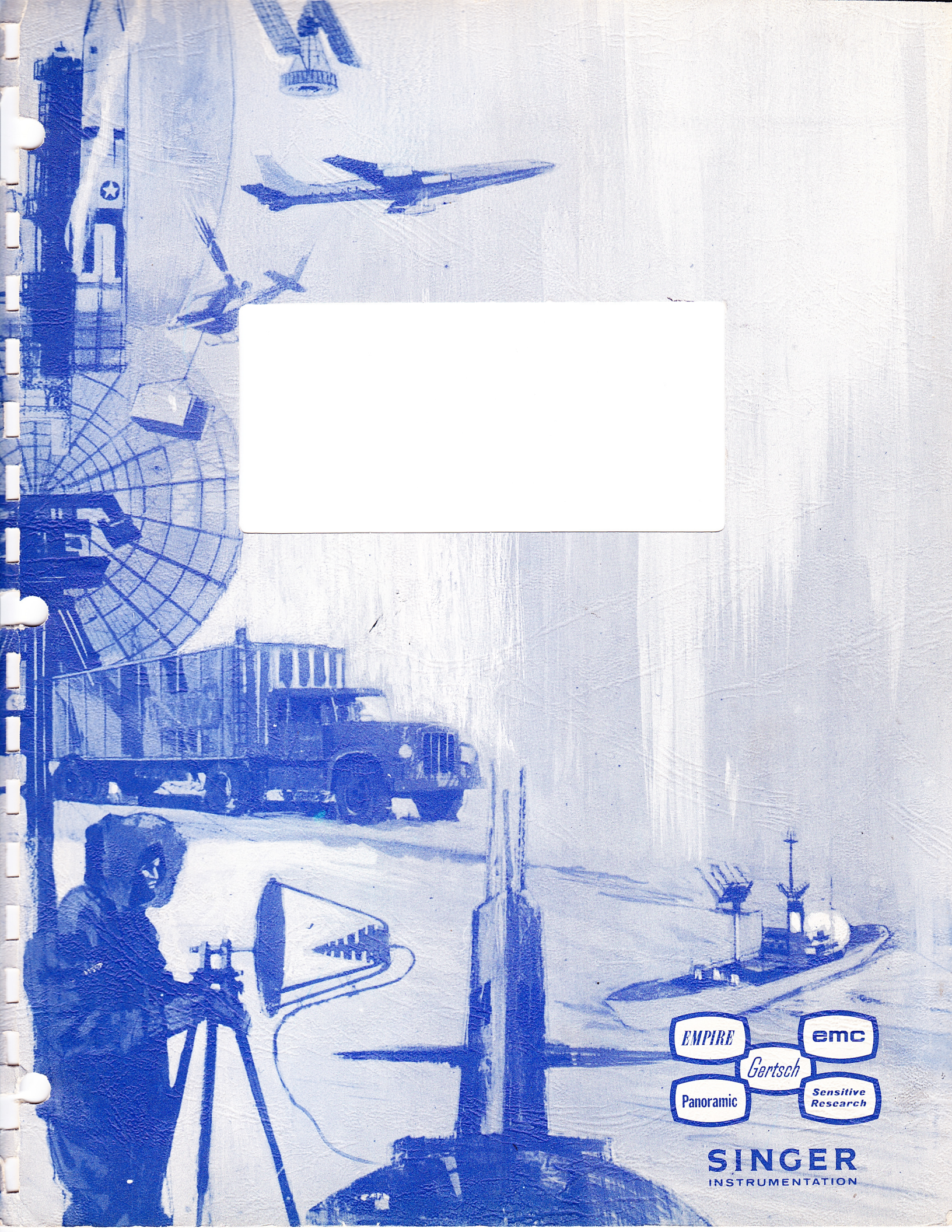
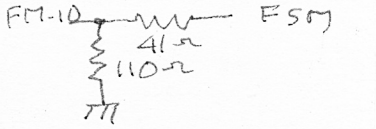

EMPIRE
emc
Gertsch
Panoramic
Sensitive
Research
SINGER
INSTRUMENTATION

FM-1D 500 uV out
= 720 uV on FSM



PRELIMINARY

OPERATION MANUAL

FM-10/MDM-1

Manual No. 1-500783-156

The Singer Company, Instrumentation Division
Gertsch Operation

WARRANTY

THE SINGER COMPANY, INSTRUMENTATION DIVISION, warrants each new instrument to be free from defects in material and workmanship, effective after delivery to the original purchaser as follows:

Sensitive Research Electrical Indicating Instruments.....2 years
Other Electrical and Electronic Measuring Instruments.....1 year

Repair or replacement (at our option) without charge (F.O.B. factory) will be effected when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron tubes, semiconductors, batteries, fuses, lamps, thermoelements, and *RatioTran* potentiometers are excluded from warranty coverage. Warranty returns must first be authorized by the factory.

If the instrument or any portion thereof, has been abused, misused, damaged by accident or negligence, or if any serial number or seal has been removed or altered, the warranty is void.

This warranty is in lieu of all other obligations or liabilities expressed or implied and The Singer Company neither assumes, nor authorizes any person to assume for them, any other liability in connection with sales of instruments manufactured by The Singer Company, Instrumentation Division.

THE SINGER COMPANY • INSTRUMENTATION DIVISION
HOME OFFICE: 915 PEMBROKE STREET, BRIDGEPORT, CONNECTICUT

REPAIR AND MAINTENANCE

Instruments should be returned only on prior written authorization from the Singer Representative or the factory(1). Warranty repair will be made upon written request. Please provide the following information in order to expedite our processing of your instrument:

1. Model or Type
2. Serial Number
3. Description of trouble(2)
4. Test instruments used
5. Approximate date instrument was placed in operation
6. Approximate number of hours of use
7. Has maintenance action been previously requested?
8. Other comments

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument to the factory prepaid. If requested, an estimate of charges will be made before work begins.

(1) Contact Instrumentation Division, 915 Pembroke St., Bridgeport, Connecticut for *Empire, Panoramic, Ballantine* and *Sensitive Research* instruments. Contact Instrumentation Division, 3211 S. LaCienega Blvd., Los Angeles, California for *Gertsch* and *EMC* instruments.

(2) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken, and any other relevant data.

