150C
1 to 60 MHz
QUARTZ CRYSTAL
TEST OSCILLATOR

SPECIFICATION,
CIRCUIT DESCRIPTION
AND
MAINTENANCE MANUAL

SAUNDERS & ASSOC. INC.

7440 E. KAREN DR., SCOTTSDALE, ARIZONA 85260

6100016-01

150C
1 to 60 MHz
QUARTZ CRYSTAL
TEST OSCILLATOR

CERTIFICATION

Saunders and Associates, Inc. certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory.

WARRANTY AND ASSISTANCE

This Saunders and Associates, Inc. product is warranted against defects in workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Saunders and Associates, Inc. No other warranty is expressed or implied. We are not liable for consequential damages.

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SECTION 1

GENERAL DESCRIPTION

The 150C (Figure 1-1) is a measurement instrument for fully characterizing a quartz crystal resonator. The 150C allows for easy setup and measurement of quartz crystals as well as conforming to most quartz crystal test specifications.

MEASUREMENTS TAKEN BY 150C

- Crystal Resonant Frequency
- Crystal Capacitances
- Crystal Resistance
- Power dissipated in crystal

All measurements are converted to digital values and displayed on the 8-digit display.

The 150C allows all characterization of the quartz crystal resonator to be done while inserted in a single test socket. Therefore, all stray capacitances or inductances are the same for all of the tests, minimizing errors.

MEASUREMENT CIRCUIT

The operating details of the circuits of the 150C are covered in Section 5; while Section 6 covers the calibration of the circuits. The 150C Block Diagram (Figure 1-2) shows the basic functional blocks.

The crystal is operated in a tuned amplifier loop. The loop is designed such that the crystal under test can be easily set up to repeatedly read the crystal series resonant frequency. The 150C setup for testing a crystal is covered in Section 4 of this manual. The tuned amplifier gain is varied to set the power dissipation level in the crystal under test. The frequency of the tuned amplifier loop is buffered and counted by a microprocessor controlled counter.

The signal amplitude at each side of the crystal is detected and is input to the analog computation circuit. The analog computation circuit computes power dissipated and the series resistance of the crystal under test. The power actually being dissipated in the crystal under test and the user setpoint are compared, and the AGC voltage is varied automatically to keep the crystal under test power equal to the user setpoint. The analog computation results drive a precision voltage to frequency converter so the results can be displayed by the frequency counter in a digital format.

The capacitance meter output is a frequency which can be counted by the frequency counter. The capacitance meter measures the load capacitance of the crystal under test by properly switching the two relays.

The frequency/control microprocessor provides the necessary control signals, remote control options and the display of the measurements results.

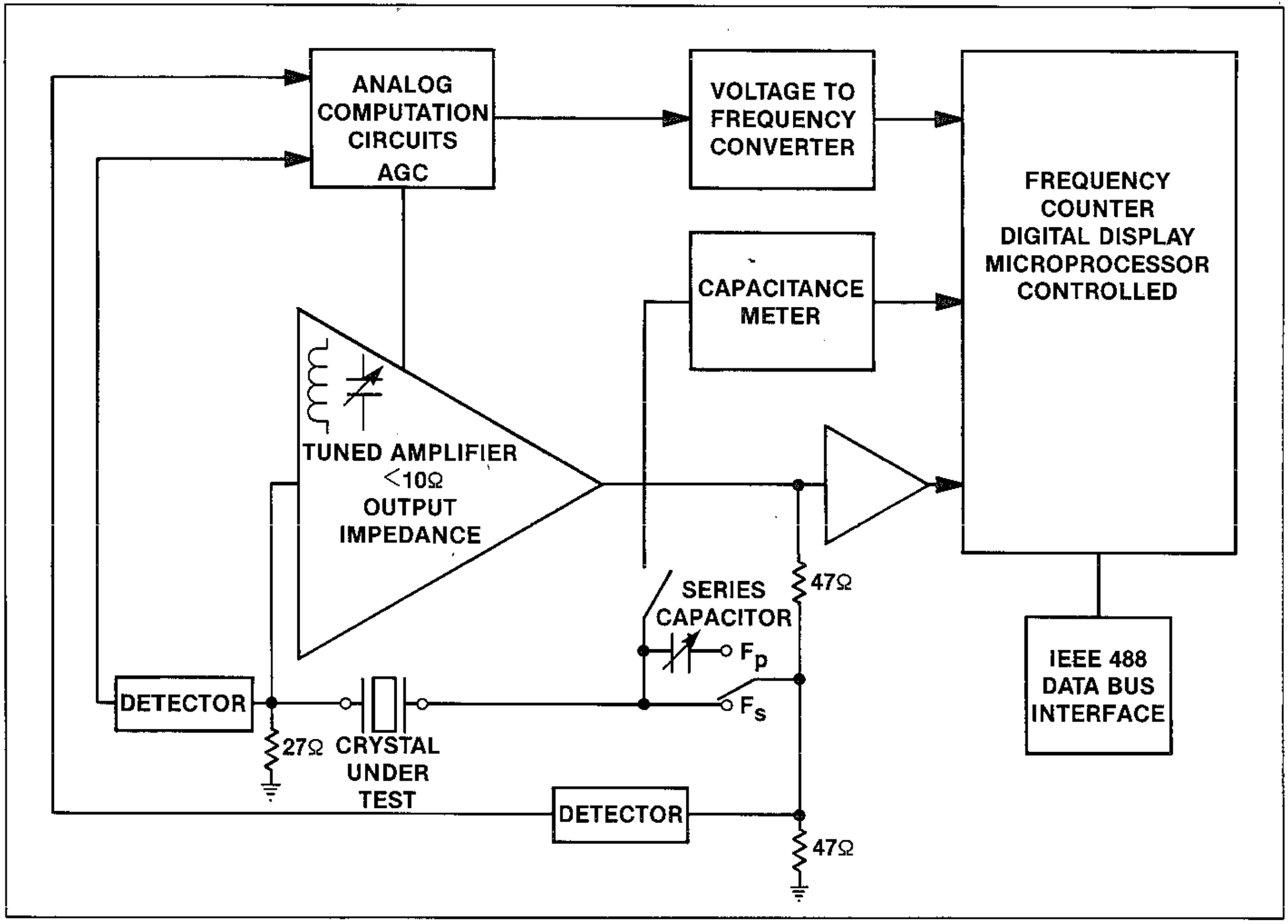


FIGURE 1-2. 150C FUNCTIONAL BLOCK DIAGRAM

TYPES OF MEASUREMENTS

The 150C can make six basic measurements on the crystal under test. The crystal under test can be fully characterized by further simple calculations using the six basic measurements.

1. C_S—Measure the capacitance of front panel setable Series Capacitor (front panel test socket empty).
2. C_t—Measure the Series Capacitor (C_S) plus the capacitance of the crystal in the test socket.
3. F_S—Measure Series Resonant Frequency of the crystal under test.
4. F_p—Measure the Resonant Frequency of the crystal under test with the Load Capacitor.
5. Power being dissipated in crystal under test.
6. R —Measure resistance of the crystal under test at Series Resonant Frequency.

CRYSTAL CHARACTERIZATION

The crystal under test can be modeled as a RLC network (Figure 1-3). The elements of the network can be computed from the 150C measurements.

$$C_o = C_t - C_s$$

$$C_1 = 2\,C_t \frac{F_p - F_s}{F_s}$$

$$L = \frac{1}{4\pi^2 F_s{}^2 C_1}$$

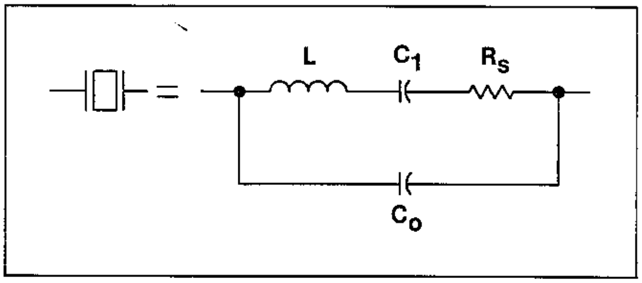


FIGURE 1-3. EQUIVALENT MODEL OF A QUARTZ CRYSTAL RESONATOR

The quality factor (Q) of the crystal under test can be calculated:

$$Q = \frac{1}{2\pi\, F_s\, C_1\, R_s} = \frac{2\pi\, F_s\, L}{R_s}.$$

The resistance (no stray capacitance) of the load resonant circuit can be calculated (R_p calc).

$$R_p \text{ Calculated } = \left(\frac{C_o + C_s}{C_s}\right)^2 R_s$$

The 150C measurements also allow for simple calculations of other useful crystal application parameters.

Assume: F_L = specified frequency at which the crystal is to operate with an unknown capacitor (C_L) in series.

$$C_L = \frac{F_p - F_s}{F_L - F_s}(C_s + C_o) - C_o.$$

In this case the crystal can be measured at any convenient F_p and C_s condition.

NOTE: The value of C_L could also be found by adjusting the Series Capacitor in the F_p mode and then using the internal capacitance meter to measure C_s which would be the desired C_L.

The sensitivity of the crystal to variations of C_L can be calculated:

$$\frac{\Delta F_L}{\Delta C_L} = \frac{1}{C_o + C_L}\left(\frac{F_L - F_s}{F_s}\right) = \frac{1}{C_t}\left(\frac{F_L - F_s}{F_s}\right)$$

The load capacitance of an unknown oscillator could also be computed using a crystal measured on the 150C. Using the calculation for C_L, substitute for F_L the frequency of oscillation of the unknown oscillator. The resulting C_L is the unknown oscillator's load capacitance.

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Saunders and Associates, Inc. assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to Saunders and Associates, Inc. for service and repair to ensure that safety features are maintained.

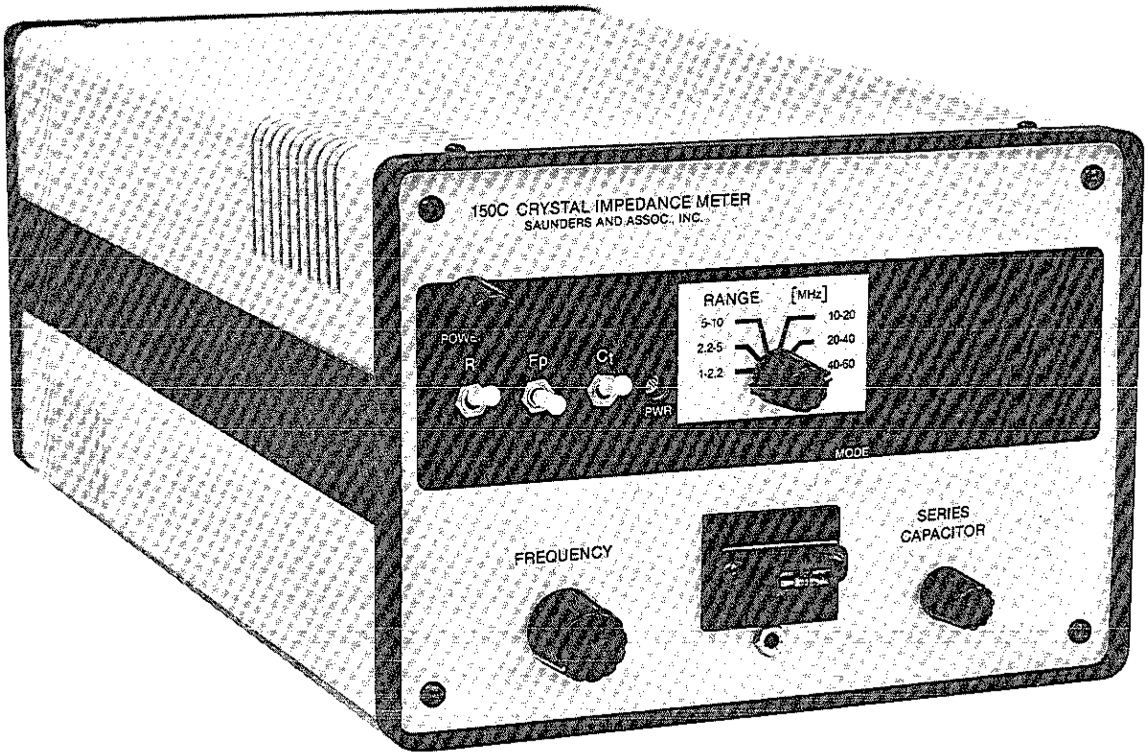


FIGURE 1-1. 150C CRYSTAL IMPEDANCE METER

SECTION 2

INSTALLATION

The information necessary for installing the 150C is contained in this section. Included are initial inspection procedures, power and grounding requirements, installation instructions, and procedures and repacking the instrument for shipment.

INITIAL INSPECTION

This instrument was carefully inspected both mechanically and electrically before shipment. It should be free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage incurred in transit. If the instrument was damaged in transit, file a claim with the carrier. Test the electrical performance of the instrument using the performance test procedures outlined in Section 6. If there is damage or deficiency, see the warranty in the front of this manual.

> ***IMPORTANT***
>
> Read the Safety Summary at the front of the manual before installing or operating the instrument.

POWER REQUIREMENT

The Model 150C can operate any power source supplying 95 to 255 volts, single phase 48 to 62 Hz. Power dissipation is 70 VA maximum.

The 150C internal supply is designed to operate continually over the entire range of 95 to 255V. The user need only plug the 150C into the power main.

If the 150C is to be connected to a different plug type, the following wire color code should be followed:

Green	Ground
White	Line Common
Black	Line

REMOTE CONNECTOR

The rear panel Remote Interface connector must be properly connected for the 150C to perform correctly.

- Local Operation—Internal Standard no connectors or external connections needed.
- Local Operation—External Standard Remote Plug (Amphenol 57-30140) must be installed with the 1-MHz standard placed on Pin 12 (Common) and Pin 8 or connect external standard to rear panel BNC connector.

See the operation section to set up for other external frequency standards.

REPACKING FOR SHIPMENT

If the instrument is to be shipped to Saunders

& Associates, Inc. for service or repair, attach a tag showing owner (with address), complete instrument serial number, and a description of the service required.

Use the original shipping carton and packing material. If the original packing material is not available, Saunders & Associates, Inc. will provide information and recommendations on materials to be used.

SECTION 3

SPECIFICATIONS

Frequency Range: 1—60 MHz in six (6) bands

Band	Frequency (MHz)
1	1-2.2
2	2.2-5
3	5-10
4	10-20
5	20-40
6	40-60

Crystal Termination: 24-ohm source
27-ohm load

Crystal Power: Adjustable 50-5000 Microwatts (Typically 1-40 MHz)
500-1000 Microwatts (Typically 40-60 MHz)
(Extremes dependent on crystal resistance)
Crystal operated at constant power (independent of resistance or frequency variation)
Accuracy ±100 Microwatts

Crystal Resistance: Maximum resistance—500 ohms at 1MHz decreasing to 100 ohms at 60 MHz

$$\text{Accuracy} = \pm\left(5 + \frac{\text{Frequency in MHz}}{10}\right)\%$$

Crystal Socket: Universal socket for .38cm to 1.24cm (.15″ to .49″) lead spacing and .04cm to .13cm (.015″ to .050″) lead diameter. The center contact is ground. The socket assembly can easily be replaced or modified. The entire socket assembly is plugged into the 150C and held in place by a single screw.

Capacitance Meter: Measures value of Series Capacitor plus value of capacitor in front panel socket.
Measurement capacity range—0 to 250 pF
Accuracy ±2% of reading

Series Capacitor: Setable with internal capacitance meter. Variable with range of 16 to 110 pF (Typical).

Displays:

- Digital Display—8 digits LED's .51cm (0.21″) high non-magnified
- When reading resistance, the display is 'EAGC' if the 150C is out of range.
- Analog Indication

  The LED below the digital display intensity varies proportionally to the value of crystal resistance. (The display is valid only when the crystal is oscillating.)
- Function Indicator

  The LED display below the F_p, R, and C_t switch indicates when these functions are activated (local or remote). All LED's on indicate power being displayed.
- Display Results

SWITCHES	FUNCTION	DISPLAY	UNITS
None	Series Resonance	XXXX.XXXX or XXXXX.XXX or XXXXXX.XX	Hz
F_p	Load Resonance F_L		
R	Crystal Resistance	XXXXXXX.X	ohms
C_t	Total Socket Capacitance	XXXXXX.XX	pF
Power	Crystal Dissipate	XXXXXX.XX	8Watts
F_p & C_t	Crystal Motional Capacitance C_1	XX.XXXXXX	pF

Most significant (left hand digit) decimal point will be on if a valid external standard is being used.

Next to the most significant (2nd from left digit) decimal point will be on to indicate Remote control.

Measurement Time: All measurements performed and displayed in less than 0.5 sec. except C_1 typical 2 sec. (depends on mode last used)

Time Base:

Internal Frequency Standard—10MHz temperature controlled crystal
Variation less than ±0.5 PPM including:
Power supply
Temperature
Aging for 6 months
External Input—Internally setable to accept any of the following frequencies: 100KHz, 500KHz, 1MHz, 5MHz or 10MHz.
Requires 1V PP sine or square wave—terminated into 1KΩ load.
Signal input through BNC connector or Remote TTL Interface connector.

Controls:

- RANGE Switch—Sets operating frequency range
- Tuning*—Sets specific operating frequency
- SERIES CAPACITOR*—Adjusts load capacitor value
- R (Momentary switch)—Activates display to measure crystal resistance
- F_p (Momentary or hold switch)—Places series capacitor in series with crystal
- C_t—(Momentary switch)—Activates display to read value of series capacitor plus capacitance across crystal sockets.
- Power Set (Screwdriver adjust potentiometer—push to read)—Activates display to read power and adjusts power being dissipated in crystal.
- Frequency Standard Set (Screwdriver adjust)—On back panel sets Internal frequency standard.

**4:1 turns ratio drive to enhance ease of setting*

- Function Set (Screwdriver adjust 16 position switch on front panel)
  Sets 150C operation and display. Permits a troubleshooting mode and normal measurement. User can specify special measurement modes which would be quoted by the factory and supplied to the user as field upgrades (ROM changes).
  (See Operation Manual for particular unit details)

Remote TTL Interface: (Amphenol Micro Ribbon Connector 57-30140)
Provides remote reading of display in a TTL level compatible digit serial—bit parallel format. The measurement mode is remote controlled—interfaces Saunders & Associates 2000A/B Printer-Processor.

488 Data Bus Interface—Option 001: (Factory Upgrade only)
Standard 488 bus connector interface with metric threads
User can specify measurements of C_t, F_r, F_p, R_r and Power
The 150C sets SRQ when conversions are complete.

Crystal Resistance Output: Output continuously available except in C_t and F_p modes.
Output is 2 volts per 100Ω of crystal resistance.

Analog Frequency Output—Option 002: (Field Upgradable)
The output is enabled by setting the function select.
Each measurement of F_r or F_p will be compared to the reference frequency entered and the output and display will be in parts per million deviation from the reference frequency. The reference frequency is entered by a sequence which measures a known crystal and stores that frequency value. The output changes 1 volt per 100 parts per million difference. The total range is 10 volts or 1000PPM.

Power: 95 through 255 volts AC, 50/60 Hz, less than 70 VA

Weight: Net: 5.67 kg (12.5 lbs); Shipping: 7.94 kg (17.5 lbs)

Dimensions: 21.07 cm Wide by 15.48 cm High by 38.07 cm Deep (8.3″ W x 6.1″ H x 15″ D)

SECTION 4

OPERATION

The general setup procedure of the 150C is described in this section. The specific 150C operation can be varied by changing the microprocessor ROMs. Refer to the 150C Operation Manual for the specific capabilities of the 150C being used. The necessary controls are located on front panel (Figure 4-1).

A. Calibration Resistor

As with all current crystal test instruments (oscillator as well as transmission), initial frequency or phase is calibrated by a substitution resistor. This resistor should have a minimum inductive component and the shortest lead length possible. One percent monolithic resistors have proved the most satisfactory for this purpose. The critical nature of the calibration resistor is a direct function of frequency becoming most significant for the 40–60 MHz band. The value of the setup resistor should be within 30% of the nominal crystal resistance for optimum accuracy.

B. Frequency and Power Set

With oscillator in F_S mode (F_p "LED" out), set range switch to appropriate band for crystal to be tested and insert calibration resistor. Display will indicate the operating frequency of the oscillator and the oscillator indication light will glow. If the right most four characters indicate "EEAGC" an AGC or an out of range condition has been encountered. (Refer to Section 3 for codes.) This typically occurs when the power set is too high or too low for the frequency range or resistance value. Increase or decrease the power setting until an in range indication is encountered.

Push in on power set potentiometer to display power. This is displayed in microwatts; set to required power while depressed, and the display will return to frequency when released. Depress R toggle and check resistance value indicated versus value of calibration resistor. (The display will read "EEAGC" if an AGC error is encountered.)

With power set to proper value, readjust the frequency of the oscillator to the frequency of the crystal to within the 3-4 most significant digits for suitable accuracy. The unit is now set for proper measurement of the crystal series resonant frequency and resistance.

C. Load Capacitance Adjustment

To set the proper load capacitance, the crystal sockets of the 150C must be empty. Depress the C_t toggle switch and the current value of load capacitance will be displayed with resolution of 0.01 pF. With C_t still depressed; adjust value with the series capacitance knob to that required. (Approximately 15–110 pF.)

D. Measurements

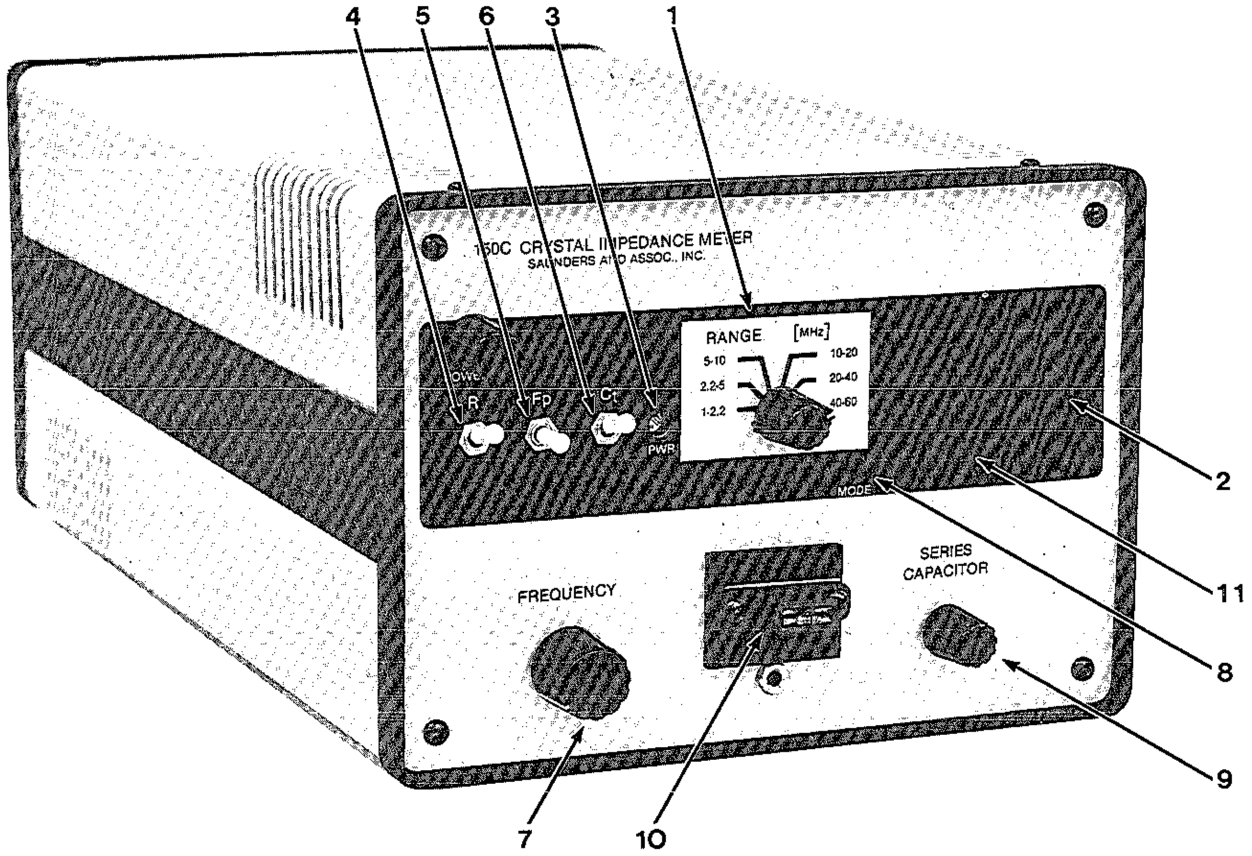
The setting of frequency, power and load capacity are all that is required for complete crystal test. With a crystal inserted in the appropriate socket, characterization can be accomplished in the following manner.

1. Insert crystal—Record F_s (series resonance)
2. Depress R—Record R_s (series resonant resistance)
3. Depress F_p—Record load frequency
4. Depress C_t—Record total capacitance

~~5.~~ Depress F_p & C_t—Record crystal C1 motional capacitance

E. Special Tests

The internal capacitance meter of the 150C results in a convenient method of determining the load capacitance requirements of Pierce or Modified Collipitts oscillators. Set up the 150C for proper operation at series resonance. Obtain the operating frequency of the crystal in the unknown oscillator and then insert the crystal into the 150C. Depress the F_p toggle and vary the series capacitor until F_p is equal to the frequency in the unknown oscillator. Remove the crystal from the 150C; depress C_t and read the required load capacitance. This method can also be utilized to determine the load capacitance variation of units at incoming inspection or determine the sensitivity in ppm/pF of the load capacity per equations in Section 1.



1. Frequency Range Bandswitch
2. Display 8 digits
3. Power set (Push in to display power in microwatts)
4. Resistance display
5. F_p inserts load capacitor (momentary-down, F_s-horizontal "LED" off, fixed-up)
6. C_t socket capacitance display
7. Frequency tune
8. Operation Mode set
9. Load capacitor set
10. Crystal sockets (replaceable panel)
11. Oscillator indicator

FIGURE 4-1. 150C FRONT PANEL

SECTION 5

CIRCUIT DESCRIPTION

The operation of the 150C Crystal Test Oscillator circuits is reviewed in this section.

The 150C Crystal Test Oscillator can be divided into ten major sections:

1. Oscillator Circuit
2. Analog Measurement Circuits
3. Capacitance Meter
4. Microcomputer
5. Time base generation
6. Period Counter
7. Display
8. Power Supply
9. Analog Frequency output
10. Remote Interface

OSCILLATOR

The oscillator is a variable gain amplifier which operates at zero phase shift across the test terminals (Figure 5-1). The input to the amplifier is terminated in a low impedance (OR118). The low impedance minimizes variations caused by the input amplifier (OQ2) and maximizes oscillator stability related to the crystal under test.

The differential amplifier (OQ2-OQ3) is capacitor-coupled to avoid imbalance in bias current which would be caused by transistor V_{BE} mismatch. The AGC voltage input to the emitter current setting resistors (OR69, OR70) sets the amplifier loop gain.

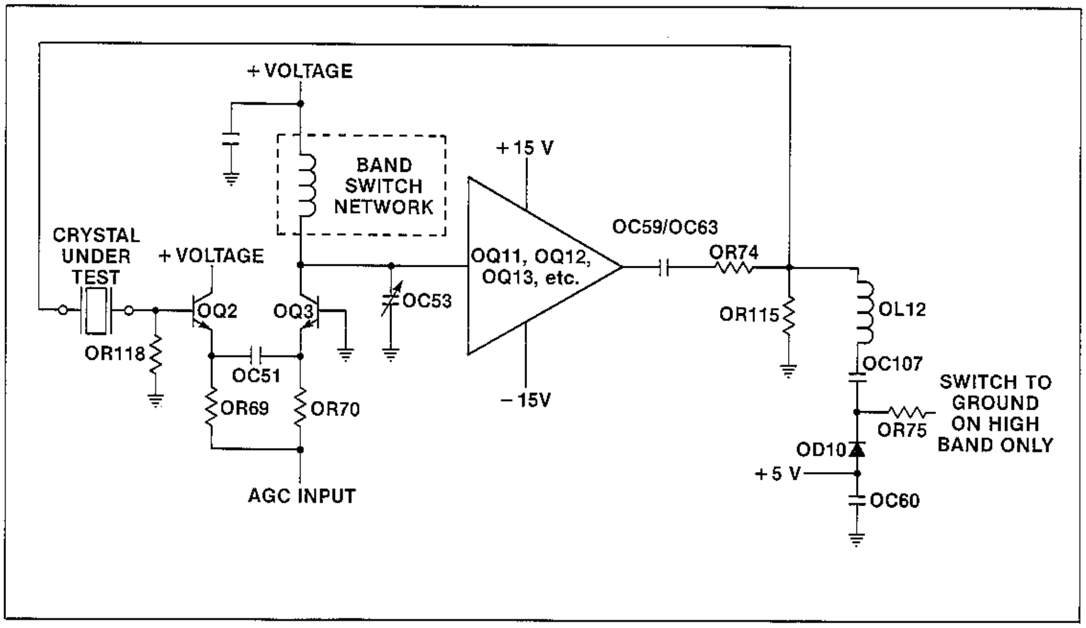


FIGURE 5-1. OSCILLATOR CIRCUIT

The gain stage output has a parallel tuned tank for a load (Band Switch Network [Figure 5-2] and OC53). The variable capacitor performs the in band tuning function.

The high impedance of the tuned tank is converted to a low impedance by a unity voltage gain buffer amplifier (OQ11, OQ12, and OQ13). The buffer amplifier drives the load through a resistive attenuator. The resistor pad isolates the buffer amplifier's output from variations in reactance of the crystal under test.

The oscillator's tuned tank is set by operating the oscillator with a resistive load in the test socket. The tuned tank is adjusted until the oscillator's frequency is equal to the crystal to be measured. This setup adjusts the oscillator such that the crystal will operate at the phase shift across the resistor (ideally zero). Even though the resistor is not ideal it does allow for a repeatable standardized setup.

In the 40-60 MHz range, the oscillator loop has excessive phase shift. The phase shift is compensated in setup by adjusting the LC tuned tank off of resonance but this results in loss of loop gain. To minimize the phase correction needed in the LC tuned tank a phase correcting inductor (OL12) is switched in on the 40-60 MHz band. The phase correcting inductor is capacitor-coupled to ground through a switching PIN diode (OD 10).

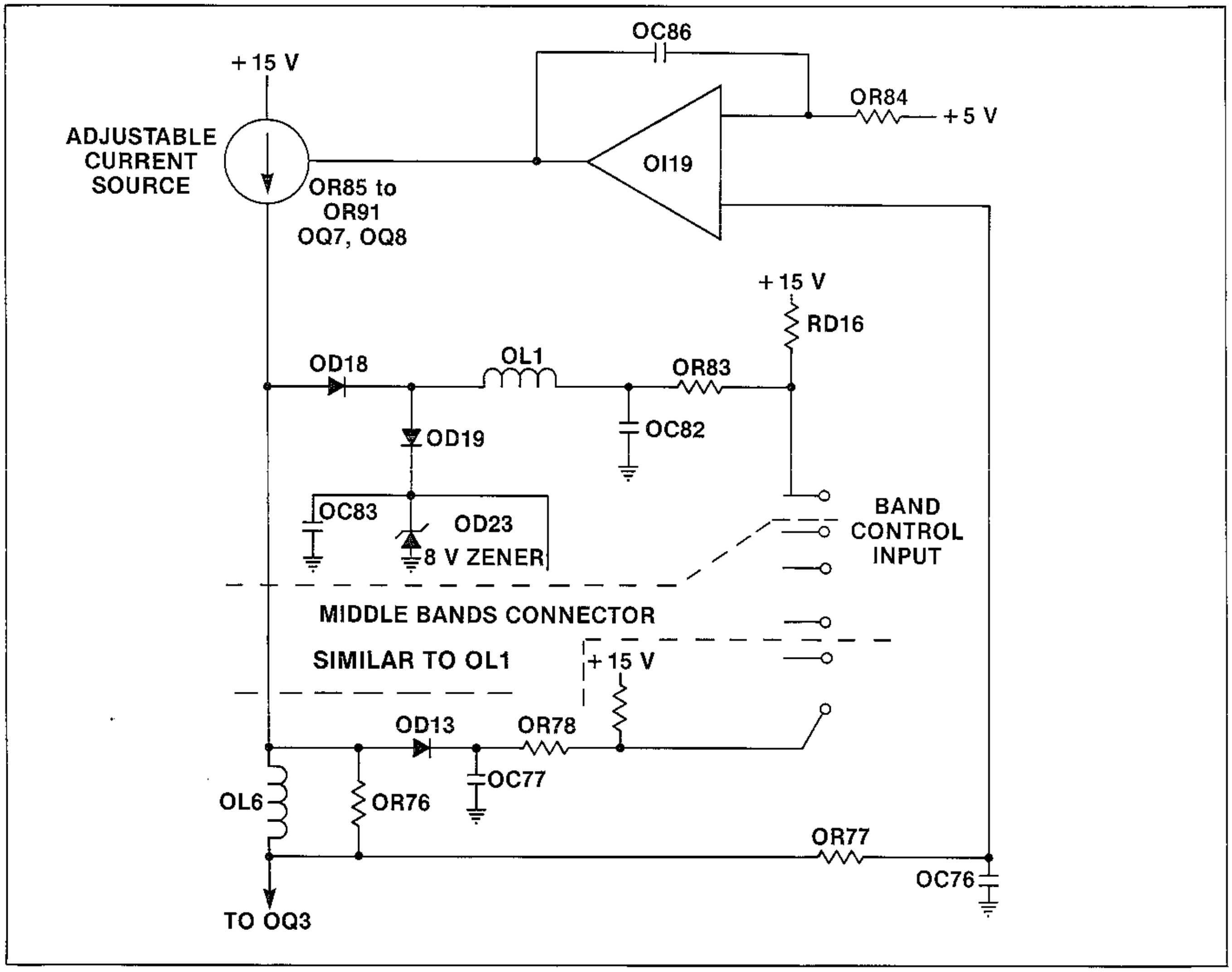


FIGURE 5-2. BAND SWITCH NETWORK

The AGC amplifier (Figure 5-3) compares the user Power Set Potentiometer (RG1) with the computed power being dissipated in the crystal test socket and adjusts the AGC input voltage to hold the oscillator circuit gain at a constant power.

The power set limits are set by resistive dividers in series with the Power Set Potentiometer (OR1, OR120).

The AGC amplifier stability is maintained by a complex RC network (OR25, OR26, OR27, CO105, OC33, OC34, OC50). The AGC amplifier output is buffered by an emitter-follower (OQ15).

The oscillator tuned tank uses 6 inductors, one for each band. The 40-60 MHz band inductor (OL6) is always in series with all other inductors. To operate on the 40-60 MHz band the Band Control input to the 40-60 MHz band is active low which connects one end of a current limiting resistor (OR78) to ground with the other end going to a PIN switching diode (OD13) and a bypass capacitor (OC77). This condition turns the switching diode to a low resistance which essentially RF grounds one end of the 40-60 MHz inductor, with the remaining inductor network non-operative. The Q of the high band inductor is set by a resistor (OR76).

The entire inductor network is biased to +5 volts by an active feedback circuit which compares the voltage at the differential transistor (OQ3) to the +5 volt supply. The comparator (OI19) adjusts the bias condition of high impedance current source network (OR85-OR90 and OQ7-OQ8) to maintain the operating voltage on the inductors at 5 volts.

The 1-40 MHz bands have individually switched in inductors. The lowest band's inductor (OL1) is switched into the current by a PIN switching diode (OD18). When the inductor is switched in, the Q swamping diode (OD19) is reverse-biased and doesn't affect band operation.

To switch to another band the PIN switching diode (OD18) is reverse-biased by pull up resistor to +15 volt supply. The Q swamping diode (OD19) conducts into the zener clamp diode (OD23) which shorts out the coil and minimizes any stray effects of the inductor in the vicinity of other driven inductors.

ANALOG MEASUREMENT CIRCUIT

The power dissipation by the crystal under test and the resistance of the crystal under test is computed with analog circuits. The voltage across the crystal under test and current through the crystal under test must be measured. The product of the voltage and current give the crystal power and the ratio of the voltage and current give the resistance.

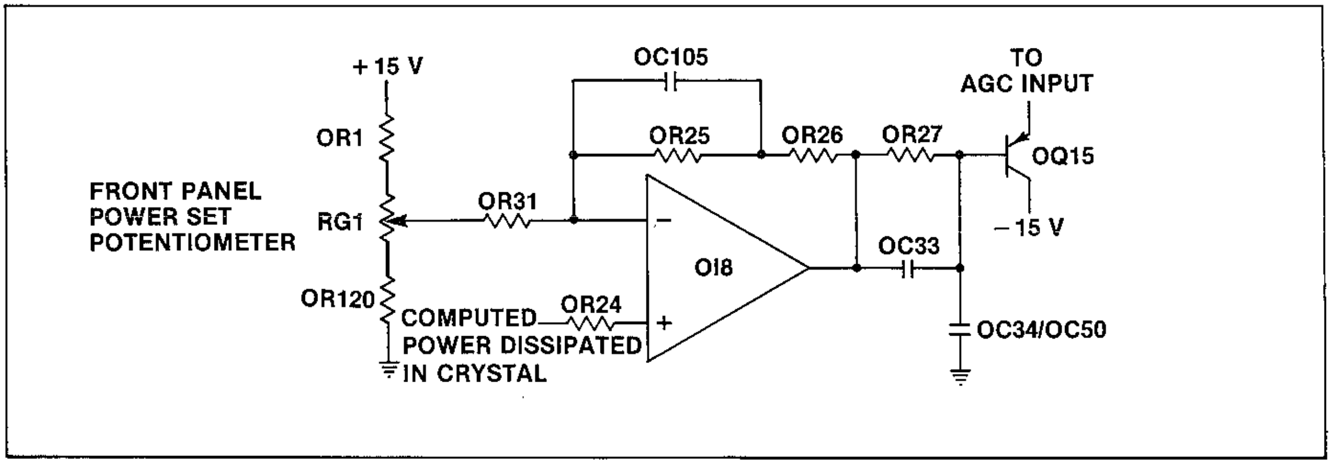


FIGURE 5-3. AGC AMPLIFIER

The computation of the ratio and product is done by detecting the AC voltage and current and utilizing analog circuits.

The final computed DC voltages needed to be displayed to the user. The already existing requirement for a frequency counter and display made the use of a voltage-to-frequency converter a simple method of performing analog-to-digital conversion.

SIGNAL DETECTORS

To achieve long-term stability and the necessary wide bandwidths, peak detectors (Figures 5-4, 5-5 and 5-6) were used. The peak detector was formed from an ultrafast emitter-coupled logic comparator (Figure 5-4). For the majority of the time the non-inverting input will be greater than the inverting input. Therefore, the Q output is more positive than the $\overline{Q}$ output.

The comparator's outputs are unterminated transistor emitters. The emitters charge the holding capacitors (C_A, C_B) which store the peak amplitude of each emitter output. The capacitor charging current is limited by resistors (R_A, R_D). The hold period is set by discharge resistor (R_B, R_C, R_E).

As the unknown input exceeds the feedback signals the $\overline{Q}$ output switches more positive on the waveform peaks, charging up the unknown output. If a DC comparator is placed between Reference Output and the Unknown Output which holds these equal and the output becomes the feedback signal, the circuit becomes a wide band peak detector (Figure 5-5).

The comparator has excellent temperature tracking due to the inherent input matching of the comparator's monolithic integrated circuit construction. The small offset match of these transistors can be compensated by injecting a small input voltage into the circuit input.

The peak detector can also have a DC output which is many times larger but proportional to the peak input voltage. The gain is obtained by dividing the output voltage (Figure 5-5) with resistive divider (OR47 in series with OR48) and using the reduced voltage as the feedback.

Offset and gain variations in the output comparator do not affect the output appreciably since these variations are reduced by the gain of the high-speed input comparator.

The peak detector can be positive peak detecting but produce a negative output voltage (Figure 5-6). An extra times one inverting amplifier is required to create the feedback voltage.

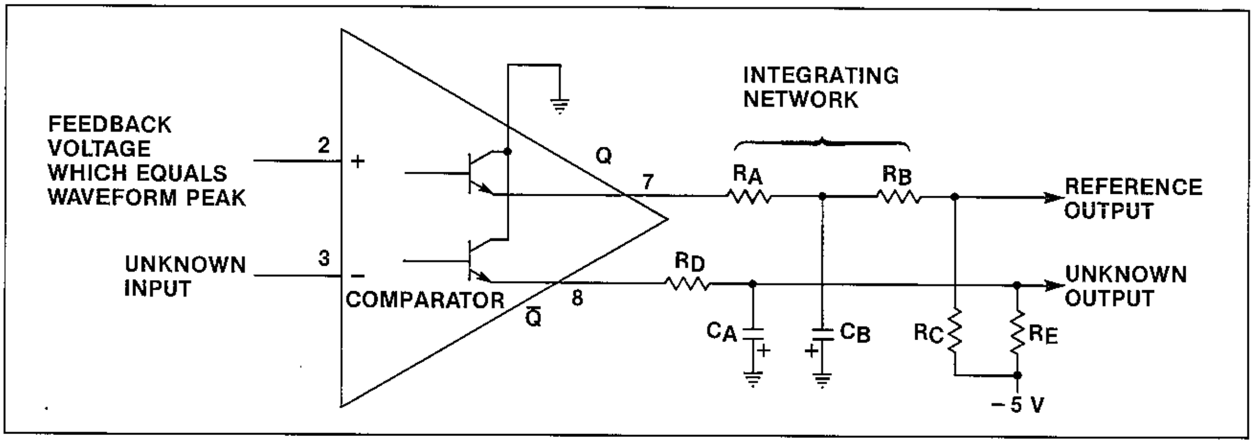


FIGURE 5-4. PEAK AMPLITUDE COMPARATOR

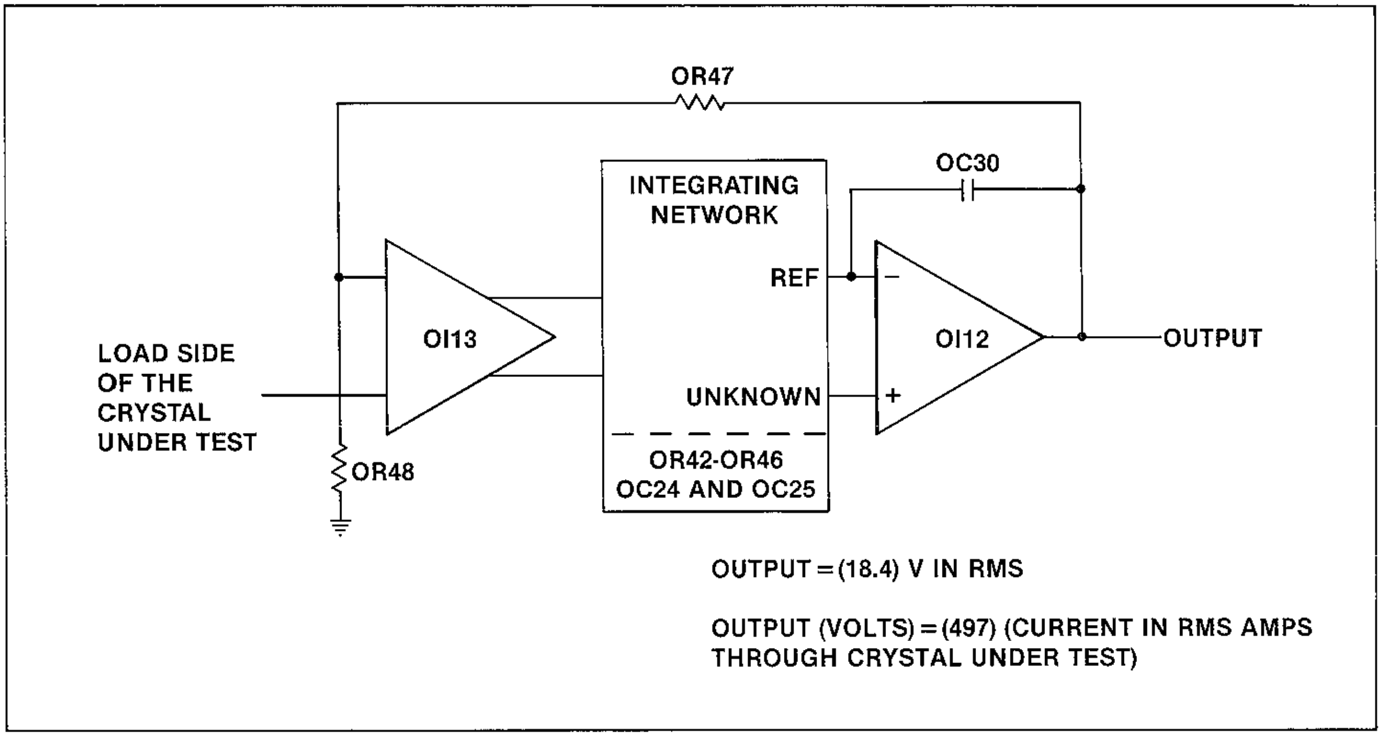


FIGURE 5-5. POSITIVE PEAK DETECTOR WITH POSITIVE OUTPUT VOLTAGE

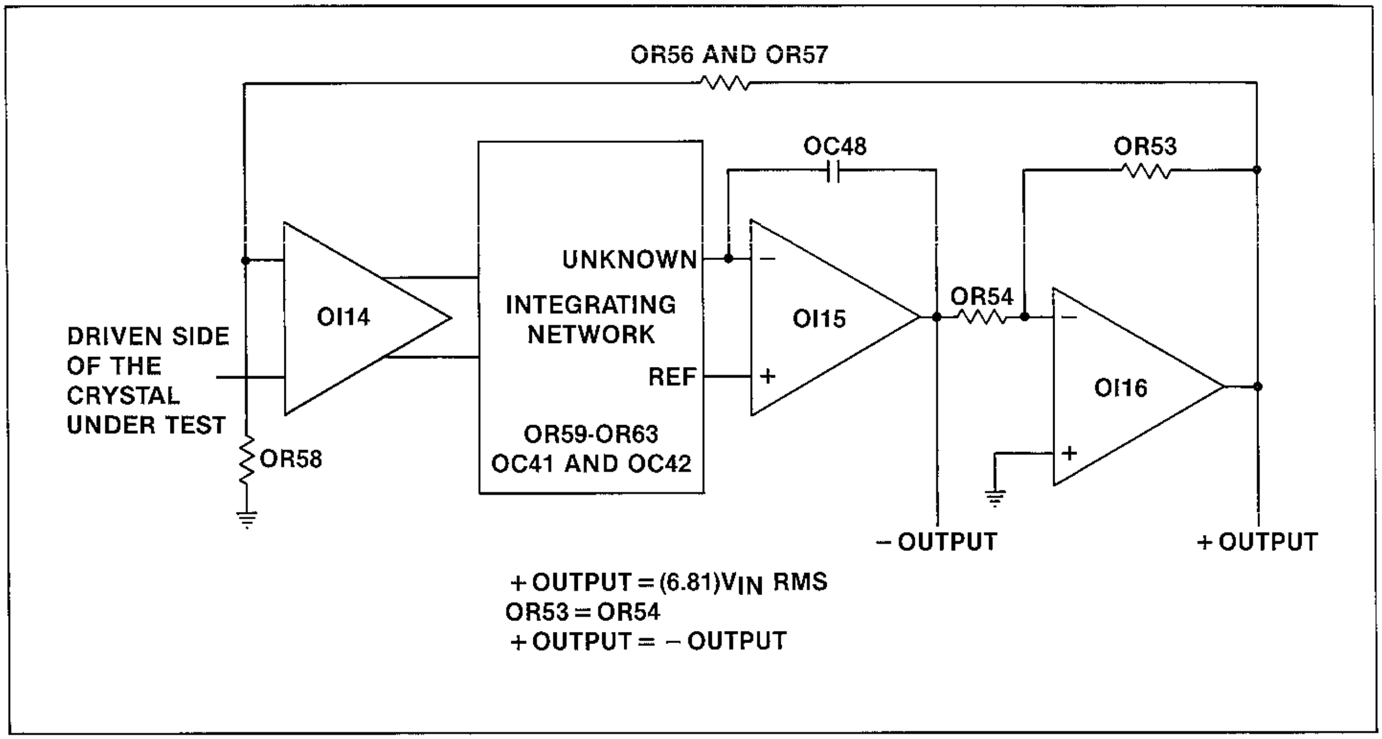


FIGURE 5-6. POSITIVE PEAK DETECTOR WITH POSITIVE AND NEGATIVE OUTPUT VOLTAGE

CRYSTAL UNDER TEST MEASUREMENT VOLTAGES

Two peak detectors are used to measure the operation of the crystal under test (Figure 5-7). One peak detector senses the current in the crystal under test by detecting the voltage across the current sensing resistor (OR118).

I_{Sense} Output = (I_{RMS} crystal under test) (27) (18.4)

= 497 (I_{RMS} crystal under test)

The voltage across the crystal under test and the current sensing resistor are detected with the second peak detector. The output is a negative voltage.

V_{Detect} (crystal and sense resistor) = (− 6.81) [(I_{RMS} crystal under test) (27) + V_{RMS} across crystal]

The voltage detector output must be reduced by the voltage across the current sensing resistor. The subtraction is done by an analog inverting adder circuit (Figure 5-7).

V_{Sense} Output = − 6.81 V_{RMS} across crystal

POWER COMPUTATION

The power in the crystal is the product of V_{Sense} Output and I_{Sense} Output. The product is taken with an analog multiplier (OI7) which has a transfer function to yield 1 volt output per 1 milliwatt of crystal dissipation (Figure 5-8). The transfer function is set by a potentiometer (OR23) with any low voltage offset errors set by an offset voltage adjustment (OR22).

Power Out Calculated = (V_{Sense}) (I_{Sense}) (.295)

= (6.81) (V_{RMS} across crystal) (497) (I_{RMS} crystal under test) (.295)

= (1000) (V_{RMS} across crystal) (I_{RMS} crystal under test)

Power Out Calculate therefore equals 1 volt per milliwatt.

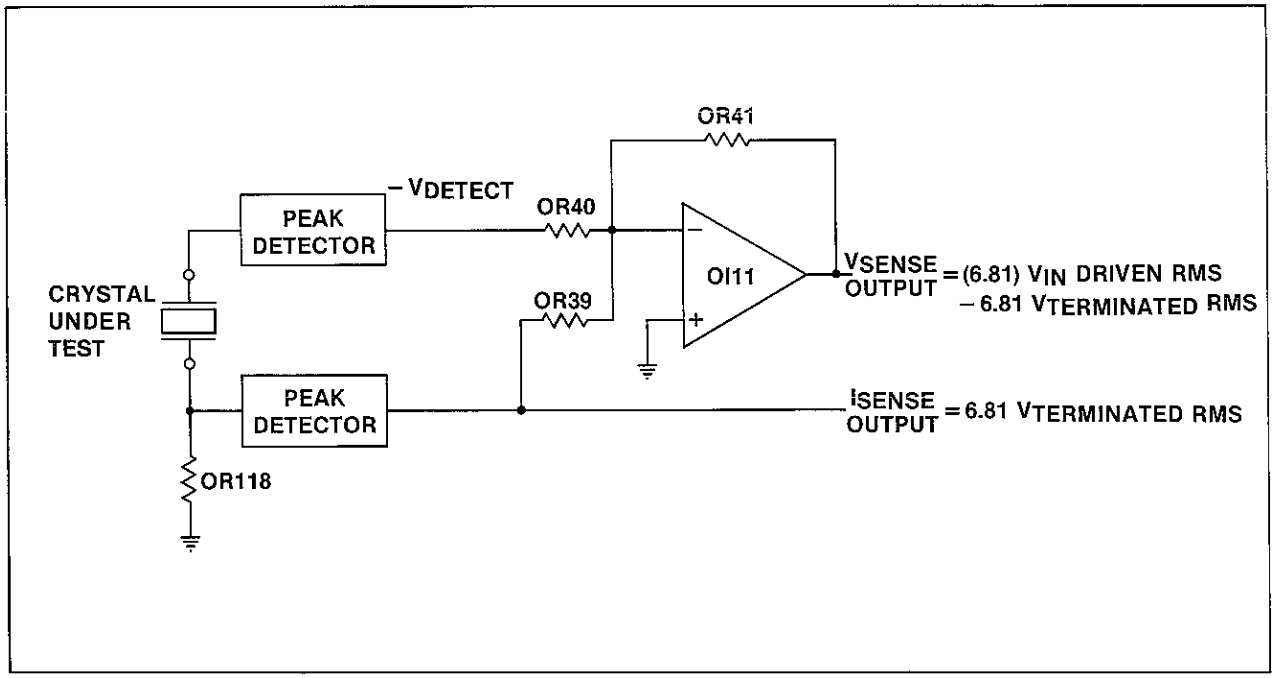


FIGURE 5-7. CRYSTAL UNDER TEST MEASUREMENT CIRCUIT

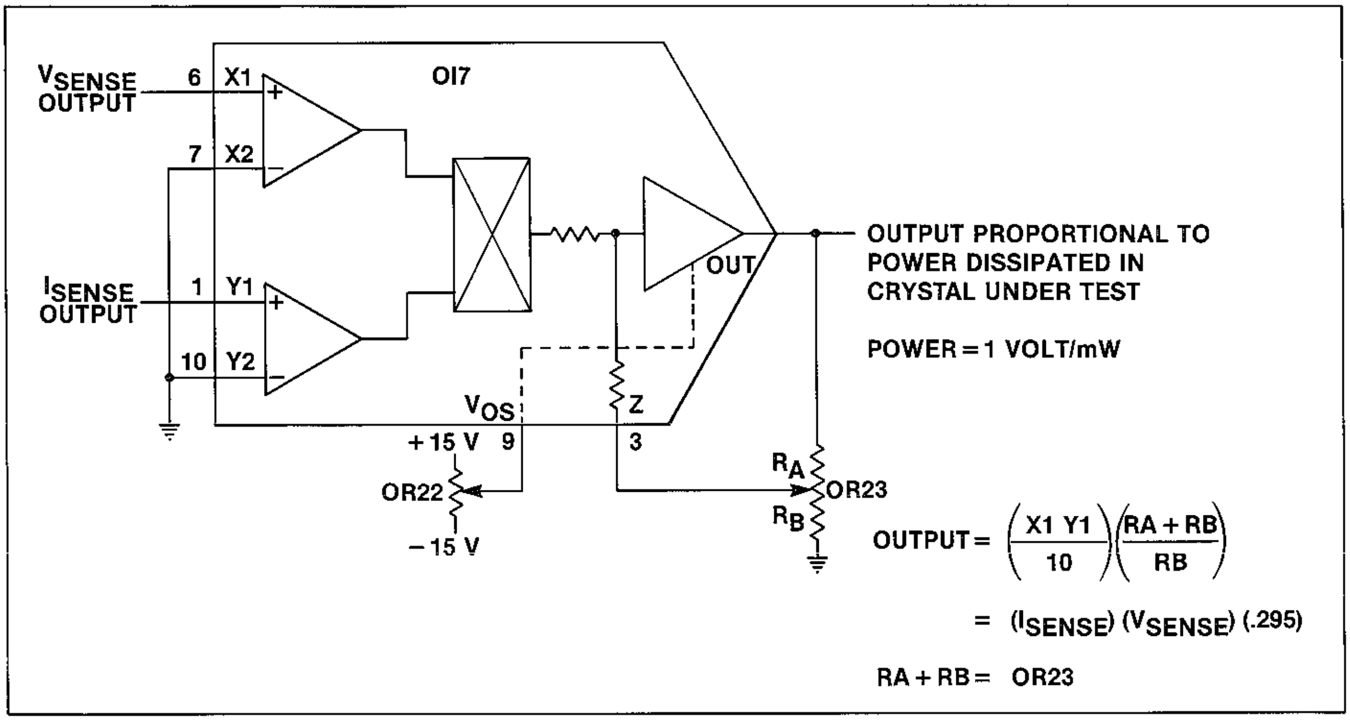


FIGURE 5-8. CRYSTAL UNDER TEST POWER DISSIPATED COMPUTATION CIRCUIT

CRYSTAL RESISTANCE COMPUTATION

The crystal resistance is computed by dividing the V_{Sense} Output by the I_{Sense} Output and scaling the results (Figure 5-9). The computation is performed by a Log-Antilog divider Circuit (IC06).

