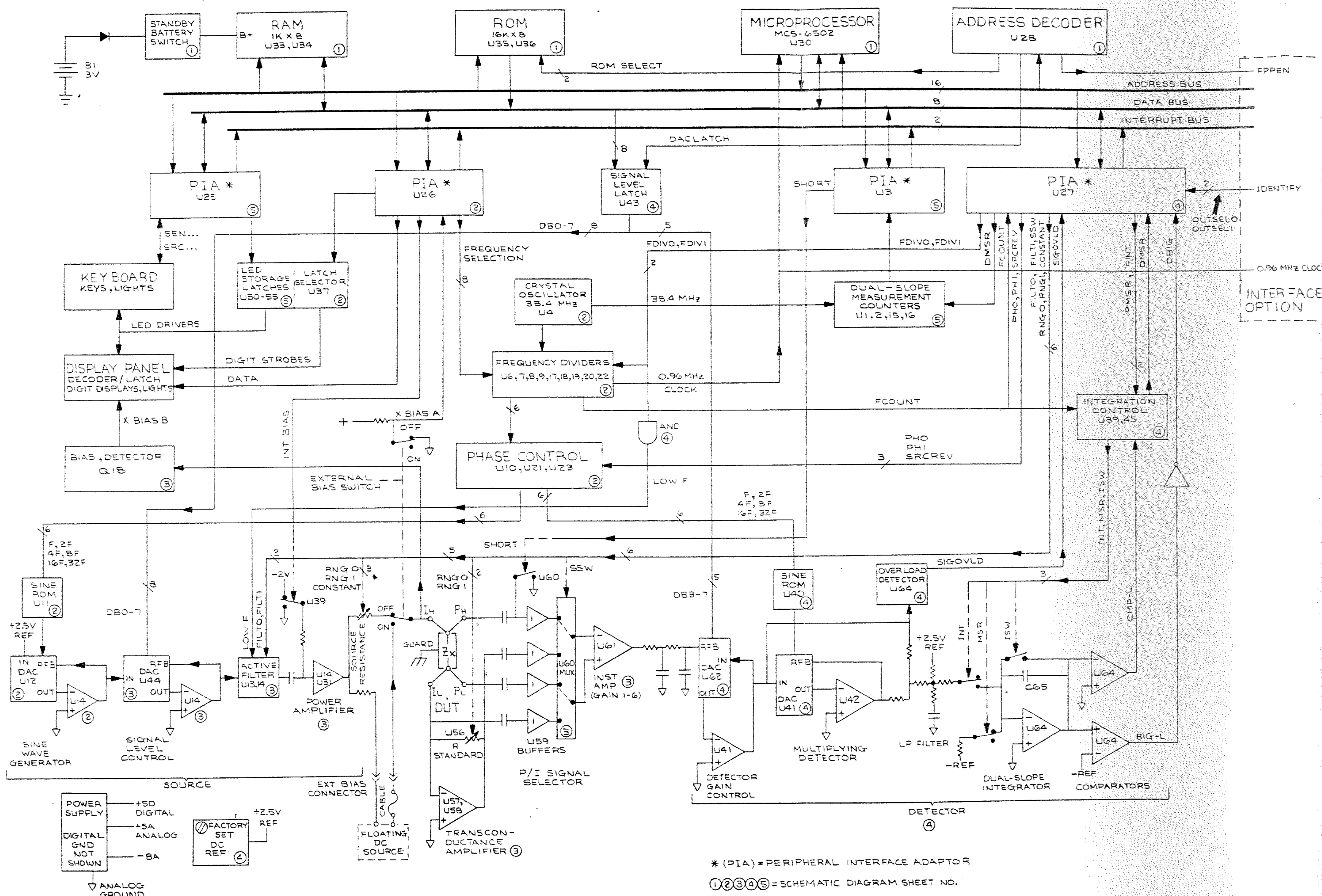


STANDBY BATTERY SWITCH ①
B1 3V
RAM 1K X 8 U33, U34 ①
ROM 16K X 8 U35, U36 ①
MICROPROCESSOR MCS-6502 U30 ①
ADDRESS DECODER U28 ①
ROM SELECT
FPPEN
ADDRESS BUS
DATA BUS
INTERRUPT BUS
DACLATCH
PIA * U25 ⑤
PIA * U26 ②
SIGNAL LEVEL LATCH U43 ④
SHORT
PIA * U3 ⑤
PIA * U27 ④
IDENTIFY
OUTSEL0 OUTSEL1
SEN...
SRC...
DB0-7
FDIV0, FDIV1
FREQUENCY SELECTION
KEYBOARD KEYS, LIGHTS
LED STORAGE LATCHES U50-55 ⑤
LATCH SELECTOR U37 ②
CRYSTAL OSCILLATOR 38.4 MHz U4 ②
38.4 MHz
DUAL-SLOPE MEASUREMENT COUNTERS U1, 2, 15, 16 ⑤
DMSR
FCOUNT
PH0, PH1, SRCREV
FILT0, FILT1, SSW
RNG0, RNG1, CONSTANT
SIGOVLD
PMSR, PINT
DMSR
DBIG
0.96 MHz CLOCK
INTERFACE OPTION
LED DRIVERS
DIGIT STROBES
DATA
DISPLAY PANEL DECODER/LATCH DIGIT DISPLAYS, LIGHTS
FREQUENCY DIVIDERS U6, 7, 8, 9, 17, 18, 19, 20, 22 ②
0.96 MHz CLOCK
INTEGRATION CONTROL U39, 45 ④
FCOUNT
X BIAS B
INT BIAS
X BIAS A
OFF
ON
AND ④
PH0 PH1 SRCREV
BIAS, DETECTOR Q18 ③
EXTERNAL BIAS SWITCH
PHASE CONTROL U10, U21, U23 ②
LOW F
F, 2F 4F, 8F 16F, 32F
INT, MSR, ISW
SHORT
SSW
SIGOVLD
F, 2F 4F, 8F 16F, 32F
SINE ROM U11 ②
+2.5V REF
DB0-7
-2V
U39
RNG0 RNG1 CONSTANT
RNG0 RNG1
U60
DB3-7
SINE ROM U40 ④
OVERLOAD DETECTOR U64 ④
IN DAC U12 ② OUT RFB
U14 ②
RFB IN DAC U44 ③ OUT
U14 ③
LOW F FILT0, FILT1
ACTIVE FILTER U13, 14 ③
U14 U31
SOURCE RESISTANCE
OFF ON
GUARD
I_H P_H
Zx
I_L P_L
DUT
U60 MUX
U61
INST AMP ③ (GAIN 1-6)
RFB IN DAC U62 ④ OUT
RFB IN DAC U41 ④ OUT
U42
+2.5V REF
INT MSR ISW
C65
U64
U64
U64
CMP-L
BIG-L
SINE WAVE GENERATOR
SIGNAL LEVEL CONTROL
POWER AMPLIFIER ③
U56
R STANDARD
U59 BUFFERS
P/I SIGNAL SELECTOR
U41
DETECTOR GAIN CONTROL
MULTIPLYING DETECTOR
LP FILTER
-REF
DUAL-SLOPE INTEGRATOR
-REF
COMPARATORS
SOURCE
EXT BIAS CONNECTOR
CABLE
FLOATING DC SOURCE
U57, U58
TRANSCONDUCTANCE AMPLIFIER ③
DETECTOR ④
POWER SUPPLY
DIGITAL GND NOT SHOWN
+5D DIGITAL
+5A ANALOG
-8A
ANALOG GROUND
FACTORY SET DC REF ④
+2.5V REF
* (PIA) = PERIPHERAL INTERFACE ADAPTOR
①②③④⑤ = SCHEMATIC DIAGRAM SHEET NO.

Figure

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. 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 1689 Digibridge.

This Digibridge ® uses a new measurement technique, in which a microprocessor calculates the desired impedance parameters from a series of 6, 6, or 8 voltage measurements (for FAST, MED, and SLOW measurement rates, respectively). A patent has been applied for. These measurements include quadrature (90 degree) and inverse (180 degree) vector components of the voltage across a standard resistor Rs carrying the same current as the device under test (the DUT), Zx. Each of these voltage measurements is rather 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 4 reference signals, precisely 90 degrees 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 Rs) 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.

Because of the measurement technique and circuitry, the only calibration adjustment in the Digibridge is the factory setting of the test-voltage-level reference. The only precision components in this instrument are four 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, the predetermined frequency, and the calibrated R and Q of the applicable standard resistor.

In these calculations, the microprocessor automatically removes from the measured result the parameters of the test connection ("stray" capacitance and conductance and series resistance and inductance), if simple open-circuit and short-circuit "ZERO" calibration measurements have been performed by the operator. The values obtained during "ZERO" calibration are stored in Digibridge memory and retained during power-down and power-up.

The impedance of each internal standard resistor is similarly stored in memory for use by the microprocessor in the calculation of parameters being measured. (For this purpose, the Digibridge measures its own internal standard resistors against an external standard during factory calibration --- and recalibration, if any.) Therefore, the impedances of the internal resistance standards are known at the calibration frequency (usually 1 kHz), and are computed by the microprocessor for other test frequencies.

The Digibridge also stores the frequency error of its crystal-referenced oscillator (actual vs nominal frequency, expressed in parts per million) so that the microprocessor uses a corrected frequency value in each calculation of capacitance or inductance from measured impedance. This frequency correction is programmed into the Digibridge during factory calibration --- and recalibration, if any.

The microprocessor controls the measurement sequence, according to programs in the read-only memory, using stored operator selections that are made available through keyboard control or (if you have the interface option) by remote-control command. Selections include for example -- parameters: R and Q, L and Q, C and D, or C and R; test voltage: .005 to 1.275 V; equivalent circuit: series or parallel; test rate: SLOW, MEDIUM, or FAST; frequency: programmable from 12 Hz to 100 kHz in 503 steps; delay: up to 99999 ms; and averaging: 2 to 255 measurements; etc.

The instrument normally autoranges to find the correct range; but operation can be restricted to any of the four ranges (1, 2, 3, 4), under keyboard control. Each range is 4 octaves wide (16:1), with reduced-accuracy extensions both above and below.

Leading zeroes before the decimal point are blanked out of the RLC and QDR displays.

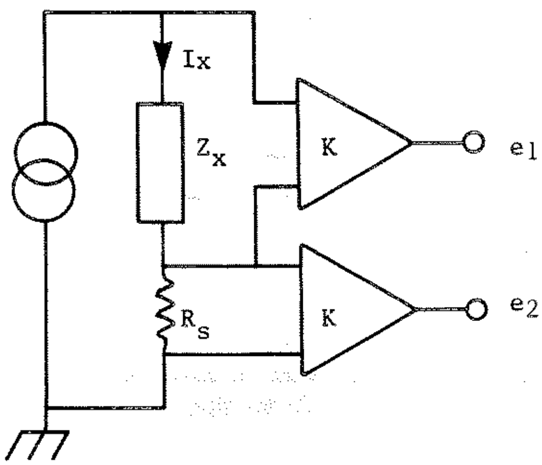
4.1.3 Block Diagram. **Figure 4-1.**

The block diagram shows the microprocessor in the upper center connected by data and address buses to digital circuitry including memories (RAM and ROM) 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 P/I signal selector and instrumentation amplifier supply an analog signal that represents 2 impedances alternately: the appropriate internal resistance standard, Rs, and the DUT, Zx.

The phase-sensitive (dual-slope) detector and measurement counters convert this analog signal into digital form. See circuit descriptions below.

From this information and criteria selected by the keyboard (or remote control), the microprocessor calculates the RLC and QDR values for display, averaging, bin assignments, etc.



$$e_1 = KZ_xI_x \qquad \frac{e_1}{e_2} = \frac{Z_x}{R_s}$$
$$e_2 = KR_sI_x$$

Figure 4-2. Elementary measurement circuit.

4.2 PRINCIPAL FUNCTIONS.

4.2.1 Elementary Measurement Circuit. Figure 4-2.

The measurement technique is illustrated by the accompanying simplified diagram, which can be correlated with the previous (block) diagram. 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 e1 and e2. 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. Two values (such as C and D or L and Q) are automatically calculated by the microprocessor from Zx, frequency, and other information.

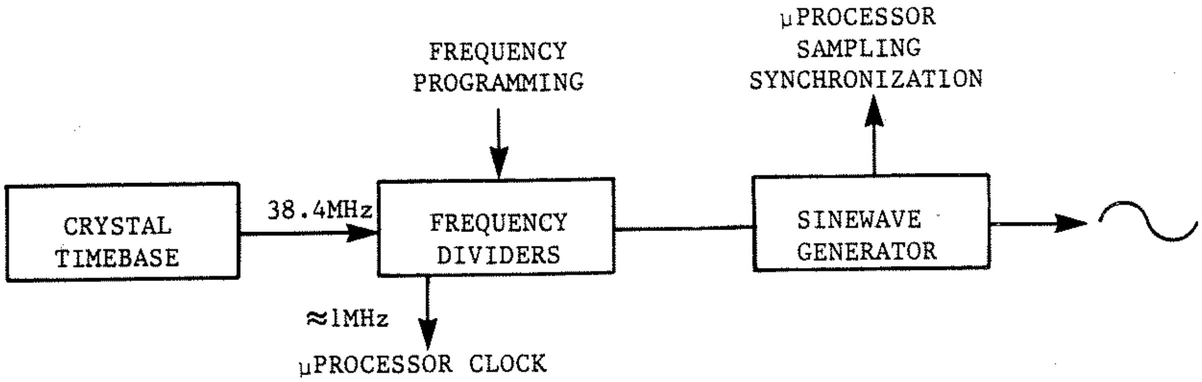


Figure 4-3. Frequency and timing source. Several clocks and synchronizing pulses as well as the measurement signal f are derived from the accurate time-base signal.

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 multi-phase references for detection and clocks for the microprocessor. Frequency and timing requirements are implemented by derivation from a single very accurate oscillator, operating at 38.4 MHz. Digital dividers and logic circuitry provide the many clocks and triggers, as well as driving the sine-wave generator described below.

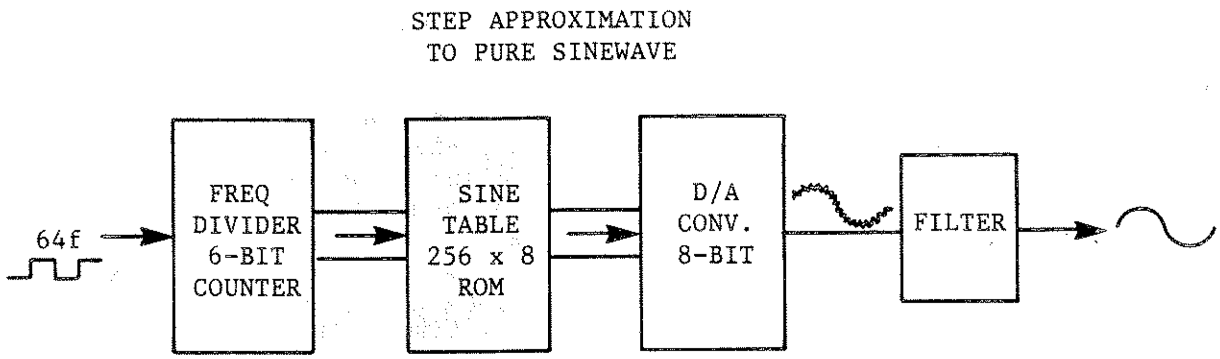


Figure 4-4. Sine wave generator. Given square waves at frequencies of 64 f, 32 f, 16 f, 8 f, 4 f, 2 f, and f, a ROM containing the mathematical sine function drives a D/A converter to form a finely stepped approximation to a sine wave at frequency f. The filter provides smoothing of the test signal.

4.2.3 Sine-Wave Generation. **Figure 4-4.**

Source of the Test Signal. Starting with a digital signal at 64 times the selected test frequency, the sinewave generator provides the test signal that drives a small but essential current through the DUT. The sine wave is generated as follows.

Binary dividers count down from 64 f, providing signals at 32 f, 16 f, ... 2f, f. This set of signals is used to address a read-only memory which contains a 64-step approximation to a sine function. The ROM output (as an 8-bit binary number) is converted by a D/A converter to a stepped approximation of a 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.

Source of the Reference Sine Wave for the Multiplying Detector. Another sine-function ROM is addressed by the same digital signals (64 f through f) to produce another stepped approximation of a sine wave at 0 degrees. Suitable inversions of signals 2f and/or f serve to shift the phase of the output sine wave, under microprocessor control, by 90, 180, or 270 degrees.

4.2.4 The Dual-Slope Integrating Detector and Converter (See Figure 4-1.)

Circuitry. The phase-sensitive detector/converter circuit consists of a multiplier whose dc output is measured by a dual-slope converter, providing the measurement in digital form. The multiplier is a multiplying D/A converter whose "reference" input is the test signal and whose digital controls are signals representing a stepwise approximation of a reference sine wave at the test frequency. The dc value of the multiplier output is proportional to the product of signal magnitude multiplied by the cosine of the phase angle between the test signal and the reference sine wave.

The dual-slope converter includes these three stages: dual-slope integrator, comparator, and counter (all controlled by the microprocessor through PIAs). In the dual-slope integrator, a capacitor is charged for a controlled integration time interval (sampling) at a rate proportional to the multiplier output voltage. This capacitor is then discharged at a fixed rate (the deintegration slope) to zero voltage, a condition that is sensed by a comparator. (See signal name "CMP-L" on the block diagram.) Thus, the integrator and comparator transform the sampled dc output from the multiplier into a precise interval of time. The dual-slope measurement counter is gated by this time interval, thus converting it into a digital number, which is a principal data input to the microprocessor.

If the integration time is relatively long, so that the integration capacitor voltage reaches a certain reference level, another comparator triggers the beginning of the return (deintegration) slope before sampling has been completed. (See signal name "BIG-L" on block diagram.) The detector is then sampling and converting simultaneously for a portion of the dual-slope conversion cycle.

Data Acquisition Time. Data acquisition time includes pauses for synchronization, and several integration/deintegration cycles.

A pause for synchronization varies depending on timing relationships among the START signal, length of settling time or programmed delay, length of the previous integration/deintegration cycle, and the Digibridge clocks (particularly FCOUNT, shown on block diagram). This pause can be as much as one test-frequency period for high frequencies or up to 1/32 of the test-frequency period for low frequencies.

The integration (sampling, gate, or capacitor charging) time of the dual-slope integrator is the number of full periods of the test frequency whose sum is closest to (4 ms)x(integration-time factor) for FAST,
closest to but not over (16.7 ms)x(integration-time factor) for MEDIUM,
or closest to but not over 100 ms for SLOW measurement rate. (The integration-time factor is normally 1.0 but can be programmed between 0.25 and 6.)

The return (deintegration) time depends on the dc voltage being converted and whether "BIG-L" has been triggered (see above); therefore, this time requirement varies in a complex manner.

Data acquisition includes several complete dual-slope conversion cycles, with the reference sine wave at 3 or 4 different phases, exactly 90 degrees apart, as follows:
For FAST and MEDIUM rates, 6 cycles (2 each with reference phases of 0, 90, and 180).
For SLOW measurement rate, 8 cycles (2 each with ref phases of 0, 90, 180, and 270).

Therefore, data acquisition time is a complex, discontinuous function of test frequency, the selected measurement rate, programmed integration-time factor, and pauses for synchronization.

Service — 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.

CAUTION

For continued protection against fire hazard, replace fuse only with same type and rating 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.

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 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 plugged in.

The symbols shown below may appear on circuit boards and/or schematic diagrams to call attention to static sensitive component parts. However, the absence of such a symbol does NOT assure the absence of static sensitive devices. 

CERTIFICATION

Products provided by GenRad are thoroughly tested and calibrated to meet product specifications. A Record of Certification of conformance (certifying that the product meets its specifications and that its calibration is traceable to appropriate national standards) is available upon request at the time of purchase.

