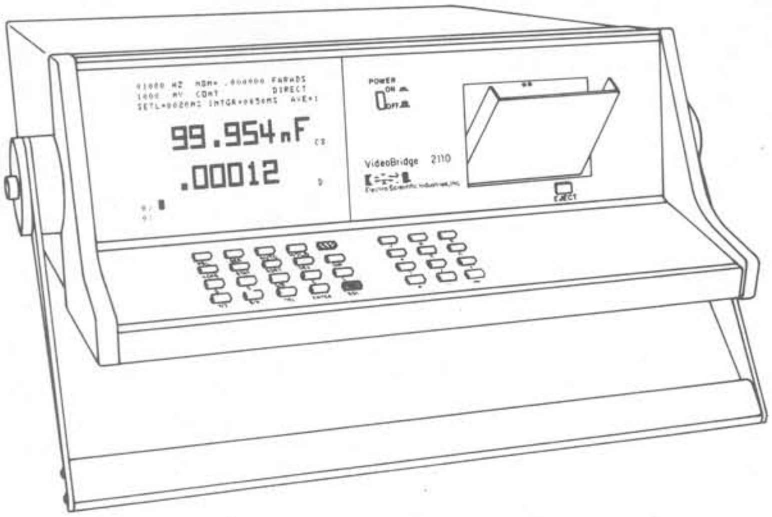
MODEL 2100/2110 VideoBridge

Auto LRC Meter

Service Manual

Part Number 46507 June 1981



Electro Scientific Industries, Inc.

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PROTECT AGAINST ELECTROSTATIC DISCHARGE

In this instrument there are MOS and FET semiconductors, which can be damaged by electrostatic discharge during handling. The following precautionary procedures are recommended to minimize this possibility.

DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES

HANDLE STATIC SENSITIVE DEVICES ONLY AT A GROUNDED, STATIC-FREE WORK STATION

HANDLE DEVICES BY THE BODY. DO NOT TOUCH THE DEVICE LEADS.

BE SURE YOUR SOLDERING IRON TIP IS GROUNDED AND DO NOT USE SOLDER-SUCKERS THAT ARE NOT ANTI—STATIC PROTECTED

AVOID HANDLING WHENEVER POSSIBLE

USE ANTI-STATIC PACKAGING FOR HANDLING AND TRANSPORT

KEEP PARTS IN MANUFACTURER'S PROTECTED CONTAINERS

DO NOT SLIDE STATIC SENSITIVE DEVICES OVER ANY SURFACE AND AVOID PLASTIC, VINYL AND STYROFOAM IN WORK AREAS

esi form no. 702 9-80

ADDENDUM TO MODEL 2100/2110 MANUAL

Please note, the following procedure should be used in addition to the installation information already existing in Appendix A in your Model 2100/2110 manual. Perform this procedure with the following manual sections:

Section A.1.2 Handler Interface Installation, page A-2

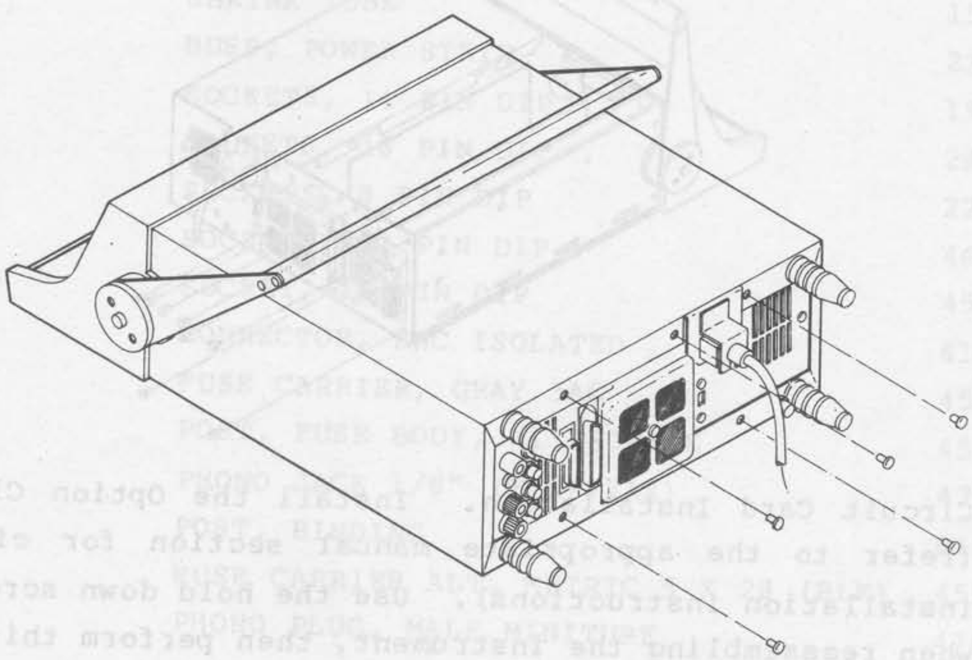
Section A.2.9 GPIB Installation, page A-14

Section A.3.8 RS-232C Circuit Card Installation, page A-36

Instrument Preparation for Circuit Card Installation

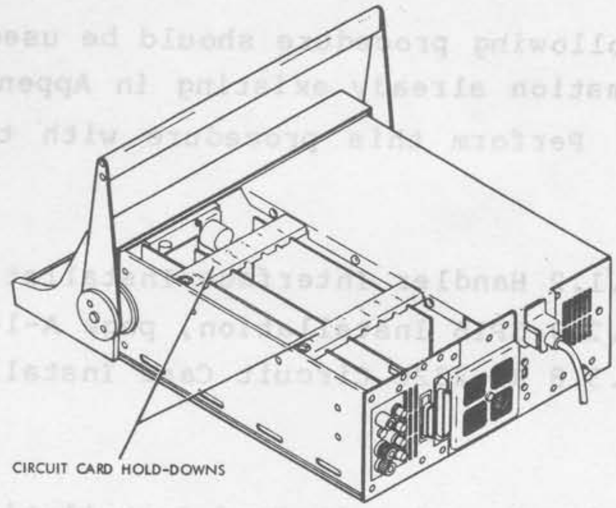
Step 1. Instrument Preparation. Turn instrument power OFF and remove all external connections.

Step 2. Outer Cover. Remove the five rear panel 8 x 32 screws holding the outer cover and slide cover off.

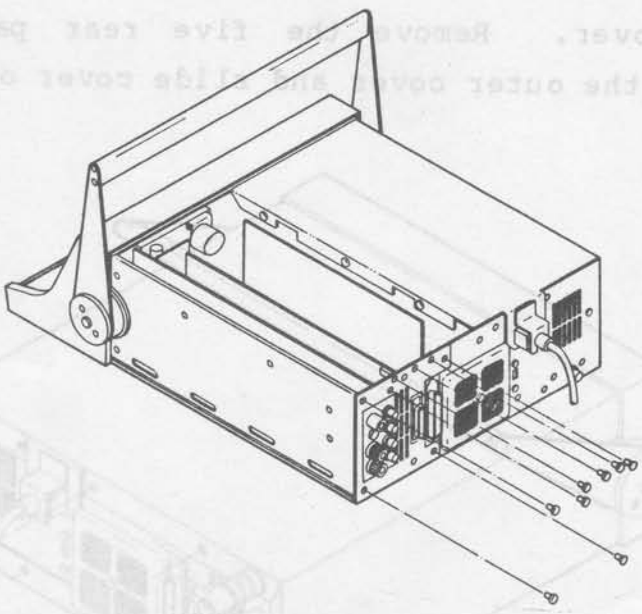


Model 2110 Rear View

Step 3. Circuit Card Hold-Downs. Remove the screws securing the two plastic circuit card hold-downs and remove.



Step 4. Rear Panel (left side). Remove the screws holding the rear panel (left side). The rear panel may have six to eight screws depending on the model and options installed.



Step 5. Circuit Card Installation. Install the Option Circuit Card (refer to the appropriate manual section for circuit card installation instructions). Use the hold down screw provided when reassembling the instrument, then perform this procedure in its reverse order.

NEW INFORMATION:

ANALOG CIRCUIT ASSEMBLY PARTS LIST AND DIAGRAM

The following parts list and diagram are for revision K of the Analog circuit card (P/N 95239). For circuit cards with revision letters earlier then K, use the parts list and diagram found in Section 5 of the Model 2100/2110 Service Manual.

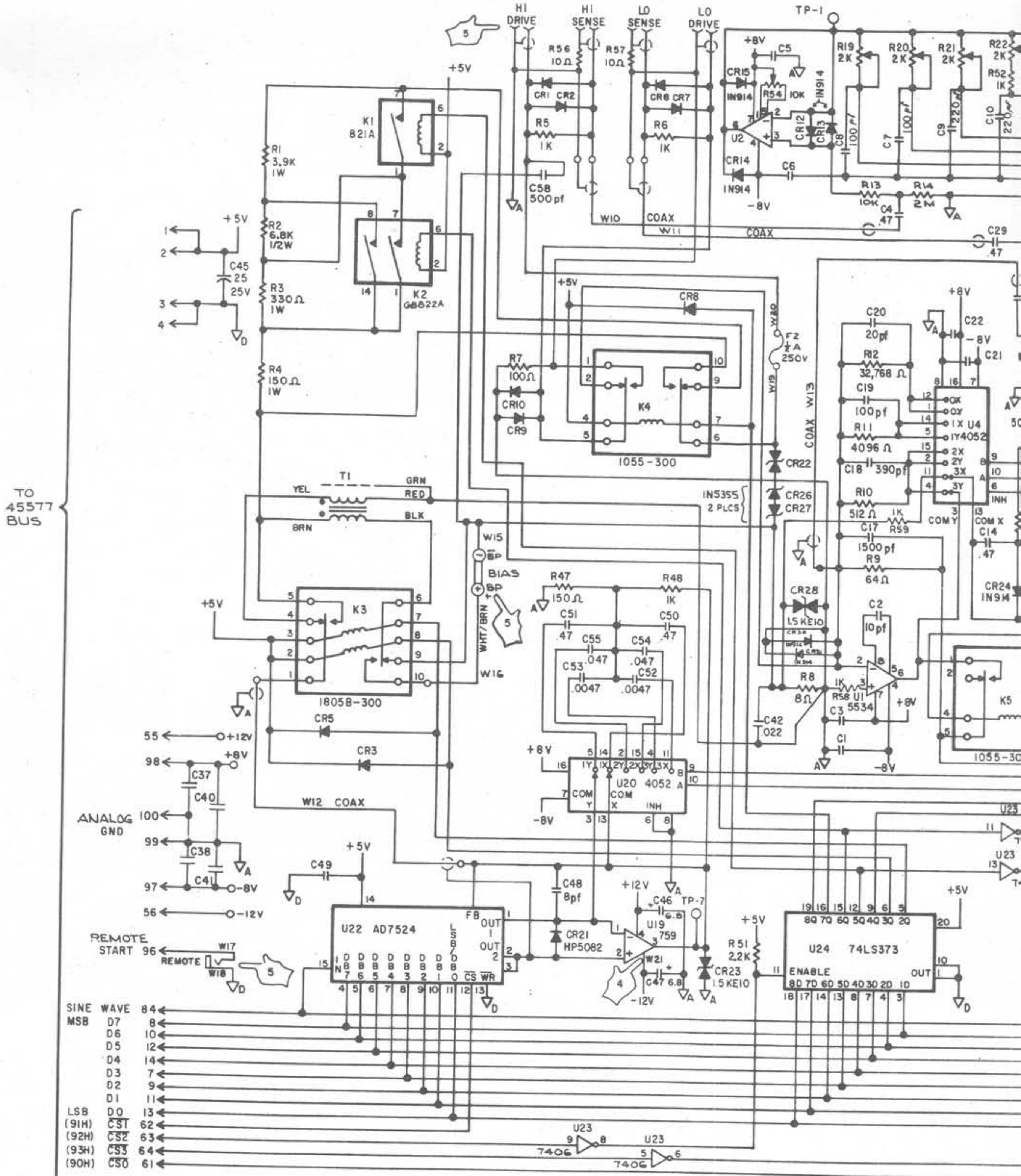
ANALOG CIRCUIT ASSEMBLY P/N 95239

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	PANEL, CONNECTOR	45162
	SLEEVING	05889
	SWING LUG, BINDING POST	03247
	COAX	45643
	BRACKET, CONNECTOR PANEL	45161
	HEATSINK	47438
	SHRINK TUBE	15926
	BUSS, POWER STRIP	23997
	SOCKETS, 14 PIN DIP	19189
	SOCKETS, 16 PIN DIP	20860
	SOCKETS, 8 PIN DIP	22410
	SOCKETS, 10 PIN DIP	46481
	SOCKET, 20 PIN DIP	45660
	CONNECTOR, BNC ISOLATED	41820
	FUSE CARRIER, GRAY 3AG	45966
	POST, FUSE BODY, HI PROFILE	45968
	PHONO JACK 1/8" (TINI-JAX)	47082
	POST, BINDING	01435
	FUSE CARRIER ALT. METRIC 5 X 20 (BLK)	45965
	PHONO PLUG, MALE MINITURE	47083

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	INSULATOR, TRANSFORMER MTG	47275
	PC BOARD, ANALOG	45238
C1,C3,C5,C6,C12, C13,C15,C16,C21,C22, C24-C27,C30-C35,C37, C38,C40,C41,C43,C49, C56	CAPACITOR, 0.01 MICROFARAD, 50V	78032
C2	CAPACITOR, 10 PICOFARADS, POLY	43130
C4,C14,C23,C29,C50, C51	CAPACITOR, 0.47 MICROFARAD, 100V	45645
C7,C8,C19,C36	CAPACITOR, 100 PICOFARADS, POLY	18760
C9,C10	CAPACITOR, 220 PICOFARADS, POLY	29297
C11	CAPACITOR, 470 PICOFARADS, POLY	44711
C17	CAPACITOR, 1500 PICOFARADS, POLY	26203
C18	CAPACITOR, 390 PICOFARADS, POLY	29299
C20	CAPACITOR, 20 PICOFARADS, POLY	20926
C28	CAPACITOR, 0.1 MICROFARD, 50V CERAMIC	45247
C39,C59	CAPACITOR, 0.001 MICROFARAD DISC	21215
C42	CAPACITOR, 0.022 MICROFARAD, CERAMIC	44626
C45	CAPACITOR, 25 MICROFARAD, 25V, ELECTROLYTIC	01941
C46,C47	CAPACITOR, 6.8 MICROFARAD TANT 35V	43792
C48,C44	CAPACITOR, 8 PICOFARADS, DISC	02127
C52,C53	CAPACITOR, 0.0047 MICROFARAD, 100VDC	13299
C54,C55	CAPACITOR, 0.047 MICROFARAD, 100VDC/ 63VAC	46200
C57	CAPACITOR, 150 PICOFARADS, POLY	29606
C58	CAPACITOR, 500 PICOFARADS, CERAMIC, 1000V	01920
CR1-CR3,CR5-CR11	DIODE, 1N4005	13654
CR12-CR17,CR24, CR25,CR30,CR31	DIODE, 1N914A	12356
CR18-CR21	DIODE, HP5082-2800	44832
CR22	VARISTOR, 68V	40993
CR23,CR28	VARISTOR, 1.5 KE10	42632
CR26,CR27	DIODE, 1N5355, 8.2V	29033
F2	FUSE, 0.5A, 250V, 3AG	01802

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
K1	RELAY, GB 821A	24804
K2	RELAY, GB 822	26667
K3	RELAY, 1805 B-300 ELECTRODYNE	46286
K4,K5	RELAY, 10-55-300	45659
R1	RESISTOR, 3.9 KILOHM, 1W, 10%	46478
R2	RESISTOR, 6.8 KILOHM, 1/2W, 10%	02075
R3	RESISTOR, 330, OHM, 1W, 10%	12174
R4	RESISTOR, 150 OHM, 1W, 10%	12171
R5,R6,R48,R52,R53, R58,R59	RESISTOR, 1 KILOHM, 1/4W, 10%	13920
R7	RESISTOR, 100 OHM, 1/4W, 10%	13907
R8	RESISTOR, 8 OHM, ESI QB +0.080%, +0.075%	46552
R9	RESISTOR, 64 OHM, ESI QB 0.005%	46555
R10	RESISTOR, 512 OHM, ESI QB 0.005%	46554
R11	RESISTOR, 4.096 KILOHM, ESI QB	46553
R12,R13,R18,R25, R33,R34,R35	RESISTOR, 10 KILOHM, 1/4W, 10%	13933
R14,R16,R24,R36	RESISTOR, 2 MEGOHM, 1%	21772
R15	RESISTOR, TRIMMER, 500 KILOHM (SIP)	46389
R17	RESISTOR, 15 MEGOHM, 10%	13976
R19-R23,R40	RESISTOR, TRIMMER 2 KILOHM	46388
R26	RESISTOR, 11 KILOHM, 1%	13359
R27	RESISTOR, 402 OHM, 1/4W, 1%	21726
R28	RESISTOR, 1 KILOHM, 1%	21730
R29	RESISTOR, 6.98 KILOHM, 1%	22857
R30,R42,R43	RESISTOR, 10 KILOHM, 1%	21740
R31	RESISTOR, 9.73 KILOHM, 1%, 1/4W	21762
R32,R50,R51	RESISTOR, 2.2 KILOHM, 10%	13924
R37	RESISTOR, 1 KILOHM, ESI QB	42631
R38	RESISTOR, 7 KILOHM, ESI QB	22777
R41	RESISTOR, 1 MEGOHM, 10%	13960
R44,R39	RESISTOR, 4.99 KILOHM, 1/4W, 1%	21737
R45,R46	RESISTOR, TRIMMER, 10 KILOHM, SIP	46204
R47	RESISTOR, 150 OHM, 1/4W, 10%	13909

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
R49	RESISTOR, 22 KILOHM, 1/4W, 10%	13937
R54,R55	RESISTOR, TRIMMER 10 KILOHM, 20T	41902
R56,R57	RESISTOR, 10 OHM, 10%, 1/4W	13895
T1	TRANSFORMER	46480
TP1-TP8	HEADER, WIRE WRAP 1 X 36	24012
U1	IC, NE5534	46406
U2,U3,U6,U8	IC, LF356N	41473
U4,U10,U20	IC, 4052AE	20743
U5	IC, CD4051	40841
U7	IC, LM311	29544
U9	IC, 4053AE	20744
U11,U13	IC, TL074	43299
U12	IC, 74LS288, PROGRAMMED	46872
U14,U17,U22	IC, AD7524JN DAC	45652
U15	IC, DIP RESISTORS R698-3-R10K	43077
U16	IC, SIP RESISTORS	47328
U18,U21	IC, 7475N	20614
U19	IC, UA759UIC	46479
U23	IC, 7406	20678
U24	IC, 74LS373	46201

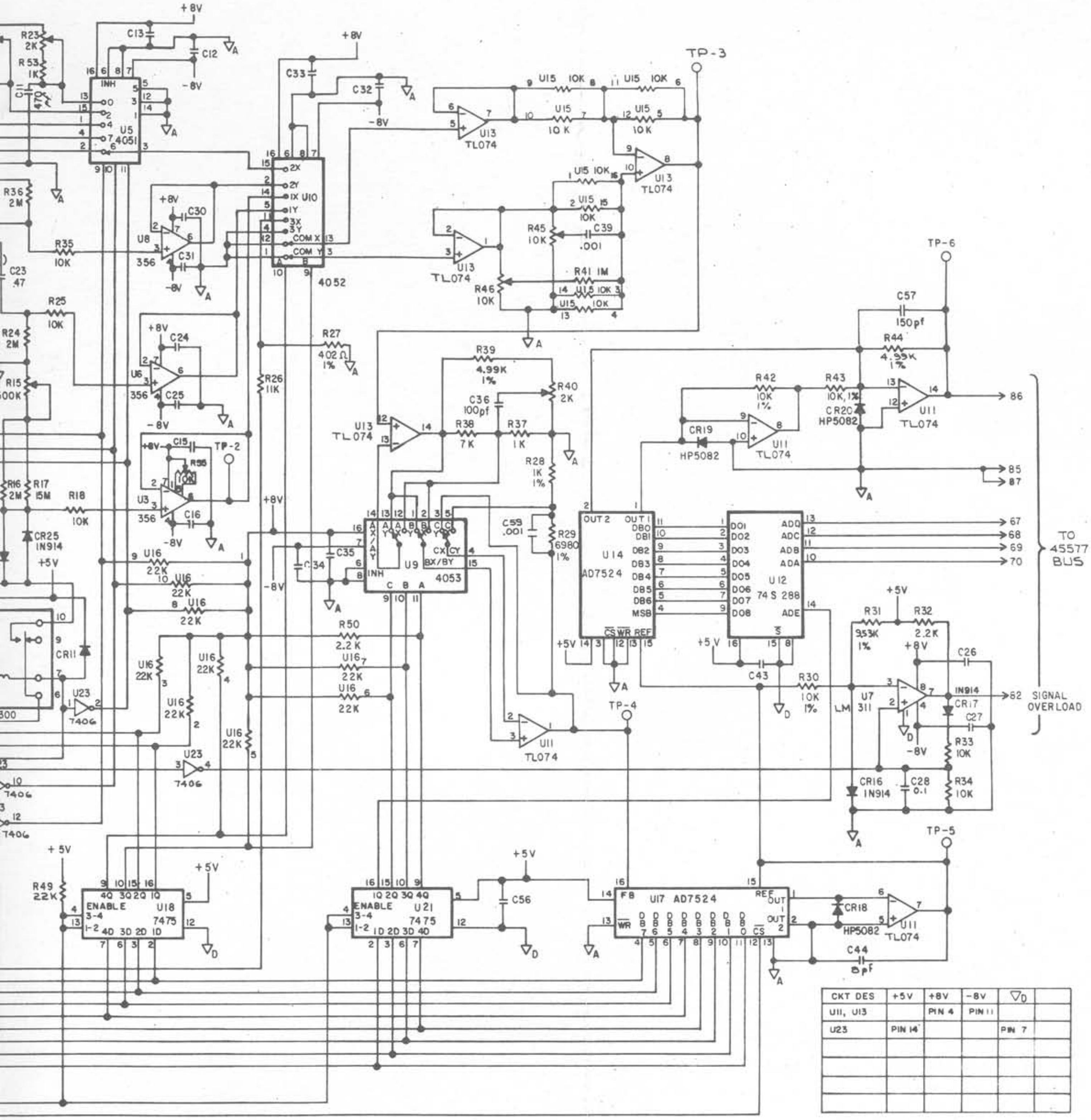


NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, 10% U
2. ALL CAPACITORS ARE IN μF , UNLISTED VALUES AR
3. ALL DIODES ARE IN4005 UNLESS OTHERWISE STATE

4 HEATSINK TAB OF DEVICE.

5 COMPONENTS NOTED ARE MOUNTED ON THE REAR PA

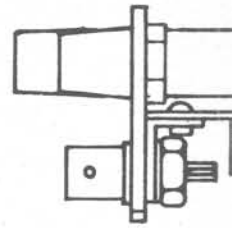


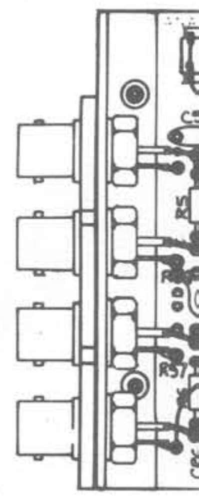
CKT DES	+5V	+8V	-8V	∇D	
U11, U13		PIN 4	PIN 11		
U23	PIN 14			PIN 7	

, UNLESS OTHERWISE STATED.
ARE .01 µF, UNLESS OTHERWISE STATED.
ATED.

PANEL.

Figure 1. Analog Circuit Assembly (P/N 95239)





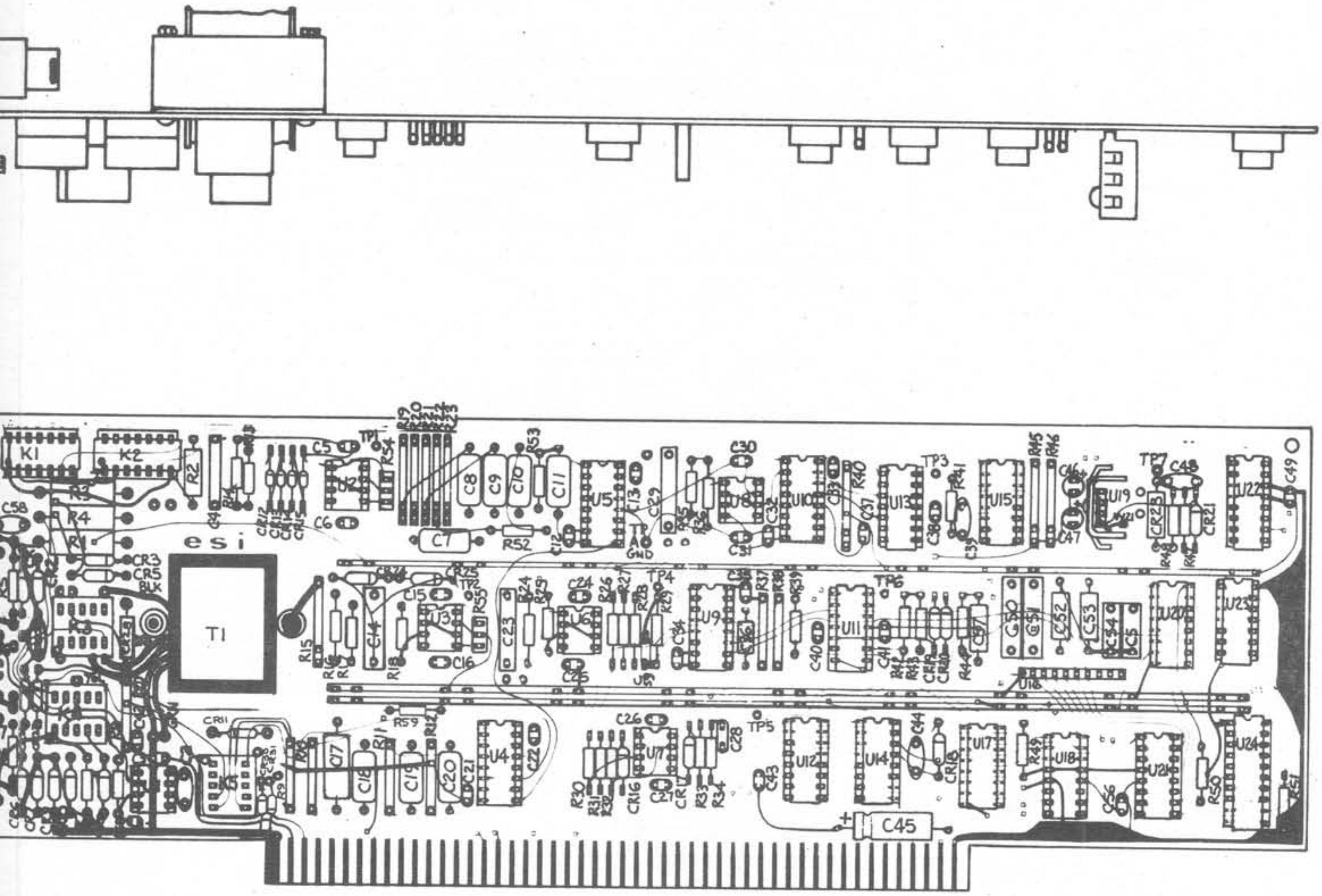


Figure 1. Analog Circuit Assembly (P/N 95239) continued

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WARNING

ELECTRICAL SHOCK HAZARD EXISTS WHEN BIAS SUPPLIES ARE CONNECTED TO THIS INSTRUMENT. WHEN EXTERNAL BIAS SUPPLIES ARE ATTACHED. THE BIAS VOLTAGES ARE PRESENT ON THE REAR PANEL BNC CONNECTORS. USE ONLY BIAS VOLTAGES UP TO +5ØVDC WITH EACH BIAS SUPPLY CURRENT LIMITED AT 1ØØMA. DO NOT TOUCH, CONNECT, OR DISCONNECT THE UNKNOWN OR BNC CABLES WHILE BIAS VOLTAGES ARE APPLIED.

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SECTION S
SAFETY INFORMATION

S.1 INTRODUCTION

Read and follow the CAUTIONS and WARNINGS in this manual. They are designed to emphasize safety during all phases of operation and maintenance.

S.2 Safety Terms And Meanings:

CAUTION -- Statements identify conditions or practices that could result in damage to the equipment or property.

WARNING -- Statements identify conditions or practices that could result in personal injury or loss of life. In addition, damage to the equipment or other property may result.

DANGER -- Indicates a personal injury hazard is near the marking.

S.3 The following WARNINGS appear in this manual:

WARNING

ELECTRICAL SHOCK HAZARD EXISTS WHEN BIAS SUPPLIES ARE CONNECTED TO THIS INSTRUMENT. WHEN EXTERNAL BIAS SUPPLIES ARE ATTACHED, THE BIAS VOLTAGES ARE PRESENT ON THE REAR PANEL BNC CONNECTORS. USE ONLY BIAS VOLTAGES UP TO +5ØVDC WITH EACH BIAS SUPPLY CURRENT LIMITED AT 1ØØmA. DO NOT TOUCH, CONNECT, OR DISCONNECT THE UNKNOWN OR BNC CABLES WHILE BIAS VOLTAGES ARE APPLIED.

WARNING

TO PREVENT POSSIBLE ELECTRICAL SHOCK OR DAMAGE TO THE INSTRUMENT, CHECK LOCAL ELECTRICAL STANDARDS BEFORE SELECTING A POWER CORD. THE INFORMATION PRESENTED HERE MAY NOT BE CORRECT FOR ALL LOCATIONS WITHIN THE REFERENCED AREAS.

WARNING

ALL PARTS OF THE POWER SUPPLY ASSEMBLY INCLUDING INPUT CIRCUIT COMMON ARE AT OR ABOVE POWER LINE VOLTAGE. THE ENERGY AVAILABLE AT ANY POINT ON THE ASSEMBLY MAY BE LIMITED ONLY BY THE INPUT FUSE. DO NOT ATTEMPT SERVICE OPERATIONS. FAILURE TO OBSERVE THIS WARNING MAY RESULT IN SEVERE INJURY OR DEATH.

WARNING

TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS MANUAL. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED IN THIS MANUAL ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.

WARNING

REMOVAL OF INSTRUMENT COVERS MAY CONSTITUTE AN ELECTRICAL HAZARD AND SHOULD BE ACCOMPLISHED BY QUALIFIED SERVICE PERSONNEL ONLY.

WARNING

TO AVOID ELECTRIC SHOCK FROM DANGEROUSLY HIGH VOLTAGES. USE THE FOLLOWING PROCEDURES ONLY WHEN TROUBLESHOOTING THE ANALOG AND DIGITAL MEASUREMENT PORTIONS OF THIS INSTRUMENT. DO NOT USE THIS PROCEDURE TO TROUBLESHOOT THE POWER SUPPLY OR CRT CIRCUITRY.

WARNING

HANDLE THE CRT WITH CARE. ROUGH HANDLING OR SCRATCHING CAN CAUSE THE CRT TO IMPLODE. TO AVOID PERSONAL INJURY FROM IMPLOSION WEAR PROTECTIVE GOGGLES AND CLOTHING WHEN WORKING WITH THE CRT. ONLY WORK WITH THE CRT IF YOU ARE QUALIFIED TO DO SO.

WARNING

THE CRT IS CAPABLE OF STORING A HIGH VOLTAGE CHARGE AFTER POWER HAS BEEN REMOVED. TO PREVENT PERSONAL INJURY FROM ELECTRIC SHOCK, USE AN OSHA OR UL APPROVED SHORTING STRAP TO DISCHARGE ALL HIGH VOLTAGE POINTS TO CHASIS GROUND. THIS PROCEDURE MUST BE PERFORMED BY QUALIFIED PERSONNEL ONLY.

WARNING

DISCONNECT ALL POWER TO THE INSTRUMENT BEFORE REPLACING COMPONENTS. FAILURE TO DO SO MAY RESULT IN ELECTRICAL SHOCK.

CAUTION

BECAUSE OF DIFFERING POWER REQUIREMENTS, INSTRUMENTS SHIPPED OUTSIDE THE UNITED STATES MAY REQUIRE A DIFFERENT POWER CORD CONNECTOR. WHEN PLACING A NEW CONNECTOR ON THE POWER CORD, CARE MUST BE TAKEN TO ASSURE THE WIRES ARE CONNECTED PROPERLY. THE GREEN OR GREEN-WITH-YELLOW-STRIPE WIRE IS ALWAYS CONNECTED TO EARTH GROUND. THE WHITE OR LIGHT-BLUE WIRE IS CONNECTED TO THE NEUTRAL SIDE OF THE POWER LINE. AND, THE BLACK OR BROWN WIRE IS CONNECTED TO THE HIGH SIDE OF THE POWER LINE. FIGURE 2-5 ILLUSTRATES THE AVAILABLE POWER CORDS, WHICH MAY BE USED IN VARIOUS COUNTRIES INCLUDING THE STANDARD POWER CORD FURNISHED WITH THE INSTRUMENT. ELECTRICAL CHARACTERISTICS AND COUNTRIES USING EACH CONNECTOR ARE LISTED IN THE FIGURE.

CAUTION

WHEN PERFORMING ANY CALIBRATION OR MAINTENANCE OPERATION, DO NOT REMOVE OR REPLACE CIRCUIT CARDS WHILE THE POWER IS TURNED ON. FAILURE TO TURN POWER OFF MAY RESULT IN ELECTRIC SHOCK OR DAMAGE TO THE INSTRUMENT.

CAUTION

AVOID THE USE OF CHEMICAL CLEANING AGENTS WHICH MIGHT DAMAGE THE PLASTICS USED IN THIS UNIT. DO NOT APPLY ANY SOLVENT CONTAINING KETONES, ESTERS, OR HALOGENATED HYDROCARBONS. TO CLEAN, USE ONLY WATER SOLUBLE DETERGENTS, ETHYL, METHYL, OR ISOPROPYL ALCOHOL.

CAUTION

DO NOT USE AN OHMMETER SCALE THAT HAS A HIGH INTERNAL CURRENT. HIGH CURRENTS MAY DAMAGE THE DIODES UNDER TEST.

DANGER

THE VIDEO CIRCUITRY CONTAINS DANGEROUSLY HIGH VOLTAGE. EXERCISE EXTREME CARE TO AVOID POSSIBLE ELECTRIC SHOCK WHICH MAY RESULT IN SEVERE INJURY OR DEATH.

S.4 The following **WARNING** labels appear on the instrument, see Figure S-1 for their locations.

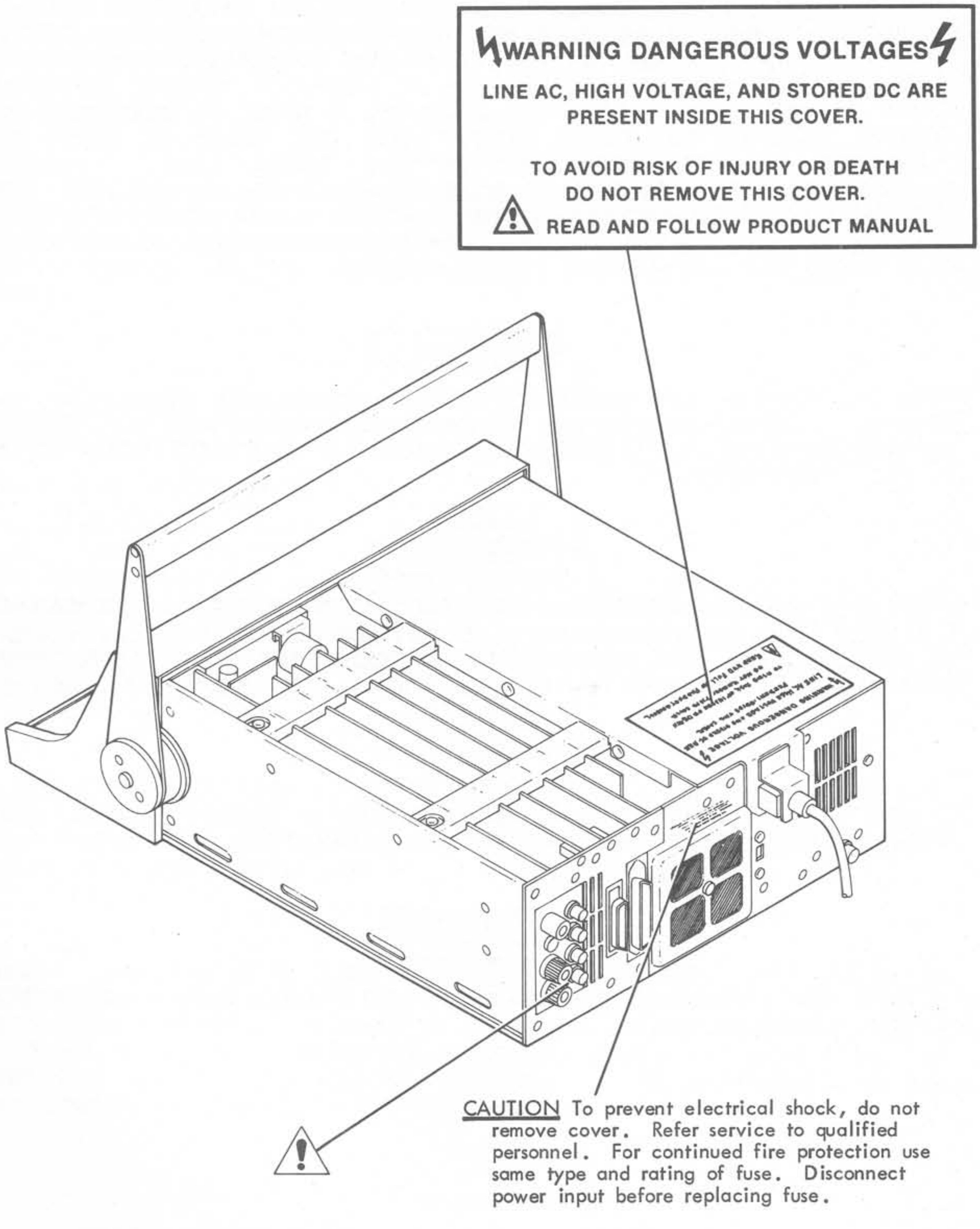

Figure S-1. Warning Label Locations

SECTION 1
DESCRIPTION

1.1 INTRODUCTION

ESI's Model 2100/2110 Auto LRC Meters are two extremely versatile impedance measuring instruments. They feature variable test frequencies (≈3000), programmable test-signal levels, component sorting, and CRT displays. They measure inductors (L), resistors (R), capacitors (C), and display up to 10 impedance characteristics in 26 different combinations. Basic accuracy of 0.05% added to the widest ranges available for passive component measurements make the 2100/2110 the most informative impedance measuring instruments available today.

Mass storage for test parameter setups and measurement results is the feature that set the Model 2110 apart from the Model 2100. The 2110 has a cassette tape loader that uses mini-cassette tapes for storing and reloading test parameter programs.

The 2100/2110 measurement system is basically composed of a frequency selectable, digital sinewave generator, a test-level regulator, precision range resistors, a phase-sensitive voltmeter, and a charge balancing analog-to-digital converter. All measurements, calculations, and displays take place under the watchful eye of the 2100/2110's Z80 microcomputer.

The level regulator's sinewave output is imposed across both the device-under-test and a selected precision, standard range resistor. The resulting voltage-drops are measured in both phase and amplitude by the phase-sensitive voltmeter. The phase-sensitive voltmeter produces four voltage outputs labeled:

$V_{\emptyset}$ or $V_{\text{unknown } \emptyset°}$
V_1 or $V_{\text{unknown } 9\emptyset°}$
V_2 or $V_{\text{standard } \emptyset°}$
V_3 or $V_{\text{standard } 9\emptyset°}$

These voltages are serially processed by the A/D converter with resistance (R) and reactance (X), when in the mA mode, or conductance (G) and susceptance (B), when in the mV mode, computed by the Z8Ø CPU.

mV MODE

$$G_{unknown} = \frac{V_{\emptyset} V_2 + V_1 V_3}{(V_{\emptyset})^2 + (V_1)^2} \times R_{standard}$$

$$B_{unknown} = \frac{V_{\emptyset} V_3 - V_1 V_2}{(V_{\emptyset})^2 + (V_1)^2} \times R_{standard}$$

mA MODE

$$R_{unknown} = \frac{V_{\emptyset} V_2 + V_1 V_3}{(V_2)^2 + (V_3)^2} \times R_{standard}$$

$$X_{unknown} = \frac{V_1 V_2 - V_{\emptyset} V_3}{(V_2)^2 + (V_3)^2} \times R_{standard}$$

All other impedance parameters are computed using the results of these measurements, the test frequency, and the formulas in Figure 1-1.

MILLIAMPERE MODE WITH SHORT CIRCUIT CORRECTION (RANGE 0 ⟶ 3)	MILLIVOLT MODE WITH OPEN CIRCUIT CORRECTION (RANGE 4 ⟶ 8)
$R_s = (R_s)m - (R_s)_0$	$G_p = (G_p)m - (G_p)_0$
$X_s = (X_s)m - (X_s)_0$	$B_p = (B_p)m - (B_p)_0$
$D = \frac{R_s}{\|X_s\|}$	$D = \frac{G_p}{\|B_p\|}$
$Q = \frac{\|X_s\|}{R_s}$	$Q = \frac{\|B_p\|}{G_p}$
$L_s = \frac{X_s}{2\pi f}$	$L_s = \frac{-B_p}{2\pi f(G_p^2 + B_p^2)}$
$L_p = \frac{R_s^2 + X_s^2}{2\pi f X_s}$	$L_p = \frac{-1}{2\pi f B_p}$
$C_s = \frac{-1}{2\pi f X_s}$	$C_s = \frac{G_p^2 + B_p^2}{2\pi f B_p}$
$C_p = \frac{-X_s}{2\pi f(R_s^2 + X_s^2)}$	$C_p = \frac{B_p}{2\pi f}$
$B_p = \frac{-X_s}{R_s^2 + X_s^2}$	$X_s = \frac{-B_p}{G_p^2 + B_p^2}$
$G_p = \frac{R_s}{R_s^2 + X_s^2}$	$R_s = \frac{G_p}{G_p^2 + B_p^2}$
$\|Z\| = \sqrt{R_s^2 + X_s^2}$	$\|Z\| = \frac{1}{\sqrt{G_p^2 + B_p^2}}$
$\|Y\| = \frac{1}{\sqrt{R_s^2 + X_s^2}}$	$\|Y\| = \sqrt{G_p^2 + B_p^2}$

R = Resistance
s = Series Measurement
m = Measured value
0 = Zero correction value
G = Conductance
p = Parallel measured
X = Reactance
B = Susceptance
D = Dissipation factor
Q = Quality factor
L = Inductance
f = Frequency
C = Capacitance
Z = Impedance
Y = Admittance

Figure 1-1. Model 2100/2110 Impedance Formulas

The 2100/2110 also offers a wide variety of test conditions: ≈3000 test frequencies (between 20Hz and 20kHz), test signal levels (10mV to 1500mV or 1mA to 100mA), settling times to 1500ms, integration time to 600ms or choose from 3 preset combinations of settling time, integration time, and number of measurements averaged are programmed for FAST, MEDIUM, or SLOW operation, and select up to 20 measurements for averaging.

Special measurement features built into the instruments include: displayed deviations from a nominal value in either absolute or percentage terms: component sorting mode that characterizes components into 10 tolerance categories or as a reject while counting the number of components that fall into each category; and automatic zero calibration for test-lead or test-fixture impedances.

Communication interfacing -- the meaningful transfer of information between instrument and its operator is the reason for the cathode-ray tube (CRT) display. The 5-inch CRT provides two levels of information and two display formats. In the direct display format, the CRT provides large easy-to-read alphanumeric characters to highlight up to 6-digits of measurement information, and small alphanumeric characters to display the settings for frequency, nominal value, measurement mode, test signal level, settling time, integration time, and number of measurements averaged. The versatility of the instrument is again exemplified by the CRT's display of component sorting information. It simultaneously displays + and - limits for all component tolerance bins, and their component counters capable of up to 64000 counts for each bin.

Three, four, five, or six digits of measurement information can be displayed on the CRT. The number of digits displayed is related to the resolution contained in the A/D conversion process. More commonly, the number of digits displayed is a product of integration time and the number of measurements averaged. Three digits are displayed when integration time is 4ms or less. Integration times greater than 4ms displays four digits, while MEDium measurement speed (50ms integration time) provides five displayed digits. A full six digits are displayed anytime the product of integration time and measurements averaged is ≥500ms (50ms integration time and 10 averages, or 25ms integration time and 20 averages).

The Model 2100/2110 offers maximum flexibility with a wide range of options. All options are field installable and are designed to tailor instrument operation to specific testing requirements. They operate as stand-alone benchtop testers or can be used with auxiliary handling equipment and easily fits into sophisticated automatic testing systems.

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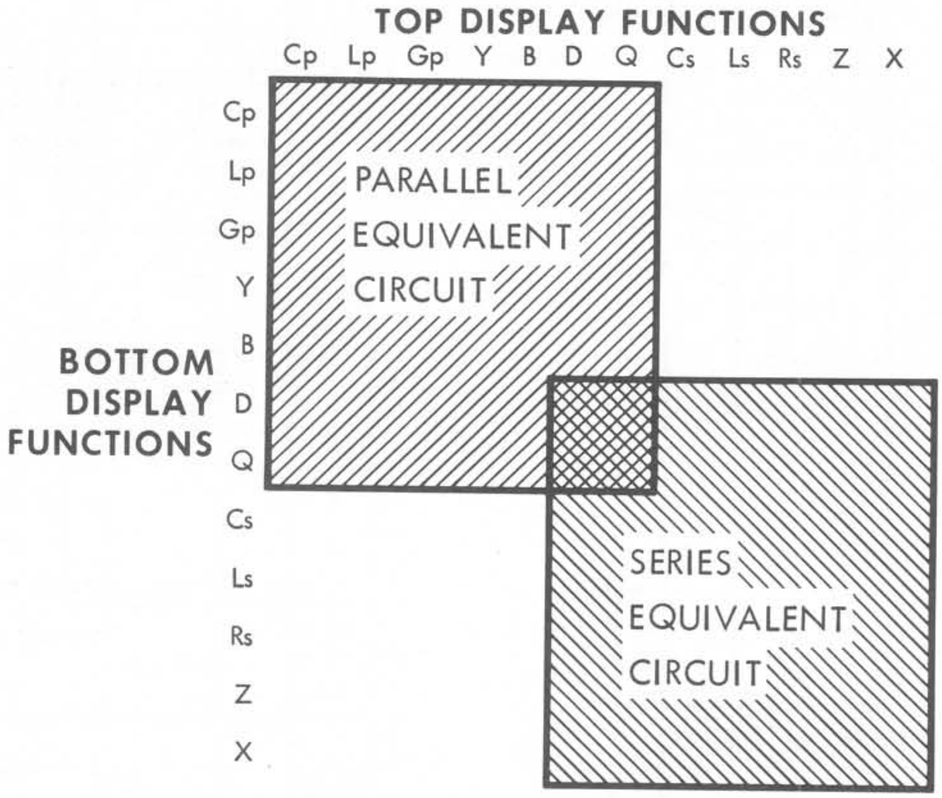
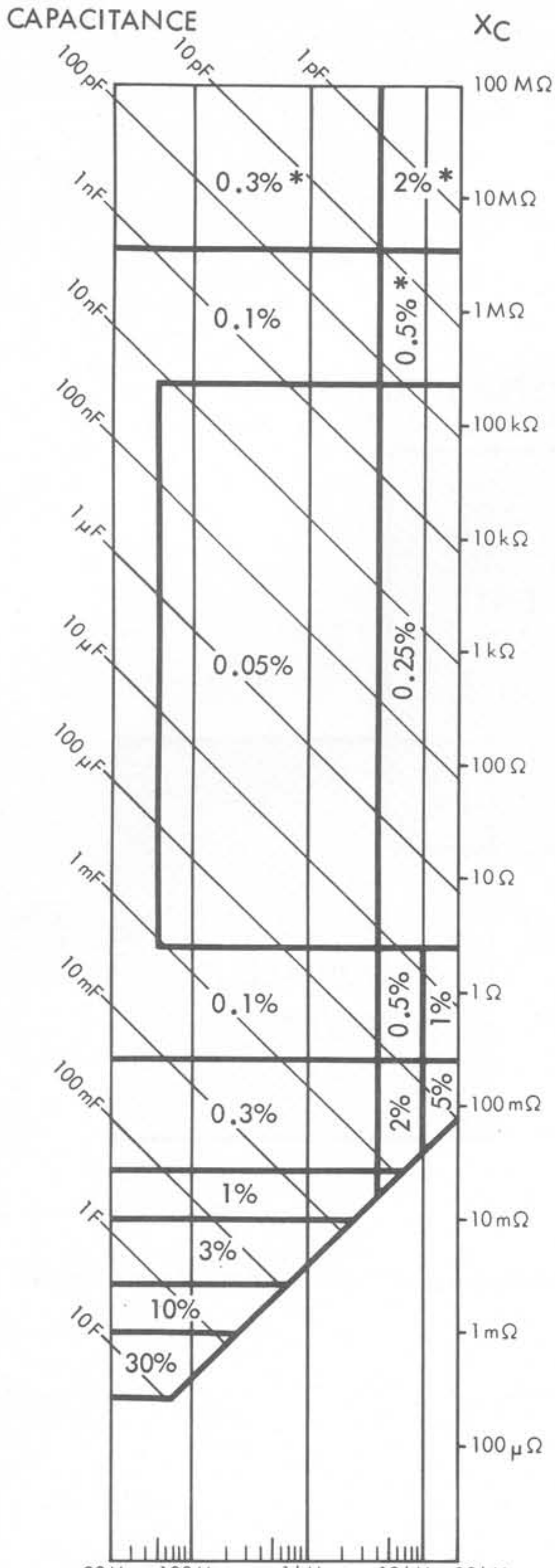
1.2 SPECIFICATIONS

1.2.1 Electrical Specifications

Measurement Functions:



NOTE: Any top display can be displayed with any bottom display within the shaded areas.



$$*\; + \left(\frac{0.01\ \text{pF}}{f(\text{kHz})} + 0.01\ \text{pF} \right)$$

If $D > 1$, add $\left[0.05\%\ (1 + 0.3D^2)\right]$ to accuracies shown

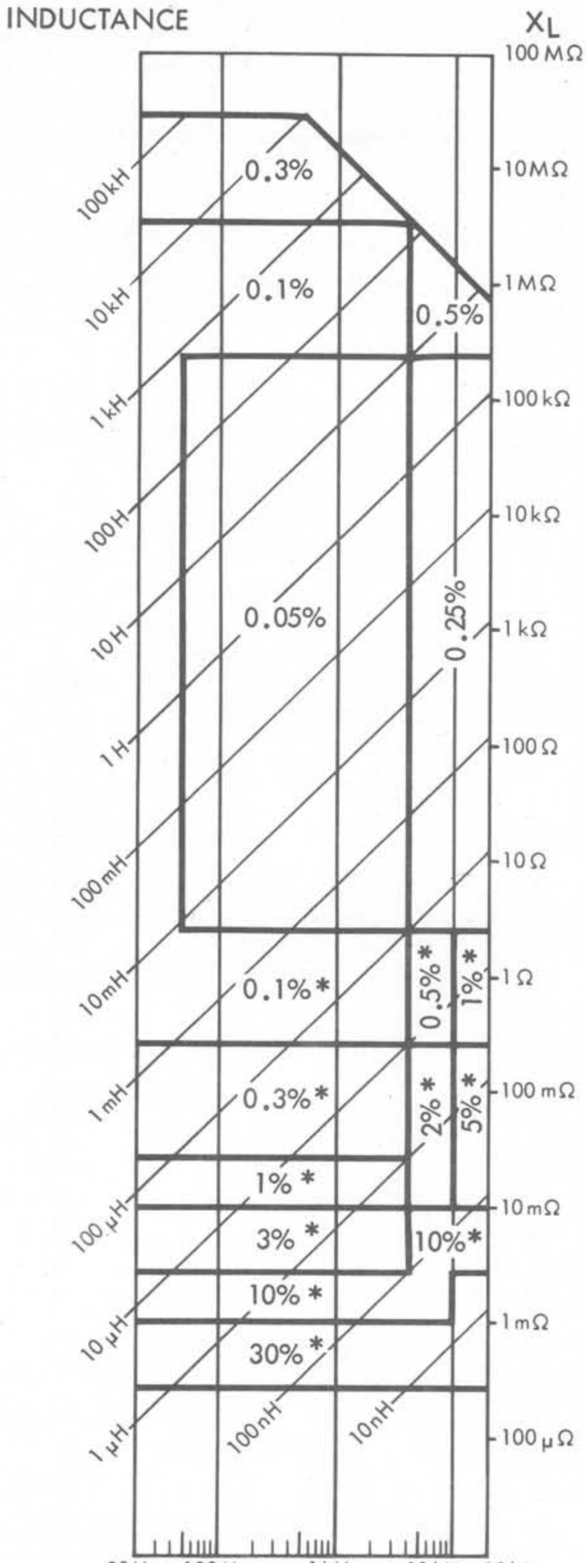
TEST CONDITIONS:

Level	-1000 mV/100 mA
Speed	-Medium
Range	-Auto
Bias	-Off
Calibrated	-Zero

V_{test} = 800 mV to 1500 mV
I_{test} = 50 mA to 100 mA

For V_{test} <800 mV	Multiply Basic Accuracy by $\left(1 + \frac{300}{\text{mV}}\right)\left(1 + \frac{\text{kHz}}{10}\right)$
For I_{test} <50 mA	Multiply Basic Accuracy ($Z > 16\Omega$) by $\left(1 + \frac{300}{\text{mA} \times Z(\Omega)}\right)$
For I_{test} <50 mA	Multiply Basic Accuracy ($Z \le 16\Omega$) by $\left(1 + \frac{30}{\text{mA}}\right)$

Table 1-1. Capacitance Measurement Accuracy



$$* + \left(\frac{0.01\mu H}{f(kHz)} + 0.01\mu H\right)$$

If D > 1, add $\left[0.1\% \, (1+0.3D^2)\right]$ to accuracies shown

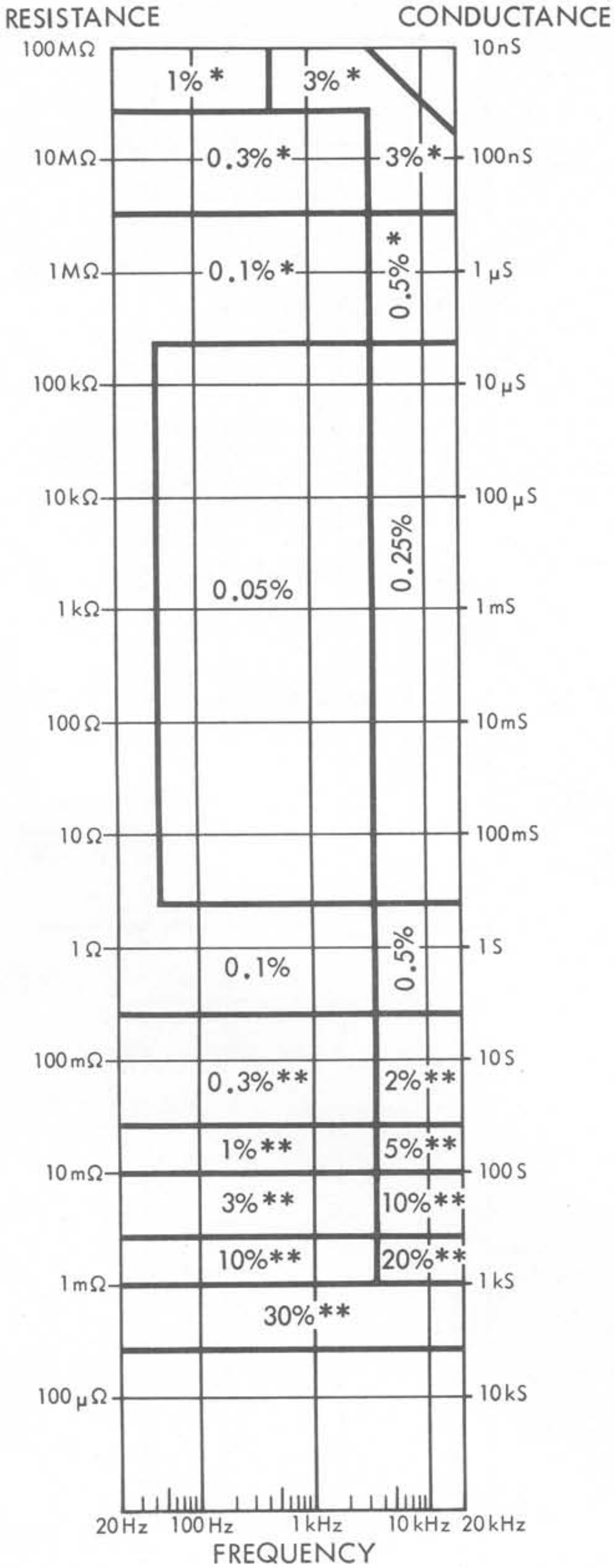
TEST CONDITIONS:

Level	-1000 mV/100 mA
Speed	-Medium
Range	-Auto
Bias	-Off
Calibrated	-Zero

V_{test} = 800 mV to 1500 mV
I_{test} = 50 mA to 100 mA

For V_{test} <800 mV	Multiply Basic Accuracy by $\left(1 + \frac{300}{mV}\right)\left(1 + \frac{kHz}{10}\right)$
For I_{test} <50 mA	Multiply Basic Accuracy $(Z > 16\Omega)$ by $\left(1 + \frac{300}{mA \times Z(\Omega)}\right)$
For I_{test} <50 mA	Multiply Basic Accuracy $(Z \leq 16\Omega)$ by $\left(1 + \frac{30}{mA}\right)$

Table 1-2. Inductance Measurement Accuracy



$* + [0.1\,nS \times f(kHz) + 0.5\,nS]$

$** + [0.01\,m\Omega \times f(kHz) + 0.1\,m\Omega]$

If $Q > 1$, add $[0.1\% \,(1 + 0.3Q^2)]$ to accuracies shown

TEST CONDITIONS:

Level	-1000 mV/100 mA
Speed	-Medium
Range	-Auto
Bias	-Off
Calibrated	-Zero

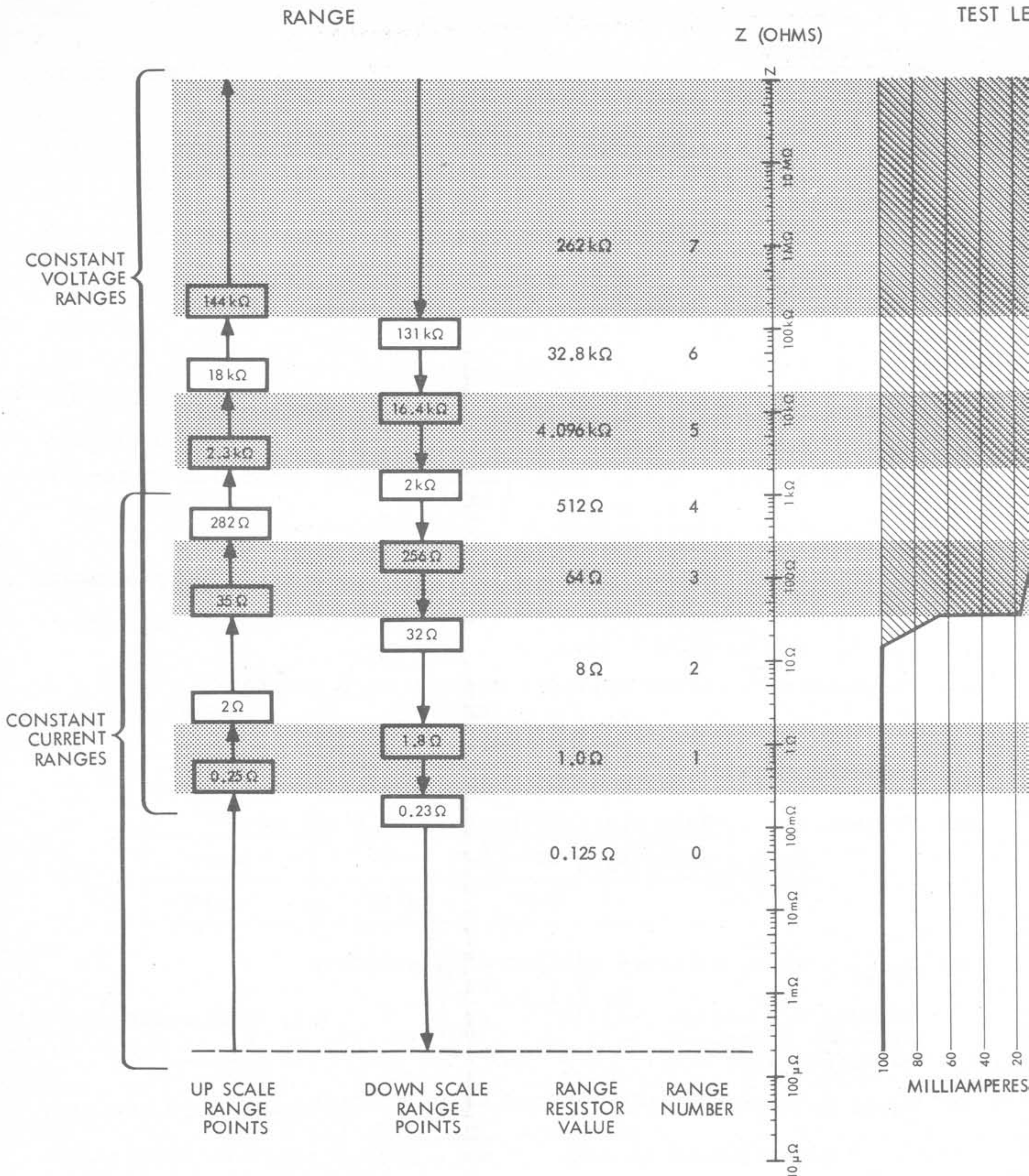
V_{test} = 800 mV to 1500 mV
I_{test} = 50 mA to 100 mA

For V_{test} <800 mV Multiply Basic Accuracy by $\left(1 + \frac{300}{mV}\right)\left(1 + \frac{kHz}{10}\right)$

For I_{test} <50 mA Multiply Basic Accuracy ($Z > 16\Omega$) by $\left(1 + \frac{300}{mA \times Z(\Omega)}\right)$

For I_{test} <50 mA Multiply Basic Accuracy ($Z \leq 16\Omega$) by $\left(1 + \frac{30}{mA}\right)$

Table 1-3. Resistance/Conductance Measurement Accuracy



RANGE
Z (OHMS)
TEST LE
CONSTANT VOLTAGE RANGES
CONSTANT CURRENT RANGES
144 kΩ
18 kΩ
2.3 kΩ
282 Ω
35 Ω
2 Ω
0.25 Ω
131 kΩ
16.4 kΩ
2 kΩ
256 Ω
32 Ω
1.8 Ω
0.23 Ω
262 kΩ
32.8 kΩ
4.096 kΩ
512 Ω
64 Ω
8 Ω
1.0 Ω
0.125 Ω
7
6
5
4
3
2
1
0
Z
10 MΩ
1 MΩ
100 kΩ
10 kΩ
1 kΩ
100 Ω
10 Ω
1 Ω
100 mΩ
10 mΩ
1 mΩ
100 μΩ
10 μΩ
UP SCALE RANGE POINTS
DOWN SCALE RANGE POINTS
RANGE RESISTOR VALUE
RANGE NUMBER
100
80
60
40
20
MILLIAMPERES

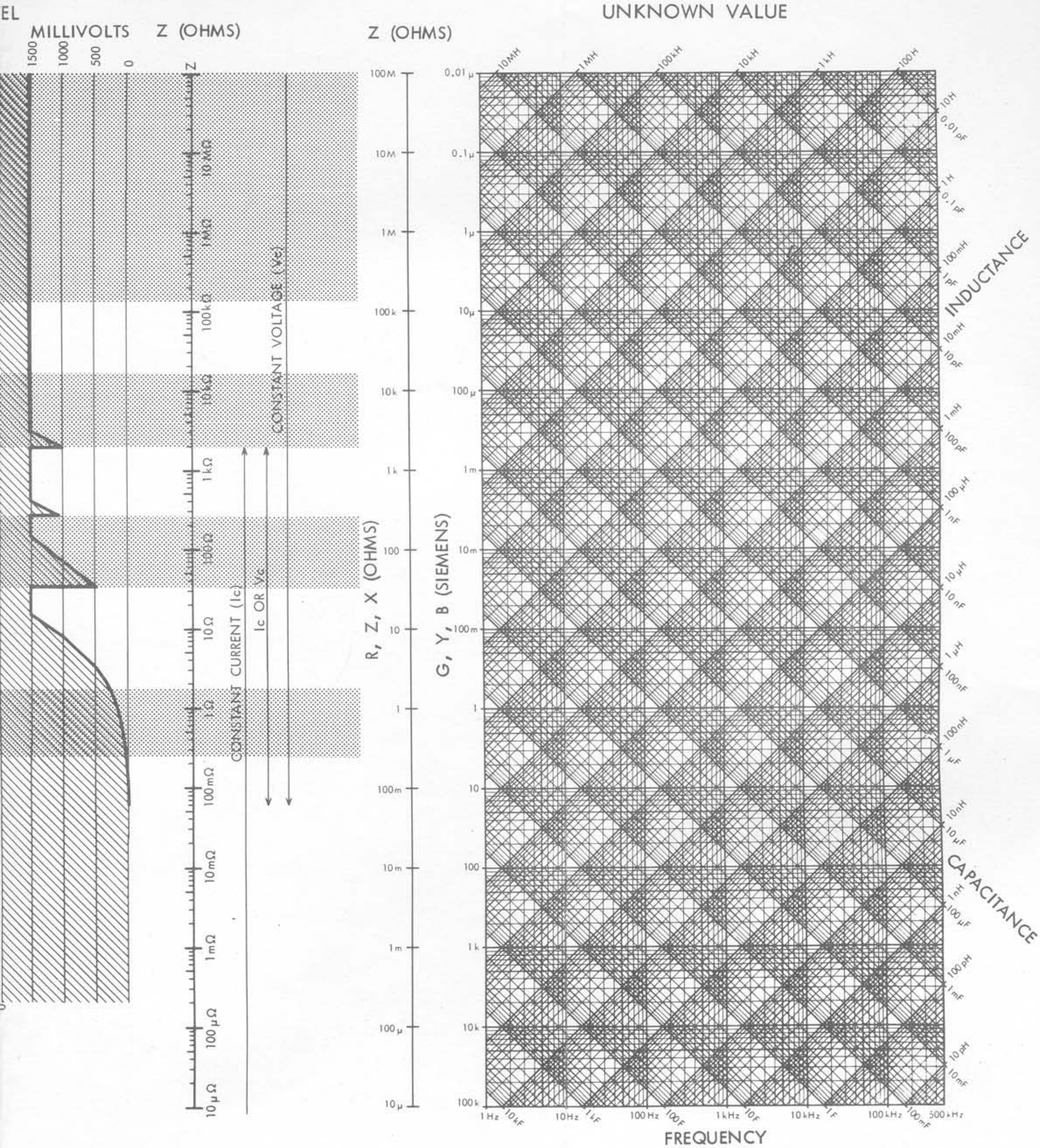


Table 1-4. Impedance Ranges vs. Test Signal Level

BASIC D ACCURACY

Capacitance: $\pm 0.00025\ (1+D^2)*$

Inductance: $\pm 0.00035\ (1+D^2)*$

BASIC Q ACCURACY

All Components $\pm 0.035 * \left(Q + \frac{1}{Q}\right)\%*$

*Correction Factors

For HI Z ($Z \geq 10M\Omega$) add $\left[0.0005 \left(\frac{Z(M\Omega)}{10M\Omega}\right)\right]$ to basic D or Q accuracy

For LO Z ($Z \leq 1\Omega$) add $\left[0.0005 \left(\frac{1\Omega}{Z(\Omega)}\right)\right]$ to basic D or Q accuracy

For Frequencies > 1000Hz multiply basic D or Q accuracy by $\left(1 + \frac{Hz}{3000}\right)$

For Frequencies < 200Hz multiply basic D or Q accuracy by $\left(1 + \frac{60}{Hz}\right)$

For V_{test} < 800mV multiply basic D or Q accuracy by $\left(1 + \frac{300}{mV}\right)$

For $I_{test} \leq$ 100mA multiply basic D or Q accuracy by $\left(1 + \frac{300}{mA \times Z(\Omega)}\right)$

TEST SIGNALS

Frequency — ≈ 2998 programmable between 20Hz and 20kHz.

