NOTE

Keep the EXT BIAS switch OFF (regardless of whether any external bias source is connected) for all measurements made WITHOUT dc bias applied to the DUT. (Switch ON, without a low-impedance bias source causes errors in measurement.)

To measure capacitors with dc bias voltage applied:

3.7.1 Bias Less Than 30 V and C Less Than 1000 μF.

a. Connect a bias supply via rear-panel connector, observing polarity, as described in para 2.6. Be sure the bias supply meets the requirements (such as current sinking and limiting to 200 mA) given in that paragraph. Generally, the external circuit must include switching for both application of bias and discharge of the DUT.

b. For capacitors less than 1000 μF only, with bias less than 30 V, use the EXT BIAS switch on the keyboard to apply bias (ON) and to discharge the DUT (OFF).

Notice that this switch should NOT be used for this purpose above 30 V, or 1000 μF, or for production quantity measurements. In such cases, leave the EXT BIAS switch ON and use switches in the external circuit.

c. Be sure to orient the DUT correctly, positive terminal to the right.

d. Operate the bridge in the usual way. Disregard any measurements that may be made by the Digibridge in continuous measurement mode during the charge or discharge transients. Notice that the BIAS ON light indicates the presence of bias voltage; it goes off when the voltage drops to zero even though the EXT BIAS switch may be ON. It will not light if the bias power supply polarity is inverted.

3.7.2 Bias Up to 60 V.

a. Observe the warning above.

b. Connect bias power supply and external switching circuit as described above.

c. Keep the EXT BIAS switch ON (toward the rear) regularly, unless you want to use it as an extra safety device. As a safety device, be sure to turn it ON before the external switch and OFF a second or more after the external switch is off.

To protect the operator and to avoid damaging the instrument, define a safe procedure like the one that follows and use it regularly:

a. Set the bias voltage to zero.
b. Attach the DUT, with correct polarity.
c. Raise the bias voltage to the specified value.
d. Allow a specified charging and soaking time.
e. Observe and record measurements (usually Cs and D).
f. Set the bias voltage source to zero.
g. Connect the 10-Ω discharging circuit.
h. After about 2 s, connect the safety short circuit.
i. Remove the DUT.

3.8 OPERATION WITH A HANDLER

If you have the interface option and have made the system connections to a handler (para 2.7), the essential Digibridge operating procedure is as follows:

a. Enter the bin limits as described above.

b. Select the measurement conditions as desired: MEASUREMENT RATE, EQUIVALENT CIRCUIT, MEASUREMENT MODE (SINGLE), RANGE HOLD (or autorange). (Do NOT change FREQUENCY or parameter – R, L, C – after limits have been entered.)

c. Select either BIN or VALUE DISPLAY for incidental monitoring of measurements while the handler automatically sorts the parts being processed.

3.9 SYSTEM CONSIDERATIONS

These considerations apply only if you have the interface option. (If you do, there will be interface connectors at the rear. See Figure 1-2.)

3.9.1 IEEE-488 Interface Unused.

If there is no system connection to the IEEE-488 INTERFACE connector, be sure to keep the TALK switch set to TALK ONLY.

3.9.2 Talk-Only Use.

This pertains to a relatively simply system, with the Digibridge outputting data to one or more "listen-only" (IEEE-488 compatible) devices such as a printer.

Operate the Digibridge in the usual way (manually). The system may constrain operation in some way. For example, a slow printer will limit the measurement rate because it needs time to print one value before it can accept the next.

3.9.3 Talk/Listen Use.

Observe the REMOTE CONTROL indicator light. If it is lighted, there is no opportunity for manual operation (except entry of limits). The displays may be observed then, but their content is controlled by the system controller, via the IEEE-488 bus.

Entry of Limits. Any remotely controlled systems use involving limit comparisons must be designed for manual entry of limits, as follows:

a. Be sure the REMOTE CONTROL light is out.

b. Enter the limits as described in para 3.6.

c. Enable the controller to proceed. (This step may require attention to controls on some other device.)

3.10 CARE OF DISPLAY PANEL.

Use caution when cleaning the display window, not to scratch it nor to get cleaning substances into the instrument. Use soft cloth or a ball of absorbent cotton, moistened with a mild glass cleaner, such as "Windex" (Drackett Products Co., Cincinnati, Ohio). Do NOT use a paper towel; do NOT use enough liquid to drip or run.

If it should be necessary to place marks on the window, use paper-based masking tape (NOT any kind of marking pen, which could be abrasive or react chemically with the plastic). To minimize retention of any gummy residue, remove the tape within a few weeks.

Theory—Section 4

4.1 INTRODUCTION.

4.1.1 General.

This instrument uses an unusual method of measurement, which is quite different from those used in most previous impedance meters or bridges. A thorough understanding of this method will be helpful in unusual applications of the instrument and be useful in trouble analysis, in case of a possible malfunction. The following paragraph gives a brief overall description outlining the measurement technique to one familiar with impedance measurement methods. A more detailed description of operation, specific circuitry, and control signals is given later.

4.1.2 Brief Description of the 1658 Digibridge.

This Digibridge™ uses a new measurement technique in which a microprocessor calculates the desired impedance parameters from a series of 5, 8, or 16 voltage measurements (for FAST, MED, and SLOW measurement rates, respectively).* These measurements include quadrature (90°) and inverse (180°) vector components of the voltage across a standard resistor Rx carrying the same current as Zx.** Each of these measurements is meaningless by itself, because the current through Zx is not controlled. But each set of voltage measurements is made in rapid sequence with the same phase-sensitive detector and analog-to-digital converter. Therefore properly chosen differences between these measurements subtract out fixed offset errors, and ratios between the differences cancel out the value of the common current and the scale factor of the detector-converter.

The phase-sensitive detector uses eight reference signals, precisely 45° apart, that have exactly the same frequency as the test signal, but whose phase relationship to any of the analog voltages or currents (such as the current through Zx and Rx) is incidental. Therefore, no precise analog phase shifter or waveform squaring circuit is required. Correct phase relationships are maintained by generating test signal and reference signals from the same high-frequency source.

There are no calibration adjustments in the Digibridge, thanks to the measurement technique. The only precision components in this instrument are three standard resistors and a quartz-crystal stabilized oscillator. There is no reactance standard. For example, C and D are calculated by the microprocessor from the set of voltage measurements and predetermined values of frequency and the applicable standard resistance.

The microprocessor also controls the measurement sequence, using programs in the ROM memory and stored keyboard selections. The desired parameters, C and D, L and Q, or R and Q; equivalent circuit, series or parallel; test rate, slow, medium or fast; and frequency, either 120 Hz (100 Hz) or 1 kHz, are selected by keyboard control. The instrument normally autoranges to find the correct range; but operation can be restricted to any of the three ranges (1, 2, 3), under keyboard control.

Each range is 2 decades wide, with reduced-accuracy extensions both above and below. For example, consider resistance measurement on Range 1 (Figure 3-2). The 2 decades extend from Ø2.000 Ω, with an automatic decimal-point shift at 21.000 going up (at Ø20.00, going down) to 200.00 Ω. The range extensions generally go as far as can be displayed without further decimal-point shifting. In our example, the low-range-held overrange extension goes up to 999.99 Ω.

However, the low underrange is different from the low extensions (range held) of mid and high ranges, in that there is an additional decimal-point shift to provide excellent resolution in small-value measurements. Continuing with the example, the shift takes place a 2.1000 Ω going up and at Ø2.000 Ω going down. Consequently, this low underrange goes down to Ø.0001 Ω. Similarly, for L/Q, the smallest measurement is .00001 mH; for C/D, it is .00001 nF.

There is a decimal-point shift without hysteresis in the high overrange for R and C only, at 120 Hz (100 Hz) only. This shift takes place between 9.9999 and 10.000 MΩ for R, between 9999.9 and 10000 μF for C.

Leading zeroes before the decimal point are blanked out of the RLC display. Such blanked zeroes are designated with the symbol Ø in some parts of this manual.

*Patent applied for.

**If the measurement rate is SLOW, vector components are sampled 45° apart, in order to reject odd harmonics (3, 5, 11, 13), for greater accuracy.

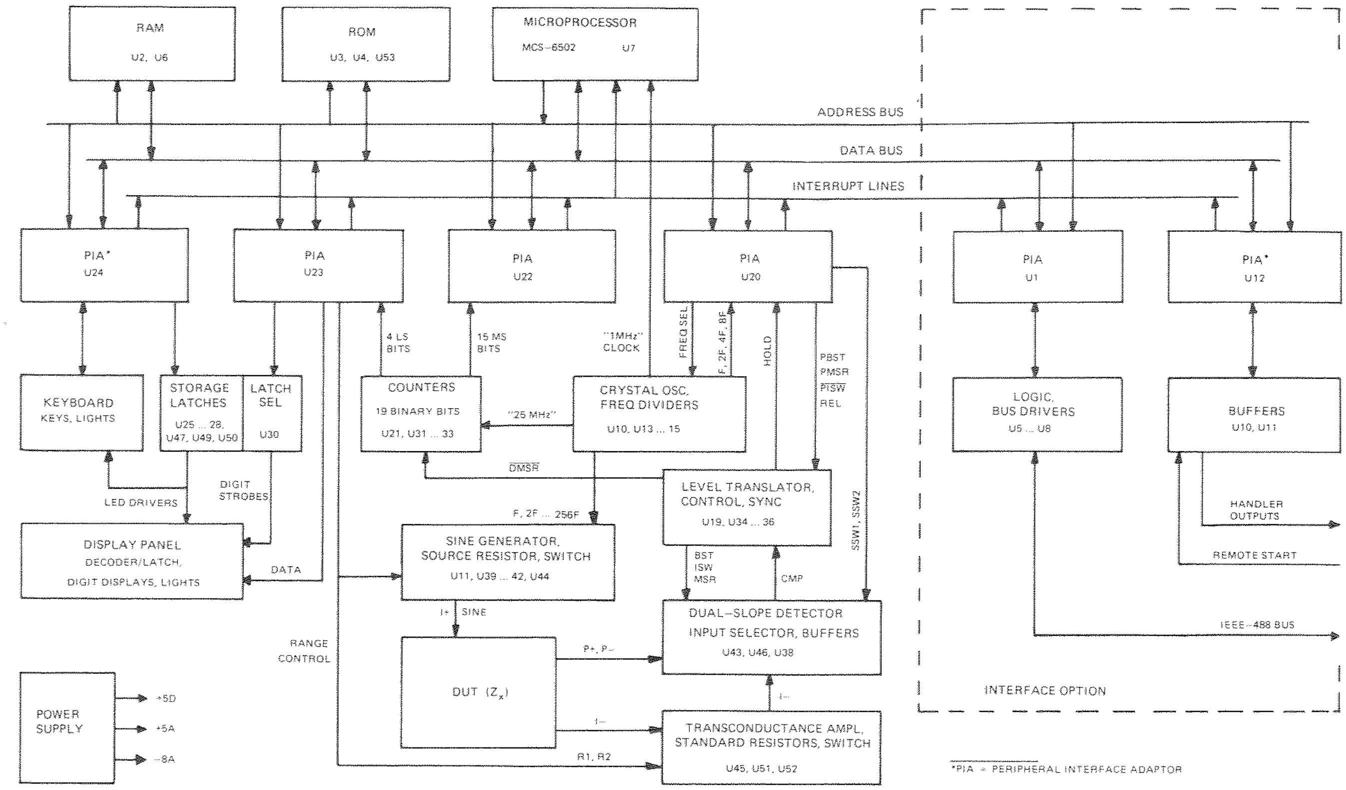

Figure 4-1. Functional block diagram.

Test frequences are within 2% of the front-panel indication. However, for reasons related to rejection of power-line-frequency stray signals that could be picked up by the DUT, thereby causing measurement errors; the actual frequencies are as follows – accurate to ±0.01%:

catalog number 1658-9700: 1020.0 Hz, 120.00 Hz
catalog number 1658-9800: 1000.0 Hz, 100.00 Hz.

4.1.3 Block Diagram.

Figure 4-1.

The block diagram shows the microprocessor in the upper center connected by data and address buses to digital circuitry including RAM and ROM memories, and peripheral interface adaptors (PIA's).

Analog circuitry is shown in the lower part of the diagram, where Zx is supplied with a test signal at frequency f from a sine-wave generator, driven by a crystal-controlled digital frequency divider circuit. The front-end amplifier circuit supplies an analog signal that represents two impedances alternately: the internal standard, Rx, and the DUT, Zx.

The detector control block provides sampling commands (in eight phases). The detector is a dual-slope converter, including an integrator and comparator, which converts each phase component of the analog signal proportionally into a period of time. The dual-slope measurement is converted into a digital number by a counter that is gated by this period.

From this information and criteria selected by the keyboard (or remote control), the microprocessor calculates the RLC and DQ values subsequently displayed.

4.2 PRINCIPAL FUNCTIONS.

4.2.1 Elementary Measurement Circuit.

Figure 4-2.

The measurement technique is shown diagrammatically. A sine-wave generator drives current Ix through the DUT Zx and standard resistor Rs in series. Two differential amplifiers with the same gain K produce voltages e_1 and e_2 Simple algebra, some of which is shown in the figure, leads to the expression for the "unknown" impedance:

$$Zx = Rs\,[e_1/e_2]$$

Notice that this ratio is complex. Both a magnitude and a loss (or quality) value are automatically calculated from Zx and frequency.

4.2.2 Frequency and Time Source

Figure 4-3.

A necessary standard for accuracy is the frequency of the test signal; and equally important are the generation of eight-phase references for detection and clocks for the microprocessor. Frequency and timing requirements are implemented by derivation from a single very accurate oscillator, operating near 25 MHz. Digital dividers and logic circuitry provide the many clocks and triggers, as well as driving the sine-wave generator described below.