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 Digibridge Technical Support Center (see last page of this manual), 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 Digibridge Technical Support Center (see last page) 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. Contract packaging companies in many cities can provide dependable custom packaging on short notice. Here are two recommended packaging methods.

Urethane Foam. Cover painted surfaces of instrument with protective wrapping paper or plastic. Pack instrument securely in strong protective corrugated container (350 lb/sq in. bursting test), with urethane foam pads at least 5 cm (2 in.) thick placed along all surfaces of the instrument. (Notice that many foamed or spongy plastics are NOT satisfactory, particularly if they can easily be compressed more than 50% between your thumb and finger.) Insert fillers between pads and container to ensure a snug fit. Mark the box "Delicate Instrument" and seal with strong tape or metal bands.

Shredded Paper. Cover painted surfaces of instrument with protective wrapping paper or plastic. Pack instrument in strong corrugated container (350 lb/sq in. bursting test), with a layer of shredded paper at least 15 cm (6 in.) thick packed firmly against all surfaces of the instrument. Mark the box "Delicate Instrument" and seal with strong tape or metal bands.

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 Digibridge Technical Support Center. (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 identify the shipment.

The technical support center will arrange for the prompt delivery of a replacement. To prevent damage to the defective board, return it to GenRad 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

5.4.1 General

This procedure is recommended for verification that the Digibridge is performing normally. No other check is generally necessary because this procedure checks operation of nearly all of the circuitry. If the Digibridge passes this performance verification, it is safe to assume that the bridge is functional. (However, to insure ACCURACY, refer to paragraph 5.8, Accuracy Verification.)

All tests are done at 1 kHz, 1 volt NOT CONSTANT, and in SLOW measure rate so that basic bridge accuracy is realized. The accuracy of each verification is therefore +/- .02% plus the tolerance of the verifying DUT, which is discussed below. Table 5-1 lists the necessary resistors, capacitors, and inductors, which are inexpensive and readily obtained. The most accurate ones available should be used; tolerances listed are the "best" commonly catalogued. There are no calibrations and only one adjustment that could require resetting; and the internal standards are very stable. This procedure checks at least one point on each of the four measurement ranges.

Table 5-1
COMPONENTS RECOMMENDED FOR PERFORMANCE VERIFICATION

Component	Type *	Nominal Valve	Tolerance
Resistors Metal Film	MIL-R-10509C (Style RN60)	49.9 ohms	+/- 0.1%
		499 ohms	+/- 0.1%
		4.99 kilohms	+/- 0.1%
		49.9 kilohms	+/- 0.1%
		499 kilohms	+/- 0.1%
Capacitors Metalized polyester	GE:BA-19A106C	10 uF	+/- 5%
Polystyrene	ARCO: 1PJ-334J	0.33 uF	+/- 0.5%
	1PJ-333J	0.033 uF	+/- 0.5%
	1PJ-332J	0.0033 uF	+/- 0.5%
Inductors	J.W.Miller		
Non-Ferrous	9220-28	1000 uH	+/- 5%
Ferrite Core	9250-107	100 mH	+/- 10%

* Equivalents may be substituted

CAUTION

Be sure that the voltage switch, rear panel, is correctly set for your power line (90 to 125 V -or- 180 to 250 V), that no components are connected to the test fixture, and that the EXTERNAL BIAS switch is OFF.

5.4.2 Performance Verification Procedure

a. After the line voltage switch has been set to correspond to the input line voltage, connect the line cord and switch the POWER ON.

The Digibridge then enters an automatic self-check routine and displays a sequence of codes. If one of these displays persists, a check failure has occurred and further checks or measurements are inhibited. (See paragraph 3.13.)

Normally, upon completion of the power-up self check, the following preset or default conditions are established, lighting a vertical line of indicators. (However, if the keyboard is locked, the locked-in conditions are re-established and most of the keyboard indicators are dark.) Normal:

[FUNCTION] -- MEASURE
[DISPLAY] -- VALUE
[MEASURE RATE] -- SLOW
[MEASURE MODE] -- CONT
[EQUIVALENT CIRCUIT] -- SERIES

The main panel displays and indicators (RLC and QDR) will normally come up with random, meaningless readings; ignore them.

b. However, if the keyboard is locked and the MEASURE indicator is lit, to unlock it, press:

[1][6][8][9][=][LOCK]

(If you have the interface option, it is possible that the FUNCTION is locked at ENTER. Then the use of remote control signals is required either to unlock the keyboard or to select the MEASURE function, which is a prerequisite for unlocking from the keyboard).

c. Confirm or select the following measurement conditions on the Digibridge:

[FUNCTION] -- ENTER (necessary for determining test frequency)
[DISPLAY] -- VALUE
[MEASURE RATE] -- SLOW
[MEASURE MODE] -- TRIGGERED (necessary for zeroing)
[EQUIVALENT CIRCUIT] -- SERIES
EXTERNAL BIAS -- OFF (slide switch)

d. Verify that the test frequency is 1 kHz (the power-up default) by pressing:

[SHIFT][FREQUENCY]

The left-hand display should read 1.0000. If any other reading is observed press:

[1][=][SHIFT][FREQUENCY]

e. Verify that the test voltage is 1 volt by pressing:

[SHIFT][VOLTAGE]

The left-hand display should read 1.0000. If any other reading is observed, press:

[1][=][SHIFT][VOLTAGE]

f. Press the [FUNCTION] key to select MEASURE function.

g. If the Digibridge has an interface option (which has two 24-pin interface connectors on the rear panel), be sure that the TALK switch (rear panel) is set to TALK ONLY.

h. Zero the Digibridge as follows, before making measurements. (Make sure that the MEASURE and TRIGGERED keyboard indicators are lit.)

Test Fixture. Install the axial-lead adaptors in the test fixture in position for accepting the largest of the verifying DUTs in Table 5-1.

Open Circuit Zero.

Press the [Cs/D] key.
Press: [1][6][8][9][=][SHIFT][OPEN].
Keep hands and all objects at least 10 cm from fixture contacts.
Press START to initialize zeroing operation.
Wait until the GO indicator lights.

Short Circuit Zero.

Short the fixture with a piece of copper wire, pressed into the test-fixture adaptors, where the DUT leads will go. Do not move the test fixture adaptors.
Press [1][6][8][9][=][SHIFT][SHORT].
Press START to initialize zeroing operation.
Wait until the GO indicator lights again.
(NOTE: For maximum accuracy, this zeroing procedure should be performed at the start of each day and every time the fixture configuration is changed.)

i. Press the [MEASURE MODE] key to select CONT. (continuous measurements).

j. Press [Rs/Q].

k. Insert, as DUT, the first resistor specified in Table 5-2.

l. Verify that the displays are within the extremes shown for check number 1 in Table 5-2, if the resistor is within the tolerance listed in Table 5-1.

NOTE ON 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 tolerances 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.

NOTE ON INSIGNIFICANT FIGURES: The right-hand digit(s) of the display may be expected to flicker and change (with the automatically repeating measurements) if they are not significant for the specified accuracy of the instrument. (See further comment with step q below.)

m. Similarly, make the other checks indicated in Table 5-2, under the Rs/Q parameter (checks number 2, 3, 4, 5).

n. Press [Cs/D].

o. Insert as DUT the first capacitor specified in Table 5-2 (check number 6).

p. Verify that the displays are within the extremes shown for check number 6 in Table 5-2, if the capacitor is within the tolerance listed in Table 5-1.

q. Similarly make the other checks indicated in Table 5-2 under the Cs/D parameter (checks number 6, 7, 8, 9).

In check number 8, verify that the fifth digit is reasonably stable, as follows. (Notice that the fourth digit is the last significant one in the readout, for 0.02 percent accuracy.) In check number 8, the flickering of the fifth digit should stay typically between 2 counts. For example, if the display is 330.1X nF, the "X" might flicker between 2 and 4. If, for example, "X" is flickering between 9 and 11, it will of course cause a flickering of the preceding digit (330.19 and 330.21). In such a case, the correct readout is the larger 4-digit number (330.2) and the fifth digit is acceptably stable.

r. Press [Ls/Q].

s. Insert as DUT the first inductor specified in Table 5-2 (check number 10).

t. Verify that the displays are within the extremes shown for check number 10 in Table 5-2, if the inductor is within the tolerance specified by Table 5-1.

u. Similarly check the inductor specified in check number 11.

Table 5-2
PERFORMANCE VERIFICATION

Check Number	Parameter	DUT	RLC Display Extremes	QDR Display Extremes
1	Rs/Q	49.9 ohms	49,840 to 49.959 ohms	*
2		499 ohms	498.40 to 499.59 ohms	
3		4.99 kilohms	4.9840 to 4.9959K ohms	
4		49.9 kilohms	49.840 to 49.959K ohms	*
5		499 kilohms	498.40 to 499.59K ohms	
6	Cs/D	0.0033 uF	3282.8 to 3317.2 pF	.0000 to .0100
7		0.033 uF	32.828 to 33.172 nF	.0000 to .0100
8		0.33 uF	328.28 to 331.72 nF	.0000 to .0100
9		10 uF	9.498 to 10.502 uF	.0000 to .0300
10	Ls/D	1000 uH	.9498 to 1.0502 mH	*
11		100 mH	89.98 to 110.02 mH	*

* The right hand display (QDR) can be expected to change frequently; accuracy of that display is not significant in these performance checks.

5.4.3. High-Speed Option Board Checkout

This procedure verifies that the 1689-9610 high-speed measurement option is functioning properly. All measurements are made with the default (power-up) values of test frequency and test voltage (1 kHz and 1 V). The procedure determines the time required per measurement for several operating conditions, without and then with the high-speed option board. Make a note of each calculated result for final comparisons to verify the speed.

Equipment Required:

1. 1689 Digibridge without high-speed option. (To remove it, see paragraph 5.5.3.)
2. 1689-9610 High-speed measurement option board (retrofit or just removed).
3. Watch or clock with digital display of seconds or a sweep second hand.
4. A suitable DUT such as the 24.9-ohm Calibration Resistor (used in the examples, see below).

NOTE

The readings can be expected to vary +/- 5% from the examples given, mostly because the manual timing method is liable to such errors. The method is adequate for the purpose intended.

a. Switch the POWER ON. Perform the zeroing procedure (both open circuit and short circuit), as described in paragraph 5.9.2 of the recalibration procedure.

b. Insert the DUT (24.9 ohms +/- 0.1% for example) in the test fixture.
Press: [FUNCTION] key to select ENTER function.
Press: [2] [4] [.] [9] [=] [SHIFT] [NOM. VALUE]
Press: [.] [2] [%] [=] [SHIFT] [BIN NO.] [0] [1]
Press: [MEASURE RATE] (if necessary) to select SLOW rate.
Press: [MEASURE MODE] to select CONTINUOUS mode.

c. With the watch or clock, time the interval between the next two keystrokes. The number of measurements made while the function is MEASURE will automatically be stored in "bin sum" for bin 01.
Press: [FUNCTION] key to select MEASURE function.
Wait 60 seconds.
Press: [FUNCTION] key to select ENTER function.
Press: [SHIFT] [BIN SUM] [0] [1].

d. Read the left-hand display, which is the number of measurements made in 60 seconds. (+/- 5% accuracy of timing is assumed.) Use this number as "x" in the following formula; retain these results. Note: the right-hand display should be 1, the bin number being reported.
Measurement time = T = 60,000 milliseconds / x
For example, if x = 58, then T = 1034 ms +/- 5%.

e. Clear all "bin sum" registers as follows. Note: the Digibridge should confirm the clearing action by displaying 0 in the left-hand display area.
Press: [=] [SHIFT] [BIN SUM] [0] [0] [1] [4]

f. Press: [MEASURE RATE] key to select MEDIUM rate.
Repeat the procedure of steps c, d, e (as summarized below), for this rate.
- o Time the interval between the next two keystrokes.
- o Press: [FUNCTION] key to select MEASURE function.
  Wait 60 seconds.
- o Press: [FUNCTION] key to select ENTER function.
- o Press: [SHIFT] [BIN SUM] [0] [1].
- o Read the left-hand display, the number of measurements made in 60 s.
- o Use this number as "x" in the following formula.
  T = 60,000 milliseconds / x
  For example, if x = 250, then T = 240 ms +/- 5%.
- o Clear "bin sum" registers by pressing: [=][SHIFT][BIN SUM][0][0][1][4]

g. Press: [MEASURE RATE] key to select FAST rate.
Repeat the procedure of steps c, d, e (as summarized below), for this rate.
- o Time the interval between the next two keystrokes.
- o Press: [FUNCTION] key to select MEASURE function.
  Wait 60 seconds.
- o Press: [FUNCTION] key to select ENTER function.
- o Press: [SHIFT] [BIN SUM] [0] [1].
- o Read the left-hand display, the number of measurements made in 60 s.
- o Use this number as "x" in the following formula.
  T = 60,000 milliseconds / x
  For example, if x = 493, then T = 122 ms +/- 5%.
- o Clear "bin sum" registers by pressing: [=][SHIFT][BIN SUM][0][0][1][4]

h. Select "Max" measurement rate by pressing: [.][2][5][=][SHIFT][SPECIAL][5]. (Note: indicated measure rate must be FAST. For explanation, see paragraph 3.5.5.) Repeat the procedure of steps c, d, e (as summarized below), for "Max" rate.

- o Time the interval between the next two keystrokes.
- o Press: [FUNCTION] key to select MEASURE function.
  Wait 60 seconds.
- o Press: [FUNCTION] key to select ENTER function.
- o Press: [SHIFT] [BIN SUM] [0] [1].
- o Read the left-hand display, the number of measurements made in 60 s.
- o Use this number as "x" in the following formula.
  T = 60,000 milliseconds / x

For example, if x = 771, then T = 78 ms +/- 5%.

- o Clear "bin sum" registers by pressing: [=][SHIFT][BIN SUM][0][0][1][4]

i. Switch the Digibridge POWER OFF. Install the high-speed option board 1689-9610 carefully, as described in paragraph 5.5.3.

NOTE

After the power-up self checks, the Digibridge with high-speed option will automatically select TRIGGERED measurement mode.

j. Repeat steps a through h, recording the results as before.

k. If the calculated values of T in step j indicate a test-time reduction compared to the values of T in steps d through h, the high-speed-measurement option is functioning properly. Refer to Table 5-3 for typical values.

Table 5-3
REDUCTIONS IN MEASUREMENT TIMES BY HIGH-SPEED OPTION

Rate	Without H-S Board Examples, steps dfgh x	T	With H-S Board Examples, step j x	T	T Differences of Examples	T Difference Ranges*
SLOW	58	1034 ms	61	984 ms	50 ms	35 +/- 100 ms
MEDIUM	250	240 ms	295	203 ms	37 ms	35 +/- 20 ms
FAST	493	122 ms	707	85 ms	37 ms	35 +/- 10 ms
"Maximum"	771	78	1195	50 ms	28 ms	25 +/- 6 ms

* The T differences stated in product specifications are 35, 35, 35, and 25 ms, as tabulated. By more accurate methods than those recommended here, T differences are typically found to be about 38, 37, 37, and 26 ms for SLOW, MEDIUM, FAST, and "Max", respectively.

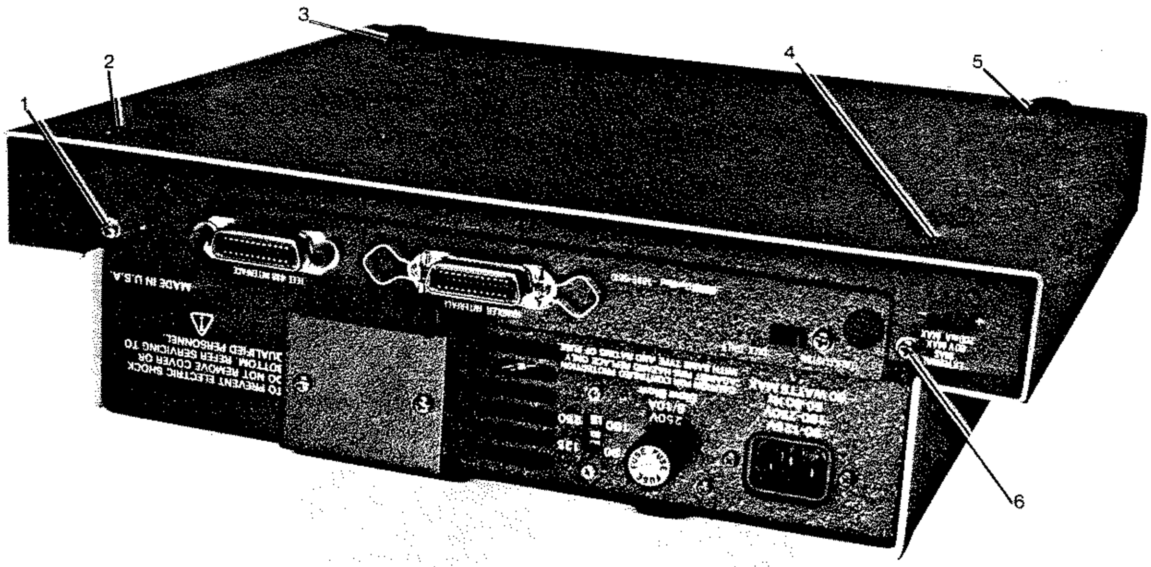


Figure 5-1. Rear and bottom view of the Digibridge, showing screw locations for disassembly: top-cover screws 1 and 6; bottom-shell screws 2, 3, 4, 5.

5.5 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. Be sure that you never short or apply voltage to the battery B1. (See para 5.7.3.)

CAUTION

Observe precautions against damage by static electricity whenever you handle a circuit board or integrated circuit in this instrument. Refer to the beginning of Section 5.

5.5.1 Disassembly

Figures 5-1 through 5-9.

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 5-1. (These screws are slightly outboard from the ones designated for interface option or cover plate. One of them is just to the right of the label EXTERNAL BIAS.) Slide the top cover forward about 6 mm so that its front corners are unhooked. Lift it directly upward (Figure 5-2). Reassembly note: Install the cove without air filter, using the 2 screws, 13 mm long. Then stuff the air filter into position through the air intake opening; using your fingers, press the edges and corners of the filter into position.

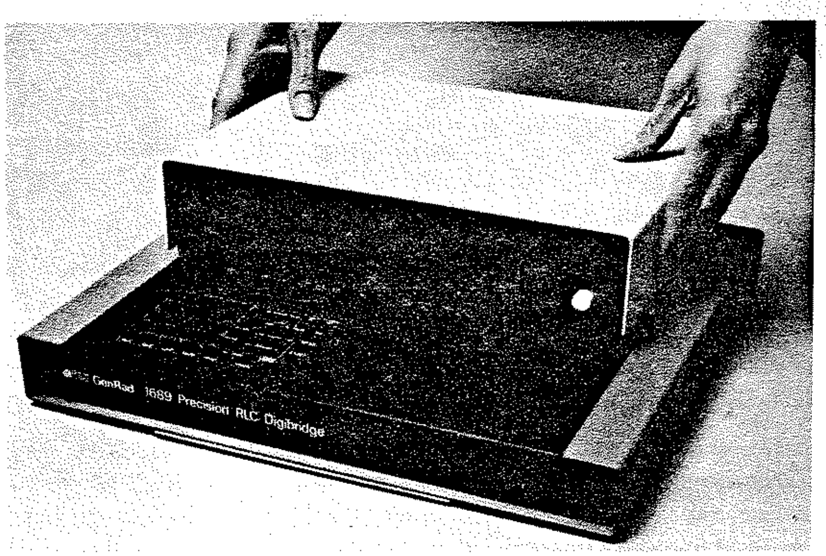


Figure 5-2. Removal of the top cover.