$f = 60kHz/N$

Where: N is an integer
$3 \leq N \leq 3000$

Accuracy — ±0.01%

Level Set

Voltage Level — 10mV to 1500mV RMS in 10mV steps

Accuracy — ±(4% + 10mV), $Z > 2\Omega$
±(4% + 2mV), $Z < 2\Omega$

Current Level — 1mA to 100mA RMS in 1mA steps

Accuracy — ±(4% + 1mA), $Z < 32\Omega$
±(4% + 0.2mA), $Z > 32\Omega$

MEASUREMENT SPEED

	SETL	I.T.	AVG
Fast	5ms	10ms	1
Medium	50ms	50ms	1
Slow	50ms	50ms	5

OR

Integration time (I.T.) — $n(\frac{1}{f})$ Where: n = integer between 1 and 256
f = Test Frequency

Settling Time (SETL) — 2ms to 1500ms in 1ms steps

Measurement Averaging (AVG) — 1 to 20 measurements

BIAS

Voltage — +50VDC maximum

Fuse — 0.5A, 250V, 3AG Fast Blow

1.2.2 Environmental Specifications

HUMIDITY

Operating	2Ø% to 8Ø% Relative
Storage	Ø% to 9Ø% Non-Condensing

TEMPERATURE

Operating	1Ø°C to 45°C (5Ø°F to 113°F)
Storage	-4Ø°C to 71.1°C (-4Ø°F to 16Ø°F)

1.2.3 General Specifications

POWER REQUIREMENTS

Line power	115VAC +15% -22% 48/66Hz 23ØVAC + 9% -22% 48/66Hz
Powerline Fuse	2A, 25ØV, Slow Blow for 115VAC operation, and 1A, 25ØV Slow Blow for 23ØV operation
Power Consumption	≈ 1ØØW

DIMENSIONS

Height	133mm (5.25 in)
Width	324mm (12.75 in)
Length	464mm (18.25 in)
Weight	28 lb

1.3 CASSETTE RECORDER SPECIFICATIONS

Tape Cassette Type:	Braemar Computer Devices Type CMC-5Ø (5Ø ft. long)
File Storage Information:	All displayed measurement parameters, binning limits, and bin counter information.
Storage Capacity:	3Ø files total (15 files per side)

1.4 OPTIONS AND ACCESSORIES

1.4.1 Accessories (available when ordered)

	ESI Part No.
Model 2ØØ3 Sorting Fixture, 4-terminal (requires 4 cables).	32ØØ3
Model 2ØØ4 Zero Insertion Force Sorting Fixture, 4-Terminal (requires 4 cables).	32ØØ4
Model 2ØØ5 Tweezers, 4-Terminal (for chip capacitors).	32ØØ5
BNC to KELVIN KLIPS® cable assembly (comes with all Model 21ØØ's and 211Ø's).	47454

1.4.2 Options (field installable)

	ESI Part No.
General Purpose Interface Bus (IEEE-488)	46725
RS232 Interface (2100 only)	TBA
Handler Interface Options*	
1. For interfacing to the Engineered Automation Autosort handler	47895
2. For interfacing to the Daymarc Type 147 and 149 handlers.	47896
3. For interfacing to Browne handlers	47897

*Consult factory for interface to specific handlers

SECTION 2
OPERATION

2.1 FRONT PANEL CONTROLS AND INDICATORS

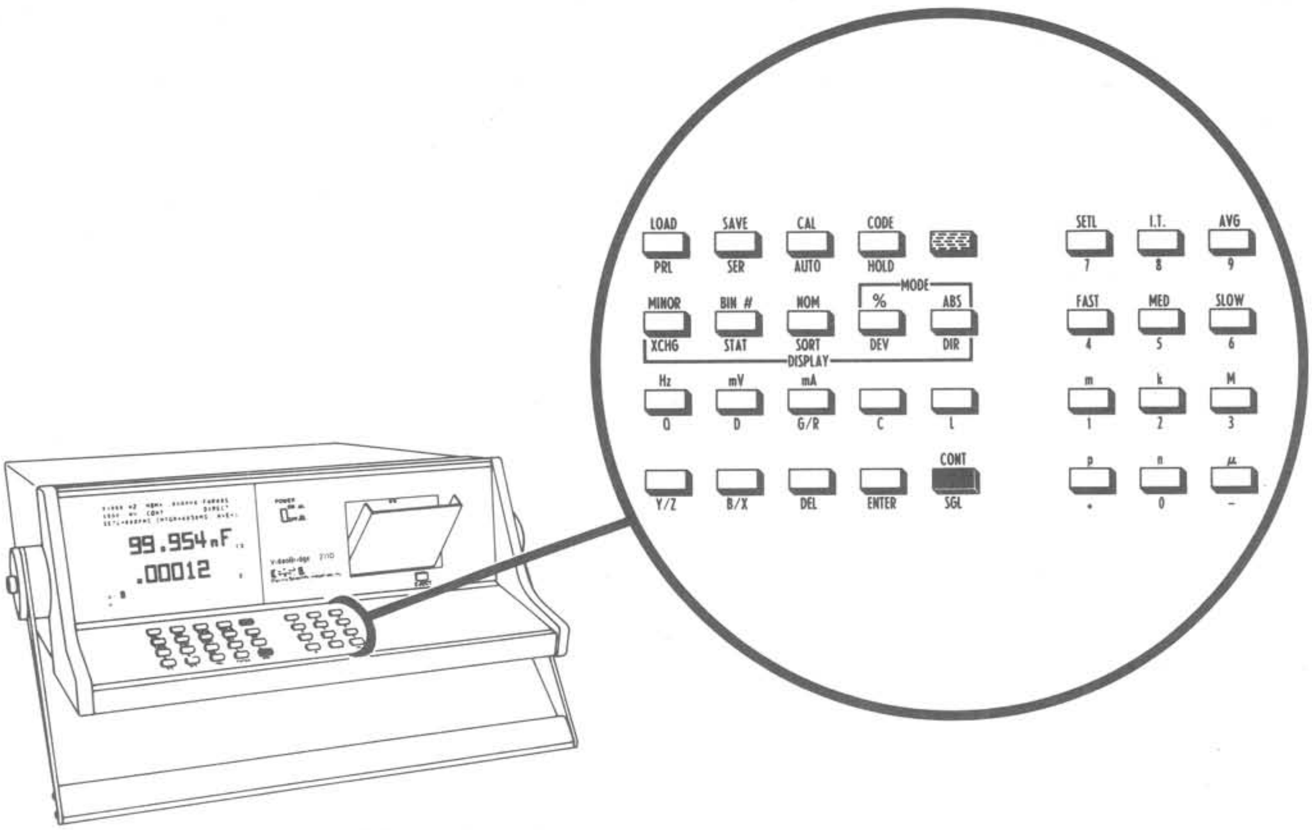


Figure 2-1. Model 211Ø Front Panel

2.1.1 Keyboard and Key Definitions

The Model 21ØØ/211Ø keyboard has 32 keys to control all instrument operations. Many of the keys have labels for more than one function. The functions labeled in white are selected by pushing the key directly above it. Alternate functions, labeled in yellow, are selected by pushing the yellow key followed by the key directly below the desired function. The following list defines each keyboard function.

Measurement Controls

Single measurement mode key makes one measurement and holds the displayed result.

Continuous measurement mode key automatically starts a new measurement as soon as the present measurement is finished. Displayed results are continuously updated at the rate of three per second at medium measurement speed.

Series equivalent circuit key, in conjunction with the measurement function, selects the equivalent circuit element of the unknown component to be measured. Also selects R, Z, and X when using the G/R, Y/Z, and B/X keys.

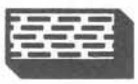
Parallel equivalent circuit key, in conjunction with the measurement function, selects the equivalent circuit element of the unknown component to be measured. Also selects G, Y, and B when using the G/R, Y/Z, and B/X keys.

Zero correction key. Stores L, R, C, and G zero correction values to compensate for test fixture reactance (L and C) and loss (R and G) components.

Range Hold key allows rapid checking of many unknowns in the same range.

Measurement Controls (continued)

Auto key returns unit to autoranging mode. Autoranging is automatically selected when the instrument is first turned on.



(Yellow)

Upper function key selects functions labeled in yellow.

Display Controls

Exchange key interchanges the top measurement display function with the bottom display function. One exchange takes place for each push of the key.

Status (display) key toggles the display format between direct display format and binning display format. Display format changes once for each push of the key. Also used to escape from sorting mode operation.

Sort key enters the instrument into the component sorting mode. Display indicates BIN number or REJect for each component measured.

Deviation (display) key enters the deviation measurement mode. After a nominal value is set, the top measurement display will indicate absolute or percent deviation from the nominal value.

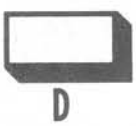
Display Controls (continued)

Direct (display) key returns the instrument to normal (direct) display operation after being in sorting or deviation mode.

Delete key erases the last digit entered; does not affect previously entered data.

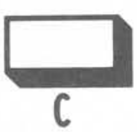
Impedance Functions

Quality Factor key selects the Q measurement function as the bottom display function.



Dissipation factor key selects D measurement function as the bottom display function.

Conductance (G)/Resistance (R) function key selects S (siemens -- units of conductance) or Ω (ohms -- units of resistance) as the bottom display function. G is selected in parallel equivalent circuit mode. R is selected in series equivalent circuit mode.

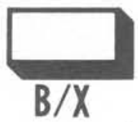


Capacitance function key selects F (farads -- units of capacitance) as the top display function.

Inductance function key selects H (henrys -- units of inductance) as the top display function.

Impedance **Functions** (continued)

Admittance (Y)/Impedance (Z) function key selects either S (siemens -- units of admittance) or Ω (ohms -- units of impedance) as the top display function. Y is selected in parallel equivalent circuit mode. Z is selected in series equivalent circuit mode.



Susceptance (B)/Reactance (X) function key selects either S (siemens -- units of susceptance) or Ω (ohms -- units of reactance) as the top display function. B is selected in parallel equivalent circuit mode. X is selected in series equivalent circuit mode.

Cassette **Functions**

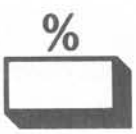
Load function key programs the instrument with measurement parameters stored on the cassette tape.

Save function key stores the instrument's parameters on the cassette tape.

Bin number key is used with a numerical argument to identify the bin in which a set of limit values will be entered.

Minor number key is used to enter a maximum or minimum reject limit for the secondary component when programming limits for the sorting mode. Minimum for Q, maximum for others.

Enter key is used for spacing device when programming limit values.



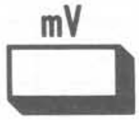
Percent mode key is used with the sorting and deviation modes to define and display percent deviation.

Absolute mode key is used with the sorting and deviation modes to define and display absolute deviation.

Nominal value key is used to enter a comparison value for deviation measurements. A nominal value set after percent limits are programmed causes the instrument to automatically calculate absolute values for each limit.

Test Frequency and Level

Frequency key enters a desired test frequency in hertz (Hz). Available frequencies are found by F = 60kHz/N Where: N is an integer $3 \leq N \leq 3000$.



Test voltage level key enters a desired test voltage in 10 millivolt steps. Test voltage levels are available between 10mV and 1500mV.

Test current level key enters a desired test current in milliamps. Maximum available test current is 100mA.

Measurement Time

Settling time key enters a time, in milliseconds. After initiation of a measurement, the instrument waits for the selected time before the actual start of the measurement.

Integration time key enters the number of test frequency cycles during which a measurement is to be made.

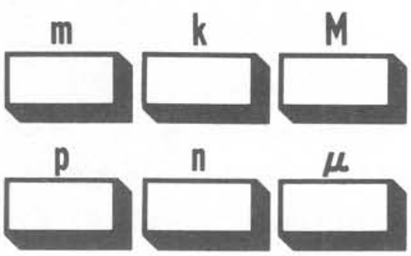
Average measurements key enters the number of measurements to be averaged with the result displayed.

Measurement Time (continued)

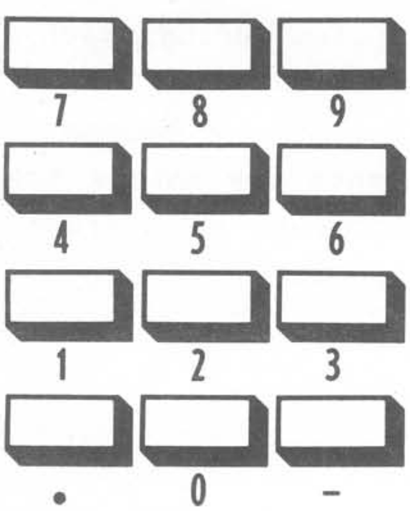
Fast, Medium, Slow keys choose pre-selected values of Settling Time, Integration Time, and average measurements.

	SETL	I.T.	AVG
Fast	5ms	10ms	1
Medium	50ms	50ms	1
Slow	50ms	50ms	5

Numerical and Unit Multiplier Keys

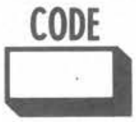


Multiplier prefix keys for the basic units programmed m = milli, k = kilo, M = mega, p = pico, n = nano, and μ = micro.



Numerical keys used for keyboard entry of desired numerical data into the instrument.

Special Functions



Code key when preceded by a numerical argument allows access to instrument functions not available directly on the keyboard. Following is a list of the functions available with the code key.

Code No.	Function
1	Bias Voltage ON (capacitor measurements with bias).
-1	Bias Voltage OFF (measurements without bias).
2	Reset STATUS display. All bin limits and counters are set to zero.
3	"Make Tape" Formats cassette tapes to accept test parameters.
4	Keyboard control transferred from the VideoBridge to an external video-terminal. Control is transferred through channel A of the RS-232C Interface option. To return control to VideoBridge keyboard type KB on the terminal connected to channel A of the RS-232.
5	Direct range setting. (To exit -- depress AUTO).
6	D correction ON (default mode when instrument is turned ON).
-6	D correction OFF.

Code No.	Function
7	Software Version. Date and version of instrument soft ware is displayed as an error message.
8	Activate Handler Interface option and Lockout the Keyboard. Component sorting begins when the option is activated. To de-activate this option, temporarily ground Pin 21 of the Handler Interface rear panel connector.
9	Keyboard Lockout. To re-activate VideoBridge keyboard: 1. Ground pin 21 on Handler Interface. 2. Type UNLOCK through the GPIB Interface. 3. Type UNLOCK through channel B of the RS-232C Interface.
1Ø	Interface output select test code. It displays measurement information on the CRT as well as outputting it through the interface

Code No.	Function
1Ø (cont)	option. To select the output option (RS-232C or IEEE-488) Enter: 1 (space) 1Ø (space) CODE -- to provide output on serial channel B of the RS-232C OR 2 (space) 1Ø (space) CODE -- to provide output on IEEE-488 To deactivate this function push either 1 or 2, depending on the option selected above, then push -1Ø (space) CODE

The procedure for programming code key function is:

1. Push the numerical key(s) representing the desired function (from list above).

2. Push the Yellow key.

3. Push the CODE key.

Example: Turn ON Bias

Push: 

To select a range via CODE 5, the number of the desired range must precede the selection of this function. Refer to range chart in Section 1.2 for range information.

Example: Select range 3

Push: 

NOTE: These functions may be remotely programmed when the interface options are installed.

2.1.2 CRT Display

The 5-inch (diagonal) cathode-ray tube (CRT) presents a simultaneous display of those test parameters and measurement results that are most important to the operator. Model 2100/2110 feature two display formats ... normal (direct) and binning (sorting).

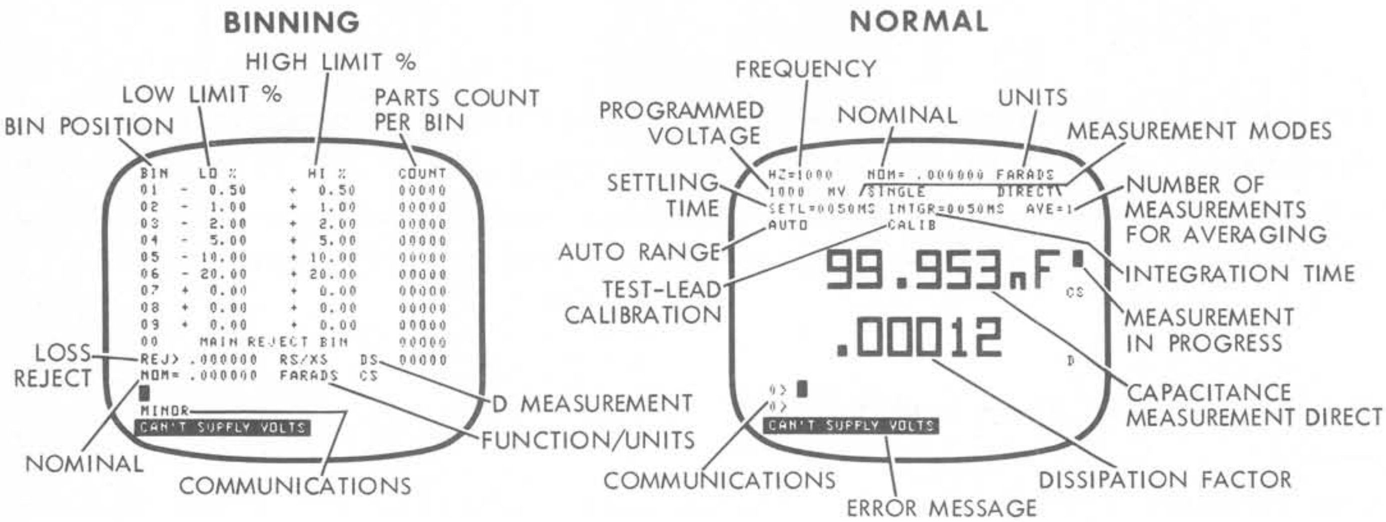


Figure 2-2. CRT Display Formats

Normal display format can be broken-down into three major areas:

1. Parameter field (top portion of CRT screen). It contains:

   . Test frequency in hertz (Hz)
   . Nominal value (when programmed)
   . Units of the top measurement display function
   . Test signal level in millivolts (mV) or milliamperes (mA)
   . Measurement mode -- continuous (CONT) or single (SINGLE)
   . Display mode -- Direct, Deviation, or % Deviation
   . Settling time in milliseconds (ms)
   . Integration time in milliseconds (ms)
   . Number of averaged measurements for each display
   . Ranging mode -- Auto or Hold
   . Calibration (CALIB) indicator for test-lead or test fixture zero

2. Measurement display (center portion of CRT screen). It contains:

- Two readings
- Units multiplier and units for each reading
- Function and equivalent circuit mode for each display

3. Data entry (bottom portion of CRT screen). It contains:

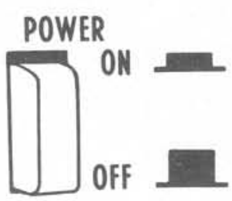
- Data entry lines that echo and display the last keyboard entries.

Binning display format is used when preparing for component sorting operation. It can be divided into two major areas ... sorting limits and reject limit. For a more detailed explanation of the sorting operation and the binning display see Section 2.7.1 in this manual.

2.1.3 Cassette Tape Loader

The cassette tape loader is a Model 2110 (optional for 2100) feature that adds to the overall versatility of the instrument. The cassette can be used as a mass storage device for either test parameters or measurement information. It relieves the tedious chore of setting test parameters by storing often used test setups for later retrieval. For a more detailed explanation of the cassette tape loader see Section 2.9 in this manual.

2.1.4 Other Front Panel Controls



Turns instrument power ON and OFF.

Opens Cassette Tape Loader door for direct access to cassette tapes. (Model 2110 only)

2.2 REAR PANEL

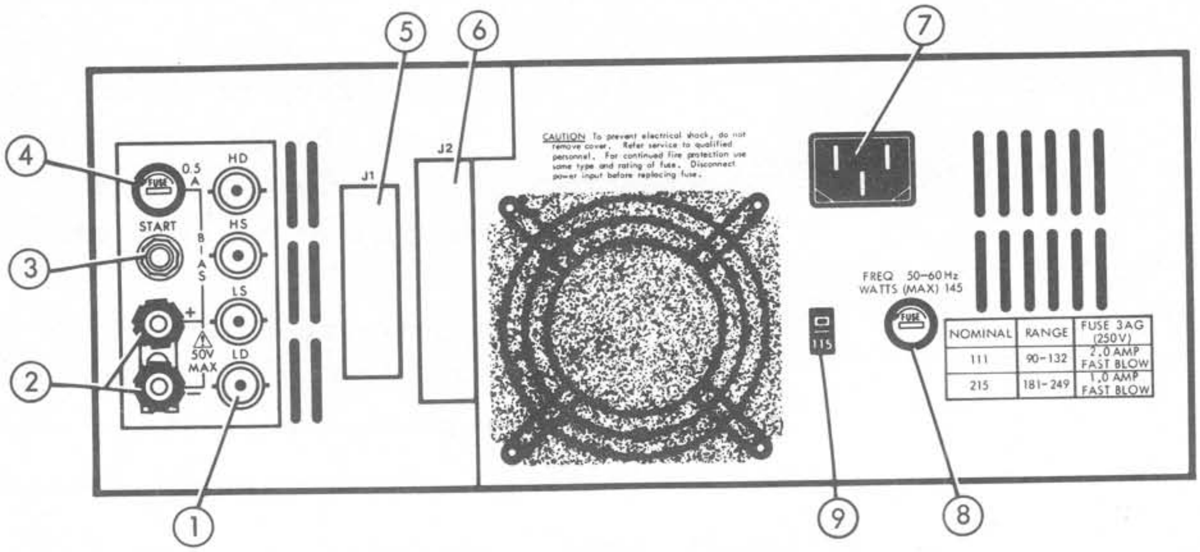


Figure 2-3. Rear Panel

2.2.1 Rear Panel Controls and Connectors

① HD, HS, LS, LD — Four BNC style connectors for making passively guarded, four-terminal-connection to the unknown.

WARNING

ELECTRICAL SHOCK HAZARD EXISTS WHEN BIAS SUPPLIES ARE CONNECTED TO THIS INSTRUMENT. WHEN EXTERNAL BIAS SUPPLIES ARE ATTACHED, THE BIAS VOLTAGES ARE PRESENT ON THE REAR PANEL BNC CONNECTORS. USE ONLY BIAS VOLTAGES UP TO +5ØVDC WITH EACH BIAS SUPPLY CURRENT LIMITED AT 1ØØMA. DO NOT TOUCH, CONNECT, OR DISCONNECT THE UNKNOWN OR BNC CABLES WHILE BIAS VOLTAGES ARE APPLIED.

② ⚠ BIAS Terminals — Two banana plug jacks for connection of external power supplies for biasing, up to 5ØVDC with bias supply current limited at 1ØØmA, the component being tested. Bias supply polarity must match the terminal indicators.

(3)	REMOTE START	A miniature phone jack style connector for remotely initiating measurements.
(4)	BIAS FUSE	A Ø.5A 3AG fuse prevents damage to the instrument if a charged capacitor is connected to the input terminals or if excessive bias current is applied.
(5)	J1	An option inputs/outputs connector which allows connection to an interface option. Connector is present only when option is installed.
(6)	J2	An option connector; outputs depend on option installed. Connector is present only when option is installed.
(7)	LINE POWER CORD	A standard 3-wire power cord for connection to 115VAC +15 -22% at 48/66Hz or 23ØVAC +9% -22% at 48/66Hz. (See Section 2.3.1 before using cord and connectors other than supplied.)
(8)	POWER FUSE	The line power fuse used is 2A, 25ØV Slow-Blow for 115V operation and 1A, 25ØV Slow-Blow for 23ØV operation.
(9)	115/23Ø Switch	Selects the nominal line voltage.

2.3 INSTRUMENT SETUP

2.3.1 Power Requirements

The 2100/2110 requires a power source of 115VAC, +15% -22%, at 48/66Hz (230VAC, +9% -22%, at 48/66Hz, optional). Before turning the power ON, make sure the instrument is set to the proper line voltage. The instrument contains a rear panel slide switch to select the nominal line voltage. See Figure 2-4 for proper line voltage settings.

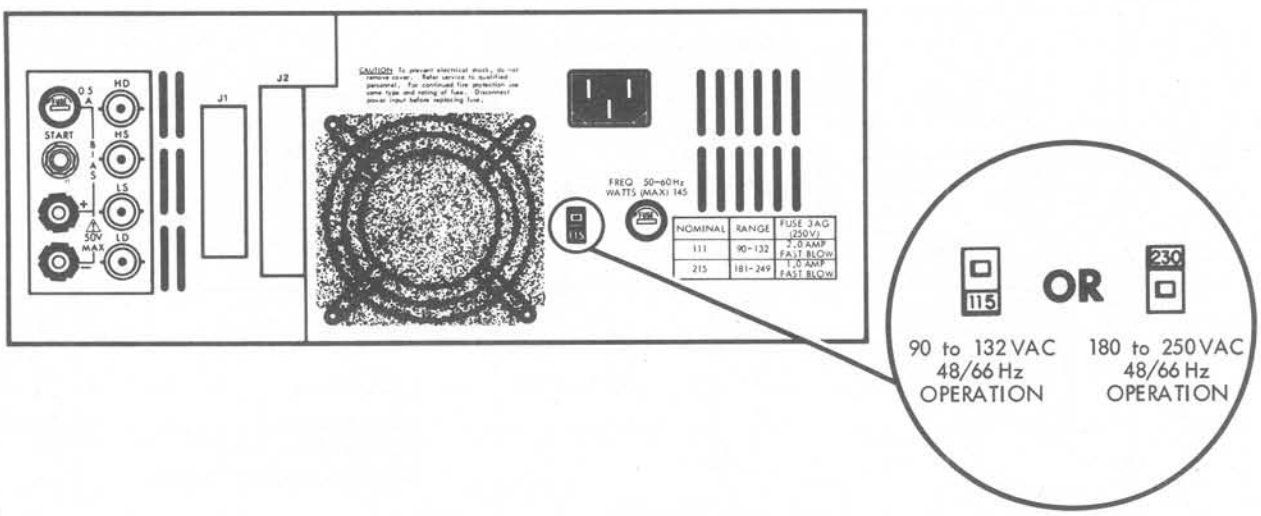


Figure 2-4. Line Voltage Settings

CAUTION

BECAUSE OF DIFFERING POWER REQUIREMENTS, INSTRUMENTS SHIPPED OUTSIDE THE UNITED STATES MAY REQUIRE A DIFFERENT POWER CORD CONNECTOR. WHEN PLACING A NEW CONNECTOR ON THE POWER CORD, CARE MUST BE TAKEN TO ASSURE THE WIRES ARE CONNECTED PROPERLY. THE GREEN OR GREEN-WITH-YELLOW-STRIPE WIRE IS ALWAYS CONNECTED TO EARTH GROUND. THE WHITE OR LIGHT-BLUE WIRE IS CONNECTED TO THE NEUTRAL SIDE OF THE POWER LINE. AND, THE BLACK OR BROWN WIRE IS CONNECTED TO THE HIGH SIDE OF THE POWER LINE. FIGURE 2-5 ILLUSTRATES THE AVAILABLE POWER CORDS, WHICH MAY BE USED IN VARIOUS COUNTRIES INCLUDING THE STANDARD POWER CORD FURNISHED WITH THE INSTRUMENT. ELECTRICAL CHARACTERISTICS AND COUNTRIES USING EACH CONNECTOR ARE LISTED IN THE FIGURE.

WARNING

TO PREVENT POSSIBLE ELECTRICAL SHOCK OR DAMAGE TO THE INSTRUMENT, CHECK LOCAL ELECTRICAL STANDARDS BEFORE SELECTING A POWER CORD. THE INFORMATION PRESENTED HERE MAY NOT BE CORRECT FOR ALL LOCATIONS WITHIN THE REFERENCED AREAS.

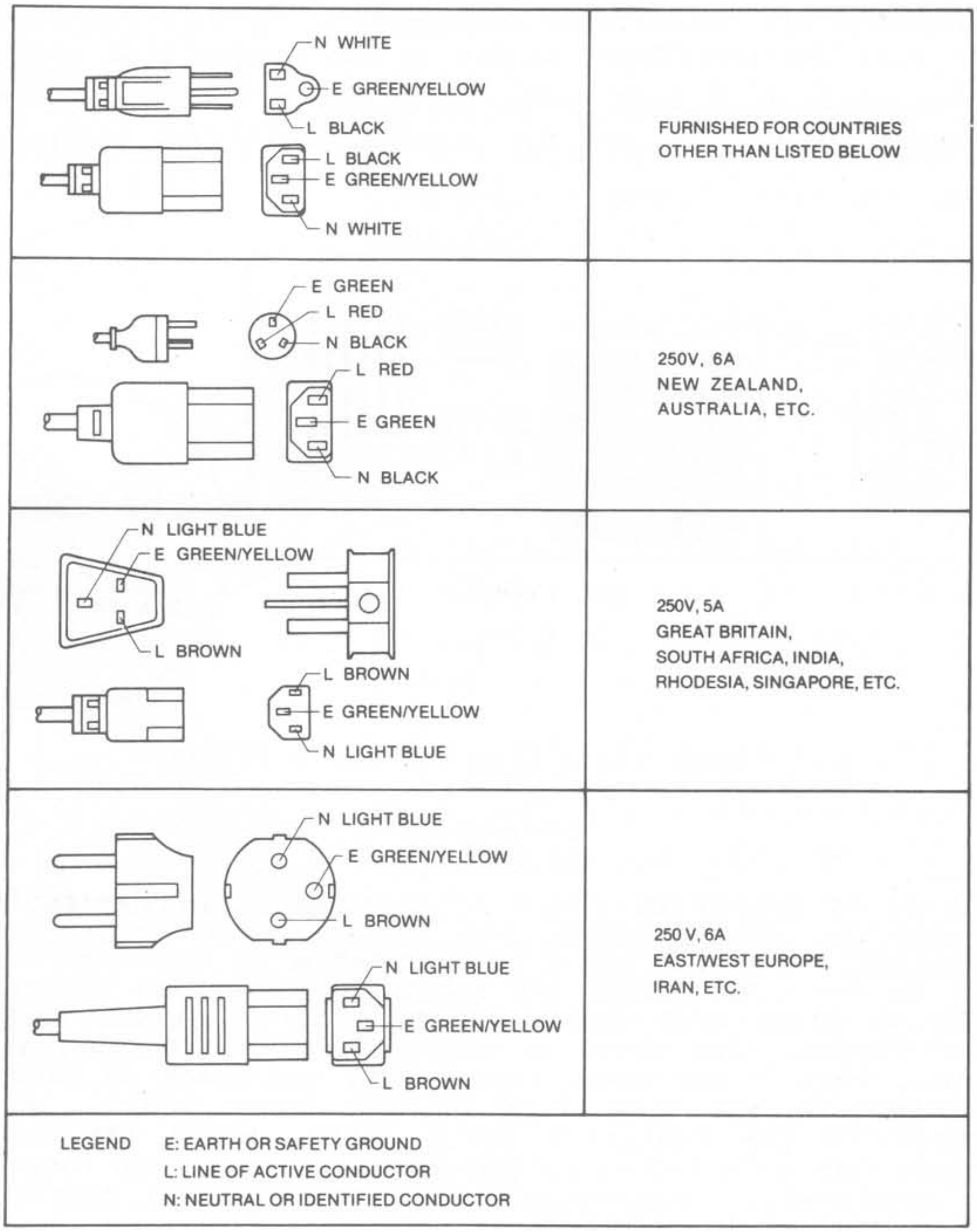


Figure 2-5. Power Cord Connectors

2.3.2 Applying Power

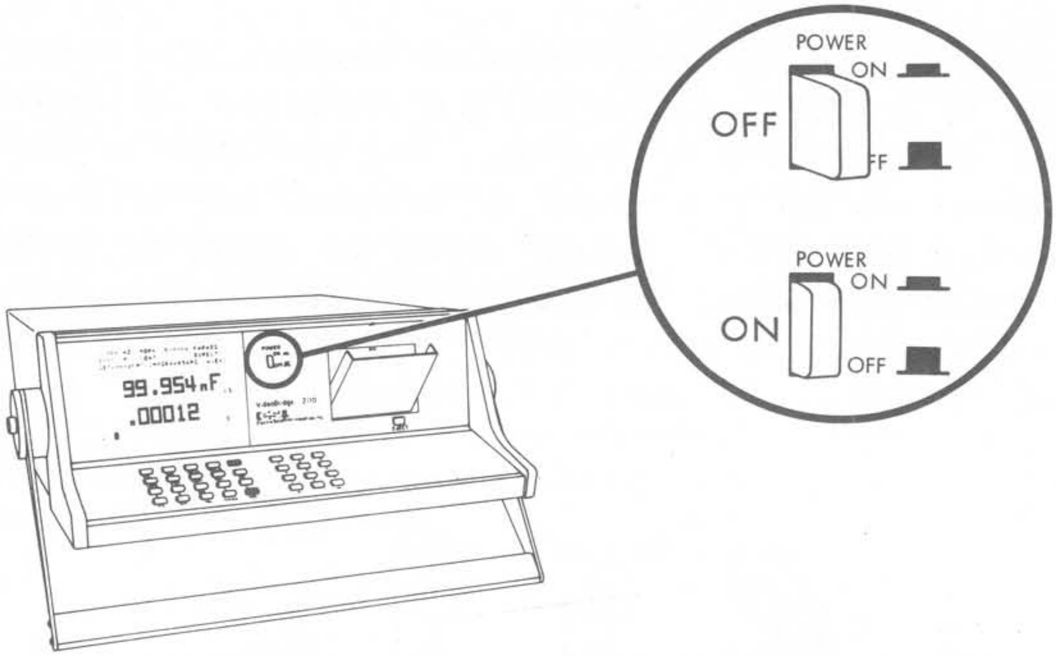


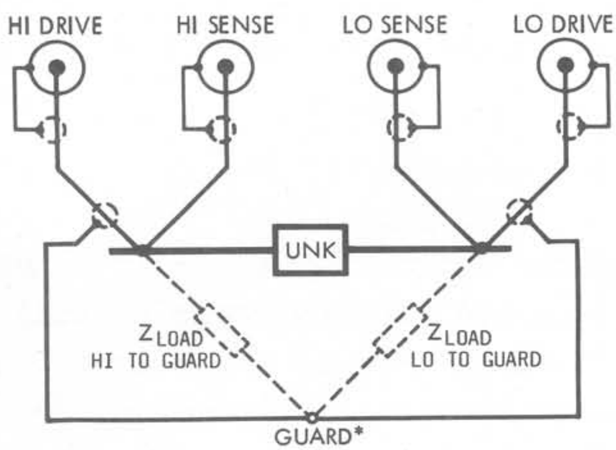
Figure 2-6. Power ON/OFF Switch

A front panel push-ON, push-OFF switch turns power ON and OFF (see Figure 2-6). When power is applied, the CRT display will illuminate in ≈15 seconds. Instrument warm-up time is ≈5 minutes. The initial starting condition for all programmable parameters is:

Display Format	Direct
Frequency	1ØØØHz
Nominal value	ØØØØ
Units of the top measurement display	Farads
Test signal level	1ØØØmV RMS
Measurement mode	Single
Settling time	5Øms
Integration time	5Øms
Measurements averaged	1
Measurement speed	Medium
Top Display function	Cs
Bottom display function	D
Binning limits 1 - REJ	ØØØØ
Limits mode	%

2.3.3 Connections to Unknown

Model 2100/2110 makes four-terminal measurements with passive guarding. It provides separate shielded connection cables for current drive and voltage sense to the high and low side of the unknown. These cables are fully shielded to minimize the effects of stray capacitance. They are labeled HI DRIVE, HI SENSE, LO DRIVE, and LO SENSE. The shields around the HIGH and LOW DRIVE cables are connected to the GUARD point (see Figure 2-7). Drive and sense leads for both HIGH and LOW terminals must be connected together for accurate measurements.



*Guard shields of HI and LO Drive cables must be connected at unknown end of test-leads.

Figure 2-7. Connection to Unknown

Separate drive and sense connections are necessary to prevent lead resistance from becoming a part of the measured unknown. This is especially true for accurate measurements of low impedance unknowns. Separate drive and sense connections can be made to a single lead connected to the unknown if the lead is a small part of the unknown impedance ($R_{lead}<Z_{unk}/1000$ for <0.1% error). With proper connections as shown in Figure 2-7, for most measurements cable lengths up to 5 feet cause no loss of accuracy. Longer cable lengths or special test conditions may result in some accuracy loss. Consult ESI factory for advise on your application.

2.3.4 Test-Leads vs Test-Fixtures

Certain measurement areas are more critical than others and require that a test-fixture be used rather than test-leads. Test-leads, with KELVIN KLIPS, are best used at low frequencies (at or below 1kHz) or for higher frequency measurements where high accuracy is not needed. At higher frequencies (above 1kHz), the need for a test-fixture becomes more and more important because test-lead (Klips) spacing cannot be fixed as in a test-fixture. Changes in test-lead position change stray capacitance and/or inductance making a true zero correction reading in either open-circuit or short-circuit mode difficult to obtain. If higher accuracy, high frequency measurements are needed, then use a test-fixture.

2.3.5 Zero Calibration

Measurement accuracy is enhanced by the 2100/2110's ability to correct for zero-offset errors caused by test-lead and test-fixture impedances (capacitance, inductance, resistance, etc.). These impedances appear in parallel or in series with the unknown component during measurement and add to the measured value. The zero calibration function measures these zero offset errors and stores them in memory. The stored value is automatically subtracted from each measured value.

The 2100/2110 makes two types of zero calibration measurements -- Open-Circuit and Short-Circuit -- that operate as follows:

<u>Open-Circuit Calibration</u>

Open-circuit calibration is used when the instrument is in the voltage mode (test signal level is mV). To activate this mode, push the yellow button followed by the CAL button. The display will echo:

OPEN UNKNOWN -- THEN PUSH "SNGL"

With the test-leads in place, but unknown not connected, push the SINGLE button. The zero calibration error will be measured and stored.

NOTE: Anytime the measurement frequency or test signal level is changed or re-entered as the same value, the zero calibration value is erased from memory. A new value can be obtained by performing the procedure described above.

Short-Circuit Calibration

Short-circuit calibration is used when the instrument is in the current mode (test signal level is mA). To activate this mode, push the yellow button followed by the CAL button. The display will echo:

CLOSE UNKNOWN -- THEN PUSH "SNGL"

With the test-leads shorted together, push the SINGLE button. The zero calibration error will be measured and stored.

NOTE: Anytime the measurement frequency or test signal level is changed or re-entered as the same value, the zero calibration is erased from memory. A new value can be obtained by performing the procedure described above.

2.3.6 Input Protection

The 2100/2110 input terminals have a circuit which prevents damage to the instrument if a charged capacitor is connected to these terminals. Protection limits can be calculated from the equation:

$$V_{MAX} = \sqrt{\frac{2}{C}}$$

where V = capacitor voltage in volts
C = capacitor value in farads

The protection circuit allows a maximum energy of 1 joule up to a maximum voltage of 1kV. Table 2-1 below gives examples of maximum voltages for various capacitance values.

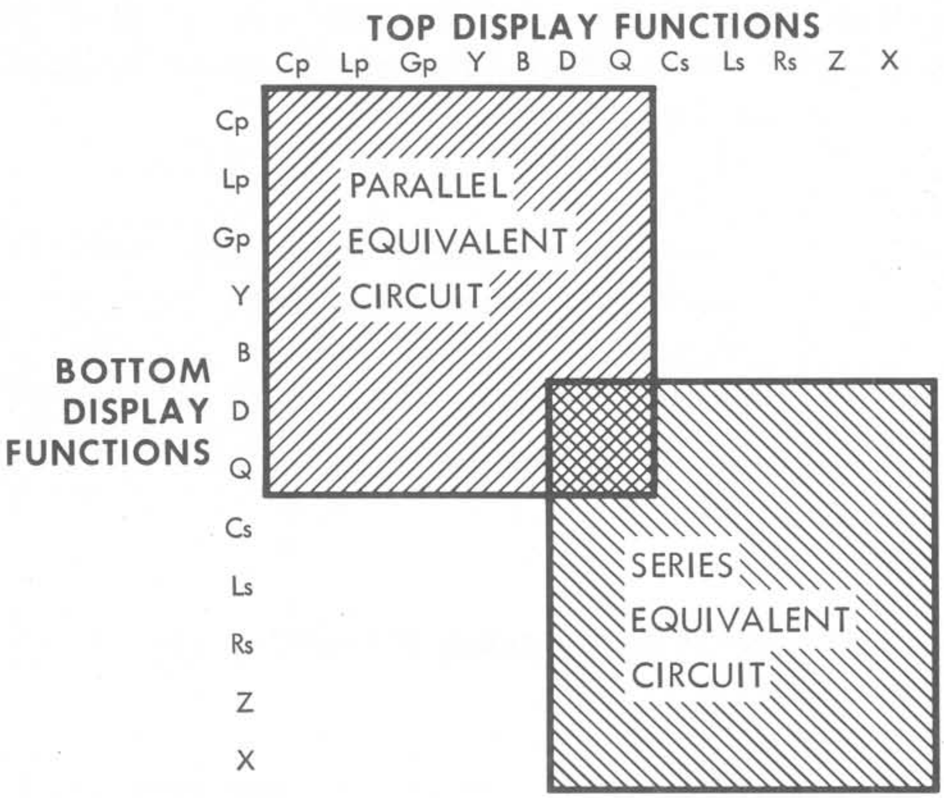
1kV	0 to 2μF
315V	20μF
100V	200μF
31V	2mF
10V	20mF
3V	200mF
1V	2F

Table 2-1. Input Protection Limits

When limits are exceeded, the fuse on the rear panel will burn out and must be replaced with a 0.5A 3AG fuse. To prevent possible damage to the instrument use only the proper replacement fuse.

2.4 MEASUREMENT FUNCTIONS

The Model 2100/2110 will measure and display a variety of function combinations. The shaded areas of Table 2-2 shows the functions that can be displayed simultaneously. Either of the two selected functions can be displayed as the top or the bottom function on the CRT screen. For a further explanation of programming measurement functions or exchanging their display positions see Sections 2.4.1 and 2.4.2 respectively, in this manual.



NOTE: Any top display can be displayed with any bottom display within the shaded areas.

Table 2-2. Measurement Functions

2.4.1 Programming Measurement Functions

Measurement functions available with the Model 2100/2110 are: capacitance (C), inductance (L), resistance (R), dissipation factor (D), quality factor (Q), conductance (G), admittance (Y), impedance (Z), susceptance (B), and reactance (X). They are selected via the front panel keyboard by pressing the pushbutton for the desired function. The selected functions are displayed, one-above-the-other, on the CRT screen. Their position on the screen can be exchanged at any time, i.e. Cs displayed above R can be exchanged to display R over Cs. Because of the versatility involved in displaying and positioning measurement displays and to assure the measurements are displayed as you want them, read the following precautions before programming measurement functions.

1. C, L, Y, Z, B, and X functions always replace the top measurement display on the CRT.

2. G, R, D, and Q functions always replace the bottom measurement display on the CRT.

3. G/R, Y/Z, and B/X functions program in conjunction with the PRL (parallel) and SER (series) keys, i.e. when in the parallel equivalent circuit mode G, Y, and B can be programmed and in the series equivalent circuit mode R, Z, and X can be programmed.

4. Top and bottom measurement displays are exchanged using the XCHG key.

The Model 2100/2110 initially measures series capacitance (Cs) and dissipation factor (D) when power is applied (see Figure 2-8). These measurement functions can be changed at any time by pushing the desired function button.

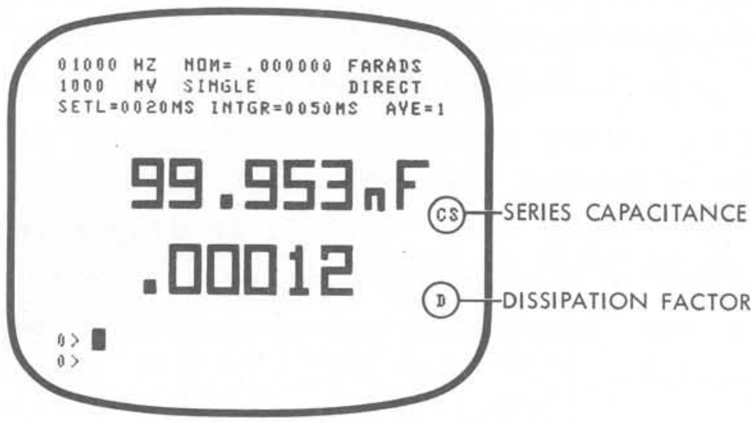
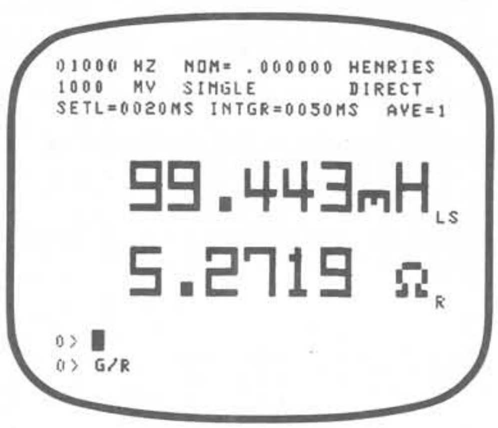


Figure 2-8. Measurement Display

Example: Measure series inductance (Ls) and resistance (Rs).

Push	Display	Comments
		L key changes Cs to Ls in top display. G/R key changes D to R (series equivalent circuit) in bottom display. Makes one measurement and holds displayed result.

Example: Measure impedance (Z) and quality factor (Q).

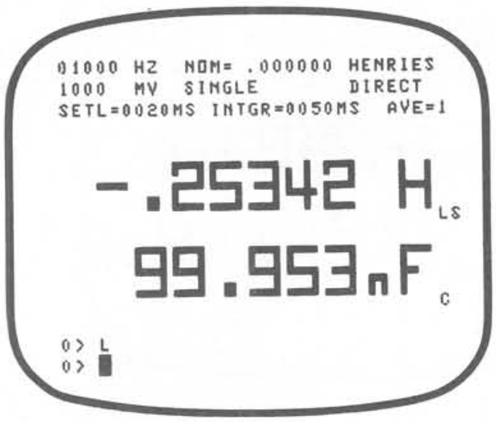
Push	Display	Comments
		Y/Z key changes Ls to Zs (series equivalent circuit) in top display.
		Q key changes R to Q in bottom display.
		Initiate single measurement.

2.4.2 Exchanging Measurement Displays

The XCHG key exchanges the position of the two displayed measurements. Using the XCHG key allows two functions that normally program into the top display to be measured and displayed simultaneously.

Example: After turning instrument power ON. Set the instrument to measure and display Ls and Cs.

Push | **Display** | **Comments**



XCHG — Exchange key moved Cs to bottom display.

L — L key set top display to series inductance.

SGL — Initiate single measurement.

In the same context, any two functions that normally appear in the bottom measurement display can also be displayed simultaneously.

Example: Set the instrument to measure Rs and Q.

Push | **Display** | **Comments**

G/R — G/R key changes D to R (series equivalent circuit) in bottom display.

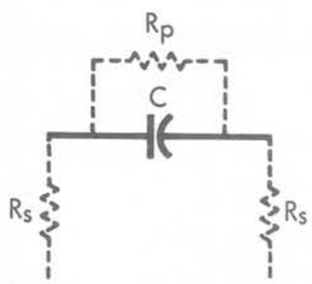
XCHG — Exchange key moves R to top display.

Q — Q key selects Q in the bottom display.

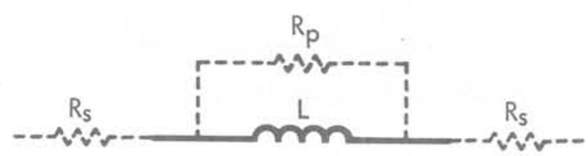
SGL — Initiate single measurement.

2.4.3 Series and Parallel Equivalent Circuit

Capacitors, inductors, and resistors are inherently imperfect impedance components, i.e. they have series and parallel, reactive and resistive elements. The Model 2100/2110 measures the reactive and resistive elements of an impedance component. (The relationship of these reactive and resistive elements is often described in terms of their series or parallel equivalent circuits.) The 2100/2110's PRL (parallel) and SER (series) functions steer the measured reactive and resistive values to an algorithm that calculates values in terms of series or parallel equivalent circuit. Series and parallel equivalent circuit mode measurements will provide differing results. The magnitude of difference depends on the quality of the component being measured. In determining which equivalent circuit mode to use, consider the following factors before making a selection.



TYPICAL CAPACITOR



TYPICAL INDUCTOR

1. What is the actual equivalent circuit of the capacitance being measured? This information should be available from the manufacturer's specifications. If not available, the equivalent circuit can be determined by a comparison of dissipation factor (D) value obtained at another frequency removed from the selected test frequency. If the test frequency goes up and the measured D decreases, then the unknown is most likely a parallel equivalent circuit. Likewise, if the test frequency goes down and the D decreases, the unknown is most likely a series equivalent circuit.

   NOTE: The dissipation factor (D) of an inductor moves in the opposite direction from the D of a capacitor for a given change in frequency.

2. What is the end use for the component? The equivalent circuit used should provide the information most useful to determining the performance of a component in a particular application. For example, the information necessary for selecting a power supply bypass capacitor is obtained from the series equivalent circuit mode, while the information needed to select a capacitor for a LC resonant circuit is obtained from the parallel equivalent circuit mode.

3. Which equivalent circuit is most valuable to me? If no other information is available, the rule-of-thumb for selecting either series or parallel equivalent circuit mode is as follows:

   Series equivalent circuit should be used when measuring components with a low impedance (basically large value capacitors, low value inductors) and parallel equivalent circuit for components with a high impedance (basically low value capacitors, high value inductors).

To convert a series equivalent circuit measurement to that of a parallel equivalent circuit use the formula given in Figure 2-9. These formulas consider the effects of dissipation factor (D) with the measured value. (Dissipation factor (D) is always equal for both series and parallel equivalent circuits at a given frequency.)

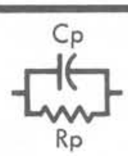
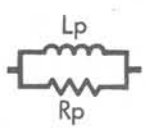
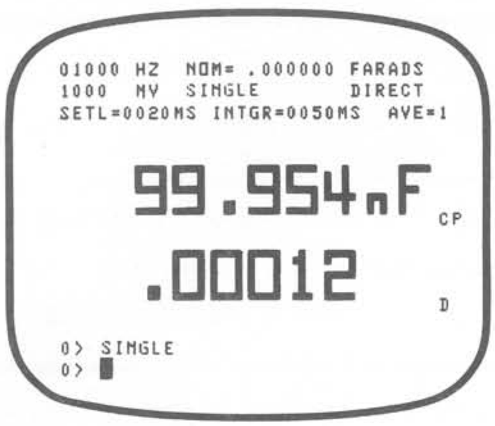
CIRCUIT MODE		DISSIPATION FACTOR	CONVERSION TO OTHER MODES
C		$D = \frac{1}{2\pi f C_p R_p} = \frac{1}{Q}$	$C_s = (1 + D^2) C_p$ $R_s = \frac{D^2}{1 + D^2} R_p$
		$D = 2\pi f C_s R_s = \frac{1}{Q}$	$C_p = \frac{1}{1 + D^2} C_s$ $R_p = \frac{1 + D^2}{D^2} R_s$
L		$D = \frac{2\pi f L_p}{R_p} = \frac{1}{Q}$	$L_s = \frac{1}{1 + D^2} L_p$ $R_s = \frac{D^2}{1 + D^2} R_p$
		$D = \frac{R_s}{2\pi f L_s} = \frac{1}{Q}$	$L_p = (1 + D^2) L_s$ $R_p = \frac{1 + D^2}{D^2} R_s$

Figure 2-9. Series and Parallel Equivalent Circuit Modes

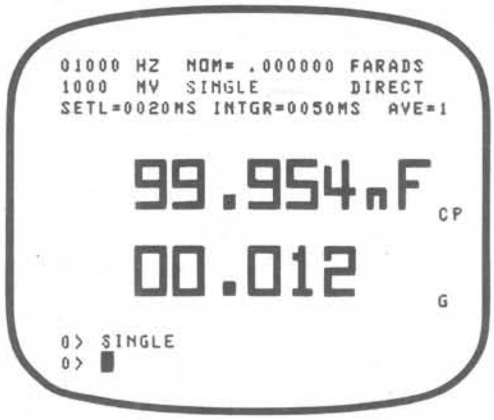
Series and parallel equivalent circuit modes are selected by pushing either the PRL (parallel) or the SER (series) keys.

Examples: The 21ØØ/211Ø initially measures series capacitance (Cs) and dissipation factor (D) when power is applied. To change to parallel capacitance (Cp) and dissipation factor (D):

Push	**Display**	**Comments**
		Cs is changed to Cp.
		Initiates a single measurement.

Three measurement functions are programmed in conjunction with the SER and PRL keys. They are Y/Z, G/R, and B/X. Admittance Y, conductance G, and susceptance B are all parallel equivalent circuit values. They are automatically replaced by their reciprocal values -- impedance Z, resistance R, and reactance X when the series equivalent circuit (SER key) is programmed.

Example: Change the displayed parameters to display parallel capacitance and conductance, then change the measurement mode to display series capacitance and resistance.

Push	Display	Comments
		G/R key changes D to G (parallel equivalent circuit) in bottom display.
		Initiates a single measurement.

THEN

Push	Display	Comments
		G automatically changes to R in series mode.
		Initiates a single measurement.

2.5 TEST SIGNAL

The test signal, applied to the device under test, is a sinusoidal waveform derived from a digital source. It is programmable both in frequency and in magnitude from either the front panel keyboard or remotely via an IEEE-488 or RS-232 interface bus. When power is applied, the instrument's frequency, and voltage level, initialize to 1ØØØHz, and 1ØØØmV RMS, respectively.

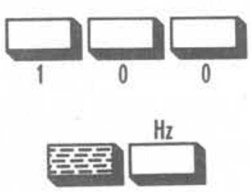
> **NOTE:** Because using voltage or current test signals at their low extremes produces a low signal-to-noise ratio, measurement accuracy at these low levels may be seriously derated.

2.5.1 Frequency

The Model 21ØØ/211Ø has ≈3ØØØ selectable test frequencies between 2ØHz and 2ØkHz. All frequencies are accurate to within ±Ø.Ø1%. When power is applied, the instrument's test frequency initializes to 1ØØØHz. All frequencies are entered directly in hertz (Hz).

Example: Set the instrument's test frequency to 1ØØHz.

Push | **Display** | **Comments**



To allow the test signal to stabilize after a frequency change, wait 2ØØms before initiating a measurement.

The frequency selected is displayed on the CRT (first line -- small letters). The displayed frequency is the nearest available frequency greater than the selected value. Table 2-3 shows some of the commonly used frequencies. The available frequencies not shown in Table 2-2 can be determined using the formula:

$$F = 60kHz/N$$

Where: N is an integer $3 \leq N \leq 3000$

N	Frequency (Hz)	N	Frequency (Hz)	N	Frequency (Hz)	N	Frequency (Hz)
3	20,000	30	2,000	300	200	3000	20
4	15,000	40	1,500	400	150		
5	12,000	50	1,200	500	120		
6	10,000	60	1,000	600	100		
8	7,500	80	750	800	75		
10	6,000	100	600	1,000	60		
12	5,000	120	500	1,200	50		
15	4,000	150	400	1,500	40		
20	3,000	200	300	2,000	30		
25	2,400	250	240	2,500	24		

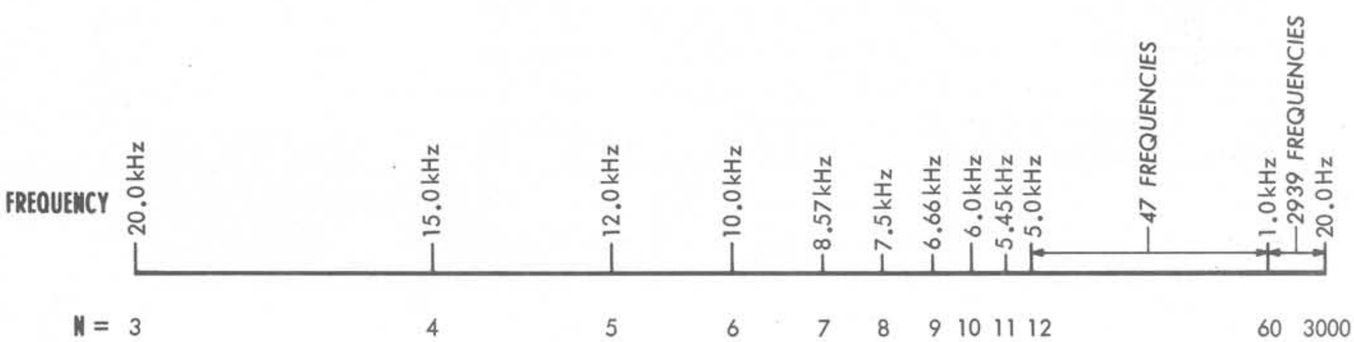
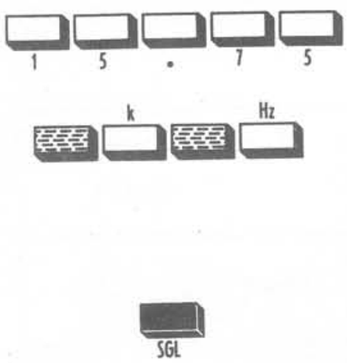


Table 2-3. Test Frequencies

Any frequency entered between two available frequencies will automatically divert to the higher frequency.

Example: Set the test frequency to 15,75ØHz.

Push



Display

Comments

Frequency (15.75kHz) automatically reverted to the closest but higher frequency (2Ø,ØØØHz).

Initiate a single measurement.

Notice in the examples above, as numbers are entered, they are echoed on the CRT. When the entry was terminated, by pushing Hz, the 21ØØ/211Ø selected the closest, but higher, frequency available.

NOTE: To provide greatest measurement accuracy, test-lead or test-fixture calibration must be performed after any frequency change.

2.5.2 Signal Levels

The test signal voltage level initializes to 1V RMS when instrument power is applied. The test signal level can be changed at any time to meet testing requirements. Voltage is programmable from 1ØmV to 15ØØmV RMS in 1ØmV steps. Current is programmable from 1mA to 1ØØmA in 1mV steps.

Example: Set the amplitude of the test signal to 1ØØmV RMS.

Push **Display** **Comments**

To allow the test signal time to stabilize after a signal level change, wait 2ØØms before initiating a measurement.

Initiate a single measurement.

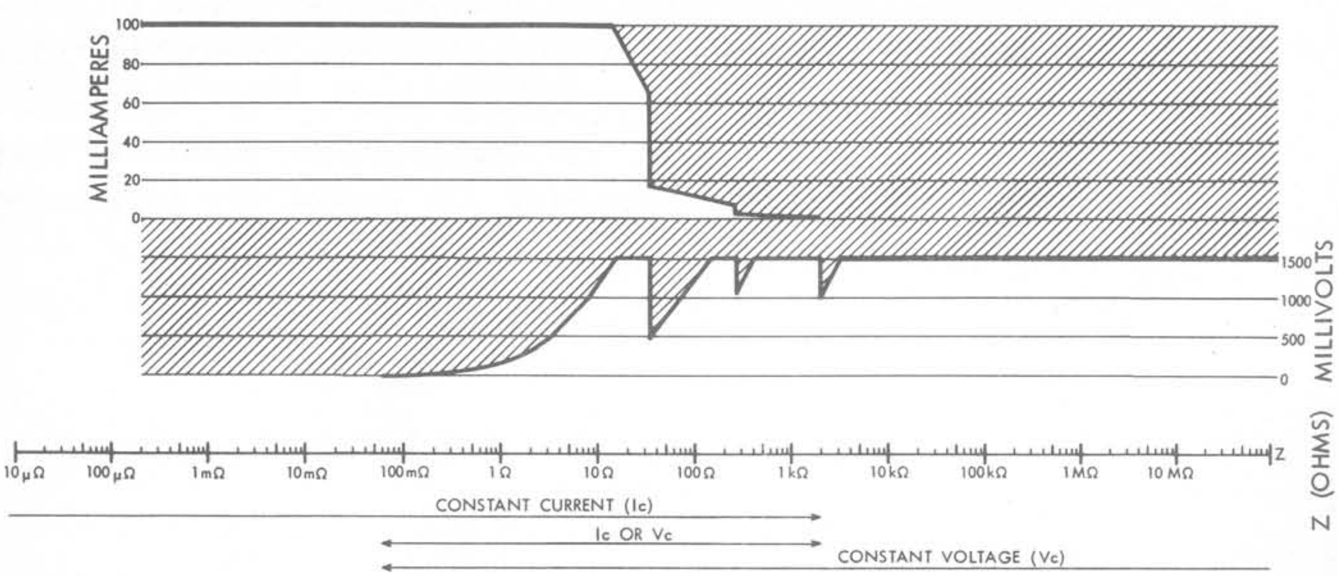


Table 2-4. Test Level vs Impedance

Test currents can be programmed between 1mA and 100mA. For unknown impedances between 0 and 2kΩ, set the test current directly. For unknown impedances over 2kΩ, the test current is determined by dividing the voltage level, by the unknown impedance.

For best measurement results, select a test signal level that will provide the best signal-to-noise ratio. High test signal levels are used for general component testing (capacitors, resistors, and certain inductors). Low test signal levels are used for testing devices requiring low operating-signal levels (semiconductor devices, inductors, and non-linear impedance devices).

Table 2-4 shows the 2100/2110's test level limitations compared to the impedance of the component under test. If the impedance of the device falls outside these limits, the following conditions result:

- At a set voltage level and with an impedance too low to produce the specified voltage drop across the unknown, the instrument will display the error message "Can't supply volts". The instrument will perform the measurement at the highest possible test voltage level. The test signal voltage will not exceed the programmed value.

- At a set current level and with an impedance too large to allow the instrument to produce this current, the instrument will display the error message "Can't supply amps". The instrument will perform the measurement at the highest possible test current level. The test current will not exceed the programmed value.

To optimize measurement accuracy, care should be taken when selecting test signal levels. Measuring high impedance components at very low test voltages or very low impedances at very low current levels can cause measurements to be erratic due to a poor signal-to-noise ratio. The test level and impedance charts in this manual, and the 2100/2110's capability to measure and display Z, the total impedance of the device under test, can be used as an aid to determining the optimum test signal level.

NOTE: To maintain measurement accuracy, test-lead or test-fixture calibration must be performed after any test level change.

2.5.3 Measurement Range

The Models 2100/2110 are basically continuously ranging instruments. Ranging is a transparent operation that makes the instrument appear to have only one range throughout its entire impedance measuring capabilities. Actually, ranging is achieved by making an initial measurement before making the actual measurements for display. This initial measurement is made with very short integration times and is completely unaffected by the values programmed for measurement speed or test level. The sole purpose for this measurement is to determine the proper range resistor. This measurement is not displayed. With the proper range resistor selected, the instrument makes a measurement and displays the results. Refer to Table 2-5 for ranging data.

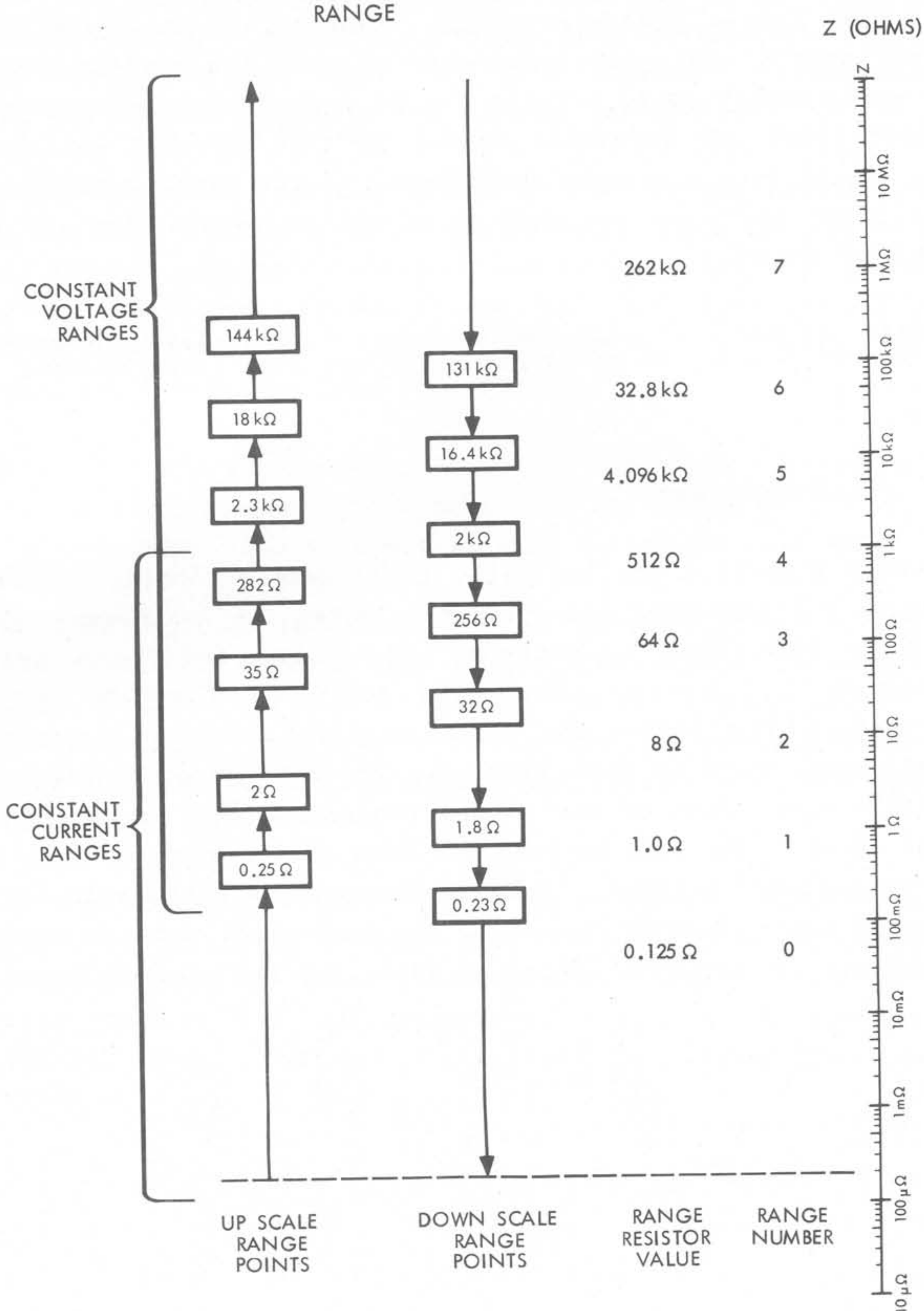


Table 2-5. Model 2100/2110 Impedance Ranging Chart

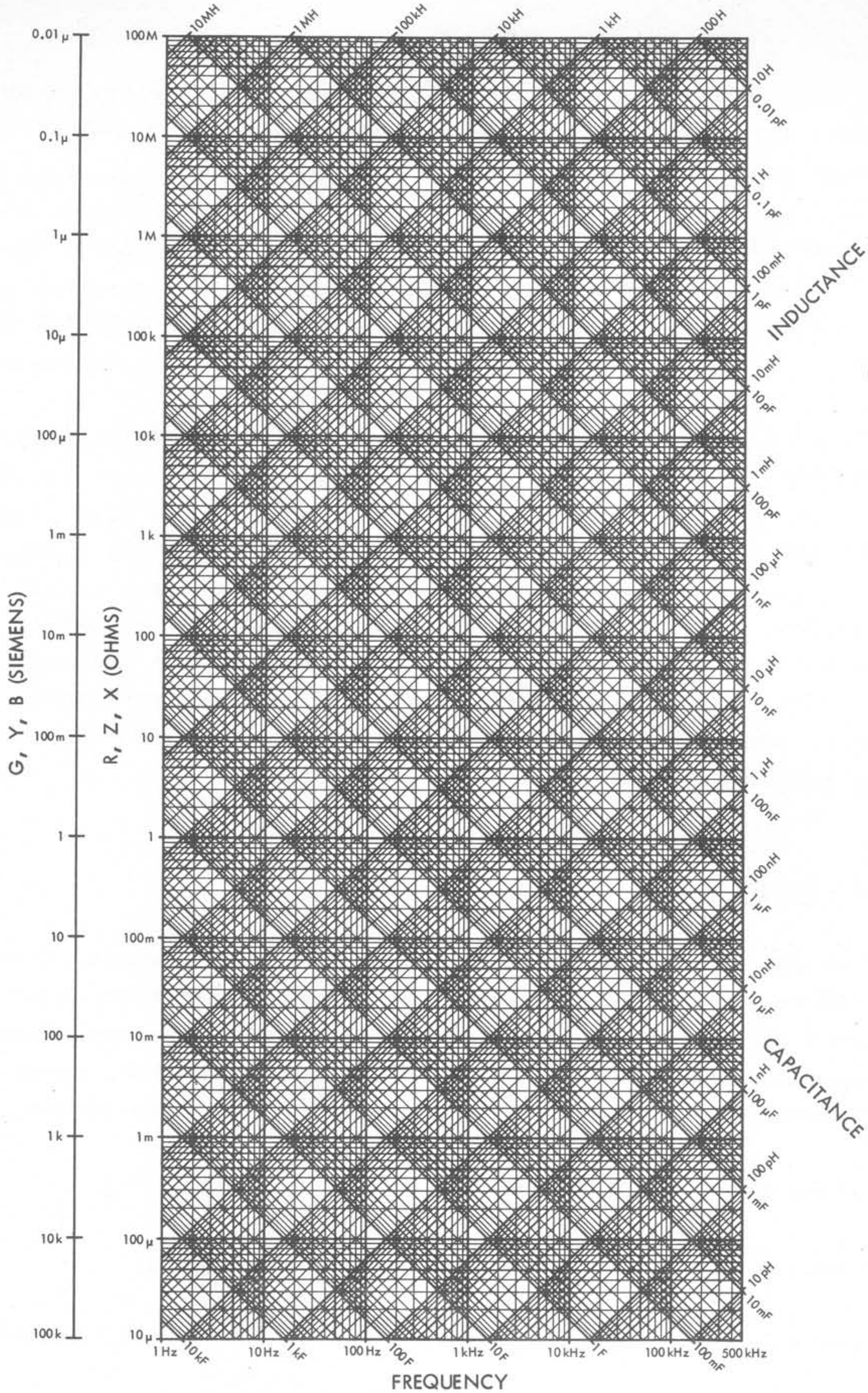


Table 2-6. Reactance Chart

To find the span of capacitance, inductance, or other measurement parameters for a particular impedance range (shown in Table 2-5) at a particular frequency use Table 2-6 as follows:

1. Find the impedance (Z) along the left margin of Table 2-6.

2. Find the operating frequency (Hz) along the bottom margin of Table 2-6.

3. Find the intersection of the horizontal impedance line and the vertical frequency line.

4. Find the closest diagonal line to the intersection.

5. Move down the diagonal line to the right or bottom margin to find the corresponding capacitance value. Move up the diagonal line to the right or top margin to find inductance. Resistance, conductance, admittance, susceptance, and reactance can be found in the two adjacent columns of the left margin.