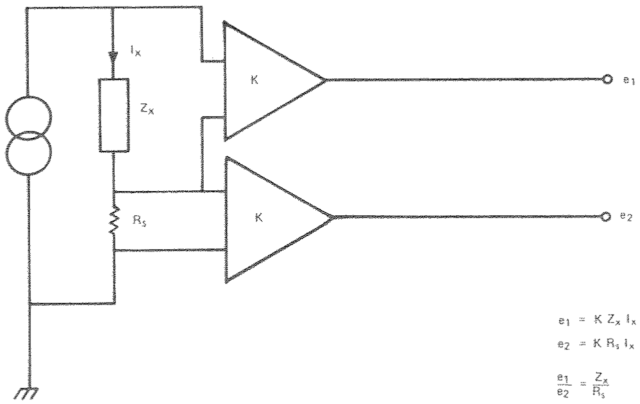

Figure 4-2. Elementary measurement circuit.

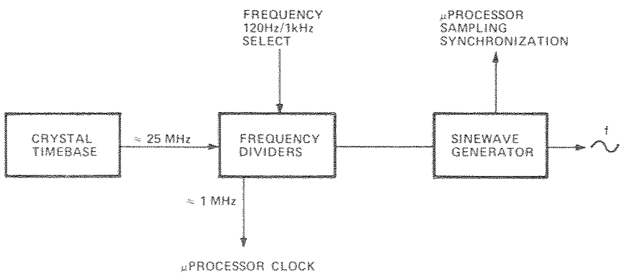

Figure 4-3. Frequency and timing source. A push-button determines the frequency select function. Several clocks and synchronizing pulses as well as the measurement signal f are derived from the accurate time-base signal.

4.2.3 Sine-Wave Generation

Figure 4-4.

Starting with a digital signal at 256 times the selected test frequency, the sine-wave generator provides the test signal that drives a small but essential current through the DUT.

Binary dividers count down from 256 F, providing 128 F, 64 F, 32 F, . . . 2F, F. This set of signals is used to address a read-only memory which contains a 256-step approximation to a sine function. The ROM output (as an eight-bit binary number) is converted by a D/A converter to a somewhat "noisy" sine-wave, which is then smoothed by filtering before its use in the measurement of a DUT. The filter is switched appropriately, according to the selected test frequency.

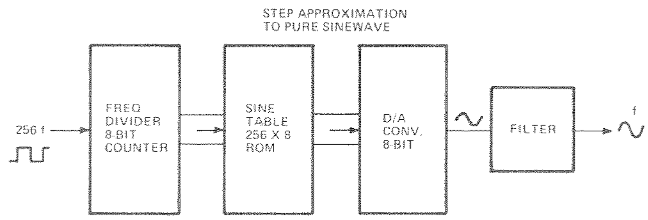

Figure 4-4. Sine wave generator. Given a square wave at 256 f, from preceding dividers, this generator uses a ROM containing the mathematical sine function to form a finely stepped approximation to a sine wave at frequency f. A filter provides smoothing.

Service and Maintenance—Section 5

WARNING

These servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing, other than that contained in the operating instructions, unless you are qualified to do so.

CAUTIONS

For continued protection against fire hazard, replace fuse only with same type and ratings as shown on rear panel and in parts list.

Service personnel, observe the following precautions whenever you handle a circuit board or integrated circuit in this instrument.

HANDLING PRECAUTIONS FOR ELECTRONIC DEVICES SUBJECT TO DAMAGE BY STATIC ELECTRICITY

Place instrument or system component to be serviced, spare parts in conductive (anti-static) envelopes or carriers, hand tools, etc. on a work surface defined as follows. The work surface, typically a bench top, must be conductive and reliably connected to earth ground through a safety resistance of approximately 250 kilohms to 500 kilohms. Also, for personnel safety, the surface must NOT be metal. (A resistivity of 30 to 300 kilohms per square is suggested.) Avoid placing tools or electrical parts on insulators, such as books, paper, rubber pads, plastic bags, or trays.

Ground the frame of any line-powered equipment, test instruments, lamps, drills, soldering irons, etc., directly to earth ground. Accordingly, (to avoid shorting out the safety resistance) be sure that grounded equipment has rubber feet or other means of insulation from the work surface. The instrument or system component being serviced should be similarly insulated while grounded through the power-cord ground wire, but must be connected to the work surface before, during, and after any disassembly or other procedure in which the line cord is disconnected. (Use a clip lead.)

Exclude any hand tools and other items that can generate a static charge. (Examples of forbidden items are non-conductive plunger-type solder suckers and rolls of electrical tape.)

Ground yourself reliably, through a resistance, to the work surface; use, for example, a conductive strap or cable with a wrist cuff. The cuff must make electrical contact directly with your skin; do NOT wear it over clothing. (Resistance between skin contact and work surface through a commercially available personnel grounding device is typically in the range of 250 kilohms to 1 megohm.)

If any circuit boards or IC packages are to be stored or transported, enclose them in conductive envelopes and/or carriers. Remove the items from such envelopes only with the above precautions; handle IC packages without touching the contact pins.

Avoid circumstances that are likely to produce static charges, such as wearing clothes of synthetic material, sitting on a plastic-covered or rubber-footed stool (particularly while wearing wool), combing your hair, or making extensive erasures. These circumstances are most significant when the air is dry.

When testing static-sensitive devices, be sure dc power is on before, during, and after application of test signals. Be sure all pertinent voltages have been switched off while boards or components are removed or inserted, whether hard-wired or plug-in.

5.1 CUSTOMER SERVICE.

Our warranty (at the front of this manual) attests the quality of materials and workmanship in our products. If malfunction does occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone the nearest GenRad service facility (see back page), giving full information of the trouble and of steps taken to remedy it. Describe the instrument by name, catalog number, serial number, and ID (lot) number if any. (Refer to front and rear panels.)

5.2 INSTRUMENT RETURN.

5.2.1 Returned Material Number.

Before returning an instrument to GenRad for service, please ask our nearest office for a "Returned Material" number. Use of this number in correspondence and on a tag tied to the instrument will ensure proper handling and identification. After the initial warranty period, please avoid unnecessary delay by indicating how payment will be made, i.e., send a purchase-order number.

5.2.2 Packaging.

To safeguard your instrument during storage and shipment, please use packaging that is adequate to protect it from damage, i.e., equivalent to the original packaging. Any GenRad field office can advise or provide packing material for this purpose. Contract packaging companies in many cities can provide dependable custom packaging on short notice. Here are two recommended packaging methods.

Rubberized Hair. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument securely in strong protective corrugated container (350 lb/sq in. bursting test), with 2-in. rubberized hair pads placed along all surfaces of the instrument. Insert fillers between pads and container to ensure a snug fit. Mark the box "Delicate Instrument" and seal with strong tape or metal bands.

Excelsior. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument in strong corrugated container (350 lb/sq in. bursting test), with a layer of excelsior about 6 in. thick packed firmly against all surfaces of the instrument. Mark and seal the box as described above.

5.3 REPAIR AND REPLACEMENT OF CIRCUIT BOARDS.

This instruction manual contains sufficient information to guide an experienced and skillful electronic technician in fault analysis and the repair of some circuits in this instrument. If a malfunction is localized to one board (or more) that is not readily repairable, it can be returned to GenRad for repair. To save time, we recommend that you obtain a replacement first, as described below, before returning the faulty board.

Exchanges. For economical, prompt replacement of any etched-circuit board, order an exchange board. Its price is considerably less than that of a new one. Place the order through your nearest GenRad repair facility. (Refer to the last page of this manual.) Be sure to request an exchange board and supply the following information:

1. Instrument description: name and catalog and serial numbers. Refer to front and rear panels.
2. Part number of board. Refer to the parts lists in this manual. (The number etched in the foil is generally NOT the part number.)
3. Your purchase order number. This number facilitates billing if the unit is out of warranty and serves to iden tify the shipment.

To prevent damage to the board, return the defective board in the packing supplied with the replacement (or equivalent protection). Please identify the return with the

Return Material number on the tag supplied with the replacement and ship to the address indicated on the tag.

New Boards. For equally prompt replacement of any etched-circuit board, and for maximum life expectancy, order a new one. Use the same procedure as described above, but request a new board. Please return the defective one to GenRad.

5.4 PERFORMANCE VERIFICATION.

This procedure is recommended for verification that the instrument is performing normally. No other check is generally necessary because this procedure checks operation of nearly all the circuitry. There are no calibrations or adjustments that could require resetting; and the internal standards are very stable. (However, for a rigorous performance and accuracy check, refer to para 5.5.) The necessary resistors, capacitors, and inductors are inexpensive and readily obtained. The most accurate ones available should be used; tolerances listed are the "best" commonly catalogued. Refer to Table 5-1.

CAUTION

Be sure the line voltage switch, rear panel, is correctly set for your power line voltage.

Table 5-1

RESISTORS, CAPACITORS, AND INDUCTORS

Name	Type*	Nominal Value	Tolerance (%)
Resistors, metal film	MIL-R-10509C Style RN60	49.9 Ω	0.1
		499 Ω	0.1
		4.99 kΩ	0.1
		49.9 kΩ	0.1
		499 kΩ	0.1
Capacitors, polystyrene	Arco: 1PJ-332J	0.0033 μF	0.5
	1PJ-333J	0.033 μF	0.5
	1PJ-334J	0.33 μF	0.5
	1PJ-504J	0.5 μF	0.5
. . . metalized polyester	GE: BA-14A105C	1.0 μF	5
	BA-19A106C	10 μF	5
Inductors,	J.W. Miller:		
nonferrous	9220-28	1000 μH	5
ferrite core	9250-107	100 mH	10

*Equivalents may be substituted.

Verify performance as follows:

a. Set the line voltage switch, connect the power cord, and depress the POWER button.

b. Press the MEASURE RATE button as many times as necessary to select SLOW. For DISPLAY, verify that the VALUE light is on; for EQUIVALENT CIRCUIT, the SERIES light. (If necessary, operate the corresponding buttons.)

c. Press the FREQUENCY button as many times as necessary to select 120 Hz (100 Hz). For MEASURE MODE, verify that the CONT light is on; for HOLD RANGE, that the RANGE HELD light (on display panel) is NOT on. (If necessary operate the corresponding buttons.)

d. Press parameter button R/Q and verify that any one of the corresponding units is indicated on the display panel (MΩ, kΩ, or Ω).

e. Set the EXT BIAS slide switch to OFF. Set the TALK switch (rear panel, provided only with the Interface Option) to TALK ONLY.

f. Install the test fixture adaptors, as described in para 3.2. Insert the 49.9-Ω resistor as the device under test or "unknown" component (DUT).

g. Verify that the displays are within the extremes shown in "check number 1" in Table 5-2, if the resistor value is within the tolerance listed above.

h. Similarly make the other checks indicated in this table. In check number 12, verify that the 5th digit is reasonably stable, as follows. (Notice that the 4th digit is the least significant one in the readout, for 0.2% accuracy.)

i. In check number 12, the flickering of the 5th digit should stay typically within a range of ±3 counts. For example, if the display is 1.051X μF, the "X" might flicker between 2 and 8 (or a smaller range). If, for example, "X" is flickering between 7 and 13, it will of course cause a flickering of the preceding digit (1.0517 to 1.0523). In such a case, the correct readout is the larger 4-digit number (1.052) and the 5th digit is acceptably stable.

Tolerances. Acceptable performance of the instrument is bracketed by the set of display "extremes" in Table 5-2. These are defined as the nominal (ideal) measurements plus-or-minus the sum of the instrument accuracy tolerance and the DUT accuracy tolerance (or slightly more). If the accuracy of your DUT is different from the recommendation, revise the acceptable "extremes" accordingly. Notice that this performance verification is NOT intended to prove the accuracy of the instrument.

Insignificant Figures. The right-hand digit(s) of the display normally flicker and change if they are not significant for the specified accuracy of the instrument. Refer to para 3.3.

5.5 MINIMUM PERFORMANCE STANDARDS.

5.5.1 General.

This procedure is a more rigorous alternative to the performance verification described above. Precision standards of impedance are required for this procedure, which checks the accuracy as well as the overall performance of the instrument. It will be controlled from the front panel, without disassembly. Table 5-3 lists the recommended standards and associated equipment.

Table 5-2

PERFORMANCE VERIFICATION

Check Number	Parameter; Frequency	DUT	RLC Display Extremes	DQ Display Extremes
1	R/Q; 120 Hz*	49.9 Ω	Ø49.80 to Ø50.00 Ω	
2		499 Ω	Ø.4980 to Ø.5000 kΩ	
3		4.99 kΩ	Ø4.980 to Ø5.000 kΩ	
4		49.9 kΩ	.04980 to .05000 MΩ	
5		499 kΩ	Ø.4980 to Ø.5000 MΩ	
6	C/D; 1 kHz	.0033 μF	Ø3.280 to Ø3.320 nF	(.0000 to .0100)
7	120 Hz*	.0033 μF	Ø3.280 to Ø3.320 nf	
8	1 kHz	.033 μF	.03280 to .03320 μF	
9	120 Hz*	.033 μF	Ø32.80 to Ø.3320 nF	(.0000 to .0100)
10	both freq	0.33 μF	Ø.3280 to Ø.3320 μF	
11	both freq	0.5 μF	Ø.4970 to Ø.5030 μF	
12	both freq	1.0 μF	Ø.9480 to 1.0520 μF	(.0000 to .0300)
13	1 kHz	10 μF	Ø9.480 to 10.520 μF	
14	120 Hz*	10 μF	Ø9.480 to 10.520 μF	
15	L/Q; 1 kHz	1000 μH	Ø.9480 to 1.0520 mH	(03.00 to 300.0)
16		100 mH	.08980 to .11020 H	(03.00 to 300.0)

*120 or 100 Hz.