The next step, removal of display board, is recommended before removal of the main circuit board.

c. Remove the 2 support screws, Figure 5-3, that hold the display board to its brackets. Pull the board directly out of its socket in the main board. Keep the display board in its original (inclined) plane until it is completely free (Figure 5-4). Reassembly note: 2 screws, 6 mm long with washers.

d. Disconnect the ribbon cable (1689-0200) from main board (at connector J5). The cable can be removed from the power supply (J1) after removal of the protective cover as described below. Notice that the connectors are symmetrical; reversing either or both is permitted; and the cable is extra long, for convenience in servicing.

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

WARNING

Dangerous voltages are present on wires and terminals that will be exposed in the following steps. BE SURE THAT THE POWER CORD IS DISCONNECTED BEFORE PROCEEDING.

e. Remove the protective cover (with the warning label) from the right-hand end of the power supply (3 screws).

CAUTION

> In reassembling, inspect carefully to be sure that none of the nearby wires touches the fan rotor or blades. Inspect by looking under the 1657-4720 board. To verify free rotation, blow on the fan and watch it spin.

f. 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 5-5). Reassembly note: 4 screws, 8 mm long.

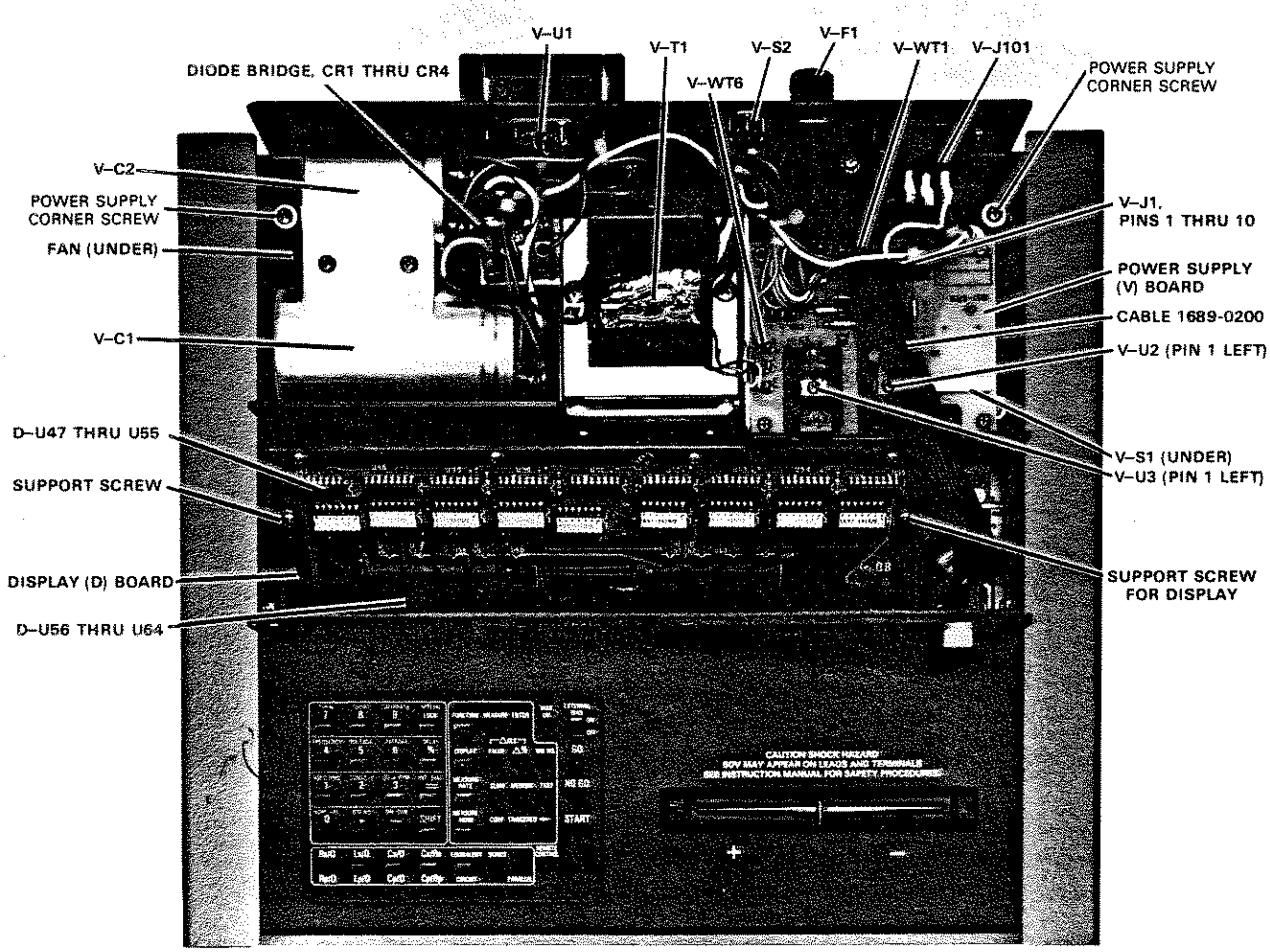


Figure 5-3. Power supply (V assembly) and display (or DB) board, shown in the instrument, with top cover off. The protective cover has been removed from above the 1657-4720 board.

Figure 5-4. Removal of the display board.

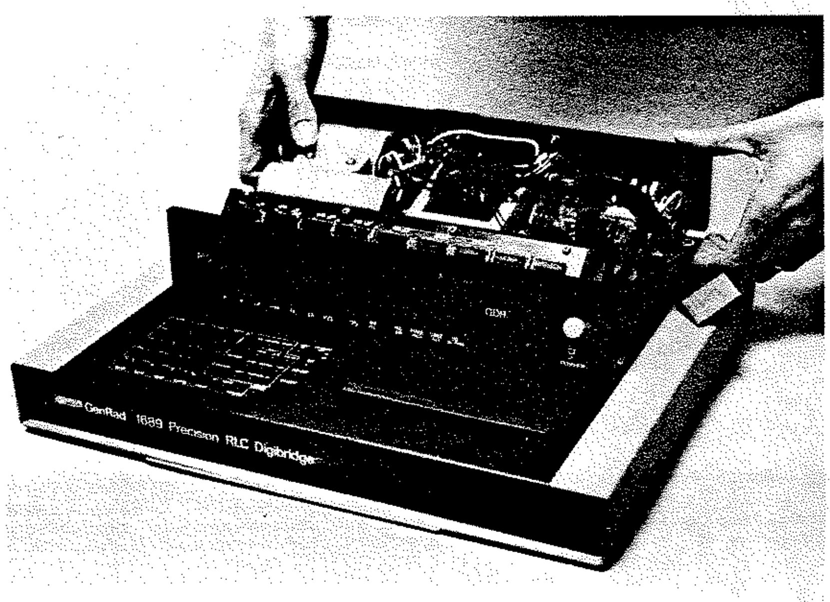


Figure 5-5. Removal of the power supply. The ribbon cable must be disconnected first. The display board can be removed first or left in place, as shown here.

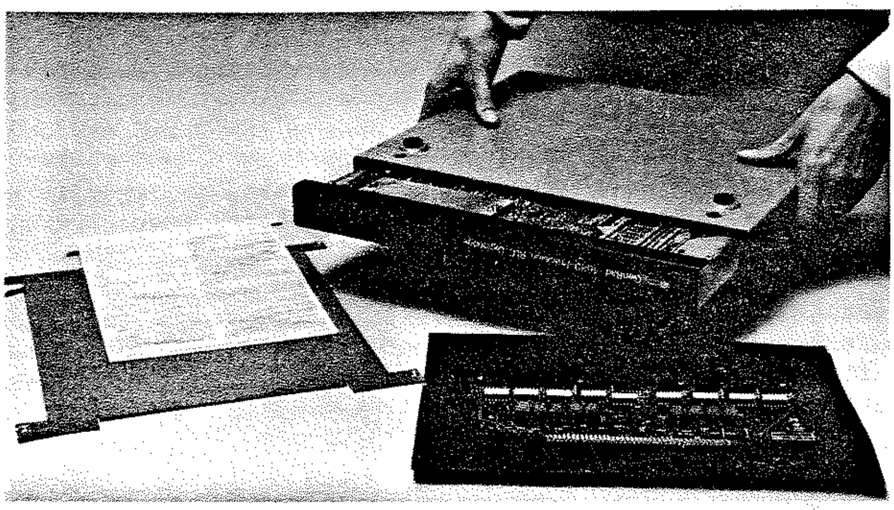


Figure 5-6. Removal of the bottom shell. Notice that the top cover has been temporarily installed as a support.

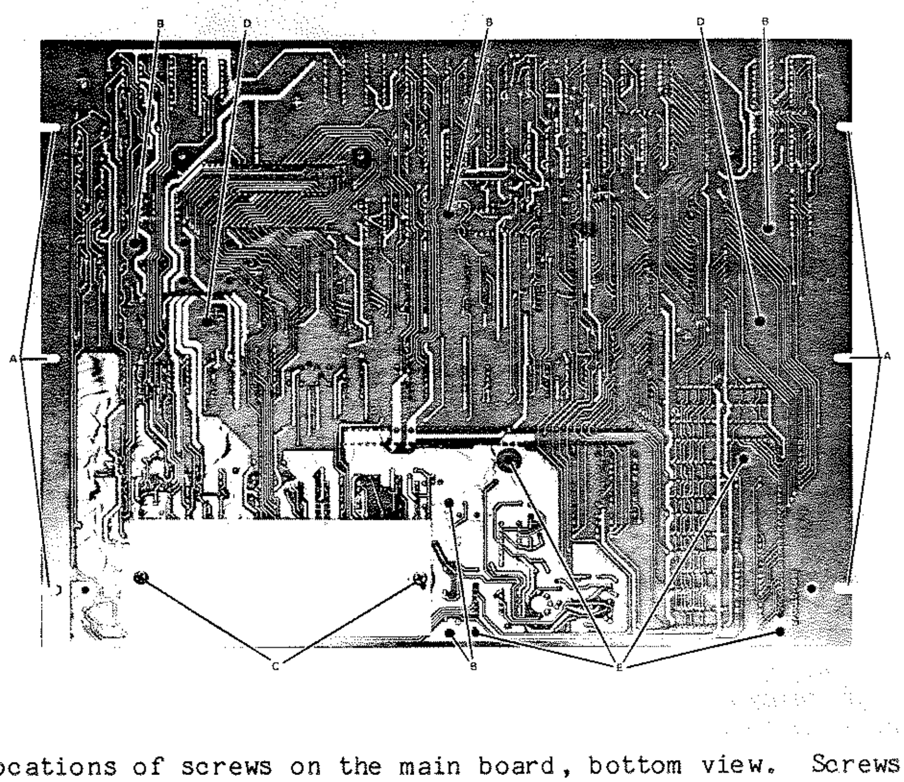


Figure 5-7. Locations of screws on the main board, bottom view. Screws at A and B hold the board to the chassis. Screws at C hold a shield and (with 2 screws from the other side) the test fixture assembly. Screws at D hold brackets for the display board; and at E, the keyboard module.

g. Remove the interface option, if you have one, after removing the 2 large screws with resilient washers in the rear panel. See Figure 1-2. (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.

h. After disconnecting the ribbon cable (step d), provide a convenient "upsidedown" support by reinstalling the top cover, temporarily. Turn the instrument, bottom up.

i. Remove 4 screws from the bottom shell, one near each rubber foot (Figure 5-1). Lift the instruction card and its retaining pan free. Slide the bottom shell back (or forward), free of the main chassis (Figure 5-6). 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.

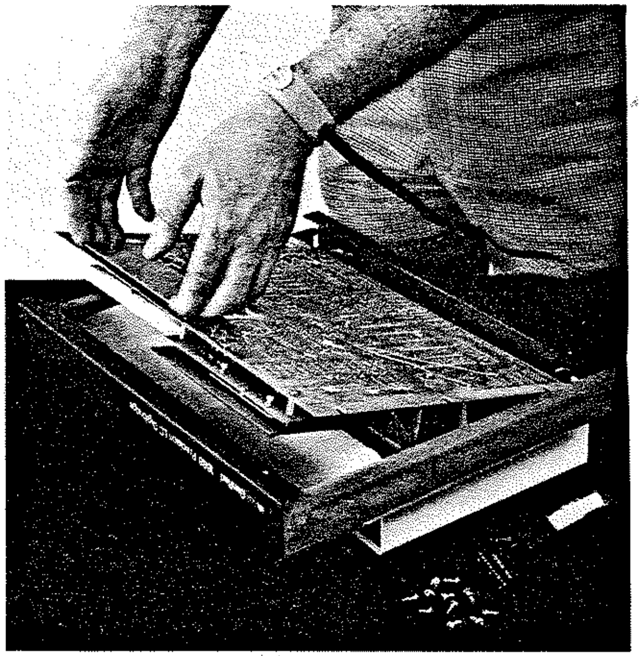


Figure 5-8. Removal of the main board. The ribbon cable must be disconnected first. Prior removal of the display board also is highly recommended. Because the board is partially enclosed by the main chassis, unusual care may be needed in removal. These motions are suggested: toward the rear, tilting, as shown, before lifting free.

j. Remove 11 screws from positions shown in Figure 5-7 as A and B, to free the main board. Lift slightly, and slide the board rearward so the keyboard can be lifted past the lip of the chassis. Tilt the front edge up about 6 cm (2 in.) before lifting the whole board out. Figure 5-8 shows how to tilt the main board to the best position for removal. Reassembly note: return washers to original positions; A screws are 6 mm long, B screws are 8 mm long.

k. To remove the keyboard module, remove the 4 screws at E (Figure 5-7) and carefully pull the module directly away from the main board. Reassembly note: be very careful not to bend pins when plugging the keyboard-module connectors into their main-board sockets; use 4 screws, 6 mm long.

1. For access to the test-fixture contacts, remove the dross tray 1657-7700 (the plastic dirt catcher) by spreading it slightly and lifting it off. Then remove the guide block assembly 1689-7010 (includes dross tray) by removing 2 screws C (and associated washers, spacers and shield plate, Figure 5-7) and 2 test-fixture center shield screws (use hexagonal wrench 2.38 mm = .094 in.) from opposite sides of the main board (Figure 5-9). Reassembly note: see paragraph 5.6.1; C screws are 13 mm long.

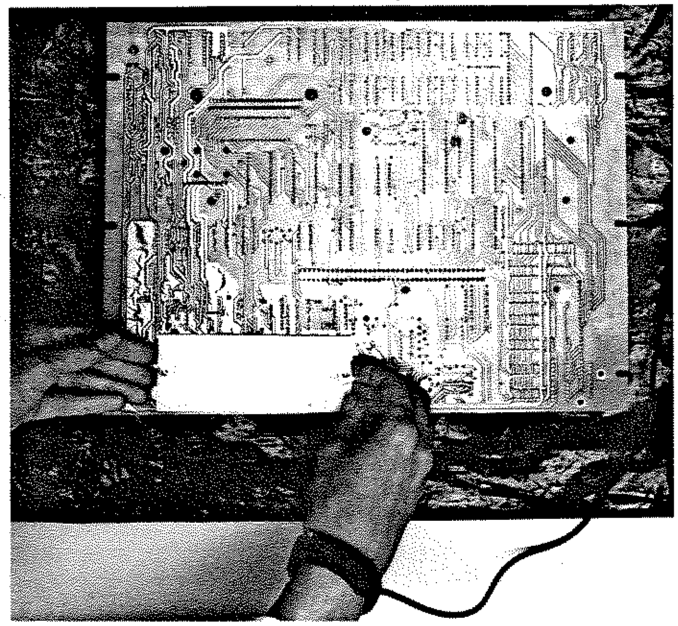


Figure 5-9. Removal of the shield from below the test fixture. Notice the use of a personnel grounding strap.

5.5.2 Access

Figure 5-10.

Main Board. Locations of principal interior parts and points of interest for trouble analysis are shown in the accompanying foldout picture. On the main board, important test points, ICs, battery B1, and the locations of signals Ih, Il, Ph, Pl at the test fixture are shown. The analog circuitry is placed along the front (forward of the display-board connector) and along the front half of the right-hand edge. However, most of this board supports digital circuitry.

For a more complete guide to parts location, refer to Table 5-4, which 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 4B or 6C are coordinates on the indicated figures. The vertical coordinates are A to E (top to bottom); the horizontal coordinates are 1 to 8 (left to right).

Power Supply. For access to parts in the power supply, refer to Figure 5-2 and Section 6.

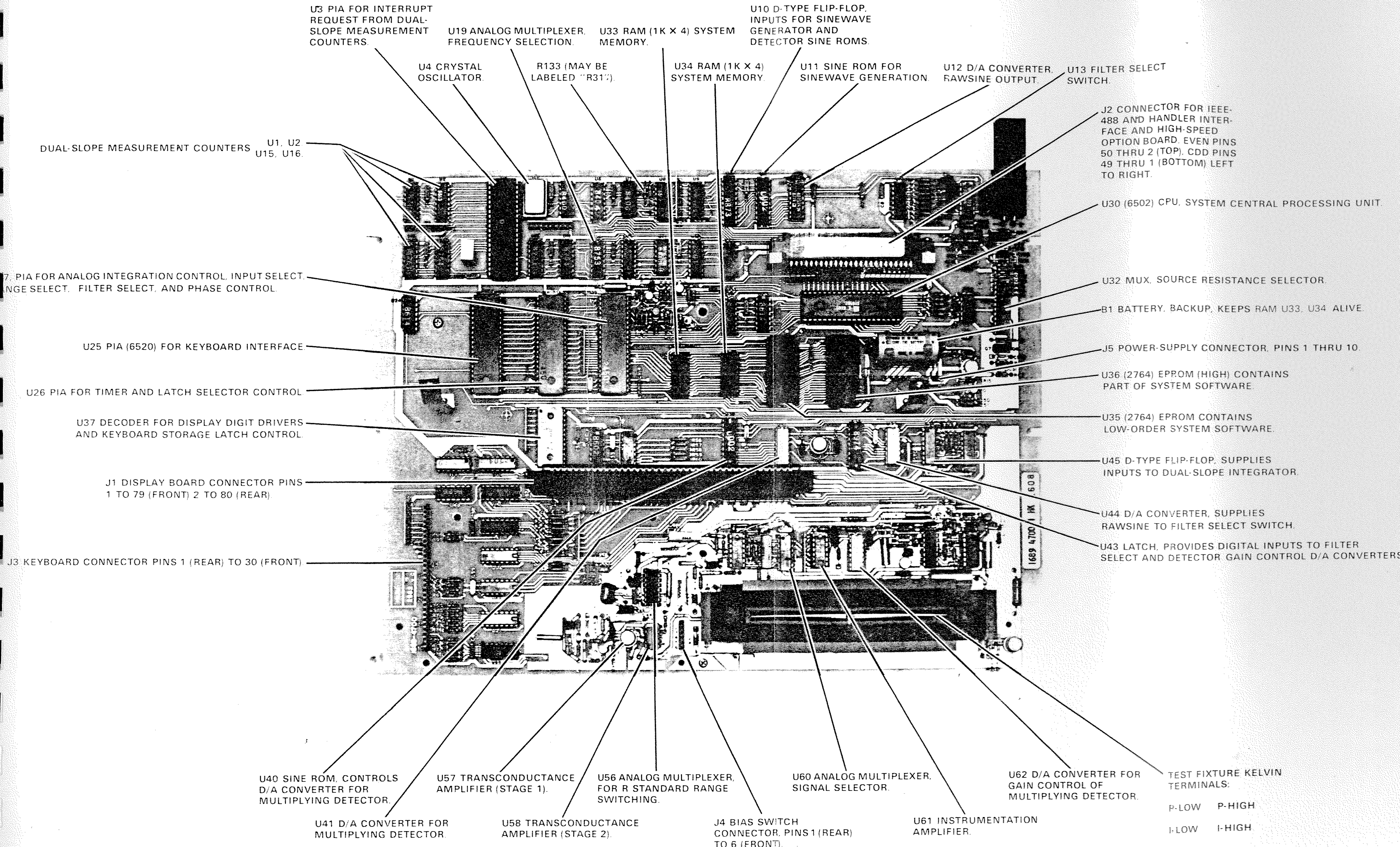


Figure 5-10. The main board, also called "analog and control board" or MB board, top view. Important points for servicing are indicated. For more detail, refer to the accompanying table and to the board layout in Section 6.

