8400A
Digital Voltmeter

Instruction Manual

FLUKE ®

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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 C9090, EVERETT, WASHINGTON 98206, 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 C9090, Everett, Washington 98206

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Section 1
Introduction & Specifications

1-1. DESCRIPTION

1-2. The Model 8400A Digital Voltmeter is a versatile instrument with five full decades of digits plus a sixth digit for 20% overrange. Its mainframe accepts a family of analog and system options that may be installed in the field at any time, in any sequence, for expansion from a bench DVM into a full systems multimeter.

1-3. Fluke's Recirculating-Remainder* A/D conversion technique is used in the 8400A. This conversion circuitry periodically samples the input and serially digitizes the sample, providing a reliable DVM with high long-term accuracy and linearity plus superior environmental characteristics.

1-4. Basic DVM

1-5. DC voltages are measured on five ranges with up to 1 microvolt of resolution. 20% overranging with 1100 volt overload capability further characterizes these ranges. A non-blinking readout contains an in-line neon tube display showing polarity, overrange digit, and five full decades of digits followed by a lighted function annunciator. The speed at which the readout updates is controlled by a variable Sample Rate control, and the switched four-pole filter has true broad-band noise rejection that cannot integrate a constant offset error into the reading. The filter may be used with all analog options.

1-6. Pushbutton selection, 1000 volt guarding, full autoranging, instantaneous auto-polarity, and calibration of all standard and optional functions through the top guard cover are standard features of the 8400A.

1-7. Analog Options

1-8. AC voltages to 1100 volts are measured on four ranges over a frequency domain of 10 Hz to 100 kHz with up to 10 microvolts resolution. A zero control is not needed to maintain the extremely low "percent of range" portions of the specifications.

1-9. True four-terminal resistance measurements on the 10 ohm through 10K ohm ranges are made with very low power dissipation in the unknown resistor. The instrument autoranges through all resistance ranges, from 10 ohms to 12 megohms, with 100 microhm resolution.

1-10. Isolated four terminal DC/DC ratios are measured in real time via the DC External Reference option. The Reference input LO terminal may be elevated by as much as ±13V from the input LO terminal without loss of ratio accuracy. Furthermore, the standard reference voltage span of +1V to +10.5V permits measurement of ratios from a wide number of sources. Special reference voltage ranges are available on request.

1-11. Three terminal AC/AC ratio measurements use the AC External Reference Option. Reference voltages from 0.1V to 105V may be applied on one of three internally selected ranges for highly accurate ratio determinations over a broad range of frequencies.

1-12. System Options

1-13. Isolated Data Output and Isolated Remote Control options use guarded toroids to transfer data and commands to and from the 8400A with no degradation of com-

**Patent Pending*

mon-mode rejection specifications. These options are also DTL/TTL compatible and are designed to permit multiplexing of several 8400A's on common sets of control and data output lines. Moreover, they are buffered to prevent interaction between the DVM and the acquisition/control devices.

1-14. External Triggering of the 8400A is accomplished via its Data Output Unit, and resulting data may be acquired fully in parallel BCD format or serially by character in multiples of four-bits. A single control line enables automatic time delays that allow for full settling of the analog input prior to digitization of the data transferred. Five flags provide continuous measurement status information for the acquisition device.

1-15. Remote Control is exerted by contact closures or logic levels. The 8400A's Control Command Storage feature permits the 8400A to latch on commands which may be later removed from inputs while the 8400A retains the commanded function and range in internal memory. Logical interlocks are a further important systems feature of this option, because they prevent incompatible calls.

1-16. SPECIFICATIONS

1-17. Mainframe

DC VOLTS

RANGES	±0.1V, ±1V, ±10V, ±100V, ±1000V (automatic polarity selection)
Resolution	±0.001% of range, (1uV maximum on ±0.1V range)
Overrange	20%, ±1100V maximum input on ±1000V range
Overload	±1100V DC or RMS (±1500V peak) may be continuously applied to any range without damage.

ACCURACY (To 120% of range or ±1100V maximum input)

24 hours (23°C ±1°C)	±10V, ±100V, ±1000V ranges	±(0.002% of input + 0.001% of range)
	±1V range	±(0.003% of input + 0.002% of range)
	±0.1V range	±(0.003% of input + 0.005% of range)
90 days (18°C to 28°C)	±10V, ±100V, ±1000V ranges	±(0.004% of input + 0.001% of range)
	±1V range	±(0.005% of input + 0.002% of range)
	±0.1V range	±(0.005% of input + 0.005% of range)
1 year (18°C to 28°C)	±10V, ±100V, ±1000V ranges	±(0.01% of input + 0.001% of range)
	±1V range	±(0.02% of input + 0.002% of range)
	±0.1V range	±(0.02% of input + 0.005% of range)

Temperature Coefficients (0°C to 18°C and 28°C to 50°C)

±10V, ±100V, ±1000V ranges	±(0.0003% of input + 0.0001% of range)/°C
±1V range	±(0.0004% of input + 0.0002% of range)/°C
±0.1V range	±(0.0005% of input + 0.0006% or range)/°C

Input Impedences	±10V range	10,000 megohms	shunted by less than 100 p.f.
	±1V range	1000 megohms	
	±0.1V range	100 megohms	
	±100V, ±1000V range	10 megohms	

Offset Current at 23°C±1°C	Less than ±5 pa. on any range
Temperature Coefficient	Less than ± 1 pa/°C on any range
Zero Stability	Better than 5 uv for 90 days after a one hour warmup.

NOISE REJECTION

Normal Mode (filtered)	Greater than 65 db @ 60 Hz (60 db @ 50 Hz)
Maximum superimposed AC Voltage	50% of range peak AC, maximum
Common Mode (with up to 1K unbalance in either lead)	
DC	Greater than 140 db
AC to 60 Hz, Filter "in"	Greater than 140 db
Filter "out"	Greater than 100 db

NOTE: Common Mode Rejection specifications are maintained with any combination of options installed and are unaffected when grounded devices are used in conjunction with the remote control or data output options.

RESPONSE TIME (from an input step change to a completed reading within 0.005% of the change when externally triggered.)

Filter "out"	less than 33 milliseconds
Filter "in"	less than 500 milliseconds

GENERAL

Digitizing Time	18 milliseconds
Sample Aperture	3 milliseconds
Sample Rate	Smoothly variable from 13 per second to one per 4.5 seconds via SAMPLE RATE control

NOTE: A maximum sample rate of 30 readings per second is obtained when Model 8400A is externally triggered via Option 8400A-03.

Autorange Time Filter "out"	50 milliseconds per range change
Filter "in"	280 milliseconds per range change
Filter	4-pole active filter for use with DC volts, AC volts, and Resistance measurements
Range Selection	Manual, Automatic Standard; Remote Optional
Function Selection	Manual Standard, Remote Optional, Autoranges from Ω to KΩ
Display	In-line neon-tube display of polarity, overrange digit and 5 full decades of digits. with automatic decimal placement plus an illuminated function annunciator.
Overload Limits (Maximum voltage that may be continuously applied without damage)	
"Hi" to "Lo"	See individual functions under "range", & "overload"
"Lo" to "Guard"	±100V DC or peak AC
"Guard" to "Chassis"	±1000V DC or peak AC maximum Common Mode Voltage
Temperature Range, Operating	0°C to +50°C
Non-Operating	−40°C to +75°C
Humidity Range 0°C to +25°C	Less than 80% relative humidity
+25°C to +50°C	Less than 70% relative humidity
Altitude Range, Operating	To 10,000 feet (3.048 kM)
Non-Operating	To 50,000 feet (15.25 kM)
Shock and Vibration	Meets requirements of MIL-T-21200H and MIL-E-16400F
Operating Power (including options)	115/230 VAC ±10%, 50 to 440 Hz, Less than 25W
Weight (including options)	Less than 20 pounds(9.08 kg)
Size, see Figure 1-1	3½" H x 17" W x 18" D (88.1 mm x 432 mm x 457.4mm),
Warm-up Time	20 minutes to 1 year accuracy, 1 hour to full accuracy.

1-18. Options

AC VOLTS (Using Option 8400A-01)

RANGES	1V, 10V, 100V, 1000V
Resolution	±0.001% of range, (10 uV maximum on 1V range)
Overrange	20%, 1100V RMS maximum on 1000V range

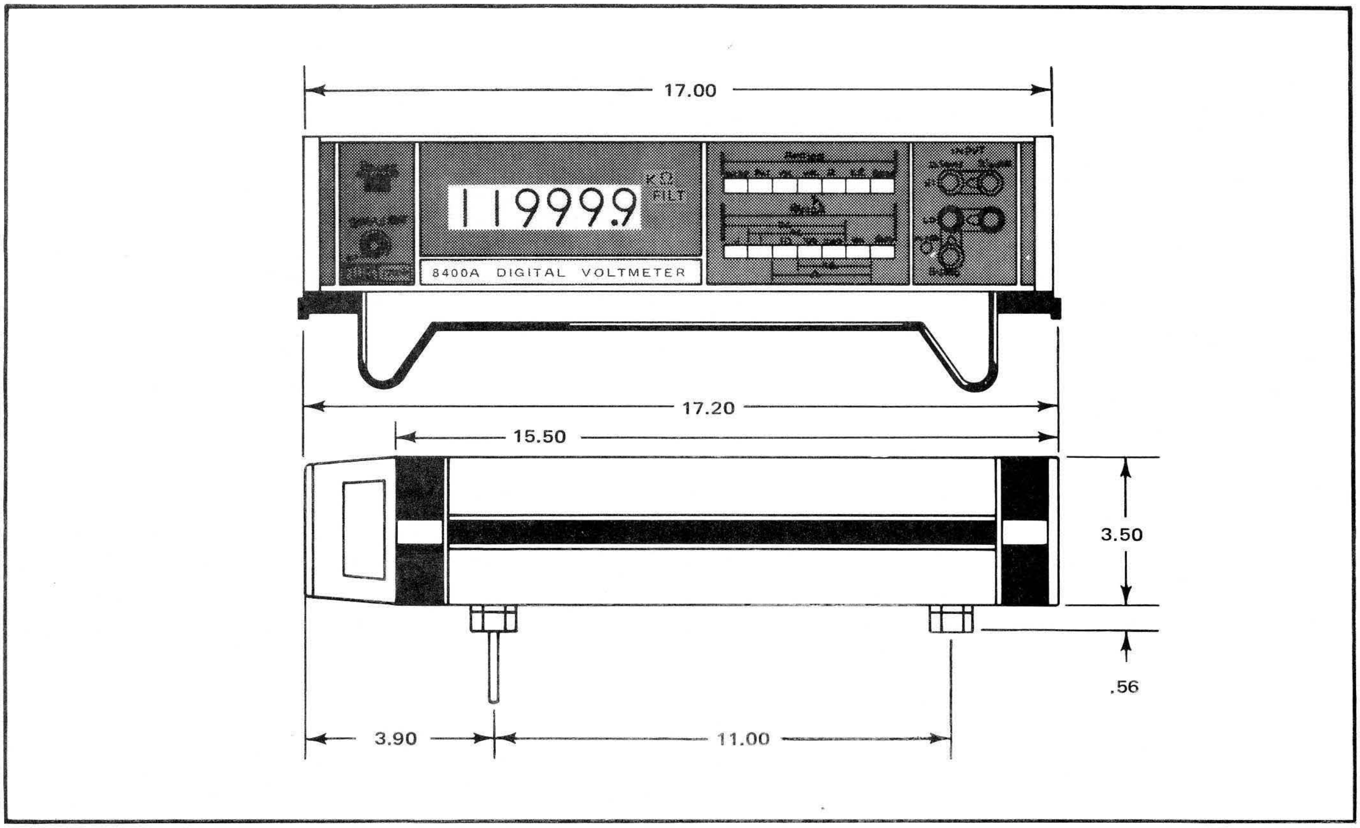


Figure 1-1. MODEL 8400A OUTLINE DRAWING

Overload . . . . 1100V RMS may be continuously applied to any range without damage

Superimposed DC. . . . . ±1100V DC (Peak AC plus DC may not exceed ±1500V)

ACCURACY (To 120% of range or 1100V maximum input)

0.001V to 500V, (90 days, 18°C to 28°C)	50 Hz - 10 kHz	±(0.05% of input +0.005% of range)
	10 kHz - 50 kHz	±(0.1% of input +0.005% of range)
	20 Hz - 50 Hz and 50 kHz - 100 kHz	±(0.5% of input +0.005% of range)*
	10 Hz - 20 Hz	±(1.0% of input +0.01% of range)
500V to 1100V, 90 days (18°C to 28°C)	50 Hz - 10 kHz	±0.1% of input
	10 kHz - 50 kHz	±0.15% of input*
	20 Hz - 50 Hz	±(0.5% of input +0.005% of range)
	10 Hz - 20 Hz	±(1.0% of input +0.01% of range)

**NOTE:* *Input Volt - Hertz product should not exceed 2 x 10^7*

Temperature Coefficients (0°C to 18°C and 28°C to 50°C)

	10 Hz - 50 kHz	±(0.002% of input +0.0005% of range)/°C
	50 kHz - 100 kHz	±(0.01% of input +0.0005% of range)/°C

Input Impedance . . . . 1.11 megohm, ±0.1%, shunted by less than 100 pf.

NOISE REJECTION

Common Mode (with up to 100Ω unbalance in either lead)

DC to 60 Hz . . . . Greater than 120 db

RESPONSE TIME (from an input step change to a completed reading within 0.05% of the change when externally triggered).

Filter "out". . . . . 100 milliseconds (input frequency greater than 400 Hz)

Filter "in" . . . . 500 milliseconds (any input frequency)

AC VOLTS (Using option 8400A–09)

For Measurement of DC-Coupled (AC + DC) Voltages or AC Only.

RANGES . . . . 1, 10, 100, 1000 VAC
Overrange . . . . 20%, 1100V RMS maximum on 1000V range
Resolution . . . . 0.001% range
Overload . . . . 1100V RMS any range (1500V peak AC)
Superimposed DC (AC only) . . . . 1100V DC (Peak AC plus DC may not exceed ±1500V)
Max. Crest Factor . . . . 7 at full-scale and increasing down scale per: $7X\sqrt{\frac{V\ Range}{V\ Input}}$

ACCURACY

		AC + DC	AC ONLY
	D.C.	±(0.1% of input + 0.03% of range)	
	50Hz-10kHz	±(0.1% of input + 0.03% of range)	±(0.1% of input + 0.012% of range)
90 days,	10kHz-30kHz(2)	±(0.2% of input + 0.06% of range)	±(0.2% of input + 0.04% of range)
(18°C to 28°C)	30kHz-50kHz(2)	±(0.3% of input + 0.12% of range)	±(0.3% of input + 0.1% of range)
(0.001V - 1100V(1))	20Hz-50Hz	±(0.5% of input + 0.03% of range)	±(0.5% of input + 0.012% of range)
	10Hz-20Hz	±(1.0% of input + 0.06% of range)	±(1.0% of input + 0.04% of range)
	50kHz-100kHz(2)	±(1.0% of input + 0.32% of range)	±(1.0% of input + 0.3% of range)
	100kHz-300kHz(2)	±(2.0% of input + 0.52% of range)	±(2.0% of input + 0.5% of range)

(1) With inputs above 500V multiply accuracy by $\left[\frac{2000V + V\ input}{2000V}\right]$

(2) Input volt x hertz, product should not exceed 2×10^7.

Temperature Coefficients (0°C to 18°C and 28°C to 50°C)
DC and 10 Hz - 10 kHz (AC + DC) . . . . ±(0.004% Inp. + 0.004% Range)
10 Hz - 10 kHz (AC only) . . . . ±(0.004% Inp. + 0.001% Range)
Input Impedance . . . . 1 Megohm, shunted by less than 150 p.f.

NOISE REJECTION
Common Mode (with up to 100Ω unbalance in either lead)
DC to 60 Hz . . . . Greater than 120 db

RESPONSE TIME (to a reading within 0.1% of range when measuring step change inputs and using external trigger).

Filter "out" . . . . 100 milliseconds maximum (3)
Filter "in" . . . . 500 milliseconds maximum
(For readings less than 10% Range, double indicated times).

(3) Above 400 Hz for rated accuracies.

RESISTANCE (Using Option 8400A-02)

RANGES. . . . . 10Ω, 100Ω, 1000Ω, 10,000Ω, 100 KΩ, 1000 KΩ, 10,000KΩ
NOTE: Model 8400A will autorange through all resistance ranges.

Resolution . . . . 0.001% of range, (100 uΩ maximum on 10 Ω range)
Overrange. . . . . 20%, 12 megohms maximum on 10,000K range
Overload, 10Ω - 10,000Ω ranges . . . . . 20V RMS (fused)
100KΩ - 10,000KΩ ranges . . . . . Up to 250V RMS may be continuously applied without damage

ACCURACY (To 120% of range)

90 days,	100kΩ - 1000kΩ ranges	±(0.01% of input +0.002% of range)
(18°C to 28°C)	100Ω - 10,000Ω ranges	±(0.01% of input +0.003% of range)
	10Ω range	±(0.01% of input +0.01% of range)
	10,000kΩ range	±(0.05% of input +0.002% of range)

Temperature Coefficients (0° to 18°C and 28° to 50°C)

100kΩ, 1000kΩ ranges . . . . ±(0.0007% of input +0.0001% of range)/°C
10,000kΩ range . . . . ±(0.003% of input +0.0001% of range)/°C
100Ω - 10,000Ω range . . . . ±(0.001% of input +0.0002% of range)/°C
10Ω range . . . . ±(0.001% of input +0.0005% of range)/°C

CONFIGURATION . . . . True 4-terminal through 10,000Ω range and 2 terminal on the 100 KΩ through 10,000 KΩ ranges.

Current through R measured

Range	10Ω	100Ω	1000Ω	10,000Ω	100KΩ	1000KΩ	10,000 KΩ
Current	10 ma		1 ma		100 μa	10 μa	1 μa

Maximum Lead Resistance (for less than 0.001% of range effect on accuracy)

4 terminal mode, Current leads . . . . 10Ω in both leads on 10Ω range and 100Ω on all other ranges
Voltage leads . . . . 1 KΩ in either lead on all ranges.
2 terminal mode . . . . Less than 0.001% of range lead resistance.

RESPONSE TIME (from an input step change to a completed reading within 0.01% of the change when externally triggered).

Filter "out". . . . . Less than 33 milliseconds
Filter "in". . . . . Less than 500 milliseconds

ISOLATED DC EXTERNAL REFERENCE (4 Terminal DC/DC Ratio using Option 8400A-05)

NOTE: Mating connector is supplied.

REFERENCE INPUT

Voltage Range . . . . +1V to +10.5V
Input Resistance . . . . 1 megohm ±0.1%
Isolation of Reference and Input Commons . . . . V input + V common difference not to exceed ±13V on 10V and lower ranges.
NOTE: Fused to prevent damage.

RANGES . . . . ±0.01:1, ±0.1:1, ±1:1, ±10:1, ±100:1

Resolution . . . . ±0.001% of Ratio range, (0.0000001: 1 maximum on ±0.01: 1 range)
Overrange . . . . 20%, 110: 1 maximum input on 100: 1 range
Overload. . . . . ±1100V DC or RMS (±1500V peak) may be continuously applied to the numerator (input) terminals without damage.
Reading vs. Ratio. . . . . 10 x Ratio

ACCURACY (To 120% of ratio range)

90 days	±1: 1, ±10: 1, ±100: 1 ranges	±(0.005% of Ratio +0.002% x $10V_{ref}$ of range)
(18°C to 28°C)	±0.1: 1 range	±(0.005% of Ratio +0.004% x $10V_{ref}$ of range)
	±0.01: 1 range	±(0.005% of Ratio +0.01% x $10V_{ref}$ of range)

NOTE: 24 hour and 1 year specifications available upon request.

Temperature Coefficients (0°C to 18°C and 28°C to 50°C)

±1: 1, ±10: 1, ±100: 1 ranges . . . . . . ±(0.0003% of ratio +0.0001% x $10V/V_{ref}$ of range)/°C
±0.1: 1 range . . . . ±(0.0004% of ratio +0.0002% x $10V/V_{ref}$ of range)/°C
±0.01: 1 range . . . . ±(0.0005% of ratio +0.0006% x $10V/V_{ref}$ of range)/°C

NOISE REJECTION (At Reference Input)

Normal Mode . . . . 30 db @ 60 Hz
Common Mode (with up to 1K unbalance). . . . . . 120 db with a + 10V Reference

REFERENCE SETTLING TIME . . . . 2 seconds

(To 0.01% of range following a step change of reference voltage. Numerator response time same as "dc volts").

AC EXTERNAL REFERENCE (3 Terminal AC/AC Ratio using Options 8400A-01 and 8400A-06)

NOTE: Mating connector is supplied.

REFERENCE INPUT

Reference Ranges	1V, 10V, 100V (internal selection)
Reference Voltage	10% to 105% of Reference Range
Input Impedance	1 megohm shunted by less than 100 pf.

RATIO RANGES

Reference Range	1V	1: 1, 10: 1, 100: 1, 1000: 1
	10V	0.1: 1, 1: 1, 10: 1, 100: 1
	100V	0.01: 1, 0.1: 1, 1: 1, 10: 1
Resolution		0.001% of Ratio range, 0.0000001: 1 maximum
Overload		130V RMS at Reference Input
Reading vs. Ratio,	1V Ref. Range	1 x Ratio
	10V Ref. Range	10 x Ratio
	100V Ref. Range	100 x Ratio

ACCURACY (90 days at 18°C to 28°C and to 120% of ratio range)

50 Hz - 10 kHz *

1: 1 Range and Reference and Input
at the same frequency . . . . ±(0.05% of Ratio + 0.005% x Ref Range/V_{ref} of range)

**NOTE: Specifications from 10 Hz - 50 Hz and 10 kHz - 100 kHz available on request.*

Input and Reference not at the same
frequency or not on the 1:1 Range . . . . ±(0.1% of Ratio + 0.005% x Ref. Range/V_{ref} of range)

Temperature Coefficient
(0°C to 18°C and 28°C to 50°C). . . . . ±(0.004% of Ratio + 0.001% x Ref Range/V_{ref} of range)

REFERENCE SETTLING TIME . . . . 2.5 seconds maximum.

(To 0.05% of range following a step change of reference voltage. Numerator response time same as "ac volts").

ISOLATED DATA OUTPUT (Using Option 8400A-03)

NOTE: Two mating connectors are supplied.

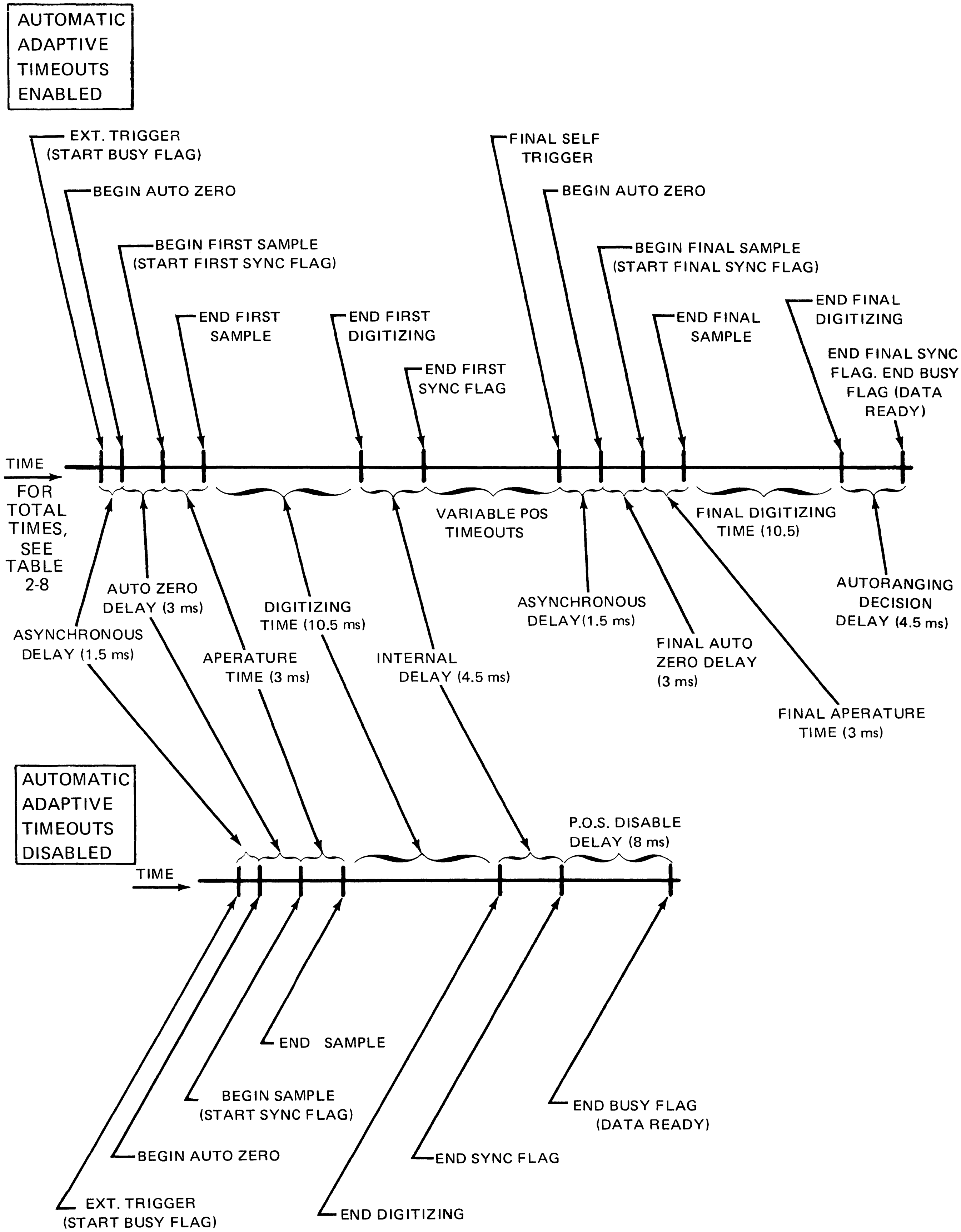
Data Available	Digits, polarity, range, functions
Coding	8 4 2 1 BCD, digits and range
Logic Levels	1 = +5V, 0 = 0V (Series 930 DTL with 6K pullup)
Maximum Trigger Rate	30 per second
Flags	Digitizing, Remotely Controlled, Remotely Triggered, Ready, Overload
Acquisition	Full parallel or serial by character in multiples of 4 bits
Automatic Adaptive Timeouts	Automatic delays to allow for settling time of all analog inputs are enabled via a single logic input line.

ISOLATED REMOTE CONTROL (Using Option 8400A-04)

NOTE: Mating connector is supplied

Control Levels	0 = function called, 1 = function inactive
Logic Levels	0 = Contact closure or 0V, 1 = open or +5V
Input Definition	Series 930 DTL
Control Command Storage	Continuous or addressed remote control of instrument. Triggered address control allows the 8200A to "latch" to input commands. Following latch, the commands may be removed but the functions and ranges commanded will continue to be in effect until the next address trigger.
Interlocks	Incompatible functions or simultaneous ranges cannot be called.

ISOLATED DATA OUTPUT TIMING DIAGRAMS



No Call . . . . Volts DC and autorange called
Flag Remotely controlled Flag in Data Output Unit

NOTE: Further Details available on request

PARALLEL REAR INPUT (Using Option 8400A-07)

NOTE: Switchable Rear/Front Inputs available on special quote.

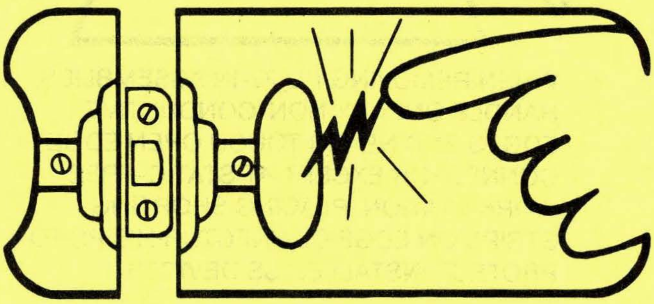
1-19. Accessories

- A90 Current Shunt
- 80F-15 High Voltage Probe
- 80RF High Frequency Probe
- 80F-5 High Voltage Probe
- M00-280-610 24-inch Rack Slide
- M03-203-601 Rack Ears
- M00-260-610 18-inch Rack Slide

static awareness

A Message From

John Fluke Mfg. Co., Inc.



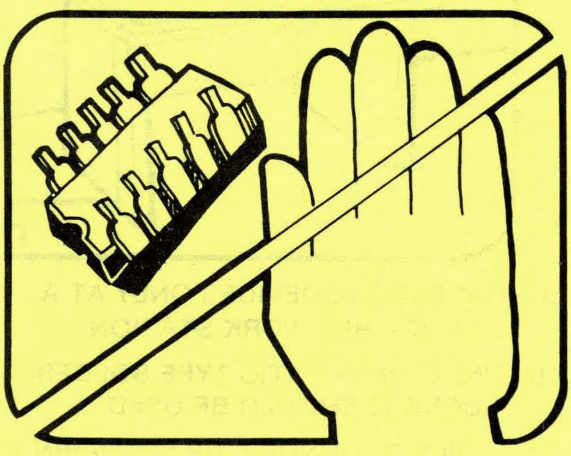
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

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.

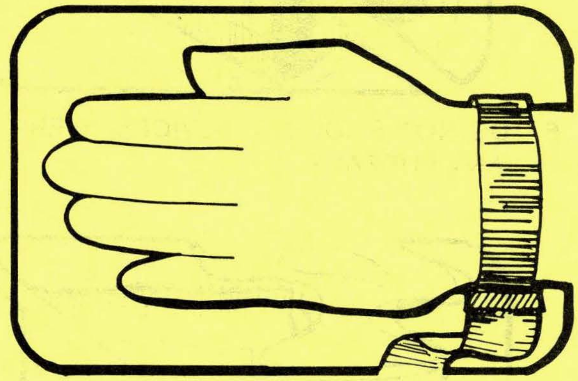
The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol

" "

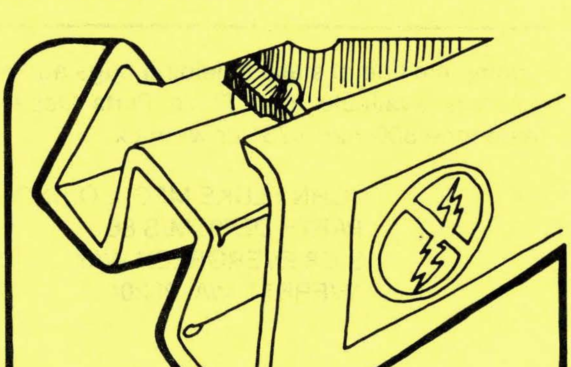
The following practices should be followed to minimize damage to S.S. devices.



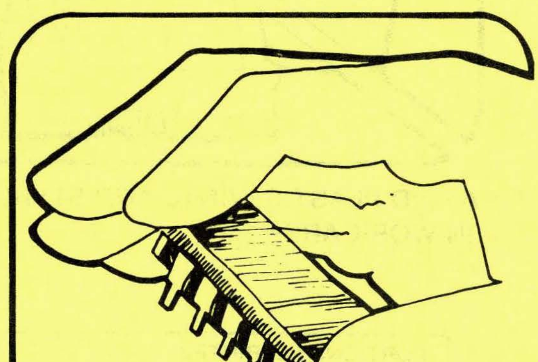
1. MINIMIZE HANDLING



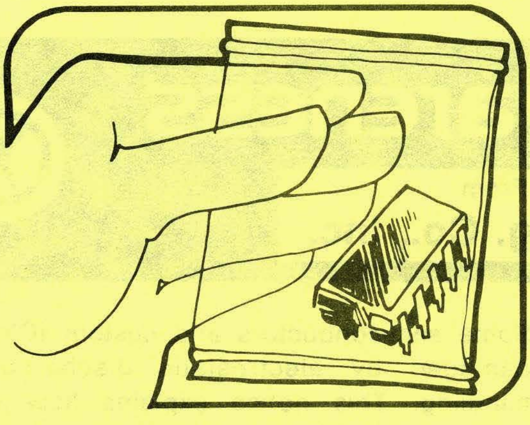
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



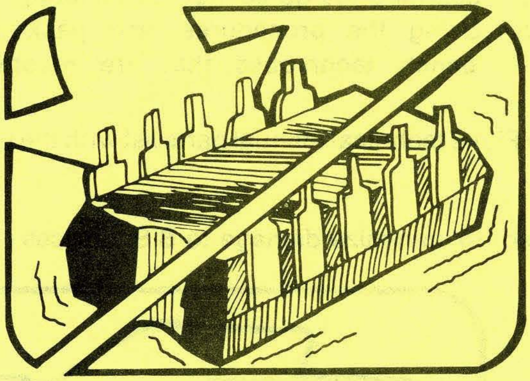
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



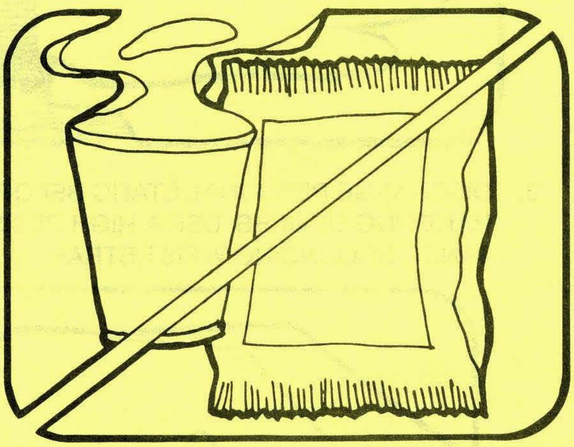
4. HANDLE S.S. DEVICES BY THE BODY



5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT



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



7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA

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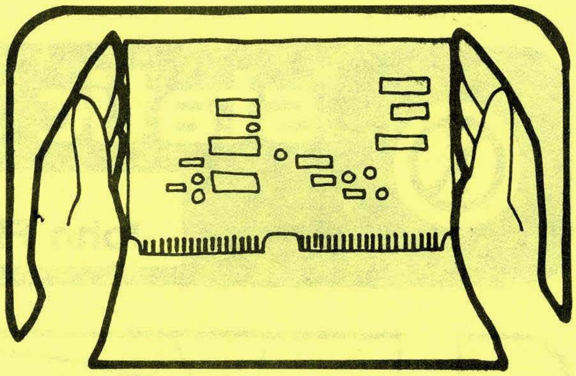
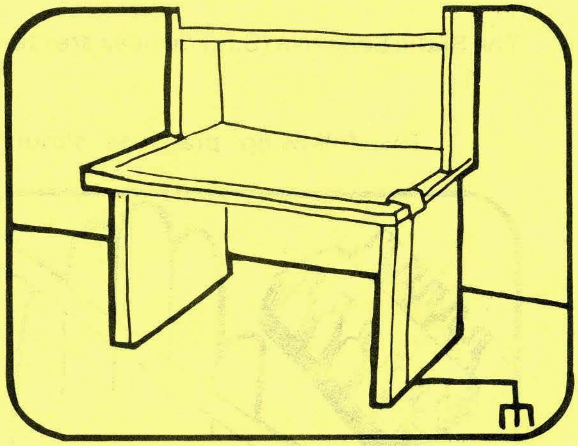


8. WHEN REMOVING PLUG-IN ASSEMBLIES, HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR HELPS TO PROTECT INSTALLED SS DEVICES.



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

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

11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

A complete line of static shielding bags and accessories is available from Fluke Parts Department, Telephone 800-526-4731 or write to:

JOHN FLUKE MFG. CO., INC.
PARTS DEPT. M/S 86
9028 EVERGREEN WAY
EVERETT, WA 98204

® Dow Chemical

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Rev. 1 MAR 86

Section 2
Operating Instructions

2-1. INTRODUCTION

2-2. This section contains operating instructions for the Model 8400A Digital Voltmeter. 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 8400A is supplied with non-marring feet and tilt-down bail for bench or field use. A rack-mounting kit and rack-slide kits for installation of the instrument in a standard 19-inch rack are available. These accessories are described in Section 6 of the manual.

2-5. REPACKAGING FOR SHIPMENT

2-6. This instrument was packed and shipped in a foam-packed cardboard carton. If reshipment is required, use the original container or request a new container from the John Fluke Mfg. Co., Inc. Please include instrument model number with your request.

2-7. OPTIONS AND ACCESSORIES

2-8. Model 8400A options and accessories are listed in Table 2-1. They are fully described in Section 6 of the manual.

Table 2-1. OPTIONS AND ACCESSORIES

Option No.	Name
8400A–01	AC Converter
8400A–02	Resistance Converter
8400A	Data Output
8400A–04	Remote Control
8400A–05	DC External Reference
8400A–06	AC External Reference
8400A–07	Rear Input
8400A–09	True RMS Converter
–01 required with –06 –01 and –09 cannot be Installed together –07 required with –05 or –06	

Accessory No.	Name
298265	Extender Assembly (Required for servicing pcb's)
M03-203-601	Rack Ears
M00-260-610	18-inch Rack Slides
M00-280-610	24-inch Rack Slides
A90	Current Shunts
80F-5	High Voltage Probe
80F-15	High Voltage Probe
80RF	High Frequency Probe

2-9. INPUT POWER REQUIREMENTS

2-10. The 8400A 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 (Figure 2-1). If the switch does not indicate the desired operating voltage, place it in the correct position.

WARNING!

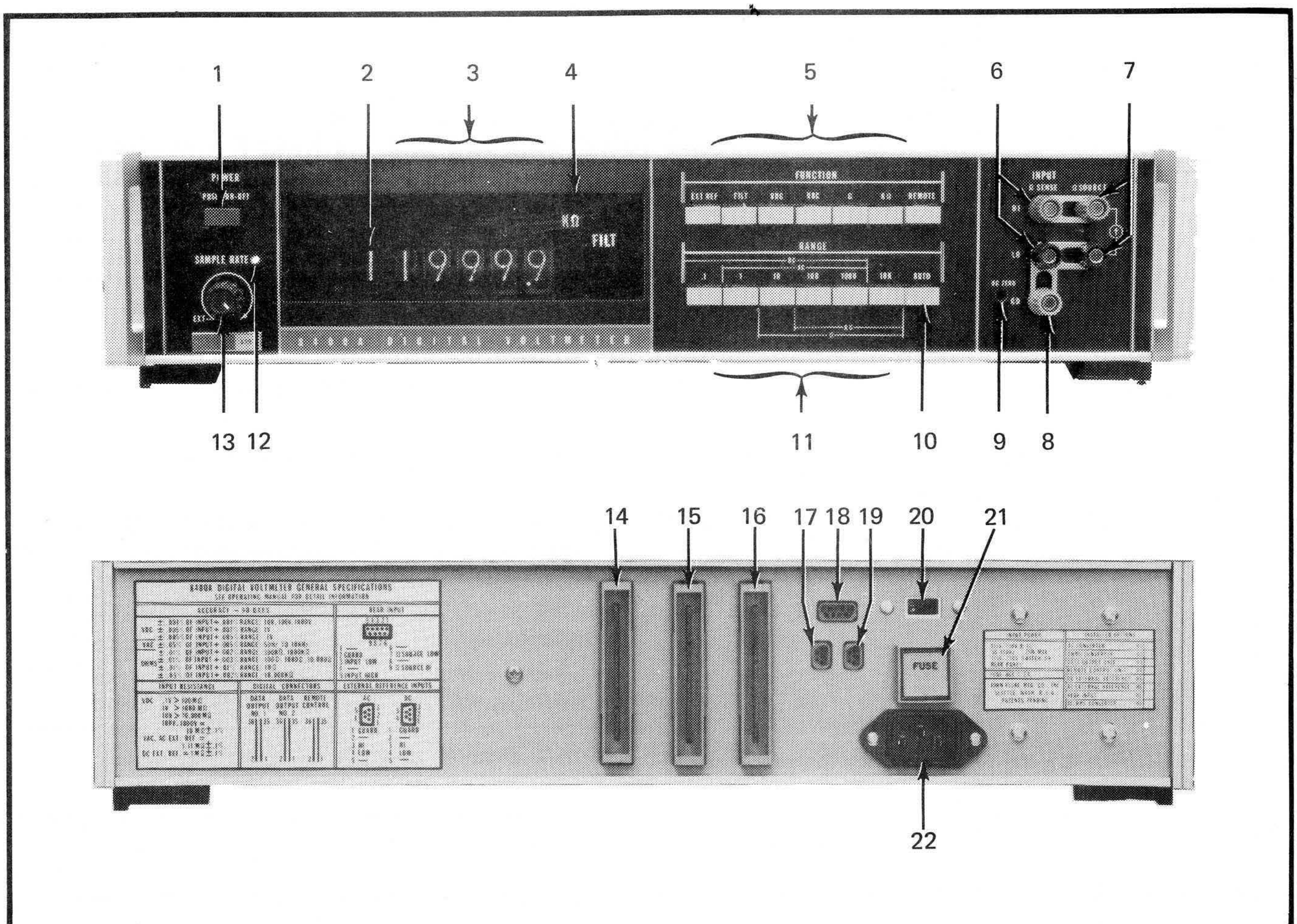
Ensure that the instrument case is connected to a high quality earth ground, either through the polarized line plug or through a separately connected ground wire.

2-11. OPERATING FEATURES

2-12. The name and function of front and rear panel controls, terminals and indicators are shown in Figure 2-1.

2-13. MEASUREMENT INSTRUCTIONS

2-14. Measurement instructions for basic DVM functions are given in Table 2-2.



REF. NO.	NAME	FUNCTION
1	POWER Switch	Controls application of input power.
2	Polarity Indicator	Automatic indication of input polarity for dc voltage: "+" for positive input voltages and "—" for negative input voltages.
3	Readout Tubes	Display DVM readout from left to right, with overrange digit displayed in left-most tube. All tubes display a decimal point, depending on range. Full overrange readout on each range would appear as follows: RANGE — READOUT .1 — .119999 1 — 1.19999 10 — 11.9999 100 — 119.999 1000 — 1199.99 10K — 11999.9

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

REF NO.	NAME	FUNCTION
4	Function/Status Annunciator	Indicate instrument function and status as follows: KΩ . . . . DVM operating in kilohm mode. AC . . . . DVM operating in ac voltage mode. DC . . . . DVM operating in dc voltage mode. Ω . . . . . DVM operating in ohms mode. X REF . . . DVM operating in External Reference mode. FILT . . . . Active 4-pole filter called for maximum noise rejection. OVER . . . DVM input is over the 20% overrange capability.
5	FUNCTION Switches	Select desired DVM operating mode: EXT REF . . Enables substitution of isolated external reference voltage for internal reference FILT . . . . Controls 4-pole active input filter to provide desired noise rejection. Functional for dc voltage, ac voltage, and resistance measurements. VDC . . . . Places DVM in dc voltage mode with full-scale ranges of .1, 1, 10, 100, and 1000. VAC . . . . Places DVM in ac voltage mode with full-scale ranges of 1, 10, 100, and 1000. Ω . . . . . Places DVM in ohms mode with full-scale ranges of 10, 100, 1000, and 10K if available range is called; otherwise, DVM autofunctions to KΩ. KΩ . . . . Places DVM in kilohms mode with full-scale ranges of 100, 1000 and 10K if available range is called; otherwise, DVM autofunctions to Ω. REMOTE . . Places DVM in remote mode, enabling DVM function and range to be controlled remotely via the Remote Control Unit.
6	INPUT Terminals	HI, LO input connections for dc and ac voltage measurement.
7	Ω SOURCE Terminals	Current source for all resistance measurements.
8	GD (Guard) Terminal	Connects to internal guard chassis. When properly connected externally, provides maximum common mode rejection.
9	DC ZERO Control	Adjusted for .000000 ±1 with VDC, Filter, and .1 Range called and INPUT terminals shorted.
10	AUTO RANGE Switch	Places DVM in autorange mode, providing automatic ranging for each function and its range complement.
11	Manual RANGE	Enable manual selection of DVM range. Not calling a range or incorrect range selection automatically places DVM in autorange mode.
12	Sample Rate Indicator	Visual indication of sample rate.
13	SAMPLE RATE Control	Permits variation of DVM sample rate from 13 readings per second to 1 reading per 4.5 seconds. In EXT position (fully counterclockwise), sample rate control is transferred to remote control point via the Data Output Unit. If the Data Output option is not installed and the control is turned to EXT, the DVM will read out and display from its internal storage circuitry indefinitely, with readout corresponding to value of last measurement sample.

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

REF NO.	NAME	FUNCTION
14	Data Output Unit Connector (No. 1)	Provides connections for Data Output Unit (Option –03).
15	Data Output Unit Connector (No. 2)	
16	Remote Control Connector	Provides connections for Remote Control (Option –04).
17	AC External Reference Connector	Provides connections for AC External Reference Unit (Option –06).
18	Rear Input Connector	Provides connections for rear input to DVM (Option –07).
19	DC External Reference Connector	Provides connections for DC External Reference Unit (Option –05).
20	115/230 Volt Input Power Switch	Selects either 115 or 230 volt ac line operation.
21	Line FUSE	Protects DVM from overloads. Fuse rating is AGC 1/2 ampere.
22	AC Line Voltage Connector	Mates with polarized 3-wire power cord for connection to 115/230 volt, 50 Hz to 440 Hz, ac line.

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

2-15. EXTERNAL REFERENCE

2-16. General

2-17. AC and DC External Reference options enable the user to substitute an external ac or dc voltage for the internal DVM reference voltage. The principal use of the instrument when operated in this manner is for voltage ratio measurements. Another important use is to allow substitution of a system voltage for the 8400A reference voltage. By this means, variables in systems measurements may be reduced.

2-18. The DC External Reference Unit makes 4-terminal voltage ratio measurements: ±dc to dc and ac to dc. The AC External Reference Unit makes 3-terminal ac to ac voltage ratio measurements. Separate rear panel input connectors are provided for ac and dc reference voltage inputs. The pin connection diagram for each connector is shown on a rear panel decal.

2-19. Operation

2-20. The following steps describe the basic operating procedure for ratio measurements using the External Reference options:

a. Select 8400A voltage range as desired according to the ratio range and corresponding readout, as shown in Table 2-3. Reference input range for the AC External Reference Unit is controlled by an internal range switch located on the AC External Reference Unit pcb. The switch is accessible through the top guard cover after removing the DVM top dust cover. Switch positions are marked on the guard cover.

Table 2-2. 8400A MEASUREMENT INSTRUCTIONS

MEASUREMENT	8400A FUNCTION	8400A RANGE	8400A INPUT CONNECTIONS	REMARKS
±DC Voltage	VDC	.1, 1, 10, 100, 1000, AUTO	Front panel HI, LO terminals or rear input terminals if equipped with Rear Input option.	DVM autoranges automatically if range is not manually called or if a range is called that is not compatible with the selected function. Use 4-terminal ohms measurements, if desired, on 10Ω through 10,000Ω ranges. SOURCE terminals must be connected, either remotely or with shorting links at INPUT binding posts, for all resistance measurements.
AC Voltage	VAC	1, 10, 100, 1000, AUTO		
Ohms	Ω	10, 100, 1000, 10K, AUTO		
Kilohms	KΩ	100, 1000, 10K, AUTO		
DVM Zero Adjustment	VDC, Filter	.1	Short INPUT terminals together. Use a low-thermal shorting link.	Adjust front panel DC ZERO control for readout of .000000 ±1.

Table 2-3. EXTERNAL REFERENCE RATIO RANGES

MODE	RATIO RANGE $\frac{V_{INPUT}}{V_{REF}}$	READOUT	REFERENCE INPUT
DC/DC X 10	0 to ±0.0119999 0 to ±0.119999 0 to ±1.19999 0 to ±11.9999 0 to ±100.00	0 to ±.119999 0 to ±1.19999 0 to ±11.9999 0 to ±119.999 0 to ±1000.00	+1V to +10.5V
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	
AC/AC	0 to 1.19999 0 to 11.9999 0 to 119.999 0 to 1000.00	0 to 1.19999 0 to 11.9999 0 to 119.999 0 to 1000.00	1V Range: 0.1V to 1.05V 10V Range: * 1V to 10.5V 100V Range: * 10V to 105V

* *Table shows values for 1V Reference Range only. For 10V and 100V Reference Ranges, readout equals 10X ratio and 100X ratio, respectively.*

EXTERNAL REFERENCE UNIT	REFERENCE VOLTAGE INPUT
DC	+1v to +10.5v
AC	1v, 10v and 100v ranges. (Maximum input: 130v rms.)

b. Connect reference voltage to rear input terminals.

c. Press EXT REF switch on the front panel.

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

2-21. Installation, theory of operation, and maintenance instructions for the External Reference options are covered in Section 6 of the manual.

2-22. REMOTE CONTROL UNIT

2-23. General

2-24. The Remote Control Unit (RCU) enables the 8400A to be programmed or controlled remotely. RCU inputs are designed to interface directly with DTL/TTL logic. Control by discrete transistors or contact switches is also possible. Operating power for the RCU must be supplied from an external +5 volt source having a current capability of at least 150 milliamperes. Power may be obtained from the Data Output Unit option if the DVM is so equipped.

2-25. The RCU provides the capability of controlling all DVM functions and ranges, with logic interlocking provided so that incompatible functions or simultaneous ranges cannot be called. Acceptable combinations are shown in Table 2-4.

2-26. RCU Command Triggering

2-27. The RCU has two operating modes which control entry of external commands into the unit: continuous command mode and triggered command mode.

2-28. In continuous command mode, the RCU requires no external triggering. The instrument always reflects present state of command inputs in continuous mode. To achieve this mode of operation, hold pin 35 (Auto Command Entry Defeat) and pin 33 (External Command Entry) at logical "1" (+5v) or open.

2-29. In triggered command mode, the RCU will only respond to programming inputs after application of an external trigger. It will memorize input commands within 10 microseconds of trigger application. Following the storage operation, programming inputs may be changed or removed without affecting stored information. To achieve this mode of operation, hold pin 35 (Auto Command Entry Defeat) low by application of logical "0" or contact closure and apply the external trigger to pin 33 (External Command Entry). RCU connector location is shown in Figure 2-1. Pin assignments are given in Table 2-5. Trigger requirements (External Command Entry) are given in Figure 2-2.

2-30. Operation

2-31. To place DVM in remote operation, proceed as follows:

a. Press REMOTE FUNCTION switch to transfer control of DVM function and range to the remote control point.

Table 2-4. REMOTE CONTROL UNIT LOGIC INTERLOCKING

FUNCTION CALLED	RANGE CALLED							FILTER	RATIO
	.1	1	10	100	1000	10K	NONE		
VDC	.1	1	10	100	1000	AUTO	AUTO	YES	YES
VAC	AUTO	1	10	100	1000	AUTO	AUTO	YES	YES
Ω	AUTO	AUTO	10	100	1000	10K	AUTO	YES	NO
KΩ	AUTO	AUTO	AUTO	100	1000	10K	AUTO	YES	NO

NOTE: 1. *If function and range are not called, DVM goes to VDC mode and autoranges (providing REMOTE button is pressed).*

2. *When ranges are selected manually, DVM will autofunction between Ω and KΩ if the selected range does not agree with the called function.*

Table 2-6. REMOTE CONTROL UNIT PIN ASSIGNMENTS

FUNCTION	PIN NO.	FUNCTION	PIN NO.
Common	*2	$\overline{\text{VAC}}$	17
Common	*4	$\overline{\text{K}\Omega}$	19
Common	*6	$\overline{\Omega}$	23
$\overline{\text{1 Range}}$	7	$\overline{\text{1 Range}}$	25
Common	*8	$\overline{\text{100 Range}}$	27
+5V Input	**9	$\overline{\text{External Reference}}$	29
$\overline{\text{1000 Range}}$	11	$\overline{\text{Filter}}$	31
$\overline{\text{10K Range}}$	13	External Command Entry	***33
$\overline{\text{10 Range}}$	15	Auto Command Defeat	***35

Spare Pins: 1, 3, 5, 10, 12, 14, 16, 18, 20, 22, 24 26, 28, 30, 32, 34, 36

LOGIC LEVELS

LOGIC 1 = +5V OR OPEN (INPUT DEVICE MUST BE ABLE TO SOURCE 40μAMP AT 2.6V)

LOGIC 0 = 0V OR CONTACT CLOSURE (INPUT DEVICE MUST BE ABLE TO SINK AT 1.6 MA AT 0V)

TRUTH TABLE

1 - FUNCTION NOT CALLED

0 = FUNCTION CALLED

NOTES:

* *Isolated from Input "LO" and chassis*

** *+5V Input: Maximum current requirement = 150 milliamperes. (Available from DOU)*

*** *Used only in Control Command Storage mode of operation. No connections are required when RCU is controlled with continuously applied commands.*

b. If remote control of DVM sample rate is desired, turn SAMPLE RATE control to its extreme CCW position (EXT). In EXT position, the internal sample rate oscillator is disabled and the DVM sample command is applied via the Data Output Unit. If the Data Output Unit is not installed and the control is turned to EXT, the DVM will readout and display from analog storage indefinitely. The readout will correspond to the value of the last measurement.

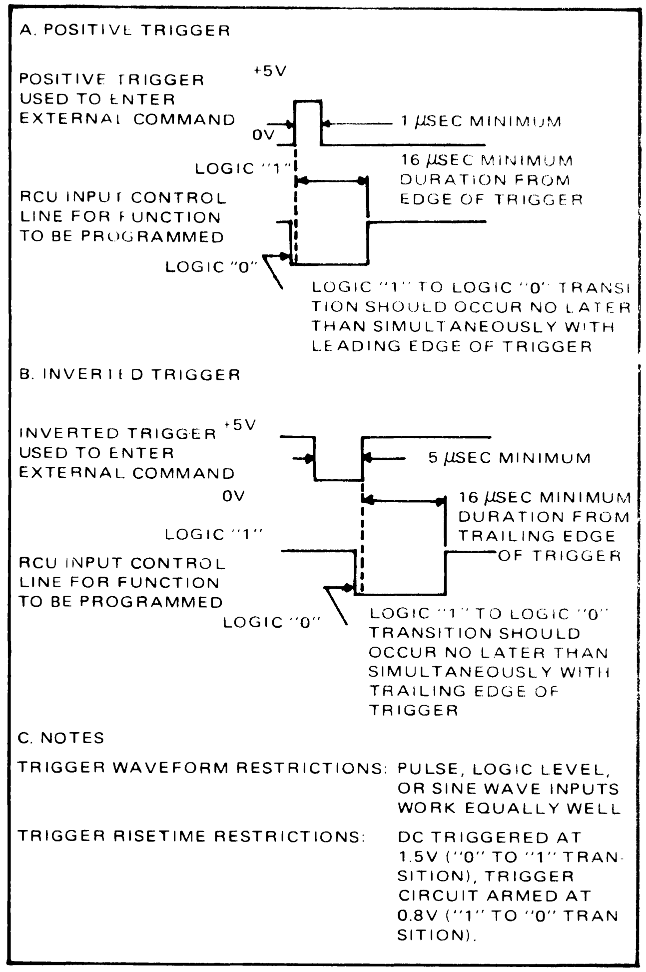


Figure 2-2. REMOTE CONTROL UNIT TRIGGER REQUIREMENTS (EXTERNAL COMMAND ENTRY)

c. Command a function or range via a contact closure or a zero volt logic level between the appropriate pin and common. For example, to program 10k ohm, filtered operation, command pins 13, 23, and 31 via contact closure or zero volts to pin 2, 4, or 6 (commons).

2-32. Installation, theory of operation, and maintenance instructions for the Remote Control Unit are covered in Section 6 of the manual.

2-33. DATA OUTPUT UNIT

2-34. General

2-35. DOU access is by means of two card-edge connectors located at the rear of the instrument (Figure 2-1). Data may be acquired fully in parallel BCD format or serially by character in multiples of four-bits. The Programmed One-Shot (POS) line enables automatic time delays that allow for full settling of analog input circuitry prior to data transfer.

2-36. The DOU is self powered and provides +5V (150 milliamperes maximum) output for operation of the Remote Control Unit (Option –04) or other logic circuitry. DOU truth tables and logic levels are given in Table 2-6. Functional pin connections for the DOU are given in Table 2-7.

2-37. Control Signals

2-38. DOU control inputs consist of External Trigger, External Trigger Inhibit, and Programmed One-Shot. The External Trigger may be a positive or negative going signal, as shown in Figure 2-3. The External Trigger Inhibit input must be a logical "0" to inhibit and a logical "1" to enable. The Programmed One-Shot input must be a logical "1" for fast operation (timeouts defeated) and a logical "0" for normal operation (programmed timeouts).

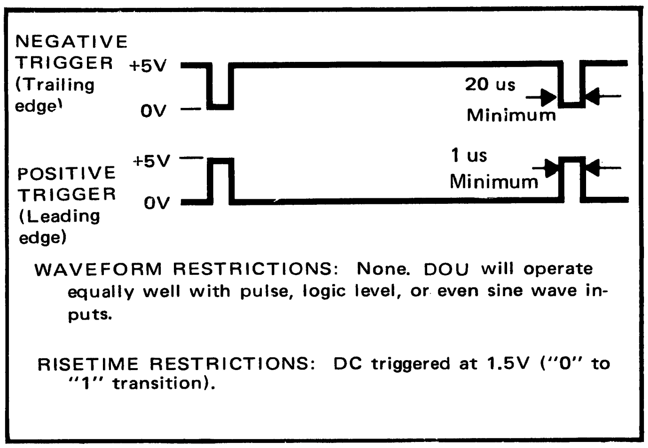


Figure 2-3. DATA OUTPUT UNIT TRIGGER REQUIREMENTS

2-39. The Sample Sync signal corresponds in timing to the DVM sample periods occurring in each measurement period, as shown in Figure 2-4. During the time the DVM is busy processing a request for data, the time of occurrence of the second or final sample period is subject to a number of delays, depending on DVM operating mode, autoranging delays, etc. The purpose of the Sample Sync signal is to inform the DVM input signal acquisition device (scanner) when the final sample is taken by the DVM. This information is useful when the DVM is used in a scanning system, where it is desirable that inputs be changed at the earliest possible time without altering the previous sample.

2-40. Programmed One-Shot

2-41. The response of the 8400A Data Output Unit to a data request consists of a function-dependent series of delays. When enabled, the Programmed One-Shot circuit in the DOU automatically sequences the delay series to provide data within specified accuracy in the minimum possible time. If settling time is not a problem in specific applications, convenience is enhanced by provision for defeat of the POS, allowing sample rates as high as 30 per second. Application of +5v logic level or open circuit to pin 2 defeats the POS (Fast Sample); application of logic zero or contact closure to pin 2 enables the POS (Normal Sample). Figure 2-5 illustrates the timing of the events that occur

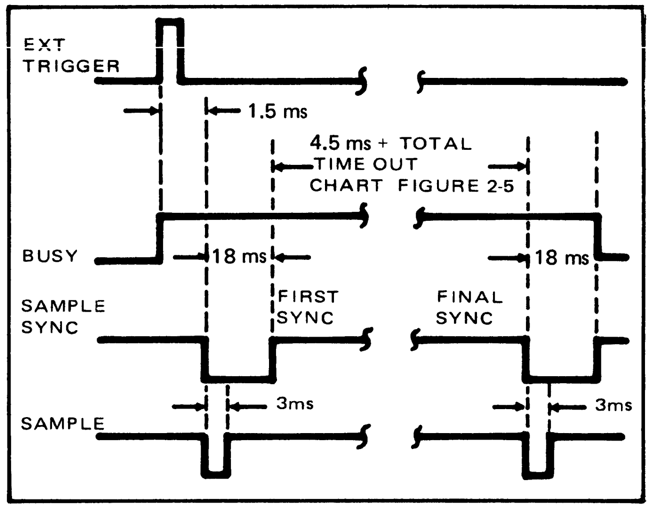


Figure 2-4. SAMPLE SYNC. SIGNAL TIMING (AUTOMATIC ADAPTIVE TIMEOUTS ENABLED).

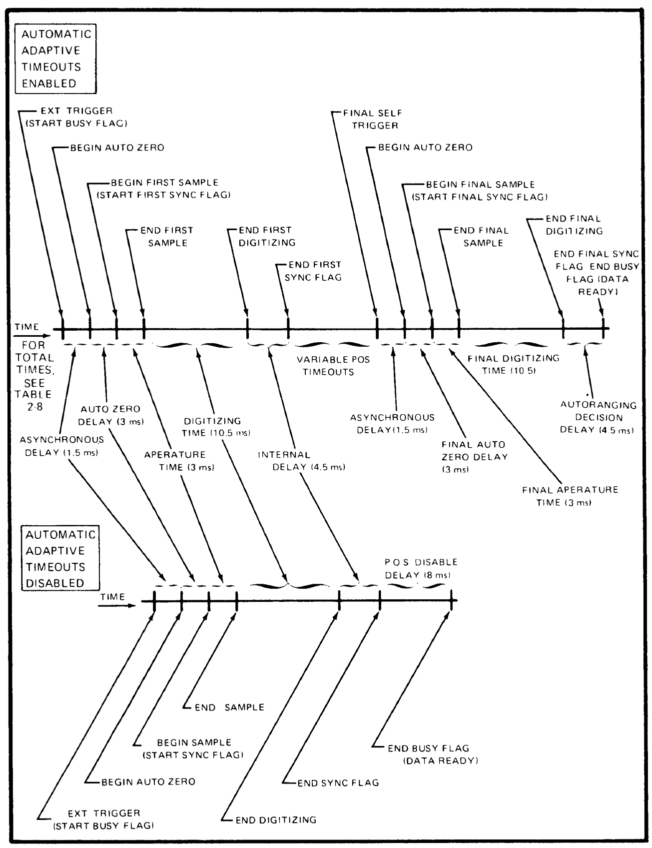


Figure 2-5. 8400A MEASUREMENT CYCLE TIMING DIAGRAM.

Table 2-6. DATA OUTPUT UNIT FUNCTIONAL PIN CONNECTIONS

DATA	CONNECTOR PIN NO. DOU NO. 1	CONNECTOR PIN NO. DOU NO. 2	REMARKS
Range (coded)			See range table below
b	33		
c	31		
d	32		
GR (gate)	36		
Overrange			
1	34		
GOR (gate)	35		
1st Decade (MSD)			Apply logic 0 to gates to inhibit decade data outputs.
8	27		
4	29		
2	28		
1	30		
G1 (gate)	25		
2nd Decade			
8	21		
4	23		
2	22		
1	24		
G2 (gate)	19		
3rd Decade			
8	15		
4	17		
2	16		
1	18		
G3 (gate)	13		
4th Decade			
8	9		
4	11		
2	10		
1	12		
G4 (gate)	5		
5th Decade			
8	3		
4	6		
2	2		
1	4		
G5 (gate)	1		

RANGE	LINE b	LINE c	LINE d
10000	0	0	0
1000	0	0	1
100	0	1	0
10	0	1	1
1	1	0	0
.1	1	0	1

Note:
Logic 1 = +5V
Logic 0 = 0 to 0.5V

DATA	CONNECTOR PIN NO. DOU NO. 1	CONNECTOR PIN NO. DOU NO. 2	REMARKS
Control Inputs			
Ext. Trig.		3	
Ext. Trig. Inhibit		1	
Programmed One-Shot		2	
Primary Function Flags			Apply logic 0 to gates to inhibit function data outputs. Logic 1: Function active, Negative polarity. Logic 0: Function inactive, Positive polarity
VDC		6	
VAC		4	
Ω		12	
KΩ		10	
GPF (gate)		26	
Secondary Function Flags			
Polarity		18	
Filter		20	
Ext. Ref.		16	
Remote		14	
GSF (gate)		22	
Flags:			Logic 1: / Logic 0:
Busy		8	Busy / Not Busy
Sample Sync		31	No Sam.Sync / Sam.Sync
Overload		13	Overload / No overload
Trigger		15	Triggered / Not Triggered
GOL (gate)		17	
Power Output			Maximum output: 150 milliamperes at +5 vdc.
+5 vdc	20	36,34	
Common		33,35	
Code Conversion Terminals			See paragraph 2-44 for code conversion information.
Z_{out}		9	
Z_1		30	
Z_{in}		25	
Y_{out}		5	
Y_1		32	
Y_{in}		21	
X_{out}		7	
X_1		29	
X_{in}		23	
W_{out}		11	
W_1		24	
W_{in}		19	

during the busy flag. The total busy flag time when the automatic adaptive timeouts are enabled, is given in Table 2-7.

2-42. Code Conversion

2-43. The 8-4-2-1 BCD code (standard) used in the 8400A may be converted to some other code, using the convenient code conversion terminals provided at the output connector on DOU No. 2. To convert to another code remove the jumpers and connect the code conversion network, as shown in Figure 2-6. Usually only two integrated circuits are required in the network vs. about twelve for parallel conversion at the outputs, so a considerable saving may be realized. Detailed information regarding code conversion is available from the factory.

2-44. Figure 2-7 contains comprehensive timing diagrams for measuring both switched and continuously applied inputs when the D.O.U.'s automatic adaptive timeouts are not enabled.

2-45. OUTPUT FLAGS

2-46. Besides the Busy Flag (Data Not Ready), there is also a Sample Sync Flag. This flag goes to logic "1" when the DVM starts sampling the input signal (aperture window opening). By using the Sample Sync Flag (negative transisition - leading edge), plus an external 3 millisecond, one-shot delay, total data acquisition time can be decreased when using input scanners or a changing input signal which require long settling times. This will take advantage of the fact that the aperture window is only open for 3 milliseconds allowing the input signal to be changed and to be settled before the next sample aperture occurs. When the Automatic Timeouts are enabled, the final sample sync flag must be used instead of the initial or intermediate sync flags. See Figure 2-4 for timing of the sample sync flag.

2-47. The trigger flag indicates if the DVM is being triggered internally or externally. Other flags are the over-

Table 2-7. TOTAL BUSY FLAG TIME OUT
(Automatic Adaptive Timeouts Enabled)

FUNCTION RANGE	TOTAL TIME FILTER OUT	MS FILTER IN
VDC-10, 100, 1000	54 ±3	523 ±42
VDC-0.1, 1.0	123 ±10	523 ±42
VAC - all ranges	123 ±10	523 ±42
Ω – all ranges	123 ±10	523 ±42
kΩ – all ranges	73 ±6	523 ±42
Autorange – per range change	Add 50	Add 280

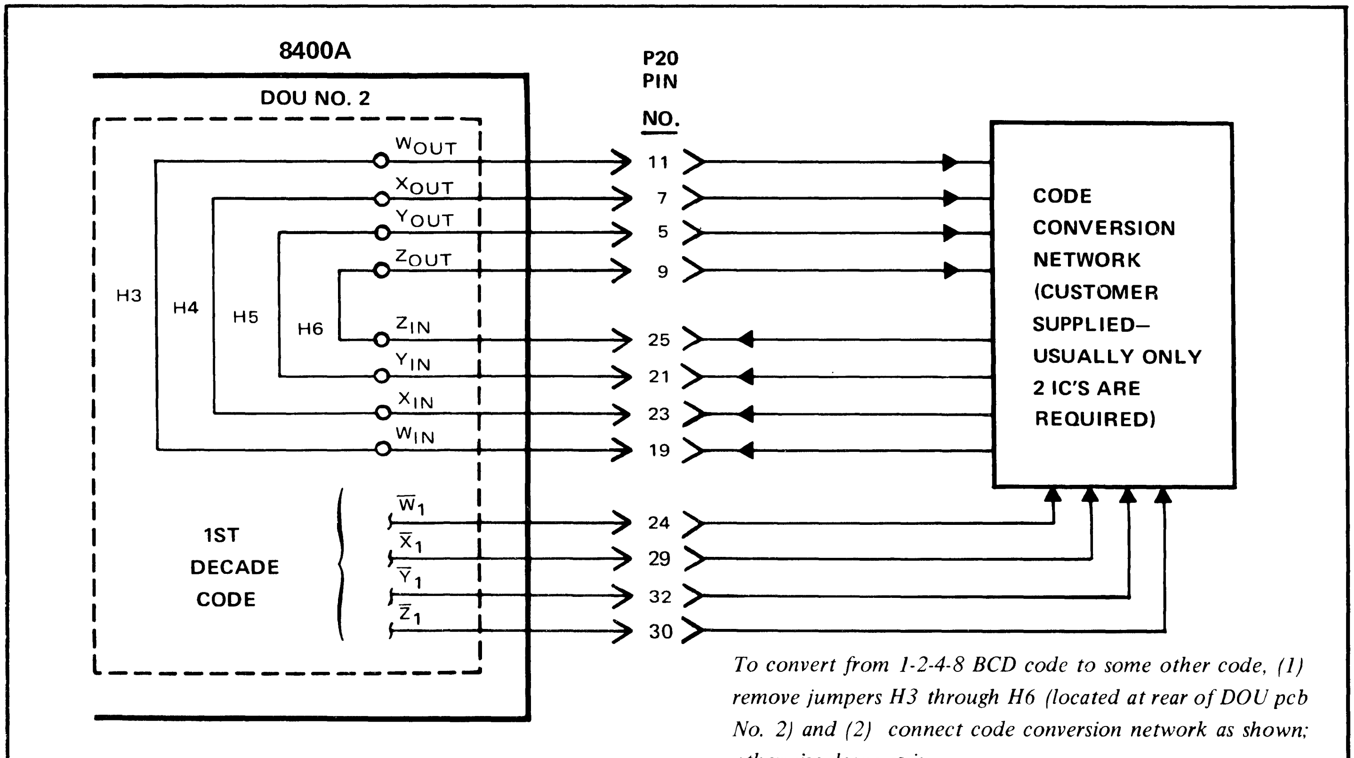
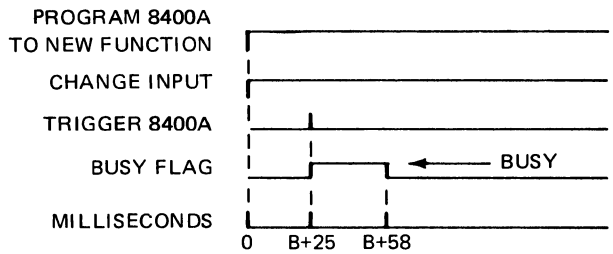


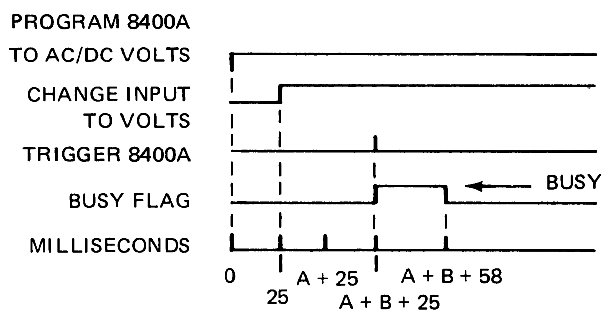
Figure 2-6. CODE CONVERSION

1. WITH PROGRAMMED FUNCTION AND/ OR RANGE CHANGE - AUTORANGING NOT ALLOWED.



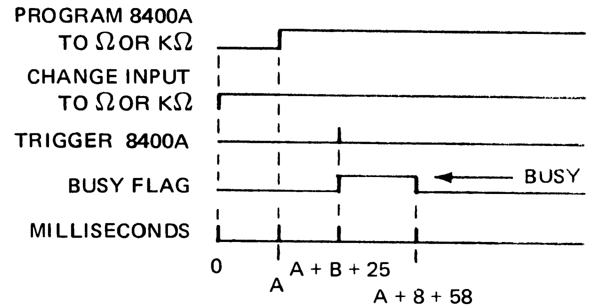
B = BUFFER SETTLING TIME FROM TABLE D
25 = TIME TO SWITCH 8400A INTERNAL RELAYS

a. SIMULTANEOUSLY CHANGE INPUT AND PROGRAM FROM A FORMER FUNCTION TO A NEW ONE WHEN FORMER INPUT DOES NOT CAUSE OVERLOAD CONDITION FOR NEW FUNCTION, OR NEW INPUT WOULD NOT CAUSE OVERLOAD CONDITION FOR OLD FUNCTION. (SEE SPECIFICATIONS ON DATA SHEET).



B = BUFFER SETTLING TIME FROM TABLE D
A = TIME TO SWITCH INPUT
25 = TIME TO SWITCH 8400A INTERNAL RELAYS

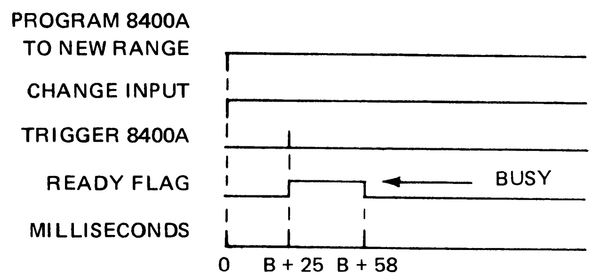
b. PROGRAM 8400A TO AC OR DC VOLTS FROM Ω OR KΩ, THEN APPLY A VOLTAGE INPUT GREATER THAN SPECIFIED Ω OR KΩ "OVERLOAD" INPUT. (SEE SPECIFI CATIONS ON DATA SHEET)



B = BUFFER SETTLING TIME FROM TABLE D
A = TIME TO SWITCH INPUT
25 = TIME TO SWITCH 8400A INTERNAL RELAYS

c. PROGRAM 8400A TO Ω OR KΩ FROM AC OR DC VOLTS WHEN INPUT VOLTAGE IS GREATER THAN SPECIFIED OVERLOAD FOR Ω OR KΩ INPUTS. (SEE SPECIFICA- TIONS ON DATA SHEET).

2. WITH PROGRAMMED RANGE CHANGE BUT NO FUNCTION CHANGE.



B = BUFFER SETTLING TIME FROM TABLE D
25 = TIME TO SWITCH 8400A INTERNAL RELAYS

TABLE D

BUFFER SETTLING TIME TABLE

FUNCTION	RANGE	BUFFER SETTLING TIME IN MILLISECONDS FILTER "OUT"	FILTER "IN"
DCV	.1V	100	500
	1,10,100	33	500
	1000	33	500
ACV	ALL	33	500
Ω	10	100	500
	100,1000	33	500
	10,000	33	500
KΩ	100	33	500
	1000,1000	33	500

Figure 2-7. SINGLE READING TIMING REQUIREMENTS WHEN D.O.U.'S AUTOMATIC ADAPTIVE TIMEOUTS ARE NOT ENABLED.

load, Volts DC, Volts AC, Ohms, Kilohms, Polarity, Filter, External Reference and Remote Flags which are self-explanatory. Refer to Table 2-7 for pin connections and level information.

2-48. Completely Parallel Data Acquisition

2-49. For completely parallel data acquisition, perform the following steps:

a. Determine the BCD code to be used and wire accordingly (see paragraph 2-42 for code conversion information).

NOTE!

8-4-2-1 BCD is supplied in standard 8400A.

b. Acquire full digits data by connection to the decade outputs. Leave inhibit lines associated with each decade open.

c. Acquire function, range, overrange and polarity data as desired. Leave associated inhibit lines open.

d. If data output is to be applied to a printer, the foregoing data could be grouped for presentation in several printer columns, with each column weighted as desired.

e. Acquire busy, overload, and trigger flags for use as desired.

2-50. Serial Character, Parallel Bit Acquisition

2-51 For serial character, parallel bit acquisition, perform the following steps:

a. Determine the BCD code to be used and wire accordingly (see paragraph 2-42 for code conversion information).

b. Connect function, range, polarity, and digit outputs in parallel, as shown in Figure 2-8 or in groups of 8, 12, 16 bits, etc., as desired.

c. User supplied clock controls inhibit lines to determine the sequence of character acquisition. Data is transferred to the output lines when the associated inhibit lines are high. Truth tables and acquisition format are also shown in Figure 2-8.

2-52. Minimum Lines Acquisition

2-53. Minimum lines acquisition is a practical application of serial character, parallel bit acquisition, in which a user-supplied clock is placed near the 8400A to sequentially control the inhibit lines. Proceed as follows:

a. Place a customer fabricated 9-segment ring counter near the 8400A and interface as shown in Figure 2-9.

b. Trigger the 8400A. (The Sample Time line may be programmed via interface or it may be hardwired).

c. When data is ready, transition of the 8400A BUSY signal 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. An OVERLOAD line is available to serve as an alarm or priority interrupt.

2-54. Installation, theory of operation, and maintenance instructions for the Data Output Unit are covered in Section 6 of the manual.

2-55. OPERATING NOTES

2-56. Overload Protection

2-57. The 8400A is protected against overload in each function and on all ranges. Table 2-8 lists the maximum voltages that may safely be applied to the DVM on all ranges.

2-58. Guarded Measurements

2-59. The 8400A employs 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 versatile systems DVM capable of fully-floating measurements without significant degradation of accuracy.

2-60. Non-floating measurements will likely be the usual case. Under these conditions, it is satisfactory to strap the front panel guard (GD) terminal to the LO input terminal using the shorting link provided.

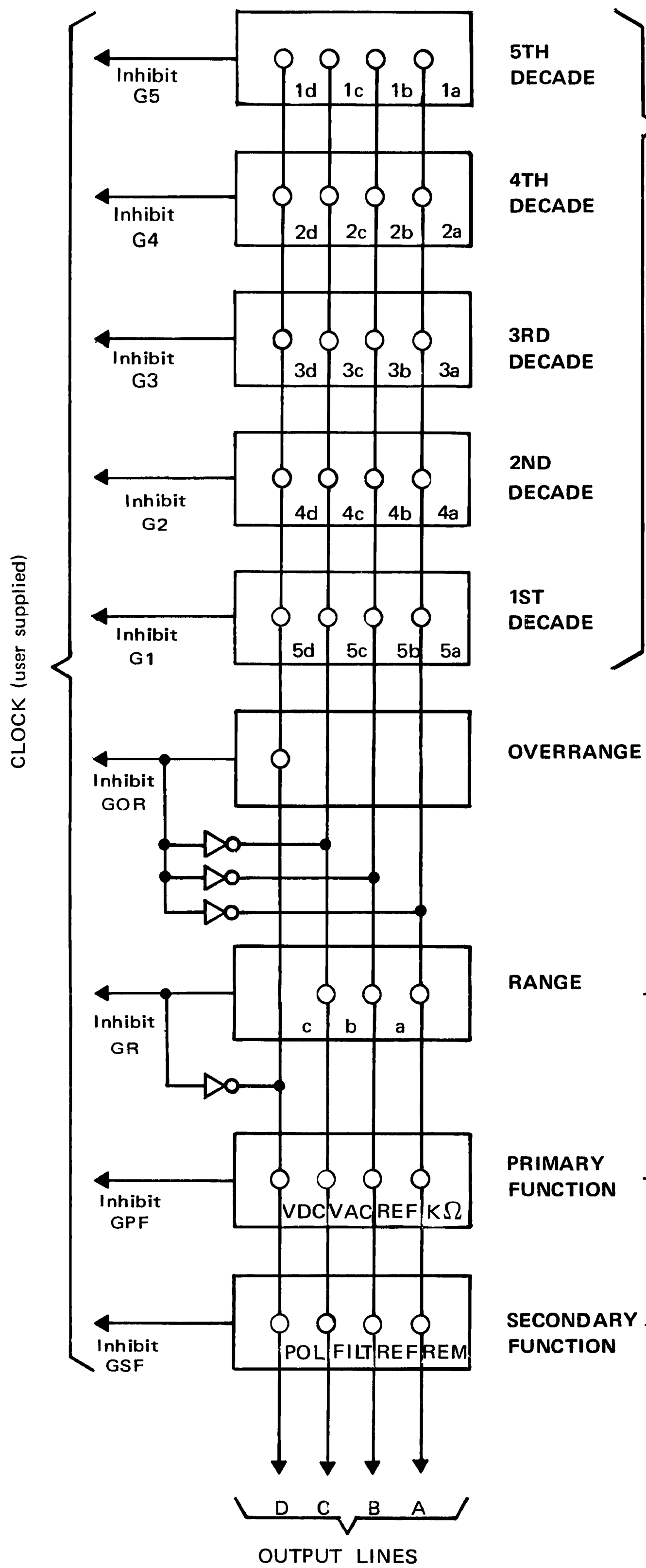
CAUTION!

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

2-61. In general, guarded voltage and resistance measurements will be necessary under the following conditions:

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

WIRING EXAMPLE



ACQUISITION FORMAT

BIT	0	1	2	3	4	5	6	7	8	9
d	0	1	0	1	0	1	0	1	0	1
c	0	0	1	1	0	0	1	1	0	0
b	0	0	0	0	1	1	1	1	0	0
a	0	0	0	0	0	0	0	0	1	1

BIT	0	1
d	0	1
c	0	0
b	0	0
a	0	0

RANGE	BIT			
	a	b	c	d
10K	0	0	0	0
1000	0	0	1	0
100	0	1	0	0
10	0	1	1	0
1	1	0	0	0
.1	1	0	1	0

FUNCTION	BIT			
	a	b	c	d
VDC	0	0	0	1
VAC	0	0	1	0
Ω	0	1	0	0
KΩ	1	0	0	0

FUNCTION	BIT			
	a	b	c	d
POL	0	0	0	1
FILT	0	0	1	0
REF	0	1	0	0
REM	1	0	0	0

Figure 2-8. WIRING EXAMPLE, ACQUISITION FORMAT, AND TRUTH TABLES FOR SERIAL CHARACTER, PARALLEL BIT ACQUISITION

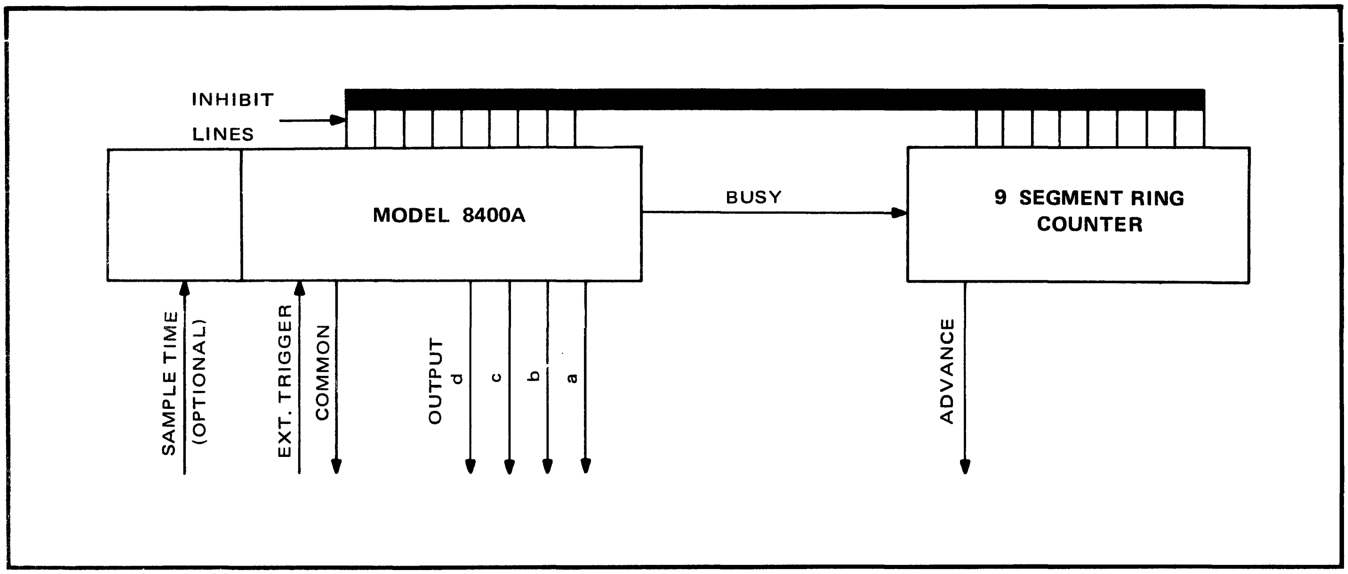


Figure 2-9. MINIMUM LINES ACQUISITION

Table 2-8. OVERLOAD PROTECTION CHARACTERISTICS

FUNCTION	MAXIMUM SAFE INPUT	FORM OF PROTECTION
VDC	±1100V dc or RMS (±1500V peak) continuously on any range.	Circuit Design
VAC	1100V RMS continuously on any range.	
RESISTANCE: 10Ω - 10,000KΩ ranges	20V RMS	FUSE: 15 ma fuse (with spare) located on Ohms Converter PCB
100 KΩ – 10,000 KΩ ranges	250V RMS continuously	Circuit Design
DC EXTERNAL REFERENCE	+10.5 (Note: The algebraic sum of the DVM input voltage and the common difference voltage should not exceed 13 volts dc or peak ac).	FUSE: 15 ma fuse located on DC External Reference Converter PCB protects mainframe if maximum common difference voltage is exceeded.
AC EXTERNAL REFERENCE	130V RMS at Reference Input terminals.	Circuit design

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

c. When the DVM is operating in the presence of high-level radiated noise, of which the most common example is stray fields at the power line frequency.

2-58. Figure 2-10 shows two methods for making guarded voltage measurements where reduction of common mode-to-normal signal conversion is desired. Figure 2-11 shows two methods for connection of the guard terminal when making ohms measurements.

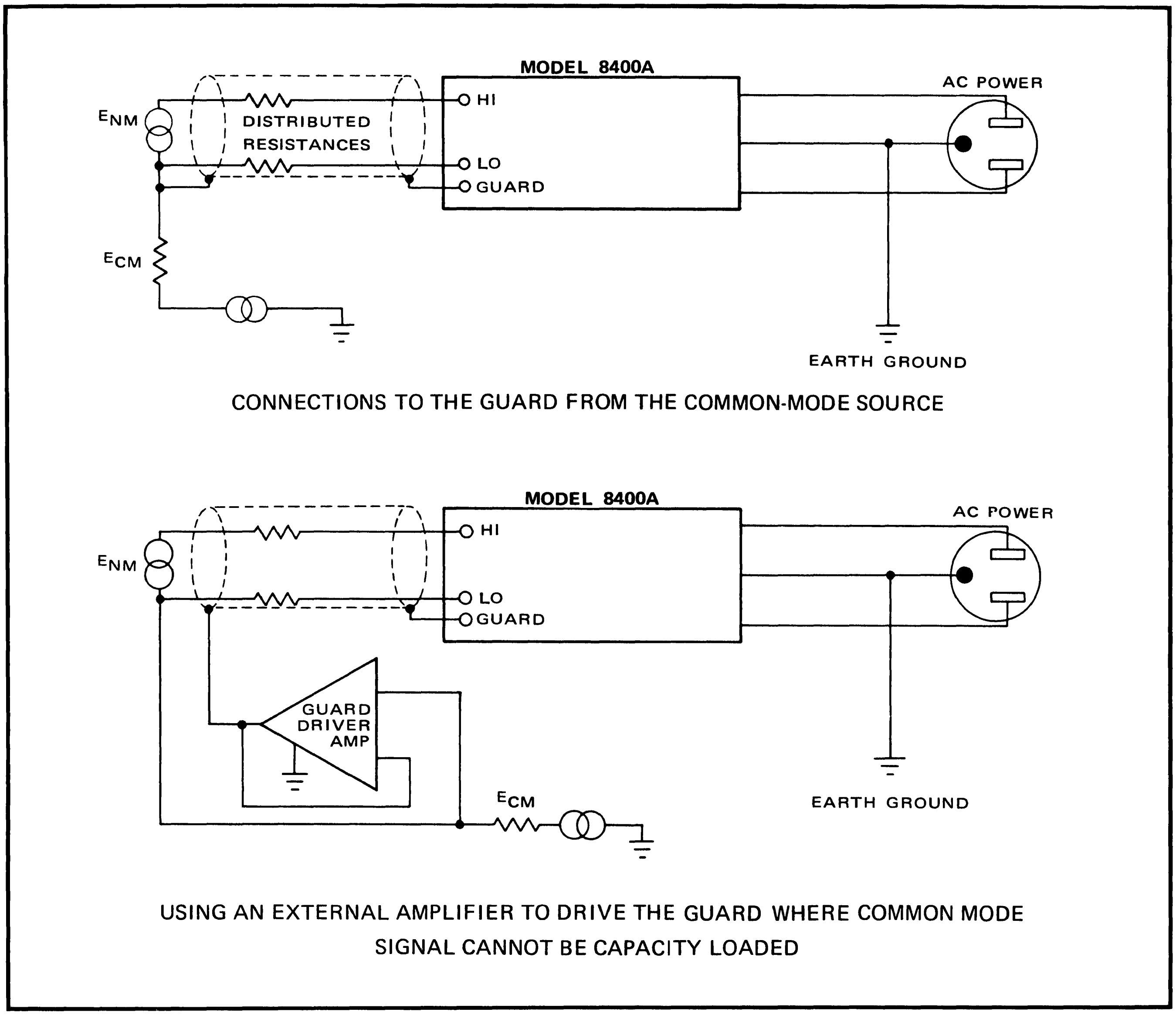


Figure 2-10. SUGGESTED GUARD CONNECTIONS FOR REDUCTION OF COMMON MODE-TO-NORMAL MODE SIGNAL CONVERSION

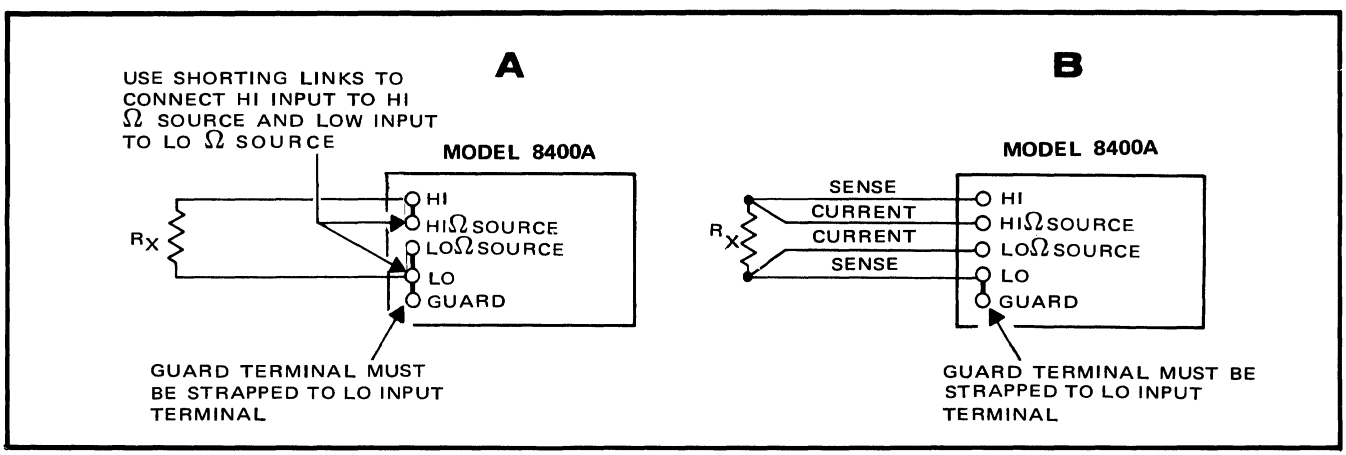


Figure 2-11. PROPER GUARD CONNECTIONS FOR (A) 2-TERMINAL Ω MEASUREMENTS WHEN SIGNAL LEADS ARE SHORT AND (B) 4-TERMINAL Ω MEASUREMENTS ON 10Ω THROUGH 10,000Ω RANGES

Section 3
Theory of Operation

3-1. INTRODUCTION

3-2. This section describes the theory of operation of the Model 8375A. The information is arranged under headings of "BLOCK DIAGRAM ANALYSIS" and "CIRCUIT DESCRIPTIONS." Simplified block diagrams and circuits are included with the text information. Schematic diagrams are located at the rear of the manual.

