SM-512 SERVICE MANUAL

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SM-512 SERVICE MANUAL

OPERATING INSTRUCTIONS

The following is a partial set of operating instructions intended to assist in the maintenance and repair of the SM-512. Full operational instructions are included in the operator's instruction manual.

DESCRIPTION OF FRONT PANEL CONTROLS:

POWER SWITCH	OFF Position	In this position, the instrument is inoperative except for battery charging, the crystal oven , and the channel entry memory which are maintained as long as the power cord is connected to the AC power source.
	AC Position	Instrument is operated from the AC power source.
	BAT Position	Instrument is operated from the internal battery. About one hour of operation is available from a fully charged battery.
POWER LIGHT		Lit when the instrument is operated from AC. In battery operation, the light wil light only if the battery has sufficient charge for proper operation.
BATTERY CHARGE SWITCH	OFF Position	Battery is-charged at a low rate whenever the power cord is connected to the AC power.
	FAST CHARGE Position	Battery is charged at a rate that will result in a full charge in 10-14 hours.
ΔF-DENS	ΔF	Left hand meter indicates KHz offset from indicated frequency.
	DENSity	Left hand meter indicates Modulation Density.

DESCRIPTION OF FRONT PANEL CONTROLS (CONTINUED)

MOD-SINAD	MODulation	Right hand meter indicates Peak Modulation Deviation
	SINAD	Right hand meter indicates SINAD
GEN-MEAS	GENerate	To GENerate a test signal
	MEASure	To MEASure a received signal
ΔF	In the GENerate mode, the ΔF control is used to determine the offset (if any) between the generated frequency and the frequency shown on the numerical readout. This control has no function in the MEASure mode.	
SET 0	Used to calibrate the ΔF measuring circuits so the ΔF meter indication will be correct. Adjustments of the SET 0 control must be done when the ΔF-DENS switch is in the ΔF position . The SET 0 knob must be pushed in all the way and then rotated to obtain a zero (center scale) reading on the ΔF meter. Avoid moving this control except when following this practice, because this will introduce errors in the ΔF readings.	
SET MOD	Adjusts the 1 KHz modulation tone level in the GENerate mode. This control has no function in the MEASure mode.	
RF OUT microvolts	Left control Right control	Vernier .1 to 1 microvolts Multiplier 1 to 100K
VOL	Controls the loudness of the loudspeaker	
SQUELCH	Used to silence the loudspeaker in the absence of any signal in the MEASure mode	
5 KHz Lamp (red)	Indicates modulation peaks of 5 KHz or more	
4.5 KHz Lamp (yellow)	Indicates modulation peaks of 4.5 KHz or more	
DISPLAY	Indicates selected channel storage number and frequency (see Channel Frequency Entry)	

OPERATION FROM VEHICULAR BATTERY SYSTEM (SERIAL # ABOVE 5725)

The SM-512 can be operated from a car or truck battery system, but operation is only possible on 12.6 volt systems with negative battery ground. The external battery input jack is located just above the AC power receptacle on the rear panel of the SM-512. A matching plug for this jack is shipped with the SM-512.

It is intended that the purchaser construct a battery power cable for his particular application. Use the same methods and precautions as in the installation of a radio trans ceiver. An alternator whine filter may be required. If the battery voltage falls much below 12.6 volts, the power indicator light on the SM-512 will go out as a warning that proper operation may not be relied upon.

To operate the SM-512 from the external battery, switch the power switch to the AC position.

The internal battery charging function of the SM-512 is operating when the external battery jack is connected to a suitable battery source. Thus, the internal battery can be charged while traveling between jobs, or even while the vehicle is parked. If the vehicle is parked for long periods, the operator should be aware of the constant drain on the vehicle battery (.5 ampere on fast charge with Power switch OFF).

NOTE: The external DC power input jack and the AC power cord should never be connected to power sources simultaneously.

OPERATING INSTRUCTIONS

CHANNEL FREQUENCY ENTRY

Press: MANUAL until desired channel appears
Press: desired frequency
Press: E (Enter)

Example:

To program 152.270 MHz into channel #5:

Press: MANUAL repeatedly to step to channel # 5
Press: 1 5 2 . 2 7 0
Press E (Enter)
Read: 5 152.270

CHANNEL FREQUENCY ENTRY FOR UHF 12.5 KHZ OFFSETS

To program 462.1375 MHz into channel #8:

Press: MANUAL repeatedly to step to channel #8
Press: 4 6 2 . 1 3 7 5 E
or
4 6 2 . 1 3 7 E
or
4 6 2 . 1 3 8 E
Read: 8 462.137 (note that although the final .5 is not showing, the frequency generated is the offset frequency, 462.1375)

TO MOVE TO ANY PREPROGRAMMED CHANNEL (e.g.#14)

Press: MANUAL repeatedly to step to desired channel
or
Press: 1 4 MANUAL

If you attempt to program a frequency outside the tuning range of the instrument, the display will show "error". If this happens, enter a new frequency.

If you make a mistake programming a frequency, Press E, then enter correct frequency.

OPERATING INSTRUCTIONS

TO GENERATE A TEST SIGNAL

1. Enter desired channel into the instrument.

2. Set GEN-MEAS switch to GEN (GENerate).

3. Set ΔF-DENS switch to ΔF position.

4. While pushing inward on SET 0 control knob so the top scale on M1 reads exactly 0 (center of scale). Check this adjustment from time to time by pushing in on the knob to be sure that the setting has not drifted.

5. Assuming that you wish to generate the exact frequency entered into the readout, adjust the ΔF control so that the top scale on M1 reads exactly 0. If you wish to generate a frequency removed slightly (say 1½ KHz) from the channel shown on the display, adjust ΔF so that the so that the top scale on M1 reads to the right 1.5 KHz.

   NOTE: On low band (30-50 MHz) the direction of M1 is reversed, and you should set ΔF to obtain a reading of 1.5 KHz to the left.

