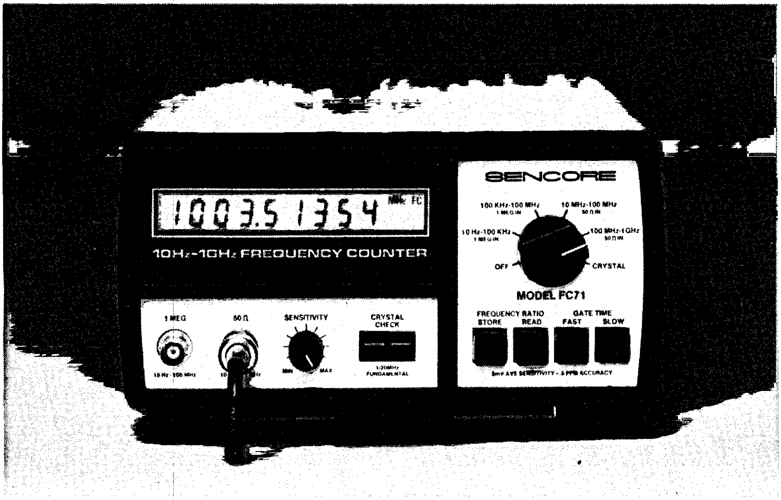
FC71

1 GHz
FREQUENCY COUNTER

Operation, Application, and Maintenance Manual



SENCORE

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DESCRIPTION

Introduction

Almost every electronic technician has a need for an accurate, reliable frequency counter. Consumer service technicians need a counter to adjust servos and color oscillators and to aid in troubleshooting UHF and VHF tuners. Both broadcast and communications technicians need a counter that covers a wide frequency range and can be used near high power transmitters. Their counter must be accurate enough to make FCC documentations of transmitter outputs. Industrial technicians need a counter to troubleshoot digital clocks, multiply and divide circuits, and to make numerous frequency adjustments.

Features

The FC71 is a portable, digital frequency counter which directly measures any frequency from 10Hz to 1GHz with accuracy that exceeds FCC requirements. The FC71 maintains useable accuracy over a wide temperature range and does not require a warm up time. It uses a microprocessor-compensated timebase that eliminates the need for an oven. This means the FC71 runs a full day on a single battery charge. A supplied AC adapter/recharger allows bench operation, while a supplied cable allows the FC71 to be powered from an outside source of 12VDC. Special shielding, along with a metal RF resistant case, provides interference-free operation even near the most powerful transmitters.

The 8½ digit display is readable under almost any lighting condition. Annunciators for "Hz", and "MHz", combined with automatic leading zero suppression, allow quick, interpretation-free readings. In addition, two annunciators monitor the condition of the battery while another warns you if the 50 ohm input fuse has been damaged by an overload.

One function switch selects the counter function, the frequency range and which input is used. The FC71 has three inputs. The first is a high impedance, 1 megohm input which minimizes circuit loading. This input has very good sensitivity. A sensitivity control reduces sensitivity on noisy signals to provide a stable reading. Diodes protect this input from overload.

The second input to the FC71 is terminated in 50 ohms to reduce cable ringing and other effects of mismatch on high frequency signals. Like the 1 megohm input, the 50 ohm input has very good sensitivity which is also adjustable for obtaining stable readings on noisy signals. A fuse protects the 50 ohm input against overload.

The third FC71 input is Sencore's exclusive Crystal Check. Any crystal can be checked for activity by simply inserting it into the front panel test socket and reading its approximate fundamental frequency.

A choice of two gate times allows either fast update for troubleshooting or a slower update and extra resolution when you need readings with extra accuracy. The FC71 provides resolution down to .01Hz without an external prescaler or gate times over 1 second.

The FC71's ratio test automatically calculates the ratio of two frequencies which are applied to it. The frequencies can be applied to either input, and can range from 10Hz to 1GHz. The ratio test greatly simplifies troubleshooting digital programmable dividers and testing the frequency multiplier stages in high frequency communications transceivers.

SPECIFICATIONS

Input Frequency:

1 MEGOHM INPUT: 10 Hz to 100 MHz
50 OHM INPUT: 10 MHz to 1 GHz
50 OHM VSWR: $<$ 2:1 to 1 GHz
CRYSTAL CHECK: 1 - 20 MHz; tests any crystal at approximate fundamental frequency

Accuracy:

± timebase ± 1 digit; ± 2 digits on frequencies $<$ 100 KHz

Timebase:

TYPE: microprocessor-compensated

TEMPERATURE STABILITY: (see chart)

2.0 ppm	1 ppm	0.5 ppm	1.0 ppm

−25°C −10°C 0°C 40°C 50°C

AGING: 0.5 PPM/1 year maximum

Resolution: (see chart)

Input	Range	Gate	Hz Resolution .01	.1	1	10	100
1 Meg Input	10 Hz - 10 KHz	Slow Gate	•				
		Fast Gate		•			
	10 KHz - 100 KHz	Slow Gate		•			
		Fast Gate			•		
	100 KHz - 100 MHz	Slow Gate			•		
		Fast Gate				•	
50 Ohm Input	10 MHz - 100 MHz	Slow Gate			•		
		Fast Gate				•	
	100 MHz - 1 GHz	Slow Gate				•	
		Fast Gate					•

Update Time:

SELECTABLE: approximately 0.1 and 1 second.

Sensitivity:

Fully variable on either input;
1 MEGOHM: 5 mVRMS sinewave average
50 OHM: 5 mVRMS sinewave average, typically 14 mVRMS at 1 GHz.

Input Protection:

1 MEGOHM: 400 VPP to 100 Hz, 250 VPP to 10 KHz, 50 VPP to 30 MHz, 8 VPP to 100 MHz; 250 V max. DC; diode protected
50 OHM: 5 VRMS, 0.5 watt; 100 V max. DC, fuse protected.

Ratio:

SINGLE INPUT; Range: 1.0000 to 99,999,999 with proper "÷" or "X" indication. First frequency is placed in memory with "STORE" button. The ratio of second frequency applied to stored frequency is displayed when "READ" button is pressed.

General:

RFI EMISSION: meets or exceeds FCC code 47 CFR 15.840
DISPLAY: 8½ digit LCD, leading zero suppression, auto decimal placement, "Hz", "KHz", "MHz", "X", "÷", "FC" (full charge), "LO" (low battery), "Fuse bad" (50 ohm input) indications.
POWER:
105-135 VAC with PA235 (supplied); 12 VDC car battery with 39G176 (supplied); Battery with BY234 battery pack (optional); Battery life with BY234: 9½ hours minimum continuous use with fresh 2.0 AH battery, 11 hours typical
AUTO OFF: after 30 to 45 minutes of battery use; automatically bypassed when powered from AC or external DC
SIZE: 4" x 8" x 11.5" HWD (10.2 cm x 20.3 cm x 29 cm)
WEIGHT: 5 lbs. (2.3 Kg) without battery, 6.6 lbs. with battery

Accessories:

SUPPLIED:
RF Pickup (Snoop) Loop (39G138); Direct/lo cap (x10) probe (39G152); Fused DC (12 V car battery) POWER LEAD (39G176); AC power adapter/recharger (PA235); Dummy probe load (39G178); BNC hookup cable (39G137); Barrel connector (26A248)
OPTIONAL:
Telescoping antenna (AN210); Lead Acid battery pack (BY234); IEEE 488 bus accessory (IB72); 220 AC Power Adapter (PA239); Carrying Case (CC238)

Specifications subject to change without notice.

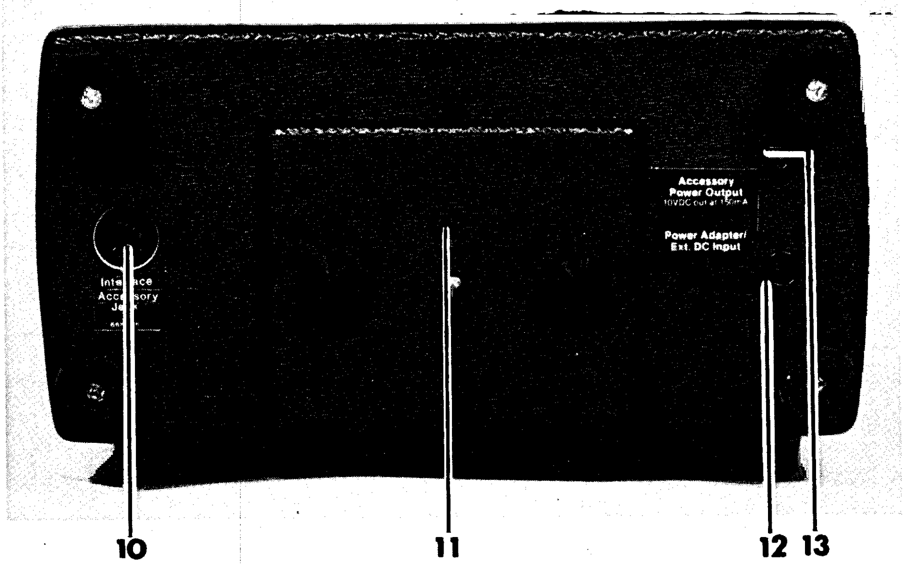

Fig. 3: Location of connectors on rear of FC71.

REAR VIEW

10. INTERFACE ACCESSORY JACK - Allows the (optional) IB72 IEEE 488 Bus Interface Accessory to be connected to feed FC71 readings to an automated measuring system.

11. BATTERY COMPARTMENT COVER - Provides access to the (optional) rechargeable battery pack.

12. POWER ADAPTER/EXT. DC INPUT CONNECTOR - Connects to the supplied PA235 Power Adapter (19) for AC operation, or to the Fused DC Leads (20) for external DC operation.

13. ACCESSORY POWER JACK - Supplies 10VDC at 150mA to power counter accessories.

SUPPLIED ACCESSORIES

14. BNC CABLE (39G137) - Used for making connections to generators and other signal sources that require a BNC connection.

15. RF PICKUP LOOP (39G138) - Used to make inductive pickup of signals in high frequency or high power circuits.

16. BNC BARREL CONNECTOR (26A248) - Used to connect cables having BNC ends.

17. COUNTER PROBE (39G152) - Allows direct connection to circuit. A switch selects direct (1:1) or isolated (10:1) measurements.

18. DUMMY PROBE (39G178) - Simulates the loading effect of the "Isolated" position of the Counter Probe (17) to allow precise measurements when using the FREQUENCY RATIO function (4) in circuits which are easily loaded.

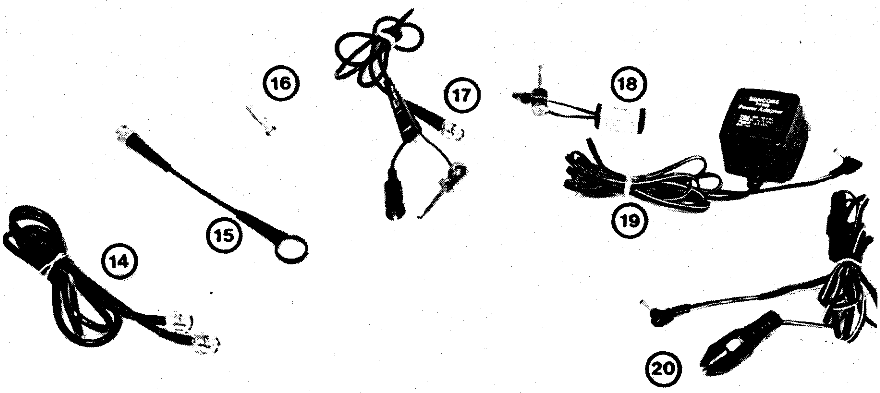

Fig. 4: Supplied accessories for FC71.

19. POWER ADAPTER (PA235) - Plugs into POWER ADAPTER/EXT. DC INPUT (12) to power unit from 105-130VAC line. It also charges the (optional) BY234 Battery Pack.

20. FUSED DC LEADS (39G176) - Plugs into the POWER ADAPTER/EXT. DC INPUT JACK (12) to power the unit from any 12VDC, negative-ground, automotive accessory jack.

OPTIONAL ACCESSORIES

21. ADJUSTABLE ANTENNA (AN210) - Used to pick up off-the-air signals.

22. RECHARGEABLE BATTERY (BY234) - Provides portable counter operation when installed into battery compartment (11).

23. IEEE 488 BUS INTERFACE ACCESSORY (IB72) - Connects between the INTERFACE ACCESSORY JACK (10) and the IEEE 488 bus port of a bus controller to allow the FC71 to be used as a bus "talker".