The V_{Sense} Output must be reduced to maintain accuracy in the divider circuit (OR20). The scaling constant is another input to the divider (OR15).

$$\text{Resistance Output} = (5)\frac{0.266\ V_{Sense}}{I_{Sense}}$$

$$= 1.33\ \frac{(7.07)\ V_{RMS}\ \text{across crystal)}}{510\ (I_{RMS}\ \text{crystal under test)}}$$

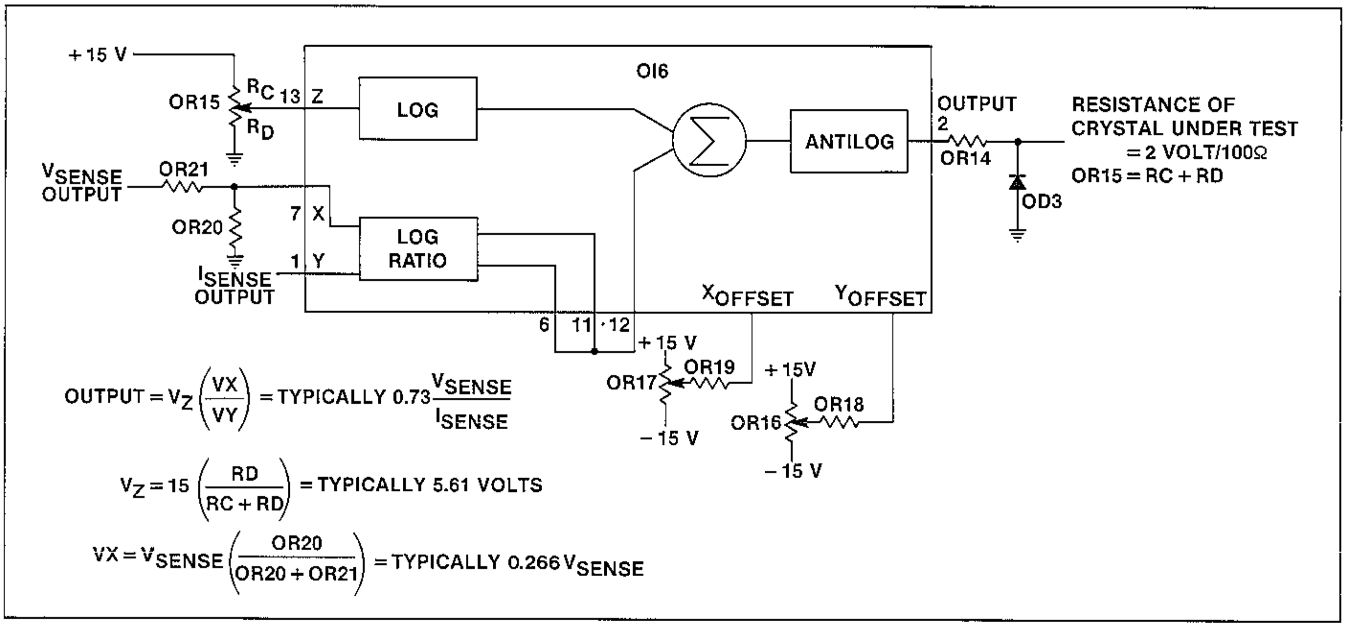
$$= 0.02\ \frac{(V_{RMS}\ \text{across crystal)}}{(I_{RMS}\ \text{crystal under test)}}$$

Therefore, Resistance Output is 2 volts per 100 ohms of crystal under test resistance.

To maintain division accuracy on very low power levels (low input voltages), the numerator and denominator portions of the divider circuit must be trimmed for offset voltage errors (OR11 and OR17).

ANALOG-TO-DIGITAL CONVERSION

The conversion function is performed with a voltage-to-frequency converter (OI3). The proper input to be converted is multiplexed with an analog multiplier (OI2) to the input of the converter. The converter output is a 1 KHz per volt of input frequency.



$$\text{OUTPUT} = V_Z\left(\frac{VX}{VY}\right) = \text{TYPICALLY } 0.73\frac{V_{SENSE}}{I_{SENSE}}$$

$$V_Z = 15\left(\frac{RD}{RC + RD}\right) = \text{TYPICALLY 5.61 VOLTS}$$

$$VX = V_{SENSE}\left(\frac{OR20}{OR20 + OR21}\right) = \text{TYPICALLY } 0.266 V_{SENSE}$$

FIGURE 5-9. CRYSTAL UNDER TEST SERIES RESISTANCE COMPUTATION CIRCUIT

CAPACITANCE METER

The capacitance meter circuit produces a digital output of 100 Hz per pF measured. The measurement is performed by an LC oscillator (Figure 5-10) which is designed to operate at 800 KHz with a pullability of 100 Hz per pF (OL8, OL10, OC90, OC92, OQ9). To obtain a useful output a reference oscillator (OL7, OL9, OC89, OC91, OQ10) is phase locked to the measurement oscillator when capacitive measurements are not being taken. The two oscillator outputs are buffered by CMOS logic circuits biased in the active region (OI21) which in turn drives an exclusive OR Mixer (OI21). The mixed output is low pass filtered (OL11 and OC101) and fed back through an analog mux and adjusts the varicap (OD24) on the reference oscillator to maintain phase lock.

During measurement of capacitance the reference oscillator remains at the phase-locked frequency due to stored charge on the varicap (OD24) and the associated capacitor (OC88). The analog multiplexer has opened the feedback path. The measurement oscillator sense lead is activated as the relay (OK2) closes. The measurement oscillator shifts to a frequency proportional to the unknown capacitance at the sense lead on measurement relay (OK2). The difference frequency (reference to measurement oscillator frequency) is available at the now enabled output analog multiplexer.

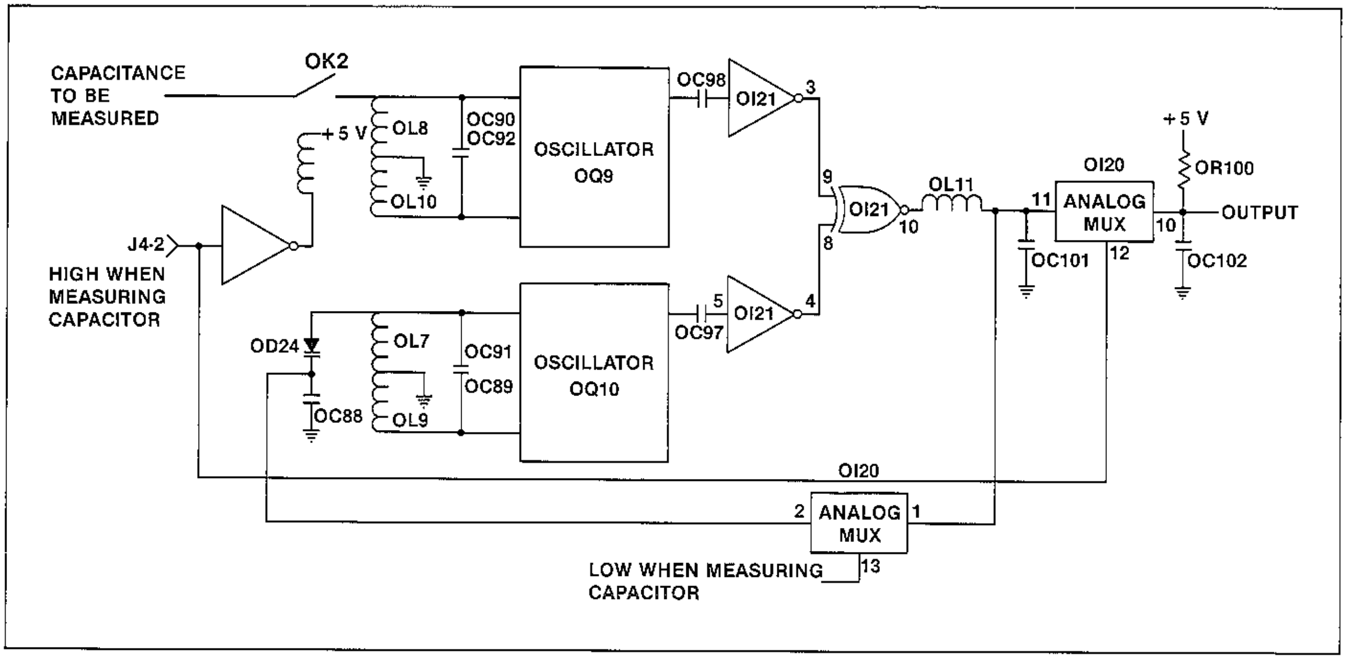


FIGURE 5-10. SIMPLIFIED DIAGRAM OF CAPACITANCE METER

CRYSTAL UNDER TEST RESISTANCE ANALOG OUTPUT INDICATORS

The crystal under test resistance has a visual and voltage indicating output. The analog voltage output of resistance (Figure 5-11) is a voltage follower output (OI4) of the computed crystal resistance (2 volts/100 ohm). The buffer is protected from load abuse by series output resistor (OR7).

The resistance visual indication is to aid in setting up the 150C. The LED drive current is proportional to the crystal under test resistance (Figure 5-11). The drive current is derived from a feedback signal set by an op amp (OI5) which is buffered with a drive transistor (OQ14). The active circuit maintains the voltage across current setting resistors (OR12, OR13) equal to the resistance output; the LED diode (DA9) current is nearly equal to the current in the resistors. At low resistance values the LED would be at very low currents and the light output is very non-linear; therefore, a quiescent bias current is drawn through the diode set by a resistor (OR11).

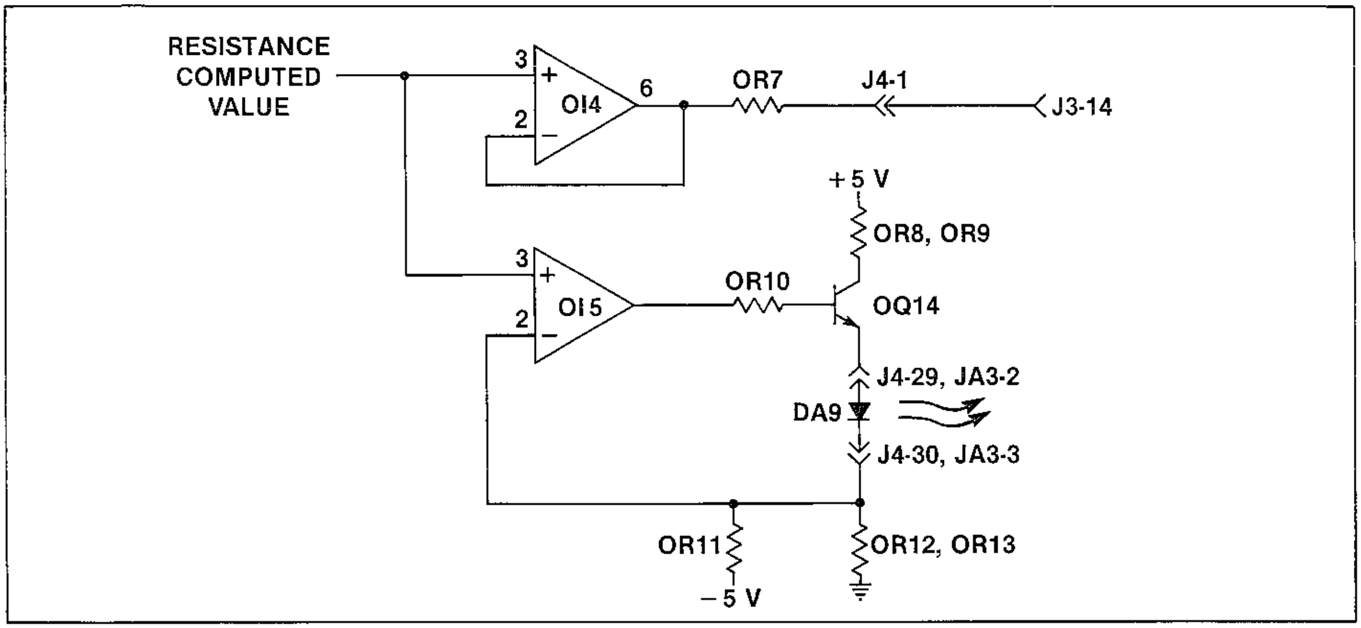


FIGURE 5-11. ANALOG OUTPUTS OF CRYSTAL UNDER TEST RESISTANCE

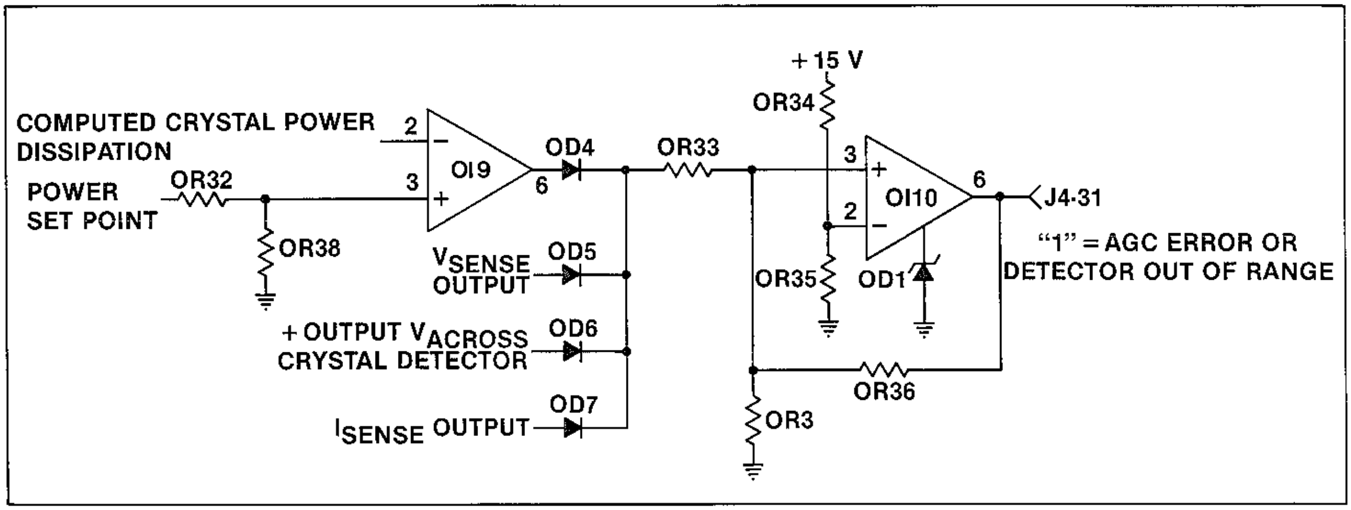


FIGURE 5-12. AGC/RANGE ERROR DETECTION CIRCUIT

AGC/RANGE ERROR DETECTION CIRCUIT

The AGC/Range error detection circuit (Figure 5-12) indicates an error when the I_{Sense} Detector or V_{Sense} Output or Voltage across the crystal under test detector is greater than +11 volts output or the computed power in the crystal is less than 85% of the power setpoint.

The power setpoint error circuit (OI9) compares the computed crystal power (Pin 2) and a voltage divided (typically 0.85 divide ratio) (OR32 and OR38) value of the power setpoint. If the divided value of the setpoint exceeds the computed power, the comparator output goes to an output greater than 11 volts.

The error output is derived by ORing all error inputs and if any exceed 11 volts a "1" level output occurs (OI10). The output of the error detector is limited by a clamp zener (OD1) to greater than −0.5 to less than +5 volts.

MICROPROCESSOR

The microprocessor executes up to 8000 instructions stored in read only memory (ROM) to control the 150C. The exact set of instructions is varied to the specific user needs.

The microprocessor also contains internal random access memory (RAM) which is used to control the 150C. Numeric data, display data is stored in the external RAM (See Figure 5-13).

The microprocessor can perform addition, subtraction, multiplication, division and numerous other mathematical functions on 12 digit mantissa binary coded decimal numbers (BCD) with exponent range of ±127. Up to 16 numbers are stored in the external RAM.

The microprocessor operates in an interpretive mode. The commands are very similar to a programmable hand held calculator. The interpretive code starts at address "$OCOO_{Hex}$". The initial machine code begins on reset at "OOO_{Hex}". The microprocessor uses signal P17 (Pin 34) to permit bank switching in up to 8000 instructions.

The microprocessor timing is shown in Figure 5-14. There are several fundamental cycles which are executed. All signals are TTL level compatible.

Read-Write Cycle

The read/write cycle is used to read data from or write data to the external RAM memory and numerous peripherals. The ALE signal latches the address on the address bus (AB) and the P1x signals enable the proper peripheral. The read signal goes low, indicating the DB will input data to the microprocessor. The write signal goes low, indicating the DB is outputting data from the microprocessor.

Expansion Bus Cycle

The processor has a 4 bit expansion bus. The PROG line is used to clock data on the P20–P23 lines. The P20–P23 lines contain address data on the high to low transition of the PROG line. Depending on the address, the P20–P23 lines the input or output data on the low to high transition of the PROG line.

Program Read Cycle

The processor needs to read program instructions from the ePROM. The 8 lines on the DB contain an address when the ALE is high. This data is latched into ID2. When PSEN goes low the ePROM gets 4 additional address lines from signal P20 through P23 and a 5th from P17. The ePROM outputs the eight bit code from the proper ePROM to the microprocessor. The microprocessor then executes the instructions.

For further microprocessor information, refer to Intel Publication "MCS-48 Microcomputer User's Manual."

Time Base Generation

The 150C uses a precision 50MHz standard to measure very accurately in a short period of time the frequency of an unknown input.

The circuitry in Figure 5-15 uses an internal oscillator or an external standard to generate a phase locked 50MHz standard. A free running 50MHz voltage controlled oscillator is reduced down to 10MHz which is the internal crystal oscillator's frequency by IB6. The signal phases are compared by IB2.

The internal oscillator has a crystal with a 50°C controlled ambient temperature. The oscillator has a varicap to permit DC voltage control (back panel adjustment) of the oscillator's frequency. The XTBE (external time base enable) selects which signal is compared to the divided 50MHz standard. If XTBE is low the internal 10MHz standard and the divided by five 50MHz standard are the inputs to the phase comparator. If XTBE is high the external signal and an appropriately divided 50MHz signal are input to the phase comparator.

The programming voltage to the 50MHz LC oscillator is compared by a level comparator to insure the signal is in a valid range. The signal TBL is high when the control voltage is proper.

The external standard buffer amplifier output is input to a level comparator to generate signal XTB. When XTB is high, the signal indicates the external standard input is at a useful signal level.

Period Counter and Remote Interface

The 150C uses a circuit to count simultaneously a 50MHz reference and the unknown for an approximately 200mSec gate time. The unknown frequency count divided by 2 times the 50MHz count times 10^9 gives the result in frequency. With a count period of 200mSec, the unknown count will be approximately 10 million giving a resolution of one part in 10 million.

The period counter (Figure 5-16) can select a low frequency TTL level or a high speed differential input for the unknown input (ID10, IF1). The microprocessor through IF4 sets the J input (IF5) high, and the next high to low transition of the unknown starts the counter. The counter IF6, IF7 and IF12 count the unknown. The 50MHz starts the same time as the unknown and is counted by IF9, IF10 and IF12. When 50 counts are counted by the microprocessor, output 2 of IF12 to RC of ID1, the J input of IF5 is set low. The counting is stopped on the next high to low transition of the unknown. The microprocessor loads the counts via the data bus and performs the necessary division to then display the frequency of the unknown. All counting is done in BCD.

The counter control circuit IF4 also performs the interface to the 2000A/B Printer Processor or the keyboard.

Power Supply

The 150C uses a switching regulator operating at nearly 5 to 20 KHz. The supply is capable of operating from an AC input of 100v to 260VAC and 50 or 60Hz. The range is covered without any switching. See Figure 5-17.

The line is isolated by TG1. The output of TG1 goes to a full wave rectifier and filter network to generate an unregulated DC voltage from 17 to 70 volts DC. The unregulated DC voltage is coupled through fuse FC1 to the balance of the supply circuits.

The unregulated DC voltage is switched through IC1 into transformer TC1. IC1 is switched on and off by the regulator control circuit to hold the 5 volt output constant. The regulator control is powered by the low voltage supply. If the 5 volt supply goes out of range, the overvoltaged detect circuit fires and opens FC1 to protect the 150C circuit.

The balance of the supply voltages is derived from windings on TC1. These windings generate unregulated DC voltages which are regulated with 3 terminal IC regulators to the desired value.

The windings are picked to permit only 1.5 to 3 volt drop across each regulator.

Because of the switching regulator design, the 150C supply dissipation doesn't vary appreciably with line variation.

Analog Frequency Output

The analog frequency output circuit permits the microprocessor to generate an analog output signal from a digital value. The circuit, Figure 5-18, uses a sample and hold circuit to hold a selected value of a ramp waveform as a constant level output. The microprocessor varies the ramp time to arrive at different output voltages.

The sequence starts by $\overline{SC}$-SHD set low. The integrated signal begins to rise. At a time set by the value in the microprocessor, the SHC goes high and the sample hold circuit output very briefly follows the integrated signal. The SHC line goes low and the output remains fixed; the $\overline{SC}$-SHD signal goes high discharging the integrated signal; therefore, the process is ready to start all over again.

Display Circuit

The display circuit is a static display. Each digit (see Figure 5-19A) consists of an IC latch decode driver and LED digit. Four bits of data are latched into the IC, decoded into a 7 segment display and drives a constant current into the display.

Eight individual digits, Figure 5-19B, have the 4 input data lines all connected together. The 1 of 8 decoder selects a particular digit to latch the data into. The microprocessor selects each display digit until the display is reloaded. The data lines to the digits and the 1 of 8 decoder also drives the decimal point. The decimal points look steady to the user since the display time is many times larger than the display load time.

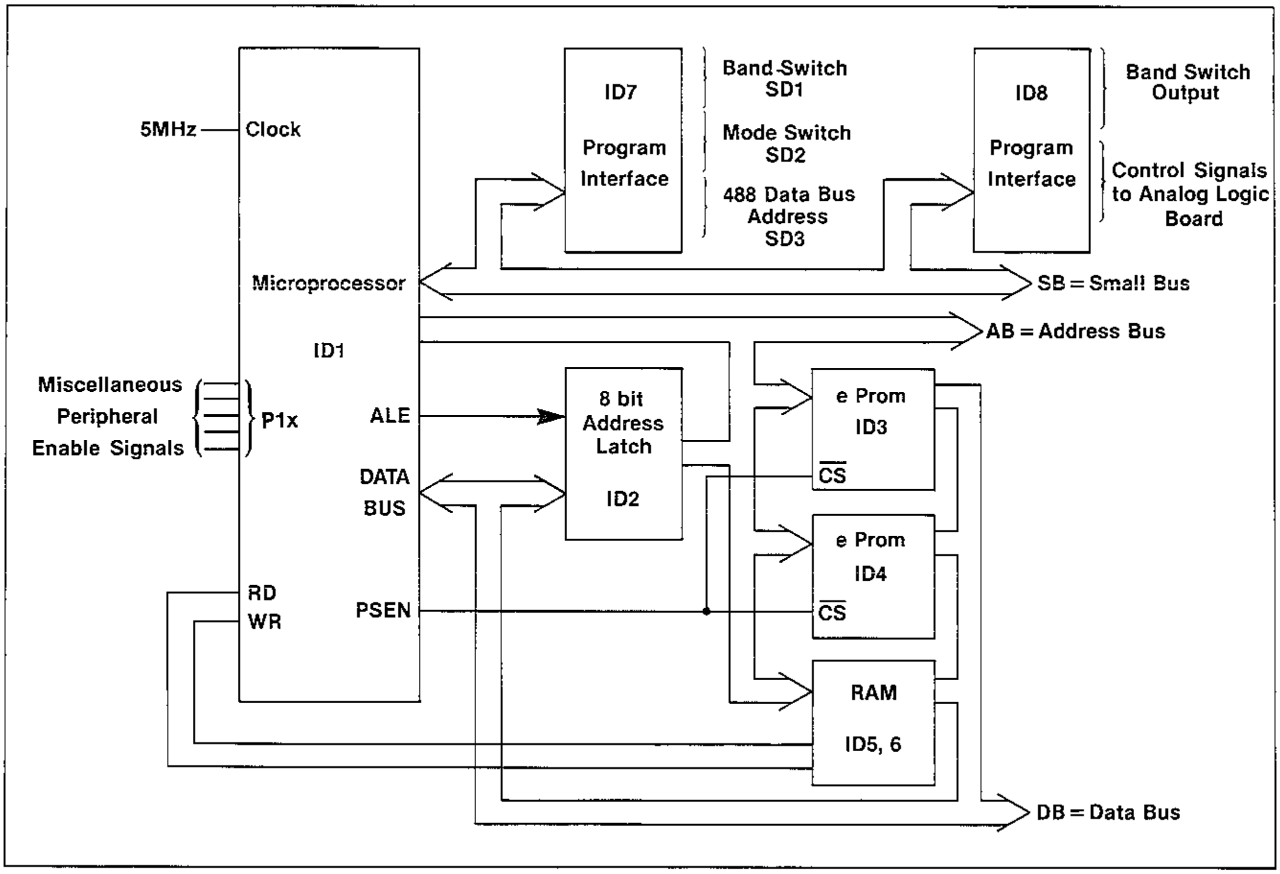
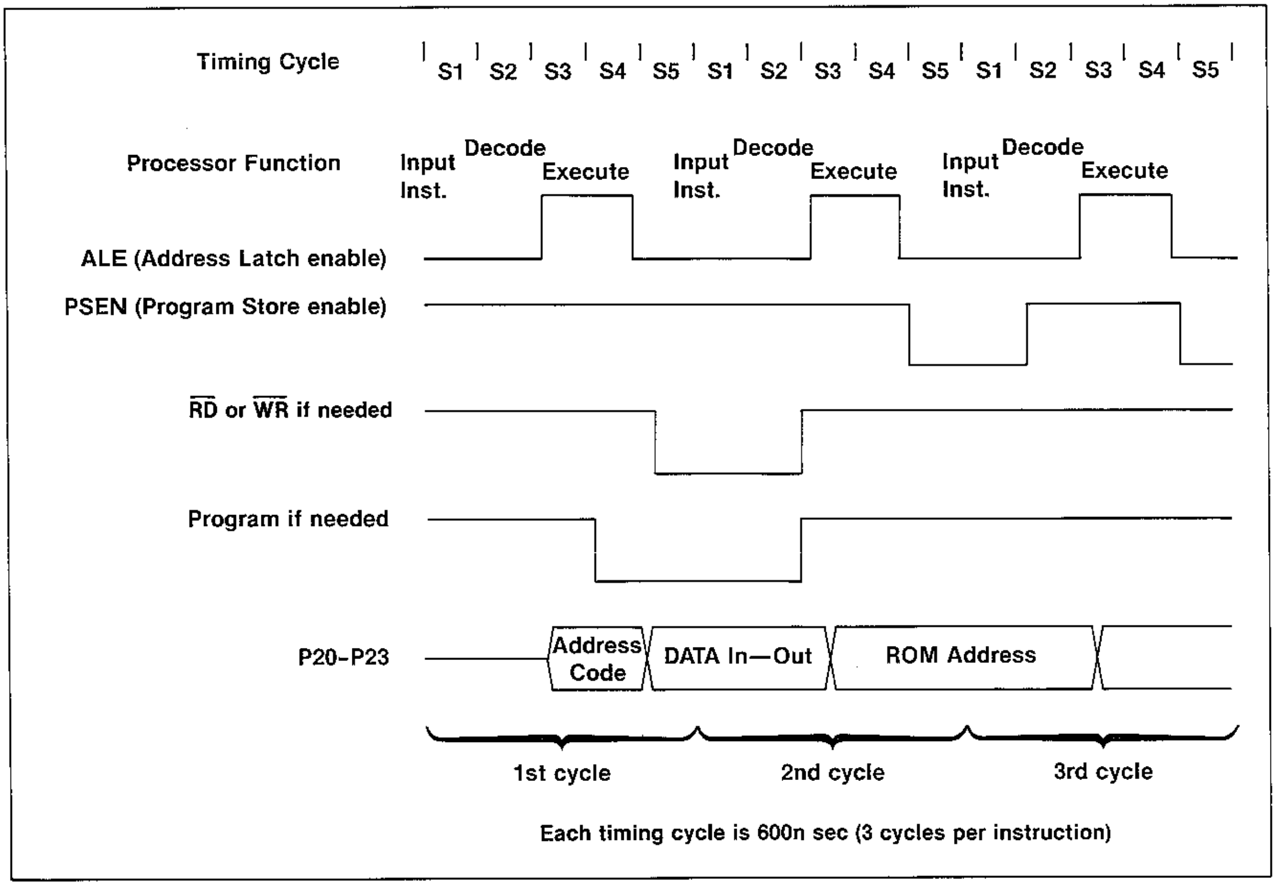


FIGURE 5-13. MICROPROCESSOR SIMPLIFIED PROGRAM



Each timing cycle is 600n sec (3 cycles per instruction)

FIGURE 5-14. MICROPROCESSOR TIMING SIGNALS

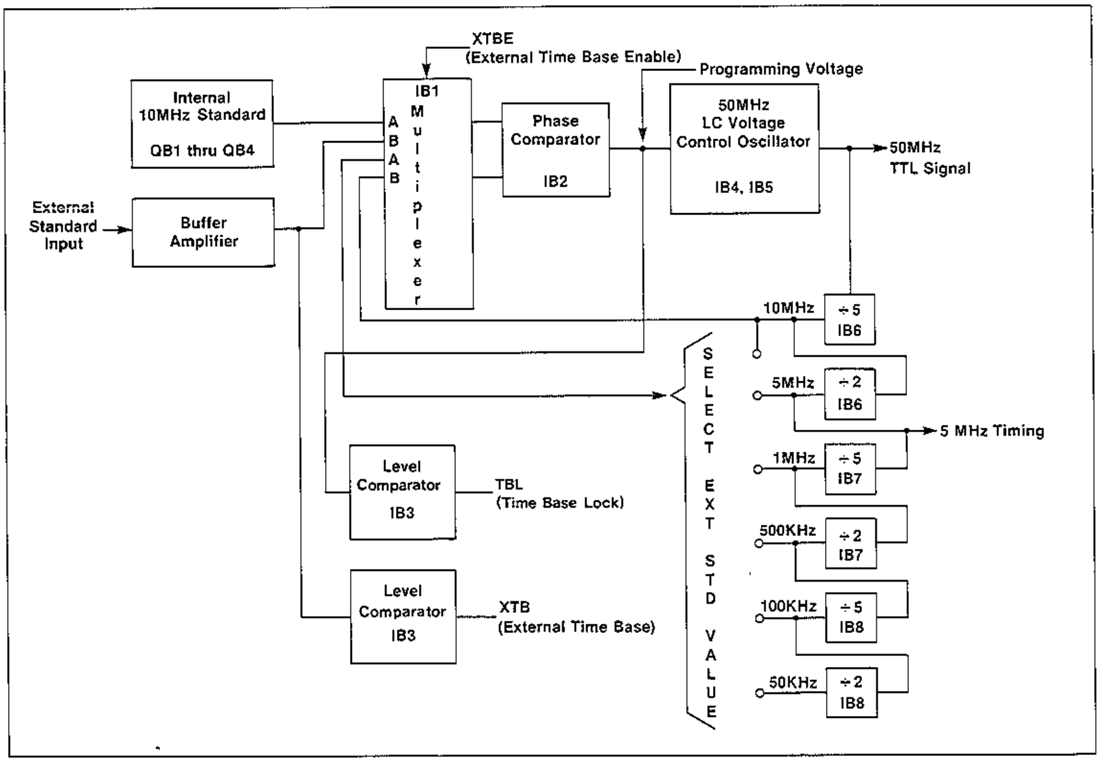


FIGURE 5-15. MHz PRECISION STANDARD GENERATION

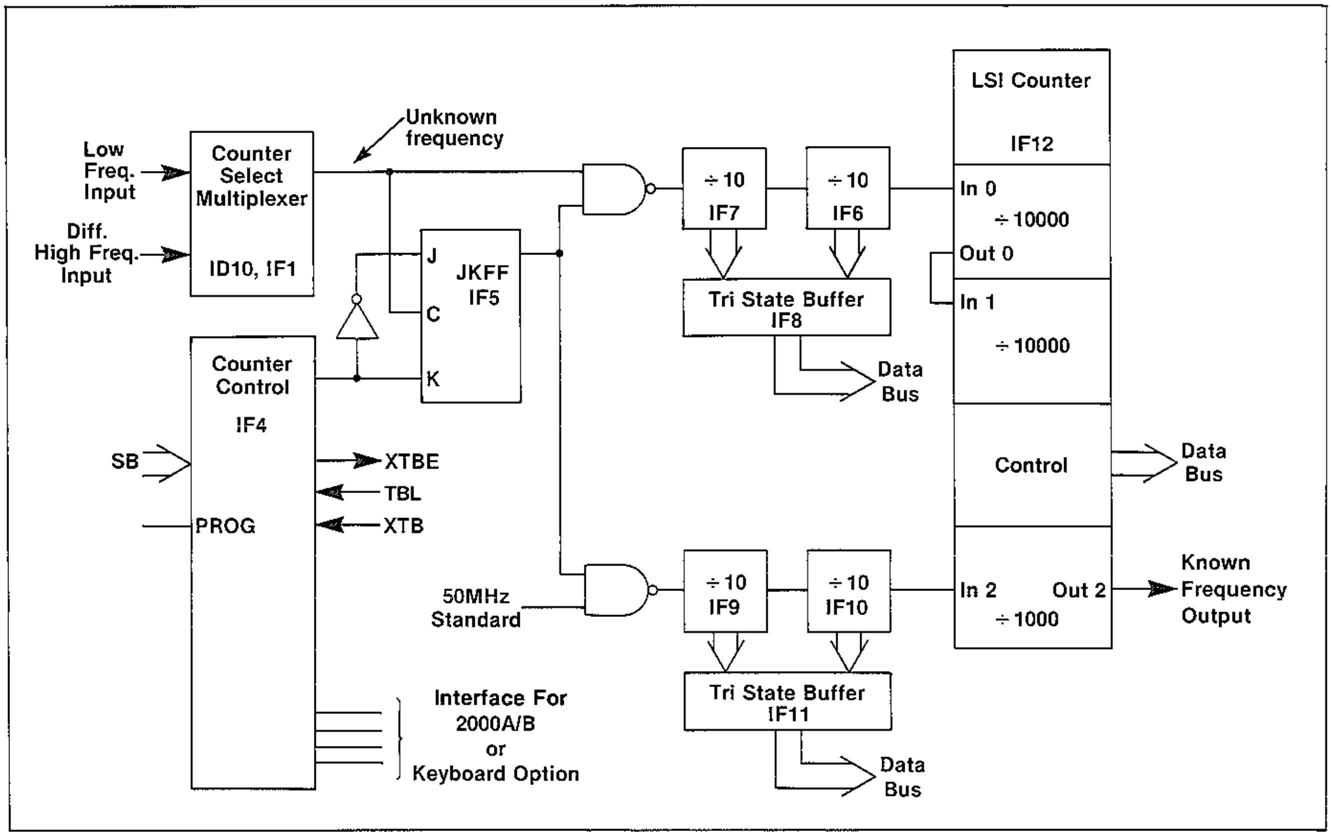


FIGURE 5-16. PERIOD COUNTER AND REMOTE INTERFACE

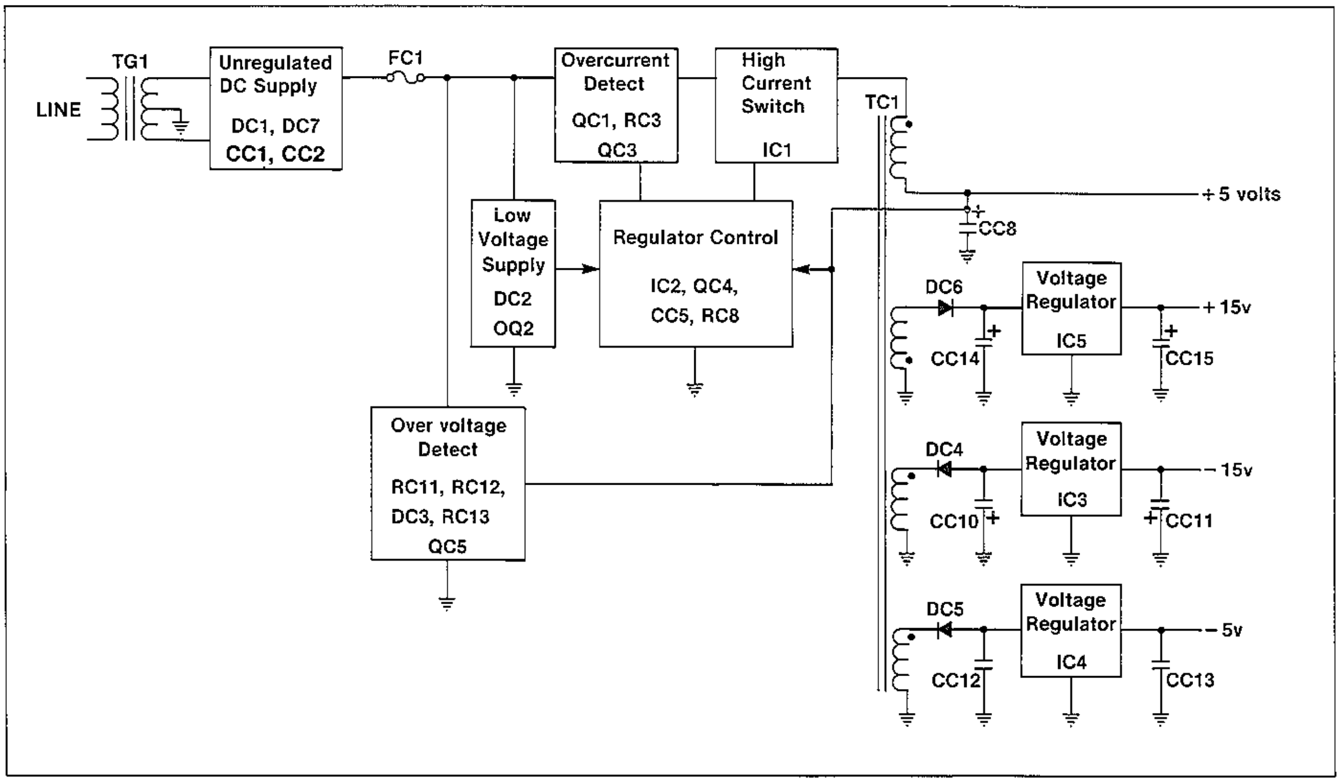


FIGURE 5-17. POWER SUPPLY CIRCUIT

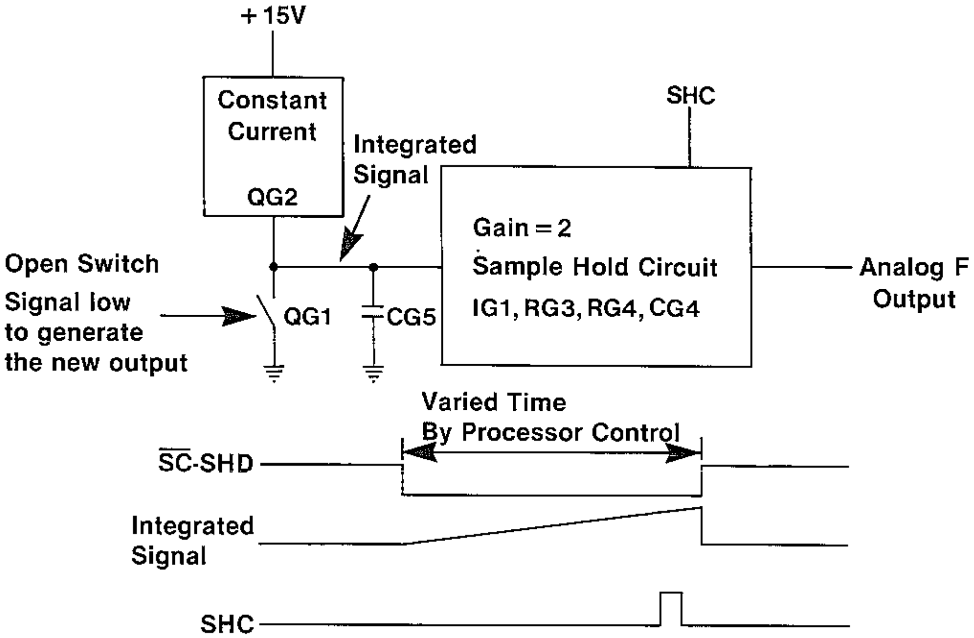


FIGURE 5-18. ANALOG FREQUENCY OUTPUT OPTION

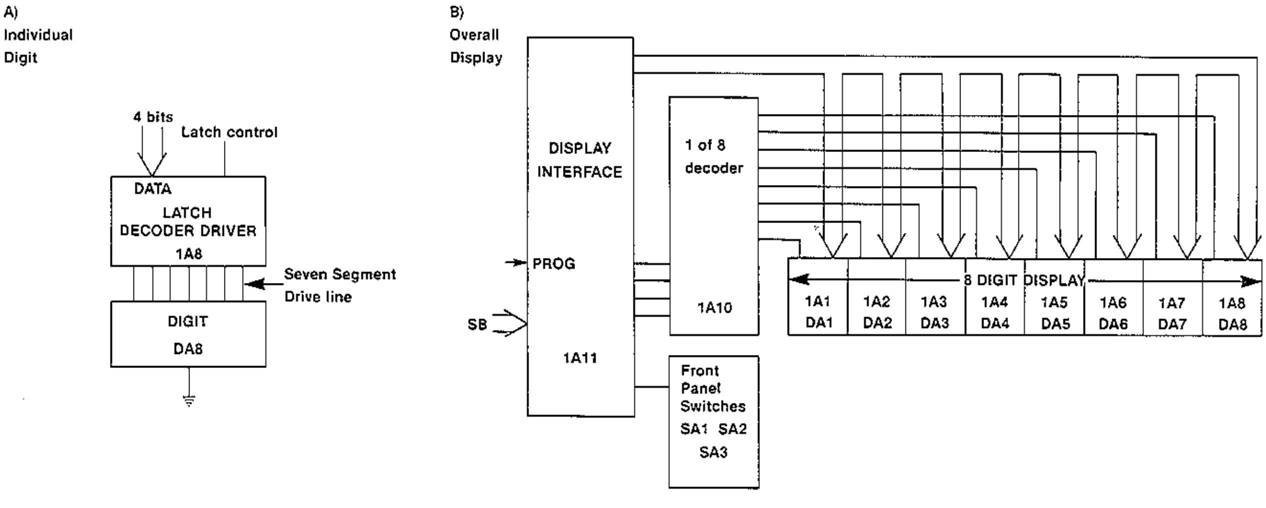


FIGURE 5-19. DISPLAY CIRCUIT

SECTION 6

MAINTENANCE, CALIBRATION AND REPAIR

The calibration procedure, as well as the checkout procedure to ensure the 150C is calibrated, is covered in this section. The only maintenance required for the 150C is to ensure the two air variable capacitors do not get excessively filled with lint which could entrap metal particles and short out the capacitors. The 150C repair is also covered in this section.

CALIBRATION CHECK

The calibration check is a simple checkout procedure to ensure the 150C is operating within the specifications.

Equipment Required:

75 pF ± ½%	Capacitor
10Ω	
50Ω	
100Ω	Non-Inductive
200Ω	1% Resistors
500Ω	

Frequency standard 1 V p-p (Accuracy better than 1 part per million.)

COUNTER STANDARD CHECK

The external standard will be driven into the crystal under test oscillator input and the external standard will be counted on the internal counter. The 150C should be operating in local mode on internal standard.

1. Insert the 50-Ω test resistor in the crystal under test socket.
2. Set the power setting for 500 μW.
3. Set frequency to the standard frequency.
4. Remove 50-Ω resistor.
5. Connect the external standard to 150C. Connect shield to the front panel Banana Jack. Connect the signal lead to crystal under test left-side pin (J7-1) through a 1-kΩ resistor.
6. If the external standard is of sufficient amplitude, the 150C counter will read the standard frequency. The unit should be within a ±0.5 ppm to be in specification.

If the unit is not within specification, see the Internal Standard Calibration section.

CAPACITANCE METER CHECK

The capacitance meter will be checked by measuring a precision capacitor.

The 150C should be in local mode operating on either the internal or an external frequency standard.

1. Depress C_t switch and adjust Series Capacitor for a display reading—
   000025.00.

Measure caps with HP 4215A LCR meter / 33pF+43pF=76pF
76 pF located inside Front cover

use ~~two~~ caps in parallel or in series to get 75 pF.

2. Insert the 75 pF precision capacitor into the crystal under test socket.
3. Depress C_t and display should read between—

   3 0000098.0 and 0000102.0

If the unit is not within specification, see the Capacitance Meter Calibration section.

RESISTANCE CHECK

The resistance will be checked by measuring precision resistors at 5 MHz and 500 μW of power. The 150C should be on local mode and operating on either the internal or on an external standard.

1. Insert the 100-Ω test resistor in crystal under test socket. Adjust power for 500 μW. Set frequency to ≈ 5 MHz.
2. Insert each precision test resistor into the crystal under test socket. Depress R switch and read resistance. If the results are not within the tolerances indicated, see the Resistance Calibration section.

Use Resistors from stock. verify resistance with Dana prior to test. inside Front cover contains Resistors.

Precision Resistor Value	Lower Limit	Upper Limit
10	00000009	00000011
50	00000046	00000054
100	00000093	00000107
200	00000178	00000222
8 500	00000472	00000528

3. Insert 100-Ω resistor in socket and vary power from minimum to maximum while simultaneously depressing the R switch. The resistance should not vary outside of range of 00000093 through 00000107. If the variation exceeds the limits, then refer to the Resistance Calibration section.

POWER CHECK

The power setting will be checked by operating the 150C on a resistor. The voltage driving the resistor will be measured with a RF voltmeter to check the power setting accuracy.

use Boonton 92C with Unterminated BNC Adapter

The 150C should be on local mode and operating on either the internal or an external standard.

1. Remove crystal under test socket from 150C.
2. Install 100-Ω test resistor between Pin 1 and Pin 3 of J7.
3. Set power to 2000 μW and frequency to ≈5 MHz. 9
4. Measure RF voltage between Pin 2 and Pin 3 of J7 and the value should be between 0.55 and 0.59 volts.

If the unit is not within specification, see the Power Calibration section.

CALIBRATE

The following procedures describe the necessary steps to calibrate the 150C. Allow 30 minutes of warm up prior to performing any calibration.

Equipment Required:

75 pF ± ½ %	Capacitor
10Ω	
50Ω	
100Ω	Non-Inductive
200Ω	1% Resistors
500Ω	

1 MHz frequency standard 1 V p-p (Accuracy better than 1 part per million.) Refer to Figure 8-1 and 2.

ADJUST COUNTER STANDARD

The external standard will be driven into the crystal under test oscillator input and the external standard will be counted on the internal counter. The 150C should be operating in local mode on internal standard.

1. Remove the 150C top cover
2. Insert the 50-Ω test resistor in the crystal under test socket.
3. Set the power setting for 500 μW.

Parallel Xtals read less than value stamped on Xtal.

(use 50 pf series dialed in)

4. Set frequency to that of the external frequency standard.
5. Remove 50-Ω resistor.
6. Connect external standard to 150C. Connect shield to the front panel Banana Jack. Connect the signal lead to crystal under test left-side pin (J7-1) through a 1-kΩ resistor.
7. If the external standard is of sufficient amplitude, the 150C counter will read the standards of frequency.
8. Adjust reading by rotating capacitor CB23 (Figure 6-1). Set the standard to within ±0.2ppm.
9. Replace the 150C top cover.
10. The internal standard is now calibrated.

CAPACITANCE METER CALIBRATION

The capacitance meter will be calibrated by adjusting two internal trimmer capacitors until the 150C will properly measure a precision capacitor.

The 150C bottom should be removed and the unit should be operated on its left side.

> **CAUTION**
>
> The rear panel has power line voltage exposed.

The 150C should be in local mode operating on either the internal or an external frequency standard.

1. Depress C_t switch and adjust Series Capacitor for a display reading—
   000025.00
2. Insert the 75 pF precision capacitor into the crystal under test socket.
3. Depress C_t switch and read display. To be within specification the display should read between 0000098.0 and 0000102.0. The unit should be adjusted to within ±0.1 pF or a display reading of 0000099.9 and 0000100.1.
4. With C_t NOT depressed, adjust the capacitance meter's measurement oscillator trimmer (OC92). Add capacitance if the reading was high and remove capacitance if the reading was low. Simultaneously adjust the reference oscillator trimmer (OC91). Adjust the capacitor (OC91) to maintain the voltage on TP6 at 3.0 volts DC. (OC91 sets lock or capture range of reference oscillator to be centered about measurement oscillator frequency.) *NOTE: If the reference oscillator is adjusted too far, large amplitude AC waveform will occur at TP6. The frequency is the difference frequency between the two oscillators. Adjust for 3.0 volts DC.*
5. Repeat steps 1 through 4 until step 3 reads within ±0.1 pF. When step 3 is correct the unit is properly calibrated.
6. Replace bottom of 150C.

ANALOG COMPUTATION CIRCUIT CALIBRATION

The peak detectors and analog computation circuits are set in this step.

1. Remove the bottom cover of the 150C.
2. Operate the unit on its side.

> **CAUTION**
>
> The back panel has power line voltage exposed.

3. Place a short across the AGC capacitor (OC34). Short test socket Pin J7-1, 2, and 3.
4. Adjust current detector offset adjust potentiometer (OR52) until TP8 is less than 500 μV.

5. Adjust the offset potentiometer (OR67) of the voltage detector until TP5 is less than 500 μV.
6. Remove test socket short and the short across the AGC capacitor (OC34).
7. Place the 100-Ω test resistor in the test socket (J7-1 and 3). Set the 150C to operate at ≈5 MHz.
8. Set the front panel power set potentiometer for a power setting of 2000 μW.
9. Adjust OR23 for a voltage of 0.568 volts RMS measured between Pin J7-3 and ground J7-2.
10. Vary power setting to minimum and adjust power multiplier offset adjust OR22 to keep 150C oscillating.
11. Insert 500-Ω test resistor in the test socket (J7-1 and 3). Adjust the Power Set potentiometer between minimum and maximum power (point where AGC error just occurs, then lower setting by 200 μW). When varying power, depress R switch and note resistance variations at high and low power. Set low power setting equal to the value at the high power setting by adjusting the denominator offset potentiometer (OR16). Repeat the sequence until best results are obtained. (Variation typically less than 10Ω).
12. Insert 10-Ω test resistor in the test socket (J7-1 and 3). Adjust the Power Set potentiometer between minimum and maximum power (point where AGC power just occurs, then lower setting by 200 μW). When varying power, depress R switch and note resistance variations at high and low power. Set low power setting equal to the value at the high power setting by adjusting the numerator offset potentiometer (OR17). Repeat this sequence until best results are obtained. (Variation typically less than 1Ω).
13. Repeat steps 11 and 12 until best results are obtained (typically twice through procedure is sufficient).
14. Adjust Power Set potentiometer for a setting of 500 μW with the 500-Ω test resistor in the test socket (J7-1 and 3).
15. Depress R switch and adjust the divider constant input (OR15) for a reading on the display of 0000500.0±1.0 count (500Ω). The 500-Ω resistor is in the test socket.
16. Insert the 10-Ω test resistor in the test socket (J7-1 and 3). Depress the R switch and adjust the voltage across crystal and current sense resistor detector gain (OR57) for a display of 0000010.0±0.3 count (10Ω).
17. Repeat steps 15 and 16 for best overall results.
18. Insert each precision test resistor into the crystal under test socket. Depress R switch and read resistance. The results should be within limits indicated. Steps 15 and 16 may be repeated to optimize results. *NOTE: If results are not satisfactory, the divider (OI6) or either peak detector circuit could be defective.*

Precision Resistor Value	Lower Limit	Upper Limit
10	0000009.5	0000010.5
50	0000046.0	0000054.0
100	0000093.0	0000107.0
200	0000178.0	0000222.0
500	0000472.0	0000528.0

19. Repeat steps 7, 8 and 9.
20. Vary power setting to minimum and adjust power multiplier offset adjust to just keep 150C oscillating (OR22). Replace bottom cover and install crystal socket in front panel.

The 150C is now calibrated for resistance and power.

REPAIR

The repair of the 150C can be very difficult without the proper digital test equipment. Saunders and Associates, Inc. offers a printed circuit board exchange program at a nominal charge to facilitate rapid repair.

UNIT HAS NO DISPLAY (Display Off)

The fuses should be checked. The back panel fuse Figure 6-1 (FGI) provides protection for the

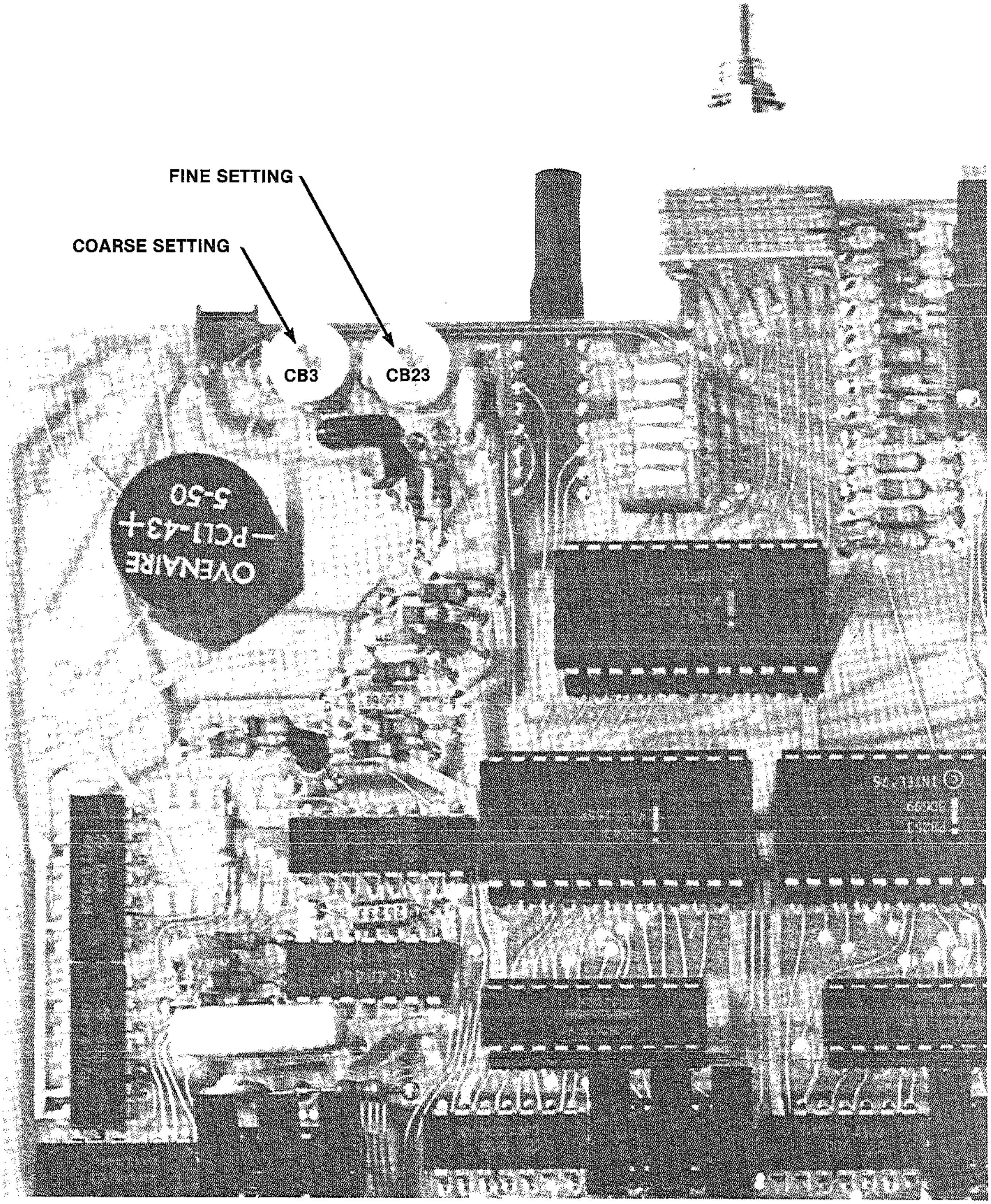


FIGURE 6-1. FREQUENCY STANDARD SETTING (TOP CIRCUIT BOARD—FRONT)

line power connection. The fuse is a ½ A Slow Blow type. The fuse FCI internal to the 150C (remove top cover with 150C disconnected from the power line) should be checked. The fuse is a 6 AMP standard type fuse. The internal fuse can be blown by two means: a) internal circuit over current demand; b) 5 volt supply voltage exceeding typically 6.5 volts. If FCI is replaced, the internal supply voltages should be checked to ensure proper operation.

150C POWER SUPPLY CHECKS

The 150C power supply can be checked for proper operation. Use pin J4-18 for a reference.

Pin or Component	Voltage DC	
	Min.	Max.
FC—1	+17	+75
J4—28	−15.1	−14.2
J4—17	−5.3	−4.7
J4—16	4.7	5.3
J4—27	14.2	15.8
IC2—Pin 14	10.5	12.1

UNIT DOESN'T RESPOND TO ANY USER CONTROLS OR REMOTE CONTROL

The 150C uses a power on reset to initialize the microprocessor. The 150C can improperly restart on severe line transients or power failures. The 150C should be disconnected from the line and then reconnected to perform a reset.

If a reset doesn't restart the circuit, the clock generator should be checked. The signal on pin 12 of IB6 should be checked for 10MHz and a 20% duty cycle. This ensures the 50MHz oscillator is operating. The signal on IB6 pin 5 should be 5MHz and a 50% duty cycle. To ensure the microprocessor has proper clock generation, check pin 1 of IB3 which should be a high level (3 volts) which indicates the 150C has valid lock to a frequency standard.

If problems still exist, try reseating the ePROMS (ID3 and ID4) with the power off. Then repower and check operation.

Check pin 9 of the processor for a clocking signal of a period of 3μSec. This indicates the microprocessor is cycling through its sequence correctly.

If further help is needed, please contact the factory or factory representative.

REMOVAL OF PRINTED CIRCUIT BOARDS

The following sequence lists how to remove the basic assemblies from the 150C chassis. Disassemble unit AFTER removing the line power.

A) Remove two screws on the top and bottom covers to expose the printed circuit cards.

B) Remove four back panel screws and pull the back panel from the unit. The unit will contain an interconnect PCB, transformer and interface connector (See Figure 8-8).