   NOTE: In generating a 12.5 KHz offset channel in the UHF band the display will not show the .5 KHz portion of the channel frequency. It is not necessary to set the ΔF control for a reading of .5 KHz on M1 to generate the exact 12.5 KHz offset frequency. EXAMPLE: Wanted channel is 462.1375, display reads 462.137 ΔF meter reads 0. Instrument is generating 462.1375.

6. To set modulation to the desired deviation: switch MOD-SINAD switch to MOD position . Turn the SET MOD control until the desired modulation deviation is indicated on the top scale of M2. The modulation source, which is controlled by the SET MOD control, is an internal 1,000 Hz oscillator , and is used for alignment and for measuring SINAD.

   If it is desired to modulate the signal with other sources (e.g. a CTCSS tone or a digital squelch signal) an external generator can be connected to the EXT MOD IN jack, and the modulation deviation adjusted by the level control on the external generator. The amount of modulation deviation will show on M2. Approximatly ½ volt RMS of input to the EXT MOD IN jack is needed to obtain 5 KHz of peak deviation.

7. To set the RF output amplitude to the desired level: Use the RF OUT controls in combination to obtain the wanted output amplitude. The control to the right is a step attenuator with 20 dB steps (i.e. X 10 voltage steps), and the control to the left is a continuously variable control.

TO GENERATE A TEST SIGNAL (CONTINUED)

8. The generated signal is available at the RF OUT jack. Connect the receiver to be tested there. If a transceiver is connected, be careful not to key the transmitter. The instrument is protected by a fuse which is part of the RF OUT jack.

TO MEASURE A TRANSMITTER SIGNAL

1. Connect a suitable pickup antenna to the RF IN jack. For nearby transmitters, the antenna supplied with the instrument will be satisfactory. DO NOT connect any transmitter output into the RF IN jack. This jack is not fused ,and serious damage could result.

2. Enter the desired channel into the instrument.

3. Set GEN-MEAS switch to MEASure.

4. Set ΔF-DENS switch to ΔF position.

5. While pushing inward on SET 0 control knob, adjust the knob so the top scale on M1 reads exactly 0 (center of scale). It will be necessary to check this adjustment from time to time by pushing in on the knob to see that the setting has not changed.

   NOTE: Adjustment of the SET 0 control is always done with the ΔF-DENS switch in the ΔF position.

6. Adjust the SQUELCH control to the edge of the noisy condition--as you would in an FM receiver.

8. When the ΔF-DENSITY switch is in the ΔF position, the upper scale on M1 indicates how many KHz the received signal differs from the channel frequency shown on the display. Readings to the right indicate that the transmitter is above the channel frequency, except on low band (30-50 MHz), when the direction of M1 is reversed.

   NOTE: When set to a 12.5 KHz offset channel in the UHF band, the display will not show the .5 KHz portion of the channel frequency, and M1 will show the deviation from channel center. EXAMPLE: Actual frequency is 462.1375. Display reads 462.137. M1 reads 0. Received signal is on 462.1375 MHz.

TO MEASURE A TRANSMITTER SIGNAL (CONTINUED)

9. Set the MOD-SINAD switch to the MOD position. M2 will then indicate the peak modulation deviation of the received signal.

NOTE: The circuits driving M2 have two important features: (1) An "AUTOPEAK" (tm) circuit that selects the greater of the positive and negative peaks and displays it. (2) A meter "hold" circuit that speeds the upward movement of the meter needle, while slowing its return.

10. Peak Deviation Flashers: The 4.5 KHz and 5 KHz flashing LEDs permit a rapid GO,NO-GO check of the transmitter deviation control. If the 5 KHz LED does NOT flash, and the 4.5 KHz LED DOES flash, the deviation setting is correct. These indicators will catch peaks that are too fast for a meter to display properly.

Use the meter primarily for measurement of steady signals, such as tone and data. It will be noticed that the peak flashing LEDs will register on voice peaks that are too fast for the meter to follow. This is a normal condition. When the meter is measuring steady tone modulation of a transmitter, the peak flashes should coordinate with the meter. The AUTOPEAK (tm) circuit of the SM-512 measures both the positive and negative peaks and presents the greater value on the meter and on the LED flashers.

The modulation of FM transmitters is not necessarily symetrical. That is, positive modulation peaks may be greater, or less, than negative going peaks. Most modulation meters are activated by the average of the positive and negative peaks, or merely indicate one or the other. For proper system operation, neither of the modulation peaks should exceed 5 KHz.

For accurate modulation deviation measurements, you must have a signal strong enough to be noise free. Otherwise noise peaks will add to the peaks caused by modulation, and will cause an improperly high reading.

11. To measure Modulation Density of the received signal, set the ΔF-DENS switch to the DENS position. Modulation density will then be indicated by the lower scale of M1. To make a Density measurement, be sure that the peak deviation of the transmitter is between 4.5 and 5 KHz, as indicated by frequent flashing of the 4.5 KHz LED, and no flashing of the 5 KHz LED. Then observe the signal for a few seconds, noting the maximum reading that is repeatedly achieved on the Density meter.

Density readings in the vicinity of 6 to 8 Density Units indicate a proper degree of speech clipping in the transmitter.

MINOR MAINTENANCE AND RECALIBRATION

INTRODUCTION:

This section provides directions for recalibration and minor maintenance of the SM-512. For major maintenance problems the technician should read the THEORY OF OPERATION section which follows this section.

IMPORTANT:

The SM-512 utilizes special shielding tape with conductive adhesive to hold the inner shields in place. This shielding tape is necessary to maintain the RF radiation integrity of the instrument and must be replaced with new tape if it has been removed. The top and bottom covers can be removed to obtain access to certain adjustments without disturbing any tape. For procedures which require access inside the top and bottom shields, a supply of tape for replacement should be on hand.

