8300A
Digital Voltmeter

Instruction Manual

P/N 294330
April 1970
Rev. 4 9/73

FLUKE®

WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive:

The JOHN FLUKE MFG. CO., INC., warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of 1-year from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90-days), or any product or parts which have been subject to misuse, neglect, accident, or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, John Fluke Mfg. Co., Inc., will repair and calibrate an instrument returned to an authorized Service Facility within 1 year of the original purchase; provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within 1 year of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident, or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. JOHN FLUKE MFG. CO., INC., SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

If any failure occurs, the following steps should be taken:

1. Notify the JOHN FLUKE MFG. CO., INC., or nearest Service facility, giving full details of the difficulty, and include the model number, type number, and serial number. On receipt of this information, service data, or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument, transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

SHIPPING TO MANUFACTURER FOR REPAIR OR ADJUSTMENT

All shipments of JOHN FLUKE MFG. CO., INC., instruments should be made via United Parcel Service or "Best Way" prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid and of adequate size. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon original delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

The JOHN FLUKE MFG. CO., INC, will be happy to answer all applications or use questions, which will enhance your use of this instrument. Please address your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. BOX 43210, MOUNTLAKE TERRACE, WASHINGTON 98043, ATTN: Sales Dept. For European Customers: Fluke (Holland) B.V., P.O. Box 5053, 5004 EB, Tilburg, The Netherlands.

*For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, Washington 98043

Rev. 4/80

Table of Contents

(continued on page ii)

TABLE OF CONTENTS, *continued*

(continued on page iii)

TABLE OF CONTENTS, *continued*

(continued on page iv)

TABLE OF CONTENTS, *continued*

List of Illustrations

(continued on page vi)

LIST OF ILLUSTRATIONS, *continued*

(continued on page vii)

LIST OF ILLUSTRATIONS, *continued*

(continued on page viii)

LIST OF ILLUSTRATIONS, *continued.*

(continued on page ix)

LIST OF ILLUSTRATIONS, *continued*

(continued on page x)

LIST OF ILLUSTRATIONS, *continued*

(continued on page xi)

LIST OF ILLUSTRATIONS, *continued*

Section 1
Introduction & Specifications

1-1. INTRODUCTION

1-2. The Model 8300A is a versatile digital voltmeter with five full decades of digits plus a sixth digit for 20% overrange. Its mainframe will accept options in any sequence for expansion from a bench DVM into a bench or systems multimeter.

1-3. The Model 8300A uses the Fluke developed Recirculating Remainder* A-to-D conversion system which determines the most significant digit by a very accurate direct comparison process, stores a sample of the remaining input voltage, and serially determines the value of succeeding digits from this sample. This process requires only one decade of BCD counter and one decade of precision resistive ladder network for five complete decades of conversion. Multiple use of components results in low parts count, and low power consumption, thus ensuring high reliability. Complete isolation of digital data outputs is yet another outstanding characteristic of this Fluke developed technique.1-4.

1-4. The basic instrument offers three ranges of dc voltage measuring capability including autorange, autopolarity, and switchable active filtering. In addition, the 8300A-10 configuration offers five ranges of dc volts, and the 8300A-02 version offers both five ranges of DC volts and five ranges of ohms measurements.

1-5. The Model 8300A's sample rate can be manually varied from the front panel or it can be remotely controlled (optional). Full guarding is accomplished by box-in-a-box construction and use of a FLUKE custom-designed isolating power transformer. Guarding is not compromised when the isolated Data Output and Remote Control units are added. Calibration is accomplished through the guard via labelled ports.

1-6. ANALOG OPTIONS

1-7. All optional functions may be installed in the field. The analog options are fully within the guard, their installation automatically enables the appropriate function light of the display. Options may be field installed. AC volts features a 50Hz to 20kHz midband with excellent accuracy to 30Hz and 100kHz. Mv function extends the dc capability of the 8300A to 100mV at full range with 1μV of resolution. The ohms function includes 5 resistance ranges, using a modified four-terminal configuration on the two lowest. DC External Reference can be used for true four-terminal ratio or for systems measurements related to a master reference. AC External Reference is available for AC/AC ratio measurement applications.

1-8. DIGITAL OPTIONS

1-9. Data Output is completely isolated from the analog input and is available in a 8-4-2-1 BCD logic level format. Data is transferred serially via guarded toroids from the Model 8300A to the Data Output unit. Single decade code conversion and serial-character, parallel-bit acquisition are unique capabilities in addition to standard full parallel output.

1-10. Remote Control is fully isolated from analog input and may be fully isolated from the Data Output unit but is normally used in conjunction with it. Control is exerted by logic levels or contact closures. Isolation from analog circuitry is accomplished through the use of light-emitting diodes and photo-transistors.

1-11. ELECTRICAL SPECIFICATIONS

DC VOLTS

RANGES . . . ±10V, ±100V and ±1000V. 20% overrange capability (1100V maximum)

POLARITY . . . Automatic, instantaneous selection and display.

RANGE SELECTION . . . Manual and autorange standard (Remote optional)

RESOLUTION . . . 0.001% of range (1 uv on 0.1V range)

ACCURACY:

24 hours, 23°C ±1°C . . . ±(0.005% of input + 0.001% of range)
30 days, 20°C to 30°C . . . ± (0.008% of input + 0.002% of range)
90 days, 20°C to 30°C . . . ±(0.01% of input + 0.002% of range)
6 months, 20°C to 30° . . . ±(0.01% of input + 0.004% of range)
1 year, 20°C to 30°C . . . ±(0.015% of input + 0.005% of range)

TEMPERATURE COEFFICIENT:

0°C to 20°C, 30°C to 50°C . . . ±(0.0007% of input + 0.0003% of range/°C

INPUT RESISTANCE . . . 10V: 10,000 megohms minimum, 100V & !000V: 10 megohms

FILTER . . . Switch selected 3 pole active filter standard (remote control optional.)

RESPONSE TIME . . . To within 0.01% of step function change including polarity change.
25 ms maximum unfiltered. (No settling time required for input applied coincident with read command. Time given is digitizing time only.)

500 ms maximum filtered.

NOTE: Filter settling time unaffected by source impedance.

REJECTION:	DC	AC	NOTE
Normal Mode (Filtered)	–	>60 db, above 50 Hz	150% of Range sum of Input Peak AC Normal Mode Voltage plus DC/Voltage
Common Mode (Unfiltered) 1 KΩ unbalance in either lead 100Ω unbalance in either lead	 >140 db >160 db	 >100 db, 60 Hz and above >120 db, 60 Hz and above	1000V DC or peak AC maximum common mode voltage.
Common Mode (Filtered) 1 KΩ unbalance in either lead	 >140 db	 >140 db, 60 Hz and above	

ADDITIONAL SPECIFICATIONS BASIC DC UNIT

1100V DC or RMS (1500V peak AC) overload with no damage (any range).
Input capacitance < 100 pf.
Input offset current less than 50 pa on any range.

DC MILLIVOLTS (USING MV OPTION 8300A-10 OR MV/OHMS OPTION 8300A-02)

RANGES . . . . ±100 mv and ±1000 mv. 20% overrange capability (Up to 1100V overload with no damage)

POLARITY . . . . Automatic, instantaneous selection and display.

RANGE SELECTION . . . . Manual and autorange standard (Remote optional)

RESOLUTION . . . . 0.001% of range (1 uv on 100 mv range)

ACCURACY
Using millivolts zero control

	1000MV RANGE	100MV RANGE
24 hrs, ± 1°C	±(0.005% of input + 0.001% of range)	±(0.005% of input + 0.004% of range)
90 days and 6 mos 20°C-30°C	±(0.01% of input + 0.002% of range)	±0.01% of input + 0.005% of range)
1 year 20°C-30°C	±(0.015% of input + 0.002% of range)	±(0.015% of input + 0.005% of range)

ZERO STABILITY (After 30 minute warmup) Better than 8 uv for 90 days. (Front panel millivolt zero control provided to compensate for external thermal EMF's etc.

TEMPERATURE COEFFICIENT:

0°C to 20°C, 30°C, to 50°C . . . . 1000 mv range ±(0.0007% of input + 0.0003% of range)/°C
100 mv range ±(0.0007% of input + 0.0005% of range)/°C

INPUT RESISTANCE . . . . 100 mv: 100 megohms min. 1000 mv: 1000 megohms min.

RESPONSE TIME: . . . . (Including polarity change, to within 0.01% of step function change)

1000 mv Range . . . . 1 second maximum.

100 mv Range . . . . 3 seconds maximum.

NOTE: Response time figures applicable for source resistance up to 50 KΩ

REJECTION

	DC	INTERFERENCE FREQUENCY 50 Hz	INTERFERENCE FREQUENCY 60 Hz
Normal Mode	–	>55 db	>60 db, 60 Hz and above
Common Mode 1 KΩ unbalance in either lead	>140 db, DC to 60 Hz		

MAXIMUM INPUT VOLTAGE . . . . 1100 VDC or RMS (1500V peak AC) overload with no damage (any range)

AC VOLTS (USING AC OPTION 8300A-01)

RANGES:. . . . . 1V, 10V, 100V and 1000V
20% overrange capability (1100V RMS maximum)**

RANGE SELECTION . . . . Manual and autorange standard (Remote Optional)

RESOLUTION. . . . . 0.001% of range (10 uv on 1V range)

ACCURACY:
20°C to 30°C

FREQUENCY RANGE	INPUT VOLTAGE .001V – 500V	INPUT VOLTAGE 500 – 1100V
50 Hz - 20 kHz	±(0.1% of input +0.005% of range)* +0.02% of range) 30 days +0.03% of range) 90 days +0.035% of range) 6 months	±0.15% of input
20 kHz - 50 kHz	±(0.2% of input +0.005% of range)* ** +0.02% of range) 30 days +0.03% of range) 90 days +0.035% of range) 6 months	±0.2% of input **
30 - 50 Hz and 50 kHz - 100 kHz	±(0.5% of input +0.005% of range)* ** +0.02% of range) 30 days +0.03% of range) 90 days +0.035% of range) 6 months	±0.5% of input **

* "±0.005% of range" accuracy can be obtained at any time during a six month period via front panel AC zero. ±0.005% accuracy is typically maintained for 24 hours following zero adjustment. 30 day, 90 day and 6 mos intervals start after the last use of the AC zero.

** Input Volt-Hertz product should not exceed 2×10^7.

TEMPERATURE COEFFICIENT

0°C to 20°C, 30°C to 50°C . . . . ±(0.002% of input + 0.001% of range)/°C.

INPUT IMPEDANCE

(All Ranges) . . . . 1 megohm shunted by < 100 pf.

RESPONSE TIME:
(To within 0.1% of step function change) . . . . 500 ms maximum.

MAXIMUM INPUT VOLTAGE. . . . . 1100V RMS
(Up to ±1100V superimposed DC is allowed if the peak voltage does not exceed 1500V).

REJECTION:

Common Mode (DC to 60 Hz) . . . . 100Ω unbalance in either lead. > 120 db
Maximum Common Mode Voltage. . . . . 1000V DC or peak AC.

OHMS (USING MV/OHMS OPTION 8300A–02)

RANGES . . . . 1KΩ, 10KΩ, 100KΩ, 1000KΩ, 10MΩ, 20% overrange capability all ranges.

RANGE SELECTION . . . . Manual and autorange 1 KΩ through 1000KΩ ranges. 10 MΩ range selected manually. (Remote selection optional all ranges).

RESOLUTION . . . . 0.001% of range
(10 milliohms on 1 K range)

ACCURACY:

	1K – 1000K	10M
90 days, 20°C to 30°C	±(0.01% of input + 0.002% of range)	±(0.05% of input + 0.002% of range)
6 months, 20°C to 30°C	±(0.01% of input + 0.004% of range)	±(0.05% of input + 0.004% of range)
1 year, 20°C to 30°C	±(0.015% of input + 0.005% of range)	±(0.06% of input + 0.005% of range)

TEMPERATURE COEFFICIENT:

0°C to 20°C, 30°C to 50°C . . . . KΩ Ranges
±(0.0007% of input + 0.0003% of range)/°C

10 MΩ Range
±(0.003% of input +0.0003% of range)/°C

MEASUREMENT CURRENT:
(And Mode)

Range (KΩ)	1	10	100	1000	10 MΩ
Current (ua)	1.1 ma	110	100	10	1
Mode	4 terminal		2 terminal		

NOTE: Power dissipated in unknown resistor is only 1.2 milliwatts at 1 KΩ

RESPONSE TIME:
(To within 0.01% of step function change)

RANGE	UNFILTERED	FILTERED
1 KΩ 10 KΩ	1 sec.	1.5 sec
100 KΩ 1000 KΩ	15 ms*	
10 MΩ	50 ms*	

* Includes 25 ms digitizing time - No settling time required on 100K & 1000K ranges for input applied coincident with read command.

MAXIMUM INPUT VOLTAGE . . . . 30V RMS opens protective fuse.

4–WIRE RATIO (USING ISOLATED REFERENCE OPTION 8300A-05)

RANGES:

MODE	RATIO RANGE $(\frac{A}{B})$	READING	V INPUT (A)	V REF. (B)
DC/DC	0 ± 1.0 0 ± 10 0 ± 100	0 ± 10.0000 0 ± 100.000 0 ± 1000.00	0 ± 10V 0 ± 100V 0 ± 1000V	+2V to +10.5V Standard
MV/DC	0 ± 0.01 0 ± 0.1	0 ± 100.000 0 ± 1000.00	0 ± 100 mv 0 ± 1000 mv	
NOTE: DC External Reference may also be used for AC measurements.				

20% overranging, autorange and autopolarity operation apply to V input for all modes above as applicable.

ACCURACY :
90 days
20°C- 30°C

RATIO RANGE	
0 ± 0.1, 0 ± 1, 0 ± 10, 0 ± 100	±(0.01% of input + 0.002% X 10V/E_{ref} of range)
0 ± 0.01	±(0.01% of input + 0.005% X 10V/E_{ref} of range)*

NOTE! 24 hr, 6 mos & 1 year accuracy same as basic DC & MV specifications except multiply "% of range" by 10V/Eref.

* Using MV zero

EXTERNAL REFERENCE INPUT SPECIFICATIONS:

Input Impedance . . . . 1 megohm.
Response Time . . . . To within 0.01% of step function change (2 seconds)

NORMAL MODE REJECTION: . . . . > 30 db at 60 Hz.

ISOLATION: . . . . Difference between "V_{INPUT}+" and DC EXT. REF. "COMMON" may be ±13V peak on 10V and MV Ranges.
(Input & reference commons)

AC/AC RATIO

AC/AC Ratio measurements may be made with the 8300A equipped with the following options:*

8300A-01 AC CONVERTER
8300A-05 DC EXTERNAL REFERENCE
8300A-06 REAR INPUT
8300A-08 AC REFERENCE CONVERTER

RATIO RANGES:

AC REF. RANGE (B)	AC:AC RATIO RANGES (A:B)
1V (0.2 to 1.05V)	1:1 to 1000:1
10V (2.0 to 10.5V)	0.1:1 to 100:1
100V (20 to 105V)	0.01:1 to 10:1

(A) Ranges & range selection same as AC Option 8300A-01
(B) Range selected manually using internal switch.

ACCURACY OF RATIO
(Input and reference need not be at same frequency)
20°C to 30°C; 50 Hz - 20 kHz
Input (A) and Ref. (B) on same range . . . . ±0.05% of input ±0.005% $\left(\frac{\text{REF. RANGE}}{\text{V REF.}}\right)$ of range.**

±0.05% of input ±0.02% $\left(\frac{\text{REF. RANGE}}{\text{V REF.}}\right)$ of range –90 days

All other ratio and frequency ranges . . . . ±0.2% of input ±0.005% $\left(\frac{\text{REF. RANGE}}{\text{V REF.}}\right)$ of range.**

±0.2% of input ±0.04% $\left(\frac{\text{REF. RANGE}}{\text{V REF.}}\right)$ of range –90 days

Accuracy Specifications from 30 Hz to 50 Hz and from 20 kHz to 100 kHz equal 2 times those listed under 8300A-01 AC Converter with "% of Range" specifications multiplied by $\left(\frac{\text{REF. RANGE}}{\text{V REF.}}\right)$

TEMPERATURE COEFFICIENT OF RATIO:
0°C to 20°C, 30°C to 55°C . . . . 2 times that listed for the 8300A-01 AC Converter.

INPUT IMPEDANCE (All Ranges) . . . . 1 megohm shunted by 100 pf.

RESPONSE TIME: (To within 0.1% of specifications)
AC EXT. REF. . . . . 2 sec. max.

* The 8300A-02 MV/OHMS converter is not compatible with the AC-AC ratio configuration. This option may be substituted for 8300A-08 in the field to allow normal MV/OHMS measurements.

**Using front panel zero controls periodically (typically 8 to 24 hours after 30 minute warmup) 90 day specifications apply if front panel zero is not used.

DATA OUTPUT UNIT (USING OPTION 8300A–03)

OUTPUTS	LINES	LOGIC LEVELS	
		0 to +0.5V	+5V
FUNCTION: DCV, MV, ACV, KΩ, MΩ Filter, Ext. Ref.	7	Function inactive.	Function called.
RANGE (Coded): 1 = 00 10 = 01 100 = 10 1000 = 11	2	Logic 0	Logic 1
POLARITY:	1	Negative	Positive
6 DIGITS (Including "Overrange "1") Binary-Coded Decimal 8-4-2-1	21	Logic 0	Logic 1
DATA READY (Print) COMMAND	1	Data Ready	Data
OVERLOAD FLAG	1	No Overload	Overload
+5V REF & RETURN (TO POWER RCU)	2	---------	---------

DATA OUTPUT UNIT (USING OPTION 8300A–03)

INPUTS	LINES	LOGIC LEVELS	
		0 to +0.5V (or short)	+5V (or open)
EXT. TRIGGER (Read Command)	1		+5V pulse > 1 usec
SAMPLE DELAY (Internally programmed timeout delays sample until the Analog functions specified settling time has elapsed.)	1	No Delay (FAST)	Settling delay enabled (NORMAL)
INHIBITS (Address Lines for Serial Acquisition)	10	Inhibit	Normal

NOTE: 8 additional output lines and 4 input lines provided for code conversion of output data -- contact factory. Output is series 930 DTL with 6K collector resisitors.

OUTPUT FORMAT . . . . Complete parallel and addressable for parallel bit-serial character in multiples of 4 bits.

BLANKING . . . . All outputs are high during conversion and programmed time outs. Outputs enabled at time "Data Ready" flag appears.

POWER . . . . +5V DC available as output to power remote control unit if desired.

ISOLATION . . . . All CMRR specifications apply with DOU installed. 1000 VDC or peak AC may be applied between DOU common and input "LO".

REMOTE CONTROL (USING REMOTE CONTROL OPTION 8300A-04)

INPUTS		LINES	LOGIC LEVELS	
Function:	DCV, MV, ACV, KΩ, MΩ Filtered, External Reference	7	0 to +0.5V (or contact closure)	+5V (or open)
			Function Called	Function inactive
Range:	1, 10, 100, 1000 uncoded	4	Range Called	All lines open Autorange

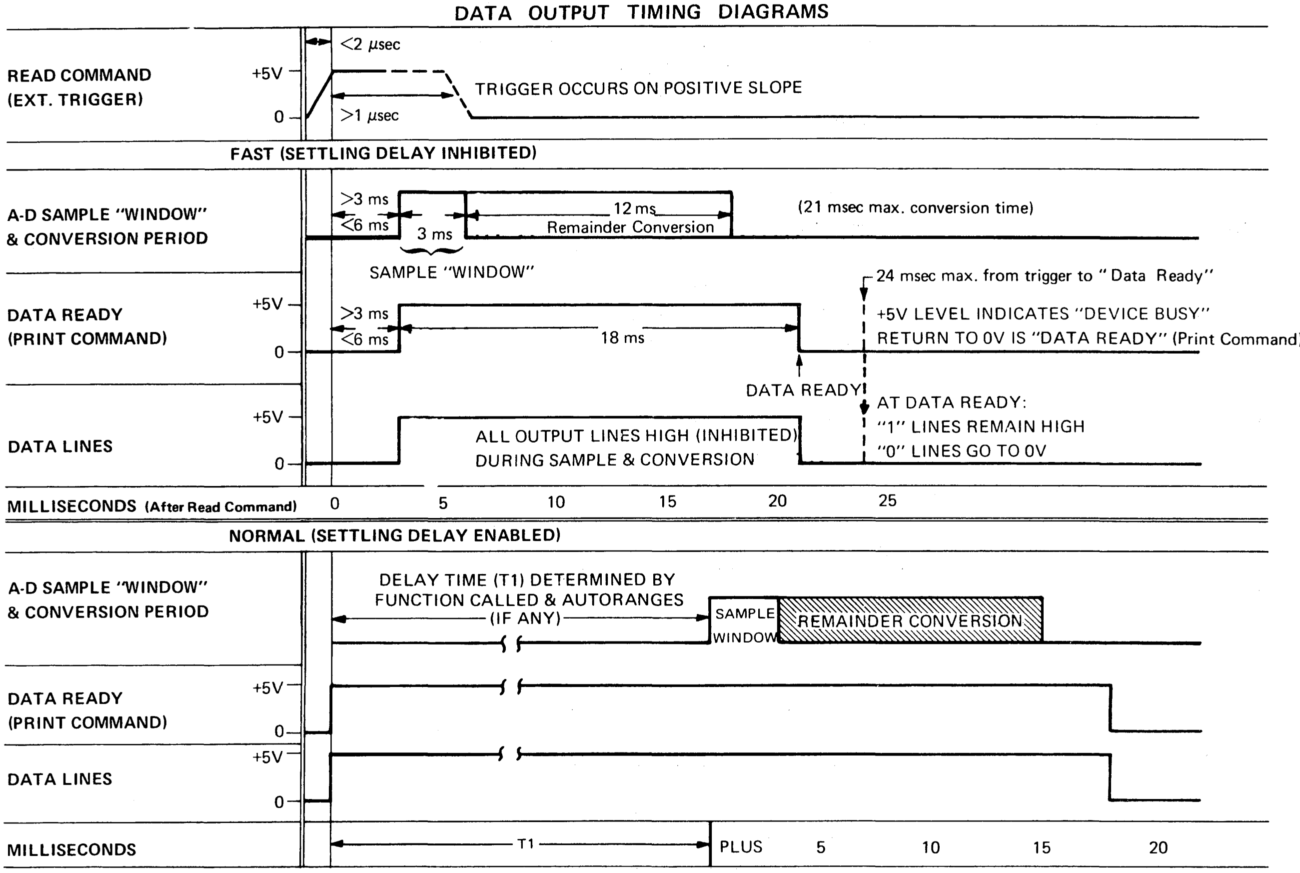
Input is series 930 DTL.

INTERLOCKS . . . . Interlocks are provided to disallow multiple function or range calls for incompatible combinations.

POWER . . . . +5V power available from Data Output Unit (May be externally powered, 5V DC at 150 ma required.)

ISOLATION . . . . All CMRR specifications apply with RCU installed. 1000 VDC or peak AC may be applied between RCU common and input "LO".

DATA OUTPUT TIMING DIAGRAMS



1-12. GENERAL SPECIFICATIONS

DISPLAY	Function/polarity display block plus six digit in-line neon readout.
DIGITIZING TIME	25 ms maximum.
SAMPLE RATE	Front panel variable from 10 readings/sec to 1 reading/3 sec + "EXT" (External Control) position. 40 reading/sec under external control through the Data Output Unit.
MAXIMUM INPUTS:	
"HI" to "LO"	See individual function specifications.
"LO" to "GUARD"	100V
"GUARD" to "GROUND"	1000V DC or peak AC.
TEMPERATURE RANGE	Operating 0°C to 50°C Storage −40°C to +75°C
HUMIDITY RANGE	Operating <80% relative humidity; 0°C to 25°C <70% relative humidity; 25°C to 50°C
ALTITUDE	Operating 10,000 Feet. (3.048 Km) Non Operating 50,000 Feet (15.24 Km)
SHOCK & VIBRATION	Meets requirements of MIL-T-21200G and MIL-E-16400F.
POWER	115/230V, ±10%, 50-440 Hz line, 20 watts with all options.
WARMUP TIME	30 minutes to meet all specifications.
WEIGHT	15 lbs basic (6.81 Kg) 19 lbs with all options (8.63 Kg)
SIZE	3.5" high by 17.5" wide by 15" deep (see outline drawing.) (88.9 mm H X 444.5 mm W X 381 mm D)

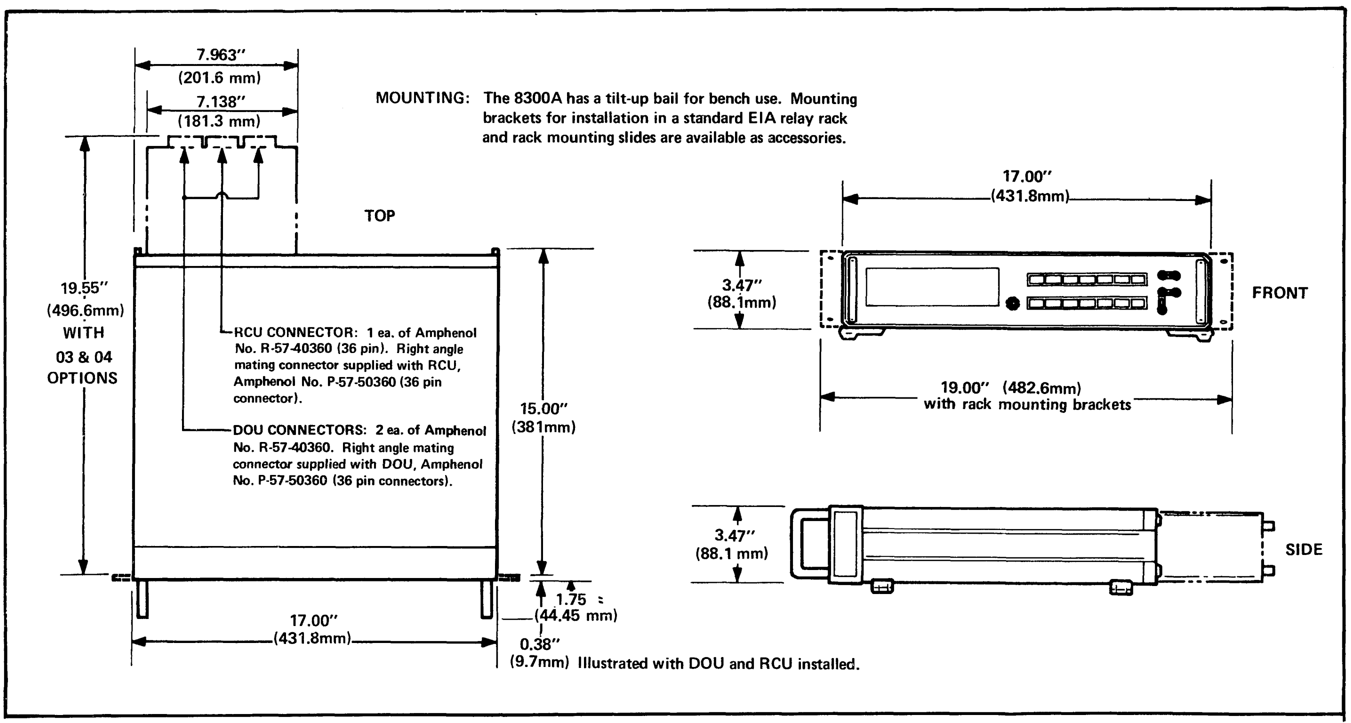
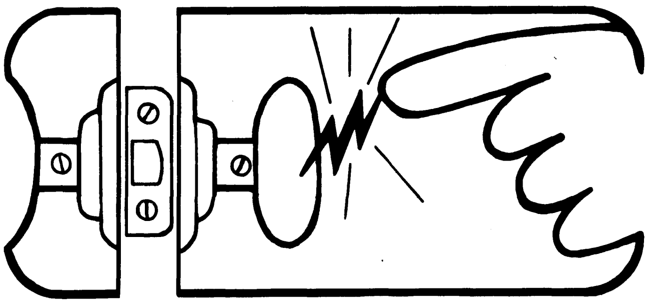


Figure 1-1. OUTLINE DRAWING

static awareness

A Message From

John Fluke Mfg. Co., Inc.

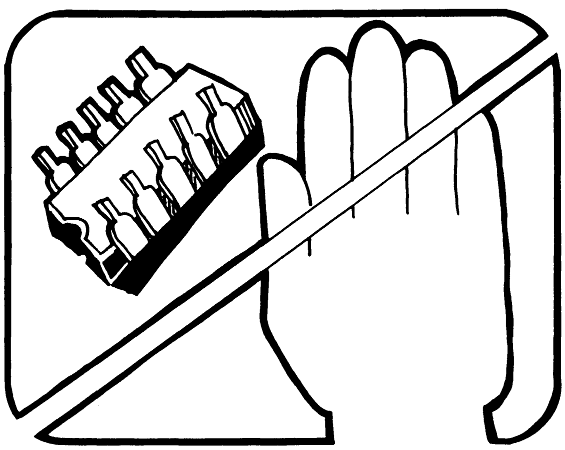


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

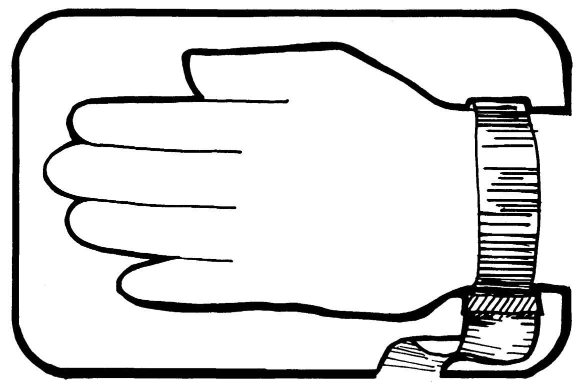
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol “ ”.

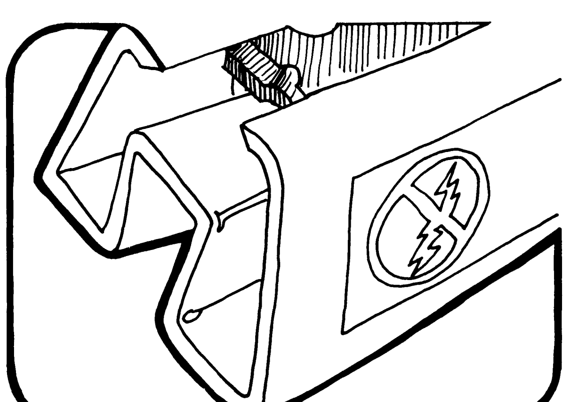
The following practices should be followed to minimize damage to S.S. devices.



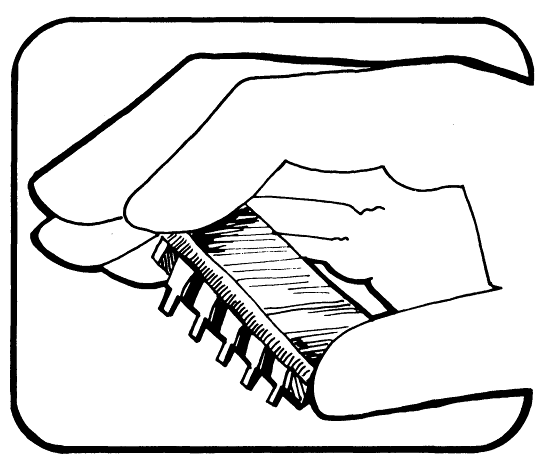
1. MINIMIZE HANDLING



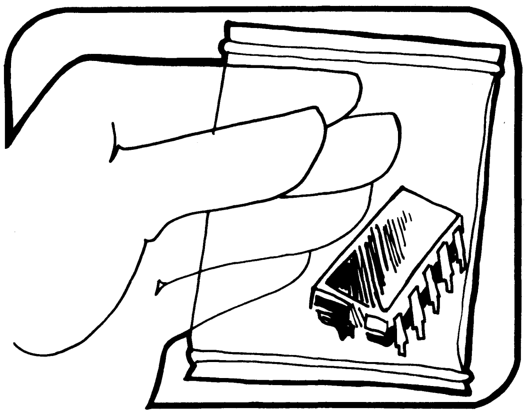
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES



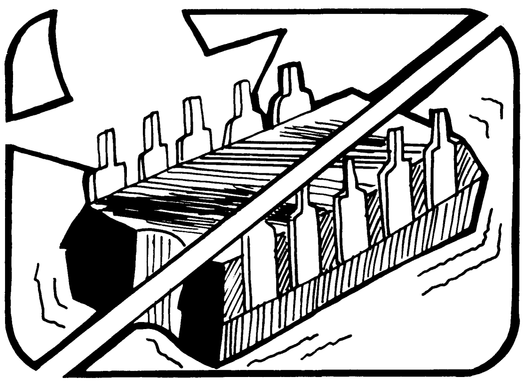
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



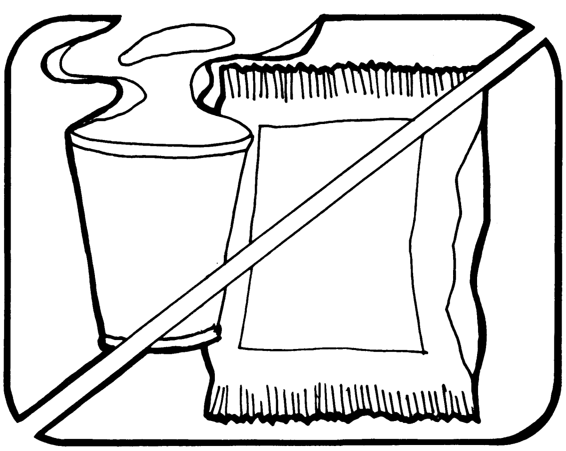
4. HANDLE S.S. DEVICES BY THE BODY



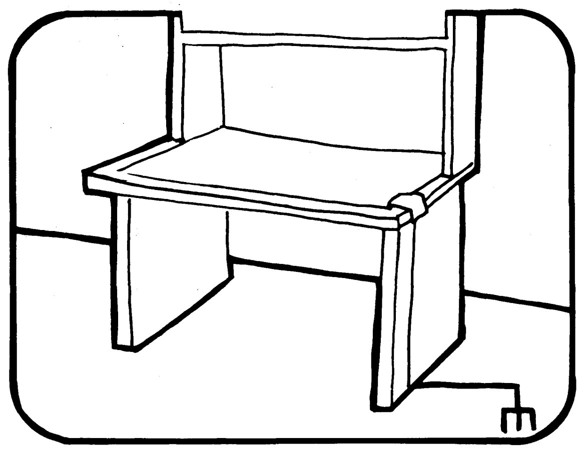
5. USE ANTI-STATIC CONTAINERS FOR HANDLING AND TRANSPORT



6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



7. AVOID PLASTIC, VINYL AND STYROFOAM IN WORK AREA



8. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION

9. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

10. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

Anti-static bags, for storing S.S. devices or pcbs with these devices on them, can be ordered from the John Fluke Mfg. Co., Inc.. See section 5 in any Fluke technical manual for ordering instructions. Use the following part numbers when ordering these special bags.

John Fluke Part No.	Bag Size
453522	6" x 8"
453530	8" x 12"
453548	16" x 24"
454025	12" x 15"

Section 2
Operating Instructions

2-1. INTRODUCTION

2-2. This section contains operating instructions and applications infromation for the Model 8300A Digital Voltmeter. The instructions cover each of the options as well as the basic digital voltmeter (DVM). Included in the instructions is a detailed description of the instrument controls, terminals, and indicators and an operational check which verifies satisfactory operation of the basic DVM using only front panel controls. If any problem is encountered in operating the instrument, contact the nearest John Fluke sales representative or write directly to the John Fluke Mfg. Co., Inc. Please include the instrument serial number when writing.

2-3. INSTALLATION

2-4. The Model 8300A is supplied with non-marring feet and tilt-down bail for bench or field use. Rack mounting kits are available. Kit MEE-7001 provides rack ears and hardware for mounting the DVM in a standard 19-inch rack. Kit MEE-8078 provides 18" rack slides and kit MEE-8079 provides 24" rack slides. Rack mounting procedures are shown in Figures 2-22 and 2-23.

2-5. Installation procedures for the various options of the Model 8300A together with circuit descriptions and maintenance procedures are contained in Section VI of the manual.

2-6. OPTIONS AND ACCESSORIES

2-7. The following Model 8300A options and accessories are available at additional cost. A detailed description of the options is given in Section V1 of the manual. When ordering an option for field installation, add the suffix "K" for example, 8300A-01K.

OPTION NO.	NAME
8300A–01	AC
8300A–02	MV/Ohms
8300A–03	Data Output Unit
8300A–04	* Remote Control Unit
8300A–05	* External Reference (Ratio)
8300A–06	Rear Input (in parallel with front)
8300A–08	** AC External Reference (for AC/AC Ratio)
8300A–10	MV (factory installed only)

* –06 required with –04 (when –04 is ordered without –03) and with –05

** Requires additional options – See Section Six of the manual

ACCESSORY	NAME
8300A–701	*** Digital Option Enclosure
8300A–4013	Option Extender (MV/Ohms, AC)
8300A–4015	Buffer Extender
MEE–7001	Rack Mounting Brackets
MEE–8078	18" Rack Slides (24" slides available)

*** –701 required when –04 option ordered without –03 Data Output Unit

2-8. INPUT POWER REQUIREMENTS

2-9. The instrument operates on 115 or 230 volt, 50 Hz to 440 Hz ac power. Before applying power to the instrument, note the position of the 115/230 volt slide switch at the rear of the instrument. If the switch does not indicate the desired operating voltage, place the switch in the desired position and ensure that the proper line fuse is installed: ¼ ampere, slow-blow, for 115 volt operation and 1/8 ampere, slow-blow, for 230 volt operation.

WARNING

The round pin on the polarized three-prong plug connects the instrument case to power system ground. If a three-to-two-wire adapter is used, ensure that the instrument ground wire is connected to a high quality earth ground.

2-10. OPERATING FEATURES

2-11. The name and function of the front and rear panel controls, terminals, and indicators are shown in Figure 2-1.

2-12. OPERATIONAL CHECK

2-13. This test verifies satisfactory operation of the DVM, using only front panel controls. It is intended as a quick functional check only. In consideration of possible wide variation in ambient temperature, the tolerances on readouts have been extended accordingly.

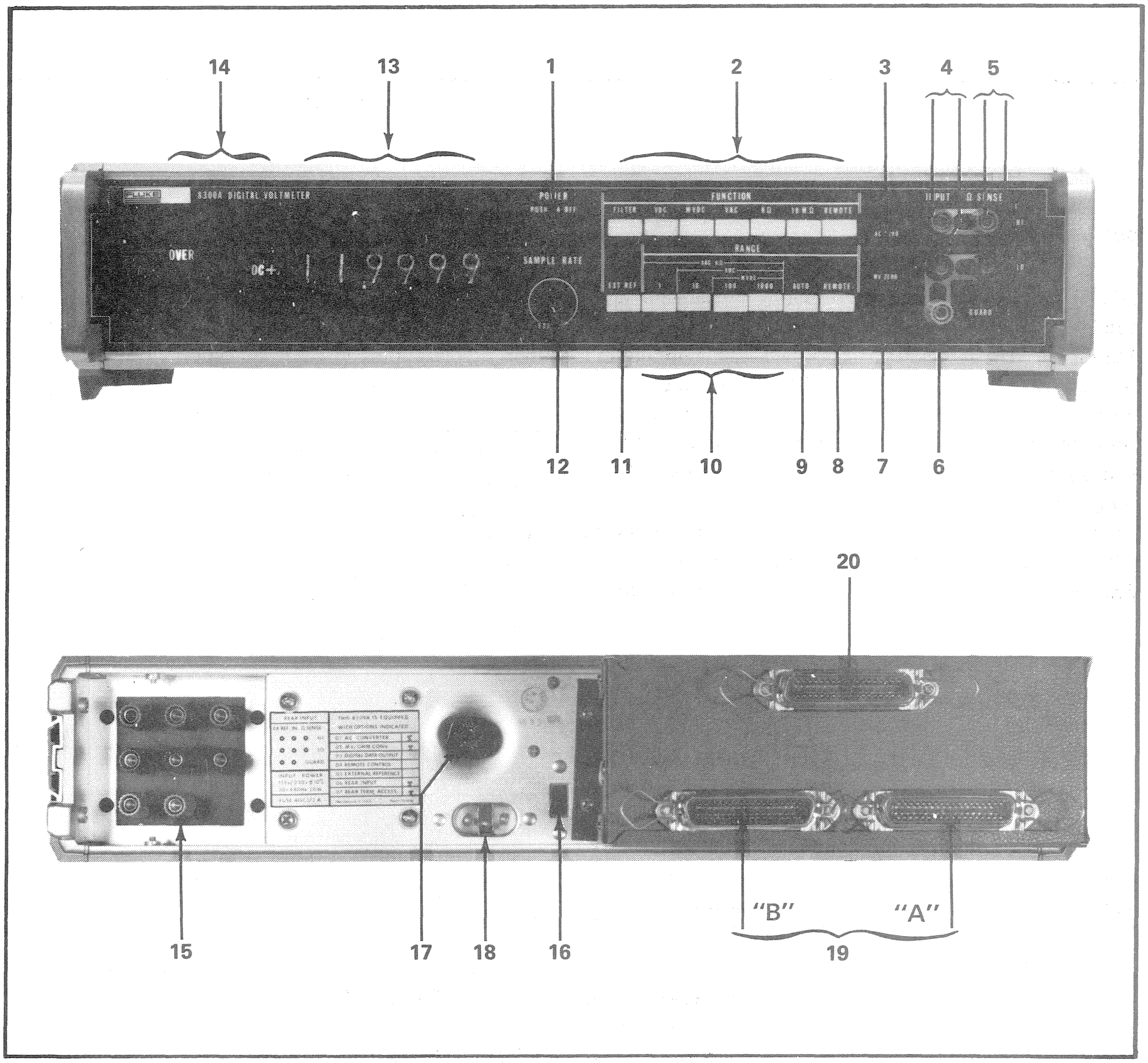


Figure 2-1. CONTROLS, TERMINALS, AND INDICATORS (Sheet 1 of 4)

REF. NO.	NAME	FUNCTION
1	POWER Switch	Alternate action pushbutton switch controls input power to the instrument. When depressed, instrument is ON; when released, instrument is OFF.
2, 11	FUNCTION Switches	Eight pushbutton switches select the desired operating mode. All switches except FILTER and EXT REF are mechanically interlocked so that only one function at a time can be called.
	FILTER	Alternate action pushbutton switch controls the active, three-pole input filter to provide desired noise rejection ratio.
	VDC	Places instrument in dc voltage mode and provides full-scale voltage ranges of 10, 100, and 1000 volts.
	MVDC	Places instrument in dc millivolt mode and provides full-scale voltage ranges of 100 and 1000 millivolts.
	VAC	Places instrument in ac voltage mode and provides full-scale voltage ranges of 1, 10, 100, and 1000 volts.
	KΩ	Places instrument in kilohm mode and provides full-scale resistance ranges of 1, 10, 100 and 1000 kilohms.
	10 MΩ	Places instrument in 10 megohm mode, with range fixed at 10 megohms full scale, independent of the four range switches.
	REMOTE (Function)	Places instrument in remote mode, enabling the seven instrument functions to be programmed or controlled remotely via the Remote Control Unit.
	EXT REF	Alternate action pushbutton switch enables dc voltage ratio measurements by selecting isolated external reference voltage to substitute for internal reference voltage.
3	AC ZERO	AC ZERO control, adjusted for a readout of 000.00 with VAC FUNCTION switch depressed and 1000 volt RANGE switch depressed.
4	INPUT Terminals	HI, LO input connections for dc voltage, ac voltage and resistance measurements.
5	Ω SENSE Terminals	For four-terminal resistance measurements on 1K and 10K range.
6	GUARD Terminal	Connects to internal guard chassis. When properly connected externally, provides increased ac and dc common mode rejection, May be connected directly to the LO terminal or disconnected from the LO terminal and driven by a separate GUARD potential.
7	MV ZERO	Millivolt zero control, adjusted for a readout of 00.000 with MVDC FUNCTION switch depressed and 100 millivolt RANGE switch depressed.

Figure 2-1. CONTROLS, TERMINALS, AND INDICATORS (Sheet 2 of 4)

REF. NO.	NAME	FUNCTION
8	REMOTE (Range)	Transfers all instrument range controls to remote location via Remote Control Unit.
9	AUTO	Places instrument in autorange mode, providing automatic ranging for each function and its range complement. The AUTO range switch is mechanically interlocked with the four RANGE switches so that only one range function at a time can be called. Calling a range not available for the called function places the instrument in autorange.
10	RANGE Switches	Four pushbutton switches select the full-scale input range for voltage and resistance measurements. The range complement for each function is as follows: FUNCTION — FULL SCALE RANGES AVAILABLE VDC — 10, 100, and 1000 vdc MVDC — 100, and 1000 mvdc VAC — 1, 10, 100 and 1000 vac KΩ — 1k, 10k, 100k and 1000k 10 MΩ — Fixed at 10 MΩ
12	SAMPLE RATE Control	Permits variation of sample rate from ten readings per second to one reading every three seconds. In EXT position (fully ccw), the internal sample rate oscillator is disabled and the instrument is commanded to sample only through the external trigger circuit in the Data Output Unit. If the Data Output Unit is not installed and the control is turned to the EXT position, the instrument will readout and display from the storage section indefinitely; the readout will correspond to the value of the last measurement.
13	Readout Tubes	Six neon indicator tubes display the instrument readout from left to right, with the overrange digit displayed in the left-most tube. All of the tubes (except the overrange indicator and the extreme right-hand tube) display a decimal point, which is controlled by the range switch. For example, an overload readout on each range would appear as follows: RANGE — READOUT 1 — 1.19999 10 — 11.9999 100 — 119.999 1000 — 1199.99
14	Function/Status Indicators	Nine indicators, illuminate to indicate function and status as follows: (The indicators corresponding to the options will not light unless the option is installed.)
	OVER	Overload input applied to instrument (over the 20% overrange capability).
	FILT	Active, three-pole input filter providing maximum noise rejection.

Figure 2-1. CONTROLS, TERMINALS, AND INDICATORS (Sheet 3 of 4)

REF. NO.	NAME	FUNCTION
14	EXT REF	Instrument operating in external reference mode.
	AC	Instrument operating in ac voltage mode.
	KΩ	Instrument operating in kilohm mode.
	MΩ	Instrument operating in 10 megohm mode.
	MV	Instrument operating in dc millivolts mode.
	DC +	DC voltage applied to instrument, with HI input terminal positive with respect to LO input terminal. Also illuminates when MVDC is called.
	DC–	DC voltage applied to instrument, with HI input terminal negative with respect to LO input terminal. Also illuminates when MVDC is called.
15	Rear Terminals (Option -06 and -07)	Rear panel connections for all measurements and for EXT REF input.
16	115/230 Volt Switch	Slide switch selects either 115 or 230 volt, 50 Hz to 440 Hz operation.
17	Line Fuse	AGC ½ ampere fuse protects instrument from overloads.
18	AC Line Connector	Mates with three-wire line cord for connection to 115/230 volt, 50 Hz to 115/230 volt, 50 Hz to 440 Hz ac line.
19	Data Output Unit Connectors Option-03	Connections for all DOU input/output signals: connector "A" and "B". (connector "A" is nearest the side of the instrument).
20	Remote Control Unit Connector Option-04	Connections for remote control of DVM

Figure 2-1. CONTROLS, TERMINALS, AND INDICATORS (Sheet 4 of 4)

a. Connect the Model 8300A to a source of 50 Hz to 440 Hz ac power and press the POWER-ON switch.

b. Set the controls and connect the INPUT terminals as shown in Figure 2-2. The readout should be as indicated.

2-14. DVM OPERATION AND APPLICATIONS

2-15. The following paragraphs describe the basic measurement and operating procedures associated with each of the DVM functions:

DC Voltage Measurement
AC Voltage Measurement
Resistance Measurement
Data Output
Remote Control
External Reference (Ratio)

2-16. The measurement instructions are summarized briefly in Figure 2-3.

2-17. DC Voltage Measurement

2-18. The basic DVM provides dc voltage measurement capability in three full-scale ranges of 10, 100, and 1000 volts, with automatic or manual ranging, autopolarity, a fully buffered three-pole (plus notch) active filter, and fully guarded input. The filter and automatic or manual range

FUNCTION	RANGE	INPUT TERMINALS	READOUT
VDC	10	Open	DVM measures changing voltage on input stray capacitance as it is being charged by the small input bias current.
VDC	100	Open	00.000 ±5 digits
VDC	1000	Open	000.00 ±5 digits
MVDC	100	Open	DVM measures changing voltage on input stray capacitance as it is being charged by the small input bias current.
VAC	1000	Shorted	000.00 $^{+30}_{-0}$ digits
VAC	1	Shorted	.00000 ±20 digits of above.
VAC	AUTO	Shorted	Same as above.
KΩ	AUTO	Open	1199.99 OVERload indicator lights.
KΩ	AUTO	Shorted	.00000 $^{+5}_{-0}$ digits
10 MΩ		Open	11.9999. OVERload indicator lights.
10 MΩ		Shorted	0.0000 $^{+5}_{-0}$ digits

NOTE: In VAC function, shorted input, the digits evident in the readout are a result of residual noise in the instrument. This noise signal will cause an insignificant error as long as ac input signals of 1 millivolt or larger are present at the input. Although the instrument is usable below 1 millivolt, the noise may cause significant errors.

Figure 2-2. MODEL 8300A OPERATIONAL CHECK.

functions are selected at the front panel or by remote programming. Addition of the Millivolt/Ohms converter option or MV converter option extends the dc voltage capability to include the 100 millivolt and 1000 millivolt full-scale ranges. The following steps describe the basic dc voltage measurement procedure:

a. Place the Model 8300A in operation by connecting it to an appropriate ac power source and operating the front panel POWER switch.

b. Select dc voltage mode by pressing either the VDC function switch or, if the Millivolt/Ohms converter or Millivolt Converter is installed, the the MVDC function switch.

c. Select the desired range by pressing the corresponding range switch or, if autoranging is desired, press the AUTO RANGE switch. In autorange, the instrument will automatically accomodate any voltage within the range of the selected function. In MVDC function, the instrument will autorange

	MODEL 8300A			
MEASUREMENT	FUNCTION	RANGE	INPUT CONNECTIONS	REMARKS
±DC Voltage	VDC	10v, 100v, 1000v, AUTO	Front panel HI, LO terminals or rear input terminals, when equipped with Rear Terminal Option.	Autoranges automatically if range is not manually selected. Does not autorange between VDC and MVDC.
	MVDC	100 mv, 1000 mv, AUTO		
AC Voltage	VAC	1v, 10v, 100v, 1000v, AUTO		Ω SENSE terminals may be used on 1k and 10k ranges for remote sensing, i.e., four-terminal ohms measurements.
Kilohms, 0 to 1000k	KΩ	1k, 10k, 100k 1000k, AUTO		
Megohms,	10 MΩ	Fixed		
DC/DC Ratio X10	EXT. REF. VDC	0 ± 10 0 ± 100 0 ± 1000	External reference voltage applied to rear input terminals (Figure 2-10)	External reference input +2 volts to +10.5 volts into 1 MΩ.
MV/DC Ratio X10	EXT. REF. MVDC	0 ± 100 0 ± 1000	Input voltage applied to front panel HI, LO terminals or rear input terminals, when equipped with Rear Terminal Option.	
AC/DC Ratio X10	EXT. REF. VAC	0 to 1.0 0 to 10 0 to 100 0 to 1000		

Figure 2-3. CONDENSED MEASUREMENT INSTRUCTIONS.

between the 100 and 1000 millivolt ranges; and in VDC function, the instrument will autorange between the 10, 100, and 1000 volt ranges.

d. Select increased noise rejection by operating the FILTER switch (see filter specifications in Section 1).

e. Connect the GUARD terminal to the LO input terminal or, if desired, disconnect the GUARD terminal from the LO terminal and drive the GUARD by applying a separate GUARD potential.

f. Connect the voltage to be measured to the HI, LO INPUT terminals. The readout will correspond to the input voltage with the decimal point positioned according to the range. The polarity indicator will register DC+ if the HI terminal is positive with respect to the LO terminal and DC– if the HI terminal is negative with respect to the LO terminal.

g. Adjust the SAMPLE RATE control for the desired sample rate.

2-19. AC Voltage Measurement

2-20. The DVM provides ac voltage measurement capability in four full-scale ranges of 1, 10, 100, and 1000 volts, when the AC Converter is installed. The basic frequency coverage is 50 Hz to 20 kHz, with the range extended to 30 Hz and 100 kHz at reduced accuracy. Selection of manual ranging or autoranging is made at the front panel. The following steps describe the basic ac voltage measurement procedure:

a. Select the ac voltage mode by pressing the VAC function switch.

b. Select the desired range by pressing the corresponding RANGE switch or if autoranging is desired, press the AUTO switch. In autorange, the instrument will automatically accomodate any voltage within the range of the selected function.

c. Connect the GUARD terminal to the LO input terminal or, if desired, disconnect the GUARD terminal from the LO terminal and drive the GUARD by applying a separate GUARD potential.

d. Connect the voltage to be measured to the HI, LO INPUT terminals. The readout will correspond to the input voltage, with the decimal point positioned according to the range.

2-21. Resistance Measurement

2-22. The DVM provides resistance measurement capability in five full-scale ranges of 1, 10, 100, and 1000 kilohms and 10 megohms, when the Millivolt/Ohms Converter is installed. Selection of manual ranging or autoranging is made at the front panel. The following steps describe the basic resistance measurement procedure:

a. Select the ohms mode by pressing either the KΩ function switch or the 10 MΩ function switch.

b. If KΩ function is called, select the desired range by pressing the corresponding RANGE switch or, if autoranging is desired, press the AUTO switch. In autorange, the instrument will accommodate any resistance within the range of the selected function.

c. If 10 MΩ function is called, the range will be fixed at 10 MΩ full scale, independent of the range switch positions.

d. Select increased noise rejection by operating the FILTER switch (see filter specifications in Section 1).

e. Connect the GUARD terminal to the LO input terminal or, if desired, disconnect the GUARD terminal from the LO terminal at the front panel, but drive the GUARD by applying a separate GUARD potential (see paragraph 2-46, Guarded Measurements).

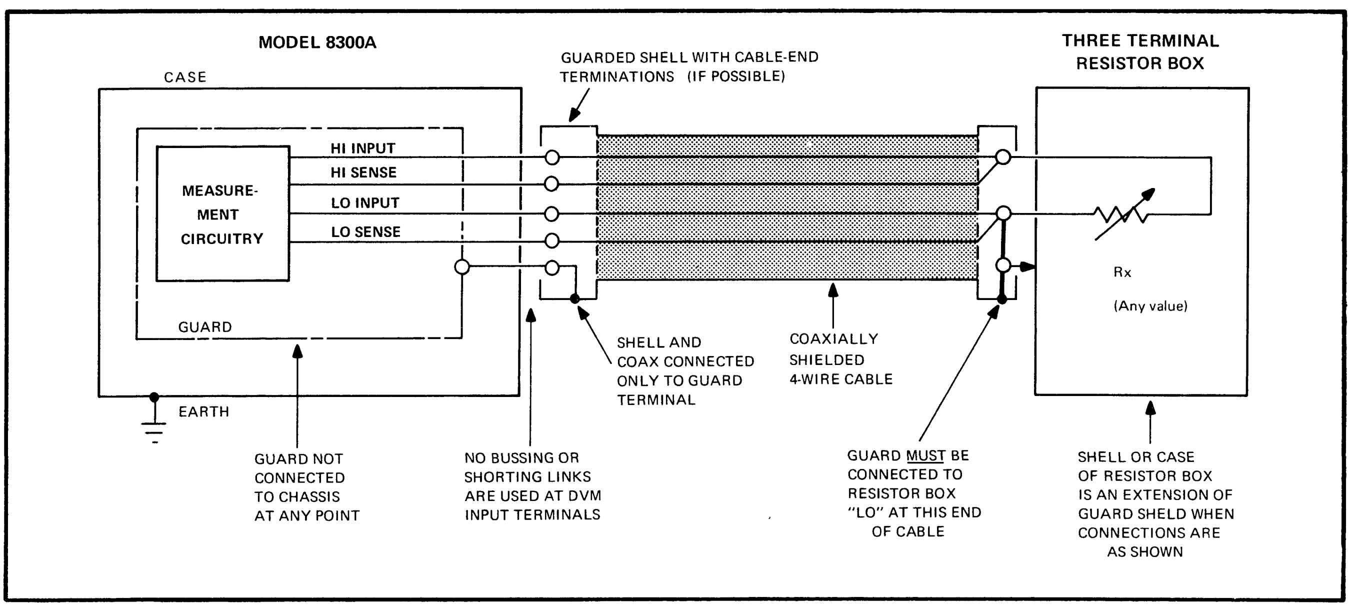


Figure 2-4. PROPER GUARD CONNECTIONS FOR FOUR-TERMINAL RESISTANCE MEASUREMENT SYSTEM

FUNCTION	1 RANGE	10 RANGE	100 RANGE	1000 RANGE	BUFFER FILTER	EXTERNAL REFERENCE
VDC	Auto Range	OBEY	OBEY	OBEY	OBEY	OBEY
MVDC	Auto Range	Auto Range	OBEY	OBEY	IGNORE	OBEY
VAC	OBEY	OBEY	OBEY	OBEY	IGNORE	OBEY
KΩ	OBEY	OBEY	OBEY	OBEY	OBEY *	IGNORE
MΩ	Remain on 10 Range	OBEY	Remain on 10 Range	Remain on 10 Range	OBEY	IGNORE

NOTE: Unit Autoranges in absence of Range Command.

* A filter is automatically in use on 1K & 10K ranges whether called or not.

Figure 2-5. LOGIC INTERLOCKING FOR REMOTE CONTROL OPERATION

f. Connect the resistance to be measured to the HI, LO INPUT terminals.

g. If it is suspected that the resistance of the connecting leads will be excessive, due to lead length for example, an increase in accuracy will be obtained by utilizing the 4-terminal ohms capability of the DVM. The increase in accuracy will depend on the ratio of the lead resistance to the unknown resistance. For low values of unknown resistance, the 4-terminal connection affords a significant increase in accuracy. When properly connected, the connections should be as shown in Figure 2-4.

NOTE!

When 4-terminal resistance measurements are not made, the Ω SENSE terminals must be connected to the input terminals as shown in Figure 2-21A to ensure proper instrument operation on the 1K and 10K ranges.

h. The instrument readout will correspond to the input resistance, with the decimal point positioned according to range.

2-23. Remote Control Unit.

2-24. DESCRIPTION. The Remote Control Unit (RCU) enables the DVM to be programmed or controlled remotely. The RCU is designed to interface directly with series 930 DTL for logic level control. Control by discrete transistors or contact switches is also possible. The switching device need only be capable of sinking 1.5 milliamps closed and withstanding 5 volts open. Power may be obtained from the Data Output Unit (DOU) or from an independent 5 volt, 150 milliamp supply. The RCU provides the capability of controlling all functions and ranges, with logical interlocking provided to make it impossible to call two or more incompatible functions simultaneously. The first call received by the RCU dominates and succeeding erroneous calls are ignored until the first call is released. Acceptable simultaneous combinations are shown in Figure 2-5.

2-25. Functions are called by switch closure or by application of DTL/TTL logic zeros. RCU connector location and pin assignments are shown in Figure 2-6. A mating right-angle connector (Amphenol P57-50360) is supplied with the RCU. A mating straight-out connector (Amphenol P-57-30360) is not supplied; if used, it will add approximately 3 inches to the overall Model 8300A depth with the RCU installed. The RCU common will be at the potential of the DOU common when powered from the DOU. When the RCU is independently powered, its common may be ±1000 volts dc or peak ac from analog input common and or DOU common with the restriction that the algebraic sum of all common mode voltages may not exceed ±1000 volts dc or peak ac. The capacitive coupling from the RCU to the Model 8300A guarded analog circuitry is less than 1.0 pf. Its insulation resistance is in excess of 10^{10} ohms.

2-26. OPERATION To place the DVM in remote operation, proceed as follows:

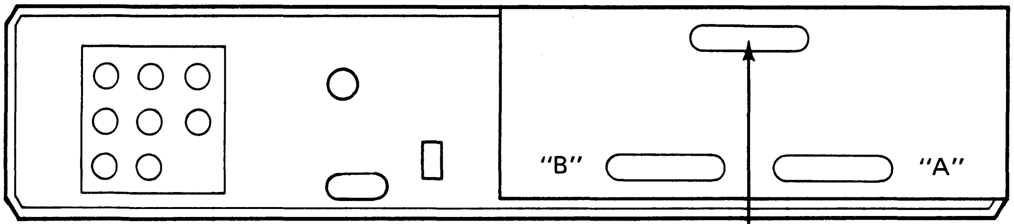
a. Press the REMOTE function switch to transfer control of the seven instrument functions to the remote control point.

b. Press the REMOTE range switch to transfer control of the instrument range to the remote control point.

NOTE!

DVM autoranges in absence of range command.

c. If it is desired to disable internal control of DVM sample rate, turn the SAMPLE RATE control to its extreme ccw position (EXT).



REMOTE CONTROL UNIT (RCU)
CONNECTOR PIN ASSIGNMENTS

Pin No.	Function	Pin No.	Function	Pin No.	Function	Pin No.	Function
1	SPARE	10	External Ref	19	SPARE	28	SPARE
2	"	11	Meg Ohm	20	"	29	"
3	"	12	1 Range	21	"	30	"
4	"	13	MV DC	22	"	31	"
5	"	14	KΩ	23	"	32	"
6	"	15	VAC	24	"	33	"
7	1000 Range	16	VDC	25	"	34	"
8	10 Range	17	Filter	26	"	35	"
9	100 Range	18	+5 VDC Power	27	"	36	COMMON

Figure 2-6. CONNECTOR LOCATION AND PIN ASSIGNMENTS FOR REMOTE CONTROL UNIT

		LOGIC LEVELS	
OUTPUTS	**LINES**	**0 to +0.5V**	**+5V**
Function: DCV, MV, ACV, KΩ, MΩ Filter, External Reference	7	Function inactive	Function called
Range (Coded): (c d) 1 = 0 0; 10 = 0 1; 100 = 1 0; 1000 = 1 1	2	Logic 0	Logic 1
Polarity:	1	Negative	Positive
6 Digits (Including "Overrange "1") Binary-coded Decimal 8-4-2-1	21	Logic 0	Logic 1
Data Ready (Print) Command	1	Data Ready	Data Blanked
Overload Flag	1	No Overload	Overload
+5V REF & Common	2	– – –	– – –

Figure 2-7. DATA OUTPUT UNIT TRUTH TABLES AND LOGIC LEVELS. (Sheet 1 of 2)

INPUTS	LINES	0 to +0.5V (or contact closure)	+5V (or open)
Ext. Trigger (Read Command)	1	+5V Pulse >1u sec.	
Sample Time (Programmed Time Out)	1	Fast	Normal
Inhibits (Address Lines for Serial Acquisition)	10	Inhibit	Normal

NOTE: 8 Additional output lines and 4 input lines provided for code conversions of output Data - - contact factory.
Output is series 930 DTL with 6 KΩ collector resistors.

Figure 2-7. DATA OUTPUT UNIT TRUTH TABLES AND LOGIC LEVELS. (Sheet 2 of 2)

d. Command a function or range via a contact closure or a zero volt logic load between the appropriate pin and common, as shown in Figure 2-9. Do not command a range to autorange.

e. For example, to program 10k ohm (filtered) command pins 14, 8 and 17 via contact closures or OV logic levels to pin 36 of the connector.

Installation, theory of operation, and maintenance instructions for the RCU are covered in Section VI of the manual.

2-27. Data Output Unit

2-28. DESCRIPTION. The Data Output Unit (DOU) enables the DVM to interface with a computer, printer, or a variety of data recording systems. DOU access is by means of two 36-pin connectors located at the rear of the unit. The DOU common may be ±1000 volts dc or peak ac from the analog input common. The capacitive coupling from the DOU to guarded analog circuitry is less than 1.0 pf. Its insulation resistance is in excess of 10^{10} ohms. The DOU is self powered. DOU truth tables and logic levels are given in Figure 2-7. DOU connector locations

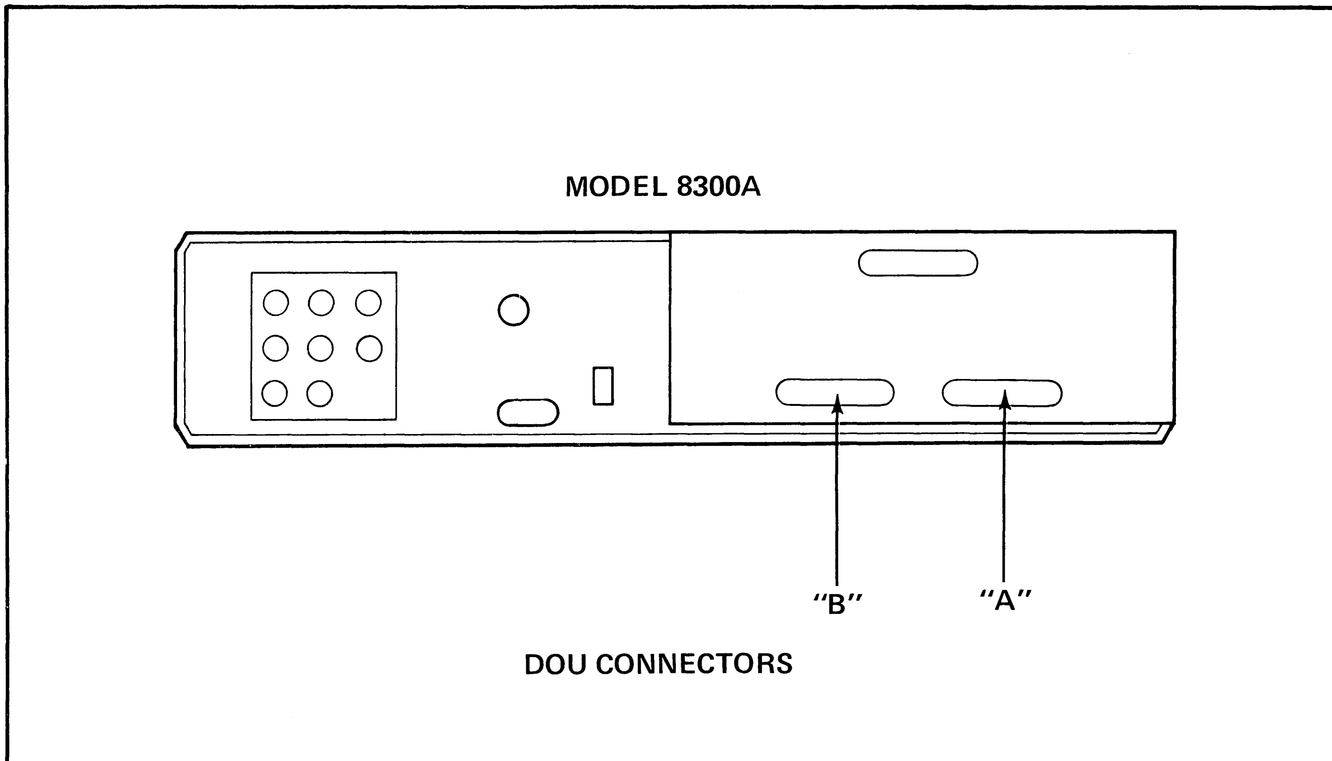


Figure 2-8. DATA OUTPUT UNIT CONNECTOR LOCATIONS

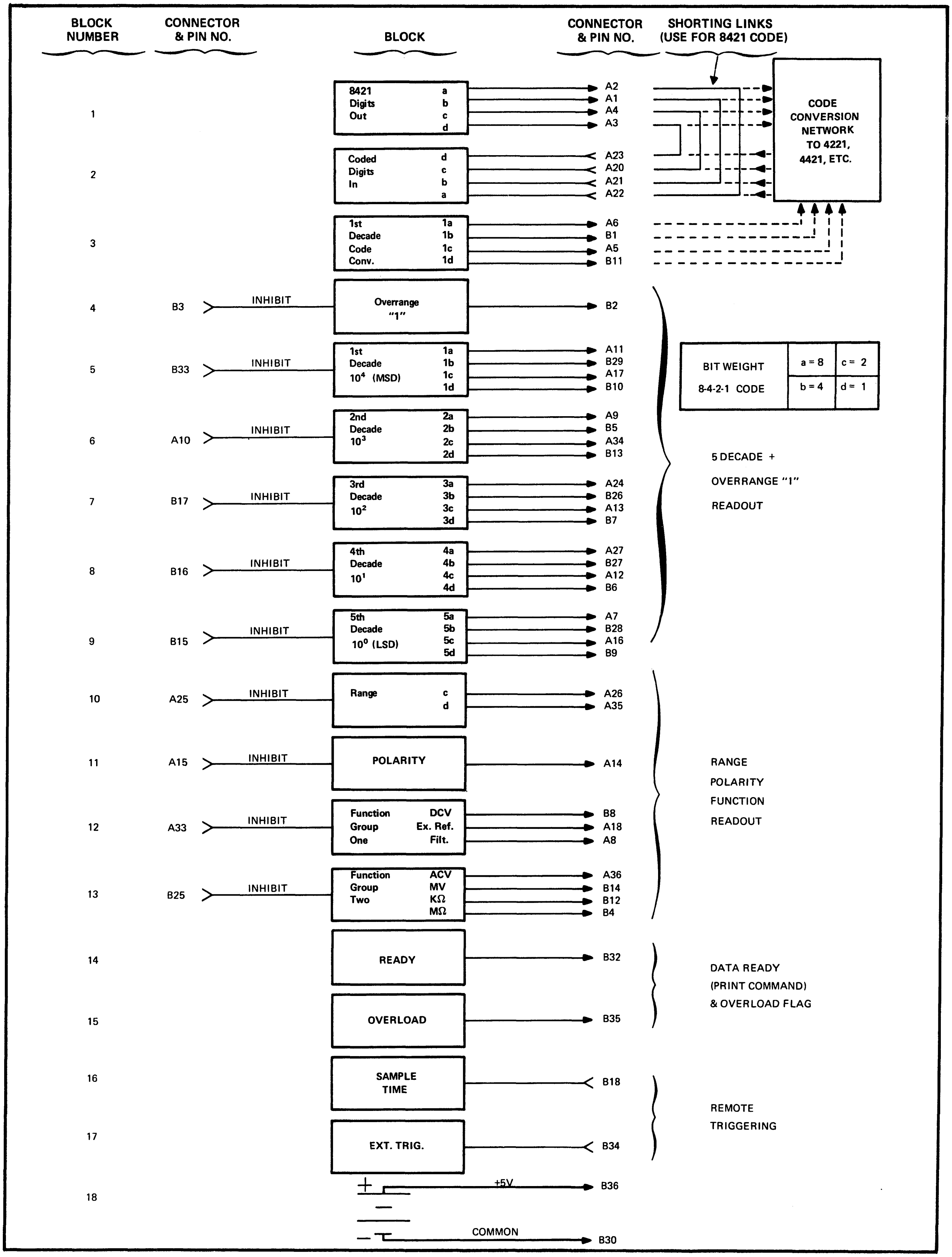


Figure 2-9. DATA OUTPUT UNIT FUNCTIONAL PIN CONNECTION DIAGRAM

are shown in Figure 2-8. Mating right-angle connections (Amphenol P-57-50360) are supplied with the DOU. Mating straight-out connectors, (Amphenol P-57-30360) are not supplied; if used, they will add approximately 3 inches to the overall Model 8300A depth with the DOU installed.

2-29. The DOU may be addressed to provide data output completely in parallel or in a series character, parallel bit format. The DOU functional pin connection diagram is given in Figure 2-9. The input/output signals are grouped by functional block in one column. Each input and output pin is assigned a letter and numeral. The letter designates which DOU connector (Figure 2-8) is to be used, and the numeral identifies the number of the pin on that connector on which the listed data appears.

2-30. Blocks 1 through 3 are used for conversion from the 1-2-4-8 BCD used in the Model 8300A to some other code such as 4-2-2-1. Detailed information is available from the factory pertaining to code conversion. If 8-4-2-1 code is desired, connect jumpers between blocks 1 and 2 on connector "A" and disregard block 3. Blocks 4 through 13 contain all data available from the Model 8300A. Inhibit lines associated with these blocks may be used for serial character, parallel bit data acquisition and/or multiplexing two or more instruments together or similar operation. Blocks 14 and 15 are flags. Block 14 may be used as a print command or ready-to-read indicator and block 15 as a priority interrupt. Block 15 output will be momentarily in the overload state during the Model 8300A automatic upranging process or whenever the input is too high for the range in use. Block 16 provides an internally programmed time-out in the normal-sample state to allow for settling time of the DVM analog circuitry. It should be used in the normal-sample mode when scanning inputs. It should be used in the fast sample mode when numerous, closely spaced samples of a stable analog input are taken. Block 17 provides the input for externally triggering the Model 8300A. The maximum external sample rate is 40 samples per second when block 16 is in the fast-sample mode. Block 18 provides power for the RCU and/or reference levels for printers.

2-31. The response of the Model 8300A data output system to a data request is a function-dependent series of delays. In each case, the delay series is automatically sequenced to provide data within specified accuracy in the minimum possible time. Figure 2-10 lists the individual delays, Figure 2-11, gives composite totals, and Figure 2-12 gives an index of possible combinations. This data includes worst-case tolerance throughout. Also included in the tolerances are delay uncertainties generated by non-synchronous sampling.

A.	Programmed One Shot Delay Times	
	VDC W/O Filter	8 ms ±1 ms
	VDC W Filter	500 ms ±25 ms
	VAC	500 ms ±25 ms
	KΩ or MΩ	1500 ms ±50 ms
	MVDC	3000 ±200 ms
B.	Autorange Delays	
	VDC W/O Filter	10 ms ±2 ms
	All Other	230 ms ±40 ms
C.	Response Uncertainty:	1.5 ±1.5 ms
D.	Digitizing Period:	13.5 ±0.27 ms
E.	DOU Autorange Detection	5 ±0.3 ms
F.	Instrument Zeroing	3 ±0.06 ms

Figure 2-10. TABLE OF INDIVIDUAL DELAYS

2-32. OPERATION

2-33. Completely Parallel Acquisition

NOTE!

Leave inhibit lines of blocks 4 through 13 open.

a. Blocks 1 through 3: Determine the code to be used and wire accordingly.

b. Blocks 4 through 13: Acquire full decades of digits from blocks 4 through 9. The data on blocks 10 through 13 may be acquired as desired for coded function, polarity, and range information. For example, "Polarity", "DC" and "MV" may be taken from blocks 11, 12 and 13 and applied to one column of a printer weighted as follows: Positive Polarity = 1, DCV = 2, and MV = 8. All operationally possible combinations of this grouping would be as follows:

		NOT DCV OR MV	DCV		MV	
			–	+	–	+
POS POL	(1)	0	0	1	0	1
DCV	(2)	0	1	1	0	0
NOT USED	(4)	0	0	0	0	0
MV	(8)	0	0	0	1	1

Programmed One-Shot Assumed Inhibited.

CONDITIONS	DELAYS	TOTAL MILLISECONDS
1. VDC W/O Filter	C+D+E+F	23 ± 2.1
Auto Range once	B+2C+D+E+2.5F	39 ± 5.7
Auto Range twice	2B+3C+D+E+4F	55 ± 9.3
2. All Other Functions	C+D+E+F = W	23 ± 2.1
Auto Range once	B+2C+D+E+2.5F = X	259 ± 43.7
Auto Range twice	2B+3C+D+E+4F = Y	495 ± 85.3
Auto Range 3 times	3B+4C+D+E+5.5F = Z	731 ± 127.9

Programmed One-Shot Assumed Operative
Steady-State Signal Applied to DVM Input

CONDITIONS	DELAYS	TOTAL MILLISECONDS
3. VDC W/O Filter	A+C+D+E+F	31 ± 3.1
Auto Range once	A+B+2C+D+E+2.5F	47 ± 6.7
Auto Range twice	A+2B+3C+D+E+4F	63 ± 10.3
4. VDC With Filter or VAC	A + 2W	546 ± 29.2
Auto Range once	A + W + X	782 ± 70.8
Auto Range twice	A + W + Y	1018 ± 112.4
Auto Range 3 times	A + W + Z	1254 ± 155
5. KΩ + MΩ	A + 2W	1546 ± 54.2
Auto Range once	A + W + X	1782 ± 95.8
Auto Range twice	A + W + Y	2018 ± 137.4
Auto Range 3 times	A + W + Z	2254 ± 188
6. MVDC	A + 2W	3046 ± 204.2
Auto Range once	A + W + X	3282 ± 245.8

Programmed One-Shot Assumed Operative
DVM Input Applied in Step Fashion Simultaneous with Command-to-Sample

CONDITIONS	DELAYS	TOTAL MILLISECONDS
7. VDC W/O Filter	(Same as item 3, this figure)	
8. VDC With Filter or VAC		
Auto Range once	2(A + W) + X	1305 ± 97.9
Auto Range twice	2(A + W) + Y	1541 ± 139.5
Auto Range 3 times	2(A + W) + Z	1777 ± 182.1

Figure 2-11. DELAY COMPOSITES (SAMPLE TIME-TO-DATA READY) (Sheet 1 of 2)

CONDITIONS	DELAYS	TOTAL MILLISECONDS
9. KΩ		
Auto Range once	2(A + W) + X	3305 ± 147.9
Auto Range twice	2(A + W) + Y	3541 ± 189.5
Auto Range 3 times	2(A + W) + Z	3777 ± 232.1
10. MVDC		
Auto Range once	2(A + W) + X	6305 ± 447.9

LEGEND: Alphabetical combinations in "DELAYS" column refer to correspondingly lettered items in Figure 2-10.

W, X, Y, and Z designations represent combinations of delays (See item 2., this Figure).

Figure 2-11. DELAY COMPOSITES (SAMPLE TIME-TO-DATA READY) (Sheet 2 of 2)

ARC	VDC	MVDC	VAC	KΩ	MΩ	
0	1	2	2	2	2	
1	1	2	2	2	–	Not Filtered
2	1	–	2	2	–	Fast Sample
3	–	–	2	2	–	
0	2	2	2	2	2	
1	2	2	2	2	–	Filtered
2	2	–	2	2	–	Fast Sample
3	–	–	2	2	–	
0	3	6	4	5	5	
1	3	6,10	4,8	5,9	–	Not Filtered
2	3	–	4,8	5,9	–	Normal Sample
3	–	–	4,8	5,9	–	
0	4	6	4	5	5	
1	4,8	6,10	4,8	5,9	–	Filtered
2	4,8	–	4,8	5,9	–	Normal Sample
3	–	–	4,8	5,9	–	

LEGEND:
1. Leftmost column (ARC) indicates number of automatic range changes.
2. Numbers in table refer to item numbers in Figure 2-11.

Figure 2-12. DELAY TIME INDEX

	1 VOLT		10 VOLT		100 VOLT		1000 VOLT	
	ON RANGE	OVER-RANGE	IN RANGE	OVER-RANGE	IN RANGE	OVER-RANGE	IN RANGE	OVER-RANGE
OVERRANGE (1)	0	1	0	1	0	1	0	1
RANGE "d" (2)	0	0	1	1	0	0	1	1
RANGE "c" (4)	0	0	0	0	1	1	1	1
(All possible operational combinations are included in this truth table.)								

c. The foregoing truth table provides a printer column whose decimal numeral data would be interpreted as follows:

DECIMAL NUMERAL	INTERPRETATION
0	Data not from a dc measurement
2 or 3	DC voltage measurement
8 or 9	Millivolts measurement
Odd	Positive polarity
Even	Negative polarity

d. "Range" and "overrange 1" data from blocks 9 and 4 could be combined for printout in a single column by assigning the following weights and using the truth table shown above.

Overrange "1" = 1
Range "d" = 2
Range "c" = 4

e. The printer column's decimal numerals for range and overrange data would be interpreted as follows:

DECIMAL NUMERAL	INTERPRETATION
Odd	Overrange "1" to precede decade numerals
0 or 1	1 volt range
2 or 3	10 volt range
4 or 5	100 volt range
6 or 7	1000 volt range

f. The remaining data could be presented in two additional columns, weighted as desired.

g. The completed interface could then be displayed in nine printer columns as follows:

COLUMN	ENCODED INFORMATION
1	External reference and/or filter.
2	ACV, KΩ or MΩ range.
3	Polarity, DCV or MV.
4	Range and overrange.
5, 9	Decade readout numerals.

h. Blocks 14 through 18: Use as outlined in paragraph 2-30.

2-34. Serial Character, Parallel Bit Acquisition

a. Blocks 1 through 3: Determine the code to be used and wire accordingly.

b. Blocks 4 through 13: Refer to pin connections in Figure 2-9 and connect blocks in parallel as shown in Figure 2-13. The user supplied clock controls the inhibit lines to determine the sequence of character acquisition. The clock can be a diode isolated ring counter at the Model 8300A or each inhibit line may be brought out for remote control. Only one inhibit line can be high at a time. Valid data is transferred from the block whose inhibit line is high. Figure 2-13 presents the acquisition, format and truth tables for serial character, parallel bit acquisition using 8-4-2-1 code and the illustrated interconnections.

c. Blocks 14 through 18: Use as needed, referring to paragraph 2-30 for application information and to Figure 2-7 for truth tables.

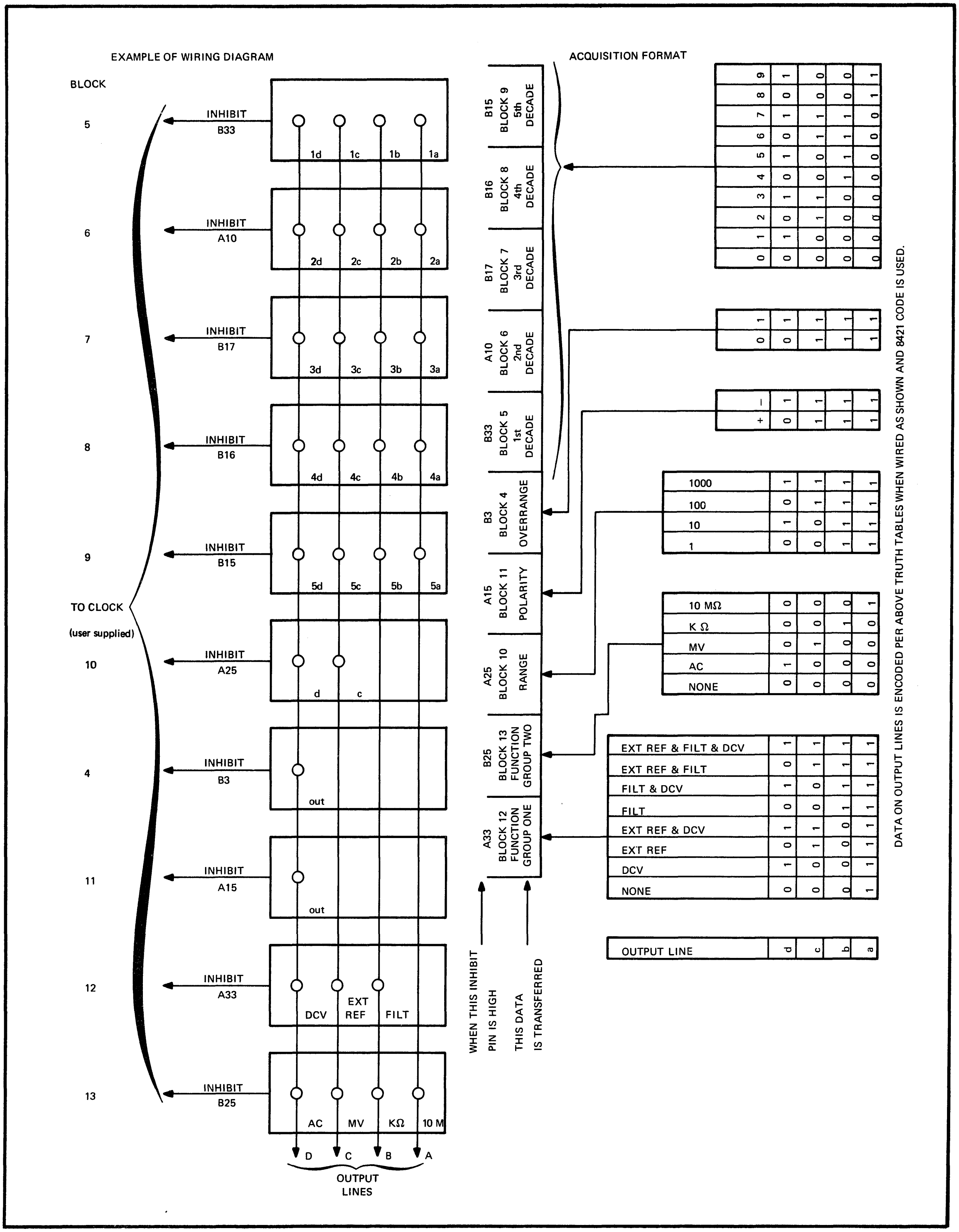


Figure 2-13. ACQUISITION, FORMAT AND TRUTH TABLES FOR SERIAL CHARACTER, PARALLEL BIT ACQUISITION USING 8-4-2-1 BCD.

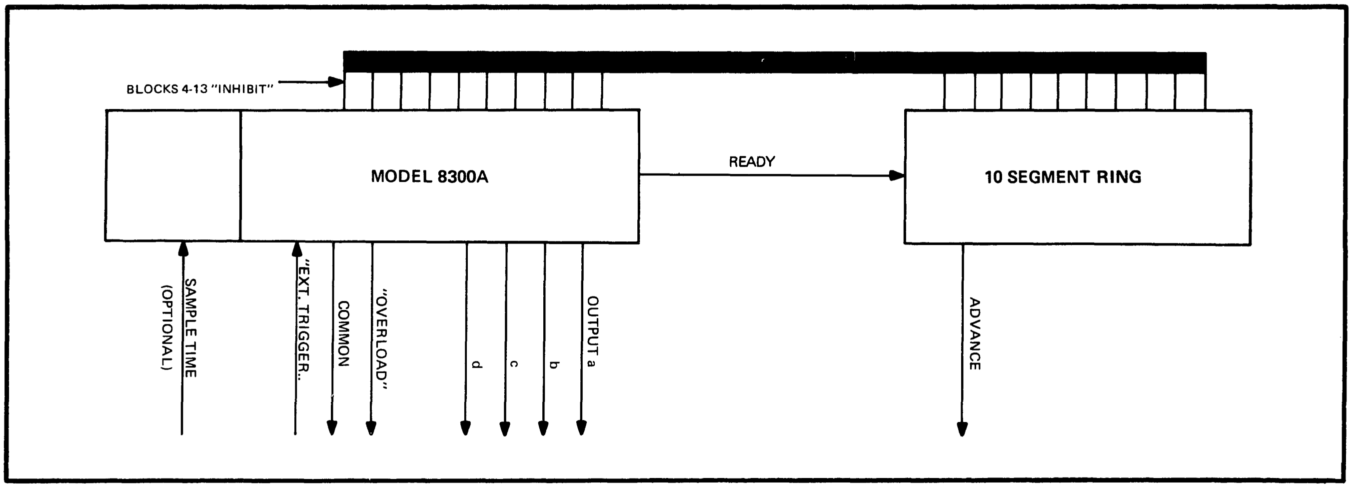


Figure 2-14. MINIMUM LINES ACQUISITION

2-35. Minimum Lines Acquisition.

a. Place a customer fabricated ten-segment ring counter near the Model 8300A and interface with lines as shown in Figure 2-14.

b. Trigger the Model 8300A. (The sample-time line may be programmed via interface or may be hard wired.)

c. When data is ready, the Model 8300A ready transition will start the ring counter. A synchronizing pulse, sent from the ring counter's advance line, will allow the acquisition device to recognize the character being acquired on the four output lines.

d. The overload line can serve as an alarm or priority interrupt.

2-36. Further information regarding code conversion and acquisition is available from the factory.

2-37. External Reference

2-38. DESCRIPTION. The External Reference option enables the user to substitute an external voltage for the internal DVM reference voltage. The principal use of the instrument when operated in this manner is for four-wire voltage ratio measurements: ±dc to dc, ±millivolts to dc, and ac to dc. The external reference voltage should be applied to the rear terminals as shown in Figure 2-15. Figure 2-16 shows the ranges available and the input voltage requirements for the External Reference. A second important use of the External Reference is to allow substitution of a system voltage for the Model 8300A reference. By this means, variables in systems measurements may be reduced.

2-39. MEASUREMENT ACCURACIES FOR RATIO-METER OPERATION. The temperature coefficient specifications for each signal input function (see Section I) are fully applicable to ratio reading accuracies. These specifications include factors for internal reference resistor matching and amplifier zero shift so that no degradation of performance will occur.

2-40. FLOATING 4-WIRE RATIO MEASUREMENTS. The algebraic sum of the DVM input voltage and the common difference voltage may not exceed 13 volts dc or peak ac, as shown in Figure 2-17.

2-41. OPERATION. The following steps describe the basic operating procedure for ratio measurements using the External Reference:

a. Connect the external reference voltage to the rear input terminals.

b. Select the Model 8300A range according to the ratio range and corresponding readout (See Figure 2-16).

c. Press the EXT REF switch on the front panel.

d. Press the VDC or MVDC function switch if dc-to-dc voltage ratios are to be measured or the VAC function switch if ac-to-dc voltage ratios are to be measured.

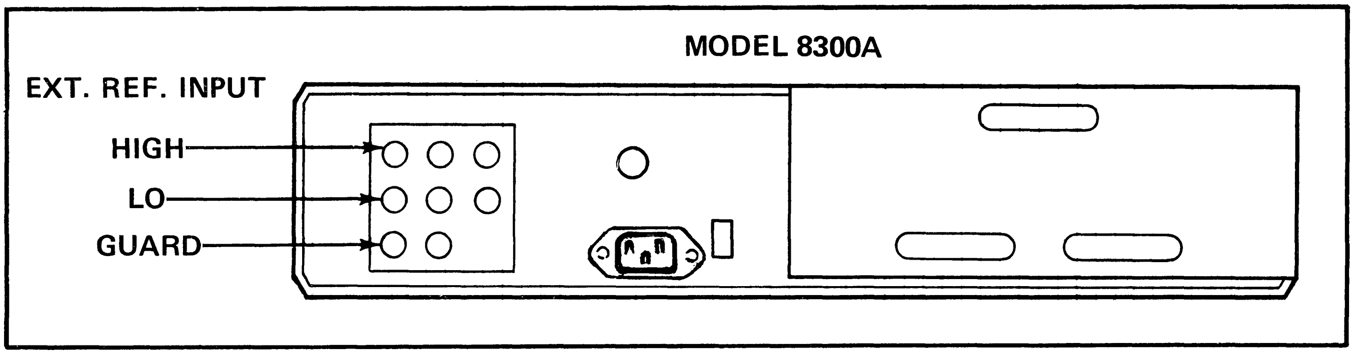


Figure 2-15. EXTERNAL REFERENCE INPUT TERMINALS

2-42. Installation, theory of operation, and maintenance instructions for the External Reference are covered in Section VI of the manual.

2-43. OPERATING NOTES

2-44. Overload Protection

2-45. The Model 8300A is protected against overload in each function and on all ranges. The following table lists the maximum voltages that may safely be applied to the instrument, on all ranges.

FUNCTION	MAXIMUM INPUT
VDC	1100 vdc or rms (1500v peak ac)
MVDC	1100 vdc or rms (1500v peak ac)
VAC	1100v rms (≤ ±1100v superimposed dc is allowable provided that total peak voltage does not exceed 1500v).
KΩ, 10 MΩ	Fused at 50 ma. Recalibration not necessary when replaced.

2-46. Guarded Measurements

2-47. Significant errors in ac and dc measurements arise out of undesired conversion of common mode signals (i.e., signals of like properties applied to both inputs) to normal mode and out of ambient noise induced into unshielded input leads. These errors add to the apparent amplitude of the unknown.

