

FC45

FREQUENCY COUNTER

OPERATION, APPLICATION AND
MAINTENANCE MANUAL



SENCORE

THE ALL AMERICAN LINE OF HIGH QUALITY TEST EQUIPMENT

WARNING

PLEASE OBSERVE THESE SAFETY PRECAUTIONS

There is always a danger present when testing electronic equipment. Unexpected high voltages can be present at unusual locations in defective equipment. Become familiar with the equipment you're working with, and observe the following safety precautions.

Every precaution has been taken in the design of your instrument to insure that it is as safe as possible. However, safe operation depends on you, the operator.

1. Never exceed the limits of this instrument as given in the specifications section and the additional special warnings in this manual.
2. A severe shock hazard can result if the chassis of the equipment being serviced is tied to the "hot" side of the AC Line. An isolation transformer should always be used with this equipment. Also, be sure that the top of your workbench and the floor underneath it are dry and made of non-conductive material.
3. Remove the circuit power before making connections to high voltage points. If this cannot be done, be sure to avoid contact with other equipment or metal objects. Place one hand in your pocket and stand on an insulated floor to reduce the possibility of shock.
4. Discharge filter capacitors before connecting test leads to them.
5. Be sure your equipment is in good order. Broken or frayed test leads can be extremely dangerous and can expose you to dangerous voltages.
6. Remove the test leads immediately after the test has been completed to reduce the possibility of shock.
7. Do not work alone when working on hazardous circuits. Always have another person close by in case of an accident. Remember, even a minor shock can be the cause of a more serious accident, such as falling against the equipment, or coming in contact with high voltages.
8. **Improper Fuse(s) Void Warranty.** Fuses are for your protection, so always replace fuse with proper type and current rating. The proper fuse type description is marked near the fuse holder and in the instruction manual. Always:
 - a. Be sure you are replacing the right fuse. On units with more than one fuse, be sure you are placing the proper fuse value in the fuse holder.
 - b. Keep spare fuse storage area stocked. Always have proper sized fuse stored in the spare fuse area on the back of the unit. If you use the spare fuse, always put a new spare of the proper value in the holder.
 - c. Have the proper size replacement fuse in stock. With each new instrument, be sure to update your fuse inventory with any special value fuses your instrument may require.
 - d. Avoid situations that will blow the fuse. When a protection fuse blows, note what caused the fuse failure. Prevent future fuse failures by following proper measuring procedures.

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SENCORE

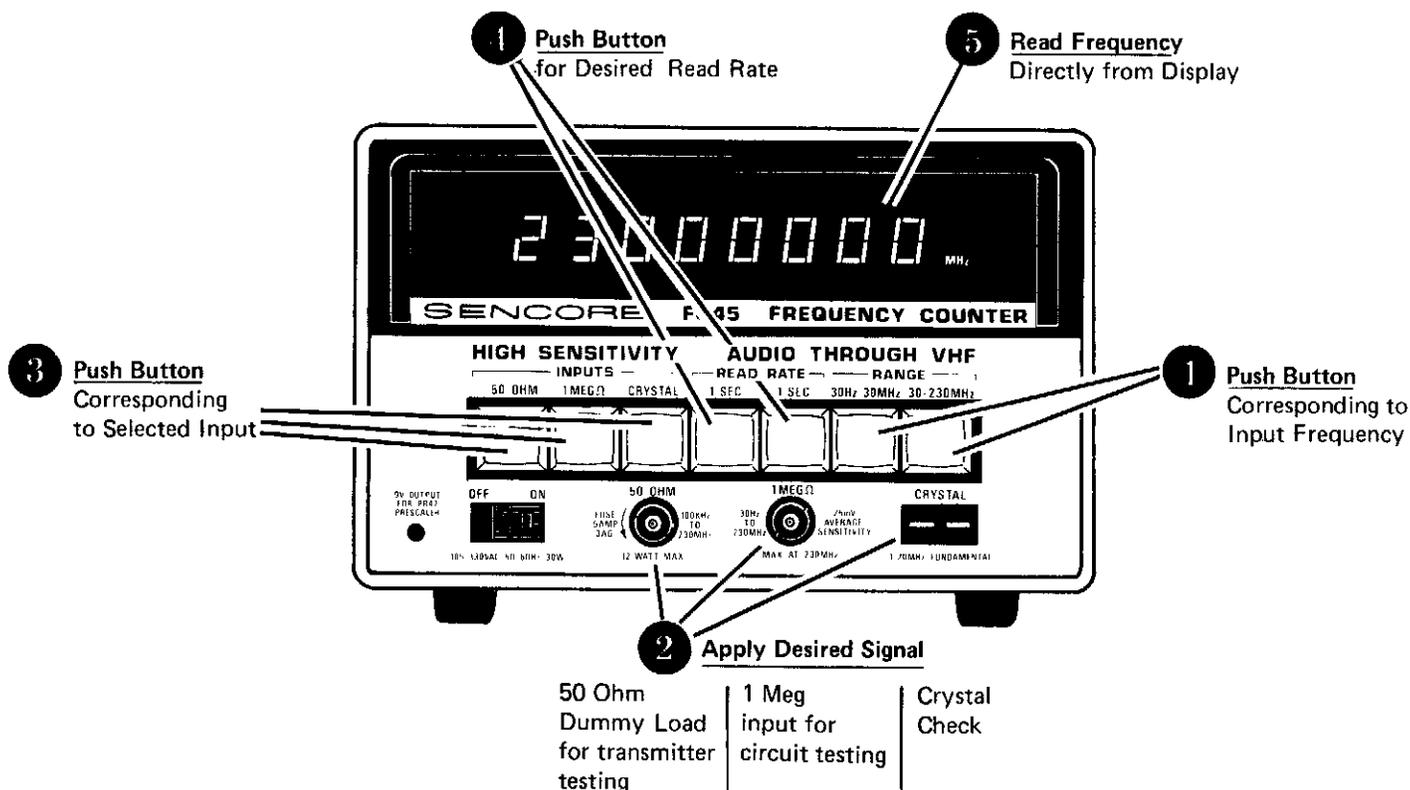
3200 SENCORE DRIVE, SIOUX FALLS, SOUTH DAKOTA 57107

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SIMPLIFIED OPERATIONS

FOR ADDITIONAL DETAILS, REFER TO TABLE OF CONTENTS FOR LOCATION OF COMPLETE INFORMATION.



WARNINGS

1. Always replace fuses with correct value. Improper fuse(s) voids warranty.
2. 50 Ohm Load fuse will blow if more than 12 Watts applied.
3. Damage to transmitter may result if continuously keyed into blown 50 Ohm Load fuse.
4. Refer to specifications for maximum 1 Meg input voltage.

SIGNAL CONNECTION SELECTOR GUIDE

SIGNAL SOURCE	1 Meg Direct	1 Meg ISO	50 Ohm Direct	50 Ohm ISO	10:1 Scope Probe	PL207 Pick-Up Loop	NE206 Noise Eliminator
FREQUENCY RANGE	30 Hz-230 MHz	30 Hz-230 MHz	100 KHz-230 MHz		30 Hz-50 MHz		30 Hz-10 MHz
Audio Circuits	✓						✓
CB Transmitter Outputs			✓				
Digital Square Wave Signals	✓						✓
Digital Pulses				✓	✓		✓
IF Stages		✓			✓	✓	
RF Oscillators (transmit or receive)		✓				✓	
Signal Tracing	✓	✓				✓	
UHF Transmitter Outputs						✓	
VHF Transmitter Outputs (Under 12 Watts)			✓				
VHF Transmitter outputs (Over 12 Watts)						✓	
High Voltage Signals					✓	✓	
RF Signal Generators			✓				

DESCRIPTION

INTRODUCTION

With the increased popularity of personal communications, the need for accurate frequency measurements is becoming more common to many shops. Communications equipment such as CB and land-mobile transceivers, as well as AM, FM, and TV transmitters require frequency measurements within FCC specifications.

The design and troubleshooting of digital equipment often requires adjustment of reference oscillators for proper operation. A frequency counter also simplifies the troubleshooting of many non-digital circuits such as TV color-burst, horizontal and vertical oscillators. In addition, a high sensitivity counter allows alignment of other test equipment such as RF generators or function generators.

FEATURES

The large (.5") 8-digit display of the FC45 allows easy reading of any frequency from the audio range through VHF. The display includes automatic decimal placement and "Hz", "MHz" indicators for direct frequency measurements.

The FC45 includes a built-in 10:1 prescaler for measurements to 230 MHz. An optional external prescaler extends the measuring capability to 600 MHz with high sensitivity. All of the measurements are accurate to 1 part per million (ppm) or .0001% to exceed FCC specifications for communications work. The crystal-controlled timebase is oven controlled to maintain this accuracy over a wide range of operating temperatures.

The FC45 offers two inputs. The high-sensitivity 1 Megohm input is usable through the entire frequency measurement range of the FC45. The second 50-Ohm input provides a dummy load rated at 12 Watts RF. This dummy load is diode protected against overloads with backup fuse protection to protect the diodes.

A choice of a .1 second or 1 second timebase allows the choice of a fast 10 updates per second, or increased resolution. Sencore's exclusive crystal check mode allows most crystals (including CB, VHF, and UHF) to be checked by simply plugging the crystal into the FC45's front panel-socket.

Finally, a choice of 12 VDC or 117 VAC operation offers true versatility for bench or portable testing.

SPECIFICATIONS

INPUT FREQUENCY

1 Meg Input: 30 Hz-230 MHz
50 Ohm Input: 100 KHz-230 MHz
Crystal Check: 1-20 MHz Fundamental Frequency--overtone crystals read at approximate fundamental frequency.

ACCURACY

\pm timebase accuracy, \pm 1 count

RESOLUTION

30 Hz-30 MHz: 1 Hz (1 S timebase) 10 Hz (.1 S timebase). 30 MHz-230 MHz: 10 Hz (1 S timebase) 100 Hz (.1 S timebase).

SENSITIVITY

50 Ohm Load: 10 milliWatts average (see graph 1)
1 Meg Input: 30 Hz-30 MHz: 20 mV. 30 MHz to 100 MHz: 25 mV. 100 MHz-230 MHz: 25 to 400 mV (see graph 2).

INPUT PROTECTION

50 Ohm: Diode protected to 12 Watts. Fuse protected over 12 Watts.
1 Meg Input: 250 VP-P to 10 KHz. 50 VP-P to 30 MHz. 8 VP-P to 230 MHz.
DC Blocking: 250 Volts.

TIMEBASE

Crystal Frequency: 10 MHz—oven controlled.
Setability: \pm 0.1 ppm (.00001%).
Temperature stability: 1 ppm (.0001%), 0-40° C ambient after 10-minute warmup.
Time Stability: 2 ppm/year after 30 days

GENERAL

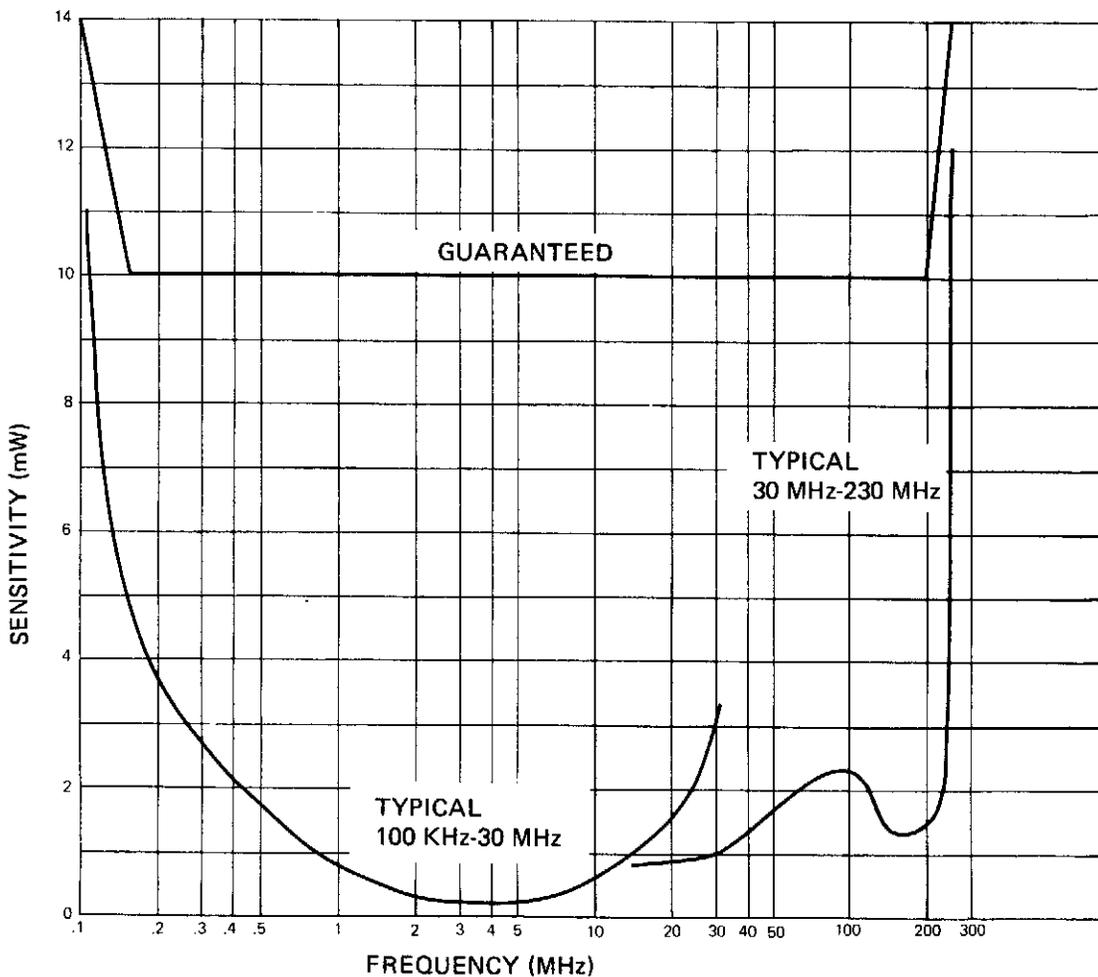
DISPLAY: 8 digit, 0.5" LED, Auto decimal, "Hz" and "MHz" indicators.
SIZE: 5.5" x 7.83" x 9" HWD (14 cm x 19.9 cm x 22.9 cm).
WEIGHT: 6.5 lbs. (3 Kg).
POWER: 105-130 VAC, 50/60 Hz, 30 W max. (220 VAC conversion available) 12 VDC, 2.2 Amps maximum.
FUSE REQUIREMENTS: .5 A, 3 AG Fastblow for 50 Ohm input, 2 A 3 AG Fastblow for 12 VDC leads. Two spare fuses supplied. AC line: transformer internally fused.
ACCESSORY OUTPUT VOLTAGE: 9-12 VDC through front panel jack to power PR47 Prescaler.