Table 5-3
MAIN (MB-) BOARD PARTS LOCATIONS

Part*	Layout**	Schematic***
B1	5B	sheet1 6B
J1	4C	sh2 4E, sh5 7B
J2	5B	sheet1 1A
J3	2D	sheet5 4B, 7D
J4	4D	
J5	6B	sheet3 1A
J6	6A	sheet3 7A
Q1	4B	sheet1 2D
Q2	4B	sheet1 3D
Q3	4B	sheet1 5C
Q4	4B	sheet1 4C
Q5	4B	sheet1 2D
Q6	4B	sheet1 5B
Q7	6B	sheet3 5A
Q8	6B	sheet3 6A
Q9	6B	sheet1 6B
Q10	6C	sheet1 6B
Q11	6C	sheet4 4B
Q12	6C	sheet4 4B
Q13	3D	sheet3 3D
Q14	3D	sheet3 3D
Q15	3D	sheet3 3D
Q16	3D	sheet3 2D
Q17	6C	sheet4 5E
Q18	6D	sheet3 7B
U1	2A	sheet5 2B
U2	2A	sheet5 2A
U3	3A	sheet5 3C
U4	3A	sheet2 1A
U5	3A	sheet2 2A

Part	Layout	Schematic
U6	3A	sheet2 2A
U7	3A	sheet2 5A
U8	4A	sheet2 4A
U9	4A	sheet2 3C
U10	4A	sheet2 5C
U11	4A	sheet2 6C
U12	5A	sheet2 7C
U13	5A	sheet3 3A
U14	6A	sh2 7C; sh3 3,4,5B
U15	2B	sheet5 2C
U16	2B	sheet5 2D
U17	3A	sheet2 2C
U18	3A	sheet2 2C
U19	3A	sheet2 6A
U20	3A	sheet2 5A
U21	4A	sh2 4B,D; sh4 3C
U22	4B	sheet2 3C
U23	4B	sheet2 4C
U24	2B	sheet1 3C
U25	2B	sheet5 5C
U26	3B	sheet
U27	3B	sheet4 2C
U28	4B	sheet1 4B
U29	4B	sh1 3D; sh4 1D
U30	5B	sheet1 2B
U31	6B	sheet3 5B
U32	6B	sheet3 5B
U33	4B	sheet1 5A
U34	4B	sheet1 6A
U35	5B	sheet1 3A

Part	Layout	Schematic
U36	5B	sheet1 4A
U37	3C	sheet2 2D
U38	3C	sheet4 3B
U39	3C	sh3 4C 5A; sh4 3D
U40	4C	sheet4 4A
U41	5C	sheet4 5A
U42	5C	sheet4 5A
U43	5C	sheet4 2A
U44	5C	sheet3 2B
U45	6C	sheet4 4C
U46	5C	sheet4 3D
U47	2C	sheet5 4B 5D
U48	2C	sheet1 3C
U49	3C	sheet5 5C
U50	3C	sheet5 6A
U51	3D	sheet5 6B
U52	3D	sheet5 6B
U53	3D	sheet5 6C
U54	3D	sheet5 6D
U55	3D	sheet5 6D
U56	4D	sheet3 4D
U57	4D	sheet3 2E
U58	4D	sheet3 3E
U59	4D	sheet3 5D
U60	5D	sheet3 6D
U61	5D	sheet3 6D
U62	5D	sheet4 3A
U63	6D	sheet4 5D
U64	6D	sheet4 6D 7A

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* Reference designator of part.
** For physical location, see Figure 5-10 and layout in Section 6 (Figure 6-4).
*** See indicated sheet of schematic diagram (1689-4700) in Section 6.

5.5.3 IEEE/Handler Interface Options — Figures 5-11, 5-12.

This Digibridge accepts either of two options that provide both IEEE-488-bus and handler interfaces. Refer to the Specifications in the front of this manual and to Table 1-3 in Section 1.

Removal of Interface Board. The procedure is the same for either option:

a. Switch POWER OFF and disconnect power cord from Digibridge.

b. With care not to damage the pull-out instruction card, position the instrument with its front panel down toward the table or workbench and its bottom toward you. (Provide support or have an assistant hold it.)

c. Remove the two screws that hold the interface-option rear panel (or the blank cover plate) from the rear panel of the Digibridge. Refer to Figure 1-2 in Section 1. Lift the interface option (or the cover plate) up, directly away from the front panel.

CAUTION

> Observe precautions while handling the interface option. Because there are static-sensitive parts on the board, DO NOT TOUCH THE CIRCUITS or ICs. Refer to Section 5 of this manual, for recommended handling procedure.

Installation. Install or reinstall the interface option as follows.

a. Hold the interface option by its rear panel, so that the labels near the connectors read left to right. Insert the board through the opening in the Digibridge, with care to align the board-edge contacts with the mating connector in the Digibridge.

b. Press the interface option fully into the Digibridge by hand, thereby making sure that alignment is correct. Then reinstall the screws that were removed earlier.

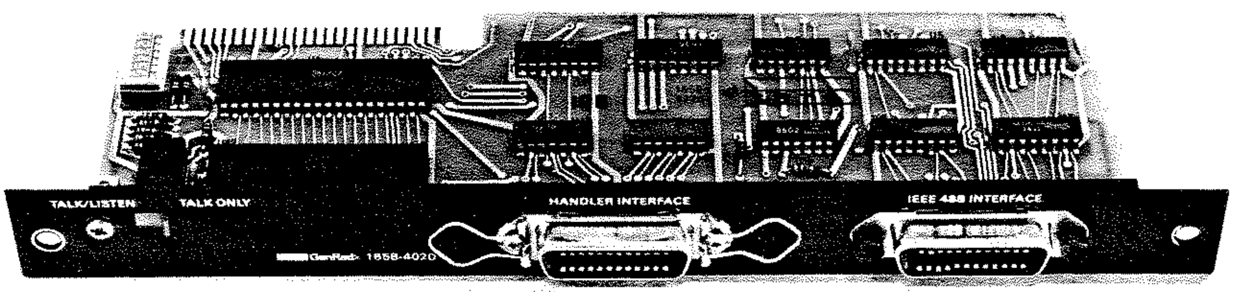

Figure 5-11. IEEE/handler interface option assembly 1658-9610, including the interface option board (IOB) 1658-4720.

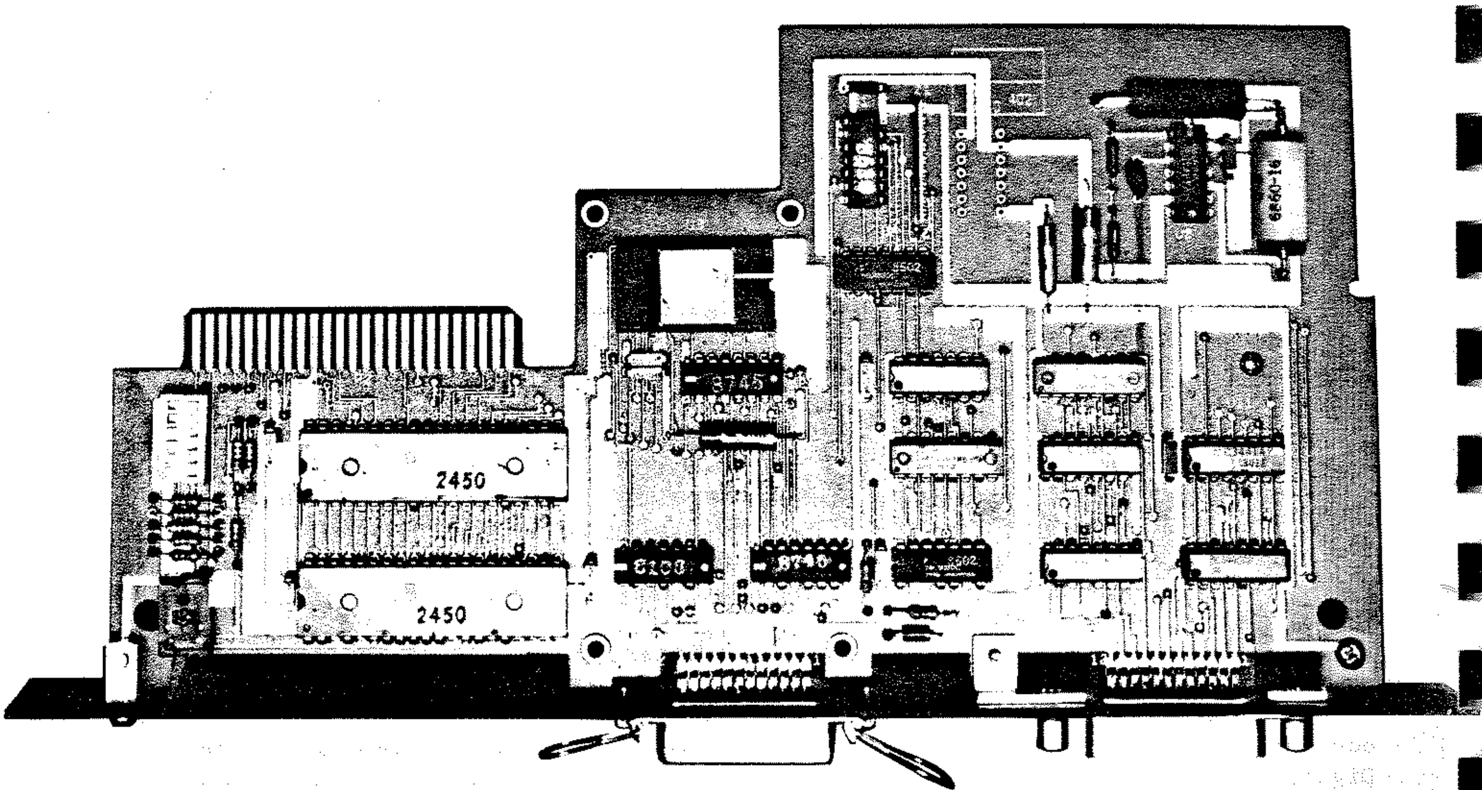

Figure 5-12. High-speed measurement and IEEE/handler option 1689-9610, including the 1689-4720 circuit board.

5.5.4 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.

5.5.5 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 static-sensitive 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.

5.6 PERIODIC MAINTENANCE

5.6.1 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 1689-7010), as described above.

Reassembly note: position the guide block assembly for smooth entry of a radial-lead DUT before tightening screws. If an extension cable is available, it can be used for a centering jig. Otherwise verify by eye, looking directly down on the board, through the slots in the guide block, to the contact gaps.

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, for better access for cleaning, remove 2 front contacts (P/N 1689-1015). Use a hexagonal wrench (2.38 mm, .094 in.) to remove 2 screws per contact. Reassembly note: gap between contacts should not exceed 0.24 mm (.009 in., or the thickness of 3 layers of typing paper); and contacts must press against each other (insulated by tiny dielectric spacers attached near each end of slot) so that a wire of 0.64 mm diameter (AWG 22, .025 in.) can be withdrawn from between them with a force of 1 (minimum) to 2 (maximum) newtons (100 to 200 grams). Tighten the hex-drive screws with a torque of 1.3 to 1.4 newton-meters (12 in-lb).

e. If necessary, remove the 2 remaining contacts as in the previous step. Reassembly note: align the contacts so that the surfaces that will press against the DUT leads are collinear (so that the guide block can be positioned with its slots matching the gaps in BOTH contact pairs); tighten hex-drive screws as specified above.

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.

5.6.2 Cleaning the Air Filter

About once a year (or more often in dusty environments) clean the air filter as follows. The air filter is a spongy piece of plastic found in the air intake vent on the right side of the Digibridge. (See Figure 6-1.) Pull the filter out with your fingers or pliers. Wash it thoroughly in warm water and a mild detergent. Rinse. Squeeze the water out and let it dry completely. Reassemble as described in step b of paragraph 5.5.1.

5.6.3 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 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.

5.7 TROUBLE ANALYSIS

5.7.1 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 at the beginning of Section 5.

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 and resistor networks. 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-ohm resistors. If one resistor is open, it is not necessary to replace the entire package. Use a 5% resistor.

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

Power-Up Self Check. Upon power-up, the Digibridge performs a self-check sequence as explained in paragraph 3.13. If a self-check failure occurs, the instrument display will indicate the nature of the failure. For more detail, refer to paragraph 5.7.2 below.

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-CR30, CR31, CR32, CR33.

Reactance Error. If C or L measurements are not accurate, the test signal source may be at fault. In checking it, verify that the frequency is within +/- 0.01% of the specified nominal frequency. Refer to paragraph 3.4.1.

Test Signal. To check performance of the test-signal source, use a scope to look at the open-circuit signal at the Ih terminal of the test fixture (right front contact --- be sure there is no DUT). The signal on each range should be an undistorted sine wave at the selected frequency, with the top of the waveform about +3.4 V and the trough about +0.85 V.

Analog Front End and Detector. To check the entire analog front end, install any typical DUT in the test fixture, select the default test conditions (including CONT MEASURE MODE) by switching POWER OFF and ON. (The keyboard must not be locked.) Use an oscilloscope to look at the signal at the instrumentation amplifier output (MB-U61 pin 14). This waveform should switch back and forth between two 1-kHz sinewaves whose amplitudes are proportional to the voltages across the DUT and the internal standard resistor. If the DUT is an open circuit or a short circuit, this signal should switch back and forth between a very small ac signal and a 6.8 V pk-pk ac signal. If these signal levels are incorrect or the signals are distorted, the problem is either in the sinewave generator or in the analog front end. Check this waveform with known "problem" test conditions. If this signal appears to be correct, use an oscilloscope to verify that the signal at MB-U64 pin 7 has the characteristic staircase/sawtooth waveform illustrated in Figure 5-13. If this is true (and if similarly normal waveform appears even when you select known "problem" test conditions), the fault is probably NOT in the analog detector.

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, do the secondary steps, if any are given at the point of failure (aa, ab, ac...).

NOTE

Reference designators, such as MB-U21, are frequently abbreviated in the following text, for example U21, because the context of the service procedure should leave no doubt as to which board is being serviced.

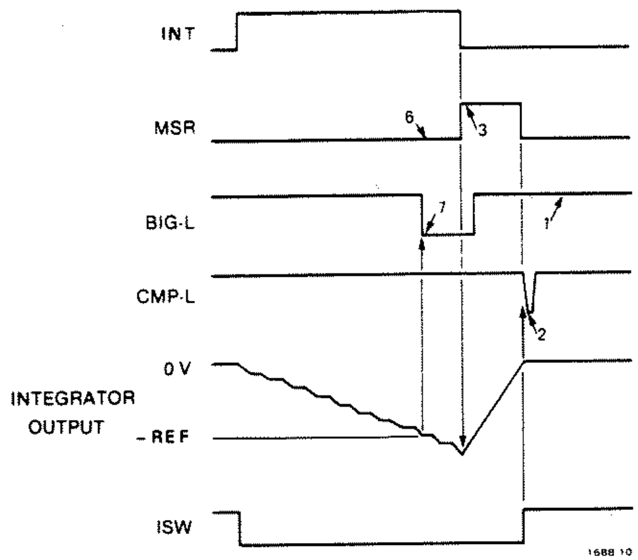

Figure 5-13. Timing diagram for the detector portion of the power-up self-check, with keys to the crucial events that are checked. Labels 7 thru 1 correspond to tests identified with displays of 77777 7777 thru 77777 1111, respectively. When the instrument is making measurements, the waveforms are different in many details.

5.7.2 Power-Up Self Check and Certain Aborted Measurements **Figure 5-13.**

The following outline of failure displays includes comments on some of the self check routines, significance of the displays, and some suggestions for appropriate service procedures. A further discussion of the self-check feature is given in the paper by Sullivan, R.C., "Automatic Self-Check in a Microprocessor-Controlled Impedance Meter", presented at session 22 of ELECTRO/79.

GENERAL NOTES

For the most rigorous self check, in servicing, repeat the power-up self check several times, at least once with a short circuit as "DUT" in the test fixture and once with the test fixture empty (open circuit). A normally functional Digibridge should pass both ways.

Keen observation of the fleeting displays associated with the tests that pass, before the one that fails, are sometimes useful. Pressing any key, such as [SHIFT] will halt the self-test routine and hold the display until the key is released. Look for trends or tests that pass only marginally.

SELF-CHECK (FAILURE) DISPLAYS

88888 8888. RAM read/write exercise failure; Digibridge hangs up. PROCEDURE: Switch POWER OFF and ON to clear hangup and repeat self check. Check RAM circuitry and data and address buses.

77777 XXXX. Detector test failure; Digibridge hangs up. PROCEDURE: Switch POWER OFF and ON to clear hangup and repeat self check. Be sure that the EXTERNAL BIAS switch is OFF. Use scope to check waveforms on the main board as indicated below and in the accompanying figure.

77777 7777. DBIG (U27 pin 2) is stuck low. Integration failure. PROCEDURE: check integrator output (U64 pin 7). Its acquisition, i.e. integration slope (downward) should cross the level of -5.1 V; then BIG-L (U64 pin 14) should go low and DBIG high, signalling the microprocessor to start conversion, i.e. deintegration.

77777 6666. DMSR (U27 pin 8) is stuck high. Integration failure. PROCEDURE: check MSR (U45 pin 11). Both of these signals should be low during integration. Check the circuit back through D flip-flop U45 to PMSR at U27 pin 10.

77777 5555. FCOUNT is not toggling (U27 pins 9, 40). Check the circuit back to frequency multiplexer U19 pin 9. Verify that all frequencies are present on the inputs to the multiplexer and that the control lines FDIV0 and FDIV1 are functioning (U19 pins 2, 14, respectively).

77777 3333. DMSR (U27 pin 8) is stuck low. Integration failure. PROCEDURE: Check MSR (U45 pin 11). Both of these signals should go high, starting the deintegration.

77777 2222. CMP-L (U64 pin 8) is stuck high. Deintegration failure. PROCEDURE: check that integrator output (U64 pin 7) rises to cross the 0-V level at the end of deintegration. CMP-L should go low at that crossing, and may remain low for only a brief pulse. The leading edge should cause DMSR to go low and ISW (U45 pin 6) should go high.

77777 1111. DBIG (U27 pin 2) is stuck high. Deintegration failure. PROCEDURE: verify that BIG-L goes high and DBIG goes low when integrator output becomes more positive than -5.1 V.

66666 XXXX. Detector scale factor and zero bias test failure; the Digibridge will loop, automatically repeating the test and updating the display. XXXX is the magnitude of "zero" measurement, normalized to 1.

COMMENT: The "zero" measurement includes a sequence of five dual-slope conversions (measurements of voltage coming into the detector from the instrumentation amplifier). Frequency is 1 kHz; test signal level is 75 mV. The signal component is removed by averaging the results of two dual-slope conversions, sampled in opposite phases. The detector is supposed to be biased so that its "zero" output is essentially in the center of its operating range. For convenience, the CPU divides the "zero" measurement by its normal value and displays the result. Consequently, the ideal value for XXXX is 1.000. If it is less than 0.875 or more than 1.125, the test fails.

ANALYSIS PROCEDURE: Check the following circuits:

1. Zero (half-scale) bias current circuit (CR38, R116).
   NOTE: R116 is a 10-kilohm potentiometer, which should be adjusted for 2.5 V measured at the cathode of CR38. These components are found about 93 mm (3 5/8 in.) from the right front corner, measured toward center of board.
2. Detector scale (integrator) current circuit (CR40, R119, U63).
3. Phase control circuit (U26, U27, U21, U23, U18 U22).
4. Detector switches (U63).

