

WARRANTY

Helper Instruments Company warrants this test instrument to be free of defects in materials and workmanship for a period of one year from the date of purchase.

Helper Instruments will repair or replace, at their option, any defective instrument which is returned freight prepaid, unless the defect has been caused by obvious abuse, or misuse of the instrument.

In no event shall Helper Instruments Company's liability under this warranty exceed the cost of repairing or replacing such defective instrument, and under no circumstances shall Helper Instruments Company be liable for consequential damages.

INSTRUCTION MANUAL

SM 512 monitor

PLEASE READ & RETURN

HELPER INSTRUMENTS COMPANY

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Indian Harbour Beach, Florida 32937
800-327-9308 305-777-1440

\$2.00

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HELPER INSTRUMENTS COMPANY
SM 512 MONITOR
(SN 5725 ON)

Specifications:

- Frequency Bands:** 30-50 MHz (66-68 MHz in European Model)
136-174 MHz
406-512 MHz
- Generator Output Level:** .1 to 100,000 microvolts @ 50 ohms
- Frequency Accuracy:** $\pm .0001\%$ from + 10 C to + 40 C Ambient
- Modulation:** Up to 7.5 KHz peak FM deviation, 1,000 Hz internal source. Input for external modulation.
- Channel Spacing:** 5 KHz below 174.5 MHz
12.5 KHz above 420 MHz
Analog frequency offset permits setting channel frequencies up to 5 KHz offset from selected channel frequency.
- Input Sensitivity:** 2 microvolts @ 50 ohms for 12 dB SINAD
- Memory:** 20 Channel frequencies can be placed in memory.
- Frequency Readout:** Digital - Plasma Display.
Analog - 5 KHz offset meter.
- Modulation Deviation:** Analog - 7.5 KHz
Go, No-Go LED indicators at 4.5 and 5 KHz.
"DEMODO" jack for external scope
- SINAD:** Built in SINADERTM.
- Modulation Density:** Analog Meter.
- Power:** (a) 110/120 or 220/240V, 50/60 Hz
(b) 12.6 volt external battery (e.g. 12 volt, negative ground vehicular battery system)
(c) Self contained Nickel Cadmium Battery.
- Dimensions:** 32.8 cm W x 14.6 cm H x 22.9 cm D with front cover (12.9" W x 5.75" H x 9" D)
- Weight:** 5.9 kg (13 lbs.)

CAUTION

Before connecting the SM-512 to the power source, be certain that it is set for the proper supply voltage. The rear panel of the SM-512 has a power cord receptacle that permits use on either 120 or 240 VAC 50/60 Hz supplies. A printed circuit card can be viewed through the plastic window of the receptacle. When this card is inserted for either 120 or 240 VAC operation, the label "120" or "240" is visible.

See Section Three for information on changing voltage of operation.

The external battery jack and the A.C. power cord should never be connected to power sources simultaneously.

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SECTION 1
OPERATION

OPERATION

SECTION 1

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 A C power source

A C Position

Instrument is operated from the A C power Instrument is operated from the internal battery About one hour of operation is available from a fully charged battery

POWER LIGHT

Lit when instrument is operated from A C When in battery operation the light will light only if the battery has sufficient charge for proper operation

BATTERY CHARGE SWITCH

OFF Position

Battery will be charged at a low maintenance rate, whenever the power cord is connected to the A C power

FAST CHARGE Position

Battery is charged at a rate that will result in a full charge in 10 - 14 hours

Δ F-DENS

Δ F

Left hand meter indicates KHz offset from indicated frequency

DENS

Left hand meter indicates Modulation Density

MOD-SINAD

MOD

Right hand meter indicates Peak Modulation Deviation

SINAD

Right hand meter indicates SINAD

GEN-MEAS

GEN

To GENERate a test signal

MEAS

To MEASure a received signal

Δ F

In the GENERate mode, the Δ F 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 Δ F measuring circuits so the Δ F meter indication will be correct Adjustments of the SET 0 control must be done when the Δ F-DENS switch is in the Δ F position The SET 0 knob must be pushed in all the way and then rotated to obtain a zero (center scale) reading on the Δ F meter Avoid moving this control except when following this procedure, because this will introduce errors in the Δ F readings

SET MOD

Adjusts the 1 KHz modulation tone in the GENERate mode This control has no function in the MEASure mode.