ACCESSORIES

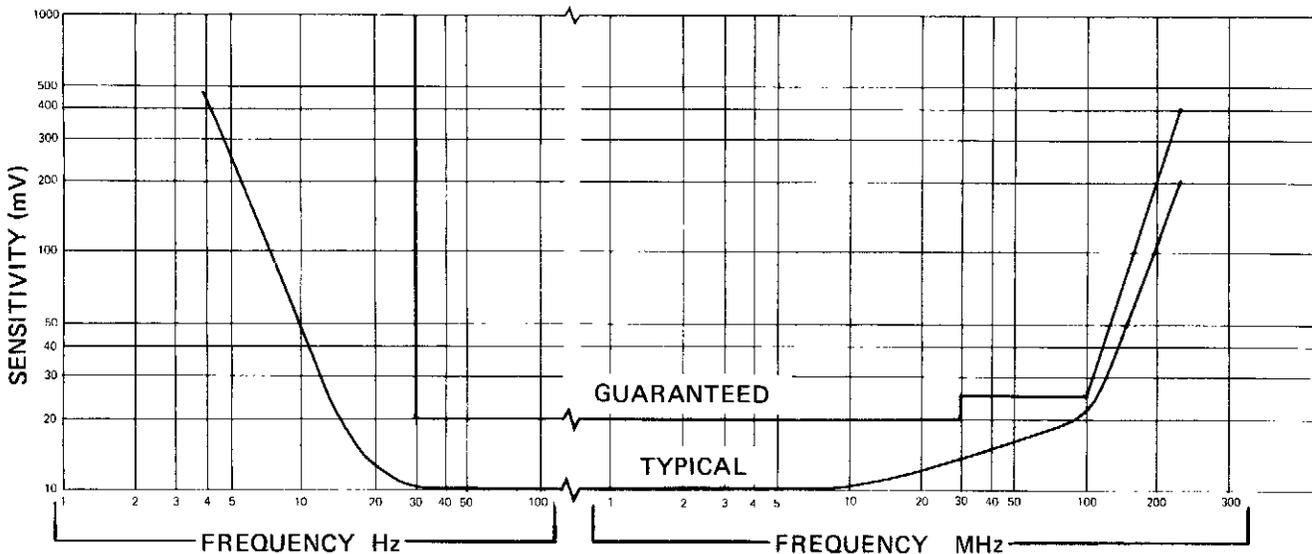
Supplied: 39G112 Direct/Isolated Counter Probe
39G111 Fused DC Supply Lead
Optional: PR47 UHF Prescaler
NE206 Noise Eliminator
PL207 RF Pick-Up Loop
39G80 10:1 Lo Cap Probe

Specifications subject to change without notice.

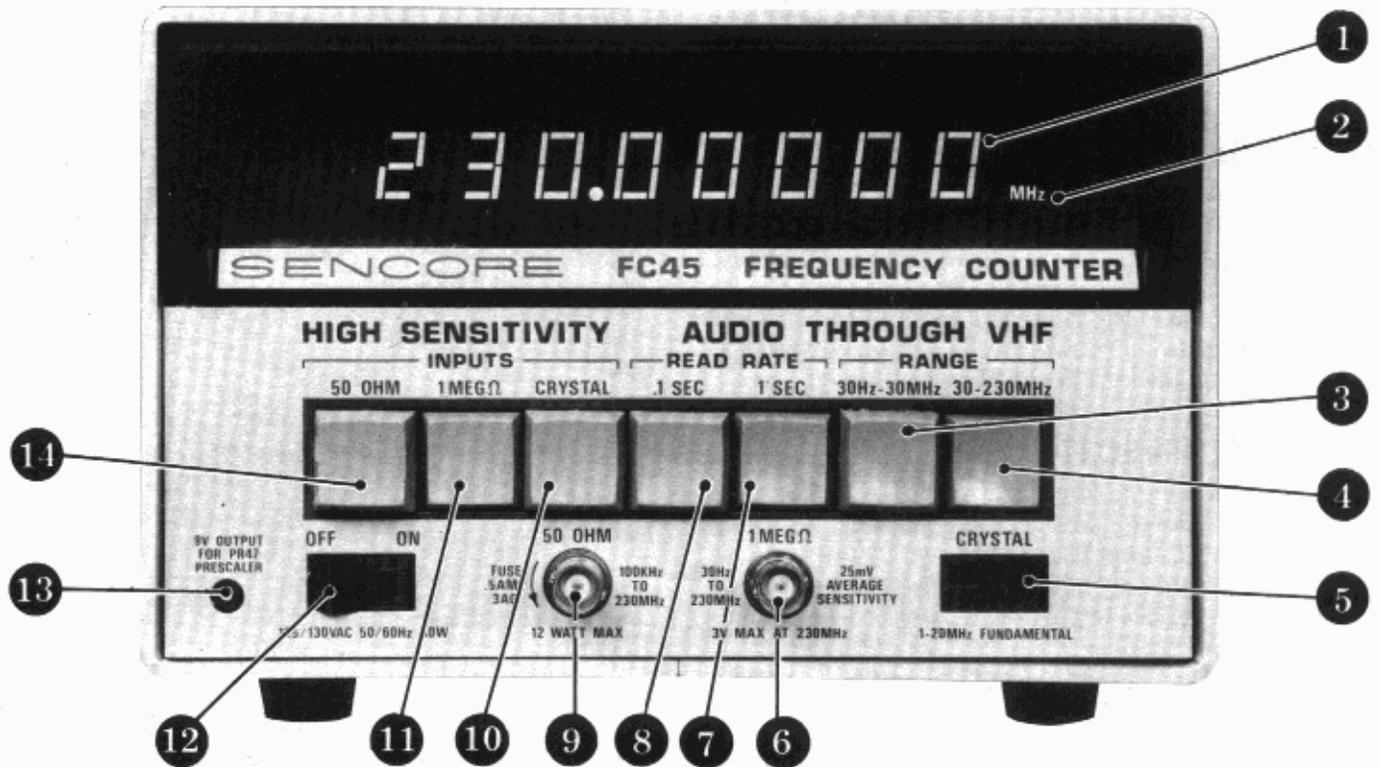
GRAPH 1 50 OHM LOAD INPUT SENSITIVITY



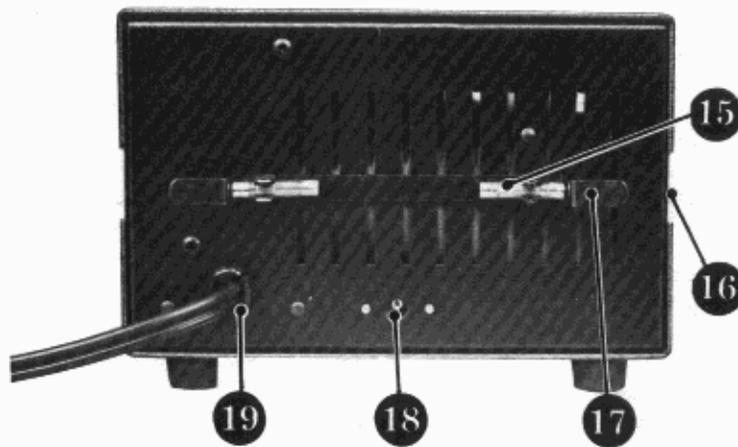
GRAPH 2 1 MEGOHM INPUT SENSITIVITY



- 1 8-digit LED readout with automatic decimal placement.
- 2 MHz, Hz range indicator lights.
- 3 30 Hz-30 MHz range button.
- 4 30 MHz-230 MHz range button which selects the FC45's internal prescaler.
- 5 Universal crystal socket for crystal check.
- 6 1 Meg input jack for measuring small signal levels with minimum circuit loading.
- 7 1 second Read Rate button—used for maximum resolution.
- 8 .1 second Read Rate button—used for faster updates when less resolution is required.
- 9 50 Ohm Dummy Load input (12 Watts) with fuse protection. Fuse (.5 Amp, 3AG) accessible by unscrewing input jack.
- 10 Crystal check function button
- 11 1 Meg input function button.
- 12 Power switch controls power when operated from DC or AC.
- 13 9 Volt Output to power optional PR47 UHF Prescaler.
- 14 50 Ohm load function button.
- 15 Spare fuses.
- 16 Tilt Bail/Handle.
- 17 Cord Wrap.
- 18 12 VDC input jack allows DC operation using the supplied power leads.
- 19 AC power cord.
- 20 Counter Probe offering a choice of direct or isolated inputs for the 1 Meg input (supplied).
- 21 DC Power leads with DC protection fuse (2 Amp 3AG) supplied.
- 22 PL207 RF Pick-Up Loop allows inductive pickup of signals.
- 23 NE206 Noise Eliminator digital signal attenuator allows measurement of noisy digital signals using the 1 Meg input (optional).
- 24 PR47 600 MHz Prescaler extends frequency range to 600 MHz UHF by dividing input frequency by ten times. (optional)
- 25 39G80 10:1 Lo-Cap Probe attenuates input signal by a factor of ten. (optional)



REAR VIEW



ACCESSORIES

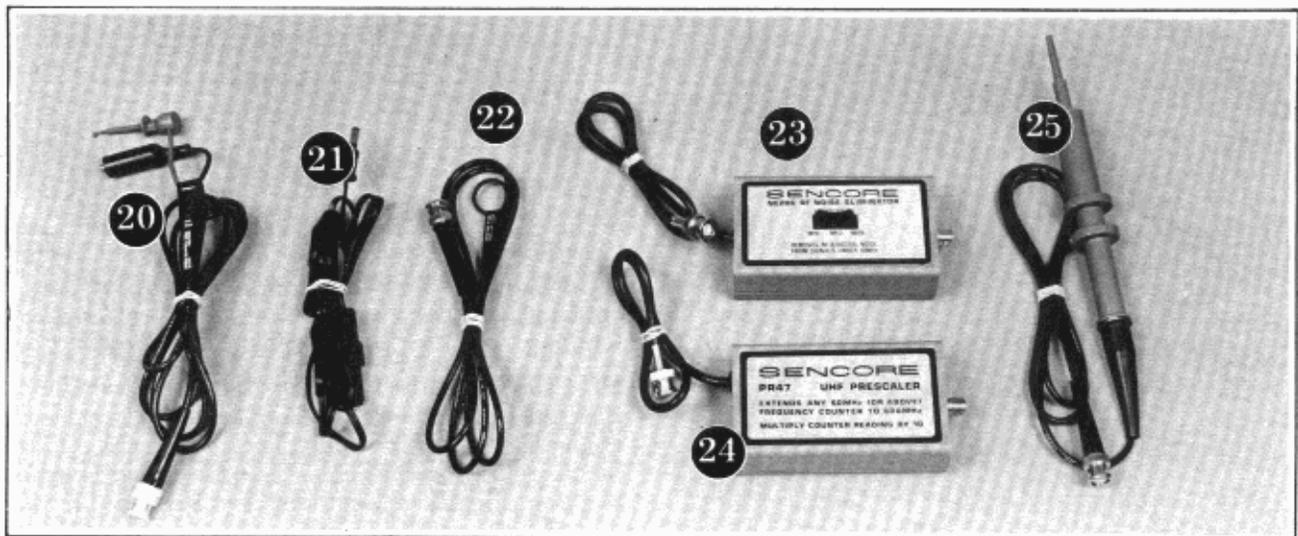


Fig. 1—Location of Controls and Features.

OPERATION

INTRODUCTION

Before using your FC45 for the first time, take a few minutes to read through the operations and applications section of the manual carefully to acquaint yourself with the features of the FC45. Once you are familiar with the general operations, most tests can be performed with the information provided on the FC45's front panel.

POWER CONNECTIONS

AC OPERATION:The FC45 is designed to be operated from 105-130 VAC (50/60 Hz). If 210-230 VAC operation is required, the unit may be modified (at additional cost) by the Sencore Service Department, 3200 Sencore Drive, Sioux Falls, SD 57107.

To operate the FC45 from a standard AC line:

1. Connect the AC cord to a 117 VAC (or 220 VAC for modified units) outlet.
2. Turn the power switch on.
3. The FC45 is immediately ready for frequency measurements. If very precise measurements are to be made, the unit should be allowed to operate for at least ten minutes to allow the temperature of the crystal oven to stabilize.

DC OPERATION:The FC45 may be operated from a 12 VDC power source capable of delivering 2.5 Amperes. Power is supplied through the standard adapter jack located at the bottom of the rear panel. A set of fused supply leads is supplied with the FC45 for DC operation. Make sure the proper size fuse (see FUSE REPLACEMENT below) is in the in-line fuse holder for protection of your FC45 during DC operation.

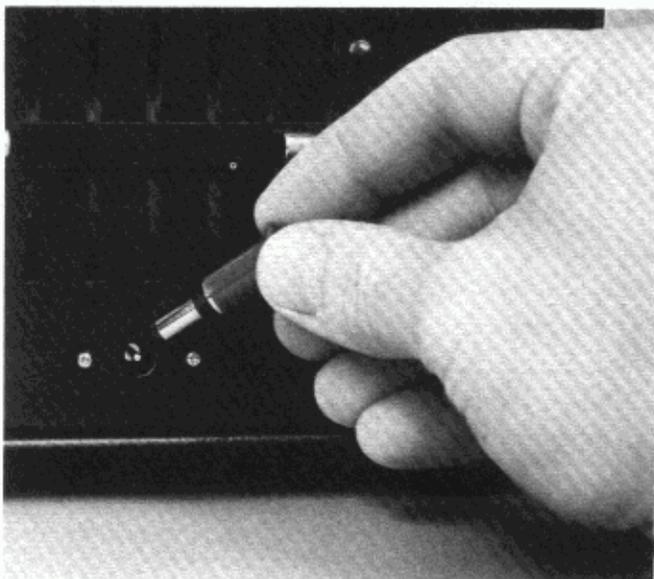


Fig. 2—Connecting DC Supply Lead.