CONTENTS

TABLES

FIGURES

FIGURE 1 - 1: FM - 10 / MDM - 1

SECTION 1

GENERAL DESCRIPTION

The MDM-1 Plug-in module is an auxiliary unit to the Singer Gertsch FM-10 Frequency Meter/Signal Generator. The MDM-1 equips the FM-10 to generate and measure the deviation of FM modulated signals to a maximum of 18 KHz deviation. It will also supply uncalibrated modulation to 60 KHz deviation.

In the measuring mode, peak deviation is displayed directly on a meter calibrated in Kilohertz. In the FM generating modes, deviation is read on the same meter and is controlled by a potentiometer. An FM signal can be generated using an internally supplied tone of 1 KHz, an external tone or a combination of the two. The 1 KHz modulation tone (controllable from 0-1 vrms) is also available at a front connector for transmitter audio tests.

The peak deviation meter can be quickly switched from reading positive half waves to negative half waves and vice versa. This affords a convenient means of detecting distortion in the transmitter modulator.

Other facilities provided for monitoring modulation are a loudspeaker presentation of the demodulated signal (controllable in volume) and a front panel signal output jack for connection to an oscilloscope or distortion analyzer.

The FM-10/MDM-1 provides a complete and self-contained FM communications field test package in the range 500 KHz to 500 MHz.

TABLE 1

SPECIFICATIONS

DEVIATION RANGE:	
At 1 KHz Mod. Freq.	0-1.8 KHz ±10% of F.S. 0-6 KHz ±5% of F.S. 0-18 KHz ±5% of F.S.
At 50 Hz to 3 KHz Mod. Freq.	Add ±2% to above tolerances.
SENSITIVITY:	6mvrms ±3db (10MHz to 500 MHz) for red line limiter current indication.
INTERNAL MODULATION:	
Mod. Freq:	1 KHz ±5%
Dev. Range:	0 to 60 KHz (max)
EXTERNAL MODULATION:	
Mod Freq:	50 Hz to 3 KHz
Dev. Range:	0 to 60 KHz (max)
Input Impedance:	Approx 600Ω
Input Level:	Approx 400 mvrms for 5 KHz dev.
COMBINED MODULATION MODE: (Internal & external modulation combined)	
Mod Freq:	Ext. 50 Hz to 3 KHz Int. 1 KHz ±5%
Dev. Range:	0 to 60 KHz (max)
SCOPE/DIST. ANAL. OUTPUT:	
Mod Freq:	50 Hz to 3 KHz (3db)
Output Level:	Approx 280 mv p-p into 1K load at 5 KHz dev.

AUDIO OUTPUT:	
Freq:	1 KHz ±5%
Voltage:	1 vrms ±3db into 600Ω load. Continuously variable 0-1V
Source Impedance:	600Ω
Distortion:	1% (max)
OPERATING TEMPERATURE RANGE:	-5°C to +50°C
WEIGHT:	2 lbs.
POWER:	Supplied by FM-10 9 volts D.C. at 100 ma max

SECTION 2

INSTALLATION

2-1 To install the MDM-1 in the FM-10 mainframe, remove the blank plate covering the plug-in aperture by turning the two screws on quarter turn CCW.

2-2 Remove the protective cover on the connector at the rear of the aperture.

2-3 Insert MDM-1 until flush with front panel.

2-4 Turn the locking pawl clockwise until the plug-in is firmly locked.