555 D XXXX. Signal strength check failure; the Digibridge will loop, automatically repeating the test and updating the display. The digit D indicates the range and voltage level used. (See below.) Test frequency is 1 kHz.

COMMENT: Possible cause is having EXTERNAL BIAS switch ON during power-up. The effect depends on what is connected to the EXTERNAL BIAS connector and what is in the test fixture. This switch must be OFF to assure normal power-up routines. The Digibridge separately squares the measurements of 4 component voltages, a quadrature pair across the DUT and a pair across the internal standard resistor. The squares are summed to represent the square of the applied voltage (essentially the open-circuit voltage from the HIGH terminals of the test fixture to ground). To normalize this result, it is divided by the square of the "zero" measurement. (See 66666 XXXX, above.) The ideal value for XXXX is about 0.64. If it is less than 0.250 or more than 1.000, this test fails.

ANALYSIS PROCEDURE: See below; depends on the failure display, which is coded to indicate test voltage (high or low) and range of the failed test.

555 5 XXXX. Low voltage (75 mV rms), range 4. If XXXX is less than 0.250, check for a malfunction in the circuits that supply the test signal Ih (U32, U31, U14, U13, U44 ... back to U4). Check the input signals and the gain through instrumentation amplifier U61.

However, if XXXX is greater than 1.000, check the test voltage and source resistance selector circuits (U32, controlled by U27 pins 6, 7); check filter selector U13, controlled by U27 pins 12, 13, as well as pins 14, 15, via U21 and U38. Also check for RAWSINE on D/A converter U44 pin 15.

555 4 XXXX. High voltage (1.275 V), range 4. Check test voltage selector circuit and instrumentation amplifier.

555 3 XXXX. High voltage (1.275 V), range 3. Check signal at Ih terminal with test fixture short circuited. Check signal at output of transconductance amplifier circuit (U58 pin 8) with test fixture short circuited.

555 2 XXXX. High voltage (1.275 V), range 2. (See previous suggestion.)

555 1 XXXX. High voltage (1.275 V), range 1. (See previous suggestion.)

444 E XXXX. Test frequency and waveform check failure; the Digibridge will loop, automatically repeating the test and updating the display. The digit E indicates the frequency used in the test. (See below.) High voltage test signal is used, on range 4. COMMENT: Meaurement, summing of squares, and normalization are exactly as described for 555 D XXXX. Also the failure limits for XXXX are the same. ANALYSIS PROCEDURE: check for the generation of the proper frequency (indicated in code by failure display, see below) by U5, U6, U7, U8, U20, U17, U18, U19, U22. Check filter circuitry in signal source (U13) and detector (U62, U40, U41).

444 6 XXXX. .0118 kHz.
444 5 XXXX. .0968 kHz.
444 4 XXXX. 0.480 kHz.
444 3 XXXX. 1.200 kHz.
444 2 XXXX. 6.000 kHz.
444 1 XXXX. 15.40 kHz.

33333 XXXX. PROM data checksum failure. If the checksum XXXX is not 0000, check all digital circuitry, starting with the 6502 microprocessor U30. Any error on the address or data bus could cause a checksum error --- check EPROMs U35, U36; check RAM U33, U34; check all of the PIAs U3, U25, U26, U27. Look for address or data lines stuck at about 2 V or stuck low.

222 F XXXX. Calibration constants check failure; Digibridge hangs up, but will respond to keyboard inputs. The digit F is the range in question. COMMMENT: Each check consists of a comparison between the stored calibration data for the range and the normal, expected values. The calibration can be expressed (essentially) as the conductance of the internal standard resistor. The Digibridge normalizes this conductance by dividing it by the nominal conductance of the standard, and displays the result, XXXX, which should be very close to 1.000. (See table giving source resistance for each range in paragraph 3.4.2.) If XXXX is less than 0.2187 or more than 1.781, this test fails. ANALYSIS PROCEDURE: depends upon display; see below.

NOTE: This is a non-catastrophic failure. If you press the [Cs/D] key, the Digibridge will proceed with the self-check routine. The instrument can be operated as usual, but results may be erroneous. To restore accuracy, recalibrate, as described in paragraph 5.9 and/or 3.14.

222 4 XXXX. Range 4 may be incorrectly calibrated. Refer to paragraph 3.14 for recalibration procedure. If calibration is accomplished correctly, but this failure display appears when POWER is cycled OFF and ON, check battery B1. (See Figure 5-10. Connect voltmeter only briefly.) If B1 voltage is less than 2.0 V, replace battery with a new one, as described in paragraph 5.7.3. If the problem is clearly associated with the loss of calibration when POWER is cycled OFF and ON, but the battery voltage is adequate, check the standby power circuit (Q9, Q10, CR9, CR15). Only if necessary, check Rs standard switching circuitry (R96 through R99, U36 pin 1, U27, U56, U57, U58).

222 3 XXXX. Range 3. Be sure that recalibration has been done correctly. If necessary, check Rs standard switching circuitry as described above.

222 2 XXXX. Range 2. Same comment as for range 3.

222 1 XXXX. Range 1. Same comment as for range 3.

222 0 XXXX. Frequency correction factor. ANALYSIS PROCEDURE: refer to 444 E XXXX.

11111 1111. Math chip operational check failure. COMMENT: This test is performed only if you have the high-speed interface option 1689-9610 installed.

NOTE: This is a non-catastrophic failure. If you press the [Cs/D] key, the Digibridge can be operated as usual, but measurement time will be typical of an instrument WITHOUT the high-speed option.

5.7.3 Battery Replacement

If, at power-up, there is a failure display of 222 4 XXXX and investigation shows the most likely cause to be low battery voltage, you probably should replace battery B1. (See power-up self check in paragraph 3.13 and above in 5.7; see part description in Table 1-3 and/or Section 6.) The procedure is as follows.

a. Remove the main board.

b. Find B1 at the right of center (see Figure 5-10). Cut its straps. Observe correct polarity, for replacement, + toward center of board.

WARNING

Wear safety glasses while doing any work on the battery. DO NOT short or apply voltage to the battery. Dispose of the old one in accordance with local regulations for disposal of hazardous materials. DO NOT incinerate.

c. Unsolder and remove the old battery with care not to overheat.

d. Install the replacement and secure with straps (like the originals) or lacing cord, to safeguard terminals from strain.

e. Solder the terminals with care and DO NOT overheat.

f. Perform complete calibration procedure. Refer to paragraph 5.9.

5.7.4 Power Supply

NOTE

In the following procedure, do the principal steps (a, b, c, d, ...) as long as everything checks out normally. But if a failure is found, follow the secondary steps, if any are given at the point of failure (aa, ab, ac, ad ...).

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 5-3.

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 = +4.75 V to +5.25 V,
Pin 3 = +4.75 V to +5.25 V,
Pin 4 = -7.6 V to -8.4 V.

aa. If trouble is found at step a, check both analog and digital "+ 5 V" circuit: At outputs of U1 and U2: + 5 V dc (regulated).

At WT1 (inputs of U1 and U2): + 10.8 V dc, when primary voltage is 115 V rms, between terminals 1 and 2 of transformer T1.

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, when primary voltage is 115 V rms, between terminals 1 and 2 of transformer T1.

Across WT7 to WT8: 11.3 V rms.

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

b. Make a check similar to step a, with ribbon cable connected, ground reference at front edge of MB board (near the test fixture), probing MB-J5 from below the board, referring to Figure 5-10. (This checks for overload outside the power supply.)

5.7.5 Sinewave Generator Checks

Check the MB-board circuits that supply the test signals to the DUT, as follows.

a. Perform the zeroing procedure (both open circuit and short circuit), as described in paragraph 5.9.2 of the recalibration procedure.

b. Make the following test setup and keyboard selections.

[FUNCTION] --- MEASURE
[DISPLAY] --- VALUE
[MEASURE RATE] --- SLOW
[MEASURE MODE] --- CONT.
[EQUIVALENT CIRCUIT] --- SERIES

c. Install a 10 kilohm resistor as the DUT.

d. Use an oscilloscope to verify that the signal at the right-hand end of the DUT in the test fixture is a sine wave, as follows. (For scope ground return, connect to the ground plane on the circuit board or via a 6-32 screw to the tapped hole in the left-hand end of the test fixture.)

Frequency: 1 kHz,
Amplitude: approx 1.5 Vpk-pk.

e. If no fault appears in steps a through d, skip to paragraph 5.7.6.

NOTE

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

f. With an oscilloscope, observe and measure the signal at U32 pin 15. It must be a 1-kHz sinewave, 3.0 Vpk-pk.

g. With an oscilloscope, check at U31 pin 8, U14 pin 14, and U14 pin 8, for a 1-kHz sinewave, 3.0 Vpk-pk.

ga. If the test signal is missing, check backward, to the precision oscillator U4, then forward through dividers and sinewave generator, as shown on the main-board schematic sheets 2 and 3, in Section 6 of this manual.

5.7.6 Front End Amplifiers and Switches

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

a. Verify that there is a normal test signal at the test fixture. (See paragraph 5.7.5 step d, above.)

b. Check the range switching circuitry as follows. (Be sure that the RANGE HELD indicator is NOT lit.) Insert as DUT each of following resistors. With a scope connected to the right side of each DUT in turn, check for a 1-kHz sinewave with the level indicated below.

10 ohm --- test signal should be 1.0 Vpk-pk (range 4)
1 kohm --- test signal should be 2.4 Vpk-pk (range 3)
10 kohm --- test signal should be 2.0 Vpk-pk (range 2)
1 Mohm --- test signal should be 3.1 Vpk-pk (range 1)

ba. If discrepancy is found in step b, check for 3.4 Vpk-pk at the appropriate signal source check point -- as described in Table 5-5 -- for the particular range in use.

c. Install a 1-kilohm resistor in the test fixture. Check the PH circuit at U59 pin 8, for a 1-kHz sinewave, 2.4 Vpk-pk.

ca. If there is discrepancy in step c, but U59 pin 10 has a 2.4 Vpk-pk sinewave, then U59 is faulty.

d. Check the output of the IL circuit at U59 pin 14 for a 1-kHz sinewave, with the following selection of DUTs in turn:

10 ohm --- signal level should be 3.2 Vpk-pk (range 4)
1 kohm --- signal level should be 970 mVpk-pk (range 3)
10 kohm --- signal level should be 1.3 Vpk-pk (range 2)
1 Mohm --- signal level should be 315 mVpk-pk (range 1)

da. If a discrepancy is found in step d, check similarly at the R-Std signal check point -- as described in Table 5-6. The signal should be the same as listed in step d above for U59 pin 14, for the particular DUT and range.

Table 5-5
SOURCE RESISTOR RANGE SWITCHING CHECKS

Control Signals					
RNG1	RNG0	LOSCRR	Range	Nom Source Resistance	Signal Source Check Point
0	0	0	4	25 ohm	U32 pin 12
0	1	1	3	400 ohm	U32 pin 14
1	0	1	2	6.4 kohm	U32 pin 15
1	1	1	1	97.4 kohm	U32 pin 11

Table 5-6
DETECTOR (STANDARD) RESISTOR RANGE SWITCHING CHECKS

Control Signals					
RNG1	RNG0	LOSCRR	Range	Nominal Standard Resistance	R-Std Signal Check Point
0	0	0	4	25 ohm	U56 pin 12
0	1	1	3	400 ohm	U56 pin 14
1	0	1	2	5.97 kohm	U56 pin 15
1	1	1	1	97.4 kohm	U56 pin 11

Table 5-7
EQUIPMENT FOR ACCURACY VERIFICATION

Name	Requirements	Recommended
Capacitor	Decade, 3-terminal, 1 pF to 1 uF, accuracy: +/- 0.05% +/- 0.5 pF	GenRad 1413-9700
Extender cable	Adapt test fixture to type 874 conectors	GenRad 1688-9600
Adaptors (2 req'd)	Tee with type 874 connectors	Gilbert 0874-9910*
Extender cable	Adapt test fixture to binding posts and banana plugs	GenRad 1657-9600
Capacitor	Four-terminal, ratio type, 10 uF to 100 uF, accuracy: +/- 0.25%	GenRad 1417-9700
Capacitor	DC blocking, 500 uF, 10 V	GE 69F2214G2
Capacitor	Three-terminal, 1 uF, acc: +/- 0.02%, certified within +/- 0.03% including effects of aging since last certification	GenRad 1409-Y
Resistor	Decade, 3-terminal, 1 ohm to 1 Mohm, accuracy: +/- 0.01%	GenRad 1433-H
Inductors	Fixed, 2-terminal, 1 mH, +/- 0.1%	GenRad 1482-E
	100 mH, +/- 0.1%	GenRad 1482-L
	1 H, +/- 0.1%	GenRad 1482-P
	10 H, +/- 0.1%	GenRad 1482-T

*Gilbert Engineering Co., Inc., 5310 W. Camelback Rd, Glendale, AZ 85301

5.8 ACCURACY VERIFICATION

5.8.1 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 5-7 lists the recommended standards and associated equipment. For the C accuracy checks, the standard is a precision decade capacitor.

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

For example, if your 10-pF standard is known to be 10.18 +/- 0.25 pF, then compute the new tollerance as follows: Digibridge accuracy +/- 0.02 percent. The limits are, therefore, 9.92 to 10.44 pF.

Verify that the instrument meets performance specifications as follows.

5.8.2 Capacitance Measurement Accuracy (Small and Medium C, Ranges 1, 2, 3)

Make the test setup and verify instrument performance as follows:

CAUTION

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

a. After the line voltage switch has been set to correspond to the input line voltage, connect the power cord and switch POWER ON.

b. Connect the 1688-9600 extender cable (type 874 connectors) to the Digibridge test fixture, as described in paragraph 3.2.5. The screws must be hand tightened because they provide the ground (guard) connection.

c. Connect the "high" leads (red and red white) to one of the 874 Tee connectors. Connect the "low" leads (black and black/white) to the other 874 tee.

d. Before measurement, zero the Digibridge as follows. In this process, the Digibridge automatically measures stray parameters and retains the data, which it uses to correct measurements so that results represent parameters of the DUT alone, without (for example) test-fixture or adaptor capacitance.

Be sure that MEASURE RATE is SLOW and that the RANGE HELD indicator is NOT lit. DO NOT have test voltage programmed to other than 1 V, nor frequency to other than 1 kHz.

Open Circuit.

o Leave the two type 874 tees connected to the 1688-9600 extender cable, but not connected to each other.
o Press [FUNCTION] key (if necessary) to select MEASURE function.
o Press [MEASURE MODE] key (if necessary) to select TRIGGERED mode.
o Press these keys deliberately: [1] [6] [8] [9] [=] [SHIFT] [OPEN].
o Confirm that the GO indicator is lit. Press the START button.
o Keep hands and objects at least 10 cm (4 in.) from test fixture.
o Wait for the GO indicator to be lit again. (The RLC display should be .00000)

Short Circuit.

o Connect the two type 874 tees together.
o Press these keys deliberately: [1] [6] [8] [9] [=] [SHIFT] [SHORT].
o Confirm that the GO indicator is lit. Press the START button.
o Wait for the GO indicator to be lit again.
o Disconnect the two type 874 tees from each other.

e. Connect the type 874 tee with the red cables to the HIGH terminal of the 1413-9700 decade capacitor. Connect the other tee (black cables) to the LOW terminal of this capacitor.

f. Set the decade capacitor dials to 00000 pF.
o Press the Cs/D key.
o Press these keys deliberately: [1] [6] [8] [9] [=] [SHIFT] [OPEN].
o Confirm that the GO indicator is lit. Press the START button.
o Wait for the GO light. The RLC display should be .00000 pF.
o Press [MEASURE MODE] key to select CONT.
o Press [EQUIVALENT CIRCUIT] key to select SERIES.

g. Set the decade capacitor to 10 pF. If necessary, press the START button. Verify that the C and D measurements subsequently displayed on the Digibridge are within the limits given in the first line of Table 5-8.

h. Similarly, for each line in the table, set the capacitor and the Digibridge measurement rate, and verify that the resulting measurements are satisfactory.

i. Disconnect the 1688-9600 extender cable from the capacitor and the Digibridge.

Table 5-8
CAPACITANCE ACCURACY CHECKS (RANGES 1 TO 3)

Capacitor Setting	Meas Rate	Digibridge Accuracy	Decade C Accuracy	RLC Display Min*	RLC Display Max*	QDR Display Max**
------ Range 1 ------						
10 pF	SLOW	.02%	5.05%	9.493	10.507	6100 ppm
100 pF	SLOW	.02%	.55%	99.430	100.57	2500 ppm
1500 pF	SLOW	.02%	.083%	1498.4	1501.6	700 ppm
1500 pF	MED	.05%	.083%	1498.0	1502.0	1002 ppm
1500 pF	FAST	.15%	.083%	1496.5	1503.5	1705 ppm
6400 pF	SLOW	.02%	.058%	6395.0	6405.0	500 ppm
10 nF	SLOW	.02%	.055%	9.9925	10.008	200 ppm
------ Range 2 ------						
25 nF	SLOW	.02%	.052%	24.982	25.018	200 ppm
25 nF	MED	.05%	.052%	24.974	25.026	500 ppm
25 nF	FAST	.15%	.052%	24.949	25.051	1200 ppm
100 nF	SLOW	.02%	.051%	99.929	100.07	200 ppm
------ Range 3 ------						
200 nF	SLOW	.02%	.05%	199.86	200.14	200 ppm
400 nF	SLOW	.02%	.05%	399.72	400.28	200 ppm
400 nF	MED	.05%	.05%	399.60	400.40	500 ppm
400 nF	FAST	.15%	.05%	399.20	400.80	1200 ppm
1000 nF	SLOW	.02%	.05%	999.30	1000.7	200 ppm

*These ranges of acceptable displays are based on specified accuracy of decade capacitor, recently calibrated. If the capacitor values are known to higher accuracy by special calibration or lesser accuracy because of long-term drift, the acceptable RLC max and min criteria must be revised accordingly.

**Based on D values stated in GenRad documentation for the type 1413 decade capacitor. If capacitor D values are known more accurately, the acceptable QDR display criteria can be reduced accordingly.

Table 5-9
CAPACITANCE ACCURACY CHECKS (RANGE 4)

Capacitor Setting	Digibridge Acuracy	St'd C Accuracy	RLC Display (Uncorrected) Min	Max	RLC Display Correction (See text)	Acceptable D Min	Max
1 uF	--	--	(Used to determine K)			.0085	.0115
10 uF	.02%	.07%	9.991	10.009	+10K	.0085	.0115
100 uF	.02%	.07%	99.91	100.09	+100K	.0085	.0115

5.8.3. Capacitance Measurement Accuracy (Large C, Range 4)

This procedure follows after paragraph 5.8.2. (Leave the test frequency at 1 kHz, the test voltage at 1 V, the measure rate SLOW, the selected parameter Cs/D, and the RANGE HELD indicator NOT lit.)

a. Connect the 1657-9600 extender cable (with banana plugs) to the Digibridge test fixture. Hand-tighten the screws, to provide the ground (guard) connection.

b. Connect the "high" leads (red and red/white) together. Separately connect the "low" leads (black and black white) together.

c. Before measurement, zero the Digibridge as follows:

Open Circuit.

- o Leave the high (red) banana plug stack disconnected from the low (black) stack.
- o Press [FUNCTION] key (if necessary) to select MEASURE.
- o Press [MEASURE MODE] key (if necessary) to select TRIGGERED mode.
- o Press these keys deliberately: [1] [6] [8] [9] [=] [SHIFT] [OPEN].
- o Confirm that the GO indicator is lit.
- o Keep hands and objects at least 10 cm (4 in.) from test fixture.
- o Press the START button.
- o Wait for the GO indicator to be lit. The RLC display should be .00000 pF.