The internal layout and certain circuitry of the SM-512 underwent a major revision at Serial # 5725. Where a difference is involved, the text will refer to serial numbers as "below 5725" and "above 5725".

FREQUENCY STANDARD CALIBRATION

The channel frequency accuracy of the SM-512 is dependent upon a stable 10.4 MHz crystal oscillator. The crystal is enclosed in a temperature stable "oven" . This oven is operative at all times that the power cord is connected to AC or external DC power and when the instrument is being operated on its internal battery . To retain the rated accuracy, the frequency of the 10.4 MHz oscillator should be checked , and (if necessary) corrected at certain intervals. Since crystals exhibit their most rapid aging during the first few months of operation, checking should be done most frequently while the instrument is new. A suggested schedule is at the end of the first month of operation, the third month, the sixth month, the twelfth month and annually thereafter.

The isolated output of the 10.4 MHz oscillator is provided by a BNC connector on the rear panel. The frequency can be checked by connecting a suitably accurate frequency counter to this jack. Checking should be accomplished after the SM-512 and the frequency counter have been in operation for several hours in a room with an ambient temperature of about 27C (80F).

FREQUENCY STANDARD CALIBRATION:(CONTINUED)

If the 10.4 MHz oscillator is more than 5 Hz from 10.4 MHz, resetting of its frequency is advisable. To reset the oscillator, the top outer cover of the SM-512 must be removed. (DO NOT remove the inner shield, which is visible when the outer cover is removed). The oscillator frequency setting adjustment is C105, accessible through the top shield.

A secondary crystal, operating at 10.8 MHz is used in the SM-512 for the operation of the SET 0 control. This frequency enters into the accuracy of the SM-512, but to a much lesser degree than does the 10.4 MHz crystal. With the top cover removed, you can observe the access hole for C104, the control for setting the frequency of the 10.8 MHz crystal. Insert a test lead into the hole. Place the 10.8 MHz crystal in operation by pushing in on the SET 0 control, and observe the frequency on a frequency counter. Then adjust C104 to within 20 Hz of 10.8 MHz, as indicated by the frequency counter

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REPLACEMENT AND TESTING OF RF OUT FUSE

The RF OUT jack is equipped with a fuse to protect the instrument in the event that a transceiver is keyed while connected to the jack.

The fuse may be tested only with a "low power" ohmmeter. Standard ohmmeters may deliver sufficient current to the fuse to blow it out.

To make the test, set the RF OUT (microvolts step attenuator to any position except the 100,000 position. Then check the resistance between the center pin of the RF OUT jack and the outer shell. A resistance of about 53 ohms indicates a good fuse.

The fuse may be replaced without opening the instrument. Use a BNC type connector as a wrench to unscrew the front barrel of the RF OUT jack (turn counterclockwise to remove). CAUTION: Unscrew only the forward portion of the fuse holder. DO NOT disturb the hex nut. Remove the fuse with a needle nosed plier or tweezer and replace with a good fuse. When replacing the front barrel, do not tighten excessively. Replace the fuse only with a 1/8 ampere Picofuse, catalog number 275.125, manufactured by Littlefuse Corp.

The use of other fuses, or use of a wire substitute may result in serious and expensive damage to the instrument.

ADJUSTING PEAK DEVIATION FLASHERS

When the instrument is shipped from the factory, the peak deviation flashers have been set so that the red LED flashes at 5 KHz Peak Deviation, and the yellow LED flashes at 4.5 KHz Peak Deviation. These flashers may be set to respond to other levels to accommodate special system requirements. The adjustment procedure follows:

Set GEN-MEAS to GEN
SET ΔF-DENS to ΔF
Set ΔF control so top scale of M1 reads 0
Set MOD-SINAD to MOD
Set SET MOD to level at which you want red Led to flash
Locate access hold for R42 (rear panel) and adjust R42 so red LED just flashes.
Test setting by varying SET MOD control about the desired modulation value.

Once the flash level of the red LED is set, the yellow LED will flash at approximately 90% of that level.