2.5.3.1 Range Hold

When testing many components of the same value where speed is a prerequisite, the pre-measurement described in Section 2.5.3 can be eliminated by using range HOLD. (The range finding measurement takes a minimum of 60ms. Due to increased integration time, range finding measurements made at frequencies below 500Hz will take longer.)

To initiate range HOLD:

1. Connect a component to the test leads or fixture.

2. Allow one measurement to be made, then push the HOLD button.

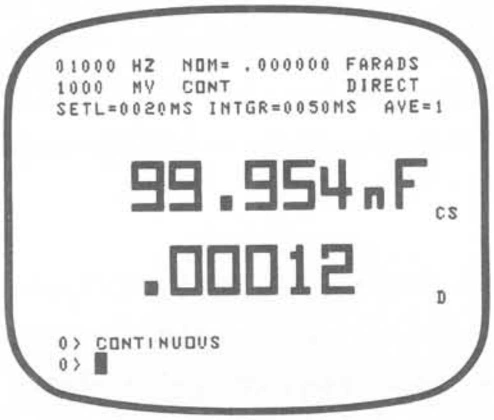
Returning to the continuous ranging mode is accomplished by pushing the AUTO button.

2.5.4 Continuous and Single Measurements

In the Continuous mode the instrument makes 1 measurement and calculates the selected display value. Immediately after a measurement is completed a new measurement is initiated. The continuous measurement mode is entered by pushing the yellow key followed by the CONT key. The CRT display is updated once every 300 milliseconds when medium measurement speed is selected.

Single measurement mode is initially selected when instrument power is applied. To perform single measurements, press the SGL button. The instrument will make one measurement and update the display. Single measurements can also be initiated via the rear panel remote start jack. Remote start requires a "de-bounced" switch or relay closure to ground to initiate a single measurement.

Example: Set the instrument to the continuous measurement mode.

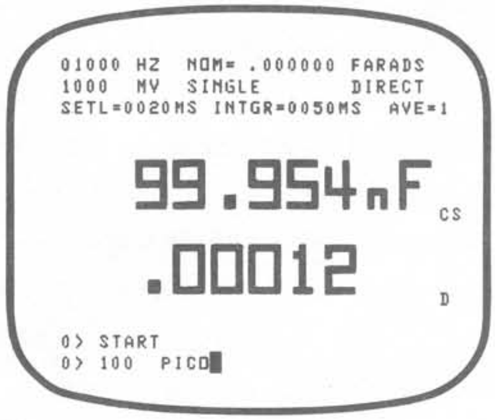
Push	Display	Comments
		Selects continuous measurement mode.

To return to single measurement mode, push the SGL key.

2.5.5 DELETE

The DEL key removes the last incorrect entry made while programming data into the 21ØØ/211Ø.

Example: Set the nominal value to 1ØØμ.

Push	Display	Comments
		OOPS! Wrong suffix.

Push	Display	Comments
DEL	Ø > 1ØØ PIC	One character is erased for each push of the delete key.
DEL	Ø > 1ØØ PI	
DEL	Ø > 1ØØ P	
DEL	Ø > 1ØØ	

Re-enter the correct data.

Push	Display	Comments
		Correct value is programmed.

If the entry has been terminated, by pushing the NOM button (in this example), the DEL button will no longer remove the incorrect data. However, the correct data can be reprogrammed as a new entry.

2.6 DEVIATION MEASUREMENT

Two types of deviation measurement are possible with the Model 2100/2110; deviation as a percent of nominal or absolute deviation from a nominal in units. Deviation measurements can be made using either autoranging or range hold modes. In the autoranging mode, the 2100/2110 will change ranges to allow percent deviations from -100% to +900% of the preset nominal value, and absolute deviation may vary up to 3 times the nominal value. In the range hold mode, the range of percent and absolute deviations are limited by the measurement ranges' upper and lower boundries. Deviation calculations require a small amount of time to complete, so measurement speed is decreased slightly.

To make deviation measurements, a nominal value must first be set. A nominal value can be programmed at any time. It is programmed as a number with multiplier and assumes the units in the top measurement display. The nominal value is compared with the measured value only when in the deviation measurement mode. The comparison result is displayed as the top reading on the CRT. In the deviation mode, the instrument's measurement resolution can be determined by using Table 2-7.

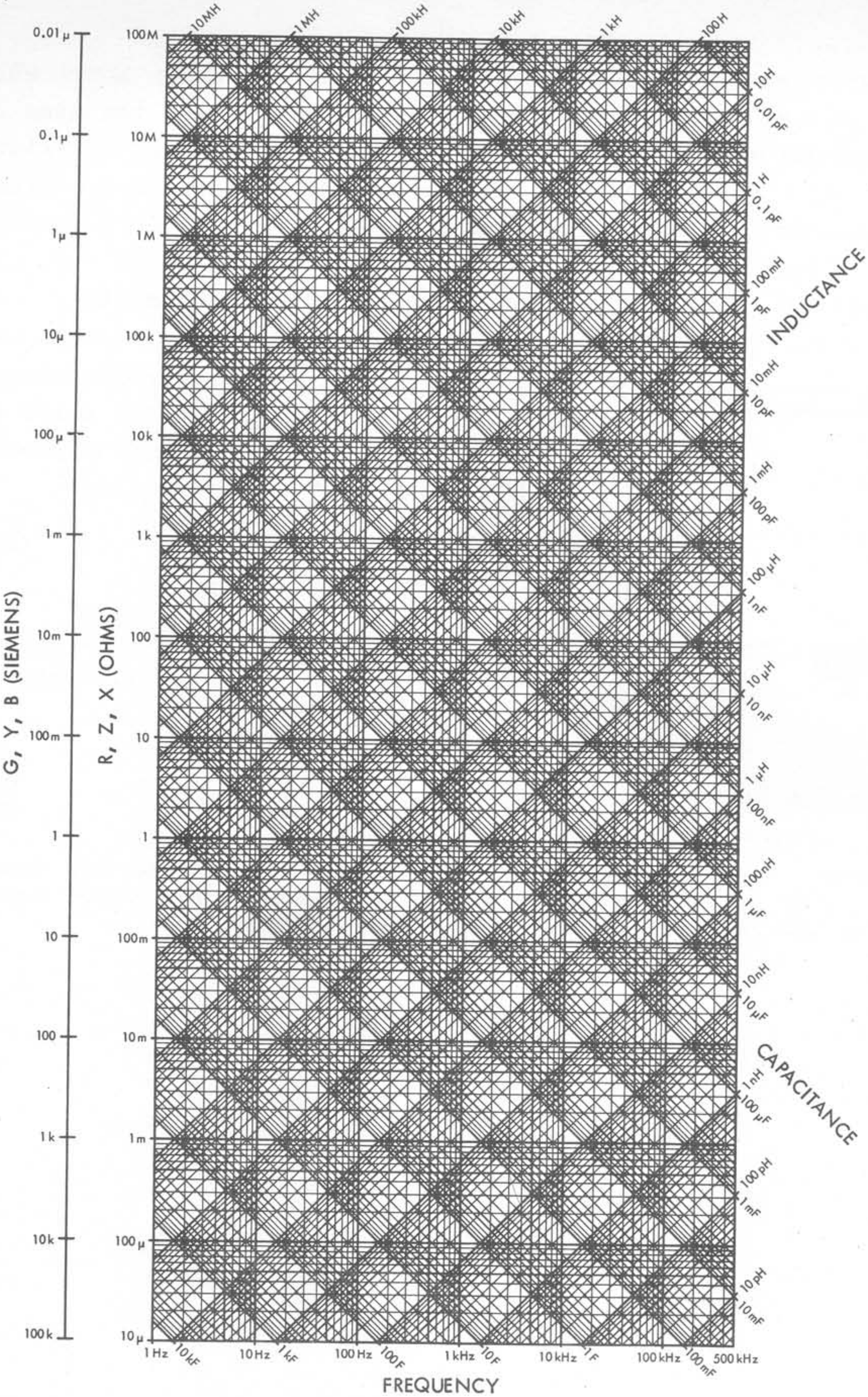
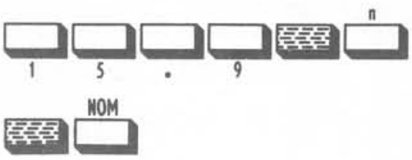
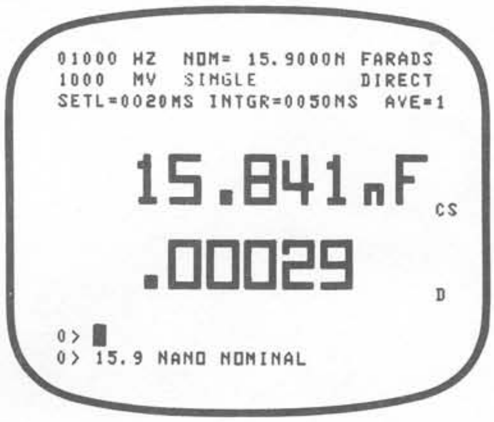

G, Y, B (SIEMENS)
0.01µ
0.1µ
1µ
10µ
100µ
1m
10m
100m
1
10
100
1k
10k
100k
R, Z, X (OHMS)
100M
10M
1M
100k
10k
1k
100
10
1
100m
10m
1m
100µ
10µ
10MH
1MH
100kH
10kH
1kH
100H
10H
0.01pF
1H
0.1pF
100mH
1pF
INDUCTANCE
10mH
10pF
1mH
100pF
100µH
1nF
10µH
10nF
1µH
100nF
100nH
1µF
10nH
10µF
CAPACITANCE
1nH
100µF
100pH
1mF
10pH
10mF
1Hz
10kF
10Hz
1kF
100Hz
100F
1kHz
10F
10kHz
1F
100kHz
100mF
500kHz
FREQUENCY

Table 2-7.

To set a nominal value, enter the desired value with multiplier (p,n,µ,m,k,M) then push NOM VALUE. The entry takes the same units as selected for the top measurement display.

Example: Set a nominal value of 15.9nF.

Push	Display	Comments
		Nominal value takes on the units of the top displayed function.
		Initiate a single measurement.

NOTE: Only one nominal value can be set. The top measurement display is the result of comparing the measured value against the nominal value only when in the deviation mode.

2.6.1 Deviation Mode

The deviation mode (DEV) compares the nominal value against the calculated value selected as the top measurement display. It displays the results, in either absolute or percent deviation, in place of the top display. To enter the deviation mode, push the DEV key.

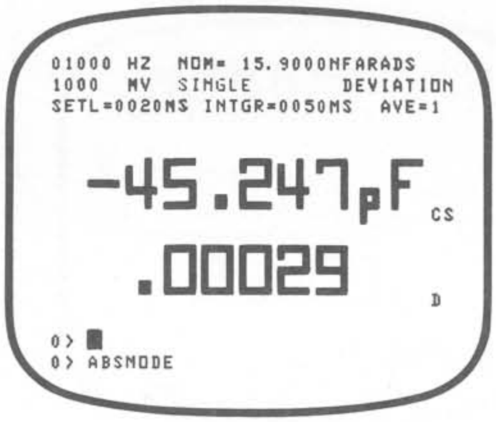
Example: Make deviation measurements using the nominal value set in the example above.

Push	Display	Comments
 DEV		Enter deviation measurement mode. Deviation is the top displayed value.
 SGL		Initiate a single measurement.

2.6.2 Absolute or Percent Deviation

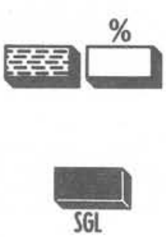
The difference between nominal value and calculated value, of the top reading, can be displayed as either absolute or percent deviation. Percent deviation is initially selected when power is applied. To display absolute deviation, Push ABS.

Example: Continuing with the previous examples, the instrument is displaying percent deviations. Change to display absolute deviation.

Push	Display	Comments
		Display absolute deviation Initiate a single measurement

The instrument will remain in the absolute mode until changed by pushing %, or until power is removed or interrupted.

Example: Return to percent deviation mode.

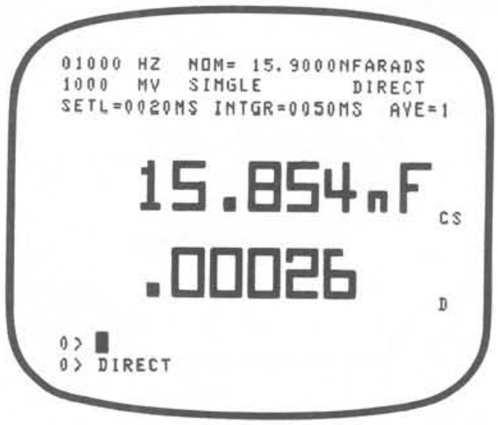
Push	Display	Comments
		Display percent deviation Initiate a single measurement

2.6.3 Exit Deviation Mode

To exit from the deviation mode, push DIR. The instrument will revert to the direct (normal) display mode. The top measurement reading will again display the calculated value of the device under test.

Example: Continuing with the examples above, return to the direct measurement mode.

Push | **Display** | **Comments**



Exit deviation mode.

Initiate a single measurement.

2.7 COMPONENT SORTING

The sorting mode allows the 21ØØ/211Ø to characterize components by tolerance. Components are categorized into one of eleven preprogrammed limit bins. There are 1Ø limit bins, numbered Ø through 9 plus one reject limit, labeled REJ. Limits can be arranged in two methods: 1.) ten bins for the reactive element of the unknown (C,L,Z,Y,B,X) and one reject limit for its loss element (R,G,D,Q); or 2.) ten bins for the loss element of the unknown and one reject limit for its reactance. The choice between these two arrangements is made when the displayed functions are selected. The 1Ø limit bins sort components according to the measurement function of the top reading on the CRT. The bottom reading is subject to the reject limit (see Figure 2-1Ø).

Bin Display **Direct Display**

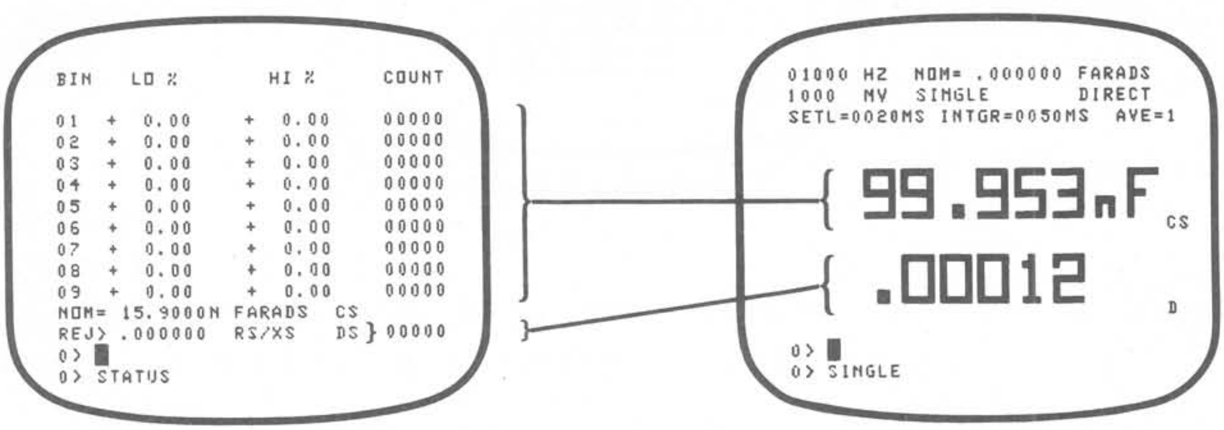


Figure 2-1Ø. STATUS Display

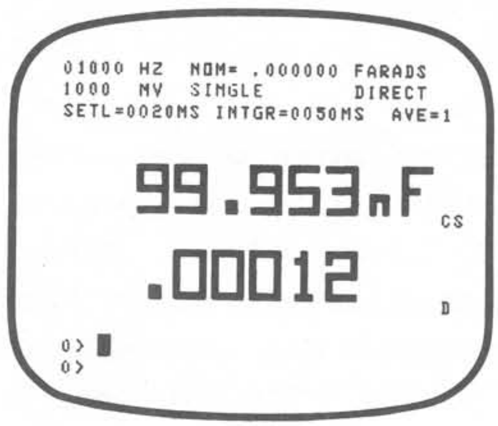
To properly characterize components, the test parameters should be set as close to the component's actual operating condition as possible. Before entering the sorting mode, set the test parameters (functions, frequency, test-signal level, settling time, integration time, etc.) to the optimum conditions for the component to be tested. Refer to Section 2.4 for setting test parameters.

2.7.1 Bin Display

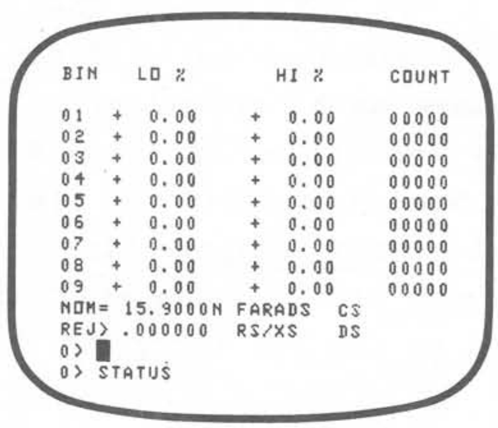
The Model 2100/2110 initializes in the DIRECT display format when instrument power is applied. To toggle the display format to the binning display, push the STAT key.

Example:

Push | **Display** | **Comments**



Direct display format.



Binning display format.

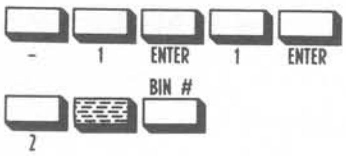
The binning display consists of ten bins, numbered Ø through 9, and one reject limit. Each bin contains a LO limit value, a HI limit value, and a component counter. (Limits programming and the component counter will be explained in the following paragraphs.) The display also contains the programmed nominal value, units, and function for bins Ø - 9, and the units, component counter, and function for the reject limit. To return to the DIRECT display format, push STAT again.

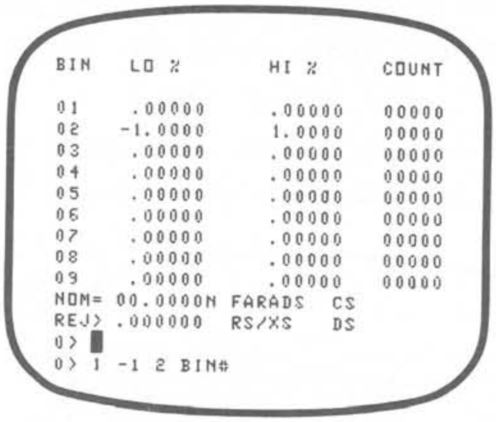
2.7.2 Programming Limits

Limits may be set as absolute units or in percent. When instrument power is applied, the 21ØØ/211Ø is in the percent limits mode. Each bin requires a LO and HI limit value. These two values can be programmed in either order - lowest value first or highest value first. (The 21ØØ/211Ø automatically arranges the values to display the most negative value first.) The bins may be programmed in any order, however, the span of the limits within each bin must be increasingly larger for each succeeding bin ; i.e. Bin 1 = -1%, 1%; Bin 2 = -2%, 2%; Bin 3 = -5%, 5%; etc. The priority for limits comparison is to compare a measured value first against the minor component limit, then against each individual bin limit from top to bottom on the display. To set values for bins Ø - 9, push numerical and/or multiplier keys representing the first limit value, ENTER key, numerical key representing the second limit value, ENTER key, numerical key representing the bin in which the limit will be entered, and the Yellow key followed by the BIN # key.

Example: Set bin number 2 for limits of ±1%.

Push | **Display** | **Comments**





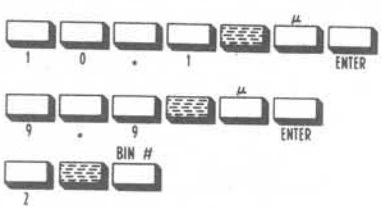
The limit values could have been entered in the reverse order with the same display and sorting results. Before sorting can begin, a nominal value must be set.

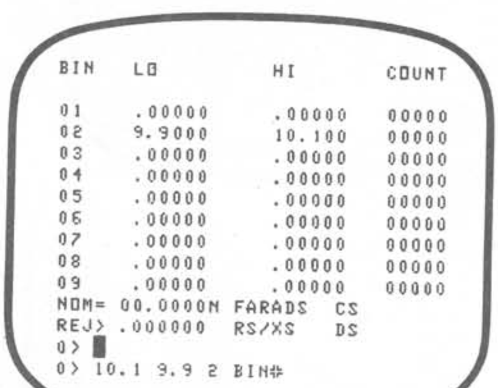
The preceeding example programmed percent limits. There are two methods for programming absolute limit values.

1. Program absolute limits directly. Place the instrument in absolute mode. (Push Yellow key, then ABS key to enter absolute limit values.)

   Example: Set bin 2 for limits 9.90μF and 10.1μF.

Push | **Display** | **Comments**



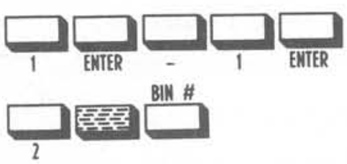


The units for the limits in bins 0-9 are taken from the top measurement display in the direct display format.

2. Program limits as percents, then set a nominal value. The instrument will automatically calculate the absolute value for each limit. Absolute values are displayed by pushing the ABS key.

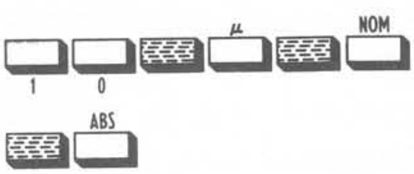
Example: Program bin 2 for absolute limits of ±1% (9.9µF and 1Ø.1µF).

Push | **Display** | **Comments**




```
BIN   LO %        HI %      COUNT

01     .00000      .00000   00000
02    -1.0000     1.0000    00000
03     .00000      .00000   00000
04     .00000      .00000   00000
05     .00000      .00000   00000
06     .00000      .00000   00000
07     .00000      .00000   00000
08     .00000      .00000   00000
09     .00000      .00000   00000
NOM= 15.9000N FARADS  CS
REJ> .000000  RS/XS   DS
0> █
0> 1 -1 2 BIN#
```

Enter percent limits.




```
BIN   LO          HI        COUNT

01    10.000U     10.000U   00000
02    9.9000U     10.100U   00000
03    10.000U     10.000U   00000
04    10.000U     10.000U   00000
05    10.000U     10.000U   00000
06    10.000U     10.000U   00000
07    10.000U     10.000U   00000
08    10.000U     10.000U   00000
09    10.000U     10.000U   00000
NOM= 10.0000U FARADS  CS
REJ> .000000  RS/XS   DS
0> ABSMODE
0> █
```

Setting nominal value causes absolute limits to be calculated.

Using percent limits allows different value parts to be sorted using the same limit values. While in this mode, the 2100/2110 automatically calculates new absolute values every time the nominal value is changed. Percent limits need not be re-entered when changing nominal value.

Example: Continuing with the above example (absolute limits of ±1% for 10µF capacitors) change the nominal value to sort 1µF capacitors, 10nF capacitors, and 100pF capacitors.

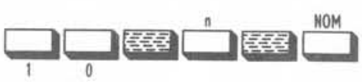
Push	Display	Comments

Push:

Display:

```
BIN   LO          HI          COUNT

01    1.0000U     1.0000U     00000
02    .99000U     1.0100U     00000
03    1.0000U     1.0000U     00000
04    1.0000U     1.0000U     00000
05    1.0000U     1.0000U     00000
06    1.0000U     1.0000U     00000
07    1.0000U     1.0000U     00000
08    1.0000U     1.0000U     00000
09    1.0000U     1.0000U     00000
NOM= 1.00000U FARADS  CS
REJ> .000000  RS/XS   DS
0> 1 MICRO NOMINAL
0> █
```

Push:

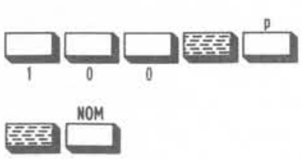


Display:

```
BIN   LO          HI          COUNT

01    10.000N     10.000N     00000
02    9.9000N     10.100N     00000
03    10.000N     10.000N     00000
04    10.000N     10.000N     00000
05    10.000N     10.000N     00000
06    10.000N     10.000N     00000
07    10.000N     10.000N     00000
08    10.000N     10.000N     00000
09    10.000N     10.000N     00000
NOM= 10.0000N FARADS  CS
REJ> .000000  RS/XS   DS
0> 10 NANO NOMINAL
0> █
```

Comments: The instrument recalculates the absolute limits for each nominal value.

Push:



Display:

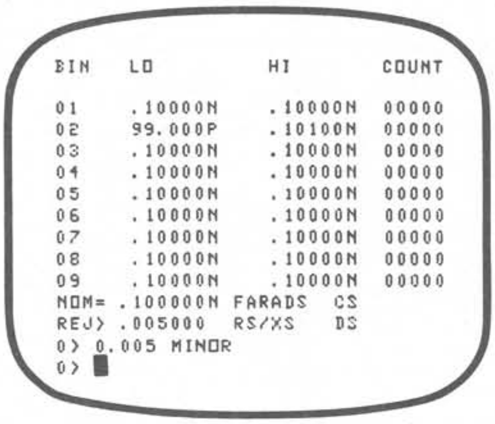
```
BIN   LO          HI          COUNT

01    .10000N     .10000N     00000
02    99.000P     .10100N     00000
03    .10000N     .10000N     00000
04    .10000N     .10000N     00000
05    .10000N     .10000N     00000
06    .10000N     .10000N     00000
07    .10000N     .10000N     00000
08    .10000N     .10000N     00000
09    .10000N     .10000N     00000
NOM= .100000N FARADS  CS
REJ> .000000  RS/XS   DS
0> █
0> 100 PICO NOMINAL
```

Comments: When in the binning display format, re-entering or changing the nominal value will reset all component counters to zero.

The reject (REJ) limit must always be set before entering the sorting mode. It is a limit for the secondary parameter (bottom measurement display when in direct display format). Reject limit is set as an absolute value for both absolute and percent mode. To program the reject limit, push the numerical and/or mutiplier keys representing the limit of the secondary parameter, then yellow key and MINOR key.

Example: Set the maximum limit of D (secondary parameter) to Ø.ØØ5.

Push **Display** **Comments**



2.7.3 Bin Counters

Adjacent to each of the bins (Ø - 9 and REJ) is a counter. The counter records the number of components that fall within the limits for each bin. During the sorting operation, the counter will record up to 65,225 parts for each bin. To view the counters and to stop the sorting operation, push the STAT key. To restart the sorting operation, push SORT. The bin counters for bins Ø-9 are reset to zero by re-entering or changing the nominal value. The counter for the reject bin is reset to zero when the minor (REJ) limit is changed. Counting is only accomplished in the single measurement mode.

> **NOTE:** The reject limit is either a maximum or a minimum value depending on the measurement function of the bottom display on the CRT. Maximum or minimum is shown on the CRT as:
>
> Rej > = Maximum Limit (all secondary components except Q)
>
> Rej < = Minimum Limit (Q only)

2.7.4 Sort Mode

Component sorting starts when the SORT key is pushed. All test parameters and limit values must be set before entering the sort mode. While in the sort mode, the keyboard is inoperative except for the SINGLE key and the escape key (SORT). Figure 2-11 is a Sorting Mode Preparation Check List.

TEST PARAMETERS

- ☐ Frequency
- ☐ Nominal Value (if required)
- ☐ Top Display Function
- ☐ Bottom Display Function
- ☐ Signal Level
- ☐ Settling Time
- ☐ Integration Time
- ☐ Measurements Averaged

BINNING LIMITS

- ☐ Correct Limits Bins Ø - 9
- ☐ Correct Reject Limit
- ☐ Nominal Value (if required)

Figure 2-11. Sorting Mode Preparation Check List

The sorting display consists of the word BIN and a number. The number represents the bin in which the component value fell. If the component exceeds the REJ limit, the display will read BIN R.

Entering the sort mode sets the instrument to the single measurement mode. Measurements can be initiated by either pushing the SINGLE key or receiving a remote start signal. To enter the sort mode, push SORT.

Example: Continuing with the preceding examples, enter the sorting mode and make several measurements.

Push | **Display** | **Comments**

SGL

```
BIN   LO          HI         COUNT

01    .10000N    .10000N    00000
02    99.000P    .10100N    00000
03    .10000N    .10000N    00000
04    .10000N    .10000N    00000
05    .10000N    .10000N    00000
06    .10000N    .10000N    00000
07    .10000N    .10000N    00000
08    .10000N    .10000N    00000
09    .10000N    .10000N    00000
NOM= .100000N FARADS  CS
REJ> .005000  RS/XS   DS
0> 0.005 MINOR
0> █
```

SGL

SGL

SGL

```
01000 HZ  NOM= 10.0000N FARADS
1000  MV  SINGLE        SORT
SETL=0020MS INTGR=0050MS  AVE=1


            BIN 2


0> █
0> SINGLE
```

To exit the sorting mode, push STAT key. When the STAT key is pushed, sorting stops, turns off bin counters, and the display reverts to the binning display format. All limits and nominal values are left intact. To re-enter the sorting mode, push SORT key.

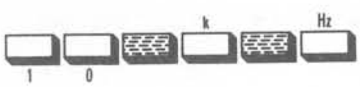
2.7.5 Component Sorting Example

This example is to illustrate the concepts presented in this portion of the manual. It is a typical setup, starting from the instrument power ON condition, for sorting 1ØØnF capacitors into tolerance bands of ±Ø.5%, ±1%, ±2%, ±5%, ±1Ø%, ±2Ø% with a maximum limit on D of Ø.ØØ5. Other test parameters include: frequency, 1ØkHz; signal level, 5ØØmVRMS; measurement speed, MED. After all parameters are programmed, the example will look at the limits in absolute units, start the sorting operation, stop sorting to look at the bin counters, and restart the sorting operation. The example will end by exiting the sorting mode to normal measurement operation.

Example:

Test Parameter Setup

Push **Display** **Comments**



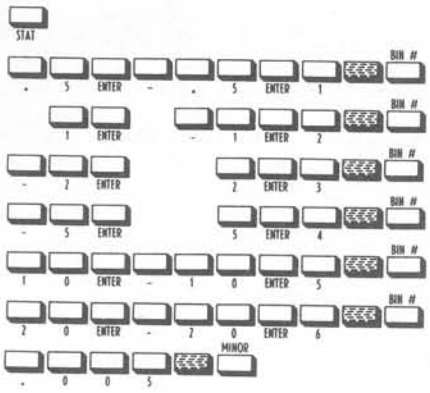
Frequency

Signal level

NOTE: In this example, the measurement functions Cs and D, settling time, integration time, and measurement averaged did not need programming because the 21ØØ/211Ø initialized to these functions when power was applied.

Limits Setup

Push



Display

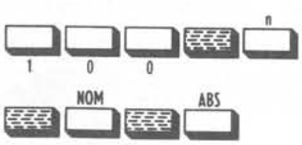
```
BIN   LO %        HI %       COUNT

01  -  0.50    +  0.50      00000
02  -  1.00    +  1.00      00000
03  -  2.00    +  2.00      00000
04  -  5.00    +  5.00      00000
05  - 10.00    + 10.00      00000
06  - 20.00    + 20.00      00000
07  +  0.00    +  0.00      00000
08  +  0.00    +  0.00      00000
09  +  0.00    +  0.00      00004
NOM= .000000  FARADS  CS
REJ> .000000  RS/XS   DS
█
MINOR
```

Comments

Limit values must be set in ascending order. They can be entered in either order (HI value first or LO value first) within each bin.

Enter Nominal Value (calculate absolute values)

Push



Display

```
BIN   LO          HI          COUNT

01    99.500N     .10050U     00000
02    99.000N     .10100U     00000
03    98.000N     .10200U     00000
04    95.000N     .10500U     00000
05    90.000N     .11000U     00000
06    80.000N     .12000U     00000
07    .10000U     .10000U     00000
08    .10000U     .10000U     00000
09    .10000U     .10000U     00004
NOM= .100000U FARADS  CS
REJ> .000000  RS/XS   DS
0> █
0>  ABSMODE
```

Comments

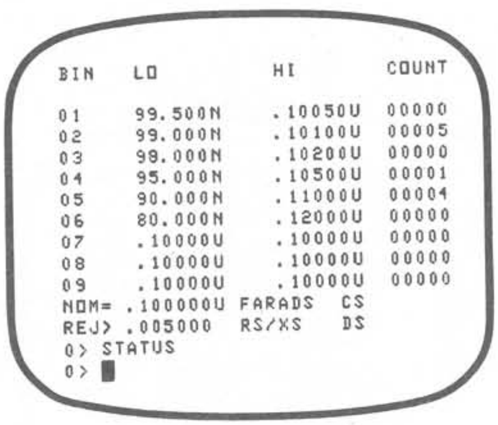
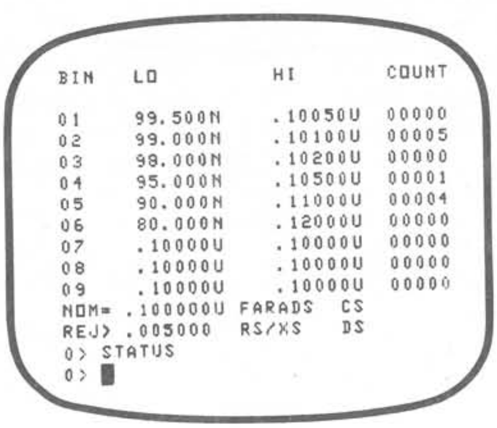
Set measurement range and calculate absolute values.

View absolute values.

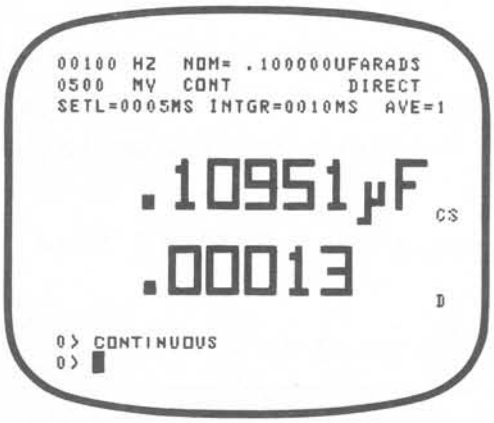
Begin Sorting Operation

Push	Display	Comments
SORT		Components exceeding the reject limit will display BIN R.

View Bin Counters then continue sorting

Push	Display	Comments
STAT		Escape from sort mode. To clear bin counters, re-enter the nominal value.
SORT		Re-enter sorting mode.

Exit Sorting Mode

Push	Display	Comments
		Sorting stops. Display reverts to direct format.
 		Normal continuous measurements are made and results displayed.

2.8 MEASUREMENT SPEED

A measurement sequence for the Model 2100/2110 is illustrated in Figure 2-12. Total measurement time consists of a number of fixed and variable elements. The following paragraphs describe and illustrate each of these elements.

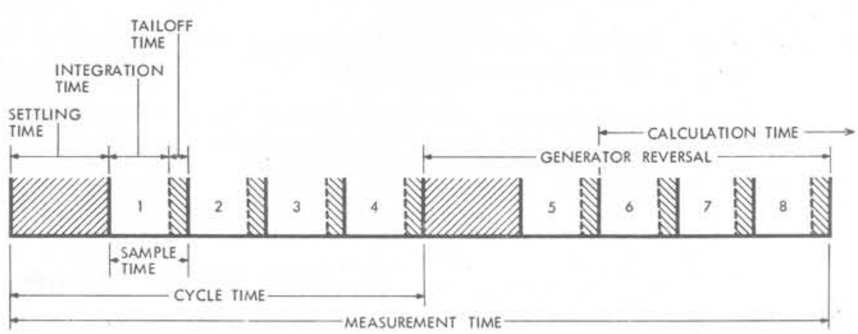


Figure 2-12.
Measurement Sequence

Integration Time is the number of test frequency cycles during which the A/D converter is making the measurement. Integration time can be determined by the formula:

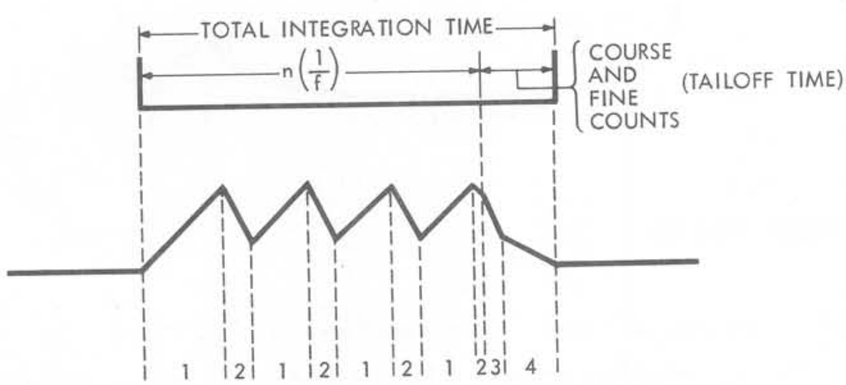
$$n\left(\frac{1}{f}\right) \qquad \text{Where: } n = \text{Integer between 1 and 256}, \quad f = \text{Test Frequency}$$

The limits between which integration time can be programmed are shown by the formula:

$$500ms \leq n\left(\frac{1}{f}\right) \leq 2ms$$

Tailoff Time is the fixed portion of measurement time which is set at 4ms. During tailoff time the A/D converter is being brought to zero, and the course and fine counters are accumulating measurement data.

Sample Time is Integration time + Tailoff time (see Figure 2-13).



1 = Integration on measured signal.

2 = Integration on mixture of measured and reference signal. Course counter sums these periods.

3 = Integration on reference signal only. Course counter sums this with previous periods.

4 = Integration on fine reference. Fine counter monitors this period adding its count to the course counter total 1 course count = 1024 fine counts.

Figure 2-13. Sample Time

Settling Time is the time required for the analog voltage representing the unknown to settle to the desired accuracy. Settling times between 2ms and 15ØØms can be programmed in 1ms steps. Settling time values are dependent on the type of component being tested and/or requirements of externally connected equipment. Typically, smaller impedances require longer settling times.

Cycle Time is settling time + (4 × Sample time), see Figure 2-14. Cycle time represents the time to acquire the four readings representing:

Ø° voltage unknown
9Ø° voltage unknown
Ø° voltage reference
9Ø° voltage reference

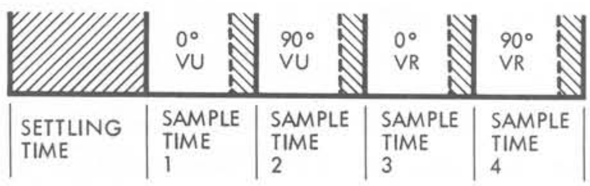


Figure 2-14. Cycle Time

Linelock Time is the average time for the line frequency to reach the zero crossing point with a positive going slope. Linelock time is added to the settling time when the test frequency is between 2ØHz and 2ØØHz.

Measurement Time is 2 x (Cycle time + Linelock time), see Figure 2-15. Measurement time is the total time from start to end of a measurement sequence or total measurement time. The second cycle time is made with the generator polarity reversed.

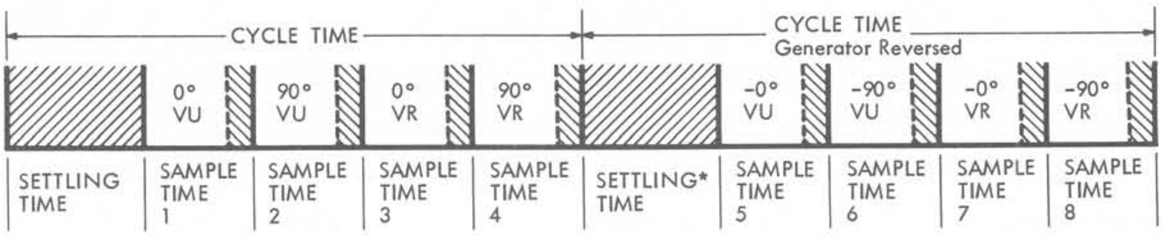


Figure 2-15. Measurement Time

Generator Reversal is the sinewave generator reversed in polarity after the first cycle time. The second series of measurements are made in the opposite polarity. These two series of measurements are algebraically added, i.e. (1-5) (2-6), (3-7), (4-8), to cancel offset voltages in operational amplifiers and syncronized line related pickup.

Measurement Averaging is n x (measurement time) Where: n is an integer between 1 and 20 (see Figure 2-16). Averaging reduces noisy readings by adding a selected number of measurements and dividing by the number of measurement times.

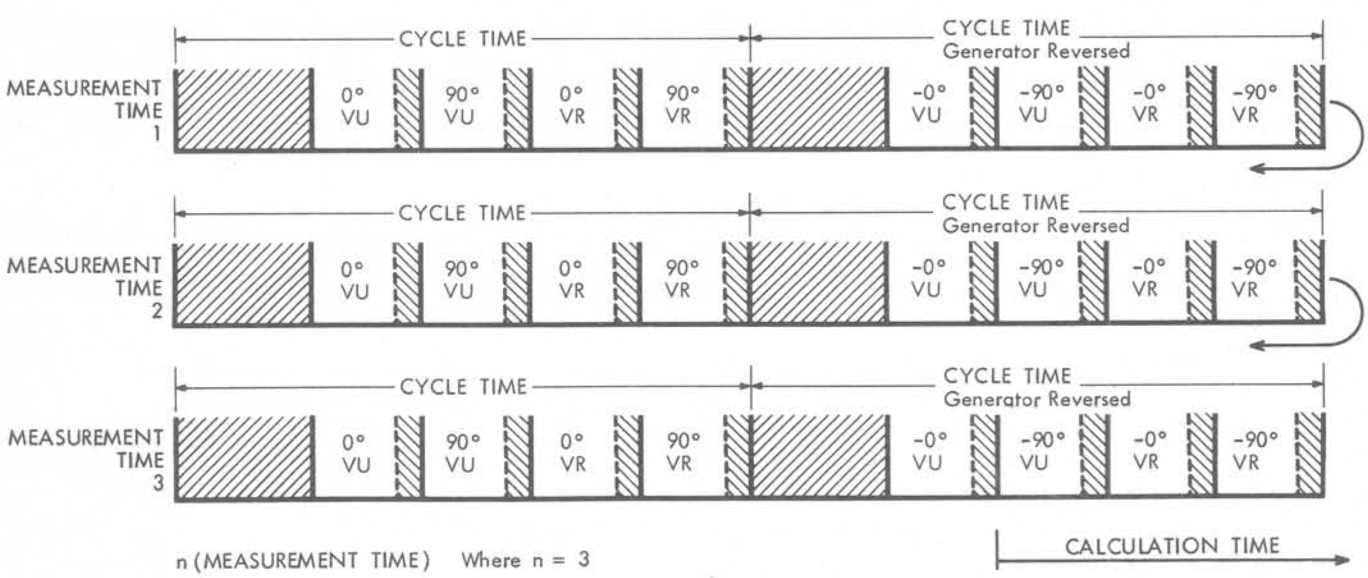


Figure 2-16. Measurement Averaging

Calculation Time is the time required to calculate display information from the raw measured data.

Display Time is the time required to display stored information on the CRT.

Measurement Speed Summary

The preceding paragraphs gave you some insight into the various elements that make up total measurement time. Now, total measurement speed can be found by using the formula:

Measurement Speed = Total Measurement Time + Calculation Time + Display Time

Where:

Total Measurement Time = 8(Sample Time) + 2(Settling Time) x Measurements Averaged

Calculation Time = 100ms

Display Time = 300ms Normal display
50ms Sorting display

Example: Measurement speed for an instrument in initial start-up mode, medium measurement speed selected (SETL = 5Øms, I.T. = 5Øms, and AVG = 1), normal display mode, and at 1kHz, is calculated as follows:

Integration time	=	5Øms	
Tailoff time	= +	3ms	
Sample time (total)	=	53ms	
Settling time	=	5Øms	
Linelock time	=	Ø	(frequency above 2ØØHz)
Measurement time	=	524ms	[8(53) + 2(5Ø)]
Measurements averaged	=	1	
Total Measurement time	=	524ms	
Calculation time	=	1ØØms	
Display time	=	3ØØms	(Normal display)
Measurement speed	=	924ms	

Example: Measurement speed for an instrument in FAST measurement speed mode (SETL 5ms, I.T. 1Øms, and AVG 1), sorting mode, and at 1kHz is computed as follows:

Integration time	=	1Øms	
Tailoff time	= +	3ms	
Sample time (total)	=	13ms	
Settling time	=	5ms	
Linelock time	=	Ø	(frequency above 2ØØHz)
Measurement time	=	114ms	[8(13) + 2(5)]
Measurements averaged	=	1	
Total Measurement time	=	114ms	
Calculation time	=	1ØØms	
Display time	=	5Øms	(Sorting display)
Measurement speed	=	264ms	

2.8.1 Programming Integration Time

Integration time is only a small portion of the overall measurement time of the Model 2100/2110. It is the variable portion of sample time (described previously), that is based on a number of cycles of the test frequency. Integration time can be programmed to a maximum of 500ms and to a minimum of 2ms.

As a rule, short integration times are less accurate then longer times and can cause less measurement resolution to be displayed. Any integration time that does not allow the instrument to integrate on a number of complete measurement frequency cycles will automatically be reprogrammed to the next larger integration time that does. When the measurement frequency is decreased below 500Hz, the instrument again automatically updates to the next valid time. Integration times continue to increase with each lower frequency programmed. To find the permissible integration times, use the formula:

$$500\text{ms} \leq n\left(\frac{1}{f}\right) \leq 2\text{ms}$$

Where: n = Integer between 1 and 256
f = Test Frequency

NOTE: Three preprogrammed measurement speeds (Fast, Medium, Slow) are available in the Model 2100/2110. Each has preset settling time, integration time, and measurements averaged (see Section 2.8.3).

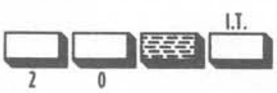
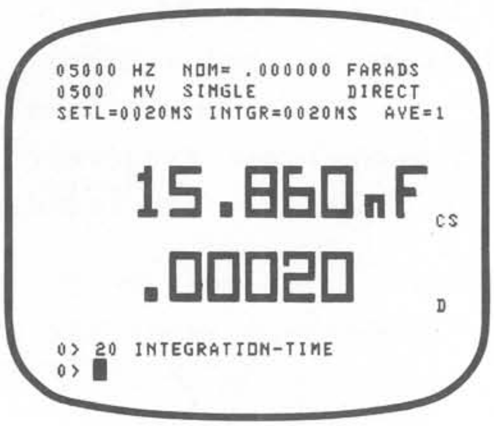
Frequency		Minimum Integration Time
500Hz	=	2ms
400Hz	=	3ms
300Hz	=	4ms
200Hz	=	5ms
100Hz	=	10ms
60Hz	=	17ms
50Hz	=	20ms
40Hz	=	25ms
30Hz	=	34ms
20Hz	=	50ms

Table 2-7. Integration Time Chart

To program integration time, push the numerical keys representing the desired integration time in milliseconds, then push the yellow key followed by the I.T. key.

Example: Program integration time based on 10 cycles of the 500Hz test frequency.

$$n\left(\frac{1}{f}\right) = 10\left(\frac{1}{500}\right) = 10(0.002) = 20\text{ms}$$

Push	Display	Comments
		Integration time is entered in milliseconds.

2.8.2 Programming Settling Time

Settling time, as described above (Section 2.8), is the time required for the analog voltage representing the unknown to settle to stated accuracy. Settling times between 2ms and 1500ms can be programmed in 1ms step. When instrument power is applied, the settling time is at 10ms. To program settling time, push the numerical keys that represent the settling time, in milliseconds, followed by the yellow key and the SETL key.

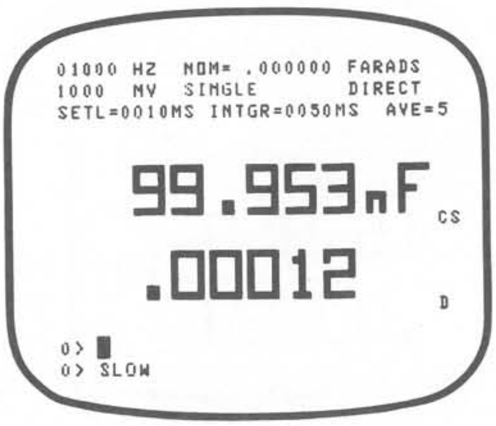
Example: Set settling time to 110 milliseconds.

Push	Display	Comments
		

2.8.3 Programming Measurement Speed

Three pushbuttons are dedicated to programming FAST, MEDium, or SLOW measurement speeds. Each speed is fixed in both settling time and integration time (see Table 2-8). Medium speed is the initial speed when instrument power is applied. FAST speed is not available at test frequencies below 2ØØHz. To program FAST, MED, or SLOW measurement speed, push the yellow key followed by the FAST, MED, or SLOW key.

Example: Set the instrument to SLOW measurement speed.

Push	Display	Comments
		Measurement speed is changed from MED to SLOW.

	SETL	I.T.	AVG
Fast	5ms	1Øms	1
Medium	5Øms	5Øms	1
Slow	5Øms	5Øms	5

Table 2-8. Measurement Speeds

2.8.4 Programming Measurement Averaging

Measurements made where stray fields introduce noise can result in fluctuating readings. The 21ØØ/211Ø can reduce these fluctuations by averaging a specified group of measurements. The noise is reduced by approximately the square root of the number of measurements averaged. As shown in Section 2.8, the total measurement time for averaging measurements is equal to:

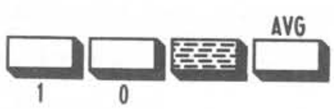
n x (Sample time)

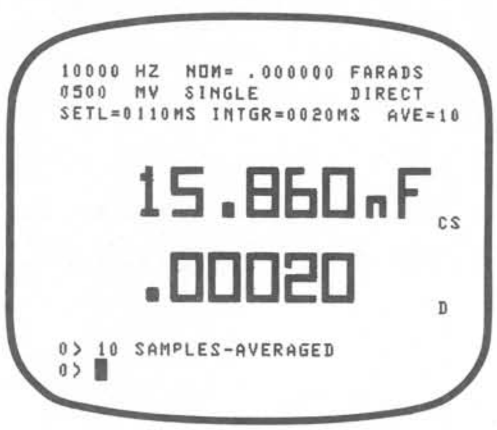
Where: n = an integer between 1 and 2Ø

To program a selected number of measurements to be averaged, push the numerical keys representing the number of measurements to be averaged followed by the yellow key and the AVG key.

Example: Average 1Ø measurements and display the results.

Push	Display	Comments





2.9 CASSETTE TAPE LOADER

The cassette tape loader is a non-volatile, mass storage unit for measurement application programs. It uses a certified digital mini-cassette recording tape for saving and reloading instrument measurement-parameter setups. All measurement parameters, binning limits, and bin counter information can be saved, then reprogrammed at a later time. The cassette tape loader saves the time required to reload test parameters and limits at the start of a production run or after a power interruption.

2.9.1 Cassette Tape Installation

The mini-cassette tape is installed in the 211Ø's cassette tape loader as shown in Figure 2-17. To install:

STEP 1. Push the front panel button labeled EJECT. The cassette tape loader door will spring open.

STEP 2. Remove any cassette tape already in the loader and install the new tape (see Figure 2-17).

STEP 3. Push the door closed.

STEP 4. The Model 211Ø is ready to save or retrieve parameter programs (see Section 2.9.3.1, 2.9.3.2).

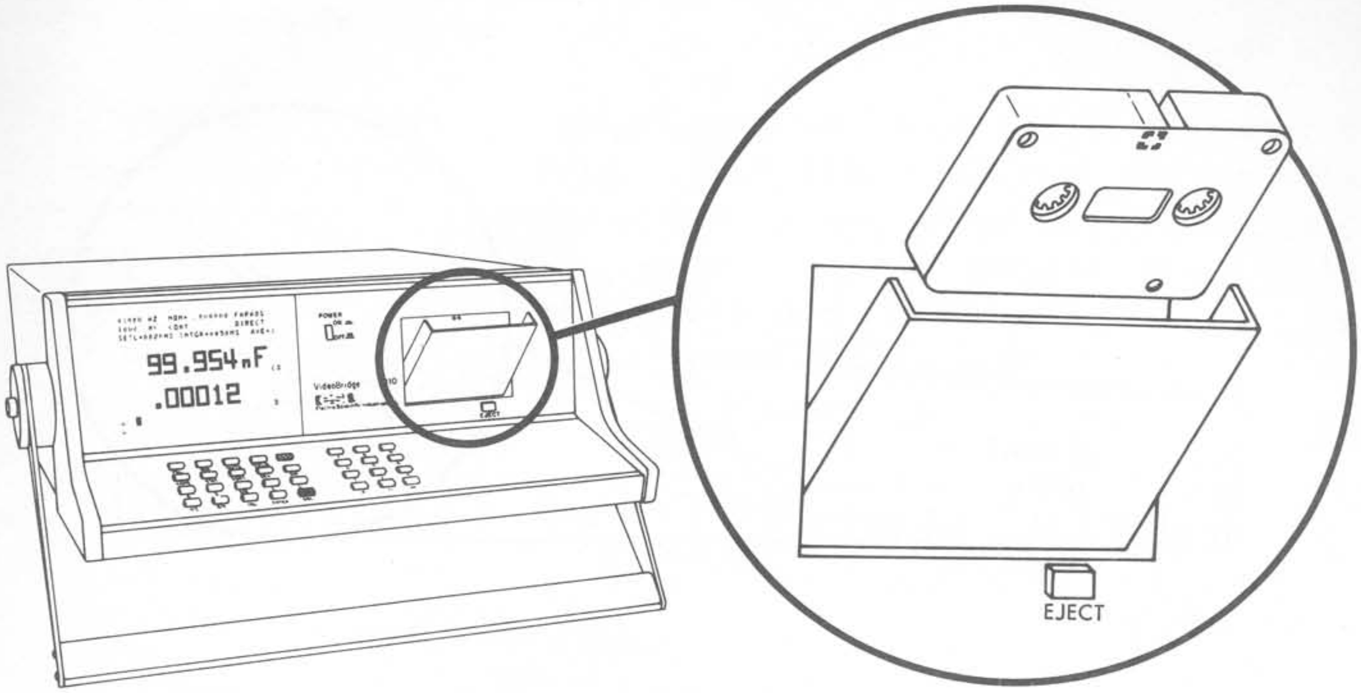


Figure 2-17. Cassette Tape Installation

2.9.2 Cassette Tape Loader Maintenance

To assure reliable data storage and playback, the recording and playback heads should be periodically checked and cleaned. The heads should be cleaned using a cotton tipped swab dipped in alcohol (see Figure 2-18). No other preventive maintenance or lubrication is required.

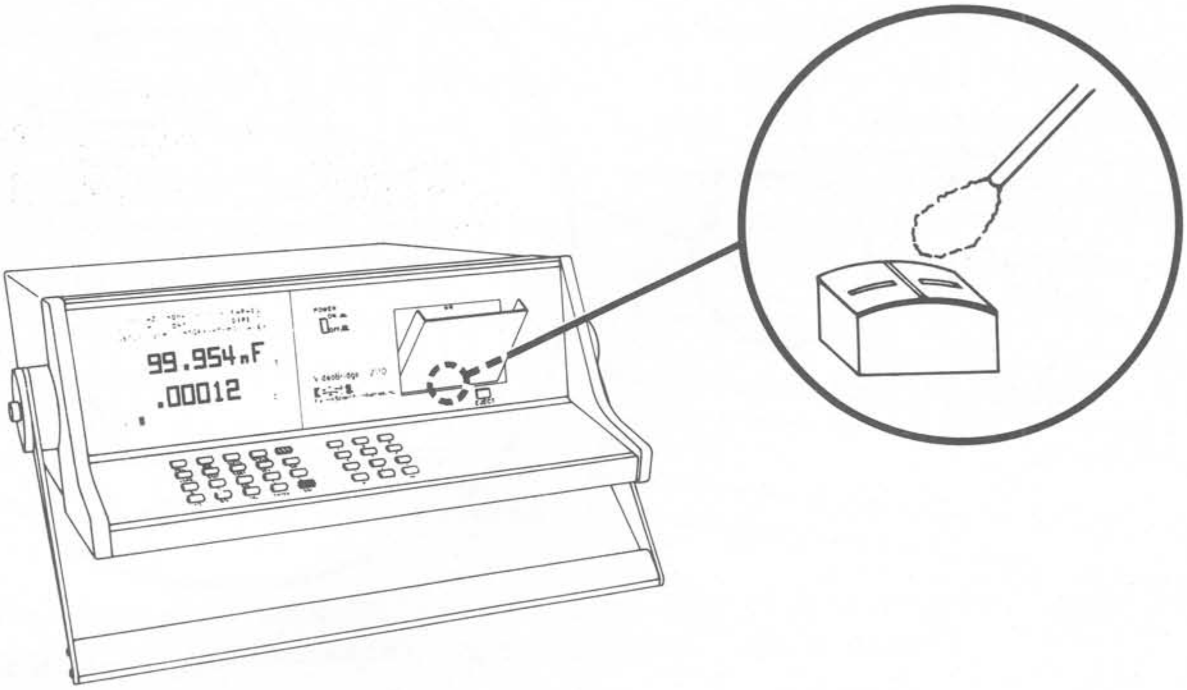


Figure 2-18. Cleaning Recording/Playback Heads

2.9.3 Cassette Tape Formatting

Cassette tapes must be formatted before instrument parameters can be stored or retrieved. The formatting sequence sets up 15 blocks, on each side of the tape, in which information can be stored. To format a new tape:

1. Place the new tape in the cassette drive unit.

2. Push 3 (yellow) CODE. The 2110 will echo the message "MAKE TAPE -- SNGL TO START".

3. Push SINGLE. The message will disappear when formatting is complete.

2.9.4 Cassette Tape Programming

The mini cassette tape is divided into 15 areas or files, numbered 1-15, as shown in Figure 2-19. Each file will hold one complete instrument setup. Instrument parameters are stored according to the identification number (1-15) assigned to the program when it is stored. Saving and reloading parameter information to/from the cassette tape is described in the following paragraphs.

Figure 2-19. Cassette Tape File Areas

2.9.4.1 <u>Saving Parameters</u>

Instrument parameters are saved on the cassette tape by pushing the numerical keys (1-15) representing the program identification number followed by the yellow key and the SAVE key.

Example: Using the component sorting example (see Section 2.7.5) set up all test parameters and binning limits. Save this parameter program under the identification number 5.

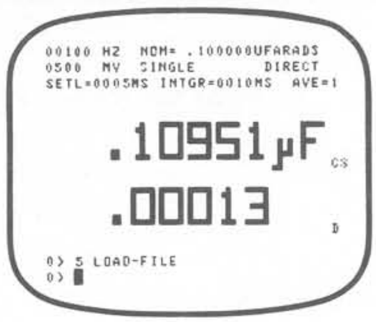
Push | **Display** | **Comments**

Completion of the save operation is signaled by OK printed on the CRT.

2.9.4.2 Loading Parameter Programs

Parameter programs saved on the cassette tape can be retrieved at any time. To reprogram the 2100/2110 with a prestored program, push the numerical keys (1-15) representing the identification number of the program followed by the yellow key and LOAD key.

Example: Turn instrument power off then on again. Reload the parameter program saved in the preceding example.

Push	**Display**	**Comments**
 	 	Completion of the reloading operation is signaled by OK printed on the CRT.

2.9.5 Program Write-Protect

Important parameter programs can be permanently protected from accidental erasure with the cassette write-protect feature. Each cassette module has a cross shaped plug located on the top back of the cassette (see Figure 2-20). To permanently protect recorded programs, punch out the cross shaped plug. With the plug removed, no additional data can be written over the existing programs on that side of the tape.

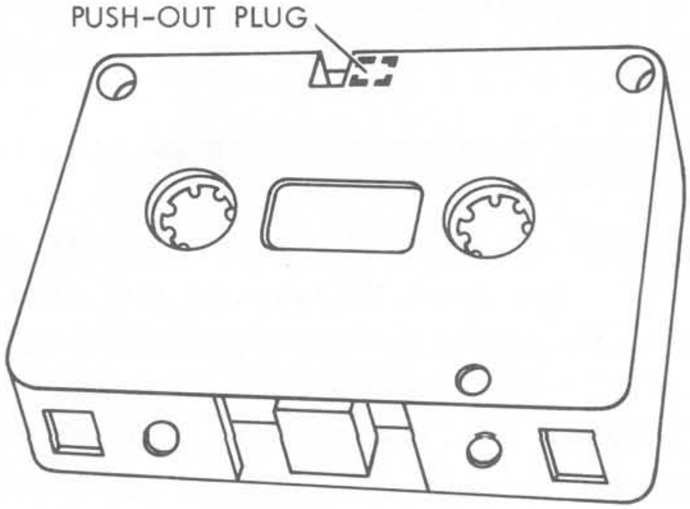


Figure 2-2Ø. Program Write-Protect Feature

Cassette tape modules with the write-protect plug removed can be reprogrammed by placing a piece of cellophane or vinyl tape over the write-protect hole.

2.9.6 Cassette Care

Careful handling procedures will extend the useful life of the mini-cassette tapes used with this instrument. Read the following precautions to extend the life of cassette tapes.

- Avoid direct sunlight, high temperatures, and moisture.
- Keep tape surface clean. Touching the tape surface can transfer any dirt from your fingers to recording and playback heads.
- Prevent tape breakage and stretching by removing any slack in the tape before putting the cassette into the recorder.
- Do not store cassette tapes on or near magnetic fields or devices. Strong magnetic fields may destroy stored programs.

2.10 CODE KEY FUNCTION OPERATION

2.10.1 ⚠ Capacitance Measurements with DC Bias (Codes 1 and -1)

A DC bias of up to 50V can be applied to the rear panel bias terminals (observe polarity). The Bias Voltage is not applied to the unknown until the Bias Key is pushed. Measurements with bias are available for capacitance only. Bias supply must have low ripple with internal current limit of 100mA and its output impedance must be less than 50mΩ. Leakage current through the unknown can be measured by sampling the current from the bias source to the bias terminals with a low impedance ammeter. If the bias source impedance is not low compared to the unknown, a bypass capacitor whose impedance is 1/5 of the unknown at the operating frequency can be connected across the bias source and ammeter (if used).

WARNING

ELECTRICAL SHOCK HAZARD EXISTS WHEN A BIAS SUPPLY IS CONNECTED TO THIS INSTRUMENT. WHEN AN EXTERNAL BIAS SUPPLY IS ATTACHED, THE BIAS VOLTAGE IS PRESENT ON THE REAR PANEL BNC CONNECTORS. USE ONLY BIAS VOLTAGES UP TO 50VDC AND BIAS SUPPLIES CURRENT LIMITED AT 100mA. DO NOT TOUCH, CONNECT, OR DISCONNECT THE UNKNOWN COMPONENT OR BNC CABLES WHILE A BIAS VOLTAGE IS APPLIED.

Use the following procedure when measuring DC-biased capacitors.

STEP 1. Connect the external biasing supply to the instrument's rear panel bias terminals (observe polarity).

STEP 2. Turn bias supply on and set to the proper bias setting.

STEP 3. Connect the unknown capacitor to the test leads. Observe proper polarity connection when testing electrolytic capacitors.

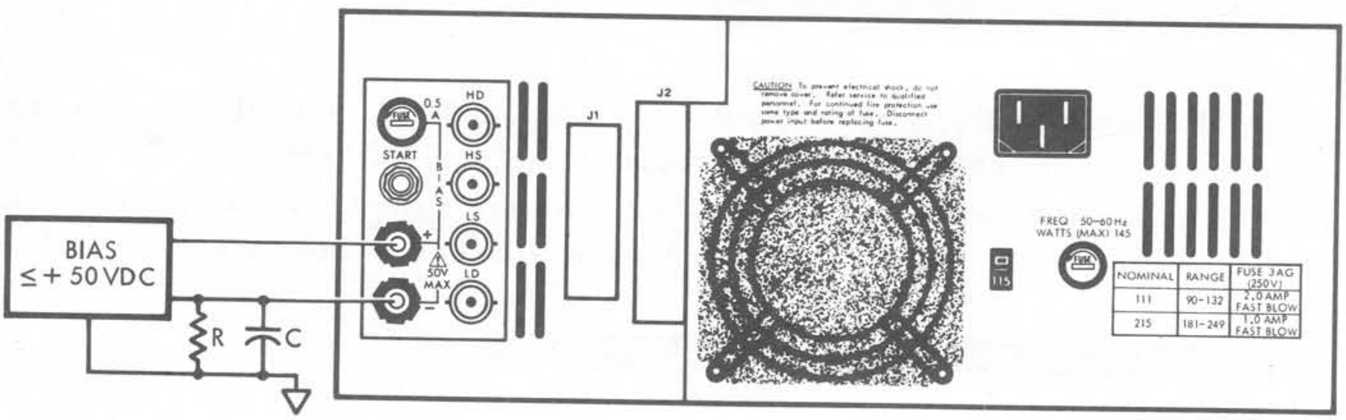
STEP 4. Turn the bias voltage on. Push 

STEP 5. Make the measurement.

STEP 6. Turn the bias voltage off. Push 

STEP 7. Remove the measured capacitor from the test leads.

STEP 8. Repeat steps 4 through 7 for each component to be measured.



NOTE: Bias supply must be floating, i.e. must be isolated from earth ground.

R > 1ØØkΩ
C < Ø.ØØ2μF

Figure 2-21. Capacitance Measurements with Bias

2.11 ERROR MESSAGES

If an improper operation is attempted, the 2100/2110 responds by displaying an error message. Error messages are displayed in reverse video (green letters on black background) at the bottom of the CRT screen. All parameters entered prior to the improper operation remain unchanged. Following is a list of error messages that may appear during the programming and operation of this instrument. Included with each error message is a short explanation of probable causes for the message.

Programming and Operating Related Errors

Input overloaded! Can't measure

This indicates that the input to the analog circuitry has been overloaded. In this case the sample is discarded and the old reading is left on the screen. Check for an overrange value if on range "HOLD". Reset to "AUTO" range and make another measurement.

Can't supply volts or Can't supply amps

If the impedance of the component in the clips is too high for the current range or too low for the voltage range to supply the level specified on the screen, this message will appear on the bottom line of the display. The instrument will set itself to the highest level possible below the specified maximum level and make a measurement.

Stack empty

Any of the commands (mostly upper case key strokes) which take numerical arguments will display this message if insufficient numbers precede the word. For instance, programming 2 3 __ Bin# will give a stack empty message because it requires an upper limit, a lower limit, and the number of the bin being programmed. Start again.

Undefined

Occasionally a combination of keys will be pressed which result in the construction of a word which the instrument does not recognize. Pushing a number key and then a key which does not use a number ahead of it will result in something like "1direct". The instrument will not recognize "1direct" and the undefined message appears. Start again.

> **NOTE:** Undefined errors and stack empty errors will take the machine out of continuous mode and put it into single. This allows the error message to stay on the screen until some action is taken. When the error has been corrected the user must put the unit back into the continuous mode.

Cassette Tape Related Errors

Discard tape

This error message says that the tape was not able to be formatted (Code 4).

Bad read

When "bad read" appears on the screen try again.

Bad write

When "bad write" appears on the screen try writing into a different block.

No tape in place

This message will appear when there is no cassette tape in the drive unit or when the LOAD or SAVE buttons are pushed on instruments without the cassette option installed.

Write Protected

This message comes onto the screen if a write or format command is tried on a cassette tape that has its write protect tab broken out.

Tape Jammed

When the cassette tape will not move forward or backward, this message appears on the screen. Remove the tape and try again.

SECTION 3
CIRCUIT DESCRIPTIONS

3.1 INTRODUCTION

This section discusses the four major circuits that make up the Model 2100/2110. These four circuits are: measurement, motherboard, CRT, and power supply. Each of the discussions that follow, start by presenting a block diagram, then continue with a discussion of the operation of the major blocks within each diagram.

3.2 MEASUREMENT OVERVIEW

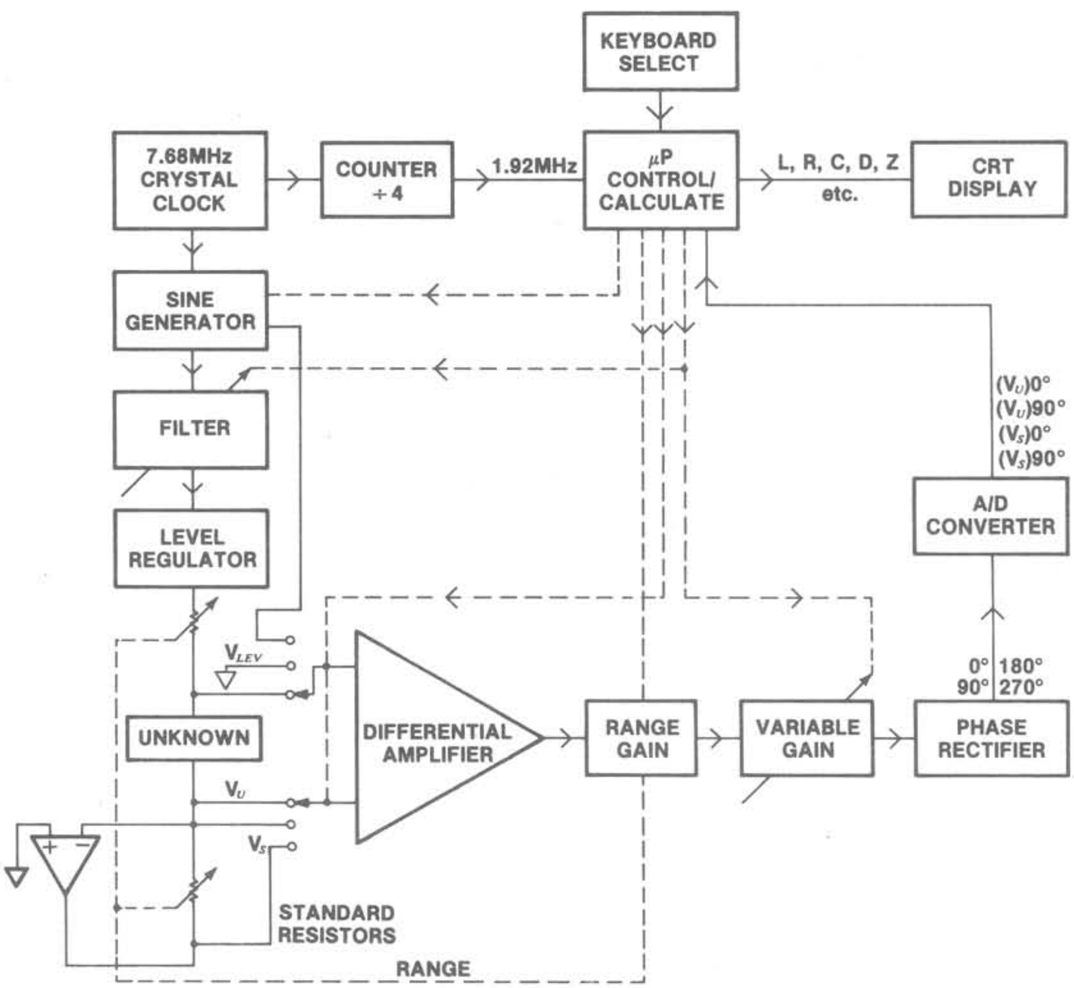


Figure 3-1. Block Diagram

The microcomputer control/calculate block is the command center for all instrument operations. It accepts input from the keyboard and coordinates all phases of a measurement sequence. It also performs all calculations required to arrive at the desired measured quantities and displays them.