3-3. BLOCK DIAGRAM ANALYSIS

3-4. Buffer (A11)

3-5. The Buffer (A11) receives the dc input voltage and scales it up or down so that a full-scale input produces a full-scale 10V output to the active filter. (Refer to Figure 3-1.) When the 0.1 or 1V range is selected, the Buffer is configured as an amplifier having a gain of 100 or 10, respectively. In the 10, 100 or 1000V range, the A11 Buffer has a fixed unity gain and the input is scaled using a divider to provide the full-scale ±10V output.

3-6. Active Filter (A10)

3-7. The A10 Active Filter suppresses ac noise present in the Buffer output. It consists of a voltage follower and a four-pole filter. Filtering is in effect when the FILTER switch on the front panel is pressed. If this switch is not pressed, the four-pole filter is bypassed and the circuit functions as a voltage follower. The resulting filtered or unfiltered output is applied to the A9 A/D Converter.

3-8. Logic (A8)

3-9. The A8 Logic produces the master timing signals from which the measurement periods in the instrument are established. It also produces the reference voltage upon which the accuracy and stability is based. The circuitry consists of a master clock, a six-state shift register, a current controlled oscillator (CCO), a four-bit binary counter, and a +7V reference supply. The master clock produces gating signals that synchronize all timing circuitry in the instrument. The shift register is driven by the clock signals and produces digit cycle control signals for the A9 A/D Converter. Any output from the A/D amplifier produces an output from the analog comparator which enables the CCO to send output pulses to the binary counter. The binary counter selects the appropriate steps in the A9 A/D Converter ladder such that the CCO output is ultimately disabled. The resulting state of the binary counter is also applied to the A14 Display and decoded to indicate the measured value. The ±7V reference supply output is applied to the ladder in the A9 A/D Converter.

3-10. A/D Converter (A9)

3-11. The A9 A/D Converter receives the output from the Active Filter, determines the polarity, and serially digitizes the input voltage. The digitizing process is controlled through commands from the A8 Logic assembly. The circuitry consists of an inverting amplifier, polarity detector, sample and hold, A/D amplifier, ladder switches, and an analog comparator amplifier. The inverting amplifier receives the positive or negative outputs of the A10 Active Filter and inverts the positive output so that the input to the A/D amplifier is always negative. Polarity of this signal is sensed by the polarity detector and applied to the A14 Display section. Any output voltage from the A/D amplifier, greater than Vref, produces an output from the analog comparator which then enables the CCO to send output pulses to the binary counter. The binary counter pulses gate the appropriate ladder switches in the A/D converter to produce a voltage across the primary ladder resistors. The resulting voltage is equal in value, but opposite in polarity,

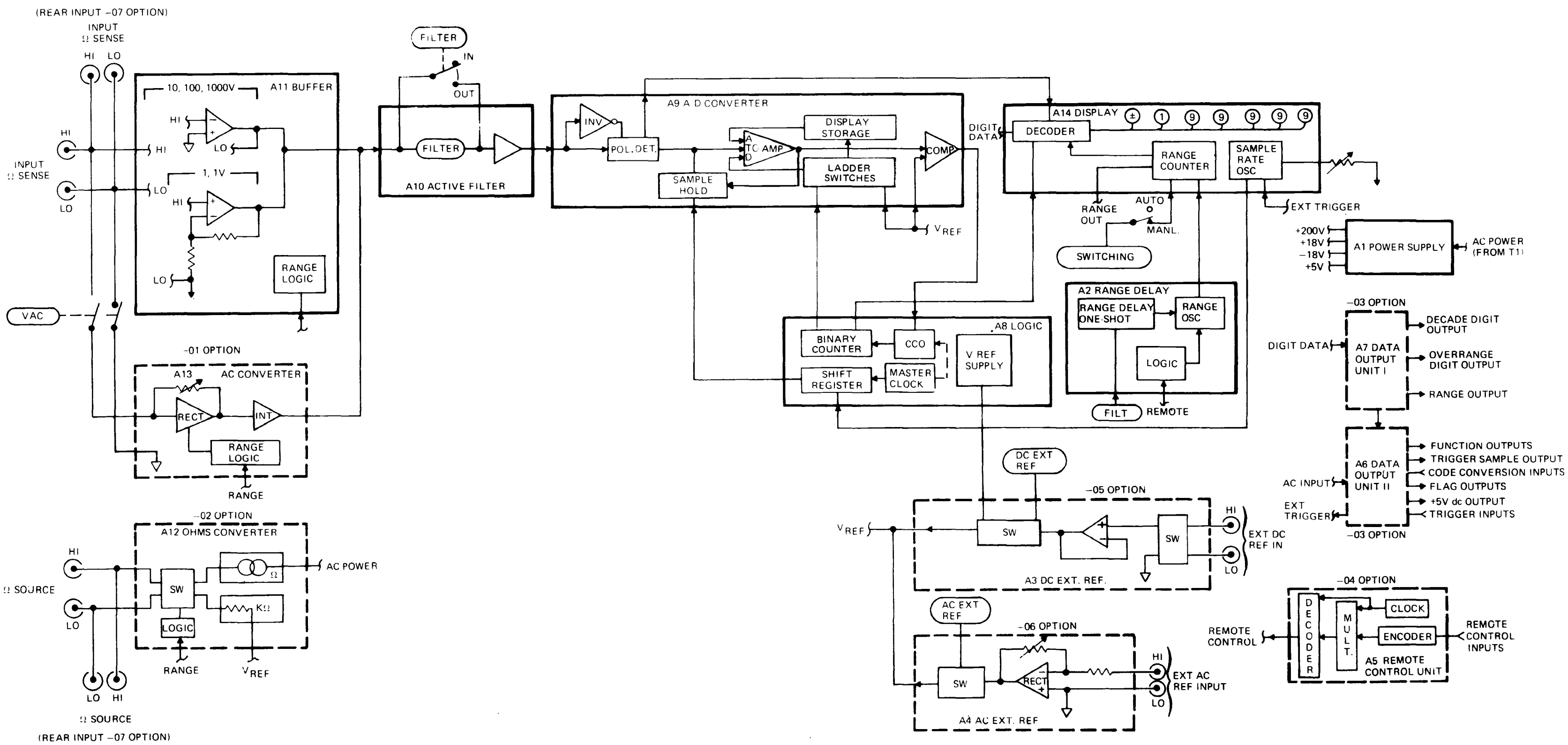


Figure 3-1. MODEL 8400A BLOCK DIAGRAM

to that portion of the A/D amplifier input voltage that caused the amplifier output to be greater than Vref. As the degenerative affect of the primary ladder voltage causes the A/D amplifier output to fall below Vref, the analog amplifier will no longer enable the CCO to send output pulses to the ladder switches. At this point the digitizing process for the most significant digit of the unit input voltage is complete. The voltage level remaining at the output of the A/D amplifier, representing the 8400A input voltage minus the most significant digit, is stored in the sample and hold circuit until the logic control gates it out to the input of the A/D amplifier. Each decade of the recirculated remainder is digitized in a simular fashion with one exception; the recirculated remainder voltage (now the A/D amplifier input voltage) and the primary ladder voltage are now the same polarity, because they are applied to opposite sides of the dual fet input transistor.

3-12. Display (A14)

3-13. The A14 Display decodes and digitally displays the input voltage magnitude and polarity. It also provides a variable sample rate for control of the measurement cycle. The circuitry consists of a sample rate oscillator, range counter, decoder, and display indicators. The sample rate oscillator frequency is controlled by a SAMPLE RATE control on the front panel and determines the rate at which the input to the instrument is sampled. The range counter receives auto-range commands from the A2 Range Delay and manual range commands from the front panel switches. The range counter applies range information to the decoder and all input signal conditioning circuitry. Range, polarity, and digit information is processed in the decoder, which then produces the correct display condition in the indicators.

3-14. Range Delay (A2)

3-15. The A2 Range Delay processes switching inputs from the front panel and produces control commands for the decoder in the A14 Display. It also produces up/down autorange commands for the range counter. The circuit consists of logic, range delay one-shot, and a pulse generator. The logic circuitry produces control signals for the pulse generator and the decoder in the A14 Display. A clock signal for the range counter in the A14 Display is produced by the pulse generator. This clock signal is required for the autorange feature. The range delay one-shot produces a programmed time delay after any range change to allow for settling time of analog signal conditioners which process the input.

3-16. Power Supply (A1)

3-17. Operating voltages for the instrument are produced in the A1 Power Supply. The voltages produced are +200V, ±18V and +5V. Each voltage is derived from the ac input using a series regulator.

3-18. Options

3-19. Optional features can be installed in the instrument. Each option is shown in Figure 3-1 and described in the following paragraphs.

3-20. AC CONVERTER. The A13 AC Converter is installed as the –01 Option. This circuitry allows ac measurements to 1000V at frequencies from 10 Hz to 100 kHz. The circuitry consists of an operational rectifier, amplifier integrator, and range logic. AC inputs are amplified or attenuated and rectified in the operational rectifier. The resulting dc voltage is then filtered and amplified by the amplifier integrator. Range commands are processed in the range logic whose output then establishes a fixed gain or attenuation factor for the operational rectifier. The resulting full-scale –10V dc output is applied to the A10 Active Filter. This voltage is then filtered, serially digitized and displayed in the same manner as previously described in the basic instrument paragraphs.

3-21. OHMS CONVERTER. The A12 Ohms Converter is installed as the –02 Option. This circuitry allows resistance measurements from 100 μΩ to 12M Ω. Resistance measurements in ohms ranges are true, four-terminal. Measurements in K ohm ranges are conventional two-terminal. The circuitry consists of a constant current generator, a current source, switching circuitry, and logic. When the ohm function is selected, the constant current generator output is made available to the Ω SOURCE terminals. Since both the Ω SOURCE and SENSE terminals are connected to the unknown resistance, the A11 Buffer input voltage is directly proportional to the resistance value. The A11 Buffer output is then serially digitized and displayed as described previously to indicate the resistance value. In the K ohm ranges, the current source output is made available to the Ω SOURCE terminals. The resulting voltage input is then measured in the same manner; however, since the voltage drop in the lead resistance of the unknown also appears at the voltage measuring terminals, true four terminal measurement is not available. Simplified diagrams of the four terminal and conventional resistance configurations are shown in Figure 3-2.

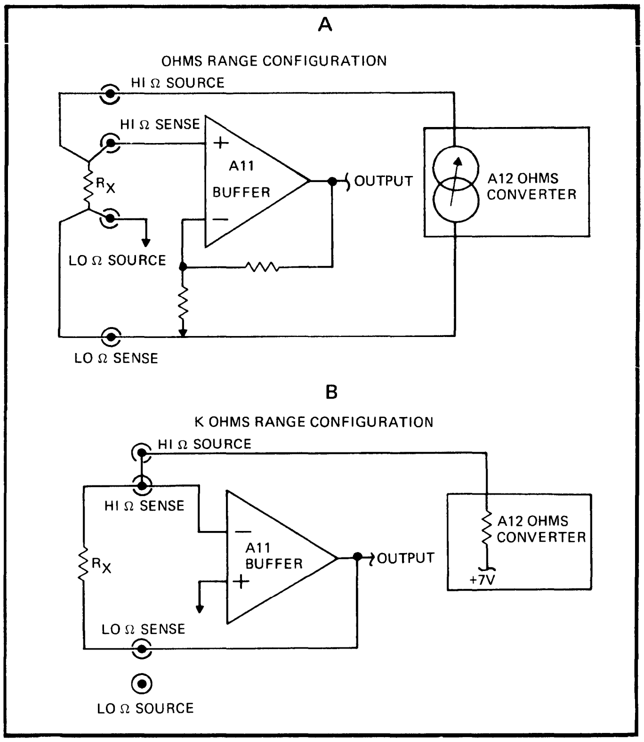


Figure 3-2. OHMS AND K OHMS RANGE CONFIGURATION

3-22. DATA OUTPUT. The A6 and A7 Data Output Units are installed as the –03 Option. This circuitry provides parallel, isolated, coded outputs of digit, polarity, range, and function. It also provides a +5V dc output for external equipment as well as input lines for external triggering and control of the measurement cycle. The circuitry is contained on two separate assemblies. Digit and range outputs are available from the Data Output Unit 1. Function indications, flag outputs, and +5V dc outputs in addition to triggering and code conversion inputs are available in the Data Output Unit II.

3-23. REMOTE CONTROL. The A5 Remote Control Unit is installed as the –04 Option. This circuitry allows remote control of mode, instrument range, and functions. Input requirements are compatible with DTL or TTL logic levels. The circuitry consists of a clock generator, encoder, multiplexer, and decoder. The clock generator produces a clock signal which gates the multiplexer and decoder. Inputs are coded in the encoder and applied to the multiplexer. The multiplexer output is then serially transferred to the decoder at the clock rate. Serial to parallel conversion takes place in the decoder and the resulting commands used to control the range and function.

3-24. DC EXTERNAL REFERENCE. The A3 DC External Reference is installed as the –05 Option. This circuitry allows dc/dc and ac/dc ratio measurements using an external dc reference voltage. Input reference voltage can be from +1 to +10.5V dc. The circuitry consists of a differential amplifier and a switching circuit. The external reference input is buffered by the differential amplifier. Application of internal or external reference voltage to the V_{REF} line is done through the switching circuit.

3-25. AC EXTERNAL REFERENCE. The A14 AC External Reference assembly is installed as the –06 Option. This circuitry allows ac/ac ratio measurements with an external ac reference voltage. Input reference voltage can be from 0.1 to 100V ac at 10 Hz to 100 kHz. The circuitry consists of an operational rectifier and switching circuitry. The ac reference input is amplified or attenuated and rectified in the operational rectifier. The resulting dc reference is then applied to the V_{REF} line by the switching circuitry.

3-26. REAR INPUT. The Rear Input terminals are installed as the –07 Option. These terminals are connected in parallel with the input terminals on the front panel.

3-27. CIRCUIT DESCRIPTIONS

3-28. The following paragraphs describe in detail the basic circuitry contained in the instrument. Circuit descriptions for options are located in the subsections of Section 6. Schematic diagrams are located at the rear of the manual.

3-29. A11 Buffer

3-30. The A11 Buffer (Drawing No. 8400A-1005) provides a full-scale dc voltage, isolated from the input under measurement, of 10V dc. It consists of four basic elements: input and output voltage dividers, amplifiers, and control logic. The circuitry has two operating configurations or modes determined by the voltage range selected: a low volts mode and a high volts mode. In the low volts mode (0.1 and 1.0 volt range) some amplification of the input occurs. In the high volts mode (10, 100, and 1000 volts range) input attenuation occurs, except in the 10 volts range when the input is processed without attenuation or amplification. Both modes are shown in block form in Figure 3-3. The A portion of the figure depicts the low volts mode, and the B portion of the figure depicts the high volts mode.

3-31. The input to the A11 Buffer is derived from input jacks J25 and J26, both jacks being shown on the block and system wiring diagrams. Buffer input current limiting resistors 1R1 and 1R2 are also located on the system diagram, along with the high and low inputs to the A11 Buffer, at jacks J4TM and J1TR, respectively, of terminal block No. 1.

3-32. On the A11 Buffer schematic, the low volts input is applied across current limiting resistor R2, through the contacts of K1, to the high input impedance amplifier com-

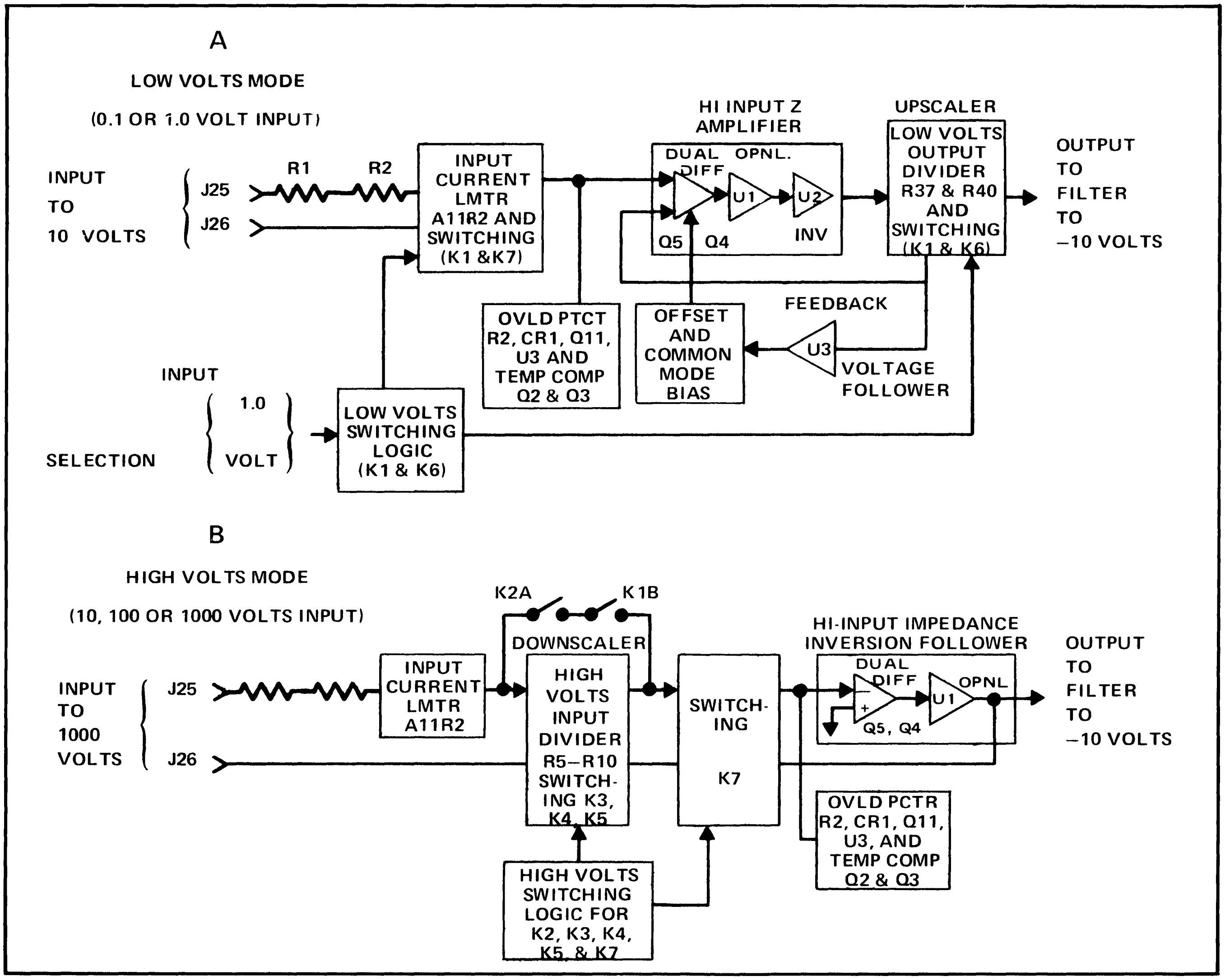


Figure 3-3. BUFFER AMPLIFIER BLOCK DIAGRAM

posed of three separate amplifiers: dual differential amplifier Q5 and Q4, operational amplifier U1, and inverter U2.

3-33. The output of the amplifier is applied in parallel to the A10 Active Filter and to a gain determining, output voltage divider, R37 through R40, through contacts of relays K1 and K6. Inspection of the resistance ratios in the output divider shows that the final amplifier output must be 100 times the input in the 0.1 volt range, and 10 times the input in the 1 volt range. Thus, the A11 Buffer output is the required 10 volts for full-scale inputs.

3-34. In the high volts mode of operation, shown in Figure 3-3B, the buffer amplifier receives the input voltage directly (10V range) or receives a scaled down voltage through an input voltage divider consisting of R5 through R10. Since the buffer is a unity gain inverter, its output is the inverse of the received input. For example, an input of +1000V would be scaled down to +10V through the input divider. With +10V at its input, the buffer output is −10V.

3-35. In the low volts mode, voltage follower U3 is used to bootstrap the operational environment of the input dual differential pair Q4 and Q5, with the input voltage to increase its effective ratio of common mode rejection. Any differential amplifier offset voltage present that would cause buffer output with no input is compensated by use of two potentiometers; one, COARSE DC ZERO, which balances the base emitter voltages of the input differential amplifier Q5 by adjusting the collector current ratio, and two, or the second potentiometer, BUFFER ZERO, which affords a fine adjustment via the front panel by applying just that amount of nulling voltage to the base of differential amplifier Q5B that results in a buffer output voltage equal to zero when the input voltage is zero. This last potentiometer is labeled DC ZERO just over the front panel access hole.

3-36. Overload protection for dual differential amplifier Q5 is afforded by the combination of components R2, CR1, Q11, and the current limiting resistors previously defined as R1 and R2 shown on the system wiring diagram. Positive overvoltage protection is afforded by transistor Q11 which clamps amplifier output to 1.7 volts. Negative overvoltage protection is afforded by diode CR1 which clamps the input to −1.7 volts. The current drawn during an overload is limited by the total input resistance of 147k ohms.

3-37. Compensation circuits are provided to reduce the temperature coefficients of the input offset voltage and offset current. Transistor Q2 and surrounding circuitry provides through R18 and R19 the temperature varying base current required by input transistor Q5. Transistor Q3 compensates the temperature variation of the base-emitter voltage in dual transistor Q4 to ensure that input transistor Q5 remains at substantially the same bias conditions irrespective of temperature.

3-38. A10 Active Filter

3-39. The A10 Active Filter (Drawing No. 8400A-1015) consists of a voltage follower preceded by four poles of low pass filtering. These four poles attenuate undesirable AC signals which may be present in the dc input signal. Filtering occurs after the FILT button on the front panel of the DVM is depressed. A block diagram of the active filter is shown in Figure 3-4. Also shown is the response curve of the active filter which plots attenuation in decibels against a log scale of frequency in Hertz.

3-40. A9 A-to-D Converter and A8 Logic

3-41. The A9 A-to-D Converter and A8 Logic circuits (respectively, drawings No. 8400A-1003 and -1004) are discussed together in the following paragraphs, since any discussion of the analog-to-digital (A-to-D) conversion process must include elements of both circuits. The basic conversion and logic circuitry involved in the conversion process is shown in Figure 3-5. Also shown is an arbitrary input voltage that is the equivalent to the inverted, unknown voltage applied across the input jacks of the DVM. The output of the converter is shown, applied to the following stage, the A14 Display, and consists of binary coded data bit groups that are serially emitted from the converter and applied to the display circuits for decoding and serial display. The basic purpose of the combined converter-logic circuitry is to convert the analog voltage input (given as +6.3524 dc volts in Figure 3-5) serially by decade to binary coded bit groups, one bit group per decade.

3-42. The inverting amplifier consists of input switch Q3, dual FET input amplifier Q4, operational amplifier U1, and associated circuitry. Once every 18 milliseconds, during the C sub-period the inverting amplifier switch Q6 is switched on by the S5 Logic Signal, to zero the inverting amplifier. The automatic zero circuit consists of transistors Q5 and Q6 and capacitor C2. The drive circuit also supplies a turn-off signal to transistor Q3, thereby removing the input to the inverting amplifier during the C sub-period.

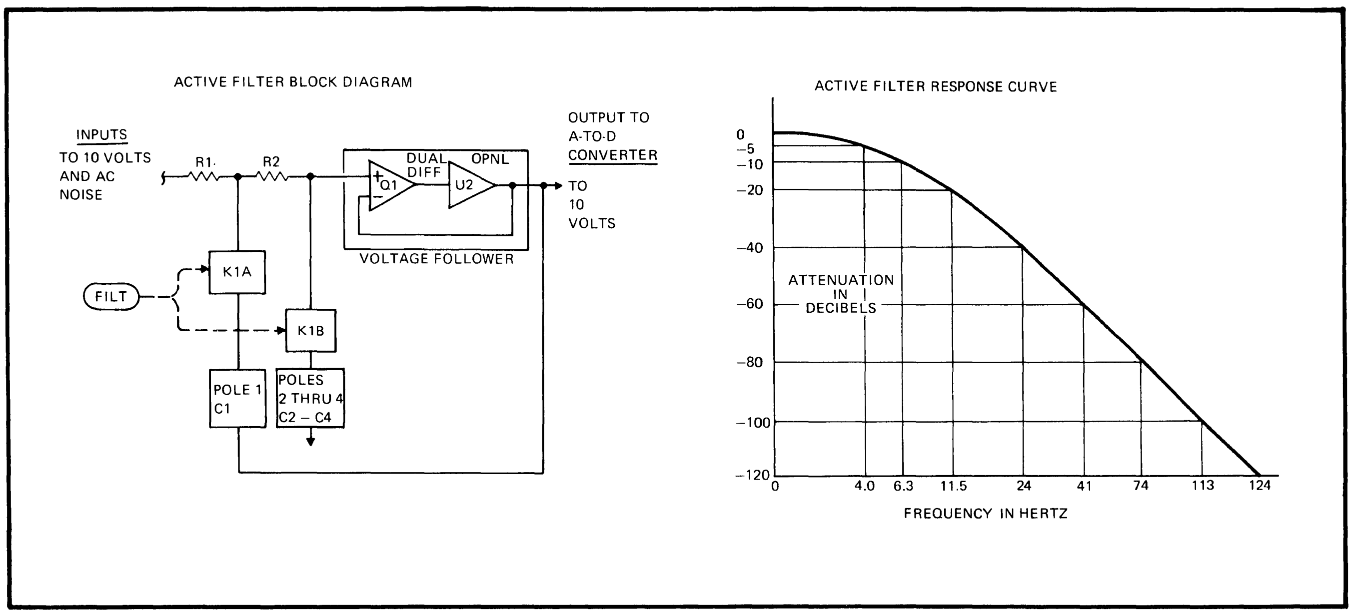


Figure 3-4. ACTIVE FILTER

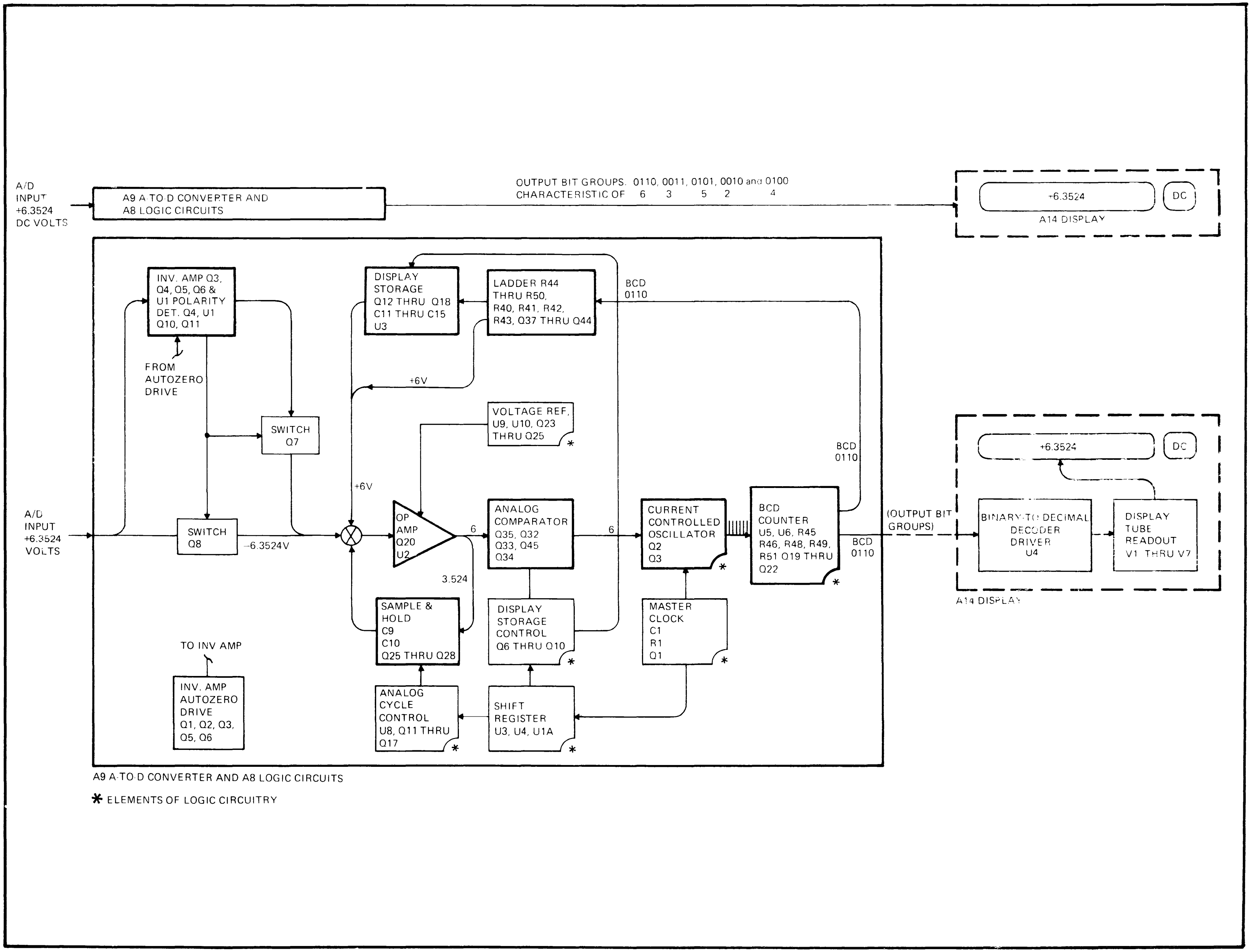


Figure 3-5. A-TO-D CONVERTER AND LOGIC BLOCK DIAGRAM

3-43. The polarity detector consists of flip-flop Q10, Q11, and associated circuitry. The flip/flop employs base triggering, which is applied through diode CR6 to the base of Q10. The gate signal, gate 4, is applied to the emitters of Q10 and Q11 and enables the detector during the A sub-period of the measure period. During the remainder of the measure period, the plus and minus gates (Q8 and Q7, respectively) are turned off and the polarity information is retained by the display circuitry.

3-44. The A/D amplifier consists of dual FET Q20, operational amplifier U2, and associated components. Switch Q24 is turned on during the ZERO (∅) sub-period of the measurement period by a ZERO signal from the logic circuit. This signal also controls switches Q19 and Q31, which are turned on during the ZERO sub-period to zero the differential amplifier, and switch Q30, which is turned off during the ZERO sub-period to disconnect the amplifier output from the ladder. Transistor Q29 and resistor R54 constitute a clamp, which prevents amplifier U2 from saturating while its output is above 7 volts.

3-45. The analog comparator, consisting of transistors Q45, Q32, Q33, Q34, Q35 and associated components, is basically a voltage comparator. Differential amplifier stage Q35 compares the A/D amplifier output with the +7 volts reference, and differential stage Q33, Q34 outputs to the current controlled oscillator (CCO) anytime the A/D amplifier output voltage is greater than the +7 volts reference. Transistor Q32 operates as a second comparator, which responds quickly to high voltage levels, thereby allowing maximum time for resolution of the least significant digit.

3-46. The sample and hold circuit consists of transistors Q25 through Q28 and capacitors C9 and C10. The sequence of operation for the sample and hold circuit is shown in Figure 3-6.

MEASURE PERIOD SUBPERIODS	SWITCHES ON	VOLTAGES STORED ON SAMPLE AND HOLD CAPACITORS	
		C9	C10
A	Q26, Q22	3.524	0
B	Q25, Q28	3.524	5.24
C	Q27, Q26	2.4	5.24
D	Q25, Q28	2.4	4.0
E	Q27	0	4.0
ZERO (∅)	Q19, Q31, Q24	0	?

1 VOLTAGES SHOWN ARE ONLY PROPORTIONAL TO ACTUAL VOLTAGES.

Figure 3-6. SAMPLE AND HOLD SWITCHING

3-47. The ladder switches of Q37 through Q44 are controlled by drivers Q19 through Q22 on the A8 logic board. 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 R44 through R50 and produces an output voltage that corresponds to the actual value of the most significant digit of the A/D amplifier input voltage. The secondary ladder, which drives only the display storage circuit through buffer amplifier U3, consists of resistors R40 through R43 and produces an output that closely approximates the actual value of the primary ladder output. A half-digit bias is produced by R38 and R39 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.

3-48. The display storage circuit consists of FET switches Q13 through Q17, capacitors C11 through C15, and FET switches Q12 and Q18. The buffered output of the secondary ladder is supplied to the appropriate storage capacitor through Q18, which is switched on during the second half (display time) of each sub-period. The first (most significant) digit is stored on C13, the second on C11, etc. When the cycle change circuitry switches to storage mode, Q12 is turned on and the analog voltages stored on the storage capacitors are serially applied to the input of the A/D amplifier. Thus, the same reading is continually digitized and displayed until a new sample of the input is taken.

3-49. The 333 Hz clock signal is produced by transistor Q1 on the A8 Logic board. The clock frequency is determined by the RC time constant of resistor R1 and capacitor C1. The output of Q1 is applied to the trigger input of flip-flop U1B. The F output of U1B is inverted in Q4 and becomes the $\overline{H}$ signal. The F, $\overline{F}$, and $\overline{H}$ signals are used by the logic to generate control signals.

3-50. The six-state shift register consists of J-K flip-flops U3A, U3B, U4A, U4B, and U1A. Error correction gate U2B controls the input to flip-flop U3B to ensure proper operation of the shift register. At the end of a typical digitizing cycle, flip-flop U1A reverts to the ZERO condition upon receiving the $\overline{H}$ clock pulse. Since all the flip-flops are now in the ZERO condition, the output of U2B goes low, thereby defining the start of the ZERO sub-period as shown in the timing diagram of Figure 3-9. The ZERO sub-period is terminated by the next $\overline{H}$ clock pulse, which sets flip-flop U3B high because its *J* input was high and its *K* input was low when the clock pulse was received. Subsequent clock pulses set the flip-flop outputs as shown in Figure 3-7.

SUBPERIOD	SHIFT REGISTER FLIP FLOP AND ZERO GATE OUTPUT STATES					
	U3B	U3A	U4A	U4B	U1A	U2B
ZERO	0	0	0	0	0	0
A	1	0	0	0	0	1
B	0	1	0	0	0	1
C	0	0	1	0	0	1
D	0	0	0	1	0	1
E	0	0	0	0	1	1

Figure 3-7. SHIFT REGISTER OUTPUTS

3-51. The sixteen-state binary counter consists of J-K flip-flop U5B, U5A, U6A, and U6B. The counter is set to ZERO at the beginning of each sub-period in the measurement period by the $\overline{H}$ clock pulse. During each subperiod of the digitizing cycle, the output pulses from the CCO, which are applied to the clock input of flip-flop U5B, are counted. The truth table for the flip-flops in the binary counter is shown in Figure 3-8. The binary counter is disabled by gate U2A if the count of 11 is attained.

CCO PULSE COUNT	SIXTEEN-STATE BINARY COUNTER			
	U5B Z	U5A Y	U6A X	U6B W
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

Figure 3-8. SIXTEEN-STATE BINARY COUNTER OUTPUT

3-52. The CCO consists of multivibrator Q2 and Q3. The CCO has no output until it is supplied current by the analog comparator and is enabled by the F output of the J-K flip-flop U1B. The CCO output is applied to the clock input of the 16-state binary counter. The 9's catcher gate U7A, disables the CCO at a count of nine, if the DVM is digitizing the second through fifth digits (sub-periods B through E).

3-53. The outputs of the six-state shift register, in conjunction with the $\overline{H}$ pulses of the output of Q4, are applied to the display storage control circuit consisting of transistors Q6 through Q10 and related components. Outputs from this circuitry control the display storage circuit located on the A9 A-to-D Converter board.

3-54. The analog cycle control circuit produces the gating and control signals which are used to control the synchronization of events in the analog portion of the DVM, principally in the A-to-D Converter circuits. These signals, together with other control signals are shown in the DVM Timing and Synchrony Diagram, Figure 3-9. The analog cycle control circuit consists of NAND gates U8A through D driving transistors Q11 through Q17 and associated circuit elements.

3-55. The ladder switch driver circuitry (Q19 through Q22 on A8 Logic board) receives 8-4-2-1 coded binary data from the sixteen-state binary counter and translates this to 4-4-2-1 coded binary data, which matches the weighting of the resistors in the ladder. Thus, the ladder output is proportional to the count in the binary counter. The count increases until the output of the ladder is sufficient to bring the A-to-D amplifier to the particular balanced position required by the input voltage.

3-56. The master +7 volts reference for the instrument is derived using reference amplifier U9 as a reference element. The reference voltage is produced using operational amplifier U10 and emitter follower Q25, which presents a low source impedance at the reference point. Transistor Q24 disables the +7 volts reference in the event the user wishes to employ an external reference and the required options are installed. Transistor Q23, coupled with the zener in the reference amplifier, produces a reference voltage for the +18 volts regulator in the A1 Power Supply.

3-57. A14 Display

3-58. The A14 Display circuits (Drawing No. 8400A-1002) control the function/status indicators and the decimal indicators associated with the readout tubes. The KΩ, AC, DC, Ω, OVER, FILT, and X REF 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 remains extinguished unless the assembly is installed in the instrument. The OVER range indicator is operated by transistor Q5 in the OVER RANGE DRIVER circuit.

3-59. The polarity signs + and – of tube V1 are controlled by a flip-flop consisting of transistors Q19, Q20, FET switches Q32, Q33, current source transistors Q9,

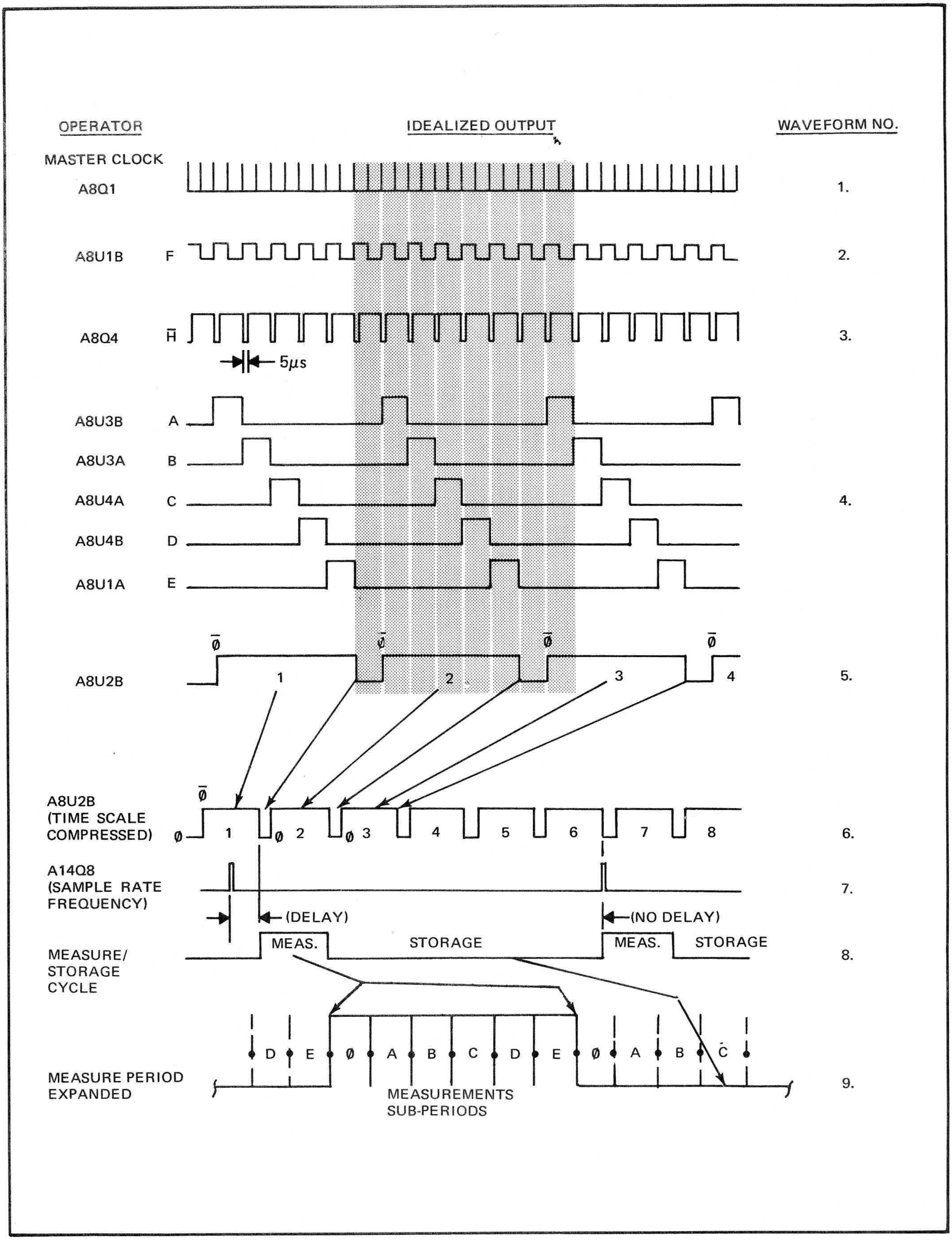


Figure 3-9. DVM TIMING AND SYNCHRONY DIAGRAM (SHEET 1)

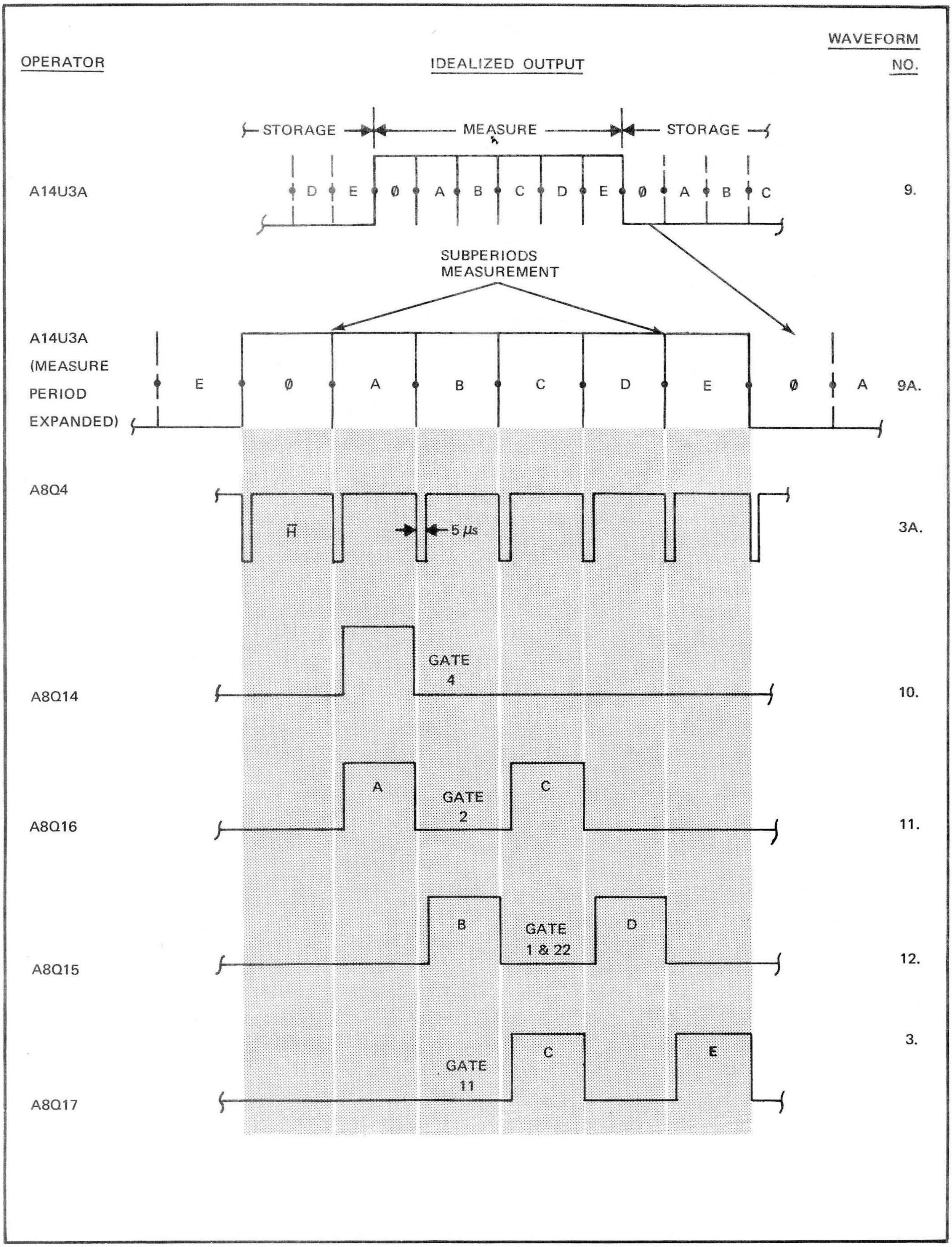


Figure 3-9. DVM TIMING AND SYNCHRONY DIAGRAM (SHEET 2)

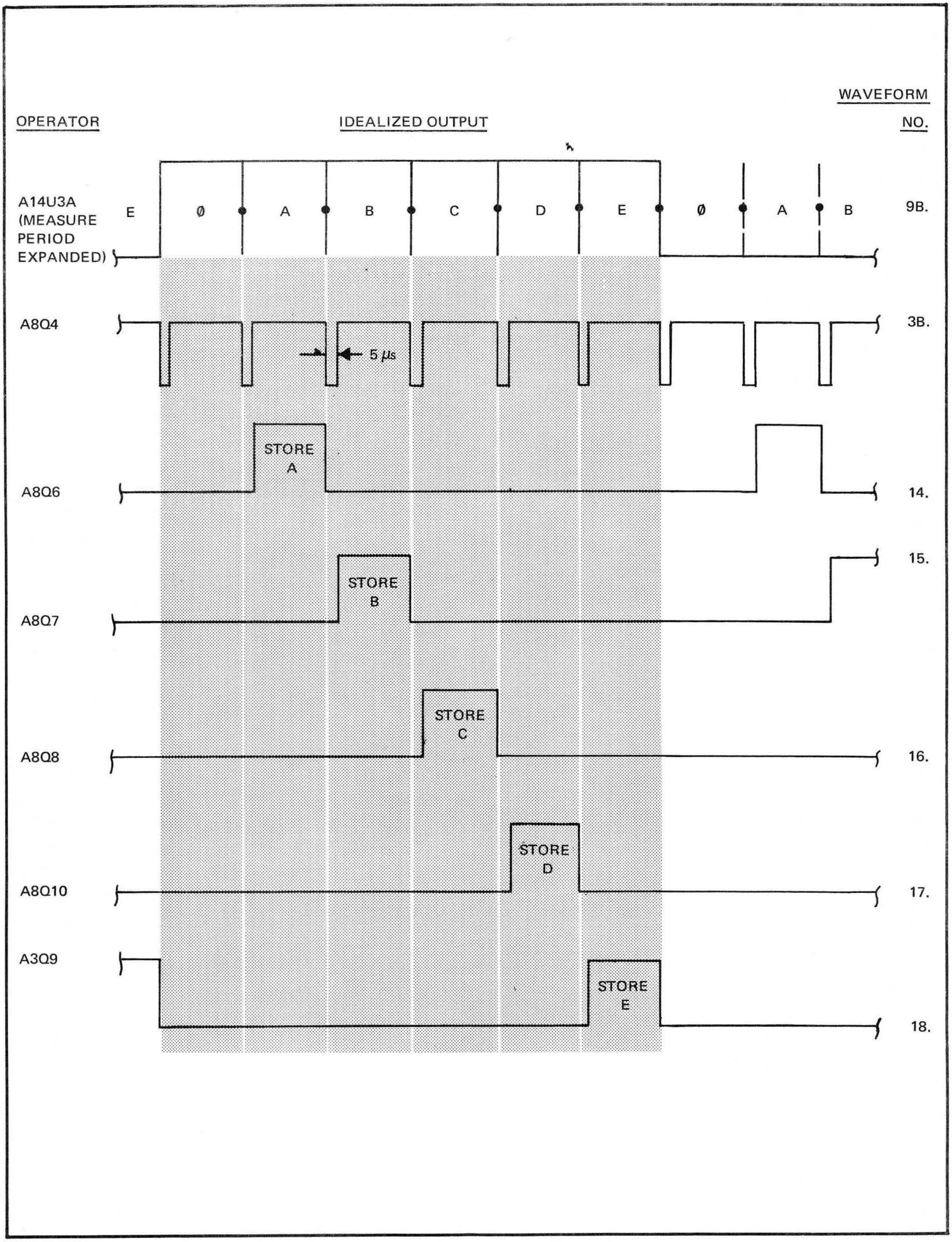


Figure 3-9. DVM TIMING AND SYNCHRONY DIAGRAM (SHEET 3)

Q10, and associated components. Inputs to this circuit are VDC, C, POL INFO A and B, and *a*. POL INFO A and B come from the polarity detector in the A-to-D Converter and determine which of the two polarity characters are illuminated. The range counter, via *a*, reverses the effects of POL INFO A and B as a function of range to account for the fact that the polarity detector receives the input to the instrument in its *true* sense on the 0.1 and 1 volt ranges, but in its *inverted* sense on all other ranges. The decimal point indicators in tubes V2 through V7 are controlled by transistor switches Q11 through Q16, which, in turn, are controlled by the range counter status.

3-60. The switches Q22 through Q26 are the main elements of the anode strobing control circuit. They are turned on sequentially by 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 of each sub-period as defined in Figure 3-9. The output of these switches controls switches Q27 through Q31, which apply +200 volts dc to the anode of each readout tube.

3-61. The overrange indicator V2 is operated by transistors Q17 and Q18. These transistors are controlled by the 6-state cycle control shift register, the 16-state binary counter, and the range counter. The *zero* character in this tube is illuminated only when the range counter commands the 0.1 or 1 range, and when the count in the binary counter is less than 10. The *one* character is illuminated when the count in the binary counter is 10 or 11. The decoder driver U4 is a monolithic BCD 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 output drivers. The cathodes of readout tubes V3 through V7 are connected in parallel. These ten nodes are, in turn, connected to the ten available outputs of the decoder driver.

3-62. The sample command oscillator (SCO) consists of Programmable Unijunction Transistor (PUT) Q8 and surrounding circuitry shown in Figure 3-10 in its normal operating state. Resistors R12 and R14 provide a bias level for the gate of the PUT. When capacitor C3 charges to approximately 0.6 volt above the gate bias level, the PUT turns on and discharges C3 through R15. This generates an output pulse which commands the measure/storage cycle J-K flip-flop U3A to the measure period to take a sample, providing the end of a $\overline{\text{ZERO}}$ pulse is coincident at the clocked input to the flip flop. If the sample results in a command to autorange, signal 3 from the A2 Range Delay one-shot turns off Q6 and disables the SCO to allow time for analog signal conditions to settle on the new range before another sample is taken. Capacitor C3 begins to recharge and the SCO cycle begins again. The oscillator frequency is dependent upon the time constant of R and C3, and the gate bias level. The frequency is varied by the adjustment of R through the front panel SAMPLE RATE control. Transistor Q7 and its base bias network (R11 and R13) ensures that PUT Q8 is turned off by forcing the gate and anode to the same potential after C3 discharges.

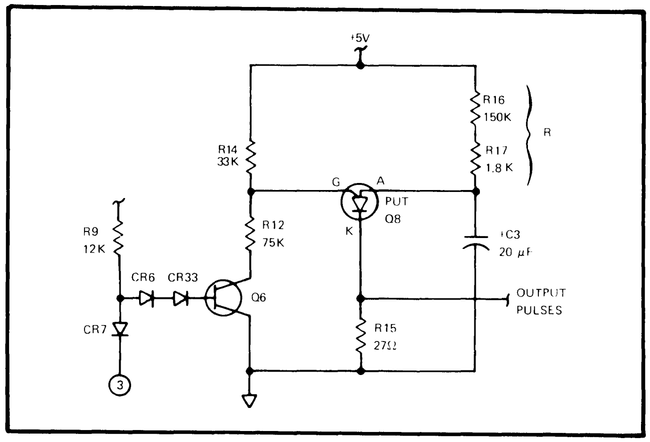


Figure 3-10. BASIC SAMPLE COMMAND OSCILLATOR

3-63. The remaining circuitry surrounding the SCO (See A14 Display schematic diagram) functions only when the SAMPLE RATE control is switched to the EXT position and samples are initiated through the external trigger input of the Data Output Unit (D.O.U) option. In this circumstance, the emitter of Q6 is normally high. Thus, the gate of PUT Q8 is near the supply voltage and the PUT is disabled. A trigger from the D.O.U., however, pulls the emitter of Q6 to ground. Its collector follows, causing the gate of Q8 to be more than 0.6 volt below the anode and the PUT fires once. If the corresponding sample results in a range change, the range delay one shot multivibrator will disable the SCO via Signal No. 3 and CR7. This means that no samples may be commanded until the range delay one-shot times out. At the end of this time delay, the SCO is automatically retriggered via CR8, by Signal No. 2 from the range delay one-shot. Diode CR9 and resistor R10 ensure that capacitor C3 is charged rapidly to ready the PUT for the next trigger pulse. Signal No. 8 interrupts the cycle control shift register on the A8 Logic board by forcing it directly to the E sub-period. This is done to minimize the time between the sample command (trigger) and actual sample.

3-64. The measure/storage cycle circuit is composed of J-K flip-flop U3A on the A14 Display board. The clocked input of U3A is connected to $\overline{\text{ZERO}}$ through a bias and differentiating network composed of capacitor C4 and resistors R18, R19. When the M output of U3A is high, the instrument is in the measurement period of the measurement/

storage cycle. When the M output from U3A is low, the storage period prevails. The clocked input is normally high as determined by the bias network, and since this is a master-slave type flip flop, the master is connected directly to the *J* and *K* inputs and isolated from the outputs. If the SCO outputs a pulse, the *J* input goes high and causes the master to assume the true state. At the start of the next ZERO (∅) time, the clock pulses low causing the slave, and, hence, the outputs, to assume the state of the master. That is to say, the output goes true and initiates a measure cycle. At the same time, the master is updated as a function of the new *J* and *K* inputs. Thus, at the start of the next ZERO (∅) time, the slave assumes the false state existing in the master, and the storage period is initiated. Not until the SCO pulses again will another measurement period be initiated. The idealized waveform output of the measure/storage cycle J-K flip-flop is seen by viewing waveform No. 8 and its two input generating waveforms 6 and 7 in Figure 3-9, Sheet 1.

3-65. The OVER RANGE DRIVER circuit is composed of programmable unijunction transistor (PUT) Q4, transistors Q3, Q5, and Q37, and associated circuitry. Transistor Q2, diode CR5, and resistors R2 and R4 are not part of the driver circuit but constitute a delay line in the speed at which the range delay one-shot multivibrator circuit on the A2 Range Delay board times out. The time-out delay is a function of the FILTer button being depressed on the front panel, applying a low at the base of PNP transistor Q2, turning it on, and effectively holding transistor Q1 in the range delay one-shot off (time-out status) for a longer time than would otherwise occur if transistor Q2 were not turned on by the filtering function being activated. The overrange driver PUT Q4 is turned on when its gate voltage is depressed about 0.6 volt relative to the anode voltage. The differential voltage developed across resistor R64 (tied between the gate and anode of the PUT) when the PUT conducts turns on PNP transistor Q5, and resultingly, turns on the OVER lamp in the function display annunciator. The gate to anode voltage relationship that turns on transistor Q5 and the OVER lamp is brought about by NPN transistor Q3 when it is turned on. Q3 is turned on by the 12th output pulse from the CCO being applied to its base. Twelve output pulses from the CCO indicate greater than twenty percent overvoltage is being applied at the input of the instrument for a given range. However, even though turned on, transistor Q3 is ineffective in gating the PUT unless an enabling signal ($\overline{\text{UP}}$) is applied through R6 to its emitter. The source of the $\overline{\text{UP}}$ signal is the output of NAND gate U2A located on the A8 Logic board. Signal No. 7 is the UP range signal that is applied to NAND gate U3B on the A2 Range Delay board. It is generated at the emitter of transistor Q37 when this transistor is turned on by the PUT firing. After firing, the PUT is reset by the application of the positive-going edge of the M signal applied to its cathode through C1.

3-66. The RANGE COUNTER circuit is composed of J-K flip-flops U2A and U2B. The clocked input to the range counter is provided by J-K range flip-flop U3B, that has as its clocked input signal No. 6. This signal originates in the range oscillator on the A2 Range Delay board and is pulsed high everytime the range oscillator PUT fires. The J-K inputs to the range flip-flop U3B are tied together at the output of the measure/storage cycle J-K flip-flop U3A and go high every measurement period. The range counter is a divide-by-6 counter that provides the 6 possible binary states for range counting, 5 pulses being considered an up-range command and 1 pulse being considered a down-range command. Signal No. 6 applied to the clocked input of the range flip-flop U3B alters the 6 states of the range counter. Transistor Q35 is provided to pull the range counter out of an unallowed state that may occur at turn-on.

3-67. A2 Range Delay

3-68. The A2 Range Delay circuits (Drawing No. 8400A-1006) consists of a series of gates, a range delay one-shot multivibrator, and a range oscillator. The gates allow the specified set of ranges to be attained, which is dependent upon the function called on the front panel. The range oscillator generates pulses which trigger the range delay one-shot while simultaneously causing the A14 range counter to change states. The range delay one-shot prevents further ranging for a specified time to allow the analog signal conditioners to settle in the new range.

3-69. The gates are U2A, U2B, U2C, U3A, and U3B. Gates U2C and U3A are up range stops which pull down on the range-up enable line. Gate U2C prevents autoranging above the 10,000 range, while gate U3A prevents autoranging above the 1000 range on the VDC function. Gates U2A and U2B are down range stops which pull down on the range-down enable line. Gate U2A prevents autoranging below the 10 range in the Ω function, while gate U2B prevents autoranging below the 0.1 range in any function. Gate U3B is the master up-range control. It enables the range oscillator only if an up range is to be expected.

3-70. The three inverters U1D, U1E, and U1F coupled with the range-up enable line provide one input for up-range control gate U3B. The result is that U3B is enabled for 1.5 milliseconds (the second half of the A sub-period of a measurement period) if an up-range is to be executed.

Signals applied to diodes CR6 through 8 and 10, coupled with the range-down enable line provide a negative going signal to the range oscillator at the end of the A sub-period of a measurement period if a down-range is to be executed. Thus, there are two ways which can enable the range oscillator.

3-71. The range oscillator is composed of capacitor C4, resistors R14 and R18, and Programmable Unijunction Transistor (PUT) Q4, with the output of this oscillator appearing at the cathode of PUT Q4. The PUT is fired, discharging capacitor C4 through R15, when the gate is about −0.6 volt relative to the anode. Thus the PUT is fired to produce one output pulse by lowering gate voltage or by raising the anode voltage, such that the voltage difference between these elements is as indicated above. The firing of PUT Q4 discharges capacitor C4 and reduces the anode and gate voltages. This causes Q3 to turn on and force the anode and gate of Q4 to the same potential. Q4 turns off and capacitor C4 charges through R14 and R18. If the firing potential between the gate and anode of Q4 is established, Q4 again fires and the cycle is repeated to produce the second output pulse. The frequency of oscillations is set by the level of gate voltage applied and the charging time constant of R14, R18, and capacitor C4.

3-72. Control of the gate of PUT Q4 is effected by one of two mutually exclusive inputs. One of these is associated with ranging up and is identified on the A2 schematic as the output of gate U3B. The other of the two inputs is associated with ranging down and is identified as the range down enable line. In an up-range situation, the output of U3B pulls low for 1.5 milliseconds during which time the range oscillator outputs five pulses. In a down-range situation, the range-down enable line pulls low. This signal is capacitively coupled via C3 to the gate of PUT Q4 causing it to output one pulse. Five pulses counted by the A14 range counter commands a transition to the next higher range, while one pulse commands a transition to the next lower range. In either case, the first output pulse triggers the range delay one-shot to allow the analog signal conditioners to settle in the new range.

3-73. Transistors Q1, Q2, and associated components make up the range delay one-shot multivibrator. A range change pulse from the range oscillator applied to the base of transistor Q2 turns this transistor on and transistor Q1 off, thereby placing the one-shot multivibrator into its unstable state. The RC charge time of combined capacitors C2, C6, and resistor R5, and the current through R16 determine how long the one-shot remains in its unstable state. With the filter selected, no current flows through R16 and the timeout is about 220 milliseconds. Without the filter selected, the timeout is decreased to about 25 milliseconds because some current flows through R16. Signal No. 3 disables the sample command oscillator during the range delay time. Signal No. 2 re-triggers the SCO at the end of the range delay time.

3-74. Transistor Q5 and associated components is a circuit that prevents the instrument remaining in a disallowed range, as in 10,000 VDC, when turned on. When Q5 is turned on by the inputs of VDC and $\overline{a}.\overline{b}.\overline{c}.$, the collector of Q5 pulls down on the set line of the counter and thereby forces the instrument out of the 10,000 range.

3-75. A1 Power Supply

3-76. The A1 Power Supply (Drawing No. 8400A-1001) consists of four regulators, a + and −18 volts regulator, a 200 volts regulator, a 5 volts regulator. The purpose of the power supply is to furnish to the instrument all of its required operating power.

3-77. The +18 and −18 volts regulators obtain filtered dc voltage from the full-wave rectifiers consisting of diodes CR5 through CR8 and filter capacitors C2 and C5. The +18 volts regulator consists of operational amplifier U1 and series pass transistor Q3. The voltage reference for the +18 volts regulator is derived from reference amplifier U9 and temperature compensation transistor Q23 on the A8 Logic board. The −18 volts regulator consists of operational amplifier U2 and series pass transistor Q5. The −18 volts regulator is referenced to the +18 volts.

3-78. The +200 volts regulator is operated from a full-wave bridge rectifier and filter consisting of diodes CR1 through CR4 and capacitor C1. The reference for the +200 volts regulator is the +18 volts. Voltage variations are amplified in transistor Q2 and applied to series pass transistor Q1.

3-79. The +5 volts regulator is operated from a full-wave rectifier and filter consisting of CR10 through CR13 and capacitor C8. The reference for the +5 volts regulator is −18 volts. The series pass element is a compound-emitter follower composed of transistor Q8 driving power transistor Q6 voltage variations which are detected by the sample string (R14, R15 and R17) are amplified by transistors Q7.

3-80. Miscellaneous Circuitry

3-81. Input power to the instrument and interconnection of various assemblies is shown in the Wiring and Interconnect Diagrams (Drawing No. 8400A-1000 and

8400A-1100). Line power is fused by F1 and applied through the contacts of POWER switch S1 and T1. The primary of T1 consists of two windings which are parallel or series connected through slide switch S2 to allow operation from either a 115 or 230V ac line. When S2 is set to 115, the primary windings of T1 are connected in parallel. The 230 position of S2 connects the windings in series. Secondary windings of T1 provide ac voltages to the A1 Power Supply and A6 Data Output Unit No. 2. Shielding between the primary and secondary windings prevents coupling of any undesired line signals to the internal sections of the instrument.

Section 4
Maintenance

4-1. INTRODUCTION

4-2. This section contains information and instructions concerning preventive and corrective maintenance for the Model 8400A Digital Voltmeter. The information and instructions are arranged under headings of "SERVICE INFORMATION, GENERAL MAINTENANCE, PERFORMANCE TEST, CALIBRATION PROCEDURE, COMPENSATING COMPONENT SELECTION, and TROUBLESHOOTING."

4-3. A calibration interval of 90 days is recommended to ensure instrument operation within the 90-day specifications as stated in Section 1.

4-4. Table 4-1 lists the required test equipment. If the recommended equipment is not available, other equipment having equivalent specifications may be used.

Table 4-1. REQUIRED TEST EQUIPMENT

EQUIPMENT NOMENCLATURE	RECOMMENDED EQUIPMENT	FUNCTION
DC Calibrator	Fluke Model 332D DC Calibrator	Performance Test Calibration Troubleshooting
Kelvin Varley Divider	Fluke Model 720A	Calibration
Differential Voltmeter	Fluke Model 885AB	Performance Test Calibration Troubleshooting
Oscilloscope	Tektronix Model 504	Troubleshooting
Oscillator	Hewlitt Packard Model 745 and 746	Troubleshooting

4-5. SERVICE INFORMATION

4-6. Each instrument that is manufactured by the John Fluke Mfg. Co., Inc. is warranted for a period of one year upon delivery to the original purchaser. The WARRANTY is located at the front of the manual.

4-7. Factory authorized calibration and service for each Fluke product is available at various world-wide locations. A complete list of these authorized service centers is located at the rear of the manual. Shipping information is given in Section 2, paragraph 2-5. If requested, an estimate will be provided to the customer before any repair work is begun on instruments that are beyond the warranty period.

4-8. GENERAL MAINTENANCE

4-9. Access/Disassembly

4-10. The following procedure is used to gain access to the interior of the Model 8400A.

a. Remove top dust cover to gain access to calibration adjustments and test points.

b. Remove top guard chassis by removing the four screws which hold it in place. Access is now provided to the plug-in assemblies shown in Figure 4-1.

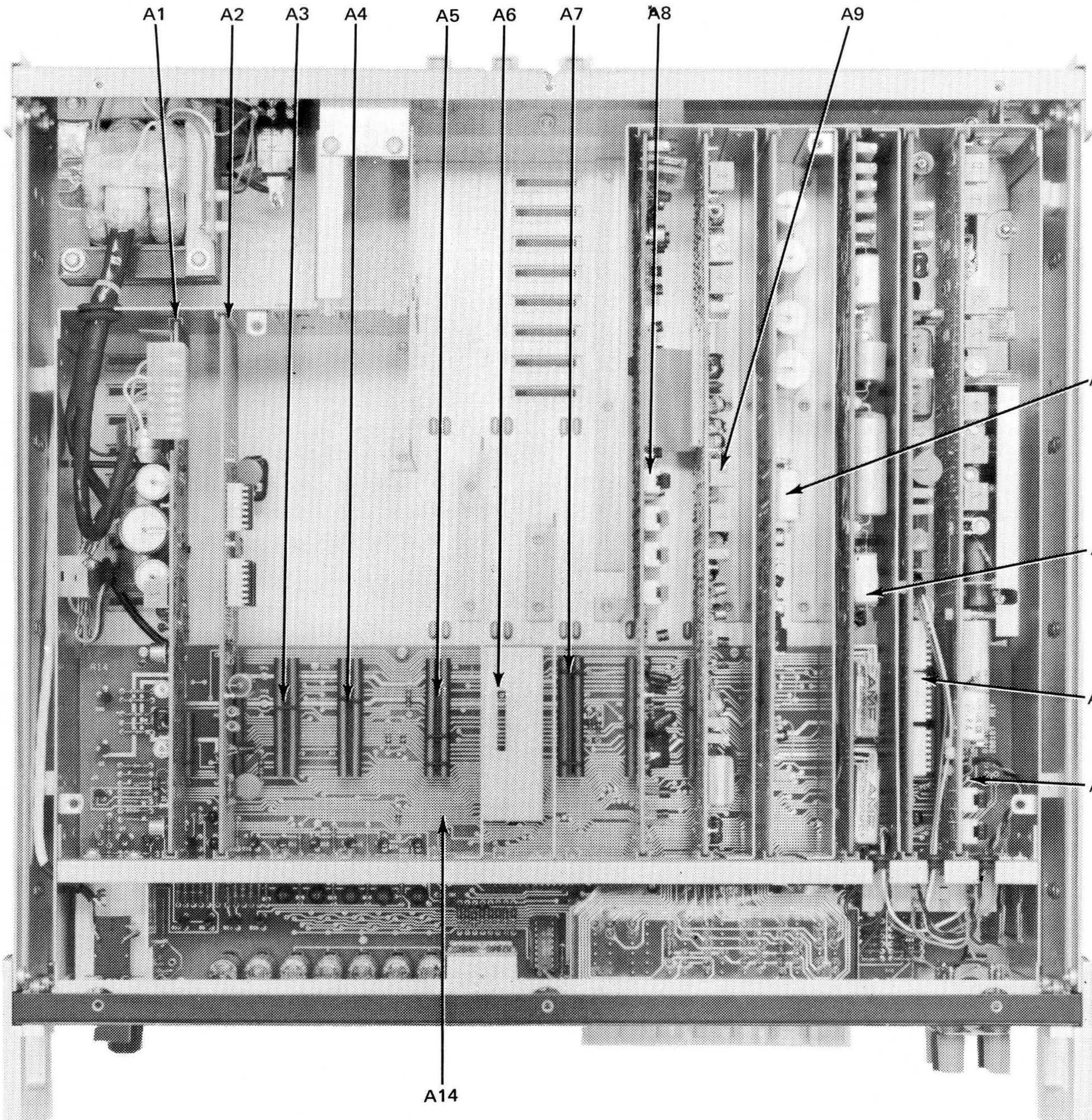


Figure 4-1. ASSEMBLY LOCATIONS

c. Remove bottom dust cover. By removing single screw securing bottom guard cover access can be gained to the bottom section of the Model 8400A.

4-11. Cleaning

4-12. Clean the instrument periodically to remove dust, grease, and other contamination. Use the following procedure:

a. Clean the interior with clean, dry air at low pressure. When the printed circuit boards require cleaning, first spray them with Freon T.F. Degreaser (Miller Stephensen Company, Inc.) and then remove the dirt with clean, dry air at low pressure.

CAUTION

Do not spray Freon T.F. on the component side of any PCB since damage to certain components may result.

b. Clean the 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.

4-13. Fuse Replacement

4-14. One fuse is located in the rear panel fuseholder. Wnen replacement is necessary, install Bussman, TYPE AGC 1/2A as shown on Decal located on the rear panel.

4-15. Lamp and Tube Replacement

4-16. The readout tubes (V1 thru V7) and the Function Display Lamps are mounted behind the left portion of the front panel. These components are replaced without special tools using the following procedure:

4-17. FUNCTION DISPLAY LAMPS

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

b. To replace the function display lamps remove the function display assembly mounting screws. Access to these mounting screws is from the bottom of the instrument.

c. Remove the function display assembly from the top of the instrument. After removal of the plexiglass 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. Instruments below serial number 208 have an extra lamp in FUNCTION Display assembly in position marked MV. All instruments above serial 209 do not have a spare lamp.

CAUTION!

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

4-18. READOUT TUBE REPLACEMENT

a. To replace the readout tubes desolder the base mounting pins and remove tube from the top of the instrument.

4-19. The SAMPLE RATE indicator (DS1) is located next to the SAMPLE RATE adjustment on front panel. Remove DS1 by desoldering both leads from A14 assembly, and pull lamp out from holder. Install and solder new lamp.

4-20. Switch Maintenance

4-21. The following procedure covers service and replacement of the push button switches. If switch contacts are deformed, or if switch module is defective, replacement parts can be obtained by ordering either the FUNCTION or RANGE switch assembly.

4-22. The procedure for servicing the FUNCTION and RANGE switch assembly is as follows:

4-23. GENERAL.

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

b. Set all switches to the nondepressed position.

c. Remove shorting links from INPUT terminals on front panel.

d. Remove knob from the SAMPLE RATE potentiometer.

4-24. REMOVAL OF DISPLAY PCB.

a. Unplug and remove all plug in circuit assemblies from instrument.

b. Remove decals from the side of handles.

c. Remove four (4) screws on side of each handle. Remove the front panel from the instrument.

d. Disconnect wires from terminal posts to terminal block at the terminal block, and pull SAMPLE RATE lamp out from its holder.

e. Remove four (4) screws which secure the front sub-panel to the inner chassis and three (3) screws which secure DISPLAY PCB (A14) to front sub-panel. Remove front sub-panel.

f. Remove seven (7) mounting screws from the display PCB (A14).

g. Pull display PCB out from front of instrument.

4-25. DISASSEMBLY – FUNCTION SWITCHES (EXCEPT EXT REF, FILT).

a. Unplug P14 (flexible plug in circuit plug) from connector J14 on DISPLAY PCB.

b. Remove four (4) mounting screws which secure FUNCTION switches to switch assembly brackets.

c. Remove button on switch to be repaired by applying pressure to the rear of the button on pulling button away from switch. Note that on some instruments buttons are cemented on the switch shaft. When replacing buttons, use a small amount of contact cement. Apply cement to shaft only.

d. Pull FUNCTION switch assembly away from brackets.

e. Remove rear support bracket and lockouts by bending all locking tabs on rear support bracket, up. (Figure 4-2).

f. Remove retaining ring and spring from switch shaft.

g. Insert a tool between the latch bar and switch shaft on adjacent switch (Figure 4-3).

h. Slide latch bar to edge of opening in front switch support bracket.

i. Holding latch bar open, push defective switch shaft out rear of module. Switch contacts will fall out of their slots when shaft is pushed out of module.

CAUTION!

Under no circumstances MUST attempts be made to re-form or add tension to the switch contacts by bending them.

j. Inspect the switch contacts for contamination and, if necessary, clean them with a clean swab saturated in alcohol. After cleaning, the contacts must be re-coated with a thin coat of grease: Use RYKON 2EP grease (American Oil Co.) or equivalent.

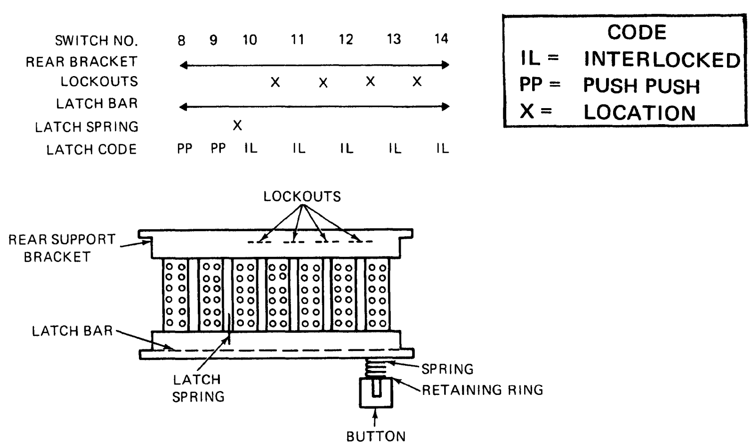


Figure 4-2. FUNCTION SWITCH ASSEMBLY

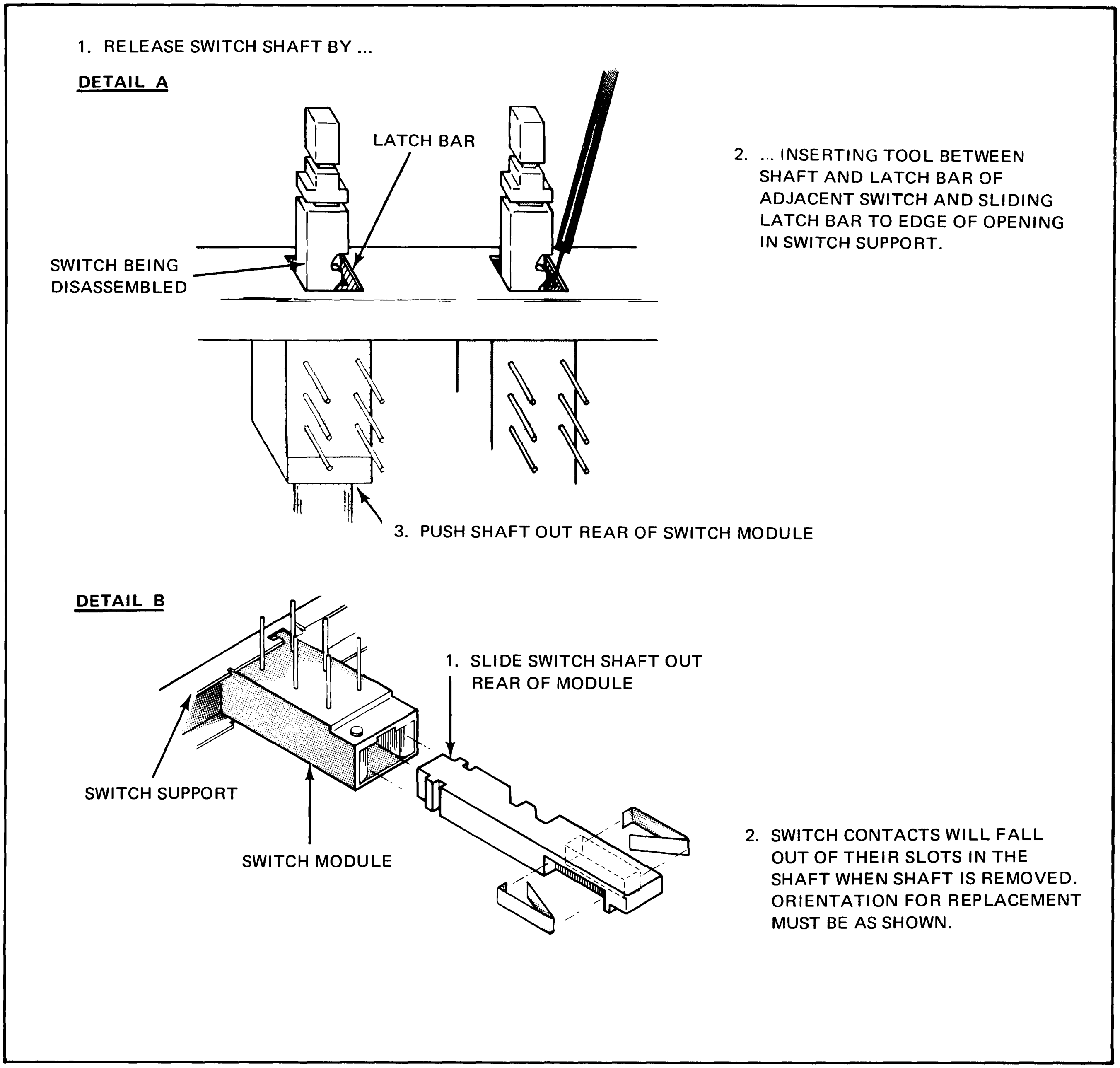


Figure 4-3. PUSHBUTTON SWITCH DISASSEMBLY

4-26. DISASSEMBLY – RANGE SWITCHES.

a. Unplug P14 (flexible plug in circuit plug) from J14.

b. Remove U2 and U3, on Display PCB, from their sockets.

c. Remove four (4) mounting screws which secure RANGE switches to switch assembly brackets.

d. Pull FUNCTION switch assembly, with brackets, away from RANGE switch assembly.

e. Desolder and remove J14 connector from Display PCB.

f. Straighten all locking tabs on rear support bracket. (Figure 4-4.)

CAUTION!

When straightening locking tabs avoid damaging land patterns on PCB.

g. Remove rear support bracket by sliding bracket to the right to clear switch module alignment pins. Remove bracket and lockouts.

h. Remove button, retaining ring and spring.

i. Insert a tool between the latch bar and switch shaft on adjacent switch (Figure 4-4).

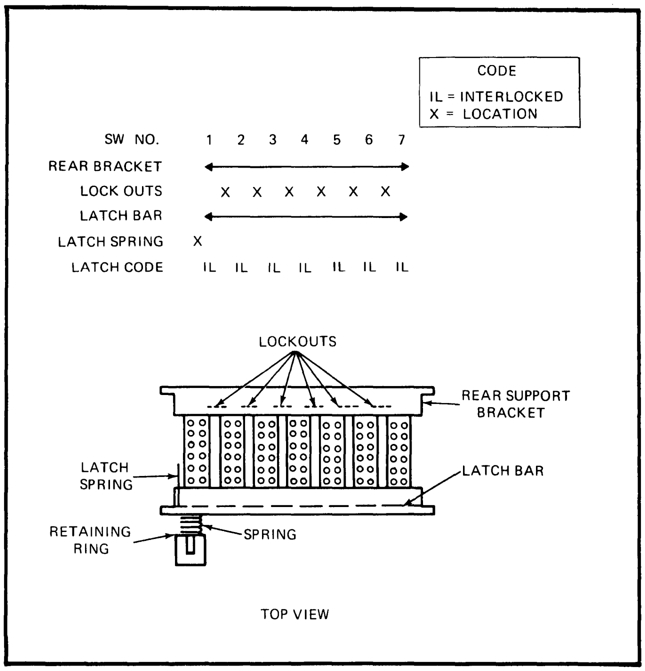


Figure 4-4. RANGE SWITCH ASSEMBLY

j. Slide latch bar to edge of opening in front switch support bracket.

k. Holding latch bar open, push defective switch shaft out rear of module. Switch contacts will fall out of their slots when shaft is pushed out of module.

CAUTION!

Under no circumstances MUST attempts be made to re-form or add tension to the switch contacts by bending them.

l. Inspect the switch contacts for contamination and, if necessary, clean them with a cotton swab saturated in alcohol. After cleaning, the contacts must be re-coated with a thin coat of grease: Use RYKON 2EP grease or equivalent.

4-27. SWITCH MODULE REPLACEMENT – FUNCTION ASSEMBLY (EXCEPT EXT REF, FILT)

a. Repeat paragraphs 4-21, 4-22, and 4-23a. thru f.

b. Desolder flexible printed circuit from all switches.

CAUTION!

Use a desoldering tool and exercise extreme caution to avoid lifting land patterns or otherwise damaging the flexible circuit assembly.

c. Unlock the locking tab on front switch support bracket and remove module (Figure 4-5).

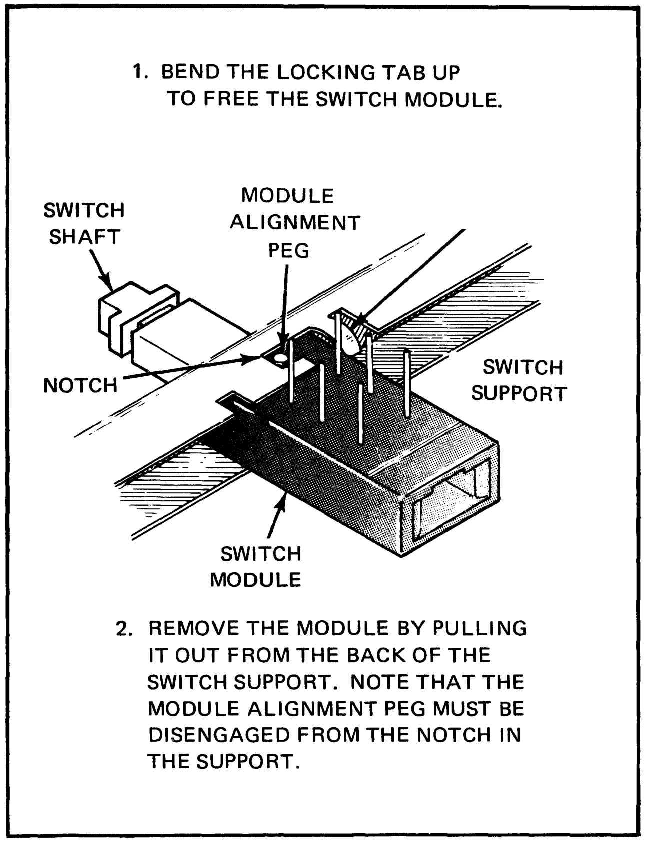


Figure 4-5. PUSHBUTTON SWITCH MODULE REPLACEMENT

d. Install new switch module by reversing the foregoing procedure.

CAUTION!

Under no circumstances MUST attempts be made to re-form or add tension to the switch contacts by bending them.

4-28. SWITCH MODULE REPLACEMENT – RANGE ASSEMBLY.

a. Repeat paragraphs 4-21, 4-22, and 4-24.

b. Remove all buttons, retaining rings, springs and latch spring.

c. Unlock all locking tabs on front support bracket and remove front support bracket and latch bar.

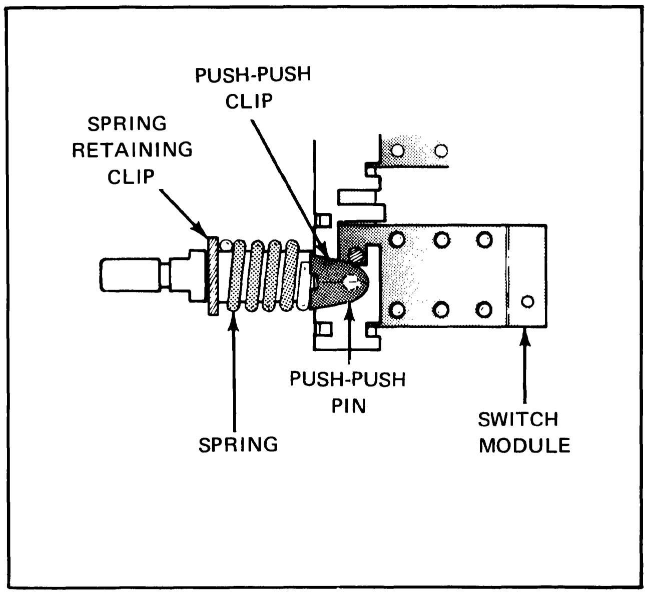


Figure 4-6. EXT REF AND FILT SWITCH DISASSEMBLY

d. Desolder module that is to be replaced.

CAUTION!

Use a desoldering tool and exercise extreme caution to avoid lifting land patterns or otherwise damaging PCB.

e. Install new switch module by reversing foregoing procedure. Refer to Figure 4-4 for assembly of RANGE SWITCH assembly.

4-29. DISASSEMBLY – EXT REF, FILT SWITCH.

a. Repeat paragraphs 4-21, 4-22, and 4-23a. thru f.

b. Desolder defective switch from flexible circuit.

c. Remove push-push pin and push-push clip (Figure 4-6).

d. Remove switch shaft per Figure 4-3 Detail B.

CAUTION!

Under no circumstances MUST attempts be made to re-form or add tension to the switch contacts by bending them.

e. Inspect the switch contacts for contamination and, if necessary, clean them with a cotton swab saturated in alcohol. After cleaning, the contacts must be re-coated with a thin coat of grease: Use RYKON 2EP grease or equivalent.

f. Assemble the switch by reversing the foregoing procedure. Exercise caution to ensure the contacts are not deformed during assembly.

4-30. PERFORMANCE TEST

4-31. The performance test in this section compares the basic instrument performance to the accuracy specifications in Section 1 of this manual to determine if the instrument is in calibration. Known dc voltages are applied to the instrument input terminals on each of five dc voltage ranges and proper operation of the manual range and autorange circuitry is verified. The performance test should be conducted prior to any instrument maintenance or calibration attempts. This test is also suited to receiving inspection of new instruments. The performance test should be conducted under the following conditions: Ambient Temperature 23°C ±5°C, relative humidity less than 70%.

4-32. Should an instrument fail the performance test corrective maintenance or calibration will be required. In the case a trouble occurs, analysis of the test results, with reference to the Troubleshooting Section, should help to locate the trouble.

NOTE!

Tolerances for dc voltage measurements are derived from the 90-day instrument specifications contained in Section 1 of this manual.

4-33. In the following procedure dc voltages are applied to the instrument at 10% and 100% of full scale on the .1, 1, 10, 100 and 1000 volt ranges.

4-34. Preliminary Operation

a. Connect the Model 8400A to the ac line and set the controls as follows:

POWER	ON
FUNCTION	VDC, FILT
RANGE	.1

4-35. Readout Checks

a. Short INPUT terminals.

b. Adjust the front panel ZERO control for a minimum reading on the Model 8400A display.

c. Connect equipment as shown in Figure 4-7.

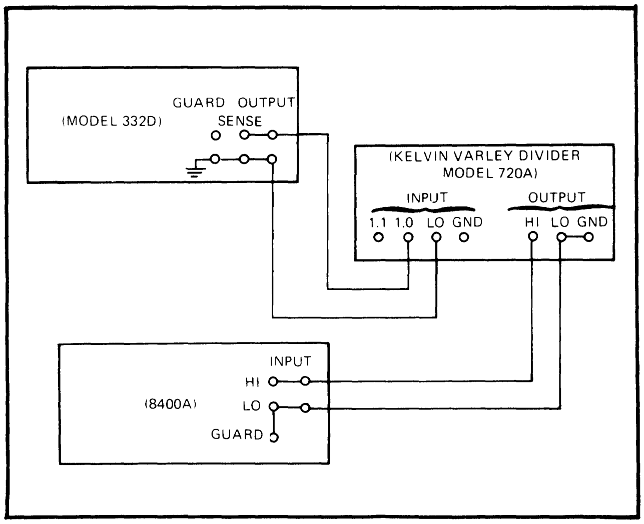


Figure 4-7. READOUT CHECK EQUIPMENT CONNECTION

d. Set the calibrator to 10.0000V output on 10V range.

e. Refer to Table 4-2 for K-V divider settings and corresponding readout limits on Model 8400A.