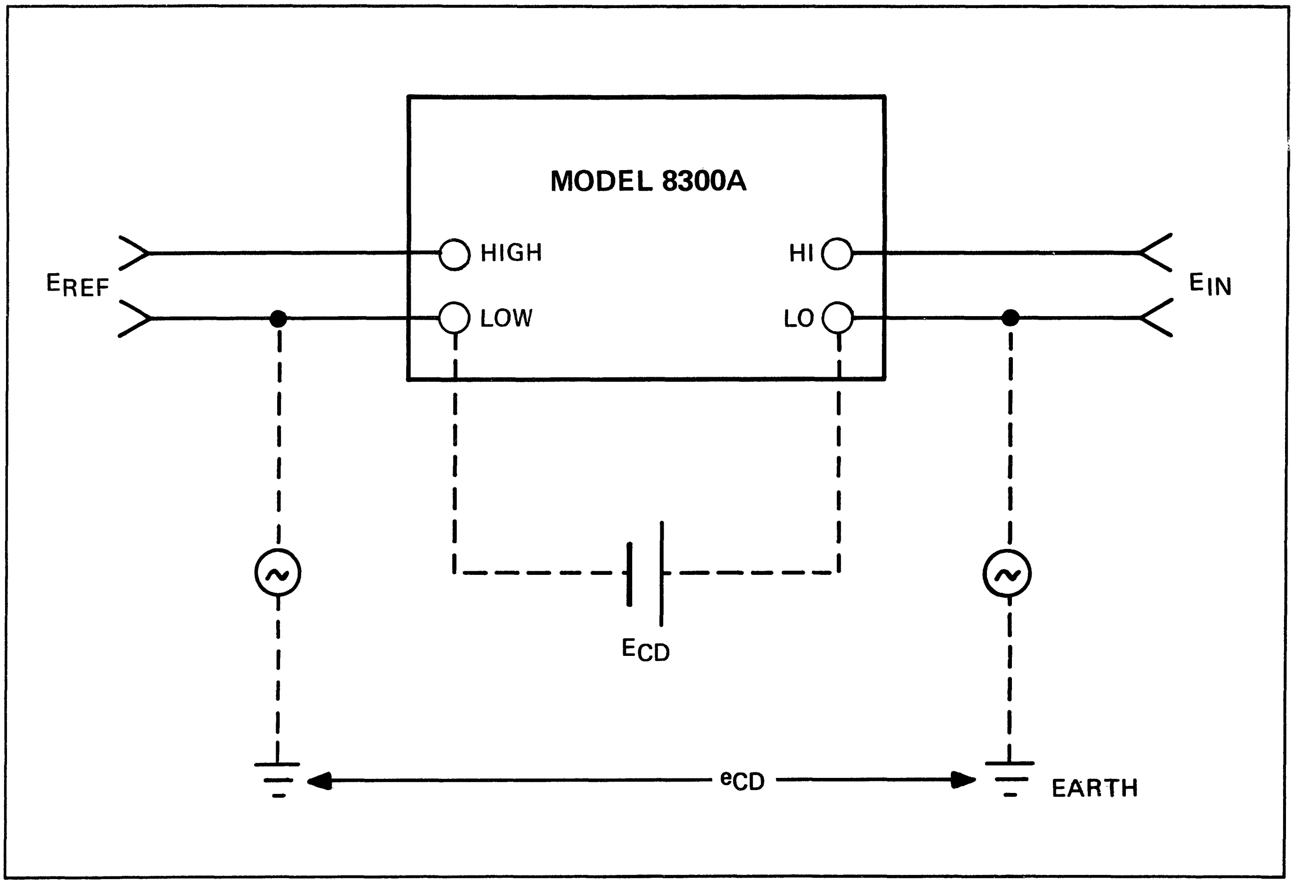
2-48. The Model 8300A has a system of shields and guards that function (when properly connected) to minimize common mode-to-normal mode signal conversion and induced noise, thereby providing the user with a very versatile system capable of fully-floating measurements without significant degradation of accuracy.

2-49. The following paragraphs describe some significant sources of errors and provide recommendations for use of the guard to reduce or eliminate these errors.

2-50. INPUT IMPEDANCE. Since measurement current flows equally in both leads, as shown in Figure 2-18,

MODE	RATIO RANGE $\left(\frac{A}{B}\right)$	READOUT	FRONT PANEL INPUT (A)	REFERENCE INPUT (B)
DC/DC X 10	0 ± 1.19999 0 ± 11.9999 0 ± 100.00	0 ± 11.9999 0 ± 119.999 0 ± 1000.00	0 ± 11.9999V 0 ± 119.999V 0 ± 1000V	+2V to +10.5V Standard into 1 MΩ
MV/DC X 10	0 ± 0.0119999 0 ± 0.119999	0 ± 119.999 0 ± 1199.99	0 ± 119.999 mV 0 ± 1199.99 mV	
AC/DC X 10	0 to 0.119999 0 to 1.19999 0 to 11.9999 0 to 100.000	0 to 1.19999 0 to 11.9999 0 to 119.999 0 to 1000.00	0 to 1.19999V 0 to 11.9999V 0 to 119.999V 0 to 1000V	

Figure 2-16. EXTERNAL REFERENCE RATIO RANGES AND INPUT REQUIREMENTS



REQUIREMENT

10V RANGE	100V RANGE	1000V RANGE
$E_{CD} \leq 13V$	$E_{CD} + \frac{E_{IN}}{10} \leq 13V$	$E_{CD} + \frac{E_{IN}}{100} \leq 13V$
$e_{CD} \leq 13V$	$e_{CD} + \frac{E_{IN}}{10} \leq 13V$	$e_{CD} + \frac{E_{IN}}{100} \leq 13V$
$E_{CD} + e_{CD} \leq 13V$	$E_{CD} + e_{CD} + \frac{E_{IN}}{10} \leq 13V$	$E_{CD} + e_{CD} + \frac{E_{IN}}{100} \leq 13V$

WHERE

E_{REF} = INPUT REFERENCE VOLTAGE

E_{IN} = DVM INPUT VOLTAGE

E_{CD} = DC COMMON DIFFERENCE VOLTAGE

e_{CD} = PEAK AC COMMON DIFFERENCE VOLTAGE

Figure 2-17. EXTERNAL REFERENCE UNIT ISOLATION REQUIREMENTS it creates an error equal to

$$E_{R01} + E_{R02} = (R_{01} + R_{02})\, I_M,$$

Where $R_{01} + R_{02}$ = Signal lead resistances

$E_{R01} + E_{R02}$ = Voltage developed in leads due to flow of measurement current.

I_M = Current flowing in instrument input circuitry

By the principle of superposition, this effect may be considered independently from other phenomenon.

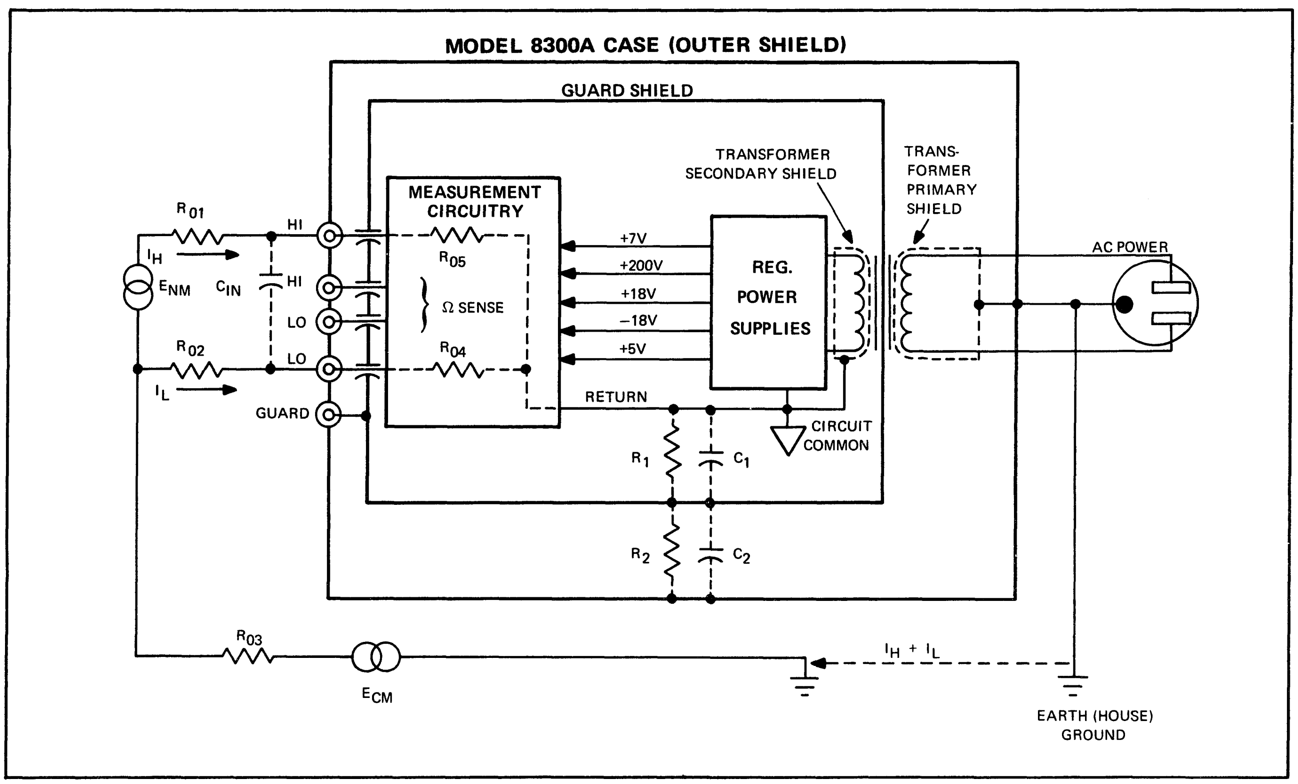
2-51. COMMON-MODE REJECTION RATIO (CMRR)

A path for common-mode currents is created by undesired stray impedances Z_1 and Z_2, which represent leakage resistances and stray capacitance between measurement circuit and guard and between guard and case, as shown in Figure 2-18. These impedances enable frequency-dependent currents to flow in the input leads to DVM when common-mode voltages are applied as shown in Figure 2-18. Current flows predominantly in the low-input lead (I_L), because I_M is designed to be very low (in the Model 8300A) and I_H is therefore very low (i.e., R_{04} is very low and R_{05} is very high). Current I_L has magnitude

$$I_L = \frac{E_{CM}}{R_{03} + R_{02} + R_{04} + Z_1 + Z_2}$$

As a result of I_L, an error voltage is developed across R_{02} whose magnitude is

$$R_{02}\, I_L = E_{R02}.$$



R_{01} & R_{02}	=	Signal lead resistances
R_{03}	=	Common-mode source resistance
R_{04} & R_{05}	=	Signal line-to-common resistances
C_{IN}	=	Input capacity (includes input cable capacity)
R_1 & C_1	=	Z_1 = Stray impedance (measurement circuit-to-guard)
R_2 & C_2	=	Z_2 = Stray impedance (guard-to-case)
E_{NM}	=	Normal-Mode Voltage (Thevenin Equivalent)
E_{CM}	=	Common-Mode Voltage (Thevinin Equivalent)
I_L & I_H	=	Frequency-dependent common-mode currents

Figure 2-18. FLOATING DVM MEASUREMENT SYSTEM SHOWING GENERATION OF COMMON-MODE SIGNALS.

Substituting for I_L we have

$$R_{02}\left[\frac{E_{CM}}{R_{03}+R_{02}+R_{04}+Z_1+Z_2}\right] = E_{R02}$$

and rearranging we have

$$\frac{E_{CM}}{E_{R02}} = \frac{R_{03}+R_{02}+R_{04}+Z_1+Z_2}{R_{02}} \approx \frac{Z_1+Z_2}{R_{02}}$$

$$\text{if } Z_1 \gg R_{03},\ R_{04},\ R_{02}$$

and

$$\text{CMRR} \approx 20\ \log_{10}\left[\frac{Z_1+Z_2}{R_{02}}\right] \text{, expressed in DB.}$$

2-52. Other factors affecting CMRR are the DVM input capacity, the resistance of R_{05}, and the DVM filter. Input capacity, C_{in}, which consists also of the capacity of the input signal cable, tends to improve the CMRR by equalizing the normal-mode inputs so far as ac is concerned. CMRR is inversely proportional to the value of R_{05}. As the value of R_{05} is reduced, I_H approaches I_L and the amount of common-mode conversion to normal-mode is consequently reduced. Filtered operation increases the CMRR as shown in paragraph 1-11 of the Model 8300A specifications. Theoretically, the filter would add 60 db to the unfiltered CMRR specifications; however, because the guard is not a perfect shield, some common-mode currents are developed within the instrument and the CMRR is degraded accordingly.

2-53. The guarding and shielding employed in the Model 8300A provide means for effectively making Z_1 very large, thereby reducing E_{R02} to an acceptable level for reasonable values of R_{02} and consequently greatly enhancing CMRR. Z_1 is effectively increased by forcing the common-mode source to drive the guard shield to a potential equal to that on the internal signal return (See Figure 2-19). Under these conditions, the terminals of Z_1 will be a small constant potential, no current will flow through R_{02} and Z_1, and consequently E_{R02} will nearly equal zero volts.

2-54. In the diagram of Figure 2-19, Z_2 is placed directly across E_{CM}. Under some circumstances, where E_{CM} cannot be conveniently loaded with Z_2, a guard driver may be used, as shown in Figure 2-20.

2-55. RADIATED NOISE. Another source of errors which is often encountered is that of unequal noise induction in the unshielded input leads. The effective magnitude of these errors is dependent on the following:

a. Value of R_{01} and R_{02} (source impedance).
b. Length of input leads.
c. Strength of interfering field.
d. Frequency of interfering field.
e. DVM input impedance.
f. DVM input filter (whether active or inactive).

The guarding and shielding techniques shown in Figures 2-19 and 2-20 are of considerable importance in reducing these errors, assuming that the noise does not originate in the source itself. Further improvement, however, may be obtained by using guarded or shielded cable terminations

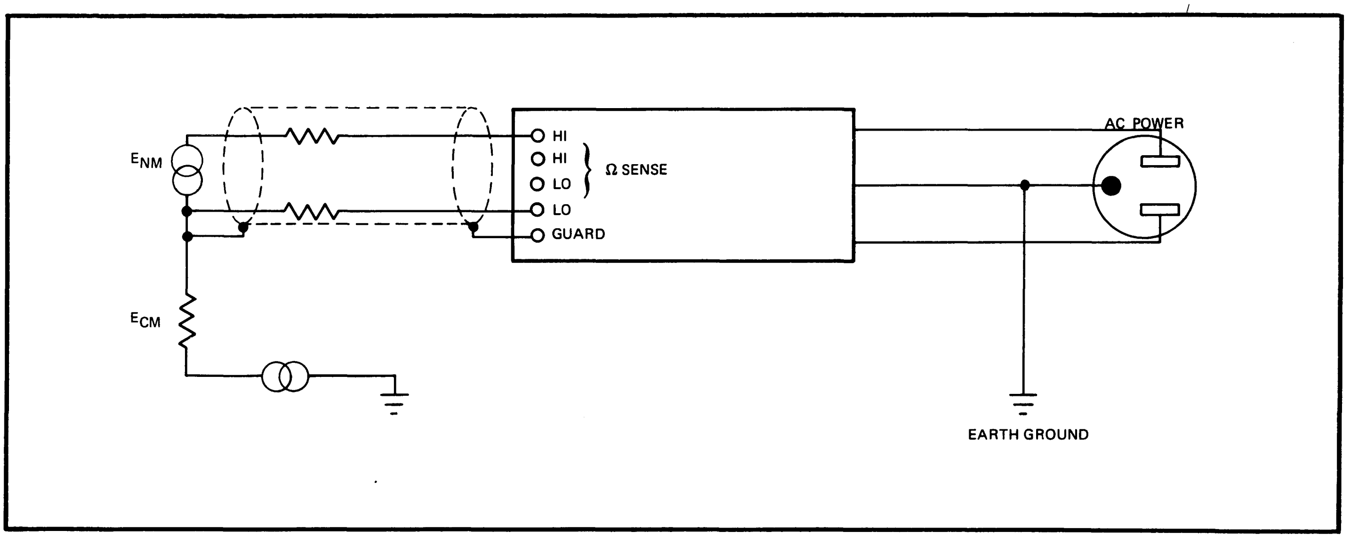


Figure 2-19. CONNECTIONS FOR DRIVING THE GUARD FROM THE COMMON-MODE SOURCE.

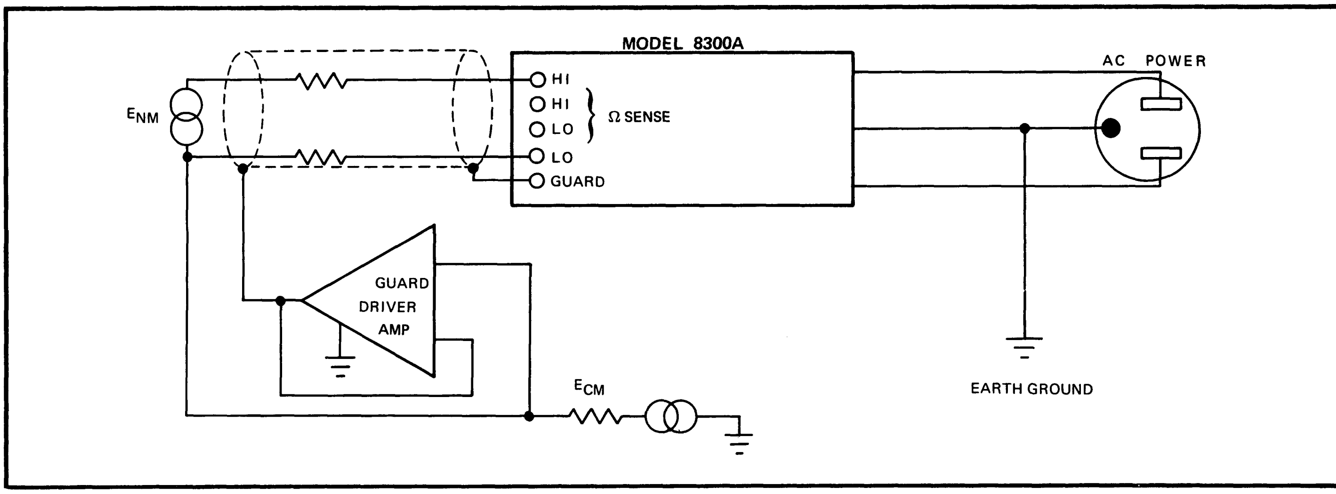


Figure 2-20. USING AN EXTERNAL AMPLIFIER TO DRIVE THE GUARD

as shown in Figure 2-4. Use of the filter in VDC and other modes will enhance noise rejection characteristics regardless of its origin.

2-56. SUGGESTIONS FOR USING THE GUARD. Non-floating measurements will likely be the usual case. Under these conditions, it is satisfactory to strap the front panel GUARD terminal to the LO input terminal using the shorting link provided.

CAUTION!

If guarded measurement is not needed, the DVM GUARD terminal should be connected to the DVM LO input terminal at the front panel to preclude possible damage to the instrument.

2-57. Figure 2-21 shows two methods for connection of the guard terminal when making ohms measurements. Figure 2-21A shows proper guard connections for 2-terminal resistance measurements when signal leads are short and Figure 2-21B shows proper guard connections for 4-terminal resistance measurements when R < 12k (when R < 12k, induced noise is generally insignificant but lead resistance can become a significant error).

2-58. In general guarded voltage and resistance measurements will be necessary under the following conditions:

a. When long signal leads are used and source impedance is high.

b. When the system is operating in the presence of high level radiated noise. The most common example is stray fields at power line frequency.

c. When floating measurements are made and the common mode voltage is a high potential, high frequency, or both.

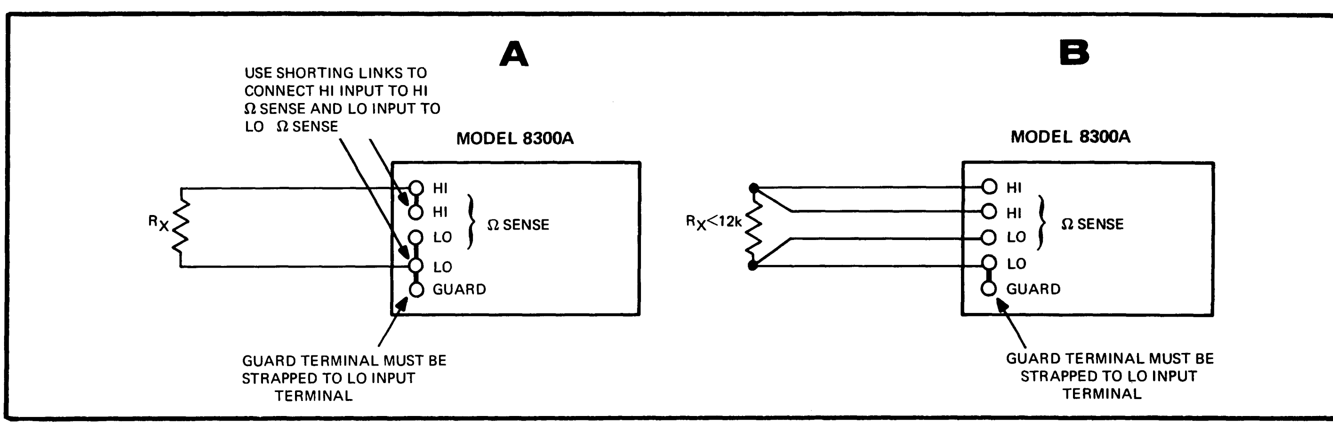
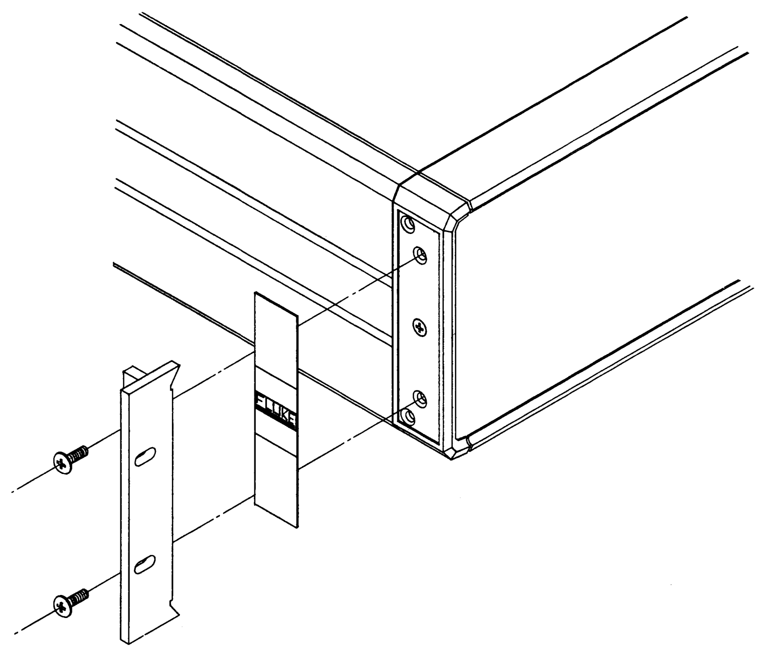


Figure 2-21. PROPER GUARD CONNECTIONS FOR (A) 2-TERMINAL Ω MEASUREMENTS WHEN SIGNAL LEADS ARE SHORT AND (B) 4-TERMINAL Ω MEASUREMENTS WHEN $R_X < 12k$.

RACK MOUNTING PROCEDURE FOR MEE SERIES INSTRUMENTS



1-REMOVE THE FOUR MOLDED FEET & BAIL FROM BOTTOM COVER.

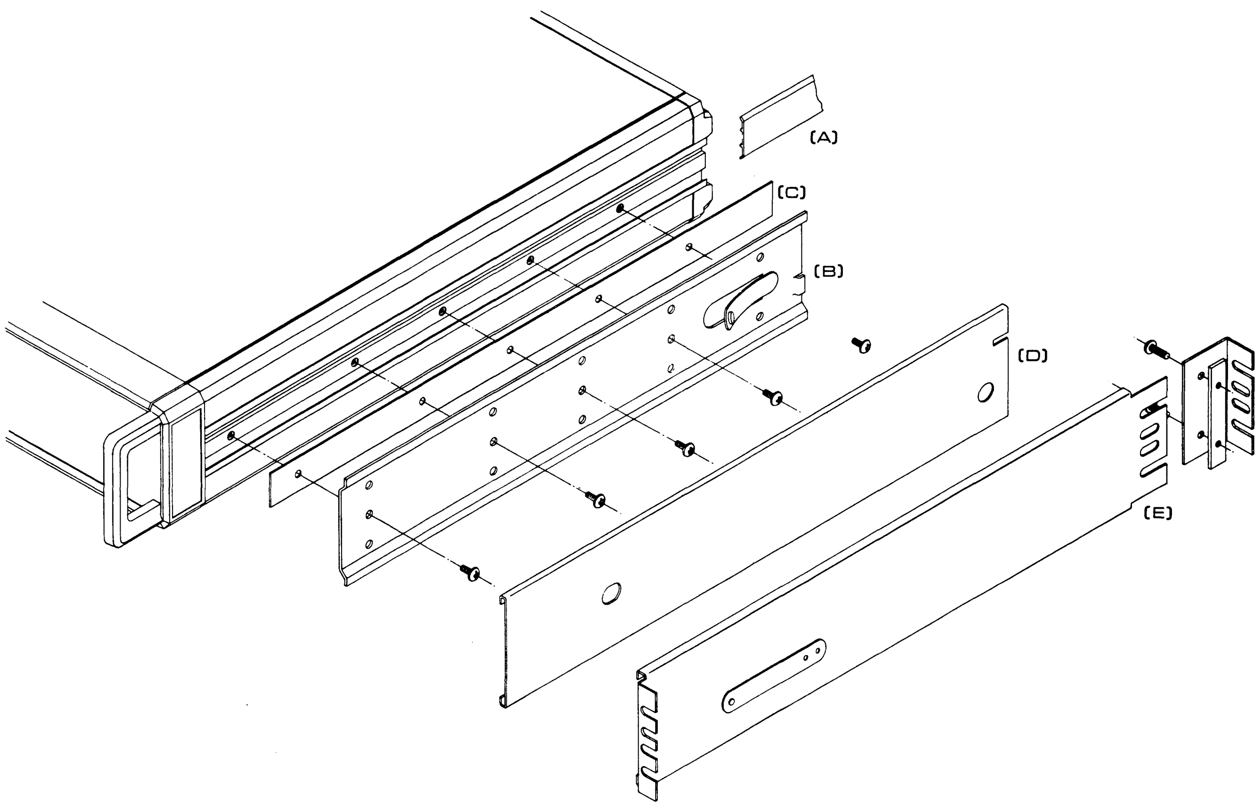
2-REMOVE THE NAMEPLATE DECALS FROM CORNER CASTINGS.

3-REMOVE THE SCREWS FROM CORNER CASTINGS THAT MATCH HOLE PATTERNS IN RACK MOUNTING EARS.

4-ATTACH RACK MOUNTING EARS WITH PAN HEAD SCREWS (ENCLOSED).

Figure 2-22. PROCEDURE FOR ATTACHING RACK EARS TO MODEL 8300A

RACK SLIDE MOUNTING PROCEDURE FOR MEE SERIES INSTRUMENTS



1. REMOVE PLASTIC TRIM STRIP (A) FROM SIDE OF INSTRUMENT BY SLIDING IT TOWARDS THE REAR.

2. ATTACH CHASSIS SECTION (B) OF SLIDE & SPACER STRIP (C) TO INSTRUMENT WITH ENCLOSED SCREWS AS FOLLOWS:

   A - FOR 3 1/2", 7", & 10 1/2" HIGH INSTRUMENTS UTILIZE THE CENTER ROW MTG HOLES.

   B - FOR 5 1/4" & 8 3/4" HIGH INSTRUMENTS UTILIZE EITHER THE UPPER OR LOWER ROW OF MTG AS DESIRED.

3. INSTALL CABINET SECTION (E) & CENTER SECTION (D) OF SLIDE INTO RACK (EXTENSION ANGLE BRACKET & HARDWARE ENCLOSED).

4. EXTEND CENTER SECTION (D) OF SLIDE TOWARDS OPERATOR UNTIL IT LOCKS IN EXTENDED POSITION

5. DEPRESS SPRING LOCK ON CHASSIS SECTION (B) & INSERT INSTRUMENT BETWEEN EXTENDED SLIDE SECTIONS.

Figure 2-23. PROCEDURE FOR ATTACHING RACK SLIDES TO MODEL 8300A

Section 3
Theory of Operation

3-1. INTRODUCTION

3-2. This section describes the theory of operation of the Model 8300A Digital Voltmeter. Only the basic DVM is covered in this section. A brief functional description of the Model 8300A options is presented at the system block diagram level; however, the detailed theory of operation of each option is given in Section VI of the manual. In the general discussion, the functional interaction of circuits and groups of circuits, as depicted in the accompanying simplified drawings, is examined. Component references and signal designations which appear on the simplified diagrams of actual instrument circuits correspond to those on the schematics. The detailed circuit description is keyed to the instrument schematics, which are located at the back of the manual.

3-3. GENERAL

3-4. System Description

3-5. The Model 8300A Digital Voltmeter system consists of the basic instrument and the options, as shown in Figure 3-1. In the basic instrument, the buffer functions as an inverting unity-gain voltage amplifier. Its primary function is to provide an impedance conversion between the signal source which is being measured and the A/D converter input. The A/D converter accepts the buffer output, determines the polarity of the voltage, and converts the voltage into a binary coded decimal (BCD) output. The display circuitry accepts the BCD output of the A/D converter and displays the digits serially in a readout consisting of six neon indicator tubes. Timing and control of all system events

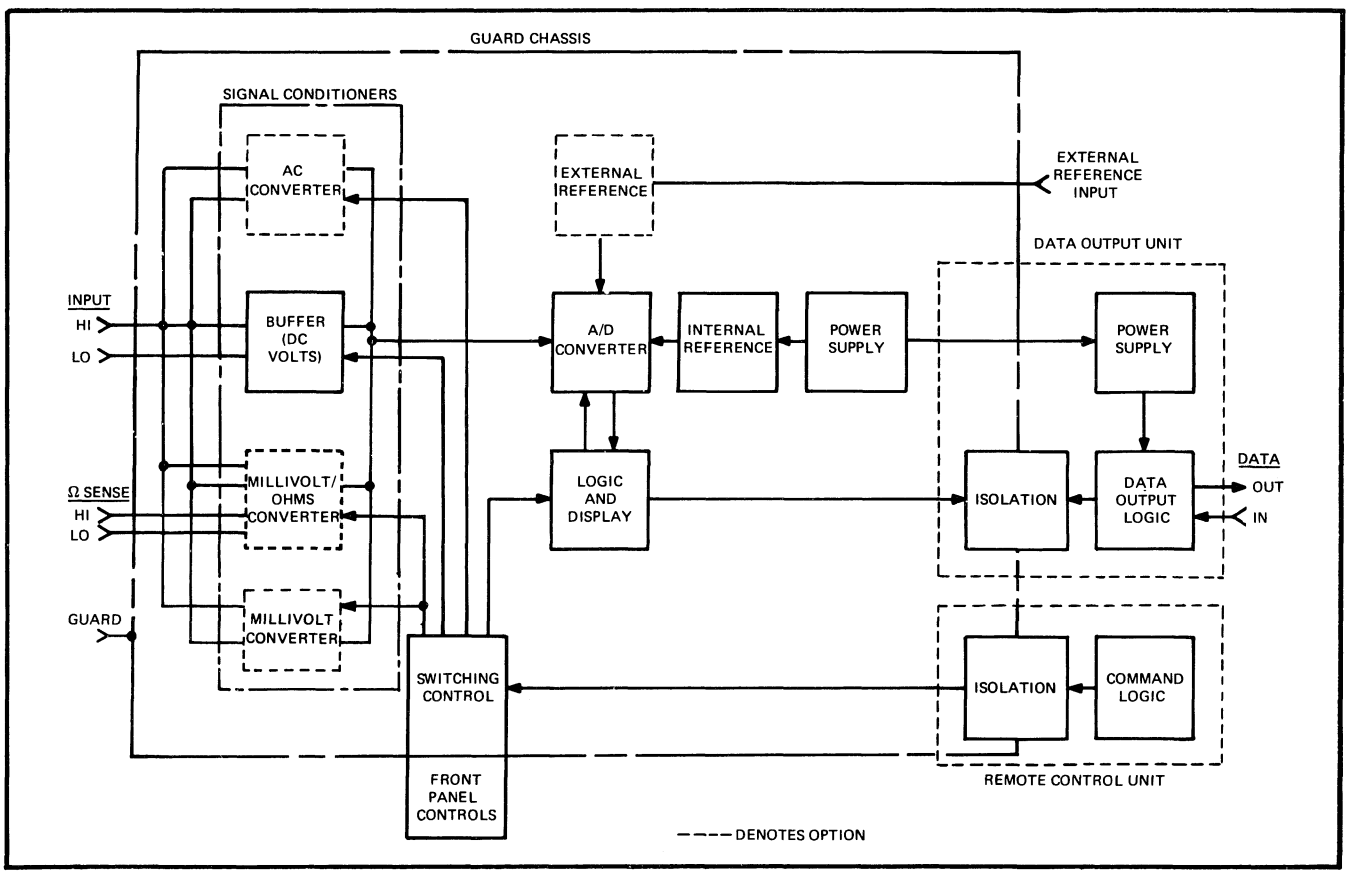


Figure 3-1. MODEL 8300A SYSTEM BLOCK DIAGRAM

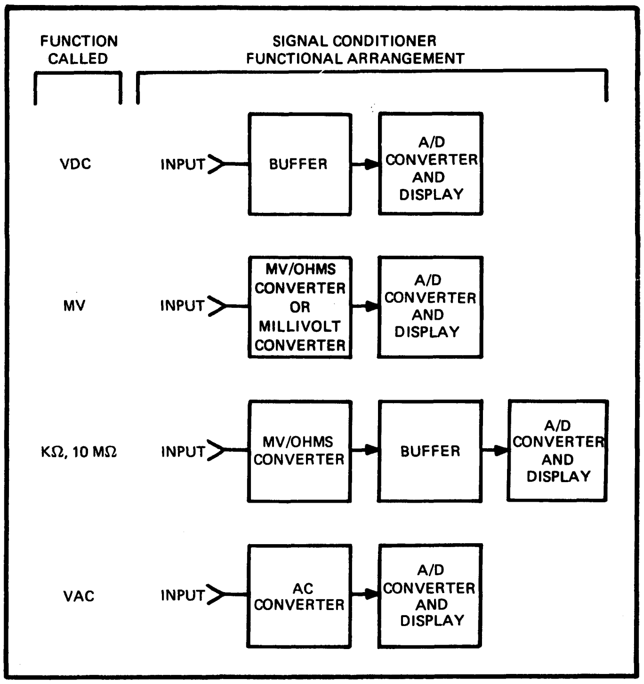


Figure 3-2. SIGNAL CONDITIONER FUNCTIONAL ARRANGEMENT.

is provided by the logic and control circuitry. The power supply produces the system operating voltages including the internal reference.

3-6. The AC Converter converts input ac voltages, in four ranges, to a full-scale voltage of 12 volts dc (including 20% overrange) for measurement by the A/D converter. The Millivolt/Ohms Converter and Millivolt Converter convert input dc voltages in the range of 0 to 1000 millivolts to levels suitable for driving the A/D converter. In ohms mode, the Millivolt/Ohms converter produces an output that is a DC voltage level proportional to the unknown resistance and is of proper level to drive the A/D converter. Figure 3-2 shows the functional arrangement of the buffer, AC Converter, Millivolt/Ohms Converter and Millivolt Converter in each of the DVM operating Modes.

3-7. The Data Output Unit (DOU) enables the instrument to interface with computers, printers, or a variety of data recording systems. DOU outputs include six decades of numerical data in 1-2-4-8 BCD form, a polarity-indicating line, a two-line code for the four instrument ranges, and seven lines to indicate instrument functions: VDC, MVDC, VAC, KΩ, 10 MΩ, FILTER, and EXTERNAL REFERENCE. DOU inputs include individual inhibit lines for each output to permit four-line output multiplexing and a trigger, which commands the DVM to make a measurement. The remote control unit (RCU) enables the instrument to be programmed or controlled remotely. It is isolated from DVM circuits by eleven guarded light channels, which add less than 0.5 picofarad capacitance coupling to measurement circuitry thus maintaining the high CMRR.

3-8. Buffer

3-9. The principle parts of the buffer are a 10 megohm input divider, which scales the dc input voltages to a maximum of ±12 volts full scale; a high gain FET, non-inverting operational amplifier (A1), which operates into a filter network; and a second operational amplifier (A2), which is connected inside of its own feedback loop to provide an inverted gain of about 2.0. The basic buffer diagram is shown in Figure 3-3.

3-10. Assume for explanation purposes that a positive voltage is placed across the input terminals. The voltage will

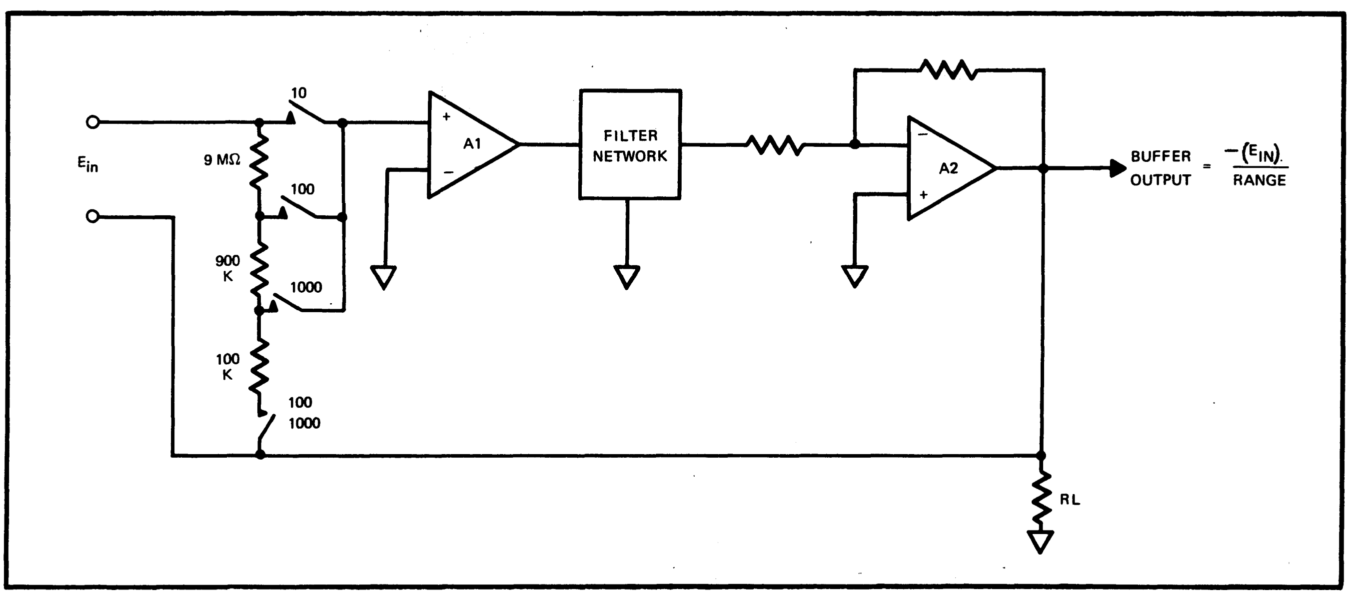
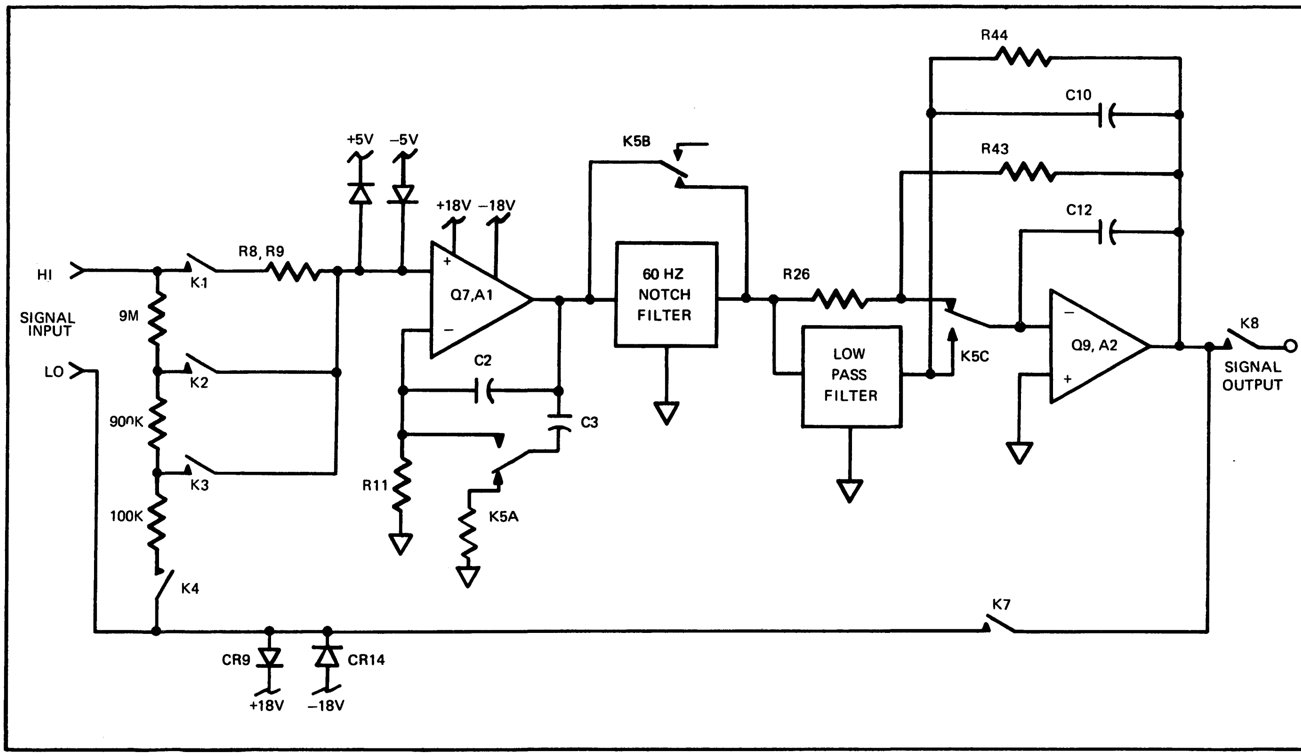


Figure 3-3. BUFFER BASIC DIAGRAM



SWITCH	CLOSURE	SWITCH	CLOSURE
K1	All KΩ Ranges MΩ 10v DC Range	K5	Filter with any KΩ, DC, or MΩ Functions
K2	100v DC Range	K7	All KΩ, and DC Ranges and MΩ
K3	1000v Dc Range	K8	DC MΩ 100 and 1000 KΩ Ranges
K4	AC 100v and 1000v DC Ranges		

Figure 3-4. BUFFER SIMPLIFIED CIRCUIT DIAGRAM

be applied through the appropriate range switch to the input of A1. Since A1 is a high gain operational amplifier, with its inverting terminal grounded, the positive input will produce a large in-phase signal at the amplifier output. When the positive output of A1 is applied through the filter network to the input of A2, A2 will be driven negative. The magnitude of the output of A2 will be determined solely by its input, which is in turn determined by the input to A1.

3-11. In addition to providing impedance buffering, the buffer also contains circuitry which is used to filter the input signal. The simplified diagram in Figure 3-4 shows the addition of the filter and input limiting circuitry to the basic buffer diagram. When the FILTER relay is operated, large capacitors are placed in the feedback paths of both A1 and A2, and a notch filter and low-pass filter are placed in the forward gain path. The feedback capacitors establish a 3 Hz unity-gain bandwidth for the buffer, thereby attenuating high frequency signals before they reach the input of the A/D converter. The notch filter provides 60 Hz filtering and the low-pass filter adds two additional poles, effective at 30 Hz. A graph of signal transfer versus frequency is shown in Figure 3-5. As shown in the graph, the rejection to ac signals having frequencies of 50 Hz and above is greater than 60 db at the instrument input.

3-12. Limiting circuits are provided at the input of A1 so that ±1100 volt inputs will not damage the buffer on the 10 and 100 volt ranges. FILTER, VDC, MVDC, VAC, KΩ, 10 MΩ, and REMOTE switches together with associated

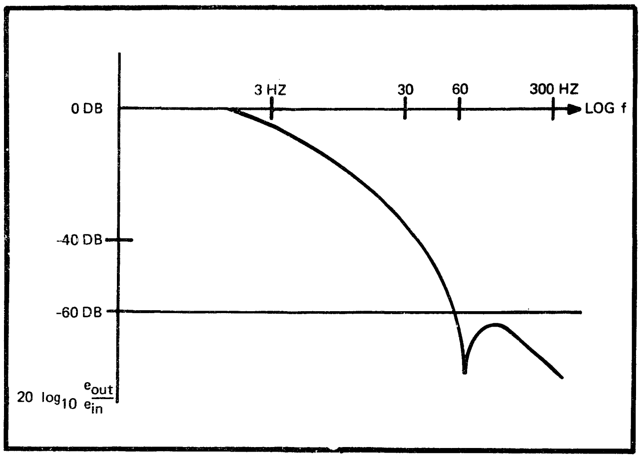


Figure 3-5. FILTER TRANSFER FUNCTION

relays and relay drivers are mounted on the buffer board. These circuits are connected via control lines to the instrument logic and to respective signal conditioners.

3-13. A/D Converter

3-14. The A/D converter employs the unique Recirculating-Remainder (R^2) A/D conversion technique developed by Fluke. A simplified diagram of the basic A/D conversion technique is shown in Figure 3-6. Accompanying the diagram is a chart showing the sequence of operation for an input of −6.3524.

3-15. The A/D converter digitizes the input serially in five 3-millisecond time periods, A through E, with each period divided equally into digitizing and display periods, 1 and 2. At the start of the measurement sequence, period A1, the A/D converter samples the −6.3524 volt input. Then the analog output voltage from the A/D amplifier causes the analog comparator to operate the current controlled oscillator (CCO), whose pulses are counted by the 16 state binary counter. When the total pulse count equals the most significant digit of the input, in this case 6, the CCO stops. The remainder of 3.524 volts is gated through Q125 and held in the sample and hold capacitor, C108. The display circuitry decodes the counter output and displays the "6" in period A2. At the beginning of period B, the 6.3524 volt input is disconnected from the input of the A/D converter and the 3.524 recirculated remainder voltage stored on the sample and hold capacitor (C108) is gated through Q124 and applied to the A/D Amp. Successively, the remainders of 5.24, 2.4, and 4 volts are digitized and displayed in the same manner. Although the five digits are digitized and displayed one at a time, the process proceeds at a sufficiently high rate of speed so that the display appears continuous to the eye.

3-16. The input voltage is sampled at a rate determined by the setting of the SAMPLE RATE control. The sample rate range is from 1 sample every 100 milliseconds to one sample every 3 seconds. Since it only requires 18 milliseconds to digitize the input, a display storage circuit is provided, which stores voltages representing each of the five digits on each of five capacitors. This stored information supplies the A/D converter input during the remaining digitize/display periods, until the DVM is ready to sample the input voltage again. The period when the actual input is sampled and digitized is known as the measurement cycle and the period when the A/D converter reads out of storage is known as the storage cycle.

3-17. The A/D converter has two basic operating modes. It is connected as an operational amplifier during the first period of the measurement cycle and it is connected as a voltage follower during the remaining four periods of the measurement cycle. The simplified diagram of Figure 3-7 (A) shows the circuit arrangement for measurement of the first digit (6) of a −6.3524 volt input. The amplifier is satisfied by two feedback loops. The loop consisting of the CCO, counter, and ladder is activated whenever the amplifier output exceeds V_{REF}, while the remainder resistor feedback loop satisfies the amplifier for all amplifier outputs less than V_{REF}. The sum of the two feedback currents and the input current flowing into the summing junction at the amplifier input result in amplifier balance. After a short interval, during which time the amplifier is allowed to settle, the "6" is displayed and the amplified remainder is applied to the sample and hold circuit. The A/D converter circuit arrangement for measurement of second, third, fourth, and fifth digits is shown in Figure 3-7 (B). The 3.524 volt remainder is applied to the input of the amplifier, now connected as a voltage follower, and is digitized and displayed as the new input signal. Succeeding remainders are applied, in turn, through the sample and hold circuit to the amplifier input, until the entire −6.3524 volt input has been digitized and displayed.

3-18. The A/D converter together with associated circuitry is shown in more detail in the simplified diagram of Figure 3-8. The inverting amplifier is an inverting operational amplifier consisting of input resistor R102, amplifier Q101, A101 and feedback network CR101, CR102, and R103. The output of A1 drives the polarity detector, which operates the positive and negative (plus and minus) gates. The inverting amplifier together with the polarity detector ensure that the A/D amplifier is always presented with a negative input. For example, a negative instrument input would appear at the A/D input as a positive voltage (because of inversion in the buffer). The positive input

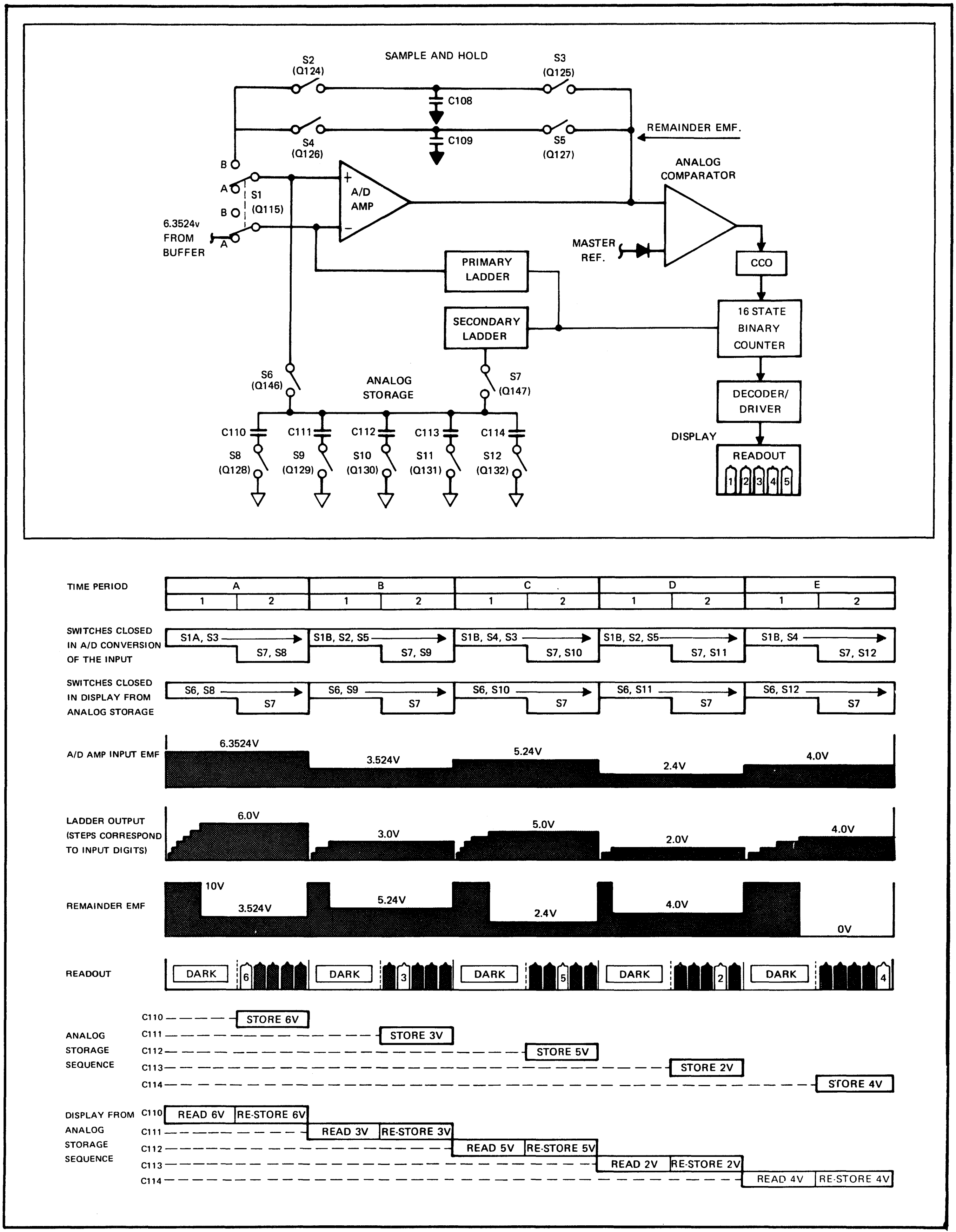


Figure 3-6. RECIRCULATING REMAINDER A/D CONVERSION

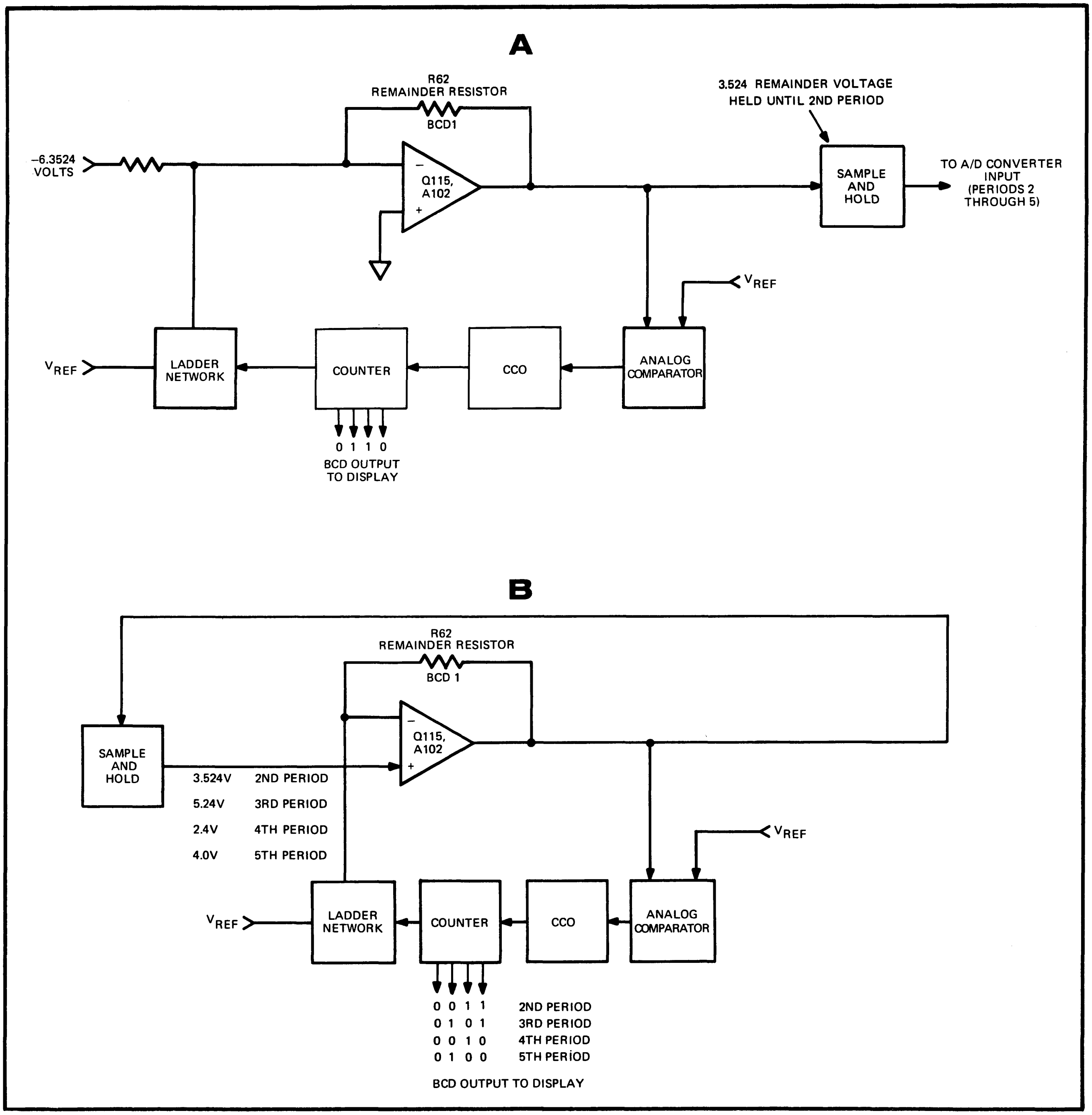


Figure 3-7. A/D CONVERTER CIRCUIT ARRANGEMENT FOR DIGITIZING AND DISPLAYING (A) FIRST DIGIT AND (B) SECOND THROUGH FIFTH DIGITS

would be inverted in the inverting amplifier and the polarity detector would turn on the minus gate. If the instrument input were positive, the inverting amplifier would produce a positive output and the polarity detector would turn on the plus gate. During the periods when the A/D amplifier input is supplied by the sample and hold circuit, the plus and minus gates are turned off by a logic signal applied to the polarity detector. Switch Q114 is also turned off by a logic signal, thereby enabling the output of the sample and hold circuit to be applied to the A/D amplifier. The half-digit bias circuit adds the voltage equivalent of a half digit to the charge stored on each display storage capacitor. This ensures proper display storage readout by compensating for the effects of voltage decay in the storage circuit.

3-19. In addition to the five periods required for digitizing and displaying the input signal, a sixth period, known as the zero period, is set aside for removal of the zero offset of the A/D amplifier. During the zeroing period, switch Q118 is turned on which connects the output of A102 to the zero holding capacitor C115; at the same time, the amplifier input is grounded. This operation places the offset of A102 across C115 and effectively removes it for the balance of the measurement cycle. The same zeroing operation is also performed on the inverting amplifier and occurs during a period in the measurement cycle when the amplifier is not being used. The complete sequence of operations for both measurement and storage cycles is shown in Figures 3-9 and 3-10. The various circuit arrangements of the A/D converter are summarized in Figure 3-11, which shows the simplified circuit for each operating mode in both measurement and storage cycles.

3-20. Logic and Control

3-21. The DVM logic and control block diagram is shown in Figure 3-12. The 333 Hz master clock is the master timing reference for the DVM and is used throughout the logic and control circuitry. The six-state shift register, which is driven from the master clock, produces signals which establish the five digitize/display periods and the zero period of the A/D converter. The analog cycle control circuitry uses signals from the shift register and cycle-change circuitry to derive A/D control signals. The display section includes circuitry which controls the nine function/status indicators and the readout decimals, including two memory circuits which provide control of

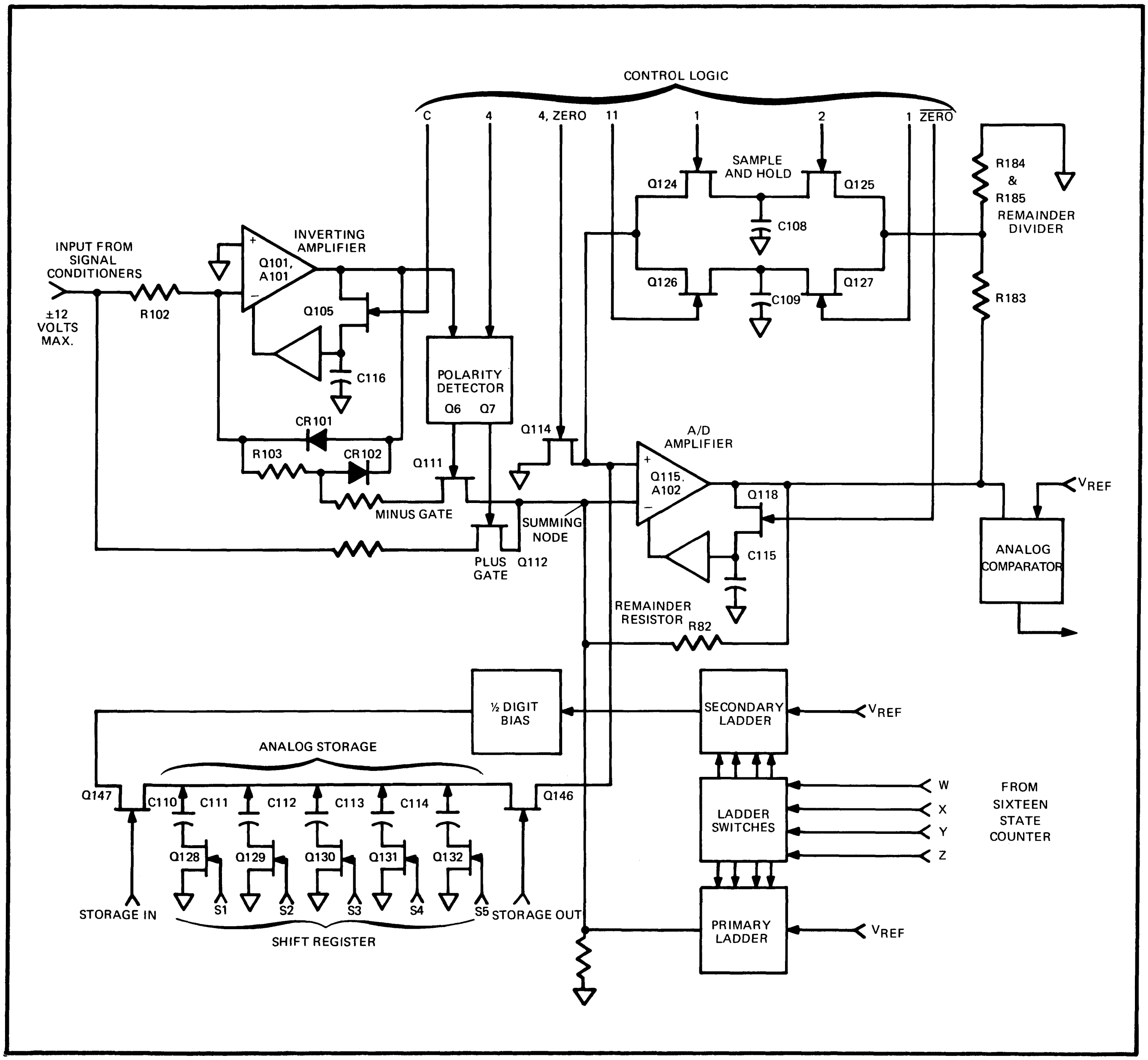


Figure 3-8. A/D CONVERTER SIMPLIFIED CIRCUIT DIAGRAM

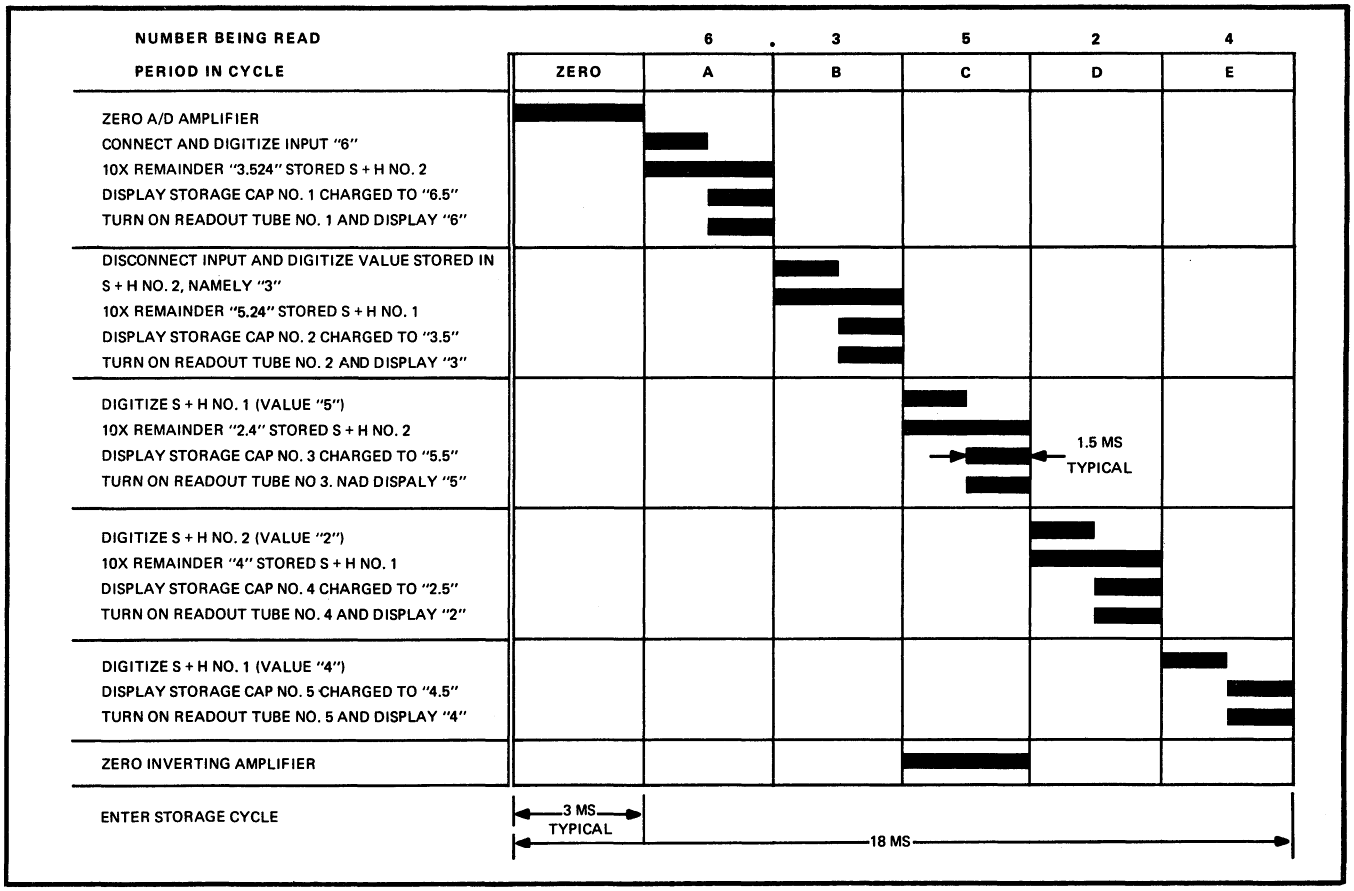


Figure 3-9. EVENT SEQUENCE – MEASUREMENT CYCLE

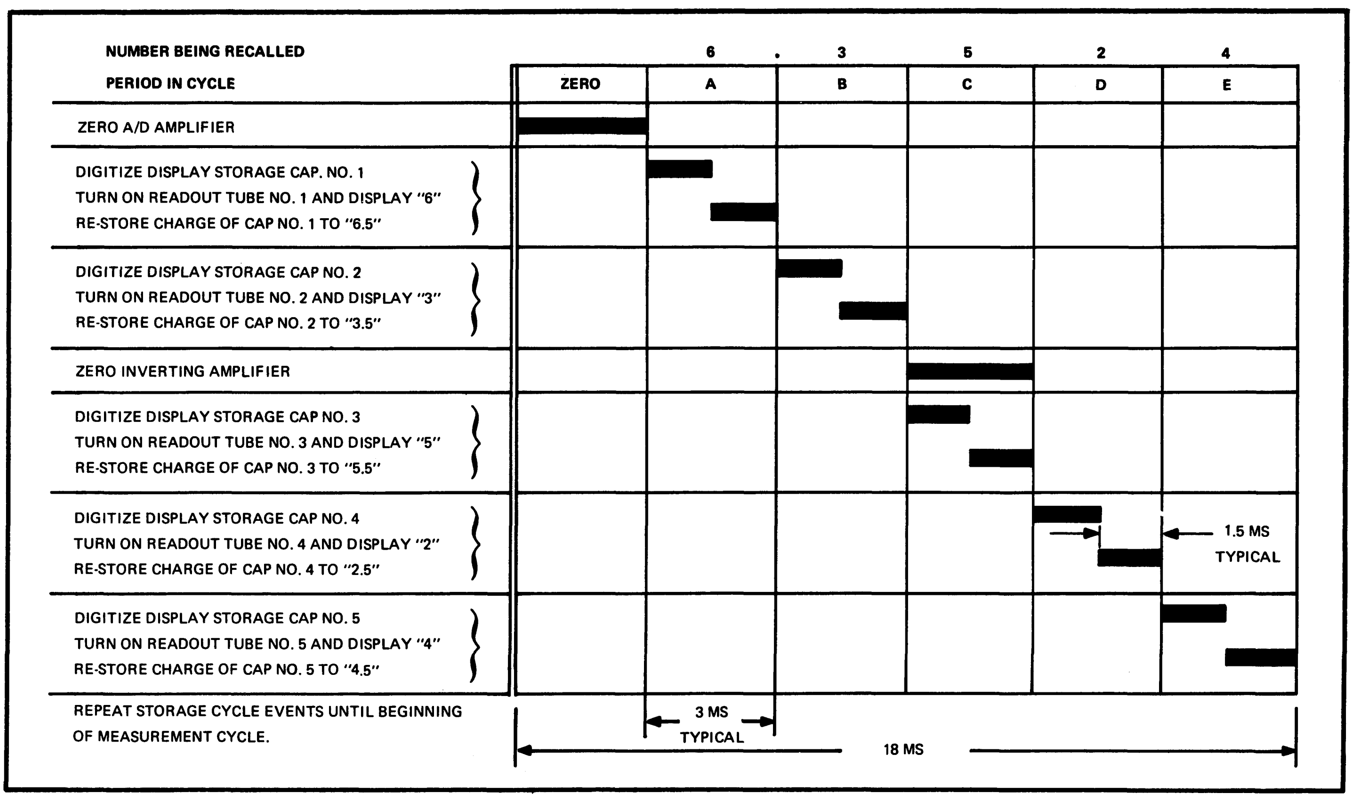


Figure 3-10. EVENT SEQUENCE – STORAGE CYCLE

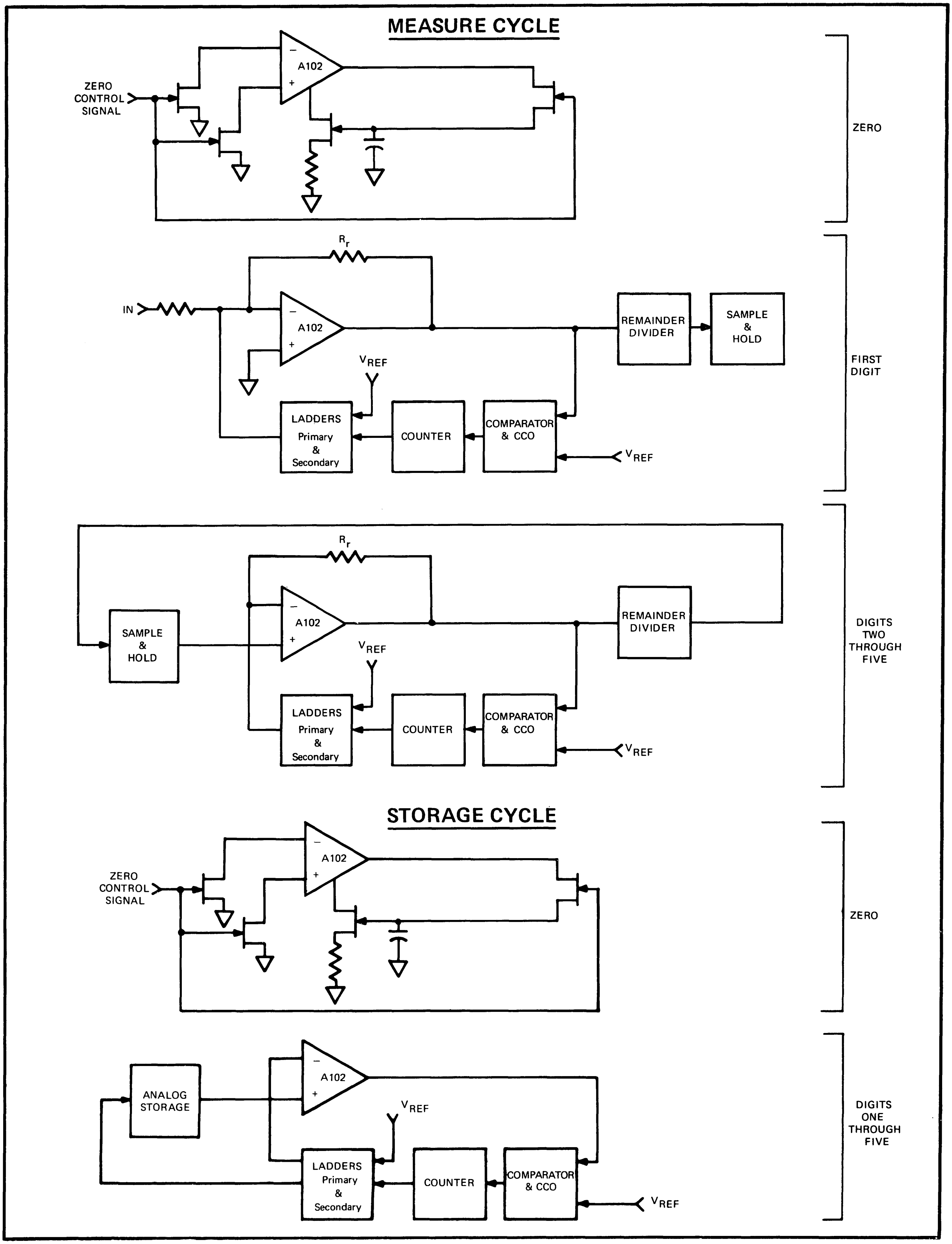


Figure 3-11. SIMPLIFIED A/D CONVERTER CIRCUIT ARRANGEMENT FOR EACH OPERATING MODE.

polarity and overload indicators. The 16-state binary counter is driven by the CCO. Counter outputs are applied to the ladder switches in the A/D converter and to the decoder/driver, which outputs to five of the six readout tubes. Counter inputs include those from two catcher circuits. The 12's catcher stops the counter unconditionally whenever its count reaches twelve. The conditional 11's catcher stops the counter when its count reaches eleven if the instrument is in 10 MΩ mode, if it is on the highest range, or if it is not autoranging. The manual and autorange circuitry accept the manual and remote range signals and provide control of all instrument ranging. The cycle change circuitry establishes the measure and storage cycles. The timing diagram for the measure portion of the measure/store cycle of the DVM is shown in Figure 3-13.

3-22. Power Supply

3-23. Operating voltages for the Model 8300A are produced by a series of regulated supplies as shown in Figure 3-14. The +18 volt and −18 volt regulator outputs are used throughout the instrument as operating voltages. The +190 volt regulator output is used to power the readout tubes. The +5 volt regulator output is used to power the DVM logic. The +7 volt regulator output is the master voltage reference for the instrument. The disable input turns the +7 volt regulator off when the External Reference function is called. The 7 volt rms output is used to power the +5 volt logic supply, which is located in the Data Output Unit. This regulator supplies power to the DOU logic and the RCU logic, if desired.

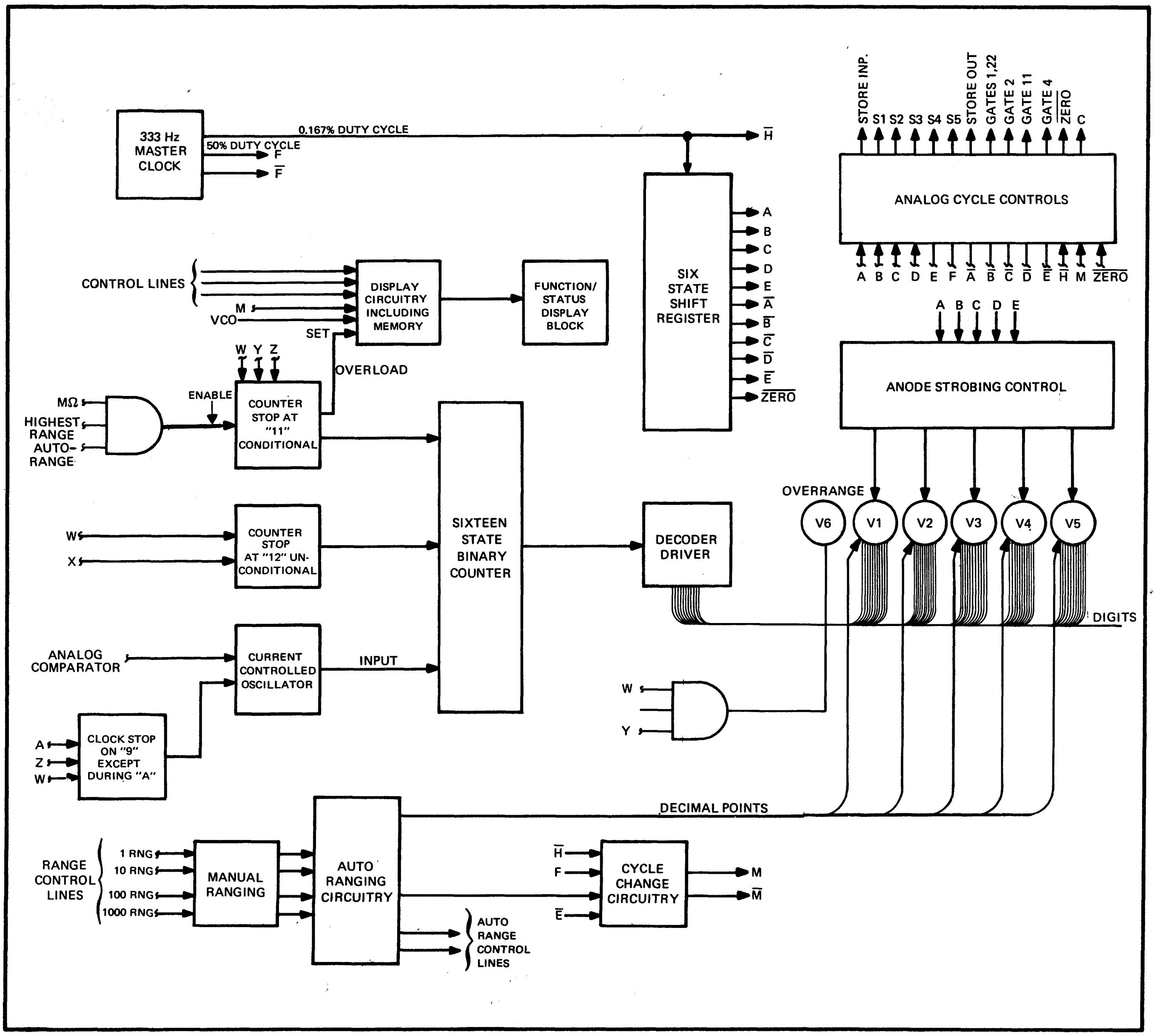


Figure 3-12. DVM LOGIC AND CONTROL BLOCK DIAGRAM

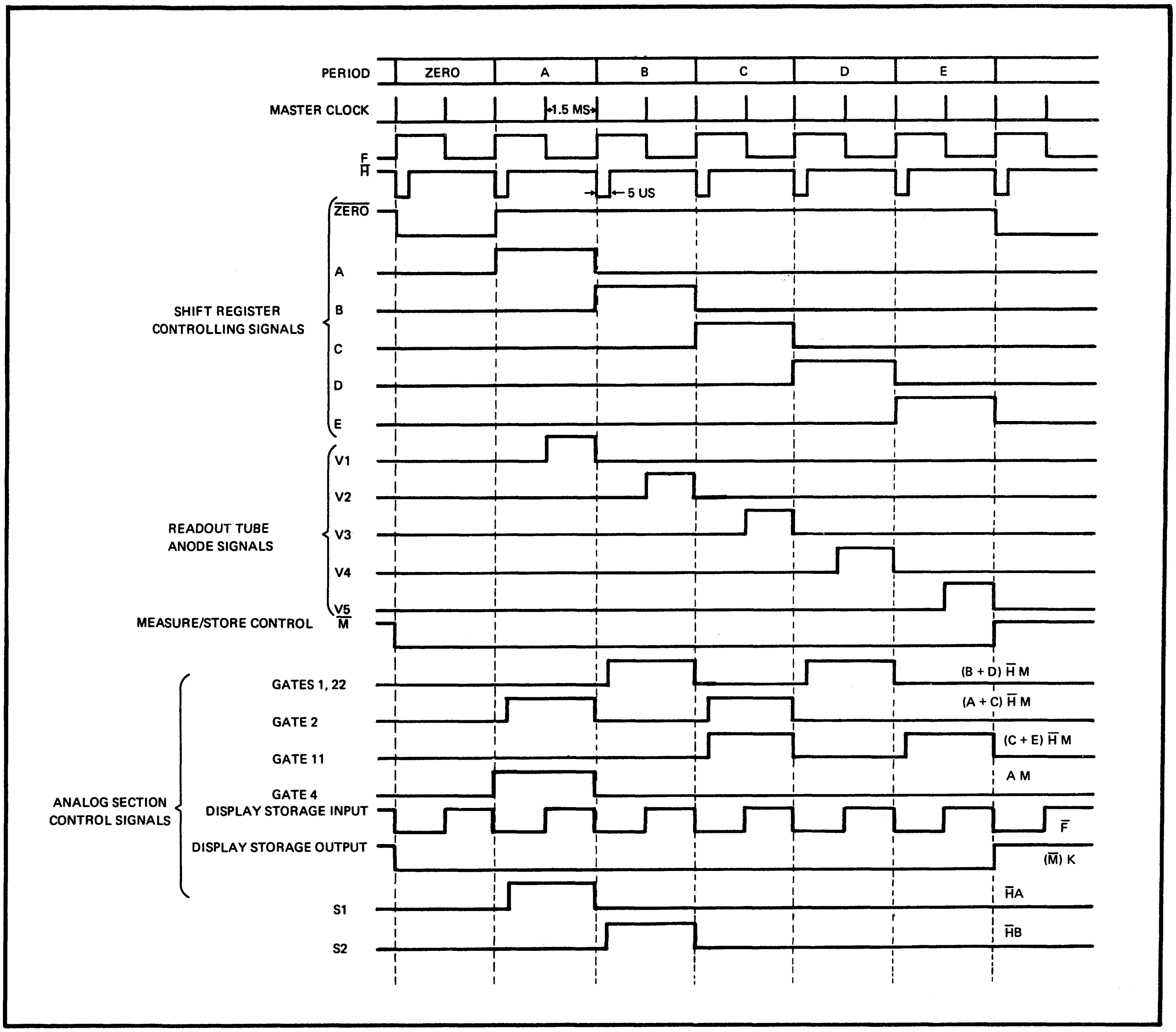


Figure 3-13. MEASUREMENT CYCLE TIME RELATIONS

3-24. CIRCUIT DESCRIPTION

3-25. Buffer

3-26. INPUT RANGE DIVIDER. The input binding posts are connected across a three-position, 10-megohm range divider consisting of resistors R1 through R7 and resistor R54. The 100 volt and 1000 volt ranges are adjusted by potentiometers R4 and R6 respectively. Depending on the range selected, the divider scales the input voltage down by a ratio of 10, 100, or 1000 so that the divider output will always be 10 volts full scale or 12 volts including 20% overrange. The input resistance is 10 megohms on the 100 and 1000 volt ranges, but the contacts of relay K4 are open on the 10 volt range and the input resistance is limited only by the leakage resistance at the input terminals. The overload protection network, consisting of transistors Q5 and Q6 and diodes CR7 and CR8, limits the voltage at the input of Q7 so that overvoltage will not damage the instrument.

3-27. AMPLIFIER/FILTER. The input amplifier consists of transistor Q7, a low-noise, low-drift FET pair operating in common-source configuration. Potentiometer R47 is the zero adjustment control, which, in conjunction with resistors R13, R14, and R55 is used to reduce the initial offset of Q7 to zero. The output of Q7 drives A1, a high-gain, monolithic operational amplifier. The filter network consists of capacitors C2 and C3 and resistors R11 and R19, which provide feedback around A1; the notch filter; the low-pass filter; and capacitors C10 and C12 and resistors R43 and R44, which provide feedback around A2.

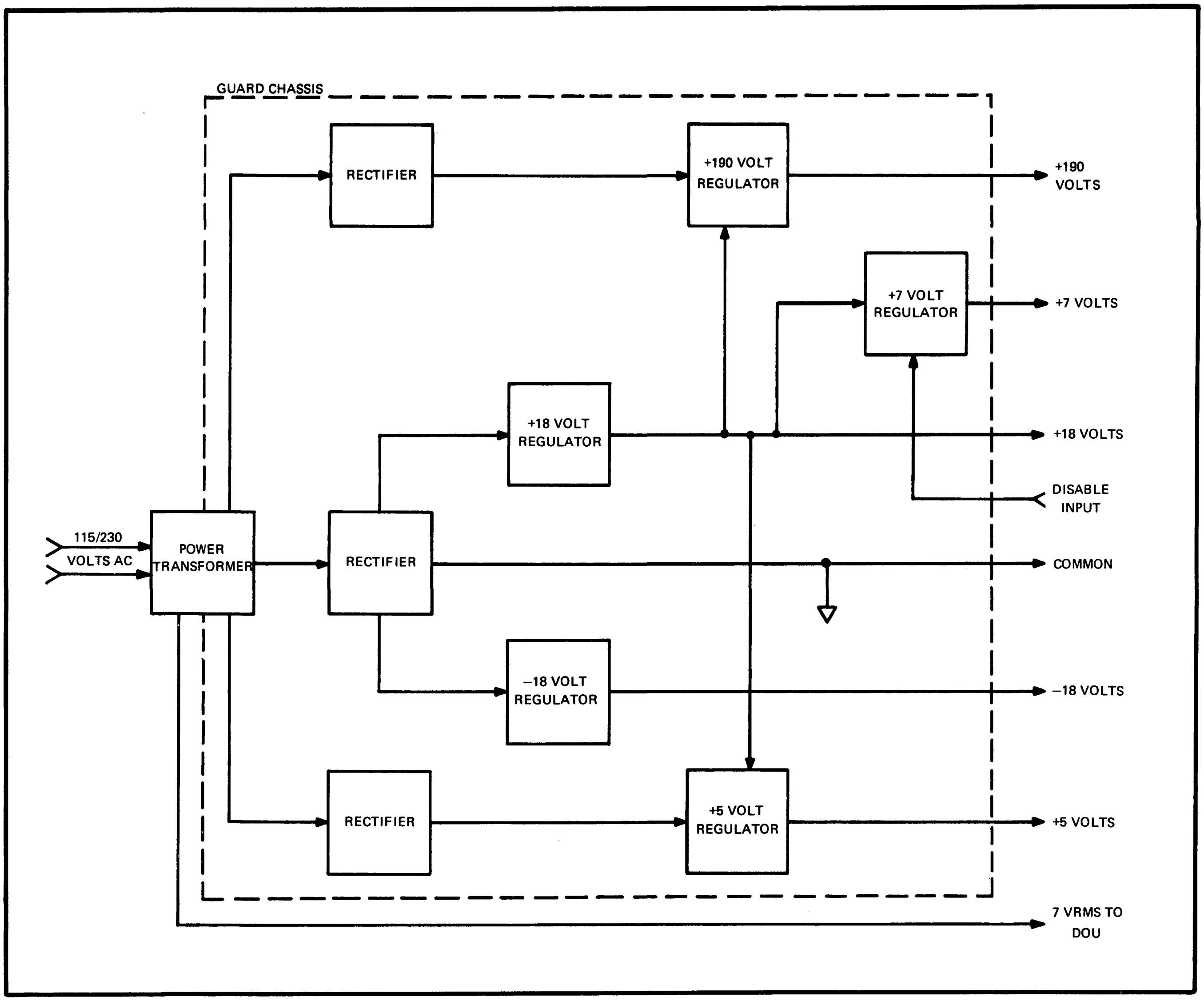


Figure 3-14. POWER SUPPLY BLOCK DIAGRAM

The purpose of transistor Q8 is to provide an impedance transformation between the notch filter and the low-pass filter. The final amplifier stage consists of differential FET pair Q9 and operational amplifier A2.

3-28. SWITCHING. Switch block S1 includes all of the front panel function switches except EXT REF. The REMOTE (FUNCTION) switch controls the function remote/local bus. In the local mode, +5 volts dc is available at each of the seven function switches. The switch outputs are applied to control lines which are connected to function control and display circuitry in the logic section. The range relays are controlled by the range flip flops in conjunction with the manual and autorange circuitry, which is located in the logic section. The filter function is called by the FILTER switch, which is enabled by transistor Q10 if the VDC, KΩ, or 10 MΩ functions are called. Figure 3-15 shows the control switching arrangement for the DVM.

3-29. A/D Converter

3-30. INVERTING AMPLIFIER. The inverting amplifier consists of input switch Q103, dual FET input amplifier Q101, operational amplifier A101, and associated circuitry. Once every 18 milliseconds, during the zero period for the inverting amplifier (period C of the measurement cycle), switch Q105 is switched on by the autozero drive circuit, which consists of amplifiers Q108 and Q109. The automatic zero circuit consists of transistors Q104 and Q105 and capacitor C116. The drive circuit also supplies a turn-off signal to transistor Q103, thereby removing the input to the inverting amplifier during the zero period.

3-31. POLARITY DETECTOR. The polarity detector consists of flip flop Q106, Q107 and associated circuitry. The flip flop employs base triggering, which is applied through diode CR110 to the base of Q106. The gate signal

(Gate 4), which is applied to the emitters of Q106 and Q107, enables the detector only during period A of the measurement cycle. During the remainder of the measure/store cycle, the plus and minus gates are turned off and the polarity information is retained by the display circuitry so that a continuous polarity indication is provided.

3-32. A/D AMPLIFIER. The A/D amplifier consists of dual FET Q115, operational amplifier A102, and associated components. The automatic zero circuit is comprised of transistors Q117 and Q118 and capacitor C115. Switch Q118 is turned on during the zero period of the measurement cycle by a signal from the autozero circuit, consisting of amplifier Q110. Transistor Q110 also controls switches Q113 and Q114, which are turned on during the zero period, and switch Q120, which is turned off during the zero period to disconnect the amplifier output from the ladder. Transistor Q119 and resistor R180 constitute a clamp, which prevents amplifier A102 from saturating while the output of A102 is above 7 volts.

3-33. ANALOG COMPARATOR. The analog comparator, consisting of transistors Q116, Q121, Q122, Q123 and associated components, is basically a voltage comparator. Differential amplifier stage Q121 compares the A/D amplifier output with the +7 volt reference, and differential stage Q122, Q123 outputs to the CCO. Transistor Q116 operates as a second comparator, which responds quickly to high voltage levels, thereby allowing maximum time for resolution of the least significant digit.

3-34. SAMPLE AND HOLD. The sample and hold circuit consists of transistors Q124 through Q127 and capacitors C108 and C109. The sequence of operation for the sample and hold circuit is shown in Figure 3-16.

3-35. LADDER. The output of the 16-state binary counter is applied to the ladder switches and their drivers, transistors Q133 through Q144. The output of the ladder switches is applied to two ladders. Each ladder comprises a 4-bit, weighted-resistor, digital-to-analog converter. The primary ladder consists of resistors R133 through R139 and produces an output that corresponds to the actual value of the digital input. The secondary ladder, which drives only the display storage circuit, consists of resistors R127 through R132 and produces an output that approximates the actual value of the digital input. The half-digit bias is produced by R131 and R132 in conjunction with the secondary ladder resistors and adds the voltage equivalent of a half-digit to the output of the secondary ladder. This ensures proper display storage readout by compensating for the effects of voltage decay in the storage circuit.