Model 2100/2110 operation essentially starts with the 7.68MHz clock. This clock is divided by 4 to obtain the 1.9MHz processor clock and divided by N (3-3000) to develop the sinewave measurement signal.

The sinewave generator is frequency programmable (20Hz to 20kHz). It produces a digitally-stairstepped, sinewave output that is band limited by the filter block, then passed through the programmable level regulator. The result is a sinewave signal of specified frequency within a specified voltage range, in the mV mode, or current range, in the mA mode. This sinewave is applied to the unknown component being measured, and the standard (range) resistor.

A differential amplifier sequentially measures the voltages across the unknown component and the standard resistor. These voltages are passed through the range gain and variable gain amplifiers to the phase rectifier. The phase sensitive voltmeter (phase rectifier) compares the vector relationships of the measured signals to determine which portions are in phase and which are in quadrature. The phase rectifier outputs the following four DC voltages:

V_0 or $V_{\text{unknown } 0°}$

V_1 or $V_{\text{unknown } 90°}$

V_2 or $V_{\text{standard } 0°}$

V_3 or $V_{\text{standard } 90°}$

These voltages are serially processed by the A/D converter with resistance (R) and reactance (X), when in the mA mode, or conductance (G) and susceptance (B), when in the mV mode, computed by the Z80 CPU.

mV MODE

$$G_{unknown} = \frac{V_0 V_2 + V_1 V_3}{(V_0)^2 + (V_1)^2} \times R_{standard}$$

$$B_{unknown} = \frac{V_0 V_3 - V_1 V_2}{(V_0)^2 + (V_1)^2} \times R_{standard}$$

mA MODE

$$R_{unknown} = \frac{V_0 V_2 + V_1 V_3}{(V_2)^2 + (V_3)^2} \times R_{standard}$$

$$X_{unknown} = \frac{V_1 V_2 - V_0 V_3}{(V_2)^2 + (V_3)^2} \times R_{standard}$$

All other impedance parameters are computed using the results of these measurements, the test frequency, and the formulas in Figure 1-1.

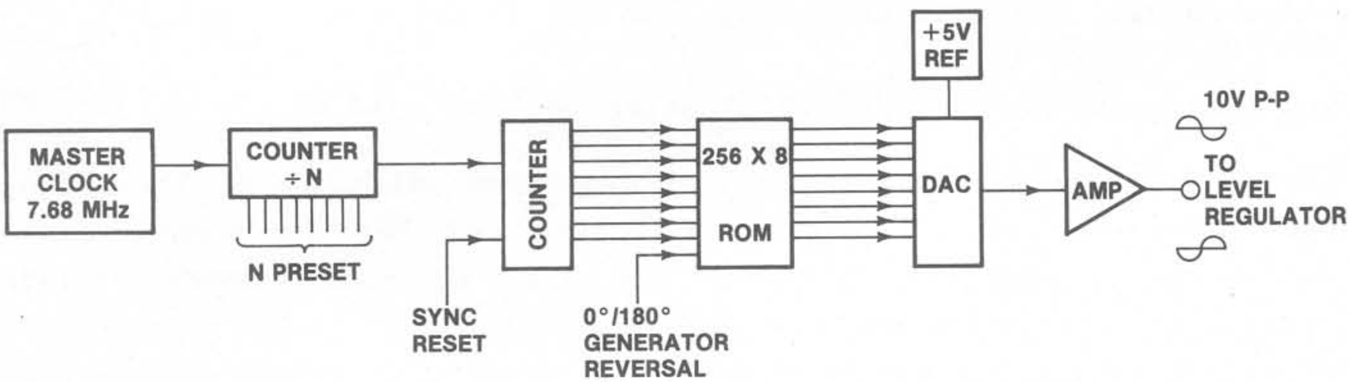
The calculated measurement information is displayed on the CRT screen.

3.3 MEASUREMENT CIRCUITRY

The electronics involved with the actual measuring of a component is contained on two circuit cards. The Digital circuit card performs two basic functions: sinewave generation, and analog-to-digital conversion. The Analog circuit card holds all other measurement circuitry, i.e. level regulator, standard (range) resistors, amplifiers, phase rectifier, etc., needed to make a measurement.

3.3.1 Digital Circuit Card (P/N 45237)

3.3.1.1 Sine Generator



$$\text{FREQUENCY} = \frac{60{,}000\text{ Hz}}{N}$$

N = 3 ⇒ 3000
N = 1 F = 60,000 Hz
N = 3 F = 20,000 Hz
N = 3000 F = 20 Hz

$$\frac{7.68\text{MHz}}{128\text{ (STEPS IN ONE COMPLETE SINEWAVE)}} = 60{,}000\text{Hz}$$

Figure 3-2. Sine Generator Block Diagram

Measurement begins when a sinewave signal at a specified frequency is applied to the unknown component. The origin of this sinewave signal is the sine generator (Figure 3-2) which consists of a preset counter chain, a second counter, a 256 x 8 bit preprogrammed ROM, a digital-to-analog converter (DAC), and a current-to-voltage buffer amplifier. The preset counter chain (U22, U24, U25) is a set of three chips configured to perform a divide-by-N function. It divides the 7.68MHz master clock into one of the 2998 frequencies that are presettable by the microcomputer. The new frequency, actually a squarewave signal, goes into a second counter chain made of U16 and U19. The second counter is connected to U17, a read only memory (ROM), in such a way that as the counter's output lines toggle, they ripple through all the addresses on the ROM. For each address the ROM outputs 8 bits of information which are fed to the D/A converter.

Two complete sinewave signals are stored in the 74S471 ROM. The 256 x 8 bit memory block reserves 128 address locations for the 0° sinewave and 128 locations for the 180° sinewave. Each address location contains 8 bits of information.

NOTE: 7.68MHz divided by 128 sinewave address locations equals the 60kHz base frequency used to determine test frequency.

$$\frac{60\text{kHz}}{N} = \text{Test Frequency}$$

Where: N = 3 to 3000

Notice in Figure 3-2 that the counter and the ROM each have an input line coming from outside the sine generator electronics. The 0°/180° line to the ROM, under microcomputer control, selects the polarity of the ROM's output sinewave, 0° or 180°. This is the generator reversal routine where the sinewave polarity is reversed for a second series of measurements. The two series of measurements, made with opposite polarities, are algebraically added to cancel offset voltages and synchronized line related pick-up.

The sync reset line to the counter is use to synchronize the 2100/2110 sinewave to the power line. At frequencies below 200Hz, the 2100/2110 detects power line zero crossings and starts its sinewave at these exact points. This is accomplished by resetting the counter at the first power line zero crossing after a completed measurement cycle. Test signal/power line synchronization maximizes rejection of line related EMI coupled to the measurement circuit.

The digital-to-analog converter (DAC) is the analog device that produces the actual waveform. It works with operational amplifier U14 to transform the DAC's current output into a voltage waveform. The sinewave output from the sine generator is 10V peak-to-peak and is symmetrical around zero.

3.3.1.2 Analog-to-Digital Converter

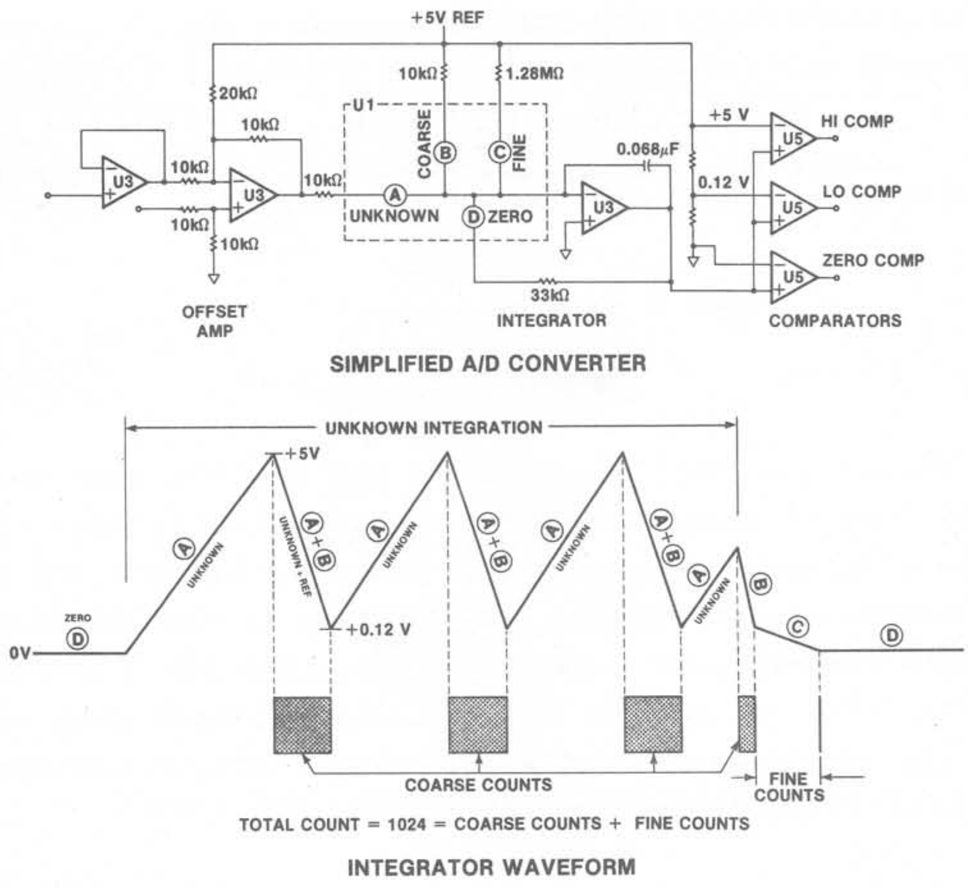


Figure 3-3. A/D Converter Simplified Diagram

The analog-to-digital converter is called a "charge balancing" A/D converter (see Figure 3-3). Moving from left to right on the diagram, the offset amplifier, two sections of quad-amplifier U3, offsets the DC input voltages, from the phase rectifier, so they always remain one polarity. Solid state switch, U1, selects inputs, i.e. unknown signal, standard signal, coarse reference, fine reference, or zero, to the third section of U3, the integrator. Three comparator sections of U5, and logic U7, U8, U6, and U11 (see schematic diagram in Section 5 of this manual), synchronize the turning ON and OFF of coarse and fine counters with the switching of coarse and fine reference inputs to the integrator. Counter timer, U29, has 3 channels: two channels are counters, one for coarse counts, and one for fine counts during A/D conversion, and the third channel sets up, through the bus system, the number of multiples of test frequency over which the integrator will integrate. The 2100/2110 is locked into exact multiples of the test cycle or test frequency because it is the test frequency that determines the actual integration time. The Digital assembly also contains support logic for the A/D converter. The support logic interfaces the A/D converter's output to the microcomputer, and performs level shifting for the drive signals to the input (reference) switches on the integrator. The easiest way to step through the A/D conversion sequence is to follow the integrator waveform (in Figure 3-3). The circled letters on the waveform correspond to the input (reference) switches in the simplified diagram.

The integrator waveform starts from the ØV level. When switch A is turned ON, the integrator starts ramping toward the +5V level. (Switch A allows the unknown signal, a DC voltage from the phase rectifier, to pass to the integrator.) Upon reaching the +5V level a comparator, called "HI COMP", causes the logic to turn switch B, the coarse reference, ON. With both switches ON, the integrator ramps back down toward zero. It ramps down to approximately +Ø.12V where the "LO COMP" comparator trips turning the B switch OFF. With the A switch ON by itself again, the integrator ramps back up toward +5V. Switch B comes back ON at the +5V level, and the integrator ramps down toward zero. The object of this switching technique is to keep the integrator in bounds, between +5V and +Ø.12V, for the duration of the unknown integration. This allows longer integration times without the integrator going out of range and provides a wide choice of integration times and also provides shorter total integration time due to the overlap of the reference signal with the unknown integration.

At the end of the unknown integration, switch A is turned OFF. (It remained ON during the unknown integration.) Now, since the integrator is still above the ØV level, switch B is turned ON driving the integrator to the Ø.12V level, then is turned OFF and switch C is turned ON. Switch C is called "fine" reference. The fine reference brings the integrator back to ØV.

The relationship between coarse and fine reference levels lies in the fact that they each have an associated counter. Each time the B switch is turned ON, a counter is being gated to keep track, by accumulating counts, of how long switch B was on. (In Figure 3-3, the waveform has four bursts of coarse counts, three of which are roughly the same level, the fourth is a finish off of the coarse counts.) The fine counter also accumulates counts when switch C is turned ON. The relationship, for counts, is one coarse count equals 1,Ø24 fine counts.

Where does this 1,024 count relationship come from?

Looking carefully at the coarse and fine reference levels, you find that the coarse and fine differ by only 128 counts, not by 1,024. The clocks associated with the coarse counter and the fine counter are not the same, one clock is 120kHz, that is the coarse count clock, and the fine clock is 8 times that or 960kHz. As a result there is a factor-of-8 difference, and 8 times 128 equals 1,024 counts.

The total of all coarse and fine counts constitutes a measured value. Accumulated counts for each of the four measured values ($V_{unknown\ 0°}$, $V_{unknown\ 90°}$, $V_{standard\ 0°}$, $V_{standard\ 90°}$) are sent to the micro-computer.

3.3.2 Analog Circuit Card (P/N 45239)

3.3.2.1 <u>Signal to the Unknown</u>

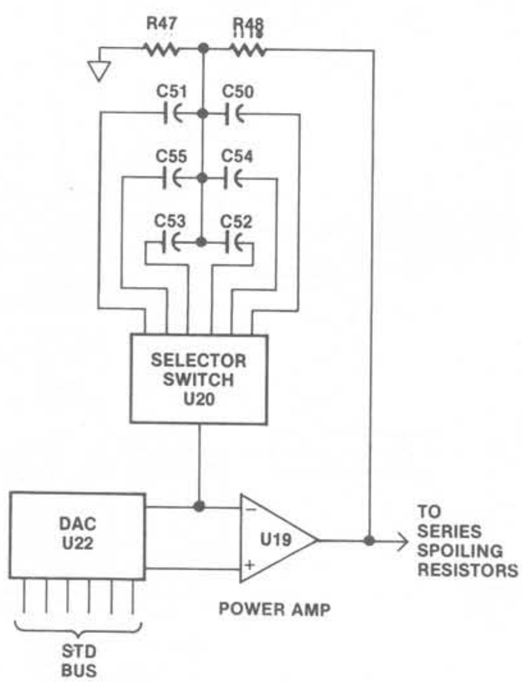


Figure 3-4. Level set, Filter, and Power Amplifier Block Diagram

As the sinewave from the sine generator comes onto the Analog circuit card, it goes through a level-setting DAC. The level-set DAC is under microcomputer control and can reduce the test signal to any one of 256 predetermined test levels. Level-set DAC, U22, is ganged with U17, the variable gain DAC, so that as the test signal level is reduced, the measured signal can be amplified by the same amount for further processing.

The level-set DAC outputs a stairstepped sinewave that must be filtered before it can be used. The Analog assembly has three filters that can be selected for this job. Filter selection is dependent on the test signal frequency such that C5Ø and C51 are selected at frequencies between 2ØHz and 2ØØHz, C54 and C55 between 2ØØHz and 2kHz, and C52 and C53 between 2kHz and 2ØkHz. The filtered sinewave is sent to the power amplifier.

Power amplifier U19 is designed to supply enough current out through the HI DRIVE port to the unknown that a measurement can be made. The power amplifier also supplies a signal to the high side of the standard (range) resistors.

3.3.2.2 Range Switching

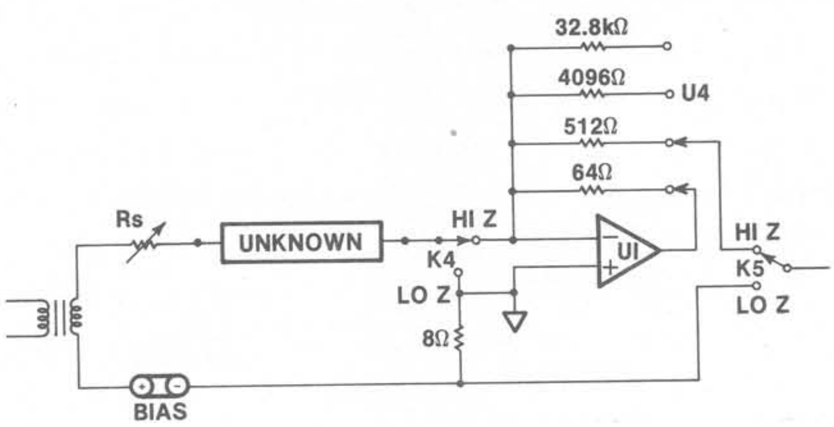


Figure 3-5. Range Switching Block Diagram

Figure 3-5 illustrates the range switching used in the 2100/2110. The diagram shows, basically, two bridge configurations or two measurement configurations, a HI Z and a LO Z configuration. Anytime the 8Ω standard resistor (measuring unknowns from 0Ω to about 32Ω) is used, relay K4 switches to the LO Z configuration. All measurements above 32Ω use the other standard resistors or the HI Z configuration. Standard resistors used in the HI Z configuration are 64Ω, 512Ω, 4.096kΩ, and 32.8kΩ. The 64Ω standard resistor is switched in/out of the circuit by relay K5, while the 512Ω, 4.096kΩ, and 32.8kΩ resistors are switched by solid state switch U4. Any ranges beyond those represented by actual resistors are the result of a range gain multiplier.

3.3.2.3 Range Gain

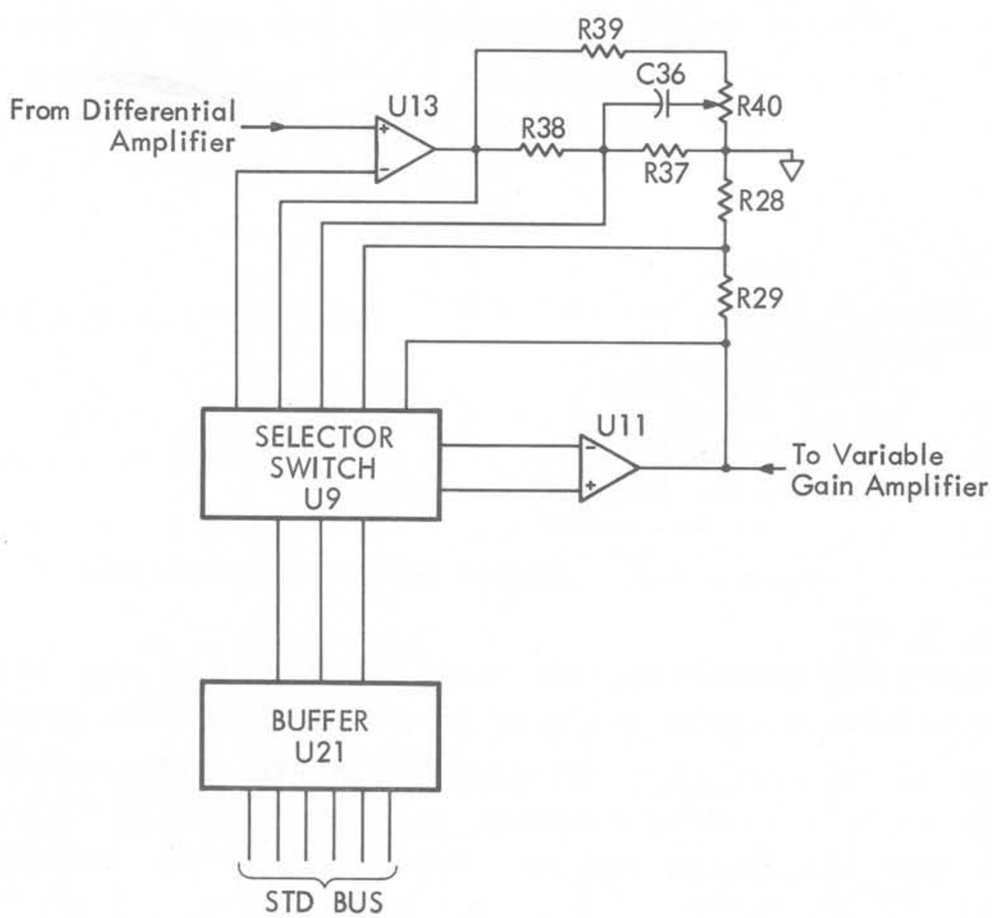


Figure 3-6. Range Gain Amplifier

The range gain amplifier, U11, U13, and U9, sets up gains of 1/8, 8, or 64 in conjunction with the range resistors to produce the 2100/2110's eight measurement ranges. Each multiplier is an exact power of 8 so that when combined with a standard resistor it provides measurement ranges between 0.125Ω and 262kΩ. The range gain amplifier is bus connected thru buffer U21 and receives programmed instructions from the microcomputer.

3.3.2.4 Series Spoiling Resistors

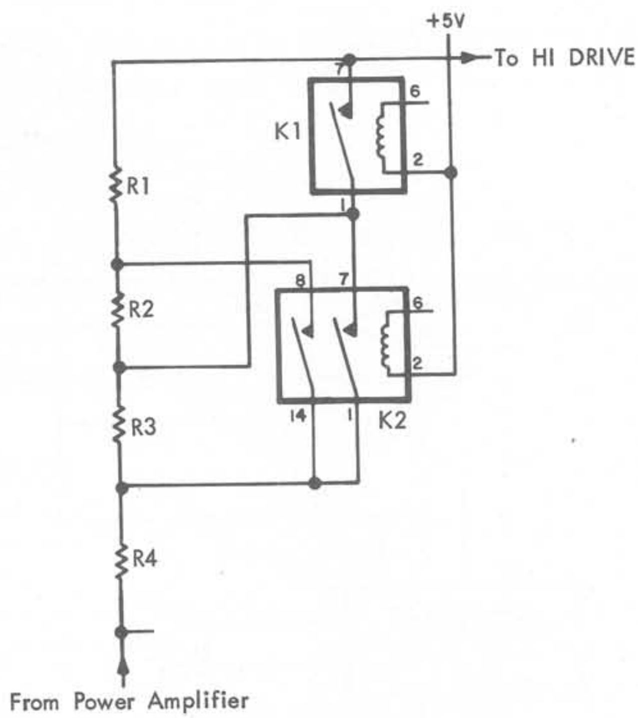


Figure 3-7. Series Spoiling Resistors

Series spoiling resistors, R1 thru R4, stablize the instrument for reactive unknowns. Each resistor is placed in series with the unknown by relays K1 and K2. The spoiling resistors are changed in conjunction with a corresponding standard resistor. The 8Ω standard resistor does not need a spoiling resistor because it is not used in U1's feedback loop.

3.3.2.5 Phase Trims

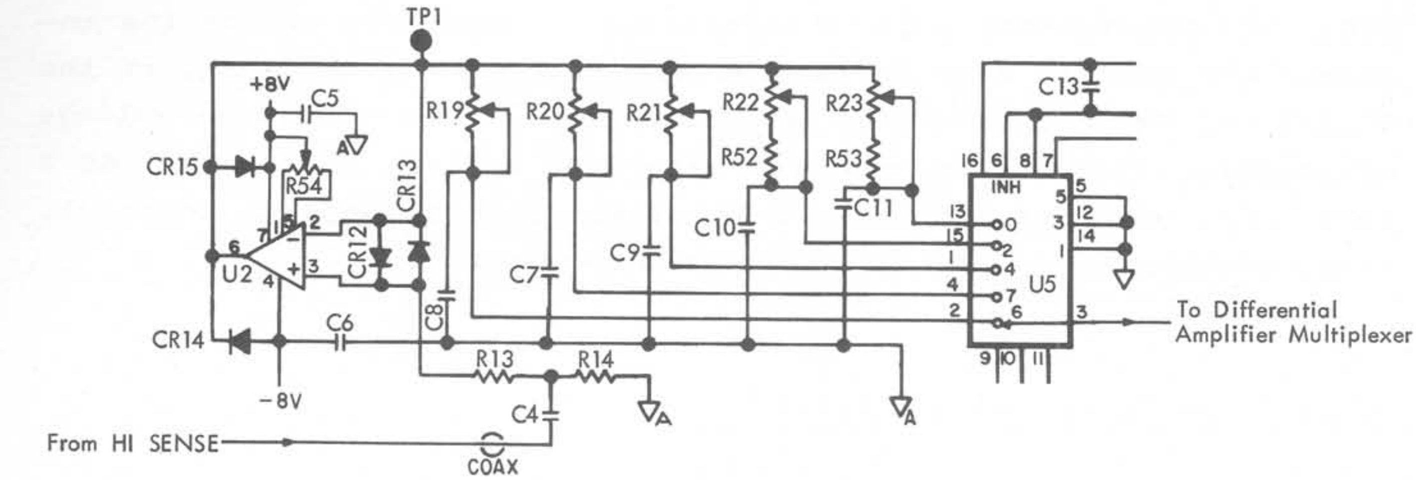


Figure 3-8. Phase Trims

Phase calibration trimmers R19 thru R23 and R4Ø calibrate dissipation factor accuracy for each measurement range. They compensate for phase differences between the unknown and standard measurement channels. Solid state switch U5 changes the phase trim when the corresponding range resistor is changed.

3.3.2.6 Differential Amplifier

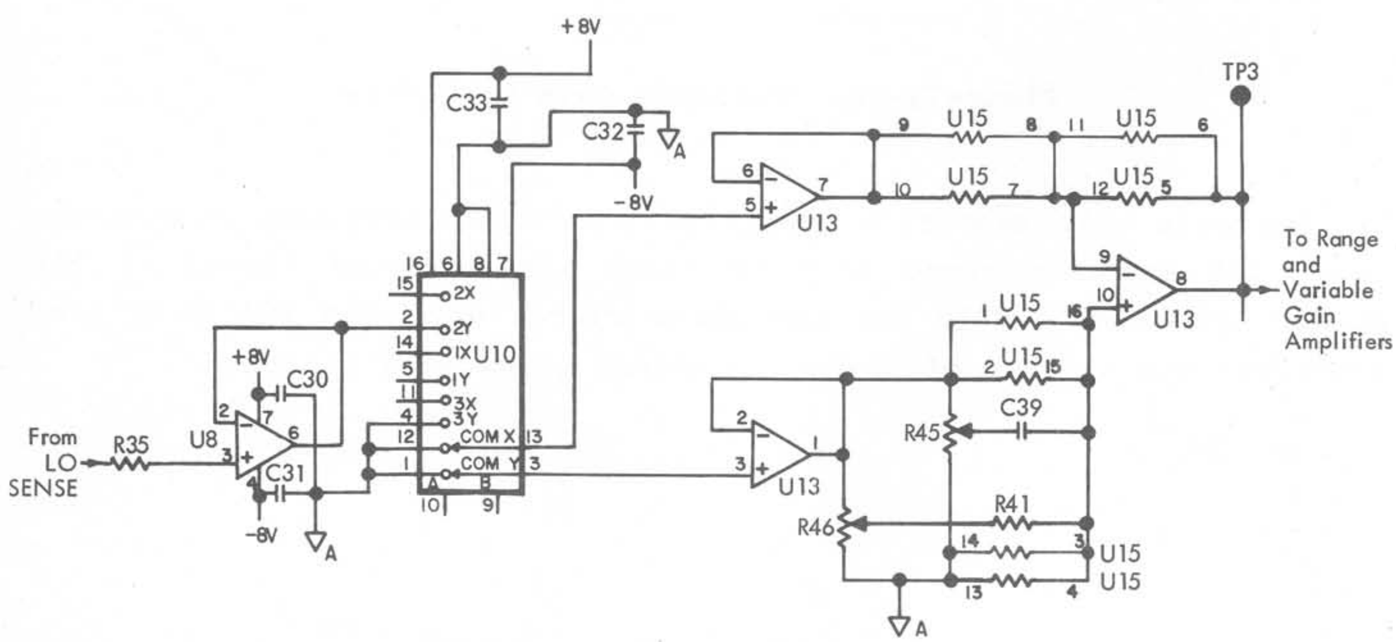


Figure 3-9. Differential Amplifier

The differential amplifier consists of 3 sections of quad-amplifier U13. It's input is sequentially selected by the input multiplexer U1Ø. The mulitplexer selects either the voltage drop across the unknown, the voltage drop across the standard (range) resistor, or the Ø.125V RMS reference voltage for measurement. The reference voltage is measured first. The measured reference voltage is recorded as a reference number of counts (A/D converter counts) against which the measured unknown and standard signals are compared.

3.3.2.7 Variable Gain Amplifier

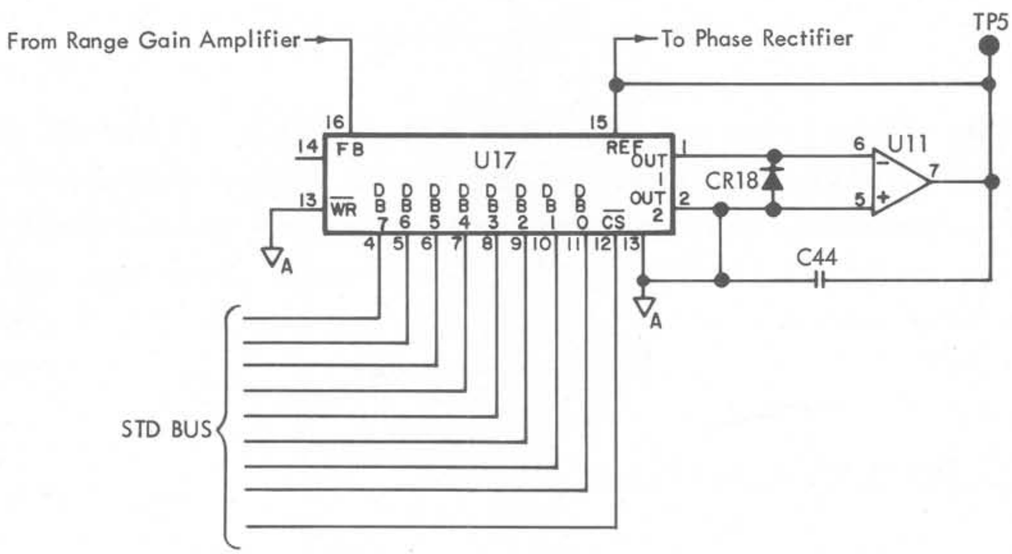


Figure 3-1Ø. Variable Gain Amplifier

The variable gain amplifier (VGA), U17, works in conjunction with the level set and the range gain to boost the measured signal to the proper operating levels for the phase rectifier. The VGA is a programmable DAC capable of producing signal gains of 1 to 256.

3.3.2.8 Overload Detector

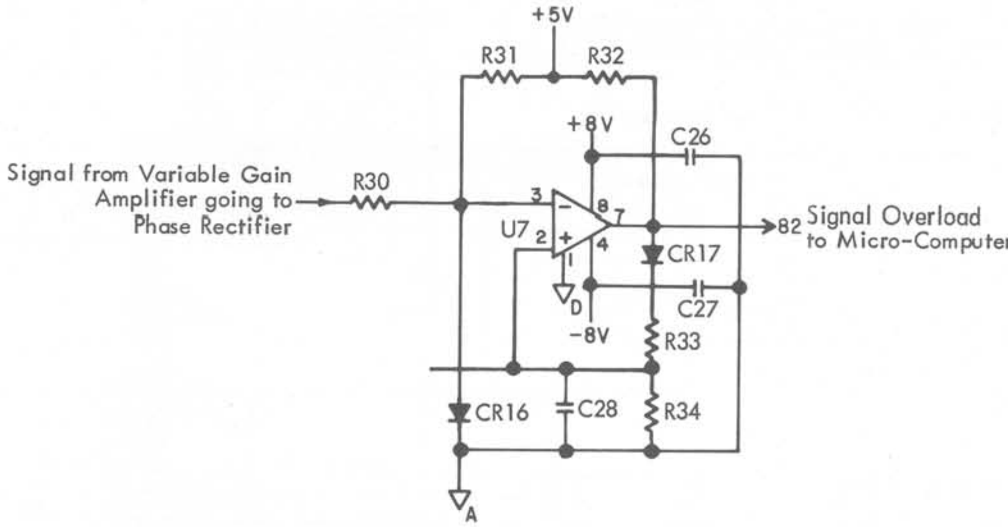


Figure 3-11. Overload Detector

Overload detector U7 monitors the signal going from the output of the variable gain amplifier to the phase rectifier. This peak detector indicates overload when the signal is too high. The detector's output goes HI when an overload occurs.

3.3.2.9 Phase Rectifier

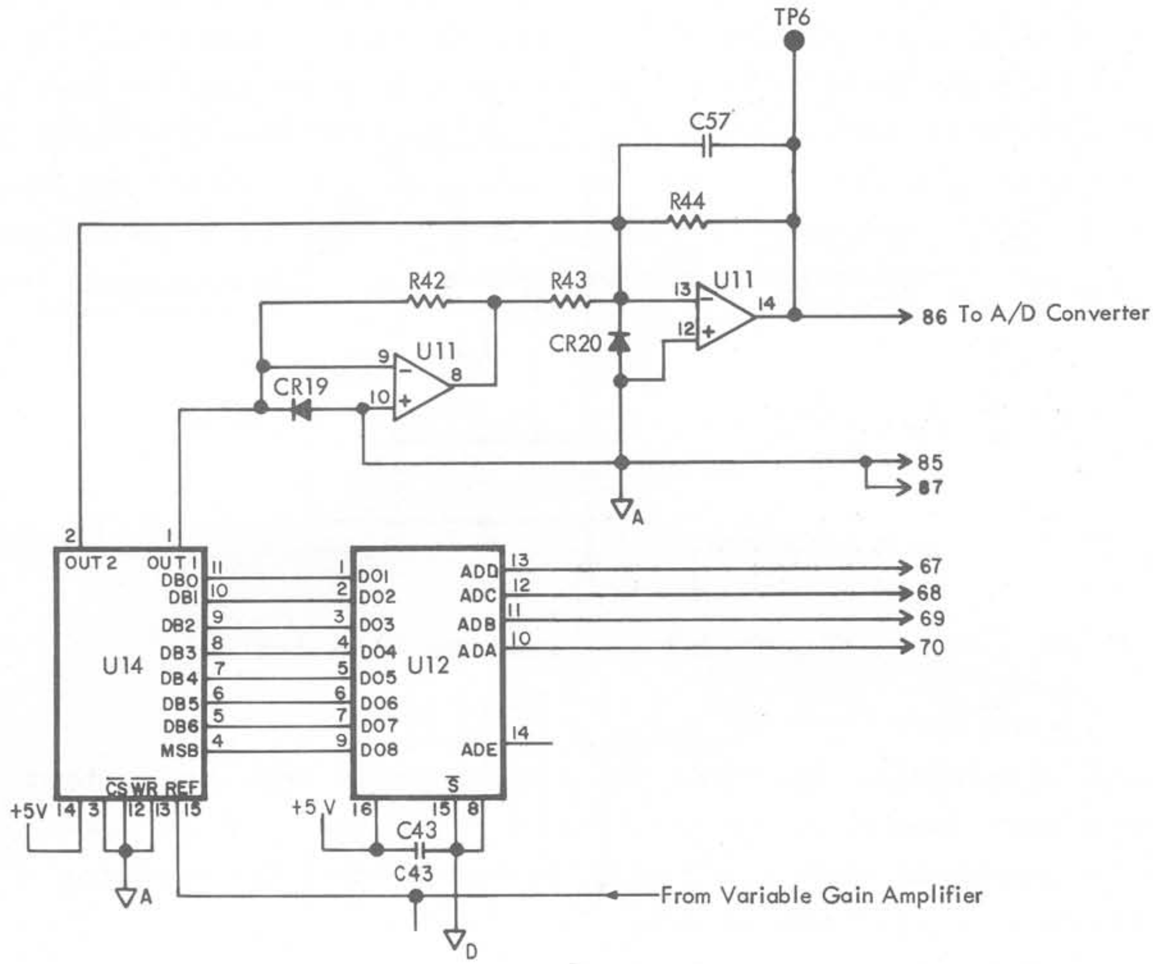


Figure 3-12. Phase Rectifier

The phase rectifier, shown in the Block Diagram, resides in U14, U12, and U11; a four quadrant, CMOS digital-to-analog converter. The phase rectifier is driven by a 32 x 8 bit PROM which does the synchronous gating needed to give a DC output. The PROM is driven by four input lines that are harmonics of the test frequency. A fifth input line is the 0°/90° bit. This circuit provides a multiplier type action of phase detection. It takes the product of the sinewave (measured signal) coming in and the digitally related sinewave (from the PROM) to produce a DC current output. The current output of U14 is summed by two sections of operational amplifier U11 to produce a full wave voltage output.

3.4 MOTHERBOARD

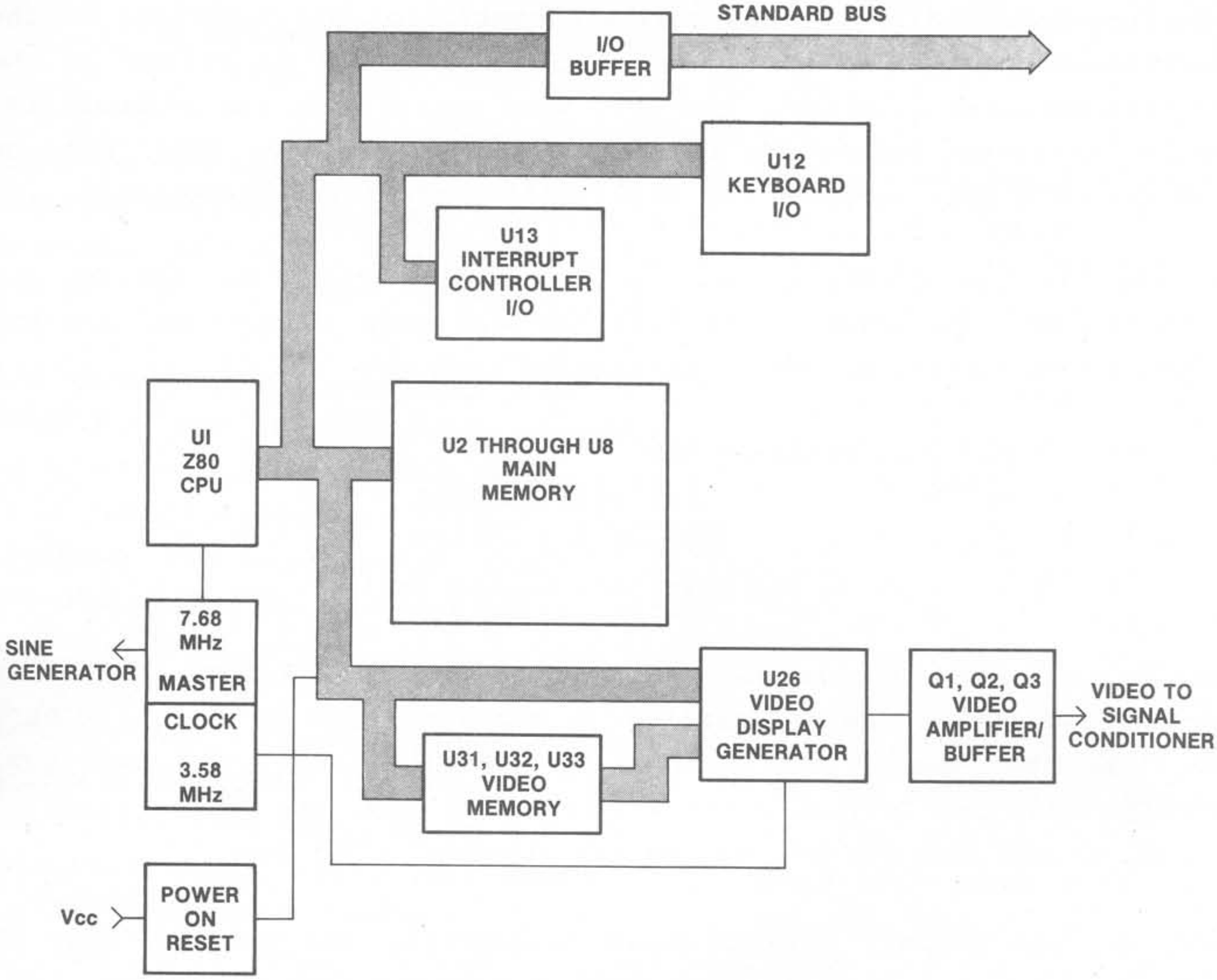


Figure 3-13. Motherboard Simplified Diagram

A simplified diagram of the motherboard is shown in Figure 3-8. The motherboard architecture centers on its standard communication bus which has 6 slots for plugging in circuit cards containing measurement circuitry, IEEE-488 interfacing circuitry, RS232 interfacing circuitry, and other bus compatable devices. The motherboard holds the Z80 CPU chip and its memory, the video generator and its memory, the master clock, and associated control logic.

3.4.1 CPU

The central processing unit (CPU) used in the 2100/2110 is a Z80 microprocessor chip. It has complete control of all functions of the instrument and does all the calculations required to arrive at the desired measured quantity. The CPU, when joined with the keyboard I/O (U12), interrupt controller I/O (U13), and main memory PROM, ROM, or RAM (U2 thru U8), comprise the 2100/2110's internal microcomputer.

A computer bus exists to convey information from the CPU to its peripherals. In order to do this the CPU must supply, and the bus must convey certain specific information such as:

1. What information?
2. To whom? To what destination?
3. When is the information valid?
4. When is the destination name valid?

The exact information is conveyed over an 8 bit DATA bus, the source or destination of the information is conveyed over a 16 bit ADDRESS bus, and the "whens" are resolved by CONTROL lines. The DATA bus, ADDRESS bus, and CONTROL lines are combined into one set of parallel lines, on the motherboard, called the standard (STD) bus.

Any CPU can support only so many capacitive, and only so many DC loads. Expansion beyond these load limits requires buffering. All ADDRESS, DATA, and CONTROL lines are buffered before they are routed to the standard (STD) bus. Thus, all things that talk to the CPU can be divided into two groups: those that exist on one side of the buffers (that talk directly to the CPU), and those that exist on the other side of the buffers (that talk to the CPU through the buffers). It is the job of the motherboard's logic to decide on which side of the buffers a device is and whether or not to enable those buffers. If an addressed device is on the CPU side of the buffers (INTERNAL), it needs to be singled out (SELECTED) before it can speak or be spoken to. Devices that are INTERNAL are:

1. Keyboard I/O, KDI18279, U12
2. Interrupt controller I/O, CTC3882, U13
3. Video display generator control, MC6847, U26
4. Video memory, RAM, U31 thru U33
5. Main memory, PROM, ROM, or RAM, U2 thru U8

Logic on the motherboard is programmed to know the addresses of these INTERNAL devices. For all devices not INTERNAL, the motherboard logic presumes that they reside somewhere on the far side of the buffer, on the STD bus, in this case the appropriate buffers are enabled.

I/O decode is accomplished with two MSI devices, a DM8131 and a 74LS139. The 8131 is a hex comparator which is set to recognize a range of I/O addresses. This range is subdivided by the 74LS139 which is a 2:4 line decoder/selector. When the DM8131 recognizes a valid INTERNAL I/O address it selects the decoder which resolves the address, allowing one particular INTERNAL I/O device to communicate with the CPU.

Memory decode is accomplished with the MSI device, a 74LS288, which is a 32 x 8 bit fused link ROM. The inputs to the ROM are address lines, the ROM is programmed to do a table lookup: "this address in, means this chip select out". The chip-select outputs are routed to one of the INTERNAL memory sockets (U2 thru U8). The same technique is used for the video memory matrix. Please note that the 74LS288 ROM is doing the same job for the memory as the comparator and selector are for the I/O.

It may be interesting to note that these are more than just address lines entering the comparator chips in both of the previous circuits, these are the CONTROL lines that tell the comparator when the address is valid and when a chip select can be output.

3.4.2 Standard Communications Bus

When the CPU addresses a device on the output side (EXTERNAL) of the CPU buffers, it also needs to be singled out (SELECTED) before it can speak or be spoken to. There are a number of lines, called the standard (STD) bus, that are dedicated to conveying address information, control signals, and data to and from these EXTERNAL devices. The STD bus has six locations for plugging in measurement and I/O dedicated devices. Standard bus signals and card edge connections are identified in Table 3-1. Devices that are serviced by the STD bus are:

1. Digital and Analog Measurement circuit assemblies.
2. IEEE-488 Interface circuit assembly (optional).
3. RS232 Interface circuit assembly (optional).
4. Cassette tape interface (Model 211Ø only).
5. External Memory circuit assembly.

	PIN	MNEMONIC	SIGNAL FLOW	DESCRIPTION	PIN	MNEMONIC	SIGNAL FLOW	DESCRIPTION
LOGIC POWER BUS	1	+5V	In	+5 Volts DC (Bussed)	2	+5V	In	+5 Volts DC (Bussed)
	3	GND	In	Digital Ground (Bussed)	4	GND	In	Digital Ground (Bussed)
	5	-5V	In	-5 Volts DC	6	-5V	In	-5 Volts DC
DATA BUS	7	D3	In/Out	Low Order Data Bus	8	D7	In/Out	High Order Data Bus
	9	D2	In/Out	Low Order Data Bus	10	D6	In/Out	High Order Data Bus
	11	D1	In/Out	Low Order Data Bus	12	D5	In/Out	High Order Data Bus
	13	D0	In/Out	Low Order Data Bus	14	D4	In/Out	High Order Data Bus
ADDRESS BUS	15	A7	Out	Low Order Address Bus	16	A15	Out	High Order Address Bus
	17	A6	Out	Low Order Address Bus	18	A14	Out	High Order Address Bus
	19	A5	Out	Low Order Address Bus	20	A13	Out	High Order Address Bus
	21	A4	Out	Low Order Address Bus	22	A12	Out	High Order Address Bus
	23	A3	Out	Low Order Address Bus	24	A11	Out	High Order Address Bus
	25	A2	Out	Low Order Address Bus	26	A10	Out	High Order Address Bus
	27	A1	Out	Low Order Address Bus	28	A9	Out	High Order Address Bus
	29	A0	Out	Low Order Address Bus	30	A8	Out	High Order Address Bus
CONTROL BUS	31	WR*	Out	Write to Memory or I/O	32	RD*	Out	Read to Memory or I/O
	33	IORQ*	Out	I/O Address Select	34	MEMRQ*	Out	Memory Address Select
	35	IOEXP*	In/Out	I/O Expansion	36	MEMEX*	In/Out	Memory Expansion
	37	REFRESH*	Out	Refresh Timing	38	MCSYNC*	NA	CPU Machine Cycle Sync
	39	STATUS 1*	Out	CPU Status (Z80-M1)	40	SATUS 0*	Out	CPU Status
	41	BUSAK*	Out	Bus Acknowledge	42	BUSRQ*	In	Bus Request
	43	INTAK*	Out	Interrupt Acknowledge	44	INTRQ*	In	Interrupt Request
	45	WAITRQ*	In	Wait Request	46	NMIRQ*	In	Non-Maskable Interrupt
	47	SYSRESET*	Out	System Reset	48	PBRESET*	In	Push Button Reset
	49	CLOCK*	Out	Clock Processor (1.92MHz)	50	CNTRL*	In	2 x CPU Clock (3.84MHz)
	51	PCO*	Out	Priority Chain Out	52	PCI*	In	Priority Chain In
POWER BUS	53	AUX GND	In	AUX Ground (Bussed)	54	AUX GND	In	AUX Ground (Bussed)
	55	AUX + V	In	AUX Positive (+12 Volts DC)	56	AUX - V	In	AUX Negative (-12 Volts DC)

*Low Level Active Indicator

Table 3-1. Standard Bus Signals and Card Edge Connections

3.4.3 Extra Bus

Some EXTERNAL devices used in the 2100/2110 communicate with signals that are not compatible with the STD bus. For these devices, a second proprietary bus called the extra bus is used. The extra bus is designed to carry analog signals as well as digital information. The extra bus transmits the following major signal categories, see Table 3-2 for a further breakdown of signals.

1. 7.68MHz master clock
2. Sinewave test signals
3. Chip select signals
4. Measurement cycle and zero crossing information
5. Remote start

PIN	MNEMONIC	DESCRIPTION	PIN	MNEMONIC	DESCRIPTION
57	AUX GND	AUX Ground (Bussed)	58	AUX GND	AUX Ground (Bussed)
59	AUX +V	AUX Positive (+12VDC)	60	AUX -V	AUX Negative (-12VDC)
61	IO1	I/O Select	62	IO2	I/O Select
63	IO3	I/O Select	64	IO4	I/O Select
65	60Hz	60Hz Square Wave	66	7.68MHz	128 x 60kHz
67	F0	Test Frequency Square Wave	68	F1	2 x F0 (F0→F6 connect to sine ROM Address Pins)
69	F2	4 x F0 (F0→F6 connect to sine ROM Address Pins)	70	F3	8 x F0
71	F4	16 x F0	72	F5	32 x F0
73	F6	64 x F0	74	$\overline{\text{FINE GATE}}$	Analog Gate Control
75	$\overline{\text{HI GATE}}$	Analog Gate Control	76	$\overline{\text{LO GATE}}$	Analog Gate Control
77	$\overline{\text{Z GATE}}$	Analog Gate Control	78	$\overline{\text{JNK}}$	Analog Gate Control
79	HI CMP	Comparator Contol	80	LO CMP	Comparator Control
81	Z CMP	Comparator Control	82	SIG OVERLOAD	Comparator Control
83	SINE GND	Ground	84	SINEWAVE	Buffered Sinewave
85	LO-V_{IN}	A/D Converter Control	86	HI-V_{IN}	A/D Converter Control
87			88		
89			90		
91			92		
93			94		
95	$\overline{\text{CPU BUSY}}$	Indicates Internal Process	96	$\overline{\text{START}}$	Start Measurement
97	-7.5V	500mA CMOS Switches	98	+7.5V	500mA CMOS Switches
99	GND	Ground	100	GND	Ground

Table 3-2. Extra Bus Signals and Card Edge Connections

3.4.4 Master Clock

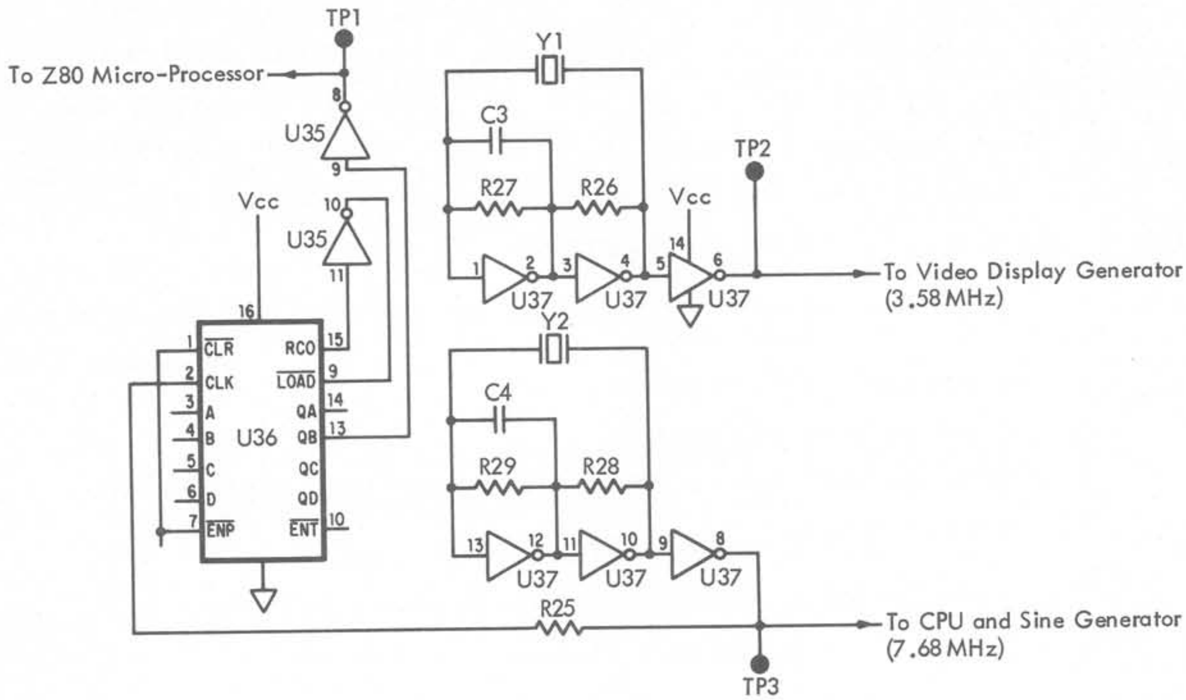


Figure 3-14. Master Clock

The master clock is actually two clock oscillators which support the motherboard. One clock is 7.68MHz for the CPU and projected analog applications. This clock is divided by 4 to produce the 1.92MHz clock signal which sets processor speed, and it is divided by 128 to provide the 60kHz base frequency used by the sine generator. The other clock is a "color burst" frequency (3.58MHz) and is the required clock for the video display generator.

3.4.5 Power ON Reset

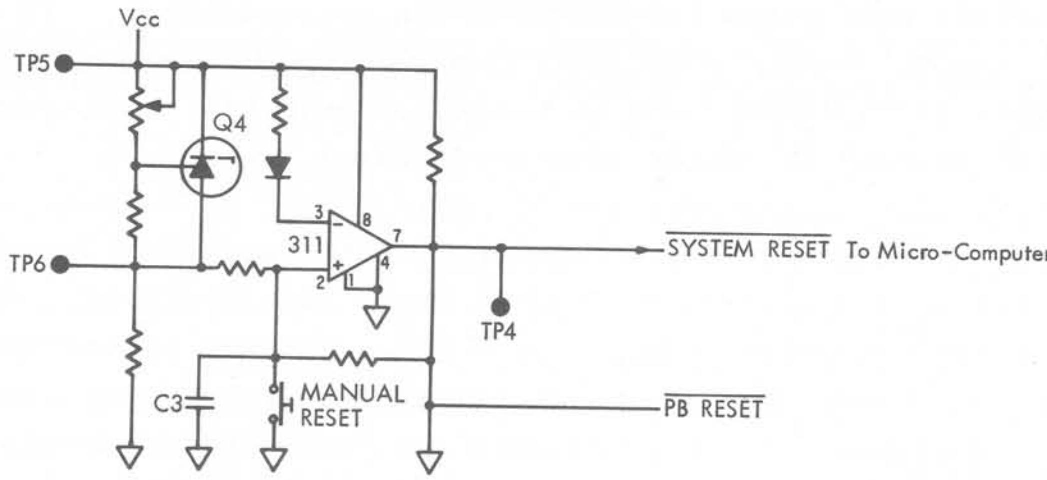


Figure 3-15. Power ON Reset

The power ON reset circuitry is necessary because of the long power-up and power-down time of the switching power supply. It keeps all logic, on the motherboard, reset until V_{cc} reaches 4.75 volts and it keeps the logic operating until V_{cc} drops below 4.75 volts, during power down. If V_{cc} is below 4.75 volts, the power ON reset circuit holds the reset line low. When V_{cc} crosses the 4.75 volt threshold, the power ON reset circuit integrates for 1/1Ø second, then releases the reset line.

3.4.6 Video Display Generator

The video display generator (VDG) is a Motorola MC6847 which accepts a binary control word gated into it from the microcomputer. In response to that binary input, the VDG creates characters, graphic, and semi-graphic information that is output in a format that corresponds to a normal television raster scan arrangement.

The VDG has three memory chips (U3, U32, U33) associated with it that store a screen of information to be scanned and displayed. The video memory has two operating modes. Initially, the VDG has access to the memory and is always scanning and converting the memory contents to characters then sends those characters out to the video display. When the processor is ready to read or write a character into that memory, it goes through a piece of arbitration logic that says, if the video display generator is doing a horizontal sync, a horizontal retrace, or a vertical sync then grant the processor access to the memory. However, if the VDG is not doing horizontal sync or vertical sync then it is putting video out and must not be interrupted. At that point the processor is told to wait, treating the video memory like slow memory. The processor will wait, keeping the address, data, and control lines activated, until a horizontal sync or a vertical sync is output, then the memory returns to normal operation and readily accepts new inputs from the processor.

The composite video, as it comes out of the VDG chip, is a very low level signal. The signal is high impedance in nature and is very susceptible to noise and interference. To counteract these undesirable qualities, there is a three transistor amplifier/buffer (Q1, Q2, Q3) that transforms the VDG output signal into a higher level, low impedance output signal. This output signal then drives the video section of the 2100/2110.

3.5 VIDEO CIRCUITRY

DANGER

THE VIDEO CIRCUITRY CONTAINS DANGEROUSLY HIGH VOLTAGE. EXERCISE EXTREME CARE TO AVOID POSSIBLE ELECTRIC SHOCK WHICH MAY RESULT IN SEVERE INJURY OR DEATH.

The video section of the 2100/2110 has two circuit assemblies that deal directly with processing and displaying video information. These circuit assemblies are:

1. Signal Conditioner Assembly (P/N 45468)
2. Deflection Assembly (P/N 45470)

The operation of the video circuitry located on these assemblies is discussed in the following paragraphs.

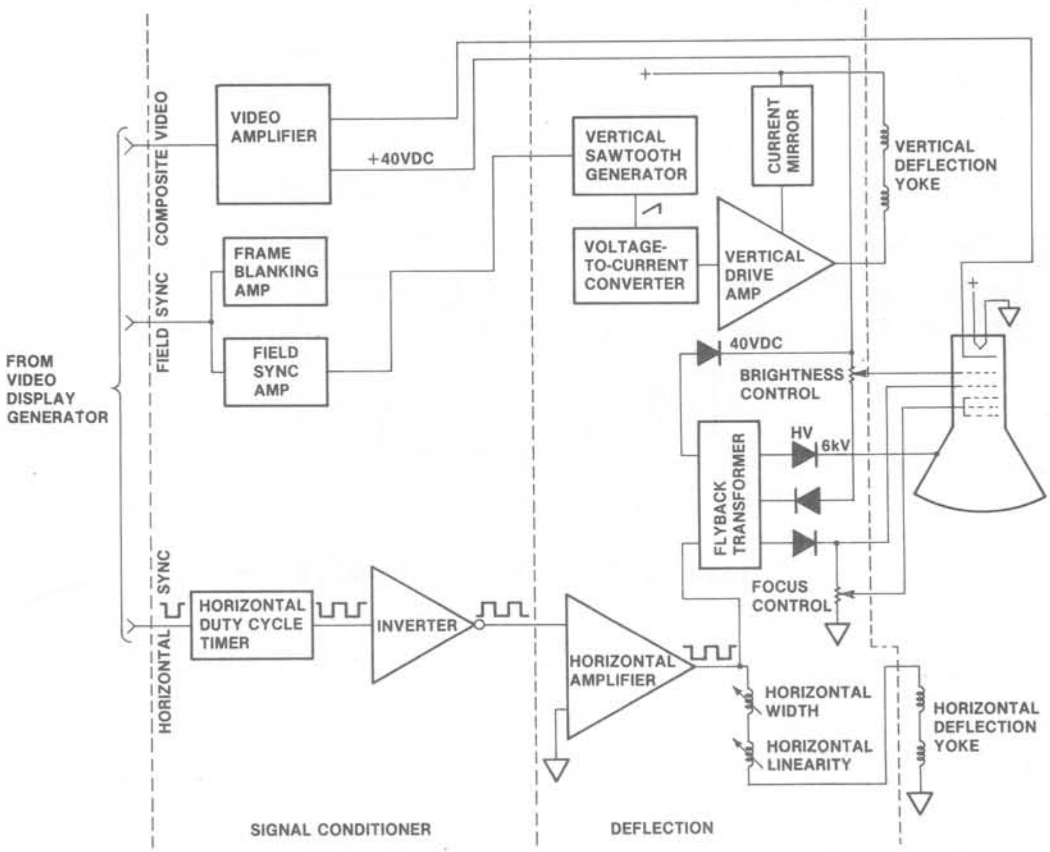


Figure 3-16. Video Circuit Block Diagram

3.5.1 Signal Conditioner Circuitry (P/N 45468)

The Signal Conditioner Assembly receives a number of input signals and operating voltages on input connector P3Ø1. Composite video, field sync, and horizontal sync signals come from the video display generator, U26, located on the motherboard.

The video display generator is a Motorola MC6847 which accepts sequences of binary words from the microcomputer. In response to that binary input it creates characters, graphic, and semi-graphic outputs in a format that corresponds to a normal raster scan arrangement. The MC6847 also provides separate field sync and horizontal sync signals which are usable directly without having to strip them from the composite video input.

3.5.2 Video Amplifier

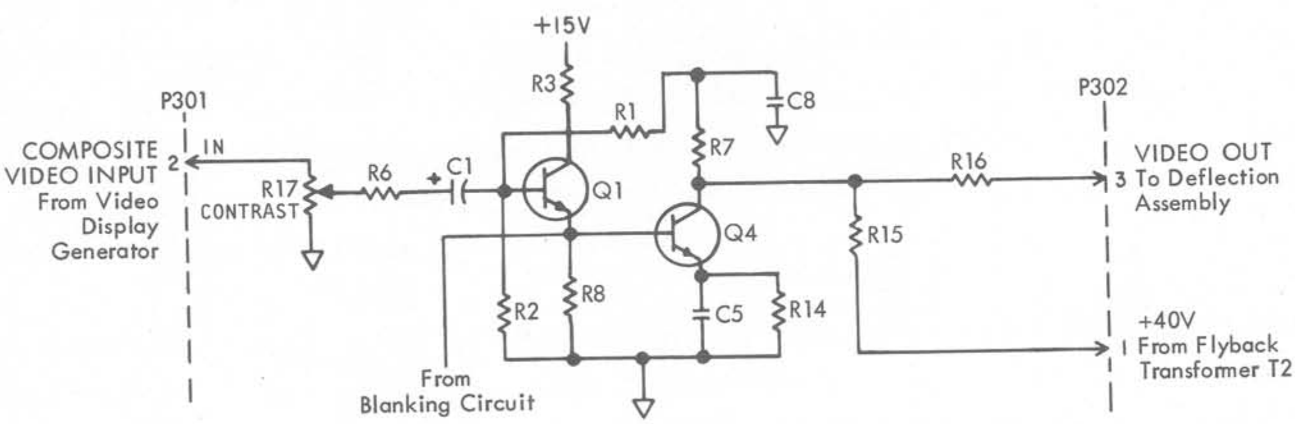


Figure 3-17. Video Amplifier

The composite video signal comes first to potentiometer R17, the contrast control. The contrast control adjusts the level of the composite video signal going to the CRT. The signal passes through RC shaping network R6 and C1 into the base of Q1. Buffer/amplifier Q1 is an emitter follower that drives the base of inverting amplifier Q4 whose collector in turn drives, through R16, to the cathode (pin 2) of the CRT. The collector of Q1 is pulled up to +15V by R3 while the emitter resistor R8 is used to develop the signal as well as for biasing the base of Q4, a 2N3Ø53. The emitter of Q4 uses R14 and C5 to increase the high frequency gain of the Q4 stage. The collector of Q4 and base of Q1 are DC biased through R15 and the +4ØV source located on the Deflection Assembly. (This 4ØV source also, through R15 and R16 provides bias for the cathode of the CRT.) The collector of Q4 can have voltage swings in the vicinity of 2Ø to 3ØV peak-to-peak which are the levels required when composite video is applied to the cathode of the CRT. These voltage swings will turn the CRT from full-on to full-off providing crisp black and white and some half-tone displays. Resistors R1, R7, and capacitor C8 provide DC feedback to bias the base of Q1. They provide negative feedback so that as Q4 turns off it's collector voltage rises. The base voltage on Q1 increases turning Q4 off through the action of Q1's emitter driving Q4's base. This feedback action stabilizes the DC operating point of the video amplifier. Capacitor C8 is a large value to prevent AC signals from being fed back to the input of Q1.

3.5.3 Frame Blanking

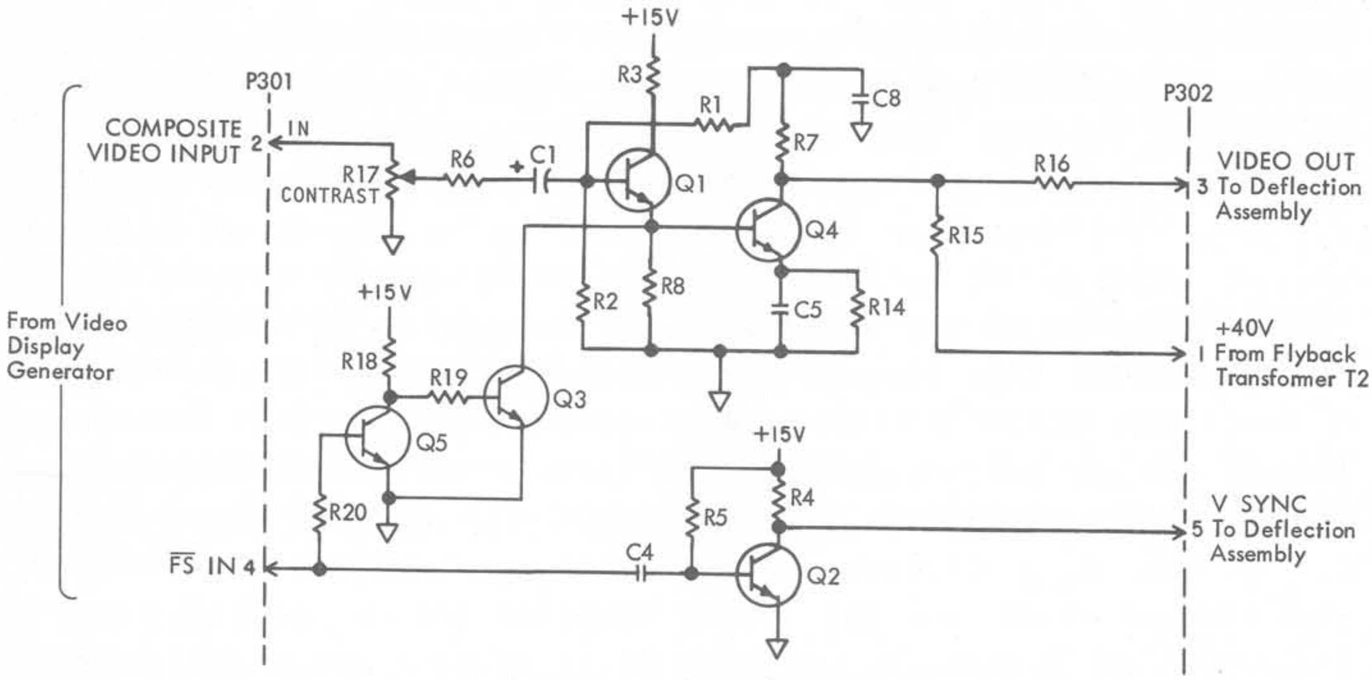


Figure 3-18. Video Amplifier with Blanking

One of the requirements of a video circuit such as the one used in the 2100/2110 is blanking the electron beam whenever one field has been completed and the electron beam is going to be retraced from the end of one field up to the beginning of the next one. The field sync (FS) input at pin 4 of P301 in addition to going through C4, a coupling capacitor, and Q2 out to the vertical sync output of this card, also comes up through Q5 and Q3, another set of DC amplifiers. Basically, this is a logic circuit made of two transistors Q5 and Q3 and resistors R18, R19, and R20, which pulls down the emitter of Q1 to shut off the video output during the retrace. When the emitter of Q1 is pulled down, which will essentially short the base of Q4 to ground, Q4's collector will go positive which is a turn off condition for the electron beam in the CRT. Positive voltages to the CRT produce black displays, near zero voltages produce white displays.

