IN	IS-15	N	TE	15	IN	IS-15	N	TE	15	IN	IS-15
IS-93	N	TE	93	IN	IS-14	N	TE	14	IN	IS-14	N	TE	14	IN	IS-14
IS-94	N	TE	94	IN	IS-13	N	TE	13	IN	IS-13	N	TE	13	IN	IS-13
IS-95	N	TE	95	IN	IS-12	N	TE	12	IN	IS-12	N	TE	12	IN	IS-12
IS-96	N	TE	96	IN	IS-11	N	TE	11	IN	IS-11	N	TE	11	IN	IS-11
IS-97	N	TE	97	IN	IS-10	N	TE	10	IN	IS-10	N	TE	10	IN	IS-10
IS-98	N	TE	98	IN	IS-9	N	TE	9	IN	IS-9	N	TE	9	IN	IS-9
IS-99	N	TE	99	IN	IS-8	N	TE	8	IN	IS-8	N	TE	8	IN	IS-8
IS-100	N	TE	100	IN	IS-7	N	TE	7	IN	IS-7	N	TE	7	IN	IS-7
IS-101	N	TE	101	IN	IS-6	N	TE	6	IN	IS-6	N	TE	6	IN	IS-6
IS-102	N	TE	102	IN	IS-5	N	TE	5	IN						

Part No.	Quantity	Remarks
A	1	PLS-858 Microprocessor Card



△ INTERFACES TO BUS (U1, U2, U3)
 △ LOGIC SUPPLY (U4, U5, U6, U7, U8, U9, U10, U11, U12, U13, U14, U15, U16, U17, U18, U19, U20, U21, U22, U23, U24, U25, U26, U27, U28, U29, U30, U31, U32, U33, U34, U35, U36, U37, U38, U39, U40, U41, U42, U43, U44, U45, U46, U47, U48, U49, U50, U51, U52, U53, U54, U55, U56, U57, U58, U59, U60, U61, U62, U63, U64, U65, U66, U67, U68, U69, U70, U71, U72, U73, U74, U75, U76, U77, U78, U79, U80, U81, U82, U83, U84, U85, U86, U87, U88, U89, U90, U91, U92, U93, U94, U95, U96, U97, U98, U99, U100)

Part No.	Quantity	Remarks
A	1	PLS-858 Microprocessor Card

PLS-858 MICROPROCESSOR CARD
 DATE: 11/10/77

FIGURE A-3. Diagram of PLS-858 Microprocessor Circuit Card.

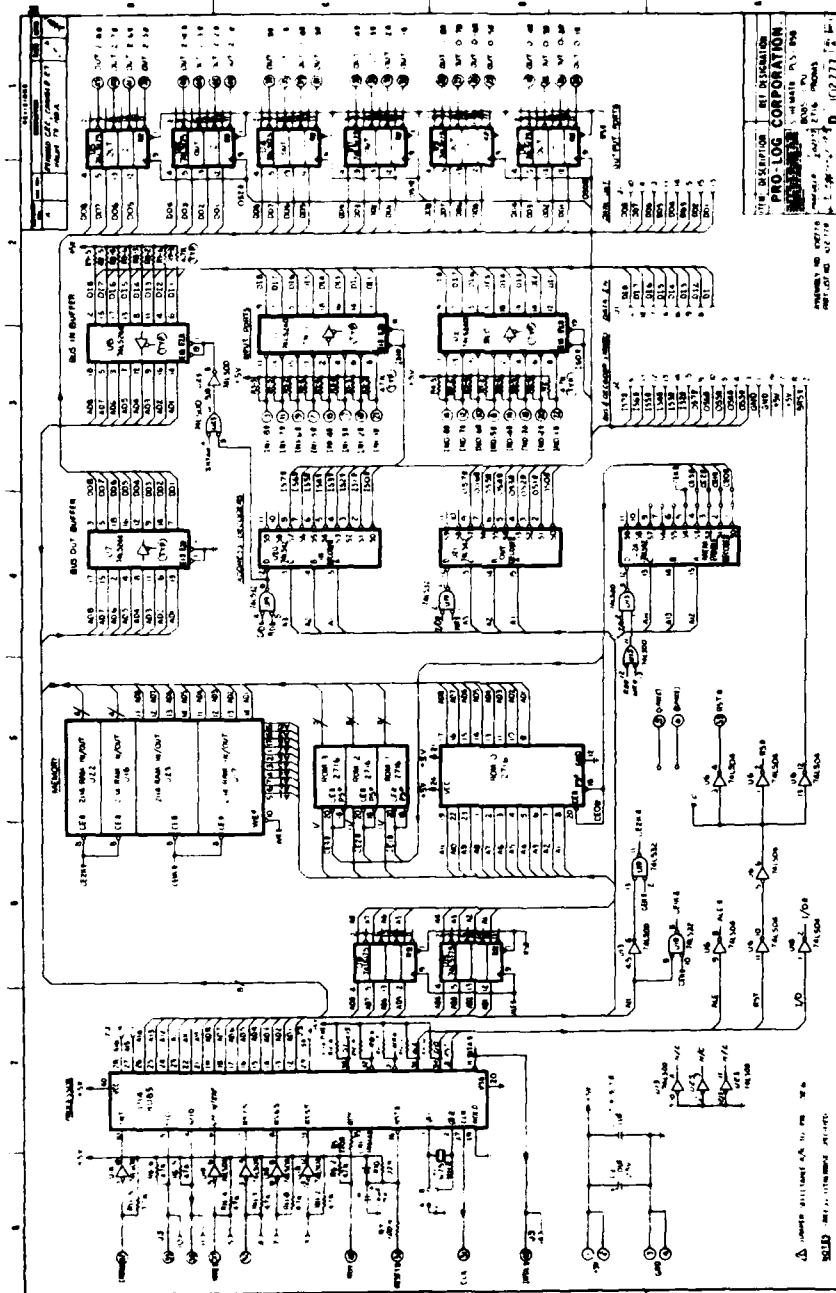


FIGURE A-4. Schematic of PLS-858 Microprocessor Circuit Card.

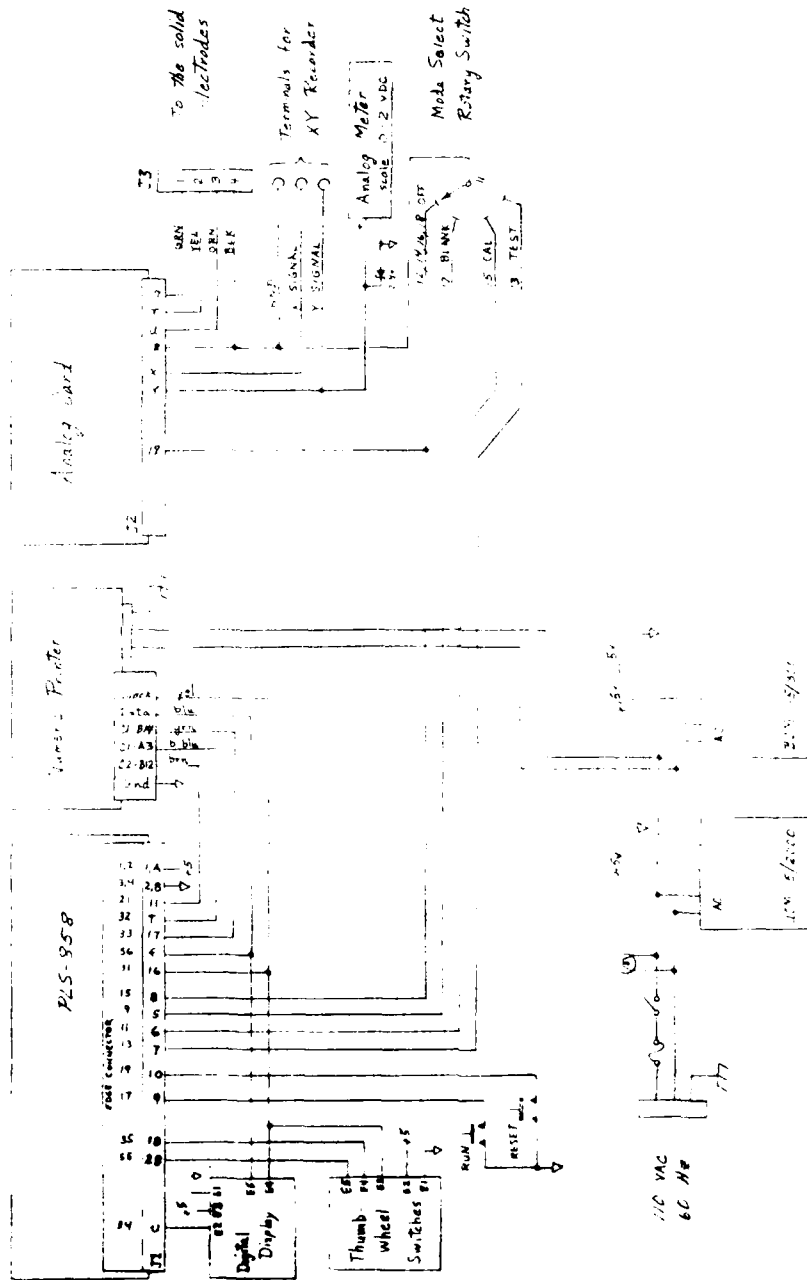
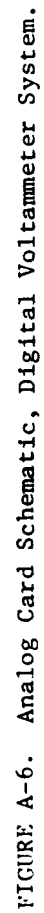


FIGURE A-5. Chassis Wiring Diagram, Digital Voltammeter.