24. 220 VAC POWER ADAPTER (PA239) - Plugs into the POWER ADAPTER/EXT. DC INPUT JACK (12) to power the unit from a 210-230 VAC line and charge the (optional) BY234 Battery Pack.

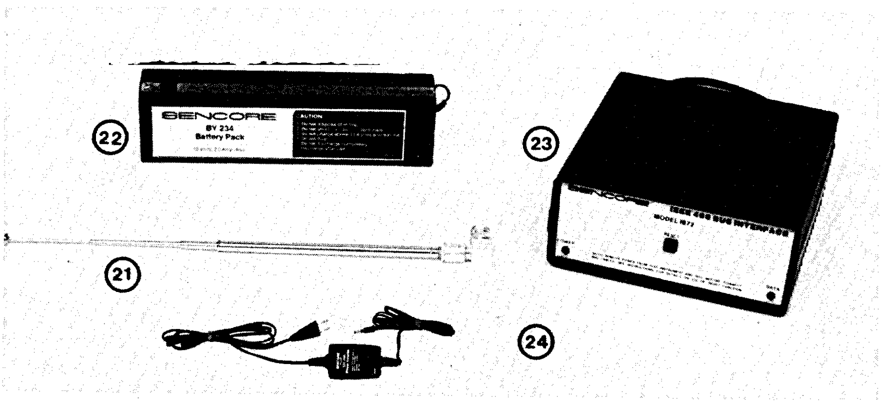

Fig. 5: Optional accessories for FC71.

NOTES

OPERATION

Introduction

This section of the manual explains how to operate the FC71. Once you have acquainted yourself with the features and operation of the FC71, most tests can be performed with the information on the front panel.

Power Connections

The FC71 can be powered by one of three different methods. The supplied PA235 Power Adapter allows the FC71 to be operated from a source of AC for bench operation. The supplied 39G176 Fused DC Power Leads allow the FC71 to be operated from an automotive accessory plug for mobile operation. The optional BY234 Battery Pack can be installed into the FC71 for totally portable operation.

AC Operation

For normal bench operation, the FC71 is powered from any 105-130 VAC (50/60 Hz) outlet using the supplied PA235 Power Adapter. The PA235 allows continuous operation of the FC71 since it electrically overrides the auto shutoff circuitry used to conserve battery life. You do not need to have a battery installed to operate the FC71 with the PA235 Power Adapter.

The PA235 Power Adapter will automatically charge the optional battery if the battery is properly installed in the unit. The battery will partially charge while the FC71 is being used. The FUNCTION switch must be in the "off" position, however, for the battery to charge completely.

An optional Power Adapter, the PA239 is available to operate the FC71 from a 210-230 VAC source. The PA239 is used exactly the same as the PA235.

WARNING

Using an AC adapter other than the PA235 or PA239 may cause damage to the FC71 or improperly charge the battery.

To operate the FC71 from the AC line:

1. Connect the Power Adapter to an AC outlet.

2. Insert the adapter plug of the Power Adapter into the POWER ADAPTER/EXT. DC INPUT JACK on the rear of the FC71.

3. Turn the FUNCTION switch to the desired frequency range to be counted. If the internal battery is installed, the "LO" or "FC" annunciators will show the amount of charge in the battery. If the internal battery is not installed, these indicators have no meaning during AC operation.

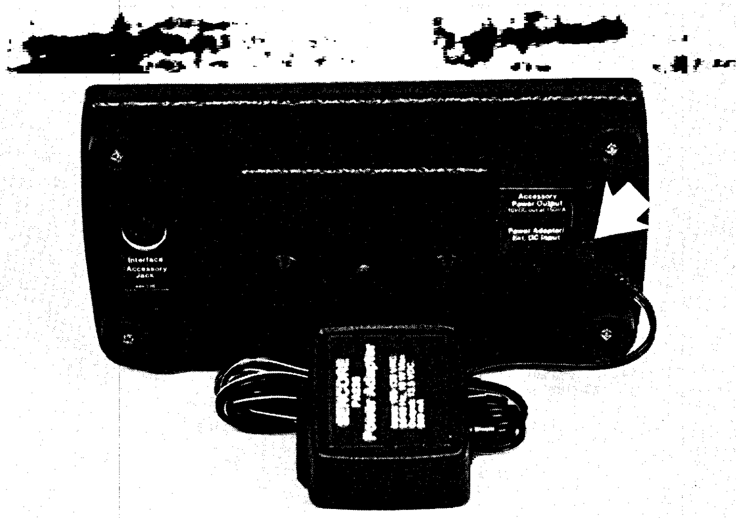

Fig. 6: Connect the Power Adapter to the Power Adapter/Ext. DC Input on the FC71 to power the FC71 from AC power.

4. The FC71 is immediately ready for use when turned on and does not require any warm-up time. However, the microprocessor may take up to 5 seconds to reset and produce a display.

NOTE: The FC71 has an automatic reset circuit which normally resets the microprocessor if its operation is disrupted, such as caused by a brief power interruption. Should the reset circuit fail to completely reset the microprocessor, the display will lock-up or have missing or random segments. If this happens, manually activate the reset circuit by momentarily switching the FC71 off and then back to the desired range.

External DC Operation

The FC71 may be operated from an external DC power source capable of supplying at least 250mA at 13.8 volts. If the FC71 is powered from an automotive accessory jack, the voltage may reach 16.5 VDC when the vehicle is running. The FC71 will operate over the normal range of automotive voltages.

WARNING

Do not apply more than 20 volts DC to the EXT. DC INPUT JACK. Damage to the FC71 or BY234 may result.

The external DC is applied to the POWER ADAPTER/EXT. DC INPUT JACK on the rear of the FC71 using the 39G176 Fused DC Leads supplied with the unit.

The fuse inside the positive lead is a 1 amp fast-blow fuse. It protects the FC71 from drawing excessive current should the FC71 develop an internal failure or if the optional battery becomes shorted.

The auto-off circuit, which is used to extend the operating time of the internal battery, is overridden when the FC71 is powered from an adequate (12 to 16 VDC) external DC voltage source. The internal battery can be recharged by the external DC supply if the supply has sufficient voltage and current. The external DC source must supply more than 13.8 volts and at least 800mA to charge the internal battery.

Fig. 7: The FC71 may be powered from an automotive accessory jack by using the supplied DC Power Supply Leads.

The FC71 can be used for mobile operation by powering it from a vehicle battery. The plug on one end of the 39G176 Fused DC Lead will fit into an automotive accessory ("cigarette lighter") jack. The lead is designed to be used on "negative ground" vehicles where the outer conductor of the plug connects to the negative ground of the vehicle. The FC71 is protected against possible damage from a reverse polarity connection, but it will not operate with incorrect polarity. The vehicle battery will operate the FC71 for extended periods. The vehicle must be running in order for the voltage to be high enough to charge the optional internal battery.

To operate the FC71 from external DC:

1. Connect the adapter plug of the fused DC leads to the POWER ADAPTER/EXT. DC INPUT JACK on the rear of the FC71.

2. Connect the automotive accessory plug of the supplied 39G176 Fused DC Lead to the source of DC. The outer ground terminal must be connected to the negative side of DC and the center terminal to the positive side of DC.

3. Turn the FUNCTION switch to the desired frequency range to be counted. If the internal battery is installed, the "LO" and "FC" annunciators will show the condition of the internal battery. Otherwise they indicate the voltage level of the DC source to which the FC71 is connected and can be ignored.

4. The FC71 is immediately ready for use and does not require any warm-up time. However, the microprocessor may take up to 5 seconds to reset and produce a display.

Battery Operation

The FC71 may be used as a completely portable unit by installing the optional BY234 Battery Pack. A fresh, fully charged BY234 will supply at least 9½ hours of portable operation above 60°F (15°C) before it needs to be recharged. This time varies with temperature and battery age. The chart in table 2 shows the effect of temperature on the BY234.

The sealed lead-acid battery used in the FC71 provides long life and requires no maintenance other than recharging. The life of the BY234 can be optimized several ways.

The life of a lead-acid battery is often called "cycle life" because it is a measure of the number of charge/discharge cycles which the battery can sustain. Each time you use the battery and recharge it, the battery has gone through one cycle. The cycle life of a lead-acid battery is very much dependent on the discharge depth and so the life of your BY234 will depend on how low you let it discharge before recharging. To obtain the longest possible battery life, recharge the battery after each use and never allow the battery to remain discharged for a long period of time. Also remember to recharge the battery before using it if it has sat unused for several weeks to replace the charge lost through self-discharge.

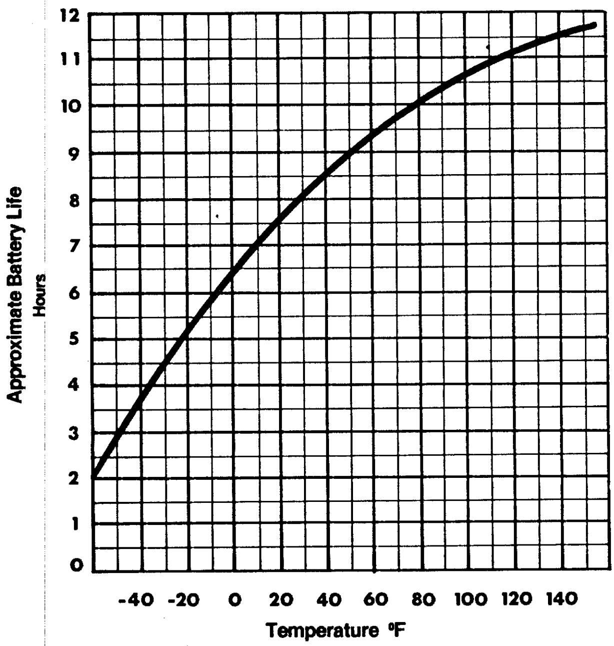

TABLE 2: The length of time that the FC71 will operate on a fully charged battery varies with temperature.

Lead-acid batteries do not develop a "memory" as Ni-Cads do, so frequent recharging will not harm them. In fact, frequently "topping off" the charge will extend their life. This also means that the BY234 does not need to be removed from the FC71 during AC operation.

Several circuits inside the FC71 help to optimize the battery life. First, two display annunciators give you an indication of how much longer the FC71 will operate from the battery before the battery needs to be recharged. The "FC" annunciator remains on until the battery drops to approximately 75% of its operating time as used in the FC71. When the "FC" indicator is out, between 2 and 7 hours of battery life remain. The "LO" annunciator comes on when the battery charge drops to the point where about 2 hours of battery life remain. Use these annunciators as a guide to keep the battery from getting too low and shortening its life.

NOTE: The display annunciators are based on typical FC71 operating time, not actual full-discharge as defined by the battery manufacturer. Thus, when the "LO" indicator comes on, the battery still has about 60% of its "charge" remaining, even though it has only 25% of its FC71 operating time left. This helps extend the life of the battery since it's never fully discharged in the FC71.

A second FC71 battery-saving feature is the auto-off circuit. This circuit removes power from the unit after it has been operated for 30-45 minutes from the internal battery. This keeps the battery from running down if you forget to turn the unit off. To reset the auto-off circuit when the unit has shut off, simply turn the FUNCTION switch to the "off" position and then return it to the desired range. You can reset the auto-off circuit to the beginning of its 30-45 minute timing cycle at any time by turning the FUNCTION switch to the "off" position and back to the desired function. This is especially helpful when you are about to make a series of measurements and the circuit has not finished running through its last timing cycle. The auto-off circuitry is electrically bypassed when the FC71 is operated from external DC or the AC Power Adapter, preventing it from turning off in the middle of a measurement, even if the unit has operated for more than 45 minutes.

A final battery-saving circuit is a low voltage shutdown circuit. This circuit removes power from the unit whenever the battery voltage drops below 9, the level needed for reliable counter operation. This circuit prevents unreliable counter operation and prevents the battery from becoming deeply discharged, which would shorten its life.