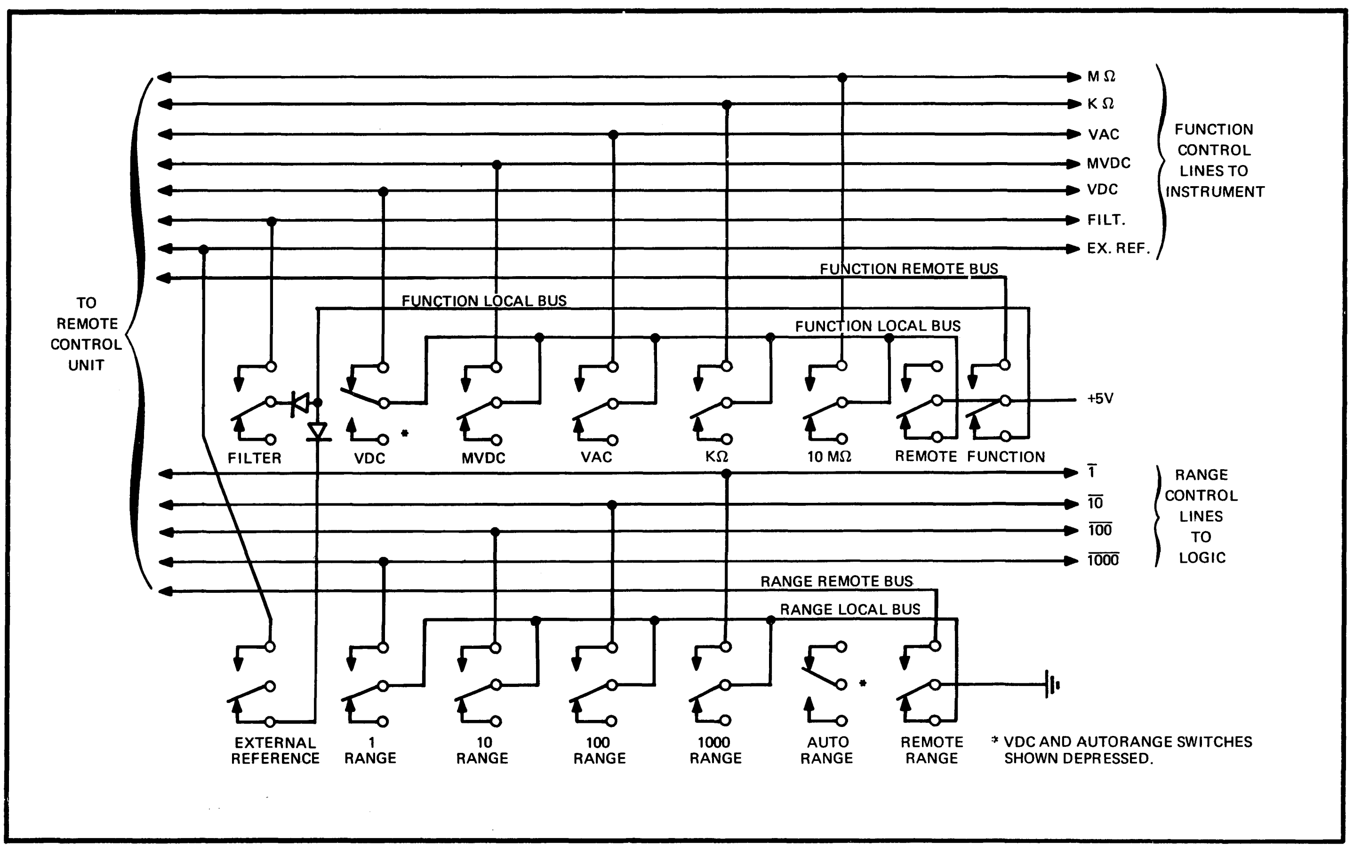


Figure 3-15. CONTROL SWITCHING CIRCUIT DIAGRAM

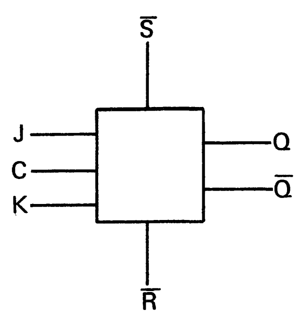
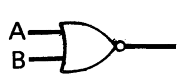
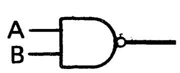
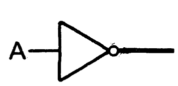
PERIOD IN CYCLE	SWITCH CONDITION	
	MEASUREMENT CYCLE	STORAGE CYCLE
A	Q125 ON	Q124 through
B	Q124, Q127 ON	Q127 OFF
C	Q125, Q126 ON	
D	Q124, Q127 ON	
E	Q126 ON	

Figure 3-16. SAMPLE AND HOLD OPERATING SEQUENCE

3-36. DISPLAY STORAGE. The storage circuit consists of FET switches Q128 through Q132, FET switches Q146 and Q147, and capacitors C110 through C114. The output of the secondary ladder is supplied to the appropriate storage capacitor through Q147, which is switched on during display time. The first (most significant) digit is stored in C110, second in C111, third in C112, fourth in C113, and the fifth in C114. When the cycle change circuitry switches to storage mode, Q146 is switched on and the analog voltages stored in the capacitors are applied, serially, to the input of Q115.

3-37. Logic and Control

3-38. LOGIC NOTATION. A description of the logic symbology used in the Model 8300A is given in Figure 3-17. A J-K flip flop that is in the "1" condition or is set "high" has a "high" output from the "Q" terminal. The orientation of the flip flops in the schematics is the same as the flip flop shown in Figure 3-17. This method of notation enables input/output terminals of the flip flops to be identified without the necessity of redundant lettering of each device symbol. In the main, the routing of logic and control signals on the schematics is accomplished without connecting lines, which greatly reduces congestion. The origin of the signals may be determined by locating the device or circuit whose circuit reference symbol bears the same nomenclature, e.g., origin of the $\overline{Y}$ signal would be flip flop "6Y" of the sixteen state binary counter and, specifically, the $\overline{Q}$ output of that flip flop.

LOGIC SYMBOL	NAME	DESCRIPTION
	J-K Flip Flop	Operation of the J-K flip flop is shown by the following truth tables. Note that "S" and "R" inputs are dominant over "J" and "K" inputs.
	NOR Gate	The following table shows gate and inverter operation. Although only two-input gates are shown, operation is identical for gates having additional inputs.
	NAND Gate	
	Inverter	

SYNCHRONOUS INPUTS

J	K	Q_{n+1}
0	0	Q_n
0	1	0
1	0	1
1	1	$\overline{Q}_n$

ASYNCHRONOUS INPUTS

$\overline{S}$	$\overline{R}$	Q	$\overline{Q}$
0	0	Undefined	
0	1	1	0 Set
1	0	0	1 Reset
1	1	Normal Condition	

A	B	NOR	NAND	INVERTER
0	0	1	1	1
0	1	0	1	1
1	0	0	1	0
1	1	0	0	0

Figure 3-17. EXPLANATION OF LOGIC SYMBOLOGY

3-39. MASTER CLOCK. The 333 Hz clock signal is produced by transistor Q45. The clock frequency is determined by the RC time constant of resistor R1 and capacitor C1. The output of Q45 is applied to the trigger input of flip flop 3F. The F output of 3F is inverted in Q1 and becomes the $\overline{H}$ signal. The F, $\overline{F}$, and $\overline{H}$ signals are used by the logic to generate control signals.

3-40. SIX-STATE SHIFT REGISTER. The shift register consists of J-K flip flops 1A, 1B, 2C, 2D, and 3E. Error-correction gate 4B controls the input to flip flop 1A to ensure proper operation of the shift register. At the beginning of the measurement cycle, the shift register is reset by the $\overline{M}$ signal, which is differentiated by capacitor C2 and resistor R70 and applied to the reset input of each flip flop. When reset, each flip flop is in the "0" condition, the "J" input of flip flop 1A is high, and the "K" input of flip flop 1A is low. Resetting the shift register initiates the zero period of the A/D amplifier, as shown in the timing diagram of Figure 3-13, and provides a ZERO control signal at pin 8 of gate 4B. The zero period is terminated by the $\overline{H}$ clock pulse, which sets flip flop 1A high and reverses its input. Subsequent clock pulses set the flip flop outputs as shown in Figure 3-18.

3-41. SIXTEEN-STATE BINARY COUNTER. The sixteen-state binary counter consists of J-K flip flops 6Z, 6Y, 7X, and 7W. The counter is set to zero at the beginning of each period in the measurement cycle by the $\overline{H}$ clock pulse. During each period of the measurement cycle, the output of the CCO, which is applied to the clock input of flip flop 6Z, is counted. The truth table for the flip flops in the binary counter is shown in Figure 3-19.

3-42. 11'S AND 12'S CATCHER. The conditional 11's catcher and 12's catcher control the "J" and "K" inputs to flip flop 6Z. The 12's catcher stops the counter unconditionally when it reaches a count of 12. It also enables circuitry which activates the OVERload indicator. The 12's catcher circuit consists of NAND gate 15C and diode CR4. When the count in the binary counter reaches 12, gate 15C will be enabled and the counter input will be clamped at zero volts dc. Activation of the 12's catcher circuit will also enable switch Q44, and the next pulse from the CCO will turn on transistor Q46, which will activate the OVERload lamp. Q46 will remain on until the beginning of the next measurement cycle, at which time it will be turned off by the M signal, which is applied to its cathode. The 11's catcher consists of NOR gates 8A and 8B and NAND gate 19C. The $\overline{W}$, $\overline{Y}$, and $\overline{Z}$ counter outputs are NORed in gate 8A with the output of gate 8B. If the count reaches 11, the $\overline{W}$, $\overline{Y}$, and $\overline{Z}$ inputs will be low; if, at the same time gate 8B is enabled, gate 8A will be inhibited, which will enable gate 19C and the counter will be stopped.

PERIOD	SHIFT REGISTER FLIP FLOP OUTPUT STATES				
	1A	1B	2C	2D	3E
ZERO	0	0	0	0	0
A	1	0	0	0	0
B	0	1	0	0	0
C	0	0	1	0	0
D	0	0	0	1	0
E	0	0	0	0	1

Figure 3-18. SHIFT REGISTER OUTPUTS

3-43. CURRENT CONTROLLED OSCILLATOR. The CCO consists of multivibrator Q2, Q3. The CCO has no output until it is supplied current by the analog comparator. The pulse repetition rate of the CCO is proportional to the magnitude of the driving current. The greater the current flowing into the base of Q3, the greater the number of pulses produced by the CCO per unit time. The CCO out-

CCO PULSE COUNT	SIXTEEN–STATE BINARY COUNTER			
	6Z	6Y	7X	7W
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1
10	0	1	0	1
11	1	1	0	1
12	0	0	1	1

Figure 3-19. SIXTEEN-STATE BINARY COUNTER TRUTH TABLE

NOR GATES	VAC AND KΩ				VDC			MVDC		MΩ
	RANGE									
	1	10	100	1000	10	100	1000	100	1000	10
12B	1	0	0	0	0	0	0	0	0	0
10D	0	1	0	0	1	0	0	0	0	0
10B	0	0	1	0	0	1	0	1	0	0
10C	0	0	0	1	0	0	1	0	1	0

Figure 3-20. RANGE GATE TRUTH TABLE.

put is applied to the clock input of the 16-state binary counter. The 9's catcher, gate 9C, disables the CCO at a count of nine, if the DVM is digitizing the second through the fifth digits (periods B through E). The purpose of transistor Q4 is to disable the CCO during display time to prevent changing the count during the display period.

3-44. MANUAL RANGE LOGIC. The manual range logic processes the range commands and overrides the auto-range function whenever a range is selected manually. The four range commands and the VDC, MVDC, and 10 MΩ function commands are NORed in gates 12B, 10D, 10B, and 10C. The gates are inhibited if the corresponding range is called, provided that the associated function agrees with the selected range. The operation of the four gates is shown in the truth table of Figure 3-20. The output of these gates is NORed in gates 11A, 10A, 12A and 11C to provide set and reset pulses to the range flip flops 18a and 18b. The truth table for the range flip flops is shown below:

RANGE	FLIP FLOP	
	a	b
1	0	0
10	0	1
100	1	0
1000	1	1

3-45. Assume, for example, that the VAC function and the 1 volt range are called. Gate 12B will be inhibited, which will enable gates 11A and 10A. The low output of these gates will be applied to the reset input of flip flops 18a and 18b, thereby setting them to the "0" condition (range 1). In similar manner, each range command enables these gates in such combination as to lock the range flip flops in the desired condition. Calling the MVDC function enables gates 12B and 12C so that only 100 and 1000 ranges may be called. Likewise, calling the 10 MΩ function enables gates 12B, 10B, and 10D so that only the 10 range is enabled; at the same time, calling the 10 MΩ function enables gate 11A and 12A, which sets flip flop 18a to the "0" condition and flip flop 18b to the "1" condition. In this way, the 10 range is automatically called whenever the 10 MΩ function is called.

3-46. NOR gate 8B is the enabling gate for the conditional 11's catcher. It will be enabled if the 1, 10, or 100 ranges are called or if the 10 MΩ function is called. If the 1000 range is called, NOR gate 16B will be inhibited, which will also enable gate 8B. NOR gates 11B and 13A constitute an interlock to prevent calling the 1 range in VDC function. Calling VDC function and range 1 enables gate 12A, which sets flip flop 18b, thereby locking the DVM out of range 1.

3-47. AUTORANGE LOGIC. The range flip flops 18a and 18b are controlled by uprange and downrange gates together with a ranging pulse circuit. Up-signal (UP) detection is accomplished by NAND gate 15C and down-signal (DN) detection is accomplished by NAND gate 4A. When the binary counter reaches a count of 12, gate 15C is enabled and will produce a low at pin 11 of gate 13C. At the same time, gate 13D will be enabled by a high from the downrange detector, gate 4A. The other input to gates 13D and 13C is supplied by flip flop 18b. If flip flop 18b is in the "0" condition, gates 13D and 13C will produce a low at both "J" and "K" inputs of flip flop 18a. Thus when the ranging pulse is applied to flip flops 18a and 18b, flip flop 18a will remain in its previous state and flip flop 18b will toggle. If flip flop 18b is in the "1" condition, gates 13D and 13C will produce a low and a high, respectively, at the "J" and "K" inputs of flip flop 18a. The ranging pulse will then cause both flip flops 18a and 18b to toggle.

3-48. The ranging pulse is developed by gates 19A, 19B, and 16A in conjunction with the 230 milliseconds delay circuitry. The UP and DN signals are NANDed in gate 19A to produce a high output from 19A if either an UP or DN signal is generated or a low output if neither is generated. Gate 19A and diode CR10 constitute a two-input AND gate, which provides an UP or DN command to gate 19B only during the A period of the measurement cycle. Gate 19B is enabled at the beginning of the second half of the A period, when the $\overline{F}$ signal goes high, if there has been an up or down range decision. The output of gate 19B is differentiated and applied as a negative pulse to NOR gate 16A. The positive pulse developed by gate 16A is applied to the clock inputs of the range flip flops and causes them to uprange or downrange, depending on the state of gates 13D and 13C.

3-49. The delay circuitry places the DVM in storage mode during the ranging operation to allow the signal conditioners to stabilize before proceeding with a measurement. This action is initiated by the ranging pulse. It is applied to the flip flop (gate 5B and 5C) of the cycle change circuitry, which causes the cycle change circuitry to change to storage mode. The range pulse also turns on transistor Q25, which provides a discharge path for capacitor C7 and thereby turns off transistor Q47. When Q47 turns off, transistor Q28 turns on and grounds pin 7 of gate 5C. This prevents any trigger pulses from switching the cycle change circuitry to measure mode until the ranging operation is complete. After approximately 230 milliseconds, the charge on C7 will be sufficient to turn on Q47. When Q47 turns on, Q28 will turn off and the cycle change circuitry will be enabled. As it first conducts, Q47 will also supply a positive pulse to gate 5C, which will trigger the cycle change circuitry and initiate a measure cycle. The purpose of transistor Q26 and associated components is to reduce the delay from 230 milliseconds to 10 milliseconds during VDC unfilitered mode, since the time required for settling and stabilization of the buffer is much less than in the other signal conditioners. If the DVM is in VDC mode without the filter function called, Q26 will be on and R41 will be effectively placed in shunt with R40. This will reduce the charge time for C7 and shorten the delay accordingly.

3-50. The purpose of gates 15A, 15B, 15D, and 13B and diodes CR13 and CR14 is to set the lowest range for the selection function, thereby setting the operating range of the autorange circuitry. Diode CR13 inhibits the down detection gate, 4A, when the 100 range is manually selected, and diode CR14 inhibits gate 4A when the 10 or 100 range is selected. On the 10 volt range in VDC mode, gate 13A will be enabled, gate 15A will be inhibited, and gate 15D will be enabled, which will inhibit the down detection gate, 4A. On the 100 range in MVDC mode, gate 13B will be enabled, gates 15A and 15B will be inhibited, and gate 15D will be enabled, which will also inhibit the down detection gate.

3-51. CYCLE CHANGE CIRCUITRY. The cycle change circuitry consists of two flip flops, an inverter, and a reset gate. The input flip flop consists of NOR gates 5C and 5B, and the output flip flop consists of gates 16C and 16D. Following application of the $\overline{H}$ pulse, the information present in the input flip flop is inverted in gates 9A and 5A and passed on to the output flip flop. The $\overline{ZERO}$ signal, which is applied to one input of gate 5A, prevents the circuitry from being cycled until it has completed the current cycle. In measurement cycle, gates 5C and 16D are enabled; and in storage cycle, gates 5B and 16C are enabled. The reset gate, 9C, produces a reset signal at the end of the E period of the storage cycle, which switches the DVM to the measurement cycle. The cycle change flow chart is shown in Figure 3-21.

3-52. INTERNAL SAMPLE OSCILLATOR. The internal sample oscillator consists of transistors Q27, Q42, Q43 and associated components. Transistors Q27 and Q42 constitute a Schmitt trigger. The stage is triggered by the charge on capacitor C9, as it charges through resistors R48 and R49 (SAMPLE RATE control). After changing state, the positive potential at the collector of Q27 turns on transistor Q43 and quickly discharges capacitor C9 to restore the initial state. The output pulse width is determined by the discharge time of C9 and the hysterisis characteristics of the Schmitt circuit. The pulse repetition rate is determined by the RC time constant of R48, R49 and C9. In the EXT position of the SAMPLE RATE control, the oscillator is disabled, because the collector load for Q27 (resistors R53, R54, and R81) is disconnected.

3-53. ANALOG CYCLE CONTROLS. The analog cycle control circuitry produces the gate and control signals, which are used to control the timing of events in the analog portion of the DVM, principally the A/D converter. These signals, together with other control signals, are shown in the timing diagram of Figure 3-13. The M and $\overline{H}$ signals are NANDed in gate 14D and the output of the gate is applied to inverter Q11, which is enabled by quantity $\overline{C \cdot E}$ from gate 14C. The resulting signal, gate 11, represents the quantity $M\overline{H}$ (C + E). The "store input" control signal is equivalent to the $\overline{F}$ signal and is produced by transistor Q12. The quantity $\overline{M}H$ from gate 14D is applied to inverter Q13, which is enabled by quantity $\overline{A \cdot C}$ from gate 14B. The

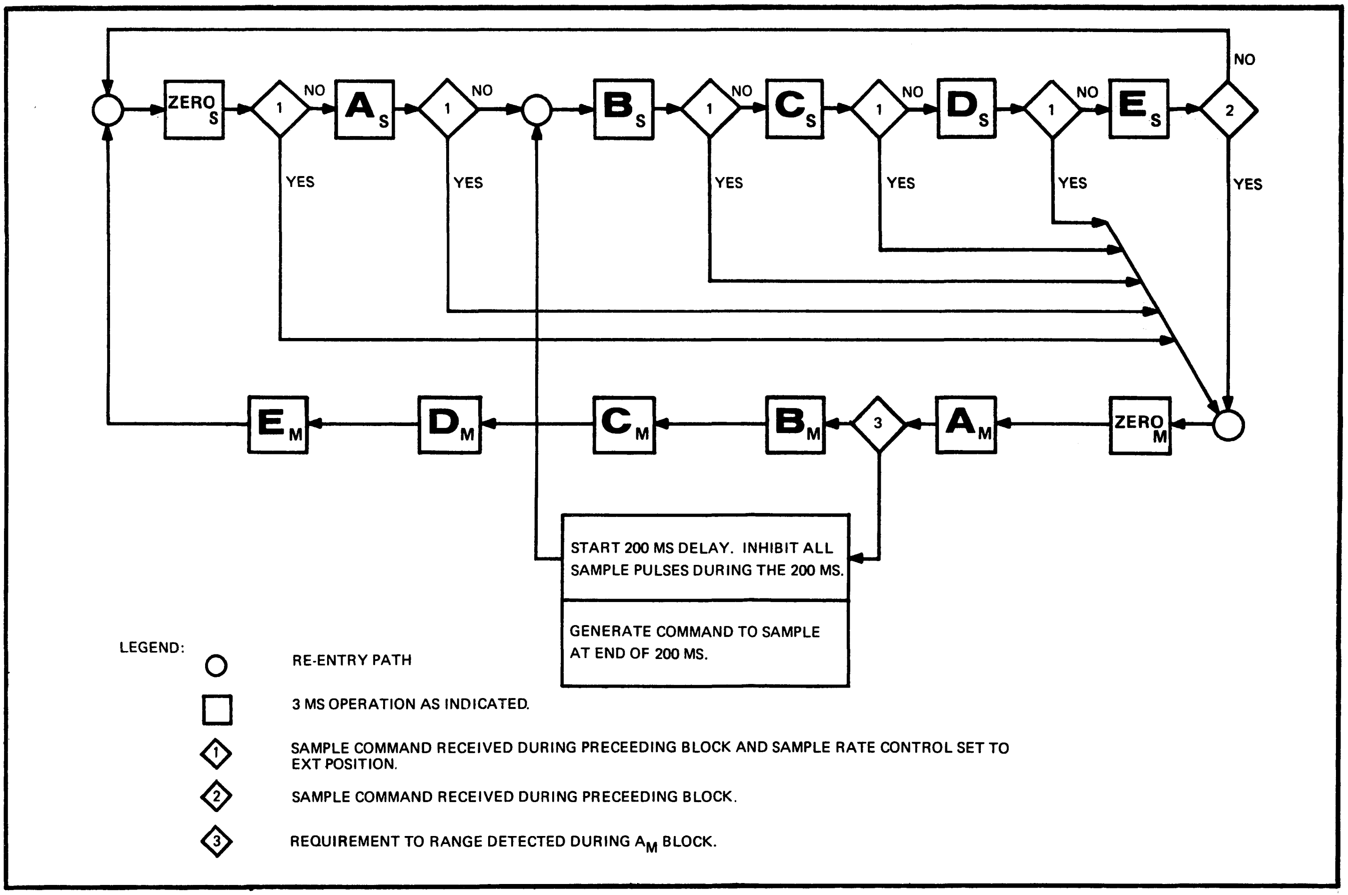


Figure 3-21. CYCLE CHANGE FLOW CHART

resulting signal, gate 2, represents the quantity $M\overline{H}$ (A + C). The quantity $\overline{M}H$, from gate 14D, is also applied to inverter Q14, which is enabled by quantity $\overline{B}\cdot\overline{D}$ from gate 14A. The resulting signal, gates 1 and 22, represents the quantity $M\overline{H}$ (B + D). The "store output" control signal is equivalent to the M signal and is produced by transistor Q15. The gate 4 signal is produced by transistor Q16 and is equivalent to $M \cdot A$.

3-54. DISPLAY CIRCUITRY. The display circuitry controls the function/status indicators and the decimal indicators associated with the readout tubes. The EX REF, AC, MV, KΩ, and MΩ indicators are controlled by the respective function control lines. They are illuminated when +5 volts dc is applied to the control line; however, the control lines are interlocked in the associated assembly so that the indicator will not light unless the assembly is installed in the instrument. The FILT indicator circuit is interlocked with KΩ, 10 MΩ, and VDC functions through transistor Q10 in the buffer assembly. The OVERload indicator is operated by transistor Q44 in conjunction with the 12's catcher, as described in paragraph 3-42.

3-55. The DC+ and DC– indicators are controlled by a flip flop consisting of transistors Q17 and Q18, FET switches Q19 and Q20, and associated components. Diodes CR6 and CR7 comprise an OR gate, which is enabled if either VDC or MVDC functions are called, thereby supplying +5 volts dc to one terminal of each polarity indicator. At the beginning of the measure cycle, Q17 is triggered on by the $\overline{M}$ signal through diode CR11, which turns off Q17, turns on Q18, and lights the DC+ indicator. If the DVM is in VDC mode and a positive instrument input voltage is detected, the polarity detector (located in the A/D converter) will turn on switch Q19, thereby connecting the MVDC control line to the base of Q17. Since the MVDC control line is low, Q17 will remain off and the DC+ indicator will remain on. If a negative instrument input voltage is detected, switch Q20 will be turned on, which will turn on Q17 and light the DC– indicator. If the DVM is in MVDC mode and a positive instrument input is detected, Q20 will be turned on and, since the VDC line is low, Q17 will remain off and the DC+ indicator will remain lighted. For a negative input, Q19 and Q17 will be on, thus lighting the DC– indicator. The decimal point indicators are controlled by transistor switches Q21 through Q24, which are operated by the range flip flops 18a and 18b.

3-56. ANODE STROBING CONTROL. Switches Q31 through Q35 are turned on sequentially by the shift register signals, A through E, beginning with signal A. The F signal ensures that the transistors are turned on only during the second half (display portion) of each period. The output of these switches controls switches Q36 through Q40, which apply +190 volts dc to the anode of each readout tube.

3-57. MISCELLANEOUS CIRCUITRY. The overrange indicator V1, is operated by transistor Q41, which is connected to the "1" digit of V1. Q41 is controlled by the W and $\overline{Y}$ outputs of the 16-state binary counter and is turned on when the counter reaches a count of 10. The decoder/driver is a monolithic Binary-Coded-Decimal to Decimal decoder, which accepts the 4-bit BCD output of the 16-state binary counter, decodes each digital word, and selects one of ten decimal output drivers. The ten outputs are applied to the readout cathodes. Transistors Q29 and Q30 buffer the range flip flop outputs for use in the buffer, where they control the range relays.

3-58. Power Supply

3-59. The +18 and −18 volt regulators obtain filtered dc voltage from two full-wave rectifiers consisting of diodes CR205 through CR208 and filter capacitors C202 and C206. The +18 volt regulator consists of differential amplifier Q209, Q210, driver Q204 and series pass transistor Q203. The voltage reference for the +18 volt regulator is zener diode CR219. The −18 volt regulator consists of differential amplifier Q211, Q212, driver Q213, and series pass transistor Q214. The −18 volt regulator is referenced to +18 volt.

3-60. Regulated +18 volts is supplied to the +7 volt regulator, which constitutes the master voltage reference for the instrument. It consists of reference amplifier A201, Q207, Q208, FET switch Q218, driver Q206, and series pass transistor Q205. Switch Q218 is turned off during external reference operation to disable the +7 volt reference. The sample string, consisting of resistors R213, R222, and R235, is connected to the ladder switches in the A/D converter so that voltage variations in the ladder will be held to a minimum.

3-61. The +190 volt regulator is operated from a full-wave bridge rectifier and filter consisting of diodes CR201 through CR204 and capacitor C201. The reference for the +190 volt regulator is regulated +18 volts. Voltage variations are amplified in Q202 and applied to series pass transistor Q201.

Section 4
Maintenance

4-1. INTRODUCTION

4-2. This section contains information and instructions concerning preventive and corrective maintenance for the Model 8300A Digital Voltmeter (basic DVM only). Maintenance instructions for the various options are covered in Section VI. Preventive maintenance consists primarily of cleaning the instrument and should be performed as often as operating conditions require. Corrective maintenance consists of troubleshooting, calibration, and performance test procedures, which are designed to aid in maintaining instrument operation within specifications. Section III of the instruction manual is an important supplement to the troubleshooting section, since a thorough knowledge of instrument theory is indispensable in troubleshooting.

4-3. A calibration interval of 90 days is recommended to ensure instrument operation within the 90-day specifications stated in Section I of the manual and a calibration interval of 30 days is recommended for operation within the 30-day specifications. The performance of the instrument should be verified in accordance with the performance test in paragraph 4-18 before calibration is attempted. An instrument that does not meet all of the requirements of the performance test will require troubleshooting and/or calibration.

4-4. SERVICE INFORMATION

4-5. Each instrument manufactured by the John Fluke Manufacturing Company is warranted for a period of one year upon delivery to the original purchaser. Complete warranty information is contained in the Warranty page located at the front of the manual. Factory authorized calibration and repair service for all Fluke instruments is available at various world wide locations. A complete list of factory authorized service centers is located at the front of the manual. If requested, an estimate will be provided to the customer before any repair work is begun on instruments which are beyond the warranty period.

4-6. TEST EQUIPMENT

4-7. The equipment recommended for performance testing, troubleshooting, and calibration of the Model 8300A is listed in Figure 4-1. If the recommended equipment is not available, other equipment which meets the required specifications may be used.

EQUIPMENT NOMENCLATURE	RECOMMENDED EQUIPMENT
Oscilloscope	Tektronix Model 547
Oscilloscope Plug-In	Tektronix Model 1A1
Oscilloscope Probes	Tektronix Model P6010
DC Voltage Source	Fluke Model 343A DC Voltage Calibrator
AC Voltage Source	Fluke Model 5200A
Differential Voltmeter	Fluke Model 885A

Figure 4-1. TEST AND CALIBRATION EQUIPMENT.

4-8. GENERAL MAINTENANCE

4-9. Access/Disassembly

The following procedure may be used to gain access to various portions of the instrument.

a. Remove the top and bottom dust covers to gain access to calibration adjustments and test points of the basic instrument.

b. If the AC Converter or MV/Ohms Converter options are installed (see Figure 4-2), remove the top front panel trim strip and inner guard chassis cover. Then remove the two converter boards to gain access to components on the two assemblies, as well as components on the Logic and A/D assembly.

c. Remove the buffer board to gain access to components on the buffer assembly as well as components on the Logic and A/D assembly.

d. Remove the bottom front panel trim strip and inner guard cover to gain access to the land-pattern side of the Logic and A/D assembly.

e. To gain access to components located on the External Reference board, (1) remove the MV/Ohms Converter (if installed) and (2) remove the External Reference board by removing the three hex nuts from the main board (bottom side). which hold down the Reference PCB mounting studs.

f. Remove the top and bottom rear panel trim strips to gain access to components mounted on the rear panel.

g. If the Data Output or Remote Control options are installed, remove the top and bottom dust covers from the protruding rear panel assembly to gain access to the land-pattern side of those printed circuit assemblies.

4-10. Fuse Replacement

4-11. The line fuse is located in a fuseholder mounted on the rear panel of the instrument. The MV/Ohms Converter contains a fuse, which protects the instrument in the event ac or dc voltages are applied to the DVM during ohms operations. This fuse is located on the MV/Ohms Converter assembly. Correct values for the fuses are as follows:

REFERENCE DESIGNATION	FUNCTION	RATING
F1	Line fuse	¼ amp, slow-blow, for 115 volt operation 1/8 amp, slow-blow, for 230 volt operation
F1	Ohmmeter fuse	1/20 amp Microfuse, located in MV/Ohms converter

4-12. 115/230 Volt Conversion

4-13. The Model 8300A may be operated from either 115 or 230 volt ac power, depending upon the connection of the power transformer primary winding. Convert the DVM from one type of power line operation to the other by the following procedure:

a. Disconnect the instrument from the line.

b. Place the 115/230 slide switch, located at the rear of the instrument, in the position which corresponds to the desired operating voltage.

c. Replace fuse with appropriate value (see paragraph 4-11).

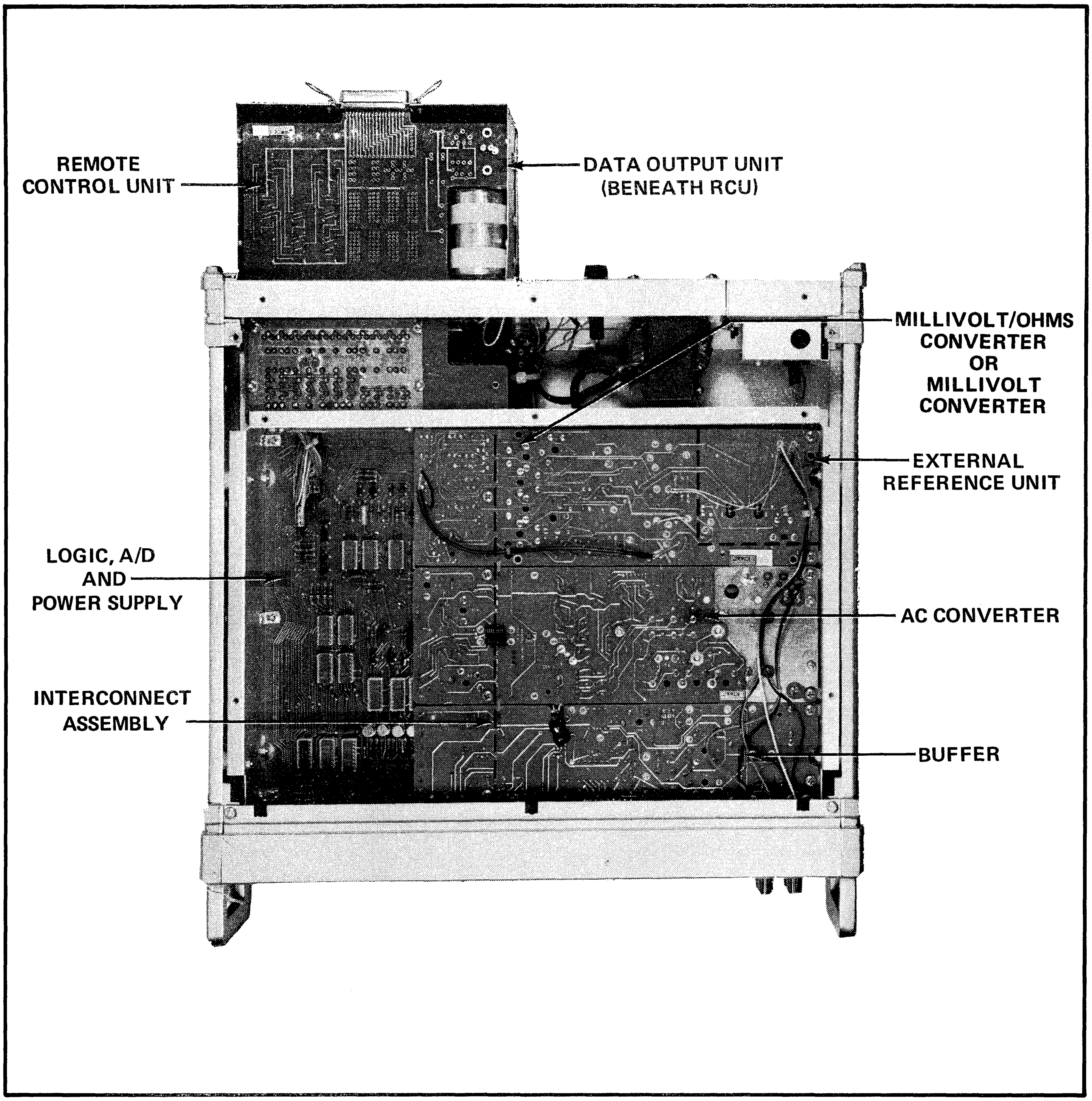


Figure 4-2. ASSEMBLY LOCATIONS

4-14. Lamp and Tube Replacement

4-15. The readout tubes (VI through V6) and the function/status indicator lamps are mounted behind the left portion of the front panel. These components are replaced without special tools using the following procedure:

a. Remove the top and bottom dust covers and inner guard chassis covers.

b. Remove the top and bottom trim strips on the front panel.

c. If the function/status indicator lamps are to be replaced, perform steps (d) and (e). Perform steps (f) through (g) to replace the readout tubes.

d. Remove the function/status indicator assembly mounting screws. Access to these mounting screws is from the bottom of the instrument.

e. Remove the function/status assembly from the top of the instrument. After removal of the plexiglas cover on the assembly, the defective lamp may be replaced by carefully unsoldering the old lamp, clearing the holes of solder, and soldering in the new lamp.

CAUTION!

Use a desoldering tool and exercise extreme caution to aviod lifting land patterns.

f. To replace the overrange indicator tube or the two adjacent readout tubes, unsolder the base mounting pins and remove the tube from the top of the instrument.

g. Replacement of the three lower order readout tubes is accomplished in the same manner after first removing the buffer board. If the AC Converter is installed, it will also have to be removed.

4-16. Cleaning

4-17. The instrument should be cleaned periodically to remove dust, grease, and other contamination. Cleaning should not be necessary too often, however, since the instrument is completely enclosed with no fans or vents. Care has been taken in design to prevent leakage, through the use of high quality insulation materials and through special attention to component locations. The following procedure should be adhered to when cleaning the instrument.

a. Remove loose contamination with low-pressure clean, dry air. Pay particular attention to the front panel binding posts and binding post wiring.

b. The front panel and exterior surfaces may be cleaned using anhydrous ethyl alcohol or a soft cloth dampened in a mild solution of detergent and water.

CAUTION!

Do not use aromatic hydrocarbons or chlorinated solvents on the front panel, because they will react with the Lexan binding posts.

c. Printed circuit boards can be cleaned by first spraying with Freon TF Degreaser (MS180 Miller Stephensen Chemical Co., Inc.) followed by application of low pressure, clean, dry air.

4-18 PERFORMANCE TEST

4-19. The performance test in this section compares the basic instrument performance to the accuracy specifications in Section I of the manual to determine if the instrument is in calibration. Known dc voltages are applied to the instrument input terminals on each of the three dc voltage ranges and proper operation of the manual range and autorange circuitry is verified. The performance test should be conducted before any instrument maintenance or calibration is attempted. The test is also suited to receiving inspection of new instruments. The performance test should be conducted under the following test conditions: ambient temperature 25°C ±5°C, relative humidity less than 70%. An instrument that fails the performance test will require corrective maintenance or calibration. In case of difficulty. analysis of the test results, with reference to the troubleshooting section, should help to locate the trouble.

NOTE!

Permissible tolerances for dc voltage measurements are derived from the 90-day instrument specifications contained in Section I of the manual.

4-20. In the following procedure dc voltages are applied to the instrument at 10% and 100% of full scale on the 10, 100, and 1000 volt ranges.

a. Connect the Model 8300A to the ac line and set the controls as follows:

POWER	ON
FUNCTION	VDC
RANGE	Manually selected, as required.

b. Apply each of the input voltages shown in Figure 4-3, in turn, to the INPUT terminals of the Model 8300A. The readout should be as indicated.

INPUT (VOLTS DC)	MODEL 8300A RANGE	MODEL 8300A READOUT LIMITS
+ 1	10	+0.9996 to +1.0004
+10	10	+9.9987 to +10.0013
+10	100	+09.996 to +10.004
+100	100	+99.987 to +100.013
+100	1000	+099.96 to +100.04
+1000	1000	+999.87 to +1000.13

Figure 4-3. DC VOLTAGE TEST REQUIREMENTS

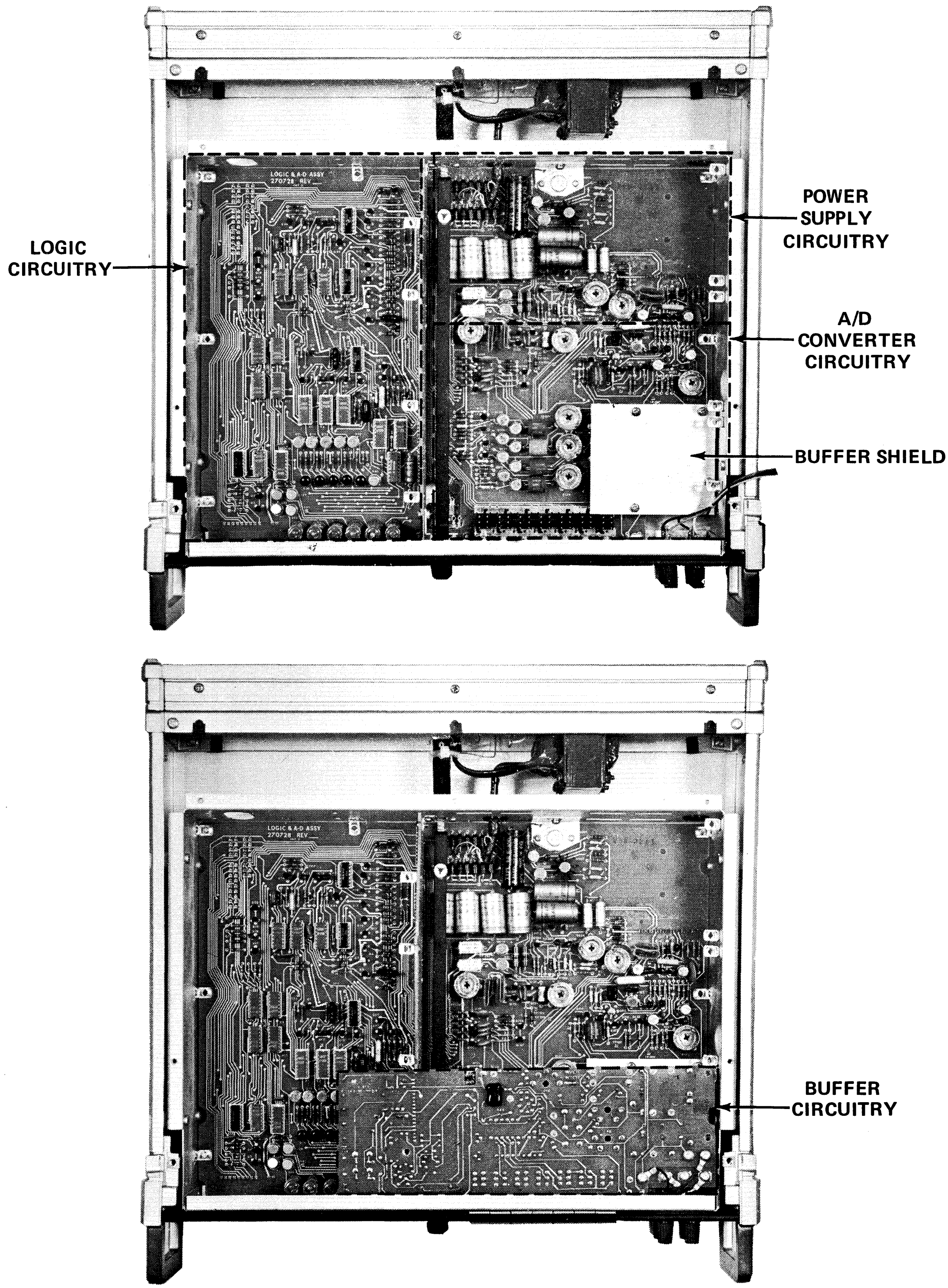
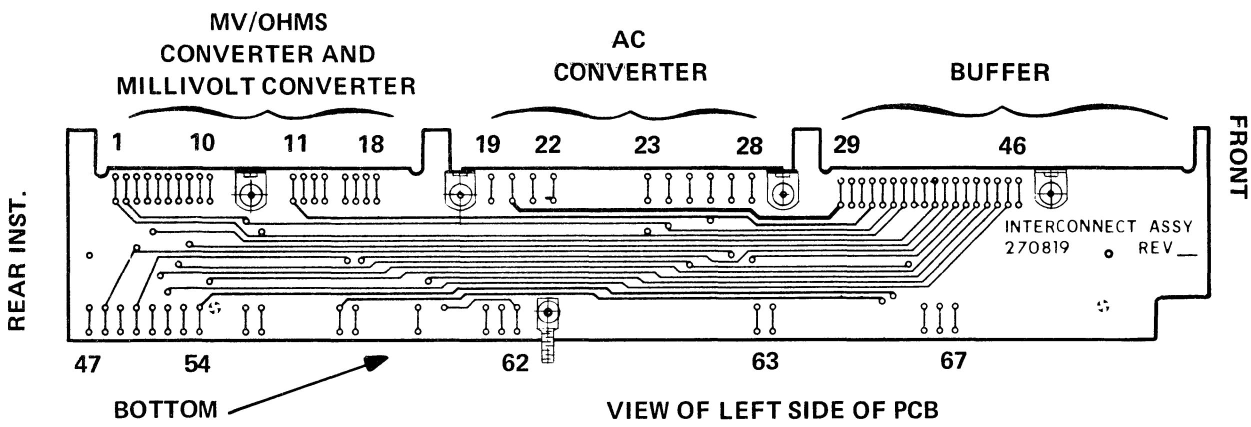


Figure 4-4. MODEL 8300A BASIC DVM-PRINCIPAL CIRCUITRY AREAS



NOTE: INPUT/OUTPUT PIN NOTATION ON THE BUFFER, AC CONVERTER, MV/OHMS CONVERTER AND MILLIVOLT CONVERTER SCHEMATICS CORRESPONDS TO THE PIN NUMBERS IN THIS FIGURE. NUMBERING IS FOR REFERENCE ONLY: PINS ON ACTUAL PCB'S ARE NOT NUMBERED. EXTENDERS ARE AVAILABLE FOR SERVICING MV/OHMS, AC, AND BUFFER BOARDS – SEE ACCESSORY DESCRIPTION PARAGRAPH 2-6.

PIN	DESIGNATION	PIN	DESIGNATION
1	RANGE b	35	RANGE b
2	RANGE a	36	REMOTE CONTROL BUSS
* 3	AC CONTROL	37	LOCAL CONTROL BUSS
4 }	KΩ CONTROL	38	FILTER CONTROL
5 }	KΩ CONTROL	39	VDC CONTROL
6	K8 CONTROL	40	MV CONTROL
7	MV/Ω OUTPUT TO A/D	41	AC CONTROL
* 8	DC CONTROL	42	KΩ CONTROL
9 }	MΩ CONTROL	43	MΩ CONTROL
10 }	MΩ CONTROL	44	AC ZERO
11	LOGIC COMMON	45	K8 CONTROL
12	7V REF	46	BUFFER OUTPUT TO A/D
13 }	MV CONTROL	47	KΩ CONTROL
14 }	MV CONTROL	48	AC CONTROL
15	SIGNAL COMMON	49	EXT REF CONTROL
16	+18V	50	MV CONTROL
17	MV ZERO	51	FILTER CONTROL
18	–18V	52	DC CONTROL
19	AC ZERO	53	MΩ CONTROL
20	SIGNAL COMMON	54	REMOTE FUNCTION BUSS
21	+18V	55	RANGE a
22	–18V	56	RANGE b
23	RANGE b	57	+5V
24	RANGE a	58	LOGIC COMMON
25	AC OUTPUT TO A/D	59	SIGNAL COMMON
26	LOGIC COMMON	60	+18V
27 }	AC CONTROL	61	–18V
* 28 }	AC CONTROL	62	+7V REF
29	SIGNAL COMMON	63	INPUT TO A/D
30	+18	64	SIGNAL COMMON
31	–18	65	MV ZERO
32	LOGIC COMMON	66	EXT REF CONTROL
33	+5V	67	LOCAL CONTROL BUSS
34	RANGE a	*	FOR AC/AC RATIO (OPTION 8300A–08)

Figure 4-5. INTERCONNECT ASSEMBLY

c. Repeat step (b) with negative input voltages. The DVM readout should be the same as for positive inputs, except that the polarity indication should be negative (DC–).

d. Apply zero volts to the input of the DVM and press the AUTO RANGE switch. The readout should be 0.0000.

e. Apply 1000 volts dc to the INPUT terminals. The DVM should range automatically and the readout should be +999.87 to +1000.13.

4-21. TROUBLESHOOTING

4-22. This section contains information selected to assist in troubleshooting the Model 8300A. Before attempting to troubleshoot the instrument, however, it should be verified that the trouble is actually in the instrument and is not caused by faulty external equipments or improper control settings. For this reason, the performance test (paragraph 4-18) is suggested as a first step in troubleshooting. The performance test may also help to localize the trouble to a particular section of the instrument. If the performance test fails to localize the trouble, the following information may be helpful. Location of principal circuitry areas in the Model 8300A basic DVM is shown in Figure 4-4. A detailed drawing of the interconnect assembly is shown in Figure 4-5, together with a table of pin assignments. Note that the terminals on the actual assembly are not numbered; they are included on the drawing of Figure 4-5 for reference purposes. Figure 4-16 gives test point and adjustment locations and intergrated circuit orientation.

4-23. Power Supply

4-24. In this test, each of the power supply output voltages is checked, using the Model 885A Differential Voltmeter.

a. Turn on the instrument. FUNCTION, RANGE, and FILTER switches may be in any position.

b. Connect the voltmeter common to test point 109 (TP 109) and measure the voltages shown in Figure 4-6. The voltages should be as indicated.

4-25. Fault Isolation - General

4-26. The following procedure may be used to help isolate a malfunction to a particular section of the 8300A circuitry. The results of each procedural step, when applied to Figure 4-7, will indicate the faulty section of the 8300A.

VOLTAGE TEST POINT	DC VOLTS		
	NOMINAL	LIMITS	ADJUSTMENT
TP 204	+18	+17.98 to +18.02	R234
TP 203	−18	−17.5 to −18.5	None
TP 202	+190	+185 to +195	None
TP 205	+7	6.99998 to 7.00002	R222

Figure 4-6. POWER SUPPLY VOLTAGE REQUIREMENTS

READOUT DISPLAY PROPERLY INDICATES				MALFUNCTION AREA
VDC	MV	OHMS	VAC	
YES	YES	YES	YES	This procedure does not indicate a malfunction
YES	NO	NO	YES	The malfunction is in the -02 option (See Section 6-02 option)
NO	YES	NO	YES	The malfunction is in the Buffer (refer to Section 3 "Buffer" and Schematic 1)
YES	YES	YES	NO	The malfunction is in the -01 option (See Section 6-01 option)
NO	NO	NO	NO	The malfunction is in the A/D converter (See Section 4 A/D converter)

Figure 4-7. MALFUNCTION AREA TRUTH TABLE

4-27. STEP ONE. Using a DC voltage calibrator (Fluke Model 343A), apply +6.3524 volts to the input of the 8300A. Does the readout display the input correctly? (Yes or No).

4-28. STEP TWO. If the -02 option (mv/ohm) is installed, apply 635.24 mv to the input of the 8300A. Does the readout display the input correctly? (Yes or No)

4-29. STEP THREE. If the -02 option (mv/ohms) is installed, connect a known precision resistance of more than 1000 ohms across the input of the 8300A. Does the readout display the value of the resistance correctly? (Yes or No).

4-30. STEP FOUR. If the -01 option (AC Converter) is installed, apply 6.3524 volts from an AC calibrator (Fluke Model 5200A) to the input of the 8300A. Does the readout display the ac voltage correctly? (Yes or No)

4-31. Fault Isolation - A/D Converter

4-32. The waveforms indicated in the following procedure are indicative of an operational unit, and provide a basis for an analytical comparison between proper and improper indications, that may point to causes for the malfunction(s). It is recommended that prior to starting this procedure, a close study of the A/D Converter theory of operation in Section 3, referenced to Schematic No. 2, be made, in order to obtain an understanding of A/D Converter operation.

4-33. STEP ONE. Remove the buffer and the -01 and -02 options (if installed). Jumper A3 TP6 to A3 TP201 This jumper will place the A/D Converter in the measurement cycle and disable the display storage section of A3.

4-34. STEP TWO. The output of a DC voltage calibrator can now be substituted for the buffer output signal as follows:

a. Connect the positive output terminal of the 343A to the input end of A3 R102, and the negative output terminal to A3 TP109. Apply +6.3524 vdc.

CAUTION!

Applied voltages greater than ± 12VDC may cause damage to the A/D Converter.

b. If the 8300A display indicates 6.3524 (with the buffer removed, the function and polarity indicators will not be displayed), the malfunction should be in the Secondary Ladder, Display Storage, or associated logic. If the display is incorrect proceed to Step Three.

4-35. STEP THREE. Reverse the polarity of the DC voltage applied to R102. If the display now indicates 6.3524, the malfunction is probably in the Polarity Detector, Plus Gate, or associated Logic Control. If the display is incorrect, proceed to Step Four.

4-36. STEP FOUR. Connect the input of an oscilloscope (Tektronix Model 547) through a X10 probe to A3 TP106. Connect the scope input ground to A3 TP108.

a. With 0.0000 volts DC applied to the A/D Converter input at A3 R102, the scope presentation should look like Figure 4-8, waveform A. If the waveform is correct, proceed to step b. If the waveform is incorrect, the malfunction may be in the A/D amplifier, or A/D Amplifier Auto Zero Drive Circuit.

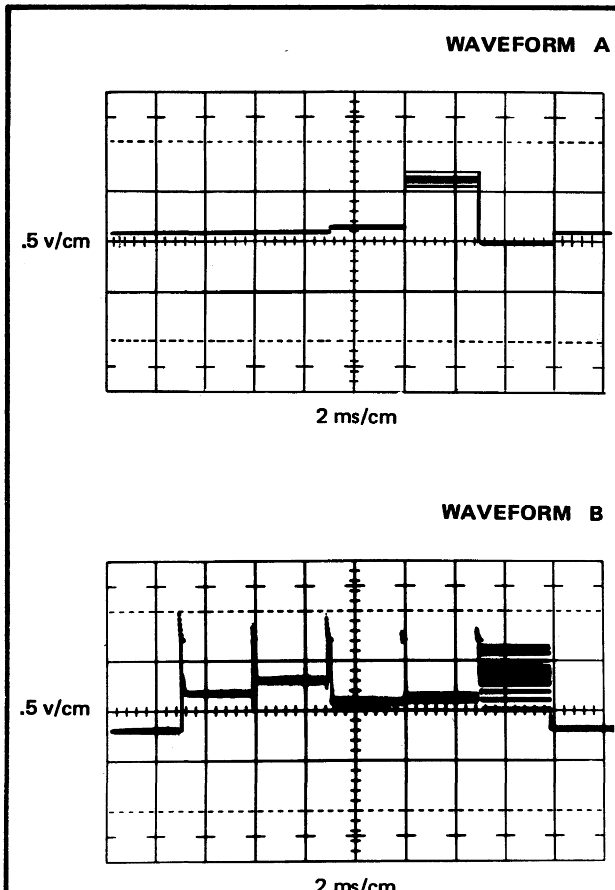


Figure 4-8. WAVEFORMS AT TP106

b. With +6.3524 Volts DC applied to the A/D Converter input at A3 R102, the scope presentation should look like Figure 4-8, waveform B. If the waveform does not indicate proper digit information (the series of small step increases at the top of each spike) for the second and fourth digits, check the sample and hold circuit Q125, C108, Q124 or logic control gate 1 and gate 2. If the digit information for the third and fifth digits is incorrect, check sample and hold circuit Q127, C109, Q126 or logic control gate 11 and gate 22 for a malfunction.

4-37. STEP FIVE. In the A/D Converter, the circuitry subsections for the A/D Amplifier, Analog Comparator, Current Controlled Oscillator, 16-State Binary Counter, Ladder Driver, and Primary Ladder form a closed loop, in which, a malfunction in one section will cause improper operation of all other sections. Troubleshooting this closed loop requires analysis of the 8300A display, and the waveforms at TP106 and TP107. The following questions about these indications may help point to the problem area:

a. With +6.3524 applied to the input of the A/D (R102), is the digit information on the spikes of the waveform at TP106 greater than +7 in amplitude? The digit information must be greater than +7, since the Analog Comparator requires an input greater than the +7V Ref. voltage in order to operate. If this voltage will not go above +7 check the A/D Amplifier for; possible leakage paths to ground through Q117 or Q118, improper operation of A102, or leakage through Q113 or Q114 of the A/D Amplifier Auto Zero Drive Circuits. If the amplitude is greater than +7 proceed to Step b.

b. Connect the oscilloscope input to TP107. With zero volts applied to the input of the A/D Converter (R102), the scope presentation should look like Figure 4-9, waveform A. Increase the input to the A/D Converter to +6.3524 vdc. The waveform at TP107 should look like Figure 4-9, waveform B. If the scope presentation does not indicate the positive going spikes of waveform B, the malfunction is in the Analog Comparator. If the waveform indicates the positive spikes of waveform B, proceed to Step c.

c. With the scope input still connected to TP107, decrease the scope sweep time to 0.2 ms/cm. The scope presentation should be similar to that shown in Figure 4-10. This is an expanded picture of one spike from Figure 4-9, waveform B. The number of sawtooth waves that make up each spike is determined by the value of each digit of the input voltage at R102. In the case of Figure 4-10, this corresponds to the "3" in the input voltage of +6.3524 volts. An incorrect digit indication at TP107 may be caused by a malfunction in the Current Controlled Oscillator, 16-State Binary Counter, or Ladder Driver Circuits.

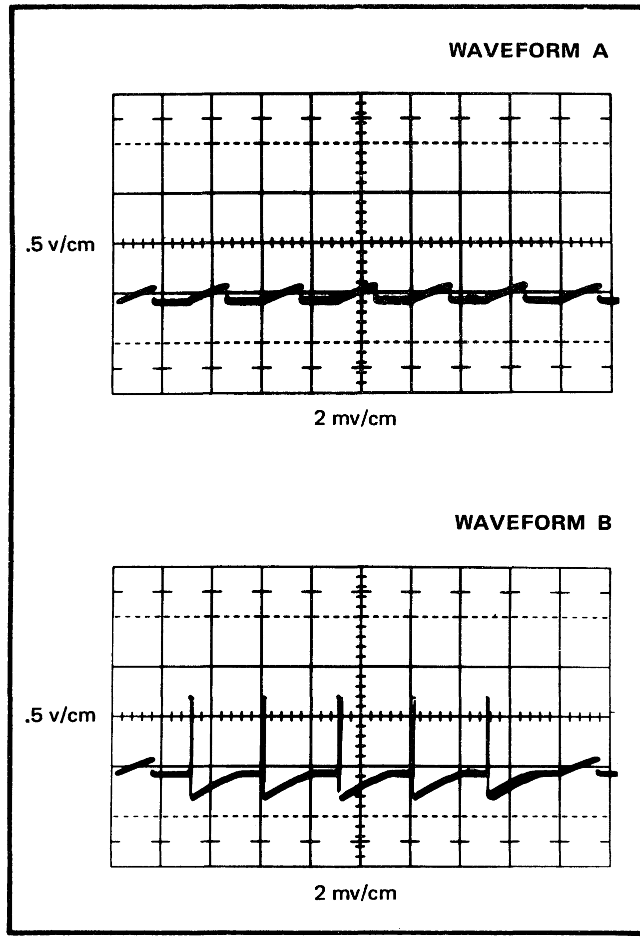


Figure 4-9. WAVEFORMS AT TP107

Refer to the figure (Figures 4-11 through 4-15) which pertains to the suspected section, as indicated by the symptoms. Waveforms and logic functions are given for every significant point. Figures 4-13 and 4-14 are troubleshooting charts, which are intended to aid in isolating troubles in the DVM analog and display circuitry. Do not overlook the possibility of shorts, which can cause certain IC's to appear inoperative, or improperly installed IC's having pins bent under and/or installed end-for-end (reversed). Also, under conditions of malfunction, spikes that are

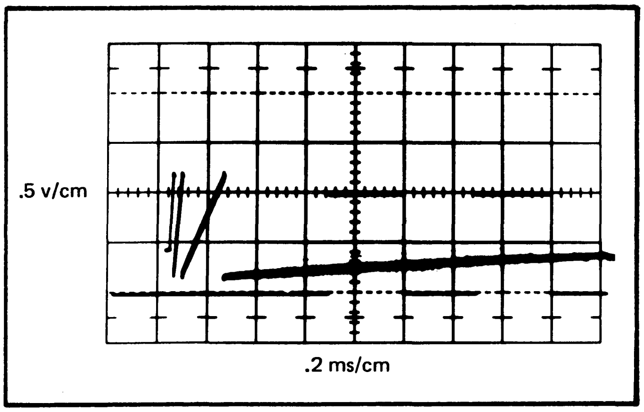


Figure 4-10. INPUT DIGIT "3" AT TP107

too fast to be seen on the recommended oscilloscope (Tektronix Model 547) may occasionally be present. The logic sections depend upon each other to some extent for proper operation, e.g., often a non-functioning autorange circuit will be caused by a problem in a manual ranging circuit.

NOTE!

Integrated circuit (IC) designations refer to like numbered devices appearing on the schematic. They may be located in the instrument by referring to the parts list and accompanying component callouts.

4-38. CALIBRATION

4-39. The basic Model 8300A should be calibrated every 30 or 90 days, depending on the degree of accuracy to be maintained (see specifications, Section 1), or whenever repairs have been made. Calibration should be done at an ambient room temperature of 250°C ±5°C. Relative humidity should be less than 70%. Refer to Figure 4-1 for recommended test equipment. Adjustment and test point locations are labeled on the top and bottom inner guard covers. Figure 4-19 shows adjustment and test point locations with the top inner guard cover removed. Option calibration methods are given in Section 6.

4-40. Preliminary Operations

a. Remove the upper and lower dust cover screws, but leave the covers in place.

b. Set the 115/230 volt slide switch on the rear panel to 115 and then connect the line cord to the output of an autotransformer set to 120V ac.

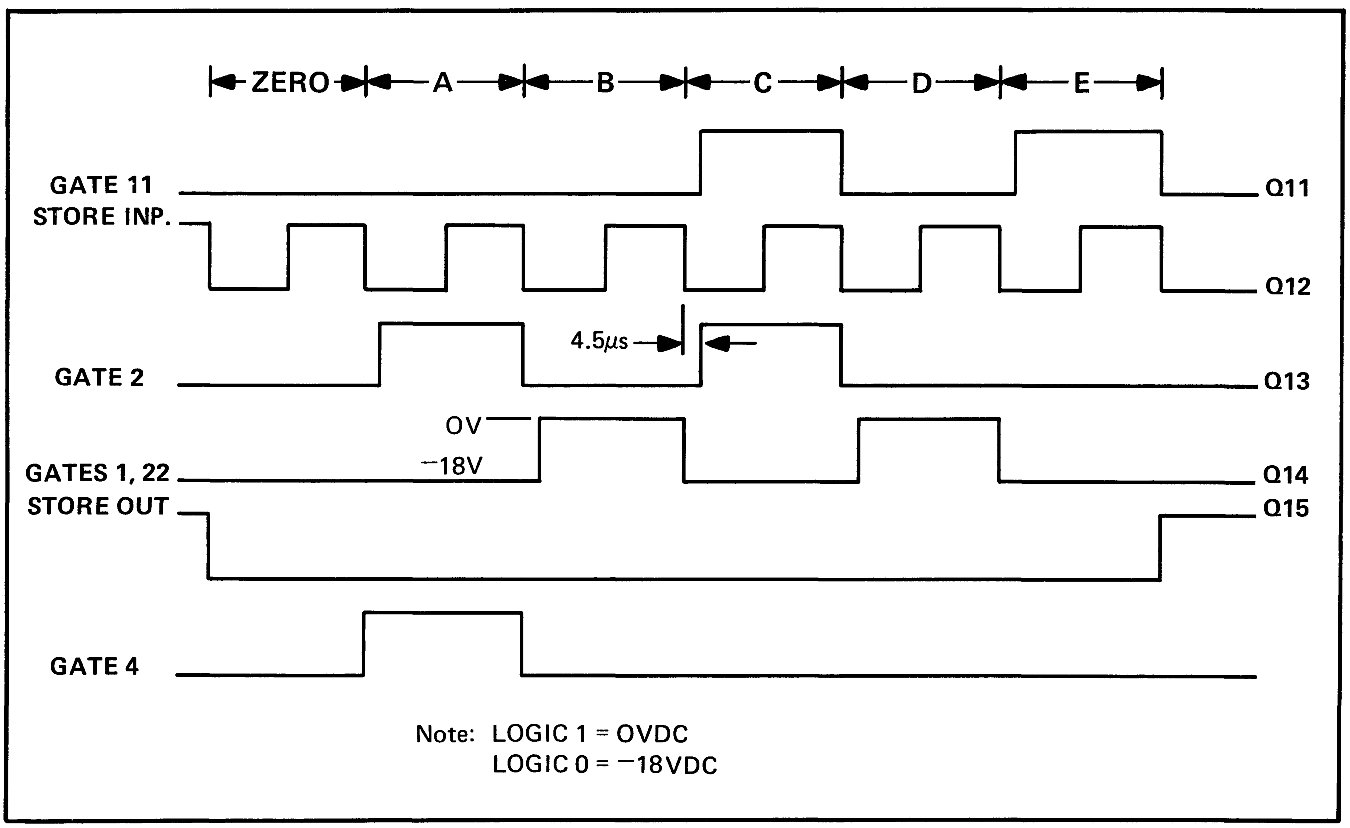


Figure 4-11. A/D CONVERTER CONTROLS

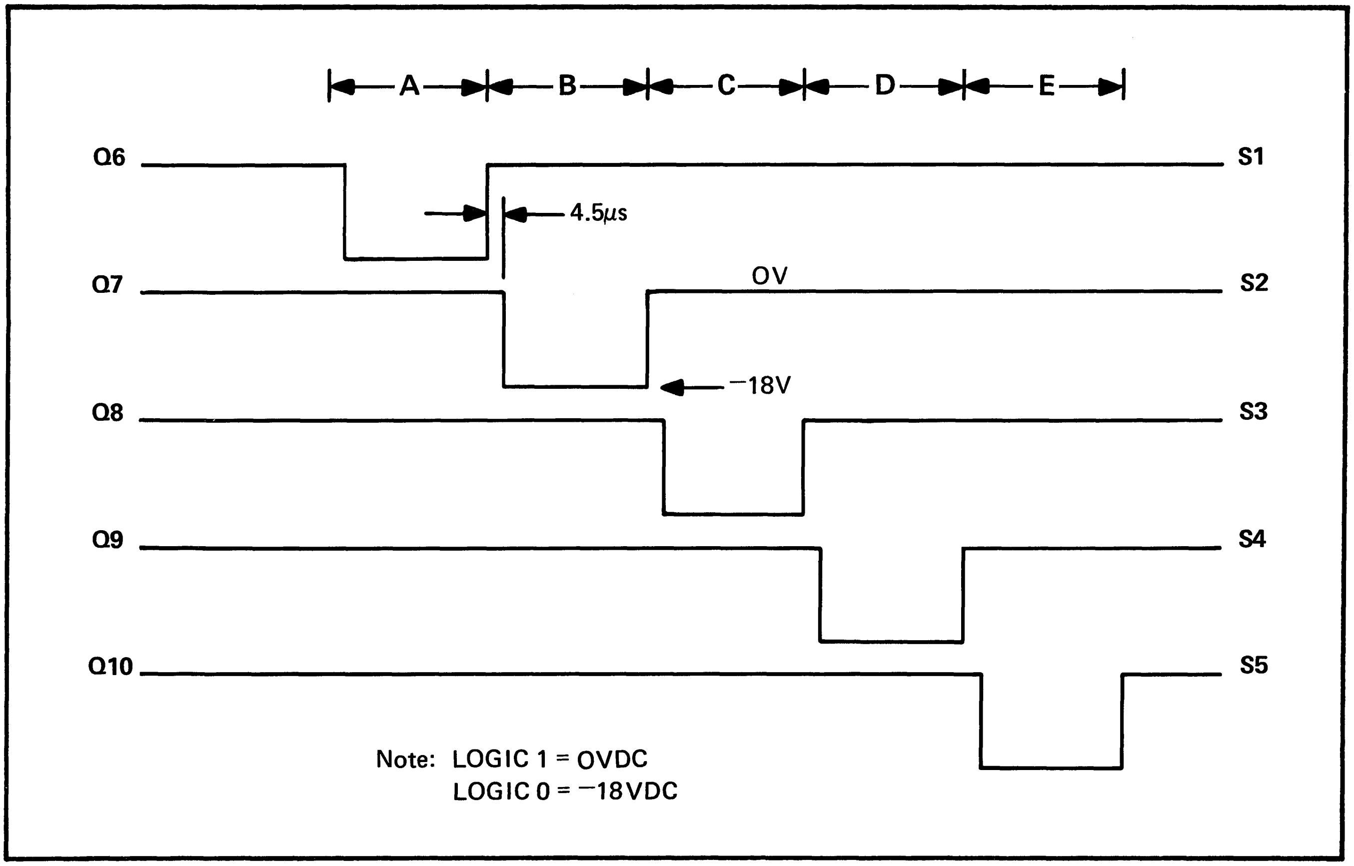


Figure 4-12. ANALOG STORAGE CONTROL

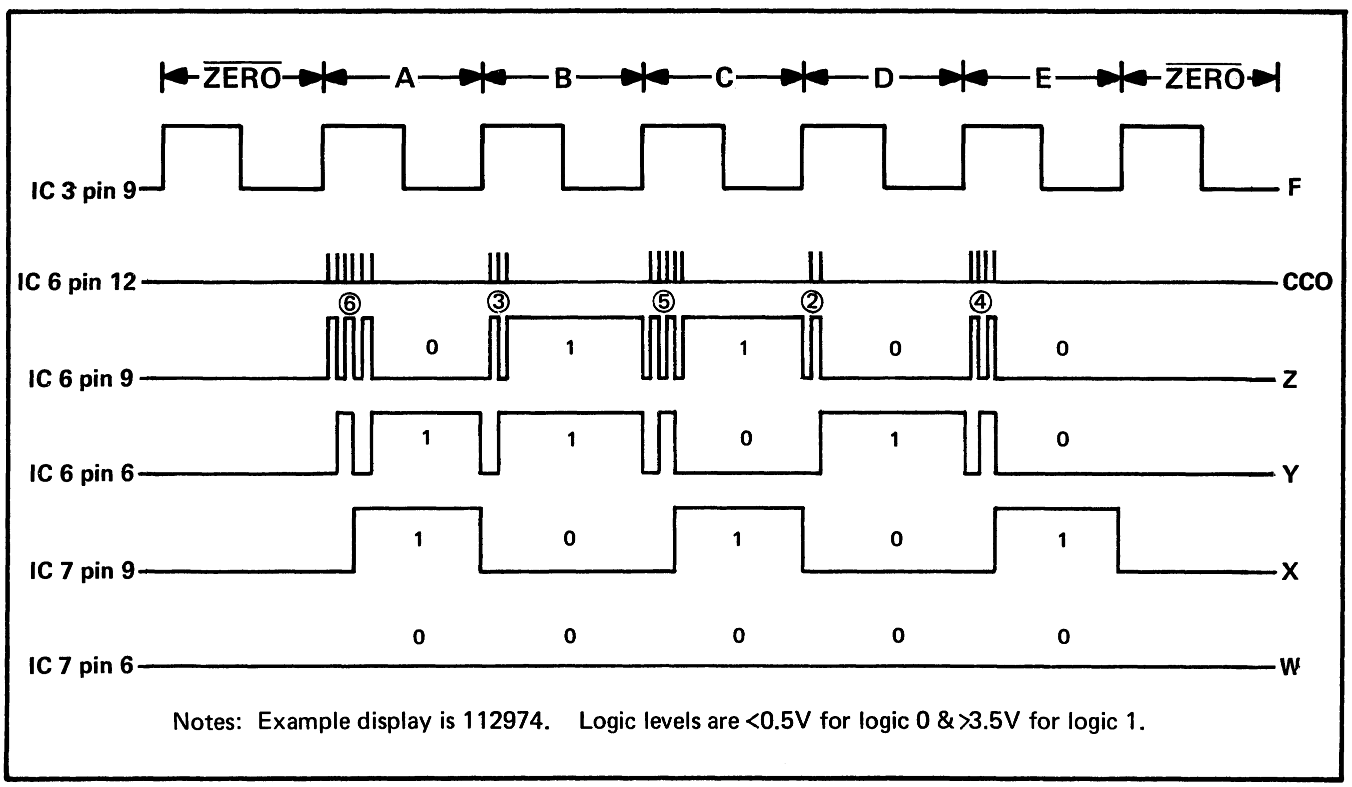


Figure 4-13. COUNTER OPERATION

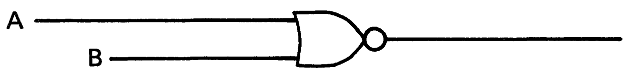
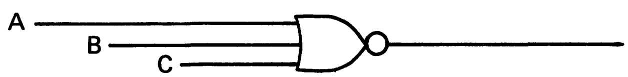
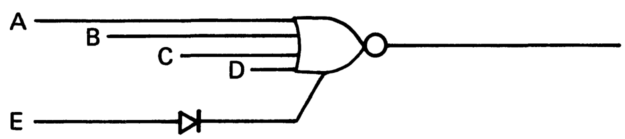
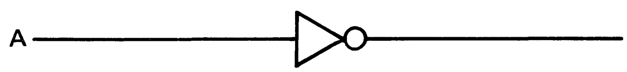
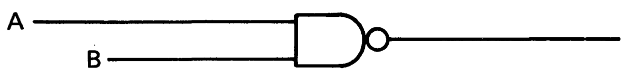
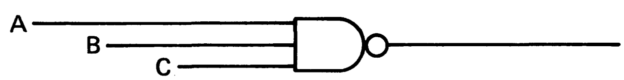
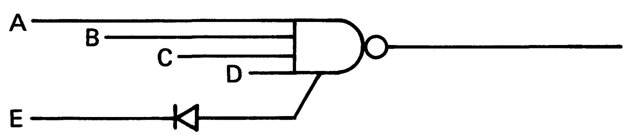
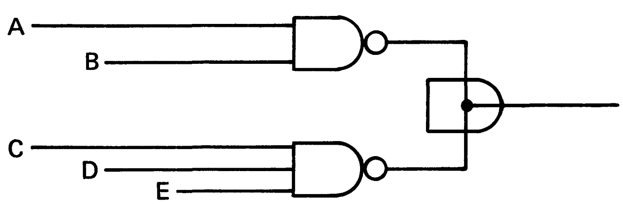
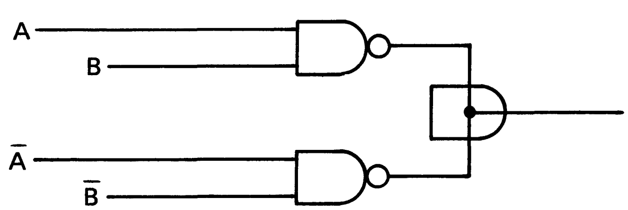
DEVICE	LOGICAL TRANSFER FUNCTION
	$\overline{A+B} \equiv \bar{A}\bar{B}$
	$\overline{A+B+C} \equiv \bar{A}\bar{B}\bar{C}$
	$\overline{A+B+C+D+E} \equiv \bar{A}\,\bar{B}\,\bar{C}\,\bar{D}\,\bar{E}$
	$\bar{A}$
	$\overline{A\,B} \equiv \bar{A}+\bar{B}$
	$\overline{A\,B\,C} \equiv \bar{A}+\bar{B}+\bar{C}$
	$\overline{A\,B\,C\,D\,E} = \bar{A}+\bar{B}+\bar{C}+\bar{D}+\bar{E}$
	$\overline{A\,B}\;\overline{C\,D\,E} = (\bar{A}+\bar{B})\;(\bar{C}+\bar{D}+\bar{E})$ $= \bar{A}\bar{C}+\bar{A}\bar{D}+\bar{A}\bar{E}+\bar{B}\bar{C}+\bar{B}\bar{D}+\bar{B}\bar{E}$
	$\overline{A\,B}\;\overline{\bar{A}\,\bar{B}} = (A+B)\;(\bar{A}+\bar{B})$ $= A\,\bar{B} + \bar{A}\,B =$ "exclusive or"

Figure 4-14. LOGICAL TRANSFER FUNCTIONS FOR DEVICES USED IN THE MODEL 8300A.

DEVICE	PIN NO.	LOGIC FUNCTION
IC12	14	$1\overline{VDC}\,\overline{M\Omega}\,\overline{MV}$
IC10	14	$10\,\overline{MV}$
IC10	3	$100\,\overline{M\Omega}$
IC10	13	$1000\,\overline{M\Omega}$
IC11	2	$\overline{1\,\overline{VDC}\,\overline{MV} + M\Omega + 10\,\overline{MV}}$
IC11	14	$\overline{100\,\overline{M\Omega} + MV + 1000\,\overline{M\Omega}}$
IC12	2	$\overline{10\,\overline{MV} + M\Omega + 1000 + DC\bar{a}\bar{b}}$
IC10	2	$\overline{100\,\overline{M\Omega} + 1\,\overline{VDC}\,\overline{M\Omega}\,\overline{MV}}$
IC4	6	$\bar{a}\bar{b} + \bar{a}VDC + \bar{b}MV + 100 + 1000 + 10\,\overline{MV} + M\Omega + \overline{\bar{W}\bar{X}\bar{Y}\bar{Z}}$
IC15	11	$\overline{\bar{a}\bar{b} + \bar{a}VDC + \bar{b}MV}$
IC15	6	$\bar{a} + MV$
IC15	3	$\bar{b} + VDC$
IC15	8	$\overline{WX}$
IC13	13	WXb
IC13	14	$a\bar{b}\,\overline{\bar{a}VDC}\,\overline{\bar{b}MV}\,\overline{100}\,\overline{1000}\,\overline{10\overline{MV}}\,\overline{M\Omega}\,\overline{WXYZ}$
IC19	6	$(UP + DN)A$
IC19	8	$\overline{UP}\,\overline{DN} + \overline{A} + F + \overline{M}$
IC8	2	$WYZ\,(1\,\overline{VDC}\,\overline{MV} + 10\,\overline{MV} + 100 + M\Omega + ab)$
IC8	14	$\overline{1\,\overline{VDC}\,\overline{MV} + 10\,\overline{MV} + 100 + M\Omega + ab}$
IC9	13	$WZ\overline{A}$
IC9	14	$\overline{F}\,E\,M$
IC16	3	ab
IC11	13	$VDC\,\bar{a}\bar{b}$
Q11	COLLECTOR	$M\overline{H}\,(C + E)$
Q12	"	F
Q13	"	$M\overline{H}\,(A + C)$
Q14	"	$M\overline{H}\,(B + D)$
Q15	"	$\overline{M}$
Q16	"	MA
Q36	"	$\overline{F}E$
Q37	"	$\overline{F}D$
Q38	"	$\overline{F}C$
Q39	"	$\overline{F}B$
Q40	"	$\overline{F}A$
Q41	"	$\overline{WY}$
IC17	16	$\overline{\overline{W}\,\overline{X}\,\overline{Y}\,\overline{Z} + W\overline{X}Y\overline{Z}}$

Figure 4-15. LOGIC FUNCTIONS (Sheet 1 of 2)

DEVICE	PIN NO.	LOGIC FUNCTION
IC17	15	$\overline{\bar{W}\bar{X}\bar{Y}Z + W\bar{X}YZ}$
IC17	8	$\overline{\bar{W}\bar{X}Y\bar{Z} + WX\bar{Y}\bar{Z}}$
IC17	9	$\overline{\bar{W}\bar{X}YZ + WX\bar{Y}Z}$
IC17	13	$\overline{\bar{W}X\bar{Y}\bar{Z} + WXY\bar{Z}}$
IC17	14	$\overline{\bar{W}X\bar{Y}Z + WXYZ}$
IC17	11	$\overline{\bar{W}XY\bar{Z}}$
IC17	12	$\overline{\bar{W}XYZ}$
IC17	1	$\overline{W\bar{X}\bar{Y}\bar{Z}}$
IC17	2	$\overline{W\bar{X}\bar{Y}Z}$
Q21	COLLECTOR	$\bar{a}\bar{b}$
Q22	"	$\bar{a}b$
Q23	"	$a\bar{b}$
Q24	"	ab
Q6	"	$A\bar{H}$
Q7	"	$B\bar{H}$
Q8	"	$C\bar{H}$
Q9	"	$D\bar{H}$
Q10	"	$E\bar{H}$
Q29	EMITTER	a buffered
Q30	EMITTER	b buffered

Figure 4-15. LOGIC FUNCTIONS (Sheet 2 of 2)

c. Turn on the Model 8300A and allow it to warm-up for one hour.

4-41. Basic Instrument Alignment

a. Turn off the instrument and remove the dust covers and top front trim strip.

b. Turn on the instrument and set the controls as follows:

FUNCTION	VDC
RANGE	10
SAMPLE RATE	(as desired)
FILTER	IN

c. Connect a shorting jumper between the HI and LO INPUT terminals.

d. Connect the shorting bars at the INPUT terminals as follows:

HI INPUT to HI SENSE
LO INPUT to LO SENSE and GUARD

e. Connect the input of a dc differential voltmeter to TP205 (high) and TP109 (common).

f. Adjust V REF (+7V) for +7.0000V dc at TP205.

g. Connect the dc differential voltmeter input to BUFFER ZERO TP2 (high) and TP1 (common).

h. Adjust ZERO VDC for a dc differential voltmeter indication of 0 ±20 uV. If unable to obtain zero, the range of this adjustment may have to be compensated with jumper selection of R13, R14, and R55 in the A4 Buffer. Before using the following procedure, however, ensure that the A4 Buffer is operating correctly.

1. Turn off the instrument and disconnect the dc differential voltmeter.

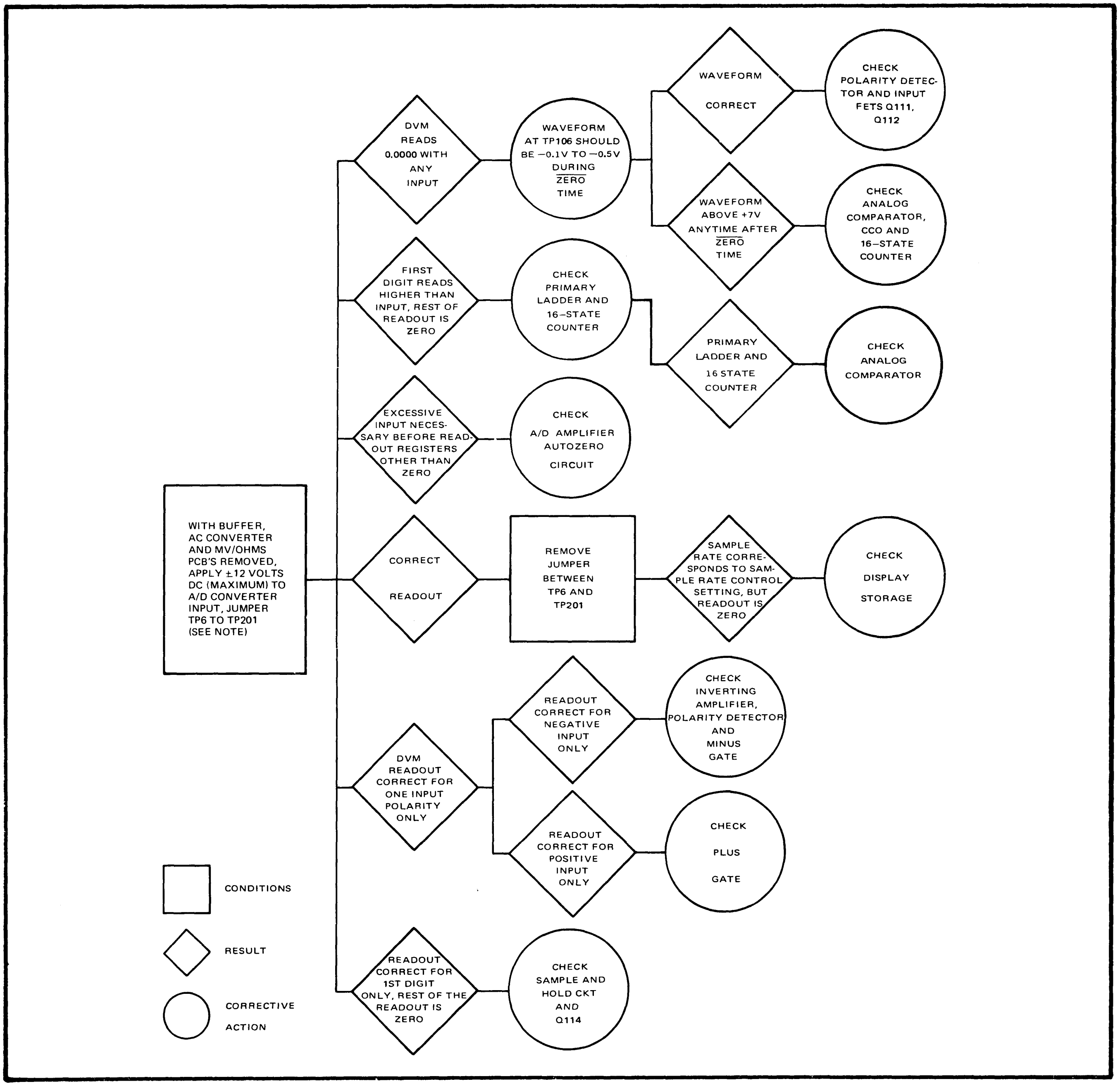


Figure 4-16. TROUBLESHOOTING DVM ANALOG CIRCUITRY

2. Remove the inner top guard cover.
3. Cut jumpers 1 through 3 on the A4 Buffer and set ZERO VDC (R47) fully counterclockwise. Refer to Figure 4-19 for jumper locations.
4. Turn on the Model 8300A and repeat step g.
5. Note the readout and polarity indication on the dc differential voltmeter and determine from the following table which jumpers on the A4 Buffer should be connected.

DIFFERENTIAL VOLTMETER INDICATION (MV)	A4 JUMPERS TO CONNECT
+5.9 to +4.4	1, 2
+4.4 to +3.0	2
+3.0 to +1.6	1
+1.6 to +0.1	NONE
+0.1 to −1.3	1, 2, 3
−1.3 to −2.8	2, 3
−2.8 to −4.2	1, 3
−4.2 to −5.7	3

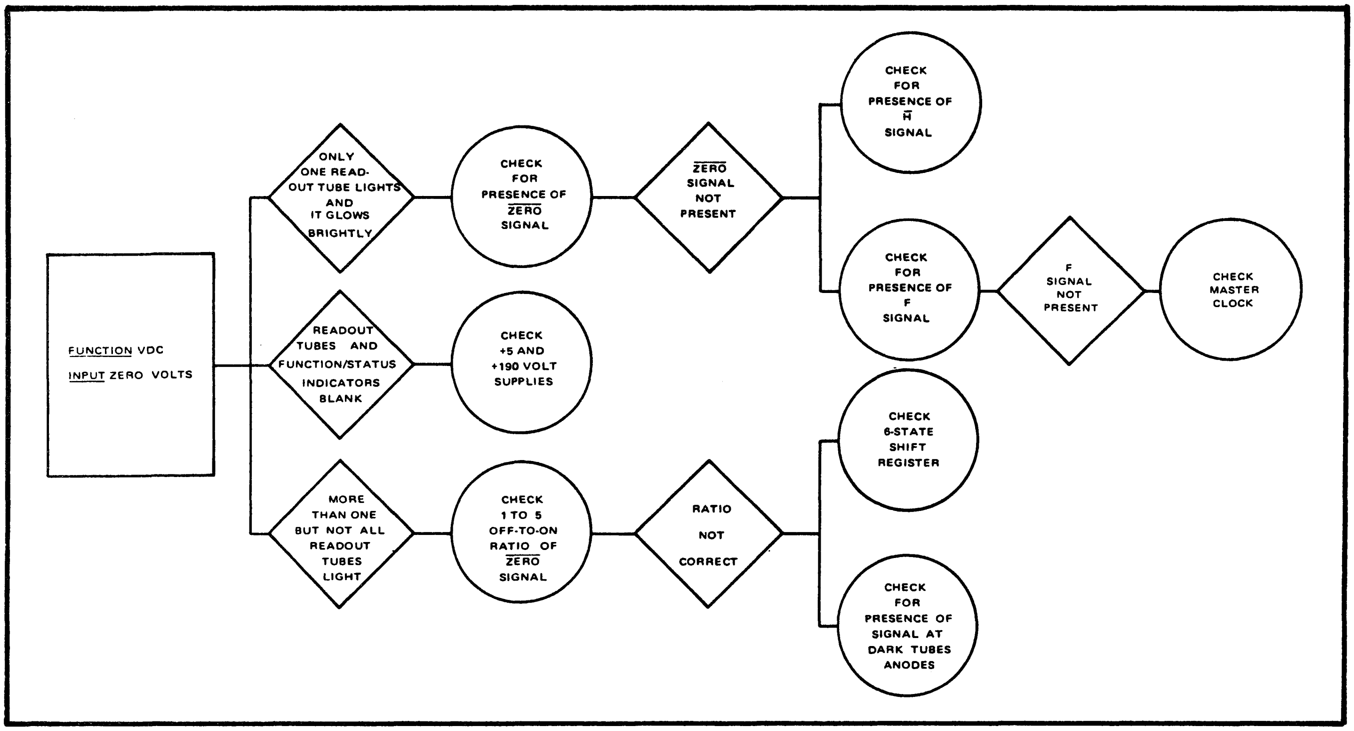


Figure 4-17. TROUBLESHOOTING DVM DISPLAY

6. Adjust ZERO VDC (R47) for a dc differential voltmeter indication of 0 ±20 uV.

7. Turn off the instrument and disconnect the dc differential voltmeter.

8. Install the top guard cover and turn on the Model 8300A.

9. Repeat steps g and h.

i. Disconnect the jumper from between the HI and LO INPUT terminals.

MODEL 8300A INPUT (VDC)	READOUT (DC)	ADJUSTMENT
+0.0020	+0.0020	A–D ZERO
+8.0020	+8.0020	+CAL
−8.0020	−8.0020	−CAL
+4.0020	+4.0020	LADDER CAL 4
+2.0020	+2.0020	LADDER CAL 2
+1.0020	+1.0020	LADDER CAL 1
+0.9995	+0.9995	REMAINDER CAL

Figure 4-18. 10 VOLT RANGE CALIBRATION

j. Apply the input dc voltages given in Figure 4-18 and perform the associated adjustments that produce the required readout.

k. Alternate a dc input to the Model 8300A between 0.9999 and 1.0000V dc and verify that the readout corresponds. If necessary, adjust the COMPARATOR LEVEL control for correct crossover readout.

l. Repeat steps c through f.

m. Disconnect the jumper from between the INPUT terminals.

n. Apply the dc input voltages given in the following table and adjust the associated control for a corresponding readout.

DC INPUT	MODEL 8300A RANGE	ADJUSTMENT
+10.0010	10	+CAL
−10.0010	10	−CAL
+100.010	100	100 VDC
+1000.10	1000	1000 VDC

o. Disconnect the test equipment and replace the top front trim strip and dust covers. Calibration of the basic Model 8300A is complete. Refer to Section 6 for calibration of the options.

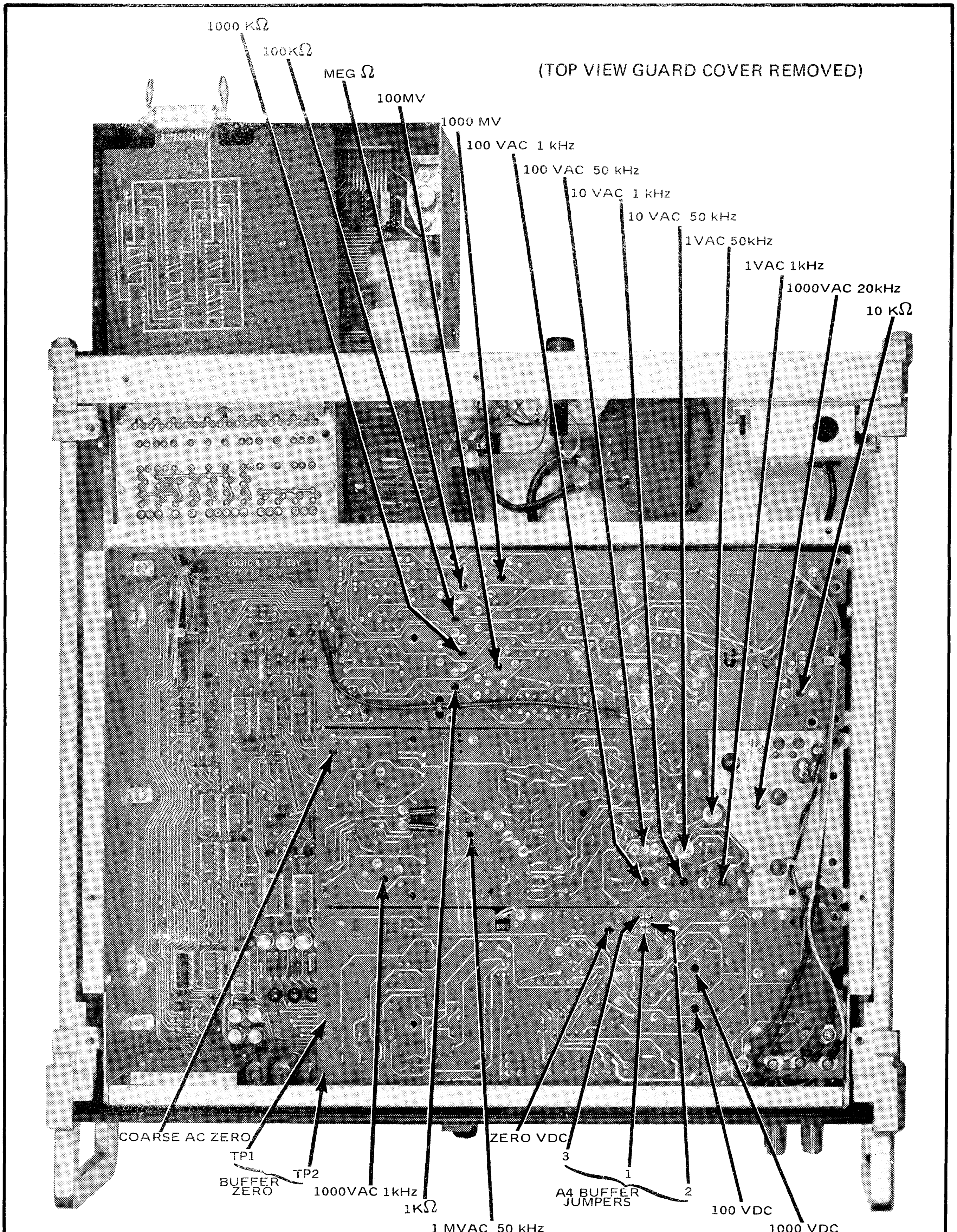


Figure 4-19. ADJUSTMENT AND TEST POINT LOCATIONS

Section 5
List of Replaceable Parts

5-1. INTRODUCTION

5-2. This section of the manual contains a listing of replaceable components for this instrument. The first listing contains a complete breakdown of all the major assemblies followed by subsequent listings that itemize the components on each major assembly. An illustration accompanies each major assembly listing to aid in locating the listed components.

5-3. Assemblies and subassemblies are identified by a reference designation beginning with the letter A followed by a number (e.g., A1 etc.). Electrical components appearing on the schematic diagram are identified by their schematic diagram reference designation. Components not appearing on the schematic diagram are consecutively numbered throughout the parts list. These components are identified with whole numbers on the arrow call-out illustrations and by index numbers on the grid illustrations. Flagnotes are used throughout the parts list and refer to special ordering explanations that are located in close proximity to the flagnotes.

