TM 11-6625-3240-14

TECHNICAL MANUAL

OPERATOR'S, UNIT, DIRECT SUPPORT, AND GENERAL SUPPORT MAINTENANCE MANUAL FOR TEST SET, ELECTRICAL CABLE TS-4165/G (NSN 6625-01-255-4248) (EIC: KD9)

HEADQUARTERS, DEPARTMENT OF THE ARMY

15 JUNE 1993

5 SAFETY STEPS TO FOLLOW IF SOMEONE IS THE VICTIM OF ELECTRICAL SHOCK

1 DO NOT TRY TO PULL OR GRAB THE INDIVIDUAL

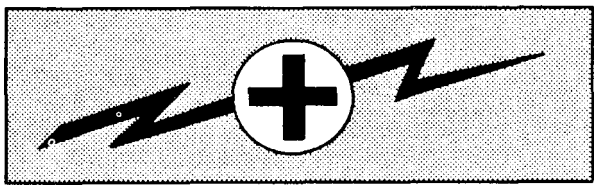
2 IF POSSIBLE, TURN OFF THE ELECTRICAL POWER

3 IF YOU CANNOT TURN OFF THE ELECTRICAL POWER, PULL, PUSH, OR LIFT THE PERSON TO SAFETY USING A DRY WOODEN POLE OR A DRY ROPE OR SOME OTHER INSULATING MATERIAL

4 SEND FOR HELP AS SOON AS POSSIBLE

5 AFTER THE INJURED PERSON IS FREE OF CONTACT WITH THE SOURCE OF ELECTRICAL SHOCK, MOVE THE PERSON A SHORT DISTANCE AWAY AND IMMEDIATELY START ARTIFICIAL RESUSCITATION

WARNING



HIGH VOLTAGE

is used in the operation of this equipment

DEATH ON CONTACT

may result if personnel fail to observe safety precautions

Never work on electronic equipment unless there is another person nearby who is familiar with the operation and hazards of the equipment and who is competent in administering first aid. When the technicians are aided by operators, they must be warned about dangerous areas.

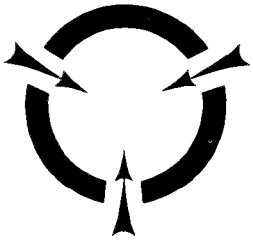
Whenever possible, the power supply to the equipment must be shut off before beginning work on the equipment. Take particular care to ground every capacitor likely to hold a dangerous potential. When working inside the equipment, after the power has been turned off, always ground every part before touching it.

Be careful not to contact high-voltage connections or 115 volt ac input connections when installing or operating this equipment.

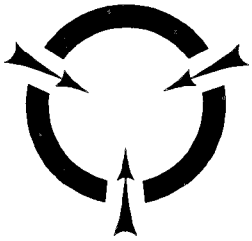
Whenever the nature of the operation permits, keep one hand away from the equipment to reduce the hazard of current flowing through the body.

Warning:
Do not be misled by the term “low voltage.” Potentials as low as 50 volts may cause death under adverse conditions.

For Artificial Respiration, refer to FM 4-25.11.



C A U T I O N



THIS EQUIPMENT CONTAINS PARTS AND ASSEMBLIES SENSITIVE TO DAMAGE BY ELECTROSTATIC DISCHARGE (ESD). USE ESD PRECAUTIONARY PROCEDURES WHEN TOUCHING, REMOVING OR INSERTING PRINTED CIRCUIT BOARDS.

ESD

CLASS 1

NOTE

The symbol for static sensitive devices in military inventory is as depicted in the caution block above.

GENERAL HANDLING PROCEDURES FOR ESDS ITEMS

- USE WRIST GROUND STRAPS OR MANUAL GROUNDING PROCEDURES
- KEEP ESDS ITEMS IN PROTECTIVE COVERING WHEN NOT IN USE
- Ž GROUND ALL ELECTRICAL TOOLS AND TEST EQUIPMENT
- PERIODICALLY CHECK CONTINUITY AND RESISTANCE OF GROUNDING SYSTEM
- USE ONLY METALIZED SOLDER SUCKERS
- HANDLE ESDS ITEMS ONLY IN PROTECTED AREAS

MANUAL GROUNDING PROCEDURES

- MAKE CERTAIN EQUIPMENT IS POWERED DOWN
- TOUCH GROUND PRIOR TO REMOVING ESDS ITEMS
- Ž TOUCH PACKAGE OF REPLACEMENT ESDS ITEM TO GROUND BEFORE OPENING
- Ž TOUCH GROUND PRIOR TO INSERTING REPLACEMENT ESDS ITEMS

ESD PROTECTIVE PACKAGING AND LABELING

- INTIMATE COVERING OF ANTISTATIC MATERIAL WITH AN OUTER WRAP OF EITHER TYPE 1 ALUMINIZED MATERIAL OR CONDUCTIVE PLASTIC FILM OR HYBRID LAMINATED BAGS HAVING AN INTERIOR OF ANTISTATIC MATERIAL WITH AN OUTER METALIZED LAYER
- LABEL WITH SENSITIVE ELECTRONIC SYMBOL AND CAUTION NOTE

CAUTION

Devices such as CMOS, NMOS, MNOS, VMOS, HMOS, thin-film resistors PMOS, and MOSFET used in many equipments can be damaged by static voltages present in most repair facilities. Most of the components contain internal gate protection circuits that are partially effective, but sound maintenance practice and the cost of equipment failure in time and money dictate careful handling of all electrostatic sensitive components.

The following precautions should be observed when handling all electrostatic sensitive components and units containing such components:

CAUTION

Failure to observe all of these precautions can cause permanent damage to the electrostatic sensitive device. This damage can cause the device to fail immediately or at a later date when exposed to an adverse environment.

STEP 1 Turn off and/or disconnect all power and signal source and loads used with the unit.

STEP 2 Place the unit on grounded conductive work surfaces.

STEP 3 Ground the repair operator using a conductive wrist strap or other device using a 1-M series resistor to protect the operator.

STEP 4 Ground any tools (including soldering equipment) that will contact the unit. Contact with the operator's hand provides a sufficient ground for tools that are otherwise electrically isolated.

STEP 5 All electrostatic sensitive replacement components are shipped in conductive foam or tubes and must be stored in the original shipping container until installed.

STEP 6 When these devices and assemblies are removed from the unit, they should be placed on the conductive work surface or in conductive containers.

STEP 7 When not being worked on, wrap disconnected circuit boards in aluminum foil or in plastic bags that have been coated or impregnated with a conductive material.

STEP 8 Do not handle these devices unnecessarily or remove from their packages until actually used or tested.

LITHIUM BATTERY DISPOSAL AND FIRST AID

The TS-4165/G contains one lithium battery, BT1010, on the A1 Main circuit board.

WARNING

To avoid personal injury, observe proper procedures for the handling of lithium batteries. Improper handling may cause fire, explosion, or severe burns. Do not recharge, crush, disassemble, heat the battery above 212°F (100°C), incinerate, or expose the contents to water.

BATTERY DISPOSAL

Dispose of the battery according to local, state, and federal regulations.

EMERGENCY FIRST AID INFORMATION

Manufacturer: Eagle-Picher, Inc.

Battery Type: Lithium Poly-Carbon monofluoride, LTG 7P

Solvent (electrolyte): Gama Butyrlactone is of low toxicity. This solvent can cause some eye and respiratory irritation. According to the manufacturer, the solvent may be released during venting. Venting is an out-gassing of battery material. Shorting circuit (for more than a few seconds) or overheating the battery usually causes venting.

Solute: LIBF4

The following table lists the actions to take if you come in contact with battery solvent.

Contact	Do This:
Skin	Wash promptly with plenty of water.
Eyes	Flush immediately with plenty of water and use an emergency eye wash, if available. Report to a medical professional for treatment.
Inhalation	Leave the area and get fresh air. Report to a medical professional for treatment.
Ingestion	Non-toxic according to laboratory testing. However, report to a medical professional for advice.

In case of venting, clear the immediate area. Usually, venting will only last a few seconds.

CHANGE)
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No. 2)

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, D.C., 27 July 2006

OPERATOR'S, UNIT, DIRECT SUPPORT, AND GENERAL SUPPORT MAINTENANCE MANUAL FOR TEST SET, ELECTRICAL CABLE TS-4165/G (NSN 6625-01-255-4248) (EIC: KD9)

HAZARDOUS MATERIAL INFORMATION – This document has been reviewed for the presence of solvents containing hazardous materials as defined by the EPCRA 302 and 313 lists by the AMCOM G-4 (Logistics) Environmental Division. As of the base document through change 01, dated 15 June 1993, all references to solvents containing hazardous materials have been removed from this document by substitution with non-hazardous or less hazardous materials where possible.

OZONE DEPLETING CHEMICAL INFORMATION – This document has been reviewed for the presence of Class I ozone depleting chemicals by AMCOM G-4 (Logistics) Environmental Division. As of the base document through change 01, dated 15 June 1993, all references to Class I ozone depleting chemicals have been removed from this document by substitution with chemicals that do not cause atmospheric ozone depletion.

DISTRIBUTION STATEMENT D – Distribution authorized to Department of Defense and DOD contractors only to protect critical technical data on systems or hardware. This determination was made OCT 1986. Other requests shall be referred to Program Manager, TMDE, ATTN: SFAE-CS-FT-T-TEMOD, Redstone Arsenal, AL 35898-5000.

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1. Remove old pages and insert new pages as indicated below. New or changed material is indicated by a vertical bar in the outer margin of the page. Illustration changes are indicated by a pointing hand. New or changed part numbers are indicated by an asterisk (*). Completely revised sections or chapters are indicated by a vertical bar next to the title only.

Remove Pages	Insert Pages
A through E/(F blank)	a through e/(f blank)
G and H	A/(B blank)
i and ii	i and ii
1-1, 1-2	1-1, 1-2
3-1, 3-2	3-1, 3-2
5-15, 5-16	5-15, 5-16
5-29, 5-30	5-29, 5-30
A-1/(A-2 blank)	A-1/(A-2 blank)
E-1, E-2	E-1, E-2
Cover	Cover

2. File this change sheet in front of the publication for reference purposes.

By Order of the Secretary of the Army:

PETER J. SCHOOMAKER
General, United States Army
Chief of Staff

Official:

JOYCE E. MORROW
Administrative Assistant to the
Secretary of the Army
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TM 11-6625-3240-14
C1

CHANGE
No. 1

Headquarters
Department of the Army
Washington, D.C., 30 September 2005

OPERATOR'S, UNIT, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL

FOR

TEST SET, ELECTRICAL CABLE
TS-4165/G
(NSN 6625-01-255-4248) (EIC:KD9)

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2. This change implements Army Maintenance Transformation and changes the Maintenance Allocation Chart (MAC) to support Field and Sustainment Maintenance.

3. File this change sheet in front of the publication for reference purposes.

Remove Pages	**Insert Pages**
None	G thru H
i, ii	i, ii
B-1 thru B-6	B-1 thru B-7/(B-8 Blank)
COVER	COVER

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Chief of Staff

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LIST OF EFFECTIVE PAGES

NOTE

ON CHANGED PAGES, THE PORTION OF THE TEXT AFFECTED BY THE LATEST CHANGE IS INDICATED BY A VERTICAL LINE OR OTHER CHANGE SYMBOL IN THE OUTER MARGIN OF THE PAGE.

Dates of issue for original and changed pages are:

Original	0	15 JUN 1993
Change	1	30 SEP 2005
Change	2	27 JUL 2006

Total number of pages in this publication is 211 consisting of the following:

Page No.	*Change No.	Page No.	*Change No.
Cover	2	Index 1	0
a	2	Index 2	0
b	2	Index 3	0
c and d	2	Index 4	0
e/(f blank)	2	Index 5	0
A/(B blank)	2	Index 6 blank	0
i and ii	2	FP-1/(FP-2 blank)	0
iii	0	FP-3/(FP-4 blank)	0
1-0	0	FP-5/(FP-6 blank)	0
1-1 and 1-2	2	FP-7/(FP-8 blank)	0
1-3 through 1-8	0	FP-9/(FP-10 blank)	0
1-9/(1-10 blank)	0	FP-11/(FP-12 blank)	0
2-1through 2-22	0	FP-13/(FP-14 blank)	0
3-1	0	FP-15/(FP-16 blank)	0
3-2	2	FP-17/(FP-18 blank)	0
3-3 through 3-28	0	FP-19/(FP-20 blank)	0
3-29/(3-30 blank)	0	FP-21/(FP-22 blank)	0
4-1/(4-2 blank)	0	FP-23/(FP-24 blank)	0
5-1 through 5-14	0	FP-25/(FP-26 blank)	0
5-15	2	FP-27/(FP-28 blank)	0
5-16 through 5-28	0	FP-29/(FP-30 blank)	0
5-29	2	FP-31/(FP-32 blank)	0
5-30 through 5-68	0	FP-33/(FP-34 blank)	0
A-1/(A-2 blank)	2	FP-35/(FP-36 blank)	0
B-1 through B-7	2	FP-37/(FP-38 blank)	0
B-8 blank	2	FP-39/(FP-40 blank)	0
C-1 AND C-2	0	FP-41/(FP-42 blank)	0
C-3/(C-4 blank)	0	FP-43/(FP-44 blank)	0
D-1/(D-2 blank)	0	FP-45/(FP-46 blank)	0
E-1	0	FP-47/(FP-48 blank)	0
E-2	2	FP-49/(FP-50 blank)	0
Glossary 1	0		
Glossary 2	0		

* Zero in this column indicates an original page.

Technical Manual)
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No. 11-6625-3240-14)

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, D.C., 15 June 1993

OPERATOR'S, UNIT, DIRECT SUPPORT GENERAL SUPPORT MAINTENANCE MANUAL FOR TEST SET, ELECTRICAL CABLE TS-4165/G (NSN 6625-01-255-4248) (EIC: KD9)

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter or DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to: Commander, U.S. Army Aviation and Missile Command, AMSAM-MMC-MA-NP, Redstone Arsenal, AL 35898-5000. A reply will be furnished to you. You may also provide DA Form 2028 information to AMCOM via email, fax or the World Wide Web. Our fax number is DSN 788-6546 or Commercial 256-842-6546. Our email address is: 2028@redstone.army.mil. Instruction for sending an electronic 2028 may be found at the back of this manual immediately preceding the hardcopy 2028. For the World Wide Web use:https://amcom2028.redstone.army.mil.

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HOW TO USE THIS MANUAL

This manual tells about the Test Set, Electrical Cable TS-4165/G, and contains instructions about how to use and maintain the Test Set.

When first receiving the Test Set manual, start at the front and go all the way through to the back. Become familiar with every part of the manual and the Test Set.

This manual has an edge index that will help locate specific information in a hurry. Simply spread the pages on the right edge of the manual until the printed blocks can be seen. Open the manual where the block on the edge of the page lines up with the selected topic printed on the front cover block.

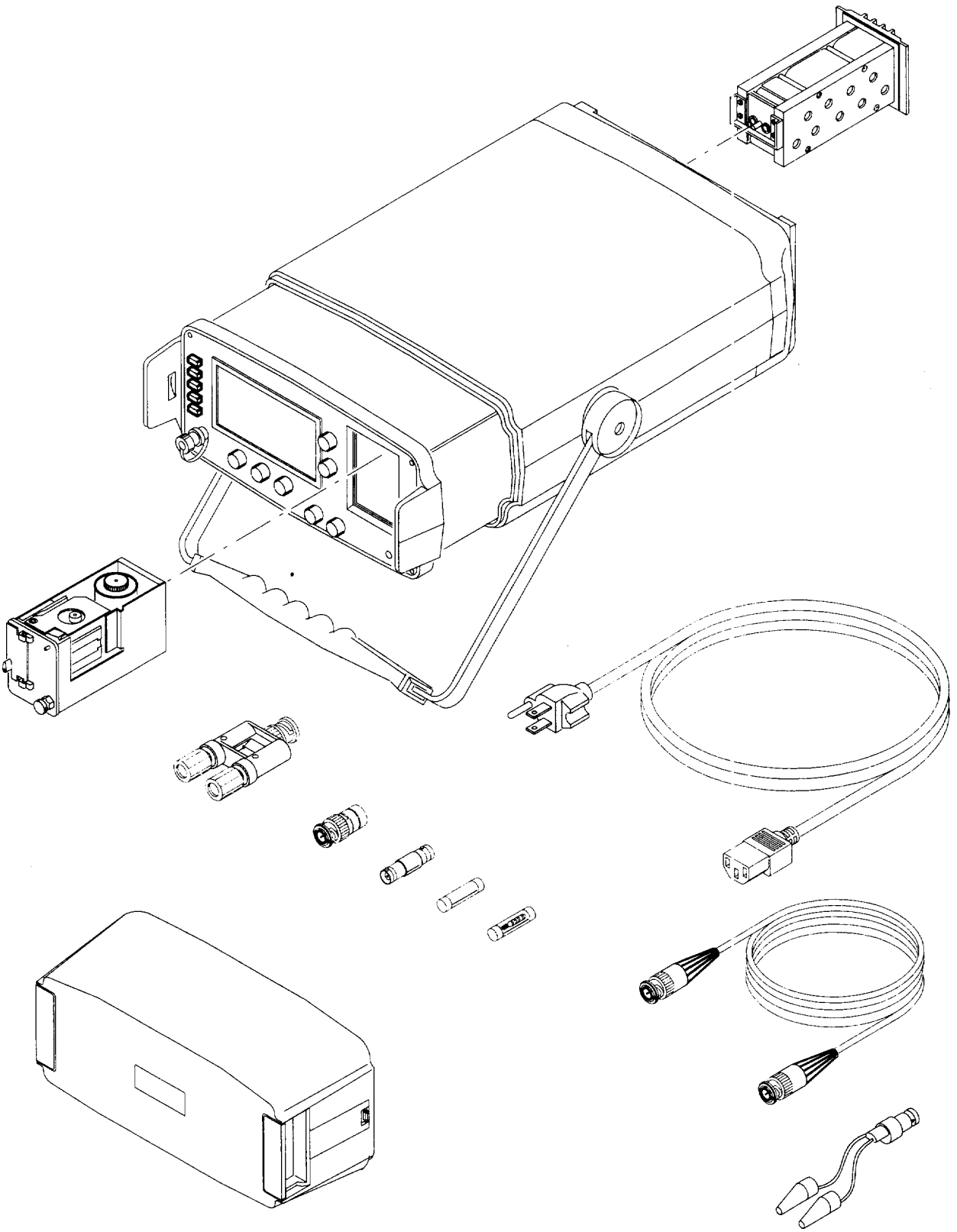

Figure 1-1. Test Set, Electrical Cable TS-4165/G

CHAPTER 1
INTRODUCTION

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Section 1. GENERAL INFORMATION.

1-1. SCOPE

a. **Type of Manual:** Operator's, Unit, Direct Support, and General Support Maintenance Manual.

b. **Equipment Name and Model Number:** Test Set. Electrical Cable TS-4165/G (Test Set)

c. **Purpose of Equipment:** The Test Set (fig. 1-1) is a short-range metallic cable tester capable of finding faults in metal cable. Tests can be made on coaxial, twisted pair, or parallel cable.

1-2. CONSOLIDATED INDEX OF ARMY PUBLICATIONS AND BLANK FORMS

Refer to the latest issue of DA Pam 25-30 to determine whether there are new editions, changes, or additional publications pertaining to the Test Set.

1-3. MAINTENANCE FORMS, RECORDS, AND REPORTS

a. **Report of Maintenance and Unsatisfactory Equipment.** Department of the Army forms and procedures used for equipment maintenance will be those prescribed by DA Pam 750-8, as contained in The Army Maintenance Management (TAMMS) Users Manual Update.

b. **Reporting of Item and Packaging Discrepancies.** Fill out and forward SF 364 (Report of Discrepancy (ROD)) as prescribe in AR 735-11-2/DLAR 4140.55/SECNAVINST 4355.18/AFR 400-54/MCO 4430.3J.

c. **Transportation Discrepancy Report.** Fill out and forward Transportation Discrepancy Report (TDR) (SF 361) as prescribed in DA Pam 25-30/NAVSUPINST 4610.3 3C/AFR 75- 18/MCO P4610.19 D/DLAR 4500.15.

1-4. DESTRUCTION OF ARMY ELECTRONICS MATERIEL TO PREVENT ENEMY USE

Destruction of Army electronics materiel to prevent enemy use shall be in accordance with TM 750-244-2.

1-5. REPORTING EQUIPMENT IMPROVEMENT RECOMMENDATIONS (EIRs)

If your Test Set needs improvement. Let us know. You, the user, are the only one who can tell us what you don't like about the equipment. Put it on an SF 365 (Product Quality Deficiency Reports. Mail it to us at: Commander. U.S. Army Aviation and Missile Command. ATTN: AMSAM-MMC-MA-NM, Redstone Arsenal, AL. 35898-5000. A reply will be furnished directly to you.

1-6. WARRANTY INFORMATION

The Test Set is warranted for 12 months by Tektronix, Inc. Warranty starts on the date of shipment to the original buyer. Report all defects in material of workmanship to your supervisor. We will take appropriate action.

1-7. NOMENCLATURE CROSS-REFERENCE LIST

Common names will be used when major components of the Test Set are mentioned in this manual.

NOTE

Official nomenclatures must be used when filling out report forms or looking up technical manuals.

Common Name	Official Nomenclature
Test Set	Test Set Electrical Cable TS-41 65/G

Section II. EQUIPMENT DESCRIPTION

1-8. EQUIPMENT CHARACTERISTICS, CAPABILITIES, AND FEATURES

The Test Set is a short-range cable tester that finds faults in metal cable.

a. Characteristics.

Ž Sensitive to impedance changes

• Detects reflections made by cable discontinuities

Ž Displays problems as impedance changes

b. Capabilities and Features.

- Provides 0.9-inch resolution between faults
- Splashproof
- Engineered with static suppression
- High-resolution Liquid Crystal Display (LCD)
- Built-in memory
- Tests coaxial, twisted pair, or parallel cable
- Finds shorts, opens, shield defects, foreign substances, or kinks
- A menu-driven, on-board HELP function
- Provides printed copy of all screens
- Provides on-screen summary of all switch settings
- Portable DC operation with rechargeable battery pack

1-9. EQUIPMENT DATA

PHYSICAL CHARACTERISTICS:

WEIGHT

Without cover, battery pack, and chart recorder	14.25 lb (6.47 kg)
With cover, battery pack, and chart recorder	19.75 lb (8.97 kg)
With cover	15.75 lb (7.15 kg)
Shipping	25.5 lb (11.58 kg)

DIMENSIONS

Height	5.0 in. (127 mm)
Width	12.4 in. (315 mm)
Depth with handle extended	18.7 in. (475 mm)

POWER REQUIREMENTS:

VOLTAGE

115 VAC operation	90-132 VAC

230 VAC operation	180-250 VAC
DC operation	12 VDC
Minimum battery pack operating time	5 hours
FREQUENCY	45-445 Hz
POWER	34.5 watts
FUSE RATING	
115 VAC	0.3 amp, 250 V
230 VAC	0.15 amp, 250 V

ENVIRONMENTAL CHARACTERISTICS:

TEMPERATURE	
Operating	+14° to +131° F (-10° to +55°C)
STORAGE TEMPERATURE	
With battery pack	-4° to +131°F (-20° to +55°C)
Without battery pack	-79.6° to +185° F (-62° to +85°C)
HUMIDITY	
Covers on and internal desiccant	To 100%
ALTITUDE	
Operating	To 15,000 ft (4.6 km)
Nonoperating	To 40,000 ft (12.2 km)
VIBRATION	MIL-T-28800C, Class 3
MECHANICAL SHOCK	
Pulse	MIL-T-28800C, Class 3
Operating	MIL-T-28800C, Class 3
Nonoperating	MIL-T-28800C, Class 3
Loose cargo bounce	MIL-STD-810, Method 514, Procedure XI, Part 2
WATER RESISTANCE	MIL-T-28800C, Style A
Operating	Splashproof and drip-proof
Nonoperating (with cover on)	Watertight to 3-ft depth of water

MISCELLANEOUS

Salt atmosphere	MIL-STD-81 0, Method 509, Procedure I: Withstand 48 hours. 20% solution without corrosion
Sand and dust	MI L-STD-81 0, Method 510, Procedure I
Washability	Capable of being washed
Fungus inert	Materials are fungus inert
Electromagnetic compatibility	VDE 0871 Class B MIL-T-28800C MIL-STD-461A notice 4(EL), CE02, CE04, CS02, CS06, RE02, RE02.1, RS03, RS03 .1 (RE02 .1 and RS03.1 from 14 kHz to 10 GHz)
Radiated susceptibi lity	MIL-STD-461A notice 4(EL) Method MIL-STD-462 notice 3 for RS03 and RS03 .1, Limited to I V/m (greater than 1 GHz, displayed noise characteristic performance shall be ±10 mp peak or less, with 50 Ω termination connected to RF input (16 averages))

ELECTRICAL CHARACTERISTICS:

PULSE

Reflected rise (excitatic)n)	≤200 ps (0.096 ft). Vp set to 0.99; 10 to 90%, into a precision short
Amplitude	300 mV nominal into 50 Ω load
Width .	25 µs nominal
Repetition time	200 µs nominal
ABERRATIONS	±5% peak within 0-10 ft (0-3 04. 8 cm) after rise ±0.5% peak beyond 10 ft (304 .8 cm)
JITTER	Vp set to 0.99 ≤0.02 ft (0.61 cm) [≤40 ps] peak-to-peak, horizontal scale set to 0. 1 ft (3.05 cm)/DIV ≤0. 2 ft (6. 1 cm) [≤400 ps] peak-to-peak, horizontal scale set to 1 ft (30.48 cm)/DIV At 23.4 ft (713 cm) to 46 .8 ft (1426 cm) jitter is ≤0.4 ft (12. 2 cm)
OUTPUT IMPEDANCE	50 Ω ±1% (while pulse is on)

VERTICAL

Scales	0.5 mp/DIV to 500 mp/DIV
Accuracy	±3% of full-scale range

DISPLAYED NOISE

Random (filter set to 1) . . . . . ±5 mρ peak or less

Random (filter set to 8) . . . . . ±2 mρ peak or less

HORIZONTAL

Scales . . . . . 0.1 ft (2.5 cm)/DIV to 200 ft (50 m)/DIV
11 values; 1,2,5 sequence

Ranges . . . . . 1 ft (2.5 m) to 2,000 ft (609.6 m)/DIV

Vp

Range . . . . . 0.30 to 0.99 (propagation velocity relative to air)

DISTANCE CURSOR RESOLUTION . . . . . 1/25 of 1 major division

CURSOR READOUT

Range . . . . . -2 ft (-61 cm) to ≥2,000 ft (609.6 m)

Resolution . . . . . 0.004 ft (0.12 cm)

DISTANCE MEASUREMENT
ACCURACY . . . . . 1.6 in. (40.64 mm) at Vp of .66, or ±1% of distance measured, whichever is greater

BATTERY PACK

Operation . . . . . 5 hrs operating time with up to 20 chart recordings, +58°F to +76°F (+15°C to +25°C) charge and discharge temperature, LCD backlight off

NOTE

- *Battery pack will charge whenever Test Set is plugged into AC power source.*
- *Battery pack may be removed during AC operation.*

Overcharge protection . . . . . Limited to 10 days of continuous charge

Section III. TECHNICAL PRINCIPLES OF OPERATION

1-10. FUNCTIONAL DESCRIPTION

The Test Set (fig. 1-2) uses radar principles to determine the impedance characteristics of metallic cables. A rapidly rising step signal generated by the Test Set is applied to the cable under test. The reflected voltage waveform from the cable is detected, processed, and then displayed on the LCD where measurements can be made using the cursor.

If the cable under test has a known propagation velocity, the time delay to a particular reflection may be interpreted in cable distance. Amplitude of the reflected voltage is a function of the cable impedance of the termination relative to the cable leading to it. The amplitude can be interpreted in rho (ρ) or decibels (dB). Rho is a convenient impedance function defined as the voltage reflection coefficient. It is the ratio between the incident step and the reflected step. R_L can be calculated by using rho and characteristic impedance (Z_O) values. For the simple case of a cable with a resistive load:

$$R_L = Z_O\left(\frac{1+\rho}{1-\rho}\right) \qquad \text{also} \qquad \rho = \frac{R_L - Z_O}{R_L + Z_O} \qquad \text{also} \qquad \rho = \frac{\text{Incident Voltage}}{\text{Reflected Voltage}}$$

The following is a functional description of the major circuits of the Test Set

① **POWER SUPPLY ASSEMBLY (A3)** – The power supply converts input power (115 VAC, 230 VAC, or 12 VDC battery power, as applicable) to provide the Test Set with regulated DC voltages via the power bus. Test Set circuits are protected with an EMI filter and fuses applicable to applied power (0.3 A for 115 VAC, 0.15 A for 230 VAC, and a 3 A fuse for battery operation).

② **PROCESSOR** – The processor provides control and decoding functions for the Test Set via the digital bus. The processor reads the front panel control settings to determine the viewing requirements of the operator. Distance settings are converted to equivalent time values and loaded into the timebase circuits.

③ **TIMEBASE** – The timebase circuits receive video-sample time-delay values in digital form from the processor and generate precisely timed strobe signals (pulse or sample) to trigger the driver/sampler circuits. The timebase circuits control the time delay of the sample strobe relative to the pulse strobe. Digital counters determine the delay in 50 ns multiples, and analog circuits further define the delay to fractions of that period.

④ **DRIVER/SAMPLER CCA (A4)** – The driver is triggered by the timebase circuits and sends out a pulse through the front panel connector. The sampler takes its input from the returning signal. Sample strobes cause a single sample of the cable voltage to be taken during a very short interval. When many sequential samples are recombined, a replica of the cable voltage is formed. This sampling technique allows extremely rapid repetitive waveforms to be viewed in detail.

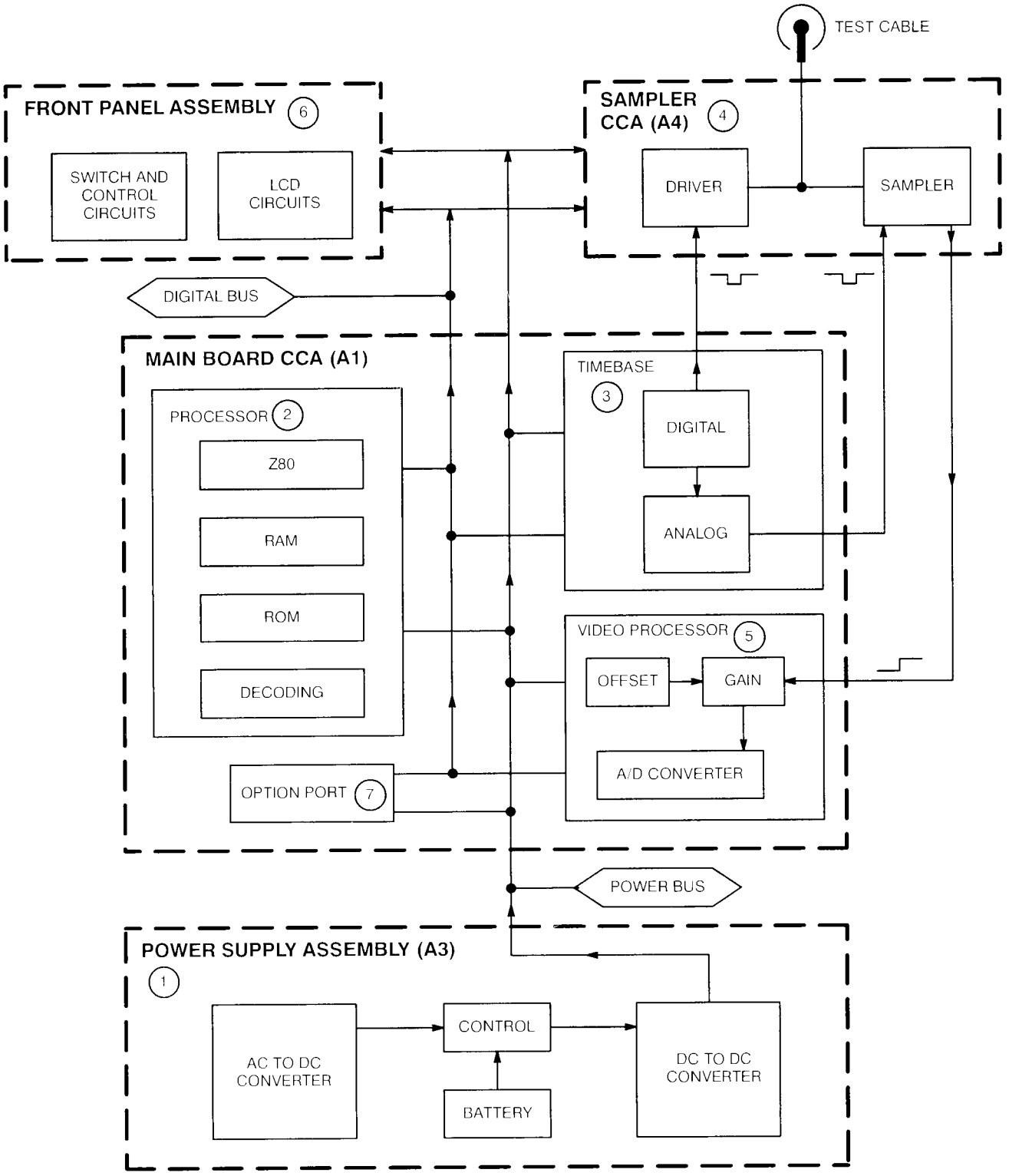
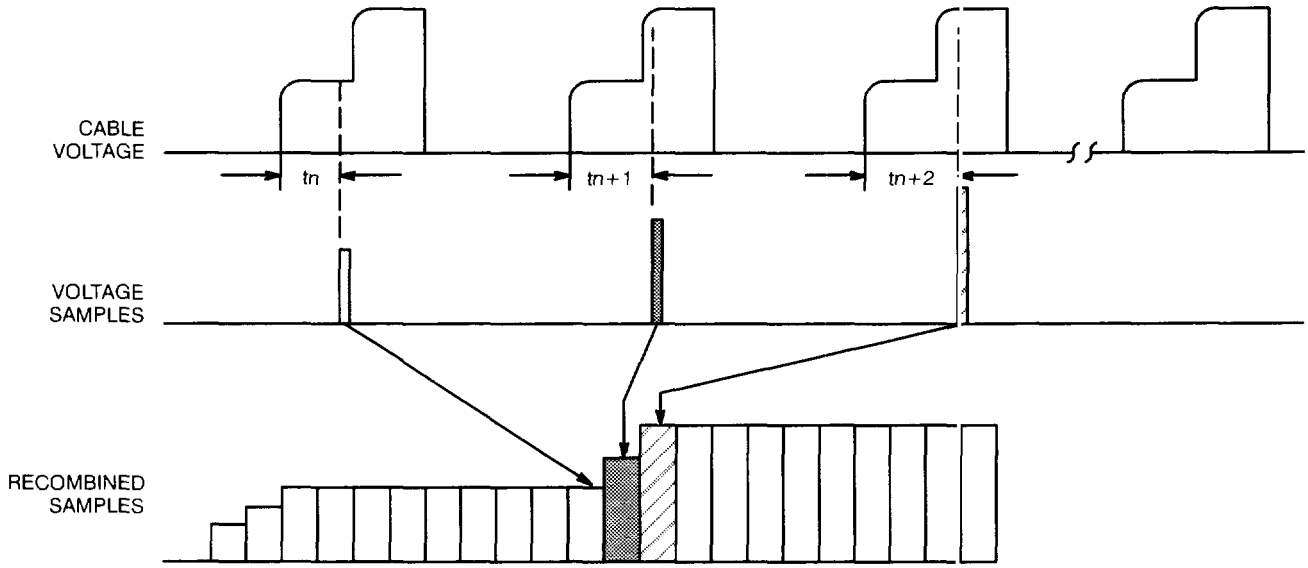


Figure 1-2. Test Set Simplified Block Diagram

Referring to the diagram below, note that the cable voltage waveforms are showr at the top. Each step is from the pulse generator (on Driver/Sampler CCA) and all steps are identical. At the illustrated time delays (tn, tn+ 1, tn+2, etc.) after the steps begin, a sample of the step amplitude is taken.



⑤ **VIDEO PROCESSOR** – The video processor receives voltage samples from the driver/sampler. These samples are combined with the vertical position voltage derived from the front panel control, and then amplified. The amplifier gain is programmed by the processor to give the selected vertical sensitivity. Each amplified sample voltage is then digitized by an analog-to-digital converter and outputs a digitized video signal to the processor. These samples are stored until sufficient points are accumulated to define the entire period of interest. The samples are then processed and displayed at a much slower rate, forming the recombined waveform show n at the bottom of the diagram.

⑥ **FRONT PANEL ASSEMBLY** – The front panel control settings are read by the processor to determine the cable information selected for viewing by the operator Cursor and readout display data is determined by the processor and combined with the formatted sample waveform before it is sent to the LCD. When the processor has accumulated sufficient samples (25 1) to form the desired waveform, the samples are formatted. This formatted data is then transferred to the display memory. The display logic routes the data to each pixel of he LCD, where each digital data bit determines whether or not a particular pixel is turned on or off. Between each wave form, samples are also taken at the cursor location for the "ohms at cursor" function, and at the leading edge of the incident step for use by the timebase correction circuit.

When the Test Set is operating in temperatures below +50°F (+10°C), a heating element in the LCD circuitry is activated to warm the LCD.

⑦ **OPTION PORT INTERFACE** – The option port interface provides the connection between the processor and the chart recorder.

CHAPTER 2
OPERATING INSTRUCTIONS

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Cable Information Menu	2-4	2-6
Chart Diagnostics Menu	2-11	2-9
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Diagnostics Menu	2-6	2-7
Entering Horizontal Set Reference	2-21	2-17
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Finding Distance to Fault/Testing a Longer Cable	2-18	2-13
General	2-12	2-9
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Section I. DESCRIPTION AND USE OF OPERATOR'S CONTROLS, INDICATORS, AND CONNECTORS

2-1. INTRODUCTION

This section describes the operator's controls, indicators, and connectors (figs. 2-1 and 2-2) for the Test Set, Electrical Cable TS-4165/G (Test Set).

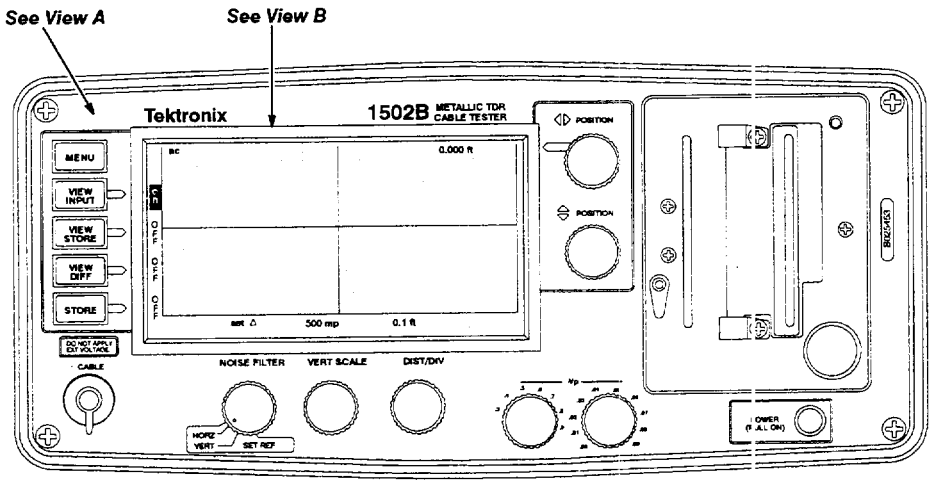
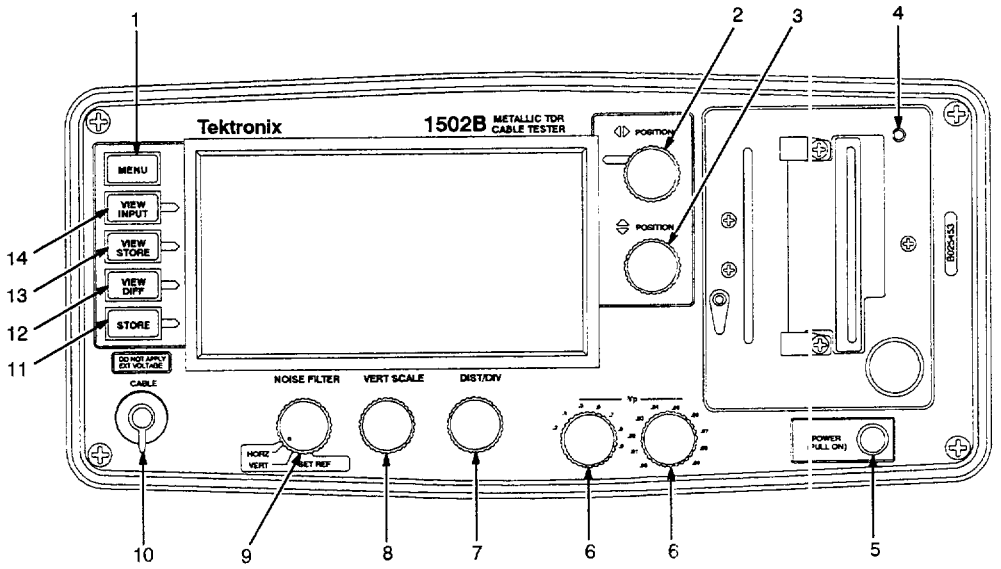
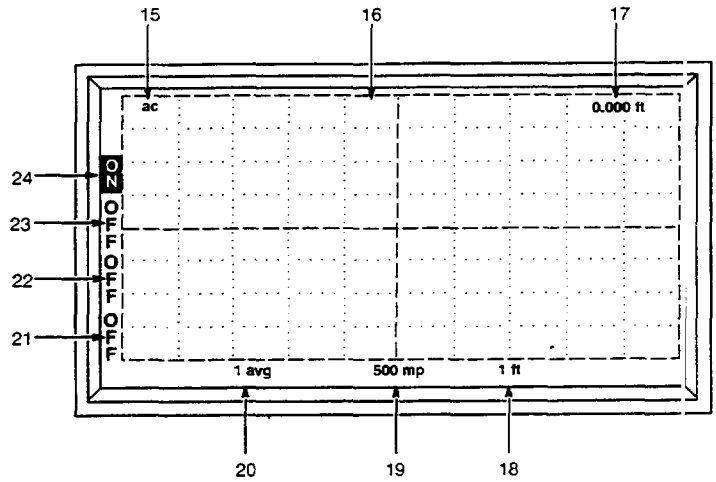


Figure 2-1. Operator's Controls, Indicators, and Connectors, Front View



VIEW A

Key	Control, Indicator, or Connector	Function
1	MENU pushbutton	Provides access to built-in manual and HELP functions that guide the operator through operating functions and common cable tables. Includes menus to configure Test Set as described in Menu Selections (para 2-2).
2	◆▶ POSITION control	Continuously rotating control that moves vertical cursor completely across LCD graticule. Displayed waveform also moves when cursor reaches extreme left or right side.
3	▲▼ POSITION control	Continuously rotating control that positions the displayed waveform up or down LCD.
4	PRINT pushbutton	After opening slot door, press to activate chart recorder. Provides printed copy of information displayed on LCD.
5	POWER switch	Pull out for power-on, push in for power-off. When cover is installed, switch is automatically pushed in to off.
6	Vp switches	Set according to propagation velocity factor of cable under test. Controls are dedicated; left control is first digit, right control is second digit. For a cable that has a Vp of 0.64, set left Vp switch to .6 and right Vp switch to .04.
7	DIST/DIV switch	An 11 -position switch that determines number of feet per division (ft/DIV) or meters per division (m/DIV) across display. Minimum setting is 0.1 ft/DIV (0.025 m/DIV); maximum setting is 200 ft/DIV (50 m/DIV).
8	VERT SCALE control	Sets vertical sensitivity, displayed in either mρ or dB per division. Mode is chosen from Setup Menu. Also provides contrast adjustment of menu screens.
9	NOISE FILTER switch	Used to reduce noise in displayed waveform by utilizing noise averaging. First two positions on switch are used for setting vertical and horizontal reference points. Remaining eight positions select degrees of averaging.
10	CABLE connector	Female BNC connector for connecting cable under test. Maximum input is 400 V peak. Remove cap for normal operation.
11	STORE pushbutton	When pressed momentarily, stores currently displayed waveform of cable under test in memory for later comparison. If waveform is already stored, pressing STORE will erase it. Settings of stored waveform are available from Main Menu under "View Stored Waveform Settings".



VIEW B

Key	Control, Indicator, or Connector	Function
12	VIEW DIFF pushbutton	When pressed momentari displays current waveform minus previously stored waveform.
13	VIEW STORE pushbutton	When pressed momentari retrieves and displays stored waveform. If there is no stored waveform, an error mess noting this will be displayed.
14	VIEW INPUT pushbutton	When a cable is connected to CABLE connector (VIEW INPUT pushbutton status display (24) indicates ON and a waveform of connected cable is displayed. Pressing VIEW INPUT pushbutton (momentarily will cause displayed waveform to disappear a ıd status display (24) to read OFF. Momentarily pressing (again will restore cable waveform ɛ status display (24) will read ON. Function is useful to make display less busy when viewing stored waveforms.
15	Operating power readout	Identifies type of operating power (ac, dc, or bat) for Test Set. Also indicates when battery power is low (bat/low).
16	LCD screen	Provides an on-screen summary of all switch settings, transmitted and reflected pulses, error messages, help screens, and menus.
17	Cable distance readout	Distance readout from front panel BNC to cursor. Converts to either feet or meters via menu.
18	DIST/DIV control readout	Displays value per display division as selected by DIST/DIV switch (7)
19	VERT SCALE control readout	Displays vertical sensitivity of Test Set in mp per division as selected by VERT SCALE control (8).

Key	Control, Indicator, or Connector	Function
20	NOISE FILTER control readout	Displays noise averagi ıg value as selected by NOISE FILTER switch (9).
21	STORE pushbutton status display	Displays status (ON/OFF) of STORE pushbutton (11).
22	VIEW DIFF pushbutton status	Displays status (ON/OFF) of VIEW DIFF pushbutton (12).
23	VIEW STORE pushbutton status display	Displays status (ON/OFF) of VIEW STORE pushbutton (13).
24	VIEW INPUT pushbutton status display	Displays status (ON/OFF) of VIEW INPUT pushbutton (14).

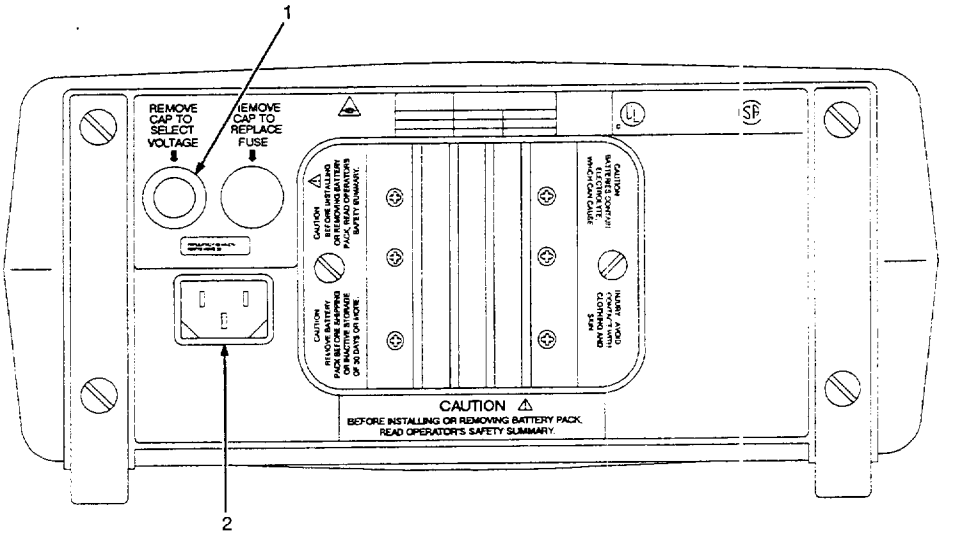
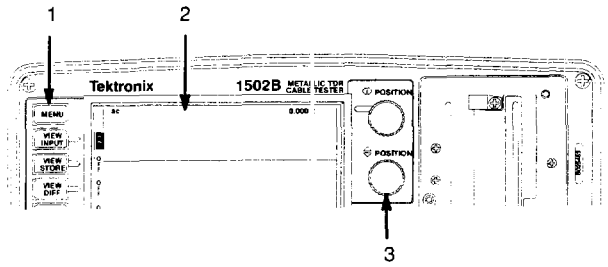


Figure 2-2. Operator's Controls, Indicators, and Connectors, Rear View

Key	Control, Indicator, or Connector	Function
1 1	Voltage Selector switch	Select either 110 or 220 VAC with a screwdriver after cap is removed.
2 2	Power CordCreceptacle	Connects Test Set to AC power source.

2-2. MENU SELECTIONS

The Test Set has many operating modes and functions that are selected from menus. Menu selections are made by moving the cursor to the desired option using the ▲▼ POSITION control (3) and then pressing the MENU pushbutton (1) to enter the selection. The following paragraphs describe the menus and their functions.



2-3. MAIN MENU

Selections from the Main Menu are listed below with function and are also showr as they appear on the display screen (2).

- **Return to Normal Operation.** Puts the Test Set in normal operation mode.
- **Help with Instrument Controls.** Explains the operation of each control. When a control or switch is adjusted or pressed, a brief explanation appears on the LCD.
- **Cable Information Menu.** Selects Cable Information Menu (para 2-4).
- **Setup Menu.** Selects Setup Menu (para 2-5).

```
→ Return to Normal Operation
  Help with Instrument Cont rols
  Cable Information Menu
  Setup Menu
  Diagnostics Menu
  View Stored Waveform Set ings
  Option Port Menu

Move ▲▼ Position to select, then push MENU button
```

- **Diagnostics Menu.** Selects Diagnostics Menu (para 2-6).
- **View Stored Waveform Settings.** Displays the stored waveform settings.
- **Option Port Menu.** Selects Option Port Menu (para 2-7).

2-4. CABLE INFORMATION MENU

Selections from the Cable Information Menu are:

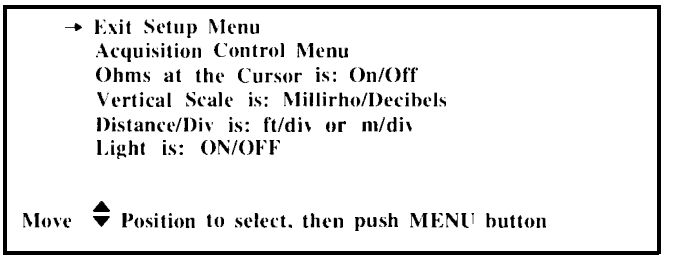
- **Exit Cable Information Menu.** Displays Main Menu.
- **Help with cables.** Gives a brief explanation of cable parameters.
- **Velocity of Propagation Values.** Displays a table of common dielectrics and Vp values.
- **Impedance Values.** Displays impedances for common cables.
- **Finding unknown Vp Values.** Describes a procedure for finding an unknown Vp.

```
→ Exit Cable Information Menu
  Help with cables
  Velocity of Propagation Values
  Impedance Values
  Finding unknown V p Values

Move ▲▼ Position to select, then p.sh MENU button
```

2-5. SETUP MENU

The Setup Menu controls how the Test Set obtains and displays the test results. Selections from the Setup Menu are:

- **Exit Setup Menu.** Displays Main Menu
- **Acquisition Control Menu.** Selects Acquisition Control Menu (para 2-8)
- **Ohms at the Cursor is: On/Off.** When On, the approximate impedance at the point of the cursor is displayed under the distance window on the LCD.

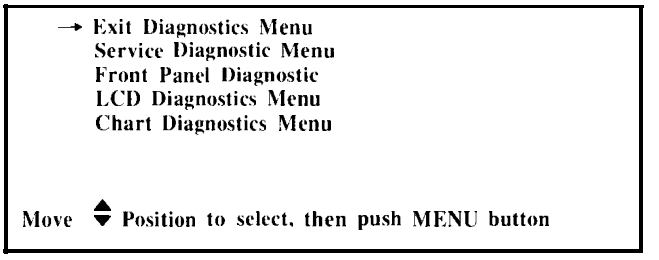


- **Vertical Scale is: Millirho/Decibels.** The vertical gain of the Test Set can be displayed in millirho or decibels. The Test Set defaults to millirho after initial power-on.
- **Distance/Div is: ft/div or m/div.** The horizontal scale of the Test Set can be displayed in feet per division or meters per division. The Test Set defaults to feet per division on initial power-on.
- **Light is: ON/OFF.** Turns LCD backlighting ON or OFF.