WARNING

Observe these precautions when using lead-acid batteries:

1. **Do not dispose of old lead-acid batteries in fire.** This may cause them to burst, spraying acid through the air.
2. **Do not short the "+" and "−" terminals together.** This will burn open internal battery connections, making the battery useless.
3. **Do not charge with a voltage greater than 20 volts.** High charging voltage may damage the battery or cause it to explode.
4. **Do not drop the battery.** Most lead-acid batteries are well sealed and will never leak. However, the battery may break if it is dropped or subjected to a strong shock. If the battery breaks and the gelled electrolyte leaks out, neutralize the acid with baking soda and water before wiping up with a cloth.
5. **Do not charge the battery below 0°C or above +40°C.** This may cause damage to the battery.

To install the optional BY234:

1. Remove the battery compartment cover located on the rear of the unit by unscrewing the two thumbscrews. The thumbscrews are secured to the cover by captive nuts.

2. Slide the battery end that does not have the connector attached into the battery compartment. (The wire should be facing out after the battery is in place.) Carefully slide the battery all the way into the compartment.

3. Connect the plug from the battery to the jack inside the battery compartment.

4. Carefully route the wire so that it will not be pinched when the cover is put back on.

5. Replace the cover. Install the cover so that the label inside it is right side up. The bottom edge of the cover has a larger angle to better match the bottom edge of the unit.

6. Tighten the thumbscrews to secure the cover and battery in place. Do not over tighten the thumbscrews.

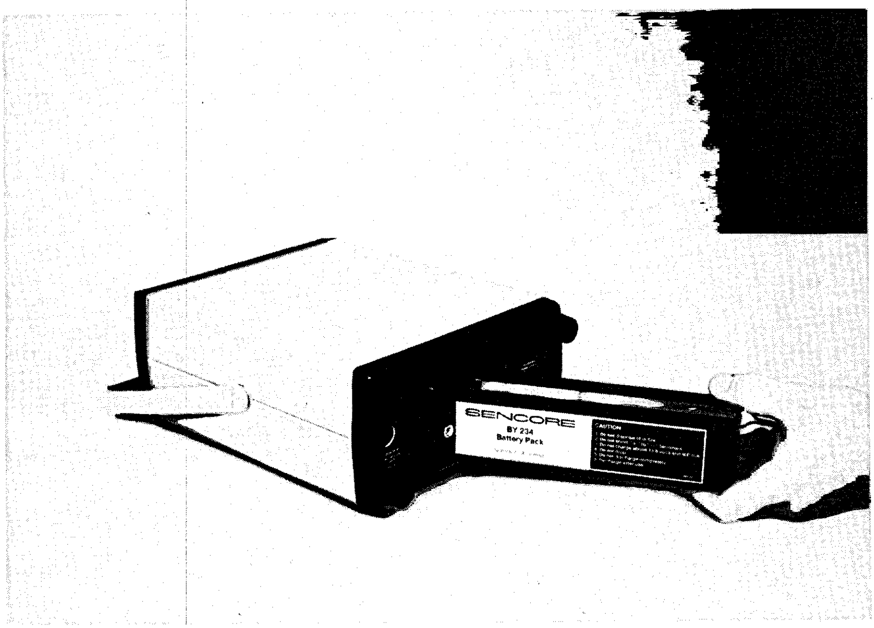

Fig. 8: The optional BY234 fits inside the FC71 to make it completely portable.

To operate the FC71 from the internal battery:

1. Install the BY234 into the battery compartment and connect the plug to the battery jack inside the battery compartment.

2. Turn the FUNCTION switch to the "off" position to reset the auto-off circuit and then to the desired frequency range.

3. The FC71 is immediately ready for use and does not require any warm-up time. However, the microprocessor may take up to 5 seconds to reset and produce a display.

4. An auto-off circuit will remove power from the unit after it has been on for 30-45 minutes. Turn the FUNCTION switch "off" and then back on to reset the auto-off. Reset the auto-off before making critical measurements, such as a frequency ratio, to keep the FC71 from being turned off in the middle of the measurement by the auto-off circuit.

Recharging The Optional Battery

The optional FC71 battery should never be allowed to remain discharged for more than a few hours since this will shorten its operating life. The battery should be recharged whenever the "LO" battery annunciator is on. It can be recharged overnight using the PA235 or an external DC source. The battery must be installed in the FC71, and the PA235 or external DC must be connected to the POWER ADAPTER/EXT. DC INPUT for the battery to charge. Operating the FC71 from the PA235 Power Adapter or external DC source allows the battery to trickle charge so that it is always ready for use and will not harm either the battery or PA235.

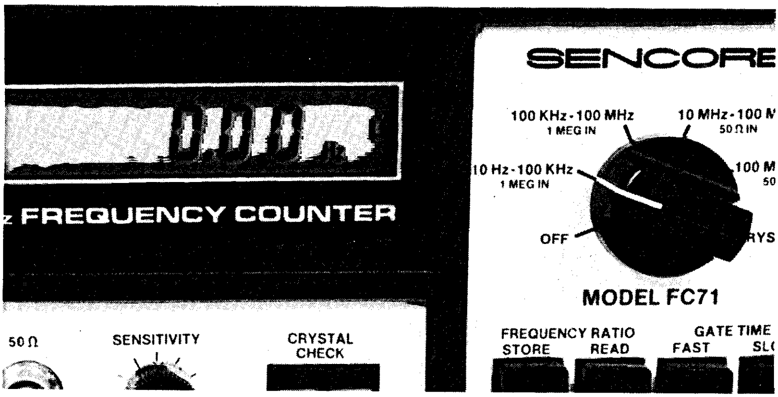

Fig. 9: The Lo battery indicator will come on when the internal battery needs to be recharged.

The amount of time it takes for the battery to recharge depends on how far it is discharged and on the amount of charging current available. If the BY234 Battery Pack is completely discharged (the FC71 has been shut off by its low voltage shutdown circuit) the battery can be fully recharged in about 8 hours using the supplied PA235.

The BY234 Battery Pack can be fully recharged by using the supplied PA235 Power Adapter. The FUNCTION switch on the FC71 must be in the "off" position for the battery to fully charge. When the battery is fully charged the "FC" annunciator will come on.

The battery can also be recharged from an external DC supply. The supply must be 13.8VDC or more, and supply at least 500mA (800mA to power the FC71 and charge the battery).

NOTE: The optional BY234 Battery Pack for the FC71 is rated at 2.0 Amp-Hours which is a larger capacity than most conventional VCR batteries. A smaller capacity VCR battery will not operate the FC71 for as much time on a single charge as the BY234 does. If you use a battery other than the BY234, make sure that it is a Lead-Acid type and that the plug polarity matches that of the BY234 as indicated on the battery compartment cover. A Ni-Cad battery will be damaged by the Power Adapter and other External DC voltages above 12 volts.

Temperature Range

The FC71 maintains FCC acceptable accuracy over a temperature range from −13°F (−25°C) to 122°F (50°C), as shown on page 5. The memory for the FC71's microprocessor contains the calibration data which allows it to be very accurate over a wide temperature range. The microprocessor's memory does not contain calibration data for temperatures below −13°F or above 122°F so the accuracy will fall outside FCC requirements beyond those points. The FC71's counting circuits will continue to operate above and below those temperatures however, and the FC71 can still be used for troubleshooting applications until the operating limit of the LCD is reached.

As the temperature falls below −8°F (−20°C), the LCD readings will become increasingly slower until the LCD finally reaches a point where it "freezes". The exact temperature at which the LCD "freezes" varies a few degrees between units. The LCD will not be harmed by cold temperature and it will begin to function properly as it warms up.

The LCD will also be affected by extremely high temperatures. When the temperature of the LCD increases above 122°F the liquid in the LCD will begin to "run together" causing the LCD to become black and unreadable. Again the temperature at which the LCD becomes unuseable varies from unit to unit. The LCD will not be harmed by high temperature and will return to normal operation after it cools off.

Signal Connections

You can use several methods to connect a signal to the FC71. The method you use will depend upon the particular signal you want to count. The FC71 allows you to use a direct connection, a high impedance connection or an indirect, "loose" connection. The FC71 comes supplied with all the probes and cables needed to make the most common signal connections. Figure 10 summarizes which signal connection to use with various signals. The following paragraphs give further details on each method of signal connection.

SIGNAL CONNECTION SELECTOR GUIDE

FREQUENCY RANGE	10 Hz - 100 MHz		10 MHz - 1 GHz		10 Hz - 1 GHz	
	1 MEG (Probe)		50 OHM (Probe)			
SIGNAL SOURCE	Direct	Isolated	Direct	Isolated	Pick-up Loop	Antenna
Audio Circuits	●					
Digital Pulses		●	● (ECL)			
Digital Square Wave Signals	●		● (ECL)			
High Voltage Signals					●	
Transmitter Outputs					●	●
IF Stages		●				
RF Oscillators		●				
RF Signal Generators			●			
Signal Tracing	●	●			●	

Fig. 10: Use this chart as a guide when making signal connections to the FC71.

Using The SUPPLIED COUNTER PROBE

For most frequency measurements below 100MHz, the FC71 is connected to a circuit by using the test clips on the 39G152 Counter Probe. A switch on the probe allows you to select either a direct (straight through) connection or an isolated (10:1 low-capacity) connection. The isolated connection greatly reduces circuit loading effects in circuits, such as oscillators, that may be pulled off frequency by the signal connection. The counter probe can be used with both the 1 meg and 50 ohm inputs.

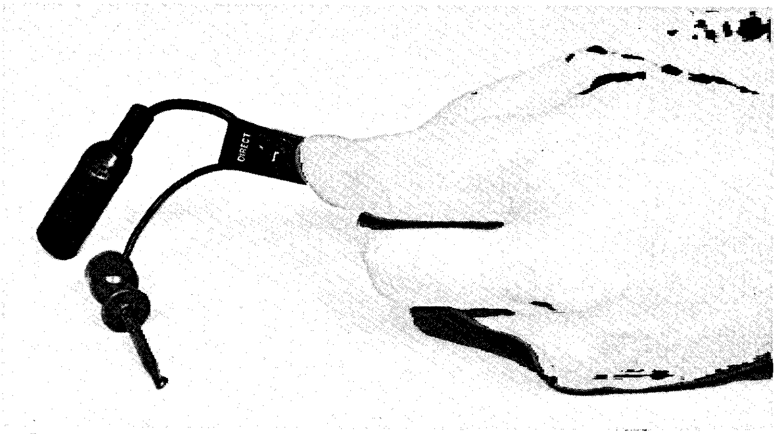

Fig. 11: The counter probe can be switched for either a direct or isolated connection.

1 Meg Input, Non-Isolated Connection

Connecting the counter probe to a circuit using the "Direct" switch position is the most widely used connection. This connection takes the fullest advantage of the counter's sensitivity because all of the signal present at the circuit test point is applied to the counter's input.

The impedance of the 1 meg input with the probe in the "Direct" position is 1 megohm paralleled with 62pF. This impedance will not load most oscillators if the probe is connected to a buffer stage after the oscillator. Some oscillators, however, may be pulled off frequency or loaded to the point where they stop oscillating. Refer to the "1 Meg Input, Isolated Connection" section of this manual should this occur.

At frequencies above 10MHz, the position of the probe ground lead may affect the stability of the reading since the short lead becomes reactive at higher frequencies. If you get an unstable reading, you can usually make it stable by repositioning the ground lead or readjusting the FC71 SENSITIVITY control.

1 Meg Input, Isolated Connection

The "ISO" position of the 39G152 Counter Probe is used to provide minimum loading for applications where the "Direct" position causes too much loading.

A 9 megohm resistor is placed in series with the counter input in the "ISO" position, decreasing the loading effect of the probe. The input impedance of the 1 meg input becomes 10 megohms in parallel with 9pF. The "ISO" connection is especially important when you must connect directly to an oscillator rather than to a buffer stage. As with the "Direct" connection, the position of the ground lead may affect the stability of readings above 10MHz.

50 Ohm Input, Non-Isolated Connection

The 50 ohm terminated input reduces reflected waves on the counter probe. Use this option carefully because many circuits will be loaded by the 50 ohm input if a direct connection is made to them with the counter probe. However, the counter probe has some very important applications when used with the 50 ohm input.

The Counter Probe is used in the "Direct" position with the 50 ohm input to reduce ringing on fast signals such as ECL logic IC's and signal generator outputs that are not affected by the low impedance.

NOTE: Don't use the "ISO" position of the Counter Probe with the 50 ohm input. Doing so places the 9 megohm resistor in series with the 50 ohm FC71 load resistor, resulting in extreme signal losses. This connection does not offer any advantages over using the 1 megohm input.