R F 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 when in the MEASure mode

5 KHz Lamp
(RED)

Indicates modulation peaks of 5 KHz or more

4.5 KHz Lamp
(AMBER)

Indicates modulation peaks of 4.5 KHz or more

DISPLAY

Indicates selected channel storage number and frequency (See Channel Frequency Entry)

CHANNEL FREQUENCY ENTRY

1 Press **MANUAL** until desired channel appears

2 Press desired Frequency and **ENTER**

Example

To program 152 270 MHz into channel #5

PRESS **MANUAL** repeatedly to step to channel #5

PRESS **1 5 2 0 2 7 E**

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 0 1 3 7 5 E**

or
4 6 2 0 1 3 7 E
or
4 6 2 0 1 3 8 E

READ 8 462 137 (note 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 (#14), 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

TO GENERATE A TEST SIGNAL

- 1 Enter desired channel into the instrument as shown on page 3
- 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, rotate the 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 see 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 plus 1.5 KHz) from the channel shown on the display, adjust ΔF so that the top of the scale on M1 reads to the right at 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 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), the tone generator may 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. Approximately $\frac{1}{2}$ 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 20dB steps (e.g. x10 voltage steps), and the control to the left is a continuously variable control (e.g. the illustration shows an output voltage of approximately 6 microvolts)

- 8 The generated signal is available at the RF OUT jack. Connect the receiver to be tested there. If a transceiver is connected, be sure not to key the transmitter. The instrument is protected by a fuse which is part of the RF OUT jack. See Section 3 for instructions on replacing or testing the fuse

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 as shown on page 3

- 3 Set GEN-MEAS switch to MEASURE

- 4 Set ΔF -DENS switch to F 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

- 7 Set the volume control to a comfortable level

NOTE In testing a nearby transmitter with a microphone, it may be necessary to reduce volume to avoid audio feedback

- 8 When the ΔF -DENS switch is in the ΔF position, the upper scale on M1 indicates how many KHz the received signal frequency differs from the channel frequency shown on the display. Readings to the right indicate that the transmitter is above the channel frequency, except on the 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 deviation from the channel center. EXAMPLE: Actual frequency is 462.1375. Display reads 462.137. M1 reads 0. Received signal is on 462.1375 MHz

- 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™" circuit which selects the greater of the positive and negative peaks and displays it. (2) A meter "hold" circuit that speeds the upward movement of the 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 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 tones and data. It will be noted that the peak flashing LEDs will register on voice peaks which are too short in duration for the meter to follow. This is a normal condition. When the meter is measuring steady tone modulation of a transmitter, the PEAK FLASHERS should coordinate with the meter. The AUTOPEAK™ circuit in the SM-512 measures both the positive and negative peaks and presents the greater value on the PEAK DEVIATION meter. This value is also indicated on the 4.5 KHz and 5 KHz flashers

The modulation of FM transmitters is not necessarily symmetrical. 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 going 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 heading

11 To measure Modulation Density of the received signal, set the Δ F-DENS switch to the DENS position. Modulation density will then be indicated by the lower scale on M1. To make a density measurement, be sure that the Peak Deviation of the transmitter is between 4.5 KHz and 5 KHz, as indicated by frequent flashing of the 4.5 KHz LED flasher and no flashing of the 5 KHz LED flasher. 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 within the transmitter. We suggest that you read the section on MODULATION DENSITY, starting on page 12 of this manual.

Proper attention to Density readings can be of substantial help in getting optimum communication performance from radio systems.

OSCILLOSCOPE CALIBRATION

A BNC connector (labeled "DEMODO") on the rear panel of the SM-512 permits the use of an oscilloscope to observe modulation waveforms of received and generated signals.

The oscilloscope presentation can be calibrated by use of the following procedure:

Set GEN-MEAS switch to GENERATE

Set MOD-SINAD switch to the MOD position

Adjust SET MOD control to obtain 5 KHz of Peak Deviation as shown on top scale of M2

Adjust the vertical gain control on the oscilloscope until the deflection is plus and minus 5 divisions. The oscilloscope is now calibrated for 1 KHz deviation per division.