SECTION 3

OPERATING INSTRUCTIONS

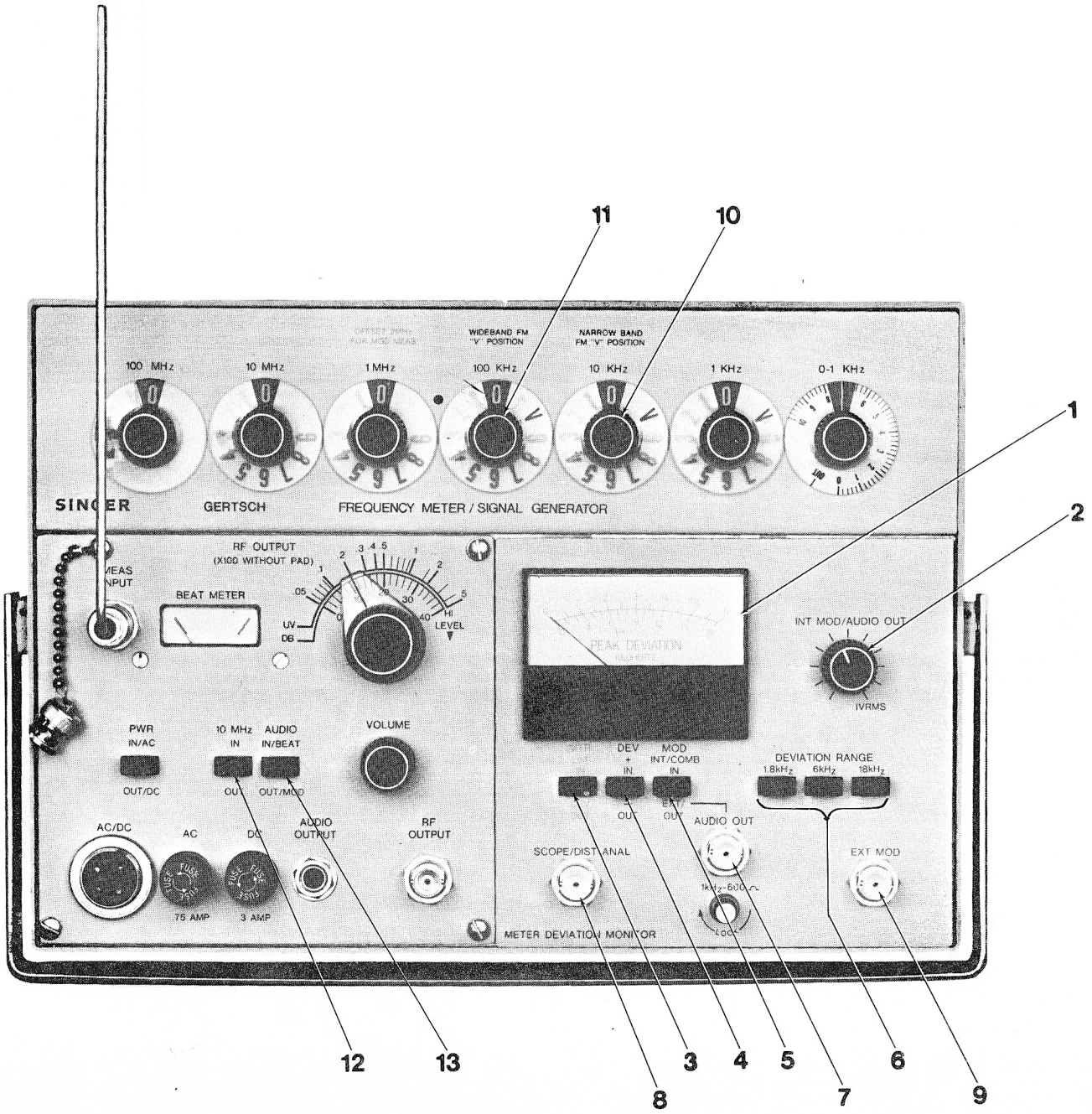


FIGURE 3-2: OPERATING CONTROLS, INDICATORS AND CONNECTORS

NOTE

Full instructions for operating the FM-10 mainframe are contained in manual 1-500783-155.

In particular, refer to the above manual for:

a. power supply set-up

b. rf output control

c. direct rf input set-up

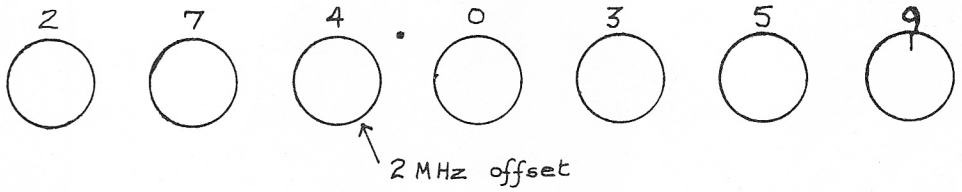
d. beat note zeroing procedure

3-1 FM DEVIATION MEASUREMENT

3-1-1 Dial frequency decade controls to frequency of transmitter.

3-1-2 Offset FM-10 frequency by ±2 MHz.

Example: Transmitter frequency: 276.0359 MHz



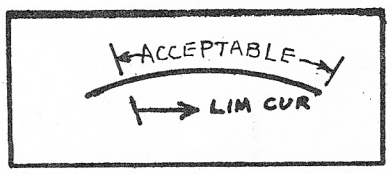
3-1-3 Connect RF input to MEAS INPUT. Use direct or antenna input with attenuation to ensure zero or minimum initial input.

3-1-4 Position other controls as follows:

MTR	IN
AUDIO	OUT
10 MHz (in-out switch)	OUT
DEV	OUT

3-1-5 Key transmitter (do not modulate).

3-1-6 Increase RF input for limiter current reading in acceptable range.



3-1-7 Push MTR to OUT.

3-1-8 Modulate transmitter by voice or tone.

(Note: 1 KHz tone variable from 0-1 vrms is available at AUDIO OUT. Refer to Section 3-6 for set up).

3-1-9 Select DEVIATION RANGE for on-scale reading.

3-1-10 Take deviation reading.

3-1-11 Push DEV to IN (+) and OUT (-). If there is noticeable difference in the meter readings in the IN and OUT positions, there is a possibility of distortion in the transmitter modulator.

3-1-12 Monitor the modulation aurally by adjusting VOLUME control to desired listening level.

NOTE: To investigate audio distortion further, connect an oscilloscope or distortion analyzer to SCOPE/DIST ANAL output.

3-2 INTERNAL FM MODULATION

3-2-1 PREFERRED METHOD - Using external RF generator or transmitter (see paragraphs 3-2-22 to 3-2-32 for alternate method without generator or transmitter).

3-2-2 Narrowband Modulation 0-6 KHz. (See paragraphs 3-2-16 to 3-2-21 for wideband modulation).

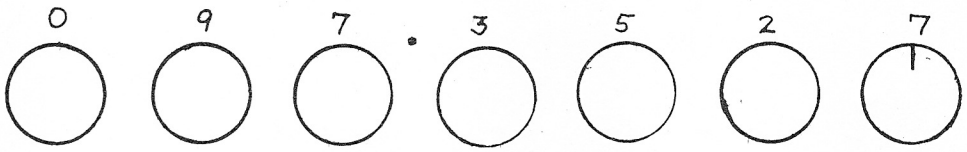
3-2-3 Connect RF input to MEAS INPUT. Use direct or antenna input with attenuation to ensure zero or minimum initial input.

3-2-4 Position other controls as follows:

10 MHz (in-out switch)	OUT
AUDIO	IN
MTR	IN
MOD	IN
DEVIATION RANGE	1.8 KHz or 6 KHz
INT MOD/AUDIO OUT	Fully CCW

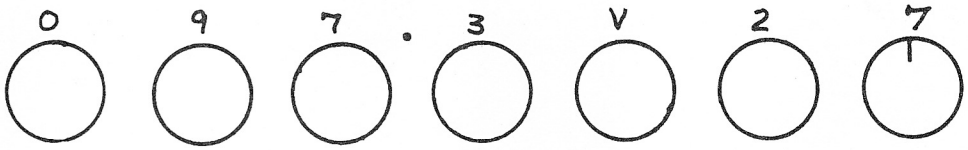
3-2-5 Set FM-10 frequency controls to frequency of test transmitter or to the frequency of an RF generator set anywhere in the range 20 MHz to 150 MHz.

Example: 97.3527MHz



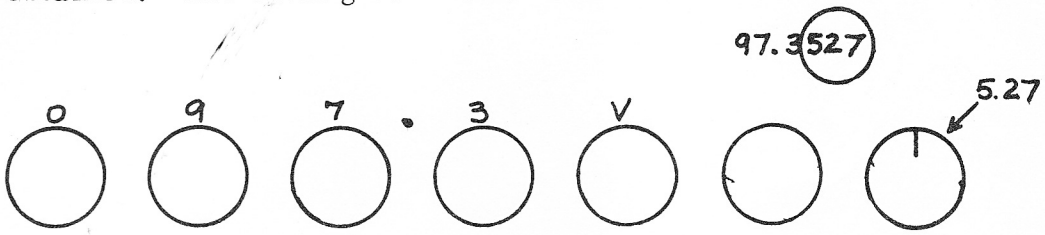
3-2-6 Observe audible beat note output.

3-2-7 Turn 10 KHz control to V position.