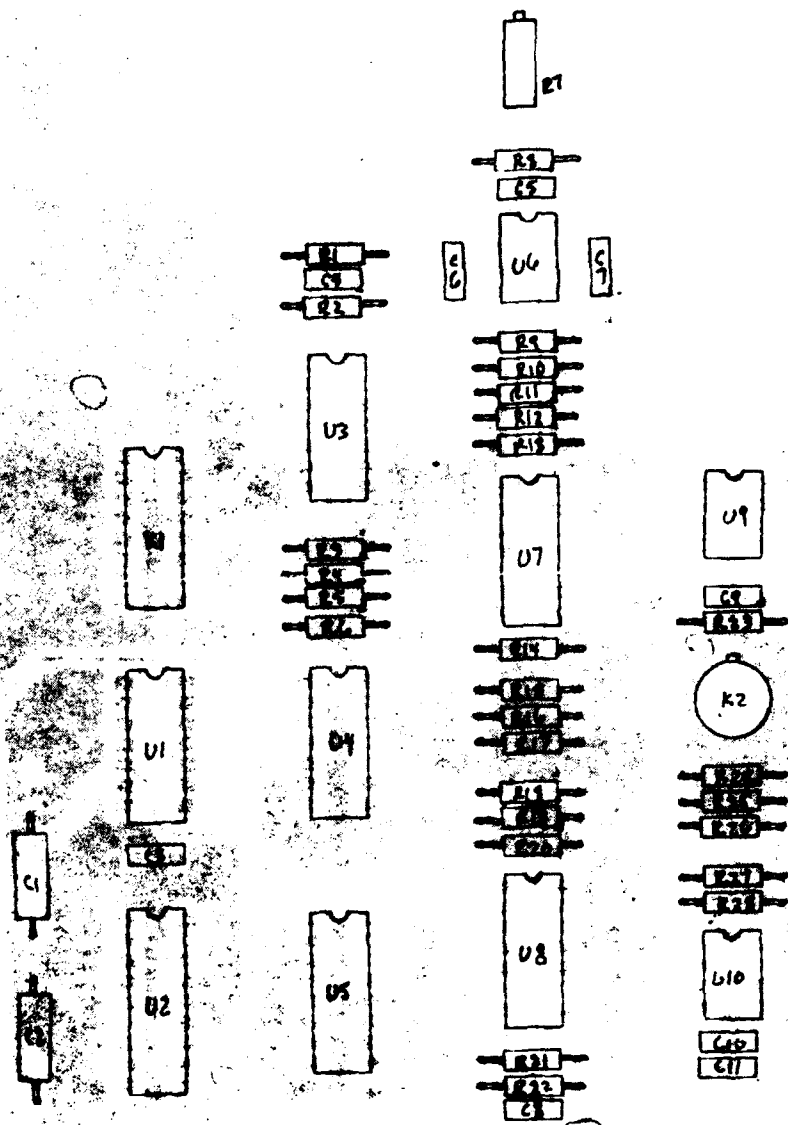


FIGURE A-7. Analog Card Component Side, Digital Voltammeter.

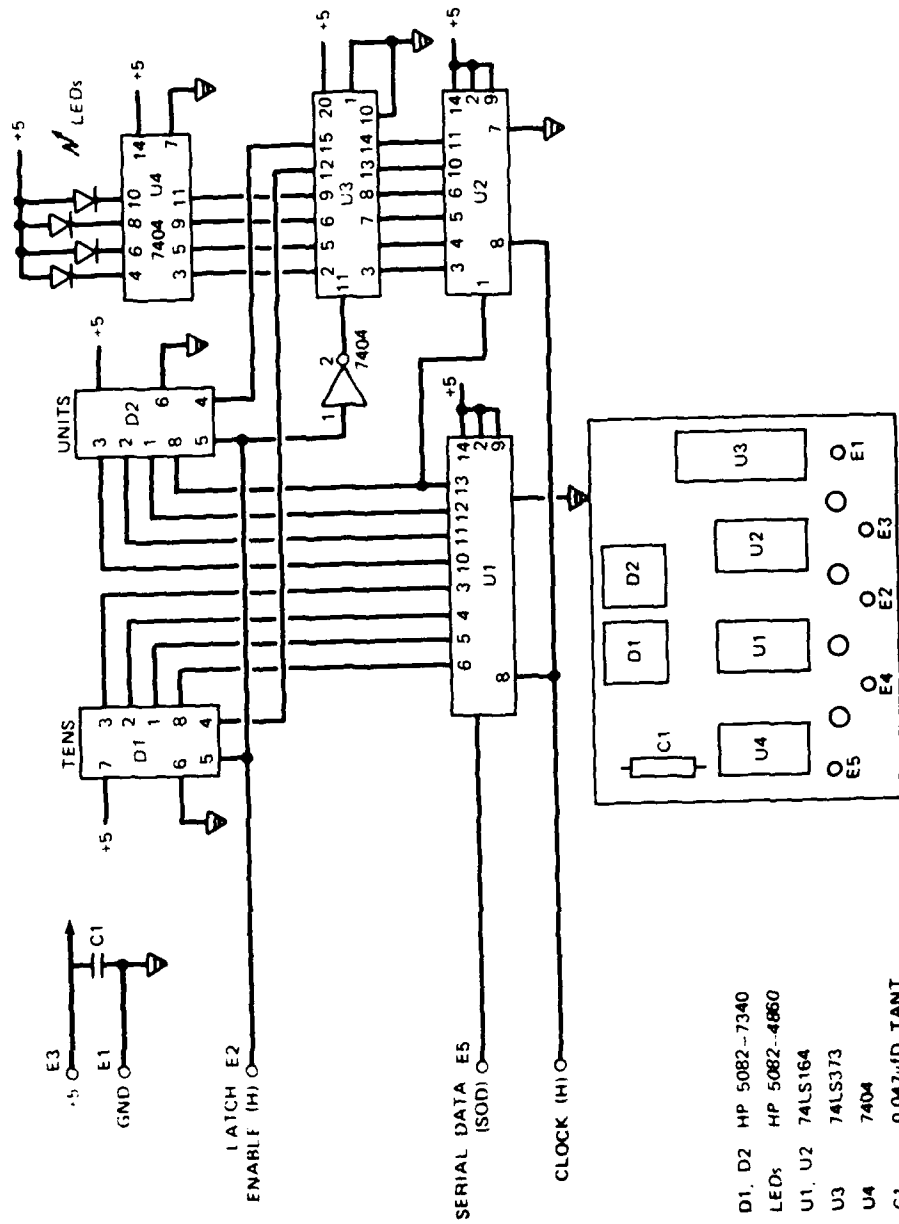


FIGURE A-8. Digital Display Card, Digital Voltammeter.