3.5.4 Horizontal Sync

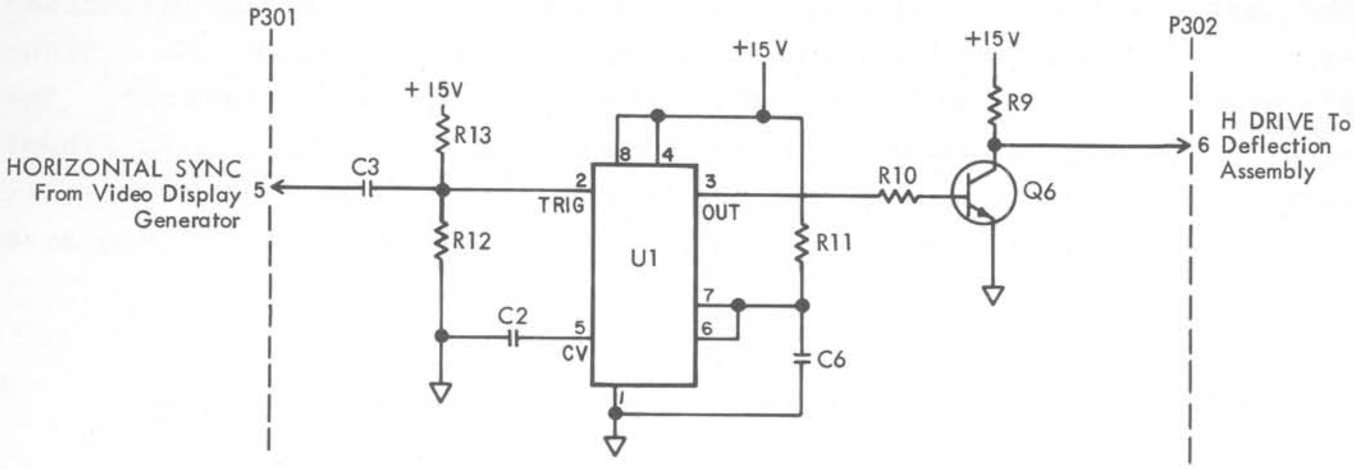


Figure 3-19. Horizontal Sync Circuitry

The horizontal, signal conditioning circuitry sets the duty cycle of the horizontal sync signal to ≈25%. The short horizontal sync (HS) pulse (negative going pulses) are coupled to the input of U1, a NE-555 timer chip, via blocking capacitor C3. Resistors R13 and R12 bias input pin 2 of U1 to trigger at 3.5VDC. The duty cycle of U1 is determined by the RC time constant set up by R11 and C6. The rectangular wave output of U1 is inverted by Q5 and sent to the Deflection assembly H DRIVE input.

3.5.5 Deflection Circuitry (P/N 45470)

The video deflection assembly passes, with no further processing, the amplified composite video signal from the Signal Conditioner assembly directly to the cathode of the CRT.

3.5.6 Vertical Sync

The vertical sync signal comes in on pin 5 of P4Ø1 of the Deflection circuit card and goes directly to the base of amplifier Q8. Transistor Q8 is the first stage of the vertical sawtooth generator. The vertical sawtooth generator transforms these vertical sync input pulses into a linear, sawtooth current waveform that will eventually drive the vertical deflection yoke. The sawtooth generator operates as follows:

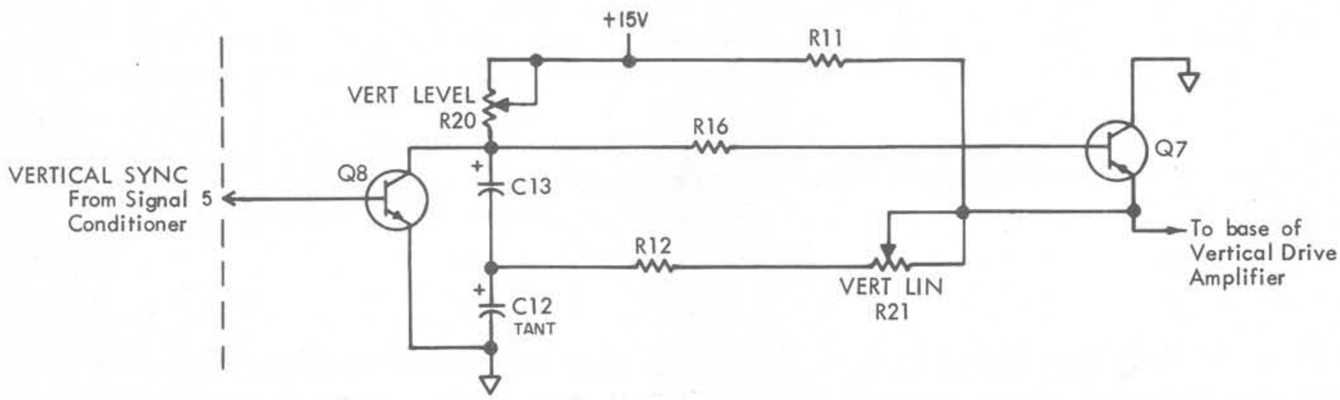


Figure 3-2Ø. Vertical Sawtooth Generator

Resistor R2Ø, the ramp level adjust, controls the slope of the sawtooth waveform. It sets the rate at which capacitors C12 and C13 will charge. These capacitors charge in a positive direction until a vertical sync pulse is received at Q8. The vertical sync pulse turns transistor Q8 ON allowing C12 and C13 to rapidly discharge. The result of the slow charge/fast discharge action is a sawtooth waveform at the base of amplifier Q7.

The voltage-to-current converter, Q7, is a PNP transistor connected as an emitter follower. It transforms the sawtooth voltage waveform on its base to a sawtooth current at its collector. A portion of Q7's collector current is picked off by resistors R21 and R12, the vertical linearity control, and fed back to the center of C12 and C13 to provide vertical linearity adjustment. Resistor R19, the vertical drive control, sets the amount of sawtooth collector current passed to the vertical drive amplifier Q6.

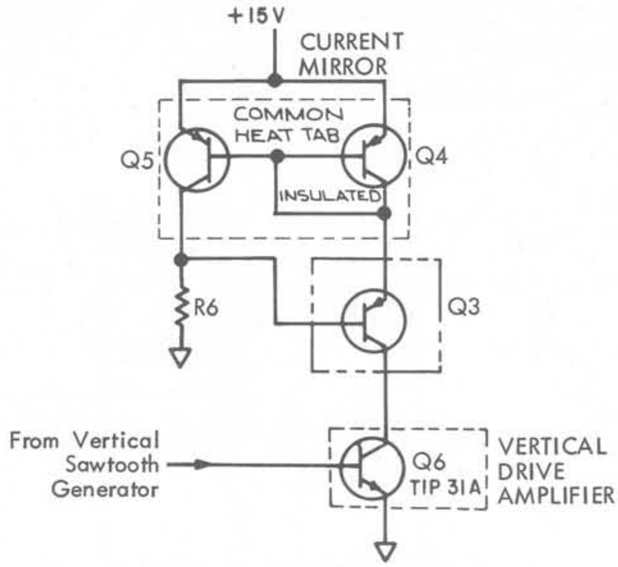


Figure 3-21. Current Mirror

The vertical drive amplifier's collector is coupled to a constant current source called a current mirror. The current mirror is designed to keep the vertical drive amplifier's current at a constant level despite changing loads on its output. This provides a low DC and a high AC impedance path for the vertical drive signal. Capacitor C11 couples vertical drive to the vertical deflection yoke which in turn moves the electron beam up/down on the CRT screen. Components C1Ø and R14 give feedback to the base of Q6 to provide vertical gain stability.

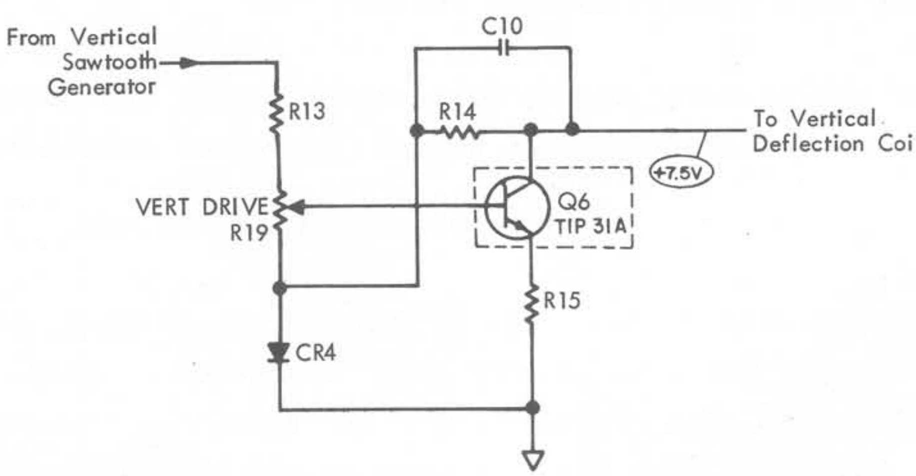


Figure 3-22. Vertical Drive Amplifier

3.5.7 Horizontal Sync

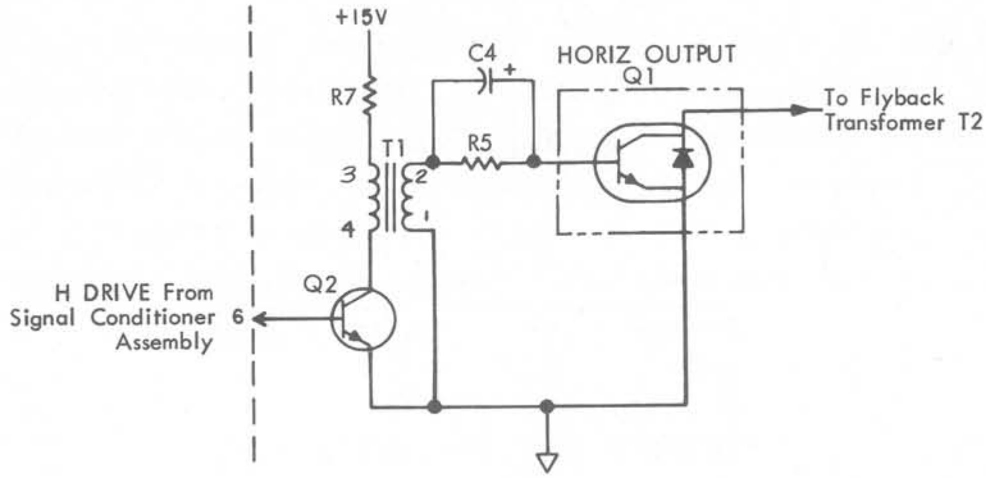


Figure 3-23. Horizontal Drive Amplifier

The horizontal sync signal, from input connector pin 6, feeds the base of transistor Q2. It is basically a digital signal which is pulled up to +15V or pulled down to ØV. Transistor Q2's collector is connected to the primary of coupling transformer T1, and also through resistor R7 to +15V. This combination, Q2, R7, T1, produces a snap action in the horizontal output transistor Q1. When transistor Q2 is shut-off, all the magnetic energy stored in T1 is coupled through C4 into the base of the horizontal output transistor. The horizontal output transistor produces base-collector current to:

1. Drive the primary of the horizontal output transformer (T2).
2. Develop the 4ØVDC voltage source for video amplifier and CRT cathode biasing.
3. Drive the horizontal deflection yoke of the CRT.

Horizontal output transformer T2 (flyback transformer) provides the voltages necessary for cathode-ray tube operation. Diode rectifiers CR1, CR2, CR3, and CR5 develop the DC accelerating and focusing voltages for the CRT. The high voltage at the CRT's anode, for final electron acceleration, is 6kVDC. Display brightness and focus are contolled by R18 and R17 respectively.

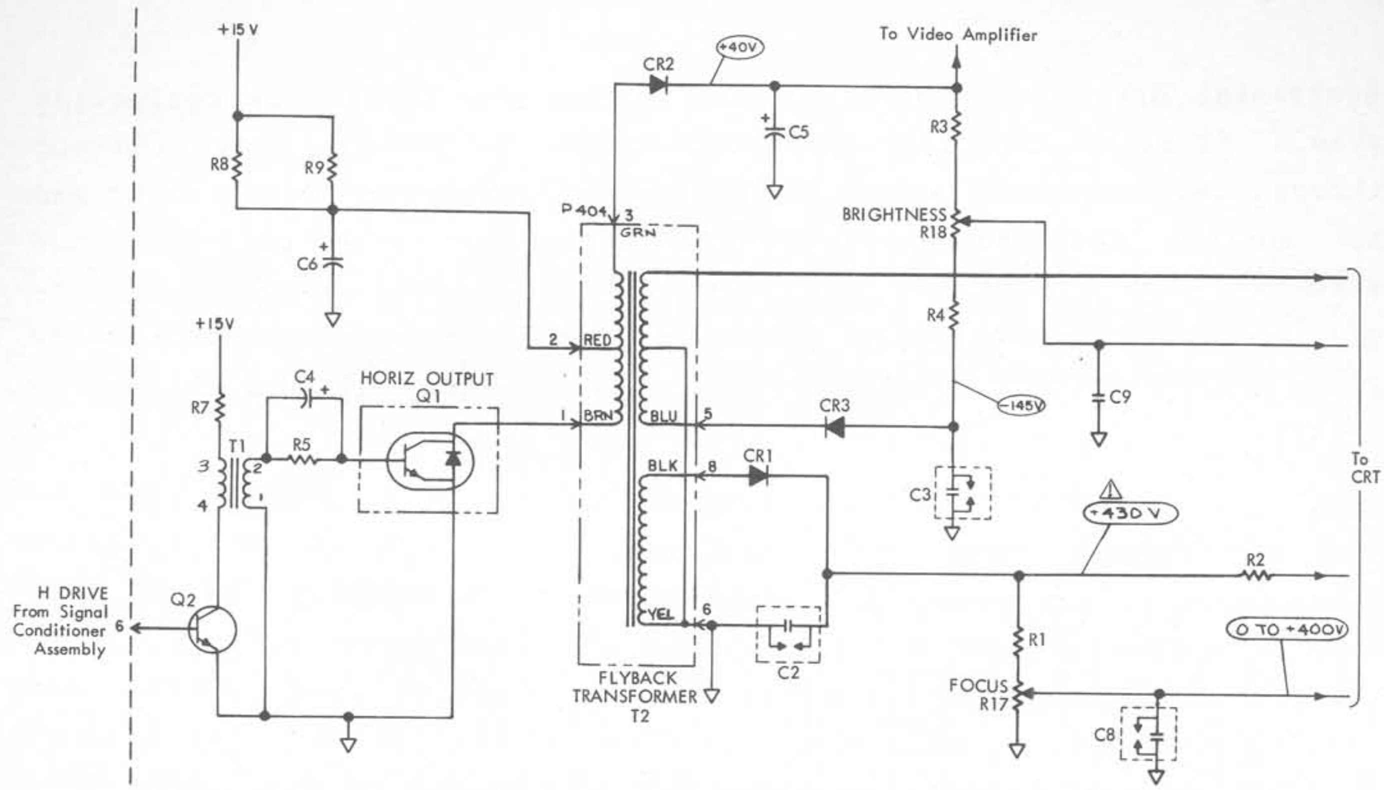


Figure 3-24. Horizontal Drive and Flyback Transformer

Diode rectifier CR2 and filter capacitor C5 develop a noise free 4ØVDC to bias the video amplifier's cathode drive transistor Q4, located on the Signal Conditioner circuit card.

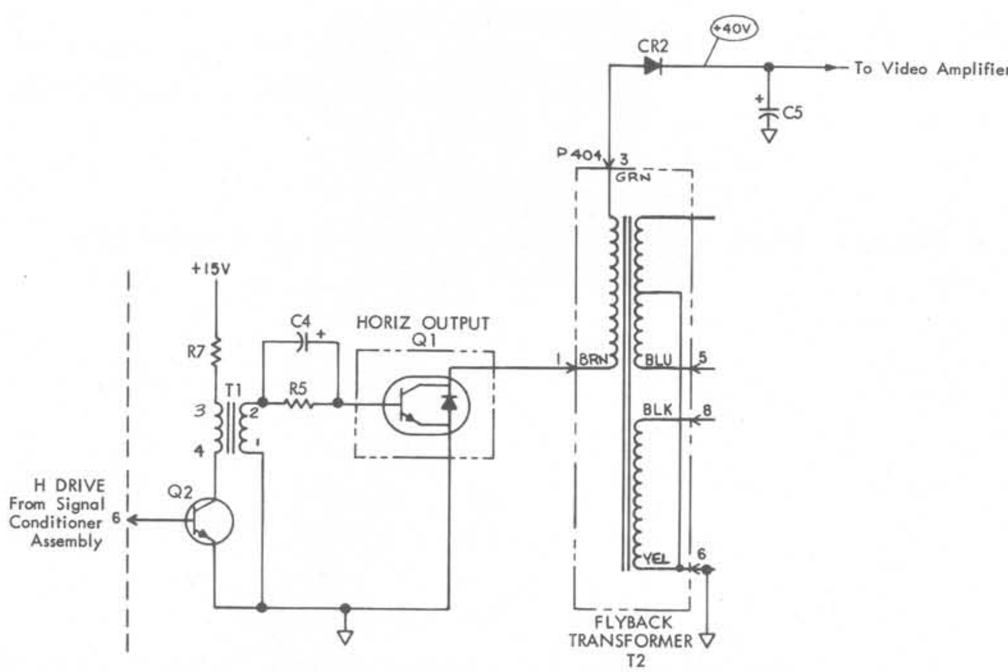


Figure 3-25. 4ØVDC Power Supply

Horizontal drive transistor Q1 also drives the horizontal deflection yoke. Blocking capacitor C14 couples the horizontal drive current through the horizontal width and horizontal linearity controls (L1 and L2) to the deflection yoke. The deflection yoke positions the electron beam across the CRT screen. Horizontal movement is proportional to the amount of current flowing through the deflection yoke. Capacitor C1 provides proper wave shaping of the deflection signal.

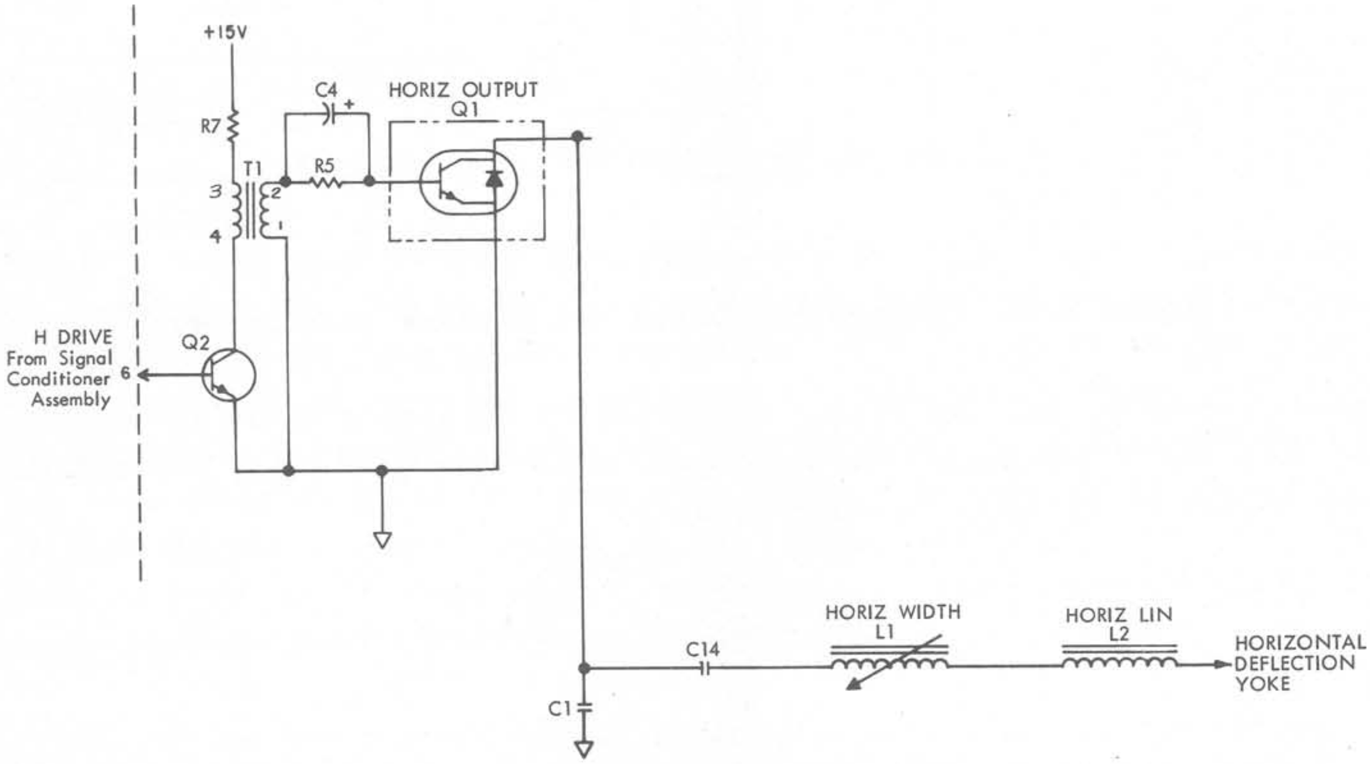


Figure 3-26. Horizontal Deflection Circuitry

3.6 POWER SUPPLY

WARNING

ALL PARTS OF THE POWER SUPPLY ASSEMBLY INCLUDING INPUT CIRCUIT COMMON ARE AT OR ABOVE POWER LINE VOLTAGE. THE ENERGY AVAILABLE AT ANY POINT ON THE ASSEMBLY MAY BE LIMITED ONLY BY THE INPUT FUSE. DO NOT ATTEMPT SERVICE OPERATIONS. FAILURE TO OBSERVE THIS WARNING MAY RESULT IN SEVERE INJURY OR DEATH.

The Power Supply, under normal conditions, has very dangerous, high voltages. Do not attempt to troubleshoot the power supply. If the power supply is suspected of being faulty, send the entire instrument back to ESI for servicing. To determine if a problem exists in the power supply, look at the five LEDs located on the motherboard (see Figure 3-27). Should one or more of these LEDs be dim or dark, the power supply may be faulty and the instrument should be sent to ESI. If all five LEDs are illuminated, the trouble is not in the power supply and normal troubleshooting procedures should be continued.

THIS IS BULLSHIT. +15V IS NOT A LED! BUT IT CAN BE DEFECT!

NOTE: Detailed service procedures on this switching power supply will be available from ESI on request at a future date.

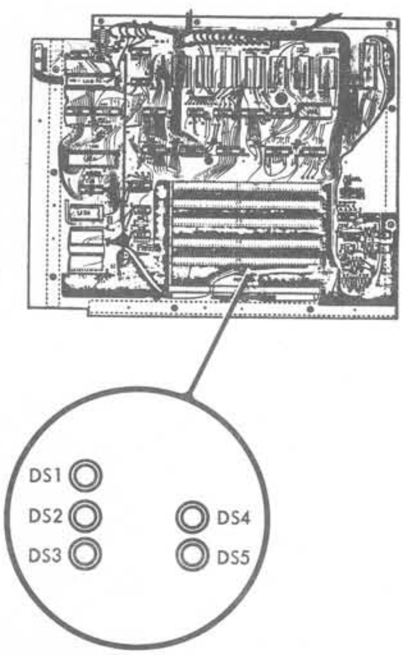


Figure 3-27. Power Supply Diagnostic LED Locations

SECTION 4

PERFORMANCE, CALIBRATION, AND MAINTENANCE

WARNING

TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS MANUAL. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED IN THIS MANUAL ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.

4.1 PERFORMANCE TESTS

The following procedures describe methods for comparing VideoBridge performance with its published specifications. These tests are made via simplified testing procedures rather than by exercising the millions of combinations of test frequencies, test levels, and L, R, and C ranges. If the test results are found to be out of specification limits, check that controls are properly set, then proceed to Section 4.2 Calibration.

When large numbers of measurements are made at a particular frequency, test level, and/or parameter, these performance tests can be customized to include the specific testing needs.

NOTE: Allow a 10 minute warm up period before conducting any performance tests.

Equipment Required	Recommended Model/Type
Resistance Standards:	
1Ω ±0.01%	ESI SR1
10Ω ±0.01%	ESI SR1
100Ω ±0.01%	ESI SR1
1kΩ ±0.01%	ESI SR1
10kΩ ±0.01%	ESI SR1
100kΩ ±0.01%	ESI SR1
1MΩ ±0.01%	ESI SR1
Capacitance Standards:	
1nF ±0.01%	Genrad 1404A, 3-term, air
100nF ±0.01%	Genrad 1409T, 3-term, Silvered mica
Frequency Counter:	
20Hz to 20kHz ±0.001%	Hewlett Packard 5315
Digital Multimeter:	
AC voltage 200mV, 2V RMS full scale	Fluke 8600
AC current 2mA, 20mA, 200mA RMS full scale	
Bandwidth 20Hz to 20kHz	
Accuracy ±0.5%	

4.1.1 Frequency Accuracy Test

STEP 1. VideoBridge setup:

Function	Cs, D
Range	AUTO
Frequency	20000Hz
Test level	1000mV
Measurement speed	MEDium
Measurement mode	Single

STEP 2. Connect a BNC-to-BNC cable between the frequency counter input and the VideoBridge HI DRIVE (HD) unknown terminal. Leave the other unknown terminals unconnected.

STEP 3. The counter should read: 20000Hz ±2Hz (50.000μs ±0.005μs).

STEP 4. Set VideoBridge frequency to: 3750Hz.

STEP 5. The counter should read: 3750.00Hz ±0.37Hz (266.667μs ±0.027μs).

STEP 6. Set VideoBridge frequency to: 1000Hz.

STEP 7. The counter should read: 1000.00Hz ±0.10Hz (1000.00μs ±0.10μs).

STEP 8. Set VideoBridge frequency to: 248.96Hz

STEP 9. The counter should read: 248.96Hz ±0.025Hz (4.01667ms ±0.0004ms).

STEP 10. Set VideoBridge frequency to: 30Hz.

STEP 11. The counter should read: 30.000Hz ±0.003Hz (33.3333ms ±0.003ms).

STEP 12. Set VideoBridge frequency to: 20Hz

STEP 13. The counter should read: 20.000Hz ±0.002Hz (50.000ms ±0.005ms).

NOTE: This frequency test uses the VideoBridge sinewave signal for the frequency counter input. Some counter types have improved stability in readout with a squarewave signal input. If this is the case, use internal bus pin 67 (F0) and instrument chassis ground for counter input.

4.1.2 Range Resistor Accuracy Test

STEP 1. VideoBridge setup:

Function	(Rs) %DEViation, Rs
Range	AUTO
Frequency	100Hz
Test level	100mA
Measurement speed	MEDium
Measurement mode	Single
Nominal value	1

STEP 2. Short test leads together (keep movable jaws and fixed jaws of KELVIN KLIPS® adjacent) and perform zero calibration (push CAL key).

STEP 3. Connect the 1Ω standard resistor, making a 4-terminal connection.

NOTE: If a proper 4-terminal connection has not been made, the error message "cannot supply current " will appear at the bottom of the display.

STEP 4. Set VideoBridge measurement mode to CONTinuous.

STEP 5. The display should read: 1.0000Ω ±0.05%.

STEP 6. Connect the 10Ω standard resistor.

STEP 7. Set VideoBridge to nominal value 10.

STEP 8. Set VideoBridge measurement mode to CONTinuous.

STEP 9. The display should read: 1.0000Ω ±0.05%.

STEP 10. Connect the 100Ω standard resistor.

STEP 11. Set VideoBridge test level to 1000mV.

STEP 12. Set VideoBridge to nominal value 100.

STEP 13. Set VideoBridge measurement mode to CONTinuous.

STEP 14. The display should read: 100.00Ω ±0.05%

STEP 15. Connect the 1kΩ standard resistor.

STEP 16 Set VideoBridge to nominal value 1000.

STEP 17. Set VideoBridge measurement mode to CONTinuous.

STEP 18. The display should read: 1.0000kΩ ±0.05%.

STEP 19. Connect the 10kΩ standard resistor.

STEP 20. Set VideoBridge to nominal value 10k.

STEP 21. Set VideoBridge measurement mode to CONTinuous.

STEP 22. The display should read: 10.000kΩ ±0.05%.

STEP 23. Connect the 100kΩ standard resistor.

STEP 24. Set VideoBridge to nominal value 1ØØk.

STEP 25. Set VideoBridge measurement mode to CONTinuous.

STEP 26. The display should read: 1ØØ.ØØkΩ ±Ø.Ø5%.

STEP 27. Connect the 1MΩ standard resistor. Connect the guard lead to the resistor case (shield).

STEP 28. Set VideoBridge to nominal value 1M.

STEP 29. Set VideoBridge measurement mode to CONTinuous.

STEP 3Ø. The display should read: 1.ØØØØMΩ ±Ø.Ø5%.

4.1.3 Capacitor Accuracy Test

STEP 1. VideoBridge setup:

Function	(Cs) %DEViation, D
Range	AUTO
Frequency	1ØØHz
Test level	1ØØØmV
Measurement speed	MEDium
Measurement mode	CONTinuous
Nominal value	1

NOTE: If the calibrated value of the standard is different, set the VideoBridge to that nominal value.

STEP 2. Space the KELVIN KLIPS® of the test leads six inches or more apart and perform an open circuit zero calibration.

STEP 3. Connect the test leads to the 1nF capacitance standard. Connect the guard lead to the capacitor case (shield). Maintain the shield between the KELVIN KLIPS® if the capacitor terminals are closely spaced.

STEP 4. The display should read: .000%Cs ±0.100% and .00000 to .00040 D.

STEP 5. Set VideoBridge frequency to: 1000Hz.

STEP 6. Repeat Steps 2, and 3.

STEP 7. The display should read: .000%Cs ±0.05% and .00000 to .00025 D.

STEP 8. Set VideoBridge frequency to: 10000Hz.

STEP 9. Repeat steps 2 and 3.

STEP 10. The display should read: .000%Cs ±0.25% and .0000 to .0010D.

STEP 11. VideoBridge setup:

Function	(Cs) %DEViation, D
Range	AUTO
Frequency	100Hz
Test level	1000mV
Measurement speed	MEDium
Measurement mode	CONTinuous
Nominal value	100

NOTE: If the calibrated value of the standard is different, set the VideoBridge to that nominal value.

STEP 12. Connect the test leads to the 100nF capacitance standard. Connect the guard lead to the capacitor case (shield).

STEP 13. The display should read: .000%Cs ±0.05% and .00000 to .00040 D.

STEP 14. Set VideoBridge frequency to: 1000Hz.

STEP 15. The display should read: .000% Cs ±0.05% and .00000 to .00025 D.

STEP 16. Set VideoBridge frequency to: 10000Hz.

STEP 17. The display should read: .000%Cs ±0.25% and .0000 to .0010D.

4.1.4 Test Level Accuracy Test

STEP 1. VideoBridge setup:

Function	Cs, D
Range	AUTO
Frequency	1000Hz
Test level	1500mV
Measurement speed	MEDium
Measurement mode	Single
Nominal value	0

STEP 2. Connect the test leads to an AC voltmeter input. Set the voltmeter to the 2V full scale range.

STEP 3. Push VideoBridge SINGLE key.

STEP 4. The AC voltmeter should read: 1500mV ±70mV.

STEP 5. Set VideoBridge test level to: 1000mV.

STEP 6. Push VideoBridge SINGLE key.

STEP 7. The AC voltmeter should read: 1000mV ±50mV.

STEP 8. Set VideoBridge test level to: 500mV.

STEP 9. Push VideoBridge SINGLE key.

STEP 10. The AC voltmeter should read: 500mV ±30mV.

STEP 11. Set VideoBridge test level to: 200mV.

STEP 12. Push VideoBridge SINGLE key.

STEP 13. The AC voltmeter should read: 200mV ±18mV.

STEP 14. Set the AC voltmeter to the 200mV full scale range.

STEP 15. Set VideoBridge test level to: 100mV.

STEP 16. Push VideoBridge SINGLE key.

STEP 17. The AC voltmeter should read: 100mV ±14mV.

STEP 18. Set VideoBridge test level to: 50mV.

STEP 19. Push VideoBridge SINGLE key.

STEP 20. The AC voltmeter should read: 50mV ±12mV.

STEP 21. Set VideoBridge test level to: 20mV.

STEP 22. Push VideoBridge SINGLE key.

STEP 23. The AC voltmeter should read: 20mV ±10.8mV.

STEP 24. Connect the test leads to the AC voltmeter current input. Set the voltmeter to the 200mA full scale range.

STEP 25. Set VideoBridge test level to: 100mA.

STEP 26. Push VideoBridge SINGLE key.

STEP 27. The AC voltmeter should read: 100mA ±5mA.

STEP 28. Set VideoBridge test level to: 50mA.

STEP 29. Push VideoBridge SINGLE key.

STEP 30. The AC voltmeter should read: 50mA ±3mA.

STEP 31. Set VideoBridge test level to: 20mA.

STEP 32. Push VideoBridge SINGLE key.

STEP 33. The AC voltmeter should read: 20mA ±1.8mA.

STEP 34. Set the AC voltmeter to the 20mA full scale range.

STEP 35. Set VideoBridge test level to: 10mA.

STEP 36. Push VideoBridge SINGLE key.

STEP 37. The AC voltmeter should read: 10mA ±1.4mA.

STEP 38. Set VideoBridge test level to: 5mA.

STEP 39. Push VideoBridge SINGLE key.

STEP 40. The AC voltmeter should read: 5mA ±1.2mA.

STEP 41. Set VideoBridge test level to: 2mA.

STEP 42. Push VideoBridge SINGLE key.

STEP 43. The AC voltmeter should read: 2mA ±1.08mA.

STEP 44. Set the AC voltmeter to the 2mA full scale range.

STEP 45. Set VideoBridge test level to: 1mA.

STEP 46. Push VideoBridge SINGLE key.

STEP 47. The AC voltmeter should read: 1mA ±0.24mA.

4.2 CALIBRATION

CAUTION

WHEN PERFORMING ANY CALIBRATION OR MAINTENANCE OPERATION, DO NOT REMOVE OR REPLACE CIRCUIT CARDS WHILE THE POWER IS TURNED ON. FAILURE TO TURN POWER OFF MAY RESULT IN ELECTRIC SHOCK OR DAMAGE TO THE INSTRUMENT.

The inherent accuracy of the Model 2100/2110 VideoBridge is based on the high stability of wire-wound, range resistors, and the frequency stability of the crystal-controlled oscillator. There are no full scale adjustments required.

Basic LRC accuracy should remain within specifications for a number of years without maintenance other than occasional (6 month) performance testing.

The only calibration trimmers used in the Model 2100/2110 are on the Analog circuit assembly (P/N 45239). They involve two DC offset trims, two AC zero trims, six high frequency zero-phase trims, and one low frequency zero-phase trim.

The DC offset trims (Section 4.2.2) are a factory adjustment and need be repeated only if one or more operational amplifiers have been replaced on the assembly.

The AC zero trims (Section 4.2.3) are shorted test-lead adjustments. They reduce the amount of digital correction made by the instrument's auto-zero calibration. They need be retrimmed for only different length test-leads. If the short circuit auto-zero calibration feature is used during measurements, these trim adjustments are not required.

The zero dissipation (D) trims (Section 4.2.4) are used to set the low D accuracy for each of the range resistors. They are more critical at the higher test frequencies (> 2000Hz) and need be retrimmed only if performance testing shows the D accuracy is out of specification.

Refer to Figure 4-1 for test point and trimmer locations.

4.2.1 Equipment Required

Oscilloscope	1MHz bandwidth, 50mV/cm vertical sensitivity
Dissipation Factor Standard Capacitors	Polystyrene Capacitors ±20%, Cs = 1µF, 0.25µF, 30nF, 4nF D ≤ 0.0001 (10000Hz)
	Polystrene (or air) Capacitors ±20%, Cs = 1nF, 100pF D ≤ 0.0001 (5000Hz)
Extender Card	S-100 Type

4.2.2 DC Offset Adjustments

STEP 1. Turn instrument power ON. Allow ten minutes warm up time.

STEP 2. Instrument setup:

Function	Cs, D
Range	Auto
Frequency	1000Hz
Test level	5mA
Measurement speed	MEDium
Measurement mode	CONTinuous

STEP 3. Connect oscilloscope probe to test point (TP5) on the Analog circuit card (P/N 45239). See Figure 4-1.

STEP 4. Connect the test leads to create a short circuit.

STEP 5. Adjust trimmer R54 (see Figure 4-1) for Vunk = ØV ±Ø.75V (noisy straight line scope trace).

STEP 6. Separate the unknown test leads to create an open circuit.

STEP 7. Set VideoBridge test level to 5ØmV.

STEP 8. Adjust trimmer R55 (see Figure 4-1) for Vstd = ØV ±Ø.75V (noisy straight line scope trace).

4.2.3 Short Circuit Zero Adjustments

STEP 9. Instrument setup:

Function	Ls, Rs
Range	Auto
Frequency	1ØØØHz
Test level	1ØØmA
Measurement speed	MEDium
Measurement mode	CONTinuous

STEP 1Ø. Connect the unknown test leads to create a short circuit. Keep the moveable jaws and the fixed jaws of the KELVIN KLIPS® adjacent.

STEP 11. Adjust trimmer R46 (see Figure 4-1) until the CRT display reads Rs = Ø ±1ØØμΩ.

STEP 12. Change the test frequency to 15ØØØHz.

STEP 13. Adjust trimmer R45 (see Figure 4-1) until the CRT display reads Rs = Ø ±2ØØμΩ.

4.2.4 High and Low Frequency Phase (D) Adjustments

STEP 14. Connect the test leads to a 1μF dissipation (D) standard.

STEP 15. Instrument setup:

Function	Cs, D
Range	Auto
Frequency	10000Hz
Test level	1000mV
Measurement speed	MEDium
Measurement mode	CONTinuous

STEP 16. Adjust trimmer R19 (see Figure 4-1) for a D reading of 0 ±0.0001.

STEP 17. Connect the test leads to a 0.25μF dissipation (D) standard. Adjust trimmer R20 (see Figure 4-1) for a D reading of 0 ±0.0001.

STEP 18. Connect the test leads to a 30μF dissipation (D) standard. Adjust trimmer R21 (see Figure 4-1) for a D reading of 0 ±0.0001.

STEP 19. Connect the test leads to a 4μF dissipation (D) standard. Adjust trimmer R22 (see Figure 4-1) for a D reading of 0 ±0.0001.

STEP 20. Change the test frequency to 5000Hz.

STEP 21. Separate the unknown test leads to create an open circuit. Perform a zero calibration.

STEP 22. Connect the test leads to a 1nF dissipation (D) standard. Adjust trimmer R23 (see Figure 4-1) for a D reading of 0 ±0.00010.

STEP 23. Separate the unknown test leads to create an open circuit. Perform a zero calibration.

STEP 24. Connect the test leads to a 100pF dissipation (D) standard. Adjust trimmer R40 (see Figure 4-1) for a D reading of 0 ±0.00010.

STEP 25. Repeat steps 20, 21, and 22.

STEP 26. Change the test frequency to 40Hz.

STEP 27. Connect the test leads to a 1μF dissipation (D) standard. Adjust trimmer R15 (see Figure 4-1) for a D reading of 0 ±0.00010.

4.2.5 Calibration Summary

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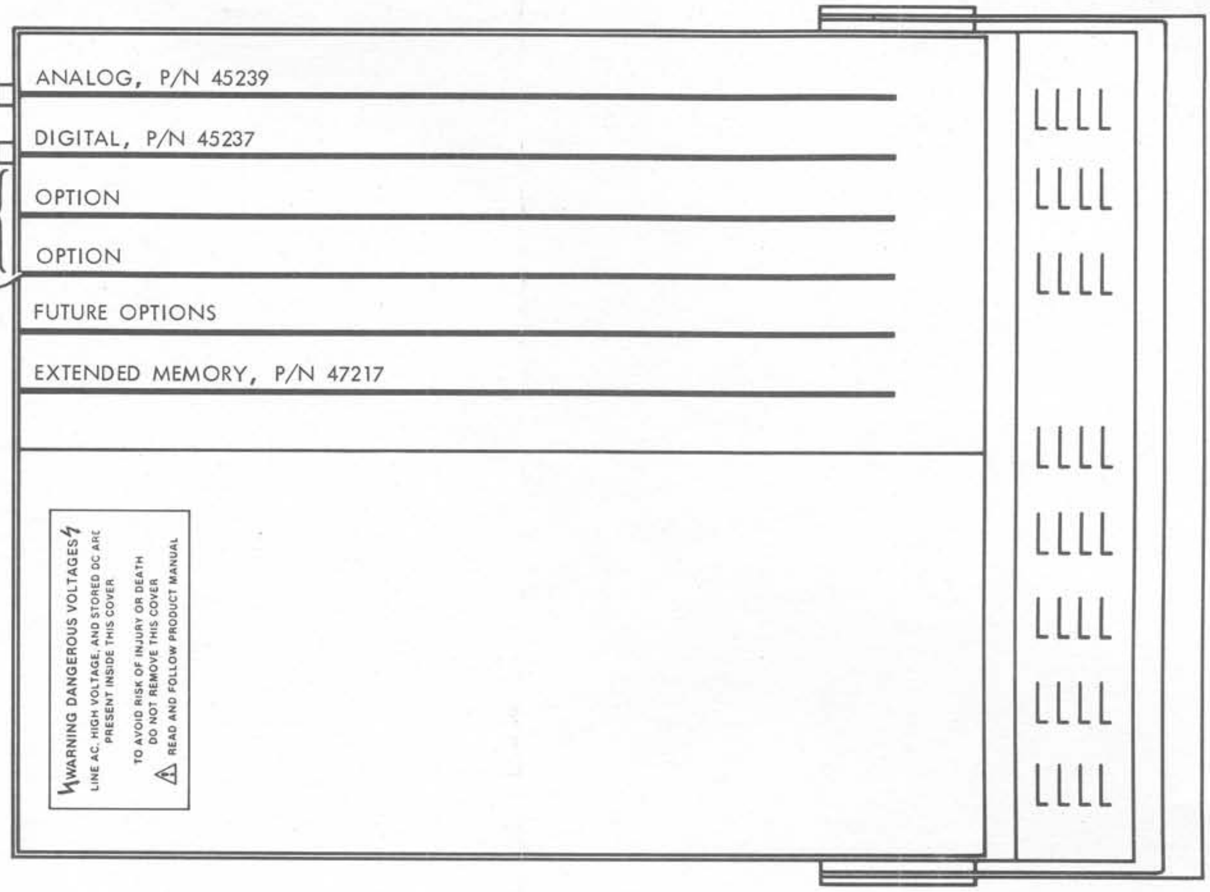
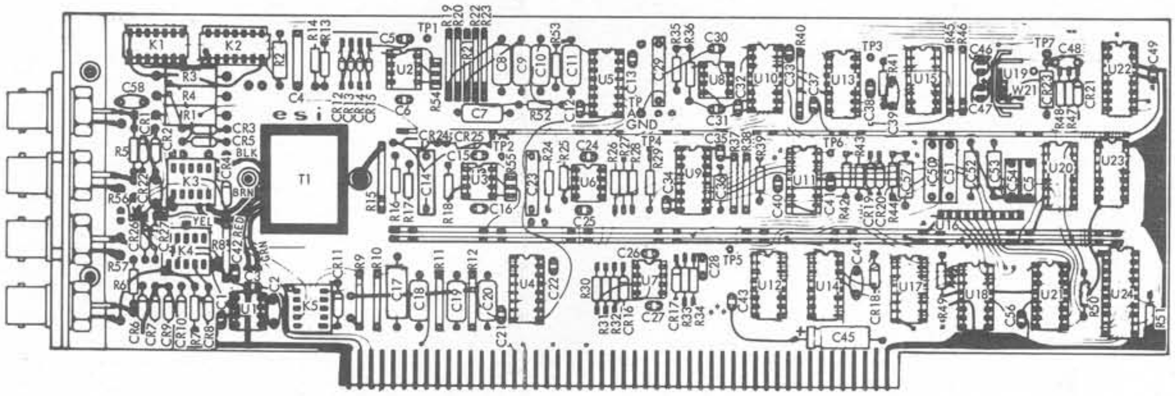
SECTION 4.1.1 STEP NO.	MODEL 2100/2110 SETUP					ADJUSTMENT			
	FUNCTION	MEAS SPEED	FREQ	TEST LEVEL	UNKNOWN VALUE	TRIMMER NO.	CARD P/N	TEST POINT	RESULT
5	C_s,D	MED	1 kHz	5 mA	SHORT	R54	45239	TP5	0V ± 0.75V
8	C_s,D	MED	1 kHz	50 mV	OPEN	R55	45239	TP5	0V ± 0.75V
11	L_s,R_s	MED	1 kHz	100 mA	SHORT	R46	45239	CRT	R_s = 0Ω ± 1
13	L_s,R_s	MED	15 kHz	100 mA	SHORT	R45	45239	CRT	R_s = 0Ω ± 2
16	C_s,D	MED	10 kHz	1000 mV	1 μF	R19	45239	CRT	D = 0 ± 0.00
17	C_s,D	MED	10 kHz	1000 mV	0.25 μF	R20	45239	CRT	D = 0 ± 0.00
18	C_s,D	MED	10 kHz	1000 mV	30 nF	R21	45239	CRT	D = 0 ± 0.00
19	C_s,D	MED	10 kHz	1000 mV	4 nF	R22	45239	CRT	D = 0 ± 0.00
21	C_s,D	MED	5 kHz	1000 mV	OPEN	—	45239	—	Zero Calibra
22	C_s,D	MED	5 kHz	1000 mV	1 nF	R23	45239	CRT	D = 0 ± 0.00
23	C_s,D	MED	5 kHz	1000 mV	OPEN	—	45239	—	Zero Calibra
24	C_s,D	MED	5 kHz	1000 mV	100 pF	R40	45239	CRT	D = 0 ± 0.00
25	Repeat Steps 20, 21, and 22								
27	C_s,D	MED	40 Hz	1000 mV	1 μF	R15	45239	CRT	D = 0 ± 0.00

ULT
75 V
75 V
± 100 μΩ
± 200 μΩ
0.0001
0.0001
0.0001
0.0001
libration
0.00010
libration
0.00010
0.00010





ANALOG CIRCUIT ASSEMBLY P/N 45239

Figure 4-1. Circuit Assembly and Trimmer Locations

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4.3 MAINTENANCE

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance, and troubleshooting of the Model 2100/2110.

4.3.1 Preventive Maintenance

WARNING

REMOVAL OF INSTRUMENT COVERS MAY CONSTITUTE AN ELECTRICAL HAZARD AND SHOULD BE ACCOMPLISHED BY QUALIFIED SERVICE PERSONNEL ONLY.

Preventive maintenance performed on a regular basis will improve the reliability of this instrument. It may include cleaning, visual inspection, or even monitoring the operating environment.

4.3.1.1 Cleaning

CAUTION

AVOID THE USE OF CHEMICAL CLEANING AGENTS WHICH MIGHT DAMAGE THE PLASTICS USED IN THIS UNIT. DO NOT APPLY ANY SOLVENT CONTAINING KETONES, ESTERS, OR HALOGENATED HYDROCARBONS. TO CLEAN, USE ONLY WATER SOLUBLE DETERGENTS, ETHYL, METHYL, OR ISOPROPYL ALCOHOL.

Exterior. Loose dust may be removed with a soft cloth or a dry brush. Water and mild detergent may be used; however, abrasive cleaners should not be used.

Interior. Use low-velocity compressed air to blow off the accumulated dust. Hardened dirt can be removed with a cotton-tipped swab, soft, dry cloth, or a cloth dampened with a mild detergent and water.

4.3.1.2 Visual Inspection

This instrument should be inspected occasionally for such defects as broken connections, improperly seated semiconductors, damaged circuit cards, and heat-damaged parts.

The corrective procedure for most visible defects is obvious. If heat damaged components are found, particular care must be taken. Overheating usually indicates other trouble may be present in the instrument. It is important that the cause of overheating be corrected to prevent recurrence of the damage.

4.3.2 Troubleshooting

The following troubleshooting information is provided to augment other sections of this manual. The Circuit Description and Part Lists and Schematic Diagrams sections should be used to full advantage. Section 3 in this manual gives circuit description information while, Section 5 contains the part lists and schematic diagrams.

4.3.2.1 Troubleshooting Aids

Schematic Diagrams. Schematic diagrams are provided on foldout pages in Section 5. The electrical value and circuit numbers of each component are shown on the diagrams. Power supply voltages are also shown.

Circuit-Card Illustrations. Illustrations of circuit cards are shown along with the schematic diagrams. Each card-mounted electrical component is identified by its circuit number.

Test Point Locations. Test point locations have been indicated on both the schematic diagrams and the circuit-card illustrations.

Component Color Code. Colored stripes or dots on resistors and capacitors signify electrical values, tolerances, etc., according to the EIA standard color code. Components not color-coded usually have the value printed on the body.

Multi-pin Connector Identification. Multi-pin connectors are soldered to the circuit cards. They mate with ribbon type cable assemblies to carry signals between cards. Connector pin 1 is indexed with a number 1 etched on the circuit card. Each connector is identified by a P number and can be located by using the circuit card illustration in Section 5 of this manual. P numbers shown on the illustration correspond to the P numbers on the schematic diagrams.

4.3.2.2 Troubleshooting Procedure

WARNING

TO AVOID ELECTRIC SHOCK FROM DANGEROUSLY HIGH VOLTAGES. USE THE FOLLOWING PROCEDURES ONLY WHEN TROUBLESHOOTING THE ANALOG AND DIGITAL MEASUREMENT PORTIONS OF THIS INSTRUMENT. DO NOT USE THIS PROCEDURE TO TROUBLESHOOT THE POWER SUPPLY OR CRT CIRCUITRY.

This troubleshooting procedure checks the simple trouble sources before proceeding with more extensive troubleshooting. The first few checks ensure proper connection and operation. If the trouble is not located by these checks, the remaining steps aid in locating the component. When the defective component is located, it should be replaced using the information given under Corrective Maintenance.

1. **Check Instrument Setup.** Make sure the instrument is properly plugged into a wall socket. Also, check the rear panel line voltage switch and the line fuse to see that they match the line voltage being used.

2. **Visual Check.** Visually check the portion of the instrument in which the trouble is suspected. Many problems can be located by visual indications such as unsoldered connections, broken wires, damaged circuit cards, damaged components, or components bent over and touching.

3. **Check Voltages.** A circuit stage may not be operating due to incorrect supply voltages. Typical supply voltages are given on the diagrams; however, these are not absolute and may vary slightly between instruments.

4. **Trace the Signal.** The analog portion of the circuitry can be checked by tracing the signal with an oscilloscope. By noting where the signal disappears or distorts, the source of trouble can be located.

5. **Check Individual Components.** The following methods are provided for checking the individual components. Components which are soldered in place can sometimes be checked by disconnecting one end to isolate the measurement from the effects of surrounding circuitry.

   a. **TRANSISTORS.** It is always best to check transistor operation under operating conditions. Transistors that are soldered to the circuit card should first be checked in-circuit using a dynamic transistor testor; then a replacement can be substituted to verify that the old transistor is bad. Socketed transistors can be checked by substituting a component known to be good; however, be sure that circuit conditions are not such that a replacement might also be damaged. If substitute transistors are not available, check the old transistor out-of-circuit using a dynamic tester. Be sure the power is off before attempting to remove or replace any transistor.

b. **INTEGRATED CIRCUITS.** Analog IC's such as comparators and operational amplifiers can usually be checked in-circuit with a voltmeter or test oscilloscope. An understanding of the device and circuit operation is essential for this type of troubleshooting. (For example, an op amp can be tested by measuring the input and output circuit voltages and comparing this ratio to the ratio of input and feedback resistors.)

Analog IC's that are socketed can also be checked out-of-circuit using a dynamic tester. Digital IC's are best checked in-circuit using a logic probe or voltmeter. Use care when checking voltages and waveforms around DIP (Dual-Inline-Package) IC's so that adjacent leads are not shorted together. A convenient means of connecting a test probe to 14 and 16 pin IC's is with an IC test clip. This device also serves as an extraction tool.

c. **DIODES.** A diode can be checked for an open or shorted condition by measuring the resistance between terminals with an ohmmeter set to the R x lk scale. The diode resistance should be very high in one direction and very low when the meter leads are reversed.

CAUTION

DO NOT USE AN OHMMETER SCALE THAT HAS A HIGH INTERNAL CURRENT. HIGH CURRENTS MAY DAMAGE THE DIODES UNDER TEST.

d. **RESISTORS.** Check resistors with an ohmmeter. Resistor tolerance is given in the Parts List. Resistors normally do not need to be replaced unless the measured value varies widely from the specified value.

e. **CAPACITORS.** A leaky or shorted capacitor can be detected by checking resistance with an ohmmeter on the highest scale. Use an ohmmeter that will not exceed the voltage rating of the capacitor. (Be careful to observe correct polarity when checking electrolytic capacitors.) The resistance reading should be high after initial charge of the capacitor. An open capacitor can best be detected with a capacitance meter, or by checking whether the capacitance passes AC signals.

4.4 CORRECTIVE MAINTENANCE

Corrective maintenance consists of component replacement and instrument repair.

4.4.1 Obtaining Replacement Parts

Standard Parts. All electrical and mechanical replacement parts for the Model 2100/2110 can be obtained from Electro Scientific Industries, Inc. However, many of the electronic components can be obtained locally in less time than is required to order them from ESI. Before purchasing or ordering replacement parts, check the parts list in Section 5 for value, tolerance, rating, and description.

> **NOTE:** When selecting replacement parts, it is important to remember that the physical size and shape of a component may affect the performance of the instrument. All replacement parts should be direct replacements unless it is known that a different component will not adversely affect instrument performance.

Order all special parts directly from Electro Scientific Industries.

4.4.2 VideoBridge - CRT Removal/Replacement

4.4.2.1 CRT Handling, Storage, and Disposal Precautions

Handling

The cathode-ray tube is very delicate and requires special care when handling. Wear protective safety goggles and clothing when handling the CRT. Avoid striking the CRT against anything that might crack the glass or otherwise cause it to implode.

Storing

Store the CRT in a protective carton whenever possible. If that is not possible, store in a protected location. The storage location should include a soft, smooth surface to protect it against damage or scratching the faceplate.

WARNING

HANDLE THE CRT WITH CARE. ROUGH HANDLING OR SCRATCHING CAN CAUSE THE CRT TO IMPLODE. TO AVOID PERSONAL INJURY FROM IMPLOSION WEAR PROTECTIVE GOGGLES AND CLOTHING WHEN WORKING WITH THE CRT. ONLY WORK WITH THE CRT IF YOU ARE QUALIFIED TO DO SO.

Disposing

Cathode-ray tube disposal requires special precautions be taken. A CRT can be extremely dangerous. Do not dispose of the CRT by putting it in the garbage; it could cause physical injury. To properly dispose of the CRT, save and re-use the package in which the replacement CRT was shipped. If the original packaging is unfit for use or not available, repackage the CRT as follows:

STEP 1. Obtain a carton of corrugated cardboard having inside dimensions of not less than six inches more than the CRT dimensions; this will allow for cushioning.

STEP 2. Surround the unit with polyethylene sheeting to protect the CRT.

STEP 3. Cushion the CRT on all sides by tightly packing dunnage of urethane foam between the carton and the CRT allowing three inches on all sides.

STEP 4. Seal the carton with shipping tape or an industrial stapler.

STEP 5. Send the CRT to the location from which the new CRT was obtained.

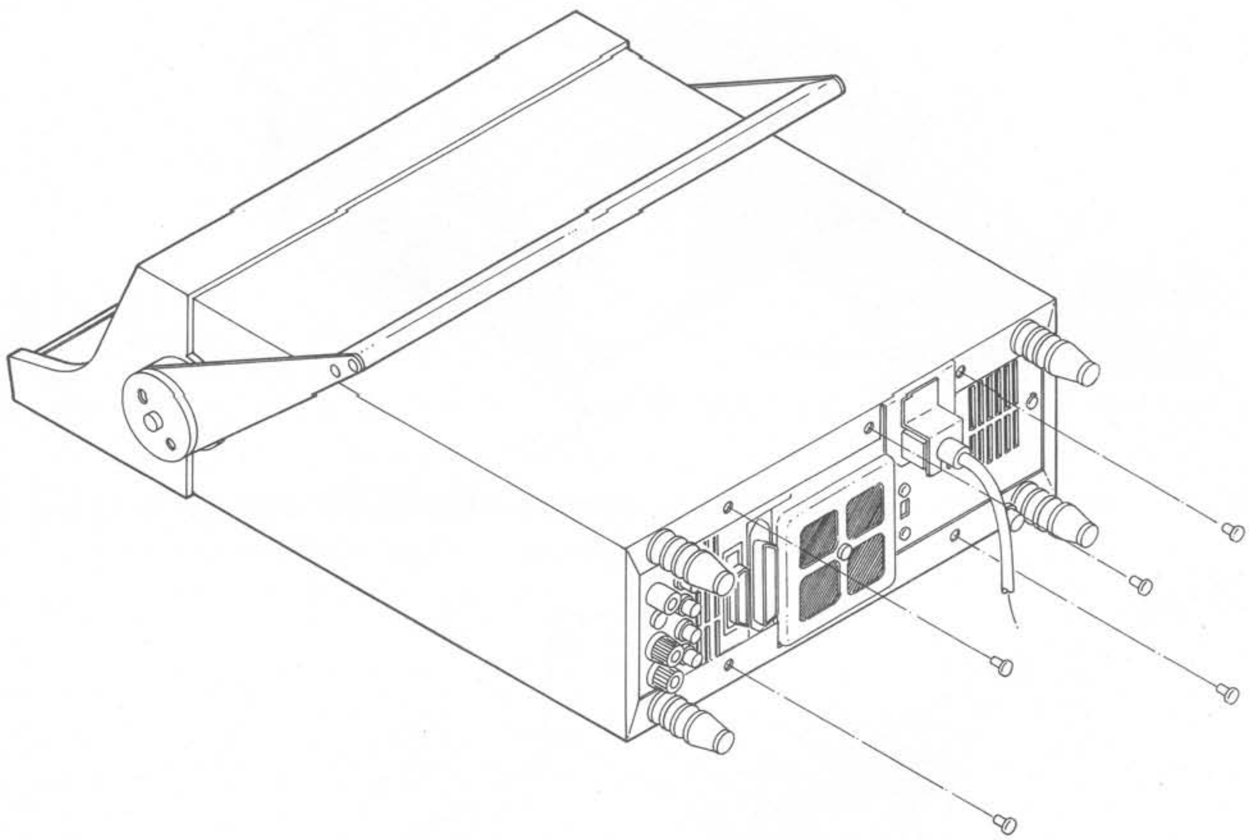
WARNING

THE CRT IS CAPABLE OF STORING A HIGH VOLTAGE CHARGE AFTER POWER HAS BEEN REMOVED. TO PREVENT PERSONAL INJURY FROM ELECTRIC SHOCK, USE AN OSHA OR UL APPROVED SHORTING STRAP TO DISCHARGE ALL HIGH VOLTAGE POINTS TO CHASSIS GROUND. THIS PROCEDURE MUST BE PERFORMED BY QUALIFIED PERSONNEL ONLY.

4.4.2.2 Removal/Replacement Procedure

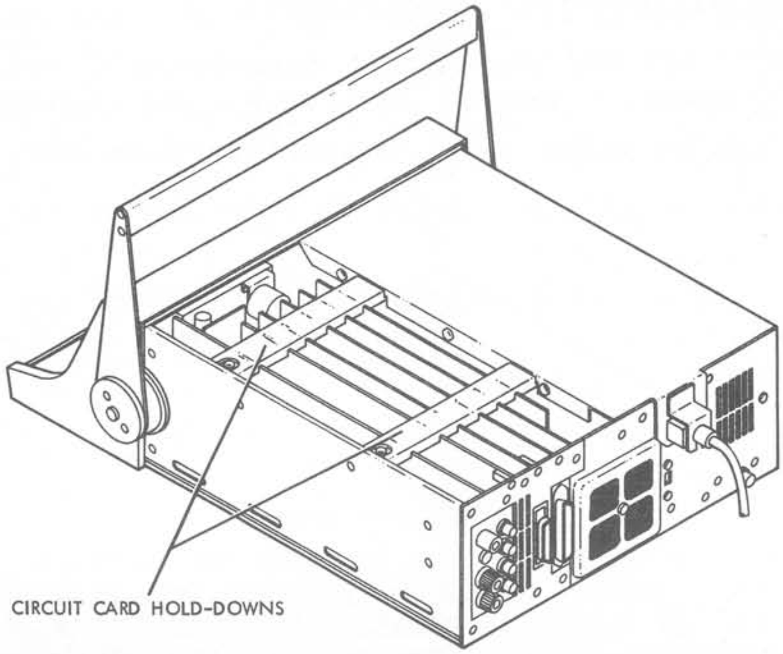
STEP 1. Instrument Preparation. Turn instrument power OFF and remove all external connections.

STEP 2. Outer Cover. Remove the five rear panel 8 x 32 screws holding the outer cover and slide cover off.

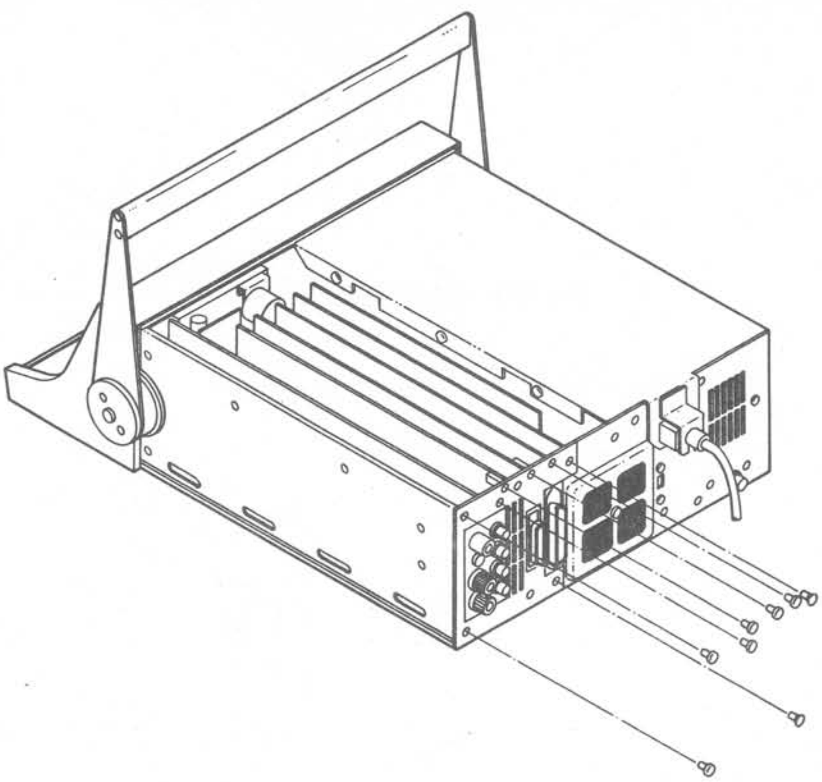


Model 211Ø Rear View

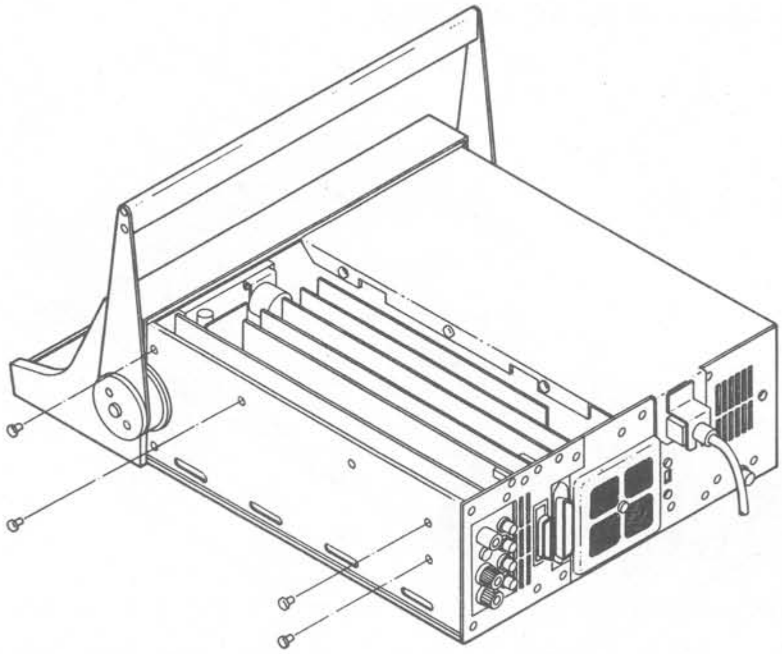
STEP 3. Circuit Card Hold-Downs. Remove the screws securing the two plastic circuit card hold-downs and remove.



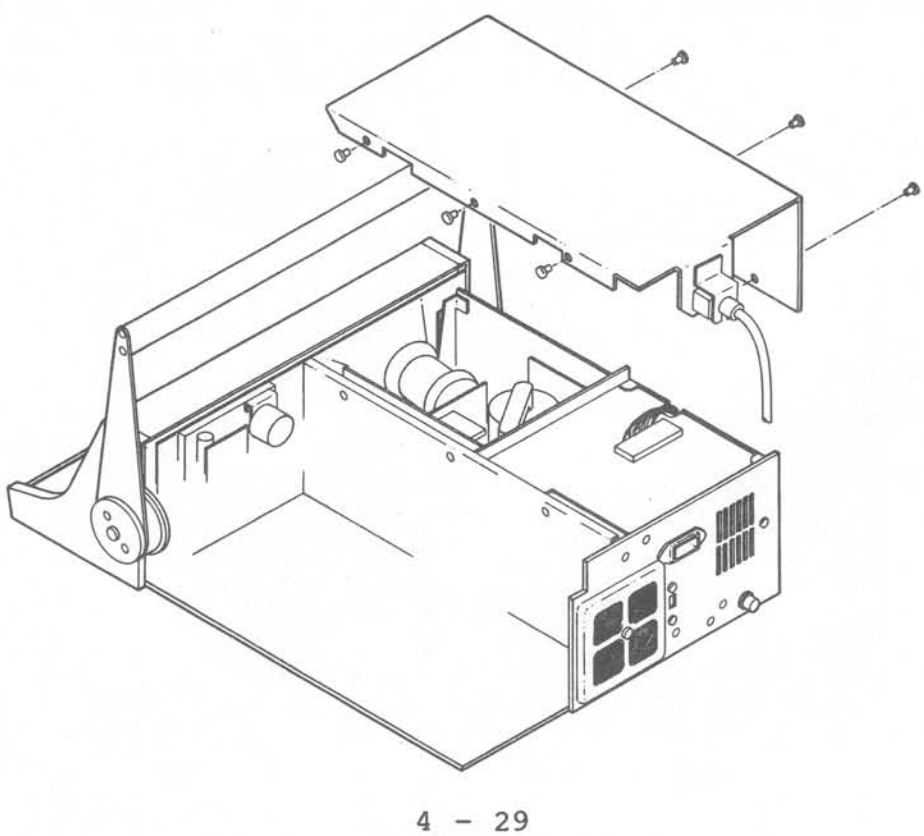
STEP 4. Rear Panel (left side). Remove the eight screws holding the rear panel (left side).



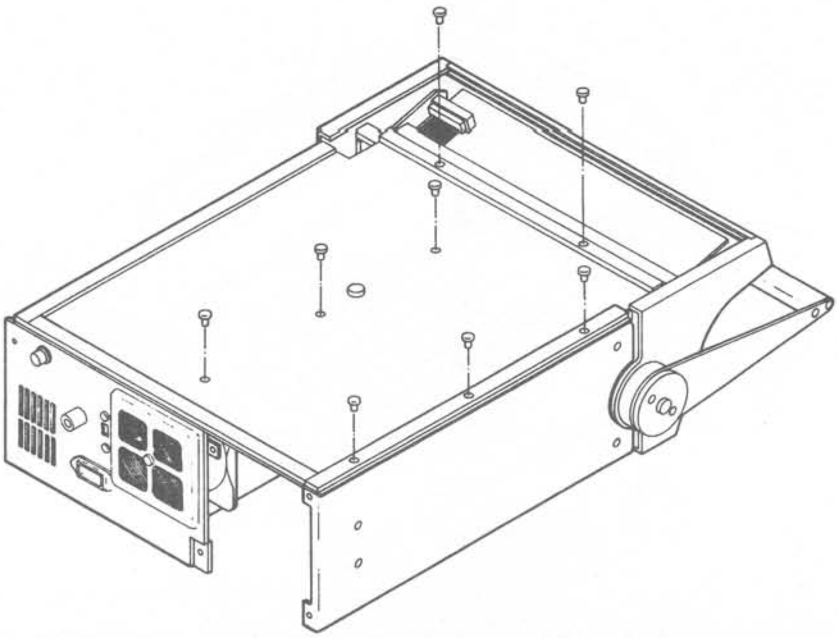
STEP 5. Circuit Assemblies. Remove four screws located on instruments left side. Remove all circuit assemblies.



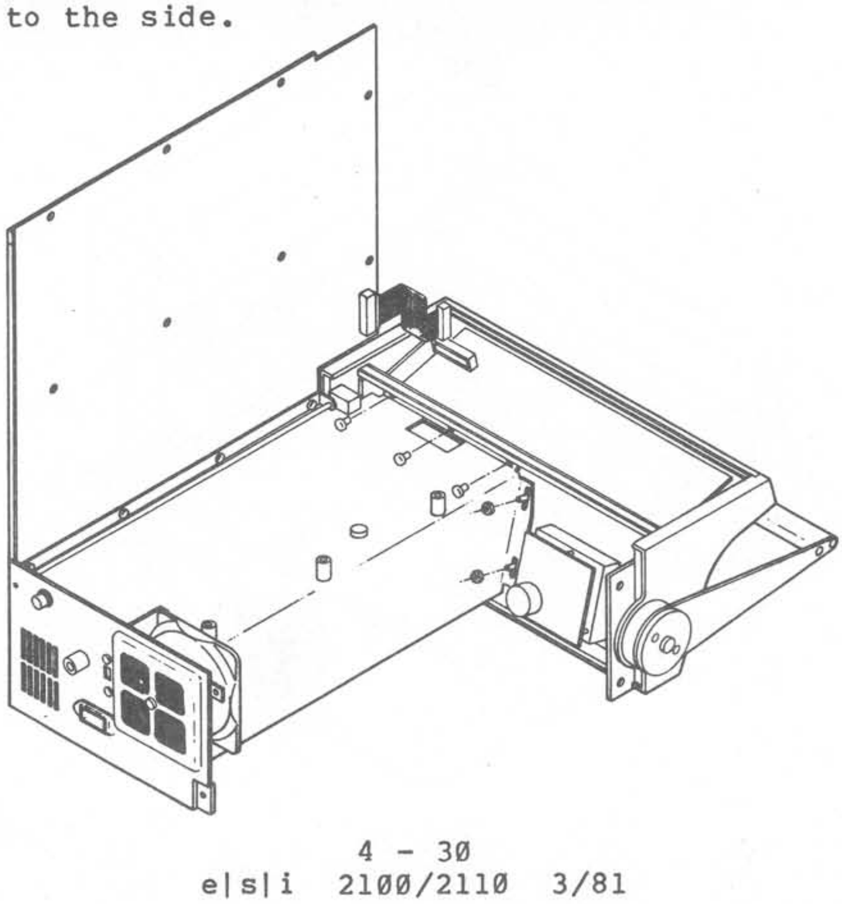
STEP 6. CRT Enclosure Cover. Remove the six screws securing the CRT enclosure cover. Remove this cover by sliding toward the back of the instrument until the power cord plug clears the instrument's power receptacle.