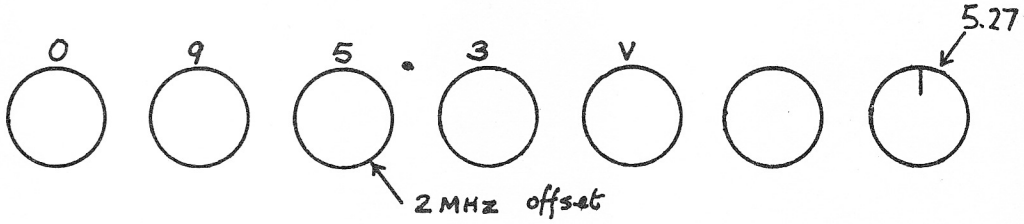


The functions of the 10 and 1 KHz controls are now taken over by the 0-1 KHz control. (See paragraphs 4-2 and 4-3 for explanation).

3-2-8 Turn 0-1 KHz control until zero beat note condition is obtained. The setting will be 5.27

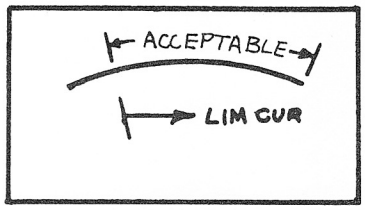


3-2-9 Offset by ±2 MHz.



3-2-10 Key transmitter (do not modulate) or increase output of RF generator.

3-2-11 Increase RF input for limiter current reading in acceptable range.



3-2-12 Push MTR switch to OUT.

3-2-13 Turn INT MOD/AUDIO OUT control CW until meter indicates desired deviation.

3-2-14 De-key transmitter or switch off generator.

3-2-15 Return FM-10 to carrier frequency by removing ±2 MHz offset.

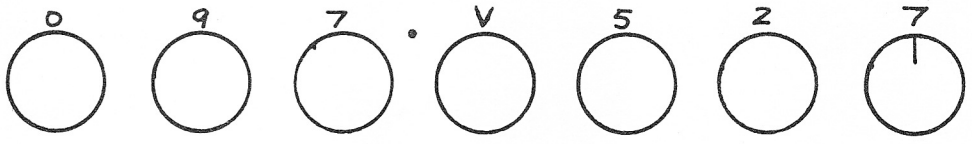
The FM-10/MDM-1 is now generating an FM output of the desired deviation and carrier frequency.

3-2-16 Wideband Modulation > 6 KHz.

3-2-17 Repeat paragraphs 3-2-3 through 3-2-6 except select DEVIATION RANGE of 18 KHz.

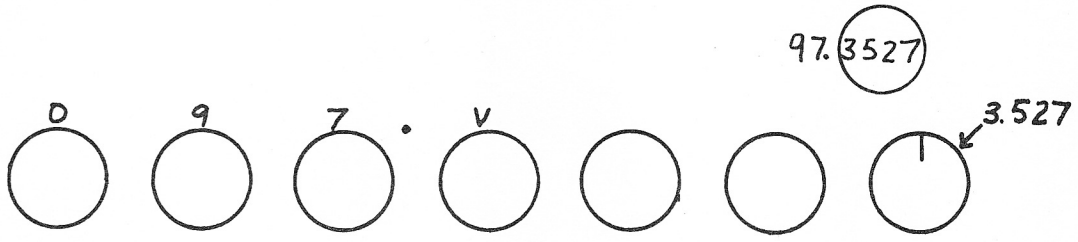
3-2-18 Turn 100 KHz control to V position.

Example: 97.3527 MHz

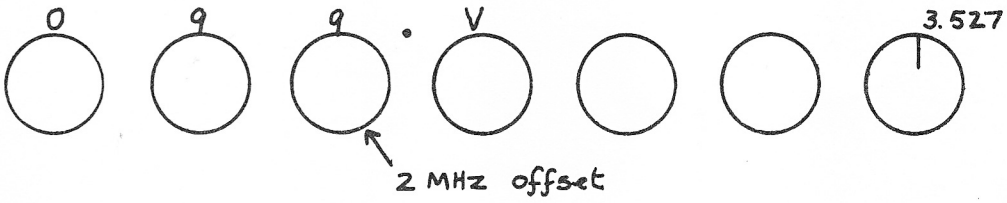


The functions of the 100, 10 and 1 KHz controls are now taken over by the 0-1 KHz control. (For explanation, see paragraphs 4-2 and 4-3).

3-2-19 Turn 0-1 KHz control until zero beat note condition is obtained. The setting will be 3.527.



3-2-20 Offset by ±2 MHz.



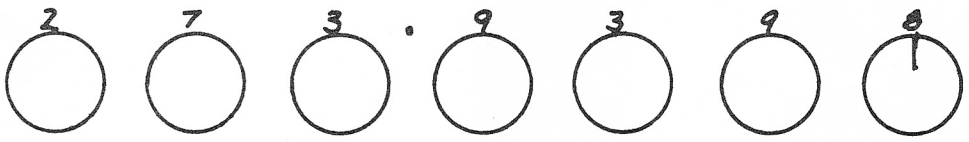
3-2-21 Repeat paragraph 3-2-10 through 3-2-15.

3-2-22 ALTERNATE METHOD - Without external transmitter or RF generator.

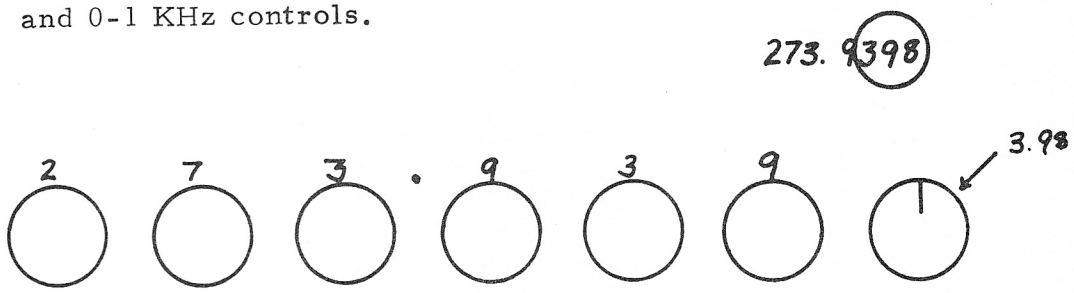
3-2-23 Narrowband Modulation 0-6 KHz. (See paragraphs 3-2-33 to 3-2-42 for wideband modulation).