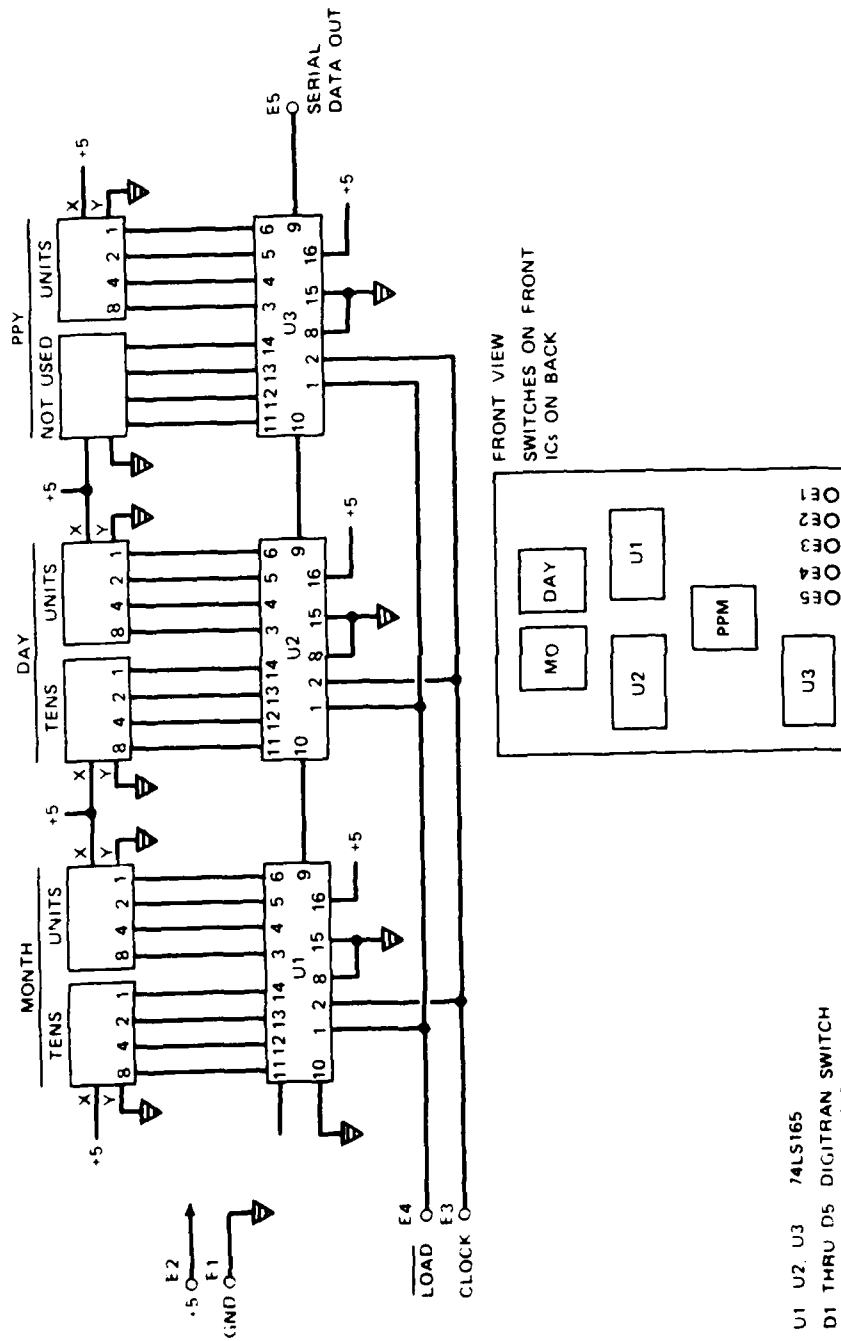


FIGURE A-9. Thumbwheel Switches Card Schematic.

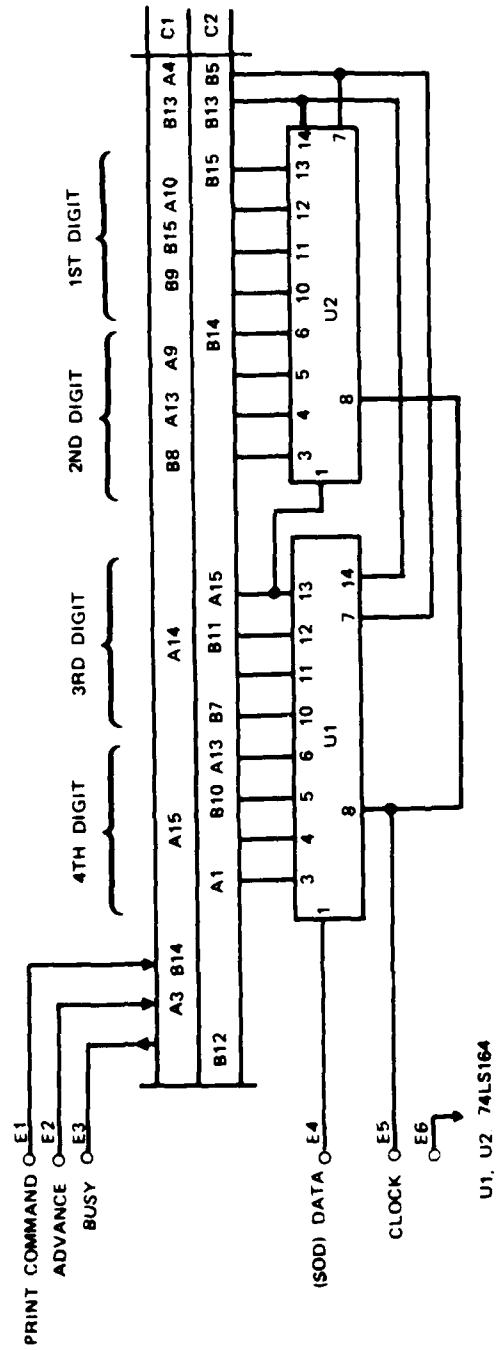
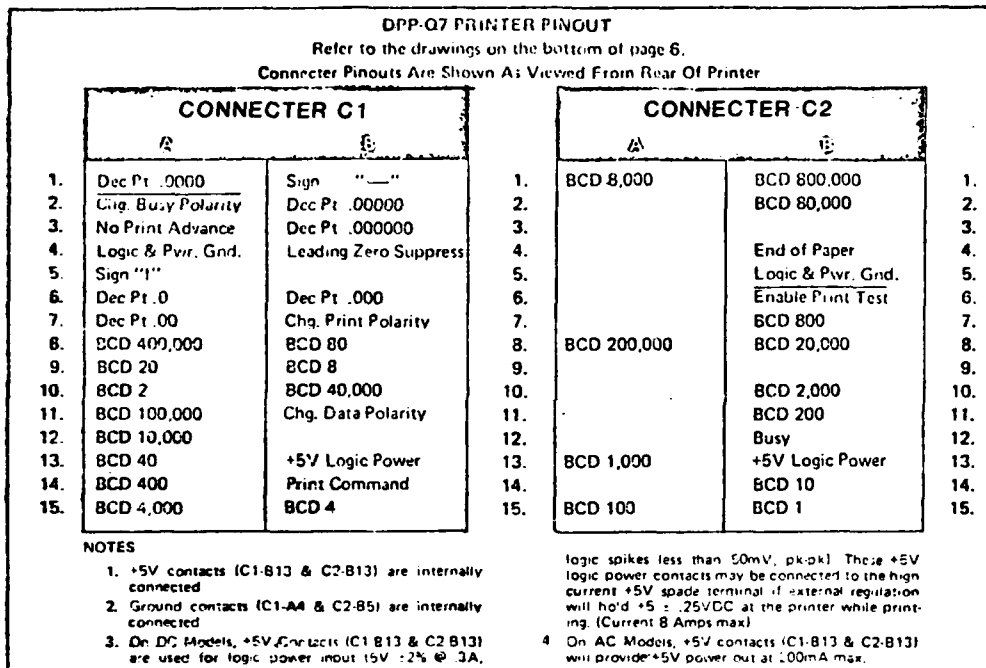


FIGURE A-10. Numeric Printer Interface Schematic, Digital Voltammeter.

INPUT/OUTPUT CONNECTIONS



GROUND C1-B11 AND C1-B7 FOR POSITIVE TRUE INPUTS.

BCD INPUTS Binary Coded Decimal inputs are shown cross-referenced to their corresponding connectors and pins.

For other print formats (see ordering guide, pr. 12) blanked columns will appear between digits shown

100,000's DIGIT 6				10,000's DIGIT 5				1,000's DIGIT 4				100's DIGIT 3				10's DIGIT 2				1's DIGIT 1			
8 4 2 1				8 4 2 1				8 4 2 1				8 4 2 1				8 4 2 1							
CONNECTOR		C1		A	A	9	A	A	A	15		A	A	14		B	A	A	8	8	A	C1	
		5	11	10	12					5	13	9	9	15	10								
CONNECTOR		C2		8	A	8	8	A	8	A	8	8	A			8					8	C2	
		1	8	2	5	1	10	13	7	11	15					14					15		

* Sign located here on type 2 print format

NOTE: PULLUPS PROVIDED ON ALL LOGIC CONNECTIONS. CHECK RESULTANT CODING ON UNCONNECTED TERMINALS

FIGURE A-11. Input/Output Connections for Printer.