Table 4-2. DC TEST REQUIREMENTS (.01V to 1V)

K-V Divider SETTINGS	MODEL 8400A RANGE	READOUT LIMITS
.0010000	.1	+.009994 to .010006
.0100000	.1	+0.99990 to .100010
.0100000	1	+0.09997 to 0.10003
.1000000	1	+0.99993 to 1.00007
.1000000	10	+0:9999 to 01.0001

f. Reverse input leads to Model 8400A.

g. Repeat step e. The DVM readout must be the same as for positive inputs, except that the polarity indication will be negative (–).

h. Disconnect equipment and connect calibrator to Model 8400A..

i. Apply each of the input voltages shown in Table 4-3 to the INPUT terminals of the Model 8400A. The readout must be as indicated.

Table 4-3. DC TEST REQUIREMENTS (10V, 100V, AND 1000V)

INPUT (Volts DC)	MODEL 8400A RANGE	READOUT LIMITS	READOUT TOLERANCES
+10.0000	10	+09.9995 to 10.0005	±.0005
+10.0000	100	+009.998 to 010.002	±.002
+100.000	100	+099.995 to 100.005	±.005
+100.000	1000	+0099.98 to 0100.02	±.02
+1000.00	1000	+0999.95 to 1000.05	±.05

j. Repeat step i. with negative input voltages. The DVM readout must be the same as for positive inputs, except that the polarity indication will be negative (–).

k. Apply zero volts to the INPUT terminals of the DVM and depress the AUTO RANGE switch. The readout must be .000000 ±.000005.

l. Apply +1000.00 volts dc to the INPUT terminals. The DVM must range automatically and the readout must be +1000.00 ±.05.

4-36. CALIBRATION PROCEDURE

4-37. Introduction

4-38. The basic Model 8400A should be calibrated every 90 days or 1 year in order to maintain rated accuracy or whenever repairs have been made. Calibration should be done under the following conditions: Ambient Temperature of 23°C ±2°C, relative humidity less than 70%. Refer to Table 4-1 for recommended test equipment. Adjustment and test point locations are labeled on the top inner guard cover. Figure 4-8 shows adjustment and test point locations with the top inner guard cover on. Option calibration appears in Section 6 of this manual.

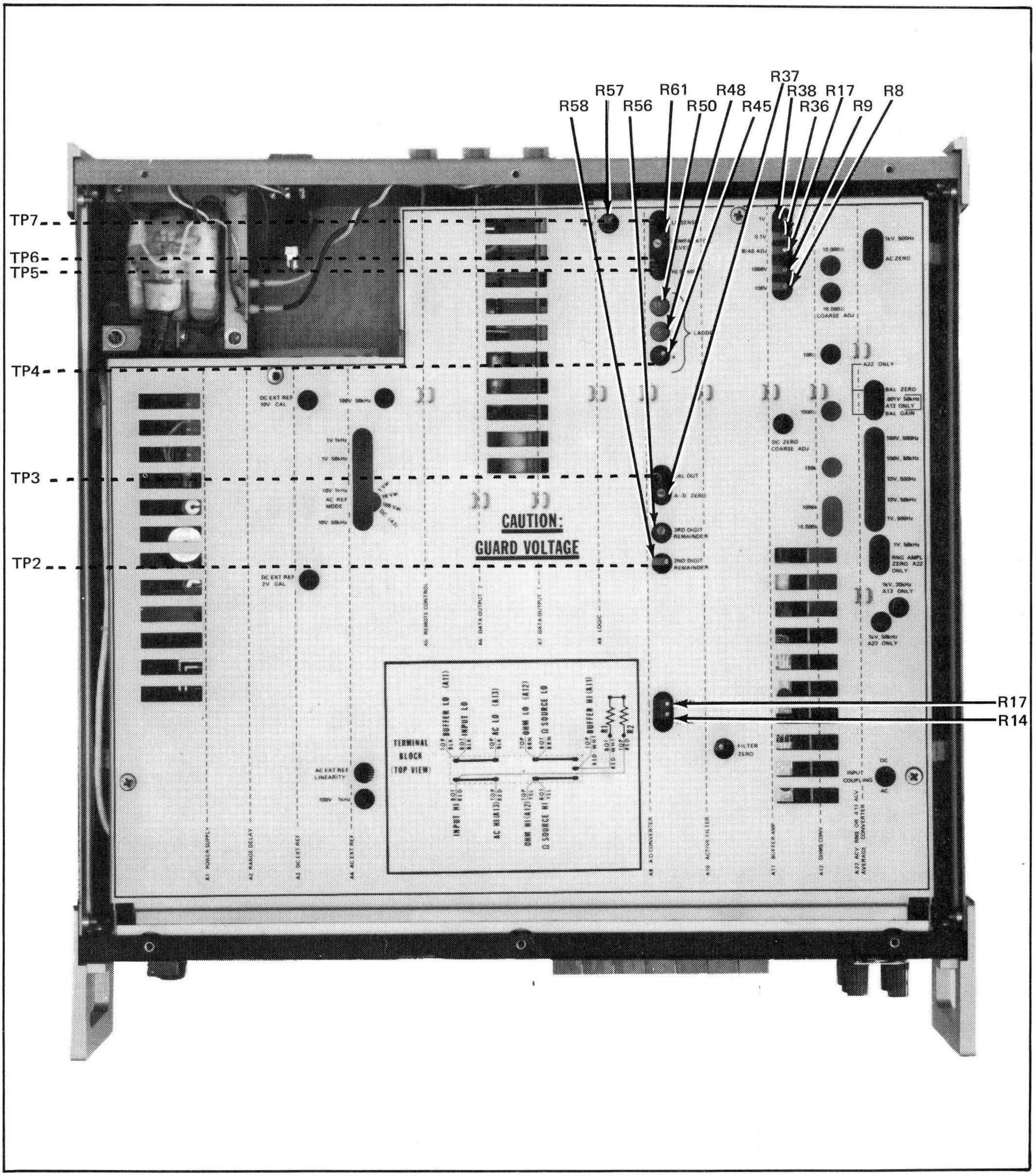


Figure 4-8. ADJUSTMENT AND TEST POINT LOCATIONS

4-39. Preliminary Operations

a. Remove the upper dust cover screws, but leave top cover in place.

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

c. Turn on the Model 8400A and allow it to warm-up for one hour.

4-40. Buffer Zero Adjustment

a. Set the Model 8400A controls as follows:

FUNCTION	VDC, FILT
RANGE	.1

b. Short the INPUT terminals.

c. Adjust front panel ZERO control for minimum reading on the display.

d. Remove top dust cover.

4-41. Bias Current Adjustment

a. Remove short across input terminals and replace with 1 megohm resistor in parallel with a .22 uf capacitor.

b. Adjust BIAS (A11R17) for a zero ±3 digit readout on the Model 8400A display.

c. Repeat steps 4-40b. and c.

4-42. Reference Voltage Adjustment

a. Connect a battery powered differential voltmeter LO SENSE to (A9TP7) and HI SENSE to (A9TP5).

b. Adjust REF (A8R57) for a reading of 7.00000±25 uV on the differential voltmeter. Remove short from the INPUT terminals.

4-43. A-D Zero Adjustment

a. Connect the HI of the differential voltmeter to CAL OUT (A9TP3).

b. Set the differential voltmeter as follows:

RANGE	1V
NULL SENSE	.1
READOUT	.550000

c. Set the Model 8400A as follows:

FUNCTION	VDC
	FILTER
SAMPLE RATE	FULL CW
RANGE	10

d. Connect test equipment as shown in Figure 4-9.

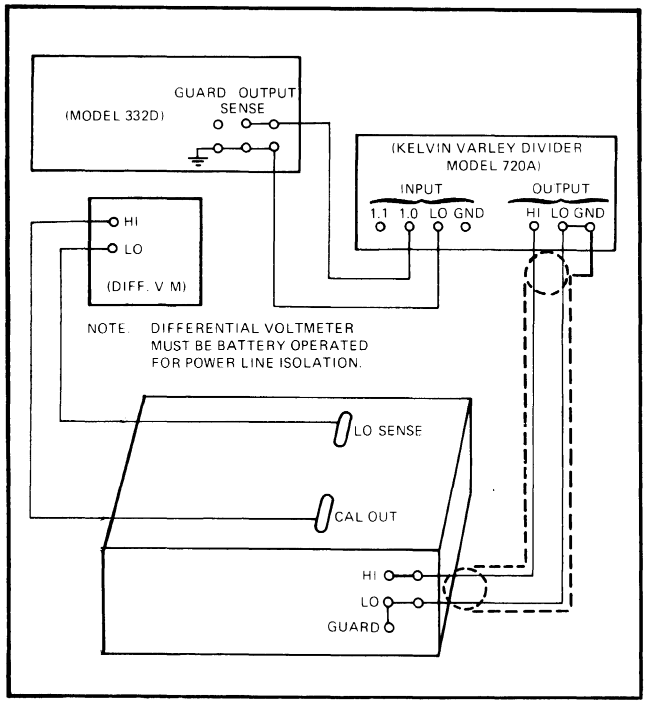


Figure 4-9. EQUIPMENT CONNECTION FOR CALIBRATION

e. Set the calibrator to 10.0000V output on 10V range and dial .000052 on 720A.

f. Adjust A-D ZERO (A9R37) for a readout of +0.0005V on the Model 8400A nixie display. Refine the adjustment for a null (zero) reading on the differential voltmeter. Reverse the input to the Model 8400A and observe –0.0005V on the display and that the reading on the differential voltmeter changes less than ±4 major divisions.

4-44. + Cal Adjustment

a. Connect equipment as shown in Figure 4-9.

b. Adjust COMPARATOR LEVEL (A9R61) to full cw.

c. Dial .800052 on divider.

d. Adjust + CAL (A9R17) for a readout of +8.0005 on Model 8400A display.

e. Refine the adjustment for a null (zero) on the differential voltmeter.

4-45. Ladder Cal

a. Connect equipment as shown in Figure 4-9.

b. Apply the input votlages given in Table 4-4 and perform the associated adjustments that produce the required readout on the Model 8400A and differential voltmeter.

Table 4-4. LADDER CALIBRATION

LADDER	MODEL 8400A			DIFF. V/M
NO.	K-V Divider	Adjustment	READOUT	READOUT
4	+.400052V	LADDER 4 (A9R45)	+4.0005V	NULL
2	+.200052V	LADDER 2 (A9R48)	+2.0005V	NULL
1	+.100052V	LADDER 1 (A9R50	+1.0005V	NULL

4-46. Negative Cal Adjustment

a. Set divider to .800052.

b. Reverse input to the Model 8400A.

c. Adjust –CAL (A9R14) for a display readout of –8.0005.

d. Refine the adjustment for a null (zero) on the differential voltmeter.

4-47. Remainder Adjustment

a. Set COMPARATOR LEVEL (A9R61) full ccw.

b. Connect equipment as shown in Figure 4-9.

c. Apply the input voltages given in Table 4-5 and perform the associated adjustments that produce the required readout on the Model 8400A and differential voltmeter.

Table 4-5. COMPARATOR LEVEL ADJUSTMENT

DIGIT	MODEL 8400A			DIFF. V/M
NO.	K-V Divider SETTING	Adjustment	READOUT	READOUT
2	+.090052V	2nd Digit Remainder (A9R58)	+0.9005	NULL
3	+.099052V	3rd Digit Remainder (A9R56)	+0.9905	NULL
4	+.099952V	–	+0.9995	±2 Major Divisions

4-48. Comparator Level Adjustment

a. Connect equipment as in Fignre 4-9, but do not make the differential voltmeter connections.

b. Set divider to .099995.

c. Adjust COMPARATOR LEVEL (A9R61) so display readout alternates between +0.9999 and +1.0000.

d. Alternate a dc input to the Model 8400A between +1.9999V and +2.0000V dc and verify that the display readout corresponds.

4-49. Buffer DC Calibration

a. Apply the dc input voltages given in Table 4-6 and adjust the associated control for a corresponding readout.

Table 4-6. BUFFER CALIBRATION

DC INPUT	MODEL 8400A		
VOLTAGE	RANGE	ADJUSTMENT	READOUT
+100.000	100	100V (A11R8)	+100.000
+1000.00	1000	1000V (A11R9)	+1000.00
+1.00000	1	1V (A11R36)	+1.00000
+.100000	.1	0.1V (A11R38)	+.100000

b. Disconnect test equipment and replace top cover. Calibration of the basic Model 8400A is complete. Refer to Section 6 for calibration of the options.

4-50. COMPENSATING COMPONENT SELECTION

4-51. The replacement of components Q5, U1, and R22 thru R27 in the Buffer Assembly will cause a deteriation of the temperature coefficient specification. If one or all of these components is found to be faulty the Buffer Assembly PCB must be returned to the factory for repair and recalibration.

4-52. Active Filter

4-53. If either Q1 or U2 are replaced in the Active Filter (A10), R11 or R12 may need to be selected in order to bring the required offset correction within the range of zero control R13. This is done as follows:

a. Depress VDC and 10 buttons on Model 8400A.

b. Short the INPUT terminals of the Model 8400A.

c. Short TP1 to TP2 on Active Filter PCB.

d. Install jumpers across R11 and R12 in positions W1 and W2.

e. Turn instrument on by depressing POWER button.

f. Observe the Model 8400A readout.

g. Select the proper offset resistor using Table 4-7.

Table 4-7. OFFSET CORRECTION RESISTOR SELECTION

8400A READOUT	RESISTANCE REQUIRED	JF PART NO.
0 – .0004	NONE	– –
.0005 – .0012	6.81k	268417
.0013 – .0020	13.7k	236752
.0021 – .0028	21.0k	229484
.0029 – .0036	28.7k	235176
.0037 – .0044	35.7k	288480
.0045 – .0052	44.2k	271676

h. Install resistor in location R11 if readout polarity is positive (+) or R12 if readout polarity is negative (–). Remove only the jumper wire for location used.

4-53. TROUBLESHOOTING

4-54. Introduction

4-55. The information in the following paragraphs is provided to assist in locating troubles in the basic Model 8400A. Figure 4-10 shows assembly location by reference number and test point locations. Since this instrument is somewhat complex, it is recommended that the theory of operation in Section 3 be understood before any attempt at troubleshooting is undertaken.

4-56. Initial Troubleshooting

4-57. Troubleshooting of the Model 8400A starts by first inspecting the instrument for improperly seated plug-in assemblies, loose wires, physically damaged parts, or other obvious problems. The next step is then to ensure that it is being operated correctly, but still fails to meet specifications. Performance checks designed for this purpose are given in paragraphs 4-30 through 4-35.

4-58. Section Localization

4-59. To aid in troubleshooting the Model 8400A, the basic instrument can be broken down into three major sections, analog, digital, and power supply.

4-60. The analog section consists of the A11 Buffer and A10 Active Filter. These assemblies supply a dc voltage from +10 to –10 volts, dependent upon the polarity and value of the input, to the digital section.

4-61. The digital section is composed of the A9 A-to-D Converter, A8 Logic, A2 Range Delay, and A14 Display assemblies. The digital section converts the dc input from the analog section to a digital signal, then processes this signal through timing, storage, and display circuits for proper readout.

4-62. The power supply section consists of an A1 Power Supply Assembly. This assembly supplies operating voltages to the internal circuits of both the analog and digital sections.

4-63. Power Supply

4-64. The A1 Power Supply can be checked for porper operation using a dc differential voltmeter and performing the voltage checks given in Table 4-8.

Table 4-8. POWER SUPPLY CHECKS

VOLTAGE TEST POINTS		DC VOLTS		
V/M Lo	V/M Hi	NOMINAL	LIMITS	ADJUSTMENT
A1TP4	A1TP2	+18V	±10 mV	A1R11
A1TP4	A1TP3	–18V	±375 mV	NONE
A1TP4	A1TP5	+5V	+.15V	Remove R17 to increase
A1TP4	A1TP1	+200V	±5V	NONE

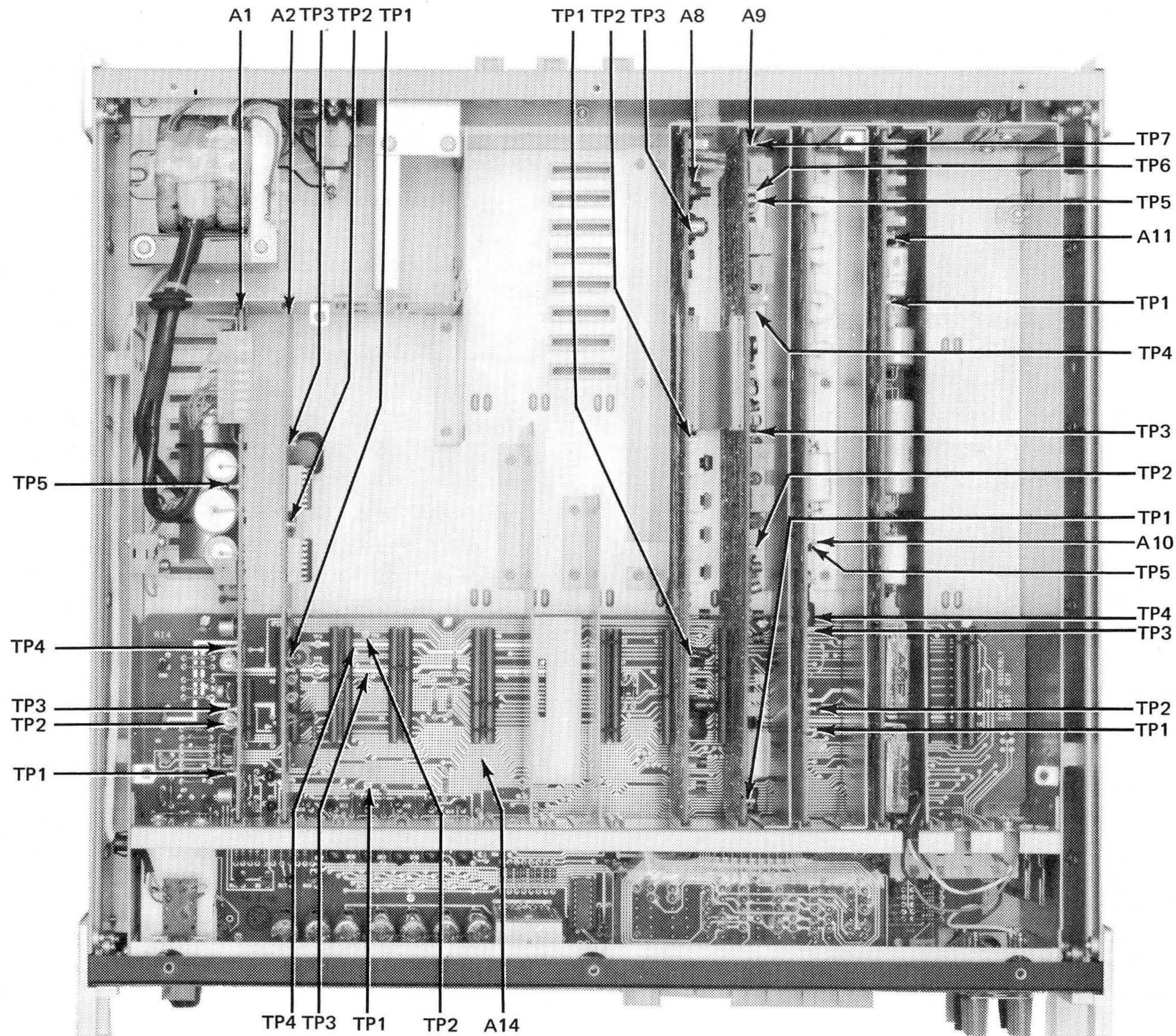


Figure 4-10. ASSEMBLY AND TEST POINT LOCATIONS

4-65. Analog Section

4-66. To determine if a trouble exists in the analog section, use the following checks:

a. Connect a battery powered differential voltmeter LO to A10TP4 and HI to A10TP3.

b. Depress VDC and 10 switches on Model 8400A.

c. Turn on the Model 8400A and apply +10V dc to INPUT terminals. The differential voltmeter should read −10V.

NOTE!

The differential voltmeter should read −10V for full scale inputs on the 10, 100, and 1000 volt ranges, and +10V for full-scale inputs on the .1 and 1 volt ranges. For inputs less than full-scale on any range, the differential voltmeter should read proportionately less.

(Example: +10V input on 100V range, the differential voltmeter will read −1V).

FAULT ANALYSIS

IF VOLTMETER READINGS DO NOT CORRESPOND TO INPUT VOLTAGES, THE TROUBLE EXISTS IN THE ANALOG SECTION. IF VOLTMETER READINGS DO CORRESPOND TO INPUT VOLTAGES, THE TROUBLE EXISTS IN THE DIGITAL SECTION.

4-67. BUFFER CHECKS.

4-68. Overload Check.

a. Connect differential voltmeter HI to K1 pin 14 and LO to the Model 8400A HI (red) INPUT terminal.

b. Depress the 1, VDC, FILT buttons and set SAMPLE RATE full cw.

c. Apply +3V ±1% to INPUT terminals of 8400A and observe readout of +1.19999. The differential voltmeter should read −.5V ±.25V.

FAULT ANALYSIS

IF READINGS DO NOT CORRESPOND, THE PROBABLE CAUSE IS IN THE OVERLOAD CIRCUITRY. THE AMPLIFIER SECTION MAY BE A SECONDARY CAUSE.

4-69. Zero Check.

a. Depress .1 and VDC buttons on Model 8400A.

b. Short the INPUT terminals on front panel.

c. Readout Zero Volts on Readout display.

d. Adjust front panel DC Zero control so readout varies from +.000030 to −.000030.

FAULT ANALYSIS

IF DC ZERO CONTROL WILL NOT SWING THROUGH ABSOLUTE ZERO, ADJUSTMENT OF COURSE DC ZERO (A11R28) IS INDICATED. IF THIS IS NECESSARY, THE AMPLIFIER SECTION OF THE BUFFER COULD BE FAULTY.

NOTE!

The BUFFER assembly must be returned to factory for replacement of faulty parts within the amplifier circuitry. Refer to paragraph 4-51 for critical components.

4-70. Gain Check.

a. Depress 10 button on Model 8400A.

b. Connect a battery powered differential voltmeter as follows:
HI to INPUT HI on Model 8400A.
LO to A11TP2

c. Apply −12.5V ±.5V to INPUT terminals of Model 8400A.

d. Readout on Model 8400A should be −11.9999.

e. Adjust the differential voltmeter to obtain measured value (null).

f. Reverse the polarity of the input voltage and observe the following:

1. Model 8400A readout is +11.9999.

2. Differential voltmeter reading changed less than +25 μV.

FAULT ANALYSIS

IF BUFFER CHECKS ARE OK, ANALOG PROBLEM CAN EXISTS IN ACTIVE FILTER CIRCUITRY.

4-71. ACTIVE FILTER CHECKS.

4-72. Gain Checks.

NOTE!

Remove Remote Control Unit if Model 8400A is so equipped.

a. Depress REMOTE button on Model 8400A.

b. Connect battery powered differential voltmeter LO to A10TP5 and HI to A10TP3.

c. Adjust differential voltmeter to obtain measured value (null).

d. Apply +10V dc ±1V between A10TP4 (common) and A10TP5. The differential voltmeter indication should not change more than 100 μV.

e. Reverse polarity of input voltage and note that differential voltmeter indication should not change more than 100 μV.

4-73. AC Rejection.

a. Depress VDC, FILT, 10 buttons.

b. Apply a 3V rms ±1%, 60 Hz signal to the INPUT terminals of Model 8400A.

c. Adjust SAMPLE RATE control so the readout changes about twice a second.

d. The Model 8400A readout should be less than 20 digits.

4-74. Digital Section

4-75. The digital section may be divided into a number of somewhat independent sections for trouble analysis. These digital sections and their locations are as follows:

LOCATION	DIGITAL SECTIONS
A14 – Display	Range Counter Sample Command Oscillator Readout Tubes and Controls
A9 – A-to-D Converter	A/D Amplifier Sample and Hold Analog Comparator Ladder (Primary and Secondary) Display Storage
A8 – Logic	Master Clock CCO Analog Cycle Control Display Storage Control 6-State Shift Register 16-State Binary Counter

4-76. Generally troubleshooting the digital section is more difficult than the analog section; therefore, troubleshooting guides (Figure 4-11 and 4-12) are important aids for localizing troubles to sections.

NOTE!

The storage cycle can be bypassed if there is a suspicion that the storage circuitry is faulty. A FAULTY storage cycle is usually seen as flashing digits. By jumpering A1TP5 (+5V) to A14TP2 (M), the Model 8400A is placed into a continuous measurement mode.

4-77. Figures 4-13 thru 4-16 are idealized waveforms from significant locations showing relationship of each waveform to the others and to the measure period. Analysis of these waveforms and a comparison to waveforms present at the same points will assist in localizing troubles. All waveforms are as shown when Model 8400A is placed in the continuous measurement condition.

FAULT ANALYSIS

IF, AFTER PLACING THE MODEL 8400A INTO THE CONTINUOUS MEASUREMENT CONDITION, THE READOUT IS CORRECT, THE FAULT LIES IN THE STORAGE CIRCUITRY. IF READOUT IS STILL INCORRECT THE FAULT LIES ELSEWHERE.

4-78. Figures 4-17 thru 4-19 show waveforms that are present at A9TP2 with Model 8400A in continuous measurement condition. Analysis of these waveforms to those present under trouble conditions will assist in troubleshooting the digital section.

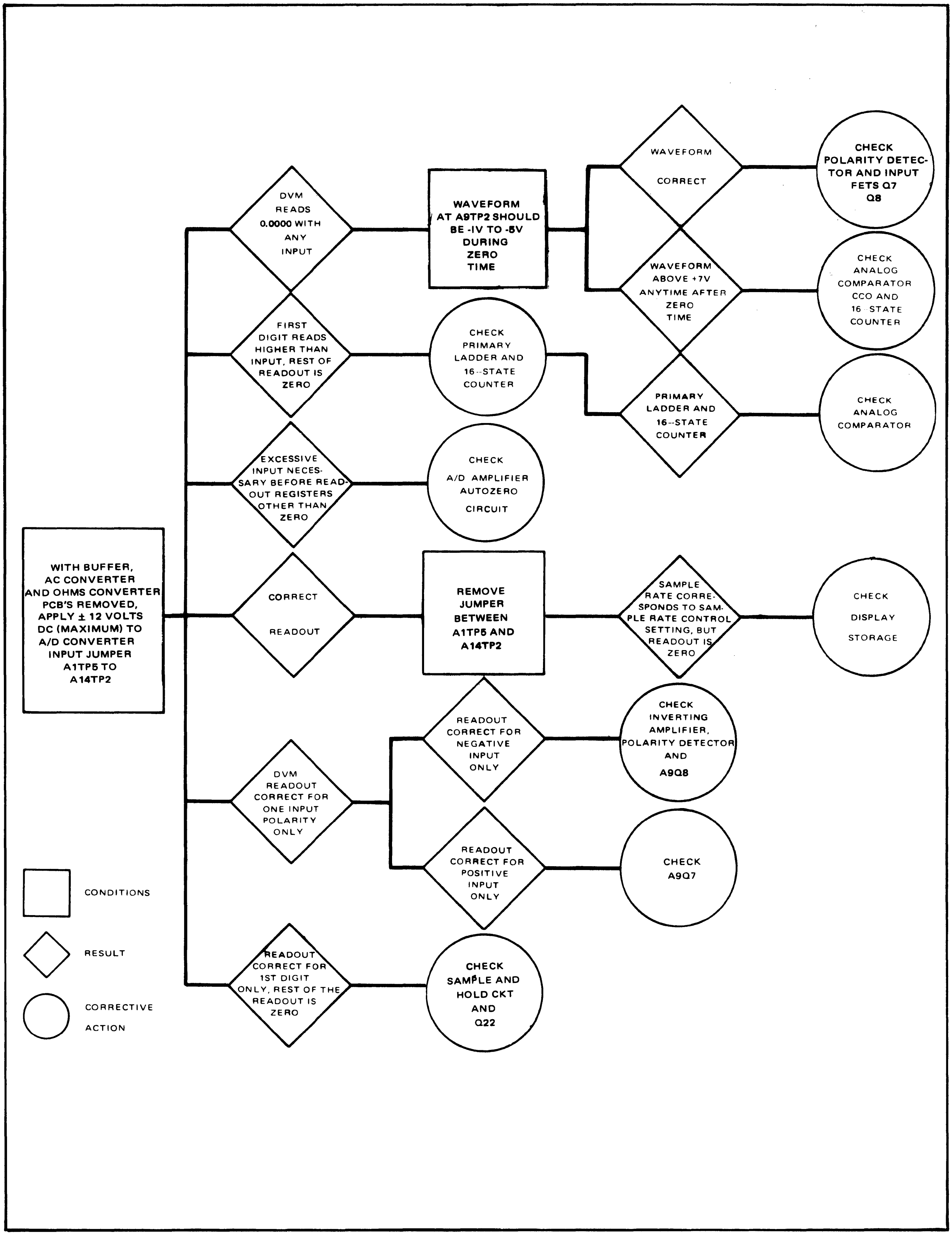


Figure 4-11. TROUBLESHOOTING DVM DIGITAL SECTION

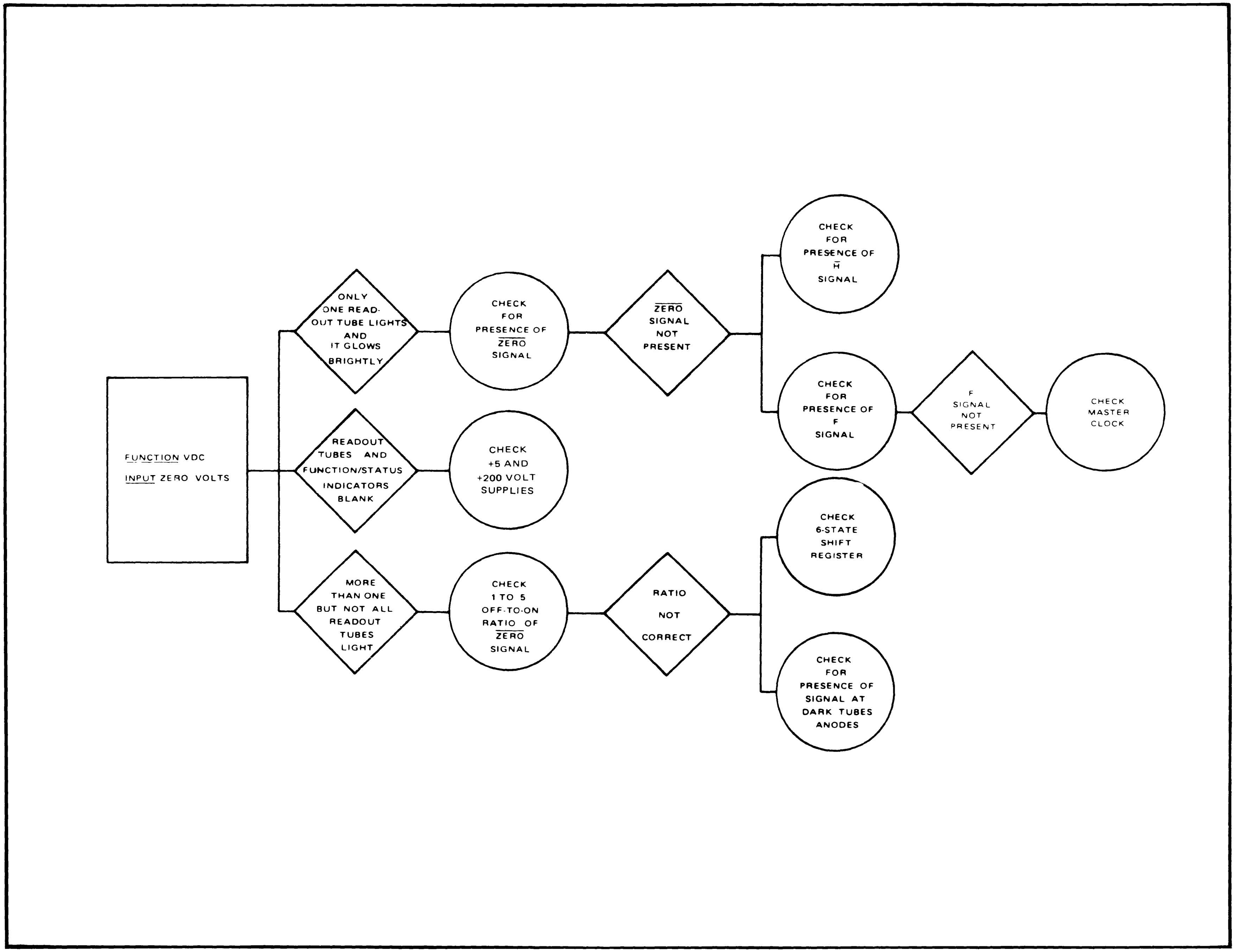


Figure 4-12. TROUBLESHOOTING DVM DISPLAY

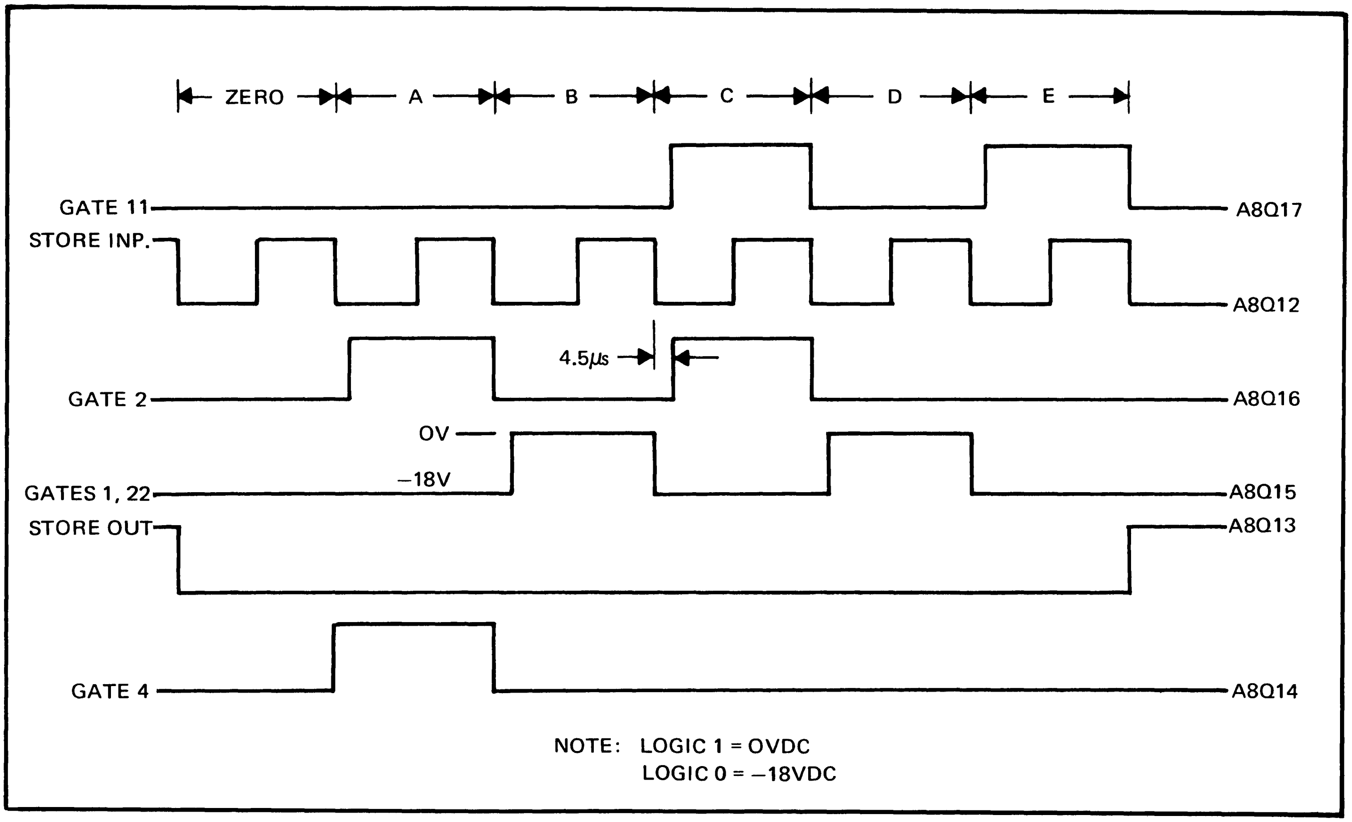


Figure 4-13. A/D CONVERTER CONTROLS

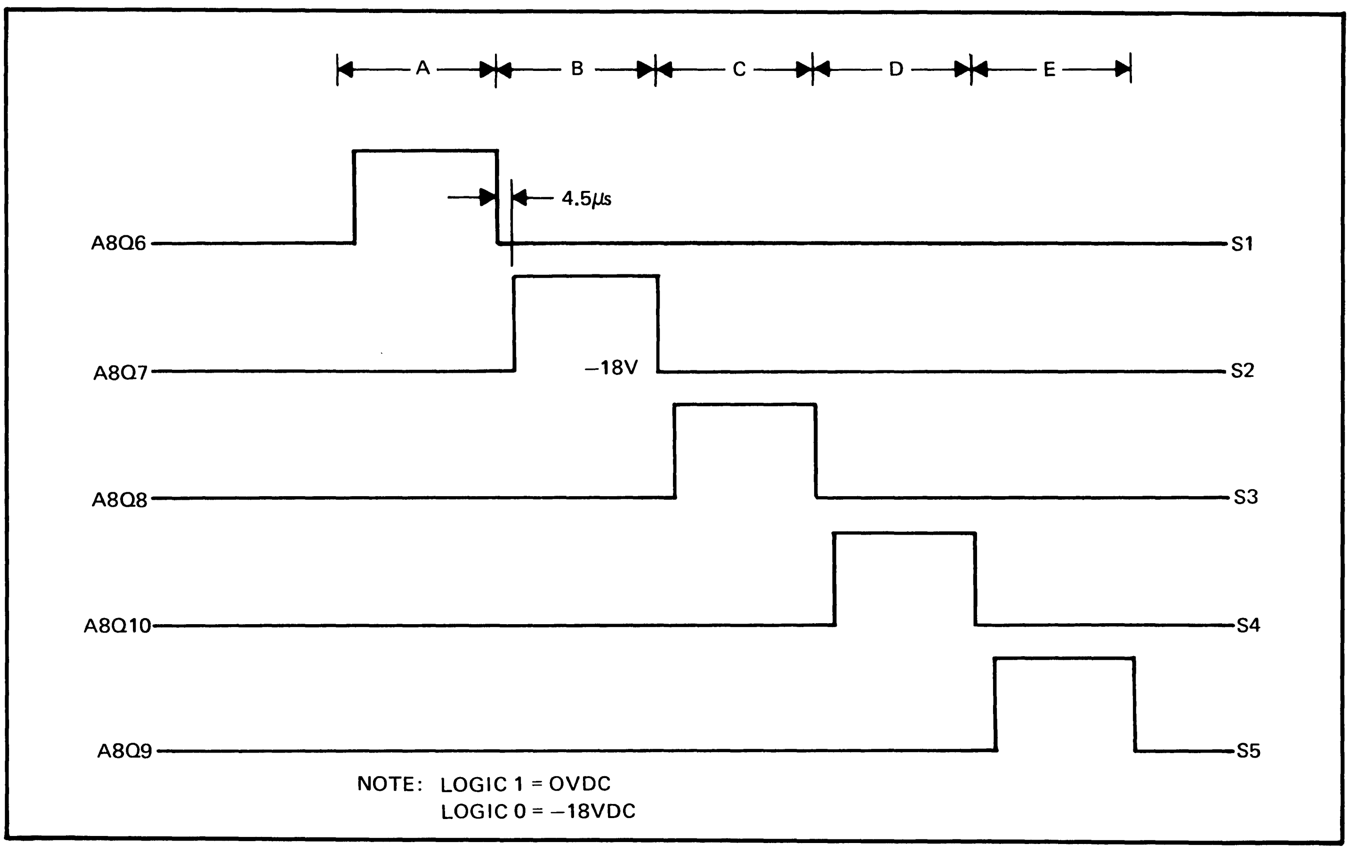


Figure 4-14. ANALOG STORAGE CONTROL

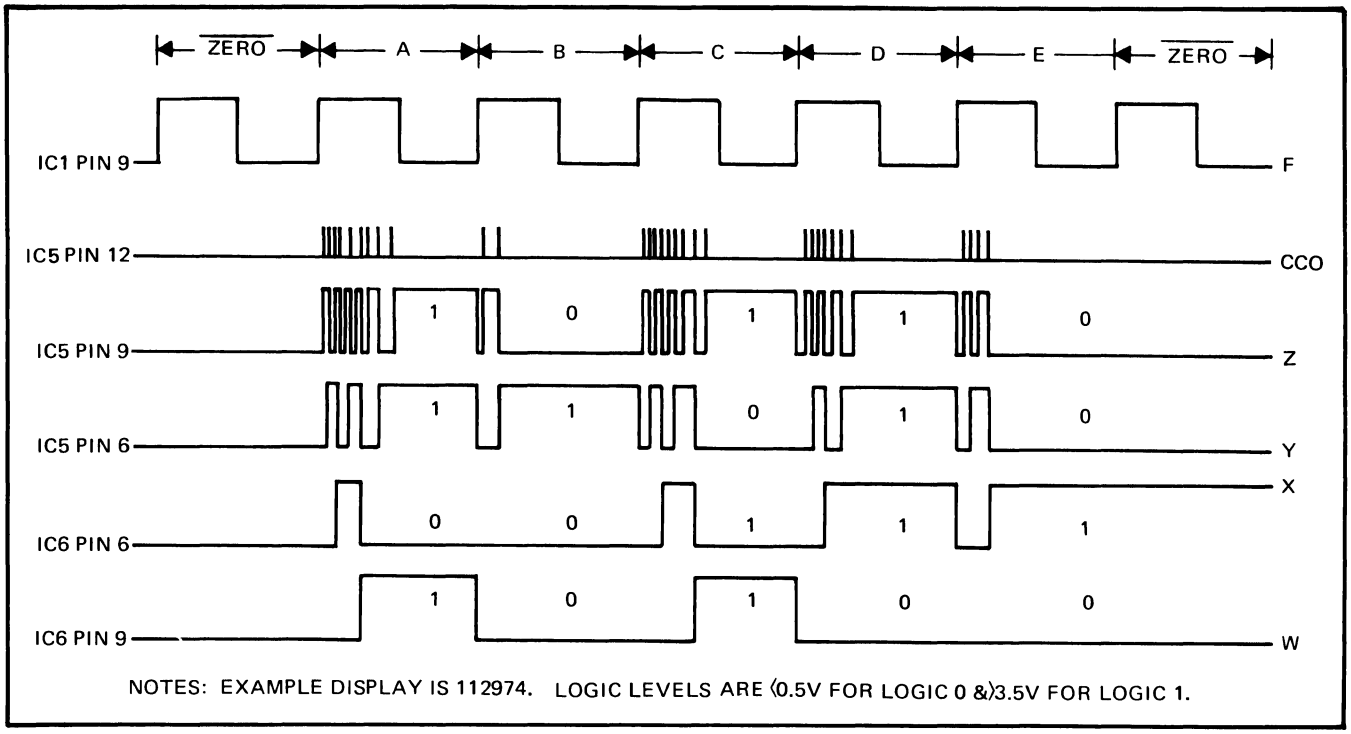


Figure 4-15. COUNTER OPERATION

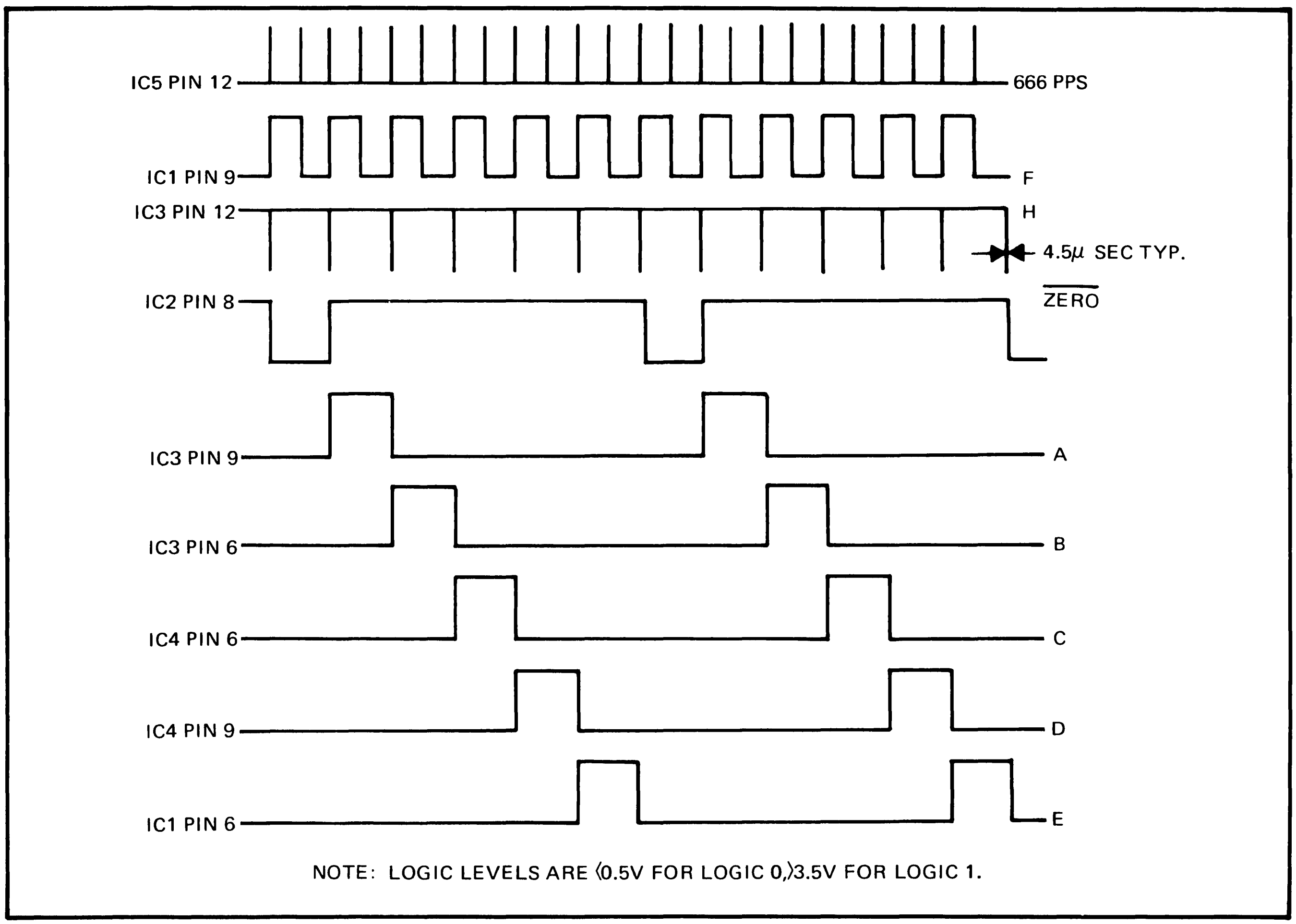


Figure 4-16. SHIFT REGISTER OPERATION

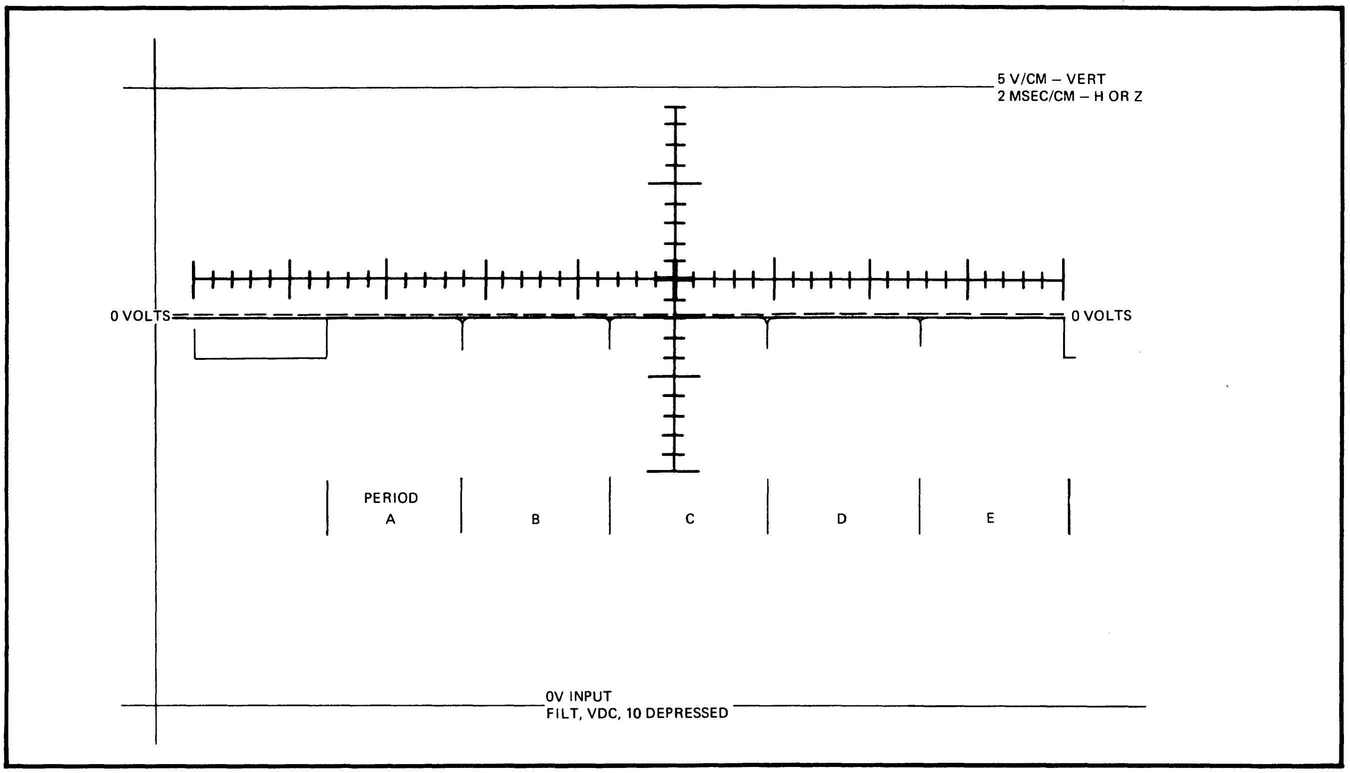


Figure 4-17. A9TP2 MEASUREMENT

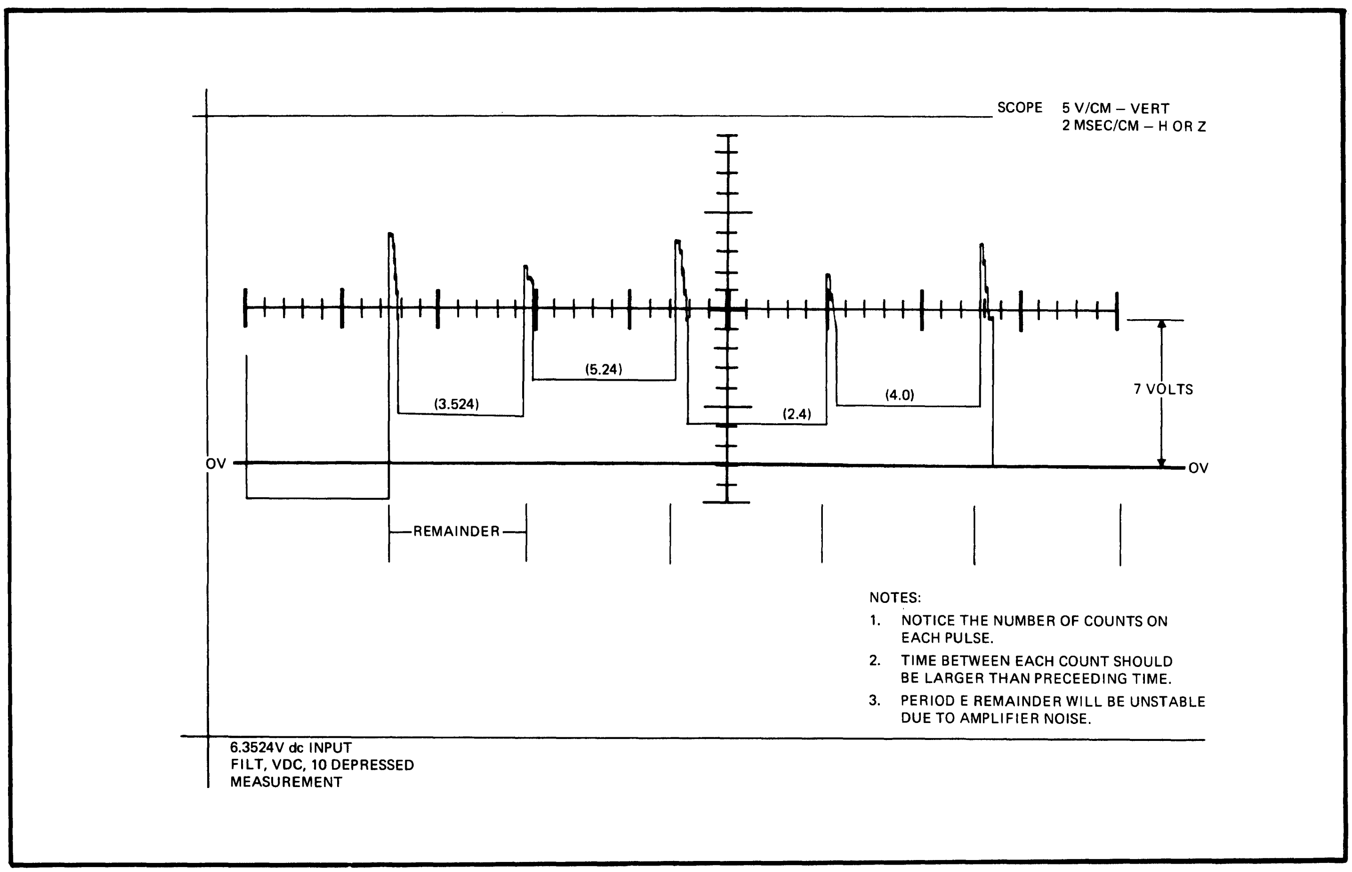


Figure 4-18. A9TP2

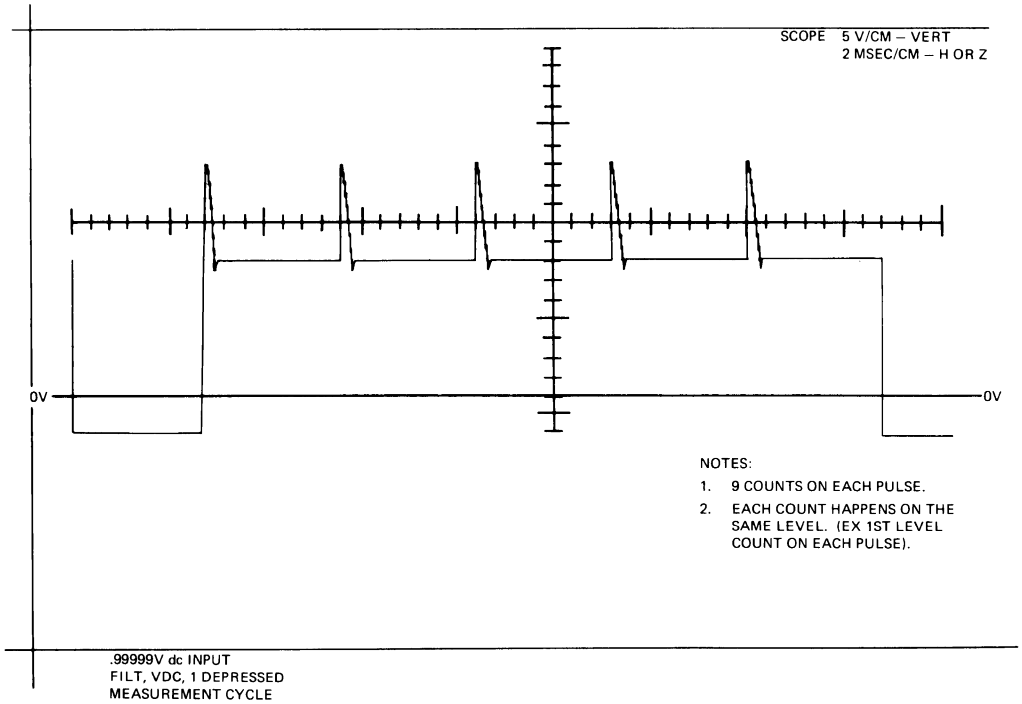


Figure 4-19. A9TP2

Section 5

List of Replaceable Parts

5-1. INTRODUCTION

5-2. This section contains an illustrated parts breakdown list of the instrument and a Cross Reference List of FLUKE stock numbers to original MANUFACTURERS' part numbers. It also lists recommended spare parts and contains part ordering information. The starting page number of each major listing is given in the Table of Contents.

5-3. The parts list shows the location of all assemblies and the replaceable components. Major assemblies are identified by a designation beginning with the letter A followed by a number (e.g., A1 etc). Subassemblies are identified in the same manner; however, the parent assembly designator precedes this designator (e.g., A1A1 etc.). Electrical components are identified by their schematic diagram designator and listed hardware parts are identified by the FLUKE stock number. All listed components are described, and the FLUKE stock number is given. The original MANUFACTURER'S part number for each listed item is given in the Cross Reference List at the rear of this section.

5-4. PARTS LIST COLUMN DESCRIPTIONS

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 may appear out of order.

b. 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, refer to Appendix B located at the rear of the manual.

c. The six-digit part number, by which the item is identified at the John Fluke Mfg. Co., Inc. is listed in the STOCK NO. column. Use this number when ordering parts from the factory or authorized representatives. In the case where a flag note is used, special ordering is required. Flag note explanations are located as close as possible to the flag note.

d. The TOT QTY column lists the total quantity of the item used in each particular assembly. This quantity reflects only the latest Use Code. Second and subsequent listings of the same item are referenced to the first listing with the abbreviation REF.

e. 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 each assembly 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.

f. The USE CODE column identifies certain parts which have been added, deleted or modified during the production of the instrument. Each part for which a Use Code has been assigned may be identified with a particular instrument serial number by consulting the Serial Effectivity List, paragraph 5-9. Sometimes when a part is changed, the new part can and should be used as a replacement for the original part.

5-5. MANUFACTURERS' CROSS REFERENCE LIST COLUMN DESCRIPTIONS

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

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

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

5-6. HOW TO OBTAIN PARTS

5-7. Standard components have been used whenever 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., Inc. factory or authorized representative by using the FLUKE stock 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.

5-8. You can insure prompt and efficient handling of your order to the John Fluke Mfg. Co., Inc. 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, 215897, Transistor, 2N4126 A2A1Q1 & Q2 for 645A, S/N 123.

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 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 8400A. 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	SERIAL NUMBER EFFECTIVITY
A	123 thru 148.
B	149 and on.
C	187 and on.
D	198 and on.
E	123 thru 264.
F	265 and on.
G	123 thru 267.
H	268 and on.
I	123 thru 265.
J	266 and on.
K	378 and on.
L	330 and on.
M	123 thru 377.
N	123 thru 332.
O	333 and on.
P	123 thru 632.
Q	633 and on.
R	123 thru 272.
S	273 and on.
T	554 and on.
U	123 thru 553.
V	76400 and on.

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	8400A DIGITAL VOLTMETER **Figure 5-1**						
A1	Power Supply (Figure 5-2)	288159			1		
A2	Range Delay (Figure 5-3)	288209			1		
A3	DC External Reference (See Section 6, –05 Option not supplied with standard 8400)	1			1		
A4	AC External Reference (See Section 6, –06 Option not supplied with standard 8400)	1			1		
A5	Remote Control (See Section 6, –04 Option not supplied with standard 8400)	1			1		
A6	Data Output No. 2 (See Section 6, –03 Option not supplied with standard 8400)	1			1		
A7	Data Output No. 1 (See Section 6, –03 Option not supplied with standard 8400)	1			1		
A8	Logic (Figure 5-4)	2			1		
A9	AD Converter (Figure 5-5)	2			1		
A10	Active Filter (Figure 5-6)	2			1		
A11	Buffer (Figure 5-7)	288191			1		
A12	Ohms Converter (See Section 6, –02 Option not supplied with standard 8400)	1			1		
A13	AC Converter (See Section 6, –01 Option not supplied with standard 8400)	1			1		
A14	Display (Figure 5-8)	288167			1		
A22	True RMS converter (See Section 6, –09 Option not supplied with standard 8400)	1			1		
C1	Cap, cer, fixed 47 pf ±10%	282145			1		
J25, J27	Binding post, red, Hi	275552			2		
J26, J28	Binding post, black, Lo	275560			2		
J30, J31	Jack, teflon, ins (Mounted on T1)	295287			2		
J32	Binding post, blue, guard	275578			1		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R1, R2	Res, ww, 50K, ±25%	307298			2		
R3	Res, comp, 10M ±10%, ½w	108142			1		C
S1	Switch, power (for push button, see below)	291526			1		
	Button, push, green	268862			1		
	Cover, top, outer	311746			1		
	Cover, top guard	346163			1		
	Cover, access	297713			1		
	Cover, bottom	298554			1		
	Foot	292870			4		
	Knob, black	190249			1		
	Lens	297903			1		
	Line, cord and plug	284174			1		
	Shorting Link	190728			3		
	Terminal, double	301382			4		
	Terminal, single	301390			5		
	Terminal strip, black	305136			4		
	Terminal strip, ins, light grey	297846			6		
	1 Order by model and option number						
	2 A8 and A9 must be purchased as a set Stock number 303461						
	Corner name Decals	296251					

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	REAR PANEL ASSEMBLY						
	Figure 5-1						
P1	Connector, AC receptacle	284166			1		
F1	Fuse, AGC ½A fast-blo	153858			1		
XF1	Fuse Holder	295741			1		
	Panel, rear (includes slide switch, stock no. 226274)	297645			1		
T1	Transformer, power	365171			1		

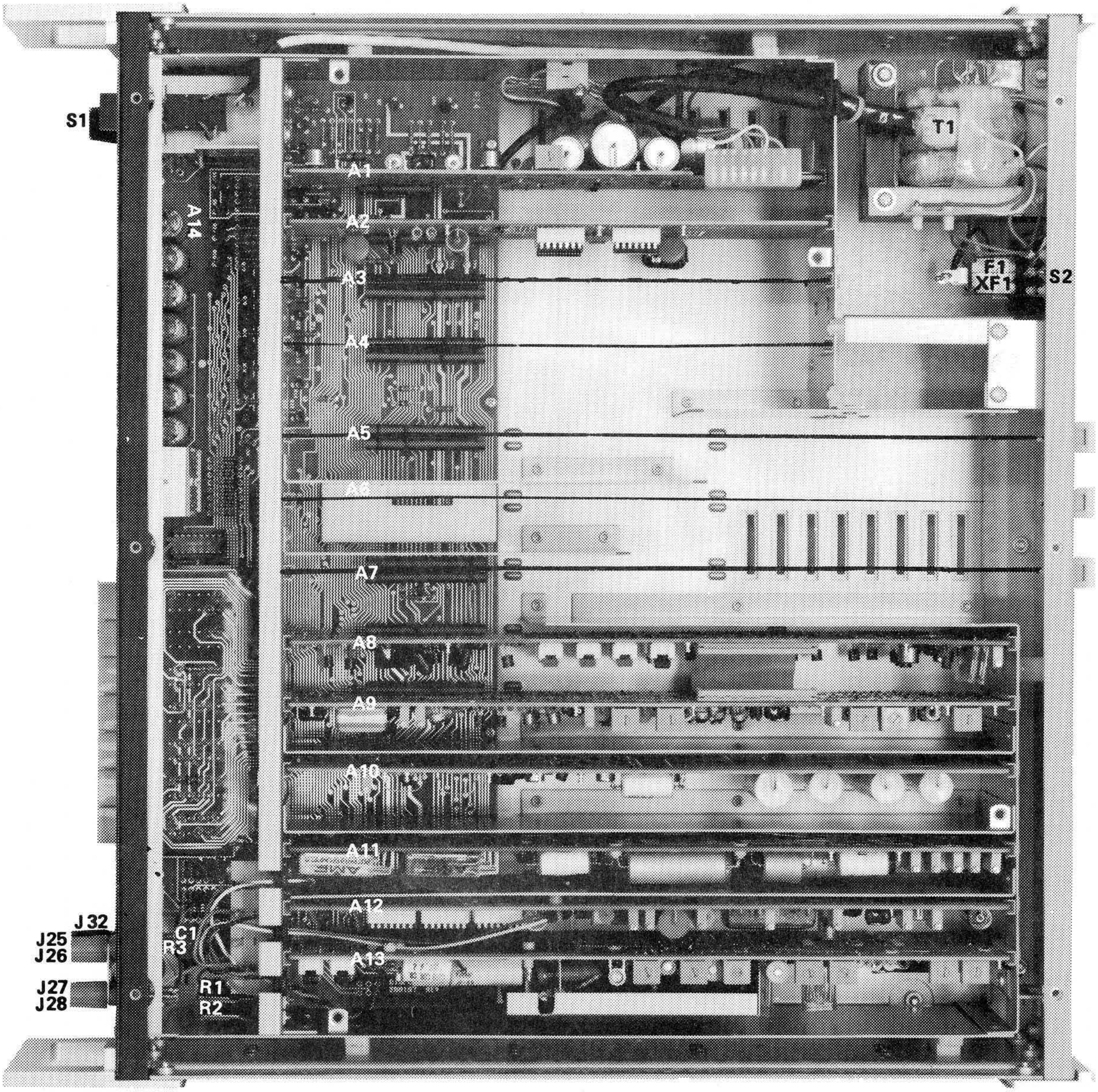


Figure 5-1. MODEL 8400A DIGITAL VOLTMETER

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A1	**POWER SUPPLY** **Figure 5-2**	288159			REF		
C1	Cap, elect, 8 uf +50/–10%, 350V	275792			1		
C2, C5	Cap, elect, 250 uf +50/–10%, 40V	178616			2		
C3, C7	Cap, mica, 33 pf ±5%, 500V	160317			2		
C4, C6	Cap, elect, 50 uf +50/–10%, 25V	168823			2		
C8	Cap, elect, 7100 uf +75/–10%, 10V	295196			1		
CR1 thru CR4	Diode, silicon, 1 amp, 600 piv	112383			4		
CR5 thru CR8, CR10 thru CR13	Diode, silicon, 1 amp, 100 piv	116111			8		
CR9	Diode, zener, 12V	249052			1		
Q1, Q2	Tstr, silicon, NPN	218511			2		
Q3, Q8	Tstr, silicon, NPN	150359			2		
Q4	Not used	150359			2		
Q5	Tstr, silicon, PNP	269076			-1		
Q6	Tstr, silicon, NPN	288381			1		
Q7	Tstr, silicon, NPN	218396			1		
R1	Res, comp, 510 ±5%, ½w	108951			1		
R2	Res, comp, 68k ±5%, ¼w	148171			1		
R3	Res, met flm, 383k ±1%, 1/8w	288498			1		
R4, R15	Res, met flm, 40.2k ±1%, 1/8w	235333			2		
R5, R8	Res, comp, 51 ±5%, ½w	144717			2		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R6	Res, ww, 7.2k ±0.1%, ¼w	295121			1		
R7	Not used						
R9	Res, ww, 4.02k ±0.1%, ¼w	240937			1		
R10, R12	Res, met flm, 10k ±1%, 1/8w	168260			2		
R11	Res, var, cer met, 500 ±10%, 1w	291120			1		
R13, R16	Res, comp, 5.6k ±5%, ¼w	148080			2		
R14	Res, met flm, 9.53k ±1%, 1/8w	288563			1		
R17	Res, comp, 220k ±5%, ¼w	160937			1		
U1, U2	IC, operational amplifier	271502			2		

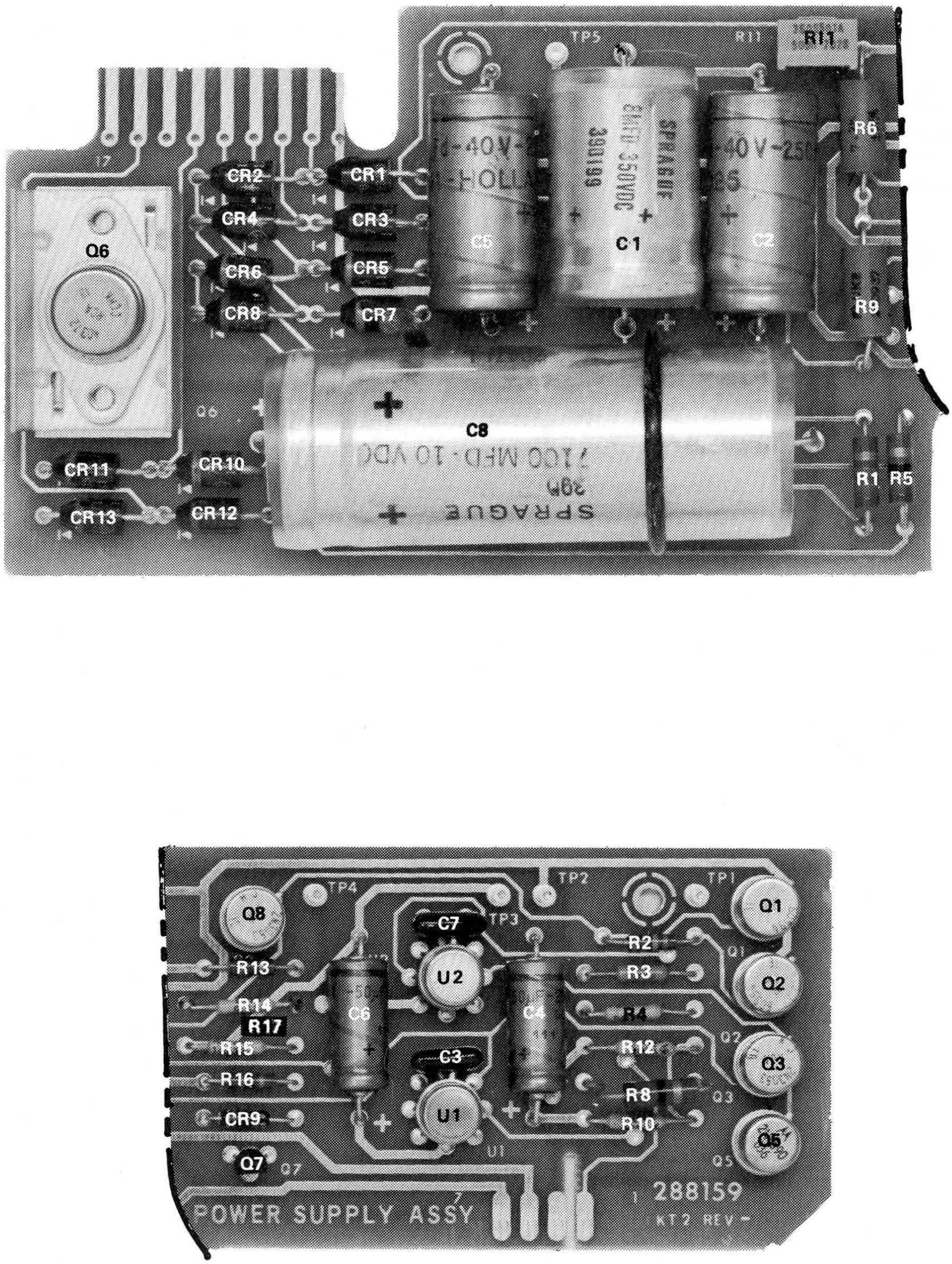


Figure 5-2. POWER SUPPLY PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A2	RANGE DELAY Figure 5-3	288209			REF		
C1, C3	Cap, cer, 0.025 uf ±20%, 100V	168435			2		
C2, C6	Cap, Ta, 3.3 uf ±5%, 20V	271320			2		
C4	Cap, mica, 0.01 uf ±1%, 300V	152470			1		
C5	Cap, elect, 200 uf +50/−10%, 10V	236935			1		
C7	Cap, cer, 2200 pf, ±10%, 500V	268425			1		Q
C8	Cap, cer, .01 uf, ±20%, 100V	149153			1		Q
CR1, CR3, CR9, CR11	Diode, silicon 150 mA	203323			4		E
CR1, CR3, CR9, CR11 CR16	Diode, silicon, 150 mA	203323			5		F
CR2, CR6, CR7, CR8, CR10	Diode, germanium, 80 mA, 100 piv	149187			5		E
CR2, CR6, CR7, CR8, CR10 CR12 thru CR15	Diode, germanium, 80 mA, 100 piv	149187			9		F
CR4, CR5	Diode, fast switching germanium, 50 piv	180505			2		
Q1, Q2	Tstr, silicon, NPN	168708			2		
Q3	Tstr, silicon, NPN	218396			1		E

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
Q3,Q5	Tstr, silicon, NPN	218396			2		F
Q4	Tstr, silicon, unijunction	268110			1		
R1,R6, R15	Res, comp, 220 ±5%, ¼w	147959			3		
R2	Res, comp, 22k ±5%, ¼w	148130			1		
R3, R7	Res, comp, 4.7k ±5%, ¼w	148072			2		
R4,R17	Res, comp, 27k ±5%, ¼w	148148			2		
R5	Res, comp, 51k ±5%, ¼w	193334			1		
R8	Res, met flm, 27.4k ±1%, 1/8w	241471			1		
R9	Res, met flm, 15.4k ±1%, 1/8w	261651			1		
R10	Res, comp, 47k ±5%, ¼w	148163			1		
R11	Res, comp, 10k ±5%, ¼w	148106			1		E
R11, R19	Res, comp, 10k ±5%, ¼w	148106			2		F
R12	Res, met flm, 10k ±1%, 1/8w	168260			1		
R13	Res, met flm, 36.5k ±1%, 1/8w	235309			1		
R14	Res, met flm, 21k ±0.5%, 1/8w	229484			1		E
	Res, met flm, 16.9k ±1%, 1/8w	267146			1		F
R16	Res, comp, 5.1k ±5%, ¼w	193342			1		
R18	Res, var, cer met, 10k ±10%, ½w	285171			1		F
U1	IC, DTL, Hex Inverter	268367			1		
U2	IC, DTL, Triple 3-Input Nand Gate	266312			1		
U3	IC, DTL, dual 4-Input Nand	268383			1		
	Socket, IC, 14 contact, U1, U2, U3	276527			3		

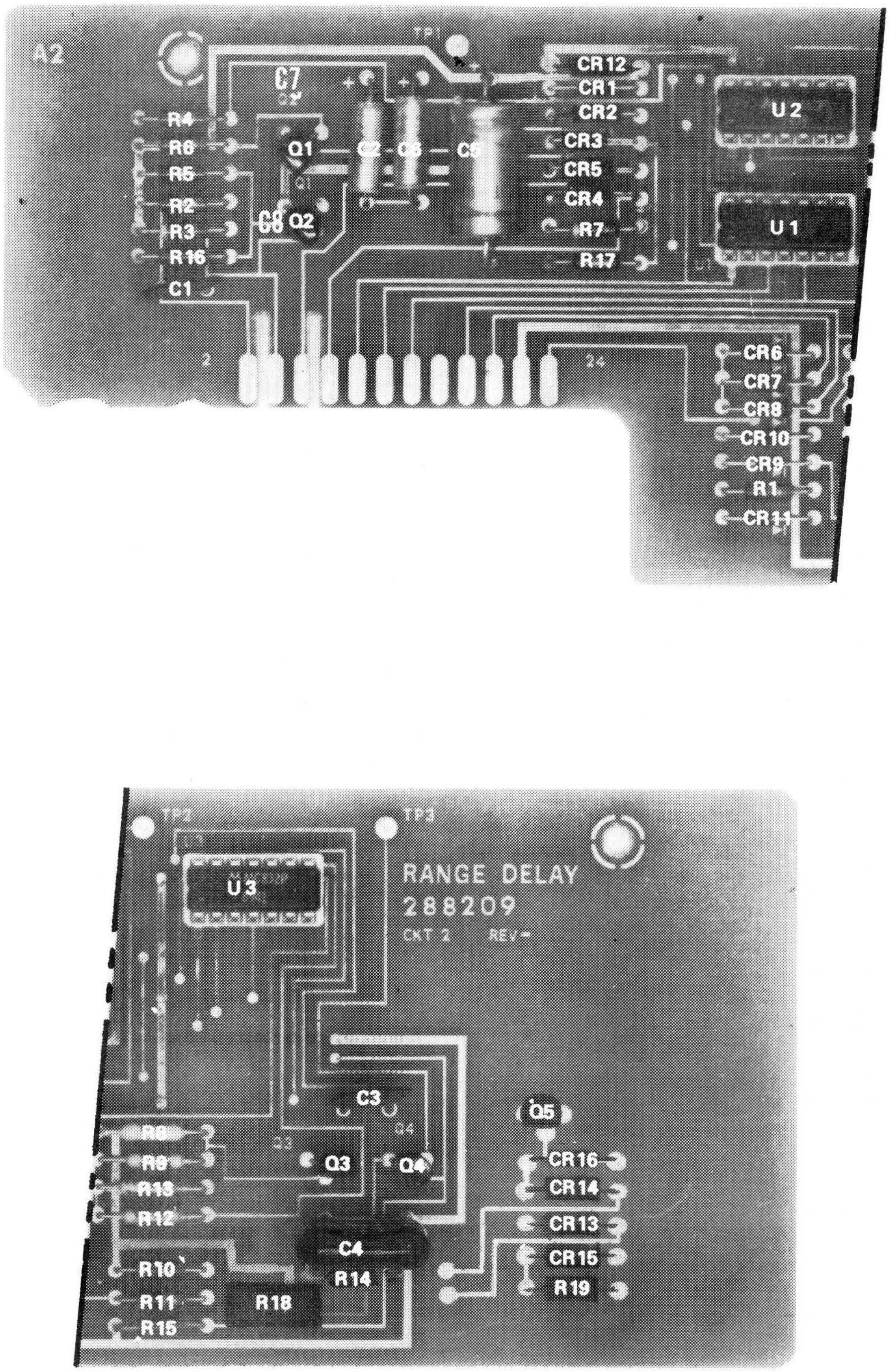


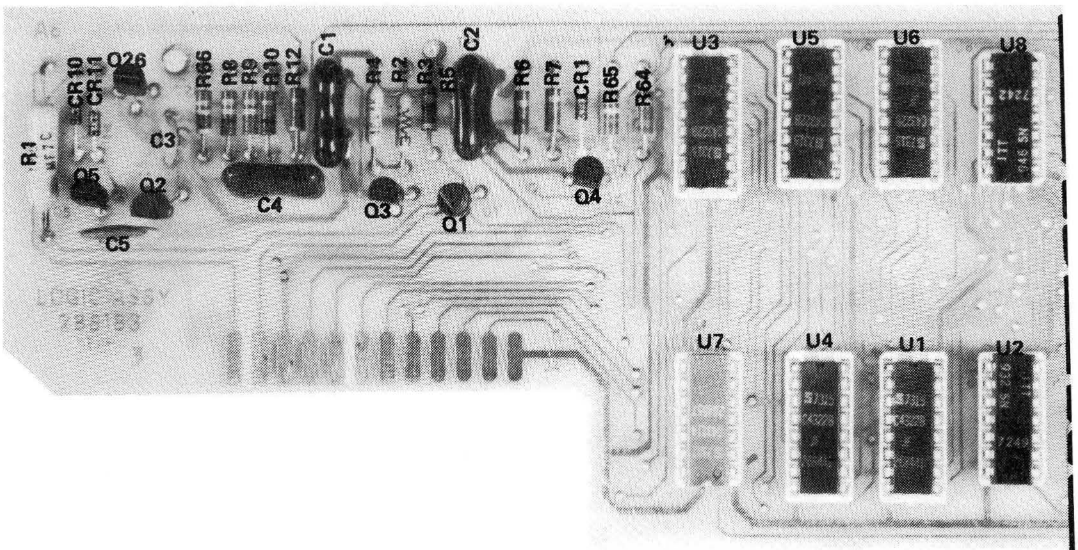
Figure 5-3. RANGE DELAY PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A8	**LOGIC**	288183			REF		
	Figure 5-4						
C1	Cap, mica, 5600 pf ±2%, 500V	182873			1		
C2	Cap, mica, 1500 pf ±5%, 500V	148361			1		
C3	Cap, cer, 180 pf ±10%, 1kV	105890			1		
C4	Cap, mica, 470 pf ±5%, 500V	148429			1		
C5	Cap, cer, 0.025 uf ±20%, 100V	168435			1		M
C5	Cap, cer, 2200 pf ±10%, 500V DC	268425			1		K
C6	Cap, mica, 33 pf ±5%, 500V	160317			1		
C7	Cap, mica, 270 pf ±5%, 500V	148452			1		
CR1, CR2, CR5, CR6, CR7	Diode, silicon, 150 mA	203323			5		M
CR1, CR2, CR5, CR6, CR7, CR10, CR11	Diode, silicon, 150 mA	203323			7		K
CR3	Diode, silicon, 1 amp, 100 piv	116111			1		
CR4, CR8	Diode, germanium, 80 mA, 100 piv	149187			2		M
CR4, CR8, CR9	Diode, germanium, 80 mA, 100 piv	149187			3		K
P23	Connector, PCB to CAble, 34 contact	295337			1		
Q1	Tstr, silicon, unijunction	268110			1		
Q2 thru Q5, Q19 thru Q22, Q24	Tstr, silicon, NPN	218396			9		M

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
Q2 thru Q5 Q19 thru Q22, Q24, Q26	Tstr, silicon, NPN	218396			10		K
Q6 thru Q17	Tstr, silicon PNP	195974			12		
Q18	Tstr, germanium, PNP	148619			1		
Q23	Tstr, silicon, NPN	168716			1		
Q25	Tstr, silicon, NPN	168708			1		
R1	Res, met flm, 750k ±1%, ½w	155192			1		
R2	Res, met flm, 110k ±1%, 1/8w	234708			1		
R3	Res, comp, 47 ±5%, ¼w	147892			1		
R4	Res, met flm, 46.4k ±1%, 1/8w	188375			1		
R5,R19	Res, comp, 2.7k ±5%, ¼w	170720			2		
R6,R21 R28, R29, R31, R32, R33	Res, comp, 1.5k ±5%, ¼w	148031			7		
R7	Res, comp, 820 ±5%, ¼w	148015			1		
R8,R59 R60	Res, comp, 10k ±5%, ¼w	148106			3		
R9	Res, comp, 27k ±5%, ¼w	148148			1		
R10	Res, comp, 1k ±5%, ¼w	148023			1		
R11, R20, R37	Not Used						
R12, R40, R41	Res, comp, 4.7k ±5%, ¼w	148072			3		
	(R40 Deleted)	148072			2		K

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R13, R25, R26, R27	Res, comp, 8.2k ±5%, ¼w	160796			4		
R14 thru R18	Res, comp, 51k ±5%, ¼w	193334			5		
	(R17 Deleted)	193334			4		K
R22, R23	Res, comp, 2.2k ±5%, ¼w	148049			2		
R24, R64	Res, comp, 1.8k ±5%, ¼w	175042			2		
R30	Res, comp, 680 ±5%, ¼w	148007			1		
R34, R35, R36, R38, R39	Res, comp, 22k ±5%, ¼w	148130			5		
R42	Res, comp, 33k ±5%, ¼w	148155			1		
R43	Res, comp, 47k ±5%, ¼w	148163			1		M
R43, R66	Res, comp, 47k ±5%, ¼w	148163			2		K
R43, R66, R67	Res, comp, 47k ±5%, ¼w	148163			3		V
R44, R50, R52	Res, comp, 220k ±5%, ¼w	160937			3		
R45, R46, R48, R49, R51, R65	Res, comp, 11k ±5%, ¼w	221580			6		
R47	Res, comp, 39k ±5%, ¼w	188466			1		
R53	Res, met flm, 182k ±1%, 1/8w	241091			1		
R54	Res, met flm, 3.74k ±1%, 1/8w, T9	260547			1		
R57	Res, var, cer met, 20 ±20%, ½w	261180			1		
R58	Res, ww, 14k ±0.1%, ¼w	275321			1		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R61	Res, comp, 1.2k ±5%, ¼w	190371			1		
R63	Res, met flm, 3.74k ±1%, 1/8w	272096			1		
U1,U3 thru U6	IC, TTL, dual J-K flip flop	268441			5		
U2	IC, DTL, dual 4-Input Nand	268383			1		
U7	IC, TTL, dual 4-Input Expandable Nor Gate	268557			1		
U8	IC, DTL, Quad 2-Input Nand Gate	268375			1		
U9, R55, R56, R62	Matched Reference Amplifier Set	290650			1		
U10	IC, operational amplifier	271501			1		
	Socket, IC, 14 contact, U2, U7, U8	276527			3		
	Socket, IC, 16 contact, U1, U3 thru U6	276535			5		



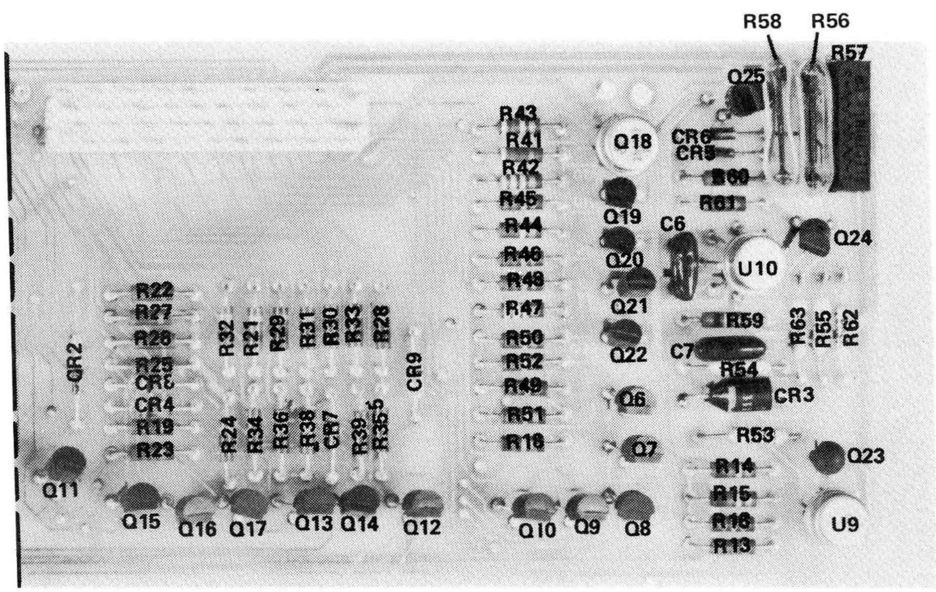


Figure 5-4. LOGIC PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A9	**A/D CONVERTER**	288175			REF		
	Figure 5-5						
C1,C3, C4,C5	Cap, mica, 390 pf ±5%, 500V	148437			4		
C2, C7	Cap, plstc, 0.47 uf ±10%, 250V	184366			2		
C6,C16 C18, C19	Cap, mica, 33 pf ±5%, 500V	160317			4		
C8	Cap, cer, 15 pf ±10%, 500V	159947			1		
C9,C10	Cap, plstc, 0.047 uf ±10%, 120V	260562			2		
C11 thru C15	Cap, cer, 0.01 uf ±20%, 100V	149153			5		
C17	Cap, plstc, 0.047 uf ±10%, 250V	162008			1		
C20	Cap, mica, 2 pf ±10%, 500V	175208			1		L
C21	Cap, mica, 1000 pf ±5%, 500V	148387			1		K
CR1, CR2, CR16	Diode, silicon, 150 mA, 125 piv	272252			3		M
CR1, CR2, CR16, CR19	Diode, silicon, 150 mA, 125 piv	272252			4		K
CR3, CR4, CR5, CR7 thru CR15	Diode, silicon, 150 mA	203323			12		
CR6	Diode, germanium, 80 mA, 100 piv	149187			1		M
CR6, CR20	Diode, germanium, 80 mA, 100 piv	149187			2		K
CR17	Diode, silicon, 75 mA, 90 piv	260554			1		
CR18	Diode, zener, 6.8V	187195			1		
P24	Connector, PCB to cable, 34 contact	295337			1		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
Q1, Q21, Q45	Tstr, silicon, NPN	218396			3		
Q2,Q32	Tstr, silicon, PNP	195974			2		M
	(Q2, Deleted)	195974			1		K
Q3, Q6 Q19, Q22, Q23, Q24	Tstr, FET, N-channel	271924			6		
Q4	Tstr, FET, dual, N-channel	257501			1		
Q5,Q13 thru Q17, Q36	Tstr, FET, N-channel	288324			7		U
Q5,Q13 thru Q17, Q31, Q36	Tstr, FET, N-channel	288324			8		T
Q7,Q8, Q9	Tstr, FET, N-channel, Matched Set (must be replaced as a set)	274795			1		
Q10, Q11, Q29, Q30, Q33, Q34	Tstr, silicon, PNP	288761			6		I
Q30	Tstr, silicon, PNP	321398			1		J
Q10, Q11, Q29, Q33, Q34	Tstr, silicon, PNP	288761			5		J
Q12, Q18, Q25 thru Q28, Q31	Tstr, FET, N-channel	261388			7		U