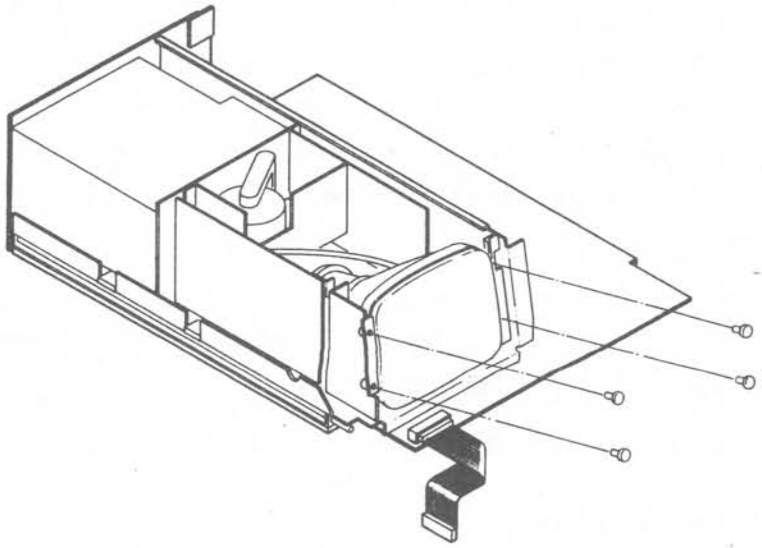
STEP 7. Motherboard. Turn instrument over to rest top-side down. Remove the eight screws, unplug the keyboard, and hinge the motherboard out of the way.



STEP 8. Front Panel. Remove the three screws and two nuts holding the front panel to the CRT enclosure. Set the front panel off to the side.



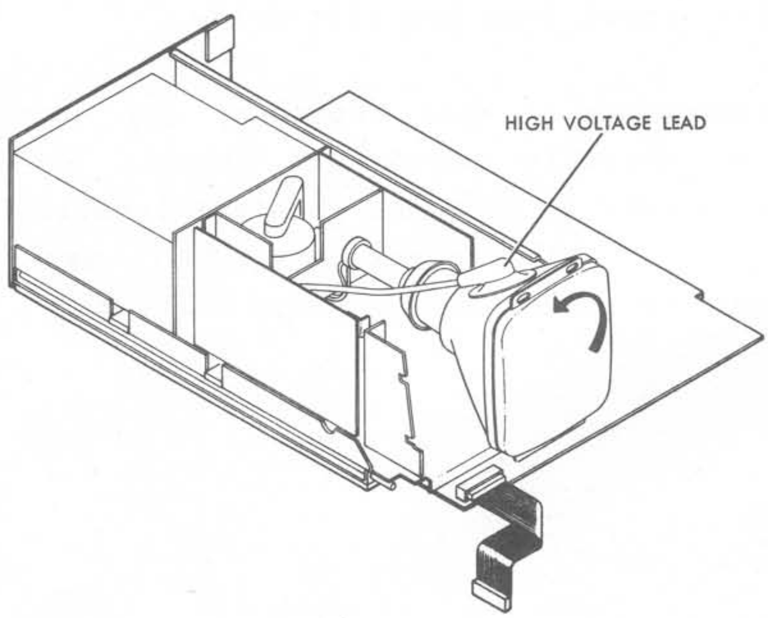
STEP 9. Cathode-Ray Tube. Turn instrument right-side up. Remove the four screws holding the CRT (2 on each side).



STEP 10. High Voltage Plug. Rotate the CRT counter-clockwise until the High Voltage anode lead is facing up. Remove the High voltage lead.

WARNING

HANDLE THE CRT WITH CARE. ROUGH HANDLING OR SCRATCHING CAN CAUSE THE CRT TO IMPLODE. TO AVOID PERSONAL INJURY FROM IMPLOSION WEAR PROTECTIVE GOGGLES AND CLOTHING WHEN WORKING WITH THE CRT. ONLY WORK WITH THE CRT IF YOU ARE QUALIFIED TO DO SO.



STEP 11a. Cathode-Ray Tube Rear Connector. Carefully pull the CRT out approximately 2 inches or until the rear plug can be removed.

OR

STEP 11b. Cathode-Ray Tube Rear Connector. Unplug the CRT connector from the Deflection circuit card.

STEP 12. To install a new CRT reverse the above procedure, carefully observing all caution notices.

4.4.3 Component Replacement

WARNING

DISCONNECT ALL POWER TO THE INSTRUMENT BEFORE REPLACING COMPONENTS. FAILURE TO DO SO MAY RESULT IN ELECTRICAL SHOCK.

Semiconductor Replacement. Replacement semiconductors should be of the original type or a direct replacement. If the replacement semiconductor is not of the original type, check the manufacturer's basing diagram for proper lead identification.

Free Standing Components. When replacing any components that are free-standing (not directly mounted to circuit cards), be sure to place the new components in the same physical location and position as the old components. If this is not done, there may be a possibility of components touching and causing a short circuit.

4.5 REPACKAGING FOR SHIPMENT

If the Model 2100/2110 is to be shipped back to ESI for service or repair, attach a tag showing: owner (with address) and the name of an individual at your firm that can be contacted, complete instrument serial number, and a description of the service required.

Save and re-use the package in which your instrument was shipped. This package was especially designed for the 2100/2110 to withstand 30 - 40 times the force of gravity (maximum) should the package fall or be dropped. If the original package is unfit for use or is not available, the package used should be able to withstand the same 30 - 40 g's as the original package.

SECTION 5

PARTS LISTS AND DIAGRAMS

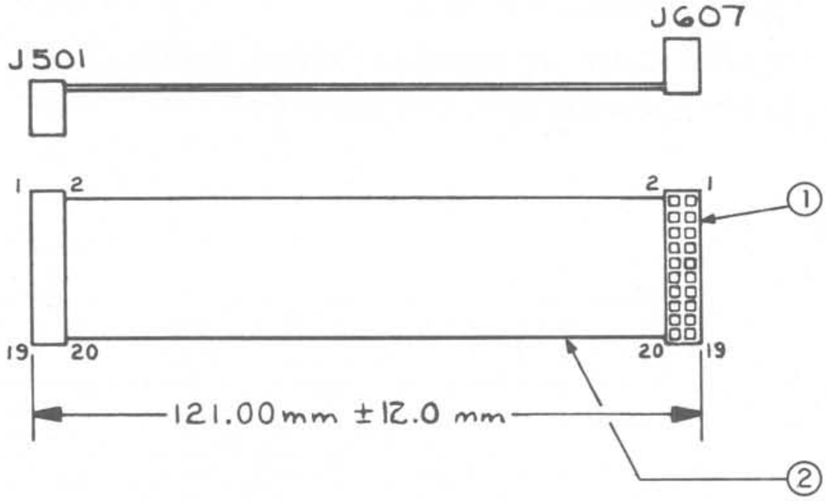
5.1 MAINFRAME PARTS (PART NO. 32110)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	SUBASSEMBLY, FRONT END	46096
	SUBASSEMBLY, CRT CASE	46095
	CIRCUIT ASSEMBLY, MOTHERBOARD	45577
	CIRCUIT ASSEMBLY, DIGITAL CARD	45237
	CIRCUIT ASSEMBLY, ANALOG CARD	45239
	IC MK4816 RAM (2110 ONLY)	45263
	CIRCUIT ASSEMBLY, CASSETTE/RS232 (2110 ONLY)	45905
	CIRCUIT ASSEMBLY, MEMORY EXPANSION	47217
	ASSEMBLY, POWER SUPPLY MODULE	45845
	PIVOT ROD	45367
	BACK PANEL, R.H.	44964
	SIDE PANEL, R.H.	44931
	CABLE MOTHERBOARD-TO-KEYBOARD	47112
	COVER, CRT CASE	45078
	STRAIN RELIEF BRACKET	45081
	BRACKET ANGLE, SIDE PANEL	46288
	POWER CORD	24077
	LABEL (WARNING DANGEROUS VOLTAGE)	46047
	MANUAL, OPERATORS 2100/2110	46508
	MANUAL, SERVICE 2100/2110	46507
	WELDMENT, CASE	45157
	CORD WRAP	45782
	FEET, 0.75SQ X 0.5 HIGH	46446
	FEET, ROUND 0.5 DIA	4276
	ASSEMBLY, CONN. COVER, HANDLER	46947
	CABLE ASSEMBLY, TAPEDECK TO RS232 (2110 ONLY)	47254
	HOLDER, PCB	46287
	SHIELD, SIDE, POWER SUPPLY	45957
	CASSETTE, TAPE	47509

5.2 FRONT END SUB ASSEMBLY (PART NO. 46Ø96)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	END CAP L.H., PAINTED	47271
	EXT, UPPER CUT	44818
	EXT, LOWER CUT	44958
	BRACKET UPPER L.H.	44828
	BRACKET UPPER R.H.	44827
	BRACKET LOWER	44826
	BRACKET SIDE PANEL	45213
	SUB PANEL, WINDOW	4535Ø
	SUB PANEL, UPPER R.H.	45337
	FRONT PANEL, UPPER L.H.	45338
	WINDOW, CRT	45349
	FRONT PANEL, UPPER R.H.	45336
	FRONT PANEL, LOWER	4534Ø
	BUTTON, KEYBOARD (GRA)	456Ø8
	END CAP R.H., PAINTED	47272
	HANDLE, PAINTED	47166
	PIVOT, PLASTIC HANDLE	44892
	PIN, HANDLE	44894
	COVER, HANDLE	44895
	BUTTON, HANDLE	44896
	SPRING, HANDLE	44897
	PLATE, HANDLE SIDE	44891
	SPACING STRIP MB	45351
	SPRING, TAPEDECK BUTTON (211Ø ONLY)	46331
	SPACER, TAPEDECK BUTTON (211Ø ONLY)	46332
	TAPEDECK (211Ø ONLY)	46447
	CIRCUIT ASSEMBLY, KEYBOARD	45573
	BUTTON, KEYBOARD (BLU)	4651Ø
	BUTTON, KEYBOARD (GOLD)	45348
	FOOT, ROUND STICKY	22343

5.2.1 Keyboard-to-Motherboard Connector Cable Assembly (Part No. 47112)

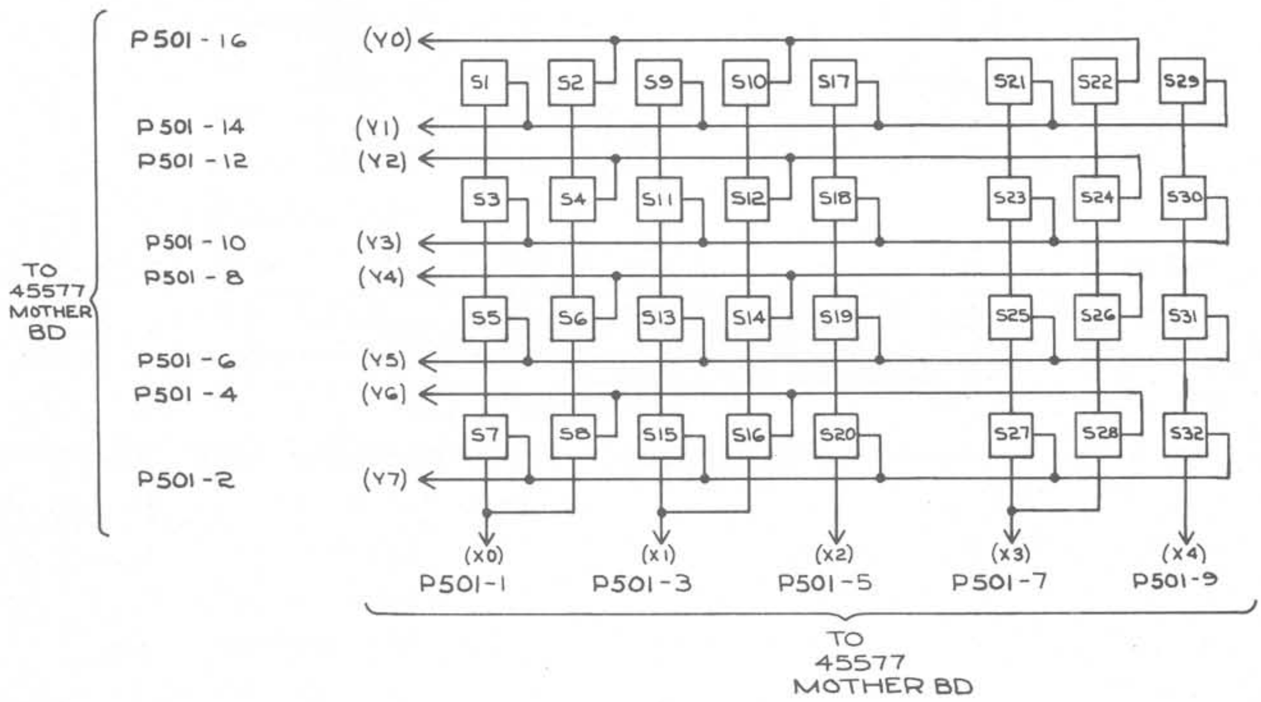


ITEM	QTY REQD	DWG SIZE	CLASS CODE	PART NO	MATERIAL OR DESCRIPTION
2	.4'	YC	—	44734	CABLE, RIBBON
1	2	YC	—	43865	CONNECTOR, 20 PIN, ANSLEY

Figure 5-1. Keyboard-to-Motherboard Cable Assembly (Part No. 47112)

5.2.2 Keyboard Circuit Assembly (Part No. 45573)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	CIRCUIT CARD, KEYBOARD	45572
P5Ø1	HEADER, I/O, 2Ø CONTACT RIGHT ANGLE	465Ø1
S1-S32	SWITCH, MOMENTARY, PUSHBUTTON	465ØØ



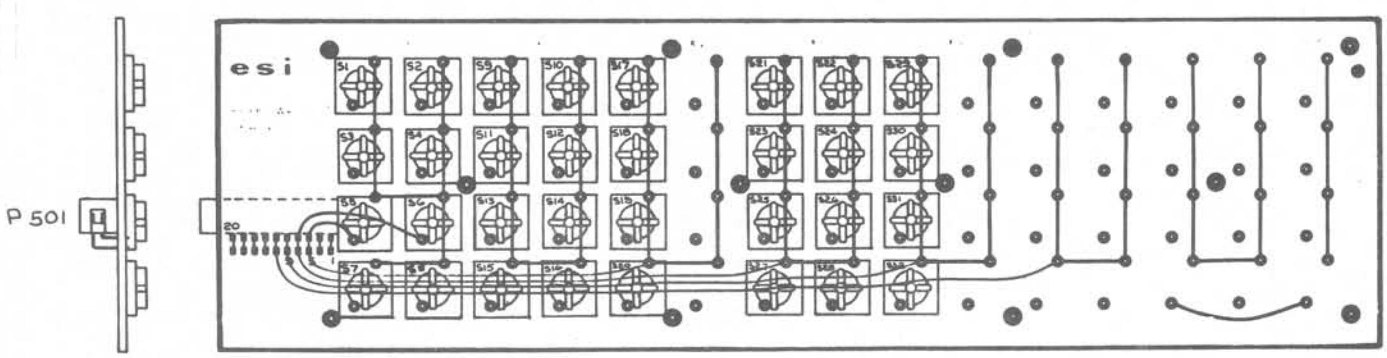


Figure 5-2. Keyboard Circuit Assembly (Part No. 45573)

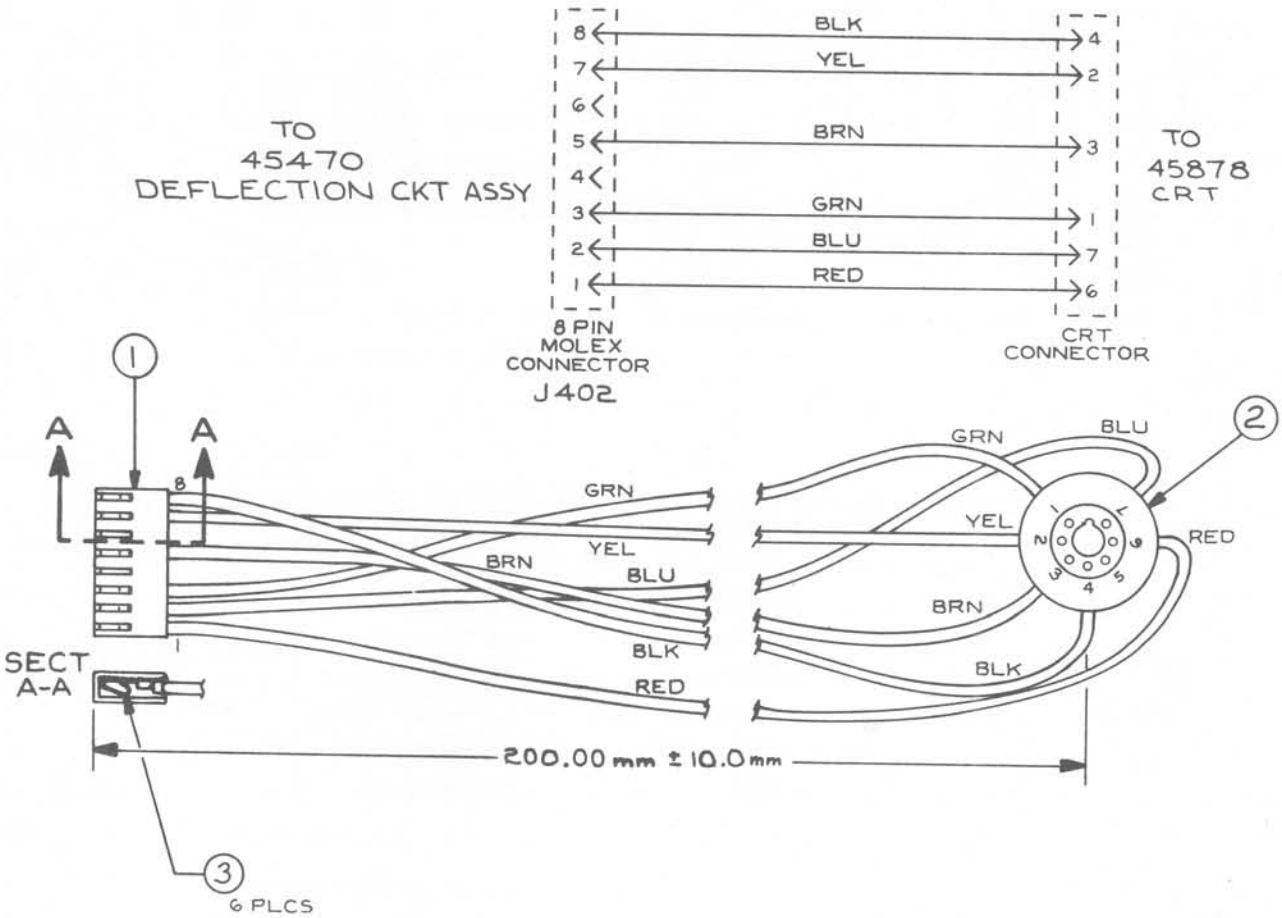
5.3 CRT SUB ASSEMBLY (PART NO. 46095)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	CASE, LOWER CRT	45075
	PANEL, REAR L.H.	45070
	PANEL, SEPARATOR, CRT	45291
	BRACKET, PCB MT.	45204
	BRACKET, CRT L.H.	45783
	BRACKET, CRT	44825
	GUIDE, PCB	45741
	BRACKET, UPPER BACK PANEL	45241
	BRACKET, LOWER BACK PANEL	45242
	INSULATOR, POWER SWITCH	45277
	ACTUATOR, POWER SWITCH	45279
	ANGLE BRACKET, POWER SWITCH	45280
	SPACER, POWER SWITCH	45281
	BRACKET, PIVOT ROD	45366
	FAN	45704
	RECEPTACLE, AC	24078
	SWITCH, 120-220	29233
	SCREEN, FAN	46289
	FILTER, FAN	46932
	CRT 5 INCH	45878
	ASSEMBLY, DEFLECTION YOKE	46490
	CABLE, CRT - VIDEO CARD	46504
	SWITCH, POWER, PUSHBUTTON	23164
	SPRING, RETURN	46505
	REWORK, COVER	46290
	CABLE, BACK PANEL - POWER SUPPLY	47115
	MOUNT, FAN GUARD	46038
	CIRCUIT ASSEMBLY, DEFLECTION CARD	45470
	CIRCUIT ASSEMBLY, SIGNAL CONDITIONER	45468
	CABLE ASSEMBLY, SIGNAL-TO-DEFLECTION	47116
	INSERT, SHEET EDGE	50749
	STANDOFF, COVER	46292

5.3 CRT SUB ASSEMBLY (PART NO. 46095) (cont)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	SPACER, FAN MOUNT 0.450D x 0.15T	46291
	BAR, MTG FAN FILTER	46264
	SPACER 3/8 x 0.6L x 6-32	29165
	FUSE HOLDER HIGH PROFILE	45968
	3AG FUSE CARRIER, GRAY	45966
	3AG FUSE 2A SLOW-BLOW	13700
	5 x 20 METRIC FUSE CARRIER, BLK	45965
	FUSE 1A SLOW-BLOW (EUROPE)	

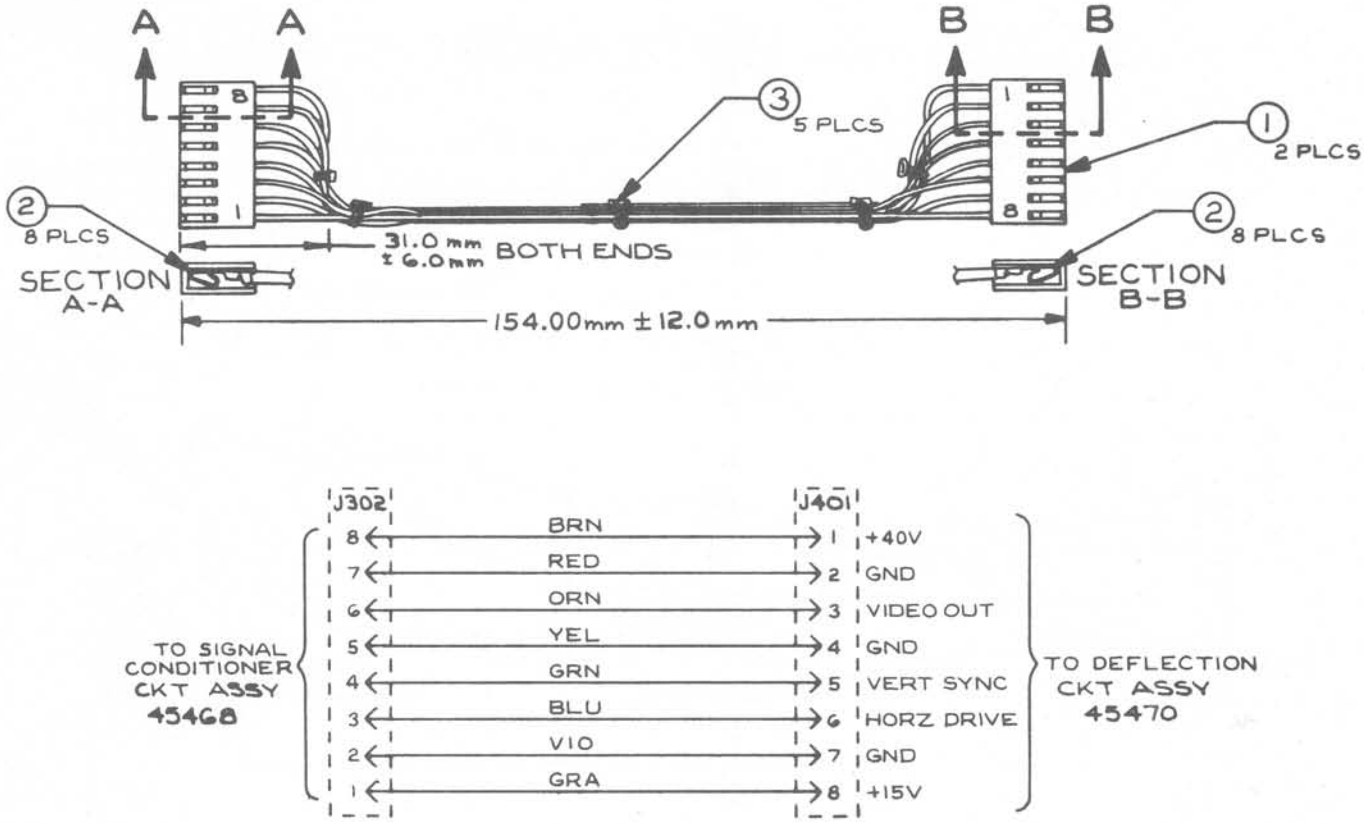
5.3.1 CRT Connector Cable Assembly (Part No. 46504)



ITEM	QTY REQD	DWG SIZE	CLASS CODE	PART NO	MATERIAL OR DESCRIPTION
3	6	YC	—	45887	CRIMP TERMINAL
2	1	YC	—	47123	CONNECTOR, 7 PIN MINI TUBE, FEM
1	1	YC	—	46633	CONNECTOR, MOLEX, 8 PIN

Figure 5-3. CRT Connector Cable Assembly (Part No. 46504)

5.3.2 Deflection-to-Signal Conditioner Cable Assembly (Part No. 47116)



ITEM	QTY REQ'D	DWG SIZE	CLASS CODE	PART NO	MATERIAL OR DESCRIPTION
3	5	YC	—	6147	CABLE TIE
2	16	YC	—	45887	CRIMP TERMINAL
1	2	YC	—	46633	CONNECTOR, MOLEX, 8 PIN

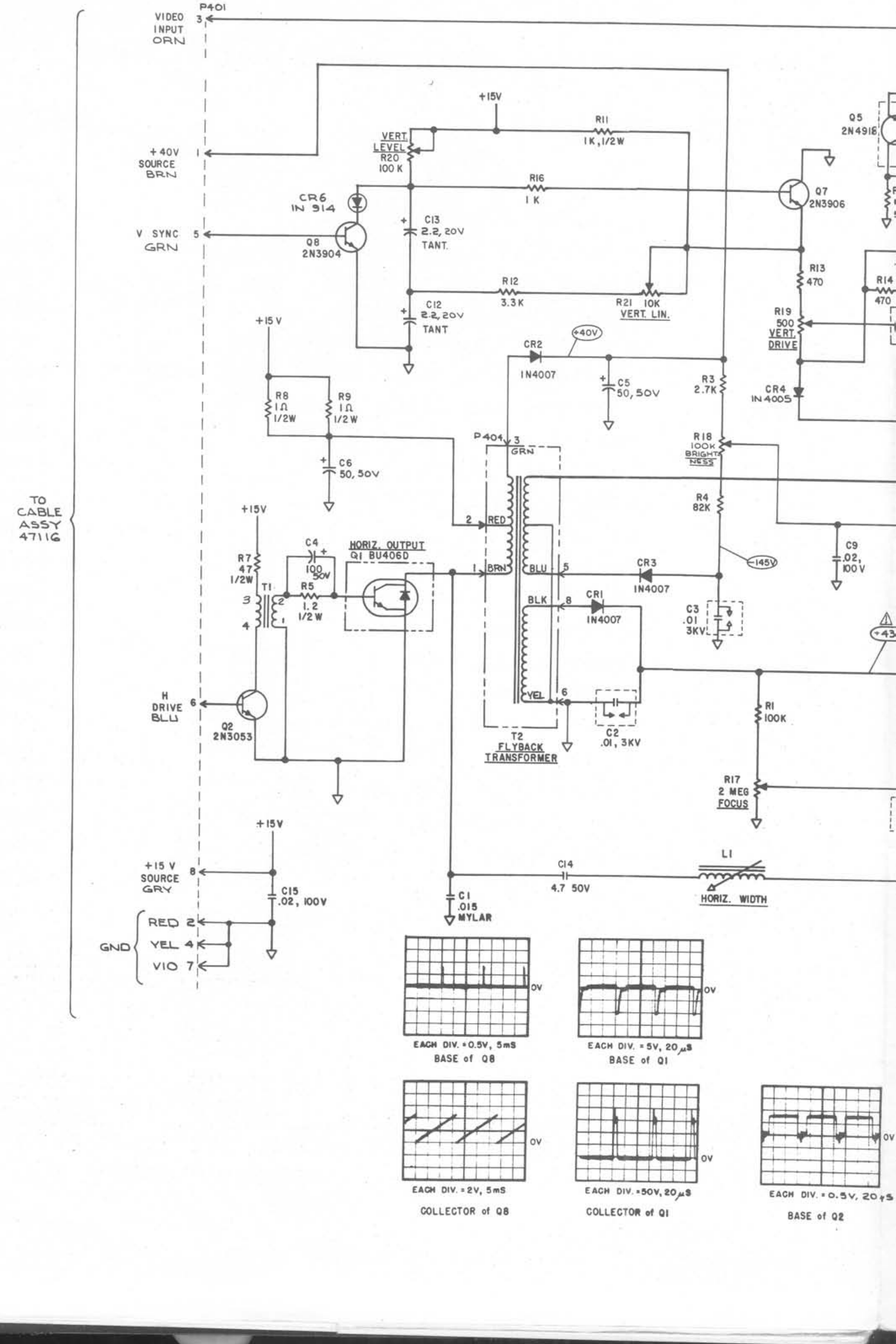
Figure 5-4. Deflection-to-Signal Conditioner Cable Assembly (Part No. 47116)

5.3.3 Deflection Circuit Assembly (Part No. 45470)

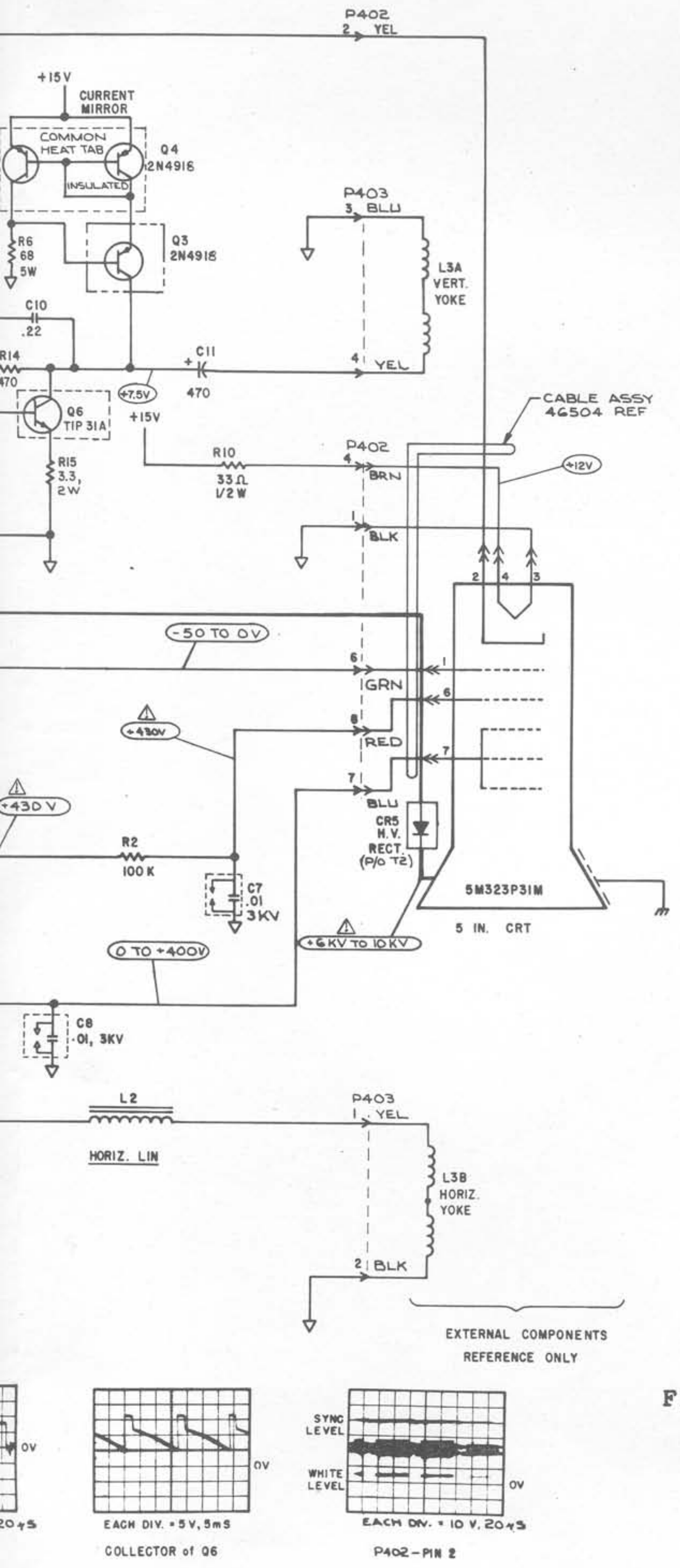
CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	CIRCUIT CARD, VIDEO DEFLECTION	45469
C1	CAPACITOR, 0.015μF MYLAR	20900
C2,3,7,8	CAPACITOR, 0.01μF "GAP CAP"	46484
C4	CAPACITOR, 100μF, 50V RADIAL	46483
C6,5	CAPACITOR, 50μF, 50V RADIAL	46482
C9,15	CAPACITOR, 0.02μF 100V CERAMIC	12115
C10	CAPACITOR, 0.22μF CERAMIC	13680
C11	CAPACITOR, 470μF, 50V ELECT. AXIAL	1942
C12,13	CAPACITOR, 2.2μF, 20V TANT	13283
C14	CAPACITOR, 4.7μF MONOLITHIC CERAMIC	47536
CR1-3	DIODE, 1N4007	12161
CR4	DIODE, 1N4005	1779
CR6	DIODE, 1N914	12356
L1	COIL, WIDTH EW4472	46487
L2	HORIZONTAL LINEARITY COIL	46486
P401,402,404	CONNECTOR, 8-PIN MOLEX, P.C. MT.	46631
P403	CONNECTOR, 4-PIN MOLEX, P.C. MT.	46629
Q1	TRANSISTOR, BU406D	46491
Q2	TRANSISTOR, 2N3053	12232
Q3,4,5	TRANSISTOR, 2N4918	18753
Q6	TRANSISTOR, TIP31A	47294
Q7	TRANSISTOR, 2N3906	18754
Q8	TRANSISTOR, 2N3904	18751
R1,2	RESISTOR, 100kΩ, 1/4W	13945
R3	RESISTOR, 2.7kΩ, 1/4W	13925
R4	RESISTOR, 82kΩ, 1/4W	24812
R5	RESISTOR, 1.2Ω, 1/2W	20828
R6	RESISTOR, 68Ω, 5W	47292
R7	RESISTOR, 47Ω, 1/2W	2024
R8,9	RESISTOR, 1Ω, 1/2W	12448
R10	RESISTOR, 33Ω, 1/2W	46485
R11	RESISTOR, 1kΩ, 1/2W	1969

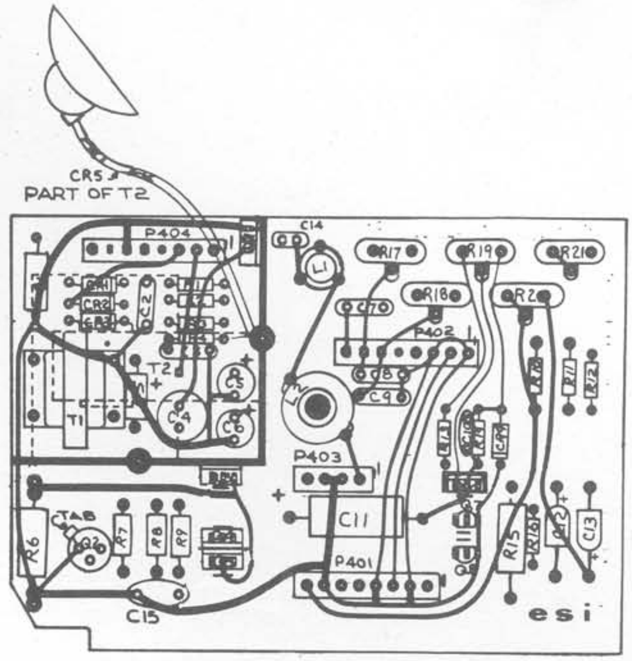
5.3.3 Deflection Circuit Assembly (cont)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
R12	RESISTOR, 3.3kΩ, 1/4W	13926
R13,14	RESISTOR, 47ØΩ, 1/4W	13915
R15	RESISTOR, 3.3Ω, 2W	47293
R16	RESISTOR, 1kΩ, 1/4W	1392Ø
R17	TRIMMER, 2.ØMΩ UPRIGHT P.C. MT.	4646Ø
R18,2Ø	TRIMMER, 1ØØkΩ UPRIGHT P.C. MT.	46459
R19	TRIMMER, 5ØØΩ UPRIGHT P.C. MT.	46457
R21	TRIMMER, 1ØkΩ UPRIGHT P.C. MT.	46458
T1	BUFFER X-FMR	46488
T2	FLYBACK X-FMR ASSEMBLY	47Ø64
	HEATSINK, TO-22Ø CLIP ON	47651
	INSULATOR, RECTANGULAR, SILICON	46256
	SHOULDER WASHER, #4 INSULATING	41937
	BOX, FLYBACK X-FMR	45445
	SCREW 6-32 x Ø.25 PHP	364Ø
	INSERT, SHEET EDGE, 6-32 (SOUTHCO)	5Ø749



P401
VIDEO INPUT ORN
+40V SOURCE BRN
V SYNC GRN
H DRIVE BLU
+15 V SOURCE GRY
GND
RED 2
YEL 4
VIO 7
TO CABLE ASSY 47116
+15V
VERT. LEVEL R20 100 K
R11 1K, 1/2W
R16 1 K
CR6 IN 914
Q8 2N3904
C13 2.2, 20V TANT.
C12 2.2, 20V TANT
R12 3.3K
R21 10K VERT. LIN.
Q5 2N4918
Q7 2N3906
R13 470
R14 470
R19 500 VERT. DRIVE
CR4 IN 4005
R8 1Ω 1/2W
R9 1Ω 1/2W
C6 50, 50V
CR2 IN4007
+40V
C5 50, 50V
R3 2.7K
R18 100K BRIGHTNESS
R4 82K
P404
T2 FLYBACK TRANSFORMER
GRN
RED
BRN
BLU
BLK
YEL
-145V
CR3 IN4007
CR1 IN4007
C3 .01 3KV
C9 .02, 100 V
C2 .01, 3KV
R1 100K
R17 2 MEG FOCUS
C4 100 50V
HORIZ. OUTPUT Q1 BU406D
R7 47 1/2W
T1
R5 1.2 1/2 W
Q2 2N3053
C14 4.7 50V
L1 HORIZ. WIDTH
C1 .015 MYLAR
C15 .02, 100V
EACH DIV. = 0.5V, 5mS
BASE of Q8
EACH DIV. = 5V, 20 µS
BASE of Q1
EACH DIV. = 2V, 5mS
COLLECTOR of Q8
EACH DIV. = 50V, 20 µS
COLLECTOR of Q1
EACH DIV. = 0.5V, 20 µS
BASE of Q2





DANGER

HIGH VOLTAGES ARE PRESENT. USE EXTREME CAUTION TO PREVENT POSSIBLE PHYSICAL INJURY AND/OR ELECTRICAL SHOCK.

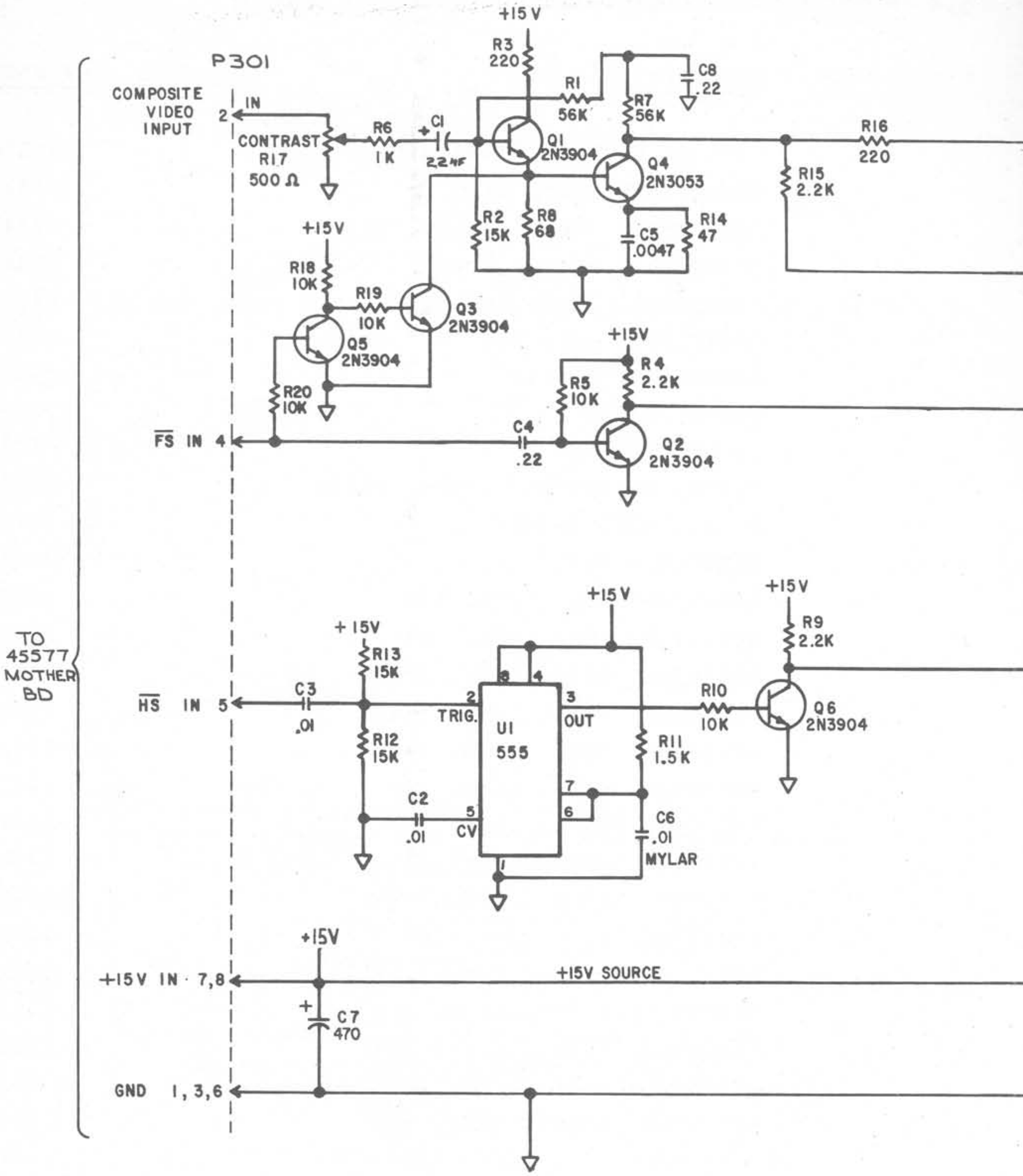
NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 10% UNLESS OTHERWISE STATED.
2. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE STATED.

Figure 5-5. Deflection Circuit Assembly (Part No. 45470)

5.3.4 Signal Conditioner Circuit Assembly (Part No. 45468)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1	CAPACITOR, 22µF, TANT 15V	18852
C2,3	CAPACITOR, Ø.Ø1µF, CERAMIC	12144
C4,8	CAPACITOR, Ø.22µF, CERAMIC	1368Ø
C5	CAPACITOR, Ø.ØØ47µF, MYLAR	13299
C6	CAPACITOR, Ø.Ø1µF, MYLAR	1226Ø
C7	CAPACITOR, 47ØµF, ELEC AXIAL	1942
P3Ø1	CONNECTOR, 8PIN MOLEX, MALE, RIGHT ANGLE PC MT	46632
P3Ø2	CONNECTOR, 8PIN MOLEX, MALE, PC MT	46631
Q1,2,3,5,6	TRANSISTOR, 2N39Ø4	18751
Q4	TRANSISTOR, 2N3Ø53	12232
R1,7	RESISTOR, 56kΩ, 1/4W	13943
R2,12,13	RESISTOR, 15kΩ, 1/4W	13935
R3,16	RESISTOR, 22ØΩ, 1/4W	13911
R4,9,15	RESISTOR, 2.2kΩ, 1/4W	13924
R5,1Ø,18-2Ø	RESISTOR, 1ØkΩ, 1/4W	13933
R6	RESISTOR, 1kΩ, 1/4W	1392Ø
R8	RESISTOR, 68kΩ, 1/4W	139Ø2
R11	RESISTOR, 1.5kΩ, 1/4W	13922
R14	RESISTOR, 47Ω, 1/4W	139Ø1
R17	TRIMMER, 5ØØΩ, UPRIGHT PC MT.	46457
	CIRCUIT CARD, SIGNAL CONDITIONER	45467
	SOCKET, 8 PIN, I.C. MINI DIP	2241Ø
U1	IC 555 TIMER	2Ø721



NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 10% UNLESS OTHERWISE STATED.

2. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE STATED.

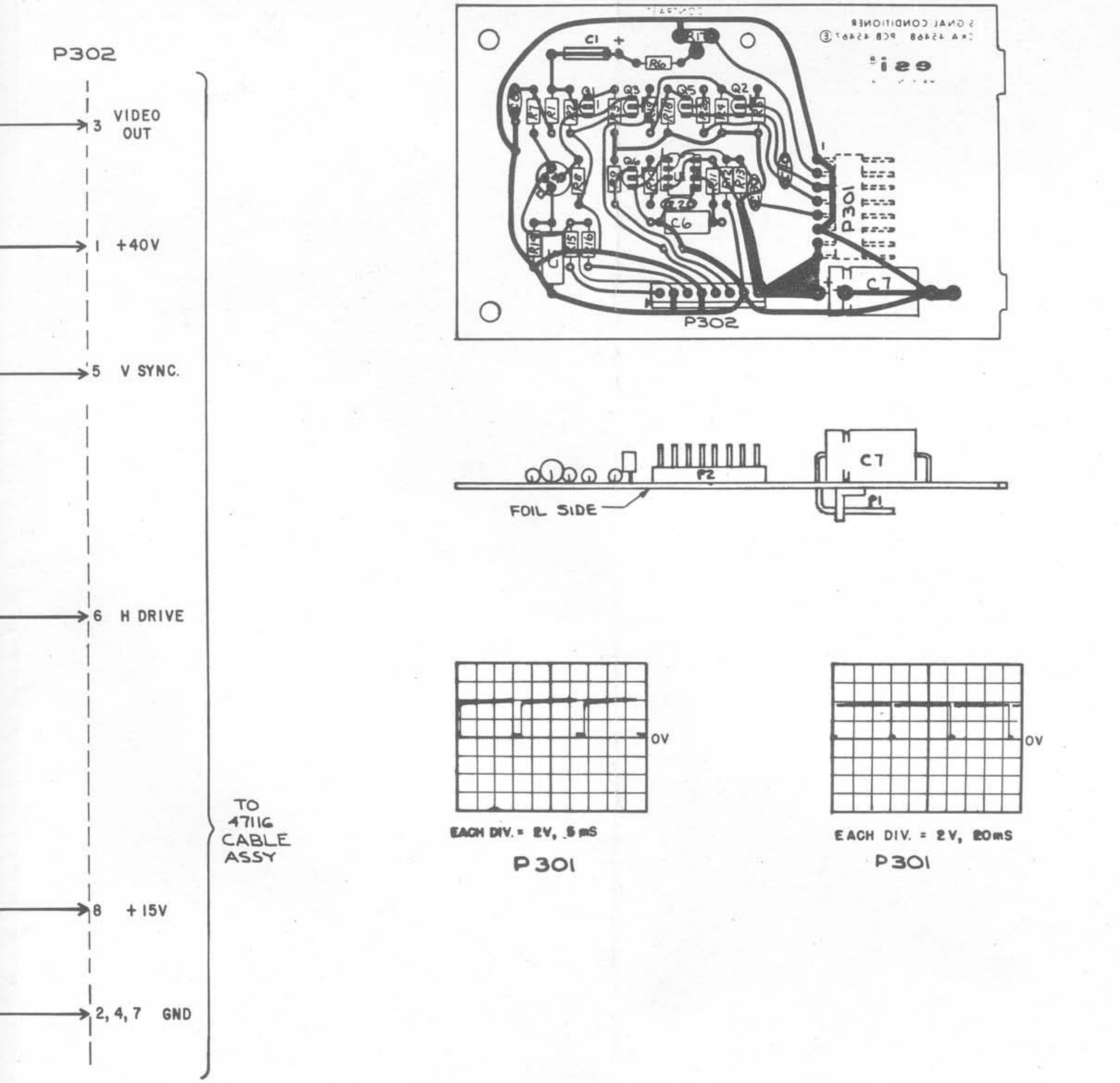


Figure 5-6. Signal Conditioner Circuit Assembly (Part No. 45468)

5.4 MOTHERBOARD CIRCUIT ASSEMBLY (PART NO. 45577)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	CIRCUIT CARD, MOTHERBOARD	45576
	CAPACITOR, 25pF, DISC	1924
	CAPACITOR, 100pF, 1000V, DISC	12241
	CAPACITOR, 560pF, POLY	25922
	CAPACITOR, 10pF, 5%, DISC	43130
	CAPACITOR, 1µF, 50V	43852
	CAPACITOR, 0.01µF	45658
	DIODE, 1N914	12356
	DIODE, 1N4005	1779
	DIODE, ADJUSTABLE ZENER, TL430	46620
	TRANSISTOR, 2N3904	18751
	TRIMMER, 10kΩ	78156
	RESISTOR, 47Ω, 1/4W, 10%	13901
	RESISTOR, 68Ω, 1/4W, 10%	13902
	RESISTOR, 120Ω, 1/4W, 10%	13908
	RESISTOR, 330Ω, 1/4W, 10%	13913
	RESISTOR, 390Ω, 1/4W, 10%	13914
	RESISTOR, 470Ω, 1/4W, 10%	13915
	RESISTOR, 560Ω, 1/4W, 10%	13916
	RESISTOR, 680Ω, 1/4W, 10%	13917
	RESISTOR, 820Ω, 1/4W, 10%	13919
	RESISTOR, 1kΩ, 1/4W, 10%	13920
	RESISTOR, 1.8kΩ, 1/4W, 10%	13923
	RESISTOR, 4.7kΩ, 1/4W, 10%	13927
	RESISTOR, 5.6kΩ, 1/4W, 10%	13928
	RESISTOR, 10kΩ, 1/4W, 10%	13933
	RESISTOR, 220kΩ, 1/4W, 10%	13949
	RESISTOR, 39Ω, 1/4W, 10%	21219
	RESISTOR, 100Ω, 1/4W, 1%	21720
	RESISTOR PAK, 330Ω, SIP	46072
	RESISTOR PAK, 10kΩ, SIP	46560
	IC, 7410	20603

5.4 MOTHERBOARD CIRCUIT ASSEMBLY (PART NO. 45577) (cont)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	IC, 7442	20608
	IC, 7404	20695
	IC, LM311	29544
	IC, DP8304B	45262
	IC, MK4816, RAM	45263
	IC, MC6847	45472
	IC, DM8131	45527
	IC, 4N28, OPTO ISOLATOR	46502
	IC, 74LS163A	45647
	IC, 8279	45651
	IC, Z80µP	45653
	IC, 74LS139	45656
	IC, 74S373, OCTAL D LATCH	46201
	IC, MK4118	46405
	IC, MK3882, PROGRAM COUNTER TIMER	46407
	IC, PAL14L4 (PRGM ARRAY LOGIC CHIP)	47321
	IC, 74LS288, PROGRAMMED	47323
	IC, 74LS288, PROGRAMMED	47324
	SOCKET, IC, 14 PIN	19189
	SOCKET, IC, 16 PIN	20360
	SOCKET, MINI DIP, 8 PIN	22410
	SOCKET, IC, 40 PIN	41342
	SOCKET, IC, 28 PIN	43844
	SOCKET, IC, 20 PIN	45660
	SOCKET, IC, 6 PIN	45831
	CRYSTAL, 7.68MHz	45662
	CRYSTAL, 3.58MHz	45663
	I/O HEADER, 20 PIN, RT ANGLE, 2 LEVEL	46501
	SWITCH, SPST MOMENTARY ON PUSH BUTTON	44520
	CONNECTOR, PCB, 100 PIN	45661
	BUSS STRIP	23997
	LED, RED, 1/8 DIA	24009

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	CABLE ASSEMBLY, MOTHERBOARD-TO-POWER SUPPLY	47111
	PIVOT, BRACKET	45163
	PIVOT, STIFFENER	46Ø31
	CABLE ASSEMBLY, MOTHERBOARD-TO-CRT	4711Ø
	BRACE, RH SIDE	46227
	BRACE, FRONT	46228
	BRACE, BACK	46229
	CABLE CLAMP	17Ø3
	CABLE CLAMP	5269

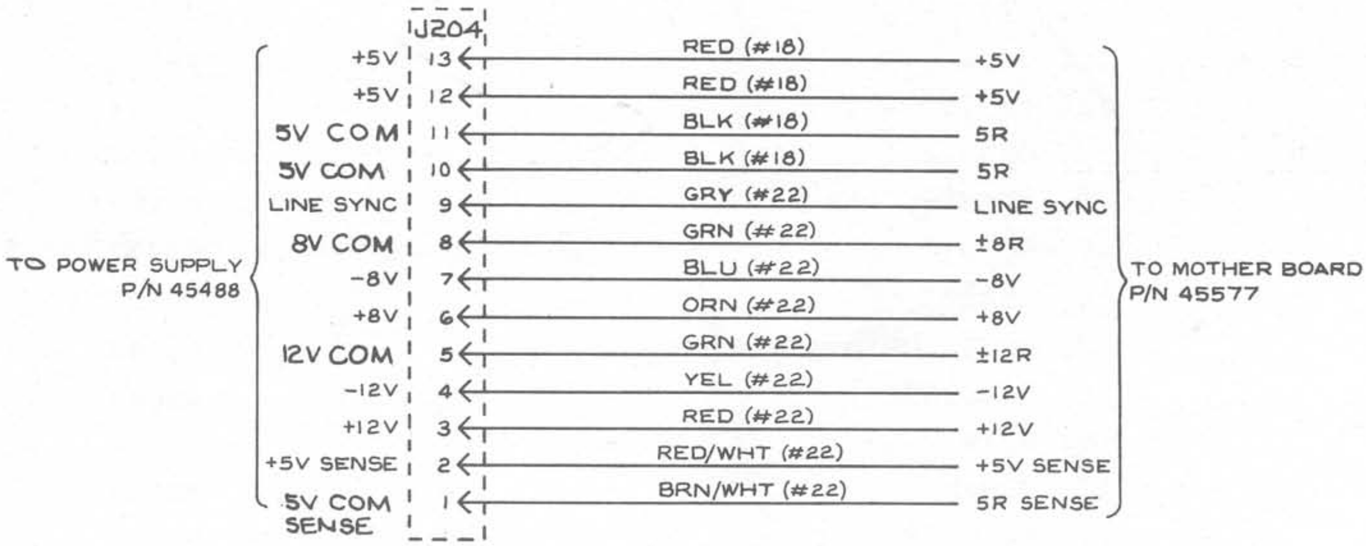
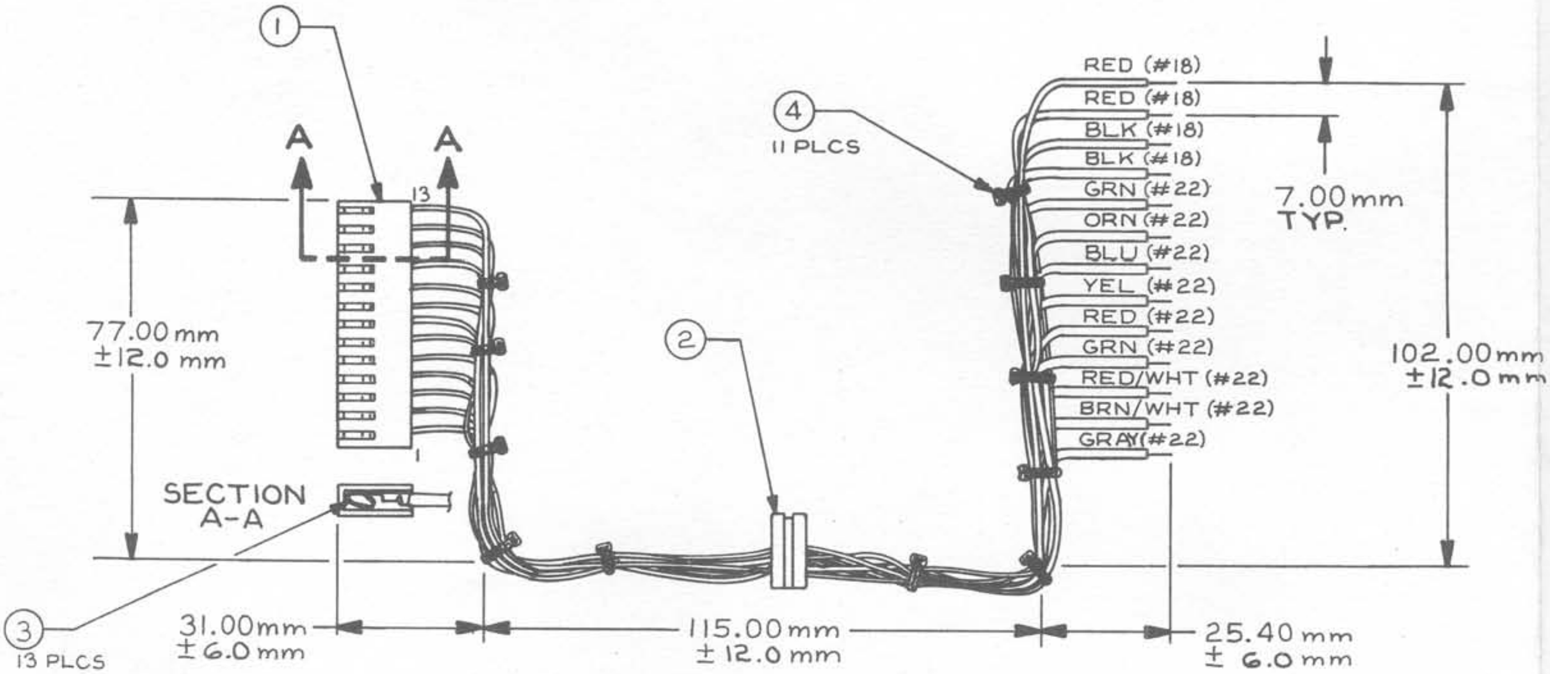


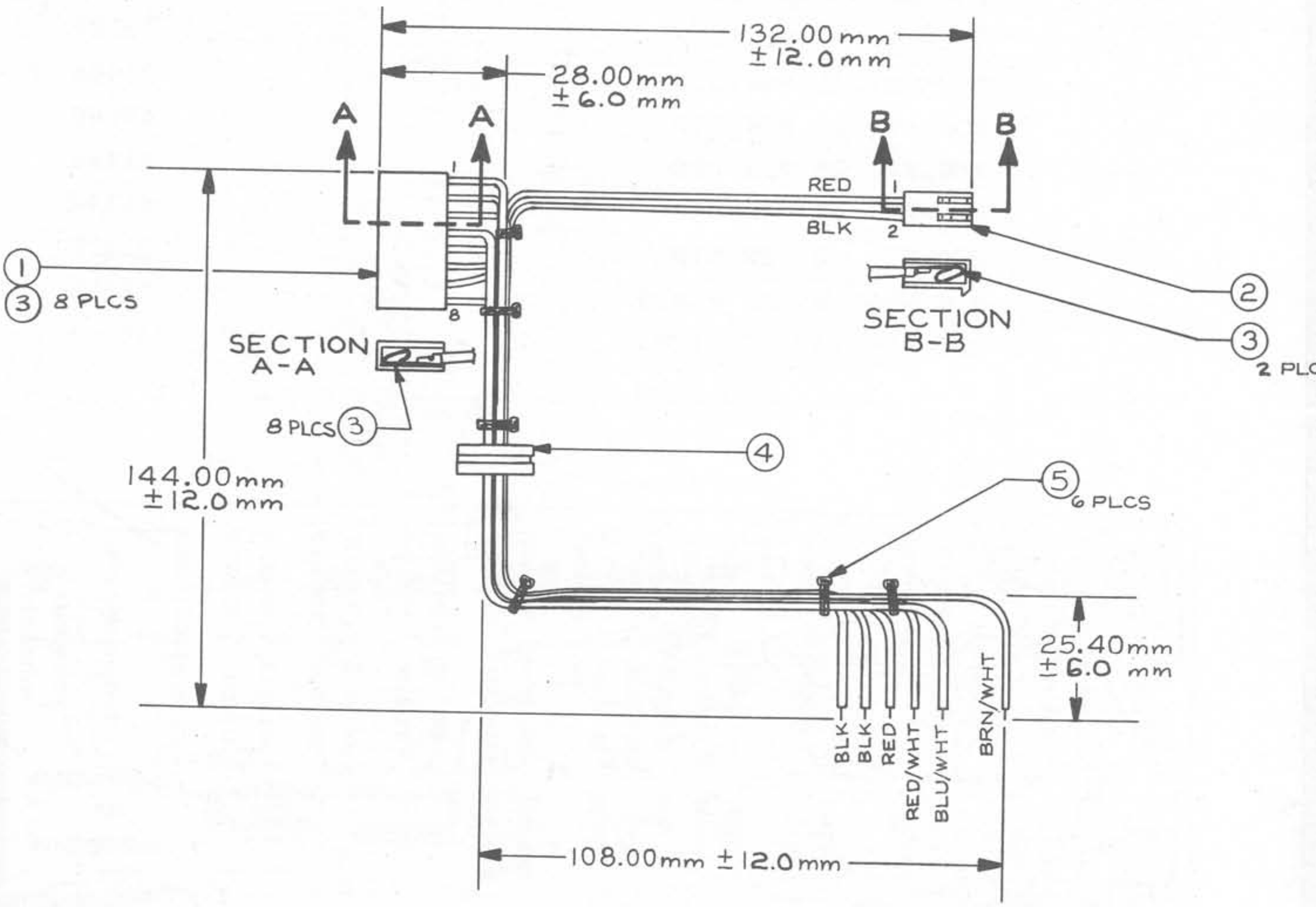
Figure 5-7. Motherboard-to-Power Supply Cable Assembly (Part No. 47111)

5.4.1 Motherboard-to-Power Supply Interconnect Cable Assembly (Part No. 47111)

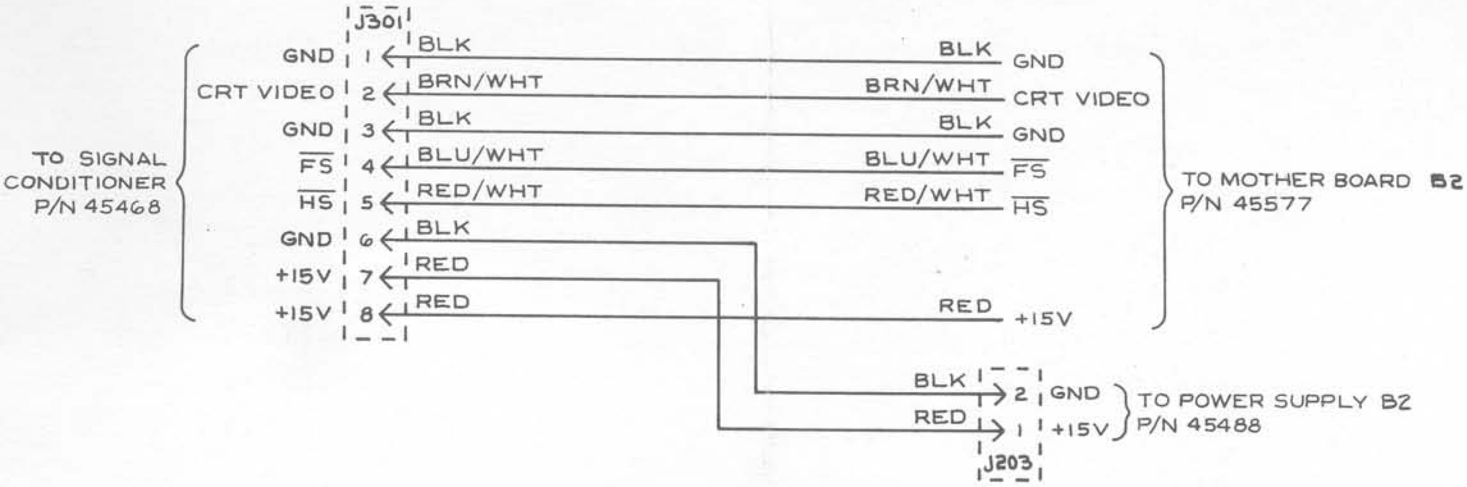


4	11	YC	—	6147	CABLE TIE
3	13	YC	—	45887	CRIMP TERMINAL
2	1	YC	—	47125	GROMMET, HORSESHOE
1	1	YC	—	46637	CONNECTOR, MOLEX, 13 PIN
ITEM	QTY REQD	DWG SIZE	CLASS CODE	PART NO	MATERIAL OR DESCRIPTION

5.4.2 Motherboard-to-CRT Interconnect Cable Assembly (Part No. 47110)



ITEM	QTY REQD	DWG SIZE	CLASS CODE	PART NO	MATERIAL OR DESCRIPTION
5	6	YC	—	6147	CABLE TIE
4	1	YC	—	47125	GROMMET, HORSESHOE
3	10	YC	—	45887	CRIMP TERMINAL
2	1	YC	—	46626	CONN, MOLEX, 2 PIN W/LOCK RAMP
1	1	YC	—	46633	CONNECTOR, MOLEX, 8 PIN



PLCS

Figure 5-8. Motherboard-to-CRT Cable Assembly (Part No. 47110)

5.4.3 Digital Circuit Assembly (Part No. 45237)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1,2,4,5,7 10-17,19-26	CAPACITOR, 0.01µF, 100V	12144
C3	CAPACITOR, POLY, 0.068µF, 250V	47081
C6	CAPACITOR, 100pF, 1kV	12241
C8,9,27	CAPACITOR, 25µF, 25V	1941
C18	CAPACITOR, 50pF, 1kV	1923
CR1,2	DIODE, 1N914	12356
R1	TRIMMER, 50kΩ	12091
R2	RESISTOR, 255kΩ, 1%	21228
R3	RESISTOR, 1MΩ, 1%	18236
R4-6,8,19	RESISTOR, 10kΩ, 10%, 1/4W	13933
R7	RESISTOR, 3.3kΩ, 10%, 1/4W	13926
R9	RESISTOR, 10kΩ, 1%	21740
R10	RESISTOR, 249Ω, 1%	21724
R11	RESISTOR, 1MΩ, 10%, 1/4W	13960
R12-14	RESISTOR, 2.2kΩ, 10%, 1/4W	13924
R15	RESISTOR, 33kΩ, 10%, 1/4W	13939
R16,18	RESISTOR, 100kΩ, 10%	13945
R17	RESISTOR, 1kΩ, 10%	13920
U1	IC AD7519JN	46476
U2,U12	DIP RESISTOR 10kΩ R698-3-R10K	43077
U3	IC, TL074	43299
U4	IC, 7406	20678
U5	IC, LM339	40849
U6	IC, 7474	26225
U7,U11	IC, 7400	20600
U8	IC, 7420	20604
U9	IC, REF02CJ OR MC1404U5	45654
U10	IC, 7404	20695
U13	IC, DAC08	44264
U14	IC, LF356	41473
U15,16,19, U22-25	IC, SN74LS163A	45647
U17	IC, 74S471 (PROGRAMMED)	46874
U18	IC, 74LS139	45656

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
U20	IC, 7410	20603
U21,U28	IC, DP8304B	45262
U26	IC, DM8131	45527
U27	IC, 8255A	45650
U29	IC, 8253	45649
	CIRCUIT CARD DIGITAL	45236
	POWER BUSS STRIP	23997
	SOCKET, 14 PIN DIP	19189
	SOCKET, 16 PIN DIP	20860
	SOCKET, 20 PIN DIP	45660
	SOCKET, 24 PIN DIP	41492
	SOCKET, 40 PIN DIP	41342
	SOCKET, 8 PIN DIP	22410
	PIN WIRE WRAP, 0.025	24458
	GROUND BRACKET, PCB	45951