CAUTION: OBSERVE PROPER POLARITIES (NEGATIVE GROUND) WHEN CONNECTING THE DC POWER SOURCE. NO DAMAGE WILL RESULT IF THE POLARITY IS REVERSED, BUT THE FC45 WILL NOT OPERATE WITH A REVERSED POLARITY.

To operate the FC45 from 12 Volts DC:

1. Connect the adapter plug of the supplied 39G111 power supply leads to the DC input jack on the back of the FC45.
2. Connect the standard automotive accessory plug of the supplied test leads to the source of 12VDC, observing proper polarity.
3. Turn the power switch on.
4. The FC45 is immediately ready for frequency measurements. If very precise measurements are to be made, the unit should be allowed to operate for at least ten minutes to allow the temperature of the crystal oven to stabilize.

FUSE REPLACEMENT

WARNING: ALWAYS REPLACE THE FUSES WITH THE VALUE SPECIFIED. LARGER VALUE FUSES MAY CAUSE INTERNAL DAMAGE TO THE FC45 OR CAUSE A FIRE HAZARD AND WILL VOID ALL WARRANTIES.

If the FC45 should fail to operate, check the power supply fuse. If the fuse continues to blow each time it is replaced, refer to the service and maintenance section of the manual.

BLOWN FUSE CONDITIONS		
FUSE	TYPE	CONDITIONS
DC Power	3 Amp 3 AG type	Unit will not turn on when DC operated.
50 Ohm Load Input	½ Amp 3 AG type	Unit will not measure frequencies applied to the 50 Ohm input jack.

AC FUSE:The FC45 does not require an AC fuse as the transformer uses a special internally protected primary winding.

DC FUSE:The fuse for DC operation is located in the in-line fuse holder in the 39G111 power supply leads. Disconnect the power supply leads from the DC supply before removing the fuse. The fuse holder is opened by pushing slightly against the two sections of the fuse

50 OHM INPUT

WARNING: THE MAXIMUM INPUT THE 50 OHM LOAD CAN SAFELY DISSIPATE IS 12 WATTS. HIGHER INPUT POWER WILL CAUSE THE PROTECTION FUSE (LOCATED BEHIND THE 50 OHM INPUT JACK) TO BLOW.

Note: The 50 Ohm input will not properly read frequencies below 100 KHz.

The 50 Ohm input is designed to terminate the output of a transmitter with a 12 Watt or less output to test higher power transmitters. An external high-powered dummy load should be used to terminate the transmitter output. The frequency may be picked up with the PL207 used at the output stage if the load is not equipped with a frequency counter tap-off. The same load may be used for cable termination to prevent ringing due to the characteristic impedance of the RG58 cable used in the counter probe.

To use the 50 Ohm input:

1. Connect the desired signal to the 50 Ohm input jack. See "Signal Connections" for details.
2. Depress the 50 OHM INPUT button on the front panel.
3. Select the desired READ RATE and FREQUENCY RANGE buttons as described in the following sections.
4. Read the resulting frequency on the digital readout.
5. To measure the frequency of a transmitter that supplies more than 12 Watts, see the "Using Pick-Up Loop" section under "Signal Connections"

holder and twisting the two sections in opposite directions. Replace the fuse with a 3 Amp Fast Blow 3 AG fuse only.

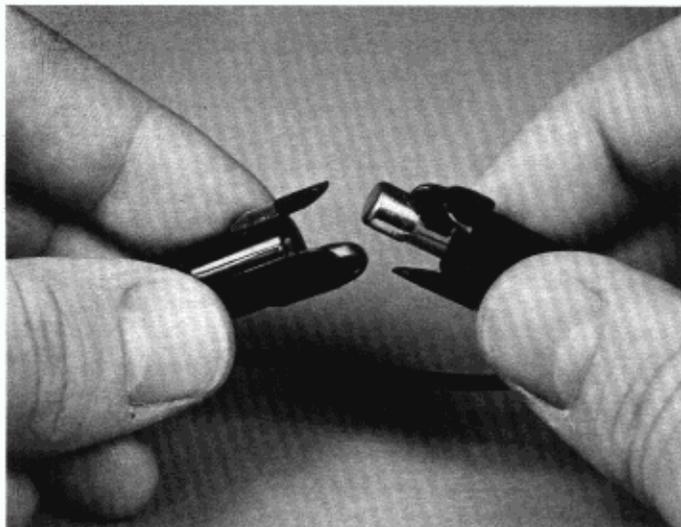


Fig. 3—Opening DC Supply Fuse Holder for Fuse Replacement.

50 OHM LOAD FUSE: The fuse for the 50 Ohm load is located behind the BNC input jack. The fuse holder may be removed by turning the BNC connector counter clockwise and unscrewing the connector until the fuse is free. The BNC connector of a set of test leads may be used as a "wrench" to aid in the removal of the fuse holder. When replacing the fuse holder, make sure the holder is screwed in tightly to prevent the connector from turning when connecting and disconnecting test leads. Replace the fuse with a .5 Amp Fast Blow 3 AG fuse only.



Fig. 4—Removing 50 Ohm Input Connector for Access to 50 Ohm Dummy Load Fuse.

SELECTING PROPER INPUT

The FC45 offers three counter inputs: A 50 Ohm dummy load, a 1 Meg high-sensitivity input, and a crystal check input. The following instructions cover each input:



Fig. 5—Selecting 50 Ohm Input.

WARNING: IF THE COUNTER FAILS TO READ, IMMEDIATELY STOP TRANSMITTING AND CHECK THE 50 OHM FUSE. IF THE TRANSMITTER IS ALLOWED TO OPERATE INTO THE OPEN LOAD, DAMAGE TO THE TRANSMITTER'S OUTPUT STAGES IS POSSIBLE.

1 MEG INPUT

WARNING: THE 1 MEG LOAD IS PROTECTED AGAINST OVERLOAD, BUT THE AMOUNT OF PROTECTION CHANGES WITH INPUT FREQUENCY. DO NOT APPLY MORE INPUT SIGNAL THAN LISTED IN THE TABLE BELOW OR POSSIBLE DAMAGE TO THE INPUT PREAMPLIFIER MAY RESULT. SUCH OVERLOAD IS NOT COVERED BY SENCORE'S 90 DAY WARRANTY OR 100% MADE RIGHT LIFETIME GUARANTEE.

OVERLOAD PROTECTION	
FREQUENCY RANGE	MAXIMUM INPUT VOLTAGE
250 VP-P	30 Hz-10 KHz
50 VP-P	10 KHz-30MHz
8 VP-P (3 V RMS)	30 MHz-230MHz

The maximum DC bias signal that may be applied is 250 Volts.

The connection to the 1 Meg input is usually made using the supplied 39G112 Counter Probe. This probe has a direct input or isolated input which is selected by means of a slide switch on the probe. For details on using this probe, refer to the "Using Supplied Probe" section under "Signal Connections".

To use the 1 Meg Input:

1. Connect the desired signal to the 1 Meg input jack. See "Signal Connections" for details.



Fig. 6—Selecting 1 Meg Input.

2. Depress the 1 MEG INPUT button on the front panel.
3. Select the desired READ RATE and FREQUENCY RANGE buttons as described in the following sections.
4. Read the resulting frequency on the Digital Readout.

CRYSTAL CHECK

The CRYSTAL CHECK function allows any crystal with a fundamental frequency of 1-20 MHz to be inserted into the front panel, universal crystal socket to check for crystal activity. The crystal will be made to resonate at its fundamental operating frequency.

Note: Most crystals used in communications equipment are designed to operate on an overtone rather than their fundamental frequency. For example, an oscillator operating at 27.000 MHz will use a third overtone crystal with a fundamental frequency of 9.000 MHz. In practice there are few if any crystals with a fundamental frequency of over 20 MHz. The exact operating frequency of the crystal depends on the circuit of which it is part. Measurement of the exact operating frequency of the crystal is only possible by measuring the output of the circuit in which it is operating.

To perform the external CRYSTAL CHECK:

1. Insert the crystal to be tested into the front panel socket marked CRYSTAL CHECK.
2. Select either the .1S or 1S READ RATE button.
NOTE: Either of the FREQUENCY RANGE buttons may be depressed without changing the results of the test.
3. Depress the CRYSTAL CHECK button.
4. Read the fundamental crystal frequency on the digital readout.

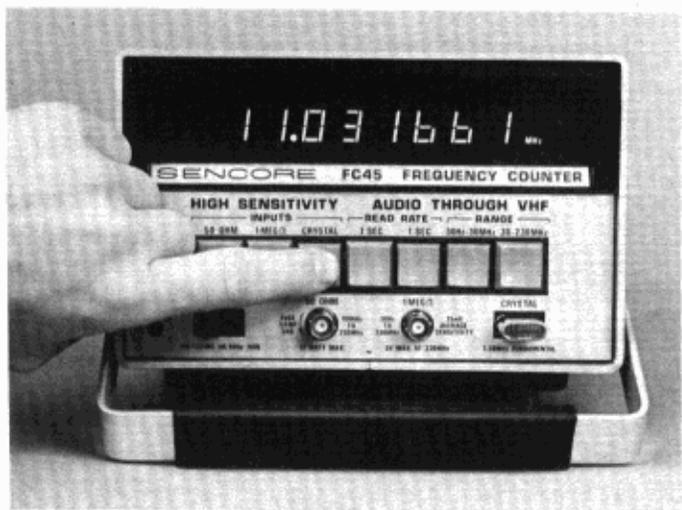


Fig. 7—Using Crystal Check Function.

Defective or inoperative crystals will be indicated by an intermittent or zero readout.

SELECTING FREQUENCY RANGE

The FC45 offers two frequency ranges plus the option of a UHF Prescaler for a total of three ranges. For optimum resolution and reliable counting, the ranges should be used as marked on the FC45 front panel. It should be noted that there is an overlap between each range which is not noted on the front panel. For example the 30 Hz-30 MHz range is usually usable to at least 35 MHz, and the 30 MHz-230 MHz range is usable as low as 10 MHz.

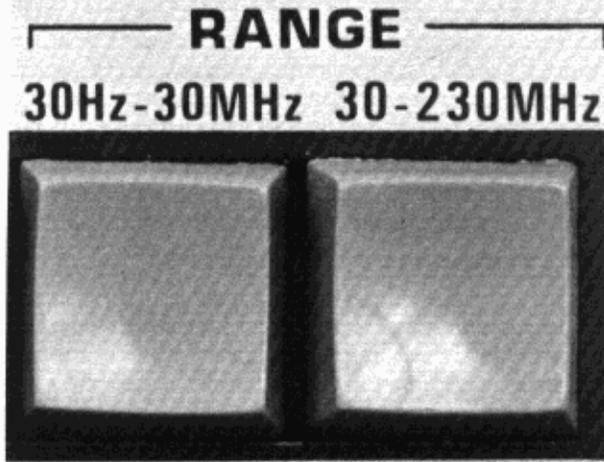


Fig. 8—Selection of Frequency Range Buttons is made to Agree with Frequency of Input Signal.

The use of the optional PR47 UHF Prescaler extends the range to 600 MHz. The PR47 divides the input frequency by ten before feeding it to the FC45. Details on the use of the PR47 are included in a later section of this manual.

Refer to Table I for the range of frequencies each of the options offer.

INPUT	RANGE SELECTED	TYPICAL FREQUENCY
DIRECT	30 Hz-30 MHz	10 Hz-35 MHz
	30 MHz-230 MHz	10 MHz-230 MHz
THROUGH PR47 PRESCALER	30 Hz-30 MHz	1 MHz-350 MHz
	30 MHz-230 MHz	100 MHz-600 MHz

SELECTING READ RATE

The FC45 allows the choice of two different read rates. When used without the PR47 UHF Prescaler, this gives four different choices of resolution. When used with the PR47, this is expanded to eight different resolution options.

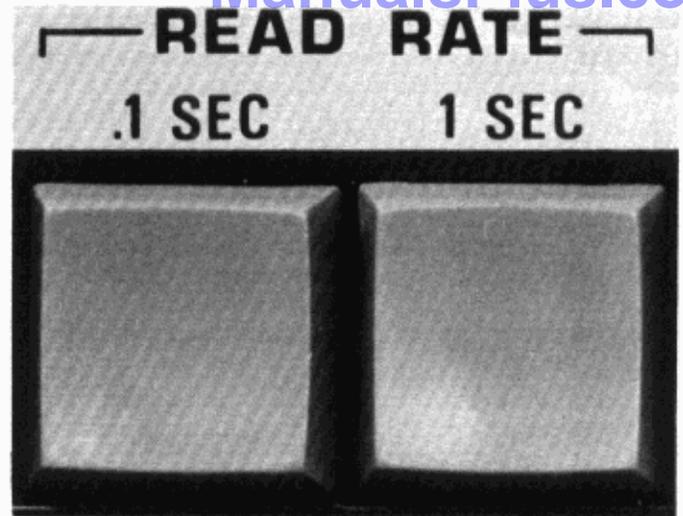


Fig. 9—Selection of Read Rate Button is Determined by need for Fast Update, or Extra Resolution.

In general, the .1 Second READ RATE button is used when a fast update time is desired. The use of the .1 Second READ RATE, however, results in one less digit of resolution for each frequency range compared to the 1 Second READ RATE. The .1 Second read rate will also show a more rapid change in the reading if the tested signal is changing in frequency. An example of such a changing frequency is one provided by an LC tank (non-crystal) oscillator circuit.

The 1 Second READ RATE offers an extra digit of resolution. Since the input frequency is counted for a longer period of time, frequency changes (such as in the LC tank mentioned above) will be averaged which often provides a more stable count. This frequency averaging often makes the 1 Second READ RATE easier to use.

Table II lists the eight resolution options available with the use of the PR47 UHF Prescaler.