2-6. DIAGNOSTICS MENU

Selections from the Diagnostics Menu are:

- **Exit Diagnostics Menu.** Displays Main Menu
- **Service Diagnostic Menu.** Selects Service Diagnostic Menu (para 2-9).
- **Front Panel Diagnostic.** Performs front panel diagnostic.
- **LCD Diagnostics Menu.** Selects LCD Diagnostics Menu (para 2-10).

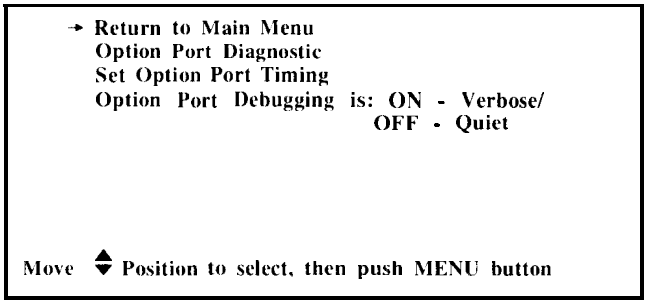


- **Chart Diagnostics Menu.** Selects Chart Diagnostics Menu (para 2-11).

2-7. OPTION PORT MENU

Selections from the Option Port Menu are:

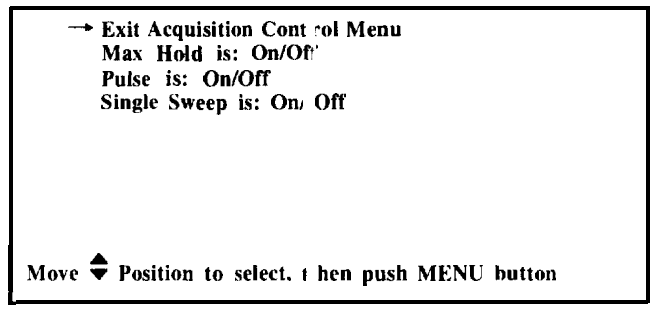
- **Return to Main Menu.** Displays Main Menu.
- **Option Port Diagnostic.** Creates a repeating pattern of signals at the option port to be measured by the technicians.
- **Set Option Port Timing.** Allows adjustment of data rate used to interface with external devices. The timing rate between bytes can be set from 0.05 to 12.8 ns. Not used with chart recorder.



- **Option Port Debugging is: ON – Verbose/OFF – Quiet.** Chooses how detailed the error message reporting will be when communicating with an external device.

2-8. ACQUISITION CONTROL MENU

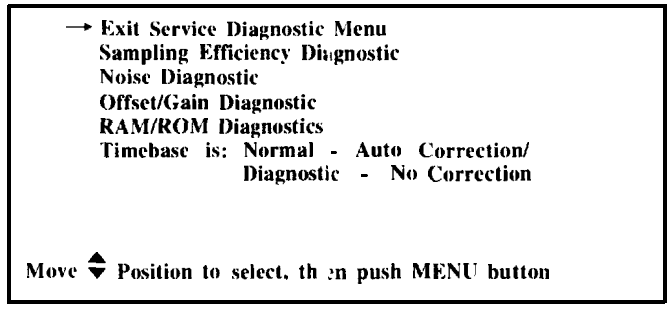
Selections from the Acquisition Control Menu are:



- **Exit Acquisition Control Menu.** Displays Setup Menu.
- **Max Hold is: On/Off.** When On, waveforms can be accumulated on the LCD. When in the operational mode, begin holding all waveforms by pressing the STORE pushbutton; press STORE again to stop. To disable Max Hold, enter the Setup Menu again and turn it Off.
- **Pulse is: On/Off.** Controls the pulse generator.
- **Single Sweep is: On/Off.** When On, one waveform will be taken and displayed each time the VIEW INPUT pushbutton is pressed or when a control that would change the appearance of the current waveform is adjusted.

2-9. SERVICE DIAGNOSTIC MENU

Selections from the Service Diagnostic Menu are:

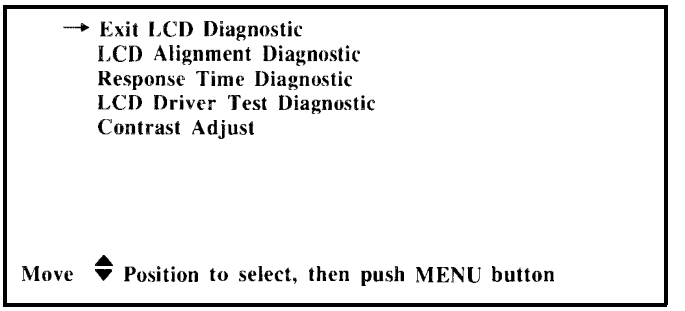


- **Exit Service Diagnostic Menu.** Displays Diagnostics Menu.
- **Sampling Efficiency Diagnostic.** Displays a continuous efficiency diagnostic of the sampling circuits.
- **Noise Diagnostic.** Measures the Test Set internal RMS noise levels.
- **Offset/Gain Diagnostic.** Reports out-of-tolerance steps in the program mable gain stages.
- **RAM/ROM Diagnostics.** Performs test on the RAM and the ROM memo ies.
- **Timebase is: Normal – Auto Correction/Diagnostic – No Correction.** When in Normal mode, the Test Set compensates for variations in temperature and voltage. When in Diagnostic mode, the circ uits will not correct for these variations.

2-10. LCD DIAGNOSTICS MENU

Selections from the LCD Diagnostics Menu are:

- **Exit LCD Diagnostic.** Displays Diagnostics Menu.
- **LCD Alignment Diagnostic.** Generates a dot pattern of every-other-pixel on the LCD. These pixels can be alternated to test the LCD.
- **Response Time Diagnostic.** Generates alternate squares of dark and light, reversing their order. This can give an indication as to the effectiveness of the LCD heater in a cold environment.

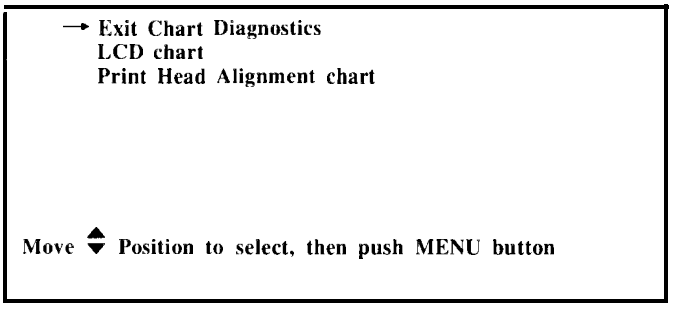


- **LCD Driver Test Diagnostic.** Generates a moving vertical bar pattern across the LCD.
- **Contrast Adjust.** Allows the operator to test adjustment of the contrast of the LCD.

2-11. CHART DIAGNOSTICS MENU

Selections from the Chart Diagnostics Menu are:

- **Exit Chart Diagnostics.** Displays Diagnostics Menu.
- **LCD chart.** Allows adjusting the number of dots per segment and the number of strikes per segment. Overstriking improves darkness of prints in extreme cold.
- **Print Head Alignment chart.** Generates a pattern to allow mechanical alignment of the chart recorder.



Section II. OPERATOR'S PREVENTIVE MAINTENANCE CHECKS AND SERVICES (PMCS)

2-12. GENERAL

To be sure that the equipment is always ready for a mission, do the scheduled Preventive Maintenance Checks and Services (PMCS). When doing any PMCS or routine checks, keep in mind the WARNINGS and CAUTIONS about electrical shock and bodily harm.

2-13. PMCS PROCEDURES

a. Tools, Materials, and Equipment Required for Preventive Maintenance. No tools or equipment are required for operator preventive maintenance. Cleaning materials required are listed in Appendix E, items 2 and 3.

b. PMCS for the Test Set is limited to routine checks such as shown below:

- cleaning
- dusting
- wiping
- checking for frayed cables
- storing items not in use
- covering unused receptacles
- checking for loose nuts, bolts, and screws

c. Perform these routine checks anytime they must be done.

Section III. OPERATION UNDER USUAL CONDITIONS

2-14. PREPARATION FOR USE

The Test Set can be operated from either an AC power source or from the removable battery pack. Operate the Test Set from an AC power source whenever possible because the battery pack is recharged during AC operation. If the Test Set is to be operated on battery, and the battery is fully charged, start at step 4.

WARNING

Test Set is equipped with a 3-wire power cable and receptacle (3). When connected to grounded AC power receptacle, this cable grounds Test Set chassis. Do not use extension cords or AC adapters without ground connection.

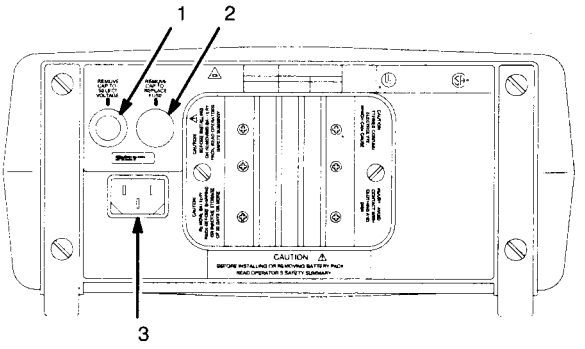
1. Remove cap on Voltage Selector switch (1) and position switch to applicable power setting.
2. Verify that fuse (2) installed in Test Set is proper type for applied power, as shown below:

VOLTAGE	FUSE TYPE	RANGE
115 VAC	0.3 amp	90-132 VAC
230 VAC	0.15 amp	180-250 VAC

3. Connect power cord to power cord receptacle (3).

CAUTION

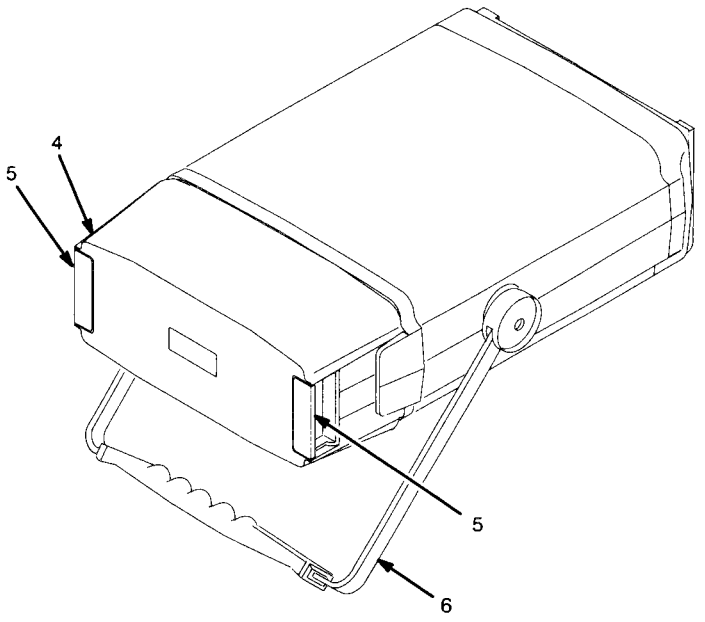
- *Do not charge battery pack below +32°F (0°C) or above +113°F (+45°C).*
- *Do not discharge battery pack below -4°F (-20°C) or above +149°F (+65°C).*



NOTE

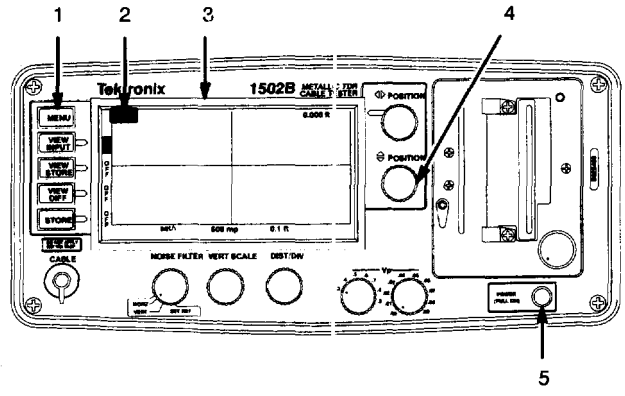
Fully charged battery pack will operate Test Set for minimum of 5 continuous hours (including 20 chart recordings) with backlight off.

4. Remove cover (4) by snapping side latches (5) inward and sliding cover forward.
5. Adjust carrying handle (6) as a stand until Test Set is in desired viewing position.



2-15. TURN-ON PROCEDURE

1. Pull POWER switch (5) out and observe progressive displays on LCD as Test Set initializes, gives instructions for accessing menu, and then enters "normal operation" mode.



NOTE

Test Set will automatically perform a set of power-up tests and initialization for several seconds. If no faults are detected after power-up tests and initializing, Test Set is ready for operation.

2. Observe LCD voltage source indicator (2). If "bat/low" is flashing, charge batteries for 16 hours.
3. If fault is detected during initialization, error messages will display across width of LCD (3). If error message is displayed, notify unit maintenance.
4. After Test Set initialization, press MENU pushbutton (1) and observe Main Menu display on LCD (para 2-3).
5. Adjust ▲▼ POSITION control (4) until cursor points to desired menu or function.
6. Press MENU pushbutton (1) to enter selection. Refer to paragraphs 2-2 through 2-11 for available operating modes and functions and how to select them from menus.
7. Allow for 5-minute warmup before use (20 minutes at temperatures less than 50°F (10°C)).

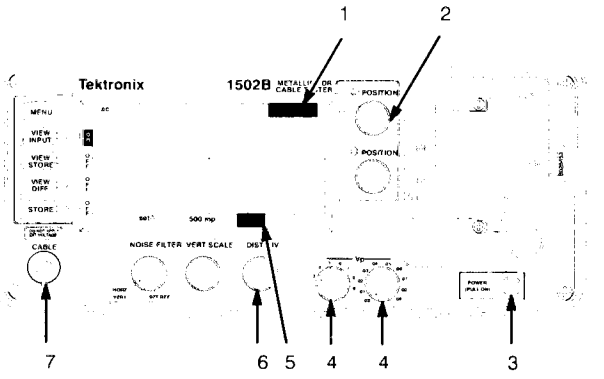
2-16. OPERATING PROCEDURES

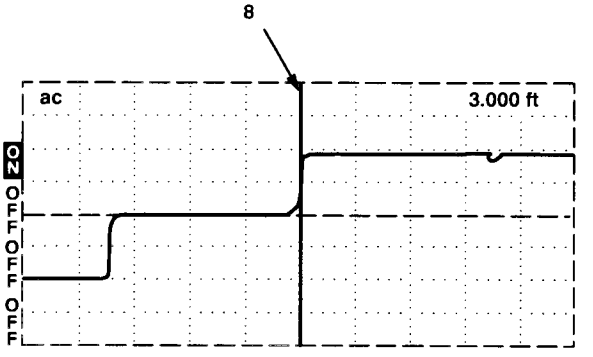
Test Set operating procedures are provided in paragraphs 2-17 through 2-24.

2-17. FINDING AN UNKNOWN VELOCITY OF PROPAGATION (Vp)

Perform the following steps to find the velocity of energy through an unknown cable.

1. Prepare Test Set for use (para 2-14)
2. Perform Turn-On Procedure (para 2-15)
3. Attach a known length of cable, of exact type to be tested, to CABLE connector (7). Lengths longer than 3 feet are recommended for accuracy.
4. Turn DIST/DIV switch (6) to an appropriate setting. For example, if trying to find Vp of a 3-foot cable, adjust DIST/DIV switch (6) to 1 ft/DIV as indicated in the readout (5).
5. Rotate ◀▶ POSITION control (2) until distance reading (1) is same as known cable length.
6. Adjust Vp switches (4) until cursor (8) is resting on rising portion of reflected pulse as shown at right. Vp switches (4) are now set to Vp of cable.
7. Push POWER (3) in to turn Test Set off.





2-18. FINDING DISTANCE TO FAULT/TESTING A LONGER CABLE

Perform the following steps to determine fault location, or condition of a cable.

1. Prepare Test Set for use (para 2-14).
2. Perform Turn-On Procedure (para 2-15).
3. Connect cable to be tested to CABLE connector (10).
4. Set Test Set front panel as follows:

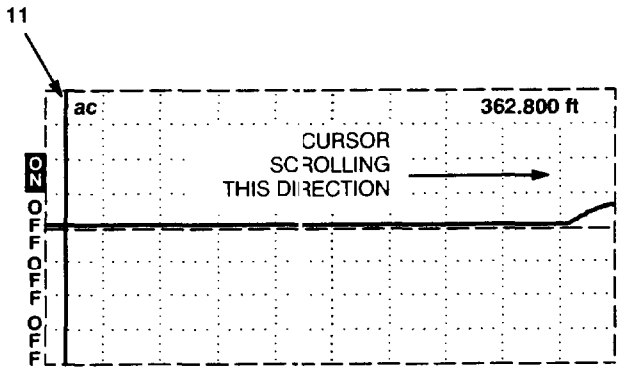
NOISE FILTER switch (8):	1 avg on readout (9)
DIST/DIV switch (5):	per cable (see step 5)
Vp switches (4):	per cable (from Cable Information Menu, para 2-4)
VERT SCALE control (7):	500 mρ on readout (6)

5. If cable length is known, set DIST/DIV switch (5) appropriately. If cable length is unknown, set DIST/DIV switch (5) to 200 ft/DIV and rotate ◀▶ POSITION control (2) clockwise until reflected pulse is visible.

NOTE

When testing a long cable, set DIST/DIV switch to a higher setting before scrolling to either end of cable. It takes less time to scroll at 200 ft/DIV than at 1 ft/DIV.

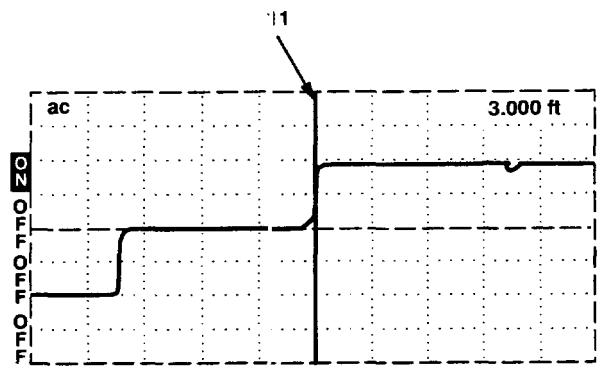
6. Increase VERT SCALE control (7), if necessary, to see reflected pulse.
7. Rotate ◀▶ POSITION control (2) until cursor (11) rests on leading edge of rising or falling waveform (notice that distance changes as ◀▶ POSITION is rotated). Decrease DIST/DIV switch (5) by turning counterclockwise. This will expand cable across LCD and allow a closer inspection of the waveform.
8. Read distance to fault (1).



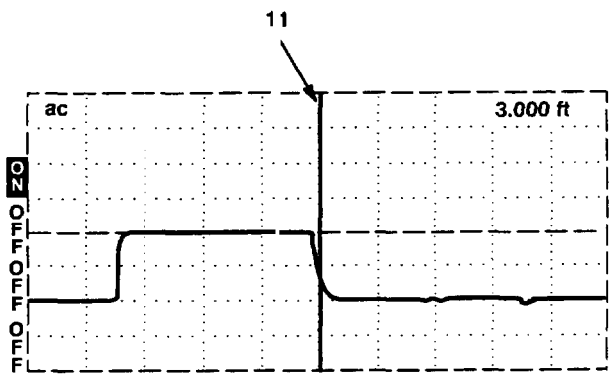
NOTE

- *Variations, such as inductive and capacitive effects on cable, will appear as bumps and dips on waveform. Capacitive faults will appear as a lowering of waveform (e.g., water). Inductive faults will appear as a rising of waveform (e.g., kinks).*

- *A rising of the waveform indicates increased impedance (e.g., open in cable).*



- *A falling waveform indicates decreased impedance (e.g., short in cable).*



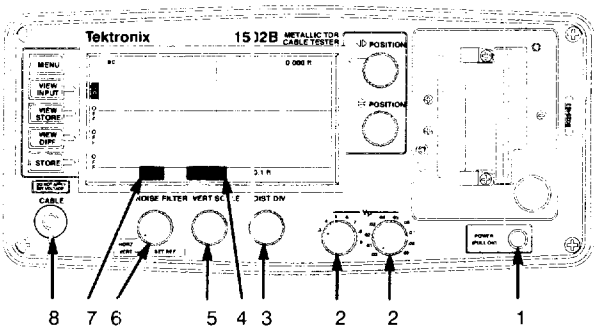
9. Push POWER (3) in to turn Test Set off.

2-19. AVERAGING OUT NOISE

Perform the following steps to filter out noise and display a smoother pulse

NOTE

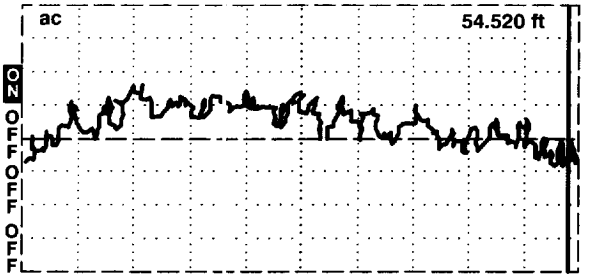
On a longer cable "noise" or "grass" may appear on the wa veform, especially when VERT SCALE is increased. This is primarily caused by cable acting as an antenna, picking up nearby electrical noise.



1. Prepare Test Set for use (para 2-14).
2. Perform Turn-On Procedure (para 2-15).
3. Connect cable to be tested to CABLE connector (8).
4. Set Test Set front panel as follows:

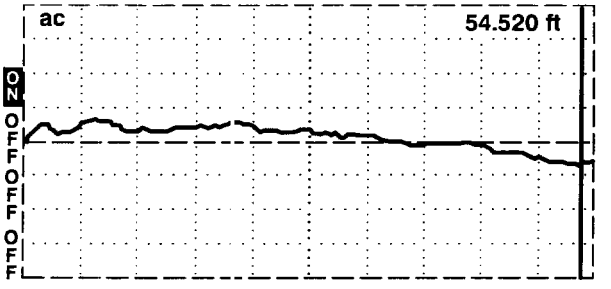
   DIST/DIV switch (3): per cable (until reflected pulse is visible)
   Vp switches (2): per cable (from Cable Information Menu, para 2-4)
   VERT SCALE control (5): as required (4) to show high noise evel

5. TurnNOISEFILTERswitch (6)clockwiseto 8 on readout(7).This will "averageout"muchofnoise.



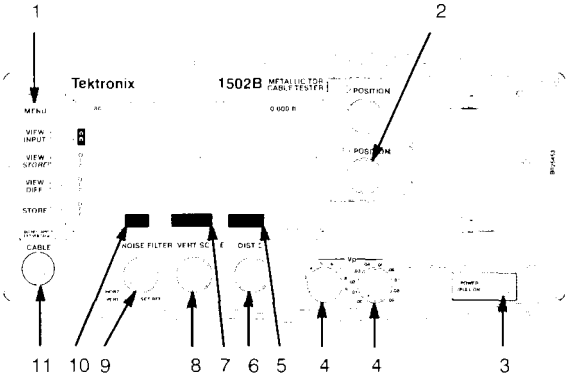
6. Increase NOISE FILTER switch (6) setting to 128 on readout (7). Notice that the higher the setting, the more time instrument takes to average waveform and that noise is averaged out as shown at right.

   Push POWER (I) in to turn Test Set off.



2-20. RETURN LOSS MEASUREMENT

Perform the following steps to determine energy loss of reflected pulse (in decibels)



1. Prepare Test Set for use (para 2-14).
2. Perform Turn-On Procedure (para 2-15).
3. Press MENU pushbutton (1) to bring up Main Menu. Turn ▲▼ POSITION control (2) to move arrow to select "Setup Menu".
4. Press MENU pshbutton (1) to bring up Setup Menu. Turn ▲▼ POSITION control (2) to move arrow to select "Vertical Scale is: Millirho". Press MENU pushbutton (1) and observe that L CD screen display changes to "Vertical Scale is: Decibels".
5. Press MENU pushb utton (1) twi ce to ret urn to normal operation.

```
      Return to Normal Operation
      Help with Instrument Controls
      Cable Information Menu
→     Setup Men u
      Diagnostics Menu
      View Stored Waveform Settings
      Option Port Menu

Move ▲▼ Position to select, then push MENU button
```

6. Connect cable to be tested to CABLE connector (11).
7. Set Test Set front panel as follows:

Vp switches (4):	per cable (from Cable Information Menu, para 2-4)
VERT SCALE control (8):	0 dB on readout (7)
D IST/DIV switch (6):	per cable (until reflected pulse is visible)
NOISE FILTER switch (9):	1 avg on readout (10)

8. Make note of height of incident pulse.
9. Adjust VE RT SCALE control (8) so reflected pulse is at height noted in step 8.
10. Read dB return loss directly from LCD on readout (7).
11. Press MENU pushbutton (1) to bring up Main Menu. Turn ▲▼ POSITION control (2) to move arrow to select "Setup Me nu".
12. Press MENU pushbutton (1) to bring up Setup Menu. Turn ▲▼ POSITION control (2) to move arrow to select "Vertical Scale is: Decibels". Press MENU pushbutton (1) and observe that LCD sc reen display changes to "Vertical Scale is: Millirho".

```
      Return to Normal Operation
      Help with Instrument Controls
      Cable Informati on Menu
→     Setup Menu
      Diagnostics Menu
      V iew Stored W aveform Settings
      Option Port Menu

Move ▲▼ Position to select, then push MENU button
```

13. Press MENU pushbutton (1) twice to return to normal operation.

14. Push POWER (3) in to turn Test Set off.

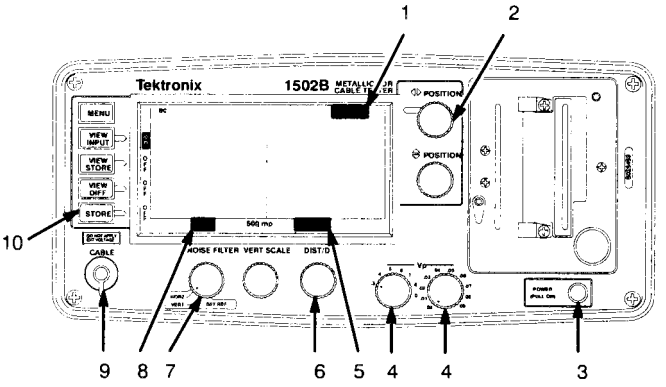
```
Exit Setup Menu
Acquisition Control Menu
Ohms at the Cursor is: Off
→ Vertical Scale is: Millirho
Distance/Div is: ft/div
Light is: ON

Move ▲▼ Position to select, then push MENU button
```

2-21. ENTERING HORIZONTAL SET REFERENCE

Perform the following steps to vary a cable distance reading starting point.

NOTE

HORZ SET REF mode allows operator to offset distance reading. For example, if a lead-in cable to a switching network is 3 feet long, HORZ SET REF mode allows starting measurement after the end of lead-in cable.



1. Prepare Test Set for use (para 2- 14).

2. Perform Turn-On Procedure (para 2- 15).

3. Connect cable to be tested to CABLE connector (9).

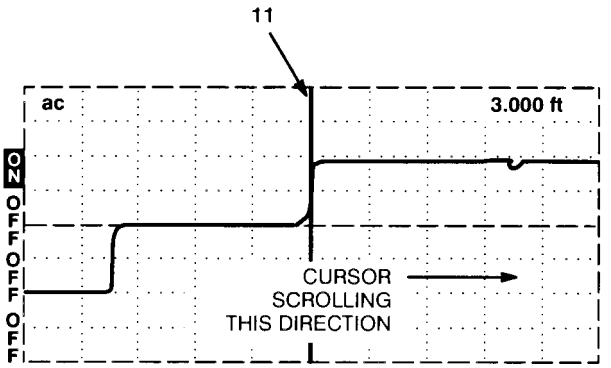
4. Set Test Set front panel as follows:

Vp switches (4):	per cable (from Cable Information Menu, para 2-4)
DIST/DIV switch (6):	0. 1/DIV on readout (5)
NOISE FILTER switch (7):	HORZ SET REF position

5. Adjust ◀▶ POSITION control (2) to set cursor (11) where distance reading will start. For a 3-foot lead-in cable, cursor would be set at 3 feet.

6. Press STORE pushbutton (10).

7. Turn NOISE FILTER switch (7) to 1 avg on readout (8). The Test Set is now in HORZ SET REF, or DELTA, mode. Distance display (1) reads 0.000 ft Δ. As cursor (11) is scrolled down cable, distance reading will be from new zero reference point.

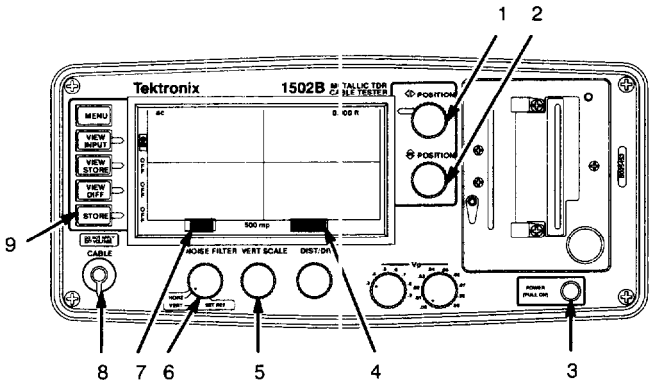


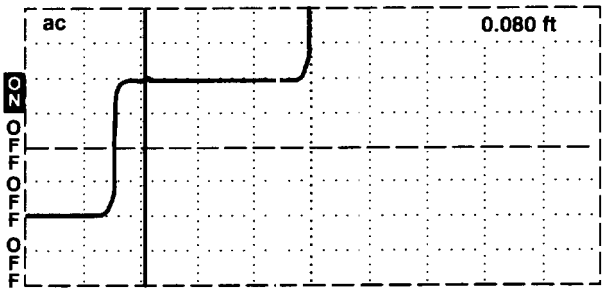
8. To exit HORZ SET REF mode, use following procedure:
   - Set NOISE FILTER switch (7) to HORZ SET REF.
   - Set DIST/DIV switch (6) to 1 ft/DIV on readout (5).
   - Adjust ◀▶ POSITION control (2) until distance display (1) reads zero.
   - Press STORE pushbutton (10).
   - Set NOISE FILTER switch (7) to desired setting.
9. Push POWER (3) in to turn Test Set off.

2-22. SETTING VERTICAL SET REFERENCE

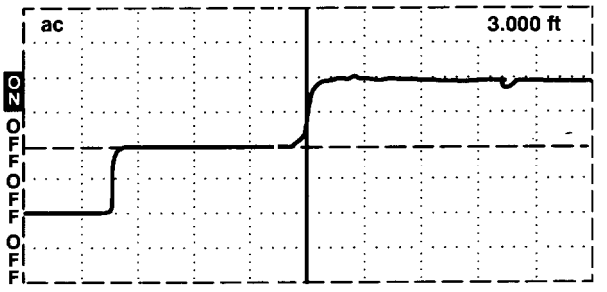
VERT SET REF allows overriding automatic waveform height circuit and adjusting waveform height manually. Perform the following steps to complete vertical set reference (VERT SET REF) and vertical compensation for higher impedance cable.

1. VERT SET REF. Perform the following:
   - Prepare Test Set for use (para 2-14).
   - Perform Turn-On Procedure (para 2-15).
   - Connect cable to be tested to CABLE connector (8).
   - Set NOISE FILTER switch (6) fully counterclockwise. "Set Ref" will appear in noise average display (7).
   - Turn VERT SCALE control (5) to adjust new VERT SET REF to desired height (for example, an incident pulse of four divisions). Use ▲▼ POSITION control (2) to keep thewaveforminview.
   - FILTER switch (6) to desired setting. The VERT SCALE reads 500 mρ/DIV on the readout (4), but the incident pulse is now four divisions high. The actual total vertical height is 1000 mρ, so when divided by four divisions, it equals 250 mρ/DIV.





2. Vertical Compensation for Higher Impedance Cable. When testing cables other than 50 Ω, the following procedure allows reflection measurement in millirho (mρ):
   - Attach a short sample of given cable to CABLE connector (8). Adjust ◀▶ POSITION control (1) to position reflected pulse to center screen as shown below.



- Turn NOISE FILTER switch (6) to VERT SET REF position.
- Adjust VERT SCALE control (5) so reflected pulse is two divisions high.
- Press STORE pushbutton (9). Return NOISE FILTER switch (6) to desired setting.
- Adjust ◀▶ POSITION control (1) to desired position on waveform to measure loss.

NOTE

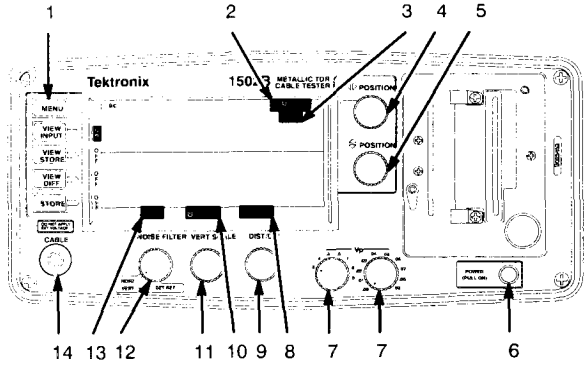
The instrument is now set to measure reflections in mρ relative to sample cable impedance. To measure reflections on a 50 Ω cable, VERT SET REF must be reset.

3. Exit VERT SET REF. To exit and reset VERT SET REF, perform following:
   - Turn NOISE FILTER switch (6) to VERT SET REF position.
   - Adjust VERT SCALE control (5) to obtain incident pulse height of two divisions.
   - Press STORE pushbutton (9).
   - Turn NOISE FILTER switch (6) to desired filter setting on readout (7).
4. Push POWER (3) in to turn Test Set off.

2-23. OHMS AT CURSOR

Perform the following steps to determine the impedance at any point along the cable

1. Prepare Test Set for use (para 2- 14).
2. Perform Turn-On Procedure (para 2- 15).
3. Set Test Set front panel as follows:

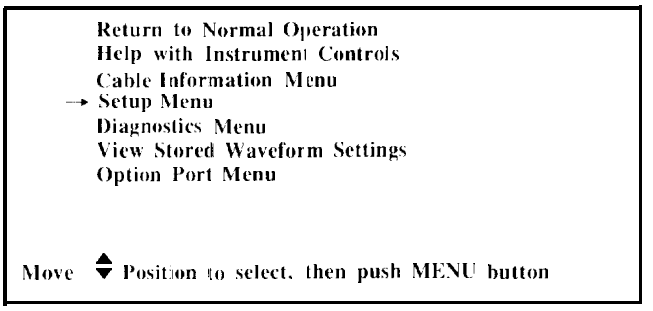


CABLE connector (14):	connect cable under test
NOISE FILTER switch (12):	1 avg on readout (13)
VERT SCALE control (11):	500 mρ on readout (10)
DIST/DIV switch (9):	1 ft on readout (8)
Vp switches (7):	per cable (from Cable Information Menu, para 2-4)

4. Press MENU pushbutton (1) to bring up Main Menu. Turn ▲▼ POSITION control (5) to move arrow to select "Setup Menu".

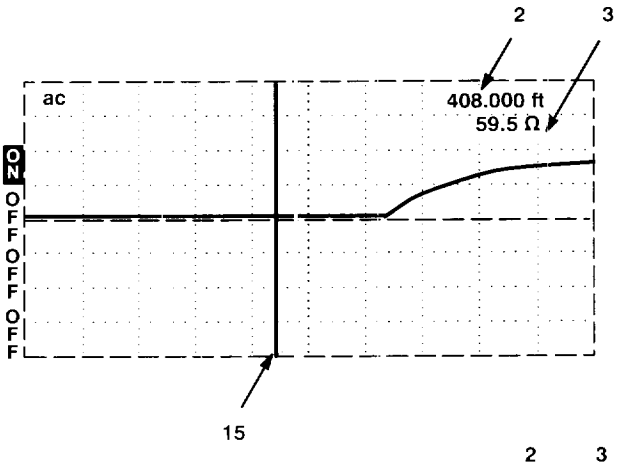
5. Press MENU push button (1) to bring up Setup Menu. Turn ▲▼ POSITION control (5) to move arrow to select "Ohms at the Cursor is Off"

6. Press MENU pushbutton (1) to turn on Ohms at Cursor function.

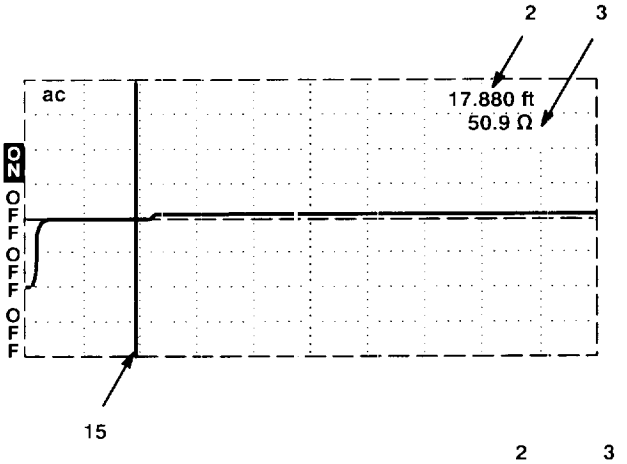


7. Press MENU push button (1) three times to return to normal operation.

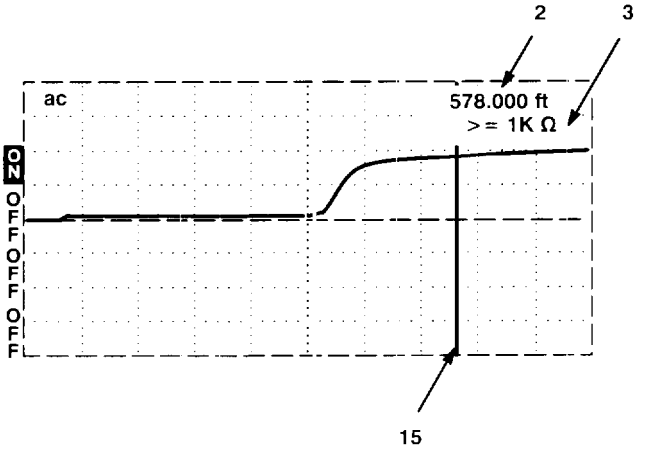
8. Turn ◀▶ POSITION control (4) to set cursor (15) near end of cable as illustrated. In the example at right, distance reading (2) is 408.000 ft and ohms at cursor reading (3) is 59.5 Ω. Ohms at cursor shows a cable impedance of 59.5 ohms.



9. Turn ◀▶ POSITION control (4) to set cursor (15) near beginning of cable. In the example at right, distance reading (2) is 17.880 ft and ohms at cursor reading (3) is 50.9 Ω. There is less loss at beginning of cable because of less series resistance



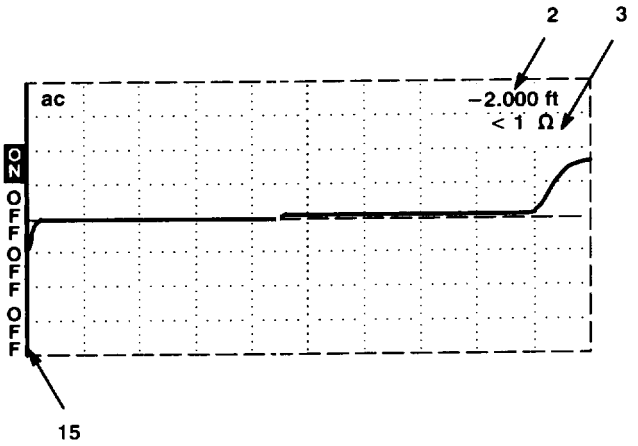
10. Turn ◀▶ POSITION control (4) clockwise to set cursor (15) past reflected pulse as shown at right. Now ohms at cursor reads ≥1K Ω.



11. Turn ◀▶ POSITION control (4) clockwise until cursor (15) rests at front panel (far left side, -2.000 ft distance). Ohms at cursor reads <1 Ω.

NOTE

If cursor is placed too near a fault, reflection will not have stabilized and reading might be misleading. This is especially true very near instrument front panel where some aberrations are still significant.



12. Press MENU pushbutton (1) to bring up Main Menu. Turn ▲▼ POSITION control (5) to move arrow to select "Setup Menu".

13. Press MENU pushbutton (1) to bring up Setup Menu. Turn ▲▼ POSITION control (5) to move arrow to select "Ohms at the Cursor is: On".

14. Press MENU pushbutton (1) to turn off Ohms at Cursor function.

15. Press MENU pushbutton twice to return to normal operation mode.

16. Push POWER (6) in to turn Test Set off.

```
Return to Normal Operation
Help with Instrume it Controls
Cable Information Menu
→ Setup Menu
Diagnostics Menu
View Stored Waveform Settings
Option Port Menu

Move ▲▼ Position to select then push MENU button
```

```
Exit Setup Menu
Acquisition Control Menu
→ Ohms at the Cursor is: On
Vertical Scale is: Millirho
Distance/Div is: ft/div
Light is: ON

Move ▲▼ Position to select then push MENU button
```

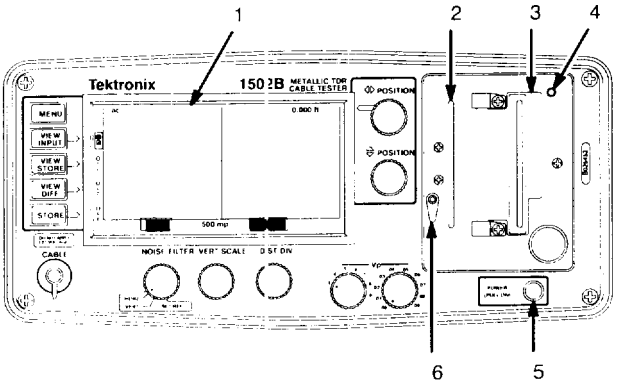
2-24. CHART RECORDER OPERATION

Perform the following steps to operate the chart recorder.

1. Prepare Test Set for use (para 2- 14).

2. Perform Turn-On Procedure (para 2-15).

3. Verify desired waveform is displayed on LCD (1).



4. Turn pivot lock (6) to release cover (3) and raise and pivot protective cover (3) to right, exposing printer paper slot (2).

5. Press PRINT pushbutton (4) and observe that printed paper feeds out of slot.

6. When chart recorder has finished, tear off paper recording by pulling paper to left.

7. When finished printing, slide protective cover (3) to left and turn pivot lock (6) to secure cover (3) in place.

8. Push POWER (5) in to turn Test Set off.

CHAPTER 3
UNIT MA NTENANCE INSTRUCTIONS

	Para	Page
Aberrations Test	3-20	3-22
Battery Pack and Battery Pack Fuse Replacement	3-22	3-24
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Cleaning	3-25	3-28
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Horizontal Scale Test	3-10	3-9
Jitter Test	3-15	3-16
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Line Fuse Replacement	3-21	3-23
Noise Test	3-12	3-12
Offset/Gain Test	3-13	3-13
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Preliminary Servicing and Adjustment of Equipment	3-6	3-2
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Zero Offset Test	3-17	3-18

Section I. REPAIR PARTS; SPECIAL TOOLS; TEST, MEASUREMENT, AND DIAGNOSTIC EQUIPMENT (TMDE); AND SUPPORT EQUIPMENT

3-1. COMMON TOOLS AND EQUIPMENT

Common tools and equipment required for unit maintenance of the Test Set, Electrical Cable TS-4165/G (Test Set) are listed in Appendix B (Maintenance Allocation Chart).

3-2. SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT

No special tools, TM DE, or support equipment are required.

3-3. REPAIR PARTS

Repair parts are listed and illustrated in the Repair Parts and Special Tools List (TM 11-6625-3240-24P).

Section II. SERVICE UPON RECEIPT

3-4. UNPACKING

The Test Set is shipped assembled in its original shipping container. Remove the Test Set from the container; be careful not to damage the Test Set or container. Save the container and undamaged packing material for use in reshipment.

3-5. CHECKING UNPACKED EQUIPMENT

a. Inspect Test Set for damage incurred during shipment. If Test Set has been damaged, report the damage on Report of Discrepancy (SF 364).

b. Check Test Set against packing slip to see that shipment is complete. Report all discrepancies in accordance with instructions in DA Pam 750-8.

c. Check to see whether equipment has been modified.

3-6. PRELIMINARY SERVICING AND ADJUSTMENT OF EQUIPMENT

a. Perform Preparation for Use (para 2-14)

b. Perform Turn-On Procedure (para 2-1 5).

c. Perform Operational Tests (para 3- 8).

Section III. UNIT TROUBLESHOOTING

SYMPTOM INDEX

Test Set Symptom	Page
1. TEST SET WILL NOT OPERATE ON BATTERY	3-3
2. TEST SET WILL NOT OPERATE ON AC ONLY	3-4
3. TEST SET DISPLAYS ERROR MESSAGE OR NO WAVEFORM	3-4
4. CHART RECORDER DOES NOT OPERATE PROPERLY	3-5
5. TEST SET FAILS ANY OPERATIONAL TEST	3-5

3-7. TROUBLESHOOTING TABLE

Troubleshooting procedures are listed in table 3-1. Problems that may occur during operation are listed under Malfunction. Tests or Inspections and their Corrective Actions are listed in the two columns to the right of the Malfunction column. Tests, Inspections, and Corrective Actions should be performed in the order listed.

Table 3-1. **Unit Troubleshooting**

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION

1. TEST SET WILL NOT OPERATE ON BATTERY.

Step 1. Remove battery pack (para 3-22). Check for missing or blown battery pack fuse.

- If fuse is missing or blown, replace fuse (para 3-22).
- If fuse is good, go to Step 2.

Step 2. Connect Test Set to AC power source. Pull out POWER switch (On position) and verify "ac" operating power readout appears in upper left of LCD display (15, para 2-1).

- If Test Set does not operate, go to Malfunction 2, Step 1.
- If Test Set does operate, go to Step 3.

Table 3-1. Unit Troubleshooting - continued

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION

Step 3. Push in POWER switch (Off position) and leave AC power cord connected to AC power source to charge battery. Allow battery to charge for 16 hours.

- After full charging time has elasped, go to step 4.

Step 4. Pull out POWER switch (On position) and verify "ac" operating power readout appears in upper left of LCD display. Unplug AC power cord at back of Test Set and verify "bat" operating power readout appears in upper left of LCD display.

- If Test Set does not operate, notify next higher level of maintenance.

2. TEST SET WILL NOT OPERATE ON AC ONLY.

Step 1. Check for missing or blown line voltage fuse

- If fuse is missing or blown, replace line voltage fuse (para 3-21)
- If fuse is good, go to Step 2.

Step 2. Connect Test Set to known good AC power source using a known good AC power cord. Pull out POWER switch (On position). Verify "ac" operating power readout appears in upper left of LCD display.

- If Test Set does not operate, notify next higher level of maintenance.
- If Test Set does operate, go to Step 3.

Step 3. Push in POWER switch (Off position) and connect Test Set to its own AC power cord. Pull out POWER switch (On position). Verify "ac" operating power readout appears in upper left of LCD display.

- If Test Set does not operate, replace original AC power cord.

3. TEST SET DISPLAYS ERROR MESSAGE OR NO WAVEFORM.

Step 1. Check Voltage Selector switch (1, para 2-14) for proper voltage selection.

- If Voltage Selector is not on proper voltage, set switch to proper voltage selection.
- If Voltage Selector is on proper voltage, go to Step 2.

Table 3-1. Unit Troubleshooting - continued

MALFUNCTION / TEST OR INSPECTION / CORRECTIVE ACTION	
Step 2. Record the error message.	
• Notify next higher level of maintenance.	
4. CHART RECORDER DOES NOT OPERATE PROPERLY.	
Step 1. Check chart recorder paper for correct installation (para 3-23)	
• If paper is installed incorrectly, remove and reinstall correctly.	
Step 2. Check chart recorder for proper operation (para 2-24).	
Ž If chart recorder does not operate, notify next higher level of maintenance.	
5. TEST SET FAILS ANY OPERATIONAL TEST.	
Record the failure of any operational test (chart recorder will print display screens from diagnostic tests).	
• Notify next higher level of maintenance.	

Section IV. UNIT MAINTENANCE PROCEDURES

3-8. OPERATIONAL TESTS

The following procedures should be performed to verify operational readiness of Test Set after the Test Set has been serviced or repaired. The operational tests are as follows:

	Para	Page
Aberrations Test	3-20	3-22
Chart Recorder Test	3-19	3-20
Display and Front Panel Tests.	3-9	3-6
Horizontal Scale Test	3-10	3-9
Jitter Test	3-15	3-16
Noise Test	3-12	3-12
Offset/Gain Test	3-13	3-13
RAM/ROM Test	3-14	3-15
Risetime Test	3-18	3-19
Sampling Efficiency Test..	3-16	3-17
Vertical Position Test.	3-11	3-11
Zero Offset Test	3-17	3-18

NOTE

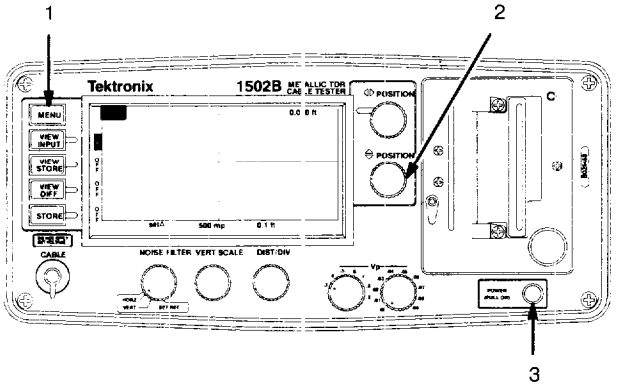
When operating Test Set in temperatures below +50° F (+ 10° C), LCD heater will activate. It may take up to 20 minutes for LCD to warm up and operate properly.

3-9. DISPLAY AND FRONT PANEL TESTS

DISPLAY

1. Pull POWER switch (3) (On position).

2. Observe that LCD waveforms and readouts are legible. If LCD appears too dark or "smeared" or if display has low contrast, refer to higher level of maintenance.



EL BACKLIGHT

1. Press MENU pushbutton (1) to bring up Main Menu.

2. Turn ▲▼ POSITION control (2) to move arrow to select "Setup Menu" and press MENU pushbutton (1). Note that Setup Menu appears on LCD as shown at right.

```
→ Return to Normal Operation
  Help with Instrument Controls
  Cable Information Menu
  Setup Menu
  Diagnostics Menu
  View Stored Waveform Settings
  Option Port Menu
Move ▲▼ Position to select, then push MENU button
```

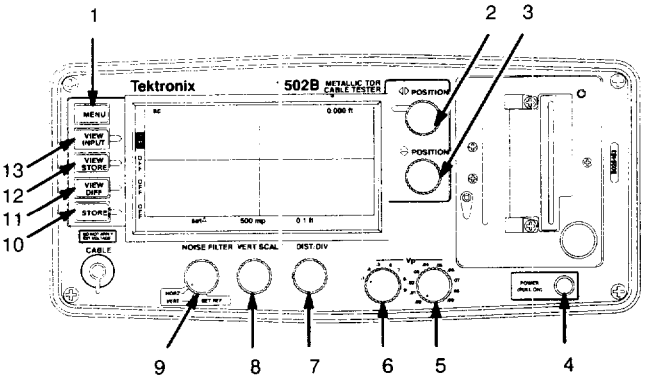
3. Turn ▲▼ POSITION control (2) to move arrow to select "Light is: ON" and press MENU pushbutton (1). Observe that:

   - EL backlight goes out
   - LCD screen displays: "Light is: OFF"

```
→ Exit Setup Menu
  Acquisition Control Menu
  Ohms at the Cursor is: Off
  Vertical Scale is: Millimho
  Distance/Div is: ft/div
  Light is: ON
Move ▲▼ Position to select, then push MENU button
```

4. Turn ▲▼ POSITION control (2) to move arrow to select "Light is: OFF" and press MENU pushbutton (1). Observe that:
   - EL backlight comes on
   - LCD screen displays: "Light is: ON"
5. If Test Set fails any of above steps, notify next higher level of maintenance.
6. Press MENU pushbutton (1) twice to return to normal operation.