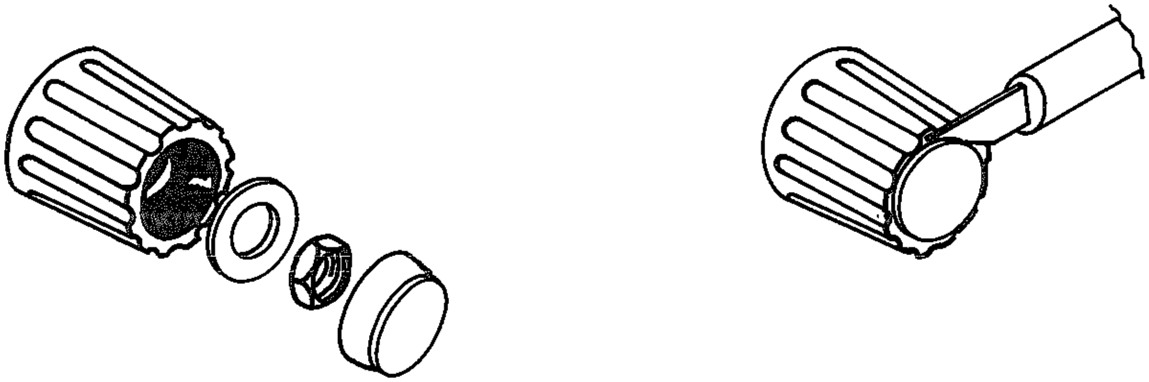
C) Remove the 3 front panel knobs. The knobs have a cover which must be pried off to expose the screw which holds them to the shaft (Figure 6-2).

D) Remove the nut from the Band Switch. Switch exposed on the front panel.

E) Slide the two circuit boards out simultaneously from the back of the 150C chassis.

   The boards are held together with a 45 pin connector. The boards can be separated after removal from the 150C chassis.

F) The display board can be removed by removing the nut on the C_t, F_p and R switches protruding through the 150C front panel. Push the board toward the back and remove. The 150C is now fully disassembled. Reverse the sequence to assemble.



A

B

FIGURE 6-2.

PRY CAP OFF OF KNOBS TO EXPOSE SCREW WHICH LOCKS KNOB TO SHAFT. INSERT KNIFE UNDER CAP AND PRY OFF AS IN (B).

SECTION 7

FREQUENCY STANDARD, IEEE 488 BUS AND REMOTE INTERFACE

The use of the Remote Interface connectors on the 150C is covered in this section. The crystal under test interface is also covered.

The selection of the external frequency standard is covered.

CRYSTAL UNDER TEST INTERFACE SOCKET

The crystal under test socket (Figure 7-1) provides the connection between the analog circuit board to the front panel test fixtures. The connector (J7) allows for easy modification or replacement of the crystal under test fixture.

The 150C socket assembly uses the pin J7-2 connected to the socket shield to minimize noise and stray signal pickup in the crystal under test socket. For most testing the crystal under test enclosure should be grounded to J7-2.

REMOTE CONTROL INTERFACE

The Remote Control Interface (Figure 7-2 and 7-3) allows for remote readout and control of the 150C. The connector is an Amphenol Part No. 57-30140 Micro Ribbon Connector.

The Remote Control Input is specifically designed to interface the Saunders and Associates 2000A/B Printer Processor. Refer to the 2000A/B manual for description of interface. The 150C external interface is not practical for general purpose I/O of the 150C.

The Remote Control Input is disabled when interfacing Option 003 Keyboard. If the 150C has Option 003 the 2000A/B Printer Processor interface is disabled unless specifically requested. Refer to the CI Meter Keyboard Manual for the interface specifications.

IEEE 488 BUS INTERFACE

The option 001 IEEE 488 bus interface is a digit serial bit parallel universal test equipment input-output bus. The details are covered in the Saunders and Associates Crystal Impedance Meter 488 Data Bus Interface Manual.

EXTERNAL FREQUENCY STANDARD

The external frequency standard is input through the Remote Control Interface Connector Amphenal Part No. 57-30140 Micro Ribbon Connector, or BNC Connector see Figure 7-2 and 7-3.

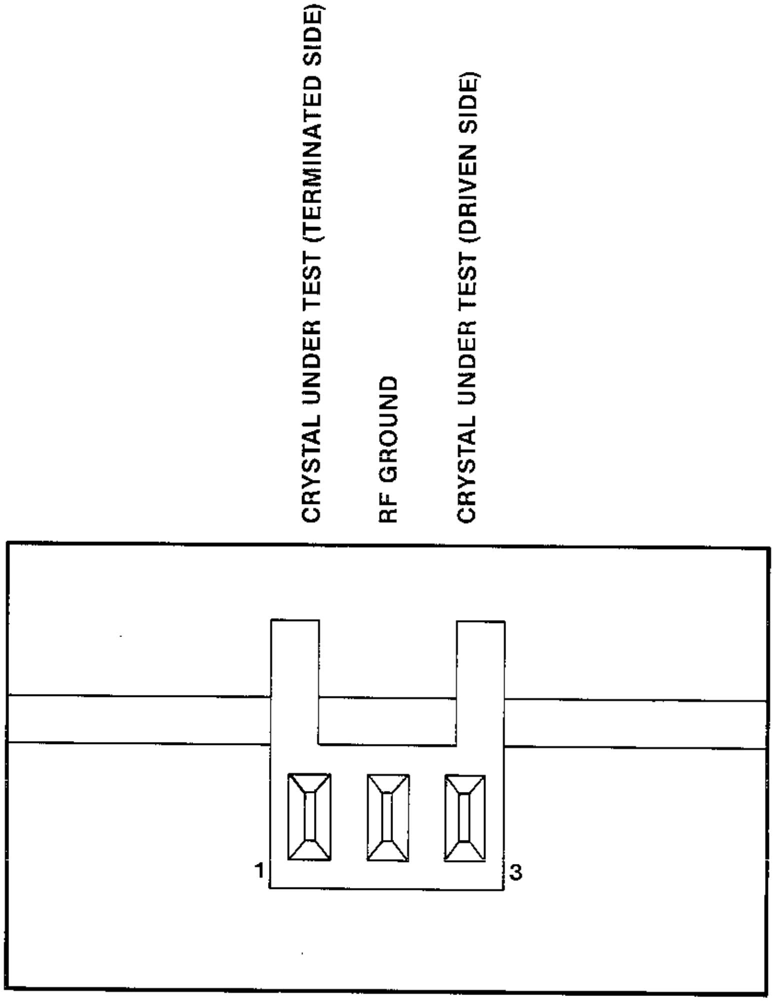
The external standard will automatically enable if greater than the minimum amplitude and within ±200PPM of the nominal frequency value.

The 150C can be used with any of several standard frequencies. The unit can be ordered with any of the possible values specified or the unit can be easily modified. There are one of several resistors which must be installed to select the proper frequency. Refer to Figure 8-3 and Figure 8-5. Only one resistor of RB38 through RB43 should be installed. The resistor is a 4.7Ω ¼ watt carbon composition or carbon film resistor.

The undesired resistor can be cut out and the new one soldered in from the top of the board without disassembling the unit.

The following chart indicates the resistor to install for the particular external standard.

RB38	10MHz
RB39	5MHz
RB40	1MHz
RB41	500KHz
RB42	100KHz
RB43	50KHz



1. Terminated side of the crystal under test.
2. RF Ground (used if crystal socket is to be grounded).
3. Driven side of crystal under test.

FIGURE 7-1. CRYSTAL UNDER TEST INTERFACE SOCKET (J7)

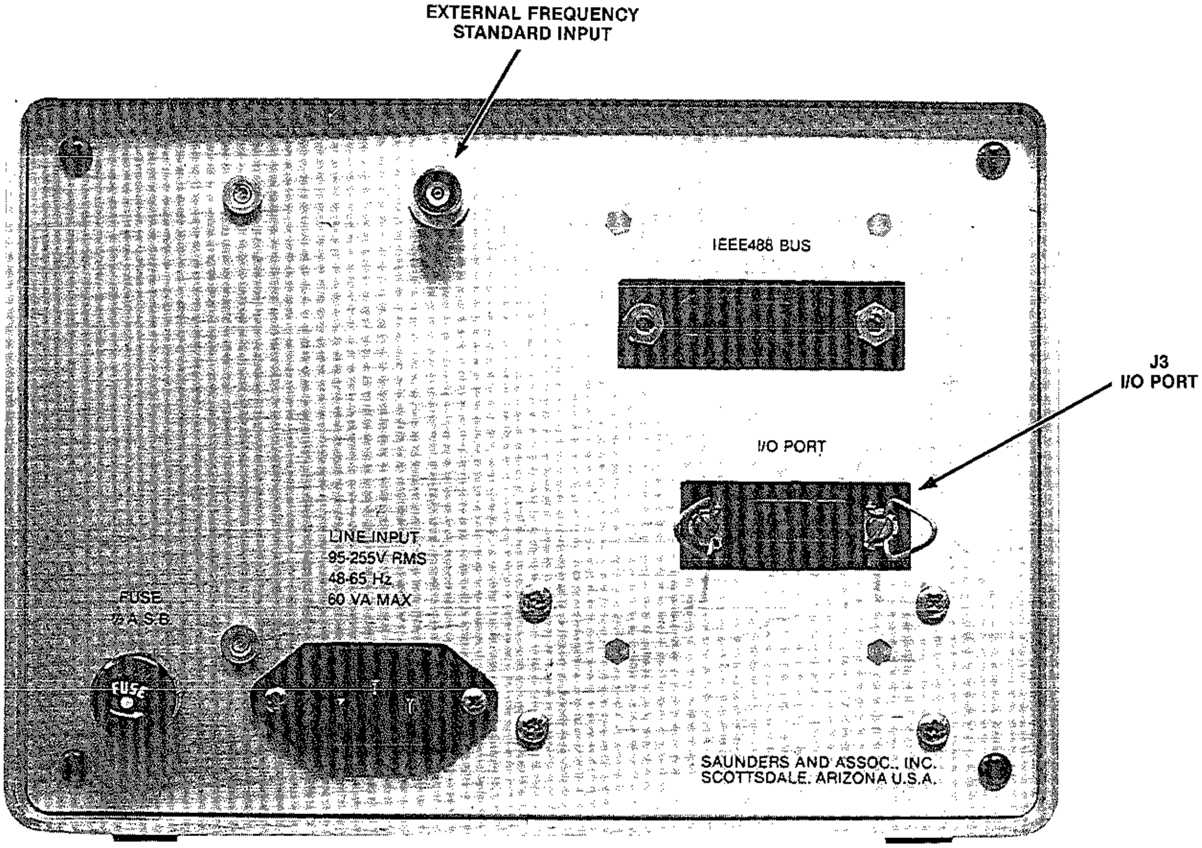
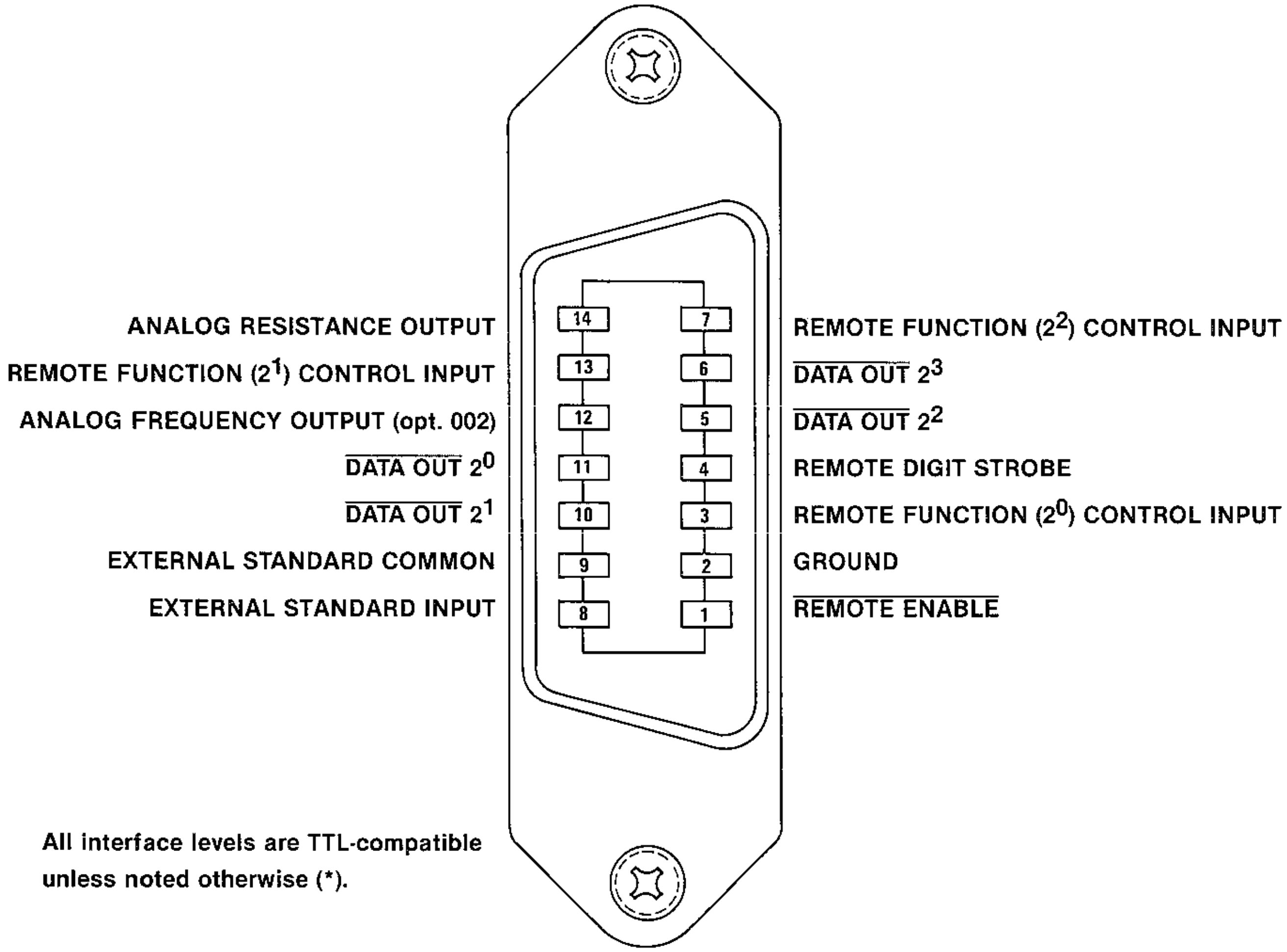


FIGURE 7-2. BACK PANEL



All interface levels are TTL-compatible unless noted otherwise (*).

Pin	Function	
2	Interface Ground	
11	2^0	Data Interface
10	2^1	Digit Strobe "1" = Digit Value Complemented
5	2^2	"0" = Digit Number Complemented
6	2^3	
4	Remote Digit Strobe	Clocks data out
1	Remote Enable	"1" = Internal Control (Front Panel Controls Enabled.) "0" = External Control (All functions must be set remotely and digit control must be done external to the 150C.)
3	2^0	
13	2^1	Remote Functional Control
7	2^2	

FIGURE 7-3. REMOTE INTERFACE CONNECTOR (J3)

J3-3 2^0	J3-13 2^1	J3-7 2^2	FUNCTION
1	1	0	Power
0	0	1	C_t
1	0	1	R
0	1	1	F_p
1	1	1	F_s

9 **External standard common.**

12 **Frequency Deviation Output (option 002) typically 1 volt per 100 ppm.**

8 **External standard input**
0.3 V p-p to 10 V p-p Sine or square waves

14 **Analog Resistance Output—Analog Voltage of crystal under test resistance. Valid in all operating modes 1, 2, 3 and 9, A, B.**

For Option	Scale Factor
STD	0.1 volt/1KΩ
004L	1 volt/1KΩ
004H	0.01 volt/1KΩ

FIGURE 7-3. (continued) 150C REMOTE INTERFACE CONNECTOR (J3)

SECTION 8

150C SCHEMATICS AND PARTS LIST

Section 8 covers the schematics of the 150C circuitry and part position photos of the parts in the 150C assembly. Also included are listings of the parts used and a list of manufacturers who can supply the parts.

SCHEMATICS

The schematics and parts layout for the 150C are shown in Figures 8-1 through 8-12. Figure 8-1 shows the parts position and Figure 8-2 shows the schematic of the Analog measurement circuit board.

Figure 8-3 shows the parts position with Figures 8-4 through 8-7 and Figure 8-9 showing the schematic of the microprocessor, counter and control logic.

Figures 8-8, 8-9 and 8-10 show the parts position and schematic respectively of the back panel.

Figures 8-11 and 8-12 show the display circuit board and the schematic.

PARTS LIST

The parts and the schematic identifiers are shown in Figures 8-13 through 8-16. The chassis assembly parts are shown in Figure 8-17.

Several parts are subassemblies. Figure 8-18 shows the several chassis parts with the painted and unpainted part numbers.

The coil assemblies with the inductance value and winding specifications are shown in Figure 8-19.

Figures 8-20 and 8-21 show the parts which are added to the Control Logic Board and the Back Panel respectively for the IEEE 488 Data Bus Option. These parts are not included in the assembly if the 488 Bus Option was not ordered.

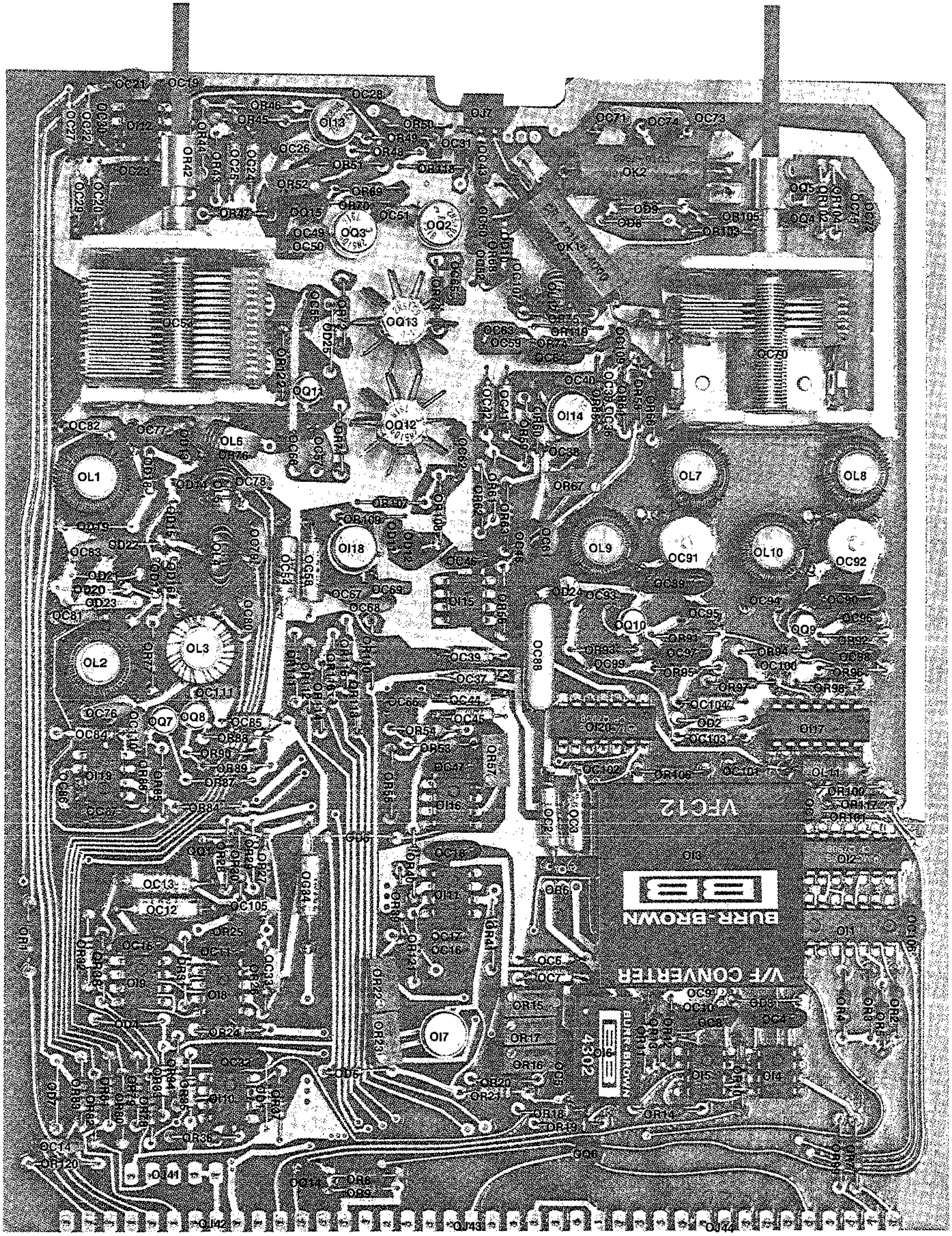


FIGURE 8-1. PARTS LOCATION ON THE ANALOG CRYSTAL MEASUREMENT CIRCUIT BOARD.