Range Selected	30 Hz-30 MHz		30 MHz-230 MHz	
	1 Sec.	.1 Sec	1 Sec	.1 Sec
Direct	1 Hz	10 Hz	10 Hz	100 Hz
Through PR47	10 Hz	100 Hz	100 Hz	1 KHz

USING THE PR47 UHF PRESCALER (OPTIONAL)

The optional PR47 UHF Prescaler extends the counting range of the FC45 to 600 MHz. The PR47 divides the incoming frequency by a factor of ten before being applied to the FC45 input. To compensate for this division, the decimal point of the digital readout must be mentally shifted one position to the right to determine the input frequency.

The PR47 is equipped with an inductive pick-up loop (Sencore PL207) to allow frequency measurements without the need of a direct connection to the circuit. The PL207 Pick-up Loop minimizes the chance that the test lead will change the operating frequency of the circuit under test. See the Signal Connections section for details.

The input impedance of the PR47 is 50 Ohms to prevent the possibility of reflected waves on the counter cable. Such reflected waves could cause the PR47 to give erroneous readings.

The PR47 is powered from the 9 Volt output jack at the front of the FC45.

WARNING: THE INPUT TERMINATION OF THE PR47 IS RATED AT 1 WATT TO 400 MHz, AND DERATED TO .25 WATTS AT 600 MHz. (SEE PR47 INSTRUCTION MANUAL FOR DETAILS) TO PREVENT POSSIBLE DAMAGE TO THE PR47 INPUT STAGE, ALWAYS USE THE PL207 PICK-UP LOOP (RATHER THAN A DIRECT CONNECTION) TO MEASURE HIGH LEVEL SIGNALS OR TRANSMITTER OUTPUT SIGNALS.

To use the PR47 UHF Prescaler:

1. Connect the power connector plug on the power supply lead supplied with the PR47 to the 9 Volt input jack on the PR47.
2. Connect the pin plug on the opposite end of the power supply lead to the 9 Volt output jack on the FC45 front panel.

NOTE: The negative supply connection is made through the shield of the RF output cable.

3. Connect the output lead of the PR47 to the 1 MEG INPUT jack of the FC45.
4. Depress the 1 MEG INPUT button on the FC45.
5. Select the desired READ RATE and FREQUENCY RANGE buttons on the FC45.
6. Connect the PL207 Pick-Up Loop supplied with the PR47 to the PR47 input jack.
7. Use the PL207 Pick-Up Loop to pick up the signals to be measured.

See "Signal Connections" for details.

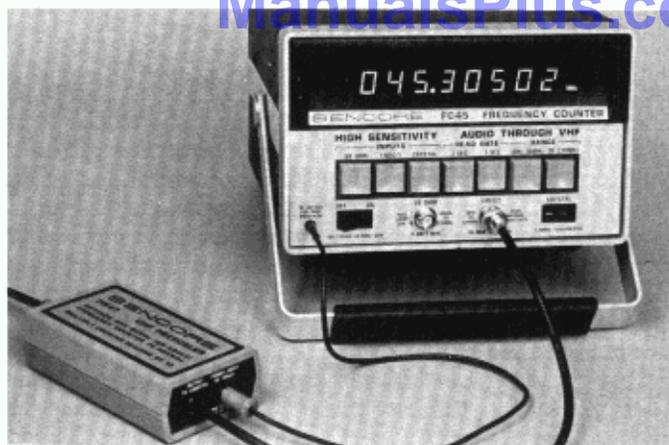


Fig. 10—9-Volt Output Supplies Power Requirements of PR47 UHF Prescaler. Power Supply Common Connection is Provided Through Shield of PR47 Output Lead.

SIGNAL CONNECTIONS

Several methods may be used for measuring frequencies with the FC45. In many cases a direct connection to the circuit under test is desired. The Frequency Counter Probe supplied with the FC45 allows a direct or capacitively isolated connection. Other testing techniques require indirect or "loose" coupling to prevent the counter's input circuits from disturbing the circuit being measured. The optional PL207 inductive pick-up loop (supplied with the PR47 UHF Prescaler or directly from the Sencore Parts Department, 3200 Sencore Drive, Sioux Falls, SD 57107 for \$9.95) allows this pickup without a direct connection.

Transmitter output frequencies to 12 Watts may be measured using the 50 Ohm dummy load. Adapter cables for connection to the dummy load may be built by the user or purchased from Sencore. Special applications may require the use of a 10:1 scope probe or filtering circuits. Each of these applications are discussed here.

USING THE SUPPLIED COUNTER PROBE

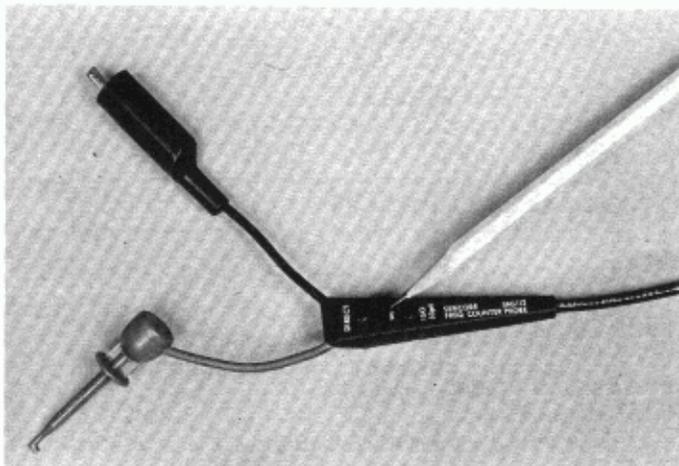


Fig. 11—Supplied 39G112 Counter Probe is Equipped with a Switch to Select Direct or Isolated Connections.

The 39G112 Frequency Counter Probe supplied with the FC45 allows a direct input or a capacitively isolated input. The choice of these two inputs is made with a miniature slide switch built into the probe. The Frequency Counter Probe may be used with the 1 MEG INPUT or the 50 OHM INPUT.

The following are guidelines as to when to use each option available with the 39G112 Frequency Counter Probe:

1 MEG INPUT, DIRECT CONNECTION

Generally this connection is used for measuring most frequencies. The 1 Megohm loading of the FC45 input will not effect most circuits isolated from an oscillator by at least one amplifier (buffer) stage. This connection offers the highest counter sensitivity for measuring low-level signals. At frequencies above 10 MHz, the positioning of the ground connection may effect the stability of the reading. If an unstable reading is obtained at these higher frequencies, it can generally be made more stable by moving the ground connections as close as possible to the test point being measured.

1 MEG INPUT, ISOLATED CONNECTION

The isolated switch position of the 39G112 Counter probe inserts a 33 pF isolation capacitor in series with the test lead. This series capacitance reduces the capacitance formed by the cable running from the counter probe to the counter input. This isolation allows connecting the probe to many oscillators that become inoperative when a direct connection is made. As with the direct connection, the position of the ground connection may effect the stability of higher frequency measurements.

50 OHM INPUT, DIRECT CONNECTION

The 50 OHM INPUT may be used for two different applications. First, the 50 OHM DUMMY LOAD may be used to terminate the output of a transmitter. The 50 OHM LOAD will terminate the output of a transmitter (with a 12 Watt or less output) to prevent possible damage to the transmitter's output stages.

Direct transmitter connections may be made using the optional 39G104 RF cable which provides a BNC connector at one end, and a PL259 UHF connector on the other. The 39G104 cable is available from the Sencore Parts Department, 3200 Sencore Drive, Sioux Falls, SD 57107 for \$7.50.

The 50 OHM LOAD also prevents reflected signals on the 50 Ohm cable of the counter probe. This termination is especially important when measuring signals with fast transitions such as square waves or logic pulses from some digital circuits. The 50 Ohm termination prevents cable ringing which may occur due to the fast rise-time of these signals.

NOTE: The 50 Ohm input may load the output of some logic ICs. See "Special Digital Applications" for techniques that prevents this circuit loading.

50 OHM INPUT, ISOLATED CONNECTION

When operating in logic circuits, the 50 Ohm impedance of the dummy load may cause DC circuit loading. This loading can be minimized by inserting a DC blocking capacitor in series with the 50 Ohm load. The "Isolation" position of the selector switch on the counter cable inserts a 33 pF capacitor in series with the load to prevent DC loading.

10:1 RESISTIVE ISOLATION

The input impedance of the 1 Meg input may be increased to 10 Megohms with the use of a standard 10:1 scope probe such as the Sencore 39G80 (\$20 from the Sencore Parts Department, 3200 Sencore Drive, Sioux Falls, SD 57107). A scope probe is generally usable to 30-50 MHz. The increased impedance reduces circuit loading more than the 1 Meg input. The use of the 10:1 probe also reduces the input signal to the FC45 by one-tenth. This offers two advantages:

First, the reduced signal level allows measurement of larger signal levels. The high (5 KVAC) breakdown rating of the 39G80 probe means that signals to 2500 VAC (ten times the protection value of the 1 Meg input) may be measured to 10 KHz, 500 VAC to 30 MHz, or 80 VAC above 30 MHz.

Secondly, the reduced signal level allows some "noisy" signals (such as digital signals with noise spikes) or signals with AC ripple to be measured without causing "false counts" on the FC45. The 10:1 attenuation action of the 39G80 reduces the amplitude of the noise pulses below the sensitivity level of the FC45 allowing just the fundamental signal to be counted.

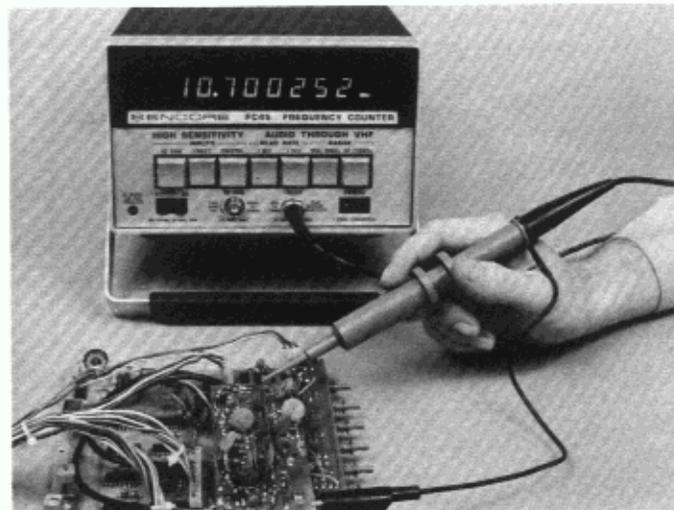


Fig. 12—Sencore 39G80 10:1 Lo-Cap Probe Provides Increased Input Impedance to Minimize Circuit Loading and Reduce Amplitude of Signal Being Fed to 1 Meg Input by Ten Times.

PL207 RF PICK-UP LOOP (OPTIONAL)

There are many times when a direct counter connection is not desired. Many oscillators used in communications equipment cannot be measured with a probe connected—even with the isolation capacitor in circuit. The probe's capacitance may cause the frequency of the oscillator to change, or cause the oscillator to stop running, as the lead capacitance is placed in parallel with the oscillator circuit.

High-powered transmitters may have voltages exceeding the protection rating of the 1 Meg input, or may provide more than 12 Watts, thus eliminating the use of the 50 Ohm dummy load.

In these applications, an inductive pick-up loop may be used to "sniff" the frequency without a direct connection. The PL207 is supplied with the optional PR47 UHF Prescaler, or available from the Sencore Parts Department, 3200 Sencore Drive, Sioux Falls, SD 57107 for \$9.95.

To use the PL207 Pick-Up Loop:

1. Connect the PL207 to the 1 Meg input of the FC45.
2. Select the 1 MEG INPUT button and the desired READ RATE and FREQUENCY RANGE buttons.
3. Place the pick-up loop near a capacitor or coil in the circuit to be tested. If an unstable count is obtained, re-position the pick-up loop as necessary to stabilize the count. If no count is obtained, turn the pick-up loop over (which reverses the polarity of the pick-up loop's coil) or select a different component in the circuit.
4. The pick-up loop will work best when placed next to or around a coil. However, the high sensitivity of the FC45 will also allow signal pickup from capacitors, transistors, or crystals in most circuits.

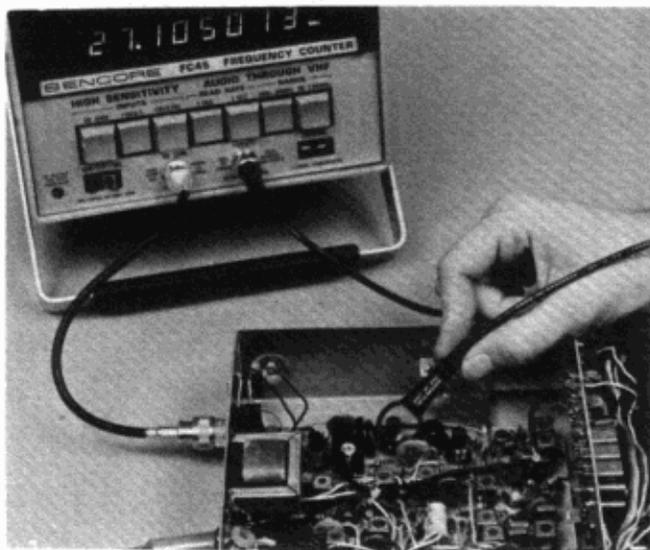


Fig. 13—Optional PL207 RF Pick-Up Loop Allows Frequency Pickup without Direct Connection to Circuit Under Test. Note that the 50 Ohm Load is Terminating the Transmitter Output, while the Frequency is Read at the 1 Megohm Input.

The pick-up loop may be used to trace a signal through various stages of a circuit by placing the coil near each stage. Generally, it is best to start with the signal source (oscillator) and work towards the output stages when signal tracing.

SPECIAL DIGITAL APPLICATIONS USING THE NE206 NOISE ELIMINATOR (OPTIONAL)

Digital signals can present special problems in use of any frequency counter. The signals are usually square waves with fast rise-times, or pulses with short durations (duty cycles). These signals can cause cable ringing which can lead to false frequency readings such as "double counting" where the counter reads twice the desired frequency.

At other times, a digital counting (dividing) stage may allow a small amount of the input signal to pass through to the output. If the amplitude of this input signal is high enough, the high sensitivity of the FC45 may count it along with the desired output frequency.