Using The RF Pickup Loop

The 39G138 RF Pickup Loop (Snoop Loop) allows you to measure frequencies without making an actual connection to the circuit. There are several applications for this.

Some oscillators are very frequency critical and may be affected by the Counter Probe, even in the ISO position. In other cases the test point you want to measure may have voltages that exceed the input rating of the FC71's inputs, as in many transmitter stages. At other times, you want to quickly move from one circuit to the next as you follow a signal through a circuit. In each of these applications, the Snoop Loop acts like a tiny, directional antenna, allowing you to inductively pick up the signal while maintaining proper circuit operation and counter protection.

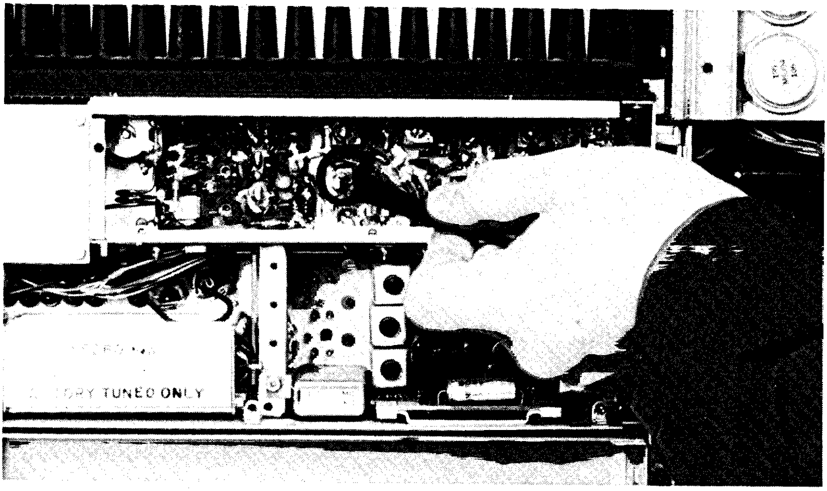

Fig. 12: The RF Pickup Loop allows low level signals to be counted without detuning the circuit.

The RF Pickup Loop can be used on either the 1 megohm or 50 ohm input. The 1 meg input allows the Snoop Loop to work at frequencies down to 1MHz. The 50 ohm input provides a termination for the cable which makes it more effective at frequencies up to 1GHz.

The RF Pickup Loop works best if it is placed near coils, but transistors and capacitors work well too. These components radiate RF more easily than other surrounding components, allowing the Snoop Loop to pick up signals.

NOTE: When using the RF Pickup Loop near high power transmitters, be careful not to place the Snoop Loop too close to high-power RF stages. This could result in too much signal being applied to the counter. Always start with the Pickup Loop several inches away from the circuit under test and move the loop closer until the FC71 gives a solid, locked-in reading.

The Snoop Loop can often be used to pick up the small amount of signal that is radiated by a coaxial cable carrying high-power RF. For example the Snoop Loop allows you to measure the output of a transmitter feeding a dummy load even though the dummy load does not have an attenuated output to hook the counter to. Simply place the Snoop Loop along side the coax and position it for a stable reading.

The RF Pickup Loop is somewhat directional. Its placement in regard to the circuit detemines how well it picks up the signal. The placement of the Snoop Loop is especially important in frequency multiplier stages (such as used in UHF transceivers) where several harmonics are present. Tilting the loop slightly or flipping it over may be necessary before the FC71 registers the correct frequency.

To Use The RF Pickup Loop:

1. Connect the RF Pickup Loop to the 1 meg or 50 ohm input of the FC71. Use the Barrel Connector and the BNC cable to extend the length of the Pickup Loop.

2. Select the desired range on the FC71.

3. Place the RF Pickup Loop near a coil, capacitor, transistor, or other component that radiates the desired RF signal.

4. Read the frequency on the FC71.

Using The BNC Cable

The BNC cable supplied with the FC71 has several applications. It can be used to extend the length of the RF Pickup Loop, or to make the (optional) AN210 Adjustable Antenna easier to position. In addition, the BNC cable is needed to connect to generators and transmitter dummy loads (sometimes called "coaxial attenuators") that have 50 ohm BNC outputs at levels that do not exceed the maximum input rating of the FC71. The characteristic impedance of the supplied BNC cable is 50 ohms.

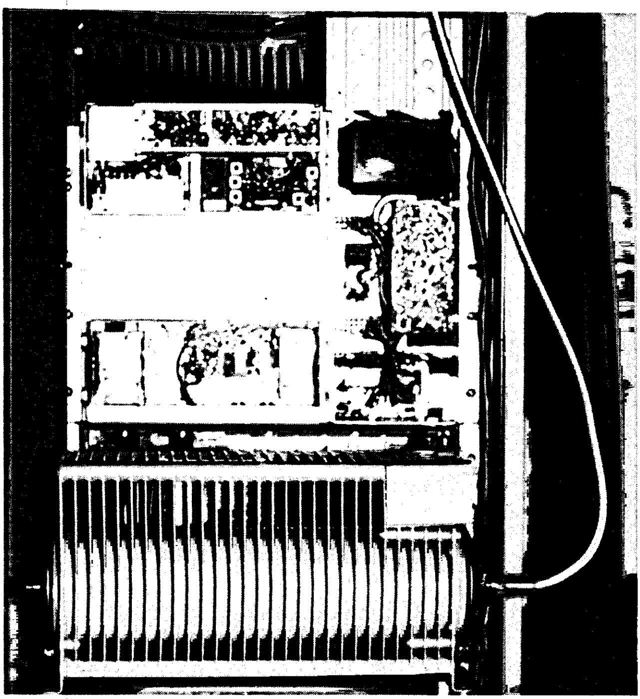

Fig. 13: Always use a dummy load when measuring the output frequency of a transmitter. Make sure that the output power of the transmitter doesn't exceed the rating of the dummy load.

CAUTION

1. Never connect the output of a transmitter directly to either input of the FC71.

2. Be sure that the output of the transmitter does not exceed the rating of the external dummy load.

3. Do not apply more than 0.5 watts of power to the 50 ohm input of the FC71. (Use a dummy load with at least 10 dB of attenuation when measuring a 5 watt output; 20 dB when measuring a 50 watt output; 30 dB when measuring a 500 watt output etc.).

Using The AN210 Adjustable Antenna (optional)

The optional AN210 Adjustable Antenna allows you to measure the output frequency of a transmitter by simply counting the RF radiated through the air, meaning that you don't have to make a connection to the transmitter or take it out of service. Applications of the AN210 include: 1) Checking the output frequency of hand-held transmitters; 2) Checking mobile radios without disconnecting them from the vehicle; 3) Testing commercial AM, FM and TV stations without having to turn the transmitter off; 4) Checking avionics transponders without removing the radio from the cockpit.

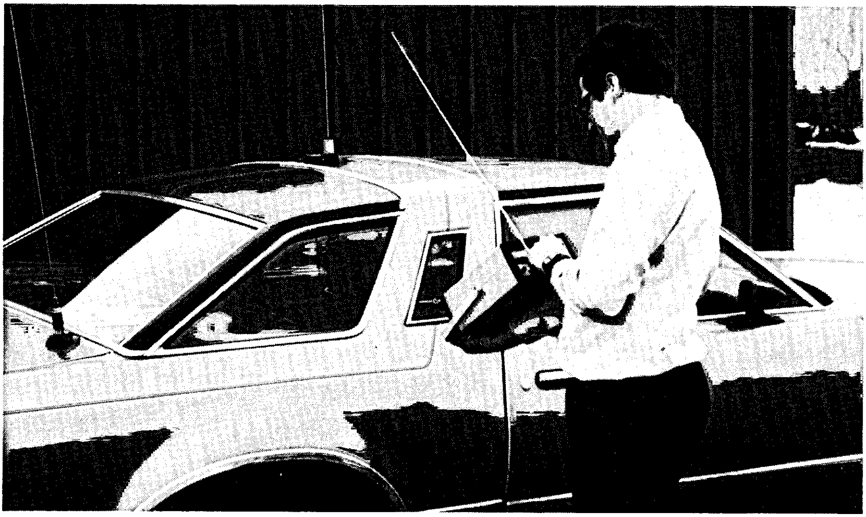

Fig. 14: The optional AN210 antenna allows the frequency of mobile radios to be checked, without removing the radio from its installation.

The AN210 can be used with either the 1 megohm input or the 50 ohm input of the FC71. The length of the AN210 is adjustable from 6 to 30 inches, allowing it to be tuned for maximum sensitivity at various frequencies. In general, you adjust the length of the antenna for the most stable reading. Antenna placement also makes a big difference in obtaining stable readings, especially if several strong signals are present. In most cases, simply moving the antenna from a vertical to a horizontal plane will cause it to pick up a different frequency.

NOTE: Adjusting the antenna length only provides a limited amount of selectivity. In applications where many, equally-strong signals are present, it may be necessary to use another method of coupling the signal to the counter, such as connecting to a dummy load as explained earlier.

In some cases, the signal picked up by the antenna might be heavily modulated by the transmitter, making accurate readings difficult. Using the slow gate time will produce a more stable reading, but the best way to make a stable, accurate reading on a heavily modulated signal is to reduce the modulation until the measurement is completed.

At times you may wish to connect the AN210 to the FC71 using the supplied BNC cable and Barrel Connector. This allows you to position the antenna for the best pickup while allowing the FC71 to remain in a stationary, more useable position.

To Use The AN210 Adjustable Antenna:

1. Connect the AN210 to either FC71 input, depending on the frequency to be counted. If critical antenna placement is necessary, use the BNC cable and Barrel Connector to connect the AN210 to the FC71. This will allow the AN210 to be positioned more freely.

2. Select the proper input and frequency range with the FUNCTION switch to match the signal input and frequency.

3. Adjust the antenna length and position as necessary to obtain a stable reading. The chart provided with the AN210 shows the antenna length for best sensitivity at different frequencies.

Selecting The Proper Input

The FC71 has three signal inputs: a 50 ohm terminated input, a 1 megohm high impedance input, and a crystal socket. The sensitivity of the 1 megohm and 50 ohm inputs can be varied with a SENSITIVITY control. The following section explains the applications and use of each input.

FREQUENCY RANGE	MAXIMUM INPUT VOLTAGE 250 VDC Max All Frequencies
10 Hz - 100 Hz	400 VP-P
100 KHz - 10 KHz	250 VP-P
10 KHz - 30 MHz	50 VP-P
30 MHz - 100 MHz	8VP-P

TABLE 3: 1 Meg Input Overload Protection.

1 Meg Input

The 1 meg input of the FC71 provides a high impedance input that minimizes circuit loading. It is used to count audio signals, oscillators, and other signals between 10Hz and 100MHz.

The 1 meg input is protected against overload to the voltages shown in Table 3, page 25.

The maximum applied voltage (DC & AC peak) cannot exceed 500 volts maximum.

WARNING

The maximum input voltage which can be safely applied to the 1 megohm input varies with frequency. Do not apply more signal than listed in table 3. Applying more than the rated voltage will cause damage to the FC71 and void all warranties.

The frequencies applied to the 1 meg input are broken into two ranges. The 100KHz to 100MHz range provides the conventional 1Hz maximum resolution. A special 10Hz to 100KHz range provides extra resolution down to 0.01Hz for frequencies between 10Hz and 10KHz, and to 0.1Hz for signals from 10KHz to 100KHz. Signals between 10Hz and 100KHz are sometimes very noisy, often having another, higher frequency interfering with them. The 10Hz-100KHz range of the FC71 provides additional noise immunity, allowing you to obtain stable readings on very noisy signals.

Signals can be applied to the 1 meg input using the Counter Probe, the RF Pickup Loop, the BNC cable or the (optional) AN210 Adjustable Antenna. The "Signal Connections" section of this manual, on page 19, explains how to use these connections and explains the application for each.

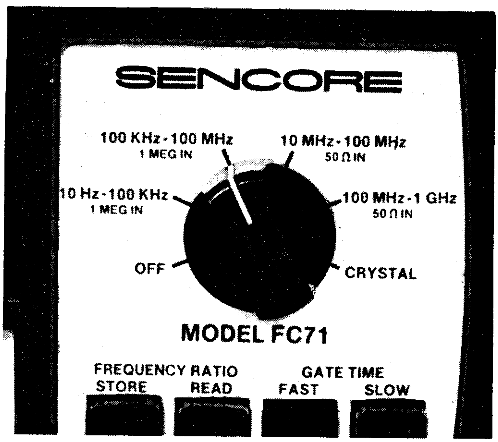

Fig. 15: Frequencies between 10Hz and 100MHz are measured using the 1 megohm input.