5-4. COLUMN DESCRIPTION

a. The REF DESIG column indexes the item description to the associated illustration. In general the reference designations are listed under each assembly in alpha-numeric order. Subassemblies of minor proportions are sometimes listed with the assembly of which they are a part. In this case, the reference designations for the components of the subassembly may appear out of order.

b. The INDEX NO. column lists coordinates which locate the designated part on the associated grid illustrations.

c. The DESCRIPTION column describes the salient characteristics of the component. Indention of the description indicates the relationship to other assemblies, components, etc. In many cases it is necessary to abbreviate in this column. For abbreviations and symbols used, see the following page.

d. The six-digit part number, by which the item is identified at the John Fluke Mfg. Co., is listed in the STOCK NO. column. Use this number when ordering parts from the factory or authorized representatives.

e. The Federal Supply Code for the item manufacturer is listed in the MFR column. An abbreviated list of Federal Supply Codes is included in the Appendix.

f. The part number which uniquely identifies the item to the original manufacturer is listed in the MFR PART NO. column. If a component must be ordered by description, the type number is listed.

g. The TOT QTY column lists the total quantity of the items used in the instrument and reflects the latest Use Code. Second and subsequent listings of the same item are referenced to the first listing with the abbreviation REF. In the case of optional subassemblies, plug-ins, etc., that are not always part of the instrument or are deviations from the basic instrument model, the TOT QTY column lists the total quantity of the item in that particular assembly.

h. Entries in the REC QTY column indicate the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of every part in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc., that are not always part of the instrument or are deviations from the basic instrument model, the REC QTY column lists the recommended quantity of the item in that particular assembly.

i. The USE CODE column identifies certain parts which have been added, deleted or modified during

ing the production of an instrument. Each part for which a Use Code has been assigned in the basic 8300A may be identified with a particular instrument serial number by consulting the Serial Number Effectivity List, Paragraph 5-9. Each additional option printed circuit assembly has also been assigned a serial number unique to that particular option. The changes and Serial Number Effectivity List for these printed circuit board assemblies are located in their respective Section 6 option subsection. Sometimes when a part is changed, the new part can and should be used as a replacement for the original part.

5-5. HOW TO OBTAIN PARTS

5-6. Standard components have been used wherever possible. Standard components may be ordered directly from the manufacturer by using the manufacturer's part number, or parts may be ordered from the John Fluke Mfg. Co. factory or authorized representative by using the Fluke part number. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-7. You can insure prompt and efficient handling of your order to the John Fluke Mfg. Co. if you include the following information:

a. Quantity.

b. FLUKE Stock Number.

c. Description.

d. Reference Designation.

e. Instrument model and serial number.

Example: 2 each, 177105, Transistors, 2N3565, Q107-108 for 845AR, s/n 168.

5-8. If you must order structural parts not listed in the parts list, describe the part as completely as possible. A sketch of the part, showing its location to other parts of the instrument, is usually most helpful.

5-9. SERIAL NUMBER EFFECTIVITY

5-10. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8300A. Each part for which a Use Code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity List below. However, these Use Codes and Serial Numbers apply only to the basic configuration. All parts with no Use Code are used on all instruments with serial numbers 123 and above. For additional option printed circuit board changes and serial number assignments, see the respective Section 6 option subsection.

USE CODE	SERIAL NUMBER EFFECTIVITY
A	123 thru 1147
B	1148 and on.
C	123 thru 1226
D	1227 and on.
E	123 thru 1495
F	1496 and on.
G	1750 and on.
H	123 thru 2040
I	2041 and on.
J	123 thru 2125
K	2126 and on.
L	123 thru 2335
M	2336 and on.
N	123 thru 2498
O	2499 and on.
P	123 thru 2735
Q	2736 and on.
R	123 thru 3479
S	3480 and on.
T	123 thru 49399
U	49400 and on.
V	123 thru 60399
W	60400 and on.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		DIGITAL VOLTMETER Figure 5-1	8300A					
A1		Front Panel Assembly	270900	89536	270900	1		
		Handle	246306	89536	246306	2		
		Panel, metal	270462	89536	270462	1		
		Panel, plastic	272856	89536	272856	1		
A2		Rear Panel Assembly	270918	89536	270918	1		
A3		Logic & A/D Assembly (Figure 5-2)	270793	89536	270793	1		
A4		Buffer P/C Assembly (Figure 5-3)	270801	89536	270801	1		
A5		Function Display Assembly	270827	89536	270827	1		
		Lamp, incandescent, 5v, 15 ma ±10%	272476	08108	USASI 7209	9	18	
A6		Interconnect Board	270819	89536	270819	1		
J1, J3		Binding, post, red, HI	275552	89536	275552	2		
J2, J4		Binding post, black, LO	275560	89536	275560	2		
J5		Binding post, blue, GUARD	275578	89536	275578	1		
R49		Res, var, comp, 150k ±20%, ½w	267930	71450	Series 45	1		
S1		Switch, pushbutton, POWER	268680	89536	268680	1		H
S1		Switch, pushbutton, POWER	291526	89536	291526	1		I
		Cover, bottom with feet & bail stand	270926	89536	270926	1		
		Cover, Data Output	270629	89536	270629	1		
		Cover, Rear Terminal	270637	89536	270637	1		
		Cover, top	230391	89536	230391	1		
		Kit, Rack Mounting	243287	89536	243287	1		
		Knob, SAMPLE RATE	190249	89536	190249	1		
		Line cord	226100	70903	17258	1		R
		Line cord	284174	70903	KHS7041	1		S
		Pushbutton, gray	268896	71590	J52304	14		
		Pushbutton, green	268862	71590	J61993	1		
		Shorting link	101220	24655	0938-9712	3		
		Switch actuator	270652	89536	270652	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A2		**REAR PANEL ASSEMBLY**	270918	89536	270918	REF		
F1		Fuse, slow-blow, ¼ amp, 250v (for 115v operation)	166306	71400	Type MDL	1	2	
F1		Fuse, slow-blow, 1/8 amp, 250v (for 230v operation)	166488	71400	Type MDL	1	2	
P1		Connector, male, 3 contact	222612	82389	AC3G	1		R
P1		Connector, male, 3 contact	284166	82389	EAC301	1		S
S2		Switch, slide, Line Voltage	226274	82389	46256LF	1		
T1		Transformer, power	275370	89536	275370	1		
TB1		Terminal strip, barrier	276519	71785	Type 140	1		
XF1		Fuse holder	100107	71400	HKP	1		R
XF1		Fuse holder	295741	75915	348-6-9-9	1		S

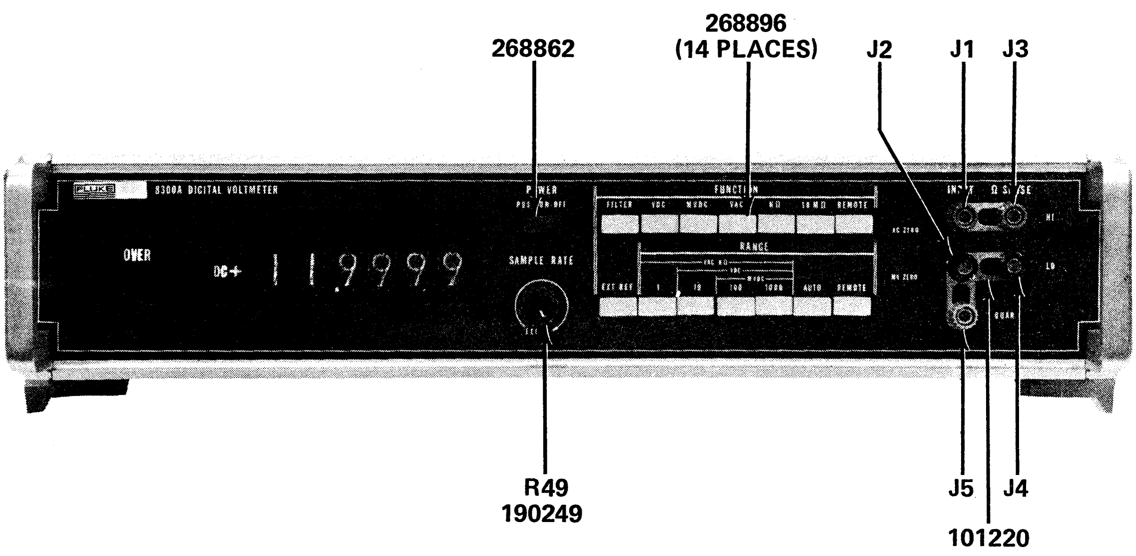


Figure 5-1. MODEL 8300A DIGITAL VOLTMETER (Sheet 1 of 2)

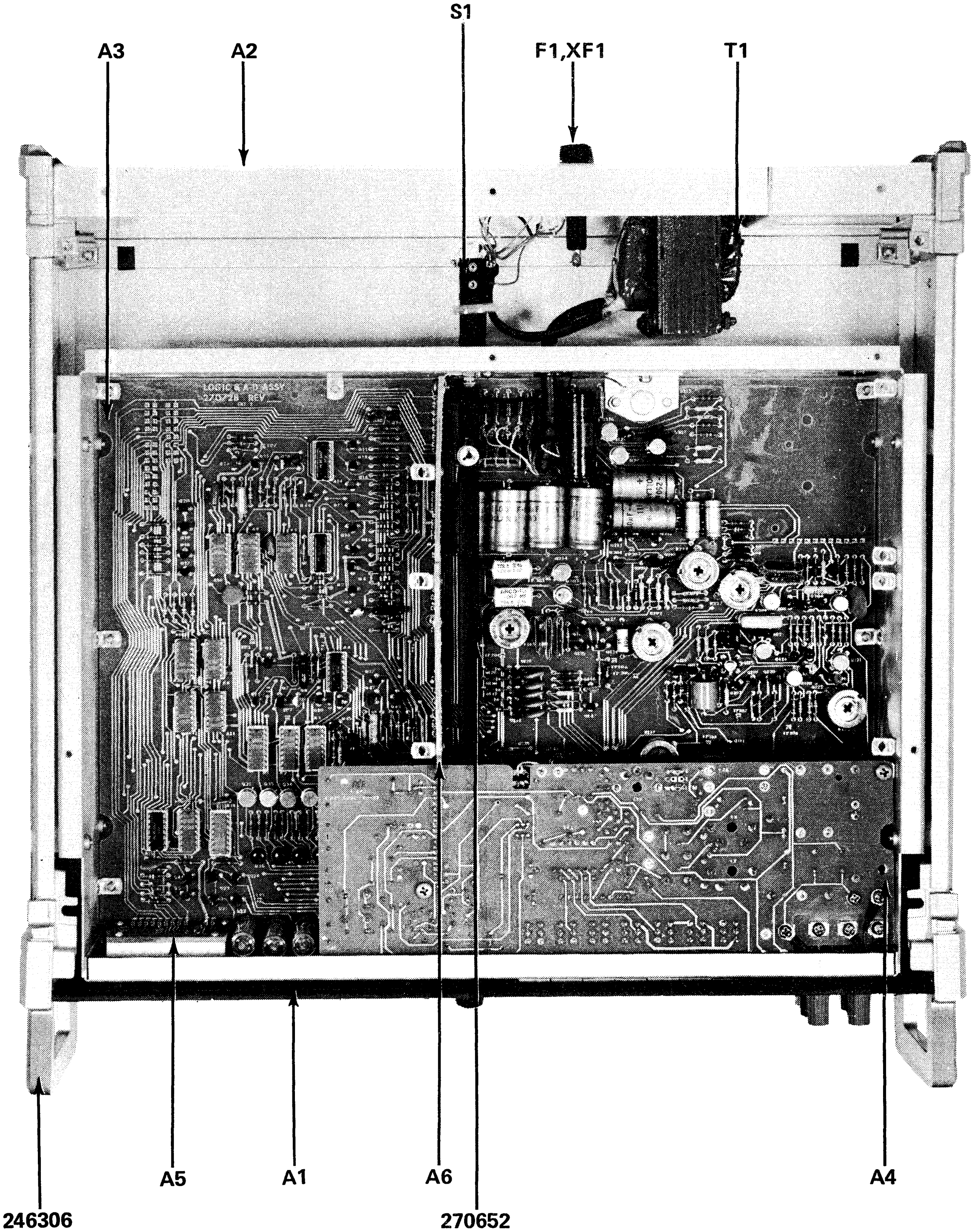


Figure 5-1. MODEL 8300A DIGITAL VOLTMETER (Sheet 2 of 2)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A3		**LOGIC & A/D P/C ASSEMBLY Figure 5-2**	270793	89536	270793	REF		
A1	D5-P2	IC, TTL, dual J-K flip flop	268441	18324	SP322B	6	2	
A2	D5-P5	IC, TTL, dual J-K flip flop	268441	18324	SP322B	REF		
A3	D5-Q2	IC, TTL, dual J-K flip flop	268441	18324	SP322B	REF		
A4	F1-Q4	IC, DTL, dual 4-Input Nand	268383	04713	MC832P	1	1	
A5	H1-P5	IC, TTL, triple 3-Input Nor Gate	268565	18324	SP370A	3	1	
A6	D2-R4	IC, TTL, dual J-K flip flop	268441	18324	SP322B	REF		
A7	D2-R1	IC, TTL, dual J-K flip flop	268441	18324	SP322B	REF		
A8	F2-O4	IC, TTL, dual 4-Input Nor Gate	268557	18324	SP317A	2	1	
A9	H1-P2	IC, TTL, triple 3-Input Nor Gate	268565	18324	SP370A	REF		
A10	F2-O2	IC, TTL, Quad 2-Input Nor Gate	268540	18324	SP380A	3	1	
A11	E3-O4	IC, TTL, triple 3-Input Nor Gate	268565	18324	SP370A	REF		
A12	E3-O2	IC, TTL, dual 4-Input Nor Gate	268557	18324	SP317A	REF		
A13	C4-O2	IC, TTL, Quad 2-Input Nor Gate	268540	18324	SP380A	REF		
A14	I2-Q3	IC, DTL, Quad 2-Input Nand Gate	268375	04713	MC846P	2	1	
A15	C3-N5	IC, DTL, Quad 2-Input Nand Gate	268375	04713	MC846P	REF		
A16	H1-O5	IC, TTL, Quad 2-Input Nor Gate	268540	18324	SP380A	REF		
A17	C3-R3	IC, Decoder driver, DM/SN7441AN, NS8840N	267211	89536	267211	1	1	
A18	C3-O5	IC, TTL, dual J-K flip flop	268441	18324	SP322B	REF		
A19	H1-Q2	IC, DTL, triple 3-Input Nand Gate	266312	04713	MC862P-6909	1	1	
A101	C2-X4	IC, operational amplifier	271502	12040	LM301A	2	1	
A102	F2-X1	IC, operational amplifier	271502	12040	LM301A	REF		
A201	G1-X2	IC, reference amplifier	▷1				1	
C1	D5-Q5	Cap, mica, 5600 pf ±2%, 500v	182873	14655	CD19F562G	1		
C2	G3-P1	Cap, cer, 0.025 uf ±20%, 100v	168435	56289	C023B101H-253M	2		
C3	F5-R3	Cap, mica, 470 pf ±5%, 500v	148429	14655	CD19F471J	1		
C4	F4-R3	Cap, cer, 180 pf ±10%, 1 kv	105890	71590	BB60181K-S3N	1		
C5	F1-Q1	Cap, mica, 1500 pf ±5%, 500v	148361	14655	CD19F152J	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C6	D1-O5	Cap, cer, 0.0012 uf ±10%, 500v	106732	71590	CF-122	1		P
C6	D1-O5	Cap, cer, 0.05 μf ±10%, 500v	148924	72982	5855X5U-5032	1		Q
C7	H4-P1	Cap, Ta, 6.8 uf ±10%, 35v	182782	56289	150D685X-9035B2	1	1	
C8	C1-N4	Cap, cer, 0.025 uf ±20%, 100v	168435	56289	C023B101H-253M	REF		
C9	C3-R5	Cap, elect, 100μf +50/–10%, 25v	192914	73445	ET101X025A5	1	1	
C10	H1-P3	Cap, cer, 2000 pf, gmv, 1 kv	105569	71590	DA140-139CB	1		
C11	H5-O4	Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/A 100K	1		
C101	C1-Y2	Cap, mica, 390 pf ±5%, 500v	148437	14655	CD15F391J	4		
C102	C3-Y2	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	2		
C103	C1-Y2	Cap, mica, 390 pf ±5%, 500v	148437	14655	CD15F391J	REF		
C105	F3-W4	Cap, mica, 390 pf ±5%, 500v	148437	14655	CD15F391J	REF		
C106	F3-W4	Cap, mica, 390 pf ±5%, 500v	148437	14655	CD15F391J	REF		
C107	F3-X1	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	REF		
C108	G1-T2	Cap, plstc, 0.047 uf ±2%, 100v	170449	84171	1PJ473G	2		
C109	G3-T2	Cap, plstc, 0.047 uf ±2%, 100v	170449	84171	1PJ473G	REF		
C110	E2-T4	Cap, cer, 3300 pf ±20%, 1kv	106674	56289	C023B102G-332M	5		
C111	E3-T4	Cap, cer, 3300 pf ±20%, 1 kv	106674	56289	C023 B102G 332M	REF		
C112	E4-T4	Cap, cer, 3300 pf ±20%, 1 kv	106674	56289	C023B102G 332M	REF		
C113	E4-T4	Cap, cer, 3300 pf ±20%, 1 kv	106674	56289	C023B102G 332M	REF		
C114	F1-T4	Cap, cer, 3300 pf ±20%, 1 kv	106674	56289	C023B102G 332M	REF		
C115	F5-X2	Cap, plstc, 0.47 uf ±10%, 250v	184366	73445	C280AE/A 470K	2		
C116	C5-Y2	Cap, plstc, 0.47 uf ±10%, 250v	184366	73445	C280AE/A 470K	REF		
C117	F3-V1	Cap, cer, 15 pf ±10%, 500v	159947	00656	Type C1-1	1		
C201	I4-U2	Cap, elect, 8 uf + 150/–10%, 350v	275792	14655	BR8-350	1	1	
C202	H3-V3	Cap, elect, 250 uf +50/–10%, 40v	178616	73445	C437ARG250	2	1	
C203	H3-W3	Cap, elect, 50 uf +50/–10%, 25v	168823	73445	C426ARF50	2	1	

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C204	G3-Y1	Cap, Ta, 1 uf ±20%, 35v	161919	56289	196D105X 0035	1		
C205	G1-Y3	Cap, cer, 0.01 uf +80/−20%, 500v	105668	56289	C023B501J 103M	1		
C206	H5-V3	Cap, elect, 250 uf +50/−10%, 40v	178616	73445	C437ARG250	REF		
C207	H3-W1	Cap, elect, 50 uf +50/−10%, 25v	168823	73445	C426ARF50	REF		
C208	H3-S4	Cap, elect, 1600 uf +50/−10%, 10v	272732	73445	C437ARD 1600	4	1	
C209	H3-T2	Cap, elect, 1600 uf +50/−10%, 10v	272732	73445	C437ARD 1600	REF		
C210	H3-T5	Cap, elect, 1600 uf +50/−10%, 10v	272732	73445	C437ARD 1600	REF		
C211	H3-U3	Cap, elect, 1600 uf +50/−10%, 10v	272732	73445	C437ARD 1600	REF		
CR3	I3-P1	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	8	2	
CR4	G1-Q2	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR5	C4-Q5	Diode, silicon, 150 ma	203323	03508	DHD1105	18	7	
CR6	B4-N5	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR7	B4-N5	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR8	E4-O3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR10	G5-Q1	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR11	G3-N5	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR12	H4-P3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR13	F4-O2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR14	D1-O2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR15	F1-Q2	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR16	D1-R2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR101	C2-X1	Diode, silicon, 150 ma, 125 piv	272252	07263	FD333	3	1	
CR102	C2-X1	Diode, silicon, 150 ma, 125 piv	272252	07263	FD333	REF		
CR103	D3-X2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR104	D1-X2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR105	E4-V4	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR106	E4-V5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR107	D2-Y2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
CR108	D3-Y2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR109	F5-U2	Diode, silicon, 150 ma, 125 piv	272252	07263	FD333	REF		
CR110	C3-X1	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR112	D3-T4	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR113	D2-T4	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR114	C5-T4	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR115	C1-T3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR116	E5-U4	Diode, silicon, 75 ma, 100 piv	260554	07910	CD55105	1	1	
CR118	D2-X2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR119	F3-Y1	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR201	I3-S5	Diode, silicon, 1 amp, 600 piv	112383	05277	1N4822	4	1	
CR202	J1-S5	Diode, silicon, 1 amp, 600 piv	112383	05277	1N4822	REF		
CR203	I3-T1	Diode, silicon, 1 amp, 600 piv	112383	05277	1N4822	REF		
CR204	J1-T1	Diode, silicon, 1 amp, 600 piv	112383	05277	1N4822	REF		
CR205	I3-T4	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	8	2	
CR206	J1-T4	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR207	I3-T5	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR208	J1-T5	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR209	G3-X5	Diode, silicon, 200 ma, 25 piv	190272	93332	1N456A	4	1	
CR212	H1-W4	Diode, silicon, 200 ma, 25 piv	190272	93332	1N456A	REF		
CR213	G5-W4	Diode, silicon, 200 ma, 25 piv	190272	93332	1N456A	REF		
CR214	G4-W4	Diode, silicon, 200 ma, 25 piv	190272	93332	1N456A	REF		
CR215	J1-T2	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR216	I3-T2	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR217	J1-T3	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR218	I3-T3	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR219	G1-V2	Diode, zener, 6.3v, 7.5 ma	172148	03877	1N3496	1	1	
Q1	F1-P3	Tstr, silicon, NPN	218396	04713	2N3904	16	5	
Q2	G2-Q5	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q3	F5-Q5	Tstr, silicon, NPN	218396	04713	2N3904	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q4	G3-Q5	Tstr, silicon, PNP	195974	04713	2N3906	21	5	
Q5	B3-O2	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q6	E3-P2	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q7	E3-P4	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q8	E3-Q1	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q9	E3-Q4	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q10	E3-Q2	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q11	I3-Q5	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q12	H4-Q5	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q13	I2-Q5	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q14	H5-Q5	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q15	G5-Q5	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q16	H2-Q5	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q17	G3-O2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q18	G5-O2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q19	H2-O2	Tstr, FET, N-channel	288324	15818	U1994E	12	2	
Q20	H3-O2	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q21	B3-O4	Tstr, silicon, NPN	245480	07263	S24496	5	1	
Q22	B3-P1	Tstr, silicon, NPN	245480	07263	S24496	REF		
Q23	B5-O4	Tstr, silicon, NPN	245480	07263	S24496	REF		
Q24	B5-P1	Tstr, silicon, NPN	245480	07263	S24496	REF		
Q25	I2-P2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q26	I2-P1	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q27	E5-R2	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q28	I2-P4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q29	J1-R3	Tstr, silicon, NPN	168708	03508	2N3391	8	2	
Q30	J1-R1	Tstr, silicon, NPN	168708	03508	2N3391	REF		
Q31	D1-P2	Tstr, silicon, NPN	218511	95303	60994	7	2	
Q32	D1-Q3	Tstr, silicon, NPN	218511	95303	60994	REF		
Q33	D1-Q1	Tstr, silicon, NPN	218511	95303	60994	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q34	D1-P5	Tstr, silicon, NPN	218511	95303	60994	REF		
Q35	D1-P3	Tstr, silicon, NPN	218511	95303	60994	REF		
Q36	C1-P2	Tstr, silicon, PNP	266619	07263	2N4888	5	1	
Q37	C1-Q4	Tstr, silicon, PNP	266619	07263	2N4888	REF		
Q38	C1-Q2	Tstr, silicon, PNP	266619	07263	2N4888	REF		
Q39	C1-Q1	Tstr, silicon, PNP	266619	07263	2N4888	REF		
Q40	C1-P4	Tstr, silicon, PNP	266619	07263	2N4888	REF		
Q41	C1-Q5	Tstr, silicon, NPN	245480	07263	S24496	REF		
Q42	E3-R2	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q43	E3-R3	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q44	H5-Q1	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q45	E1-Q4	Tstr, silicon, unijunction	268110	03508	2N6027	3	1	
Q46	B5-Q2	Tstr, silicon, unijunction	268110	03508	2N6027	REF		
Q47	I2-P5	Tstr, silicon, unijunction	268110	03508	2N6027	REF		
Q101	B5-X4	Tstr, FET, dual, N-channel	257501	17856	DN423	2	1	
Q102	E4-W4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q103	B4-X2	Tstr, FET, N-channel	271924	07910	CFE13041	4	1	
Q104	C4-X4	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q105	C4-X3	Tstr, FET, N-channel	271924	07910	CFE13041	REF		
Q106	D1-X5	Tstr, silicon, PNP	288761	07933	RS2048	6		
Q107	D2-X5	Tstr, silicon, PNP	288761	07933	RS2048	REF		
Q108	C2-W1	Tstr, silicon, PNP	195974	14713	2N3906	REF		
Q109	C2-W4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q110	E5-X4	Tstr, germanium, PNP	182709	01295	GA3938	5	1	
Q111	D4-W4	Tstr, FET, N-channel	[2]				1	
Q112	D2-X1	Tstr, FET, N-channel	[2]					
Q113	E5-W1	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q114	E5-V4	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q115	F1-W4	Tstr, FET, Dual, N-channel	257501	17856	DN423	REF		
Q116	E4-Y2	Tstr, silicon, PNP	288761	07933	RS2048	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q117	F2-X5	Tstr, FET, N-channel	271924	07910	CFE13041	REF		
Q118	F1-X3	Tstr, FET, N-channel	271924	07910	CFE13041	REF		
Q119	E4-X1	Tstr, silicon, PNP	288761	07933	RS2048	REF		
Q120	E4-X2	Tstr, silicon, PNP	288761	07933	RS2048	REF		
Q121	F1-Y2	Tstr, silicon, NPN	220087	03508	12E-1516	1	1	
Q122	E5-Y1	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q123	E5-X5	Tstr, silicon, PNP	288761	07933	RS2048	REF		
Q124	F2-U4	Tstr, FET, N-channel	261388	04713	SPF179	6	2	
Q125	F2-U2	Tstr, FET, N-channel	261388	04713	SPF179	REF		
Q126	F4-U2	Tstr, FET, N-channel	261388	04713	SPF179	REF		
Q127	F4-U4	Tstr, FET, N-channel	261388	04713	SPF179	REF		
Q128	F1-T2	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q129	E5-T2	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q130	E4-T2	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q131	E2-T2	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q132	E3-T2	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q133	D3-U1	Tstr, germanium, NPN	182691	01295	GA3937	4	1	
Q134	D2-U2	Tstr, germanium, PNP	182709	01295	GA3938	REF		
Q135	D4-T3	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q136	D1-U1	Tstr, germanium, NPN	182691	01295	GA3937	REF		
Q137	C5-U2	Tstr, germanium, PNP	182709	01295	GA3938	REF		
Q138	D2-T4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q139	C4-U1	Tstr, germanium, NPN	182691	01295	GA3937	REF		
Q140	C3-U2	Tstr, germanium, PNP	182709	01295	GA3938	REF		
Q141	D1-T4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q142	C2-U1	Tstr, germanium, NPN	182691	01295	GA3937	REF		
Q143	C1-U2	Tstr, germanium, PNP	182709	01295	GA3938	REF		
Q144	C4-T4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q145	E5-W3	Tstr, FET, N-channel	2					
Q146	E4-U3	Tstr, FET, N-channel	261388	04713	SPF179	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q147	E2-U3	Tstr, FET, N-channel	261388	04713	SPF179	REF		
Q201	I3-V3	Tstr, silicon, NPN	218511	95303	60994	REF		
Q202	I2-V1	Tstr, silicon, NPN	218511	95303	60994	REF		
Q203	G1-U1	Tstr, silicon, PNP	269076	95303	2N4037	1	1	
Q204	G4-U5	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q205	G1-Y2	Tstr, silicon, PNP	246462	04713	SS7526	1	1	
Q206	G1-Y1	Tstr, silicon, NPN	168708	03508	2N3391	REF		
Q207	G1-X5	Tstr, silicon, NPN	168708	03508	2N3391	REF		
Q208	G1-X3	Tstr, silicon, NPN	168708	03508	2N3391	REF		
Q209	G4-V2	Tstr, silicon, NPN	168708	03508	2N3391	REF		
Q210	G4-V4	Tstr, silicon, NPN	168708	03508	2N3391	REF		
Q211	H1-V3	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q212	H1-V2	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q213	H1-U5	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q214	G3-U1	Tstr, silicon, NPN	150359	95303	2N3053	2	1	
Q215	J2-V2	Tstr, silicon, NPN	170787	95303	2N3054	1	1	
Q216	I4-U5	Tstr, silicon, NPN	150359	95303	2N3053	REF		
Q217	I4-V1	Tstr, silicon, NPN	168708	03508	2N3391	REF		
Q218	G1-Y4	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q219	E3-V3	Tstr, FET, N-channel	288324	15818	U1994E	REF		O
R1	E1-R1	Res, met flm, 750k ±1%, ½w	155192	91637	Type MFF½	1		
R2	E1-R1	Res, met flm, 110k ±1%, 1/8w	234708	91637	Type MFF1/8	1		
R3	D4-Q4	Res, met flm, 46.4k ±1%, 1/8w	188375	91637	Type MFF1/8	1		
R4	B3-N5	Res, comp, 470Ω ±5%, ¼w	147983	01121	CB4715	4		
R5	F1-P3	Res, comp, 820Ω ±5%, ¼w	148015	01121	CB8215	3		
R6	H1-N5	Res, comp, 470Ω ±5%, ¼w	147983	01121	CB4715	REF		
R7	G1-R2	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	5		
R8	F5-R2	Res, comp, 27k ±5%, ¼w	148148	01121	CB2735	5		
R9	F4-R2	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	5		
R10	G3-R2	Res, comp, 27k ±5%, ¼w	148148	01121	CB2735	REF		
R11	G2-R2	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	9		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R12	F1-Q2	Res, comp, 2.7k ±5%, ¼w	170720	01121	CB2725	6		
R13	F1-P5	Res, comp, 1.5k ±5%, ¼w	148031	01121	CB1525	9		
R14	F1-P2	Res, comp, 8.2k ±5%, ¼w	160796	01121	CB8225	9		
R15	H5-R5	Res, comp, 8.2k ±5%, ¼w	160796	01121	CB8225	REF		
R16	I3-R2	Res, comp, 1.5k ±5%, ¼w	148031	01121	CB1525	REF		
R17	H3-R2	Res, comp, 1.5k ±5%, ¼w	148031	01121	CB1525	REF		
R18	H4-R2	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	3		
R19	H4-R2	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	8		
R20	I2-R2	Res, comp, 1.5k ±5%, ¼w	148031	01121	CB1525	REF		
R21	I2-R2	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R22	H5-R2	Res, comp, 1.5k ±5%, ¼w	148031	01121	CB1525	REF		
R23	I1-R2	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R24	G4-R2	Res, comp, 1.5k ±5%, ¼w	148031	01121	CB1525	REF		
R25	G5-R2	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R26	H2-R2	Res, comp, 1.8k ±5%, ¼w	175042	01121	CB1825	1		
R27	H1-R2	Res, comp, 680Ω ±5%, ¼w	148007	01121	CB6815	1		
R28	G2-R2	Res, comp, 1.5k ±5%, ¼w	148031	01121	CB1525	REF		
R29	G1-O1	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	8		
R30	G1-O3	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R31	G1-N5	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R32	G1-O2	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R33	B5-N5	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R35	C1-O2	Res, comp, 2.7k ±5%, ¼w	170720	01121	CB2725	REF		
R36	B5-N5	Res, comp, 6.8k ±5%, ¼w	148098	01121	CB6825	2		
R37	C1-O5	Res, comp, 1.2k ±5%, ¼w	190371	01121	CB1225	3		
R38	C1-O5	Res, comp, 1.2k ±5%, ¼w	190371	01121	CB1225	REF		
R39	H5-P2	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	1		
R40	H5-P1	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R41	I4-P1	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R42	H5-P4	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	4		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R43	H5-P3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R44	G5-N5	Res, comp, 470Ω ±5%, ¼w	147983	01121	CB4715	REF		
R45	G4-N5	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R46	H2-R5	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R47	G4-R2	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R48	B4-R5	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		V
R48	B4-R5	Res, comp, 3k ±5%, ¼w	193508	01121	CB3025	1		W
R50	E1-R3	Res, comp, 27k ±5%, ¼w	148148	01121	CB2735	REF		
R51	E1-R5	Res, comp, 2.7k ±5%, ¼w	170720	01121	CB2725	REF		
R52	E1-R3	Res, comp, 27k ±5%, ¼w	148148	01121	CB2735	REF		
R53	G2-Q2	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R54	G3-Q2	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R55	H5-R4	Res, comp, 8.2k ±5%, ¼w	160796	01121	CB8225	REF		
R56	C3-R1	Res, comp, 820Ω ±5%, ¼w	148015	01121	CB8215	REF		
R57	H2-R4	Res, comp, 8.2k ±5%, ¼w	160796	01121	CB8225	REF		
R58	C4-P2	Res, comp, 8.2k ±5%, ¼w	160796	01121	CB8225	REF		
R59	C4-Q3	Res, comp, 8.2k ±5%, ¼w	160796	01121	CB8225	REF		
R60	C4-Q1	Res, comp, 8.2k ±5%, ¼w	160796	01121	CB8225	REF		
R61	C4-P4	Res, comp, 8.2k ±5%, ¼w	160796	01121	CB8225	REF		
R62	C4-P3	Res, comp, 8.2k ±5%, ¼w	160796	01121	CB8225	REF		
R63	C4-Q4	Res, comp, 2.7k ±5%, ¼w	170720	01121	CB2725	REF		
R64	C4-P3	Res, comp, 1.2M ±5%, ¼w	188425	01121	CB1255	5		
R65	C4-Q2	Res, comp, 1.2M ±5%, ¼w	188425	01121	CB1255	REF		
R66	C4-Q1	Res, comp, 1.2M ±5%, ¼w	188425	01121	CB1255	REF		
R67	C4-P5	Res, comp, 1.2M ±5%, ¼w	188425	01121	CB1255	REF		
R68	C4-P4	Res, comp, 1.2M ±5%, ¼w	188425	01121	CB1255	REF		
R69	G2-P2	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R70	G1-P2	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R71	D4-Q3	Res, comp, 47Ω ±5%, ¼w	147892	01121	CB4705	2		
R72	H5-P5	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R73	I3-P1	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R74	H5-P5	Res, comp, 47Ω ±5%, ¼w	147892	01121	CB4705	REF		
R75	H5-O5	Res, comp, 2.7k ±5%, ¼w	170720	01121	CB2725	REF		
R76	E1-R2	Res, comp, 2.7k ±5%, ¼w	170720	01121	CB2725	REF		
R77	E1-R4	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R78	I4-R2	Res, comp, 1.5k ±5%, ¼w	148031	01121	CB1525	REF		
R79	I4-R2	Res, comp, 1.5k ±5%, ¼w	148031	01121	CB1525	REF		
R80	G1-Q2	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		
R81	H2-N5	Res, comp, 150Ω ±5%, ¼w	147934	01121	CB1515	1		
R82	C4-Q3	Res, comp, 820Ω ±5%, ¼w	148015	01121	CB8215	REF		
R83	G5-N5	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R84	I2-Q4	Res, comp, 470Ω ±5%, ¼w	147983	01121	CB4715	REF		G
R101	B3-Y1	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R102	B5-X1	Res, ww, 10k, factory matched to R103	▷3					
R103	C1-X1	Res, ww, 10k, factory matched to R102	▷3					
R104	B5-Y1	Res, met flm, 45.3k ±1%, 1/8w	234971	91637	Type MFF1/8	3		
R105	B4-Y1	Res, met flm, 45.3k ±1%, 1/8w	234971	91637	Type MFF1/8	REF		
R106	B5-Y1	Res, met flm, 49.9k ±1%, 1/8w	268821	91637	Type MFF1/8	1		
R107	E2-X3	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R108	C2-Y2	Res, comp, 68k ±5%, ¼w	148171	01121	CB6835	4		
R109	C3-Y2	Res, comp, 220Ω ±5%, ¼w	147959	01121	CB2215	1		
R110	E2-X4	Res, comp, 33k ±5%, ¼w	148155	01121	CB3335	3		
R111	C4-X1	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R112	F4-T5	Res, comp, 3.9Ω ±5%, ¼w	268722	01121	CB39G5	2		
R113	E2-W5	Res, comp, 120Ω ±5%, ¼w	170712	01121	CB1215	1		
R114	E3-W3	Res, comp, 82Ω ±5%, ¼w	149484	01121	CB8205	1		
R115	C4-X1	Res, comp, 33k ±5%, ¼w	148155	01121	CB3335	REF		
R116	C5-X1	Res, comp, 33k ±5%, ¼w	148155	01121	CB3335	REF		
R117	D1-Y2	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R118	D1-Y2	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R119	D1-X2	Res, comp, 5.6K±5%, ¼w	148080	01121	CB5625	5		
R120	D2-Y2	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	7		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R121	D3-Y2	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		
R122	E2-T1	Res, comp, 51k ±5%, ¼w	193334	01121	CB5135	6		
R123	E3-T1	Res, comp, 51k ±5%, ¼w	193334	01121	CB5135	REF		
R124	E4-T1	Res, comp, 51k ±5%, ¼w	193334	01121	CB5135	REF		
R125	E5-T1	Res, comp, 51k ±5%, ¼w	193334	01121	CB5135	REF		
R126	F1-T1	Res, comp, 51k ±5%, ¼w	193334	01121	CB5135	REF		
R127	E2-U1	Res, met flm, 249k ±1%, 1/8w	268805	91637	Type MFF1/8	2		
R128	E3-U1	Res, met flm, 249k ±1%, 1/8w	268805	91637	Type MFF1/8	REF		
R129	E4-U1	Res, met flm, 499k ±1%, 1/8w	268813	91637	Type MFF1/8	1		
R130	E4-U1	Res, comp, 1M ±5%, ¼w	182204	01121	CB1055	3		
R131	E5-U1	Res, comp, 2M ±5%, ¼w	268771	01121	CB2055	2		
R132	E5-U1	Res, comp, 2M ±5%, ¼w	268771	01121	CB2055	REF		
R133	D3-U5	Res, ww, 50k, factory matched	4					
R134	C5-U5	Res, ww, 50k, factory matched	4					
R135	C3-U5	Res, ww, 100k, factory matched	4					
R136	C1-U5	Res, ww, 200k, factory matched	4					
R137	D4-V3	Res, var, ww, 50Ω ± 20%, 1¼w	112490	71450	Type 110	1		N
R137	D4-V3	Res, var, cer met, 50Ω ± 10%, 1¼w	326082	89536	326082	1		O
R138	C5-V3	Res, var, ww, 100Ω ± 20%, 1¼w	112797	71450	Type 110	1		N
R138	C5-V3	Res, var, cer met, 100Ω ± 10%, 1¼w	326116	89536	326116	1		O
R139	C2-V3	Res, var, ww, 200Ω ± 20%, 1¼w	144766	71450	Type 110	3		N
R139	C2-V3	Res, var, cer met, 200Ω ± 10%, 1¼w	326090	89536	326090	3		O
R140	D3-T1	Res, met flm, 32.4k ±1%, 1/8w	182956	91637	Type MFF1/8	4		
R141	D3-T1	Res, met flm, 7.5k ±1%, 1/8w	223529	91637	Type MFF1/8	4		
R142	D4-T1	Res, comp, 11k ±5%, ¼w	221580	01121	CB1135	5		
R143	D4-T1	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		
R144	C5-T1	Res, met flm, 32.4k ±1%, 1/8w	182956	91637	Type MFF1/8	REF		
R145	D1-T1	Res, met flm, 7.5k ±1%, 1/8w	223529	91637	Type MFF1/8	REF		
R146	D1-T1	Res, comp, 39k ±5%, ¼w	188466	01121	CB3935	1		
R147	D2-T1	Res, comp. 11k ±5%, ¼w	221580	01121	CB1135	REF		
R148	D2-T1	Res, comp, 11k ±5%, ¼w	221580	01121	CB1135	REF		
R149	C3-T3	Res, met flm 32.4k ±1%, 1/8w	182956	91637	Type MFF1/8	REF		
R150	C3-T3	Res, met flm, 7.5k ±1%, 1/8w	223529	91637	Type MFF1/8	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R151	C4-T1	Res, comp, 11k ±5%, ¼w	221580	01121	CB1135	REF		
R152	C4-T1	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		
R153	B5-T4	Res, met flm, 32.4k ±1%, 1/8w	182956	91637	Type MFF 1/8	REF		
R154	C1-T4	Res, met flm, 7.5k ±1%, 1/8w	223529	91637	Type MFF 1/8	REF		
R155	C3-T3	Res, comp, 11k ±5%, ¼w	221580	01121	CB1135	REF		
R156	C2-T3	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		
R157	C1-V5	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R158	C1-W2	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	3		
R160	C1-W2	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R161	C1-W3	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R162	C1-W3	Res, comp, 100k ±5%, ¼w	148189	01121	CB1045	6		
R163	D3-W5	Res, ww, 28.588k, factory matched	4					
R164	C5-W5	Res, ww, 28.588k, factory matched	4					
R165	C4-W3	Res, var, ww, 15Ω ±20%, 1¼w	163634	71450	Type 110	2		N
R165	C4-W3	Res, var, cer met, 20Ω ± 20%, 1¼w	326074	89536	326074	2		O
R166	D3-W3	Res, var, ww, 15Ω ± 20%, 1¼w	163634	71450	Type 110	REF		N
R166	D3-W3	Res, var, cer met, 20Ω ± 20%, 1¼w	326074	89536	326074	REF		O
R169	E2-X5	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R170	E3-V4	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		
R171	E3-W3	Res, met flm, 45.3k ±1%, 1/8w	234971	91637	Type MFF1/8	REF		
R172	E2-Y3	Res, var, ww, 150Ω ±20%, 1¼w	163642	71450	Type 110	1		N
R172	E2-Y3	Res, var, cer met, 200Ω ± 20%, 1¼w	326090	89536	326090	REF		O
R173	F2-W1	Res, met flm, 21.5k ±1%, 1/8w	168278	91637	Type MFF1/8	1		
R174	F2-W2	Res, met flm, 22.1k ±1%, 1/8w	235234	91637	Type MFF1/8	1		
R175	F2-W2	Res, comp, 820k ±5%, ¼w	220541	01121	CB8245	1		
R177	F3-X5	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		
R178	F3-X3	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R179	F3-X4	Res, comp, 100k ±5%, ¼w	148189	01121	CB1045	REF		
R180	E2-X1	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		
R181	E2-X2	Res, comp, 100k ±5%, ¼w	148189	01121	CB1045	REF		
R182	E3-W2	Res, ww, 200k, factory matched	4					
R183	F4-U1	Res, ww, 1.02k ±0.1%, ½w	145128	89536	145128	1		
R184	F3-T4	Res, ww, 5k ±0.03%, ½w	195768	89536	195768	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R185	F4-T2	Res, var, ww, 200Ω ±20%, 1¼w	144766	71450	Type 110	REF		N
R185	F4-T2	Res, var, cermet, 200Ω ±10%, 1¼w	326090	89536	326090	REF		O
R186	F3-X4	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R187	F3-Y3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R188	E2-X5	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		
R189	F3-Y2	Res, comp, 100k ±5%, ¼w	148189	01121	CB1045	REF		
R190	F3-Y2	Res, comp, 100k ±5%, ¼w	148189	01121	CB1045	REF		
R191	F3-X5	Res, comp, 1M ±5%, ¼w	182204	01121	CB1055	REF		
R192	F3-V3	Res, var, ww, 10k ±20%, 1¼w	112862	71450	Type 110	2		N
R192	F3-V3	Res, var, cermet, 10k ±10%, 1¼w	326108	89536	326108	2		O
R193	F3-U1	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		T
R193	F3-U1	Res, comp, 12k ±5%, ¼w	159731	01121	CB1235	1		U
R194	A5-X1	Res, var, comp, 100k ±30%, ¼w	223149	37942	Type MTC-1	1		
R195	E5-U4	Res, comp, 100k ±5%, ¼w	148189	01121	CB1045	REF		
R196	E3-V5	Res, comp, 27k ±5%, ¼w	148148	01121	CB2735	REF		
R201	J2-U4	Res, comp, 510Ω ±5%, ½w	108951	01121	EB5115	1		
R202	I4-W2	Res, comp, 68k ±5%, ¼w	148171	01121	CB6835	REF		
R203	I3-W2	Res, met flm, 357k ±1%, 1/8w	235002	91637	Type MFF1/8	1		
R204	I2-W2	Res, met flm, 39.2k ±1%, 1/8w	236414	91637	Type MFF1/8	1		
R205	G4-W4	Res, comp, 15Ω ±5%, ¼w	147876	01121	CB1505	1		
R206	G1-V1	Res, comp, 3.9M ±5%, ¼w	188417	01121	CB3955	1		
R207	G2-U3	Res, comp, 51Ω ±5%, ½w	144717	01121	EB5105	2		J
R207	G2-U3	Res, comp, 10Ω ±5%, ½w	108092	01121	EB1001	1		K
R208	G1-U5	Res, comp, 5.6k ±5%, ¼w	148080	01121	CB5425	REF		
R209	G1-V4	Res, met flm, 30.9k ±1%, 1/8w	235275	91637	Type MFF1/8	1		C
R209	G1-V4	Res, met flm, 30.9k ±1%, 1/8w	291500	91637	Type MFF1/8	1		D
R210	G3-Y3	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	1		
R211	G3-Y4	Res, comp, 5.6k ±5%, ¼w	148080	01121	CB5625	REF		A
R211	G3-Y4	Res, comp, 560Ω ±5%, ¼w	147991	01121	CB5615	1		B
R212	G2-X5	Res, met flm, factory selected and matched	▷1					
R213	G4-X3	Res, ww, factory selected and matched	▷1					
R214	G3-X5	Res, comp, 1.2k ±5%, ¼w	190371	01121	CB1225	REF		
R215	G1-V2	Res, met flm, 4.22k ±1%, 1/8w	168245	91637	Type MFF1/8	1		C
R215	G1-V2	Res, met flm, 1.87k ±1%, 1/8w	267229	91637	Type MFF 1/8	1		D
R216	F5-W1	Res, comp, 68k ±5%, ¼w	148171	01121	CB6835	REF		
R217	G1-V3	Res, comp, 68k ±5%, ¼w	148171	01121	CB6835	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R218	G1-V3	Res, met flm, 19.1k ±1%, 1/8w	234963	91637	Type MFF1/8	1		C
R218	G1-V3	Res, met flm, 19.1k ±1%, 1/8w	291518	91637	Type MFF1/8	1		D
R219	G3-Y3	Res, comp, 3.9Ω ± 5%, ¼w	268722	01121	CB39G5	REF		
R220	G3-X4	Res, comp, 51k ±5%, ¼w	193334	01121	CB5135	REF		
R221	G3-Y1	Res, met flm, 3.74k ±1%, 1/8w	272096	91637	Type MFF1/8	2		
R222	G2-W5	Res, var, ww, 500Ω ± 10%, 1¼w	112433	71450	Type 110	1		N
R222	G2-W5	Res, var, cermet, 500Ω ±10%, ½w	326124	85936	326124	1		O
R223	G1-W1	Res, met flm, 10k ±1%, 1/8w	168260	91637	Type MFF1/8	3		
R224	H1-W4	Res, comp, 24k ±5%, ¼w	193425	01121	CB2435	1		
R225	G1-U5	Res, comp, 5.6k ±5%, ¼w	148080	01121	CB5625	REF		
R226	H2-W4	Res, comp, 6.8k ±5%, ¼w	148098	01121	CB6825	REF		
R227	I4-W2	Res, comp, 5.6k ±5%, ¼w	148080	01121	CB5625	REF		
R228	I5-W2	Res, met flm, 10k ±1%, 1/8w	168260	91637	Type MFF1/8	REF		
R229	J2-W2	Res, comp, 5.6k ±5%, ¼w	148080	01121	CB5625	REF		
R230	J1-W2	Res, met flm, 42.2k ±1%, 1/8w	221655	91637	Type MFF1/8	1		
R231	G1-W1	Res, met flm, 10k ±1%, 1/8w	168260	91637	Type MFF1/8	REF		
R232	G3-Y2	Res, comp, 1M ±5%, ¼w	182204	01121	CB1055	REF		
R233	G2-U4	Res, comp, 51Ω ±5%, ½w	144717	01121	EB5105	REF		J
R233	G2-U4	Res, comp, 22Ω ±5%, ½w	169847		EB2205	1		K
R234	G4-W2	Res, var, ww, 10k ± 20%, 1¼w	112862	71450	Type 110	REF		N
R234	G4-W2	Res, var, cer met, 10k ±10%, ½w	326108	89536	326108	REF		O
R235	G3-X3	Res, ww, 14k ±0.1%, ¼w	275321	89536	275321	1		
R236	G2-X3	Res, met flm, 3.74k ±1%, 1/8w	272096	91637	Type MMF1/8	REF		
S1	A5-U1	Switch Assembly	268664	89536	268664	1		
V1	B1-P2	Tube, Nixie ®, 0-9 Readout	266502	83594	B5750S	6		L
V1	B1-P2	Tube, Nixie ®, 0-9 Readout	271494			6		M
V2	B1-P4	Tube, Nixie ®, 0-9 Readout	266502	83594	B5750S	REF		L
V2	B1-P4	Tube, Nixie ®, 0-9 Readout	271494			REF		M
V3	B1-Q1	Tube, Nixie ®, 0-9 Readout	266502	83594	B5750S	REF		L
V3	B1-Q1	Tube, Nixie ®, 0-9 Readout	271494			REF		M

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
V4	B1-Q3	Tube, Nixie ®, 0-9 Readout	266502	83594	B5750S	REF		L
V4	B1-Q3	Tube, Nixie ®, 0-9 Readout	271494			REF		M
V5	B1-Q5	Tube, Nixie ®, 0-9 Readout	266502	83594	B575 .S	REF		L
V5	B1-Q5	Tube, Nixie ®, 0-9 Readout	271494			REF		M
V6	B1-R3	Tube, Nixie ®, 0-9 Readout	266502	83594	B5750S	REF		L
V6	B1-R3	Tube, Nixie ®, 0-9 Readout	271494			REF		M
	J3-V1	Heat sink, Q215	270611	89536	270611	1		
		Socket, IC, 14 contact	276527	23880	TSA-2900-14W	12		
		Socket, IC, 16 contact 276535	276535	23880	TSA-2900-16W	7		

1▷ A201, R212 and R213 are a matched set and must be replaced as a set. For replacement, order Reference-Amplifier Set, part number 277814.

2▷ Q111, Q112, and Q145 are a J-FET matched set and must be replaced as a set. For replacement, order part number 274795.

3▷ R102 and R103 are a matched set and must be replaced as a set. For replacement, order Inverting Amplifier Resistor Set, part number 277798.

4▷ R133, R134, R135, R136, R163, R164 and R182 are a matched Ladder Divider Resistor Set, part number 277780. However, the resistors may be replaced individually if model serial number, full reference designation and all information stamped on the old resistor are included when ordering a new one.

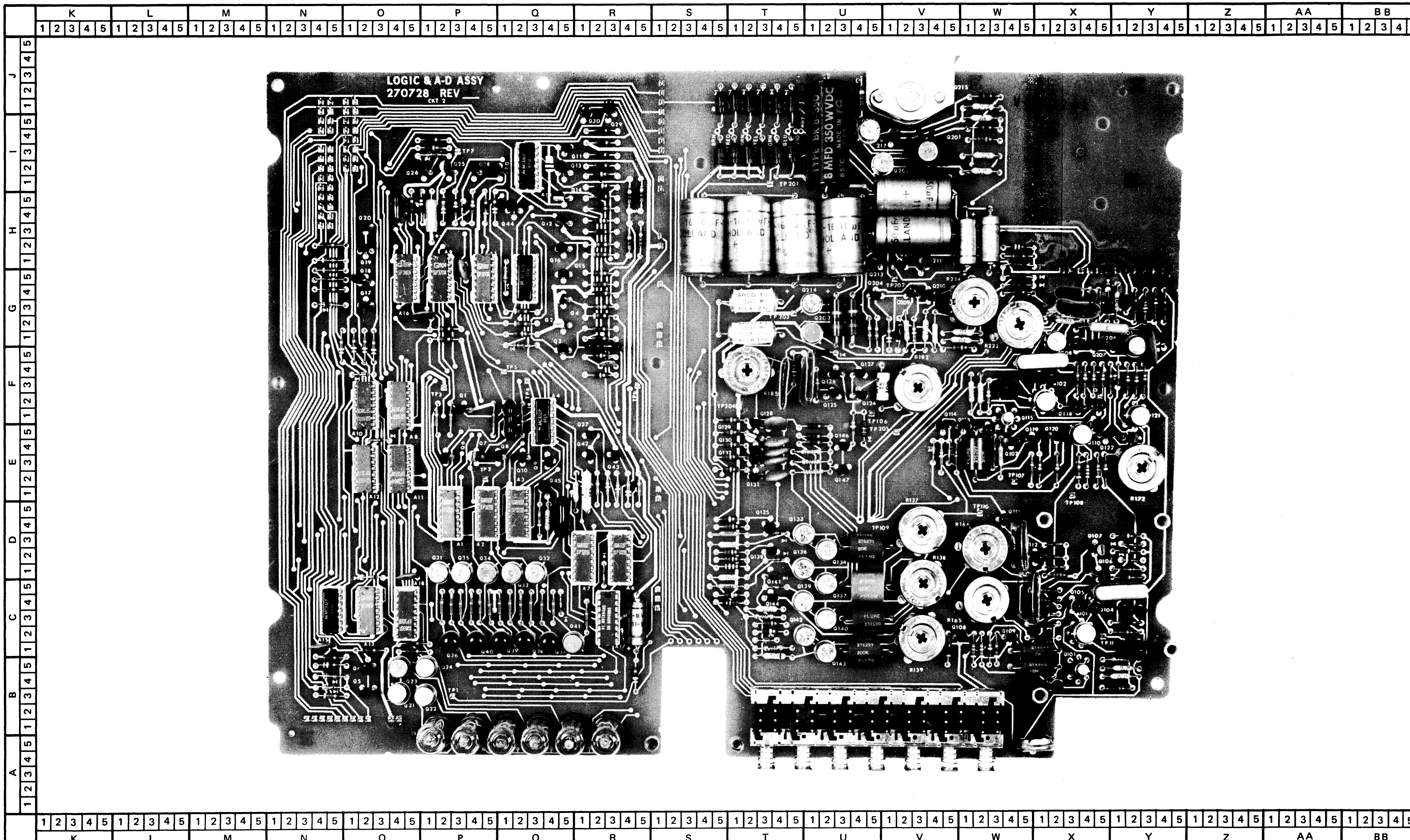


Figure 5-2. LOGIC AND A/D P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A4		**BUFFER P/C ASSEMBLY Figure 5-3**	270801	89536	270801	REF		
A1	F1-M5	IC, operational amplifier	271502	12040	LM301A	2	1	
A2	I1-03	IC, operational amplifier	271502	12040	LM301A	REF		
C1	E3-N4	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	2		
C2	F3-M5	Cap, mica, 47 pf ±5%, 500v	148536	14655	CD15E470J	2		
C3	G1-M4	Cap, plstc, 0.1 uf ±2%, 100v	188706	84171	1PJ104G	3		
C4	F1-M3	Cap, mica, 390 pf ±5%, 500v	148437	14655	CD15F391J	4		
C5	J1-M4	Cap, plstc, 0.047 uf ±2%, 100v	170449	84171	1PJ473G	2		
C6	J1-M5	Cap, plstc, 0.047 uf ±2%, 100v	170449	84171	1PJ473G	REF		
C7	J1-M2	Cap, plstc, 0.1 uf ±2%, 100v	188706	84171	1PJ104G	REF		
C8	J1-N2	Cap, plstc, 0.22 uf ±10%, 80v	159392	56289	192P2249R8	1		
C9	J1-N4	Cap, plstc, 0.12 uf ±10%, 200v	223594	56289	192P12492	1		
C10	G4-O2	Cap, plstc, 0.1 uf ±2%, 100v	188706	84171	1PJ104G	REF		
C11	I1-O4	Cap, mica, 390 pf ±5%, 500v	148437	14655	CD15F391J	REF		
C12	H3-O3	Cap, mica, 47 pf ±5%, 500v	148536	14655	CD15E470J	REF		
C13	E4-M5	Cap, mica, 390 pf ±5%, 500v	148437	14655	CD15F391J	REF		
C14	F2-M3	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	REF		
C15	I2-O3	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	REF		A
C15	I2-O3	Cap, mica, 68 pf ±5%, 500v	148510	14655	CD15E630J	1		B
C16	H3-N5	Cap, mica, 390 pf ±5%, 500v	148437	14655	CD15F391J	REF		
CR1	E5-N2	Diode, silicon, 150 ma	203323	03508	DHD1105	15		
CR2	F3-N5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR3	F2-N5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR4	F3-N5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR5	I4-N5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR6	I4-O4	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR7	E1-N2	Diode, silicon, 75 ma, 100 piv	260554	07910	CD55105	2		
CR8	E1-N4	Diode, silicon, 75 ma, 100 piv	260554	07910	CD55105	REF		
CR9	B3-N3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR10	I4-N3	Diode, silidon, 150 ma	203323	03508	DHD1105	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
CR11	I4-O2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR12	F1-N2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR13	J1-O2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR14	B5-N3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR15	F5-N5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR16	F4-N5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR17	J1-O4	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
K1	C3-M4	Reed switch	277020	12617	SRR-3	1		
	C3-N4	Coil, reed switch	269001	71707	SR-6-P	1		
K2	D3-N3	Reed switch	219097	15898	765972	5		
	D5-N3	Coil, reed switch	269019	71707	U-6-P	5		
K3	D3-N1	Reed switch	219097	15898	765972	REF		
	D5-N1	Coil, reed switch	269019	71707	U-6-P	REF		
K4	D3-N5	Reed switch	219097	15898	765972	REF		
	D5-N5	Coil, reed switch	269019	71707	U-6-P	REF		
K5	H2-M5	Relay, 4 pdt, 5 vdc	272716	24796	R40-E030-1	1		
K7	I4-O3	Reed switch	219097	15898	765972	REF		
	J2-O3	Coil, reed switch	269019	71707	U-6-P	REF		
K8	I4-O1	Reed switch	219097	15898	765972	REF		
	J2-O1	Coil, reed switch	269019	71707	U-6-P	REF		
Q1	E4-N2	Tstr, silicon, NPN	218396	04713	2N3904	6		
Q2	E4-N4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q3	E4-O1	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q4	E4-N1	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q5	D3-N3	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q6	C5-M4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q7	D3-M4	Tstr, FET, dual, N-channel	267963	17856	DN503	1	1	
Q8	I1-M2	Tstr, FET, N-channel	271924	07910	CFE13041	REF		
Q9	H3-O2	Tstr, FET, dual, N-channel	257501	17856	DN423	REF		
Q10	G2-O1	Tstr, germanium, NPN	117127	01295	2N1304	2	1	
Q11	F1-M1	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q12	G2-N4	Tstr, germanium, NPN	117127	01295	2N1304	REF		
R1	C1-N4	Res, ww, selected & matched	5					

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R2	B5-M4	Res, ww, selected & matched	5					
R3	B3-M4	Res, ww, selected & matched	5					
R4	D1-N5	Res, var, ww, 2k ±5%, 1¼w	160705	71450	Type 110	1		
R5	B1-N3	Res, ww, 898.84k, matched	5					
R6	D1-N1	Res, var, ww, 200Ω ±20%, 1¼w	144766	71450	Type 110	REF		
R7	B1-M3	Res, ww, 99.91k, matched	5					
R8	C5-M3	Res, comp, 220k ±10%, 2w	110197	01121	HB2241	2		
R9	C5-M1	Res, comp, 220k ±10%, 2w	110197	01121	HB2241	REF		
R10	D5-M4	Res, ww, 33k ±0.1%, ½w	277921	89536	277921	2		
R11	F5-M3	Res, met flm, 1M ±1%, ½w	161075	91637	Type MFF ½	3		E
R11	F5-M3	Res, met flm, 604k ±1%, ½w	182493	91637	Type MFF ½	3		F
R12	D5-M5	Res, ww, 33k ±0.1%, ½w	277921	89536	277921	REF		
R13	D5-M1	Res, met flm, 28.7Ω ±1%, 1/8w	272823	91637	Type MFF 1/8	1		
R14	D5-M2	Res, met flm, 13.7Ω ±1%, 1/8w	272815	91637	Type MFF 1/8	1		
R15	C2-N5	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		E
R15	C2-N5	Res, comp, 68k ±5%, ¼w	148171	01121	CB6835	REF		F
R16	C2-N2	Res, comp, 100k ±5%, ¼w	148189	01121	CB1045	2		
R17	C2-M5	Res, comp, 100k ±5%, ¼w	148189	01121	CB1045	REF		
R18	C2-M2	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		E
R18	C2-M2	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		F
R19	F4-M2	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	1		
R21	H3-N5	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R22	F4-N3	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	5		
R23	I2-M4	Res, met flm, 54.9k ±1%, 1/8w	271353	91637	Type MFF 1/8	2		
R24	I2-M4	Res, met flm, 28.7k ±1%, 1/8w	235176	91637	Type MFF 1/8	1		
R25	I3-M4	Res, met flm, 54.9k ±1%, 1/8w	271353	91637	Type MFF 1/8	REF		
R26	I2-N5	Res, met flm, 499k ±1%, 1/8w	268813	91637	Type MFF 1/8	1		
R28	C3-P1	Res, var, comp, 100k±30%, ¼w	223149	37942	Type MTC-1	REF		
R32	I1-N2	Res, comp, 30k ±5%, ¼w	193417	01121	CB3035	3		
R33	I1-N2	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R34	E5-N5	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	3		
R35	I3-N1	Res, met flm, 402k ±1%, 1/8w	217984	91637	Type MFF 1/8	1		
R36	I2-N5	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R37	F5-N3	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R38	F1-N5	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R40	F3-N3	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R41	F3-N3	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R42	F5-N3	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R43	H2-05	Res, met flm, 1M ±1%, ½w	161075	91637	Type MFF ½	REF		E
R43	H2-05	Res, met flm, 604k ±1%, ½w	182493	91637	Type MFF ½	REF		F
R44	H2-04	Res, met flm, 1M ±1%, ½w	161075	91637	Type MFF ½	REF		E
R44	H2-04	Res, met flm, 604k ±1%, ½w	182493	91637	Type MFF ½	REF		F
R45	H3-N4	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R46	H3-N4	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R47	E4-M3	Res, var, ww, 10Ω ±10%, 2w	183921	71450	Type 115	1		
R48	F4-M2	Res, comp, 30k ±5%, ¼w	193417	01121	CB3035	REF		
R49	F3-M2	Res, comp, 30k ±5%, ¼w	193417	01121	CB3035	REF		
R50	F2-M2	Res, comp, 13k ±5%, ¼w	221598	01121	CB1335	1		
R51	F1-N5	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R52	F2-N3	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R54	B3-N5	Res, ww, selected & matched	▷5					
R55	D5-M2	Res, comp, 6.2Ω ±5%, ¼w	272831	01121	CB62G5	1		
R56		Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	1		B
S1	F1-P4	Switch Assembly	268656	89536	268656	1		

▷5 R1, R2, R3, R5, R7 and R54 are a factory matched set. For replacement, order Input Attenuator Resistor Set, part number 277806.

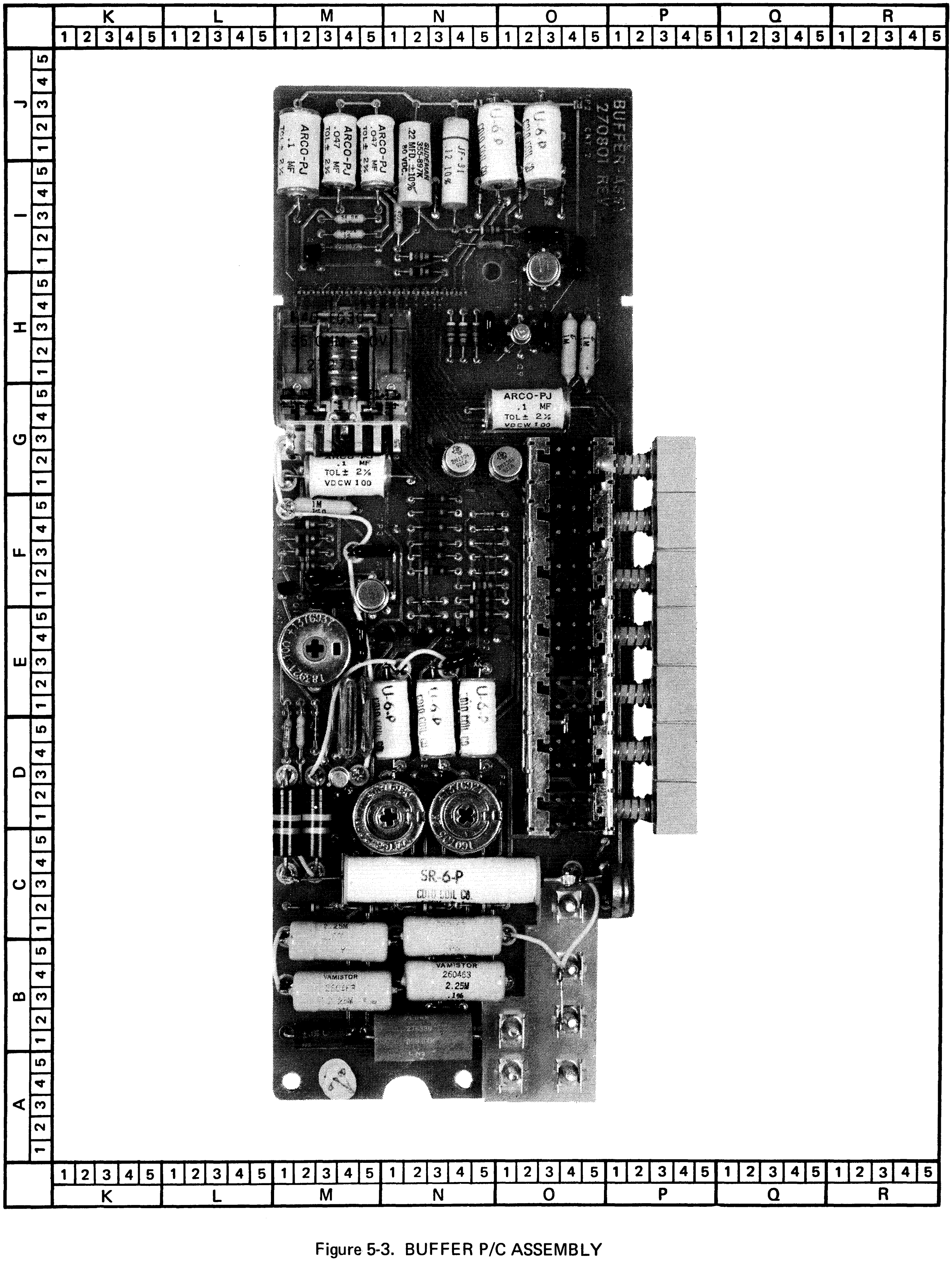


Figure 5-3. BUFFER P/C ASSEMBLY

5-9. SERIAL NUMBER EFFECTIVITY

5-10. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8300A. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity List below. All parts with no code are used on all instruments with serial numbers above 123.

USE CODE	EFFECTIVITY
NO CODE	Model 8300A serial number 123 and on.
A	123 thru 3345
B	3346 and on.

Section 6
Accessory & Option Information

6-1. INTRODUCTION

6-2. This section of the manual contains information pertaining to the accessories and options available for your instrument.

6-3. ACCESSORY INFORMATION

6-4. The accessory information, if applicable, will contain details concerning accessories that may be used with this particular instrument.

6-5. OPTION INFORMATION

6-6. Each of the options available for this instrument, if any, are described separately under headings containing the option number. The option descriptions contain applicable operating and maintenance instructions and field installation procedures. A complete list of replaceable parts for each option is contained at the end of that option description.

OPTION 8300A-01

AC CONVERTER

6-1. INTRODUCTION

6-2. The AC Converter is used in conjunction with the Model 8300A basic DVM to provide ac voltage capability in four ranges: 1, 10, 100, and 1000 volts ac. It converts input ac voltages to dc voltages for measurement by the A/D Converter, where 12 volts dc represents full scale.

6-3. SPECIFICATIONS

6-4. Specifications for the AC Converter are located in Section I of the manual.

6-5. INSTALLATION

6-6. The following procedure should be used to install the AC Converter in the Model 8300A:

a. Remove the Model 8300A top dust cover and guard chassis cover. Check connector pins on AC Converter to assure that every pin is straight and perpendicular to PCB.

b. Align the notches on the AC Converter board with the tabs on the Model 8300A interconnect board and insert the board in place in the position shown on the guard cover.

c. Fasten the board in place using the screws provided with the converter. Check the connector pins for correct mating with receptacle using a small mirror.

d. Complete the installation by connecting the red and black converter wires to the input terminal connection point as shown on the guard cover.

6-7. THEORY OF OPERATION

6-8. General

6-9. The AC Converter is divided into two major parts, as shown in Figure 6-1: a wide band operational rectifier circuit where the ranging is accomplished and a dc— difference (or subtracting) amplifier/integrator to filter and amplify

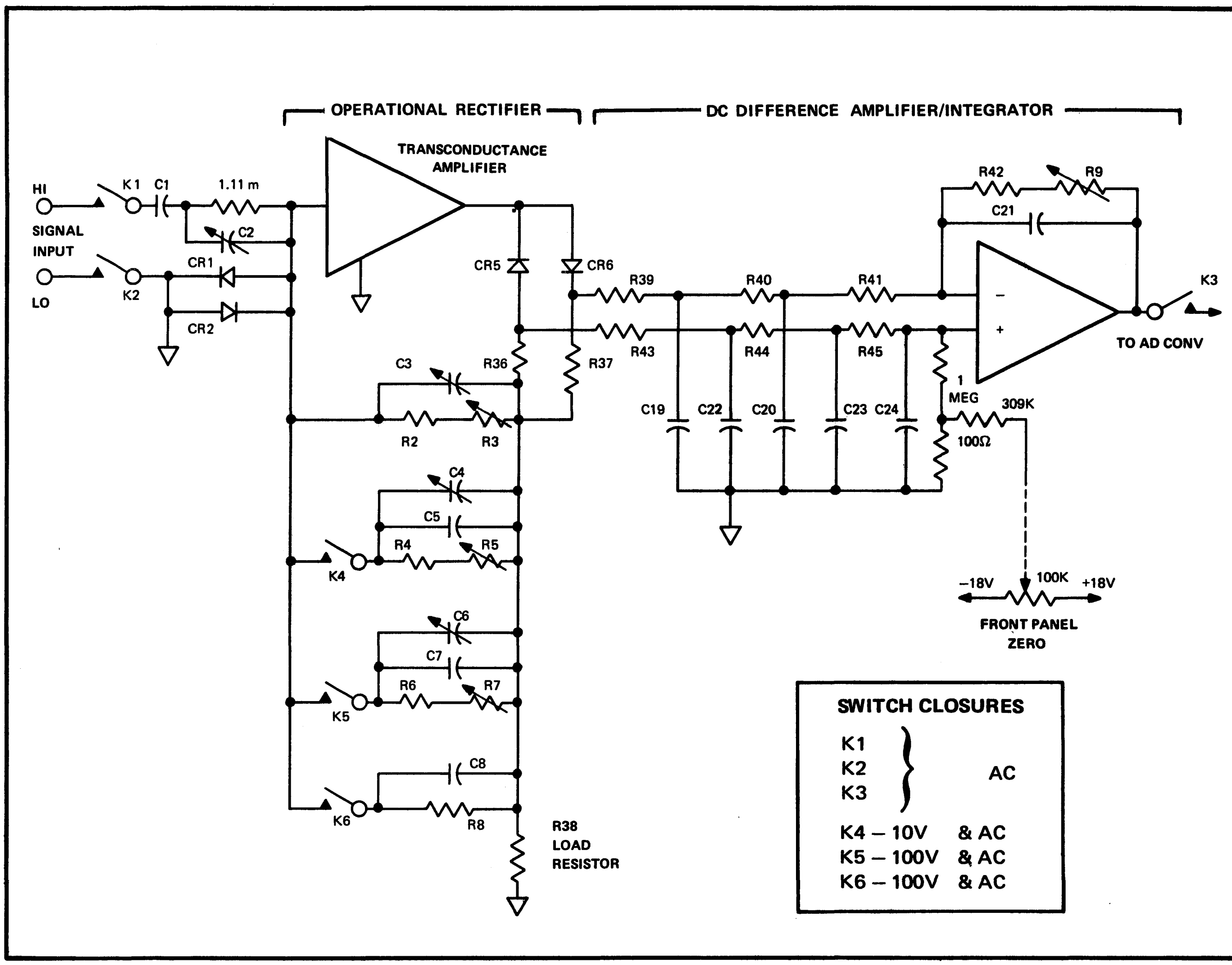


Figure 6-1. BLOCK DIAGRAM AC CONVERTER

the rectifier output. The dc amplifier also provides the low source impedance required by the A/D Converter.

6-10. The operational rectifier circuit consists of an inverting transconductance amplifier and load resistor with negative feedback arranged to provide a loop gain of about 5×10^3 at mid band. The feedback is changed with reed switches for range purposes. The input resistor is 1.11 megohms and this value shunted by the 10 megohm input divider (located on buffer board) provides 1 megohm input impedance at the Model 8300A input terminals. A symmetrical half wave rectifier placed between the amplifier and load resistor develops equal positive and negative dc voltages proportional to the amplifier output current. At full scale, this current is near 2 milliamps. The two outputs have wave forms as shown in Figure 6-2.

6-11. The dc– difference amplifier/integrator filters the waveform shown in Figure 6-2 and amplifies the dc difference between them by about ten times for measurement by the A/D converter. Three sections of filtering reduce the ac voltage to a ripple level which cannot be observed on the readout when the input is at full scale and above a frequency of 100 Hz. Below 100 Hz a few digits respond to the ripple. At 50 Hz the readout excursions are typically less than ±0.01% of reading and at 30 Hz are within ±0.05% of reading.

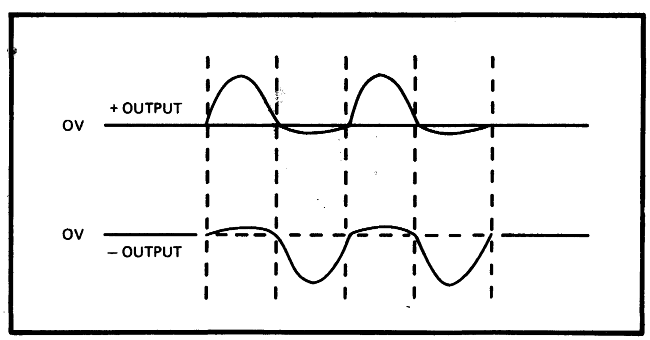


Figure 6-2. RECTIFIER OUTPUT WAVEFORMS

6-12. Circuit Description

6-13. OPERATIONAL RECTIFIER. Input FET Q1 functions as a source follower, while transistor Q2 provides a low impedance guard voltage which is used to bootstrap most of the capacity that otherwise would appear between the FET gate and common. The first two differential pairs are in dual in-line package IC1. Together with Q4 and Q5, they develop the required gain. Transistors Q3 and Q6 function as current sources, with values such that clipping due to overload is symmetrical. Changes in capacitor charges are small and amplifier recovery time is minimized. Transistor Q7 compensates for capacitance losses in the diodes at low levels.

6-14. DC–DIFFERENCE AMPLIFIER/INTEGRATOR. The filter network, which provides the input to the amplifier/integrator, consists of resistors R39, R40, R41, R43, R44, R45 and capacitors C19, C20, C22, and C23. Capacitors C19 and C20 are matched with C22 and C23, respectively, to maintain good common-mode rejection. Transistor Q9 is a dual FET, which functions as the input of the low drift dc amplifier. Further gain for the dc amplifier is provided by monolithic operational amplifier IC2, thereby producing a total loop gain at dc of about 5×10^5.

6-15. RANGE AND FUNCTION CONTROL. The converter input and output relays K1 through K3, are operated from the VAC control line. The range relays K4 through K6, are operated by driver circuitry consisting of transistors Q10 through Q15 and associated components. The range control transistors accept the input from range flip flops 18a and 18b, located in the DVM logic section, and perform the logic function associated with calling of the ac ranges.

6-16. MAINTENANCE

6-17. Introduction

6-18. This section contains maintenance information specifically intended for the AC Converter. Factory service information and general instructions regarding instrument access and cleaning are located in Section IV of the Manual.

6-19. Test Equipment

6-20. The following equipment is recommended for testing, troubleshooting, and calibration of the AC Converter. If the recommended equipment is not available, equivalent or better instruments may be substituted.

EQUIPMENT NOMENCLATURE	RECOMMENDED EQUIPMENT
AC Voltage Source	HP Model 745A AC Calibrator with companion 1000 volt amplifier
Multimeter	Fluke Model 8100A Digital Multimeter
Oscilloscope	Tektronix Model 547
Oscilloscope Plug-In	Tektronix Model IA1
DC Differential Voltmeter	Fluke Model 885A

6-21. Performance Test

6-22. The performance test in this section compares the AC Converter performance to the accuracy specifications in Section I of the manual to determine if the converter is in calibration. Known ac voltages are applied to the DVM input terminals on each of the four ranges. The performance test should be conducted before any instrument maintenance or calibration is attempted. The test is also suited to receiving inspection of new converters. The performance test should be conducted under the following environmental conditions: ambient temperature 25°C ±5°C, relative humidity less than 70%. An instrument that fails the performance test will require corrective maintenance or calibration. In case of difficulty, analysis of the test results with reference to the troubleshooting section, should help to locate the trouble.

NOTE!

Permissible tolerances for ac voltage measurements are derived from the 90-day instrument specifications contained in Section I of the manual.

6-23. AC VOLTAGE TEST. In the following procedure, 20 kHz voltages are applied to the instrument at 100% of full scale on the 1, 10, and 100 volt ranges and at 0.1% and 100% of full scale on the 1000 volt range.

a. Set the Model 8300A controls as follows:

FUNCTION	VAC
RANGE	Manually selected, as required.

b. Apply each of the 20 kHz test signals shown in Figure 6-3 to the INPUT terminals of the Model 8300A. The readout should be as indicated.

INPUT (VAC)	MODEL 8300A			
	RANGE	READOUT LIMITS		
1	1	.99870	to	1.00130
10	10	9.9870	to	10.0130
100	100	99.870	to	100.130
1	1000	000.70	to	001.30
1000	1000	998.70	to	1001.30

Figure 6-3. AC VOLTAGE TEST REQUIREMENTS

6-24. Troubleshooting

6-25. This section contains information selected to aid in troubleshooting the AC Converter. Before attempting to troubleshoot the unit, however, it should be verified that the trouble is actually in the converter and is not caused by faulty external equipments or improper control settings. For this reason, the performance test (paragraph 6-21) is suggested as a first step in troubleshooting. The performance test may also help to localize the trouble to a particular section of the instrument. If the performance test fails to localize the trouble, the following information may be helpful. Connector pin locations are shown in Section IV, Figure 4-5.

6-26. POWER SUPPLY VOLTAGE CHECK

6-27. In this test, each of the supply voltages for the AC Converter is checked at the pin connectors. This test verifies only presence of voltages; a detailed check of Model 8300A power supply voltages is given in Section IV of the manual.

a. Connect the oscilloscope common to TP2 of the converter. Use the internal dc oscilloscope trigger. Set the scope controls for dc voltage measurement, and check the following voltages:

Connector Pin No.	Required Voltage
22	−18 volts
21	+18 volts
19	−18V to +18V (rotate front panel AC Zero control)

6-28. COMMAND VOLTAGE CHECK

6-29. The presence of proper command voltages is checked in the following test.

a. Connect the oscilloscope common to the converter as indicated in the preceeding test.

b. Perform each of the connector pin voltage checks given in Figure 6-4. The voltages should be as indicated.

6-30. RELAY CHECKS

6-31. The truth table (Figure 6-5) will help locate defective relays or associated drive circuits. Assuming there are no errors in the command voltage check, if the voltage across the coil does not appear as indicated on the truth table, the relay drive circuit is at fault. If the coil voltage is correct but the relay fails to respond, then the relay is defective. Neither side of K4, K5, or K6 is connected to the circuit common.

6-32. SEVERE CONVERTER MALFUNCTIONS

a. Symptom: Full-scale output with shorted input.

Procedure: If dc voltage at TP4 and ac voltage on TP3 are zero, then troubleshoot converter output difference amplifier-integrator, Q8, Q9, A2, and associated circuits.

If the dc voltage on TP4 is greater than ± 1V (normal is less than 10 mV) check for defective Q1 through Q7, A1, C11, C20, or associated circuits.

If ac voltage is present on TP3, check for open or shorted feedback circuit or defective component in rectifier amplifier causing oscillation.

b. Symptom: Zero output with input applied.

Procedure: If ac voltage on TP3 is zero, check for open or short in ac circuit between input and Q1.

PIN NO.	FUNCTION: VAC RANGE: 1V	FUNCTION: VAC RANGE: 10V	FUNCTION: VAC RANGE: 100V	FUNCTION: VAC RANGE: 1000V	FUNCTION: ANY EXCEPT VAC RANGE: ANY	POSSIBLE TROUBLE
23	<0.6V	>3.0V	<0.6V	>3.0V	<0.6V	1. Improper connections between converter board and main frame, e.g., misalignment of connector pins.
24	<0.6V	<0.6V	>3.0V	>3.0V	<0.6V	
27	>4.0V	>4.0V	>4.0V	>4.0V	<0.6V	2. Faulty function switch on buffer board.
						3. Defect in auto ranging logic, main PCB.
						4. Defective range switch
						5. Short in relay drive circuits on AC option PCB, Q10-Q15, CR7-CR10.
						6. Short between control lines on AC option board.

Figure 6-4. AC CONVERTER FUNCTION COMMAND CHECK

If ac voltage does appear on TP3 (full scale is approximately 0.25V RMS) check K3 or troubleshoot output difference amplifier-integrator.

c. Symptom: Range of operation does not correspond to range selected.

Procedure: Make command voltage and relay checks, Figures 6-4 and 6-5.

CONVERTER RELAYS	FUNCTION: VAC RANGE: 1V	FUNCTION: VAC RANGE: 10V	FUNCTION: VAC RANGE: 100V	FUNCTION: VAC RANGE: 1000V	FUNCTION: ANY EXCEPT VAC RANGE: ANY	POSSIBLE TROUBLE
K1	1	1	1	1	0	1. Improper voltages on connector pins, 23, 24, 27 as shown in Figure 6-4.
K2	1	1	1	1	0	
K3	1	1	1	1	0	
K4	0	1	0	0	0	2. Defective relay.
K5	0	0	1	0	0	
K6	0	0	0	1	0	3. Defective relay drive circuit Q10-Q15.

Legend: Logical 1 = >4.0V
Logical 0 = <0.6V

Figure 6-5. AC CONVERTER RELAY TRUTH TABLE.

6-33. Calibration

6-34. The AC Converter should be calibrated every 30 or 90 days, depending on the degree of accuracy to be maintained (see specifications, Section 1), or whenever repairs have been made to circuitry which may affect the calibration accuracy. Calibration of the converter should be performed at an ambient room temperature of 25°C ±5°C. Relative humidity should be less than 70%. Consult paragraph 6-19 for recommended test equipment.

6-35. PRELIMINARY OPERATIONS

a. Remove the upper dust cover retaining screws, but leave the dust cover in place on the instrument.

b. Set the rear panel 115/230 volts slide switch to the 115 volt position and connect the line cord to an autotransformer set to 120 volts ac.

c. Turn on the Model 8300A and allow the instrument to operate for one hour.

6-36. AC CONVERTER ALIGNMENT

a. Set the Model 8300A controls as follows:

FUNCTION	VAC
RANGE	1000
SAMPLE RATE	Fully clockwise

b. Connect the GUARD terminal to the LO input terminal using the shorting like provided.

c. Short the INPUT terminals together.

d. Connect the differential voltmeter to TP4 with its common connected to TP2. Adjust R30 for zero volts ±3 millivolts at TP4. Remove the differential voltmeter.

e. Center the front panel AC ZERO control. Adjust coarse AC zero for less than 5 digits on readout.

f. Adjust the AC ZERO control on the front panel for a 0000.00 readout.

g. Remove the short between the INPUT terminals.

h. Perform the checks and adjustments contained in Figure 6-6.

6-37. Calibration of the AC Converter is now complete.

STEP	MODEL 8300A AC INPUT & READOUT	FREQUENCY (kHz)	RANGE	ADJUSTMENT	READOUT TOLERANCE (± DIGITS)
1	500.00	1	1000	1000 VAC 1 kHz	5
2	500.00	30	1000	1000 VAC 20 kHz	5
3	1.00000	1	1	1 VAC 1 kHz	10
4	1.00000	50	1	1 VAC 50 kHz	10
5	.00100	1	1	(none)	3
6	.00100	50	1	1 MVAC 50 kHz	Same as step (5)
7	(Repeat steps 4 through 6 as necessary)				
8	1.00000	100	1	(none)	250
9	1.00000	20	1	(none)	25
10	1.00000	.05	1	(none)	25
11	10.0000	1	10	10 VAC, 1 kHz	10
12	10.0000	50	10	10 VAC, 50 kHz	10
13	10.0000	100	10	(none)	200
14	100.000	1	100	100 VAC, 1 kHz	10
15	100.000	50	100	100 VAC, 50 kHz	10
16	100.000	20	100	(none)	20
17	1000.00	10	1000	(none-wait 30 sec.)	80

Figure 6-6. AC CONVERTER RANGE CALIBRATION

6-38. LIST OF REPLACEABLE PARTS

6-39. For column entry explanations, part ordering information and basic instrument configuration Use Codes and Serial Number Effectivity List, see Section 5, paragraphs 5-1 through 5-10. See paragraph 6-40, this option subsection, for additional Use Codes and Serial Number Effectivity List assigned to this printed circuit assembly option.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		DIGITAL VOLTMETER - AC CONVERTER OPTION	8300A-01					
		NOTE: The basic Model 8300A can be modified in the field by installing the AC Converter Option Kit (8300-01K), order by Model and Option No. (8300A-01K)						
		AC Converter P/C Assembly (See Figure 6-7)	270959	89536	270959	1		
A1	E3-M4	IC, 5-Transistor Array	248906	95303	CA3046	1	1	
A2	I3-O3	IC, operational amplifier	271502	12040	LM301A	1	1	
C1	A5-O1	Cap, plstc, 0.22 uf ±20%, 1200v	220079	84411	Type JF17	1		
C2	B4-N4	Cap, var, teflon, 0.25 - 1.5 pf, 2kv	273151	74970	Type 273-1-2	1		
C3	C4-N5	Cap, var, 0.8 - 10 pf, 250v	193912	91293	JMC-2950	2		
C4	D1-O3	Cap, var, 0.8 - 10 pf, 250v	193912	91293	JMC-2950	REF		
C5	C3-O3	Cap, mica, 12 pf ±5%, 500v	175224	14655	CD15E120J	1		
C6	D5-O3	Cap, var, ceramic, 9 - 35 pf, 200v	153080	72982	538-028D9-35	2		
C7	D3-O3	Cap, mica, 150 pf ±1%, 500v	226134	14655	CD15F151-F500	1		
C8	E3-O3	Cap, mica, 4700 pf ±5%, 500v	208975	84171	DM19472J	1		
C9	D1-M5	Cap, Ta, 4.7 uf ±20%, 20v	161943	56289	196D475X-0020	3	1	
C10	E1-M4	Cap, Ta, 4.7 uf ±20%, 20v	161943	56289	196D475X-0020	REF		
C11	D5-N1	Cap, elect, 50 uf +50/–10%, 25v	168823	73445	C426ARF50	1	1	
C12	G1-M5	Cap, cer, 500 pf ±10%, 1kv	105692	56289	C067B102E 501K	2		
C13	G1-N1	Cap, cer, 500 pf ±10%, 1kv	105692	56289	C067B102E 501K	REF		
C14	E4-N3	Cap, Ta, 4.7 uf ±20%, 20v	161943	56289	196D475X-0020	REF		
C15	F2-O4	Cap, elect, 20 uf ±50/–10%, 16v	241356	73445	C426ARE20	1	1	
C16	F2-N1	Cap, cer, 0.01 uf ±20%, 100v	149153	56289	C023B101-F103M	2		
C17	F2-N2	Cap, cer, 0.01 uf ±20%, 100v	149153	56289	C023B101-F103M	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C18	G1-O3	Cap, var, ceramic, 9-35 pf, 200v	153080	72982	538-028D9-35	REF		
C19	G5-O4	Cap, plstc, 2 uf ±20%, 200v matched	▷1					
C20	H3-O4	Cap, plstc, 2 uf ±20%, 200v matched	▷1					
C21	I2-O1	Cap, plstc, 0.027 uf ±10%, 250v	267120	73445	C280AE/A 27K	2		
C22	G5-N2	Cap, plstc, 2 uf ±20%, 200v matched	▷1					
C23	H3-N2	Cap, plstc, 2 uf ±20%, 200v matched	▷1					
C24	I3-N5	Cap, plstc, 0.027 uf ±10%, 250v	267120	73445	C280AE/A 27K	REF		
C25	J3-P1	Cap, mica, 390 pf ±5%, 500v	148437	14655	CD15F391J	2		
C26	J3-O4	Cap, mica, 390 pf ±5%, 500v	148437	14655	CD15F391J	REF		
C27	J3-O5	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	1		
C28	D2-O3	Cap, mica, 47 pf ±5%, 500v	148536	14655	CD15E470J	1		
C29	C4-N3	Cap, cer, 3 pf ±10%, 500v	226316	00656	Type C1-1	1		
CR1	C4-N2	Diode, silicon, 100 ma at 1.5v	261370	22767	S1330	4	4	
CR2	C3-N2	Diode, silicon, 100 ma at 1.5v	261370	22767	S1330	REF		
CR3	G1-N1	Diode, silicon, 100 ma at 1.5v	261370	22767	S1330	REF		
CR4	G1-N2	Diode, silicon, 100 ma at 1.5v	261370	22767	S1330	REF		
CR5	G2-N5	Diode, silicon, 100 ma at 1.5v	348177	07910	CD8606	2	2	
CR6	G1-O1	Diode, silicon, 100 ma at 1.5v	348177	07910	CD8606	REF		
CR7	B2-M5	Diode, silicon, 150 ma	203323	03508	DHD1105	4	2	
CR8	D2-N4	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR9	E4-O1	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR10	D5-N4	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR11	I1-O3	Diode, silicon, 75 ma, 100 piv	260554	07910	CD55105	1	1	
CR12	I1-O4	Diode, zener, 13v	110726	07910	IN964B	1	1	
K1	B3-P1	Reed switch	233916	12617	Type DRR5	1	1	C
	B3-P1	Reed switch	284091	12617	Type MRR5	1	1	D
	B3-O1	Coil, reed switch	269001	71707	SR-6-P	1	1	C
	B3-01	Coil, reed switch	269019	71707	U-6-P	5	1	D
K2	B4-M4	Reed switch	219097	15898	765972	6	2	
	B2-M4	Coil, reed switch	269019	71707	U-6-P	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
K3	J1-P2	Reed switch	219097	15898	765972	REF		
	J1-O5	Coil, reed switch	269019	71707	U-6-P	REF		
K4	D2-O2	Reed switch	219097	15898	765972	REF		
	D1-N4	Coil, reed switch	269019	71707	U-6-P	REF		
K5	D4-N2	Reed switch	219097	15898	765972	REF		
	D4-N4	Coil, reed switch	269019	71707	U-6-P	REF		
K6	E1-O2	Reed switch	219097	15898	765972	REF		
	E1-N4	Coil, reed switch	272070	71707	UD-6-P	1	1	
Q1	D1-N1	Tstr, FET, N-channel	271924	07910	CFE13041	1	1	A
Q1	D1-N1	Tstr, FET, N-channel	246066	04713	EL131	1	1	B
Q2	D1-M4	Tstr, silicon, NPN	218081	04713	MPS6520	2	2	
Q3	F5-N4	Tstr, silicon, PNP	229898	04713	MPS6522	4		
Q4	G1-N4	Tstr, silicon, PNP	229898	04713	MPS6522	REF		
Q5	G2-N4	Tstr, silicon, PNP	229898	04713	MPS6522	REF		
Q6	F5-O1	Tstr, silicon, NPN	218081	04713	MPS6520	REF		
Q7	F5-O3	Tstr, silicon, PNP	229898	04713	MPS6522	REF		
Q8	I4-N5	Tstr, silicon, NPN	218396	04713	2N3904	7	2	
Q9	I1-N5	Tstr, FET, dual, N-channel	267963	17856	DN503	1	1	
Q10	F2-P2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q11	F3-P2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q12	F1-P1	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q13	F3-P1	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q14	F3-O5	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q15	F2-O5	Tstr, silicon, NPN	218396	04713	2N3904	REF		
R1	C2-M5	Res, met flm, 1.11M ±0.1%, 1w, matched	[2]					
R2	C5-N4	Res, met flm, 267k ±0.1%, ¼w, matched	[2]					
R3	C3-P1	Res, var, ww, 1.5k ±10%, 1¼w	156398	71450	Type 110	1		
R4	C2-O3	Res, ww, 29.53k ±0.1%, ½w	277657	89536	277657	1	1	
R5	C5-P1	Res, var, ww, 150Ω ±20%, 1¼w	163642	71450	Type 110	1		
R6	E2-O5	Res, ww, 2.573k ±0.1%, ½w	277665	89536	277665	1	1	
R7	D5-P1	Res, var, ww, 15Ω ±20%, 1¼w	163634	71450	Type 110	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R8	E4-O2	Res, ww, 143.7Ω ±0.1%, ¼w	277640	89536	277640	1	1	
R9	I4-P1	Res, var, ww, 10k ±20%, 1¼w	112862	71450	Type 110	1		
R10	C3-N2	Res, met flm, 32.4k ±1%, 1/8w	182956	91637	Type MFF1/8	2		
R11	D4-M4	Res, comp, 8.2k ±5%, ¼w	160796	01121	CB8225	1		
R12	D4-M5	Res, met flm, 16.2k ±1%, 1/8w	226233	91637	Type MFF1/8	1		A
R12	D4-M5	Res, met flm, 32.4k ±1%, 1/8w	182956	91637	Type MFF1/8	REF		B
R13	E3-N1	Res, met flm, 4.22k ±1%, 1/8w	168245	91637	Type MFF1/8	1		
R14	D4-M4	Res, comp, 39k ±5%, ¼w	188466	01121	CB3935	1		
R15	F2-M5	Res, comp, 120k ±5%, ¼w	193458	01121	CB1245	2		
R16	F2-M4	Res, comp, 11k ±5%, ¼w	221580	01121	CB1135	2		
R17	F2-M4	Res, comp, 11k ±5%, ¼w	221580	01121	CB1135	REF		
R18	F2-N1	Res, comp, 120k ±5%, ¼w	193458	01121	CB1245	REF		
R19	G1-M4	Res, comp, 47Ω ±5%, ¼w	147892	01121	CB4705	2		
R20	G1-M4	Res, comp, 47Ω ±5%, ¼w	147892	01121	CB4705	REF		
R21	E3-N1	Res, met flm, 84.5k ±1%, 1/8w	229492	91637	Type MFF1/8	1		
R22	E4-N4	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	1		
R23	E4-N3	Res, met flm, 82.5k ±1%, 1/8w	246223	91637	Type MFF1/8	1		
R24	F3-N3	Res, met flm, 10k ±1%, 1/8w	168260	91637	Type MFF1/8	1		
R25	F3-N3	Res, met flm, 21.5k ±1%, 1/8w	168278	91637	Type MFF1/8	2		
R26	F3-N4	Res, met flm, 590Ω ±1%, 1/8w	261883	91637	Type MFF1/8	1		
R27	F3-O1	Res, met flm, 21.5k ±1%, 1/8w	168278	91637	Type MFF1/8	REF		
R28	F3-N5	Res, met flm, 10.5k ±1%, 1/8w	234096	91637	Type MFF1/8	1		
R29	F3-N5	Res, met flm, 1.27k ±1%, 1/8w	267369	91637	Type MFF1/8	1		
R30	I3-N2	Res, var, car, 100k ±30%, ¼w	281675	71450	Type 201	2		
R31	G1-N3	Res, comp, 10M ±5%, ¼w	194944	01121	CB1065	1		
R32	F3-O2	Res, met flm, 40.2k ±1%, 1/8w	235333	91637	Type MFF1/8	2		
R33	E4-N2	Res, met flm, 40.2k ±1%, 1/8w	235333	91637	Type MFF1/8	REF		
R34	F2-O2	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	2		E
R34	F2-O2	Res, comp, 220k ±5%, ¼w	160937	01121	CB2235	1		F
R35	F2-O3	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	3		E
R35	F2-O3	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	2		F
R36	G4-O1	Res, ww, 564.5Ω ±0.1%, ¼w	277632	89536	277632	2	1	
R37	G3-O2	Res, ww, 564.5Ω ±0.1%, ¼w	277632	89536	277632	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R38	E3-O5	Res, ww, 125Ω ±0.1%, ¼w	249284	89536	249284	1	1	
R39	G3-O4	Res, ww, 40k ±0.1%	271403	89536	271403	6	2	
R40	H1-O4	Res, ww, 40k ±0.1%	271403	89536	271403	REF		
R41		Res, ww, 20k ±0.1% (mounted on back)	271395	89536	271395	2	1	
R42	H5-O3	Res, ww, 1M ±0.1%	271411	89536	271411	2	1	
R43	G3-N2	Res, ww, 40k ±0.1%	271403	89536	271403	REF		
R44	H1-N2	Res, ww, 40k ±0.1%	271403	89536	271403	REF		
R45		Res, ww, 20k ±0.1% (mounted on back)	271395	89536	271395	REF		
R46	I1-N3	Res, ww, 1M ±0.1%	271411	89536	271411	REF		
R47	I3-M5	Res, met flm, 487k ±1%, 1/8w	237206	91637	Type MFF 1/8	1		
R48	I3-M4	Res, met flm, 24.3k ±1%, 1/8w	236745	91637	Type MFF 1/8	1		
R49	I3-M5	Res, met flm, 100Ω ±1%, 1/8w	168195	91637	Type MFF 1/8	1		
R50	J2-N2	Res, met flm, 30.9k ±1%, 1/8w	235275	91637	Type MFF 1/8	1		
R51	J2-N2	Res, met flm, 2.87k ±1%, 1/8w	185629	91637	Type MFF 1/8	1		
R52	J2-N3	Res, met flm, 1k ±1%, 1/8w	168229	91637	Type MFF 1/8	1		
R53	J3-M5	Res, var, cer, 100k ±30%, ¼w	281675	71450	Type 201	REF		
R54	J2-N5	Res, ww, 40k ±0.1%	271403	89536	271403	REF		
R55	J2-O2	Res, ww, 40k ±0.1%	271403	89536	271403	REF		
R56	G1-P2	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	4		
R57	G1-P2	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R58	G1-P1	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R59	G1-P1	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R60	G1-O5	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R61	G1-O5	Res, comp. 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R62	I3-O4	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		

1 ▷ C19, C20, C22 & C23 are a matched set and must be replaced as a set. For replacement, order capacitor set, part number 270470.