**Refer to paragraphs headed "Tolerances" and "Insignificant figures," in the accompanying text.

Table 5-3

EQUIPMENT FOR ACCURACY VERIFICATION AND TROUBLE ANALYSIS

Name	Requirements	Recommended Type*
Extender cable	Adapts text fixture to standards with binding posts and banana plugs.	GR 1657-9600
Resistors	Four-terminal, 1 Ω, 0.02%	GR 1440-9601
	10 Ω, 0.01%	GR 1440-9611
	Decade, 100 to 11 111 000 Ω, 0.01%	GR 1433-9719 (-Y)
Capacitors	Three-terminal, 100 pF, 0.02%	GR 1403-9704 (-D)
	1000 pF, 0.02%	GR 1403-9701 (-A)
	Decade, 3-terminal, 1 pF to 1 (+) μF, 0.05% ± 0.5 pF.	GR 1413-9700
	Four-terminal, ratio type, 1 μF to 10 mF, 0.25% (ratios, 0.02%).	GR 1417-9700
	Dc blocking, 500 μF, 10 V.	GE 69F2214G2
Inductors	Fixed, 2-terminal, 100 mH, 0.1%.	GR 1482-9712 (-L)
Adaptors	GR874® (for 1413 capacitor) and binding-post pair (two required).	GR 0874-9870 (-Q2)
Shorting link	Ground jumper connection.	GR 0938-9712 (-L)
Scope**	General purpose, 100 MHz, dual trace.	Tektronix 465
Scope probe**	Capacitance less than 10 pF, X10.	Tektronix P6053B
Voltmeter**	Digital, general purpose, with probe.	Data Precision 3400
Counter**	Dc to 35 MHz, 10 V rms.	Tektronix DC504
Pulse generator**	General purpose.	Tektronix PG501
Resistor**	200 ohm, 1/4 watt.	—

*Equivalents may be substituted.

**Required for trouble analysis (Paragraph 5.8); not required for Paragraph 5.5.

Verify that the instrument meets performance specifications as follows.

Calibration of Standard. The acceptable RLC readout (min to max range) may have to be modified if the actual (calibrated) value of your standard — Zx — or its accuracy — Zx accuracy — (either or both) is different from the tabulated value(s).

For example, if your 10-Ω standard is known to be 10.006 ± .002 Ω, then add .005 Ω to the lower acceptable extreme and add .007 Ω to the upper one. (In Table 5-4, 2nd line, substitute the numbers 09.994 to 10.018.)

Insignificant Digits. The right-hand digit(s) of the display normally may flicker and change if they are not significant for the specified accuracy of the instrument. Refer to para 3.3.

Cable Capacitance. Because the cable adds capacitance in parallel with the DUT, it is sometimes necessary to obtain a "corrected readout" from the numerical display on the instrument. Do this for all checks involving small capacitance (less than about 1000 pF). The equivalent correction for large inductance (above 30 H at 1 kHz or 3000 H at 120 Hz) is not applicable in the recommended inductance check procedure. For capacitance measurement, obtain the corrected readout by subtracting the cable capacitance from the visible readout, as described in para 3.2. Because C is large compared to cable capacitance and D is small, the simple calculation (subtraction) is applicable whether the measurement is "parallel" or "series."

CAUTION

Be sure the line voltage switch, rear panel, is correctly set for your power line voltage.

5.5.2 Resistance Measurement Accuracy.

Make the test setup and verify instrument performance as follows.

a. Set the line voltage switch, connect the power cord, and depress the POWER button, as described in para 3.1.

b. Connect the extender cable to the Digibridge test fixture, as described in para 3.2.

c. Connect a standard resistor (1-Ω initially) to the extender cable, as follows:

RED, I+: left front terminal of resistor
RED & WHITE; P+: left rear terminal
BLACK, I—: right front terminal
BLACK & WHITE, P—: right rear terminal
BLACK & GREEN, G: no connection.

Table 5-4
RESISTANCE ACCURACY CHECKS

Standard as DUT*	Test Frequency	Equivalent Circuit	Measure Rate	Typical Standard Accuracy* (%)	Digibridge Accuracy (%)	RLC Display Acceptable Extremes*
1.000 Ω	1 kHz	SERIES	SLOW	.02	0.2	0.9978 to 1.0022 Ω
10.00 Ω	1 kHz	SERIES	SLOW	.01	0.1	09.989 to 10.011 Ω
10.00 Ω	1 kHz	SERIES	MEDIUM	.01	0.2	09.979 to 10.021 Ω
10.00 Ω	1 kHz	SERIES	FAST	.01	0.5	09.949 to 10.051 Ω
100.0 Ω	1 kHz	SERIES	SLOW	-.01, +.02	0.1	099.89 to 100.12 Ω
100.0 Ω	1 kHz	SERIES	MEDIUM	-.01, +.02	0.2	099.79 to 100.22 Ω
100.0 Ω	1 kHz	SERIES	FAST	-.01, +.02	0.5	099.49 to 100.52 Ω
1.000 kΩ	1 kHz	SERIES	SLOW	.01	0.1	0.9989 to 1.0011 kΩ
1.000 kΩ	1 kHz	SERIES	MEDIUM	.01	0.2	0.9979 to 1.0021 kΩ
1.000 kΩ	1 kHz	SERIES	FAST	.01	0.5	0.9949 to 1.0051 kΩ
10.00 kΩ	1 kHz	PARALLEL	SLOW	.01	0.1	09.989 to 10.011 kΩ
10.00 kΩ	1 kHz	PARALLEL	MEDIUM	.01	0.2	09.979 to 10.021 kΩ
10.00 kΩ	1 kHz	PARALLEL	FAST	.01	0.5	09.949 to 10.051 kΩ
100.0 kΩ	1 kHz	PARALLEL	SLOW	.01	0.1	.09989 to .10011 MΩ
100.0 kΩ	1 kHz	PARALLEL	MEDIUM	.01	0.2	.09979 to .10021 MΩ
100.0 kΩ	1 kHz	PARALLEL	FAST	.01	0.5	.09949 to .10051 MΩ
1.000 MΩ	1 kHz	PARALLEL	SLOW	.01	0.1	0.9989 to 1.0011 MΩ
1.000 MΩ	120 Hz†	PARALLEL	SLOW	.01	0.1	0.9989 to 1.0011 MΩ
1.000 MΩ	1 kHz	PARALLEL	MEDIUM	.01	0.2	0.9979 to 1.0021 MΩ
1.000 MΩ	120 Hz†	PARALLEL	MEDIUM	.01	0.2	0.9979 to 1.0021 MΩ
1.000 MΩ	120 Hz†	PARALLEL	FAST	.01	0.5	0.9949 to 1.0051 MΩ
1.000 MΩ	1 kHz	PARALLEL	FAST	.01	0.5	0.9949 to 1.0051 MΩ

*If the calibrated value of your resistance standard is slightly different from the nominal value or if the standard's accuracy is different from the typical accuracy, correct the "acceptable extremes" accordingly.
†120 Hz or 100 Hz, depending on model of Digibridge.

d. Set up the measurement conditions on the Digibridge as tabulated below. (See para 3.1.)

DISPLAY – VALUE
MEASURE RATE – SLOW (initially)
EQUIVALENT CIRCUIT – SERIES (initially)
FREQUENCY – 1 kHz (initially)
MEASURE MODE – CONT
HOLD RANGE – autorange (RANGE HELD light off)
Parameter – R/Q (resistance units light on)
EXT BIAS – OFF
TALK (on Interface Option only) – TALK ONLY.

e. Refer to Table 5-4. Verify that the RLC display is between the extremes (inclusively) shown in the 1st row. Proceed down the table, changing the resistance standard and verifying the RLC readout as shown; refer to the next step.

f. For larger values of resistance standard, use the decade resistor, making connection as follows.

RED, I+: stack on P+
RED & WHITE, P+: resistor H
BLACK, I–: stack on P–
BLACK & WHITE, P–: resistor L
BLACK & GREEN, G: resistor G.

5.5.3 Single and Average Modes.

Retain the conditions of the last row in Table 5-4 except as follows. Set the Digibridge to:

MEASURE MODE – SINGLE

a. Press START.

b. Verify that the subsequent RLC display is acceptable, as before. (Repeated starts will yield different display values but they should be within the acceptable extremes, inclusively.)

c. Set the Digibridge to:

MEASURE MODE – AVERAGE.

d. Press START.

e. Verify that the RLC display is acceptable, as before, after allowing 5 s (time for the instrument to complete 10 measurements). Repeated starts will yield different display values, but the "final" averages should be less variable than the measurements in step b.

5.5.4 Capacitance Measurement Accuracy (Small C).

Make the test setup and verify Digibridge performance as a continuation of the previous procedure, except as follows:

a. Remove the resistance standard and connect the test-fixture extender cable tips to the pair of 874 adaptors thus:

RED, I+: stack on P+
RED & WHITE, P+: center post of 1st adaptor
BLACK, I–; stack on P–
BLACK & WHITE, P–: center post of 2nd adaptor
BLACK & GREEN, G: side post of 2nd adaptor

When the standard is the 1403 type of capacitor, connect each adaptor to one of the coaxial ports. When it is the 1413 (decade box) capacitor, connect the 1st adaptor to the port labeled H, connect 2nd adaptor to port L, and be sure to link the side (ground) posts together, using the recommended link or a short piece of bus wire.

b. Confirm or select measurement conditions on the Digibridge thus:

DISPLAY – VALUE
MEASURE RATE – SLOW
EQUIVALENT CIRCUIT – PARALLEL
FREQUENCY – 1 kHz
MEASURE MODE – CONT
HOLD RANGE – autorange (RANGE HELD light off)
Parameter – C/D (capacitance units light on)
EXT BIAS – OFF
TALK (on Interface Option only) – TALK ONLY.

c. Refer to Table 5-5, 1st row. Connect the capacitance standard and arrange the cable as desired for the complete measurement. Determine Co, the "zero capacitance" of extender cable and associated connections, as follows.

Carefully lift the red stacked pair of cable tips free from the post in the 1st adaptor. Hold them about 0.5 cm (1/4 in.) above the binding post where they belong. DO NOT rearrange the cable branches or change their spacing more than is absolutely necessary to follow these directions. Hold the plastic tips (not the wires or conductors) and firmly touch a finger to the guard (G) circuit, to minimize the effect of capacitance in your body.

Read the capacitance Co on the RLC display. Then plug the stacked pair of cable tips into the 1st adaptor as described before.

d. Read the RLC display, with the capacitance standard connected. Correct the reading by subtracting "zero" capacitance, shown in the table as Co." Verify that this result is within the specifications.

e. Proceed down the table, changing capacitance standard if necessary and determining Co again with each such change. For each row in the table, also select frequency and measurement rate as tabulated; then verify that the RLC display (corrected) meets the specifications.

Notice that different values of Co are to be expected with each change in the capacitance standard (Co" with 100 pF, Co' with 1000 pF, and Co with the decade capacitor are shown in the table). When the decade capacitor is connected, determine Co with the decade switches all set to zero and the extender cable connected. (In this case, do NOT hold any extender-cable tips in the lifted position.)

5.5.5 Limit Comparison Bins.

Verify the Digibridge performance with regard to limit comparison and bin assignments as follows. The test setup is unchanged from the previous one.

a. Confirm or select measurement conditions on the Digibridge as listed:

DISPLAY – ENTER LIMITS (new condition)
MEASURE RATE – SLOW
EQUIVALENT CIRCUIT – PARALLEL

Table 5-5

CAPACITANCE ACCURACY CHECKS

Standard as DUT*	Test Frequency	Measure Rate	Typical Standard Accuracy* (%)	Digibridge Accuracy* (%)	Correction	Corrected Display* Acceptable Extremes	DQ Display Maximum
100.0 pF	1 kHz	SLOW	.03	0.2	–Co″	.09977 to 1.0023 nF	–
1000. pF	1 kHz	SLOW	.02	0.1	–Co′	Ø.9988 to 1.0012 nF	.0010
1000. pF	120 Hz†	SLOW	.02	0.2	–Co′	Ø.9978 to 1.0022 nF	.0010
1000. pF	120 Hz†	MEDIUM	.02	0.4	–Co′	Ø.9958 to 1.0042 nF	–
1000. pF	1 kHz	MEDIUM	.02	0.2	–Co′	Ø.9978 to 1.0022 nF	–
1000. pF	1 kHz	FAST	.02	0.5	–Co′	Ø.9948 to 1.0052 nF	–
1000. pF	120 Hz†	FAST	.02	1.0	–Co′	Ø.9898 to 1.0102 nF	–
10000 pF	Both	FAST	.05	0.5	–Co	Ø9.945 to 10.055 nF	–
10000 pF	Both	MEDIUM	.05	0.2	–Co	Ø9.975 to 10.025 nF	–
10000 pF	Both	SLOW	.05	0.1	–Co	Ø9.985 to 10.015 nF	.0010
0.100 μF	1 kHz	SLOW	.05	0.1	–Co	.09985 to .10015 μF	–
0.100 μF	120 Hz†	SLOW	.05	0.1	–Co	Ø99.85 to 100.15 nF	–
0.100 μF	120 Hz†	MEDIUM	.05	0.2	–Co	Ø99.75 to 100.25 nF	–
0.100 μF	1 kHz	MEDIUM	.05	0.2	–Co	.09975 to .10025 μF	–
0.100 μF	1 kHz	FAST	.05	0.5	–Co	.09945 to .10055 μF	–
0.100 μF	120 Hz†	FAST	.05	0.5	–Co	Ø99.45 to 100.55 nF	–
1.000 μF	Both	FAST	.05	0.5	–Co	Ø.9945 to 1.0055 μF	–
1.000 μF	Both	MEDIUM	.05	0.2	–Co	Ø.9975 to 1.0025 μF	–
1.000 μF	Both	SLOW	.05	0.1	–Co	Ø.9985 to 1.0015 μF	.0010
0.500 μF	1 kHz	SLOW	.05	0.1	–Co	Ø.4992 to Ø.5008 μF	.0010

* If the calibrated value of your capacitance standard is slightly different from the nominal value or if the standard's accuracy is different from the typical accuracy, correct the "acceptable extremes" accordingly.
†120 Hz to 100 Hz, depending on model of Digibridge.