NWC TP 6577

Appendix B
PRINTOUT OF SOFTWARE PROGRAM

```

00001          SECTION MAIN,ABSOLUTE
00003          GLOBAL BSFLNE,FSCAN,PAUSE,SSCAN,LED,TIMMHL,PRNTL,WAITS
00004          GLOBAL LEDDGT,LEDLTS,DECCS,DECDAY,BFCMTH,PFIELD,PSCD
00005          GLOBAL DV1616,TEMP,COUNT
00006          ORG 2000H
00006 2000 0001 IRLANK BLOCK 1
00007 2001 0001 IRLANK BLOCK 1
00008 2002 0002 ITEST BLOCK 2
00009 2004 0001 LEDDGT BLOCK 1
00010 2005 0001 LEDLTS BLOCK 1
00011 2006 0001 CS BLOCK 1
00012 2007 0001 DECCS BLOCK 1
00013 2008 0001 DECDAY BLOCK 1
00014 2009 0001 BFCMTH BLOCK 1
00015 200A 0002 PFIELD BLOCK 2
00016 200C 0002 TEMP BLOCK 2
00017 200E 0001 COUNT BLOCK 1
00018          0000 ORG 0000H
00019 0000 F3 DI
00020 0001 31FF23 LXI SP,23F7H
00021 0004 3E84 MVI A,084H ;SET MUX ADDRESS
00022 0005 D301 OUT 1
00023 0008 3E1B MVI A,1BH
00024 000A 30 SIM
00025 000B CD0000 ) CALL BSFLNE ;INITIALIZE ANALOG DRIVE VOLTAGE
00026 000E 3E00 MVI A,00H ;INITIALIZE LED DISPLAYS
00027 0010 320420 STA LEDDGT
00028 0013 3E0C MVI A,0CH
00029 0015 320520 STA LEDLTS
00030 0018 CD0000 ) CALL LED
00031 001B DR01 RUNT IN 1
00032 001D E004 ANI 04H
00033 001F CA1B00 JZ RUNT
00034 0022 1638 MVI D,38H
00035 0024 1E00 RUNT1 MVI E,0B00H
00036 0026 1D RUNT2 DCR E
00037 0027 C22600 JNZ RUNT2
00038 002A 15 DCR D
00039 002B C22400 JNZ RUNT1
00040 002E DE01 IN 1
00041 0030 E004 ANI 04H
00042 0032 CA1B00 JZ RUNT
00043 0035 C33D00 JMP BEGIN
00044          003C ORG 003CH
00045 003C E9 PCHL
00046 003D 3E00 BEGIN MVI A,00H ;RESET LED DISPLAYS
00047 003F 320420 STA LEDDGT
00048 0042 3E0C MVI A,0CH
00049 0044 320520 STA LEDLTS
00050 0047 CD0000 ) CALL LED
00051 004A 210000 ) LXI H,WAITS ;SET WAIT VECTOR
00052 004D 0600 MVI B,00H
00053 004F FB WLOOP1 EI ;WAIT 5 SECONDS

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00054 0050 20          RIM
00055 0051 E604        ANI 04H
00056 0053 CA4F00      JZ  WLOOP1
00057 0056 3E1B        MVI A,1BH
00058 0058 30          SIM
00059 0059 210000      LXI H,FSCAN ;SET FAST SCAN VECTOR
00060 005C 01003B      LXI B,3B00H
00061 005F FB          FLOOP1 EI ;FIRST FAST SCAN
00062 0060 20          RIM
00063 0061 E604        ANI 04H
00064 0063 CA5F00      JZ  FLOOP1
00065 0066 CD0000      CALL BSELNE
00066 0069 3E8C        MVI A,8CH ;TURN ON LED #1
00067 006B 320520      STA LEDLTS
00068 006E CD0000      CALL LED
00069 0071 3E1B        MVI A,1BH
00070 0073 30          SIM
00071 0074 210000      LXI H,WAIT5 ;SET WAIT VECTOR
00072 0077 0600        MVI B,00H ;WAIT 5 SECONDS
00073 0079 FB          WLOOP2 EI
00074 007A 20          RIM
00075 007B E604        ANI 04H
00076 007D CA7900      JZ  WLOOP2
00077 0080 3E1B        MVI A,1BH
00078 0082 30          SIM
00079 0083 210000      LXI H,FSCAN ;SET FAST SCAN VECTOR
00080 0086 01003B      LXI B,3B00H
00081 0089 FB          FLOOP2 EI ;SECOND FAST SCAN
00082 008A 20          RIM
00083 008B E604        ANI 04H
00084 008D CA8900      JZ  FLOOP2
00085 0090 CD0000      CALL BSELNE
00086 0093 3ECC        MVI A,0CCH ;TURN ON LED #2
00087 0095 320520      STA LEDLTS
00088 0098 CD0000      CALL LED
00089 009B 3E1B        MVI A,1BH
00090 009D 30          SIM
00091 009E 210000      LXI H,WAIT5 ;SET WAIT VECTOR
00092 00A1 0600        MVI B,00H ;WAIT 5 SECONDS
00093 00A3 FB          WLOOP3 EI
00094 00A4 20          RIM
00095 00A5 E604        ANI 04H
00096 00A7 CA4300      JZ  WLOOP3
00097 00AA 3E1B        MVI A,1BH
00098 00AC 30          SIM
00099 00AD 210000      LXI H,FSCAN ;SET FAST SCAN VECTOR
00100 00B0 01003B      LXI B,3B00H
00101 00B3 FB          FLOOP3 EI ;THIRD FAST SCAN
00102 00B4 20          RIM
00103 00B5 E604        ANI 04H
00104 00B7 CA5300      JZ  FLOOP3
00105 00BA CD0000      CALL BSELNE
00106 00BD 3EEC        MVI A,8ECH ;TURN ON LED #3

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Tektronix 8080/8085 ASM V3.3

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00107 008F 320520 STA LEDLTS
00108 00C2 CD0000 ) CALL LED
00109 00C5 210000 ) LXI H,PAUSE ;SET PAUSE VECTOR
00110 00C9 010000 LXI B,0000H
00111 00CB 3E1B MVI A,1BH
00112 00CD 30 SIM
00113 00CE FB PLOOP EI
00114 00CF 20 RIM
00115 00DA E604 ANI 04H
00116 00D2 CACE00 JZ PLOOP
00117 00D5 3EFC MVI A,0FCH ;TURN ON LED #4
00118 00D7 320520 STA LEDLTS
00119 00DA CD0000 ) CALL LED
00120 00DD 210000 ) LXI H,SSCAN ;SET SLOW SCAN VECTOR
00121 00F0 01003B LXI B,3B00H
00122 00F3 110973 LXI D,7300H
00123 00E6 3E1B MVI A,1BH
00124 00E8 30 SIM
00125 00E9 FB SLOOP EI
00126 00EA 20 RIM
00127 00FB E604 ANI 04H
00128 00FD CAE900 JZ SLOOP
00129 00F0 CD0000 ) CALL BSELNE
00130 00F3 F3 DI
00131 00F4 3E1B MVI A,1BH
00132 00F6 30 SIM
00133 00F7 DB01 IN 1 ;TEST FOR OFF MODE
00134 00F9 2F CMA
00135 00FA E609 ANI 0BH
00136 00FC CA1B00 JZ RUNT
00137 00FF DB01 IN 1 ;TEST FOR BLANK MODE
00138 0101 2F CMA
00139 0102 E620 ANI 20H
00140 0104 CAA201 JZ BLANK
00141 0107 DB01 IN 1 ;TEST FOR CALIBRATE MODE
00142 0109 2F CMA
00143 010A E640 ANI 40H
00144 010C CA7E01 JZ CAL
00145 010F C32201 JMP TEST
00146 0112 0F1F1F2F FR BYTE 0FH,1FH,1FH,2FH
00147 0116 3F3F4F4F BYTE 3FH,3FH,4FH,4FH
00148 011A 5F6F6F7F BYTE 5FH,6FH,6FH,7FH
00149 011E 8F8F9F9F BYTE 8FH,8FH,9FH,9FH
00150 0122 7B TEST MOV A,E
00151 0123 210020 LXI H,IBLANK
00152 0126 96 SUR M
00153 0127 00 NOP ;WAS DILUTION FACTOR (DF)
00154 0128 57 MOV D,A
00155 0129 1E00 MVI E,00H ;DIVIDEND IS READY
00156 012B 210120 LXI H,ICAL
00157 012E 4E MOV C,M
00158 012F 0600 MVI B,00H ;DIVISOR IS READY - ICAL (8 BIT)
00159 0131 CD0000 ) CALL DV1616

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Tektronix 8080/8085 ASM V3.3

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00160 0174 7B      MOV    A,E
00161 0175 320320   STA    ITEST+1 ;STORES HEX FRACTNL VALUE
00162 0176 7A      MOV    A,D
00163 0177 320220   STA    ITEST ;STORES INTEGER VALUE
00164 0178 C10000 )  CALL    DFC ;CONVERTS INTEGER INTO BCD
00165 0179 00      NOP
00166 0180 320420   STA    LEDDGT
00167 0181 3CF0     MVI    A,0F0H
00168 0182 320520   STA    LEDLTS
00169 0183 C00000 )  CALL    LED
00170 0184 7FFF     MVI    A,0FFH
00171 0185 320A20   STA    PFIELD
00172 0186 320B20   STA    PFIELD+1
00173 0187 00      NOP
00174 0188 C00000 )  CALL    PRNTL ;ADVANCE PAPER
00175 0189 320420   LDA    LEDDGT
00176 0190 FE0A     CPI    0AH