MEASURING SINAD:

To measure SINAD, set the MOD-SINAD switch to the SINAD position. Plug a shielded test lead into the SINAD jack on the front panel of the SM-512. Connect the other end of the test lead to the receiver loudspeaker, being sure to connect the shield side to the grounded side of the loudspeaker. SINAD will be read on the lower scale of M2. The 1,000 Hz internal oscillator of the SM-512 generates the 1,000 Hz modulation required for the SINAD measurements. In typical SINAD measurement, the modulation deviation should be set to 3.0 KHz. The SM-512 incorporates a SINADDER™ circuit which automatically computes SINAD as long as the input voltage from the receiver under test is between 20 millivolts and 10 volts RMS. Read the section on SINAD, starting on page 9 of this manual.

MONITORING DISTANT TRANSMITTERS

For testing transmitters on the bench and for checking base stations within their normal coverage area, the antenna supplied with the SM-512 will provide suitable signal pickup.

To measure distant transmitters, an elevated antenna suitable for the frequency band involved, may be desirable.

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.

If intermodulation interference is bothersome when a high antenna is used, it can be substantially reduced by inserting a 6 or 10 dB, 50 ohm, pad between the antenna and the RF IN jack. A high antenna results in a greater increase in signal on distant stations than it does on the nearby stations, which are usually the ones that create the intermodulation problems. A 10 dB pad can result in a 30 dB reduction in intermodulation products, yet only gives a loss of 10 dB on the wanted signal.

ALIGNMENT OF RECEIVERS WITH 10.8 MHz IF

The output spectrum of the SM-512 includes an image signal 21.6 MHz below the displayed channel. On the 30 - 50 MHz band, the image is higher in frequency. The image has the same amplitude and modulation deviation as the displayed channel signal.

This image signal will be of no consequence when working with most receivers and transmitters, and will not cause confusion unless the 1 F Frequency of the receiver is 10.8 MHz. When testing a receiver with a 10.8 MHz IF, it is possible that a "birdie" will be heard because the image signal may coincide with the image frequency of the receiver. Also, when aligning a set to a new frequency, it is possible that the front end of the receiver could be tuned to the image signal instead of the wanted channel.

If either of these problems occur on the 150 or 450 MHz band frequencies, it can be eliminated by entering a frequency 21.6 MHz above the wanted channel into the SM-512. The SM-512's image signal will then occur on the wanted channel, and can be used for receiver alignment and test.

EXAMPLE

You are aligning a receiver having a 10.8 MHz IF for operation on 450,000 MHz. The receiver has an image frequency of 439.20 MHz (displaced from the wanted frequency by twice the IF frequency). You have aligned the receiver, using the SM-512, which has been set to generate 450.0 MHz. You want to be sure that you have not aligned the receiver to the image frequency from the SM-512, which is 439.20 MHz - the same as the expected image of the receiver.

Set the SM-512 to generate 471.6 MHz (as shown by the display). The SM-512 will then deliver 450.00 MHz, as well as 471.6 MHz. If the receiver operates at proper sensitivity under this condition, you know you have not erroneously tuned to its image (439.20 MHz).

OPERATION ON FREQUENCIES OUTSIDE PRIMARY COVERAGE OF THE SM-512 USING IMAGES.

As mentioned earlier, the output spectrum of the SM-512 includes an image frequency 21.6 MHz removed from the frequency entered into the display. This image has the same amplitude and modulation deviation as the displayed channel frequency. On low band (30 - 50 MHz), the image is 21.6 MHz higher than the displayed frequency. On other bands, the image is 21.6 MHz lower than the displayed frequency.

This image permits the use of the SM-512 on frequencies other than those given in the specifications. (See inside cover of this manual.)

When using the image frequency, the following should be remembered:

The direction of indication of the ΔF meter is reversed from what it would be normally.

The sensitivity of the SM-512 in the MEASURE mode is substantially less than the specifications for normal frequency coverage.

72-76 MHz OPERATION:

Although 72-76 MHz frequencies are not included in its synthesizer, the SM-512 can be used for maintenance and repair of 72-76 MHz equipment as well as the 66-88 MHz equipment used in many countries.

51.60 to 71.60 MHz

Frequencies from 51.6 to 71.6 can be obtained by use of the image signal. Subtract 21.6 MHz from the wanted frequency and enter the result into the SM-512.

The MEASURE sensitivity of the SM-512 will be reduced, precluding using it to monitor stations at a distance, the GENERATE microvolts output will be the same as indicated by the MICROVOLTS dial, and the ΔF meter will swing to the right for the positive values of ΔF .