Example: Modulate 273.9398 MHz to 5 KHz deviation.

3-2-24 Set FM-10 frequency controls to carrier frequency.



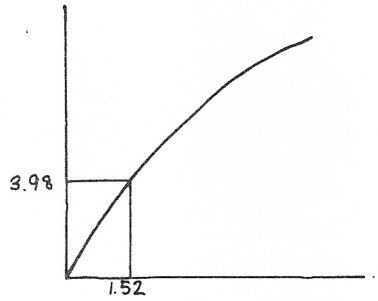
3-2-25 Turn 0-1 KHz control to same value as the 10 KHz, 1 KHz and 0-1 KHz controls.



3-2-26 Take setting of 0-1 KHz control and find correction factor from Figure 3-1. (For explanation of correction factors see paragraphs 4-3 and 4-4).

Example: 0-1 KHz control setting 3.98

Correction factor 1.52



3-2-27 Divide correction factor into desired deviation.

Example 5 KHz ÷ 1.52 = 3.3 KHz

The corrected deviation is 3.3 KHz

3-2-28 Position other controls as follows:

Frequency Controls	012.0V00
10 MHz (in-out switch)	IN
DEVIATION RANGE	1.8 or 6 KHz

MTR	OUT
MOD	IN
INT MOD/AUDIO OUT	Fully CCW

3-2-29 Turn INT MOD/AUDIO OUT control until meter indicates the corrected deviation obtained in paragraph 3-2-27. In the example, the corrected deviation is 3.3 KHz. This will become 5 KHz when the 0-1 KHz control is re-set to 3.98 in paragraph 3-2-31.

3-2-30 Push 10 MHz (in-out) switch to OUT.

3-2-31 Repeat paragraphs 3-2-24 and 3-2-25.

3-2-32 Turn 10 KHz control to V.

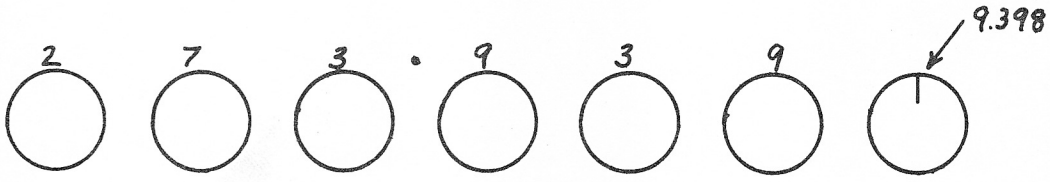
The FM-10/MDM-1 is now generating an FM output of the desired frequency with narrowband modulation (5 KHz).

3-2-33 Wideband Modulation > 6 KHz.

Example: Modulate 273.9398 MHz to 15 KHz.

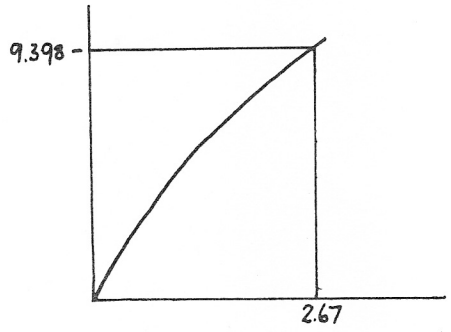
3-2-34 Set FM-10 frequency controls to carrier frequency.

3-2-35 Turn 0-1 KHz control to same setting as 100 KHz, 10KHz and 1 KHz controls.



3-2-36 Take setting of 0-1 KHz control and find correction factor from Figure 3-1.

Example: 0-1 KHz control setting 9.398
Correction factor 2.67



3-2-37 Divide correction factor into desired deviation.

Example: 15 KHz ÷ 2.67 = 5.6 KHz

3-2-38 Position other controls as follows:

Frequency controls	012.V000
10 MHz (in-out switch)	IN
DEVIATION RANGE	18 KHz
MTR	OUT
MOD	IN
INT MOD/AUDIO OUT	Fully CCW

3-2-39 Turn INT MOD/AUDIO OUT control until meter indicates the corrected deviation obtained in paragraph 3-2-37 (5.6 KHz).

3-2-40 Push 10 MHz (in-out) switch to OUT.

3-2-41 Repeat paragraphs 3-2-34 and 3-2-35.

3-2-42 Turn 100 KHz control to V.

The FM-10/MDM-1 is now generating an FM output of the desired frequency with wideband modulation (15 KHz).