The use of the optional NE206 Noise Eliminator will allow these special signals to be counted. The NE206 has two circuits -- a low-pass filter and a selectable attenuator. The use of the three-position attenuator switch eliminates the need of calculating damping resistor values as is required with other frequency counters.

NOTE: The NE206 is designed for measuring fundamental frequencies under 10 MHz.

To use the NE206 for counting "noisy" signals:

1. Connect the output cable of the NE206 to the 1 MEG INPUT.
2. Connect the 39G112 Counter Probe to the input of the NE206.
3. Select the 1 MEG INPUT button and the desired READ RATE and FREQUENCY RANGE buttons.



Fig. 14—Optional NE206 Noise Eliminator Provides Both Filtering and Attenuation of Noisy Signals Often Found in Digital and Audio Applications.

4. Generally, start with the attenuator switch in the MIN. position. The low-pass filter of the NE206 will often provide enough attenuation of the undesired signals to give a stable count.
5. If the count is unstable, or reads a multiple (such as twice) the expected frequency, increase the amount of attenuation by switching the attenuator to the MED. or MAX. position.
6. Leave the attenuator switch in the position giving the most stable count.

COUNTING "NOISY" AUDIO SIGNALS

Occasionally, audio signals may contain other frequencies than the fundamental audio frequency. An example is the output of a stereo FM receiver. The audio signal may contain some of the 19 KHz pilot signal or 38 KHz subcarrier signal in addition to the audio frequency being measured. The FC45 may trigger on (count) these super-audible signals along with the desired audio frequency. Two methods are available to eliminate this type of extraneous signal.

1. The use of a 10:1 scope probe (described previously) may be used to reduce the amplitude of the extraneous signal to a point that will not give a false count.
2. The NE206 (also described previously) may be used to attenuate the unwanted signal.

APPLICATIONS

SPECIAL FREQUENCY COUNTER APPLICATIONS

For most frequency counter applications, the technician merely connects the test leads to the frequency source, selects the proper input, frequency range and read rate buttons, and reads the frequency on the digital readout. In addition, the high sensitivity of the FC45 allows low-level signals to be measured in circuit.

Any high sensitivity frequency counter such as the FC45 may give erratic counts with some signal waveforms. There are three common types of signals that will produce these erratic readings: modulated signals, signals with superimposed noise information, and pulse signals, such as found in some digital circuitry. This section will explain the cause of the erratic readings or "false counts" and the proper methods of eliminating the causes of the improper readings. The NE206 Noise Eliminator accessory is designed to eliminate most causes of counting errors.

MODULATED WAVEFORMS

Modulation should be removed from transmitter signals before they are counted. Two types of counting errors may result if a modulated signal is connected to the FC45 input. The first is due to the varying signal levels of an AM signal, and the second is due to the changing frequency of an FM signal.

The signal level of an AM signal is constantly varying. During periods of high modulation, a portion of the signal falls very close to zero. The FC45 will count the portion of the signal that is larger than the sensitivity rating of the input circuitry, but will fail to count those portions of the signal that are lower in amplitude than the counter sensitivity. The result may be an erratic count. Always use an unmodulated signal when measuring the frequency of an AM transmitter to prevent erratic counting.

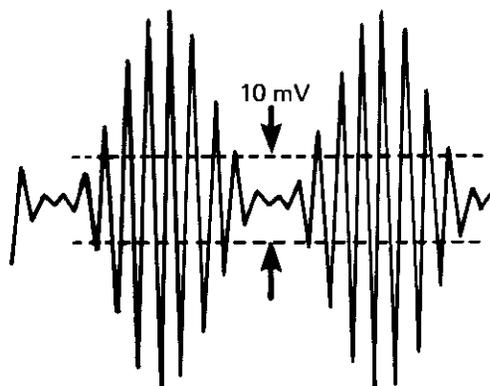


Fig. 15—The Amplitude of an AM Modulated Signal May Drop Below the Sensitivity Point of the FC45, Causing Part of the Signal to Be Missing by the Counting Stages.

The cause of erratic counting of an FM signal is that the frequency of the signal is constantly changing. The waveform shown in Fig. 16 shows an example of the change in frequency between two counting periods. Such a signal may produce an erratic count since the number of cycles counted during one counter update will be different than the next counter update. Thus, always use an unmodulated signal when measuring the frequency of an FM transmitter to prevent erratic counting.

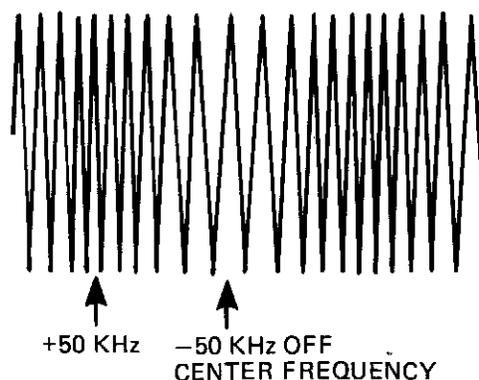


Fig. 16—The Frequency of an FM Modulated Signal is Constantly Changing, Causing Erratic Counting Due to the Averaging of Different Frequencies.

COUNTING "NOISY" SIGNALS

Signals with noise may produce an erratic count. The four most common types of noise are: (1) a signal with crossover distortion or transition noise, (2) a signal with a second frequency (such as ripple) superimposed on the desired frequency, (3) the output of a digital counting stage with a portion of the input signal superimposed on the desired signal, and (4) a fast rise-time pulse which produces ringing on the counter cable.

Proper counting of all four of these special signal conditions is possible with the optional NE206 Noise Eliminator. The NE206 is designed for fundamental frequencies below 10 MHz. The NE206 includes a low-pass filter circuit which reduces the amount of high-frequency noise, and a three-step attenuator to reduce the amount of noise information which the filter may not remove. To better understand the applications of the NE206, we will examine the causes of the erratic counting for each typical noisy signal we have listed.

CROSSOVER DISTORTION

Fig. 17 shows a typical signal with crossover distortion present. This figure shows two types of distortion: a positive and a negative "glitch."

Two types of erratic counting may occur, depending on the amplitude of the "glitch." First, if the amplitude is well over the sensitivity of the counter, the display will show a frequency that is twice that of the signal. This is known as double counting. The FC45 will count both the desired frequency and the transitions caused by the distortion.

Secondly, if the amplitude of the distortion is lower than the sensitivity of the counter, the false counts may not occur on every cycle. Since the counter is only adding the crossover distortion on a few of the cycles of the desired frequency, the result will be an erratic count.

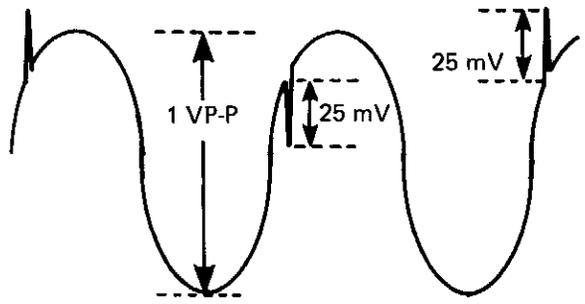


Fig. 17—A Sinusoidal Waveform with Two Types of Crossover Distortion Which May Cause False Counting.

Both types of counting errors are eliminated with the NE206. The attenuation action of the NE206 reduces both the amplitude of the desired signal and the distortion signal. If the amplitude of both signals are reduced by 20 dB, (as shown in Fig. 18) the desired signal will still be of sufficient amplitude to trigger the counter, but the amount of noise information will be reduced below the counter's sensitivity. The result is an elimination of the erratic or improper counting.

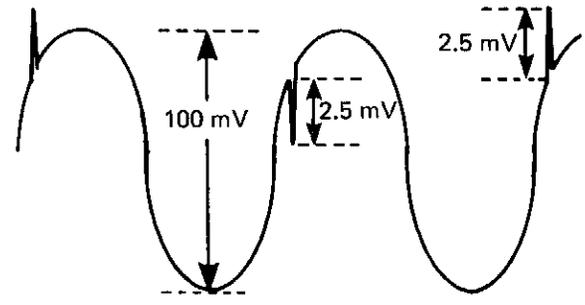


Fig. 18—The Attenuation Action of 10:1 Scope Probe or Noise Eliminator reduces the Amplitude of the Crossover Points Below the FC45 Sensitivity.

SIGNALS WITH RIPPLE

Fig. 19 shows a signal with another signal superimposed. This signal is typical of the outputs of many FM stereo receivers, as well as many types of signal generator signals. The high-frequency ripple is produced by multiplexing or synthesizing.

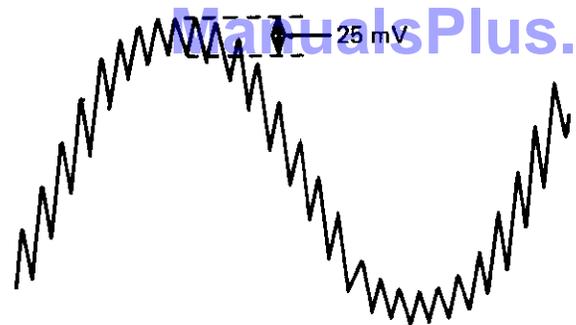


Fig. 19—An Audio Signal with a Super-Audible Signal from the FM Multiplexing Superimposed.

If the amplitude of the ripple information is sufficiently high, the counter may trigger on it rather than the desired low-frequency signal. The result is a counter reading many times that which is expected.

The NE206 is used to reduce the signal levels to a point that allows the fundamental signal to be counted, but with the ripple level reduced below the sensitivity point of the FC45.

DIGITAL NOISE

Fig. 20 shows a typical output of a TTL "divided by 10" stage. The output signal is a 4 Volt P-P square wave, which is one-tenth the frequency of the input signal. In many cases, however, a portion of the original input signal is present as ripple information superimposed on the output signal. The result is that the FC45 will show the input frequency rather than the desired output frequency.

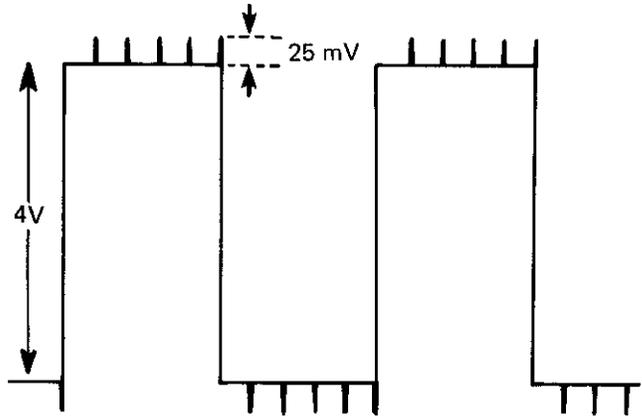


Fig. 20—The Output of a Digital Divide-By-Ten Stage with a Small Amount of Input Signal Superimposed.

The NE206 is used to reduce the signal levels to a point that allows the output signal to be counted, but with the amplitude of the input frequency reduced below the sensitivity point of the FC45.

PULSE RINGING

Fig. 21 shows the signal present at the FC45 input when a short-duration, fast rise-time pulse is fed to the 1 Meg input through a coaxial cable. The ringing is a result of an impedance mismatch between the counter cable and the 1 Meg input. The resulting

PRIMARY FREQUENCY STANDARDS

reflected waves pass down the cable towards the signal source where they are again reflected towards the counter, until the resistance of the cable damps the ringing signal.

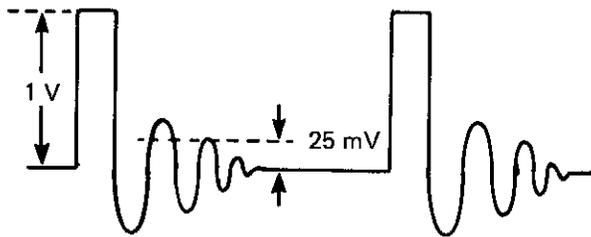


Fig. 21—Pulse Waveform Causing Ringing on Cable Due to Impedance Mismatch.

The FC45 internal 10 MHz reference oscillator provides a high degree of counting accuracy to within 1 ppm. However, some applications (such as FCC broadcast frequency monitoring, production line calibrations, etc.) may require that the measurements be directly traceable to a National Bureau of Standards reference.

The FC45 will serve as a primary frequency monitoring standard when used with an external reference drive, such as provided by a receiver tuned to WWV at 10 MHz. Instructions for modifying the FC45 for this purpose are found on Page 23 of this manual.

Fig. 22 shows the resulting output signal after passing through the NE206. First, the low-pass filter circuit results in a reduction of the rise-time of the signal which reduces the tendency for the cable to ring.

Secondly, the attenuator section of the NE206 allows any ringing pulses to be reduced in amplitude to a point where the FC45 will no longer count. The NE206 allows such pulse signals to be counted without the need of calculating the value of a series damping resistor, as with most other frequency counters. It is even possible to count signals with duty cycles as small as 1000:1, which is not practical with most other frequency counting methods.

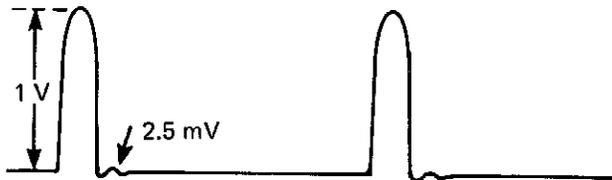


Fig. 22—Effects of Low-Pass Filter in NE206 to Filter the High Frequency Components of Ringing Waveform.

CIRCUIT DESCRIPTION

THEORY OF OPERATION

To understand the operation of the FC45, refer to the block diagram and the enclosed schematic diagram. The schematic uses Sencore's "Circuit Trace" color coding to aid in tracing power supply, key signal, and control paths.

INPUT CIRCUITS

The 1 Meg input is fed to the buffer comprised of TR114 and 115 and then to a combination preamp/Schmitt Trigger in IC113. The Schmitt Trigger reduces the false counting which may be caused by some noisy signals.

The output of IC113 is fed to one input of IC112 which is used as an electronic switch which selects between the 1 Meg and the 50 Ohm input. IC112 is a high-speed ECL device which will allow the full frequency band to be switched. It also provides input gating and is controlled by the ENABLE signal from the Sequencer.