EXAMPLE

To GENERATE or MEASURE at 52.40 MHz

52.40 - 21.6 = 30.8
Enter 30.8 into the SM-512

70.8 to 110.8 MHz

Frequencies from 70.8 to 110.8 MHz can be checked by use of second harmonic mixing products in the SM-512. In this condition, the ΔF meter will read to the left for a positive ΔF .

The MEASURE sensitivity of the SM-512 will be reduced, precluding using it to monitor stations at a distance, and the GENERATE microvolts output will be about 1/2 that indicated by the MICROVOLTS dial.

EXAMPLE

To GENERATE or MEASURE at 76.5 MHz

$$\frac{76.50}{2} = 38.25 \text{ MHz} \quad 38.25 + 5.4 \text{ MHz} = 32.85$$

Enter 32.85 MHz into the SM-512

ABOUT SINAD

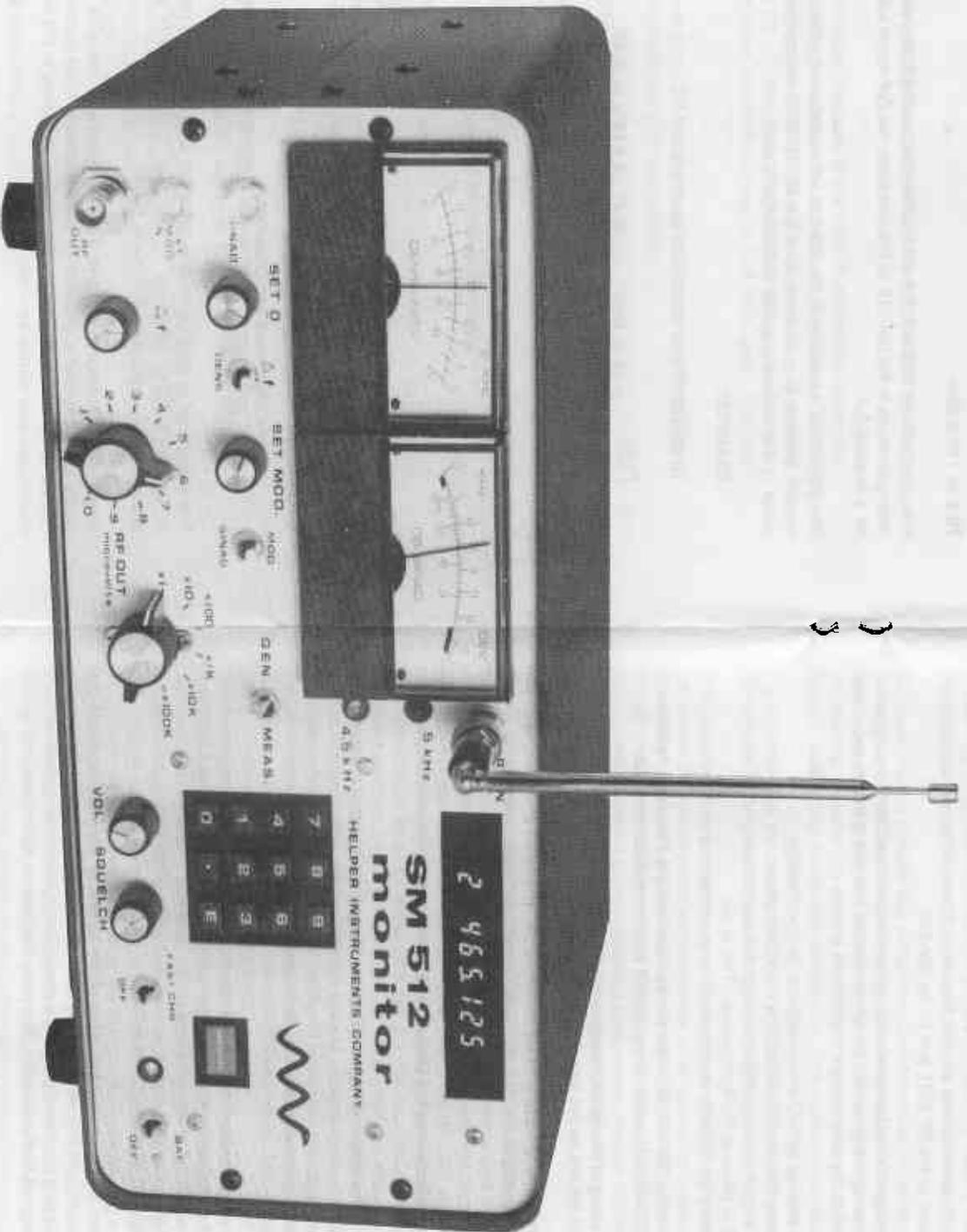
The term SINAD is abbreviation for the following ratio

$$\frac{\text{Signal plus Noise and Distortion}}{\text{Noise plus Distortion}} \quad \text{expressed in Decibels}$$