Most signals that are applied to the FC71 are easily counted with the sensitivity control set at maximum. However, some extremely noisy signals may cause unstable readings. Should the FC71 read unstably, reduce the setting of the sensitivity control until the readings stabilize. Also double check the signal connections. Make sure that the instability isn't caused by an improper signal connection, circuit loading, or an improperly placed ground lead.

To Use The 1 Meg Input:

1. Connect the signal to the 1 meg input. Refer to the section entitled SIGNAL CONNECTIONS to determine the best method to use.

2. Select the range for the frequency to be counted. Use either the 10Hz to 100KHz or 100KHz to 100MHz range.

3. Select the desired read rate. Use the slow gate time for maximum resolution and the fast gate time for a fast update speed.

4. Adjust the SENSITIVITY control, if necessary, to obtain a stable reading. For most applications simply leave the SENSITIVITY control at "MAX".

5. Read the frequency of the applied signal directly on the LCD.

50 Ohm Input:

The 50 ohm input provides a 50 ohm termination to prevent standing waves on the input cable. This prevents ringing and unstable readings on high frequency signals. The 50 ohm input is used to count signals ranging in frequency from 10MHz to 1GHz.

The 50 ohm input is protected against overload by an internal fuse. The maximum input to the 50 ohm input is 5VRMS. The input can dissipate 0.5 watts. The maximum DC voltage that can be applied to this input is 100 volts.

A "FUSE bad" reading appears on the display if the 50 ohm input protection fuse opens. This prevents erroneous readings caused by using the FC71 with an open protection fuse. Two spare fuses are located inside the counter, just behind the 50 ohm input. Refer to the section, entitled "Replacing The 50 Ohm Protection Fuse" on page 44 for details on replacing the fuse.

CAUTION

A blown 50 ohm protection fuse indicates that the 50 ohm input rating was exceeded. Determine the cause of the overload and correct it before reconnecting the signal to the counter.

The 50 ohm input is capable of counting signals from 10MHz to 1GHz. Two ranges are used so that maximum resolution is possible on signals from 10MHz to 100MHz. The 50 ohm termination reduces signal ringing and standing waves on connecting cables. It has a good VSWR of less than 2:1 when used with a 50 ohm source and a 50 ohm cable. This keeps impedance mismatch to a minimum, even at high frequencies. This input is usually used with the RF Pickup Loop or AN210 Adjustable Antenna, but may also be used with the supplied counter probe. For details on how to use each of these signal connections, refer to the "Signal Connection" section.

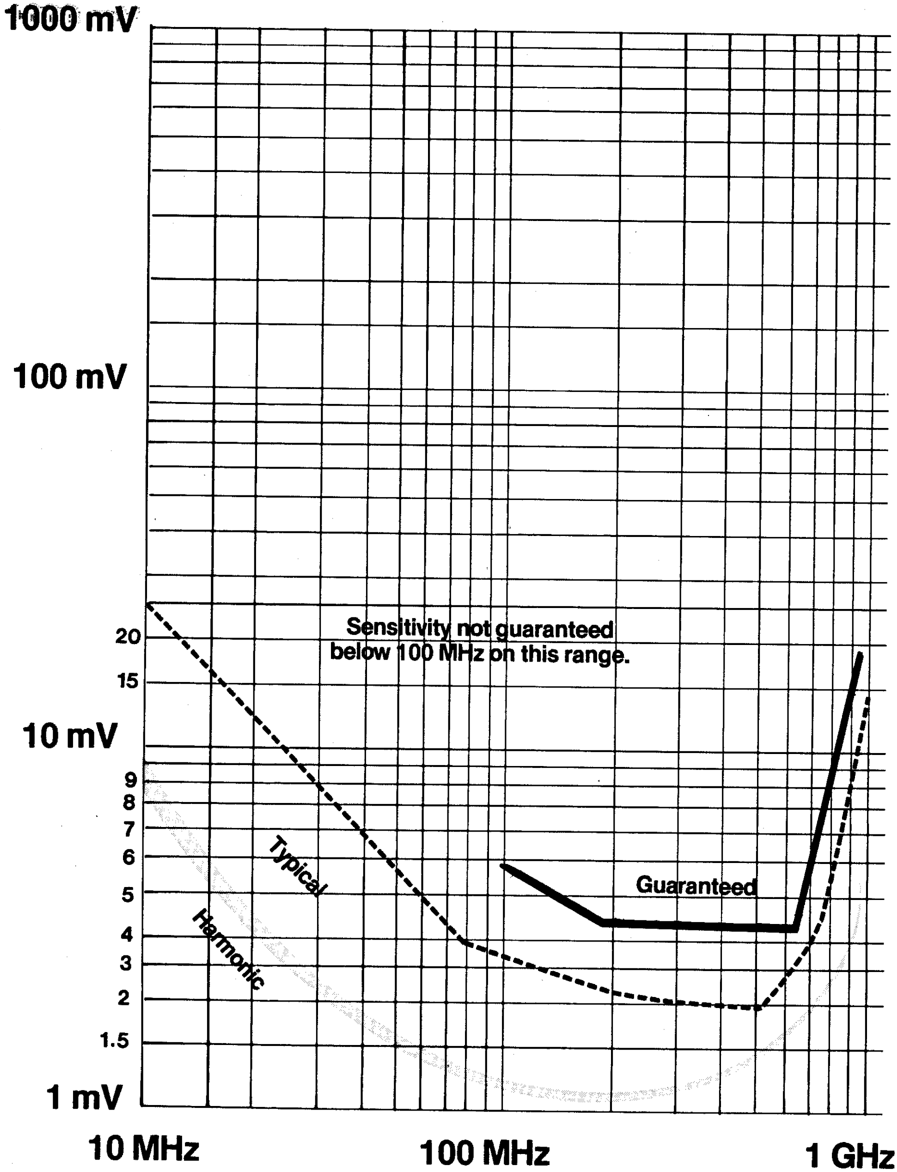

TABLE 4: Guaranteed and typical sensitivity curves for the 100 MHz - 1 GHz range of the 50 ohm input showing possible area of harmonic counting.

The SENSITIVITY control can be used with the 50 ohm input to obtain a stable reading on noisy signals. As with the 1 megohm input, unstable readings may be caused by signals having extreme ringing or signals with noise spikes. The "Applications" section explains the problems associated with these signals. For most signals, simply leaving the sensitivity at "MAX" will provide stable readings. Reduce the sensitivity if necessary to obtain a stable reading on noisy signals.

The FC71 has an average sensitivity of 5mV over the entire range of the 50 ohm input. As with all counters, however, the sensitivity at the very high frequencies begins to drop off as the input circuits reach their operating limits. The chart in Table 4 shows the guaranteed worst-case sensitivity and typical operating sensitivity. The FC71 will properly count signals larger than these values.

Table 4 shows a narrow band in the 100MHz-1GHz range that is marked "harmonic". Similar bands occur in most other frequency counters. The "harmonic" band is a very small region at low signal amplitude stretching across a band of frequencies within the 100MHz-1GHz range of the FC71. This harmonic area is not a problem. When a signal within the harmonic band is applied to the FC71, the FC71 may display a frequency reading that is two, three, four, or five times higher than the actual frequency. However, in almost every case you will know the approximate operating frequency of the circuit and realize that the FC71 is displaying a harmonic. Changing the signal level just a few tenths of a millivolt will either produce the proper reading or cause the FC71 to read unstable or drop to zero. Adjusting the SENSITIVITY control or moving the RF Pickup Loop confirms that an improper frequency reading is not caused by a signal level that is in the harmonic band.

To Use The 50 Ohm Input:

1. Connect the signal to the 50 ohm input. Refer to the manual section entitled "Signal Connections" to determine the best method to use.

2. Select the range of the frequency to be counted. Use either the 10MHz to 100MHz or the 100MHz to 1GHz range with the 50 ohm input.

3. Select the desired gate time. Use the slow gate time for maximum resolution and the fast gate time for a fast update speed.

4. Adjust the SENSITIVITY control, if necessary, to obtain a stable reading. For most applications simply leave the SENSITIVITY control at "MAX".

5. Read the frequency of the applied signal directly on the LCD.

Crystal Check

The Crystal Check function allows you to check any crystal with a fundamental frequency between 1 and 20MHz for crystal activity. The FC71 will indicate the fundamental frequency of the crystal. Many crystals operate at an overtone or harmonic of their fundamental. For example, a crystal that is marked 27.000MHz has a fundamental frequency of 9.000MHz. The crystal operates at its third overtone in the circuit. The FC71 will show the crystals frequency as 9.000MHz.

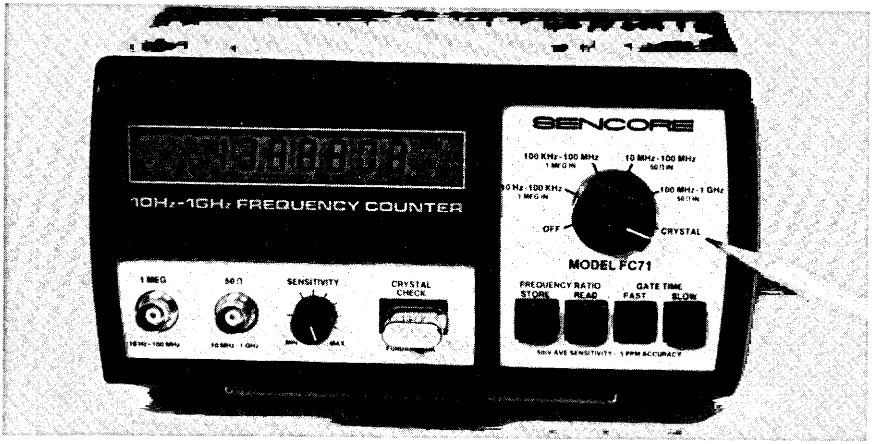

Fig. 16: The FC71 CRYSTAL function will measure the fundamental frequency of any crystal from 1 to 20MHz.

The exact frequency at which a crystal oscillates depends on the circuit it is used in because of circuit capacities and other parameters. To determine the exact frequency at which the crystal is oscillating, you must measure the output frequency of the circuit.

CAUTION

The Crystal Check input will not be damaged by normal use. But it is a sensitive, high impedance input. A high voltage discharge of static electricity to the socket may cause damage to the circuitry. To avoid possible damage from static discharge, touch the crystal case to the metal body of the 1 meg or 50 ohm input jack before you place it in the crystal check socket.

To Use The Crystal Check:

1. Set the FUNCTION switch to CRYSTAL.

2. Insert the crystal into the front panel Crystal Check socket.

3. Read the fundamental crystal frequency on the LCD. A defective crystal will result in a reading of all zeros.

Ratio

The FC71 automatically calculates the ratio of any two frequencies between 10Hz and 1GHz. This greatly simplifies troubleshooting circuits such as frequency multipliers and programmable dividers. The same inputs and connections are used for making frequency ratio measurements as for making frequency measurements. Therefore using the ratio function is very much like making a frequency measurement; the only difference is that you will use the STORE and READ buttons after you obtain a frequency reading.

When using the RATIO function, the frequency at the input of the multiplier or divder stage being tested is counted and stored in the FC71's memory. Then the frequency at the output of the stage is measured and compared to the stored, input frequency. The FC71's digital readout shows the resulting ratio along with special annunciators that indicate whether the stage is multiplying or dividing the input frequency.

To Use The Frequency Ratio Test

1. Connect the FC71 to the input of the circuit under test. Use either input and set the FUNCTION switch, GATE TIME switch and SENSITIVITY control for a stable, locked-in reading.

NOTE: Remember to reset the auto-off circuit by turning the FC71 off and then on if you are operating only from the internal battery. This prevents the unit from shutting off in the middle of a ratio test.

2. Push the FREQUENCY RATIO STORE button. Hold it down until a "–" begins to move through the display from left to right, indicating the frequency has been stored in the FC71's memory.

3. Connect the FC71 to the output of the circuit under test. Use either input and set the FUNCTION switch, GATE TIME and SENSITIVITY for a stable, locked-in reading.