CENTERING THE ΔF CONTROL

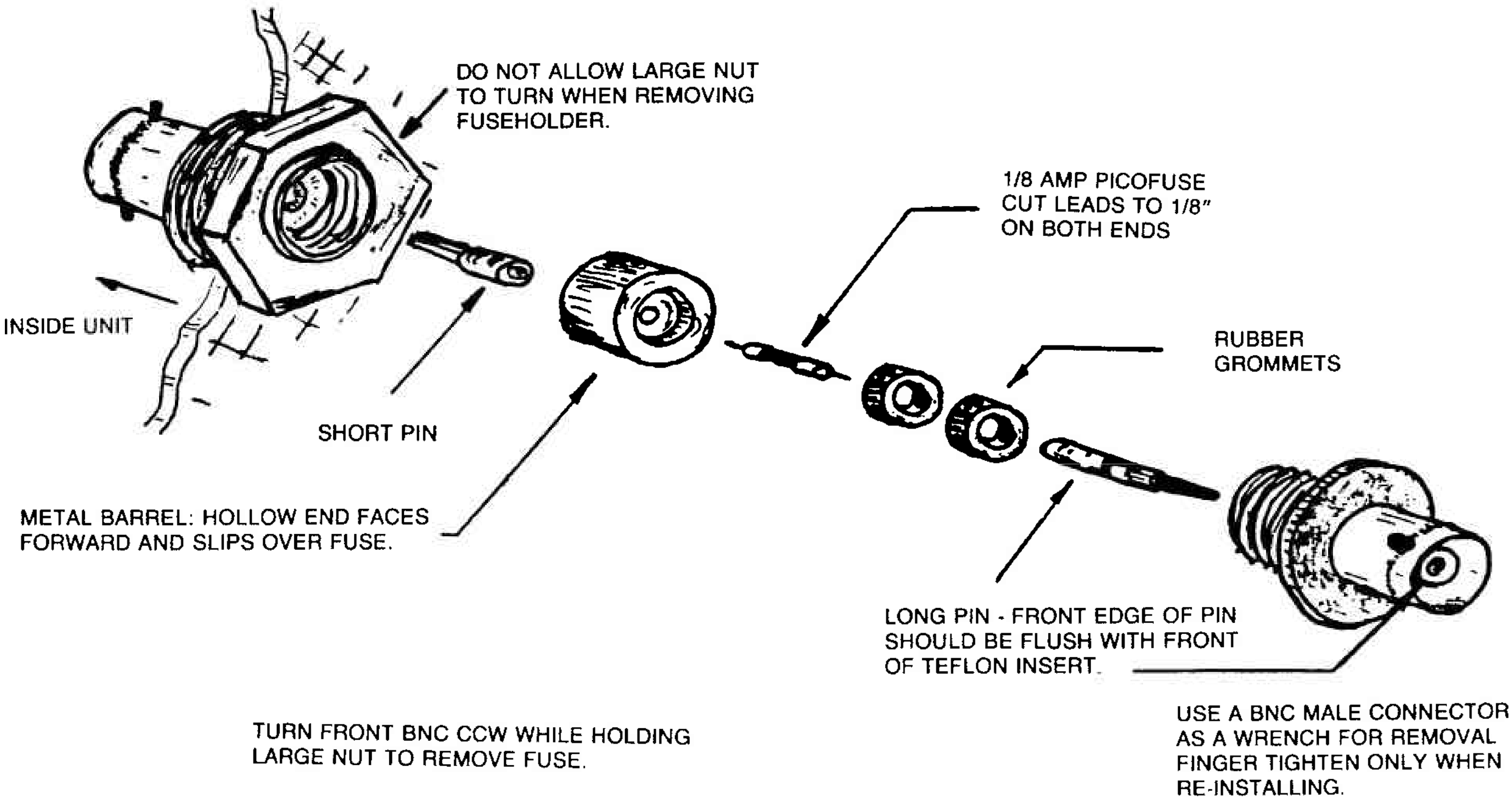
Once the SET 0 control has been properly adjusted as outlined in the operation instructions, with the instrument in the GENerate mode, it should be possible to swing the ΔF reading on M1 all the way from plus 5 to minus 5 KHz by rotating the ΔF control. If component aging should make this impossible, a readjustment of T201 will correct the problem.

Access to T201 may be obtained by removing the outer bottom cover of the SM-512. DO NOT remove the inner shield. A hole in the inner shield provides access to T201.

This is the procedure for making the adjustment:

Set GEN-MEAS switch to GEN position
Set ΔF-DENS to ΔF position
While pushing in on SET 0 control, adjust it to obtain a reading of 0 (center of scale) on M1. Release SET 0 knob. Set ΔF control to the center of its rotation.
Adjust T201 to obtain a reading of 0 (center of scale) on M1.

PICOFUSE INSTALLATION



MINOR MAINTENANCE AND RECALIBRATION

CALIBRATING OUTPUT LEVEL

The RF output level is best checked using a spectrum analyzer. In the absence of a spectrum analyzer, a bolometer type RF power meter , accurate at the power level involved can be used.

To check the output level, set the RF OUT step control to 100 K and set the variable RF OUT control to 1.0 (note that 1.0 is not the maximum clockwise rotation of the variable control--the knob on this control should be oriented on the shaft so that it extends equally past the .1 and the 1.0 markings at its counterclockwise and clockwise limits of rotation.

This setting should produce 1,000 microvolts (- 7 dBm) reading on a spectrum analyzer. If you are measuring the level with a bolometer type RF power meter, the power level should read 3 dB higher, because the power meter will "see" the image signal as well as the main signal.

If found to be inaccurate, the RF level can be corrected by adjusting R212 while observing the output level as described in the above paragraph. For access to R212, remove the bottom outer cover from the SM-512. R212 can be adjusted through an access hole in the bottom inner shield. It is not necessary to remove the inner shield. Use a 150 MHz channel for the adjustment.

RF AGC ADJUSTMENT

If it is found that the RF output level varies excessively from frequency to frequency, a readjustment of the AGC system in the RF ADAPTOR board may be required. It is unlikely that such adjustment will be needed unless components in the RF board have been replaced.

Program the following frequencies into the SM-512 memory:

Serial below 5725	Serial above 5725
30 MHz	30 MHz
50	50
144	136
174	174
420.5	406
440	440
480	480
512	512

RF AGC ADJUSTMENT (CONTINUED)

Connect a spectrum analyzer to the RF OUT jack on the SM-512. Set both RF OUT controls to the maximum level. Set the SM-512 to generate an unmodulated RF signal at 30 MHz. You should see a pair of signals with equal amplitude at 30 MHz and 51.6 MHz of approximately -7 dBm (100,000 microvolts). You should also see another pair of signals of lower amplitude at twice these frequencies, and a third pair of signals at three times the frequencies.

Temporarily, set R212 (on RF board) full counter clockwise, and set R236 full clockwise. The 30 MHz and 51.6 Mhz signals should now have an amplitude of about 0 dBm and the second and third pair of signals will show a corresponding increase in amplitude. Now, slowly turn R236 in the counter clockwise direction. The 30 and 51.6 MHz pair will decrease as you turn R236. While turning R236, you will see the second and third pair suddenly switch amplitudes. (i.e. the second pair had the greater amplitude, suddenly the third pair will be the greater). Set R236 to the point where the third pair of signals are about three dB higher than the second pair. This is the correct setting of R236. Then set R212 so that the level of the 30 MHz and 51.6 MHz pair is -7 dBm.

Now, go through the frequencies which were programmed into the SM-512 and see if the output level remains at -7 dBm plus or minus ½ dB. If the level changes from one end of the UHF band to the other, it may be corrected by adjusting C20 (on scanner serial below 5725) or CT3 (on scanner serial above 5725 for a compromise between the two ends of the band.