FRONT PANEL PUSHBUTTONS



1. Pull POWER switch (4) (On position).

2. Press MENU pushbutton (1) to bring up Main Menu. Turn ▲▼ POSITION control (3) to move arrow to select "Diagnostics Menu".

```
      Return to Normal Operation
      Help with Instrument Controls
      Cable Information Menu
      Setup Menu
→     Diagnostics Menu
      View Stored Waveform Settings
      Option Port Menu

Move ▲▼ Position to select, then push MENU button
```

3. Press MENU pushbutton (1) to bring up Diagnostics Menu. Turn ▲▼ POSITION control (3) to move arrow to select "Front Panel Diagnostic".

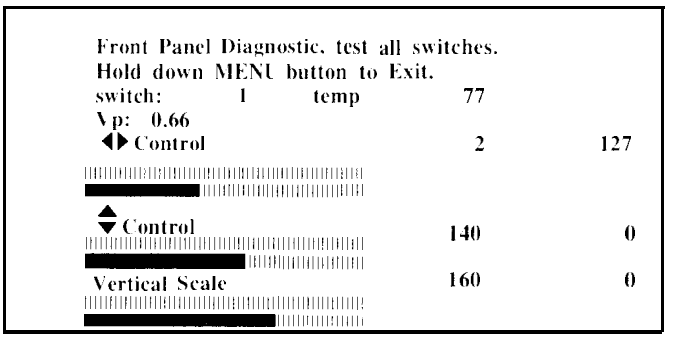
4. Press MENU pushbutton (1) to bring up Front Panel Diagnostic.

```
      Exit Diagnostics Menu
      Service Diagnostic Menu
→     Front Panel Diagnostic
      LCD Diagnostics Menu
      Chart Diagnostics Menu

Move ▲▼ Position to select then push MENU button
```

5. Press VIEW IN PUT pushbutton (13) and observe that LCD readout number to right of "switch:" changes to 1.

6. Press VI EW STO RE p ushbutton (12) and o bserve that LCD rea dout num ber to right of "switch:" changes to 2.

7. Press VIEW DIFF pushbutton (11) and observe that LCD readout number to right of "switch:" changes to 3.



8. Press STORE pushbutton (10) and observe that LCD readout number to right of "switch:" changes to 4.

9. If Test Set fails any of above steps, notify next higher level of maintenance.

ROTATING CONTROLS

1. Turn NOISE FILTER switch (9) counterclockwise to VERT SET REF position. LCD readout to right of "switch:" should be 5.

2. Slowly turn NOISE FILTER switch (9) clockwise to the stop. Each sw itch position will increase LCD "switch:" readout one count, from 5 to 14.

3. Turn D IST/DIV switch (7) counterclockwise to its far stop. L CD "switch:" readout will be 15.

4. Slowly turn DIST/DIV switch (7) clockwise. Each switch position will increase LCD "switch:" readout one count, from 15 to 25.

5. Slowly turn left Vp switch (6) fully counterclockwise. At each click, LCD reading to right of "Vp:" should correspond to front panel control setting. Turn right Vp switch (5) fully counterclockwise. Again, LCD reading should match corresponding front panel control setting. Turn both Vp switches fully clockwise. Final reading with both switches fully clockwise should be .99.

6. Turn ◀▶ POSITION control (2) slowly in either direction. Bargraph shown on LCD represents two elements in each control. The readings on right of bargraph represent numbers used by Test Set to calc ulate position of knob. As control is turned, these values and bargraph will change. The lower value in each column should be between 0 and 10; higher value in each column between 245 and 255.

7. Turn ▲▼ POSITION control (3) slowly in either direction. The lower value in each column should be between 0 and 10; higher value in each column between 245 and 255.

8. Turn VERT SCALE control (8) slowly in either direction. The lower value in each column should be between 0 and 10; higher value in each column between 245 and 255.

9. If Test Set fails any of above steps, notify next higher level of maintenance.

LCD HEATER

1. Observe LCD "temp:". Reading should be 50 to 90, depending on ambient temperature.

2. If reading is near 0 or 255, LCD heater is defective. Notify next higher level of maintenance.

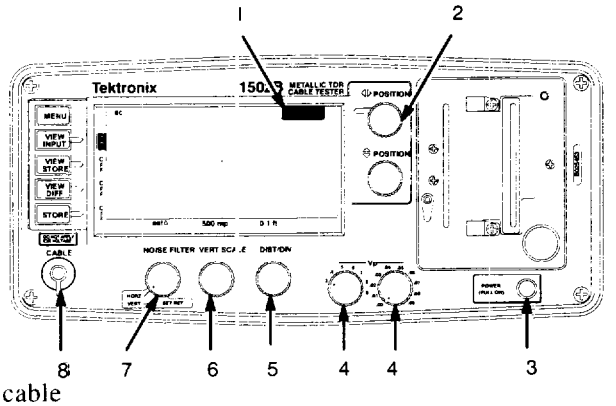
3. Press MENU pushbutton (1) four times to return to normal operation.

3-10. HORIZONTAL SCALE TEST

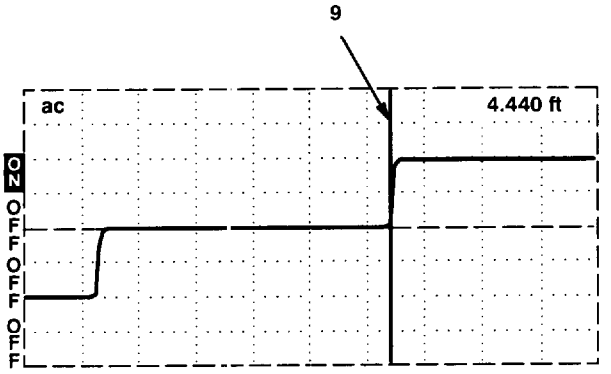
1. Pull POWER switch (3) (On position).

2. Set front panel controls as follows:

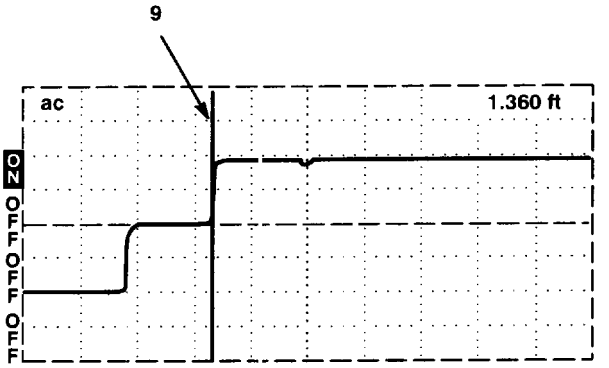
NOISE FILTER switch (7):	1 avg
VERT SCALE control (6):	500 mρ
DIST/DIV switch (5):	1 ft/DIV
Vp switches (4):	.99
CABLE connector (8):	Precision 50 Ω cable



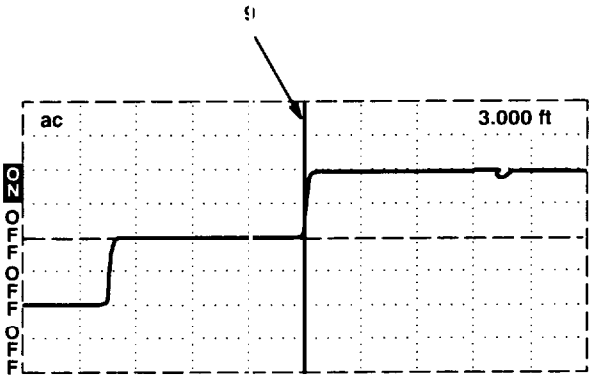
3. Turn ◀▶ POSITION control (2) to set cursor (9) on rising edge of reflected pulse. LCD distance window (1) should read 4.360-4.640 ft.



4. Set Vp switches (4) to .30. Position cursor (9) to rising edge of reflected pulse. LCD distance window (1) should read 1.320-1.400 ft.

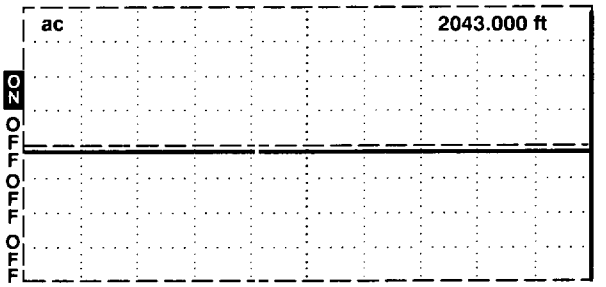


5. Set Vp switches (4) to .66. Turn ◀▶ POSITION control (2) to set cursor (9) to rising edge of reflected pulse. LCD distance window (1) should read 2.890-3.110 ft.



6. Set Vp switches (4) to .30. Remove precision 50 Ω cable and connect termination. Set DIST/DIV switch (5) to 200 ft/DIV.

7. Turn ◀▶ POSITION control (2) clockwise until OFF LCD distance window (1) reads a distance greater than 2000.000 ft. Waveform should remain as a flat line from zero ft to this distance.



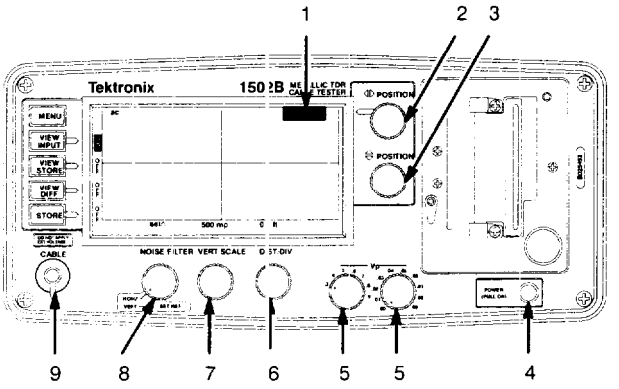
8. If Test Set fails any of above steps, notify next higher level of maintenance.

3-11. VERTICAL POSITION TEST

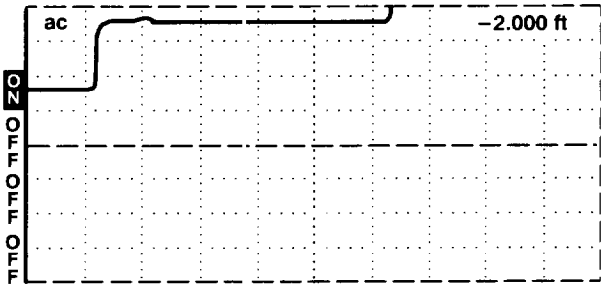
1. Pull POWER switch (4) (On position).

2. Set front panel controls as follows:

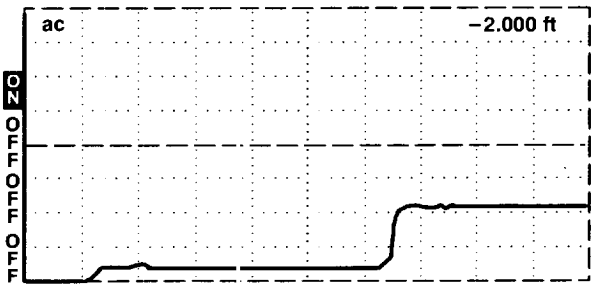
NOISE FILTER switch (8):	1 avg
VERT SCALE control (7):	500 mρ
DIST/DIV switch (6):	1 ft/DIV
Vp switches (5):	.99
CABLE connector (9):	50 Ω cable



3. Turn ◆▶ POSITION control (2) to set LCD distance window (1) to -2.000 ft. Turn ▲▼ POSITION control (3) to verify that entire waveform can be moved upward past center graticule line.

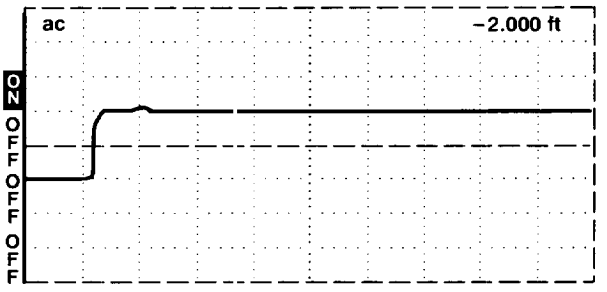


4. Turn ▲▼ POSITION control (3) to verify that entire waveform can be moved so that top of pulse is below center graticule line.



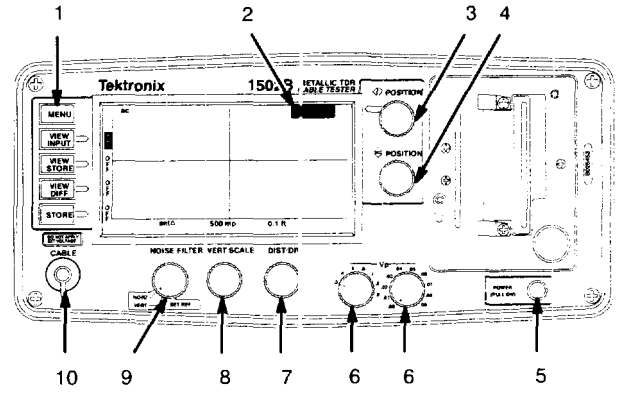
5. Remove precision 50 Ω cable. Connect termination to CABLE connector (9). Turn ▲▼ POSITION control (3) to center pulse in LCD. Pulse should be two divisions higher.

6. If Test Set fails any of above steps, notify next higher level of maintenance.



3-12. NOISE TEST

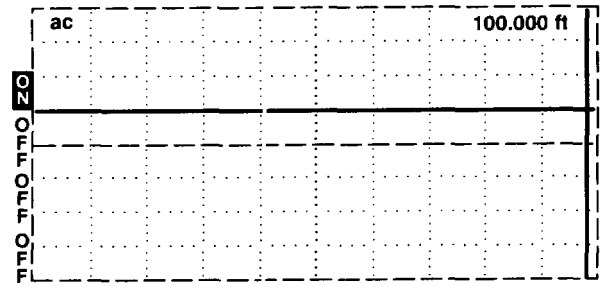
1. Pull POWER switch (5) (On position).



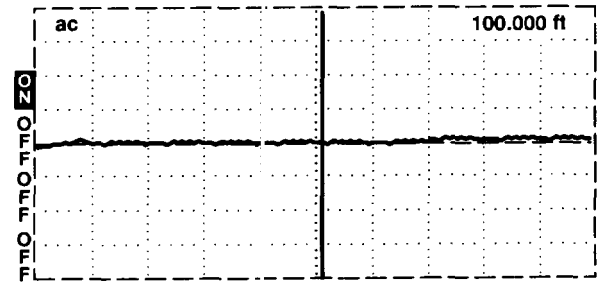
2. Set front panel controls as follows:

NOISE FILTER switch (9):	1 avg
VERT SCALE control (8):	500 mp
DIST/DIV switch (7):	10 ft/DIV
Vp switches (6):	.99
CABLE connector (10):	termination

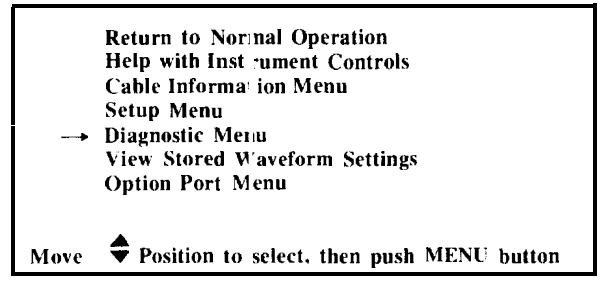
3. Turn ◆▶ POSITION control (3) until LCD distance window (2) reads 1 00.000 ft.



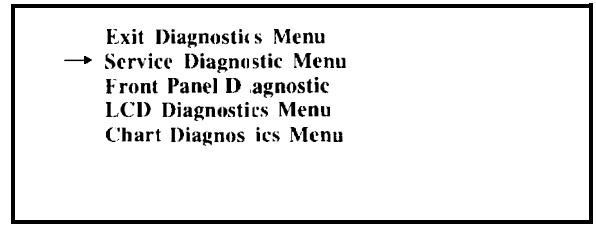
4. Set DIST/DIV switch (7) to 0. 1 ft/DIV. Turn VERT SCALE control (8) to set gain to 5.00 mp. Turn ▲▼ POSITION control (4) to keep waveform centered in LCD.



5. Press MENU pushbutton (1) to bring up Main Menu. Turn ▲▼ POSITION control (4) to move arrow to select "Diagnostic Menu".



6. Press MENU pushbutton (1) to bring up Diagnostics Menu. Turn ▲▼ POSITION control (4) to move arrow to select "Service Diagnostic Menu".



7. Press MENU pushbutton (1) to bring up Service Diagnostic Menu. Turn ▲▼ POSITION control (4) to move arrow to select "Noise Diagnostic".

```
      Exit Service Diagnostic Menu
      Sampling Efficiency Diagnostic
→     Noise Diagnostic
      Offset/Gain Diagnostic
      RAM/ROM Diagnostics
      Timebase is:  Normal  -  Auto Correction

Move ▲▼ Position to select, then push MENU button
```

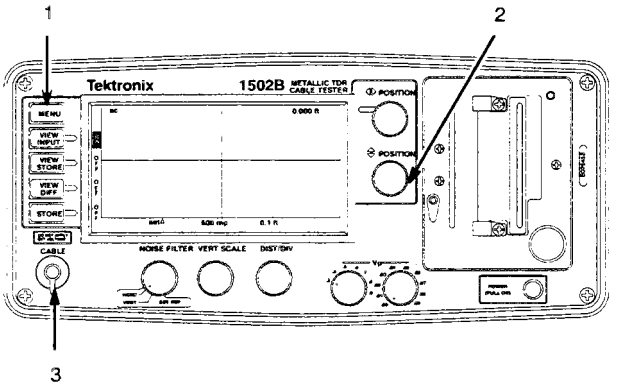
8. Press MENU pushbutton (1) to bring up Noise Diagnostic screen. LCD readout number below "Result" identifies whether or not test was within acceptable range.

```
            Noise Diagnostic
        Continuous Result Update

Acceptable Range          Result
   0 - 11 pixels             1
At 5mp & cursor at location to sample.
        Push MENU button to Exit  -
```

9. If step 8 results are more than 11, notify next higher level of maintenance.

10. Press MENU pushbutton (1) to return to Service Diagnostic Menu. Perform Offset/Gain Test.

3-13. OFFSET/GAIN TEST



1. Perform Noise Test (para 3-12) and while still on Service Diagnostic Menu, turn ▲▼ POSITION control (2) to move arrow to select "Offset/Gain Diagnostic".

```
      Exit Service Diagnostic Menu
      Sampling Efficiency Diagnostic
      Noise Diagnostic
→     Offset/Gain Diagnostic
      RAM/ROM Diagnostics
      Timebase is:  Normal  -  Auto Correction

Move ▲▼ Position to select, then push MENU button
```

2. Press MENU pushbutton (1) and note that display on LCD appears as shown at right.

```
            Offset/Gain Diagnostic
  - Remove all connectors from front panel -

    The front end video signal must be
    shorted to ground for best results. If OK
    without video shorted, it will be OK
    when shorted. If this test fails, the
    service manual has a Procedure to short
    out the video signal.

      -  Then Push MENU to Continue.  -
```

3. Remove termination from CABLE connector (3) and press MENU pushbutton (1) to bring up Summing Stage data screen.

4. If number shown under "error%" exceeds 2.0, notify next higher level of maintenance.

dB	Gain	Actual	error%
0.00	1.000	0.992	- 0.8

This is the summing amp gain which has typically less than two percent error.

Summing Stage - push MENU to Continue -

5. Press MENU pushbutton (1) to bring up Low Gain Stage data screen.

6. If any number shown under "error%" exceeds 3.0, notify next level of maintenance.

dB	Gain	Actual	error%
0.25	1.029	1.030	+ 0.1
0.50	1.059	1.059	+ 0.0
0.75	1.090	1.090	+ 0.0
1.00	1.122	1.122	+ 0.0
1.25	1.155	1.155	+ 0.0
1.50	1.189	1.188	- 0.1
1.75	1.223	1.223	+ 0.0

Low Gain Stage - push MENU to Continue -

7. Press MENU pushbutton (1) to bring up Middle Gain Stage data screen.

8. If any number shown under "error%" exceeds 3.0, notify next higher level of maintenance.

dB	Gain	Actual	error%
2.00	1.259	1.260	+ 0.1
4.00	1.585	1.584	- 0.1
6.00	1.995	1.994	- 0.1
8.00	2.512	2.504	- 0.3
10.00	3.162	3.156	- 0.2
12.00	3.981	3.976	- 0.1
14.00	5.012	5.001	- 0.2

Middle Gain Stage - push MENU to Continue -

9. Press MENU pushbutton (1) to bring up High Gain Stage data screen.

10. If any number shown under "error%" exceeds 3.0, notify next higher level of maintenance.

11. Press MENU pushbutton (1) to bring up Worst Case data screen.

dB	Gain	Actual	error%
16.00	6.310	6.347	+ 0.6
32.00	39.811	40.081	+ 0.7
48.00	251.189	249.127	- 0.8

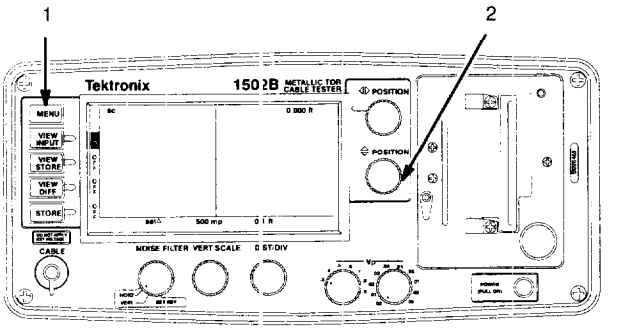
High Gain Stage - push MENU to Continue -

12. If either number following "Worst Case Positive Error%" or "Worst Case Negative Error%" exceeds 3.0, notify next higher level of maintenance.

13. Press MENU pushbutton (1) to return to Service Diagnostic Menu. Perform RAM/ROM Test.

```
The instrument gain tolerance is three per cent. If the
worst case positive a id worst case negative errors are
each less than three per cent, the instrument is in
tolerance.

Worst Case Positive Error% + 1.2      Pass

Worst Case Negative Error% - 1.9      Pass

push M ENU to Exit -
```

3-14. RAM/ROM TEST



1. Perform Offset/Gain Test para 3-13) and while still in Service Diagnostic Menu, turn ▲▼ POSITION control (2) to move arrow to select "RAM/ROM Diagnostics".

2. Press MENU Pushbutton (1). Diagnostic is automatic and will display test results on LCD.

3. If any RAM/ROM sectors fail to pass, notify next higher level of maintenance

4. Press MENU pushbutton (1) four times to return to normal operation.

```
Exit Service Diagnostic Menu
Sampling Efficiency Diagnostic
Noise Diagnostic
Offset/Gain Diagnostics
→ RAM/ROM Diagnostics
Timebase is: Normal - Auto Correction

Move ▲▼ Position to select, then push MENU button
```

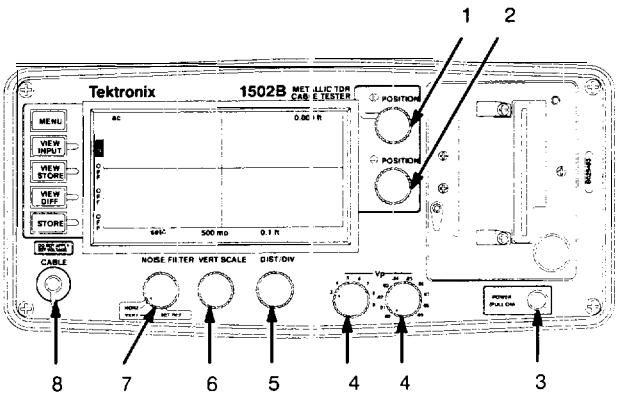
```
RAM/ROM Diagnostic Results

ROM Bank 0                Pass
ROM Bank 1                Pass
RAM                       Pass
Non-Volatile RAM          Pass

push MENU button to Exit -
```

3-15. JITTER TEST

1. Pull POWER switch (3) (On position).

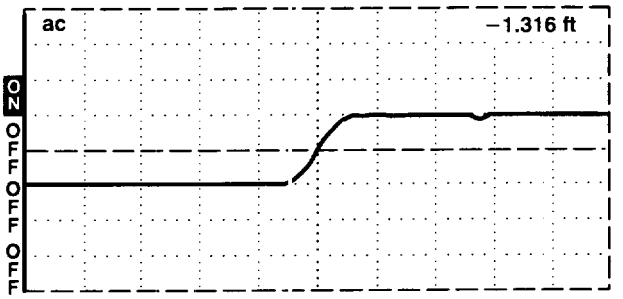
2. Set front panel controls as follows:

NOISE FILTER switch (7):	1 avg
VERT SCALE control (6):	500 mρ
DIST/DIV switch (5):	0.1 ft/DIV
Vp switches (4):	.99
CABLE connector (8):	termination



3. Turn ◀▶ POSITION control (1) and ▲▼ POSITION control (2) to center rising edge of waveform on center horizontal graticule line.

4. Turn VERT SCALE control (6) clockwise for reading of less than 1.0 mρ/DIV. Verify that leading edge of pulse moves less than five horizontal pixels (or <5 ft. on readout).



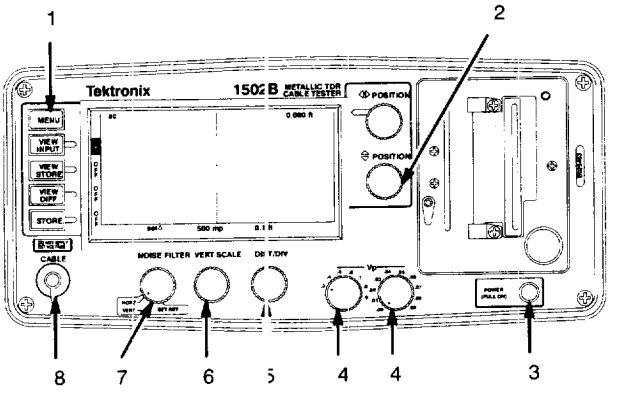
NOTE

Using Max Hold function in Acquisition Control Menu can simplify this measurement by displaying jitter accumulating in waveform over period of time (more than 30 seconds).

5. If Test Set fails this test, notify next higher level of maintenance

3-16. SAMPLING EFFICIENCY TEST

1. Pull POWER switch (3) (On position).



2. Set front panel controls as follows:

NOISE FILTER switch (7):	1 avg
VERT SCALE control (6):	500 mp
DIST/DIV switch (5):	1 ft/DIV
Vp switches (4):	.99
CABLE connector (8):	no connectors

3. Press MENU pushbutton (1) to bring up Main Menu. Turn ▲▼ POSITION control (2) to move arrow to select "Diagnostic Menu".

```
Return to Norma l Operation
Help with Instrument Controls
Cable Informatio n Menu
Setup Menu
→ Diagnostic Menu
View Stored Wav eform Settings
Option Port Menu

Move ▲▼ Position to sel ect, then push MENU button
```

4. Press MENU pushbutton (1) to bring up Diagnostics Menu. Turn ▲▼ POSITION control (2) to move arrow to select "Service Diagnostic Menu".

```
Exit Diagnostics Menu
→ Service Diagnosti : Menu
Front Panel Diagnostic
LCD Diagnostics Menu
Chart Diagnostics Menu

Move ▲▼ Position to sel ect, then push MENU button
```

5. Press MENU pushbutton (1) to bring up Service Diagnostic Menu. Turn ▲▼ POSITION control (2) to move arrow to select "Sampling Efficiency Diagnostic".

6. Press MENU pushbutton (1) and follow directions on LCD screen.

```
Exit Service Diag nostic Menu
→ Sampling Efficien cy Diagnostic
Noise Diagnostic
Offset/Gain Diagn ostics
RAM/ROM Diagn ostics
Timebase is: Nor mal - Auto Correction

Move ▲▼ Position to se ect, then push MENU button
```

```
Sampling Efficiency Diagnostic

Remove all connectors from front panel -

Push MENU button to Exit -
```

NOTE

If result is more than 90%, the waveforms will appear noisy. If result is less than 50%, the waveform will take longer to move from bottom to top of reflected pulse (uses more pixels). This smoothing effect might hide faults that would normally be only one or two pixels wide on the LCD.

7. If results are outside of acceptable range, notify next higher level of maintenance.

8. Press MENU pushbutton (1) four times to return to normal operation.

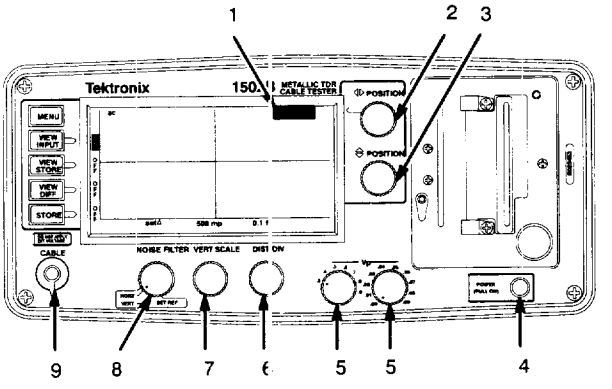
Sampling Efficiency Diagnostic Continuous Result Update	
Acceptable Range	**Result**
50% - 90%	**%**
Push MENU button to Exit -	

3-17. ZERO OFFSET TEST

1. Pull POWER switch (4) (On position).

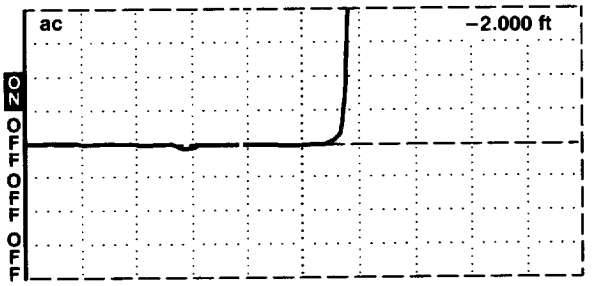
2. Set front panel controls as follows:

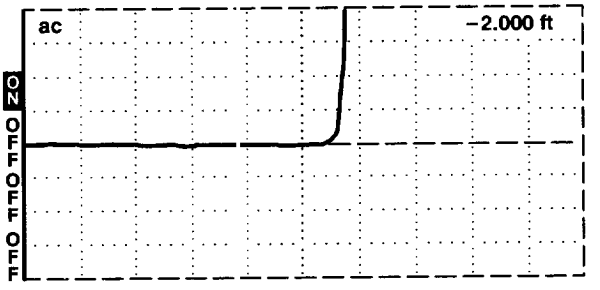
NOISE FILTER switch (8):	1 avg
VERT SCALE control (7):	500 mρ
DIST/DIV switch (6):	0.2 ft/DIV
Vp switches (5):	.99
CABLE connector (9):	no connectors



3. Adjust ◀▶ POSITION control (2) until LCD distance window (1) reads approximately -2.000 ft. Turn ▲▼ POSITION control (3) to center baseline before incident pulse and increase VERT SCALE control (7) to 10 mρ, keeping baseline on LCD.

4. CABLE connector (9) has shorting bar that shorts input when cable is removed. Attach precision 50 Ω cable to CABLE connector (9). Waveform prior to leading edge may change shape slightly, but should not shift more than one minor division.

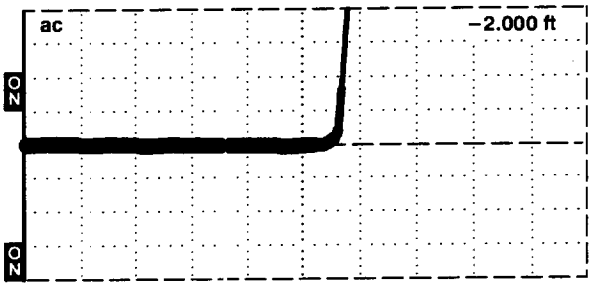




5. Max Hold may be used to easily monitor any changes.

6. If Test Set fails this test, notify next higher level of maintenance.

7. Turn Test Set off and then on again. This will reset it for next test.



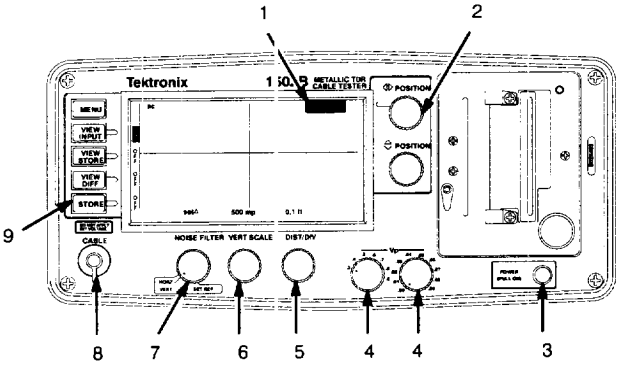
3-18. RISETIME TEST

If risetime is out of specification, it may be difficult to make accurate short di stance measurements near the front panel, and it may affect resolution of the Test Set.

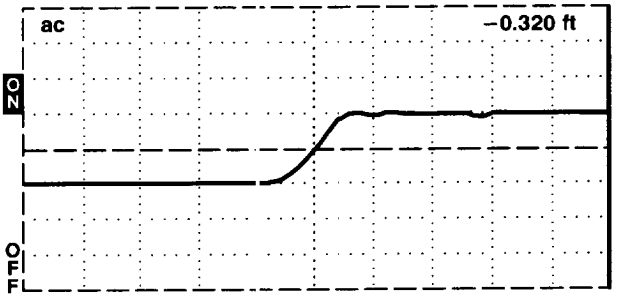
1. Pull POWER switch (3) (On position).

2. Set front panel controls

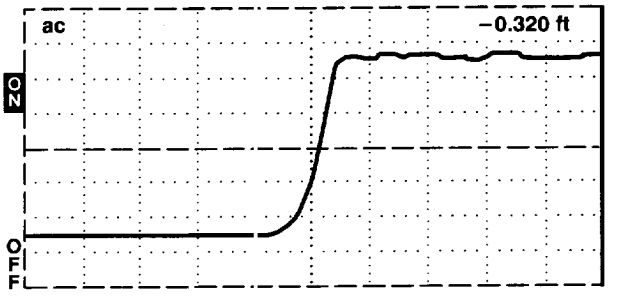
NOISE FILTER switch (7):	1 avg
VERT SCALE control (6):	500 mρ/DIV
DIST/DIV switch (5):	0.1 ft/DIV
Vp switches (4):	.99
CABLE connector (8):	termination



3. Turn ◀▶ POSITION control (2) to move incident pulse to center of LCD



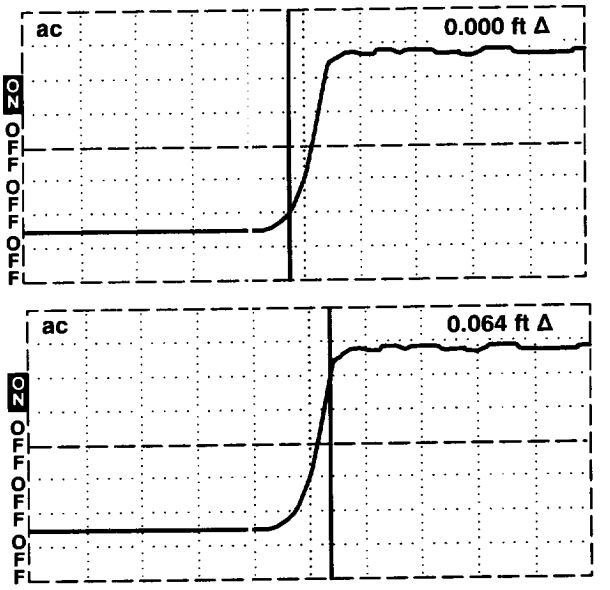
4. Turn VERT SCALE control (6) clockwise until leading edge of incident pulse is five major divisions high (about 200 mρ). Position waveform so that it is centered horizontally and vertically on middle graticule lines.



5. Turn NOISE FILTER switch (7) to HORZ SET REF. Turn ◀▶ POSITION control (2) to set cursor to point where lower portion of pulse's rising edge first crosses a major horizontal graticule line. Press STORE pushbutton (9) and turn NOISE FILTER switch (7) to 1 avg.

6. Turn ◀▶ POSITION control (2) to set cursor to point where upper portion of pulse's rising edge first crosses a major horizontal graticule line. Verify that distance window (1) is less than or equal to 0.096 ft Δ.

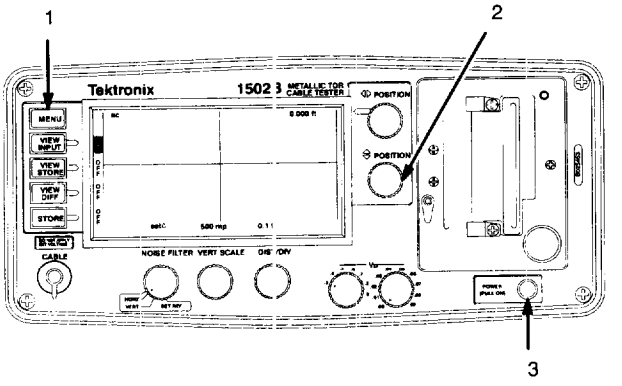
7. If Test Set fails this test, notify next higher level of maintenance.



3-19. CHART RECORDER TEST

If the chart recorder does not pass this test, chart recordings may not be possib e.

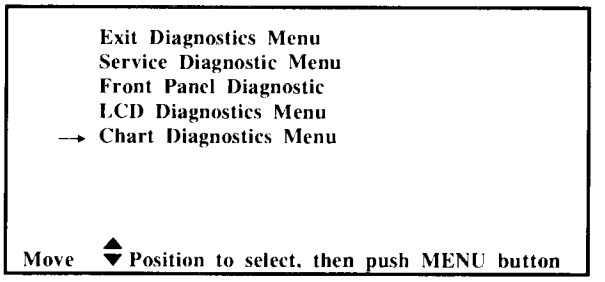
1. Pull POWER switch (3) (On position).



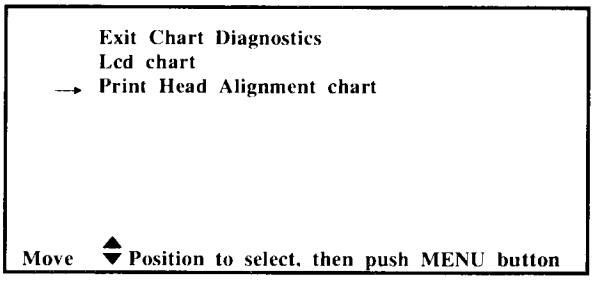
2. Press MENU pushbutton (1) to bring up Main Menu. Turn ▲▼ POSITION control (2 to move arrow to select "Diagnostic Menu".

```
Return to Nor nal Operation
Help with Instrument Controls
Cable Informa :ion Menu
Setup Menu
→ Diagnostic Menu
View Stored V/aveform Settings
Option Port Menu

Move ▲▼ Position to select, then push MENU button
```

3. Press MENU pushbutton (1) to bring up Diagnostics Menu. Turn ▲▼ POSITION control (2) to move arrow to select "Chart Diagnostics Menu".

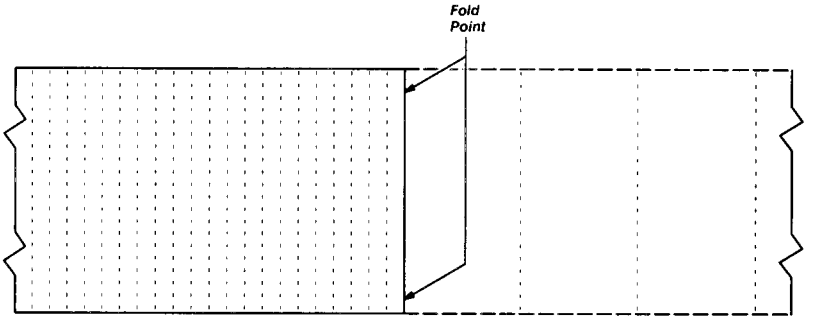


4. Press MENU pushbutton (1) to bring up Chart Diagnostics Menu Turn ▲▼ POSITION control (2) to move arrow to select "Print Head Alignment chart".



5. Press MENU pushbutton (1) and follow instructions on LCD screen to get printout.

6. On printout, there should be about 6 in. of wide lines and 6 in. of narrow lines. Total length should measure 10.87 in. to 12.76 in.



7. Fold paper in half at last narrow line. Two halves should be equal in length.

8. Entire diagnostic should be printed within boundaries of paper.

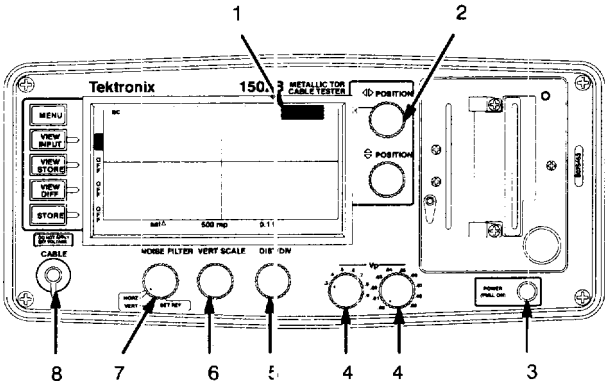
9. If chart recorder fails any of above steps, notify next higher level of maintenance.

3-20. ABERRATIONS TEST

1. Pull POWER switch (3) (On position).

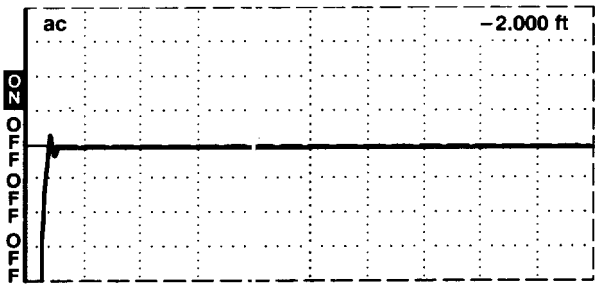
2. Set front panel controls as follows:

NOISE FILTER switch (7):	1 avg
VERT SCALE control (6):	500 mρ
DIST/DIV switch (5):	5 ft/DIV
Vp switches (4):	.99
CABLE connector (8):	termination

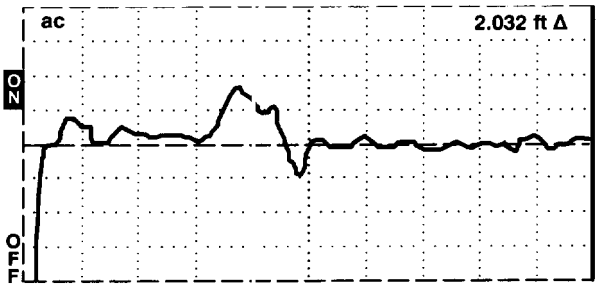


3. Decrease ◀▶ POSITION control (2) so that LCD distance window (1) reads -2.000 ft.

4. Adjust VERT SCALE control (6) to 50 mρ/DIV. Center waveform on center graticule line.

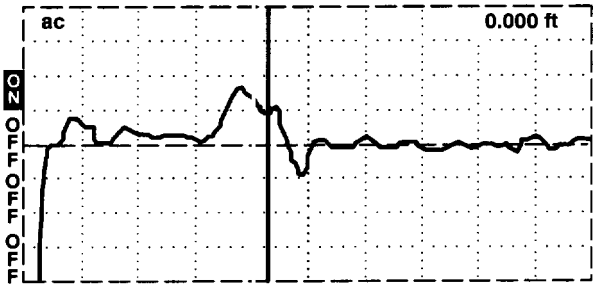


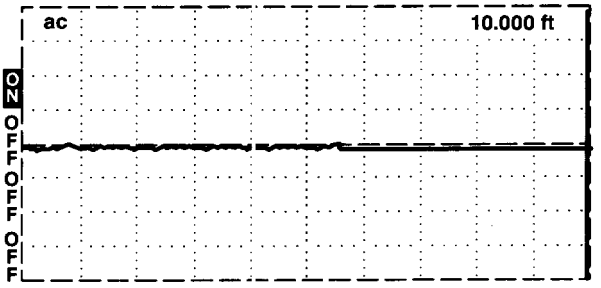
5. Set DIST/DIV switch (5) to 0.2 ft/DIV and adjust ◀▶ POSITION control (2) until rising edge of pulse is in left-most major division on LCD.



6. Turn ◀▶ POSITION control (2) to move cursor to 0.000 ft/DIV. All aberrations except one under cursor should be within one division of center graticule line.

7. Increase DIST/DIV to 200 ft/DIV and increase VERT SCALE control (6) to 5 mρ. Verify that trace is flat ±1 division after incident step.





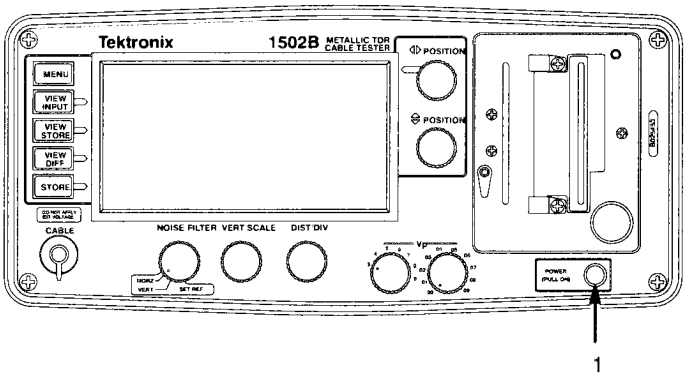
8. If Test Set fails this test, notify next higher level of maintenance.

3-21. LINE FUSE REPLACEMENT

DESCRIPTION

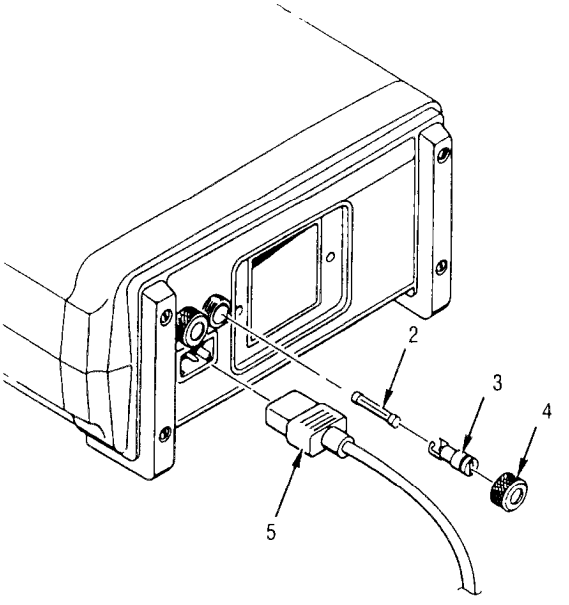
This procedure covers: Remove and Install

REMOVE



1. Push in POWER switch (1) (Off position).
2. Working from rear, disconnect power cord (5) from AC power source.
3. Remove cap (4) by turning counterclockwise.
4. Turn line fuse holder (3) counterclockwise. Spring tension forces line fuse holder (3) and line fuse (2) out from rear panel of Test Set.

INSTALL



1. Install new line fuse (2) of correct rating (para 2-14) in line fuse holder (3).
2. Working from rear, install line fuse holder (3) in line fuse receptacle in rear panel. Push line fuse holder (3) in and rotate approximately 1/4 turn clockwise until line fuse holder locks in place.
3. Replace cap (4) and secure by rotating clockwise until snug.
4. Connect power cord (5) to AC power source.
5. Working from front, pull POWER switch (1) (On position) and verify that Test Set turns on.

END OF TASK

3-22. BATTERY PACK AND BATTERY PACK FUSE REPLACEMENT

DESCRIPTION

This procedure covers: Remove and Install

WARNING

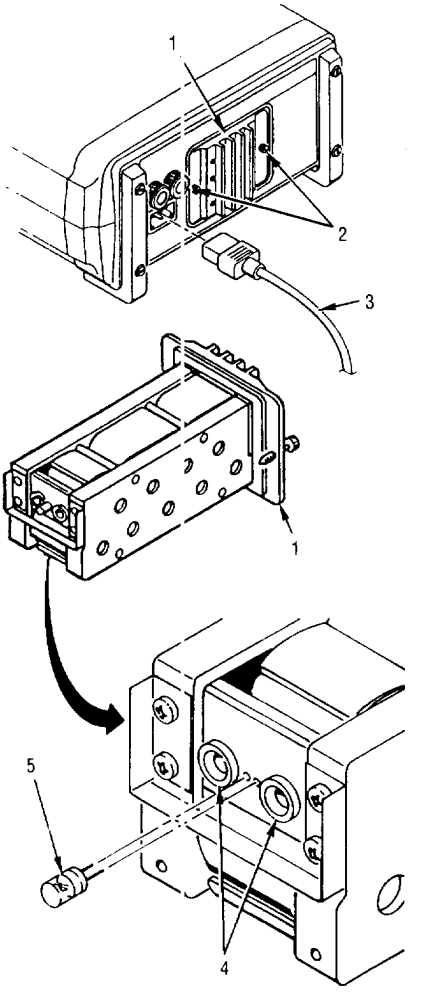
Do not charge battery pack below +32°F (0°C) or above 113°F (45° C). Do not discharge battery pack below -4°F (-20°C) or above 149°F (65°C). Do not use Test Set outside of these parameters or batteries may emit explosive gas (hydrogen). If removing battery pack during or after exposure to these conditions, turn Test Set off and remove power cord. Move Test Set to an spark-free area before removing battery pack.

REMOVE

1. Push in POWER switch (Off position).
2. Working from rear of Test Set, disconnect power cord (3) from AC power source.
3. Unscrew two screws (2) and remove battery pack (1) from Test Set by pulling it straight out.
4. Pull fuse (5) straight out from inner end of battery pack (1) and discard.

INSTALL

1. Install new fuse (5) in battery pack (1).
2. Working from rear of Test Set, install new battery pack (1) in Test Set. Make sure female connectors (4) on battery are aligned with male probes in Test Set.
3. Tighten two screws (2) securing battery pack (1).
4. Working from front of Test Set, pull POWER switch (On position) and verify Test Set turns on.



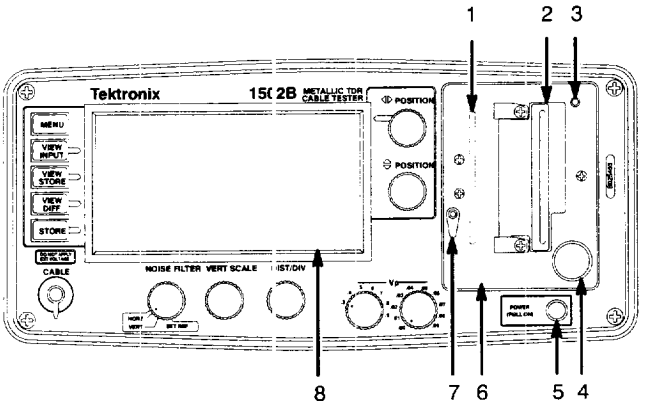
END OF TASK

3-23. CHART RECORDER AND CHART RECORDER PAPER REPLACEMENT

DESCRIPTION

This procedure covers: Remove and Install

REMOVE



1. Push in POWER switch (5) (off position).
2. Turn front locking knob (4) counterclockwise until it loosens locking lever.
3. Remove chart recorder (6) from option port by pulling it straight out.
4. Set chart recorder on flat surface.
5. Push frame (13) surrounding motor pulley until motor assembly latch (12) locks motor assembly to side frame. This loosens tension in paper path, allowing any remaining paper to be removed.
6. Remove paper retaining knob (10) by rotating counterclockwise.
7. Remove any remaining paper and empty paper core.

INSTALL

1. Following diagram on top of chart recorder, place fresh roll of paper (9) in chart recorder so that paper unwinds clockwise off roll (1 1) into paper path. (Looking down on chart recorder, paper unrolls clockwise). Tearing end of paper roll on a slant will facilitate placing paper in slot.

2. Release pivot lock (7) and open slot door (2).

3. Make sure paper drops down into paper path without binding, and paper protrudes through slot (1) in front of chart recorder.