4. Push the FREQUENCY RATIO READ button to its locked position with the FC71 still connected to the output signal. The FC71 display will show the ratio of the two frequencies. An "X" annunciator indicates that the frequency currently being counted (the output) is larger than the "STORED" frequency, as in a frequency multiplier stage. A "÷" annunciator indicates that the frequency currently being counted is smaller than the "STORED" frequency, as in a frequency divider stage.

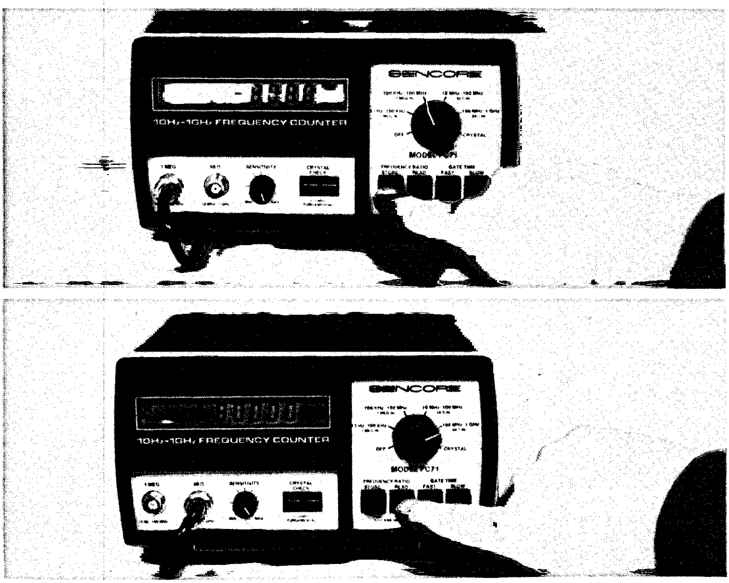

Fig. 17: a. The input frequency to a multiplier or divider is measured and STORED into the FC71's memory.

b. Press the READ button to display the ratio of the output to the input frequency.

NOTE: The frequency stored in Step 2 remains in memory until the FC71 is turned off or until it is replaced with a new frequency. You can make any number of standard readings with the READ button in the out position, and then return to the ratio function without needing to re-store the input frequency if it has not changed since the first time it was stored.

5. The "STORED" frequency can be recalled by pressing the "STORE" button while the "READ" button is locked in.

NOTE: The FC71's microprocessor computes the ratio of frequencies using more internal digits than are displayed on the LCD. The ratio displayed by the FC71 is the exact ratio of the frequencies, not a rounded-off number obtained by dividing the two displayed readings. On large ratios, the ratio displayed by the FC71 may be slightly different than the number obtained by using a calculator to divide the two individual frequencies displayed by the FC71.

Reducing Circuit Loading In Ratio Tests

Most circuits tested with the FREQUENCY RATIO test allow direct measurements of input and output frequencies without needing to use special measuring procedures. A few circuits, however, may be loaded by the FC71 probe when measuring the input signal. This is especially true when an oscillator feeds directly into a divider or multiplier stage without an intervening buffer to prevent loading. If this is the case, your frequency Counter Probe may pull the oscillator off frequency when you are storing the input frequency, and the oscillator returns to its unloaded frequency when you move the FC71 probe to the output of the multiplier or divider.

This produces a calculation error because the FC71's FREQUENCY RATIO test compares the frequency being applied to its input to the one stored earlier, not to the actual input frequency on a moment-by-moment basis. The FC71 stored the oscillator frequency when it was loaded by the Counter Probe. The oscillator changes to its unloaded frequency when you move the probe to the multiplier or divider stage's output. Thus, the calculation will be in error by an amount equal to the loading error.

For example, let's consider a 1MHz oscillator feeding a divide-by 100 stage. For the sake of comparison, let's use a loading factor of 10% when we measure the input frequency. The divider circuit normally operates with an input of 1MHz and an output of 10KHz (1MHz/100). When we connect the FC71 probe, however, the oscillator loads by 10%, resulting in a reading of 900KHz (0.9MHz) being stored in memory. When we move to the divider's output, however, the oscillator returns to 1MHz. The output frequency then measures 10KHz. But the FC71 divides 900KHz by 10KHz and displays a ratio of 90.

The amount of frequency shift is greatly reduced by using the "ISO" position of the switch on the 39G152 Counter Probe. Even this low loading, however, may cause ratio errors in a few extremely sensitive circuits. This final amount of error can virtually be eliminated with the use of the supplied 39G138 Dummy Probe.

The Dummy Probe closely duplicates the loading of the "ISO" mode of the 39G152 Counter Probe. You attach the Dummy Probe to the test point affected by loading after you have stored the frequency value in the FC71 memory. Thus, the Dummy Probe causes the oscillator's frequency to shift by nearly the same amount as it

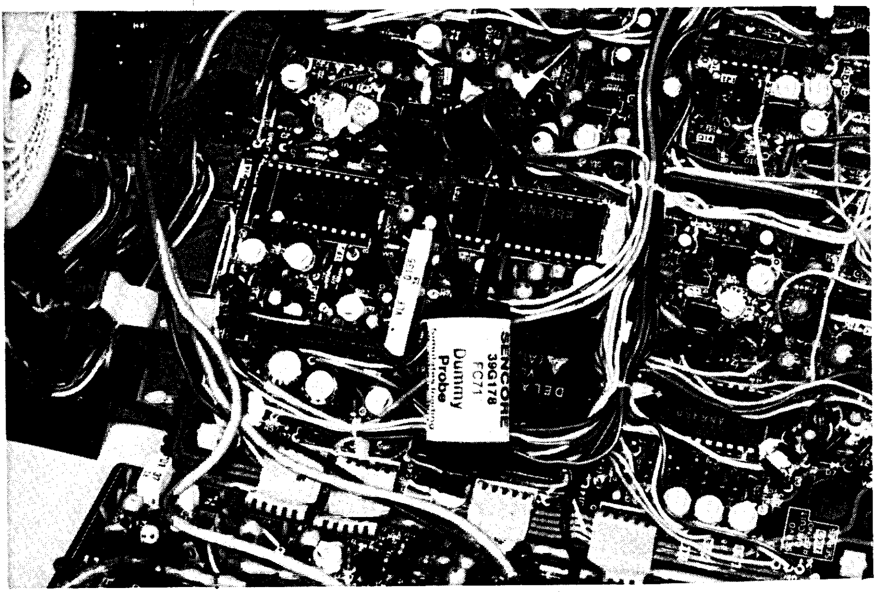

Fig. 18: The dummy probe simulates the loading effects of the counter probe. It is used when making a ratio measurement in circuits which are easily pulled off frequency.

shifted when you had the counter probe connected. This cancels the calculation error. In the case of the example we used earlier, the Dummy Probe returns the oscillator to the 900KHz it operated at when storing the input frequency. The output of the divide-by 100 stage then reads 9KHz. The FC71 ratio test then shows the correct ratio of "100".

You rarely need to use the Dummy Probe because most test points are buffered by at least one stage from an oscillator. The probe gives you a way to make accurate tests in those few rare cases where loading simply cannot be avoided.

To Use The Dummy Probe:

1. Connect the FC71 Counter Probe to the input of the circuit using the "ISO" position for minimum loading.

2. Adjust the FC71 for a stable, locked-in reading.

3. Push the FREQUENCY RATIO STORE button to store the frequency.

4. Remove the FC71 Counter Probe.

5. Connect the 39G178 Dummy Probe to the same circuit test point that the Counter Probe was connected to.

6. Connect the FC71 Counter Probe to the output of the circuit and read the Ratio following the normal RATIO test procedure.

Selecting Gate Time

The FC71 has two different gate times which change the display update speed along with the amount of resolution. This allows you to choose a fast update for troubleshooting or a slower update with extra resolution for documenting and verifying critical frequencies. Table 5 summarizes the resolution for each combination of frequency range and gate time.

			Hz Resolution				
			.01	.1	1	10	100
1 Meg Input	10 Hz - 10 KHz	Slow Gate	•				
		Fast Gate		•			
	10 KHz - 100 KHz	Slow Gate		•			
		Fast Gate			•		
	100 KHz - 100 MHz	Slow Gate			•		
		Fast Gate				•	
50 Ohm Input	10 MHz - 100 MHz	Slow Gate			•		
		Fast Gate				•	
	100 MHz - 1 GHz	Slow Gate				•	
		Fast Gate					•

TABLE 5: Resolution for different combinations of gate times and frequencies.

The fast gate time is generally used for troubleshooting. It allows you to monitor a quickly changing signal, such as an oscillator that you are tuning.

The slow gate time provides an extra digit of resolution. It is used for documenting the frequency output of a transmitter or fine tuning an oscillator. It also will produce a more stable reading on changing frequencies such as FM signals and less stable oscillators because it averages the varying frequency over a longer period of time.

IEEE 488 Bus Operation (optional)

The FC71 becomes an IEEE 488 Bus Talker when it is used with the Sencore IB72 IEEE 488 Bus Interface accessory. The IB72 serves as a translator between the bus controller and the FC71's microprocessor. Complete information on using the IB72, as well as program examples, are included in the IB72 manual.

WARNING

Only connect the matching IB72 connector to the INTERFACE ACCESSORY JACK on the rear of the FC71. Do not connect any other communications or interface bus to the FC71, even though the connectors may fit.

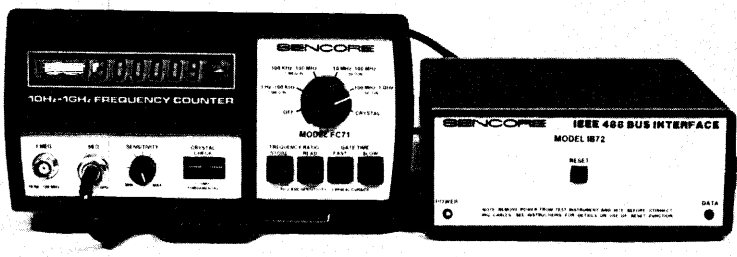

Fig. 19: The IB72, IEEE 488 Bus Interface allows the FC71 to function as a bus talker.

The operation of the FC71 with the IEEE 488 bus is the same as the non-bus operation explained in the preceeding sections of this manual. Be sure you fully understand the operation of the FC71 before connecting it to the bus.

The FC71 is a bus talker only. This means that the FUNCTION, GATE TIME and other controls must be operated manually. As a talker, the FC71 sends data over the bus (when requested by the bus controller) that consists of all the digits in the frequency reading.

To make the data readily useable by the controller the "Hz", "KHz" and "MHz" annunciators are sent as exponents. In addition, neither of the battery level indicators (LO and FC) are sent over the bus. The "FUSE Bad" indication is sent as "−1.00000000E−10". Figure 20 shows examples of FC71 display readings and the corresponding data sent over the bus.

FC71 Display	Data Sent Over Bus
10.00 Hz	00000010.00E+00
1.00000 KHz	00001.00000E+03
1000.0000 MHz	001000.0000E+06
197.0051 MHz	000197.0051E+06
x 1.1762	000001.1762 X
÷ 2.2389	000002.2389 /
FUSE bAd	−1.00000000E−10

Fig. 20: This chart shows examples of data that is sent over the bus, and the corresponding FC71 display.

WARNING

Do not apply power to the FC71 or IB72 until all connections have been made.

To Use The FC71 With The IB72:

1. Connect the IB72 IEEE 488 Bus Interface Accessory to the bus controller.

2. Connect the IB72 to the INTERFACE ACCESSORY JACK on the rear of the FC71.

3. Connect the adapter plug from the Power Adapter supplied with the IB72 to the Power Jack on the rear of the IB72.

4. Select the bus address of the FC71 using the address switches on the rear of the IB72 and press the RESET button.

5. Connect a signal to the FC71 and obtain a stable, locked-in reading.

NOTE: Be sure to power the FC71 from the PA235 Power Adapter to override the auto-off circuit.