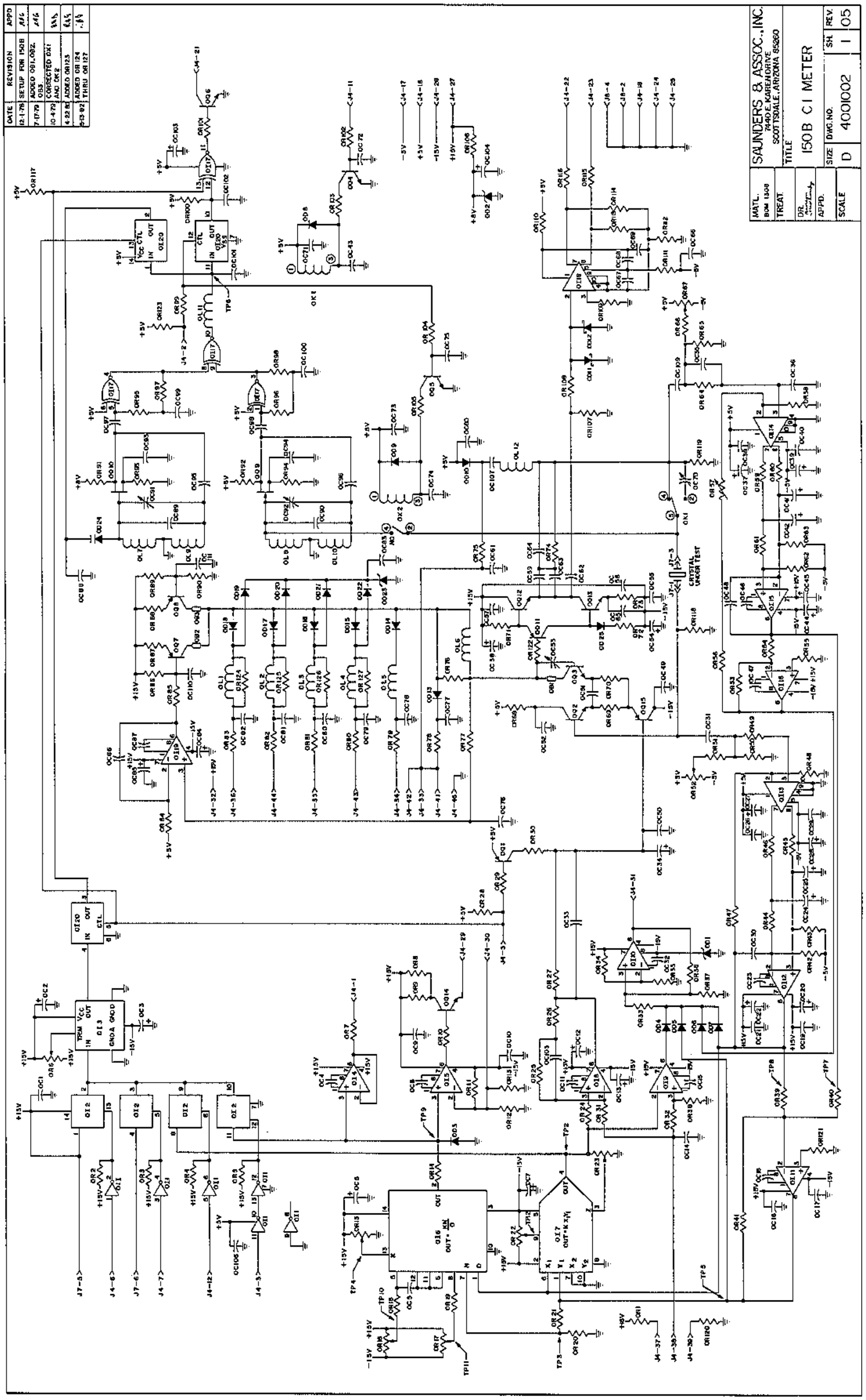


FIGURE 8-2. ANALOG CRYSTAL MEASUREMENT CIRCUIT

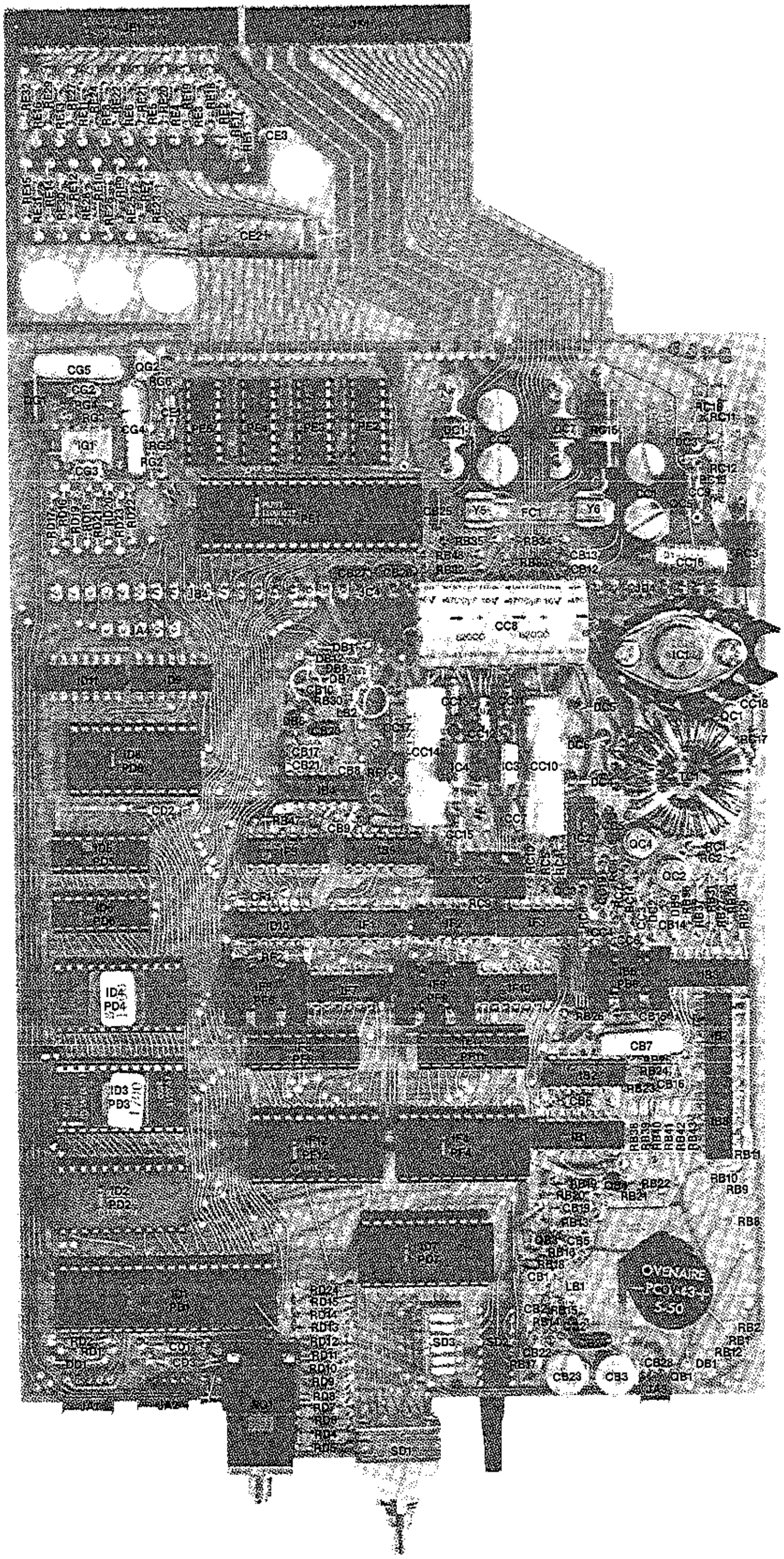


FIGURE 8-3. 150C CI METER CONTROL LOGIC BOARD

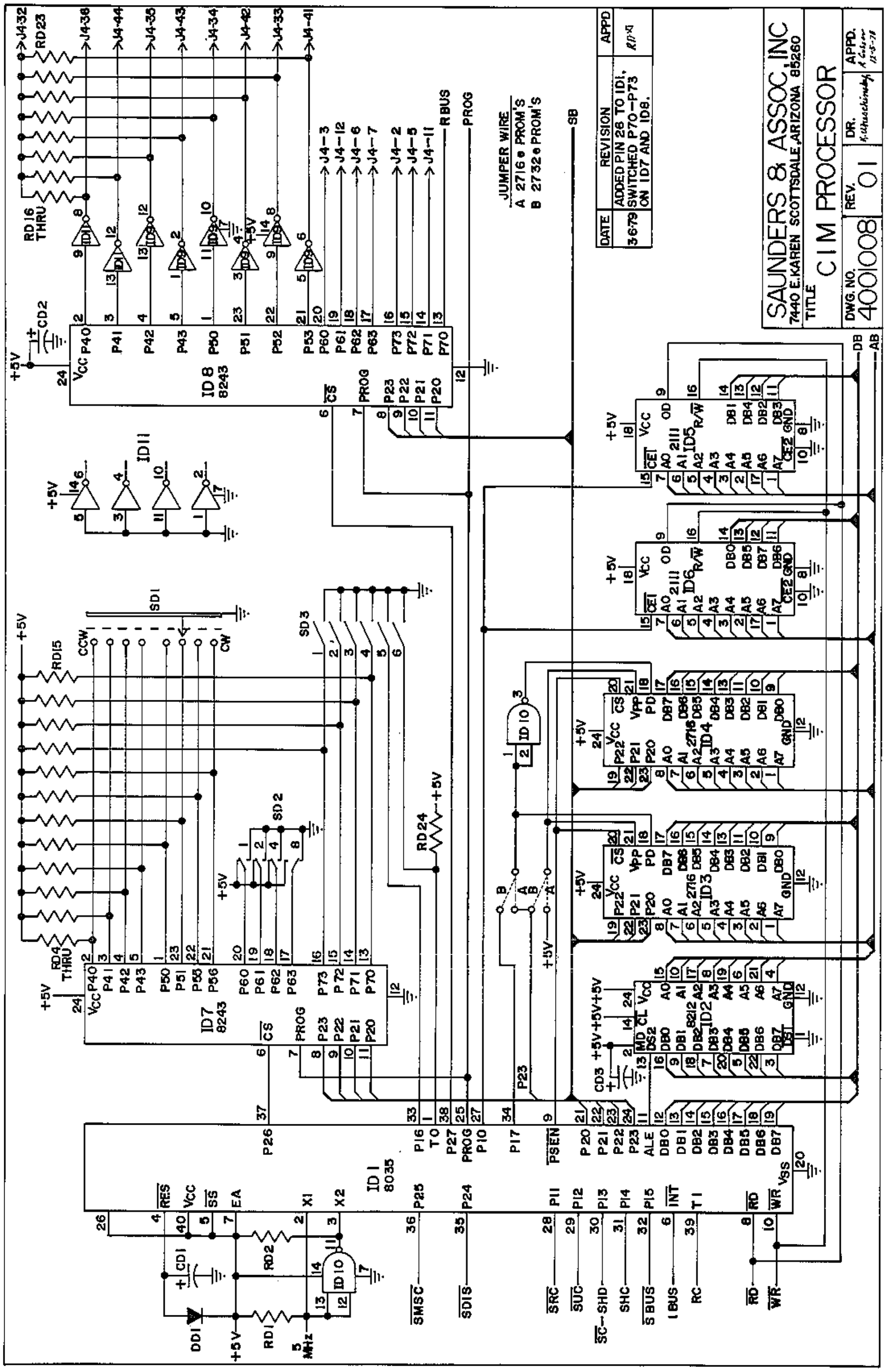


FIGURE 8-4. CONTROL PROCESSOR
INCLUDING ROM & RAM MEMORY AND MISCELLANEOUS INPUT OUTPUT

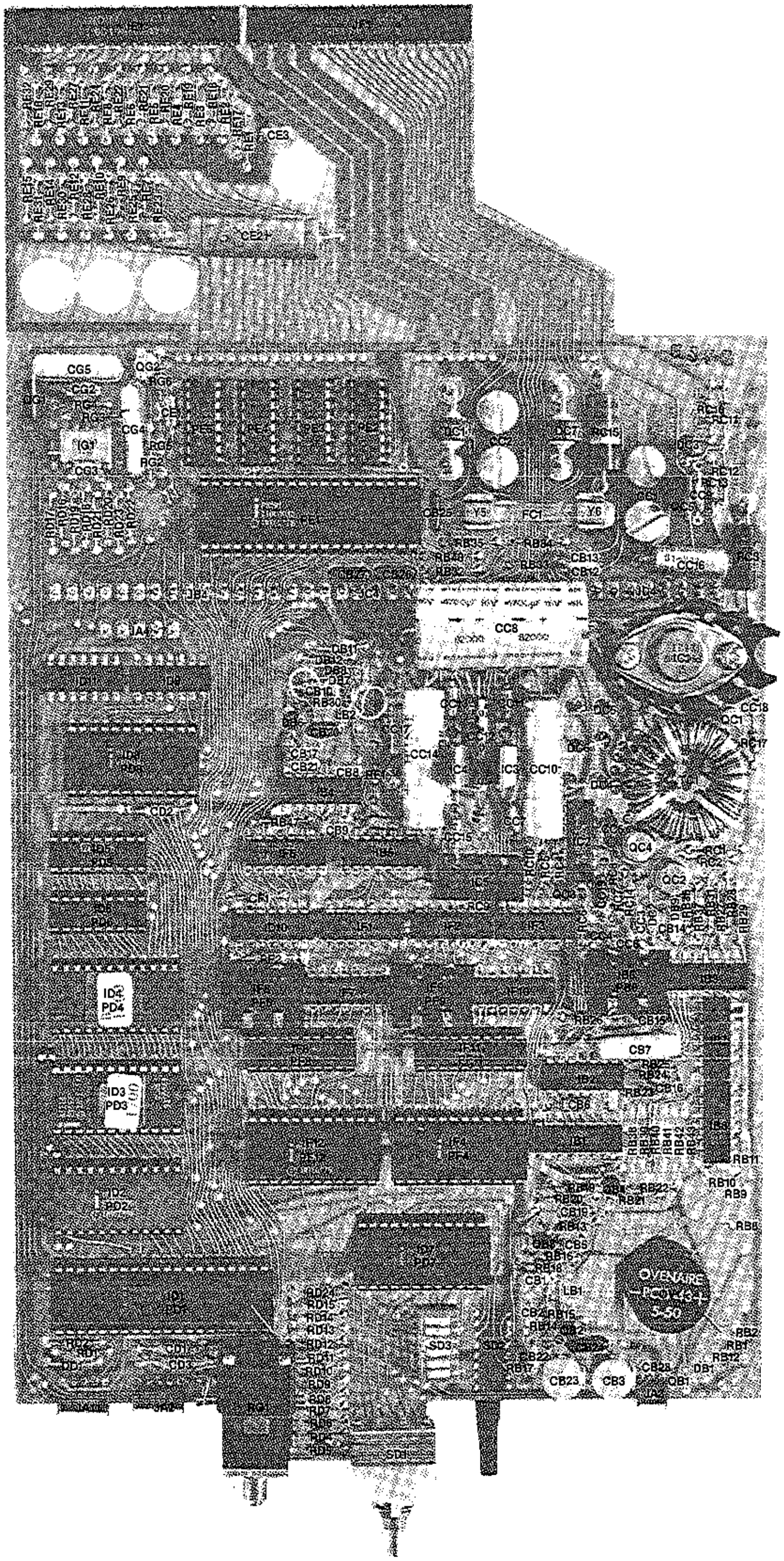


FIGURE 8-3. REPEATED

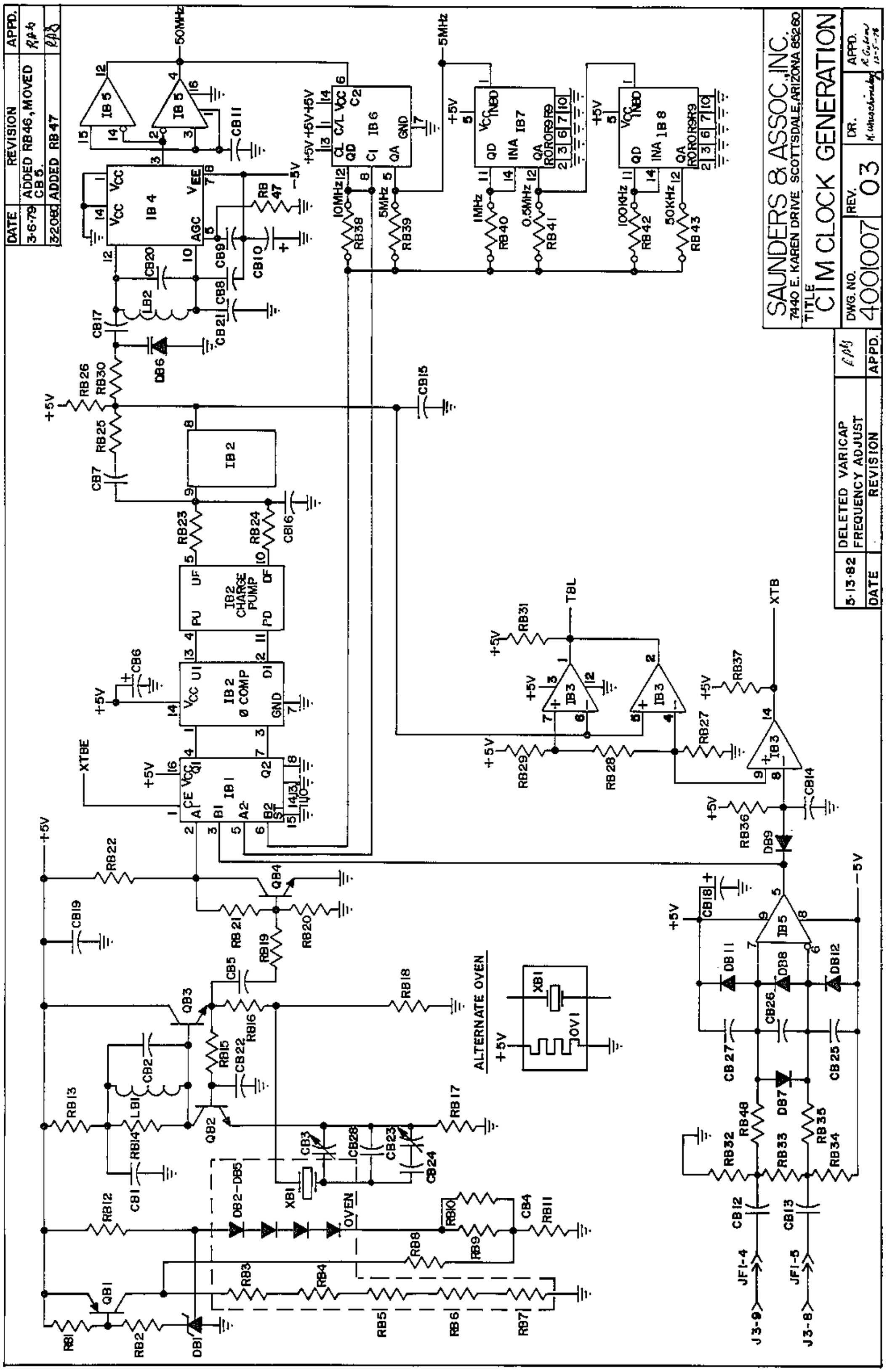


FIGURE 8-5. PRECISION STANDARD GENERATION

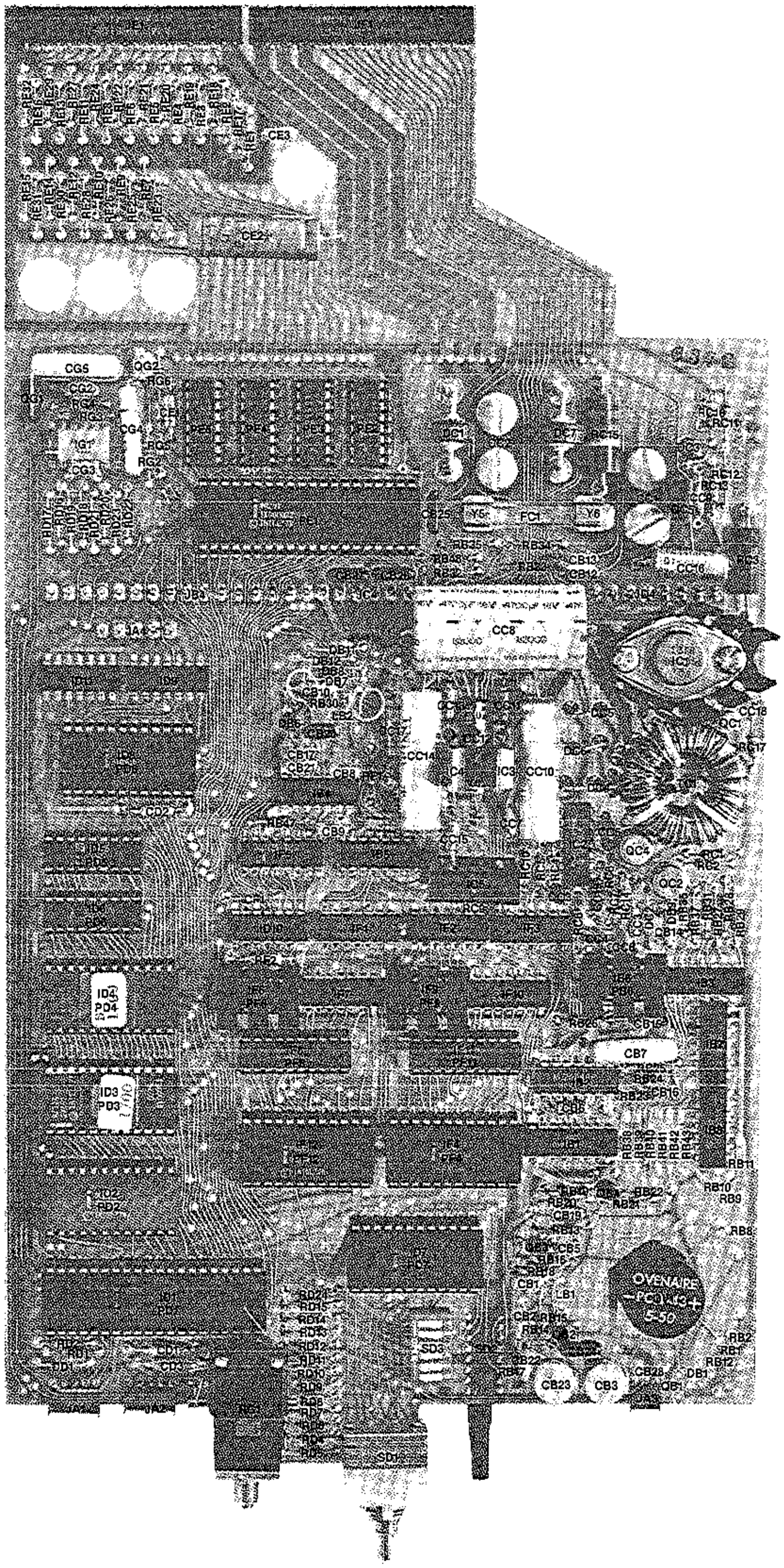


FIGURE 8-3. REPEATED

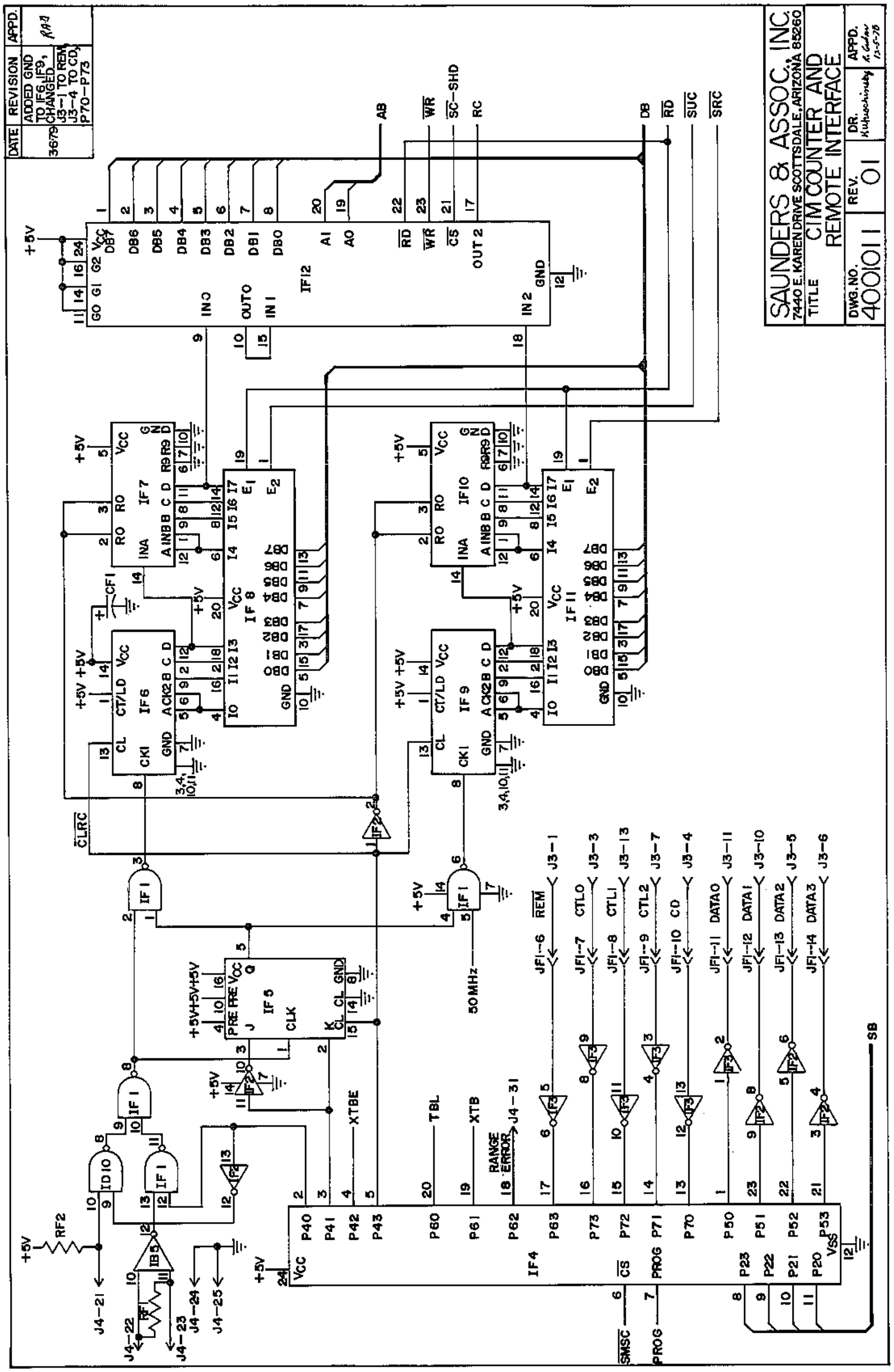


FIGURE 8-6. PERIOD COUNTER AND KEYBOARD/DIGIT SERIAL REMOTE OUTPUT

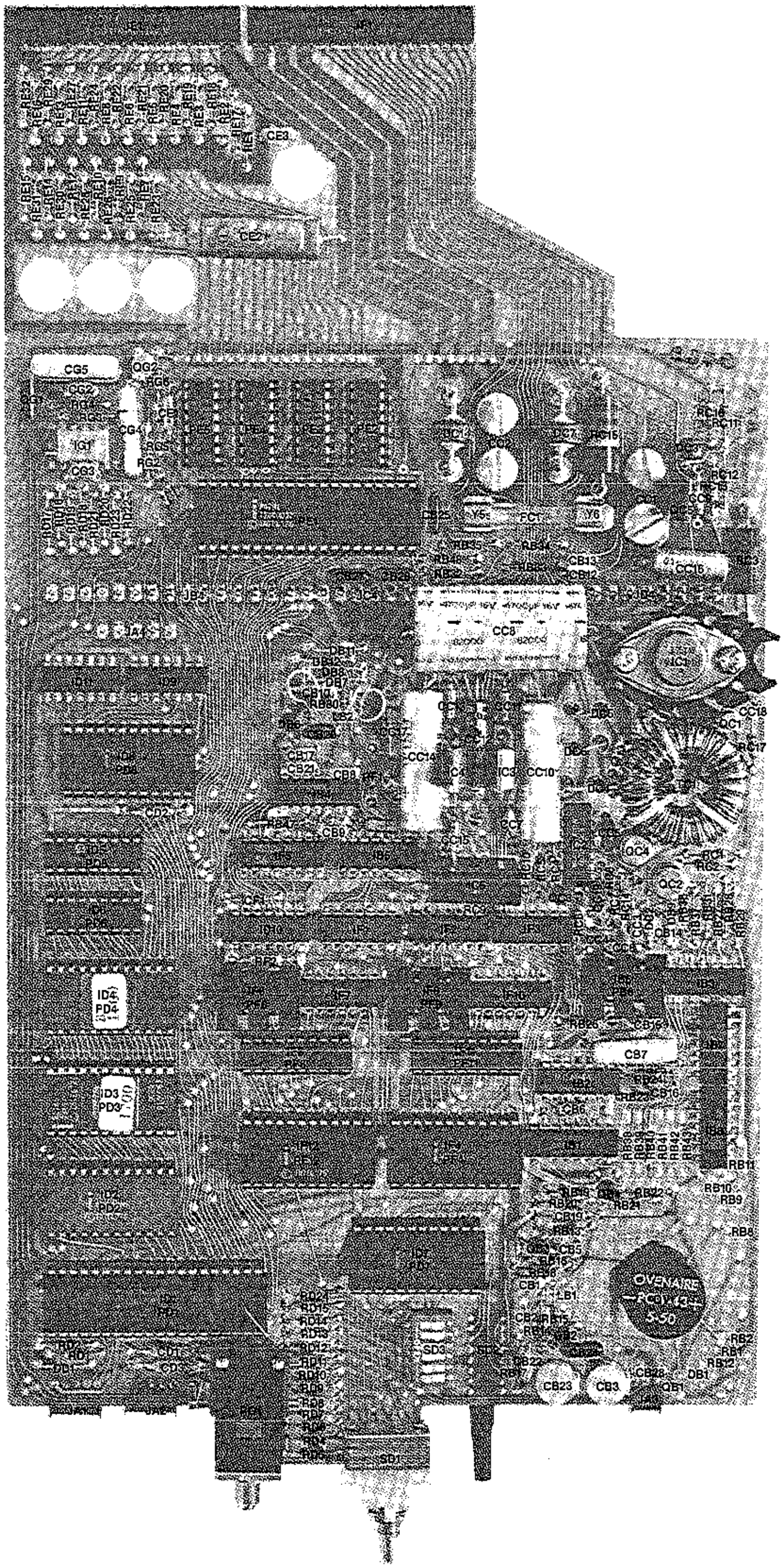


FIGURE 8-3. REPEATED

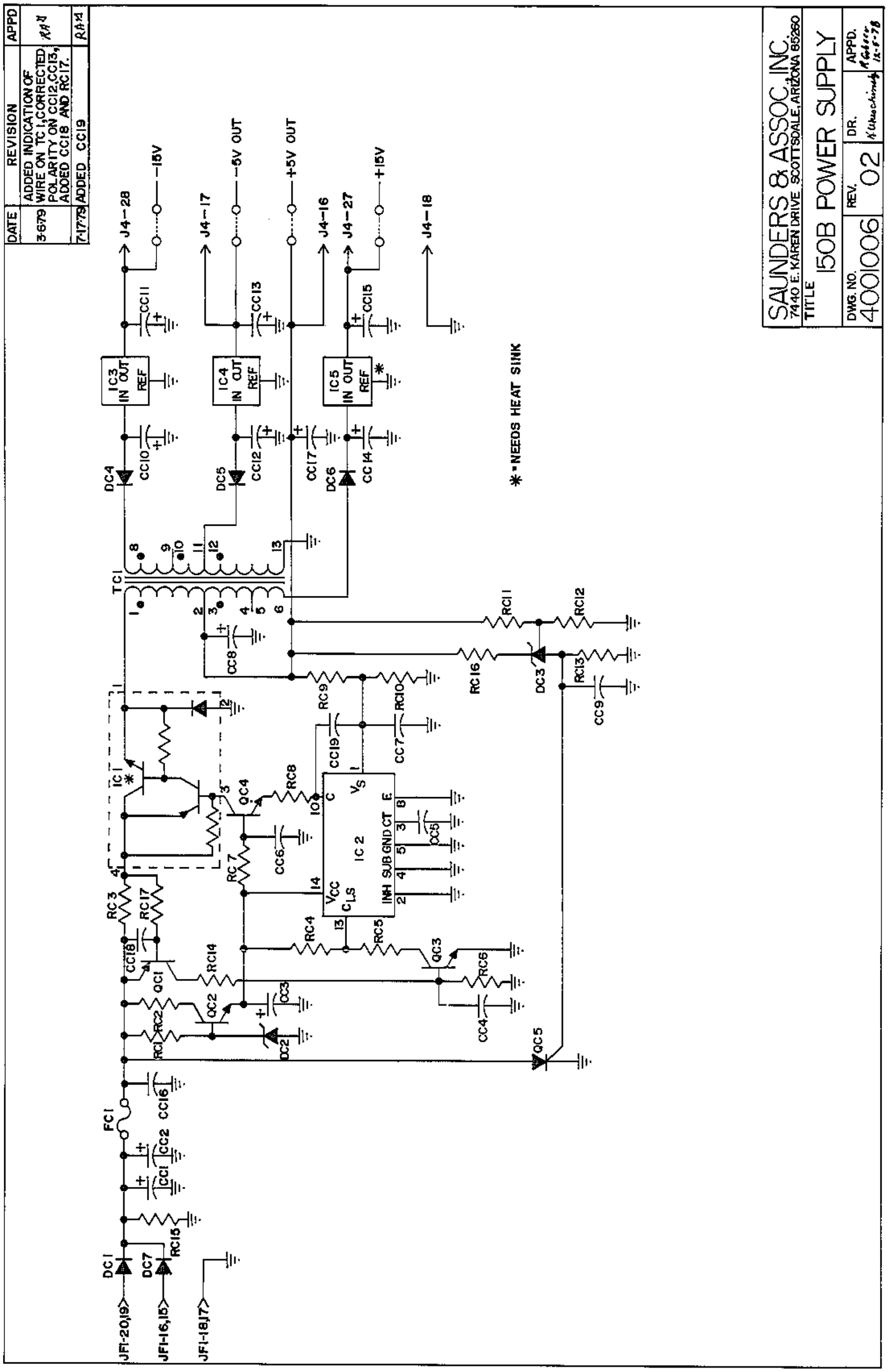


FIGURE 8-7. POWER SUPPLY

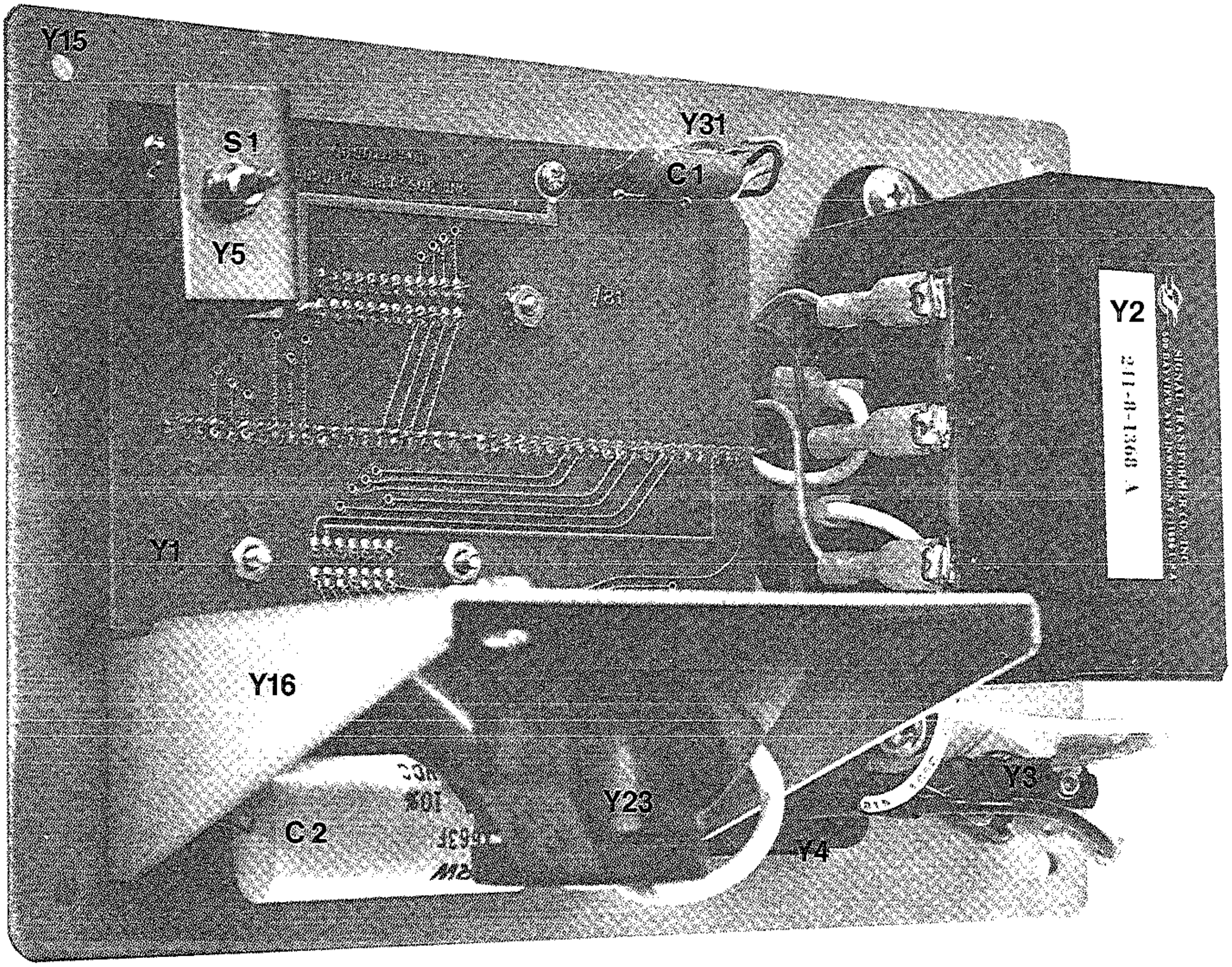


FIGURE 8-8. BACK PANEL CONNECTORS AND TRANSFORMER MOUNTING

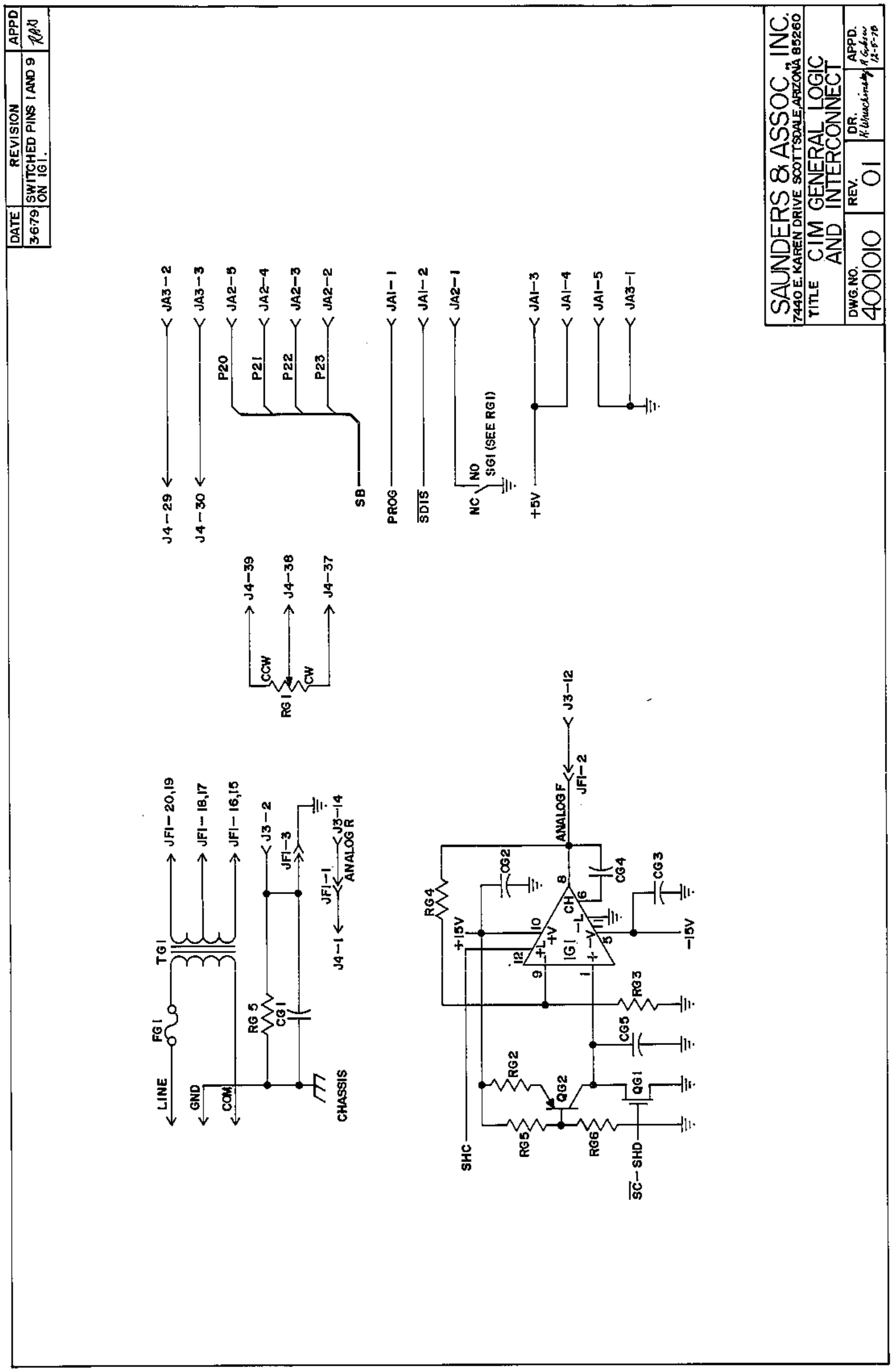


FIGURE 8-9. CIRCUIT INTERCONNECT AND ANALOG FREQUENCY OUTPUT OPTION

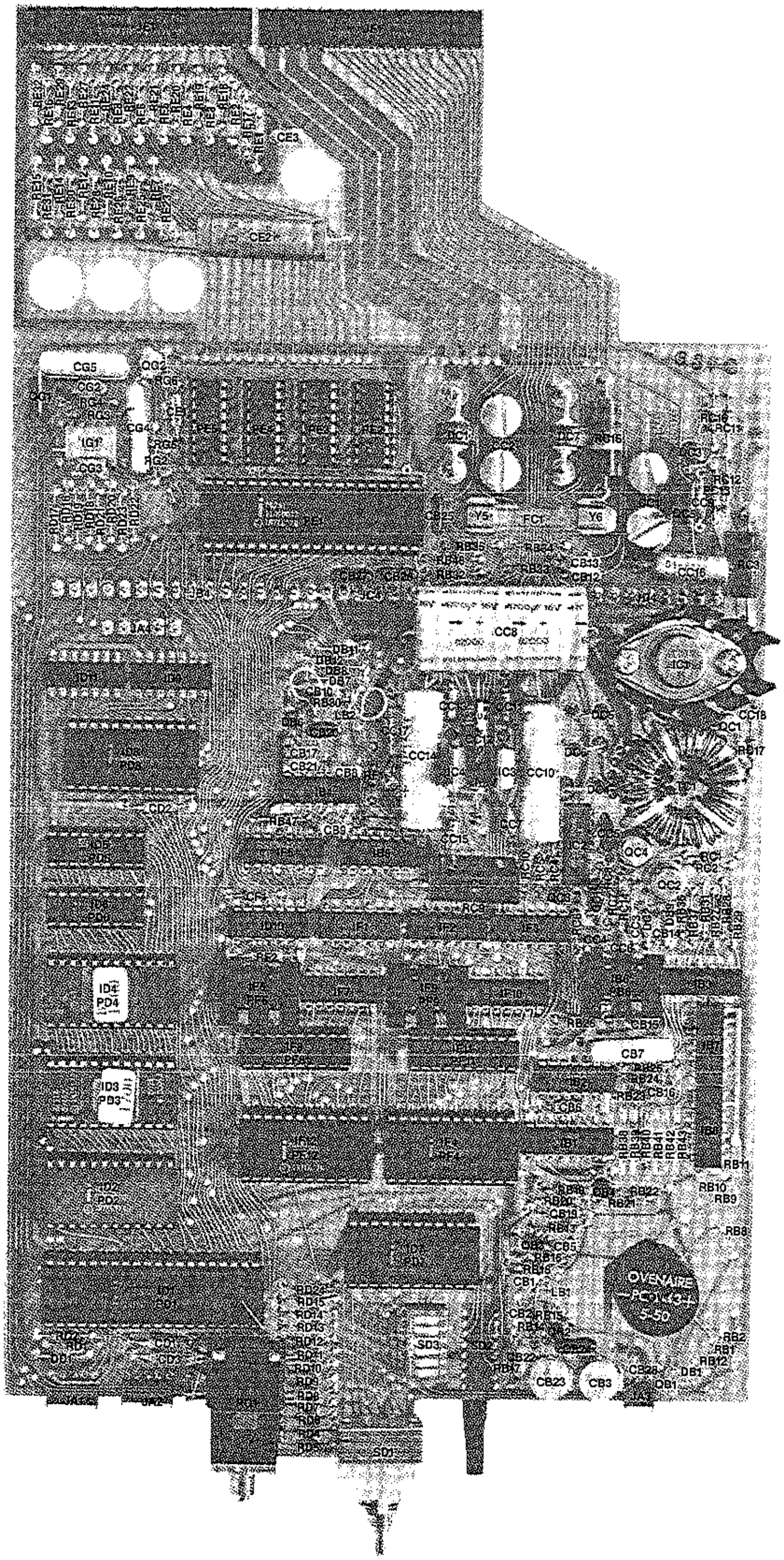


FIGURE 8-3. REPEATED

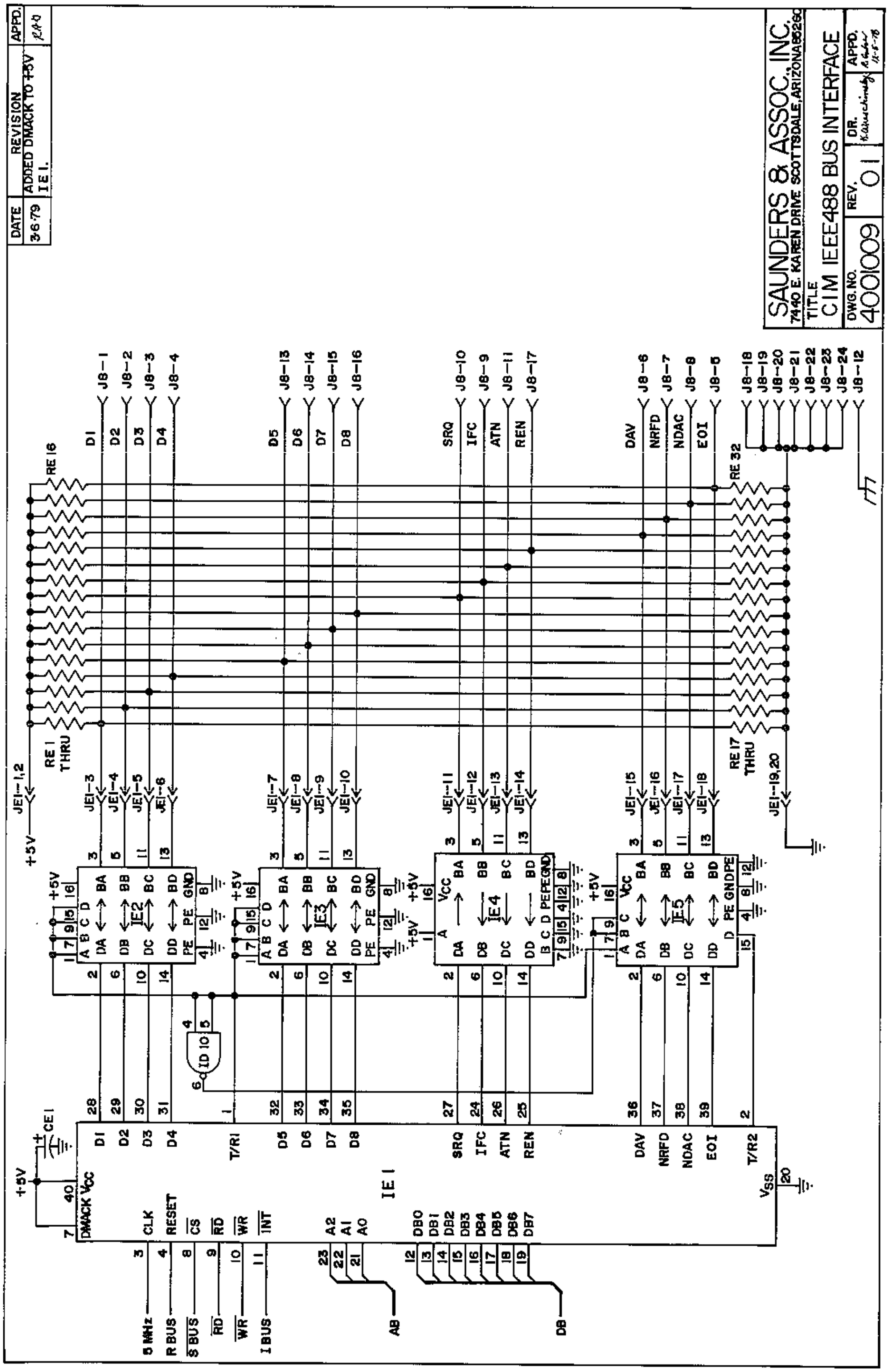


FIGURE 8-10. IEEE 488 DATA BUS OPTION

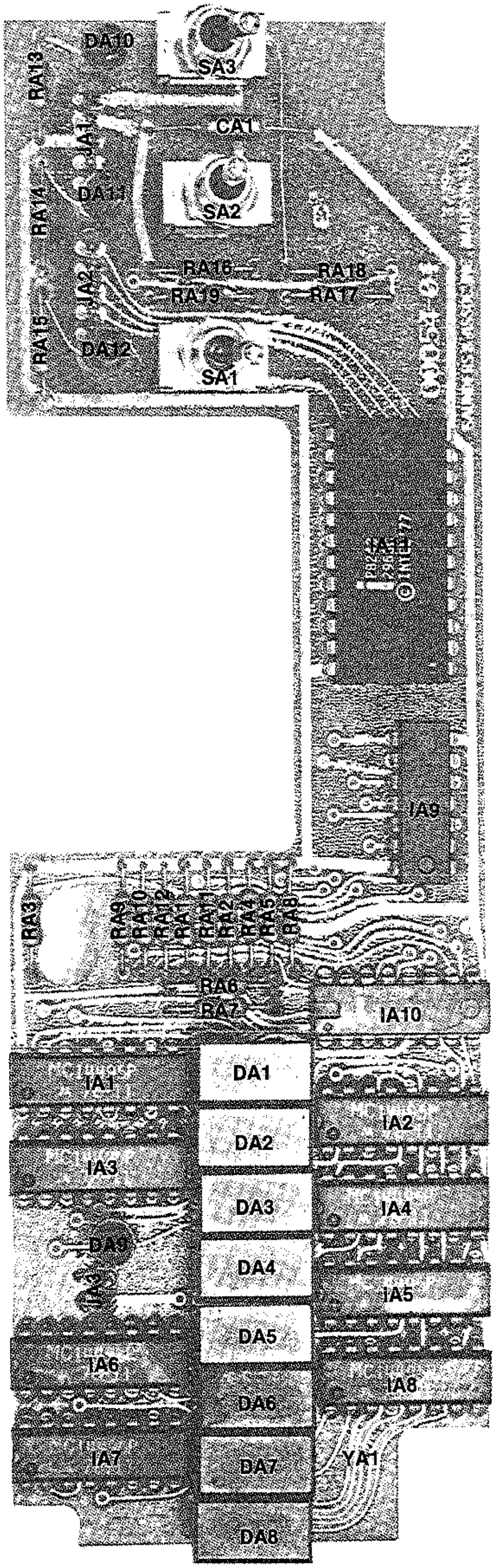


FIGURE 8-11. DISPLAY CIRCUIT BOARD PARTS POSITION

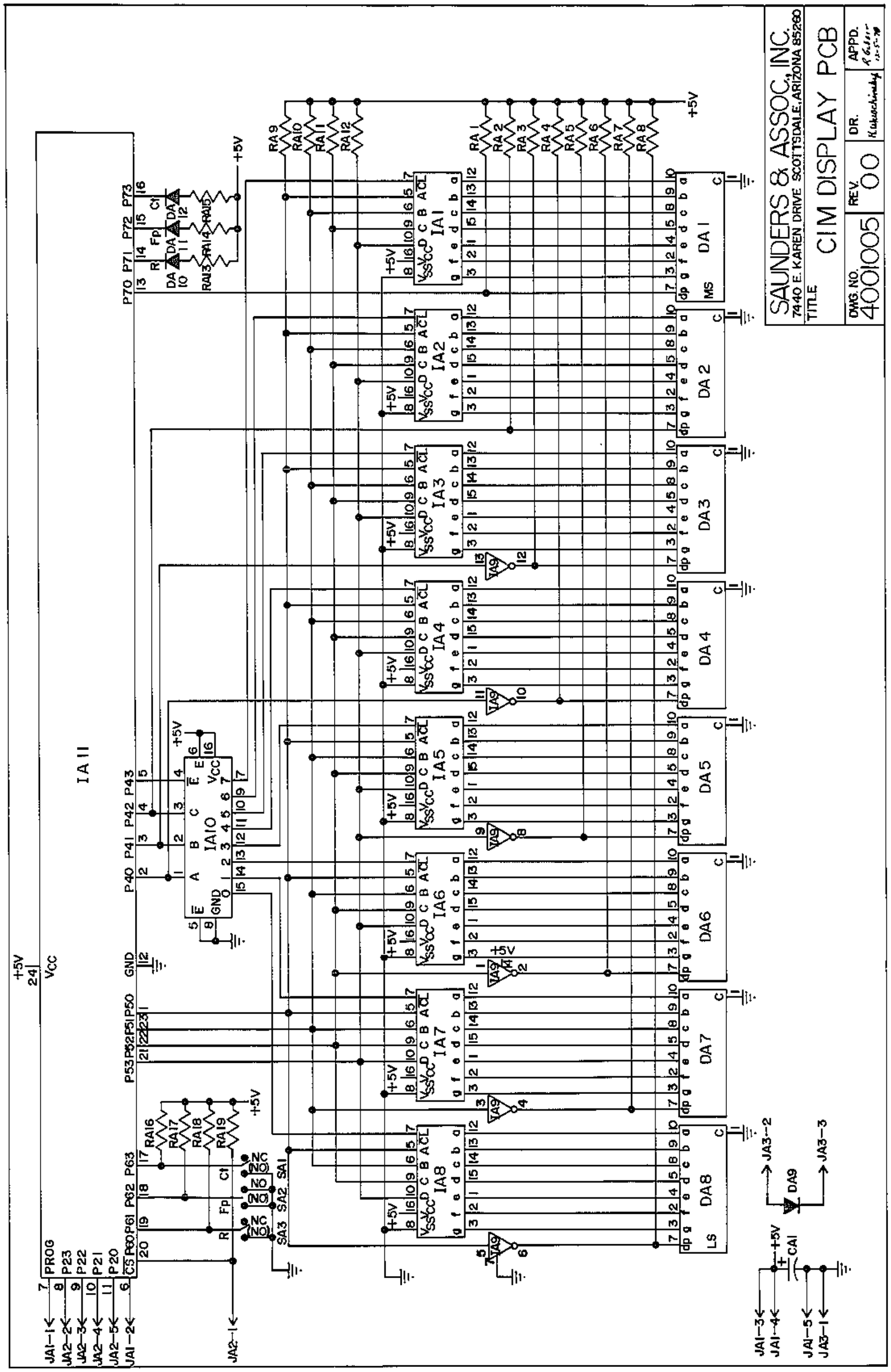


FIGURE 8-12. DISPLAY CIRCUIT

150B CI METER ANALOG BOARD
BILL1308

ID	CATEGORY	DESCRIPTION		S&A PART #
0B1	IND	TORROIDAL	FERRITE BEAD	2110002
0B2	IND	TORROIDAL	FERRITE BEAD	2110002
0B3	IND	TORROIDAL	FERRITE BEAD	2110002
0C1	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C2	CAP	Tantalum	4.7UF 50V	3400000
0C3	CAP	Tantalum	4.7UF 50V	3400000
0C4	CAP	MICA	5% 30PF	3230300
0C5	CAP	Ceramic Fix	0.1UFML 50V	3010000
0C6	CAP	Tantalum	2.2UF 20V	3400001
0C7	CAP	Tantalum	2.2UF 20V	3400001
0C8	CAP	MICA	5% 30PF	3230300
0C9	---Not Used			
0C10	---Not Used			
0C11	CAP	MICA	5% 30PF	3230300
0C12	CAP	Tantalum	4.7UF 50V	3400000
0C13	CAP	Tantalum	4.7UF 50V	3400000
0C14	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C15	CAP	MICA	5% 30PF	3230300
0C16	CAP	Ceramic Fix	0.1UFML 50V	3010000
0C17	CAP	Ceramic Fix	0.1UFML 50V	3010000
0C18	CAP	MICA	5% 30PF	3230300
0C19	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C20	CAP	Tantalum	2.2UF 20V	3400001
0C21	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C22	CAP	Tantalum	2.2UF 20V	3400001
0C23	CAP	MICA	5% 30PF	3230300
0C24	CAP	Tantalum	2.2UF 20V	3400001
0C25	CAP	Tantalum	2.2UF 20V	3400001
0C26	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C27	CAP	Tantalum	2.2UF 20V	3400001
0C28	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C29	CAP	Tantalum	2.2UF 20V	3400001
0C30	CAP	Ceramic Fix	0.1UFML 50V	3010000
0C31	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C32	CAP	MICA	5% 30PF	3230300
0C33	CAP	Ceramic Fix	.47UFML 50V	3010001
0C34	CAP	Tantalum	4.7UF 50V	3400000
0C35	Selected Part			
0C36	Selected Part			
0C37	CAP	Tantalum	2.2UF 20V	3400001
0C38	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C39	CAP	Tantalum	2.2UF 20V	3400001
0C40	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C41	CAP	Tantalum	2.2UF 20V	3400001
0C42	CAP	Tantalum	2.2UF 20V	3400001
0C43	CAP	Ceramic Fix	.01UF 50VDC	3000010

FIGURE 8-13. PARTS USED ON THE ANALOG MEASUREMENT CIRCUIT BOARD

150B CI METER ANALOG BOARD
BILL1308

ID	CATEGORY	DESCRIPTION		S&A PART #
OC44	CAP	Tantalum	2.2UF 20V	3400001
OC45	CAP	Tantalum	2.2UF 20V	3400001
OC46	CAP	MICA	5% 30PF	3230300
OC47	CAP	MICA	5% 30PF	3230300
OC48	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC49	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC50	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC51	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC52	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC53	CAP	AIR VAR	0-360PF PCBM	3600004
OC54	CAP	Tantalum	4.7UF 50V	3400000
OC55	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC56	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC57	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC58	CAP	Tantalum	4.7UF 50V	3400000
OC59	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC60	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC61	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC62	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC63	CAP	Ceramic Fix	0.1UFML 50V	3010000
OC64	CAP	MICA	5% 20PF	3230200
OC65	CAP	Ceramic Fix	0.1UFML 50V	3010000
OC66	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC67	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC68	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC69	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC70	CAP	AIR VAR	6-100PF PCBM	3600005
OC71	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC72	CAP	Ceramic Fix	4700PF25VDC	3000000
OC73	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC74	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC75	CAP	Ceramic Fix	4700PF25VDC	3000000
OC76	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC77	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC78	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC79	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC80	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC81	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC82	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC83	CAP	Ceramic Fix	.01UF 50VDC	3000010
OC84	CAP	Tantalum	2.2UF 20V	3400001
OC85	CAP	Tantalum	2.2UF 20V	3400001
OC86	CAP	Ceramic Fix	0.1UFML 50V	3010000
OC87	CAP	MICA	5% 30PF	3230300
OC88	CAP	Misc.	.47uF 250V	3900000
OC89	CAP	MICA	2% 1.20NF	3221201
OC90	CAP	MICA	2% 1.20NF	3221201
OC91	CAP	AIR VAR	6-60PF PCM	3610000

FIGURE 8-13. CONTINUED

150B CI METER ANALOG BOARD
BILL1308

ID	CATEGORY	DESCRIPTION		S&A PART #
0C92	CAP	AIR VAR	6-60PF PCM	3610000
0C93	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C94	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C95	CAP	Ceramic Fix	4700PF25VDC	3000000
0C96	CAP	Ceramic Fix	4700PF25VDC	3000000
0C97	CAP	MICA	5% 30PF	3230300
0C98	CAP	MICA	5% 30PF	3230300
0C99	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C100	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C101	CAP	Ceramic Fix	4700PF25VDC	3000000
0C102	CAP	Ceramic Fix	4700PF25VDC	3000000
0C103	CAP	Tantalum	2.2UF 20V	3400001
0C104	CAP	Tantalum	2.2UF 20V	3400001
0C105	CAP	Ceramic Fix	.47UFML 50V	3010001
0C106	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C107	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C109	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C110	CAP	Ceramic Fix	.01UF 50VDC	3000010
0C111	CAP	Ceramic Fix	.01UF 50VDC	3000010
0D1	SEM	ZENER DIODE	4.7V 1/4W	5615230
0D2	SEM	ZENER DIODE	8.2V 1/4W	5615237
0D3	SEM	DIODE	GOLD DOPED	5314148
0D4	SEM	DIODE	GOLD DOPED	5314148
0D5	SEM	DIODE	GOLD DOPED	5314148
0D6	SEM	DIODE	GOLD DOPED	5314148
0D7	SEM	DIODE	GOLD DOPED	5314148
0D8	SEM	DIODE	GOLD DOPED	5314148
0D9	SEM	DIODE	GOLD DOPED	5314148
0D10	SEM	PIN DIODE	SWITCH	5503401
0D11	SEM	DIODE H CAR	SMALL SIGNAL	5400101
0D12	SEM	DIODE H CAR	SMALL SIGNAL	5400101
0D13	SEM	PIN DIODE	SWITCH	5503401
0D14	SEM	PIN DIODE	SWITCH	5503401
0D15	SEM	PIN DIODE	SWITCH	5503401
0D16	SEM	PIN DIODE	SWITCH	5503401
0D17	SEM	PIN DIODE	SWITCH	5503401
0D18	SEM	PIN DIODE	SWITCH	5503401
0D19	SEM	DIODE	GOLD DOPED	5314148
0D20	SEM	DIODE	GOLD DOPED	5314148
0D21	SEM	DIODE	GOLD DOPED	5314148
0D22	SEM	DIODE	GOLD DOPED	5314148
0D23	SEM	ZENER DIODE	8.2V 1/4W	5615237
0D24	SEM	VARICAP	42PF 2.6/1	5800104
0D25	SEM	DIODE	GOLD DOPED	5314148
0H1	SUP	NUTS, ETC	6X1 NY SCREW	6233203
0H2	SUP	NUTS, ETC	6X1 NY SCREW	6233203

FIGURE 8-13. CONTINUED

150B CI METER ANALOG BOARD
BILL1308

ID	CATEGORY	DESCRIPTION		S&A PART #
OH3	SUP	NUTS, ETC	6X1 NY SCREW	6233203
OH4	SUP	NUTS, ETC	6X1 NY SCREW	6233203
OH5	SUP	NUTS, ETC	6X1 NY SCREW	6233203
OH6	SUP	NUTS, ETC	6X1 NY SCREW	6233203
OH7	SUP	NUTS, ETC	6X1 NY SCREW	6233203
OH8	SUP	NUTS, ETC	NYLON WASH	6233270
OH9	SUP	NUTS, ETC	NYLON WASH	6233270
OH10	SUP	NUTS, ETC	NYLON WASH	6233270
OH11	SUP	NUTS, ETC	NYLON WASH	6233270
OH12	SUP	NUTS, ETC	NYLON WASH	6233270
OH13	SUP	NUTS, ETC	NYLON WASH	6233270
OH14	SUP	NUTS, ETC	NYLON WASH	6233270
OI1	I C	TTL	HEX INVERTER	4128121
OI2	I C	DIGITAL	ANLG MULT	4214016
OI3	I C	OP AMP BIP	V/F CONVERT	4400012
OI4	I C	OP AMP BIP	GEN PURPOSE	4400301
OI5	I C	OP AMP BIP	GEN PURPOSE	4400301
OI6	I C	OP AMP BIP	MULTFUNCT CV	4404302
OI7	I C	Mis.Lin BJT	MULTIPLIER	4304205
OI8	I C	OP AMP BIP	GEN PURPOSE	4400301
OI9	I C	OP AMP BIP	GEN PURPOSE	4400301
OI10	I C	OP AMP BIP	GEN PURPOSE	4400301
OI11	I C	OP AMP BIP	GEN PURPOSE	4400301
OI12	I C	OP AMP BIP	GEN PURPOSE	4400301
OI13	I C	Mis.Lin BJT	HS COMP	4300685
OI14	I C	Mis.Lin BJT	HS COMP	4300685
OI15	I C	OP AMP BIP	GEN PURPOSE	4400301
OI16	I C	OP AMP BIP	GEN PURPOSE	4400301
OI17	I C	DIGITAL	OD EX-OR	4214507
OI18	I C	Mis.Lin BJT	HS COMP	4300685
OI19	I C	OP AMP BIP	GEN PURPOSE	4400301
OI20	I C	DIGITAL	ANLG MULT	4214016
OJ7	SUP	ASSEM PART	RECP-3 RT. L	6110032
OJ41	SUP	ASSEM PART	RECP-5 ST	6110052
OJ42	SUP	ASSEM PART	RECP 15 ST	6110151
OJ43	SUP	ASSEM PART	RECP 10 RT.L	6110101
OJ44	SUP	ASSEM PART	RECP 15 ST	6110151
OK1	IND	RELAYS	SPDT 5V	2001003
OK2	IND	RELAYS	1P1T 5V	2001000
OL1	ABY	WOUND IND	70UH TORR	0001280
OL2	ABY	WOUND IND	14.25 uH	0001046
OL3	ABY	WOUND IND	3.4uH Tor.	0001068
OL4	ABY	WOUND IND	0.8uH Tor.	0001069
OL5	ABY	WOUND IND	0.17uH Tor.	0001070

FIGURE 8-13. CONTINUED

150B CI METER ANALOG BOARD
BILL1308

ID	CATEGORY	DESCRIPTION	S&A PART #
0L6	ABY	WOUND IND 0.095uH Tor.	0001071
0L7	ABY	WOUND IND 14.25 uH	0001046
0L8	ABY	WOUND IND 14.25 uH	0001046
0L9	ABY	WOUND IND 17.8 uH	0001044
0L10	ABY	WOUND IND 17.8 uH	0001044
0L11	IND	WEEDUCTOR 5% 1.00MH	2331004
0L12	ABY	WOUND IND .5UH	0001092
0Q1	SEM	TRANSISTOR PNP GEN. PUR	5123905
0Q2	SEM	TRANSISTOR NPN VHF-CATV	5125109
0Q3	SEM	TRANSISTOR NPN VHF-CATV	5125109
0Q4	SEM	TRANSISTOR NPN AU DOPED	5125769
0Q5	SEM	TRANSISTOR NPN AU DOPED	5125769
0Q6	SEM	TRANSISTOR NPN AU DOPED	5125769
0Q7	SEM	TRANSISTOR PNP SWITCH	5122907
0Q8	SEM	TRANSISTOR PNP SWITCH	5122907
0Q9	SEM	FET JFET	5204416
0Q10	SEM	FET JFET	5204416
0Q11	SEM	TRANSISTOR PNP SWITCH	5122894
0Q12	SEM	TRANSISTOR NPN VHF-CATV	5125109
0Q13	SEM	TRANSISTOR NPN VHF-CATV	5125109
0Q14	SEM	TRANSISTOR NPN AU DOPED	5125769
0Q15	SEM	TRANSISTOR PNP GEN. PUR	5123905
0R1	RES	15.0KO CC 1/4W 5%	1415005
0R2	RES	22.0KO CC 1/4W 5%	1422005
0R3	RES	22.0KO CC 1/4W 5%	1422005
0R4	RES	22.0KO CC 1/4W 5%	1422005
0R5	RES	22.0KO CC 1/4W 5%	1422005
0R6	---Not Used		
0R7	RES	120 O CC 1/4W 5%	1212005
0R8	RES	120 O CC 1/4W 5%	1212005
0R9	RES	120 O CC 1/4W 5%	1212005
0R10	RES	1000 O CC 1/4W 5%	1310005
0R11	RES	10.0KO CC 1/4W 5%	1410005
0R12	RES	270 O CC 1/4W 5%	1227005
0R13	RES	270 O CC 1/4W 5%	1227005
0R14	RES	2200 O CC 1/4W 5%	1322005
0R15	RES	Misc. 10K 20T POT	1921001
0R16	RES	Misc. 10K 20T POT	1921001
0R17	RES	Misc. 10K 20T POT	1921001
0R18	RES	4.70MO CC 1/4W 5%	1647005
0R19	RES	4.70MO CC 1/4W 5%	1647005
0R20	RES	1500 O CC 1/4W 5%	1315005
0R21	RES	10.0KO CC 1/4W 5%	1410005
0R22	RES	Misc. 10K 20T POT	1921001
0R23	RES	Misc. 10K 20T POT	1921001
0R24	RES	10.0KO CC 1/4W 5%	1410005

FIGURE 8-13. CONTINUED

150B CI METER ANALOG BOARD
BILL1308

ID	CATEGORY	DESCRIPTION	S&A PART #
OR25	---Not Used		
OR26	RES	100 O CC 1/4W 5%	1210005
OR27	RES	4700 O CC 1/4W 5%	1347005
OR28	RES	100.0KO CC 1/4W 5%	1510005
OR29	RES	10.0KO CC 1/4W 5%	1410005
OR30	RES	680 O CC 1/4W 5%	1268005
OR31	RES	10.0KO CC 1/4W 5%	1410005
OR32	RES	33.0KO CC 1/4W 5%	1433005
OR33	RES	10.0KO CC 1/4W 5%	1410005
OR34	RES	4700 O CC 1/4W 5%	1347005
OR35	RES	10.0KO CC 1/4W 5%	1410005
OR36	RES	220.0KO CC 1/4W 5%	1522005
OR37	RES	100.0KO CC 1/4W 5%	1510005
OR38	RES	100.0KO CC 1/4W 5%	1510005
OR39	RES	27.0KO CC 1/4W 5%	1427005
OR40	RES	10.0KO CC 1/4W 5%	1410005
OR41	RES	10.0KO CC 1/4W 5%	1410005
OR42	RES	27.0KO CC 1/4W 5%	1427005
OR43	RES	39.0KO CC 1/4W 5%	1439005
OR44	RES	4700 O CC 1/4W 5%	1347005
OR45	RES	2200 O CC 1/4W 5%	1322005
OR46	RES	2200 O CC 1/4W 5%	1322005
OR47	RES	12.0KO CC 1/4W 5%	1412005
OR48	RES	1000 O CC 1/4W 5%	1310005
OR49	RES	120 O CC 1/4W 5%	1212005
OR50	RES	1000 O CC 1/4W 5%	1310005
OR51	RES	56.0KO CC 1/4W 5%	1456005
OR52	RES	Misc. 10K 20T POT	1921001
OR53	RES	4700 O CC 1/4W 5%	1347005
OR54	RES	4700 O CC 1/4W 5%	1347005
OR55	RES	2200 O CC 1/4W 5%	1322005
OR56	RES	2200 O CC 1/4W 5%	1322005
OR57	RES	Misc. 10K 20T POT	1921001
OR58	RES	1000 O CC 1/4W 5%	1310005
OR59	RES	2200 O CC 1/4W 5%	1322005
OR60	RES	2200 O CC 1/4W 5%	1322005
OR61	RES	4700 O CC 1/4W 5%	1347005
OR62	RES	27.0KO CC 1/4W 5%	1427005
OR63	RES	39.0KO CC 1/4W 5%	1439005
OR64	RES	120 O CC 1/4W 5%	1212005
OR65	RES	1000 O CC 1/4W 5%	1310005
OR66	RES	56.0KO CC 1/4W 5%	1456005
OR67	RES	Misc. 10K 20T POT	1921001
OR68	RES	120 O CC 1/4W 5%	1212005
OR69	RES	1000 O CC 1/4W 5%	1310005
OR70	RES	1000 O CC 1/4W 5%	1310005
OR71	RES	1500 O CC 1/4W 5%	1315005
OR72	RES	100 O CC 1/4W 5%	1210005

FIGURE 8-13. CONTINUED

150B CI METER ANALOG BOARD
BILL1308

ID	CATEGORY	DESCRIPTION	S&A PART #
OR73	RES	12.0 O CC 1/4W 5%	1112005
OR74	RES	47.0 O CC 1/4W 5%	1147005
OR75	RES	470 O CC 1/4W 5%	1247005
OR76	---Not Used		
OR77	RES	27.0KO CC 1/4W 5%	1427005
OR78	RES	100 O CC 1/4W 5%	1210005
OR79	RES	100 O CC 1/4W 5%	1210005
OR80	RES	100 O CC 1/4W 5%	1210005
OR81	RES	100 O CC 1/4W 5%	1210005
OR82	RES	100 O CC 1/4W 5%	1210005
OR83	RES	100 O CC 1/4W 5%	1210005
OR84	RES	27.0KO CC 1/4W 5%	1427005
OR85	RES	3300 O CC 1/4W 5%	1333005
OR86	RES	3300 O CC 1/4W 5%	1333005
OR87	RES	180 O CC 1/4W 5%	1218005
OR88	RES	180 O CC 1/4W 5%	1218005
OR89	RES	470 O CC 1/4W 5%	1247005
OR90	RES	1000 O CC 1/4W 5%	1310005
OR91	RES	22.0KO CC 1/4W 5%	1422005
OR92	RES	22.0KO CC 1/4W 5%	1422005
OR93	RES	15.0KO CC 1/4W 5%	1415005
OR94	RES	15.0KO CC 1/4W 5%	1415005
OR95	RES	220.0KO CC 1/4W 5%	1522005
OR96	RES	220.0KO CC 1/4W 5%	1522005
OR97	RES	220.0KO CC 1/4W 5%	1522005
OR98	RES	220.0KO CC 1/4W 5%	1522005
OR99	RES	1000 O CC 1/4W 5%	1310005
OR100	RES	100.0KO CC 1/4W 5%	1510005
OR101	RES	3300 O CC 1/4W 5%	1333005
OR102	RES	10.0KO CC 1/4W 5%	1410005
OR103	RES	10.0 O CC 1/4W 5%	1110005
OR104	RES	10.0KO CC 1/4W 5%	1410005
OR105	RES	10.0 O CC 1/4W 5%	1110005
OR106	RES	680 O CC 1/4W 5%	1268005
OR107	RES	1000 O CC 1/4W 5%	1310005
OR108	RES	470 O CC 1/4W 5%	1247005
OR109	RES	1000 O CC 1/4W 5%	1310005
OR110	RES	10.0 O CC 1/4W 5%	1110005
OR111	RES	10.0 O CC 1/4W 5%	1110005
OR112	RES	10.0 O CC 1/4W 5%	1110005
OR113	RES	270 O CC 1/4W 5%	1227005
OR114	RES	270 O CC 1/4W 5%	1227005
OR115	RES	47.0 O CC 1/4W 5%	1147005
OR116	RES	47.0 O CC 1/4W 5%	1147005
OR117	RES	100.0KO CC 1/4W 5%	1510005
OR118	RES	27.0 O CC 1/4W 10%	1127006
OR119	RES	47.0 O CC 1/4W 5%	1147005
OR120	RES	33.0 O CC 1/4W 5%	1133005

FIGURE 8-13. CONTINUED

150B CI METER ANALOG BOARD
BILL1308

ID	CATEGORY	DESCRIPTION	S&A PART #
OR121	RES	4700 O CC 1/4W 5%	1347005
OR122	RES	470 O CC 1/4W 5%	1247005
OR123	RES	4700 O CC 1/4W 5%	1347005
OR124	RES	1200 O CC 1/4W 5%	1312005
OR125	RES	820 O CC 1/4W 5%	1282005
OR126	RES	680 O CC 1/4W 5%	1268005
OR127	RES	560 O CC 1/4W 5%	1256005
OS6	SUP	ASSEM PART ICS S 14P 1	6101141
OS17	SUP	ASSEM PART ICS S 14P 1	6101141
OS20	SUP	ASSEM PART ICS S 14P 1	6101141
OY1	SUP	MISC. 1.28 SHAFT	6740000
OY2	SUP	MISC. 1.28 SHAFT	6740000
OY3	SUP	NUTS, ETC COUPLER	6291501
OY4	SUP	NUTS, ETC COUPLER	6291501
OY5	SUP	PC BOARD 150B BOTBRD	6002406
OY6	SUP	MISC. FIN HT SINK	6720000
OY7	SUP	MISC. FIN HT SINK	6720000

FIGURE 8-13. CONTINUED

140/150/160 DISPLAY BOARD
BILL1301

ID	CATEGORY	DESCRIPTION	S&A PART #
CA1	CAP	Tantalum 2.2UF 20V	3400001
DA1	SEM	LED 7SEG DISPLAY	5007342
DA2	SEM	LED 7SEG DISPLAY	5007342
DA3	SEM	LED 7SEG DISPLAY	5007342
DA4	SEM	LED 7SEG DISPLAY	5007342
DA5	SEM	LED 7SEG DISPLAY	5007342
DA6	SEM	LED 7SEG DISPLAY	5007342
DA7	SEM	LED 7SEG DISPLAY	5007342
DA8	SEM	LED 7SEG DISPLAY	5007342
DA9	SEM	LED PANEL LIGHT	5005025
DA10	SEM	LED PANEL LIGHT	5005025
DA11	SEM	LED PANEL LIGHT	5005025
DA12	SEM	LED PANEL LIGHT	5005025
IA1	I C	DIGITAL 7SEG DEC	4214495
IA2	I C	DIGITAL 7SEG DEC	4214495
IA3	I C	DIGITAL 7SEG DEC	4214495
IA4	I C	DIGITAL 7SEG DEC	4214495
IA5	I C	DIGITAL 7SEG DEC	4214495
IA6	I C	DIGITAL 7SEG DEC	4214495
IA7	I C	DIGITAL 7SEG DEC	4214495
IA8	I C	DIGITAL 7SEG DEC	4214495
IA9	I C	TTL HEX INV	4100040
IA10	I C	TTL 1/8 DECODER	4122054
IA11	I C	Misc. MOS 16LIN INT	4708243
JA1	SUP	ASSEM PART 5 PIN ST	6110053
JA2	SUP	ASSEM PART 5 PIN ST	6110053
JA3	SUP	ASSEM PART 3 PIN ST	6110033
RA1	RES	330 0 CC 1/4W 5%	1233005
RA2	RES	330 0 CC 1/4W 5%	1233005
RA3	RES	330 0 CC 1/4W 5%	1233005
RA4	RES	330 0 CC 1/4W 5%	1233005
RA5	RES	330 0 CC 1/4W 5%	1233005
RA6	RES	330 0 CC 1/4W 5%	1233005
RA7	RES	330 0 CC 1/4W 5%	1233005
RA8	RES	330 0 CC 1/4W 5%	1233005
RA9	RES	10.0K0 CC 1/4W 5%	1410005
RA10	RES	10.0K0 CC 1/4W 5%	1410005
RA11	RES	10.0K0 CC 1/4W 5%	1410005
RA12	RES	10.0K0 CC 1/4W 5%	1410005
RA13	RES	180 0 CC 1/4W 5%	1218005
RA14	RES	180 0 CC 1/4W 5%	1218005
RA15	RES	180 0 CC 1/4W 5%	1218005
RA16	RES	10.0K0 CC 1/4W 5%	1410005

FIGURE 8-14. PARTS USED IN DISPLAY CIRCUIT ASSEMBLY

140/150/160 DISPLAY BOARD
BILL1301

ID	CATEGORY	DESCRIPTION		S&A PART #
RA17	RES	10.0KO CC 1/4W 5%		1410005
RA18	RES	10.0KO CC 1/4W 5%		1410005
RA19	RES	10.0KO CC 1/4W 5%		1410005
SA1	SUP	SWITCHES	1PL1P TOG	6401010
SA2	SUP	SWITCHES	1PL2P TOG	6401021
SA3	SUP	SWITCHES	1PL1P TOG	6401010
SI1	SUP	ASSEM PART	ICS S 16P 1	6101161
SI2	SUP	ASSEM PART	ICS S 16P 1	6101161
SI3	SUP	ASSEM PART	ICS S 16P 1	6101161
SI4	SUP	ASSEM PART	ICS S 16P 1	6101161
SI5	SUP	ASSEM PART	ICS S 16P 1	6101161
SI6	SUP	ASSEM PART	ICS S 16P 1	6101161
SI7	SUP	ASSEM PART	ICS S 16P 1	6101161
SI8	SUP	ASSEM PART	ICS S 16P 1	6101161
YA1	SUP	PC BOARD	CIM FRT PCB	6005402
YA2	ABY	MISC	5PIN CONTACT	0401317

150C FRONT PANEL ASSEMBLY
BILL1541

ID	CATEGORY	DESCRIPTION		S&A PART #
P1	SUP	ENCCLOSURES	150C DEC FRT	6500431
P2	SUP	ENCCLOSURES	140B/150CSUP	6500432
Y1	SUP	NUTS, ETC	4X1/4 PANHD	6224014
Y2	SUP	NUTS, ETC	4X1/4 PANHD	6224014
Y5	SUP	ENCCLOSURES	B SER BLOCK	6500340
Y6	SUP	ASSEM PART	GROUND LUG	6150102
Y7	SUP	ASSEM PART	PANEL BUSH	6150150
Y8	SUP	ASSEM PART	PANEL BUSH	6150150
Y9	SUP	ASSEM PART	PANEL BUSH	6150150
Y10	SUP	ENCCLOSURES	B SER CTRSHD	6500319
Y11	SUP	NUTS, ETC	1/4 LockWash	6295000
Y12	SUP	NUTS, ETC	1/4 LockWash	6295000
Y13	SUP	NUTS, ETC	1/4 LockWash	6295000
Y14	SUP	NUTS, ETC	1/4 LockWash	6295000

FIGURE 8-14. CONTINUED

BACK PANEL PCB FOR 129,140,150 BILL1421

ID	CATEGORY	DESCRIPTION		S&A PART #
C1	CAP	Ceramic Fix	.01UF 600V	3041002
C2	CAP	Misc.	5MFD 200V	3900015
J2	SUP	ASSEM PART	14PN PCB REC	6131143
J3	SUP	ASSEM PART	PRESS IN-5	6110059
J4	SUP	ASSEM PART	24P PCB REC	6131145
J5	SUP	ASSEM PART	PRESS IN-20	6110209
J6	SUP	ASSEM PART	PRESS IN-20	6110209
R1	RES	Misc.	40ohm 5W WW	1941006
R2	RES	1.00MO CC 1/4W 5%		1610005
S1	SUP	SWITCHES	PCB PUSH BUT	6451015
Y1	SUP	PC BOARD	129A BK PAN	6011801
Y2	SUP	NUTS, ETC	BAIL LOCK	6224092
Y3	SUP	ASSEM PART	F-ON RED.187	6150717
Y4	SUP	ASSEM PART	F-ON RED.250	6150718
Y5	SUP	ASSEM PART	F-ON RED.187	6150717
Y6	SUP	ASSEM PART	F-ON RED.187	6150717
Y7	SUP	ASSEM PART	F-ON RED.187	6150717
Y8	SUP	ENCCLOSURES	B SER SW BRK	6500341
Y9	SUP	NUTS, ETC	MET/ENG STUD	6224082
Y10	SUP	NUTS, ETC	MET/ENG STUD	6224082
Y11	SUP	NUTS, ETC	#4 KEP NUT	6224045
Y12	SUP	NUTS, ETC	#4 KEP NUT	6224045

BACK PANEL ASSEMBLY FOR 129A,140B,150C BILL1420

ID	CATEGORY	DESCRIPTION		S&A PART #
Y2	IND	AC POW TRAN	105-255 CT	2400016
Y3	SUP	MISC.	FUSHOLD SPLU	6713501
Y4	SUP	ASSEM PART	LN CD HOUSE	6133043
Y5	SUP	NUTS, ETC	4X1/4 PANHD	6224014
Y6	SUP	NUTS, ETC	4X1/4 PANHD	6224014
Y7	SUP	NUTS, ETC	4X1/4 PANHD	6224014
Y8	SUP	NUTS, ETC	4X1/4 PANHD	6224014
Y9	SUP	NUTS, ETC	#8X1/4PANHD	6243204
Y10	SUP	NUTS, ETC	#8X1/4PANHD	6243204
Y11	SUP	NUTS, ETC	4X1/4 PANHD	6224014
Y12	SUP	NUTS, ETC	4X1/2PNHDS/S	6224002
Y13	SUP	ASSEM PART	#4 RED RING	6150712
Y14	SUP	NUTS, ETC	#4 KEP NUT	6224045
Y15	ABY	PAINT PART	LOPRO BK PAN	0501425
Y16	SUP	ENCCLOSURES	129A FAN SUP	6500283
Y17	SUP	NUTS, ETC	6X1/4 PN HD	6233209
Y18	SUP	NUTS, ETC	6X1/4 PN HD	6233209
Y19	SUP	NUTS, ETC	6X1/4 PN HD	6233209
Y20	SUP	NUTS, ETC	6X1/4 PN HD	6233209
Y21	SUP	NUTS, ETC	6X1/4 PN HD	6233209
Y22	SUP	NUTS, ETC	6X1/4 PN HD	6233209
Y23	SUP	EL EQUIP	129/150 FAN	6815005
Y25	SUP	ASSEM PART	MTS RECP-5	6110056
Y26	SUP	ASSEM PART	AMP POL KEY	6110005
Y27	SUP	ASSEM PART	F-ON RED.187	6150717
Y28	SUP	ASSEM PART	F-ON RED.250	6150718
Y29	SUP	NUTS, ETC	#8 METAL WAS	6243220
Y30	SUP	NUTS, ETC	#8 METAL WAS	6243220
Y31	SUP	ASSEM PART	BNC CHASSCON	6180517
Y32	SUP	ASSEM PART	LINE CD PIN	6143016
Y33	SUP	ASSEM PART	LINE CD PIN	6143016
Y34	SUP	ASSEM PART	LINE CD PIN	6143016

FIGURE 8-15. PARTS USED FOR BACK PANEL ASSEMBLY

129A,140B,150C TOP PCB
BILL1472

ID	CATEGORY	DESCRIPTION	S&A PART #
CB1	CAP	Ceramic Fix 0.1UFML 50V	3010000
CB2	---Not Used		
CB3	CAP	AIR VAR 6-60PF PCM	3610000
CB4	---Not Used		
CB5	CAP	Ceramic Fix .01UF 50VDC	3000010
CB6	CAP	Tantalum 2.2UF 20V	3400001
CB7	CAP	Misc. .47uF 250V	3900000
CB8	CAP	Ceramic Fix 0.1UFML 50V	3010000
CB9	CAP	Ceramic Fix 0.1UFML 50V	3010000
CB10	CAP	Tantalum 2.2UF 20V	3400001
CB11	---Not Used		
CB12	CAP	Ceramic Fix .47UFML 50V	3010001
CB13	CAP	Ceramic Fix .47UFML 50V	3010001
CB14	CAP	Ceramic Fix .47UFML 50V	3010001
CB15	CAP	Ceramic Fix .01UF 50VDC	3000010
CB16	CAP	Ceramic Fix .01UF 50VDC	3000010
CB17	CAP	Ceramic Fix .01UF 50VDC	3000010
CB18	CAP	Tantalum 2.2UF 20V	3400001
CB19	CAP	Tantalum 2.2UF 20V	3400001
CB20	CAP	MICA 5% 50PF	3230500
CB21	CAP	Ceramic Fix 0.1UFML 50V	3010000
CB22	CAP	Ceramic Fix .01UF 50VDC	3000010
CB23	CAP	AIR VAR 6-60PF PCM	3610000
CB24	CAP	MICA 5% 10PF	3230100
CB25	CAP	MICA 5% 10PF	3230100
CB26	CAP	MICA 5% 10PF	3230100
CB27	CAP	MICA 5% 10PF	3230100
CB28	---Not Used		
CC1	CAP	Electrol. 2000MF 75V	3100023
CC2	CAP	Electrol. 2000MF 75V	3100023
CC3	CAP	Tantalum 2.2UF 20V	3400001
CC4	---Not Used		
CC5	CAP	MICA 5% 100PF	3231000
CC6	CAP	Ceramic Fix .01UF 50VDC	3000010
CC7	CAP	Ceramic Fix .001UF 25VDC	3000005
CC8	CAP	Electrol. 4700/16 SE	3100011
CC9	CAP	Ceramic Fix .01UF 50VDC	3000010
CC10	CAP	Electrol. 100UF 50V	3100004
CC11	CAP	Tantalum 2.2UF 20V	3400001
CC12	CAP	Electrol. 100UF 50V	3100004
CC13	CAP	Tantalum 2.2UF 20V	3400001
CC14	CAP	Electrol. 100UF 50V	3100004
CC15	CAP	Tantalum 2.2UF 20V	3400001
CC16	CAP	Tantalum 4.7UF 75V	3400003
CC17	CAP	Electrol. 39UF 10V	3100001
CC18	CAP	Ceramic Fix 4700PF25VDC	3000000

FIGURE 8-16. PARTS USED TO ASSEMBLE CONTROL LOGIC CIRCUIT

129A,140B,150C TOP PCB
BILL1472

ID	CATEGORY	DESCRIPTION		S&A PART #
CC19	CAP	MICA	5% 50PF	3230500
CD1	CAP	Tantalum	2.2UF 20V	3400001
CD2	CAP	Tantalum	2.2UF 20V	3400001
CD3	CAP	Tantalum	2.2UF 20V	3400001
CE1	CAP	Tantalum	2.2UF 20V	3400001
CE2	CAP	Electrol.	1000UF 10V	3100020
CE3	CAP	Ceramic Fix	0.1UFML 50V	3010000
CF1	CAP	Tantalum	2.2UF 20V	3400001
CG2	CAP	Ceramic Fix	.01UF 50VDC	3000010
CG3	CAP	Ceramic Fix	.01UF 50VDC	3000010
CG4	CAP	POLYSTYRENE	20% 2.20NF	3352201
CG5	CAP	Misc.	.47uF 250V	3900000
DB1	---Not Used			
DB2	---Not Used			
DB3	---Not Used			
DB4	---Not Used			
DB5	---Not Used			
DB6	SEM	VARICAP	42PF 2.6/1	5800104
DB7	SEM	DIODE	GOLD DOPED	5314148
DB8	SEM	DIODE	GOLD DOPED	5314148
DB9	SEM	DIODE	GOLD DOPED	5314148
DB10	---Not Used			
DB11	SEM	DIODE	GOLD DOPED	5314148
DB12	SEM	DIODE	GOLD DOPED	5314148
DC1	SEM	RECTIFIER	6A 200V	5700752
DC2	SEM	ZENER DIODE	12V 1/4W	5615242
DC3	I C	REGULAT BIP	SHUNT ADS	4500430
DC4	SEM	DIODE	AU 200PIV	5314120
DC5	SEM	DIODE	AU 200PIV	5314120
DC6	SEM	DIODE	AU 200PIV	5314120
DC7	SEM	RECTIFIER	6A 200V	5700752
DD1	SEM	DIODE	GOLD DOPED	5314148
FC1	SUP	MISC.	4AMP FUSE	6710400
IB1	I C	TTL	QD2-1LnMULT	4101570
IB2	I C	DIGITAL	PHASE DET	4204044
IB3	I C	Mis.Lin BJT	QUAD COMP	4300339
IB4	I C	DIGITAL	LC ECL OSC	4201648
IB5	I C	Mis.Lin BJT	4MECL-TLL TR	4310125
IB6	I C	TTL	DEC DIVIDER	4101964

FIGURE 8-16. CONTINUED

129A,140B,150C TOP PCB
BILL1472

ID	CATEGORY	DESCRIPTION		S&A PART #
IB7	I C	TTL	DEC. COUNTER	4100900
IB8	I C	TTL	DEC. COUNTER	4100900
IC1	I C	REGULAT BIP	15A 80V	4500626
IC2	I C	REGULAT BIP	SWITCH CNTL	4500497
IC3	I C	REGULAT BIP	-15V1A 3Tfix	4507915
IC4	I C	REGULAT BIP	-5v1A 3Tfix	4507905
IC5	I C	REGULAT BIP	15v1A 3T Fix	4507815
ID1	I C	Misc. MOS	MICRO PROC	4708035
ID2	I C	Misc. MOS	8-BIT LATCH	4708212
ID3	I C	ROM RAM MOS	16KBIT EPROM	4902716
ID4	I C	ROM RAM MOS	16KBIT EPROM	4902716
ID5	I C	ROM RAM MOS	1Kb St RAMC	4902111
ID6	I C	ROM RAM MOS	1Kb St RAMC	4902111
ID7	I C	Misc. MOS	16LIN INT	4708243
ID8	I C	Misc. MOS	16LIN INT	4708243
ID9	I C	TTL	HEX INV OCHV	4100060
ID10	I C	TTL	4-2IN NAND	4100000
ID11	I C	TTL	HEX INV OCHV	4100060
IF1	I C	TTL	4-2IN NAND S	4100004
IF2	I C	TTL	HEX INV	4100040
IF3	I C	TTL	HEX INV	4100040
IF4	I C	Misc. MOS	16LIN INT	4708243
IF5	I C	TTL	2SJKF SRIN	4101124
IF6	I C	TTL	DEC DIVIDER	4101964
IF7	I C	TTL	DEC. COUNTER	4100900
IF8	I C	DIGITAL	3ST OCT BUF	4218195
IF9	I C	TTL	DEC DIVIDER	4101964
IF10	I C	TTL	DEC. COUNTER	4100900
IF11	I C	DIGITAL	3ST OCT BUF	4218195
IF12	I C	Misc. MOS	INT. TIMER	4708253
IG1	I C	OP AMP BIP	S/H AMP	4400582
JA1	SUP	ASSEM PART	RECP-5 RT.L	6110050
JA2	SUP	ASSEM PART	RECP-5 RT.L	6110050
JA3	SUP	ASSEM PART	RECP-3 RT. L	6110032
JA4	SUP	ASSEM PART	PLUG-5 PIN	6110051
JB4	SUP	ASSEM PART	PLUG 15 PIN	6110152
JC4	SUP	ASSEM PART	PLUG 10 PIN	6110103
JD4	SUP	ASSEM PART	PLUG 15 PIN	6110152
JE1	SUP	ASSEM PART	20P DUAL PCB	6110205