METER ZERO ADJUSTMENTS:

Place the SM-512 in its usual operating position. If panel is normally tilted by using the bail, make adjustments in that position.

Set the BAT-AC-OFF switch to OFF, and adjust the mechanical zero adjusters on M1 and M2 for exactly 0 readings.

Set the BAT-AC-OFF switch to AC.

Set GEN-MEAS switch to MEASure.

Set ΔF-Dens to DENS.

Set MOD-SINAD to MOD

Set SQUELCH fully counterclockwise (silent position)

METER 0 ADJUSTMENTS (CONTINUED)

Adjust R28 to obtain a 0 reading on M2. Note that this corresponds to a 0 reading on M1, but M1 settles to 0 slowly. R28 is accessible through the rear panel in serials above 5725. The bottom shield must be removed for access to R28 in serials below 5725.

CALIBRATION OF THE MODULATION DEVIATION METER:

Prior to shipment from the factory, the modulation deviation meter is calibrated using the highly accurate Bessel Function method. Should it be necessary to adjust the calibration, use the following procedure:

Be sure that you have an accurately calibrated standard of modulation deviation before you attempt to calibrate your SM-512

To calibrate using a signal source:

Set GEN-MEAS to MEASure.

Set calibrated source and SM-512 to same channel frequency.

Set source to at least 100 microvolts.

Set calibrated source to 5 KHz peak modulation deviation.

Adjust R5 (rear panel) to obtain a reading of 5 KHz on M2.

If you are using a modulation standard that operates from a modulated signal, use this procedure:

Set GEN-MEAS to GENerate.

Set MOD-SINAD to MOD.

Set RF OUT controls to signal level required by standard.

Set SM-512 to channel frequency required by standard.

Adjust SET MOD until standard shows 5 KHz peak modulation.

Adjust R5 (rear panel) to obtain a reading of 5 KHz on M2.

MINOR MAINTENANCE AND RECALIBRATION

CALIBRATION OF DENSITY METER:

Set GEN-MEAS to GENerate.

Set MOD-SINAD to MOD.

Adjust SET 0 and ΔF controls for a ΔF reading of 0 as in normal operation.

Adjust SET MOD for 4 KHz deviation as shown on M2.

SET ΔF-DENS to DENSity.

Adjust R36 to obtain a full scale reading on M1. R36 is accessible through the rear panel on serials above 5725. On serials below 5725, it is necessary to remove the bottom inside shield.

CALIBRATION OF ΔF METER:

Accurate adjustment of the ΔF calibration requires a signal generator operating at any frequency within the SM-512 coverage range, and having digital means to vary the frequency in accurate 1 KHz steps. For this instruction, a generator having a center frequency of 40.005 MHz is assumed.

Set GEN-MEAS switch to MEASure.

Set ΔF-DENS switch to ΔF.

Enter the frequency of 40.005 MHz into the SM512.

Set the test generator to 40.005 MHz, unmodulated, output of about 100 microvolts.

Connect test generator to RF IN connector of SM-512.

Adjust the SET 0 knob so M1 reads at the center scale 0. Do NOT push in on the SET 0 knob as you would in normal operation.

Increase the test generator frequency to 40.009 MHz. The M1 indication should move to the 4 KHz mark on the left. If not, make an adjustment to R41 (rear panel) to bring the indication to 4 KHz, then continue adjusting R41 an equal amount in the same direction.

Change the test generator frequency back to 40.005 KHz. Adjust SET 0 knob again (do not push in) so M1 reads center scale 0.

CALIBRATION OF THE ΔF METER: (CONTINUED)

Decrease test generator frequency to 40.001 MHz. If the M1 indication is 4 KHz to the right, you have completed the adjustment. If not make another adjustment of R41. Continue the process until the proper adjustment is achieved.

CORRECTION OF 1,000 Hz INTERNAL GENERATOR:

For best operation of the SINADDER function, the internal 1,000 Hz tone generator should be within 2 or 3 Hz of 1,000 Hz. The frequency of the internal tone generator can be checked and/or corrected as follows:

Set GEN-MEAS to GENerate.

Set MOD-SINAD to MODulation.

Adjust SET MOD to obtain 5 KHz reading on M2.

Connect a frequency counter to the DEMOD OUT jack (rear panel).

If necessary adjust R55 to obtain a 1,000 Hz reading on the frequency counter. R55 is accessible through the rear panel on serials above 5725. On serials below 5725 it is necessary to remove the bottom inside shield.

BATTERY REPLACEMENT:

The battery is located inside the bottom inside shield. To gain access to the battery, remove the bottom cover of the SM-512, and the bottom inside shield. The inside shield utilizes a special shielding tape with conductive adhesive which will have to be removed. This shielding tape is necessary to maintain the RF radiation integrity of the instrument. A supply of tape should be on hand before removing the bottom inside shield. Replacement batteries and shielding tape are available from Helper Instruments Co.

CHANGING AC POWER SUPPLY VOLTAGE:

To change AC Power remove the fuse, using the "fuse pull" lever. Remove the printed circuit card, and replace it so that "120 or "240" shows. Insert a fuse. Proper fuse for 120 volts is ½ ampere; for 240 volts, use ¼ ampere fuse.

OVERALL THEORY OF OPERATION

The theory of operation is best followed if one has first read the operating instructions. Abbreviated operating instructions are included at the first of this manual.

Refer to the SM-512 block diagram. The SM-512 Service monitor is built around a popular brand scanner receiver. The reference crystal oscillator of the receiver has been modified to accomplish the rated frequency stability of the monitor, primarily by the use of a tightly regulated temperature control oven. The scanner's reference crystal operates at 10.4 MHz, and all of the LO injection frequencies for the various channels are derived from this reference frequency.