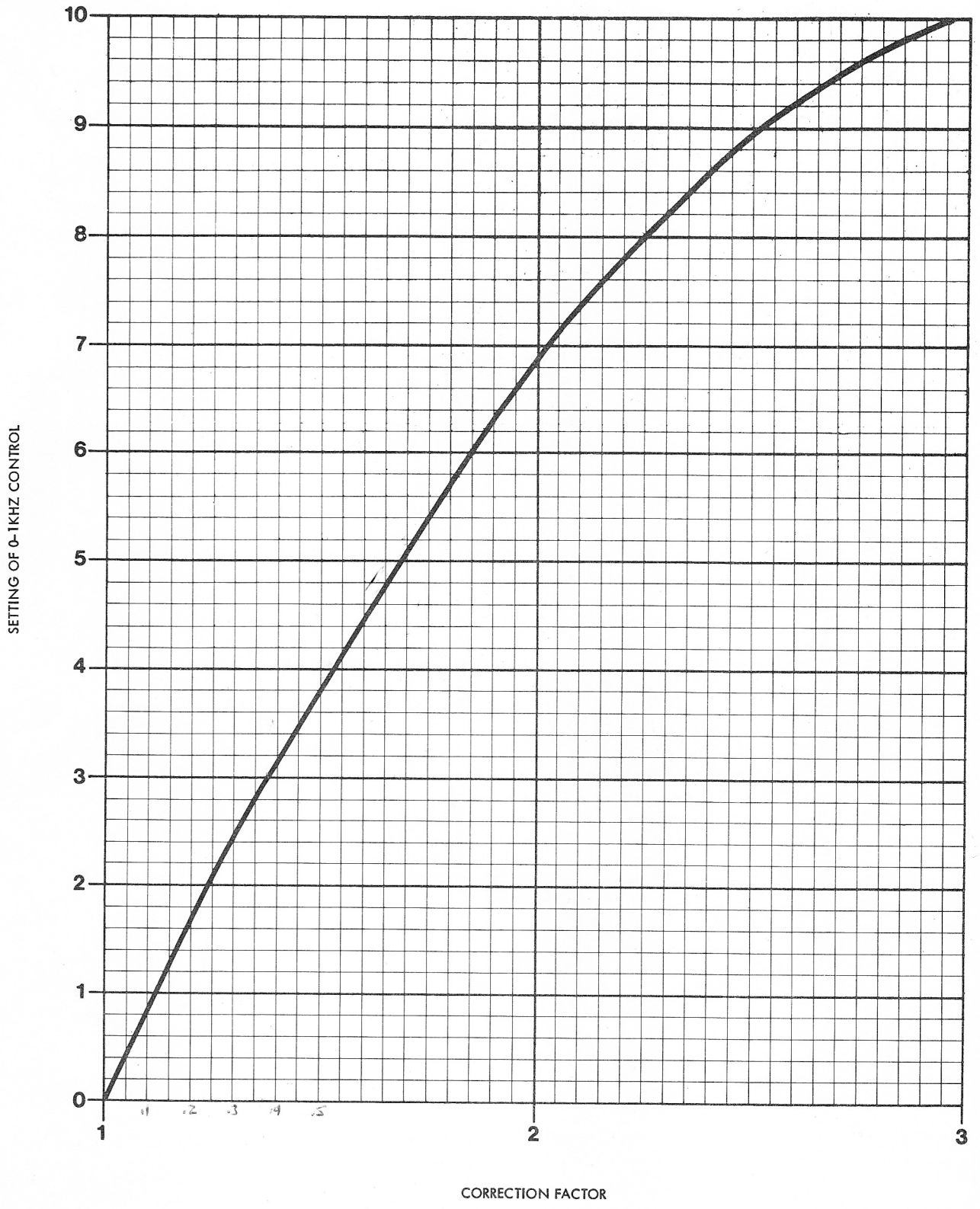


Figure 3-1, Deviation Correction Chart

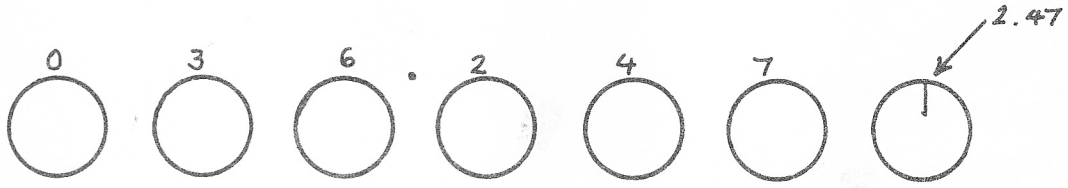
3-3 FM MODULATION TO 60 KHZ DEVIATION

The FM-10/MDM-1 provides metered deviation to 18 KHz. However, unmetered deviation as high as 60 KHz can be obtained by the following procedure.

Example: Modulate 36.2471 MHz to 50 KHz deviation.

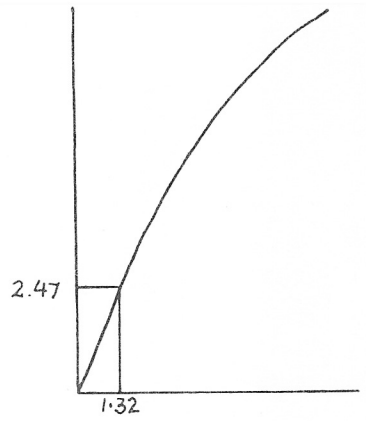
3-3-1 Set FM-10 to carrier frequency.

3-3-2 Turn 0-1 KHz control to same value as the 100, 10 and 1 KHz controls.



3-3-3 Take setting of 0-1 KHz control and find correction factor from Figure 3-1 (for explanation of correction factor see paragraphs 4-3 and 4-4).

Example: 0-1 KHz control setting 2.47
Correction factor 1.32



3-3-4 Divide correction factor into one tenth of the desired deviation.

Example:

Desired deviation:	50 KHz
One tenth desired deviation:	5 KHz
Correction factor:	1.32

5 KHz ÷ 1.32 = 3.78 KHz (corrected deviation)

3-3-5 Position other controls:

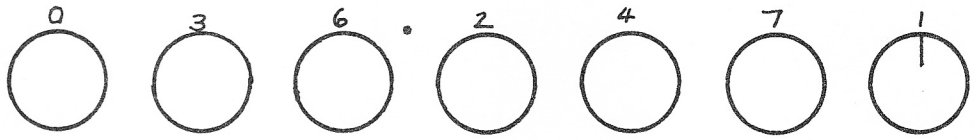
Frequency Controls	012.0V00
10 MHz	IN
AUDIO	OUT
INT MOD/AUDIO OUT	Fully CCW
MOD	IN
MTR	OUT

3-3-6 Turn INT MOD/AUDIO OUT control until meter indicates the corrected deviation obtained in paragraph 3-3-4 (3.78 KHz in example).

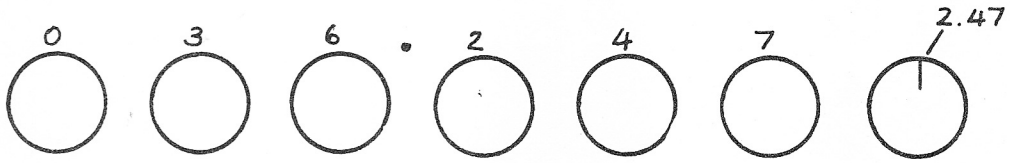
3-3-7 Position other controls:

MTR	IN
10 MHz (in-out switch)	OUT

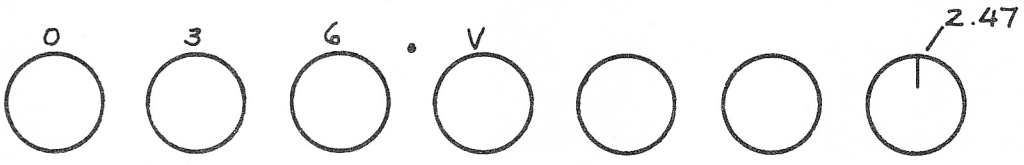
3-3-8 Re-set frequency controls to carrier frequency.