00177 0191 026101   JNC    TEST1
00178 0192 F6F0     ORI    0F0H
00179 0193 320A20   STA    PFIELD ;INTEGER IS READY
00180 0194 3A0320   LDA    ITEST+1 ;BEGIN FRACTNL PRCSG
00181 0195 0F      RRC
00182 0196 0F      RRC
00183 0197 0F      RRC
00184 0198 0F      RRC
00185 0199 E60F     ANI    0FH
00186 0200 1600     MVI    D,00H
00187 0201 5F      MOV    E,A
00188 0202 211201   LXI    H,FR
00189 0203 19      DAD    D
00190 0204 7E      MOV    A,M
00191 0205 320B20   STA    PFIELD+1 ;END FRACTNL PRCSG
00192 0206 C00000 )  CALL    PRNTL ;PRINT RESULT
00193 0207 C31600   JMP    RUNT
00194 0208 017E 7B  CAL    MOV    A,E
00195 0209 017F 210020 LXI    H,IBLANK
00196 0210 0182 96   SUB    M
00197 0211 0183 4F   MOV    C,A
00198 0212 0184 0E00 MVI    B,00H
00199 0213 0185 210720 LXI    H,DECCS ;DECCS BEING USED
00200 0214 0189 5E   MOV    E,M ;CS = SETTING ON FRONT PANEL
00201 0215 018A C00000 )  CALL    DIV
00202 0216 018D 7C   MOV    A,H
00203 0217 018E 320120 STA    ICAL
00204 0218 0191 C00000 )  CALL    DEC
00205 0219 0194 320420 STA    LEDDGT
00206 0220 0197 3CF0     MVI    A,0F0H
00207 0221 0199 320520 STA    LEDLTS
00208 0222 019C C00000 )  CALL    LED
00209 0223 019F C31500 JMP    RUNT
00210 0224 01A2 7B     MOV    A,E
00211 0225 01A3 320A20 STA    IBLANK
00212 0226 01A6 C00000 )  CALL    DFC

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Tektronix 8080/8085 ASM V3.3

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00213 01A9 320420      STA      LEDDGT
00214 01AC 3EFG      MVI      A,0FGH
00215 01AE 320520      STA      LEDLTS
00216 01B1 CF0000      CALL     LED
00217 01B4 CD0000      CALL     THMWHL
00218 01B7 3A0920      LDA      DECMTH
00219 01BA 320A20      STA      PFIELD
00220 01BD 3A0820      LDA      DECDAY
00221 01C0 320B20      STA      PFIELD+1
00222 01C3 CD0000      CALL     PRNTL
00223 01C6 C31B00      JMP      RUNT
00224
00225      ; SECTION MUL
00226      ;MULTIPLIER INTO REG B
00227      ;MULTIPLICAN INTO REG C
00228      ;PRODUCT IS RETURNED IN REGS D AND E
00229 0000 1600      MVI      D,00H
00230 0002 1E00      MVI      E,00H
00231 0004 7B      MUL2     MOV      A,E
00232 0005 81      ADD      C
00233 0006 D20A00      JNC     MUL1
00234 0009 14      INR      D
00235 000A 5F      MUL1     MOV      E,A
00236 000B 05      DCR      B
00237 000C C20400      JNZ     MUL2
00238 000F C9      RET
00239
00240      ; SECTION DIV
00241      ;DIVIDEND INTO REGS B AND C
00242      ;DIVISOR INTO REG E
00243      ;QUOTIENT IS RETURNED IN REG H
00244 0000 2600      MVI      H,00H
00245 0002 7B      MOV      A,E
00246 0003 2F      CMA
00247 0004 5F      MOV      E,A
00248 0005 16FF      MVI      D,0FFH
00249 0007 13      INX      D
00250 0008 79      DIV3     MOV      A,C      ;ADD LOW BYTES
00251 0009 83      ADD      E
00252 000A D20E00      JNC     DIV1
00253 000D 14      INR      B
00254 000E 4F      DIV1     MOV      C,A      ;ADD HIGH BYTES
00255 000F 7B      MOV      A,B
00256 0010 82      ADD      D
00257 0011 FA1F00      JM      DIV2      ;TEST FOR SIGN CHANGE
00258 0014 47      MOV      B,A
00259 0015 24      INR      H
00260 0016 7C      MOV      A,H      ;TEST FOR DIVIDEND OVERRUN
00261 0017 FE63      CPI      63H
00262 0019 CA1F00      JZ      DIV2
00263 001C C30900      JMP      DIV3
00264 001F C9      DIV2     RET
00265

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		SECTION DEC	
		VALUE IN REG A IS CONVERTED FROM HEXADECIMAL TO DECIMAL	
00266			
00267			
00268	0000 FF63	CPI	63H
00269	0002 D03800 >	JC	DEC3
00270	0005 3E99	MVI	A,99H
00271	0007 C9	RET	
00272	0008 FF0A	DEC3 CPI	0AH
00273	000A D20E00 >	JNC	DEC2
00274	000D C9	RET	
00275	000E 1E00	DEC2 MVI	E,00H
00276	0010 D50A	DEC1 SUI	GAH
00277	0012 3E	INR	E
00278	0013 FF0A	CPI	0AH
00279	0015 D21000 >	JNC	DEC1
00280	0018 57	MOV	D,A
00281	0019 7D	MOV	A,E
00282	001A 07	RLC	
00283	001B 07	RLC	
00284	001C 07	RLC	
00285	001D 07	RLC	
00286	001E 82	ADD	D
00287	001F C9	RET	
00288			

Tektronix 9081/9085 ASM V3.3 Symbol Table

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Scalars

A ----- 0007	B ----- 0008	C ----- 0001	D ----- 0002	E ----- 0003
H ----- 0004	L ----- 0005	M ----- 0006	PSW ----- 0006	SP ----- 0006

DEC Section (0020)

DEC1 --- 0010	DEC2 --- 000E	DEC3 --- 0008
---------------	---------------	---------------

DIV Section (0020)

DIV1 --- 000E	DIV2 --- 001F	DIV3 --- 0008
---------------	---------------	---------------

MAIN Section Absolute (200F)

BEGIN -- 003D	BLANK -- 01A2	CAL --- 017E	COUNT -- 200F G	CS --- 2006
DECCS -- 2007 G	DECDAY - 2008 G	DECMTH - 2009 G	FLOOP1 - 005F	FLOOP2 - 0039
FLOOP3 - 0083	FR --- 0112	IRLANK - 2000	ICAL --- 2001	ITEST -- 2002
LEDDGT - 2004 G	LEDLTS - 2005 G	PFIELD - 200A G	PLOOP -- 00CE	RUNT --- 0018
RUNT1 -- 0024	RUNT2 -- 0026	SLOOP -- 0029	TEMP -- 200C G	TEST --- 0122
TEST1 -- 0161	WLOOP1 - 004F	WLOOP2 - 0079	WLOOP3 - 00A3	

MUL Section (0010)

MUL1 --- 000A	MUL2 --- 0004
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BSELNE Unbound Global

BV1616 Unbound Global

FSCAN Unbound Global

FSCD Unbound Global

LED Unbound Global

PAUSE Unbound Global

PRNTL Unbound Global

SSCAN Unbound Global

THMHAL Unbound Global

WAIT5 Unbound Global

288 Source Lines 288 Assembled Lines 14347 Bytes available

>>> No assembly errors detected <<<

Tektronix 8080/8085 ASM V3.3

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00001          SECTION BASELINE
00002          :SETS ANALOG OUTPUT TO .3 VOLTS
00003          MVI    A,0DFH
00004          OUT    0
00005          MVI    A,0FFH
00006          OUT    0
00007          MVI    A,0DFH
00008          OUT    0
00009          MVI    A,94H
00010          OUT    0
00011          MVI    A,0B4H
00012          OUT    0
00013          MVI    A,94H
00014          OUT    0
00015          MVI    A,5CH
00016          OUT    0
00017          MVI    A,7CH
00018          OUT    0
00019          MVI    A,5CH
00020          OUT    0
00021          MVI    A,1FH
00022          OUT    0
00023          MVI    A,3FH
00024          OUT    0
00025          RET
00026
00027          SECTION FSCAN
00028          GLOBAL FSCD
00029          :GENERATES RAMP OUTPUT FROM STARTING VALUE IN REGS B AND C
00030          :RAMP UP IN 20 SECONDS, DOWN IN 20 SECONDS
00031          PUSH    PSW