The frequencies covered by the SM-512 are as follows:

	SERIAL BELOW 5725	SERIAL ABOVE 5725
LOW BAND	30-50 MHz	30-50 MHz
HIGH BAND	144-174 MHz	136-174 MHz
UHF BAND	420.5-512 MHz	406-512 MHz

MEASURE MODE

In the MEASURE mode, the scanner receives off-the-air signals via the RF IN jack . The output of the scanner receiver's discriminator is fed to the Modulation and SINAD board, where measurement circuitry provides current drive to operate the meters which indicate Modulation Deviation, Modulation Density, and ΔF. The measurement circuitry also provides drive to the 5 KHz and 4½ KHz LED indicators. The SET control (associated with the Modulation and SINAD board) is used to calibrate the ΔF meter reading to the proper center indication. When doing this calibration, the SET 0 knob is pushed in, thereby turning on a 10.8 MHz crystal controlled oscillator for reference, while the SET 0 knob is rotated to obtain a 0 center reading on the ΔF meter.

GENERATE MODE

In the GENERATE mode, energy from the scanner receiver's frequency synthesizer is fed to the RF adaptor board. Two connections for obtaining this energy are used, one for the low band and high band, and another for the UHF band. A DC control voltage from the scanner receiver (a positive

GENERATE MODE (CONTINUED)

voltage on UHF band) causes switching to occur in the RF adaptor board, connecting the proper synthesizer output to a coaxial lead that feeds the synthesizer energy to the RF board. In the RF board. an amplifier with tight AGC amplifies the synthesized signal to a fixed level and delivers it to Mixer M202.

Also in the RF board, a 400 KHz VCO is mixed with the 10.4 MHz synthesizer reference frequency to create a 10.8 MHz signal. This 10.8 MHz signal is fed to mixer M202, where it is mixed with the synthesizer signal. On low band, the mixer product of the synthesizer injection frequency minus the generated 10.8 MHz signal equals the desired generated frequency. On high band, and on the UHF band, the synthesizer injection frequency plus the generated 10.8 MHz signal equals the desired generated frequency. In addition to these desired generated frequencies, images of these frequencies (10.8 MHz above the synthesizer signal on the low band and 10.8 MHz below the synthesizer signal on high band and UHF band) are generated. These images permit the generation of certain frequencies outside of the specified frequency range of the SM-512. The output of Mixer M202 is amplified by the output amplifier, passes through the RF step attenuator and on to the RF OUT connector on the front panel of the SM-512.

Modulation of generated frequency is accomplished by applying the output of a 1,000 Hz oscillator A(located in the Modulation and Sinad Board) to the frequency control varactor of the 400 KHz VCO (located in the RF board). Small variations from the center frequency of the generated signal are accomplished by the ΔF control, which changes the bias on the frequency control varactor of the 400 KHz VCO.

Analog control over a range of 20 dB of the amplitude of the generated frequency is accomplished by changing the ampli- amplitude of the 10.8 MHz signal generated in the RF board. 20 dB steps of attenuation are provided by the step attenuator

To monitor the modulation and the ΔF of the generated signal, the 10.8 MHz generated frequency from the RF board is fed into the 10.8 MHz section of the scanner receiver, where it is demodulated by the scanner's discriminator circuit and delivered to the Modulation and SINAD board and used to drive the appropriate meters.

THEORY OF OPERATION BY MODULE

SCANNER CHASSIS - SERIAL NUMBERS ABOVE 5725.

Refer to the schematic of the scanner chassis for serial numbers above 5725. The scanner chassis used in these units covers three bands: Low Band 30-50 MHz, High Band 136-174 MHz, and the UHF Band 406-512 MHz. A brief description of the scanner receiver operation follows:

The local oscillator is a VCO whose frequency is controlled by a synthesizer system. The heart of the synthesizer is IC-3 on the scanner chassis, which is commanded by the entry and display board. IC-3 contains an oscillator, with X-1 as a controlling element, to provide the 10.4 MHz reference frequency to which all the synthesizer output frequencies are locked. IC-4 serves as the loop filter for the synthesizer with pin 6 of IC-4 delivering varactor control voltage to the VCO. The output of the VCO is amplified by TR-9 and fed to the input of the synthesizer IC-3. The VCO is also amplified by TR-8 and then by TR10. The output of TR-10 is the receiver's local oscillator source for the Low Band and the High Band.

On Low Band the TR-10 output will be between 40.8 and 60.8 MHz. That is the local oscillator injection frequency is 10.8 MHz above the received frequency. On High Band the local oscillator is 10.8 MHz below the received frequency, and the output of TR-10 is between 125.2 and 163.2 MHz. On the UHF Band the output of TR-10 is roughly in the 150 MHz regionand this signal is fed to TR-3, which acts as a frequency tripler to create injection for the UHF band. In UHF the injection frequency is always 10.8 MHz below the received frequency . Therefore the output of TR-3 is 395.2 MHz for a received freuqncy of 406 MHz, and 501.2 MHz for a received frequency of 512 MHz. It follows that the VCO operates between 131.7 and 167.6 MHz on UHF Band.

On Low Band and High Band diode switching arrangements commanded by IC-3 select the proper coil taps and cause the signals from the antenna to be fed to TR-4 which operates as an amplifier for the incoming signals. The output of TR-4 is fed to TR12 which acts as a mixer. The output of TR-12 is a 10.8 MHz replica of the received signal, and is fed to the IF system of the scanner receiver.

On the UHF Band TR-1 is activated by command of IC-3, which turns on TR-1's collector supply. TR-1 then acts as a RF amplifier of incoming UHF signals . Its output is fed to TR-12, which serves as a mixer to 10.8 MHz, and fed to the receiver's IF system.

In the IF system FT-1 serves as the primary selectivity at 10.8 MHz. The signals which pass through FT-1 are amplified by TR-14 and supplied to the input of IC-1. IC-1 serves as a converter to a 400 KHz IF, using the X-1 crystal as its scource of the 10.4 MHz necessary for the conversion.