3-3-9 Turn 0-1 KHz control to same value as the 100, 10 and 1 KHz controls.



3-3-10 Turn 100 KHz control to V.



The FM-10/MDM-1 is now generating an FM output of the desired frequency modulated to the desired deviation.

NOTE: In the example, the deviation of 3.78 KHz is set up with the 10 KHz control in the V position. This is multiplied by 10 when the 100 KHz control is set to V instead, in paragraph 3-3-10. The deviation thus becomes 37.8 KHz. This corresponds to 50 KHz when the 0-1 KHz control is set to 2.47.

3-4 COMBINED INTERNAL/EXTERNAL (TWO-TONE) MODULATION

(Note: An external RF generator or transmitter must be used).

3-4-1 Set external audio oscillator to desired frequency and set to zero output.

3-4-2 Connect oscillator to EXT MOD.

3-4-3 Repeat paragraphs 3-2-3 through 3-2-13.

3-4-4 Increase output of oscillator until meter indicates total deviation required.

3-4-5 De-key transmitter (or switch off RF generator).

3-4-6 Re-set FM-10 to transmitter frequency by removing ±2 MHz offset.

The FM-10/MDM-1 is now supplying two-tone FM modulation at the desired carrier frequency.

3-5 EXTERNAL MODULATION ONLY

3-5-1 Using external transmitter (see paragraphs 3-5-4 through 3-5-6 for modulation without external transmitter).

3-5-2 For narrowband modulation (see paragraph 3-5-3 for wideband modulation):

a. Connect external oscillator (set at required frequency and zero output) to EXT MOD.

b. Repeat paragraphs 3-2-3 through 3-2-12, except push MOD to OUT.

c. Increase external oscillator output until meter indicates desired deviation.

d. Repeat paragraphs 3-2-14 and 3-2-15.

The FM-10/MDM-1 is now generating an FM output of the desired deviation.

3-5-3 For wideband modulation:

a. Connect external oscillator set at required frequency and zero output to EXT MOD.

b. Repeat paragraphs 3-2-3 through 3-2-12 except push MOD to OUT and select DEVIATION RANGE of 18 KHz.

c. Increase external oscillator output until meter indicates desired deviation.

d. Repeat paragraphs 3-2-14 and 3-2-15.

The FM-10/MDM-1 is now generating an FM output of the desired deviation.

3-5-4 Without external transmitter.

3-5-5 For narrowband modulation (for wideband modulation see paragraph 3-5-6):

a. Repeat paragraphs 3-2-24 through 3-2-28 except push MOD to OUT.

b. Increase external oscillator output until meter indicates corrected deviation obtained in paragraph 3-2-27.

c. Push 10 MHz (in-out) switch to OUT.

d. Repeat paragraphs 3-2-24 and 3-2-25.

e. Turn 10 KHz control to V.

The FM-10/MDM-1 is now generating an FM output of the desired frequency with narrowband modulation.

3-5-6 For wideband modulation:

a. Repeat paragraphs 3-2-34 through 3-2-38 except push MOD to OUT.

b. Increase external oscillator output until meter indicates corrected deviation obtained in 3-2-37.

c. Push 10 MHz (in-out) switch to OUT.

d. Repeat paragraphs 3-2-34 and 3-2-35.

e. Turn 100 KHz control to V.

The FM-10/MDM-1 is now generating an FM output of the desired frequency with wideband modulation.

3-6 AUDIO TEST TONE

The 1 KHz modulation tone developed by the FM-10/MDM-1 is available at the AUDIO OUT connector for testing of transmitters and repeaters.

3-6-1 Push MOD to OUT.

3-6-2 Connect transmitter microphone input to AUDIO OUT.

3-6-3 Turn INT MOD/AUDIO OUT control to level desired (a maximum of 1 vrms into 600 ohms is available).

The FM-10/MDM-1 is now supplying a 1 KHz tone with 600 ohms output impedance.

TABLE 2

OPERATING CONTROLS, INDICATORS AND CONNECTORS

REF DES	PANEL MARKING	TYPE	FUNCTIONS
1	PEAK DEVIATION	Meter	Has two functions controlled by meter switch (MTR): 1. Indicates limiter current 2. Indicates frequency deviation in KHz The limiter current mode indicates whether sufficient IF signal is present to make a deviation measurement. A red line on the scale labelled "LIM CUR" indicates minimum limiter current necessary to make a deviation reading. The scale markings are in KHz.

REF DES	PANEL MARKING	TYPE	FUNCTIONS
2	INT MOD/AUDIO OUT	Variable resistor control	Has two functions controlled by modulation switch (MOD): 1. Varies frequency deviation from zero to 60 KHz maximum when modulation switch is in IN (INT/COMB) position. 2. Varies voltage of 1 KHz tone output from 0 to 1 vrms. When modulation switch is in OUT (EXT) position.
3	MTR LIM/IN DEV/OUT	Switch, in/out position pushbutton	Controls function of PEAK DEVIATION meter. IN position: Meter reads limiter current OUT position: Meter reads peak deviation in KHz

REF DES	PANEL MARKING	TYPE	FUNCTIONS
4	DEV IN + OUT -	Switch, in/out position pushbutton	Selects positive or negative half waves of recovered modulation. Provides a means of checking distortion of an FM input signal. A difference of peak deviation meter readings in the in and out positions indicates presence of distortion.
5	MOD INT/COMB IN EXT/ OUT	Switch, in/out position	1. In the IN position, the internal 1 KHz modulation tone and any external tone connected to the external modulation (EXT MOD) connector frequency modulate the RF output. The level of the internal tone is controlled by the INT MOD/AUDIO OUT variable control. 2. In the OUT position, the internal 1 KHz tone is eliminated from the modulation circuit and

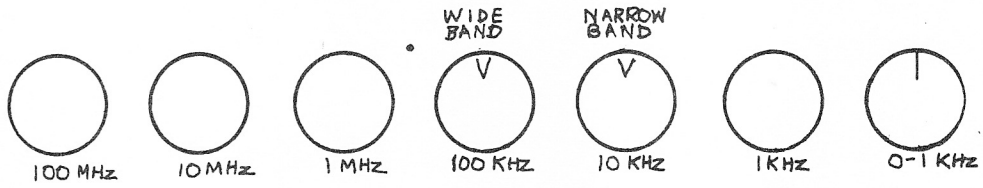
REF DES	PANEL MARKING	TYPE	FUNCTIONS
5 Cont			only the external tone modulates the RF output. In the OUT position, the 1 KHz internally generated tone is available at the AUDIO OUT (1 KHz, 600 ohms) CONNECTOR.
6	DEV, RANGE, 1.8 KHz, 6 KHz, 18 KHz	Switches, in/out position	Switches set frequency range of meter in the deviation mode.
7	AUDIO OUT	Connector, BNC female	Provides 1 KHz output when modulation switch (MOD) is in the OUT (EXT) position. Output level is 0-1 vrms into 600 ohms controlled by INT MOD/AUDIO OUT variable control.