FREQUENCY – 1 kHz
MEASURE MODE – CONT
HOLD RANGE – autorange
Parameter – C/D
Units selected – μF
EXT BIAS – OFF.

b. Refer to Table 5-6. After making the sequence of keystrokes (using the appropriate limit entry keys) shown under "Entry," verify that the Digibridge numerical displays are like the numbers tabulated in the same row of the table under "Displays." Make all entries as tabulated; this is part of the setup for later procedures.

Table 5-6

ENTRY OF LIMITS

Entry	RLC Display	DQ Display
(none)	(blank)	(blank)
[.] [5] [=] [NOM VALUE]	.49999	(blank)
[.] [0] [0] [1] [=] [BIN No.] [0]	(blank)	.0010
[1] [%] [=] [BIN No.] [1]	.50499	.4949
[2] [%] [=] [BIN No.] [2]	.50999	.4899
[3] [%] [=] [BIN No.] [3]	.51499	.4849
[4] [%] [=] [BIN No.] [4]	.51999	.4799
[5] [%] [=] [BIN No.] [5]	.52499	.4749
[6] [%] [=] [BIN No.] [6]	.52999	.4699
[7] [%] [=] [BIN No.] [7]	.53499	.4649
[8] [%] [=] [BIN No.] [8]	.53999	.4599

c. Select on the Digibridge:
DISPLAY – VALUE.

Verify that the GO light is on. (The RLC and DQ displays should be within the extremes given in Table 5-5, as checked previously.)

d. Select on the Digibridge:
DISPLAY – BIN No.

e. Refer to Table 5-7. For each setting of the capacitance standard, verify that the DQ display is blank, the bin (RLC) display is a single digit as tabulated, and the GO/NO-GO lights work as tabulated.

f. Select on the Digibridge:
DISPLAY – ENTER LIMITS.

g. Make the following entry (as in step b):
[=] [NOM VALUE].

Verify that the RLC display is five zeroes.

h. Select on the Digibridge:
DISPLAY – VALUE

Notice that the RLC and DQ displays are normal (last entry in Table 5-5). Verify that both of the GO/NO-GO lights are off.

i. Select on the Digibridge:
DISPLAY – BIN NO.

Verify that both RLC and DQ displays are blank.

j. Select on the Digibridge:
DISPLAY – ENTER LIMITS.

Table 5-7
BIN ASSIGNMENT CHECK

DUT (μF)	GO/NO-GO	Bin Display
0.5000	GO	1
0.5057	GO	2
0.5107	GO	3
0.5157	GO	4
0.5207	GO	5
0.5257	GO	6
0.5307	GO	7
0.5357	GO	8
0.5407	NO-GO	9
0.0000	NO-GO	0
0.5000	GO	1

Check that each of the 7 unit indicator lights is functioning, in the RLC display area, as follows. Repeatedly depress the R/Q key for the 3 resistance units, the L/Q key for the 2 inductance units, and then the C/D key for the 2 capacitance units. Be sure the last parameter key to be used is C/D.

5.5.6 Capacitance Measurement Accuracy (Large C).

Continue the procedure as follows:

a. Confirm or select measurement conditions as listed:
DISPLAY – VALUE (new condition)
MEASURE RATE – SLOW
EQUIVALENT CIRCUIT – SERIES (new condition)
FREQUENCY – 1 kHz
MEASURE MODE – CONT
HOLD RANGE – autorange
Parameter – C/D
EXT BIAS – OFF.

b. Remove the decade capacitor and connect the 4-terminal 1-μF capacitance standard (GR 1409-Y) as follows. This standard should be certified to an accuracy of ±.03%, including aging effects.
RED, I+: capacitor H binding post
RED & WHITE, P+: capacitor H banana plug
BLACK, I–: capacitor L binding post
BLACK & WHITE, P–: capacitor L banana plug
BLACK & GREEN, G: capacitor G.

c. Verify that the RLC display agrees with the certified value of the standard (corrected for temperature if appropriate) within ±.0013 μF i.e., within the sum of .03% for the standard and 0.1% for the Digibridge. See Table 5-8, line 1. Calculate the difference D1 = (displayed measurement) – (value of standard), for future use. Units of D1 are μF.

d. Remove the 1-μF standard and connect the 4-terminal ratio-type capacitance standard (GR 1417) as follows. Be sure the dc blocking capacitor is fully discharged before connecting it. Notice that only the left-hand terminals of the standard are used.
RED, I+: + end of blocking capacitor (500 μF);
other end to capacitance standard, CURRENT H
RED & WHITE, P+: standard, POTENTIAL H
BLACK, I–: standard, CURRENT L
BLACK & WHITE, P–: standard, POTENTIAL L
BLACK & GREEN, G: standard, uninsulated terminal.

e. Set the dials on the capacitance standard thus:
TEST FREQUENCY – 1 kHz
CAPACITANCE – 1 μF.

NOTE
For detailed information on the GR 1417 4-Terminal Capacitance Standard, refer to its instruction manual.

f. Read the RLC display, which should be close to 1 μF. Calculate the difference D2 = (1.0000 μF) – displayed measurement. Units of D2 are μF. The DQ display should show D = .0085 to .0115.

g. Calculate the calibration factor K as follows:
K = D1 + D2.

Example. In step c, the display is 1.0012, the standard is 1.0006; then D1 = +.0006 μF. In step f, the nominal is 1.0000, the display is 1.0024; then D2 = –.0024 μF. The factor K is therefore –.0018 (no units required).

h. Reset the capacitance-standard dial to:
CAPACITANCE – 10 μF.

Read the RLC display and correct it by adding 10K. (For example, if display is 10.023 μF, corrected measurement [for K = –.0018] is 10.005 μF.) Verify that the corrected measurement is within the acceptable extremes of Table 5-8, line 2.

i. Resetting the capacitance standard and Digibridge frequency, as indicated, continue to line 3 in the table. Verify results as above.

j. Set the Digibridge frequency thus:
FREQUENCY – 120 Hz (or 100 Hz).

Repeat steps b and c. (See line 4 of table.) Also determine a new value of D1 for this frequency.

k. Repeat step d and set the capacitance-standard dials as follows. (Choose frequency to agree with Digibridge.)
TEST FREQUENCY – 120 Hz or 100 Hz
CAPACITANCE – 1 μF.

l. Repeat steps f and g, determining a new value of K for this frequency. (Call it K′.)

m. Continue down Table 5-8, making the settings, calculations, and verifications indicated there.

5.5.7 D-Measurement Accuracy. **Figure 5-1.**

Verify D-measurement accuracy with the following procedure. Dissipation-factor checks will be made using both series and parallel equivalent circuits, with corresponding connections of resistance and capacitance standards.

a. Using the extender cable and plain bus wire, connect the decade R and C standards in series, as DUT to the Digibridge, as shown in the diagram and tabulated below. (Use adaptors on the coaxial connectors, as before.)
RED, I+: stack on P+
RED & WHITE, P+: resistor H

Table 5-8

CAPACITANCE ACCURACY CHECKS

Standard as DUT*	Test Frequency	Typical Standard Accuracy (%)	Digibridge Accuracy (%)	Correction	Corrected C Display Acceptable Extremes	DQ Display Acceptable
1.000 µF	1 kHz	.03	0.1	–	±.0013 µF*	–
10.00 µF	1 kHz	.07	0.1	+10 K	Ø9.983 to 10.017 µF	.0085 to .0115
100.0 µF	1 kHz	.07	0.1	+100 K'	Ø99.83 to 100.17 µF	.0085 to .0015
1.000 µF	120 Hz†	.03	0.1	–	±.0013 µF*	–
10.00 µF	120 Hz†	.05	0.1	+10 K'	Ø9.985 to 10.015 µF	.0085 to .0115
100.0 µF	120 Hz†	.05	0.1	+100 K'	Ø99.85 to 100.15 µF	.0085 to .0115
1.000 mF	120 Hz†	.05	0.1	+1000 K'	Ø998.5 to 1001.5 µF	.0085 to .0115
10.00 mF	120 Hz†	.06	0.5	10000 K'	9944.0 to 10056 µF	.0065 to .0135

*Acceptable display is certified value of standard, plus or minus the tolerance given.
†120 Hz or 100 Hz, depending on model of Digibridge.

BLACK, I–: stack on P–
BLACK & WHITE, P–: capacitor L, center
BLACK & GREEN, G: resistor G, capacitor H side post, and capacitor L side post (suitably connected together with a link and/or bus wire).

Also connect with a short jumper from resistor L to capacitor H, center post.

b. Confirm or select measurement conditions on the Digibridge thus:

DISPLAY – VALUE
MEASURE RATE – SLOW
EQUIVALENT CIRCUIT – SERIES
FREQUENCY – 120 Hz (100 Hz)
MEASURE MODE – CONT
HOLD RANGE – autorange
Parameter – C/D
EXT BIAS – OFF.

c. Set the resistance and capacitance standards to the values given in line 1 of Table 5-9. Verify that the DQ display is within the range given, inclusive. (Notice that the C-standard value depends on the test frequency of your particular model.)

d. Continue down the table, verifying each line. Because the capacitance in the series equivalent circuit is different from the decade capacitor setting when the series resistance is large, use the RLC readout to indicate capacitance in those lines of the table.

e. Reconnect the standards in parallel as shown in the diagram and change the Digibridge measurement conditions as follows:

EQUIVALENT CIRCUIT – PARALLEL
FREQUENCY – 1 kHz.

f. Verify the D accuracy, as before, by following Table 5-10. Notice that the 1658-9700 (which has 120 Hz for its lower test frequency) actually tests at 1020 Hz, whereas the 1658-9800 tests at 1000 Hz; hence the different requirements for capacitance in the table.

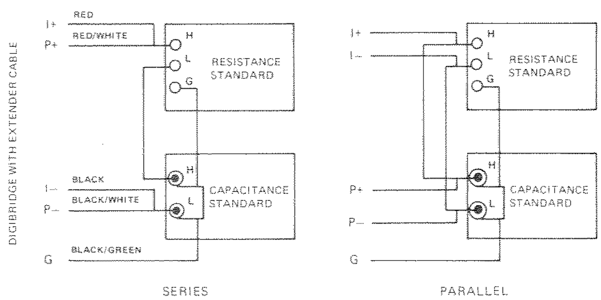

Figure 5-1. Series and parallel connections of standards for D accuracy checks.

Table 5-9

SERIES-CIRCUIT D-ACCURACY CHECK

Resistance Standard	Capacitance Standard (120 Hz)	(100 Hz)	DQ Display (Min to Max)
50 Ω	0.1326 µF	0.1592 µF	.0045 to .0055
100 Ω	same	same	.0095 to .0105
500 Ω	same	same	.0494 to .0506
1 kΩ	same	same	.0994 to .1006
5 kΩ	same	same	.4987 to .5013
10 kΩ	same	same	.9975 to 1.003
50 kΩ	reset*	reset*	4.969 to 5.031
90 kΩ	reset*	reset*	8.909 to 9.091

*Reset the capacitance standard to obtain, on the RLC readout, the tabulated capacitance.

Table 5-10

PARALLEL-CIRCUIT D-ACCURACY CHECKS

Resistance Standard	Capacitance Standard (-9700)	(-9800)	DQ Display (Min to Max)
1 MΩ	31.22 nF	31.84 nF	.0045 to .0055
500 kΩ	same	same	.0095 to .0105
100 kΩ	same	same	.0494 to .0506
50 kΩ	same	same	.0994 to .1006
10 kΩ	same	same	.4987 to .5013
5 kΩ	same	same	.9975 to 1.003
1 kΩ	same	same	4.969 to 5.031
500 Ω	same	same	9.889 to 10.11

5.5.8 Inductance Measurement Accuracy.

Verify the accuracy of inductance measurements, as follows.

a. Using the extender cable, connect the 100-mH inductance standard as DUT, thus:

RED, I+: stack on P+
RED & WHITE, P+: inductor HIGH
BLACK, I–: stack on P–
BLACK & WHITE, P–: inductor LOW
BLACK & GREEN, G: inductor case (ground).

b. Confirm or select measurement conditions on the Digibridge as follows.

DISPLAY – VALUE
MEASURE RATE – SLOW
EQUIVALENT CIRCUIT – SERIES
FREQUENCY – 120 Hz (100 Hz)
MEASURE MODE – CONT
HOLD RANGE – autorange
Parameter – L/Q.

c. Verify that the RLC display is within ±0.10 mH of the certified effective 100-Hz series inductance of the standard.

d. Calculate the low-frequency Q of the standard inductor as follows:

$Q = 6.2832\ f\ L/R$

where f is the measurement frequency, L is the certified series inductance, and R is the dc resistance, also given on the certificate. (Notice that the 100-Hz Q is given on the certificate; but not the 120-Hz Q.)

e. Verify that the DQ display is within ±.0114 of the calculated low-frequency Q.

f. Change test frequency as follows:

FREQUENCY – 1 kHz.

g. Verify that the RLC display is within 0.10 mH of the certified effective 1000-Hz series inductance of the standard.

h. Calculate the high-frequency Q of the standard inductor using the above formula and the present test frequency.

i. Verify that the DQ display is within ±.078 of the calculated high-frequency Q.

5.5.9 Zero Capacitance.

Check the "zero" or residual capacitance in the Digibridge and its test fixture as follows.

a. Remove the extender cable from the Digibridge.

b. Confirm or select the measurement conditions thus:

DISPLAY – VALUE
MEASURE RATE – SLOW
EQUIVALENT CIRCUIT – SERIES
FREQUENCY – 1 kHz
MEASURE MODE – CONT
HOLD RANGE – autorange
Parameter – C/D (new condition).

c. Verify that the RLC display is less than .002 nF (i.e., 2 pF).