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
Q12, Q18, Q25 thru Q28	Tstr, FET, N-channel	261388			6		T
Q20	Tstr, FET, dual, N-channel	267963			1		
Q35	Tstr, silicon, NPN, dual, monolithic	295717			1		
Q37, Q39, Q41, Q43	Tstr, germanium, NPN	306126			4		
Q38, Q40, Q42, Q44	Tstr, germanium, PNP	306118			4		
R1, R4 R18	Res, comp, 4.7k ±5%, ¼w	148072			3		M
R4	Res, comp, 4.7k ±5%, ¼w	148072			1		K
R2, R3	Res, comp, 47k ±5%, ¼w	148163			2		
R5, R34, R53, R62, R63, R80	Res, comp, 100k ±5%, ¼w	148189			6		
R6, R36, R59, R64	Res, comp, 10k ±5%, ¼w	148106			4		
R7, R13	Res, ww, 10k, Matched Set	291690			1		
R8,R9, R31	Res, met flm, 45.3k ±1%, 1/8w	234971			3		
R10	Res, met flm, 49.9k ±1%, 1/8w	268821			1		
R11	Res, comp, 68k ±5%, ¼w	148171			1		
R12	Res, comp, 220 ±5%, ¼w	147959			1		
R14, R17, R45	Res, var, cer met, 20 ±20%, ½w	261180			3		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R15, R16	Res, ww, 28.578k (Matched Set)	285239			1		
R44, R46	Res, 22, 50k (Matched Set)						
R47	Res, ww, 100k (Matched Set)						
R49	Res, ww, 200k (Matched Set)						
R51	Res, ww, 199.98k (Matched Set)						
R19, R22	Res, comp, 33k ±5%, ¼w	148155			2		M
R19, R22	Res, met flm 33.2k .0, –5%, 1/8w	334102			2		K
R20, R21	Res, comp, 22k ±5%, ¼w	148130			2		M
R20, R21	Res, met flm 22.1k ±5%, 1/8w	229476			2		K
R23	Res, comp, 5.6k ±5%, ¼w	148080			1		M
R23, R18	Res, met flm, 4.99k 0.1%. 1/8w	334110			2		K
R24, R25, R35	Res, comp, 220k ±5%, ¼w	160937			3		
R26	Res, comp, 82 ±5%, ¼w	149484			1		
R27	Res, met flm, 21.5k ±1%, 1/8w	168278			1		
R28, R78	Res, comp, 27k ±5%, ¼w	148148			2		
R29	Res, met flm, 22.1k ±1%, 1/8w	235234			1		
R30	Res, comp, 820k ±5%, ¼w	220541			1		
R32, R79	Res, comp, 15k ±5%, ¼w	148114			2		
R33	Res, comp, 1k ±5%, ¼w	148023			1		
R37	Res, var, cer met, 10k ±10%, 1w	285171			1		
R38, R39	Res, comp, 6.2M ±5%, ¼w	221960			2		
R40, R41	Res, met flm, 750k ±1%, 1/8w	271361			2		
R42	Res, met flm, 1.5M ±1%, ¼w	284976			1		
R43	Res, comp, 3M ±5%, ¼w	221952			1		
R48	Res, var, cer met, 50 ±10%, 1w	285122			1		
R50	Res, var, cer met, 100 ±10%, 1w	285130			1		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R52	Res, comp, (nominally 22 ±5%, ¼w)	147884			1		
R54	Res, comp, 18k ±5%, ¼w	148122			1		
R55	Res, ww, 1.022k ±0.05%, ¼w	288654			1		
R56	Res, var, cer met, 20 ±20%, 1w	285114			1		
R57	Res, ww, 5k ±0.05%, ¼w	288647			1		
R58	Res, var, cer met, 200 ±20%, ½w	284711			1		
R60	Res, comp, 150k ±5%, ¼w	182212			1		
R61	Res, var, cer met, 200 ±10%, 1w	285148			1		
R65	Res, comp, 1M ±5%, ¼w	182204			1		G
R65	Res, comp, 510k ±5%, ¼w	275685			1		H
R66, R68, R70, R72	Res, met flm, 4.99k ±1%, 1/8w	168252			4		
R67, R69, R71, R73	Res, met flm, 32.4k ±1%, 1/8w	182956			4		
R74	Res, met flm, 6.04k ±1%, 1/8w	285189			1		
R75	Res, met flm, 1k ±1%, 1/8w	168229			1		
R76	Res, comp, 270k ±5%, ¼w	220061			1		
R77	Res, met flm, 16.9 ±1%, 1/8w	281790			1		
R81	Res, comp, 4.7m ±5%, ¼w	220046			1		K
U1 thru U4	IC, operational amplifier	271502			4		

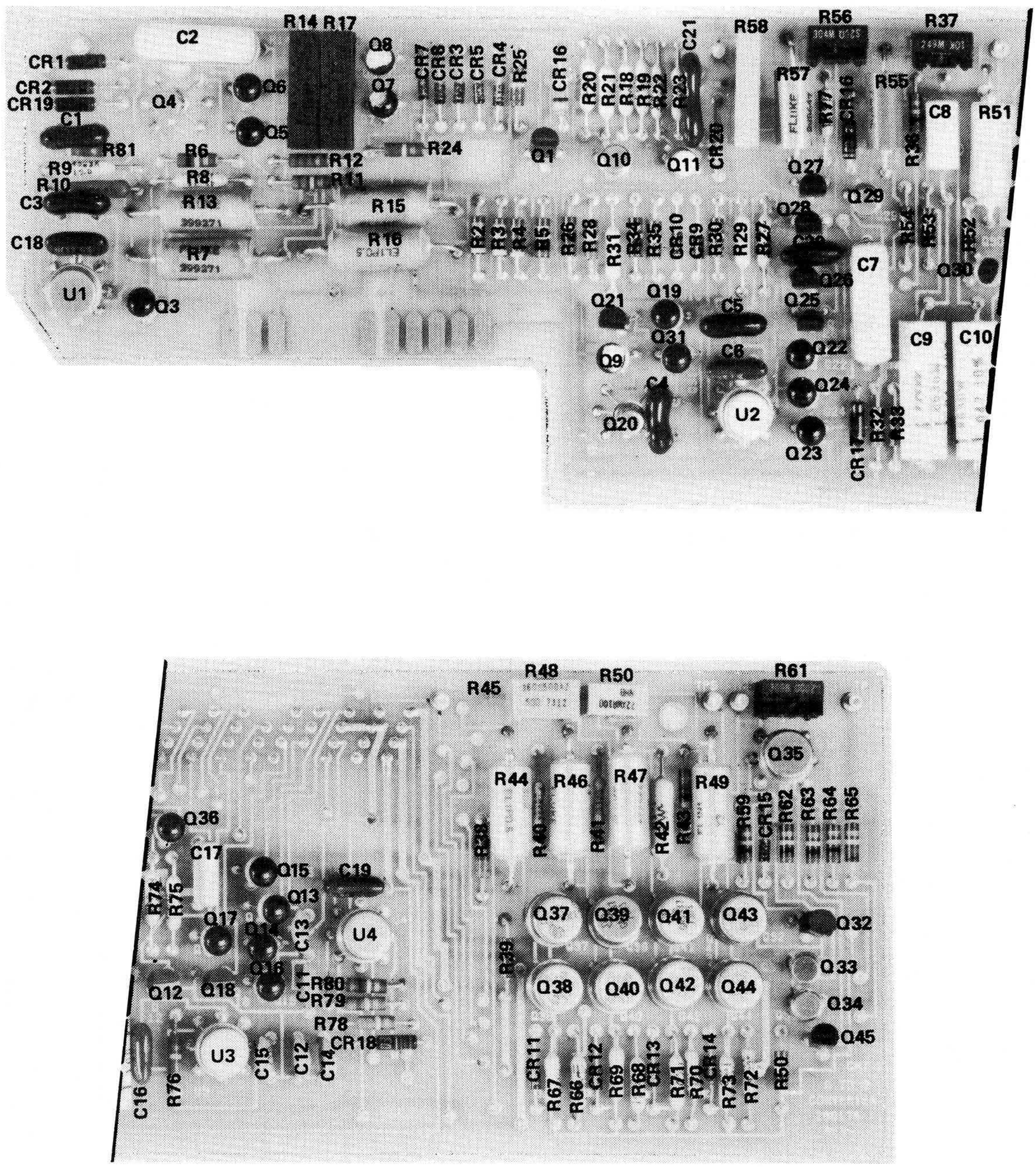


Figure 5-5. A TO D CONVERTOR PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A10	**ACTIVE FILTER** **Figure 5-6**	290346			REF		
C1 thru C4	Cap, plstc, 0.47 uf ±20%, 120V	190553			4		
C5, C8	Cap, mica, 33 pf ±5%, 500V	160317			2		
C6, C7	Cap, mica, 150 pf ±5%, 500V	148478			2		
CR1, CR2	Diode, silicon, 10 mA, 2 piv	180554			2		
CR3	Diode, silicon, 150 mA	203323			1		D
K1	Relay, reed switch	219097			2		
	Coil, relay	272070			1		
Q1	Tstr, silicon, NPN, Super beta dual monolithic	284075			1		
Q2	Tstr, silicon, NPN	218396			1		
Q3	Tstr, silicon, PNP	195974			1		
R1, R2, R4, R5	Res, met flm, 46.4k ±1%, 1/8w	188375			4		
R3	Res, comp, 6.8k ±5%, ¼w	148098			1		
R6	Res, met flm, 140k ±1%, 1/8w	289439			1		
R7	Res, comp, 100k ±5%, ¼w	148189			1		
R8	Res, met flm, 8.66k ±1%, 1/8w	260364			1		
R9,R10	Res, met flm, 215k ±1%, 1/8w	289470			2		
R11, R12	Res, factory selected value						
R13	Res, var, cer met, 5k ±20%, ½w	267872			1		
R14	Res, met flm, 100k ±1%, 1/8w	248807			1		
R15	Res, met flm, 2.49k ±1%, 1/8w	226209			1		
R16	Res, met flm, 82.5k ±1%, 1/8w	246223			1		
R17	Res, met flm, 2k ±1%, 1/8w	235226			1		
R18	Res, met flm, 7.15k ±1%, 1/8w	260356			1		
U1, U2	IC, operational amplifier	271502			2		

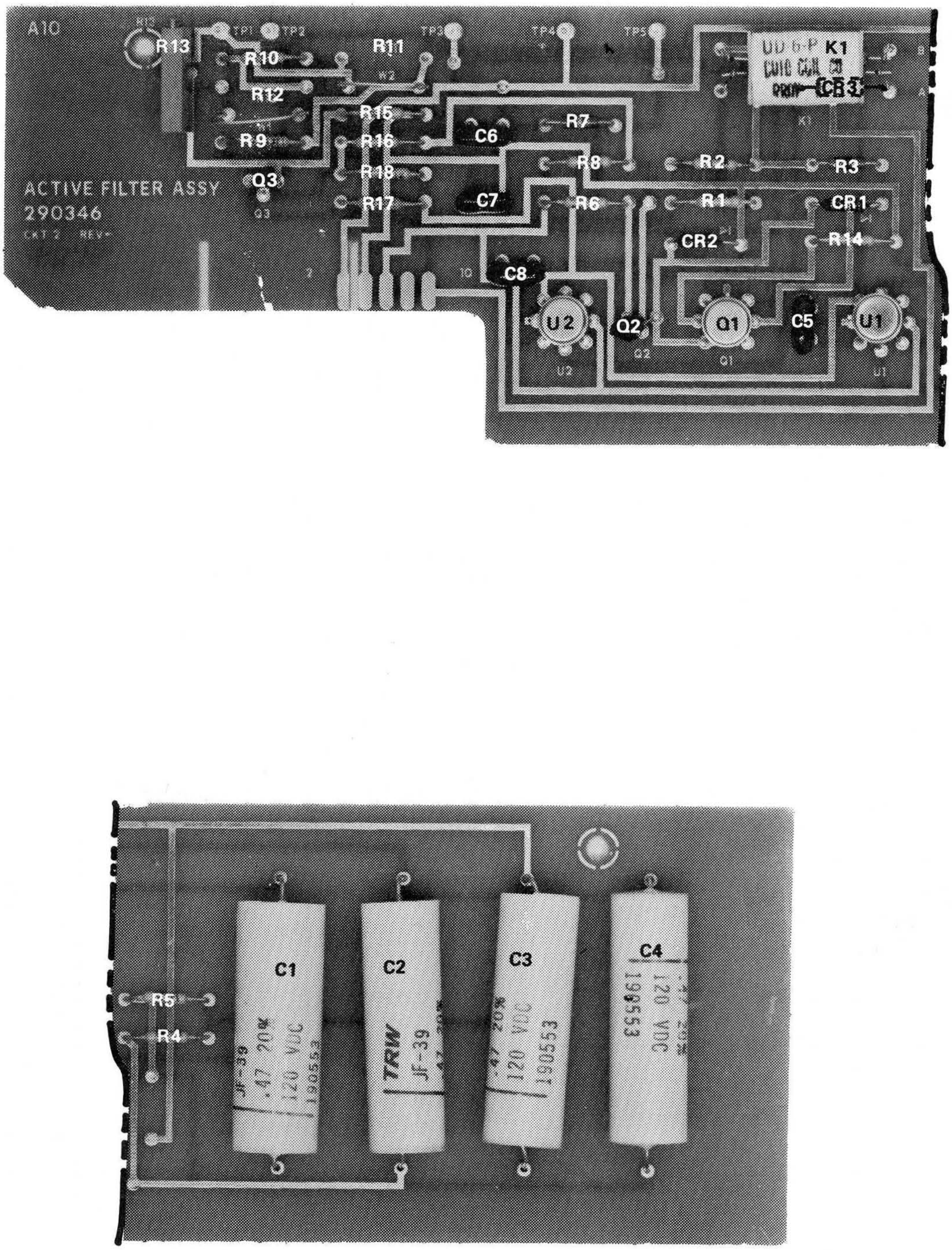
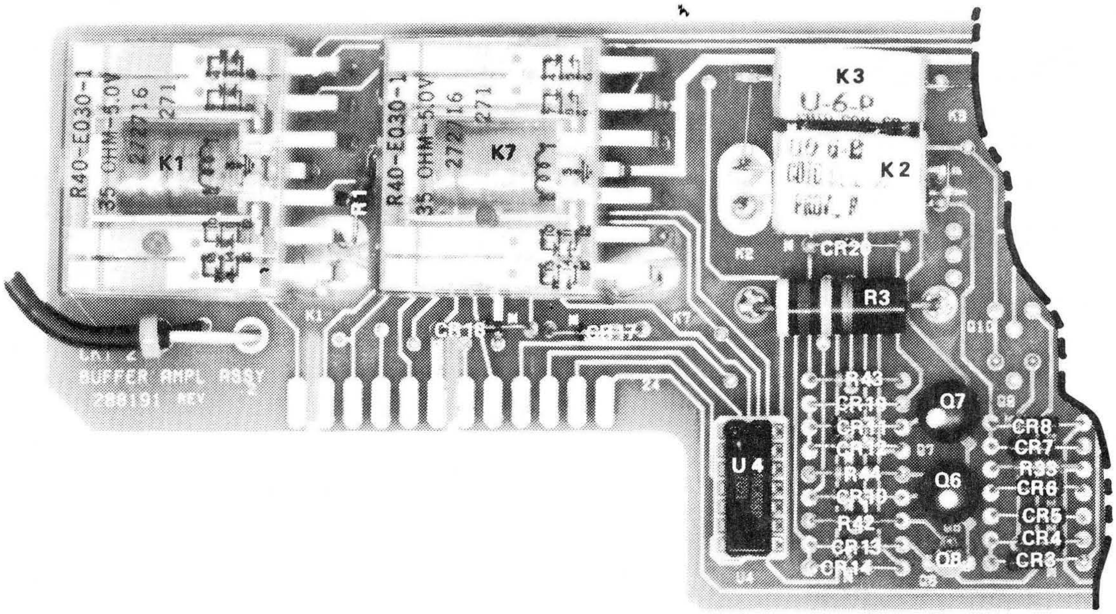


Figure 5-6. ACTIVE FILTER PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A11	**BUFFER**	288191			REF		
	Figure 5-7						
C1,C3	Cap, mica, 100 pf ±5%, 500V	148494			2		
C2, C4	Cap, mica, 33 pf ±5%, 500V	160317			2		
C5	Cap, mica, 270 pf ±5%, 500V	148452			1		
C6, C7	Cap, cer, 0.05 uf ±20%, 100V	149161			2		
C8	Cap, plstc, 0.1 uf ±5%, 100V	167460			1		
C9,C10	Not Used						
C11	Cap, mica, 2200 pf ±5%, 500V	148346			1		
CR1	Diode, silicon, 10 mA, 2 piv	180554			1		
CR2	Not Used						
CR3	Diode, zener, 6.8V	166199			1		
CR4 thru CR8	Diode, silicon, 200 mA, 25 piv	190272			5		
CR9 thru CR17	Diode, germanium, 80 mA, 100 piv	149187			9		
CR18 thru CR24	Diode, silicon, 150 mA	203323			7		
K1, K7	Relay, 4 PDT, 5V coil	- 272716			2		
K2	Relay, reed switch	284091			1		
	Coil, relay	272070			1		
K3	Relay, reed switch	284091			REF		
	Coil, relay	269019			4		
K4, K5, K6	Relay, reed switch	289850			3		
	Coil, relay	269019			REF		
Q1, Q8	Tstr, silicon, PNP	195974			2		
Q2	Tstr, germanium, PNP	148643			1		
Q3	Tstr, silicon, NPN	168716			1		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
Q4	Tstr, silicon, NPN, dual, monolithic	295717			1		
Q5	Tstr, silicon, NPN, Super beta dual monolithic 1	284075			1		
Q6, Q7	Tstr, silicon, PNP, selected	280198			2		
Q9,Q10	Not Used						
Q11	Tstr, selected	321638			1		
R1	Res, comp, 1M ±5%, ¼w	182204			1		
R2	Res, comp, 47k ±5%, ½w	150219			1		
R4	Not Used						
R3	Res, comp, 910k ±5%, 2w	110171			1		
R5, R6 R7 R10	Res, ww, 4.45M Res, ww, 899.55k Res, ww, 99.95k } Matched Input Divider Set	284505			1		
R8	Res, var, cer met, 1k ±20%, ½w	267856			1		
R9	Res, var, cer met, 100 ±20%, ½w	267823			1		
R11	Res, met flm, 10k ±1%, 1/8w	168260			1		
R12	Res, met flm, 13.7k ±1%, 1/8w	236752			1		
R13	Res, met flm, 34k ±1%, 1/8w	261602			1		
R14	Res, met flm, 2.61k ±1%, 1/8w	289983			1		
R15	Res, met flm, 232 ±5%, 1/8w	289975			1		
R16	Res, met flm, 84.5k ±1%, 1/8w	229492			1		
R17	Res, var, cer met, 100k ±20%, ½w	268581			1		
R18, R19	Res, comp, 100M ±10%, ½w	190520			2		
R20, R33	Res, comp, 10k ±5%, ¼w	148106			2		
R21	Res, comp, 270k ±5%, ¼w	220061			1		
R22, R23, R25, R26	Res, met flm, factory selected value (may not be installed)						

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R24, R27	Res, met flm, 2M, Matched Set	290320			1		
R28	Res, var, cer met, 1k ±10%, 1w	285155			1		R
	Res, var, cer met, 10k ±10%, 1w	285171			1		S
R29	Res, met flm, 3.83M ±1%, ½w	289660			1		
R30, R31	Res, comp, 22k ±5%, ¼w	148130			2		
R32	Res, comp, 470 ±5%, ¼w	147983			1		
R34	Res, comp, 3.3k ±5%, ¼w	148056			1		
R35 R37 R39	Res, ww, 90k Res, ww, 9k Res, ww 1k Matched Output Divider Set	289686			1		
R36	Res, var, cer met, 200 ±20%, ½w	284711			1		
R38	Res, var, cer met, 20 ±20%, ½w	261180			1		
R40	Res, comp, 1 ±5%, ½w	218693			1		
R41	Res, met flm, 499k ±1%, 1/8w	268813			1		
R42	Res, comp, 1k ±5%, ¼w	148023			1		
R43, R44	Res, comp, 330 ±5%, ¼w	147967			2		
U1	IC, operational amplifier 1	284760			1		
U2	IC, operational amplifier	271502			1		
U3	IC, voltage follower	288365			1		
U4	IC, DTL, Quad 2-Input Nand Power Gate	288597			1		
	Socket, IC, U4	276527			1		
	Cover (not shown)	298893			1		
	1 Replacement of this part requires factory recalibration. Return A11 buffer PCB only						



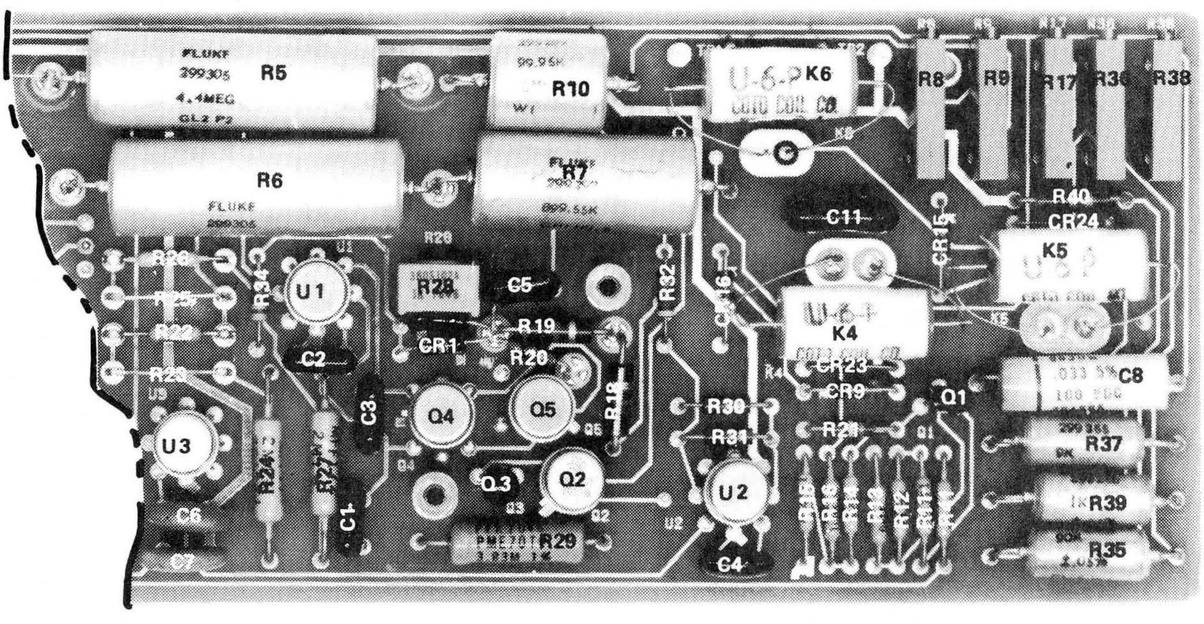


Figure 5-7. BUFFER AMPLIFIER PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A14	**DISPLAY**	288167			REF		
	Figure 5-8						
C1	Cap, cer, 0.05 uf ±20%, 50V	149161			1		
C2	Cap, cer, 300 pf ±10%, 500V	105734			1		P
C2, C100	Cap, cer, 1200 pf ±10%, 500V	106732			2		Q
C3	Cap, elect, 20 uf +50/−10%, 16V	241356			1		
C4	Cap, cer, 0.025 uf ±20%, 50V	168435			1		
C5	Cap, cer, 0.005 uf ±20%, 50V	175232			1		P
C5	Cap, cer, 2200 pf ±10%, 500V	268425			1		Q
C6	Cap, cer, 0.01 uf ±20%, 100V (on bottom side of PCB)	149153			1		P
C6, C103	Cap, cer, 0.01uf ±20%, 100V	149153			2		Q
C101	Cap, cer, 500 pf ±10%, 500V	105692			1		Q
C102	Cap, cer, 0.025 uf ±20%, 50V	175232			1		Q
CR1, CR2, CR7, CR10, CR12, CR16, CR18, CR19, CR25 thru CR30, CR32	Diode, germanium, 80 mA, 100 piv	149187			15		P
CR1, CR2, CR7, CR10, CR12, CR16, CR18, CR19, CR25 thru CR30,	Diode, germanium, 80 mA, 100 piv	149187			16		Q

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
CR32, CR100							
CR3, CR4, CR17, CR20 thru CR24	Not used						
CR5, CR6, CR8, CR9, CR11, CR13, thru CR15, CR31, CR33	Diode, silicon, 150 mA	203323			10		P
CR5, CR6, CR8, CR9, CR11, CR13, thru CR15, CR31, CR33, CR34	Diode, silicon, 150 mA	203323			11		Q
DS1	Lamp, incandescent, 5V	272476			1		
J1,J10	Connector, femal, 12 contact	291898			2		
J2,J5, J7,J8, J11, J12, J13	Connector, femal, 24 contact	295352			7		
J3,J4, J9	Connector, femal, 24 contact with 6 removed	284240			3		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
J14	Connector, female, 18 contact	291906			1		
Q1,Q21	Not used						
Q2, Q5	Tstr, silicon, PNP	195974			2		
Q3, Q6, Q7,Q19 Q20, Q34, Q35, Q36	Tstr, silicon, NPN	218396			8		
Q4, Q8	Tstr, silicon, unijunction	268110			2		
Q9 thru Q18	Tstr, silicon, NPN	245480			10		
Q22 thru Q26	Tstr, silicon, NPN	218511			5		
Q27 thru Q31	Tstr, silicon, PNP	266619			5		
Q33, Q33	Tstr, FET, N-channel	288324			2		
Q37	Tstr, silicon, NPN	168708			1		
R1, R3, R60	Not used						
R2, R4	Res, comp, 82k ±5%, ¼w	188458			2		
R5	Res, comp, 6.8k ±5%, ¼w	148098			1		
R6, R11, R20, R25	Res, co np, 3.9k ±5%, ¼w	148064			4		
R7, R58	Res, comp, 470 ±5%, ¼w	147983			2		
R8, R18	Res, comp, 2.7k ±5%, ¼w	170720			2		
R9, R63	Res, comp, 12k ±5%, ¼w (R63 on bottom side of PCB)	159731			2		P

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R9	Res, comp, 1.2k ±5%, ¼w	190371			1		Q
R10	Res, comp, 1k ±5%, ¼w	148023			1		P
R10	Res, comp, 510 ±5%, ¼w	218032			1		Q
R12	Res, comp, 75k ±5%, ¼w	220525			1		
R13, R30	Res, comp, 2.2k ±5%, ¼w	148049			2		
R14, R57	Res, comp, 33k ±5%, ¼w	148155			2		
R15	Res, comp, 27 ±5%, ¼w	160812			1		
R16	Res, var, comp, 150k ±20%, ½w	256479			1		
R17	Res, comp, 1.8k ±5%, ¼w	175042			1		
R19, R48 thru R54, R64	Res, comp, 10k ±5%, ¼w (R64 on bottom side of PCB)	148106			9		P
R19, R48 thru R54, R64, R65	Res, comp, 10k ±5%, ¼w	148106			10		Q
R26, R27, R28	Res, comp, 1.2k ±5%, ¼w	190371			3		
R29, R34 thru R38, R61	Res, comp, 8.2k ±5%, ¼w	160796			7		
R31	Res, comp, 430 ±5%, ¼w	203869			1		
R32	Res, comp, 330 ±5%, ¼w	147967			1		
R33	Res, comp, 470k ±5%, ¼w	188441			1		
R39	Res, comp, 820 ±5%, ¼w	148015			1		N
R39	Res, comp, 430 ±5%, ¼w	203869			2		O
R40	Res, comp, 22k ±5%, ¼w	148130			1		M

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R40	Res, comp, 4.7k ±5%, ¼w	148072			1		K
R41	Res, comp, 2.7k ±5%, ¼w	170720			1		N
R41	Res, comp, 5.1k ±5%, ¼w	193342			1		O
R43 thru R46, R55, R56, R62	Res, comp, 39 ±5%, ¼w	193391			7		
R47	Res, comp, 3.3k ±5%, ¼w	148056			1		
	Switch Assembly	298232			1		
	Switch section, S1 thru S7, RANGE	288688			1		
	Switch section, S8 thru S14, FUNCTION	288670			1		
	Flex circuit	207504			1		
U1	IC, TTL, Hex Inverter Buffer Driver	288605			1		
U2,U3	IC, TTL, dual J-K flip flop	268441			2		
U4	IC, Decoder Driver, DM/SN7441AN, NS8840N	267211			1		
V1	Tube, polarity indicator	272922			1		
V2 thru V7	Tube, neon readout	271494			6		
	Display, function assembly (lamp, P/N 272476 may be purchased separately) Socket, IC, 14 contact	291542			1		
	Socket, IC, 16 contact	291534			3		

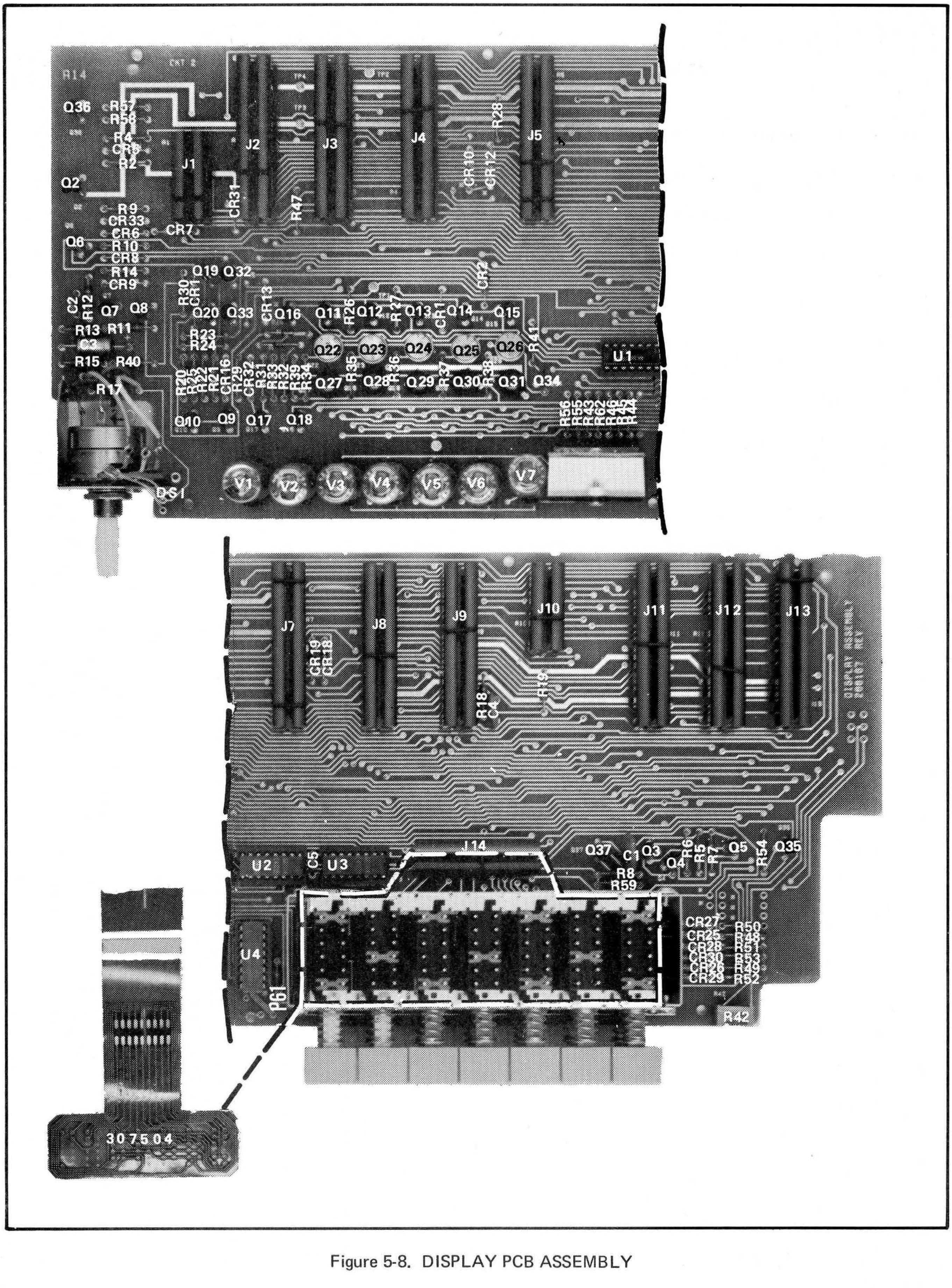


Figure 5-8. DISPLAY PCB ASSEMBLY

MANUFACTURERS' CROSS REFERENCE LIST

FLUKE STOCK NO.	MFR.	MFR. PART NO.
105668	56289	C023B501J103M
105692	71590	2DDH60N501K
105734	71590	BB60301KW7W
105890	71590	BB60181KS3N
106732	71590	CF122
108308	01121	EB4751
108951	01121	EB5115
110171	01121	HB9145
110726	07910	1N964B
112383	05277	1N4822
113316	07910	1N748
116111	05277	1N4817
144717	01121	EB5105
147892	01121	CB4705
147926	01121	CB1015
147934	01121	CB1515
147959	01121	CB2215
147967	01121	CB3315
147975	01121	CB3915
147983	01121	CB4715
147991	01121	CB5615
148007	01121	CB6815
148015	01121	CB8215
148023	01121	CB1025
148031	01121	CB1525
148049	01121	CB2225
148056	01121	CB3325
148064	01121	CB3925
148072	01121	CB4725
148080	01121	CB5625
148098	01121	CB6825
148106	01121	CB1035
148114	01121	CB1535
148122	01121	CB1835
148130	01121	CB2235
148148	01121	CB2735
148155	01121	CB3335
148163	01121	CB4735
148171	01121	CB6835
148189	01121	CB1045
148346	14655	CD19F222J
148361	14655	CD19F152J
148387	14655	CD19F102J
148429	14655	CD19F471J
148437	14655	CD15F391J
148452	14655	CD15F271J
148478	14655	CD15F151J
148494	14655	CD15F101J
148528	14655	CD15F560J
148536	14655	CD15E470J
148551	14655	CD15E220J
148569	14655	CD15C150J
148619	01295	2N1303
148643	01295	2N1307
149153	56289	C023B101F103M
149161	56289	55C23A1
149187	93332	1N270
149484	01121	CB8205
150359	95303	2N3053
152470	53021	D20F103F
153056	56289	150D156X9020B2
155192	91627	TYPE MFF 1/2
159582	72928	C102K
159731	01121	CB1235
159947	00656	TYPE C1-1
160226	05397	K2R2C20K
160317	14655	CD15E330J
160796	01121	CB8225
160804	01121	CB2715

MANUFACTURERS' CROSS REFERENCE LIST

FLUKE STOCK NO.	MFR.	MFR. PART NO.	FLUKE STOCK NO.	MFR.	MFR. PART NO.
160812	01121	CB2705	182790	56289	150D684X9035A2
160937	01121	CB2245	182873	14655	CD19F562G
161810	03877	SG5658	182956	91637	TYPE MFF 1/8
161919	56289	196D105X0035	184366	73445	C280AE/A470K
161943	56289	196D475X0020	186296	73445	C426ARE125
161992	73445	C280AEA100K	187195	07910	CD36554
162008	73445	C280AEA47K	188375	91637	TYPE MFF 1/8
166199	07910	1N754	188441	01121	CB4745
167460	84411	TYPE 863UW	188458	01121	CB8235
168195	91637	TYPE MFF 1/8	188466	01121	CB3935
168229	91637	TYPE MFF 1/8	190249	89536	190249
168252	91637	TYPE MFF 1/8	190272	93332	1N456A
168260	91637	TYPE MFF 1/8	190371	01121	CB1225
168278	91637	TYPE MFF 1/8	190520	01121	EB1071
168435	56289	C128B101H253M	190553	84411	TYPE 863UW
168708	03508	2N3391	190728	24655	0938-9751
168716	07263	S19254	193318	01121	CB9125
168823	73445	C426ARF50	193334	01121	CB5135
170423	14655	CD15F221J	193342	01121	CB5125
170720	01121	CB2725	193391	01121	CB3905
170738	01121	CB5635	193441	01121	CB1845
175042	01121	CB1825	193458	01121	CB1245
175208	84171	DM15020K	194803	73445	C280AEA220K
175224	14655	CD15E120J	194944	01121	CB1065
175232	56289	C023B101E502M	195974	04713	2N3906
176644	14655	CD19F362G	198390	01121	CB2255
177998	14655	CD15E270J	200030	91637	RN55D1820F
178616	73445	C437ARG250	203323	03508	DHD1105
180406	07910	1N758	203869	01121	CB4315
180463	07910	1N968B	208975	14655	CD19F472J
180505	18927	1N276	216986	14655	CD15C080K
180554	07910	CD12599	218081	04713	MPS6520
182204	01121	CB1055	218206	72982	530–000
182212	01121	CB1545	218396	04713	2N3904

MANUFACTURERS' CROSS REFERENCE LIST

FLUKE STOCK NO.	MFR.	MFR. PART NO.
218511	95303	60994
218693	01121	EB1065
219097	15898	765972
220061	01121	CB2735
220525	01121	CB7535
220541	01121	CB8245
221580	01121	CB1135
221606	01121	CB1635
221614	01121	CB2035
221903	01121	CB6215
221911	01121	CB6225
221937	01121	CB7545
221952	01121	CB3055
221960	01121	CB6255
225599	07263	S22650
226134	14655	CD15F151F500
226209	91637	TYPE MFF 1/8
226274	82389	46256LFE
226316	00656	TYPE MFF C1-1
229146	91637	TYPE MFF 1/8
229476	91637	TYPE MFF 1/8
229484	91637	TYPE MFF 1/8
229492	91637	TYPE MFF 1/8
229898	04713	MPS6522
229930	91293	JMC2951
234484	73445	C280AEA22K
234492	73445	C280AEA33K
234682	01121	CB3045
234708	91637	TYPE MFF 1/8
234971	91637	TYPE MFF 1/8
235266	91637	TYPE MFF 1/8
235234	91637	TYPE MFF 1/8
235309	91637	TYPE MFF 1/8
235333	91637	TYPE MFF 1/8
236752	91637	TYPE MFF 1/8
236802	91637	TYPE MFF 1/8
236901	73445	C437ARF160
236935	73445	C426ARD200
237206	91637	TYPE MFF 1/8
237297	91637	TYPE MFF 1/8
240937	89536	240937
241091	91637	TYPE MFF 1/8
241356	73445	C426ARE20
241471	91637	TYPE MFF 1/8
241497	91637	TYPE MFF 1/8
245480	07263	S24496
246066	04713	EL131
246223	91637	TYPE MFF 1/8
246611	07910	1N961B
248807	91637	TYPE MFF 1/8
248906	95303	CA3046
249052	07910	1N963B
249284	89536	249284
256479	71450	TYPE 45
257501	17856	DN423
260356	91637	TYPE MFF 1/8
260364	91637	TYPE MFF 1/8
260547	91637	TYPE MFF 1/8
260554	07910	CD55105
260562	84411	863UW47391
260695	07910	1N754A
261180	71450	190PC200B
261370	22767	S1330
261388	04713	SPF179
261602	91637	TYPE MFF 1/8
261651	91637	TYPE MFF 1/8
261842	01121	CB6205
261883	91637	TYPE MFF 1/8
266312	04713	MC862P
266619	07263	2N4888
267120	73445	C280AE/A27K
267153	04713	MC839P
267211	89536	267211

MANUFACTURERS' CROSS REFERENCE LIST

FLUKE STOCK NO.	MFR.	MFR. PART NO.
267385	91637	TYPE MMF 1/8
267823	71450	190PC200B
267856	71450	190PC102B
267872	71450	190PC502B
267880	71450	190PC103B
267963	17856	DN503
268011	AMI	T-1483
268110	03508	2N6027
268367	04713	MC836P
268375	04713	MC846P
268383	01295	SN15832N
268441	18324	C4312A
268540	18324	C4319A
268557	18324	C4321A
268581	71450	190PC104B
268789	91637	TYPE MFF 1/8
268797	91637	TYPE MMF 1/8
268813	91637	TYPE MFF 1/8
268821	91637	TYPE MFF 1/8
268904	84411	TYPE X663F
269019	71707	U-6-P
269076	95303	2N4037
269092	89536	269092
271320	56289	150D335X5020B2
271361	91637	TYPE MFF 1/8
271403	54294	TYPE SP22
271411	54294	TYPE VA32
271478	81741	TYPE 23–021
271494	83594	B5853ST
271502	12040	LM301A
271908	91637	TYPE MFF 1/8
271924	07910	CFE13041
272070	71707	UD-6-P
272096	91637	TYPE MFF 1/8
272138	12040	DM8570
272252	07263	FD333
272476	71744	TYPE T1
272716	77342	TYPE R40
272732	73445	C437ARD1600
272922	83594	B585-6ST
273151	74970	273-1-2
274795	89536	274795
275321	89536	275321
275362	89536	275362
275552	32767	820-65
275560	32767	820-45
275578	32767	820-55
275792	56289	39D805G350GE4
276527	23880	TSA-2900-14W
276535	23880	TSA-2900-16W
276691	11236	360T105A
277657	89536	277657
277665	89536	277665
277905	89536	277905
277913	89536	277913
278309	89536	278309
280198	89536	280198
281790	91637	TYPE MFF 1/8
281865	12615	SL-841-777
282145	56289	HVD3-47
283697	91637	TYPE MFF 1/8
284075	11726	QD200-78
284091	12617	TYPE MRR5
284174	70903	KHS-7041
284240	00779	TYPE 583650
284505	89536	284505
284711	71450	190PC201B
284760	12040	LM308H

MANUFACTURERS' CROSS REFERENCE LIST

FLUKE STOCK NO.	MFR.	MFR. PART NO.	FLUKE STOCK NO.	MFR.	MFR. PART NO.
284885	84411	863UW33351	288563	91637	TYPE MFF 1/8
284968	75042	TYPE MEH	288597	04713	MC858P
284976	91637	TYPE MFF 1/4	288605	01295	SN7416P
285031	75915	279.015	288639	91637	TYPE MFF 1/8
285106	07910	CRE3021			
285114	71450	360S-200B	288647	89536	288647
285122	71450	360S-500A	288654	89536	288654
285130	71450	360S-101A	288670	89536	288670
285148	71450	360S201A	288688	89536	288688
285155	71450	360S-102A	288761	49956	RS2048
285163	71450	360S-202A	288803	01295	SN158097N
			288811	01537	MC856P
285171	71450	360S-103A	288837	01295	SN74100N
285189	91637	TYPE MFF 1/8	288845	01295	SN7402N
285213	71450	190PC253B	288852	04713	MC8312P
285239	89536	285239	288928	12040	LM308AH
285361	89536	285361	289066	91637	TYPE MFF 1/8
288043	89536	288043	289439	91637	TYPE MFF 1/8
288159	89536	288159	289470	91637	TYPE MFF 1/8
288167	89536	288167	289637	72982	538-006D-9-35
288175	89536	288175	289660	00327	TYPE M12
288183	89536	288183	289686	89536	289686
288191	89536	288191	289850	12617	TYPE MRR2
288209	89536	288209	289975	91637	TYPE MFF 1/8
288217	89536	288217	289983	91637	TYPE MFF 1/8
288225	89536	288225	290130	89536	290130
288233	89536	288233	290148	89536	290148
288308	71450	360S-104A	290155	89536	290155
288324	15818	U2412	290163	89536	290163
288365	12040	LM310H	290247	89536	290247
288381	95303	40372	290262	89536	290262
288480	91637	TYPE MFF 1/8			
288498	91637	TYPE MFF 1/8	290270	89536	290270
288555	91637	TYPE MFF 1/8	290296	89536	290296

MANUFACTURERS' CROSS REFERENCE LIST

FLUKE STOCK NO.	MFR.	MFR. PART NO.	FLUKE STOCK NO.	MFR.	MFR. PART NO.
290304	89536	290304	298893	89536	298893
290312	89536	290312	298992	89536	298992
290320	89536	290320	299610	89536	299610
290346	89536	290346	301382	89536	301382
290650	89536	290650	301390	89536	301390
291120	71450	360S501A	303412	89536	303412
291294	91637	TYPE MFF 1/8			
291526	89536	291526	303461	89536	303461
291534	00779	583529	306118	01295	GA3938A
291542	00779	583527	306126	01295	GA3937A
291690	89536	291690	307298	89536	307298
291898	00779	583650-2	307504	89536	307504
291906	00779	583650-3	309633	77342	TYPE R40
292193	89536	292193	309849	72982	8131-050-651-224M
292201	89536	292201	311746	89536	311746
292888	89536	292888	321398	89536	321398
292896	89536	292896	329912	12040	LM318H
292904	89536	292904	334722	71450	360S105A
292946	71785	133-59-02-011	339309	89536	339309
292953	01537	MC7400P	340133	91637	TYPE MFF ¼
292979	01295	SN7404N	340158	91637	TYPE MFF ¼
295121	89536	295121	340166	91637	TYPE MFF 1/8
295196	56289	39D718G010JP4	340208	91637	TYPE MFF 1/8
295337	28213	SF3402	340216	91637	TYPE MFF 1/8
295352	00779	583650-9	340224	91637	TYPE MFF 1/8
295535	89536	295535	340232	91637	TYPE MFF 1/8
295717	11726	QD101-78E	340240	91637	TYPE MFF 1/8
296582	75915	281005	340257	91637	TYPE MFF 1/8
297713	89536	297713	340265	03888	TYPE PME 75
297762	89536	297762	340273	95275	VY10CA2R2CA
297903	89536	297903			
298232	89536	298232			
298554	89536	298554			

MANUFACTURERS' CROSS REFERENCE LIST

FLUKE STOCK NO.	MFR.	MFR. PART NO.	FLUKE STOCK NO.	MFR.	MFR. PART NO.
340315	91637	TYPE MFF 1/8			
340323	91637	TYPE MFF ¼			
340745	95275	VY10CA2R7CA			
342873	73445	C280AEA10K			
342881	73445	C280AEA6K8			
344283	95275	VY10CA270JA			
347963	80294	3329H-J81-3R0			

Section 6

Option & Accessory Information

6-1. INTRODUCTION

6-2. This section contains information describing the options and accessories usable with this instrument.

6-3. OPTIONS

6-4. Each of the options usable with this instrument are described under headings that list the option name and number. The descriptions give detailed field installation, operating, and maintenance data for each option as well as a complete list of replaceable parts.

6-5. ACCESSORIES

6-6. Accessories usable with this instrument are described under headings that list the accessory name and number.

6-7. A listing of included options and accessories is given in the contents at the front of this manual.

Option – 01
AC Converter

6-1. INTRODUCTION

6-2. The A13 AC Converter (Drawing No. 8400A–1007) when used in conjunction with the 8400A DVM provides an ac voltage measurement capability through four ranges of 1, 10, 100, and 1000. The converter rectifies ac input voltage to dc and applies the dc to the A9 A-to-D Converter for measurement in exactly the same manner as described in the Theory of Operation for measurement of dc voltage.

6-3. SPECIFICATIONS

6-4. AC Converter specifications are given in Section 1, Introduction and Specifications.

6-5. INSTALLATION

6-6. Use the following procedure to install the AC Converter Option in the 8400A DVM.

a. With the DVM disconnected from the power source, remove the top dust and chassis guard covers. On the A14 Display Motherboard in the instrument, determine that connector J13 is clear of obstructions and that alignment key is inserted between pin pairs J13-23, -24 and J13-21, -22. See Drawing No. 8400–1002, Sheet 1 of 2. Locate terminal block No. 1 terminals P2TF and P2TR and connect the red and black wires from the AC Converter board to these terminals, respectively.

b. Check that shield on AC Converter is securely attached to board and align board vertically with plastic guide slots on inner vertical faces of guard chassis. Align rubber grommet with slot in front guard chassis and insert. Slide converter board downward to fully engage board card edge connector with J13 connector on Motherboard.

c. Attach guard and instrument dust cover, connect ac power, and perform receiving inspection test of converter as described in paragraph 6-22, Performance Test.

6-7. OPERATING INSTRUCTIONS

6-8. Operation of the DVM with the A13 AC Converter Option 8400–01 installed is covered in Section 2, Operating Instructions.

6-9. THEORY OF OPERATION

6-10. General

6-11. The A13 AC Converter consists of two basic parts as shown in Figure 6-1: an operational rectifier and a dc difference amplifier integrator. The operational rectifier consists of an inverting, trans-conductance amplifier and load resistor with negative feedback arranged to provide a loop gain of about 5×10^3 at midband. The feedback is changed with reed switches for range purposes. The input resistor is 1.11 megohms and this value provides 1.11 megohm input impedance at the DVM input jacks. 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 two milliamps. The two output waveforms are shown in Figure 6-2.

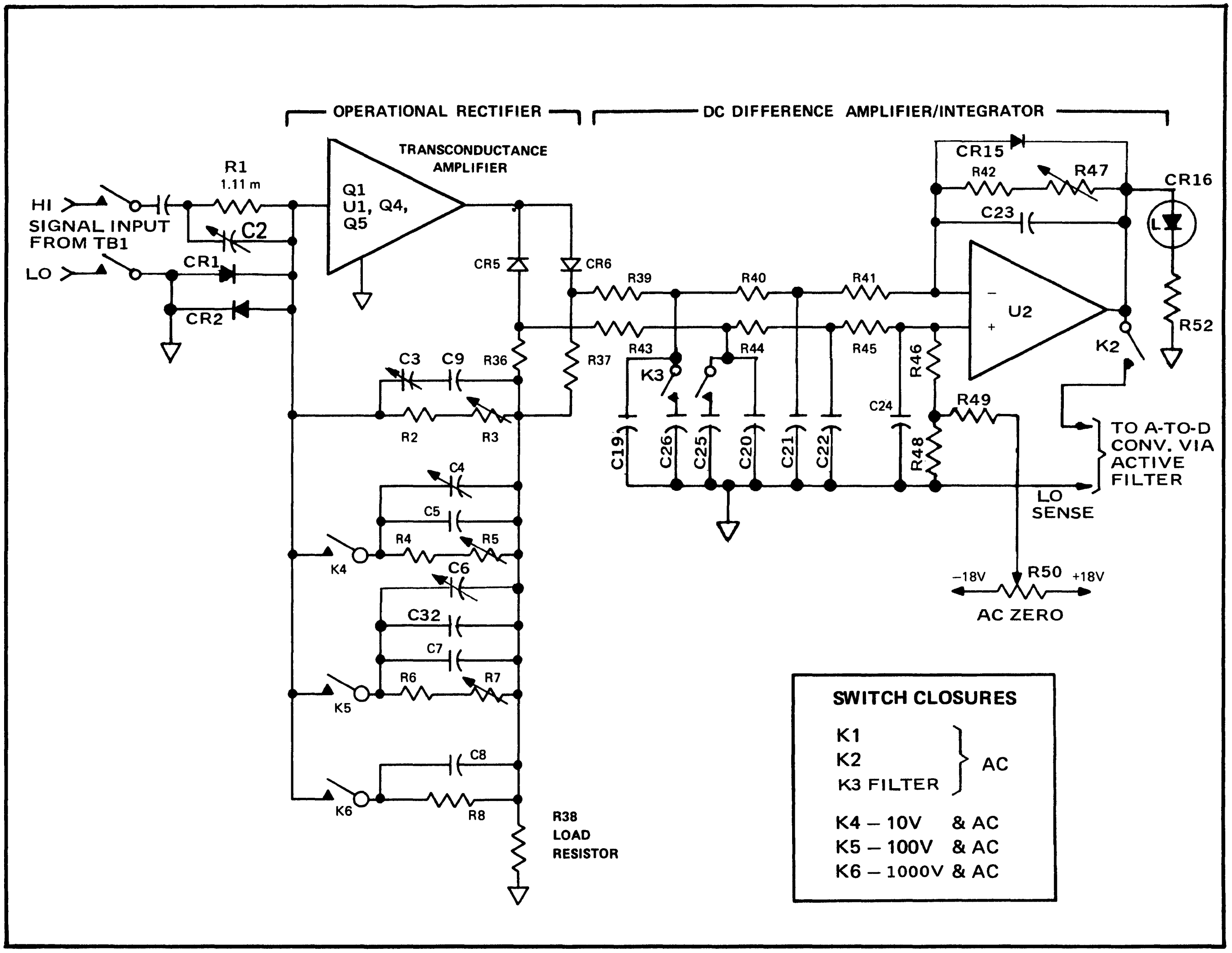


Figure 6-1. CIRCUIT DIAGRAM AC CONVERTER

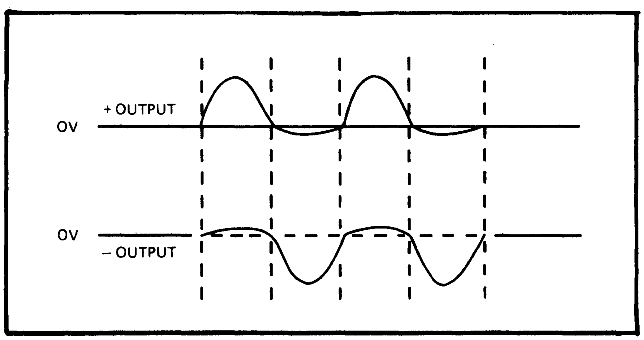


Figure 6-2. RECTIFIER OUTPUT WAVEFORMS

6-12. The dc difference amplifier/integrator filters the output wave forms of Figure 6-2 and amplifies the difference between them by a factor of 3.33333 etc. for measurement by the A-to-D Converter. A minimum three sections of filtering are provided at all times. Additional filtering is available by depressing the FILT button on the front panel to further reduce ripple for low frequency inputs.

NOTE!

Depressing the FILT button inserts the A10 Active Filter assembly into the signal ratio. This reduces ripple with a corresponding sacrifice in settling time. See Section 1 for detailed specifications.

6-13. Circuit Description

6-14. 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 circuit common. The first two differential pairs are in dual in-line package U1. 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.

6-15. 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, C21, C22, C25 and C26. Capacitors C19, C21, C23 and C26 form matched pairs with capacitors C20, C22, C24, and C25, respectively, to maintain good common-mode rejection. Gain for the dc amplifier is provided by monolithic operational amplifier U2, thereby providing a total loop gain at dc of about 5×10^5.

6-16. RANGE AND FUNCTION CONTROL. The converter input and output relays, K1 and K2, are operated from the VAC control line. The range relays, K4 through K6, are operated by driver circuitry consisting of NAND gates U4A, C, D and associated components. These range control gates accept the buffered outputs of the range counter on the A14 Display board. U3B and U4B deliver the up and down range stop commands, for VAC function, to A2 Range Delay board. The NAND gates U3A and U3C deliver the set and reset commands to the range counter, on A14 Display board, for prevention of a disallowed range in the VAC function.

6-17. MAINTENANCE

6-18. Introduction

6-19. 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 4 of the Manual.

6-20. Test Equipment

6-21. The following equipment is recommended for testing, troubleshooting, and calibrating 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

6-22. Performance Test

6-23. The performance test in this section compares the AC Converter performance to the accuracy specifications in Section 1 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 after 1 hour warm up: ambient temperature 23°C ±2°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 1 of the manual.

6-24. AC VOLTAGE TEST. In the following procedure, 10 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 DVM controls as follows:

FUNCTION	VAC
RANGE	Manually selected, as required.

b. Apply each of the 10 kHz test signals shown in Figure 6-3 to the INPUT terminals of the DVM. The readout should be as indicated.

INPUT (VAC)	RANGE	READOUT LIMITS
1	1	.99945 to 1.00055
10	10	9.9945 to 10.0055
100	100	99.945 to 100.055
1	1000	000.95 to 001.05
1000	1000	999.00 to 1001.00

Figure 6-3. AC VOLTAGE TEST REQUIREMENTS

6-25. Calibration

The AC Converter should be calibrated every 90 days, or whenever repairs have been made to circuitry. Calibration of the converter should be performed at an ambient room temperature of 23°C ±5°C. Relative humidity should be less than 70%. Consult paragraph 6-20 for recommended test equipment.

6-26. 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 and allow the instrument to operate for one hour.

6-27. AC CONVERTER ALIGNMENT

a. Set the DVM controls as follows:

FUNCTION	VAC
RANGE	1000
SAMPLE RATE	Fully clockwise

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

c. Connect a shorting jumper between the INPUT terminals.

d. Adjust AC zero for 000.00 on the readout.

e. Rotate the .001V 50 kHz adjustment (A13 C18) slowly in a CW direction. Note that one digit will be displayed longer than the others. When this "long duration digit" changes to a new number STOP; back the adjustment off so that the "long duration digit" just remains steady on the readout.

f. Readjust AC zero for 000.00 on the readout.

g. Remove the short between the INPUT terminals.

h. Perform the checks and adjustments contained in Figure 6-4.

6-28. Calibration of the AC Converter is now complete.

6-29. Troubleshooting

6-30. 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 equipment or improper control settings. For this reason, the performance test (paragraph 6-22) is suggested as a first step in troubleshooting. The performance test may also help to localize trouble to a particular section of the instrument. If the performance test fails to localize the trouble, the following information may be helpful.

6-31. POWER SUPPLY VOLTAGE CHECK

6-32. 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 the DVM power supply voltages is given in Section 4.

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
21	–18 volts
19	+18 volts

6-33. COMMAND VOLTAGE CHECK

6-34. 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 6-5. The voltages should be as indicated.

6-35. RELAY CHECKS

The truth table (Figure 6-6) 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

STEP	INPUT FREQ	INPUT VOLTS	RANGE	ADJUSTMENT	TOLERANCE (± DIGITS)
1	500 Hz	.001	1	Check Only	3
2	50 kHz	.001	1	.001V 50 kHz (A13C18)	Same reading as Step 1
3	500 Hz	500.00	1000	500V 1 kHz (A13R47)	3
4	30 kHz	500.00	1000	500V 30 kHz (A13C2)	3
5	500 Hz	1.0000	1	1V 500 Hz (A13R3)	5
6	50 kHz	1.0000	1	1V 50 kHz (A13C3)	5
7	100 kHz	1.0000	1	Check Only	200
8	20 kHz	1.0000	1	Check Only	20
9	50 Hz	1.0000	1	Check Only	30
10	500 Hz	10.0000	10	10V 500 Hz (A13R5)	5
11	50 kHz	10.0000	10	10V 50 kHz (A13C4)	5
12	100 kHz	10.0000	10	Check Only	200
13	1 kHz	100.000	100	100V 500 Hz (A13R7)	5
14	50 kHz	100.000	100	100V 50 kHz (A13C6)	5
15	20 kHz	100.000	100	Check Only	20
16	10 kHz	1000.00	1000	Check Only (wait 30 sec.)	50

Figure 6-4. AC CONVERTER RANGE CALIBRATION

PIN NO.	FUNCTION VAC / RANGE 1V	FUNCTION VAC / RANGE 10V	FUNCTION VAC / RANGE 100V	FUNCTION VAC / RANGE 1000V	FUNCTION ANY EXCEPT VAC / RANGE ANY
18	0	1	1	0	0
2	1	0	0	0	0
8	1	1	1	1	0
4	0	1	0	1	0
3	1	0	0	1	0
6	0	1	1	1	0
16	1	0	1	0	0

POSSIBLE TROUBLE

1. Improper connections between converter board and main frame, e.g., misalignment of connector pins.
2. Faulty function switch.
3. Defect in range counter on A14 Display PCB.
4. Defective range switch.
5. Short in relay gate circuits on AC option PCB.
6. Short between control lines on AC option board.

Legend: Logical 1 = >3.0V
Logical 0 = <0.6V

Figure 6-5. AC CONVERTER FUNCTION COMMAND CHECK

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, 18, 2, 8, 4, 3, 6, 16 as shown in Figure 6-5.
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 gate circuits.

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

Figure 6-6. AC CONVERTER RELAY TRUTH TABLE.

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.

6-36. SEVERE CONVERTER MALFUNCTIONS

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

Procedure: If dc voltage at TP1 and ac voltage on TP2 are zero, then troubleshoot converter output difference amplifier/integrator, and associated circuits.

If the dc voltage on TP1 is greater than ±1V (normal is less than 10 mV) check for defective Q1 through Q6, U1, C11, C21 or associated circuits.

If ac voltage is present on TP2, check for open or shorted feedback circuit or defective component in amplifier causing oscillation.

b. Symptom: Zero output with input applied.

Procedure: If ac voltage on TP2 is zero, check for open or short in ac circuit between input and Q1.

If ac voltage does appear on TP2 (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 6-5 and 6-6.

6-37. LIST OF REPLACEABLE PARTS

6-38. For column entry explanations, part ordering information and basic instrument configuration Use Codes and Serial Number Effectivity, see Section 5, paragraphs 5-1 through 5-10. See paragraph 6-39, this option subsection, for additional Use Codes and Serial Number Effectivity List assigned to this printed circuit assembly option.

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A13	**AC CONVERTER –01 Option**				REF		
	Figure 6-7						
C1	Cap, plstc, 0.22 uf ±20%, 1200V	268904			1		
C2	Cap, var, teflon, 0.25 – 1.5 pf, 2 kV	273151			1		
C3, C4	Cap, var, air, 0.8 – 10 pf, 250V	229930			2		
C5	Cap, mica, 12 pf ±5%, 500V	175224			1		
C6,C18	Cap, var, cer 9 – 35 pf, 350V	289637			2		
C7	Cap, mica, 150 pf ±1%, 500V	226134			1		
C8	Cap, mica, 4700 pf ±5%, 500V	208975			1		
C9	Cap, cer, 3 pf ±10%, 500V	226316			1		
C10, C14	Cap, Ta, 4.7 uf ±20%, 20V	161943			2		
C11	Cap, elect, 150 uf +50/–10%, 16V	186296			1		
C12, C13	Cap, cer, 500 pf ±10%, 500V	105692			2		
C15	Cap, elect, 47 uf +50/–10%, 25V	168823			1		
C16, C17	Cap, cer, 0.01 uf ±20%, 100V	149153			2		
C19, C20	Cap, plstc, 0.068 uf, Matched Set	290148			1		
C21, C22	Cap, plstc, 0.12 uf, Matched Set	290130			1		
C23, C24	Cap, plstc, 0.0047 uf, Matched Set	290163			1		
C25, C26	Cap, plstc, 0.47 uf, Matched Set	288233			1		
C27	Cap, mica, 33 pf ±5%, 500V	160317			1		
C28 thru C31	Not Used						
C32	Cap, mica, 56 pf ±5%, 500V	148528			1		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
CR1 thru CR4, CR15	Diode, silicon, 100 mA at 1.5V	261370			5		
CR5, CR6	Diode, silicon, 100 mA at 1.5V	161810			2		
CR7, CR8, CR9	Diode, silicon, 150 mA	203323			3		
CR10 thru CR14	Diode, germanium, 80 mA, 100 piv	149187			5		
CR16	Diode, zener, 13V	110726			1		
K1	Relay reed switch	284091			1		
	Coil, relay	269019			3		
K2,K3 K6	Relay, reed switch	219097			8		
	Coil, relay	272070			3		
K4, K5	Relay, reed switch	219097			REF		
	Coil, relay	269019			REF		
Q1	Tstr, FET, N-channel	246066			1		
Q2,Q6	Tstr, silicon, NPN	218081			2		
Q3, Q4, Q5, Q7	Tstr, silicon, PNP	229898			4		
R1	Res, met flm, 1.11M } Matched Set	269092			1		
R2	Res, met flm, 267k } Matched Set						
R3	Res, var, cer met, 2k ±10%, 1w	285163			1		
R4	Res, ww, 29.53k ±0.1%, ½w	277657			1		
R5, R32	Res, var, cer met, 200 ±10%, 1w	285148			2		
R6	Res, ww, 2.573k ±0.1%, ½w	277665			1		
R7	Res, var, cer met, 20 ±20%, 1w	285114			1		
R8	Res, ww, 143.3 ±0.1%, ¼w	292193			1		
R9	Res, met flm, 49.9k ±1%, 1/8w	268821			1		

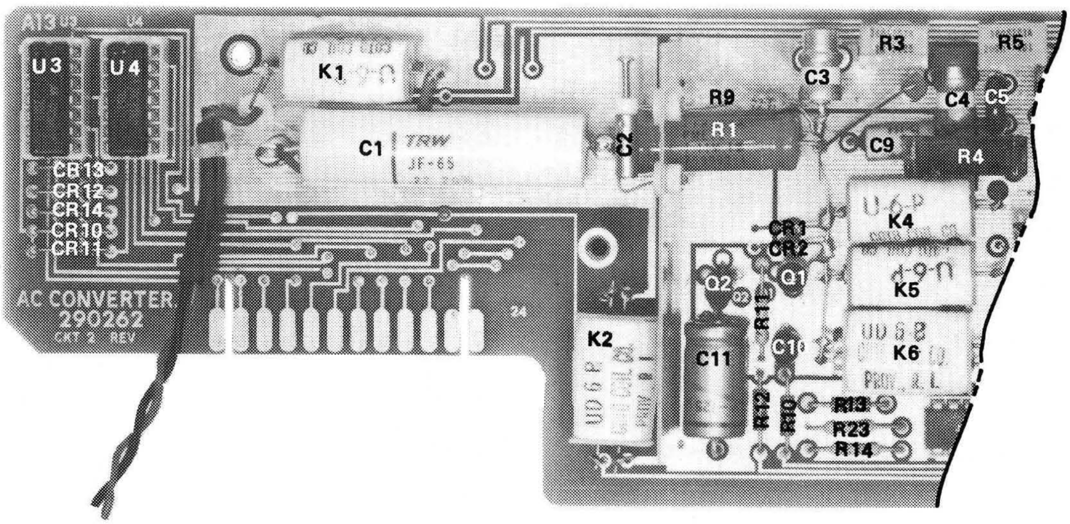
REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R10	Res, comp, 8.2k ±5%, ¼w	160796			1		
R11, R26	Res, met flm, 590 ±1%, 1/8w	261883			2		
R12, R33	Res, comp, 10k ±5%, ¼w	148106			2		
R13	Res, comp, 15k ±5%, ¼w	148114			1		
R14	Res, met flm, 84.5k ±0.5%, 1/8w	229492			1		
R15, R18	Res, comp, 120k ±5%, ¼w	193458			2		
R16, R17	Res, comp, 11k ±5%, ¼w	221580			2		
R19, R20	Res, comp, 47 ±5%, ¼w	147892			2		
R21, R22	Res, met flm, 40.2k ±1%, 1/8w	235333			2		
R23	Res, met flm, 82.5k ±1%, 1/8w	246223			1		
R24, R28	Res, met flm, 10k ±1%, 1/8w	168260			2		
R25, R27	Res, met flm, 21.5k ±1%, 1/8w	168278			2		
R29	Res, met flm, 1.1k ±1%, 1/8w	241497			1		
R30, R50	Res, var, cer met, 100k ±10%, 1w	288308			2		
R31	Res, comp, 10M ±5%, ¼w	194944			1		
R34	Res, comp, 22k ±5%, ¼w	148130			1		
R35	Res, comp, 2.2k ±5%, ¼w	148049			1		
R36, R37	Res, ww, 1.702k ±0.1%, ¼w	292201			2		
R38	Res, ww, 125 ±0.1%, ¼w	249284			1		
R39, R40, R43, R44	Res, ww, 130k ±0.1%, ¼w	285361			4		
R41, R45	Res, ww, 40k ±0.1%	271403			2		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R42, R46	Res, ww, 1M ±0.1%	271411			2		
R47	Res, var, cer met, 10k ±10%, 1w	285171			1		
R48	Res, met flm, 100 ±1%, 1/8w	168195			1		
R49	Res, met flm, 487k ±1%, 1/8w	237206			1		
R51	Res, comp, 9.1k ±5%, ¼w	193318			1		
R52	Res, comp, 1k ±5%, ¼w	148023			1		
U1	IC, 5 transistor array	248906			1		
U2	IC, operation amplifier	288928			1		
U3	IC, DTL, triple 3-Input Nand Gate	266312			1		
U4	IC, DTL, Quad 2-Input Nand Power Gate	288597			1		
	Socket, IC, 14 contact, U1, U3, U4	276527			3		

6-39. SERIAL NUMBER EFFECTIVITY

A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8400A. 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



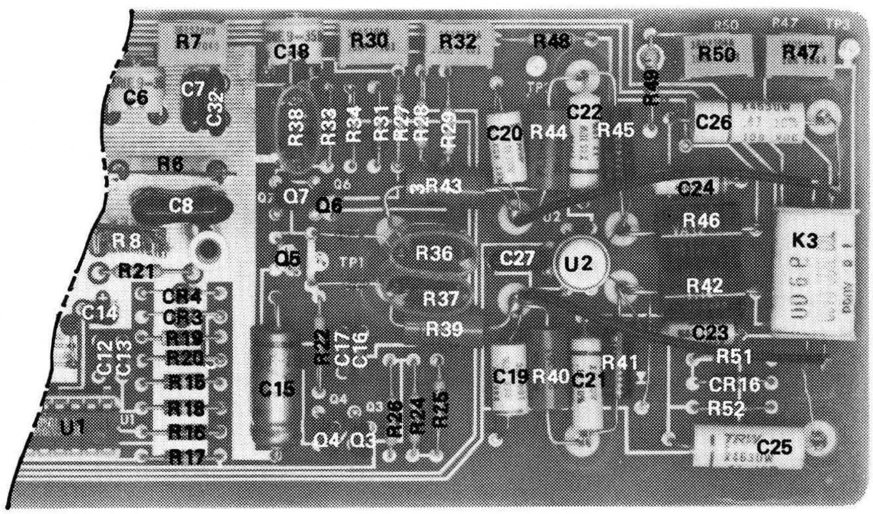


Figure 6-7. AC CONVERTER PCB ASSEMBLY

Option – 02
Ohms Converter

6-1. INTRODUCTION

6-2. The Ohms Converter (Option –02) is used in conjunction with the basic DVM to provide resistance measuring capability in seven ranges: 10, 100, 1000, and 10000 ohms, and 100, 1000, and 10000 kilohms.

6-3. SPECIFICATIONS

6-4. Specifications for the ohms converter are located in Section 1, Introduction and Specifications.

6-5. INSTALLATION

6-6. Ohms Converter installation procedures are as follows:

a. Disconnect the power cord from line power.

b. Remove the top dust and guard chassis covers. On the A14 Display motherboard in the instrument, determine that connector J12 is clear of obstructions and that the alignment spacer is inserted between pin pairs J12-8, -9 and J12-10, -11 (see Drawing No. 8400A-1002, Sheet 1 of 2). Locate terminal block No. 1, terminals P3TF and P3TR, and connect the yellow and brown wires from the Ohms Converter board to these terminals, respectively. Layout other cable attached to rear of A12 Ohms Converter along inside bottom of the DVM chassis, underneath the other circuit boards, and emerge adjacent to terminal block No. 2. Attach to terminal block No. 2 terminals as shown on the wiring diagram, Drawing No. 8400A-1000. Also see terminal block layout diagram on guard cover.

c. Align converter board vertically with plastic guide slots on inner vertical faces of guard chassis. Align rubber grommet with slot in front guard chassis and insert. Slide converter board downward to fully engage card-edge connector with J12 connector on motherboard.

d. Attach guard and instrument dust cover, connect ac power, and perform receiving inspection test of converter as described in paragraph 6-27, Performance Test.

6-7. OPERATING INSTRUCTIONS

6-8. Operation of the DVM with the A12 Ohms Converter Option 8400A–02 installed is covered in Section 2, Operating Instructions.

6-9. THEORY OF OPERATION

6-10. General

6-11. The Ohms Converter is operated in one of two configurations associated with the functions of Ohms and K ohms. In the Ω function, the ohms converter is a constant current source which is connected to the SOURCE Terminals on the front panel of the 8400A. In K Ω function the ohms converter is a precision scaling resistor, which, in conjunction with the Buffer amplifier located in the basic instrument, and the unknown resistor, produces a voltage proportional to the unknown resistor. Simplified diagrams are shown in Figure 6-1.

6-12. Ω CONFIGURATION. A constant current is supplied to the HI and LO SOURCE Terminals of the

8400A from a current source as shown in Figure 6-1. A regulated dc voltage supplies a fixed current to a reference zener diode. The zener reference voltage is impressed across a precision resistor causing a current to flow into the emitter of a transistor. Because this transistor is a high gain device, the majority of the emitter current flows out of the collector, hence, out of the HI SOURCE terminal. The LO SOURCE terminal provides a return path for the precision current.

6-13. The constant current generator produces one of three currents dependent upon the range selected. Table 6-1 shows the current generated for each range selected on the front panel of the 8400A.

Table 6-1. CURRENT OUTPUT, Ω CONFIGURATION

OHMS RANGE CALLED	CURRENT CALLED
10	10 ma
100	10 ma
1000	1 ma
10K	100 μa

6-14. True four-terminal resistance measurements can be made in the ohms function. The term true four-terminal is used because the current generator is completely isolated from the remaining circuitry in the instrument, and hence, no current will flow in the voltage sense terminals even in the presence of relatively large lead resistances.

6-15. KΩ CONFIGURATION. In the KΩ function, a range dependent scaling resistor is placed between the master +7 volt reference and the HI SOURCE terminal. A voltage proportional to the unknown resistance (R_X) is available at the buffer output as shown in Figure 6-1.

6-16. Circuit Description

6-17. CONSTANT CURRENT GENERATOR. Regulated dc voltage is developed by resistors R2, R4, R5, zener diode CR3, transistor Q1 and operational amplifier U1. Divider string, R6, R7, and R8, scales the zener reference voltage and applies it to U2. Range resistors R10 through R16, in conjunction with zener CR3, the regulated dc voltage, and amplifier U2, apply a range dependent, constant current to the emitter of a Darlington pair composed of Q2 and Q3. Fuse F1, capacitor C6, and diodes CR2, CR4 are used as an overvoltage protection circuit for the current generator.

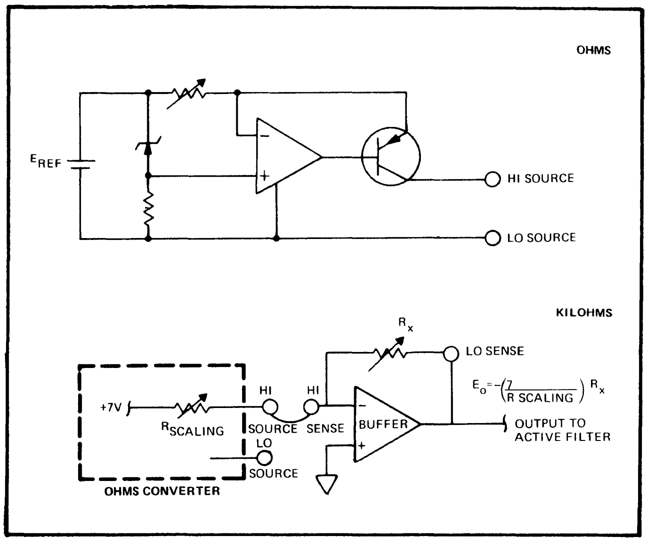


Figure 6-1. SIMPLIFIED DIAGRAM OF OHMS CONVERTER SHOWING TWO CONFIGURATIONS

6-18. RANGE SCALING NETWORK. Resistors R17 through R22, and relay contacts K1–A, K2–A and K4 are the range scaling network. The relay contacts K1–A and K2–A are actuated by range selection on front panel. Relay K4 is actuated in the KΩ function and connects one end of the scaling network to the HI SOURCE terminal on front panel.

6-19. RELAY DRIVE CIRCUIT. Range control relay K1 receives its call commands from the A11 BUFFER assembly, whereas relay K2 receives its call commands from the buffered A14 range counter. Function control relays K3 and K4 are controlled by transistors Q6 and Q5, respectively. A manual range condition is detected by Gate U5B which enables gates U5C and U5D to control Q5 and Q6. In an autorange condition, gates U5C and U5D are disabled and function control is transferred by gate U3B to RS flip-flop U3A and U3C. The mutually exclusive outputs of this flip-flop, in turn, control switches Q5 and Q6. Gates U4A and U4B operate on the set and reset lines of the RS flip-flop to enable an automatic change of functions in an autorange condition.

6-20. MAINTENANCE

6-21. Introduction

6-22. This section contains maintenance information for the Ohms Converter. Factory service information and general instructions regarding instrument access and cleaning are located in Section 4 of the manual.

6-23. Test Equipment

6-24. The resistance valves for performance testing, troubleshooting, and calibration of the Ohms Converter is listed in Table 6-2.

Table 6-2. REQUIRED RESISTANCE VALVES

STANDARD RESISTANCE VALVE	TOLERANCE
10Ω	±30 PPM
100Ω	±30 PPM
1KΩ	±20 PPM
10KΩ	±20 PPM
100KΩ	±20 PPM
1MΩ	±20 PPM
10MΩ	±100 PPM

6-25. Fuse Replacement

6-26. The Ohms Converter contains two fuses, one of 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 20 volts rms on 10Ω through 10,000Ω range before the fuse will blow. Up to 250V rms may continuously be applied to the 100kΩ through 10,000kΩ ranges without damage. A spare fuse is located on the ohms converter pcb, next to the in-circuit fuse.

6-27. Performance Tests

6-28. The performance tests in this section compare the Ohms Converter performance to the accuracy specifications in Section 1 of the manual to determine if the converter is in calibration. 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 23°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 resistance measurements are derived from the 90-day instrument specifications tained in Section 1 of the manual.

6-29. KILOHMS TEST. The kilohms function is checked at full scale on each of three ranges of the DVM. Connect each of the standard resistors shown in Table 6-3, in turn, to the INPUT terminals of the Model 8400A. Use short, low-resistance connecting leads. Set the DVM controls as shown in the table. The readout should be as indicated.

Table 6-3. KILOHMS TEST REQUIREMENTS

STANDARD RESISTANCE	MODEL 8400A FUNCTION	RANGE	READOUT LIMITS
100KΩ	KΩ	100	99.988 to 100.012
1000KΩ	KΩ	1000	999.88 to 1000.12
10MΩ	KΩ	10K	9994.8 to 1005.2

6-30. OHMS TEST. The ohms function is checked at full scale on each of four ranges on the DVM. Connect equipment as shown in Figure 6-2. Connect each of the standard resistors in Table 6-4, observing appropriate readout as indicated.

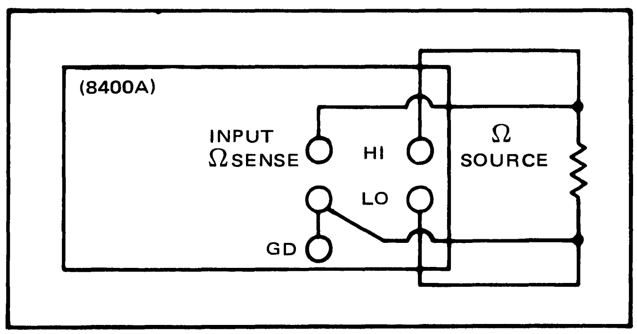


Figure 6-2. EQUIPMENT CONNECTIONS FOR OHMS TEST

Table 6-4. OHMS TEST REQUIREMENTS

STANDARD RESISTANCE	MODEL 8400A FUNCTION	RANGE	READOUT LIMITS
10Ω	Ω	10	9.9980 to 10.0020
100Ω	Ω	100	99.987 to 100.013
1KΩ	Ω	1000	999.87 to 1000.13
10KΩ	Ω	10K	9998.7 to 10001.3

6-31. Calibration

6-32. The Ohms Converter should be calibrated every 90 days to maintain specifications (see specifications, Section 1), or whenever repairs have been made to circuitry. Calibration of the converter should be performed at an ambient room temperature of 23 ±5°C. Relative Humidity should be less than 70%. Consult Table 6-2 for recommended test equipment.

6-33. 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 8400A and allow the instrument to operate for one hour.

d. Remove the upper dust cover and set the Model 8400A controls as follows:

FUNCTION	VDC, FILT
RANGE	.1
SAMPLE RATE	full clockwise

e. Connect the GUARD terminal to the LO INPUT terminal and the HI SOURCE terminal to the HI INPUT terminal, and the LO SOURCE terminal to the LO INPUT terminal using the shorting links provided with the instrument.

f. Short the INPUT terminals together.

g. Adjust the DC ZERO control on the front panel for a zero ±1 digit.

6-34. KILOHMS CALIBRATION

a. Depress 10K and KΩ buttons.

b. Remove the short between the INPUT terminals.

c. Connect the resistances indicated in Table 6-5 between the INPUT terminals and perform the corresponding adjustment.

Table 6-5. KΩ RANGE CALIBRATION

RESISTANCE	RANGE	ADJUSTMENT	READOUT
10M	10K	10000K (A12R17)	10000.0
1M	1000	1000K (A12R19)	1000.00
100K	100	100K (A12R21)	100.000

NOTE!

The readout indicated in Table 6-5 should match the exact value of the calibration resistor, not the nominal value.

6-35. OHMS CALIBRATION

a. Remove shorting links between the INPUT HI and SOURCE HI binding posts, and between INPUT LO and SOURCE LO binding posts.

b. Connect equipment as shown in Figure 6-2.

c. Depress Ω and 10K buttons on Model 8400A.

d. Connect the resistance indicated in Table 6-6 as shown in Figure 6-2 and perform the corresponding adjustment.

Table 6-6. OHMS RANGE CALIBRATION

STANDARD	RANGE	ADJUSTMENT	READOUT
10K	10K	10000Ω (A12R7)	10000.0
1K	1000	1000Ω (A12R14)	1000.00
100Ω	100	100Ω A12R10)	100.000
10Ω	10	NONE	10.000 ±.006*
NOTE* IF MORE THAN ±.006 RESET VDC ZERO AND RECALIBRATE OHMS RANGES			

e. Re-install shorting links.

6-36. Calibration of the Ohms Converter is now complete.

6-37. TROUBLESHOOTING

6-38. Introduction

6-39. This section contains information selected to aid in troubleshooting the Ohms Converter. Before any attempt is made to troubleshoot the converter, however, it should be verified that the trouble is actually in the converter and not caused by faulty external equipments or improper control settings. For this reason, the performance tests (paragraph 6-27) 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.

6-40. TROUBLESHOOTING

a. Depress KΩ, FILT and 1000 buttons on Model 8400A.

b. Place a 1 meg ±.01% resistor across the INPUT terminals and readout 1000.00 ±.10.

FAULT ANALYSIS

IF READOUT IS BAD, FAULT MAY BE THE REFERENCE VOLTAGE OR R17, R18, R19, R20 OR RELAY K1.

c. Depress 100 button.

d. Place a 100k ±.01% resistor across INPUT terminals and readout 100.000 ±.010.

FAULT ANALYSIS

IF READOUT IN STEP d. IS BAD, FAULT MAY LIE IN RESISTORS R21 OR R22 OR RELAY K2

e. Depress Ω and 1000 buttons.

f. Measure a 1000 ±.01% resistor using the four-terminal measurement technique (see Figure 6-2).

g. Readout 1000.00 ±.10.

FAULT ANALYSIS

IF READOUT IS BAD, RESISTOR NETWORK R10, R11, R12 OR REGULATED SUPPLY, OR K2 MAY BE FAULTY.

h. Depress 100 button.

i. Using modified four-terminal technique measure 100 ±.01% resistor.

j. Readout 100.000 ±.010.

FAULT ANALYSIS

IF READOUT IS BAD, RELAY K1 OR RESISTORS R13, R14, R15, R16 OR REGULATED SUPPLY MAY BE FAULTY

6-41. LIST OF REPLACEABLE PARTS

6-42. 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 6-43, this option subsection, for additional Use Codes and Serial Number Effectivity List assigned to this printed circuit assembly option.

6-43. SERIAL NUMBER EFFECTIVITY

6-44. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8400A. 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
A	123 thru 73399
B	73400 and on

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A12	**OHMS CONVERTER –02 Option**				REF		
	Figure 6-3						
C1	Cap, elect, 150 uf +50/–10%, 25V	236901			1		
C2, C7	Cap, cer, 0.01 uf ±20%, 100V	149153			2		
C3, C4	Cap, mica, 33 pf ±5%, 500V	160317			2		A
C3, C4, C8	Cap, mica, 33 pf ±5%, 500V	160317			3		B
C5	Cap, Ta, 1.0 uf ±20%, 35V	161919			1		
C6	Cap, mica, 470 pf ±5%, 500V	148429			1		
CR1	Diode, silicon, 1 amp, 100 piv	116111			1		
CR2	Diode, zener, 20V	180463			1		
CR3	Diode, zener, 6.3V, selected & tested	288043			1		
CR4	Diode, silicon, 150 mA, 125 piv	272252			1		
CR5	Diode, zener, 10V	180406			1		
CR6 thru CR13, CR16 thru CR20	Diode, silicon, 150 mA	203323			13		
CR14	Diode, silicon, 1 amp, 600 piv	112383			1		
CR15	Diode, germanium, 80 mA, 100 piv	149187			1		
F1	Fuse, pigtail, 15 mA, 125V (one fuse provided as a spare)	285031			2		
K1	Relay, reed switch	219097			2		
	Coil, relay	272070			1		
K2	Relay, armature, DPDT, 115V Coil	309633			1		
K3, K4	Relay, reed switch	284091			2		
	Coil, relay	269019			2		
Q1	Tstr, silicon, NPN	150359			1		
Q2, Q3	Tstr, silicon, PNP	225599			2		
Q4, Q7	Tstr, silicon, NPN	218396			2		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
Q5, Q6	Tstr, silicon, PNP, selected	280198			2		
Q8	Tstr, silicon, PNP	195974			1		
R1, R9 R29	Res, comp, 10k ±5%, ¼w	148106			3		
R2, R4	Res, met flm, 10k ±1%, 1/8w	168260			2		
R3	Res, comp, 2.2k ±5%, ¼w	148049			1		
R5	Res, met flm, 953 ±1%, ¼w	288555			1		
R6	Res, met flm, 619k ±1%, 1/8w	288639			1		
R7, R19	Res, var, cer met, 1k ±20%, ½w	267856			2		
R8, R17	Res, var, cer met, 25k ±20%, ½w	285213			2		
R10	Res, var, cer met, 10k ±20%, ½w	267880			1		
R11	Res, met flm, 46.4k ±1%, 1/8w	188375			1		
R12	Res, ww, 634.13 ±0.05%, ¼w	292888			1		
R13	Res, met flm, 464k ±1%, 1/8w	271908			1		
R14	Res, var, cer met, 100k ±20%, ½w	268581			1		
R15	Res, ww, 6.983k ±0.05%, ¼w	292896			1		
R16	Res, ww, 62k ±0.05%, ¼w	292904			1		
R18	Res, met flm, 6.99M ±0.1%, 2w	284968			1		
R20	Res, ww, 777.15k ±0.05%, 3/4w	277913			1		
R21	Res, var, cer met, 100 ±20%, ½w	267823			1		
R22	Res, ww, 70.555k ±0.05%, ½w	277905			1		
R23	Res, met flm, 100 ±1%, 1/8w	168195			1		
R24, R25	Res, comp, 390 ±5%, ¼w	147975			2		
R26	Res, comp, 8.2k ±5%, ¼w	160796			1		A
R26, R34	Res, comp, 8.2k ±5%, ¼w	160796			2		B
R27	Res, comp, 4.7k ±5%, ¼w	148072			1		
R28	REs, comp, 1k ±5%, ¼w	148023			1		A

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R28, R33	Res, comp, 1k ±5%, ¼w	148023			2		B
R30, R31	Res, comp, 560 ±5%, ¼w	147991			2		
R32	Res, comp, 220 ±5%, ¼w	147959			1		
U1	IC, operational amplifier	271502			1		
U2	IC, operational amplifier	284760			1		
U3	IC, DTL, triple 3-Input Nand Gate	266312			1		
U4	IC, DTL, dual 4-Input Nand	268383			1		
U5	IC, DTL, Quad 2-Input Nand Gate	268375			1		
	Fuse holder	296582			2		
	Socket, IC, 14 contact, U3, U4, U5	276527			3		

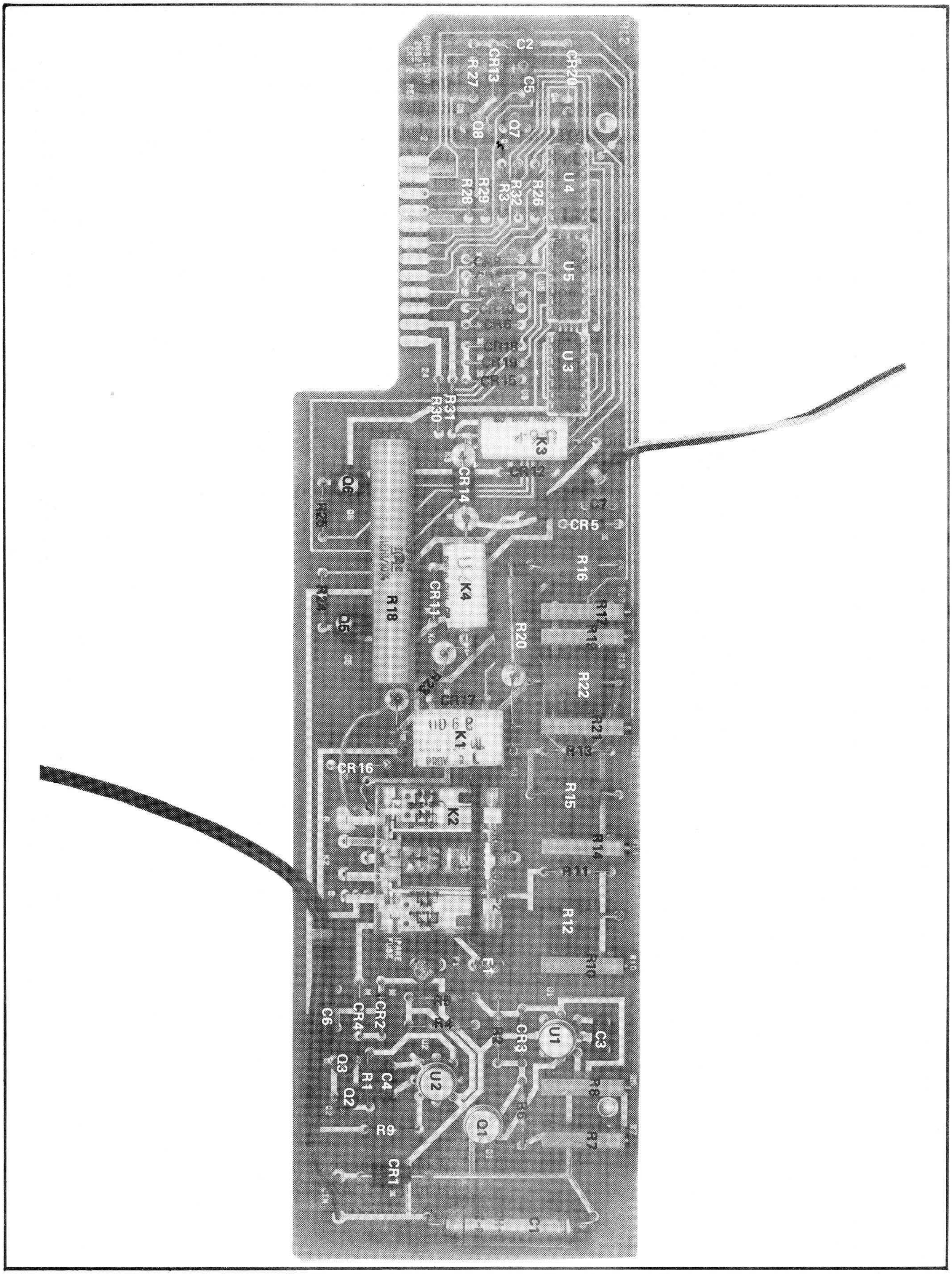


Figure 6-3. OHMS CONVERTER PCB ASSEMBLY

Option–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 8400A 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 1 of the manual.