The output of the 50 Ohm Load is fed directly to the second input of IC112.

The Crystal Check function uses TR111 as an oscillator, with TR112 as its buffer. TR113 is a gating

switch controlled by the ENABLE signal from the Sequencer.

The output of the Electronic Switch (IC112) is fed to the switches and a decade divider (IC110) which acts as a 10:1 prescaler. The output of IC110 is also fed to the switches. The switches now feed the output of the Electronic Switch, the decade divider, or the Crystal Check to the counter chain.

COUNTER CHAIN

The output of the switches (Sections A, B, C, F, and G) is fed to the input of the first eight stages of decade counting (IC117). The first two decade counters (IC116 and 117) are TTL logic for higher speed counting. The remaining counting is done in the two CMOS triple decade counters IC104 and 105. Since the first two stages are discrete decade counters, they have separate latches (IC114 and 115) and decoder/drivers (IC403 and 404) and are not multiplexed. IC104 and 105 have internal latches and multiplex circuits, and therefore require only one decoder/driver each (IC401 and 402).

The output of IC105 is used to feed both the next counter stage and the Auto-Decimal circuit. If an overflow is present, the MHz light will turn on, and the decimal point inserted when the low Frequency Range and 1 Hz Read Rate are selected. In any

FUNCTIONAL BLOCK DIAGRAM

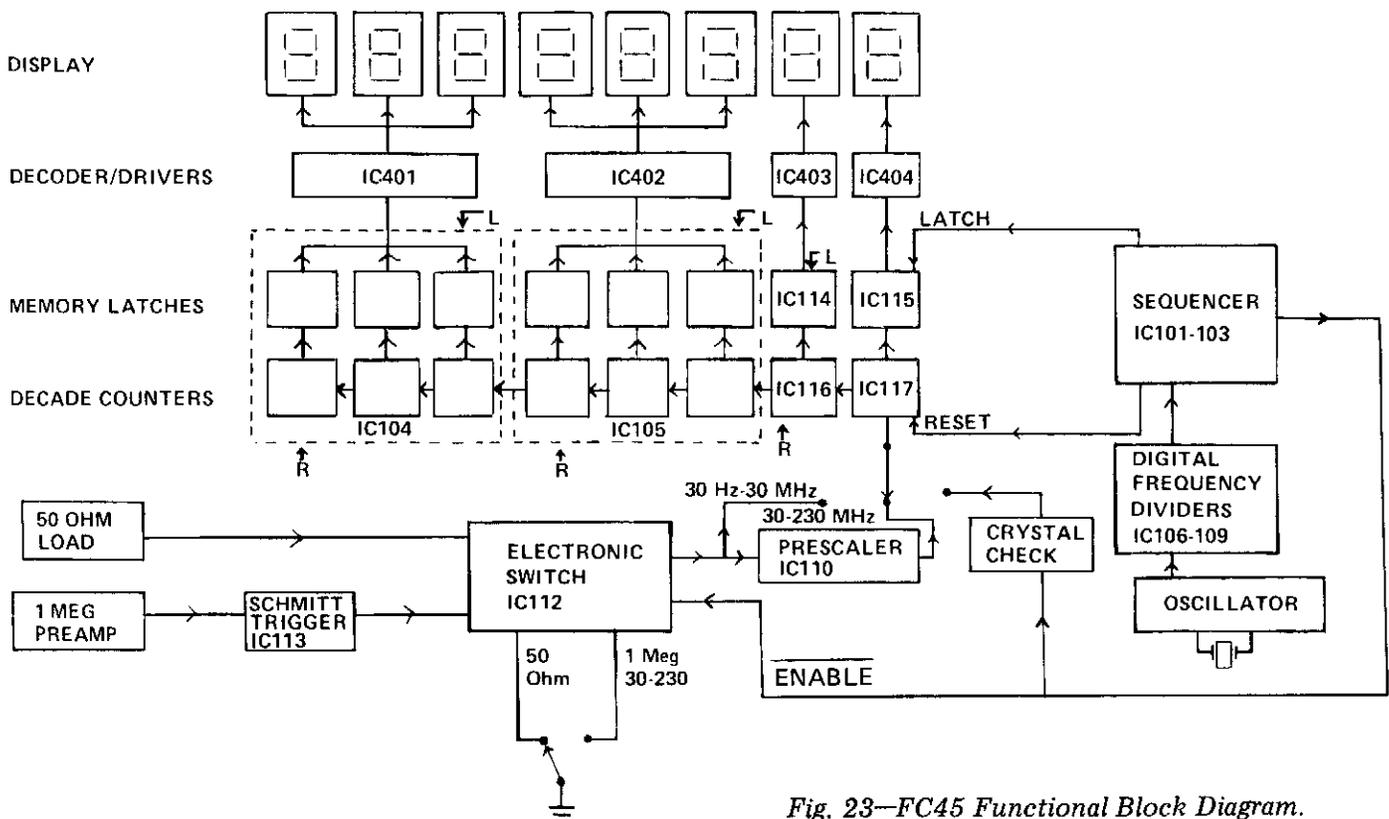


Fig. 23—FC45 Functional Block Diagram.

other switch combination, the decimal is placed by the switches.

SEQUENCER

Three control signals are necessary for the operation of the counter chain: (1) An ENABLE signal to allow the input signal to be counted for a very precise period, (2) A LATCH signal to cause the count at the end of the enable segment to be stored in memory, and (3) A RESET pulse to zero the decade counters after the information has been stored in the memory latches.

A simplified schematic of the Sequencer is shown in Fig. 24. All pulses are derived from the single 10 MHz clock. The timing diagram for the outputs shows the relationships of the various signals.

The choice of the 1 Second or .1 Second ENABLE signal is made by the front-panel switches. The Sequencer Delay control compensates for the delays in the extra divide by 10 stage needed for the 1 Second period.

The $\overline{\text{ENABLE}}$ (DISABLE) signal is fed to the electronic switch and the crystal check circuits to halt the input signals while the LATCH and RESET signals are present.

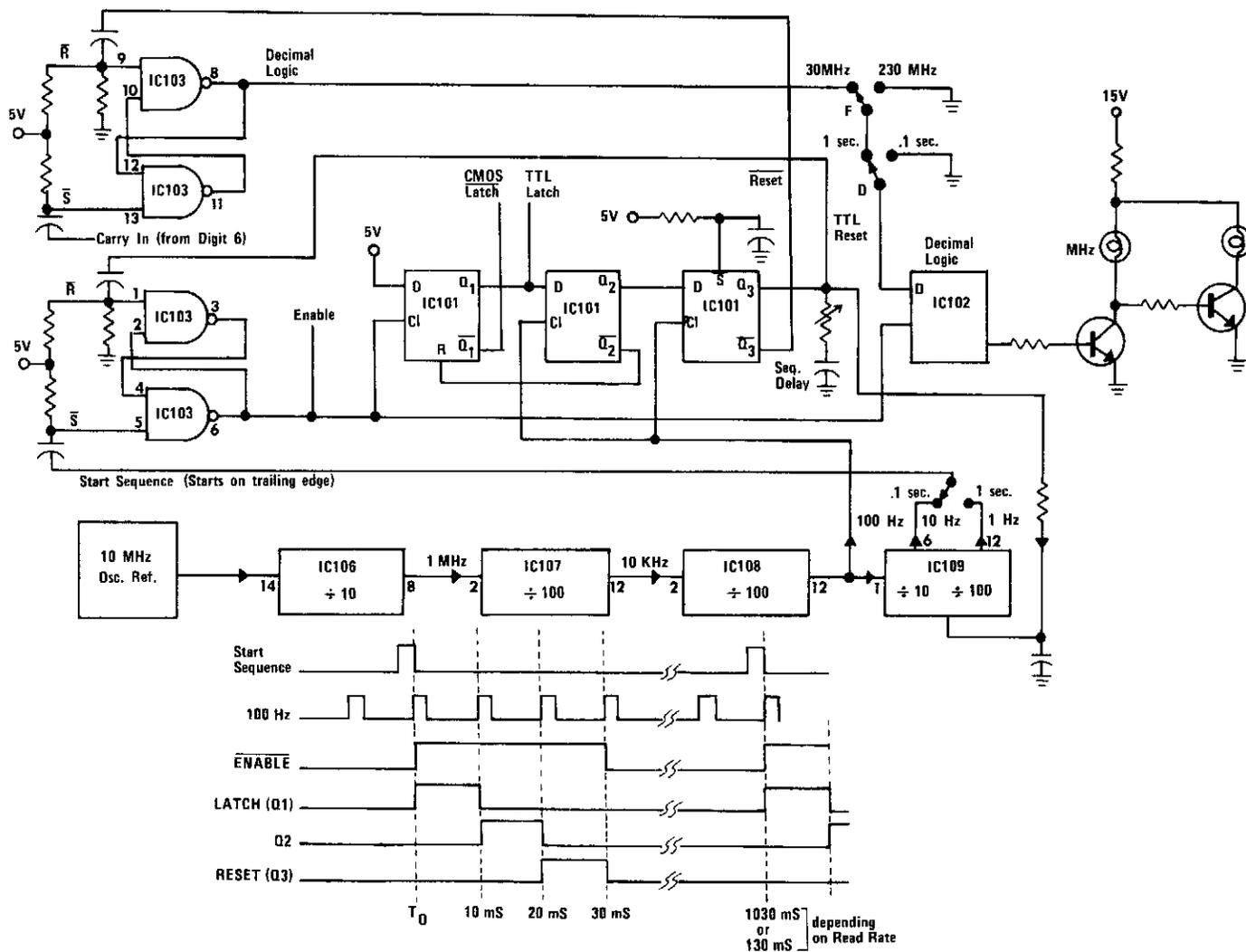


Fig. 24—Simplified Sequencer Circuit Diagram.

WARNING

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

INTRODUCTION

This Maintenance and Service Section will help you maintain your FC45 within the published specifications and assure years of useful application.

This section covers general maintenance and complete recalibration instructions. The schematic and parts list as well as board legends are included on separate sheets. The schematic uses Sencore's "Circuit Trace" color coding to aid in circuit tracing if service ever becomes necessary.

Complete warranty information is included in the Quality Assurance Tag attached to the FC45. The QA Tag also includes general warnings applying to your FC45 and information on factory service. If you should ever find it necessary to return your FC45 for service, enclose the QA tag with the final tester's signature.

VERIFYING COUNTER ACCURACY

The accuracy of the FC45 may be verified at any time by injecting a signal of known frequency with at least a .1 ppm (.0001%) accuracy. To obtain a full accuracy check, the frequency must be at least 10 MHz.

If such a signal is not available, the color subcarrier of a television station will allow a check to within .28 ppm (.00028%) providing the local television station's signal is locked (GEN-LOCKED) to an incoming network signal. A phone call to the local station will determine if the broadcast signal is locked to network sync.

To verify the FC45 accuracy:

1. Remove the cabinet of a color TV receiver.
WARNING: TV receivers contain possibly lethal voltages at certain areas--especially around the high voltage section, boost and focus voltage sections and horizontal output stages. Use extreme caution in making connections to avoid dangerous shocks to yourself or damage to the FC45.
2. Locate the output of the receiver's burst oscillator. Make sure this test point is isolated by at least one amplifier stage from the 3.58 MHz oscillator to prevent the FC45 test leads from pulling the oscilla-

tor off-frequency. The PL207 Pick-Up Loop may be used to prevent circuit loading.

3. Tune in a local station whose signal is locked to a network color program.
4. Fine-tune the receiver for a proper color display on the TV picture tube.
5. Connect the 1 Meg input of the FC45 to the 3.58 MHz test point.
6. Verify the receiver is still properly locked after the connection is made.
7. Select the 1 Hz Read Rate, and the 30 Hz-230 MHz Frequency Range.
8. Read the burst oscillator's frequency.

The proper frequency of the burst oscillator is 3.579545 MHz. A 1 ppm tolerance (.0001%) allows ± 5 counts from this frequency. If the reading is outside this range (3.579540-3.579550) the timebase of the FC45 should be recalibrated.

ACCESS/DISASSEMBLY

Access to the interior of the FC45 for recalibration or service may be obtained using the following procedure:

1. Remove the four screws (two on each side) holding the top cover in place.
2. Lift the top cover free from the remainder of the unit.
NOTE: Access is now available to all recalibration controls.
3. Remove the four screws (two on each side) that hold the bottom cover in place.
4. Lift the bottom cover free from the remainder of the unit.
5. To remove the 50 Ohm Dummy Load:
 - a. Remove the two mounting screws accessible from the top side of the P. C. Board.
 - b. Slide the 50 Ohm assembly away from the front panel.
 - c. Disconnect the output cable from the rear of the 50 Ohm assembly.
 - d. The 50 Ohm Load assembly is now completely free from the rest of the unit.

For re-assembly, simply reverse the above procedure.

EQUIPMENT REQUIREMENTS FOR CALIBRATION	
Equipment	Minimum Specification
Fixed Signal Source	10 MHz-230 MHz, .1 ppm accuracy.
Adjustable Signal Source	Adjustable frequency from 190 to 250 MHz with adjustable amplitude of 5 to 25 mV RMS.
3½ digit meter	.1%, capable of reading 1.999 VDC.

ENVIRONMENTAL CONDITION

Temperature	22°-25° (72°-77° F)
Humidity	50-70%

RECALIBRATION PROCEDURES

The FC45 should be checked at regular intervals (six months recommended) to verify performance within published specifications. If the FC45 is found to be outside of specifications, the Sencore Service Departments (addresses located on inside back cover) provide complete recalibration facilities using NBS traceable standards for a nominal recalibration charge.

If the proper standards are available for recalibration, the following procedure may be used to restore the FC45 to its rated accuracy.

CRYSTAL OVEN

Turn the FC45 off for a period of at least 1 hour to allow the crystal oven to reach room temperature. Do not turn the power on until the temperature control has been disabled.