2 ▷ R1 and R2 are matched and must be replaced as a set. For replacement order resistor set, part number 269092.

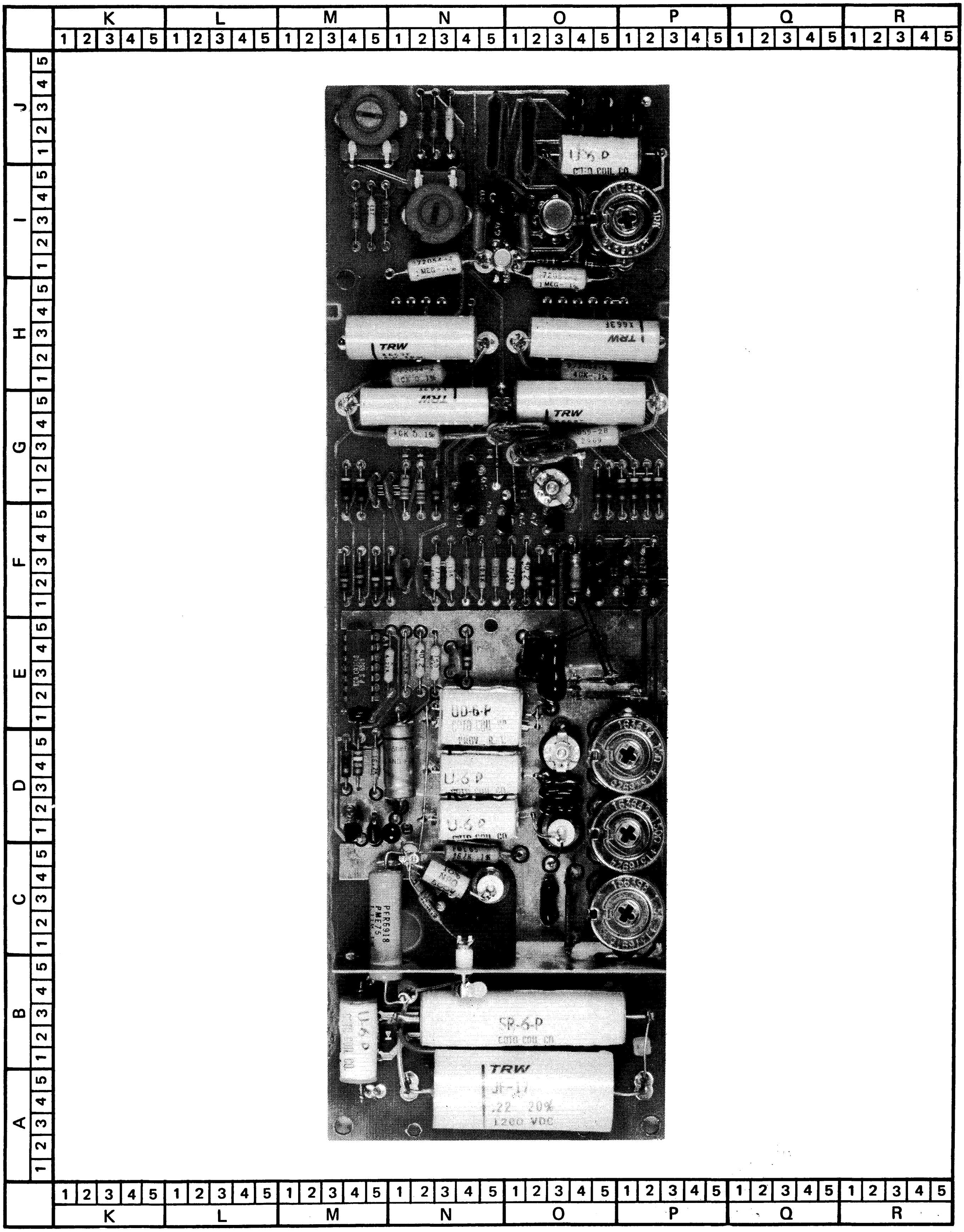


Figure 6-7. AC CONVERTER P/C ASSEMBLY

6-40. SERIAL NUMBER EFFECTIVITY

6-41. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8300A. Each part in this option for which a use code has been assigned may be identified with a particular printed circuit board serial number by consulting the Use Code Effectivity List below. All parts with no code are used on all printed circuit boards with serial numbers 123 and on. NOTE: These Use Codes and Serial Number Effectivity apply to this option printed circuit board assembly only. For the standard instrument configuration, see Section 5, paragraph 5-9, and for additional options, see the appropriate option subsection.

USE CODE	SERIAL NUMBER EFFECTIVITY
A	123 thru 999
B	1000 and on.
C	123 thru 1275
D	1276 and on.
E	123 thru 1390
F	1391 and on.

OPTION 8300A-02 MILLIVOLT/OHMS CONVERTER AND OPTION 8300A-10 MILLIVOLT CONVERTER

6-1. INTRODUCTION

6-2. The MV/Ohms Converter (Option -02) is used in conjunction with the Model 8300A basic DVM to provide voltage measuring capability in two ranges and resistance measuring capability in five ranges. Full-scale ranges include 100 and 1000 millivolts; 1, 10, 100, and 1000 kilohms; and 10 megohms.

6-3. The Millivolt Converter (Option –10) is used in conjunction with the Model 8300A to provide dc voltage measuring capability only in two ranges of 100 and 1000 millivolts full-scale. This option is identical to the millivolt portion of the Millivolt/Ohms Converter which is described in the following paragraphs. Schematic No. 11, unique to the Millivolt Converter, is located at the back of the manual.

NOTE!

Option –10 is a factory installed option only.

6-4. SPECIFICATIONS

6-5. Specifications for the MV/Ohms Converter are located in Section I of the manual.

6-6. INSTALLATION

6-7. The following procedure should be used to install the MV/Ohms Converter in the Model 8300A.

a. Remove power cord from the instrument before installing the MV/Ohms option.

b. Remove the Model 8300A top dust cover and guard chassis cover. Check connector pins on MV/Ohms board to assure that every pin is straight and perpendicular to PCB.

c. Align the notches on the MV/Ohms converter board with the tabs on the Model 8300A interconnect board and insert the board in place in the position shown on the guard cover (rearmost position).

d. Fasten the board in place using the screws provided with the converter. Check connector pins for correct mating with receptacle using a small mirror.

e. Complete the installation by connecting the red, yellow, brown, and black converter wires to the input terminal connection point as shown on the guard cover.

6-8. OPERATING INSTRUCTIONS

6-9. Operating instructions for the Model 8300A with MV/Ohms converter installed are located in Section II of the manual.

6-10. THEORY OF OPERATION

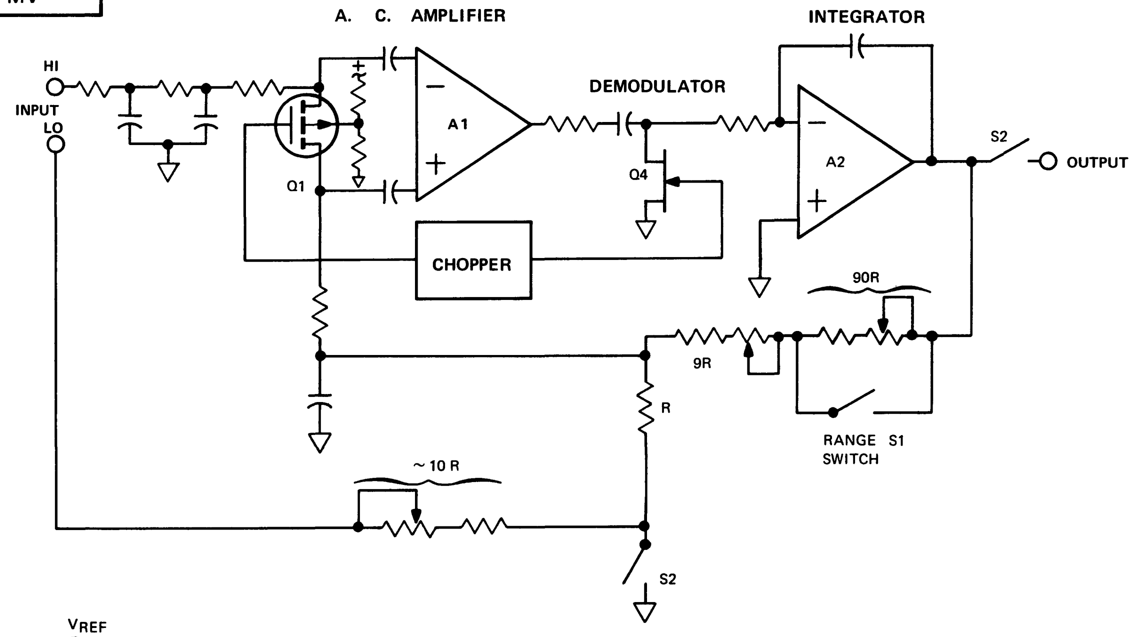
6-11. General

6-12. The MV/Ohms converter may be thought of as two separate converters. One converter is a chopper stabilized amplifier, which provides dc amplification of the unknown voltage to levels suitable for driving the A/D Converter. The other converter is a precision current ladder, which, in conjunction with the Buffer amplifier located in the basic instrument, provides a known current through the unknown resistor at the input terminal of the MV/Ohms Converter. Simplified diagrams of the two converters are shown in Figure 6-1.

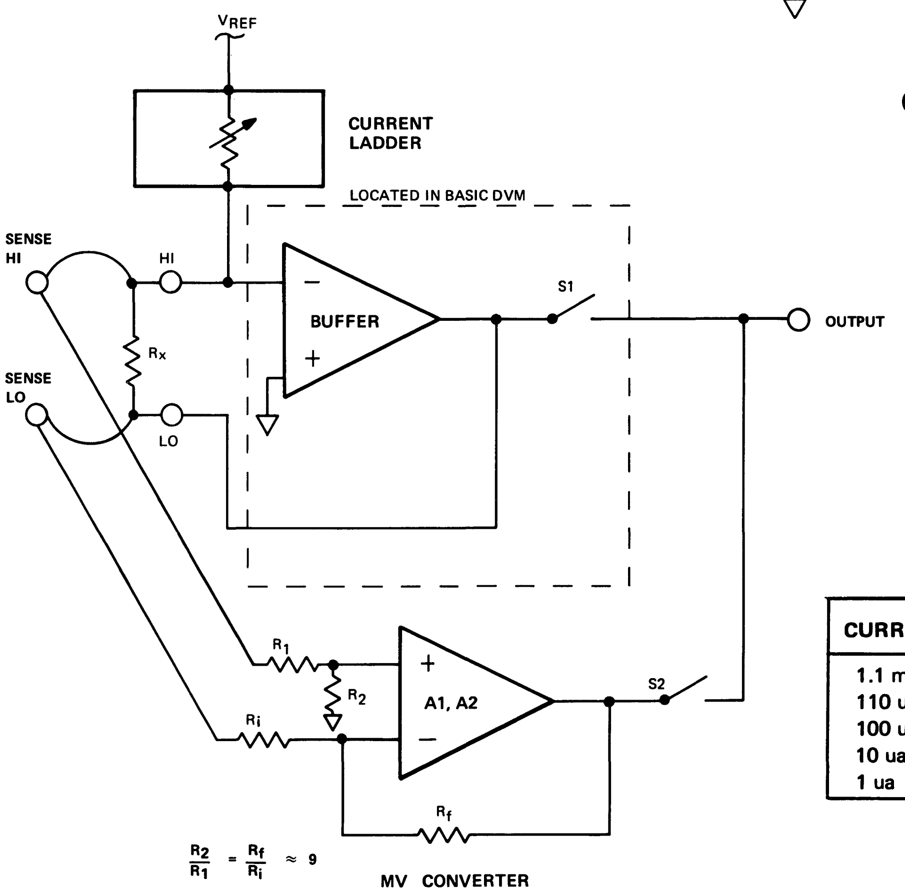
6-13. MILLIVOLTS CONVERTER. Overall, the millivolt amplifier can be considered to be a high dc gain operational amplifier utilizing potentiometric feedback to provide programmed gains of +10 or +100 and very high input impedance at dc. The A/D Converter (located in the basic instrument) follows the millivolts converter and digitizes its amplified analog output, which represents the input signal to the millivolts converter.

SWITCH CLOSURES	
S1	1000 MV
S2	MV

MILLIVOLTS CONVERSION



OHMS CONVERSION



$\frac{R_2}{R_1} = \frac{R_f}{R_i} \approx 9$

CURRENT	RANGE	SWITCH CLOSURE
1.1 ma	1k	S2
110 ua	10k	S2
100 ua	100k	S1
10 ua	1000k	S1
1 ua	10 M	S1

Figure 6-1. SIMPLIFIED DIAGRAM OF MV/OHMS CONVERTER SHOWING CIRCUIT ARRANGEMENT FOR EACH OPERATING MODE.

6-14. A MOSFET chopper is used across the summing junctions of the operational amplifier. The signal developed by the chopping action is amplified and applied through a capacitor to a half-wave synchronous demodulator. The demodulator output is applied to a high gain (at dc) operational amplifier connected as an integrator. The integrator output is applied to the MOSFET chopper in such manner as to insure negative feedback. The RC network at the input provides filtering to prevent beat frequency products at the amplifier output and to provide balanced ac impedance for the chopper.

6-15. The use of the MOSFET chopper allows spikes developed due to capacitive coupling from gate drive to channel to become a common mode signal for a high CMRR operational amplifier. Balanced ac impedances at the chopper provide a cancellation effect on the offset current and voltage which result from the capacitive spike. The net result is a chopper amplifier capable of operating at a fairly high frequency with small voltage and current offsets and with spikes of low enough value to keep the ac amplifier from saturating. The above operation is achieved without adjustments for spike compensation.

6-16. OHMS CONVERTER. The current ladder is connected to the Buffer and millivolts converter as shown in Figure 6-1. The inverting terminal of the buffer amplifier is held very near analog common by the feedback connection of the unknown resistance. Because the inverting terminal is held near ground and because the input current to the buffer is small, the current through the unknown resistor is set by V_{REF} and the selected current-ladder resistor. For the three upper kilohm ranges, the output of the buffer is presently directly to the A/D Converter. Thus, since the A/D Converter digitizes 11.9999V as full scale, that voltage must represent full scale on the 10 megohm, 1000 kilohms, and 100 kilohm ranges where 1199.99 kilohms and 119.99 kilohms represent full scale respectively. For the 1 and 10 kilohm ranges, smaller full scale voltages are used to minimize power dissipation in the unknown. Thus, on these two ranges, the millivolts converter is used to amplify the voltage across the unknown resistor and present the amplified voltage to the A/D Converter.

6-17. In addition to providing smaller full-scale measurement voltages in the lower two resistance ranges, use of the millivolts converter allows a modified four-terminal resistance measurement to be made. The term modified four-terminal is used, because the technique employed requires a small current in one of the sense lines that would not be present in a true four-terminal resistance measurement. The sense current magnitude is determined by the voltage impressed on the unknown resistor divided by Ri. The error thus contributed by the sense current can be expressed as the ratio of the resistance in the sense line to R1, i.e., if the sense line resistance is 1 ohm, then the error due to the sense current can be computed roughly as follows:

$$\text{Error} = \frac{1.0\Omega}{Ri} = \frac{1.0\Omega}{100K\Omega} = 10^{-5} \text{ or 10 ppm of reading.}$$

6-18. If a two terminal reading were made at the 1 kilohm level with a 1.0 ohm resistance in the hook-up wires, the error would be ≈1000 ppm. The improvement in performance using the modified four-terminal measurement is obvious.

6-19. Circuit Description

6-20. AMPLIFIER. The input stage of the ac amplifier consists of differential stage Q2, Q3 (see schematic at back of manual). The MOSFET chopper, Q1, is switched off and on at a 200 Hz rate by the squarewave signal applied to its gate, thus modulating the input signal and producing a square wave output signal to Q2 having an amplitude proportional to the amplitude of the loop error signal. The differential output of Q2, Q3, is amplified in A1 and applied to Q4, where it is demodulated. The demodulated output is applied to integrator A2. The 1000 MV and 100 MV adjustments, R32 and R28, are located in the negative feedback path. The chopper switching signal is produced by a multivibrator using transistors Q6 and Q7.

6-21. CURRENT LADDER. The current ladder consists of resistors R39 through R47 and resistor R58. The ladder is operated by relays K5, K6, and K7, which are selected by appropriate function and range commands as shown in Figure 6-2.

RELAY	LOGIC FUNCTION	FUNCTION PERFORMED
K1	MV	100MV, 1000MV
K2	KΩ • a + MV	1KΩ, 10KΩ, 100MV, 1000MV
K3	KΩ + MΩ	1KΩ, 10KΩ, 100KΩ, 1000KΩ, MΩ
K4	KΩ • a	1KΩ, 10KΩ
K5	KΩ • a • b	1KΩ
K6	KΩ • (a + b)	1KΩ, 10KΩ, 100KΩ
K7	KΩ • b	10KΩ, 1000KΩ
K8	MV • b	1000MV

Figure 6-2. RELAY FUNCTION

6-22. RELAY DRIVERS. The relays are operated by drive circuitry consisting of transistors Q8 through Q10, integrated circuit A3, and associated components. This circuitry accepts inputs from the function control lines and the range flip flops, 18a and 18b, in the DVM logic section and implements the logic functions of Figure 6-2 to operate the MV/Ohms Converter.

6-23. MAINTENANCE

6-24. Introduction

6-25. This section contains maintenance information for the MV/Ohms Converter. Factory service information and general instructions regarding instrument access and cleaning are located in Section IV of the manual.

6-26. Test Equipment

6-27. The equipment recommended for performance testing, troubleshooting, and calibration of the MV/Ohms Converter is listed in Figure 6-3. If the recommended equipment is not available, other equivalent equipment may be used.

EQUIPMENT NOMENCLATURE	RECOMMENDED EQUIPMENT
DC Voltage Source	Fluke Model 343A DC Voltage Calibrator
Standard Resistors 1K 10K 100K 1000K 10 MΩ	General Radio-Type 1440, Standard Resistors

Figure 6-3. TEST AND CALIBRATION EQUIPMENT

6-28. Fuse Replacement

6-29. The MV/Ohms Converter contains a fuse, which prevents damage in the event large ac or dc voltages are inadvertantly applied to the DVM input during ohms operation. The circuit will withstand a maximum applied voltage of 30 volts dc or 30 volts rms before the fuse will blow. Replace with same type 1/20 ampere–fast Microfuse.

6-30. Performance Tests

6-31. The performance tests in this section compare the MV/Ohms Converter performance to the accuracy specifications in Section I of the manual to determine if the converter is in calibration. Known dc voltages are applied to the DVM input terminals on each millivolt range and appropriate resistance standards are connected to the input on each ohms range. The performance tests should be conducted before any instrument maintenance or calibration is attempted. The tests are also suited to receiving inspection of new converters. Performance tests should be conducted under the following environmental conditions: ambient temperature 25°C ±5°C, relative humidity less than 70%. An instrument that fails any of the performance tests will require corrective maintenance or calibration. In case of difficulty, analysis of the test results, with reference to the troubleshooting section, should help to locate the trouble.

NOTE!

Permissible tolerances for voltage and resistance measurements are derived from the 90-day instrument specifications contained in Section I of the manual.

6-32. DC MILLIVOLTS TEST. In the following procedure, dc voltages are applied to the instrument at 10% and 100% of full scale on the 100 and 1000 millivolt ranges.

a. Connect the Model 8300A to the ac line and set the controls as follows:

POWER	ON
FUNCTION	MVDC
RANGE	Manually selected, as required.

b. Apply each of the input voltages shown in Figure 6-4 in turn, to the INPUT terminals of the Model 8300A. The readout should be as indicated.

INPUT (MILLIVOLTS DC)	MODEL 8300A	
	RANGE	READOUT LIMITS
+10	100	+09.989 to +10.011
+100	100	+99.980 to +100.020
+100	1000	+099.96 to +0100.04
+1000	1000	+999.80 to +1000.20

Figure 6-4. MILLIVOLTS TEST REQUIREMENTS

c. Repeat steps (b) with negative input voltages. The DVM readout should be the same as for positive inputs, except that the polarity indication should be negative (MV, DC–).

d. Remove the input from the DVM and press the AUTO RANGE switch. The readout should be 00.000.

e. Apply 1000 millivolts dc to the INPUT terminals. The DVM should range automatically and the readout should be between +999.80 and +1000.20.

6-33. OHMS TEST. The ohms function is checked at full scale on each ohms range of the DVM. Connect each of the standard resistors shown in Figure 6- 5, in turn, to the INPUT terminals of the Model 8300A. Use short, low-resistance connecting leads. Set the DVM controls as shown in the figure. The readout should be as indicated.

STANDARD	MODEL 8300A		
RESISTANCE	FUNCTION	RANGE	READOUT LIMITS
1K	KΩ	1	.99987 to 1.0013
10K	KΩ	10	9.9987 to 10.0013
100K	KΩ	100	99.987 to 100.013
1000K	KΩ	1000	999.87 to 1000.13
10 MΩ	10 MΩ		9.9947 to 10.0053

Figure 6–5. OHMS TEST REQUIREMENTS

6-34. Troubleshooting

6-35. This section contains information selected to aid in troubleshooting the MV/Ohms Converter. Before attempting to troubleshoot the converter, however, it should be verified that the trouble is actually in the converter and is not caused by faulty external equipments or improper control settings. For this reason, the performance tests (paragraph 6-30) are suggested as a first step in troubleshooting. The performance tests may also help to localize the trouble to a particular section of the converter. If the performance tests fail to localize the trouble, the following information may be helpful. Connector pin locations are shown in Figure 4-5. (Section IV of the manual).

6-36. POWER SUPPLY VOLTAGE CHECK. In this test, each of the input supply voltages for the MV/Ohms Converter is checked at the input connector. This test verifies only presence of voltages; a detailed check of Model 8300A power supply voltages is given in Section IV of the manual.

a. Connect the oscilloscope common to TP3 of the converter. Use the signal at TP4 to externally trigger the oscilloscope. Set the scope controls for dc voltage measurement, and check the following voltages:

Connector Pin No.	Required Voltage
18	–18 volts
16	+18 volts
12	+ 7 volts

6-37. COMMAND VOLTAGE CHECK. The presence of proper command voltages is checked in the following test:

a. Connect the oscilloscope to the converter as indicated in the preceeding test.

b. Perform each of the checks given in Figure 6-6. The voltages should be as indicated.

c. Rotate the MV ZERO control on the front panel from fully clockwise to fully counter-clockwise: verify that the voltage at pin 17 of the converter board connector changes from +18 volts to –18 volts.

6-38. MULTIVIBRATOR CHECK. This test verifies that the multivibrator is working.

a. Connect the oscilloscope as indicated in paragraph 6-35. and monitor the waveform at TP4.

b. The waveform should be approximately as shown on the MV/Ohms Converter schematic.

c. If no signal is present, the multivibrator may have stopped due to the oscilloscope probe shorting the drive transistors. Turn the instrument off and then on. If no signal is then present, the multivibrator is defective.

d. If the waveform is radically different from the one shown on the schematic, either the drive transistors (Q6 and Q7) or the chopping transistors (Q1 and Q4) are defective.

CONNECTOR PIN NO.	FUNCTION	RANGE	REQUIRED VOLTAGE	POSSIBLE TROUBLE
14	Any function except MVDC	Any	<0.6v	1. Improper connections between converter board and main frame, e.g., misalignment of connector pins. 2. Faulty function switches on buffer board.
14	MVDC	Any	>4.5v	
9	Any function except 10 MΩ	Any	<0.6v	
9	10 MΩ	Any	>4.5v	
5	Any function except KΩ	Any	<0.6v	
5	KΩ	Any	>4.5v	
2	KΩ	1, 10	> 3.0v	1. Improper connections between converter board and main frame. 2. Defect in autorange logic (main PCB) 3. Defective range switch.
2	KΩ	100,1000	<0.6v	
1	KΩ	1, 100	<0.6v	
1	KΩ	10, 1000	>3.0v	
6	10 MΩ	Any	>4.0v	CR21 Defective
6	KΩ	100, 1000	>4.0v	Q10 or A3 Defective
6	KΩ	1, 10	<0.6v	
6	VDC	Any	> 4.0v	Improper connection between converter board and main frame
6	VAC	Any	<0.6v	Short between VAC line and K8 control line.

Figure 6-6. MV/OHMS CONVERTER FUNCTION COMMAND CHECK

6-39. RELAY CHECK. The following truth table (Figure 6-7) is designed to help locate defective relays or associated components. A logical "1" indicates that the relay should be in opposite state from that shown in the schematic. This can be monitored by placing a dc voltmeter or oscilloscope across the coil. If the voltage across the coil

FUNCTION CALLED	RANGE CALLED	CONVERTER RELAYS								FRONT PANEL SWITCHES						
										RANGE MVDC		RANGE – KΩ				10 MΩ
		K1	K2	K3	K4	K5	K6	K7	K8	100	1000	1	10	100	1000	
MVDC	100	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
MVDC	1000	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0
KΩ	1	0	1	1	1	1	1	0	0	0	0	1	0	0	0	0
KΩ	10	0	1	1	1	0	1	1	0	0	0	0	1	0	0	0
KΩ	100	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0
KΩ	1000	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0
10 MΩ	ANY	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1

LEGEND: LOGIC 0 → RELAY DE-ENERGIZED (<0.5v across coil)
LOGIC 1 → RELAY ENERGIZED (> 4.0v across coil)

Figure 6-7. MV/OHMS CONVERTER RELAY TRUTH TABLE

SYMPTOM	PROCEDURE
Severe converter malfunction, i.e., full-scale output with shorted input, no output with full-scale input etc.	Check operational amplifiers, A1 and A2, by measuring their individual inputs and outputs. There should be approximate operational correspondence between input and output levels; however, because the amplifiers are self-protected, only gross errors on the order of 1 or 2 volts should be considered significant.
Readout is zero for an open-circuit input in KΩ or 10 MΩ modes.	Check fuse F1 and relay K3 for opens as follows: a. The voltage at the junction of R38 and R39 should be < 200 MV relative to analog common. If the voltage is correct, either relay K2 on the MV/Ohms Converter board or K8 on the buffer board is not working properly. b. If the voltage in step (a) is high (> 1.0v dc), then F1 can be checked with a voltmeter to see if it is open. If the same voltage is measured across F1, the fuse should be replaced. c. If the fuse is good, measure across the contacts of K3; if the voltage measured in step (a) is also measured across the contacts of K3, the relay switch, coil, or drive circuitry is faulty.
Readout in KΩ mode is grossly different than measured resistor.	Check relays K5, K6, and K7 and their drivers.
Readout does not change between 100 MV range and 1000 MV range for a valid input signal of approximately 100 MV.	Check relay K8.
Gain is approximately 10X to low in 1000 MV range and 100X too low in 100 MV range.	Check relay K4 and its drive circuitry.

Figure 6-8. MV/OHMS CONVERTER TROUBLE CHART

is not >4v for logic "1" or <0.5v for logic "0", the drive relay circuitry is at fault. If the voltage is present but the relay does not change, the relay coil and/or function or range switch is defective.

6-40. TROUBLESHOOTING CHART. Figure 6-8 describes possible troubles which may be encountered in the MV/Ohms Converter together with appropriate troubleshooting procedures.

6-41. Calibration

6-42. The MV/Ohms Converter should be calibrated every 30 or 90 days, depending on the degree of accuracy to be maintained (see specifications, Section I), or whenever repairs have been made to circuitry, which may affect the calibration accuracy. Calibration of the converter should be performed at an ambient room temperature of 25°C ±5°C. Relative humidity should be less than 70%. Consult Figure 6-3 for recommended test equipment.

INPUT (VOLTS DC)	RANGE	ADJUSTMENT	READOUT	READOUT DIGIT TOLERANCE
+1.00020	1000	1000 MV	+1000.20	±0
–1.00020	1000	(none)	–1000.10	±2
–0.100020	100	100 MV	+ 100.020	±0
+0.100020	100	(none)	–100.020	±2
+0.050020	100	(none)	+50.020	±2
+0.50020	1000	(none)	+500.20	±2

Figure 6-9. MVDC RANGE CALIBRATION.

6-43. PRELIMINARY OPERATIONS.

a. Remove the upper dust cover retaining screws, but leave the dust cover in place on the instrument.

b. Set the rear panel 115/230 volt slide switch to the 115 volt position and connect the line cord to an autotransformer set to 120 volts ac.

c. Turn on the Model 8300A and allow the instrument to operate for one hour.

6-44. MV/OHMS CONVERTER ALIGNMENT.

a. Remove the upper dust cover and set the Model 8300A controls as follows.

FUNCTION	MVDC
RANGE	100
SAMPLE RATE	(as desired)

b. Connect the GUARD terminal to the LO INPUT terminal using the shorting link provided with the instrument.

c. Short the INPUT terminals together.

d. Adjust the MV ZERO control on the front panel for a 00.000 ±3 digit readout.

e. Select the 1000 MVDC RANGE. The readout should be 000.00 ±1 digit.

f. Remove the short between the INPUT terminals.

g. Perform the checks and adjustments contained in Figure 6-9.

h. Select the 10 MΩ and FILTER functions.

i. Connect the resistances indicated in Figure 6-10 between the INPUT terminals and perform the corresponding adjustment:

INPUT RESISTANCE	RANGE	ADJUSTMENT	READOUT
10M	10 MΩ	MEG Ω	10.0000
1M	1000 KΩ	1000 K	1000.00
100K	100 KΩ	100K	100.000
10K	10 KΩ	10K	10.0000
1K	1 KΩ	1K	1.00000

Figure 6-10. RESISTANCE RANGE CALIBRATION

NOTE!

The readout indicated in Figure 6-10 should match the exact value of the calibration resistor, not the nominal value.

6-45. Calibration of the MV/Ohms Converter is now complete.

6-46. LIST OF REPLACEABLE PARTS

6-47. For column entry explanations, part ordering information and basic instrument configuration Use Codes and Serial Number Effectivity List, see Section 5, paragraphs 5-1 through 5-10. See paragraph 6-48, this option subsection, for additional Use Codes and Serial Number Effectivity List assigned to this printed circuit assembly option.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		DIGITAL VOLTMETER - MV/OHMS CONVERTER OPTION	8300A-02					
		NOTE: The basic Model 8300A can be modified in the field by installing the MV/Ω Converter Kit (8300A-02K), order by Model and Option No. (8300A-02K)						
		Millivolt/Ohms Converter P/C Assembly (See Figure 6-11)	270967	89536	270967	1		
A1	F5-P1	IC, operational amplifier	271502	12040	LM301A	2	1	
A2	J1-P1	IC, operational amplifier	271502	12040	LM301A	REF		
A3	J1-M5	IC, transistor array	248906	95303	CA3046	1	1	
C1	C1-O5	Cap, plstc, 0.1uf±20%, 120v	167460	84411	Type JF39	1		
C2	C1-P2	Cap, plstc, 0.22 uf ±20%, 120v	167452	84411	Type JF39	1		
C3	E2-P2	Cap, plstc, 0.01 uf ±20%, 100v	235390	84411	Type 663UW	3	3	
C4	E2-P1	Cap, plstc, 0.01 uf ±20%, 100v	235390	84411	Type 663UW	REF		
C5	G3-P2	Cap, Ta, 1 uf ±20%, 35v	161919	56289	196D105X 0035	1	1	
C6	G2-P1	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	2		
C7	F4-P1	Cap, mica, 10 pf ±10%, 500v	175216	14655	CD15C0 100K	2		
C8	I1-P1	Cap, plstc, 0.47 uf ±10%, 250v	184366	73445	C280AE/ A470K	1	1	
C9	I3-P1	Cap, plstc, 0.22 uf ±10%, 250v	309489	73445	C280AE/ A220K	1	1	
C10	J2-O4	Cap, cer, 0.22 uf +80/–20%, 3v	153015	56289	C052B3R0 E224Z	1		
C11	J3-O5	Cap, plstc, 2.2 uf ±20%, 250v	222232	73445	C280AE/ A2M2	1	1	G
C11	J3-05	Cap, plstc, 2.2uf±10%, 250v	306522	73445	C280MCH/A2M2	1	1	H
C12	J2-P3	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E33 0J	REF		
C13	E1-O3	Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/A 100K	1	1	
C14	J2-O1	Cap, mica, 4700 pf ±5%, 500v	208975	84171	DM19472J	1		C
C14	J2-01	Cap, mica, 3900 pf ±5%, 500v	160325	14655	CD19F392J	1		D
C15	J1-O1	Cap, mica, 5600 pf ±2%, 500v	182873	14655	CD19F562G	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C16	E2-O1	Cap, plstc, 0.01 uf ±20%, 100v	235390	84411	Type 663UW	REF		
C17	F4-P1	Cap, mica, 10 pf ±10%, 500v	175216	14655	CD15C0 100K	REF		
CR1	D1-O3	Diode, silicon, 75 ma, 100 piv	260554	07910	CD55105	6	4	
CR2	D1-O3	Diode, silicon, 75 ma, 100 piv	260554	07910	CD55105	REF		
CR3	D2-O2	Diode, silicon, 75 ma, 100 piv	260554	07910	CD55105	REF		
CR4	D3-O2	Diode, silicon, 75 ma, 100 piv	260554	07910	CD55105	REF		
CR5	I5-O4	Diode, zener, 6.2v	180497	07910	1N753	2		
CR6	I5-P1	Diode, zener, 6.2v	180497	07910	1N753	REF		
CR7	E1-N4	Diode, silicon, 75 ma, 100 piv	260554	07910	CD55105	REF		
CR8	E1-N1	Diode, silicon, 75 ma, 100 piv	260554	07910	CD55105	REF		
CR9	D5-N4	Diode, zener, 6.2v	180497	07910	1N753	REF		E
CR9	D5-N4	Diode, zener, 20v	291575	12969	UZ8720	2		F
CR10	D5-N1	Diode, zener, 6.2v	180497	07910	1N753	REF		E
CR10	D5-N1	Diode, zener, 20v	291575	12969	UZ8720	REF		F
CR11	I2-N3	Diode, silicon, 150 ma	203323	03508	DHD1105	15	5	
CR12	I2-M5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR13	E4-N1	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR14	E4-N3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR15	C1-O2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR16	E4-N5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR17	F3-O2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR18	F5-O2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR19	F3-N5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR20	C2-O2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR21	I4-N3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR22	F5-N5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR23	I3-N3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR24	I4-N3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR25	B5-O2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
F1	D4-M5	Fuse, pigtail, 50 ma, 125v (1 provided as a spare)	272088	75915	279.050	2	5	
K1	C4-N4	Relay, dpdt, 5 vdc	268995	24796	R40-E025-2	2	2	
K2	F2-N4	Reed switch	219097	15898	765972	5	5	
	F4-N4	Coil, reed switch	269019	71707	U-6-P	6	6	

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
K3	B1-M5	Reed switch	233916	12617	Type DRR5	1	1	G
	B1-M5	Reed switch	284091	12617	Type MRR5	1	1	H
	B4-M5	Coil, reed switch	269001	71707	SR-6-P	1	1	G
	B4-M5	Coil, reed switch	269019	71707	U-6-P	REF		H
K4	B3-N4	Relay, dpdt, 5 vdc	268995	24796	R40-E025-2	REF		
K5	E2-N4	Reed switch	219097	15898	765972	REF		
	E4-N4	Coil, reed switch	269019	71707	U-6-P	REF		
K6	F1-M5	Reed switch	219097	15898	765972	REF		
	E4-M5	Coil, reed switch	269019	71707	U-6-P	REF		
K7	F1-N2	Reed switch	219097	15898	765972	REF		
	E4-N2	Coil, reed switch	269019	71707	U-6-P	REF		
K8	F2-O1	Reed switch	219097	15898	765972	REF		
	F4-O1	Coil, reed switch	269019	71707	U-6-P	REF		
Q1	D4-P2	Tstr, MOS-FET, P-channel	272146	17856	M104	1	2	
Q2	E5-P2	Tstr, silicon, PNP	225599	07263	S22650	2	2	
Q3	E5-O5	Tstr, silicon, PNP	225599	97263	S22650	REF		
Q4	I2-O3	Tstr, FET, N-channel	288324	15818	U1994E	1	1	
Q6	J3-O2	Tstr, silicon, PNP	288761	01295	SKA5153	2	2	
Q7	J3-N5	Tstr, silicon, PNP	288761	01295	SKA5133	REF		
Q8	I1-N1	Tstr, silicon, PNP	195974	04713	2N3906	3	3	
Q9	I1-M4	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q10	I1-N2	Tstr, silicon, PNP	195974	04713	2N3906	REF		
R1	D5-02	Res, comp, 100k ±10%, 2w	158659	01121	HB1041	2	2	
R2	D2-O4	Res, comp, 100k ±10%, 2w	158659	01121	HB1041	REF		
R3	C5-P1	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	1		
R4	D2-P2	Res, met flm, 100k ±1%, 1/8w	248807	91637	Type MFF1/8	3	3	
R5	D1-P1	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	1		
R6	D1-O5	Res, comp, 120k ±5%, ¼w	193458	01121	CB1245	1		
R7	E3-P3	Res, comp, 1M ±5%, ¼w	182204	01121	CB1055	4		
R8	F3-P2	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	3		
R9	F2-P2	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R10	F1-P2	Res, comp, 1M ±5%, ¼w	182204	01121	CB1055	REF		
R11	G3-P1	Res, comp, 1M ±5%, ¼w	182204	01121	CB1055	REF		
R12	D2-O3	Res, met flm, 909k ±1%, ½w	159483	91637	Type MFF ½	1	1	
R13	F3-P2	Res, comp, 2.2M±5%, ¼w	198390	01121	CB2255	1		
R14	G4-P1	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	7		
R15	I4-O4	Res, met flm, 49.9k ±1%, 1/8w	268821	91637	Type MFF 1/8	2	2	
R16	I4-P1	Res, met flm, 49.9k ±1%, 1/8w	268821	91637	Type MFF1/8	REF		
R17	J1-O4	Res, met flm, 100k ±1%, 1/8w	248807	91637	Type MFF1/8	REF		
R18	I2-P1	Res, comp, 100M ±10%, ½w	190520	01121	EB1071	2	1	
R19	I2-O5	Res, comp, 100M ±10%, ½w	190520	01121	EB1071	REF		
R20	E1-O5	Res, met flm, 100k ±1%, 1/8w	248807	91637	Type MFF1/8	REF		
R21	E3-O5	Res, comp, 1M ±5%, ¼w	182204	01121	CB1055	REF		
R22	D2-N5	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	2		
R23	D4-O2	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		
R24	D4-N5	Res, comp, 1.2k ±5%, ¼w	190371	01121	CB1225	2		
R25	D3-N5	Res, comp,1.2k ±5%, ¼w	190371	01121	CB1225	REF		
R26	B1-O5	Res, var, comp, 100Ω ±30%, ¼w	281634	71450	Type 201	2	2	
R27	A4-O3	Res, ww, 97.835k, matched	1				1	
R28	G3-N1	Res, var, ww, 50Ω ±20%, 1¼w	112490	71450	Type 110	1	1	
R29	E4-O4	Res, ww, 9.9975k, matched	1					
R30	E4-O2	Res, ww, 90k, matched	1					
R31	F4-O5	Res, ww, 899.73k, matched	1					
R32	G3-O4	Res, var, ww, 500Ω ±10%, 1¼w	112433	71450	Type 110	1	1	
R33	I5-O1	Res, met flm, 715k ±1%, 1/8w	236836	91637	Type MFF1/8	2	2	
R34	I4-O1	Res, comp, 20k ±5%, ¼w	221614	01121	CB2035	1		
R35	I3-O1	Res, comp 39k ±5%, ¼w	188466	01121	CB3935	2		
R36	I4-O1	Res, met flm, 715k ±1%, 1/8w	236836	91637	Type MFF1/8	REF		
R37	I2-O1	Res, comp,39k ±5%, ¼w	188466	01121	CB3925	REF		
R38	K4-N2	Res, ww, 96.8Ω ±1%, ½w	277897	89536	277897	1	1	G
R38	K4-N2	Res, met flm, 97.6Ω ±1%, 1/8w	151092	91637	Type MFF1/8	1	1	H

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R39	E4-M4	Res, film, 6.99M, factory sealed	270710	89536	270710	1	1	A
R39	E4-M4	Res, film, 6.99M ±0.1%, 2w	284968	75042	Type MEH	1	1	B
R40	H1-N1	Res, var, comp, 25k ±30%, ¼w	281659	71450	Type 201	1	1	
R41	F4-N2	Res, ww, 777.15k ±0.05%, ¾w	277913	89536	277913	1	1	
R42	H1-O2	Res, var, comp, 1k ±30%, ¼w	281642	71450	Type 201	1	1	
R43	F4-M5	Res, ww, 70.555k ±0.05%, ½w	277905	89536	277905	1	1	
R44	H2-N4	Res, var, comp, 100Ω ±30%, ¼w	281634	71450	Type 201	REF		
R45	F4-O3	Res, car flm, 330k ±1%, ½w	107359	75042	Type DCC	1	1	
R46	H2-O5	Res, var, comp, 100k ±30%, ¼w	281675	71450	Type 201	1	1	
R47	G4-N5	Res, ww, 7.0323k ±0.05%, ½w	277889	89536	277889	1	1	
R48	I3-M5	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R49	J3-M5	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R50	I4-M5	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R51	I2-M5	Res, comp, 390Ω ±5%, ¼w	147975	01121	CB3915	1		
R52	J3-M5	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R53	I4–M5	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R54	I2-N3	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R55	I5-M5	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R58	F4-O4	Res, met flm, 243k ±1%, 1/8w	235242	91637	Type MFF1/8	1	1	
R59	E5-O2	Res, comp, 4.7Ω ±5%, ¼w	193359	01121	CB47G5	1		
R60	A5-P2	Res, comp, 22Ω ±5%, ¼w	147884	01121	CB2205	1		
R61	F4-N1	Res, comp, 240Ω ±5%, ¼w	221895	01121	CB2415	1		
R62	B3-P3	Res, comp, 1k ±5%, 1/4w	148023	01121	CB1025	1		I

1 R27, R29, R30 and R31 are a factory matched set. For replacement, order Millivolt/Ohms Converter Resistor Set, part number 278291.

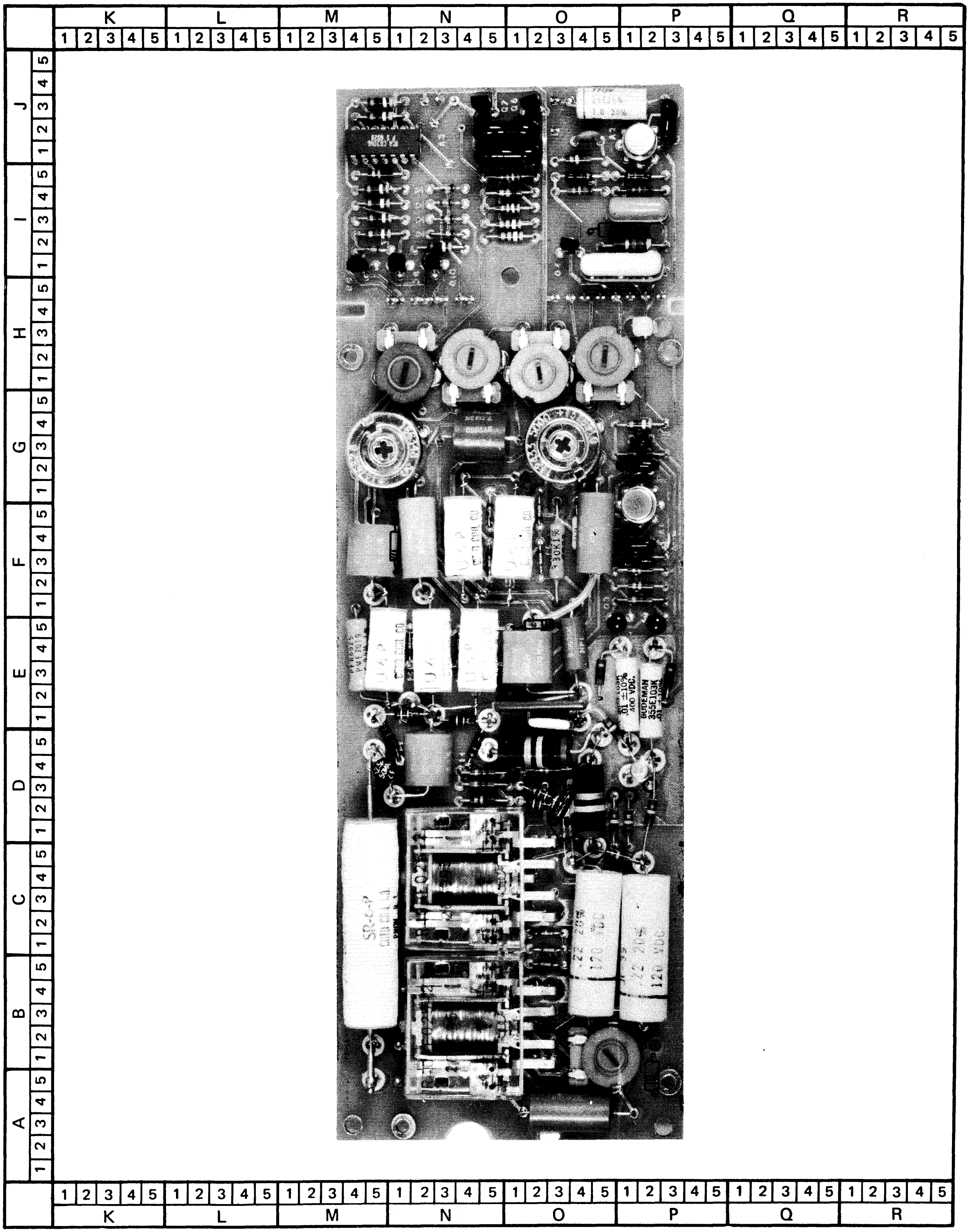


Figure 6-11. MILLIVOLT/OHMS CONVERTER P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		MILLIVOLT CONVERTER PCB Figure 6-12	339572			1		
A1, A2		IC, Operational amplifier	271502	27014	LM301A	2		
A3		IC, 5 transistor array	248906	95303	CA3406	1		
C1		Cap, plstc, 0.22 uf ±10%, 120v	167452	02799	1.2PJ224K	1		
C2		Cap, plstc, 0.1 uf ±20%, 120v	167460	84411	Type 863UW	1		
C3, C4, C16		Cap, plstc. 0.01 uf ±20%, 120v	235390	84411	Type 663UW	3		
C5		Cap, Ta, 1 uf ±20%, 35v	161919	56289	196D105X0035	1		
C6, C12		Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	2		
C7, C17		Cap, mica, 10 pf ±10%, 500v	175216	14655	CD15C0100K	2		
C8		Cap, plstc, 0.47 uf ±10%, 250v	184366	73445	C280AE/A470K	1		
C9		Cap, plstc, 0.22 uf ±10%, 250v	194803	73445	C280AE/A220K	1		
C10		Cap, cer, 0.22 uf ±20%, 50v	309849	32897	8131-050-W5R-022N	1		
C11		Cap, plstc, 2.2 uf ±10%, 100v	306522	73445	C280MCH/A2M2	1		
C13		Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/A100K	1		
C14		Cap, mica, 3900 pf ±5%, 500v	160325	14655	CD19F392J	1		
C15		Cap, mica, 5600pf ±2%, 500v	182873	14655	CD19F562G	1		
CR1 thru CR4		Diode, Si, 75 mA, 90 piv	260554	07910	CD55105	4		
CR5, CR6		Diode, zener, 6.2v	180497	07910	IN753	2		
CR7 thru CR18, CR21		Not used						
CR19, CR20, CR22		Diode, Si, 150mA	203323	03508	DHD1105	3		
K1		Relay, armature	268995	24796	R40-E025-2	1		
K2, K8		Coil, reed relay Switch dry reed	269019 219097	71707 15898	U-6-P 765792	2 2		
Q1		Xstr, FET, P-Channel	272146	17856	M104	1		
Q2, Q3		Xstr, Si, PNP	225599	07263	S22650	2		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q4		Xstr, J-FET, N-Channel	288324	15818	U1994E	1		
Q5		Not used						
Q6,Q7		Xstr, Si, PNP	288761	49956	RS-2048	2		
R1, R2		Res, comp, 100k ±10%, 2w	158659	01121	HB1041	2		
R3		Res, comp, 220k ±5%, 1/4w	160937	01121	CB2245	1		
R4, R17, R20		Res, met flm, 100k ±1%, 1/8w	248807	91637	Type MFF1/8	3		
R5		Res, comp, 180k ±5%, 1/4w	193441	01121	CB1845	1		
R6		Res, comp, 120k ±5%, 1/4w	193458	01121	CB1245	1		
R7, R10, R11, R21		Res, comp, 1M ±5%, 1/4w	182204	01121	CB1055	4		
R8, R9		Res, comp, 22k ±5%, 1/4w	148130	01121	CB2235	2		
R12		Not used						
R13		Res, comp, 2.2M ±5%, 1/4w	198390	01121	CB2255	1		
R14, R53		Res, comp, 3.9k ±5%, 1/4w	148064	01121	CB3925	2		
R15, R16		Res, met flm, 49.9k ±1%, 1/8w	268821	91637	Type MFF1/8w	2		
R18, R19		Res, comp, 100M ±10%, 1/2w Res, comp, 100M ±10%, ½w	190520 190520	01121 01121	EB1071 EB1071	2 REF		
R22, R23		Res, comp, 15k ±5%, 1/4w	148114	01121	CB1535	2		
R24, R25		Res, comp, 1.2k ±5%, 1/4w	190371	01121	CB1225	2		
R26, R27		Not used						
R28		Res, ww, 50Ω ±20%, 1 1/4w	112490	71450	Type 110	1		
R29, R30, R31		Res, matched set	339101	89536	339101	1		
R32		Res, ww, 500Ω ±10%, 1 1/4 w	112433	71450	Type 110	1		
R33, R36		Res, met flm, 715k ±1%, 1/8w	236836	91637	Type MFF1/8	2		
R34		Res, comp, 20k ±5%, 1/4w	221614	01121	CB2035	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R35, R37		Res, comp, 39k ±5%, 1/4w	188466	01121	CB3935	2		
R38, thru R58, R60		Not used						
R61		Res, comp, 240Ω ±5%, 1/4w	221895	01121	CB2415	1		
R62		Res, comp, 1k ±5%, 1/4w	148023	01121	CB1025	1		
		Cable Assy, MIL/OHMS	279737	89536	279737	1		

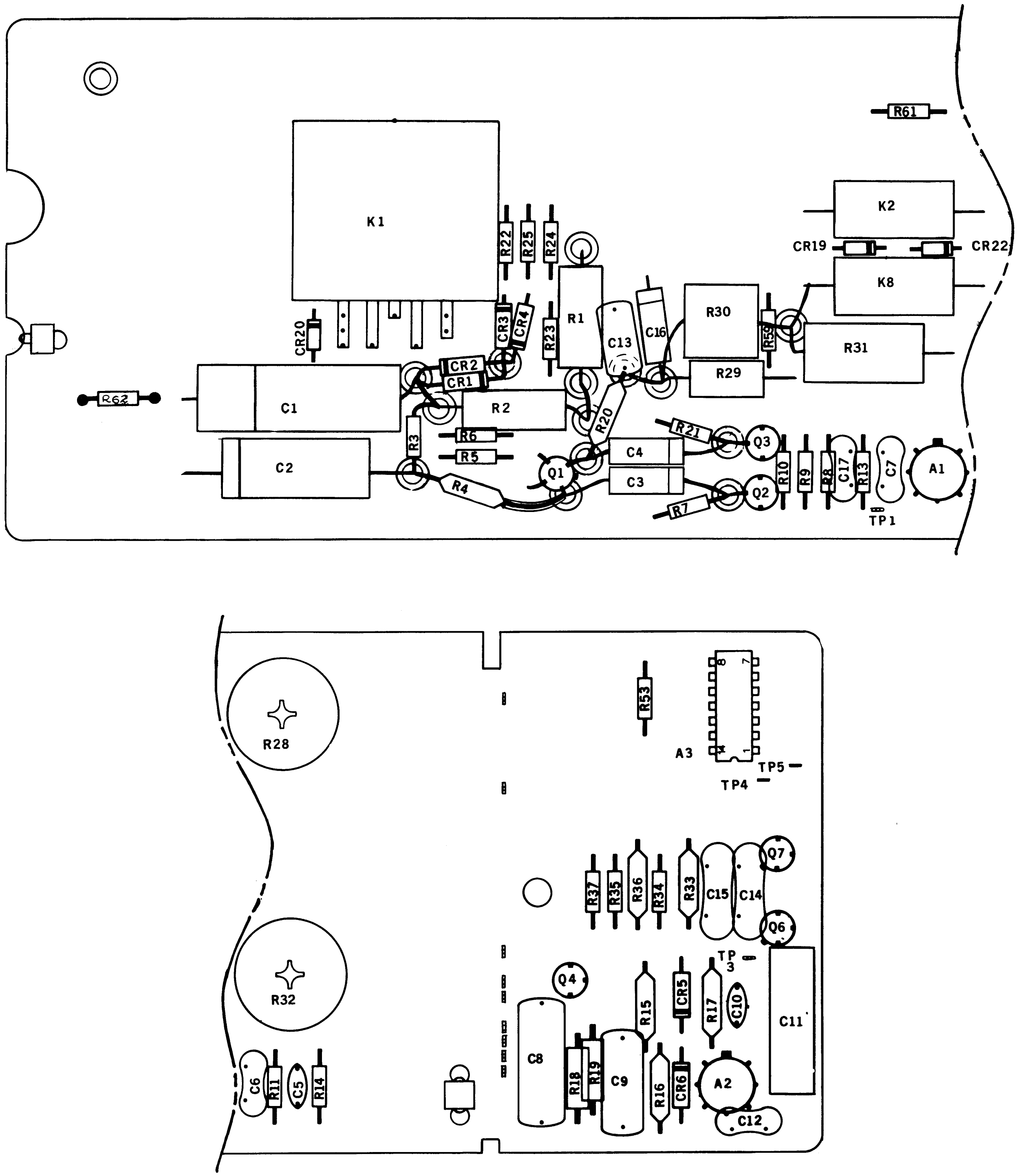


Figure 6-12. MILLIVOLT CONVERTER P/C ASSEMBLY

6-48. SERIAL NUMBER EFFECTIVITY

6-49. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8300A. Each part in this option for which a use code has been assigned may be identified with a particular printed circuit board serial number by consulting the Use Code Effectivity List below. All parts with no code are used on all printed circuit boards with serial numbers 123 and on. NOTE: These Use Codes and Serial Number Effectivity apply to this option printed circuit board assembly only. For the standard instrument configuration, see Section 5, paragraph 5-9, and for additional options, see the appropriate option subsection.

USE CODE	SERIAL NUMBER EFFECTIVITY	
	(OPTION–02)	(OPTION–10)
A	123 thru 599	
B	600 and on.	
C	123 thru 1142	
D	1143 and on.	
E	123 thru 1427	
F	1438 and on.	
G	123 thru 1732	
H	1733 and on.	
I	2618 and on.	

OPTION 8300A - 03

DATA OUTPUT UNIT

6-1. INTRODUCTION

6-2. The Data Output Unit (Option -03) provides data output that is completely isolated from the analog input and is available in 8-4-2-1 BCD logic level format. Data is transferred serially via guarded toroids from the Model 8300A to the Data Output Unit. Single decade code conversion and serial-character, parallel-bit acquisitions are unique capabilities in addition to standard full parallel output.

6-3. SPECIFICATIONS

6-4. Specifications for the Data Output Unit are located in Section I of the manual.

6-5. INSTALLATION

6-6. The following procedure should be used to install the Data Output Unit in the Model 8300A (refer to Figure 6-1).

a. Remove the top dust cover, guard chassis cover, and top rear trim strip.

b. Remove the blank rear cover at the left rear of the instrument and install the DOU assembly using the hardware supplied.

c. Pass the DOU input connector/cable through the hole in the left rear of the guard chassis and con-

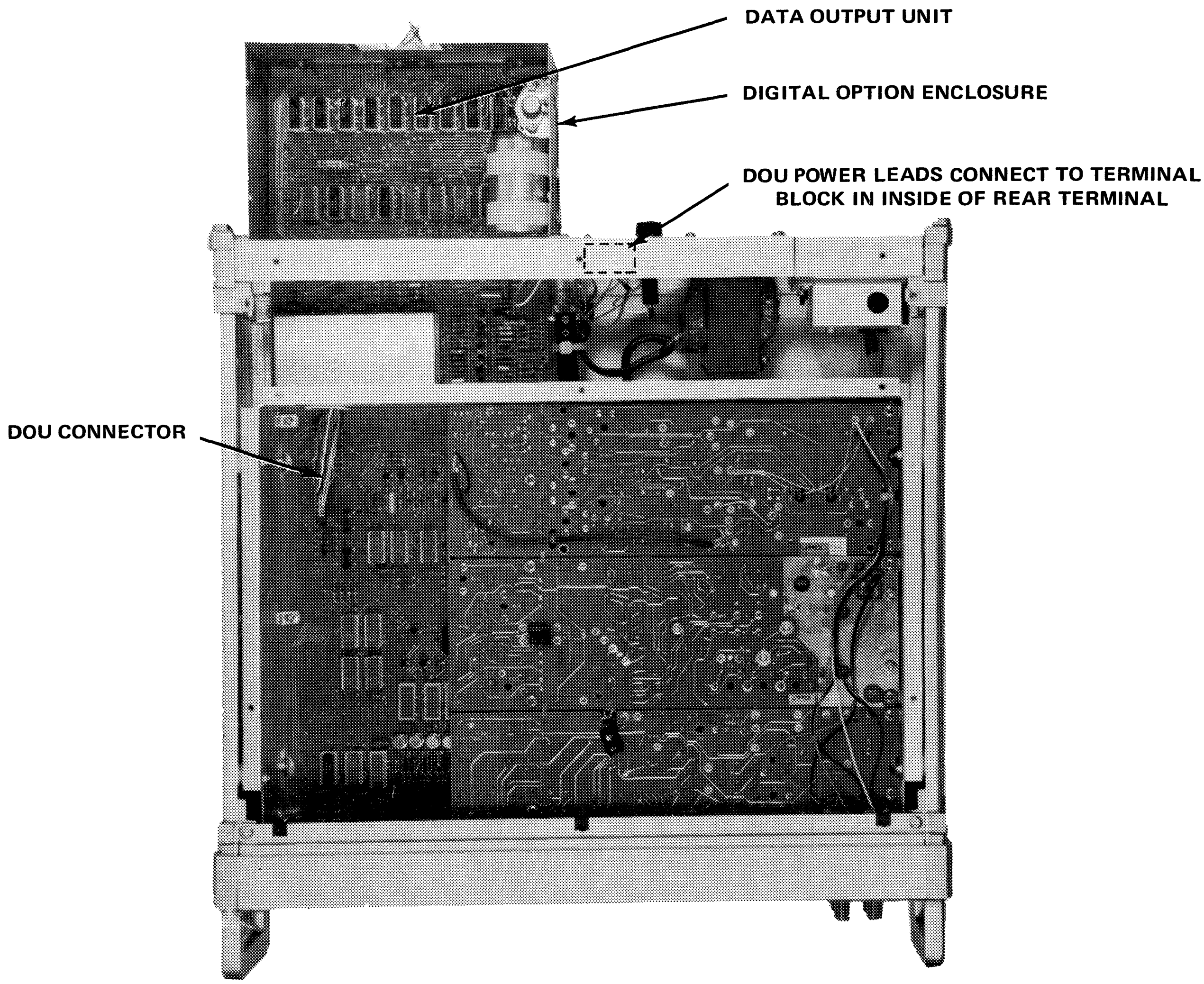


Figure 6-1. DOU INSTALLATION

nect it to the row of pins on the main PCB as shown in the figure.

d. Connect the two DOU power leads (white) to the terminal block on the inside of the Model 8300A rear panel. Either lead may be connected to either terminal.

6-7. OPERATING INSTRUCTIONS

6-8. Operating instructions and applications information for the Model 8300A with DOU installed are located in Section II of the manual.

6-9. THEORY OF OPERATION

6-10. General

6-11. The Data Output Unit (DOU) receives DVM measurement data through guarded pulse transformers and, by means of appropriate control circuitry, enters this data into a self-contained, random-access digital memory. Outputs are available in positive logic, BCD 1-2-4-8, full-parallel format. A strobing operation which produces a parallel-bit, serial-character format may be easily implemented by connecting outputs together in groups, as desired, and manipulating gate inputs (see DOU block diagram, Figure 6-2).

6-12. A system of output blanking is incorporated which has a threefold purpose. Firstly, it holds all outputs in an off state any time the DVM is performing a measurement or is in the digitizing process. It is during these periods that the DOU memory is being loaded; and if outputs were turned on, transient, meaningless data would be momentarily displayed. Secondly, signal conditioner settling time is automatically considered by a circuit called the programmed one-shot (POS). The POS ensures that the user obtains rated-accuracy data in the minimum possible time, regardless of function performed, by holding outputs off or blanked until valid data is obtainable. The advantages of this circuit are especially apparent when the instrument is commanded to sample upon simultaneous application of a transient signal or step change to the DVM input. The POS holds outputs off just long enough for the signal conditioner in use to settle to rated accuracy. When a different signal conditioner is called into operation by the user, the POS automatically adjusts timeout delay to the new conditions. At timeout, the POS triggers a new measurement before turning on the outputs 23 milliseconds later. Thirdly, automatic ranging is detected by the DOU, and data outputs are blanked during operations associated with that function. After the blanking process is complete, the outputs will remain on and unchanged until the DVM is again commanded to sample.

6-13. Following is an example of a typical sequence of internal events as initiated by a user-generated sample command.

a. An unknown input and a trigger (command to sample) are applied simultaneously to the DVM.

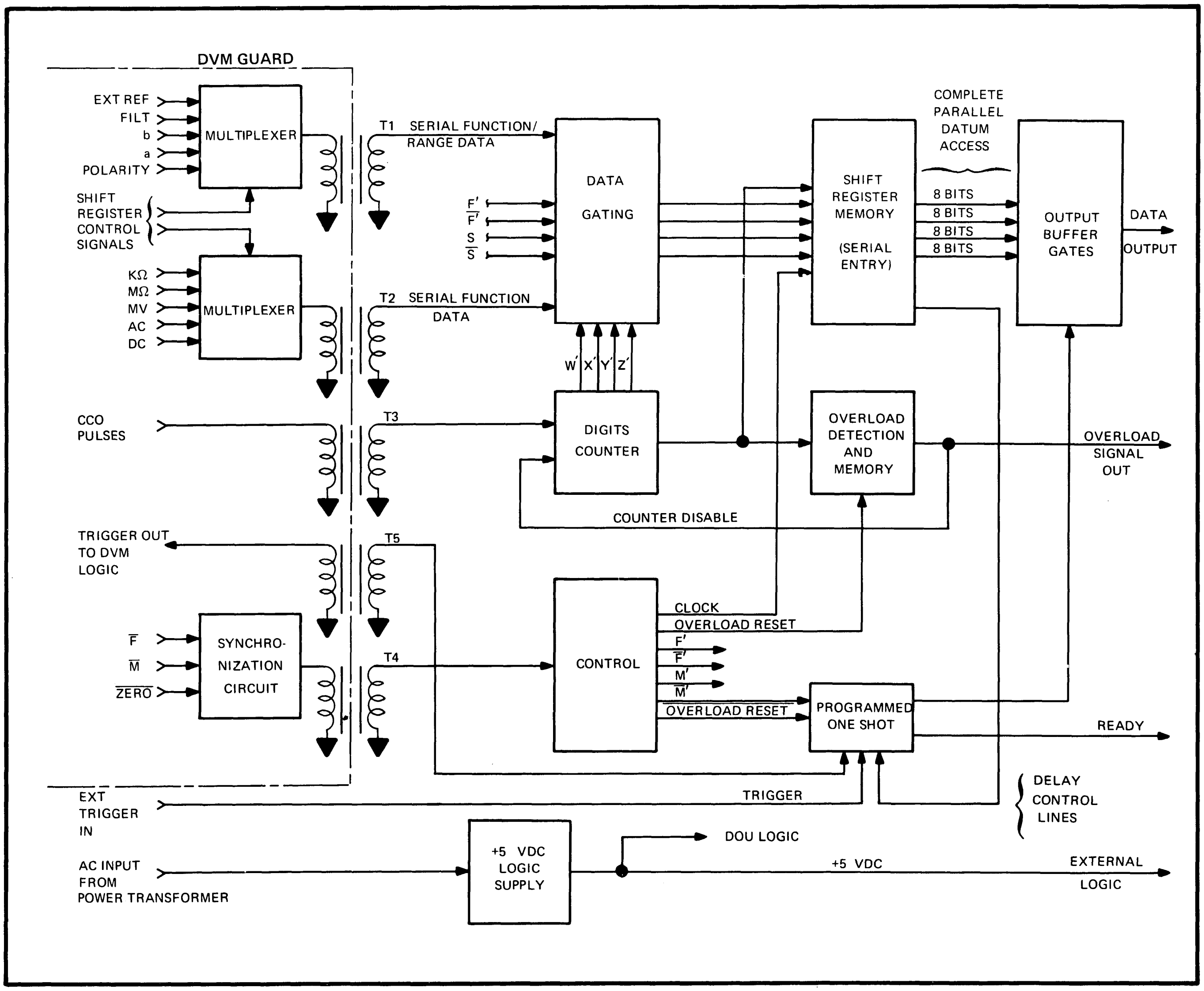


Figure 6-2. DATA OUTPUT UNIT BLOCK DIAGRAM.

b. The POS reverts to its unstable state, thereby inhibiting all outputs.

c. The DVM makes a preliminary measurement, (requiring 6 milliseconds) to determine if ranging is necessary.

d. Autoranging takes place and the timeout is increased by 250 milliseconds for each range change.

e. The programmed one-shot begins to time out in accordance with the function delay data registered in the DOU memory.

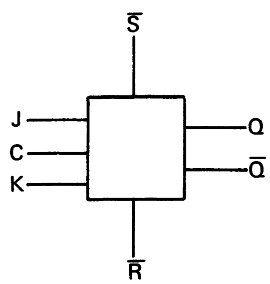
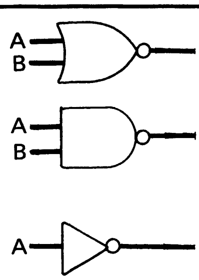
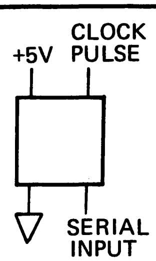
f. At the end of the required settling time, the DVM is automatically commanded to sample again by the POS as it reverts to its stable state.

g. New data is registered in the DOU memory as a result of this final sample.

h. All the outputs are then turned on to provide function, range, polarity, and specified-accuracy numerical data. A ready flag indicates whether outputs are on or off.

6-14. Circuit Description

6-15. LOGIC NOTATION. A description of the logic symbology used in the DOU is given in Figure 6-3. A J-K flip flop that is in the "1" condition or is set "high" has a "high" output from the "Q" terminal. The orientation of the flip flops in the schematics is the same as the flip flops shown in Figure 6-3. This method of notation enables input/output terminals of the flip flops to be identified with-

LOGIC SYMBOL	NAME	DESCRIPTION
	J-K Flip Flop	Operation of the J-K flip flop is shown by the following truth tables. Note that "S" and "R" inputs are dominant over "J" and "K" inputs.
	NOR Gate NAND Gate Inverter	The following table shows gate and inverter operation. Although only two-input gates are shown, operation is identical for gates having additional inputs.
	Shift Register	Four 8-bit, serial-in parallel-out shift registers are used. A logical "1" at the input enters a logical "1" into the register. The register output terminals are not shown on the schematic; however, they are given in the following table:

SYNCHRONOUS INPUTS

J	K	Q_{n+1}
0	0	Q_n
0	1	0
1	0	1
1	1	$\overline{Q}_n$

ASYNCHRONOUS INPUTS

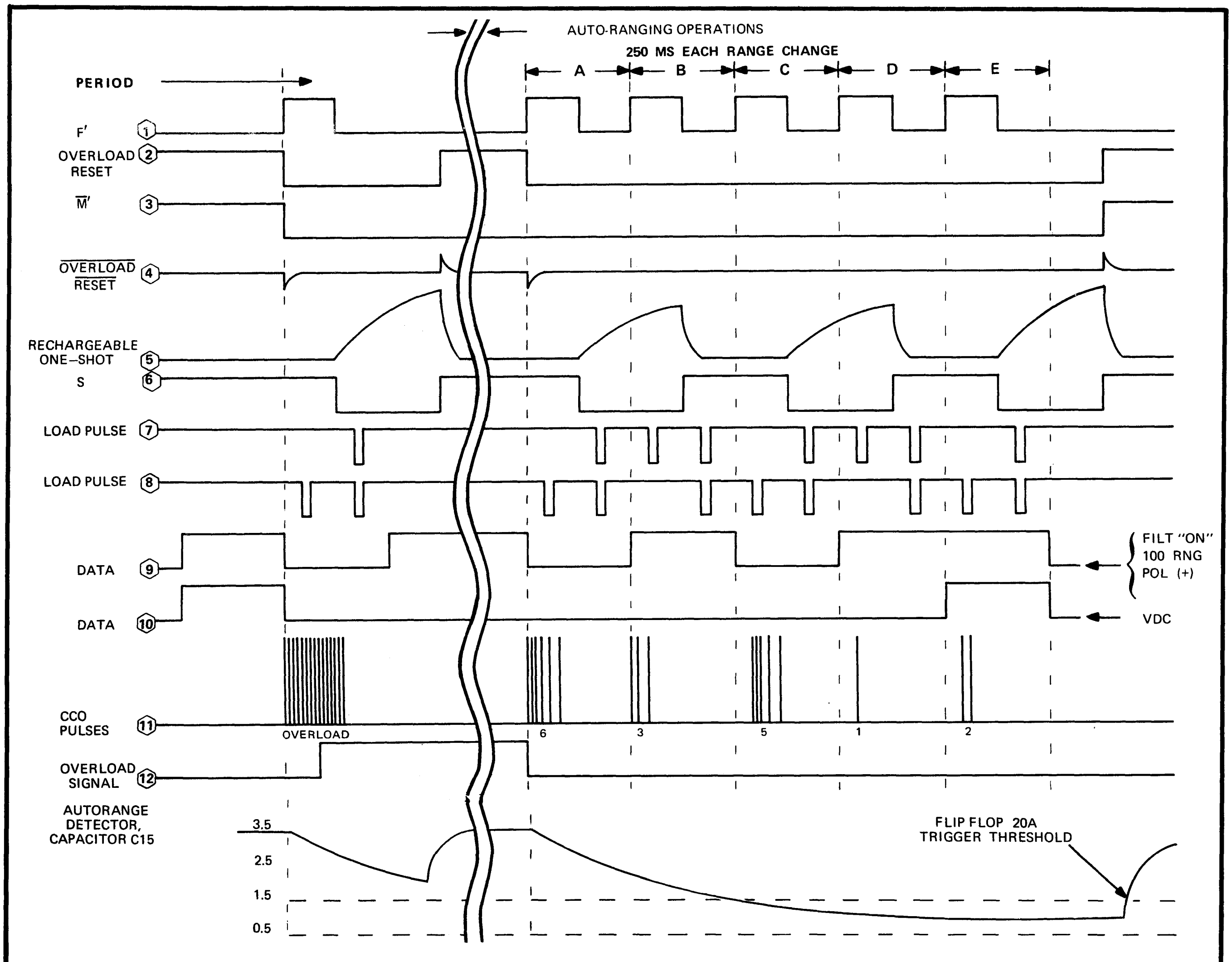
S	R	Q	$\overline{Q}$
0	0	Undefined	
0	1	1	0 Set
1	0	0	1 Reset
1	1	Normal Condition	

A	B	NOR	NAND	INVERTER
0	0	1	1	1
0	1	0	1	1
1	0	0	1	0
1	1	0	0	0

SHIFT REGISTER OUTPUTS

Q1	3	Q5	10
Q2	4	Q6	11
Q3	5	Q7	12
Q4	6	Q8	13

Figure 6-3. EXPLANATION OF LOGIC SYMBOLOGY USED IN DOU



CONDITIONS: VDC AND FILTER FUNCTIONS CALLED
100 RANGE CALLED
+63.512 VOLTS DC APPLIED TO INPUT

NOTE: SIGNAL NUMBERS CORRESPOND TO NUMBERED SIGNAL LOCATIONS ON DOU SCHEMATIC

Figure 6-4. DOU TIMING DIAGRAM

out the necessity of redundant lettering of each device symbol. In the main, the routing of logic and control signal on the schematics is accomplished without connecting lines, which greatly reduces conjestion. The routing of the memory outputs within the DOU is given by numerical designations. For example, "16-P3", which appears at pin 2 of output buffer gate 3A, refers to pin 3 of shift register 16.

6-16. MULTIPLEXERS. The DVM function, range, and polarity inputs are applied to dual multiplexer circuitry consisting of transistors Q14 through Q20 and NAND gates 28A, 28B, and 28D (see DOU schematic at back of manual). The five gates comprising each multiplexer are enabled sequentially by the 6-state shift register signals. The multiplexer outputs are applied to trigger circuits consisting of NOR gates 27A through 27D and transformers T1 and T2. The pulses produced by T1 and T2 secondaries are applied to RS flip flops composed of inverters 13B, 13C, 13D, 13E and 13F, which reconstruct the multiplexer inputs for application to the data gates. Examples of the RS flip flop outputs are shown in the timing diagram of Figure 6-4 (signals 9 and 10) and correspond to the following DVM functions and input conditions: VDC function with filter called, 100 range, and positive voltage applied to input. A complete list of waveforms appearing at the output of the RS flip flops is given in the troubleshooting section of the manual. (See Figures 6-10 and 6-11).

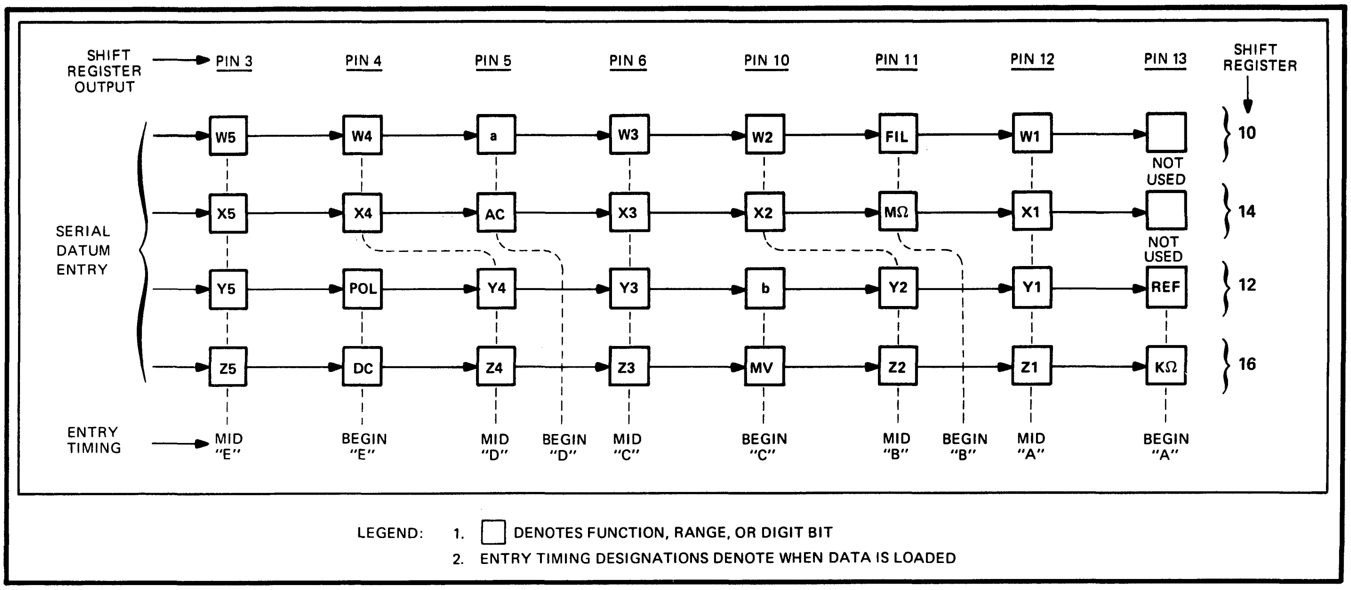


Figure 6-5. SHIFT REGISTER LOAD SEQUENCE

6-17. DIGITS COUNTER. The digits counter consists of J-K flip flops 26W, 26X, 25Y, and 25Z. The input flip flop, 25Z, is toggled by positive pulses, which are transferred through the guard by transistor Q13 and transformer T3. The counter produces a 4-bit binary output that is entered into the memory via the data gates. The counter is reset at the beginning of each sub-period of the measurement cycle by the $\overline{F}$ signal. The W , Y , and Z counter outputs are also applied to NAND gate 22A, which stops the counter at a count of "11" and generates a high at the input of flip flop 21L. If another pulse appears at the secondary of T3, it is indicative of "12" in the first decade (i.e., instrument overload). The 12th pulse toggles flip flop 21L to produce an overload indication at the DOU output, pin 35B.

6-18. DATA GATES. The data gates consist of NAND gates 22B, 23A through 23C, and 24A through 24D. The gates are controlled by the F', $\overline{F'}$, S, and $\overline{S}$ signals so that the 10 bits of function, range, and polarity data and 20 bits of numerical data are presented to the shift register memory at the proper times. These data bits are loaded in accordance with the load sequence (see Figure 6-5) and are steered by the data gates.

6-19. RANDOM ACCESS MEMORY. The DOU memory is composed of shift registers 10, 12, 14, and 16. Data is loaded serially into the shift registers. The loading sequence is controlled by clock pulses, which are produced by gates 15A through 15D, gate 19D, and associated circuitry. Steering signals, S and $\overline{S}$, together with the loading signal, F', develop loading pulses as shown in Figure 6-4. NAND gate 19D, inverter 13A, and associated circuitry delay the F' signal for approximately 10 microseconds so that all data present at the shift register inputs will be stabilized before clocking occurs.

6-20. CONTROL F' and $\overline{F'}$ signals are produced by an RS flip flop consisting of NOR gates 19A, 19B, and associated circuitry. The trigger for the flip flop is developed by gates 29A through 29C and transformer T4. The F' and $\overline{F}$ signals are conditioned by the $\overline{F}$, $\overline{M}$, and $\overline{ZERO}$ signals so that the F' and $\overline{F'}$ signals occur only during periods A through E of the DVM measurement cycle. The steering flip flop is triggered by the F' signal and produces S and S signals.

6-21. The $\overline{F'}$ output of the RS flip flop is applied to transistor Q9 and associated components, which comprise a rechargeable one-shot. This circuit is responsible for initializing control circuit conditions and providing for generation of the M signal. The sequence of operation of the rechargeable one-shot and associated circuitry is as follows (control timing signals are shown in Figure 6-4):

a. Measurement cycle is initiated.

b. RS flip flop 19A, B is set to "1" condition (pin 2 of 19A high).

c. Flip flop 20B is reset by $\overline{F}$.

d. Overload flip flop 21L is reset by a measurement inclusion signal generated at pin 9 of flip flop 20B.

e. Measure/store flip flop (20A) is set by overload reset signal (signal No. 4).

f. Gate 17C is inhibited, thereby inhibiting all output buffer gates.

g. The steering flip flop is toggled (Middle of "A" period) and capacitor C14 begins to charge toward +5V.

h. The steering flip flop is again toggled (middle of "B" period) and capacitor C14 is quickly discharged to 0.9V.

i. Steps (f) and (g) repeat for "C", "D", and "E" periods.

j. Following "E" period, C14 continues to charge until Q9 is turned on.

k. Q8 then turns on and sets the overload reset flip flop (20B) and the steering flip flop (21S).

l. The measure/store flip flop is reset by a negative trigger developed in the circuit of Q7.

m. The output buffer gates are enabled and the data becomes available.

6-22. In addition to providing a pseudo measure/store signal, the circuit of flip flop 20A and transistor Q7 also function as an autorange detector. Control signal timing under autorange conditions is shown in Figure 6-6. If the decision to autorange is made (middle of "A" period), the DVM logic places the instrument in storage mode. This locks out the $\overline{F}$ signal in the DOU control circuit and, consequently, no pulses are produced in T4 secondary, excepting the first. With no F′ signal to toggle flip flop 21S, the rechargeable one-shot times out and sets the overload reset flip flop to the "1" condition. The resulting signal (signal No. 2) is applied as a reset pulse to Q7; however, because capacitor C15 has not had time to discharge sufficiently, the trigger threshold of flip flop 20A is not reached and the flip flop remains in its previous state. Thus, the output buffer gates are inhibited during the autorange operation. If the instrument had not autoranged, C14 would have acquired sufficient charge during the measurement cycle to enable flip flop 20A to be triggered, as shown in the timing diagram of Figure 6-4.

6-23. The programmed one-shot consists of NOR gates 18A and 18B, transistors Q3 through Q6, capacitor C9, and associated programming resistors. In its stable state, gate 18A output is high and gate 18B output is low. Assume that an external trigger is applied to pin 34 of connector B. The trigger enables gate 18D, thereby triggering the DVM to initiate a measurement cycle. The trigger also enables

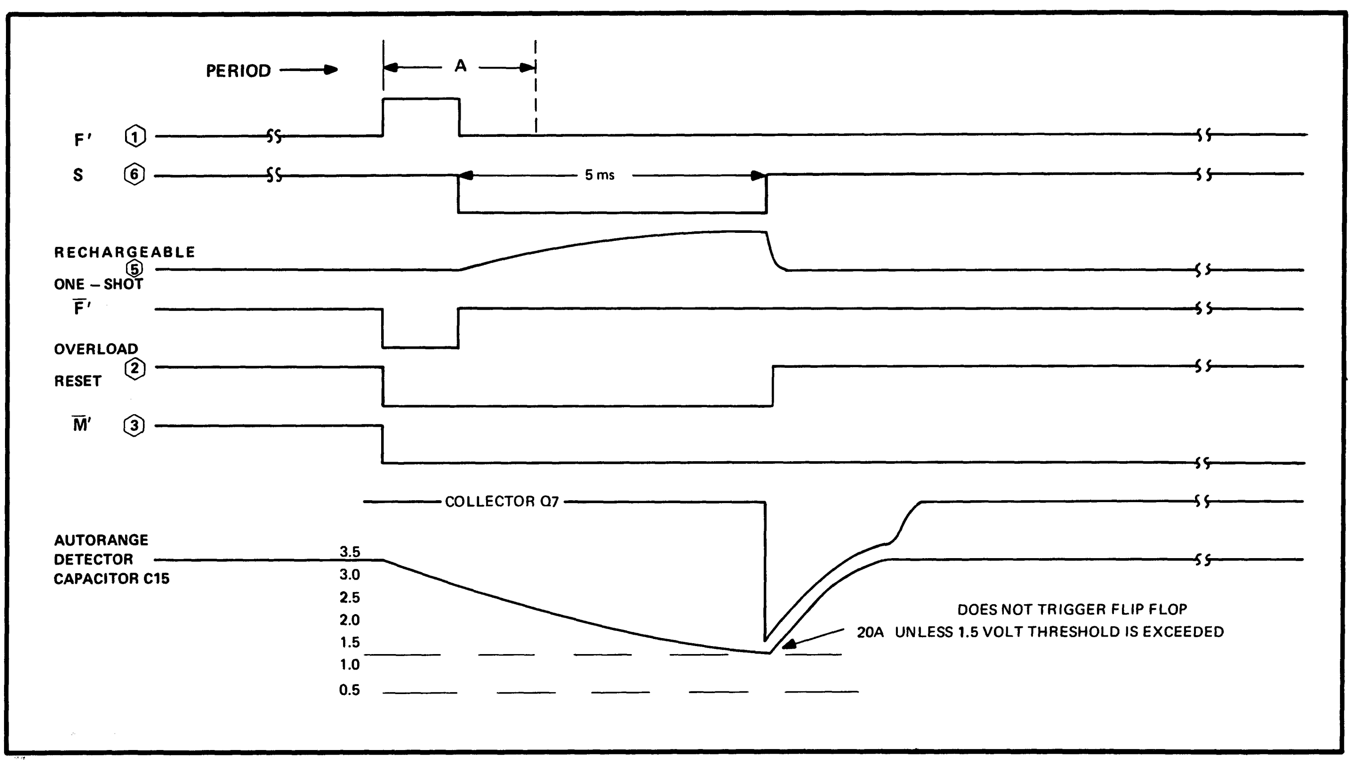


Figure 6-6. CONTROL SIGNAL TIMING DURING AUTORANGE

gate 18A, and the POS then switches to its unstable state. When the POS switches states, the output of gate 19C goes low, resulting in gates 17C being inhibited. Inhibiting gate 17C causes all of the output data buffer gates to be inhibited.

6-24. The timeout of POS delay is initiated as soon as the circuit is triggered, i.e., when the POS is triggered, switch Q3 is turned off and C9 begins to charge through the programming network to zero volts. Delay time is controlled by the memory, which selects resistor R19, R20, R21, or R22, depending on the selected DVM function. When C9 has accumulated sufficient charge, transistors Q5 conducts, turning on Q4, which causes gate 18A to switch. The POS switches back to its stable state and retriggers the DVM for a final measurement.

6-25. The POS is automatically retriggered if the DVM autoranges as a result of the final measurement. For example, if a step voltage were applied to the DVM in MVDC mode, the DVM logic might not make an autorange decision before the measurement caused by POS timeout. If this occurs, NOR gate 18C goes high, retriggering the POS and initiating a second delay. All autorange operations that are to occur do so at this time. Termination of the second POS delay causes yet another measurement. All settling times having been considered at this time, this measurement is the last; and upon completion 23 milliseconds later, outputs are turned on and data becomes available.

6-26. In VDC mode without the FILTER function called, transistor Q6 is enabled. This programs the POS for fastest timeout and clamps pin 9 of gate 18D so that the DVM will not be retriggered by POS timeout.

6-27. +5 VOLT LOGIC SUPPLY. The +5 volt dc logic supply is operated from a full-wave bridge rectifier and filter consisting of diodes CR19 through CR22 and capacitor C20. The series regulator is comprised of zener reference CR23, voltage amplifier Q10, driver Q11, and series pass transistor Q12. This supply has sufficient reserve to power the Remote Control Unit (Option 8300A-04), if installed. The +5 volts is connected to pin 36B and returned to pin 30B for that purpose.

6-28. MAINTENANCE

6-29. Introduction

6-30. This section contains maintenance information for the DOU. Factory service information and general instructions regarding instrument access and cleaning are located in Section IV of the manual.