FIGURE 8-16. CONTINUED

```
129A,140B,150C TOP PCB
BILL1472

  ID    CATEGORY  DESCRIPTION          S&A PART #


JF1     SUP    ASSEM PART    20P DUAL PCB   6110205

LB1     ---Not Used
LB2     Selected Part

OV1     SUP    MISC.         10 MHZ OVEN    6796024

PB6     SUP    ASSEM PART    ICS   S 14P 1  6101141

PD1     SUP    ASSEM PART    ICS   S 40P 1  6101401
PD2     SUP    ASSEM PART    ICS   S 24P 1  6101241
PD3     SUP    ASSEM PART    ICS   S 24P 1  6101241
PD4     SUP    ASSEM PART    ICS   S 24P 1  6101241
PD5     SUP    ASSEM PART    ICS   S 18P 1  6101181
PD6     SUP    ASSEM PART    ICS   S 18P 1  6101181
PD7     SUP    ASSEM PART    ICS   S 24P 1  6101241
PD8     SUP    ASSEM PART    ICS   S 24P 1  6101241

PE1     SUP    ASSEM PART    ICS   S 40P 1  6101401
PE2     SUP    ASSEM PART    ICS   S 16P 1  6101161
PE3     SUP    ASSEM PART    ICS   S 16P 1  6101161
PE4     SUP    ASSEM PART    ICS   S 16P 1  6101161
PE5     SUP    ASSEM PART    ICS   S 16P 1  6101161

PF4     SUP    ASSEM PART    ICS   S 24P 1  6101241
PF6     SUP    ASSEM PART    ICS   S 14P 1  6101141
PF8     SUP    ASSEM PART    LP 20P SOCK    6101201
PF9     SUP    ASSEM PART    ICS   S 14P 1  6101141
PF11    SUP    ASSEM PART    LP 20P SOCK    6101201
PF12    SUP    ASSEM PART    ICS   S 24P 1  6101241

QB1     ---Not Used
QB2     SEM    TRANSISTOR    NPN UHF        5125770
QB3     SEM    TRANSISTOR    NPN UHF        5125770
QB4     SEM    TRANSISTOR    NPN AU DOPED   5125769

QC1     SEM    TRANSISTOR    PNP SWITCH     5122907
QC2     SEM    TRANSISTOR    NPN GEN PUR    5122219
QC3     SEM    TRANSISTOR    NPN AU DOPED   5125769
QC4     SEM    TRANSISTOR    NPN GEN PUR    5122219
QC5     SEM    MISC.         12A SCR        5926401

QG1     SEM    FET           VMOS 60V 2A    5210066
QG2     SEM    TRANSISTOR    PNP SWITCH     5122907

RB10    Selected Part
RB13    RES     2200 O CC 1/4W  5%          1322005
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FIGURE 8-16. CONTINUED

129A,140B,150C TOP PCB
BILL1472

ID	CATEGORY	DESCRIPTION	S&A PART #
RB14	RES	1000 O CC 1/4W 5%	1310005
RB15	RES	10.0KO CC 1/4W 5%	1410005
RB16	RES	47.0 O CC 1/4W 5%	1147005
RB17	RES	22.0 O CC 1/4W 5%	1122005
RB18	RES	22.0 O CC 1/4W 5%	1122005
RB19	RES	1000 O CC 1/4W 5%	1310005
RB20	RES	10.0KO CC 1/4W 5%	1410005
RB21	RES	10.0KO CC 1/4W 5%	1410005
RB22	RES	2200 O CC 1/4W 5%	1322005
RB23	RES	1000 O CC 1/4W 5%	1310005
RB24	RES	1000 O CC 1/4W 5%	1310005
RB25	RES	1000 O CC 1/4W 5%	1310005
RB26	RES	1000 O CC 1/4W 5%	1310005
RB27	RES	1500 O CC 1/4W 5%	1315005
RB28	RES	1500 O CC 1/4W 5%	1315005
RB29	RES	2200 O CC 1/4W 5%	1322005
RB30	RES	5600 O CC 1/4W 5%	1356005
RB31	RES	10.0KO CC 1/4W 5%	1410005
RB32	RES	1200 O CC 1/4W 5%	1312005
RB33	RES	1000 O CC 1/4W 5%	1310005
RB34	RES	22.0KO CC 1/4W 5%	1422005
RB35	RES	470 O CC 1/4W 5%	1247005
RB36	RES	10.0KO CC 1/4W 5%	1410005
RB37	RES	10.0KO CC 1/4W 5%	1410005
RB40	RES	4.7 O MF 1/4W 5%	1047025
RB47	RES	4700 O CC 1/4W 5%	1347005
RB48	RES	470 O CC 1/4W 5%	1247005
RC1	RES	22.0KO CC 1/4W 5%	1422005
RC2	RES	220 O CC 1/4W 5%	1222005
RC3	RES	0.1 O WW 2W 5%	1001057
RC4	RES	1000 O CC 1/4W 5%	1310005
RC5	RES	10.0KO CC 1/4W 5%	1410005
RC6	RES	3300 O CC 1/4W 5%	1333005
RC7	RES	220 O CC 1/4W 5%	1222005
RC8	RES	560 O CC 1/4W 5%	1256005
RC9	RES	3900 O CC 1/4W 5%	1339005
RC10	RES	1200 O CC 1/4W 5%	1312005
RC11	RES	1000 O CC 1/4W 5%	1310005
RC12	RES	1000 O CC 1/4W 5%	1310005
RC13	RES	6.8 O MF 1/4W 5%	1068025
RC14	RES	27.0KO CC 1/4W 5%	1427005
RC15	RES	2700 O CC 2W 20%	1327019
RC16	RES	47.0 O CC 1/4W 5%	1147005
RC17	RES	100 O CC 1/4W 5%	1210005
RD1	RES	1000 O CC 1/4W 5%	1310005
RD2	RES	1000 O CC 1/4W 5%	1310005

FIGURE 8-16. CONTINUED

129A,140B,150C TOP PCB
BILL1472

ID	CATEGORY	DESCRIPTION	S&A PART #
RD4	RES	27.0KΩ CC 1/4W 5%	1427005
RD5	RES	27.0KΩ CC 1/4W 5%	1427005
RD6	RES	27.0KΩ CC 1/4W 5%	1427005
RD7	RES	27.0KΩ CC 1/4W 5%	1427005
RD8	RES	27.0KΩ CC 1/4W 5%	1427005
RD9	RES	27.0KΩ CC 1/4W 5%	1427005
RD10	RES	27.0KΩ CC 1/4W 5%	1427005
RD11	RES	27.0KΩ CC 1/4W 5%	1427005
RD12	RES	27.0KΩ CC 1/4W 5%	1427005
RD13	RES	27.0KΩ CC 1/4W 5%	1427005
RD14	RES	27.0KΩ CC 1/4W 5%	1427005
RD15	RES	27.0KΩ CC 1/4W 5%	1427005
RD16	RES	4700 Ω CC 1/4W 5%	1347005
RD17	RES	4700 Ω CC 1/4W 5%	1347005
RD18	RES	4700 Ω CC 1/4W 5%	1347005
RD19	RES	4700 Ω CC 1/4W 5%	1347005
RD20	RES	4700 Ω CC 1/4W 5%	1347005
RD21	RES	4700 Ω CC 1/4W 5%	1347005
RD22	RES	4700 Ω CC 1/4W 5%	1347005
RD23	RES	4700 Ω CC 1/4W 5%	1347005
RD24	RES	27.0KΩ CC 1/4W 5%	1427005
RE1	RES	3000 Ω CC 1/4W 5%	1330005
RE2	RES	3000 Ω CC 1/4W 5%	1330005
RE3	RES	3000 Ω CC 1/4W 5%	1330005
RE4	RES	3000 Ω CC 1/4W 5%	1330005
RE5	RES	3000 Ω CC 1/4W 5%	1330005
RE6	RES	3000 Ω CC 1/4W 5%	1330005
RE7	RES	3000 Ω CC 1/4W 5%	1330005
RE8	RES	3000 Ω CC 1/4W 5%	1330005
RE9	RES	3000 Ω CC 1/4W 5%	1330005
RE10	RES	3000 Ω CC 1/4W 5%	1330005
RE11	RES	3000 Ω CC 1/4W 5%	1330005
RE12	RES	3000 Ω CC 1/4W 5%	1330005
RE13	RES	3000 Ω CC 1/4W 5%	1330005
RE14	RES	3000 Ω CC 1/4W 5%	1330005
RE15	RES	3000 Ω CC 1/4W 5%	1330005
RE16	RES	3000 Ω CC 1/4W 5%	1330005
RE17	RES	6200 Ω CC 1/4W 5%	1362005
RE18	RES	6200 Ω CC 1/4W 5%	1362005
RE19	RES	6200 Ω CC 1/4W 5%	1362005
RE20	RES	6200 Ω CC 1/4W 5%	1362005
RE21	RES	6200 Ω CC 1/4W 5%	1362005
RE22	RES	6200 Ω CC 1/4W 5%	1362005
RE23	RES	6200 Ω CC 1/4W 5%	1362005
RE24	RES	6200 Ω CC 1/4W 5%	1362005
RE25	RES	6200 Ω CC 1/4W 5%	1362005
RE26	RES	6200 Ω CC 1/4W 5%	1362005

FIGURE 8-16. CONTINUED

129A,140B,150C TOP PCB
BILL1472

ID	CATEGORY	DESCRIPTION	S&A PART #
RE27	RES	6200 O CC 1/4W 5%	1362005
RE28	RES	6200 O CC 1/4W 5%	1362005
RE29	RES	6200 O CC 1/4W 5%	1362005
RE30	RES	6200 O CC 1/4W 5%	1362005
RE31	RES	6200 O CC 1/4W 5%	1362005
RE32	RES	6200 O CC 1/4W 5%	1362005
RF1	RES	100 O CC 1/4W 5%	1210005
RF2	RES	1000 O CC 1/4W 5%	1310005
RG1	RES	Misc. 10K MOD POT	1921002
RG2	RES	150.0KO CC 1/4W 5%	1515005
RG3	RES	22.0KO CC 1/4W 5%	1422005
RG4	RES	22.0KO CC 1/4W 5%	1422005
RG5	RES	3300 O CC 1/4W 5%	1333005
RG6	RES	10.0KO CC 1/4W 5%	1410005
SD1	SUP	SWITCHES 1P 8Pos ROT	6421080
SD2	SUP	SWITCHES DIP SWITCH	6408021
SD3	SUP	SWITCHES DIP SWITCH	6404022
TC1	ABY	WOUND IND SW SUP XTR	0001302
XB1	CRY	GEN. PURPOSE 10MHZ	7000003
Y1	SUP	PC BOARD 150B CNT PCB	6005605
Y5	SUP	MISC. PC FUSE HOLD	6713001
Y6	SUP	MISC. PC FUSE HOLD	6713001
Y8	SUP	MISC. HS TO-220	6721008
Y9	SUP	MISC. HS TO-66	6721009
Y10	SUP	NUTS, ETC 6X1/2PANHD	6233205
Y11	SUP	NUTS, ETC 6X1/2PANHD	6233205
Y12	SUP	NUTS, ETC #6 METAL NUT	6233240
Y13	SUP	NUTS, ETC #6 METAL NUT	6233240
Y14	SUP	NUTS, ETC #6 METAL NUT	6233240
Y15	SUP	NUTS, ETC #6 METAL NUT	6233240
Y16	SUP	NUTS, ETC NYLON WASH	6233270
Y17	SUP	NUTS, ETC NYLON WASH	6233270
Y18	SUP	NUTS, ETC LOCK WASHER	6233230
Y19	SUP	NUTS, ETC LOCK WASHER	6233230
Y20	SUP	MISC. PS INSUL WAS	6796029
Y24	SUP	NUTS, ETC #10 SPL WASH	6260103
Y25	SUP	NUTS, ETC #10 SPL WASH	6260103
Y26	SUP	NUTS, ETC #10 SPL WASH	6260103
Y27	SUP	NUTS, ETC #10 SPL WASH	6260103
Y28	SUP	ASSEM PART 2PIN SHUNT	6110022
Y29	SUP	ASSEM PART 2PIN SHUNT	6110022
Y30	SUP	ASSEM PART .025X.5 PIN	6143005
Y31	SUP	ASSEM PART .025X.5 PIN	6143005
Y32	SUP	ASSEM PART .025X.5 PIN	6143005
Y33	SUP	ASSEM PART .025X.5 PIN	6143005
Y34	SUP	ASSEM PART .025X.5 PIN	6143005
Y35	SUP	ASSEM PART .025X.5 PIN	6143005
Y36	SUP	MISC. 6020A H.S.	6721011

FIGURE 8-16. CONTINUED

PART#	CAT DESCRIPTION	QUAN 1 UNIT
MAIN CHASSIS ASSEMBLY (BILL1563)		
0501565	ABY PAINT PART LOPRO BEZEL	2
6233205	SUP NUTS, ETC 6X1/2PANHD	12
6233215	SUP NUTS, ETC 6X3/8 FL HD	8
6500280	SUP ENCCLOSURES LOPRO CD SUP	2
6500452	SUP ENCCLOSURES BLK SIDERAIL	2
6700002	SUP MISC. CARD GUIDES	12
FINAL ASSEMBLY (BILL1540)		
0301211	ABY CHASSIS 150 AD AUTO	
0301212	ABY CHASSIS 150 TTOOLSKT	1
6178070	SUP ASSEM PART LINE CORD	1
6224015	SUP NUTS, ETC 4X3/8BLKPNHD	8
6224018	SUP NUTS, ETC 4X5/16PNHD	4
6224030	SUP NUTS, ETC LOCK WASH	4
6233202	SUP NUTS, ETC 6X3/8BLKPNHD	8
6291501	SUP NUTS, ETC COUPLER	1
6300055	SUP RAW MATERIAL FIBGLASROD''	13
6490000	SUP SWITCHES SWITCH COVRS	3
6700105	SUP MISC. 0.6Rub Feet	4
6710100	SUP MISC. 1/2A SB FUSE	1
6751400	SUP MISC. 14.5MM CAP	3
6751410	SUP MISC. 14.5MM KNOB	2
6751450	SUP MISC. 14.5mm wing	1
6752101	SUP MISC. 21MM BL CAP	1
6752111	SUP MISC. 21MM KNOB	1

FIGURE 8-17. MISCELLANEOUS CHASSIS ASSEMBLY PARTS

FINISHED S & A PART NO.	DESCRIPTION	RAW MATERIAL S & A PART NO.
0401317	5 Pin Contact Assembly for Display	6101051 or 6101990
0501425	Chassis Back Panel	6500282
0501562	140/150 Covers	6500281
0501565	Chassis Bezels	6500279

FIGURE 8-18. SPECIAL PARTS ASSEMBLY

WOUND INDUCTOR S & A PART NO.	INDUCTANCE μH	DESCRIPTION	CORE MATERIAL S & A PART NO.
0001044	17.8	61 turns #30 AW6 WIRE	2105002
0001046	14.3	53 turns #30 AW6 WIRE	2105002
0001066	67.8	63 turns #30 AW6 WIRE	2105003
0001067	13.9	50 turns #30 AW6 WIRE	2105002
0001068	3.4	28 turns #30 AW6 WIRE	2105006
0001069	0.8	16 turns #22 AW6 WIRE	2103706
0001092	0.5	11 turns #22 AW6 WIRE	2103006
0001070	0.17	6 turns #22 AW6 WIRE	2103006
0001071	0.09	5 turns #22 AW6 WIRE	2105012
0001302	—	Winding 1-2 25 turns #22 AW6 WIRE 3-4 30 turns #30 AW6 WIRE 5-6 30 turns #30 AW6 WIRE 7-8 25 turns #30 AW6 WIRE 9-10 25 turns #30 AW6 WIRE 11-12 35 turns #30 AW6 WIRE	2110000

FIGURE 8-19. COIL ASSEMBLIES

SA PART #	VENDOR/MANUFACTURER		MANUFACTURER PART #
1001057	5140	KRL ELECTRONICS, INC	P-2AW1R10F
1001057	6333	OMTRONICS MFG, INC.	T2A/.1OHM/1%
1047025	7334	R-OHM CORP.	R25/J/4.7ohm
1068025	7334	R-OHM CORP.	R25/J/6.8ohm
1110005	7334	R-OHM CORP.	R25/J/10.0ohm
1112005	7334	R-OHM CORP.	R25/J/12.0ohm
1122005	7334	R-OHM CORP.	R25/J/22.0ohm
1127006	7334	R-OHM CORP.	R25/J/27.0ohm
1133005	7334	R-OHM CORP.	R25/J/33.0/OHM/5%
1147005	7334	R-OHM CORP.	R25/J/47.0ohm
1210005	7334	R-OHM CORP.	R25/J/100ohm
1212005	7334	R-OHM CORP.	R25/J/120ohm
1218005	7334	R-OHM CORP.	R25/J/180ohm
1222005	7334	R-OHM CORP.	R25/J/220ohm
1227005	7334	R-OHM CORP.	R25/J/270ohm
1233005	7334	R-OHM CORP.	R25/J/330ohm
1247005	7334	R-OHM CORP.	R25/J/470ohm
1256005	7334	R-OHM CORP.	R25/J/560ohm
1268005	7334	R-OHM CORP.	R25/J/680ohm
1282005	7334	R-OHM CORP.	R25/J/820ohm
1310005	7334	R-OHM CORP.	R25/J/1000ohm
1312005	7334	R-OHM CORP.	R25/J/1200ohm
1315005	1851	CAPAR COMPONENTS COR	CCF-25-1/4W-5%-1.5K
1315005	7334	R-OHM CORP.	R25/J/1500ohm
1322005	7334	R-OHM CORP.	R25/J/2200ohm
1327019	1003	ALLEN BRADLEY CO.	RC42GF272K
1330005	7334	R-OHM CORP.	R25/J/3000OHM
1333005	7334	R-OHM CORP.	R25/J/3300ohm
1339005	7334	R-OHM CORP.	R25/J/3900ohm
1347005	7334	R-OHM CORP.	R25/J/4700ohm
1356005	7334	R-OHM CORP.	R25/J/5600ohm
1362005	7334	R-OHM CORP.	R25/J/6.2KOHM
1410005	7334	R-OHM CORP.	R25/J/10.0Kohm
1410005	7690	SHIGMA INC.	10.0KOHM1/4W5%
1412005	7334	R-OHM CORP.	R25/J/12.0Kohm
1415005	7334	R-OHM CORP.	R25/J/15.0Kohm
1422005	7334	R-OHM CORP.	R25/J/22.0Kohm
1427005	7334	R-OHM CORP.	R25/J/27.0Kohm
1433005	7334	R-OHM CORP.	R25/J/33KOHM
1439005	7334	R-OHM CORP.	R25/J/39.0Kohm
1456005	7334	R-OHM CORP.	R25/J/56ohm
1510005	7334	R-OHM CORP.	R25/J/100.0Kohm
1515005	7334	R-OHM CORP.	R25/J/150.0KOHM
1522005	7334	R-OHM CORP.	R25/J/220.0Kohm
1610005	7334	R-OHM CORP.	R25/J/1.00Mohm
1647005	7334	R-OHM CORP.	R25/J/4.70Mohm
1921001	1500	BECKMAN INSTRS/HELIP	66WR10K
1921001	9001	WESTON/SCHLUMBERGER/	850WR10K
1921002	1003	ALLEN BRADLEY CO.	15M047
2001000	2253	COTO-CORP	4003-5-4000

FIGURE 8-20. LISTS ACCEPTABLE MANUFACTURERS AND THE MANUFACTURERS' PART NUMBERS FOR THE S & A PART NUMBERS

SA PART #		VENDOR/MANUFACTURER	MANUFACTURER PART #
2001000	5667	MAGNECRAFT ELECTRIC	W101MX35
2001003	2253	COTO-CORP	CR-4011-4000
2001003	5667	MAGNECRAFT ELECTRIC	W104MX-9
2103006	5676	MICRO METALS, INC.	T30-6
2103706	5676	MICRO METALS, INC.	T37-6
2105002	5676	MICRO METALS, INC.	T50-2
2105003	5676	MICRO METALS, INC.	T50-3
2105006	5676	MICRO METALS, INC.	T50-6
2105012	5676	MICRO METALS, INC.	T50-12
2110000	1252	ARNOLD ENGINEERING C	A930157-2
2110002	3338	FAIR-RITE PRODUCTS C	2643000101
2331004	4667	J W MILLER DIV DEPT	1.00MH-5%-9220-28
2400016	7702	SIGNAL TANSFORMER CO	241-8/1368A
3000000	7834	SPRAGUE PRODUCTS CO.	HY510
3000005	7834	SPRAGUE PRODUCTS CO.	5GAD10
3000010	5666	MALLORY/CAPACITOR	MAG5011
3010000	7834	SPRAGUE PRODUCTS CO.	2CZ5U224D8050C4
3010000	7834	SPRAGUE PRODUCTS CO.	2CZ5U104D8050C4
3010001	5668	MEPCO/ELECTRA INC	6133Z5U474MB050ST
3010001	7834	SPRAGUE PRODUCTS CO.	2CZ5U474D8050C4
3041002	5666	MALLORY/CAPACITOR	PVC611
3100001	7834	SPRAGUE PRODUCTS CO.	150D396X9010B2
3100004	5635	MARCOM AMERICA CORP.	CEUST1H101
3100011	7666	SIEMENS CORP.	4700/16SE/8218
3100011	7834	SPRAGUE PRODUCTS CO.	841010-4700/16
3100020	5668	MEPCO/ELECTRA INC	ET102X010A01
3100023	5668	MEPCO/ELECTRA INC	3110HA202U075
3221201	1253	ARCO ELECTRONICS	DM19FD122G03
3221201	2255	CORNELL-DUBILIER	CD19FD122G03
3221201	5669	MICONICS INDS INC	RDM15-122G
3230100	5669	MICONICS INDS INC	RDM15CD100J03
3230200	1253	ARCO ELECTRONICS	DM15ED200J03
3230200	2255	CORNELL-DUBILIER	CD15ED200J03
3230200	5669	MICONICS INDS INC	RDM15ED200J03
3230300	1253	ARCO ELECTRONICS	DM15CD300J03
3230300	2255	CORNELL-DUBILIER	CD15CD300J03
3230300	5669	MICONICS INDS INC	RDM15CD300J03
3231000	5669	MICONICS INDS INC	RDM15FD101J03
3352201	8166	TRW CAPACTIROS DIV	863UW
3400000	5002	KEMET/UNION CARBIDE	T110B475K050A
3400000	6002	NATIONAL COMPONENTS/	CS13BG475K
3400000	7666	SIEMENS CORP.	GS13BG475K
3400000	7834	SPRAGUE PRODUCTS CO.	150D475X9050B2
3400001	7834	SPRAGUE PRODUCTS CO.	150D225X9020A2
3400003	5002	KEMET/UNION CARBIDE	T110B475K075A5
3400003	5002	KEMET/UNION CARBIDE	CSR13H475KL
3400003	5002	KEMET/UNION CARBIDE	CSR13H475KM
3400003	7834	SPRAGUE PRODUCTS CO.	150D475X9075R2
3600004	1002	ALL STAR PRODUCTS, I	X729
3600005	1002	ALL STAR PRODUCTS, I	X730

FIGURE 8-20. CONTINUED

SA PART #		VENDOR/MANUFACTURER	MANUFACTURER PART #
3610000	5668	MEPCO/ELECTRA INC	2810C5R565QJ02F
3900000	5668	MEPCO/ELECTRA INC	C280AE/A470K
3900015	8166	TRW CAPACTIROS DIV	X663F
4100000	6000	NATIONAL SEMICONDUCT	DM7400N
4100004	6000	NATIONAL SEMICONDUCT	DM74S00N
4100004	7700	SIGNETICS INC	SA74S00
4100040	6000	NATIONAL SEMICONDUCT	DM7404N
4100060	6000	NATIONAL SEMICONDUCT	DM7406N
4100900	3334	FAIRCHILD/SEMICONDUC	7490PC/9390PC
4100900	6000	NATIONAL SEMICONDUCT	DM7490N
4100900	7700	SIGNETICS INC	N7490N
4101124	6000	NATIONAL SEMICONDUCT	DM74S112N
4101124	7700	SIGNETICS INC	74S112N
4101124	8000	TEXAS INSTRUMENTS IN	SN74S112N
4101570	6000	NATIONAL SEMICONDUCT	DM74157N
4101964	8000	TEXAS INSTRUMENTS IN	SN74S196J
4101964	8000	TEXAS INSTRUMENTS IN	SN74S196N
4122054	4503	INTEL CORP.	P3205
4128121	6000	NATIONAL SEMICONDUCT	DS88L12N
4201648	5834	MOTOROLA SEMICONDUCT	MC1648P
4204044	5834	MOTOROLA SEMICONDUCT	MC4044P
4214016	5834	MOTOROLA SEMICONDUCT	MC14016BCP
4214016	7333	RCA HDQTRS	CD4016BE
4214495	5834	MOTOROLA SEMICONDUCT	MC14495L
4214495	5834	MOTOROLA SEMICONDUCT	MC14495P(BCD-7SGG-DEC/DR)
4214507	5834	MOTOROLA SEMICONDUCT	MC14070BCP
4214507	5834	MOTOROLA SEMICONDUCT	MC14507CP
4218195	6000	NATIONAL SEMICONDUCT	DM81LS95N
4218195	8000	TEXAS INSTRUMENTS IN	SN74LS541N
4300339	1006	ADVANCE MICRO DEVICE	LM339N
4300339	5834	MOTOROLA SEMICONDUCT	LM339N
4300339	7700	SIGNETICS INC	LM339A
4300685	1006	ADVANCE MICRO DEVICE	AM685HL
4304205	1250	ANALOG DEVICES INC.	AD532JH
4304205	1750	BURR-BROWN RESEARCH	4205K
4310125	5834	MOTOROLA SEMICONDUCT	MC10125P
4400012	1250	ANALOG DEVICES INC.	AD450J
4400012	1750	BURR-BROWN RESEARCH	VFC-12
4400301	3334	FAIRCHILD/SEMICONDUC	UA301ATC
4400301	5834	MOTOROLA SEMICONDUCT	MLM301
4400301	6000	NATIONAL SEMICONDUCT	LM301AN
4400301	7700	SIGNETICS INC	LM301AN
4400582	1250	ANALOG DEVICES INC.	AD582KD
4404302	1750	BURR-BROWN RESEARCH	4302
4500430	8000	TEXAS INSTRUMENTS IN	TL430CLP
4500497	8000	TEXAS INSTRUMENTS IN	TL497ACN
4500497	8000	TEXAS INSTRUMENTS IN	TL497CN
4500626	8502	UNITRODE CORP.	PIC626
4507815	5834	MOTOROLA SEMICONDUCT	MC7815CT
4507815	6000	NATIONAL SEMICONDUCT	LM340T-15

FIGURE 8-20. CONTINUED

SA PART #	VENDOR/MANUFACTURER	MANUFACTURER PART #
4507905	5834 MOTOROLA SEMICONDUCT	MC7905CT
4507905	6000 NATIONAL SEMICONDUCT	LM7905CT
4507915	5834 MOTOROLA SEMICONDUCT	MC7915CT
4507915	6000 NATIONAL SEMICONDUCT	LM7915CT
4708035	4503 INTEL CORP.	P8035L
4708035	4503 INTEL CORP.	P8035
4708035	4503 INTEL CORP.	C8035
4708035	6051 NEC MICROCOMPUTERS,	D8048C
4708212	4503 INTEL CORP.	P8212
4708243	4503 INTEL CORP.	P8243
4708243	4503 INTEL CORP.	C8243
4708253	1006 ADVANCE MICRO DEVICE	AM8253PC
4708253	4503 INTEL CORP.	P8253
4902111	4503 INTEL CORP.	P2111
4902716	3580 FUJITSU AMERICA, INC	MB8516
4902716	3580 FUJITSU AMERICA, INC	MBM2716
4902716	4503 INTEL CORP.	P2716
4902716	4503 INTEL CORP.	C2716
5005025	5835 MONSANTO COMMERCIAL	MV5025
5007342	3334 FAIRCHILD/SEMICONDUC	FND357
5007342	4333 ICON DIV.,USM CORP.	FND357
5122219	3334 FAIRCHILD/SEMICONDUC	2N2219A
5122219	5834 MOTOROLA SEMICONDUCT	2N2219AS
5122894	5834 MOTOROLA SEMICONDUCT	2N2894
5122907	3334 FAIRCHILD/SEMICONDUC	2N2907A
5122907	5834 MOTOROLA SEMICONDUCT	2N2907A
5122907	6000 NATIONAL SEMICONDUCT	2N2907A
5123905	3334 FAIRCHILD/SEMICONDUC	F2N3905
5123905	5834 MOTOROLA SEMICONDUCT	2N3905
5125109	5834 MOTOROLA SEMICONDUCT	2N5109
5125109	7333 RCA HDQTRS	2N5109
5125769	3334 FAIRCHILD/SEMICONDUC	F2N5769
5125769	5834 MOTOROLA SEMICONDUCT	2N5769
5125770	5834 MOTOROLA SEMICONDUCT	2N5770
5125770	6000 NATIONAL SEMICONDUCT	2N5770
5204416	4505 INTERSIL	2N4416
5204416	5834 MOTOROLA SEMICONDUCT	2N4416
5204416	6000 NATIONAL SEMICONDUCT	J304
5204416	6000 NATIONAL SEMICONDUCT	2N4416
5210066	7701 SILICONIXS INC.	VN66AF
5314120	8167 TRW/CINCH CONNECTORS	DRS5200
5314120	8502 UNITRODE CORP.	UTX4120
5314148	3334 FAIRCHILD/SEMICONDUC	1N4148
5314148	3334 FAIRCHILD/SEMICONDUC	1N914
5314148	3334 FAIRCHILD/SEMICONDUC	1N914A
5314148	8502 UNITRODE CORP.	IN4148
5400101	5834 MOTOROLA SEMICONDUCT	MBD101
5503401	4003 HEWLETT PACKARD/SCIE	5082-3168
5503401	5834 MOTOROLA SEMICONDUCT	MPN3504
5503401	5834 MOTOROLA SEMICONDUCT	MPN3401

FIGURE 8-20. CONTINUED

SA PART #		VENDOR/MANUFACTURER	MANUFACTURER PART #
5615230	5834	MOTOROLA SEMICONDUCT	1N5230A
5615237	5834	MOTOROLA SEMICONDUCT	IN5237B
5615237	5834	MOTOROLA SEMICONDUCT	1N5237
5615242	5834	MOTOROLA SEMICONDUCT	IN5242B
5615242	5834	MOTOROLA SEMICONDUCT	1N5242A
5700752	5834	MOTOROLA SEMICONDUCT	MR752
5800104	5834	MOTOROLA SEMICONDUCT	MV104
5926401	5834	MOTOROLA SEMICONDUCT	2N6401
6002406	9901	S&A CUSTOM	0000024-06
6005402	9901	S&A CUSTOM	
6005605	9900	GENERAL PURPOSE	0000056
6011801	9901	S&A CUSTOM	0000118
6101051	7650	SAMTEC, INC.	SSA-105-SG
6101141	8000	TEXAS INSTRUMENTS IN	C841402
6101141	8000	TEXAS INSTRUMENTS IN	83-14-02
6101161	8000	TEXAS INSTRUMENTS IN	C841602
6101181	8000	TEXAS INSTRUMENTS IN	TI/C84-18-02
6101201	8000	TEXAS INSTRUMENTS IN	C842002
6101241	8000	TEXAS INSTRUMENTS IN	C842402
6101401	8000	TEXAS INSTRUMENTS IN	C844002
6110005	1004	AMP SPECIAL INDUSTRI	640628-1
6110022	1004	AMP SPECIAL INDUSTRI	530153-2
6110022	1004	AMP SPECIAL INDUSTRI	530153-6
6110032	5833	MOLEX	22-15-2031
6110033	5833	MOLEX	22-03-2031
6110050	5833	MOLEX	22-16-2051
6110050	5833	MOLEX	22-15-2051
6110051	5833	MOLEX	09-64-1053
6110052	5833	MOLEX	09-52-3053
6110053	5833	MOLEX	22-10-2051
6110056	1004	AMP SPECIAL INDUSTRI	640440-5
6110059	1004	AMP SPECIAL INDUSTRI	86090-4
6110101	5833	MOLEX	09-52-3103
6110103	5833	MOLEX	09-64-1103
6110151	5833	MOLEX	09-62-3153
6110151	5833	MOLEX	09-52-3153
6110152	5833	MOLEX	09-64-1153
6110205	1004	AMP SPECIAL INDUSTRI	1-86105-1
6110209	1004	AMP SPECIAL INDUSTRI	86090-4
6131143	1004	AMP SPECIAL INDUSTRI	552212
6131145	1004	AMP SPECIAL INDUSTRI	552224-1
6143005	1254	AUGAT INC	317-17P5
6150102	7667	HERMAN H. SMITH INC.	SMITH109
6150150	7667	HERMAN H. SMITH INC.	SMITH184
6150712	1004	AMP SPECIAL INDUSTRI	1-31885-2
6150717	1004	AMP SPECIAL INDUSTRI	2-350800-4
6150718	1004	AMP SPECIAL INDUSTRI	2-350804-4
6159912	8004	TEXTOOL PRODUCTS,INC	203-2737-00-1125
6178070	1501	BELDEN CORP	17250
6178070	6664	PACFIC ELECTRI CORD,	03120-008-BL

FIGURE 8-20. CONTINUED

SA PART #	VENDOR/MANUFACTURER	MANUFACTURER PART #
6180517	1009 AMPHENOL NORTH AMERC	31-010
6224002	9900 GENERAL PURPOSE	4X1/2PANHDS/S
6224014	9900 GENERAL PURPOSE	4-40X1/4PANHEAD
6224015	9900 GENERAL PURPOSE	4X3/8BLKPANHEAD
6224018	9900 GENERAL PURPOSE	4-40X5/16PANHEAD
6224030	9900 GENERAL PURPOSE	#4,INSIDE,STAR,LOCK,WASHER
6224045	9900 GENERAL PURPOSE	4-40KEPNUT
6224082	2204 CATALINA MANUFACTURI	2211022(#4METRIC/ENG-MNT-STUD)
6224092	1004 AMP SPECIAL INDUSTRI	552562-1
6233202	9900 GENERAL PURPOSE	6-32X3/8PANHD-BLK
6233203	9900 GENERAL PURPOSE	6-32X1NYLONPANHEAD
6233205	9900 GENERAL PURPOSE	6-32X1/2,PANHEAD,PHILIPS
6233209	9900 GENERAL PURPOSE	6X1/4PANHD
6233215	9900 GENERAL PURPOSE	6X3/8FLTHD
6233230	9900 GENERAL PURPOSE	#6STARLOCKWASHER
6233240	9900 GENERAL PURPOSE	6-32,HEXNUT
6233270	9008 WECKESSER CO.	#N63122
6233270	9900 GENERAL PURPOSE	#6,NYLON/WASHER
6243204	9901 S&A CUSTOM	#8X1/4PANHEAD/CAD
6243220	9900 GENERAL PURPOSE	#8METALWASHER
6260103	9900 GENERAL PURPOSE	#10SPLITWASHER
6291501	7667 HERMAN H. SMITH INC.	SMITH180
6295000	9900 GENERAL PURPOSE	1/4''InsideStarWasher
6300055	9901 S&A CUSTOM	FIBERGLASS
6401010	1826 C & K COMPONENTS, IN	7108
6401010	3585 FUJISOKU ELECTRIC CO	8A1061
6401010	4168 J-B-T SWITCHES	JMT-126
6401010	5670 MICRO SWITCH	8A1061
6401010	7339 RAYTHEON COMPANY	105F
6401021	1826 C & K COMPONENTS, IN	7107
6401021	3585 FUJISOKU ELECTRIC CO	8A1051
6401021	4168 J-B-T SWITCHES	JMT-131
6401021	5670 MICRO SWITCH	8A1051
6401021	7339 RAYTHEON COMPANY	105H
6404022	3833 GRAYHILL INC	76/B06
6408021	1004 AMP SPECIAL INDUSTRI	54359-1
6421080	7835 STACKPOLE COMPONENTS	39-4067
6451015	1001 ALCO ELECTRONICS PRO	MSP105D
6490000	3585 FUJISOKU ELECTRIC CO	8Z0151
6490000	5670 MICRO SWITCH	8Z0151
6500126	9901 S&A CUSTOM	2001011
6500279	9901 S&A CUSTOM	DWG#2219001
6500280	9901 S&A CUSTOM	DWG#2001030
6500281	9901 S&A CUSTOM	DWG#2219002
6500282	9901 S&A CUSTOM	DWG#2001031
6500283	9901 S&A CUSTOM	DWG#2001032
6500319	9901 S&A CUSTOM	2001034
6500341	9901 S&A CUSTOM	2001038
6500431	9901 S&A CUSTOM	2001040
6500432	9901 S&A CUSTOM	2001042

FIGURE 8-20. CONTINUED

SA PART #	VENDOR/MANUFACTURER	MANUFACTURER PART #	COM
6510000	9901 S&A CUSTOM	OUTSIDEWORK	
6700002	7669 SCANBE CANOGA INDS	23071-3	
6700105	7667 HERMAN H. SMITH INC.	2184	
6710100	5333 LITTLEFUSE	FU3AGSB/313.500	
6710400	5333 LITTLEFUSE	3AG4A(312)	
6710400	5333 LITTLEFUSE	312.400/3AG	
6713001	5333 LITTLEFUSE	102074	
6713501	5333 LITTLEFUSE	342858AL	
6720000	9000 WAKEFIELD ENGINEERIN	207-CB/CAT#58F530	
6721008	8001 THERMALLOY INC	6043PB	
6721009	8001 THERMALLOY INC	6019B	
6721011	8001 THERMALLOY INC	6020A	
6740000	1950 CENTRAL PLASTICS & R	1/8DIA.G10	
6751400	4500 INTERLOCK	040-3020	
6751410	4500 INTERLOCK	020-3220	
6751450	4500 INTERLOCK	023-3220	
6752101	4500 INTERLOCK	040-4020	
6752111	4500 INTERLOCK	021-4220	
6796029	9900 GENERAL PURPOSE	POWERSUPPLYWASHER	
6815005	6679 PAMOTOR	MODEL#900	
7000003	2250 COLORADO CRYSTAL COR	10MHz	
7000003	7836 STANDARD CYRSTAL CO.	10MHZ32PFLOAD<1PPM45TO55C	
6133043	1004 AMP SPECIAL INDUSTRI	206637-1	
6143016	1004 AMP SPECIAL INDUSTRI	206638-3	
3000000	7834 SPRAGUE PRODUCTS CO.	TG-D50	
6101241	1004 AMP SPECIAL INDUSTRI	641266-3	
6101201	1004 AMP SPECIAL INDUSTRI	641264-3	
6500340	9901 S&A CUSTOM	2001037	
6500452	9901 S&A CUSTOM	2211009	
3400001	5002 KEMET/UNION CARBIDE	T110A225K020AS	

FIGURE 8-20. CONTINUED

1001
ALCO ELECTRONICS PRODUCTS, INC
1551 OSGOOD ST.
NORTH ANDOVER   ,MA   01845

1002
ALL STAR PRODUCTS, INC.
P.O. BOX 216
EDGERTON   ,OH   43517

1003
ALLEN BRADLEY CO.
1201 SO. 2ND ST.
MILWAUKEE   ,WI   53204

1004
AMP SPECIAL INDUSTRIES
ROOM #333
3500 N. CENTRAL AVE.
PHOENIX ,AZ   85012

1006
ADVANCE MICRO DEVICES
901 THOMPSON PL
SUNNYVALE   ,CA   94086

1009
AMPHENOL NORTH AMERCIAN DIV.
DIV. BUNKER RAMO CORP.
900 COMMERCE DR.
OAK BROOK   ,IL   60521

1250
ANALOG DEVICES INC.
2225 28TH ST. #500
LONG BEACH   ,CA   90806

1252
ARNOLD ENGINEERING CO.
1551 E. ORANGETHORPE AVE.
FULLERTON   ,CA   92634

1253
ARCO ELECTRONICS
COMMUNITY DR
GREAT NECK   ,NY   11022

1254
AUGAT INC
33 PERRY AVE
PO BOX 779
ATTLEBORO   ,MA   02703

1500
BECKMAN INSTRS/HELIPOT DIV
2500 HARBOR BLV
FULLERTON   ,CA   92634

1501
BELDEN CORP
P.O. BOX 1331
RICHMOND   ,IN   47374

1750
BURR-BROWN RESEARCH CORP.
6730 S. TUCSON BLDV.
INTERNATIONAL AIRPORT IND. PARK
TUCSON ,AZ   85734

1826
C & K COMPONENTS, INC.
15 RIVERDALE AVE
NEWTON ,MA   02158

1851
CAPAR COMPONENTS CORP.
303 CROSSWAYS PK DRIVE
WOODBURY   ,NY   11797

1950
CENTRAL PLASTICS & RUBBER
1015 S. 23RD ST.
PHOENIX ,AZ   85034

2204
CATALINA MANUFACTURING CO.
1652 E. PRINCESS DRIVE
TEMPE   ,AZ   85281

2250
COLORADO CRYSTAL CORP.
2303 W. 8TH ST.
LOVELAND   ,CO   80537

2253
COTO-CORP
65 PAVILION AVE.
PROVIDENCE   ,RI   02905

2255
CORNELL-DUBILIER
118 E JONES
FUQUAY-VARINA   ,NC   27526

3334
FAIRCHILD/SEMICONDUCTORS
464 ELLIS
MTN VIEW   ,CA   94040

3338
FAIR-RITE PRODUCTS CORP.
P.O. BOX J
WALLKILL   ,NY   12589

3580
FUJITSU AMERICA, INC.
2945 KIFER ROAD
SANTA CLARA ,CA   95051

3585
FUJISOKU ELECTRIC CO.,LTD.
1890 KIZUKISUMIYOSHI-CHO NAKAHARA-KU
KAWASAKI   -0062

FIGURE 8-21. MANUFACTURERS' ADDRESSES

\# 3833
GRAYHILL INC
545 HILLGROVE AVE
LA GRANGE ,IL 60525

\# 4003
HEWLETT PACKARD/SCIENTIFIC INSTRUMENTS
1601 CALIFORNIA AVE
PALO ALTO ,CA 94304

\# 4168
J-B-T SWITCHES
CUTLER-HAMMER
P.O. BOX 1904
NEW HAVEN ,CT 06509

\# 4333
ICON DIV.,USM CORP.
156 6TH ST.
CAMBRIDGE ,MA 02142

\# 4500
INTERLOCK
770 AIRPORT BLVD.
BURLINGAME ,CA 94010

\# 4503
INTEL CORP.
3065 BOWERS AVE.
SANTA CLARA ,CA 95051

\# 4505
INTERSIL
10710 N. TANTAU AVE.
CUPERTINO ,CA 95014

\# 4667
J W MILLER DIV DEPT EM
19070 REYES AVE
COMPTON ,CA 90221

\# 5002
KEMET/UNION CARBIDE
P.O.BOX 5928
GREENVILLE ,SC 29606

\# 5140
KRL ELECTRONICS, INC.
160 BOUCHARD STREET
MANCHESTER ,NH 03103

\# 5333
LITTLEFUSE
800 E. NORTHWEST HWY.
DES PLAINS ,IL 60016

\# 5635
MARCOM AMERICA CORP.
700 LANDWEHR ROAD
NORTHBROOK ,IL 60062

\# 5666
MALLORY/CAPACITOR
2615 MEM PKWY S W
HUNTSVLE ,AL 35801

\# 5667
MAGNECRAFT ELECTRIC CO.
5575 N LYNCH AVE.
CHICAGO ,IL 60630

\# 5668
MEPCO/ELECTRA INC
11468 SORRENTO VLY RD
SAN DIEGO ,CA 92121

\# 5669
MICONICS INDS INC
ONE FAIRCHILD AVE
PLAINVIEW ,NY 11803

\# 5670
MICRO SWITCH
11 W SPRING
FREEPORT ,IL 61032

\# 5676
MICRO METALS, INC.
1190 N. HAWK CIRCLE
ANAHEIM ,CA 92807

\# 5833
MOLEX
2222WILLINGTON CT.
LISLE ,IL 60532

\# 5834
MOTOROLA SEMICONDUCTOR PROD. DI
5005 E MCDOWELL RD.
PHOENIX ,AZ 85008

\# 5835
MONSANTO COMMERCIAL PRODUCTS
3400 HLLVW
PALO ALTO ,CA 94304

\# 6000
NATIONAL SEMICONDUCTOR
2900 SEMICONDUCTOR
SANTA CLARA ,CA 95051

\# 6002
NATIONAL COMPONENTS/NCI
CAPACITOR DIV.
5900 AUSTRIALIAN
WEST PALM BEACH ,FL 33407

\# 6051
NEC MICROCOMPUTERS, INC.
173 WORCESTER STREET
WELLESLEY ,MA 02181

FIGURE 8-21. CONTINUED

6333
OMTRONICS MFG, INC.
2420 S. 60TH ST.
OMAHA ,NE 68106

6664
PACFIC ELECTRI CORD, CO.
747 REDONDO BEACH BLVD.
GARDENA ,CA 90247

6679
FAMOTOR
770 GIRPORT BLVD.
BURLINGAME ,CA 94010

7333
RCA HDQTRS
30 ROCKEFELLER PLZ
NEW YORK ,NY 10020

7334
R-OHM CORP.
16931 MILLIKEN/BX 4455
IRVINE ,CA 92705

7339
RAYTHEON COMPANY
DISTRIBUTOR PRODUCTS OPERATION
FOURTH AVE, P.O. BOX 184
BURLINGTON ,MA 01803

7650
SAMTEC, INC.
810 PROGRESS BLVD.
NEW ALBANY ,IN 47150

7666
SIEMENS CORP.
186 WOOD AVE. SO.
ISELIN ,NJ 08830

7667
HERMAN H. SMITH INC.
812 SNEDIKER AVE.
BROOKLYN ,NY 11207

7669
SCANBE CANOGA INDS
3445 FLETCHER AVE
EL MONTE ,CA 91731

7690
SHIGMA INC.
80 MARTIN LN.
ELK GROVE VILLAGE ,IL 60007

7700
SIGNETICS INC
811 E. ARQUES AVENUE
SUNNYVALE ,CA 94086

7701
SILICONIXS INC.
2201 LAURELWOOD RD.
SANTA CLARA ,CA 95054

7702
SIGNAL TANSFORMER CO.,INC
500 BAYVIEW
INWOOD ,NY 11696

7834
SPRAGUE PRODUCTS CO.
551 MARSHALL ST.
NORTH ADAMS ,MA 01247

7835
STACKPOLE COMPONENTS
P O BOX 14466
RALEIGH ,NC 27610

7836
STANDARD CYRSTAL CO.
9940 E. BALDWIN PLACE
EL MONTE ,CA 91731

8000
TEXAS INSTRUMENTS INC.
BOX 5012
DALLAS ,TX 75222

8001
THERMALLOY INC
P.O. BOX 34829
DALLAS ,TX 75234

8004
TEXTOOL PRODUCTS,INC.
1410 PIONEER DRIVE
IRVING ,TX 75061

8166
TRW CAPACTIROS DIV
301 WEST O STREET
OGALLALA ,NE 69153

8167
TRW/CINCH CONNECTORS
1801 MORSE AVE
ELK GROVE VILLAGE ,IL 60607

8502
UNITRODE CORP.
580 PLEASANT ST
WATERTOWN ,MA 02172

9000
WAKEFIELD ENGINEERING CO.
77 AUDUBON RD.
WAKEFIELD ,MA 01880

9001
WESTON/SCHLUMBERGER/WESTON COMPONENTS
ARCHBALD ,PA 18403

9008
WECKESSER CO.
4444 W. IRVING PK
CHICAGO ,IL 60641

FIGURE 8-21. CONTINUED

150C
1MHZ-60MHZ
QUARTZ CRYSTAL TEST OSCILLATOR
OPERATION MANUAL

AND MISCELLANEOUS INFORMATION

Revised
June 1983

SAUNDERS & ASSOC. INC.
7440 E. KAREN DR. • SCOTTSDALE, ARIZONA 85260 • (602) 991-9250 • TWX 910-950-0087

150C
1MHZ to 60MHZ
QUARTZ CRYSTAL TEST OSCILLATOR

FOREWORD

This manual covers the operating sequence of a standard 150C. If your 150C has an option 007 or higher, this manual may not apply.

The 150C operational sequence is determined by Read Only Memory (ROM) which can be changed. The ROM can be changed to set up a new operational sequence.

Refer to the 150C Operation, Calibration and Maintenance Manual for specification, circuit description, schematics, parts list, etc.

The 150C CI Meter is capable of acquiring the following measurment parameters:

Fr - Series resonant frequency or deviation in PPM from a reference

Fp - Load resonant frequency or deviation in PPM from a reference