4. Install paper retaining knob (10) by rotating clockwise.

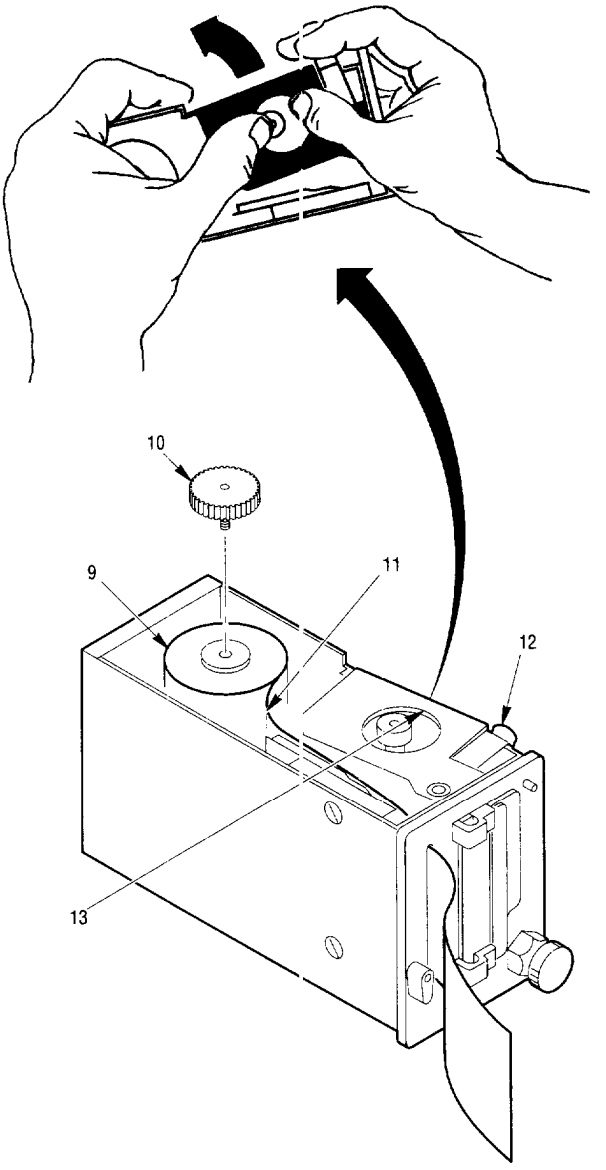
5. Release motor assembly latch (13) from frame, and paper drive mechanism will spring return to operating position.

6. Insert chart recorder (6) in option port and turn front locking knob (4) clockwise until snug.

7. Pull out power switch (5) (On position) and set up a waveform on LCD (8).

8. Press PRINT pushbutton (3) and verify that chart recorder makes a test print.

9. Tear off test print.



END OF TASK

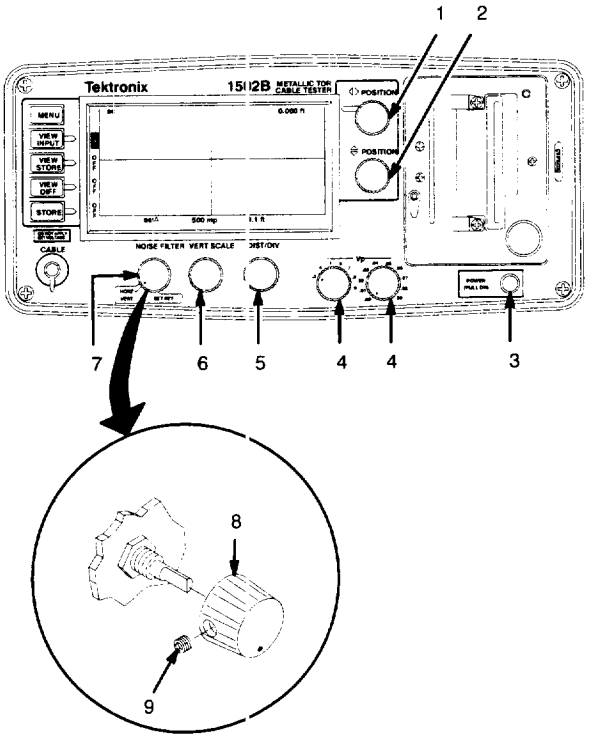
3-24. KNOB REPLACEMENT (SETSCREW)

DESCRIPTION

This procedure covers: Remove and Install

The following knobs are held on with a single setscrew:

◀▶ POSITION control (1)
▲▼ POSITION control (2)
Vp switches (4)
DIST/DIV switch (5)
VERT SCALE control (6)
NOISE FILTER switch (7)



REMOVE

1. Working from front panel, push in POWER switch (3) (Off position).
2. Loosen setscrew (9) and remove knob (8) by pulling from shaft.

INSTALL

1. Line up knob (8) setscrew hole to flat portion of shaft and press knob onto shaft.
2. Tighten setscrew (9).

NOTE

If knob shaft is broken, notify next higher level of maintenance.

END OF TASK

3-25. CLEANING

CAUTION

Do not use chemical cleaning agents that contain benzene, toluene, xylene, acetone, etc. These cleaning agents may damage Test Set.

a. Clean exterior case and front panel with mild liquid detergent (Appendix E, item 3) and water.

b. Clean LCD screen using lintless cotton cheesecloth (Appendix E, item 2) moistened with isopropyl alcohol (Appendix E, item 1).

Section V. PREPARATION FOR STORAGE OR SHIPMENT

3-26. PACKING FOR STORAGE OR SHIPMENT

If original packing material was saved, pack Test Set in the same manner as it was received. When using packing materials other than original, use the following guidelines:

a. Remove battery pack from Test Set (para 3-10).

b. Wrap Test Set in polyethylene sheeting before placing in container.

c. Select corrugated cardboard container having inside dimensions at least 6 nches greater than Test Set dimensions and having a carton test strength of at least 275 pounds.

d. Use plenty of shock-absorbing material all around Test Set to protect it against damage.

e. Seal carton with shipping tape or an industrial stapler.

f. Mark container **FRAGILE—DELICATE INSTRUMENT** to ensure proper handling.

3-27. TYPES OF STORAGE

CAUTION

Store Test Set in a clean, dry environment. In high humidity, temperature variations may cause internal condensation and damage to Test Set components.

- Short-term (administrative) = 1 to 45 days.
- Intermediate = 46 to 180 days.
- Long-term = over 180 days (after long term storage, perform Operational Tests (para 3-8)).

3-28. ENVIRONMENT

The Test Set should be stored in a clean, dry environment. In high-humidity environments, protect the Test Set from temperature variations that could cause internal condensation. The following environmental conditions apply to both shipping and storage:

Temperature (without battery pack) . . . . . -79.6° to +185° F (-62° to +85°C)

Temperature (for battery pack) . . . . . -4° to +131°F (-20° to +55°C)

Relative Humidity (sea level) . . . . . To 100%

Altitude . . . . . Less than 40,000 ft (12,195 m)

CHAPTER 4
DIRECT SUPPORT MAINTENANCE

There is no direct support maintenance authorized for the Test Set, Electrical Cable TS-4165/G.

CHAPTER 5
GENERAL SUPPORT MAINTENANCE

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Section I. REPAIR PARTS; SPECIAL TOOLS; TEST, MEASUREMENT, AND DIAGNOSTIC EQUIPMENT (TMDE); AND SUPPORT EQUIPMENT

5-1. COMMON TOOLS AND EQUIPMENT

Common tools and equipment required for generation support maintenance of the Test Set. Electrical Cable TS-4165/G (Test Set) are listed in Appendix B (Maintenance Allocation Chart).

5-2. SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT

No special tools, TMDE, or support equipment are required.

5-3. REPAIR PARTS

Repair parts are Iisted and illustrated in the Repair Parts and Special Tools List (TM 11-6625-324-24P).

Section II. SERVICE UPON RECEIPT

5-4. SERVICE UPON RECEIPT

For service upon receipt information, refer to Chapter 3. Section II.

5-5. PRELIMINARY SERVICING AND ADJUSTMENT OF EQUIPMENT

For preliminary servicing and adjustment of the Test Set, refer to Chapter 3. Section II.

Section III. THEORY OF OPERATION

5-6. GENERAL

The following paragraphs provide detailed descriptions for the Test Set circuitry. Refer to Chapter 1. Section III, for an overall functional description.

5-7. A3 POWER SUPPLY ASSEMBLY DESCRIPTION

The power supply (fig. 5-1) converts either 115/230 VAC line power, or takes +12 VDC power from the battery pack, to provide the Test Set with regulated DC voltages

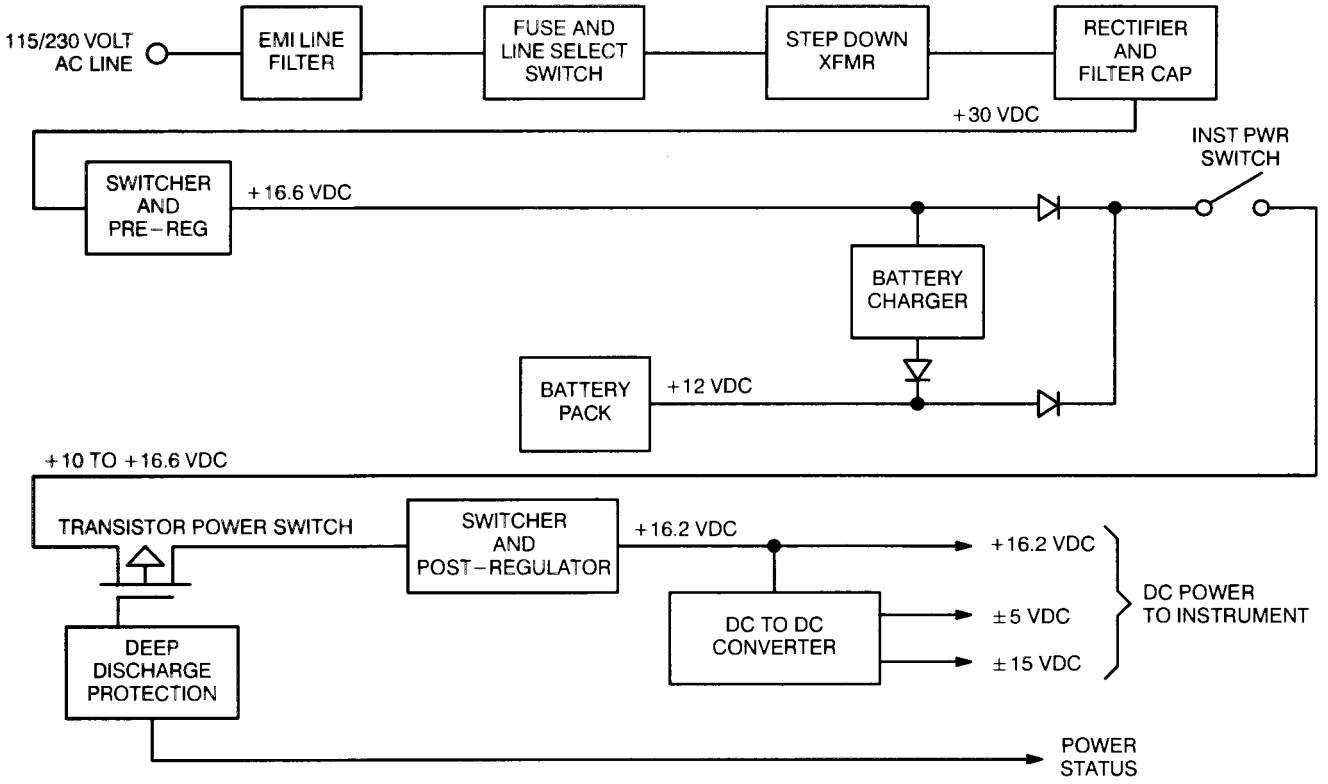

Figure 5-1. A3 Power Supply Assembly Block Diagram

Single-phase AC line voltage is applied to the power supply module through a power plug with the integral EMI filter. The filtered line voltage is immediately fused, routed through a line selector switch, and applied to a stepdown transformer. The transformer's secondary voltage is rectified and filtered to provide a nominal +30 VDC. A switching pre-regulator reduces this voltage to + 16.6 VDC, used to power the battery charger circuit. The +16.6 VDC is also processed through a rectifier and power switch to power the post-regulator.

The battery pack consists of nine nickel-cadmium C-size cell batteries connected in series. This combination provides a terminal voltage of +10 to +12.5 VDC with a nominal capacity of up to 2.0 ampere/hours. It also is connected through a rectifier to the Test Set power switch and post-regulator.

With the battery pack installed, the battery charger circuit operates as a current source to provide a constant charging current. As battery voltage approaches +12.5 VDC, voltage limiting circuits begin to reduce charge current to prevent battery overcharge.

When the POWER switch is pulled to On position, an FET power transistor is momentarily turned on by the deep discharge protection circuit. If the voltage to the post-regulator rises to +9.7 volts or greater, the transistor switch remains on. If at any time the voltage drops below +9.7 volts, the transistor turns off and the power switch must be recycled to restart the Test Set. This operation prevents discharge of the battery pack below +10 volts. Such a discharge could cause a reverse charge in a weak cell, resulting in permanent cell damage.

The post-regulator is a boost switching regulator that increases the input voltage to provide a constant +16.2 VDC output. This voltage is supplied directly to the processor for large loads such as the display heater, electroluminescent (EL) backlight, and option port. The post-regulator also supplies a DC-to-DC converter that generates 15 VDC.

Status signals are supplied by the deep discharge protection circuits and are used to detect whether the Test Set is running on AC line voltage or the battery pack, and if the battery pack is approaching turn-off level.

5-8. PROCESSOR CIRCUIT DESCRIPTION

The processor (fig. 5-2) consists of microprocessor, address decoding, memory, and interrupt logic circuits that provide the control and calculation functions for the Test Set.

An 8-bit microprocessor clocked at 5 MHz provides the processing capability in a bus organized system. Instructions are read from the erasable programmable read-only memory (EPROM) and executed by the microprocessor to accomplish essentially all Test Set functions. Random-access memory (RAM) is connected to the microprocessor through its data and address buses, allowing control, video, and display data to be stored and retrieved, as required.

The processor communicates with all other Test Set circuits via the address, data, and select signals, and receives requests for service from those circuits via the interrupt and status signals. Select signals are generated in address decoding circuits under control of the system and used to read or write data from a circuit, or to trigger a circuit function. Interrupts from the circuit are combined in the interrupt logic to generate an interrupt request to the microprocessor. The microprocessor responds by reading a data word from this logic to determine the source of the interrupt, or status data, and then performs the required service routine.

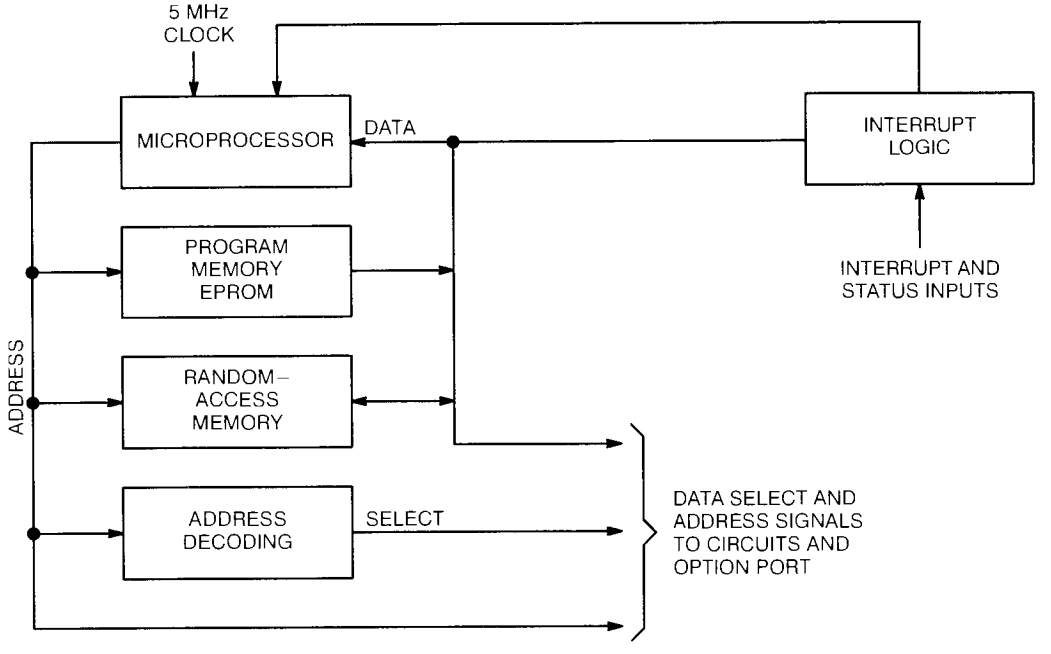

Figure 5-2. Processor Block Diagram

5-9. VIDEO PROCESSOR CIRCUIT DESCRIPTION

The video processor (fig. 5-3) receives sampled video from the driver/sampler circuit and outputs a digitized video signal to the processor data bus.

Vertical position information is loaded by the processor into a digital-to-analog converter (DAC) to generate a DC signal. Sampled video is combined with this vertical position DC voltage in a summing amplifier to allow vertical positioning of the displayed waveform.

The combined video and position signal is amplified by an operator-selected gain in the video amplifier. Gain of the amplifier is set by the processor via the data bus and video amplifier select signal.

The amplified video is digitized by the video analog-to-digital converter (ADC) upon receipt of a control signal from the processor. The processor is notified by the ADC interrupt request when the conversion has been completed. The processor then reads the value via the data bus.

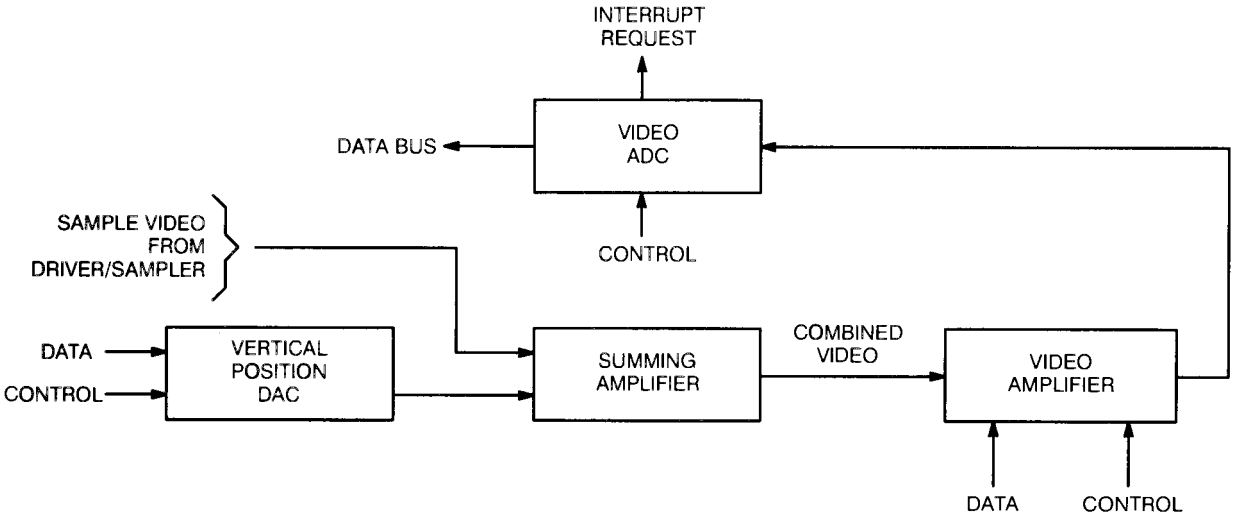

Figure 5-3. Video Processor Block Diagram

5-10. TIMEBASE CIRCUIT DESCRIPTION

The timebase circuits (fig. 5-4) receive video sample time delay values in digital form from the processor and generate precisely timed strobes to the driver/sampler circuits. Digital counters determine the delay in 50 ns multiples, and analog circuits further define the delay to fractions of that period.

The digital portion of the timebase contains a clock generator that develops all frequencies used in the Test Set circuitry.

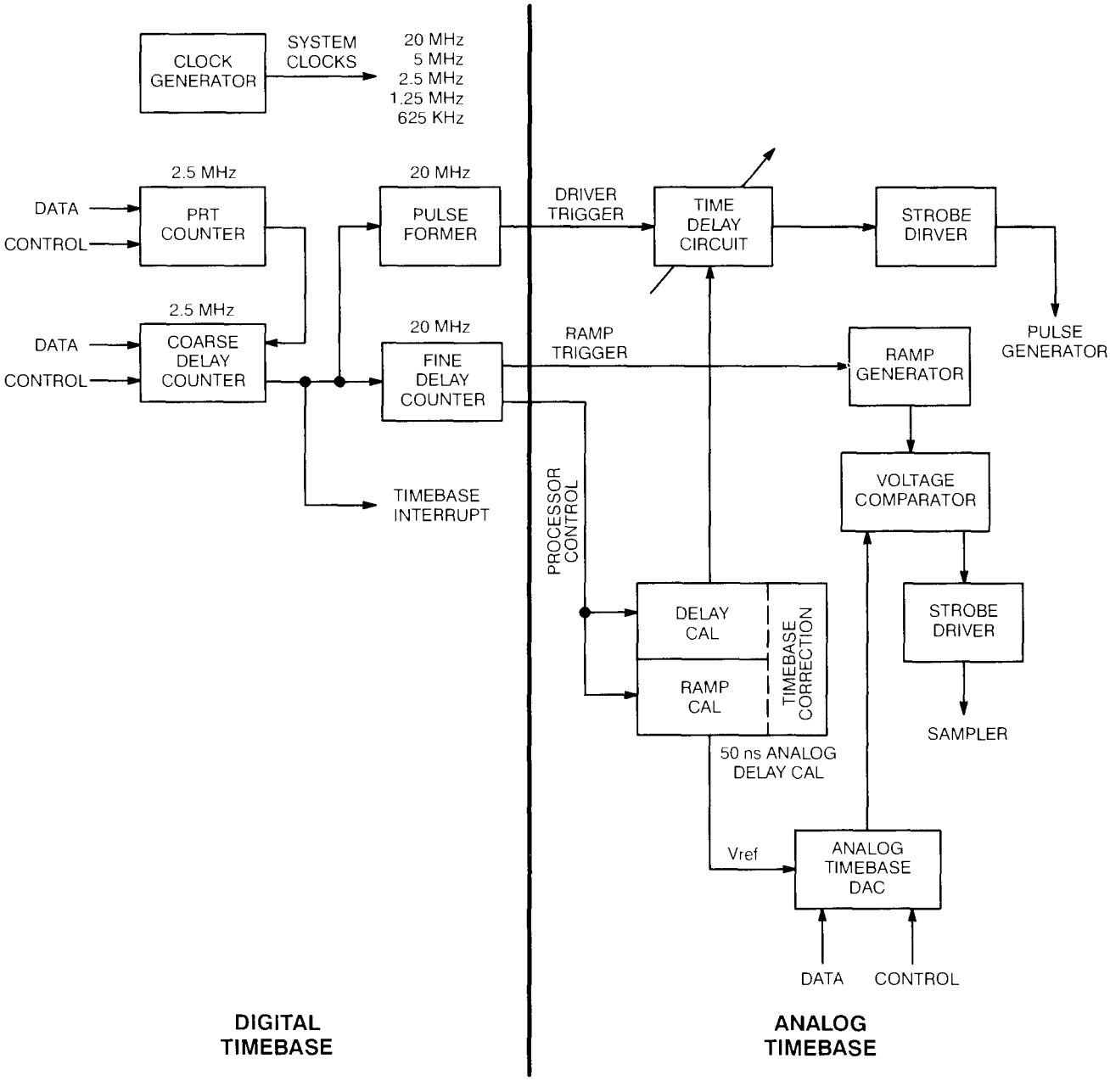

Figure 5-4. Timebase Block Diagram

A programmable digital counter, clocked at 2.5 MHz, is used to determine the pulse repetition time (PRT) of the driver/sampler test pulse. The Test Set is programmed with a PRT of 200 µs. The output of the PRT counter is used to trigger a delay counter, also clocked at 2.5 MHz, to provide coarse (400 ns resolution) digital time delay. The end of this time delay triggers a fine delay counter that is clocked at 20 MHz, providing 50 ns resolution to the sampler time delay. Both the coarse and fine delay counters are programmed by the processor via the data bus. The end of the coarse time delay is used to generate a timebase interrupt request to the processor to inform it that a sample is being taken and a timebase update is required for the next sample.

The output of the fine delay counter is provided to the analog timebase circuits for further delay control to become the sampler trigger. The beginning of the coarse delay counter period is detected by a pulse former that generates a driver trigger for the analog timebase.

The analog timebase circuits receive the driver and sampler triggers and provide strobes to the driver/sampler. The driver trigger is delayed by an analog time delay and amplified by a driver circuit to provide the driver strobe.

The ramp trigger is used to start a linear voltage ramp generator. A voltage comparator detects the time when this ramp reaches the programmed voltage of the timebase DAC and signals a driver to produce a strobe for the video sampler. The timebase DAC is programmed by the processor to provide a voltage proportional to the portion of the 50 ns time delay period desired.

The processor controls the timebase (fig. 5-5) as follows: Each period of the pulse rate, the processor calculates a new 33-bit digital time delay value for the next sample to be taken. The 16 most significant bits of this value are loaded into the coarse delay counter, causing it to count that number of 2.5 MHz clock periods before starting the fine delay counter.

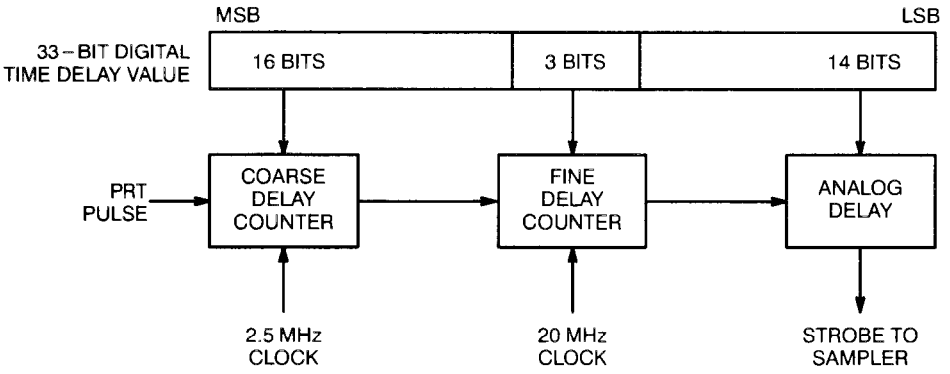

Figure 5-5. Timebase Control

The next three bits from the processor time delay value are loaded into the fine delay counter. This counter starts at the end of the coarse delay, and counts the selected number of 20 MHz clock periods (0 through 7) before triggering the analog delay.

The analog delay circuit receives the 14 least-significant bits of the time delay word. A DAC conversion provides a proportional voltage that is compared to a linear voltage ramp to produce the programmed time delay (0 to 50 ns).

The timing diagram (fig. 5-6) shows the combined effects of the three time delays. The output of the PRT counter, waveform (a), begins the coarse time delay (b). The falling edge of this signal triggers the driver strobe (c), which causes a pulse to be applied to the cable test output.

At the end of the coarse delay, the rising edge of this signal enables the fine delay (d), which produces a single ramp trigger pulse after the programmed delay. This pulse is shown expanded in waveform (e). The ramp generator waveform (f), also shown expanded, has a linear voltage ramp beginning on the falling edge of the trigger. This voltage is compared to the voltage from the timebase DAC such that when the ramp exceeds the DAC voltage, the sampler strobe (g) falls. This falling edge is used as the sampler strobe for video sampling.

At the beginning of each sweep, the zero distance ref is calibrated to the front panel connector, and the length of the analog ramp to 50 ns.

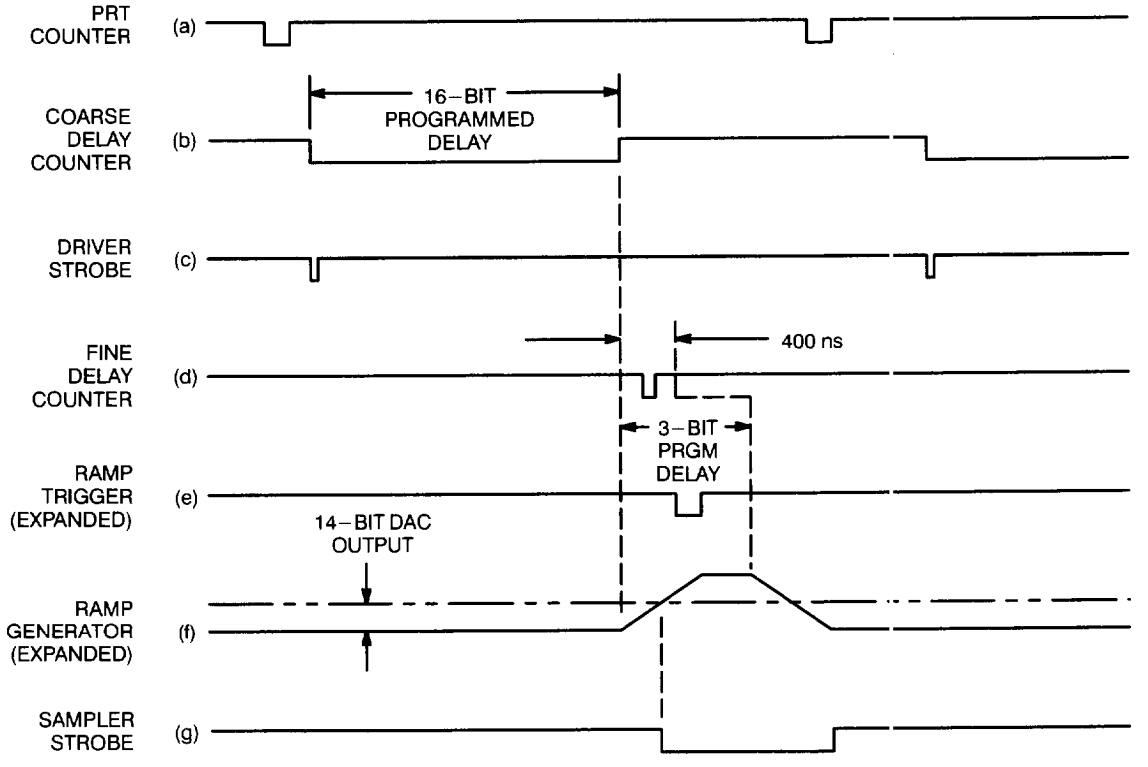

Figure 5-6. Combined Effects of Time Delay

Zero distance reference is aligned by setting the digital and analog timebase for zero delay. Then the processor adjusts the driver delay to sample at the 10 percent point of the pulse. The ramp is aligned by removing 50 ns of delay (one 50 ns clock cycle) from the sample trigger and then reinserting it with the analog delay. The processor adjusts the reference for the timebase DAC so as to sample at the previous level. This matches the analog delay to the 50 ns period of the clock (fig. 5-7).

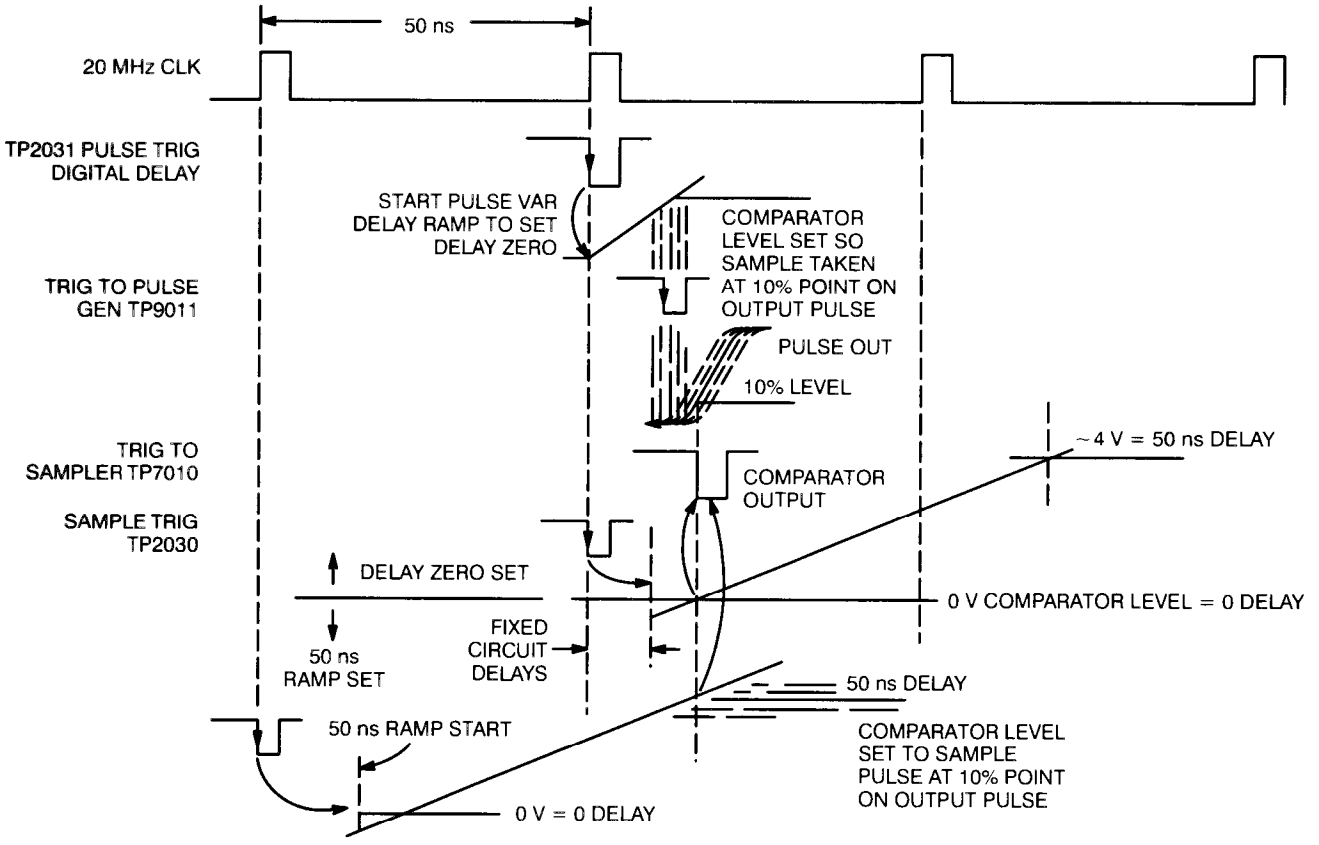

Figure 5-7. Delay Alignment

5-11. A4 DRIVER/SAMPLER CCA CIRCUIT DESCRIPTION

The A4 driver/sampler circuit card assembly (CCA) (fig. 5-8) generates the step test signal to sample and hold the reflections from the cable under test.

Most of the primary active circuitry is located within the hybrid. The balance of the driver CCA is dedicated to interfacing with the rest of the Test Set.

The step generator is triggered by a negative pulse from the main CCA. One of the trigger pulse shapers stretches this to 25 µs to set the length of the output step. The 0.6 V adjustable power source sets the on voltage for the output step.

The sampler is also triggered by a negative pulse from the main CCA. Inside the hybrid, this trigger causes the strobe generator to apply 50 ps pulses to turn on the bridge, capturing a portion of the input waveform. This sample is stored outside the hybrid in the second sampler to reduce droop rate. The stored signal goes two places: back to the main CCA as the video output, and to the bridge bias circuit, which holds the sampling bridge off between samples.

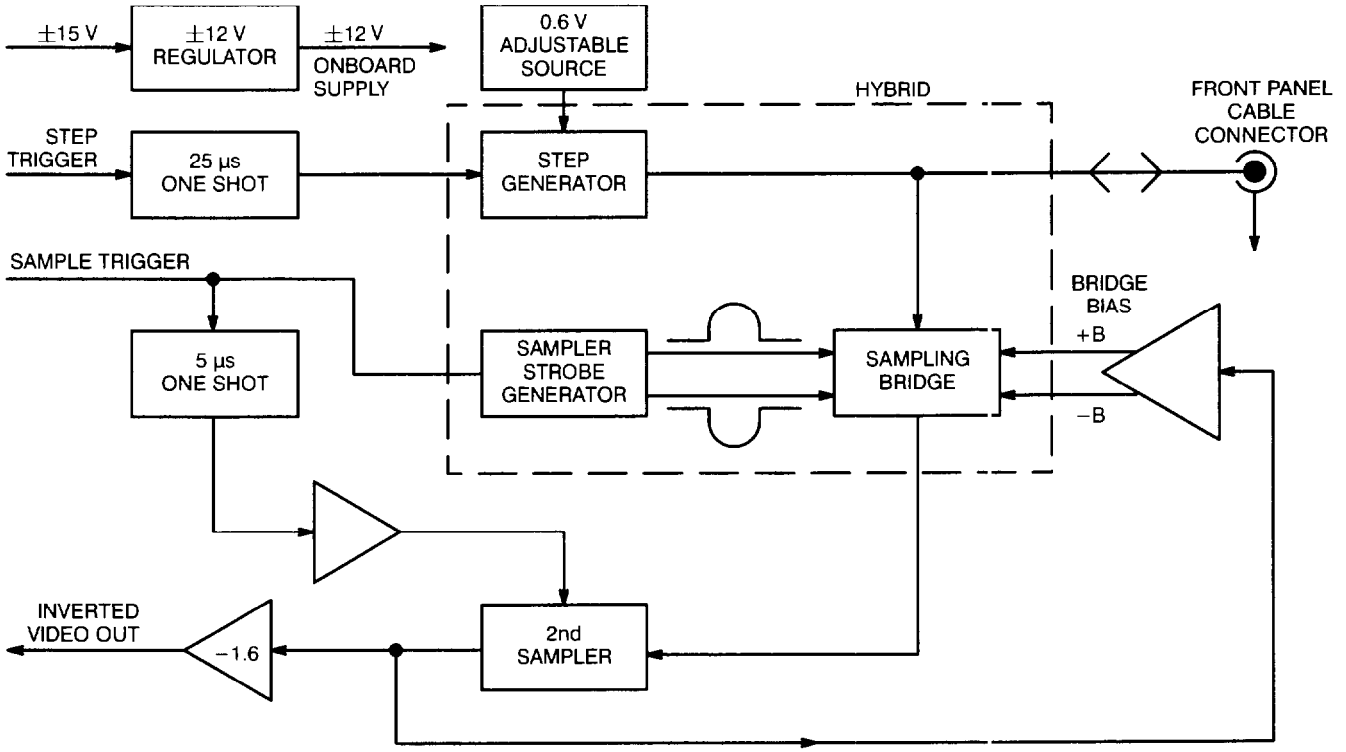

Figure 5-8. A4 Driver/Sampler CCA Block Diagram

5-12. FRONT PANEL ASSEMBLY DESCRIPTION

The front panel assembly (fig. 5-9) contains most of the Test Set controls and the circuitry for the LCD.

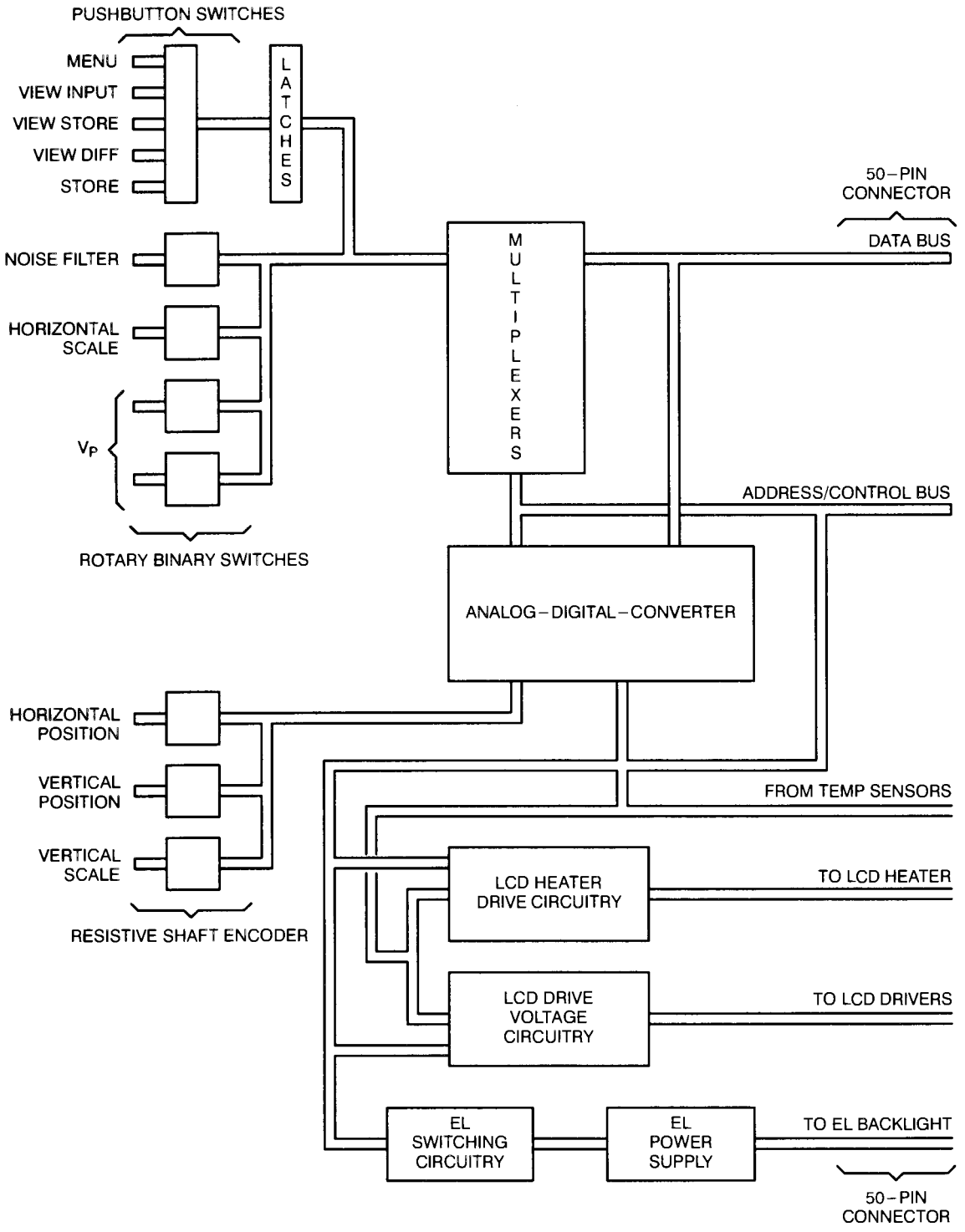

Figure 5-9. Front Panel Assembly Block Diagram

5-13. OPTOELECTRIC DISPLAY CIRCUIT DESCRIPTION

The optoelectric display (fig. 5- 10) function is to take bit pattern data generated by the Test Set circuitry and display it on the LCD.

The LCD screen displays information generated by the processor. The processor updates the display memory periodica lly with a new displ ay, and the display memory holds this bit pattern data. This data is received by the display controller and sent to the drivers, along with some control and timing signals that provide operating information to the drivers. The row and column drivers are attached electrically to the LCD screen through elastomeric connectors and a flex cable. These drivers place signal voltages on the electrode matrix in the L CD and thus generate the video display.

There are other circuits contained in the optoelectric display. An indium tin oxide (ITO) heater warms the display when operating in cold temperatures. A temperature sensor attached to the LCD provides screen temperature data to the heater and drive voltage circuitry. An EL backlight provides illumination during low light conditions

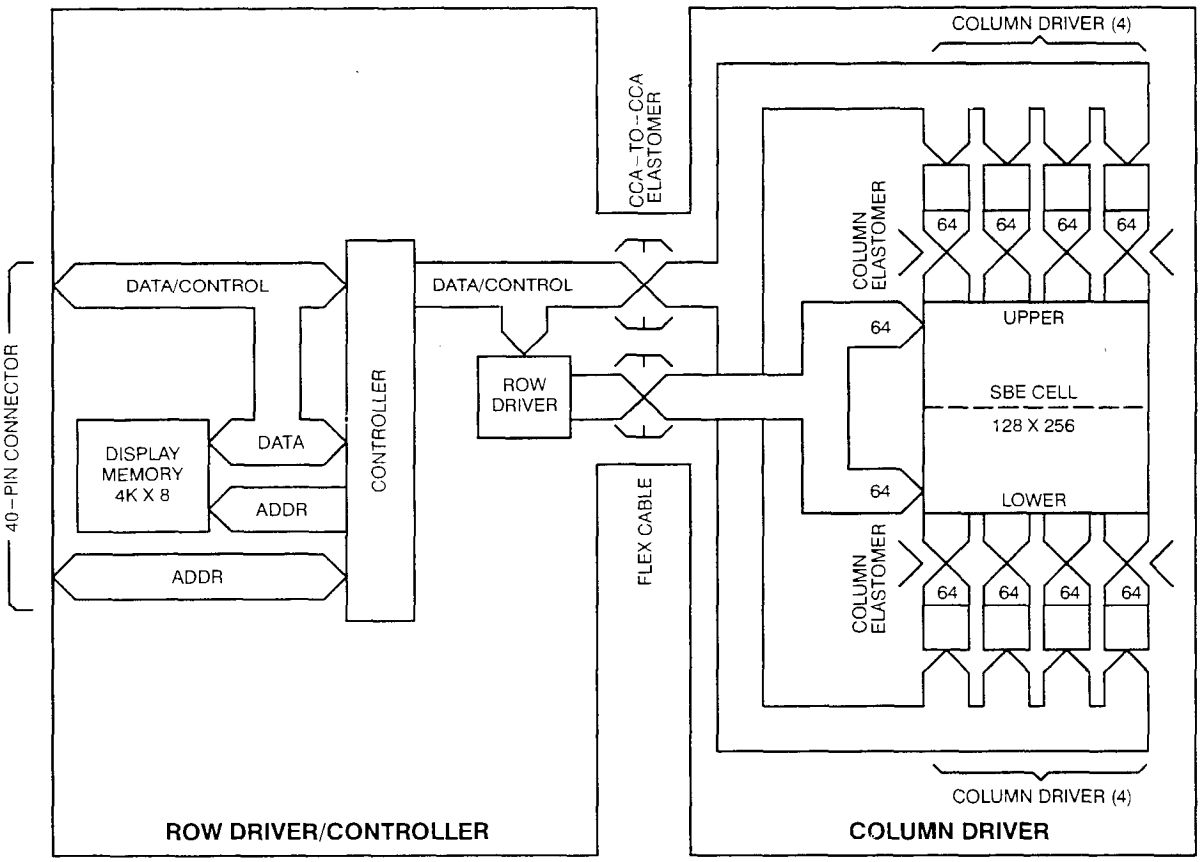

Figure 5-10. Optoelectric Display Block Diagram

5-14. OPTION PORT INTERFACE CIRCUIT DESCRIPTION

The option port interface (fig. 5-1 1) consists of supply controller, buffer, and output latch circuits. These circuits provide the connection between the processor and the chart recorder.

The option port interface receives +5 and +16 VDC and control signals from the processor. The data, address, and control lines from the processor are then buffered for increased drive. Feedback circuits are used to slow down the turn-on time and allow load charging without excessive power drain to the Test Set

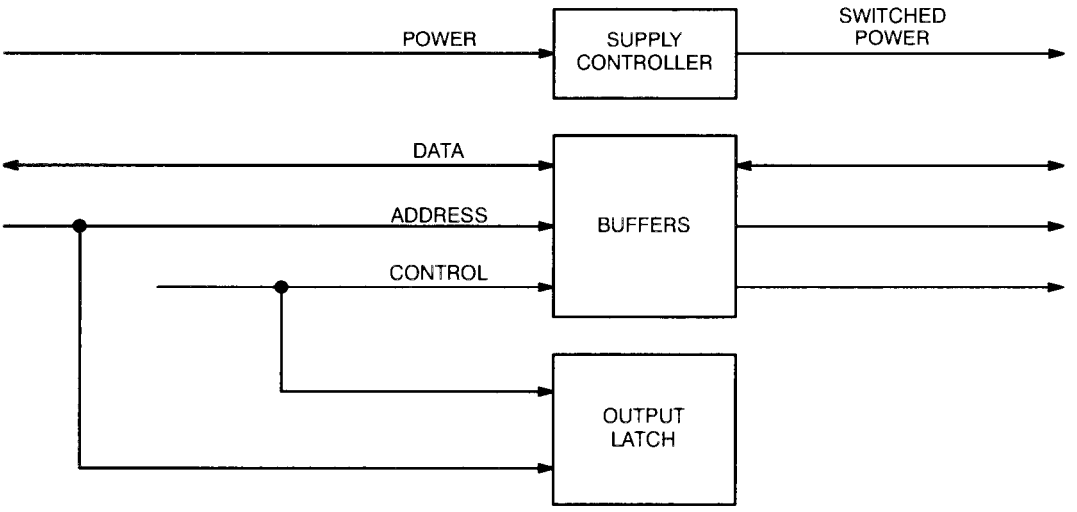

Figure 5-11. Option Port Interface Block Diagram

Section IV. GENERAL SUPPORT TROUBLESHOCTING

SYMPTOM INDEX

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1. WILL NOT OPERATE ON BATTERY	5-19
2. WILL NOT OPERATE ON AC ONLY	5-21
3. DISPLAYS ERROR MESSAGEOR NO WAVEFORM	5-21
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5. FAILS DISPLAY OR FRONT PANEL TESTS	5-27
6. FAILS HORIZONTAL SCALE TEST	5-31
7. FAILS VERTICAL POSITION TEST	5-34
8. FAILS NOISE TEST	5-35
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13. FAILS ZERO OFFSET TEST	5-37
14. FAILS RISETIME TEST	5-37
15. FAILS OPTION PORT DEVICE TEST..	5-37
16. FAILS ABERRATIONS TEST	5-37

5-15. GENERAL

Troubleshooting at the general support maintenance level requires locating any malfunction as quickly as possible. The amount of troubleshooting done is based on the Maintenance Allocation Chart (MAC). The trouble symptoms listed here are these that could be caused by faulty items that can be repaired/replaced. They are not the only malfunctions the equipment can have.

Before using the troubleshooting table, check the work order and talk to unit maintenance, if possible, for a description of the symptoms and the steps taken to correct them. Check all forms and tags attached to, or accompanying, the equipment to determine the reason for removal from service.

5-16. TROUBLESHOOTING GUIDELINES

Following is a list of aids used when troubleshooting the Test Set.

a. The Test Set has built-in self tests used to aid in troubleshooting. Procedures for self tests are specified in the troubleshooting procedures.

b. When possible, the Test Set built-in diagnostics will be used to aid in troubleshooting. Error messages that may be automatically displayed during initialization or operation of the Test Set are listed in Table 5-1 as Malfunction 3. Perform the maintenance response procedures as indicated.

c. Refer to Theory of Operation, Section III, as required. This provides circuit theory of the section needing troubleshooting. Detailed schematic diagrams for the Test Set circuit are shown in figures FO-2 through FO-7.

d. Some problems on Test Sets that have been in service for awhile are caused by corrosion. Sometimes removing and reseating the affected cable or circuit card will correct a malfunction. Cleaning connector pins and/or switch contacts may repair many types of digital and analog circuit malfunctions.

e. Circuit Cooler Freezing Compound (Appendix E, item 7) can be used in isolating problems. The most generally used method is to spray suspected circuits/components to see if the malfunction can be temporarily fixed. This method will not work all the time, but can be especially helpful on intermittent problems that get worse with a rise in temperature.

5-17. EQUIPMENT INSPECTION

a. Inspect all external surfaces of Test Set for physical damage or breakage.

b. Remove Test Set case and EMI shields (para 5-20) to access internal components.

WARNING

- *With case and EMI shields removed, several dangerous voltage po nts may be exposed. Contact with these points could cause serious injury or death to personnel.*
- *Observe proper procedures for handling and disposing of lithium batteries. Improper handling may cause fire, explosion, or severe burns. Do not recha rge, crush, disassemble, heat above 212°F (100° C), incinerate, or expose batte ry contents to water. Disposal of small quantities (less than 20) can be safely done with ordinary garbage in a sanitary landfill.*

CAUTION

Do not disconnect or remove any components or CCAs unless Test Se t is unplugged from power line and power switch is off. Test Set CCAs contain elect ostatic discharge sensitive devices. Use conductive foam or grounding straps when servi cing near CCAs. Use care when replacing integrated circuits.

c. Inspect CCA surfaces for discoloration, cracks, breaks, and warping.

d. Inspect CCA conductors for breaks, cracks, cuts, erosion, or looseness.

e. Inspect all assemblies for burnt or loose components.

f. Inspect all assemblies and surfaces for evidence of water leakage.

NOTE

Test Set controls, line fuse, and Voltage Selector switch access covers are sealed with rubber O-rings. These are not glued in place.

g. Inspect battery pack port, option port, and front panel-to-case and front panel-to-cover seals for damage. Replace any damaged seals (para 5-21).