00032          MVI    A,0DFH
00033          OUT    0
00034          MOV    A,C          ;INCREMENT COUNTER
00035          ACI    7EH
00036          JNC    ZOT
00037          INR    B
00038          : JZ    KILLF      TEST FOR END V 3
00039          ZOT    MOV    C,A
00040          MOV    A,B
00041          CPI    0ECH        ;H S
00042          MOV    A,C
00043          JC     FOUT
00044          JMP    KILLF      :PEAK AT 1.2V (EC30)
00045          FOUT    MOV    C,A  :OUTPUT LOWER
00046          RAR
00047          RAR
00048          RAR
00049          RAR
00050          ANI    0FH
00051          CMA
00052          OUT    0
00053          ANI    0DFH

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Tektronix 8080/8085 ASM V3.3

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00054 0023 D300      OUT      0
00055 0025 3E9F      MVI      A,9FH
00056 0027 D300      OUT      0
00057 0029 78        MOV      A,B      ;OUTPUT MIDDLE
00058 002A E60F      ANI      0FH
00059 002C F640      ORJ      40H
00060 002E 2F        CMA
00061 002F D300      OUT      0
00062 0031 E60F      ANI      0DFH
00063 0033 D300      OUT      0
00064 0035 3E5F      MVI      A,5FH
00065 0037 D300      OUT      0
00066 0039 78        MOV      A,B      ;OUTPUT UPPER
00067 003A 1F        RAR
00068 003B 1F        RAR
00069 003C 1F        RAR
00070 003D 1F        RAR
00071 003E E60F      ANI      0FH
00072 0040 F680      ORI      80H
00073 0042 2F        CMA
00074 0043 D300      OUT      0
00075 0045 E6DF      ANI      0DFH
00076 0047 D300      OUT      0
00077 0049 3E1F      MVI      A,1FH
00078 004B D300      OUT      0
00079 004D 3E3F      MVI      A,3FH      ;LATCH OUTPUT
00080 004F D300      OUT      0
00081 0051 F3        DI          ;RESET INTERRUPT
00082 0052 3E10      MVI      A,10H
00083 0054 30        SIM          ;CLEAR THE RST 7.5 LATCH
00084 0055 F1        POP      PSW
00085 0056 C9        RET
00086 0057 3E1B      KILLF MVI      A,1BH
00087 0059 30        SIM          ;RESET THE RST 7.5 LATCH
00088 005A 216300    ) LXI      H,FSCD ;SET FAST SCAN RETURN VECTOR
00089                      ;20 SEC RAMP BACK TO INITIAL V.
00090 005D 0130EC    ) LXI      B,0EC30H ;PEAK AT 1.2V
00091 0060 C36400    ) JMP      FSCD1
00092 0063 F5        FSCD PUSH
00093 0064 79        FSCD1 MOV      A,C
00094 0065 D67E      SUI      07EH
00095 0067 D26800    ) JNC      HERR ;SUBTRACT 07E CHUNKS
00096 006A 05        DCR      B ;FROM REG B-C UNTIL
00097 006B 4F        HERR MOV      C,A ;REG B EQUALS 3B
00098 006C 78        MOV      A,B
00099 006D D600      SUI      00H
00100 006F 47        MOV      B,A
00101 0070 FE3B      CPI      03BH
00102 0072 DA7900    ) JC       KILL2
00103 0075 79        MOV      A,C
00104 0076 C31700    ) JMP      FOUT
00105 0079 3E0F      KILL2 MVI      A,0FH ;SET END INDICATOR
00106 007B 30        SIM          ;DISABLE RST 7.5 INTERRUPT

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Tektronix 8080/8085 ASM V3.3

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00107 007C F1      POP    PSW
00108 007D C9      RET
00109              ;
00110              SECTION WAITS
00111              ;5 SECOND WAIT ROUTINE
00112 0000 F5      PUSH    PSW
00113 0001 78      MOV     A,B      ;INCREMENT COUNTER
00114 0002 CE02    ACI     02H
00115 0004 FEC8    CPI     0CBH    ;TEST FOR DONE
00116 0006 CA0000  )      JZ     KILLW
00117 0009 47      MOV     B,A
00118 000A F3      DI           ;RESET INTERRUPT
00119 000B 3E10    MVI     A,10H
00120 000D 30      SIM
00121 000E F1      POP     PSW
00122 000F C9      RET
00123 0010 3E0F    KILLW MVI     A,0FH    ;SET END INDICATOR
00124 0012 30      SIM
00125 0013 F1      POP     PSW
00126 0014 C9      RET
00127              ;
00128              SECTION PAUSE
00129              ;60 SECOND WAIT ROUTINE
00130 0000 F5      PUSH    PSW
00131 0001 79      MOV     A,C      ;INCREMENT COUNTER
00132 0002 CE37    ACI     37H
00133 0004 D20800  )      JNC    PCONT
00134 0007 04      INR     B
00135 0008 CA1200  )      JZ     KILLP    ;TEST FOR END
00136 000B 4F      PCONT MOV     C,A
00137 000C F3      DI           ;RESET INTERRUPT
00138 000D 3E10    MVI     A,10H
00139 000F 30      SIM
00140 0010 F1      POP     PSW
00141 0011 C9      RET
00142 0012 3E0F    KILLP MVI     A,0FH    ;SET END INDICATOR
00143 0014 30      SIM
00144 0015 F1      POP     PSW
00145 0016 C9      RET
00146              ;
00147              SECTION SSCAN
00148              ;GENERATES RAMP OUTPUT FROM STARTING VALUE IN REGS B AND C
00149              ;COMPLETE IN 100 SECONDS
00150              ;BEGINNING OF MEASUREMENT WINDOW IS IN REGS D AND E
00151              ;PEAK MEASURED VALUE IS RETURNED IN REG E
00152 0000 F5      PUSH    PSW
00153 0001 3EDF    MVI     A,0DFH
00154 0003 D300    OUT     0
00155 0005 3E00    MVI     A,00H    ;READ OUTPUTED VALUE
00156 0007 D302    OUT     2
00157 0009 3E10    MVI     A,10H
00158 000B D302    OUT     2
00159 000D 3EBC    MVI     A,0BCH    ;CHANGE MUX ADDRESS FOR MEASUREMENT

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Tektronix 8080/8085 ASM V3.3

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00160 000F D301      OUT      1
00161 0011 D801      SLOOP1  IN      1
00162 0013 2F        CMA
00163 0014 E610      ANI      10H
00164 0016 C21100    )      JNZ      SLOOP1
00165 0019 D800      IN      0
00166 001B 2F        CMA
00167 001C D5        PUSH     D
00168 001D BA        CMP      D      ;TEST FOR MEASUREMENT TIME
00169 001E D1        POP      D
00170 001F D23E00    )      JNC      MSMT
00171 0022 FECC      CPI      0CCH    ;TEST FOR END
00172 0024 DA3000    )      JC      OTPT
00173 0027 3EB4      MVI      A,0B4H  ;RESET MUX ADDRESS
00174 0029 D301      OUT      1
00175 002B 3E0F      MVI      A,0FH   ;SET END INDICATOR
00176 002D 30        SIM
00177 002E F1        POP      PSW
00178 002F C9        RET
00179 0030 3EB4      OTPT  MVI      A,0B4H  ;RESET MUX ADDRESS
00180 0032 D301      OUT      1
00181 0034 79        MOV      A,C      ;INCREMENT COUNTER
00182 0035 CE0C      ACI      0CH
00183 0037 D27800    )      JNC      SOUT
00184 003A 04        INR      B
00185 003B C37800    )      JMP      SOUT
00186 003E FEA6      MSMT  CPI      0A6H    ;TEST FOR SAMPLE PERIOD END