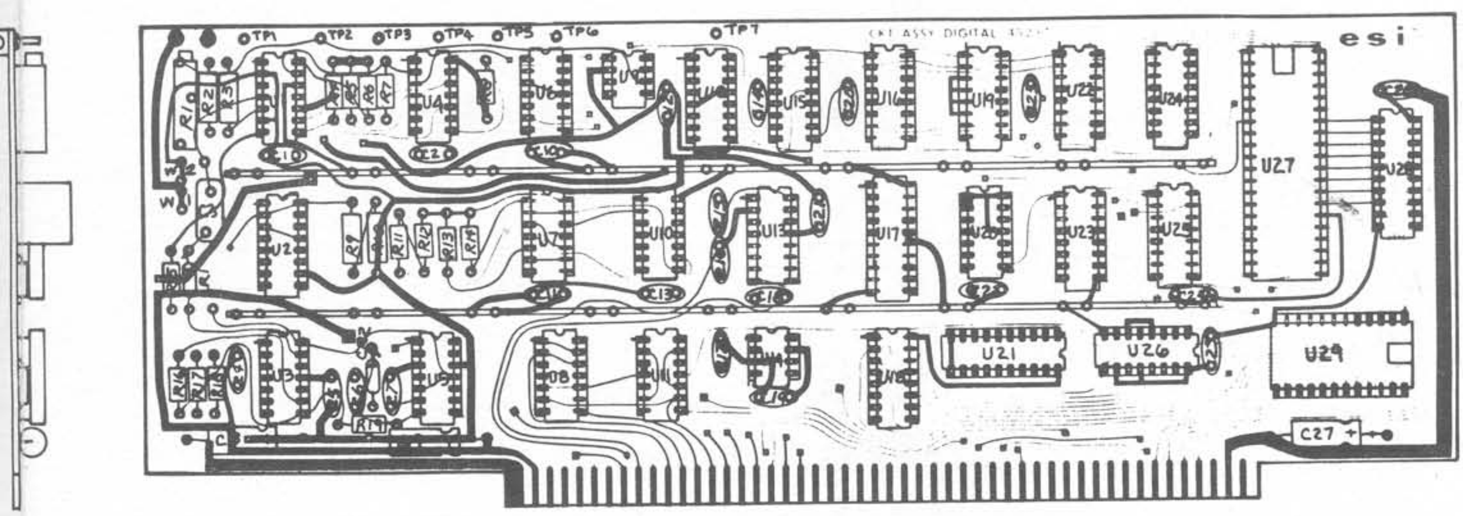
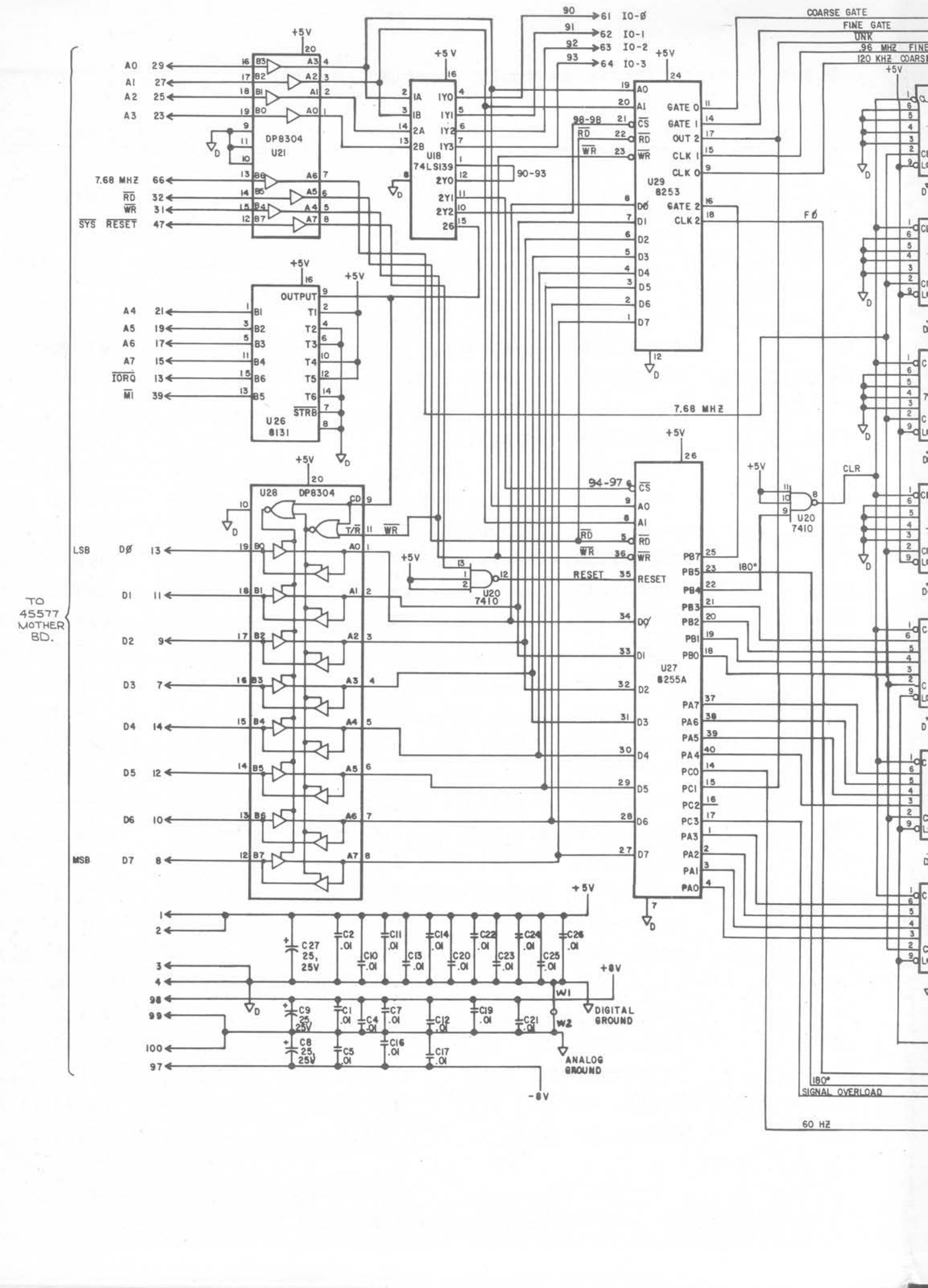


Figure 5-9. Digital Circuit Assembly (Part No. 45237)


TO 45577 MOTHER BD.
A0 29
A1 27
A2 25
A3 23
7.68 MHZ 66
RD 32
WR 31
SYS RESET 47
DP8304
U21
A4 21
A5 19
A6 17
A7 15
IORQ 13
MI 39
OUTPUT
STRB
U26
8131
U28 DP8304
T/R
WR
LSB D0 13
D1 11
D2 9
D3 7
D4 14
D5 12
D6 10
MSB D7 8
U18
74LS139
90-93
90
91
92
93
61 IO-0
62 IO-1
63 IO-2
64 IO-3
98-98
U29
8253
GATE 0
GATE 1
OUT 2
CLK 1
CLK 0
GATE 2
CLK 2
COARSE GATE
FINE GATE
UNK
.96 MHZ FINE
120 KHZ COARSE
F0
7.68 MHZ
94-97
RESET
U27
8255A
U20
7410
CLR
180°
180°
SIGNAL OVERLOAD
60 HZ
+5V
+8V
-8V
DIGITAL GROUND
ANALOG GROUND
W1
W2
C27 25, 25V
C2 .01
C10 .01
C11 .01
C13 .01
C14 .01
C20 .01
C22 .01
C23 .01
C24 .01
C25 .01
C26 .01
C9 25, 25V
C8 25, 25V
C1 .01
C4 .01
C5 .01
C7 .01
C16 .01
C12 .01
C17 .01
C19 .01
C21 .01

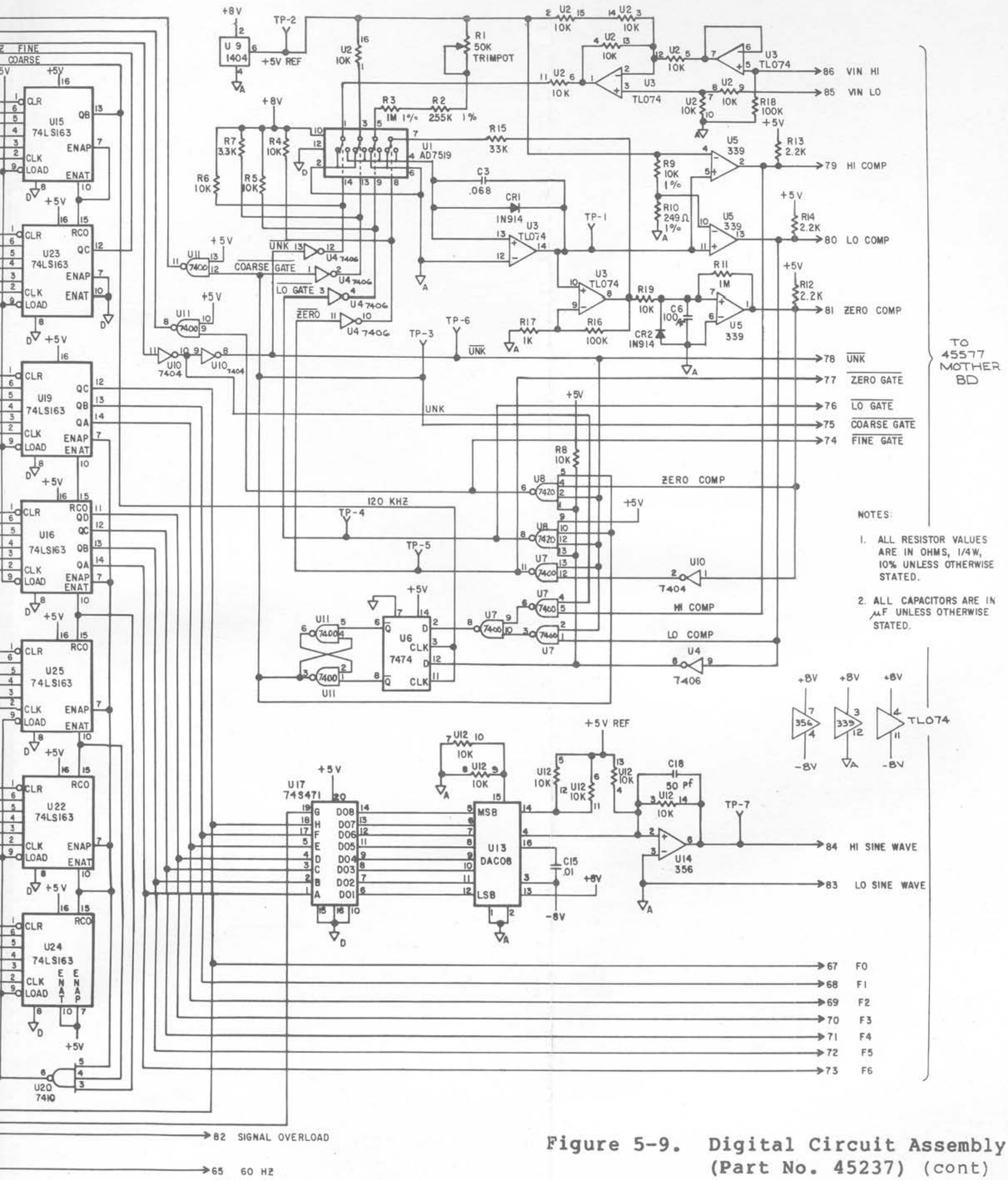


Figure 5-9. Digital Circuit Assembly (Part No. 45237) (cont)

5.4.4 Analog Circuit Assembly (Part No. 45239)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1,3,5,6,12 13,15,16,21 22,24-27,30- 35,37,38,40 41,43,49,56	CAPACITOR, 0.01µF, 50V	78032
C2	CAPACITOR, 10pF, POLY	43130
C4,14,23,24 50,51	CAPACITOR, 0.47µF, 100V	45645
C7,8,19,36	CAPACITOR, 100pF, POLY	18760
C9,10	CAPACITOR, 220pF, POLY	29297
C11	CAPACITOR, 470pF, POLY	44711
C17	CAPACITOR, 1500pF, POLY	26203
C18	CAPACITOR, 390pF, POLY	29299
C20	CAPACITOR, 20pF, POLY	20926
C28	CAPACITOR, 0.1µF, 50V CER	45247
C39	CAPACITOR, 0.001µF, DISC	21215
C42	CAPACITOR, 0.022µF, MYLAR	44626
C45	CAPACITOR, 25µF, 25V, ELECTROLYTIC	1941
C46,47	CAPACITOR, 6.8µF, TANT 35V	43792
C48,44	CAPACITOR, 8pF, DISC	2127
C52,53	CAPACITOR, 0.0047µF, 100VDC	13299
C54,55	CAPACITOR, 0.047µF, 100VDC, 63VAC	46200
C57	CAPACITOR, 150pF, POLY	29606
C58	CAPACITOR, 500pF, CERAMIC, 1000V	1920
CR1-11	DIODE 1N4005	13654
CR12-17,24, 25	DIODE 1N914	12356
CR18-21	DIODE HP 5082-2800	44832
CR22	VARISTOR, 68V	40993
CR23	VARISTOR, 1.5 KE10	42632
CR26,CR27	DIODE, 1N4738, 8.2V	12160
K1	RELAY, GB 821A	24804

5.4.4 **Analog Circuit Assembly (Part No. 45239)** (cont)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
K2	RELAY, GB 822	26667
K3	RELAY, 1805 B-300 ELECTRODYNE	46286
K4,K5	RELAY, 10-55-300	45659
R1	RESISTOR, 3.9kΩ, 1W, 10%	46478
R2	RESISTOR, 6.8kΩ, 1/2W, 10%	2075
R3	RESISTOR, 330Ω, 1W, 10%	12174
R4	RESISTOR, 150Ω, 1W, 10%	12171
R5,6,48,52, 53	RESISTOR, 1kΩ, 1/4W, 10%	13920
R7	RESISTOR, 100Ω, 1/4W, 10%	13907
R8	RESISTOR, 8Ω, ESI QB 0.005%	46552
R9	RESISTOR, 64Ω ESI QB 0.005%	46555
R10	RESISTOR, 512Ω ESI QB 0.005%	46554
R11	RESISTOR, 4.096kΩ ESI QB	46553
R12	RESISTOR, 32.768kΩ ESI QB 0.005% ±5 TG	41838
R13,18,25,30, 31,33,34,35, 42,43	RESISTOR, 10kΩ, 1/4W, 10%	13933
R14,16,24,36	RESISTOR, 2MΩ, 1%	21772
R15	RESISTOR, TRIMMER, 500kΩ (SIP)	46389
R17	RESISTOR, 15MΩ, 10%	13976
R19-23, 40	RESISTOR, TRIMMER 2kΩ	46388
R26	RESISTOR, 11kΩ, 1%	13359
R27	RESISTOR, 402Ω, 1/4W, 1%	21726
R28	RESISTOR, 1kΩ, 1%	21730
R29	RESISTOR, 6.98kΩ, 1%	22857
R32,50,51	RESISTOR, 2.2kΩ, 10%	13924
R37	RESISTOR, 1kΩ ESI QB	42631
R38	RESISTOR, 7kΩ ESI QB	22777
R41	RESISTOR, 1MΩ, 10%	13960
R44	RESISTOR, 4.99kΩ, 1/4W, 1%	21737
R45,46	RESISTOR, TRIMMER 10kΩ SIP	46204

CIRCUIT NO.	DESCRIPTION		ESI PART NO.
R47	RESISTOR, 150Ω, 1/4W, 10%		13909
R49	RESISTOR, 22kΩ, 1/4W, 10%		13937
R56,R57	RESISTOR, 10Ω, 10%, 1/4W		13895
R70,71	RESISTOR, TRIMMER, 10kΩ, 20T		41902
T1	TRANSFORMER		46480
TP1-7	WIRE WRAP PINS		24458
U1	IC, NE5534		46406
U2,3,6,8	IC, LF356N		41473
U4,10,20	IC, 4052AE		20743
U5	IC, CD4051		40841
U7	IC, LM311		29544
U9	IC, 4053AE		20744
U11,U13	IC, TL074		43299
U12	IC, 74LS288, PROGRAMMED		46872
U14,17,23	IC, AD7524JN DAC		45652
U15	IC, DIP RESISTORS R698-3-R10K		43077
U16	IC, SIP RESISTORS	BECKMAN 765-1-R22K	47328
		DALE 4310-R-101-222	
U18,U21	IC, 7475N		20614
U19	IC, UA759UIC		46479
U23	IC, 7406		20678
U24	IC, 74LS373		46201

5.4.4 Analog Circuit Assembly (Part No. 45239) (cont)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	BUS, POWER STRIP	23997
	SOCKET, 14 PIN DIP	19189
	SOCKET, 16 PIN DIP	20860
	SOCKET, 8 PIN DIP	22410
	SOCKET, 10 PIN DIP	46481
	SOCKET, 20 PIN DIP	45660
	CONNECTOR, BNC ISOLATED	41820
	GRAY FUSE CARRIER 3AG	45966
	FUSE, 1/2A, 250V, 3AG	1802
	POST, FUSE BODY, HI PROFILE	45968
	JACK, 1/8", PHONO (TINI-JAX)	47082
	POST, BINDING	1435
	ALT. METRIC, 5 x 20 FUSE CARRIER (BLK)	45965
	PLUG, MALE MINIATURE PHONO	47083
	INSULATOR, X-FMR MTG	47275
	PC CARD ANALOG	45238
	SPACER, X-FMR BRACKET	46306
	PANEL, CONNECTOR	45162
	SLEEVING	5889
	SWING LUG, BINDING POST	3247
	BRACKET, X-FMR MTG	45164
	COAX	45643
	BRACKET, CONNECTOR PANEL	45161
	HEATSINK	47438
	SHRINK TUBE	15926

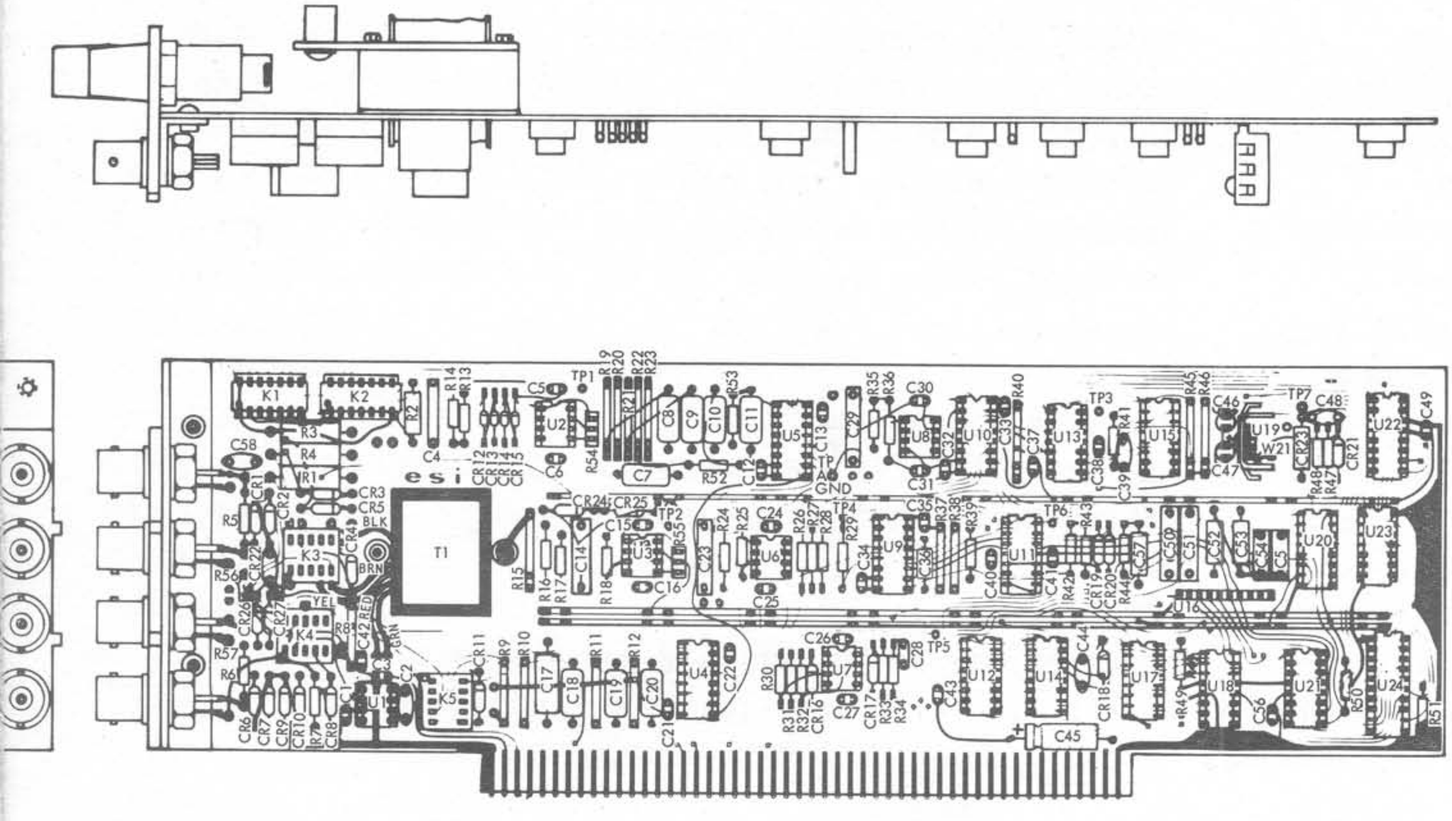
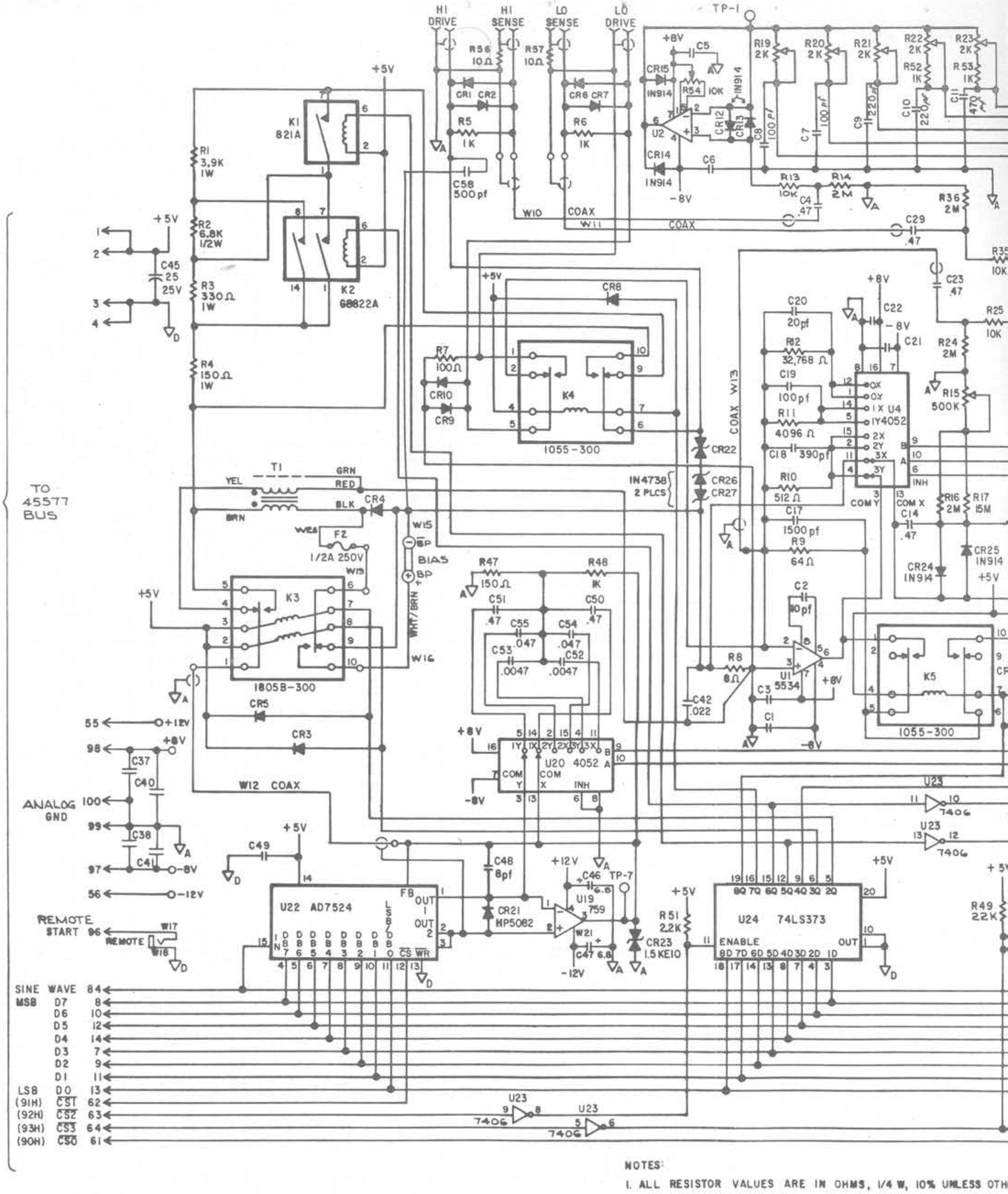
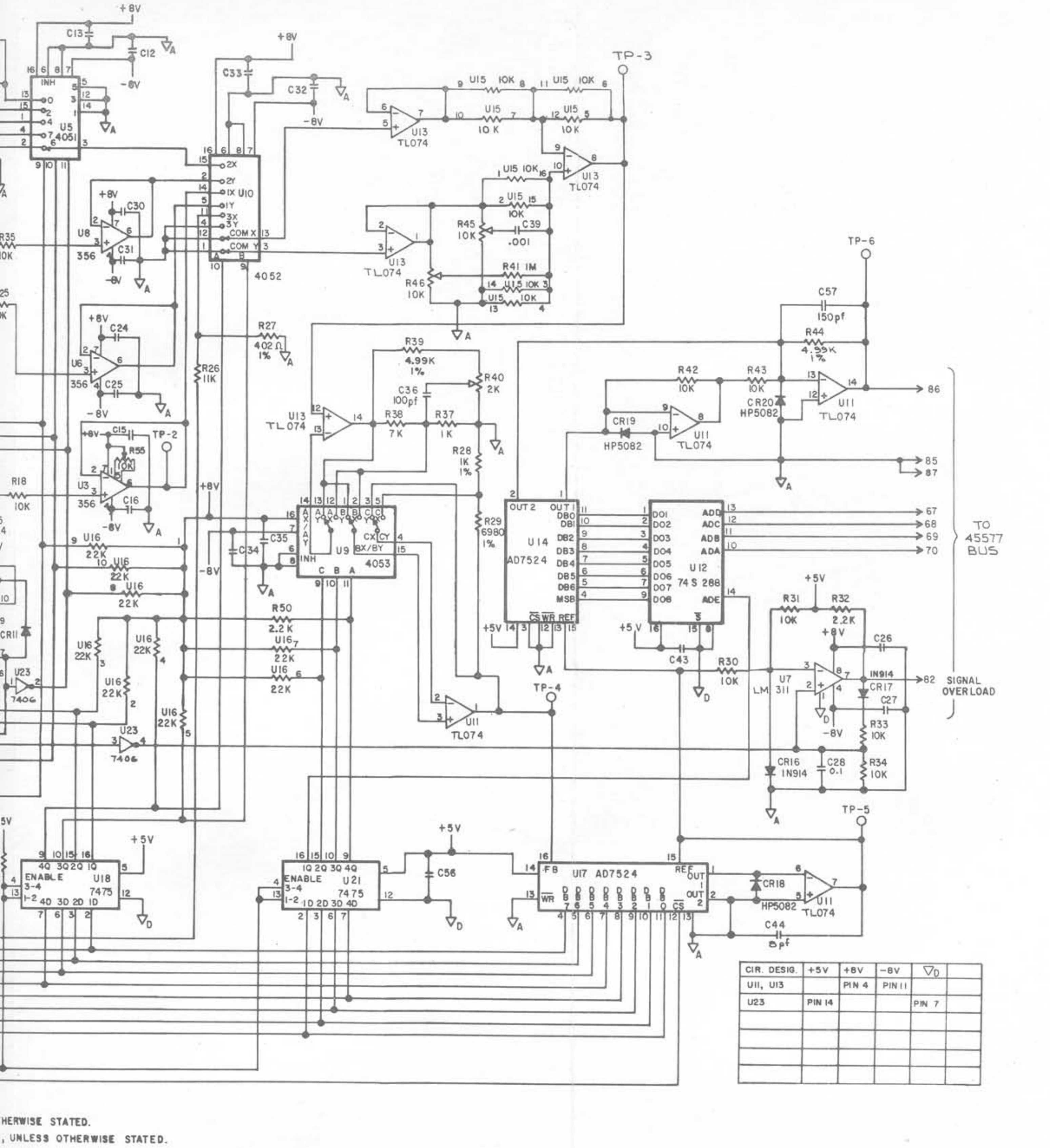


Figure 5-1Ø. Analog Circuit Assembly (Part No. 45239)



NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, 10% UNLESS OTH
2. ALL CAPACITORS ARE IN μF, UNLISTED VALUES ARE .01 μF,
3. ALL DIODES ARE IN4005 UNLESS OTHERWISE STATED.



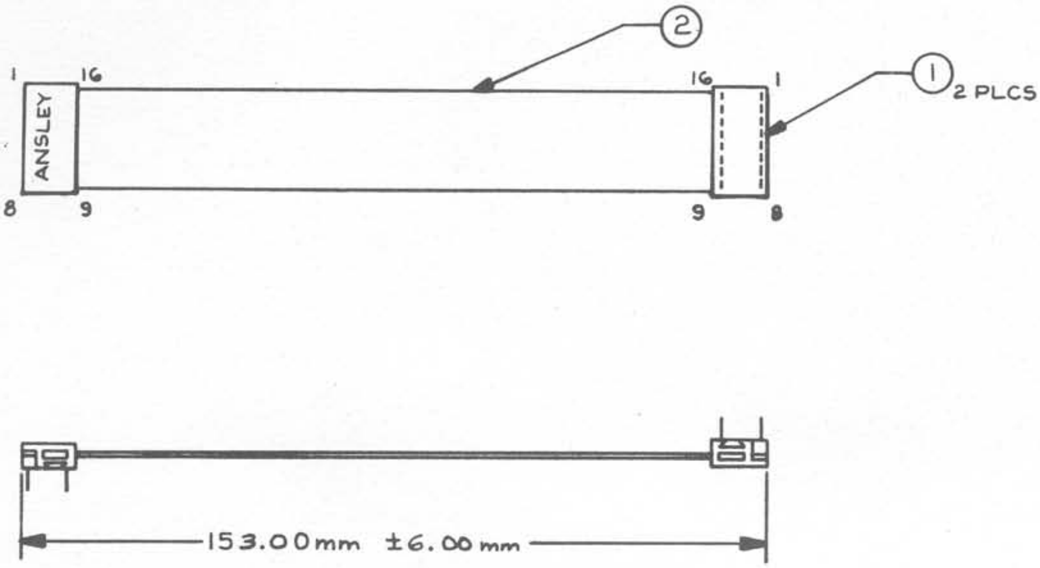
CIR. DESIG.	+5V	+8V	-8V	∇D	
U11, U13		PIN 4	PIN 11		
U23	PIN 14			PIN 7	

HERWISE STATED.

, UNLESS OTHERWISE STATED.

Figure 5-1Ø. Analog Circuit Assembly (Part No. 45239) (cont)

5.4.5 Tape Deck-to-RS232 Cable Assembly (Part No. 47254)



2	.5'	YC	—	44733	RIBBON CABLE
1	2	YC	—	43765	CONNECTOR, 16 PIN, ANSLEY
ITEM	QTY REQ	[illegible]	CLASS	PART NO	MATERIAL OR DESCRIPTION

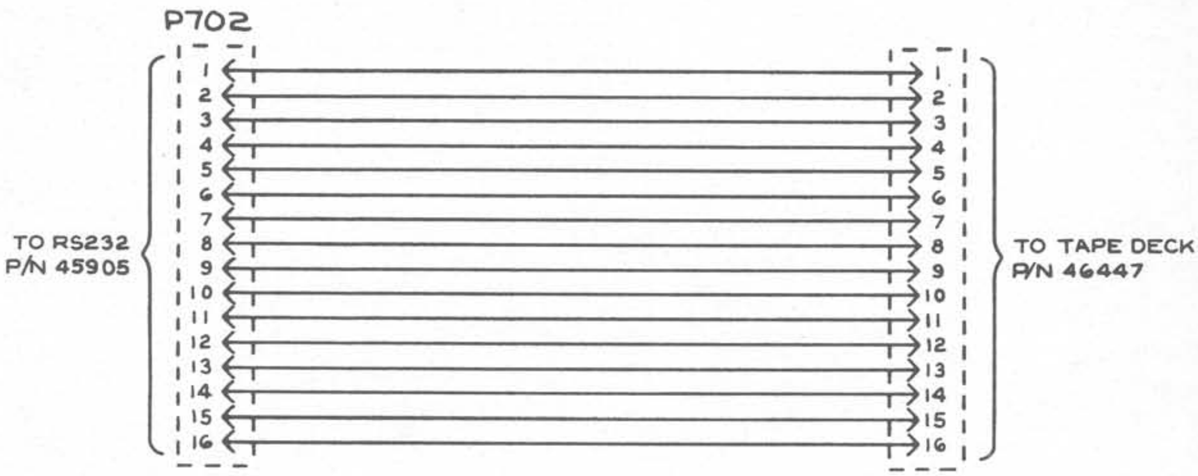


Figure 5-11. Tape Deck-to-RS232 Cable Assembly (Part No. 47254)

5.4.6 RS232/Cassette Interface Circuit Assembly (Part No. 459Ø5)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
CR1	DIODE, 1N4734, 5.6V	12258
C1-6,8-21, 23-26	CAPACITOR, Ø.Ø1µF, ±2Ø%	45658
C22,27,28	CAPACITOR, Ø.Ø1µF, 5ØV, DISC	12144
J7Ø1	CONNECTOR, DB25S	45983
R1,3,12,13	RESISTOR, 1kΩ, 1/4W, 1Ø%	1392Ø
R2,9,15,16	RESISTOR, 22ØΩ, 1/4W, 5%	13911
R4	RESISTOR, 2.7kΩ, 1/4W, 1Ø%	13925
R8	RESISTOR, 47Ω, 1/4W, 1Ø%	139Ø1
R14	RESISTOR, 15MΩ, 1/4W, 1Ø%	13976
U1	IC, 74Ø6	2Ø678
U2	IC, MC1489L	423Ø2
U4,5,15-17	IC, IC74161	42622
U6	IC, 7442	2Ø6Ø8
U7,28	IC, 74Ø8	2Ø717
U8,12,29	IC, 74Ø4	2Ø695
U9	IC, 8224	47319
U1Ø	IC, 74Ø2	2Ø6Ø2
U13	IC, 74S257	45982
U14	IC, MC1488L	423Ø1
U18,25	IC, 74ØØ	2Ø6ØØ
U19	IC, 7474	26225
U2Ø	IC, µPD371NEC	45261
U21	IC, 74S471 (PROGRAMMED)	45655
U22	IC, MC14411	42933
U23	IC, Z8ØS1Ø/9	4598Ø
U26	IC, 8131	45527
U27	IC, 83Ø4	45262
U3Ø	RESISTOR PAK, SIP, 1Ø PIN, 2.2kΩ	45846
U31	RESISTOR PAK, SIP, 6 PIN, 2.2kΩ	45847
Y1	CRYSTAL, 1.8432MHz, Ø.Ø5% (HCIBU)	45974
Y2	CRYSTAL, 18MHz	47327

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	BRACKET, RS232	45815
	BRACKET, GROUND	45951
	CIRCUIT CARD, RS232/CASSETTE INTERFACE	45904
	SOCKET, 14 PIN DIP	19189
	SOCKET, 16 PIN DIP	20860
	SOCKET, 40 PIN DIP	41342
	SOCKET, 24 PIN DIP	41492
	SOCKET, 20 PIN DIP	45660
	SOCKET, 42 PIN	47277

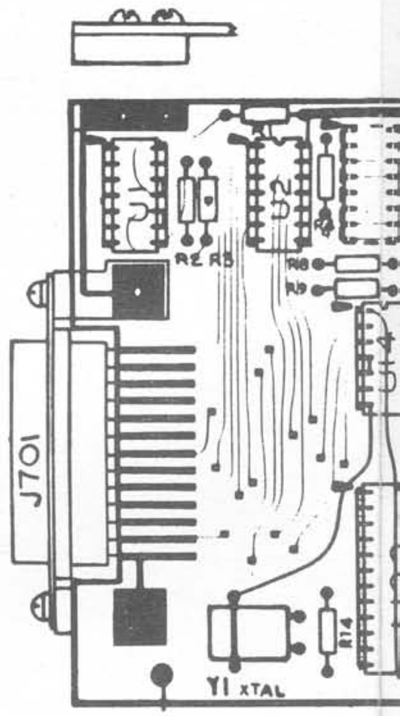
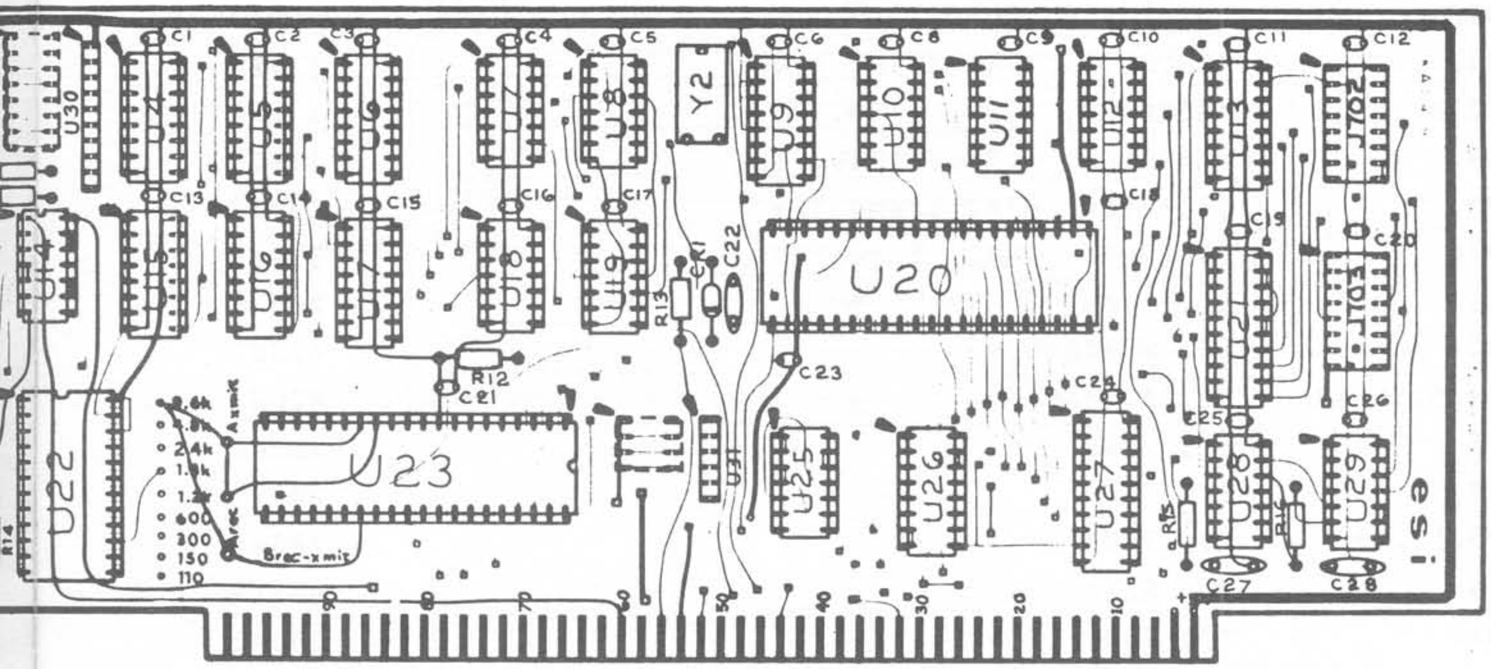
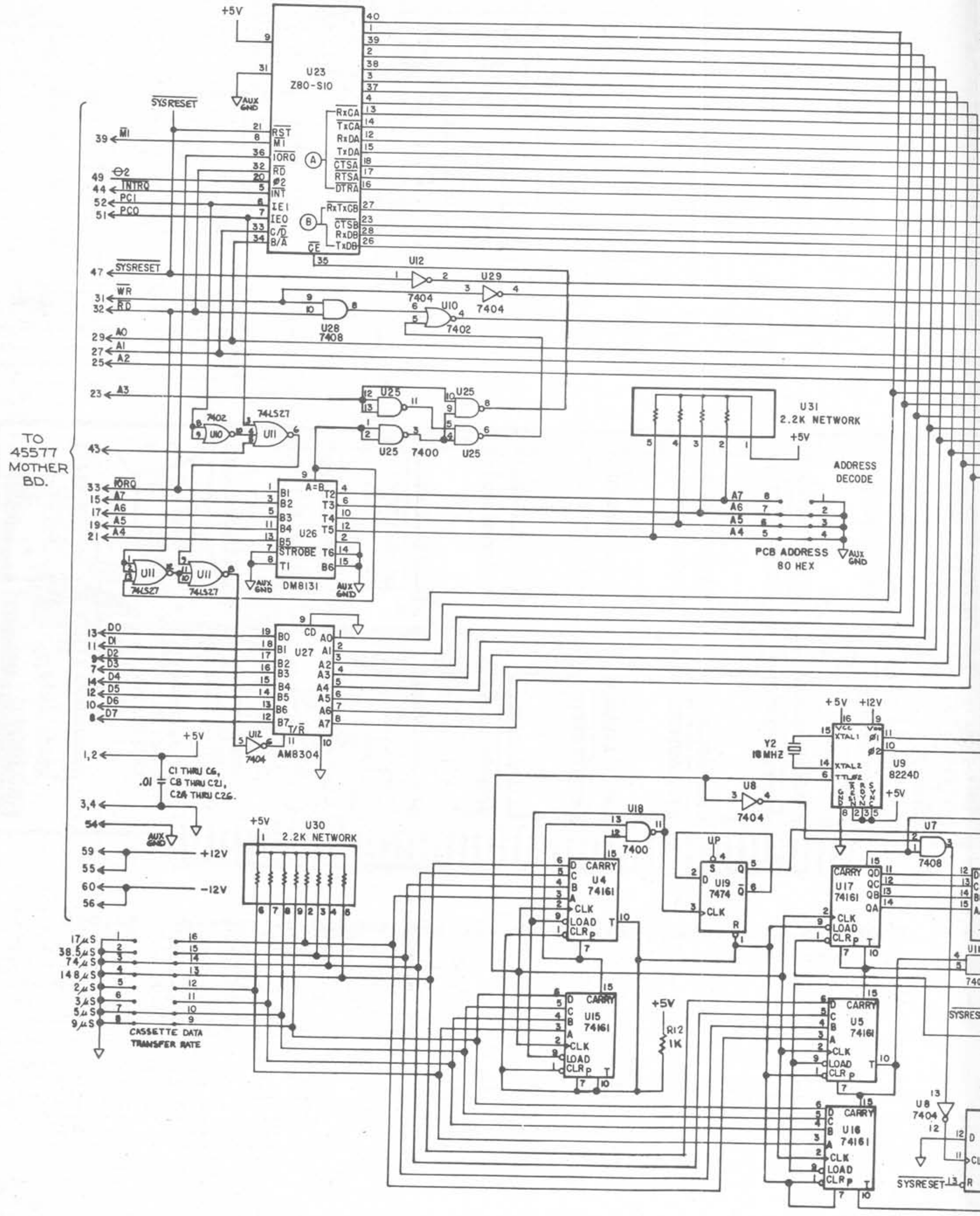


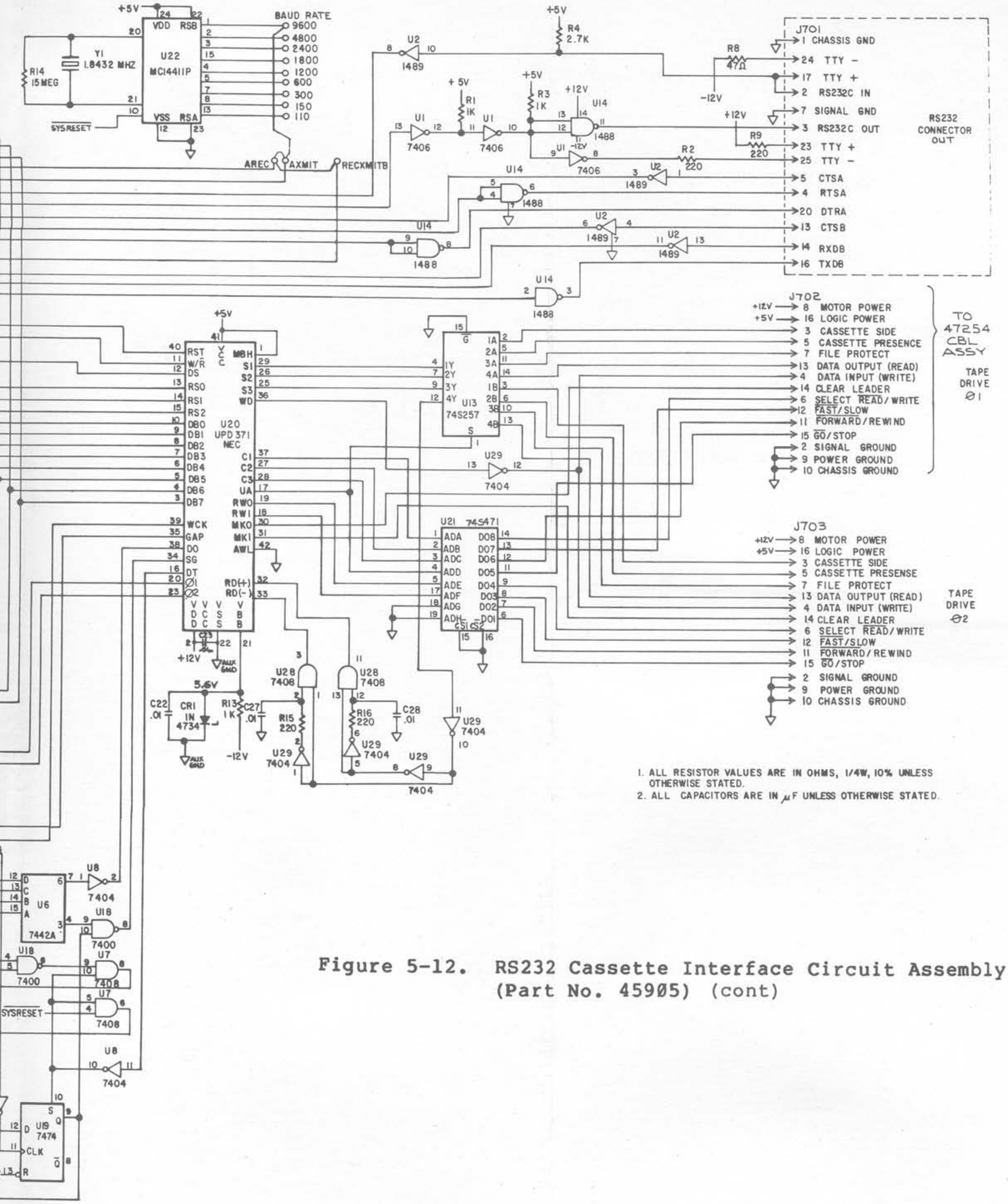
Figure 5-



e 5-12. RS232 Cassette Interface Circuit Assembly (Part No. 45905)



U23
Z80-SIO
+5V
AUX GND
SYSRESET
TO 45577 MOTHER BD.
U12
7404
U29
U10
7402
U28
7408
U25
7400
U11
74LS27
U31
2.2K NETWORK
ADDRESS DECODE
PCB ADDRESS 80 HEX
U26
DM8131
U27
AM8304
C1 THRU C6, C8 THRU C21, C24 THRU C26.
+12V
-12V
U30
2.2K NETWORK
Y2
18MHZ
U9
8224D
U8
U18
U19
7474
U4
74161
U15
U17
U5
U16
U7
R12
1K
CASSETTE DATA TRANSFER RATE



1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 10% UNLESS OTHERWISE STATED.
2. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE STATED.

Figure 5-12. RS232 Cassette Interface Circuit Assembly (Part No. 45905) (cont)

5.4.7 Memory Expansion Circuit Assembly (Part No. 46193)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	CIRCUIT CARD, MEMORY CARD	46192
C1	CAPACITOR, 100µF, 25V, ELECT	13683
C2-20	CAPACITOR, 0.01µF, 50V, CHIP	45658
Q1	TRANSISTOR, 2N3904	18751
R1,5	RESISTOR, 47Ω, 1/4W, 10%	13901
R2,3,4,6,8	RESISTOR, 1kΩ, 1/4W, 10%	13920
R7,9	RESISTOR, 330Ω, 1/4W, 10%	13913
U9,17,18,19	IC, 8304, OCTAL BI-DIRECTIONAL BUFFERS	45262
U11	IC, 7400, QUAD 2 INPUT NAND	20600
U20,21	RESISTOR PAK, 330Ω SIP	46072
	POWER BUSS STRIP	23997
	IC SOCKET, 14 PIN	19189
	IC SOCKET, 16 PON	20860
	IC SOCKET, 20 PIN	45660
	IC SOCKET, 28 PIN	43844

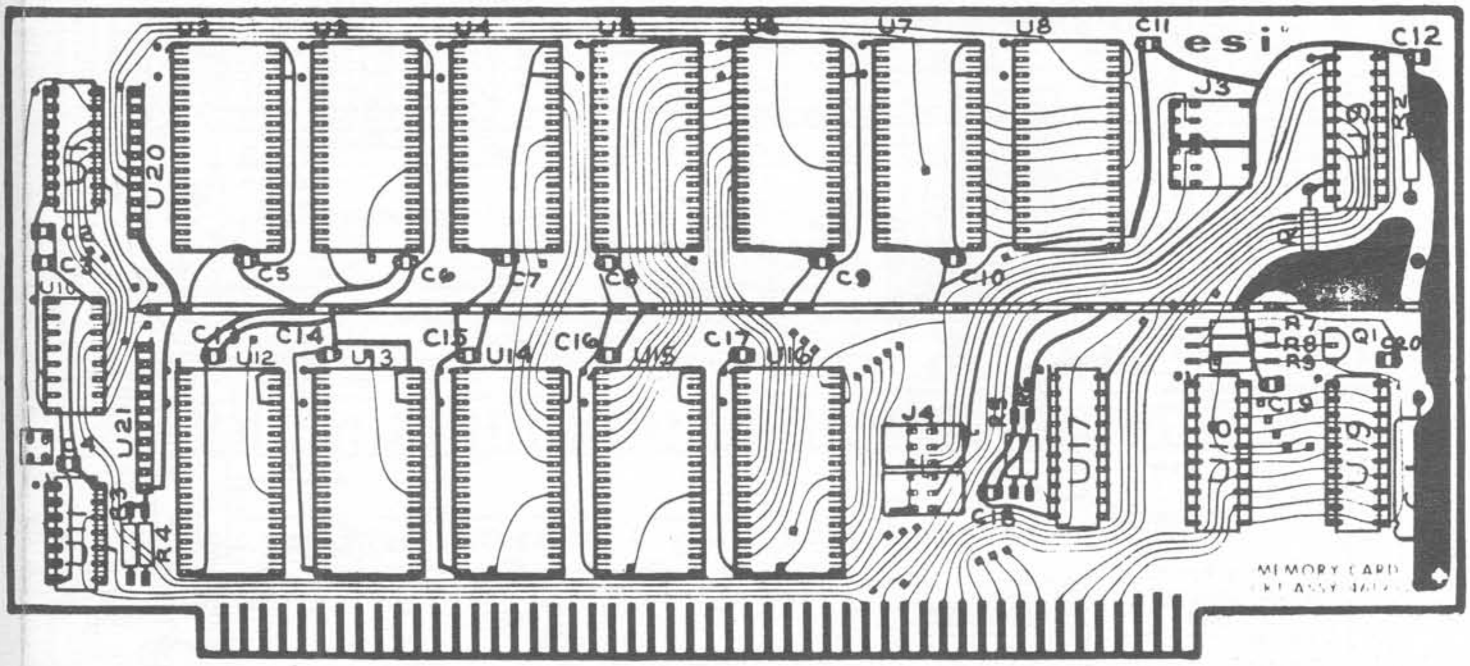
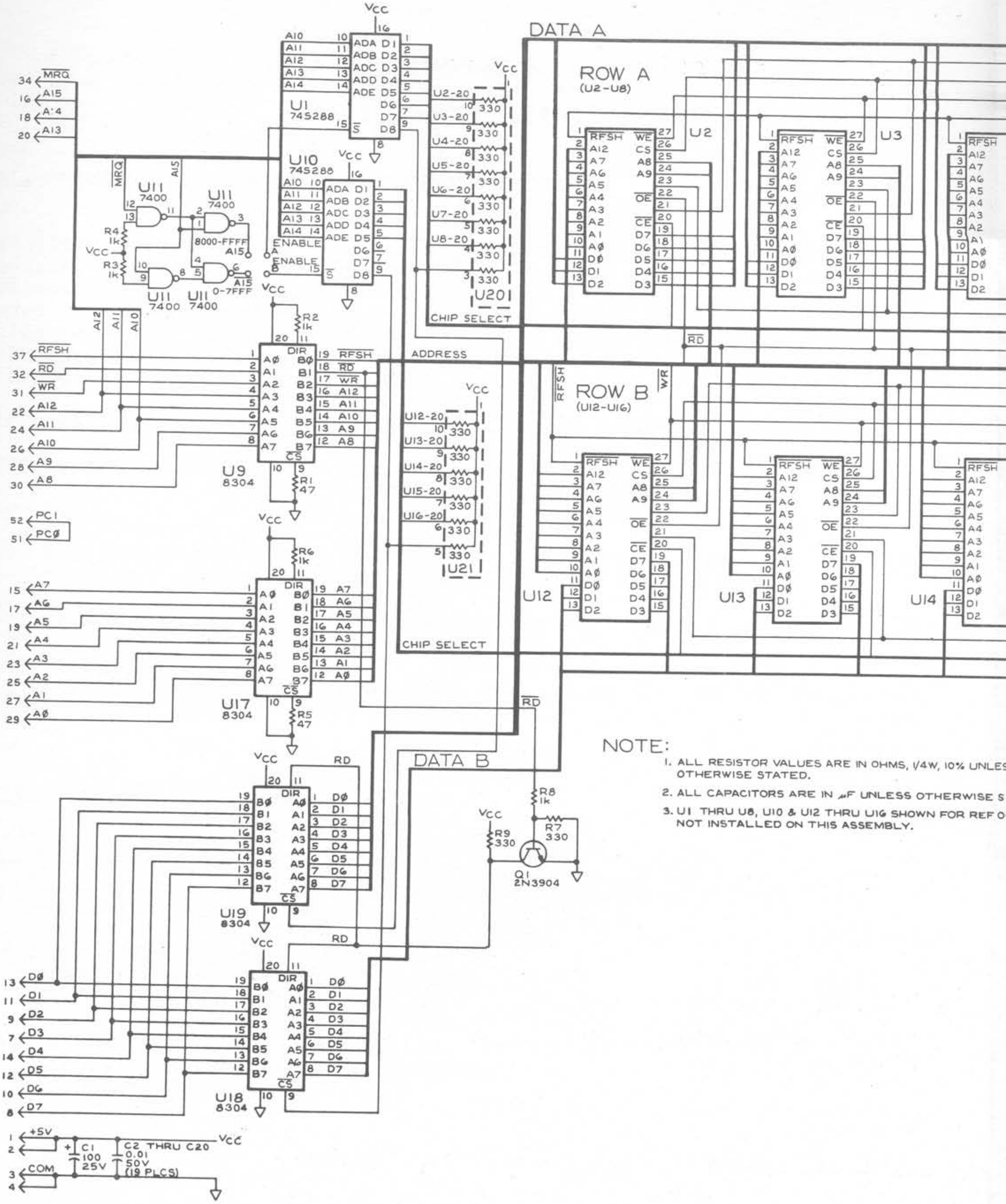


Figure 5-13. Memory Expansion Circuit Assembly (Part No. 46193)

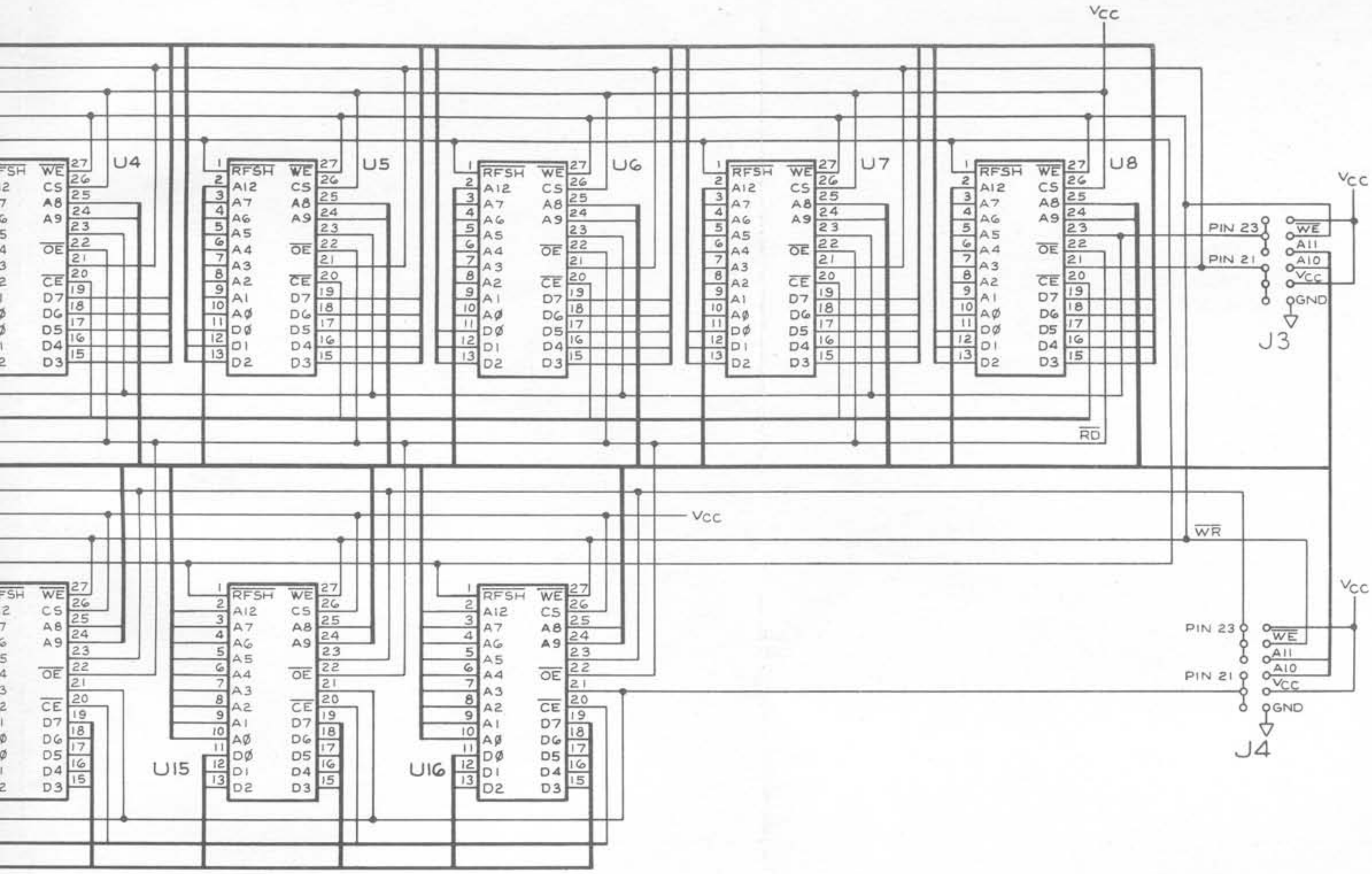


NOTE:

1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 10% UNLES
OTHERWISE STATED.

2. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE S

3. U1 THRU U8, U10 & U12 THRU U16 SHOWN FOR REF O
NOT INSTALLED ON THIS ASSEMBLY.

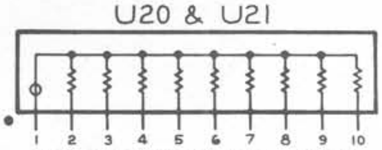


UNLESS

ISE STATED.
REF ONLY.

POWER CONNECTIONS			
DEVICE	TYPE	GND	VCC
U1, U10	74S288	8	16
U9, U17, U18, U19	8304	10	20
U11	7400	7	14
U2-U8, U12-U16	MEMORY	14	26,28

U20 & U21



RESISTOR NETWORK 330Ω 10 PIN SIP

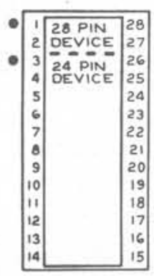


Figure 5-13. Memory Expansion Circuit Assembly (Part No. 46193) (cont)

APPENDIX A

OPTIONS OPERATION

A.1 MODEL 2100/2110 HANDLER INTERFACE OPTION

Handler Interface options enable the Model 2100/2110 VideoBridge to operate with a mechanical parts handler. The option accepts a START signal to initiate measurements, provides a BUSY signal which may be used to arrest handler operation during test, and offers a contact closure output corresponding to one of thirteen preselected component bins (refer to Instruction Manual Section 2.7 for component sorting operation).

Three standard handler interface options are available. They are:

ESI Part No. 47895 -- For interfacing the Engineered Automation Auto-Sort Handler to the VideoBridge via the ESI Model 1453 Handler Adapter.

ESI Part No. 47896 -- For interfacing the Daymarc Type 147 and 149 handlers directly to the VideoBridge.

ESI Part No. 47897 -- For interfacing Browne handlers to the Video-Bridge.

Contact the factory for information concerning the use of other part handlers with the Model 2100 or 2110.

A.1.1 Hardware Included

Handler Interface Option 47895
- Handler Interface Circuit Assembly
- Instruction Sheet

Handler Interface Option 47896
- Handler interface Circuit Assembly
- Instruction Sheet

Handler Interface Option 47897
- Handler Interface Circuit Assembly
- Instruction Sheet

A.1.2 Installation

WARNING

TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS MANUAL. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED IN THIS MANUAL ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.

CAUTION

TO AVOID DAMAGE TO CIRCUITRY, TURN POWER OFF WHILE PLUGGING IN OR REMOVING CIRCUIT ASSEMBLIES.

The Handler Interface Assembly is plugged into the VideoBridge's motherboard (see Figure A-1).

Installation of the BNC-to-BNC cable assemblies and the Handler Interface cable assembly, for option part number 47895, are dependent upon the component handler being used. The BNC cables interconnect the instrument's HI and LO unknown terminals to the part handler's component contactors. The Handler Interface Cables make all logic connections between the instrument's rear panel OUTPUTS connector and the component handler.

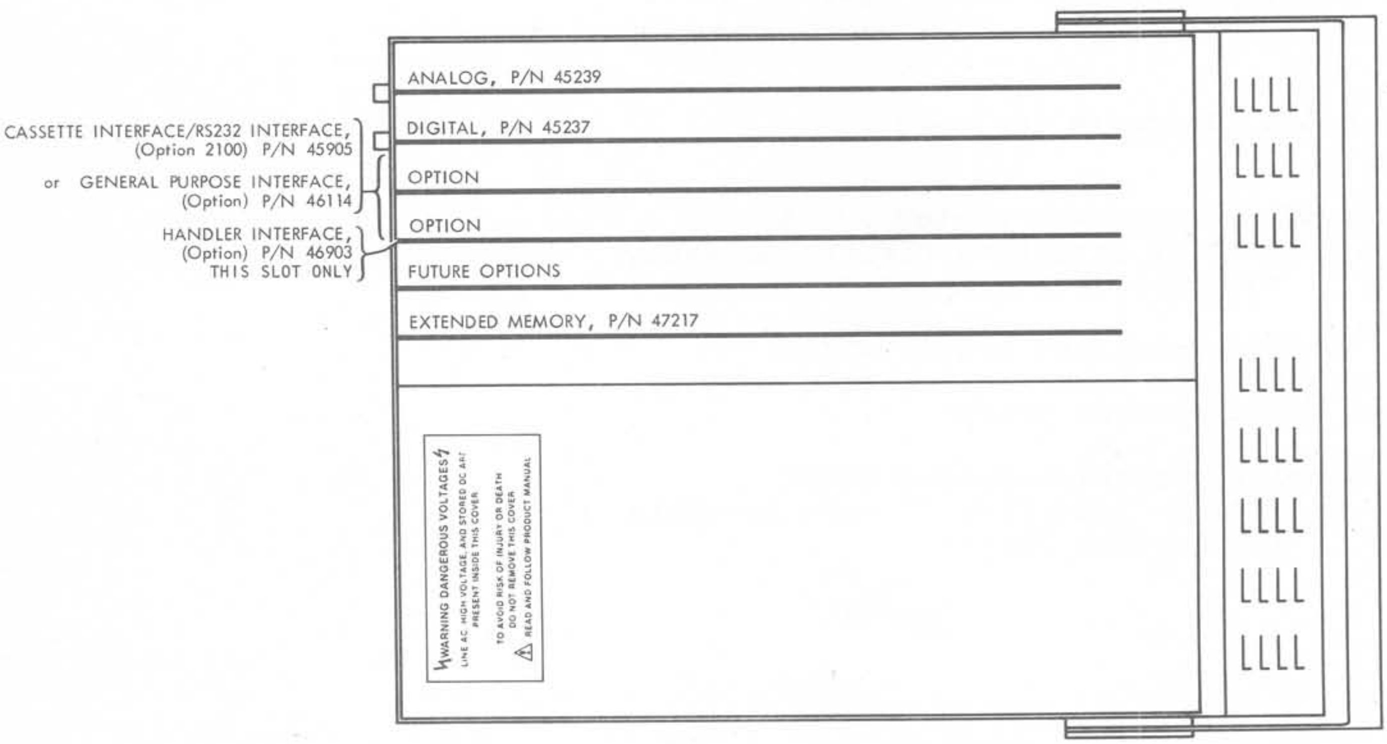


Figure A-1. Handler Interface Circuit Assembly Location

A.1.3 Operation

The Handler Interface option will only operate with instruments that have software revision 1.5 or greater. To determine which revision software is present in your instrument.

Push [7] [yellow key] (yellow key) [CODE]

To assure proper Handler Interface option operation:

1. Set the instrument's bin limits and nominal value.*

2. Activate the Handler Interface option.

   Push [8] [yellow key] (yellow key) [CODE]

   The VideoBridge will begin sorting components immediately.

As shown in the example above, the Handler Interface Option is activated using CODE 8. To deactivate this option either:

1. Temporarily ground Pin 21 of the Handler Interface rear panel connector. Grounding is accomplished by connecting Pin 21 to Pin 13 (System Ground) on the same connector.

2. Turning instrument power OFF then ON again. In this case, the nominal value, bin limits, and bin counters are zeroed.

---

* Refer to the Model 2100/2110 Operators manual, Section 2.7, for component sorting operation.

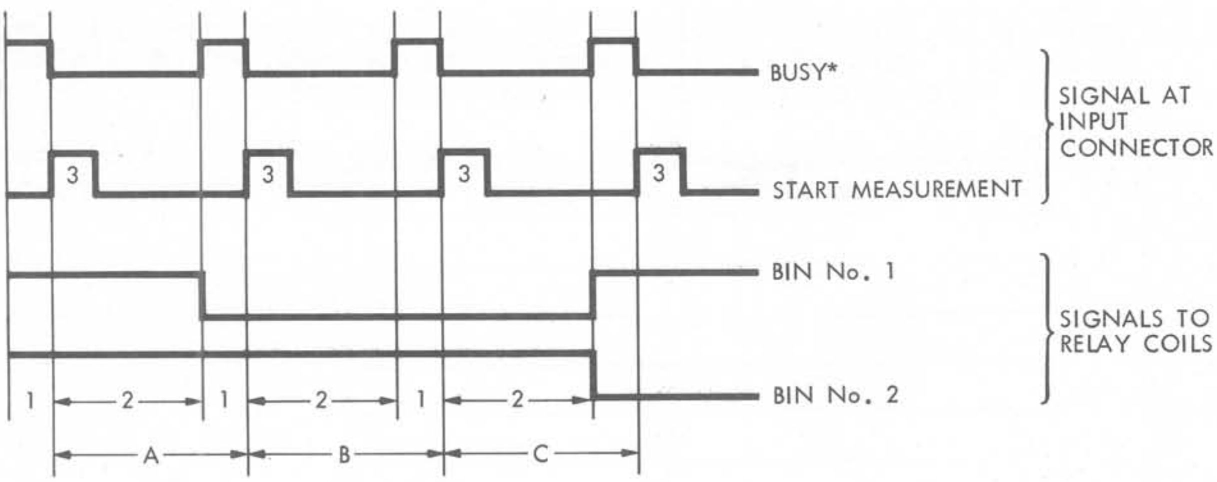
The Handler Interface provides the following functions:

1. START TEST - is the input to an opto-isolator. It requires a holding current of 1Ø to 8ØmA to initiate a measurement.

2. BUSY - is the open collector output of an opto-isolator. This signal can be used to arrest handler operation during test. The BUSY signal can be changed from a high true to a low true signal by cutting the jumper labeled W3 on the Handler Interface Circuit Card.

3. Output Relays - contact closures that are selected according to preset limits, see Component Sorting section of the instruction manual. (One relay is closed at a time.) The relays are rated at 1ØØVDC, 25ØmA switching current, and 1Ø million operations. Higher currents can be switched with a possible reduction in operation life, especially if contacts arc on opening. Resistive loads are more desirable than inductive loads. For example, a 4ØØmA, 15V, resistive load will not appreciably reduce life. Relays are on sockets for easy replacement.

4. 5V TTL (open collector) Outputs - are available at the rear panel OUTPUTS connector. They require the addition of a jumper wire in place of each output relay.



1. Handler Time -- User dependent.
2. Measurement Time -- Dependent on range and functions. See measurement speed section of the manual.
3. A measurement is initiated on the rising edge of the START signal.

A. First part was in bin No. 1 (low signal to relay coil).
B. Second part was also in bin No. 1 (low signal to relay coil).
C. Third part was in bin No. 2 (low signal to relay coil).
* Contact factory for special modifications.

NOTE: Outputs are latched until changed. Also note that the busy signal can be either high or low true depending on the setting of jumpers located on the Handler Interface circuit assembly.

Figure A-2. Handler Interface Option Signal Timing

All Handler Interface operations take place via the instrument's rear panel OUTPUTS connector. Table A-1 lists the functions for each pin of the OUTPUTS connector.