Short Circuit.

- o Connect the two banana plug stacks together; leave the guard (black/green) open.
- o Press these keys deliberately: [1] [6] [8] [9] [=] [SHIFT] [SHORT].
- o Confirm that the GO indicator is lit.
- o Press the START button.
- o Wait for the GO indicator to be lit. The RLC display should be .00000 ohms.
- o Press the [MEASURE MODE] key to select CONT.

d. Connect the three-terminal 1-uF capacitance standard (GR 1409-Y) as follows. This standard should be certified to an accuracy of +/- .03% including the effects of aging.

RED,	IH:	capacitor H binding post
RED & WHITE,	PH:	stacked on the red banana plug
BLACK,	IL:	capacitor L binding post
BLACK & WHITE,	PL:	stacked on the black banana plug
BLACK & GREEN,	G:	capacitor G, NOT linked to L

e. Verify that the RLC display agrees with the certified value of the standard (corrected for temperature if appropriate) within +/-.0005 uF which is the sum of .03% for the standard and 0.02% for the Digibridge.

f. Calculate the difference D1, as follows, and retain it for future use.
D1 = (displayed measurement) - (value of standard) uF

g. Remove the 1-uF standard and connect the 4-terminal ratio-type capacitance standard (GR 1417) and the blocking capacitor (500 uF) as follows. Be sure that the dc blocking capacitor is fully discharged before connecting it. Notice that only the left-hand terminals of the standard are used.

RED,	IH:	+ end of blocking capacitor
- end of blocking cap:		CURRENT H terminal of capacitance standard
RED & WHITE,	PH:	POTENTIAL H terminal of capacitance standard
BLACK,	IL:	CURRENT L terminal of capacitance standard
BLACK & WHITE,	PL:	POTENTIAL L terminal of capacitance standard
BLACK & GREEN,	G:	uninsulated terminal of capacitance standard

h. Set the dials on the capacitance standard thus:

CAPACITANCE : 1 uF
TEST FREQUENCY : 1 kHz

NOTE

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

i. Read the RLC display, which should be close to the nominal value of the standard: 1 uF.

j. Calculate the difference D2, as follows, and retain it for future use.
D2 = (1.0000 uF) - (displayed measurement) uF
NOTE: The DQ display should show D = .0085 to .0115.

k. Calculate the calibration factor K as follows.
K = D1 + D2 (uF)

Example. Suppose that in step e, the display is 1.0013, and the value of the standard is 1.0006; then D1 = +.0007 uF. In step i, the nominal is 1.0000; suppose that the display is 1.0024; then D2 = -.0024uF. The correction K would therefore be:
+.0007 -.0024 = -.0017 (uF).

l. Reset the capacitance-standard dial to: CAPACITANCE = 10 uF.

m. Read the RLC display and correct it by adding 10K. (For example, if the display is 10.023 uF and if K = -.0017, the corrected measurement is 10.006 uF.) Verify that the corrected measurement is within the acceptable extremes for the 10-uF setting in Table 5-6.

n. Reset the capacitance-standard dial to: CAPACITANCE = 100 uF.
Read the RLC display and correct it by adding 100K.
As in step m, verify that the corrected measurement is within the acceptable extremes shown in Table 5-9.

Table 5-10
RESISTANCE ACCURACY CHECKS (at 1 kHz)

Standard Resistor Setting	Equivalent Circuit	Measure Rate	Typical Standard Accuracy*	Digibridge Accuracy	RLC Display Acceptable Extremes*
10.00 ohms	Series	SLOW	.36%	.07%	9.996 to 10.004
25.00 ohms	Series	SLOW	.046%	.02%	24.983 to 25.016
25.00 ohms	Series	MED	.046%	.05%	24.976 to 25.024
25.00 ohms	Series	FAST	.046%	.15%	24.952 to 25.048
90.00 ohms	Series	SLOW	.02%	.02%	89.964 to 90.036
200.0 ohms	Series	SLOW	.015%	.02%	199.93 to 200.07
400.0 ohms	Series	SLOW	.01%	.02%	399.88 to 400.21
400.0 ohms	Series	MED	.01%	.05%	399.76 to 400.24
400.0 ohms	Series	FAST	.01%	.15%	399.36 to 400.64
1500 ohms	Parallel	SLOW	.01%	.02%	1499.5 to 1500.5
2000 ohms	Parallel	SLOW	.01%	.02%	1999.4 to 2000.6
6400 ohms	Parallel	SLOW	.01%	.02%	6398.1 to 6401.9
6400 ohms	Parallel	MED	.01%	.05%	6396.2 to 6403.8
6400 ohms	Parallel	FAST	.01%	.15%	6389.8 to 6410.2
24 kilohms	Parallel	SLOW	.01%	.02%	23.993 to 24.007
30 kilohms	Parallel	SLOW	.01%	.02%	29.991 to 30.009
100 kilohms	Parallel	SLOW	.01%	.02%	99.97 to 100.03
100 kilohms	Parallel	MED	.01%	.05%	99.94 to 100.06
100 kilohms	Parallel	FAST	.01%	.15%	99.84 to 100.16

* If the calibrated value of the 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.

5.8.4 Resistance Measurement Accuracy

This procedure follows after paragraph 5.8.3. (Thus, test frequency = 1 kHz, test voltage = 1 V, measure rate = SLOW, range held indicator is NOT lit, and parameter Cs/D is specified.)

a. With the Digibridge still connected to the 1657-9600 extender cable, connect its banana plugs to the 1433-H Decade Resistor as follows:

o "high" leads (red and red/white) to the H binding post
o "low" leads (black and black/white) to the L binding post
o guard lead (black/green) to the G binding post.
o Disconnect any link between the G and L binding posts.

b. Set the decade resistor dials to 00000 ohms.

- o Press the [Rs/Q] key.
- o Press [MEASURE MODE] key to select TRIGGERED.
- o Press these keys deliberately: [1] [6] [8] [9] [=] [SHIFT] [SHORT].
- o Confirm that the GO indicator is lit. Press the START button.
- o Wait for the GO indicator to be lit again. The RLC display should be .00000 ohms.
- o Press [MEASURE MODE] key to select CONT.

c. Refer to Table 5-10. Set the decade resistor dials to 0000010, as indicated in the first line of the table and verify that the RLC display is between the extremes listed. Repeat for each line of the table, setting the decade resistor dials, Digibridge equivalent circuit, and measurement rate, and verifying the results, as tabulated.

5.8.5 Inductance Measurement Accuracy

This procedure follows after paragraph 5.8.4. (Thus, test frequency = 1 kHz, test voltage = 1 V, measure rate = SLOW, range held indicator is NOT lit, and parameter Rs/Q is specified.)

a. Connect the 1657-9600 extender cable to the Digibridge test fixture. Hand tighten the screws, to provide ground (guard) connection.

b. Connect the "high" leads (red and red/white) together and separately connect the "low" leads (black and black/white) together.

c. Before measurement, zero the Digibridge as follows:

Open Circuit.

- o Keep the "high" banana-plug stack separated from the "low" stack.
- o Press [FUNCTION] key (if necessary) to select MEASURE function.
- o Press [MEASURE MODE] key (if necessary) to select TRIGGERED mode.
- o Press these keys deliberately: [1] [6] [8] [9] [=] [SHIFT] [OPEN].
- o Confirm that the GO indicator is lit.
- o Keep hands and objects at least 10 cm (4 in.) from test fixture.
- o Press the START button.
- o Wait for the GO indicator to be lit again. The RLC display should be .00000 pF.

Short Circuit.

- o Connect the 2 banana plug stacks together, leave the guard (black/green) open.
- o Press these keys deliberately: [1] [6] [8] [9] [=] [SHIFT SHORT].
- o Confirm that the GO indicator is lit.
- o Press the START button.
- o Wait for the GO indicator to be lit again. The RLC display should be .00000 ohms.
- o Press the [MEASURE MODE] key to select CONT.

Table 5-11
INDUCTANCE ACCURACY CHECKS (at 1 kHz)

Standard Inductor (LS)	Range	Measure Rate	Digibridge Accuracy	Typical Standard Accuracy	RLC Display* Acceptable Extremes	Expected Q**
1 mH	4	SLOW	.02%	0.1%	.9988 to 1.0012	7.5
		MED	.05%	0.1%	.9985 to 1.0015	---
		FAST	.15%	0.1%	.9975 to 1.0025	---
100 mH	3	SLOW	.02%	0.1%	99.88 to 100.12	7.5
		MED	.05%	0.1%	99.85 to 100.15	---
		FAST	.15%	0.1%	99.75 to 100.25	---
1 H	2	SLOW	.02%	0.1%	.9988 to 1.0012	10
		MED	.05%	0.1%	.9985 to 1.0015	---
		FAST	.15%	0.1%	.9975 to 1.0025	---
10 H***	1	SLOW	.02%	0.1%	9.988 to 10.012	10
		MED	.05%	0.1%	9.985 to 10.015	---
		FAST	.15%	0.1%	9.975 to 10.025	---

---

* These ranges of acceptable displays are based on specific accuracy of decade inductors, recently calibrated. If the inductance values are known to higher accuracy by special calibration or lesser because of long-term drift, the "acceptable RLC extremes" must be revised accordingly.

** Based on Q of Type 1482 Standard Inductor, as stated in GenRad documentation. If inductor Q values are known more accurately, the Q can be checked to tighter tolerances.

*** The effective value of a high-valued inductor depends on the capacitance shunting the inductor. For a 10-H inductor at 1 kHz, the guarded value is about 1/2% lower than the two terminal (calibration) value. So when measuring a 10-H inductor on the 1689 Digibridge, connect the inductor as follows:
"High" leads (red and red/white) to the H binding post.
"Low" leads (black and black/white) to the L binding post.
Allow the guard lead (black/green) to hang free.
Connect the grounding link between the ground and L binding posts.

d. Connect the banana plugs of the 1687-9600 extender cable to the 1-mH inductance standard (1482-E) as follows:
"high" leads (red and red/white) to the HIGH binding post
"low" leads (black and black/white) to the LOW binding post
guard lead (black/green) to the ground (unmarked) binding post.
Disconnect any link between ground and LOW binding posts.

e. Press the [Ls/Q] key to select inductance parameter.
Press the [EQUIVALENT CIRCUIT] key (if necessary) to select SERIES.

f. Refer to Table 5-11 and verify that the RLC display is between the extremes listed for 1 mH, SLOW measurement rate (first line of table).

g. Similarly, with the inductance standards 1 mH, 100 mH, and 1 H, as indicated in the LS column, and with the indicated measurement rate, verify that the RLC display is acceptable for each line of the table, for ranges 4, 3, and 2.

h. Use the 2-terminal connections for the 10-H inductance standard, as described in the footnote to the table. Verify that the RLC display is acceptable for each corresponding line of the table, for range 1.

5.9 RECALIBRATION

5.9.1 Preparation

Introduction. This service procedure requires a set of external calibration resistors whose R and Q values are exactly known (and which are obtained from GenRad) and generally requires a frequency counter. For the frequency correction, the counter makes a measurement; but for the four internal resistance standards, the Digibridge makes the measurements. After recalibration, the Digibridge retains in RAM the corrections that the microprocessor needs to compensate for the small errors in the actual values of test frequency and internal standard resistor parameters. (Therefore, the Digibridge calculates its measurement results correctly, accomplishing by calculation the same result that would be obtained if the recalibration process actually trimmed the internal standards exactly to their nominal values.)

Required Equipment. Refer to Table 5-12.

Table 5-12
EQUIPMENT FOR RECALIBRATION

GenRad No.	Description	Requirements
---	Temperature stabilized room	23 degrees C (73.4 F) recommended
---	Set of four "calibration" resistors with nominal resistances of 24.9, 374 ohms; 5.97, 95.3 kilohms	R and Q values known at 1 kHz, R accuracy +/-.001%, calibration traceable to NBS; Q calibrated to +/- 10 ppm.
---	Universal counter/timer*, with ground strap	Accuracy better than +/-10 ppm (+/-2 ppm preferred) in averaging multiple period measurement
---	Screw*, bright plated brass	Size: 0.138-32 x 0.5 (diam-thds/in. x length, in.)

* Counter and screw are needed for frequency calibration only.

Decision Whether Frequency Calibration is Needed. The frequency calibration (paragraph 5.9.7) is necessary — and should be completed before recalibrating any range — if any of the following is true:

1. If the battery B1 has been replaced or disconnected for any reason.
2. If either of the RAM devices U33 or U34 has been replaced or disconnected.
3. If the RAM standby battery circuit has been serviced.
4. If oscillator U4 has been replaced.

Procedure

a. Remove any adaptor that may be in the test fixture. Inspect the Digibridge test fixture for cleanliness. If it is dirty or if it is scheduled for periodic cleaning soon, clean the test fixture as described in paragraph 5.6.

b. Place all equipment including the Digibridge(s) to be recalibrated in the temperature stabilized room, normally at 23 degrees C.

c. Switch Digibridge(s) ON and if frequency calibration is needed (see above) switch the counter power ON. Allow all equipment to warm up for at least two hours. Leave the Digibridge test conditions at the defaults.

d. If frequency calibration is needed (see "Decision ..." above), skip to the procedure of paragraph 5.9.7 before zeroing and recalibrating ranges 4, 3, 2, and 1.

5.9.2 Zeroing and Selecting "DQ in PPM"

This zeroing procedure is like the routine procedure in Operation, Section 3. In this process, the Digibridge automatically measures stray parameters related to the test fixture and associated circuits and retains the data, which it uses in each recalibration step below to correct measurements so that results most accurately represent parameters of the external calibration resistor alone.

Open Circuit.

a. Press [FUNCTION] key (if necessary) to select MEASURE mode. Press [MEASURE MODE] key (if necessary) to select TRIGGERED mode.

b. Be sure that the test fixture is open circuited.

c. Press these keys: [1] [6] [8] [9] [=] [SHIFT] [OPEN]. (A zero in each, left and right displays, and the GO indicator should be lit, confirming this step.)

d. Keep hands and objects at least 10 cm (4 in.) from test fixture.

e. Press the START button. The GO indication disappears.

f. Wait for the GO indicator to be lit again (approximately 10 seconds).

Short Circuit.

a. Short the fixture with a very low-resistance "short circuit".

b. Press the keys: [1] [6] [8] [9] [=] [SHIFT] [SHORT]. (A 5 in each, left and right displays, and the GO indicator should be lit, confirming this step.) Keep away from test fixture, as in step d above.

c. Press the START button. The GO indication disappears.

d. Wait for the GO indicator to be lit again (aproximately 10 seconds). The RLC display should be .00000 (ohms or mH).

e. Disconnect the short circuit.

DQ in PPM. Press [SHIFT][DQ in PPM] keys if necessary to light this indicator.

5.9.3 Recalibration for Range 4

a. Connect the 24.9-ohm calibration resistor to the Digibridge test fixture.

b. Enter the known parameters of the calibration resistor as in the following example, based on the values R = 24.895 ohms and Q = 15 ppm. (NOTES: The Digibridge will accept six digits for R, even though only five will be displayed. The Q is associated with "bin 00", and its value must be preceded with "-" if the known Q is negative.)

Select ENTER with [FUNCTION] key and CONTINUOUS with [MEASURE MODE] key.
Press [4][=][SHIFT][SPECIAL][1]
Press [2][4][.][8][9][5][=][SHIFT][NOM VALUE]

NOTE: the calibration resistance value should appear in the left display. The DQ in PPM indicator must be lit.

Press [1][5][=][SHIFT][BIN NO][0][0]

NOTE: the calibration Q value should appear in the right-hand display.

c. Enable and execute the recalibration for this range as follows. (The following keystrokes are the same for any range.)

Select MEASURE with the [FUNCTION] key and TRIGGERED with [MEASURE MODE] key.
Press [1][6][8][9][=][1][SHIFT][CALIBRATE]

NOTE: The GO indicator being lit and a 6 in the left and a 6 in the right displays confirm that calibration is enabled.

Press START (The GO indicator remains unlit while calibration proceeds.)

Keeping hands away from the test fixture, wait until the GO indicator is lit again. This completes recalibration of one range.

d. Check as follows that the Digibridge operates properly with the recalibration.

Select CONTINUOUS with the [MEASURE MODE] key.

The Digibridge should measure the calibration resistor like any ordinary resistor and display its R and Q (ppm) values. The Q display can be expected to "jump" a bit. (Precision and repeatability are in the order of 5 ppm). Also, the NO-GO indicator will probably be lit; this is normal.

e. Disconnect the calibration resistor from the test fixture.

5.9.4 Recalibration for Range 3

a. Connect the 374-ohm calibration resistor to the Digibridge test fixture.

b. Enter the known parameters of the calibration resistor as in the following example, based on the values R = 374.06 ohms and Q = 5 ppm. (NOTES: The Digibridge will accept six digits for R, even though only five will be displayed. The Q is associated with "bin 00", and its value must be preceded with "-" if the known Q is negative.)

Select ENTER with [FUNCTION] key and verify that measure mode is CONT.
Press [3][=][SHIFT][SPECIAL][1]
Press [3][7][4][.][0][6][=][SHIFT][NOM VALUE]

NOTE: the calibration resistance value should appear in the left display. The DQ in PPM indicator must be lit.

Press [5][=][SHIFT][BIN NO][0][0]

NOTE: the calibration Q value should appear in the right-hand display.

c. Enable and execute the recalibration for this range as follows. (The following keystrokes are the same for any range.)

Select MEASURE with the [FUNCTION] key and TRIGGERED with [MEASURE MODE] key.

Press [1][6][8][9][=][1][SHIFT][CALIBRATE]

NOTE: The GO indicator being lit and a 6 in the left and a 6 in the right displays confirm that calibration is enabled.

Press START (The GO indicator remains unlit while calibration proceeds.)

Keeping hands away from the test fixture, wait until the GO indicator is lit again. This completes recalibration of one range.

d. Check as follows that the Digibridge operates properly with the recalibration.

Select CONTINUOUS with the [MEASURE MODE] key.

The Digibridge should measure the calibration resistor like any ordinary resistor and display its R and Q (ppm) values. The Q display can be expected to "jump" a bit. (Precision and repeatability are in the order of 5 ppm). Also, the NO-GO indicator will probably be lit; this is normal.

e. Disconnect the calibration resistor from the test fixture.

5.9.5 Recalibration for Range 2

a. Connect the 5.97-kilohm calibration resistor to the Digibridge test fixture.

b. Enter the known parameters of the calibration resistor as in the following example, based on the values R = 5.9581 kilohms and Q = -22 ppm. (NOTES: The Digibridge will accept six digits for R, even though only five will be displayed. The Q is associated with "bin 00", and its value must be preceded with "-" if the known Q is negative.)

Select ENTER with [FUNCTION] key and verify that measure mode is CONT.

Press [2][=][SHIFT][SPECIAL][1]

Press [5][.][9][5][8][1][=][SHIFT][NOM VALUE]

NOTE: the calibration resistance value should appear in the left display. The DQ in PPM indicator must be lit.

Press [-][2][2][=][SHIFT][BIN NO][0][0]

NOTE: the calibration Q value should appear in the right-hand display.

c. Enable and execute the recalibration for this range as follows. (The following keystrokes are the same for any range.)

Select MEASURE with the [FUNCTION] key and TRIGGERED with [MEASURE MODE] key.

Press [1][6][8][9][=][1][SHIFT][CALIBRATE]

NOTE: The GO indicator being lit and a 6 in the left and a 6 in the right displays confirm that calibration is enabled.

Press START (The GO indicator remains unlit while calibration proceeds.)

Keeping hands away from the test fixture, wait until the GO indicator is lit again. This completes recalibration of one range.

d. Check as follows that the Digibridge operates properly with the recalibration.