SCANNER CHASSIS - SERIAL NUMBERS ABOVE 5725 (CONTINUED)

The 400 KHz IF is further filtered by FT-3, a ceramic filter, and returned to IC-1 where it is further amplified, limited, and frequency demodulated. The recovered audio (that is, the modulation on the incoming signal) appears at pin 10 of IC-1.

IC-1 also serves as a squelch system. The recovered audio on Pin 10 of IC-1 is amplified by TR7, and further amplified to loudspeaker level by IC-7.

SCANNER CHASSIS - SERIAL NUMBERS BELOW 5725:

Refer to the schematic of the scanner chassis for serial numbers below 5725. The scanner chassis used in these units covers three bands: Low Band 30-50 MHz, High Band 144-174 MHz, and UHF Band 420.5 to 512 MHz. A brief description of the scanner receiver operation follows: The local oscillator is a VCO whose frequency is controlled by a synthesizer system. The heart of the synthesizer is IC-3 on the scanner board, which is commanded by the entry and display board. IC-3 contains an oscillator, with Y-1 as a controlling element, to provide the 10.4 MHz reference frequency to which all the synthesizer frequencies are locked. IC-2 serves as the loop filter for the synthesizer arrangement with pin 6 of IC-2 delivering varactor control voltage for the VCO. The output of the VCO is amplified by Q-11 and fed to the input of the synthesizer IC-3. The VCO output is also amlplified by Q-9 and Q-10. The output of Q-10 becomes the receiver's local oscillator for the Low Band and the High Band. On Low band, the Q-10 output will be between 40.8 and 60.8 MHz. That is, the local oscillator injection frequency is 10.8 MHz above the received frequency. On High Band, the local oscillator frequency is 10.8 MHz below the received frequency, and the output of Q-10 will be between 133.2 and 163.2 MHz. On UHF Band, the output of Q-10 is roughly in the 150 MHz region, and this signal is fed to Q-3, which acts as a frequency tripler to create injection for the UHF band. In UHF, the injection frequency is always 10.8 MHz below the received frequency. Therefore, the output of Q3 is 409.7 MHz to receive 420.5 MHz, and 501.2 MHz to receive 512 MHz. It follows that the VCO operates between 136.5 and 167.6 MHz.

On Low Band and High Band, diode switching arrangements commanded by IC-3 select the proper coil taps and cause the signals for the antenna to be fed to Q-4, which operates as an amplifier for the incoming signals. The output of Q-4 is fed to Q-5 which acts as a mixer. The output of Q-5 is 10.8 MHz, and is fed to the 10.8 MHz IF system of the receiver.

THEORY OF OPERATION BY MODULE

SCANNER CHASSIS - SERIAL NUMBERS BELOW 5725

On the UHF Band, Q-1 is activated by command of the IC-3 synthesizer chip, which turns on Q-1's collector supply. Q-1 then acts as an amplifier of the incoming UHF signals. Its output is fed to a combination of Q-2 and Q-20 which serves as a mixer to 10.8 MHz and fed to the receiver's IF system. In the IF system, FL-1 serves as the primary selectivity at 10.8 MHz. The signals which pass through FL-1 are amplified by Q-12 and supplied to the input of IC-1. IC-1 serves as a converter to a 400 KHz IF, using the Y-1 crystal as its source of 10.4 MHz necessary for the conversion. A 400 KHz internal signal is further filtered by FL3, then amplified and limited, and demodulated in IC-1. The recovered audio (that is, the frequency modulation on the signal) appears at pin 10 of IC-1.

IC-1 also serves as a squelch system. The recovered audio from pin 10 of IC-1 is amplified by Q15 and further amplified to loudspeaker level by IC-7.

RF ADAPTOR BOARD:

The RF Adaptor board is mounted on the scanner receiver circuit board so that certain leads between the adaptor board and the scanner receiver can be kept very short.

The 10.4 MHz frequency reference crystal of the scanner receiver has been physically removed from the scanner receiver and relocated in a temperature controlled oven on the RF Adaptor board. U101, Q104, and associated components constitute the temperature controlling circuit. CR101,2,3,4 serve as the temperature sensing elements.

A portion of the 10.4 MHz frequency reference signal is fed from the 10.4 MHz crystal to emitter follower Q102. Emitter follower Q109 provides a low impedance source of 10.4 MHz energy for the 10.4 MHz test jack on the rear of the SM-512.

On the UHF Band,Q105 is coupled to the source of UHF injection energy on the scanner receiver. Acting as an emitter follower, Q105 provides a low impedance source of injection energy (the UHF output of the synthesizer -- 10.8 MHZ below the received or generated UHF frequency).

Similarly, Q108 is coupled to the source of VHF injection energy on low band and high band, and provides a source of the injection frequency on low and high band. On low band, the injection frequency is 10.8 MHz above the received or generated frequency. On high band, the injection frequency is 10.8 MHz below the received or generated frequency.

RF ADAPTOR BOARD (CONTINUED):

The point G is connected to a location on the scanner receiver which is positive by about six volts on the UHF band only. The voltage at point G, in combination with Q106 and Q107 and switching diodes CR105,6,7 determine whether Q106 (UHF band) or Q106 (low band and high band) feeds the coax line to the RF board.

Q101 is an oscillator, controlled by Y101, to operate at 10.8 MHz. This oscillator is turned on when calibrating the ΔF meter to 0 center.

RF BOARD:

The RF board supplies the RF signals for the Generate function of the SM-512.

Q201 is a VCO operating at 400 KHZ. Audio frequency signals entering the RF board at point A will frequency modulate the 400 KHZ VCO, and a varying DC voltage, provided by front panel control R205 (the ΔF control) permits varying the center frequency of the VCO. Q202 and Q203 amplify the frequency modulated 400 KHz and feed it to double balanced mixer M201.