5.6 DISASSEMBLY AND ACCESS.

WARNING

If disassembly or servicing is necessary, it should be performed only by qualified personnel familiar with the electrical shock hazards inherent to the high-voltage circuits inside the cabinet.

CAUTION

Observe the following precautions whenever you handle a circuit board or integrated circuit in this instrument.

HANDLING PRECAUTIONS
FOR ELECTRONIC DEVICES
SUBJECT TO DAMAGE BY STATIC ELECTRICITY

Refer to page 5-0 for details. The following integrated circuits are known to require these precautions.

1658-4700: MB-U2, -U3, -U4, -U6, -U8, -U19 through -U24, -34 through -U37, -U41, -U42, -U45, -U46, -U52, -U53. 1658-4715: DB-U47 through -U55.

Notice that it is safe to assume that all circuits in this instrument are subject to damage by static electricity, and observe the precautions always.

5.6.1 Disassembly.

Use the following procedure for access to replaceable parts and contact points used in trouble analysis.

a. Disconnect the power cord.

b. Remove the top-cover screws from the rear panel of the main chassis. See Figure 1-2. Slide the top cover forward about 6 mm so that its front corners are unhooked. Lift it directly upward (Figure 5-2). Reassembly note: 2 screws, 13 mm long.

The next step, removal of display board, is recommended (though not absolutely necessary) before removal of the main circuit board.

c. Remove the 2 support screws, at left and right, that hold the display board to its brackets. (See Figure 5-2.) Pull the board directly out of its socket in the main board. Keep the display board in its original (inclined) plane until

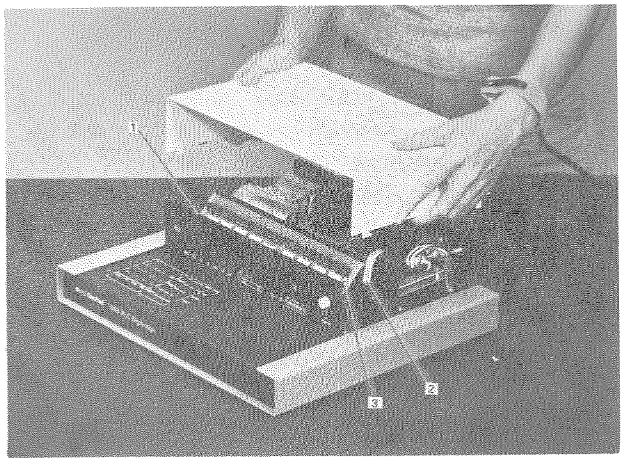

Figure 5-2. Removal of top cover. Items 1 and 3 are screws that hold the display board. Item 2 is ribbon cable 1657-0200 that connects power supply to main board.

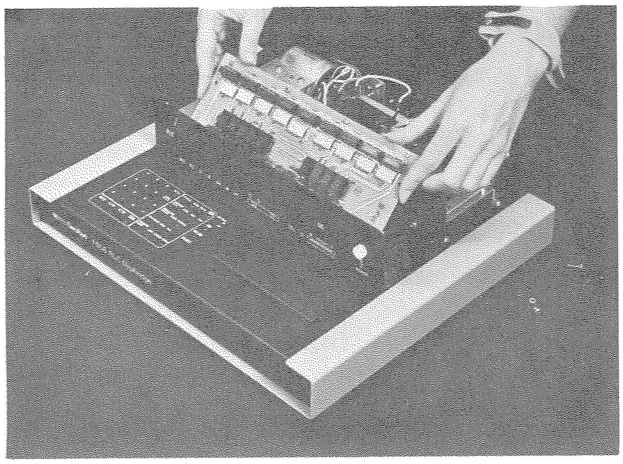

Figure 5-3. Removal of the display board.

it is completely free (Figure 5-3). Reassembly note: 2 screws, 6 mm long with washers.

d. Remove the ribbon cable (1657-0200) from power supply (at V-J1) and main board (at MB-J5). Notice that the connectors are symmetrical and reversible; and the cable is extra long, for convenience in servicing.

The next step, removal of the power supply, is NOT related to the removal of the main board. Either can be left in place while the other is removed.

e. Remove the 4 screws that pass vertically through the 4 corners of the power supply into the main chassis. Lift the power supply slightly and move it back carefully while disengaging the POWER pushbutton extension from its hole in the front panel (Figure 5-4). Reassembly note: 4 screws, 8 mm long.

f. Remove the interface option, if you have one, after removing the 2 large screws with resilient washers in the rear panel. (If the panel held by these screws is blank, leave it in place.) Reassembly note: align board edges carefully with connector and guide that are inside of instrument, while pushing interface option into position.

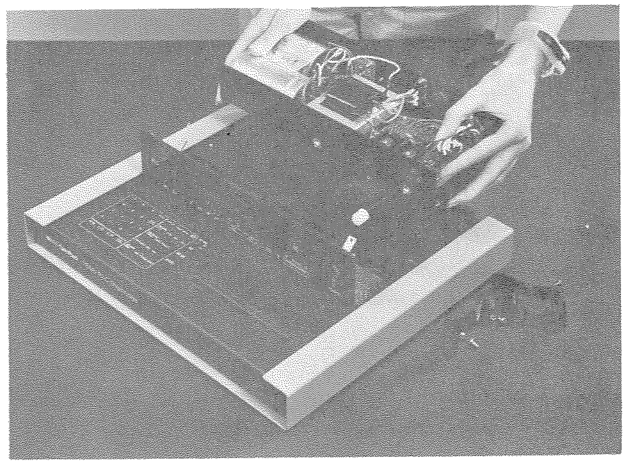

Figure 5-4. Removal of the power supply. The ribbon cable must be disconnected first. The display board can be left in place, but has been removed in this picture.

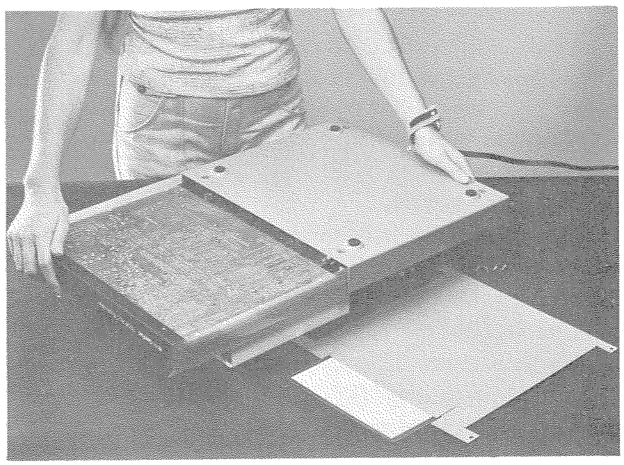

Figure 5-5. Removal of the bottom shell. The top cover has been temporarily installed as a support.

g. Provide a convenient "upsidedown" support by reinstalling the top cover, temporarily. Turn the instrument, bottom up.

h. Remove 4 screws from the bottom shell, one near each rubber foot. Lift the instruction card and its retaining pan free. Slide the bottom shell back (or forward), free of the main chassis (Figure 5-5). Reassembly notes: Be sure to enfold the pliable dirt seals at left and right sides of main chassis as you start to slide bottom shell onto main chassis; use 4 screws, 8 mm long.

i. Remove 11 screws from positions shown in Figure 5-6 as A and B, to free the main board. Slide it forward so the bias connector can be lifted past the lip of the chassis. Figure 5-7 shows how to tilt and rotate the main board to the best position for removal. Reassembly note: return washers (if any) to original positions; screws at A are 6 mm, B are 8 mm long.

j. To remove the keyboard module, remove the 4 screws at D and carefully pull the module directly away from the main board. Reassembly note: be very careful not to bend

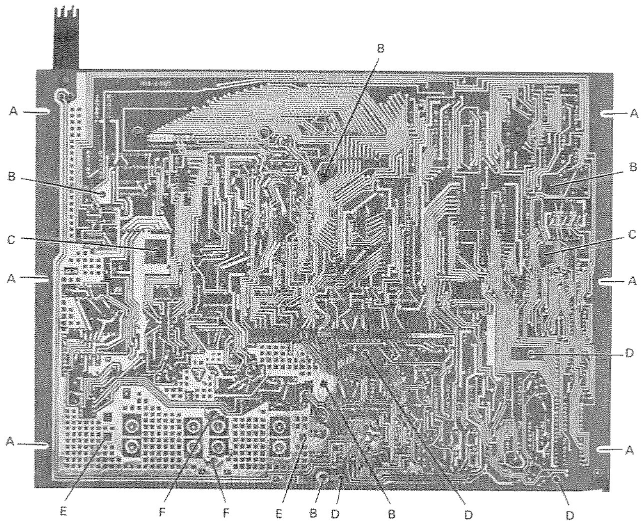

Figure 5-6. Locations of screws on the main board, bottom view. Screws at A and B hold the board to the chassis. Screws at C hold brackets for display board; D, the keyboard module; E and F, the test fixture guide block. All except F are accessed from this side.

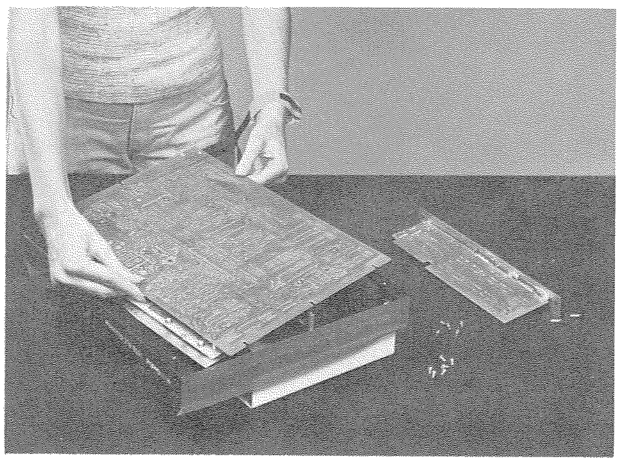

Figure 5-7. Removal of the MB board. The ribbon cable must be disconnected first. Prior removal of the display board also is highly recommended. Because the board is partially enclosed by the main chassis, some motions are necessary: toward front, disengaging bias connector, tilting, turning as shown, and toward the rear.

pins when plugging the keyboard-module connectors into their main-board sockets.

k. Remove dross shield assembly separately if desired (or as part of guide block; see below). The shield can be removed by spreading the mid parts of the long sides slightly and lifting it off.

l. For access to the test-fixture contacts, remove the guide block 1657-2200 (includes dross shield) by removing 2 screws E and 2 hex-socket screws F (.094-inch wrench) from opposite sides of the main board (Figure 5-6). Reassembly note: see para 5.7.1.

5.6.2 Access. Figures 5-8, 5-9, and 5-10.

Locations of principal interior parts and points of interest for trouble analysis are shown in the accompanying pictures. On the main board, the crystal oscillator U14 and DIP switch S900 are identified, being the key components in alteration of the test frequencies. (By changing U14 and depressing the correct switch tabs, you can convert a 1658-9700 functionally to a 1658-9800, and vice versa. Details are tabulated on the schematic diagram. Also, refer to Table 5-13.)

Also on the main board, notice that the analog circuitry is placed along the front (forward of the display-board connector) and along the front half of the right-hand edge. Most of this board supports digital circuitry.

For a more complete guide to parts location, refer to Table 5-11. This lists the principal parts of the main (MB–) board and indicates where each one is shown on both board layout and schematic diagrams. The alphanumerics such as B4 or C6 are coordinates on the indicated figures in Section 6. The vertical coordinates are A to E (top to bottom); the horizontal coordinates are 1 to 8 (left to right).

5.6.3 Reference Designations.

Refer to Section 6 for an explanation of these designations. For example, V-T1 designates transformer number one in the power supply (V) assembly. MB-U3 is integrated circuit number 3 on the MB board, which is the analog and control board, often called the main board.

5.6.4 Removal of Multiple-Pin Packages.

Use caution when removing a plug-in integrated-circuit or other multiple-pin part, not to bend pins nor stress the circuit board. Withdraw the part straight away from the board. Unless an IC is known NOT to be a MOS type, place it immediately on a conductive pad (pins in the pad) or into a conductive envelope.

DO NOT attempt to remove a soldered-in IC package unless you have the proper equipment and skills to do so without damage. If in doubt, return the board to GenRad.

5.7 PERIODIC MAINTENANCE.

5.7.1 Care of the Test Fixture.

About once a year (more or less depending on usage) the test fixture and its axial-lead adaptors should be inspected and cleaned as follows:

a. Clean the contact surfaces and blades of the axial-lead adaptors with isopropyl alcohol. Rub with a cotton swab (Q-tip). Remove any remaining liquid alcohol by blowing with the breath and remove any remaining cotton fibers, with tweezers.

b. Remove the MB board and expose the text-fixture contacts by removing its guide block (part number 1657-2200), as described above. See Figure 5-6.