6. The FC71 is ready to begin sending data when requested by the bus controller.

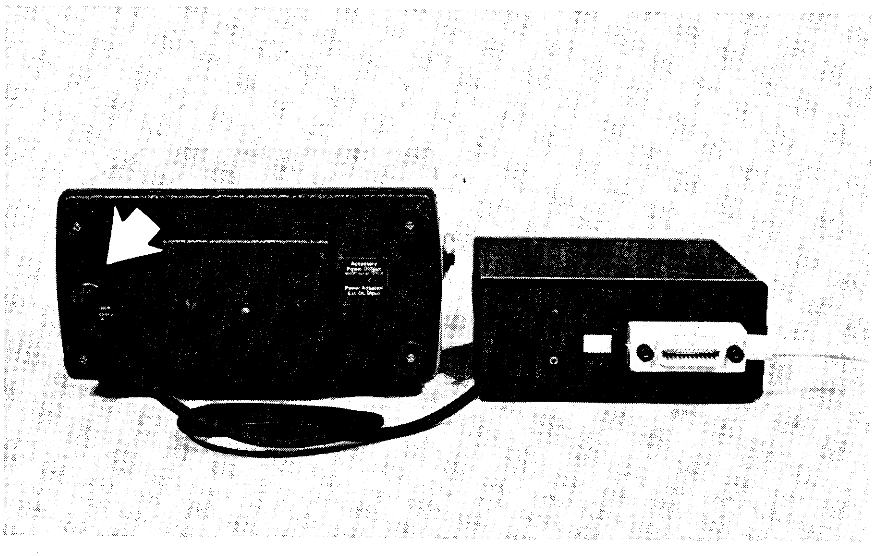

Fig. 21: The IB72 is connected to the Interface Accessory Jack on the FC71.

NOTES: Several conditions will cause the FC71 to hang up the bus. Use the following check list if the bus hangs up:

1. The IB72 must be connected to the INTERFACE ACCESSORY JACK on the FC71.

2. The IB72 must be set to the correct address.

3. The POWER LED indicator on the IB72 must be on, indicating that the IB72 is receiving power.

4. The FC71 must be properly set to read the frequency or ratio applied to it.

5. The FC71 should be powered using the PA235 Power Adapter to prevent the auto-off circuits from removing power.

APPLICATIONS

The procedures outlined in the OPERATIONS section will produce a stable, accurate reading of almost every frequency measurement encountered. Certain signals, however, are difficult to count because the signals are noisy or unstable.

In general, the problem signals will either be modulated or have extra, unwanted noise. This section explains why these signals are more difficult to count and how to count them with the FC71.

AM Modulated Signals

In many cases the FC71 will count an AM (amplitude modulated) signal. However, if the modulation level is very high and constantly changing, the FC71 may produce an unstable reading. As the modulation increases, the amount of signal applied to the counter quickly varies from a relatively large level to a level below the input sensitivity level of the FC71.

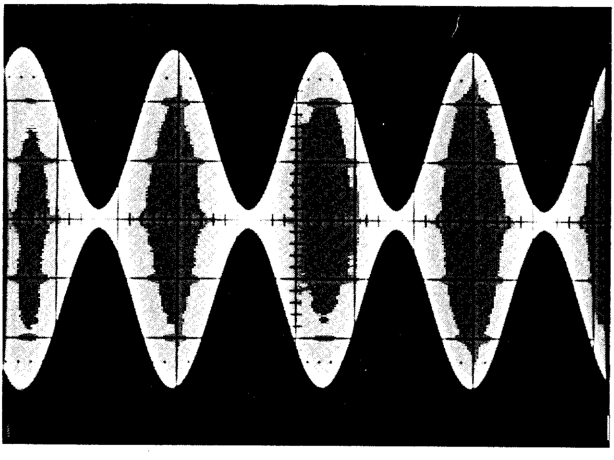

Fig. 22: An AM signal that is heavily modulated may drop below the sensitivity of the FC71.

FM Modulated Signals

The FC71 may count erratically on FM signals because it is trying to count a signal that is varying in frequency. The best way to insure a stable count on an FM signal is to remove modulation. Simply reducing the modulation, as in an AM signal, may not result in a stable reading. This is because the modulation in FM actually varies the carrier frequency while in AM the modulation simply varies the signal amplitude. A very close measurement of an FM signal may be obtained using the slow gate time. This will average the deviation of the signal around the carrier.

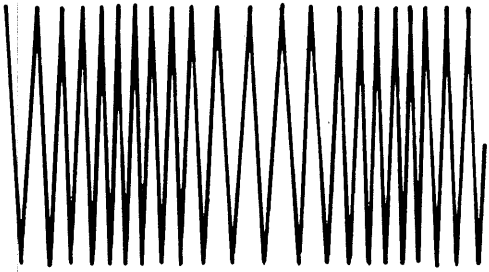

Fig. 23: An FM signal may produce an unstable reading on the FC71 because the frequency of the signal is changing.

Composite Sync And Video

The FC71 or any other counter will not count a composite sync or video signal correctly because these signals include several frequencies. A standard video signal has a 15734.3Hz horizontal signal, a 59.94Hz vertical signal, and a 3.58MHz color signal plus random signals representing video information. The FC71 may display a stable reading. However, the reading will be meaningless since it is a mixture of all the applied frequencies.

The only way to measure individual frequencies is to remove all frequencies except the one you want to count. This is seldom a problem since the signals which make up the video signal can usually be counted individually in a receiver or the sync generator circuits of a camera or studio. For example, the composite sync signals can be accurately counted at the vertical and horizontal oscillators respectively.

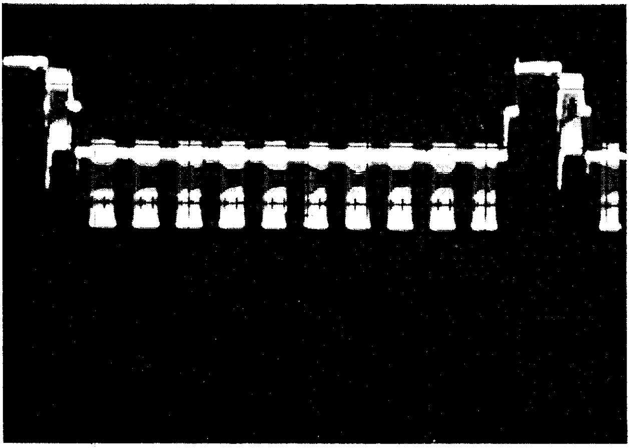

Fig. 24: A composite video signal consists of many frequencies. The FC71 will try to count all of them and may display an unstable or meaningless frequency.

PL Tones

The FC71 has several features that allow it to be used to measure PL ("Private Line") tones used in two-way radios. First, the FC71 has fast update to measure tones that last only a few seconds. Secondly, it will count the entire range of PL frequencies without needing to change ranges. This allows you to quickly determine an unknown PL tone.

The PL tone is modulated on the signal's carrier. Therefore, you must demodulate it before it can be counted. Most scanners and communications monitors have a "demod" output which can be used to feed the PL frequency to the FC71.

To count a PL Tone:

1. Connect the FC71 to the demod output of a receiver.

2. Tune the receiver to the carrier frequency which the PL is on.

3. Set the FC71 to the 10Hz - 100KHz frequency range, fast gate time. Use the slow gate time to obtain .01Hz resolution.

4. Key the transmitter. The FC71 will display the PL tone. Make certain that the microphone doesn't pick up any noise that would also be counted by the FC71.

Interfering Signals

So far we have discussed special considerations for counting signals that are hard to count because they have modulation or consist of several frequencies. In each case the signal was normal and did not contain any unwanted noise or interference. But signals are sometimes hard to count because of unwanted noise and interference. These signals are a bigger problem for most counters because you don't expect the interference and you are left wondering if the signal is wrong or if the counter is not working and causing an unstable reading.

The FC71 has special input circuits as part of its 1 megohm input which allow it to count signals that have too much interference for other frequency counters to count reliably. Briefly, here is how the FC71 works.

As the signal enters the FC71 it passes through a clipper stage. This stage acts as a "window", allowing only the middle portion of the signal to pass through. The window clips off the peaks of large amplitude signals along with interference such as ringing. The SENSITIVITY control adjusts the window's opening, compensating for different signal conditions.

This method is different than the AGC method used in other counters. Counters that use AGC automatically change the gain of the input circuit so that the whole signal, along with the noise, is passed on to the counting circuits. With the FC71 method, the interference is stopped before it goes any further into the counter.

After passing through the clipper, the signal applied to the FC71 is fed into a high gain amplifier. The gain of the amplifier is limited only by the supply voltages ("rails") of the IC. The input to the amplifier is relatively small, but the output is normally "rail to rail". The only time the output is not rail to rail is when the input signal is below the 5mV typical input sensitivity of the FC71. Because the signal is amplified hundreds of times and driven to the power supply rails of the chip, the slew rate of the IC amplifier filters out any remaining noise, such as transitional glitches and other signals which are slower, or smaller in amplitude.

Distorted Signals

Two types of distorted signals are shown in Figure 25. They are crossover distortion and harmonic distortion. Both types of distortion may cause an unstable reading, if the counting circuits are triggered by them. If the FC71 counts unstable at maximum sensitivity, reduce the SENSITIVITY control on the FC71. This will effectively remove the distorted peaks of the signal and pass a clean signal on to the remaining circuitry.

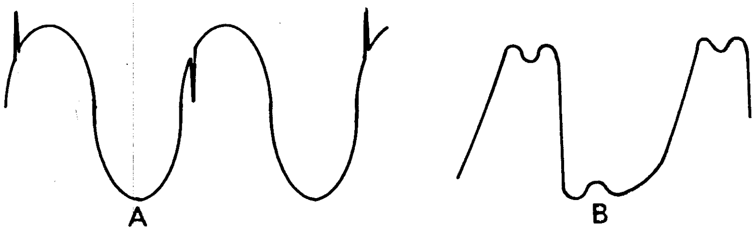

Fig. 25:Cross over distortion (a) and harmonic distortion (b) may cause a frequency counter to read in error.

Extra Signals

Figure 26 shows another type of interference where an unwanted signal gets on top of the signal you wish to count. For example, the 19KHz pilot may interfere with the audio signal in an FM transmitter, or perhaps the RF from an AM, FM, TV or some other high-power transmitter may be picked up by the circuit in which you are measuring a frequency.

The FC71 provides a stable, accurate count of the frequency which you are connected to unless the amplitude of the interference is close to the amplitude of the desired frequency. In general, the FC71 will count the frequency having the largest amplitude. Adjusting the SENSITIVITY control will have little effect since it will reduce both frequencies by the same amount.

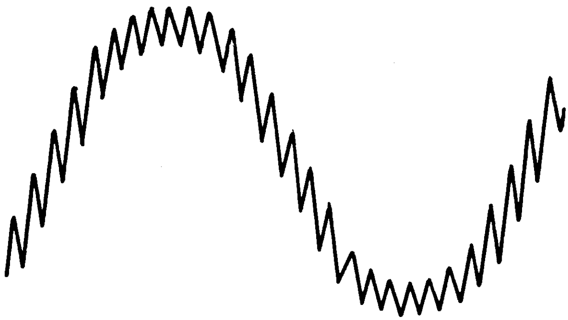

Fig. 26: The FC71 will ignore interference and count the desired signal.

The FUNCTION switch acts as a filter, eliminating those frequencies outside its range. For example, if you are measuring a 19KHz pilot with a carrier frequency of 100MHz riding on it, the FC71 will count 19KHz on the 10Hz - 100KHz range and 100MHz on the 10MHz - 100MHz range.

Digital Noise

Digital noise, as shown in Figure 27 results from noise getting onto a digital power supply, or from a signal from an input stage getting through to the output stage. If the signal is fed to most counters they will display a frequency that is too high. In most cases, the FC71 will provide an accurate, stable reading with the SENSITIVITY control at MAX. Again you may occasionally need to adjust the SENSITIVITY control for less sensitivity to obtain a stable reading on digital signals having a large amount of noise.

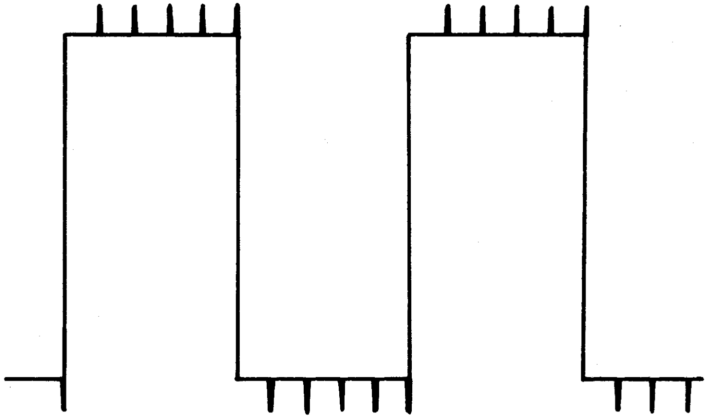

Fig. 27: Noise on a digital power supply, or a digital signal coupled through from an input stage, can cause a counter to read too high.