5-18. TROUBLESHOOTING TABLE

The general support troubleshooting table (table 5-1) lists many of the most common malfunctions. References in table 5-1 and in the succeeding paragraphs refer to locators and schematics. Figures FO-2 through FO-7 illustrate the waveforms and schematic diagrams.

WARNING

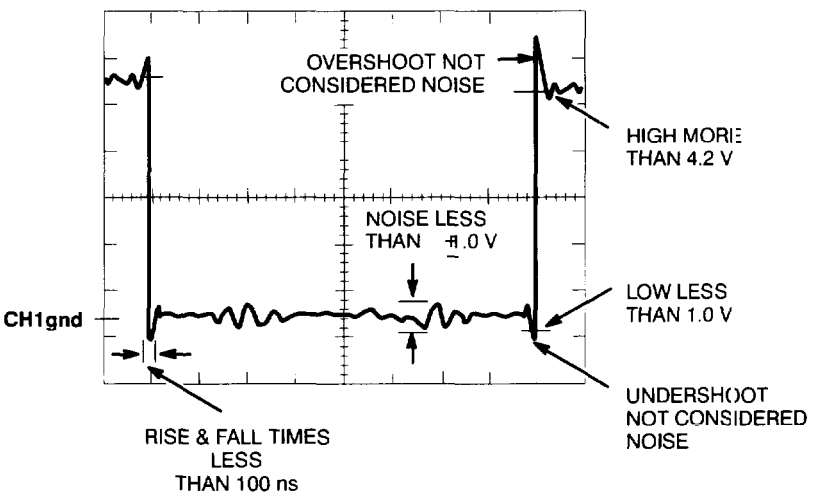
With case and EMI shields removed, dangerous voltages are exposed. Contact with these points could cause serious injury or death.

CAUTION

With cases removed, do not insert battery into instrument unless steps have been taken to ensure that battery will not be shorted against frame. Use extender cables if possible.

NOTE

- *Most of following steps are for acceptable logic levels and rise/fall times.*
- *Typical oscilloscope data logic signal measurement waveform is shown below:*



- *Use the following oscilloscope settings:*

  DC coupling
  100 ns/DIV
  1 V/DIV
  Single sweep
  Trigger on negative edge
  Trigger level about 2.5 V

- *All waveforms and measurements are to chassis ground unless otherwise noted.*

NOTE

- *All voltages have a tolerance of ±10%, unless otherwise noted, or unless given as a range with specific limits.*
- *When operating Test Set in temperatures below +50°F (+ 10° C), the LCD heater will turn on. It might take up to 20 minutes for the LCD to warm up and operate properly.*
- *Prior to troubleshooting the Test Set, perform Operational Tests in Chapter 3 to ascertain the nature of the malfunction. Always verify correct power supply voltages are present on the CCA prior to troubleshooting circuits on that CCA. After troubleshooting and repair, perform Operational Tests again to verify that the problem has been corrected.*
- *For each Malfunction, it is assumed you will turn power on prior to making voltage or waveform measurements and that you will turn power off at the end of troubleshooting.*
- *After replacing any component(s), repeat the step which isolated that particular defect.*

5-19. INITIAL SETUP

Remove case and EMI shields (para 5-20).
Set front panel controls:

Vp switches (1):	0.66
NOISE FILTER switch (3):	1 avg.
DIST/DIV switch (2):	1 ft/DIV.
CABLE connector (4):	50 Ω cable

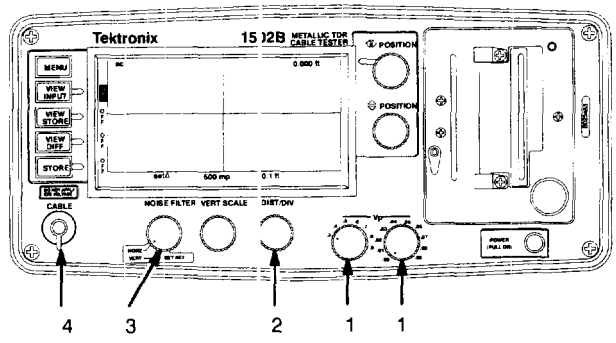


Table 5-1. Troubleshooting

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

1. WILL NOT OPERATE ON BATTERY

Step 1. Disconnect AC power cord. Measure A3A1 Power Supply output voltages (fig. FO-5, Sheet 3).

- If +5, -5, +15 or -15 VDC are out of tolerance, go to step 2.
- If +16.2 or +16.6 VDC are out of tolerance, go to Malfunction 2.

Step 2. Check voltage at A3A1J2010, pins 1 and 2 for +10.7 to +13.8 VDC (fig. FO-5, Sheets 1 and 2).

- If voltage is not acceptable, check A3C 102, W2020, and battery banana posts for shorts. Replace if defective (para 5-28).
- If voltage is acceptable, go to step 3.

Step 3. Check A3A1 CR2012, for 0.3 V drop across the diode.

- Replace if defective.
- If A3A 1CR2012 is functional, go to step 4.

Step 4. Connect AC power cord, then check for voltage drop of 0.4 to 1.2 V across A3A1R2012.

- If less than 0.4 V, check A3A1 U2010 and associated circuitry. Replace any defective components.
- If greater than 1.2 V, check battery for shorted cells. Replace if defective (para 5-35).
- If voltage is acceptable, go to step 5.

Step 5. Check for +15.9 to +16.5 VDC at A3A 1TP2030.

- If voltage is not acceptable, unsolder pin 9 (wire) on A3A 1T 1030. then go to step 6.
- If voltage is acceptable, go to step 14.

Step 6. Check again for +15.9 to +16.5 VDC at A3A1TP2030.

- If voltage is not acceptable, go to step 7.
- If voltage is acceptable, go to step 11.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
Step 7. Check the junction of A3A1L2020 and A3A1C2021 for -12 to +13 VDC if testing on battery power, or + 15.8 VDC if testing on AC power. • If voltage is not acceptable, check A3A1Q2011, A3A1Q2012, and associated circuitry. Replace any defective components. • If voltage is acceptable, go to step 8.
Step 8. Check A3A1U1022, pin 2, for +2.3 to +2.7 VDC. • If voltage is not acceptable, replace A3A1U1022. • If voltage is acceptable, go to step 9.
Step 9. Check the gate of A3A1Q2022 for waveform 3 (fig. FO-5, Sheets 1, 2 and 3). • If waveform is not acceptable, go to step 10. • If waveform is acceptable, go to step 11.
Step 10. Check A3A1U1023, pin 3, for waveform 4. • If waveform is not acceptable, replace A3A1U1023. • If waveform is acceptable, replace A3A1Q2021, then go to step 11.
Step 11. Check the gates of A3A1Q2030 and A3A1Q2031 for waveform 5. • If waveform is acceptable, replace A3A1Q2030, A3A1Q2031, and A3A1T1030. • If waveform is not acceptable, go to step 12.
Step 12. Check A3A1U2030. • If waveform 6 is not acceptable, replace A3A1Q2021. • If waveform 7 is acceptable, but 8 is not, replace A3A1U1024. • If waveforms 6 and 8 are acceptable, replace A3A1U2030, go to step 13.
Step 13. Resolder pin 9 (wire) of A3A1T1030.
Step 14. Check the anode ends of A3A1CR1030 and A3A1CR1031 for waveform 9. • If the waveform is not acceptable, replace A3A1T1030. • If waveform is acceptable, go to step 15.
Step 15. Check A3A1CR1030, A3A1CR1031, A3A1CR1032, A3A1CR1033, and associated capacitors. • Replace any defective components.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

2. WILL NOT OPERATE ON AC ONLY

Step 1. Check for +30 VDC (+28 to +36 VDC) at A3A1TP2010 (fig. FO-5, Sheets 1 and 2).

- If voltage is not acceptable, disconnect A3A1J1010 and measure AC output from A3L201 (+25 to +30 VAC). Check A3S201, A3FL1, A3F101, A3T201, and all associated components. Replace if defective (para 5-25).
- If voltage is acceptable, go to step 2.

Step 2. Check for +16.6 VDC at A3A1TP1020.

- If voltage is acceptable, troubleshooting complete.
- If voltage is not acceptable, go to step 3.

Step 3. Check for A3A1U1011, pin 2, for +2.5 VDC.

- If voltage is not acceptable, replace A3A1U1011.
- If voltage is acceptable, go to step 4.

Step 4. Check cathode end of A3A1CR1011 for waveform 1 (fig. FO-5, Sheets 1, 2 and 3).

- If waveform is not acceptable, replace A3A1U1010.
- If waveform is acceptable, go to step 5.

Step 5. Check the drains of A3A1Q1010 and A3A1Q1011 for waveform 2.

- If the waveform is not acceptable, replace both A3A1Q1010 and A3A1Q1011.
- If waveform is acceptable, go to Malfunction 1, starting at step 5.

3. DISPLAYS ERROR MESSAGE OR NO WAVEFORM

NOTE

Use built-in diagnostics to troubleshoot the error message displayed.

Error Displayed: OPTION PORT DEVICE NOT RESPONDING.

- Go to Malfunction 4.

Error Displayed: THERE IS NO WAVEFORM CURRENTLY STORED IN MEMORY.

- Go to Malfunction 4, starting at step 13.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
Error Displayed: ACQUISITION INITIALIZATION, PULSE GAP 3.75dB • Replace A4 Driver/Sampler CCA (para 5-32).
Error Displayed: ACQUISITION INITIALIZATION, INITIAL PULSE HEIGHT 2 DIVS AT 0dB. • Check cable from Driver/Sampler to front panel input connector and perform offset adjustments (para 5-41). If error remains, go to Malfunction 7.
Error Displayed: ACQUISITION INITIALIZATION, VERTICAL SCALE FAILURE • Go to Malfunction 7.
Error Displayed: ACQUISITION INITIALIZATION, VERTICAL POSITION FAILURE • Go to Malfunction 7.
Error Displayed: ACQUISITION INITIALIZATION, LEADING EDGE OF PULSE NOT FOUND. • Go to Malfunction 6. • If error remains, replace A4 Driver/Sampler CCA (para 5-32).
Error Displayed: ACQUISITION INITIALIZATION, TOP OF 50 ns RAMP NOT FOUND • Go to Malfunction 6.
Error Displayed: DISPLAY TEMPERATURE SENSOR. • Go to Mal function 5, starting at "LCD is Unreadable or Splotchy at Low Temperature s."
Error Displayed: OPTION PORT, UNKNOWN OPTION PORT ID. • Go to Malfunction 4, starting at step 7.
No wa veform: • Go to Malfunction 6, starting at step 13.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

4. OPTION PORT DEVICE (CHART RECORDER) DOES NOT OPERATE PROPERLY

NOTE

Use built-in Option Port diagnostics to troubleshoot the chart recorder.

Step 1. Check the drain of A1Q1010 (fig. FO-2 and FO-3, Sheet II) and verify that voltage switches from 0 to +5 VDC when PRINT button is pushed.

- If voltage switches, go to step 5.
- If voltage does not switch, go to step 2.

Step 2. Check A 1U1012B, pin 7, to verify that voltage switches from +5 VDC to -11.8 VDC when PRINT button is pushed.

- If voltage switches, check A1Q1010 and associated components. Replace any defective components.
- If voltage does not switch, go to step 3.

Step 3. Check A 1U1011B, pin 8, to verify that signal switches from low (L) to high (H) when PRINT button is pushed.

- If signal switches, replace A 1U 1012.
- If signal does not switch, go to step 4.

Step 4. Check A1 U1011B, pin 13, for waveform 1.

- If signals are not acceptable, go to step 13.
- If signals are present, replace A1 U 1011.

Step 5. Check drain of A 1Q2012 to verify that voltage switches from 0 to +16 VDC when PRINT button is pushed.

- If voltage switches, go to step 23.
- If voltage does not switch, go to step 6.

Step 6. Check A 1 U 1012A, pin 1, to verify that voltage switches from +5 VDC to -11.8 VDC when PRINT button is pushed.

- If voltage does not switch, perform steps 3 and 4 again.
- If voltage switches, check A 1Q2011, A 1Q2012, and associated circuitry. Replace any defective components.
- If the options port power circuits are functional, but the options port device is still not operating, go to step 7.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

Step 7. Perform LCD Alignment Diagnostic (para 2-10)

- Go to Step 8.

Step 8. Check A1U2011 (fig. FO-2 and FO-3, Sheets 5 and 6)

- If waveforms 3, 4, or 5 are not acceptable on inputs, go to step 13.
- If waveforms 3, 4, and 5 are acceptable, but output waveform 1 is not, replace A1U2011.
- If waveform 1 is acceptable, go to step 9

Step 9. Check A1U2012

- If waveforms 2, 5, or 7 are not acceptable on inputs, go to step 12.
- If input waveforms 2, 5, and 7 are acceptable, but output waveform 2, 5, 6 or 9 are not, replace A1U2012.
- If waveform 6 is acceptable, go to step 10.

Step 10. Check A1U1011A

- If either waveform 7 or 10 is not acceptable, go to step 11.
- If waveforms 7 and 10 are acceptable but waveform 11 is not acceptable, replace A1U1011.
- If waveform 11 is acceptable, go to step 22.

Step 11. Check A1TP1041 (fig. FO-2 and FO-3, Sheets 7 and 8) to verify the 5 MHz clock signal (waveform 13) is present.

- If 5 MHz is not present, check A1U2040D, A1U2042, A1U2031, A1U1034 and associated components. Replace any defective components.
- If 5 MHz is present, go to step 12.

Step 12. Verify Chip Select signals are present by checking A1U2021, A1U2022, A1U2024, and A1U2026 (Fig. FO-2 and FO-3, Sheet 3 and 4).

- If either waveform 2 or 5 is not acceptable, go to step 13.
- If waveforms 2 and 5 are acceptable, go to step 14.
- If Address signals (waveforms 3 and 4) are not acceptable, go to step 18.
- Replace defective components

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

Step 13. Verify $\overline{\text{CSEN}}$ signals by checking A1U1043B (fig. FO-2 and FO-3, Sheet 3) and A1U1022 (fig. FO-2 and FO-3, Sheet 1).

- If ICs are functional, but waveforms 1 or 5 are not acceptable, check A1U2040C, A1U2033A, A1U1031C, and A1U1042B. Replace defective components.
- If waveforms 1 and 5 are acceptable, go to step 14.

Step 14. Check A1U1031B, pin 4, (fig. FO-2 and FO-3, Sheets 1 and 2) for +4.8 to +5.4 VDC.

- If voltage is not acceptable, replace A1U1031.
- If voltage is acceptable, go to step 15.

Step 15. Check Microprocessor A1U1023.

- If outputs are not acceptable, replace A1U1023.
- If outputs are acceptable, go to step 16.

Step 16. Check A1U1041 (fig. FO-2 and FO-3, Sheets 3 and 4) and associated components.

- If output is not acceptable, check A1U1042 and A1U1040. Replace defective components.
- If waveform is acceptable, go to step 17.

Step 17. Check the emitters of A1Q1030 and A1Q1031 (fig. FO-2 and FO-3, Sheets 1 and 2) for waveform 9.

- If waveform is not acceptable, check A1Q1030, A1Q1031, A1CR1022, and A1CR1023. Replace any defective components.
- If waveform is acceptable, go to step 18.

Step 18. Check the emitters of A1Q1020 and A1Q1021 for waveform 10.

- If waveform is not acceptable, check A1Q1020, A1Q1021, A1CR1020, and A1CR1021. Replace any defective components.
- If waveform is acceptable, go to step 19.

Step 19. Check A1U1043A, pin 3, for waveform 11.

- If waveform is acceptable, replace A1U2020.
- If waveform is not acceptable, replace A1U1043, then go to step 20.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

Step 20. Check A1U1010, pin 6, for waveform 12.

- If waveform is not acceptable, replace A1U1010.
- If waveform is acceptable, go to step 21.

Step 21. Check A1U1031A.

- If input is not acceptable, replace A1U1023.
- If input is acceptable and output is not, replace A1U1031.
- If output waveform is acceptable, troubleshooting complete

Step 22. Check cable W2010 from A1 Main CCA (fig. FO-1) to A10 Chart Recorder Assembly.

- If cable is faulty, replace cable.
- If cable is acceptable, go to step 23.

NOTE

Use AC power for Steps 23-28 unless it is known that battery pack is at full charge.

Step 23. Remove A10 Chart Recorder Assembly from test set and disassemble (para 5-23), leaving all electrical connections intact. Plug Chart Recorder CCA into test set using an extender cable. Push PRINT button.

- If test set shuts down, go to step 24.
- If test set functions, but chart recorder motor does not, go to step 25.
- If test set functions and chart recorder motor functions, go to step 28.

Step 24. Unplug the print head connector (fig. FO-7) from the Chart Recorder CCA, then push PRINT button.

- If test set functions, replace print head assembly (para 5-23).
- If test set shuts down, plug print head connector back in and go to step 25.

Step 25. Unplug motor connector from Chart Recorder CCA, then push PRINT button.

- If test set shuts down, replace Chart Recorder CCA (para 5-23)
- If test set functions, go to step 26.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

Step 26. Measure the resistance between the first and second pins and between the third and fourth pins of the motor connector. This resistance should be approximately 10 Ohms.

- If resistance is not acceptable, replace motor assembly (para 5-23).
- If resistance is acceptable, plug motor connector back in and go to step 27.

Step 27. Measuring across the PRINT switch, verify that voltage goes from approximately 5 VDC to 0 VDC momentarily when PRINT button is pushed.

- If voltage stays high, replace PRINT switch (para 5-23).
- If voltage switches acceptably, or no voltage is found across the switch, replace Chart Recorder CCA (para 5-23).

Step 28. Perform LCD Alignment Diagnostic (para 2-10), then check print head connector for the following voltages while the chart recorder is running (negative probe on pin 5 or 6):

Pins 1, 4, 13, 14	+5 VDC ±0.5 VDC
Pins 2, 3	+16 VDC ±1.5 VDC
Pins 5, 6	0 VDC (ground)
Pins 7, 8	5 V 500 Hz square wave
Pins 8, 9, 10	5 V data stream
Pin 12	no connection

- If voltages are acceptable, replace print head assembly (para 5-23).
- If voltages are not acceptable, replace Chart Recorder CCA (para 5-23).

5. FAILS DISPLAY OR FRONT PANEL TESTS

NOTE

Use built-in diagnostics to troubleshoot the display or front panel.

EL Backlight Does Not Turn On

Step 1. Disassemble Optoelectric Display A2 Front Panel CCA (para 5-34) and leave all electrical connections intact.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

Step 2. Check A2PS2030 output at A2J 1020, pin 1, for 90 to 100 VAC (fig. FO-4, Sheets 1, 2 and 3).

- If voltage is acceptable, replace Optoelectric Display (para 5-34).
- If voltage is not acceptable, go to step 3.

Step 3. Check drain of A2Q1030 for +15 VDC.

- If voltage is acceptable, replace A2PS2030.
- If voltage is not acceptable, go to step 4.

Step 4. Check gate of A2Q 1030 to see if it switches from 0 to +16 VDC when the EL backlight is turned off and on.

- If voltage switches, replace A2Q 1030.
- If voltage does not switch, go to step 5.

Step 5. Check A2U3020A, pin 1, for high (H) or low (L) when the EL backlight is turned off and on.

- If logic switches, replace A2U2020.
- If logic does not switch, go to step 6.

Step 6. Check A2U3020D inputs for waveforms 1, 2, and 3.

- If waveforms are not acceptable, go to Malfunction 4, step 11.
- If waveforms are acceptable, replace A2U 3020.

LCD is Unreadable or Splotchy at Low Temperatures

NOTE

Heater circuits will not operate simultaneously with a chart recorder. If a chart is being printed, heater circuits are disabled.

Step 1. Verify that the temperature displayed during the Display and Front Panel Tests is within 15°F of ambient free air temperature.

- If not acceptable, replace Optoelectric Display (para 5-34).
- If acceptable, go to step 2.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

Step 2. Apply Circuit Cooler Freezing Compound (Appendix E, item 7) to thermistor on Optoelectric Display CCA to activate heater. Check the drain of A2Q1020 for +16VDC (fig. FO-4, Sheets 1, 2 and 3).

- If voltage is acceptable, replace Optoelectric Display (para 5-34)
- If voltage is not acceptable, go to step 3.

Step 3. Check the gate of A2Q1020 for +2 VDC.

- If voltage is acceptable, replace A2Q1020.
- If voltage is not acceptable, go to step 4.

Step 4. Check A21J2020A, pin 2, for +5 VDC.

- If voltage is acceptable, go to step 5.
- If voltage is not acceptable, go to step 6.

Step 5. Check A2U2020A, pin 3, for +5 VDC.

- If voltage is acceptable, replace A2Q2020.
- If voltage is not acceptable, replace A21J2020.

Step 6. Check A2U2023.

- If A21J2023 is acceptable, replace the Optoelectric Display (para 5-34).
- If not acceptable, replace A2U2023.

LCD Contrast Does Not Adjust

Check A2U2010, pin I, for -3 to -8 VDC, while varying A2R1018.

- If voltage is acceptable, replace the Optoelectric Display (para 5 - 3 4).
- If voltage is not acceptable, replace A21J2010.

Front Panel Switches Do Not Operate

Step I. Check that +5 VDC is on the A2 Front Panel CCA (fig. FO-4, Sheets 1, 2 and 3),

- If not present, go to Malfunctions 1 and 2.
- If present, go to step 2.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

Step 2. MENU switch fails Display and Front Panel Test (para 3-9): check for +5 VDC across A2S 1010 when MENU switch is pushed in.

- If +5 VDC is not present, replace A2S10 10.
- If voltage is present, replace A2U3021.

Step 3. VIEW INPUT switch fails Display and Front Panel Test (para 3-9): check for +5 VDC across A2S 101 1 when VIEW INPUT switch is pushed in.

- If +5 VDC is not present, replace A2S 101 1.
- If voltage is present, replace A2U3022.

Step 4. VIEW STORE switch fails Display and Front Panel Test (para 3-9): check for +5 VDC across A2S2010 when VIEW STORE switch is pushed in.

- If +5 VDC is not present, replace A2S2010.
- If voltage is present, replace A2U3022.

Step 5. VIEW DIFF switch fails Display and Front Panel Test (para 3-9): check for +5 VDC across A2S201 1 when VIEW DIFF switch is pushed in.

- If +5 VDC is not present, replace A2S201 1.
- If voltage is present, replace A2U3023.

Step 6. STORE switch fails Display and Front Panel Test (para 3-9): check for +5 VDC across A2S3010 when STORE switch is pushed in.

- If +5 VDC is not present, replace A2S301 0.
- If voltage is present, replace A2U3023.

Step 7. NOISE FILTER switch fails Display and Front Panel Test (para 3-9): check A2S3012, for H (5 V) and L (0 V) signals when switch is rotated.

- If no H and L signals, replace A2S3012.
- If H and L are found, check A2U2024 and A2U3025. Replace defective components.

Step 8. DIST/DIV switch fails Display and Front Panel Test (para 3-9): check A2S3020 for high (H) and low (L) when it is rotated (fig. FO-4. Sheets 1 and 3).

- If no H and L signals, replace A2S3020.
- If H and L are found, check A2U2025 and A2U3031. Replace defective components

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

Step 9. Vp COARSE and Vp FINE switches fails Display and Front Panel Test (para 3-9): check A2S302 1 and A2S3022 for high (H) and low (L) when they are rotated.

- If no H and L signals, replace A2S302 1 and/or A2S3022.
- If H and L are found, check A2U2025 and A2U3031. Replace defective components.

Step 10. VERTICAL POSITION (A2R 1022), HORIZONTAL POSITION (A2R2024), or VERTICAL SCALE (A2R3020) controls fail Display and Front Panel Test (para 3-9):

- If only one fails, replace that potentiometer.
- If all three fail, replace A2U2023.

6. FAILS HORIZONTAL SCALE TEST

Step 1. Check A1 U9030, pin 7, for -15 VDC and pin 14, for +15 VDC (fig. FO-2 and FO-3, Sheet 11).

- If voltages are not acceptable, go to Malfunction 1 .
- If voltages are acceptable, go to step 2.

Step 2. Check A1 U9030, pin 1, for +12 VDC (±0.2 VDC) and pin 8 for -12 VDC (±0.2 VDC).

- If voltages are acceptable, go to step 4.
- If voltages are not acceptable, go to step 3.

Step 3. Adjust A1R9032 (para 5-39) and recheck +12 VDC and -12 VDC output.

- If voltages are not acceptable, replace A 1 U9030.
- If voltages are acceptable, go to step 4.

Step 4. Check A1TP7010 (fig. FO-2 and FO-3, Sheets 12 and 14) for waveform 1.

- If waveform is acceptable, replace A4 Driver/Sampler CCA (para 5-32).
- If waveform is not acceptable, go to step 5.

Step 5. Check the base of A 1 Q7020 for waveform 2.

- If waveform is acceptable, check A 1 Q7020 and associated components. Replace defective components.
- If waveform is not acceptable, go to step 6.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

Step 6. Check the base of A 1Q702 1A for waveform 3

- If waveform is acceptable, check A1O7021, A 1Q6020, A 1Q5020, and associated components. Repl ace defective components
- If waveform is not acceptable, go to step 7.

Step 7. Check the base of A 1Q5030 for waveform 4.

- If waveform is acceptable, check A1Q5030, A1 Q7030, A 1Q5020, and associated components. Replace defective components.
- If waveform is not acceptable, go to step 8.

Step 8. Check the collector of A 1 Q4040 for waveform 5.

- If waveform is not acceptable, go to step 20.
- If waveform is acceptable, check A1Q5031, A1 Q5032, A1Q4031, A 1CR4032, A 1CR5040 and associated components. Replace defective components. Go to step 9.

Step 9. Check A 1 TP90 I I for waveform 6.

- If waveform is acceptable, replace A4 Driver/Sampler CCA (para 5-32).
- If waveform is not acceptable, go to step 10.

Step 10. Check the collector of A 1 Q9010 for waveform 7.

- If waveform is acceptable, check A 1 U7010A and A1 U8010B. Replace defective components.
- If waveform is not acceptable, go to step 1 1.

Step 11. Check the base of A 1Q8020A for waveform 8.

- If waveform is acceptable, check A 1 Q8020, A 1Q9020, A 1Q901 0, and associated components. Replace defective components.
- If waveform is not acceptable, go to step 12.

Step 12. Check the base of A 1Q902 1 for waveform 9.

- If waveform is not acceptable, go to step 13.
- If waveform is acceptable, check A 1O9021 and associated components. Replace de fective components.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

Step 13. Check A1TP3041 (fig. FO-2 and FO-3, Sheets 7 and 8) for waveform 1.

- If waveform is acceptable, check A 1 Q4040. Replace if defective.
- If waveform is not acceptable, go to step 14.

Step 14. Check A 1U2045C, pin 9, for waveform 2, and pin 1 1 for waveform 17

- If both waveforms are acceptable, replace A 1 U2045.
- If waveform 2 is not acceptable, go to step 15.
- If waveform 17 is not acceptable, go to step 21.

Step 15. Check A1 U2037.

- If waveform 3 is not acceptable, check A1 U2034A and A1U2031. Replace any defective components.
- If waveform 3, and either 4 or 5 are acceptable, replace A1U2037.
- If waveform 4 or 5 is not acceptable, go to step 16.
- If waveform 8 is not acceptable, go to step 16.

Step 16. Check A 1U2043.

- If A1 U2043 is not acceptable, replace A 1 U2043 Go to step 17.
- If A1 U2043 is acceptable, go to Malfunction 4, step 1.

Step 17. Check A1U2036C, pin 12, for waveforms 4 or 5.

- If waveform is acceptable, replace A1U2036.
- If waveform is not acceptable, go to step 18.

Step 18. Check A 1 U2034C.

- If input waveforms are acceptable, replace A 1 U2034.
- If waveforms are not acceptable, go to step 19.

Step 19. Check A 1U2032D, pin 12, for waveform 5.

- If waveform is acceptable, replace A1U2032.
- If waveform is not acceptable, go to step 20.

Step 20. Check A 1 U2030.

- If input signals are acceptable, replace A 1 U2030. Go to step 21.
- If input signals are not acceptable, go to Malfunction 4, step 1.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

Step 21. Check A 1TP3040 for waveform 14.

- If waveform is not acceptable, check A 1U2045 and A1U2036. Replace any defective components.
- If waveform is acceptable, troubleshooting complete.

7. FAILS VERTICAL POSITION TESTS

Step 1. Check at A 1TP9041 for waveform 1 (fig. FO-2 and FO-3, Sheets 9 and 10).

- If waveform is not acceptable, replace A4 Driver/Sampler CCA (para 5-32),
- If waveform is acceptable, go to step 2

Step 2. Check A 1U8041, pin 6, for waveform 2.

- If no waveform is present, or is present but vertically displaced, go to step 3.
- If waveform is acceptable, go to step 5.

Step 3. Check A 1 U3041, pin 6, for waveform 3.

- If waveform is acceptable, check A1 U8041 and associated components. Replace any defective components.
- If waveform is not acceptable, replace A1 U3041, then go to step 4.

Step 4. After replacing A 1U3041, check pin 6 again for waveform 2.

- If waveform is still not acceptable, replace A 1U2046.
- If waveform is acceptable, go to step 5.

Step 5. Check A 1 U7040, pin 6, for waveform 4.

- If waveform is not acceptable, and OFFSET/GAIN Test (para 3-13) shows no errors, replace A 1 U7040.
- If waveform is not acceptable, and OFFSET/GAIN Test (para 3-13) shows errors, go to Malfunction 9.
- If waveform is acceptable, go to step 6.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

Step 6. Check A 1 U5040, pin 6, for waveform 5.

- If waveform is not acceptable, and OFFSET/GAIN Test (para 3-13) shows no errors, replace A1 U5040.
- If waveform is not acceptable, and OFFSET/GAIN Test (para 3-13) shows errors, go to Malfunction 9.
- If waveform is acceptable, go to step 7.

Step 7. Check A1U3042, pin 6, (A1TP4040) for waveform 6.

- If waveform is not acceptable, and OFFSET/GAIN Test (para 3-13) shows no errors, replace A 1 U3042.
- If waveform is not acceptable, and OFFSET/GAIN Test (para 3-13) shows errors, go to Malfunction 9.
- If waveform is acceptable, troubleshooting complete.

8. FAILS NOISE TEST

Perform Noise Test (para 3-12).

- If test fails again, replace A4 Driver/Sampler CCA (para 5-32).

9. FAILS OFFSET/GAIN TEST

Summing Stage or Low Gain Stage Diagnostic:

Step 1. Check A1U4040 for high (H) signals on pins 9,10, and 11 (fig. FO-2 and FO-3, Sheet 9).

- If no H signals are present, replace A 1 U2044.
- If H signals are present, go to step 2.

Step 2. Check A 1U4040, pins 1, 2, 4, 5, and 12 through 15 for H signals.

- If H signals are not present, replace A 1 U4040.
- If H signals are present, check A 1 R4040 through A 1 R4047. Replace any defective components.

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

Middle Gain Stage Diagnostic:

Step 1. Check A 1 U6040 for high (H) signals on pins 9, 10, and 1 1

- If no H signals are present, replace A 1 U2044
- If H signals are present, go to step 2.

Step 2. Check A 1 U6040, pins 1, 2, 4, 5, and 12 through 15 for H signals.

- If H signals are not present, replace A1 U6040.
- If H signals are present, check A 1R6040 through A1R6047. Replace any defective components.

High Gain Stage Diagnostic:

Step 1. Check A1U8040 for high (H) signals on pins 10 and 11.

- If no H signals are present, replace A1 U2044.
- If H signals are present, go to step 2.

Step 2. Check A 1 U8040, pins 12 through 15 for H signals.

- If H signals are not present, replace A 1 U8040.
- If H signals are present, check A 1R8040 through A 1 R8043. Replace any defective components.

1 0. FAILS RAM/ROM TEST

Step 1. ROM shows FAIL:

- Replace A1U2020 EPROM (para 5-30).

Step 2. RAM shows FAIL:

- Replace A1U1021.

Step 3. RAM Non -Volatile shows FA IL:

- If A1BT1010 does not measure +3.5 VDC, replace it (para 5-31).
- If A1 BT1010 does measure +3.5 VDC, replace A1U 1020

Table 5-1. Troubleshooting - continued

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
11. FAILS JITTER TEST
Perform tests in Malfunction 6. • Replace any defective components.
12. FAILS SAMPLING EFFICIENCY TEST
Perform tests in Malfunction 7. • Replace any defective components.
13. FAILS ZERO OFFSET TEST
Perform Zero Offset Adjustment (para 5-41). • If adjustment does not correct the failure, go to Malfunction 6.
14. FAILS RISETIME TEST
Perform Risetime Test (para 3-18). • If test fails again, replace A4 Driver/Sampler CCA (para 5-32).
15. FAILS OPTION PORT DEVICE TEST
Perform tests in Malfunction 4, starting at step 7. • Replace any defective components.
16. FAILS ABERRATIONS TEST
Perform Aberrations Test (para 3-20). • If test fails again, replace A4 Driver/Sampler CCA (para 5-32).

Section V. GENERAL SUPPORT MAINTENANCE PROCEDURES

5-20. CASE AND EMI SHIELDS REPLACEMENT

DESCRIPTION

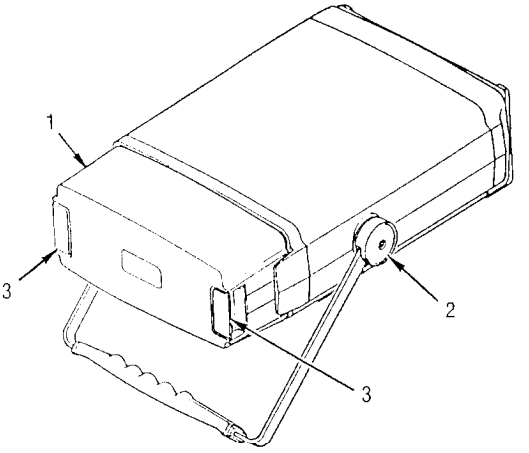
This procedure covers: Remove and Install

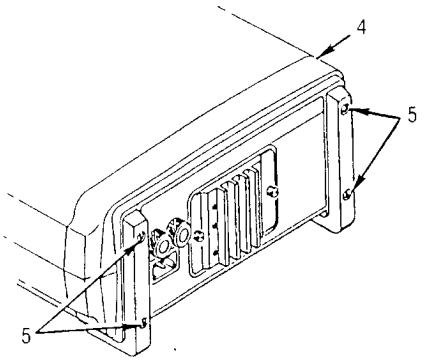
WARNING

With case and EMI shields removed, dangerous voltage points may be exposed. Contact with these points could cause serious injury or death to personnel.

REMOVE

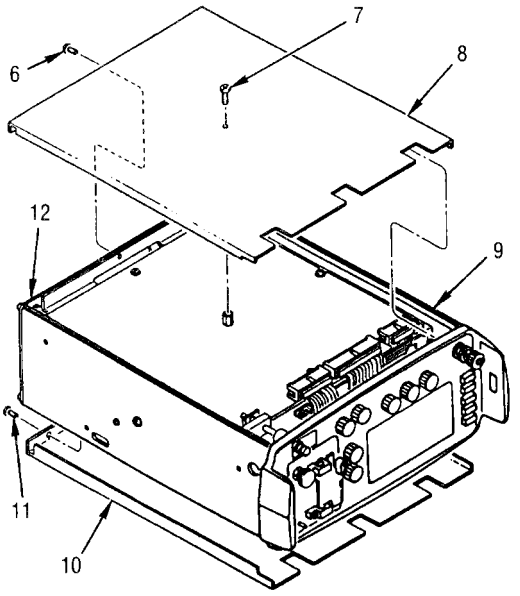
1. Disconnect power cord and remove battery pack (para 3-22).
2. Remove front cover (1) by pulling locking levers (3) away from Test Set and withdrawing cover.
3. Loosen four screws (5) on back of case (4).
4. Position Test Set face up on flat surface. Break chassis seal by pushing downward on handle swivels (2) on each side of case (4).
5. Grasp outside perimeter of front panel and lift chassis (12) from case (4).
6. Remove one screw (7) and three screws (6) from bottom EM I shield (8).
7. Remove three screws (11) from top EM I shield (10).
8. Remove EMI shields from top and bottom of chassis by carefully running a screwdriver between EMI shield and groove (9) in chassis rail





INSTALL

1. Install top and bottom EMI shields by pressing EMI shields into grooves (9) of chassis rail.
2. Install three screws (11) in top EMI shield (10) and three screws (6) in bottom EMI shield (8).
3. Install one screw (7) in bottom EMI shield (8).
4. Place Test Set face down on cushioned surface. Lower case (4) over guide tabs on chassis (12). Ensure case is over guide tabs and mating against gasket.
5. Tighten four screws (5) on back of case (4) in a cross rotation to approximately 4 in./lb to ensure case seats evenly over chassis (12), and then tighten screws (5) to 7 in./lb in same cross rotation.
6. Install front cover (1).
7. Install battery pack (para 3-22) and connect power cord.



END OF TASK

5-21. WATERTIGHT SEAL REPLACEMENT

DESCRIPTION

This procedure covers: Remove and Install

NOTE

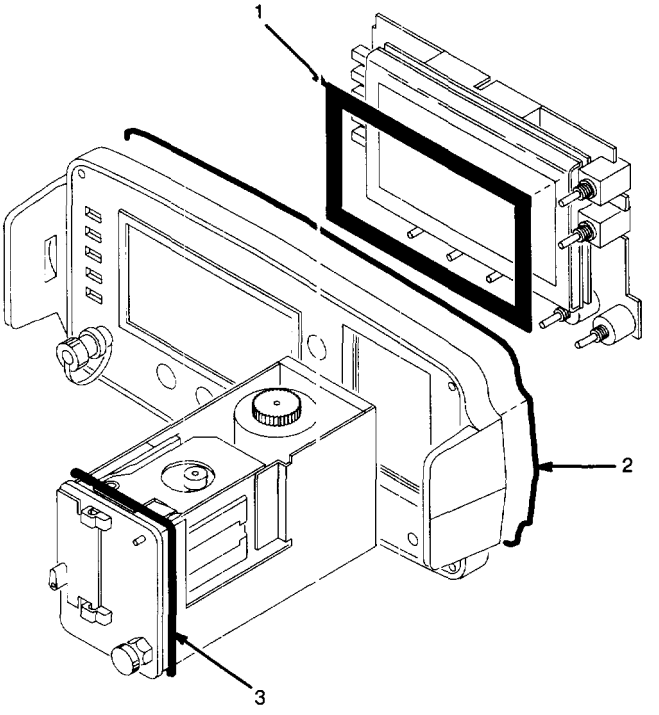
- *Te st Set rotary controls and fuse and Voltage Selector switch access covers are sealed with rubber O-rings. These should be inspected and replaced as necessary* (para 5-34).
- *To prevent moisture and dirt from getting into the Test Set, watertight seals are used around the LCD screen, option port, battery pack port, front panel, front panel controls, and the rubber boot on front panel pushbuttons. Disturbing any of these components may require performing resealing procedures to retain Test Set watertightness.*

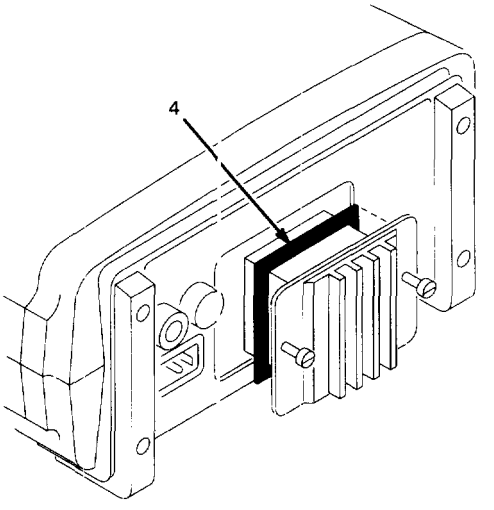
REMOVE

1. Remove old gasket and all dried adhesive from LCD (1), front panel (2), chart recorder (3), and battery pack (4).
2. Clean area with alcohol (Appendix E, item 1) and allow to air dry.

INSTALL

1. Clean new gasket with alcohol (Appendix E, item 1), and dry.
2. Run a small bead of Dow Corning 3140 coating (Appendix E, item 5) in cutout where new gasket will go.
3. Smooth coating into an even, thin layer.
4. Place gasket on coating and smooth into place. Make sure edges are secure and there are no air bubbles under gasket.
5. Allow to dry 24 hours before using or reassembling front panel.
6. Use silicone grease (Appendix E, item 6) on outer side of front panel gasket (2), and battery port gasket (4).





END OF TASK

5-22. DESICCANT CARTRIDGE REPLACEMENT

DESCRIPTION

This procedure covers: Remove and Install

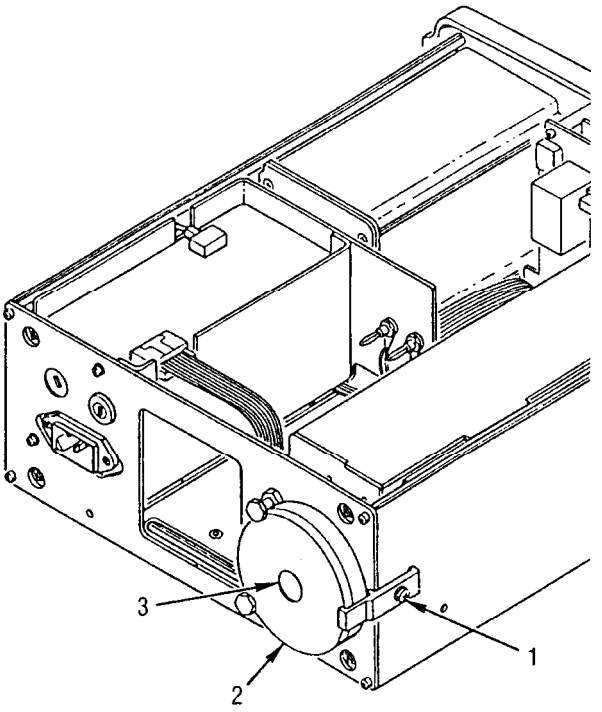
REMOVE

1. Remove case (para 5-20).
2. Check desiccant cartridge window (3). If crystals are blue, no further maintenance is needed. If crystals are pink, go to step 3.

WARNING

- *Do not disassemble desiccant cartridge. Drying action of this material causes irritation to skin and mucous membranes of nose and throat. Do not eat.*
- *If material comes in contact with eyes, wash with large amounts of water and seek medical attention immediately.*
- *If material comes in contact with skin, wash with soap and water immediately.*

3. Loosen hold-down bracket (1) at rear of Test Set and remove desiccant cartridge (2).



INSTALL

1. Install new desiccant cartridge (2) in Test Set and tighten hold-down bracket (1).
2. Install case (para 5-20).

END OF TASK

5-23. A10 CHART RECORDER ASSEMBLY PARTS REPLACEMENT

DESCRIPTION

This procedure covers: Remove and Install

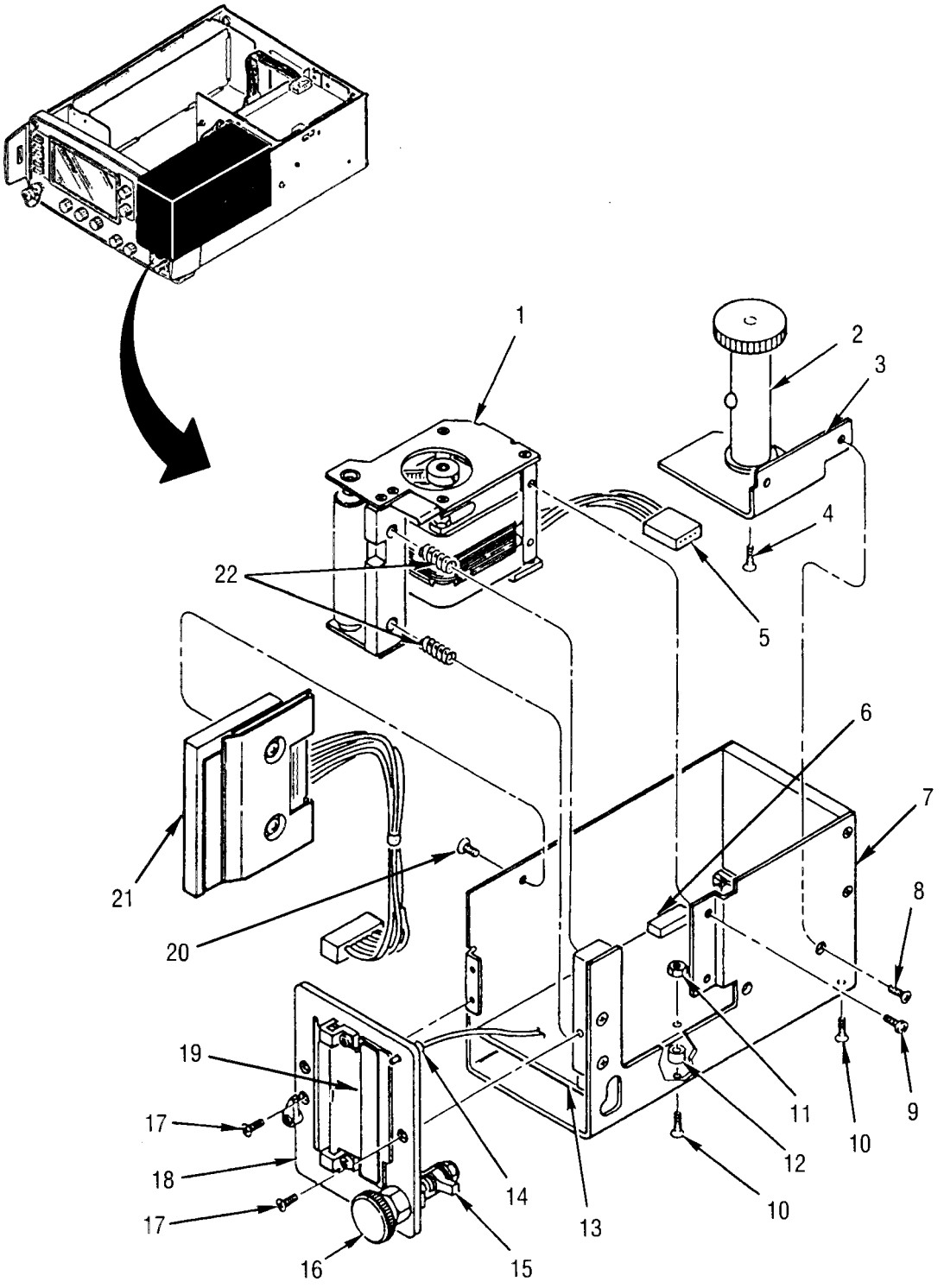
REMOVE

1. Remove A 10 Chart Recorder Assembly (para 3-23).
2. Remove chart recorder paper roll (para 3-23).
3. Remove two screws (8) on right side panel (7) attaching paper retaining mandrel assembly, and remove assembly from chart recorder.
4. Remove two screws (4) attaching mandrel (2) to bracket (3).
5. Open paper slot door (19). Remove three screws (17) attaching front panel plate (18) to chart recorder.
6. Rotate front panel thumbscrew (16) to move nut latch (15) so front panel plate (18) is free of chart recorder but still attached by means of PRINT pushbutton wiring harness.

CAUTION

Be careful not to twist or otherwise damage PRINT pushbutton harnes s

7. Remove PRINT pushbutton (14) from front panel plate (18) by holding PRINT pushbutton firmly and unscrew by rotating front panel plate counterclockwise around PRINT pushbutton.
8. Remove two compression springs (22) between forward support strut of right side panel (7) and drive motor assembly (1) by carefully compressing each at one end and working spring out of seat while holding spring firmly.
9. Remove two screws (9) holding drive motor assembly (1) to right side panel (7).
10. Pull drive motor assembly wiring connector (5) straight up to remove it from Chart Recorder CCA (13).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CAUTION

Use extreme care to avoid scratching face of thermal printhead while removing drive motor assembly. Slip sheet of stiff paper between printhead surface and drive motor assembly to help prevent damage.

11. Carefully remove drive motor assembly (1) through top of case. Lay to right side
12. Remove two screws (20) attaching printhead (21) to left side panel.
13. Carefully disconnect thermal printhead connector (6) on Chart Recorder CCA (13).
14. Remove three screws (10), three nuts (11), and three standoff spacers (12) from Chart Recorder CCA (13) and remove CCA.

INSTALL

1. Position Chart Recorder CCA (13) in place in bottom of case and install three standoff spacers (12) between CCA and bottom of case, three screws (10), and three nuts (11).

CAUTION

Use extreme care to avoid scratching face of thermal printhead while installing drive motor assembly. Slip sheet of stiff paper between printhead surface and drive motor assembly to help prevent damage.

2. Carefully connect thermal printhead (21) connector (6) on Chart Recorder CCA (13)
3. Install two screws (20) and printhead (2 1) to left side panel.
4. Install drive motor assembly wiring connector (5) on Chart Recorder CCA (13).
5. Carefully install drive motor assembly (1) through top of case and position it over two screw holes in right side panel (7).
6. Install two screws (9).
7. Install two compression springs (22) between forward support strut of right side panel (7) and drive motor assembly (1) by carefully compressing each and working into seat.

CAUTION

Be careful not to twist or otherwise damage PRINT pushbutton harness.

8. Install PRINT pushbutton (14) in front panel plate (18) by holding PRINT pushbotton firmly and screw in by rotating front panel clockwise around PRINT pushbutton.

9. Position front panel plate (18) in place and install three screws (17) attraching front panel plate 18) to chart recorder.

10. Place mandrel (2) on bracket (3) and secure with two screws (4).

11. Position mandrel assembly (2, 3 and 4) down inside case and install two screws (8) on right side panel (7) attaching paper retaining mandrel assembly.

12. Install chart recorder paper roll (para 3-23).

13. Install ^10 Chart Recorder Assembly in Test Set (para 3-23). Refer to paragraph 5-21 for watertight seal replacement procedures.

14. Perform Chart Recorder Paper Skew Adjustment (para 5-42).

15. Perform Chart Recorder Test (para 3-19).

16. Install EMI shields and case (para 5-20).

END OF TASK

5-24. A3A1 POWER SUPPLY CCA/A3 POWER SUPPLY ASSEMBLY REPLACEMENT

DESCRIPTION

This procedure covers: Remove and Install

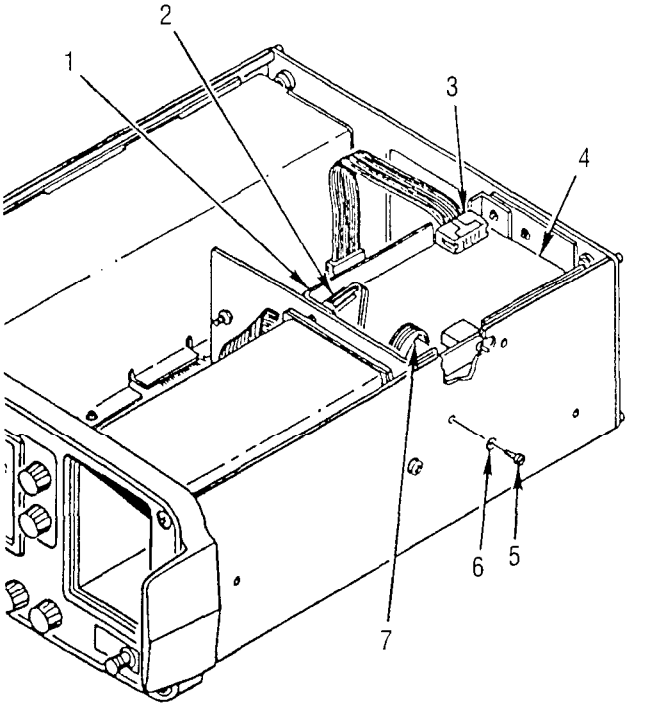
REMOVE

1. Remove case and EMI shields (para 5-20).
2. Remove ribbon cable and connector (3) from A3A1 Power Supply CCA (4).
3. Remove 1/2-in. screw (5) and washer (6) from right side panel.