6-5. INSTALLATION

6-6. The following procedure should be used to install the Data Output Unit in the Model 8400A.

a. Disconnect the power cord from the instrument before installing the Data Output Unit option.

b. Remove the top dust and guard chassis covers.

c. Determine that connector J7, on A14 Display board, is clear of obstructions and that alignment spacer is inserted between pin pairs J7-1, -2 and J7-3, -4. A second alignment spacer must be inserted between pin pairs J7-21, -22 and J7-23, -24.

d. Determine that connector slots on rear panel for P20 and P21 on Data Output Unit boards are clear of any obstructions.

e. Attach spring to bottom portion of guard bar on A7 Data Output Unit No. 1.

f. Insert P21, on A7 Data Output Unit No. 1, into connector slot on rear panel while inserting P20 on A6 Data Output Unit No. 2 into rear panel connector slot. (Refer to Section 5, Figure 5-1 for physical location of A7 and A6)

g. Insert edge of both the Data Output Units (A6 & A7) into card guides on the inner chassis bulkhead.

h. Observe that alignment spacers on J7 line up with slots on the Data Output Unit card-edge connector.

i. Slide both boards downward until the card-edge connector on A7 is fully engaged with J7 on A14 Display board, and A6 is seated into bracket.

j. Lay the twisted pair cable under the top position of the rear panel and route toward transformer.

j. Connect wires to jacks mounted on transformer so yellow mates to yellow and blue to blue.

k. Attach guard and dust covers, connect ac power, and perform receiving inspection test of the Data Output Units as described in paragraph 6-33, Performance Test.

6-7. OPERATING INSTRUCTIONS

6-8. Operating instructions and applications information for the Model 8400A with DOU installed are located in Section 2 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 8-4-2-1, 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 blovk diagram, Figure 6-1).

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

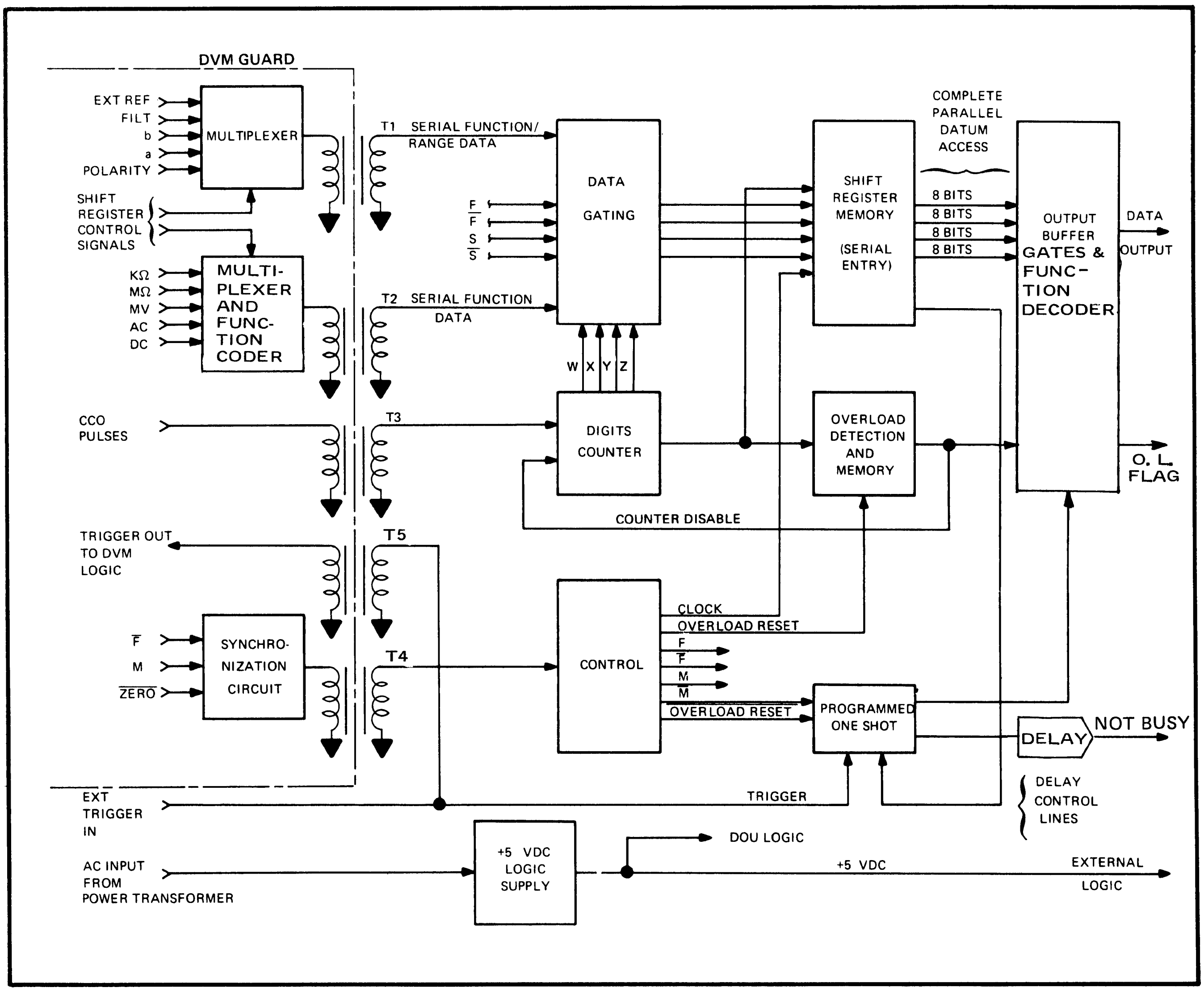


Figure 6-1. DATA OUTPUT UNIT BLOCK DIAGRAM.

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.

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.

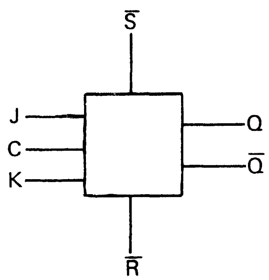
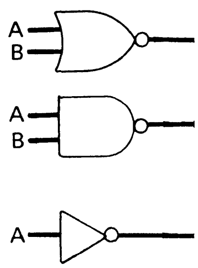
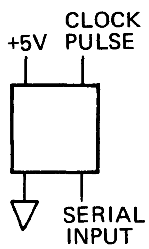
6-14. Circuit Description

6-15. LOGIC NOTATION. A description of the logic symbology used in the DOU is given in Figure 6-2. 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 6-2. 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 signal on the schematics is accomplished without connecting lines, which greatly reduces conjestion.

6-16. MULTIPLEXERS. The DVM function, range, and polarity inputs are applied to dual multiplexer circuitry consisting of NAND gates A7U27A through D, A7U28A through D, A7U29C and A7U29D, (see DOU schematic at rear of manual). The gates comprising each multiplexer are enabled sequentially by the 6-state shift register signals. The multiplexer outputs are applied to inverter circuits consisting of NOR gates A7U31A, A7U31D, A7U31E, A7U31F, and transformers T1 and T2. The pulses produced by T1 and T2 secondaries are applied to RS flip flops composed of inverters A7U13A, A7U13B, A7U13D, A7U13E, 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 6-3 (signals 13-8 and 13-4) and correspond to the following DVM functions and input conditions: VDC function with filter called, 1 range, negative voltage applied to input and remotely controlled. A complete list of waveforms appearing at the output of the RS flip flops is given in the troubleshooting section. (See Figure 6-9). Waveforms are labeled according to circuit location (e.g., 13-4 means I. C. U13 pin 4).

6-17. DIGITS COUNTER. The digits counter consists of J-K flip flops A6U26A, A6U26B, A6U25A and A6U25B. The input flip flop, A6U25A is toggled by positive pulses, which are transferred through the guard by A7U32C 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 A6U22A, which stops the counter at a count of "11" and generates a high at the input of flip flop A6U21B. 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 A6U21B to produce an overload indication at the DOU output, A7P20-13.

6-18. DATA GATES. The data gates consist of NAND gates A7U22C, A7U23A through U23C, and A7U24A through U24D. 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

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.

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

Figure 6-2. EXPLANATION OF LOGIC SYMBOLOGY USED IN DOU

the shift register memory at the proper times. These data bits are loaded in accordance with the load sequence (see Figure 6-4) and are steered by the data gates.

6-19. RANDOM ACCESS MEMORY. The DOU memory is composed of shift registers A7U10, A7U12, A7U14 and A7U16. Data is loaded serially into the shift registers. The loading sequence is controlled by clock pulses which are produced by gates A7U15A through U15D, gate A7U19B and associated circuitry. Steering signals, S and $\overline{S}$, together with the loading signal, F, develop loading pulses as shown in Figure 6-3. NAND gate A7U19B, inverter A7U13C, 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 A7U19A, A7U19C and associated circuitry. The trigger for the flip flop is developed by inverters A7U31B and C, A7U32A, B, and E, and transformer T4. The F and $\overline{F}$ signals are conditioned by the $\overline{F}$, M, and $\overline{ZERO}$ signals so that the F and $\overline{F}$ signals occur only during periods A through $\overline{E}$ of the DVM measurement cycle. The steering flip flop is triggered by the F signal and produces S and $\overline{S}$ signals.

6-21. The $\overline{S}$ output of the steering flip flop is applied to transistor A6Q9 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 6-3):

a. Measurement cycle is initiated.

b. RS flip flop A7U19A, A7U19C is set to "1" condition (pin 2 of 19A high).

c. Flip flop A6U20B, C is reset by $\overline{F}$.

d. Overload flip flop A6U21B is reset by a measurement inclusion signal generated at pin 8 of flip flop A6U20B, C.

e. Measure/store flip flop (A6U20A, D) is set by overload reset signal (signal No. 21-10).

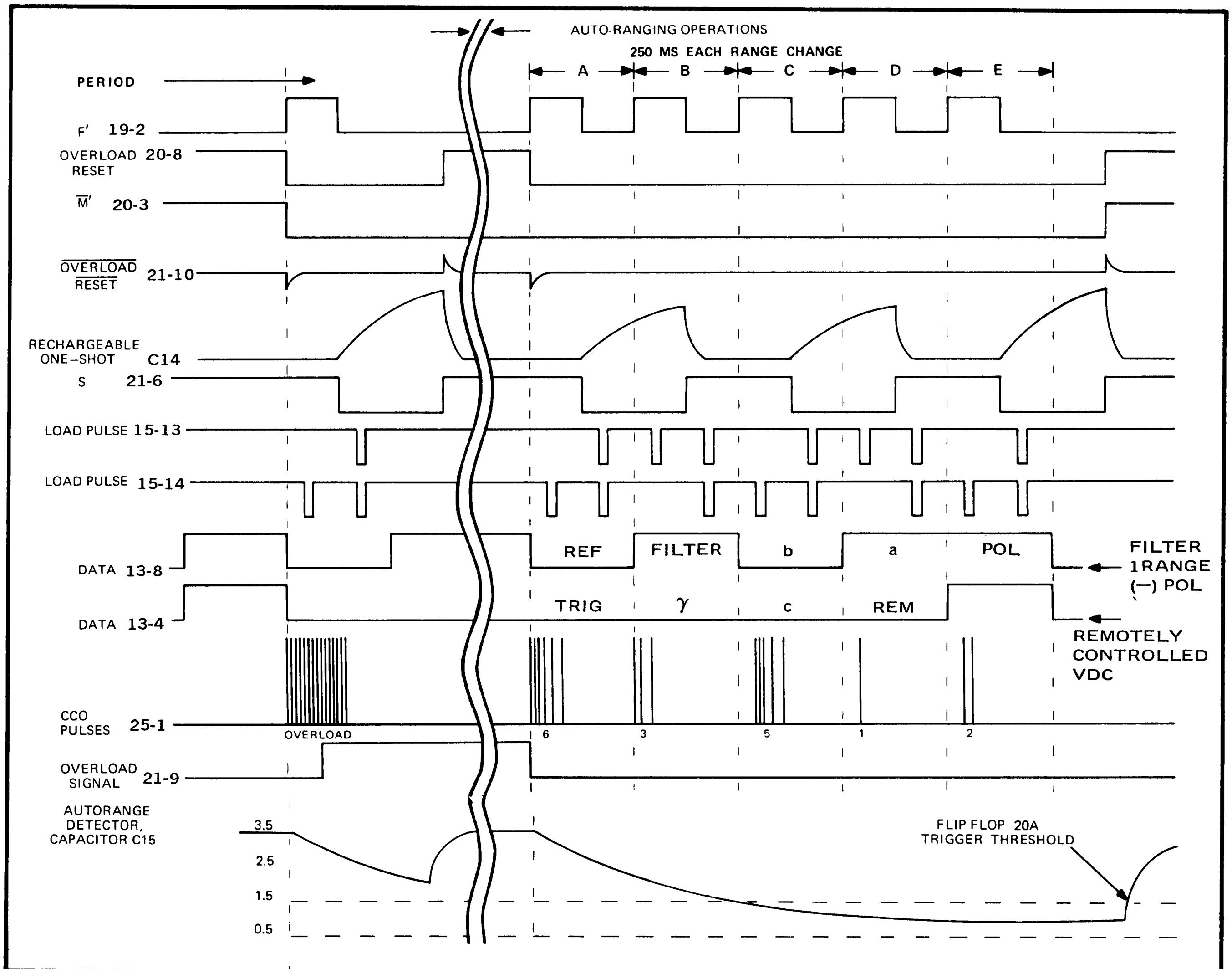
f. Gate A6U17A is inhibited, thereby inhibiting all output buffer gates.

g. The steering flip flop is toggled (Middle of "A" period) and capacitor A6C14 begins to charge toward +5V.

h. The steering flip flop is again toggled (Middle of "B" period) and capacitor A6C14 is quickly discharged to 0.9V.

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

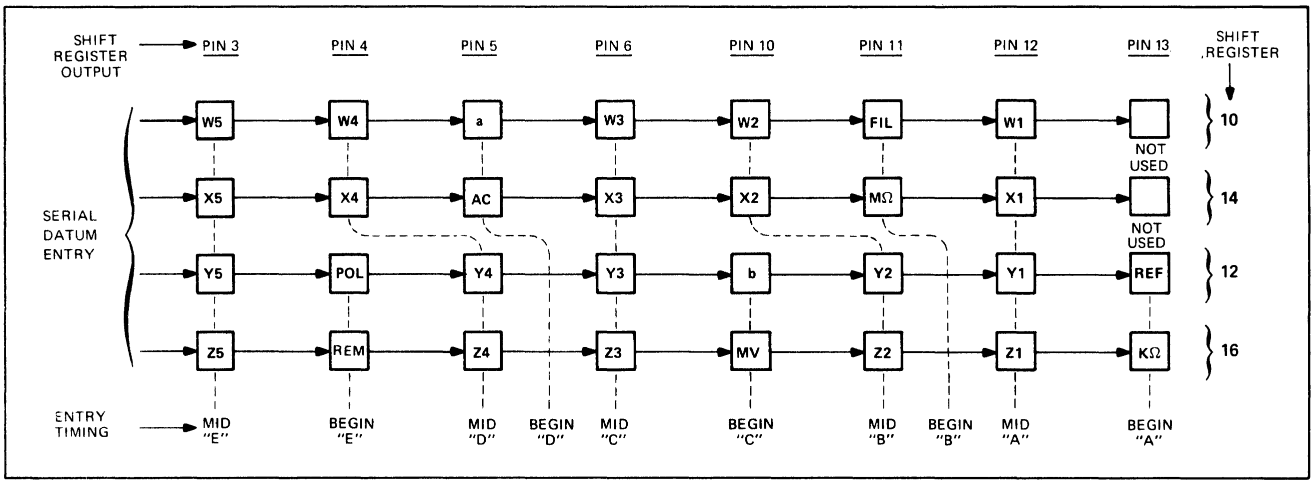
j. Following "E" period, A6C14 continues to charge until A6Q9 is turned on.



CONDITIONS: VDC AND FILTER FUNCTIONS CALLED
1 RANGE CALLED
-0.63512 VOLTS APPLIED TO INPUT
REMOTELY CONTROLLED

NOTE: SIGNAL NUMBERS CORRESPOND TO NUMBERED I/C'S & PINS LOCATIONS ON DOU SCHEMATIC

Figure 6-3. DOU TIMING DIAGRAM



RANGE CODE

	a	b	c
10000	0	0	0
1000	0	0	1
100	0	1	0
10	0	1	1
1	1	0	0
0.1	1	0	1

FUNCTION CODE

	γ	α	POL
VDC	0	0	0
–VDC	0	0	1
KΩ	0	1	0
Ω	1	0	0
VAC	1	1	0

NOTE:
1. All data in the shift register memory is inverted. It is inverted to positive logic on passing through the output gates.

Figure 6-4. SHIFT REGISTER LOAD SEQUENCE

k. A6Q8 then turns on and sets the overload reset flip flop A6U20B, C and the steering flip flop (A6U21A).

l. The measure/store flip flop is reset by a negative trigger developed in the circuit of A6Q7.

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 A6U20A, D and transistor A6Q7 also function as an autorange detector. Control signal timing under autorange conditions is shown in Figure 6-5. If the decision to autorange is made (middle of "A" period), the DVM logic places the DOU 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 A6U21B the rechargeable one-shot times out and sets the overload reset flip flop to the "1" condition. The resulting signal (signal 21-9) is applied as a reset pulse to A6Q7; however, because capacitor A6C15 has not had time to discharge sufficiently, the trigger threshold of flip flop A6U20A, D 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, A6C14 would have acquired sufficient charge during the measurement cycle to enable flip flop A6U20A, D to be triggered, as shown in the timing diagram of Figure 6-3.

6-23. The programmed one-shot consists of NOR gates A6U18A, C, transistors A6Q3 through A6Q6, capacitor A6C9, and associated programming resistors. In its stable state, gate A6U18C output is high and gate A6U18A output is low. Assume that an external trigger is applied to A6P20-3. The trigger enable gate A6U18B, thereby triggering the DVM to initiate a measurement cycle. The trigger also enables gate A6U18C, and the POS then switches to its unstable state. When the POS switches states, the output of gate A6U18D goes low, resulting in gates A6U17A being inhibited. Inhibiting gate A6U17A causes all of the output data 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 A6Q3 is turned off and A6C9 begins to charge through the programming network to zero volts. Delay time is controlled by the memory, which selects resistor A6R22, R42, R45, R46, R47, R48, R52, R53, R54, R56, R57, depending on the selected DVM function. When A6C9 has accumulated sufficient charge, transistors A6Q4

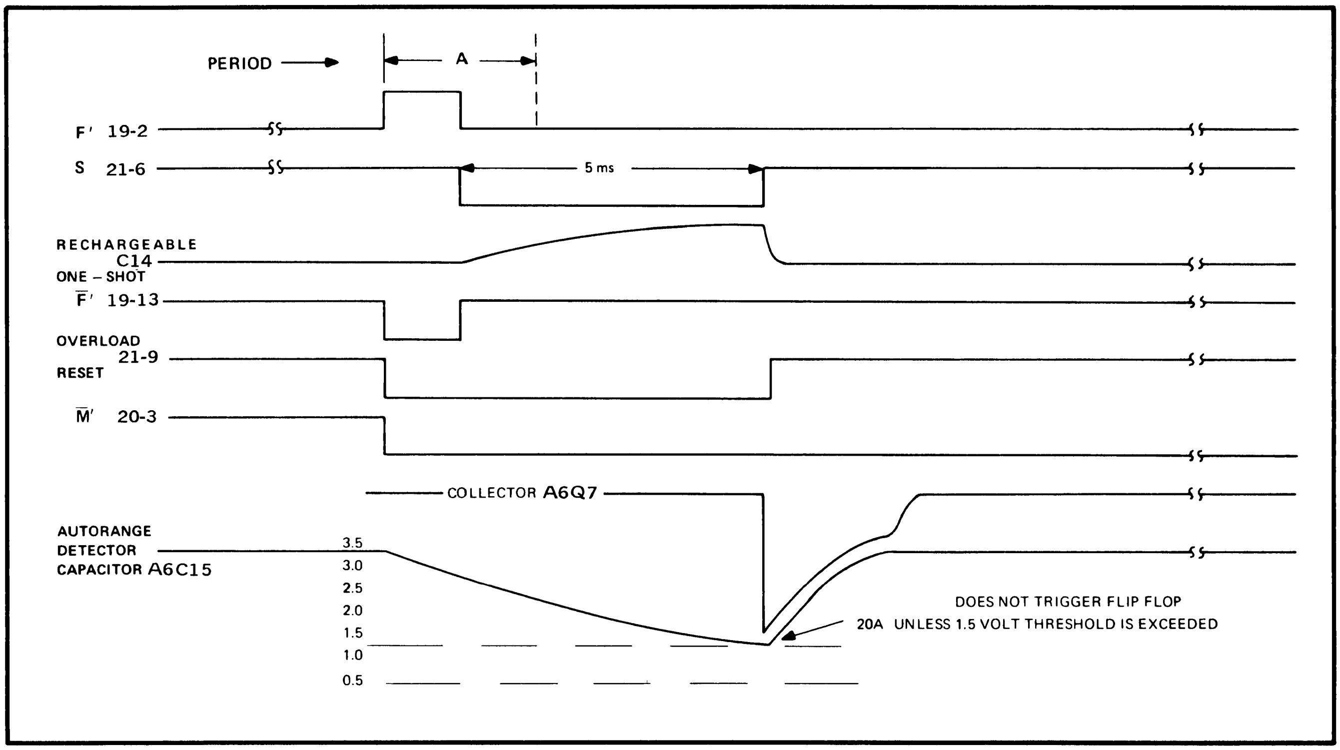


Figure 6-5. CONTROL SIGNAL TIMING DURING AUTORANGE

and A6Q5, connected to operate like an SCR, turn on, applying a positive pulse to the input of gate A6U18A through capacitor A6C24. 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 A6U18B 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 30 milliseconds later, outputs are turned on and data becomes available.

6-26. In VDC mode without the FILTER function called, transistor A6Q13 is enabled. This programs the POS for fastest timeout and clamps pin 4 of gate A6U18B 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 A6CR19 through A6CR22 and capacitors A6C25 through C28. The series regulator is comprised of zener reference A6CR23, voltage amplifier A6Q10, driver A6Q11, and series pass transistor A6Q12. This supply has sufficient reserve to power the Remote Control Unit (Option 8400A–03), if installed. The +5 volts is connected to A6P6-1 and returned to A6P6-4 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 4 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 6-6. 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 SYSTEM (CUSTOMER SUPPLIED)	

Figure 6-6. 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 23°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 A6P6-1 (+) and A6P6-4 (–) of DOU NO: 2.

b. If necessary, adjust potentiometer A6R38 for 5.05 ±0.05 volts dc indication on the voltmeter.

6-36. DIGITS REGISTRATION

a. Set Model 8400A 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 8400A 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 8400A controls as follows:

FUNCTION	VAC
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 VAC 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
KΩ	KΩ, 00.000
10 Ω	Ω, 0.0000
VDC, FILT, EXT. REF.	VDC, 00.000 FILT, EXT. REF.

6-39. OUTPUT GATES

a. Set Model 8400A 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 A6P6-4. The DOU output should be as indicated.

GATE TERMINALS (PIN AND CONNECTOR)	DOU OUTPUT
A6P20-26	DC, FILT, EXT.
A6P20-22	REF, AC, Ω, KΩ,
A6P20-17	REMOTE CONTROL,
A7P21-36	OVERLOAD, EXT.
A7P21-35	TRIG.
A7P21-19	and readout of 1555.55
A7P21-13	
A7P21-1	
A7P21-25	
A7P21-5	

6-40. PROGRAMMED ONE SHOT.

a. Set the Model 8400A 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, A6P20-8 of DOU output connector. Command instrument to sample. Delay length should be 523 ±20 milliseconds.

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

	POS Operative	Function Calls	Range Call	Observe Length (m5)
a.	Yes	VDC, Filt	100	523 ±20 ms
b.	”	VAC, Filt	”	523 ±42
c.	”	Ω, Filt	”	523 ±42
d.	”	KΩ, Filt	”	523 ±42
e.	No	KΩ, Filt	”	31 ±2 ms
f.	Yes	VDC	1	123 ±10 ms
g.	”	VDC	100	54 ±3 ms
h.	”	VAC	”	123 ±10 ms
i.	”	Ω	”	123 ±10 ms
j.	”	KΩ	”	73 ±6 ms

6-41. Calibration

6-42. Calibration of the DOU consists only of adjustments of the +5 volt dc logic supply. The adjustment procedure is located in paragraph 6-35.

6-43. Troubleshooting

6-44. 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.

6-45. 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.

6-46. In any analysis, certain decisions and/or conclusions must be made. Consult Figure 6-7 for the suggested decision sequence. Figure 6-8 is a table of decision aids, which should help to determine how to make the decisions.

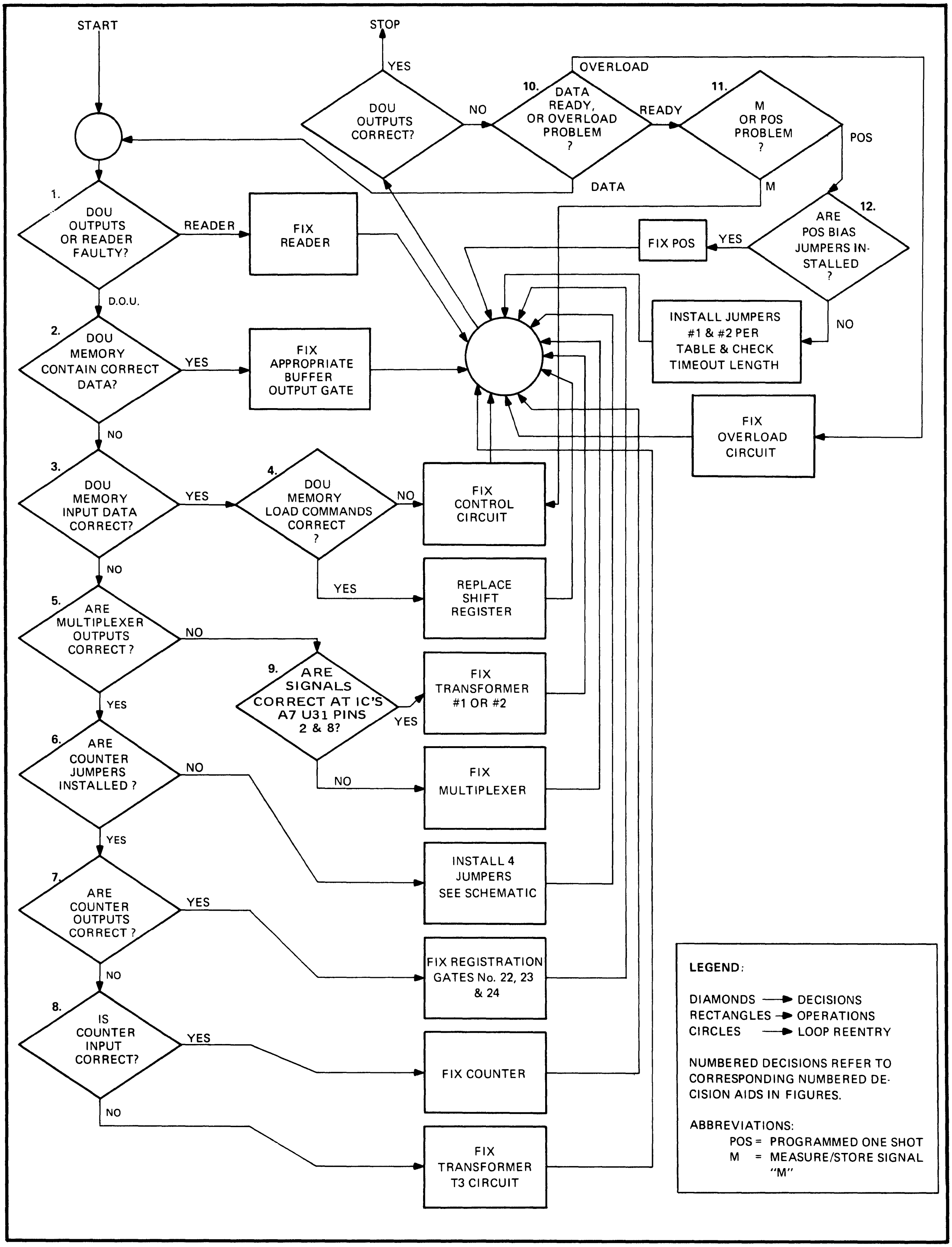


Figure 6-7. DECISION FLOW CHART DOU TROUBLE SHOOTING

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.

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

	MODEL 8400A PANEL	READER PANEL	CONSIDER
	00000	00400	An open in the cable from DOU to reader (probably A7P21-17 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	

EXAMPLE No. 2.

	MODEL 8400A PANEL	READER PANEL	CONSIDER
Only these combinations need to be considered for trouble analysis.	00000	08000	An open DOU–to–reader (probably A7P21-21 DOU output connector).
	11111	19111	
	22222	20222	
	44444	42444	
	88888	88888	

EXAMPLE No. 3. Reader panel is 155555, DC+, AC, KΩ, Ω, EXT. REF., FILT., REM., TRIG., OVER.

The above display remains regardless of Model 8400A 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.

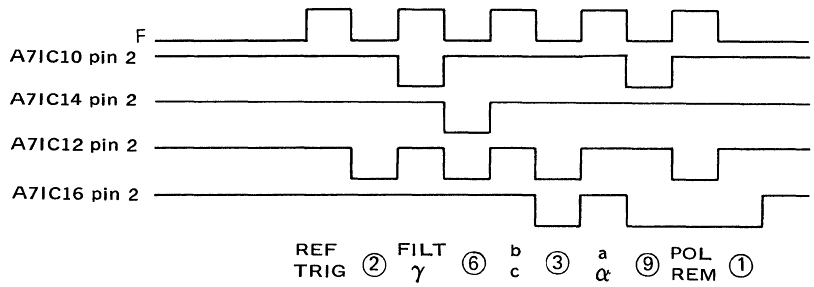
NOTE: The above examples assume a reader with full overranging in each decade. Other overrange patterns will not defeat the analysis if the pattern is known.

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 8400A 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.

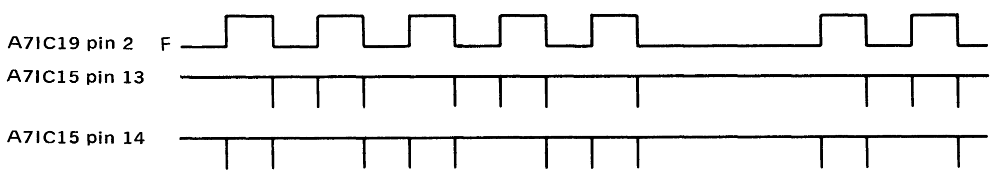
Figure 6-8. DECISION AIDS (Sheet 1 of 3)

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 8400A and input source) for desired trouble analysis information. Set internal sample command potentiometer on Model 8400A 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 13-8 and 13-4 and refer to the waveshape index, Figure 6-9. These waveforms are multiplexed with numerical data from the counter and inverted by registration gates IC22, IC23, and IC24 on A7 PCB. Study the schematic and Figures 6-4, 6-9 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.

<u>EXAMPLE</u>: –.026391 VDC, FILT, REM. CONT.



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 4 and IC13 pin 8 of A7 Assembly respectively. If the waveforms are correct, registration gates A7IC23 and A7IC24 may be faulty.

6. **ARE COUNTER JUMPERS INSTALLED?** With reader connected, check continuity between the following points on Data Output Unit No. 2 (A6):

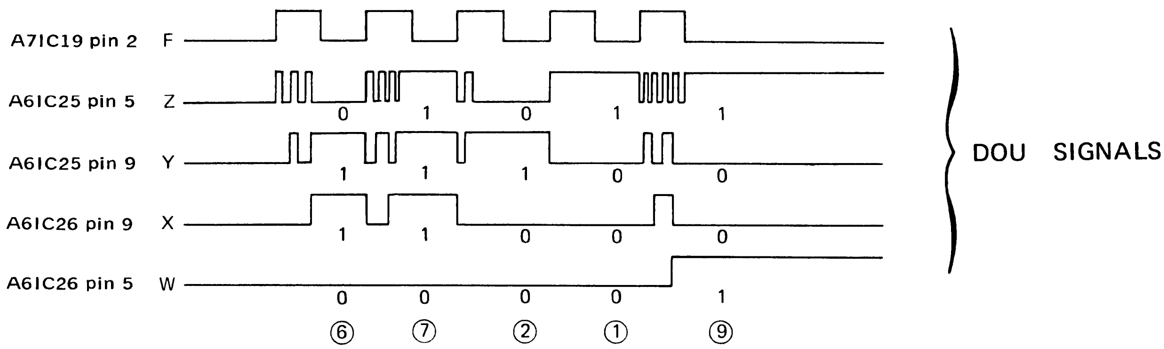
P20-9 & P20-25
P20-5 & P20-21
P20-7 & P20-23
P20-11 & P20-19

} A6 DOU Output Connector

Figure 6-8. DECISION AIDS (Sheet 2 of 3)

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:

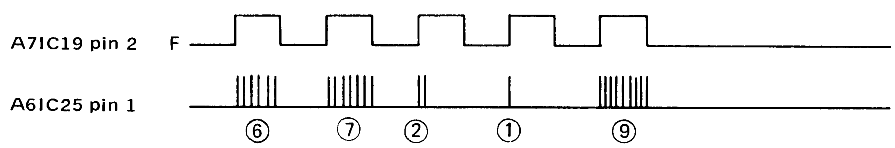
EXAMPLE: .67219 on Model 8400A panel.



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

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 A7IC31 pins 2 & 8?** This DOU circuit is inside the guard. Therefore, the scope must be synced to a signal inside the guard. Use $\overline{\text{zero}}$ signal. 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 2 and 8 of A7U31 should have waveforms like Figure 6-9. 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 8400A 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 of displaying 1555.55 VDC+, FILT, REM., AC, KΩ, Ω, or EX. REF., OVER, TRIG. 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 A6U18 pin 10 for 0 to 0.5V (POS) and A6U17 pin 2 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 A6R50 in accordance with delay length table. (This is a factory installation procedure and jumper installation need only be verified as indicated.)

Figure 6-8. DECISION AIDS (Sheet 3 of 3)

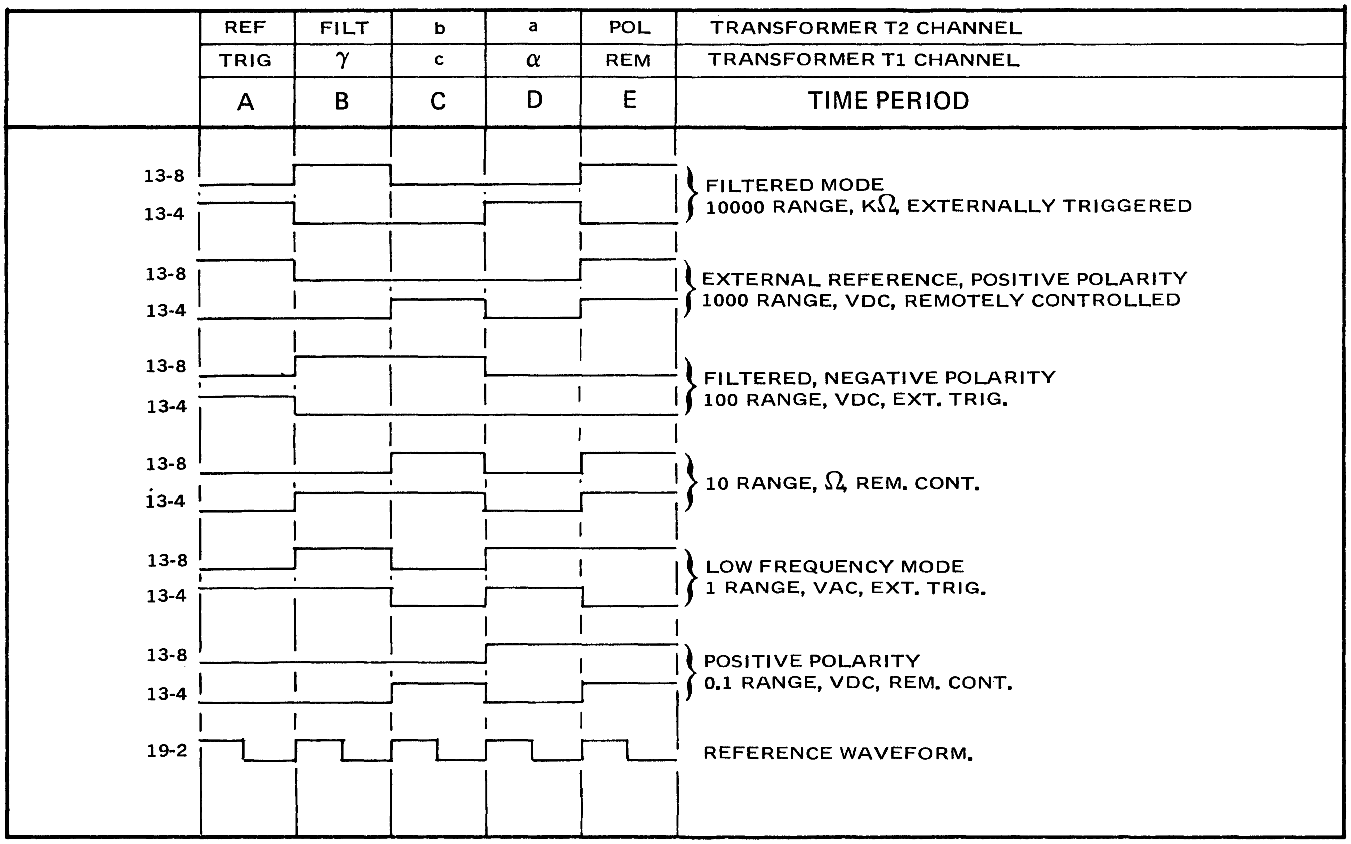


Figure 6-9. EXAMPLE WAVEFORMS FOR TROUBLESHOOTING

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 6-50, this option subsection, for additional Use Codes and Serial Number Effectivity List assigned to this printed circuit assembly option.

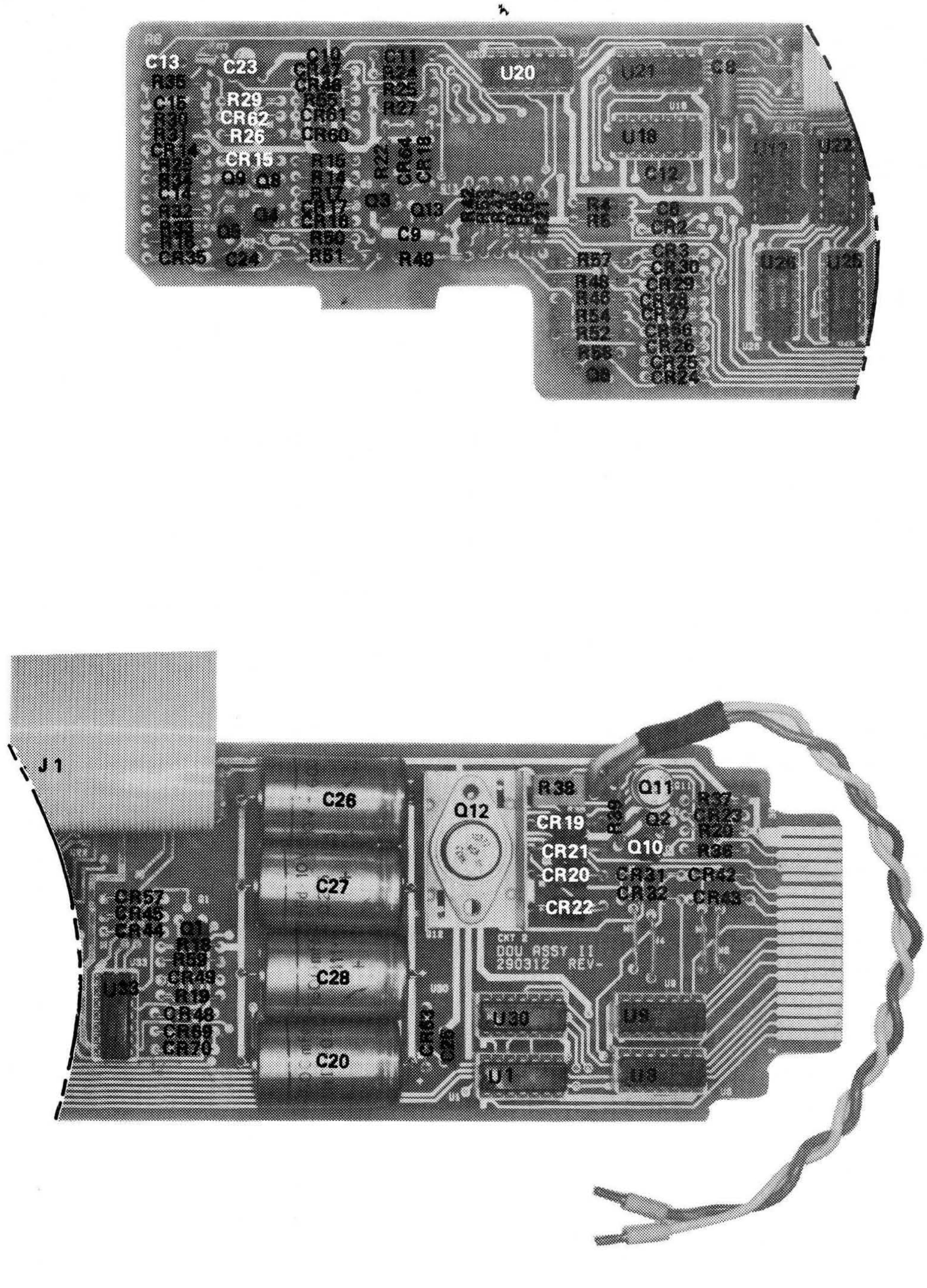


Figure 6-10. DATA OUTPUT NO. 2 PRINTED CIRCUIT BOARD ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	DATA OUTPUT –03 Option						
	DATA OUTPUT NO. 2 **Figure 6-10**	1			REF		
C6, C12, C24, C25, C31	Cap, cer, 0.0012 uf ±10%, 500V	106732			5		
C8	Cap, plstc, 0.22 uf ±10%, 250V	194803			1		
C9	Cap, Ta, 3.3 uf ±5%, 20V	271230			1		
C10, C13, C30, C32, C33, C35, C36, C40	Cap, cer, 0.01 uf ±20%, 100V	149153			8		
C11	Cap, Ta, 2.2 uf ±10%, 20V	160226			1		
C14	Cap, Ta, .33 uf ±5%, 20V	271338			1		
C15	Cap, Ta, 0.68 uf ±10%, 35V	182790			1		
C20, C26, C27, C28	Cap, elect, 1600 uf +50/–10%, 10V	272732			4		
C23, C29	Cap, cer, 0.025 uf ±2%, 100V	168435			2		
CR2, CR14, CR18, CR31, CR32, CR42 thru CR49, CR60 thru CR63, CR71, CR72	Diode, germanium, 80 mA, 100 piv	149187			19		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
CR3, CR15, CR16, CR17, CR24 thru CR30, CR35, CR57, CR64, CR66, CR69, CR70, CR100	Diode, silicon, 150 mA	203323			18		
CR19 thru CR22	Diode, silicon, 1 amp, 100 piv	116111			4		
CR23	Diode, zener, 3.9V, 20 mA	113316			1		
CR23	Diode zener, 4.3V	180455			1		L
J1	Connector, PCB to cable, 34 contact	295337			1		
Q1, Q2, Q6, Q7, Q8	Tstr, silicon, NPN	218396			5		
Q3, Q9, Q13	Tstr, silicon, PNP	195974			3		
Q4	Tstr, semicon, silicon NPN	218081			1		
Q5	Tstr, silicon, PNP Order by model and option no. (8400A 03 option)	229898			1		
Q10	Tstr, silicon, NPN	168708			1		
Q11	Tstr, silicon, NPN	150359			1		
Q12	Tstr, silicon, NPN	288381			1		
R4, R5, R30, R31, R61, R62,	Res, comp, 4.7k ±5%, ¼w	148072			8		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R63, R64, R14, R15	Res, comp, 2.7k ±5%, ¼w	170720			2		
R16	Res, comp, 47k ±5%, ¼w	148163			1		
R17	Res, comp, 6.8k ±5%, ¼w	148098			1		
R18, R59	Res, comp, 680 ±5%, ¼w	148007			2		
R19, R20, R21, R25, R26, R27	Res, comp, 10k ±5%, ¼w	148106			6		
R22	Res, fxd, met flm, 1.62k ±1%, 1/8w	283697			1		
R24, R55	Res, comp, 1k ±5%, ¼w	148023			2		
R28	Res, comp, 220 ±5%, ¼w	147959			1		
R29	Res, comp, 1.8k ±5%, ¼w	175042			1		
R32	Res, comp, 2.2k ±5%, ¼w	148049			1		
R33	Res, comp, 3.3k ±5%, ¼w	148056			1		
R34	Res, comp, 27k ±5%, ¼w	148114			1		
R35	Res, comp, 15k ±5%, ¼w	148148			1		
R36	Res, comp, 3.9k ±5%, ¼w	148064			1		
R37	Res, comp, 5.6k ±5%, ¼w	148080			1		
R38	Res, var, cer met, 500 ±10%, 1w	291120			1		
R39	Res, met flm, 182 ±1%, 1/8w	20020			1		
R42	Res, comp, 150k ±5%, ¼w	182212			1		
R45, R47, R53, R56	Res, fxd, met flm, 105k ±1%, 1/8w	291294			4		
R46	Res, met flm, 20.5k ±1%, ¼w	261669			1		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R48, R54	Res, met flm, 6.81k ±1%, 1/8w	268417			2		A
R48, R54	Res, met flm, 20.5k ±1%, 1/8w	261669			2		B
R49	Res, fxd, met flm, 274k ±1%, 1/8w	237297			1		
R50	Res, comp, factory selected				1		
R51	Res, met flm, 140k ±1%, 1/8w	233148			1		
R52	Res, met flm 6.81k ±1%, 1/8w	268417			1		
R57	Res, met flm, 2.15k ±1%, 1/8w	293712			1		A
R57	Res, met flm, 1.87k ±1%, 1/8w	267229			1		B
R58	Res, comp, 56k ±5%, ¼w	170738			1		
U1	IC, DTL, Hex Inverter	268367			1		
U8, U9, U30, U33	IC, DTL, Quad 2-Input Nand Gate	268375			4		
U17	IC, DTL, Quad 2-Input Nand Power Gate	288597			1		
U18	IC, TTL, Quad 2-Input Nor Gate	268540			1		
U20	IC, TTL, Quad 2-Input Nand Gate	292953			1		
U21, U25, U26	IC, DTL, Dual JK Flip-Flop	288811			3		
U22	IC, DTL, Triple 3-Input Nand Gate	266312			1		
	Socket, IC, 14 contact	276527			10		
	Socket, IC, 14 contact	291542			2		
	1 Order by model and option number (8400A–03)						

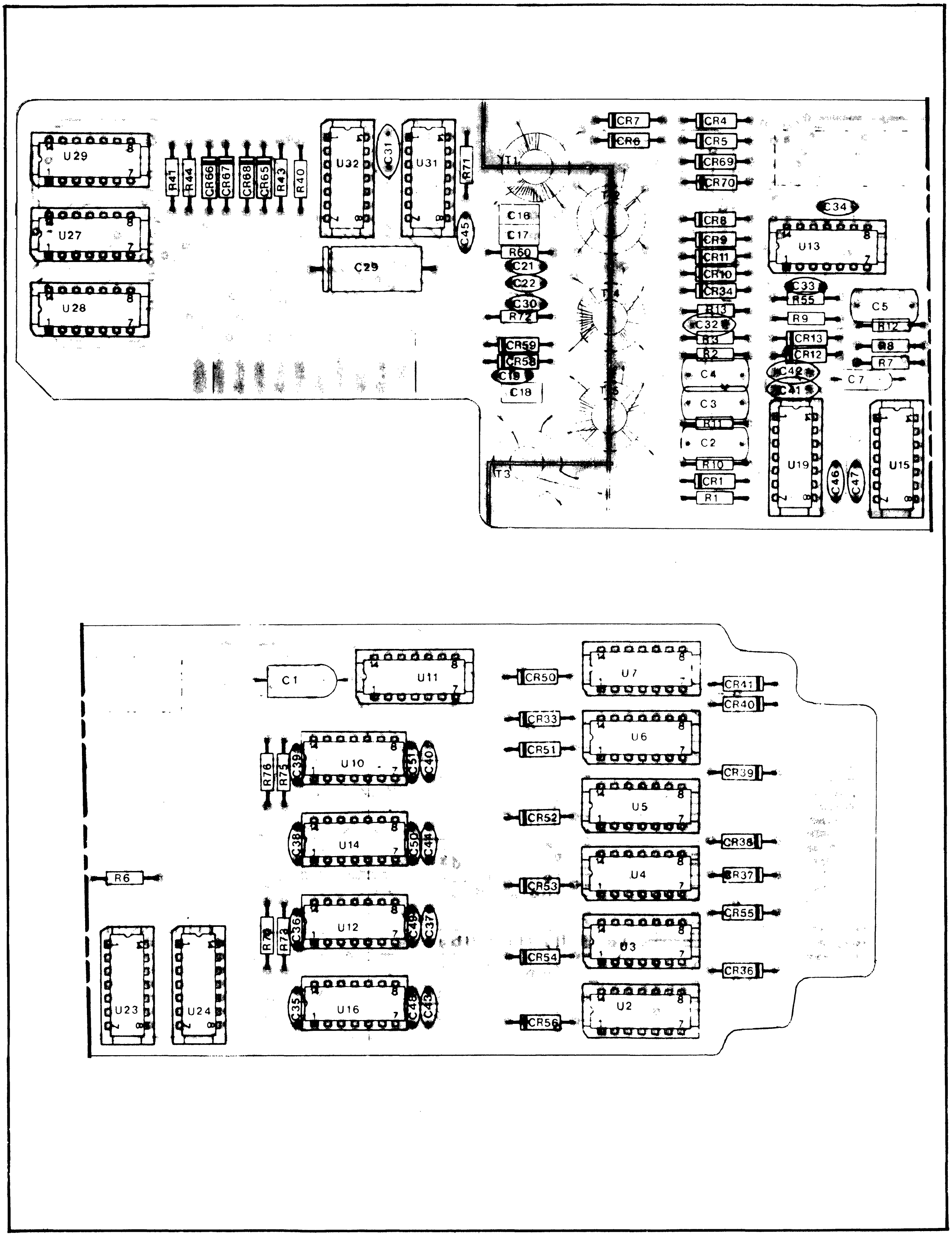


Figure 6-11. DATA OUTPUT NO. 1 PRINTED CIRCUIT BOARD ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A7	**DATA OUTPUT NO.1**	1			REF		
	Figure 6-11						
C1	Cap, tant, 33 uf ±10%, 10V	182832			1		
C2, C4	Cap, plstc, 0.1 uf ±10%, 250V	161992			2		
C3, C5	Cap, plstc, 0.027 uf ±10%, 250V	267120			2		
C6, C8 thru C15, C20, C23 thru C28	Used on D.O. U. No. 2						
C7	Cap, Ta, 0.68 uf ±10%, 35V	182790			1		
C16, C17, C18	Cap, cer, 0.22 uf ±20%, 50V	309849			3		
C19, C21, C22, C30, C33, C34, C37, C40, C43 thru C51	Cap, cer, 0.01 uf ±20%, 100V	149153			17		
C29	Cap, elect, 200 uf +50/–10%, 10V	236935			1		
C31	Cap, cer, .005 uf ±20%, 50V	175232			1		
C32, C41, C42	Cap, cer, .025 uf ±20%, 50V	168435			3		
C35 thru C39	Cap, cer, .0012 uf ±10%, 500V	106732			4		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
CR1, CR4 thru CR13, CR33, CR34, CR36 thru CR41, CR50 thru CR56, CR58, CR59, CR65 thru CR70	Diode, germanium, 80 mA, 100 piv	149187			34		
CR2, CR3, CR14 thru CR32, CR35, CR42 thru CR49, CR57, CR60 thru CR64	Not Used						
P22	Connector, PCB to cable, 34 contact	295337			1		
R1, R11	Res, comp, 100 ±5%, ¼w	147926			2		
R2,R3 R72	Res, comp, 220 ±5%, ¼w	147959			3		
R4,R5, R14 thru R39, R45 thru R54	Not Used						
R6,R7 R13	Res, comp, 3.9k ±5%, ¼w	148064			3		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R8, R40, R41, R43, R44	Res, comp, 470 ±5%, ¼w	147983			5		
R9, R55	Res, comp, 12k ±5%, ¼w	159731			2		
R10	Res, comp, 10k ±5%, ¼w	148106			1		
R12	Res, comp, 1k ±5%, ¼w	148023			1		
R60, R71	Res, comp, 390 ±5%, ¼w	147075			2		
R73 thru R76	Res, comp, 27 ±5%, ¼w	160812			4		
T1 thru T5	Transformer, pulse	275362			5		
U1, U8, U9, U17, U18, U20, U21, U22, U25, U26, U30	Not Used						
U2 thru U7, U11, U24, U27, U28, U29	IC, DTL, Quad 2-Input Nand Gate	268375			11		
U10, U12, U14, U16	IC, TTL, 8-Bit Shift Register	272138			4		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
U13, U32	IC, DTL, Hex Inverter	268367			2		
U15, U19	IC, TTL, Quad 2-Input Nor Gate	268540			2		
U23	IC, DTL, triple 3-Input Nand Gate	266312			1		
U31	IC, TTL, Hex Inverter	292979			1		
	Socket, IC, 14 contact	276527			17		
	Socket, IC, 14 contact Low profile	291542			4		
	1 Order by model and option no. (8400A–03 option)						

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 8400A. 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	Serial number 123 through 148.
B	Serial number 149 and on.

Option–04
Remote Control Unit

6-1. INTRODUCTION

6-2. The A5 Remote Control Unit (Option–04) enables the Model 8400A 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.

6-3. SPECIFICATIONS

6-4. Specifications for the Remote Control Unit are located in Section 1 of the manual.

6-5. INSTALLATION

6-6. The following procedure is to be used to install the Remote Control Unit in the Model 8400A (refer to Section 5, Figure 5-1).

a. Disconnect the power cord from the instrument.

b. Remove the top dust and guard chassis covers.

c. Determine that connector J5, on the A14 Display board, is clear of obstructions and that alignment spacers are inserted between pin pairs J5-1, -2; J5-3, -4 and J5-7, -8; J5-9, -10.

d. Determine that connector slot on rear panel for P19 on Remote Control Unit board is clear of any obstructions.

e. Attach spring to bottom portion of guard bar.

f. Insert P19 into connector slot on rear panel (refer to Section 5, Figure 5-1).

g. Insert edge of Remote Control Unit board into card guide on the inner chassis bulkhead.

h. Observe that alignment spacers on J5 line up with slots on the Remote Control Unit card-edge connector.

i. Slide pcb downward until the card-edge connector is fully engaged with J5 on A14 Display board.

j. Attach top guard and chassis covers, connect ac power, and perform receiving inspection test of the Remote Control Unit as described in paragraph 6-27, Performance Test.

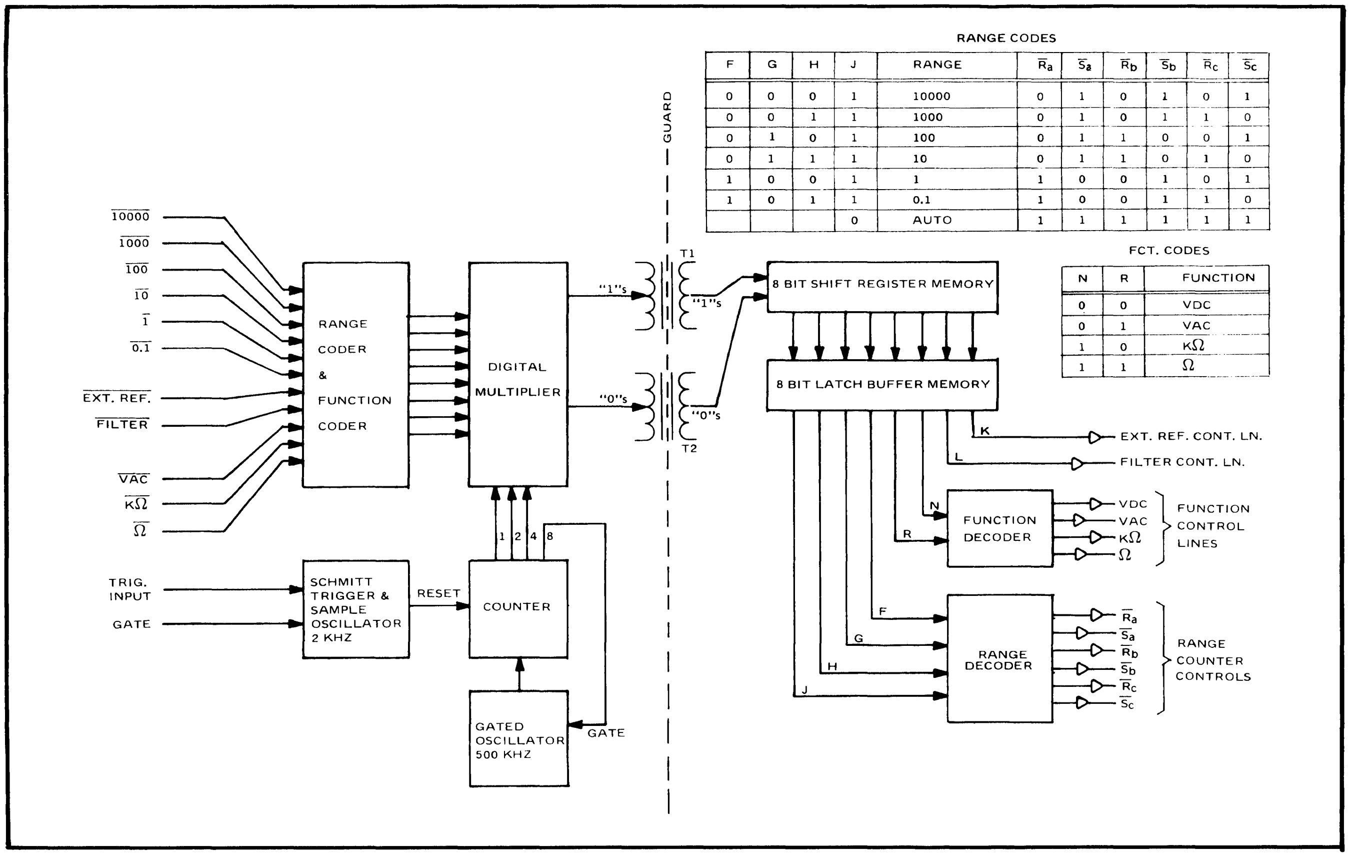
6-7. OPERATING INSTRUCTIONS

6-8. Operation of the DVM with the A5 Remote Control Unit installed is covered in Section 2.

6-9. THEORY OF OPERATION

6-10. General

6-11. The RCU functional block diagram is given in Figure 6-1. The input function and range commands are applied to coders and then delivered to a multiplexer. The multiplexer receives sequential address information from a counter and, combined with the range and function codes, applies control information to two isolation pulse transformers. The serial output of these two pulse transformers is applied to the shift register for conversion back to 8 time slots which is then buffered and decoded and presented for use. For the following discussion refer to Schematic Diagram 8400A–1011, Figure 6-1 and Figure 6-2.



RANGE CODES

F	G	H	J	RANGE	$\overline{R_a}$	$\overline{S_a}$	$\overline{R_b}$	$\overline{S_b}$	$\overline{R_c}$	$\overline{S_c}$
0	0	0	1	10000	0	1	0	1	0	1
0	0	1	1	1000	0	1	0	1	1	0
0	1	0	1	100	0	1	1	0	0	1
0	1	1	1	10	0	1	1	0	1	0
1	0	0	1	1	1	0	0	1	0	1
1	0	1	1	0.1	1	0	0	1	1	0
			0	AUTO	1	1	1	1	1	1

FCT. CODES

N	R	FUNCTION
0	0	VDC
0	1	VAC
1	0	KΩ
1	1	Ω

Figure 6-1. 8400A REMOTE CONTROL UNIT BLOCK DIAGRAM

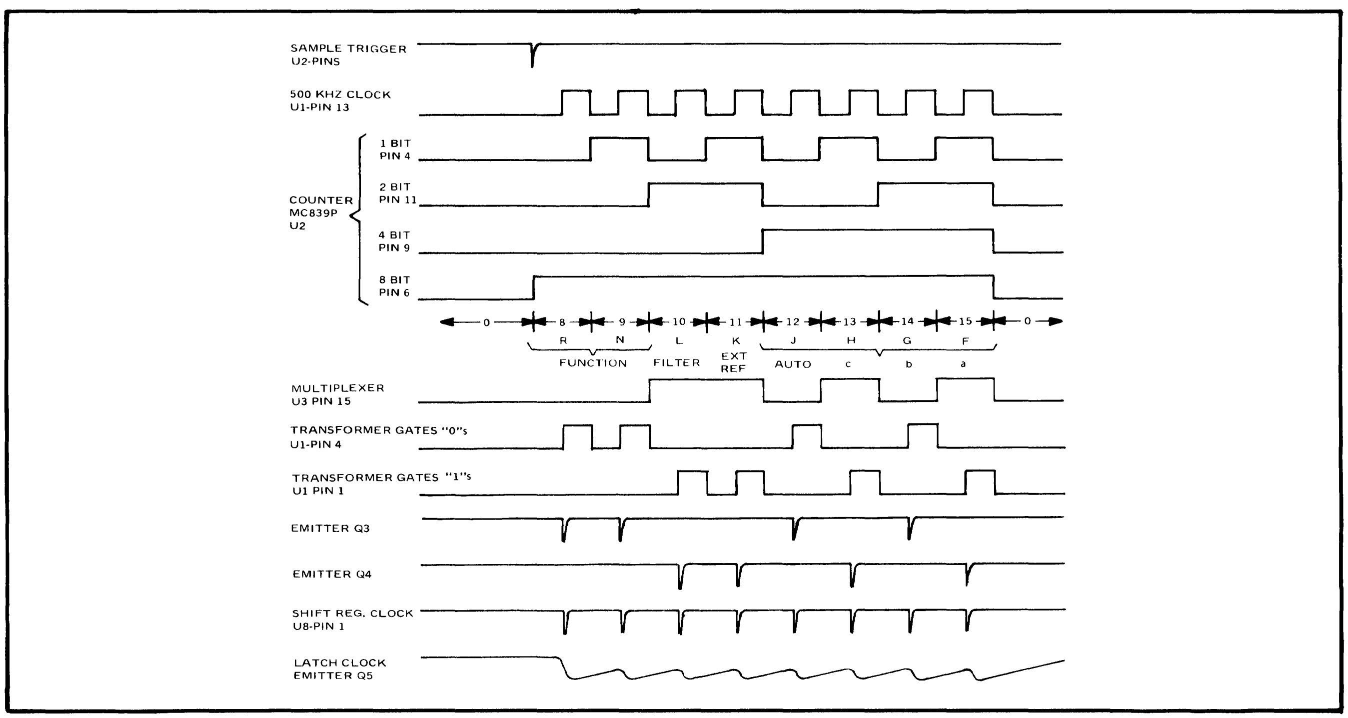


Figure 6-2. REMOTE CONTROL SAMPLE LOAD SEQUENCE

6-12. Circuit Description

6-13. FUNCTION AND RANGE CODERS. The purpose of the function and range coders is to compress the 12 input lines into 8 channels with function/range interlocking. Transistor Q15, inverters U15 A, C, F and diodes CR2, 3, 4, 5, 12, 19 and 20 combined are the function/range interlocking feature which disallows incorrect function and range combinations. Gates U5A, U5B, U6A through U6D present encoded range and function information to the digital multiplexer. Table 6-1 shows Function codes and Table 6-2 shows Range codes.

Table 6-1. FUNCTION CODES

INPUTS			RESULTING COMMAND	INFORMATION CHANNEL	
VAC	KΩ	Ω		N	R
1	1	1	VDC	0	0
0	1	1	VAC	0	1
1	0	1	KΩ	1	0
1	1	0	Ω	1	1

Table 6-2. RANGE CODES

FUNCTION COMMANDS POSSIBLE WITH THESE RANGES	RCU INPUTS						RANGE INFORMATION CHANNEL				OUTPUTS						RESULTING RANGE
	10k	1k	100	10	1	0.1	F	G	H	J	Ra	Sa	Rb	Sb	Rc	Sc	
Ω, KΩ, AC, DC	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	AUTO
Ω, KΩ	0	1	1	1	1	1	0	0	0	1	0	1	0	1	0	1	10k
Ω, KΩ, AC, DC	1	0	1	1	1	1	0	0	1	1	0	1	0	1	1	0	1k
Ω, KΩ, AC, DC	1	1	0	1	1	1	0	1	0	1	0	1	1	0	0	1	100
Ω, AC, DC	1	1	1	0	1	1	0	1	1	1	0	1	1	0	1	0	10
AC, DC	1	1	1	1	0	1	1	0	0	1	1	0	0	1	0	1	1
DC ONLY	1	1	1	1	1	0	1	0	1	1	1	0	0	1	1	0	0.1

6-14. COUNTER AND GATED OSCILLATOR. The purpose of the counter and gated oscillator circuitry is to supply sequential address information to the multiplexer in response to the 8 bit set pulses from the Schmitt Trigger and Sample Oscillator Circuitry. The 8 bit set pulses reset the counter to an 8 state (i.e. 1000). The counter U2 then releases the gated oscillator and allows it to oscillate at 500 kHz. Gates UIC and UID, capacitors C1, C2 and resistors R1, R2 are the gated 500 kHz oscillator circuitry. The output of the gated oscillator is applied to the counter U2. When enabled, the oscillator causes the counter to cycle through eight states. (Refer to Table 6-3). As soon as state "0" (i.e. 000) is reached by the counter, the oscillator is disabled by the counter, which in turn stops the counter from further counting. This sequence will not start again until an 8 bit set pulse is received by the counter from the Schmitt Trigger circuitry.

6-15. SCHMITT TRIGGER AND SAMPLE OSCILLATOR. The purpose of the Schmitt Trigger and Sample Oscillator is to set the sample rate of the RCU. Gates U4A through U4D, capacitors C3 and C4, resistors R3, R4, R5 and diodes CR30 and CR31 comprise the Schmitt Trigger and Sample Oscillator circuitry. There are two possible modes of operation for this circuitry: continuous or triggered command mode.

6-16. CONTINUOUS COMMAND MODE. In this mode of operation, P19-33 (EXTERNAL COMMAND ENTRY) and P19-35 (AUTO COMMAND DEFEAT) must be at logic level "1" (+5V dc or open). A "1" command simultaneously present at pin 1 of gate U4A and pin 5 of gate U4B will cause gates U4A, B, C and D to oscillate. The frequency of

Table 6-3. COUNTER SEQUENCE

STATE	COMMENTS
0000	Oscillator is enabled at this point and count sequence begins.
1000	
1001	
1011	
1010	
1100	
1101	
1110	
1111	
0000	Oscillator is disabled at this point.

the oscillation is 2kHz as determined by R3, C4. Each pulse in the 2kHz pulse train at pin 8 of U4C acts as the 8 bit set pulse for counter U2. Thus, commands are updated at a 2kHz rate. Since this rate is faster than the instrument can respond, command appears continuous.

6-17. TRIGGERED COMMAND MODE. In this mode of operation, P19-35 (AUTO COMMAND DEFEAT) is held at logic level "0" and an external trigger is applied to P19-33 (EXTERNAL COMMAND ENTRY). With a logic level "0" at P19-35 gate U4A is disabled. The application of an external pulse to P19-33 will enable the schmitt trigger circuit, gates U4B, C and D, resulting in a negative pulse presented to the counter. As in the continuous command mode, this pulse initiates the command update cycle.

6-18. DIGITAL MULTIPLEXER. The Digital Multiplexer U3 is a medium scale integrated circuit constructed to connect various input signals, one at a time, to a single two-phase output in response to certain input addresses. Table 6-4 defines its operation. The output is serialized into eight time slots; each is 1μs in length.

6-19. PULSE TRANSFORMER CIRCUITRY. The purpose of this circuitry is to couple the serialized information to the shift register and provide isolation. Gates U1A and U1B pass the serialized information to primaries of pulse transformers T1 and T2 through buffer Q1, Q2, Gate U1A passes logic "1" information, and gate U1B passes Logic "0" information. The secondaries of T1 and T2 impose their respective logic to buffers Q4 and Q5 and thereby to the shift register.

6-20. 8 BIT SHIFT REGISTER MEMORY. J-K flip flops U7A & B, U8A & B, U9A & B and U10A & B comprise the shift register. Diodes CR10, CR11, resistors R23, R24 comprise the clock network for the flip flops. The loading of the shift register occurs at pins 2 and 3 of U7A. The logic sequencially shifts through the flip flops until the last pulse of the loading cycle is loaded into U7A. At this time the shift register is fully loaded and will not change until another loading cycle occurs.

6-21. 8 BIT LATCH BUFFER MEMORY. U11 and latch clock network, transistor Q5, diodes CR6 and CR7 plus capacitor C5, comprise the 8 Bit Latch Buffer Memory circuit. During the loading cycle of the 8 bit shift register memory circuit, transistor Q5 is turned on, which disconnects the inputs of ICU11 to preclude undesirable pulsing of output lines during the loading cycle. After the shift register is fully loaded, transistor Q5 turns off, thereby allowing the outputs of U11 to assume the states of the present inputs.

6-22. DECODERS. Decoder-buffers U12, U13, U14 and transistors Q6-Q11 decode the U11 latch information to the same format as seen on the inputs. Diodes CR21, CR22 provide for external reference lockout in Ohms and KΩ functions as is done by the front panel pushbuttons when the instrument is commanded locally.

6-23. MAINTENANCE

6-24. Introduction

6-25. 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 4 of the manual.

Table 6-4. MULTIPLEXER OPERATION

IF THE INPUT ADDRESS IS:			THEN OUTPUT PIN 15 HAS THE SIGNIFICANCE	AND OUTPUT PIN 14 HAS THE SIGNIFICANCE	CHANNEL INFORMATION IS:
PIN 13	PIN 12	PIN 11			
0	0	0	R (pin 1)	$\overline{R}$	FUNCTION BIT
0	0	1	N (pin 2)	$\overline{N}$	FUNCTION BIT
0	1	0	L (pin 3)	$\overline{L}$	FILTER
0	1	1	K (pin 4)	$\overline{K}$	EXTERNAL REFERENCE
1	0	0	J (pin 5)	$\overline{J}$	AUTORANGE
1	0	1	H (pin 6)	$\overline{H}$	RANGE LSB
1	1	0	G (pin 7)	$\overline{G}$	RANGE BIT
1	1	1	F (pin 9)	$\overline{F}$	RANGE MSB

6-26. Performance Test

6-27. 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 is attempted. The test should be conducted under the following environmental conditions: Ambient Temperature 0°C to 50°C, Relative Humidity less than 70%. An instrument that fails the performance test will require corrective maintenance. In case of difficulty, analysis of the test results, with reference to the troubleshooting section, should help to locate the trouble.

6-28. To test the RCU, proceed as follows:

a. Supply +5 volts dc to the RCU, P19-9 (+5V dc) and P19-2 or 4 or 6 (common).

b. Press REMOTE FUNCTION switch on the Model 8400A front panel.

c. Activate each of the combination of functions and ranges shown in column 1 and 2 of Figure 6-3 by contact closure between the appropriate pin and common of the RCU connector (refer to Table 2-5 of Section 2 for connector pin assignments). Observe the resulting front panel display and verify correct response for each call combination listed in Figure 6-3. Function annunciator will not show option functions if the pertinent option is not installed.

COMMANDED		DVM RESPONSE													
		FUNCTIONS							RANGES						
FUNCTIONS	RANGES	DC	AC	KΩ	Ω	X REF	FILT	OVER	.1	1	10	100	1000	10K
FILT, EXT REF*	.1	0			0	0			0					
	1	0			0	0				0				
	10	0			0	0					0			
	100	0			0	0						0		
	1000	0			0	0							0	
	NONE	0			0	0			Down ranges from 1000 to .1					
FILT, EXT REF,* Ω*	10			0							0			
	100			0		0						0		
	1000			0		0							0	
	10K			0		0								0
FILT, EXT REF,* KΩ	100		0			0						0		
	1000		0			0							0	
	10K		0			0								0
	NONE		0			0			Autoranges in the following order: 10,000K, 1000K, 100K, 10Ω and STOP					
EXT* REF, VAC*	1		0		0					0				
	10		0		0						0			
	100		0		0							0		
	1000		0		0								0	
	NONE		0		0				Downranges from 1000 to 1					
* Options Disregard DVM response for these functions if option is not installed.														

Figure 6-3. REMOTE CONTROL UNIT TEST REQUIREMENTS

6-29. Calibration

6-30. The RCU does not require calibration.

6-31. Troubleshooting

6-32. 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 6-26) 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 and code information in Figure 6-5 may be helpful.

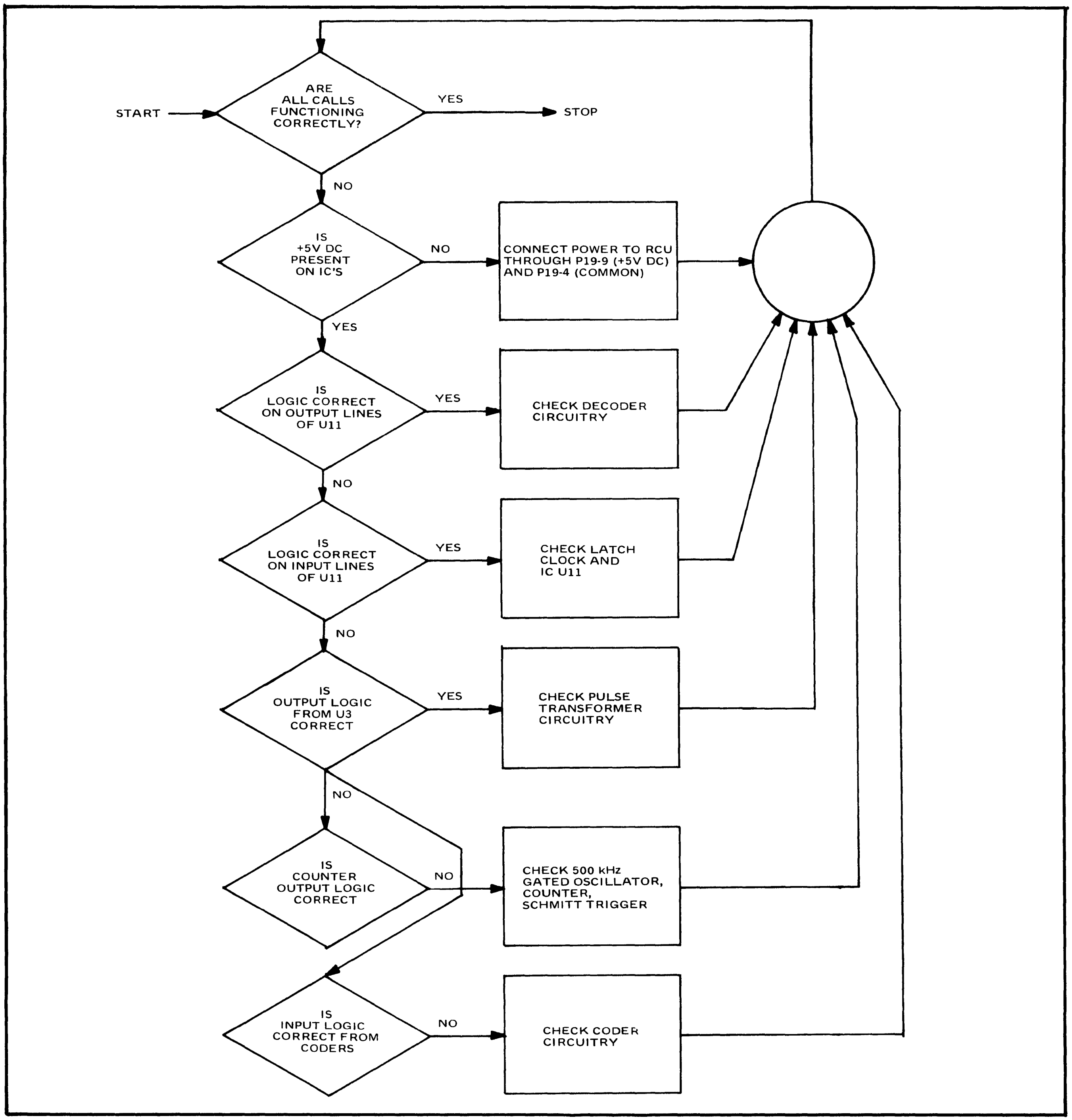


Figure 6-4. REMOTE CONTROL UNIT TROUBLE ANALYSIS (FLOW CHART)

RANGE CODES

F	G	H	J	RANGE
			0	AUTO
0	0	0	1	10,000
0	0	1	1	1000
o	1	0	1	100
0	1	1	1	10
1	0	0	1	1
1	0	1	1	0.1

FCT. CODES

N	R	FUNCTION
0	0	VDC
0	1	VAC
1	0	KΩ
1	1	Ω

Figure 6-5. FUNCTION AND RANGE CODES

6-33. LIST OF REPLACEABLE PARTS

6-34. 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 6-35, this option subsection, for additional Use Codes and Serial Number Effectivity List assigned to this printed circuit assembly option.

6-35. SERIAL NUMBER EFFECTIVITY

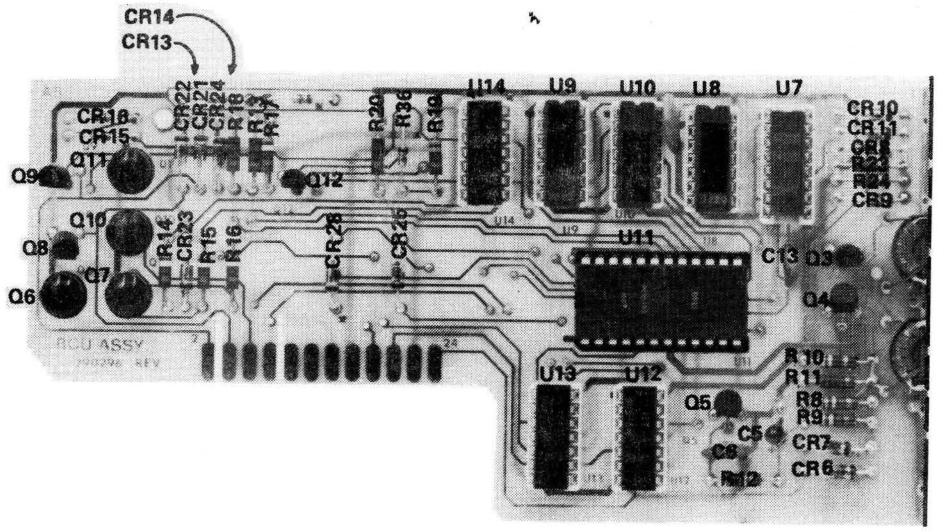
6-36. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8400A. Each part in this option for which a use code has been assigned may be identified with a particular printed circuit board serial number by consulting the Use 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 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	Serial number 123 through 313
B	Serial number 314 and on

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A5	**REMOTE CONTROL –04 Option**				REF		
	Figure 6-6						
C1, C2	Cap, mica, 1500 pf ±5%, 500V	148361			2		
C3	Cap, mylar, .01 uf ±20%, 100V	149753			1		B
C3,C6	Cap, cer, 1200 pf ±10%, 500V	106732			2		A
C6, C15	Cap, cer, 1200 pf ±10%, 500V	106732			2		B
C4	Cap, Ta, 0.68 uf ±10%, 35V	182790			1		A
C4	Cap, Ta, 3.3 uf ±10%, 35V	182808			1		B
C5	Cap, Ta, 1 uf ±20%, 35V	161919			1		
C7	Cap, elect, 200 uf +50/–10%, 1-V	236935			1		
C8	Cap, cer, 0.01 uf +80/–20%, 500V	105668			1		A
	(Deleted)						B
C9	Cap, mica, 33pf ±5%, 500V	160317			1		B
C10, C11	Cap, cer, .025 uf ±20%, 50V	168435			2		B
C12, C13	Cap, cer, .005 uf ±20%, 50V	175232			2		B
C14	Cap, Tan, 39 uf ±20%, 20V	163915			1		B
CR1 thru CR12, CR19 thru CR28	Diode, germanium, 80 mA, 100 piv	149187			22		
CR13 thru CR18, CR29 thru CR36	Diode, silicon, 150 mA	203323			14		A
CR13 thru CR18, CR29 thru CR32, CR36	Diode, silicon, 150 mA	203323			11		B

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
Q1,Q2, Q12 thru Q15	Tstr, silicon, NPN	218396			6		A
Q1,Q2, Q12, Q15	Tstr, silicon, NPN	218396			4		B
Q3,Q4, Q5,Q8, Q9	Tstr, silicon, PNP	195974			5		
Q6,Q7, Q10, Q11	Tstr, silicon, PNP, selected	280198			4		
R1,R2	Res, comp, 820 ±5%, ¼w	148015			2		
R3	Res, comp, 47 ±5%, ¼w	147892			1		
R4,R5	Res, comp, 1k ±5%, ¼w	148023			2		B
R4,R5, R20	Res, comp, 4.7k ±5%, ¼w	148072			3		A
R6,R7	Res, comp, 100 ±5%, ¼w	147926			2		
R8,R9	Res, comp, 330 ±5%, ¼w	147967			2		
R10, R19	Res, comp, 3.3k ±5%, ¼w	148056			2		
R11	Res, comp, 2.2k ±5%, ¼w	148049			1		
R12, R25	Res, comp, 10k ±5%, ¼w	148106			2		
R13, R18	Res, comp, 270 ±5%, ¼w	160804			2		A
R13, R18, R20	Res, comp, 270 ±5%, ¼w	160804			3		B
R14 thru R17	Res, comp, 390 ±5%, ¼w	147975			4		
R21, R22	Res, comp, 15k ±5%, ¼w	148114			2		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R23, R24	Res, comp, 1.2k ±5%, ¼w	190371			2		
R26, R27	Res, comp, 4.7k ±5%, ¼w	148072			2		B
T1, T2	Transformer, pulse	275362			2		
U1	IC, TTL, Quad 2-Input Nor Gate	288845			1		
U2	IC, DTL, Binary Counter	267153			1		
U3	IC, TTL, Digital Multiplexer	288852			1		
U4	IC, TTL, Quad 2-Input Nand Gate	292953			1		B
U4,U6, U12, U13, U14	IC, DTL, Quad 2-Input Nand Gate	268375			5		A
U5	IC, DTL, dual 4-Input Nand	268383			1		
U6, U12, U13, U14	IC, DTL, Quad 2-Input Nand Gate	268375			4		B
U7	IC, TTL, dual J-K Flip-Flop	268441			1		
U8,U9, U10	IC, DTL, dual J-K Flip-Flop	288803			3		
U11	IC, TTL, 8-Bit Latch	288837			1		
U15	IC, DTL, Hex Inverter	268367			1		
	Socket, IC, 14 contact, U1, U2, U4, U5, U6, U8, U9, U10 & U12 thru U15	276527			12		
	Socket, IC, 16 contact, U3 & U7	276535			2		
	Socket, IC, 24 contact, U11	292946			1		



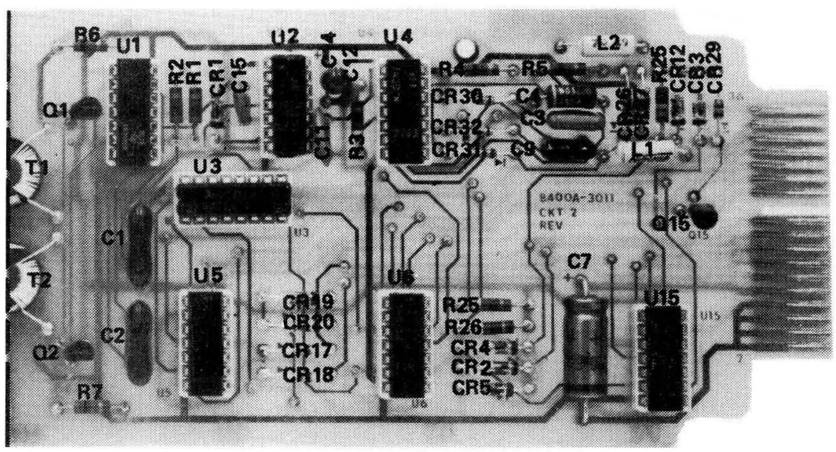


Figure 6-6. REMOTE CONTROL UNIT PCB ASSEMBLY

Option–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 8400A. The principal use of the DVM when operated in this matter is for four-wire voltage ratio measurements: ±dc 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 8400A.

NOTE

The DC External Reference option is not field installable in 8400A mainframes serial No. 634 and below.

a. Disconnect power cord from line power.

b. Remove the Model 8400A top dust cover and top inner guard chassis cover.

c. Determine that connector J3 on A14 Display board is clear of obstructions and that alignment keys are inserted between pin pairs J3-1, -2; J3-3, –4 and J3-13, -14; J3-15, -16.

d. Remove connector mounting bracket located on rear portion of inner chassis, next to power transformer.

e. Mount the DC External Reference connector to the connector bracket with orientation as shown on the rear panel decal. The lug attached to pin 1 of the connector is to be attached to the guard chassis through one of the mounting screws on the DC External Reference connector.

f. Reinstall connector mounting bracket on the inner chassis.

g. Align DC External Reference board with vertical card guides mounted on inner chassis bulkhead.

h. Align rubber grommet with slot in rear inner chassis and slide grommet into slot.

i. Slide DC External Reference board downward while observing that alignment keys on J3 are in proper alignment with the slots in the printed circuit board.

j. Engage printed circuit board fully in J3 connector.

k. Attach guard and top dust covers, connect power cord to line power, and perform receiving inspection test of DC External Reference assembly as described in paragraph 6-26, Performance Test.

6-7. OPERATING INSTRUCTIONS

6-8. Operating instructions for the Model 8400A with DC External Reference installed are located in Section 2 of the manual.

6-9. THEORY OF OPERATING

6-10. General

6-11. The DC External Reference unit consists basically of an input divider, an isolation circuit, and a buffer amplifier, as shown in Figure 6-1.

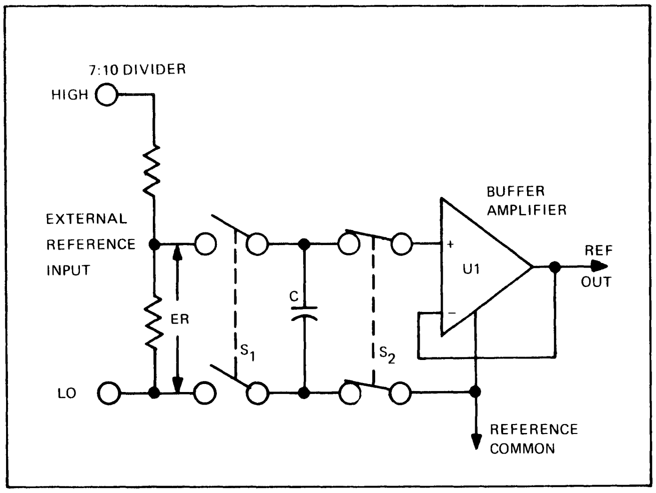


Figure 6-1. DC EXTERNAL REFERENCE SIMPLIFIED DIAGRAM.

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 +1 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 to provide 4 terminal ratio capability, and because the Model 8400A 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 must be E_R.

6-12. Circuit Description

6-13. INPUT DIVIDER. The input divider consists of resistors R3 through R5. The input divider is adjusted by resistor R4, (10V CAL control). Capacitor C1 together with the divider resistors form an RC filter which improves the signal to noise ratio.

6-14. ISOLATION CIRCUIT. Input dual MOSFET Q9 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 CR3. Resistor R11 limits the current through CR3 and capacitor C4 compensates for the capacity of CR3.

6-15. BUFFER AMPLIFIER. The buffer amplifier consists of super beta transistor Q8 followed by operational amplifier U1. Transistor Q7 and resistor R23 comprise a constant current source for amplifier Q8. Resistor R29 provides base current for the input terminal of transistor Q8. Transistor Q6 and associated circuitry provide a constant current source for the collectors of Q8. Transistor Q8 is bootstrapped by the output of amplifier U1, via resistors R15 and R16, to increase the SMRR of the buffer amplifier. Frequency compensation is provided by capacitors C7, C8. Capacitor C6 holds the input voltage to the buffer amplifier during the time switches Q4 and Q5 are off. The reference voltage in the A/D Converter is sensed through resistor R28, thereby compensating for line drops. Low sense (reference common) also originates in the Logic and A/D assemblies. Diodes CR8 and CR9 provide feedback to the voltage follower input when reed relay K1 is open, thereby maintaining amplifier output within 0.5 volts of the voltage on C2 and thus controlling the gate drive for Q4. Resistors R30 through R32, coupled with resistor R28, generate small corrections in the output reference voltage to compensate small errors proportional to the voltage difference between the input common and circuit common.