Select CONTINUOUS with the [MEASURE MODE] key.

The Digibridge should measure the calibration resistor like any ordinary resistor and display its R and Q (ppm) values. The Q display can be expected to "jump" a bit. (Precision and repeatability are in the order of 5 ppm). Also, the NO-GO indicator will probably be lit; this is normal.

e. Disconnect the calibration resistor from the test fixture.

5.9.6 Recalibration for Range 1

a. Connect the 95.3-kilohm calibration resistor to the Digibridge test fixture.

b. Enter the known parameters of the calibration resistor as in the following example, based on the values R = 94.986 kilohms and Q = -280 ppm. (NOTES: The Digibridge will accept six digits for R, even though only five will be displayed. The Q is associated with "bin 00", and its value must be preceded with "-" if the known Q is negative.)

Select ENTER with [FUNCTION] key and verify that measure mode is CONT.
Press [1][=][SHIFT][SPECIAL][1]
Press [9][4][.][9][8][6][=][SHIFT][NOM VALUE]

NOTE: the calibration resistance value should appear in the left display. The DQ in PPM indicator must be lit.

Press [-][2][8][0][=][SHIFT][BIN NO][0][0]

NOTE: the calibration Q value should appear in the right-hand display.

c. Enable and execute the recalibration for this range as follows. (The following keystrokes are the same for any range.)

Select MEASURE with the [FUNCTION] key and TRIGGERED with [MEASURE MODE] key.
Press [1][6][8][9][=][1][SHIFT][CALIBRATE]

NOTE: The GO indicator being lit and a 6 in the left and a 6 in the right displays confirm that calibration is enabled.

Press START (The GO indicator remains unlit while calibration proceeds.)

Keeping hands away from the test fixture, wait until the GO indicator is lit again. This completes recalibration of one range.

d. Check as follows that the Digibridge operates properly with the recalibration.

Select CONTINUOUS with the [MEASURE MODE] key.

The Digibridge should measure the calibration resistor like any ordinary resistor and display its R and Q (ppm) values. The Q display can be expected to "jump" a bit. (Precision and repeatability are in the order of 5 ppm). Also, the NO-GO indicator will probably be lit; this is normal.

e. Disconnect the calibration resistor from the test fixture.

5.9.7 Frequency Calibration

a. If frequency calibration is not necessary (refer to "Decision ..., in paragraph 5.9.1), omit the procedures of paragraph 5.9.7. If necessary at all, these steps should be done before paragraphs 5.9.2 through 5.9.6.

b. Connect the counter as follows to measure the period of the test frequency, nominally 1 kHz. If the Digibridge is not disassembled, provide for a ground connection as follows. (Otherwise, see NOTE below.) Insert a 6-32 (1/2 - inch long) screw into the tapped hole at the right-hand end of the Digibridge's test fixture (tighten gently). Connect the ground return of the counter's probe to this screw.

Insert the short-circuit wire used above (for example) into the right-hand slot of the test fixture only. Connect the counter's probe to this wire.

NOTE: If calibration is being done with the main board out of the cabinet, a more convenient ground connection is found near the front edge of the board at a guard-jumper terminal labeled E1 on the board (DUT CONNECTOR GND on the schematic diagram).

b. Measure the test signal frequency, preferably as a period and calculate its reciprocal.

For example, if the period is 1.000007 ms, the frequency is 0.999993 kHz

c. Calculate the frequency correction "c" (error) in ppm, as follows.

$$c = \frac{(\text{measured frequency}) - 1.000000\text{ kHz}}{1\text{ kHz}} \times 1{,}000{,}000.$$

For example: c = (0.999993 - 1.000000) x 1,000,000 = -7 ppm.

d. Enter the frequency correction "c" (error) in ppm, as follows. The allowable range of entry is -99 to +99.

For example, if the value of "c" is -7 ppm:
Select ENTER function and press:
[-][7][=][SHIFT][SPECIAL][0]
Notice that the correction "c" appears in the left display, followed by a decimal point. The correction has NOT been enterred yet. Confirm the value. Then continue the entry process by pressing:
[1][6][8][9]
The decimal point should disappear, indicating that the correction has been entered.

e. Confirm normalcy as follows.

Press [1][=][SHIFT][FREQUENCY]	(The left display should now be 1)
Press [1][=][SHIFT][VOLTAGE]	(The left display should be 1)

f. Now continue with the zeroing and range recalibration procedures, starting at paragraph 5.9.2.

5.10 INTERNAL SETTINGS

5.10.1 Address for IEEE-488 Interface

Each device (instrument) in a system linked by an IEEE-488 bus must have its own address (except in the simple case of a single "talker only" with one or more "listeners" that are always listening). The initial setting of address, provided by the factory, in the interface option of this Digibridge, is 00011. If the requirements of a system installation make it necessary to change the Digibridge address, use the following procedure. Refer to paragraph 2.8.4 for further comments and a table of possible addresses.

a. Remove the interface option, after removing the 2 large screws with resilient washers in the rear panel. See Figure 1-2.

CAUTION

Observe the handling precautions given at the beginning of the Service Section.

b. Find S2 which is located at the end of the interface option board, about 3 cm (1 in.) from the TALK switch S1. If S2 is covered, lift the cover off, exposing the "DIP" switch, which has 2 rows of 6 tiny square pads with numbers 1 thru 6 between the rows. The five device-dependent bits of the address are set by this switch.

c. Set in the desired bits as follows. To enter logical 1's, depress pads nearest the end of the board. To enter logical 0's, depress pads on the other side of the "DIP" switch, the side marked with a + sign. The address is read from 5 to 1 (not using 6). Thus, for example, to set up the address 00011, enter 0's at positions 5, 4, 3; enter 1's at positions 2, 1. (This makes the talk address "C" and the listen address "#".)

NOTE: Strictly speaking, the address includes more; S2 determines only the device-dependent bits of the address. You cannot choose talk and listen addresses separately, only as a pair. The list of possible pairs is shown in Table 2-3. In the above example, the remote message codes MLA and MTA are X0100011 and X1000011, respectively. Thus the listen address and the talk address are distinguished, although they contain the same set of device-dependent bits, which are set into S2.

d. Replace the interface option assembly in its former place. Reassembly note: align board edges carefully with connector and guide that are inside of instrument, while pushing interface option into position.

5.10.2 Making +5 Volts Available via the Handler Interface Connector

A five-volt low-power dc bus can be brought out via pin 10 of the handler interface connector as follows. This bus is useful to supply voltage for opto-couplers in a handler.

a. Remove the interface option, after removing the 2 large screws with resilient washers in the rear panel. See Figure 1-2.

CAUTION

Observe the handling precautions given at the beginning of the Service Section.

b. Find wire tie points WT2 and WT3, on the circuit board, near the handler interface connector.

c. Connect a wire jumper between WT2 and WT3.

d. Replace the interface option assembly in its former place. Reassembly note: align board edges carefully with connector and guide that are inside of instrument, while pushing interface option into position.

Parts Lists and Diagrams — Section 6

6.1 GENERAL

This section contains the parts lists, circuit board layout drawings, and schematic diagrams for the instrument. Refer to Section 4 for the functional block diagram and Section 5 for further details about part locations.

6.2 REFERENCE DESIGNATIONS

Each electrical component part on an assembly is identified on the equipment and drawings by means of a reference designator comprised of letters and numbers. Component parts on a circuit board or assembly are classified by the letter or letters of the reference designators (R for resistor, C for capacitor, etc) and individually identified by the numerical part of the reference designator (R1 for the first resistor, R2 for the second, etc). Some of the less obvious designator letters are: DS or CR for indicator light, Q for transistor, U for integrated-circuit device, WT for wire tie point, J or P for connector, and Z for network.

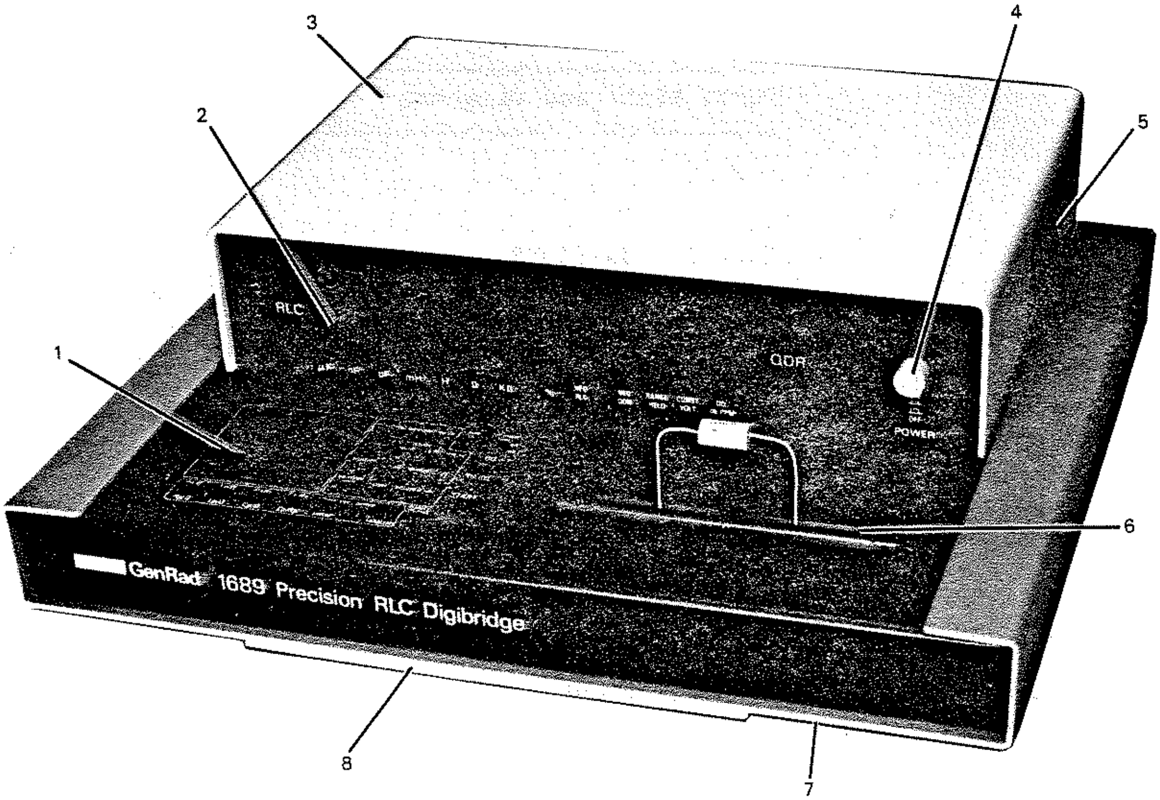

Figure 6-1. Front view, showing replaceable mechanical parts.

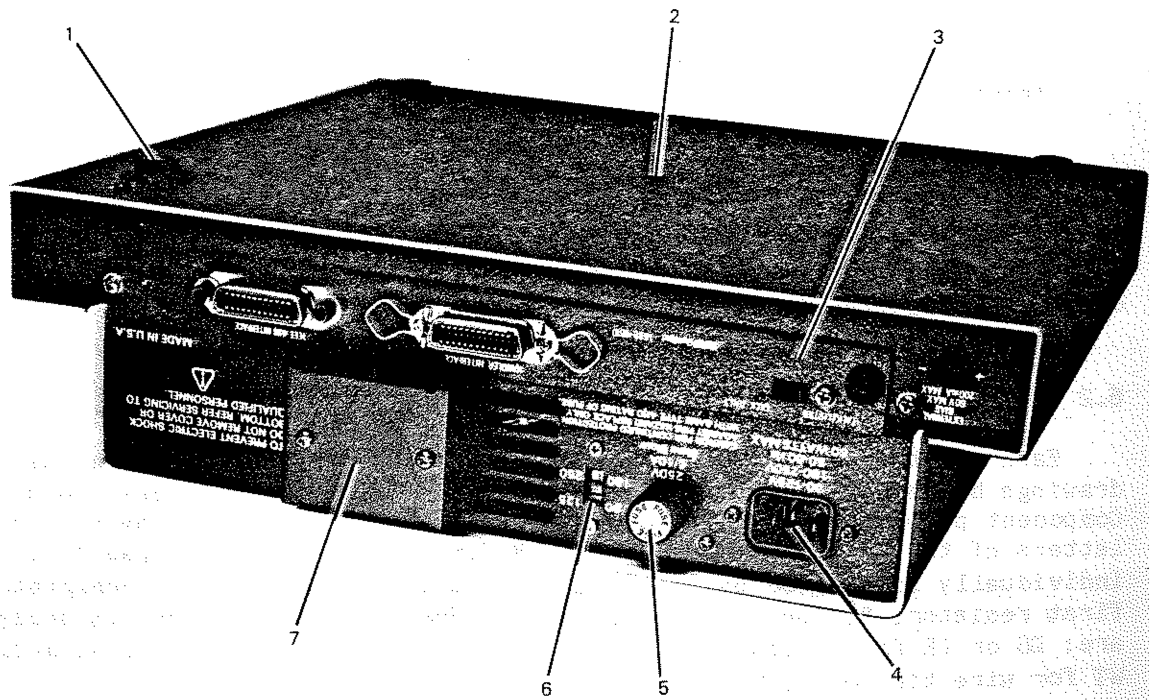

Figure 6-2. Rear view, showing replaceable mechanical parts.

MECHANICAL PARTS LIST

FRONT (Figure 6-1)

Item	Description	GenRad Part	Mftr	Mftr Part No.
1	Keyboard top plate	1689-8040	24655	1689-8040
2	Display panel	1689-7000	24655	1689-7000
3	Top cover	1689-8003	24655	1689-8003
4	Switch actuator rod assembly	1689-2006	24655	1689-2006
5	Air filter (washable, dry type)	5270-5456	24655	5270-5456
6	Test fixture upper assembly	1689-2000	24655	1689-2000
	(includes dross tray	1657-7700	24655	1657-7700
	and foamed plastic pad)	1657-7800	24655	1657-7800
-	Test fixture contacts (4 required; included on 1689-4700 board) each:	1689-1015	24655	1689-1015
7	Card Pan	1658-8200	24655	1658-8200
8	Instruction card	1689-0110	24655	1689-0110

REAR (Figure 6-2)

Item	Description	GenRad Part	Mftr	Mftr Part No.
1	Foot (4 required) each:	5260-2051	24655	5260-2051
2	Bottom shell (card pan not shown)	1657-8000	24655	1657-8000
3	(High-speed meas interface option shown) Blank plate used if no option present	1658-8040	24655	1658-8040
4	Power connector J101	4240-0250	82389	EAC-302
5	Fuse extractor post F1	5650-0100	75915	342-004
6	Line voltage switch S2	7910-0832	82389	11A-1266
7	Cover (over transistor U1)	1657-8120	24655	1657-8120

6.3 DIAGRAMS

In this section, the schematic diagrams are located on right-hand fold-out pages for convenience. The associated parts list, layout drawing, assembly view, etc for each schematic diagram are located on the apron of the same page, the facing page, or otherwise nearby.