The signal level at which a receiver produces a 12 dB SINAD ratio is referred to as the "12 dB SINAD sensitivity" of a receiver. In practice, a 12 dB SINAD signal is a reasonably intelligible and useful signal.

Since SINAD measurement give a more meaningful measure of a receiver's useful sensitivity that is obtained by other methods, it has become the preferred method of specifying and measuring receiver sensitivity in FM receivers used in land mobile and marine services.

The SINADDER™ was pioneered by Helper Instruments to simplify SINAD measurements. The SM-512 includes a SINADDER™ circuit, accessible from the "SINAD" jack on the front panel.



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MAKING A SINAD SENSITIVITY MEASUREMENT:

Put the SM-512 in the GEN mode, and enter the channel frequency. Connect the antenna input terminal of the receiver to be tested to the RF OUT jack of the SM-512

Connect a test lead from the receiver's loudspeaker voice coil terminals to the SINAD input jack on the SM-512. If one side of the voice coil is grounded, be sure to connect that side to the grounded test lead. Adjust the volume control of the receiver to a comfortable level.

NOTE

When making SINAD measurements for specification purposes, the receiver should be run at its rated audio output power, using an appropriate resistor as a load in place of the loudspeaker. This is not necessary for ordinary maintenance shop procedures.

Set the modulation deviation of the SM-512 to 3 KHz (for systems using 5 KHz peak modulation deviation). Then switch the MOD:SINAD switch to the SINAD position and observe M2.

Note that the needle of M2 will swing to the right if the signal output from the SM-512 is decreased to the minimum, and will swing to the left as the signal level is increased.

Adjust the signal level output from the SM-512 until M2 shows 12 dB. The value of microvolts as indicated by the MICROVOLTS controls is the "12 dB SINAD sensitivity" of the receiver.

MODULATION DENSITY

The Helper SM-512 provides a measurement of Modulation Density in addition to Peak Deviation Measurement.

All modern FM communication transmitters employ a modulation limiter (clipper) circuit to assure that the modulation never exceeds the correct amount. In most administrations, a legal maximum of 5 KHz is imposed. In addition to the legal requirement of keeping peak modulation within this limit, the modulation acceptance limitations of receivers make it necessary that the 5 KHz peak deviation not be exceeded.

A good clipper circuit, with the proper amount and type of clipping, permits higher average levels of speech signal to be applied to the modulation stage while preventing the peaks from exceeding the 5 KHz limit. If the speech is not subjected to enough clipping, the "average" amount of modulation will be low, and the speech will sound weak in comparison to circuit noise. If the limiting is excessive, the speech will sound distorted and intelligibility will suffer.

A peak deviation measurement indicates only the value of the peaks. It tells nothing about the "average" amount of modulation, and therefore nothing about the degree of clipping that has occurred in the clipper circuits. Clipping can be so low that the peak value is reached only occasionally, or it can be so severe that speech is badly distorted. The peak deviation in either case may be the same.

The degree of clipping in a transmitter is determined by the level of the speech signal as it reaches the modulation limiter (clipper) stage. A high level input creates more clipping, a low level decreases the amount of clipping.

If the peak deviation control of a transmitter has been set so that modulation peaks reach a 5 KHz limit, a measurement of the "average" amount of modulation will be an indication of the degree of clipping imposed on the speech signal. An extremely high "average" value would indicate excessive clipping, a low "average" value would indicate inadequate clipping.

* The term "average" has been put in quotations throughout this explanation to avoid confusion with various mathematical and electrical definitions of the word "average".

The density measurement circuits of the SM-512 actually make a measurement of the "average" modulation, integrate it, and present it on a meter scaled from 0 to 10 density units (D U).

Before attempting to make any judgements about modulation density of a transmitter, be sure that its deviation control has been set so the peak deviation is running between 4.5 KHz and 5.0 KHz. The proper setting is reached when the 4.5 KHz LED is flashing frequently and the 5.0 KHz LED is not flashing. Observe the density meter for a few seconds of continuous speech and notice the highest reading that is repeated consistently. This reading is the modulation density.