6-16. VOLTAGE DISTRIBUTION. Voltage distribution is shown in the simplified schematic Figure 6-2. Since Q9 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 −7.25 volts to turn on and a maximum of ~20 volts to turn off under all possible operating circumstances.

6-17. The MOSFET gate driver is redrawn in Figure 6-3 to show the peak voltages. When Q3 is saturated, CR4 is back biased. When the transistor is cutoff, C5 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 external reference is called, relay K1 is energized by Q10 and the internal reference disable line is pulled to +5V. Input protection is provided by diodes CR1 and CR2 and fuse F1.

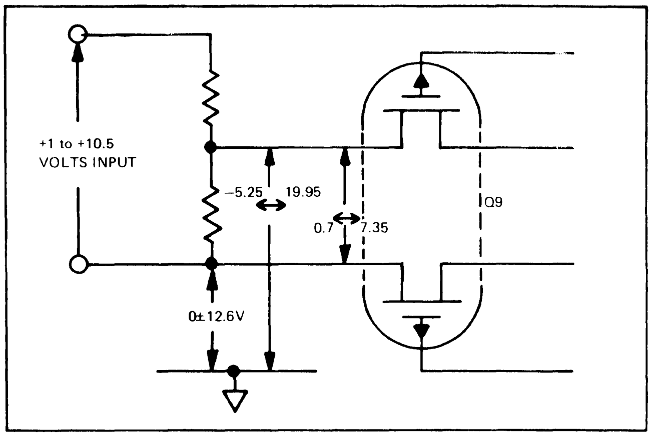


Figure 6-2. VOLTAGE DISTRIBUTION IN MOSFET Q9.

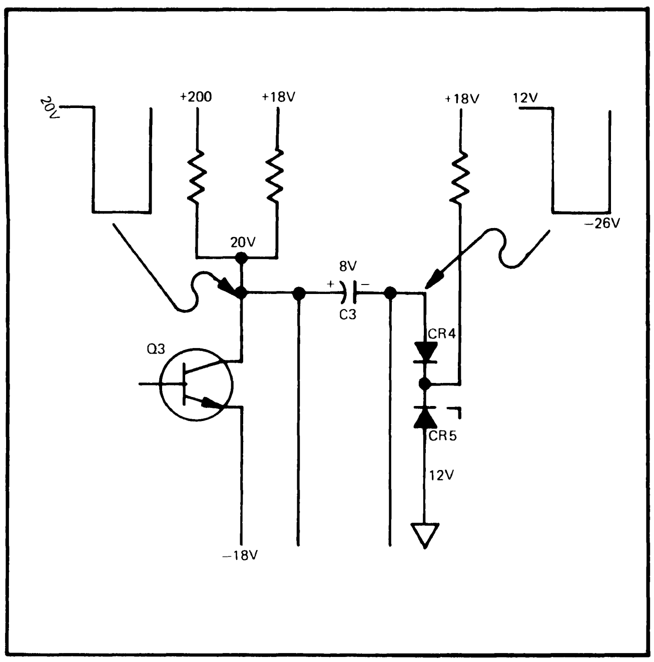


Figure 6-3. GATE DRIVER VOLTAGES.

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 4 of the manual.

6-22. Fuse Replacement

6-23. There are two fuses located on the DC External Reference board. F1 is the active fuse and is to be replaced with the SPARE FUSE when necessary. Both fuses are 15 ma, pigtail fuses.

6-24. Test Equipment

6-25. 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
Kelvin Varley Divider	Fluke Model 720A
Oscilloscope	Tektronix Model 547
Oscilloscope Plug-IN	Tektronix Model 1A1

6-26. Performance Test

6-27. 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 23°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.

6-28. To test the DC External Reference unit, proceed as follows:

a. Connect the dc voltage source to the Model 8400A as shown in Figure 6-4.

b. Set the Model 8400A 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 8400A readout should be +10.0000 ±0.0007.

6-29. Calibration

6-30. The DC External Reference Unit should be calibrated every 90 days 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 23°C ±2°C. Relative humidity should be less than 70%. Consult paragraph 6-4 for recommended test equipment.

6-31. PRELIMINARY OPERATIONS

a. Remove the top 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. Connect equipment as shown in Figure 6-4.

d. Turn on the Model 8400A and allow the instrument to operate for one hour.

6-32. ALIGNMENT

a. Set Model 8400A controls as follows:

FUNCTION	EXT REF, VDC
RANGE	10
SAMPLE RATE	as desired

b. Set the 720A dials to 8005000.

c. Set the 343A output to 10 volts.

d. Adjust DC EXT REF 10V CAL (A3R4) in the DC External Reference Unit for a readout of 8.0050. ±1 digit.

e. Set the 343A output to 2 volts.

f. Adjust DC EXT REF 2V CAL (A3R20) in the DC External Reference Unit for a readout of 8.0050 ±1 digit.

g. Repeat steps (b) through (f), as required, until no more adjustment is necessary.

h. Set the 343A output to 10.000 volts.

i. Record DVM reading.

j. Reverse the input to the DVM only. DVM reading should be within 2 digits of value recorded in step (i).

k. Reverse the input to the DVM only, and set calibrator to 5.0 volts.

l. DVM readout should be 8.0050 ±3 digits.

m. Disconnect calibration equipment from Model 8400A.

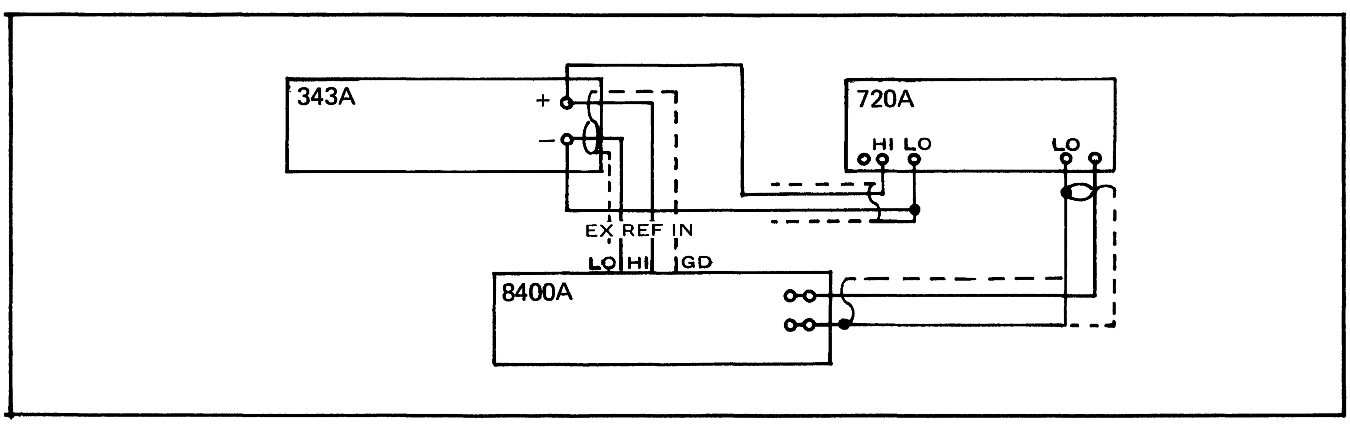


Figure 6-4. EQUIPMENT CONNECTIONS FOR DC EXTERNAL REFERENCE UNIT CALIBRATION.

6-33. Troubleshooting

6-34. 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 6-26) 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.

6-35. 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 A8TP3, with scope common connected to A8TP1. Connect the scope input probe also to A8TP3 and adjust the scope trigger controls so that it triggers on the negative going edge of the $\overline{\text{ZERO}}$ pulse.

6-36. VOLTAGE AND WAVEFORM CHECKS. If the reference voltage stays at about 7 volts no matter what the input reference voltage is, check transistor Q10, diode CR13, or transistor A8Q24.

6-37. If the reference output voltage is zero or negative, check the gate drives of Q9, Q4, and Q5. If either of the waveforms of Q9 are not correct (stylized waveforms are shown in Figure 6-5), check to see if the same defective waveform appears at other than the gate terminals of Q9; if it does, Q9 is defective and should be replaced. If Q9 does not check bad, gate driver Q3 is probably defective.

6-38. 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 C1 should be 7 ±0.1 volts. The voltage across C2 should be equal to the voltage across C1 less the amount drained by the measurement instrument. The voltage across both C1 and C2 will be pulled high if the output of U1 is higher than 8 volts. No voltage or extremely low voltage across C2 indicates Q9 is bad. Check integrated circuit U1 to see if pin 2 is low or high with respect to pin 3. If it is low, the output at pin 6 of U1 should be +18 volts; if it is high, the output should be −18 volts. The combined voltage developed across R17, R18, R21 and R22 should be about 9.2 volts. If not, check the following components in the order given: U1, Q7, or Q8. 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 Q9, Q5, CR4, or CR5.

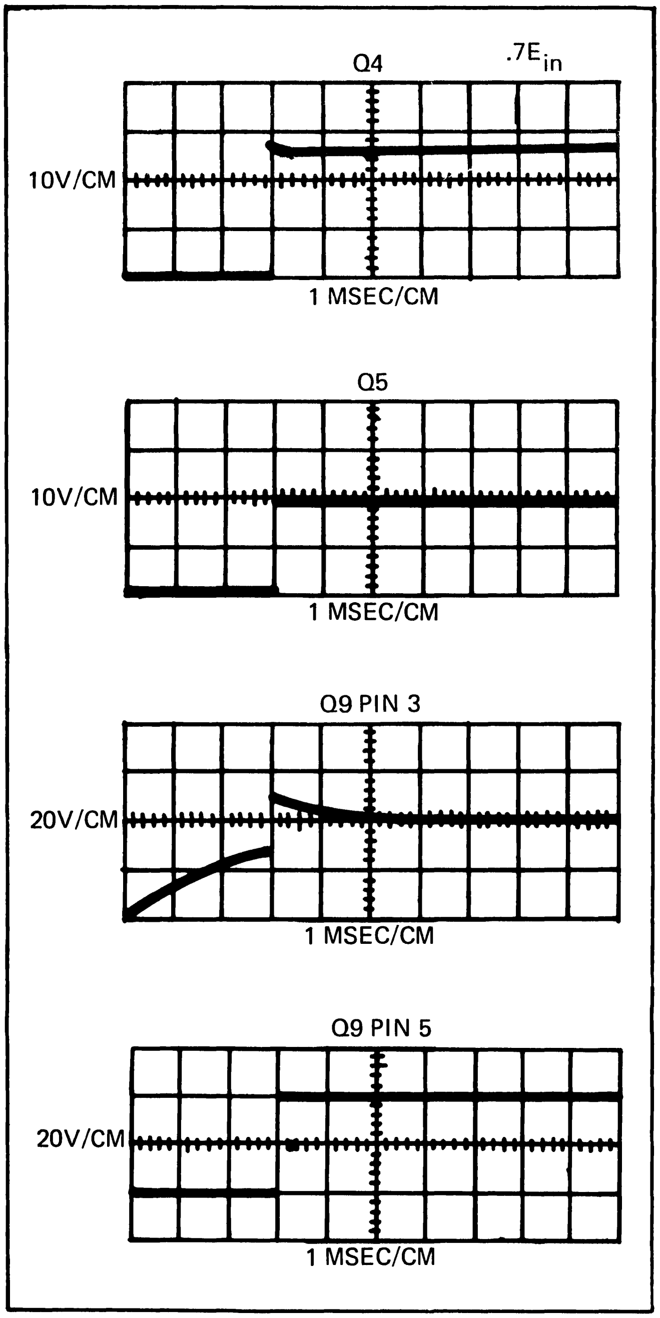


Figure 4-24. DC External Reference Stylized Waveforms

6-39. LIST OF REPLACEABLE PARTS

6-40. 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 6-41, this option subsection, for additional Use Codes and Serial Number Effectivity List assigned to this printed circuit assembly option.

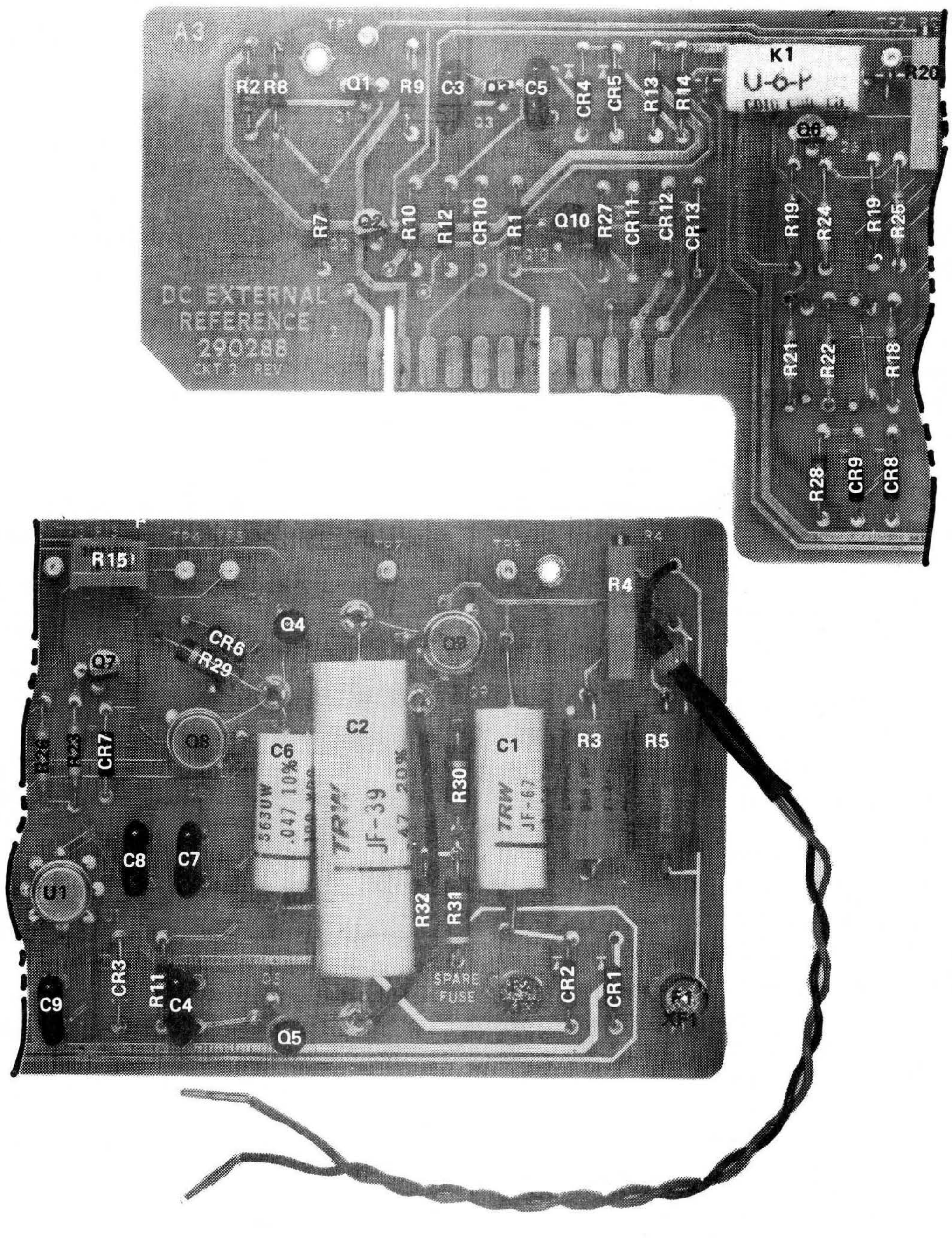


Figure 6-6. DC EXTERNAL REFERENCE

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A3	**DC EXTERNAL REFERENCE** **Figure 6-6**	2	REF		
C1	Cap, plstc, 0.1 uf ±20%, 120V	167460	1		
C2	Cap, plstc, 0.47 uf ±20%, 120V	190553	1		
C3	Cap, mica, 100 pf ±5%, 500V	148494	1		
C4	Cap, mica, 47 pf ±5%, 500V	148536	1		
C5, C7, C8	Cap, mica, 220 pf ±5%, 500V	170423	3		
C6	Cap, plstc, 0.047 uf ±10%, 120V	260562	1		
C9	Cap, mica, 33 pf ±5%, 500V	160317	1		
CR1, CR2, CR4, CR6, CR7, CR8, CR9	Diode, silicon, 150 mA, 125 piv	272252	7		
CR3	Diode, fast switching, germanium, 40 mA, 50 piv	180505	1		
CR5	Diode, zener, 5.1V	159780	1		
CR10, CR13	Diode, germanium, 80 mA, 100 piv	149187	2		
CR11, CR12	Diode, silicon, 150 mA	203323	2		
F1, F2	Fuse, pigtail, 15 mA, 125V (F2 fuse is a spare)	285031	2		
K1	Relay, Reed switch	219097	1		
	Coil, relay	269019	1		
Q1, Q6, Q10	Tstr, silicon, PNP	195974	3		
Q2, Q3, Q7	Tstr, silicon, NPN	218396	3		
Q4, Q5	Tstr, J-FET, N-channel	271924	2		
Q8	Tstr, silicon, NPN, Super beta dual monolithic	284075	1		
Q9	Tstr, FET, dual, P-channel	268011	1		
R1	Res, comp, 4.7k ±5%, 1/4w	148072	1		
R2	Res, comp, 33k ±5%, 1/4w	148155	1		
R3, R5	Res, set, ext ref, divider	278309	1		
R4, R20	Res, var, cer met 5k ±20%, 1/2w	267872	2		
R6	Not used				
R7, R8, R13	Res, comp, 22k ±5%, 1/4w	148130	3		
R9	Res, comp, 6.8k ±5%, 1/4w	148098	1		
R10, R28	Res, comp, 12k ±5%, 1/4w	159731	2		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R11	Res, comp, 120k ±5%, 1/4w	193458	1		
R12	Res, comp, 2.2M ±5%, 1/4w	198390	1		
R14	Res, comp, 180k ±5%, 1/4w	193441	1		
R15	Res, var, cer met, 1k ±10%, 1w	285155	1		
R16	Res, met flm, 1.54k ±1%, 1/8w	289066	1		
R17, R21	Res, selected in test (R17 not shown on art)	1	2		
R18, R22	Res, met flm, 215k ±1%, 1/8w	289470	2		
R19	Res, met flm, 2k ±1%, 1/8w	235226	1		
R23	Res, met flm, 140k ±1%, 1/8w	289439	1		
R24	Res, met flm, 7.15k ±1%, 1/8w	260356	1		
R25	Res, met flm, 82.5k ±1%, 1/8w	246223	1		
R26	Res, met flm, 8.66k ±1%, 1/8w	260364	1		
R27	Res, comp, 1k ±5%, 1/4w	148023	1		
R29, R30, R32	Res, comp, 100M ±10%, 1/2w	190520	3		
R31	Res, comp, 4.7M ±10%, 1/2w	108308	1		
U1	IC, operational amplifier	271502	1		
XF1	Fuse holder	296582	2		
	Cable, Ref, input	304030	1		
	Terminal, teflon, feed thru, 4 lead	281865	4		
	1 R17 and R21 factory selected at time of test.				
	2 This option is not field installable in mainframe S/N 634 and below.				

6-41. SERIAL NUMBER EFFECTIVITY

6-42. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8400A. 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–06
AC External Reference

6-1. INTRODUCTION

6-2. The A4 AC External Reference Converter (Drawing No. 8400A-1008) when used in conjunction with the A13 AC Converter and the 8400A DVM provides three terminal ac to ac voltage ratio measurement capability through three ranges of 1, 10, and 100. The AC External Reference Converter rectifies the ac input voltage to a dc voltage which becomes the instrument reference voltage.

6-3. SPECIFICATIONS

6-4. Specifications for the AC External Reference Converter are located in Section 1 of the manual.

6-5. INSTALLATION

6-6. The following procedure should be used to install the AC External Reference Converter option in the Model 8400A.

NOTE

The AC External Reference option is not field installable in 8400A mainframes serial No. 634 and below.

a. Disconnect power cord from line power.

b. Remove the Model 8400A top dust cover and inner guard chassis cover.

c. Determine that connector J4 on A14 Display board is clear of obstructions and that alignment keys are inserted between pin pairs J4-1, -2; J4-3, -4 and J4-15, -16; J4-17, -18.

d. Remove connector mounting bracket located on rear portion of inner chassis, next to power transformer.

e. Mount the AC External Reference Converter connector to the connector bracket with orientation as shown on the rear panel decal. The lug attached to pin 1 of connector is to be mounted to the guard chassis through one of the mounting screws on the DC External Reference Connector.

f. Remount connector bracket back to the inner chassis.

g. Align AC External Reference Converter board with vertical card guides mounted on inner chassis bulkhead.

h. Align rubber grommet with slot in rear inner chassis and slide grommet into slot.

i. Slide AC External Reference Converter board downward while observing that alignment keys in J4 are in proper alignment with the slots in the printed circuit board.

j. Engage printed circuit board fully in J4 connector.

k. Attach guard and top dust covers, connect power cord to line power, and perform receiving inspection test of DC External Reference assembly as described in paragraph 6-22, Performance Test.

6-7. OPERATING INSTRUCTIONS

6-8. Operation of the DVM with the A4 AC External Reference Converter Option 8400–06 installed is covered in Section 2, Operating Instructions.

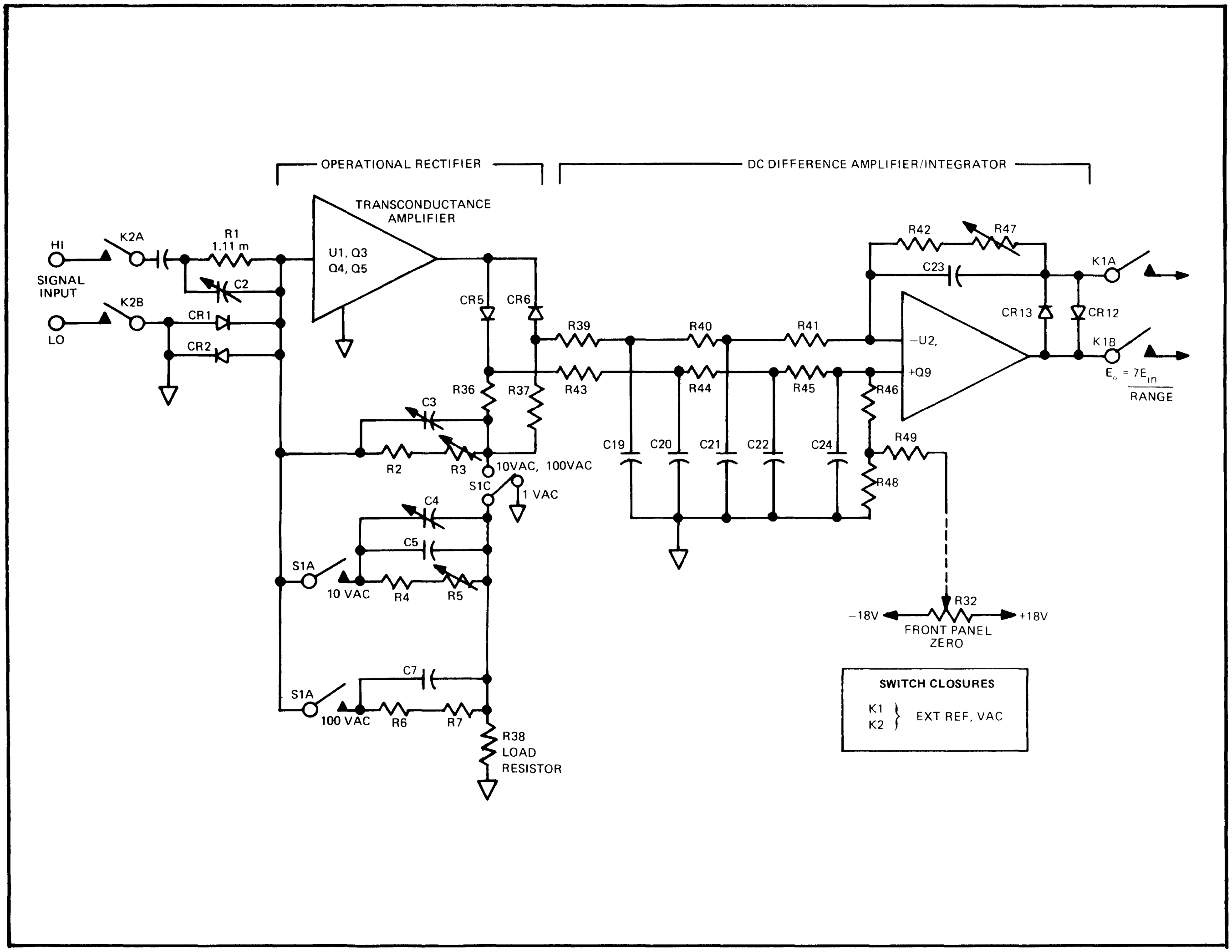


Figure 6-1. BLOCK DIAGRAM AC EXTERNAL REFERENCE CONVERTER.

6-9. THEORY OF OPERATION

6-10. General

6-11. The A4 AC External Reference Converter consists of two basic parts as shown in Figure 6-1: an operational rectifier and a dc difference amplifier integrator. The operational rectifier consists of an inverting trans-conductance amplifier and load resistor with negative feedback arranged to provide a loop gain of about 5 x 10^3 at mid-band. The feedback is changed with switch S1 for range purposes. The input resistor is 1.11 megohms and provides 1.11 megohm input impedance at the AC Ext. Ref. input jacks. 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 two milliamps. The two output waveforms are shown in Figure 6-2.

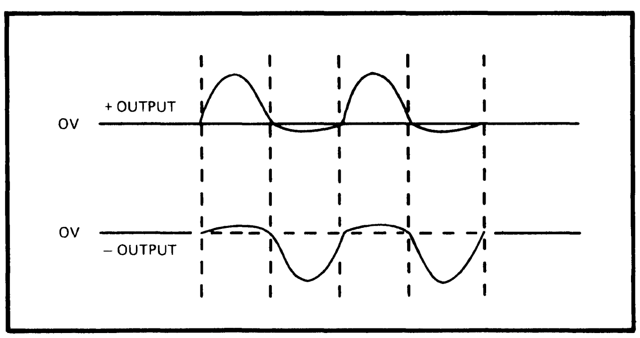


Figure 6-2. RECTIFIER OUTPUT WAVEFORMS

6-12. The dc difference amplifier/integrator filters the output waveforms of Figure 6-2 and amplifies the difference between them by a factor of 3.33, providing a buffered voltage which becomes the instrument reference voltage. A minimum three sections of filtering are provided at all times.

6-13. Circuit Description

6-14. 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 circuit common. The first two differential pairs are in dual in-line package U1. 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.

6-15. 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, C21, C22. Capacitors C19, C21, and C23 form matched pairs with capacitors C20, C22, and C24, respectively, to maintain good common-mode rejection. Gain for the dc amplifier is provided by monolithic operational amplifier U2, thereby providing a total loop gain at dc of about 5×10^5.

6-16. RANGE AND FUNCTION CONTROL. The A4 AC External Reference Converter input and output relays, K1 and K2, are driven by the combination of front panel pushbuttons and Q8. The range control of the External Reference Converter is controlled by switch S1A, B, and C for selection of ranges 1, 10, 100. Transistor Q10 provides an interlocking feature which prevents the AC External Reference Converter from operating on any function but VAC. Switch S1 has a fourth position (DC ONLY) which prevents the AC External Reference from operating under any circumstances. This feature allows AC/DC ratios to be measured without removing the AC Ext. Ref. option from the mainframe, and the DC External Reference option is present.

6-17. MAINTENANCE

6-18. Introduction

6-19. This section contains maintenance information specifically intended for the AC External Reference Converter. Factory service information and general instructions regarding instrument access and cleaning are located in Section 4 of the Manual.

6-20. Test Equipment

6-21. The following equipment is recommended for testing, troubleshooting, and calibrating the AC External Reference 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

6-22. Performance Test

6-23. The performance test in this section compares the AC External Reference Converter performance to the accuracy specifications in Section 1 of the manual to determine if the converter is in calibration. To test the unit, a reference voltage is applied to the AC External Reference input terminals, an ac 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 calibration is attempted. The test is also suited to receiving inspection of new units. The performance test should be conducted under the following environmental conditions after 1 hour warm up: ambient temperature 23°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 1 of the manual.

6-24. To test the AC External Reference Converter unit, proceed as follows:

a. Connect the ac voltage source to the Model 8400A as shown in Figure 6-3.

b. Set the DVM controls as follows:

FUNCTION VAC, EXT REF, FILT

RANGE Manually selected, as required.

c. Apply each of the test signals shown in Table 6-1 to the INPUT terminals of the DVM. The readout should be as indicated.

Table 6-1. AC EXTERNAL REFERENCE CHECK

STEP	INPUT		RANGE		READOUT
	FREQ	VOLTS	8400A	A4S1	
1	10 kHz	1	1	1	.99945 to 1.00055
2	10 kHz	10	10	10	9.9945 to 10.0055
3	10 kHz	100	100	100	99.945 to 100.055
4	10 kHz	10	100	100	99.900 to 100.100

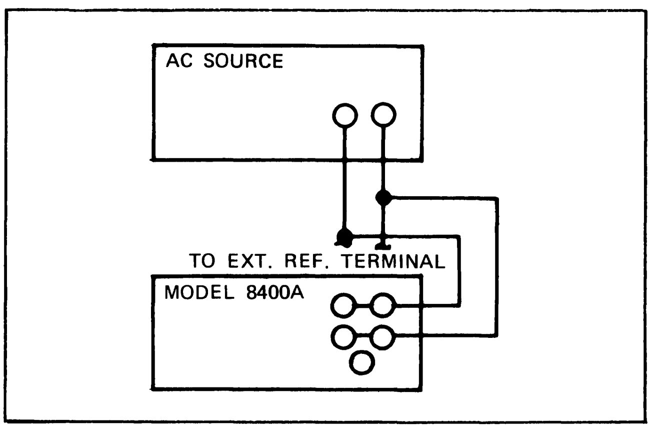


Figure 6-3. EQUIPMENT CONNECTION FOR TESTING.

6-25. Calibration

The AC External Reference Converter should be calibrated every 90 days or whenever repairs have been made to circuitry. Calibration of the converter should be performed at an ambient room temperature of 23°C ±5°C. Relative humidity should be less than 70%. Consult paragraph 6-20 for recommended test equipment.

NOTE!

Since calibration matches the AC External Reference to the AC Converter option – 01, the alignment of the latter should be verified before attempting to align the former. Refer to this section, Section 6, of this manual for the AC Converter (–01) option information.

6-26. 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 and allow the instrument to operate for one hour.

6-27. AC CONVERTER ALIGNMENT

a. Set the DVM controls as follows:

FUNCTION VAC

INPUT RANGE 100

EXT REF RANGE 100

SAMPLE RATE Fully clockwise

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

c. Connect a shorting jumper between the input terminals.

d. Adjust AC ZERO (A13R50) for 000.00 on the readout.

e. Remove the short between the INPUT terminals.

f. Select the 100 range on the front panel. Connect AC Ext. Ref. INPUT and front panel INPUT together and apply 100V 1 kHz to the input. Turn external reference on from front panel. Readout should be near full scale (uncalibrated). While changing input between 100Vac and 20Vac, adjust the Ext. Ref. linearity, A4R32, for the same reading, ±1 digit, with either voltage.

g. Perform the checks and adjustments contained in Table 6-2.

6-28. Calibration of the AC Ext. Ref. Converter is now complete.

Table 6-2. AC EXTERNAL REFERENCE CONVERTER RANGE CALIBRATION

STEP	INPUT FREQ	INPUT VOLTS	RANGE 8400A	RANGE S1	ADJUSTMENT	READING TOLERANCE
1	1 kHz	100.000	100	100	100V 1 kHz (A4R47)	99.995 to 100.005
2	50 kHz	100.000	100	100	100V 50 kHz (A4C2)	99.995 to 100.005
3	20 kHz	100.000	100	100	Check Only	99.995 to 100.005
4	1 kHz	10.0000	10	10	10V 1 kHz (A4R5)	9.9995 to 10.0005
5	50 kHz	10.0000	10	10	10V 50 kHz (A4C4)	9.9995 to 10.0005
6	100 kHz	10.0000	10	10	Check Only	9.9800 to 10.0200
7	1 kHz	1.0000	1	1	1V 1 kHz (A4R3)	.99995 to 1.00005
8	50 kHz	1.0000	1	1	1V 50 kHz (A4C3)	.99995 to 1.00005
9	100 kHz	1.0000	1	1	Check Only	.99800 to 1.00200
10	20 kHz	1.0000	1	1	Check Only	.99995 to 1.00005

6-29. Troubleshooting

6-30. This section contains information selected to aid in troubleshooting the AC External Reference 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 equipment or improper control settings. For this reason, the performance test (paragraph 6-22) is suggested as a first step in troubleshooting. The performance test may also help to localize trouble to a particular section of the instrument. If the performance test fails to localize the trouble, the following information may be helpful.

6-31. POWER SUPPLY VOLTAGE CHECK

6-32. In this test, each of the supply voltages for the AC External Reference Converter is checked at the pin connectors. This test verifies only presence of voltages; a detailed check of the DVM power supply voltages is given in Section 4.

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
3	–18 volts
1	+18 volts

6-33. SEVERE CONVERTER MALFUNCTIONS

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

Procedure: If dc voltage at TP3 and ac voltage on TP2 are zero, then troubleshoot converter output difference amplifier/integrator, and associated circuits.

If the dc voltage on TP3 is greater than ±1V (normal is less than 10 mV) check for defective Q1 through Q6, U1, C11, C21 or associated circuits.

If ac voltage is present on TP2, check for open or shorted feedback circuit or defective component in amplifier causing oscillation.

b. Symptom: Zero output with input applied.

Procedure: If ac voltage on TP2 is zero, check for open or short in ac circuit between input and Q1.

If ac voltage does appear on TP2 (full scale is approximately 0.25V rms) check S1 or troubleshoot output difference amplifier/integrator.

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

Procedure: Check S1 for proper range selection.

6-34. LIST OF REPLACEABLE PARTS

6-35. For column entry explanations, part ordering information and basic instrument configuration Use Codes and Serial Number Effectivity, see Section 5, paragraphs 5-1 through 5-10. See paragraph 6-36, this option subsection, for additional Use Codes and Serial Number Effectivity List assigned to this printed circuit assembly option.

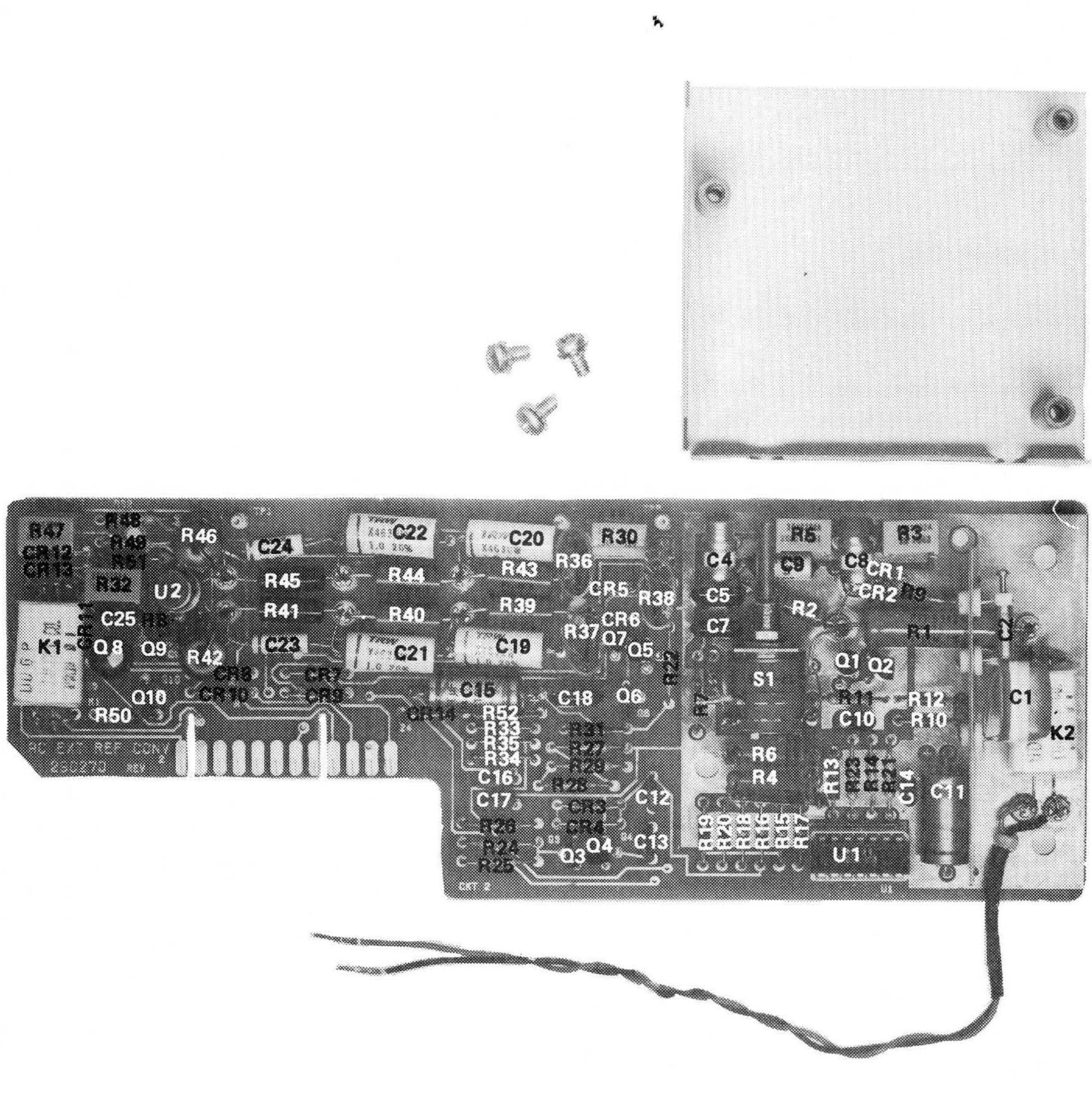


Figure 6-4. AC EXTERNAL REFERENCE PCB ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4	**AC EXTERNAL REFERENCE –06 Option Figure 6-4**	1	REF		
C1	Cap, plstc, 0.22 uf ±10%, 250V	194803	1		
C2	Cap, var, teflon, 0.25 – 1.5 pf, 2 kV	273151	1		
C3, C4	Cap, var, air, 0.8 – 10 pf, 250V	229930	2		
C5	Cap, mica, 12 pf ±5%, 500V	175224	1		
C6, C8	Not Used				
C7	Cap, mica, 220 pf ±5%, 500V	170423	1		
C9	Cap, cer, 3 pf ±10%, 500V	226316	1		
C10, C14	Cap, Ta, 4.7 uf ±20%, 20V	161943	2		
C11	Cap, elect, 125 uf +50/–10%, 16V	186296	1		
C12, C13	Cap, cer, 500 pf ±10%, 1 kV	105692	2		
C15	Cap, elect, 50 uf +50/–10%, 25V	168823	1		
C16, C17	Cap, cer, 0.01 uf ±20%, 100V	149153	2		
C18	Cap, mica, 27 pf ±5%, 500V	177998	1		
C19/C20, C21/ C22	Cap, plstc, 1 uf, Matched pairs (Replace in pairs)	288225	2		
C23, C24	Cap, plstc, 0.033 uf, Matched pair	290155	1		
C25	Cap, mica, 33 pf ±5%, 500V	160317	1		
CR1 thru CR4	Diode, silicon, 100 mA at 1.5V	261370	4		
CR5, CR6	Diode, silicon, 100 mA at 1.5V	161810	2		
CR7 thru CR10, CR14	Diode, germanium, 80 mA, 100 piv	149187	5		
CR11 thru CR13	Diode, silicon, 150 mA	203323	3		
K1	Relay, reed switch	219097	2		
	Coil, relay	272070	2		
K2	Relay, reed switch	284091	2		
	Coil, relay	272070	REF		
Q1	Tstr, FET, N-channel	246066	1		
Q2, Q6	Tstr, silicon, NPN	218081	2		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
Q3, Q4, Q5, Q7	Tstr, silicon, PNP	229898	4		
Q8	Tstr, silicon, PNP, selected	280198	1		
Q9, Q10	Tstr, silicon, NPN	218396	2		A
Q9, Q10	Tstr, silicon, NPN	168708	2		B
R1	Res, met flm, 1.11M Matched Set	269092	1		
R2	Res, met flm, 276k				
R3	Res, var, cer met, 2k ±10%, 1w	285163	1		
R4	Res, ww, 29.53k ±0.1%, ½w	277657	1		
R5	Res, var, cer met, 200Ω ±10%, 1w	285148	1		
R6	Res, ww, 2.573k ±0.1%, ½w	277665	1		
R7	Res, met flm, 10Ω ±1%, 1/8w	268789	1		
R8	Res, comp, 620Ω ± 5%, ¼w	221903	1		
R9	Res, met flm, 49.9k ±1%, 1/8w	268821	1		
R10	Res, comp, 8.2k ±5%, ¼w	160796	1		
R11, R26	Res, met flm, 590Ω ±1%, 1/8w	261883	2		
R12, R33, R52	Res, comp, 10k ±5%, ¼w	148106	3		
R13	Res, comp, 15k ±5%, ¼w	148114	1		
R14	Res, met flm, 84.5k ±0.5%, 1/8w	229492	1		
R15, R18	Res, comp, 120k ±5%, ¼w	193458	2		
R16, R17	Res, comp, 11k ±5%, ¼w	221580	2		
R19, R20	Res, comp, 47Ω ±5%, ¼w	147892	2		
R21, R22	Res, met flm, 40.2k ±1%, 1/8w	235333	2		
R23	Res, met flm, 82.5k ±1%, 1/8w	246223	1		
R24, R28	Res, met flm, 10k ±1%, 1/8w	168260	2		
R25, R27	Res, met flm, 21.5k ±1%, 1/8w	168278	2		
R29	Res, met flm, 1.21k ±1%, 1/8w	229146	1		
R30, R32	Res, var, cer met 100k ±10%, 1w	288308	2		
R31	Res, comp, 10M ±5%, ¼w	194944	1		
R34	Res, comp, 22k ±5%, ¼w	148130	1		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R35	Res, comp, 2.2k ±5%, ¼w	148049	1		
R36, R37	Res, ww, 1.196k ±0.1%, ¼w	299610	2		
R38	Res, ww, 125Ω ±0.1%, ¼w	249284	1		
R39, R40, R43, R44	Res, ww, 130k ±0.1%, ¼w	285361	4		
R41, R45	Res, ww, 40k ±0.1%	271403	2		
R42, R46	Res, ww, 1M ±0.1%	271411	2		
R47	Res, var, cer met, 10k ±10%, 1w	285171	1		
R48	Res, met flm, 100Ω ±1%, 1/8w	168195	1		
R49	Res, met flm, 487k ±1%, 1/8w	237206	1		
R50	Res, comp, 430Ω ±5%, ¼w	203869	1		
R51	Res, comp, 6.2k ±5%, ¼w	221911	1		
R53	Res, comp, 120k±5%, ¼w	193458	2		D
R54	Res, comp, 120k±5%, ¼w	193458	Ref		D
S1	Switch, rotary	295535	1		C
U1	IC, 5–Transistor Array	248906	1		
U2	IC, operational amplifier	288928	1		
	Socket, IC, 14 contact, U1	276527	1		
	1 This option is not field installable in mainframes S/N 634 and below.				

6-36. SERIAL NUMBER EFFECTIVITY

A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8400A. 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	Serial number 123 thru 132.
B	Serial number 133 and on.
C	Serial number 123, 125, 128, 131, 133 and on.
D	Serial number 148 and on.

Option –07
Rear Input

6-1. INTRODUCTION

6-2. The Rear Input Option provides INPUT HI, INPUT LO, Ω SENSE, Ω SOURCE and GUARD terminals at the rear of the instrument, in parallel 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 dust and chassis guard covers.

b. Remove A13 AC CONVERTER from instrument if instrument is so optioned.

c. Remove connector bracket on inner chassis, right rear portion.

d. Mount Rear Input Connector onto the connector bracket top slot. Ensure that the lug which is attached to connector pin 2 is affixed to the inner guard chassis with one of the connector mounting screws.

e. Remount connector bracket to inner chassis.

f. Lay the Rear Input harness along side the Right side of the inner chassis and between the A14 Display PCB and TB1. Clamp harness to inner chassis.

g. Connect Rear Input harness to terminals on rear of the front panel binding posts as follows:

RED – INPUT HI
BLACK – INPUT LO
YELLOW– HI Ω SOURCE
BROWN – LO Ω SOURCE

h. Install the A13 AC Converter if instrument is so optioned.

i. Attach guard and instrument dust cover.

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 option.

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
	REAR INPUT –07 Option		REF		
	Cable, rear input	311639	1		
	Hardware kit, option	321661	1		
	Cable clamps	165951	2		

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 8400A. 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 Rear Input Options with serial numbers 123 and on. NOTE: These Use Codes and Serial Number Effectivity apply to this option 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 –09

True RMS Converter

6-1. INTRODUCTION

6-2. Equipped with Option –09, the Model 8400A provides true rms measurement capabilities through the four AC ranges. A choice of input coupling for the True RMS Converter is available to the operator. Choosing ac coupling allows measurement of the ac component of the input voltage. Choosing direct coupling provides measurement of the ac plus dc components.

6-3. SPECIFICATIONS

For Measurement of DC-Coupled (AC + DC) Voltages or AC Only.

RANGES . . . . 1, 10, 100, 1000 VAC

Overrange . . . . 20%, 1100V RMS maximum on 1000V range

Resolution . . . . 0.001% range

Overload . . . . 1100V RMS any range (1500V peak AC)

Superimposed DC (AC only) . . . . 1100V DC (Peak AC plus DC may not exceed ±1500V)

Max. Crest Factor . . . . 7 at full-scale and increasing down scale per: $7X\sqrt{\frac{V\ Range}{V\ Input}}$

ACCURACY

90 days, (18°C to 28°C) (0.001V - 1100V(1))

	AC + DC	AC ONLY
D.C.	±(0.1% of input + 0.03% of range)	
50Hz-10kHz	±(0.1% of input + 0.03% of range)	±(0.1% of input + 0.012% of range)
10kHz-30kHz(2)	±(0.2% of input + 0.06% of range)	±(0.2% of input + 0.04% of range)
30kHz-50kHz(2)	±(0.3% of input + 0.12% of range)	±(0.3% of input + 0.1% of range)
20Hz-50Hz	±(0.5% of input + 0.03% of range)	±(0.5% of input + 0.012% of range)
10Hz-20Hz	±(1.0% of input + 0.06% of range)	±(1.0% of input + 0.04% of range)
50kHz-100kHz(2)	±(1.0% of input + 0.3% of range)	±(1.0% of input + 0.3% of range)
100kHz-300kHz(2)	±(2.0% of input + 0.5% of range)	±(2.0% of input + 0.5% of range)

(1) With inputs above 500V multiply accuracy by $\left[\frac{2000V + V\ input}{2000V}\right]$

(2) Input volt x hertz, product should not exceed 2×10^7.

Temperature Coefficients (0°C to 18°C and 28°C to 50°C)

DC and 10 Hz - 10 kHz (AC + DC) . . . ±(0.004% Inp. + 0.004% Range)

10 Hz - 10 kHz (AC only) . . . . ±(0.004% Inp. + 0.001% Range)

Input Impedance . . . . 1 Megohm, shunted by less than 150 p.f.

NOISE REJECTION

Common Mode (with up to 100Ω unbalance in either lead)

DC to 60 Hz . . . . Greater than 120 db

RESPONSE TIME (to a reading withing 0.1% of range when measuring step change inputs and using external trigger)

Filter "out" . . . . 100 milliseconds maximum[4]
Filter "in" . . . . 500 milliseconds maximum
(For readings less than 10% Range, double indicated times).

(4) Above 400Hz for rated accuracies.

6-4. KIT INSTALLATION

6-5. Use the following procedure for installing True RMS Converters received as kits:

a. With DVM disconnected from power source, remove top dust cover and inner guard cover.

b. Locate AC Converter position on right side of instrument, as viewed from front panel.

c. Insert True RMS Converter Assembly into AC converter position, fully engaging board edge connector into mating connector.

d. Route red and black wires through rubber grommet above front card guide.

e. Connect red and black wires to grey terminal block mounted under grommets on front of bulkhead (see Figure 6-1).

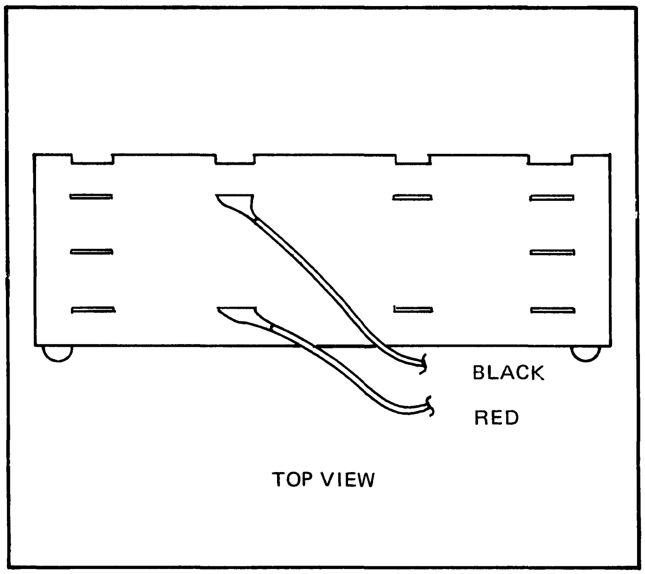


Figure 6-1. TERMINAL BLOCK

f. Install new guard cover and set INPUT COUPLING switch on converter to either AC or DC. Install dust cover.

6-6. OPERATION

6-7. True rms measurements are performed with the 8400A DVM by pressing the VAC FUNCTION pushbutton and the desired RANGE pushbuttons (1, 10, 100, 1000 or AUTO). Input coupling selection is accomplished by removing the top dust cover and setting the INPUT COUPLING switch to either AC (ac component only) or DC (ac plus dc components).

6-8. THEORY OF OPERATION

6-9. General Description

6-10. The True RMS Converter provides a dc voltage, proportional to the rms value of the applied INPUT voltage, to the A/D Converter for digitizing and subsequent display on the front panel readout. A simplified diagram of the circuits involved in the rms conversion process is illustrated in Figure 6-2. As shown in the diagram, the RMS Converter consists, basically, of a Range Amplifier and RMS Detector. Output voltage from the Range Amplifier is 1 volt rms ac, maximum, for a full scale INPUT voltage. A scaled output voltage from the Range Amplifier is applied to the RMS Detector's Balance Amplifier where any negative going signals are inverted. The output of the Balance Amplifier is summed with the output of the Range Amplifier at the summing junction of the Squaring Amplifier. This provides a rectified version of the Range Amplifier output. The rectified signal is processed by the Squaring Amplifier, Integrating Amplifier, and Square Root Amplifier, respectively. These three amplifiers perform squaring, integrating, and square rooting functions which result in a dc voltage proportional to the rms value of the INPUT voltage.

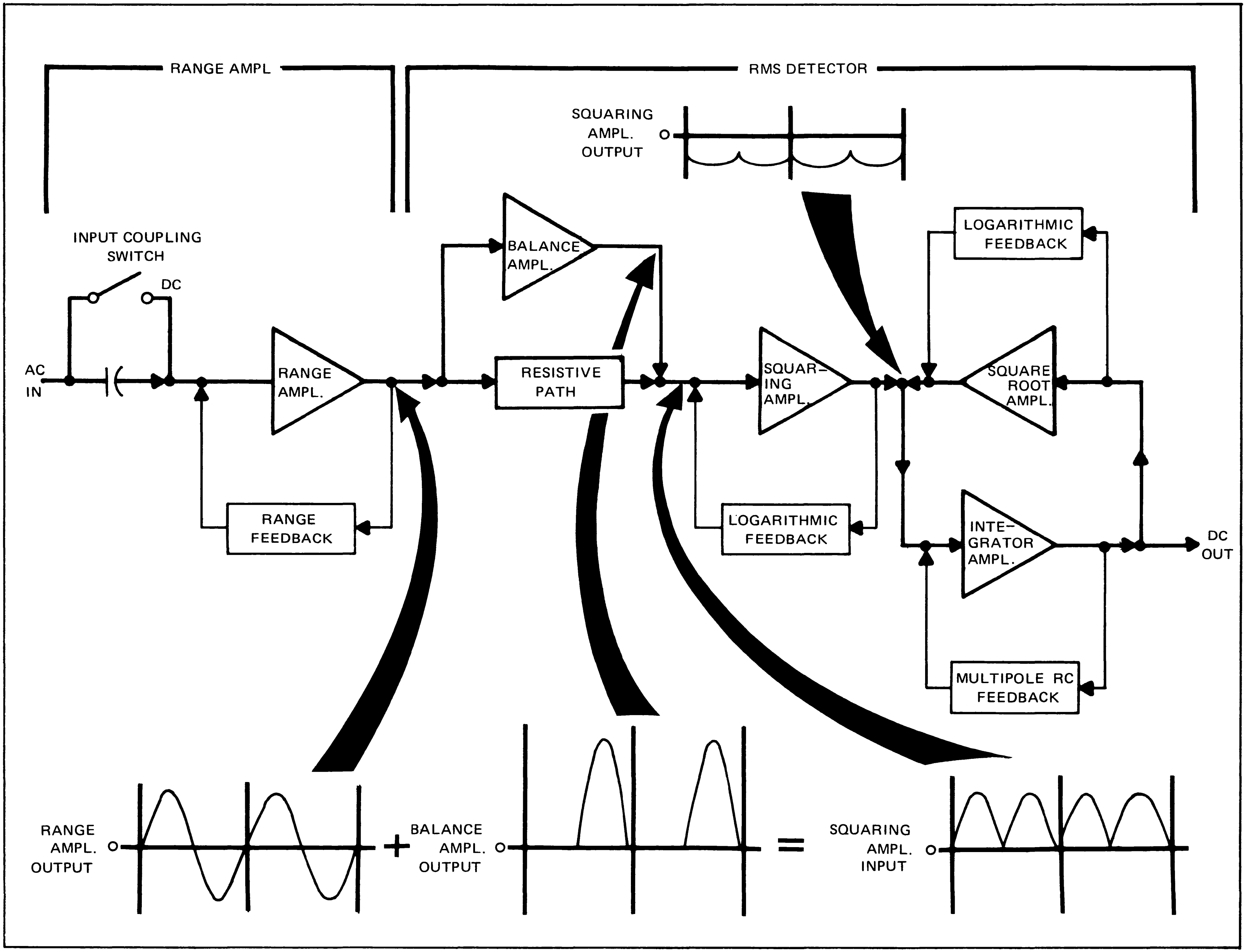


Figure 6-2. TRUE RMS CONVERTER BLOCK DIAGRAM

6-11. Circuit Description

6-12. RANGE AMPLIFIER

6-13. The Range Amplifier scales the applied input voltage to the Converter to 1 volt rms ac for a full scale input. Basically, the Range Amplifier is an inverting operational amplifier whose gain changes as the range changes. Voltage gains of –1, –10, –100, and –1000 correspond with the 1 through 1000 volt ranges, respectively. Active elements of the Range Amplifiers are Q1, Q2, Q5 and U3 with protection diodes CR6, CR7, CR18, CR20, CR21, and CR22. Transistor Q2 drives the guard at the summing point of the operational amplifier, and Q5 switches C5 into feedback path in the 10, 100, and 1000 volt ranges. Diodes CR6, CR7, CR21, and CR22 provide clipping for input overload protection to Q1. Diodes CR18 and CR20 provide overload clipping at the output of the Range Amplifier for protection of the following circuitry.

6-14. BALANCE AMPLIFIER

6-15. The Balance Amplifier is a rectifying amplifier with a gain of –1 that changes all negative going signals from the Range Amplifier output to positive voltages prior to summing with the Range Amplifier output from R33. Balance Gain adjustment (R32) controls the input to the Balance Amplifier, such that positive and negative signals at the summing junction of R31, R33 and U5 will be equal in magnitude. Active components of the Balance Amplifier are CR15, Q6, Q9, Q10, and U4. Balance Zero Adjustment, R42, is an adjustment for zeroing the input of U4. Primary or low frequency signal path is through U4 followed by CR15 and final output stage Q10. At frequencies above a few hundred kilohertz, amplification takes place through Q6 followed by Q10. The final output stage, Q10, has a current source load, CL1, which maintains a high amplifier output impedance for driving CR14 and CR16. Any stray capacitance in CR14 and CR16 is compensated by Q9. Transistor Q9 samples the waveform driving CR14 and CR16 and feeds back a capacitive charge through C17 to the input of the Balance Amplifier.

6-16. SQUARING AMPLIFIER

6-17. The Squaring Amplifier is an inverting operational amplifier with non-linear feedback through matched transistors Q8A and Q12A. These transistors transform the input current into an output voltage that is the logarithim of the input current. Since this operation is performed twice (by Q8A and Q12A), the output voltage is twice the log of the input current. Therefore, the amplifier essentially accomplishes a squaring operation ($2 \log X = \log X^2$). U5 is an integrated operational amplifier which is paralleled by Q7 at high frequencies in a manner similar to Q6 in the Balance Amplifier. AC Zero Adjustment, R45, provides for zeroing of U5, and has the greatest effect, of all other zero adjusts, for overall converter zero. Both amplifying paths, U5 and Q7, share the common final output stage, Q11. Output voltage from Q11 is sampled by Q12B which provides a current to the summing point of the Integrator Amplifier. Potentiometer R38 provides an adjustment for crest factor gain.

6-18. INTEGRATOR AMPLIFIER

6-19. The Integrator Amplifier consists primarily of U7 and U8, and is a complex multipole integrator which acts as a three pole filter. Voltage at terminal 2 of U7 is held at zero, and all of the current applied is passed through the feedback elements R56, R65, and whichever feedback capacitors are switched into the circuit. Switchable capacitors are connected through FET's Q13, Q14, Q16 and Q17 by operation of the FILT switch on the instrument front panel. If the FILT/RMS DC switch is depressed, the FET's are turned on, and the capacitors are a part of the feedback circuitry. Since each switchable capacitor is paralleled by a non-switchable capacitor, some filtering action takes place in the Integrator Amplifier whether the FILT/RMS DC switch is depressed or not. Amplifier U7 and associated multipole feedback circuitry provides the integration for the Integrator Amplifier. Amplifier U8 is a unity gain, high input impedance, low output impedance amplifier. Three poles of feedback for U7 consist of C30, R68 and C32, and R69 and C33. Capacitor C29 can be switched in parallel with C30, C34 with C32, C35 with C33, and C28 with C27. Output from U8 is the output of the total Integrator Amplifier which is then applied to the A-to-D Converter and to the Square Root Amplifier.

6-20. SQUARE ROOT AMPLIFIER

6-21. The Square Root Amplifier consists of the input resistor R57, the trimming and selection resistors R61, R62, R63, and R64, the feedback transistor Q8B, protection diode CR19, and amplifier U6. Diode CR19 acts as a feedback path to prevent saturation of U6 should input polarity to the amplifier reverse. The Square Root Amplifier uses logarithmetric feedback to produce a square root of the input in a manner similar to that used by the Squaring Amplifier. The square root process is accomplished by matched transistors Q8B and Q12B. Resistors R48, R79, and R80 are factory selected for overall converter temperature coefficient and linearity. Some or none of these resistors may be installed.

6-22. MAINTENANCE

6-23. Introduction

6-24. Maintenance information, described in the following paragraphs, is specifically intended for the True RMS Converter Assembly. Service information and general instructions regarding instrument access and cleaning are described in Section 4 of the Instruction Manual. Test equipment for calibrating and troubleshooting the True RMS Converter is listed in Table 6-1. If the recommended equipment is not available, equipment having, at least, equivalent specifications may be used.

6-25. Calibration

6-26. The True RMS Converter should be calibrated every 90 days, or whenever repairs have been made to circuitry. Calibration of the converter should be performed at an ambient temperature of 28°C ±5°C. Relative humidity should be less than 70%.

6-27. PRELIMINARY OPERATIONS

a. Remove top dust cover screws, but leave the cover in place.

b. Set rear panel 115/230 volt switch to 115 volt position. Connect line cord to autotransformer set to 120 volts ac.

c. Turn instrument on and allow one hour for warm-up.

6-28. RANGE AMPLIFIER ZERO

a. Short the HI and LO INPUT terminals. Select VAC, FILT, and 10 RANGE pushbuttons. Place AC-DC switch on RMS converter to DC. This switch is accessible through the top guard cover.

NOTE!

For Option –09's without dc coupling, connect jumper wire across input coupling capacitor C1.

b. Connect high lead of external dc voltmeter to body of C11 (10V 50kHz adjustment) via a 10k isolation resistor.Connect low lead to the 8400A LO INPUT terminal.

c. Adjust R12 (Range Zero Adjust) for external voltmeter indication of 0 ± 30μV.

d. Remove external voltmeter and INPUT short.

6-29. BALANCE AMPLIFIER ZERO

a. Apply –0.1V dc to INPUT terminals from dc voltage source. Note 8400A reading.

b. Reverse input voltage polarity to +0.1Vdc.

c. Adjust R42 (Balance Zero Adjust) for reading noted in step a.

d. Repeat steps a and b until difference between readings for each polarity is within 10 digits.

Table 6-1. TEST EQUIPMENT

NOMENCLATURE	REQUIRED SPECIFICATIONS	RECOMMENDED EQUIPMENT
AC Voltage Source	1mV and 1000V @ 500Hz 1V, 10V, 1000V @ 500Hz and 50kHz ———— ±0.03% 1000V @ 50kHz ——— ±0.3%	Fluke Model 5200A AC Calibrator and 5205A power Amplifier
DC Voltage Source	10V ———————— ±0.01%	Fluke Model 341A DVM Calibrator
DC Differential Voltmeter	100μV Range ±0.005%	Fluke Model 895A Differential Voltmeter
RMS Differential Voltmeter	100Hz @ ±0.05% Crest Factor of 10	Fluke Model 931A True RMS Differtial Voltmeter
Oscilloscope	General Purpose	Tektronix 544 W/Type L Plug-In and Low Capacitance Probe
Pulse Generator	50Ω Source Impedance, 5V max. across 50Ω, (+) and (–) pulse polarity, Rise and Fall Time <50 ns	HP 8003A Pulse Generator

6-30. BALANCE GAIN

a. Apply –10V dc to INPUT terminals. Note 8400A reading.

b. Reverse input voltage polarity to +10V dc.

c. Adjust R32 (Balance Gain Adjust) for 8400A reading equivalent to step a.

d. Repeat steps a through c until difference between readings for each polarity is within 10 digits.

e. Remove dc voltage source.

6-31. AC ZERO

a. Select 1 RANGE and AC INPUT COUPLING. Apply 0.001 volts at 500 Hz to INPUT terminals.

b. Adjust R45 (AC Zero Adjust) for reading of .00100 ± 3 digits.

c. Remove ac input voltage.

6-32. CALIBRATION ADJUSTMENT/CHECK

6-33. Before performing calibration, allow one hour "warm-up" with outer covers installed. Refer to Table 6-2; apply each of the rms voltages at the specified frequencies to the INPUT terminals and, if necessary, perform the indicated adjustments to complete the calibration. If R64 (1000V, 500Hz adjustment) is not within adjustment range, refer to paragraph titled "Course Calibration."

6-34. COURSE CALIBRATION

6-35. Use the following procedure only when R64 is out of adjustment range.

a. Connect any opened shorting links (1, 2, or 4) across course calibration resistors R61, R62 or R63.

b. Select the 1000 volt range and apply 500V @ 500 Hz to the INPUT terminals.

c. Adjust the "1000V, 500 Hz" control (R64) for a minimum reading.

d. Cut open the appropriate link or links as indicated below depending upon the 8400A reading.

READING	CUT LINKS
465.7 – 470.1	1, 2, 4
470.1 – 474.3	2, 4
474.3 – 478.7	1, 4
478.7 – 482.5	4
482.5 – 486.9	1,2
486.9 – 491.1	2
491.1 – 495.5	1
495.5 – 500	NONE

e. Repeat the "Calibration Adjustment/Check" paragraph to complete calibration.

6-36. Troubleshooting

6-37. The troubleshooting procedure presents a technique for isolating a malfunction to one of the five amplifier circuits within the RMS Converter. Troubleshooting procedures for the power supply, command voltages, and relays are located in Option –01 troubleshooting section of the Instruction Manual. Before using any of these procedures, ensure that the malfunction is within the RMS Converter and not due to operator error, faulty test leads, etc. Refer to Figure 6-3 for location of adjustments and test points.

Table 6-2. CALIBRATION ADJUSTMENT/CHECK

INPUT		RANGE	ADJUSTMENT		TOLERANCE
VOLTAGE (RMS VOLTS)	FREQUENCY		NAME	REF DESIG.	
500.0	500Hz	1000	1000V 500Hz	R64	±10 digits
500.0	50kHz	1000	1kV 50kHz	C4	±10 digits
1.0000	500Hz	1	1V 500Hz	R14	±10 digits
1.0000	50kHz	1	1V 50kHz	C9	±10 digits
10.000	500Hz	10	10V 500Hz	R16	±10 digits
10.000	50kHz	10	10V 50kHz	C11	±10 digits
100.00	500Hz	100	100V 500Hz	R18	±10 digits
100.00	50kHz	100	100V 50kHz	C14	±10 digits

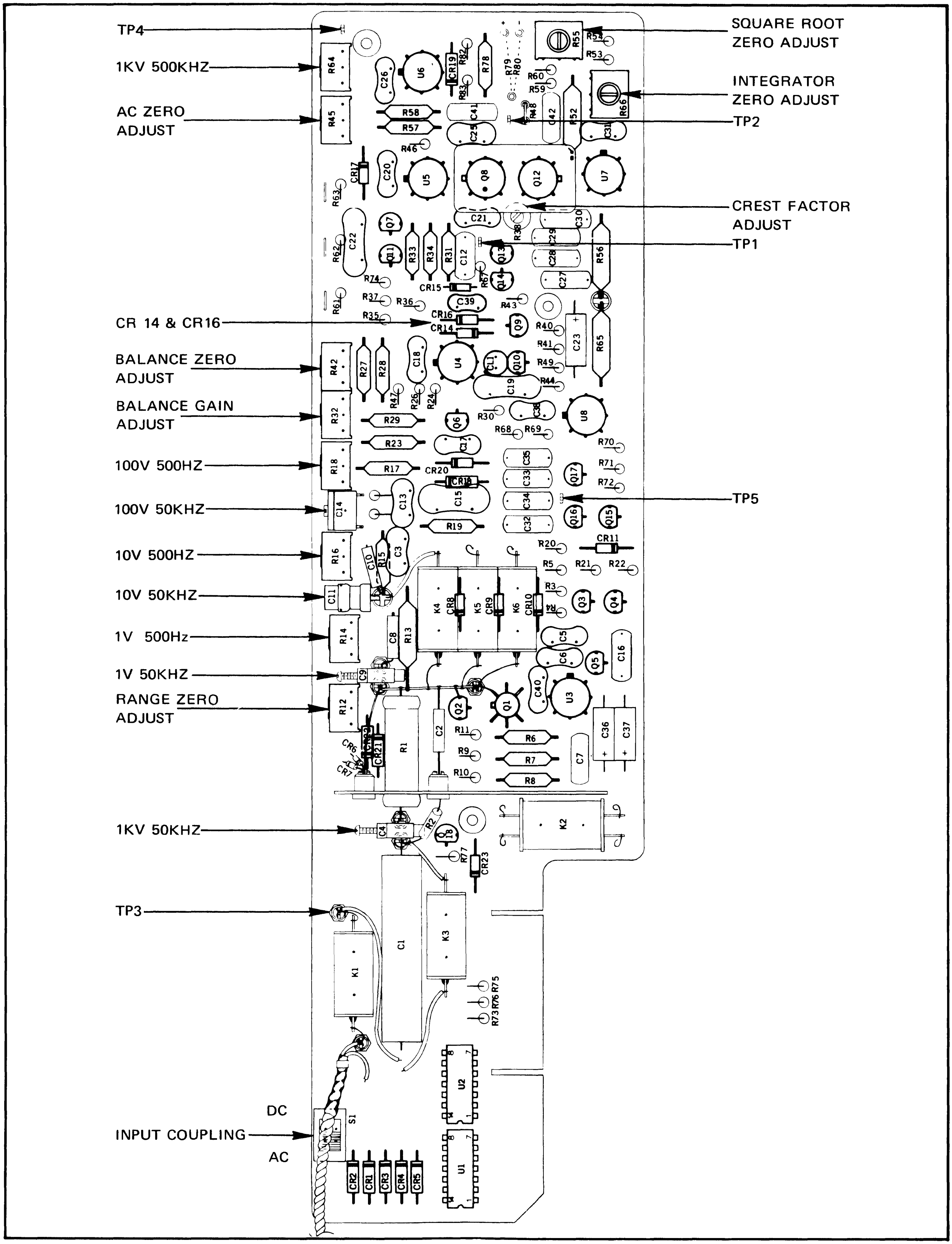


Figure 6-3. RMS CONVERTER ADJUSTMENTS AND TEST POINTS

6-38. TROUBLESHOOTING PROCEDURE

a Turn instrument on and allow to operate for at least 10 minutes. Erroneous indications may be observed if instrument does not have sufficient "warm-up" time.

b. Depress VAC and any range button.

c. Connect DC voltmeter between TP4 and common (shield).

d. Short HI to LO INPUT terminals. DC voltmeter should indicate within 100 millivolts of zero.

FAULT ANALYSIS

If indication is incorrect, go to step f.

e. Remove input terminal short and apply full range voltage at 500Hz. The dc voltmeter should indicate within 9.95 to 10.05 volts.

FAULT ANALYSIS

If indication is incorrect, go to step j.

f. Remove any INPUT voltage or short. Short TP1 to common (shield).

FAULT ANALYSIS

If dc voltmeter indication changes to within 100 millivolts of zero, go to step j.

g. Short TP1 and TP2 to TP5.

h. Connect dc voltmeter high lead to TP4. DC voltmeter should indicate within 100 microvolts of zero and adjustable with R66 (Integrator Amplifier Zero Adjust).

FAULT ANALYSIS

If indication is incorrect, troubleshoot Integrator Amplifier circuit.

i. Remove short at TP2 (maintain short between TP1 and common) and connect high lead of dc voltmeter to TP2. DC voltmeter should indicate within 200 millivolts of zero and be adjustable with R55 (Square Root Amplifier Zero Adjust).

FAULT ANALYSIS

If indication is incorrect, troubleshoot Square Root Amplifier circuit.

j Remove any input voltage, disconnect dc voltmeter and all shorts.

k. Connect a dc coupled scope with low capacitance probe to the threaded body of C11 (10V 50 kHz adjust) and common.

l. With no input voltage applied to 8400A, scope should indicate zero volts. With full range voltage at 500 Hz applied to 8400A, scope should indicate a clean sinewave of 2.8 volts peak-to-peak.

FAULT ANALYSIS

If scope indication is incorrect, troubleshoot Range Amplifier circuit.

m. Move scope probe to cathode of CR16 or anode of CR14.

n. With no input voltage applied to 8400A, scope should indicate within 100 millivolts of zero. With full range voltage at 500Hz applied to 8400A scope should indicate a clean halfwave rectified sinewave of 1.4 volts peak.

FAULT ANALYSIS

If scope indication is incorrect, troubleshoot Balance Amplifier Circuit.

o. Move scope probe to TP1.

p. With no input voltage applied to 8400A, scope should indicate within 100 millivolts of zero. With full range voltage at 500 Hz applied to 8400A, scope should indicate approximately –1.2 volts dc with a clean ac "scallop" superimposed.

FAULT ANALYSIS

If scope indication is incorrect, troubleshoot Squaring Amplifier.

6-39. PRE-CALIBRATION ADJUSTMENTS

6-40. Three adjustments within the RMS Converter are not readjusted during routine calibration. These adjustments are the Square Root Zero, Integrator Zero, and Crest Factor. It is recommended that these three adjustments be attempted only if previously moved or if components are replaced within the converter. Procedure for performing these adjustments is as follows:

a. With power off, extend the RMS Converter from the 8400A mainframe and remove shield from converter. Turn on power and allow instrument 10 minutes to stabilize.

b. Short INPUT terminals. Short TP1 and TP2 to common (shield). Connect dc voltmeter (Table 6-1) between TP4 (+) and TP5 (–).

c. Adjust R66, Integrator Zero Adjust, for 0 volts ±100 microvolts.

d. Remove short from TP2 and connect dc voltmeter (+) lead to TP2.

e. Adjust R55, Square Root Zero, for 0 volts ±200 millivolts.

f. Remove short from TP1 and disconnect dc voltmeter.

g. Complete Preliminary Operations of calibration procedure starting with paragraph 6-27 thru 6-31.

h. Connect equipment as diagramed in Figure 6-4. Set Model 8400A to ac coupling and auto range.

NOTE!

The following adjustment procedure is for crest factor. Crest factor (cf) is the relationship between the peak and rms value, such that $cf = V_{Peak}/V_{RMS}$.

i. Adjust generator repetition rate for 100 pulses per second (10 msec) and pulse width for a maximum indication on Model 931. (This will be a symmetrical waveform.)

j. Adjust generator negative output amplitude control for 1 volt rms indication on 931. This establishes a waveform with crest factor of 1. Note Model 8400A reading.

k. Adjust generator amplitude control for 4 volts peak to peak indication on scope and pulse width con-

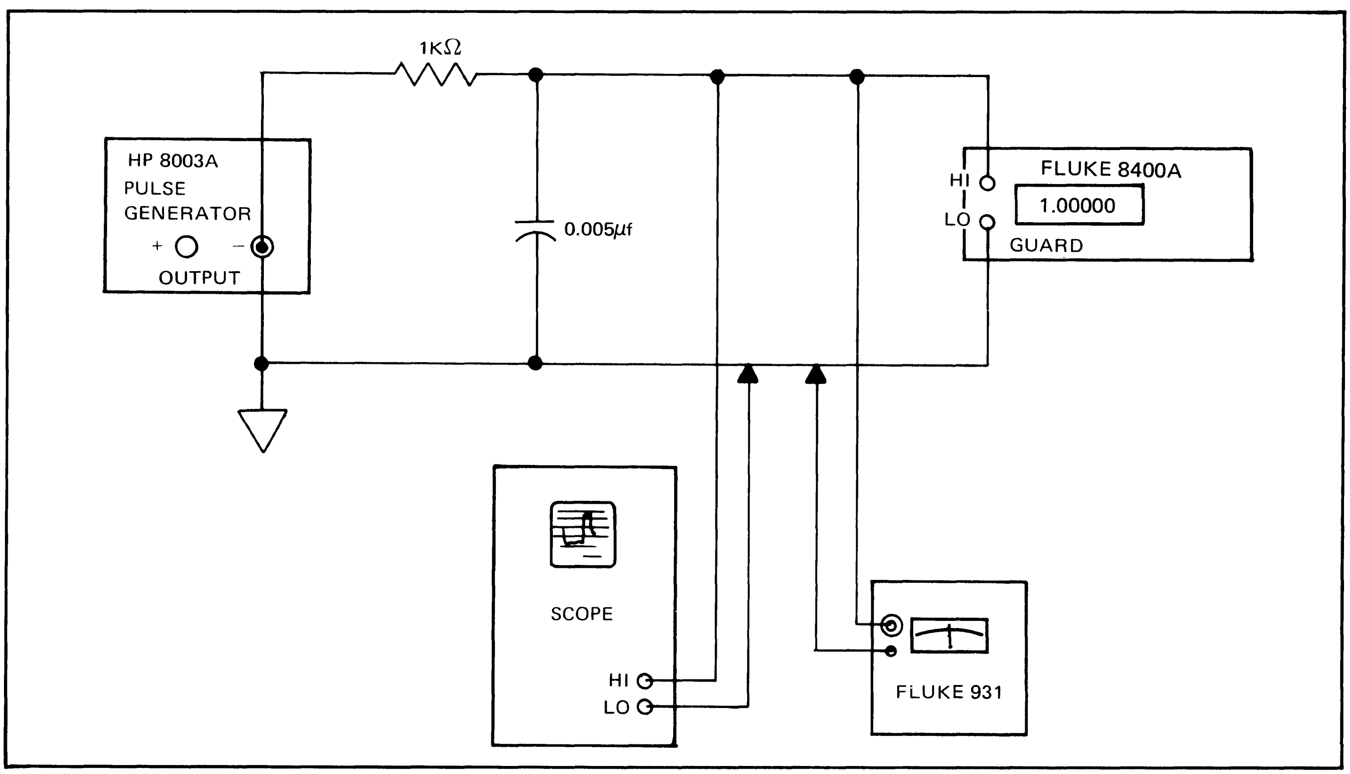


Figure 6-4. EQUIPMENT CONNECTIONS FOR CREST FACTOR ADJUST

trol for 1 volt RMS indication on Model 931. This establishes a waveform with crest factor of 4.

l. Adjust R38 (Crest Factor Adjust) for Model 8400A indication noted in step j.

m. Repeat steps b through e until difference between readings for crest factors of 1 and 4 is less than 10 digits.

n. Check positive polarity pulse with crest factor of 4 by connecting equipment to pulse generator positive output and make adjustments described in step k.

o. 8400A indication should be within 30 digits of finalized value noted in step j.

p. Turn power off. Disconnect all test equipment from 8400A. Re-install shield on RMS Converter and install the converter in 8400A mainframe. Install top guard and dust cover. Turn on instrument and allow to "warm-up" for one hour before performing Calibration Adjustment/Check, paragraph 6-30.

6-40. MATCHED COMPONENTS

6-41. A few components within the RMS Converter are matched at the factory. Two transistors, Q8 and Q9, are matched to each other. Resistors R56, R76, and R77 are factory selected for overall converter temperature coefficient and linearity which also affects Q8 and Q9. Should any of these components require replacement, a complete matched set will have to be ordered. In the case of replacement, the total set must be installed. Depending upon the matched set received, some or none of the three resistors may be included. Therefore, in positions where there is no resistor to install, a bus wire must be installed. Refer to List of Replaceable Parts for ordering information.

6-42. LIST OF REPLACEABLE PARTS

6-43. 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 6-44, this option subsection, for additional Use Codes and Serial Number Effectivity List assigned to this printed circuit assembly option.

6-44. SERIAL NUMBER EFFECTIVITY

6-45. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8400A. 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 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 54300
B	54400 and on.

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A22	**RMS CONVERTER (–09 Option)** **Figure 6-**	339309	REF		
C1	Cap, plstc, 0.22 uf ± 20%, 1200V	268904	1		
C2	Cap, porc, 2.7 pf ± 0.25 pf, 1700V	340745	1		
C3	Cap, mica, 220 pf ± 5%, 500V	170423	1		
C4,C9	Cap, var, teflon, 0.25 – 1.5 pf, 2kV	218206	2		
C5	Cap, mica, 22 pf ± 5%, 500V	148551	1		
C6	Cap, mica, 8 pf ± 10%, 500V	216986	1	A	
C6	Cap, mica, 4 pf ± 10%, 500V	190397		B	
C7,C34	Cap, plstc, 0.1 uf ± 10%, 250V	161992	2		
C8	Cap, porc, 2.2 pf ± 0.25 pf, 1700V	340273	1		
C10	Cap, porc, 27 pf ± 5%, 500V	344283	1		
C11	Cap, var, air, 0.8 – 10 pf, 250V	229930	1		
C12,C16, C41,C42	Cap, plstc, 0.047 uf ± 10%, 250V	162008	4		
C13	Cap, mica, 330 pf ± 1%, 500V	226142	1		
C14	Cap, var, cer, 9 – 35 pf, 350V	289637	1		
C15	Cap, mica, 3600 pf ± 2%, 500V	176644	1		
C17	Cap, mica, 15 pf ±5%, 500V	148569	1		
C18,C20	Cap, mica, 27 pf ±5%, 500V	177998	2		
C19,C22	Cap, mica, 1000 pf ±5%, 500V	178387	2		
C21,C40	Cap, mica, 2 pf ±0.5 pf, 500V	175208	2		
C23,C36, C37	Cap, Ta, 15 uf ± 10%, 20V	153056	3		
C24	Not Used				
C25	Cap, mica, 390 pf ± 5%, 500V	148437	1		
C26,C31, C38	Cap, mica, 33 pf ± 5%, 500V	160317	3		
C27,C30	Cap, plstc, 6800 pf ± 10%, 250V	342881	2		
C28,C29	Cap, plstc, 0.022 uf ± 10%, 250V	234484	2		
C32,C35	Cap, plstc, 0.033 uf ± 10%, 250V	234492	2		
C33	Cap, plstc, 4700 pf ± 10%, 250V	342873	1		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
C39	Cap, plstc, 0.1μf ± 10%, 250V	161992			B
CL1	Current regulator FET	285106	1		
CR1 thru CR5	Diode, germanium, 80 mA, 100 piv	149187	5		
CR6,CR7, CR20	Diode, silicon, 100 mA at 1.5V	261370	3		
CR8,CR9, CR10,CR11, CR17,CR23	Diode, silicon, 150 mA	203323	6		
CR12,CR13	Not Used				
CR14,CR16	Diode, silicon, 100 mA at 1.5V	161810	2		
CR15,CR18	Diode, zener, 10V	246611	2		
CR19	Diode, silicon, 10 mA, 2 piv	180554	1		
CR21,CR22	Diode, zener, 6.8V	260695	2		
K1,K3	Relay, reed switch Coil, relay Foil wrap	284091 269019 313833	2 5 2		
K2A,K2B, K4,K5,K6	Relay reed switch Coil, relay (K2) Coil, relay (K4,K5,K6) Foil wrap (K4,K5,K6)	289850 272070 269019 280008	5 1 REF 3		
Q1	Tstr, FET, dual, N-channel	267963	1		
Q2,Q6,Q7	Tstr, FET, N-channel	343103	3		
Q3,Q101,Q18 Q9	Tstr, silicon, NPN Tstr, sil, NPN	218396 218081	3 1		 B
Q4,Q11,Q15	Tstr, silicon, PNP	195974	3		
Q5,Q13,Q14 Q16,Q17	Tstr, FET, N-channel	288324	5		
Q8,Q12	Part of matched set	1	1		
R1	Res, met flm, 1M ± 0.1%, 1w	340265	1		
R2,R11	Res, comp, 12k ± 5%, ¼w	159731	2		
R3,R4,R5, R47	Res, comp, 51k ± 5%, ¼w	193334	4		
R6,R7,R31	Res, met flm, 50k ± 0.1%, 1/8w	340257	3		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R8	Res, met flm, 48.7k ± 1%, 1/8w	267385	1		
R9,R20, R35,R53, R59,R67, R70	Res, comp, 1M ± 5%, ¼w	182204	7		
R10	Res, comp, 390Ω ± 5%, ¼w	147975	1		
R12,R42, R45	Res, var, cermet, 1M ± 10%, ½w	334722	3		
R13	Res, met flm, 995k ± 0.1%, ½w	340158	1		
R14,R64	Res, var, cermet, 10k ± 10%, ½w	385171	2		
R15	Res, met flm, 110.6k ± 0.1%, 1/8w	340224	1		
R16	Res, var, cermet, 1k ± 10%, ½w	285155	1		
R17	Res, met flm, 10.05k ± 0.1%, 1/8w	340216	1		
R18	Res, var, cermet, 100Ω ± 10%, ½w	285130	1		
R19	Res, met flm, 1.001k ± 0.1%, 1/8w	340208	1		
R21,R72, R75	Res, comp, 22k ± 5%, ¼w	148130	3		
R22	Res, comp, 300k ± 5%, ¼w	234682	1		
R23	Res, met flm, 4.975k ± 0.1%, 1/8w	340232	1		
R24	Res, comp, 5.1k ± 5%, ¼w	193342	1		
R25	Not Used				
R26	Res, comp, 3.9k ± 5%, ¼w	148064	1		
R27	Res, met flm, 1M ± 1%, 1/8w	268797	1		
R28	Res, met flm, 100Ω ± 1%, 1/8w	168195	1		
R29	Res, met flm, 5k ± 0.1%, 1/8w	340240	1		
R30,R37	Res, comp, 6.8k ± 5%, ¼w	148098	2		
R32	Res, var, cermet, 50Ω ± 10%, ½w	285122	1		
R33	Res, met flm, 100k ± 0.1%, 1/8w	340166	1		
R34	Res, met flm, 35.7k ± 1%, 1/8w	288480	1		
R36	Res, comp, 68Ω ± 5%, ¼w	247918	1		
R38	Res, var, cermet, 3Ω ± 25% ½w	347963	1		
R39	Not Used				

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R40	Res, comp, 5.6k ± 5%, ¼w	148080	1		
R41	Res, comp, 56k ± 5%, ¼w	170738	1		
R43,R82	Res, comp, 1k ± 5%, ¼w	148023	2		
R44	Res, comp. 9.1k ± 5%, ¼w	193318	1		
R46	Res, comp, 560Ω ± 5%, ¼w	147991	1		
R48	Part of matched set, may not be installed	1	1		
R49,R83	Res, comp, 330Ω ± 5%, ¼w	147967	2		
R50	Res, comp, 100Ω ± 5%, ¼w	147926	1		
R51,R77	Res, comp, 82k ± 5%, ¼w	188458	2		
R52	Res, met flm, 2M ± 1%, ¼w	340323	1		
R54,R60	Res, comp, 470Ω ± 5%, ¼w	147983	2		
R55,R66	Res, var, cermet, 1M ± 10%, ½w	276691	2		
R56,R65	Res, met flm, 1M ± 0.25%, ¼w	340133	2		
R57	Res, met flm, 465k ± 0.25%, 1/8w	340315	1		
R58	Res, met flm, 499k ± 1%, 1/8w	268813	1		
R61	Res, met flm, 8.87k ± 1%, 1/8w	294967	1		
R62	Res, met flm, 17k ± 1%, 1/8w	236802	1		
R63	Res, met flm, 34k ± 1%, 1/8w	261602	1		
R68	Res, comp, 200k ± 5%, ¼w	248781	1		
R69	Res, comp, 750k ± 5%, ¼w	221937	1		
R71	Res, comp, 470k ± 5%, ¼w	188441	1		
R73	Res, comp, 47k ± 5%, ¼w	148163	1		
R74	Res, comp, 20k ± 5%, ¼w	221614	1		
R76	Res, comp, 180k ± 5%, ¼w	193441	1		
R78	Res, met flm, 10Ω ± 1%, 1/8w	268789	1		
R79,R80	Part of matched set, one or none may be installed	1			
R81	Not Used				
S1	Switch, slide SPDT	271478	1		
U1	IC, DTL, triple 3-Input Nand Gate	266312	1		
U2	IC, DTL, Quad 2-Input Nand Gate	288597	1		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
U3	IC, operational amplifier	329912	1		
U4	IC, operational amplifier	225961	1		
U5	IC, operational amplifier	288928	1		
U6,U7	IC, operational amplifier	284760	2		
U8	IC, operational amplifier	271502	1		
	Cable, Input	304048	1		
	Heat dissipator	347732	1		
	Cover, pcb	339366	1		

1 Q8, Q12, R48, R79, and R80 form a factory matched set. If any of these components require replacement, complete set must be installed. Order "TC Matched Set" part number 361048.

Accessory

Rack Mounting Fixtures

6-1. INTRODUCTION

6-2. The Model 8400A can be mounted in a standard 18-inch or 24-inch deep equipment rack. The rack mounting kits are as follows:

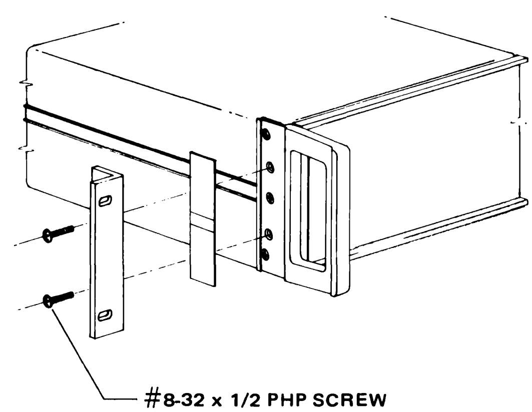
KIT NAME	RACK KIT NO.
18-inch Rack Slide	M00-260-610
24-inch Rack Slide	M00-280-610
Rack Ears	M03-203-601

6-3. INSTALLATION

6-4. Procedures for installation of rack mounting kits are given in the following illustrations. Each illustration is identified with a form number in the lower lefthand corner. This form number is related to the kit number as follows:

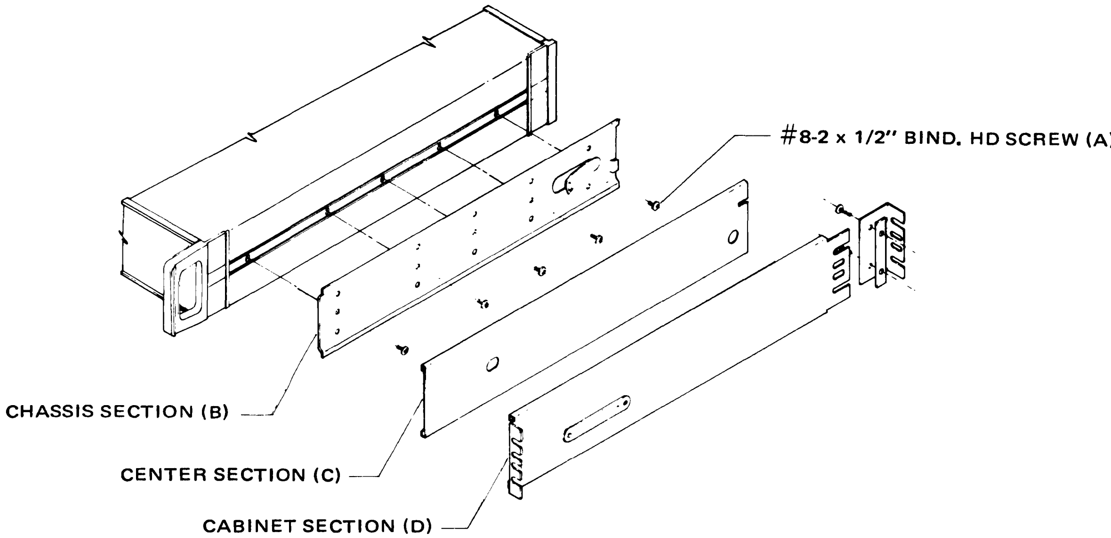
FORM NO.	RACK KIT
A404a	M03-203-601
A405	M00-260-610, M00-280-610

RACK MOUNTING PROCEDURE FOR MODULAR SERIES INSTRUMENTS



1. REMOVE THE FOUR MOLDED FEET AND BAIL FROM BOTTOM COVER.
2. REMOVE THE NAMEPLATE DECALS FROM THE FRONT CORNERS.
3. REMOVE THE SCREWS FROM CORNERS WHICH MATCH HOLE PATTERNS IN RACK MOUNTING EARS.
4. ATTACH RACK MOUNTING EARS WITH PAN HEAD SCREWS (ENCLOSED).