NOTE

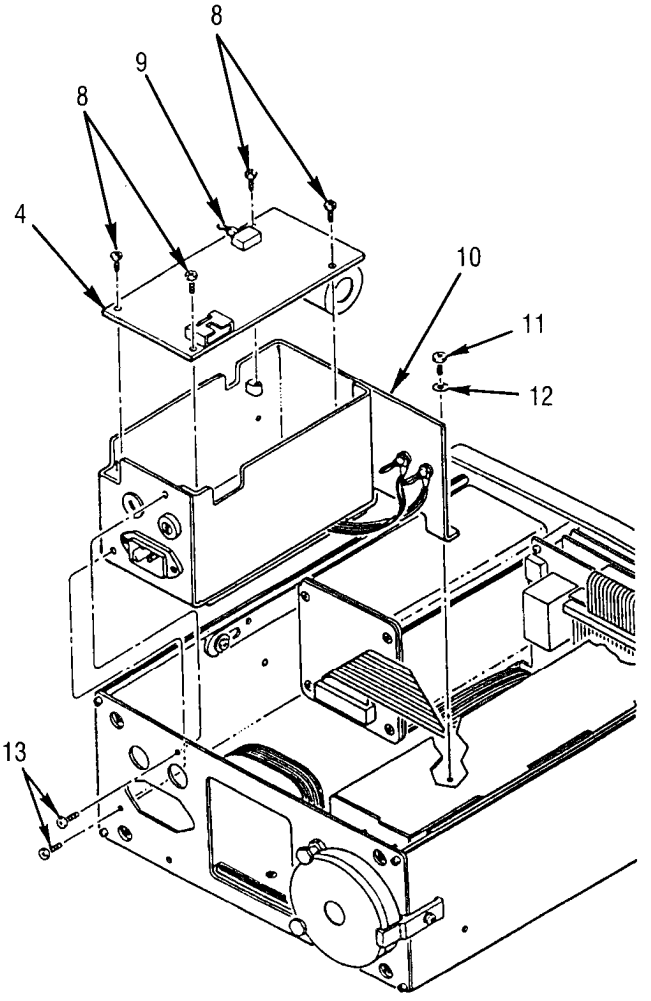
A3 Power Supply Assembly does not have to be removed to remove A3A1 Power Supply CCA.

4. To remove A3A1 Power Supply CCA (4), remove two-conductor connector (2) and four-conductor connector (7) from front end of CCA.
5. Remove four 1/4-in. screws (8) from A3A1 Power Supply CCA (4).
6. Lift out A3A1 Power Supply CCA (4) by tilting inboard side up first and carefully sliding CCA free of power switch toggle notch (9).
7. To remove A3 Power Supply Assembly (10), remove 1/4-in. screw (11) and washer (12) holding assembly to bottom of chassis.
8. Remove two 1/4-in. screws (13) securing assembly to back of chassis.
9. Slide A3 Power Supply Assembly (10) toward front of Test Set about 3/8-in. until power cord receptacle and line fuse receptacle clear their respective holes.
10. Tilt A3 Power Supply Assembly (10) up and remove toward center of Test Set.



INSTALL

1. Tilt A3 Power Supply Assembly (10) and carefully lower it into place from center of Test Set toward outer edge, ensuring all screw holes align.
2. Slide assembly toward rear of Test Set about 3/8-in. until power cord receptacle and line fuse receptacle enter their respective holes.
3. Install two 1/4-in. screws (13) securing assembly to back of chassis.
4. Install 1/4-in. screw (11) and washer (12) holding assembly to bottom of chassis.
5. Install A3A 1 Power Supply CCA (4) in chassis by tilting outboard side down and inserting power switch toggle into notch (9) and carefully working CCA into position over its screw holes.
6. Install four 1/4-in. screws (8) in A3A1 Power Supply CCA (4).
7. Install two-conductor connector (2) and four-conductor connector (7) on front end of CCA.
8. Install 1/2-in. screw (5) and washer (6) in right side panel.
9. Insert ribbon cable and connector (3) into A3A1 Power Supply CCA (4).
10. Install EMI shields and case (para 5-20).



END OF TASK

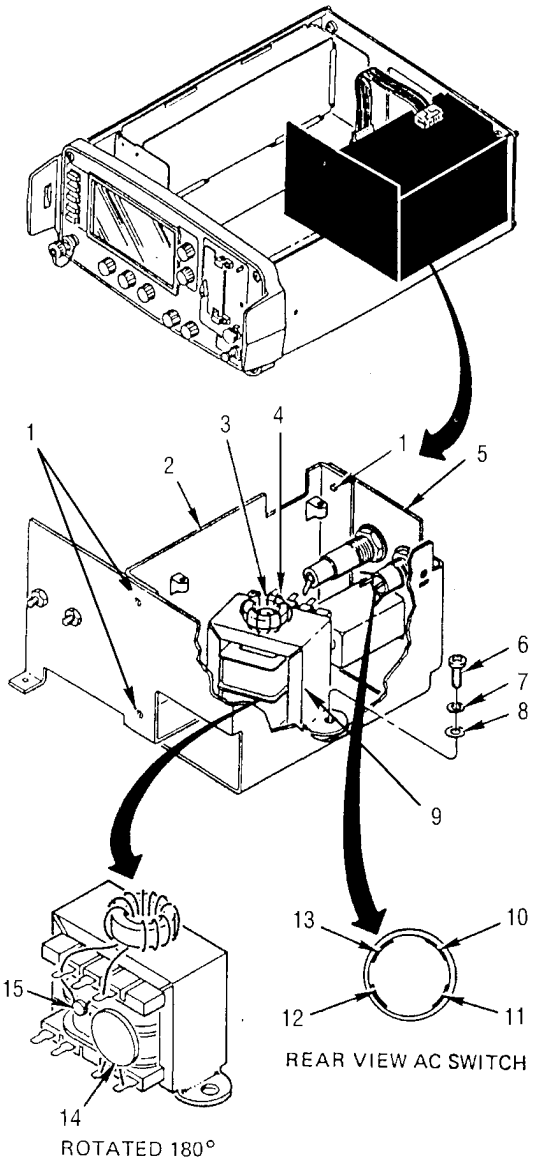
5-25. A3T201 POWER TRANSFORMER REPLACEMENT

DESCRIPTION

This procedure covers: Remove and Install

REMOVE

1. Remove case and EMI shields (para 5-20).
2. Remove A3A 1 Power Supply CCA/A3 Power Supply Assembly (5) (para 5-24).
3. Remove three 1/4-in. screws (1) holding side panel (2) to A3 Power Supply Assembly (5). Remove side panel (2).
4. Remove two screws (6), lockwashers (7), and washers (8) holding power transformer (9) to chassis.
5. Move power transformer (9) out to limit of six multi-colored attached wires and clip off six wires at transformer lugs.
6. Unsolder inductor (3) from transformer lugs 7 and 9 (4) and remove inductor, which is attached by a small amount of Dow Corning 3 145 adhesive (Appendix E, item 4). Retain inductor for reinstallation.
7. Unsolder and remove capacitor (14) from lugs 1 and 2. Retain capacitor for reinstallation.
8. Unsolder and remove varistor (15) from lugs 7 and 9. Retain varistor for reinstallation.
9. Remove and dispose of old power transformer (9).



INSTALL

1. Solder varistor (15) to lugs 7 and 9 of new power transformer.
2. Solder capacitor (14) to lugs 1 and 2 of new power transformer.
3. Solder inductor (3) to transformer lugs 7 and 9 (4) and attach to transformer with a small amount of Dow Corning 3145 adhesive (Appendix E, item 4).
4. Place new power transformer (9) in A3 Power Supply Assembly (5) close enough to six multi-colored wires to attach.
5. Strip about 3/8-in. at end of each wire and route and solder six multi-colored wires to transformer lugs as follows:
    - White with blue and yellow tracers from fuseholder to lug 5.
    - White with blue and yellow tracers from AC switch (12) to lug 5.
    - White with blue and red tracers from AC switch (13) to lug 2.
    - White with blue and red tracers from AC switch (10) to lug 4.
    - White with blue and brown tracers from AC switch (11) to lug 1.
6. Secure power transformer (9) in place with two screws (6), lockwashers (7), and washers (8).
7. Install side panel (2) and secure with three 1/4-in. screws (1).
8. Install A3A 1 Power Supply CCA/A3 Power Supply Assembly (5) (para 5-24).
9. Install EMI shields and case (para 5-20).

END OF TASK

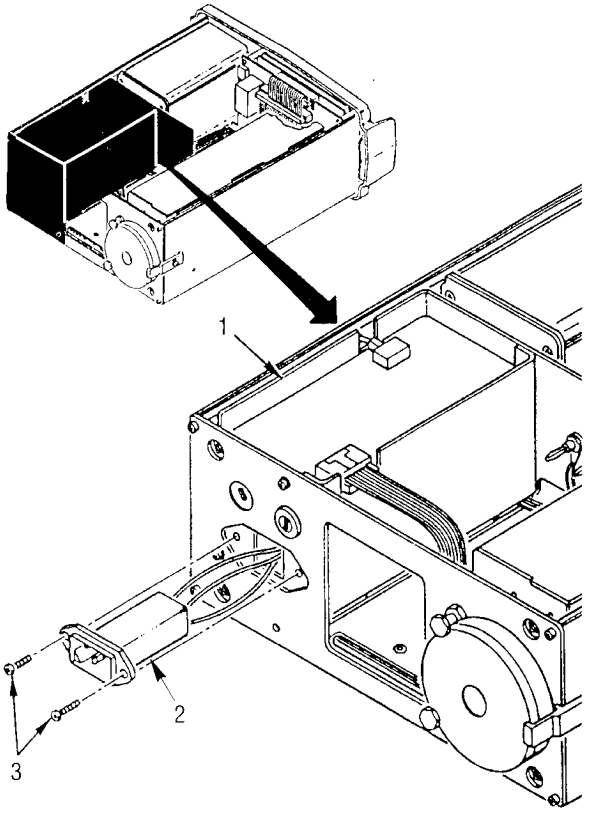
5-26. POWER CORD RECEPTACLE/FILTER REPLACEMENT

DESCRIPTION

This procedure covers: Remove and Install

REMOVE

1. Remove case and EM I shields (para 5-20)
2. Remove A3A 1 Power Supply CCA/A3 Power Supply Assembly (para 5-24).
3. Remove side panel (1) (para 5-25).
4. Remove two screws (3) and withdraw power cord receptacle/filter unit (2) enough to unsolder its terminals.
5. Unsolder three wires on receptacle/filter unit (2).
6. Remove receptacle/fi lter unit (2).



INSTALL

1. Solder three wires to terminals on rear of unit as follows:
   - Yellow-Green from chassis ground to ground lug.
   - White with red and black tracers from line fuse cartridge to P lug.
   - White with red and brown tracers from transformer lug 5 to N lug.
2. Insert receptacle/filter unit (2) fully into position and secure with two screws (3).
3. Install side panel (1) (para 5-25).
4. Install A3A 1 Power Supply CCA/A3 Power Supply Assembly (para 5-24).
5. Install EMI shields and case (para 5-20).

END OF TASK

5-27. LINE FUSE HOLDER AND VOLTAGE SELECTOR SWITCH REPLACEMENT

DESCRIPTION

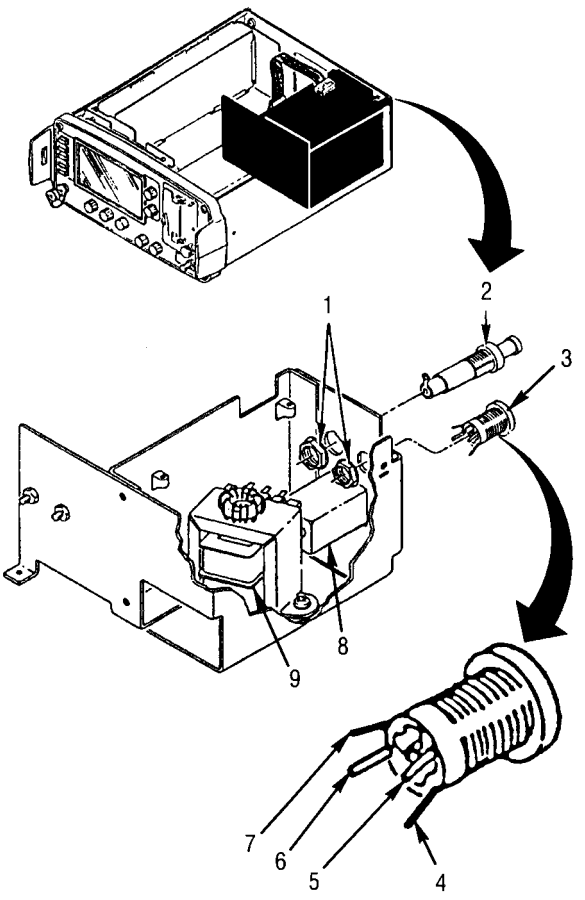
This procedure covers: Remove and Install

REMOVE

1. Remove case and EMI shields (para 5-20).
2. Remove A3A1 Power Supply CCA (para 5-24).
3. Unsolder two wires from line fuse holder (2).
4. Unsolder four wires (4-7) from Voltage Selector switch (3).
5. Remove two hold-down nuts (1) and remove line fuse holder (2) and Voltage Selector switch (3).

INSTALL

1. Install Voltage Selector switch (3) and line fuse holder (2).
2. Secure, using two hold-down nuts (1).
3. Solder four wires (4-7) to Voltage Selector switch (3) as follows:
   - White with brown and blue tracers from power transformer lug 1 to AC switch (4).
   - White with blue and red tracers from power transformer lug 4 to AC switch (5).
   - White with blue and yellow tracers from power transformer lug 5 to AC switch (6).
   - White with blue and red tracers from power transformer lug 2 to AC switch (7).
4. Solder two wires to line fuse holder (2) as follows:
   - Blue-Yellow-White from power transformer (9) lug 5 to top lug.
   - Black-Red-White from filter unit (8) lug P to center lug.
5. Install A3A1 Power Supply CCA (para 5-24).
6. Install EMI shields and case (para 5-20).



END OF TASK

5-28. DC BANANA PLUG REPLACEMENT

DESCRIPTION

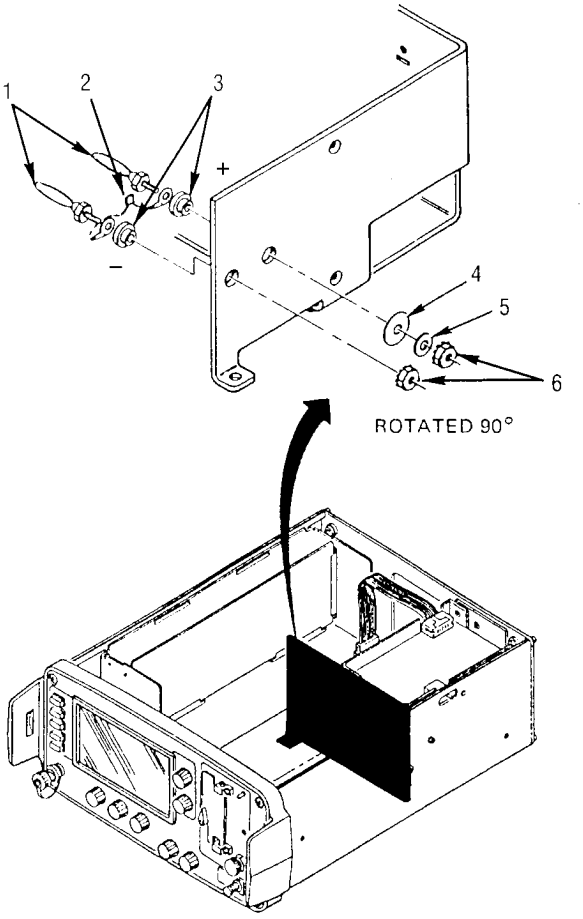
This procedure covers: Remove and Install

REMOVE

1. Remove case and EMI shields (para 5-20).
2. Unsolder two wires from each banana plug (1)
3. Unsolder and remove ceramic capacitor (2)
4. Remove two nuts (6), metal washer (5), and mica washer (4).
5. Remove two banana plugs (1) and ins ulators (3).

INSTALL

1. Install two ba nana plugs (1) and insulators (3), using mica washer (4) and metal washer (5) for positive (+) banana plug.
2. Secure, using two nuts (6)
3. Solder ceramic capacitor (2) between banana plugs (1).
4. Solder red and orange wires to positive (+) banana plug.
5. Solder brown and yellow wires to negative (-) banana plug.
6. Install EMI shields and case (para 5-20).



END OF TASK

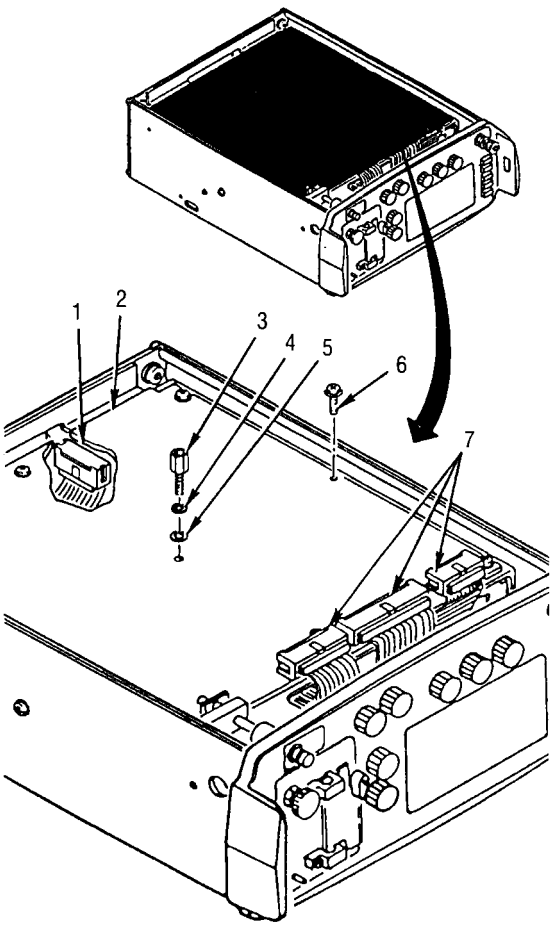
5-29. A1 MAIN CCA REPLACEMENT

DESCRIPTION

This procedure covers: Remove and Install

REMOVE

1. Remove case and EMI shields (para 5-20).
2. Remove power supply ribbon cable connector (1) from top side of A1 Main CCA (2).
3. Remove eight screws (6) from A 1 Main CCA (2).
4. Remove standoff (3), lockwasher (4), washer (5), and lift A 1 Main CCA (2) up enough to remove three cable connectors (7).
5. Remove three cable connectors (7) and A1 Main CCA (2).



INSTALL

1. Attach three cable connectors (7) to front of A1 Main CCA (2).
2. Position A 1 Main CCA over nine standoffs and install washer (5), lockwasher (4), and standoff (3).
3. Install eight screws (6) to secure A 1 Main CCA (2).
4. Install power supply ribbon cable connector (1) in top side of A1 Main CCA (2).
5. Install EMI shields and case (para 5-20).

END OF TASK

5-30. A1U2020 EPROM REPLACEMENT

DESCRIPTION

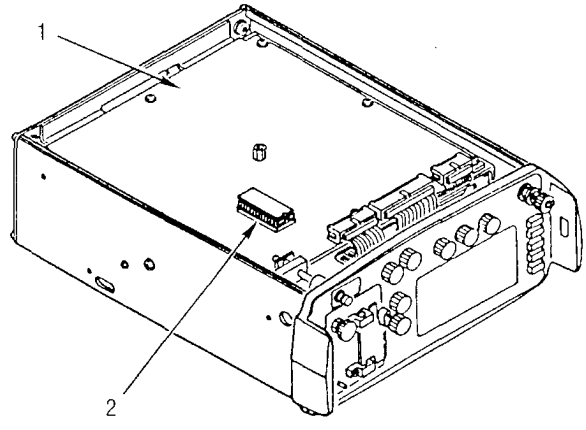
This procedure covers: Remove and Install

REMOVE

CAUTION

Observe ESD precautionary procedures.

1. Remove case and bottom EMI shield (para 5-20).
2. Carefully remove 28-pin EPROM (2) from A1 Main CCA (1).



INSTALL

1. Install EPROM (2) on A1 Main CCA (1). Make sure notch in IC is facing toward front of instrument and all pins are inserted correctly in socket.

Install bottom EMI shield and case (para 5-20).

END OF TASK

5-31. A1BT1010 LITHIUM BATTERY REPLACEMENT

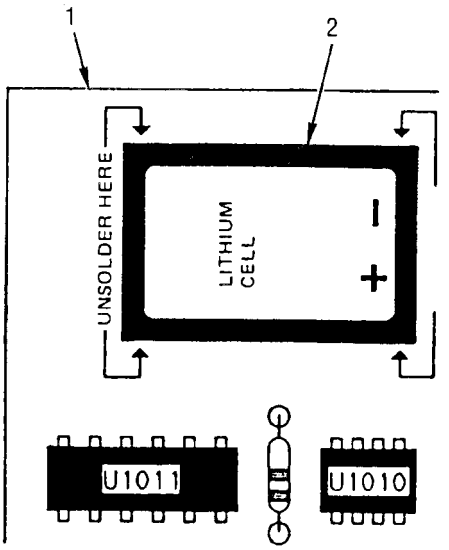
DESCRIPTION

This procedure covers: Remove and Install

REMOVE

WARNING

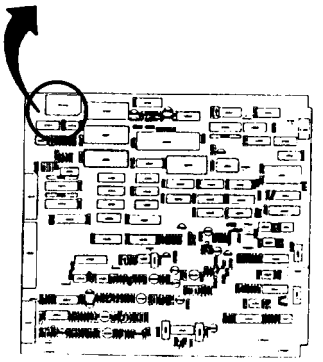
Observe proper procedures for handling and disposing of lithium batteries. Improper handling may cause fire, explosion, or severe burns. Do not recharge, crush, disassemble, heat above 212°F (100° C), incinerate, or expose battery contents to water. Disposal of small quantities (less than 20) can be safely done with ordinary garbage in a sanitary landfill.



1. Remove case and lower EMI shield (para 5-20).
2. Remove A1 Main CCA (para 5-29).
3. Unsolder four leads of lithium battery (2).
4. Remove lithium battery (2) from A1 Main CCA (1).

INSTALL

1. Install lithium battery (2) on A1 Main CCA (1).
2. Solder four leads to A1 Main CCA (1), being careful not to overheat cell.
3. Install A1 Main CCA (para 5-29).
4. Install lower EMI shield and case (para 5-20).



END OF TASK

5-32. A4 DRIVER/SAMPLER CCA REPLACEMENT

DESCRIPTION

This procedure covers: Remove and Install

REMOVE

1. Remove case and EMI shields (para 5-20).
2. Remove two screws (1) and cover (2).
3. Disconnect ribbon cable connector (6) from A4 Driver/Sampler CCA (3).
4. Disconnect coaxial cable connector (5) from A4 Driver/Sampler CCA (3).
5. Remove A4 Driver/Sampler CCA (3) by lifting up out of CCA card guide slots (4).

INSTALL

1. Install A4 Driver/Sampler CCA (3) by sliding into CCA card guide slots (4), component side of board inboard.
2. Connect coaxial cable connector (5) to outboard side of A4 Driver/Sampler CCA (3).
3. Connect ribbon cable connector (6) to inboard side of A4 Driver/Sampler CCA (3).
4. Position cover (2) and secure with two screws (1).
5. Install EMI shields and case (para 5-20).

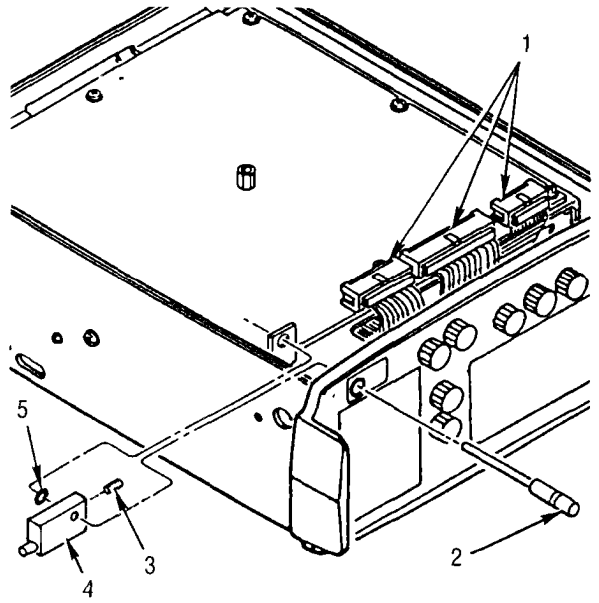
END OF TASK

5-33. FRONT PANEL ASSEMBLY REPLACEMENT

DESCRIPTION

This procedure covers: Remove and Install

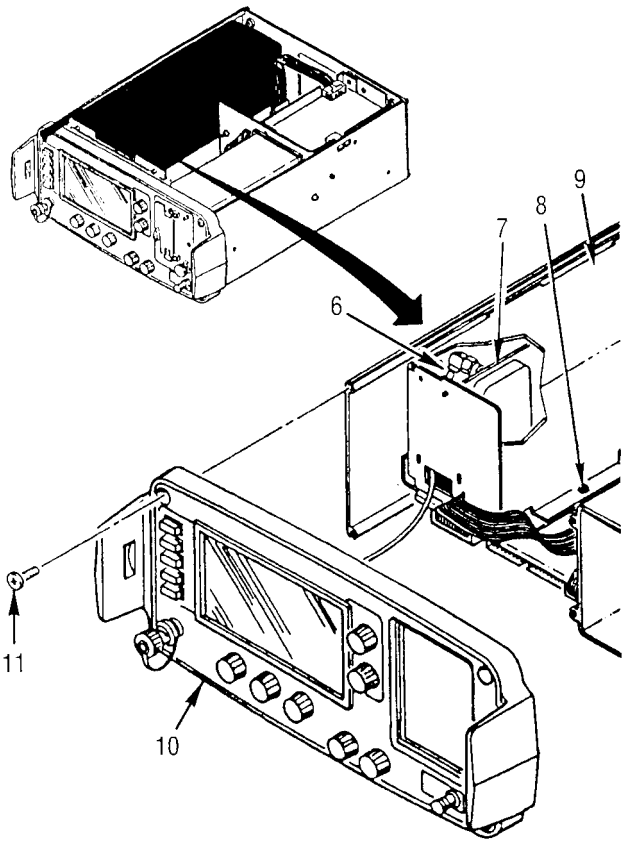
REMOVE



1. Remove case and EMI shields (para 5-20).
2. Loosen setscrew (3) and remove nut block (4), POWER switch knob (2), and O-ring (5).
3. Remove two screws (8) and A4 Driver/Sampler CCA cover (9).
4. Disconnect coaxial cable connector (6) from A4 Driver/Sampler CCA (7).
5. Remove four screws (11) securing front panel (10).
6. Carefully guide coaxial cable through A4 Driver/Sampler CCA cage while pulling front panel (10) away from main chassis until three A1 Main CCA cable connectors (1) can be removed.
7. Remove three A1 Main CCA cable connectors (1) and front panel (10).

INSTALL

1. Position front panel (10) and plug three cable connectors (1) into A 1 Main CCA.
2. Carefully guide coaxial cable through A4 Drive r/Sampler CCA cage while pushing front panel (10) onto chassis.
3. Install four screws (11) securing front panel (10).
4. Connect coaxial cable connector (6) to A4 Driver/Sampler CCA (7).
5. Install A4 Driver/Sampler CCA cover (9) and secure with two screws (8).
6. Insert POWER switch knob (2) through front panel and install O-ring (5) and nut block (4) on POWER switch knob shaft.
7. Tighten setscrew (3).
8. Install EMI shields and case (para 5-20).



END OF TASK

5-34. OPTOELECTRIC DISPLAY AND A2 FRONT PANEL CCA REPLACEMENT

DESCRIPTION

This procedure covers: Remove and Install

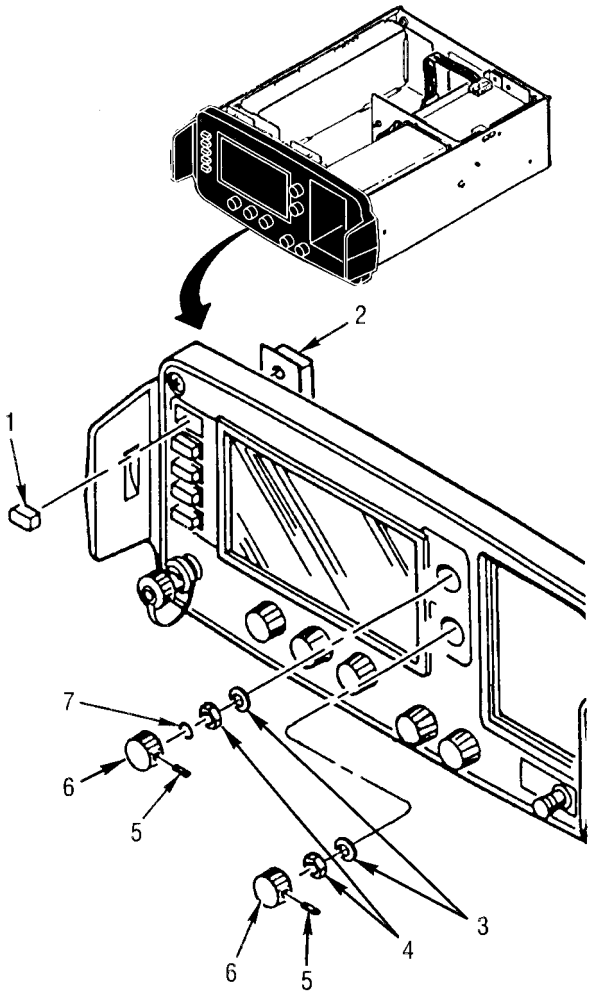
REMOVE

1. Remove Front Panel Assembly (para 5-33).
2. Loosen setscrews (5) and remove seven knobs (6) from front panel controls.
3. Remove seals (7) from all controls.
4. Remove nuts (4) and washers (3) from front panel control shafts.
5. Disconnect ribbon cable and separate A2 Front Panel CCA (9) and optoelectric display (8).

CAUTION

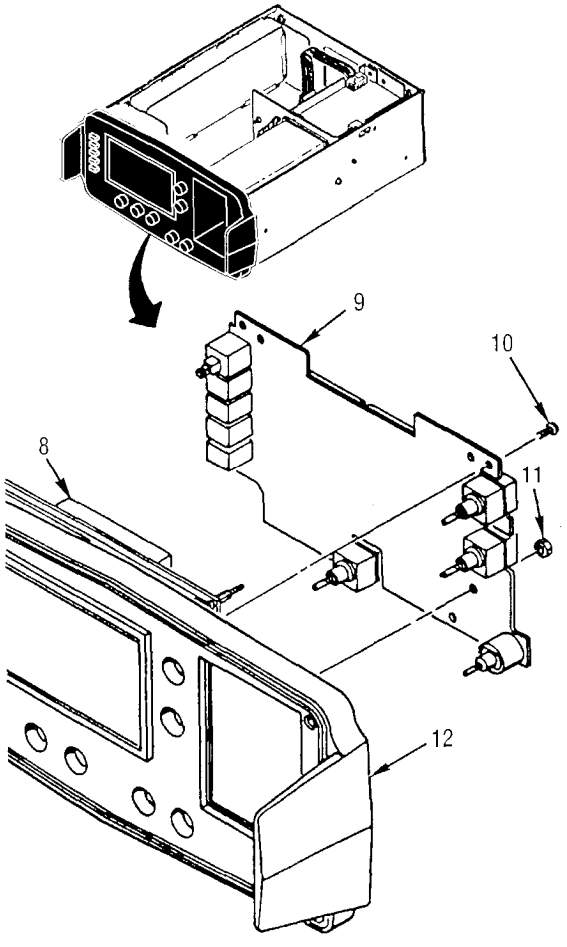
Do not use sharp object when performing following procedure. Sharp objects may puncture rubber boot.

6. Gently press rubber boot (2) behind each pushbutton and remove five pushbuttons (1).
7. Remove four screws (10).
8. Remove four nuts (11).
9. Carefully lift A2 Front Panel CCA (9) and optoelectric display (8) from front panel (12).
10. Clean excess adhesive sealant from five pushbutton switches.



INSTALL

1. Carefully position optoelectric display (8) and A2 Front Panel CCA (9) together on front panel (12).
2. Secure optoelectric display (8) and A2 Front Panel CCA (9) using four nuts (11).
3. Install optoelectric display (8) and A2 Front Panel CCA (9) on front panel (12) and secure using four screws (10). Connect ribbon cable.
4. Replace watertight seal (para 5-21).



CAUTION

Do not use sharp object when performing following procedure. Sharp objects may puncture rubber boot.

5 Apply Dow Corning 3145 adhesive sealant (Appendix E, item 4) to five pushbuttons (1).

6 Installfive pushbuttons (1) on front panel (12)and reposition rubber boot (2).

7 Install washers (3) and nuts (4) on front panel control shafts.

8 Install seals (7) on all controls.

9 Install seven knobs (6) on front panel controls and tighten setscrews (5).

10. Install Front Panel Assembly (para 5-33).

END OF TASK

5-35. BATTERY UNIT REPLACEMENT

DESCRIPTION

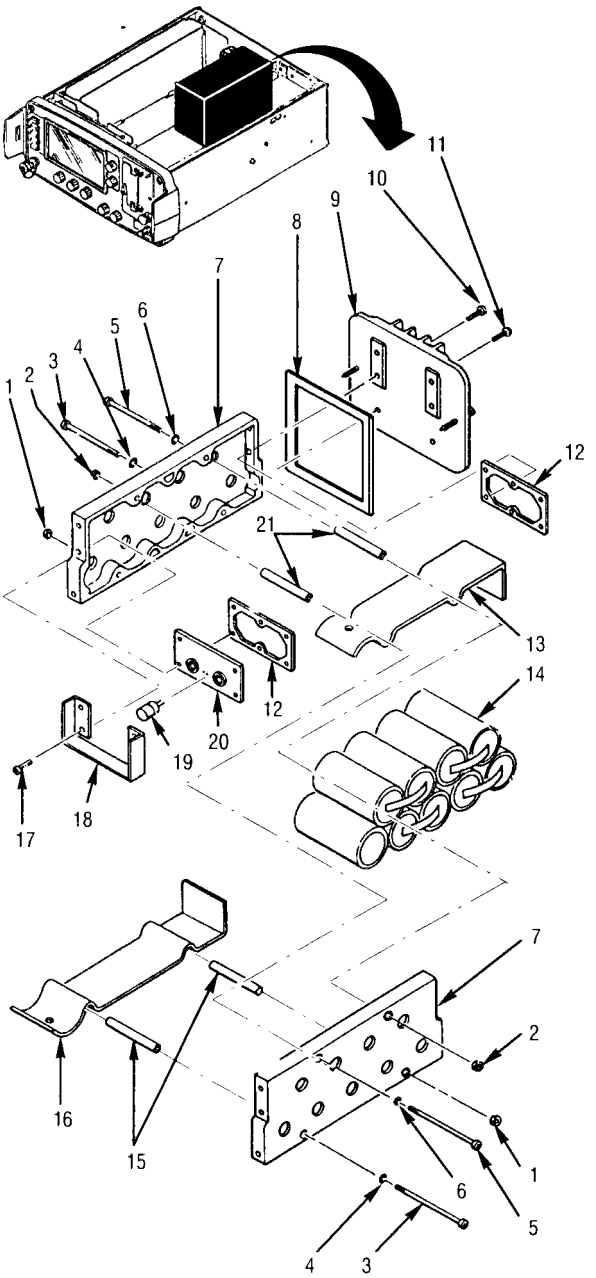
This procedure covers: Remove and Install

REMOVE

WARNING

Avoid eye and skin contact with heat sink grease, which can cause eye and skin irritation. Wash affected skin area immediately with soap and water. Flush eyes with water and seek medical aid as soon as possible.

1. Remove battery pack from Test Set (para 3-22).
2. Remove battery pack fuse (19) by pulling fuse straight back.
3. Remove four 1/4-in. screws (17) and fuse shield (18).
4. Remove four 1/2-in. screws (10) and two 3/8-in. screws (11) from front panel (9).
5. Remove front panel (9) and gasket (8).
6. Remove two screws (5), washers (6), and nuts (2).
7. Remove spacers (21) and upper heat sink (13).
8. Remove two screws (3), washers (4), and nuts (1).
9. Remove spacers (15) and lower heat sink (16).
10. Separate two ring clamps (7) and remove two metallic plates (12), CCA (20), and battery unit (14).
11. Unsolder two wires from battery unit (14) to CCA (20).



INSTALL

WARNING

Avoid eye and skin contact with heat sink grease, which can cause eye and skin irritation. Wash affected skin area immediately with soap and water. Flush eyes with water and seek medical aid as soon as possible.

1. Solder brown and white wire leading from CCA (20) to negative (-) cathode of battery unit (14).
2. Solder red and white wire leading from CCA (20) to positive (+) anode of battery unit (14).
3. Install battery unit (14), CCA (20), and two metallic plates (12) between two ring clamps (7).
4. Install lower heat sink (16) and two spacers (15) and secure using two screws (3), washers (4), and nuts (1).
5. Install upper heat sink (13) and two spacers (21) and secure using two screws (5), washers (6), and nuts (2).
6. Install gasket (8) and front panel (9) and fill holes with Dow Corning 3 140 coating (Appendix E, item 5) for watertightness. Secure using two 3/8-in. screws (11) and four 1/2-in. screws (10).
7. Install fuse shield (18) using four 1/4-in. screws (17), ensuring rear metallic plate (12) is pressed rearward to meet screws.
8. Install fuse (19).
9. Install battery pack in Test Set (para 3-22).

END OF TASK

5-36. OPTION PORT ASSEMBLY REPLACEMENT

DESCRIPTION

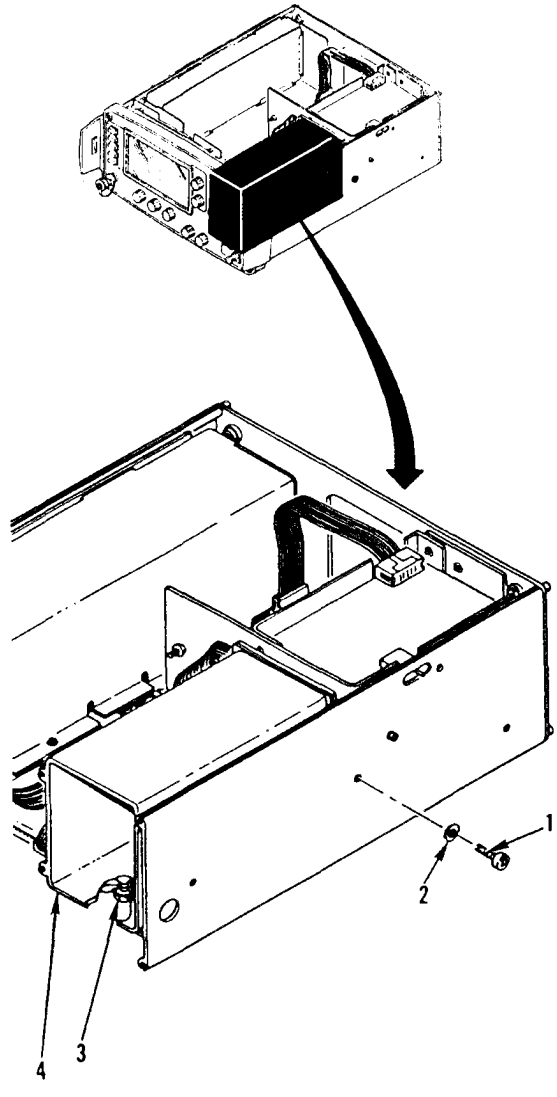
This procedure covers: Remove and Install

REMOVE

1. Remove Front Panel Assembly (para 5-33).
2. Disconnect ribbon cable J2010 on A1 Main CCA.
3. Remove screw (1) and washer (2).
4. Remove nut (3) and option port assembly (4).

INSTALL

1. Install option port assembly (4) and secure using nut (3).
2. Install washer (2) and screw (1).
3. Connect ribbon cable J20 10.
4. Install Front Panel Assembly (para 5-33).



END OF TASK

5-37. ADJUSTMENTS

The following paragraphs describe Test Set adjustments to ensure the Test Set meets performance specifications after replacement of parts. The adjustment procedures are divided into four categories, each of which can be performed individually. After completion of the adjustment procedures, do the operational tests (para 3-8). The four adjustment categories are:

	Para
A1 Main CCA Power Supply Adjustment	5-39
Chart Recorder Paper Skew Adjustment	5-42
LCD Adjustment	5-40
Zero Offset Adjustment	5-41

NOTE

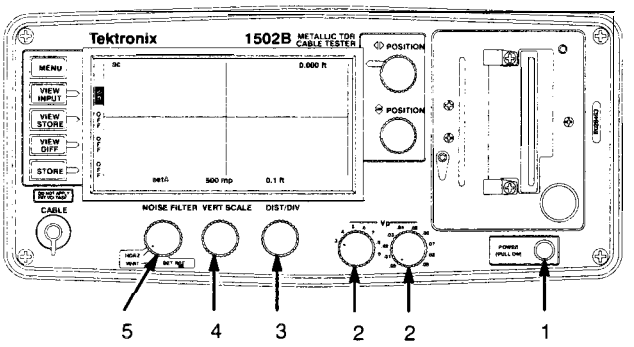
- *A ll waveforms and measurements are to chassis ground unless otherwise noted.*
- *Each procedure must be done in order and in its entirety.*
- *All voltages have a tolerance of ±10%, unless otherwise noted, or unless given as a range with specific limits.*

5-38. INITIAL SETUP

Before making any adjustments:

- Ensure that Test Set has been at an ambient temperature of 75° ±5° F (25° ±3°C) for at least 2 hours (operating or nonoperating).
- Allow at least 5-minute warmup time.
- Remove case and top EMI shield (para 5-20).

5-39. A1 MAIN CCA POWER SUPPLY ADJUSTMENT



1. Push POWER switch (1) (Off position).

2. Connect Test Set to variable autotransformer. Set autotransformer for 115 VAC output.

3. Set front panel controls as follows:

NOISE FILTER switch (5)	1 avg
VERT SCALE control (4)	500 mp
DIST/DIV switch (3)	1 ft/DIV
Vp switches (2)	.99

4. Pull POWER switch (1) (On position).

5. Check power supply voltages at test points per voltage tables (fig. FO-5, Sheets 1, 2 and 3). If voltages are out of tolerance, go to Table 5-1, Malfunction 2.

6. On A1 Main CCA, attach positive (+) probe from DMM to positive (+) side of A1C9031 (fig. FO-2 and FO-3, Sheet 11). Attach negative (-) probe to A1TP9040 (ground).

7. Adjust A1R9032 for +12 VDC.

8. Move positive (+) probe to negative (-) side of A1C9035. Verify voltage is - 11.8 to -12.2 VDC.

9. If ± 12 VDC cannot be adjusted properly, go to Table 5-1, Malfunction 6.

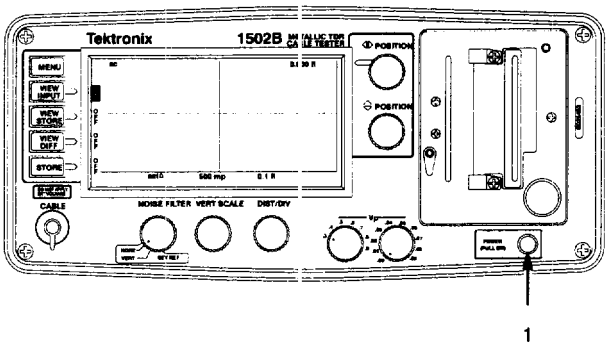
5-40. LCD ADJUSTMENT

1. Pull POWER switch (1) (On position) and allow 5-minute warmup time.

2. Turn A2R101 8 (fig. FO-4, Sheets 1 and 2) on A2 Front Panel CCA counterclockwise until most of display has dimmed.

3. Rotate A2R1018 slowly clockwise until all pixels are just visible on screen. If rotation goes too far, restart this step.

4. Rotate A2R101 8 one-half turn clockwise.



NOTE

Always adjust contrast setting by starting with faded display. It takes higher threshold voltage to turn on a pixel than to turn it off. If this condition is no' observed, display will be too light.

5. Inspect display for any bleeding (areas that are too dark) or fading.

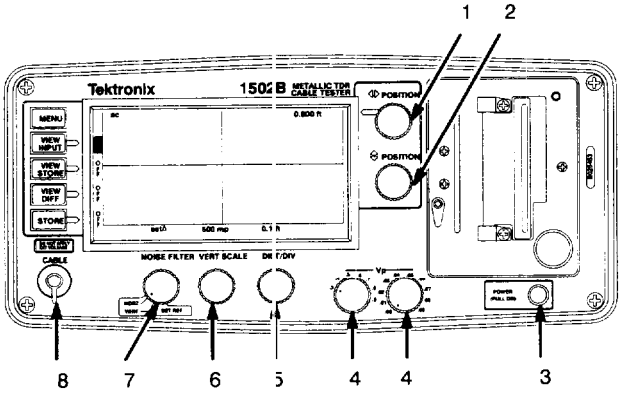
6. Push POWER switch (1) (Off position), wait a few seconds, then pull POWER switch (1) (On position). Inspect display again and readjust if necessary.

5-41. ZERO OFFSET ADJUSTMENT

1. Pull POWER switch (3) to (On position).

2. Set front panel controls as follows:

NOISE FILTER switch (7)	1 avg
VERT SCALE control (6)	10 mρ
DIST/DIV switch (5)	0.2 ft/DI
Vp switches (4)	.99

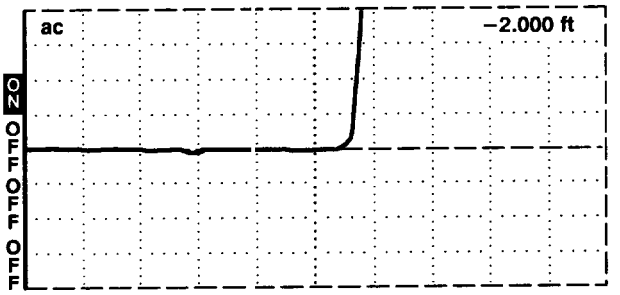


3. Adjust ◆▶ POSITION control (1) until LCD distance window reads -2.000 ft. Adjust ▲▼ POSITION control (2) to center baseline on center graticule line.

4. Attach precision 50 Ω cable to CABLE connector (8).

5. Adjust A4R 1042 on A4 Driver/Sampler CCA (fig. FO-6, Sheets 1 and 2) to move waveform to same position as when no connection was attached to front panel.

6. Remove precision 50 Ω cable and verify that waveform moves less than ±0.5 DIV.



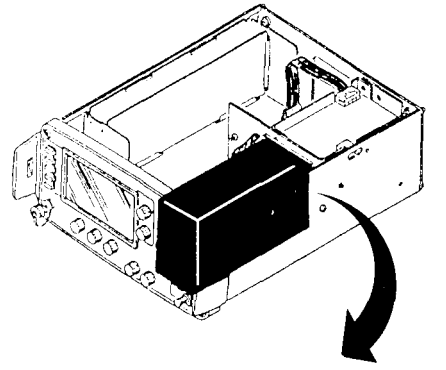
NOTE

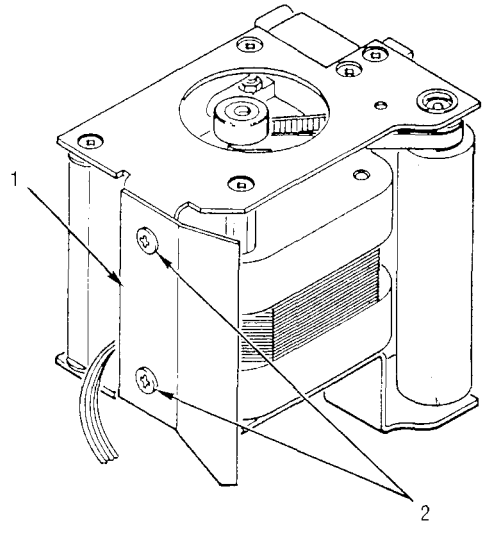
Some change in shape of baseline before leading edge is normal. If this measurement is difficult to make, access Service Diagnostic Menu and change timebase mode from "Timebase is: Normal - Auto Correction" to " Timebase is: Diagnostic - No Correction". This will give more stability to pulse when short is applied.

7. If adjustment cannot be made to reduce movement to ±0.5 DIV, replace A4 Driver/Sampler CCA (para 5-32).

5-42. CHART RECORDER PAPER SKEW ADJUSTMENTS

1. Remove A10 Chart Recorder Assembly from Test Set (para 3-23).
2. Remove chart recorder paper roll (para 3-23).
3. Remove paper retaining mandrel assembly (para 5-23).
4. Slightly loosen two screws (2) holding paper guide (1) on rear of drive motor assembly.
5. If paper skews up or down, position paper guide as follows:
   - Move top of paper guide (1) slightly (away from printhead side for downward skewing, closer to prin thead side for upward skewing).
   - Tighten two paper guide screws (2).
   - Install paper retaining mandrel assembly (para 5-23).
   - Install chart recorder paper roll (para 3-23).
   - Perform Chart Recorder Test (para 3-19) and check for proper pape r tracking.
   - Repeat steps 1 through 4 to fine-tune skew, if necessary.





REAR VIEW

Section VI. PREPARATION FOR STORAGE OR SHIPMENT

5-43. PREPARATION FOR STORAGE OR SHIPMENT

Procedures for preparing the Test Set for storage or shipment are provided in Chapter 3, Section V.

APPENDIX A
REFERENCES

A-1 SCOPE

This appendix lists all forms, field manuals, technical manuals, and miscellaneous publications referenced in this manual.

A-2. FORMS

Transportation Discrepancy Report ..... Form SF 361

Equipment Inspection and Maintenance Worksheet..... DA Form 2404

Product Quality Deficiency Report ..... Form SF 368

Recommended Changes to Publications and Blank Forms..... DA Form 2028

Report of Discrepancy..... Form SF 364

A - 3. TECHNICAL MANUALS

Unit, Direct Support, and General Support Repair Parts
and Special Tools List for Test Set, Electrical Cable TS-4165/G ..... TM 11-6625-3240-24P

Procedures for Destruction of Electronics Materiel to
Prevent Enemy Use (Electronics Command) ..... TM 750-244-2

A - 4. MISCELLANEOUS PUBLICATIONS

Abbreviations for Use on Drawings, and In Specifications,
Standards and Technical Documents MIL-STD-12

Common Table of Allowances ..... CTA 50-970

Consolidated Index of Army Publications and Blank Forms..... DA Pam 25-30

First Aid ..... FM 4-25.11

Safety Precautions for Maintenance of
Electrical/Electronic Equipment ..... TB 385-4

The Army Maintenance Management System (TAMMS) Users Manual..... DA PAM 750-8

APPENDIX B

MAINTENANCE ALLOCATION CHART (MAC)

Section 1. INTRODUCTION

B.1 GENERAL.

a. This introduction provides a general explanation of all maintenance and repair function authorized at the two maintenance levels under the Two-Level Maintenance System concept.

b. The MAC in Section II designates overall authority and responsibility for the performance of maintenance functions on the identified end item or component. The application of the maintenance functions to the end item or component levels, which are shown on the MAC in column (4) as:

1. Field – includes two columns, Unit maintenance and Direct Support maintenance. The Unit maintenance column is divided again into two more subcolumns, C for Operator or Crew and O for Unit maintenance.
2. Sustainment – includes two subcolumns, general support (H) and depot (D).

c. The tools and test equipment requirements in Section III list the tools and test equipment (both special tools and common tool sets) required for each maintenance function as referenced from the MAC.

d. The remarks in Section IV contain supplemental instructions and explanatory notes for a particular maintenance function.

B.2 MAINTENANCE FUNCTIONS.