To set the temperature control:

1. Disable the oven heater by shorting the end of R118 closest to the rear of the P.C. board to ground.
2. Turn the FC45 on.
3. Connect the common lead of a .1% accuracy DVM to the chassis of the FC45.
4. Measure the voltage across the two sensor diodes inside the crystal oven by connecting the probe of the meter to the lead of R117 farthest from the rear of the P.C. board.
5. Subtract 100 mV from the reading obtained in Step 3.
6. Move the meter probe from the test point in Step 3 to the wiper of the Oven Temperature Control, R114.
7. Adjust the control for the voltage determined in Step 4 (100 mV less than the voltage drop of the reference diodes).

8. Disconnect the jumper from R118 to ground.

The adjustment of the heater control is now complete. If it is desired to monitor the temperature of the crystal, a sensor may be placed at the surface of the crystal. The temperature of the crystal oven should be allowed to stabilize for two hours. The nominal temperature of the surface of the crystal case is 55° C.

10 MHz OSCILLATOR FREQUENCY

1. After performing the crystal oven calibration adjustments, allow the FC45 to operate for 45 minutes to allow the oven to stabilize.
2. Feed a signal with a frequency accuracy of at least .1 ppm and with a frequency of at least 10 MHz to the input.
3. Set the front-panel controls to display 8 full digits of resolution. EXAMPLE: Using a 10 MHz signal, the Frequency Range buttons should have the low range selected, and the Read Rate buttons should be set for a 1 Sec. update.
4. Set the Crystal Trimmer (C143) for the exact reading of the frequency standard.
5. Switch to a .1 Sec. Read Rate.
6. Set the Sequencer Delay control (R102) for the exact reading of the frequency standard.
7. Repeat Steps 3-6 until both Read Rates give the proper frequency reading.

HIGH FREQUENCY SENSITIVITY

1. Connect an adjustable frequency generator with a frequency of at least 100 MHz and a signal level of 25 mV to the 1 Meg input.
2. Select the .1 Sec. Read Rate, and the 30-230 MHz Frequency Range button.
3. Gradually increase the frequency of the generator until the readout becomes unstable.
4. Adjust High Frequency Sensitivity Control (R157) for a stable count.
5. Repeat Steps 3 and 4 until no further improvement is possible.

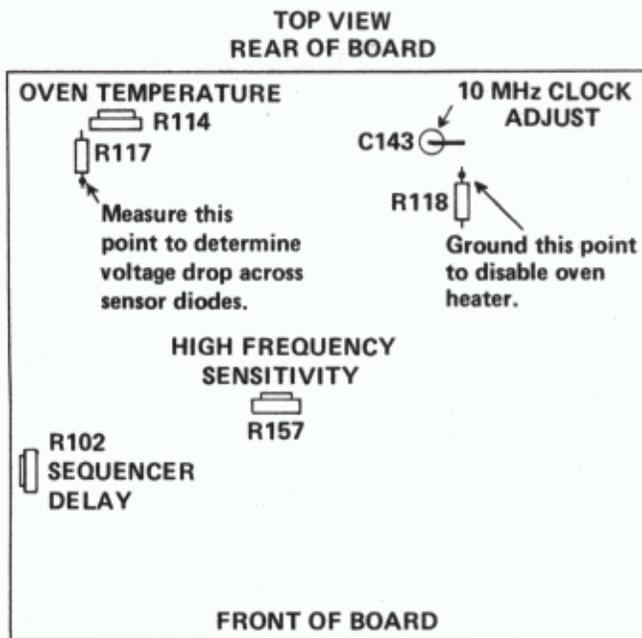


Fig. 25—Location of Recalibration Test Points and Controls.

EXTERNAL REFERENCE DRIVE MODIFICATION

The internal 10 MHz reference oscillator provides the best combination of a portable Digital Frequency Counter with a high degree of counting accuracy. Some applications, however, may require the FC45 to be referenced to an external source of 10 MHz, such as a WWV reference. The FC45 may be modified to accept an external 10 MHz input, providing:

1. The 10 MHz oscillator is more accurate than 1 ppm, and
2. The 10 MHz source is capable of driving TTL logic.

To modify the FC45 to accept an external reference signal:

1. Remove the top cover of the FC45.
2. Drill a hole through the back of the FC45 (taking care to not drill through any components) and mount a BNC jack.
3. Locate the foil on the component side of the P.C. board running to pin 14 of IC106. Cut through this foil with a sharp knife, leaving a 1/8" gap between the two segments of the foil run.
4. Connect the center conductor of the BNC connector mounted on the rear panel to the foil running to IC106.

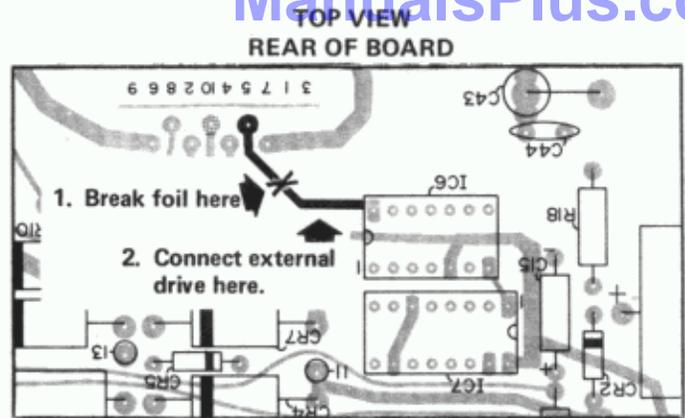


Fig. 26—External Reference Drive Modification.

5. If desired, a switch may be added which will allow either the internal timebase, or an external timebase to be used. Wire the switch as follows:

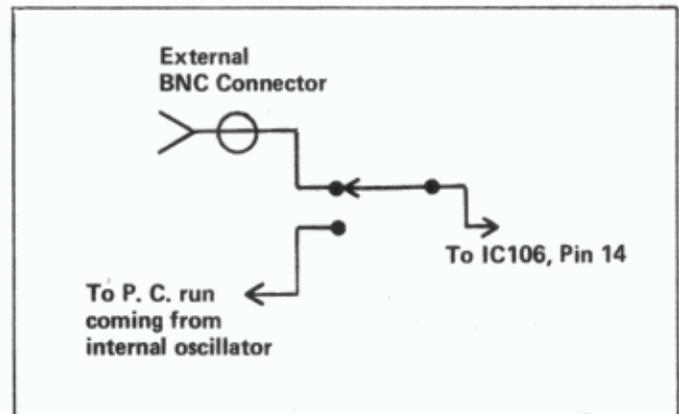


Fig. 27—Internal/External Selector Switch for Use with External Reference Drive Modification.

SERVICE AND WARRANTY

You have just purchased one of the finest frequency counters on the market today. The Sencore FC45 has been inspected and tested twice at the factory and has passed a rugged use test by our Quality Assurance Department to insure the best quality instrument to you. If something should happen, the FC45 is covered by the exclusive 100% Made Right Lifetime Guarantee as explained on the warranty policy enclosed with your instrument.

Sencore has two Regional Offices to serve you. Instruments to be serviced should be returned to the nearest Regional Office by UPS if possible. Parcel Post should only be used as a last resort. Instruments should be packed with the original packing material or equivalent, and double boxed to insure safe arrival at the Regional Office. The display carton is not an acceptable shipping container. When returning an instrument for service, be sure to state the nature of the problem to insure faster service.

If you wish to repair your own FC45, we have included a schematic and parts list. Any of these parts may be ordered directly from the Regional Office nearest you.

We reserve the right to examine defective components before an in-warranty replacement is issued.

SENCORE REGIONAL OFFICES:

Sencore Eastern
2459 Roosevelt Highway
College Park, GA 30337
(404) 768-0606

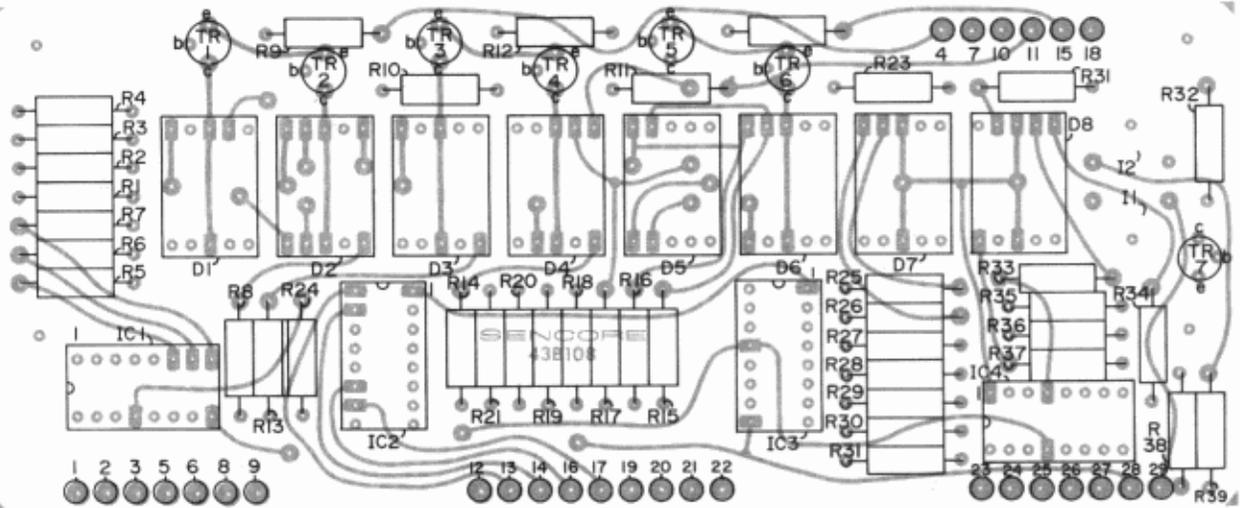
Sencore Western
3200 Sencore Drive
Sioux Falls, SD 57107
(605) 339-0100

FC45 PARTS LIST

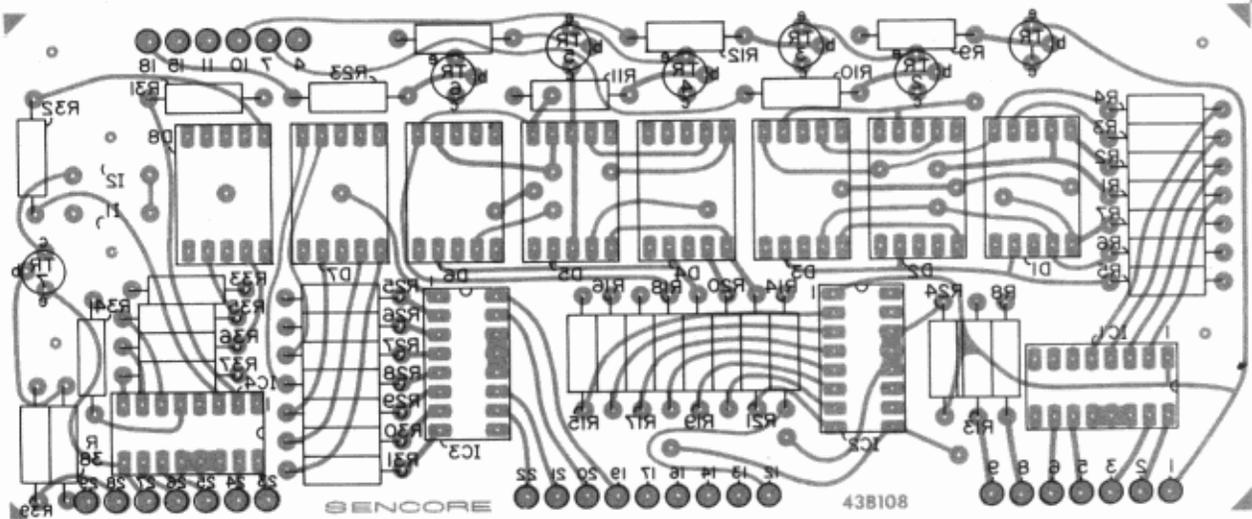
SCHEMATIC REFERENCE	PART NUMBER	DESCRIPTION	PRICE
IC101, 102	69G31	IC, 74LS74, Dual D Flip-Flop	1.50
IC103	69G37	IC, 74LS00, Quad NAND Gate	1.00
IC104, 105	69G23	IC, 14553, Three decade counter	9.75
IC106, 116, 117	69G42	IC, 74LS90, Decade Counter	2.00
IC107, 108, 109	69G36	IC, 14518, Dual Decade Counter	2.50
IC110	69G38	IC, 95H90, 300 MHz Decade Counter	15.00
IC111	69G13	IC, LM324, Quad Op Amp	3.25
IC112	69G40	IC, 10211, ECL Dual 3-Input NOR	3.25
IC113	69G39	IC, 10216, ECL Triple Line Receiver	3.25
IC114, 115	69G41	IC, 74LS75, Quad D Flip-Flop	2.50
IC401-404	69G35	IC, 7447 Decoder/Driver	2.25
TR101-3, 7, 9, 12, 13, 202, 203, 407	19A33	Transistor, 2N3904 NPN	.50
TR104, 110	19A29	Transistor, MJE180, NPN	1.50
TR105, 106	19A34	Transistor, 2N3906 PNP	.50
TR108	19A39	Transistor, MJE200, NPN	2.00
TR111, 115, 201	19A19	Transistor, MPF102, N-Channel FET	.75
TR114	19A21	Transistor, 2N3563, NPN	.50
TR401-406	19A20	Transistor, 2N4403, PNP	.75
CR101, 16, 17, 19-23 301, 302	50L5-2	Diode, 1N4148	.25
CR102, 3, 5, 6, 11-14	16S10	Diode, 1N4004, 1 Amp	.50
CR104, 7-10	16S14	Diode, 3 Amp	.50
CR115	50C4-2	Diode, 8.2 V Zener, 5%	.75
CR118	50C4-14	Diode, 5.6 V Zener, 5%	.50
CR124, 125	50A14	Diode, MRD502, High Freq. Hot Corner	2.25
R115	14C29, 2002A	Resistor, 200 Ohm, 1/2w, 1%	.75
R116	14C29-1203	Resistor, 1.2K, 1/2w, 1%	.75
R122	14C29-6003	Resistor, 6K, 1/2w, 1%	.75
R123	14C29-3903	Resistor, 3.9K, 1/2w, 1%	.75
D401-8	23G63	LED display .5" common cathode	3.50
I401, 2	20G15	Incandescent bulb, 10ES	1.00
SW101	25A248A	Switch, Pushbutton, 7 station, 2P2T	8.00
L101	46G9	Coil, 10 mH	1.25
L102	46G72	Coil, 680 uH	.50
L3, 4	46G62	Coil, 200 uH	.50
T201	47A20	Crystal, 10 MHz	8.25
T1	28K71	Transformer, power	7.50
—	39G103	Socket, universal crystal	1.50
—	63K22	Filter, Red LED	1.25

Components not listed are standard replacement parts and may be purchased locally. When ordering parts, please specify instrument model number, schematic reference, part number, and description. Please include remittance (check or money order) with your order, otherwise invoice will be shipped C.O.D. Minimum billing is \$3.00. Prices and specifications in effect at date of printing and are subject to change without notice.