6-31. Test Equipment

6-32. The equipment recommended for performance testing, troubleshooting, and calibration of the DOU is listed in Figure 6-7. If the recommended equipment is not available, equivalent or better instruments may be substituted.

EQUIPMENT NOMENCLATURE	RECOMMENDED EQUIPMENT
OSCILLOSCOPE	TEKTRONIX MODEL 547
OSCILLOSCOPE PLUG-IN	TEKTRONIX MODEL 1A1
OSCILLOSCOPE PROBES	TEKTRONIX MODEL P6010
DC VOLTAGE SOURCE	FLUKE MODEL 343A DC VOLTAGE CALIBRATOR
DC DIFFERENTIAL VOLTMETER	FLUKE MODEL 885A
DOU OUTPUT READER/DISPLAY TEST SYSTEM	

Figure 6-7. TEST AND CALIBRATION EQUIPMENT.

6-33. Performance Tests

6-34. The following performance tests exercise the DOU to determine if the unit is working properly. The tests should be conducted before maintenance or calibration is attempted. The tests are also suited to receiving inspection of new units. Performance tests should be conducted under the following environmental conditions: ambient temperature 25°C ±5°C, relative humidity less than 70%. In case of trouble, analysis of the test results, with reference to the troubleshooting, should help to locate the trouble.

6-35. LOGIC VOLTAGE CHECK

a. Connect a dc voltmeter between pin 36 (+) and pin 30 (–) of DOU output connector "B".

b. If necessary, adjust potentiometer R38 for 5.05 ±0.05 volts dc indication on the voltmeter.

6-36. DIGITS REGISTRATION

a. Set Model 8300A controls as follows:

FUNCTION	VDC
RANGE	10
SAMPLE RATE	EXT (sample as required)

b. Connect a +1.1111 volt dc test signal to the INPUT terminals.

c. Command the DVM to take a reading. The DOU output and the front panel display should indicate DC +1.1111.

d. Repeat steps (b) and (c) for test signal inputs of +2.2222, +4.4444, and +8.8888 volts dc. The DOU output and front panel display should correspond.

6-37. OVERLOAD INDICATOR

a. Set Model 8300A controls as follows:

FUNCTION	VDC
RANGE	10
SAMPLE RATE	EXT (sample as required)

b. Connect a +20 volt dc test signal to the INPUT terminals.

c. Command the DVM to take a reading by applying one external sample pulse. The DOU outputs and front panel display should indicate DC +11.9999 and OVERload.

6-38. FUNCTION REGISTRATION

a. Set Model 8300A controls as follows:

FUNCTION	MVDC
RANGE	100
SAMPLE RATE	EXT

b. Short the INPUT terminals.

c. Apply one external sample pulse. The DOU outputs and front panel display should indicate MV, DC+ or DC-, and a readout of 00.000 ±2 digits.

d. Repeat steps (a) through (c) for each of the following DVM functions. The DOU output and front panel display should be as indicated.

FUNCTION	DOU OUTPUT/DVM DISPLAY
VAC	AC, 00.000
KΩ	KΩ, 00.000
10 MΩ	MΩ, 0.0000
VDC, FILT, EXT. REF.	VDC, 00.000 FILT, EXT. REF.

6-39. OUTPUT GATES

a. Set Model 8300A controls as follows:

FUNCTION	VDC
RANGE	10
SAMPLE	EXT

b. Connect a –0.0010 volt dc test signal to the INPUT terminals.

c. Command the DVM to take a reading. The DOU output and DVM display should indicate DC – 0.0010 ±2 digits.

d. Short all of the following DOU output gate terminals to ground (pin 30 of connector "B"). The DOU output should be as indicated.

GATE TERMINALS (PIN AND CONNECTOR)	DOU OUTPUT
33B	DC+, MV, FILT, EXT. REF, AC, MΩ, KΩ and readout of 1555.55
15B	
3B	
25A	
25B	
15A	
33A	
10A	
17B	
16B	

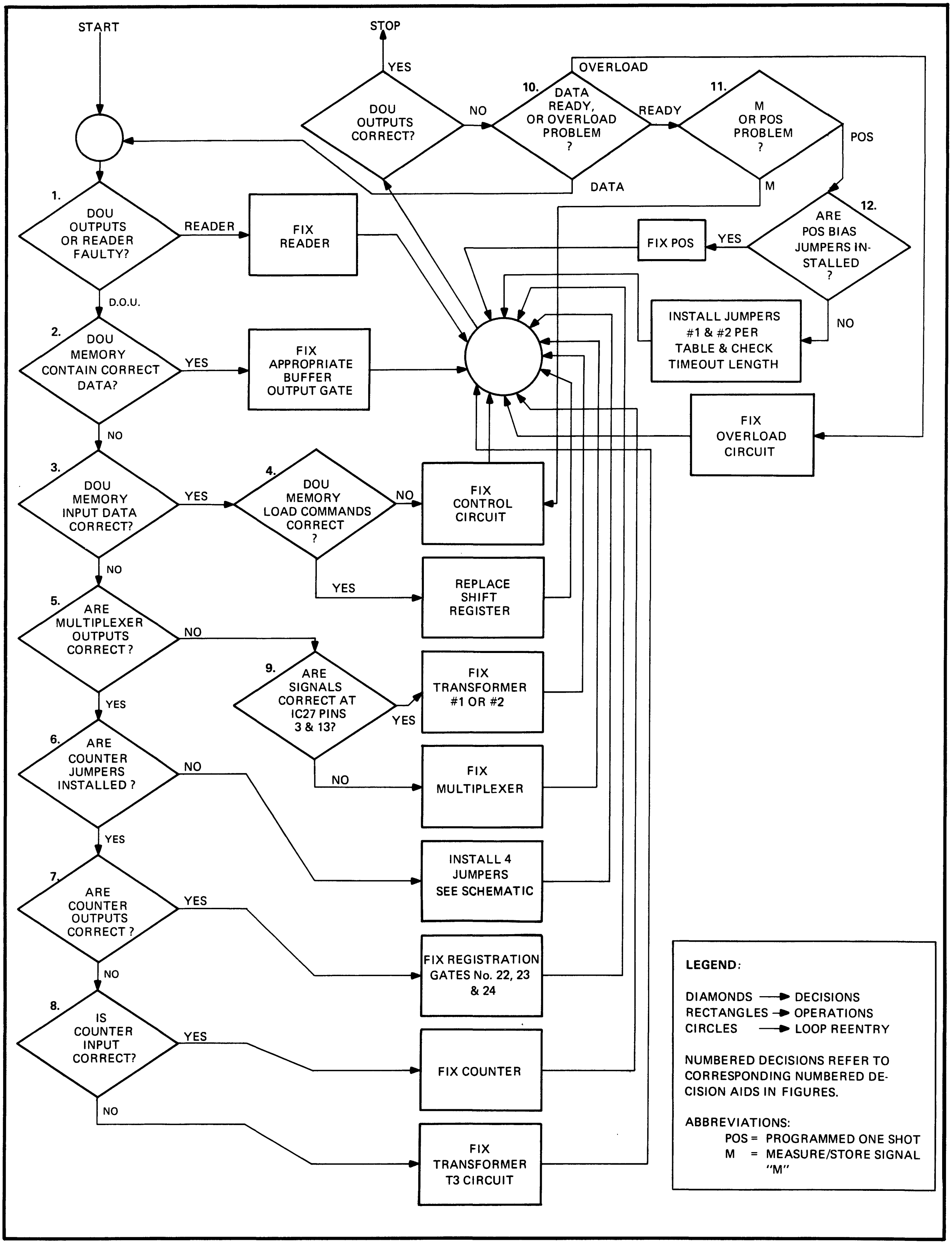


Figure 6-8. DECISION FLOW CHART DOU TROUBLE SHOOTING

6-40. PROGRAMMED ONE SHOT.

a. Set the Model 8300A controls as follows:

FUNCTION	VDC, FILTERED
RANGE	100
SAMPLE RATE	EXT (rate should be approximately 1 sample/5 seconds).

b. Connect oscilloscope to ready line, pin 32B of DOU output connector. Command instrument to sample. Delay length should be 545 ±20 milliseconds.

c. Set the function and range controls as follows. The delay lengths should be as indicated.

DVM FUNCTION/RANGE	DELAY (MILLISECONDS)
KΩ, 100 RANGE	1546 $^{+234}_{-80}$
10MΩ, FILTER 100 RANGE	1546 $^{+234}_{-80}$
MVDC, 100 RANGE	3250 $^{+480}_{-190}$
VDC, 100 RANGE (NO FILTER)	31 $^{+4.5}_{-3.5}$

6-41. Troubleshooting

6-42. This section contains information selected to aid in troubleshooting the DOU. Before attempting to troubleshoot the unit, however, it should be verified that the trouble is actually in the DOU and is not caused by faulty external equipments or improper control settings. For this reason, the performance tests (paragraph 6-33) are suggested as a first step in troubleshooting. The performance tests may also help to localize the trouble to a particular section of the instrument. If the performance tests fail to localize the trouble, the following information may be helpful.

6-43. Trouble analysis of the Data Output Unit is most efficiently performed by a systematic sequence of checks through the unit beginning at the malfunctioning output or outputs and working progressively backwards. As familiarity with the unit increases the operator will discover he can truncate the process omitting obviously irrelevant steps.

6-44. In any analysis, certain decisions and/or conclusions must be made. Consult Figure 6-8 for the suggested decision sequence. Figure 6-9 is a table of decision aids, which should help to determine how to make the decisions.

6-45. Calibration

6-46. Calibration of the DOU consists only of adjustments of the +5 volt dc logic supply. The adjustment procedure is located in paragraph 6-35.

1. **DOU OUTPUTS OR READER FAULTY?** This decision must be based upon a point-by-point measurement of DOU outputs at points of origin. Many short cuts are available, depending upon the nature of the reader.

<u>EXAMPLE No. 1.</u> Suppose all decades except the third are producing correct numbers. The third decade generates the following table:

	MODEL 8300A PANEL	READER PANEL	CONSIDER
	00000	00400	An open in the cable from DOU to reader (probably pin 26B DOU connector.) This is the "4" line of the 1-2-4-8 four line BCD code.
All possible combinations shown for illustration	11111	11511	
	22222	22622	
	33333	33733	
	44444	44444	
	55555	55555	
	66666	66666	
	77777	77777	
	88888	88288	
	99999	99399	

Figure 6–9. DECISION AIDS (Sheet 1 of 4)

EXAMPLE No. 2.	MODEL 8300A PANEL	READER PANEL	CONSIDER
Only these combinations need to be considered for trouble analysis.	00000 11111 22222 44444 88888	08000 19111 20222 42444 88888	An open DOU–to–reader (probably pin 9A DOU output connector).

EXAMPLE No. 3. Reader panel is 155555, DC+, MV, AC, KΩ, MΩ, EXT. REF., FILT.

The above display remains regardless of Model 8300A PANEL.

CHECK: Pin 32B DOU connector. If not 0 to 0.5Vdc, disconnect reader and measure again. If now 0 to 0.5V, reader is at fault–if not, look for problem in DOU ready circuit.

NOTE: The above examples assume a reader with full overranging in each decade. Other overrange patterns will not defeat the analysis if the pattern is known.

2. **DOU MEMORY CONTAIN CORRECT DATA?** It is assumed here that data outputs were determined to be faulty. This is a static test. Set Model 8300A stimulous to produce the trouble analysis information desired. Command to sample once only. Using a vtvm, check data in shift register (DOU memory) 10, 12, 14, and 16. Use chart of Figure 6-5 for location of data. All data in this memory is inverted phase, e.g., 6 would normally be represented as 0110, but it is in the memory as 1001. The chart of Figure 6-5 will prove to be a valuable troubleshooting tool for several areas of the DOU circuitry. If data in the memory is correct, the problem must be in an output buffer gate or in the first decade binary-to-BCD converter, IC11. If not, it must be determined whether a shift register is faulty. This is proven by determination that serial data input signals are correct and that load signals are correct.

3. **DOU MEMORY INPUT DATA CORRECT?** Unfortunately this must be a dynamic test and for the uninitiated user may require observation of a properly operating unit. Set stimulous equipment (Model 8300A and input source) for desired trouble analysis information. Set internal sample command potentiometer on Model 8300A panel to EXT position and externally trigger the instrument. The rate should be 25 pps for good oscilloscope displays. Ignore reader display as it is unimportant at this point. Sync the scope with F signal and observe shift register data inputs. Refer to waveshapes at points ⑨ and ⑩ and refer to the waveshape index, Figures 6-10 and 6-11. These waveforms are multiplexed with numerical data from the counter and inverted by registration gates IC22, IC23, and IC24. Study the schematic and Figures 6-5, 6-10, and 6-11 to visualize what appearance these signals should have for various combinations of data. A table is not given as there would be 256^4 possible variations. It is much easier to determine what a particular combination should produce and will require only a few seconds for an experienced operator using Figure 6-5. Again, remember that all data in memory is inverted phase.

EXAMPLE: 26.391 VDC+, FILTERED.

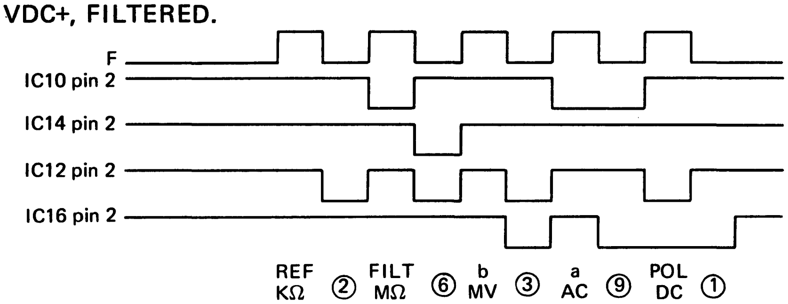
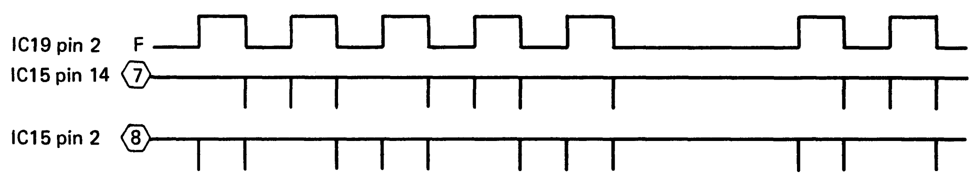


Figure 6–9. DECISION AIDS (Sheet 2 of 4)

4. **DOU LOAD COMMANDS CORRECT?** Refer to the following load signals. Use the same setup as in part 3 of this figure. A dual-trace scope is useful.



LOAD SIGNALS

If the load commands are correct, then something may be wrong with the operation of one of the shift registers. If replacement does not solve the problem, one of the shift register output may be shorted.

5. **ARE MULTIPLEXER OUTPUTS CORRECT?** Use the same setup as in part 3 of this figure. Figures 6-10 and 6-11 give tables which illustrate all possible waveforms at IC13 pin 6 and IC13 pin 10 respectively. If the waveforms are correct, registration gates IC22, IC23, and IC24 may be faulty.

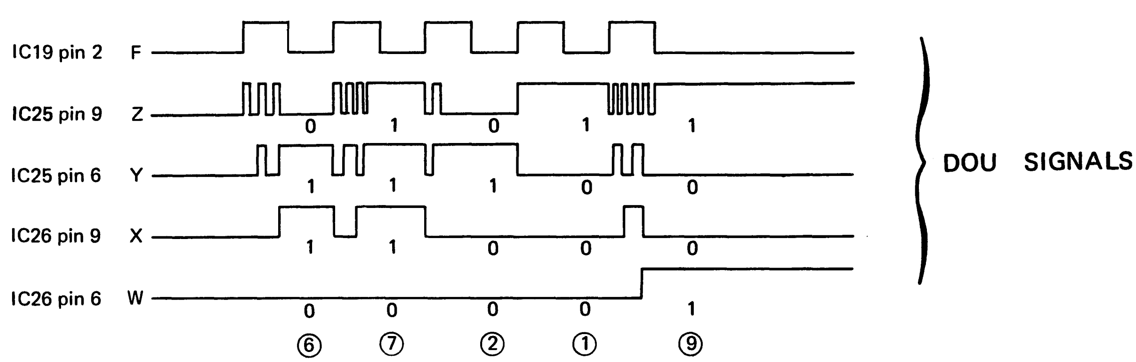
6. **ARE COUNTER JUMPERS INSTALLED?** With reader connected, check continuity between the following points:

23A and 3A 20A and 4A 21A and 1A 22A and 2A	DOU Output Connector

IC25 pin 9 and IC24 pin 13 IC25 pin 6 and IC24 pin 1 IC26 pin 9 and IC24 pin 4 IC26 pin 6 and IC24 pin 10	Convenient alternate locations

7. **ARE COUNTER OUTPUTS CORRECT?** Use the same setup as in part 3 of this figure. Consider counter outputs only during second half of each subperiod as follows:

<u>EXAMPLE:</u> .67219 on Model 8300A panel.

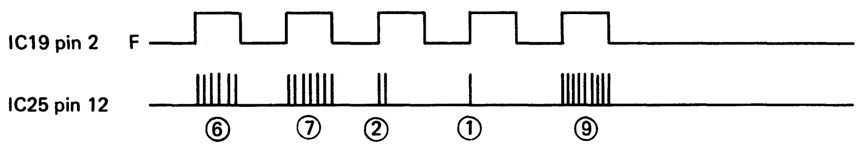


Again, correct counter operation is indicative of a problem in registration gates IC22, IC23 and IC24.

Figure 6–9. DECISION AIDS (Sheet 3 of 4)

8. **IS COUNTER INPUT CORRECT?** Use same setup as in part 3 of this figure. The same example as in part 7 is used.

EXAMPLE:



Correct input but incorrect outputs are indicative of counter malfunction.

9. **ARE SIGNALS CORRECT AT IC27 pins 3 & 13?** This DOU circuit is inside the guard. Therefore, the scope must be synced to a signal inside the guard. Use $\overline{\text{zero}}$ signal at TP4, with TP3 as common. If multiplexer outputs (test portion of part 5) are incorrect but observations of part 9 are normal, the transformer circuits of T1 or T2 may be faulty. Signals at pins 3 and 13 of IC27 should have waveforms like Figures 6-11 and 6-12 respectively. If not, multiplexers may be at fault or wires may be broken between DOU input terminals and the connector inside the guard box.

10. **DATA, READY OR OVERLOAD PROBLEM?** This is a static test. Command Model 8300A to sample only once, with SAMPLE RATE control on front panel in external position, then observe. If numerals, range, polarity, or function data is faulty, it will be observable on the reader (monitor). If the reader is either blank or displaying 1555.55 VDC+, FILT, MV, AC, KΩ, MΩ, or EX. REF., then the ready line is probably high. The overload display should coincide with a numeral display of 119999 and will be visible on the reader.

11. **M OR POS PROBLEM?** Command to sample only once, with SAMPLE RATE control in external position. Check IC19 pin 12 for 0 to 0.5V (POS) and IC17 pin 17 for 3.5 to 4.5V ($\overline{M}$ signal). If M is low it is likely that POS will be high, but the cause will be $\overline{M}$, which comes from the control circuit. If $\overline{M}$ is normal but POS is high, the programmed one-shot is faulty.

12. **ARE POS BIAS JUMPERS INSTALLED?** Visually check to insure that jumpers No. 1 and 2 are installed or jumpers No. 1 or No. 2 and R50 in accordance with delay length table. (This is a factory installation procedure and jumper installation need only be verified as indicated.)

Figure 6–9. DECISION AIDS (Sheet 4 of 4)

FUNCTIONS CALLED			
EXT. REF.	FILT.	RNGE.	POL.
		1	NA
	X	1	NA
X		1	NA
X	X	1	NA
		10	(–)
	X	10	(–)
X		10	(–)
X	X	10	(–)
		10	(+)
	X	10	(+)
X		10	(+)
X	X	10	(+)
		100	(–)
	X	100	(–)
X		100	(–)
X	X	100	(–)
		100	(+)
	X	100	(+)
X		100	(+)
X	X	100	(+)
		1000	(–)
	X	1000	(–)
X		1000	(–)
X	X	1000	(–)
		1000	(+)
	X	1000	(+)
X		1000	(+)
X	X	1000	(+)

REFERENCE POINT ⟨9⟩ ON SCHEMATIC

WAVESHAPE

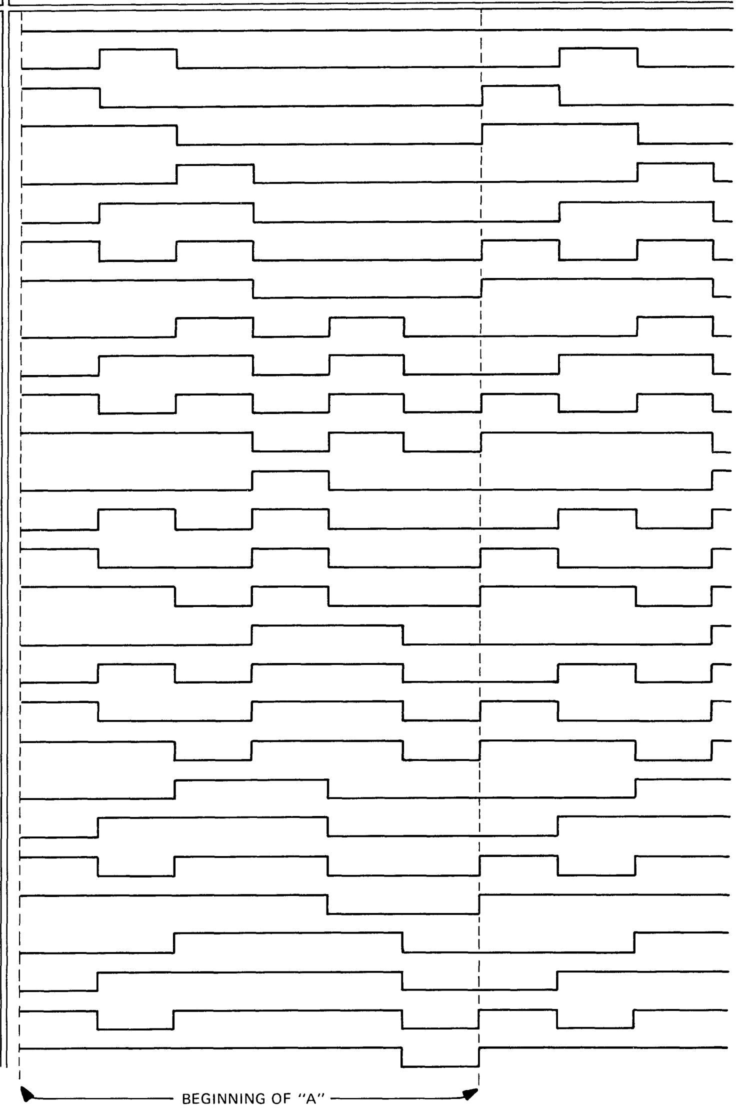


Figure 6-10. DOU WAVESHAPE INDEX

FUNCTIONS CALLED				
DC	MV	AC	KΩ	MΩ
X				
	X			
		X		
			X	
				X

REF. PT. ⟨10⟩ SCHEMATIC

WAVESHAPE

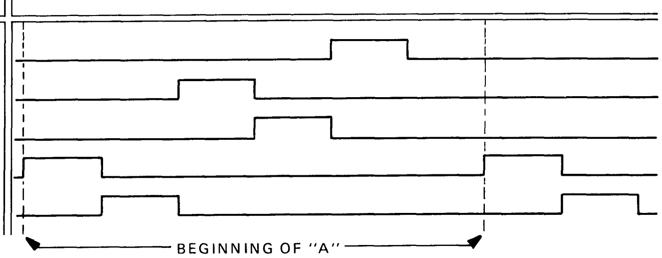


Figure 6-11. DOU WAVESHAPE INDEX

6-47. LIST OF REPLACEABLE PARTS.

6-48. For column entry explanations, part ordering information and basic instrument configuration Use Codes and Serial Number Effectivity List, see Section 5, paragraphs 5-1 through 5-10. See paragraph 6-49, this option subsection, for additional Use Codes and Serial Number Effectivity List assigned to this printed circuit assembly option.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		DIGITAL VOLTMETER - DATA OUTPUT UNIT OPTION	8300A-03					
		NOTE: The basic Model 8300A can be modified in the filed by installing the Data Output Unit Kit(8300A-03K) order by Model and Option No. (8300A-03K).						
		Chassis Frame, Data Output Unit, Kit	270553	89536	270553	1		
		Cover, Kit	270538	89536	270538	2		
		Connector opening cover, Kit	280891	89536	280891	1		
C20		Cap, elect, 6000 μf +75/−10%, 10V, Kit	271460	56289	36D602G010 AA2A	1	1	
		Data Output P/C Assembly (See Figure 6-12	270975	89536	270975	1		
A1	C1-M1	IC, DTL, Hex Inverter	268367	04713	MC836P	2	1	
A2	C1-M4	IC, DTL, Quad 2-Input Nand Gate	268375	04713	MC846P	11	7	
A3	C1-N2	IC, DTL, Quad 2-Input Nand Gate	268375	04713	MC846P	REF		
A4	C1-N4	IC, DTL, Quad 2-Input Nand Gate	268375	04713	MC846P	REF		
A5	C1-O2	IC, DTL, Quad 2-Input Nand Gate	268375	04713	MC846P	REF		
A6	C1-O5	IC, DTL, Quad 2-Input Nand Gate	268375	04713	MC846P	REF		
A7	C1-P2	IC, DTL, Quad 2-Input Nand Gate	268375	04713	MC846P	REF		
A8	C1-P5	IC, DTL, Quad 2-Input Nand Gate	268375	04713	MC846P	REF		
A9	C1-Q3	IC, DTL, Quad 2-Input Nand Gate	268375	04713	MC846P	REF		
A10	E1-Q1	IC, TTL, Shift Register	272138	12040	DM8570	4	3	
A11	E1-P4	IC, DTL, Quad 2-Input Nand Gate	268375	04713	MC846P	REF		
A12	E1-P1	IC, TTL, Shift Register	272138	12040	DM8570	REF		
A13	E1-O3	IC, DTL, Hex Inverter	268367	04713	MC836P	REF		
A14	E1-O1	IC, TTL, Shift Register	272138	12040	DM8570	REF		
A15	E1-N3	IC, TTL, Quad 2-Input Nor Gate	268540	18324	SP380A	4	3	
A16	E1-M5	IC, TTL, Shift Register	272138	12040	DM8570	REF		
A17	E1-M3	IC, DTL, Quad 2-Input Nand Gate	268375	04713	MC846P	REF		B
A17	E1-M3	IC, TTL, Quad 2-Input Nand Buffer	296228	01295	SN7437N	1		C
A18	F1-M1	IC, TTL, Quad 2-Input Nor Gate	268540	18324	SP380A	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A19	F1-M4	IC, TTL, Quad 2-Input Nor Gate	268540	18324	SP380A	REF		
A20	F1-N2	IC, TTL, dual J-K flip flop	268441	18324	SP322B	4	3	
A21	F1-N4	IC, TTL, dual J-K flip flop	268441	18324	SP322B	REF		
A22	F1-O2	IC, DTL, triple 3-Input Nand Gate	266312	04713	MC862P-6909	2	1	
A23	F1-O5	IC, DTL, triple 3-Input Nand Gate	266312	04713	MC862P-6909	REF		
A24	F1-P2	IC, DTL, Quad 2-Input Nand Gate	268375	04713	MC846P	REF		
A25	F1-P5	IC, TTL, dual J-K flip flop	268441	18324	SP322B	REF		
A26	F1-Q3	IC, TTL, dual J-K flip flop	268441	18324	SP322B	REF		
A27	H2-P2	IC, TTL, Quad 2-Input Nor Gate	268540	18324	SP380A	REF		
A28	H2-Q2	IC, DTL, Quad 2-Input Nand Gate	268375	04713	MC846P	REF		
A29	H2-N5	IC, TTL, triple 3-Input Nor Gate	268565	18324	SP370A	1	1	
C1	D1-P4	Cap, elect, 200 uf +50/−10%, 10v	236935	73445	C426ARD-200	1	1	G
C1	D1-P4	Cap, elect 33 uf ±10%, 10v	182832			1	1	F
C2	E4-N3	Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/A100K	2	1	
C3	F3-M3	Cap, cer, 0.01 uf ±20%, 100v	149153	56289	C023B101-F103M	6		
C4	D2-N5	Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/A100K	REF		
C5	D3-N3	Cap, cer, 0.01 uf ±20%, 100v	149153	56289	C023B101-F103M	REF		
C6	F2-P4	Cap, cer, 0.0012 uf ±10%, 500v	106732	71590	CF-122	3		
C7	F4-O1	Cap, Ta, 0.68 uf ±10%, 35v	182790	56289	150D684X9-035A2	2	1	
C8	F5-P3	Cap, plstc, 0.22 uf ±20%, 50v	190314	72982	8131-050-W5R224K	4	1	
C9	F5-M2	Cap, Ta, 3.3 uf ±5%, 20v	271320	56289	150D335X-5020B2	1	1	
C10	E4-M3	Cap, cer, 0.01 uf ±20%, 100v	149153	56289	C023B101-F103M	REF		
C11	H3-M1	Cap, Ta, 2.2 uf ±10%, 20v	160226	05397	K2R2C20K	1	1	
C12	E1-M1	Cap, cer, 0.0012 uf ±10%, 500v	106732	71590	CF-122	REF		
C13	E2-N2	Cap, cer, 0.0012 uf ±10%, 500v	106732	71590	CF-122	REF		
C14	H1-N1	Cap, Ta, 0.33 uf ±5%, 20v	271338	56289	150D334X-5020A2	2	1	
C15	H5-N1	Cap, Ta, 0.68 uf ±10%, 35v	182790	56289	150D684X-9035A2	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C16	G5-P3	Cap, plstc, 0.22μf ± 20%, 50v	190314	72982	8131-050-W5R224K	REF		
C17	G4-P2	Cap, plstc, 0.22μf ± 20%, 50v	190314	72982	8131-050-W5R224K	REF		
C18	H1-O1	Cap, plstc, 0.22μf ± 20%, 50v	190314	72982	8131-050-W5R224K	REF		
C19	G5-O1	Cap, cer, 0.01μf ± 20%, 100v	149153	56289	C023B101-F103M	REF		
C21	G5-P2	Cap, cer, 0.01μf ± 20%, 100v	149153	56289	C023B101-F103M	REF		
C22	G4-P5	Cap, cer, 0.01μf ± 20%, 100v	149153	56289	C023B101-F103M	REF		
C23	I1-L3	Cap, cer, 0.025μf ± 20%, 100v	168435	56289	C023B101-H253M	3		
C24	G3-M2	Cap, cer, 0.0012μf ± 10%, 500v	106732	71590	Cf-122	REF		F
C24		Cap, Ta, .33μf ± 5%, 20v	271338	56289	150D334X-5020A2	REF		G
C25	H2-P4	Cap, elect, 200μf +50/−10%, 10v	23625	73445	C426ARD200	REF		A
C26		Cap, cer, 0.025μf ± 20%, 100v	168435	56289	C023B101-F103M	REF		G
C27		Cap, cer, 0.025μf ± 20%, 100v	168435	56289	C023B101-F103M	REF		G
CR1	G1-Q4	Diode, silicon, 150 ma	203323	03508	DHD1105	33	10	
CR2	F3-O1	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	12	5	
CR4	G1-O5	Diode, silicon, 150 ma	203323	03508	DKD1105	REF		
CR5	F5-O5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR6	F4-O5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR7	F4-O5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR8	G1-O3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR9	F5-O3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR10	F4-O3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR11	F4-O3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR12	G4-N1	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR13	G3-N1	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR14	F5-N2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR15	F2-N3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR16	G1-M4	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR17	G2-M4	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR18	H3-L3	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR19	E4-L3	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	4	2	
CR20	D5-L3	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR21	E4-L2	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR22	D5-L2	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR23	D1-L4	Diode, zener, 3.9v	113316	07910	1N748	1	1	H

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
CR23	D1-L4	Diode, zêner, 4.3v	180455	07910	1N749A	1		I
CR24	G2-L2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR25	G4-L3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR26	G4-L3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR27	G5-L3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR28	G5-L3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR29	H1-M1	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR30	H1-L3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR31	D1-M2	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR32	D1-M3	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR33	D1-M3	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR34	F5-M5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR35	F4-L5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR36	B3-M2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR37	B4-M1	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR38	B5-L5	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR39	B5-P4	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR40	B5-L5	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR41	B2-N3	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR42	B5-P1	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR43	D2-Q3	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR44	B2-O2	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR45	B3-N4	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR46	H4-L3	Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		
CR47		Diode, silicon, 150 ma	203323	03508	DHD1105	REF		G
CR48		Diode, silicon, 150 ma	203323	03508	DHD1105	REF		G
CR49		Diode, silicon, 150 ma	203323	03508	DHD1105	REF		G
CR50		Diode, silicon, 150 ma	203323	03508	DHD1105	REF		G
CR51		Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		G
CR52		Diode, germanium, 80 ma, 100 piv	149187	93332	1N270	REF		G
J1	A5-P3	Connector "A", female, 36 contact	158469	03660	57-40360	2		
J2	A5-M5	Connector "B", female, 36 contact	158469	02660	57-40360	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q3	G3-M4	Tstr, silicon, PNP	195974	04713	2N3906	2	2	
Q4	G4-M4	Tstr, silicon, NPN	218081	04713	MPS6520	1	1	
Q5	G5-M4	Tstr, silicon, PNP	229898	04713	MPS6522	1	1	
Q6	H2-M4	Tstr, silicon, NPN	218396	04713	2N3904	11	5	
Q7	I1-M4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q8	H4-M4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q9	H3-M4	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q10	D3-L4	Tstr, silicon, NPN	168708	03508	2N3391	1	1	
Q11	D3-L3	Tstr, silicon, NPN	150359	95303	2N3053	1	1	
Q12	B5-L3	Tstr, silicon, NPN	170787	95303	2N3054	1	1	
Q13	G5-Q4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q14	G5-P4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q15	G5-P5	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q16	G5-O5	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q17	G5-O5	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q18	G5-O4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q19	G5-O3	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q20	G5-O2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
R1	F5-Q3	Res, comp, 100Ω ±5%, ¼w	147926	01121	CB1015	3		
R2	G5-N1	Res, comp, 150Ω ±5%, ¼w	147934	01121	CB1515	2		
R3	G3-N1	Res, comp, 150Ω ±5%, ¼w	147934	01121	CB1515	REF		
R4	E4-Q4	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	5		
R5	F1-Q4	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R6	G1-O1	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	5		
R7	F5-O1	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R8	D3-P3	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	3		
R9	D2-P3	Res, comp, 100k ±5%, ¼w	148189	01121	CB1045	1		
R10	F1-M3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	6		
R11	E3-M5	Res, comp, 100Ω ±5%, ¼w	147926	01121	CB1015	REF		
R12	D3-N4	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	3		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R13	F1-M5	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R14	G1-M1	Res, comp, 2.7k ±5%, ¼w	170720	01121	CB2725	2		
R15	G1-M1	Res, comp, 2.7k ±5%, ¼w	170720	01121	CB2725	REF		
R16	G2-M1	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	1		F
R16		(Deleted)				0		G
R17	G2-N1	Res, comp, 6.8k ±5%, ¼w	148098	01121	CB6825	1		
R18	H5-L3	Res, comp, 1k, ±5%, ¼w	148023	01121	CB1025	REF		
R19	G3-L5	Res, met flm, 665k ±1%, ½w	187922	91637	Type MFF ½	1		F
R19	G3-L5	Res, met flm, 715k ±1%, ½w	236836	91637	Type MFF1/8	1		G
R20	G4-M1	Res, met flm, 309k ±1%, 1/8	235283	91637	Type MFF1/8	1		F
R20	G4-M1	Res, met flm, 576k ±1%, 1/8	344291	91637	Type MFF1/8	1		G
R21	G5-M1	Res, met flm, 100k ±1%, 1/8w	248807	91637	Type MFF1/8	1		F
R21	G5-M1	Res, met flm, 107k ±1%, 1/8w	288399	91637	Type MFF1/8	1		G
R22	H1-M1	Res, comp, 1.5k ±5%, ¼w	148031	01121	CB1525	1		F
R22	H1-M1	Res, comp, 1.8k ±5%, ¼w	175042	01121	CB1825	1		G
R23	H4-M1	Res, comp, 2.7k ±5%, ¼w	170720	01121	CB2725	REF		F
R23		(Deleted)						G
R24	H3-M1	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R25	H2-M1	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R26	H4-L3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R27	H4-M1	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R28	H2-N1	Res, comp, 220Ω ±5%, ¼w	147959	01121	CB2215	1		
R29	H5-M1	Res, comp, 1.8k ±5%, ¼w	175042	01121	CB1825	2		
R30	G5-N1	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R31	H1-N1	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R32	H4-N1	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R33	H3-N1	REs, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	1		
R34	H3-N1	Res, comp, 27k ±5%, ¼w	148148	01121	CB2735	1		
R35	I1-M1	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	1		D
R35	I1-M1	Res, comp, 16k ±5%, ¼w	221606	01121	CB1635	1		E
R36	D2-L2	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		
R37	D1-L3	Res, comp, 5.6k ±5%, ¼w	148080	01121	CB5625	REF		
R38	C4-L4	Res, var, comp, 500Ω ±30%, ¼w	272161	37942	Type MTC-1	1	1	
R39	D5-L4	Res, met flm, 182Ω ±1%, 1/8w	200030	75042	RN55D182OF	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R40	H2-P4	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	9		
R41	H2-P5	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R42	H2-O5	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R43	H2-O4	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R44	H2-O3	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R45	H2-O3	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R46	H2-O3	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R47	H2-Q4	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R48	H2-P1	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R49	G4-M1	Res, met flm, 274k ±1%, 1/8w	237297	91637	Type MFF1/8	1		F
R49	G4-M1	Res, met flm, 27.4k ±1%, 1/8w	241471	91637	Type MFF1/8	1		G
R50	F5-L5	Res, comp, ¼w, factory selected (replace with exact value)		01121	Type CB	1		G
R51	F4-L5	Res, met flm, 140k ±0.5%, 1/8w	233148	91637	Type MFF1/8	1		F
R51	F4-L5	Res, met flm, 14k ±0.5%, 1/8w	343168	91637	Type MFF1/8	1		G
R52		Res, comp, 100Ω ±5%, ¼w	147926	01121	CB1015	REF		G
R53		Res, comp, 39k ±5%, ¼w	188466	01121	CB1245	1		G
R54		Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		G
R55		Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	REF		G
R56		Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		G
R57		Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		G
R58		Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		G
T1	G3-P2	Transformer, pulse	275362	89536	275362	5	3	
T2	G3-O3	Transformer, pulse	275362	89536	275362	REF		
T3	G3-Q3	Transformer, pulse	275362	89536	275362	REF		
T4	G3-N5	Transformer, pulse	275362	89536	275362	REF		
T5	G3-P5	Transformer, pulse	275362	89536	275362	REF		
	J1-P5	Harness with connector	280073	89536	280073	1		
	C2-L1	Heat sink	270611	89536	270611	1		
		Guard, transformer	279513	89536	279513	1		
		Socket, IC, 14 contact	276527	23880	TSA-2900-14W	25	10	
		Socket, IC, 16 contact	276535	23880	TSA-2900-14W	4	2	
		Shield	279505	89536	279505	1		

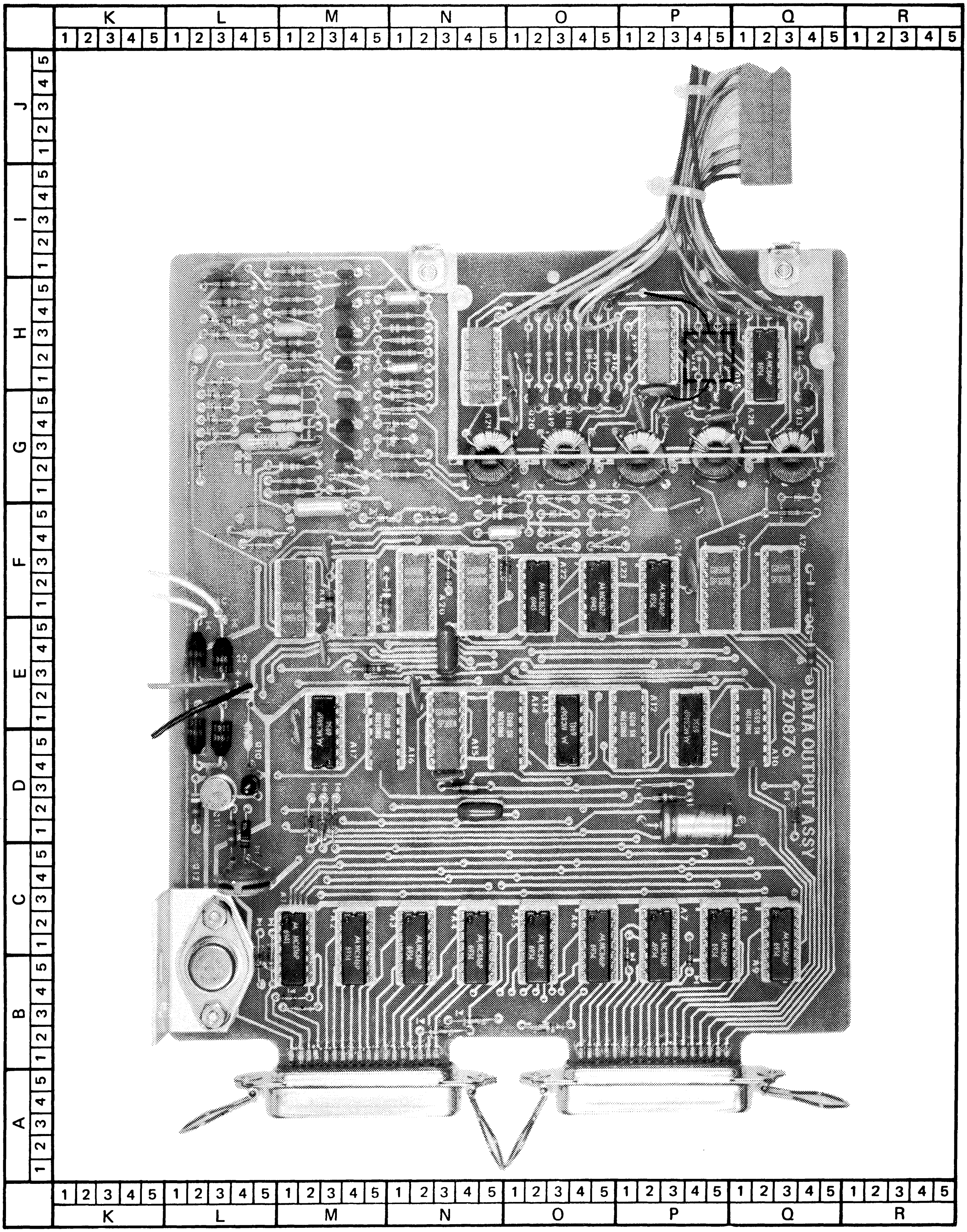


Figure 6-12. DATA OUTPUT P/C ASSEMBLY

6-49. SERIAL NUMBER EFFECTIVITY

6-50. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8300A. Each part in this option for which a use code has been assigned may be identified with a particular printed circuit board serial number by consulting the Use Code Effectivity List below. All parts with no code are used on all printed circuit boards with serial numbers 123 and on. NOTE: These Use Codes and Serial Number Effectivity apply to this option printed circuit board assembly only. For the standard instrument configuration, see Section 5, paragraph 5-9, and for additional options, see the appropriate option subsection.

USE CODE	SERIAL NUMBER EFFECTIVITY
A	400 and on.
B	123 thru 524
C	525 and on.
D	123 thru 614
E	615 and on.
F	123 thru 729
G	730 and on
H	123 thru 768
I	769 and on.

OPTION 8300A - 04

REMOTE CONTROL UNIT

6-1. INTRODUCTION

6-2. The Remote Control Unit (Option -04) enables the Model 8300A to be programmed remotely. The RCU provides the capability of controlling all functions and ranges, with logic interlocking provided to make it impossible to call two or more incompatible functions simultaneously. If the RCU Option is installed without the DOU, the 8300A-7001 Digital Option Enclosure must be ordered to complete RCU installation.

6-3. SPECIFICATIONS

6-4. Specifications for the Remote Control Unit are located in Section I of the manual.

6-5. INSTALLATION

6-6. The following procedure should be used to install the Remote Control Unit option in the Model 8300A (refer to Figure 6-1).

a. Install the RCU printed circuit board in the 8300A-7001 Digital Option Enclosure, using the hardware supplied.

b. Remove the Model 8300A top dust cover and guard chassis cover.

c. Remove the blank rear cover at the left rear of the instrument and install the assembled RCU using the hardware supplied.

d. Pass the RCU connector/cable through the hole in the left rear of the guard chassis and connect to the main PCB as shown in the figure.

e. Replace enclosure and instrument covers.

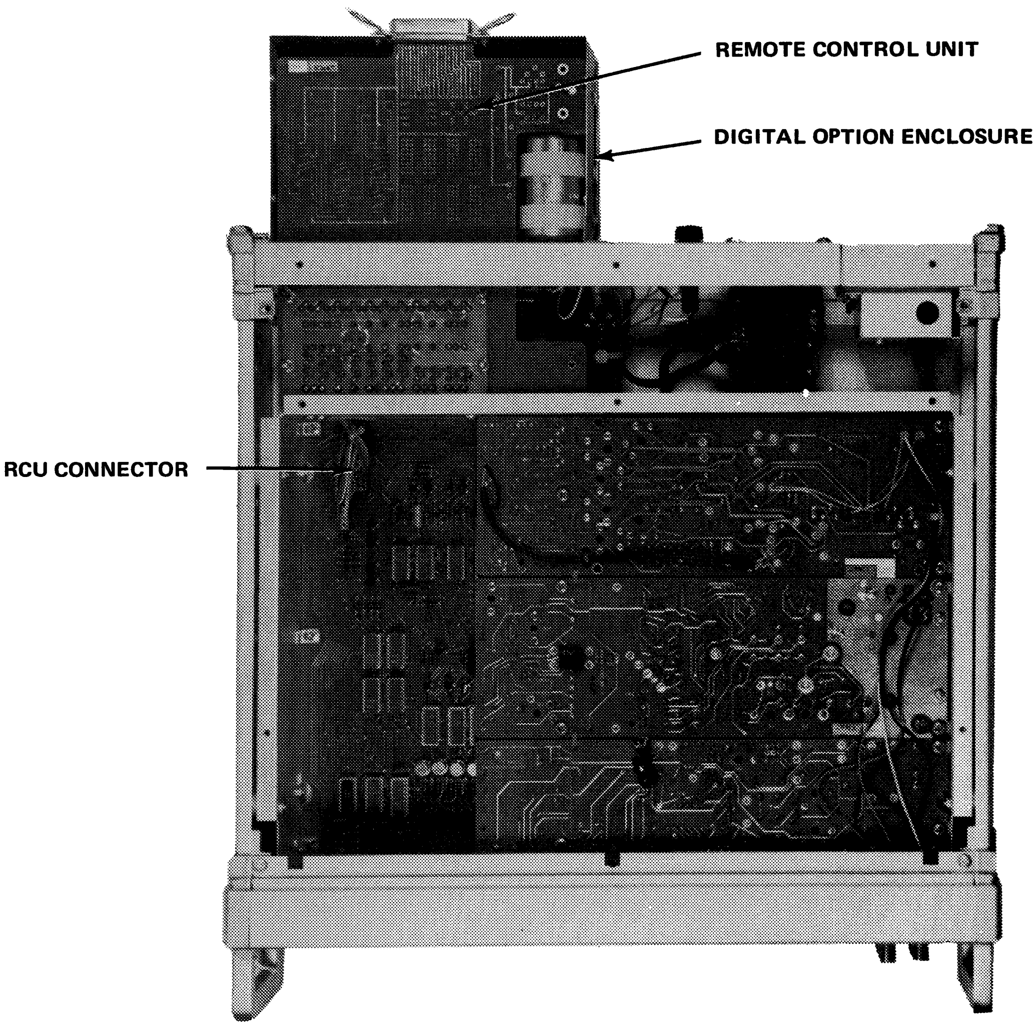


Figure 6-1. RCU INSTALLATION

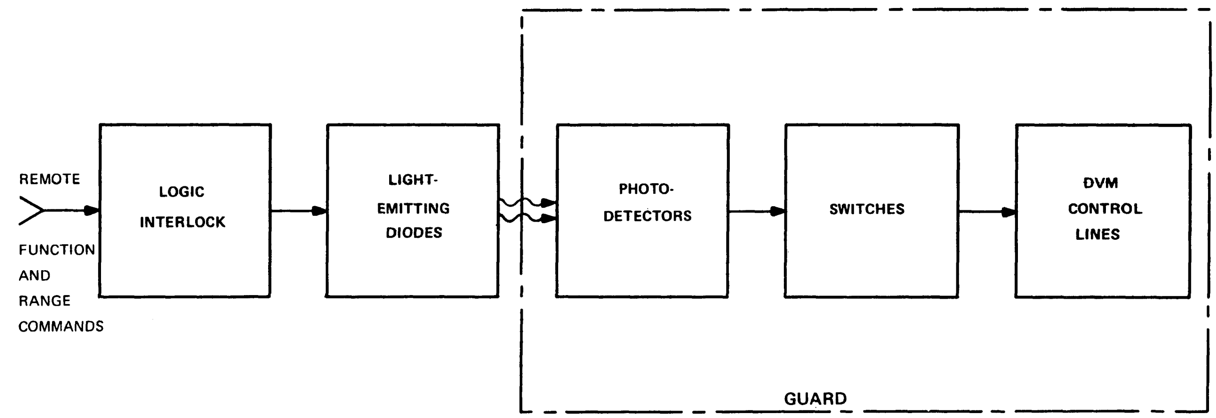


Figure 6-2. REMOTE CONTROL UNIT BLOCK DIAGRAM

6-7. OPERATING INSTRUCTIONS

6-8. Operating instructions for the Model 8300A with the Remote Control Unit installed are located in Section II of the manual.

6-9. THEORY OF OPERATION

6-10. General

6-11. The RCU functional block diagram is given in Figure 6-2. The input function and range commands are applied to circuitry which provides logical interlocking (see Section II, Figure 2-5) so that the RCU will respond only to acceptable command combinations. The range and function commands are applied to the photodetectors inside the guard chassis via the light-emitting diodes (LED's). The resulting signal is applied to the switches, which activate the DVM control lines.

6-12. Circuit Description

6-13. Input function commands, consisting of switch closure or zero volts dc, are applied to inverters A through F (see RCU schematic at back of manual). The inverter outputs are applied to NAND gates which provide logic interlocking and drive the light-emitting diodes, CR1 through CR11.

6-14. The logical interlocking is such that the instrument will respond to the first call received and will ignore succeeding erroneous calls until the first call is released. For example, if KΩ function were called, gate 7B would be enabled, which would inhibit gates 4A, 7A, 3A, 3B, and 4B, thereby preventing EXT REF, VDC, MVDC, VAC, and 10 MΩ functions from being called.

6-15. The detector circuitry consists of phototransistors Q1 through Q11, which detect and amplify the LED outputs. The outputs of the phototransistors are applied to the output switches and their drivers, transistors Q12 through Q29. The phototransistors and switches are enabled by the remote function and remote range busses, which supply +5 volts dc to the circuitry when the remote switches are pressed.

6-16. MAINTENANCE

6-17. Introduction

6-18. This section contains maintenance information for the Remote Control Unit. Factory service information and general instructions regarding instrument access and cleaning are located in Section IV of the manual.

COMMANDED FUNCTIONS	DVM RESPONSE										
	DC	MV	AC	KΩ	MΩ	FILT	REF	1	10	100	1000
DC & FILT & REF	O					O	O		O	O	O
MV & FILT & REF		O					O			O	O
AC & FILT & REF			O				O	O	O	O	O
KΩ & FILT & REF				O		O		O	O	O	O
MΩ & FILT & REF					O	O			O		

Figure 6-3. REMOTE CONTROL UNIT TEST REQUIREMENTS

6-19. Test Equipment

6-20. The following equipment is recommended for performance testing, troubleshooting, and calibration of the Remote Control Unit. If the recommended equipment is not available, other equivalent equipment may be used.

EQUIPMENT NOMENCLATURE	RECOMMENDED EQUIPMENT
Multimeter	Fluke Model 8100A Digital Multimeter
Oscilloscope	Tektronix Model 547
Oscilloscope Plug-In	Tektronix Model 1A1

6-21. Performance Test

6-22. The following performance test exercises each RCU input to determine if the unit is working properly. The performance test should be conducted before any instrument maintenance or calibration is attempted. The test should be conducted under the following environmental conditions: ambient temperature 25°C ±5°C, relative humidity less than 70%. An instrument that fails the performance test will require corrective maintenance or calibration. In case of difficulty, analysis of the test results, with reference to the troubleshooting section should help to locate the trouble.

6-23. To test the RCU, proceed as follows:

a. Supply +5 volts dc to the RCU, pin 18 (+5 vdc) and pin 36 (common) of the RCU connector.

b. Press the REMOTE FUNCTION and REMOTE RANGE switches at the Model 8300A front panel.

c. Activate each of the combination of functions shown in column 1 of Figure 6-3 by contact closure between the appropriate pin and common of the RCU connector (refer to Figure 2-6 for connector pin assignments). Observe the resulting front panel display and verify correct response (O) for each call combination listed in Figure 6-3. Check all ranges for each call combination listed.

6-24. Troubleshooting

6-25. This section contains information designed to aid in troubleshooting the RCU. Before attempting to troubleshoot the RCU, however, it should be verified that the trouble is actually in the instrument and is not caused by faulty external equipments or improper control settings. For this reason, the performance test (paragraph 6-21) is suggested as a first step in troubleshooting. The performance test may also help to localize the trouble to a particular section of the instrument. If the performance test fails to localize the trouble, the trouble analysis flow chart in Figure 6-4 may be helpful.

6-26. Calibration

6-27. The RCU does not require calibration.

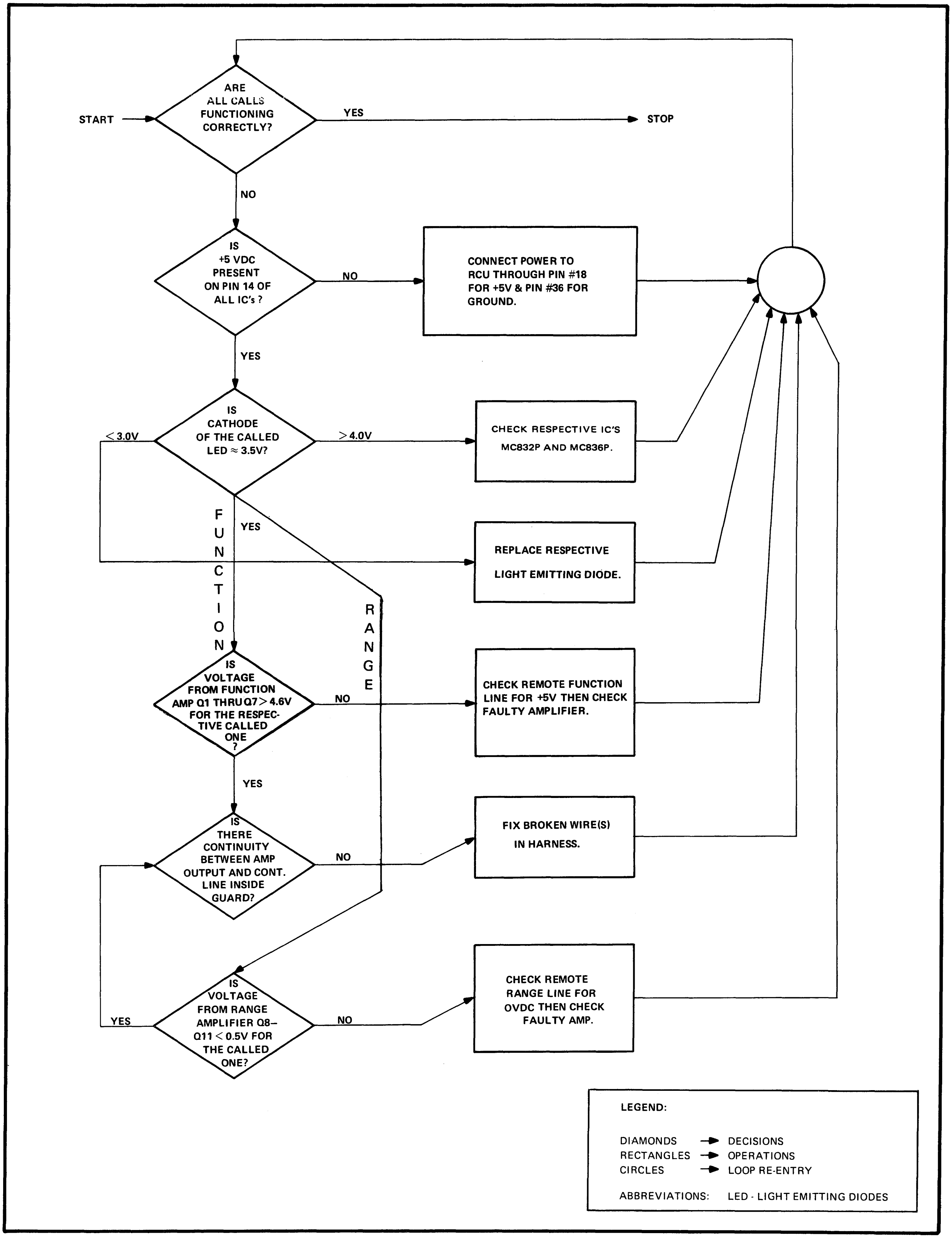


Figure 6-4. REMOTE CONTROL UNIT TROUBLE ANALYSIS (FLOW CHART)

6-28. LIST OF REPLACEABLE PARTS

6-29. For column entry explanations, part ordering information and basic instrument configuration Use Codes and Serial Number Effectivity List, see Section 5, paragraphs 5-1 through 5-10. See paragraph 6-30, this option subsection, for additional Use Codes and Serial Number Effectivity List assigned to this printed circuit assembly option.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		DIGITAL VOLTMETER - REMOTE CONTROL OPTION	8300A-04					
		NOTE: The basic Model 8300A can be modified in the field by installing the Remote Control Unit Option Kit (8300A-04K) order by Model and Option No. (8300A-04K).						
		Digital Option Enclosure (Not included in kit. Must be ordered as separate item if -03 Data Output Option is not not installed.)	280917	89536	280917	1		
		Remote Control P/C Assembly (See Figure 6-5)	273557	89536	273557	1		
A1	C2-L4	IC, DTL, Hex Inverter	268367	04713	MC836P	2	1	
A2	C2-N1	IC, DTL, Hex Inverter	268367	04713	MC836P	REF		
A3	D1-L4	IC, DTL, dual 4-Input Nand	268383	04713	MC832P	6	3	
A4	D1-M2	IC, DTL, dual 4-Input Nand	268383	04713	MC832P	REF		
A5	D1-N1	IC, DTL, dual 4-Input Nand	268383	04713	MC832P	REF		
A6	D5-L4	IC, DTL, dual 4-Input Nand	268383	04713	MC832P	REF		
A7	D5-M2	IC, DTL, dual 4-Input Nand	268383	04713	MC832P	REF		
A8	D5-N1	IC, DTL, dual 4-Input Nand	268383	04713	MC832P	REF		
J1	A4-N5	Connector, female, 36 contact	158469	02660	57-40360	1		
Q1	F5-L4	Tstr, photo, light detector	271791	03508	L14B	11	6	
Q2	F5-L5	Tstr, photo, light detector	271791	03508	L14B	REF		
Q3	F5-M2	Tstr, photo, light detector	271791	03508	L14B	REF		
Q4	F5-M3	Tstr, photo, light detector	271791	03508	L14B	REF		
Q5	F5-M5	Tstr, photo, light detector	271791	03508	L14B	REF		
Q6	F5-N1	Tstr, photo, light detector	271791	03508	L14B	REF		
Q7	F5-N3	Tstr, photo, light detector	271791	03508	L14B	REF		
Q8	F5-N4	Tstr, photo, light detector	271791	03508	L14B	REF		
Q9	F5-O1	Tstr, photo, light detector	271791	03508	L14B	REF		
Q10	F5-O2	Tstr, photo, light detector	271791	03508	L14B	REF		
Q11	F5-O4	Tstr, photo, light detector	271791	03508	L14B	REF		
Q12	G5-L4	Tstr, silicon, NPN	218396	04713	2N3904	11	5	

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q13	H1-L4	Tstr, silicon, PNP, selected	280198	89536	280198	7	4	
Q14	G4-N3	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q15	G5-M2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q16	H1-M2	Tstr, silicon, PNP, selected	280198	89536	280198	REF		
Q17	G5-L5	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q18	H1-L5	Tstr, silicon, PNP, selected	280198	89536	280198	REF		
Q19	G5-M3	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q20	H1-M3	Tstr, silicon, PNP, selected	280198	89536	280198	REF		
Q21	G5-M5	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q22	H1-M5	Tstr, silicon, PNP, selected	280198	89536	280198	REF		
Q23	G5-N1	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q24	H1-N1	Tstr, silicon, PNP, selected	280198	89536	280198	REF		
Q25	H1-N4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q26	H1-O1	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q27	H1-O2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q28	H1-O4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q29	H1-N3	Tstr, silicon, PNP, selected	280198	89536	280198	REF		
R1	E5-L4	Res, comp, 180Ω ±5%, ¼w	147942	01121	CB1815	12		
R2	E5-L5	Res, comp, 180Ω ±5%, ¼w	147942	01121	CB1815	REF		
R3	E5-M2	Res, comp, 180Ω ±5%, ¼w	147942	01121	CB1815	REF		
R4	E5-M3	Res, comp, 180Ω ±5%, ¼w	147942	01121	CB1815	REF		
R5	E5-M5	Res, comp, 180Ω ±5%, ¼w	147942	01121	CB1815	REF		
R6	E5-N1	Res, comp, 180Ω ±5%, ¼w	147942	01121	CB1815	REF		
R7	E5-N2	Res, comp, 180Ω ±5%, ¼w	147942	01121	CB1815	REF		
R8	E5-N4	Res, comp, 180Ω ±5%, ¼w	147942	01121	CB1815	REF		
R9	E5-N5	Res, comp, 180Ω ±5%, ¼w	147942	01121	CB1815	REF		
R10	E5-O2	Res, comp, 180Ω ±5%, ¼w	147942	01121	CB1815	REF		
R11	E5-O3	Res, comp, 180Ω ±5%, ¼w	147942	01121	CB1815	REF		
R12	G2-L4	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	7		
R13	G2-N3	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R14	G2-L4	Res, comp, 270Ω ±5%, ¼w	160804	01121	CB2705	1		
R15	G2-M1	Res, comp, 180Ω ±5%, ¼w	147942	01121	CB1815	REF		
R16	G2-M2	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R17	G2-L5	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R18	G2-M3	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R19	G2-M5	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R20	G2-N1	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R21	G2-N4	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		A
R21	G2-N4	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	r		B
R22	G2-O1	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		A
R22	G2-O1	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		B
R23	G2-O2	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		A
R23	G2-O2	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		B
R24	G2-O4	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		A
R24	G2-O4	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		B
R25	G2-N3	Res, comp, 820Ω ±5%, ¼w	148015	01121	CB8215	1		
R26	G2-O3	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	1		
	F2-M1	Light Diode Assembly	270892	89536	270892	1		
	F3-L4	Diode, light emitting	276436	03508	SSL5C	11	6	
	J1-M1	Harness with connector	280081	89536	280081	1		
		Socket, IC, 14 contact	276527	23880	TSA-2900-14W	8		
		Cover, photor isolator	280024	89536	280024	1		
		Plate, aperture	280016	89536	280016	1		
		Shield	279992	89536	279992	1		

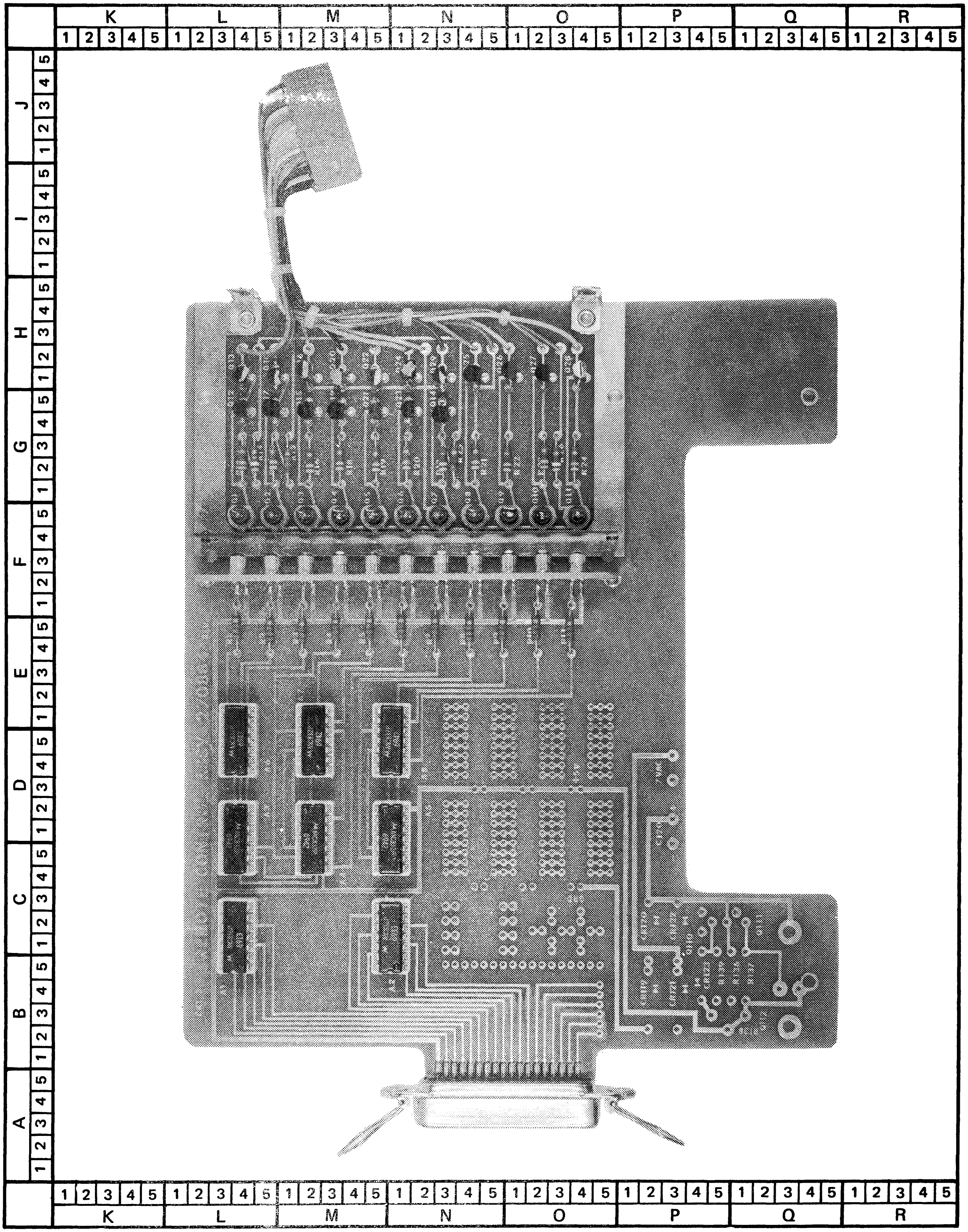


Figure 6-5. REMOTE CONTROL P/C ASSEMBLY

6-30. SERIAL NUMBER EFFECTIVITY

6-31. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8300A. Each part in this option for which a use code has been assigned may be identified with a particular printed circuit board serial number by consulting the Use Code Effectivity List below. All parts with no code are used on all printed circuit boards with serial numbers 123 and on. NOTE: These Use Codes and Serial Number Effectivity apply to this option printed circuit board assembly only. For the standard instrument configuration, see Section 5, paragraph 5-9, and for additional options, see the appropriate option subsection.

USE CODE	SERIAL NUMBER EFFECTIVITY
A	123 thru 499
B	500 and on.

OPTION 8300A-05

DC EXTERNAL REFERENCE

6-1. INTRODUCTION

6-2. The DC External Reference (Option −05) enables the user to substitute an external voltage for the internal reference of the Model 8300A. The principal use of the DVM when operated in this matter is for four-wire voltage ratio measurements: ±dc to dc, ±millivolts to dc, and ac to dc.

6-3. SPECIFICATIONS

6-4. Specifications for the DC External Reference are located in Section 1 of the manual.

6-5. INSTALLATION

6-6. The following procedure should be used to install the DC External Reference option in the Model 8300A.

NOTE!

Rear Input (Option -06) must be installed before installation of the DC External Reference option can be completed.

a. Remove the Model 8300A top dust cover and guard chassis cover.

b. Locate the DC External Reference mounting area. See (Figure 6-1).

c. Connect the DC External Reference Board to the row of interconnect pins on the main PCB (right rear), and fasten the board in place using the three machine screws provided. Check pins to assure they are correctly mated with receptacles.

d. Pass the shielded cable, which is the input to the DC External Reference Unit, through the grommeted hole in the corner of the guard chassis.

e. Complete the installation by connecting the cable lugs to the rear terminals as shown in Figure 6-1).

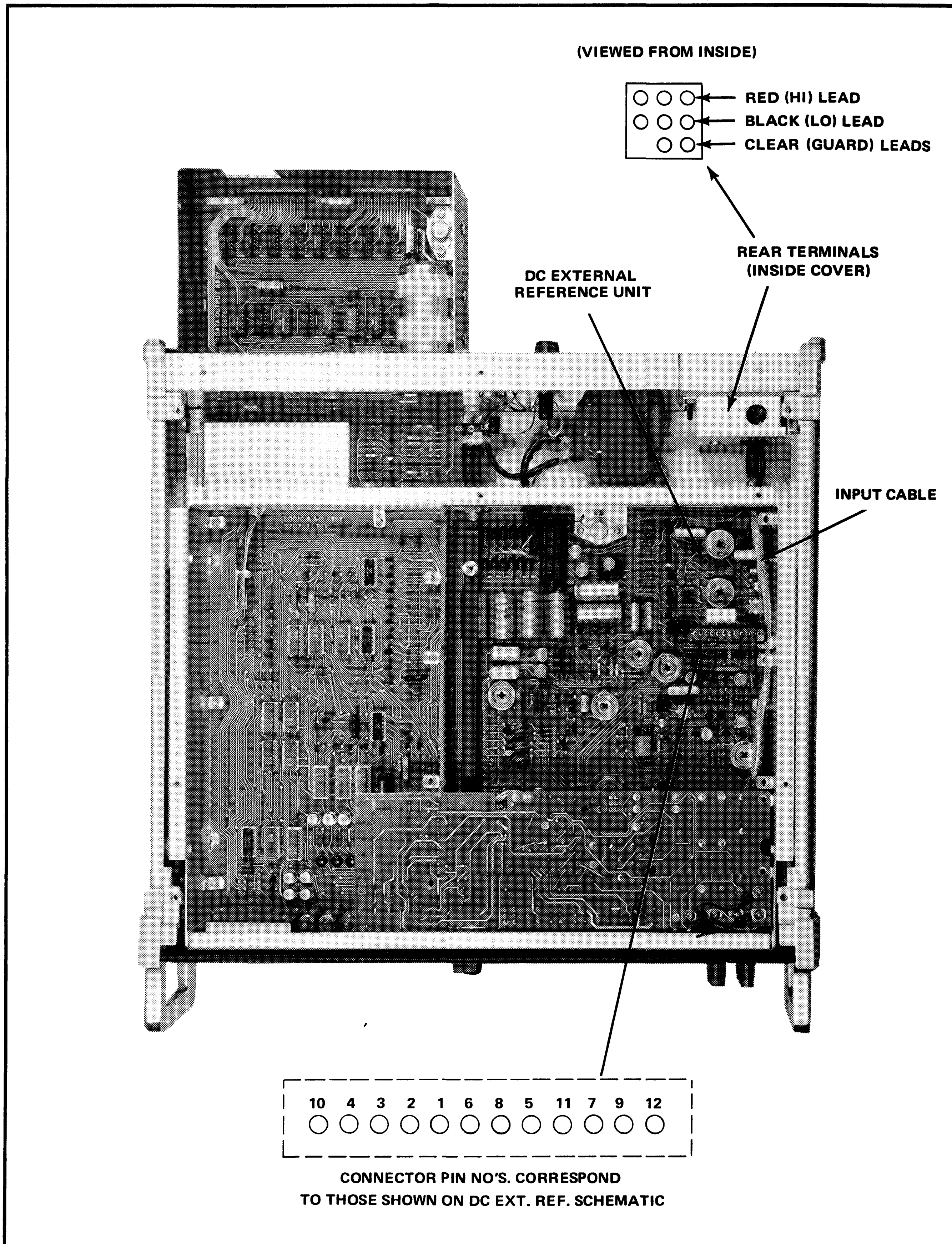


Figure 6-1. DC EXTERNAL REFERENCE OPTION INSTALLATION

6-7. OPERATING INSTRUCTIONS

6-8. Operating instructions for the Model 8300A with DC External Reference installed are located in Section II of the manual.

6-9. THEORY OF OPERATION

6-10. General

6-11. The DC External Reference unit consists basically of an input divider, an isolation circuit, and a voltage follower, as shown in Figure 6-2.

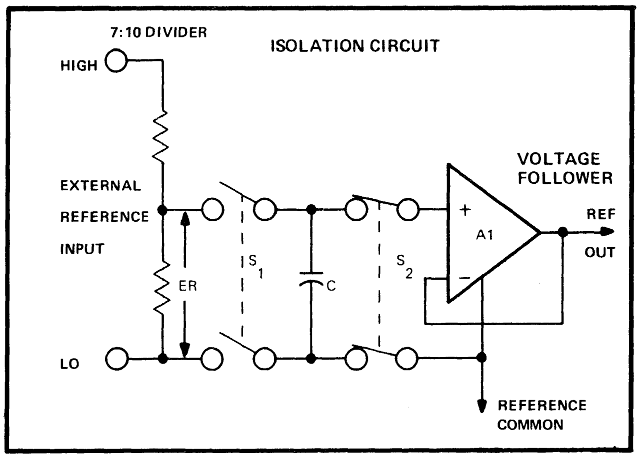


Figure 6-2. DC EXTERNAL REFERENCE SIMPLIFIED DIAGRAM

The input divider produces an output that is 7/10 of the reference input voltage. The circuit is designed to operate with a reference input voltage between +2 and +10.5 volts dc. The isolation circuit provides a means of isolating the input common of the DC External Reference unit from the output common of the DC External Reference unit. This is necessary because the Model 8300A input common terminal (LO) and the instrument common are not equivalent. In fact, the LO instrument input terminal is the actual input to the A/D Converter and can have a potential of ±12 volts dc with respect to instrument common. Switches S1 and S2 are arranged so that when one is closed, the other is open. S1 is closed during a non-critical portion of the measurement cycle (A/D zero time) and capacitor C is allowed to charge to voltage E_R. When S2 is closed, the output of A_1 goes to E_R satisfying the voltage follower.

6-12. Circuit Description

6-13. INPUT DIVIDER. The input divider consists of resistors R9 through R11 and R24. The input divider is adjusted by resistor R10, (EXT REF CAL control). Capacitor C7 together with the divider resistors form an RC filter which improves the signal to noise ratio.

6-14. ISOLATION CIRCUIT. Input dual MOSFET Q7 functions as switch S1 in the simplified diagram and JFET switches Q4 and Q5 function as switch S2. Transistors Q1 and Q2 are gate drivers for switches Q4 and Q5. Using the reference voltage for the collector supply of Q2 assures that the gate signal of Q4 never goes positive with respect to its source and drain terminals. The gate of Q5 is clamped to within 0.2 volts of common by diode CR6. Resistor R13 limits the current through CR6 and capacitor C2 compensates for the capacity of CR6.

6-15. VOLTAGE FOLLOWER. The voltage follower consists of matched JFET Q6 followed by monolithic amplifier A1. Transistor Q8 and resistor R17 comprise a constant current source for amplifier Q6. Frequency compensation is provided by capacitors C4, C5, and C6. Capacitor C9 provides an input impedance for the voltage follower during the time switches Q4 and Q5 are off. The reference voltage in the A/D Converter is sensed through resistor R18, thereby compensating for line drops. Low sense (reference common) also originates in the Logic and A/D assembly. Diodes CR7 and CR8 provide feedback to the voltage follower input when the reed relay, K1, is open, thereby maintaining amplifier output within 0.5 volts of the voltage on C8 and thus controlling the gate drive for Q4.

6-16. VOLTAGE DISTRIBUTION. Voltage distribution is shown in the simplified schematic of Figure 6-3. Since Q7 is a P-channel enhancement mode device, a negative gate voltage of 2 volts or more is needed to ensure that the transistor is on. Zero volts or a positive gate voltage turns the transistor off. As shown in the figure, the upper switch needs a minimum of −7 volts to turn on and a maximum of 19.0 volts to turn off.

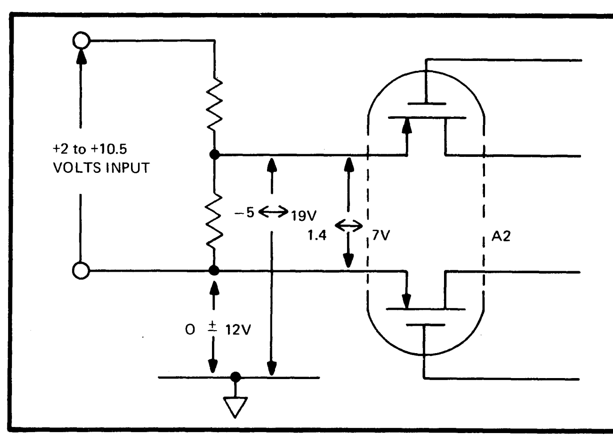


Figure 6-3. VOLTAGE DISTRIBUTION IN MOSFET Q7

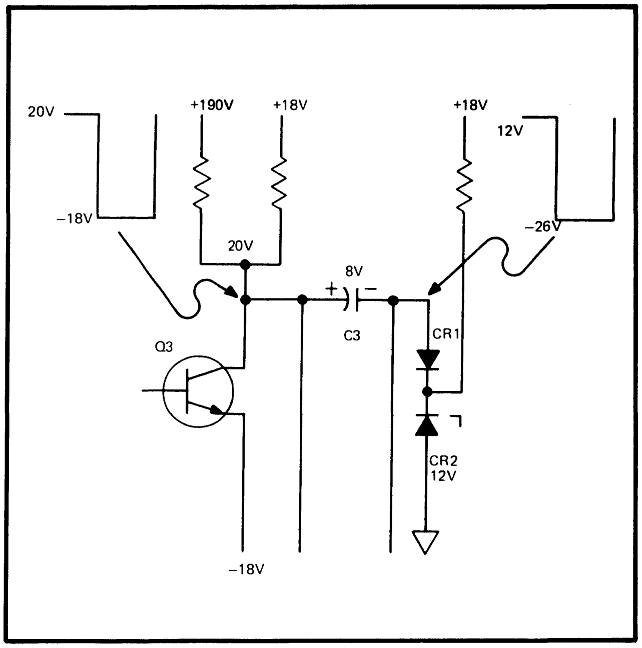


Figure 6-4. GATE DRIVER VOLTAGES

6-17. The MOSFET gate driver is redrawn in Figure 6-4 to show the peak voltages. When Q3 is saturated, CR1 is back biased. When the transistor is cutoff, C3 charges to 8 volts because of the 12 volt drop across the zener. This voltage subtracts from the collector voltage giving the voltage shown.

6-18. DISABLE AND PROTECTION CIRCUITS. When the EXT REF switch on the front panel is pressed, −18 volts is applied to the local-disable line through transistors Q10 and Q12, which in turn operate relay K1. Input protection is provided by diodes CR4 and CR5 and resistor R12.

6-19. MAINTENANCE

6-20. Introduction

6-21. This section contains maintenance information for the DC External Reference. Factory service information and general instructions regarding instrument access and cleaning are located in Section IV of the manual.

6-22. Test Equipment

6-23. The following equipment is recommended for performance testing, troubleshooting, and calibration of the DC External Reference. If the recommended equipment is not available, equivalent or better instruments may be substituted.

EQUIPMENT NOMENCLATURE	RECOMMENDED EQUIPMENT
DC Voltage Source	Fluke Model 343A DC Voltage Calibrator
Oscilloscope	Tektronix Model 547
Oscilloscope Plug-IN	Tektronix Model 1A1

6-24. Performance Test

6-25. The performance test in this section compares the DC External Reference performance to the accuracy specifications in Section 1 of the manual to determine if the unit is in calibration. To test the unit, a reference voltage is applied to the DC External Reference input terminals, a dc voltage is applied to the DVM INPUT terminals, and proper DVM readout is verified. The performance test should be conducted before any instrument maintenance or calibrating is attempted. The test is also suited to receiving inspection of new units. Performance test should be conducted under the following environmental conditions: ambient temperature 25°C ±5C, relative humidity less than 70%. An instrument that fails the performance test will require corrective maintenance or calibration. In case of difficulty, analysis of the test results, with reference to the troubleshooting section, should help to locate the trouble.

NOTE!

Permissible tolerances for voltage and resistance measurements are derived from the 90-day instrument specifications contained in Section I of the manual.

6-26. To test the DC External Reference unit, proceed as follows:

a. Connect the dc voltage source to the Model 8300A as shown in Figure 6-5.

b. Set the Model 8300A controls as follows:

POWER	ON
FUNCTION	EXT REF, VDC
RANGE	10

c. Set the dc voltage source controls for 10 volt dc output.

d. The Model 8300A readout should be +10.0000 ±0.0005.

6-27. Troubleshooting

6-28. This section contains information designed to aid in troubleshooting the DC External Reference Unit. Before attempting to troubleshoot the unit, however, it should be verified that the trouble is actually in the unit and is not caused by faulty external equipments or improper control settings. For this reason, the performance test (paragraph 6-24) is suggested as a first step in troubleshooting. The performance test may also help to localize the trouble to a particular section of the instrument. If the performance test fails to localize the trouble, the following information may be helpful.

6-29. OSCILLOSCOPE CONNECTIONS. To observe waveforms on the DC External Reference Unit, it will be necessary to synchronize the oscilloscope with the $\overline{\text{ZERO}}$ signal. Connect a lead from the scope external trigger input to TP108, with scope common connected to TP109. Connect the scope input probe also to TP108 and adjust the scope trigger controls so that it triggers on the negative going edge of the $\overline{\text{ZERO}}$ pulse.

6-30. VOLTAGE AND WAVEFORM CHECKS. If the reference voltage stays at about 7 volts no matter what the input reference voltage is, check transistors Q10 and Q12.

6-31. If the reference output voltage is zero or negative, check first the gate drives of Q7, Q4, and Q5. If either of the waveforms of Q7 are not correct (stylized waveforms are shown on the DC External Reference Unit schematic at the back of the manual), check to see if the same defective waveform appears at other than the gate terminals of Q7; if it does, Q7 is defective and should be replaced. If Q7 does not check bad, gate driver Q3 is probably defective.

6-32. If the waveforms are correct, connect the external reference input LO terminal to instrument common and apply 10 ±0.1 volts to the external reference input HI terminal. The resulting voltage across capacitor C7 should be 7 ±0.1 volts. The voltage across C8 should be equal to the voltage across C7 less the amount drained by the measurement instrument. The voltage across both C7 and C8 will be pulled high if the output of A1 is higher than 8 volts. No voltage or extremely low voltage across C8 indicates Q7 is bad. Check integrated circuit A1 to see if pin 2 is low or high with respect to pin 3. If it is low, the output at pin 6 of A1 should be +18 volts; if it is high, the output should be −18 volts. The combined voltage developed across R14 and R15 should be about 9.2 volts. If not, check the following components in the order given: A1, Q8, or Q6. If the unit operates normally with the LO reference input terminal connected to DVM common but does not operate properly with the LO terminal high or low with respect to DVM common, suspect Q7, Q5, CR1, or CR2.

6-33. Calibration

6-34. The DC External Reference Unit should be calibrated every 30 to 90 days, depending on the degree of accuracy to be maintained (see specifications, Section 1), or whenever repairs have been made to circuitry which may affect the calibration accuracy. Calibration of the unit should be performed at an ambient temperature of 25°C ± 5°C. Relative humidity should be less than 70%. Consult paragraph 6-22 for recommended test equipment.

6-35. PRELIMINARY OPERATIONS

a. Remove the lower dust cover retaining screws but leave the dust cover in place on the instrument.

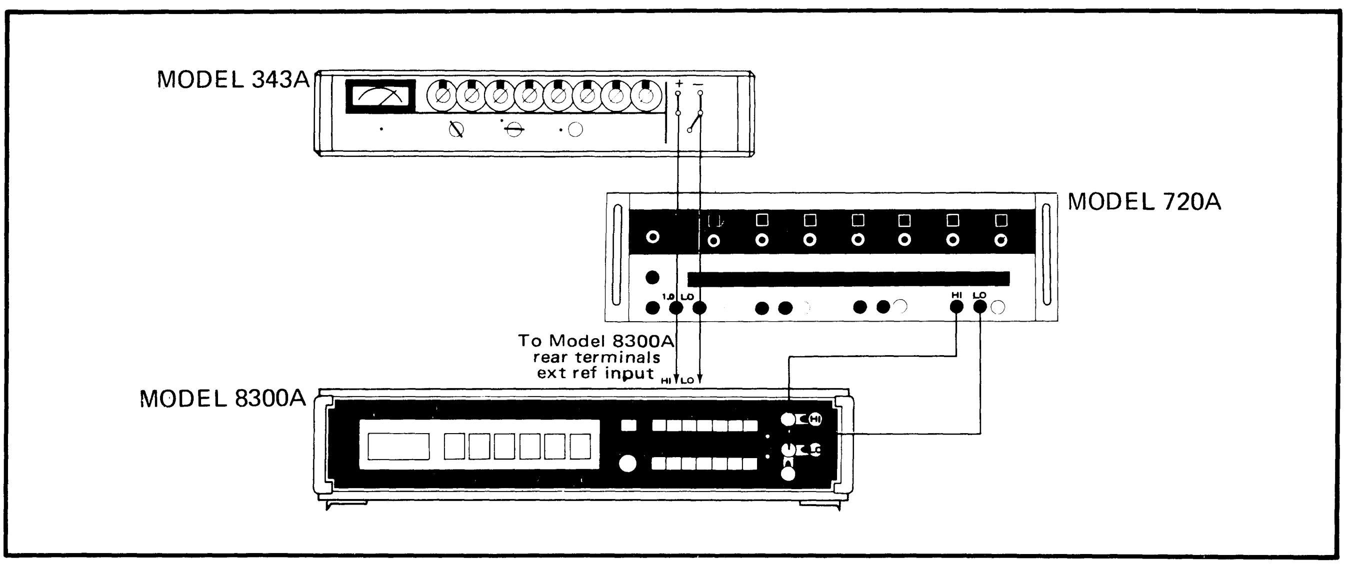


Figure 5-6. EQUIPMENT CONNECTIONS FOR DC EXTERNAL REFERENCE UNIT CALIBRATION

b. Set the rear panel 115/230 volt slide switch to the 115 volt position and connect the line cord to an autotransformer set to 120 volts ac.

c. Connect equipment as shown in Figure 6-5.

d. Turn on the Model 8300A and allow the instrument to operate for one hour.

6-36. ALIGNMENT

a. Set Model 8300A controls as follows:

FUNCTION	EXT REV, VDC
RANGE	10
SAMPLE RATE	as desired

b. Set the 720A dials to 8002000.

c. Set the 343A output to 10.000000 volts.

d. Adjust R10 in the DC External Reference Unit for a readout of 8.0020.

e. Set the 343A output to 4.000000 volts.

f. Adjust R16 in the DC External Reference Unit for a readout of 8.0020.

g. Repeat steps (b) through (f), as required, until no

h. Disconnect calibration equipment from Model 8300A.

6-37. CALIBRATION VERIFICATION

a. Set DVM controls as follows:

FUNCTION	EXT REF, VDC
RANGE	10

b. Apply 10.000 volts from a dc source to the DVM input terminals. Also apply 10.0000 volts from the same source to the EXT REF input terminals.

c. Record the DVM readout.

d. Reverse the input to the DVM only. DVM readout should be within 5 digits of value recorded in step (c).

e. Change the dc source output to 5.0000 volts and set the EXT REF switch on the DVM to off. DVM readout should be +DC 5.0000 ±2 digits

f. Press the EXT REF switch. DVM readout should be +DC 10.0000 ±7 digits.

6-38. LIST OF REPLACEABLE PARTS

6-39. For column entry explanations, part ordering information and basic instrument configuration Use Codes and Serial Number Effectivity List, see Section 5, paragraphs 5-1 through 5-10. See paragraph 6-40, this option subsection, for additional Use Codes and Serial Number Effectivity List assigned to this printed circuit assembly option.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		DIGITAL VOLTMETER - EXTERNAL REFERENCE OPTION	8300A-05					
		NOTE: The basic Model 8300A can be modified in the field by installing the External Reference Option Kit (8300A-05K) order by Model and Option No. (8300A-05K).						
		DC External Reference P/C Assembly (See Figure 6-6)	273565	89536	273565	1		
A1	H3-P1	IC, operational amplifier	271502	12040	LM301A	1	1	
C1	D4-M5	Cap, mica, 100 pf ±5%, 500v	148494	14655	CD15F101J	1		
C2	D4-M2	Cap, mica, 47 pf ±5%, 500v	148536	14655	CD15E470J	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C3	D3-L4	Cap, mica, 220 pf ±5%, 500v	170423	14655	CD15F221J	1		
C4	E2-Q1	Cap, mica, 390 pf ±5%, 500v	148437	14655	CD15F391J	2		
C5	C5-L3	Cap, mica, 390 pf ±5%, 500v	148437	14655	CD15F391J	REF		
C6	H1-P4	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	1		
C7	E4-M1	Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/ A100K	1		
C8	H1-N1	Cap, plstc, 0.47 uf ±10%, 250v	184366	73445	C280AE/ A470K	1		
C9	H2-N4	Cap, plstc, 0.047 uf ±10%, 250v	162008	73445	C280AE/ A47K	1		
CR1	C5-M1	Diode, silicon, 250 ma, 125 piv	272252	07263	FD333	5	1	
CR2	C5-M3	Diode, zener, 12v	159780	07910	1N759	1	1	
CR3	F4-P5	Diode, silicon, 150 ma	203323	03508	DHD1105	1	1	
CR4	C5-L4	Diode, silicon, 150 ma, 125 piv	272252	07263	FD333	REF		
CR5	C5-L3	Diode, silicon, 150 ma, 125 piv	272252	07263	FD333	REF		
CR6	C5-M4	Diode, germanium, 60 ma, 100 piv	205484	03877	JAN1N270	1	1	
CR7	E3-O3	Diode, silicon, 150 ma, 125 piv	272252	07263	FD333	REF		
CR8	E4-O5	Diode, silicon, 150 ma, 125 piv	272252	07263	FD333	REF		
K1	F1-P3	Reed switch	219097	15898	765972	1	1	
	F5-P3	Coil, reed switch	269019	71707	U-6-P	1	1	
Q1	D4-O5	Tstr, silicon, PNP	195974	04713	2N3906	2	1	
Q2	D4-N3	Tstr, silicon, NPN	218396	04713	2N3904	4	1	
Q3	D4-N5	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q4	G5-N2	Tstr, FET, N-channel	288324	15818	U1994E	1	1	
Q5	H3-N3	Tstr, FET, N-channel	271924	07910	CFE13041	1	1	
Q6	H3-O2	Tstr, FET, dual N-channel	267963	17856	DN503	1	1	
Q7	H2-M1	Tstr, FET, dual P-channel	268011	16952	T1483	1	1	
Q8	D4-O2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q10	D4-P5	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q12	D4-P3	Tstr, silicon, NPN	218396	04713	2N3904	REF		
R1	F3-Q3	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	1		
R2	C5-O3	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	3		
R3	C5-N5	Res, comp, 6.8k ±5%, ¼w	148098	01121	CB6825	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R4	C5-O1	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R5	C5-N1	Res, comp, 12k ±5%, ¼w	159731	01121	CB1235	1		
R6	C5-N4	Res, comp, 2.2M ±5%, ¼w	198390	01121	CB2255	1		
R7	C5-N3	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R8	C5-L5	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	1		
R9	H1-L4	Res, ww, 298.8k, matched	▷1					
R10	F5-M2	Res, var, ww, 5k ±5%, 2w	111609	71450	Type E115	1		
R11	F1-L4	Res, ww, 698.8k, matched	▷1					
R12	E3-M3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	1		
R13	C5-M5	Res, comp, 120k ±5%, ¼w	193458	01121	CB1245	1		
R14	H1-Q3	Res, ww, 23.158k ±0.1%, ¼w	277939	89536	277939	2		
R15	G1-N4	Res, ww, 23.158k ±0.1%, ¼w	277939	89536	277939	REF		
R16	F5-O2	Res, var, ww, 10Ω ±10%, 2w	183921	71450	Type 115	1		
R17	E4-O2	Res, met flm, 43.2k ±1%, 1/8w	272153	91637	Type MFF1/8	1		
R18	E4-P1	Res, comp, 33k ±5%, ¼w	148155	01121	CB3335	2		
R19	F4-Q4	Res, comp, 33k ±5%, ¼w	148155	01121	CB3335	REF		
R20	E4-N4	Res, met flm 13.7Ω ±1%, 1/8w	272815	91637	Type MFF1/8	1		
R21	E2-Q4	Res, comp, 5.6k ±5%, ¼w	148080	01121	CB5625	2		
R22	E4-N5	Res, met flm, 28.7Ω ±1%, 1/8w	272823	91637	Type MFF1/8	1		
R23	E2-Q3	Res, comp, 5.6k ±5%, ¼w	148080	01121	CB5625	REF		
R24	E5-L5	Res, met flm, 4.75k ±1%, 1/8w	260679	91637	Type MFF1/8	1		
R25	E3-M5	Res, comp, 6.2Ω ±5%, ¼w	272831	01121	CB62G5	1		

▷1 R9 and R11 are factory matched and must be replaced as a set. For replacement order External Reference Divider Resistor Set, part number 278309.