A404a 2/71



1. REMOVE SIDE TRIM DECAL AND BOTTOM FEET FROM INSTRUMENT.
2. ATTACH CHASSIS SECTION (B) OF SLIDE TO INSTRUMENT WITH # 8-32 x 1/2" PHP SCREWS (A) (ENCLOSED) AS FOLLOWS:
   A. FOR 3–1/2", 7" AND 10–1/2" HIGH INSTRUMENTS UTILIZE THE CENTER ROW MOUNTING HOLES.
   B. FOR 5–1/4" AND 8–3/4" HIGH INSTRUMENTS UTILIZE EITHER THE UPPER OR LOWER ROW OF MOUNTING HOLES.
3. INSTALL CABINET SECTION (D) AND CENTER SECTION (C) OF SLIDE INTO RACK (EXTENSION ANGLE BRACKET AND HARDWARE ENCLOSED).
4. EXTEND CENTER SECTION (C) OF SLIDE TOWARD OPERATOR UNTIL IT LOCKS IN EXTENDED POSITION.
5. DEPRESS SPRING LOCK ON CHASSIS SECTION (B) AND INSERT INSTRUMENT BETWEEN EXTENDED SLIDE SECTIONS.

Form No. A405-3/71- Rev. 1

Accessory

DOU, RCU Mating Connector

6-1. INTRODUCTION

6-2. The mating connector shown in Figure 6-1 is required for interface between the Remote Control Unit and the programming equipment. It also provides interface between Data Output Unit No. 1 & 2 and external equipment. This connector is obtained when either option is ordered, or can be obtained by ordering from the factory, referencing FLUKE PART NO. 321687.

6-3. ASSEMBLY INSTRUCTIONS

6-4. Wiring and assembly of the mating connector is done as follows:

a. Solder the wiring to the appropriate terminals of the connector. Refer to Figure 6-1, detail I for terminal locations. Functional pin assignments for the Remote Control Unit and the Data Output Unit No. 1 & 2 can be found in Section 2.

b. Mount alignment spacers (F) between proper pins on Connector (B). Spacer positions are given in Figure 6-2.

c. Mount Connector (B) into Backshell half (C). Refer to detail II of Figure 6-1.

d. Mount Backshell half (A) onto Backshell half (C). When correctly mounted together, the Backshell halves snap in place.

e. Secure Backshell halfs (A) and (C) together with 4 screws (D), supplied.

f. Secure Connector (B) to Backshell halfs (A) and (C) with two screws (E), supplied.

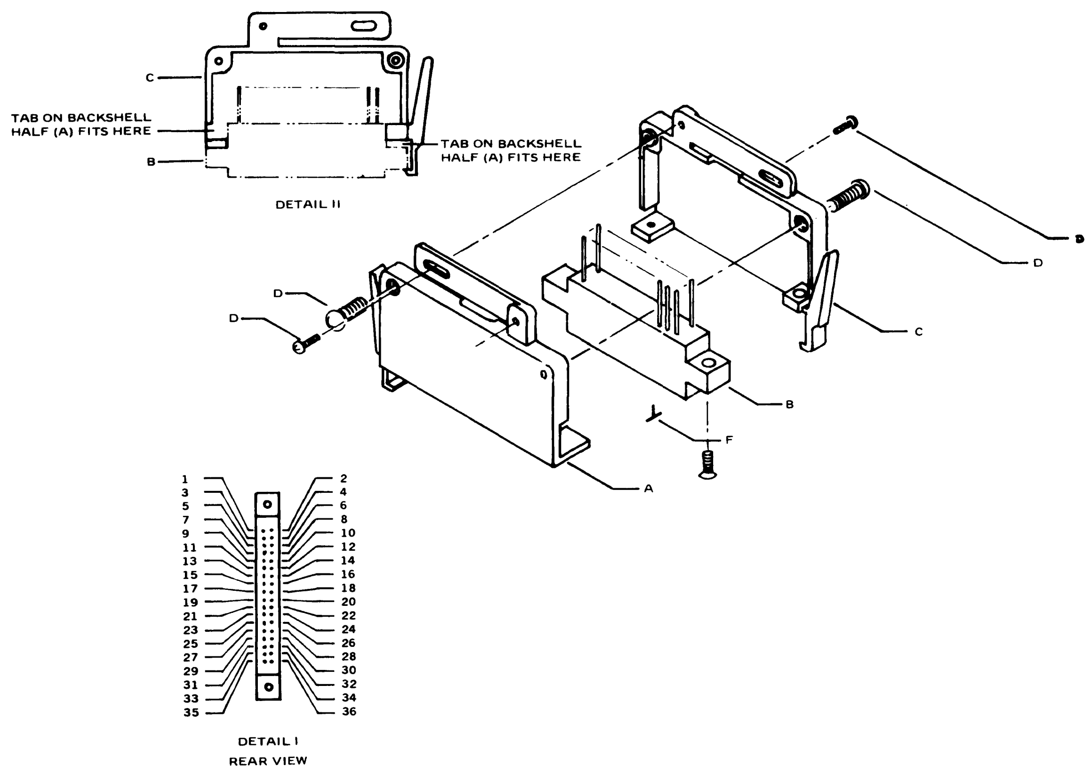


Figure 6-1. DOU, RCU MATING CONNECTOR

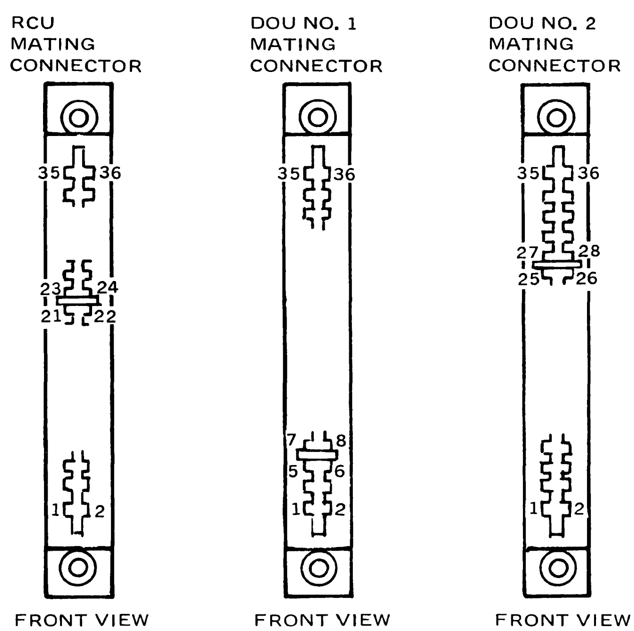


Figure 6-2. ALIGNMENT SPACER POSITIONS

Accessory

Rear Input Mating Connector

6-1. INTRODUCTION

6-2. The mating connector shown in Figure 6-1 is required for interface between the rear panel INPUT connector and external equipment. This connector is obtained when the Rear Input Option (–07) is ordered, or can be obtained from the factory by referencing FLUKE PART NO. 321661.

6-3. ASSEMBLY INSTRUCTIONS

6-4. Wiring and assembly of the mating connector is done as follows:

a. Solder wiring to connector pins (B).

b. Insert connector pins (B) into Connector (A). Refer to Figure 6-1 for terminal locations. Refer to the rear panel decal for functional pin assignments.

c. Mount and secure Cable Clamps (C) onto Connector (A) with proper hardware (D).

d. Secure Cable Clamps (C) together with screws (E).

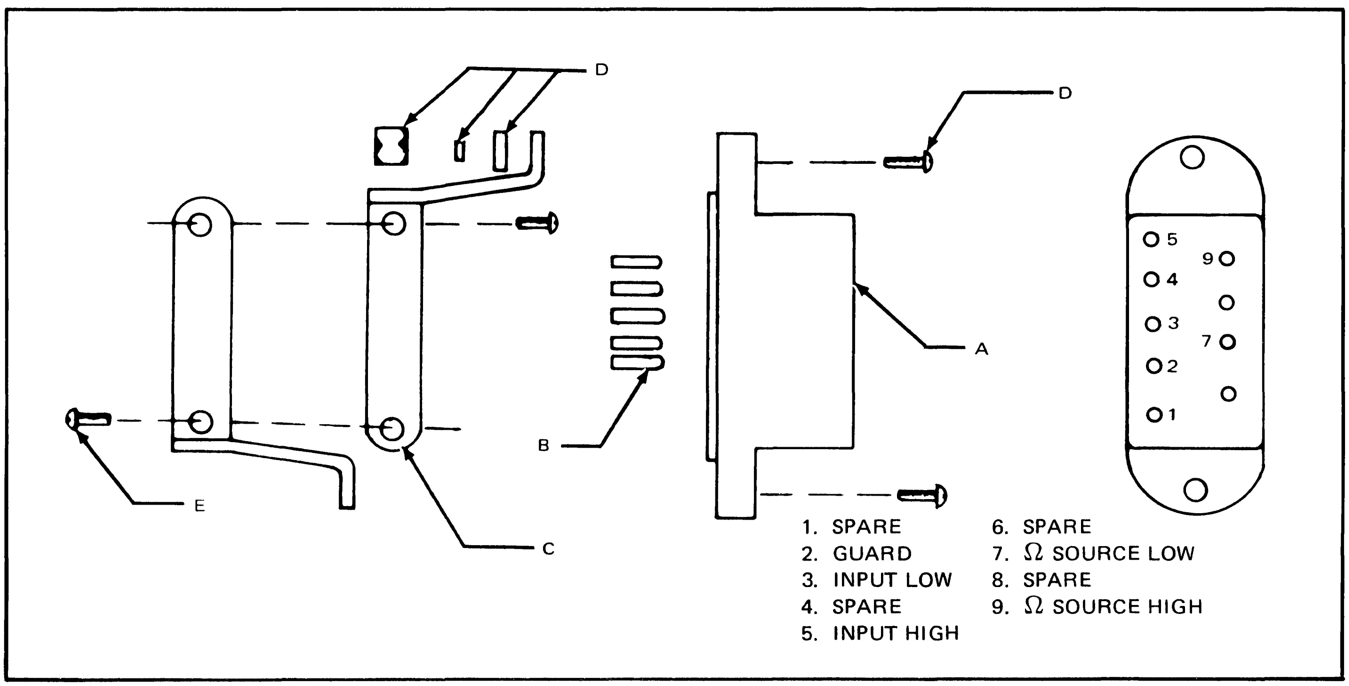


Figure 6-1. REAR INPUT MATING CONNECTOR

Accessory

External Reference Mating Connector

6-1. INTRODUCTION

6-2. The mating connector shown in Figure 6-1 is required for interface between the DC and AC External Reference connector and the external equipment. This connector is obtained when either option is ordered, or can be obtained by ordering from the factory by referencing FLUKE PART NO. 321679.

6-3. ASSEMBLY INSTRUCTIONS

6-4. Wiring and assembly of the mating connector is done as follows:

a. Solder the wiring to Terminals (B).

b. Insert Terminals (B) in Connector (A). Refer to Figure 6-1 for terminal locations. Rear panel decal on instrument shows pin connections from External Reference Assembly to Connector.

c. Mount Cable Clamps (C) onto Connector (A) and secure with hardware (D) to Connector (A).

d. Secure both halfs of Cable Clamp (C) together with screws (E).

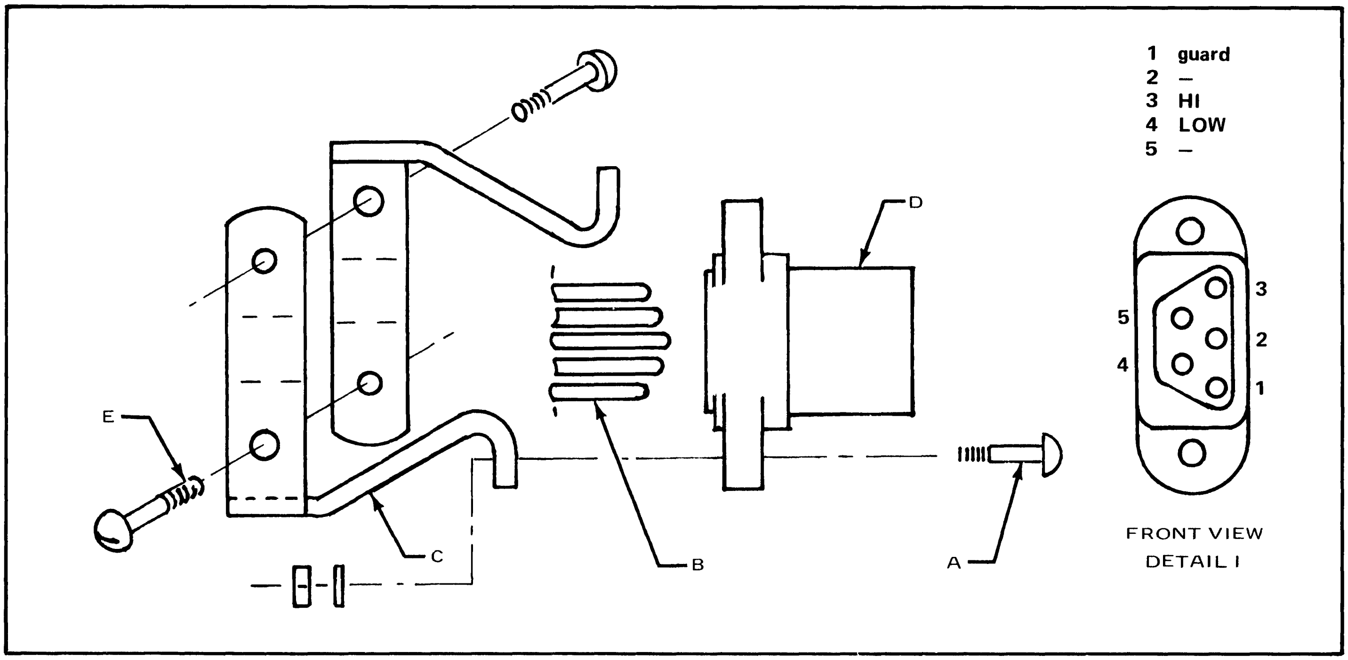


Figure 6-1. EXTERNAL REFERENCE MATING CONNECTOR

Accessory

Extender Card

6-1. INTRODUCTION

6-2. The Extender Card shown in Figure 6-1 is available as an Accessory for the FLUKE 8400A digital voltmeter. This accessory permits the printed circuit boards in the Model 8400A to be extended for servicing. The Extender Card can be obtained by ordering it under FLUKE PART NO. 298265.

6-3. INSTALLATION

6-4. To install a printed circuit board on the Extender Card proceed as follows:

a. Disconnect 8400A from line power.

b. Remove top dust and guard covers from instrument.

c. Locate the printed circuit board to be serviced and remove it from the instrument.

d. Install the Extender Card into the connector vacated by the removal of the printed circuit board.

e. Install the printed circuit board into the connector on the Extender Card. The printed circuit board must face the same direction as it did when installed into the instrument.

f. Connect 8400A to line power and turn on instrument. The printed circuit board can now be serviced.

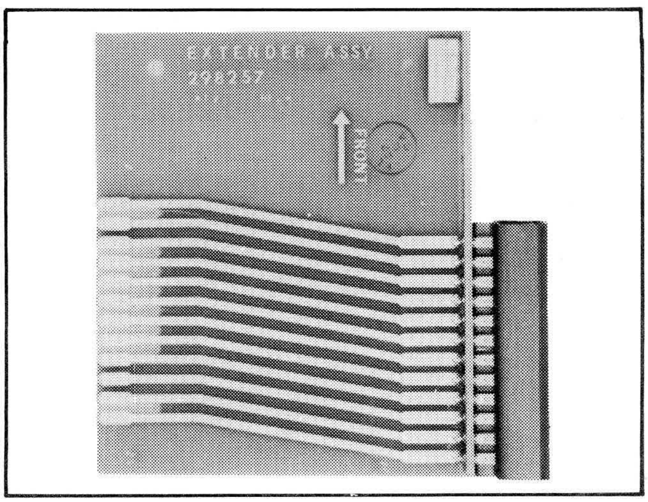


Figure 6-1. EXTENDER CARD

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.

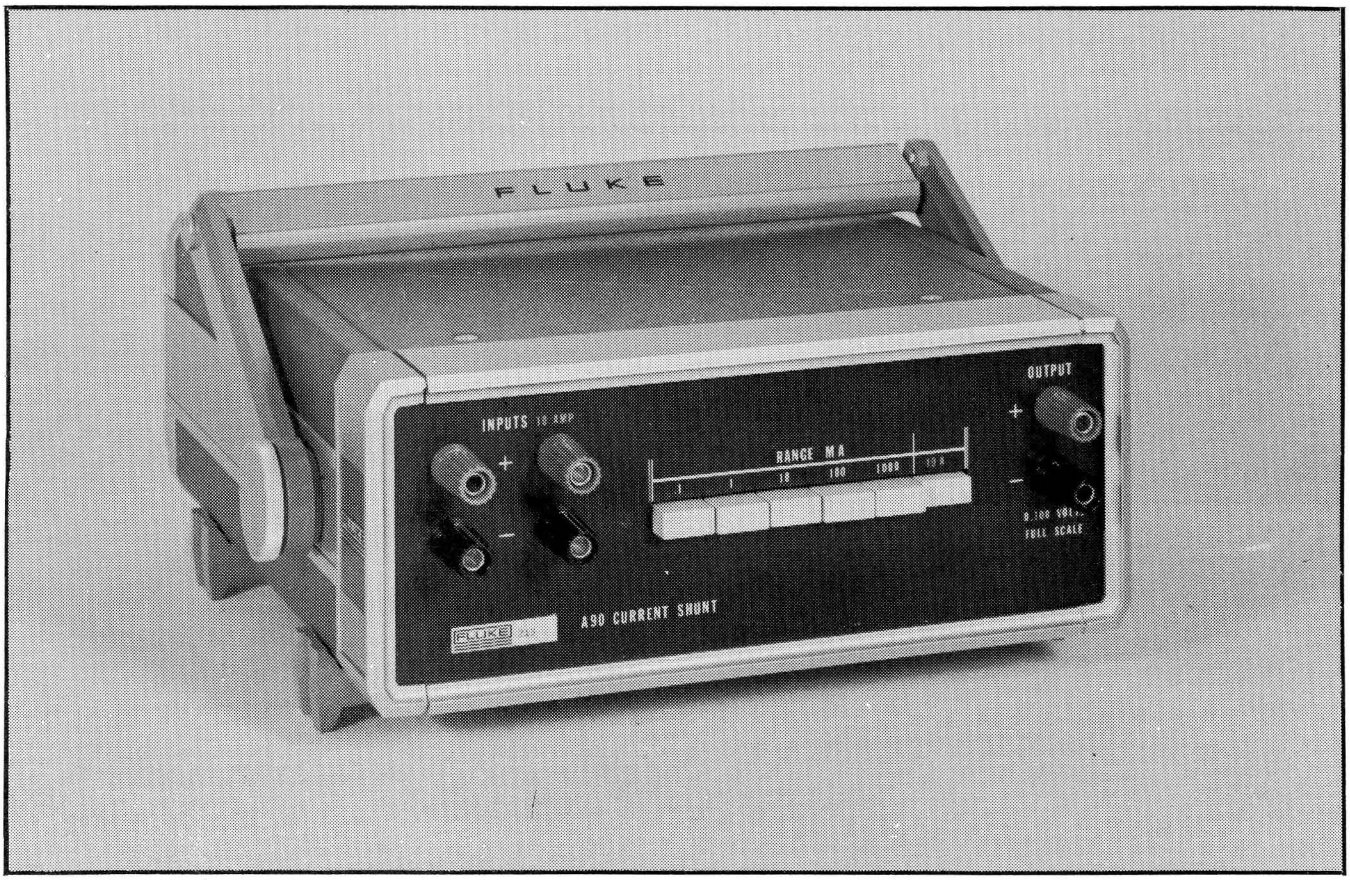
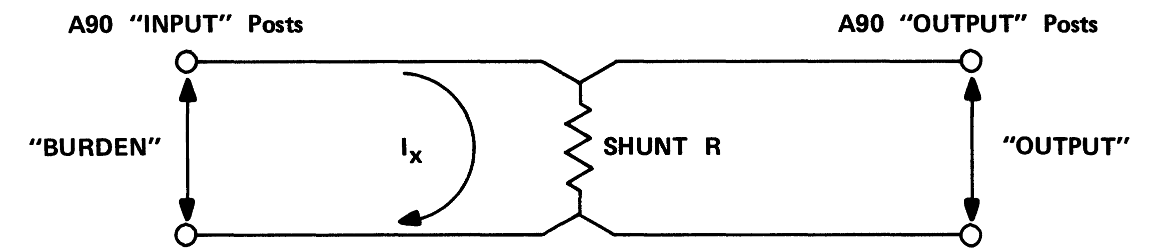


Figure 6-1. MODEL A90 CURRENT SHUNT

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

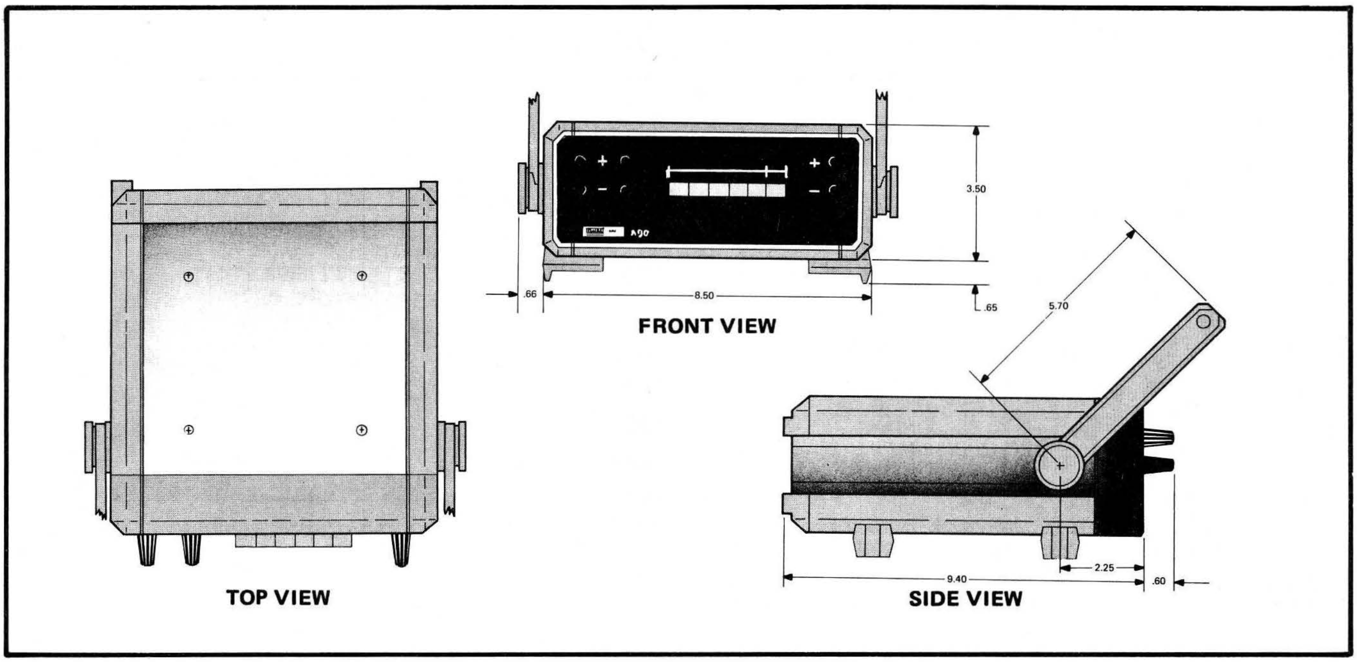


Figure 6-2. MODEL A90 OUTLINE DRAWING

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°C ±1°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°C ±1°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°C ±1°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/°C 20 Hz –50 Hz
0.004% of current input/°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.

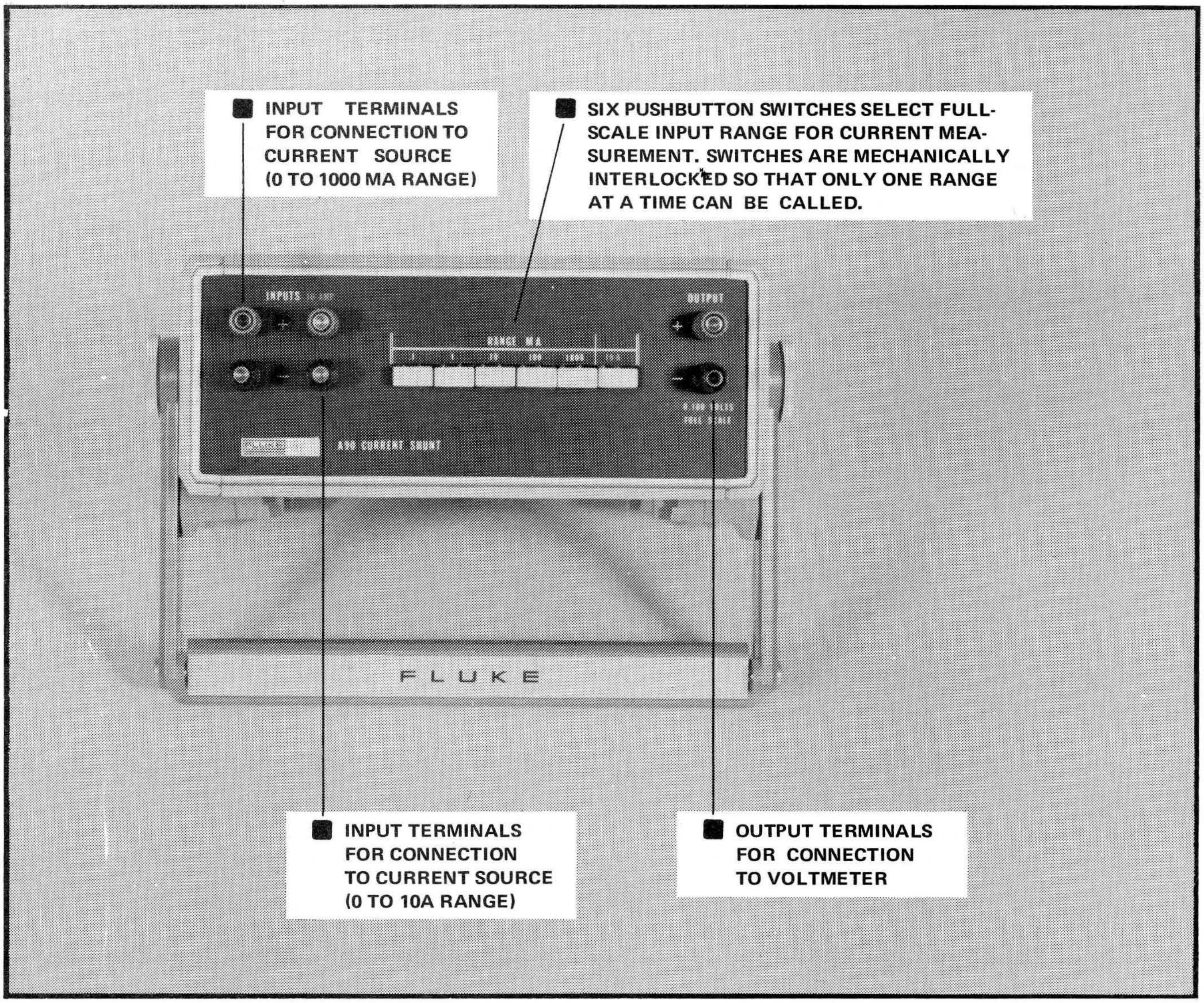


Figure 6-3. MODEL A90 CONTROLS AND TERMINALS.

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-

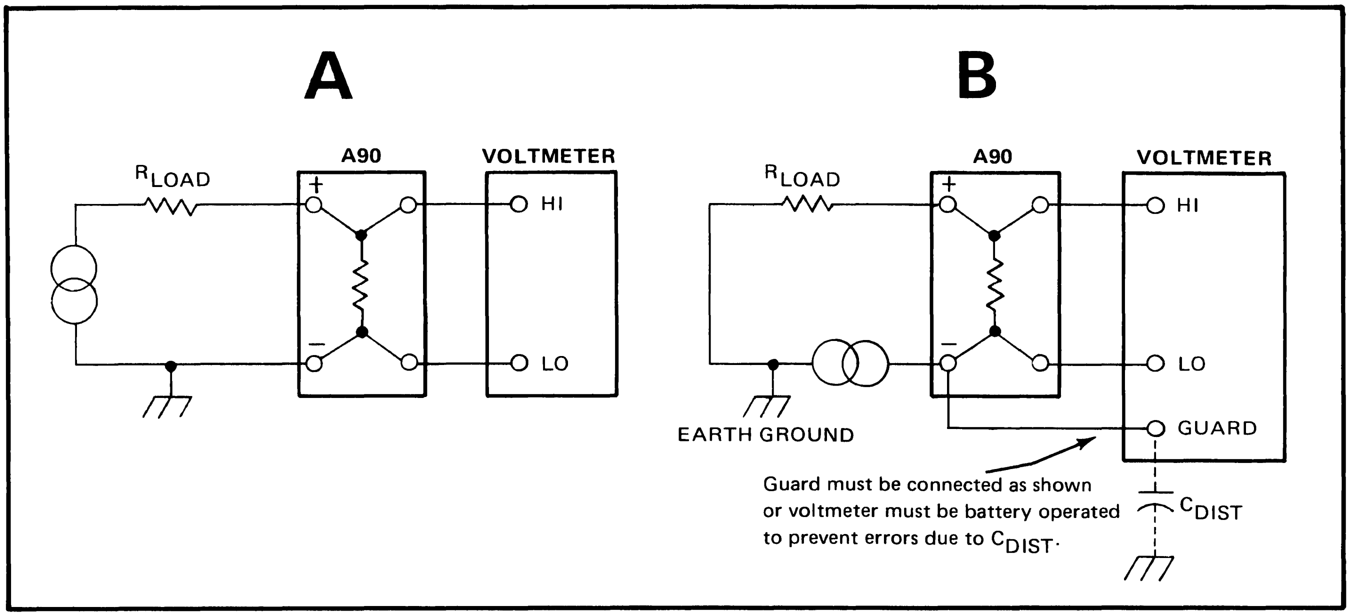


Figure 6-4. EQUIPMENT CONNECTIONS FOR CURRENT MEASUREMENT.

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

$$+\ 0.0\ \% \qquad \pm\ 0.2\ \%\text{ of input}\ +\ 25\ \text{uv}$$

"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

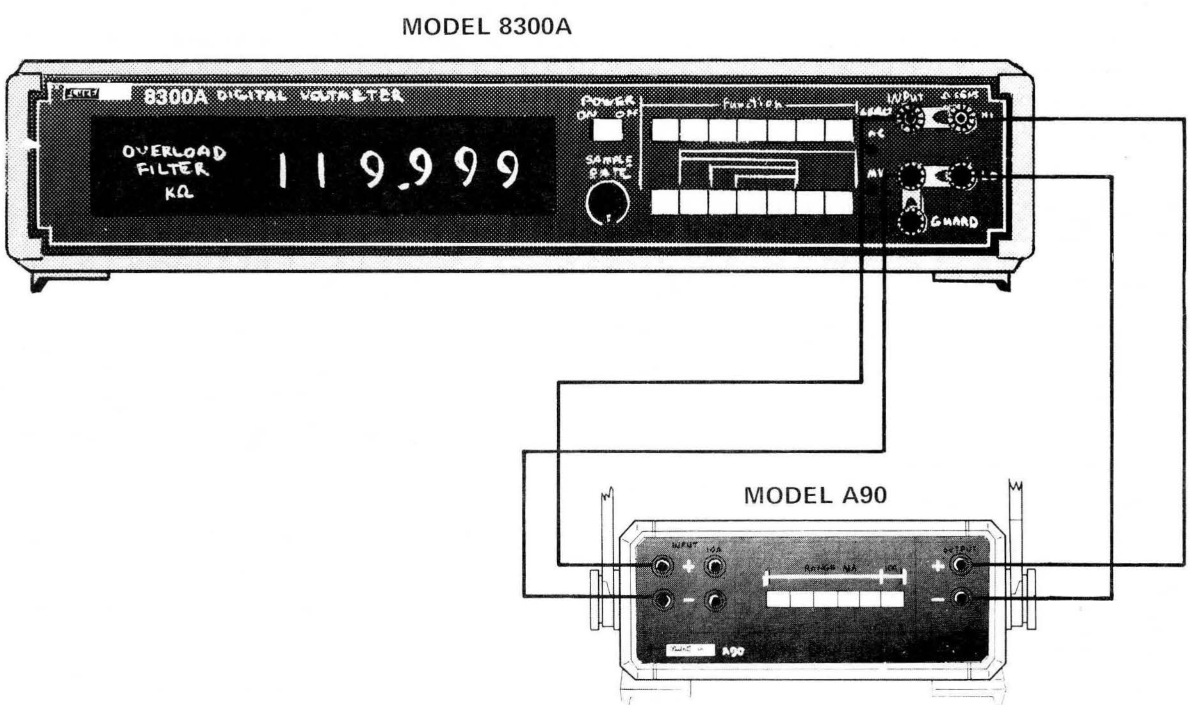


Figure 6-7. EQUIPMENT CONNECTIONS – .1 MA AND 1 MA RANGE CHECKS

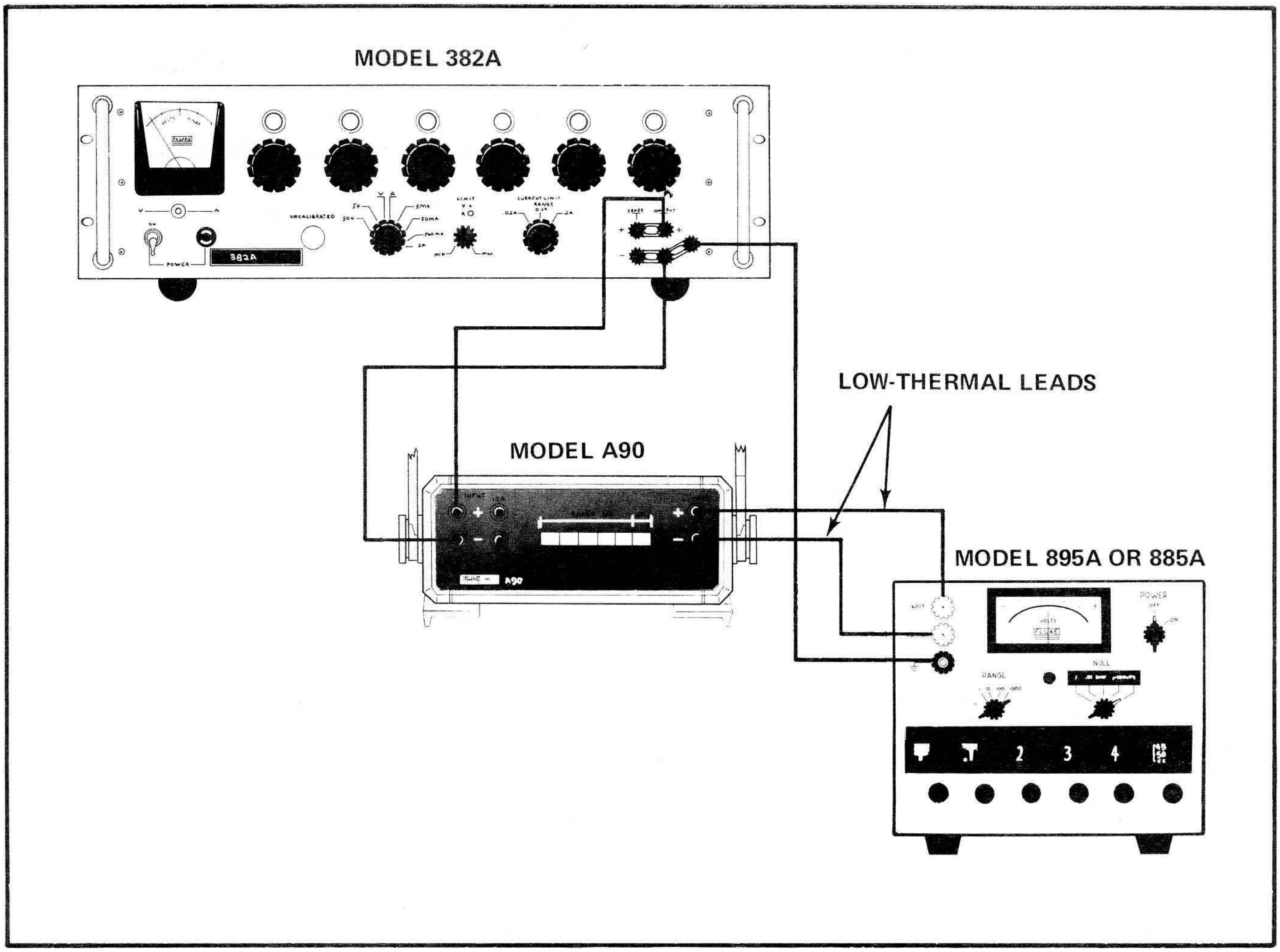


Figure 6-8. EQUIPMENT CONNECTIONS – 10 MA, 100 MA, AND 1000 MA RANGE CHECKS

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		

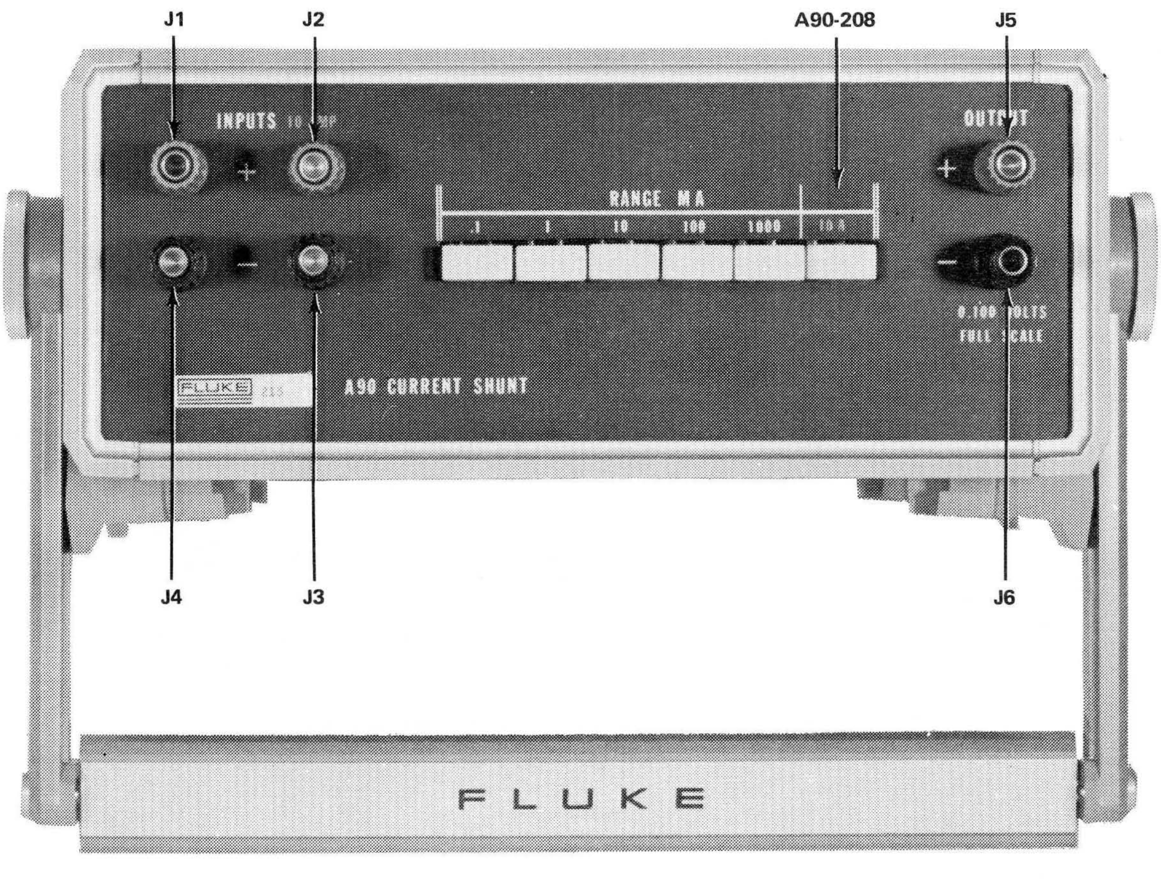


Figure 6-9. MODEL A90 CURRENT SHUNT (Sheet 1 of 2)

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		

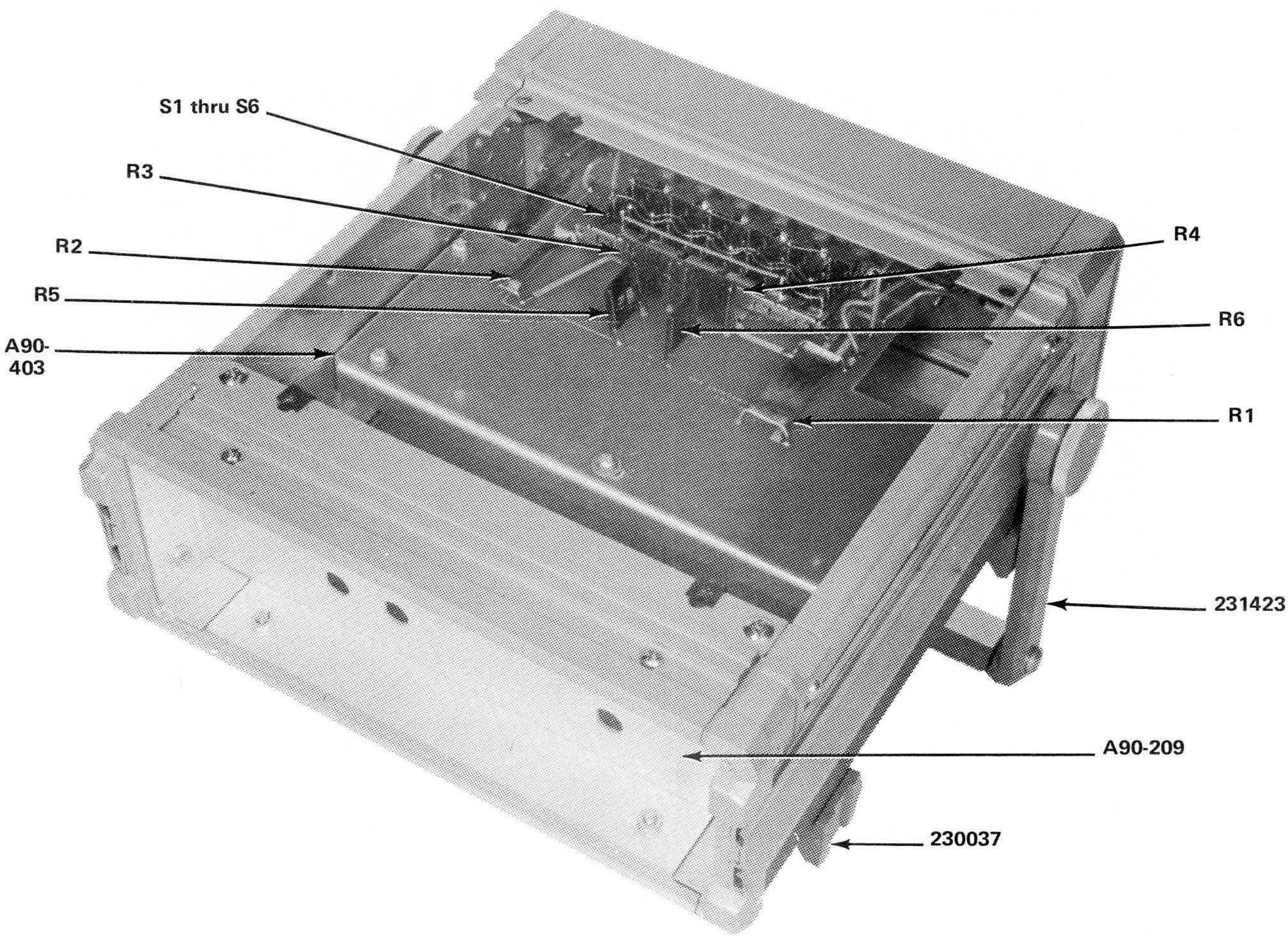
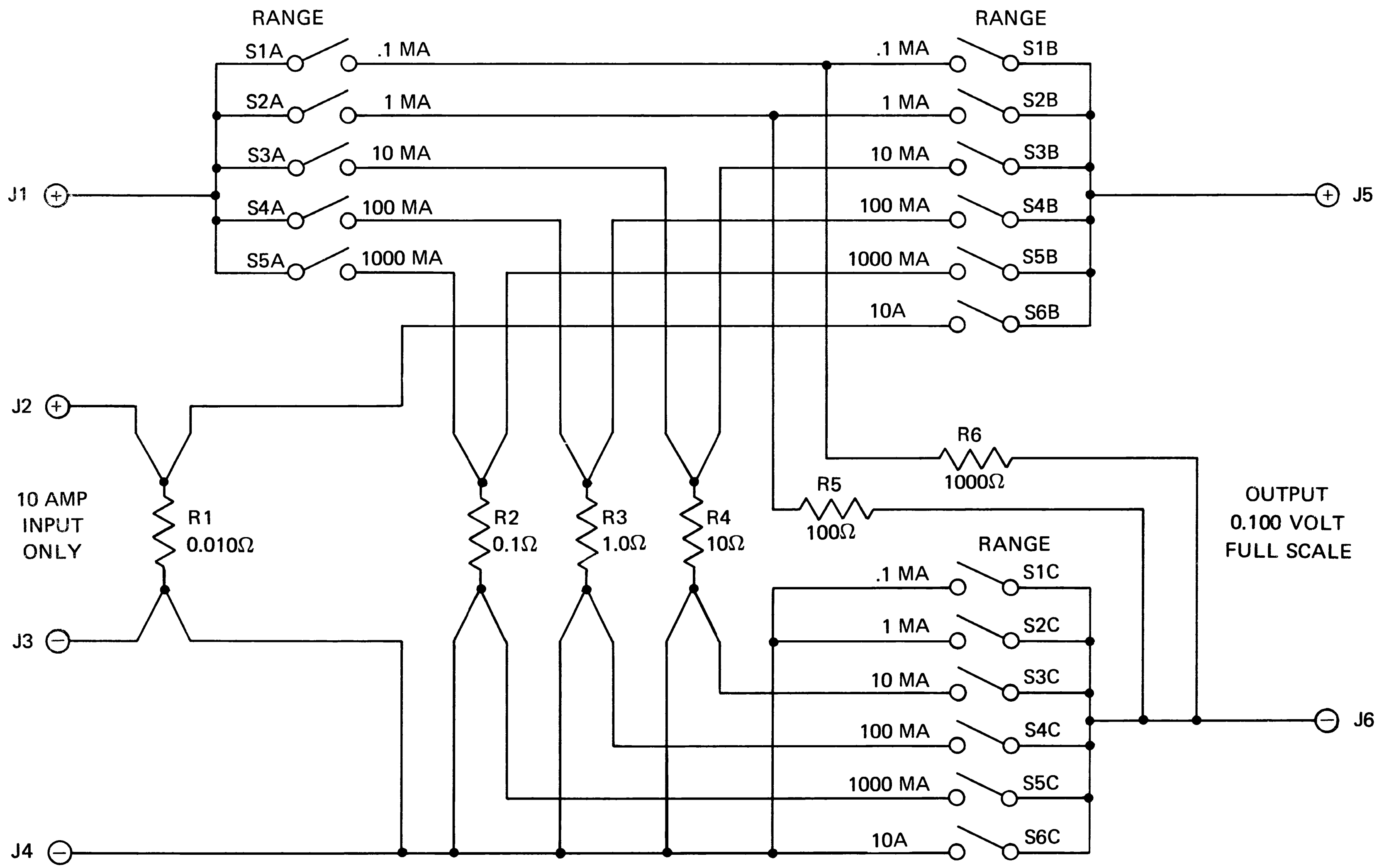


Figure 6-9. MODEL A90 CURRENT SHUNT (Sheet 2 of 2)



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

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.

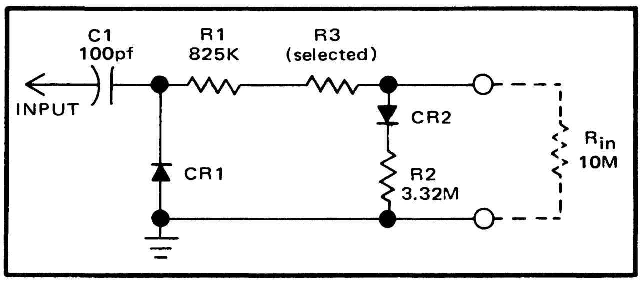


Figure 6-1. SCHEMATIC

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).

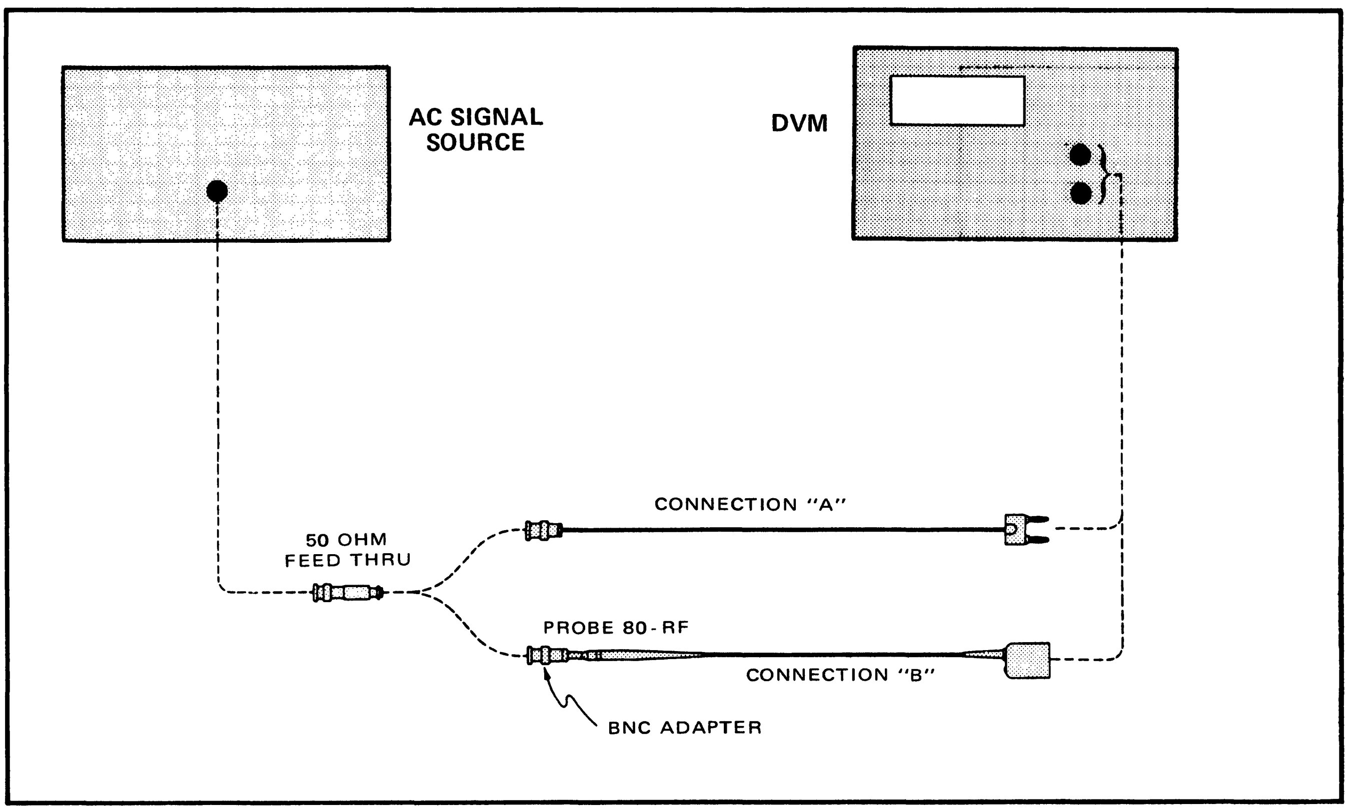


Figure 6-2. LOW FREQUENCY RESPONSE CHECK

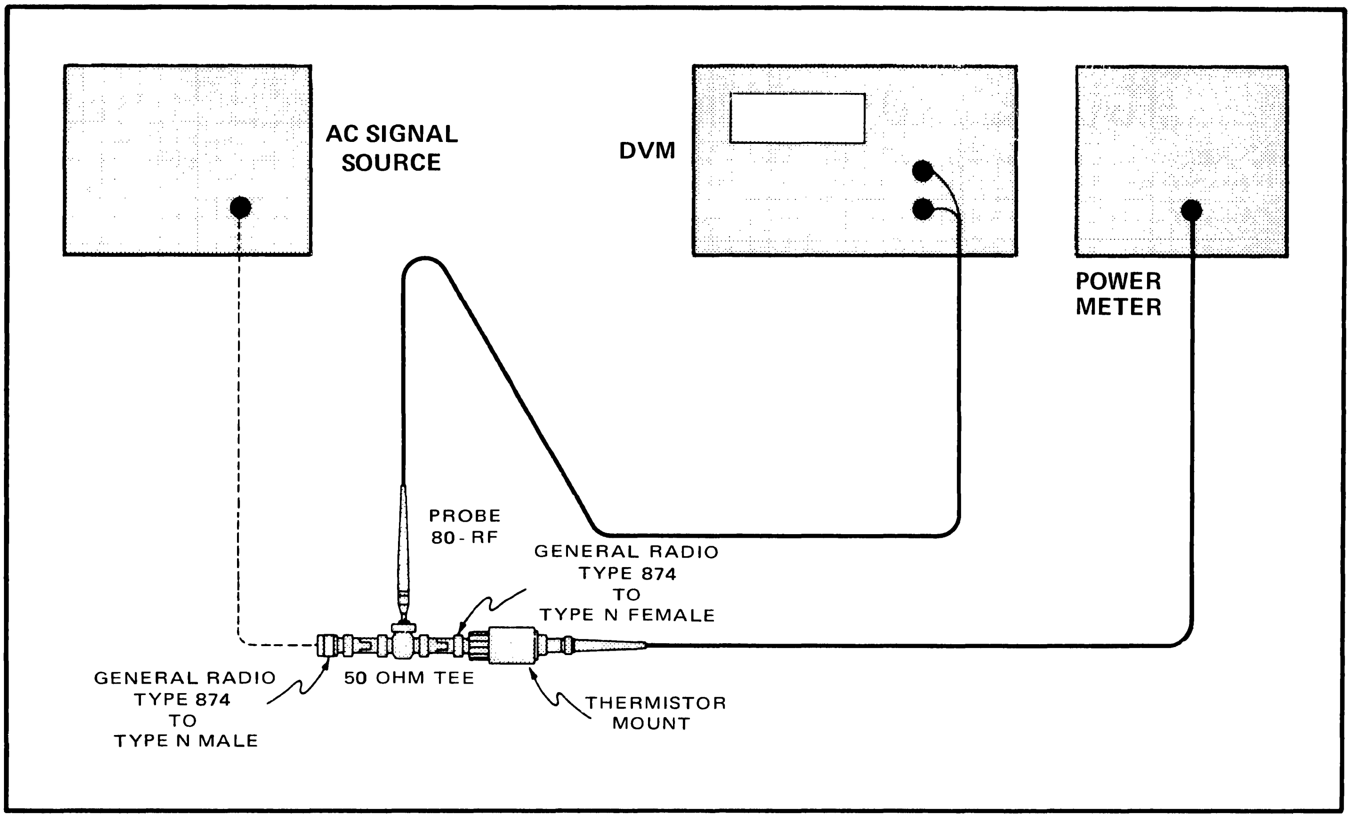


Figure 6-3. HIGH FREQUENCY RESPONSE CHECK

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.

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.

Federal Supply Codes for Manufacturers

D9816
Westermann Wilhelm Augusta-Anlage
Mannheim-Nackarau Germany

S0482
Sony Corp.
Tokyo, Japan

S3774
Oshino Electric Lamp Works
Tokoyo, Japan

0AD86
IN General
El Paso, TX

0AE89
Autosplice Inc.
Woodside, NY

0BW21
Noritake Co. Inc.
Burlington, MA

0ANF0
Topaz Semiconductor Inc
San Jose, CA

0DSM7
Conductive (Pkg) Containers Inc.
Brookfield, WI

0CLN7
Emhart Fastening Group
Shelton, CT

0FB81
S-Mos Systems Inc.
San Jose, CA

0FFP1
Eveready LTD
Ever Ready Special Battery Div.
Dawley Telford Salop UK

00199
Marcon Electronics Corp
Keamy, NJ

00213
Nytronics Comp. Group Inc.
Darrlingon, NC

00327
Welwyn International Inc.
Westlake, OH

00656
Aerovox Corp.
New Bedford, MA

00686
Film Capacitors Inc.
Passaic, NJ

00779
AMP, Inc.
Harrisburg, Pennsylvania

00853
Sangamo Weston Inc
Components Div
Pickens, NC

01091
Allied Plastics Co.
Los Angeles, CA

01101
Wabash Inc
(Formerly Wabash Magnetics)
Wabash, IN

01121
Allen Bradley Co.
Milwaukee, WI

01281
TRW Electronics & Defense Sector
R F Devices
Lawndale, CA

01295
TX Instruments Inc.
Semiconductor Group
Dallas, TX

01526
Genicom
Waynesboro, VA

01537
Motorola Communications &
Electronics Inc.
Franklin Park, IL

01686
RCL Electronics/Shallcross Inc.
Electro Components Div.
Manchester, NH

01884
Sprague Electric Co.
(Now 56289)

01961
Varian Associates Inc.
Pulse Engineering Div.
Convoy, CT

01963
Cherry Electrical Products Corp
Waukegan, IL

02111
Spectrol Electronics Corp.
City of Industry, CA

02114
Amperex Electronic Corp.
Ferrox Cube Div.
Saugerties, NY

02131
General Instrument Corp.
Government Systems Div.
Westwood, MA

02395
Sonar Radio Corp.
Hollywood, FL

02533
Leigh Instruments Ltd.
Frequency Control Div.
Don Mills, Ontario, Canada

02606
Fenwal Labs
Division of Travenal Labs
Morton Grove, IL

02660
Bunker Ramo-Eltra Corp.
Amphenol NA Div.
Broadview, IL

02697
Parker-Hannifin Corp.
O-Ring Div
Lexington, KY

02735
RCA-Solid State Div.
Somerville, NJ

02768
ITW (IL Tool Works)
Fastex Division
Des Plaines, IL

02799
Arco Electronics Inc.
Chatsworth, CA

03296
Nylon Molding Corp.
Monrovia, CA

03445
Lercon Electronics Inc
Burbank, CA

03508
General Electric Co.
Semiconductor Products
& Batteries
Auburn, NY

03797
Genisco Technology Corp.
Eltronics Div.
Rancho Dominquez, CA

03877
Gilbert Engineering Co.Inc
Incon Sub of Transitron
Electronic Corp.
Glendale, AZ

03888
KDI Electronics Inc.
Pyrofilm Div.
Whippany, NJ

03911
Clairex Corp.
Clairex Electronics Div.
Mount Vernon, NY

03980
Muirhead Inc.
Mountainside, NJ

04009
Cooper Industries, Inc.
Arrow Hart Div.
Hartford, CT

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, CA

04221
Midland-Ross Corp.
Midtex Div.
N. Mankato, MN

04222
AVX Corp.
AVX Ceramics Div.
Myrtle Beach, SC

04423
Telonic Berkley Inc.
Laguna Beach, CA

04713
Motorola Inc.
Semiconductor Group
Phoenix, AZ

04946
Standard Wire and Cable
Rancho Dominquez, CA

05173
General Radio
NY,NY.
Replaced by:

24655
Genrad,INC.
Concord, MA

05236
Jonathan Mfg. Co.
Fullerton, CA

05245
Corcom Inc.
Libertyville, IL

05276
ITT Pomona
Electronics Div.
Pomona, CA

05277
Westinghouse Elec. Corp.
Semiconductor Div.
Youngwood, PA

05347
Ultronix Inc
Grand Junction, CO

05397
Union Carbide Corp.
Materials Systems Div.
Cleveland. OH

05571
Sprague Electric Co.
(Now 56289)

05574
Viking Connectors Inc
Sub of Criton Corp.
Chatsworth, CA

05791
LYN-TRON
Burbank, CA

05820
EG & G Wakefield Engineering
Wakefield, MA

05839
Advance Electrical
Chicago, IL

05972
Loctite Corp.
Newington, CT

06001
General Electric Co.
Electric Capacitor Product
Section
Columbia, SC

06141
Fairchild Weston Systems Inc.
Data Systems Div.
Sarasota, FL

06192
La Deau Mfg. Co.
Glendale, CA

06229
Electrovert Inc.
Elmsford, NY

06383
Panduit Corp.
Tinley Park, IL

06473
Bunker Ramo Corp.
Amphenol NA Div.
SAMS Operation
Chatsworth, CA

06540
Mite Corp
Amatom-Electrical Div

06555
Beede Electrical Instrument
Penacook, NH

06665
Precision Monolithics
Sub of Bourns Inc.
Santa Clara, CA

06666
General Devices Co. Inc.
INpolis, IN

06739
Electron Corp.
Littleton, CO

06743
Gould Inc.
Foil Div.
Eastlake, OH

06751
Components Inc.
Semcor Div.
Phoenix, AZ

06776
Robinson Nugent Inc.
New Albany, IN

06915
Richco Plastic Co.
Chicago, IL

06961
Vernitron Corp.
Piezo Electric Div.
Bedford, OH

06980
EIMAC
(See Varian)
San Carlos, CA

07047
Ross Milton Co., The
Southampton, PA

07138
Westinghouse Electric Corp.
Industrial & Government
Tube Div.
Horseheads, NY

07233
Benchmark Technology Inc.
City of Industry, CA

07239
Biddle Instruments
Blue Bell, PA

07256
Silicon Transistor Corp.
Sub of BBF Inc.
Chelmsford, MA

07261
Avnet Corp.
Culver City, CA

07263
Fairchild Semiconductor
North American Sales
Ridgeview, CT

07344
Bircher Co. Inc., The
Rochester, NY

07374
Optron Corp
Woodbridge, CT

07557
Campion Co. Inc.
Philadelphia, PA

07597
Burndy Corp.
Tape/Cable Div.
Rochester, NY

07716
TRW Inc. (Can use 11502)
IRC Fixed Resistors/
Burlington
Burlington, VT

07792
Lerma Engineering Corp.
Northampton, MA

07810
Bock Corp.
Madison, WI

07910
Teledyne Semiconductor
Mtn. View, CA

07933
Raytheon Co.
Semiconductor Div.
Mountain View, CA

08FG6
Calmos Systems Inc.
Kanata, Ont. Canada

080A9
Dallas Semiconductor
Dallas, TX

08111
MF Electronics
New Rochelle, NY

08235
Industro Transistor Corp.
Long Island City, NY

08261
Spectra-Strip
An Eltra Co.
Garden Grove, CA

08445
Electri-Cord Mfg., Inc
Westfield, PA

08530
Reliance Mica Corp.
Brooklyn, NY

08718
ITT Cannon Electric
Phoenix Div.
Phoenix, AZ

08806
General Electric Co.
Minature Lamp Products
Cleveland, OH

08863
Nylomatic
Fallsington, PA

08988
Skottie Electronics Inc.
Archbald, PA

09021
Airco Inc.
Airco Electronics
Bradford, PA

09023
Cornell-Dublier Electronics
Fuquay-Varina, NC

09214
General Electric Co.
Semiconductor Products Dept.
Auburn, NY

09353
C and K Components Inc.
Newton, MA

09423
Scientific Components Inc.
Santa Barbara, CA

09922
Burndy Corp.
Norwalk, CT

09969
Dale Electronics Inc.
Yankton, SD

09975
Burroughs Corp.
Electronics Components
Detroit, MI

1A791
LFE Electronics
Danvers, MA

1B715
(United Shoe & Nylock Corp)
-Nylock Fastener Corp.-
Paramus, NJ

10059
Barker Engineering Corp.
Kenilworth, NJ

10389
IL Tool Works Inc.
Licon Div.
Chicago, IL

11236
CTS Corp.
Resistor Products Div.
Berne, IN

11237
CTS Corp of CA
Electro Mechanical Div.
Paso Robles, CA

11295
ECM Motor Co.
Schaumburg, IL

11358
Columbia Broadcasting System
CBS Electronic Div.
Newburyport, MA

11403
Vacuum Can Co.
Best Coffee Maker Div.
Chicago, IL

11502 (can also use 35009)
TRW Inc.
TRW Resistive Products Div.
Boone, NC

11503
Keystone Columbia Inc.
Freemont, IN

11532
Teledyne Relays Teledyne
Industries Inc.
Hawthorne, CA

11711
General Instrument Corp.
Rectifier Div.
Hicksville, NY

11726
Qualidyne Corp.
Santa Clara, CA

12014
Chicago Rivet & Machine Co.
Naperville, IL

12020
Ovenaire
Div. of Electronic Technologies
Charlottesville, VA

12038
Simco
(Div of Ransburg Corp)
Hatfield, PA

12040
National Semiconductor Corp.
Danbury, CT

12060
Diodes Inc.
Northridge, CA

12136
PHC Industries Inc.
Formerly Philadelphia Handle Co.
Camden, NJ

12300
AMF Canada Ltd.
Potter-Brumfield
Guelph, Ontario, Canada

12323
Practical Automation Inc.
Shelton, CT

12327
Freeway Corp.
Cleveland, OH

12406
Elpac Electronics Inc.
Santa Ana, CA

12443
Budd Co.,The
Plastics Products Div.
Phoenixville, PA

12581
Hitachi Metals Inemational Ltd.
Hitachi Magna-Lock Div.
Big Rapids, MO

12615
US Terminals Inc.
Cincinnati, OH

12617
Hamlin Inc.
LaKe Mills, WI

12673
Wesco Electrical
Greenfield, MA

12697
Clarostat Mfg. Co. Inc.
Dover, NH

12749
James Electronic Inc.
Chicago, IL

12856
MicroMetals Inc.
Anaheim, CA

12881
Metex Corp.
Edison, NJ

12895
Cleveland Electric Motor Co.
Cleveland, OH

12954
Microsemi Corp.
Components Group
Scottsdale, AZ

12969
Unitrode Corp.
Lexington, MA

13050
Potter Co.
Wesson, MS

13103
Thermalloy Co., Inc.
Dallas, TX

13327
Solitron Devices Inc.
Tappan, NY

13511
Bunker-Ramo Corp.
Amphenol Cadre Div.
Los Gatos, CA

13606
Sprague Electric Co.
(Use 56289)

13689
SPS Technologies Inc.
Hatfield, NJ

13764
Micro Plastics
Flippin, AZ

13919
Burr-Brown Research Corp.
Tucson, AZ

14099
Semtech Corp.
Newbury Park, CA

14140
McGray-Edison Co.
Commercial Development Div.
Manchester, NH

14189
Ortronics, Inc.
Orlando, FL

14193
Cal-R-Inc.
Santa Monica, CA

14301
Anderson Electronics
Hollidaysburg, PA

14329
Wells Electronics Inc.
South Bend, IN

14482
Watkins-Johnson Co.
Palo Alto, CA

14552
Microsemi Corp.
(Formerly Micro-Semiconductor)
Santa Ana, CA

14604
Elmwood Sensors, Inc
Pawtucket, RI

14655
Cornell-Dublier Electronics
Div. of Federal Pacific
Electric Co. Govt Cont Dept.
Newark, NJ

14704
Crydom Controls
(Division of Int Rectifier)
El Segundo, CA

14752
Electro Cube Inc.
San Gabriel, CA

14936
General Instrument Corp.
Discrete Semi Conductor Div.
Hicksville, NY

14949
Trompeter Electronics
Chatsworth, CA

15412
Amtron
Midlothian, IL

15542
Scientific Components Corp.
Mini-Circuits Laboratory Div.
Brooklyn, NY

15636
Elec-Trol Inc.
Saugus, CA

15782
Bausch & Lomb Inc.
Graphics & Control Div.
Austin, TX

15801
Fenwal Eletronics Inc.
Div. of Kidde Inc.
Framingham, MA

15818
Teledyne Inc. Co.
Teledyne Semiconductor Div.
Mountain View, CA

15849
Useco Inc.
(Now 88245)

15898
International Business
Machines Corp.
Essex Junction, VT

16068
International Diode Div.
Harrison, NJ

16162
MMI
Southfield, MI

16245
Conap Inc.
Olean, NY

16258
Space-Lok Inc.
Burbank, CA

16352
Codi Corp.
Linden, NJ

16469
MCL Inc.
LaGrange, IL

16473
Cambridge Scientific Industries
Div. of Chemed Corp.
Cambridge, MD

16733
Cablewave Systems Inc.
North Haven, CT

16742
Paramount Plastics
Fabricators Inc.
Downey, CA

16758
General Motors Corp.
Delco Electronics Div.
Kokomo, IN

17069
Circuit Structures Lab
Burbank, CA

17117
Electronic Molding Corp.
Woonsocket, RI

17338
High Pressure Eng. Co. Inc.
OK City, OK

17504
Aluminum Filter Co.
Carpinteria, CA

17545
Atlantic Semiconductors Inc.
Asbury Park, NJ

17745
Angstrohm Precision, Inc.
Hagerstown, MD

17856
Siliconix Inc.
Santa Clara, CA

18178
E G & Gvactee Inc.
St. Louis, MO

18235
KRL/Bantry Components Inc.
Manchester, NH

18310
Concord Electronics
New York, NY

18324
Signetics Corp.
Sacramento, CA

18377
Parlex Corp.
Methuen, MA

18520
Sharp Electronics Corp.
Paramus, NJ

18542
Wabash Inc.
Wabash Relay & Electronics Div.
Wabash, IN

18565
Chomerics Inc.
Woburn, MA

18612
Vishay Intertechnology Inc.
Vishay Resistor Products Group
Malvern, PA

18632
Norton-Chemplast
Santa Monica, CA

18677
Scanbe Mfg. Co.
Div. of Zero Corp.
El Monte, CA

18736
Voltronics Corp.
East Hanover, NJ

18786
Micro-Power
Long Island City, NY

18927
GTE Products Corp.
Precision Material Products
Business Parts Div.
Titusville,PA

19080
Robinson Electronics Inc.
San Luis Obispo, CA

19112
Garry Corp.
Langhorne, PA

19315
Bendix Corp., The
Navigation & Control Group
Terboro, NJ

19451
Perine Machine Tool Corp.
Kent, WA

19482
Delta Electronics
Alexandria, VA

19613
MN Mining & Mfg. Co.
Textool Products Dept.
Electronic Product Div.
Irving, TX

19647
Caddock Electronics Inc.
Riverside, CA

19701
Mepco/Centralab Inc.
A N. American Philips Co.
Mineral Wells, TX

2B178
Wire Products
Cleveland, OH

2K262
Boyd Corporation
Portland, OR

2Y384
North American Philips Lighting Corp.
Van Wert, OH

20584
Enochs Mfg. Inc.
INpolis, IN

20891
Cosar Corp.
Dallas, TX

21317
Electronics Applications Co.
El Monte, CA

21604
Buckeye Stamping Co.
Columbus, OH

21845
Solitron Devices Inc.
Semiconductor Group
Rivera Beach, FL

21847
Aertech
Now TRW Microwave Inc.
Sunnyvale, CA

21962
Vectron Corp.
Replaced by: S.W. Electronics

22526
DuPont, EI DeNemours & Co. Inc.
DuPont Connector Systems
Advanced Products Div.
New Cumberland, PA

22626
Micro Semiconductor
(Now 14552)

22670
GM Nameplate
Seattle, WA

22767
ITT Semiconductors
Palo Alto, CA

22784
Palmer Inc.
Cleveland, OH

23050
Product Comp. Corp.
Mount Vernon, NY

23223
CTS Microelectronics
Lafayette, NY

23237
I.R.C., Inc.
Microcircuits Divison
Philadelphia, PA

23302
S.W. Electronics & Mfg. Corp.
Cherry Hill, NJ

23730
Mark Eyelet and Stamping Inc.
Wolcott, CT

23732
Tracor Applied Sciences Inc.
Rockville, MD

23880
Stanford Applied Engineering
Santa Clara, CA

23936
William J. Purdy Co.
Pamotor Div.
Burlingame, CA

24347
Penn Engineering Co.
S. El Monte, CA

24355
Analog Devices Inc.
Norwood, MA

24444
General Semiconductor
Industries, Inc.
Tempe, AZ

24546
Bradford Electronics
Bradford, PA

24618
Transcon Mfg.
Now: D.J. Associates Inc.

24655
Genrad Inc.
(Replaced General Radio 05173)
Concord, MA

24759
Lenox-Fugle Electronics Inc.
South Plainfield, NJ

24796
AMF Inc.
Potter & Brumfield Div.
San Juan Capistrano, CA

24931
Specialty Connector Co.
Greenwood, IN

24995
ECS
Grants Pass, OR

25088
Siemen Corp.
Isilen, NJ

25099
Cascade Gasket
Kent, WA

25403
Amperex Electronic Corp.
Semiconductor & Micro-Circuit Div.
Slatersville, RI

25435
Moldtronics, Inc
Downers Grove, IL

25706
Daburn Electronic & Cable Corp.
Norwood, NJ

26402
Lumex,Inc.
Bayshore, NY

26629
Frequency Sources Inc.
Sources Div.
Chelmsford, MA

26806
American Zettler Inc.
Irvine, CA

27014
National Semiconductor Corp.
Santa Clara, CA

27167
Corning Glass Works Corning
Electronics
Wilmington, NC

27264
Molex Inc.
Lisle, IL

27440
Industrial Screw Products
Los Angeles, CA

27494
Staffall, Inc.
Providence, RI

27745
Associated Spring Barnes Group Inc.
Syracuse, NY

27918
Component Parts Corp.
Bellmore, NY

27956
Relcom (Now 14482)

28175
Alpha Metals
Chicago, IL

28198
Positronic Industries
Springfield, MO

28213
MN Mining & Mfg. Co.
Consumer Products Div.
3M Center
Saint Paul, MN

28309
Kaiser
Minette,AL

28425
Serv-O-Link
Euless, TX

28478
Deltrol Corporation
Deltrol Controls Div.
Milwaukee, WI

28480
Hewlett Packard Co.
Corporate HQ
Palo Alto, CA

28484
Emerson Electric Co.
Gearmaster Div.
McHenry, IL

28520
Heyco Molded Products
Kenilworth, NJ

28932
Lumax Industrials, Inc
Altoona, PA

29083
Monsanto Co.
Santa Clara, CA

29604
Stackpole Components Co.
Raleith, NC

29907
Omega Engineering Inc.
Stamford, CT

3D536
Aimsco Inc.
Seattle, WA

30035
Jolo Industries Inc.
Garden Grove, CA

30045
Solid Power Corp.
Farmingdale, NY

30146
Symbex Corp.
Painesville, OH

30148
AB Enterprise Inc.
Ahoskie, NC

30161
Aavid Engineering Inc.
Laconia, NH

30315
Itron Corp.
San Diego, CA

30323
IL Tool Works Inc.
Chicago, IL

30800
General Instrument Corp.
Capacitor Div.
Hicksville, NY

30838
Fastec
Chicago,ILL

31019
Solid State Scientific Inc.
Willow Grove, PA

31091
Alpha Industries Inc.
Microelectronics Div.
Hatfield, PA

31323
Metro Supply Company
Sacramento, CA

31433
Kemet Electonics Corp.
Simpsonville, NC

31448
Army Safeguard Logistics Command
Huntsville, AL

31471
Gould Inc
Semiconductor Div
Santa Clara, CA

31522
Metal Masters Inc.
Baldwin, MS

31746
Cannon Electric
Woodbury, TN

31827
Budwig
Ramona, CA

31918
ITT-Schadow
Eden Prairie, MN

32293
Intersil
Cupertino, CA

32539
Mura Corp.
Westbury, Long Island, N.Y.

32559
Bivar
Santa Ana, CA

32719
Siltronics
Santa Ana, CA

32767
Griffith Plastics Corp.
Burlingame, CA

32879
Advanced Mechanical Components
Northridge, CA

32897
Murata Erie North America Inc.
Carlisle Operations
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Div.
Riverside, CA

33025
M/A ComOmni Spectra, Inc. (Replacing Omni Spectra)
Microwave Subsystems Div.
Tempe, AZ

33096
CO Crystal Corp.
Loveland, CO

33173
General Electric Co.
Owensboro, KY

33246
Epoxy Technology Inc.
Billerica, MA

33292
Pioneer Sterilized Wiping Cloth Co.
Portland, OR

33297
NEC Electronics USA Inc.
Electronic Arrays Inc. Div.
Mountain View, CA

33919
Nortek Inc.
Cranston, RI

34114
Oak Industries
Rancho Bernardo, CA

34263
CTS Electronics Corp.
Brownsville,TX

34333
Silicon General Inc.
Garden Grove, CA

34335
Advanced Micro Devices (AMD)
Sunnyvale, CA

34359
MN Mining & Mfg. Co.
Commercial Office Supply Div.
Saint Paul, MN

34371
Harris Corp.
Harris Semiconductor
Products Group
Melbourne, FL

34576
Rockwell International Corp.
Newport Beach, CA

34641
Instrument Specialties
Euless, TX

34649
Intel Corp.
Santa Clara, CA

34802
Electromotive Inc.
Kenilworth, NJ

34848
Hartwell Special Products
Placentia, CA

35009
Renfrew Electric Co. Ltd.
IRC Div.
Toronto, Ontario, Canada

35986
Amrad
Melrose Park, IL

36665
Mitel Corp.
Kanata, Ontario, Canada

36701
Van Waters & Rogers
Valley Field, Quebec, Canada

37942
Mallory Capacitor Corp.
Sub of Emhart Industries
INpolis, IN

39003
Maxim Industries
Middleboro, MA

4F434
Plastic Sales
Los Angeles, CA

40402
Roderstein Electronics Inc.
Statesville, NC

42498
National Radio
Melrose, MA

43543
Nytronics Inc.(Now 53342)

43744
Panasonic Industrial Co.
San Antonio, TX

43791
Datron Systems
Wilkes Barre, PA

44655
Ohmite Mfg. Co.
Skokie, IL

47001
Lumberg Inc.
Richmond, VA

47379
ISOCOM
Campbell, CA

49569
IDT (International Development & Trade)
Dallas, TX

49671
RCA Corp.
New York, NY

49956
Raytheon Company
Executive Offices
Lexington, MA

5D590
Mostek Corp.
Replaced by: SGS Thompson Microelectronics

5F520
Panel Components Corp.
Santa Rosa, CA

5P575
Nobel Electronics
Suffern, NY

5W664
NDK
Div. of Nihon Dempa Kogyo LTD
Lynchburg, VA

5U802
Dennison Mfg. Co.
Framingham, MA

50088
SGS - Thomson Microelectronics Inc.
Carrollton, TX

50120
Eagle-Picher Industries Inc.
Electronics Div.
CO Springs, CO

50157
Midwest Components Inc.
Muskegon, MS

50356
Teac Corp. of America
Industrial Products Div
Montebello, CA

50364
MMI, Inc.(Monolithic Memories Inc)
Military Products Div.
Santa Clara, CA

50472
Metal Masters, Inc.
City of Industry, CA

50541
Hypertronics Corp.
Hudson, MA

50558
Electronic Concepts, Inc.
Eatontown, NJ

50579
Litronix Inc.
Cupertino, CA

50891
Semiconductor Technology
Stuart, FL

50934
Tran-Tec Corp
Columbus, NE

51167
Aries Electronics Inc.
Frenchtown, NJ

51284
Mos Technology
Norristown, PA

51249
Heyman Mfg. Co.
Cleveland, OH

51372
Verbatim Corp.
Sunnyvale, CA

51398
MUPAC Corp.
Brockton, MA

51406
Murata Erie, No. America Inc.
(Also see 72982)
Marietta, GA

51499
Amtron Corp.
Boston, MA

51506
Accurate Screw Machine Co.
(ASMCO) Nutley, NJ

51605
CODI Semiconductor Inc.
Kenilworth, NJ

51642
Centre Engineering Inc.
State College, PA

51705
ICO/Rally
Palo alto, CA

51791
Statek Corp.
Orange, CA

51984
NEC America Inc.
Falls Church, VA

52063
Exar Integrated Systems
Sunnyvale, CA

52072
Circuit Assembly Corp.
Irvine, CA

52152
MN Mining & Mfg.
Saint Paul, MN

52333
API Electronics
Haugpauge,Long Island,NY

52361
Communication Systems
Piscataway, NJ

52500
Amphenol, RF Operations
Burlington, MA

52525
Space-Lok Inc.
Lerco Div.
Burbank, CA

52531
Hitachi Magnetics
Edmore, MO

52745
Timco
Los Angeles, CA

52763
Stettner-Electronics Inc.
Chattanooga, TN

52769
Sprague-Goodman Electronics Inc.
Garden City Park, NY

52771
Moniterm Corp.
Amatrom Div.
Santa Clara, CA

52840
Western Digital Corp.
Costa Mesa, CA

53021
Sangamo Weston Inc.
(See 06141)

53036
Textool Co.
Houston, TX

53184
Xciton Corp.
Lathan, NY

53217
Technical Wire Products Inc.
Santa Barbara, CA

53342
Opt Industries Inc.
Phillipsburg, NJ

53673
Thompson CSF Components Corp.
(Semiconductor Div)
Conaga Park, CA

53718
Airmold/W. R. Grese & Co.
Roanoke Rapids, NC

53848
Standard Microsystems
Hauppauge, NY

53894
AHAM Inc.
RanchoCA, CA

53944
Glow-Lite
Pauls Valley, OK

54178
Plasmetex Industries Inc.
San Marcos, CA

54294
Shallcross Inc.
Smithfield, NC

54453
Sullins Electronic Corp.
San Marcos, CA

54473
Matsushita Electric Corp.
(Panasonic)
Secaucus, NJ

54492
Cinch Clamp Co., Inc.
Santa Rosa, CA

54583
TDK
Garden City, NY

54590
RCA Corp
Distribution & Special Products
Cherry Hill, NY

54869
Piher International Corp.
Arlington Heights, IL

54937
DeYoung Mfg.
Bellevue, WA

54590
RCA Corp.
Electronic Components Div.
Cherry Hill, NJ

55026
American Gage & Machine Co.
Simpson Electric Co. Div.
Elgin, IL

55112
Plessey Capacitors Inc.
(Now 60935)

55261
LSI Computer Systems Inc.
Melville, NY

55285
Bercquist Co.
Minneapolis, MN

55322
Samtech Inc.
New Albany, IN

55408
STI-CO Industries Co
Buffalo, NY

55464
Central Semiconductor Corp.
Hauppauge, NY

55557
Microwave Diode Corp.
W.Stewarstown, NH

55566
R A F Electronic Hardware Inc.
Seymour, CT

55576
Synertek
Santa Clara, CA

55680
Nichicon/America/Corp.
Schaumburg, IL

55943
D J Associates, Inc
(Replaced Transcon Mfg.-24618)
Fort Smith, AZ

56282
Utek Systems Inc.
Olathe, KS

56289
Sprague Electric Co.
North Adams, MA

56365
Square D Co.
Corporate Offices
Palatine, IL

56375
WESCORP
Div. Dal Industries Inc
Mountain View, CA

Federal Supply Codes for Manufacturers (cont)

56481
Shugart Associates
Sub of Xerox Corp.
Sunnyvale, CA

56637
RCD Components Inc.
Manchester, NH

56708
Zilog Inc.
Campbell, CA

56856
Vamistor Corp. of TN
Sevierville, TN

56880
Magnetics Inc.
Baltimore, MD

57026
Endicott Coil Co. Inc.
Binghamton, NY

57053
Gates Energy Products
Denver, CO

57170
Cambridge Thermionic
Cambridge, MA
Replaced by:
71279
Interconnection Products Inc.

57668
R-ohm Corp
Irvine, CA

57962
SGS - Thomson Microelectronics Inc
Montgomeryville, PA

58014
Hitachi Magnalock Corp.
(Now 12581)

58104
Simco
Atlanta, GA

58364
BYCAP Inc.
Chicago, IL

58451
Precision Lamp
Cotat, CA

58474
Superior Electric Co.
Bristol, CT

58614
Communications Instruments Inc.
Fairview, NC

59124
KOA-Speer Electronics Inc.
Bradford, PA

59422
Holmberg Electronics
Irvine, CA

59610
Souriau Inc
Valencia, CA

59635
HV Component Associates
Howell, NJ

59640
Supertex Inc.
Sunnyvale, CA

59660
Tusonix Inc.
Tucson, AZ

59730
Thomas and Betts Corp.
IA City, IA

59831
Semtronics Corp.
Watchung, NJ

6I1053:
American Components Inc.
an Insilco Co. RPC Div.
Hayesville, NC

6L611
Allen, Robert G. Inc.
Van Nuys, CA

6U850
Burgess Switch Co., Inc
Northbrook, IL

6U095
AMD Enterprises, Inc.
Roswell, GA

6X403
SGS/ATES Semiconductor Corp.
INpolis, IN

6Y440
Micron Technology Inc.
Boise, ID

60046
Power Dynamics Inc
West Orange, NJ

60197
Precicontact Inc.
Langhome, PA

60386
Squires Electronics Inc
Cornelius, OR

60395
Xicor Inc.
Milpitas, CA

60399
Torin Engineered Blowers
Div. of Clevepak Corp.
Torrington, CT

60496
Micrel Inc.
Sunnyvale, CA

60705
Cera-Mite Corp.
(formerly Sprague)
Grafton, WI

60911
Inmos Corp.
CO Springs, CO

60935
Westlake Capacitor Inc.
Tantalum Div.
Greencastle, IN

60958
ACIC
Intercomp Wire & Cable Div.
Hayesville, NC

61271
Fujitsu Microelectronics Inc
San Jose, CA

61394
SEEQ Technology Inc.
San Jose, CA

61429
Fox Electronics
Cape Coral, FL

61529
Aromat Corp.
New Providence, NJ

61752
IR-ONICS Inc
Warwick, RI

61772
Integrated Device Technology
Santa Clara, CA

61802
Toshiba
Houston, TX

61857
SAN-O Industrial Corp.
Bohemia, Long Island, NY

61935
Schurter Inc.
Petaluma, CA

62351
Apple Rubber
Lancaster, NY

62643
United Chemicon
Rosemont, IL

62712
Seiko Instruments
Torrance, CA

62793
Lear Siegler Inc.
Energy Products Div.
Santa Ana, CA

63743
Ward Leonard Electric Co.Inc.
Mount Vernon, NY

64154
Lamb Industries
Portland, OR

64155
Linear Technology
Milpitas, CA

64537
KDI Electronics
Whippany, NJ

64782
Precision Control Mfg. Inc.
Bellevue, WA

64834
West M G Co.
San Francisco, CA

64961
Electronic Hardware LTD
North Hollywood, CA

65092
Sangamo Weston Inc.
Weston Instruments Div.
Newark, NJ

65786
Cypress Semi
San Jose, CA

65940
Rohm Corp & Whatney
Irvine, CA

65964
Evox Inc.
Bannockbum, IL

66150
Entron Inc.
Winslow Teltronics Div.
Glendale, NY

66302
VLSI Technology Inc.
San Jose, CA

66419
Exel
San Jose, CA

66450
Dyna-Tech Electronics, Inc
Walled Lake, MI

66608
Bering Industries
Freemont, CA

66891
BKC International Electronics
Lawrence, MA

66958
SGS Semiconductor Corp.
Phoenix, AZ

66967
Powerex Inc
Aubum, NY

67183
Altera
Santa Clara, CA

68919
WIMA
% Harry Levinson Co.
Seattle, WA

7F361
Richmond-Division of Dixico
% Zellerbach Paper Co.
Seattle, WA

7F844
Moore Business Forms, Inc
Seattle, WA

7G902
Textron Inc.
Camcar Div.
Rockford, IL

7J395
Universal Plastics
Welshpool, WA

7J696
AMD Plastics
East Lake, OH

7K354
Omni Spectra Inc
Los Altos, CA

7Z884
ALPS
Seattle, WA

7X634
Duracell USA
Div. of Dart & Kraft Inc.
Valdese, NC

70290
Almetal Universal Joint Co.
Cleveland, OH

70485
Atlantic India Rubber Works Inc.
Chicago, IL

70563
Amperite Company
Union City, NJ

70903
Cooper-Belden Corp.
Geneva, IL

71002
Bimbach Co. Inc.
Farmingdale, NY

71034
Bliley Electric Co.
Erie, PA

71183
Westinghouse Electric Corp.
Bryant Div.
Bridgeport, CT

71279
Interconnection Products Inc.
Formerly Midland-Ross Cambion Div.
Santa Ana, CA

71400
Bussman Manufacturing
Div. McGraw-Edison Co.
St. Louis, MO

71450
CTS Corp.
Elkhart, IN

71468
ITT Cannon Div. of ITT
Fountain Valley, CA

71482
General Instrument Corp.
Clare Div.
Chicago, IL

71590
Mepco/Centralab
A North American Philips Co.
Fort Dodge, IA

71707
Coto Corp.
Providence, RI

71744
General Instrument Corp.
Lamp Div/Worldwide
Chicago, IL

71785
TRW Inc.
Cinch Connector Div.
Elk Grove Village, IL

71984
Dow Corning Corp.
Midland, MI

72005
AMAX Specialty Metals Corp.
Newark, NJ

72136
Electro Motive Mfg. Corp.
Florence, NC

72228
AMCA International Corp.
Continental Screw Div.
New Bedford, MA

72259
Nytronics Inc.
New York, NY

72619
Amperex Electronic Corp.
Dialight Div.
Brooklyn, NY

72653
G C Electronics Co.
Div. of Hydrometals Inc.
Rockford, IL

72794
Dzus Fastner Co. Inc.
West Islip, NY

72928
Gulton Industries Inc.
Gudeman Div.
Chicago, IL

72962
Elastic Stop Nut
Div. of Harrard Industries
Union, NJ

72982
Erie Specialty Products, Inc
Formerly: Murata Erie
Erie, PA

73138
Beckman Industrial corp.
Helipot Div.
Fullerton, CA

73168
Fenwal Inc.
Ashland, MA

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrance, CA

73445
Amperex Electronic Corp.
Hicksville, NY

73559
Carlingswitch Inc.
Hartford, CT

73586
Circle F Industries
Trenton, NJ

73734
Federal Screw Products Inc.
Chicago, IL

73743
Fischer Special Mfg. Co.
Cold Spring, KY

73893
Microdot
Mt. Clemens, MS

73899
JFD Electronic Components
Div. of Murata Erie
Oceanside, NY

73905
FL Industries Inc.
San Jose, CA

73949
Guardian Electric Mfg. Co.
Chicago, IL

74199
Quam Nichols Co.
Chicago, IL

74217
Radio Switch Co.
Marlboro, NJ

74306
Piezo Crystal Co.
Div. of PPA Industries Inc.
Carlisle, PA

74445
Holo-Krome Co.
Elmwood, CT

74542
Hoyt Elect.Instr. Works Inc.
Penacook, NH

74840
IL Capacitor Inc.
Lincolnwood, IL

74970
Johnson EF Co.
Waseca, MN

75042
TRW Inc.
IRC Fixed Resistors
Philadelphia, PA

75297
Kester Solder Div.
Litton Systems, Inc
Des Plaines, IL

75376
Kurz-Kasch Inc.
Dayton, OH

75378
CTS Knights Inc.
Sandwich, IL

75382
Kulka Electric Corp.
(Now 83330)
Mount Vernon, NY

75569
Performance Semiconductor Corp.
Sunnyvale, CA

75915
Littelfuse Tracor
(Formerly: Tracor-Littelfuse)
Des Plaines, IL

76854
Oak Switch Systems Inc.
Crystal Lake, IL

77122
TRW Assemblies & Fasteners Group
Fastener Div.
Moutainside, NJ

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, IN

77542
Ray-O-Vac Corp
Madison, WI

77638
General Instrument Corp.
Rectifier Div.
Brooklyn, NY

77900
Shakeproof Lock Washer Co.
(Now 78189)

77969
Rubbercraft Corp. of CA Ltd.
Torrance, CA

78189
IL Tool Works Inc.
Shakeproof Div.
Elgin, IL

78277
Sigma Instruments Inc.
South Braintree, MA

78290
Struthers Dunn Inc.
Pitman, NJ

78553
Eaton Corp.
Engineered Fastener Div.
Cleveland, OH

Federal Supply Codes for Manufacturers (cont)