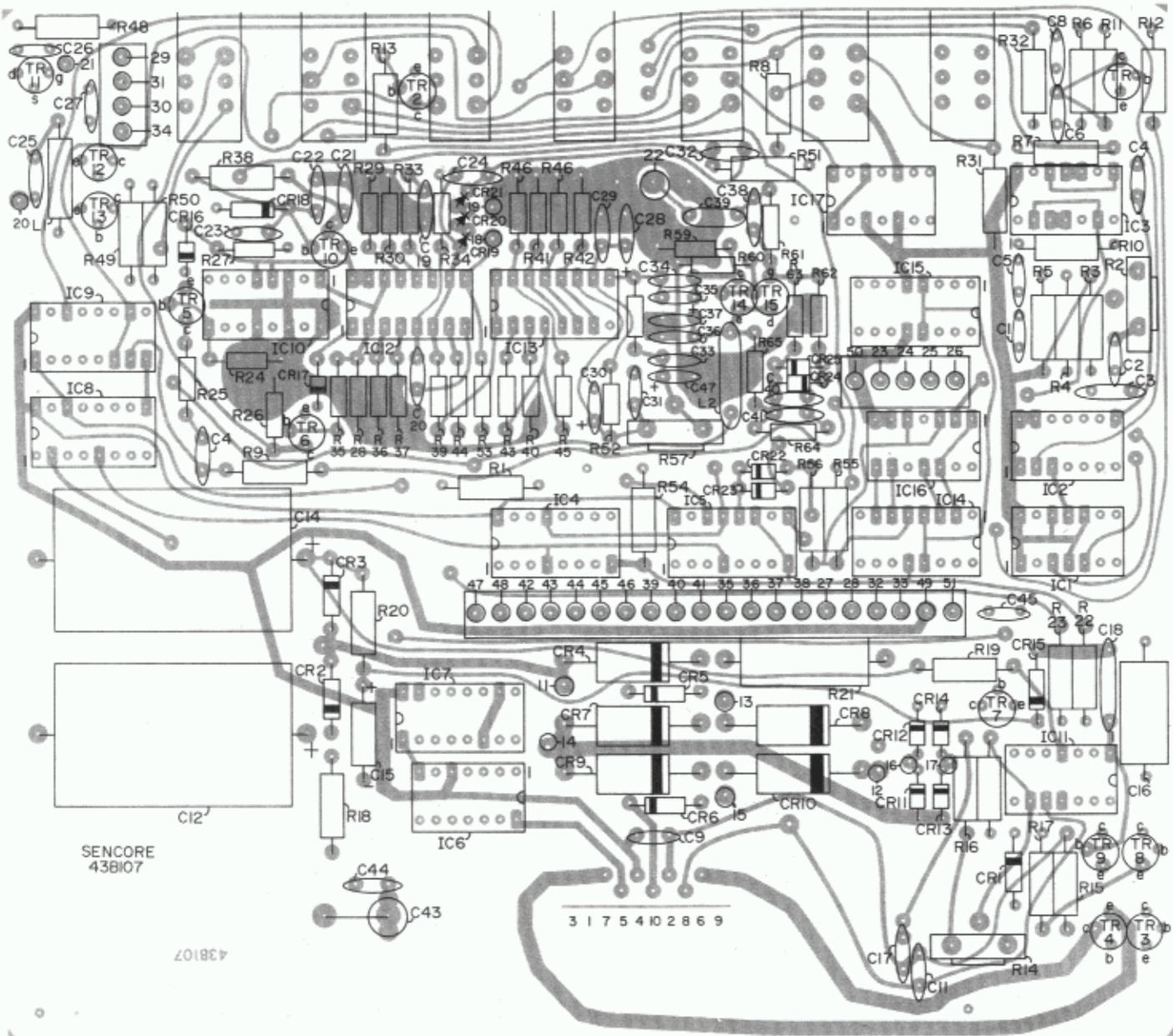
FC45 BOARD LAYOUT DIAGRAMS



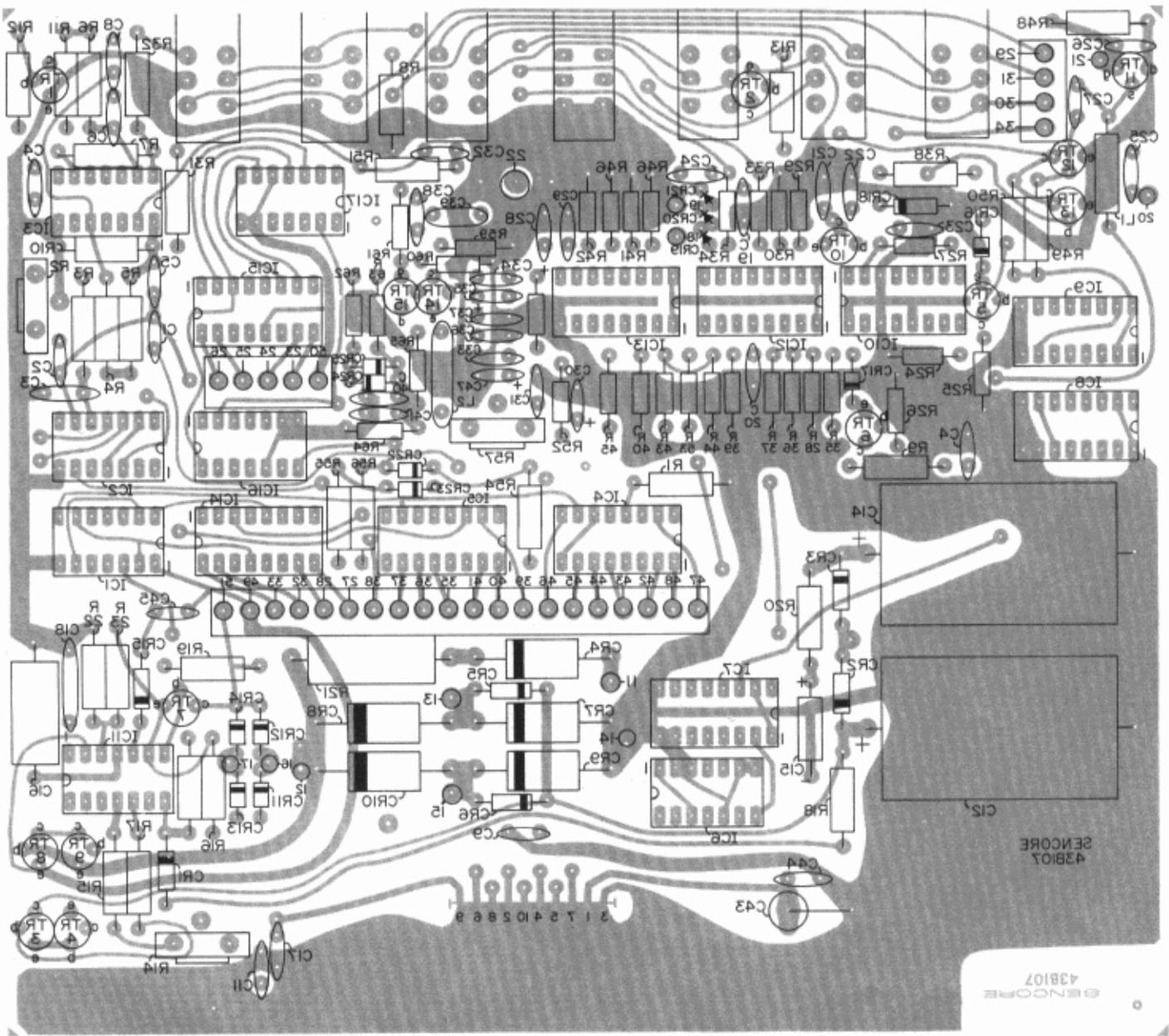
DISPLAY BOARD, Component Side



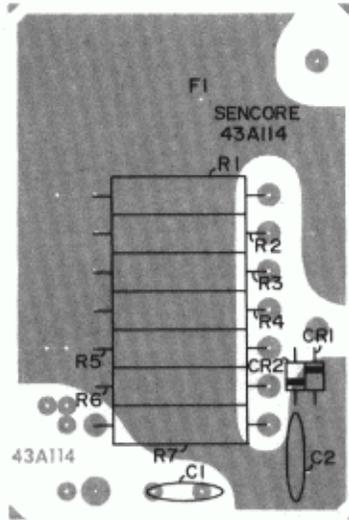
DISPLAY BOARD, Foil Side



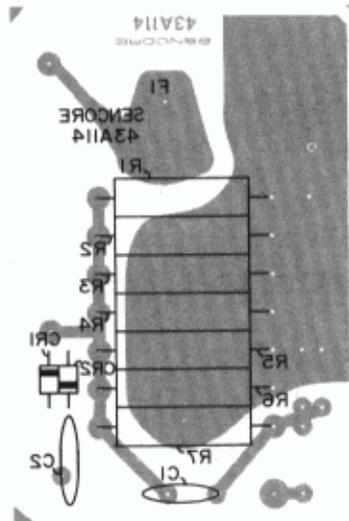
FUNCTION BOARD, Component Side



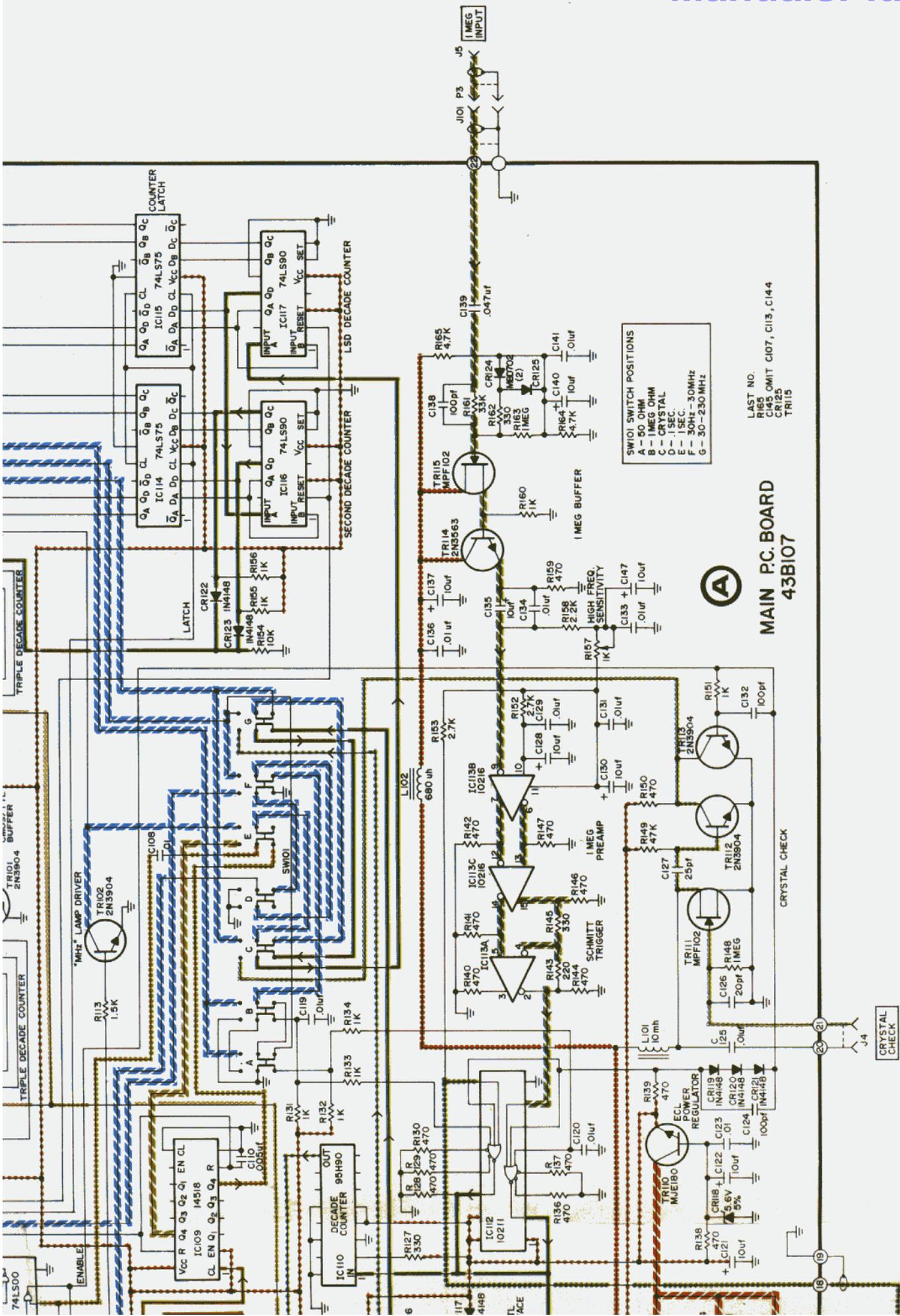
FUNCTION BOARD, Foil Side



50 OHM LOAD BOARD, Component Side



50 OHM LOAD BOARD, Foil Side



SW101 SWITCH POSITIONS

A	50 OHM
B	1MEG OHM
C	CRYSTAL
D	.1SEC.
E	1SEC.
F	30Hz - 30MHz
G	30 - 230 MHz

LAST NO.
 R165
 C145 OMIT C107, C113, C144
 CR125
 TR115

MAIN P.C. BOARD
43B107

SCHEMATIC DIAGRAM
FREQUENCY COUNTER