Maintenance functions are limited to and defined as follows:

a. **Inspect.** To determine the serviceability of an item by comparing its physical, mechanical, and/or electrical characteristics with established standards through examination (e.g. by sight, sound, or feel). This includes scheduled inspection and gagings and evaluation of cannon tubes.

b. **Test.** To verify serviceability by measuring the mechanical, pneumatic, hydraulic, or electrical characteristics of an item and comparing those characteristics with prescribed standards on a scheduled basis, i.e., load testing of lift devices and hydrostatic testing of pressure hoses.

c. **Service.** Operations required periodically to keep an item in proper operating condition; e.g., to clean (includes decontaminate, when required), to preserve, to drain, to paint, or to replenish fuel, lubricants, chemical fluids, or gases. This includes scheduled exercising and purging of recoil mechanisms. The following are examples of service functions:

1. Unpack. To remove from packing box for service or when required for the performance of maintenance operations.
2. Repack. To return item to packing box after service and other maintenance operations.
3. Clean. To rid the item of contamination.
4. Touch up. To spot paint scratched or blistered surfaces.
5. Mark. To restore obliterated identification.

d. **Adjust.** To maintain or regulate, within prescribed limits, by bringing into proper position, or by setting the operating characteristics to specified parameters.

e. **Align.** To adjust specified variable elements of an item to bring about optimum or desired performance.

f. **Calibrate.** To determine and cause corrections to be made or to be adjusted on instruments of test, measuring, and diagnostic equipment used in precision measurement. Consists of comparisons of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared.

g. **Remove/install.** To remove and install the same item when required to perform service or other maintenance functions. Install may be the act of emplacing, seating, or fixing into position a spare, repair part, or module (component or assembly) in a manner to allow the proper functioning of an equipment or system.

h. **Paint.** To prepare and spray color coats of paint so that the ammunition can be identified and protected. The color indicating primary use is applied, preferably, to the entire exterior surface as the background color of the item. Other markings are to be repainted as original so as to retain proper ammunition identification.

i. **Replace.** To remove an unserviceable item and install a serviceable counterpart in its place "Repair" is authorized by the MAC and assigned maintenance level is shown as the third position code of the Source, Maintenance and Recoverability (SMR) code.

j. **Repair.** The application of maintenance services, including fault location/troubleshooting, removal/installation, disassembly/assembly procedures and maintenance actions to identify troubles and restore serviceability to an item by correcting specific damage, fault, malfunction, or failure in a part, subassembly, module (component or assembly), end item or system.

NOTE

The following definitions are applicable to the "repair" maintenance function:

1. Services. Inspect, test, service adjust, align, calibrate, and/or replace.
2. Fault location/troubleshooting. The process of investigating and detecting the case of equipment malfunctioning; the act of isolating a fault within a system or Unit Under Test (UUT).
3. Disassembly/assembly. The step-by-step breakdown (taking apart) of a spare/functional group coded item to the level of its least component, that is assigned an SMR code for the level of maintenance under consideration (i.e., identified as maintenance significant).
4. Actions. Welding, grinding, riveting, straightening, facing, machining, and/or resurfacing.

k. **Overhaul.** That maintenance effort (service/action) prescribed to restore an item to a completely serviceable/operational condition as required by maintenance standards in appropriate technical publications. Overhaul is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like new condition.

l. **Rebuild.** Consists of those services/actions necessary for the restoration of unserviceable equipment to a like new condition in accordance with original manufacturing standards. Rebuild

is the highest degree of material maintenance applied to Army equipment. The rebuild operation includes the act of returning to zero those age measurements (e.g., hours/miles) considered in classifying army equipment/components.

B.3 EXPLANTION OF COLUMNS IN THE MAC, SECTION II.

a. **Column (1) Group Number.** Column (1) lists FGC numbers, the purpose of which is to identify maintenance significant components, assemblies, subassemblies, and modules with the Next Higher Assembly (NHA).

b. **Column (2) Component/Assembly.** Column (2) contains the item names of components, assemblies, subassemblies, and modules for which maintenance is authorized.

c. **Column (3) Maintenance Function.** Column (3) lists the functions to be performed on the item listed in column (2). (For a detailed explanation of these functions, refer to "Maintenance Functions" outlined above.)

d. **Column (4) Maintenance Level.** Column (4) specifies each level of maintenance authorized to perform each function listed in column (3), by indicating work time required (expressed as manhours in whole hours or decimals) in the appropriate subcolumn. The work time figure represents the active time required to perform that maintenance function at the indicated level of maintenance. If the number or complexity of the tasks within the listed maintenance function varies at different maintenance levels, appropriate work time figures are to be shown for each level. The work time figure represents the average time required to restore an item (assembly, subassembly, component, module, end item or system) to a serviceable condition under typical field operating conditions. This time includes preparation time (including any necessary disassembly/assembly time), troubleshooting/fault location time, and quality assurance time in addition to the time required to perform the specific tasks identified for the maintenance functions authorized in the MAC. The symbol designations for the various maintenance levels are as follows:

1. Field:
   - C Operator or Crew maintenance
   - O Unit maintenance
   - F Direct Support maintenance

2. Sustainment:
   - L Specialized Repair Activity
   - H General Support maintenance
   - D Depot maintenance

NOTE

The "L" maintenance level is not included in column (4) of the MAC. Functions to this level of maintenance are identified by work time figure in the "H" column of column (4), and an associated reference code is used in the REMARKS column (6). This code is keyed to the remarks and the SRA complete repair application is explained there.

e. **Column (5) Tools and Equipment Reference Code.** Column (5) specifies, by code, those common tool sets (not individual tools), common Test, Measurement and Diagnostic Equipment (TMDE), and special tools, special TMDE and special support equipment required to perform the designated function. Codes are keyed to the entries in the tools and test equipment table.

f. **Column (6) Remarks Code.** When applicable, this column contains a letter code, in alphabetical order, which is keyed to the remarks table entries.

B.4 EXPLANATION OF COLUMNS IN TOOLS AND TEST EQUIPMENT REQUIREMENTS, SECTION III.

a. **Column (1) Tool or Test Equipment Reference Code.** The tool or test equipment reference code correlates with a code used in column (5) of the MAC.

b. **Column (2) Maintenance Level.** The lowest level of maintenance authorized to use the tool or test equipment.

c. **Column (3) Nomenclature.** Name or identification of the tool or test equipment.

d. **Column (4) National Stock Number (NSN).** The NSN of the tool or test equipment.

e. **Column (5) Tool Number.** The manufacturer's part number, model number, or type number.

B.5 EXPLANATION OF COLUMNS IN THE REMARKS, SECTION IV.

a. **Column (1) Remarks Code.** The code recorded in column (6) of the MAC.

b. **Column (2) Remarks.** This column lists information pertinent to the maintenance function being performed as indicated in the MAC."

SECTION II. MAINTENANCE ALLOCATION CHART (MAC)

FOR

TEST SET, ELECTRICAL CABLE, TS-4165/G

TABLE 1. MAC FOR TEST SET, ELECTRICAL CABLE, TS-4165/G

(1) GROUP NUMBER	(2) COMPONENT/ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE LEVEL					(5) TOOLS AND EQUIPMENT REFENENCE CODE	(6) REMARKS CODE
			FIELD			SUSTAINMENT			
			UNIT		DS	GS	DEPOT		
			C	O	F	H	D		
00	Test Set, Electrical Cable TS-4165/G	INSPECT		0.1					A
		TEST		1.5				3-4	B
		REPAIR		0.2				1	C
		INSPECT			0.2			8	D
		REPAIR			1.0			2-10	E
		REPAIR					*		F
01	Chassis	INSPECT			0.1				
		REPAIR			0.5			7	G
02	Battery Pack	INSPECT		0.1					
		TEST		0.1					
		REPAIR		0.1					H
		INSPECT			0.1				
		TEST			0.2				
		REPAIR			0.5			2,7,9	
03	Main Board CCA: A!	INSPECT			0.1				
		TEST			0.2			2-9	
		REPAIR			3.4			2-9	
04	Front Panel Assembly	INSPECT			0.1				
		TEST			0.2			2-7,9	
		REPAIR			0.5			2-7,9	I
0401	Front Panel CCA: A2	INSPECT			0.1				
		TEST			0.2			2-7,9	
		REPAIR			3.5			2-7,9	
05	Power Supply Assembly: A3	INSPECT			0.1				
		TEST			0.2			2-9	
		REPAIR			1.0			2-9	J
0501	Power Supply CCA: A3A1	INSPECT			0.1				
		TEST			0.2			2-9	
		REPAIR			3.5			2-9	
06	Driver/Sampler CCA: A4	INSPECT			0.1				
		TEST			0.2			2-7,9	
		REPLACE			0.5			7	
		REPAIR					2.5	2-7,9	K
07	Chart recorder Assembly: A10	INSPECT		0.1					
		TEST		0.1					
		SERVICE		0.3					L
		REPLACE		0.1					
		REPAIR			2.0			7,9	

SECTION III. TOOLS AND TEST EQUIPMENT REQUIREMENTS
FOR
TEST SET, ELECTRICAL CABLE, TS-4165/G

TABLE 2. TOOLS AND TEST EQUIPMENT REQUIREMENTS FOR TEST SET, ELECTRICAL CABLE, TS-4165/G

(1) TOOLS/ TEST EQUIPMENT CODE	(2) MAINTENANCE LEVEL	(3) NOMENCLATURE	(4) NATIONAL STOCK NUMBER	(5) TOOL NUMBER
1	O	Tool Kit, Electronic Equipment	5180-00-064-5178	TK-101/G
2	F	Multimeter, Digital	6625-01-112-7153	DM-501A
3	O,F	Termination	5935-01-321-9333	011-0123-00
4	O,F	Cable, Precision 50-ohm	5995-01-352-5506	012-1350-00
5	F	BNC Connector	5935-00-926-7523	M55339/17-00274
6	F	Transformer, Variable Auto	6130-00-054-7794	W10MT3A
7	F	Tool Kit, Electronic Equipment	5180-01-073-3845	JTK-17LAL
8	F	Oscilloscope	6695-01-074-7954	MIS-30526/2
9	F	Mainframe	6695-01-074-7953	MIS-30526/1 TYPE3
10	F	Extension Cable, Flexible	5995-01-335-8980	174-0950-00

SECTION IV. REMARKS FOR TEST SET, ELECTRICAL CABLE, TS-4165/G

TABLE 3. REMARKS FOR TEST SET, ELECTRICAL CABLE, TS-4165/G

REMARKS CODE	REMARKS
A	External inspection.
B	Perform operational test.
C	Repair limited to replacement of fuses, cables, knobs, battery pack, and chart recorder.
D	Internal and external inspection.
E	Repair by replacement of subassemblies.
F	Disposition purposes only.
G	Repair limited to replacement of instrument cover, desiccant, and chassis mounted parts, except handle.
H	Repair limited to replacement of battery pack fuse and faulty battery pack.
I	Repair limited to replacement of power switch, front panel cover, BNC connector, and optoelectric display.
J	Repair limited to replacement of faulty transformer, RF1 filter, banana plugs, and voltage selector switch.
K	Contractor repair/exchange.
L	Service limited to replacement of chart paper.

APPENDIX C

COMPONENTS OF END ITEM AND BASIC ISSUE ITEMS LISTS

Section I. INTRODUCTION

C-1. SCOPE

This appendix lists components of end item and basic issue items for the Test Set, Electrical Cable TS-41 65/G (Test Set) to help you inventory items required for safe and efficient operation.

C-2. GENERAL

The Components of End Item and Basic Issue Items Lists are divided into the following sections:

a. Section II. **Components of End Item.** This listing is for informational purposes only, and is not authority to requisition replacements. These items are part of the end item, but are removed and separately packaged for transportation or shipment. As part of the end item, these items must be with the end item whenever it is issued or transferred between property accounts. Illustrations are furnished to assist you in identifying the items.

b. Section III. **Basic Issue Items (BII).** These are the minimum essential items required to place the Test Set in operation, to operate it, and to perform emergency repairs. Although shipped separately packaged, BII must be with the Test Set during operation and whenever it is transferred between property accounts. The illustrations will assist you with hard-to-identify items. This manual is your authority to request/requisition replacement BII, based on TOE/MTOE authorization of the end item.

C-3. EXPLANATION OF COLUMNS

The following is an explanation of columns found in the tabular listings:

a. **Column (1) — Illustration Number (Illust No.).** This column indicates the number of the illustration in which the item is shown.

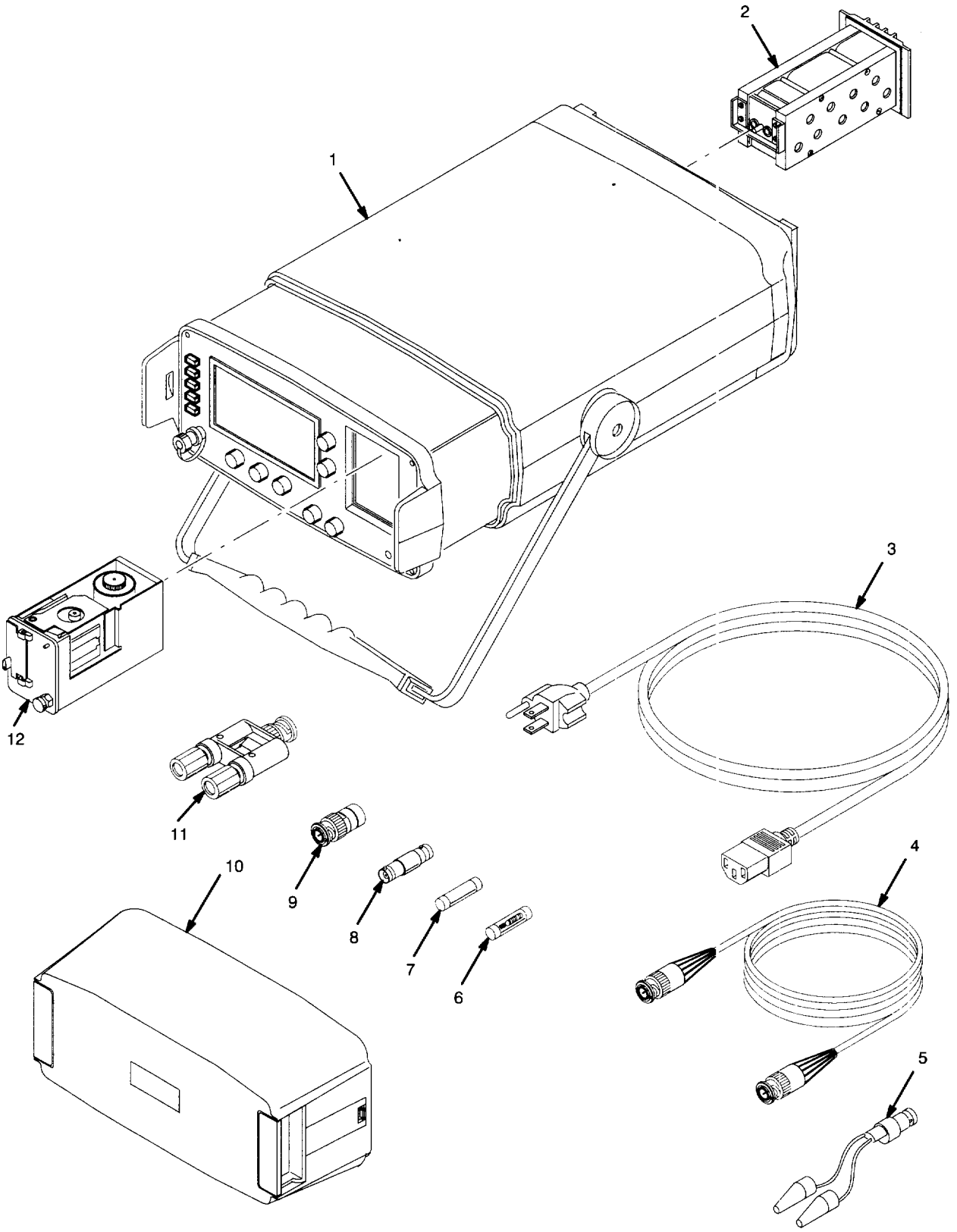
b. **Column (2) — National Stock Number.** Indicates the National Stock Number assigned to the item, and will be used for requisitioning purposes.

c. **Column (3) — Description.** Indicates the Federal item name and, if required, a minimum description to identify and locate the item. The last line for each item indicates the Cage (Contractor and Government Entity) Code (in parentheses) followed by the part number.

d. **Column (4) — Unit of Measure (U/M).** Indicates the measure used in performing the actual operational/maintenance function. This measure is expressed by a two-character alphabetical abbreviation (e.g., ea, in, pr).

e. **Column (5) — Quantity Required (Qty Rqr).** Indicates the quantity of the item authorized to be used with the Test Set.

Section II. COMPONENTS OF END ITEM



(1) ILLUST NO.	(2) NATIONAL STOCK NUMBER	(3) DESCRIPTION	(4) U/M	(5) QTY RQR
1		Metallic TDR Cable Tester, (80009) 1502B	EA	1
2	6140-01-336-6632	Battery Pack, 12 V (80009) 016-0813-01	EA	1
3	5995-01-336-7076	Power Cord (80009) 161-0228-00	EA	1
4		Precision 50-ohm Cable (80009) 012-1350-00	EA	1
5		BNC/Alligator Clip Adapter (80009) 013-0261-00	EA	1
6		AC Line Fuse, 115 VAC (80009) 159-0029-0 1	EA	1
7		AC Line Fuse, 230 VAC (80009) 159-0054-00	EA	1
8	5935-01-033-1478	Female to Female BNC Adapter (80009) 103-0028-00	EA	1
9	5935-01-321-9333	Termination (80009) 011-0123-00	EA	1
10		Cover (80009) 437-0338-00	EA	1
11	5935-00-410-1399	BNC/Banana Plug Adapter (80009) 103-0035-00	EA	1
12		Chart Recorder (80009) YT-1S	EA	1

APPENDIX D

ADDITIONAL AUTHORIZATION LIST

Section I. INTRODUCTION

D-1. SCOPE

This appendix lists additional items you are authorized for the support of the Test Set, Electrical Cable TS-4165/G (Test Set).

D-2. GENERAL

This list identifies items that do not have to accompany the Test Set and that do not have to be turned in with it. The items are all authorized to you by CTA, MTOE, TDA, or JTA.

D-3. EXPLANATION OF LISTING

National stock numbers, descriptions, and quantities are provided to help you identify and request the additional items you require to support the Test Set. The items are listed in alphabetical sequence by item name.

Section II. ADDITIONAL AUTHORIZATION LIST

(1) NATIONAL STOCK NUMBER	(2) DESCRIPTION		(3) U/M	(4) QTY AUTH
	CAGE & PART NUMBER	USABLE ON CODE		
	Fuse, 0.3 Amp, 115 V (80009) 159-0029-01		EA	1
	Fuse, 0.15 Amp, 230 V (80009) 159-0054-00		EA	1
	Fuse, 0.3 Amp, 120 V (80009) 159-0266-00		EA	1
9310-01-292-4681	Paper, Chart Recorder YT-1S (80009) 006-7647-00		EA	1

APPENDIX E

EXPENDABLE SUPPLIES AND MATERIALS LIST

Section I. INTRODUCTION

E-1. SCOPE

This appendix lists expendable supplies and materials you will need to maintain the Test Set, Electrical Cable TS-4 165/G. These items are authorized to you by CTA 50-970, Expendable Items (except Medical, Class V, Repair Parts, and Heraldic Items).

E-2. EXPLANATION OF COLUMNS

a. **Column (1) — Item Number.** This number is assigned to the entry in the listing and is referenced in the narrative instructions to identify the material (e. g., "Use cleaning compound, item 5, Appendix E").

b. **Column (2) — Level.** This column identifies the lowest level of maintenance that requires the listed item. Enter as applicable:

C	—	Operator/Crew
O		Unit Maintenance
F	—	Direct Support Maintenance
H	—	General Support Maintenance

c. **Column (3) — National Stock Number.** This is the National Stock Number assigned to the item; use it to request or requisition the item.

d. **Column (4) — Description.** Indicates the Federal item name and, if required, a description to identify the item. The last line for each item indicates the CAGE (Contractor and Government Entity) Code (in parentheses) followed by the part number.

e. **Column (5) — Unit of Measure (U/M).** Indicates the measure used in performing the actual maintenance function. This measure is expressed by a two-character alphabetical abbreviation (e.g., ea, in, pr). If the unit of measure differs from the unit of issue, requisition the lowest unit of issue that will satisfy your requirements.

Section II. EXPENDABLE SUPPLIES AND MATERIALS

(1) ITEM NO.	(2) LEVEL	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION	(5) U/M
1	H	6810-00-753-4993	Alcohol, Isopropyl, 8-oz Can, TT-I-735, Grade A (81349), P/N 006-0034-00	CN
2	C, O	8305-00-267-3015	Cloth, Cheesecloth, Cotton Lintless, CCC-C-440, Type II, Class 2 (81349)	YD
3	C, O		Detergent, Mild, Liquid	OZ
4	H		Adhesive Sealant, Dow Corning 3145 (94499) P/N 006-2302-00	OZ
5	H		Coating, Dow Corning 3140 (94499) P/N 006-4395-00	OZ
6	H		Silicone Grease, GE G-661 (24451) P/N 006-2207-00	OZ
7	H	6850-00-409-2602	Circuit Cooler, Freezing Compound 10 oz (18598)	CN

GLOSSARY

Section I. ABBREVIATIONS

ADC	Analog-to-digital converter
CCA	Circuit card assembly
CMOS	Complementary metal oxide semiconductor
DAC	Digital-to-analog converter
DIST	Distance
DIV	Division
DMM	Digital multimeter
EL	Electroluminescent
EMI	Electromagnetic interference
EPROM	Erasable programmable read-only memory
ESD	Electrostatic discharge
FET	Field-effect transistor
FO	Foldout
ITO	Indium tin oxide
LCD	Liquid crystal display
mp	Millirho
MNOS	Metal-nitride oxide semiconductor
MOSFET	Metal-oxide semiconductor field-effect transistor
NMI	Non-maskable interrupt
NMOS	N-channel metal oxide semiconductor
PROS	P-channel metal oxide semiconductor
prgm	Programmed
PRT	Pulse repetition time
RAM	Random-access memory
ρ	Rho
RFI	Radio frequency interference
R_L	Load impedance
R M S	Root-mean-square
R O M	Read-only memory
T P	Test point
var	Variable
VERT	Vertical
Vp	Velocity of propagation
Z_O	Characteristic impedance

Section II. DEFINITION OF UNUSUAL TERMS

Characteristic Impedance - The ratio of voltage to current at every point along a transmission line on which there are no standing waves. In a delay line, the value of terminating resistance which provides minimum reflection to the network input and output.

Complementary Metal 0xide Semiconductor - Pertains to N- and P-channel enhancement-mode devices fabricated compatibly on a silicon chip and connected into push-pull complementary digital circuits.

Electroluminescence - Direct conversion of electrical energy into light energy in a liquid or solid.

Electromagnetic Interference - Electromagnetic phenomena which, either directly or indirectly, can contribute to a degradation in performance of an electronic instrument or system.

Electrostatic Discharge - The discharge of electricity that can take place between a charged object (such as a human body) and an object of the opposite polarity (such as an integrated circuit chip or transistor). The resulting discharge may ruin the chip or transistor.

Liquid Crystal Display - A display device consisting basically of a liquid crystal sealed between two glass plates. The Test Set's type depends upon a backlighting source to produce dark characters on a lighter background.

Load Impedance - The impedance which a load presents to the transducer.

Metal-Nitride Oxide Semiconductor - Pertains to a process using a layer of nitride between the metal gate contact and the oxide protective layer.

MetaI-Oxide Semiconductor Field-Effect Transistor - A device consisting of diffused source and drain regions on either side of a P- or N-channel region, and a gate electrode insulated from the channel by silicon oxide.

N-channel Metal Oxide Semiconductor - Pertains to MOS devices made on P-type silicon substrates in which the active carriers are electrons that flow between N-type source and drain contacts.

P-channel Metal Oxide Semiconductor - Pertains to MOS devices made on N-type silicon substrates in which the active carriers are holes that flow between P-type source and drain contacts.

Pixel - A small rectangular division of a display screen.

Random-Access Memory - A memory storage arrangement from which information can be retrieved with a speed that is independent of the location of the information in storage.

Read-Only Memory - A storage arrangement primarily for information-retrieval applications; stored permanently.

Rho - Impedance function defined as voltage reflection coefficient. The ratio between the incident and reflected steps.

Velocity of Propagation - The speed at which a disturbance (sound waves, radio waves, light waves, etc.) is radiated through a medium.

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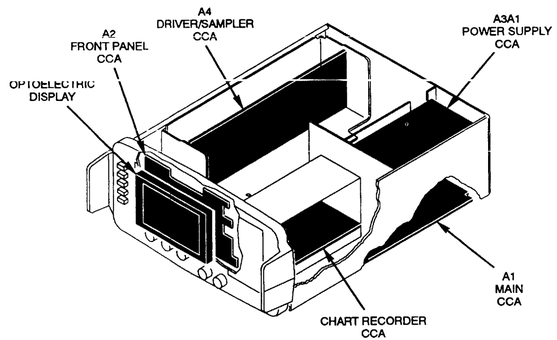
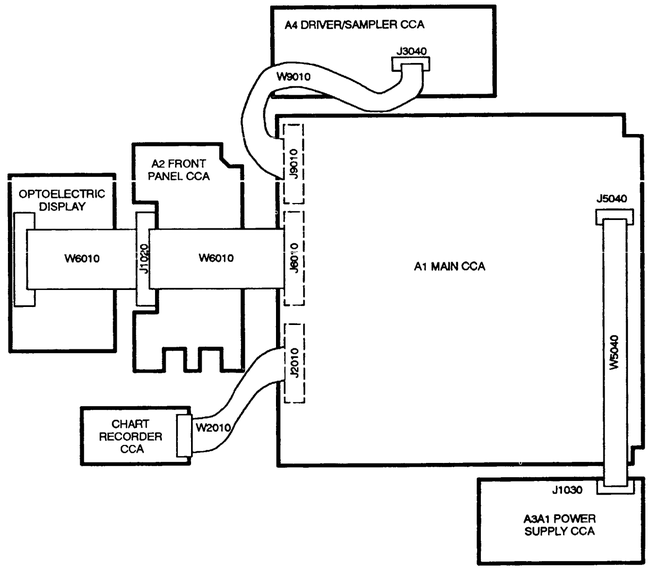


CIRCUIT CARD ASSEMBLY LOCATION DIAGRAM

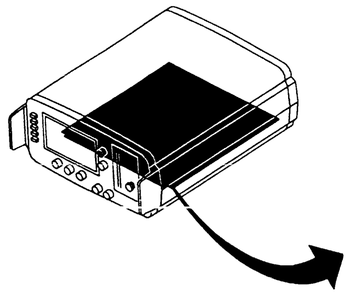


INTERCONNECT DIAGRAM

CE2DZ054

Figure FO-1. CCA Location and Interconnect Diagrams

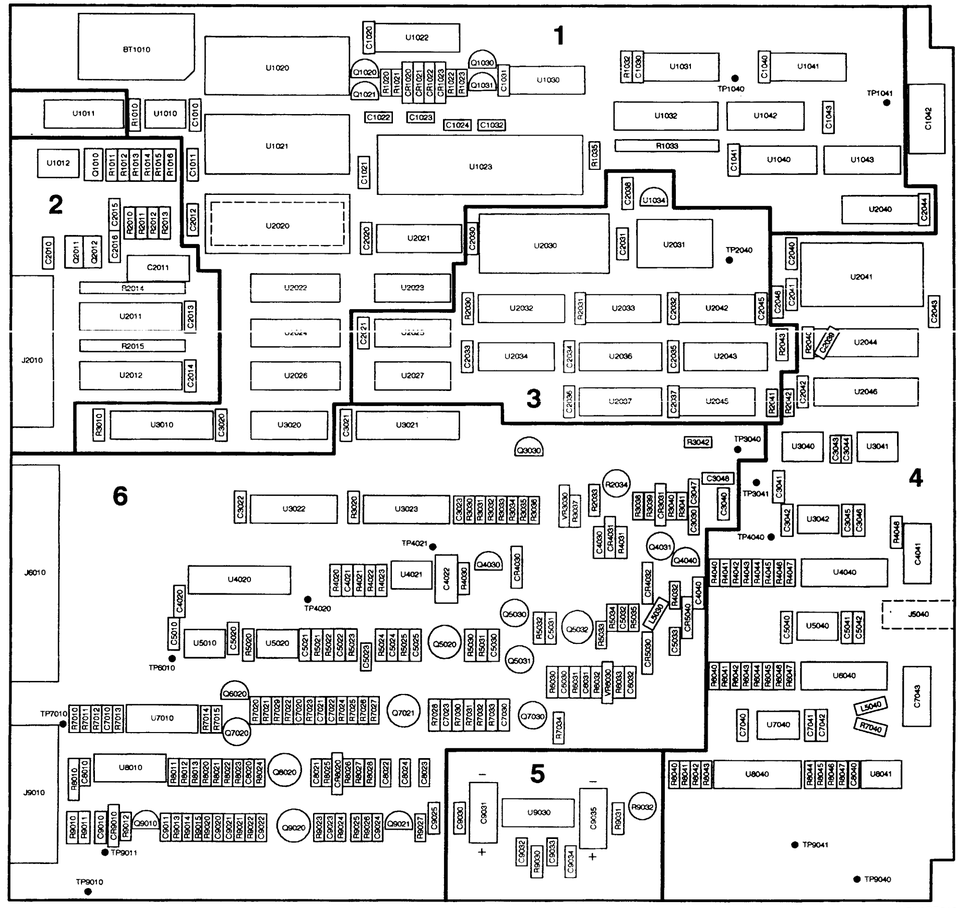
A1



KEY:

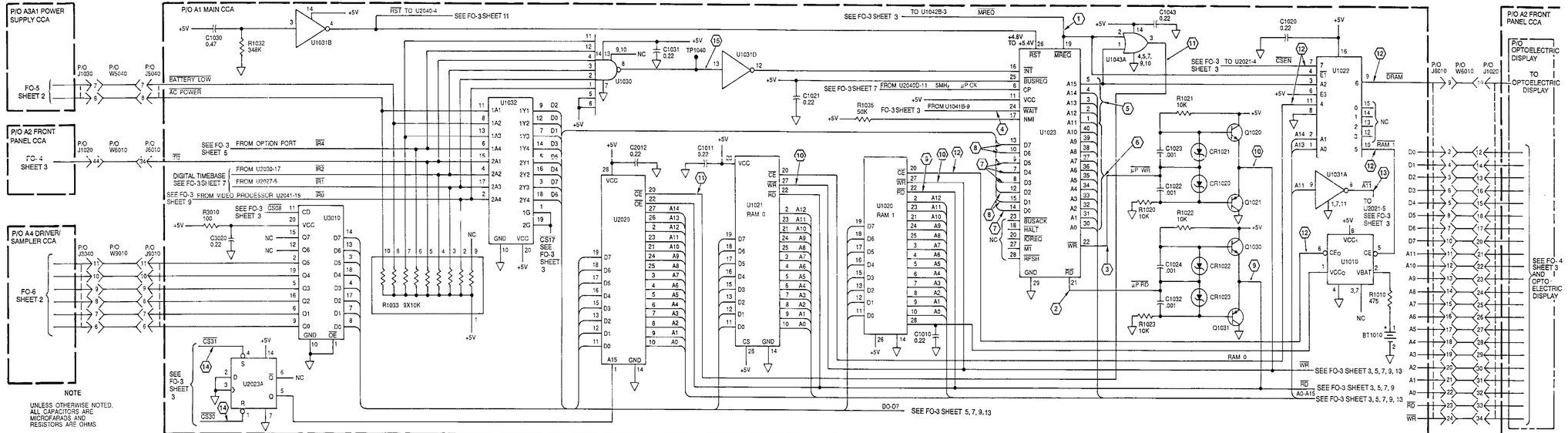
ALL A1 MAIN CCA SCHEMATIC DIAGRAMS ARE LOCATED IN FIGURE FO-3. THE FUNCTIONAL AREAS OF THE A1 MAIN CCA ARE AS FOLLOWS:

1. PROCESSOR AND ADDRESS DECODE (SHEETS 1, 2, 3, 4)
2. OPTION PORT INTERFACE (SHEETS 5, 6)
3. DIGITAL TIMEBASE (SHEETS 7, 8)
4. VIDEO PROCESSOR (SHEETS 9, 11)
5. MISCELLANEOUS ANALOG (SHEET 11)
6. ANALOG TIMEBASE (SHEETS 12, 13, 14)



CE2DZ012

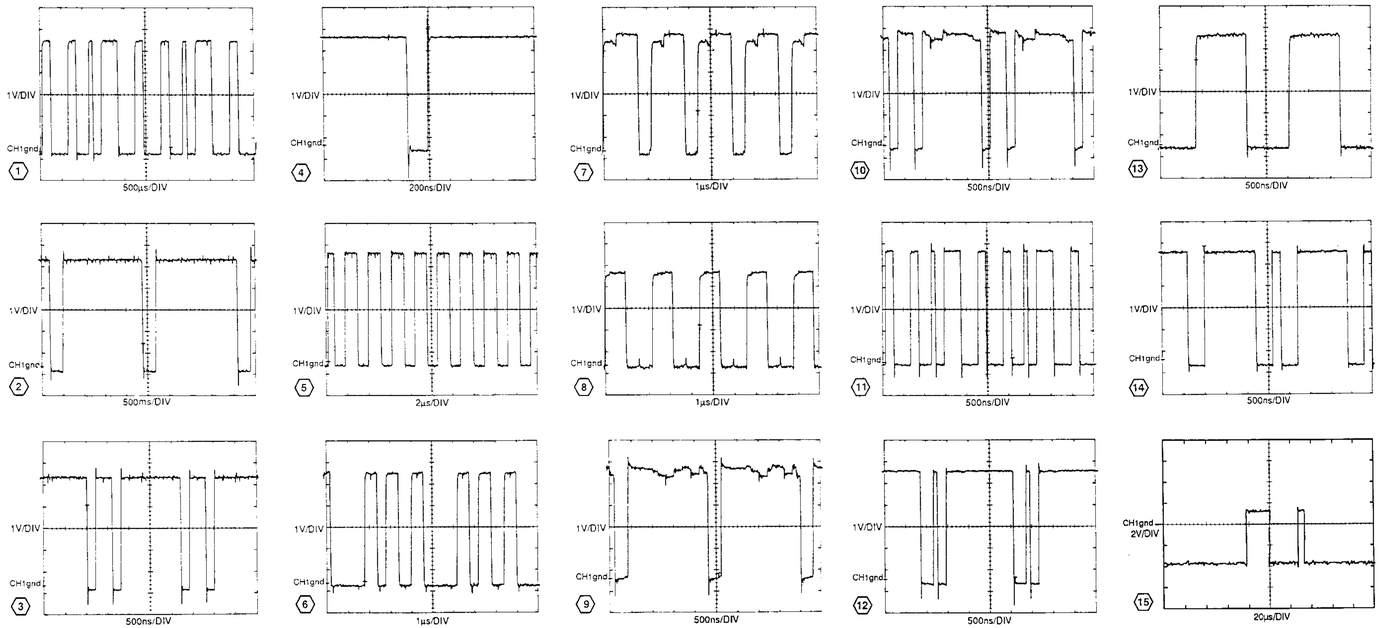
Figure FO-2. A1 Main CCA Component Locator



NOTE

UNLESS OTHERWISE NOTED, ALL CAPACITORS ARE MICROFARADS AND RESISTORS ARE OHMS.

Figure FO-3. A1 Main CCA Schematic Diagrams (Sheet 1 of 14)



NOTE:
TEST SET FRONT-PANEL CONTROL SETTINGS HAVE NO IMPACT ON THESE WAVEFORMS.

U1022

PIN	TEST FOR
1	Waveform 5
2	Waveform 5
3	Waveform 5
4	Waveform 1
5	Waveform 12
6	+5 VDC
7	Waveform 12
8	GND
9	Waveform 12
10	Waveform 12
11	Waveform 12
12	NC
13	NC
14	NC
15	NC
16	+5 VDC

U1023

PIN	TEST FOR
1	Waveform 5
2	Waveform 5
3	Waveform 5
4	Waveform 5
5	Waveform 5
6	5 MHz clock
7	Waveform 7
8	Waveform 7
9	Waveform 7
10	Waveform 8
11	+5 VDC
12	Waveform 8
13	Waveform 8
14	Waveform 7
15	Waveform 8
16	Waveform 15 inverted
17	+5 VDC
18	NC
19	Waveform 1
20	NC
21	Waveform 2
22	Waveform 3
23	NC
24	Waveform 4
25	+5 VDC
26	+4.8 to +5.4 VDC
27	NC
28	NC
29	GND
30	Waveform 6
31	Waveform 6
32	Waveform 6
33	Waveform 6
34	Waveform 6
35	Waveform 6
36	Waveform 6
37	Waveform 6
38	Waveform 6
39	Waveform 6
40	Waveform 6

U1030

PIN	TEST FOR
1	+12 VDC
2	Waveform 8
3	Waveform 7
4	Waveform 10
5	Waveform 9
6	Waveform 10
7	Waveform 9
8	GND
9	Waveform 9
10	Waveform 10
11	Waveform 9
12	Waveform 10
13	NC
14	GND
15	NC
16	NC

U1031A

PIN	TEST FOR
1	GND
7	GND
8	Waveform 13
9	Waveform 5
11	GND

CE2DZ021

Figure FO-3. A1 Main CCA Schematic Diagrams (Sheet 2 of 14)

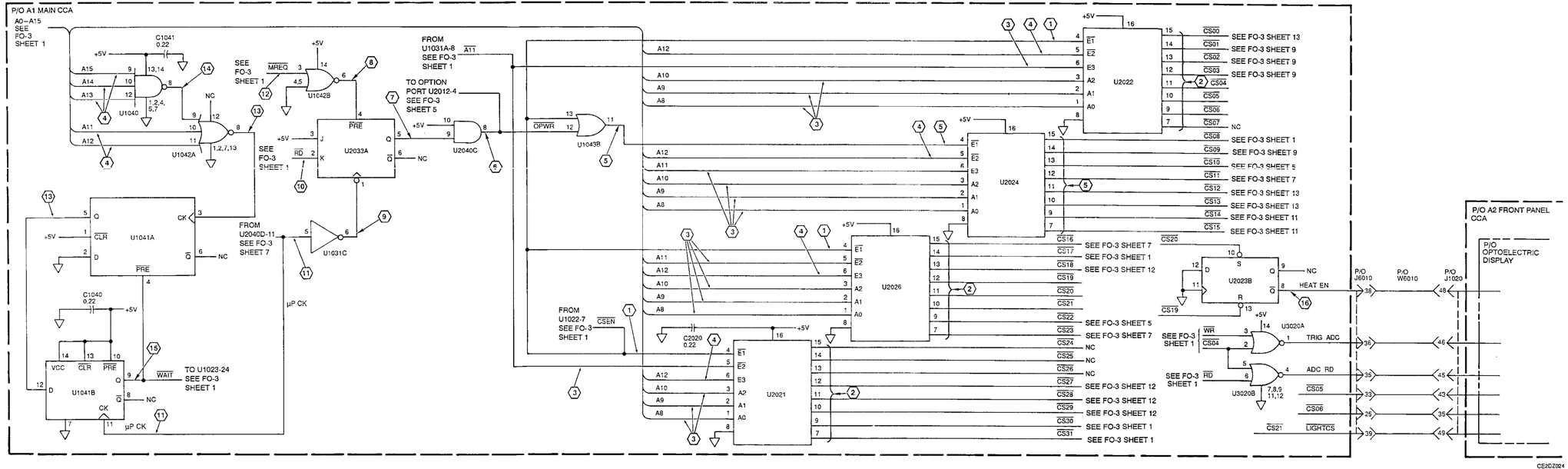
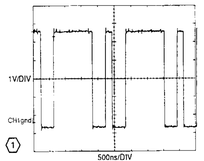
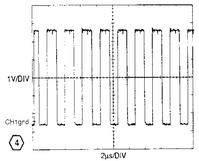
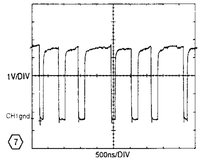
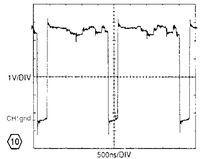


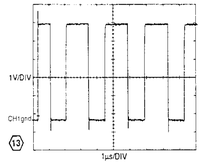
Figure FO-3. A1 Main CCA Schematic Diagrams (Sheet 3 of 14)

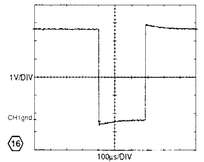


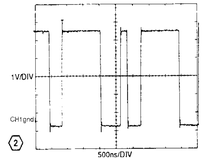


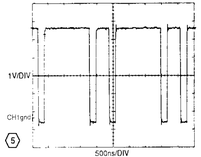


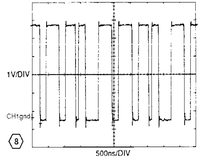


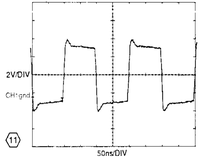


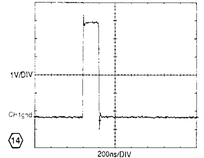


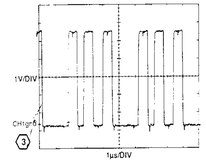


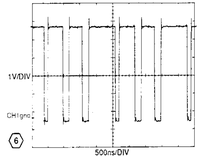


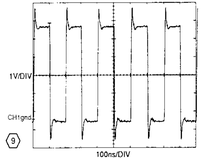


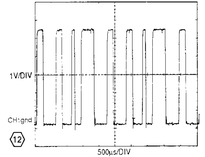


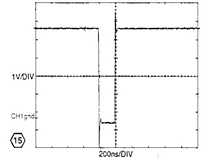












NOTE:
TEST SET FRONT-PANEL CONTROL SETTINGS HAVE NO IMPACT ON THESE WAVEFORMS.

U1031C

PIN	TEST FOR
5	Waveform 11
6	Waveform 9

U1040

PIN	TEST FOR
1	GND
2	GND
4	GND
5	GND
7	GND
8	Waveform 14
9	Waveform 4
10	Waveform 4
12	Waveform 4
13	+5 VDC
14	+5 VDC

U1041

PIN	TEST FOR
1	+5 VDC
2	GND
3	Waveform 13
4	Waveform 15
5	Waveform 13
6	NC
7	GND
8	NC
9	Waveform 15
10	+5 VDC
11	Waveform 11
12	Waveform 13
13	+5 VDC
14	+5 VDC

U1042

PIN	TEST FOR
1	GND
2	GND
3	Waveform 12
4	GND
5	GND
6	Waveform 8
7	GND
8	Waveform 13
9	Waveform 14
10	Waveform 4
11	Waveform 4
12	NC
13	GND
14	+5 VDC

U1043B

PIN	TEST FOR
11	Waveform 5
12	Waveform 6
13	Waveform 1

U2021

PIN	TEST FOR
1	Waveform 3
2	Waveform 3
3	Waveform 3
4	Waveform 1
5	Waveform 3 inverted
6	Waveform 4
7	Waveform 2
8	GND
9	Waveform 2
10	Waveform 2
11	Waveform 2
12	Waveform 2
13	Waveform 2
14	Waveform 2
15	Waveform 2
16	+5 VDC

U2022

PIN	TEST FOR
1	Waveform 3
2	Waveform 3
3	Waveform 3
4	Waveform 1
5	Waveform 4
6	Waveform 3 inverted
7	Waveform 2
8	GND
9	Waveform 2
10	Waveform 2
11	Waveform 2
12	Waveform 2
13	Waveform 2
14	Waveform 2
15	Waveform 2
16	+5 VDC

U2024

PIN	TEST FOR
1	Waveform 3
2	Waveform 3
3	Waveform 3
4	Waveform 5
5	Waveform 4
6	Waveform 3
7	Waveform 5
8	GND
9	Waveform 5
10	Waveform 5
11	Waveform 5
12	Waveform 5
13	Waveform 5
14	Waveform 5
15	Waveform 5
16	+5 VDC

U2026

PIN	TEST FOR
1	Waveform 3
2	Waveform 3
3	Waveform 3
4	Waveform 1
5	Waveform 3
6	Waveform 4
7	Waveform 2
8	GND
9	Waveform 2
10	Waveform 2
11	Waveform 2
12	Waveform 2
13	Waveform 2
14	Waveform 2
15	Waveform 2
16	+5 VDC

U2033A

PIN	TEST FOR
1	Waveform 9
2	Waveform 10
3	+5 VDC
4	Waveform 8
5	Waveform 7
6	NC

U2040C

PIN	TEST FOR
8	Waveform 6
9	Waveform 7
10	+5 VDC

CB2D028

Figure FO-3. A1 Main CCA Schematic Diagrams (Sheet 4 of 14)

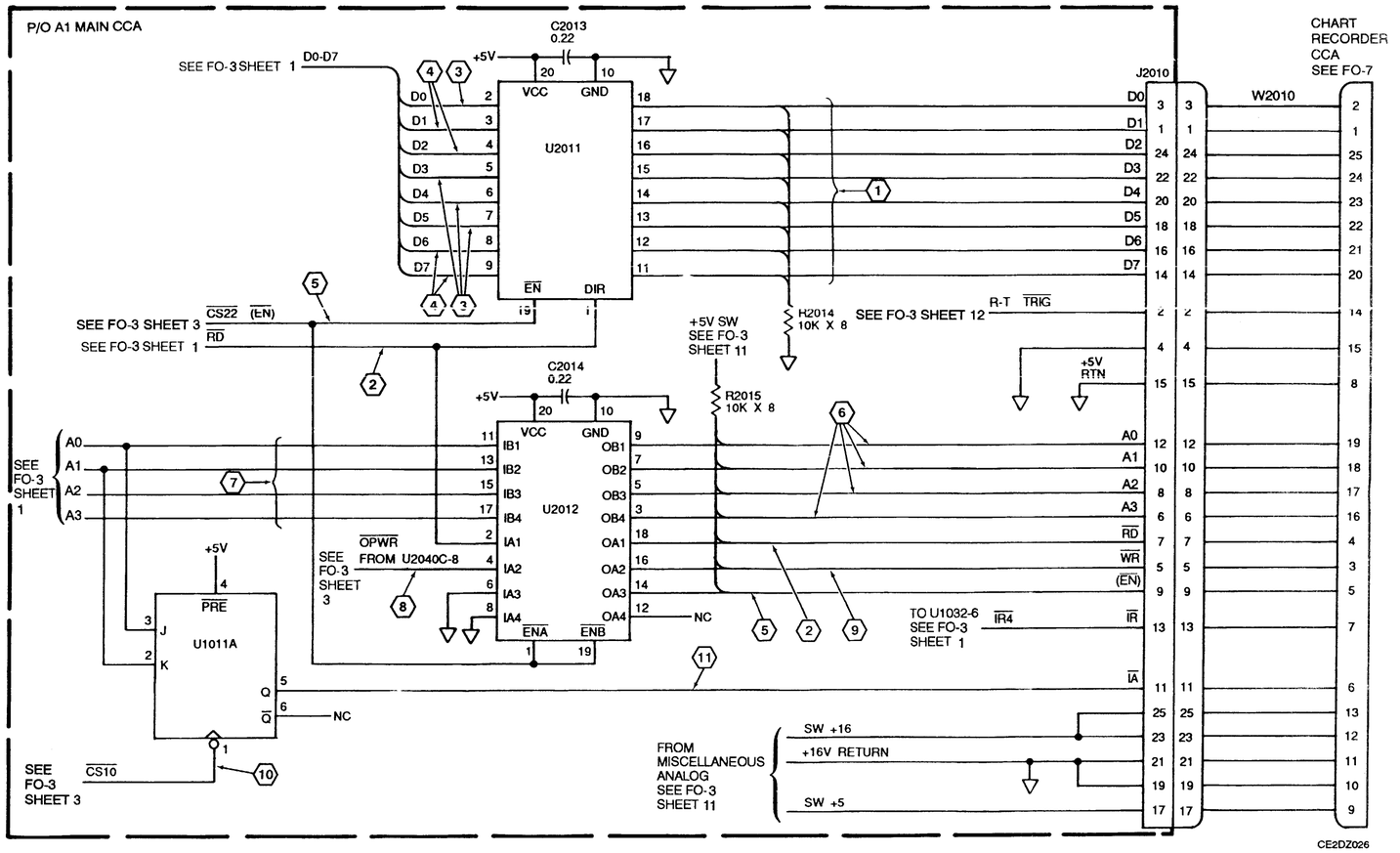
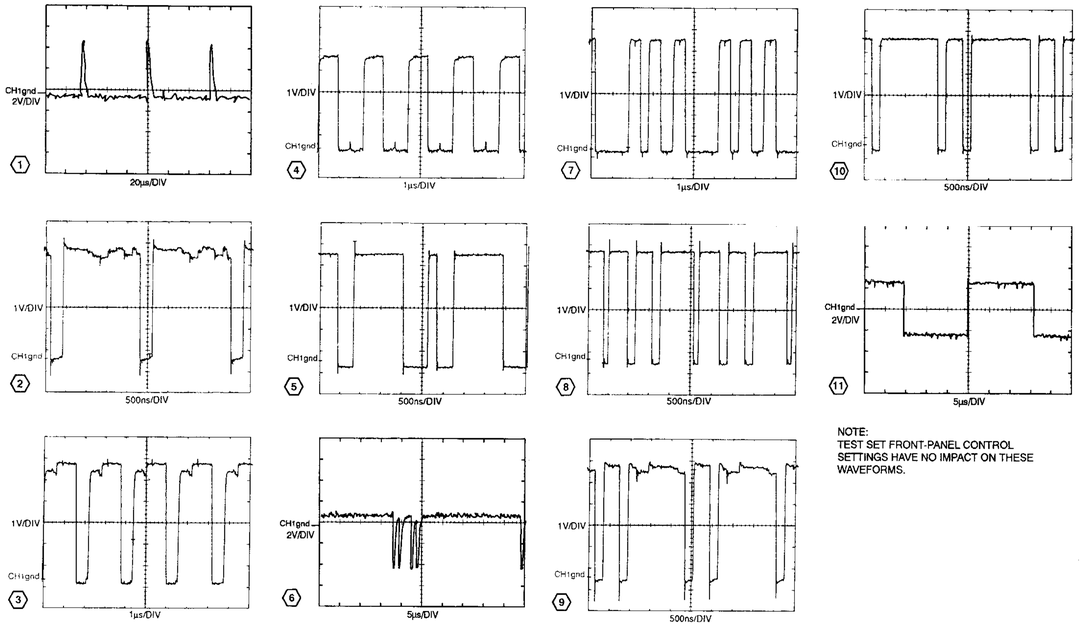


Figure FO-3. A1 Main CCA Schematic Diagrams (Sheet 5 of 14)



NOTE:
TEST SET FRONT-PANEL CONTROL SETTINGS HAVE NO IMPACT ON THESE WAVEFORMS.