Cs and Ct - total capacitance measurement

C1 - Motional capacitance

Rr - Series resonant crystal resistance

P - Power dissipated in crystal

Option 002 - if ordered with 150C Analog output of frequency deviation in PPM from a reference.

The operating procedures for Option 004 are the same; the only effect is to change the nominal operating range.

The 150C will not be able to interface the 2000A/B Printer Processor unlessthe customer specifically requests this feature.

SECTION 1

FRONT PANEL CONTROLS

The CI meter front panel, Figure 1-1, has several user setable controls. This section covers the function of various controls and displays.

1 - Band switch selector. The band switch must be set to the proper range of the crystal to be tested.

2 - 8-digit light emitting diode display. The display shows all measurement results.

3 - Crystal under test power dissipation set (P). The setting is done with a standard screwdriver. The adjustment can be depressed to enable the CI Meter to read power in the crystal in microwatts. All 3 LED's under the switches will light.

4 - Resistance test switch (Rr). Depress to activate. The LED below the switch will light when the switch is activated locally or under remote control.

5 - Load resonance enable (Fp). The switch is a momentary when depressed. The switch can be locked up to enable load resonant measurements continually. The LED below the switch will light when the switch is activated locally or under remote control.

6 - Load capacitance (Cs) or load capacitance + crystal capacitance (Ct) measurement enable. Depress to activate. The LED below the switch will light when the switch is activated locally or under remote control.

7 - Frequency adjust to set the CI Meter to frequency with resistor in test socket.

8 - Mode set switch. 16-position screwdriver adjust switch which sets the operating mode. Read Position on the display when R, Fp and Ct are depressed simultaneously.

9 - Load capacitance (Cs). Adjust.

10 - Crystal test socket. Various configurations are available from Saunders Associates, Inc.

11 - Crystal activity display - Brightness proportional to crystal resistance. (B right is maximum resistance.)

12 - Banana lug to permit holding various test fixtures to the front panel (not RF-ground).

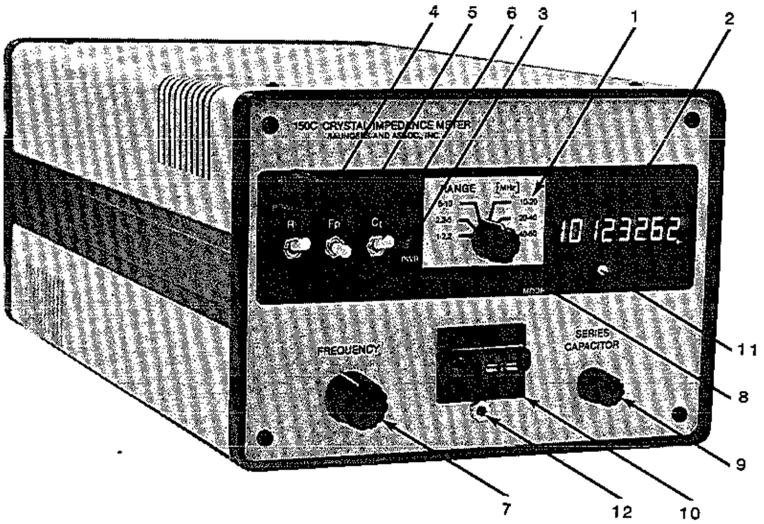


Figure 1-1 CI Meter Front Panel

Special front panel control conditions require multiple switches to be depressed simultaneously.

Switches depressed	Mode	Description of Measurement	Display
None	0 and 2	Series resonant frequency*	XXXXXXX.X or Hz XXXXXXXX.
	1 and 3	Series resonance will display in PPM deviation from reference	XXXXXXX.X or PPM bbXXXXX.X(below)
R	0-3	Series resonant resistance	XXXXXXX.X ohms
Fp	0 and 2	Load resonant frequency*	XXXXXXX.X Hz or XXXXXXXX. Hz
	1 and 3	Load resonance with display in PPM deviation from reference *	XXXXXXX.X or PPM bbXXXXX.X (below)
Ct	0-3	If crystal socket empty the value of Cs with crystal under test Cs + Co of crystal	XXXXXX.XX pF
Power	0-3	Power dissipated in crystal under test	XXXXXX.XX μW
R and Fp	0-3	Load resonant frequency Value saved as reference Vary Cs to get desired reference frequency	XXXXXXX.X Hz or XXXXXX.XX
Fp and Ct	0-3	Motional capacitance of the crystal	XX.XXXXXX pF
R and Fp and Ct	-	Mode set Vary the mode set switch The value of 'X' in the display is the new mode.	CCCCCCCX

*If Option 002 is supplied with the unit and the unit is operating in Mode 2 and 3, the analog frequency output is enabled.

SECTION 2

GENERAL SETUP

The setup procedure of the 150C CI Meter is described in this section. The sequence presented should be rigorously followed to maintain maximum instrument accuracy. The 150 holds power constant independent of crystal resistance, for many crystal test specifications. This permits a single resistor value to be used during setup. For most setups, 50 ohms is recommended as an average value. Minimal correlation error in Fr has been obtained in utilizing a single resistor.

> NOTE
>
> Correlation errors can be reduced even further by setup procedures covered in Appendix B.

The necessary controls are located on the front panel (Section 1).

A. Calibration Resistor

As with all current crystal test instruments (oscillator, as well as transmission), initial frequency or phase is calibrated by a substitution resistor. This resistor should have a minimum inductive component and the shortest lead length possible. One percent monolithic resistors have proved the most satisfactory for this purpose. The critical nature of the calibration resistor is a direct function of the test frequency becoming most significant for the 40-60MHz band.

B. Frequency and Power Set

With oscillator making Fr readings (no front panel switches depressed and mode 0 or 2), set range switch to appropriate band for crystal to be tested and insert calibration resistor. Display will indicate the operating frequency of the oscillator and the oscillation indication light will glow. If the right 5 characters of the display are "EEAGC", and AGC or an out of range condition has been encountered.

(Refer to Section 3 codes.) This typically occurs when the power set is too high or too low for the frequency range or resistance value. Increase or decrease the power setting until an in-range indication is encountered.

Push in on power set potentiometer to display power. This is displayed in microwatts; set to required power while depressed. Release power set potentiometer. Depress R toggle and check resistance value indicated versus value of calibration resistor.

With power set to proper value, adjust the frequency of the oscillator to the frequency of the crystal to within the 3-4 most significant digits for suitable accuracy. The unit is now set for proper measurement of the crystal series resonant frequency and resistance.

C. Load Capacitance Adjustment

To set the proper load capacitance, the crystal socket of the CI Meter must be empty. Depress the Ct toggle switch and the current value of load capacitance (Cs) will be displayed with resolution of 0.01 pF. With Ct still depressed, adjust the value with the series capacitance knob to that required.(approximately 20-110pF).

D. Measurements

The setting of frequency, power and load capacity are all that is required to begin crystal testing. With a crystal inserted in the appropriate socket, characterization can be accomplished in the following manner:

1. Insert crystal - Record Fr (series resonance)
2. Depress R - Record Rr (series resonant resistance)
3. Depress Fp - Record load frequency
4. Depress Ct - Record total capacitance
5. Depress Fp and Ct - Record motional capacitance.

E. Special Tests

The internal capacitance meter of the 150C results in a convenient method of determining the load capacitance requirements of an oscillator. Set the 150C up for proper operation at series resonance. Obtain the operating frequency of the crystal in the unknown load oscillator and then insert the crystal into the 150C. Depress the Fp switch and vary the series capacitor until the displayed frequency is equal to the frequency in the unknown oscillator. Remove the crystal from the 150C, depress Ct and read the required load capacitance. The capacitance is the load presented by the unknown oscillator.

SECTION 3

ANALOG OUTPUT OPTION 002

Section 3 covers option 002 for analog frequency output. This section covers the setup and utilization of the analog output option.

The analog output option uses the reference frequency entered by holding down the R and Fp switches and adjusting Cs to the proper frequency. The last read frequency is the reference which is stored in the 150C memory. As the 150C makes Fs or Fp readings and the analog output mode is enabled, the analog output is set to a new value proportional to the deviation from the reference frequency.

The analog output is ~ 5 volts for an 0PPM deviation. An output of ~ 0 volts corresponds to -500PPM and an output of ~ 10 volts corresponds to +500PPM. The high resolution digitial to analog converter used to generate the analog frequency output does not have high absolute accuracy. The following sequence should be followed to set up the analog output.

1. Set 150C to Mode 4. The display will remain:

   C.C.C.C.C.C.C.4.

2. The analog output will remain at the mid-point corresponding to zero PPM deviation. The equipment connected to the analog output can now be adjusted for the mid-output level.

3. Set the 150C to Mode 5. The display will remain:

   C.C.C.C.C.C.C.5.

4. The analog output will be at the maximum signal level corresponding to +500PPM. The equipment connected to the analog output can be set for the maximum level.

5. Set the 150C to Mode 0. The display should be Fs with no switches depressed.

6. The analog output will be at the minimum signal level corresponding to -500PPM. The equipment connected to the analog output can be set and checked at the minimum level.

7. Set the 150C Mode to 2 or 3. Mode 2 displays frequency in hertz for Fs and Fp. Mode 3 displays deviation in PPM from the reference frequency for Fs and Fp.

The analog output will be enabled and operational. In mode 0 and 1 the analog output is set to the minimum level output.

The analog output will be upgraded approximately every 400m sec.

An example application would be to use the 150C to plot on a two pen strip chart recorder, frequency and resistance. Assume a -55 to +105 deg. C.run in 7 minutes. The 150C would update the plot every 400m sec. or every 0.15 deg. C. With the option 002 resolution of 0.1PPM, the strip chart will show excellent results. The chart is easily calibrated with its axis always in PPM and (independent of frequency), therefore, no scale setup modifications are required when the frequency is changed. The resistance will always be in ohms.

APPENDIX A

Errata Information

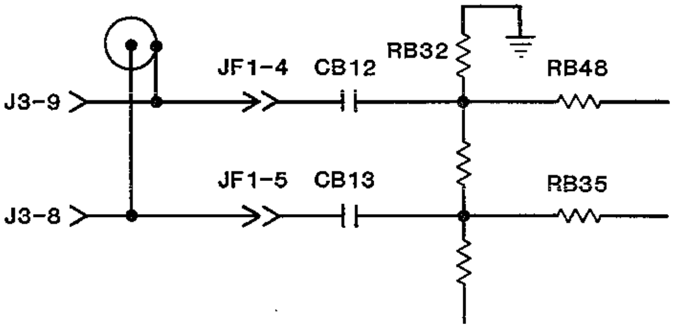
150B/C UPDATE
SEPTEMBER 1983

A) EXTERNAL FREQUENCY STANDARD INPUT

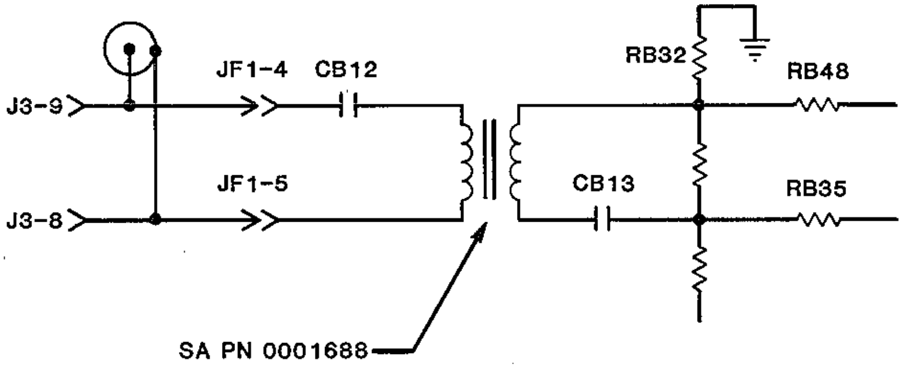
Problem: Because of excessive standard input noise and having the frequency standard ground very different than the powermains ground IC-IB5 has been destroyed and bad external standard operation has occurred.

Solution: All new units are being shipped with an input isolation transformer (150 SN and higher - 140 SN and higher).

OLD CIRCUIT (Page 8-7 of 150C)



NEW CIRCUIT



APPENDIX B

REVISED
JUNE 1983

APPENDIX B

Review of 150C Accuracy Versus Other Test Methods and Methods for More Precise Setup

GENERAL

The following addendum to the 150C Test Oscillator Manual provides more detailed setup procedures.

In addition, some overview of current crystal measurement techniques is provided with comments as to correlation between various methods.

There are currently three methods, or instruments, most commonly utilized for characterizing quartz crystal units. These are:

1) HP 4815 Vector Impedance Meter
2) IEC recommended Pi-Network
3) Various oscillators

Each of the above has assets and liabilities. The 4815 could be an excellent standard were it not for its limited frequency range and the fact that its power capability is 1-2 orders of magnitude less than is typically specified. Its significant advantage is that of the three instruments; it does not appreciably load the crystal Q and therefore gives better resolution of series resonance. It is an excellent instrument for low drive tests related to starting resistance problems.

The IEC recommended Pi-Network has become the most universal standard in the industry and is used as a basis for correlation in this report. It should be recognized that it also has some basis for error. Some care or thought must be given to the inductive component of the calibration resistor if phase is utilized. The PI-Network does load the crystal Q by adding 25 ohms in series which degrades resolution and is driven by a constant voltage generator, resulting in crystals with varying resistance being measured with varying power.

While the Pi-Network is an excellent standard for correlation purposes, its mechanical configuration presents difficulty in automation in an environmental chamber. The paragraph of Section 5 of IEC Publication 444 (defines Pi-Network) should be given consideration - "The construction of the Pi-Network determines the accuracy of the setup." Additionally, the associated equipment required to automate the Pi-Network would considerably increase system cost and reduce speed of measurement. As such, we still hold to the oscillator for production measurements.

FREQUENCY CORRELATION

As indicated, we will defer to the Pi-Network as the ultimate standard of the industry and in the following relate the accuracies and excentricities of the SA150C Test Oscillator to it. A prefacing comment might be appropriate. In general, instrument correlation has been related to ppm deviation from the accepted standard. The Philips Company in Eindhoven has been kind enough to suggest the SA150C Test Oscillator as a secondary test unit, if measurement accuracies on the order of 5ppm are tolerable. This is believed to be more than a fair observation over the frequency range of the instrument. However, an absolute ppm error is not an appropriate rating for any test instrument since the resolution of the series resonant frequency is not only a function of the test instrument but of the crystal impedance as well.

Consider the networks of both the oscillator and Pi shown in Figure B-1A and B.

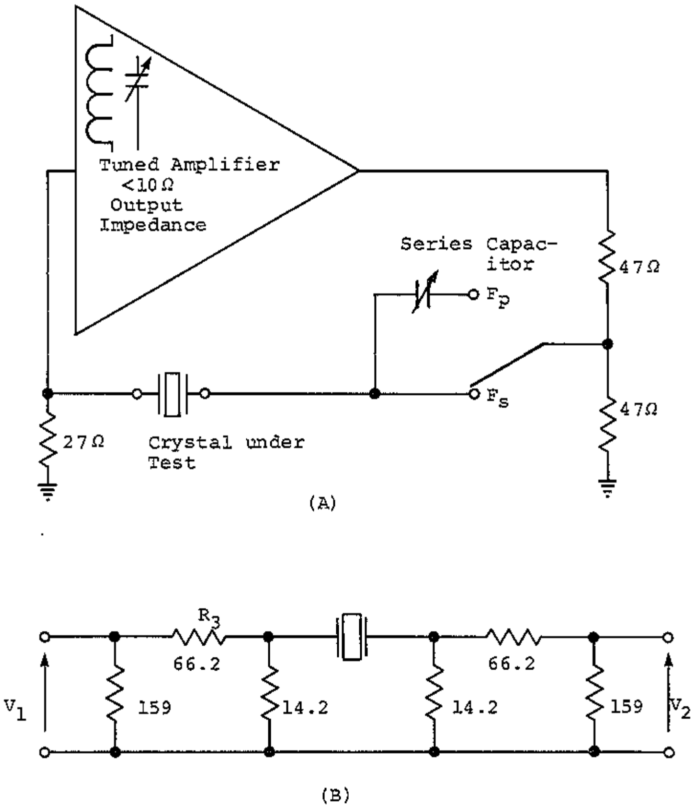


FIGURE B-1 A) 150B Equivalent Circuit
B) IEC444 Pi-Network

Neglecting reactive elements which to a great extent are minimized by the values of resistance, the above networks in the vicinity of the crystal frequency can be reduced to that of Figure B-2.

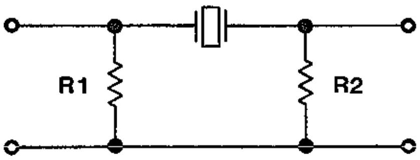


Figure B-2 Simplified Equivalent Circuit

For the Pi, R1 = R2 = 12.5
For the 150, R1 = 23, R2 = 27

By virtue of the measurement, it can be shown that R1 and R2 occur in series with the crystal and degrade its equivalent Qc by the following function.

$$Qn = \frac{Qc}{\left[1 + \frac{R1 + R2}{Rr}\right]} \qquad (1)$$

Where: Qc = Actual crystal Q
Rr = Crystal series resonant resistance

Equation 1 in effect gives an indication of the ability of the test method to resolve the resonant frequency of a crystal. From relationships of Q, the 45 deg. phase points and frequency, it can be shown that phase slope in the instrument is:

$$\Delta \approx \left[\frac{10^{4}}{Qc} + Rt * (\omega C1) * 10^{4} \right] \text{ppm/deg} \qquad (2)$$

Rt = R1 + R2

The above equation reflects that the phase slope at resonance is steeper than at the 45 deg. points, and is approximately the average of two.

The first term is the best that can be done with an unloaded crystal. Assuming a typical crystal Qc = 100,000, then the phase slope is .10 ppm/deg. Assuming phase resolution is +/-2 deg., the resulting error of measurement due to the first term is 2 * 10 to the -7. This is the same for all instruments.

It is the second term which produces the difficulty. Figure 3 is a graphical projection of ppm/deg. vs. frequency for typical crystal motional capacitance values. The larger, the more difficult the frequency resolution. The upper limit of motional capacity is based on the typical maximum crystal shunt capacity (7pf). Again, assuming a 2 deg. phase error and desiring a 2ppm correlation error, the cross hatched area indicates the prime area of difficulty. The break at 30MHz is where typical production changes from fundamental mode to third overtone with motional capacity decreasing as the order of overtone squared, which in turn increases the crystal impedance by the same factor.

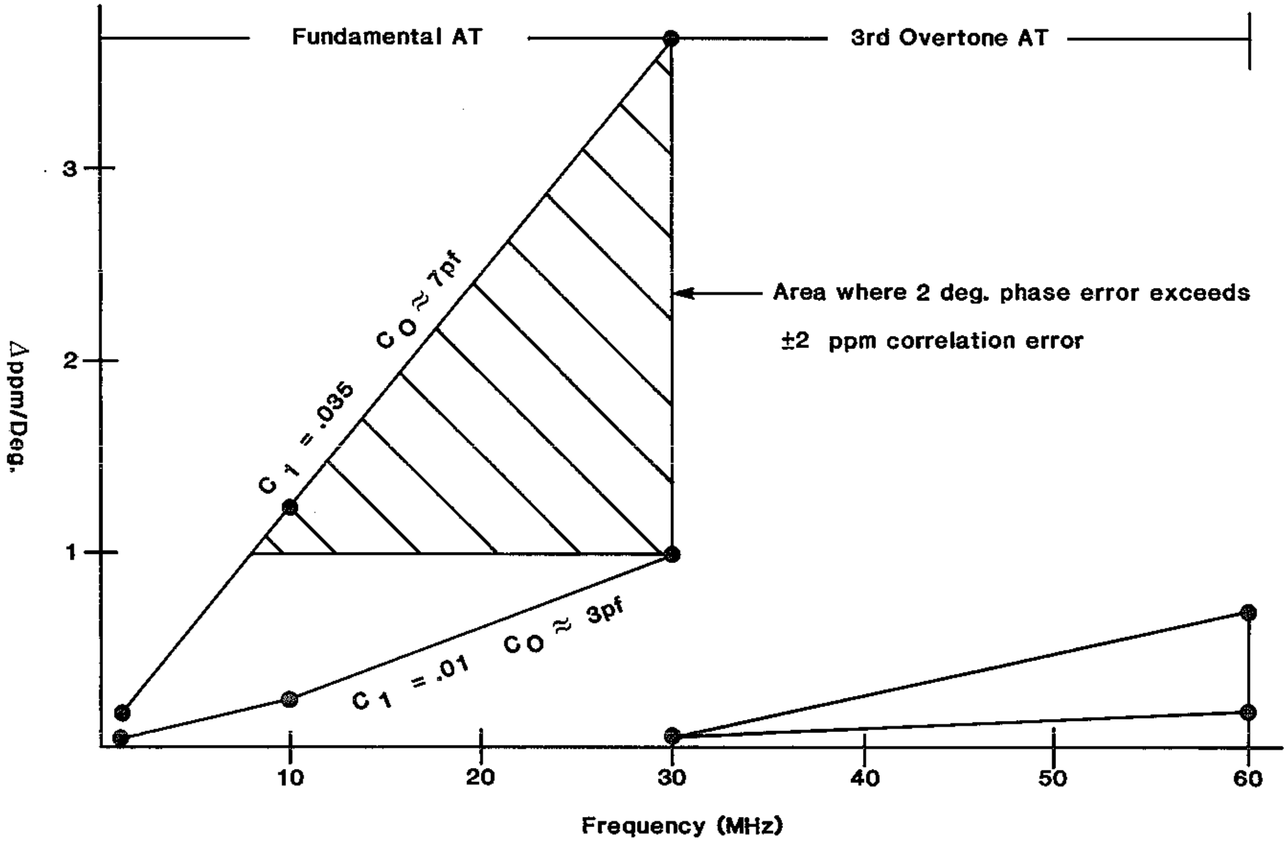


Figure B-3 Crystal Pullability in PPM per Degree of Phase Shift for Various C Motional (C1 Values Versus Frequency) for the SA 140B.

Figure B-3 is a graphical projection which relates entirely to the SA 150C Test Oscillator. The error or deviation in ppm/deg. for the Pi-Network is half that shown by virtue of its lower terminations. In addition, the allowed phase error of the Pi is .2 deg. with possible degradation to 1 deg. with associated test equipment and setup errors such that the Pi should lie within +/-1ppm for all conditions.

With regard to the 150C, it is possible to reduce the +/-5ppm indicated by Philips to within +/-2ppm, with a more specific setup procedure than the 50 ohm resistance value originally recommended. (We have recently encountered deviations from Pi-Network measurements as high as 10-12ppm on crystals with 2 ohm resistance and .027 pf motional capacity values. These errors stem from the recommendation of using a 50 ohm setup resistor.)

There was, and still is, valid reasoning behind the suggestion of the 50 ohm resistor. First, since the 150C truly AGC's on power, the power requirement of a typical specification is maintained for all resistance values. This eliminated the multi-resistor values required by constant voltage instruments. 50 ohms also minimizes the effect of the stray inductance of the setup resistor which could produce correlation errors in the 40-60MHz band. It also met, in all cases tested, the +/-2ppm window which Saunders and Associates, Inc. was attempting to meet. Unfortunately, at the time recommended, Saunders and Associates, Inc. did not have all of the infinite variety of crystals available which have recently caused difficulty.

Consider, in setting up on a 50 ohm resistor and then inserting a 2 ohm crystal maintaining constant power across the terminals, the oscillator is required to increase voltage to the network by 2.8 times and power by almost 8 times. Evaluation of four random 150 units from the production line resulted in the crystal resistance vs. oscillator phase function shown in Figure B-4.

From Figure B-4 and Equation 2, correlation errors can be predicted and minimized. Related to setup procedures, setup resistance should be used as follows:

Crystal Resistance	Setup Resistor
2-5 ohm	3 ohm
5-15 ohm	8 ohm
15-up	50 ohm

This should result in errors less than +/-5ppm in all cases. Where greater accuracy is required, closer resistance values may be necessary.

The use of setup resistors closer to the resistance value of the crystal to obtain closer correlation brings up a question as to the real need for such tight correlation requirements.

A typical example of a crystal where correlation was a problem is as follows:

Name plate frequency = 16.135000MHz
Series Resonance (PI)= 16.125461MHz
C1 = .027 pf
RR = 2.4 ohms

Computed correlation error	14.1 ppm
Actual correlation error	12.5 ppm

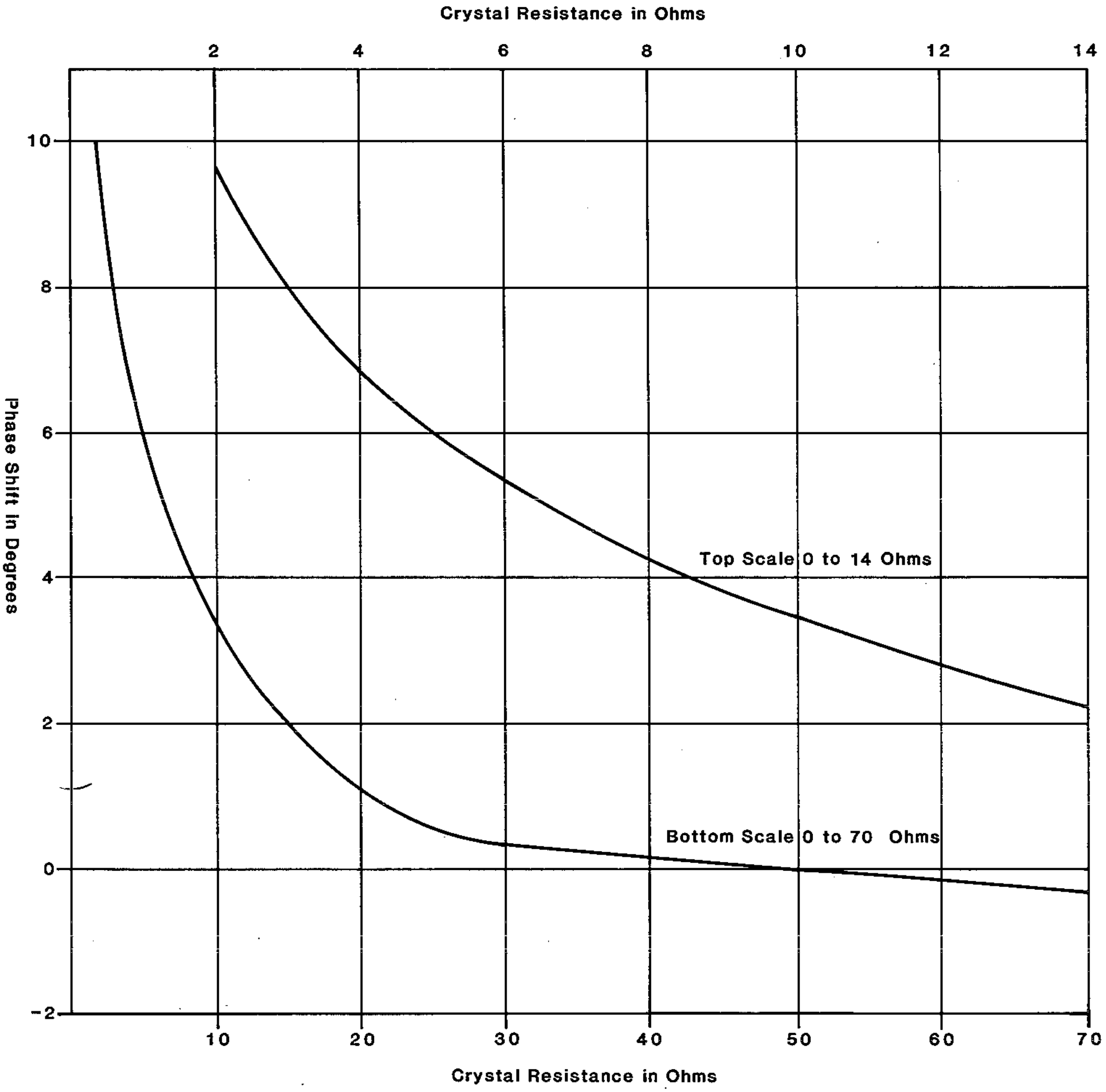


Figure B-4
Oscillator Induced Phase Shift on the Crystal Under Test as a Function of Crystal Resistance when Using a 50 ohm Setup Resistor

From the nameplate frequency the crystal was obviously load resonant. The difference in nameplate and FR is 591 ppm.

$$\text{Then } Ct = \frac{Cl * 10^{6}}{2 \ * 591}$$

$$Ct = 22.8 \text{ pf}$$

The sensitivity in ppm/pf at load is:

$$S = \frac{Cl * \ 10^{6}}{2. \ (22.8)^{2}} = 26 \text{ ppm/pf}$$

What appears to be a significant error in frequency is actually an error of .54 pf in the required load, which, from Saunders and Associates, Inc. experience in building oscillators, is of virtually no consequence.

If we were to assume series resonant operation, the 12-14 ppm error is equivalent to a reactive component in series with the crystal of 10 ohms or .1 micro-henry or 1000 pf, again, far less than can be held in oscillator design.

In addition to the setup resistor, a correlation error can be introduced by the tuned circuit of the amplifier. The Q of the tuned circuits on any band, ranges from approximately 6 to 26, the latter being the worst case condition. From this we can derive the required setup resistor frequency setting as:

$$Sr \text{ ppm} = Sc \text{ ppm} * \frac{Qn}{26}$$

Where:

Sr is oscillator deviation in ppm with resistor from FR.

Sc is required crystal resolution in ppm from FR.

Qn is per equation (1).

Using the previous crystal as an example, Qc = 152 K ohm, Qn = 6976. Then to resolve the crystal to 1 ppm, we must set the oscillator to within +/-250 ppm. This is about the limit of the capabilities of the 150B. For most semi-precision crystals we have tested, the factor Sr is in the vicinity of 2000 ppm/ppm and repeatability typically within +/-2 - 3 * 10 to the -7.

CAPACITANCE CORRELATION

In addition to frequency correlation, we have received inquiries as to capacitance measurement accuracy, specifically the crystal shunt capacity. This is one of the most difficult parameters to measure since typical values are less than 7 pf and highly subject to strays.

The accuracy of the Saunders and Associates, Inc. 150C Capitance Meter is rated at +/-2%. It is also a single ended capacitance bridge (one crystal pin is at virtual ground) as opposed to most precision bridges which are essentially double ended instruments with both terminals guarded and at virtual ground. The SA 150 is comparable, for example, to the HP4815. It should also be noted that any load resonant oscillator is single ended, with a high impedance point at the junction of the load capacitance and crystal. Since this is the case, the SA 150 accounts for the capacitance which will be encountered in the end use oscillator.

Consider Figure B-5A and B-5B. Figure B-5A presents the inherent capacitance of an enclosed crystal unit. A comparison of measurements between a double ended and single ended capacitance bridge would lead to the following values:

Co Measurements for Various Test Conditions

	Double Ended Measurements	Single Ended Measurements
Test Condition for Crystal Case	Typical Capacitance Meter bridges with guarded virtual grounded test terminals	SA150 - HP4815 One crystal pin held at virtual ground
Ungrounded	$Co = CB + CE + \frac{C}{2}$	$Co = CB + CE + \frac{C}{2} + CX$
Grounded	Co = CB + CE	Co = CB + CE + C

A typical crystal can be found to have the following values:

C1 = .01pf	(The actual capacity ratio
CE = 1.7 pf	of AT cut crystal is
C = 1 pf	approximately 160-170)
CB = .1 pf	
CX = .3 pf	

Assuming the crystal to be grounded in the end use oscillator, it might be the decision to ground the crystal for static capacity test. Then for the double ended bridge Co = 1.8 and Co/Cl = 180. For the SA 150, Co = 2.8 and Co/Cl = 280, resulting in a considerable difference. Again, the secondset of readings would be those encountered in the end oscillator circuit.

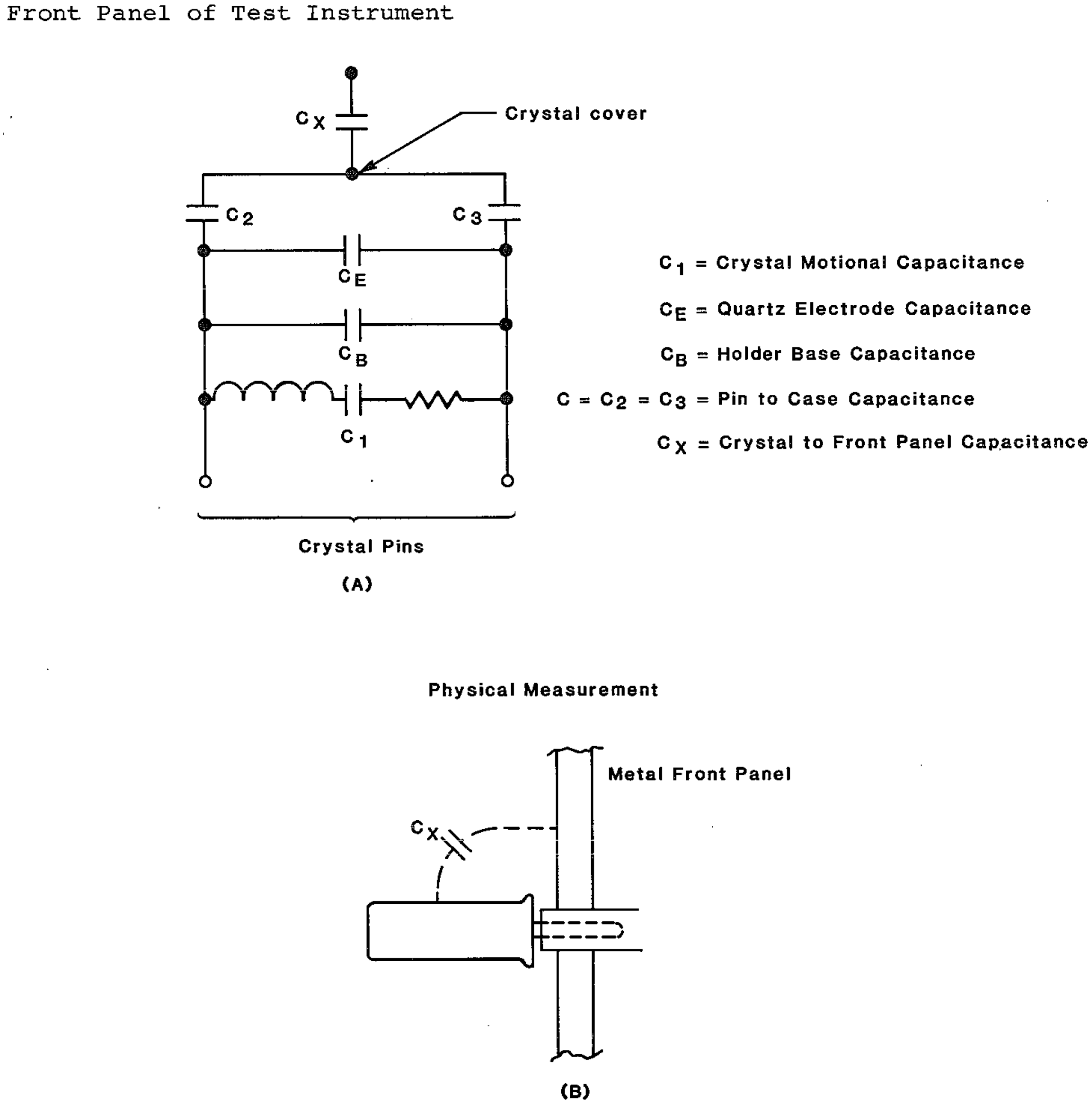


Figure 5 - Crystal Capacitance Equivalent Circuit
(A) Shows Crystal and Stray Capacitance
(B) Shows Crystal Can to Front Panel of 150C Stray

OPTION 001

IEEE 488 DATA BUS INTERFACE

FOR

DIRECT DISPLAY CI METER

001-1 DESCRIPTION

The Option 001 permits the Crystal Impedance Meter measurements to be set and read by a controller operating to the IEEE 488-1978 Data Bus specification.

The IEEE 488 bus is also known as the Hewlett Packard Interface Bus (HPIB) or the General Purpose Interface Bus (GPIB).

The functions and specifications of the bus interface are covered in the "IEEE Standard Digital for Programmable Instrumentation" IEEE Std. 488-1978.

The IEEE 488 bus permits the user to set the CI Meter to Series Resonant Frequency (F_r), Load Resonant Frequency (F_p), Total Capacitance (C_t), Series Resonant Resistance (R_r) and Power (P). The user sends a Trigger Character of 8ASCII to start a Crystal Impedance Meter Measurement. The results of the measurement are then available to send over the bus to the controller.

Refer to the Crystal Impedance Meter User Manual and Maintenance Calibration Manual for a full description of the measurements.

001-2 OPERATIONAL CHARACTERISTICS

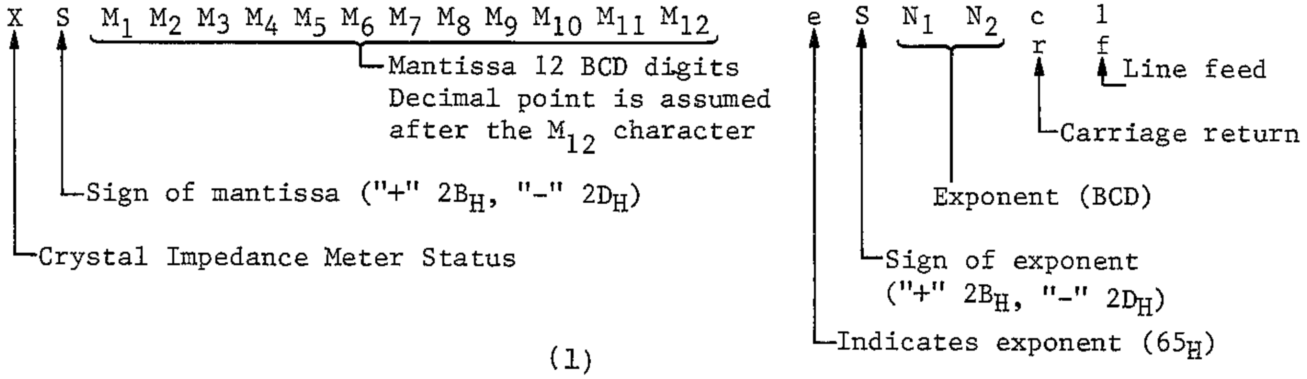
The CI Meter is controlled by a Command Character which sets the instrument mode. After the Command Character, the trigger character 8ASCII must be sent to trigger the conversion. Sending of the Command Character will set the CI Meter Function Display.

Do not send the CI Meter any other characters. Do not send carriage return and line feed.

IEEE 488 BUS INTERFACE CONTROL CHARACTERS

Function Set	ASCII Command Character	Hex Value of Character	Results
F_r Series Resonant Frequency	0	30	Frequency in Hz
F_p Load Resonant Frequency	4	34	Frequency in Hz
R_r Series Resonant Resistance	2	32	Resistance in Ohms
C_t Capacitance in picofarads	6	36	Capacitance in picofarads
P Power in microwatts	1	31	Power in microwatts

Resulting Data Format on IEEE 488 Bus (All results are sent in this format)



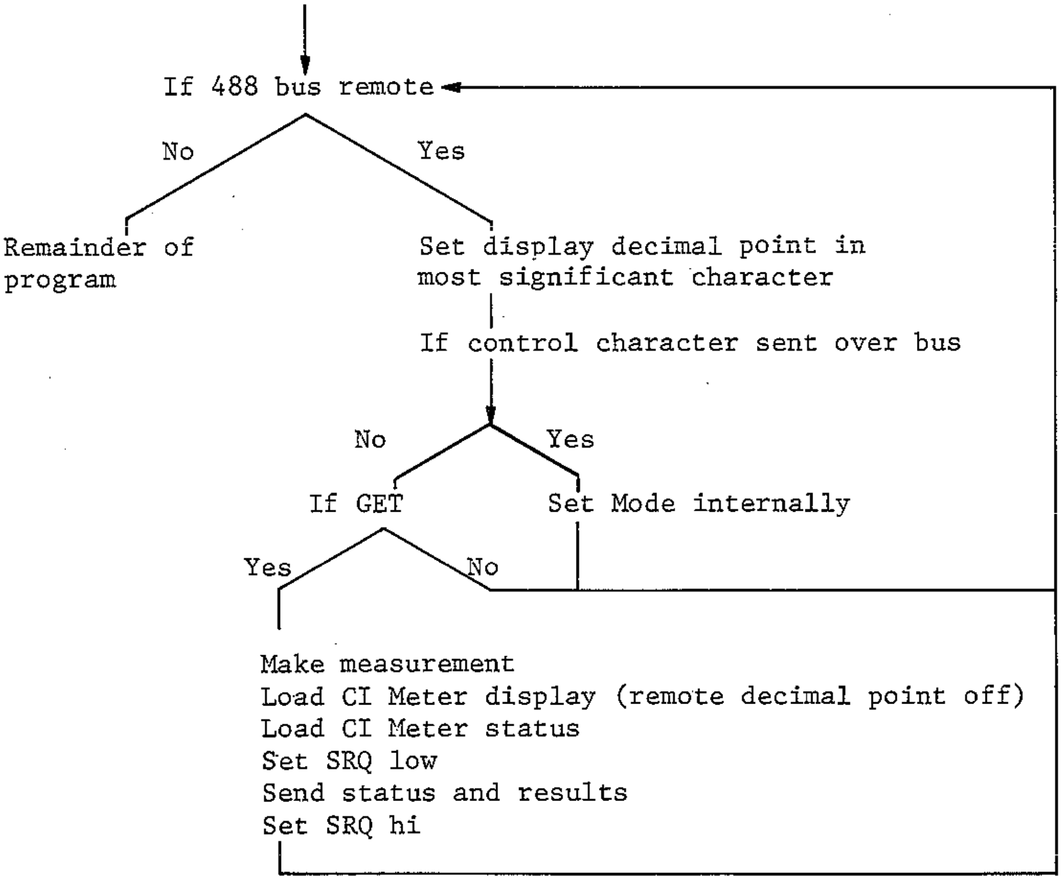
Crystal Impedance Meter Status Character

ASCII Character	Hex Value of Character	Indicated Status
L	4C	Valid Results CI Meter on Internal Standard
D	44	AGC error or CI Meter out of range CI Meter on Internal Standard
M	4D	Valid Results CI Meter on External Standard
E	45	AGC error or CI Meter out of range CI Meter on External Standard

The Crystal Impedance Meter sets the bus SRQ line low when a conversion is complete.

The SRQ line is set high when either the data of the conversion is read or the controller executes a serial poll of the Crystal Impedance Meter. The Serial Poll character contains no information except the character is 40_H when SRQ is active and 00_H when inactive.

The Crystal Impedance Meter measurement sequence in the IEEE 488 measurement mode is flow charted below:



001-3 BUS ADDRESS SETTING:

The bus address is loaded about 3 seconds after the Crystal Impedance Meter powers up. The address is not reloaded at any other time. The switch setting should be set prior to power up. The address switch is located on the front of the Crystal Impedance Meter control board. Remove the Crystal Impedance Meter cover with POWER DISCONNECTED to set the address.

Switch 6 should always be closed.

SD3 Switch Position					Talk		Listen	
5	4	3	2.	1	Hex	ASCI1	Hex	ASCI1
C	C	C	C	C	40	@	20	SP
C	C	C	C	0	41	A	21	!
C	C	C	0	C	42	B	22	"
C	C	C	0	0	43	C	23	#
C	C	0	C	C	44	D	24	$
C	C	0	C	0	45	E	25	%
C	C	0	0	C	46	F	26	&
* C	C	0	0	0	47	6	27	' *
C	0	C	C	C	48	H	28	(
C	0	C	C	0	49	I	29	)
C	0	C	0	C	4A	J	2A	*
C	0	C	0	0	4B	K	2B	+
C	0	0	C	C	4C	L	2C	,
C	0	0	C	0	4D	M	2D	–
C	0	0	0	C	4E	N	2E	.
C	0	0	0	0	4F	O	2F	/
0	C	C	C	C	50	P	30	0
0	C	C	C	0	51	Q	31	1
0	C	C	0	C	52	R	32	2
0	C	C	0	0	53	S	33	3
0	C	0	C	C	54	T	34	4
0	C	0	C	0	55	U	35	5
0	C	0	0	C	56	V	36	6
0	C	0	0	0	57	W	37	7
0	0	C	C	C	58	X	38	8
0	0	C	C	0	59	Y	39	9
0	0	C	0	C	5A	E	3A	:
0	0	C	0	0	5B	C	3B	:
0	0	0	C	C	5C	/	3C	<
0	0	0	C	0	5D	]	3D	=
0	0	0	0	C	5E	Λ	3E	>

C = Closed

0 = Open

* Value set when shipped from factory

001-4 CIRCUIT DESCRIPTION

The interface circuitry consists of a complex large scale integrated circuit, 16 bus transceivers and bus termination resistors.

The bus transceivers have a control line which sets the direction of signal flow. The bus driver portion of the transceivers has a control line which sets the direction of signal flow. The bus driver portion of the transceiver is an open collector output. The receiver portion drives the LSI circuit with a TTL compatible output. See Figure 001-1.

The bus transceiver direction is determined by the control circuit IE1 of Figure 001-2. The control circuit interfaces with the CI Meter's processor to read CI Meter control and send measurement data.

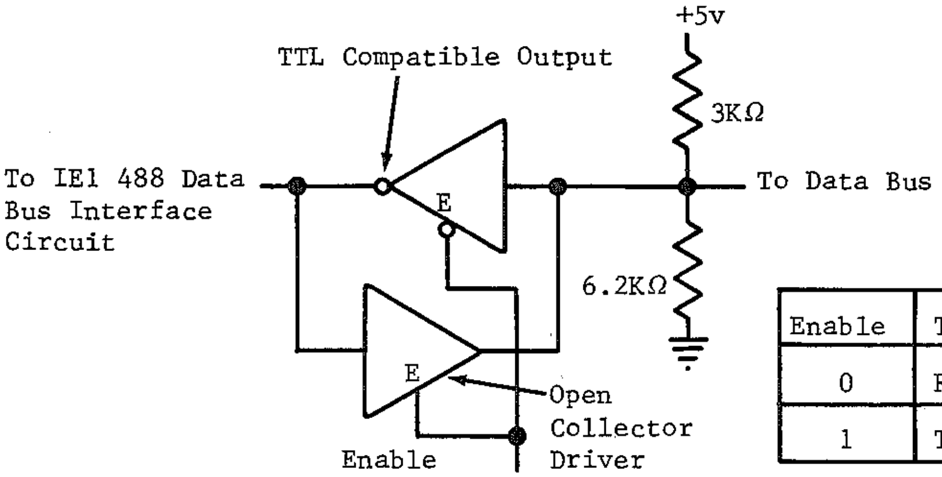
001-5 MAINTENANCE/REPAIR

The IEEE 488 Data Bus option requires no maintenance except the back panel connector should be kept clean to ensure good electrical contact.

The most common repair would be to replace a failed bus transceiver. The circuits which receive data can be checked by grounding the appropriate 488 Data Bus line and checking the signal on the proper pin of IE1. The IE1 pin 1 (T/R1) signal should be checked as this line determines the bus transceiver's communication direction. These drivers would need to be carefully unsoldered, replaced and resoldered if a failure is found.

The 488 bus address setting switch SD3 contacts may become oxidized. Repeated opening and closing of the switch before setting a new address will ensure a good switch closure.

If malfunction of the 488 Data Bus option continues to occur and the remainder of the Crystal Impedance Meter is operating satisfactorily, the Crystal Impedance Meter should be returned to the factory for repair.



Enable	Transceiver Direction
0	Receive
1	Transmit

Figure 001-1 IEEE 488 Data Bus Transceiver Interface

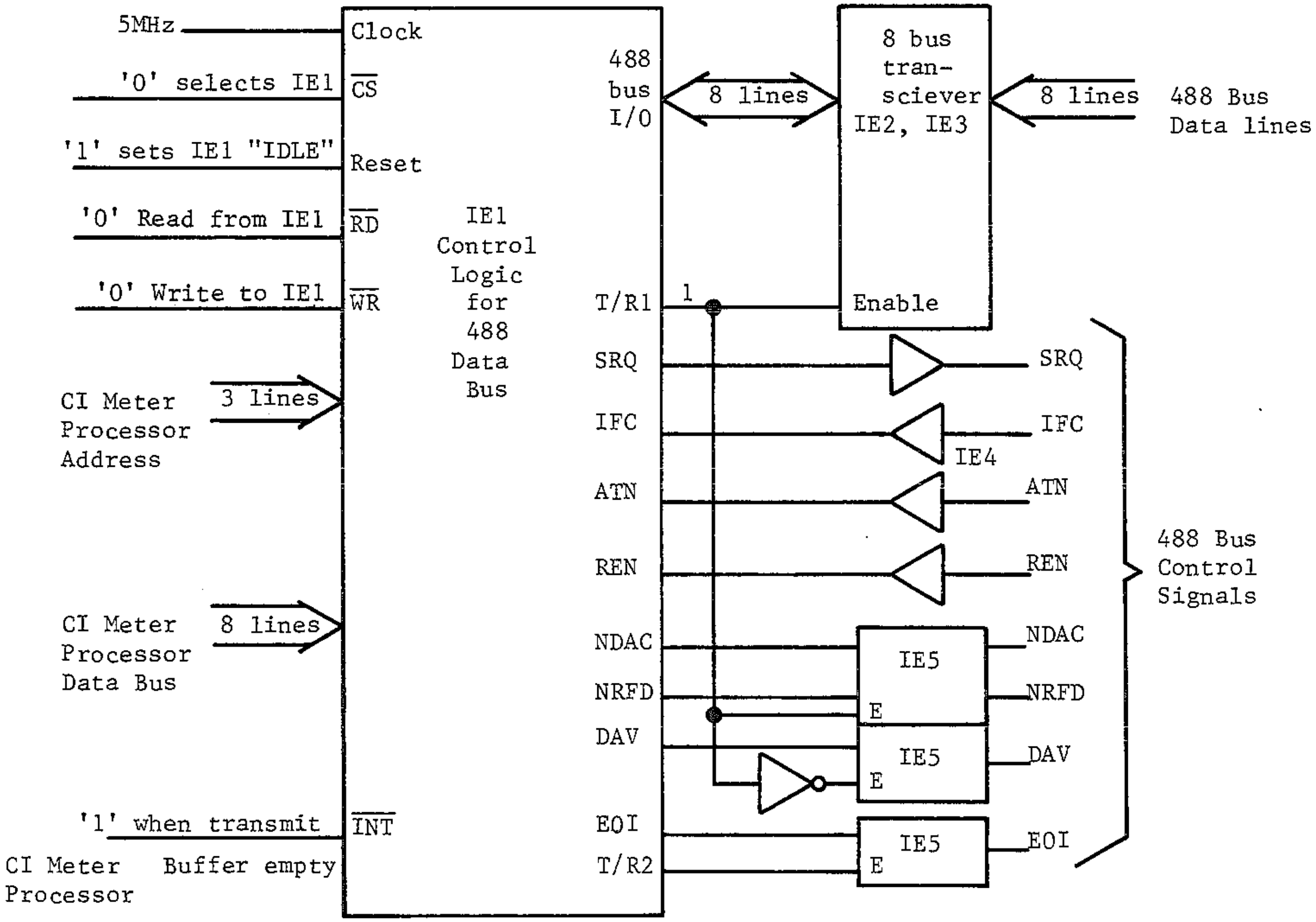
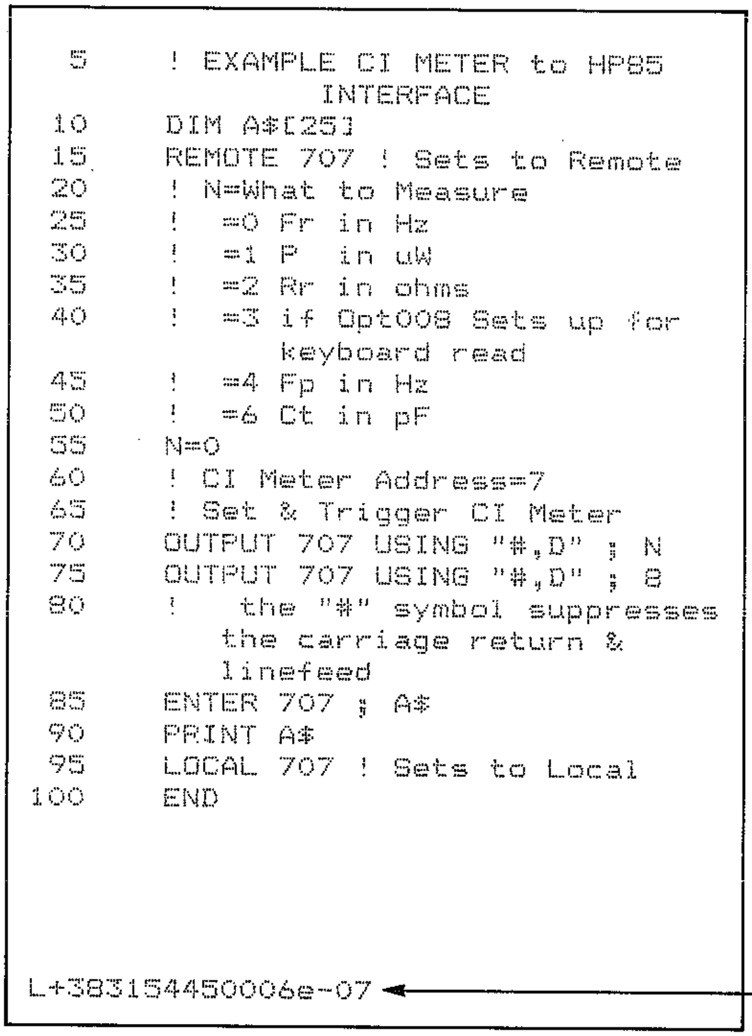


Figure 001-2 Block Diagram of 488 Data Bus Interface Circuit

001-6 CALIBRATION

There is no calibration required for the IEEE 488 Data Bus Interface. The setup of the Crystal Impedance Meter per the unit's Operation and Maintenance Manual will ensure the IEEE 488 Data Bus option is operating per the Saunders and Associates, Inc. and the IEEE 488-1978 Bus specification.

001-7 TYPICAL HP85 CALCULATOR PROGRAM