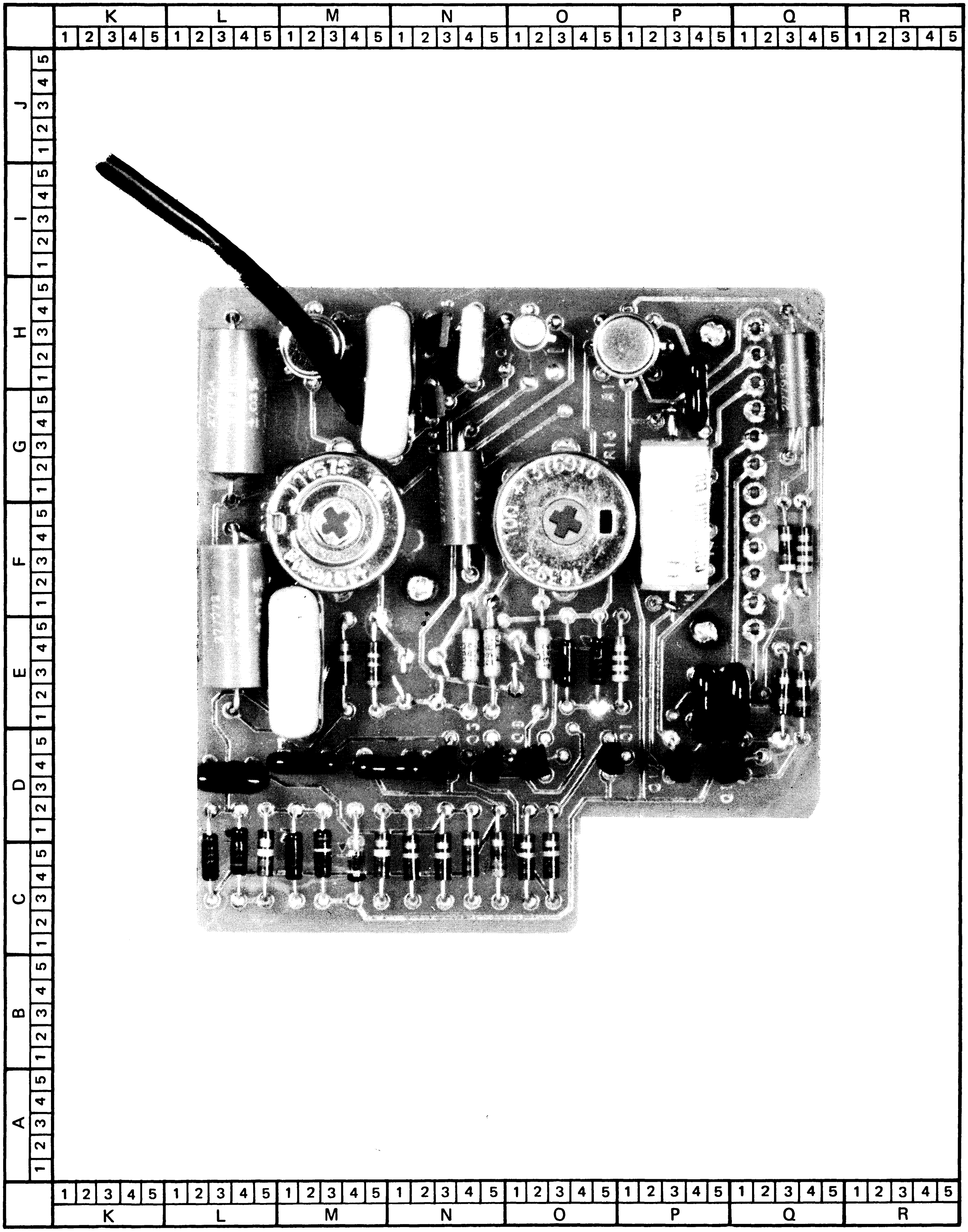


Figure 6-6. DC EXTERNAL REFERENCE P/C ASSEMBLY

6-40. SERIAL NUMBER EFFECTIVITY

6-41. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8300A. Each part in this option for which a use code has been assigned may be identified with a particular printed circuit board serial number by consulting the Use Code Effectivity List below. All parts with no code are used on all printed circuit boards with serial numbers 123 and on. NOTE: These Use Codes and Serial Number Effectivity apply to this option printed circuit board assembly only. For the standard instrument configuration, see Section 5, paragraph 5-9, and for additional options, see the appropriate option subsection.

USE CODE	SERIAL NUMBER EFFECTIVITY

OPTION 8300A-06

REAR INPUT

6-1. INTRODUCTION

6-2. The Rear Input Option provides INPUT, Ω SENSE and GUARD terminals at the rear of the instrument, in paralled with the front panel terminals.

6-3. INSTALLATION

6-4. The following procedure should be used to install the Rear Input Option:

a. Remove the instrument top and bottom dust covers, the top guard cover, the rear trim strips, and the small dust cover located at the accessory board mounting position on the rear panel.

b. Assemble the accessory board by mounting the eight banana jacks at the locations shown in Figure 6-1, using the hardware supplied.

c. Connect one end of the blue wire supplied in the kit to the rear terminal of either of the guard jacks (blue jacks).

d. IMPORTANT – Position the assembled accessory board inside the rear panel at the right-hand side of panel (See Figure 6-2), and secure the board in position using the four nylon screws. Ensure that the free end of the blue wire is passed through the grommeted hole in the accessory board rear cover before securing the assembly.

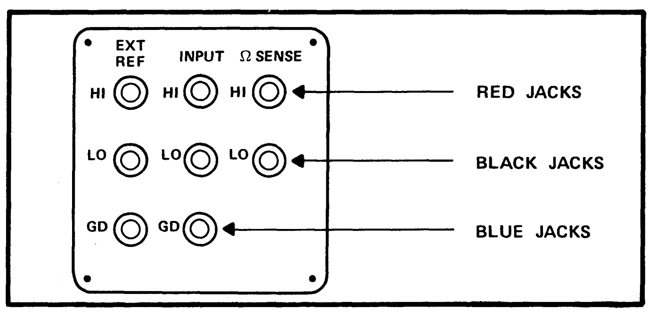


Figure 6-1. REAR TERMINAL LAYOUT

e. Pass the free end of the blue wire through the grommeted hole in the guard chassis and connect it to the guard chassis as shown in Figure 6-2.

f. Install the shield cable supplied in the kit so that the cable end with five wires passes through the grommeted hole in the bulkhead just in front of the rear terminals. (See Figure 6-3). The other end of the cable (four wires) should pass between the buffer and the small guard cover on the main

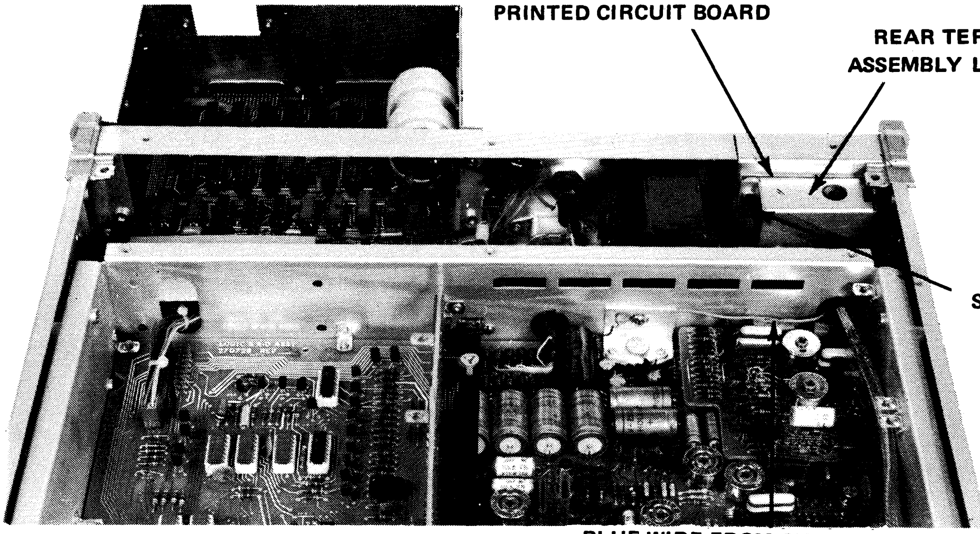


Figure 6-2. REAR TERMINAL BOARD INSTALLATION

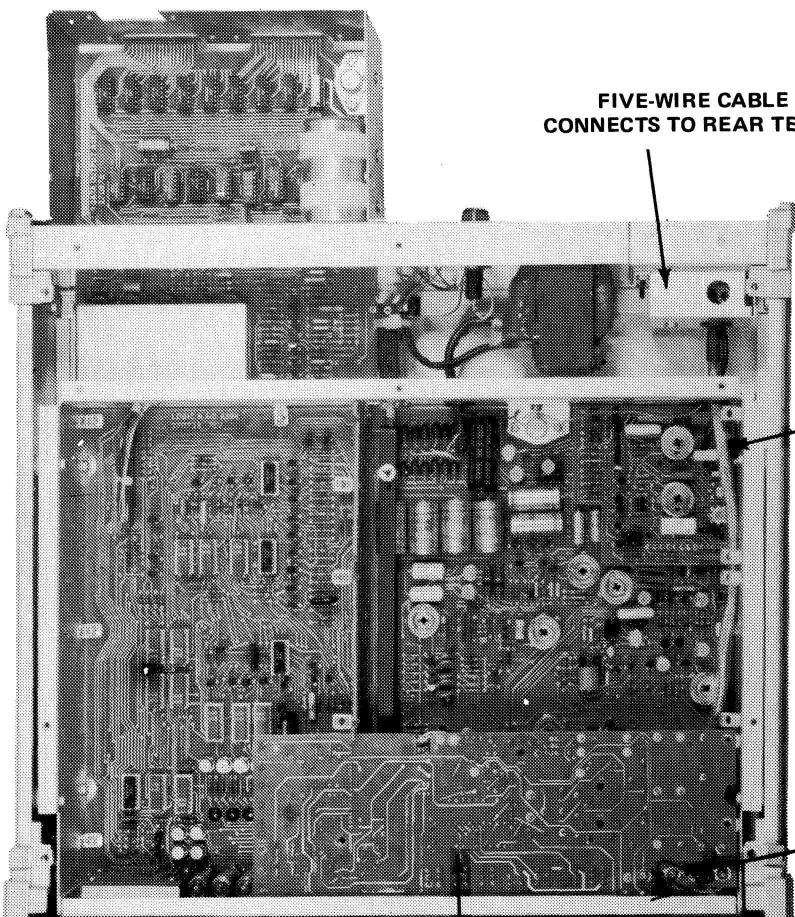


Figure 6-3. SHIELDED CABLE INSTALLATION

PCB. The four wires should be brought through the opening at the right front corner of the buffer board.

g. Remove the four terminal screws and connect the cable wires to the terminals along with the existing front terminal wires and replace the screws. Observe the connection diagram on the guard chassis cover to ensure proper connections.

NOTE!

If only rear terminal operation is desired, the front terminal wires may be removed from the buffer terminals and secured or taped.

h. Temporarily remove the terminal cover from the rear of the rear terminal board and connect the five-wire cable end to the rear terminals as follows:

5-WIRE CABLE END	CONNECTED TO
RED	HI INPUT
BLACK	LOW INPUT
YELLOW	Ω SENSE HI
BROWN	Ω SENSE LO
BLUE	GUARD

i. Replace instrument covers.

6-5. LIST OF REPLACEABLE PARTS

6-6. For column entry explanations, part ordering information and basic instrument configuration Use Codes and Serial Number Effectivity List, see Section 5, paragraphs 5-1 through 5-10. See paragraph 6-7, this option subsection, for additional Use Codes and Serial Number Effectivity List assigned to this printed circuit assembly option.

6-7. SERIAL NUMBER EFFECTIVITY

6-8. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8300A. Each part in this option for which a use code has been assigned may be identified with a particular serial number by consulting the Use Code Effectivity List below. All parts with no code are used on all serial numbers 123 and on. NOTE: These Use Codes and Serial Number Effectivity apply to this option only. For the standard instrument configuration, see Section 5, paragraph 5-9, and for additional options, see the appropriate option subsection.

USE CODE	SERIAL NUMBER EFFECTIVITY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		DIGITAL VOLTMETER - REAR INPUT OPTION	8300A-06					
		NOTE: The basic Model 8300A can be modified in the field by installing the Rear Input Option Kit (8300A-06K).						
		Decal, Parallel input	293548	89536	293548	1		
		Rear Terminal Cable	279729	89536	279729	1	1	
		Binding post, red	275552	89536	275552	3		
		Bind post, black	275560	89536	275560	3		
		Binding post, blue	275578	89536	275578	2		
		Bushing, snap black nylon	102780	89536	102780	1		
		Screw, 6-32 x ½ black nylon	115006	89536	115006	4		

ACCESSORY INFORMATION

MODEL 80-RF HIGH FREQUENCY PROBE

6-1. INTRODUCTION

62. The Model 80-RF High Frequency Probe allows measurements over a frequency range of 100 kHz to 500 MHz from 0.25 to 30 volts when using FLUKE voltmeters having an input impedance of 10 megohms ±10%. The accuracy of measurement is ±5% from 100 kHz to 100 MHz and +7% to 500 MHz. The probe operates into any dc voltmeter having an input impedance of 10 megohms ±10%. A shielded dual-banana plug on the probe permits direct connection to the voltmeter input.

6-3. SPECIFICATIONS

6-4. Electrical

VOLTAGE 0.25V to 30V

RESPONSE: Responds to peak value of input. Calibrated to read rms value of a sine wave input.

AC TO DC TRANSFER ACCURACY:
Loaded with 10 megohms ±10%.

	100 KHz – 100 MHz	100 MHz – 500 MHz
+10°C to +30°C	±5%	±7%
–10°C to +40°C	±7%	±15%

<±3 db at 10 kHz and 700 MHz.

INPUT IMPEDANCE: 4 megohms shunted by 2 ±0.5 pf.

MAXIMUM INPUT: 30 volts rms AC, 200 volts DC.

6-5. General

CABLE CONNECTIONS: Shielded dual banana plug Fits all standard 3/4-inch dual banana connectors.

CABLE LENGTH: 4 ft(121.9 cm) minimum.

WEIGHT: 3-½ oz. net.

ACCESSORIES SUPPLIED
Ground Lead
Straight Tip
Hook Tip
High Frequency Adapter

6-6. OPERATING INSTRUCTIONS

6-7. Connect the shielded dual banana plug directly to the voltmeter input terminals, GND to COMMON or LO. Affix the appropriate probe tip to the probe body, then connect the probe to the high frequency circuit under test. When using the Straight or Hook Tip the ground clip must be connected to the test circuit. When using the high frequency adaptor with appropriate 50 ohm connectors, the ground clip is not required.

6-8. The Straight Tip or Hook Tip supplied with the probe can be used for measurements up to 100 MHz. For measurements above 100 MHz the High Frequency Adapter allows connections to 50 ohm terminations. Ensure that the probe is used in conjunction with dc voltmeters having 10 MΩ ±10% input impedance to meet its specifications.

6-9. The maximum input to the probe is 30 volts rms ac, or 200 volts dc. These factors may be used in combination so that an ac signal may be measured riding on a dc voltage of up to 200 volts. However, it must be noted that if ac superimposed on dc is being measured, the dc level must not be changed by more than 200 volts or the resulting transient is apt to damage the diodes inside the probe.

6-10. THEORY OF OPERATION

6-11. Figure 6-1 contains a schematic diagram of the probe. C1 is a dc blocking capacitor, CR1 is used as a detector, and R1, R3, CR2, R2, and Rin form a divider network. C1, charging through CR1 during the negative half cycle of the input produces a positive dc voltage at the CR1-R1 junction which equals the negative peak value of the input signal. The divider network reduces this to the rms value of the input. It can be seen that the probe must be operated into a 10 MΩ load in order to maintain the proper division ratio.

6-12. CR2 provides compensation for the non-linearity of the detector. R3 is a selected part having a value of 50 kΩ to 100 kΩ, as required for proper divider action.

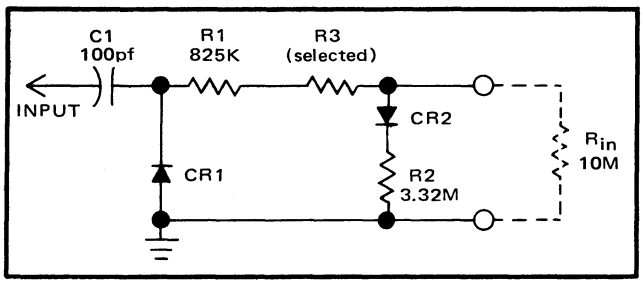


Figure 6-1. SCHEMATIC

6-13. MAINTENANCE

6-14. Performance Checks

6-15. The following checks verify the probe AC to DC Transfer accuracy.

6-16. LOW FREQUENCY RESPONSE. Connect equipment as shown in Figure 6-2, and perform the following steps.

a. With equipment as shown in connection "A" adjust the ac signal source for an output of 3.000 volts rms at 100 kHz as measured on the DVM.

b. In connection "B" with the DVM set to measure dc, observe a probe output of 3.15 to 2.85 volts.

c. Placing cables back in connection "A", decrease the ac signal source by 10db (0.95 volts).

d. Moving back to connection "B", observe a voltmeter indication of between 1.00 and 0.90 volts (10 db down from 3 volts).

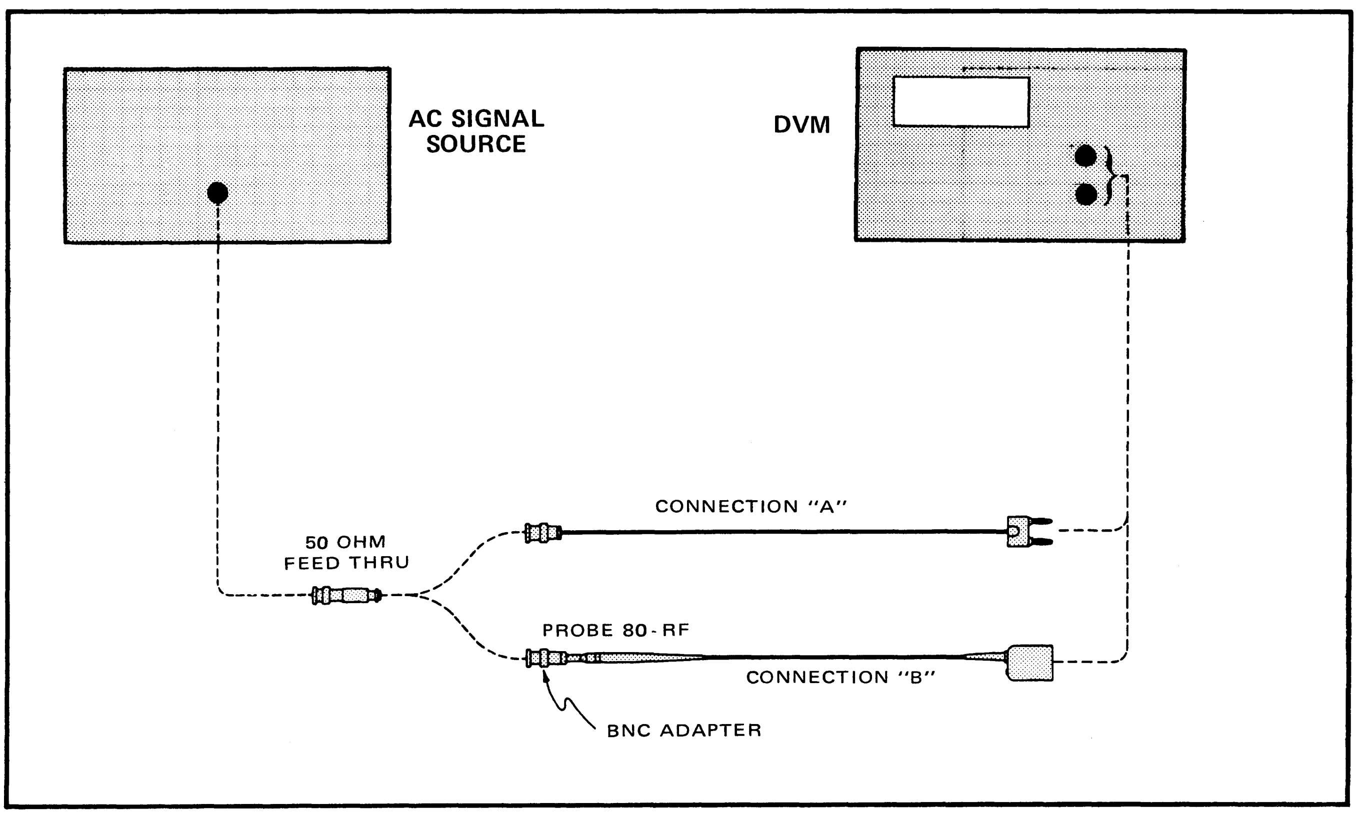


Figure 6-2. LOW FREQUENCY RESPONSE CHECK

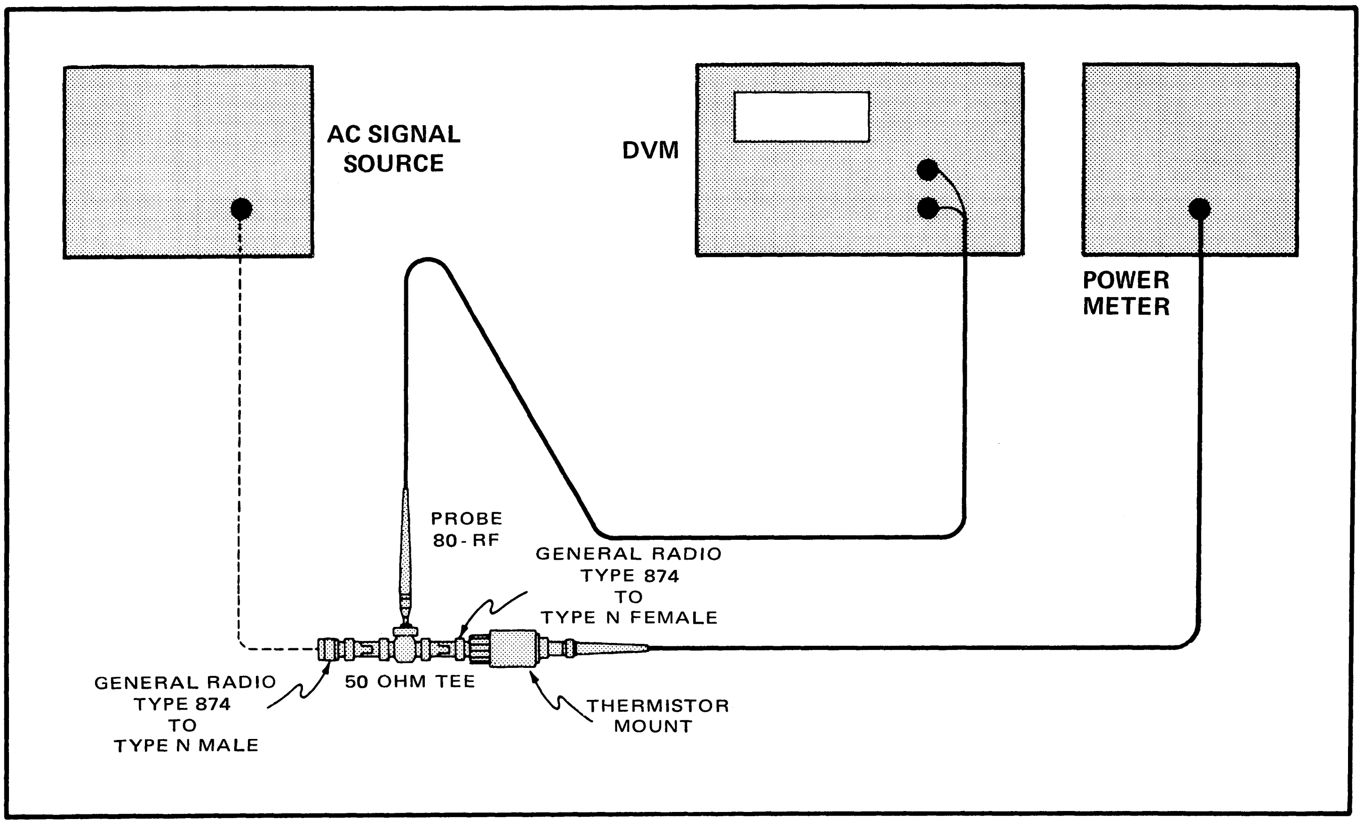


Figure 6-3. HIGH FREQUENCY RESPONSE CHECK

e. In connection "A", decrease the ac signal source an additional 10 db (to 0.3 volts) as indicated by the voltmeter in its ac function.

f. Back to "B", observe a voltmeter reading of .315 to .285 vdc.

g. Return the ac signal source back to 3.000 vrms.

h. Repeat steps a through g with frequencies of 500 kHz, 1 MHz, and 10 MHz.

6-17. HIGH FREQUENCY RESPONSE. Connect equipment to the 80-RF probe as shown in Figure 6-3, and perform the following steps:

a. Set the ac signal source ot 100 MHz with an output level of 10 milliwatts as indicated on the power meter. Ensure that the ac signal source has stabilized at 10 millivolts output.

b. Observe that the voltmeter indication is between 0.757 and 0.657 volts. (0.707 volts corresponds to 10 milliwatts in 50 ohms).

c. Repeat the above for frequencies of 200 MHz, 300 MHz, 400 MHz, and 480 MHz.

6-18. Calibration

6-19. Should the 80-RF require recalibration, perform the following steps:

a. Perform steps a and b in paragraph 6-16, with a frequency of 1 MHz.

b. Observe the dc voltmeter indication; a reading below 3 volts calls for a decrease in the value of R3, a reading above 3 volts calls for an increase in R3. Resistor R3 should be a 1/8 W metal film type. In a probe that is working properly, a 30 kΩ change in R3 will produce about a 1% reading deviation.

6-20. Cleaning

6-21. The Model 80-RF requires a minimum amount of cleaning. Accumulation of dust or dirt particles between the output terminals of the Model 80-RF can be removed using clean dry pressurized air. Stubborn particles can be removed following an application of isopropyl alcohol.

ACCESSORY INFORMATION

MODEL A90 CURRENT SHUNT

6-1. INTRODUCTION

6-2. The Model A90 Current Shunt is designed for use with any high-impedance ac or dc voltmeter capable of accurately measuring 100 millivolts. Six Fluke precision wire wound and strip resistors provide a 100 millivolt full-scale output for each of six pushbutton current ranges: 0.1, 1, 10, 100, and 1000 milliamperes and 10 amperes (ac or dc). Basic accuracy is specified over a frequency range of dc to 4 kHz for the 10 ampere range and dc to 10 kHz for the milliampere ranges.

6-3. The instrument is supplied in half-rack case so that it may be conveniently mounted side-by-side with other half-rack instruments in a standard 19-inch rack. A carrying handle detents into custom non-marring feet and serves as a tilt-up bail for bench use.

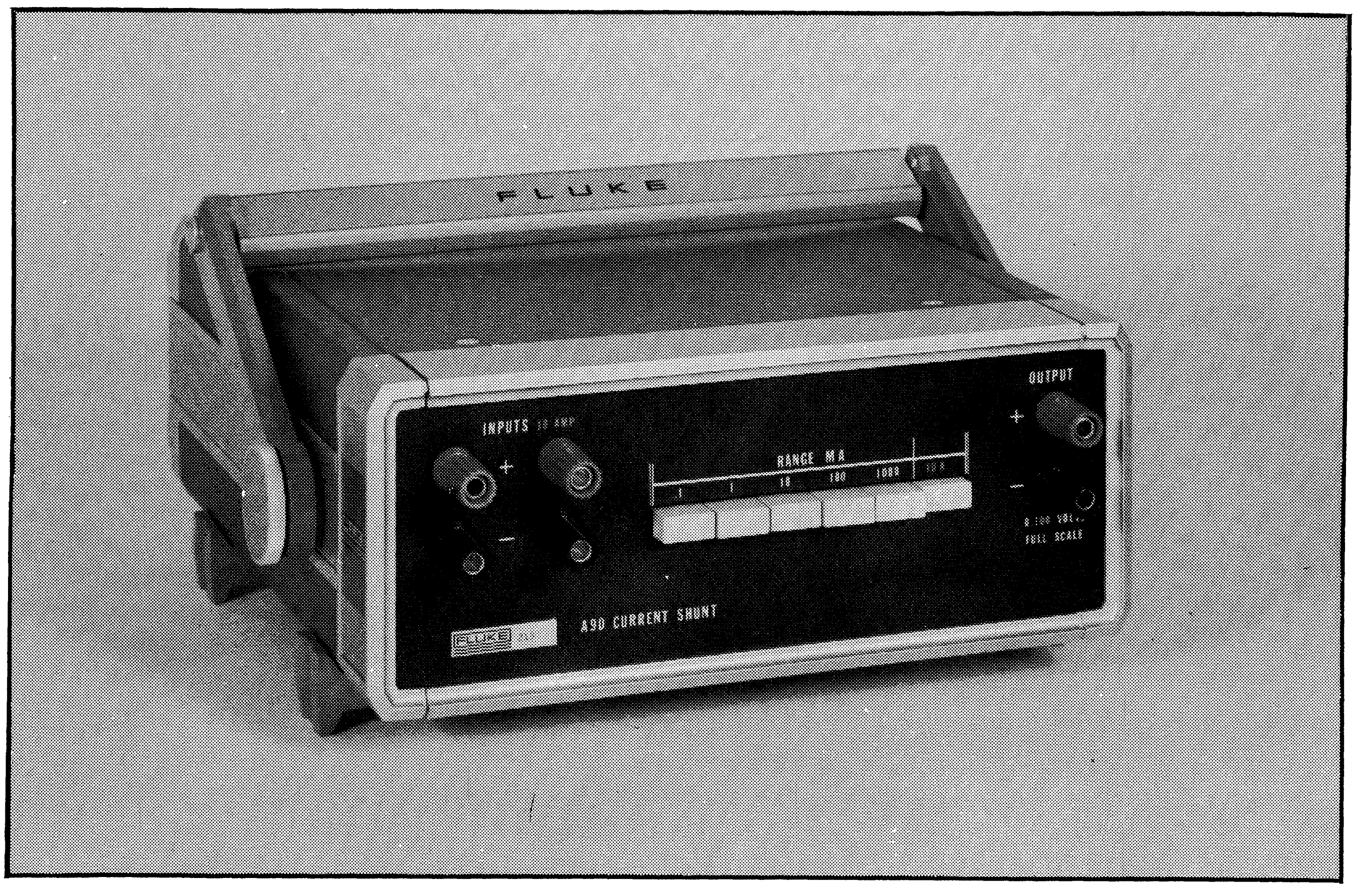
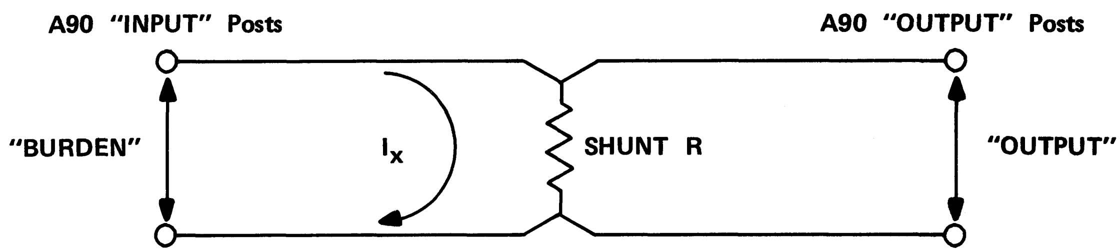


Figure 6-1. MODEL A90 CURRENT SHUNT

Table 6-1. ACCURACY OF A90 (1 year, 15°C - 35°C)

RATED CURRENT RANGE	E BURDEN (APPROX.)	SHUNT R	"OUTPUT" AT RATED CURRENT	"OUTPUT" ACCURACY AS % OF CURRENT INPUT	
				DC ONLY	DC TO 10 KHZ AC
0.1 ma	100 mv	1 kΩ	100 mv	±0.1%	±0.1%
* 0.1 ma	100 mv	1 kΩ	100 mv	+0.0% −0.2%	+0.0% −0.2%
1.0 ma	100 mv	100Ω	100 mv	±0.1%	±0.1%
10 ma	100 mv	10Ω	100 mv	±0.1%	±0.1%
100 ma	102 mv	1Ω	100 mv	±0.1%	±0.1%
1A	120 mv	0.1Ω	100 mv	±0.1%	±0.2%
10A	300 mv	0.01Ω	100 mv	±0.2%	±0.3% (to 4 kHz)

* With 1 MΩ Input R Voltmeter.
When Input R is ⩾10 MΩ, use non-asterisked 0.1 ma specification.



Simplified diagram illustrating terms used in table.

6-4. SPECIFICATIONS

6-5. Electrical

RANGE
0.1, 1, 10, 100, and 1000 milliamps and 10 amperes.

ACCURACY
Table 6-1 gives accuracy specifications for the Model A90 only. Total current measurement accuracy is also dependent on the accuracy and input impedance of the voltmeter being used.

SENSITIVITY
100 millivolts full scale.

OVERLOAD
Model A90 will not be damaged by 100% overload on each range below 10 amperes or by 50% overload on the 10 ampere range.

6-6. Mechanical

CURRENT SELECTION
Pushbutton, each range.

CONNECTORS
Positive (+) and negative (−) INPUT and OUTPUT binding posts with separate input posts for 10 ampere range.

DIMENSIONS
The Model A90 outline drawing is shown in Figure 6-2.

RACK MOUNTING KITS (OPTIONAL)
MEE-7014: Side-by-side Half-rack Mounting Kit
MEE-7006: Center Rack Mounting Kit
MEE-7013: Left or right of center Mounting Kit.

6-7. AUXILIARY ELECTRICAL SPECIFICATIONS

6-8. Tables 6-2 through 6-6 provide accuracy specifications for the Model A90 when used with Fluke Models

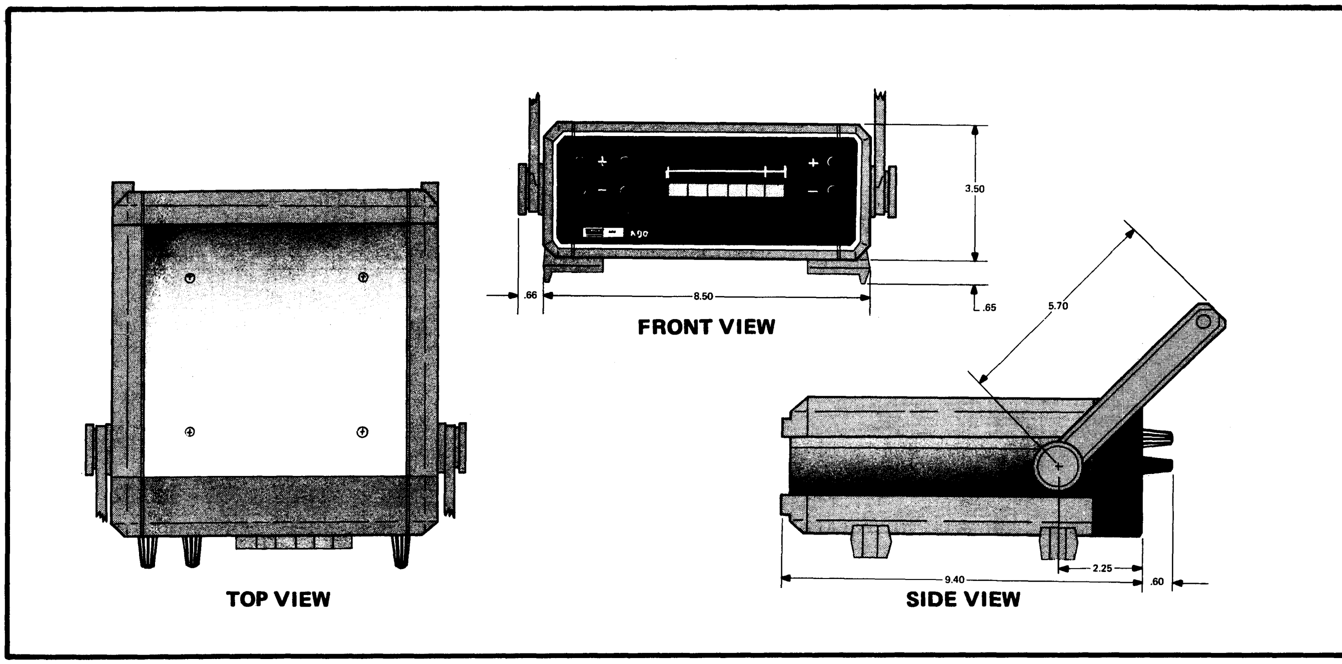


Figure 6-2. MODEL A90 OUTLINE DRAWING

Table 6-2. A90/8100A ACCURACY. 30 days, @ 23°C ±5°C.

DC ACCURACY	
CURRENT RANGE	SPECIFICATION
0.1 ma	±(0.12% of current input + 0.1 ua)
1.0 ma	±(0.12% of current input + 1.0 ua)
10 ma	±(0.12% of current input + 10 ua)
100 ma	±(0.12% of current input + 0.1 ma)
1A	±(0.12% of current input + 1.0 ma)
10A	±(0.22% of current input + 10 ma)

AC ACCURACY		
CURRENT RANGE	30 Hz – 50 Hz	50 Hz – 10 kHz
0.1 ma	+(0.5% of current input + 1.0 ua) –(0.7% of current input + 1.0 ua)	+(0.2% of current input + 0.5 ua) –(0.4% of current input + 0.5 ua)
1.0 ma	±(0.6% of current input + 10 ua)	±(0.3% of current input + 5.0 ua)
10 ma	±(0.6% of current input + 0.1 ma)	±(0.3% of current input + 50 ua)
100 ma	±(0.6% of current input + 1.0 ma)	±(0.3% of current input + 0.5 ma)
1A	±(0.7% of current input + 10 ma)	±(0.4% of current input + 5.0 ma)
10A	±(0.8% of current input + 100 ma)	±(0.5% of current input + 50 ma)*

*10A specified to 4 kHz only.

For:	DC CURRENT	AC CURRENT
	V_r = 1v	V_r = 1v
	V_{dfs} = ±.1000	V_{dfs} = .1000

Table 6-3. A90/8300A ACCURACY

DC CURRENT ACCURACY

MEASUREMENTS WITHOUT MV/OHMS OPTION INSTALLED

CURRENT RANGE	24 hr @ 23°C ±1°C	90 days @ 23°C ±5°C
0.1 ma	±(0.1% of current input + 0.1 ua)	±(0.11% of current input + 0.3 ua)
1.0 ma	±(0.1% of current input + 1.0 ua)	±(0.11% of current input + 3.0 ua)
10 ma	±(0.1% of current input + 10 ua)	±(0.11% of current input + 30 ua)
100 ma	±(0.1% of current input + 0.1 ma)	±(0.11% of current input + 0.3 ma)
1A	±(0.1% of current input + 1.0 ma)	±(0.11% of current input + 3.0 ma)
10A	±(0.2% of current input + 10 ma)	±(0.21% of current input + 30 ma)

V_r = 10 VDC

V_{dfs} = 0.1000 (Readout also will display "DC +" or "DC –").

MEASUREMENTS WITH MV/OHMS OPTION (8300A-02) INSTALLED

CURRENT RANGE	90 days @ 23°C ±5°C
0.1 ma	±(0.11% of current input + 0.01 ua)
1.0 ma	±(0.11% of current input + 0.1 ua)
10 ma	±(0.11% of current input + 1.0 ua)
100 ma	±(0.11% of current input + 10 ua)
1A	±(0.11% of current input + 0.1 ma)
10A	±(0.21% of current input + 1.0 ma)

V_r = 100 MV (0.1v)

V_{dfs} = 100.000 (Readout will also display MV DC + or MV DC–)

AC CURRENT ACCURACY

MEASUREMENTS WITH AC OPTION 8300A-01 INSTALLED

90 days @ 23°C ±5°C using AC Zero control periodically.

CURRENT RANGE	30 Hz – 50 Hz	50 Hz – 10 kHz
0.1 ma	+(0.5% of current input + 0.05 ua) –(0.7% of current input + 0.05 ua)	+(0.1% of current input + 0.05 ua) –(0.3% of current input + 0.05 ua)
1.0 ma	±(0.6% of current input + 0.5 ua)	±(0.2% of current input + 0.5 ua)
10 ma	±(0.6% of current input + 5.0 ua)	±(0.2% of current input + 5.0 ua)
100 ma	±(0.6% of current input + 50 ua)	±(0.2% of current input + 50 ua)
1A	±(0.7% of current input + 0.5 ma)	±(0.3% of current input + 0.5 ma)
10A	±(0.8% of current input + 5.0 ma)	±(0.4% of current input + 5.0 ma)*

V_r = 1 VAC

V_{dfs} = .10000 (Readout will also display "AC")

*10A specified to 4 kHz only.

Table 6-4. A90/9500A SPECIFICATIONS

ACCURACY WHEN UNKNOWN CURRENT IS 20% OR MORE OF A90 CURRENT RANGE. ($23^{o}C \pm 1^{o}C$)		
CURRENT RANGE	20 Hz – 50 Hz	50 Hz – 10 kHz
0.1 ma	+(0.3% of current input + 0.02 ua) –(0.5% of current input + 0.02 ua)	+(0.05% of current input + 0.015 ua) –(0.25% of current input + 0.015 ua)
1.0 ma	±(0.4% of current input + 0.2 ua)	±(0.15% of current input + 0.15 ua)
10 ma	±(0.4% of current input + 2.0 ua)	±(0.15% of current input + 1.5 ua)
100 ma	±(0.4% of current input + 20 ua)	±(0.15% of current input + 15 ua)
1A	±(0.5% of current input + 0.2 ma)	±(0.25% of current input + 0.15 ma)
10A	±(0.6% of current input + 2.0 ma)	±(0.35% of current input + 1.5 ma)*

ACCURACY WHEN UNKNOWN CURRENT IS BETWEEN 10% AND 20% OF A90 CURRENT RANGE.

A90 INPUT (% OF CURRENT RANGE)	% OF INPUT ABSOLUTE ACCURACY 20 Hz – 50 Hz @ $23^{o}C \pm 1^{o}C$ FOR A90 CURRENT RANGE				
	0.1 ma				
	+	–	1 ma – 100 ma	1A	10A
10-11%	0.53%	0.73%	± 0.63%	±0.73%	±0.83%
12-14%	0.50%	0.70%	± 0.60%	±0.70%	±0.80%
15-17%	0.47%	0.67%	± 0.57%	±0.67%	±0.77%
18-20%	0.44%	0.64%	± 0.54%	±0.64%	±0.74%

A90 INPUT (% OF CURRENT RANGE)	% OF INPUT ABSOLUTE ACCURACY 50 Hz – 10 kHz @ $23^{o}C \pm 1^{o}C$ FOR A90 CURRENT RANGE				
	0.1 ma				
	+	–	1 ma – 100 ma	1A	10A*
10-11%	0.23%	0.43%	±0.33%	±0.43%	±0.53%
12-14%	0.20%	0.40%	±0.30%	±0.40%	±0.50%
15-17%	0.17%	0.37%	±0.27%	±0.37%	±0.47%
18-20%	0.13%	0.33%	±0.23%	±0.33%	±0.43%

V_r = .1v
V_{dfs} = .10000
TC = 0.005% of current input/^{o}C 20 Hz –50 Hz
0.004% of current input/^{o}C 50 Hz – 10 kHz

*10A is specified to 4 kHz only.

8100A, 8300A, 9500A, 891A, 893A, and 931B. Table 6-7 gives V_r and V_{dfs} for each of the voltmeters listed in the tables in addition to various other Fluke voltmeters, where

V_r = Voltage range to be used on the voltmeter
and V_{dfs} = Nominal voltmeter reading with full-scale current in A90 shunt.

6-9. INSTALLATION

6-10. There are three rack-mount kits available, at additional cost, for use with the Model A90. Kit MEE-7014 allows the Model A90 to be mounted side-by-side with another half-rack instrument in a standard 19-inch rack. Kit MEE-7006 supplies hardware necessary to mount the

Table 6-5. A90/891A AND 893A ACCURACY (Sheet 1 of 2)

WITH 891A AND 893A – DC ACCURACY

CURRENT RANGE	@ 23°C ±2°C	@ 15°C –35°C
0.1 ma	±(0.11% of current input + 0.02 ua)	±(0.12% of current input + 0.02 ua)
1.0 ma	±(0.11% of current input + 0.2 ua)	±(0.12% of current input + 0.2 ua)
10 ma	±(0.11% of current input + 2.0 ua)	±(0.12% of current input + 2.0 ua)
100 ma	±(0.11% of current input + 20 ua)	±(0.12% of current input + 20 ua)
1A	±(0.11% of current input + 0.2 ma)	±(0.12% of current input + 0.2 ma)
10A	±(0.21% of current input + 2.0 ma)	±(0.22% of current input + 2.0 ma)

V_r = 1v

V_{dfs} = 0.10000

WITH 893A – AC ACCURACY
@ 23°C ±2°C

CURRENT RANGE	50 Hz – 10 kHz
0.1 ma	+(0.05% of current input + 0.025 ua) –(0.25% of current input + 0.025 ua)
1.0 ma	±(0.15% of current input + 0.25 ua)
10 ma	±(0.15% of current input + 2.5 ua)
100 ma	±(0.15% of current input + 25 ua)
1A	±(0.25% of current input + 0.25 ma)
10A	±(0.35% of current input + 2.5 ma)*

WITH 893A – AC ACCURACY
@ 15°C –35°C

CURRENT RANGE	5 Hz – 10 Hz	10 Hz – 20 Hz
0.1 ma	+(1.0% of current input + 0.25 ua) –(1.2% of current input + 0.25 ua)	+(0.5% of current input + 0.1 ua) –(0.7% of current input + 0.1 ua)
1.0 ma	±(1.1% of current input + 2.5 ua)	±(0.6% of current input + 1.0 ua)
10 ma	±(1.1% of current input + 25 ua)	±(0.6% of current input + 10 ua)
100 ma	±(1.1% of current input + 0.25 ua)	+(0.6% of current input + 0.1 ma)
1A	±(1.2% of current input + 2.5 ma)	±(0.7% of current input + 1.0 ma)
10A	±(1.3% of current input + 25 ma)	±(0.8% of current input + 10 ma)

893A – AC ACCURACY
@ 15°C –35°C.

CURRENT RANGE	20 Hz – 50 Hz	50 Hz – 10 kHz
0.1 ma	+(0.15% of current input + 0.025 ua) –(0.35% of current input + 0.025 ua)	+(0.1% of current input + 0.025 ua) –(0.3% of current input + 0.025 ua)
1.0 ma	±(0.25% of current input + 0.25 ua)	±(0.2% of current input + 0.25 ua)
10 ma	±(0.25% of current input + 2.5 ua)	±(0.2% of current input + 2.5 ua)
100 ma	±(0.25% of current input + 25 ua)	±(0.2% of current input + 25 ua)
1A	±(0.35% of current input + 0.25 ma)	±(0.3% of current input + 0.25 ma)
10A	±(0.45% of current input + 2.5 ma)	±(0.4% of current input + 2.5 ma)*

Table 6-5. A90/891A AND 893A ACCURACY (Sheet 2 of 2)

V_r = 1v (AC or DC)
V_{dfs} = 0.10000

*10A is specified to 4 kHz only.

Table 6-6. A90/931B SPECIFICATIONS

ACCURACY WHEN UNKNOWN CURRENT IS 10% OR MORE OF A90 CURRENT RANGE				
CURRENT RANGE	% OF INPUT ABSOLUTE ACCURACY 2 Hz – 3 Hz	3 Hz – 5 Hz	5 Hz – 30 Hz	SPECIFICATIONS 30 Hz – 10 kHz
0.1 ma	+1.0% −1.2%	+0.5% −0.7%	+0.2% −0.4%	+(0.05% of current input + 5 na) −(0.25% of current input + 5 na)
1.0 ma	±1.1%	±0.6%	±0.3%	±(0.15% of current input + 50 na)
10 ma	±1.1%	±0.6%	±0.3%	±(0.15% of current input + 0.5 ua)
100 ma	±1.1%	±0.6%	±0.3%	±(0.15% of current input + 5 ua)
1A	±1.2%	±0.7%	±0.4%	±(0.25% of current input + 50 ua)
10A	±1.3%	±0.8%	±0.5%	±(0.35% of current input + 0.5 ma)*
TC=	±0.1%/°C	±0.05%/°C	±0.025%/°C	±0.0025%/°C

V_r = 100 MV
V_{dfs} = 100.000

*10A is specified to 4 kHz only.

Table 6-7. "V_r" AND "V_{dfs}" FOR VOLTMETERS OF TABLES 6-2 THROUGH 6-6

VOLTMETER	"V_r"	"V_{dfs}"
8300A (Without MV/Ohms)	10v	.010
8100A, 871A, 873A, 881A, 883A, 885A, 887A, 891A, 893A	1v	.100
801, 803, 801B, 803B, 803D, 821A, 823A, 825A	0.5v	.100
9500A, 910A	0.1v	.100
8300A (With MV/Ohms), 931A, 931B	100 MV	100.0

V_r = Voltage range to be used on the voltmeter.
V_{dfs} = Nominal voltmeter reading with full-scale current in A90 shunt.

instrument in the center of the rack. Kit MEE-7013 supplies two different sized rack ears so that the instrument can be mounted to the left or to the right of rack center.

6-11. OPERATING INSTRUCTIONS

6-12. A description of Model A90 controls and terminals is given in Figure 6-3.

6-13. Equipment Connections

6-14. It is recommended that the Model A90 always be used in the "LO" lead as shown in Figure 6-4A. When used in the "HI" lead, as shown in Figure 6-4B, the distributed capacitance, C_{DIST}, loads the source. When connected in the "HI" lead, the voltmeter guard should either be connected as shown or else the voltmeter should be battery operated.

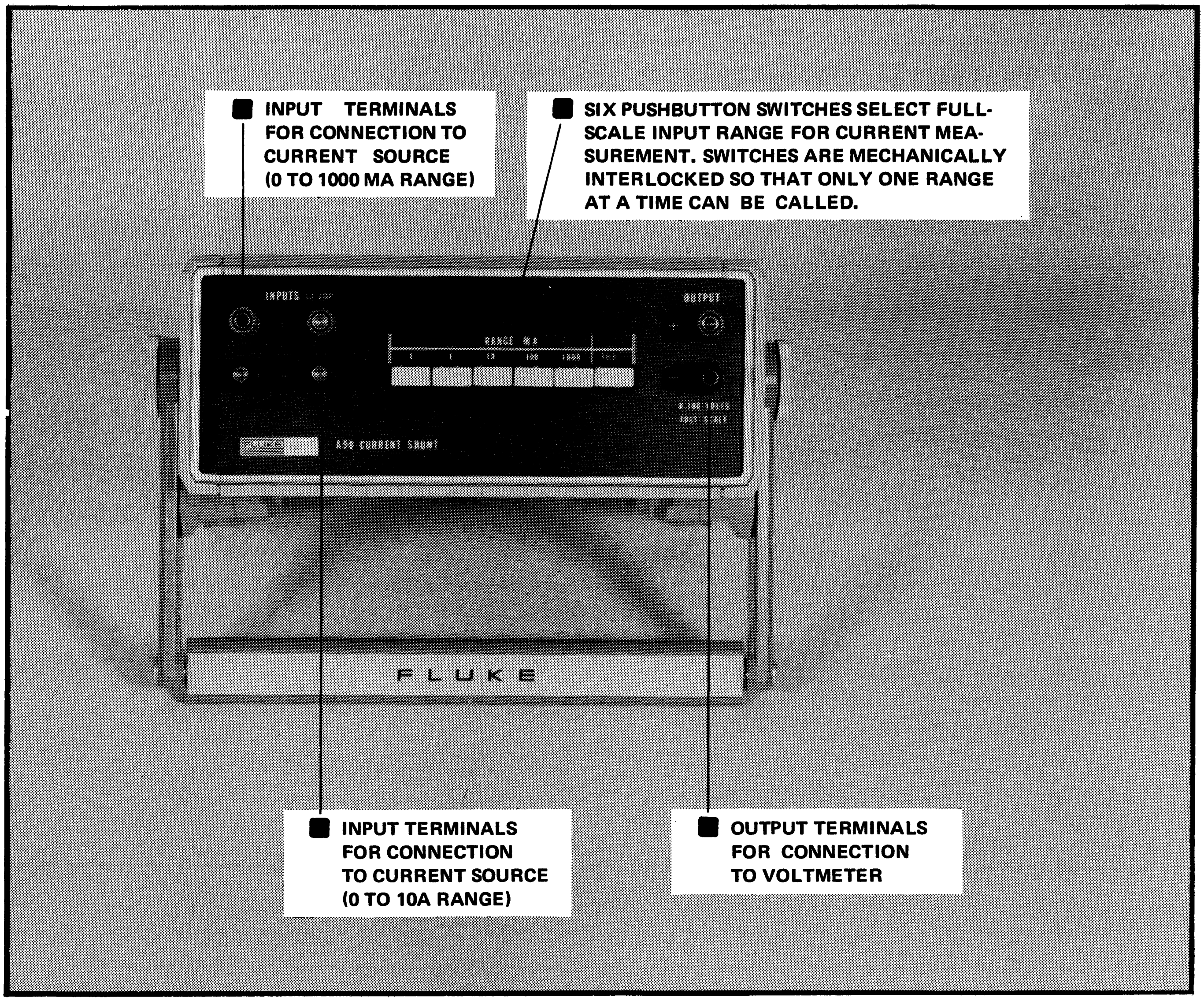


Figure 6-3. MODEL A90 CONTROLS AND TERMINALS.

6-15. At high ac currents, performance of the A90 may depend upon the manner in which the current leads are connected to the input binding posts. Optimum performance is obtained when the input current leads are twisted.

6-16. Voltmeter Impedance

6-17. The input impedance of the voltmeter which is used with the Model A90 is significant with regard to total measurement accuracy. As indicated in the specifications, Model A90 measurement accuracy is derated for voltmeters having finite input impedance. As the voltmeter input capacity increases, the Model A90 response rolls off at the high end; and as the voltmeter input resistance decreases, the response shifts downward, resulting in negative measurement errors.

6-18. Combining Model A90 And Voltmeter Specifications

6-19. Combined specifications for the A90 when used with various Fluke voltmeters is given in Tables 6-2 through 6-6. When the A90 is used with other voltmeters, the following information may be used to combine specifications.

6-20. Equation 1 (Figure 6-5) is used to combine A90 and voltmeter specifications for overall accuracy. The "W" term is taken from Table 6-1, and the "X", "Y" and "Z" terms are taken from voltmeter specifications (data sheets). All Fluke voltmeter specifications, except the Model 910A, contain the "X" term; they usually list the "Y" term and occasionally the "Z" term. Model 910A accuracy specifi-

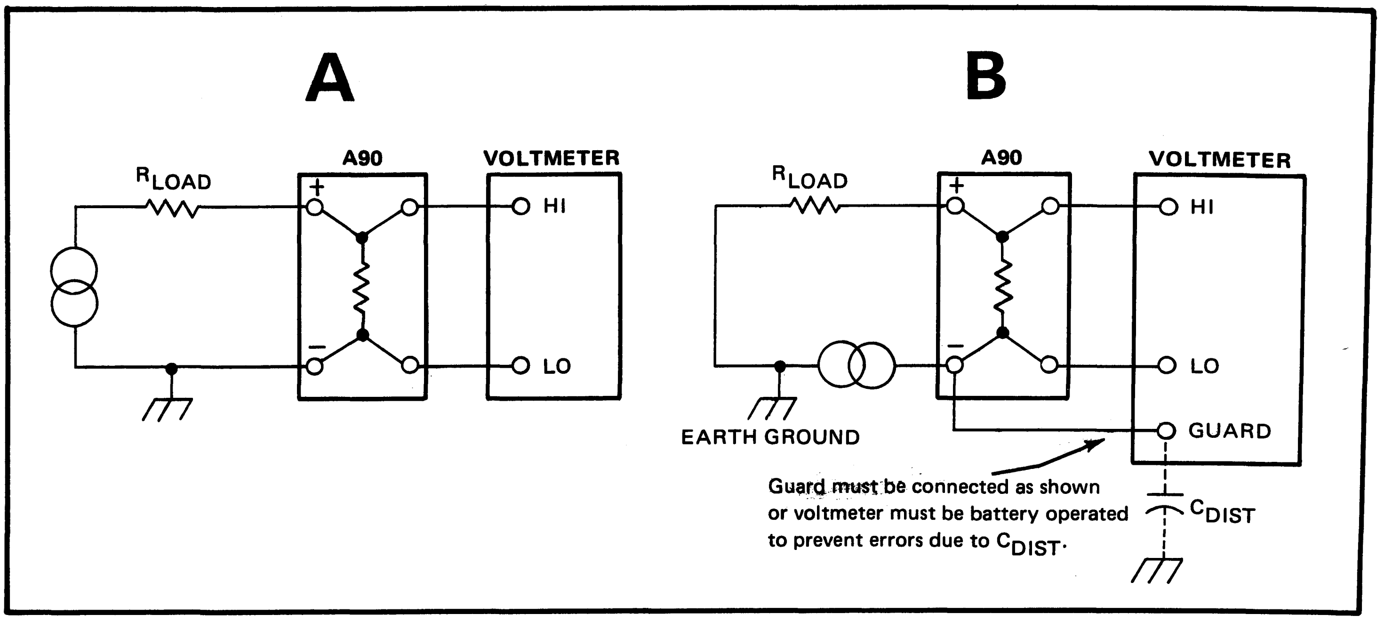


Figure 6-4. EQUIPMENT CONNECTIONS FOR CURRENT MEASUREMENT.

EQUATION 1. COMBINING A-90 SPECIFICATION WITH VOLTMETER SPECIFICATION.

A-90 Specification (from Table 6-1): $\pm$ W %

Voltmeter Specification (from Voltmeter Data Sheet): $\pm$ (X % of input + Y % of range + Z uv)

Vr = Lowest voltmeter range that will measure 100 MV

$$= + \left[(W + X)\ \%\text{ of current input} + \frac{Vr}{0.1} \times \left(Y + \frac{Z}{10000} \right) \%\text{ of current range} \right]$$

EXAMPLE 1: Accuracy using 10 ma DC A-90 range with 891A.

A-90 Specification (from Table 6-1): $\pm$ 0.1 %

891A Specification (from 891A Data Sheet): $\pm$ (0.01 % of input + 0.001 % of range + 10 uv)

Vr = 1.0 (891A's 1v DC Range)

$$= \pm \left[(0.1 + 0.01)\ \%\text{ of current input} + \frac{1.0}{0.1} \times \left(0.001 + \frac{10}{10{,}000} \right) \%\text{ of current range} \right]$$

$$= \pm \left[0.11\%\text{ of current input} + 0.02\%\text{ of current range} \right]$$

$$= \pm \left[0.11\%\text{ of current input} + 2\text{ ua} \right]$$

Figure 6-5. EQUATION 1 – COMBINING A90 AND VOLTMETER SPECIFICATIONS (Sheet 1 of 2)

EXAMPLE 2: Accuracy using 0.1 ma AC A-90 range with 873A at 1 kHz.

Model 873A has 1 megohm input impedance in its AC mode so separate accuracy statements are required for positive and negative limits of error for measurements made on the A-90's 0.1 ma range.

Positive Limit of Error

A-90 Specification — 873A Specification

+ | 0.0 | % ± | 0.2 | % of input + | 25 | uv

"Vr" is 873A's 1v AC Range

No "Y" Term In Spec.

$$= +\left[(0.0 + 0.2)\ \text{\% of current input} + \frac{1}{0.1} \times \left(0 + \frac{25}{10000}\right)\ \text{\% of current range}\right]$$

$$= +\left[\ 0.2\%\ \text{of current input} + 0.025\%\ \text{of current range}\ \right]$$

Negative Limit of Error

$$= -\left[(0.2 + 0.2)\ \text{\% of current input} + 0.025\%\ \text{of current range}\right]$$

$$= -\left[0.4\%\ \text{of current input} + 0.025\%\ \text{of current range.}\right]$$

Figure 6-5. EQUATION 1 – COMBINING A90 AND VOLTMETER SPECIFICATIONS (Sheet 2 of 2)

cation consists of "Y" term only. If "X", "Y", or "Z" do not appear in a voltmeter accuracy specification, it should be treated as a zero in Equation 1. The voltmeter must be used on the lowest range that can measure 100 millivolts. This range is assigned the symbol "V_r" in Equation 1. V_r is always stated as volts, i.e., 100 millivolt range equals 0.1 volts for V_r .

6-21. Equation 2 (Figure 6-6) may be used to convert the voltmeter voltage reading to current.

6-22. THEORY OF OPERATION

6-23. The schematic diagram of the Model A90 is located at the back of the manual. In the milliampere ranges, current is directed through the appropriate shunt resistor by switches S1A through S5A, and the corresponding output voltage is connected to the output terminals through switches S1 through S5, decks B and C. In 10 ampere range, the input current is applied directly to the shunt resistor, and the output voltage is connected to the output terminals through switch S6.

6-24. All shunt resistors are four-terminal shunts or are connected in a four-terminal switching arrangement so that lead resistance does not affect measurement accuracy.

6-25. MAINTENANCE

6-26. The following paragraphs contain instructions for cleaning and calibrating the Model A90.

6-27. Cleaning

6-28. The instrument should be cleaned periodically to remove dust, grease, and other contamination. The following procedure should be adhered to when cleaning the instrument:

a. Remove loose contamination with low-pressure, clean, dry air.

b. Clean front panel and exterior surfaces with anhydrous ethyl alcohol or a soft cloth dampened in a mild solution of detergent and water.

CAUTION!

Do not use aromatic hydrocarbons or chlorinated solvents on the front panel, because they will react with the Lexan binding posts.

$$I_x = I_r \times \frac{V_d}{V_{dfs}}$$

Where:

I_x = magnitude of unknown current in units of A90 "RANGE" used. (i.e. ma or amps).

I_r = A90 Rated Current "RANGE".

V_d = Voltmeter reading.

V_{dfs} = Nominal Voltmeter reading with rated current flowing in A90. "V_{dfs}" and "V_r" are tabulated in Table 6-7 for each voltmeter listed in Tables 6-2 through 6-6. Note that "V_{dfs}" multiplies or divides "V_d" by powers of 10 so it is simple to manipulate.

EQUATION 2. CONVERTING VOLTAGE READINGS TO CURRENT

Example: An 8100A reads =.0643 when used with an A90 in the 10 ma range. What current is flowing?

I_r = 10 ma (A90 "Rated Current Range")

V_d = .0643 (Voltmeter reading)

V_{dfs} = .1000 (From Table 6-7)

Answer: $I_x = 10 \text{ ma} \times \frac{.0643}{.1000} = 6.43 \text{ ma}$

Figure 6-6. Equation 2 – CONVERTING VOLTAGE READINGS TO CURRENT

6-29. Test Equipment

6-30. Test equipment required for calibration and testing of the Model A90 is shown in Table 6-8. If the recommended equipment is not available, other equivalent equipment may be used.

Table 6-8. LIST OF TEST EQUIPMENT

NAME	RECOMMENDED EQUIPMENT
Constant Current Source	Fluke Model 382A
DC Differential Voltmeter	Fluke Model 895A or 885A
Low-Thermal Leads	
4-Terminal Ohmmeter	Fluke Model 8300A with Option -02

6-31. Calibration

6-32. PRELIMINARY CHECKS. Make the resistance checks shown in Table 6-9. Values are approximate since check is intended to show only gross errors, such as defective or open resistors.

6-33. .1 MA AND 1 MA RANGE CHECKS. Connect the ohmmeter and A90, as shown in Figure 6-7, for 4-terminal resistance measurements, and perform the following steps:

a. Set the A90 to the .1 MA range. The ohmmeter should indicate between 1.00050 and 0.99950 kilohms. If the measured resistance is not within these limits, the .1 MA shunt, R6, is defective and must be replaced.

b. Set the A90 to the 1 MA range. The ohmmeter should indicate between 100.07 and 99.93 ohms. If the measured resistance is not within these limits, the 1 MA shunt, R5, is defective and must be replaced.

6-34. 10 MA, 100 MA, AND 1000 MA RANGE CHECKS. Connect the constant current generator, differential voltmeter, and A90 as shown in Figure 6-8 and perform the following steps:

a. Set the A90 to the 10 MA range.

b. Set the differential voltmeter controls as follows:

RANGE	1 Volt
NULL Sensitivity	100 μV
Readout Dials	0.100000

Table 6-9. RESISTANCE CHECKS

OHMMETER CONNECTIONS	MODEL A90	
	RANGE	APPROXIMATE RESISTANCE (OHMS)
INPUT Terminals	.1 MA	1000
	1 MA	100
	10 MA	10
	100 MA	1
	1000 MA	0.1
	10A	∞
INPUT (10A Terminals)	10A	0.01
OUTPUT Terminals	10A	0.01
	1000 MA	0.1
	100 MA	1
	10 MA	10
	1 MA	100
	.1 MA	1000

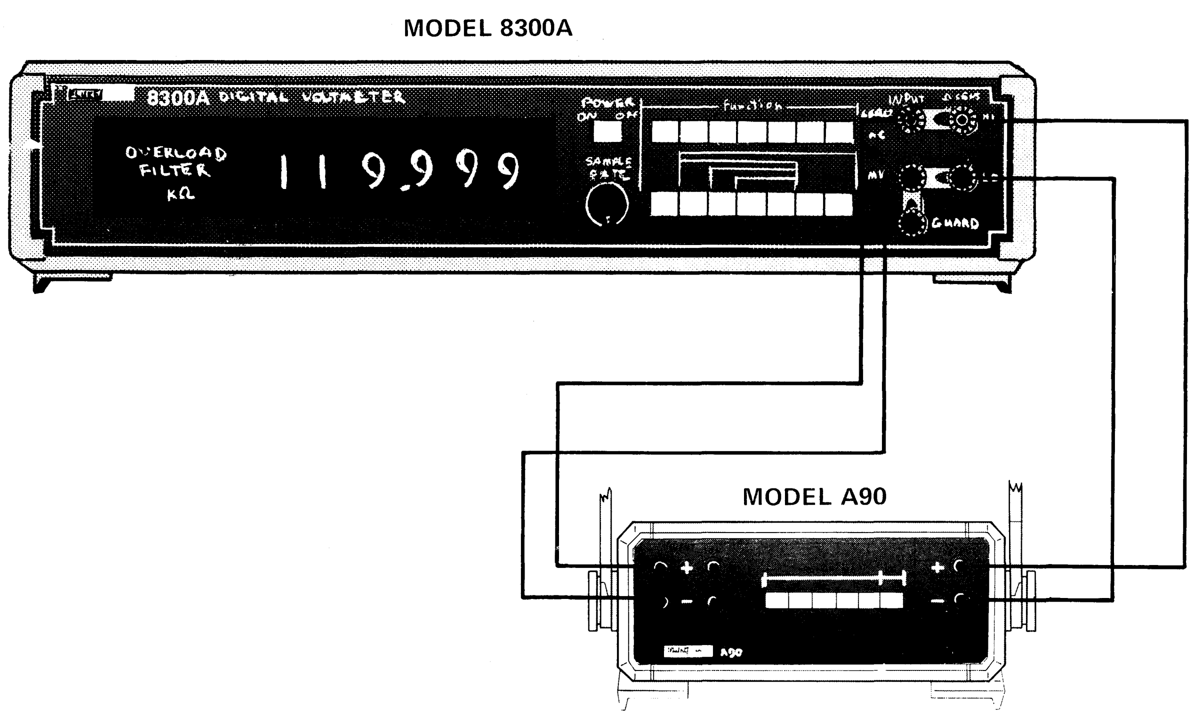


Figure 6-7. EQUIPMENT CONNECTIONS – .1 MA AND 1 MA RANGE CHECKS

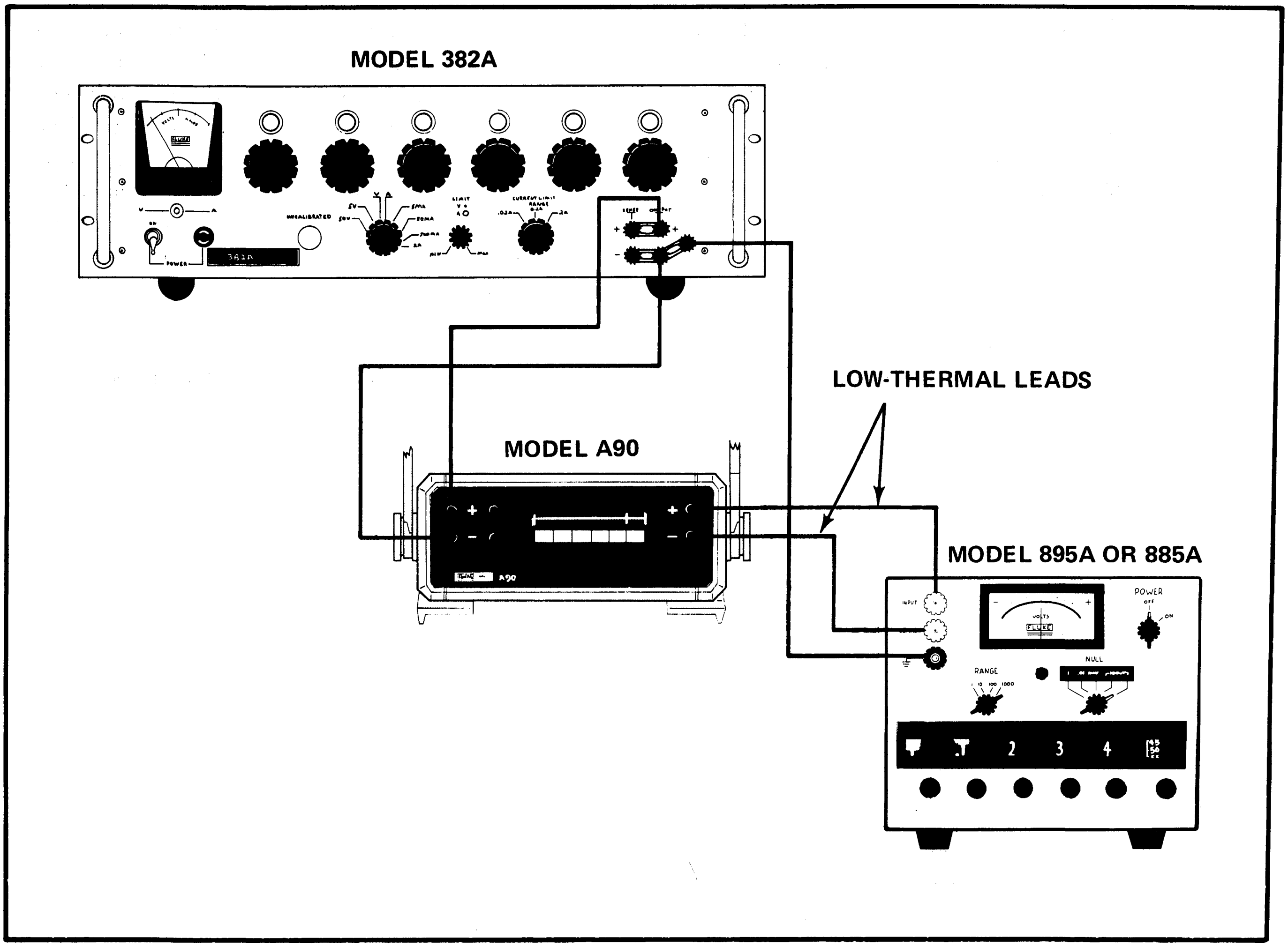


Figure 6-8. EQUIPMENT CONNECTIONS – 10 MA, 100 MA, AND 1000 MA RANGE CHECKS

c. Set the constant current generator for 10.0000 milliamperes output. The differential voltmeter should indicate null within ±80 micorvolts. If the voltmeter does not indicate within these limits, the 10 MA shunt, R4, is defective and must be replaced.

d. Change the A90 range to 100 MA and the constant current generator output to 100 milliamperes. The differential voltmeter should indicate null within ±80 microvolts. If the voltmeter does not indicate within these limits, the 100 MA shunt, R3, is defective and must be replaced.

e. Change the A90 range to 1000 MA and the constant current generator output to 1000 milliamperes. The differential voltmeter should indicate null within ±80 microvolts. If the +80 microvolt limit is not met, the 1000 MA shunt, R2, should be replaced. If the –80 microvolt limit is not met, R2 is low in ohmic value and can be trimmed to its desired value by carefully removing a small amount of material from the edge of the shunt using a whetstone.

6-35. 10 AMPERE RANGE CHECK. Connect equipment as shown in Figure 6-8, leaving the constant current generator temporarily disconnected from the A90, and perform the following steps:

a. Set the differnetial voltmeter controls as follows:

RANGE	1 Volt
NULL Sensitivity	100 μV
Readout Dials	0.00000

The voltmeter should indicate less than ±4 microvolts of thermal offset. If more than ±4 microvolts of offset is observed, check for cold solder joints or possible thermal generators in the test setup. When thermal offset has been reduced to within ±4 microvolts, proceed to step (b).

b. Connect the constant current generator to the 10 AMP binding posts of the A90 and set the A90 to the 10A range.

c. Set the differential voltmeter controls as follows:

RANGE	1 Volt
NULL Sensitivity	100 μV
Readout Dials	.020000

d. Set the constant current generator output to 2 amperes. The voltmeter should indicate null within ±80 microvolts. If the +80 microvolt limit is not met, the 10 ampere shunt, R1, should be replaced. If the −80 microvolt limit is not met, R1 is low in ohmic value and can be trimmed to its desired value by carefully removing a small amount of material from the edge of the shunt using a whetstone.

6-36. LIST OF REPLACEABLE PARTS

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		CURRENT SHUNT – Figure 6-9	A90					
		Shunt PCB Assembly (See Figure 6-9)	A90-403	89536	A90-403	1		
J1, J2, J5		Binding post, red, +	275552	89536	275552	3		
J3, J4, J6		Binding post, black –	275560	89536	275560	3		
		Cover, bottom	224360	89536	224360	1		
		Cover, top	224352	89536	224352	1		
		Foot	230037	89536	230337	4		
		Handle, carrying	231423	89536	231423	1		
		Panel, front	A90-208	89536	A90-208	1		
		Panel, rear	A90-209	89536	A90-209	1		

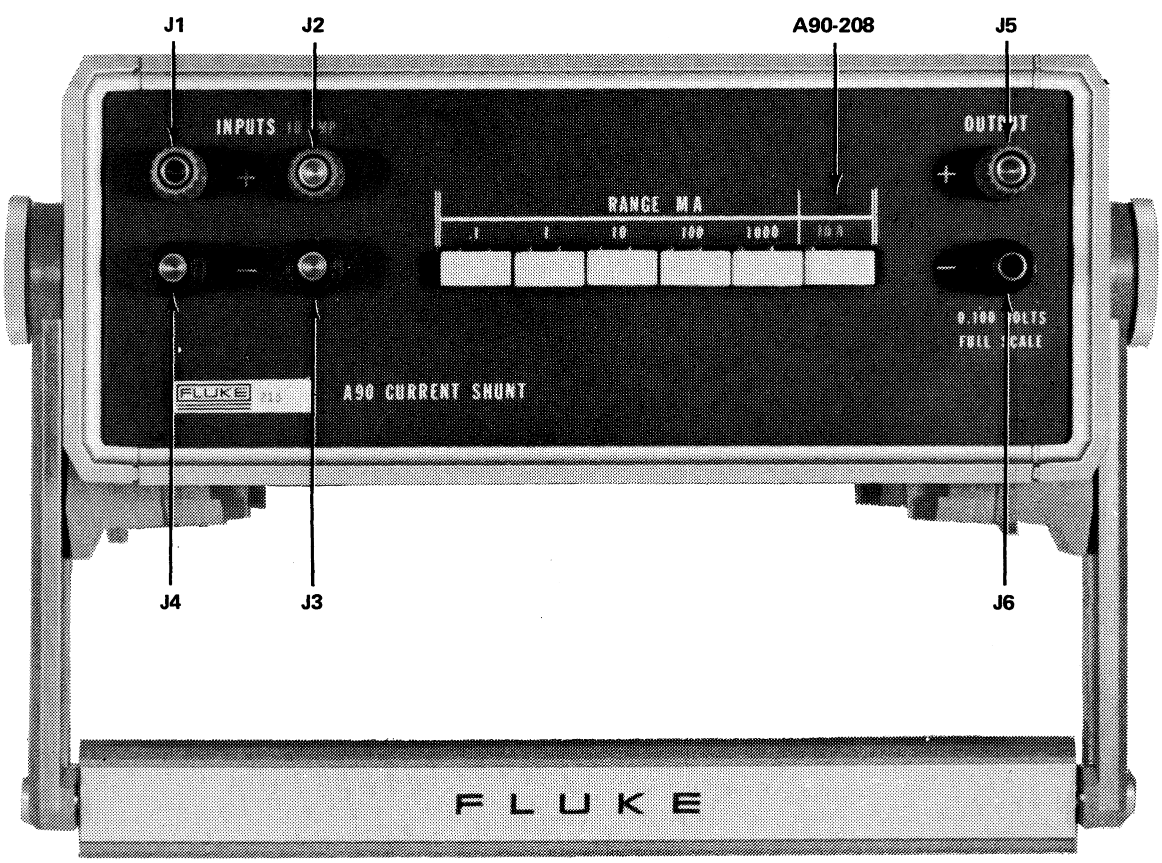


Figure 6-9. MODEL A90 CURRENT SHUNT (Sheet 1 of 2)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		SHUNT PCB ASSEMBLY – Figure 6-9	A90-403	89536	A90-403	REF		
R1		Res, ww, 0.010Ω ±0.2%, 1w	34-4022	89536	34-4022	1		
R2		Res, ww, 0.10Ω ±0.1%, 1w	224121	89536	224121	1		
R3		Res, ww, 1.0Ω ±0.1%, ½w	224089	89536	224089	1		
R4		Res, ww, 10Ω ±0.1%, ½w	224071	89536	224071	1		
R5		Res, ww, 100Ω ±0.03%, ½w	155846	89536	155846	1		
R6		Res, ww, 1 KΩ ±0.04%, ½w	131706	89536	131706	1		
S1 thru S6		Switch assembly, RANGE MA	A90-802	89536	A90-802	1		

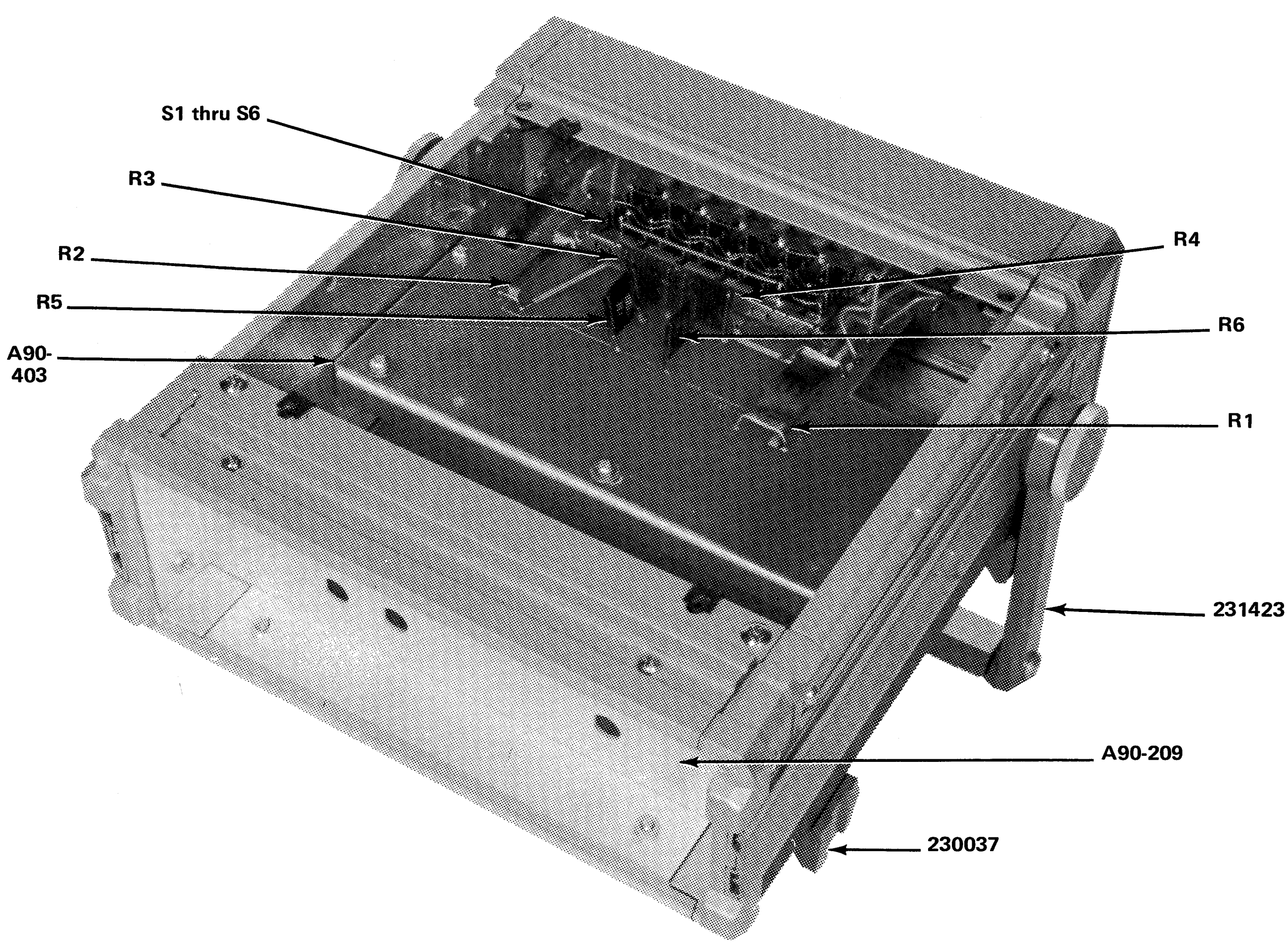
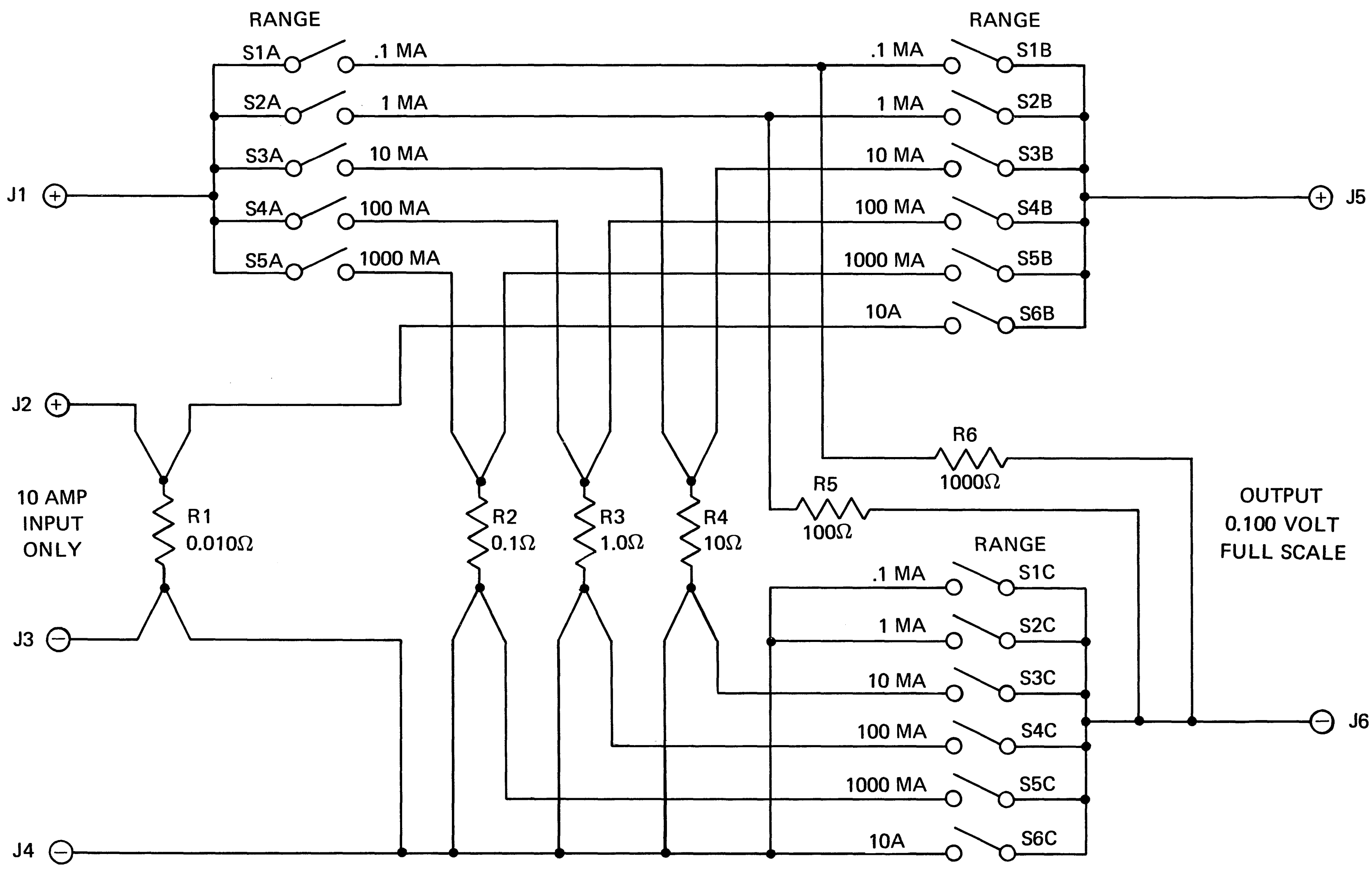


Figure 6-9. MODEL A90 CURRENT SHUNT (Sheet 2 of 2)



FUNCTIONAL SCHEMATIC DIAGRAM

MODEL A90

CURRENT SHUNT

SER. NO. 123 & ON

REV. a

FLUKE JOHN FLUKE MFG. CO., INC. P.O. Box 7428 Seattle, Washington 98133

Section 7
General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable parts contained in Section 5. The following information is presented in this section:

List of Abbreviations

Federal Supply Codes for Manufacturers

Fluke Technical Service Centers — U.S. and Canada

Sales and Service Locations — International

Sales Representatives — U.S. and Canada

List of Abbreviations and Symbols

A or amp	ampere
ac	alternating current
af	audio frequency
a/d	analog-to-digital
assy	assembly
AWG	american wire gauge
B	bel
bcd	binary coded decimal
^{o}C	Celsius
cap	capacitor
ccw	counterclockwise
cer	ceramic
cermet	ceramic to metal (seal)
ckt	circuit
cm	centimeter
cmrr	common mode rejection ratio
comp	composition
cont	continue
crt	cathode-ray tube
cw	clockwise
d/a	digital-to-analog
dac	digital-to-analog converter
dB	decibel
dc	direct current
dmm	digital multimeter
dvm	digital voltmeter
elect	electrolytic
ext	external
F	farad
^{o}F	Fahrenheit
FET	Field-effect transistor
ff	flip-flop
freq	frequency
FSN	federal stock number
g	gram
G	giga (10^{9})
gd	guard
Ge	germanium
GHz	gigahertz
gmv	guaranteed minimum value
gnd	ground
H	henry
hd	heavy duty
hf	high frequency
Hz	hertz
IC	integrated circuit
if	intermediate frequency
in	inch(es)
intl	internal
I/O	input/output
k	kilo (10^{3})
kHz	kilohertz
kΩ	kilohm(s)
kV	kilovolt(s)
lf	low frequency
LED	light-emitting diode
LSB	least significant bit
LSD	least significant digit
M	mega (10^{6})
m	milli (10^{-3})
mA	milliampere(s)
max	maximum
mf	metal film
MHz	megahertz
min	minimum
mm	millimeter
ms	millisecond
MSB	most significant bit
MSD	most significant digit
MTBF	mean time between failures
MTTR	mean time to repair
mV	millivolt(s)
mv	multivibrator
MΩ	megohm(s)
n	nano (10^{-9})
na	not applicable
NC	normally closed
(–) or neg	negative
NO	normally open
ns	nanosecond
opnl ampl	operational amplifier
p	pico (10^{-12})
para	paragraph
pcb	printed circuit board
pF	picofarad
pn	part number
(+) or pos	positive
pot	potentiometer
p-p	peak-to-peak
ppm	parts per million
PROM	programmable read-only memory
psi	pound-force per square inch
RAM	random-access memory
rf	radio frequency
rms	root mean square
ROM	read-only memory
s or sec	second (time)
scope	oscilloscope
SH	shield
Si	silicon
serno	serial number
sr	shift register
Ta	tantalum
tb	terminal board
tc	temperature coefficient or temperature compensating
tcxo	temperature compensated crystal oscillator
tp	test point
u or μ	micro (10^{-6})
uhf	ultra high frequency
us or μs	microsecond(s) (10^{-6})
uut	unit under test
V	volt
v	voltage
var	variable
vco	voltage controlled oscillator
vhf	very high frequency
vlf	very low frequency
W	watt(s)
ww	wire wound
xfmr	transformer
xstr	transistor
xtal	crystal
xtlo	crystal oscillator
Ω	ohm(s)
μ	micro (10^{-6})

Federal Supply Codes for Manufacturers (Continued)

00213
Nytronics Comp. Group Inc.
Subsidiary of Nytronics Inc.
Formerly Sage Electronics
Rochester, New York

00327
Welwyn International, Inc.
Westlake, Ohio

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors, Inc.
Passaic, New Jersey

00779
AMP Inc.
Harrisberg, Pennsylvania

01121
Allen-Bradley Co.
Milwaukee, Wisconsin

01281
TRW Electronic Comp.
Semiconductor Operations
Lawndale, California

01295
Texas Instruments, Inc.
Semiconductor Group
Dallas, Texas

01537
Motorola Communications &
Electronics Inc.
Franklin Park, Illinois

01686
RCL Electronics Inc.
Manchester, New Hampshire

01730
Replaced by 73586

01884 - use 56289
Sprague Electric Co.
Dearborn Electronic Div.
Lockwood, Florida