OUTPUTS CONNECTOR

PIN NUMBER	FUNCTION
1	COMMON
2	BIN 0
3	BIN 1
4	BIN 2
5	BIN 3
6	BIN 4
7	BIN 5
8	BIN 6
9	BIN 7
10	BIN 8
11	BIN 9
16	BIN 10
17	BIN 11
15	BIN 12
12*	+5V (SYSTEM) OUT
13*	SYSTEM GROUND
14	START IN
18	BUSY OUT
19	BUSY COM
20	START COM
21	KEYBOARD UNLOCK

*ESI recommends that Pin 12 (+5V OUT) and Pin 13 (SYSTEM GROUND) not be used. Noise introduced into the 2100/2110 through these connections may affect measurement results.

Table A-1. VideoBridge OUTPUTS Connector Wiring

NOTE: The Handler Interface cabling used with ESI's Model 296, 296V, and 410 will not be compatible with the Model 2100/2110's connections since pin 21 is not connected in the Model 296 cable. Contact ESI factory for further details.

START COM/BUSY COM

The Handler Interface Option is shipped with the START COM (pin 20) and BUSY COM (pin 19) lines tied, on the circuit card, to the COMMON (pin 1) side of the relay closures. If the binning operation requires relay COMMON (pin 1) be raised above ground potential, then START COM and BUSY COM must be disconnected from relay COMMON (pin 1) and connected to SYSTEM GROUND (pin 13). The following procedure tells how to do this.

STEP 1. Turn Instrument power OFF and remove its cover.

STEP 2. Remove the circuit card hold-downs and the Handler Interface circuit card (P/N 46903).

STEP 3. Locate and cut the connecting stripes labeled W4 and W5 in Figure A-3.

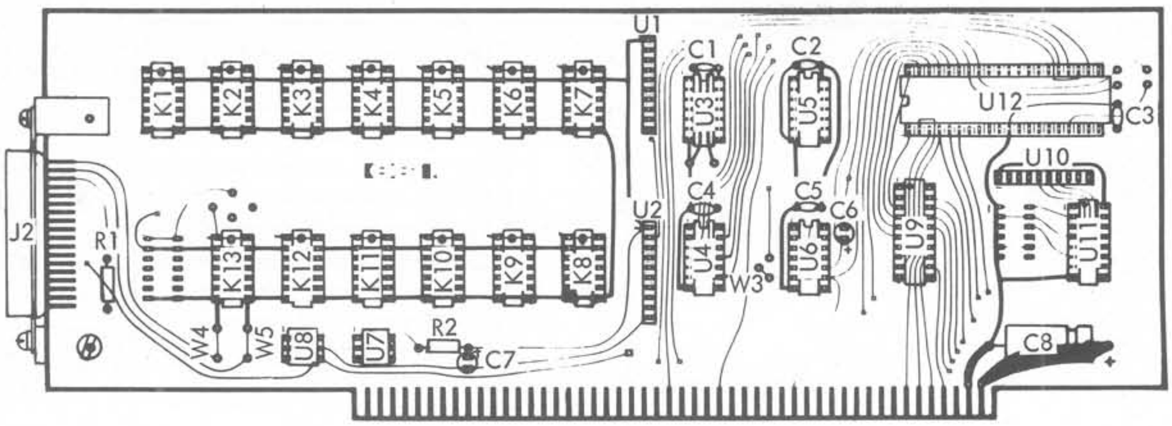


Figure A-3. Handler Interface Circuit Card

STEP 4. Add jumper wires to the rear panel connector. Connect START COM (pin 20) and BUSY COM (pin 19) to SYSTEM GROUND (pin 13).

STEP 5. Re-install the Handler Interface circuit card and instrument cover.

Connections to the Handler Interface Option should be made with a 36 contact receptacle that has a trapizoidal, polarized shell. Use Amphenol P/N 57-40360 or ESI P/N 15739.

ESI also has available the Model 1453 Handler Adapter. The 1453 connects to component handler bin actuators that require high currents or that have excessive electrical noise.

A.1.4 Calibration

The VideoBridge needs no adjustment, other than normal calibration, when a Handler Interface Option is installed. The Handler Interface Assembly contains no service adjustments.

A.2 MODEL 2100/2110 GENERAL PURPOSE INTERFACE BUS (GPIB) OPTION

A.2.1 Introduction

The GPIB Interface option allows the Model 2100/2110 VideoBridge to communicate on the bus structure defined by IEEE 488-1975 specifications. The bus itself is a passive structure. It is the active components on the interface option that enable the 2100/2110 to operate according to this universal standard. With the GPIB option installed, the 2100/2110 can be connected directly to the bus, and operated by a controller and the appropriate programming instructions. The instructions to and the data generated by the instrument are coded in ASCII code. Before continuing with a discussion of the GPIB hardware option and its programming structure, lets take a closer look at the requirements of the IEEE standard.

A.2.2 Bus Structure

The IEEE-488 bus is a set of sixteen signal lines that can be grouped functionally into three specifically dedicated busses.

1. 8 bidirectional data lines -- DIO 1 through DIO 8.
2. 3 interface signal lines -- DAV, NRFD, and NDAC
3. 5 general management lines -- ATN, EOI, IFC, REN, and SRQ.

Information is transferred along the bus in bit-parallel, byte-serial fashion by an asynchronous handshake. The handshake signals (interface signals DAV, NRFD, NDAC) guarantee the transfer of each byte of data from an addressed talker to all addressed listeners. This allows instruments with different data transfer rates to operate together on the bus as long as they conform to the handshake state diagrams defined in the IEEE standard.

Instruments connected to the bus are classified as either talkers, listeners, or controllers. A talker is capable of transmitting data on the data lines; there can be only one talker at a time to avoid confusion in message and data transfer. A listener is capable of responding to data received on the data lines; there can be more than one listener at a time. A controller designates which devices are to talk or listen and exercise other bus management functions; there can be only one controller at a time.

A device need not always be a talker or listener or controller, it may be idle part of the time. An instrument may alternate as a talker and a listener depending on whether it is generating data or receiving instructions. Figure A-4 is a typical system based on the IEEE-488 bus structure.

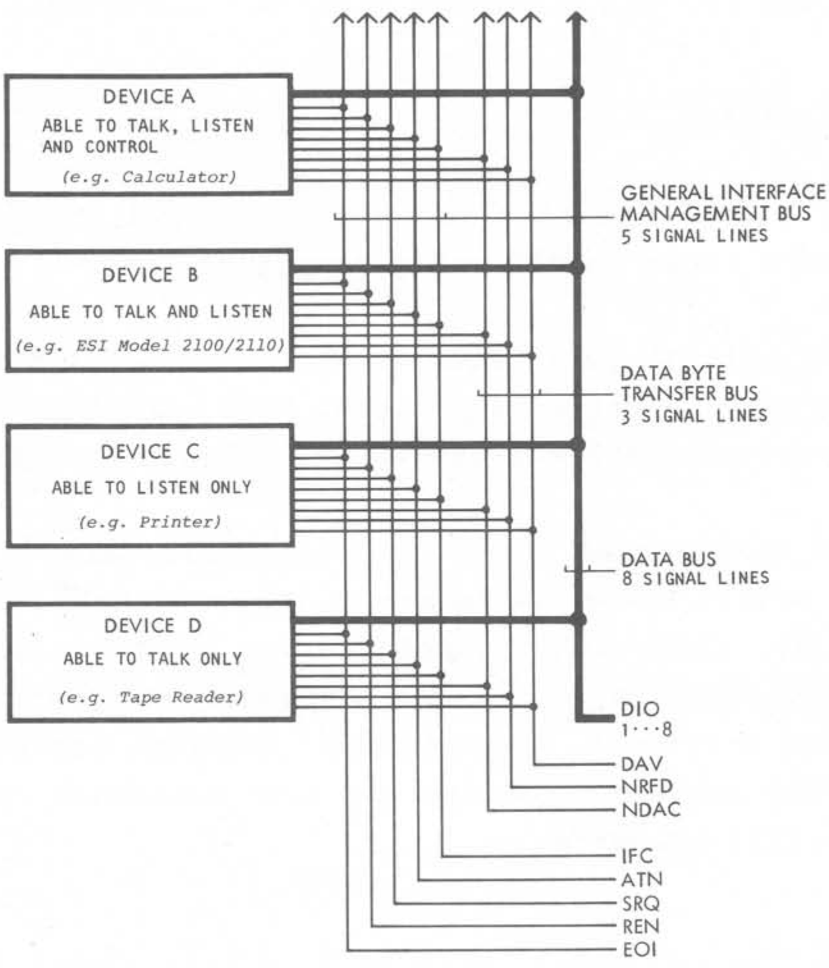


Figure A-4. A Typical IEEE-488 Bus Based System

A.2.3 Number of Devices

The IEEE-488 bus can handle up to 15 devices. More than 15 devices can be interfaced if they are not directly connected to the bus but are interfaced through another device. More than half of the main devices connected to the bus at any time must be powered up for the system to be operational.

A.2.4 Cable Length

The maximum cable length that can be used to connect a group of devices within one bus system is:

> 2 meters times the number of devices, or 20 meters, whichever is less.

Cables may be interconnected in either star or linear configuration, or in any combination of the two methods (see Figure A-5).

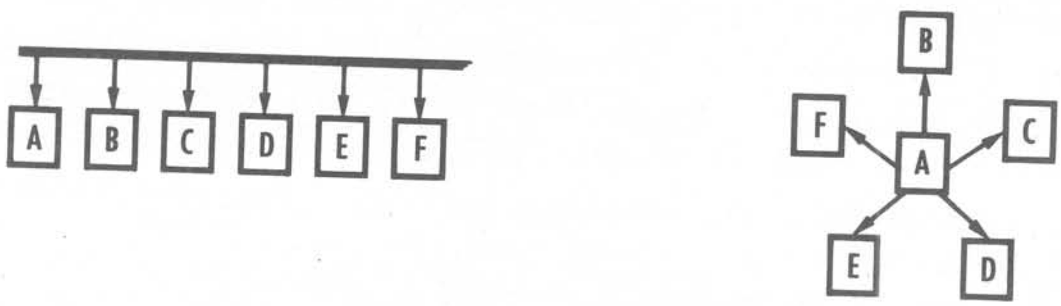


Figure A-5. IEEE-488 Bus Interconnection Configurations

A.2.5 Electrical Specifications

The relationship between the binary logic states and their voltage levels is as follows:

Logical State	Voltage Level
Ø	$\geq$ +2.ØV High is inactive state
1	$\leq$ +Ø.8V Low is active state

The high and low electrical states are based on standard TTL (transistor-transistor logic) levels where the power source does not exceed +5.25VDC and is referenced to logic ground.

A.2.6 Signal Lines

The IEEE-488 bus is divided by function into three separate busses: an eight-line data bus, a three line transfer bus, and a five-line management bus (see Figure A-5).

The data bus (signal lines DIO 1 through DIO 8) are used to convey data or device-dependent messages. DIO 1 represents the least significant bit in the transmitted byte; DIO 8 represents the most significant bit. One eight-byte word can be transmitted bidirectionally in byte-serial, bit parallel fashion. The data lines are considered active when their signal level is low.

The transfer bus is a three-wire handshake process that is executed between the talker and all designated listeners each time a byte is transferred over the data bus. This handshake process assures that new data is not placed on the data bus faster than the slowest listener can receive it. The three transfer bus lines and their functions are:

NRFD (Not Ready For Data) -- This signal line is low until all addressed listeners are ready to receive the next data byte. When all addressed listeners are ready, they release the NRFD line, the NRFD signal goes high, allowing the talker to place the next byte on the data line.

DAV (Data Valid) -- The DAV signal line is set low by the talker a short time after placing a valid byte on the data lines. This signal tells each listener to capture the byte presently on the data lines. DAV can not be set low until the NRFD signal goes high.

NDAC (Not Data Accepted) -- The NDAC signal line is set low by each addressed listener until they all have captured the byte currently on the data lines. When all listeners have captured the data byte, the NDAC signal goes high. With the NDAC signal high, the talker is able to remove the byte from the data lines and at that point set the DAV line high until the handshake cycle is repeated.

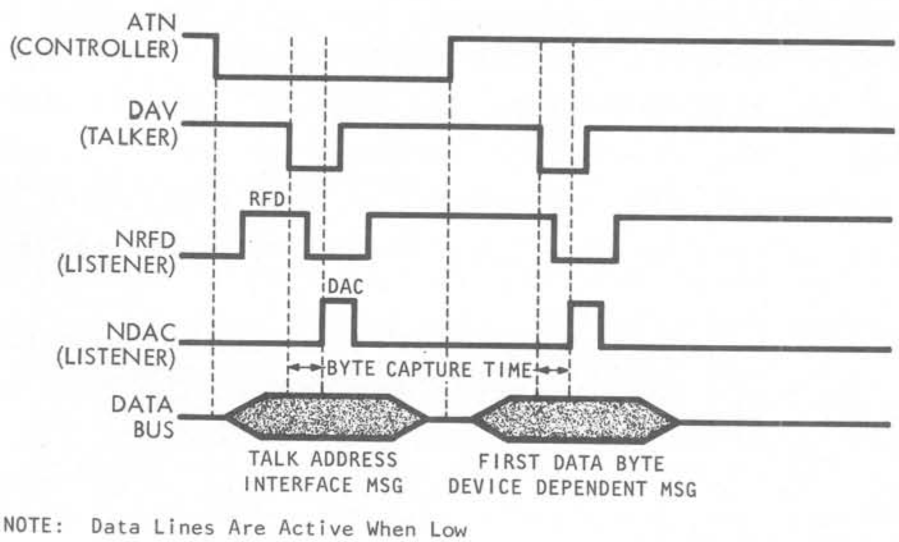


Figure A-6. A Typical Handshake Cycle

The group of signal lines used to control the orderly flow of information across the IEEE-488 data bus is called the management bus. These signal lines perform such important tasks as detecting interrupts, setting a device to remote control, and announcing the end of a message. The five management bus signals are:

ATN (Attention) -- This signal specifies how data on the bus are to be interpreted. It also specifies which devices along the bus must respond to the data. When ATN is set low, the data bus will convey addressed commands, talk addresses (MTA), listen addresses (MLA), secondary addresses, or universal commands. The codes corresponding to these various commands and addresses are defined in Appendix E of the IEEE-488 standard.

IFC (Interface Clear) -- This signal is set low, by the system controller, to initialize the interface functions of all devices connected to the data bus, i.e., set them to an inactive state, then return control to the system controller.

SRQ (Service Request) -- This signal line is set low, by a device connected to the data bus, to request service from the system controller. The controller conducts a poll to determine which device activated the interrupt. The controller can take the appropriate action by branching to an interrupt service routine.

EOI (End Or Identify) -- The EOI line is set low to indicate the end of a multiple byte transfer sequence. The controller executes a parallel polling sequence when the EOI and the ATN lines are set low simultaneously. The Model 2100/2110 does not support the parallel polling mode.

REN (Remote Enable) -- The system controller sets this line low to activate the remote mode in the instruments on the bus. When in the remote mode, the front panels of the instruments are disabled except for non-programmable functions.

A.2.7 Bus Connector

Instruments that connect to the IEEE-488 bus use of 24 contact, trapizoidal, polarized shell connector. The contact assignments for the connector are shown in Table A-2.

CONTACT	SIGNAL LINE	CONTACT	SIGNAL LINE
1	DIO 1	13	DIO 5
2	DIO 2	14	DIO 6
3	DIO 3	15	DIO 7
4	DIO 4	16	DIO 8
5	EOI	17	REN
6	DAV	18	Gnd (6)
7	NRFD	19	Gnd (7)
8	NDAC	20	Gnd (8)
9	IFC	21	Gnd (9)
10	SRQ	22	Gnd (10)
11	ATN	23	Gnd (11)
12	SHIELD	24	Gnd LOGIC

NOTE: Gnd (n) refers to the signal ground return of the referenced contact.

Table A-2. IEEE-488 Bus Connector Contact Assignments

A.2.8 Instrument Address Selection

Bus addresses for the 2100/2110 are set via switches on the GPIB interface circuit card (see Figure A-7). Primary bus addresses can be set over the full range allowed by the IEEE-488 standard: 32 to 62 (decimal) for LISTEN addresses and 64 to 94 (decimal) for TALK addresses. However, the values of the LISTEN and TALK addresses are not independent since they share the same switch setting (see Figure A-7). The address switches are set in binary fashion. The LISTEN address is achieved by the instrument's software automatically adding 32 to the switch setting. The TALK address is achieved by adding 64 to the switch setting.

The first five switch positions, starting with the top switch position, are used to set the LISTEN and TALK addresses. A switch position is activated when its left side is down, see Figure A-7. The decimal values for the first five switch positions are: 1, 2, 4, 8, and 16. In Figure A-7, switch positions 1 and 2 are activated providing: a value of 3, a LISTEN address of 35, and a TALK address of 67.

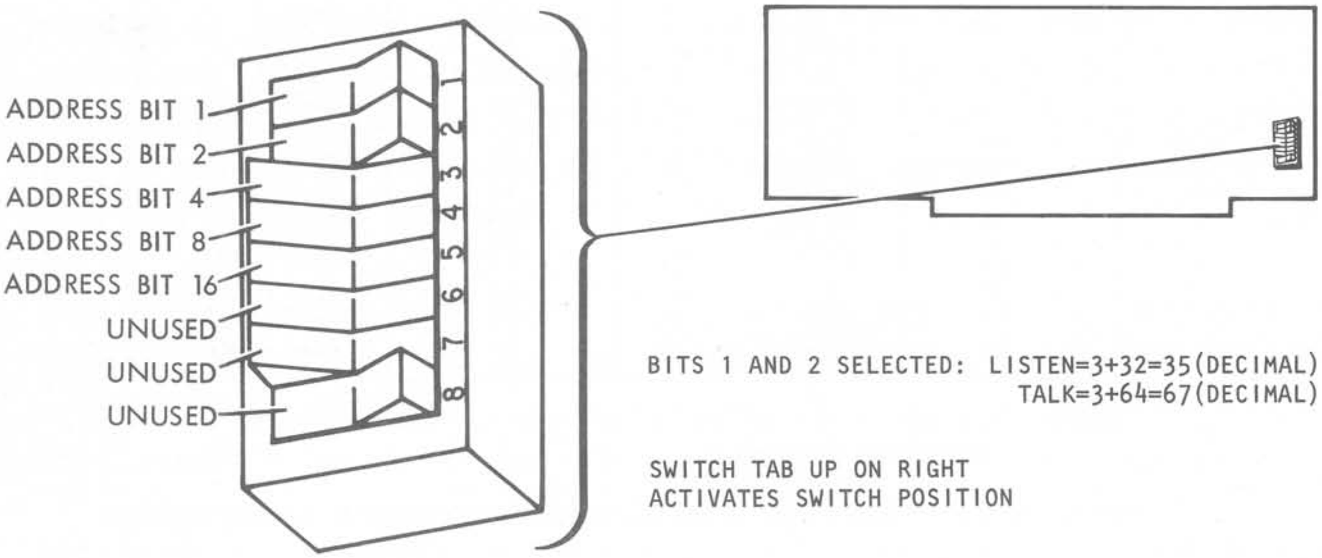


Figure A-7. GPIB Address Switches

A.2.9 GPIB Option Installation

WARNING

TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS INSTRUCTION MANUAL. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED HERE ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.

CAUTION

TO AVOID DAMAGE TO CIRCUITRY, TURN AC POWER OFF WHILE PLUGGING IN OR REMOVING CIRCUIT CARDS.

GPIB option installation involves plugging in the GPIB circuit card (ESI P/N 64114) and one or more Interrupt-Chain circuit cards (ESI P/N 48194). The GPIB circuit card is plugged into either slot shown in Figure A-8. Fill all empty circuit card slots with Interrupt-Chain circuit cards.

> **NOTE:** The Interrupt-Chain circuit cards are installed with the arrow, on the card, pointing toward the front of the instrument.

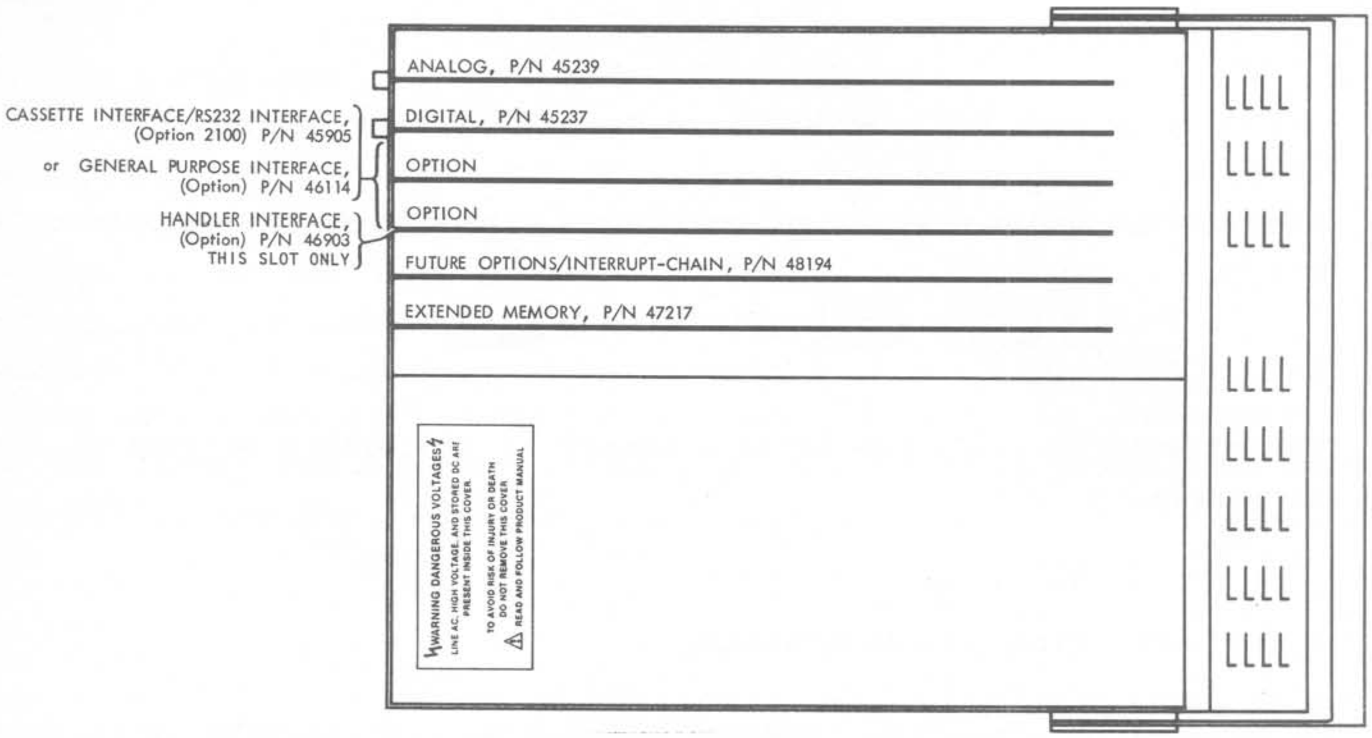


Figure A-8. GPIB Circuit Card Location

The GPIB Interface option will only work with instruments that have D revision letter, or greater, motherboards, and that have software revision 1.5 or greater. The motherboard revision letter is located on the bottom side of the motherboard in the location shown in Figure A-9.

> **NOTE:** D revision motherboards do not allow use of the 2100/2110's external START feature. Contact ESI if you have a D revision motherboard and want to use the external START feature.

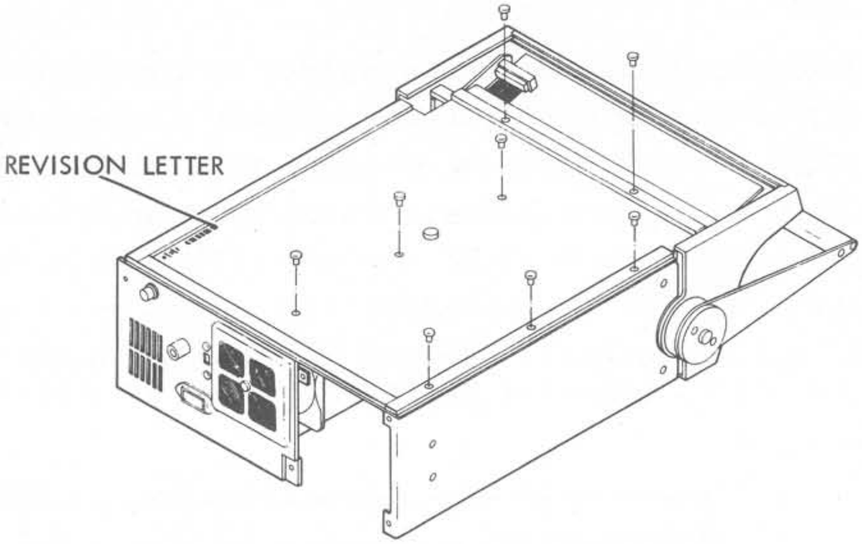


Figure A-9. Motherboard Revision Letter Location

To determine which revision of software is present in your instrument:

Push [7] [yellow key] (yellow key) [CODE]

The software revision number will appear at the bottom portion of the CRT screen.

A.2.10 GPIB Interface Programming

The process of using the IEEE-488 bus can be conveniently split into two phases:

Instrument Setup
Result Accumulation

A.2.10.1 Instrument Setup

After being addressed, the VideoBridge continuously checks for input from the IEEE-488 bus as it takes measurements or waits for input. If IEEE input is available, the instrument keyboard is disconnected and the IEEE bus is connected as the input device. Characters are received from the IEEE-488 bus as ASCII character strings and submitted to the 2100/2110 in the same manner as strings from the keyboard. In other words, transmitting the string:

5 -5 1 BIN# <CR> <LF>

over the IEEE-488 bus will be like performing the same operation at the 2100/2110 keyboard. The key to programming is that the string submitted over the IEEE-488 bus must be exactly what appears on the screen when the 2100/2110 keys are pushed (see Table A-3). For example, when the mV button is pushed, MILLIVOLTS appears on the screen in the operator communication area. It is always what appears on the screen and not what appears on the keyboard which must be transmitted over the IEEE-488 bus.

Table A-3. Model 2100/2110 Remote Setup Dictionary

KEYBOARD COMMANDS	IEEE-488 PROGRAMMING COMMANDS	DESCRIPTION
MEASUREMENT CONTROLS		
SGL	SINGLE	Single Measurement Mode
CONT	CONTINUOUS	Continuous Measurement Mode
SER	SERIES	Series Equivalent Circuit
PRL	PARALLEL	Parallel Equivalent Circuit
CAL	CALIBRATE	Zero Correction (test leads/fixture)
HOLD	HOLD	Range Hold
AUTO	AUTO	Autorange
DISPLAY CONTROLS		
XCHG	EXCHANGE	Function Exchange (on CRT)
STAT	STATUS	Status (limits) Display
SORT	SORT	Enter Sorting Mode
DEV	DEVIATION	Deviation Display (top function only)
DIR	DIRECT	Direct Display (normal operation)
IMPEDANCE FUNCTIONS		
Q	Q	Quality Factor Measurement Function
D	D	Dissipation Factor Measurement Function
G/R	G/R	Conductance (G)/Resistance (R) Measurement Function
C	C	Capacitance Measurement Function
L	L	Inductance Measurement Function
Y/Z	Y/Z	Admittance (Y)/Impedance (Z) Measurement Function
B/X	B/X	Susceptance (B)/Reactance (X) Measurement Function
DEL	RUB OUT	Delete the last character entered
ENTER	SPACE BAR	Spacing device when programming
CASSETTE FUNCTIONS		
LOAD	LOAD-FILE	Load Programs via Cassette Tape
SAVE	SAVE-FILE	Save Programs On Cassette Tape
DEVIATION AND LIMITS FUNCTIONS		
BIN#	BIN#	Bin Number Entry
MINOR	MINOR	Minor Number or Maximum/Minimum Reject Entry
%	%MODE	Percent (deviation) Mode
ABS	ABSMODE	Absolute (deviation) Mode
NOM	NOMINAL	Nominal Value Entry
TEST FREQUENCY AND LEVEL		
Hz	HZ	Test Frequency Entry
mV	MILLIVOLTS	Test Voltage (signal level) Entry
mA	MILLIAMPS	Test Current (signal level) Entry

Table A-3. Model 2100/2110 Remote Setup Dictionary (Continued)

KEYBOARD COMMANDS	IEEE-488 PROGRAMMING COMMANDS	DESCRIPTION
MEASUREMENT TIME		
SETL	MS-SETTLING-TIME	Settling Time Entry
I.T.	INTEGRATION-TIME	Integration Time Entry
AVG	SAMPLES-AVERAGED	Average Measurements Entry
FAST	FAST	Fast Measurement Speed
MED	MEDIUM	Medium Measurement Speed
SLOW	SLOW	Slow Measurement Speed
NUMERICAL PREFIXES		
m	MILLI	Milli 10^{-3}
k	KILO	Kilo 10^{3}
M	MEGA	Mega 10^{6}
p	PICO	Pico 10^{-12}
n	NANO	Nano 10^{-9}
μ	MICRO	Micro 10^{-6}
SPECIAL FUNCTIONS		
CODE	CODE	Extra Functions Entry
	REMOTE [	Temporarily Disconnect the Keyboard and Startswitch (start of setup)
	]	Re-activate the Keyboard and Start-switch at the end of setup unless the
	LOCK	command was part of the setup
	REMOTEON	Measurement Results into IEEE Buffer
	REMOTEOFF	No Measurement Output
	LOCK	Keyboard Lock Out
	UNLOCK	Re-activate the Keyboard
	SCREENOFF	Display Lock Out
	SCREENON	Enable CRT Display

The IEEE-488 input is not echoed on the screen and carriage returns <CR> are necessary, line feeds <LF> are optional. With the exception of "REMOTE[" and "]", multiple commands can appear on the same line.

To allow fastest setup times and also to ensure that the IEEE-488 input will not be disturbed by keyboard input between successive lines of setup information, the first character output (instruction in the program) should be:

"REMOTE["

which temporarily disconnects the keyboard and external START switch. This character must sit on a line by itself followed by a carriage return before additional input will be accepted by the 2100/2110.

The "]" character is issued at the end of the setup phase to restore the instrument to its measurement loop and make the keyboard active again. "]" also issues a service request which will indicate if any errors occurred during the measurement. The setup program must explicitly lock the keyboard out if that is desired. This may be done with the LOCK command. After the desired measurements have been made, the instrument can be UNLOCKed.

If an error occurs as the 2100/2110 processes the setup information, it will be indicated in the status byte transmitted by the service request generated by "]" at the end of the setup phase. After the controller has set up the 2100/2110, it must perform a serial poll at the instrument's bus address and make sure no errors have occurred. In the case of multiple errors, only the last error will be indicated. Example:

UNDEFINED ARGH!

In this example, "ARGH!" was unknown when the 2100/2110's dictionary was searched. It may also be helpful too if the controller prints each string on its operator console as it transmits it to the 2100/2110, and then prints the error string received from the 2100/2110. This will greatly facilitate the development of setup programs.

Example Setup:

```
REMOTE[
  REMOTEON            % MEASUREMENT RESULTS INTO IEEE BUFFER
  SCREENOFF           % LOCK OUT CRT DISPLAY
  LOCK                % LOCK OUT THE KEYBOARD
  1000 HZ             % SET FREQUENCY
  FAST                % SET AVERAGES, INTEGRATION TIME AND
                      % SETTLING TIME
  C D                 % MEASUREMENT FUNCTIONS
  SERIES              % SERIES EQUIVALENT CIRCUIT
  2 CODE              % SET ALL BINS TO ZERO
  1 -1 1 BIN#
  5 -5 2 BIN#
  10 -10 3 BIN#
  20 -20 4 BIN#       % SET UP BIN VALUES
  100 NANO NOMINAL    % NOMINAL VALUE
  .0005 MINOR         % SET MINOR REJECT VALUE
]                     % END OF SETUP
                      % THIS INITIATES A SERVICE REQUEST
                      % WITH STATUS OF THE SETUP
  SINGLE              % REQUEST FIRST READING AND
                      % WAIT FOR SERVICE REQUEST
```

SETUP COMMENTS

The percent sign (%) is used to separate comments from the information which is to be acted upon by the 2100/2110. Therefore, comments can be included with the setup information as shown in the preceeding example.

SEPARATORS

All numbers and words in the setup strings must be separated by either SPACES, TABS, or be followed by a CARRIAGE RETURN.

LINE TERMINATION

Line feeds are accepted and discarded. A carriage return is all that is required.

UPPER AND LOWER CASE

Lower case characters are equivalent to upper case characters when naming definitions in the dictionary. When in doubt, use upper case characters. Comments can be either upper or lower case characters.

ERRORS DURING SETUP

Any errors occurring during the remote setup will result in an english description of the error and, in the case of undefined words, the offending word. This information becomes available after the "]" is digested by the instrument. If all went well the string "NO ERRORS" will be transmitted. In the case of multiple errors only the last will be transmitted.

DATA OVERFLOW

Data flowing into the GPIB Interface option is placed in an intermediate queue, on an interrupt basis, allowing up to two-hundred characters of input to back-up before overflow occurs. This technique allows full lines of data to be transmitted without concern about lost data.

However, should the serial device fail to interpret control S as a request to terminate transmission the input queue will overrun and information will be lost. At this point, the GPIB will not respond to additional input. The 2100/2110 must remove data from the queue until it is no more than one-quarter full, then it can accept data again.

Data overflow will result in a hung bus and should be considered carefully if several instruments require prompt service. One may always construct the setup in multiple phases of less than 256 characters each and then wait for the service-request to indicate phase completion before transmission of the next phase.

SETUP CAUTIONS

During the setup phase it is convenient to issue a STATUS command so the process of bin setup is visible on the screen. Remember that when the setup is complete STATUS must be issued again to put the instrument in the measurement mode. Otherwise the SINGLE measurement commands will not result in the transmission of measurement data to the remote device.

In summary, the procedure for remote setup is:

STEP 1. Sit down with a pad of paper and write what appears on the screen as you push the keys and set up the instrument manually.

STEP 2. Add "REMOTE[" to the start of this list of words "]" to the end. Be sure that these two words each sit on a separate line apart from the other words.

STEP 3. Write a program in the language of the computer which will be setting up the 2100/2110 which outputs this list of words to the remote programming device.

STEP 4. After the list has been transmitted, request an output from the 2100/2110 (take one reading) and make certain no errors are encountered.

A.2.10.2 <u>Result Accumulation</u>

Special Display Words

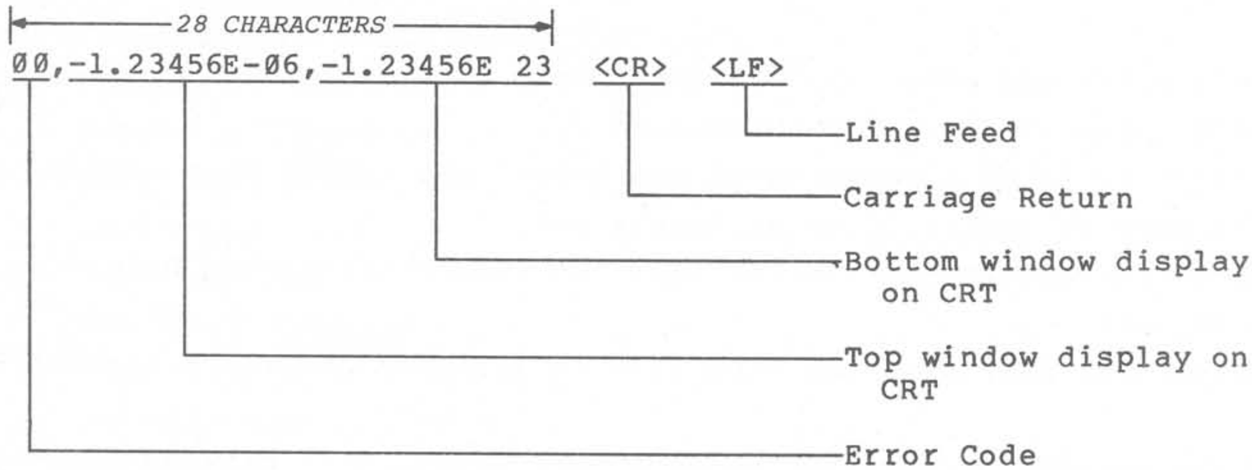
Here, the word display is used to indicate some form of output. One form is the top and bottom display on the instrument screen - the one formed in large characters. Another is the more standard floating point numbers which are output to the remote device after a SINGLE command has been remotely issued. The conversion of an inner floating point representation to a string of characters suitable for display takes considerable processing time. The following words were devised so the time between measurements can be as brief as possible.

SCREENON/SCREENOFF

This pair of words enables and disables the large video display on the screen of the 2100/2110. When the instrument is not being monitored on site and the measurement results are being transmitted by way of the remote output, SCREENOFF will greatly increase measurement speed.

REMOTEON/REMOTEOFF

REMOTEON must be part of the setup information before the results of a measurement are transmitted to the remote device which last transmitted information to the 2100/2110. The output string looks like this:



The field sizes are fixed so FORTRAN programs can use fixed field format statements to receive the input.

LOCK/UNLOCK

LOCK is issued in the setup phase to lock out the keyboard of the instrument during remote operation. UNLOCK can be issued at the termination of a run to restore control, or the keyboard can be unlocked by using pin 21 of the Handler Interface circuit card in case one wishes to override the remote device.

REMOTE[/]

REMOTE[disables the 2100/2110 keyboard and directs error messages normally appearing in the bottom reverse video line of the 2100/2110 to the remote device. It also disables the instrument from taking measurements during the setup phase. <u>It is absolutely necessary that this word appear on a line by itself!</u>

] restores the instrument to measurement mode and, if the setup didn't lock out the keyboard, re-enables the keyboard, and generally undoes any change made by REMOTE[. This word also must appear on a line by itself!

The protocol for taking measurements is:

-Controller addresses the 2100/2110 as a listener.
-Controller issues a SINGLE command.
-2100/2110 takes a measurement and stores the result in a buffer, sets the service request line at completion.
-Controller performs a serial poll and inputs the status byte from the 2100/2110.
-Controller addresses the 2100/2110 as a talker and reads the buffer.

If the controller neglects to conduct a serial poll between commanding measurements, the previous measurement will be written over.

The IEEE-488 protocol does not support the use of continuous mode measurement. The controller must initiate each measurement by the use of a SINGLE command. If continuous is used, then no guarantee is made that the 2100/2110 is not writing to the middle of the buffer at the same time that the controller is reading the buffer.

Error code assignments for 21ØØ/211Ø.

ØØ	No error
Ø1	Unused
Ø2	Stack Empty
Ø3	Stack Full
Ø4	Syntax Error
Ø5	Dictionary Full
Ø6	Compiler Buffer Full
Ø7	Vocabulary Stack Full
Ø8	Vocabulary Stack Full
Ø9	Loop Stack Empty
1Ø	Loop Stack Full
11	Undefined Word
12	Ram Space Full
13	Open File Error (CPM only)
14	Bad Filename (CPM only)
15	Unused
16	Block Error (Tape I/O)
17	Unused
18	End of File Encountered
19	Unused
2Ø	Floating Point Overflow
21	Floating Point Underflow
22	Float -> Fix error - Number too big
23	Unused
24	Unused
25	Float -> Double Precision Fix error - number too big
26	Unused
27	Input overloaded
28	Can't supply volts
29	Can't supply current

A.2.11 Calibration

The 2100/2110 needs no adjustment, other than normal calibration, when the GPIB option is installed. The GPIB Interface circuit assembly contains no service adjustments.

WARNING

TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS INSTRUCTION SHEET. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED IN THIS INSTRUCTION SHEET ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.

A.3 RS-232C INTERFACE OPTION

The RS-232C Interface option is used to interface the 2100/2110 Video-Bridge to peripheral equipment; i.e. video display terminals, keyboards, printers, etc. With this option installed, the 2100/2110 can interface with:

0-20mA Current Loop Systems
RS-232C Systems.

A.3.1 0-20mA Current Loop Systems

Constant current loops were originally used in devices like the teletype. As a result, some of todays faster terminals also use current loops. The RS-232C option provides a communication link to these types of terminals.

The RS-232C option's rear panel output connector has pins 17 and 24 reserved for the + and - sides of the RECEIVER input to the 2100/2110, while connector pins 23 and 25 are reserved for the + and - sides of the TRANSMIT output from the 2100/2110. Data are transmitted by opening (SPACE or no current flow) and closing (MARKing) the current loop.

NOTE: Teletypes are not supported by this option because they need two STOP bits. However, the option will support devices that operate at 110 baud and that will accept 1 STOP bit.

A.3.2 RS-232C Systems

The RS-232C standard defines electrical, logical, and mechanical specification for the transmission of bit serial information. The VideoBridge's RS-232C option supports two bidirectional communication channels (A and B) that are used to communicate instrument setup and measurement information.

NOTE: ESI recommends using RS-232C Channel B only. Channel A is reserved for future programming features.

A.3.2.1 Channel A

Serial Channel A is an input channel only. Input characters are echoed back to the terminal for display. Channel A allows the instrument to be set up via an external terminal. Keyboard control is transferred from the VideoBridge to the external terminal by special function CODE 4. Transfer of control is signaled by the prompt "Ø>" appearing on the terminal's screen. All terminal entries are echoed back and displayed on the terminal's screen. See Section A.3.9 for programming instrument setup instructions.

A.3.2.2 Channel B

Channel B is used in two ways:

1. As a serial output for driving a printer.

2. As a means to provide remote programming. Programming instrument setups is very similar to that used on the IEEE-488 Interface Bus.

Data flowing into Channel B is placed in an intermediate queue on an interrupt basis. It allows up to two-hundred characters of input before overflow occurs and it enables full lines of data to be transmitted without concern about lost data.

NOTE: Entries made through channel B are not echoed back for display.

The Channel B output buffer transmits three pieces of data when the remote display mode is activated (by including the command REMOTEON as part of the setup program) and the measurement is completed.

1. A two digit error code.

2. Measurement from the top window of the instrument.

3. Measurement from the bottom window of the instrument.

See Section A.3.9 for measurement output information.

A.3.2.2.1 RS-232C Signal Flow

The simplest use of the RS-232C bus requires three lines.

RS-232C OPTION CONNECTOR PIN		SIGNAL NAME
Channel A	Channel B	
2	14	Receive Data
3	16	Transmit Data
7	7	Signal Ground

As shown in Figure A-1Ø, the terminal's transmit line points toward pin 2 of the 21ØØ/211Ø, and pin 3, the 21ØØ/211Ø transmit line, points toward the data terminal. When the 21ØØ/211Ø is to act as a terminal, the meanings and direction of signal flow are interchanged.

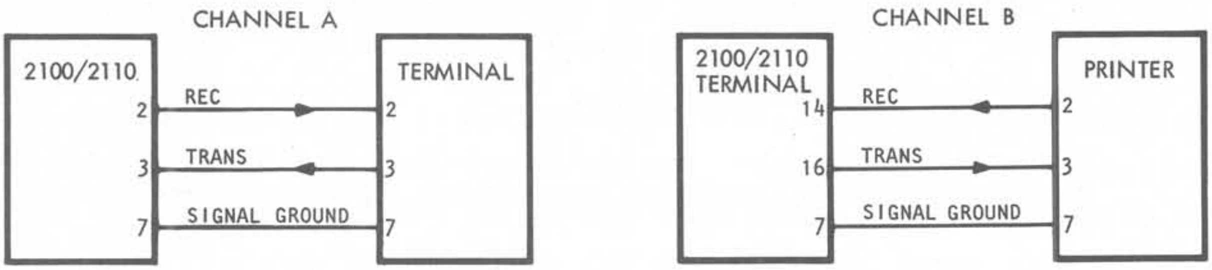


Figure A-10. RS-232C Signal Flow

Because Channel A is normally used to connect to a local terminal, it only uses the three signal lines shown in Figure A-10. This provides for very simple interconnection. However, some RS-232C terminals require additional signals to those mentioned above. They may require that the Data Set Ready (pin 6) or the Clear to Send (pin 5) or both be set high (true) to indicate readiness to transmit information. In such cases, connect pins 5 and 6 to pin 4. Pin 4 is the Request to Send line and is set high by the terminal RS-232C option connector to indicate when it is ready to transmit information. By connecting this signal to pins 5 and 6, conditions for data transmission are met.

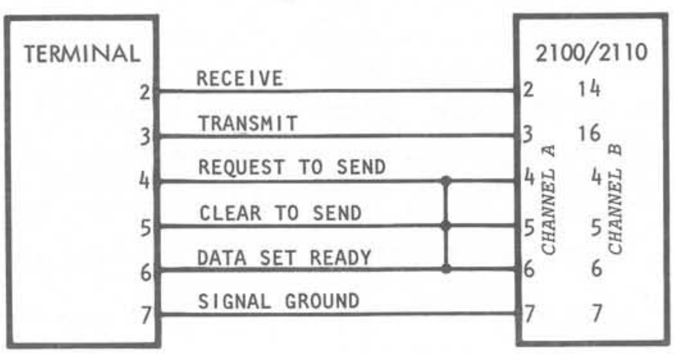


Figure A-11. RS-232C with Request to Send, Clear to Send, and Data Set Ready.

NOTE: Occasionally, pin 2Ø (Data Terminal Ready) is used in place of pin 4 (Request To Send). Therefore, if connecting to pin 4 doesn't work, try connecting pins 5 and 6 to pin 2Ø.

A.3.3 Cable Length

Cable length for RS-232C transmission will vary according to the baud rates selected. For maximum transmission rate of 96ØØ baud, a cable length of less than 1ØØ feet must be used. The capacitance of the cable must be less than 5ØØØ picofarads. The essential parameter is the signal risetime which must be less than 1/2 the bit width so that the sampled signal will be correct. Each time the baud rate is halved the allowable risetime doubles and the acceptable cable capacitance doubles. Therefore, 48ØØ baud can be transmitted over 2ØØ feet; 24ØØ baud will work at 4ØØ feet.

A.3.4 Signal Levels

Tables A-4 and A-5 show the signal levels specified by the RS-232C standard. The signal states shown in Table A-4 apply to the Receive and Transmit signals. Table A-5 applies to all control inputs.

NOTATION	SIGNAL STATE	
	POSITIVE	NEGATIVE
BINARY STATE	0	1
SIGNAL CONDITION	SPACING	MARKING
FUNCTION	ON	OFF
VOLTAGE LEVEL	+3V to +25V	-3V to -25V

Table A-4. RS-232C Receive and Transmit Signal Levels

NOTATION	SIGNAL STATE	
	POSITIVE	NEGATIVE
BINARY STATE	1	0
SIGNAL CONDITION	TRUE	FALSE
VOLTAGE LEVEL	+3V to +25V	-3V to -25V

Table A-5. RS-232C Control Signal Levels

A.3.5 Bus Connector

The pin assignments used by the RS-232C option are as follows:

CONNECTOR PIN	SIGNAL LINE
1	Chassis Ground
2	Transmitted Data from terminal (RS-232C IN)
3	Received Data to terminal (RS-232C OUT)
4	Request to Send (Channel A)
5	Clear to Send (Channel A)
7	Signal Ground
13	Clear to Send (Channel B)
14	Receive Data (Channel B)
16	Transmit Data (Channel B)
17	+ Current Loop Transmit
2Ø	Data Terminal Ready (Channel A)
23	+ Current Loop Receive
24	- Current Loop Transmit
25	- Current Loop Receive

Table A-6. RS-232C Pin Assignments

When connecting to the RS-232C option use a 36-contact, trapezoidal, polarized-shell connector; ESI P/N 2643Ø, Manufacturer P/N CINCH DB-25P.

A.3.6 Selecting the Baud Rate

Baud rate is equivalent to bits per second. The RS-232C Interface has the following baud rate selections:

15Ø	12ØØ	96ØØ
3ØØ	24ØØ	
6ØØ	48ØØ	

The RS-232C Interface circuit card is shipped with channels A and B wired for 96ØØ baud.

To select another baud rate:

1. Cut the circuit card stripe labeled W1, for Channel A, and/or W3, for Channel B, see Figure A-12.

2. Jumper between AXMIT and the desired baud rate for Channel A and/or between RECXMITB and the desired baud rate for Channel B.

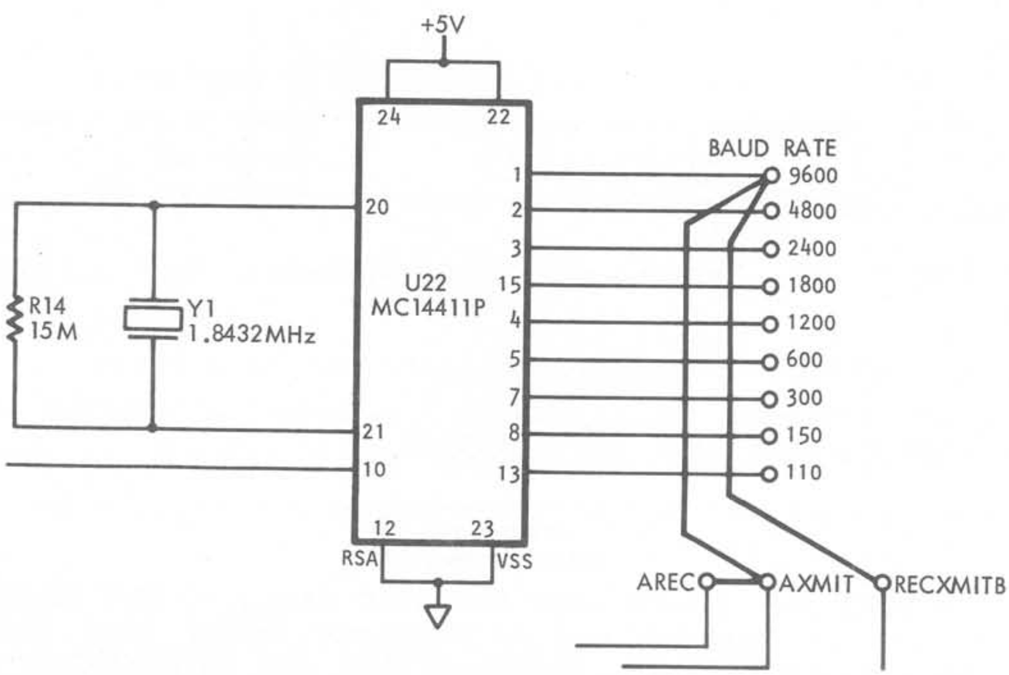


Figure A-12. Selecting the Baud Rate

The RS-232C option also provides independent baud rate clocks for the Channel A Transmitter and Receiver.

To select different Channel A Transmit and Receive baud rates:

1. Cut the circuit card stripes labeled W1 and W2 in Figure A-12.

2. Jumper between AXMIT and the desired Transmit baud rate.

3. Jumper between AREC and the desired Receiver baud rate.

NOTE: Channel B receive and transmit baud rates can not be set independently.

A.3.7 Data Format

The RS-232C option transmits and receives 7-bit ASCII with one Start bit and one Stop bit. There are no parity generation or checking bits.

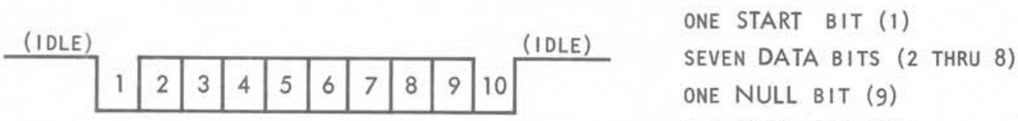


Figure A-13. Data Format

A.3.8 RS-232C Circuit Card Installation

WARNING

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CAUTION

TO AVOID DAMAGE TO THE CIRCUITRY, TURN POWER OFF WHILE PLUGGING IN OR REMOVING CIRCUIT CARDS.

RS-232C option installation involves plugging in the RS-232C Interface circuit card (ESI P/N 459Ø5) and one or more Interrupt-Chain circuit cards (ESI P/N 48194). The RS-232C circuit card is plugged into either slot shown in Figure A-14. Fill all empty circuit card slots with Interrupt-Chain circuit cards.

> **NOTE:** The Interrupt-Chain circuit cards are installed with the arrow, on the card, pointing toward the front of the instrument.

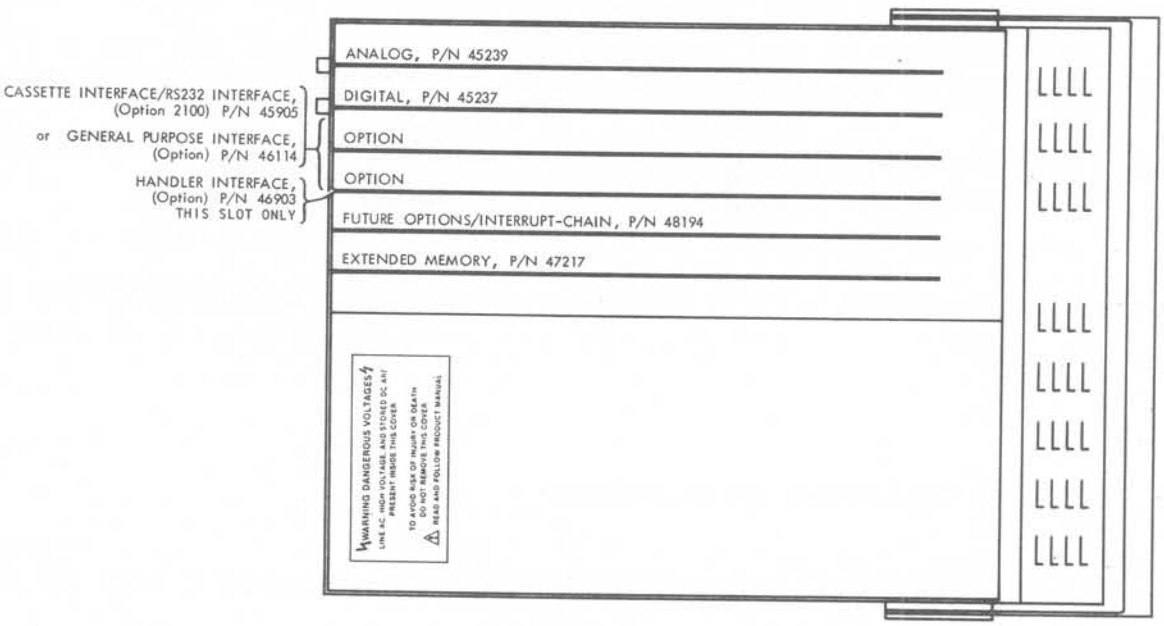


Figure A-14. RS-232C Interface Circuit Card Location

The RS-232C Interface option will only work with instruments that have D revision letter, or greater, motherboards, and that have software revision 1.5 or greater. The motherboard revision letter is located on the bottom side of the motherboard in the location shown in Figure A-15.

> **NOTE:** D revision motherboards do not allow use of the 21ØØ/211Ø's external START feature. Contact ESI if you have a D revision motherboard and want to use the external START feature.

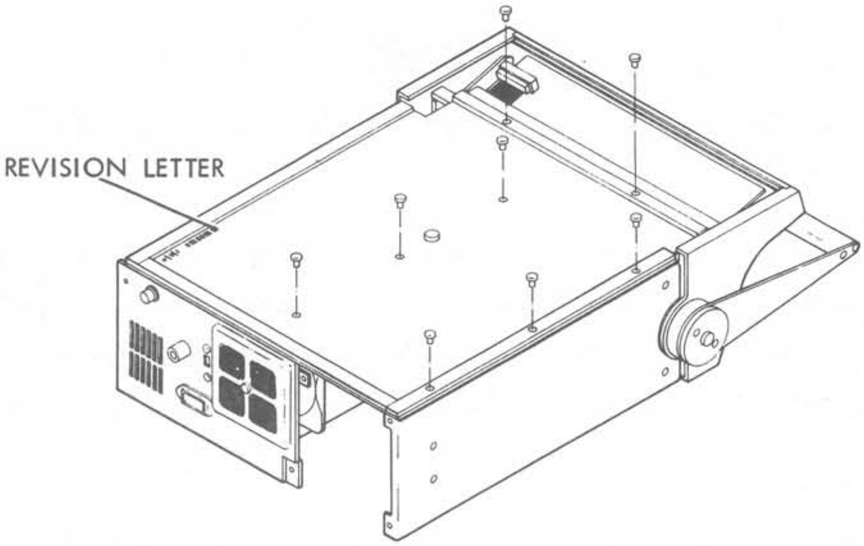


Figure A-15. Motherboard Revision Letter Location

To determine which revision of software is present in your instrument:

Push [7] [yellow key] (yellow key) [CODE]

The software revision number will appear at the bottom portion of the CRT screen.

A.3.9 RS-232C Interface Programming

The process of using the RS-232C Interface's Channel B can be conveniently split into two phases:

Instrument Setup
Result Accumulation

A.3.9.1 Instrument Setup

The VideoBridge continuously checks for input from the RS-232C bus as it takes measurements or waits for input. If RS-232C input is available, the instrument keyboard is disconnected and the RS-232C bus (Channel B) is connected as the input device. Characters are received from the RS-232C bus as ASCII character strings and submitted to the 2100/2110 in the same manner as strings from the keyboard. In other words, transmitting the string:

```
5 -5 1 BIN# <CR> <LF>
```

over the RS-232C bus (Channel B) will be like performing the same operation at the 2100/2110 keyboard. The key to programming is that the string submitted over the RS-232C bus (Channel B) must be <u>exactly what appears on the screen when the 2100/2110 keys are pushed</u> (see Table A-7). For example, when the mV button is pushed, MILLIVOLTS appears on the screen in the operator communication area. It is always what appears on the screen and <u>not</u> what appears on the keyboard which must be transmitted over the RS-232C bus.

Table A-7. Model 2100/2110 Remote Setup Dictionary

KEYBOARD COMMANDS	RS-232C PROGRAMMING COMMANDS	DESCRIPTION
MEASUREMENT CONTROLS		
SGL	SINGLE	Single Measurement Mode
CONT	CONTINUOUS	Continuous Measurement Mode
SER	SERIES	Series Equivalent Circuit
PRL	PARALLEL	Parallel Equivalent Circuit
CAL	CALIBRATE	Zero Correction (test leads/fixture)
HOLD	HOLD	Range Hold
AUTO	AUTO	Autorange
DISPLAY CONTROLS		
XCHG	EXCHANGE	Function Exchange (on CRT)
STAT	STATUS	Status (limits) Display
SORT	SORT	Enter Sorting Mode
DEV	DEVIATION	Deviation Display (top function only)
DIR	DIRECT	Direct Display (normal operation)
IMPEDANCE FUNCTIONS		
Q	Q	Quality Factor Measurement Function
D	D	Dissipation Factor Measurement Function
G/R	G/R	Conductance (G)/Resistance (R) Measurement Function
C	C	Capacitance Measurement Function
L	L	Inductance Measurement Function
Y/Z	Y/Z	Admittance (Y)/Impedance (Z) Measurement Function
B/X	B/X	Susceptance (B)/Reactance (X) Measurement Function
DEL	RUB OUT (on keyboard)	Delete the last character entered
ENTER	SPACE BAR (on keyboard)	Spacing device when programming
CASSETTE FUNCTIONS		
LOAD	LOAD-FILE	Load Programs via Cassette Tape
SAVE	SAVE-FILE	Save Programs On Cassette Tape
DEVIATION AND LIMITS FUNCTIONS		
BIN#	BIN#	Bin Number Entry
MINOR	MINOR	Minor Number or Maximum/Minimum Reject Entry
%	%MODE	Percent (deviation) Mode
ABS	ABSMODE	Absolute (deviation) Mode
NOM	NOMINAL	Nominal Value Entry

Table A-7. Model 2100/2110 Remote Setup Dictionary (Continued)

KEYBOARD COMMANDS	RS-232C PROGRAMMING COMMANDS	DESCRIPTION
TEST **FREQUENCY AND LEVEL**		
Hz	HZ	Test Frequency Entry
mV	MILLIVOLTS	Test Voltage (signal level) Entry
mA	MILLIAMPS	Test Current (signal level) Entry
MEASUREMENT TIME		
SETL	MS-SETTLING-TIME	Settling Time Entry
I.T.	INTEGRATION-TIME	Integration Time Entry
AVG	SAMPLES-AVERAGED	Average Measurements Entry
FAST	FAST	Fast Measurement Speed
MED	MEDIUM	Medium Measurement Speed
SLOW	SLOW	Slow Measurement Speed
NUMERICAL PREFIXES		
m	MILLI	Milli 10^{-3}
k	KILO	Kilo 10^{3}
M	MEGA	Mega 10^{6}
p	PICO	Pico 10^{-12}
n	NANO	Nano 10^{-9}
µ	MICRO	Micro 10^{-6}
SPECIAL FUNCTIONS		
CODE	CODE	Extra Functions Entry
	REMOTE[	Temporarily Disconnect the Keyboard and Start switch (start of setup)
	]	Re-activate the Keyboard and Start-switch at the end of setup unless the LOCK command was part of the setup
	REMOTEON	Measurement Results into RS-232C Buffer
	REMOTEOFF	No Measurement Output
	LOCK	Keyboard Lock Out
	UNLOCK	Re-activate the Keyboard
	SCREENOFF	Display Lock Out
	SCREENON	Enable CRT display

The RS-232C Channel B input is not echoed on the screen and carriage returns <CR> are necessary, line feeds <LF> are optional. With the exception of "REMOTE[" and "]", multiple commands can appear on the same line.

To allow fastest setup times and also to ensure that the RS-232C input will not be disturbed by keyboard input between successive lines of setup information, the first character output (instruction in the program) should be:

"REMOTE["

which temporarily disconnects the keyboard and external START switch. This character must be entered on a line by itself followed by a carriage return before additional input will be accepted by the 2100/2110.

The "]" character is issued at the end of the setup phase to restore the instrument to its measurement loop and make the keyboard active again. "]" automatically transmits error information. The setup program must explicitly lock the keyboard out if that is desired. This may be done with the LOCK command. After the desired measurements have been made, the instrument can be UNLOCKed.

If an error occurs as the 2100/2110 processes the setup information, it will be indicated by "]" at the end of the setup phase. In the case of multiple errors, only the last error will be indicated.
Example:

UNDEFINED ARGH!

In this example, "ARGH!" was unknown when the 2100/2110's dictionary was searched. It may also be helpful if the controller prints each string on its operator console as it transmits it to the 2100/2110, and then prints the error string received from the 2100/2110. This will greatly facilitate the development of setup programs.

Example Setup:

```
REMOTE[
  REMOTEON            % MEASUREMENT RESULTS INTO RS-232C BUFFER
  SCREENOFF           % LOCK OUT CRT DISPLAY
  LOCK                % LOCK OUT THE KEYBOARD
  1000 HZ             % SET FREQUENCY
  FAST                % SET AVERAGES, INTEGRATION TIME AND
                      % SETTLING TIME
  C D                 % MEASUREMENT FUNCTIONS
  SERIES              % SERIES EQUIVALENT CIRCUIT
  2 CODE              % SET ALL BINS TO ZERO
  1 -1 1 BIN#
  5 -5 2 BIN#
  10 -10 3 BIN#
  20 -20 4 BIN#       % SET UP BIN VALUES
  100 NANO NOMINAL    % NOMINAL VALUE
  .0005 MINOR         % SET MINOR REJECT VALUE
]                     % END OF SETUP
  SINGLE              % REQUEST FIRST READING
```

SETUP COMMENTS

The percent sign (%) is used to separate comments from the information which is to be acted upon by the 2100/2110. Therefore, comments can be included with the setup information as shown in the preceeding example.

SEPARATORS

All numbers and words in the setup strings must be separated by either SPACES, TABS, or be followed by a CARRIAGE RETURN.

LINE TERMINATION

Line feeds are accepted and discarded. A carriage return is all that is required.

UPPER AND LOWER CASE

Lower case characters are equivalent to upper case characters when naming definitions in the dictionary. When in doubt, use upper case characters. Comments can be either upper or lower case characters.

ERRORS DURING SETUP

Any errors occurring during the remote setup will be displayed as an english description of the error plus, in the case of undefined words, the offending word. This information becomes available after the "]" is processed by the instrument. If the setup went well the string "NO ERRORS" will be transmitted. In the case of multiple errors only the last will be transmitted.

DATA OVERFLOW

Data flowing into the RS-232C Interface option is placed in an intermediate queue, on an interrupt basis, allowing up to 256 characters of input to back-up before overflow occurs. This technique allows full lines of data to be transmitted without concern about lost data.

If the serial device fails to interpret control S as a request to terminate transmission, the input queue will overrun and information will be lost.

Once the queue is full, RS-232C Channel B responses to additional input are disallowed until the queue is one-quarter full.

Data overflow will result in a "hung" bus and should be considered carefully if several instruments require prompt service. One may always construct the setup in multiple phases of less than 256 characters each and then wait for phase completion before transmission of the next phase.

SETUP CAUTIONS

During the setup phase it is convenient to issue a STATUS command so the process of bin setup is visible on the screen. Remember that when the setup is complete STATUS must be issued again to put the instrument in the measurement mode. Otherwise the SINGLE measurement commands will not result in the transmission of measurement data to the remote device.

In summary, the procedure for remote setup is:

STEP 1. Sit down with a pad of paper and write what appears on the screen as you push the keys and manually set up the instrument.

STEP 2. Add "REMOTE[" to the start of this list of words and "]" to the end. Be sure that these two entries are each entered on a separate line apart from the other entries.

STEP 3. Write a program, in the language of the computer which will be setting up the 2100/2110, which outputs this list of words to the remote programming device.

STEP 4. After the list has been transmitted, request an output from the 2100/2110 (take one reading) and make certain no errors are encountered.

A.3.9.2 Result Accumulation

Special Display Words

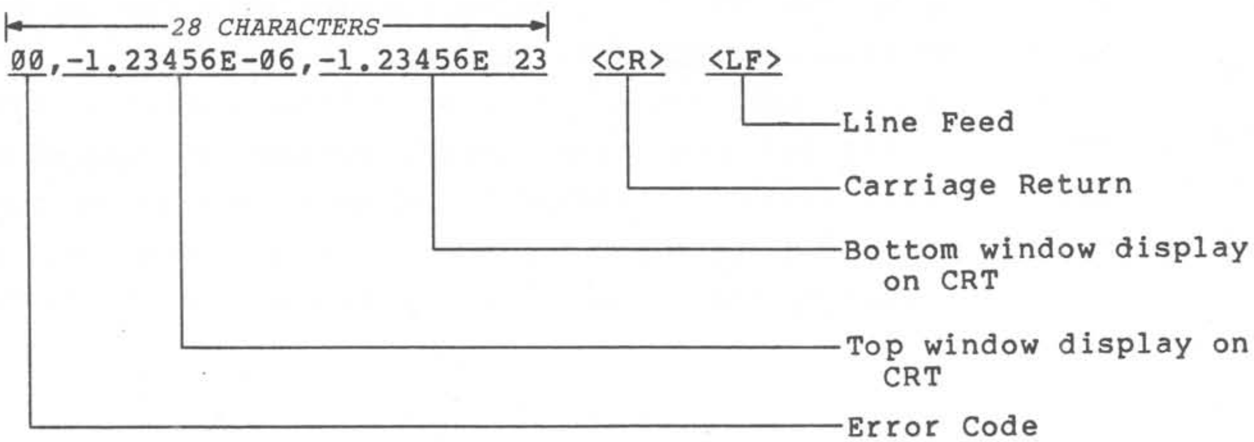
Here, the word display is used to indicate some form of output. One form is the top and bottom display on the instrument screen - the one formed in large characters. Another is the more standard floating point numbers which are output to the remote device after a SINGLE command has been remotely issued. The conversion of an inner floating point representation to a string of characters suitable for display takes considerable processing time. The following words were devised so the time between measurements can be as brief as possible.

SCREENON/SCREENOFF

This pair of words enables and disables the large video display on the screen of the 2100/2110. When the instrument is not being monitored on site and the measurement results are being transmitted by way of the remote output, SCREENOFF will greatly increase measurement speed.

REMOTEON/REMOTEOFF

REMOTEON must be part of the setup information before the results of a measurement are transmitted to the remote device which last transmitted information to the 2100/2110. The output string looks like this:



The field sizes are fixed so FORTRAN programs can use fixed field format statements to receive the input.

LOCK/UNLOCK

LOCK is issued in the setup phase to lock out the keyboard of the instrument during remote operation. UNLOCK can be issued at the termination of a run to restore control, or the keyboard can be unlocked by using pin 21 of the Handler Interface circuit card in case one wishes to override the remote device.

REMOTE[/]

REMOTE[disables the 2100/2110 keyboard and directs error messages normally appearing in the bottom reverse video line of the 2100/2110 to the remote device. It also disables the instrument from taking measurements during the setup phase. It is absolutely necessary that this word appear on a line by itself!

"]" restores the instrument to measurement mode and, if the setup didn't lock out the keyboard, re-enables the keyboard, and generally undoes any change made by REMOTE[. "]" also must appear on a line by itself!

Error code assignments for 2100/2110.

00	No error
01	Unused
02	Stack Empty
03	Stack Full
04	Syntax Error
05	Dictionary Full
06	Compiler Buffer Full
07	Vocabulary Stack Full
08	Vocabulary Stack Full
09	Loop Stack Empty
10	Loop Stack Full
11	Undefined Word
12	Ram Space Full
13	Open File Error (CPM only)
14	Bad Filename (CPM only)
15	Unused
16	Block Error (Tape I/O)
17	Unused
18	End of File Encountered
19	Unused
20	Floating Point Overflow
21	Floating Point Underflow
22	Float -> Fix error - Number too big
23	Unused
24	Unused
25	Float -> Double Precision Fix error - number too big
26	Unused
27	Input overloaded
28	Can't supply volts
29	Can't supply current

A.3.1Ø Calibration

The 21ØØ/211Ø needs no adjustment, other than normal calibration, when the RS-232C option is installed. The RS-232C Interface circuit assembly contains no service adjustments.

WARNING

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Final calibration of this instrument was performed with reference to the mean values of the ESI reference standards or to ratio devices that were verified at the time and place of use.

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