78592
Stoeger Industries
South Hackensack, NJ

79497
Western Rubber Co.
Goshen, IN

79727
C - W Industries
Southampton, PA

79963
Zierick Mfg. Corp.
Mount Kisco, NY

8C798
Ken-Tronics, Inc.
Milan, IL

8D528
Baumgartens
Atlanta, GA

8F330
Eaton Corp.
Cutler Hammer Product Sales Office
Mountain View, CA

8T100
Tellabs Inc.
Naperville, IL

80009
Tektronix
Beaverton, OR

80031
Mepco/Electra Inc.
Morristown, NJ

80032
Ford Aerospace &
Communications Corp.
Western Development
Laboratories Div.
Palo Alto, CA

80145
LFE Corp.
Process Control Div.
Clinton, OH

80183
Sprague Products
(Now 56289)

80294
Bourns Instruments Inc.
Riverside, CA

80583
Hammerlund Mfg. Co. Inc.
Paramus, NJ

80640
Computer Products Inc.
Stevens-Arnold Div.
South Boston, MA

81073
Grayhill Inc.
La Grange, IL

81312
Litton Systems Inc.
Winchester Electronics Div.
Watertown, CT

81439
Therm-O-Disc Inc.
Mansfield, OH

81483
International Rectifier Corp.
Los Angeles, CA

81590
Korry Electronics Inc.
Seattle, WA

81741
Chicago Lock Co.
Chicago, IL

82227
Airpax Corp.
Cheshire Div.
Cheshire, CT

82240
Simmons Fastner Corp.
Albany, NY

82305
Palmer Electronics Corp.
South Gate, CA

82389
Switchcraft Inc.
Sub of Raytheon Co.
Chicago, IL

82415
Airpax Corp
Frederick Div.
Frederick, MD

82872
Roanwell Corp.
New York, NY

82877
Rotron Inc.
Custom Div.
Woodstock, NY

82879
ITT
Royal Electric Div.
Pawtucket, RI

83003
Varo Inc.
Garland, TX

83014
Hartwell Corp.
Placentia, CA

83055
Signalite Fuse Co.
(Now 71744)

83058
TRW Assemblies & Fasteners Group
Fasteners Div.
Cambridge, MA

83259
Parker-Hannifin Corp.
O-Seal Div.
Culver City, CA

83298
Bendix Corp.
Electric & Fluid Power Div.
Eatonville, NJ

83315
Hubbell Corp.
Mundelein, IL

83330
Kulka Smith Inc.
A North American Philips Co.
Manasquan, NJ

83478
Rubbercraft Corp. of America
West Haven, CT

83553
Associated Spring Barnes Group
Gardena, CA

83740
Union Carbide Corp.
Battery Products Div.
Danbury, CT

84171
Arco Electronics
Commack, NY

84411
American Shizuki
TRW Capacitors Div.
Ogallala, NE

84613
FIC Corp.
Rockville, MD

84682
Essex Group Inc.
Peabody, MA

84830
Lee Spring Co. Inc
Brooklyn, NY

85367
Bearing Distributing Co.
San Fransisco, CA

85372
Bearing Sales Co.
Los Angeles, CA

85480
W. H. Brady Co.
Industrial Product
Milwaukee, WI

85840
Brady WH Co
Industrial Products Div
Milwaukee, WI

85932
Electro Film Inc.
Valencia, CA

86577
Precision Metal Products Co.
Peabody, MA

86684
Radio Corp. of America
(Now 54590)

86928
Seastrom Mfg. Co. Inc.
Glendale, CA

87034
Illuminated Products Inc.
(Now 76854)

87516
Standard Crystal
KS City, KS

88044
Aeronautical Standards Group
Dept. of Navy & Air Force

88219
GNB Inc.
Industrial Battery Div.
Langhorne, PA

88245
Winchester Electronics
Litton Systems-Useco Div.
Van Nuys, CA

88486
Triangle PWC Inc.
Jewitt City, CT

88690
Essex Group Inc.
Wire Assembly Div.
Dearborn, MI

88786
Atlantic India Rubber Co.
Goshen, IN

88978
Philips (Now Fluke)
Mahwah, NJ

89020
Amerace Corp.
Buchanan Crimptool Products Div.
Union, NJ

89265
Potter-Brumfield
(See 77342)

89462
Waldes Truarc, Inc.
Long Island, NY

89536
John Fluke Mfg. Co., Inc.
Everett, WA

89597
Fredericks Co.
Huntingdon Valley, PA

89709
Bunker Ramo-Eltra Corp.
Amphenol Div.
Broadview, IL

89730
General Electric
Lamp Div.
Newark, NJ

9R216
Data Composition Svc, Inc
Laurel, MD

9S171
Port Plastics
Tukwila, WA

Federal Supply Codes for Manufacturers (cont)

9W423
Amatom
El Mont, CA

90201
Mallory Capacitor Co.
Sub of Emhart Industries Inc.
Indianapolis, IN

90215
Best Stamp & Mfg. Co.
KS City, MO

90303
Duracell Inc.
Technical Sales & Marketing
Bethel, CT

91094
Essex Group Inc.
Suflex/IWP Div.
Newmarket, NH

91247
IL Transformer Co.
Chicago, IL

91293
Johanson Mfg. Co.
Boonton, NJ

91462
Alpha Industries Inc.
Logansport, IN

91502
Associated Machine
Santa Clara, CA

91506
Augat Alcoswitch
N. Andover, MA

91507
Froeliger Machine Tool Co.
Stockton, CA

91637
Dale Electronics Inc.
Columbus, NE

91662
Elco Corp.
A Gulf Western Mfg. Co.
Connector Div.
Huntingdon, PA

91737
ITT Cannon/Gremar
(Now 08718)

91802
Industrial Devices Inc.
Edgewater, NJ

91833
Keystone Electronics Corp.
NY, NY

91836
King's Electronics Co. Inc.
Tuckahoe, NY

91929
Honeywell Inc.
Micro Switch Div.
Freeport, IL

91934
Miller Electric Co.
Woonsocket, RI

91967
National Tel-Tronics
Div. of electro Audio Dynamics Inc
Meadville, PA

91984
Maida Development Co.
Hampton, VA

91985
Norwalk Valve Co.
S. Norwalk, CT

92218
Wakefield Corp., The
Wakefield, ME

92527
VTC Inc.
Bloomington, MN

92607
Tensolite Co.
Div. of Carlisle Corp.
Buchanan, NY

92914
Alpha Wire Corp.
Elizabeth, NJ

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, MA

94144
Raytheon Co.
Microwave & Power Tube Div.
Quincy, MA

94222
Southco Inc.
Concordville, PA

94988
Wagner Electric Corp.
Sub of Mcgraw-Edison Co.
Whippany, NJ

95146
Alco Electronic Products Inc.
Switch Div.
North Andover, MA

95263
Leecraft Mfg. Co.
Long Island City, NY

95275
Vitramon Inc.
Bridgeport, CT

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, OH

95348
Gordo's Corp.
Bloomfield, NJ

95354
Methode Mfg. Corp.
Rolling Meadows, IL

95573
Campion Laboratories Inc.
Detroit, MI

95712
Bendix Corp.
Electrical Comp. Div.
Franklin, IN

95987
Weckesser Co. Inc.
(Now 85480)

96733
SFE Technologies
San Fernando, CA

96853
Gulton Industries Inc.
Measurement & Controls Div.
Manchester, NH

96881
Thomson Industries Inc.
Port WA, NY

97464
Industrial Retainer Ring
Irvington, NJ

97525
EECO Inc.
Santa Ana, CA

97540
Whitehall Electronics Corp.
Master Mobile Mounts Div.
Fort Meyers, FL

97913
Industrial Electronic
Hardware Corp.
NY, NY

97945
Pennwalt Corp.
SS White Industrial Products
Piscataway, NJ

97966
CBS
Electronic Div.
Danvers, MA

98094
Machlett Laboratories Inc.
Santa Barbara. CA

98159
Rubber-Teck Inc.
Gardena, CA

98278
Malco A Microdot Co.
South Pasadena, CA

98291
Sealectro Corp.
BICC Electronics
Trumbill, CT

98372
Royal Industries Inc.
(Now 62793)

98388
Lear Siegler Inc.
Accurate Products Div.
San Deigo, CA

98978
IERC
(International Electronic Research Corp.)
Burbank, CA

99120
Plastic Capacitors Inc.
Chicago, IL

99217
Bell Industries Inc.
Elect. Distributor Div.
Sunnyvale, CA

99378
ATLEE of DE Inc.
N. Andover, MA

99392
Mepco/Electra Inc.
Roxboro Div.
Roxboro, NC

99515
Electron Products Inc.
Div. of American Capacitors
Duarte, CA

99779
Bunker Ramo- Eltra Corp.
Barnes Div.
Lansdown, PA

99800
American Precision Industries
Delevan Div.
East Aurora, NY

99942
Mepco/Centralab
A North American Philips Co.
Milwaukee, WI

U.S. Service Locations

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Fluke Technical Center
16969 Von Karman Avenue
Suite 100
Irvine, CA 92714
Tel: (714) 863-9031

Fluke Technical Center
46610 Landing Parkway
Fremont, CA 94538
Tel: (415) 651-5112

Colorado
Fluke Technical Center
14180 East Evans Avenue
Aurora, CO 80014
Tel: (303) 695-1171

Florida
Fluke Technical Center
940 N. Fern Creek Avenue
Orlando, FL 32803
Tel: (407) 896-4881

Illinois
Fluke Technical Center
1150 W. Euclid Ave.
Palatine, IL 60067
Tel: (312) 705-0500

Maryland
Fluke Technical Center
5640 Fishers Lane
Rockville, MD 20852
Tel: (301) 770-1576

New Jersey
Fluke Technical Center
East 66 Midland Avenue
Paramus, NJ 07652-0930
Tel: (201) 599-9500

Texas
Fluke Technical Center
1801 Royal Lane, Suite 307
Dallas, TX 75229
Tel: (214) 869-2848

Washington
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John Fluke Mfg. Co., Inc.
1420 75th St. S.W.
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Everett, WA 98203
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International

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Virrey del Pino 4071 DPTO E-65
1430 CAP FED
Buenos Aires
Tel: 54 1 522-5248

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Tally Ho Technology Park
East Burwood
Victoria 3151

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Scientific & Industrial
25-27 Paul St. North
North Ryde N.S.W. 2113
Tel: 61 02 888 8222

Austria
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Unternehmensbereich Prof. Systeme
Triesterstrasse 66
Postfach 217
A-1101 Wein
Tel: 43 222-60101, x1388

Belgium
Philips & MBLE Associated S.A.
Scientific & Industrial Equip. Div
Service Department.
80 Rue des deux Gares B-1070
Brussels
Tel: 32 2 525 6111

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Section 8
Schematic Diagrams

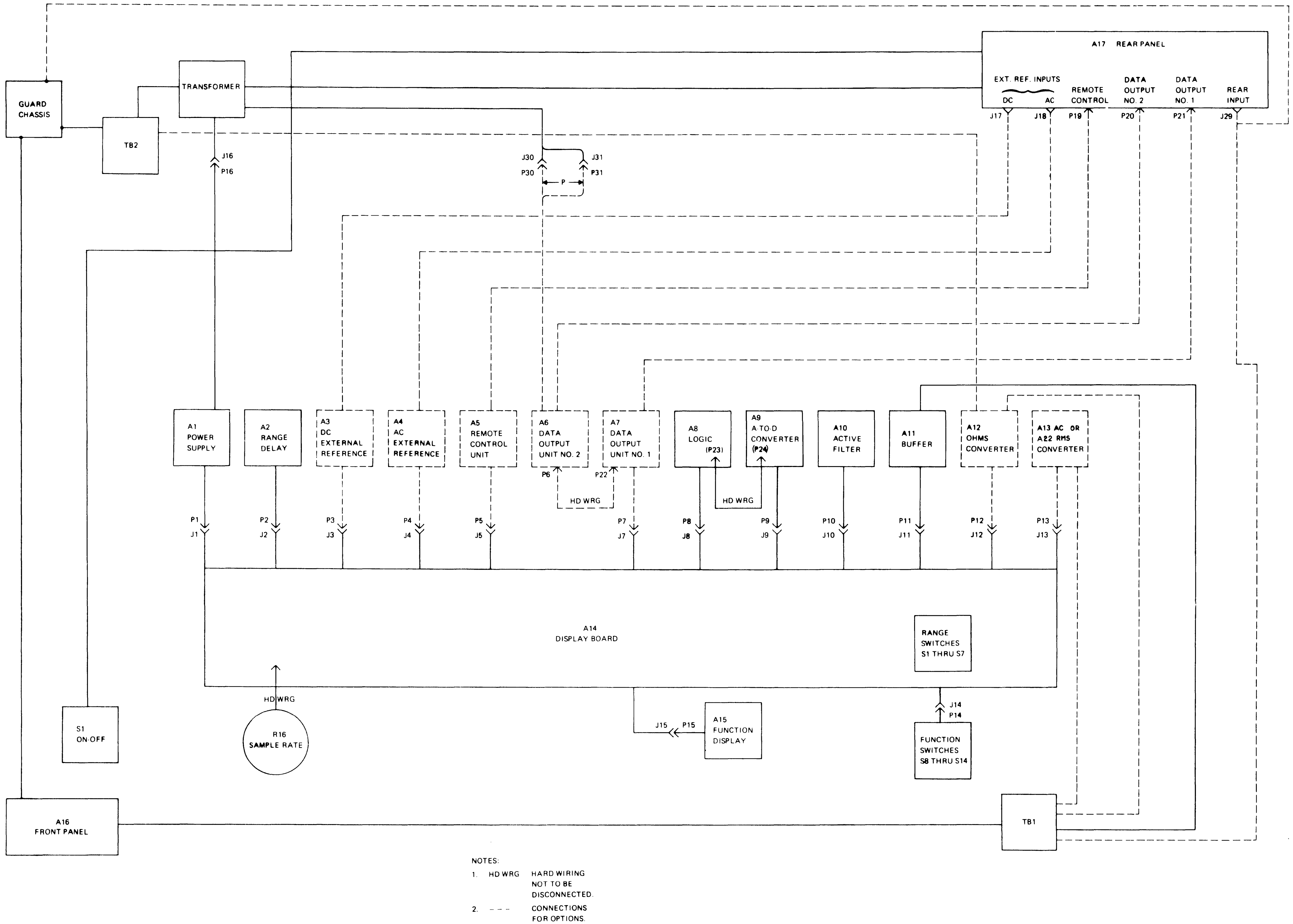
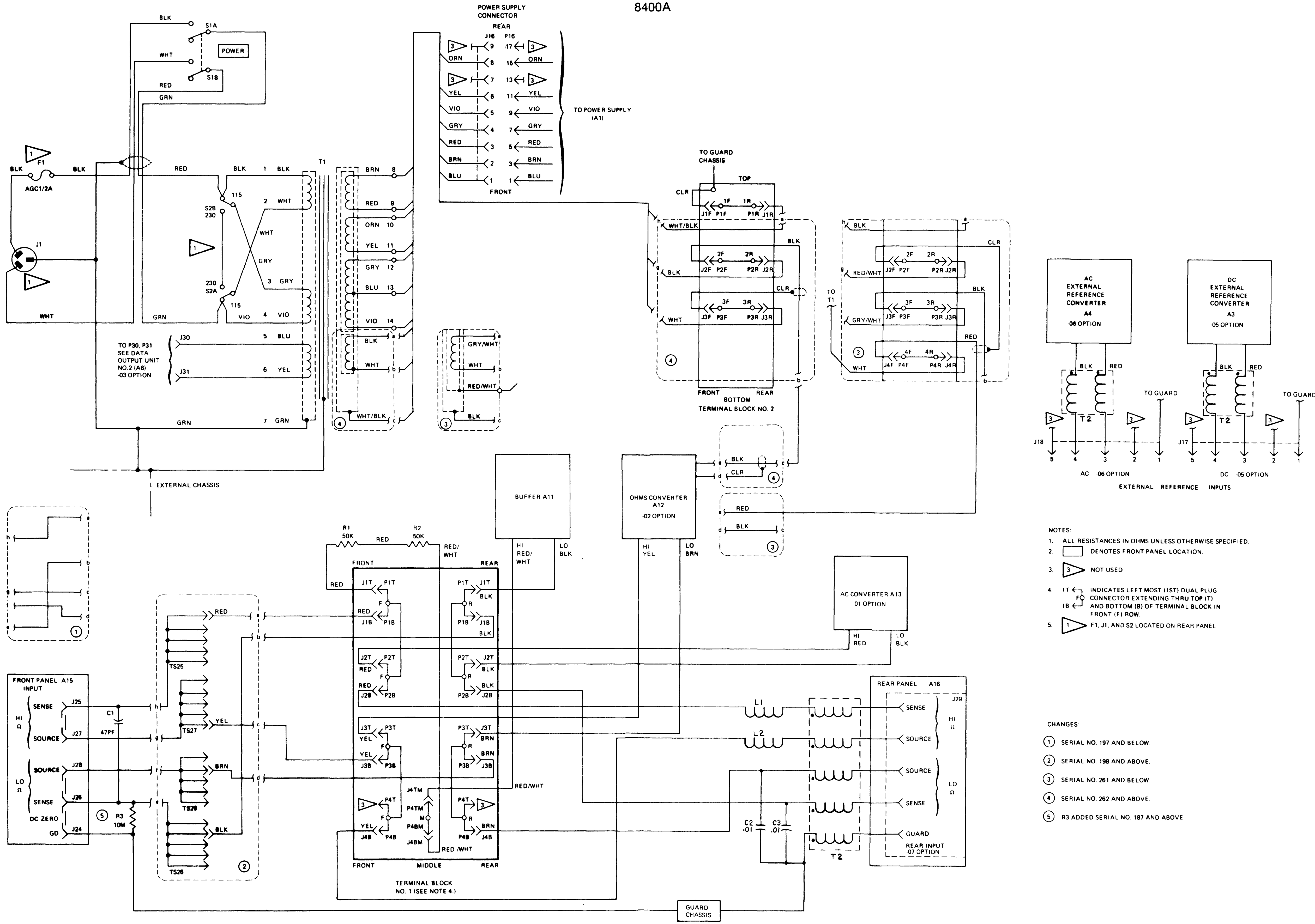


FIGURE 8-1 MODEL 8400A INTERCONNECT DIAGRAM (8400A-1100)



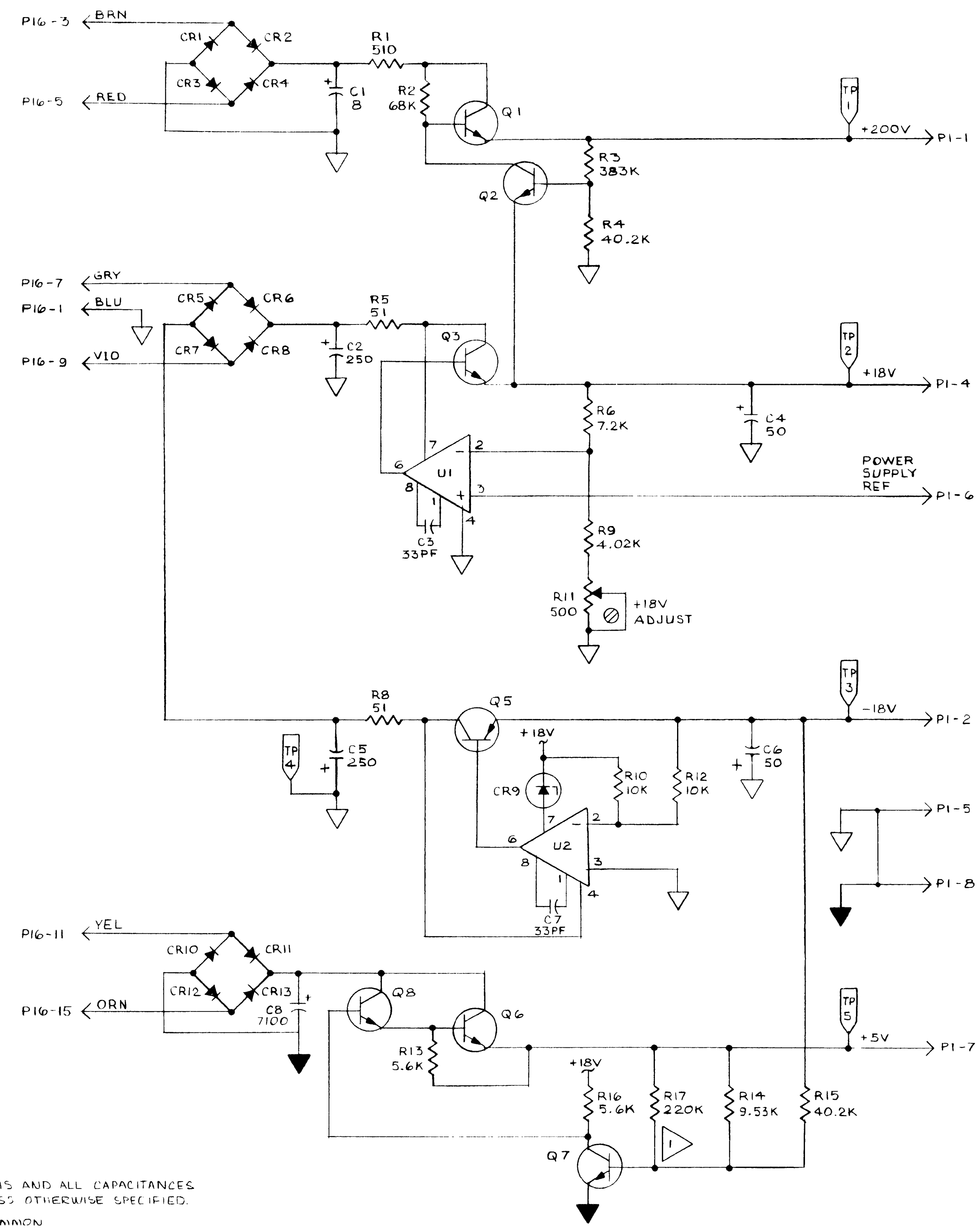
NOTES:

1. ALL RESISTANCES IN OHMS UNLESS OTHERWISE SPECIFIED.
2. DENOTES FRONT PANEL LOCATION.
3. 3 NOT USED
4. 1T F 1B INDICATES LEFT MOST (1ST) DUAL PLUG CONNECTOR EXTENDING THRU TOP (T) AND BOTTOM (B) OF TERMINAL BLOCK IN FRONT (F) ROW.
5. 1 F1, J1, AND S2 LOCATED ON REAR PANEL

CHANGES:

1 SERIAL NO. 197 AND BELOW.
2 SERIAL NO. 198 AND ABOVE.
3 SERIAL NO. 261 AND BELOW.
4 SERIAL NO. 262 AND ABOVE.
5 R3 ADDED SERIAL NO. 187 AND ABOVE

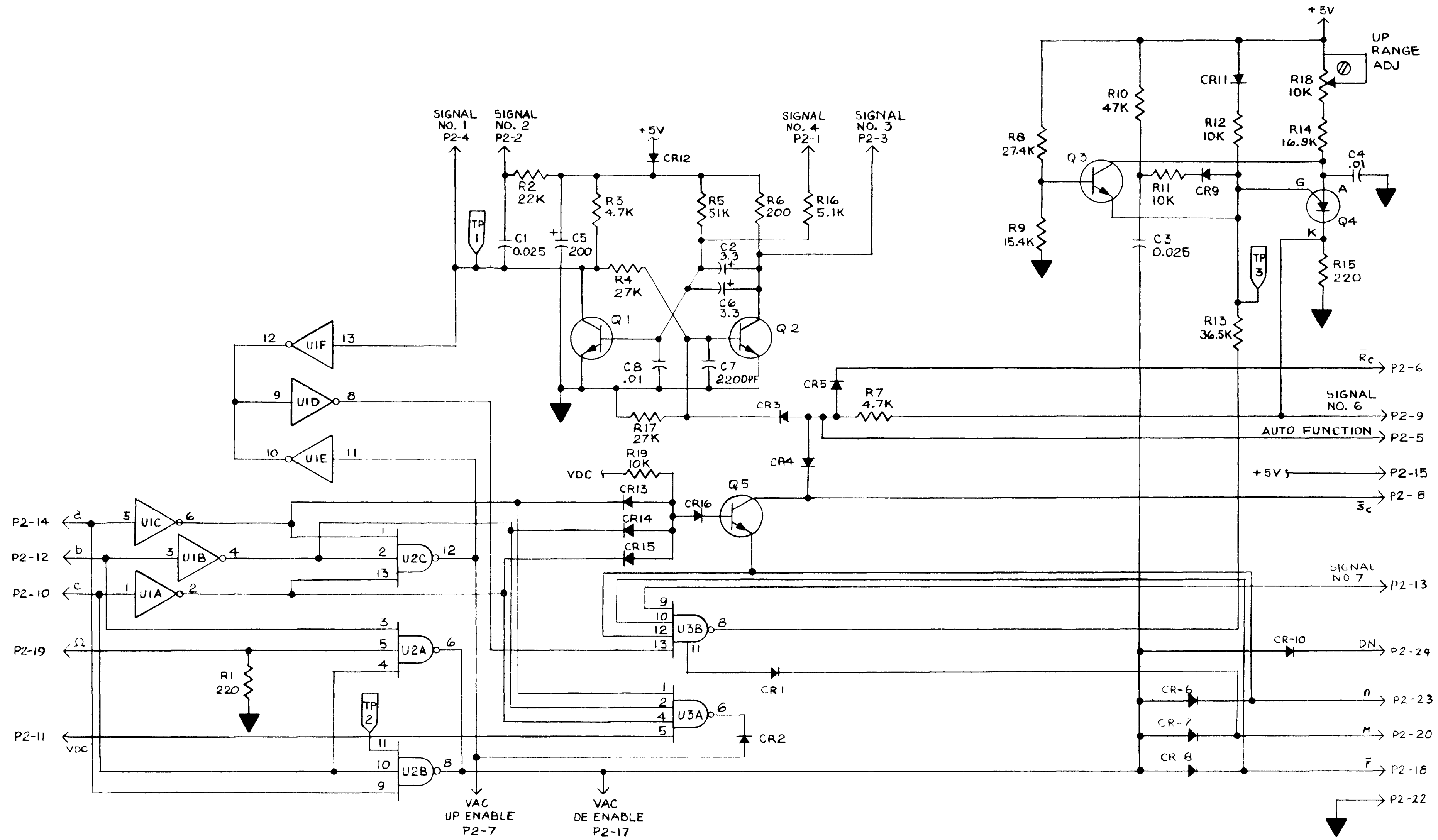
FIGURE 8-2 MODEL 8400A WIRING DIAGRAM (8400A-1000)



NOTES:

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ▽ DENOTES SIGNAL COMMON
3. ▼ DENOTES LOGIC COMMON
4. ⊘ DENOTES INTERNAL ADJUSTMENT
5. [1] R17 MAY BE OMITTED DURING ADJUSTMENT OF +5V SUPPLY

FIGURE 8-3 A1 POWER SUPPLY PCB ASSEMBLY (8400A-1001)

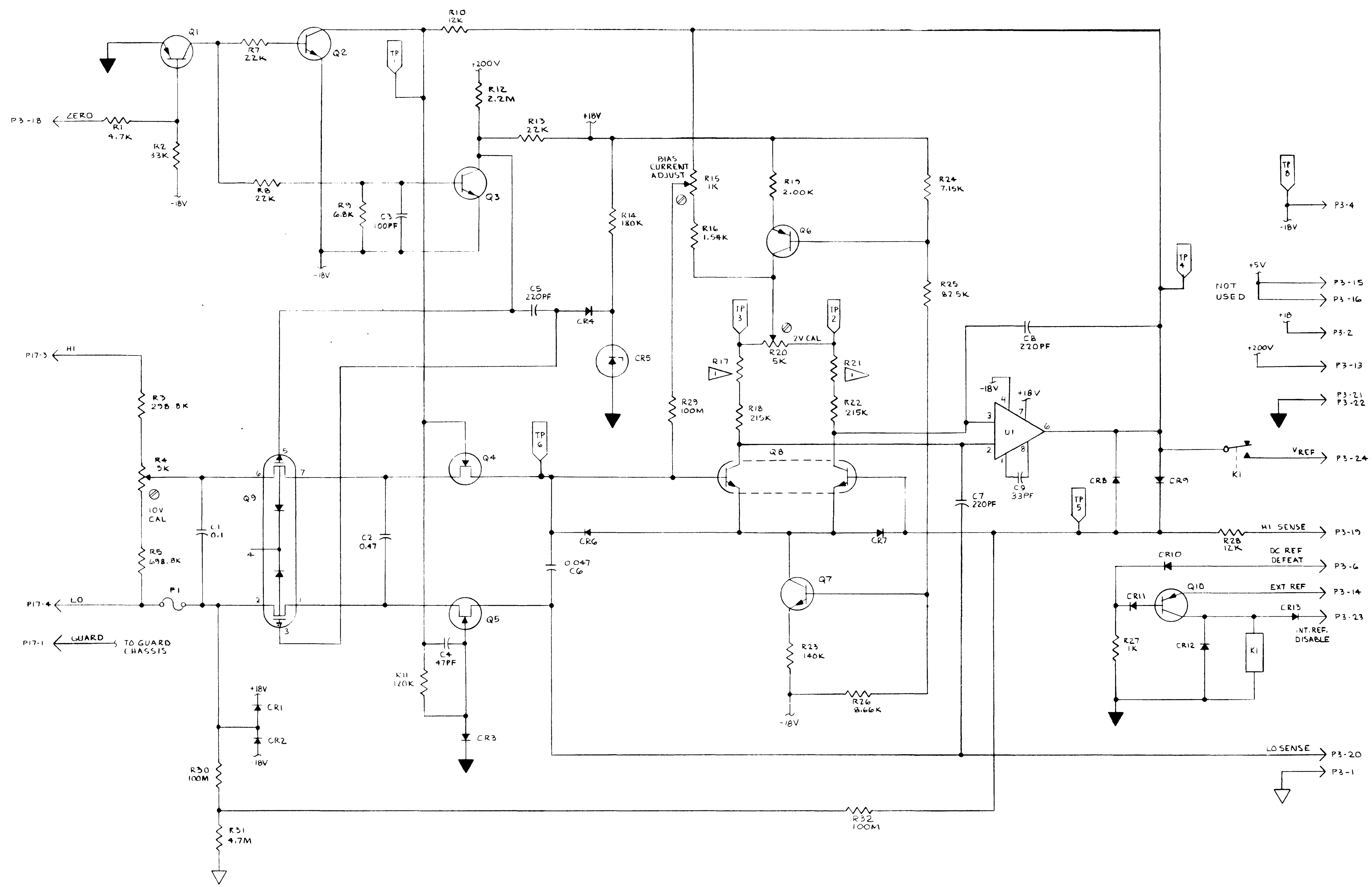


NOTES:

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ▼ DENOTES LOGIC COMMON
3. ⊘ DENOTES INTERNAL ADJUSTMENT

IC	PIN CONNECTIONS	
	+5V	COMMON
U1	14	7
U2	14	7
U3	14	7

FIGURE 8-4 A2 RANGE DELAY PCB ASSEMBLY (8400A-1003)



NOTES:

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED
2. ▽ DENOTES SIGNAL COMMON
3. ▼ DENOTES LOGIC COMMON
4. ⊘ DENOTES INTERNAL ADJUSTMENT
5. ▷ DENOTES FACTORY SELECTED PART

FIGURE 8-5 A3 DC EXTERNAL REFERENCE CONVERTER PCB ASSEMBLY (8400A-1009)

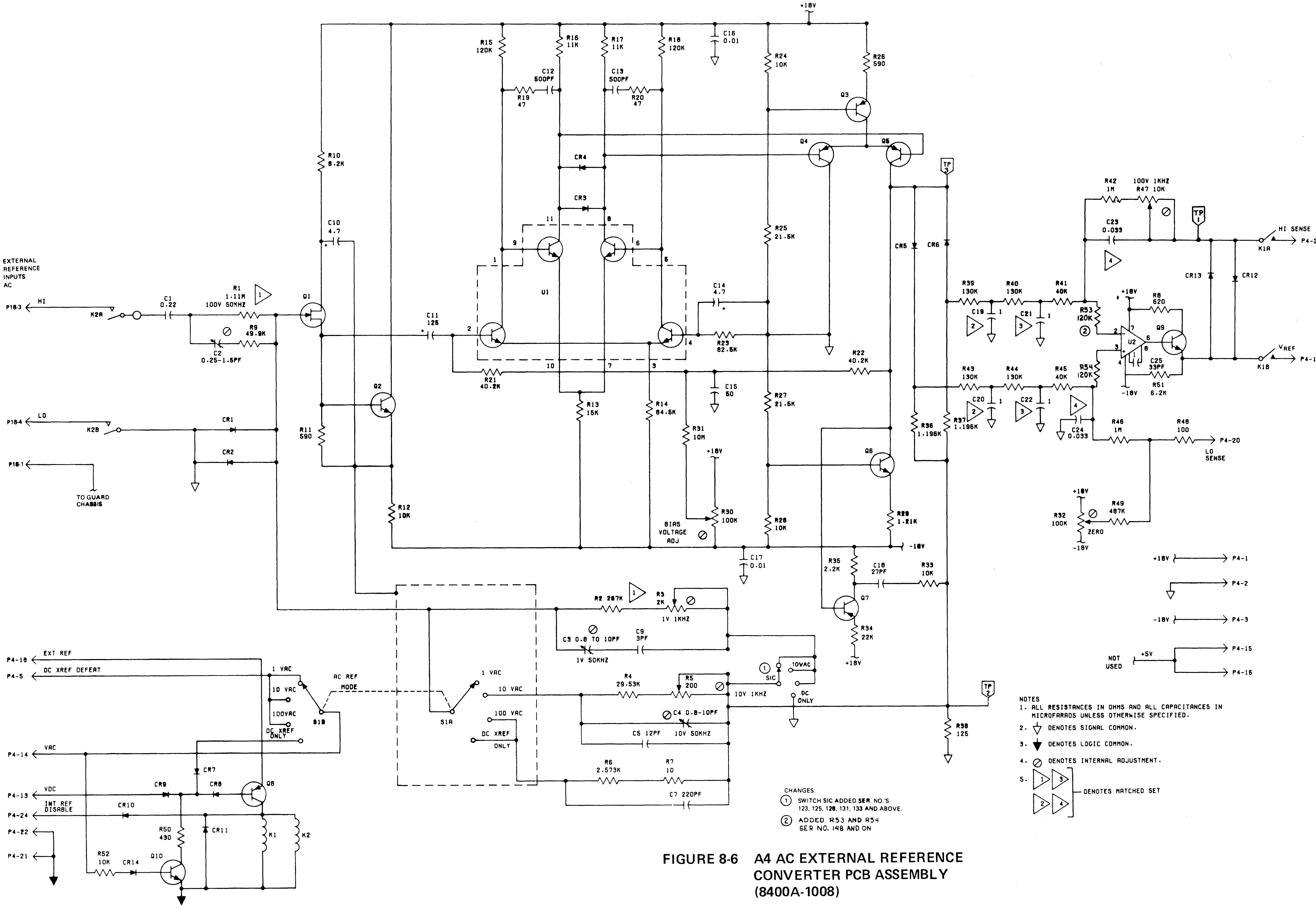
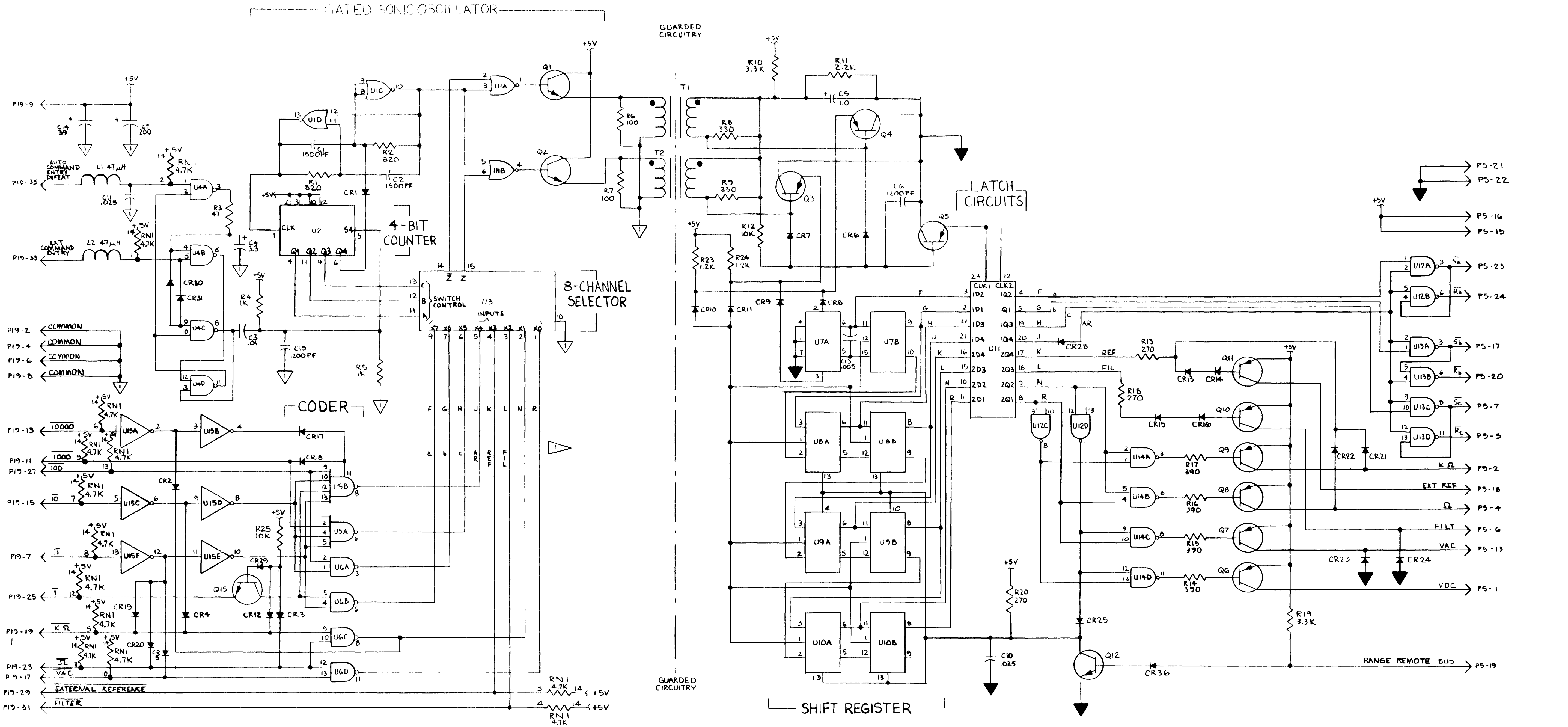
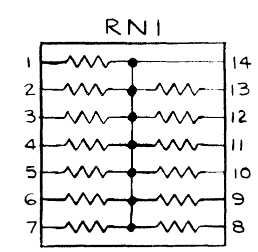


FIGURE 8-6 A4 AC EXTERNAL REFERENCE CONVERTER PCB ASSEMBLY (8400A-1008)





DETAIL A
(SEE NOTE 5)

HIGHEST REF DES	REF DES NOT USED
C15	C8, 9, 10 & 12
Q15	Q13, 14
U15	U11
R25	R21, 22
CR36	CR26, 27, 32 33, 34 & 35
RN1	
L2	
T2	

NOTES:

1 ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

2 ▼ DENOTES LOGIC COMMON

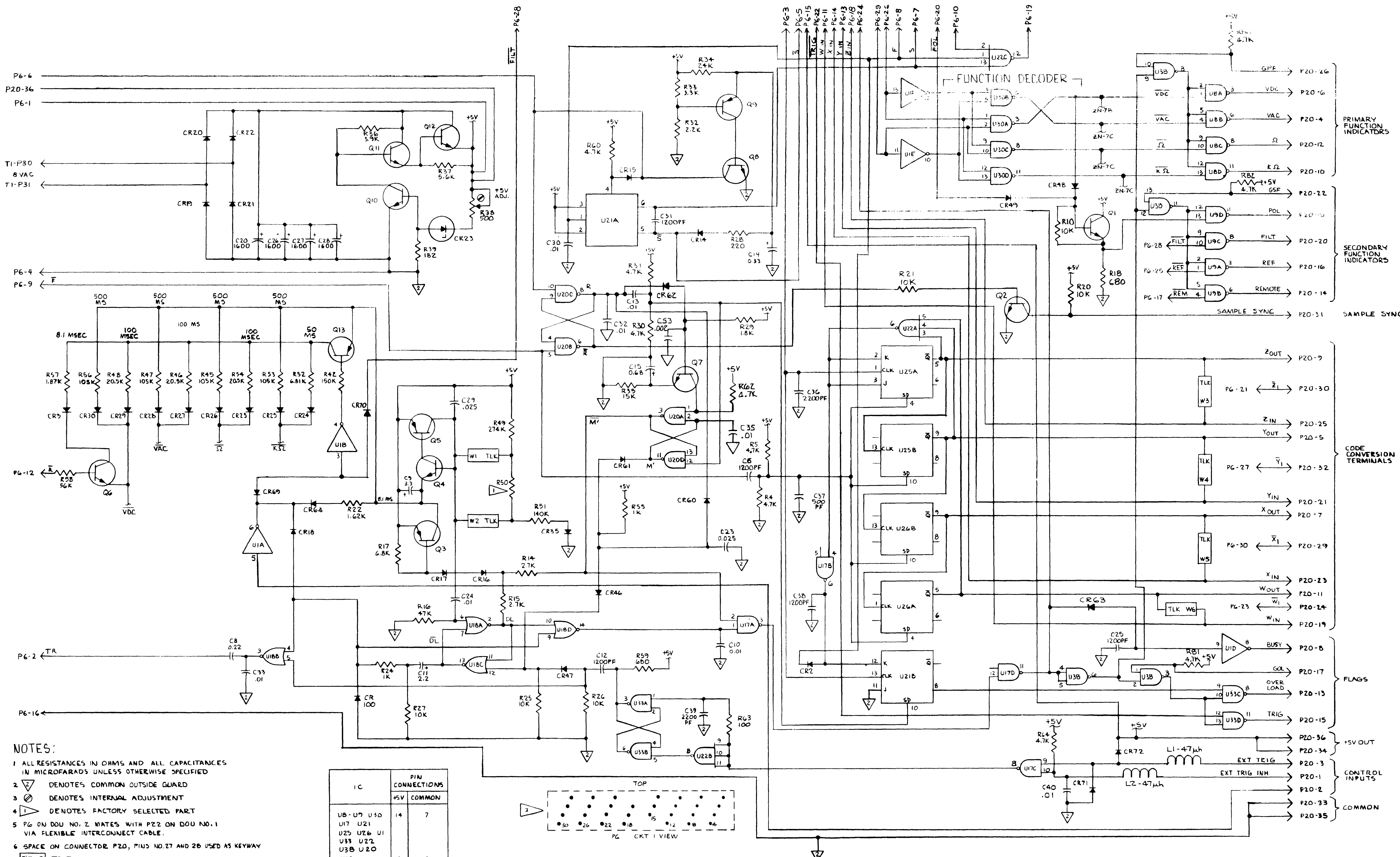
3 ▽ DENOTES COMMON OUTSIDE GUARD

4 SIGNALS a. b c. AR. REF. AND FIL CORRESPOND IN FUNCTION TO THOSE IN BASIC DVM. BUT ARE NOT IDENTICAL SIGNALS.

5. REF DESIGNATION, RN1, DENOTES A RESISTOR NETWORK (SEE DETAIL A).

IC	PIN CONNECTIONS	
	+5V	COMMON
U1 - U6 U8 - U10 U12 - U15	14	7
U7	16	8
U11	24	7

FIGURE 8-7 A5 REMOTE CONTROL UNIT PCB ASSEMBLY (8400A-1011)

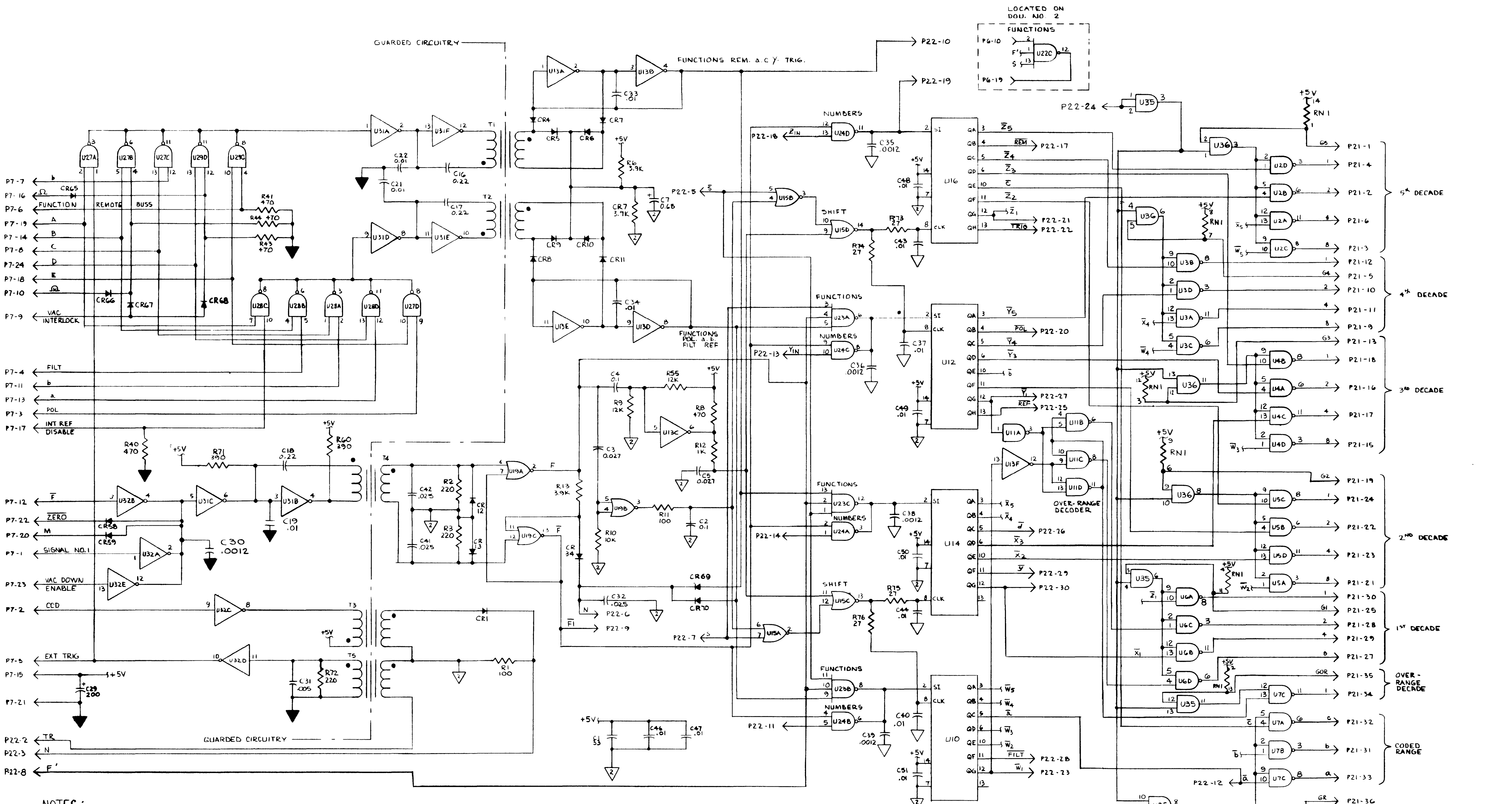


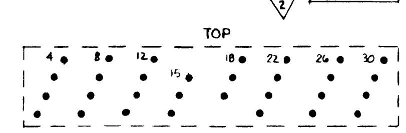
NOTES:

1 ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED
2 (2) DENOTES COMMON OUTSIDE GUARD
3 DENOTES INTERNAL ADJUSTMENT
4 (1) DENOTES FACTORY SELECTED PART
5 P6 ON DOU NO. 2 MATES WITH P22 ON DOU NO. 1 VIA FLEXIBLE INTERCONNECT CABLE.
6 SPACE ON CONNECTOR P20, PINS NO. 27 AND 28 USED AS KEYWAY
7 TLK # TEST LINK
8 (3) SEE WIRING DIAGRAM FOR CONNECTIONS TO P22
9. SEE 8400A-4013 & 8375A-4013 FOR ASSY DWGS.

IC	PIN CONNECTIONS +5V	PIN CONNECTIONS COMMON
U8-U9 U30 U17 U21 U25 U26 U1 U33 U22 U38 U20	14	7
U18	8	1

FIGURE 8-8 A6 DATA OUTPUT UNIT NO. 2 PCB ASSEMBLY (8400A-1013)



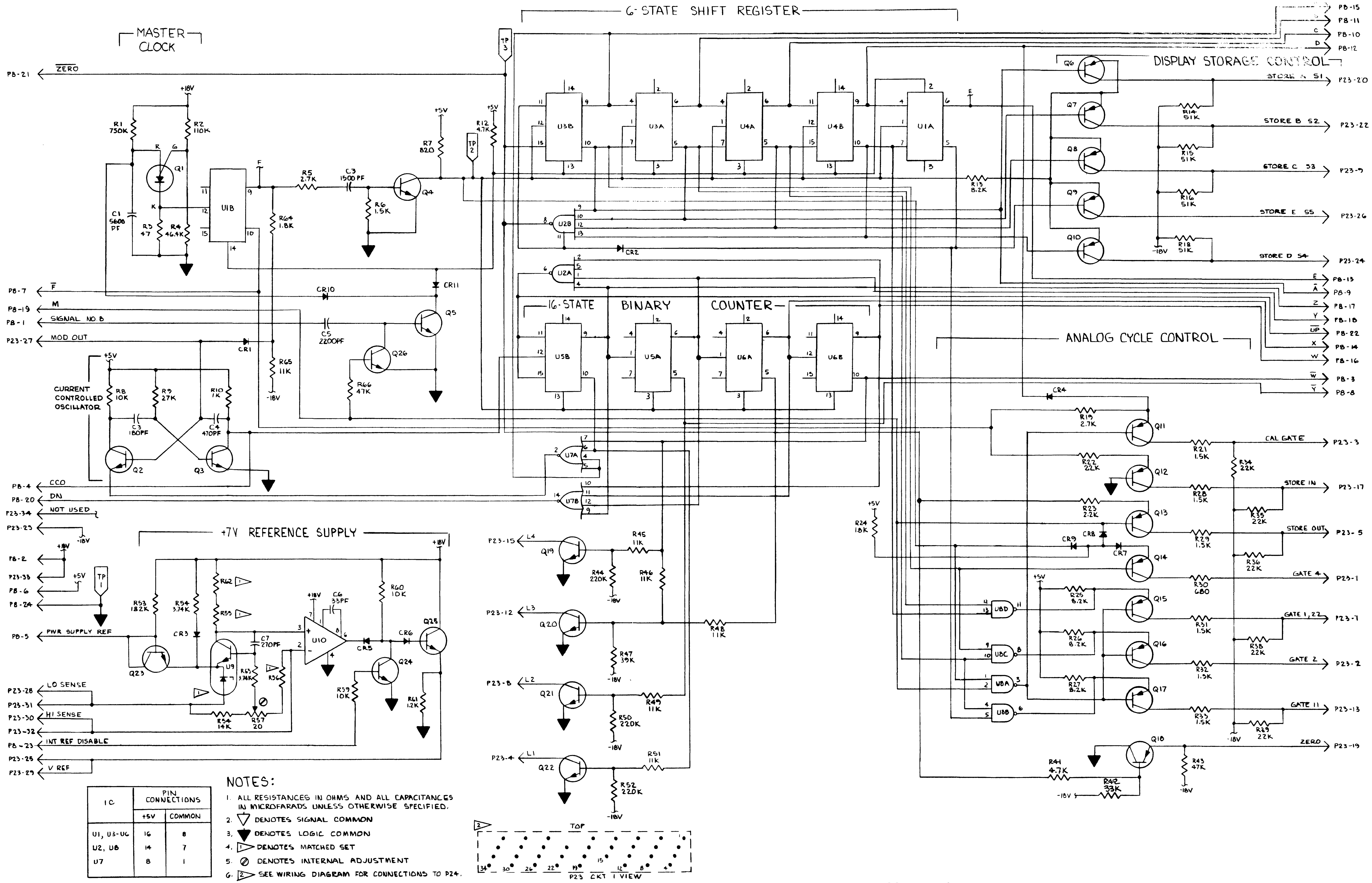


NOTES:

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED
2. ▼ DENOTES LOGIC COMMON
3. ⊘ DENOTES INTERNAL ADJUSTMENT
4. ▽ DENOTES COMMON OUTSIDE GUARD
5. P22 ON DOU. NO. 1 MATES WITH P6 ON DOU NO. 2 VIA FLEXIBLE INTERCONNECT CABLE
6. ▷ SEE WIRING DIAGRAM FOR CONNECTIONS TO P6

IC	PIN CONFIGURATIONS	
	+5V	COMMON
U2-U7, U11, U24, U27, U29	14	7
U10 U12 U14 U16	14	7
U23	14	7
U15 U19	8	1

FIGURE 8-9 A7 DATA OUTPUT UNIT NO. 1 PCB ASSEMBLY (8400A-1012)

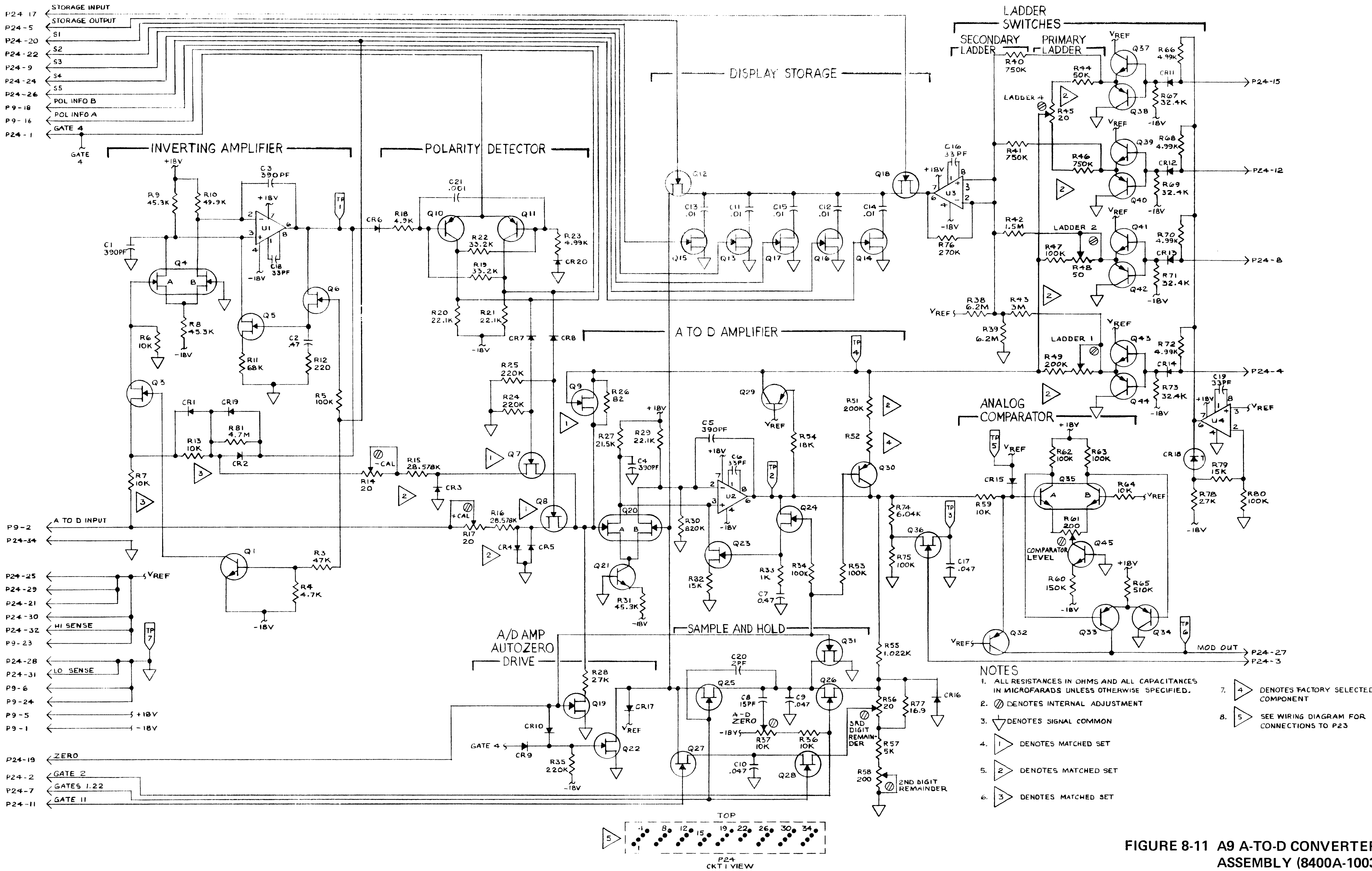


NOTES:

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ▽ DENOTES SIGNAL COMMON
3. ▼ DENOTES LOGIC COMMON
4. 1▷ DENOTES MATCHED SET
5. ⊘ DENOTES INTERNAL ADJUSTMENT
6. 2▷ SEE WIRING DIAGRAM FOR CONNECTIONS TO P24.

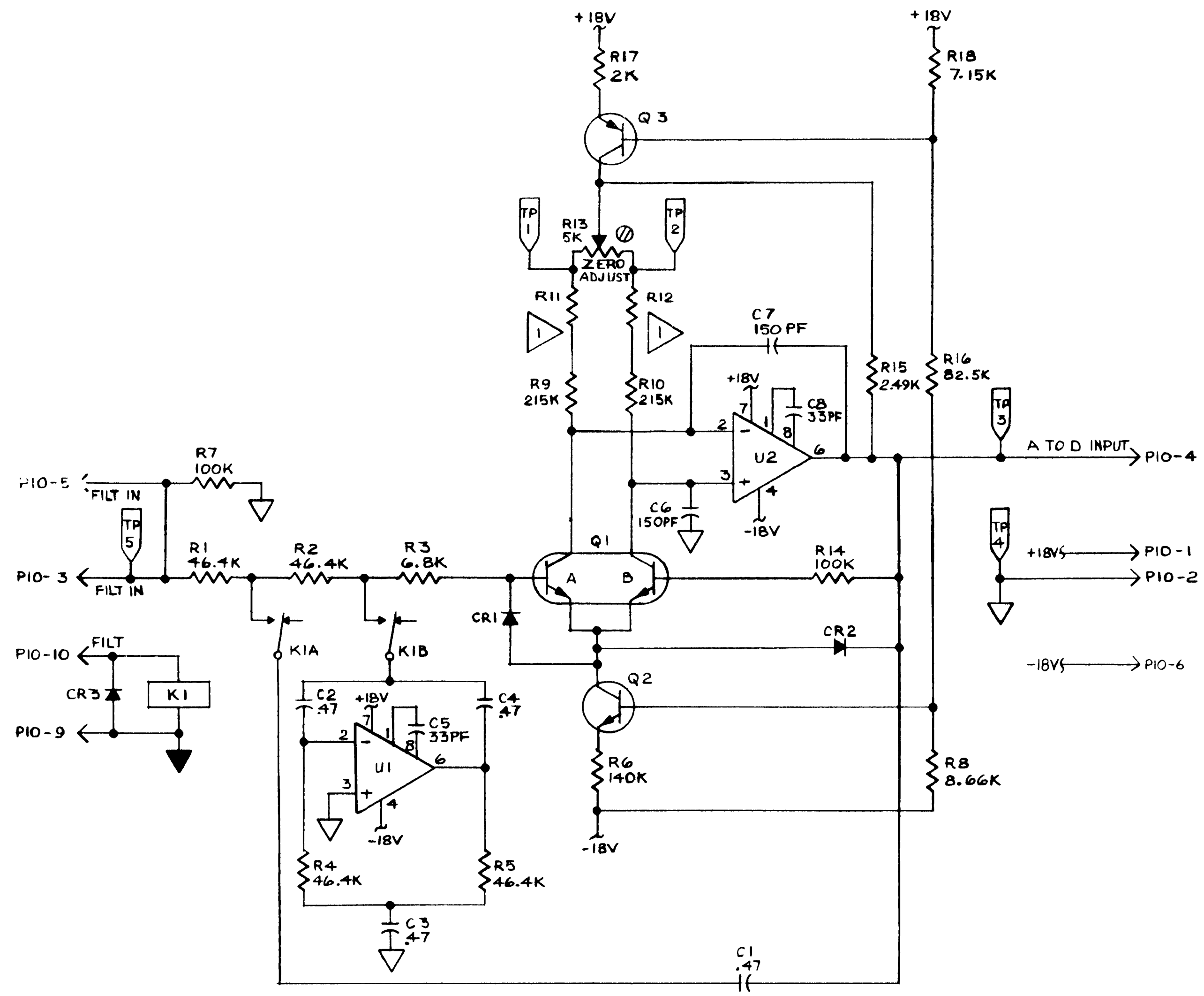
IC	PIN CONNECTIONS	
	+5V	COMMON
U1, U3-U6	16	8
U2, U8	14	7
U7	8	1

FIGURE 8-10 A8 LOGIC PCB ASSEMBLY (8400A-1004)



NOTES
1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ⊘ DENOTES INTERNAL ADJUSTMENT
3. ▽ DENOTES SIGNAL COMMON
4. ▷1 DENOTES MATCHED SET
5. ▷2 DENOTES MATCHED SET
6. ▷3 DENOTES MATCHED SET
7. ▷4 DENOTES FACTORY SELECTED COMPONENT
8. ▷5 SEE WIRING DIAGRAM FOR CONNECTIONS TO P23

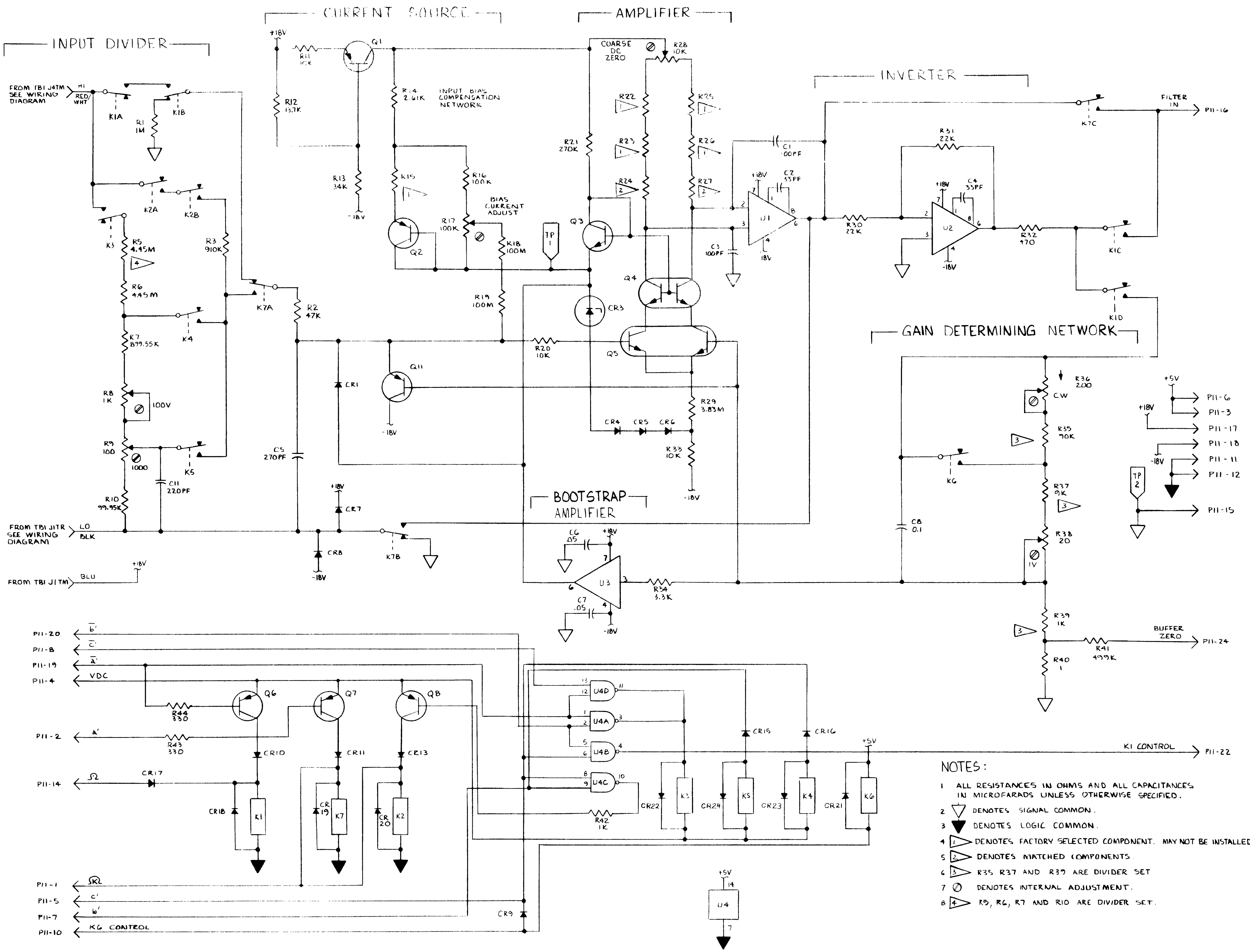
FIGURE 8-11 A9 A-TO-D CONVERTER PCB ASSEMBLY (8400A-1003)



NOTES

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ▽ DENOTES COMMON.
3. ▼ DENOTES LOGIC COMMON.
4. ▷ FACTORY SELECTED
5. Ø DENOTES INTERNAL ADJUSTMENT

FIGURE 8-12 A10 ACTIVE FILTER PCB ASSEMBLY (8400A-1013)

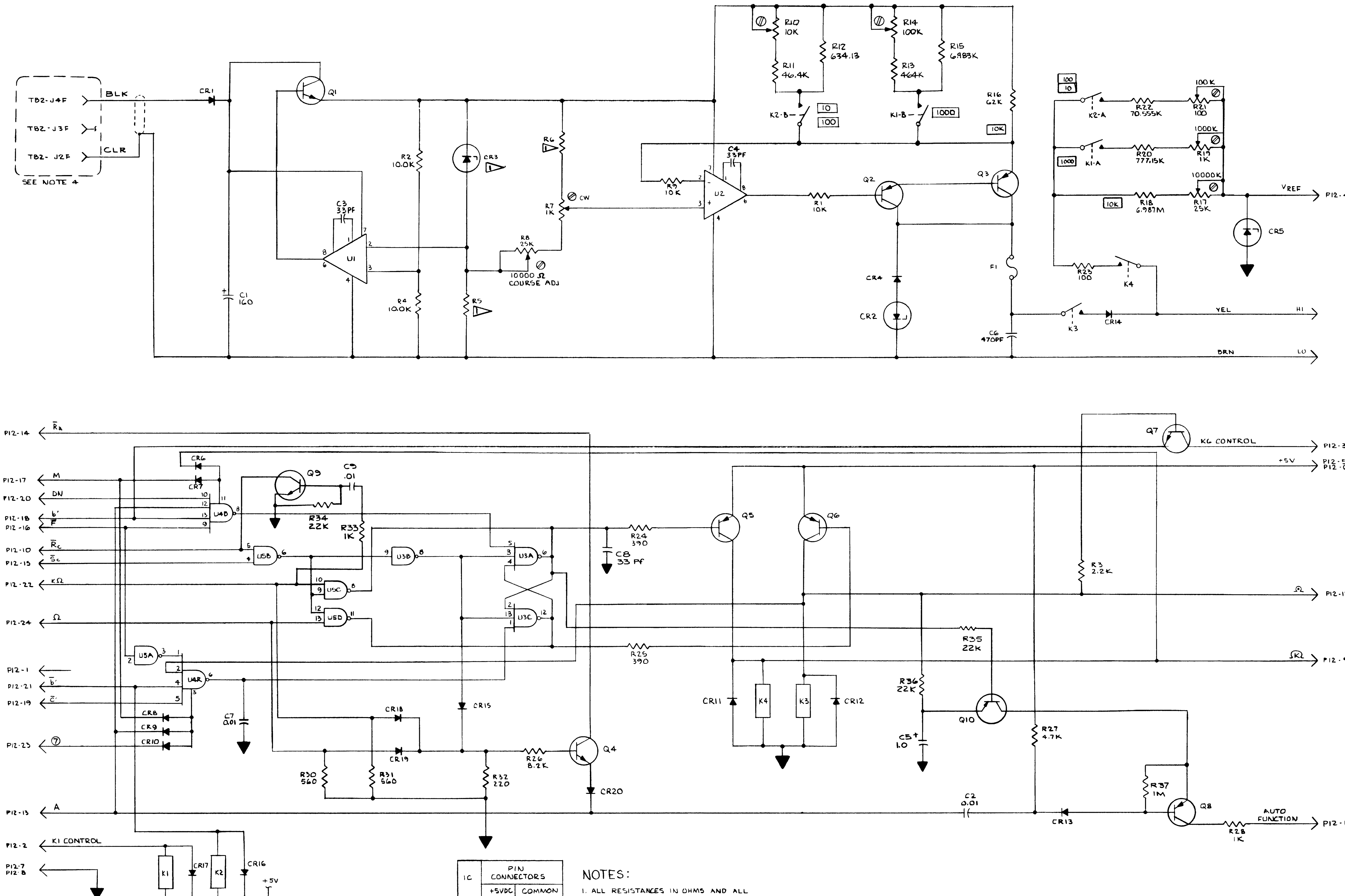


BUFFER RELAY LOGIC

	VOLTAGE RANGE				
	LO		HI		
RELAY	0.1	1.0	10	100	1000
K1	•	•			
K2			•		
K3				•	•
K4				•	
K5					•
K6		•			
K7			•	•	•
• INDICATES RELAY ENERGIZED					

FIGURE 8-13 A11 BUFFER PCB ASSEMBLY (8400A-1005)

8400A

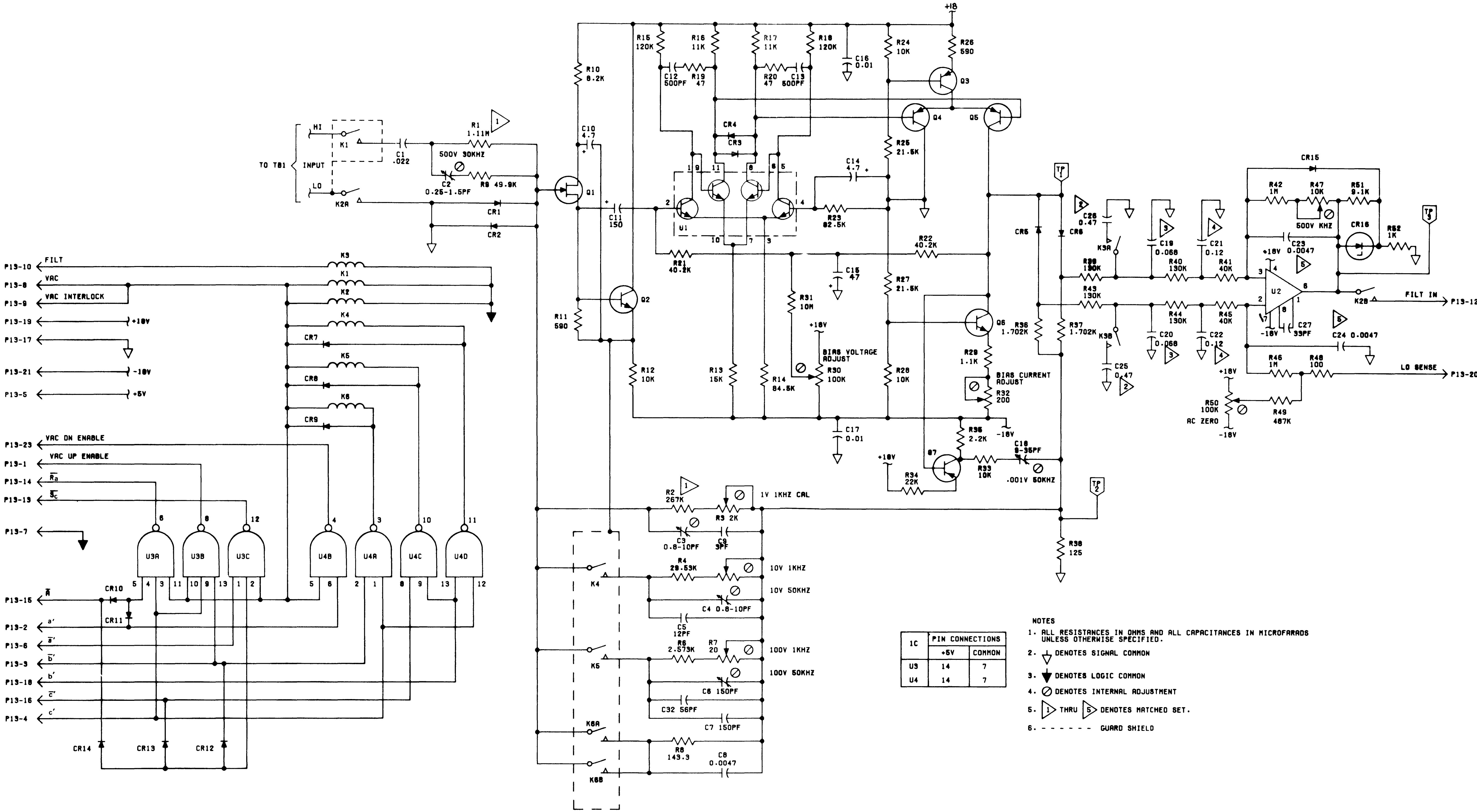


IC	PIN CONNECTORS +5VDC	PIN CONNECTORS COMMON
U3	14	7
U4	14	7
U5	14	7

NOTES:

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ▼ DENOTES LOGIC COMMON
3. ⊘ DENOTES INTERNAL ADJUSTMENT
4. SEE WIRING DIAGRAM
5. ▷ FACTORY SELECTED SET.

FIGURE 8-14 A12 OHMS CONVERTER PCB ASSEMBLY (8400A-1010)



IC	PIN CONNECTIONS	
	+5V	COMMON
U3	14	7
U4	14	7

NOTES

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. DENOTES SIGNAL COMMON
3. DENOTES LOGIC COMMON
4. DENOTES INTERNAL ADJUSTMENT
5. 1 THRU 5 DENOTES MATCHED SET.
6. - - - - - - - GUARD SHIELD

FIGURE 8-15 A13 AC CONVERTER PCB ASSEMBLY (8400A-1007)

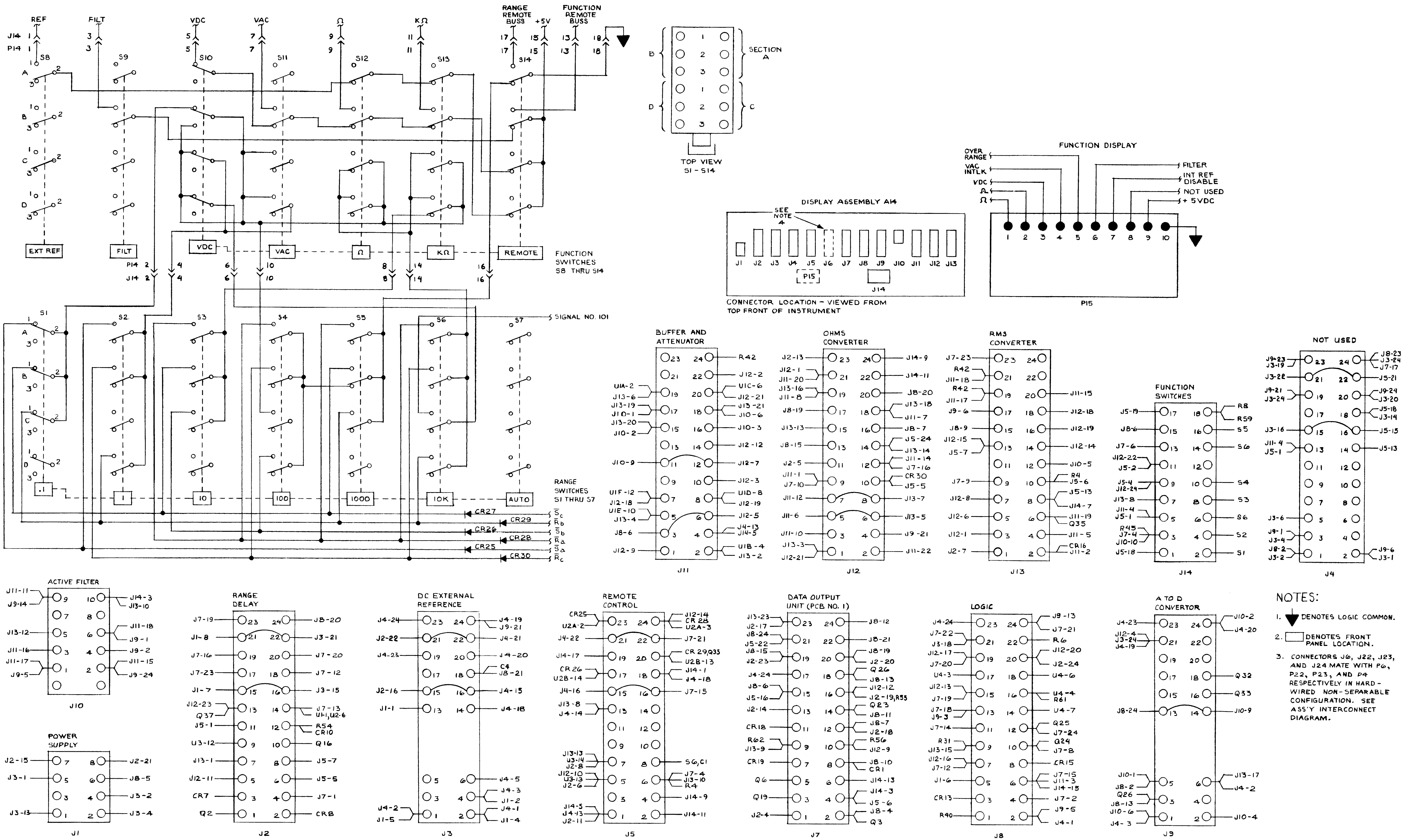
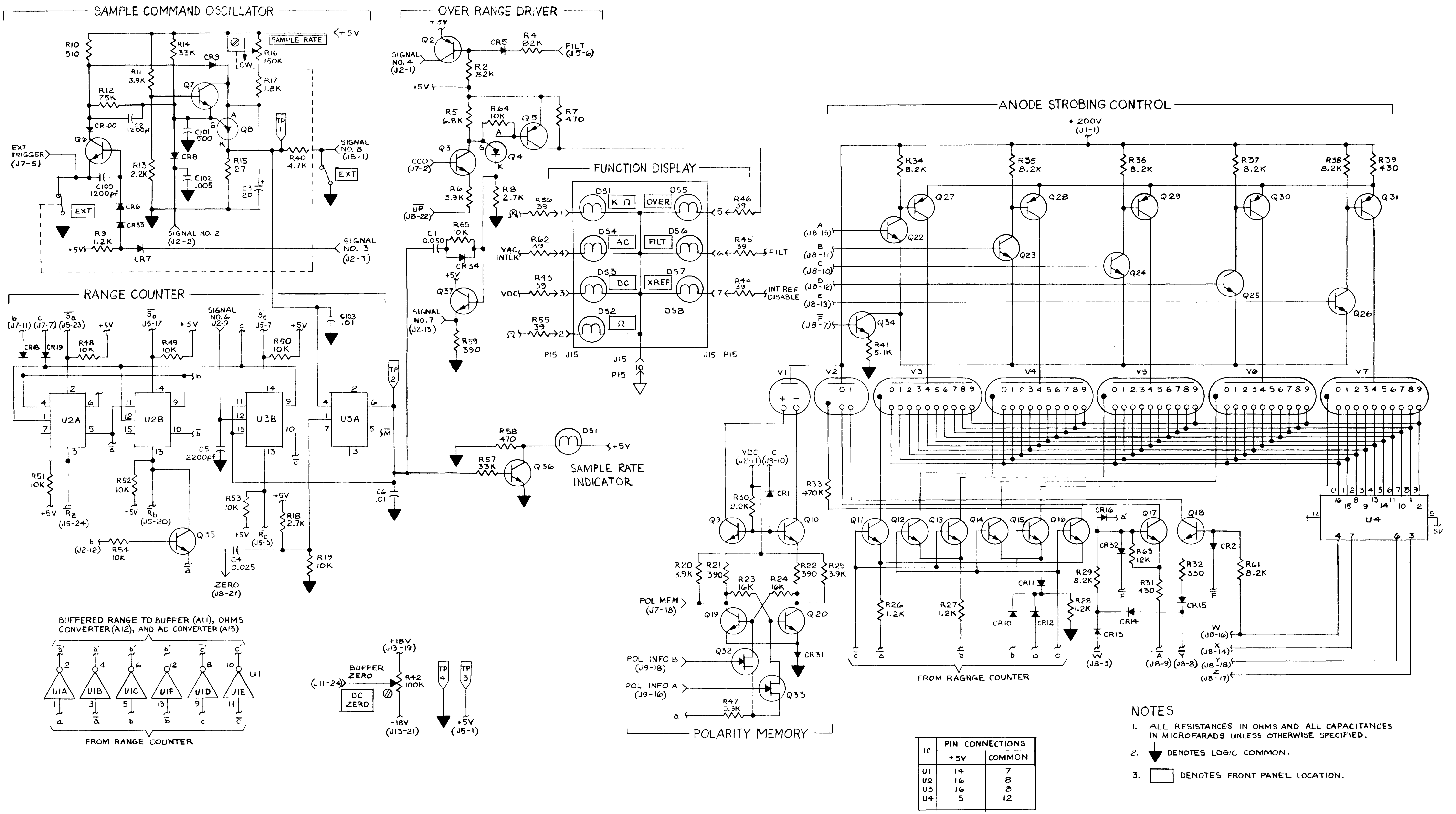


FIGURE 8-16 A14 DISPLAY PCB ASSEMBLY SHEET 1 of 2 (8400A



IC	PIN CONNECTIONS	
	+5V	COMMON
U1	14	7
U2	16	8
U3	16	8
U4	5	12

FIGURE 8-17 A14 DISPLAY PCB ASSEMBLY SHEET 2 of 2 (800A)

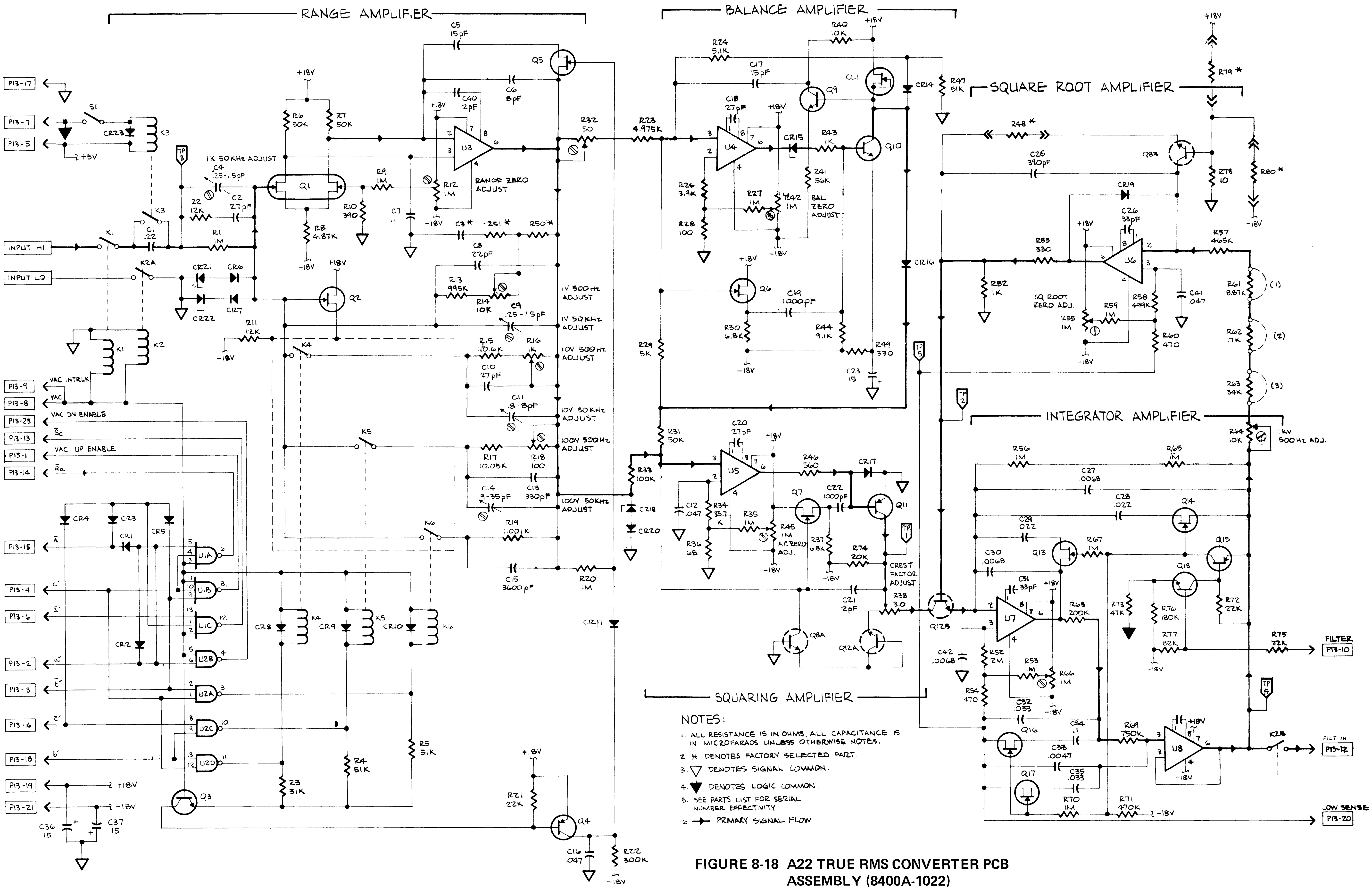


FIGURE 8-18 A22 TRUE RMS CONVERTER PCB ASSEMBLY (8400A-1022)