```
  5     ! EXAMPLE CI METER to HP85
                 INTERFACE
 10     DIM A$[25]
 15     REMOTE 707 ! Sets to Remote
 20     ! N=What to Measure
 25     !   =0 Fr in Hz
 30     !   =1 P  in uW
 35     !   =2 Rr in ohms
 40     !   =3 if Opt008 Sets up for
              keyboard read
 45     !   =4 Fp in Hz
 50     !   =6 Ct in pF
 55     N=0
 60     ! CI Meter Address=7
 65     ! Set & Trigger CI Meter
 70     OUTPUT 707 USING "#,D" ; N
 75     OUTPUT 707 USING "#,D" ; 8
 80     !    the "#" symbol suppresses
           the carriage return &
           linefeed
 85     ENTER 707 ; A$
 90     PRINT A$
 95     LOCAL 707 ! Sets to Local
100     END




L+383154450006e-07
```

EXAMPLE RESULTS

CRYSTAL IMPEDANCE
METER
KEYPAD
OPTION 003
OPTION 005

OPERATION
AND
MAINTENANCE
MANUAL

SAUNDERS & ASSOC. INC.

7440 E. KAREN DR., • SCOTTSDALE, ARIZONA 85260 • (602) 991-9250

CRYSTAL IMPEDANCE
METER
KEYPAD

CERTIFICATION

Saunders and Associates, Inc. certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory.

WARRANTY AND ASSISTANCE

This Saunders and Associates, Inc. product is warranted against defects in workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Saunders and Associates, Inc. No other warranty is expressed or implied. We are not liable for consequential damages.

TABLE OF CONTENTS

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Saunders and Associates, Inc. assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to Saunders and Associates, Inc. for service and repair to ensure that safety features are maintained.

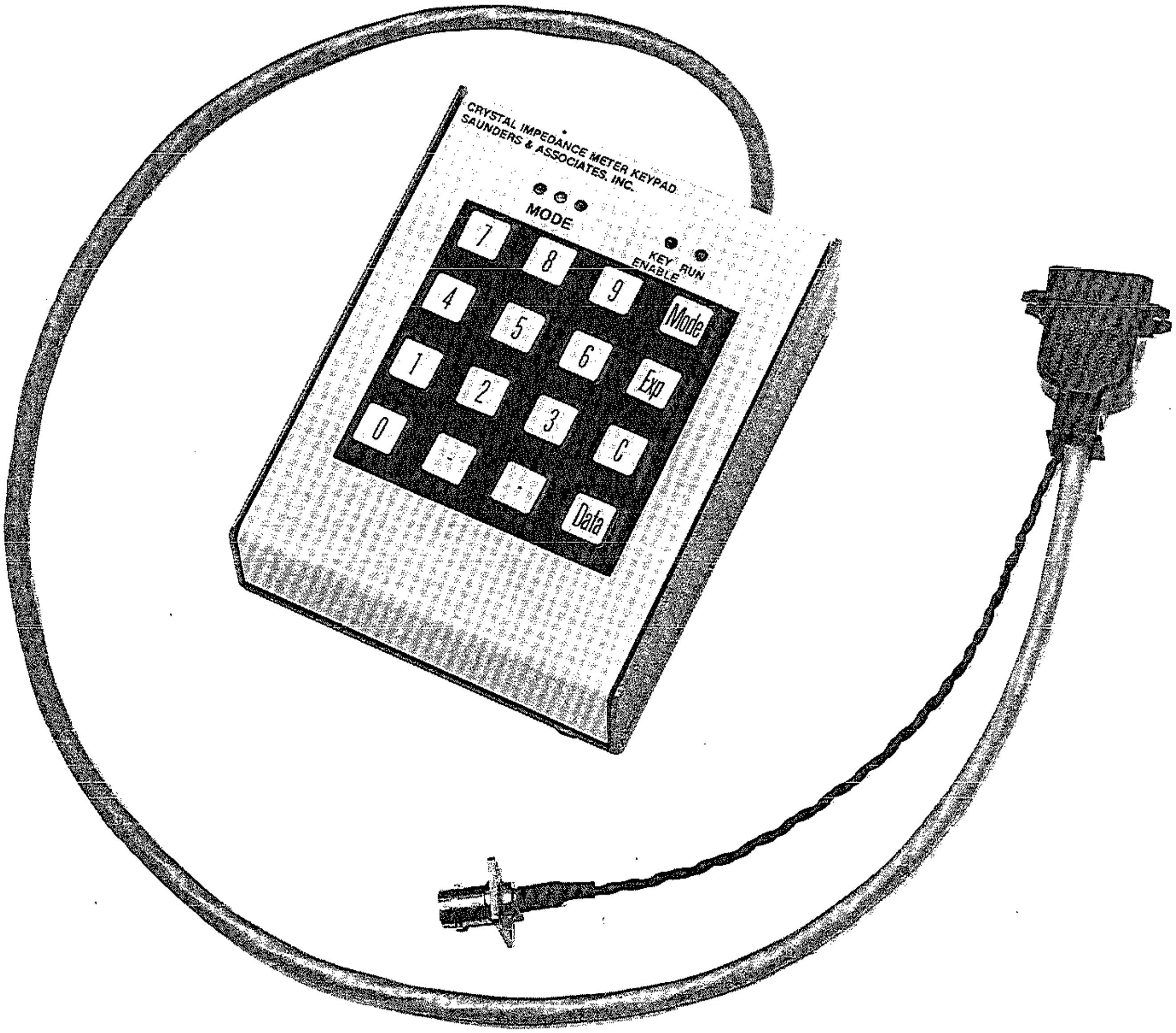


FIGURE 1-1. CI METER INTERFACE KEYBOARD

SECTION 1

DESCRIPTION

The keyboard is designed to interface with the 140A/150B/150C/160A Crystal Impedance Meters. The keyboard permits keying in numbers, setting or changing the operating condition and displaying CI Meter status. Figure 1-1 shows the 16 keypad, which is Option 003.

All operation conditions covered in the Basic Operation manual can be performed as well as the additional conditions covered in this manual.

In the basic configuration, Option 003, the keyboard permits the user to input a reference frequency and deviation to be displayed as in the standard CI Meter unit. The Option 003 can also permit the following option and functions to exist.

Option 001	IEEE 488 Bus Interface
Option 002	Analog Output (reference frequency from keyboard)
Option 004	Limited Power Range
—	2000A/B Interface

The keyboard also permits a special measurement option to be enabled. Option 005 in conjunction with Option 003 permits two basic types of testing.

a. Engineering type measurement:
Many possible crystal measurements are permissible with the CI Meter displaying the results.

b. Inspection Pass/Fail Mode:
Crystals are checked against limits and pass/fail indication given. This test is very useful for incoming crystal inspection.

The keyboard interfaces the CI Meter through the I/O port which also interfaces the 2000A/B Printer Processor. The keyboard derives all power from the interface. The keyboard function is determined by ROM programming of the CI Meter.

Several of the calculations and measurements performed by the CI Meter are designed to reduce the burden of engineering. For example:

- The CI Meter can compute the load capacitance necessary to put the crystal at a specified frequency. In fact, the program can compute the value of a negative capacitor (inductor) which would move the crystal down to a specified frequency.
- Pullability of the crystal at any specified frequency in parts per million per picofarad can be calculated.
- The load resonant frequency of a crystal can be computed at any specified load capacitance. This permits the user to specify a load capacitance less than the 14pF the CI Meters are typically capable of. The CI Meter measures the value at the CI Meter settings and computes the value at the user specified load and displays the result.

An example of an oscillator design follows.

Requirement:

10MHz Oscillator, resettable to 10MHz at 25°C for 5 years.

Circuit Results:

28pF load with a trim range of ±8pF.

Trim range was found by using the CI Meter. The actual oscillator was set to the minimum capacitance value and the resonant frequency value was measured with a frequency counter. The actual oscillator was also measured at maximum capacitance.

The crystal was removed from the oscillator and installed in the CI Meter. The CI Meter was input to the highest recorded frequency and told to compute the load capacitance. The same was performed at the lowest recorded frequency. The values displayed by the CI Meter are the actual crystal load seen by the crystal.

Final Crystal Specification:

The CI Meter showed the crystal to have a 4.5PPM/pF pullability at 10MHz.
± 1pF of the trim range is assumed to be needed to allow for circuit variation in production.

The crystal manufacturer guarantees the crystal will not shift more than 1PPM/year or the worst case, 5PPM in 5 years. We must allow 1.1pF of the trim range to cover crystal aging.

The finally usable trim range available is ± 5.9pF or (4.5PPM/pF) (5.9pF) = ± 26.5PPM. Therefore, the crystal must be specified as a 10MHz crystal at 28pF with a tolerance of 26PPM.

SECTION 2

SPECIFICATION

This section covers the specifications of the keyboard function as well as the calculations used in the various modes.

2.1. KEYBOARD

16 Keypad

9 number keys 0 through 9

−	minus key	Makes number or exponent minus.
·	decimal point key	Adds decimal point to entry.
C	clear key	Clears current number being entered.
Exp	exponent key	Sets to exponent mode.
MODE	mode key	Increment mode display
DATA	data key	Enables keyboard or enters keyed-in number and mode.

Display on keyboard

The keyboard has 5 display light emitting diodes.

Mode Display—
Only one LED or none can be on at any given time.

Keyboard Enable—
Indicates keyboard enabled to change modes or input numbers.

Run—
Indicates CI Meter running and keyboard disabled.

2.2. KEYBOARD OPERATION

CI Meter must be in Mode 8, 9, A or B.

Mode 8 same as Mode 0	display frequency	Analog output set to −500PPM
Mode 9 same as Mode 1	display PPM from reference frequency	Analog output set to −500PPM
Mode A same as Mode 2	display frequency	Analog output enabled
Mode B same as Mode 3	display PPM deviation from the reference frequency	Analog output enabled

The modes operate as modes 0 through 3 except the reference frequency can also be entered by the keyboard.

2.3. OPTION 005 SPECIAL KEYBOARD OPERATION

The CI Meter can operate with additional capabilities to modes 8, 9, A or B.

2.3.1. Engineering Measurement Mode

The CI Meter operates in Mode 6.

User Entries:

F_{LS} —Reference frequency keyed-in and stored Hz

C_1 ref—Reference C_1 value keyed-in and stored pF

C_{LS} —Specified C_{LOAD} value keyed-in and stored pF

The measurements made and calculations are:

F_R —Series resonant frequency as measured Hz

F_P —Load resonant frequency as measured Hz

R_R —Series resonant resistance as measured — ohms

C_L —Measurement of C_{Series} (value saved) (no crystal in crystal test socket) — pF

P —Measurement of crystal power setting

C_t —Measurement of C_{Series} with a crystal in the test socket — pF

C_0 —Crystal pin to pin capacity — pF

$= C_t - C_L$

F_R Deviation = Deviation in PPM from F_{LS} reference

$$= \frac{F_R - F_{LS}}{F_{LS}} 10^6$$

F_P Deviation = Deviation in PPM from F_{LS} reference

$$\frac{F_P - F_{LS}}{F_{LS}} 10^6$$

F_L = Resonant frequency of the crystal calculated at the specified C_L Ref

$$= F_R + (F_P + F_R) \frac{C_t}{C_{LS} + C_0}$$

F_L Deviation = Deviation in PPM from F_{LS} reference

$$= \frac{F_L - F_{LS}}{F_{LS}} 10^6$$

C_{LC} = Calculated load capacitance needed to put the crystal at the F_{LS} frequency

$$= \frac{F_P - F_R}{F_{LS} - F_R} C_t - C_0$$

Trim Sensitivity (T.S.) in PPM/pF

TS = Pullability of the crystal at the frequency F_{LS}

$$= \left| \left(\frac{F_{LS} - F_R}{F_P - F_R} \right) \left(\frac{F_{LS} - F_R}{F_R} \right) \frac{1}{C_t} \right|$$

C_1 = Motional crystal capacitance — pF

$$= 2C_t \frac{F_P - F_R}{F_R}$$

L = Motional Capacitance — mH

$$= \frac{1}{4\pi^2 F_R{}^2 C_1}$$

Q = Crystal quality factor

$$= \frac{1}{2\pi F_R C_1 R_R}$$

Change of C_1 = Change of C_1 from C_1 ref

$$= \frac{C_1}{C_1 \text{ ref}}$$

Delta F = Difference of F_P and F_R — Hz

$= F_P - F_R$

Capacity Ratio = Ratio of C_0 to C_1

$$= \frac{C_0}{C_1}$$

2.3.2. Inspection Q.C. Mode

CI Meter Mode 7 permits Go/No Go testing of crystal against limits.

Six types of test are available.

TEST TYPE	SPECIFIED VALUES (Min/Max Limits)				
	0	1	2	3	INPUT PARAMETER
A	F_L at C_{LS}* Hz	C_0 pF	R_R ohms	C_1 pF	C_{LS} * Load Capacity
B	F_L at C_{LS}* Hz	C_0 pF	Q	pF	C_{LS} * Load Capacity
C	F_L at C_{LS}* Hz	C_0 pF	R_R ohms	L mH	C_{LS} * Load Capacity
D	F_L at C_{LS}* Hz	C_0 pF	Q	L mH	C_{LS} * Load Capacity
E	C_{LC} at F_{LS} pF	C_0 pF	R_R ohms	Trim Sensitivity PPM/pF	F_{LS} Reference Frequency
F	C_{LC} at F_{LS} pF	C_0 pF	Q	Trim Sensitivity PPM/pF	

*Input C_{LS} as 1 x 10^{50}pF to specify series resonance.

User inputs the 8 limits, test type and reference parameters by using the CI Meter front panel controls and keyboard.

2.4. SIZE AND WEIGHT

Size 5.1cm H. x 10.8cm W. x 14cm D. with a 76cm cord (2″ H. x 4.3″ W. x 5.5″D. with a 30″ cord)

Weight	0.5 Kg	(1 lb.)
Shipping weight	1.5Kg	(3 lbs.)

Shipping size 31.8cm x 31.8 cm x 21.1cm (12.5″ x 12.5″ x 8.5″)

SECTION 3

INSTALLATION

The information necessary for installing the Crystal Impedance Meter Keypad is contained in this section. Included are initial inspection procedures, power and grounding requirements, installation instructions, and procedures for repackaging the instrument for shipment.

3.1. INITIAL INSPECTION

This instrument was carefully inspected both mechanically and electrically before shipment. It should be free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage incurred in transit. If the instrument was damaged in transit, file a claim with the carrier. Test the electrical performance of the instrument using the performance test procedures outlined in Section 4. If there is damage or deficiency, see the warranty in the front of this manual.

> ***IMPORTANT***
>
> Read the Safety summary at the front of the manual before installing or operating the instrument.

3.2. POWER REQUIREMENTS

The CI Meter Keypad has no external power requirements. The unit derives all the power necessary from the CI Meter I/O port.

3.3. INSTALLATION

Connect the connector at the end of the CI Meter Keypad to the I/O port of the Crystal Impedance Meter.

The BNC cable coming from the Keypad connector is the optional frequency standard input to the Crystal Impedance Meter. Refer to the Crystal Impedance Manual for more details.

The Keypad is installed. Follow the operating procedures in Section 4 for use of the Keypad.

3.4. REPACKING FOR SHIPMENT

If the instrument is to be shipped to Saunders & Associates, Inc. for service or repair, attach a tag showing owner (with address), complete instrument serial number, and a description of the service required.

Use the original shipping carton and packing material. If the original packing material is not available, Saunders & Associates, Inc. will provide information and recommendations on materials to be used.

SECTION 4

OPERATING PROCEDURES

The operation of the Keypad and the operation with the CI Meter are covered in this section. The Option 005, Engineering and Go/No Go modes, is also covered in this section. Option 005 is an option which can be purchased with the CI Meter as a field upgrade.

4.1. KEYPAD OPERATION

The layout of the Keypad is shown in Figure 4-1. Only the Data key can activate or enable the Keypad. After the $\boxed{\text{DATA}}$ key has requested enabling of the Keypad, the KEY ENABLE LED is ON indicating enabling has occurred. With the Keypad enabled, all 16 keys are active.

The $\boxed{\text{MODE}}$ key caused the Keypad displayed mode to increment. The displayed mode is entered with the keyed-in number. Both are entered when the $\boxed{\text{DATA}}$ key is pressed after keying in the value.

The entry of the number −123.45 is shown in Figure 4-2. The minus key can be depressed any time during the mantissa entry. The "*b* " character is used as a minus character in the display as the display is not capable of displaying a " − ". The CI Meter display follows the various key depressions. Figure 4-3 shows entry of 1,750,000. The exponent mode is used to minimize key strokes. Figure 4-4 shows entry of 8.37 x 10^{-12}. The entry was begun wrong and the clear key depressed to permit clearing the error and starting the entry again.

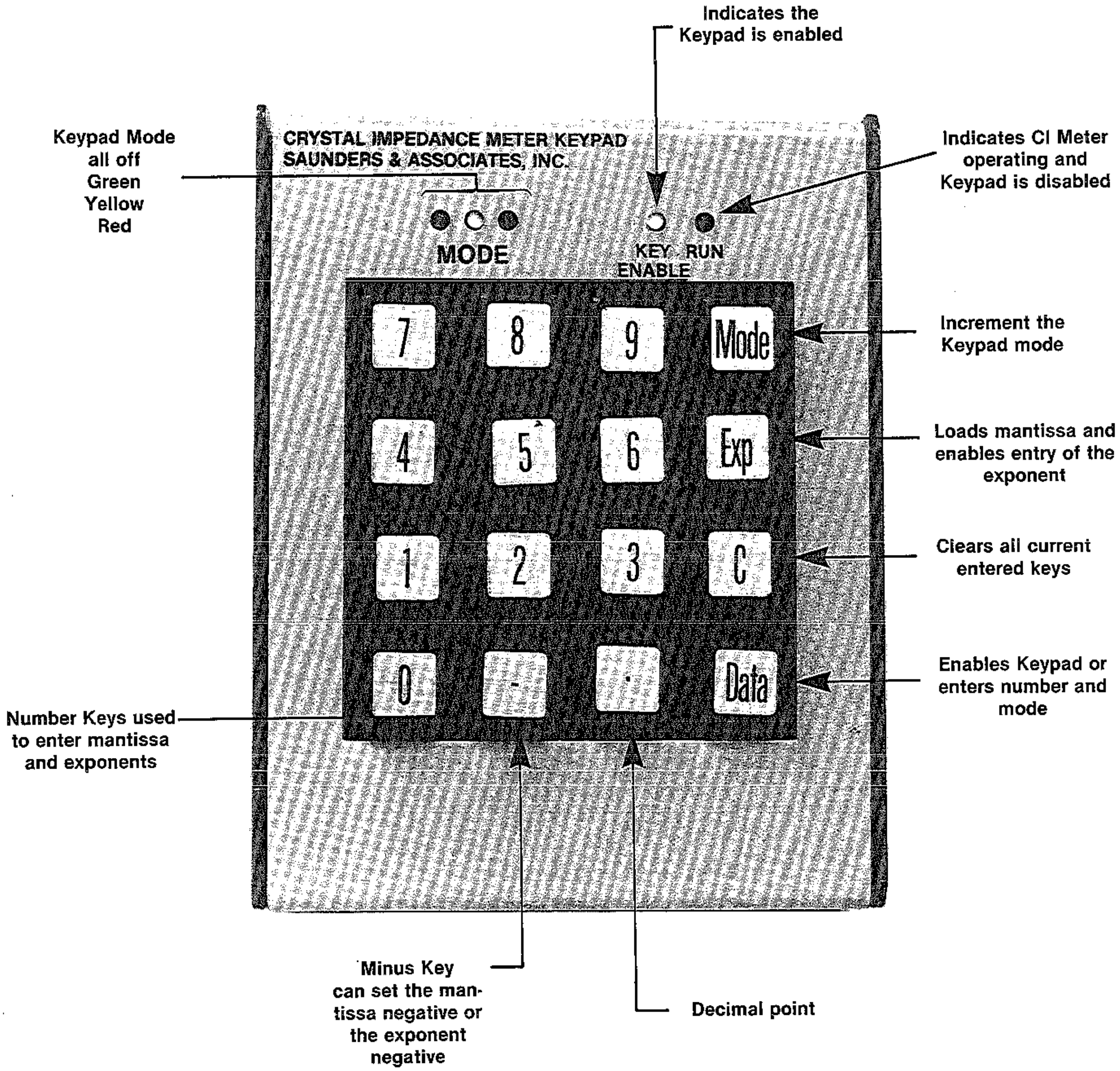
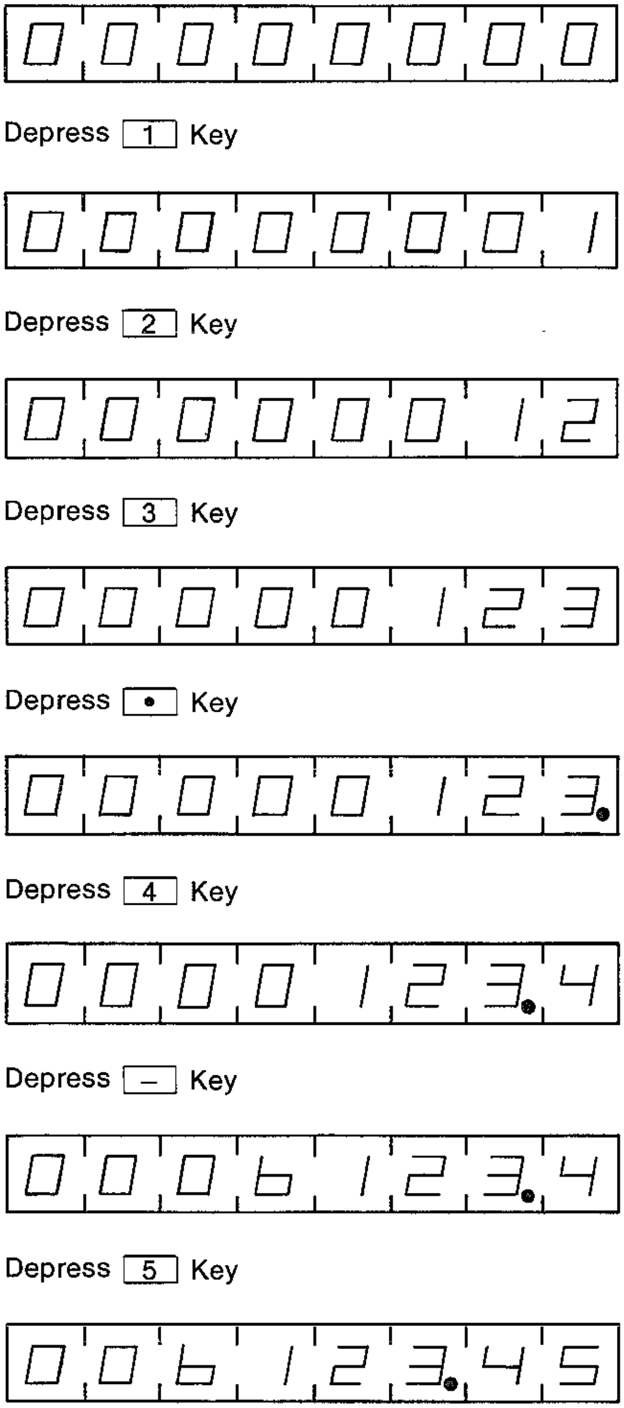


FIGURE 4-1. KEYPAD LAYOUT AND KEY AND DISPLAY FUNCTIONS

Hold down DATA until Key Enable is ON and Run OFF.



Depress 1 Key

Depress 2 Key

Depress 3 Key

Depress • Key

Depress 4 Key

Depress – Key

Depress 5 Key

Depress DATA Key to enter number

150B Display

The b is for below zero or minus. The minus could be entered any time during the mantissa entry.

FIGURE 4-2. EXAMPLE OF ENTERING –123.45

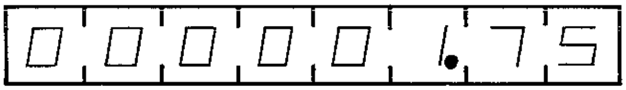
Hold down [DATA] until Key Enable is ON and Run is OFF.

Depress [1] Key

Depress [•] Key

Depress [7] Key

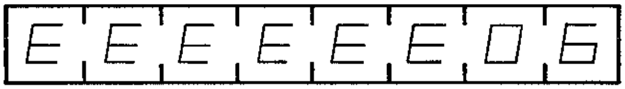
Depress [5] Key



Depress [Exp] Key

—Set to exponent mode

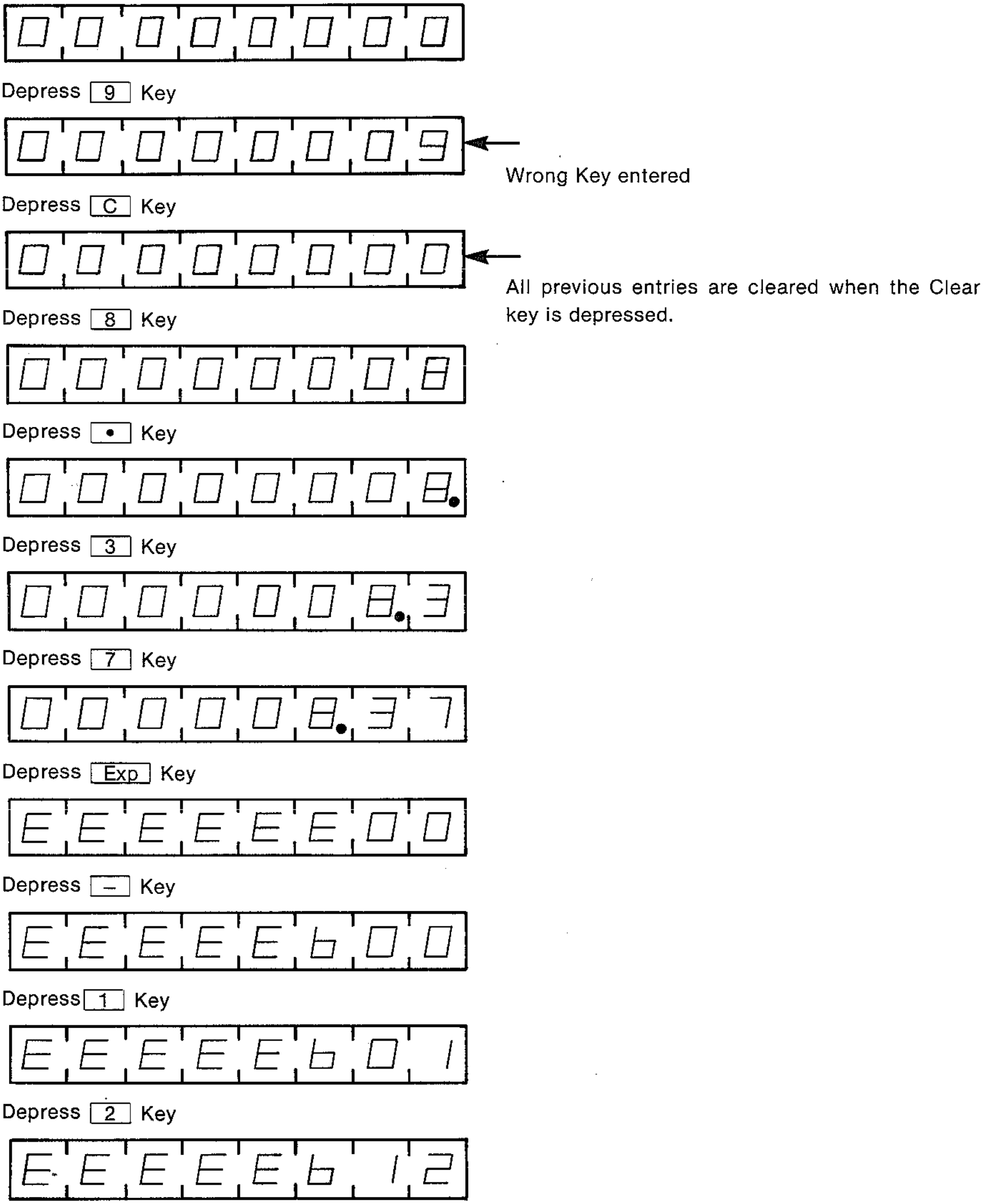
Depress [6] Key



Depress [DATA] Key to enter number

FIGURE 4-3. EXAMPLE OF ENTERING 1.75 x 10^6

Hold down DATA until Key Enable is ON and Run is OFF.



Depress 9 Key

Depress C Key

Depress 8 Key

Depress • Key

Depress 3 Key

Depress 7 Key

Depress Exp Key

Depress – Key

Depress 1 Key

Depress 2 Key

Wrong Key entered

All previous entries are cleared when the Clear key is depressed.

FIGURE 4-4. EXAMPLE OF ENTERING 8.37 x 10^{-12}

4.2. ENTERING A REFERENCE FREQUENCY FROM THE KEYPAD

All operations of Operation Sequence No. 01208 remain as before. Modes 0 through 3 are repeated as 8 through B respectively and the new modes allow the Keypad to enter the reference frequency. The various modes are performed as shown in Figure 4-5.

MODES		Functions	Analog Output Option If Enabled
Keypad Enabled	Keypad Disabled		
8	0	Standard operation F_R and F_P in Hertz	–500PPM
9	1	Standard operation with F_R and F_P displayed as deviation in PPM from the reference frequency	–500PPM
A	2	Standard operation F_R and F_P in Hertz	Operational
B	3	Standard operation with F_R and F_P displayed as deviation in PPM from the reference frequency	Operational

FIGURE 4-5. CI METER/KEYPAD OPERATING MODES

The sequence for use of the reference frequency option would be:

a. Depress R_R, F_P, and C_t switch.
b. Using screwdriver to adjust the CI Meter mode switch and watching the display, set to mode 9, A or B.
c. Release switches.
d. Depress Keypad [DATA] Key. Hold down until Keypad is enabled and CI Meter display clears.
e. Key in reference frequency.
f. Depress [DATA] Key.
   CI Meter will begin normal operation with new keyed-in reference frequency.

4.3. OPTION 005

The Option 005 adds additional program capabilities to the CI Meter which makes use of the CI Meter Keypad. The programs cover two specific areas:

a. Engineering—CI Meter under Keypad control will display many of the possible crystal parameters.
b. Incoming Inspection/Receiving—The CI Meter tests and compares the results against user input limits. The tests check against commonly specified crystal parameters. The CI Meter and Keypad can indicate Go/No Go results or display the parameters which failed.

4.3.1. Engineering Crystal Measurements

In the engineering measurement mode, the CI Meter Switches function as in Mode 0, except the series resonant measurement condition of no switches depressed has been modified. With no CI Meter front panel switches depressed, the Keypad can select what is displayed.

4.3.1.1. Entering Engineering Crystal Measurement Mode

The operating sequence to enter Engineering Mode is:

a. Depress the R, F_P and C_t switch.
b. Rotate the Mode switch to Mode 6.
c. Release all switches. The CI Meter is in the Engineering mode.
d. Depress the Keypad [DATA] Key.
   Display should come up all zeroes. The Keypad should enable.

e. Release the DATA Key.

f. Depress the DATA Key (enter zero) with Keypad mode display off. The number entered selects the type of measurement to make. A zero entered selects the F_R measurement.

g. The CI Meter now functions exactly as in Mode 0 and can be set up in similar fashion.

4.3.1.2. Entering Various Reference Values in the Engineering Mode

To perform some of the calculations, reference values need to be entered to the CI Meter. The Keypad can enter the values. The type of value being entered is set by the Keypad display mode, Figure 4-5.

The sequence for entering F_{LS} reference and C_L reference is:

Given: $F_{LS} = 10.7MHz$
C_L ref. = 28pF

Assume: Already in Engineering Mode

a. Depress the Keypad DATA Key until:
Display will become all zeroes.
The Keypad should enable.

b. Depress the Keypad MODE Key once so the Keypad display mode is Red.

c. Key in the 10.7MHz F_{LS} value.

d. Depress the DATA Key and release. The CI Meter will perform the previously set measurements and the new value of F_{LS} is saved until either written over or exiting the Engineering Mode.

Keypad Display Mode	Description
Off	Number entered defines which measurement to perform.
Red	Number entered becomes the reference value F_{LS} in Hertz.
Yellow	Number entered is saved as C_L ref. in pF.
Green	Number entered is saved as C_1 ref. in pF.

FIGURE 4-5. KEYPAD MODES VERSUS REFERENCE VALUE ENTERED

e. Depress the Keypad DATA Key.
The CI Meter display will become all zeroes.
The Keypad will enable.

f. Depress the Keypad MODE Key until the Yellow Keypad Mode is enabled. (3 valid depressions of the Mode key)

g. Key in 28, the value of C_L reference.

h. Depress the Keypad DATA Key to enter the value of C_L reference.

i. The CI Meter will perform the previously set measurements and the new value of C_L reference is saved until either written over or exiting the Engineering Mode.

The three reference values in Figure 4-5 can be modified at any time in the Engineering Mode.

4.3.1.3. Requesting The Various Engineering Mode Measurements

The Keypad is used to change the measurement being displayed in the case of NO CI Meter front panel switches depressed.

The test type is entered similar to the reference values except the Keypad display mode is off. (Figure 4-4) The various measurement types are shown in Figure 4-5.

For example, assume the crystal Q is wanted:

a. Set up the CI Meter to measure the crystal properly.

b. Depress the Keypad DATA Key until display becomes all zeroes.
The Keypad enables.

c. Key in a "12" which is the test number for Q.

d. Depress the Keypad DATA Key.

The CI Meter with no switches depressed on the front panel will display the value of crystal Q. The test will be repetitiously performed and the new value displayed. All of the different measurement types can be selected in the same manner.

NOTE

Several measurements need to have the value of C series (C_L). The test measurement 10 reads and saves the value. The measurement 10 *must be made without* a crystal in the test socket. The last read value when exiting the measurement number 10 is the value saved.

Keyboard Number Keypad Mode-Off	Measurement Mode	Unit	Comments
0	F_R	Hz	
1	F_R deviation	PPM	Reference value F_{LS} keyed in on Red Mode
2	F_P	Hz	
3	F_P deviation	PPM	Reference value F_{LS} keyed in on Red Mode
4*	F_L at specified C_L reference	Hz	C_L reference keyed in on Yellow Mode
5*	F_L deviation	PPM	C_L reference keyed in on Yellow Mode Reference value F_{LS} keyed in on Red Mode
6*	C_{LC} Load capacitance needs to set crystal to F_{LS}	pF	Reference value F_{LS} keyed in on Red Mode
7	Trim sensitivity at F_{LS}	PPM/pF	Reference value F_{LS} keyed in on Red Mode
8*	C_0	pF	
9	C_1	pF	
10	C_L (C_t)	pF	Crystal socket must be empty. Value saved for all * calculations
11	L	mH	
12	Q	—	
13	R	ohms	
14	C_t	pF	
15	P	μW	
16	Change of C_1		C_1 reference keyed in on Green Mode
17	Delta F	Hz	$F_P - F_R$
18*	Capacity Ratio		C_0/C_1

*The measurement 10 must be run before the indicated tests to store C_L.

FIGURE 4-5. ENGINEERING MODE MEASUREMENTS

4.3.2. Incoming Inspection Testing

The Incoming Inspection Mode has six possible tests. The different tests allow the user to select the one which fits the parameters of their specification. Figure 4-6 shows a Test Program Specification page filled out for an example 11.25MHz crystal. This example specification will be used throughout this section to illustrate how to set up CI Meters. The example uses test Type B which specifies F_L, C_0, Q and C_1.

4.3.2.1. Entering Inspection Testing

The Inspection Testing Mode is number 7. Depress the R, F_p, and C_t switch and adjust the mode switch to 7. Releasing any of the switches, the CI Meter will enter the Limits and Reference Value entry condition.

4.3.2.2. Limits and Reference Value Entry

The CI Meter front panel switches permit the user to select the various tests and enter the limits. There are only eight limits and one reference value saved. When switching tests, the prior values are still retained and would be used as the limit in the new test type unless modified by the user.

The table position is indicated by the CI Meter display. The format of the display is shown in Figure 4-7. The display indicates test type and limit table position. The display can be advanced by holding down the CI Meter switches. Figure 4-7 also indicates which switch advances which display position.

The table position can be displayed at any time during the table entry sequence. Depress any CI Meter front panel switch momentarily and the position display will appear for 1.5 seconds. At the end of 1.5 seconds, if a CI Meter front panel switch is still depressed, the digit defined by the switch or switches will increment. The Figure 4-8 indicates how the display incrementing occurs.

After the table position display times out the actual stored limit will be displayed. The Keypad may be enabled at this point and a new limit value entered. After the new value is entered (DATA Key depressed) that value will be displayed. Figure 4-9 shows an example of entering the sample table of Figure 4-6.

SAUNDERS & ASSOCIATES, INC. 140/150/160 CRYSTAL IMPEDANCE METER AND KEYBOARD GO/NO GO LIMIT TESTING

Part Number ABCD Specification xyz

Drive Level 150μWatts Setup Resistor 50Ω Setup Frequency 11.25MHz

Setup C_{Series} 27 pF Date Initials

Comments

Test A	Test B	Test C	Test D	Test E	Test F	LIMIT	DISPLAY	SPECIFICATION
F_L* Hertz at specified C_{Load}	F_L* Hertz at specified C_{Load}	F_L* Hertz at specified C_{Load}	F_L* Hertz at specified C_{Load}	C_{LC} pF at specified F_{Load}	C_{LC} pF at specified F_{Load}	Upper	0A	11250100
						Lower	0b	11249900
C_o pF	C_o pF	C_o pF	C_o pF	C_o pF	C_o pF	Upper	1A	2.2
						Lower	1b	2.6
R_R ohms	Q	R_R ohms	Q	R_R ohms	Q	Upper	2A	2E6 } Set high so failure on upper limit will not occur
						Lower	2b	300000
C_1 pF	C_1 pF	L mH	L mH	Trim Sensitivity PPM/pF	Trim Sensitivity PPM/pF	Upper	3A	10 } Set out of any practical range so failure will never occur
						Lower	3b	1E-6
C_{LS} pF	C_{LS} pF	C_{LS} pF	C_{LS} pF	F_{LS} Hertz	F_{LS} Hertz	Reference	4A 4b	27

*Use of C_L of 1 x 10^{50} pF for Series Resonant specification

Measurement Parameters

F_R—Crystal Series Resonant Frequency

F_p—Crystal Load Resonant Frequency (At C_L)

R_R—Crystal Series Resonant Resistance

C_L—Load Capacitor Value

Set C_{Series} with NO crystal in test socket

C_t—Capacitance with crystal in test socket ($C_L + C_0$)

Calculated Parameters

C_{LS}—Specified C_{LOAD}

C_{LC}—Calculated C_{LOAD}

F_{LS}—Specified Load Resonant Frequency

F_{LC}—Calculated Load Resonant Frequency at C_{LS}

Test Limit Values

F_{LC} = Load Resonant Frequency at a specified C_L

$$F_{LC} = F_R + \frac{C_t\,(F_p - F_R)}{C_{LS} + C_0}$$

Q = Crystal Quality factor

$$= \frac{1}{2\pi F_R C_1 R}$$

C_1 and L = Crystal motional resonant values

$$C_1 = 2C_t\frac{F_p - F_R}{F_R} \quad L = \frac{1}{4\pi^2 F_R{}^2 C_1}$$

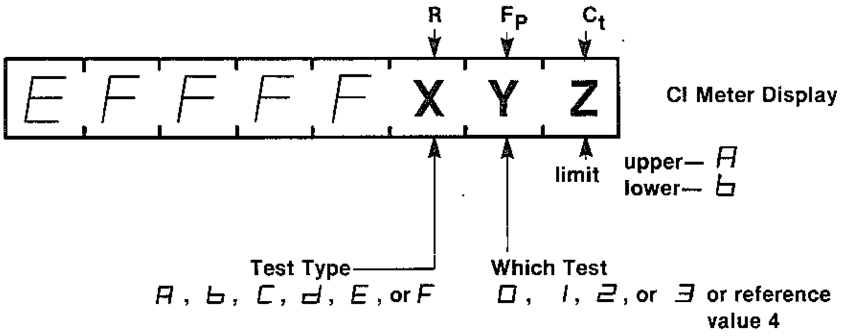
C_{LC} = Load capacitance needed to resonate crystal at F_{LS}

$$C_{LC} = \frac{C_t\,(F_p - F_R)}{F_{LS} - F_R} - C_0$$

Trim Sensitivity = pullability of crystal resonant frequency at F_{LS}

$$\text{Trim Sensitivity} = \left(\frac{F_{LS} - F_R}{F_p - F_R}\right)\left(\frac{F_{LS} - F_R}{F_R}\right)\left(\frac{1}{C_t}\right)$$

FIGURE 4-6. EXAMPLE OF INCOMING INSPECTION SPECIFICATION SHEET WITH A SAMPLE CRYSTAL SPECIFICATION



During entry of the table, its display can be incremented by the switches on the CI Meter front panel

FIGURE 4-7. DISPLAY SHOWING INPUT TABLE POSITION OR WHICH TEST FAILURE

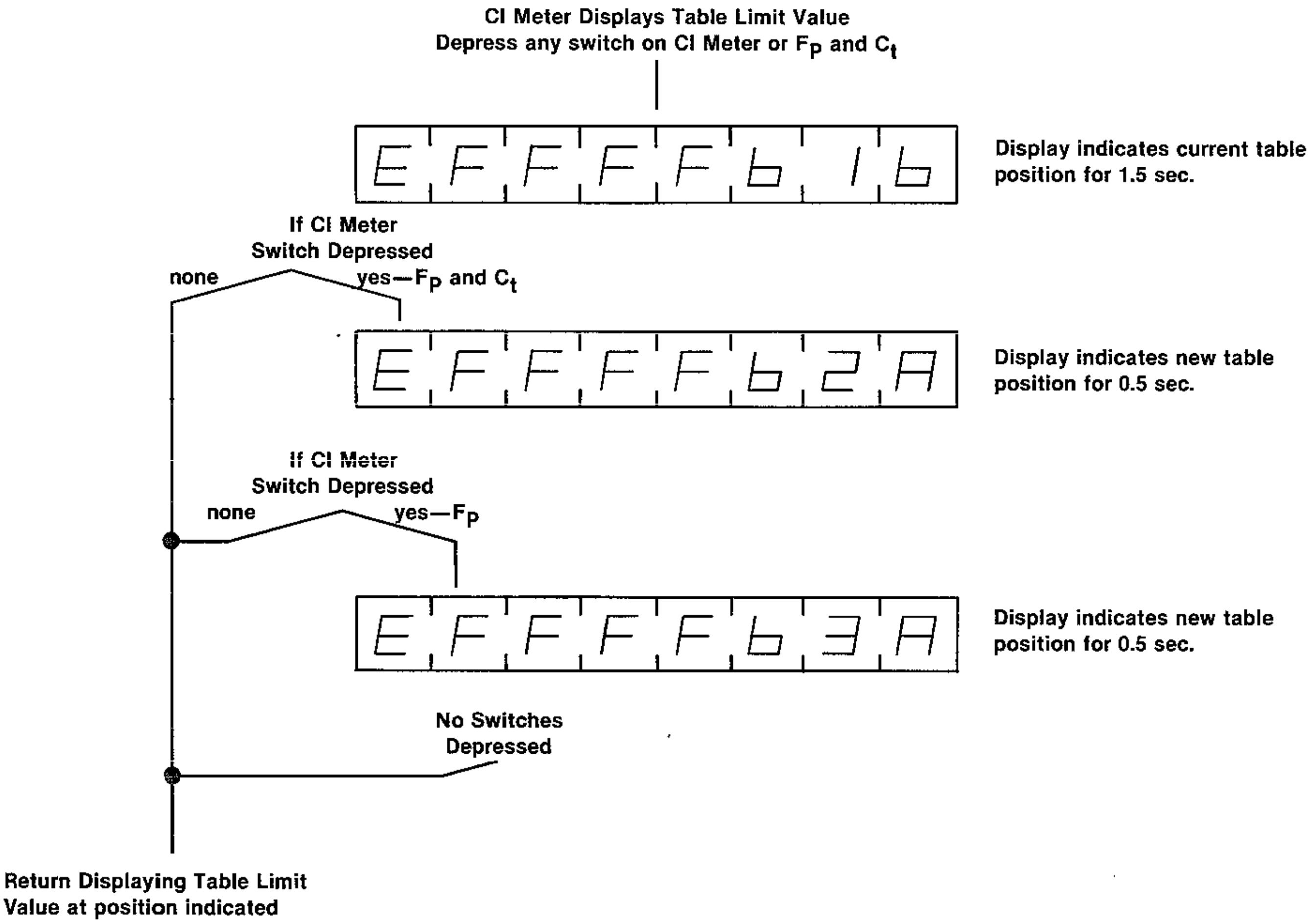
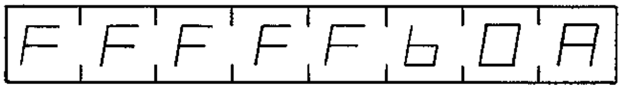


FIGURE 4-8. DISPLAY INCREMENTATION OF TABLE POSITION

Enter Table entry mode.

Depress F_P switch momentarily to read table position and advance display if necessary and release switches.



Display is current limit value.

Depress [Data] Key until display goes to zero and Keypad enables. Key in value 11250100. Depress [Data] Key to enter value.

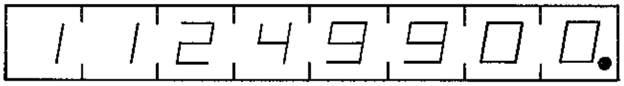
Display will be new limit value.

Depress the C_t switch and advance display to

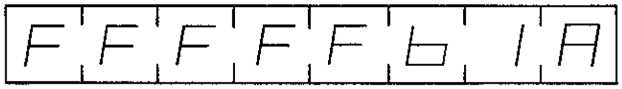
Display will be current limit value.

Use Keypad to enter new limit value of 11249900Hz.

Display will be limit value.



Depress the F_P and C_t switch and advance the display to

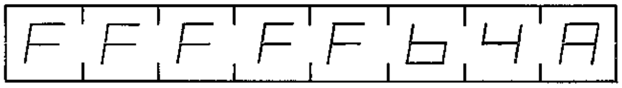


Use Keypad to enter limit value 2.2.

Display will be limit value

CONTINUE INPUT OF ALL LIMITS

Depress the F_P and C_t switch and advance the display.



Use Keypad to enter reference value 27.

Display will be limit value.

All limits and references entered.

FIGURE 4-9. EXAMPLE OF ENTERING LIMITS OF FIGURE 4-6

4.3.2.3. Testing

With the limits and reference value entered, testing can begin. The test mode is entered from the data entry condition by depressing the R and F_P switch.

The CI Meter needs to be set up. Follow the procedure used for standard setup. Set up the following parameters:

—Frequency
—Power
—C_{Series} (C_L)

When the CI Meter is idle in the test mode, the front panel switches are active as in Mode 0. With no switches depressed the display is F_R; F_P depressed is load resonance, etc.

NOTE

The C_t switch must be depressed with *NOTHING* in the crystal socket and the value read C_L is saved to be used in the limit calculations.

CAUTION

Any subsequent depressions of the C_t switch will replace the prior saved value.

The test is begun by first placing the crystal to be tested in the CI Meter Test Socket. If the display is

the crystal will not oscillate and the crystal is therefore a reject.

Depress the Keypad DATA Key and wait for ENABLE LED to come on. Release the DATA Key and testing will begin. The overall sequence is shown in Figure 4-10.

If the crystal passes, the Green Mode LED on the Keypad will come on.

If the crystal fails, the Red Mode LED on the Keypad will come on. If during the testing any one of the CI Meter front panel switches was on, the testing will halt at the failure and display the location and value which failed. Refer to Figure 4-11. The Keypad DATA Key is needed to exit the failure display mode. If multiple failures have occurred, then the program will halt at each failed parameter.

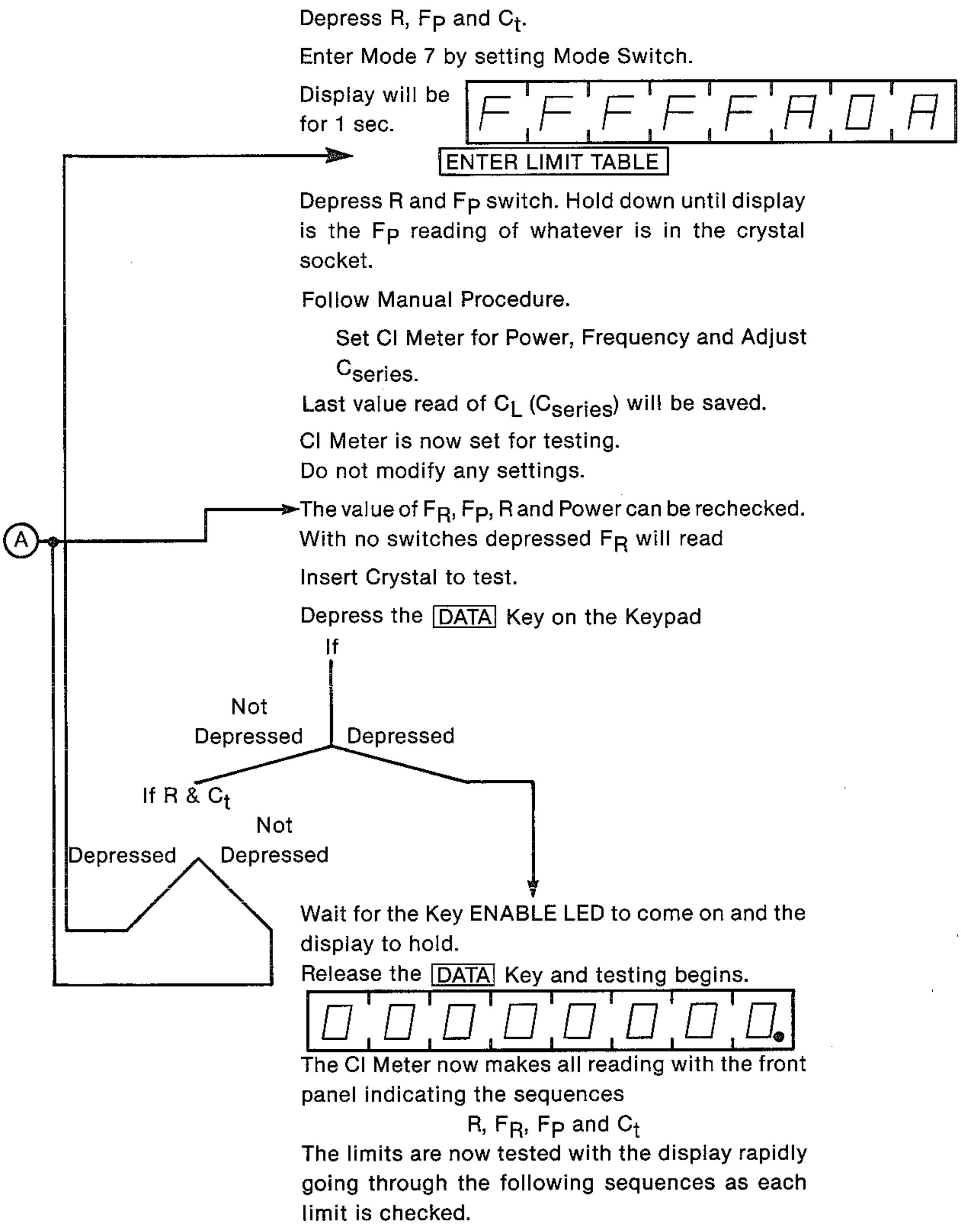
The table entry condition can be re-entered from the test condition by depressing the R and C_t switch simultaneously.

4.3.2.4. Exiting Inspection Test

The table entry condition can be exited to any other CI Meter Modes. This is accomplished by depressing the R, F_P and C_t switches simultaneously and adjusting the front panel mode set switch to the new mode.

Releasing the switches simultaneously will cause the display to hold at:

Depressing any front panel switch will then cause the CI Meter to proceed to the new mode.



Depress R, F_P and C_t.

Enter Mode 7 by setting Mode Switch.

Display will be for 1 sec.

ENTER LIMIT TABLE

Depress R and F_P switch. Hold down until display is the F_P reading of whatever is in the crystal socket.

Follow Manual Procedure.

Set CI Meter for Power, Frequency and Adjust C_{series}.

Last value read of C_L (C_{series}) will be saved.

CI Meter is now set for testing.
Do not modify any settings.

The value of F_R, F_P, R and Power can be rechecked.
With no switches depressed F_R will read

Insert Crystal to test.

Depress the DATA Key on the Keypad

Wait for the Key ENABLE LED to come on and the display to hold.
Release the DATA Key and testing begins.

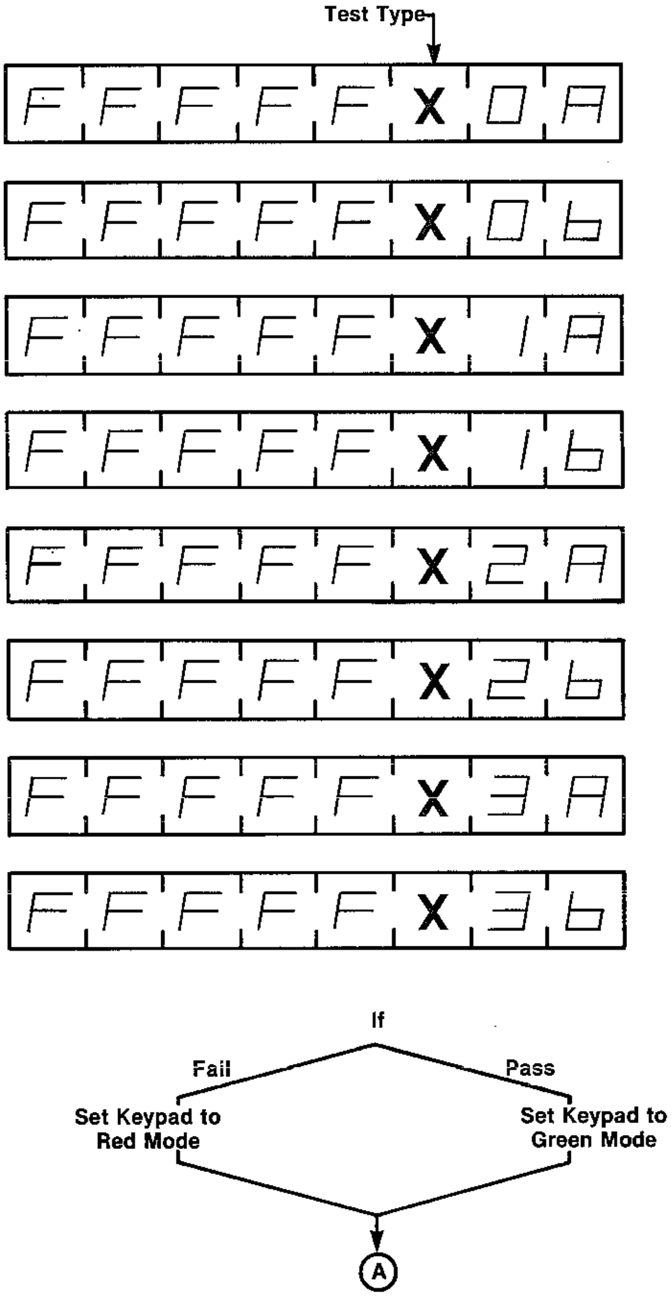
The CI Meter now makes all reading with the front panel indicating the sequences

R, F_R, F_P and C_t

The limits are now tested with the display rapidly going through the following sequences as each limit is checked.

continued

FIGURE 4-10. INCOMING TEST PROGRAM SEQUENCE



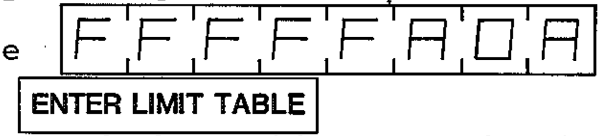
If an error occurs and a CI Meter front panel switch is depressed, the display will rotate through the error condition. See Figure 4-11.

FIGURE 4-10. INCOMING TEST PROGRAM SEQUENCE (continued)

Depress R, Fp and C_t.

Enter Mode 7 by setting Mode Switch.

Display will be
for 1 sec.



Depress R and Fp switch. Hold down until display is the Fp reading of whatever is in the crystal socket.

Follow Manual Procedure.

Set CI Meter for Power, Frequency and Adjust C_{series}.

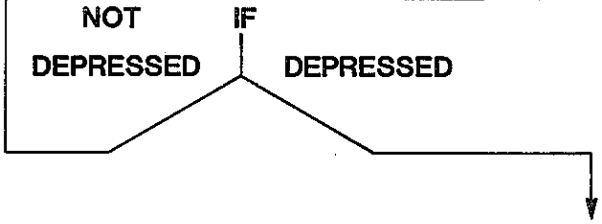
Last value read of C_L (C_{series}) will be saved.

CI Meter is now set for testing.
Do not modify any settings.

The value of F_R, Fp, R and Power can be rechecked.
With no switches depressed F_R will read

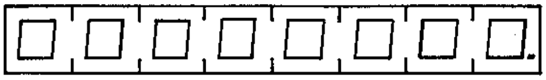
Insert Crystal to test.

→ Depress the DATA Key on the Keypad



Wait for the Key ENABLE LED to come on and the display to hold. Release the DATA Key.

Ⓐ → Depress the DATA Key and testing begins.



The CI Meter now makes all reading with the front panel indicating the sequences

R, F_R, Fp and C_t

The limits are now tested with the display rapidly going through the folllowing sequences as each limit is checked.

Continued

Option 5 - Mode 7 Operation Changes When 1D4 ROM is Labeled "C1M2"

Option 003, 005 - Manual Page 4-14
Section 4.3.2.3. Testing
3rd Paragraph, 2nd Column

If the crystal fails, the Red Mode LED on the Keypad will come on. If during the testing any one of the CI Meter front panel switches is held on, the testing will halt at the failure and display the location and value that failed. Refer to Figure 4-11. The testing will continue when the switch is released. If the keypad [Data] key is depressed while a failure is being displayed, the test will continue until another failed parameter is found. Locking the Fp switch in the "Up" position will help locate multiple failures.

4th Paragraph, 2nd Column

The table entry condition can be re-entered from the test condition by depressing the R, Fp and C_t switches simultaneously; then without releasing the switches, depress and release Data key, then rotate the mode switch until a "6" is displayed on the right of the display. Release the switches and wait for display to timeout and begin displaying frequency. Depress the R, Fp and C_t switches again and rotate the mode switch back to a display of "7". Releasing the switches will place the CI Meter in the table entry condition. Prior table values will still be valid at this point.

Section 4.3.2.4. Exiting Inspection Test
1st Paragraph

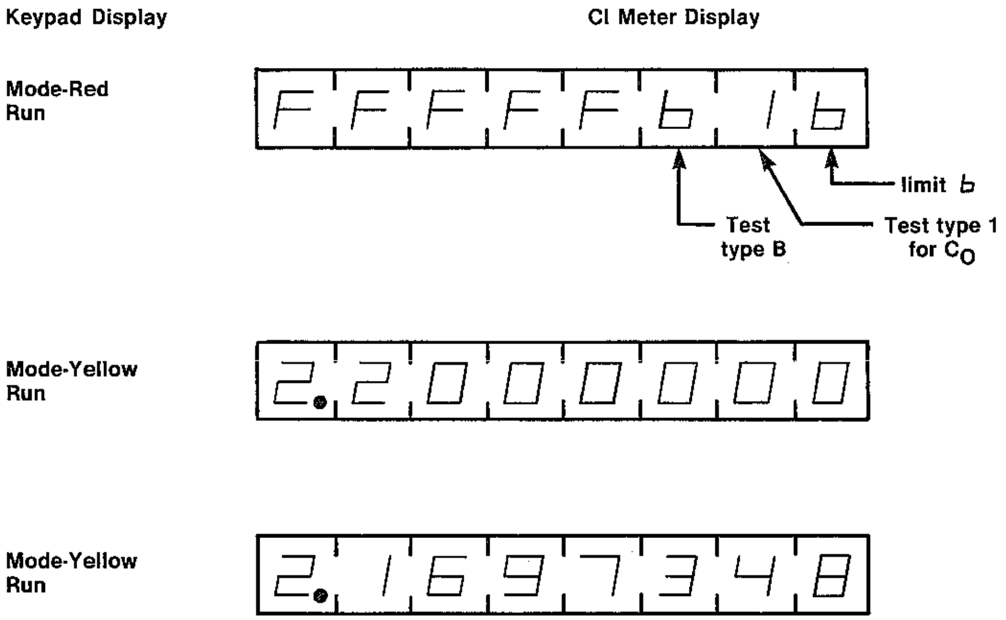
The inspection test mode can be exited by depressing the keypad [Data] key while the R, Fp ad C_t switches are depressed simultaneously, then rotating the mode switch until the desired mode number is displayed on the right side of the display.

2nd Paragraph

Releasing the switches will cause the meter to exit to mode "0". Depressing and releasing the three switches a second time will cause the CI Meter to enter the new mode.

3rd Paragraph

Not applicable.



Displays table position which failed for 0.6 sec.

Displays limit value which failed for 0.8 sec.

Displays measurement value which failed for 0.8 sec.

If Keypad Data Key is depressed, the display holds until released and then proceeds through the test.

FIGURE 4-11. EXAMPLE DISPLAY OF C_O REJECT WITH A SPECIFICATION OF 2.2 TO 2.6pF WITH THE VALUE ACTUALLY BEING 2.17pF.

SECTION 5

KEYBOARD OPERATION, SCHEMATIC AND PARTS LIST

The keyboard operation, maintenance and parts lists are covered in this section.

5.1. KEYBOARD OPERATION

The keyboard is interfaced from the CI Meter I/O port. The CI Meter is programmed to strobe the keyboard and recognize key enclosure. The strobe lines also drive the keyboard display. Refer to Figure 5-1.

5.1.1. Keyboard Display

The Run and Key ENABLE LED's connect to J1-10 and J1-11 key strobes respectively. If either line or both can be set high, turning the LED on.

The Mode LED's are connected such that one or none can be on at any given time. Figure 5-2 shows the logic control levels versus which LED is on. The logic display is performed by D7 through D15 and R6 through R9.

5.1.2. Key Closure

The DATA key is wired directly to the CI Meter. The DATA key is used to interrupt the CI Meter to then start scanning the remaining 15 keys. The DATA key also indicates the key entries are finished and the result should be loaded to the CI Meter and the CI Meter is to continue running.

The strobe lines through diodes D1 through D4 charge up capacitor C1 to the maximum strobe voltage. The charge stored on C1 is used to pull up the 5 key sense lines. The four sense lines and the keyboard strobe signals can read the keyboard's 15 keys.

Only one strobe line is low at any given keyboard scan line time. When J1-11 is low, then one of the sense lines will go low if the 0, 1, 2 or 3 key is depressed. The remaining strobe lines will cover the remaining 11 keys. The CI Meter Software loads the keyboard entries to the CI Meter registers for use in calculations.

Figure 5-3 shows the overall keyboard scan time and a blown-up image of the actual keyboard strobe signals. Between the strobe times, the digit strobe lines are set to the desired display condition.

5.2. KEYBOARD MAINTENANCE

No maintenance is required.

5.3. KEYBOARD ASSEMBLY

All of the Keypad components are mounted on a printed circuit board. Figure 5-4 shows the PCB assembly.

The PCB assembly is mounted into a chassis with an interconnect cable as shown in Figure 5-5.

The parts lists are shown in Figure 5-6, 5-7 and 5-8.

Figure 5-9 lists the manufacturers and manufacturers' part numbers referenced to the S & A part numbers which meet Saunders & Associates, Inc. specifications.

Figure 5-10 lists the manufacturers' addresses.

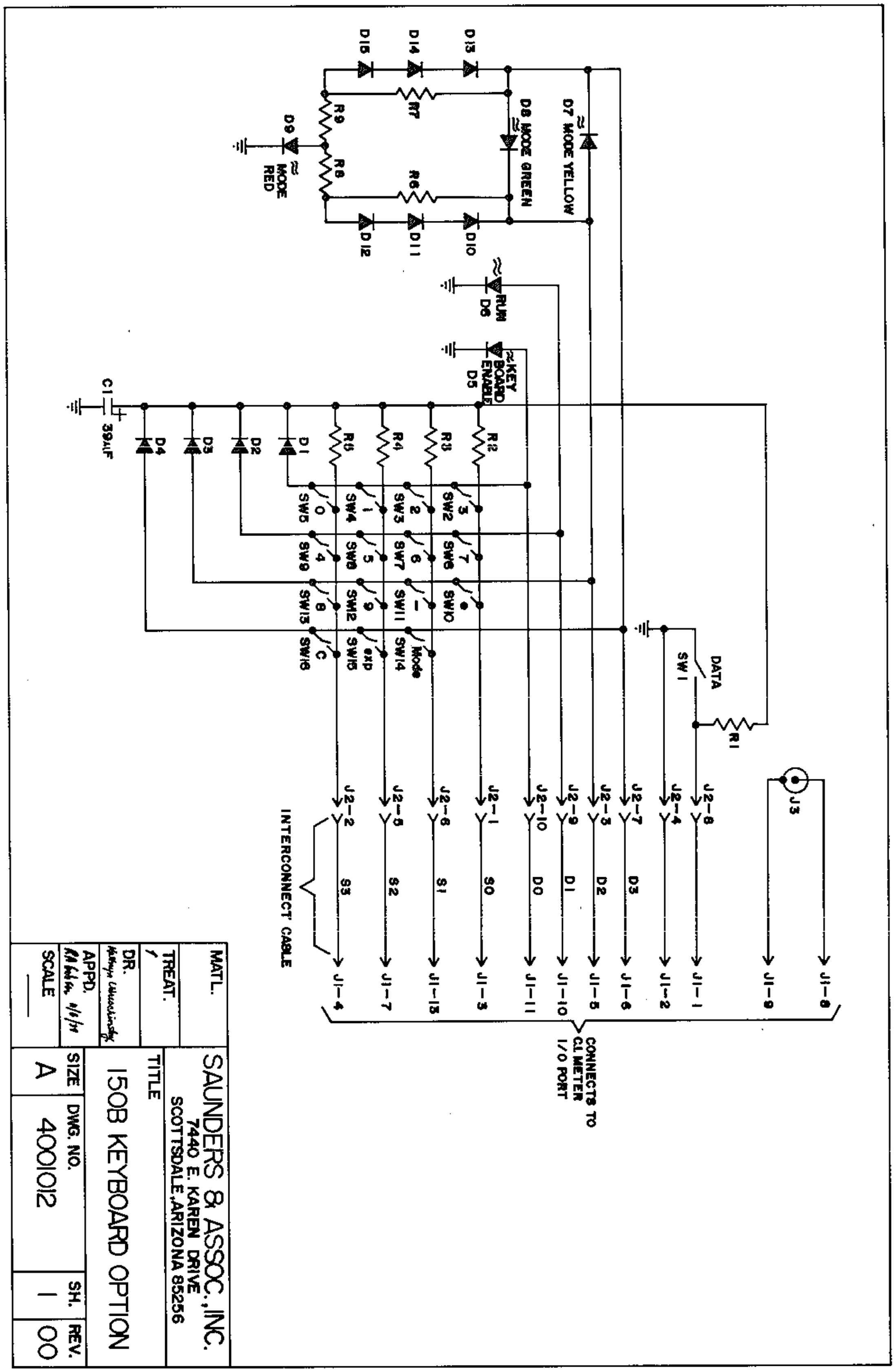


FIGURE 5-1. CI METER KEYBOARD

J1-5	J1-6	MODE
low	low	off
low	high	Green
high	low	Yellow
high	high	Red

FIGURE 5-2. KEYBOARD MODE DISPLAY

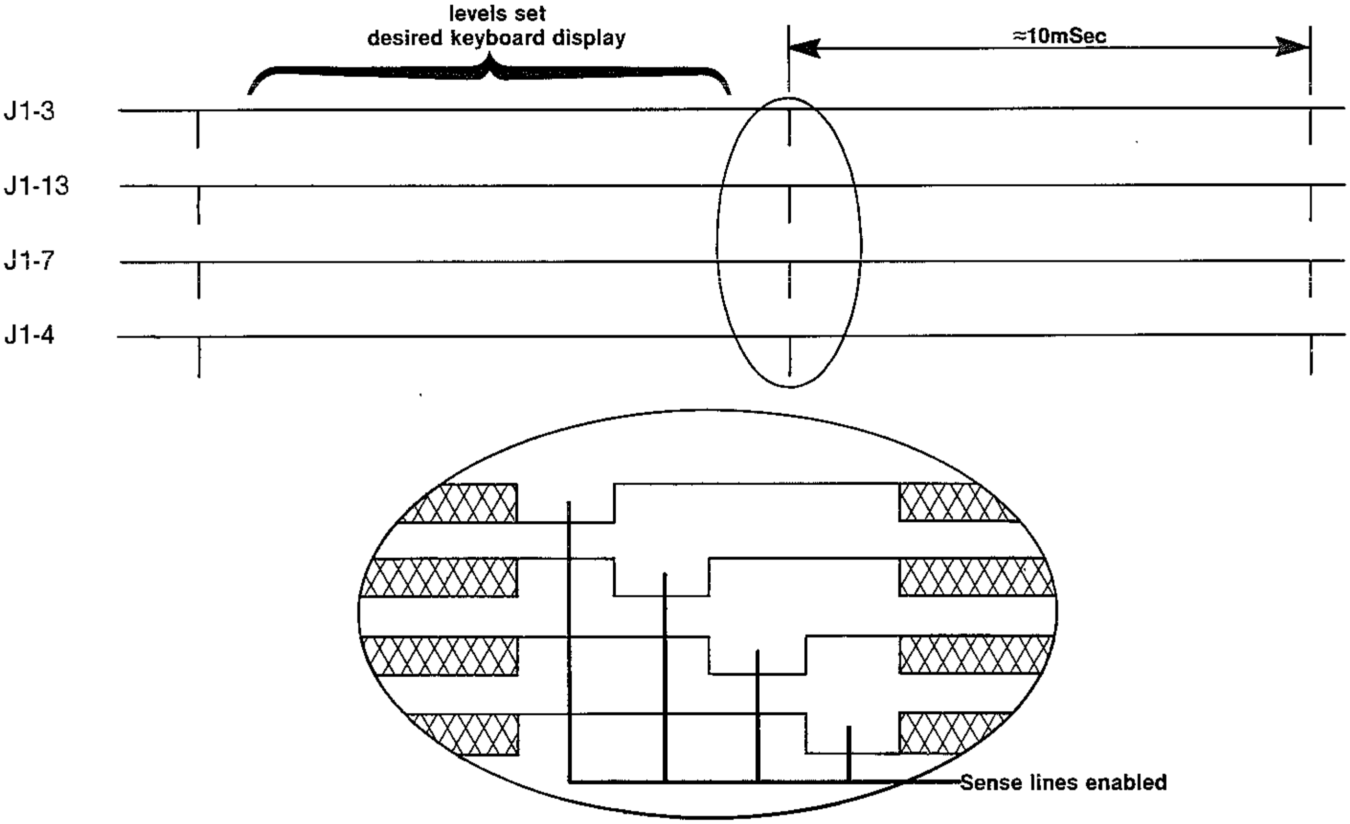


FIGURE 5-3. KEYBOARD SCAN TIMING

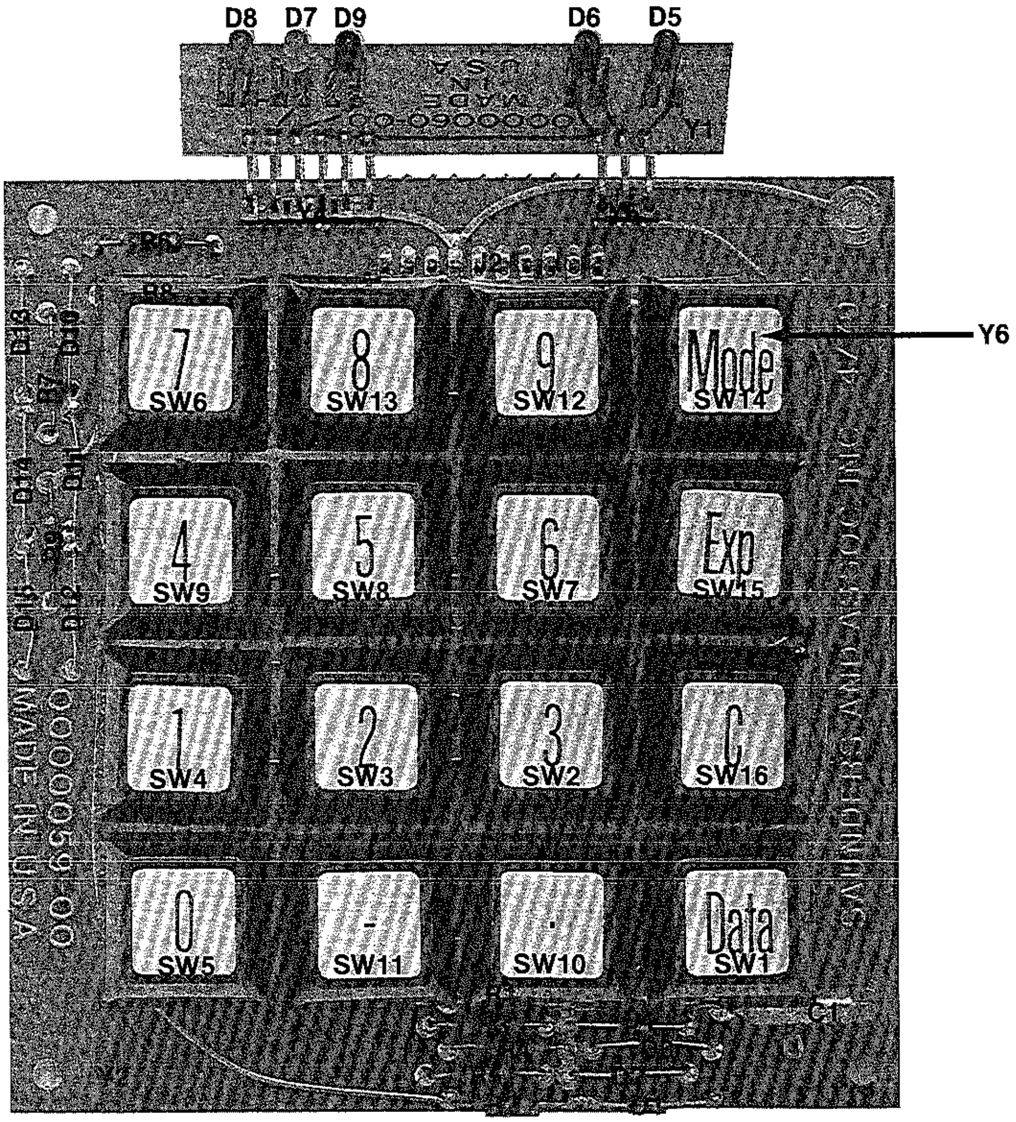
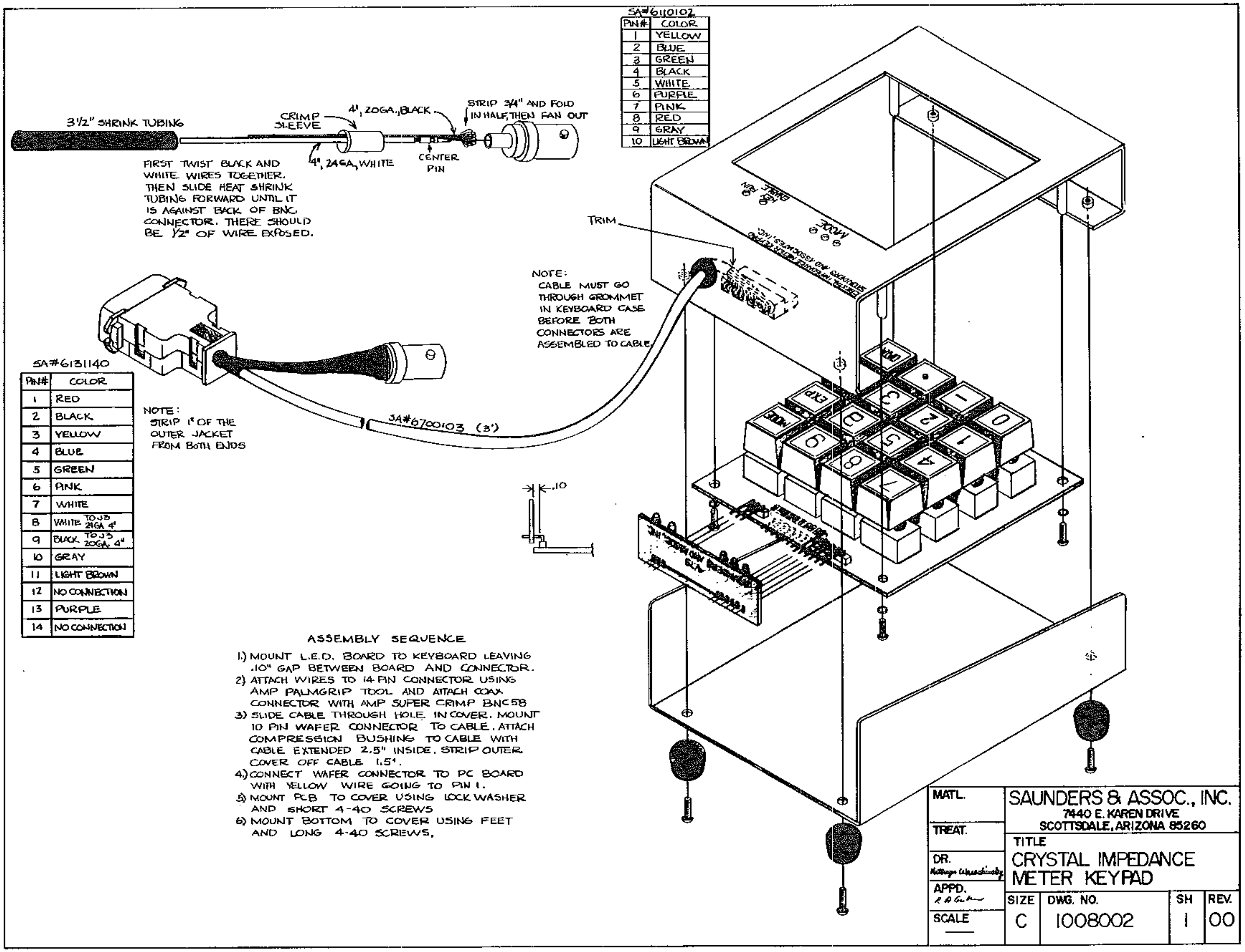


FIGURE 5-4. KEYPAD PRINTED CIRCUIT BOARD ASSEMBLY



FIRST TWIST BLACK AND WHITE WIRES TOGETHER. THEN SLIDE HEAT SHRINK TUBING FORWARD UNTIL IT IS AGAINST BACK OF BNC CONNECTOR. THERE SHOULD BE ½" OF WIRE EXPOSED.

NOTE:
CABLE MUST GO THROUGH GROMMET IN KEYBOARD CASE BEFORE BOTH CONNECTORS ARE ASSEMBLED TO CABLE.

SA#6110102

PIN#	COLOR
1	YELLOW
2	BLUE
3	GREEN
4	BLACK
5	WHITE
6	PURPLE
7	PINK
8	RED
9	GRAY
10	LIGHT BROWN

SA#6131140

PIN#	COLOR
1	RED
2	BLACK
3	YELLOW
4	BLUE
5	GREEN
6	PINK
7	WHITE
8	WHITE TO J3 24GA 4"
9	BLACK TO J3 20GA. 4"
10	GRAY
11	LIGHT BROWN
12	NO CONNECTION
13	PURPLE
14	NO CONNECTION

NOTE:
STRIP 1" OF THE OUTER JACKET FROM BOTH ENDS

ASSEMBLY SEQUENCE

1.) MOUNT L.E.D. BOARD TO KEYBOARD LEAVING .10" GAP BETWEEN BOARD AND CONNECTOR.
2) ATTACH WIRES TO 14 PIN CONNECTOR USING AMP PALMGRIP TOOL AND ATTACH COAX CONNECTOR WITH AMP SUPER CRIMP BNC58
3) SLIDE CABLE THROUGH HOLE IN COVER. MOUNT 10 PIN WAFER CONNECTOR TO CABLE. ATTACH COMPRESSION BUSHING TO CABLE WITH CABLE EXTENDED 2.5" INSIDE. STRIP OUTER COVER OFF CABLE 1.5".
4.) CONNECT WAFER CONNECTOR TO PC BOARD WITH YELLOW WIRE GOING TO PIN 1.
5) MOUNT PCB TO COVER USING LOCK WASHER AND SHORT 4-40 SCREWS
6) MOUNT BOTTOM TO COVER USING FEET AND LONG 4-40 SCREWS.

MATL.
TREAT.
DR.
APPD.
SCALE

SAUNDERS & ASSOC., INC.
7440 E. KAREN DRIVE
SCOTTSDALE, ARIZONA 85260

TITLE
CRYSTAL IMPEDANCE
METER KEYPAD

SIZE	DWG. NO.	SH	REV.
C	1008002	1	00

FIGURE 5-5. KEYPAD CHASSIS ASSEMBLY

5.4. PARTS LISTS