U1011A

PIN	TEST FOR
1	Waveform 10
2	Waveform 7
3	Waveform 7
4	+5 VDC
5	Waveform 11
6	NC

U2011

PIN	TEST FOR
1	Waveform 2
2	Waveform 3
3	Waveform 4
4	Waveform 4
5	Waveform 3
6	Waveform 3
7	Waveform 3
8	Waveform 4
9	Waveform 4
10	GND
11	Waveform 1
12	Waveform 1
13	Waveform 1
14	Waveform 1
15	Waveform 1
16	Waveform 1
17	Waveform 1
18	Waveform 1
19	Waveform 5
20	+5 VDC

U2012

PIN	TEST FOR
1	Waveform 5
2	Waveform 2
3	Waveform 6
4	Waveform 8
5	Waveform 6
6	GND
7	Waveform 6
8	GND
9	Waveform 6
10	GND
11	Waveform 7
12	NC
13	Waveform 7
14	Waveform 5
15	Waveform 7
16	Waveform 9
17	Waveform 7
18	Waveform 2
19	Waveform 5
20	+5 VDC

CE2DZ025

Figure FO-3. A1 Main CCA Schematic Diagrams (Sheet 6 of 14)

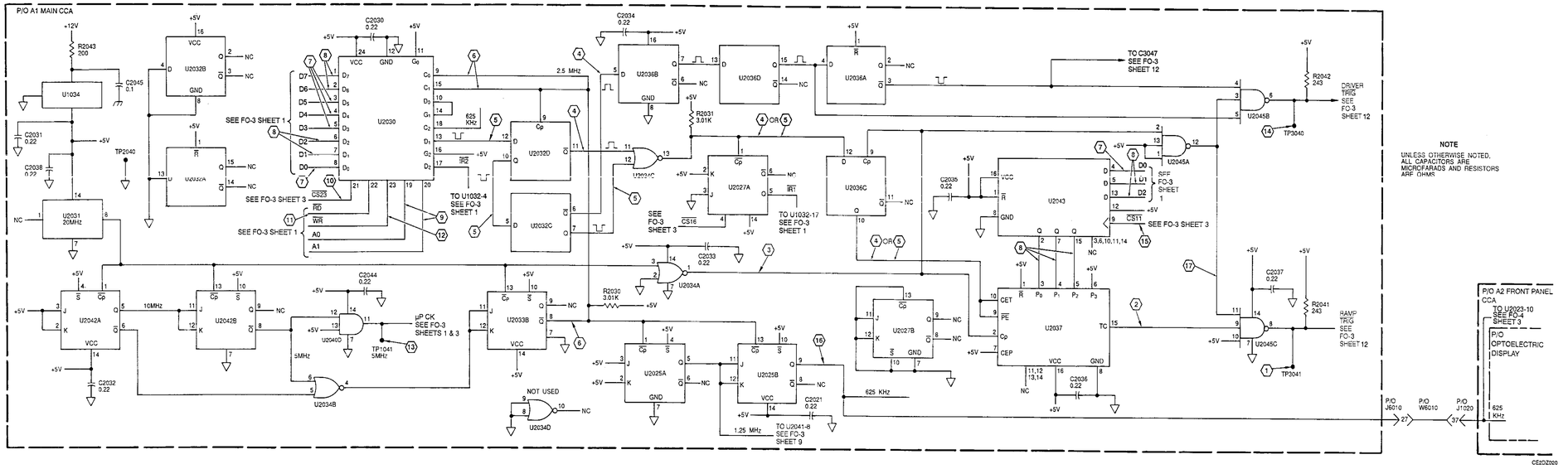
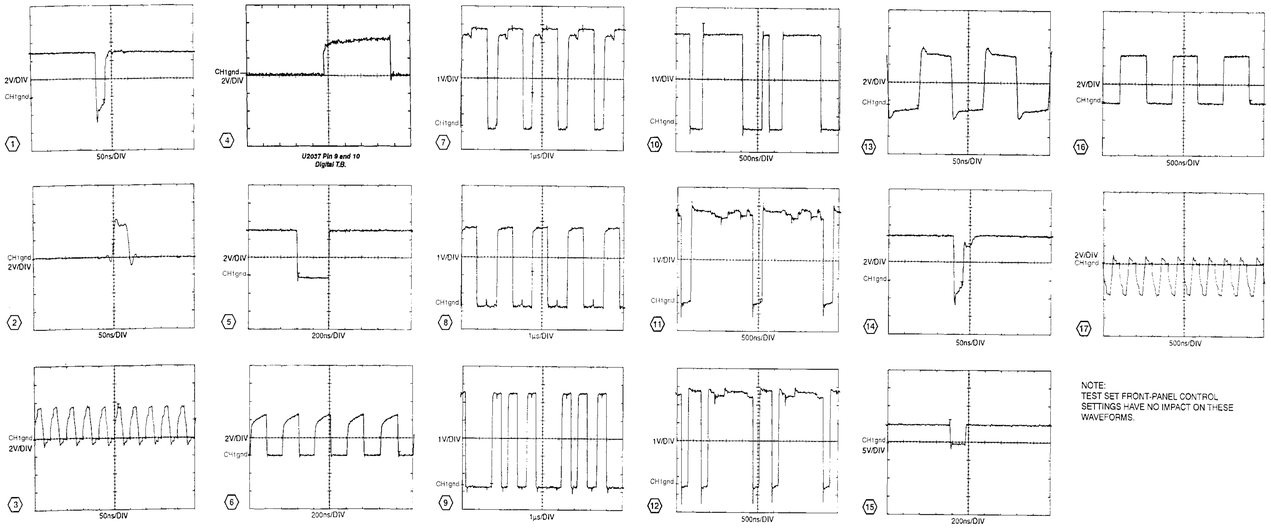


Figure FO-3. A1 Main CCA Schematic Diagrams (Sheet 7 of 14)



NOTE:
TEST SET FRONT-PANEL CONTROL SETTINGS HAVE NO IMPACT ON THESE WAVEFORMS.

U1034

PIN	TEST FOR
Input	+12 VDC
Output	+5 VDC
Ground	GND

U2025

PIN	TEST FOR
1	Waveform 6
2	+5 VDC
3	+5 VDC
4	+5 VDC
5	1.25 MHz
6	NC
7	GND
8	NC
9	Waveform 16
10	+5 VDC
11	1.25 MHz
12	1.25 MHz
13	Waveform 6
14	+5 VDC

U2045

PIN	TEST FOR
1	+5 VDC
2	Waveform 3
3	Waveform 3 inverted
4	Waveform 5
5	Waveform 4
6	Waveform 14
7	GND
8	Waveform 1
9	Waveform 2
10	+5 VDC
11	Waveform 3 inverted
12	Waveform 3 inverted
13	+5 VDC
14	+5 VDC

U2030

PIN	TEST FOR
1	Waveform 8
2	Waveform 8
3	Waveform 7
4	Waveform 7
5	Waveform 7
6	Waveform 8
7	Waveform 8
8	Waveform 7
9	2.5 MHz
10	Jump to pin 14
11	+5 VDC
12	GND
13	Waveform 5
14	Jump to pin 10
15	2.5 MHz
16	+5 VDC
17	IR2
18	625 kHz
19	Waveform 9
20	Waveform 9
21	Waveform 10
22	Waveform 11
23	Waveform 12
24	+5 VDC

U2031

PIN	TEST FOR
1	NC
7	GND
8	20 MHz
14	+5 VDC

U2032

PIN	TEST FOR
1	+5 VDC
2	NC
3	NC
4	GND
5	Waveform 5
6	Waveform 4
7	Waveform 5
8	GND
9	Waveform 6
10	Waveform 5
11	Waveform 4
12	Waveform 5
13	GND
14	NC
15	NC
16	+5 VDC

U2034

PIN	TEST FOR
1	Waveform 3
2	GND
3	20 MHz
4	Waveform 6 inverted
5	10 MHz low
6	5 MHz low
7	GND
8	GND
9	GND
10	NC
11	Waveform 4
12	Waveform 5
13	Waveform 4 or 5
14	+5 VDC

U2036

PIN	TEST FOR
1	+5 VDC
2	NC
3	Waveform 5
4	Waveform 4
5	Waveform 4
6	NC
7	Waveform 5
8	GND
9	Waveform 3
10	Waveform 4 or 5
11	NC
12	Waveform 4 or 5
13	Waveform 4
14	NC
15	Waveform 4
16	+5 VDC

U2037

PIN	TEST FOR
1	+5 VDC
2	Waveform 3
3	Waveform 8
4	Waveform 8
5	Waveform 8
6	+5 VDC
7	+5 VDC
8	GND
9	Waveform 4
10	Waveform 4
11	NC
12	NC
13	NC
14	NC
15	Waveform 2
16	+5 VDC

U2040D

PIN	TEST FOR
7	GND
11	5 MHz waveform 13
12	5 MHz low
13	+5 VDC
14	+5 VDC

U2042

PIN	TEST FOR
1	20 MHz
2	+5 VDC
3	+5 VDC
4	+5 VDC
5	10 MHz high
6	10 MHz low
7	GND
8	5 MHz low
9	NC
10	+5 VDC
11	10 MHz high
12	10 MHz high
13	20 MHz
14	+5 VDC

U2043

PIN	TEST FOR
1	+5 VDC
2	Waveform 8
3	NC
4	Waveform 7
5	Waveform 8
6	NC
7	Waveform 8
8	GND
9	Waveform 15
10	NC
11	NC
12	+5 VDC
13	Waveform 8
14	NC
15	Waveform 8
16	+5 VDC

CE2DD019

Figure FO-3. A1 Main CCA Schematic Diagrams (Sheet 8 of 14)

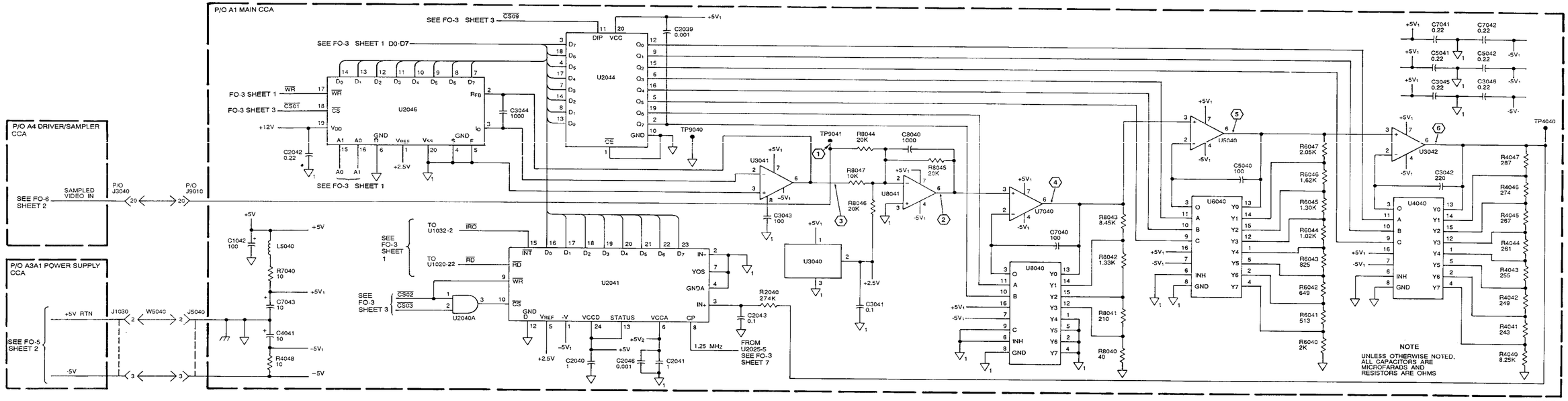


Figure FO-3. A1 Main CCA Schematic Diagrams (Sheet 9 of 14)

NOTE:
TEST SET FRONT-PANEL CONTROL SETTINGS HAVE NO IMPACT ON THESE WAVEFORMS.

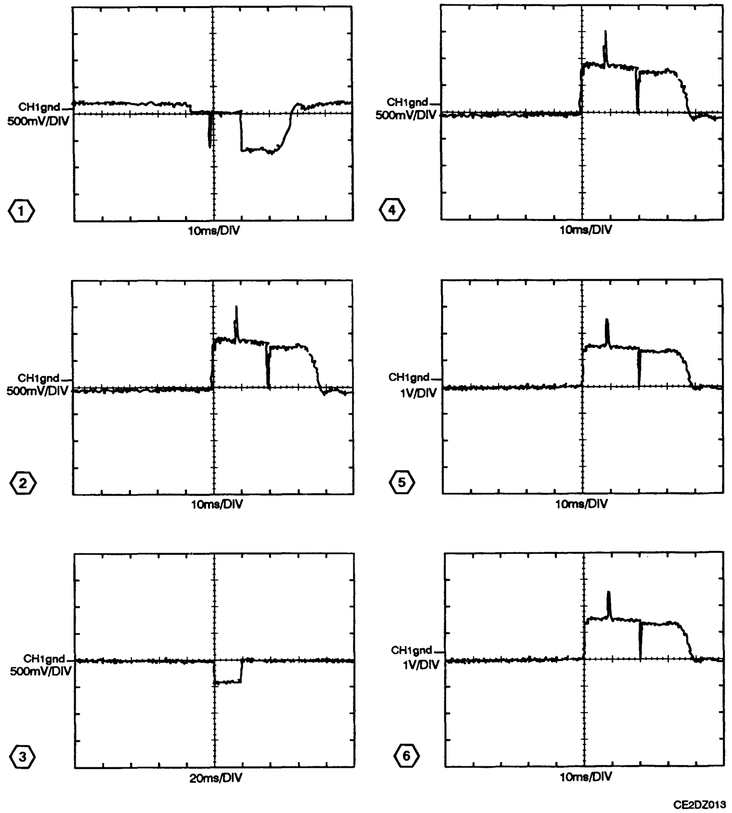
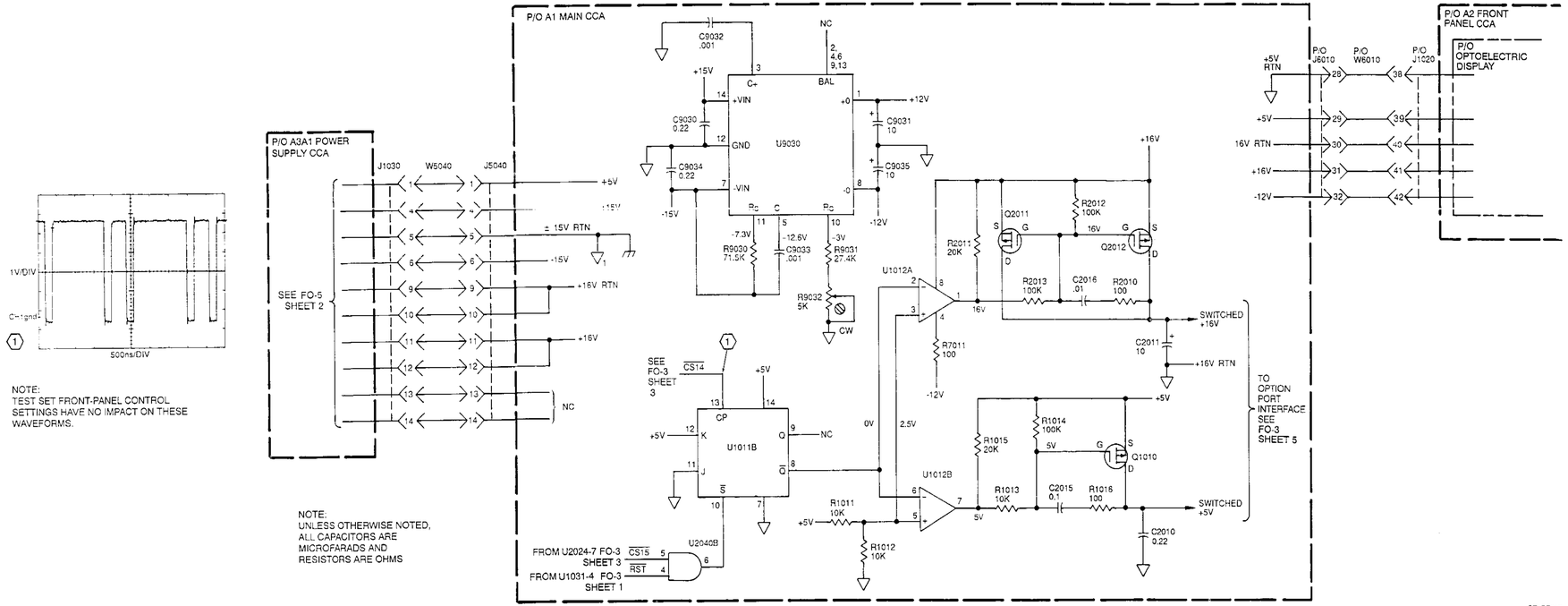


Figure FO-3. A1 Main CCA Schematic Diagrams
(Sheet 10 of 14)



CE2DZ015

Figure FO-3. A1 Main CCA Schematic Diagrams (Sheet 11 of 14)

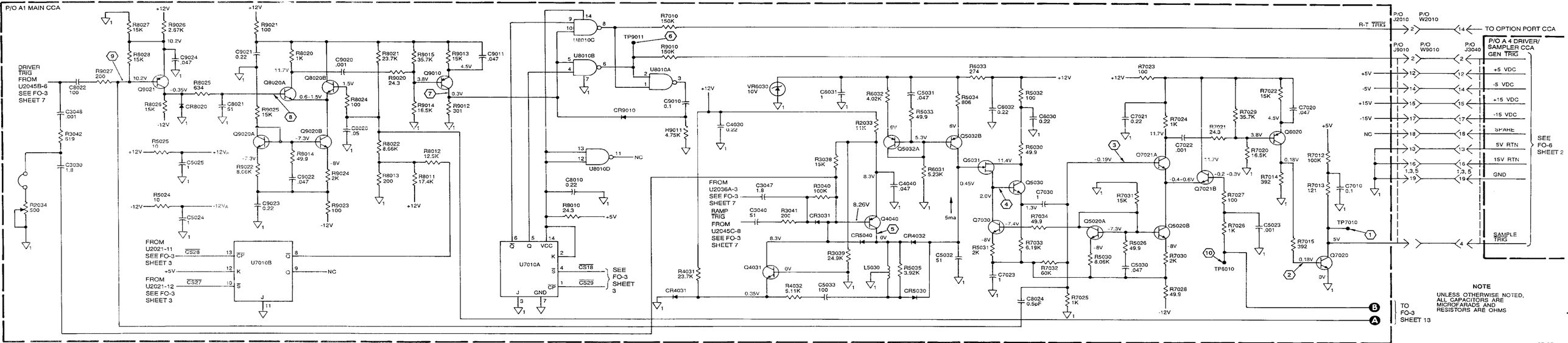


Figure FO-3. A1 Main CCA Schematic Diagrams (Sheet 12 of 14)

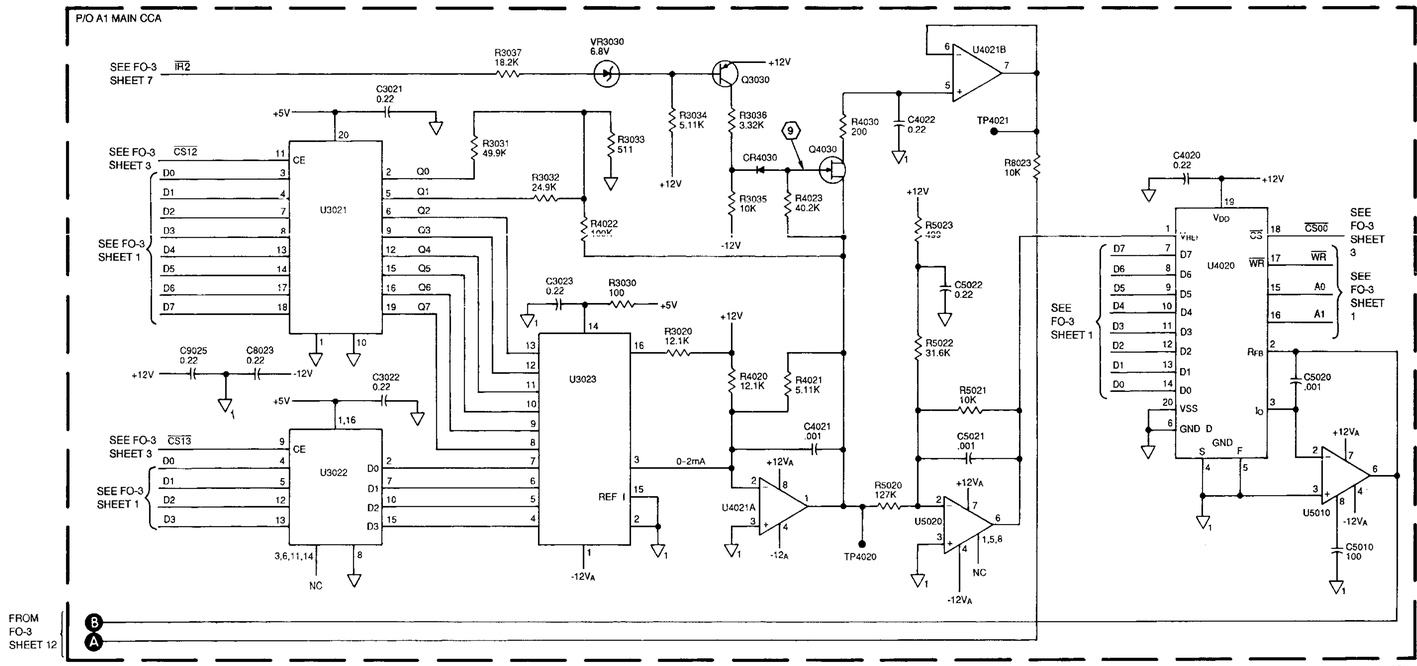
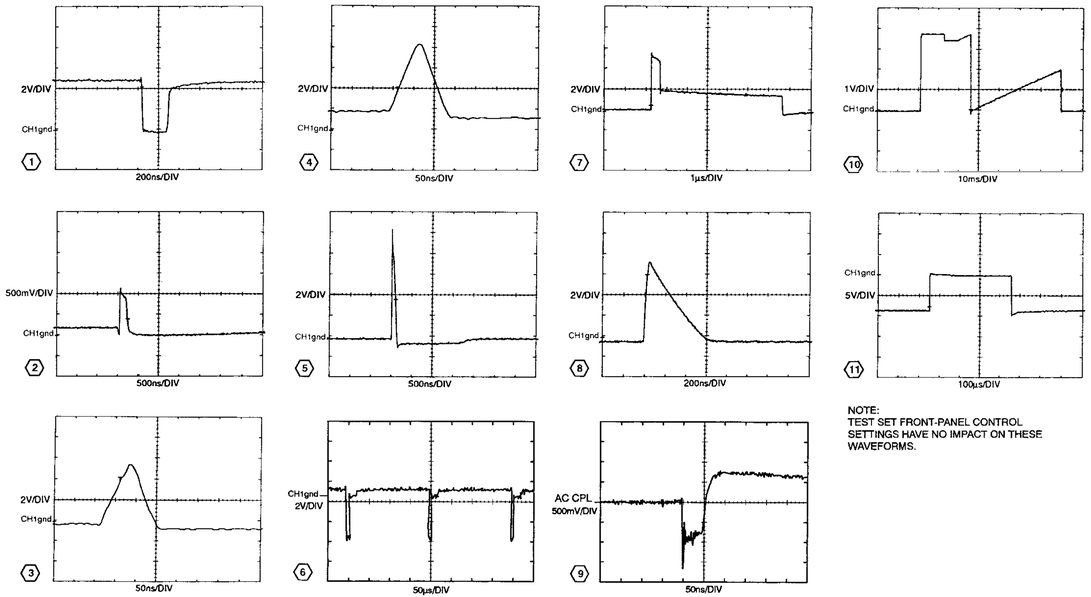


Figure FO-3. A1 Main CCA Schematic Diagrams (Sheet 13 of 14)



NOTE:
TEST SET FRONT-PANEL CONTROL SETTINGS HAVE NO IMPACT ON THESE WAVEFORMS.

U7010A

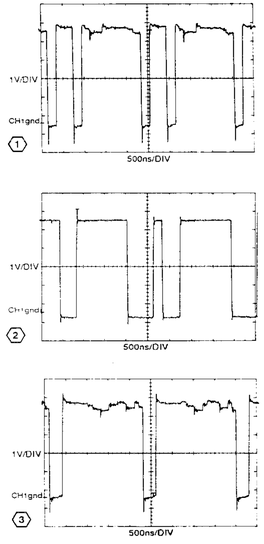
PIN	TEST FOR
1	H
2	+5 VDC
3	GND
4	H
5	H
6	L
7	GND
14	+5 VDC

U8010B

PIN	TEST FOR
4	H
5	Waveform 7
6	Waveform 6

CE20Z016

Figure FO-3. A1 Main CCA Schematic Diagrams (Sheet 14 of 14)



U2024, U2025, U3025, U3031

PIN	TEST FOR								
1	H	L	L	L	L	L	L	L	L
2	*	L	L	L	L	H	H	H	H
3	*	*	*	*	*	*	*	L	H
4	*	*	*	*	*	L	H	*	*
5	*	*	*	L	H	*	*	*	*
6	*	L	H	*	*	*	*	*	*
7	Z	L	H	L	H	L	H	L	H
8	GND	GND	GND	GND	GND	GND	GND	GND	GND
9	Z	L	H	L	H	L	H	L	H
10	*	L	H	*	*	*	*	*	*
11	*	*	*	L	H	*	*	*	*
12	*	*	*	*	*	L	H	*	*
13	*	*	*	*	*	*	*	L	H
14	*	L	L	H	H	L	L	H	H
15	H	L	L	L	L	L	L	L	L
16	+5 VDC	+5 VDC	+5 VDC	+5 VDC	+5 VDC	+5 VDC	+5 VDC	+5 VDC	+5 VDC

KEY:
* NA
H HIGH 4 TO 5V
L LOW 0 TO 1V
Z HIGH IMPEDANCE

NOTE:
TEST SET FRONT-PANEL CONTROL SETTINGS HAVE NO IMPACT ON THESE WAVEFORMS.

FRONT PANEL SWITCH SETTINGS

SWITCH	CKT NUMBER	FULLY CCW COUNTS	FULLY CW COUNTS
NOISE FILTER switch	S3012	0	9
DIST/DIV switch	S3020	0	10
Vp tenths' switch	S3021	3	9
Vp hundreths'	S3022	0	9

TRUTH TABLE
FRONT PANEL SWITCHES

L = 0–1 Volts H = 4–5 Volts

COUNTS	PIN 2	PIN 3	PIN 4	PIN 5
0	L	L	L	L
1	H	L	L	L
2	L	H	L	L
3	H	H	L	L
4	L	L	H	L
5	H	L	H	L
6	L	H	H	L
7	H	H	H	L
8	L	L	L	H
9	H	L	L	H

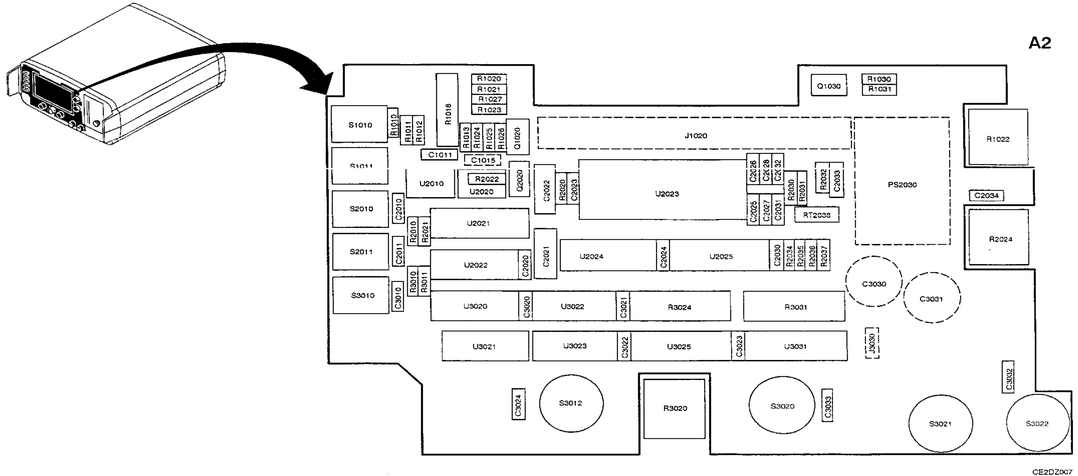


Figure FO-4. A2 Front Panel CCA Component Locator and Schematic Diagrams (Sheet 1 of 3)

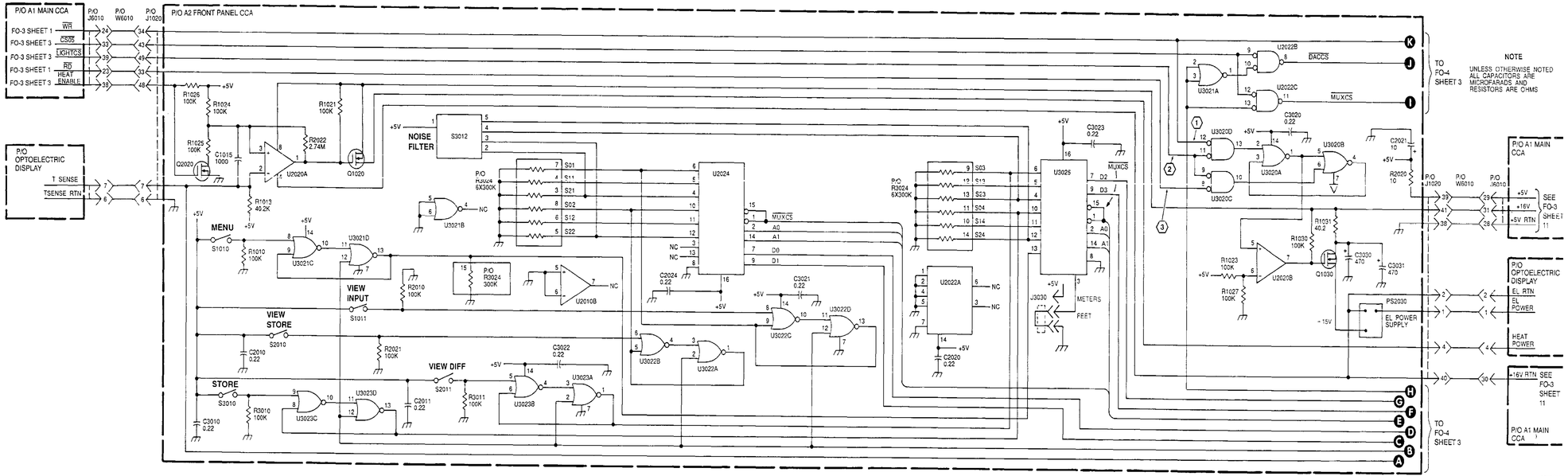


Figure FO-4. A2 Front Panel CCA Component Locator and Schematic Diagrams (Sheet 2 of 3)

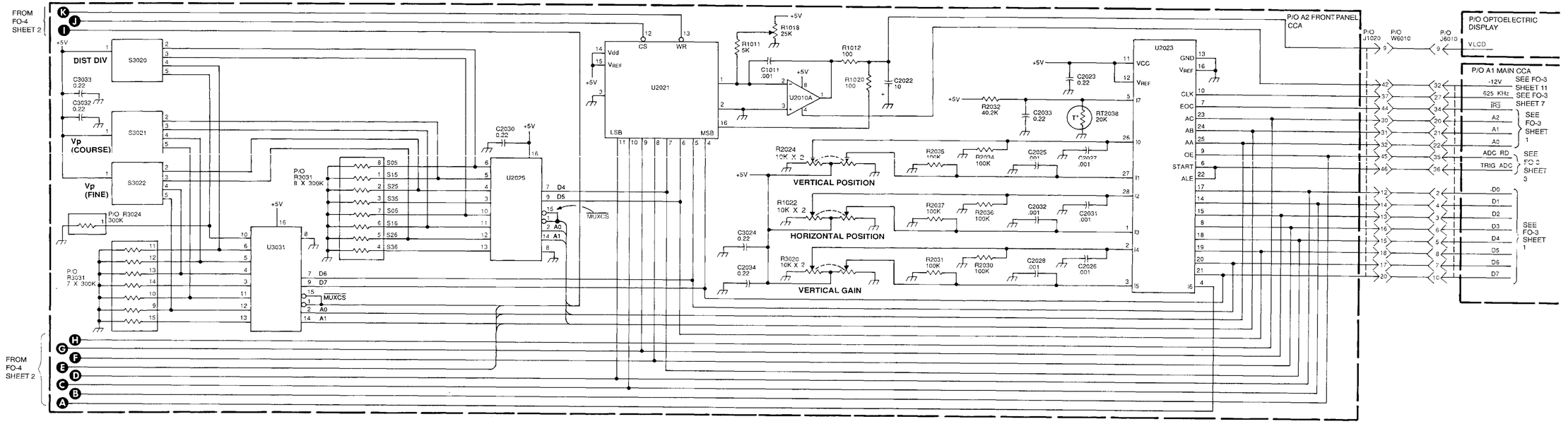
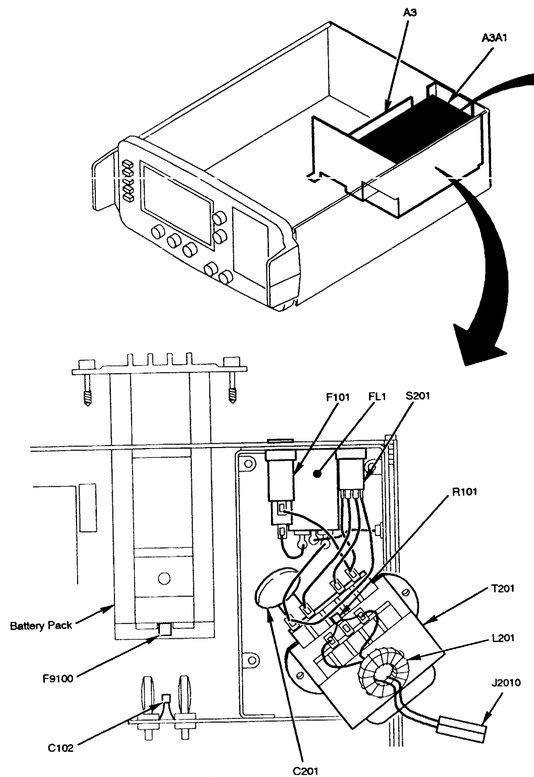
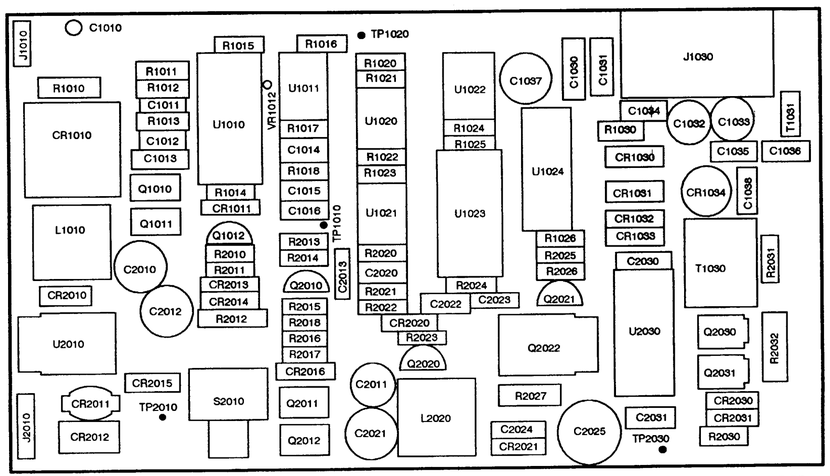


Figure FO-4. A2 Front Panel CCA Component Locator and Schematic Diagrams (Sheet 3 of 3)



A3

A3A1



CE2DZ002

Figure FO-5. A3 Power Supply and A3A1 Power Supply CCA Component Locator and Schematic Diagrams (Sheet 1 of 3)

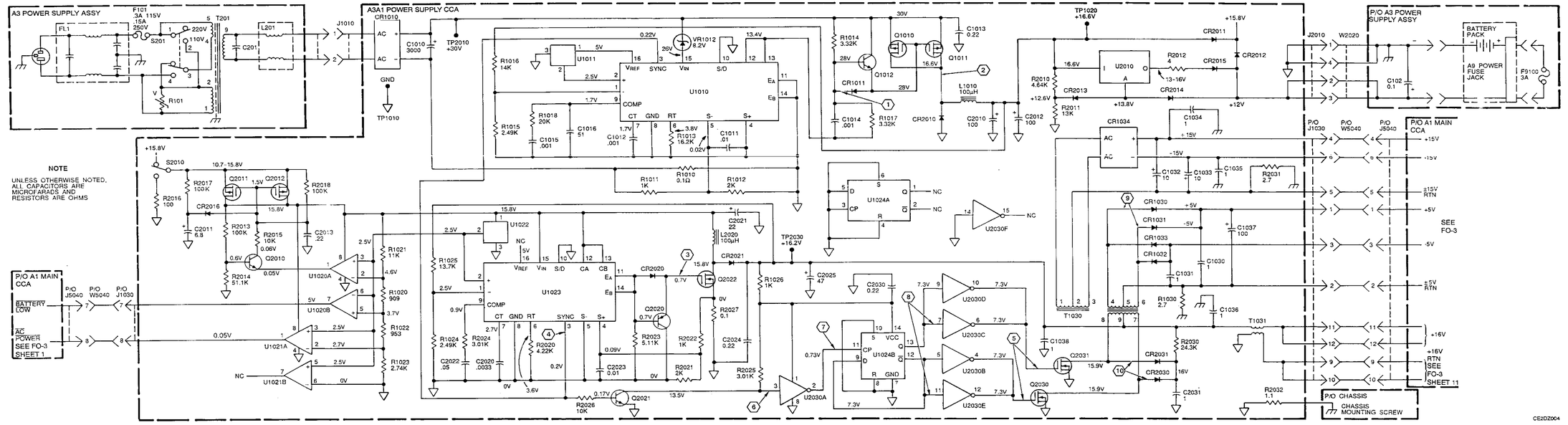
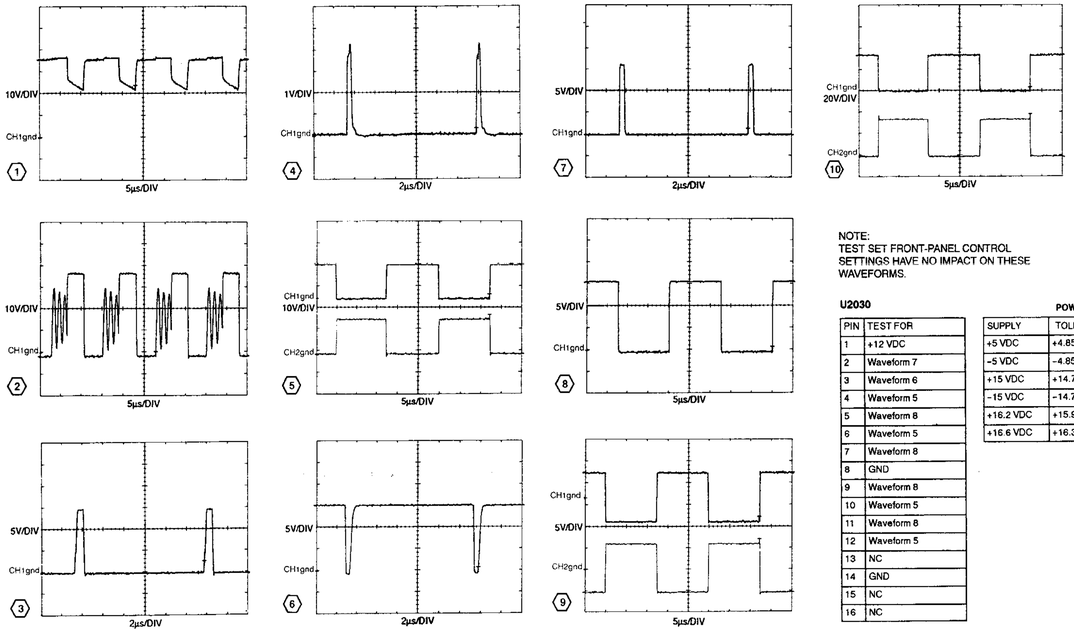


Figure FO-5. A3 Power Supply and A3A1 Power Supply CCA Component Locator and Schematic Diagrams (Sheet 2 of 3)



NOTE:
TEST SET FRONT-PANEL CONTROL SETTINGS HAVE NO IMPACT ON THESE WAVEFORMS.

U2030

PIN	TEST FOR
1	+12 VDC
2	Waveform 7
3	Waveform 6
4	Waveform 5
5	Waveform 8
6	Waveform 5
7	Waveform 8
8	GND
9	Waveform 8
10	Waveform 5
11	Waveform 8
12	Waveform 5
13	NC
14	GND
15	NC
16	NC

POWER SUPPLY VOLTAGES

SUPPLY	TOLERANCE	TEST POINT
+5 VDC	+4.85 to +5.25 VDC	J1030/J5040, PIN 1
-5 VDC	-4.85 to -5.25 VDC	J1030/J5040, PIN 3
+15 VDC	+14.7 to +15.3 VDC	J1030/J5040, PIN 4
-15 VDC	-14.7 to -15.3 VDC	J1030/J5040, PIN 6
+16.2 VDC	+15.9 to +16.5 VDC	TP2030
+16.6 VDC	+16.3 to +16.9 VDC	TP1020

CE2DZ009

Figure FO-5. A3 Power Supply and A3A1 Power Supply CCA Component Locator and Schematic Diagrams (Sheet 3 of 3)

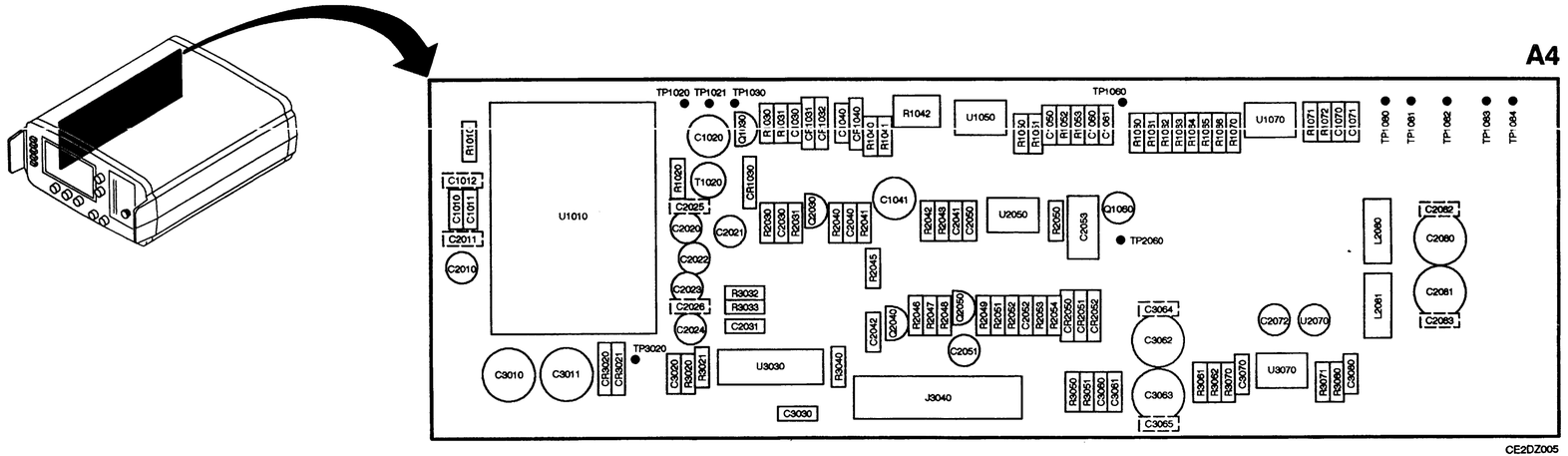


Figure FO-6. A4 Driver/Sampler CCA Component Locator and Schematic Diagrams (Sheet 1 of 2)

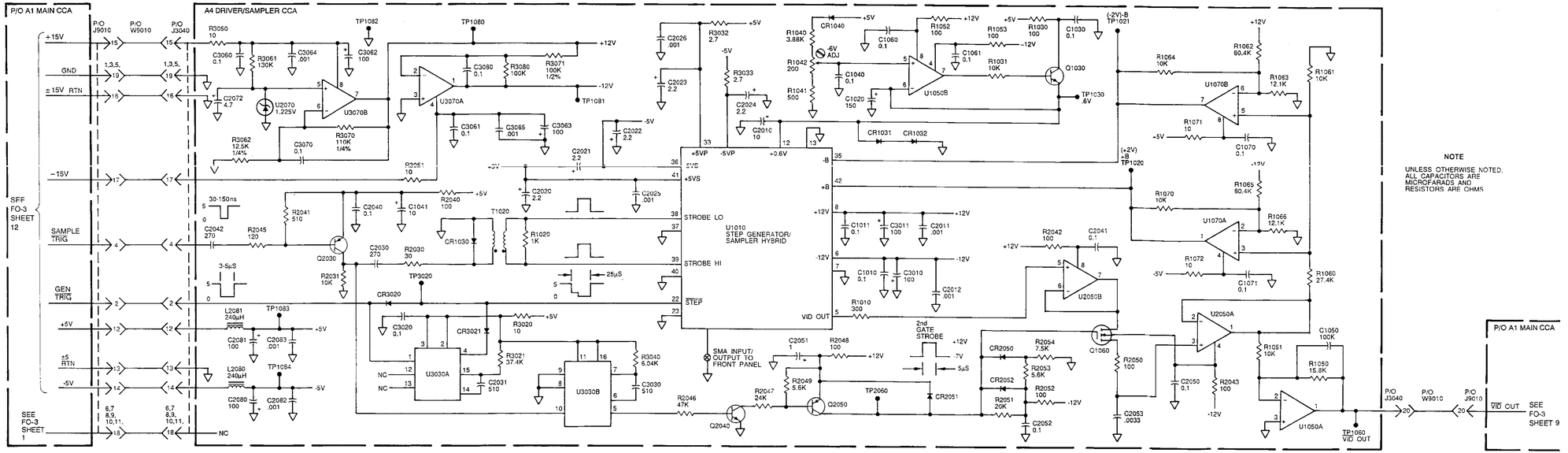


Figure FO-6. A4 Driver/Sampler CCA Component Locator and Schematic Diagrams (Sheet 2 of 2)

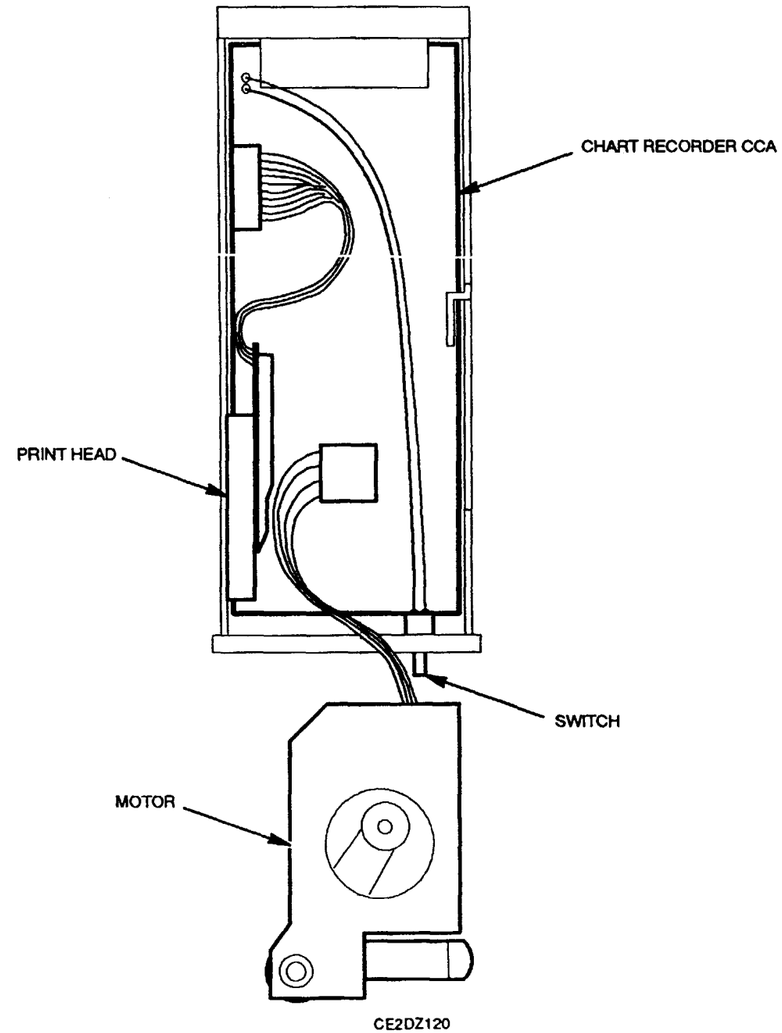
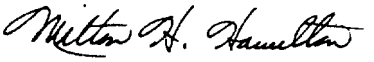


Figure FO-7. A10 Chart Recorder Assembly Component Locator

By Order of the Secretary of the Army:

GORDON R. SULLIVAN
General, United States Army
Chief of Staff

Official:



MILTON H. HAMILTON
Administrative Assistant to the
Secretary of the Army

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To: 2028@redstone.army.mil

Subject: DA Form 2028

1. ***From:*** Joe Smith
2. *Unit:* home
3. ***Address:*** 4300 Park
4. ***City:*** Hometown
5. ***St:*** MO
6. ***Zip:*** 77777
7. ***Date Sent:*** 19−OCT−93
8. ***Pub no:*** 55−2840−229−23
9. ***Pub Title:*** TM
10. ***Publication Date:*** 04−JUL−85
11. *Change Number:* 7
12. *Submitter Rank:* MSG
13. ***Submitter FName:*** Joe
14. *Submitter MName:* T
15. ***Submitter LName:*** Smith
16. ***Submitter Phone:*** 123−123−1234
17. ***Problem:*** **1**
18. *Page:* 2
19. *Paragraph:* 3
20. *Line:* 4
21. *NSN:* 5
22. *Reference:* 6
23. *Figure:* 7
24. *Table:* 8
25. *Item:* 9
26. *Total:* 123
27. ***Text:***

This is the text for the problem below line 27.

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TO: (*Forward to proponent of publication or form)(Include ZIP Code)* Commander, U.S. Army Aviation and Missile Command ATTN: AMSAM–MMC–MA–NP Redstone Arsenal, 35898	FROM: (*Activity and location)(Include ZIP Code)* MSG, Jane Q. Doe 1234 Any Street Nowhere Town, AL 34565	

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PUBLICATION/FORM NUMBER	DATE	TITLE
TM 9–1005–433–24	16 Sep 2002	Organizational, Direct Support, And General Support Maintenance Manual for Machine Gun, .50 Caliber M3P and M3P Machine Gun Electrical Test Set Used On Avenger Air Defense Weapon System

ITEM NO.	PAGE NO.	PARA–GRAPH	LINE NO. *	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON
1	WP0005 PG 3		2			Test or Corrective Action column should identify a different WP number.

** Reference to line numbers within the paragraph or subparagraph.*

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/ AUTOVON, PLUS EXTENSION	SIGNATURE
MSG, Jane Q. Doe, SFC	788–1234	

TO: (*Forward direct to addressee listed in publication)*	**FROM:** (*Activity and location) (Include ZIP Code)*	**DATE**
Commander, U.S. Army Aviation and Missile Command ATTN: AMSAM–MMC–MA–NP Redstone Arsenal, 35898	MSG, Jane Q. Doe 1234 Any Street Nowhere Town, AL 34565	8/30/02

PART II – REPAIR PARTS AND SPECIAL TOOL LISTS AND SUPPLY CATALOGS/SUPPLY MANUALS

PUBLICATION NUMBER	DATE	TITLE

PAGE NO.	COLM NO.	LINE NO.	NATIONAL STOCK NUMBER	REFERENCE NO.	FIGURE NO.	ITEM NO.	TOTAL NO. OF MAJOR ITEMS SUPPORTED	RECOMMENDED ACTION

PART III – REMARKS (*Any general remarks or recommendations, or suggestions for improvement of publications and blank forms. Additional blank sheets may be used if more space is needed.)*

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MSG, Jane Q. Doe, SFC	788–1234	

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PUBLICATION/FORM NUMBER	DATE	TITLE

ITEM NO.	PAGE NO.	PARA–GRAPH	LINE NO. *	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON

** Reference to line numbers within the paragraph or subparagraph.*

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PAGE NO.	COLM NO.	LINE NO.	NATIONAL STOCK NUMBER	REFERENCE NO.	FIGURE NO.	ITEM NO.	TOTAL NO. OF MAJOR ITEMS SUPPORTED	RECOMMENDED ACTION

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ITEM NO.	PAGE NO.	PARA–GRAPH	LINE NO. *	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON

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PAGE NO.	COLM NO.	LINE NO.	NATIONAL STOCK NUMBER	REFERENCE NO.	FIGURE NO.	ITEM NO.	TOTAL NO. OF MAJOR ITEMS SUPPORTED	RECOMMENDED ACTION

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ITEM NO.	PAGE NO.	PARA–GRAPH	LINE NO. *	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON

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TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/ AUTOVON, PLUS EXTENSION	SIGNATURE

TO: (*Forward direct to addressee listed in publication)*	**FROM:** (*Activity and location) (Include ZIP Code)*	**DATE**

PART II – REPAIR PARTS AND SPECIAL TOOL LISTS AND SUPPLY CATALOGS/SUPPLY MANUALS

PUBLICATION NUMBER	DATE	TITLE

PAGE NO.	COLM NO.	LINE NO.	NATIONAL STOCK NUMBER	REFERENCE NO.	FIGURE NO.	ITEM NO.	TOTAL NO. OF MAJOR ITEMS SUPPORTED	RECOMMENDED ACTION

PART III – REMARKS (*Any general remarks or recommendations, or suggestions for improvement of publications and blank forms. Additional blank sheets may be used if more space is needed.)*

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE

The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 decagram = 10 grams = .35 ounce
1 hectogram = 10 decagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Liquid Measure

1 centiliter = 10 milliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3.38 fl. ounces
1 liter = 10 deciliters = 33.81 fl. ounces
1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

To change	*To*	*Multiply by*	*To change*	*To*	*Multiply by*
inches	centimeters	2.540	ounce-inches	Newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29,573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	Newton-meters	1.356	metric tons	short tons	1.102
pound-inches	Newton-meters	.11296			

Temperature (Exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C