It is important that the density observation be made while the transmitter operator is using typical microphone technique and is talking with typical loudness.

The proper modulation density depends somewhat upon the amount of distortion acceptable to the user of the system, whether naturalness of the speech or optimum intelligibility is more important. Our observations are that a density below 4 D U definitely indicates inadequate clipping. A density reading in the region of 6 to 8 density units will result on a transmitter that is giving crisp, clear sounding speech capable of giving good communication into the poorer signal areas. A density reading of 10 or more indicates excessive clipping and obvious distortion.

USE OF A POWER PAD

If your work is with transceivers, you will find that a power pad is a handy accessory to your SM-512. It is connected between the transceiver antenna port and the RF OUTPUT port of the SM-512. With the power pad, you need not disconnect the transceiver from the SM-512 when testing the transmitter function. With it, the fuse in the RF OUT jack will not blow if the transceiver is inadvertently keyed. When using a 20 dB power pad, the RF OUT step control should be set one step higher than it would be without the pad (i.e. for 1 to 1 microvolts output, the RF OUT step control would normally be set to X1. If a 20 dB pad is used, the step control should be set to X10. If a 40 dB pad is used, the step control should be set to X100).

20 dB pads, with ratings from 5 watts to 100 watts are available from JFW Industries Inc., 5134 Commerce Square Drive, Indianapolis, IN 46237. Telephone number 317-897-1340. A 100 watt, 40 dB pad is available from Communications Instruments, 145 Shelton Street, El Segundo, CA 90245. Telephone number 213-322-3666.

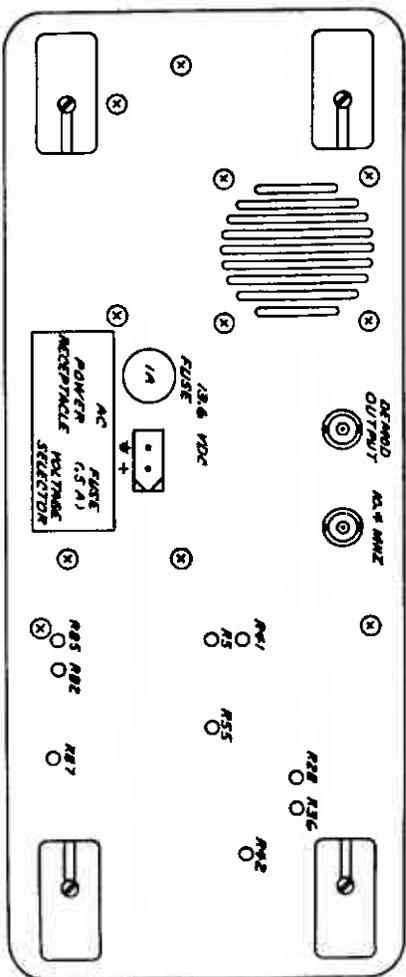
OPERATION FROM VEHICULAR BATTERY SYSTEM

The SM-512 can be operated from a car or truck battery system, but operation is only possible in 12.6 volt systems with negative battery ground. The external battery input jack is located just above the A C power receptacle on the rear 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 suitable for his particular application. Wiring requires the same methods and precautions as in the installation of a radio transceiver. 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 A C position.

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

NOTE: The external D C input jack and the A C power cord should never be connected to power sources simultaneously.

**CHANGING A.C. POWER SUPPLY VOLTAGE**

To change AC Power remove the fuse, using the "fuse pull" lever. Then remove the printed circuit card, using a hook inserted into the hole in the card, and replace it so that either the "120" or "240" shows

Then, insert an appropriately rated fuse for the voltage in use. Proper fuse for 120 volts is $\frac{1}{2}$ ampere. Proper fuse for 240 volts is $\frac{1}{4}$ ampere.

CAUTION

The construction of the SM-512 uses conductive tape to obtain shielding integrity and avoid the leakage of signals from the instrument case. Do not remove tape unless you have a replacement supply on hand. Certain adjustments are available to the user without removal of the tape, and these adjustments are described here.

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 controlled "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.

An isolated output from the 10.4 MHz oscillator is provided by a BNC connector on the rear panel. The frequency of this oscillator may 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 27°C (80°F).