```
          16 KEYPAD
          CRYSTAL IMPEDANCE METER KEYPAD

      PART # CAT DESCRIPTION                    QUAN
                                              1 UNIT

     0201328 ABY PCB's          16 KEY PCB      1
     0501326 ABY PAINT PART     KEYBRDCOVER     1
     0501327 ABY PAINT PART     KEYBRDBASE      1
     6110102 SUP ASSEM PART     10PosSq Rec.    1
     6131140 SUP ASSEM PART     14pinM uRib.    1
     6180500 SUP ASSEM PART     BNC ChassCon    1
     6224001 SUP NUTS, ETC      3/8 PnHdPhil    4
     6224014 SUP NUTS, ETC      4-40 1/4 SCR    4
     6224030 SUP NUTS, ETC      LOCK WASH       4
     6272000 SUP NUTS, ETC      CblClmp Bush    1
     6700103 SUP MISC.          #22-12 CABLE   36
     6700105 SUP MISC.          0.6Rub Feet     4
```

FIGURE 5-6. KEYPAD CHASSIS ASSEMBLY PARTS

S & A FINAL PART	DESCRIPTION	OPERATION	MATERIALS
0201328	Keypad PCB	Assembly	See Figure 5-8
0501326	Cover	Paint & Silk Screen	6500198
0501327	Base	Paint & Silk Screen	6500199

FIGURE 5-7. SPECIAL PARTS

16 KEY PCB
CI METER KEYPAD PCB ASSEMBLY
BILL1328

ID	CATEGORY	DESCRIPTION		S&A PART #
C1	CAP	Electrol.	39UF 10V	3100001
D1	SEM	DIODE	GOLD DOPED	5314148
D2	SEM	DIODE	GOLD DOPED	5314148
D3	SEM	DIODE	GOLD DOPED	5314148
D4	SEM	DIODE	GOLD DOPED	5314148
D5	SEM	LED	RED	5004684
D6	SEM	LED	RED	5004684
D7	SEM	LED	YELLOW	5004584
D8	SEM	LED	GREEN	5004984
D9	SEM	LED	RED	5004684
D10	SEM	DIODE	GOLD DOPED	5314148
D11	SEM	DIODE	GOLD DOPED	5314148
D12	SEM	DIODE	GOLD DOPED	5314148
D13	SEM	DIODE	GOLD DOPED	5314148
D14	SEM	DIODE	GOLD DOPED	5314148
D15	SEM	DIODE	GOLD DOPED	5314148
J2	SUP	ASSEM PART	10SqPin rt.L	6110090
R1	RES	22.0KΩ CC 1/4W	5%	1422005
R2	RES	22.0KΩ CC 1/4W	5%	1422005
R3	RES	22.0KΩ CC 1/4W	5%	1422005
R4	RES	22.0KΩ CC 1/4W	5%	1422005
R5	RES	22.0KΩ CC 1/4W	5%	1422005
R6	RES	100 Ω CC 1/4W	5%	1210005
R7	RES	100 Ω CC 1/4W	5%	1210005
R8	RES	180 Ω CC 1/4W	5%	1218005
R9	RES	180 Ω CC 1/4W	5%	1218005
SW1	SUP	SWITCHES	2000 KEYS	6480002
SW2	SUP	SWITCHES	2000 KEYS	6480002
SW3	SUP	SWITCHES	2000 KEYS	6480002
SW4	SUP	SWITCHES	2000 KEYS	6480002
SW5	SUP	SWITCHES	2000 KEYS	6480002
SW6	SUP	SWITCHES	2000 KEYS	6480002
SW7	SUP	SWITCHES	2000 KEYS	6480002
SW8	SUP	SWITCHES	2000 KEYS	6480002
SW9	SUP	SWITCHES	2000 KEYS	6480002
SW10	SUP	SWITCHES	2000 KEYS	6480002
SW11	SUP	SWITCHES	2000 KEYS	6480002
SW12	SUP	SWITCHES	2000 KEYS	6480002
SW13	SUP	SWITCHES	2000 KEYS	6480002
SW14	SUP	SWITCHES	2000 KEYS	6480002
SW15	SUP	SWITCHES	2000 KEYS	6480002
SW16	SUP	SWITCHES	2000 KEYS	6480002

FIGURE 5-8. KEYPAD PCB ASSEMBLY PARTS

16 KEY PCB
CI METER KEYPAD PCB ASSEMBLY
BILL1328

ID	CATEGORY	DESCRIPTION		S&A PART #
Y1	SUP	PC BOARD	LEDMTKEYBRD	6006000
Y2	SUP	PC BOARD	140/150/160K	6005900
Y4	SUP	ASSEM PART	6SqPin rt.L	6110060
Y5	SUP	ASSEM PART	3SqPin rt.L	6110030
Y6	SUP	ENCCLOSURES	16KEYPADLAB	6510004

FIGURE 5-8. CONTINUED

SA PART #	VENDOR/MANUFACTURER	MANUFACTURER PART #	COMMENT
1210005	7334 R-OHM CORP.	R25/J/100ohm	
1218005	7334 R-OHM CORP.	R25/J/180ohm	
1422005	7334 R-OHM CORP.	R25/J/22.0Kohm	
3100001	7834 SPRAGUE PRODUCTS CO.	150D396X9010B2	
5004584	4004 HEWLETT PACKARD	5082-4584	
5004684	4004 HEWLETT PACKARD	5082-4684	
5004984	4004 HEWLETT PACKARD	5082-4984	
5314148	3334 FAIRCHILD/SEMICONDUC	1N4148	
5314148	3334 FAIRCHILD/SEMICONDUC	1N914	
5314148	3334 FAIRCHILD/SEMICONDUC	1N914A	
5314148	8502 UNITRODE CORP.	IN4148	
6005900	9901 S&A CUSTOM	0000059	
6006000	9901 S&A CUSTOM	0000060	
6110030	5333 LITTLEFUSE	22-05-2031	
6110060	5833 MOLEX	22-05-2061	
6110090	5833 MOLEX	22-12-2101	
6110102	1004 AMP SPECIAL INDUSTRI	640441-0	
6110102	5833 MOLEX	22-01-2101	
6131140	1004 AMP SPECIAL INDUSTRI	552316-1	
6131140	1004 AMP SPECIAL INDUSTRI	57-30140	
6180500	1004 AMP SPECIAL INDUSTRI	225397-1	
6180500	1009 AMPHENOL NORTH AMERC	31-221/UG1094/U	
6224001	9900 GENERAL PURPOSE	4-40X3/8PANHEAD/PHILIPS	
6224014	9900 GENERAL PURPOSE	4-40X1/4PANHEAD	
6224030	9900 GENERAL PURPOSE	#4,INSIDE,STAR,LOCK,WASHER	
6272000	7336 RICHCO PLASTIC CO	STRAINRELIEFBUSHING#R-5	
6480002	7835 STACKPOLE COMPONENTS	LO-PRO-5-MOMENTARY	
6500198	9901 S&A CUSTOM	2001019	
6500199	9901 S&A CUSTOM	2001020	
6510000	9901 S&A CUSTOM	OUTSIDEWORK	
6510004	5675 MCLOONE METAL GRAPHI	16-KEY-PAD-LABEL	
6700103	7837 STORM PRODUCTS CO.	M3312/3563	
6700105	7667 HERMAN H. SMITH INC.	2184	

FIGURE 5-9. SAUNDERS AND ASSOCIATES INC. PART NUMBERS REFERENCED TO ACCEPTABLE MANUFACTURERS AND THEIR PART NUMBERS

5.5. VENDOR LISTS

\# 1004
AMP SPECIAL INDUSTRIES
1850 SO. WILMINGTON AVE.
COMPTON ,CA 90220

\# 3334
FAIRCHILD/SEMICONDUCTORS
464 ELLIS
MTN VIEW ,CA 94040

\# 5333
LITTLEFUSE
800 E. NORTHWEST HWY.
DES PLAINS ,IL 60016

\# 5833
MOLEX
2222WILLINGTON CT.
LISLE ,IL 60532

\# 7336
RICHCO PLASTIC CO
5825 NORTH TRIPP AVENUE
CHICAGO ,IL 60646

\# 7834
SPRAGUE PRODUCTS CO.
551 MARSHALL ST.
NORTH ADAMS ,MA 01247

\# 7837
STORM PRODUCTS CO.
3047 N. 31ST. AVE.
PHOENIX ,AZ 85260

\# 1009
AMPHENOL NORTH AMERCIAN DIV.
DIV. BUNKER RAMO CORP.
900 COMMERCE DR.
OAK BROOK ,IL 60521

\# 4004
HEWLETT PACKARD
2336 E. MAGNOLIA
PHOENIX ,AZ 85034

\# 5675
MCLOONE METAL GRAPHICS,INC.
CAUSEWAY BLVD. & SUMNER ST.
P.O. BOX 1117
LA CROSSE ,WI 54601

\# 7334
R-OHM CORP.
16931 MILLIKEN/BX 4455
IRVINE ,CA 92705

\# 7667
HERMAN H. SMITH INC.
812 SNEDIKER AVE.
BROOKLYN ,NY 11207

\# 7835
STACKPOLE COMPONENTS
P O BOX 14466
RALEIGH ,NC 27610

\# 8502
UNITRODE CORP.
580 PLEASANT ST.
WATERTOWN ,MA 02172

FIGURE 5-10. MANUFACTURERS' ADDRESSES

OPTION 004
LOW POWER MODIFICATION 150A & 150B CI METERS
ASSUMING THE UNIT HAS BEEN PREVIOUSLY CALIBRATED

MAY 28, 1980

OPTION 004
LOW POWER MODIFICATION 150A & 150B CI METERS
ASSUMING THE UNIT HAS BEEN PREVIOUSLY CALIBRATED

I) Replace the following Components.

A) 150A

1) Change R38 from 10K to 22K ohms.
2) Change R97 from 2.2K to 12K ohms.
3) Change R91 from 4.7K to 10K ohms.
4) Change R60 from 27K to 15K ohms.
5) Change R21 from 33 ohms to 270 ohms.
6) Change R20 from 15K to 3.9K ohms.
7) Change R115 from 47 ohms to 27 ohms.
8) Add 2.2 micro Farad capacitor in parallel with C105. Positive side toward C15.

B) 150B

1) Change OR47 from 12K to 22K ohms.
2) Change OR56 from 2.2K to 12K ohms.
3) Change OR39 from 27K to 15K ohms.
4) Change OR1 from 15K to 3.9K ohms.
5) Change OR120 from 33 ohms to 270 ohms.
6) Change OR119 from 47 ohms to 27 ohms.
7) Install new roms in the top PCB in sockets ID3 and ID4.
8) Add 2.2 micro Farad capacitor in parallel with OC105. Positive side toward OC15.

II) Calibration (All calibration is done on the bottom PCB for either the 150A or 150B.)

A) 150A - Allow warm up period of 1 hour.

1) Place unit in the 2.2 to 5MHz band.
2) Place a jumper across C34.
If your 150A is used with an automatic system, remove the front socket assembly by unscrewing the black #4-40 retaining screw and sliding this assembly free from the front panel.
3) With a shorting device, short three front connector pins together, J7-1, 2 and 3.
4) Monitor TP8 with a DVM and rotate R45 for .000V.
5) Monitor TP7 with a DVM and rotate R95 for .000V.
6) Remove jumper from C34 and the shorting device from J7.
7) Insert a small screwdriver through the front panel, (right side of the C_t switch) and rotate the power pot (R34) to midpoint.

8) Install the front crystal socket if it was removed.
9) Insert a precision 10 ohm resistor in the crystal socket, depress "R" and rotate R96 for a display of 10.
10) Insert a precision 220 ohm resistor in the crystal socket, depress "R" and rotate R15 for a display of 220.
11) Repeat steps 9 & 10 until the correct reading is displayed for both the 10 ohm and 220 ohm.
12) Monitor the center leg of relay RL1 (J7-3) with an oscilloscope.
13) Insert a 10 ohm resistor in the crystal socket.
14) While observing the scope trace, rotate the power pot (R34) fully CW. Distortion of the waveshape may be observed. The power pot should be rotated CCW until the waveshape changes to a sine wave. At this point, depress the "R" switch, note the resistance reading displayed, rotate the power pot fully CCW (minimum power) and adjust R17 for the same reading as was previously noted.
15) Insert a 220 ohm resistor in the crystal socket.
16) While observing the scope trace, rotate the power pot (R34) fully CW. Distortion of the waveshape may be observed. The power pot should be rotated CCW until the waveshape changes to a good sine wave. Depress "R" switch, note the resistance reading displayed, rotate the power pot fully CCW and adjust R16 for the same reading as was previously noted.
17) Repeat steps 13 and 14, and steps 15 and 16 as necessary until resistance reads the same at high and low power.
18) Repeat steps 7, 9, 10 and 11 as necessary to achieve proper resistance readings for the 10 and 220 ohm resistors.
19) Insert a 125 ohm resistor in the crystal socket. Depress power pot switch SW5 and rotate for a display of 10,000 (1000 micro Watts). (The unit will now normally read high by a factor of 10.) While monitoring the center leg of RL-1 (J7-3) with the oscilloscope, rotate R22 for 1.22 V. P-P.
20) Depress power pot switch SW5 and rotate for a display of 500 (50 micro Watts). Adjust R18 for .27 V. P-P.
21) Repeat steps 19 and 20 until no change of R22 and R18 is needed.
22) If the unit dies at low power it my be necessary to rotate R18 CCW until oscillation starts.

23) With a 125 ohm resistor in the socket, depress "R" switch, rotate the power pot R34 from minimum to maximum and observe the resistance displayed to be from 124 to 126 ohms.

B) 150B. Allow a warm-up period of 1 hour.

1) Place unit in the 2.2 to 5MHz band.
2) Place a jumper across OC34.
   If your 150B is used with an automatic system, remove the front socket assembly by unscrewing the black #4-40 retaining screw and sliding this assembly free from the front panel. If your unit has the black textool socket on the front panel, leave it installed.
3) With shorting device, short the three front connector pins together J7-1, 2 and 3.
4) Monitor TP8 with a DVM and rotate OR52 for .000V.
5) Monitor TP7 with a DVM and rotate OR67 for .000V.
6) Remove the jumper from OC34 and the shorting device from J7.
7) Insert a small screwdriver through the front panel, (right side of the C_t switch) and rotate the power pot RG1 to midpoint.
8) Install the front crystal socket if it was removed.
9) Insert a precision 10 ohm resistor in the crystal socket, depress "R" switch and rotate OR57 for a display of 10.0.
10) Insert a 220 ohm precision resistor in the crystal socket, depress "R" switch and rotate OR15 for a display of 220.0.
11) Repeat steps 9 and 10 until the reading is correct for both the 10 ohm and 220 ohm resistors.
12) Monitor the center leg of relay OK1 (J7-3) with an oscilloscope.
13) Insert a 10 ohm resistor in the crystal socket.
14) While observing the scope trace, rotate the power pot (RG1) fully CW. Distortion of the waveshape may be observed. The power pot should be rotated CCW until the waveshape changes to a good sine wave. Depress "R" switch, note the resistance reading displayed, rotate the power pot fully CCW and ajdust OR17 for the same reading as was previously noted.
15) Insert a 220 ohm resistor in the front crystal socket.
16) While observing the scope trace, rotate the power pot fully CW. Distortion of the waveshape may be observed. The power pot should be rotated CCW until the waveshape changes to a good sine wave. Depress "R" switch, note the resistance reading displayed, rotate the power pot fully CCW and ajust OR16 for the same reading as was previously noted.
17) Repeat steps 13 and 14, and steps 15 and 16 as necessary until the resistance reads the same at low and high power.
18) Repeat steps 7, 9, 10 and 11 as necessary to achieve proper resistance readings for the 10 ohm and 220 ohm resistors.

19) Insert a 125 ohm resistor in the crystal socket. Depress power pot switch SG1 (SG1 & RG1 are the same device) and rotate for a display of 1000. While monitoring the center leg of OK-1 (J7-3) with the oscilloscope, rotate OR23 for 1.22 V. P-P.
20) Depress power pot switch SG1 and rotate for a display of 50 (50 micro Watts). Adjust OR22 for .27 V. P-P. It may be necessary to change OC33 from a 4.7 micro Farad to a .1 micro Farad.
21) Repeat steps 19 and 20 until no change of OR23 or or OR22 is necessary.
22) With a 125 ohm resistor in the socket, depress "R" switch, rotate the power pot RG1 from minimum to maximum and observe the resistance displayed to be from 124 ohm to 126 ohm.

CAE LAB

CRYSTAL IMPEDANCE
METER
AND
PRINTER
OPTION 006

OPERATION
MANUAL

SAUNDERS & ASSOC. INC.

7440 E. KAREN DR., • SCOTTSDALE, ARIZONA 85260 • (602) 991-9250

CRYSTAL IMPEDANCE METER AND PRINTER

OPTION 006

CERTIFICATION

Saunders and Associates, Inc. certifies this option was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory.

WARRANTY

This Saunders and Associates, Inc. option is a software modification for the Crystal Impedance Meter. The option is warranted to be free of any defects. Saunders and Associates, Inc. is not liable for consequential damage.

TABLE OF CONTENTS

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Saunders and Associates, Inc. assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to Saunders and Associates, Inc. for service and repair to ensure that safety features are maintained.

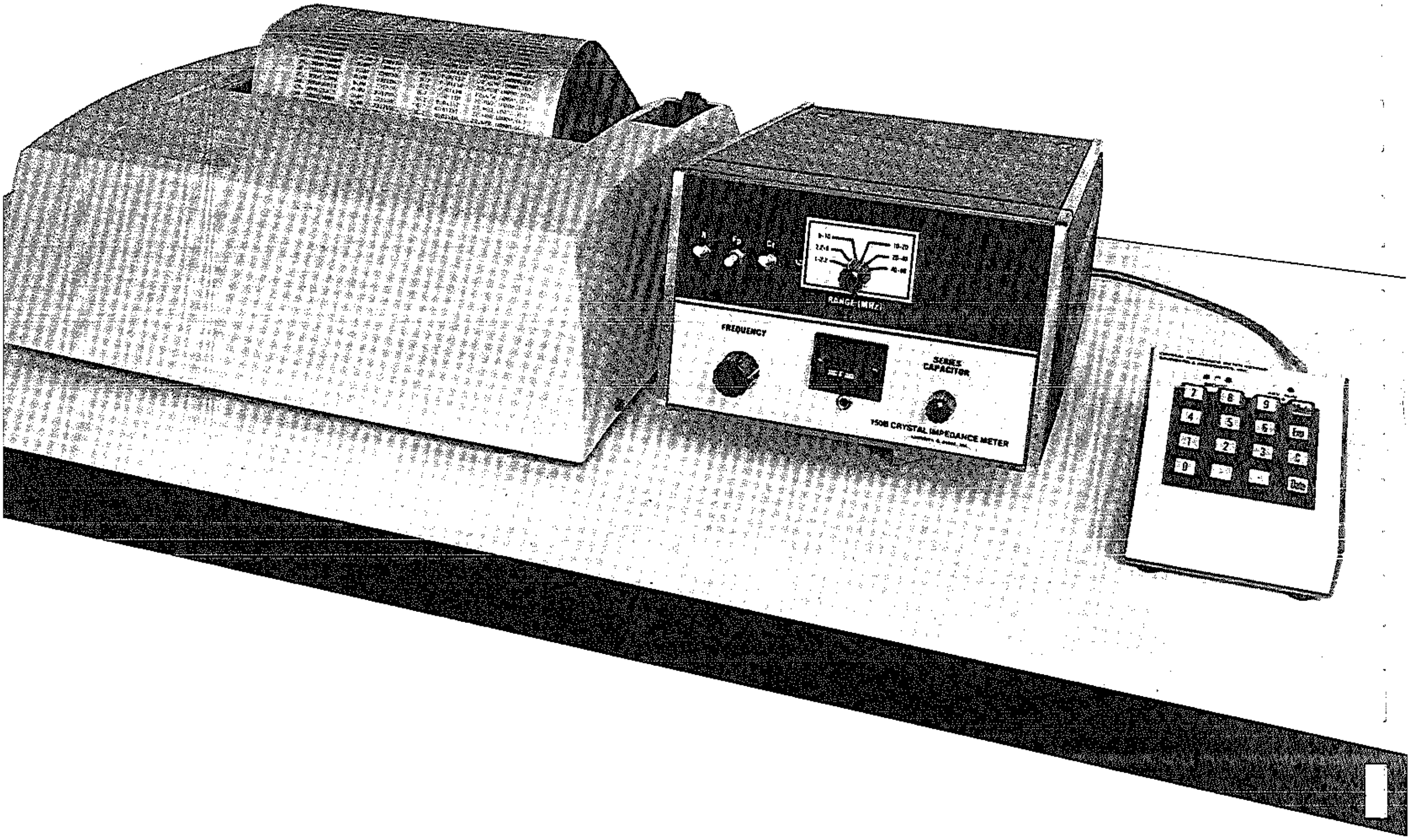


Figure 1-1. CI Meter-Printer Option shown with a Printer and Keypad Option

SECTION 1

DESCRIPTION

The printer option allows the 140A/150B/150C/160A Crystal Impedance Meter to print the results of the Option 005 measurements. Figure 1-1 shows the setup of the printer and CI Meter.

All operation conditions covered in the Basic Operation Manual, Option 001 and Option 003/005 remain operational as described, as well as the additional conditions covered in this manual. A thorough understanding of Option 003/005 is assumed when reading this manual.

The Option 006 requires the following options to be installed in the CI Meter.

Option 001—IEEE488 Data Bus. Operates in talk only mode to send printer format to the printer.

Option 003—Keypad Capabilities. Used to key in operating conditions and limits.

Option 005—Adds engineering calculations and GO/NO GO testing.

The following options can also operate with Option 006.

Option 001—Standard Talk-Listen operation.

Option 002—Analog output proportional to frequency deviation from a reference frequency.

Option 004—Limited power range.

Option 008—2001 Series Test System (IEEE488 bus interface).
2000A/B Printer Processor interface.

The printer for Option 006 is supplied by the CI Meter user. The printer must be capable of powering up as an IEEE488 bus listener, print up to 80 columns per page. The CI Meter with Option 006 will operate properly with most printers meeting the aforementioned requirements.

Saunders and Associates, Inc. has used a COMPRINT 912P Printer with Option 006. Figure 1-1 shows the COMPRINT 912P. The COMPRINT 912P prints on a metalized paper. The printer is available in most common line voltages and line frequencies. The printer can be purchased retail from MicroAge or Computerland stores or from the manufacturer.

Computer Printers International
340 East Middlefield Road
Mountain View, California 94043 U.S.A.
Order as Model 912P—IEEE488 Bus

The printer is supplied with an unterminated interface cable. Saunders and Associates, Inc. supplies the cable connector and Section 5 covers cable-connector assembly as well as printer setup.

SECTION 2

SPECIFICATIONS

This section covers the specification of the printer option.

2.1. EQUIPMENT REQUIREMENTS

There is certain equipment and options required for Option 006 to operate.

2.1.1. CI Meter Requirements

The CI Meter must have the following options:

Option 001 IEEE488 bus interface
Option 003 Keypad
Option 005 Engineering measurements and GO/NO GO testing
Option 006 Printer interface software

2.1.2. Printer Requirements

The printer must have the following capabilities:

a. Operate as an IEEE488 listener.
b. 80 columns minimum print width
c. Print characters as defined in the ASCII character set.
d. Upper-lower case is desirable.
e. Print rate should be as high as possible or the printer should have a buffered input to maintain maximum CI Meter speed.

2.2. ENGINEERING MODE PRINTOUT

The CI Meter operates in Mode C .

The following parameters are always printed:

F_R—Series resonant frequency as measured.
C_0—Crystal pin to pin capacity. (Value of C_L is read and stored)
Q—Crystal quality factor.
R_R—Series resonant resistance as measured.
C_1—Motional crystal capacitance.

If the user keys in a specified C_{Load} the printout will also have:

F_L—Computed load resonant frequency at the specified C_{Load}.
TS—Trim sensitivity at the specified C_{Load}.

If the user keys in a specified F_{Load} frequency, the printout will also have:

C_L—Computed C_{Load} required to set the crystal to the specified F_{Load}.
TS—Trim sensitivity at the specified F_{Load}.

If the user does not key in any special condition the printout will be:

L—Crystal motional inductance.
Fp—Load resonant frequency as measured.

When the engineering mode is ended a summary printout is given. The average value for F_R, R_R and C_1 is printed for all crystals tested. The standard deviation for F_R, R_R and C_1 is also printed.

$$\text{Average} = \sum_{i=1}^{n} \frac{1}{n} x_i$$

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i \right)^2}{n-1}}$$

Where: n = total number of crystals measured
x = value measured

2.3. GO/NO GO TESTING

The CI Meter operates in Mode d .

The GO-NO GO testing functions as in Option 005 with the following exceptions:

a. The limit table and the type of test being executed is printed when beginning testing.
b. When each crystal is tested all four measured/computed values are printed. Those values out of the limits are followed by an 'R'. If any of the four parameters are rejects (R) then the word FAIL is printed.

With a buffered printer such as the COMPRINT 912P, the test time ranges between 1.5 to 2 seconds per crystal for a 150B to 5 seconds for a 140A.

SECTION 3

INSTALLATION

The Printer Option 006 is a software addition to the CI Meter. If the CI Meter was ordered with Option 006, no further installation action is required.

If the Option 006 is to be added to an existing CI Meter, follow the sequence indicated below.

> ***IMPORTANT***
>
> Read the Safety Summary at the front of the manual before installing this option.

This sequence assumes Options 003 and 005 were previously operational.

1. Remove power from the CI Meter.
2. Remove top cover by removing two screws at the rear of the top cover.
3. Remove either the integrated circuit ROM or assembly of ROMs in positions ID3 and ID4. (See Specification, Circuit Description and Maintenance Manual).

4.a. If installation is ROM assembly, install assembly with ROMs labeled xxxA and xxxB
xxxx xxxx
in the ID3 socket. Chamfered assembly edge matching pin 1 marking on the socket.

Install assembly with ROMs labeled
xxxC and xxxD into the ID4 socket.
xxxx xxxx

4.b. If the 2732 ROM type integrated circuit:
ROM labeled xxx1 into ID3 socket
xxxx
Carefully check IC pin 1 to socket pin 1.
ROM labeled xxx2 into ID4 socket
xxxx

5. Push the removed circuits into the foam pads which are shipped with the option. Return to Saunders and Associates, Inc.
6. Replace CI Meter top cover.

The new option is now installed. Proceed to the Operation Section for the use of the option.

SECTION 4

OPERATING PROCEDURES

The operation of the CI Meter and printout by the printer is covered in this section. Full understanding of Option 003 and 005 is assumed.

4.1. EQUIPMENT SETUP

The keypad should be attached as described in the Option 003/005 Manual. The printer should be plugged into the IEEE488 Data Bus plug. Refer to Figure 4-1.

Turn the printer on and set to the line position. Plug the CI Meter into the power main.

4.2. ENGINEERING MODE PRINTOUT

Set the CI Meter to the desired band.

Set the mode to ⊏. When releasing the CI Meter front panel switches, the first 3 lines of Figure 4-2 will print. These are instructions to remind the user of the sequence to follow.

> ***NOTE***
>
> If Mode ⊏ is entered without an enabled printer, the CI Meter will hang up. The CI Meter must be disconnected from the power main and reconnected (reset).

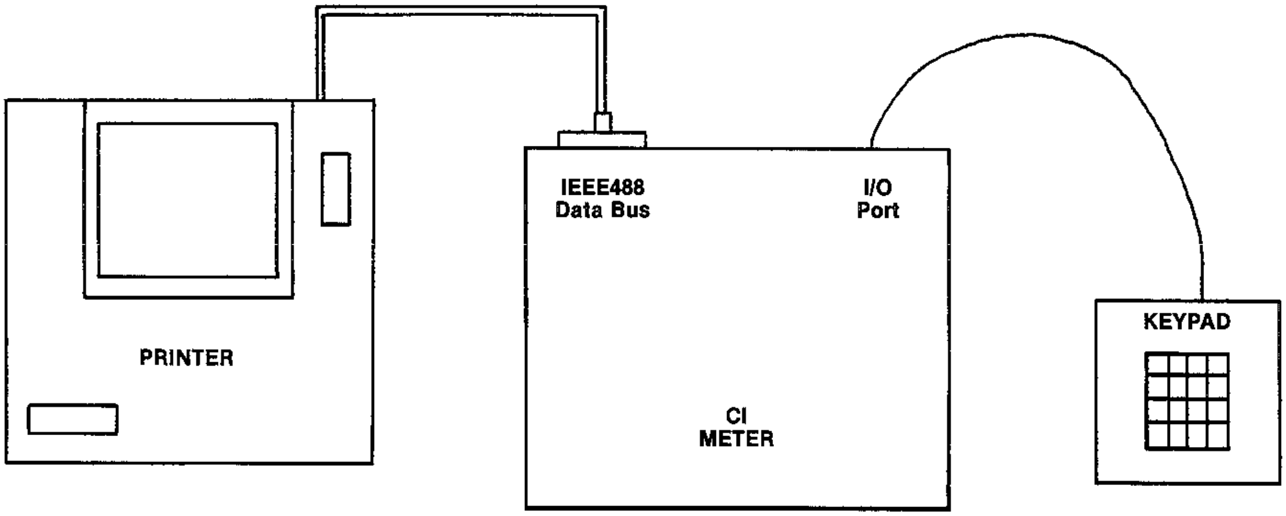


FIGURE 4-1. EQUIPMENT CONNECTION FOR OPTION 006

```
Set CI Meter
Load Cs by reading Ct with NO Crystal in Socket
   Input Fl,Cl or '0'
```

Instructions printed

1. Set up the CI Meter as outlined in the Operating Manual for the CI Meter.
2. Remove crystal from socket, depress Ct switch. This stores the setup value for the series capacitor. The series capacitor should not be changed.
3. Depress data key on keypad to enable keypad.
4. Key in F_L or C_L or zero, depressing data key to enter.

```
Input XTAL No. (Mode RED=End)
```

Indicates the CI Meter is now set.

A. Insert next crystal to test.

B. Key in crystal under test number. Depress DATA key to input number. Printout will now occur for the crystal. Repeat A and B until all crystals are tested.

```
Cs=    19.96pF
Power     249.uW
```

Value of series capacitor stored in the CI Meter

Power being dissipated in first crystal listed on top of the page.

```
 XTAL No.   Fr(kHz)    Co(pF)       Q     Rr(ohms)   Ci (pF)     L(mH)   Fp(kHz)
      11.  5016.1392     5.49   124398.      16.8    0.01515    66.448 5017.6323
      12.  5016.3056     5.61   147912.      15.8    0.01356    74.212 5017.6360
      13.  5016.0029     5.46   149713.      12.8    0.01652    60.957 5017.6327
      14.  5016.1871     5.37    84126.      25.8    0.01463    68.829 5017.6355
      15.  5015.9507     5.36   137297.      13.6    0.01697    59.317 5017.6318
      16.  5016.1416     5.26   150413.      14.1    0.01496    67.288 5017.6294

 Average   5016.1212                         16.5   0.01530
Std. Dev.  +1.288E-01.                          4.8   0.00126
```

To end the printout enter the crystal number in the RED keypad mode. (Depress the MODE key until the keypad is in the RED mode.) The printout will give the average and standard deviation and returns to Mode 0.

FIGURE 4-2. COMPLETE PRINTOUT FOR ENGINEERING MODE

1. Set up the CI Meter as described in the Operating Manual. (Band switch should already be set.)
    Set power
    Set frequency
2. Set C series. Depress C_t with no crystal in test socket. Adjust the C series capacitor. The last read C_t value is stored and used by the CI Meter in later calculation.

    DO NOT change C series.
3. Key in a value to define how to make the measurements.

    Value = 0—Print L and Fp
    0<Value<1000 Value is the specified C_{Load}
    Compute F_{Load} and trim sensitivity
    Value≥1000 Value is the specified F_{Load}
    Compute C_{Load} and trim sensitivity
4. The CI Meter and the printer are now ready to begin testing.
    a. Insert the crystal to test.
    b. Key in crystal under test number. Heading will automatically print on top of the page and the device data will follow.

        The heading contains the C series value which was stored in step 2, the power measured in the crystal whose measurements occur on the first line of the current page and either specified value, if specified.
    c. Measurements are made.
    d. When the keypad enables remove the current crystal which was just tested.

        If more crystals are to be tested, repeat steps "a" to "d".

        If done advance keypad mode to RED and enter zero (any number will do).

        The average and standard deviation will print. The CI Meter will be operating in Mode 0 (the switch is still in the C position but will not be read or entered until the 3 front panel switches are depressed).

The other types of printouts are shown in Figure 4-3 and Figure 4-4.

4.3. GO/NO GO Testing

Set the CI Meter to the desired band.

Set the Mode to d . When releasing the CI Meter front panel switches the words "QC Test" will print.

NOTE

If Mode d is entered without an enabled printer, the CI Meter will hang up. The CI Meter must be disconnected from the power main and reconnected (reset).

Enter table exactly as done in Option 005. (In fact, switching between Mode 7 and d will retain the table.) Figure 4-5 shows a sample table. Advance to testing as in Option 005. When doing so, the table of limits will print as shown in Figure 4-6.

Set up the CI meter as in Option 005 Mode 7 and load value of C series.

```
Cs=      19.97pF
Power      249.uW
Cl  spec=     20.00pF  ← User specified load capacitance


 XTAL No.   Fr(kHz)    Co(pF)         Q     Rr(ohms)    C1 (pF)  Fl(kHz) Trim(ppm/pF)

      20.  5016.1402      5.39   122001.      17.2    0.01513 5017.6351     11.74
      23.  5016.3042      5.59   148585.      15.7    0.01357 5017.6348     10.36
      29.  5016.0000      5.48   104480.      18.4    0.01654 5017.6274     12.73
      34.  5016.1843      5.37    84089.      25.8    0.01463 5017.6314     11.37
      37.  5015.9498      5.43   136917.      13.6    0.01698 5017.6245     13.12
      38.  5016.1401      5.30   148486.      14.3    0.01496 5017.6233     11.68

 Average  5016.1198                          17.5   0.01530
Std. Dev. +1.304E-01.                          4.4   0.00126
```

Computed F Load at C Load specified

Trim sensitivity at C Load specified. Value is negative but absolute value is printed.

FIGURE 4-3. EXAMPLE PRINTOUT WITH A USER SPECIFIED C LOAD

```
Cs=      19.97pF
Power      249.uW
Fl  spec=5017.6000kHz


 XTAL No.   Fr(kHz)    Co(pF)         Q     Rr(ohms)    C1 (pF)    Cl(pF) Trim(ppm/pF)

       1.  5016.1350      5.45   122175.      17.1    0.01520     20.57       11.22
       2.  5016.2967      5.69   148942.      15.7    0.01357     20.43        9.94
       3.  5015.9986      5.44   148628.      12.9    0.01651     20.42       12.34
       4.  5016.1820      5.40    83366.      26.0    0.01462     20.46       10.93
       5.  AGC-error  ← Crystal could not properly oscillate in Cl Meter
       6.  5015.9498      5.35   136263.      13.7    0.01699     20.46       12.74
       7.  5016.1364      5.32   149038.      14.2    0.01496     20.33       11.38

 Average  5016.1164                          16.6   0.01531
Std. Dev. +1.273E-01.                          4.8   0.00125
```

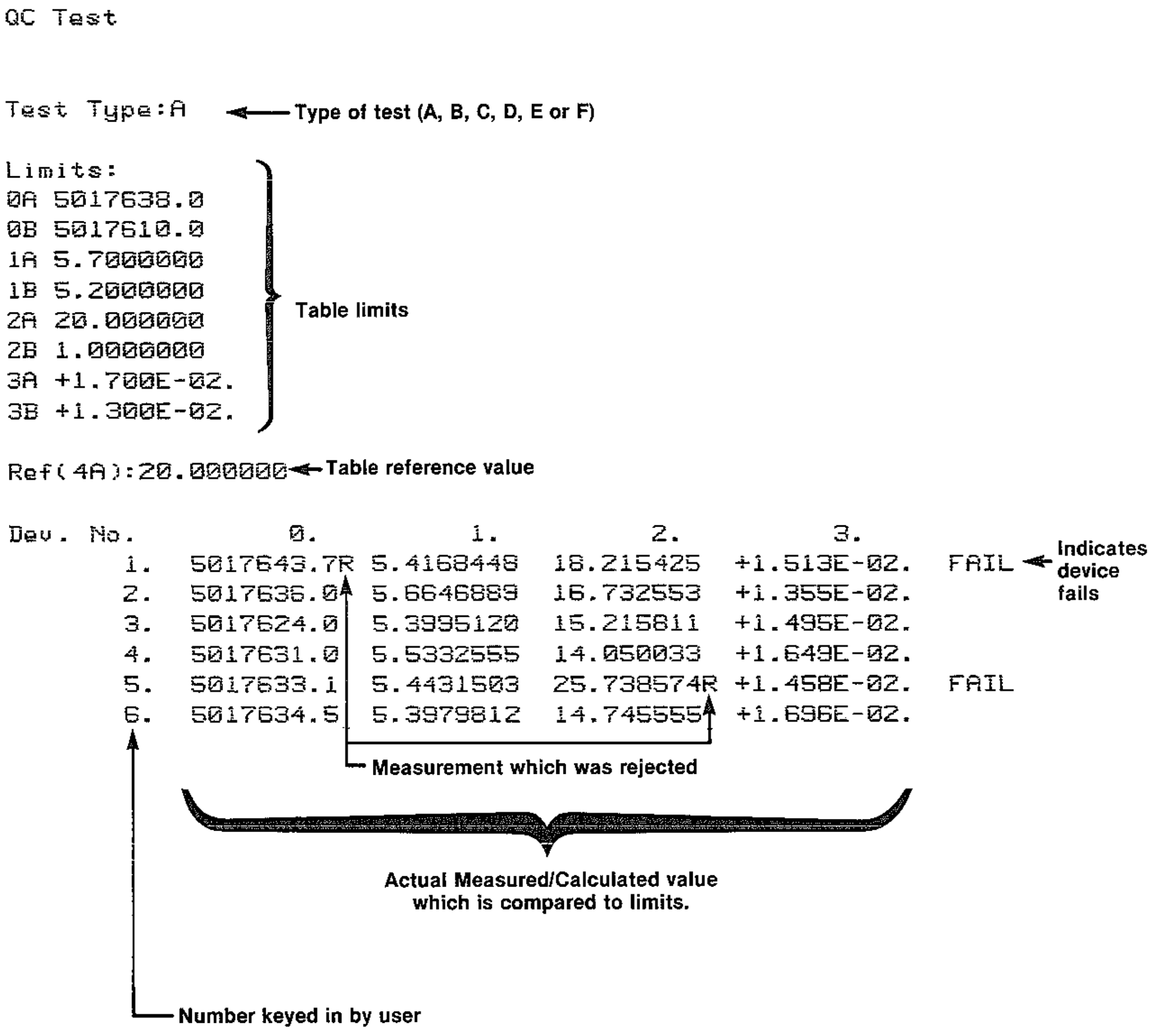
Computed C Load for the specified F Load

Trim sensitivity at the specified F Load

FIGURE 4-4. EXAMPLE PRINTOUT WITH A USER SPECIFIED F LOAD

Test A	Test B	Test C	Test D	Test E	Test F	LIMIT	DISPLAY	SPECIFICATION
F_L* Hertz at specified C_{Load}	F_L* Hertz at specified C_{Load}	F_L* Hertz at specified C_{Load}	F_L* Hertz at specified C_{Load}	C_{LC} pF at specified F_{Load}	C_{LC} pF at specified F_{Load}	Upper	0A	5017638
						Lower	0b	5017610
C_o pF	C_o pF	C_o pF	C_o pF	C_o pF	C_o pF	Upper	1A	5.7
						Lower	1b	5.2
R_R ohms	Q	R_R ohms	Q	R_R ohms	Q	Upper	2A	20
						Lower	2b	1
C_1 pF	C_1 pF	L mH	L mH	Trim Sensitivity PPM/pF	Trim Sensitivity PPM/pF	Upper	3A	.017
						Lower	3b	.013
C_{LS} pF	C_{LS} pF	C_{LS} pF	C_{LS} pF	F_{LS} Hertz	F_{LS} Hertz	Reference	4A or 4b	20

FIGURE 4-5. SAMPLE SPECIFICATION



```
QC Test

Test Type:A

Limits:
0A 5017638.0
0B 5017610.0
1A 5.7000000
1B 5.2000000
2A 20.000000
2B 1.0000000
3A +1.700E-02.
3B +1.300E-02.

Ref(4A):20.000000

Dev. No.          0.          1.          2.          3.
      1.    5017643.7R  5.4168448  18.215425  +1.513E-02.   FAIL
      2.    5017636.0   5.6646889  16.732553  +1.355E-02.
      3.    5017624.0   5.3995120  15.215811  +1.495E-02.
      4.    5017631.0   5.5332555  14.050033  +1.649E-02.
      5.    5017633.1   5.4431503  25.738574R +1.458E-02.   FAIL
      6.    5017634.5   5.3979812  14.745555  +1.696E-02.
```

FIGURE 4-6. EXAMPLE OF GO/NO GO TESTING

The sequence from this point on is slightly different.

a. Depress the data key to enable the keypad.

b. Key in the number of the device to test.

c. The keypad will go to "RUN" in Mode YELLOW.

d. Measurement will occur.

e. Limits will be compared and the measured calculated values will print. All the values which are "R"ejected will have an "R" following. If any of the four values get an "R" the word "FAIL" will print to the right. See Figure 4-6. When the word "FAIL" prints the Bell function in the printer will be activated.

   If the device passes the keypad will be in the "GREEN" mode.

   If the device fails the keypad will be in the "RED" mode.

f. The keypad will enable maintaining the pass-fail mode, indicating the current device is now ready to remove.

   If more crystals are to be tested, repeat steps b through f.

If this is the end of the testing, advance the keypad to the YELLOW mode and enter. The CI Meter will return to the table entry mode. The table entry mode is exited as in Option 005.

SECTION 5

COMPRINT 912P PRINTER SETUP

The Comprint 912P Printer requires the CI Meter user to install a connector on the interface cable.

The pin connection for the interface cable is shown in Figure 5-1. The connector assembly is shown in Figure 5-2.

The Comprint 912P must be internally jumpered to perform as a proper 488 bus listener. The Comprint Manual describes how to do the jumper set setup. For interface to the CI Meter, jumper A and D are required.

All other Comprint wires remain disconnected. Make sure they are trimmed and insulated so they do not short to the connector cover. The interface cable red stripe indicates the pin 1 side.

Comprint Cable Wire Number	Connector Pin No.	Function
1	1	Data 1
3	2	Data 2
5	3	Data 3
7	4	Data 4
2	13	Data 5
4	14	Data 6
6	15	Data 7
11	6	DAV
13	7	NRFD
15	8	NDAC
12	18	Ground
14	19	Ground
16	20	Ground
18	21	Ground
22	22	Ground
24	23 24	Ground

FIGURE 5-1. COMPRINT CABLE TO 488 BUS CONNECTOR COVER INFORMATION

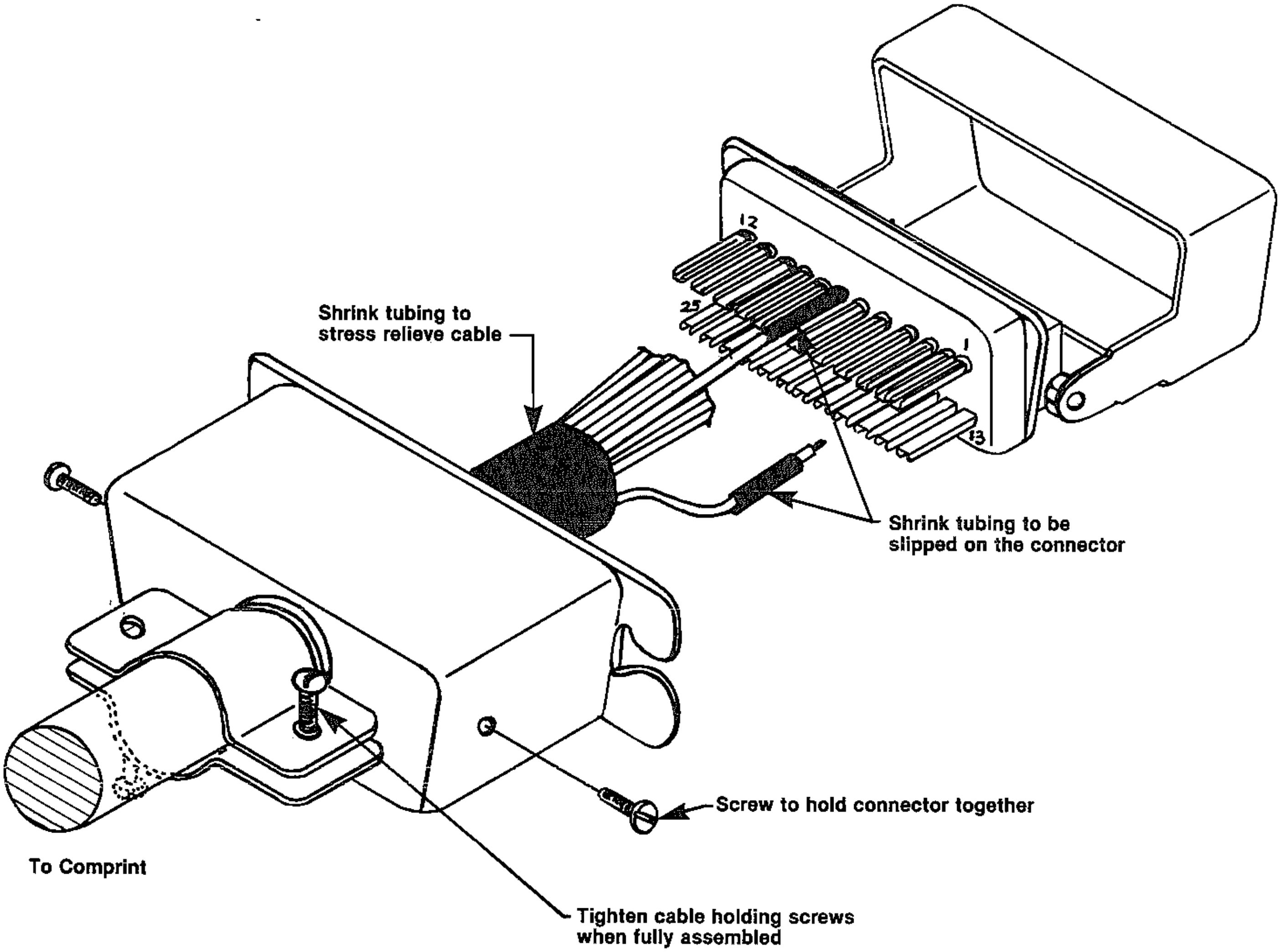


FIGURE 5-2. CONNECTOR ASSEMBLY