00187 0040 DA4F00    )      JC      INGATE
00188 0043 16FD      MVI      D,0FDH
00189 0045 79        MOV      A,C      ;INCREMENT COUNTER
00190 0046 CE0C      ACI      0CH
00191 0048 D27800    )      JNC      SOUT
00192 004B 04        INR      B
00193 004C C37800    )      JMP      SOUT
00194 004F 7A        INGATE MOV      A,D      ;INCREMENT SAMPLE TEST POINT
00195 0050 C602      ADI      02H
00196 0052 57        MOV      D,A      ;SAVE INCREMENTED SAMPLE TEST POINT
00197 0053 3E90      MVI      A,06H    ;READ DATA
00198 0055 D302      OUT      2
00199 0057 3E10      MVI      A,10H
00200 0059 D302      OUT      2
00201 005B 3EB4      MVI      A,0B4H  ;RESET MUX ADDRESS
00202 005D D301      OUT      1
00203 005F D801      SLOOP2  IN      1
00204 0061 2F        CMA
00205 0062 E610      ANI      10H
00206 0064 C25F00    )      JNZ      SLOOP2
00207 0067 D800      IN      0
00208 0069 2F        CMA
00209 006A D5        PUSH     D
00210 006E EB        CMP      E      ;TEST FOR NEW PEAK DATA VALUE
00211 006C D1        POP      D
00212 006D DA7100    )      JC      RKSD

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Tektronix 8080/8085 ASM V3.3

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00213	0070	5F	MOV	E,A	
00214	0071	79	MOV	A,C	; INCREMENT COUNTER
00215	0072	CEBC	ACI	0CH	
00216	0074	D27800	JNC	SOUT	
00217	0077	8A	INR	B	
00218	0078	4F	MOV	C,A	; OUTPUT LOWER
00219	0079	1F	RAR		
00220	007A	1F	RAR		
00221	007B	1F	RAR		
00222	007C	1F	RAR		
00223	007D	E60F	ANI	0FH	
00224	007E	2F	CMA		
00225	0080	D300	OUT	0	
00226	0082	E60F	ANI	0DFH	
00227	0084	D300	OUT	0	
00228	0086	3F9F	MVI	A,9FH	
00229	0088	D300	OUT	0	
00230	008A	78	MOV	A,B	; OUTPUT MIDDLE
00231	008B	E60F	ANI	0FH	
00232	008D	F640	ORI	40H	
00233	008F	2F	CMA		
00234	0090	D300	OUT	0	
00235	0092	E60F	ANI	0DFH	
00236	0094	D300	OUT	0	
00237	0096	3F5F	MVI	A,5FH	
00238	0098	D300	OUT	0	
00239	009A	78	MOV	A,B	; OUTPUT UPPER
00240	009B	1F	RAR		
00241	009C	1F	RAR		
00242	009D	1F	RAR		
00243	009E	1F	RAR		
00244	009F	E60F	ANI	0FH	
00245	00A1	F680	ORI	80H	
00246	00A3	2F	CMA		
00247	00A4	D300	OUT	0	
00248	00A6	E60F	ANI	0DFH	
00249	00A8	D300	OUT	0	
00250	00AA	3F1F	MVI	A,1FH	
00251	00AC	D300	OUT	0	
00252	00AE	3F3F	MVI	A,3FH	; LATCH OUTPUT
00253	00B0	D300	OUT	0	
00254	00B2	F3	DI		; RESET INTERRUPT
00255	00B3	3E10	MVI	A,10H	
00256	00B5	30	SIM		
00257	00B6	F1	POP	PSW	
00258	00B7	C9	RET		
00259					
00260					

NWC TP 6577

Tektronix 8080/8085 ASM V3.3 Symbol Table

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Scalars

A ---- 0007	B ---- 0000	C ---- 0001	D ---- 0002	E ---- 0003
H ---- 0004	L ---- 0005	M ---- 0006	PSW ---- 0006	SP ---- 0006

BASELINE Section (0020)

FSCAN Section (007E)

FDUT --- 0017	FSCD --- 0063 G	FSCD1 --- 0064	HERR --- 006B	KILL2 --- 0079
KILLF --- 0057	ZOT --- 000C			

PAUSE Section (0017)

KILLP --- 0012	PCONT --- 000B
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SSCAN Section (00B0)

BKSD1 --- 0071	INCATE --- 004F	MSMT --- 003E	OTPT --- 0030	SLOOP1 --- 0011
SLOOP2 --- 005F	SOUT --- 007B			

WAITS Section (0015)

KILLW --- 0010

260 Source Lines 260 Assembled Lines 14710 Bytes available

>>> No assembly errors detected <<<

Tektronix 8080/8085 ASM V3.3

Page 1

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00001          SECTION OUTSHF
00002          ;OUTPUTS VALUE OF CARRY BIT TO SERIAL OUTPUT WITH NECESSARY CLOCK
00003          ;TRANSITIONS
00004 0000 DA0C00 ) JC      OUT1
00005 0003 3E00    MVI     A,00H
00006 0005 30     SIM
00007 0006 3E40    MVI     A,40H
00008 0008 30     SIM
00009 0009 C31200 ) JMP     OUT2
00010 000C 3E80    OUT1  MVI     A,80H
00011 000E 30     SIM
00012 000F 3EC0    MVI     A,0C0H
00013 0011 30     SIM
00014 0012 3EA4    OUT2  MVI     A,0A4H ;CLOCK HIGH
00015 0014 D301    OUT      1
00016 0016 3EB4    MVI     A,0B4H ;CLOCK LOW
00017 0018 D301    OUT      1
00018 001A C9     RET
00019
00020          SECTION LED
00021          ;OUTPUTS LED INDICATOR INFORMATION CONTAINED IN CONTROL BYTES LEDDGT
00022          ;AND LEDLTS
00023          GLOBAL LEDDGT,LEDLTS
00024 0000 0600    MVI     B,00H ;ZERO COUNT FIELD
00025 0002 3A0000 ) LDA     LEDLTS ;OUTPUT BLANKING AND LIGHTS
00026 0005 1F     RAR
00027 0006 1F     RAR
00028 0007 1F     RAR
00029 0008 04     LED2  INR      B
00030 0009 4F     MOV     C,A
00031 000A CD0000 ) CALL    OUTSHF
00032 000D 78     MOV     A,B
00033 000E FE06    CPI     06H
00034 0010 D21800 ) JNC     LED1
00035 0013 47     MOV     B,A
00036 0014 79     MOV     A,C
00037 0015 C30700 ) JMP     LED2
00038 0018 0600    LED1  MVI     B,00H ;ZERO COUNT FIELD
00039 001A 3A0000 ) LDA     LEDDGT ;OUTPUT DIGITS
00040 001D 1F     LED4  RAR
00041 001E 04     INR      B
00042 001F 4F     MOV     C,A
00043 0020 CD0000 ) CALL    OUTSHF
00044 0023 78     MOV     A,B
00045 0024 FE08    CPI     08H
00046 0026 D22E00 ) JNC     LED3
00047 0029 47     MOV     B,A
00048 002A 79     MOV     A,C
00049 002B C31D00 ) JMP     LED4
00050 002E 3EB6    LED3  MVI     A,0B6H ;STROBE LED LATCH
00051 0030 D301    OUT      1
00052 0032 3EB4    MVI     A,0B4H
00053 0034 D301    OUT      1

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00054 0036 C9      RET
00055              ;
00056              SECTION INSHF
00057              ;SERIAL IN DATA IS PLACED IN THE MSR POSITION OF REG B
00058 0000 78      MOV     A,B
00059 0001 1F      RAR
00060 0002 47      MOV     B,A
00061 0003 20      RIM
00062 0004 E6B0   ANI     B0H
00063 0005 B0      ORA     B
00064 0007 47      MOV     B,A
00065 0008 3EA4   MVI     A,0A4H ;CLOCK HIGH
00066 000A D301   OUT     1
00067 000C 3EB4   MVI     A,0B4H ;CLOCK LOW
00068 000E D301   OUT     1
00069 0010 C9      RET
00070              ;
00071              SECTION THMWHL
00072              ;READ THUMBWHEEL SWITCH INFORMATION INTO DATA BYTES DECCS, DECDAY, AND
00073              ;DECMTH
00074              GLOBAL DECCS,DECDAY,DECMTH
00075 0000 3EF4   MVI     A,0FAH ;STROBE THUMBWHEEL LATCHES
00076 0002 D301   OUT     1
00077 0004 3EB4   MVI     A,0B4H
00078 0006 D301   OUT     1
00079 0008 0600   MVI     B,00H ;READ BCD CS VALUE
00080 000A CD0000 ) CALL     INSHF
00081 000D CD0000 ) CALL     INSHF
00082 0010 CD0000 ) CALL     INSHF
00083 0013 CD0000 ) CALL     INSHF
00084 0016 CD0000 ) CALL     INSHF