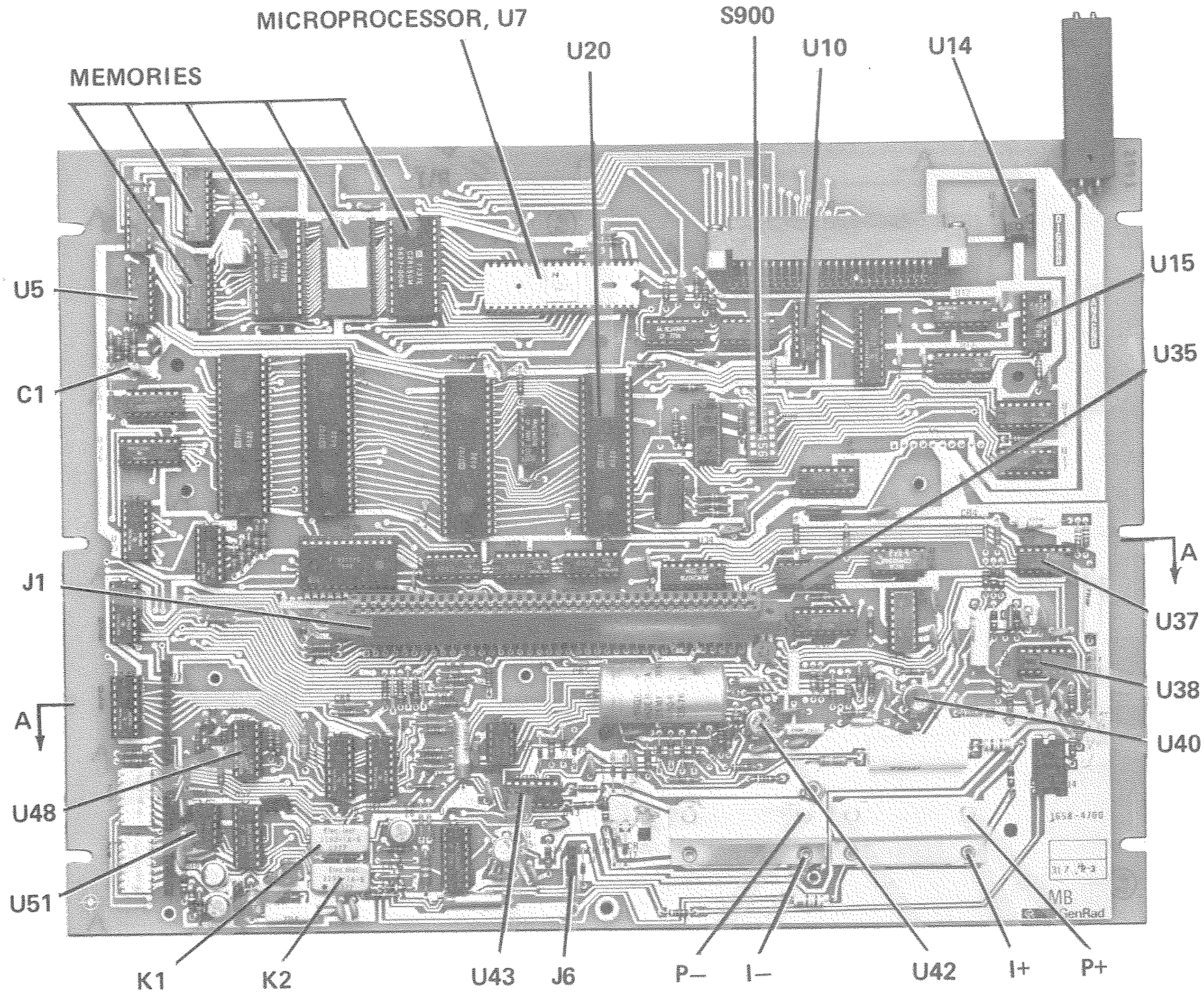

Figure 5-8. Main or MB board, top view. Functional conversion between 1658-9700 and 1658-9800 involves replacement of precision oscillator and depressing switch tabs; locations indicated. Arrows A–A indicate approximately the area of analog circuitry.

c. Clean and check the 4 contact strips. Use a card wet with isopropyl alcohol for cleaning. Hold the board at an angle so that any drip falls away from the circuits.

d. If necessary, the contact strips (part number 1686-1940) can be removed (2 screws apiece). In reassembly, observe the following. Align them, so both contact gaps are the same distance from the front edge of the board. The contact strips are supposed to press against each other, with tiny dielectric spacers preventing contact. Except at the ends of the gap (where the spacers are) the gap should be .05 to 0.2 mm (.002 to .008 in.) all along the gap.

When tightening the 8 screws that hold the 4 contact strips, use 12 inch-pounds of torque. When replacing the guide block, be sure the slots are aligned with the gaps between contact strips, as verified by eye, looking directly down on the board. Guide-block screws are 8 mm long, with washers.

For best results and minimum maintenance effort, the operator must remove any obvious dirt from leads of DUT's before inserting them into the test fixture. Its contacts will wipe through a film of wax, but they can become clogged and ineffectual if the operator is careless about cleanliness.

5.7.2 Care of the Display Panel.

Use caution when cleaning the display window, not to scratch it nor to get cleaning substances into the instrument. Use soft cloth or a ball of absorbent cotton, moistened with

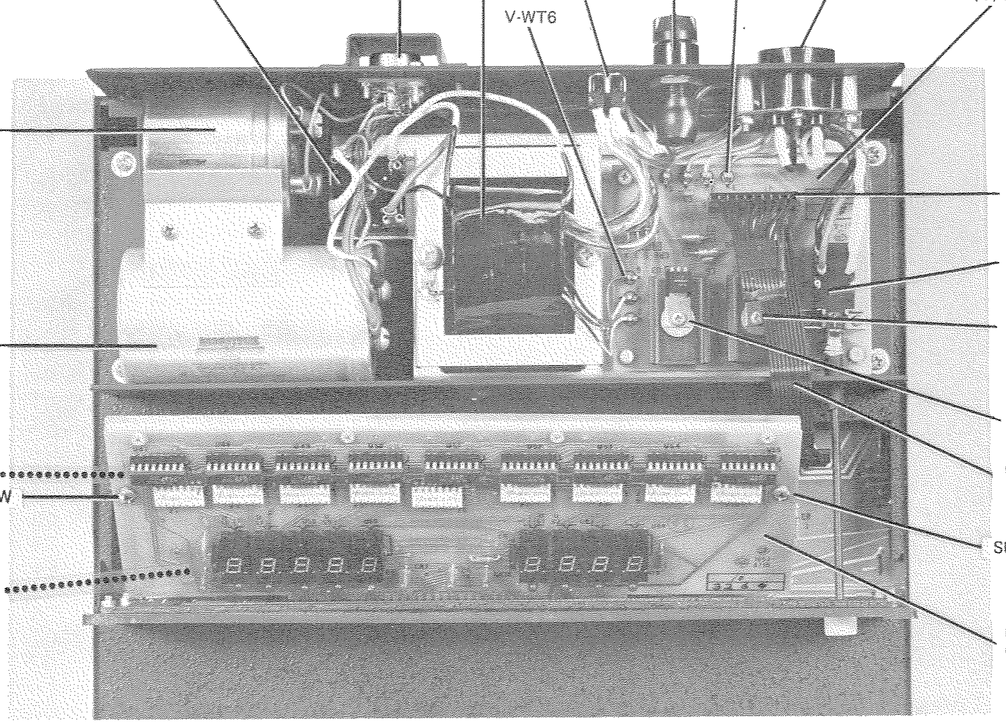

Figure 5-9. Power supply (V assembly) and display or DB board, shown in the instrument, with top cover off.

a mild glass cleaner, such as "Windex" (Drackett Products Co., Cincinnati, Ohio). DO NOT use a paper towel; do NOT use enough liquid to drip or run.

If it should be necessary to place marks on the window, use paper-based masking tape (NOT any kind of marking pen, which could be abrasive or react chemically with the plastic). To minimize retention of any gummy residue, remove the tape within a few weeks.

5.8 TROUBLE ANALYSIS.

5.8.1 General.

CAUTION

Only well qualified personnel should attempt trouble analysis. Be sure power is OFF during disassembly and setting up for tests. Carefully observe the HANDLING PRECAUTIONS given in para 5.6.

Resources. Refer to Section 4 for a good understanding of the theory of operation. The block diagrams and discussion there provide necessary background, which can generally save time in trouble analysis. Refer to Section 6 for hardware details: circuit layouts, schematic diagrams, and parts lists.

Abnormal digital signal levels. Most digital signal levels in this instrument are normally near zero (logic low), about +3.5 to +5 V (logic high), or rapidly switching between these states. Failure of a digital source often produces a dc voltage of about +2 V on a signal line. Use high-impedance probes in measuring. Use a scope as well as a voltmeter, because an average of 2 V may be normal for a digital signal that has a duty cycle near 50%.

Duplicated circuits. Some circuits, as in the display board for example, are duplicated several times. The IC's can usually be exchanged between a faulty circuit and a functional one, to identify a "bad" IC. Notice, also, that the resistor networks DB-Z2 . . . DB-Z10 are simply compact packages of 220-Ω resistors. If one resistor is open, it is not necessary to replace the entire package. Use a 5% resistor.

Circuit board replacement. Refer to para 5.3 for recommended procedures to obtain replacements.

Telltale symptoms. Scan the following group of symptoms for a preliminary analysis of trouble and suggestions for more detailed procedures if applicable.

Display. A perpetually blank digit or decimal point may be caused by a fault in the directly associated circuit on the display board. (Refer to comments above.)

D Error. A large D error may be caused by faulty "protection" diodes in the analog front end. Check MB-CR15 . . . MB-CR26 (a total of 12 diodes).

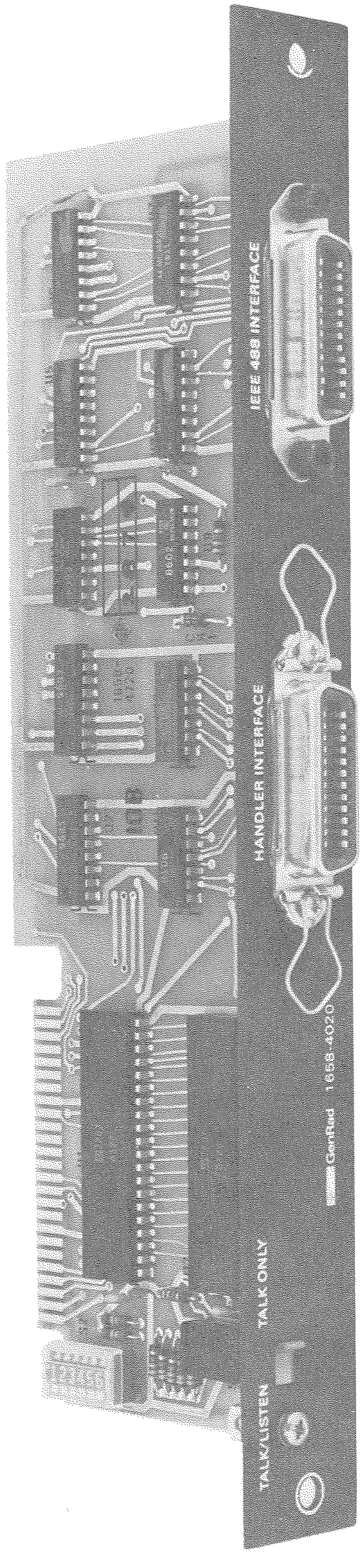

Figure 5-10. Interface option assembly 1658-4020, including the interface option board (IOB) 1658-4720.

Table 5-11

MB– BOARD PARTS LOCATIONS

Part	Layout*	Schematic**	
J1	D4	6-8	D5
—	—	6-9	E–
J2	A5	6-7	C1
J3	D1	6-9	C7
—	—	6-9	E–
J4	D7	6-5	3,5
J5	B6	6-5	E1
J6	E4	6-5	B1
J7	A7	6-5	B1
K1	E2	6-5	B2
K2	E2	6-5	C2
Q1	B1	6-7	B2
Q2	D2	6-5	D3
Q3	D2	6-5	D3
Q4	E3	6-5	A2
Q5	E2	6-5	D3
Q6	E2	6-5	C3
S900	B5	6-3	B7
S901†	B5	6-3	B5
U1	A1	6-7	A4
U2	A2	6-7	B7
U3	A2	6-7	B5
U4	A3	6-7	B4
U5	A1	6-7	A3
U6	B2	6-7	E7
U7	A4	6-7	B3
U8	B4	6-3	C4
—	—	6-3	D1
U9	B5	6-3	C5
U10	B5	6-3	D3
U11	B6	6-3	D3
U12	B6	6-3	B5
U13	B6	6-3	B3
U14	A6	6-3	B1
U15	B7	6-3	B3
U16	B7	6-9	B5
—	—	6-3	C6
U17	C7	6-3	B5

Part	Layout*	Schematic**	
U18	C5	6-3	E3
U19	C4	6-5	B6
—	—	6-5	D2
U20	B4	6-7	E6
—	—	6-5	A6
U21	B4	6-8	C6
U22	B3	6-8	B5
—	—	6-7	E4
U23	B2	6-8	B3
—	—	6-7	E3
U24	B2	6-7	E2
—	—	6-9	A6
U25	B1	6-9	B6
U26	B1	6-9	C6
U27	C1	6-9	C5
U28	C1	6-9	C3
U29	C2	6-9	B6
U30	C2	6-8	D2
U31	C3	6-8	C3
U32	C3	6-8	C4
U33	C4	6-8	C5
U34	C5	6-5	C6
U35	C5	6-5	B7
U36	C6	6-5	C7
U37	C7	6-5	D7
U38	D7	6-5	D5
—	—	—	D7
U39	C6	6-3	D4
U40	D6	6-3	D5
U41	C5	6-3	E5
U42	D5	6-3	D6
U43	D4	6-5	D4
U44	D3	6-3	D7
U45	E3	6-5	E2
U46	E3	6-5	D5
U47	D3	6-9	C4
U48	D2	6-5	C1
U49	D2	6-9	C2
U50	D1	6-9	C1
U51	E1	6-5	E3
U52	E2	6-5	D2
U53	A2	6-7	C5

*See Figure 6-4 for physical location.

**See indicated figure, 6-3, 6-5, 6-7, 6-8, or 6-9, for location on schematic diagram.

†Not present on standard models. (Used on special models with non-standard test frequencies.)

Reactance Error. If R measurements are accurate but C (and L) measurements are not, the test signal source may be at fault. In checking it, as in the following paragraph, verify that the frequency is within ±0.01% of the specified "actual" frequency. (See front of manual.)