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 C 105, 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 crystal 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 from the SM-512 you can observe the access hole for C 104, the control for setting the frequency of the 10.8 MHz crystal. Insert a test lead into the hole. Place the 10.8 oscillator into operation by pushing in on the SET 0 control, and observe the frequency counter. Then adjust C 104 to within about 20 Hz of 10.8 MHz, as indicated by the frequency counter.

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 in 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 approximately 53 ohms indicates a good fuse.

The fuse may be replaced from the front panel 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 a tweezers, 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 Littelfuse 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 at other levels to accommodate special system requirements. The adjustment procedure follows:

SET GEN - MEASURE to GEN

SET Δ F-DENS to Δ F

SET Δ F 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 hole for R 42 (rear panel) and adjust R 42 so that the red LED just flashes. Test your setting by varying SET MOD control about the desired value of modulation.

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

CENTERING OF Δ F 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 Δ F reading on M1 all the way from plus 5 to minus 5 KHz, by rotating the Δ F control. If the 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-MEASURE switch to the GEN position. While pushing in on the SET 0 control knob, adjust it to obtain a reading of 0 (center of scale) on M1. Release SET 0 knob. Set the Δ F control in approximately the center of its rotation. Adjust T201 to obtain a reading of 0 (center of scale) on M1.

CALIBRATING RF OUTPUT LEVEL

The R F output level is best checked using a Spectrum Analyzer. In the absence of a spectrum analyzer, a bolometer type R F Power Meter, accurate at the power level involved should be used.

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

This setting should produce a 100,000 microvolts (-7 dBm) deflection on a spectrum analyzer. If you are measuring the level with a bolometer type R F power Meter, the power level should read 3 dBm higher, because the Power Meter will "see" the image signal as well as the main signal.

If found to be inaccurate, the R F MICROVOLTS can be corrected by adjusting R 212 while observing the output level as described in the above paragraph. For access to R 212, remove the bottom outer cover from the SM-512. R 212 can be adjusted through an access hole in the bottom inner shield. It is not necessary to remove the bottom inner shield. Use a 150 MHz channel for the adjustment.

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 R F radiation integrity of the instrument, and must be replaced with new tape. Replacement batteries and shielding tape are available from Helper Instruments Co.

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 A.C.

Set GEN MEAS to MEAS

Set Δ F-DENS to DENS

Set MOD SINAD to MOD

Set SQUELCH fully counterclockwise (silent condition)

Adjust R 28 (rear panel) to obtain a 0 reading on M2. Note that this corresponds to a 0 reading on M1, but M1 settles to zero slowly.

CALIBRATION OF 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 are using an accurately calibrated source for your modulation standard. If using a modulated signal source as your standard.

Set GEN-MEASURE to MEASURE

Set MOD-SINAD to MOD.

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

Set calibrated source to at least 100 microvolts.

Set calibrated source to 5 KHz peak modulation deviation.

Adjust R 5 (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-MEASURE to GEN

Set MOD-SINAD to MOD

Set R F OUT controls to provide signal level required by standard.

Set the SM-512 to the channel frequency appropriate to the standard.

Adjust SET MOD control until standard shows 5 KHz peak modulation deviation.

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

CALIBRATION OF DENSITY METER

Set GEN-MEAS to GEN

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 DENS

Adjust R 36 (rear panel) to obtain a full scale reading on M1

CALIBRATION OF ΔF METER

Accurate adjustment of the ΔF calibration requires a signal generator, operating on any frequency within the SM-512 coverage range, and having digital means to vary the frequency in 1 KHz steps. For this instruction, a signal generator operating at a center frequency of 40 005 MHz is assumed.

Set GEN-MEAS switch to MEAS

Set ΔF -DENS switch to ΔF

Enter the frequency of 40 005 MHz into the SM-512

Set the test generator to 40 005 MHz, unmodulated, output of about 100 microvolts

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

Adjust the SET 0 knob so M1 reads at the center scale 0. (Do not push the SET 0 knob in while making this adjustment.)

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 R 41 (rear panel), to bring the indication to 4 KHz, then continue adjusting R 41 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 zero.

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 to R 41. Continue this 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 GEN

Set MOD-SINAD to MOD

Adjust SET MOD to obtain 5 KHz reading on M2

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

If necessary, adjust R 55 (rear panel) to obtain a 1,000 Hz reading on the frequency counter