00085 0019 CD0000 ) CALL     INSHF
00086 001C CD0000 ) CALL     INSHF
00087 001F CD0000 ) CALL     INSHF
00088 0022 210600 ) LXI     H,DECCS
00089 0025 70      MOV     M,B
00090 0026 0600   MVI     B,00H ;READ BCD DAY
00091 0028 CD0000 ) CALL     INSHF
00092 002B CD0000 ) CALL     INSHF
00093 002E CD0000 ) CALL     INSHF
00094 0031 CD0000 ) CALL     INSHF
00095 0034 CD0000 ) CALL     INSHF
00096 0037 CD0000 ) CALL     INSHF
00097 003A CD0000 ) CALL     INSHF
00098 003D CD0000 ) CALL     INSHF
00099 0040 210600 ) LXI     H,DECDAY
00100 0043 70      MOV     M,B
00101 0044 0600   MVI     B,00H ;READ BCD MONTH
00102 0046 CD0000 ) CALL     INSHF
00103 0049 CD0000 ) CALL     INSHF
00104 004C CD0000 ) CALL     INSHF
00105 004F CD0000 ) CALL     INSHF
00106 0052 CD0000 ) CALL     INSHF

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Tektronix 8080/8085 ASM V3.3

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00107 0055 CD0000 ) CALL INSHF
00108 0058 CD0000 ) CALL INSHF
00109 005B CD0000 ) CALL INSHF
00110 005E 210000 ) LXI H,DECMTH
00111 0061 70 MOV M,B
00112 0062 C9 RET
00113 ;
00114 ; SECTION PRNTL
00115 ; TRANSMITS 2 BYTE FIELD IN PFIELD TO PRINTER AND INITIATES PRINTING
00116 ; GLOBAL PFIELD
00117 0000 DB01 PRNTL1 IN 1 ;TEST FOR BUSY
00118 0002 E601 ANI 01H
00119 0004 CA0000 ) JZ PRNTL1
00120 0007 0500 MVI B,00H ;ZERO COUNT FIELD
00121 0009 3A0100 ) LDA PFIELD+1 ;GET FIRST BYTE
00122 000C 1F PRNTL3 RAR
00123 000D 04 INR B
00124 000E 4F MOV C,A
00125 000F CD0000 ) CALL OUTSHF
00126 0012 78 MOV A,B
00127 0013 FE08 CPI 08H
00128 0015 D21000 ) JNC PRNTL2
00129 0018 47 MOV B,A
00130 0019 79 MOV A,C
00131 001A C30C00 ) JMP PRNTL3
00132 001D 0500 PRNTL2 MVI B,00H ;ZERO COUNT FIELD
00133 001F 3A0000 ) LDA PFIELD ;GET SECOND BYTE
00134 0022 1F PRNTL5 RAR
00135 0023 04 INR B
00136 0024 4F MOV C,A
00137 0025 CD0000 ) CALL OUTSHF
00138 0028 78 MOV A,B
00139 0029 FE08 CPI 08H
00140 002B D23300 ) JNC PRNTL4
00141 002E 47 MOV B,A
00142 002F 79 MOV A,C
00143 0030 C32200 ) JMP PRNTL5
00144 0033 3E94 PRNTL4 MVI A,94H ;STROBE PRINT COMMAND
00145 0035 D301 OUT 1
00146 0037 3EB4 MVI A,0B4H
00147 0039 D301 OUT 1
00148 003B C9 RET
00149 ;
00150 ; SECTION DV1616
00151 ; DOUBLE PRECISION DIVIDE
00152 ; DIVIDEND: REG D-E
00153 ; DIVISOR: REG B-C
00154 ; QUOTIENT RETURNED IN REG D-E
00155 ; GLOBAL TEMP,COUNT
00156 0004 210000 ) LXI H,TEMP
00157 0003 71 MOV M,C
00158 0004 23 INX H
00159 0005 70 MOV M,B

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Tektronix 8080/8085 ASM V3.3

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00160 0006 23      INX      H
00161 0007 3611    MVI      H,11H ;SET COUNT=17DECIMAL
00162 0009 010000   LXI      H,0100H
00163 000C 210000   LXI      H,COUNT ;INITIALLY IS 17DECIMAL
00164 000F 78      MOV      A,E
00165 0010 17      RAL
00166 0011 5F      MOV      E,A
00167 0012 7A      MOV      A,D
00168 0013 17      RAL
00169 0014 57      MOV      D,A
00170 0015 35      DCR      H
00171 0016 C8      RZ
00172 0017 79      MOV      A,C
00173 0018 17      RAL
00174 0019 4F      MOV      C,A
00175 001A 78      MOV      A,B
00176 001B 17      RAL
00177 001C 47      MOV      B,A
00178 001D 2B      DCX      H
00179 001E 2B      DCX      H ;REG H-L NOW POINTS TO
                                ;DIVISOR IN MEMORY
00180
00181 001F 79      MOV      A,C
00182 0020 96      SUB      H
00183 0021 4F      MOV      C,A
00184 0022 23      INX      H
00185 0023 78      MOV      A,B
00186 0024 9E      SBB      H
00187 0025 47      MOV      B,A
00188 0026 023100   JNC      NOADD ;IF CY=0 DO NOT ADD DIVISOR
00189                                     ;TO RESULT OF PRVS SBTRCTN
00190 0029 2B      DCX      H
00191 002A 79      MOV      A,C
00192 002B 86      ADD      H
00193 002C 4F      MOV      C,A
00194 002D 23      INX      H
00195 002E 78      MOV      A,B
00196 002F 8E      ADC      H
00197 0030 47      MOV      B,A
00198 0031 3F      CMC
00199 0032 C38C00   JMP      NOADD
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Tektronix 8091/8095 ASM V3.3 Symbol Table

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Scalars

A ----- 0007	B ----- 0008	C ----- 0001	D ----- 0002	E ----- 0003
H ----- 0004	L ----- 0005	M ----- 0006	PSW ----- 0006	SP ----- 0006
DV1616 Section (0035)				
NOADD -- 0031	NXTBIT - 000C			
INSHF Section (0011)				
LED Section (0037)				
LED1 --- 0018	LED2 --- 0007	LED3 --- 002E	LED4 --- 001D	
OUTSHF Section (001B)				
OUT1 --- 000C	OUT2 --- 0012			
PRNTL Section (003C)				
PRNTL1 - 0000	PRNTL2 - 001D	PRNTL3 - 000C	PRNTL4 - 0033	PRNTL5 - 0022
THRWHL Section (0063)				
COUNT Unbound Global				
DECOS Unbound Global				
DECDAY Unbound Global				
DECDTH Unbound Global				
LEDDGT Unbound Global				
LEGLTS Unbound Global				
PFIELD Unbound Global				
TEMP Unbound Global				

209 Source Lines 200 Assembled Lines 14622 Bytes available

))) No assembly errors detected (((

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 - AIR-330 (1)
 - AIR-35 (1)
 - AIR-5356A1 (1)
 - AIR-7226 (2)
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 - Library (1)
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 - L52, E. Lory (1)
 - L54
 - J. Crane (1)
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 - Technical Library (1)
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- 3 Naval Ocean Systems Center, San Diego
 - Code 513
 - S. Yamamoto (1)
 - A. Zirmo (1)
 - Code 5131, M. H. Salazar (1)
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 - Code E, Pollution Abatement Program Manager (1)
 - Technical Library (1)
- 3 Naval Research Laboratory
 - Code 4300 (1)
 - Code 6100 (1)
 - Library (1)
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 - SEAL Team 5 (1)
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 - G 51
 - J. Bromfield (1)
 - D. Knudsen (1)
 - R. Gibbs (1)
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 - Code R16, J. Hoffsommer (1)
 - Code R17 (1)
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- 2 Naval Weapons Station, Yorktown
 - Code 203, M. West (1)
 - Code 50 (1)
- 6 Naval Weapons Support Center, Crane
 - Code 3025, D. Burch (1)
 - Code 50C, B. E. Douda (1)
 - Code 505, J. E. Short (1)
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 - MAT-0723 (1)
 - MAT-0724 (1)