02114
Ferroxcube Corp.
Saugerties, New York

02131
General Instrument Corp.
Harris ASW Div.
Westwood, Maine

02395
Rason Mfg. Co.
Brooklyn, New York

02533
Snelgrove, C.R. Co., Ltd.
Don Mills, Ontario, Canada
M3B 1M2

02606
Fenwal Labs
Div. of Travenal Labs.
Morton Grove, Illinois

02660
Bunker Ramo Corp., Conn Div.
Formerly Amphenol-Borg
Electric Corp.
Broadview, Illinois

02799
Areo Capacitors, Inc.
Chatsworth, California

03508
General Electric Co.
Semiconductor Products
Syracuse, New York

03614
Replaced by 71400

03651
Replaced by 44655

03797
Eldema Div.
Genisco Technology Corp.
Compton, California

03877
Transistron Electronic Corp.
Wakefield, Massachusetts

03888
KDI Pyrofilm Corp.
Whippany, New Jersey

03911
Clairex Electronics Div.
Clairex Corp.
Mt. Vernon, New York

03980
Muirhead Inc.
Mountainside, New Jersey

04009
Arrow Hart Inc.
Hartford, Connecticut

04062
Replaced by 72136

04202
Replaced by 81312

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, California

04221
Aemco, Div. of
Midtex Inc.
Mankato, Minnesota

04222
AVX Ceramics Div.
AVX Corp.
Myrtle Beach, Florida

04423
Telonic Industries
Laguna Beach, California

04645
Replaced by 75376

04713
Motorola Inc. Semiconductor
Products
Phoenix, Arizona

04946
Standard Wire & Cable
Los Angeles, California

05082
Replaced by 94988

05236
Jonathan Mfg. Co.
Fullerton, California

05245
Components Corp. now
Corcom, Inc.
Chicago, Illinois

05277
Westinghouse Electric Corp.
Semiconductor Div.
Youngwood, Pennsylvania

05278
Replaced by 43543

05279
Southwest Machine &
Plastic Co.
Glendora, California

05397
Union Carbide Corp.
Materials Systems Div.
New York, New York

05571 - use 56289
Sprague Electric Co.
Pacific Div.
Los Angeles, California

05574
Viking Industries
Chatsworth, California

05704
Replaced by 16258

05820
Wakefield Engineering Inc.
Wakefield, Massachusetts

06001
General Electric Co.
Electronic Capacitor &
Battery Products Dept.
Columbia, South Carolina

06136
Replaced by 63743

06383
Panduit Corp.
Tinley Park, Illinois

06473
Bunker Ramo Corp.
Amphenol SAMS Div.
Chatsworth, California

06555
Beede Electrical Instrument Co.
Penacook, New Hampshire

06739
Electron Corp.
Littleton, Colorado

06743
Clevite Corp.
Cleveland, Ohio

06751
Components, Inc. Semcor Div.
Phoenix, Arizona

06860
Gould Automotive Div.
City of Industry, California

06961
Vernitron Corp., Piezo
Electric Div.
Formerly Clevite Corp., Piezo
Electric Div.
Bedford, Ohio

06980
Eimac Div.
Varian Associates
San Carlos, California

07047
Ross Milton, Co., The
South Hampton, Pennsylvania

07115
Replaced by 14674

07138
Westinghouse Electric Corp.,
Electronic Tube Division
Horsehead, New York

07233
TRW Electronic Components
Cinch Graphic
City of Industry, California

07256
Silicon Transistor Corp.
Div. of BBF Group Inc.
Chelmsford, MA

07261
Aumet Corp.
Culver City, California

07263
Fairchild Semiconductor
Div. of Fairchild Camera
& Instrument Corp.
Mountain View, California

07344
Bircher Co., Inc.
Rochester, New York

07597
Burndy Corp.
Tape/Cable Div.
Rochester, New York

07792
Lerma Engineering Corp.
Northampton, Massachusetts

07910
Teledyne Semiconductor
Formerly Continental Device
Hawthorne, California

07933 - use 49956
Raytheon Co.
Semiconductor Div. HQ
Mountain View, California

08225
Industro Transistor Corp.
Long Island City, New York

08261
Spectra Strip Corp.
Garden Grove, California

08530
Reliance Mica Corp.
Brooklyn, New York

08806
General Electric Co.
Miniature Lamp Products Dept.
Cleveland, Ohio

08863
Nylomatic Corp.
Norrisville, Pennsylvania

08988 - use 53085
Skottie Electronics Inc.
Archbald, Pennsylvania

09214
G.E. Co. Semi-Conductor
Products Dept.
Power Semi-Conductor
Products OPN Sec.
Auburn, New York

09353
C and K Components
Watertown, Massachusetts

09423
Scientific Components, Inc.
Santa Barbara, California

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, S. Dakota

10059
Barker Engineering Corp.
Formerly Amerace, Amerace
ESNA Corp.
Kenilworth, New Jersey

11236
CTS of Berne
Berne, Indiana

11237
CTS Keene Inc.
Paso Robles, California

11358
CBS Electronic Div.
Columbia Broadcasting System
Newburyport, MN

11403
Best Products Co.
Chicago, Illinois

11503
Keystone Columbia Inc.
Warren, Michigan

11532
Teledyne Relays
Hawthorne, California

Federal Supply Codes for Manufacturers (Continued)

11711
General Instrument Corp
Rectifier Division
Hickville, New York

11726
Qualidyne Corp.
Santa Clara, California

12014
Chicago Rivet & Machine Co.
Bellwood, Illinois

12040
National Semiconductor Corp.
Danburry, Connecticut

12060
Diodes, Inc.
Chatsworth, California

12136
Philadelphia Handle Co.
Camden, New Jersey

12300
Potter-Brumfield Division
AMF Canada LTD.
Guelph, Onatrio, Canada

12323
Presin Co., Inc.
Shelton, Connecticut

12327
Freeway Corp. formerly
Freeway Washer & Stamping Co.
Cleveland, Ohio

12443
Budd Co. The, Polychem Products
Plastic Products Div.
Bridgeport, PA

12615
U.S. Terminals Inc.
Cincinnati, Ohio

12617
Hamlin Inc.
Lake Mills, Wisconsin

12697
Clarostat Mfg. Co.
Dover, New Hampshire

12749
James Electronics
Chicago, Illinois

12856
Micrometals
Sierra Madre, California

12954
Dickson Electronics Corp.
Scottsdale, Arizona

12969
Unitrode Corp.
Watertown, Massachusetts

13103
Thermalloy Co., Inc.
Dallas, Texas

13327
Solitron Devices Inc.
Tappan, New York

13511
Amphenol Cadre Div.
Bunker-Ramo Corp.
Los Gatos, California

13606 - use 56289
Sprague Electric Co.
Transistor Div.
Concord, New Hampshire

13839
Replaced by 23732

14099
Semtech Corp.
Newbury Park, California

14140
Edison Electronic Div.
Mc Gray-Edison Co.
Manchester, New Hampshire

14193
Cal-R-Inc. formerly
California Resistor, Corp.
Santa Monica, California

14298
American Components, Inc.
an Insilco Co.
Conshohocken, Pennsylvania

14655
Cornell-Dublier Electronics
Division of Federal Pacific
Electric Co. Govt. Control Dept.
Newark, New Jersey

14752
Electro Cube Inc.
San Gabriel, California

14869
Replaced by 96853

14936
General Instrument Corp.
Semi Conductor Products Group
Hicksville, New York

15636
Elec-Trol Inc.
Saugus, California

15801
Fenwal Electronics Inc.
Div. of Kidde Walter and Co., Inc.
Framingham, Massachusetts

15818
Teledyne Semiconductors, formerly
Amelco Semiconductor
Mountain View, California

15849
Litton Systems Inc. Useco Div.
formerly Useco Inc.
Van Nuys, California

15898
International Business
Machines Corp.
Essex Junction, Vermont

15909
Replaced by 14140

16258
Space-Lok Inc.
Burbank, California

16299
Corning Glass
Electronic Components Div.
Raleigh, North Carolina

16332
Replaced by 28478

16473
Cambridge Scientific Ind.
Div. of Chemed Corporation
Cambridge, Maryland

16742
Paramount Plastics Fabricators, Inc.
Downey, California

16758
Delco Electronics
Div. of General Motors Corp.
Kokomo, Indiana

17001
Replaced by 71468

17069
Circuit Structures Lab.
Burbank, California

17338
High Pressure Eng. Co., Inc.
Oklahoma City, Oklahoma

17545
Atlantic Semiconductors, Inc.
Asbury Park, New Jersey

17856
Siliconix, Inc.
Santa Clara, California

17870
Replaced by 14140

18178
Vactec Inc.
Maryland Heights, Missouri

18324
Signetics Corp.
Sunnyvale, California

18612
Vishay Resistor Products Div.
Vishay Intertechnology Inc.
Malvern, Pennsylvania

18736
Voltronics Corp.
Hanover, New Jersey

18927
G T E Sylvania Inc.
Precision Material Group
Parts Division
Titusville, Pennsylvania

19451
Perine Machinery & Supply Co.
Seattle, Washington

19701
Electro-Midland Corp.
Mepco-Electra Inc.
Mineral Wells, Texas

20584
Enochs Mfg. Inc.
Indianapolis, Indiana

20891
Self-Organizing Systems, Inc.
Dallas, Texas

21604
Buckeye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Transistor Division
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23050
Product Comp. Corp.
Mount Vernon, New York

23732
Tracor Inc.
Rockville, Maryland

23880
Stanford Applied Engrng.
Santa Clara, California

23936
Pamotor Div., Wm. J. Purdy Co.
Burlingame, California

24248
Replaced by 94222

24355
Analog Devices Inc.
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

24759
Lenox-Fugle Electronics Inc.
South Plainfield, New Jersey

25088
Siemen Corp.
Isilen, New Jersey

25403
Amperex Electronic Corp.
Semiconductor &
Micro-Circuits Div.
Slatersville, Rhode Island

27014
National Semiconductor Corp.
Santa Clara, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg. Co.
Consumer Products Div.
St. Paul, Minnesota

28425
Serv-/-Link formerly
Bohannan Industries
Fort Worth, Texas

28478
Deltrol Controls Div.
Deltrol Corporation
Milwaukee, Wisconsin

28480
Hewlett Packard Co. Corporate H.Q.
Palo Alto, California

28520
Heyman Mfg. Co.
Kenilworth, New Jersey

29083
Monsanto, Co., Inc.
Santa Clara, California

29604
Stackpole Components Co.
Raleigh, North Carolina

30148
A B Enterprise Inc.
Ahoskie, North Carolina

30323
Illinois Tool Works, Inc.
Chicago, Illinois

31091
Optimax Inc.
Colmar, Pennsylvania

32539
Mura Corp.
Great Neck, New York

32767
Griffith Plastic Corp.
Burlingame, California

32879
Advanced Mechanical Components
Northridge, California

32897
Erie Technological Products, Inc.
Frequency Control Div.
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Products Division
Riverside, California

33173
General Electric Co.
Products Dept.
Owensboro, Kentucky

Federal Supply Codes for Manufacturers (Continued)

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc.
Kenilworth, New Jersey

37942
Mallory, P.R. & Co., Inc.
Indianapolis, Indiana

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc.
Transformer Co. Div.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc.
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co.
Springfield, Illinois

54294
Cutler-Hammer Inc. formerly
Shallcross, A Cutter-Hammer Co.
Selma, North Carolina

55026
Simpson Electric Co.
Div. of Am. Gage and Mach. Co.
Elgin, Illinois

56289
Sprague Electric Co.
North Adams, Massachusetts

58474
Superior Electric Co.
Bristol, Connecticut

60399
Torin Corp, formerly
Torrington Mfg. Co.
Torrington, Connecticut

63743
Ward Leonard Electric Co., Inc.
Mount Vernon, New York

64834
West Mfg. Co.
San Francisco, Californai

65092
Weston Instruments Inc.
Newark, New Jersey

66150
Winslow Tele-Tronics Inc.
Eaton Town, New Jersey

70485
Atlantic India Rubber Works
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71002
Birnbach Radio Co., Inc.
Freeport, LI New York

71400
Bussmann Mfg.
Div. of McGraw-Edison Co.
Saint Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

71482
Clare, C.P. & Co.
Chicago, Illinois

71590
Centrelab Electronics
Div. of Globe Union Inc.
Milwaukee, Wisconsin

71707
Coto Coil Co., Inc.
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Cinch Connector Operations Div.
Elk Grove Village, Chicago, Illinois

72005
Driver, Wilber B., Co.
Newark, New Jersey

72092
Replaced by 06980

72136
Electro Motive Mfg. Co.
Williamantic, Connecticut

72259
Nytronics Inc.
Pelham Manor, New Jersey

72619
Dialight Div.
Amperex Electronic Corp.
Brooklyn, New York

72653
G.C. Electronics
Div. of Hydrometals, Inc.
Brooklyn, New York

72665
Replaced by 90303

72794
Dzus Fastener Co., Inc.
West Islip, New York

72928
Gulton Ind. Inc.
Gudeman Div.
Chicago, Illinois

72982
Erie Tech. Products Inc.
Erie, Pennsylvania

73138
Beckman Instruments Inc.
Helipot Division
Fullerton, California

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrence, California

73445
Amperex Electronic Corp.
Hicksville, LI, New York

73559
Carling Electric Inc.
West Hartford, Connecticut

73586
Circle F Industries
Trenton, New Jersey

73734
Federal Screw Products, Inc.
Chicago, Illinois

73743
Fischer Special Mfg. Co.
Cincinnati, Ohio

73899
JFD Electronics Co.
Components Corp
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74199
Quan Nichols Co.
Chicago, Illinois

74217
Radio Switch Corp.
Marlboro, New Jersey

74276
Signalite Div.
General Instrument Corp.
Neptune, New Jersey

74306
Piezo Crystal Co.
Carlisle, Pennsylvania

74542
Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970
Johnson E.F., Co.
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75376
Kurz-Kasch Inc.
Dayton, Ohio

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76854
Oak Industries Inc.
Switch Div.
Crystal Lake, Illinois

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, Indiana

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

77969
Rubbercraft Corp. of CA. LTD.
Torrance, California

78189
Shakeproof
Div. of Illinois Tool Works Inc.
Elgin, Illinois

78277
Sigma Instruments, Inc.
South Braintree, Massachusetts

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp. Engineered
Fastener Div.
Tinnerman Plant
Cleveland, Ohio

79136
Waldes Kohinoor Inc.
Long Island City, New York

79497
Western Rubber Company
Goshen, Indiana

79963
Zierick Mfg. Corp.
Mt. Kisko, New York

80031
Electro-Midland Corp., Mepco Div.
A North American Phillips Co.
Morristown, New Jersey

80145
LFE Corp., Process Control Div.
formerly API Instrument Co.
Chesterland, Ohio

80183 - use 56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

80583
Hammarlund Mfg. Co., Inc.
Red Bank, New Jersey

80640
Stevens, Arnold Inc.
South Boston, Massachusetts

81073
Grayhill, Inc.
La Grange, Illinois

81312
Winchester Electronics
Div. of Litton Industries Inc.
Oakville, Connecticut

81439
Therm-O-Disc Inc.
Mansfield, Ohio

81483
International Rectifier Corp.
Los Angeles, California

81590
Korry Mfg. Co.
Seattle, Washington

81741
Chicago Lock Co.
Chicago, Illinois

82305
Palmer Electronics Corp.
South Gate, California

82389
Switchcraft Inc.
Chicago, Illinois

Federal Supply Codes for Manufacturers (Concluded)

82415
North American Phillips
Controls Corp.
Frederick, Maryland

82872
Roanwell Corp.
New York, New York

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83058
Carr Co., The United Can Div.
of TRW
Cambridge, Massachusetts

83298
Bendix Corp.
Electric Power Division
Eatontown, New Jersey

83330
Smith, Herman H., Inc.
Brooklyn, New York

83478
Rubbercraft Corp. of America, Inc.
West Haven, Connecticut

83594
Burroughs Corp.
Electronic Components Div.
Plainfield, New Jersey

83740
Union Carbide Corp.
Battery Products Div.
formerly Consumer Products Div.
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
TRW Capacitors
Ogallala, Nebraska

84613
Fuse Indicator Corp.
Rockville, Maryland

84682
Essex International Inc.
Industrial Wire Div.
Peabody, Massachusetts

86577
Precision Metal Products,
of Malden Inc.
Stoneham, Massachusetts

86684
Radio Corp. of America
Electronic Components Div.
Harrison, New Jersey

86928
Seastrom Mfg. Co., Inc.
Glendale, California

87034
Illuminated Products Inc.
Subsidiary of Oak Industries Inc.
Anahiem, California

88219
Gould Inc.
Industrial Div.
Trenton, New Jersey

88245
Litton Systems Inc.
Useco Div.
Van Nuys, California

88419
Cornell-Dubilier Electronic Div.
Federal Pacific Co.
Fuquay-Varian, North Carolina

88486
Plastic Wire & Cable
Jewitt City, Connecticut

88690
Replaced by 04217

89536
Fluke, John Mfg. Co., Inc.
Seattle, Washington

89730
G.E. Co., Newark Lamp Works
Newark, New Jersey

90201
Mallory Capacitor Co. Div of
P.R. Mallory Co., Inc.
Indianapolis, Indiana

90211 - use 56365
Square D Co.
Chicago, Illinois

90215
Best Stamp & Mfg. Co.
Kansas City, Missouri

90303
Mallory Battery Co.
Div. of Mallory Co., Inc.
Tarrytown, New York

91094
Essex International Inc.
Suglex/IWP Div.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91407
Replaced by 58474

91502
Associated Machine
Santa Clara, California

91506
Augat Inc.
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

91737 - use 71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91836
King's Electronics Co., Inc.
Tuckahoe, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934
Miller Electric Co., Inc.
Div of Aunet
Woonsocket, Rhode Island

92194
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, Massachusetts

94145
Replaced by 49956

94154 - use 94988
Wagner Electric Corp.
Tung-Sol Div.
Newark, New Jersey

94222
Southco Inc. formerly
South Chester Corp.
Lester, Pennsylvania

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

95263
Leecraft Mfg. Co.
Long Island City, New York

95264
Replaced by 98278

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, Ohio

95348
Gordo's Corp.
Bloomfield, New Jersey

95354
Methode Mfg. Corp.
Rolling Meadows, Illinois

95712
Bendix Corp.
Electrical Components Div.
Microwave Devices Plant
Franklin, Indiana

95987
Weckesser Co. Inc.
Chicago, Illinois

96733
San Fernando Electric Mfg. Co.
San Fernando, California

96853
Gulton Industries Inc.
Measurement and Controls Div.
formerly Rustrak Instruments Co.
Manchester, New Hampshire

96881
Thomson Industries, Inc.
Manhasset, New York

97540
Master Mobile Mounts
Div. of Whitehall Electronics Corp.
Ft. Meyers, Florida

97913
Industrial Electronic Hdware Corp.
New York, New York

97945
Penwalt Corp.
SS White Industrial Products Div.
Piscataway, New Jersey

97966
Replaced by 11358

98094
Replaced by 49956

98159
Rubber-Teck, Inc.
Gardena, California

98278
Malco A Microdot Co., Inc.
Connector & Cable Div.
Pasadena, California

98291
Sealectro Corp.
Mamaroneck, New York

98388
Royal Industries
Products Div.
San Diego, California

98743
Replaced by 12749

98925
Replaced by 14433

99120
Plastic Capacitors, Inc.
Chicago, Illinois

99217
Bell Industries Elect. Comp. Div.
formerly Southern Elect. Div.
Burbank, California

99392
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Div. of ITT Jennings formerly
Marshall Industries Capacitor Div.
Monrovia, California

99779 - use 29587
Bunker-Ramo Corp.
Barnes Div.
Landsdowne, Pennsylvania

99800
American Precision Industries Inc.
Delevan Division
East Aurora, New York

99942
Centrelab Semiconductor
Centrelab Electronics Div. of
Globe-Union Inc.
El Monte, California

Toyo Electronics
(R-Ohm Corp.)
Irvine, California

National Connector
Minneapolis, Minnesota

Fluke Technical Service Centers — U.S. and Canada

United States

CALIFORNIA
Burbank
Fluke Technical Center
2020 N. Lincoln St.
Zip: 91504
Tel. (213) 849-4641

Santa Clara
Fluke Technical Center
2300 Walsh Avenue
Zip: 95050
Tel. (408) 985-1200

COLORADO
Denver
Fluke Technical Center
1980 S. Quebec St.
Unit 4
Zip: 80231
Tel. (303) 750-1228

FLORIDA
Orlando
Fluke Technical Center
940 N. Fern Creek Ave.
Zip: 32803
Tel. (305) 896-2296

ILLINOIS
Rolling Meadows
Fluke Technical Center
1400 Hicks Road
Zip: 60008
Tel. (312) 398-5800

MARYLAND
Kensington
Fluke Technical Center
11501 Huff Court
Zip: 20795
Tel. (301) 881-6155

MASSACHUSETTS
Waltham
Fluke Technical Center
244 Second Ave.
Zip: 02154
Tel. (617) 890-1604

MINNESOTA
Minneapolis
Fluke Technical Center
10800 Lyndale Ave. So.
Zip: 55420
Tel. (612) 884-4541

NEW JERSEY
Clifton
Fluke Technical Center
460 Colfax Ave.
Zip: 07013
Tel. (201) 778-1339

NORTH CAROLINA
Greensboro
Fluke Technical Center
1310 Beaman Place
Zip: 27408
Tel. (919) 273-1918

TEXAS
Dallas
Fluke Technical Center
14400 Midway Road
Zip: 75240
Tel. (214) 233-9945

WASHINGTON
Mountlake Terrace
John Fluke Mfg. Co., Inc.
21707 66th Ave. W. Suite 1
Zip: 98043
Tel. (206) 774-2206

Canada

ALBERTA
Calgary
Allan Crawford Assoc. Ltd.
Fluke Technical Center
14-2280 39th N.E.
Zip: T2E 6P7
Tel. (403) 276-9658

ONTARIO
Mississauga
Allan Crawford Assoc. Ltd.
Fluke Technical Center
6503 Northam Drive
Zip: L4V 1J5
Tel. (416) 678-1500

QUEBEC
Longueuil
Allan Crawford Assoc. Ltd.
Fluke Technical Center
1330 Marie Victorin Blvd. E.
Zip: J4G 1A2
Tel. (514) 670-1212

Sales and Service Locations — International

Supplied and supported by Fluke (Nederland) B.V., P.O. Box 5053, Zevenheuvelenweg 53, Tilburg, Netherlands.

EUROPE

AUSTRIA
*Walter Rekirsch Elektronische
Gerate GmbH & Co. Vertrieb KG.
Liechtensteinstrasse 97/6
A-1090 Vienna, Austria
Tel. (222) 347646-0

BELGIUM
*C. N. Rood S/A
37 Place de Jamblinne de Meux
B-1040 Brussels, Belgium
Tel. (02) 27352135

CYPRUS
Chris Radiovision Ltd.
P.O. Box 1989
Nicosia, Cyprus
Tel. 66121

DENMARK
*Tage Olsen A/S
Ballerup Byveg 222
DK-2750 Ballerup
Tel. (01) 2-65 81 11

FINLAND
*Oy Findip AB
Teollisuustie 7
02700 Kauniainen
Helsinki, Finland
Tel. (080) 502255

FRANCE
*M. B. Electronique S.A.
Rue Fourney
ZAC de BUC
B. P. No. 31
78530 BUC, France
Tel. (01) 9563130

GERMAN FEDERAL REPUBLIC
*Fluke (Deutschland) GmbH
4-Dusseldorf
Meineckestrasse 53
West Germany
Tel. 211-450831

*Fluke (Deutschland) GmbH
8000 Munich 80
Vertriesburo Bayern
Rosenheimer Strasse 139
West Germany
Tel. 089-404061

GREECE
*Hellenic Scientific
Representations Ltd.
11 Vrassida Street
Athens 612, Greece
Tel. (021) 7792320

ITALY
*Sistrel S.p.A.
Via Giuseppe Armellini No. 39
00143 Rome, Italy
Tel. (06) 5915551

*Sistrel S.p.A.
Via Timavo 66
20099 Sesto S. Giovanni (Milan)
Italy
Tel. (02) 2476693

NETHERLANDS
*C.N. Rood, B.V.
Cort van der Lindenstraat 11-13
Rijswijk ZH2280AA
Netherlands
Tel. (070) 996360

NORWAY
*Morgenstierne & Co. A/A
Konghellegate 3
P.O. Box 6688, Rodelokka
Oslo 5, Norway
Tel. (02) 356110

PORTUGAL
*Equipamentos
De Laboratorio Ltda.
P.O. Box 1100
Lisbon 1, Portugal
Tel. (019) 976551

SPAIN
*Hispano Electronica S.A.
Poligono Industrial Urtinsa
Apartado de Correos 48
Alcorcon (Madrid), Spain
Tel. 09-341-6194108

SWEDEN
*Teleinstrument AB
P.O. Box 490
S-162 Vallingby-4
Sweden
Tel. (08) 380370

SWITZERLAND
*Traco Electronic AG
Jenatschstrasse 1
8002 Zurich, Switzerland
Tel. (01) 2010711

TURKEY
*Erkman Electronik Aletler
Necatibey Cad 92/2
Karakoy/Istanbul
Turkey
Tel. 441546

UNITED KINGDOM
*Fluke International Corp.
Colonial Way
Watford Herts WD2 4TT, England
Tel. (0923) 40511

MIDDLE EAST

EGYPT
Lotus Engineering Organisation
P.O. Box 1252
Cairo, Egypt
Tel. 71617

IRAN
*Irantronics Company Ltd.
20 Salm Road, Roosevelt Ave.
Tehran, Iran
Tel. 828294

ISRAEL
*R.D.T. Electronics
Engineering Ltd.
46, Sokolov Street
Ramat Hasharon 47235, Israel
Tel. 482311

JORDAN
Trading & Agricultural
Development Co.
P.O. Box 567
Amman, Jordan
Tel. 23052

KUWAIT
Tareq Company
P.O. Box Safat 20506
Kuwait, Arabian Gulf
Tel. 436100

LEBANON
Mabek
P.O. Box 11-3823
Beirut, Lebanon
Tel. 252631

MOROCCO
Mainvest
Residence Moulay Ismail
Bat.C Boulevard
Moulay Slimane, Rabat, Morocco
Tel. 276-64

SAUDI ARABIA
Electronic Equipment
Marketing Est.
P.O. Box 3750
Riyadh, Saudi Arabia
Tel. 32700

SYRIA
Mabek Electronics
C/O Messers G. Ghazzi
P.O. Box 4238
Damascus, Syria

Customers in the following countries: Bulgaria, Czechoslovakia, Hungary, Poland, Romania, U.S.S.R. and Yugoslavia. Contact: Amtest Associates Ltd., P.O. Box 55, Addlestone, Surrey, KT 15 1DU, England, Tel. (0932) 52121

***Technical Service Available**

Sales and Service Locations — International (Concluded)

Supplied and supported by Fluke International Corporation, P.o. Box 43210, Mountlake Terrace, WA 98043

ARGENTINA
*Coasin S.A.
Virrey del Pino 4071
Buenos Aires, Argentina
Tel. 523185

AUSTRALIA
*Elmeasco Instruments Pty. Ltd.
P.O. Box 30
Concord, N.S.W.
Australia 2137
Tel. (02) 736-2888

Elmeasco Instruments Pty. Ltd.
P.O. Box 107
Mt. Waverly, VIC 3149
Australia
Tel. 233-4044

BANGLADESH
Kabir Brothers Ltd.
97 - Gulshan Ave., Gulshan
G.P.O. Box 693
Dacca-12, Bangladesh
Tel. 303104

BOLIVIA
Coasin Bolivia S.R.L.
Casilla 7295
La Paz, Bolivia
Tel. 40962

BRAZIL
*Arotec S.A.
Industrial e Comercio
Av. Pacaembu 811
Sao Paulo S.P., Brazil
Tel. (67) 2393

*Arotec S.A.
Av. Rio Branco, 277
Grupo 1309
Rio de Janeiro - R. J., Brazil

CHILE
*Intronica Chile Ltda.
Casilla 16228
Manuel Montt 024-Of. D
Santiago 9, Chile
Tel. 44940

COLOMBIA
Coasin Ltda.
Carrera 13, No. 37-37, Of. 407
Ap. Aereo 29583
Bogota DE, Colombia
Tel. 285-0230

ECUADOR
*Proteco Coasin CIA, Ltda.
Edifica "Jerico"
Ave. 12 de Octubre
No. 2285 y Ave. Orellana
(Planta Baja)
Quito, Ecuador
Tel. 529-684

HONG KONG
*Gilman & Co., Ltd.
P.O. Box 56
Hong Kong
Tel. 794266

ICELAND
Kristjan O. Skagfjord Ltd.
P.O. Box 906
Reykjavik, Iceland
Tel. 24120

INDIA
*Hinditron Services Pvt. Ltd.
69/A.L. Jagmohandas Marg
Bombay 400 006, India
Tel. 365344

*Hinditron Services Pvt. Ltd.
412 Raj Mahal Vilas Extn.
Bangalore 560 006, India
Tel. 33139

INDONESIA
*P.T. DWI Tunggal Jaya Sakti
Sangga Buana Bldg., 1st Floor
J1 Senen Raya 44, P.O. Box 4435
Jakarta, Indonesia
Tel. 367390

P.T. DWI Tunggal Jaya Sakti
Jalan Sasakgantung 45
Bandung, Indonesia

JAPAN
Panetron Division
Tokyo Electron Ltd.
1 Higashikata-machi
Midori-ku
Yokohama 226, Japan
Tel. (045) 471-8811

*John Fluke Mfg. Co., Inc.
1 Higashikata-machi
Midori-ku
Yokohama 226, Japan
Tel. (045) 473-5425
Tlx: 3823-666 FLUKJP J

KENYA
Adcom Limited Inc.
P.O. Box 30070
Nairobi, Kenya
East Africa
Tel. 331955

KOREA
*Electro-Science Korea Co.
C.P.O. Box 8446
Rm. 1201 Bowon Bldg.
490 Chongro-5Ka
Chongro-ku
Seoul, Korea
Tel. 261-7702

MALAYSIA
O'Connor's (Pte) Ltd.
P.O. Box 1197
Kota Kinabalu, Sabah
East Malaysia
Tel. 54082

O'Connor's (Pte) Ltd.
P.O. Box 91
Petaling Jaya, Selangor
West Malaysia
Tel. 51563

MEXICO
*C.J. Christensen S.A. de C.V.
Instrumentos Electronicos
de Medicion
Melchor Ocampo 150-8
Mexico 4, D.F., Mexico
Tel. (905) 535-2258

NEW ZEALAND
*W & K McLean Ltd.
P.O. Box 3097
Auckland, New Zealand
Tel. 587-037

NIGERIA
Mofat Engineering Co., Ltd.
P.O. Box 6369
Lagos, Nigeria

PAKISTAN
Pak International Operations
505 Muhammadi House
McLeod Road
P.O. Box 5323
Karachi, Pakistan
Tel. 221127

PERU
*Importaciones
y Representaciones
Electronicas S.A.
Avda, Franklin D. Roosevelt 105
Lima 1, Peru
Tel. 288650

SINGAPORE
*O'Connor's (Pte) Ltd.
98 Pasir Panjang Road
Singapore 5, Singapore
Tel. 637944

SOUTH AFRICA
*Fluke S.A. (Pty) Ltd.
P.O. Box 39797
Bramley 2018
Republic of South Africa
Tel. (011) 786-3170

TAIWAN
CCT Associates, Inc.
P.O. Box 24209
Taipei, Taiwan
Republic of China
Tel. (02) 391-6894

THAILAND
Dynamic Supply
Engineering R.O.P.
No. 56 Ekamai, Sukhumvit 63
Bankok 11, Thailand
Tel. 914434

URUGUAY
Coasin Uruguaya S.R.L.
Cerrito 617-4° Piso
Montevideo, Uruguay
Tel. 917978

VENEZUELA
*Coasin C.A.
APDO Postal 50939
Sabana Grande No. 1
Caracas 105, Venezuela
Tel. 782-9109

***Technical Service Available**

Sales Offices — U.S. and Canada

John Fluke Mfg. Co., Inc.
P.O. Box 43210, Mountlake Terrace, WA 98043
Tel. (206) 774-2211 Toll Free: (800) 426-0361 TWX: 910-449-2850 TLX: 32-0013 Cable: Fluke

United States

AK, Anchorage
Harry Lang & Associates
1406 W. 47th Ave.
Anchorage, AK 99503
(907) 279-5741

AL, Huntsville
John Fluke Mfg. Co., Inc.
3322 S.Memorial Parkway
Huntsville, AL 35807
(205) 881-6220

AZ, Phoenix
John Fluke Mfg. Co., Inc.
7319 E. Stetson Drive
Scottsdale, AZ 85251
(602) 994-3883

CA, Burbank
John Fluke Mfg. Co., Inc.
2020 N. Lincoln Blvd.
Burbank, CA 91504
(213) 849-7181

CA, Santa Clara
John Fluke Mfg. Co., Inc.
2300 Walsh Ave.
Santa Clara, CA 95050
(408) 244-1505

CA, Tustin
John Fluke Mfg. Co., Inc.
15441 Red Hill Ave, Unit B
Tustin, CA 92680
(714) 752-6200

CO, Denver
Barnhill Three, Inc.
1980 S. Quebec St., Unit 4
Denver, CO 80231
(303) 750-1222

CT, Hartford
John Fluke Mfg. Co., Inc.
124 Hebron Ave.
Glastonbury, CT 06033
(203) 633-0777

FL, Orlando
John Fluke Mfg. Co., Inc.
940 N. Fern Creek Ave.
Orlando, FL 32803
(305) 896-4881

HI, Honolulu
EMC Corporation
2979 Ualena St.
Honolulu, HI 96819
(808) 847-1138

IL, Chicago
John Fluke Mfg. Co., Inc.
1400 Hicks Road
Rolling Meadows, IL 60008
(312) 398-0850

IN, Indianapolis
John Fluke Mfg. Co., Inc.
5610 Crawfordsville Rd.
Suite 802
Indianapolis, IN 46224
(317) 244-2456

MA, Waltham
John Fluke Mfg. Co., Inc.
244 Second Avenue
Waltham, MA 02154
(617) 890-1600

MD, Baltimore
John Fluke Mfg. Co., Inc.
11501 Huff Court
Kensington, MD 20795
(301) 881-3370
(301) 792-7060 (Baltimore)

MI, Detroit
John Fluke Mfg. Co., Inc.,
13955 Farmington Rd.
Livonia, MI 48154
(313) 522-9140

MN, Minneapolis
John Fluke Mfg. Co., Inc.
10800 Lyndale Ave. S.
Minneapolis, MN 55420
(612) 884-4336

MO, Kansas City
John Fluke Mfg. Co., Inc.
4406 Chouteau Traffic Way
Kansas City, MO 64117
(816) 454-5836

MO, St. Louis
John Fluke Mfg. Co., Inc.
300 Brooks Dr., Suite 100
Hazelwood, MO 63042
(314) 731-3388

NC,, Greensboro
John Fluke Mfg. Co., Inc.
1310 Beaman Place
Greensboro, NC 27408
(919) 273-1918

NJ, Clifton
John Fluke Mfg. Co., Inc.
460 Colfax Avenue
Clifton, NJ 07013
(201) 778-4040
(516) 935-6672 (Long Island)

NM, Albuquerque
Barnhill Three, Inc.
1410 D Wyoming N.E.
Albuquerque, NM 87112
(505) 299-7658

NY, Rochester
John Fluke Mfg. Co., Inc.
4515 Culver Road
Rochester, NY 14622
(716) 266-1400

OH, Cleveland
John Fluke Mfg. Co., Inc.
7830 Freeway Circle
Middleburg Heights, OH 44130
(216) 234-4540

OH, Dayton
John Fluke Mfg. Co., Inc.
4756 Fishburg Rd.
Dayton. OH 45424
(513) 233-2238

PA, Philadelphia
John Fluke Mfg. Co., Inc.
1010 West 8th Ave., Suite H
King of Prussia, PA 19406
(215) 265-4040

TX, Austin
John Fluke Mfg. Co., Inc.
111 W. Anderson Lane
Suite 213
Austin ,TX 78752
(512) 458-6279

TX, Dallas
John Fluke Mfg. Co., Inc.
14400 Midway Road
Dallas, TX 75240
(214) 233-9990

TX, Houston
John Fluke Mfg. Co., Inc.
1014 Wirt Road, Suite 270
Houston, TX 77055
(713) 683-7913
(512) 222-2726 (San Antonio)

UT, Salt Lake City
Barnhill Three, Inc.
54 West 2100 South
Suite 3
Salt Lake City, UT 84115
(801) 484-4496

WA, Seattle
John Fluke Mfg. Co., Inc.
691 Strander Blvd.
Seattle, WA 98168
(206) 575-3765

Canada

ALB, Calgary
Allan Crawford Assoc., Ltd.
2280 - 39th N.E.
Calgary, ALB T2E 6P7
(403) 276-9658

BC, North Vancouver
Allan Crawford Assoc., Ltd.
3795 William Street
Burnaby, BC Y5C 3H3
(604) 294-1326

NS, Halifax
Allan Crawford Assoc., Ltd.
Suite 201, Townsend Pl.
800 Windmill Road
Burnside Industrial Park
Dartmouth, NS B3B 1L1
(902) 469-7865

ONT, Ottawa
Allan Crawford Assoc., Ltd.
1299 Richmond Road
Ottawa, ONT K2B 7Y4
(613) 829-9651

ONT, Toronto
Allan Crawford Assoc., Ltd.
6503 Northam Drive
Mississauga, ONT L4V 1J5
(416) 678-1500

QUE, Montreal
Allan Crawford Assoc., Ltd.
1330 Marie Victorin Blvd. E.
Longueuil, QUE J4G 1A2
(514) 670-1212

For Canadian areas not listed, contact the office nearest you or Allan Crawford Assoc. Ltd., Mississauga (Toronto), Ontario.

For more information on Fluke products or Sales Offices you may dial (800) 426-0361 toll free in most of U.S. From Alaska, Hawaii, Washington, or Canada phone (206) 774-2481. From other countries phone (206) 774-2398.

Section 8
Schematic Diagrams

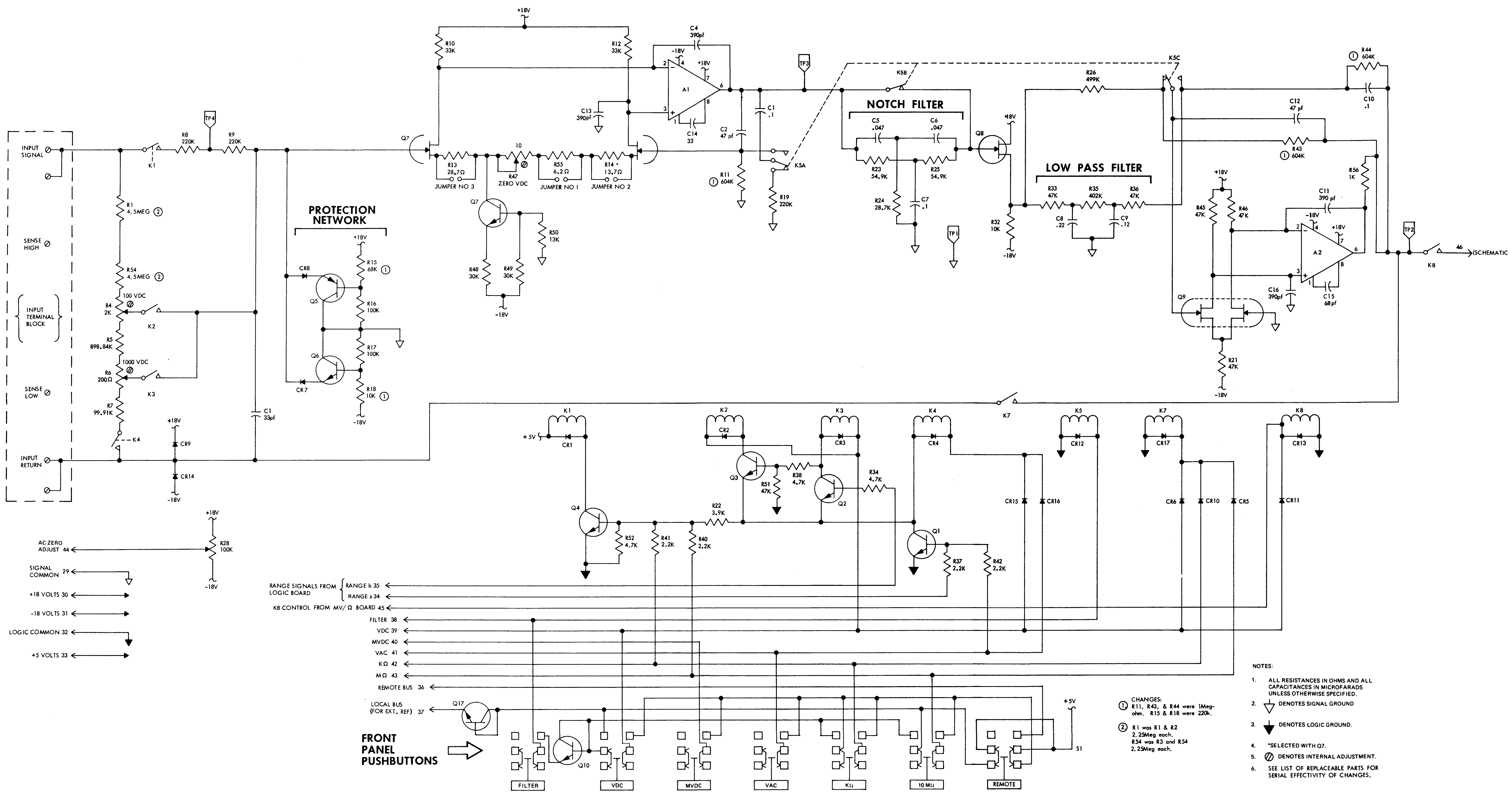


FIGURE 8-1. MODEL 8300A BUFFER

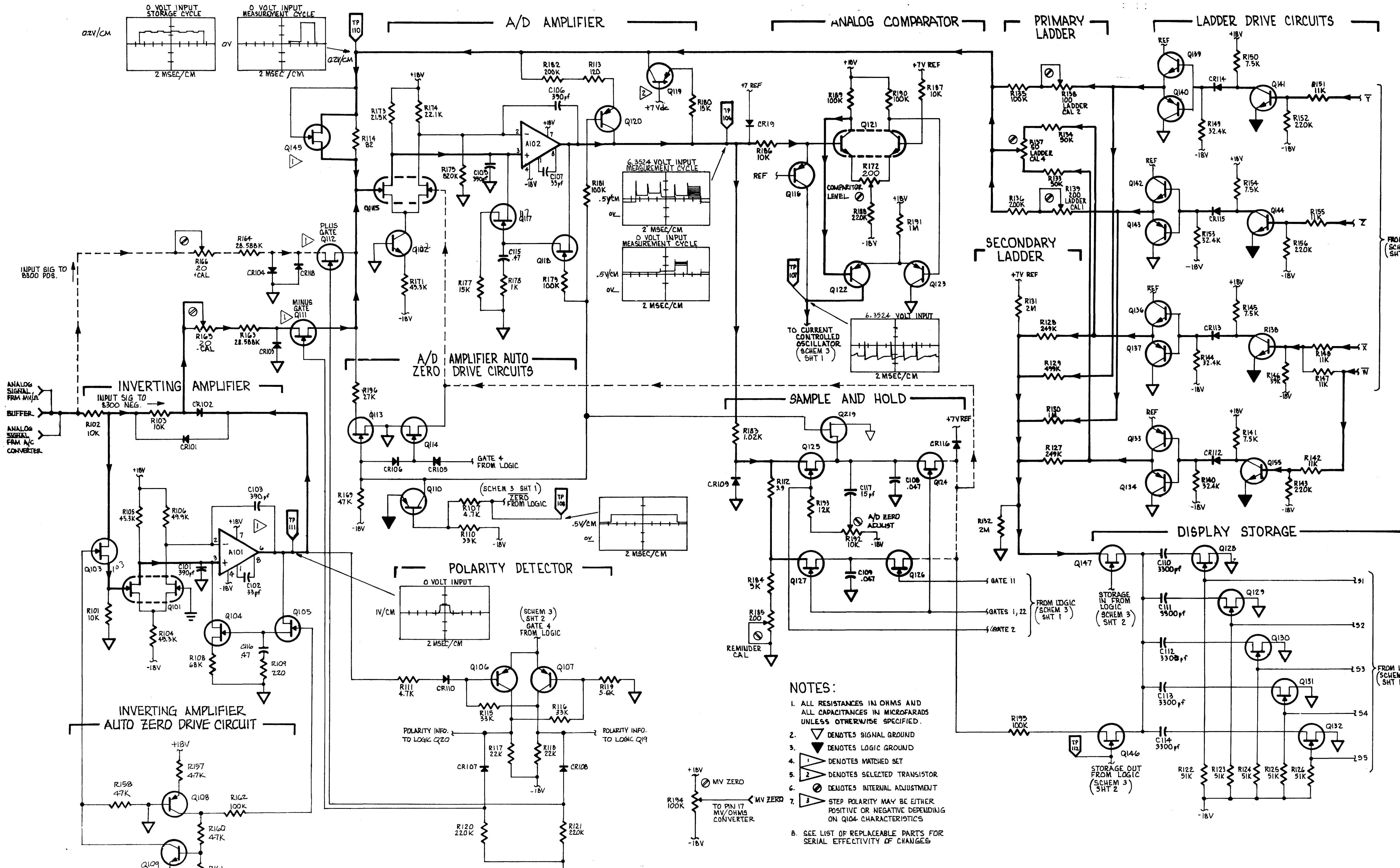
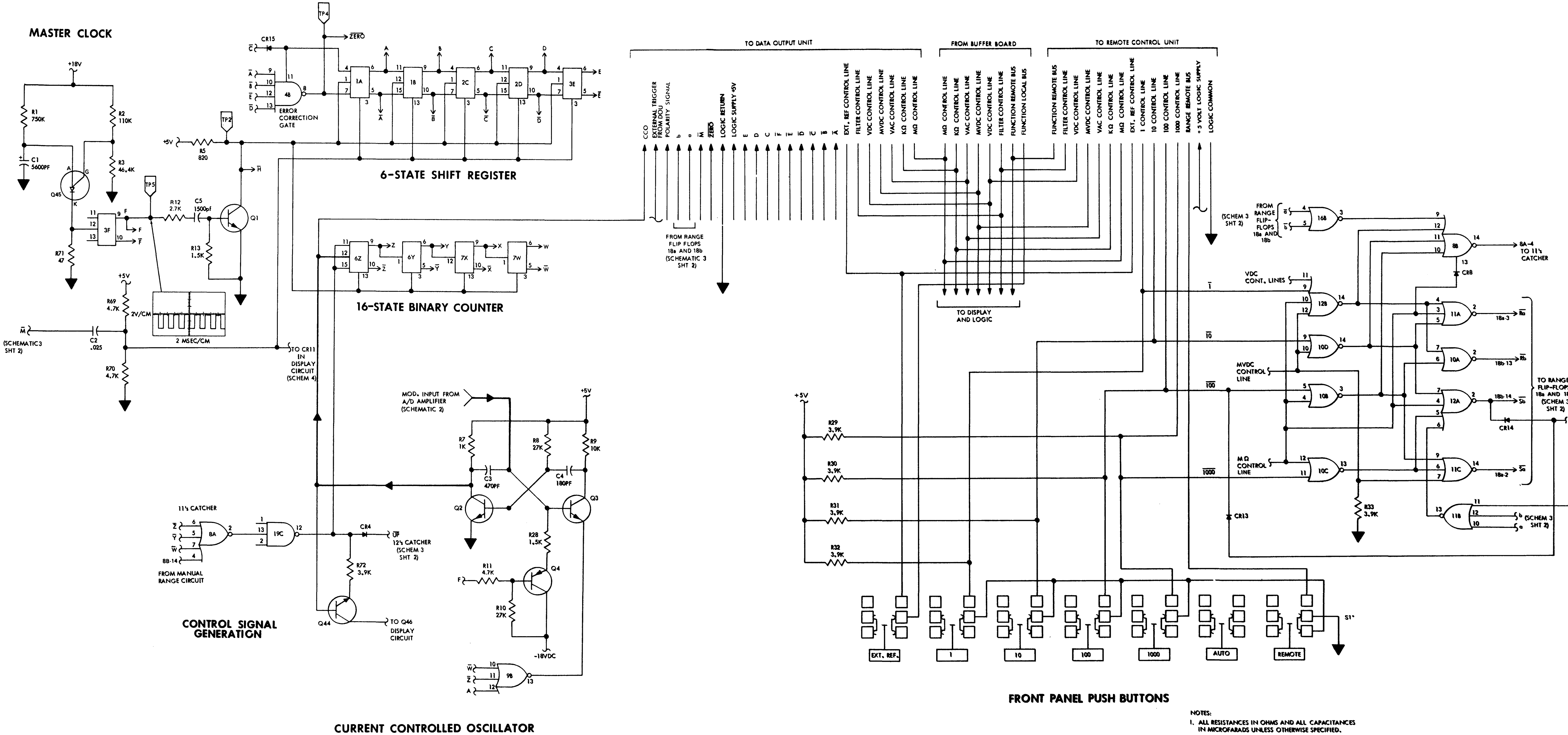
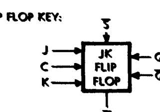


FIGURE 8-2. MODEL 8300A A/D CONVERTER



NOTES:

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. FLIP FLOP KEY:



3. ⏚ DENOTES LOGIC GROUND.
4. * SWITCHES COMPRISING S1 SHOWN IN OFF (NON-DEPRESSED) POSITION.
5. SEE LIST OF REPLACEABLE PARTS FOR SERIAL NUMBER EFFECTIVITY OF CHANGES.

CHANGES:

① R84 ADDED
② C6 was .0012pf
③ R48 was 3.9K

FIGURE 8-3. (1 of 2) MODEL 8300A DVM LOGIC & CONTROL

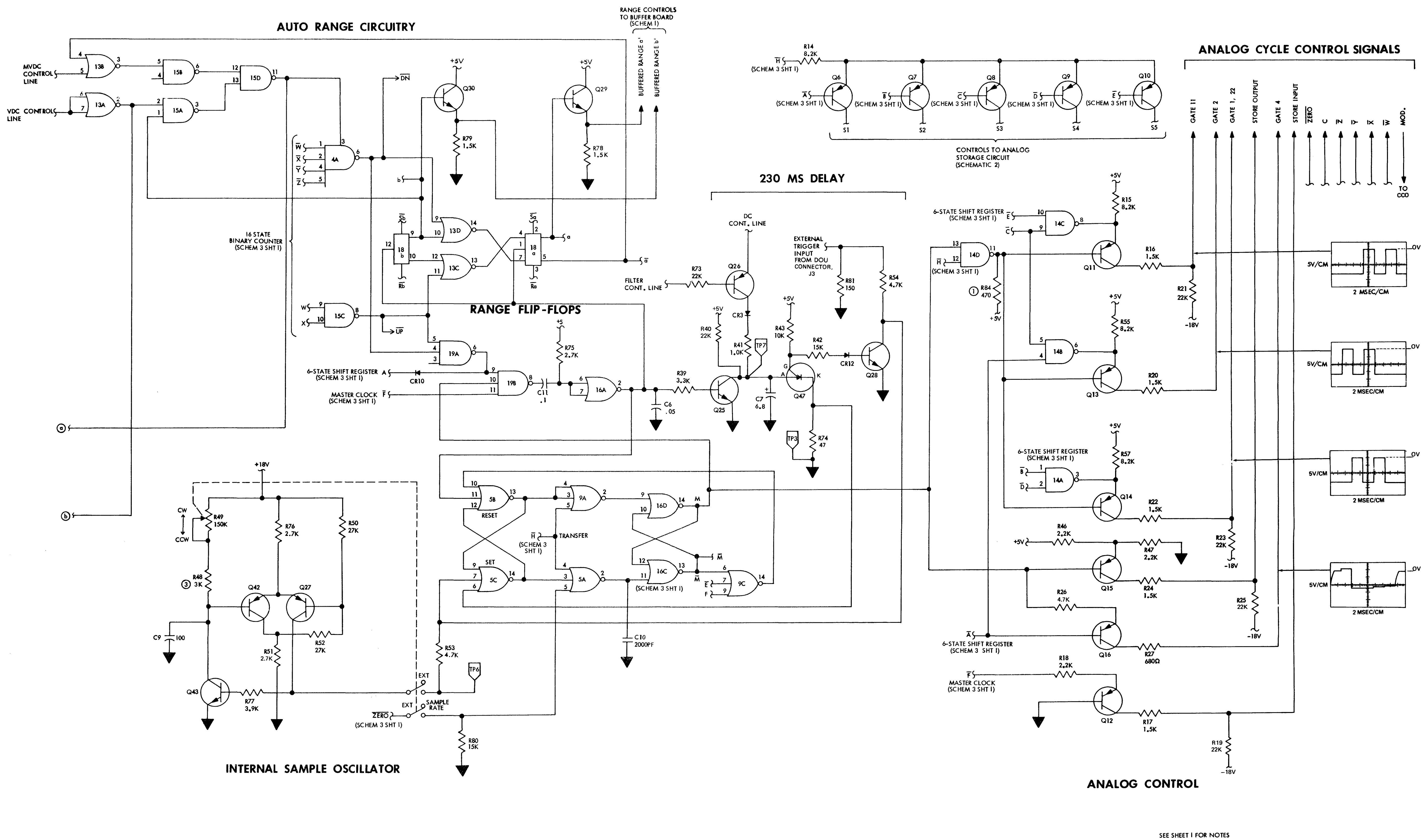


FIGURE 8-3. (2 of 2) MODEL 8300A DVM LOGIC & CONTROL

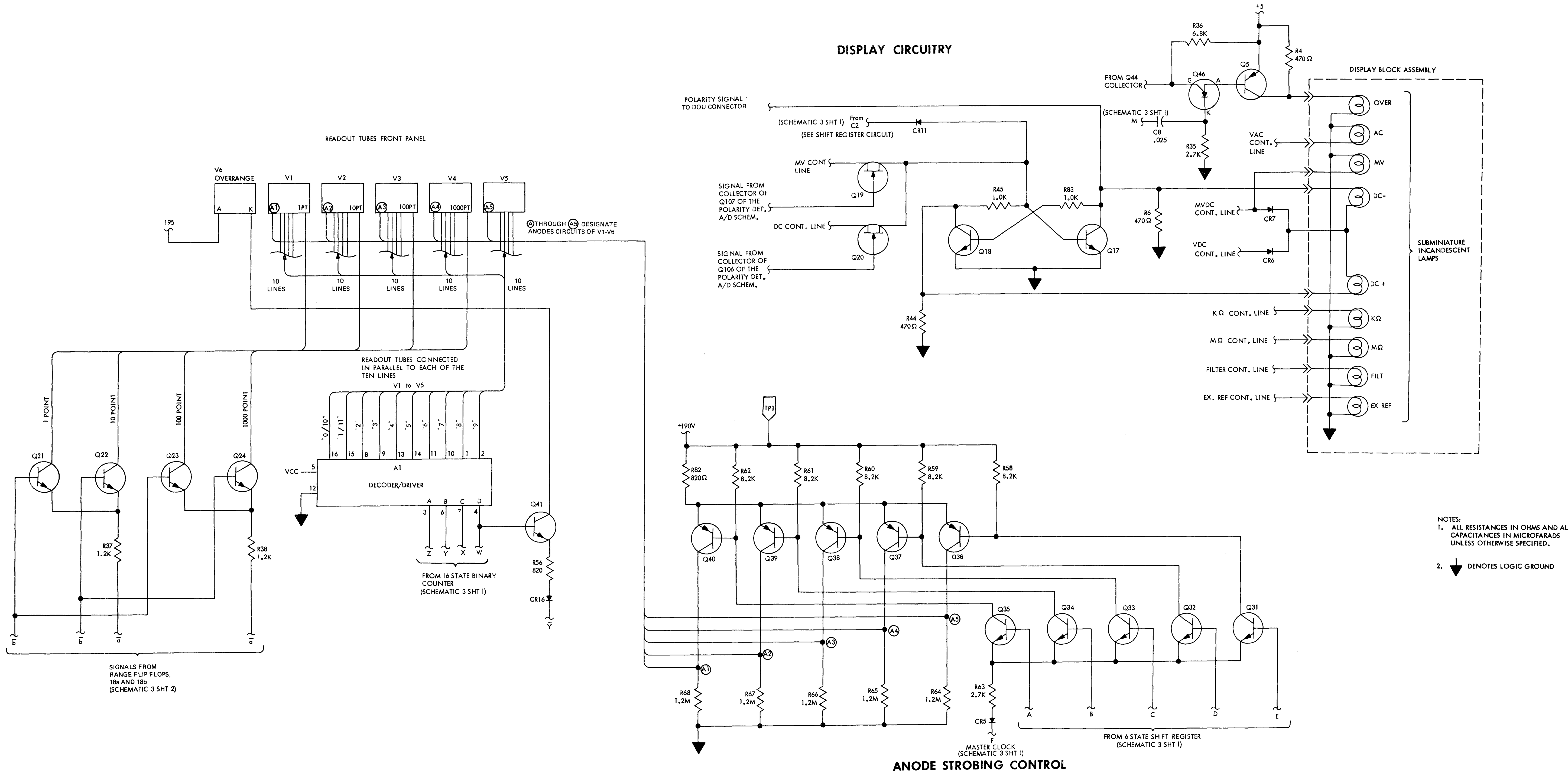


FIGURE 8-4. MODEL 8300A DISPLAY

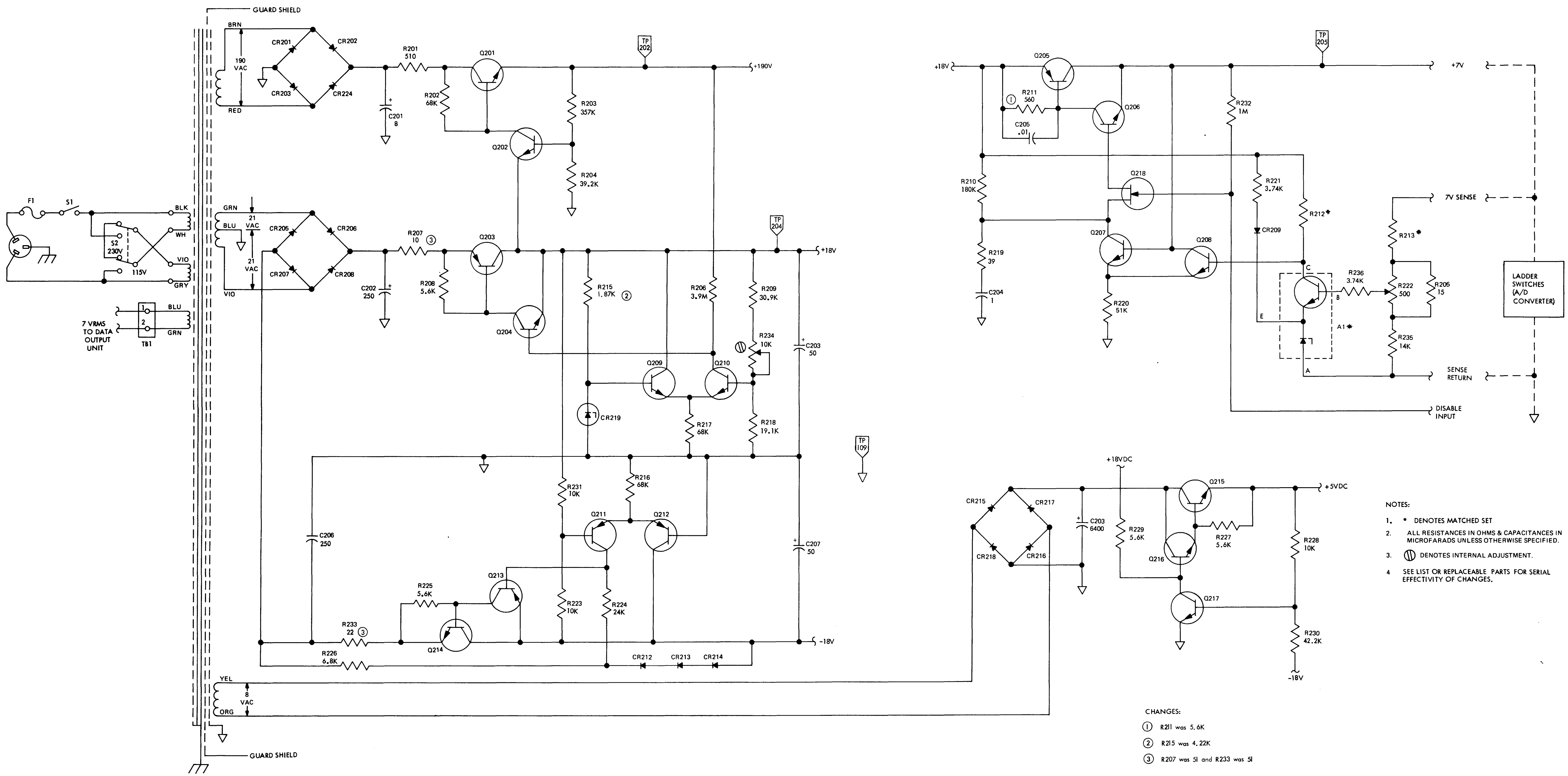


FIGURE 8-5. MODEL 8300A POWER SUPPLY

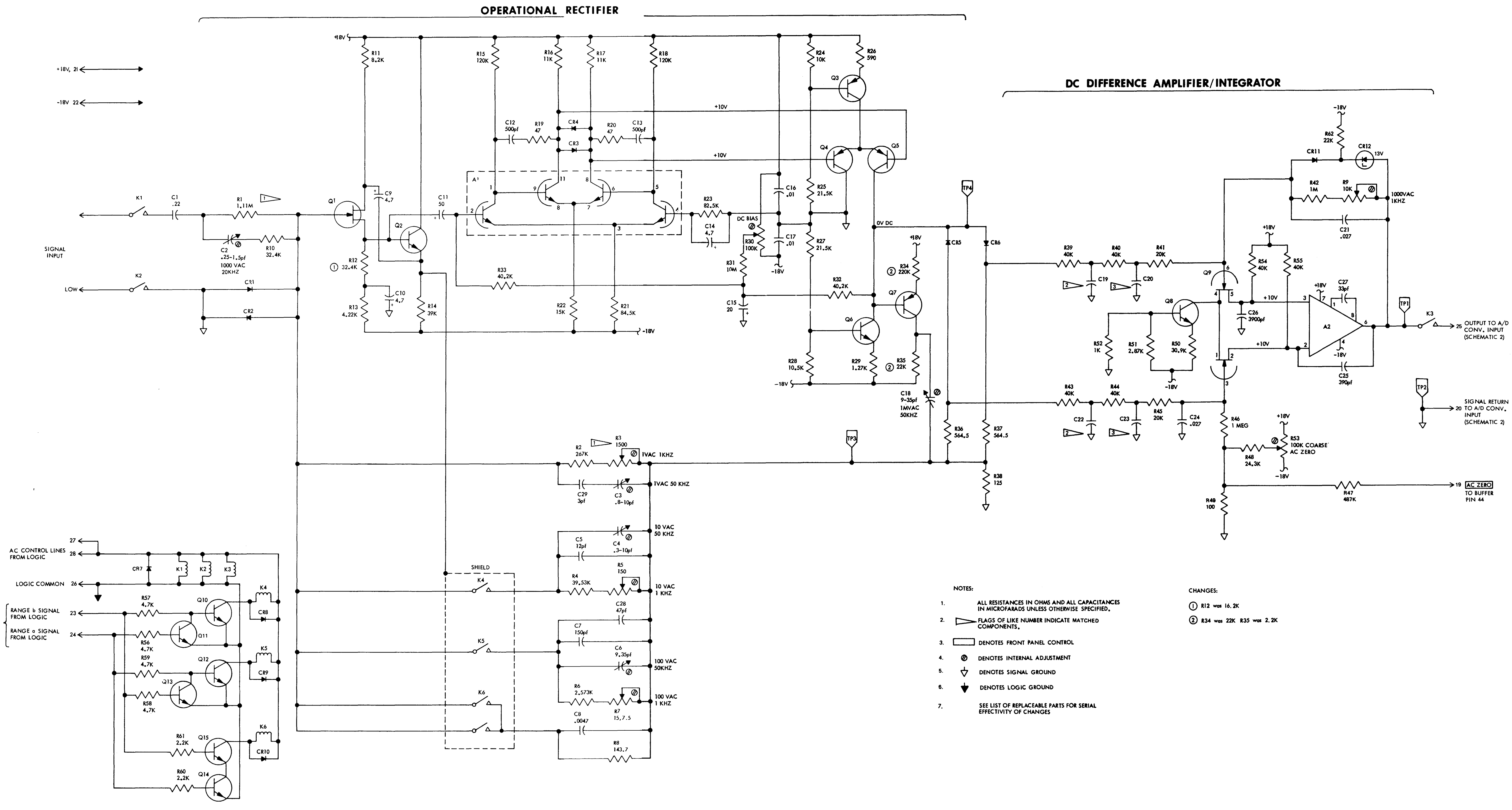
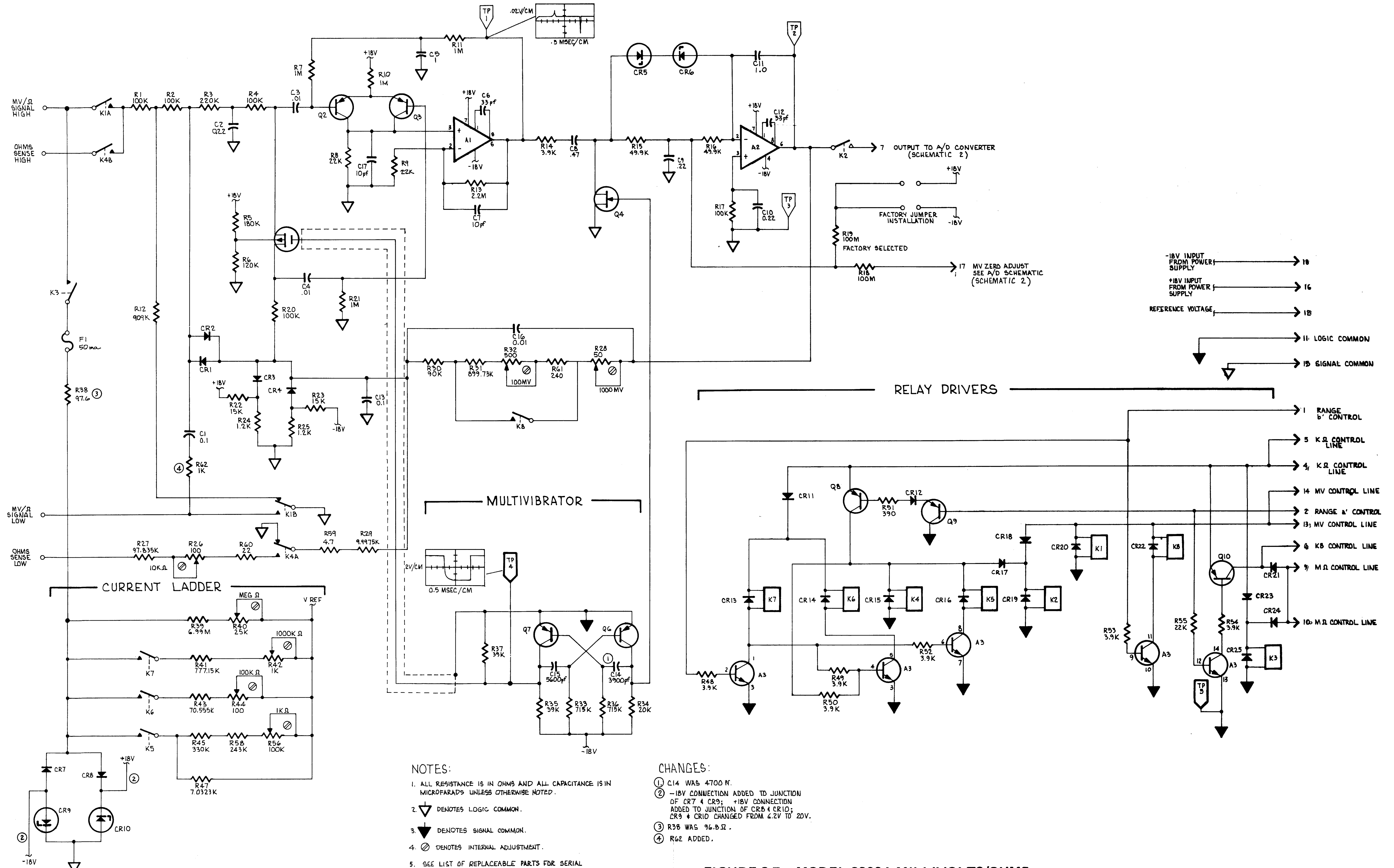


FIGURE 8-6. MODEL 8300A AC CONVERTER



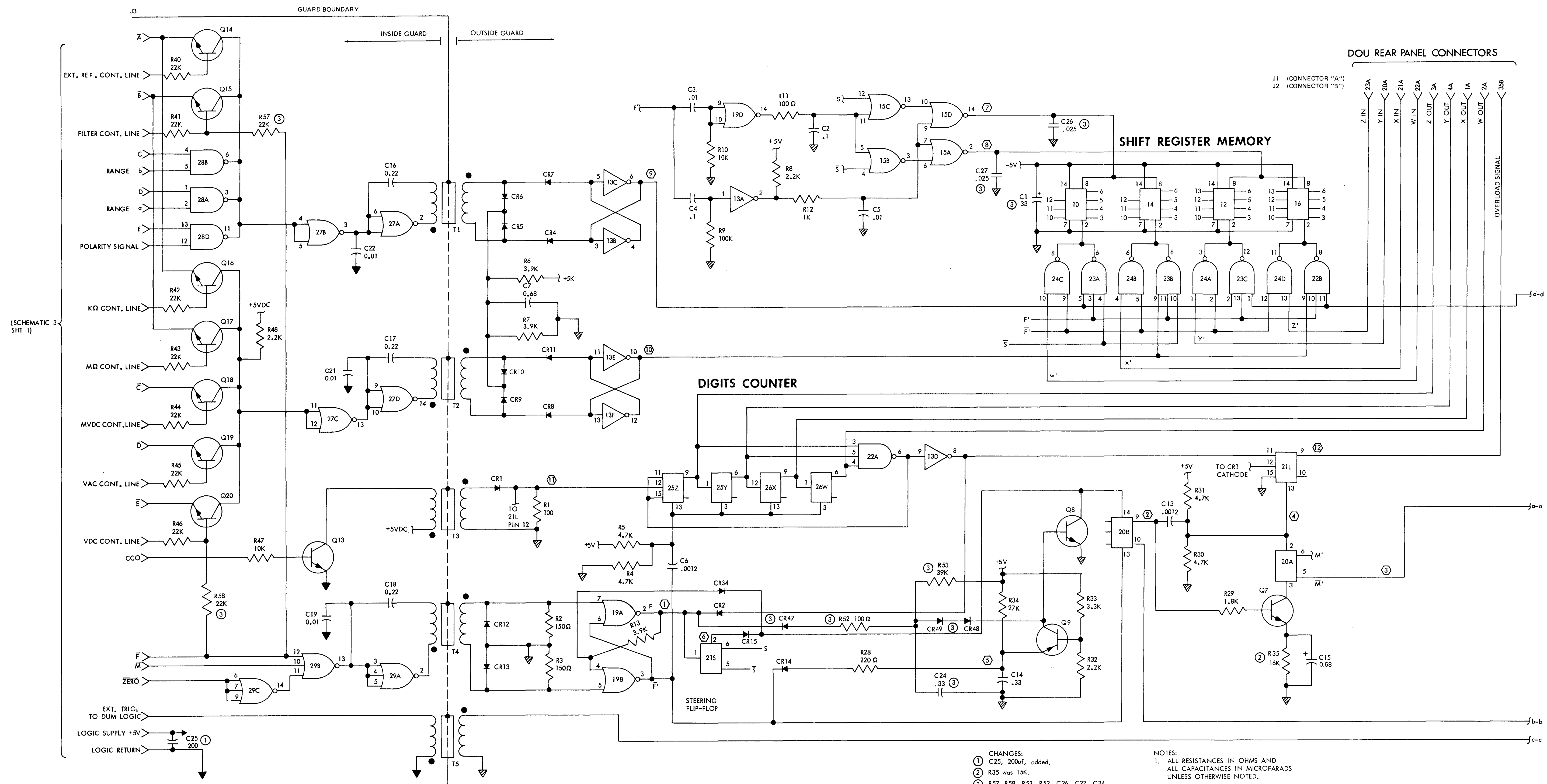
NOTES:

1. ALL RESISTANCE IS IN OHMS AND ALL CAPACITANCE IS IN MICROFARADS UNLESS OTHERWISE NOTED.
2. ▽ DENOTES LOGIC COMMON.
3. ▼ DENOTES SIGNAL COMMON.
4. ⊘ DENOTES INTERNAL ADJUSTMENT.
5. SEE LIST OF REPLACEABLE PARTS FOR SERIAL EFFECTIVITY OF CHANGES.

CHANGES:

① C14 WAS 4700 PF.
② −18V CONNECTION ADDED TO JUNCTION OF CR7 & CR9; +18V CONNECTION ADDED TO JUNCTION OF CR8 & CR10; CR9 & CR10 CHANGED FROM 6.2V TO 20V.
③ R38 WAS 96.8Ω.
④ R62 ADDED.

FIGURE 8-7. MODEL 8300A MILLIVOLTS/OHMS CONVERTER



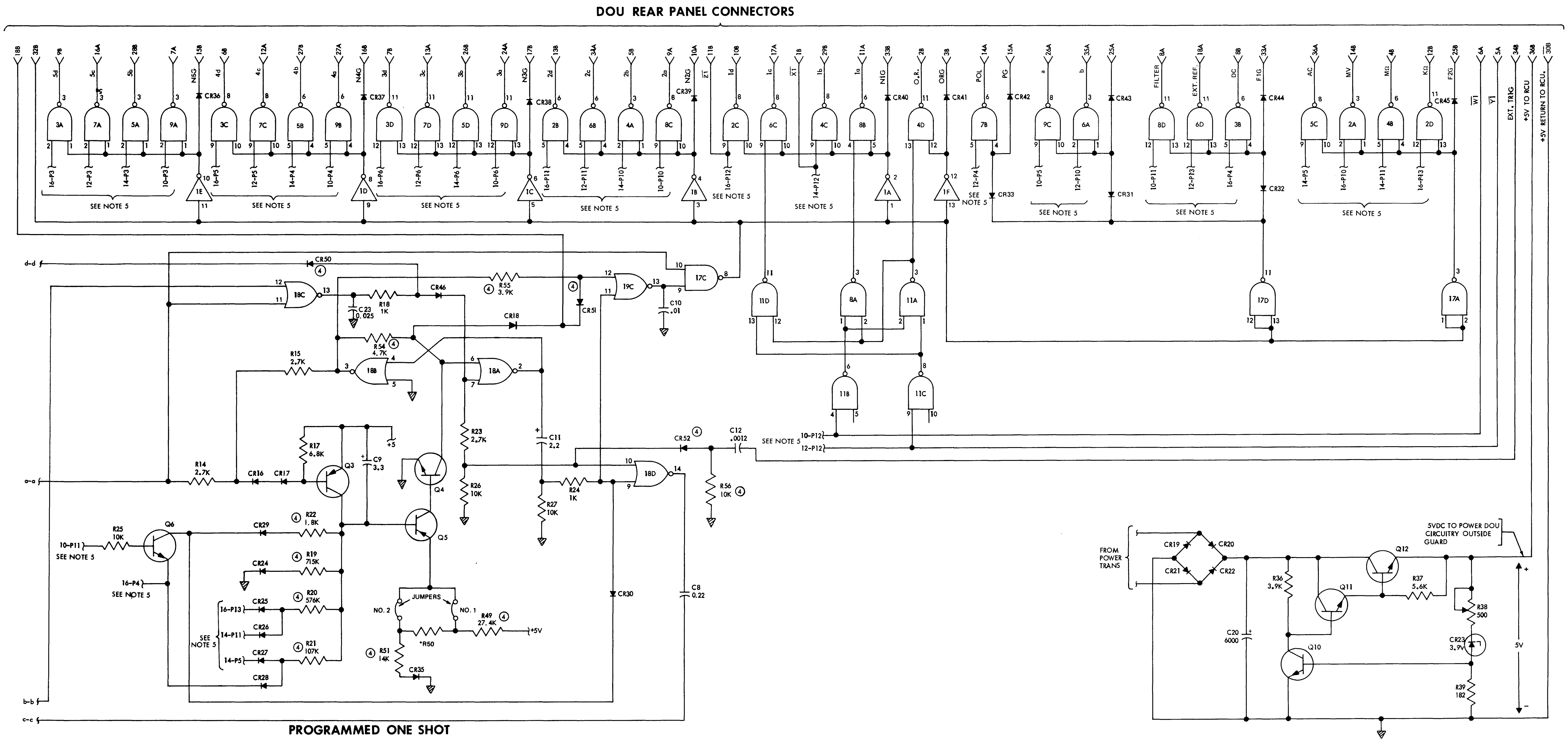
CHANGES:

1. C25, 200uf, added.
2. R35 was 15K.
3. R57, R58, R53, R52, C26, C27, C24, CR47, CR48, and CR49 were added. C1 was 200.
4. CR50, CR51, and CR52 added. R54, R55 and R56 added. R19 was 665K, R20 was 309K, R21 was 100K, R22 was 1.5K, R49 was 274K, and R51 was 140K.

NOTES:

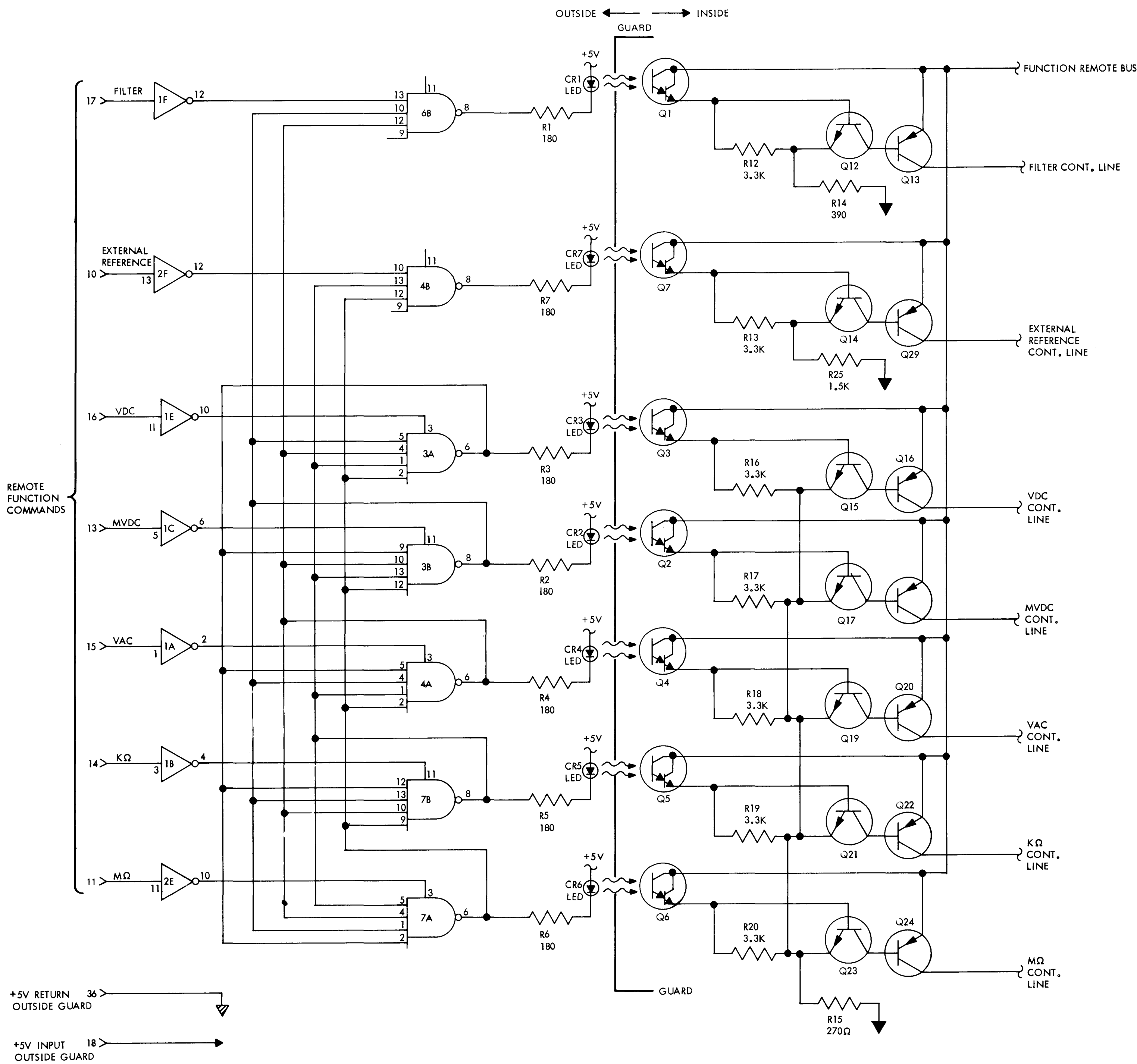
1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE NOTED.
2. DENOTES LOGIC COMMON (INSIDE GUARD)
3. DENOTES COMMON (OUTSIDE GUARD)
4. * DENOTES SELECTED COMPONENT
5. ROUTING OF MEMORY OUTPUTS WITHIN THE DOU IS GIVEN BY NUMERICAL DESIGNATIONS. FOR EXAMPLE, "16-P3" REFERS TO PIN 3 OF SHIFT REGISTER 16.
6. ⬡ CORRESPONDS TO NUMBERED WAVEFORMS GIVEN IN FIGURES 6-4, DOU TIMING DIAGRAM.
7. SEE LIST OF REPLACEABLE PARTS FOR SERIAL EFFECTIVITY OF CHANGES.

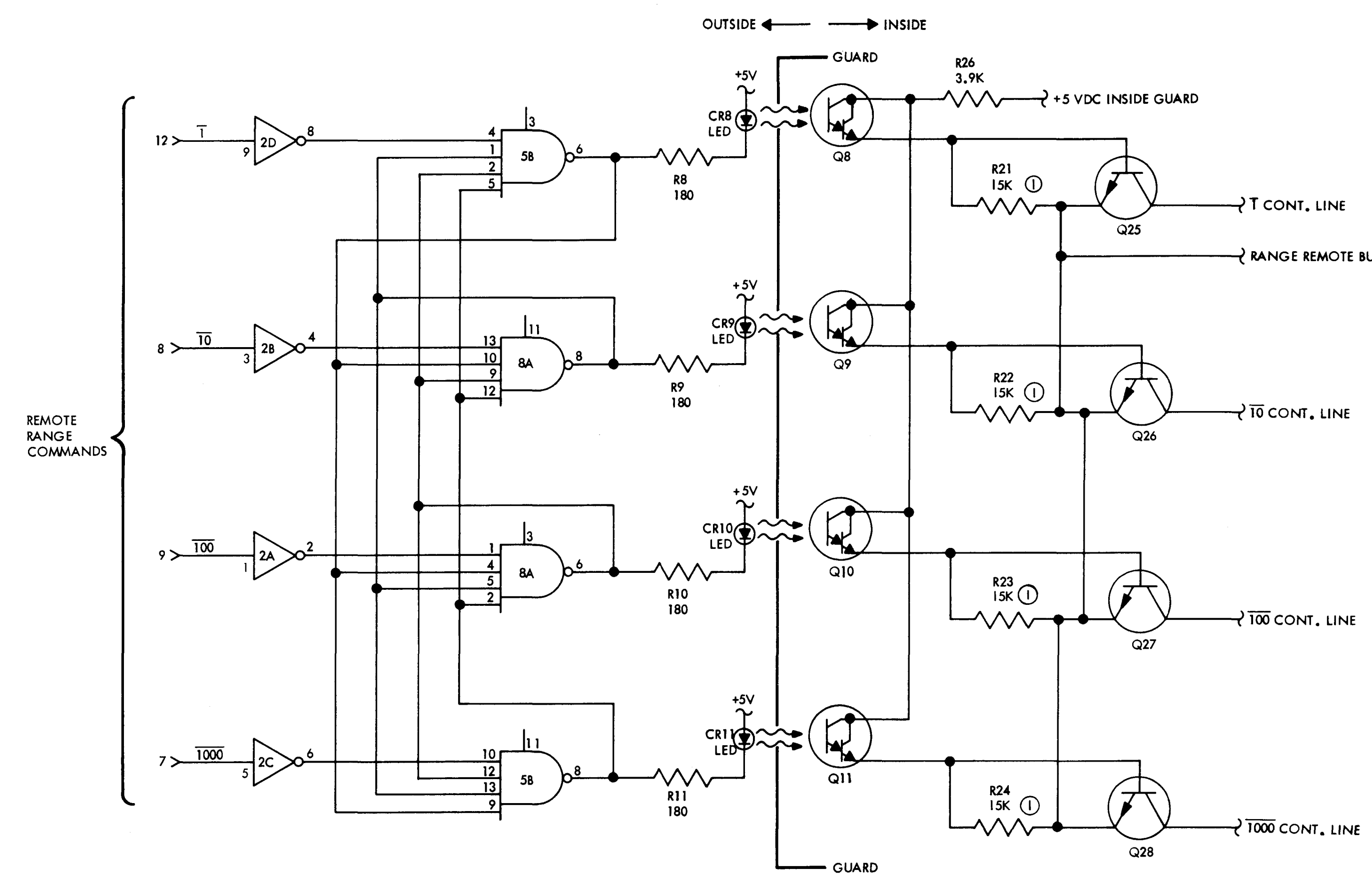
FIGURE 8-8. (1 of 2) MODEL 8300A DATA OUTPUT UNIT



SEE SHEET 1 FOR NOTES

FIGURE 8-8. (2 of 2) MODEL 8300A DATA OUTPUT UNIT





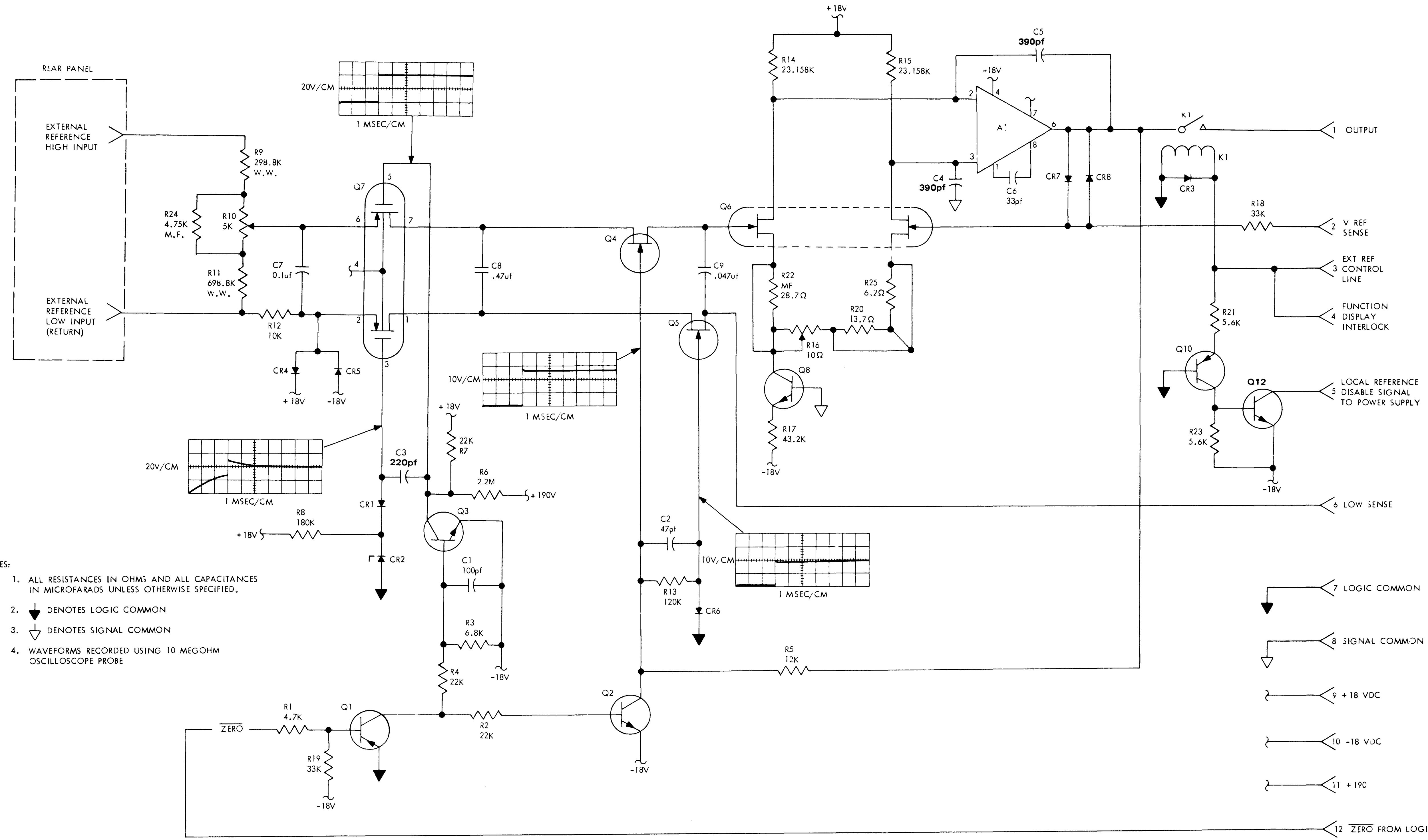
NOTES:

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. DENOTES LOGIC COMMON (INSIDE GUARD)
3. DENOTES COMMON (OUTSIDE GUARD)
4. LED DENOTES LIGHT-EMITTING DIODE
5. SEE LIST OF REPLACEABLE PARTS FOR SERIAL EFFECTIVITY OF CHANGES.

CHANGES:

(1) R21, R22, R23, and R24 were 3.3K

FIGURE 8-9. MODEL 8300A REMOTE CONTROL UNIT



NOTES:

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ▼ DENOTES LOGIC COMMON
3. ▽ DENOTES SIGNAL COMMON
4. WAVEFORMS RECORDED USING 10 MEGOHM OSCILLOSCOPE PROBE

FIGURE 8-10. MODEL 8300A DC EXTERNAL REFERENCE UNIT

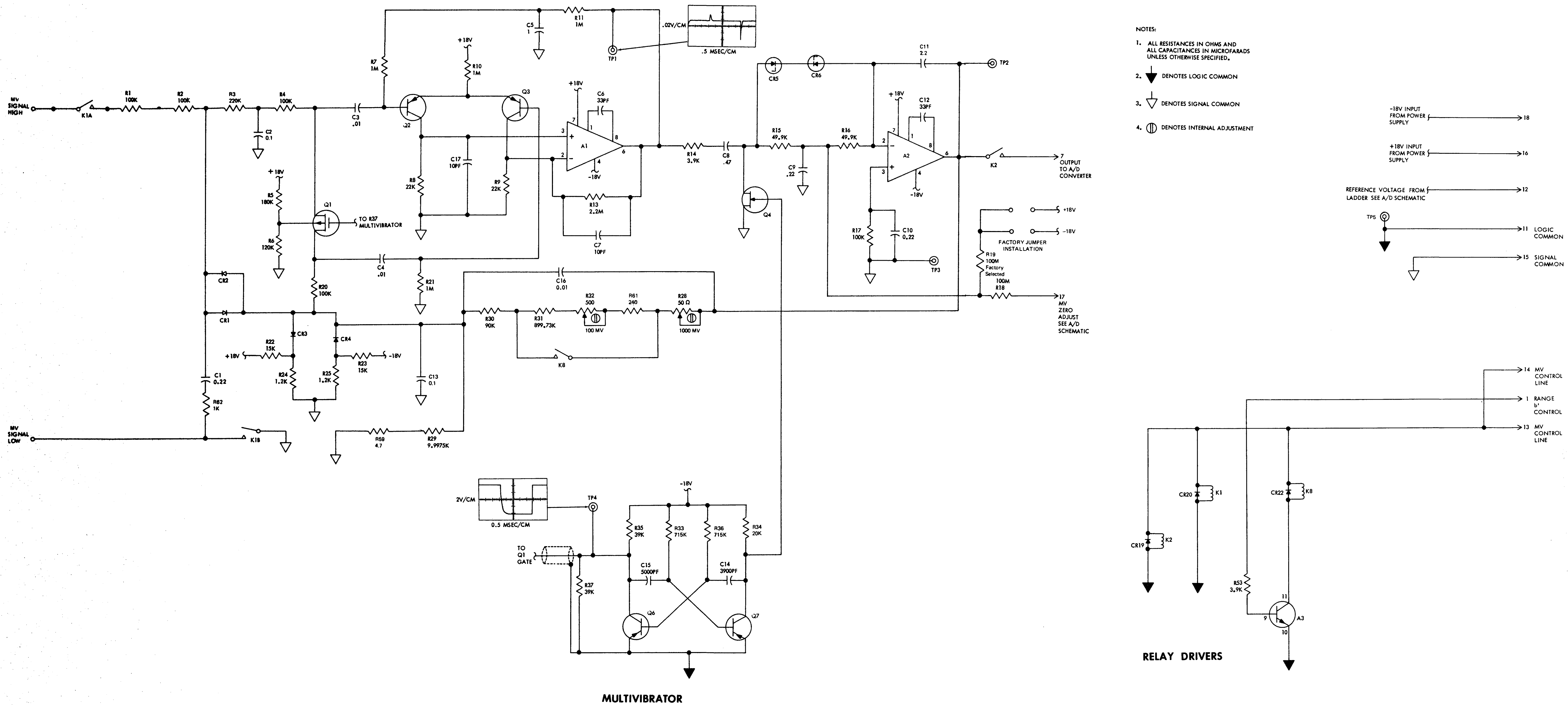


FIGURE 8-11. MODEL 8300A MILLIVOLT CONVERTER