Test Signal. To check performance of the test-signal source, use a scope to look at the open-circuit signal at the I+ terminal of the test fixture (right front contact – be sure there is no DUT). The signal should be an undistorted sine wave at the selected frequency, amplitude about 0.65 V pk-pk (±15%) on each range. If this is correct, skip over para 5.8.3.

Analog Front End. To check the entire analog front end, verify that the signal at MB-U3 pin 12 has the characteristic staircase/sawtooth waveform illustrated in para 5.8.4, while the instrument is measuring a DUT. If this is true for all modes (EQUIVALENT CIRCUIT, FREQUENCY, parameter R/Q, L/Q, and C/D), skip to para 5.8.6. Otherwise, check the test signal at the test fixture as outlined above.

Introduction to Detailed Analysis. The following trouble analysis procedures will serve as a guide for localizing a fault to a circuit area. In some cases, a specific component part can be isolated for replacement. In other cases, the problem can be narrowed down only to a circuit board.

Except for the short-cuts indicated above, follow the procedure strictly in the order given, doing the principal steps (a, b, c, d, . . .) until a failure is found. If so, follow the secondary steps, if any are given at the point of failure (aa, ab, ac . . .).

5.8.2 Power Supply.

Check the power supply (V assembly) if there is a massive failure (nothing works) or as a starting procedure in any thorough analysis. Refer to Figure 5-9.

NOTE

If a voltage regulator (U1, U2, or U3) must be replaced, be sure to spread silicone grease (like Dow Corning compound no. 5) on the surface toward the heat sink. For U1, coat both sides of the insulating washer.

a. Check the output voltages, using a digital voltmeter, with ground reference at V-J1, pin 9 (ribbon cable unplugged), as follows:

Pin 1 = +5 V.
Pin 3 = +5 V.
Pin 4 = −8 V.

b. Make a check similar to step a, with ribbon cable connected, ground reference at right edge of MB board, probing MB-J5 from below the board. (This checks for overload outside the power supply.)

aa. If trouble is found at step a, check "+5 V" circuit:
At outputs of U1 and U2: +5 V dc (regulated).
At WT1 (inputs of U1 and U2): +10.8 V dc.
Across input to diode bridge (yellow-to-yellow): 10 V rms.

ab. Check "−8 V" circuit:
At output of U3: −8 V dc (regulated).
At input (center terminal) of U3: −13.8 V dc.
Across WT7 to WT8: 11.3 V rms.

ac. Check power-line circuit to primary of transformer V-T1.

5.8.3 Sinewave Generator.

Check the MB-board circuits that supply the test signal to the DUT, as follows: (We proceed backward, to the precision oscillator, then forward through dividers and sinewave generator.)

a. Make the following test setup and keyboard selections:

DUT: 0.1 μF and 3 kΩ, connected in series.
MEASURE RATE – SLOW
EQUIVALENT CIRCUIT – SERIES
FREQUENCY – 1 kHz
Parameter – C/D.

b. Verify that the signal at test fixture, + side (right hand), is a 1-kHz sine wave, 490 mV pk-pk. Use an oscilloscope.

ba. If this signal is distorted or missing on all ranges, but present at MB-U42 pin 2 or J4 pin 5, check diode network MB-CR19 . . . -CR23. To change range, select ENTER as FUNCTION and press the Cs/D key one or more times.

c. If no fault appears in steps a, b, skip to para 5.8.4.

NOTE

The prefix "MB-" is omitted in the following text, where it is not necessary for clarity.

d. Verify that "1.4 V RMS TEST SIGNAL" found at U42 pin 2 is a 1-kHz sine wave, approx 4.0 V pk-pk (±10%).

e. Check at U42 pin 6 for a 1-kHz sine wave, 4.0 V pk-pk.

ea. Check at U42 pin 3 for a 1-kHz sine wave, 3.4 V pk-pk. If this is verified but step e is not, isolate the fault to U42 or to U44.

f. Verify that the output of U40, found at J4 pin 10 is a 1-kHz sine wave, 4.0 V pk-pk. (A "noisy" waveform is normal.)

g. Remove U40. Connect a 200-Ω resistor across its socket between pins 2 and 3. (Note: if the resistor leads are about 0.5 mm [0.02 in.] in diameter, they will fit the socket directly.) Check at U39 pin 4 for a 1-kHz sine wave, 0.4 V pk-pk. If this is verified but step f is not, fault is in U40. If neither is verified, reinstall U40 and continue.

h. Check that each input to the D/A converter U39 (pins 5 . . . 12), is a digital signal, about 4 V pk-pk. Each of these 8 signals should repeat with a period of 1 ms.

ha. If these inputs are verified but step g is not, fault is in U39 circuit. Check at the end of R46 closer to the test fixture for +3 V dc; if that is correct, replace U39. Otherwise, fault is in associated circuit.

If these digital signals are NOT correct, continue the analysis by checking the crystal oscillator and divider chain, as follows.

NOTE

Dual specifications of frequency appear below. The first frequency is correct for 1658-9700 (the 120-Hz version). The second is correct for 1658-9800 (the 100-Hz version). Frequency tolerance is ±0.01%.

i. Make the following test setup. Connect from the scope vertical-channel output to a counter. Be sure to use a low-capacitance probe at the scope input, so as not to load the high-impedance circuits being analyzed.

j. Oscillator. Check at U15 pin 14 for a fast digital waveform (see schematic diagram) of the following frequency: 25.067 or 24.576 ± 0.003 MHz. If correct, skip to step k. If oscillator signal is not verified, U14 is faulty.

k. Check at U15 pin 8 for a noisy square wave, 4 V pk-pk, 2.0889 or 2.0480 MHz. Otherwise, U15 is faulty.

l. Check at U13, pins 1 and 8 for pulses (essentially rectangular), with frequencies as follows:

Pin 1, 1.0445 or 1.0240 MHz.
Pin 8, 261.12 or 256.00 kHz.

Otherwise, U13 is faulty.

m. Check at U12 for similar pulses, with frequencies as follows:

Pin 12, 522.24 or 512.00 kHz.
Pin 9, 276.00 or 216.12 kHz.
Pin 8, 122.80 or 156.00 kHz.
Pin 11, 61.44 or 78.00 kHz.

n. Check at U17 pin 9 for a 5 V pk-pk rectangular wave, with frequency of 30.72 or 26.11 kHz. Otherwise, U17 is faulty.

o. Check at U9 pin 8 for a square wave, 5 V pk-pk, at 261.12 or 256.00 kHz.

oa. If step o is not confirmed, be sure you have selected 1 kHz on the front panel. Check that FREQ SEL (U9 pin 1) is logic high. (Otherwise check back to U20 pin 39.)

ob. If those checks are confirmed, fault is in the gates, U9.

NOTE

Servicing the digital circuitry, such as that "behind" FREQ SEL, is beyond the scope of this manual. Swapping identical PIA's may be informative; refer to para 5.8.1.

p. While monitoring U9 pin 8, press the FREQUENCY key and select 120 Hz, (or 100 Hz). Check that the monitored signal (which should always be 256 times the test frequency) is now 30720 Hz or 25600 Hz. Again press the FREQUENCY key and select "1 kHz."

q. Check that the outputs of U18 are square waves, 5 V pk-pk, with frequencies as follows (for 1658-9700 or 1658-9800 respectively). Otherwise, U18 is faulty.

Pin 12, 130.56 or 128.00 kHz.
Pin 9, 65.28 or 64.00 kHz.
Pin 8, 32.64 or 32.00 kHz.
Pin 11, 16.32 or 16.00 kHz.

r. Check U10 similarly. (Otherwise U10 is faulty.)

Pin 12, 8.160 or 8.000 kHz.
Pin 9, 4.080 or 4.000 kHz.
Pin 8, 2.040 or 2.000 kHz.
Pin 11, 1.0200 or 1.0000 kHz.

s. If inputs to the sine rom U11 are valid (steps i . . . r) but its output is not (steps a . . . h), U11 is faulty; or possibly (because step h does not check the output code from U11) U39 may be faulty. They can be checked against their manufacturer's data sheets.

5.8.4 Front End Amplifiers and Switches. Figure 5-11.

Check the MB-board analog circuits that process the measurement signals from the test fixture to the point of A/D conversion, as follows.

NOTE

When it is necessary to access parts under the keyboard, select the desired measurement conditions (usually including CONT MEASURE MODE), and then remove the keyboard module as described above. Connect temporarily from the right end of R68 to the front end of C21 or plug in a temporary jumper of AWG No. 20 wire between pins 5 and 6 of MB-J6. Carefully plug the module into its connectors again whenever the procedure requires keyboard operation.

a. Verify that there is a normal test signal at the test fixture. (See para 5.8.1 or para 5.8.3 step b.)

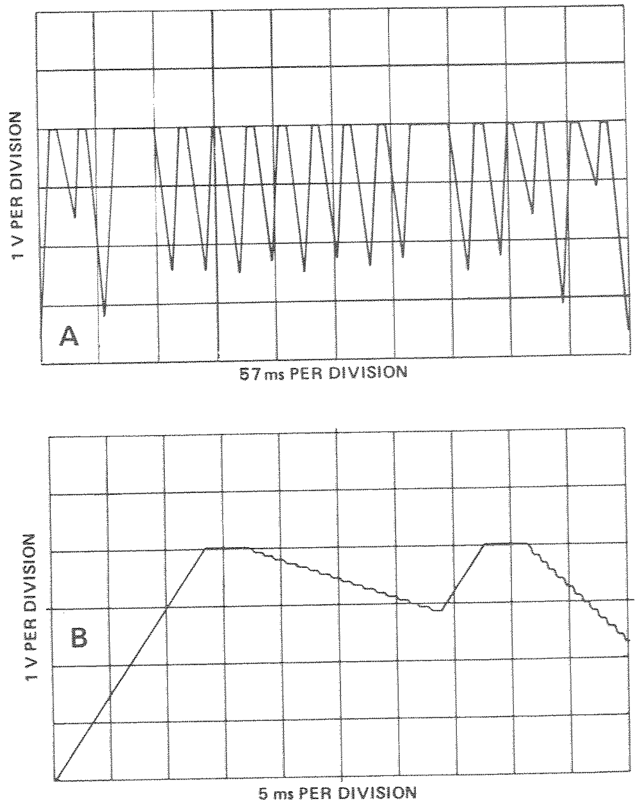

Figure 5-11. Integrator output waveform for the conditions of para 5.8.4: VALUE, SLOW, SERIES, 1 kHz, CONT, R/Q, autorange; DUT is 1 Ω. The waveform repeats every 570 ms, including 16 staircases, for a complete measurement cycle. The expansion, B, shows typical detail in the first 2 staircases. Each staircase has 17 or 20 steps. For details, refer to Table 5-13.

b. Check the range switching circuitry as follows. Insert as DUT each of the following resistors; and check for a 1-kHz sine wave with a scope connected to the + (right) end of each DUT in turn:

1 Ω; test signal should be 60 mV pk-pk
1 kΩ; 330 mV pk-pk
1 MΩ; 580 mV pk-pk.

c. Install a 1 k-Ω resistor in the test fixture. Check the P+ circuit at U43 pin 1, for a 1-kHz sine wave, 350 mV pk-pk.

d. Check part of the I− circuit at U43 pin 10, for a 1-kHz sine wave, 330 mV pk-pk.

Table 5-12

SOURCE-RESISTOR RANGE SWITCHING CHECKS

DUT	K1,(1-4)	K2,(1-4)	U48 Pin 10	U48 Pin 8
1 Ω	open	closed	high	low
1 kΩ	closed	open	low	high
1 MΩ	open	open	high	high

ba. If discrepancy is found in step b, check for continuity through relays K1, K2 (pin 1 to pin 4) and for their control signals, as shown in Table 5-12.

ca. If there is a discrepancy in step c, but U43 pin 3 has a 330-mV pk-pk sine wave, then U43 is faulty.

da. If discrepancy in step d, check at U52 pin 14 for a 1-kHz sine wave, 330 mV pk-pk; and at pin 10 for a logic high (+5V).

db. Check U52 pins 12, 15 for presence of signal. If the signal is correct at pin 15 but missing at 12, check Q5, Q6, and associated circuit, or U52.

dc. Conversely, if the signal is correct at pin 12 but missing at pin 15, replace U52.

dd. If both signals at U52 are correct, check at U51 pin 3 for a 1-kHz sine wave, 360 mV pk-pk. If discrepant, check U45 pin 6; replace U45.

e. Check at U43 pin 8 for a 1-kHz sine wave, 330 mV pk-pk. Otherwise U43 is faulty.

f. Exchange the DUT for a 1-Ω resistor. Check the output of the signal selector, U46 pin 13 for a 1-kHz switched sine wave, 580 and 60 mV pk-pk levels.

g. Check at output of differential amplifier U38 pin 1 for a 1-kHz switched sine wave, 4 V and 0.4 V pk-pk, or somewhat larger. The ratio should be 10 to 1.

h. Check the integrator output at U38 pin 12 (or the front end of C38) for the staircase waveform shown in the accompanying figure. Notice that there are 17 steps for the 1658-9700, but 20 steps for the 1658-9800, *if* the test frequency is "1 kHz." The amplitudes of the staircases depend on the range as well as the impedance components of the DUT. For details, refer to Table 5-13.

The waveform is more easily stopped on the scope if the chosen conditions make one staircase taller than the others. Careful setting of scope trigger adjustment is usually required, preferably on the positive slope, at a low voltage, near the negative peak.

Table 5-13
FREQUENCY SELECTION AND VARIOUS CHARACTERISTICS OF STANDARD MODELS

Characteristic	-9700	-9800
Hi-f "1 kHz"	1020 Hz	1000 Hz
Lo-f "120 Hz"	120 Hz	100 Hz
Crystal f (MHz)	25.0675	24.576
Rejected freq	60 Hz	50 Hz
DIP switch, set:		
S900, 1	–	–
S900, 2	ON	OFF
S900, 3	OFF	ON
S900, 4	OFF	OFF
S900, 5	ON	ON
S900, 6	OFF	ON
Steps* for Hi-f:	17/17/8	20/20/10
for Lo-f:	2/2/1	2/2/1
Staircases**	16/8/5	16/8/5

*Steps per staircase (pulses/burst, BST; Figure 5-12) slow/med/fast rates.
**Staircases (BST bursts; Figure 5-13) per measurement, for slow/med/fast rates, either frequency.