Ringing

Signals with fast rise times may have ringing, as shown in Figure 28. Ringing is often caused by an impedance mismatch between the circuit and FC71, resulting in standing waves on the counter cable. In a few cases the ringing may actually be occuring in the circuit, and the counter cable only contributes to the ringing. In either case, the FC71 will usually provide an accurate, stable reading at maximum sensitivity since the input clipper stage removes the ringing. If an unstable reading is caused by ringing, check the connection to the circuit. Try different circuit connections, such as the Direct and ISO positions of the counter probe. Also make sure that the cable is terminated as closely as possible to the impedance of the circuit. For example, if the FC71 is connected to a 50 ohm generator output, use the 50 ohm input of the FC71.

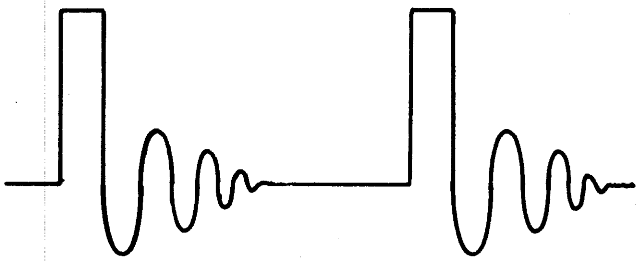

Fig. 28: Ringing is caused by a mismatch.

MAINTENANCE

The FC71 is designed to provide good service while requiring very little user maintenance. This section will provide you with the information necessary to keep your unit in good operating condition.

Replacing The 50 OHM Input Protection Fuse

The 50 ohm input is protected from overload by a protection fuse located inside the unit. If the protection fuse needs replacement, the LCD will indicate "FUSE Bad" when the FUNCTION switch is set to either of the 50 ohm positions.

Two spare fuses are supplied with the FC71. They are located on the signal PC board, beside the 50 ohm input, as shown in figure 29. The case must be removed to gain access to the fuses.

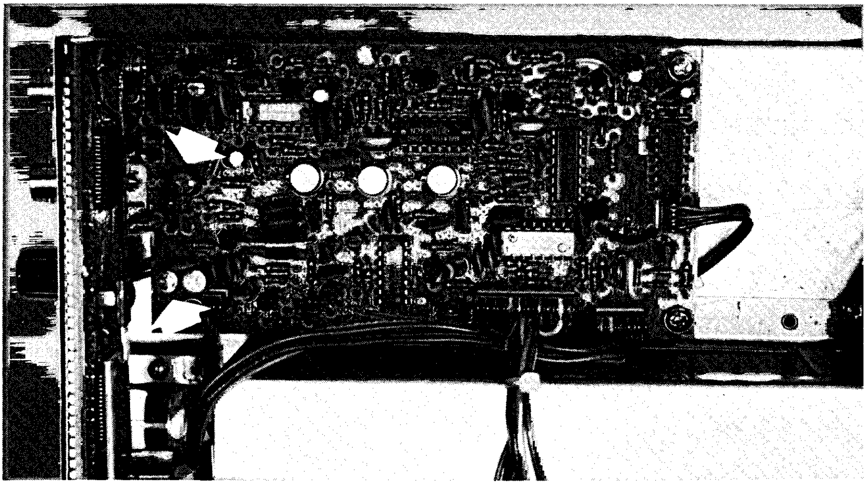

Fig. 29: The 50 ohm protection fuse, and replacement fuses are located inside the FC71 near the input.

To replace The 50 Ohm protection Fuse:

1. Stand the FC71 upright with the handle and front panel facing upward.

2. Remove the four screws (two on each side) at the rear of the unit.

3. Gently pull on the handle while holding the back portion of the case. The case will slip easily away from the chassis.

4. Remove the open protection fuse from its location on the PC board behind the 50 ohm input. Grasp the fuse firmly with a pair of needle-nose pliers and pull it straight away from the board.

5. Replace the protection fuse with one of the spare protection fuses.

WARNING

Only replace the 50 ohm input protection fuse with a 1/8 amp, microfuse. A larger fuse may cause internal damage to your FC71 and will void all warranties. Additional spare fuses (part number 44G21) may be ordered from the Sencore Service Parts Department.

6. Re-assemble the FC71 by reversing Steps 1-3 above.

Verifying Accuracy Of The FC71

The accuracy of the FC71 may be verified at any time by one of the methods listed below. If your FC71 is used for FCC documentation, its accuracy should be traceable to the National Bureau of Standards. If, on the other hand your FC71 is used for troubleshooting, lesser accuracy may be allowable, in which case a non-NBS traceable source is acceptable. Choose the method that gives you the necessary accuracy.

NOTE: The FC71's accuracy cannot be verified by using the method of zero beating its internal oscillator to a 10MHz standard, or receiver tuned to WWV. The reason for this is explained in the section "How the FC71 Is Calibrated".

A good method of verifying the accuracy of the FC71 is to inject a known frequency having at least .05PPM (.000005%) accuracy. (The FC71 will be at least .5PPM accurate if it reads the .05PPM frequency exactly.) To obtain the best accuracy check of the FC71, the frequency should be at least 10MHz. There are several possible sources of this frequency.

First, a known accurate, recently calibrated communication monitor with a signal generator that is accurate to .05PPM may be used. In addition, some communication monitors allow you to receive WWV (the NBS frequency standard) to check calibration. Check your individual communication monitors for specific instructions.

Special WWV receivers are also available and may be used. To avoid propagation errors caused by changing atmospheric conditions, these receivers should compare a long time (usually 100 seconds) WWV signal to a local reference oscillator. Receivers of this type are available in many calibration labs and some large 2-way shops.

NOTE: A shortwave receiver should not be used as a WWV receiver. Most shortwave receivers use a superhetrodyne principal resulting in a tuning error too great for counter calibration.

A final way of verifying accuracy using a more accurate signal is to use another, more accurate frequency counter as a "standard" to verify a less accurate generator frequency. First measure the frequency of the generator with the counter. Write down the exact reading of the counter. In order to achieve the best accuracy, the counter should show more digits of resolution than the FC71. Apply the generator signal to the FC71. The FC71 should read the frequency within the combined tolerances of .5ppm (FC71 accuracy) and the tolerance of the counter used as the "standard".

If none of the above .05ppm signals are available, the color subcarrier of a network television program may be used to check the FC71 accuracy to within .28ppm. (The FC71 will be accurate to at least .28ppm if it reads the signal exactly.) Not all television stations are locked to network sync, however. If they are not locked to network sync, the color sync subcarrier frequency will not be NBS traceable. Before using the following procedure, be sure that the station you are tuned to is locked to network sync by calling the station and speaking to an engineer. If they are feeding the network signal directly or have their local sync generator "gen-locked" to the incoming network signal, you can rely on their signal being accurate. If they are using a "frame synchronizer", the network program is locked to their local master oscillator, meaning the signal is only as accurate as the local station's crystal oscillator, which is not accurate enough to use as a "standard".

To Verify FC71 Accuracy Using a TV Color Subcarrier:

WARNING

This procedure requires that you make a frequency measurement in a color television receiver. TV receivers contain possible lethal voltages at certain areas such as the high voltage, boost, and focus voltage sections. Use an isolation transformer to reduce the shock hazard of a "hot chassis". Use extreme caution when making connections to avoid a dangerous shock or damage to your FC71.

1. Remove the cabinet or the back from a properly working color TV receiver so you can gain access to the chassis.

2. Locate the output of the receiver's color burst oscillator and find a point that is isolated from the oscillator by at least one buffer stage. (The counter probe will be connected to this point later, in Step 5.) Connecting to a buffer stage will prevent the oscillator from being pulled off frequency. The RF Pickup Loop may be used instead of the Counter Probe to prevent circuit loading.

3. Tune the receiver to a local station whose signal is locked to a color, network program.

4. Fine tune the receiver for a proper color picture on the TV screen.

5. Connect the 1 meg input of the FC71 to the point you located in Step 2.

6. Verify that the TV receiver is still properly color-locked after the connection is made.

7. Select the slow gate time and the 100KHz - 100MHz range on the FC71.

8. Read the oscillator's frequency.

The proper burst oscillator frequency is 3.579545MHz. The .5ppm accuracy, +/− 1 count error of the FC71 allows a +/− 3 count variation from this frequency (3.579542 to 3.579548MHz). Taking the .5ppm one year aging into account, the FC71 should read between 3.579540 and 3.579550MHz after one year.

If the FC71 reads outside these limits, it must be recalibrated.

Recalibration

The FC71 should be periodically checked to verify accuracy and performance within its published specifications. If the FC71 is found to be out of tolerance it should be recalibrated. The Sencore Service Department provides complete recalibration services.

If the only calibration that is required is for frequency accuracy, a replacement module and EPROM may be ordered from the Sencore Service Department. The timebase module and the EPROM must be replaced as a pair. Their replacement can easily be done in the field. Complete replacement instructions are included with the new module and EPROM. A certificate of recalibration is also included with each replacement module and EPROM to meet FCC requirements.

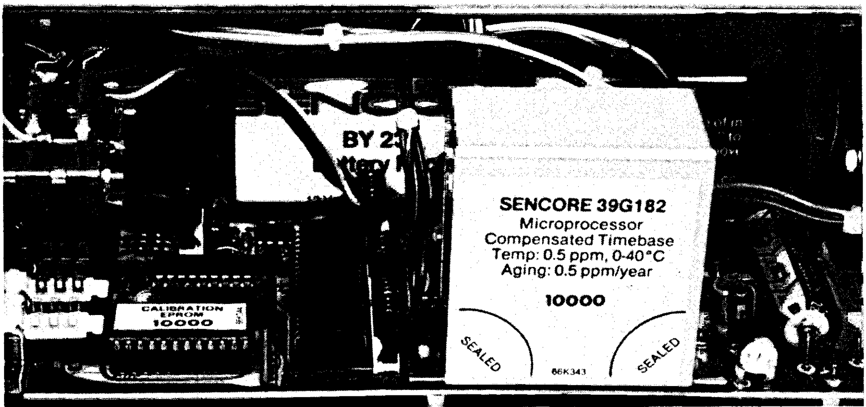

Fig. 31: The FC71 is recalibrated by replacing the crystal timebase along with the microprocessor memory which contains the calibration data.

WARNING

Avoid damage to parts caused by static electicity!

The EPROM is very static sensitive. Also most other solid-state devices and film resistors are susceptible to damage due to discharge of static electricity. Observe the following precautions when the EPROM is removed from the unit, or when handling other components and PC boards:

1. The person handling the part must be grounded through a 1 megohm resistor via a wrist strap or similar ground connection.

2. A PC board or component should never be placed on an insulated surface. The surface must be grounded (through a 1 megohm resistor) and conductive.

3. All replacement parts must be left in completely enclosed, conductive container or package until ready for use. The person removing the part from the container must be properly grounded. All parts susceptible to static damage are shipped in conductive containers when ordered from the Sencore Service Department.

How The FC71 Is Calibrated

The following paragraphs give a brief overview of how the FC71's accuracy is achieved and explains why field calibration, except for timebase module and EPROM replacement, is not recommended.

The FC71 uses a microprocessor compensated crystal timebase which doesn't operate at a conventional timebase frequency of 10MHz. In addition, the crystal timebase, (which is also the clock for the microprocessor) is allowed to change with temperature. The exact amount that the crystal changes is unique to each crystal. Calibration information for the crystal is programmed into the microprocessor's memory. The microprocessor senses the crystal's temperature and automatically compensates for the crystal's change before each update.

In order to recalibrate the FC71, a known, very accurate, NBS traceable frequency must be applied to it. Then the temperature of the crystal must be varied over the FC71's operating range while the change in the crystal's frequency is monitored and recorded. Finally, a correction factor for the crystal's change must be programmed into the micoprocessor's memory. The equipment necessary to calibrate the FC71 includes an NBS traceable frequency source, a controlled temperature chamber and an EPROM (Electrically Programmable Read Only Memory) programmer. Specific calibration instructions, as well as a complete circuit description are available from the Sencore Service Department.