FEDERAL SUPPLY CODE FOR MANUFACTURERS

From Defense Logistics Agency Microfiche

H4-2 SB 708-42 GSA-FSS H4-2

Ref FMC Column in Parts Lists

Code	Manufacturer
00136	McCoy Elctrns.,Mt.Holly Springs,PA 17065
00192	Jones Mfg.,Chicago,IL 60181
00194	Walsco Elctrns.,Los Angeles,CA 90018
00327	Welwyn Intntl.,Westlake,OH 44145
00434	Schweber Elctrns.,Westburg,NY 11590
00656	Aerovox.,New Bedford,MA 02745
00779	AMP Inc.,Harrisburg,PA 17105
01009	Alden Products.,Brockton,MA 02413
01121	Allen Bradley.,Milwaukee,WI 53204
01255	Litton Inds.,Beverly Hills,CA 90213
01281	TRW.,Lawndale,CA 90260
01295	TI.,Dallas,TX 75222
01526	GE.,Waynesboro,VA 22980
01930	Amerock:,Rockford,IL 61101
01963	Cherry Elctrc.,Waukegan,IL 60085
02111	Spectrol Elctrns.,City of Industry,CA 91745
02114	Ferroxcube.,Saugerties,NY 12477
02606	Fenwall Lab.,Morton Grove,IL 60053
02639	GE.,Schenectady,NY 12307
02660	Amphenol.,Broadview,IL 60153
02735	RCA.,Somerville,NJ 08876
02768	Fastex.,Desplains,IL 60016
03042	Carter Ink.,Cambridge,MA 02142
03508	GE.,Syracuse,NY 13201
03550	Vanguard Elctrns.,Inglewood,CA 90302
03636	Grayburne.,Yonkers,NY 10701
03877	Transitron Elctrns.,Wakefield,MA 01880
03888	KDI Pyrofilm.,Whippany,NJ 07981
03911	Clairex.,New York,NY 10001
04009	Arrow Hart.,Hartford,CT 06106
04643	Digitronics.,Albertson,NY 11507
04713	Motorola.,Phoenix,AZ 85008
04919	Component Mfg.,W.Bridgewater,MA 02379
05079	Tansistor Elctrns.,Bennington,VT 05201
05245	Corcom.,Chicago,IL 60639
05276	ITT Elctrns.,Pomona,CA 91766
05402	Controls Co.of Amer.,Melrose Pk,IL 60160
05574	Viking Inds.,Chatsworth,CA 91311
05624	Barber Colman.,Rockford,IL 61101
05748	Barnes Mfg.,Mansfield,OH 44901
05820	Wakefield Eng.,Wakefield,MA 01880
06383	Panduit.,Tinley Pk,IL 60477
06406	Truelove & Maclean.,Waterbury,CT 06708
06665	Precision Monolith.,Santa Clara,CA 95050
06743	Clevite.,Cleveland,OH 44110
06795	WLS Stamp.,Cleveland,OH 44104
06915	Richco Plstc.,Chicago,IL 60646
06928	Teledyne Kntcs.,Soland Bch,CA 92075
06978	Aladdin Elctrns.,Nashville,TN 37210
07047	Ross Milton.,Southampton,PA 18966
07126	Digitran.,Pasadena,CA 91105
07127	Eagle Signal.,Baraboo,WI 53913
07233	Cinch Graphik.,City of Industry,CA 91744
07261	Avnet.,Culver City,CA 90230
07263	Fairchild.,Mountain View,CA 94040
07387	Birtcher.,N.Los Angeles,CA 90032
07595	Amer.Semicond.,Arlington Hts,IL 60004
07699	Magnetic Core.,Newburgh,NY 12550
07707	USM Fastener.,Shelton,CT 06484
07828	Bodine.,Bridgeport,CT 06605
07829	Bodine Elctrc.,Chicago,IL 60618
07910	Cont Device.,Hawthorne,CA 90250
07983	State Labs.,New York,NY 10003
07999	Borg Inst.,Delavan,WI 53115
08524	Deutsch Fastener.,Los Angeles,CA 90045
08556	Bell Elctrc.,Chicago,IL 60632
08730	Vemaline Prod.,Franklin Lakes,NJ 07417
09213	GE.,Buffalo,NY 14220
09353	C&K Components.,Watertown,MA 02172
09408	Star-Tronics.,Georgetown,MA 01830
09823	Burgess Battery.,Freeport,IL 61032
09856	Fenwal Elctrns.,Framingham,MA 01701
09922	Burndy.,Norwalk,CT 06852
10025	Glasseal Prod.,Linden,NJ 07036
10389	Chicago Switch.,Chicago,IL 60647
11236	CTS of Berne.,Berne,IN 46711
11599	Chandler Evans.,W.Hartford,CT 06101
11983	Nortronics.,Minneapolis,MN 55427
12040	National.,Santa Clara,CA 95051
12045	Elctrc Transistors.,Flushing,NY 11354
12498	Teledyne.,Mountain View,CA 94043
12617	Hamlin.,Lake Millis,WI 53551
12672	RCA.,Woodbridge,NJ 07095
12697	Clarostat.,Dover,NH 03820
12856	Micrometals.,City of Industry,CA 91744
12954	Dickson Elctrns.,Scottsdale,AZ 85252
12969	Unitrode.,Watertown,MA 02172
13094	Electrocraft.,Hopkins,MN 55343
13103	Thermalloy.,Dallas,TX 75234
13148	Vogue Inst.,Richmond Hill,NY 11418
13150	Vernitron.,Laconia,NH 03246
13327	Solitron Devices.,Tappan,NY 10983
13715	Fairchild.,San Rafael,CA 94903
13919	Burr Brown.,Tucson,AZ 85706
14010	Anadex Inst.,Van Nuys,CA 91406
14195	Elctrc Controls.,Wilton,CT 06897
14196	American Labs.,Fullerton,CA 92634
14332	Relton.,Arcadia,CA 91006
14433	ITT.,W.Palm Beach,FL 33402
14482	Watkins & Johnson.,Palo Alto,CA 94304
14608	Corbin.,Berlin,CT 06037
14655	Cornell Dubilier.,Newak,NJ 07101
14674	Corning Glass.,Corning,NY 14830
14749	Acopian.,Easton,PA 18042
14752	Electrocube.,San Gabriel,CA 91776
14889	R&G Sloan.,Sun Valley,CA 91352
14908	Elctrc Inst & Spclty.,Stoneham,MA 02180
14936	General Inst.,Hicksville,NY 11802
15238	ITT.,Lawrence,MA 08142
15476	Digital Equip.,Maynard,MA 01754
15605	Cutler Hammer.,Milwaukee,WI 53202
15782	Houston Inst.,Bellaire,TX 77401
15801	Fenwal Elctrns.,Framingham,MA 01701
15819	Sinclair & Rush.,St.Louis,MO 63111
16037	Spruce Pine Mica.,Spruce Pine,NC 28777
16068	Intntl Diode.,Jersey City,NJ 07304
16179	Ommi Spectra.,Farmington,MI 48024
16301	Astrolab.,Linden,NJ 07036
16352	Codi.,Fairlawn,NJ 07410
16485	Sterling Inst.,New Hyde Park,NY 11040
16636	Indiana General.,Oglesby,IL 61348
16758	Delco.,Kokomo,IN 46901
16950	Precision Dynamics.,Burbank,CA 91504
16952	Amer Micro Devices.,Summerville,SC 29483
17117	Elctrc Molding.,Woonsocket,RI 02895
17540	Mohawk Spring.,Schiller Park,IL 60176
17745	Angstrohm Precsn.,Hagerstown,MD 21740
17771	Singer.,Somerville,NJ 08876
17850	Zeltex.,Concord,CA 94520
17856	Siliconix.,Santa Clara,CA 95054
18324	Signetics.,Sunnyvale,CA 94086
18542	New Prod Eng.,Wabash,IN 46992
18677	Scanbe.,El Monte,CA 91731
18736	Computer Diode.,S.Fairlawn,NJ 07936
18795	Cycon.,Sunnyvale,CA 94086
18911	Durant.,Watertown,WI 53094
19178	Zero.,Monson,MA 01057
19209	GE.,Gainesville,FL 32601
19373	Eastron.,Haverhill,MA 01830
19396	Paktron.,Vienna,VA 22180
19617	Cabtron.,Chicago,IL 60622
19644	LRC Elctrns.,Horseheads,NY 14845
19701	Electra.,Independence,KS 67301
20093	Elect Inds.,Murray Hill,NJ 07974
20754	KMC.,Long Valley,NJ 07853
21335	Fafnir Bearing.,New Britian,CT 06050
21688	Raytheon.,Norwood,MA 02062
21759	Lenox Fugle.,Watchung,NJ 07060
22526	Berg Elctrcs.,New Cumberland,PA 17070
22589	Electro Space Fabrctrs.,Topton,PA 19562
22753	UID Elctrcs.,Hollywood,FL 33022
23338	Wavetek.,San Diego,CA 92112
23342	Avnet Elctrcs.,Franklin Park,IL 60131
23936	Pamotor.,Bulingham,CA 94010
24351	Indiana Gnrl Elctrc.,Keasby,NJ 08832
24355	Analog Devices.,Cambridge,MA 02142
24444	General Semicond.,Tempe,AZ 85281
24446	GE.,Schenectady,NY 12305
24454	GE.,Syracuse,NY 13201
24455	GE.,Cleveland,OH 44112
24602	EMC Technlgy.,Cherry Hill,NJ 08034
24655	Gen Rad.,Concord,MA 01742
24759	Lenox Fugle.,S.Plainfield,NJ 07080
25008	Vactite.,Berkeley,CA 94710
25289	EG&G.,Bedford,MA 01730
26601	Tri-County Tube.,Nunda,NY 14517
26805	Omni Spectra.,Waltham,MA 02154
26806	American Zettler.,Costa Mesa,CA 92626
27014	National.,Santa Clara,CA 95051
27545	Hartford Universal Ball.,Rocky Hill,CT 06067
28480	HP.,Palo Alto,CA 94304
28520	Heyman Mfg.,Kenilworth,NJ 07033
28875	IMC Magnetics.,Rochester,NH 03867
28959	Hoffman Elctrcs.,El Monte,CA 91734
30043	Solid State Devices.,LaMirada,CA 90638
30646	Beckman Inst.,Cedar Grove,NJ 07009
30874	IBM.,Armonk,NY 10504
30985	Permag Magnetics.,Toledo,OH 43609
31019	Solid State Scntfc.,Montgomerville,PA 18936
31514	Standford Appld Engs.,Costa Mesa,CA 92626
31814	Analogic.,Wakefield,MA 01880
31951	Triridge.,Pittsburgh,PA 15231
32001	Jensen.,Chicago,IL 60638
33095	Spectrum Control.,Fairview,PA 16415
33173	GE.,Owensboro,KY 42301
34141	Koehler.,Marlboro,MA 01752
34156	Semicoa.,Costa Mesa,CA 92626
34333	Silicon Genrl.,Westminster,CA 92683
34335	Advanced Micro Devices.,Sunnyvale,CA 94086
34649	Intel.,Santa Clara,CA 95051
34677	Solitron Devices.,Jupiter,FL 33458
35929	Constanta.,Montreal,QUE,CAN
36462	National Ltd.,Montreal,QUE,CAN
37942	Mallory.,Indianapolis,IN 46206
38443	Marlin Rockwell.,Jamestown,NY 14701
39317	McGill Mfg.,Valpariso,IN 46383
40931	Honeywell.,Minneapolis,MN 55408
42190	Muter.,Chicago,IL 60638
42498	National.,Melrose,MA 02176
43334	New Departure-Hyatt.,Sandusky,OH 44870
43991	Norma Hoffman.,Stanford,CT 06904
49671	RCA.,New York,NY 10020
49956	Raytheon.,Waltham,MA 02154
50088	Mostek.,Carrollton,TX 75006
50101	GHZ Devices.,S.Chelmsford,MA 01824
50507	Micro Networks.,Worcester,MA 01606
50522	Monsanto.,Palo Alto,CA 94304
50721	Datel Systems.,Canton,MA 02021
51167	Aries Elctrcs.,Frenchtown,NJ 08825
51553	Diablo Systems.,Hayward,CA 94545
51642	Centre Eng.,State College,PA 16801
52648	Plessey.,Santa Ana,CA 92705
52676	SKF Inds.,Philadelphia,PA 19132
52763	Stettner Trush., Cazenovia, NY 13035
53021	Sangamo Elctrc.,Springfield,IL 62705
53184	Xciton.,Latham,NY 12110
53421	Tyton.,Milwaukee,WI 53209
54294	Shallcross.,Selma,NC 27576
54297	Assoc Prec Prod.,Huntsville,AL 35805
54715	Shure Bros.,Evanston,IL 60202
56289	Sprague.,North Adams,MA 01247
57771	Stimpson.,Bayport,NY 11705
58553	Superior Valve.,Washington,PA 15301
59730	Thomas & Betts.,Elizabeth,NJ 07207
59875	TRW.,Cleveland,OH 44117
60399	Torrington.,Torrington,CT 06790
61007	Townsend.,Braintree,MA 02184
61637	Union Carbide.,New York,NY 10017
61864	United Carr Fast.,Boston,MA
63060	Victoreen.,Cleveland,OH 44104
63743	Ward Leonard.,Mt.Vernon,NY 10550
65083	Westinghouse.,Bloomfield,NJ 07003
65092	Weston.,Newark,NJ 07114
70106	Acushnet Cap.,New Bedford,MA 02742
70109	Adams & Westlake.,Elkhart,IN 46514
70417	Chrysler.,Detroit,MI 48231
70485	Atlantic India Rubber.,Chicago,IL 60607
70563	Amperite.,Union City,NJ 07087
70611	Ark-Les Switch.,Watertown,MA 02172
70892	Bead Chain.,Bridgeport,CT 06605
70903	Belden.,Chicago,IL 60644
71126	Bronson.,Beacon Falls,CT 06403
71279	Cambridge Thermionic.,Cambridge,MA 02138
71294	Canfield.,Clifton Forge,VA 24422
71400	Bussmann.,St.Louis,MO 63107
71450	CTS.,Elkhart,IN 46514
71468	Cannon.,Los Angeles,CA 90031
71482	Clare.,Chicago,IL 60645
71590	Centralab.,Milwaukee,WI 53212
71666	Continental Carbon.,New York,NY
71707	Coto Coil.,Providence,RI 02905
71729	Crescent Box.,Philadelphia,PA 19134
71744	Chicago Min Lamp.,Chicago,IL 60640
71785	Cinch.,Chicago,IL 60624
71823	Darnell.,Downey,CA 90241
72136	Electromotive.,Willimantic,CT 06226
72228	Continental Screw.,New Bedford,MA 02742
72259	Nytronics.,Berkeley Hts,NJ 07922
72619	Dialight.,Brooklyn,NY 11237
72699	General Inst.,Newark,NJ 07104
72765	Drake.,Chicago,IL 60631
72794	Dzus Fastener.,W.Islip,NY 11795
72825	Eby.,Philadelphia,PA 19144
72962	Elastic Stop Nut.,Union,NJ 07083
72982	Erie.,Erie,PA 16512
73445	Amperex Elctrcs.,Hicksville,NY 11801
73559	Carling Elctrc.,Hartford,CT 06110
73690	Elco Resistor.,New York,NY
73803	TI.,Attleboro,MA 02703
73899	JFD Elctrcs.,Brooklyn,NY 11219
73957	Groov-Pin.,Ridgefield,NJ 07657
74193	Heinemann.,Trenton,NJ 08602
74199	Quam Nichols.,Chicago,IL 60637
74445	Holo-Krome.,Hartford,CT 06110
74545	Hubbell.,Stratford,CT 06497
74861	Industrial Cndnsr.,Chicago,IL 60618
74868	Amphenol.,Danbury,CT 06810
74970	Johnson.,Waseca,MN 56093
75042	IRC(TRW).,Burlington,IA 52601
75376	Kurz-Kasch.,Dayton,OH 45401
75382	Kuka.,Mt Vernon,NY 10551
75491	Lafayette.,Syosset,NY 11791
75608	Linden.,Providence,RI 02905
75915	Littelfuse.,Des Plains,IL 60016
76005	Lord Mfg.,Erie,PA 16512
76149	Mallory Elctrc.,Detroit,MI 48204
76241	Maurey.,Chicago,IL 60616
76381	3 M Co.,St.Paul,MN 55101
76385	Minor Rubber.,Bloomfield,NJ 07003
76487	Millen.,Malden,MA 02148
76545	Mueller Elctr.,Cleveland,OH 44114
76684	National Tube.,Pittsburg,PA
76854	Oak Inds.,Crystal Lake,IL 60014
77132	Dot Fastener.,Waterbury,CT 06720
77147	Patton MacGuyer.,Providence,RI 02905
77166	Pass Seymour.,Syracuse,NY 13209
77263	Pierce Roberts Rubber.,Trenton,NJ 08638
77315	Platt Bros.,Waterbury,CT 06720
77339	Positive Lockwasher.,Newark,NJ
77342	AMF.,Princeton,IN 47570
77542	Ray-o-Vac.,Madison,WI 53703
77630	TRW.,Camden,NJ 08103
77638	General Inst.,Brooklyn,NY 11211
78189	Shakeproof.,Elgin,IL 60120
78277	Sigma Inst.,Braintree,MA 02184
78429	Airco Speer.,St Marys,PA 15867
78488	Stackpole.,St Marys,PA 15867
78553	Tinnerman.,Cleveland,OH
78711	Telephonics.,Huntington,NY 11743
79089	RCA.,Harrison,NJ 07029
79136	Waldes Kohinoor.,New York,NY 11101
79497	Western Rubber.,Goshen,IN 46526
79725	Wiremold.,Hartford,CT 06110
79727	Continental Wirt.,Philadelphia,PA 19101
79840	Mallory Controls.,Frankfort,IN 46041
79963	Zierick.,Mt Kisco,NY 10549
80009	Tektronix.,Beaverton,OR 97005
80030	Prestole Fastener.,Toledo,OH 43605
80048	Vickers.,St Louis,MO 63166
80103	Lambda.,Melville,NY 11746
80183	Sprague.,N.Adams,MA 01247
80211	Motorola.,Franklin Pk,IL 60131
80251	Formica.,Cincinnati,OH 45232
80258	Standard Oil.,Lafeyette,IN 47902
80294	Bourns Labs.,Riverside,CA 92506
80368	Sylvania.,New York,NY 10017
80431	Air Filter.,Milwaukee,WI 53218
80583	Hammarlund.,New York,NY 10010
80740	Beckman Inst.,Fullerton,CA 92834
80756	TRW Ramsey.,St Louis,MO 63166
80894	Pure Carbon.,St Marys,PA 15857
81030	Int'l Inst.,Orange,CT 06477
81073	Grayhill.,LaGrange,IL 60525
81143	Isolantite.,Stirling,NJ 07980
81312	Winchester.,Oakville,CT 06779
81349	Military Specifications
81350	Joint Army-Navy Specifications
81483	Int'l Rectifier.,El Segundo,CA 90245
81741	Chicago Lock.,Chicago,IL 60641
81831	Filtron.,Flushing,NY 11354
81840	Ledex.,Dayton,OH 45402
81860	Barry Wright.,Watertown,MA 02172
82219	Sylvania.,Emporium,PA 15834
82227	No.Amer.Philips.,Cheshire,CT 06410
82273	IN Pattern & Model.,LaPort,IN 46350
82389	Switchcraft.,Chicago,IL 60630
82567	Reeves Hoffman.,Carlisle,PA 17013
82647	Metals & Controls.,Attleboro,MA 02703
82807	Milwaukee Resistor.,Milwaukee,WI 53204
82877	Rotron.,Woodstock,NY 12498
82901	IN General Magnet.,Valparaiso,IN 46383
83003	Varo.,Garland,TX 75040
83014	Hartwell.,Placentia,CA 92670
83033	Meissner.,Mt Carmel,IL 62863
83058	Carr Fastener.,Cambridge,MA 02142
83186	Victory Eng.,Springfield,NJ 07081
83259	Parker Seal.,Culver City,CA 90231
83330	H.H.Smith.,Brooklyn,NY 11207
83361	Bearing Spclty.,San Francisco,CA
83587	Solar Elctrc.,Warren,PA 16365
83594	Burroughs.,Plainfield,NJ 07061
83740	Union Carbide.,New York,NY 10017
83766	Mass Engrg.,Quincy,MA 02171
83781	National Elctrcs.,Geneva,IL 60134
84411	TRW.,Ogallala,NB 69153
84835	Lehigh Metals.,Cambridge,MA 02140
84970	Sarkes Tarzian.,Bloomington,IN 47401
84971	TA Mfg.,Los Angeles,CA 90039
86604	Kapco.,Flushing,NY 11352
86420	Payson Casters.,Gurnee,IL 60031
86577	Prec Metal Prod.,Stoneham,MA 02180
86684	RCA.,Harrison,NJ 07029
86687	REC.,New Rochelle,NY 10801
86800	Cont Elctrcs.,Brooklyn,NY 11222
88140	Cutler Hammer.,Lincoln,IL 62656
88204	GTE Sylvania.,Ipswitch,MA 01938
88219	Gould Nat Battery.,Trenton,NJ 08697
88419	Cornell Dubilier.,Fuquay Varina,NC 27526
88627	K&G Mfr.,New York,NY
89265	Potter & Brumfield.,Princeton,IN 47671
89482	Holtzer Cabot.,Boston,MA 02119
89665	United Transformer.,Chicago,IL
89870	Berkshire Transformer.,Kent,CT 06757
90201	Mallory Cap.,Indianapolis,IN 46206
90303	Mallory Bat.,Tarrytown,NY 10591
90634	Gulton Inds.,Metuchen,NJ 08840
90750	Westinghouse.,Boston,MA 02118
90952	Hardware Prod.,Reading,PA 19602
91032	Continental Wire.,York,PA 17405
91146	Cannon.,Salem,MA 01970
91210	Gerber.,Mishawaka,IN 46544
91293	Johanson.,Boonton,NJ 07005
91417	Harris.,Melbourne,FL 32901
91506	Augat Bros.,Attleboro,MA 02703
91598	Chandler.,Wethersfield,CT 06109
91637	Dale Elctrcs.,Columbus,NE 68601
91662	Elco.,Willow Grove,PA 19090
91719	General Inst.,Dallas,TX 75220
91836	Kings Elctrcs.,Tuckahoe,NY 11223
91916	Mephisto Tool.,Hudson,NY 12534
91929	Honeywell.,Freeport,IL 61032
92519	Electra Insul.,Woodside,NY 11377
92678	Edgerton Germeshuasen.,Boston,MA 02115
92702	IMC Magnetics.,Westbury,NY 11591
92739	Ampex.,Redwood City,CA 94063
92966	Hudson Lamp.,Kearny,NJ 07032
93332	Sylvania.,Woburn,MA 01801
93346	Amer Elctrcs Labs.,Lansdale,PA 19446
93618	R&C Mfg.,Ramsey,PA 16671
93916	Cramer.,New York,NY 10013
94144	Raytheon.,Quincy,MA 02169
94154	Wagner Elctrc.,Livingston,NJ 07039
94271	Weston.,Archibald,PA 18403
94322	Tel Labs.,Manchester,NH 03102
94589	Dickson.,Chicago,IL 60619
94696	Magnecraft.,Chicago,IL 60630
94800	Atlas Ind.,Brookline,NH 03033
95076	Garde.,Cumberland,RI 02864
95121	Quality Comp.,St Marys,PA 15857
95146	Alco Elctrcs.,Lawrence,MA 01843
95238	Continental Conn.,Woodside,NY 11377
95275	Vitramon.,Bridgeport,CT 06601
95348	Gordos.,Bloomfield,NJ 07003
95354	Methode.,Rolling Meadow,IL 60008
95794	Amer Brass.,Torrington,CT 06790
95987	Weckesser.,Chicago,IL 60646
96095	Aerovox Hi Q.,Olean,NY 14760
96341	Microwave Assoc.,Burlington,MA 01801
96906	Military Standards
97918	Linemaster Switch.,Woodstock,CT 06281
98291	Sealectro.,Mamaroneck,NY 10544
98474	Compar.,Burlingame,CA 94010
98821	North Hills.,Glen Cove,NY 11542
99017	Protective Closures.,Buffalo,NY 14207
99117	Metavac.,Flushing,NY 11358
99313	Varian.,Palo Alto,CA 94303
99378	Atlee.,Winchester,MA 01890
99800	Delevan;E.Aurora,NY 14052
99934	Renbrandt.,Boston,MA 02118
99942	Centralab.,Milwaukee,WI 53201

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