5.8.5 Control Signal Checks. Figures 5-12, 5-13.

If there is no staircase waveform at the integrator output, in the phase-sensitive detector, as described above, use the following procedure to determine whether the fault is in the digital control circuitry.

de. Check at U51 pin 8 for a 1-kHz sine wave, 360 mV pk-pk. If discrepant, fault is in U51.

df. Check at U52 pin 13 for a 1-kHz sine wave, 330 mV pk-pk. If discrepant, check C50, U43, and U52 for loading or an open circuit.

fa. If discrepancy in step f, check the digital signal SSW1 at U46 pin 10 (or J1 pin 57, display-board connector). It should be a slow rectangular wave, switching between 0 and +4 V. Refer to timing diagram, below.

ga. Otherwise, using a X10 scope probe with a short connection to ground, check at U38 pin 2 for a switched sine wave, 30 and 10 mV pk-pk. Check pin 3 similarly. If these verified but not step g, U38 is faulty.

ha. If step h is not verified, check at detector-switch control terminals U37 pins 5, 6, 12, 13 for the presence of digital signals with logic high and low levels of +5 V and −8 V. If all of these signals are present, either U37 or U38 is faulty; replace both of them. Otherwise, check the quad flip-flop U34. Also, refer to para 5.8.5.

a. Examine the frequency synchronizing signals, which should all be similar except for frequency (differing by factors of 2): F, 2F, 4F, 8F at U20 pins 2, 3, 4, 5. If there is a fault, check the circuit of U10.

b. Look at the following control signals with a scope and compare them with the timing diagram:

PBST, at U20 pin 12,
PMSR, at U20 pin 20.

If they are normal, skip to step c. If they are inactive, perhaps they can be stimulated by applying pulses to the power-on reset circuit; see step ba.

ba. Provide reset pulses in either of 2 ways. Preferably, set up a pulse generator as follows:

Source resistance: 50 Ω.
Repetition rate (period): 1 s.
Pulse polarity and duration: positive, 0.5 s.
Dc levels: high = 4.5 V; low = 0 V.
Connect from ground to U5 pin 11.

bb. The alternative method is to short across C1 momentarily (and repeatedly) with a clip lead. Watch the scope carefully for activation, perhaps for only 1 cycle, of PBST and/or PMSR, after each application of the short circuit. Notice that this short must be only momentary and that it must not be applied while the pulse generator is connected. Find C1 between Q1 and U25.

bc. If PBST and PMSR remain inactive in spite of the preceding stimulation, the digital control circuitry is at fault: go to para 5.8.6. Otherwise, proceed to step b, continuing to use the reset pulses.

c. Examine each of the following digital feedback signals and compare it with the timing diagram. If any one is questionable, check the circuit from which it is derived:

MSR, at U34 pin 10 and its converse $\overline{\text{DMSR}}$, at U20 pin 40 (from PMSR).

$\overline{\text{DONE}}$; at U36 pin 6 (comment follows).

Notice that $\overline{\text{DONE}}$ is normally a negative pulse that starts with the rising edge of CMP and very quickly terminates, when $\overline{\text{REL}}$ drops to "low." (CMP stays high for a variable length of time.) However, if reset pulses are being provided as in step aa, and CMP is low, then $\overline{\text{DONE}}$ is triggered by $\overline{\text{RES}}$.

d. If the digital feedback signals are present, look at each of the following control signals and compare it with the timing diagram: (The first 5 signals have logic low and high levels of 0 and +5 V; the last 6 signals, –8 and +5 V.)

PBST, at U19 pin 6;
$\overline{\text{PISW}}$, at U19 pin 4;
PMSR, at U19 pin 2;
$\overline{\text{RES}}$, at U35 pin 8 (reset, normally only at power-up);
SSW1, at U20 pin 14;
Clock at U34 pin 9 (from 8F, at U35 pin 6);
$\overline{\text{DONE}}$, at U34 pin 1;
BST, at U37 pin 12 (clocked by 8F, enabled by PBST);
$\overline{\text{BST}}$, at U37 pin 13 (clocked by 8F, enabled by PBST);
MSR at U37 pin 6 (clocked by 8F, enabled by PMSR);
ISW, at U37 pin 5 (clocked by 8F, enabled by $\overline{\text{PISW}}$).

If any is abnormal, trace back to the source of the signal, with the help of the schematic diagram (to check for poor connections or other interface problems). If the source is faulty, go to para 5.8.6. If these control signals are all valid, the digital control circuitry is functional; the fault is probably in the integrator U38 or associated circuits.

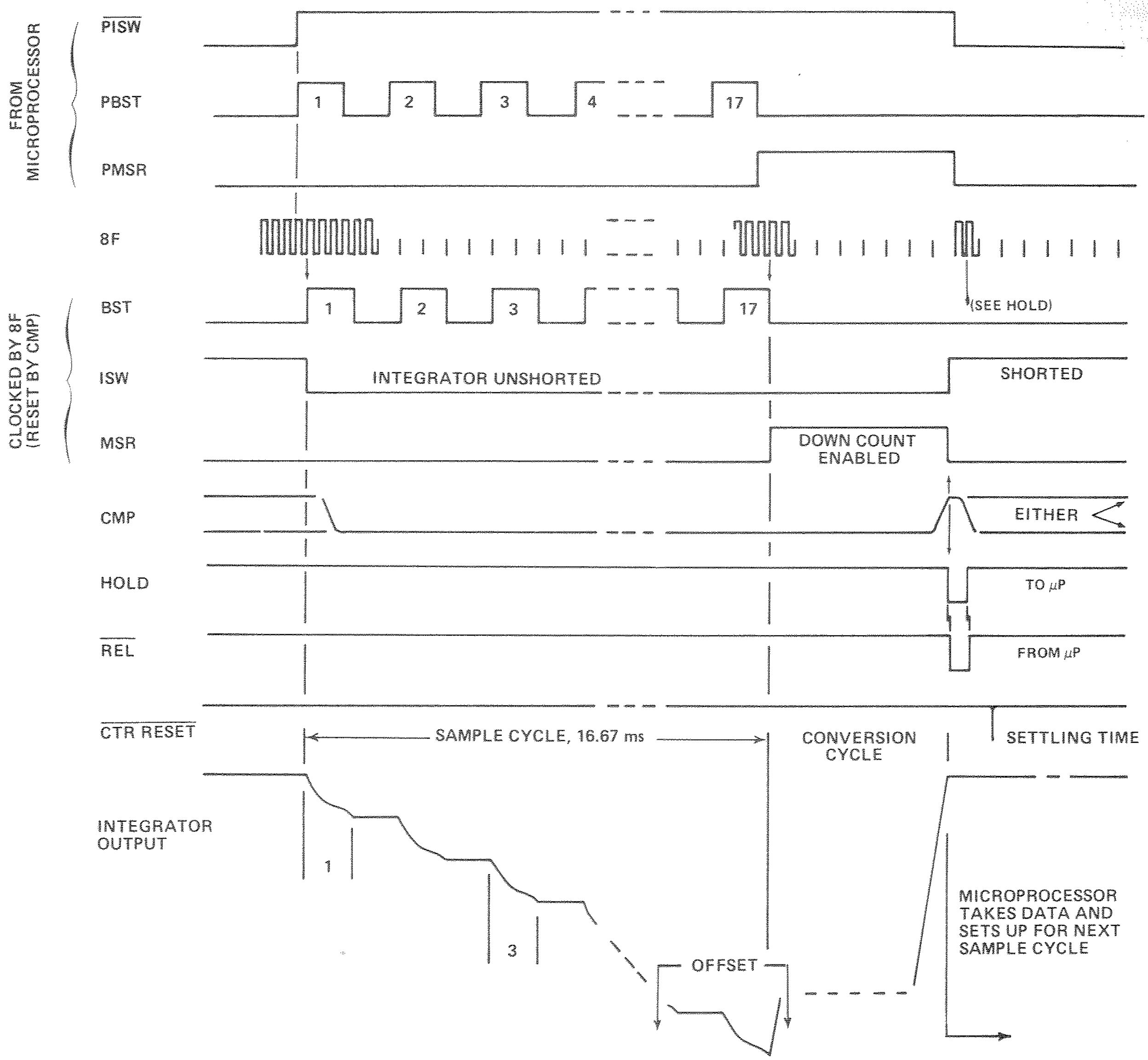

Figure 5-12. Timing diagram. One complete staircase cycle for a typical SLOW- or MEDIUM-rate 1-kHz measurement on a 1658-9700. The 3 main divisions are: sample cycle (stair steps down), conversion cycle (smooth ramp up, during which a counter arrives at digital value of signal being sampled), and data-taking cycle (microprocessor takes data and sets up for next staircase). In this example, there are 17 samples taken.

5.8.6 Digital Circuitry.

Display Board. A faulty integrated-circuit package can usually be identified by interchanging plug-in component parts of the same type between display channels. Notice that a resistor network need NOT be replaced as a unit; use ordinary resistors. (See para 5.8.1.)

Recommended Procedure. If careful analysis of a faulty instrument, using the preceding information, indicates that the trouble is in the digital circuitry (whether in control, computation, or display decoding), further analysis is beyond the scope of this manual. Return the faulty board (the MB board, if the fault is digital, and not in the display board) or return the instrument for service. Refer to para 5.2 and 5.3.

Special Testing. Because of the very high speed and considerable complexity of the digital circuitry in the MB Board and IOB (Interface Board), it is impossible to analyze trouble there with ordinary test equipment. GenRad production and in-factory service departments make use of fast, versatile automatic test systems (GenRad products). Their efficiency and accuracy are important factors in our recommendation that digital circuit problems be solved by exchanging boards.

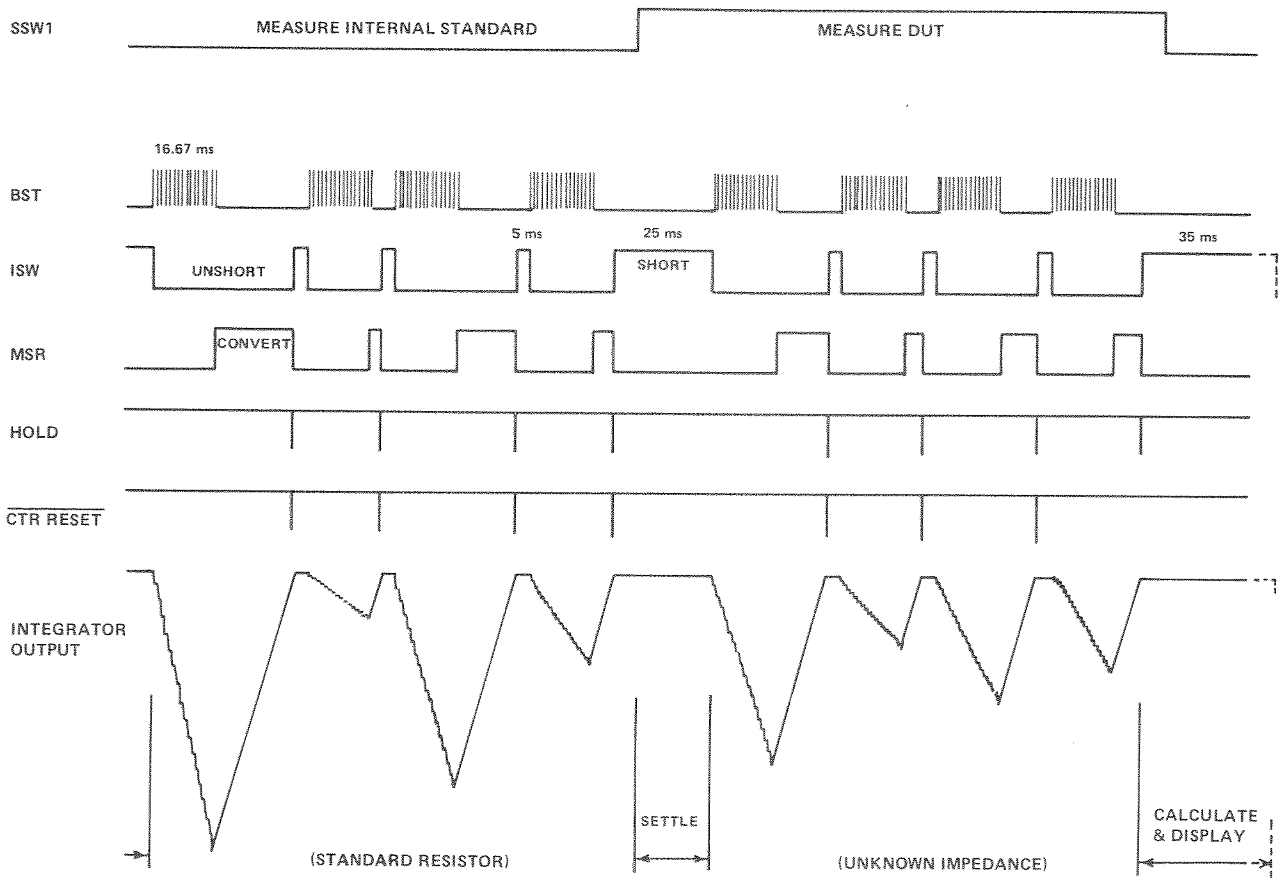

Figure 5-13. Timing diagram. One complete measurement cycle for a typical MEDIUM-rate 1-kHz measurement on a 1658-9700. There are 8 staircase cycles, one with each phase of BST for the signal from the standard and one with each phase of BST for the signal from the DUT.