10.4 MHz from the synthesizer reference crystal is amplified by Q205 and fed to M201. The output of Q201 consists of the sum and the difference of its input frequencies (10.4 +/- .400 = 10.8 MHz and 10.0 MHz). This signal is fed through a frequency selective amplifier consisting of Q206,7,8,9, and 10. The selective amplifier removes the 10.0 MHz signal, leaving only the 10.8 MHz frequency modulated signal. This signal is fed to mixer M202,

One of the outputs of the RF adaptor board (the one delivering a sample of the scanner receiver injection frequency) is fed through broad band AGC amplifier Q211,12. The AGC amplifier output is a replica of the scanner receiver injection except that the AGC action results in a uniform amplitude as the scanner is tuned to different frequencies.

The output of M202 consists of the sum and difference of its inputs. One of these outputs is the same as the receive signal of the scanner receiver. For example: Consider that the scanner receiver has been programmed to receive on 150.000 MHz . The scanner receiver injection frequency would be 150.000 - 10.8 = 139.2 MHz. The input to M202 from

RF BOARD (CONTINUED):

the AGC amplifier would thus be 139.2 MHz and the output of M202 would be 139.2 +/-10.8 MHz = 150.000 MHz (the receive frequency) and 128.4 MHz, (which we will call the image frequency and is the same as the scanner receiver image frequency.) This image frequency is the same amplitude as the intended 150.MHz output of M202, and is always displaced by 21.6 MHz from the frequency programmed into the scanner receiver. This imagae permits use of the SM-512 on certain frequencies outside of its specified range.

The output of M202 is amplified by Q214 to a level of 100,000 microvolts and fed to the front panel of the step attenuator.

MODULATION AND SINAD BOARD:

Modulation, Density, and ΔF measurement circuits:

The output of the scanner receiver discriminator circuit is fed to pin 3 of U1. U1 serves as a voltage follower and a voltage level changing circuit. (The latter function by virtue of the voltage drop across CR1). Thus, the pin 6 output of U1 is a replica of the scanner receiver discriminator output, displaced by about 2.5 volts in the positive direction. The DC component of this voltage is a function of the frequency error, ΔF, from channel center of a signal being received by the scanner receiver, and the AC component is a replica of the frequency modulation on the received signal.

The DC component is amplified by U2D to a level sufficient to operate M501, which provides front panel indication of ΔF. The SET 0 control, R502, permits setting the 0 center condition of the meter.

The AC component of the output of U1 is fed through a 5 KHz notch circuit consisting of U2A and associated components. This is to prevent any 5 KHz "loop sing" of the frequency synthesizer from affecting modulation readings. The signal is further amplified by a low pass filter consisting of U2A and U2B, and fed to modulation, rectification and measurement circuits U3A, U3B, U4, and U5. These circuits determine the maximum modulation amount, whether it be positive or negative from the carrier, and feed M502 to provide a front panel reading of peak modulation deviation.

In addition to the meter indication of modulation peaks, flasher lamps LED502 (red) and LED503 (yellow) show when peaks of 5 KHz or 4.5 KHz, respectively, occur. These lamps are actuated by circuits of U7A and U7B.

MODULATION AND SINAD BOARD (CONTINUED):

Modulation, Density, and ΔF measurement circuits:

U3C and U3D are the circuits which provide the drive for the front panel indication of Modulation Deviation which is availaable from M501 when SW501 is switched to the DENSity position.

SINADDER (tm) Circuit:

The four sections of U9 and U10 constitute the SINADDER(tm) circuit. U9 A,B,C serve as an agc amplifier. U9 serves as a 1,000 Hz notch, and U10 as a precision rectifier and meter driver.

1,000 Hz Oscillator Circuit:

The 1,000 Hz oscillator consists of U8A, B, C, and D. This oscillator feeds U7D, which serves as an amplifier. R501, the SET MOD control, adjusts 1KHz level which is delivered to 400KHz-VCO on the RF Board.

POWER SUPPLY

AC power to the supply is supplied from a transformer in a shielded compartment inside the SM-512 housing. This transformer supplies AC power at 12.6 volts RMS to a bridge circuit consisting of CR301,2,3,4. The output of the bridge circuit is fed to voltage regulators Q303 and Q304, which provide regulated power to various parts of the instrument. A voltage divider is connected between the input and output of Q304 to sense when the supply voltage is adequate to provide proper regulation. If drop across the voltage regulator is adequate, Q306 will light up the Green LED501 light, located on the front panel of the SM-512. Under conditions of inadequate voltage input (such as low battery) LED501 does not light. Q306 is a voltage regulator to provide a 5 volt supply to portions of the Modulation and SINAD board.

A voltage doubling arrangement is used to provide adequate voltage to charge the internal battery. U303, Q301, and Q302 operate with CR305 and CR306 in a voltage doubler configuration. R303 and R304 serve to limit the amount of charge to the battery, R304 being switched in for the higher battery charging rate of approximately 100 milliamperes, and being switched out of the circuit for a lower rate of 50 milliamperes.

POWER SUPPLY (CONTINUED)

CR-307 and CR-308 are diodes which pass power to the crystal heaters regardless of the position of S-501 (the BATtery-AC-OFF switch on the front panel). As long as the AC power cord is connected to a power source, (all serial numbers) or the DC external battery leads are connected to a power source (serial numbers above 5725 only) the crystal heaters will function.

In serial numbers below 5725, the scanner memory will be retained regardless of the position of S-501 if the unit is plugged into AC power. If no AC power supply is connected, the memory will be retained only as long as the equipment is operated from the internal battery.

In serial numbers above 5725, the scanner memory will be retained regardless of the position of S501 if the unit is plugged into AC power or the external battery leads are connected to a power source. Otherwise, the memory will be retained only as long as the instrument is operated from the internal battery.