REF DES	PANEL MARKING	TYPE	FUNCTIONS
8	SCOPE/DIST ANAL	Connector, BNC female	Provides demodulated signal output for oscilloscope display or analysis by a distortion analyzer.
9	EXT MOD	Connector, BNC female	An external modulation tone may be applied to this connector. A modulation signal applied to this connector will modulate the FM-10 when the modulation switch (MOD) is in both the IN (INT MOD/COMB) position and the out (EXT) position.

SECTION 4

THEORY OF MODULATION CONTROLS

4-1 For modulation to occur, either the 100 KHz or the 10 KHz decade switches (on the FM-10 mainframe) must be in the V position. The 100 KHz decade is set to V when the required deviation is greater than 6 KHz (wideband modulation). The 10 KHz decade is set to V when the deviation is less than 6 KHz (narrowband modulation). (See Figure 4-1).



Switch	Switch Position	Deviation
100 KHz	V	Wideband ($\geq$ 6 KHz)
10 KHz	V	Narrowband ($<$ 6 KHz)

Figure 4-1: Control Positions for Modulation

4-2 When the 100 KHz switch is at V, the 10 KHz and 1 KHz switches are inoperative. Similarily when the 10 KHz is at V, the 1 KHz switch is inoperative.

To compensate for the fact that these switches are inoperative, the 0-1 KHz control is designed to take over their functions and is set to the value that would otherwise be set up on the decade switches. For example, suppose a frequency of 197.8326 MHz is to be set for (a) narrowband deviation and

(b) wideband deviation.

a. For narrowband deviation the decades are set up as in Figure 4-2a. The 0-1 KHz control is set to 3.26 to compensate for the fact that the 10 KHz and 1 KHz controls are inoperative.

Note: Due to lack of resolution, the 0-1 KHz control can only be set to two places, so in practice it would be set to 3.2.

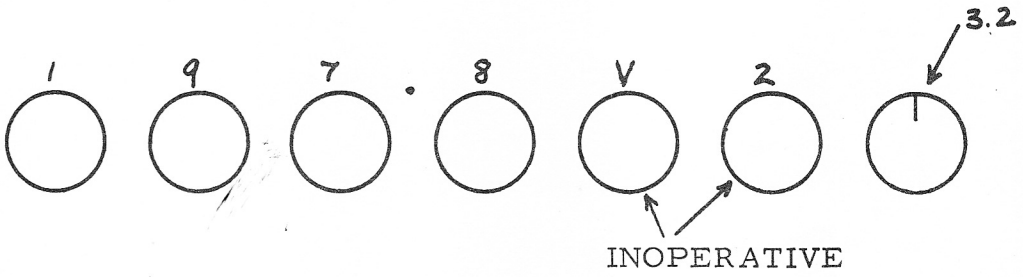


Figure 4-2a

b. For wideband deviation, the decades are set up as in Figure 4-2b. The 0-1 KHz control is set to 8.326 to compensate for the fact that the 100 KHz, 10 KHz and 1 KHz controls are inoperative.

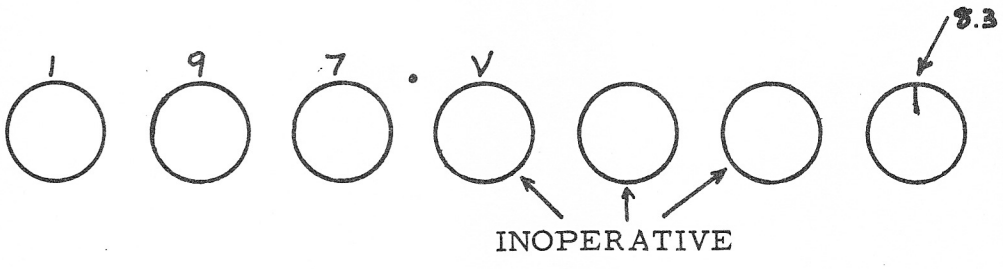


Figure 4-2b

4-3 When the FM-10/MDM-1 is used for internal modulation without an external RF generator (see paragraphs 3-2-22 to 3-2-42) the 0-1 KHz control must be calibrated for use at the specific carrier frequency. This is because the circuit of which the 0-1 KHz control is a part, is used to generate the modulation tone. Because it is non-linear, the degree of deviation varies with dial setting. It is therefore necessary to calculate an amended deviation using a correction factor derived from the deviation correction chart in Figure 3-1. A general description of the procedure is given below (paragraph 4-4).

4-4 Suppose the frequency 197.8325 MHz is to be modulated to 14 KHz deviation. The frequency controls will be set as in Figure 4-3.

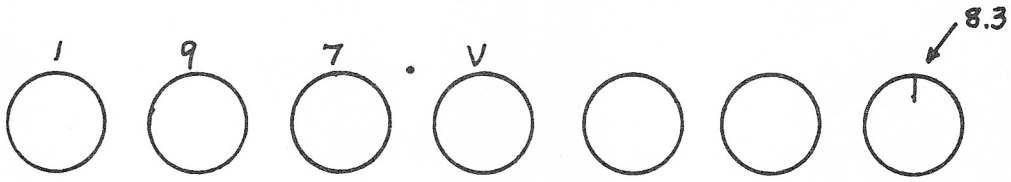


Figure 4-3: Typical Frequency Control Set-up

Note that the 0-1 KHz control will be set to 8.3. However, before the FM-10 is set to 197.8325 MHz, it is necessary to set up the MDM for a deviation of 14 KHz. The MDM

operates on an I. F. of 2 MHz. To obtain a 2 MHz I. F., the FM-10 is set for 12 MHz which is mixed with an internal 10 MHz signal obtained by pushing the 10 MHz (in-out) switch to IN. (See Figure 4-4).

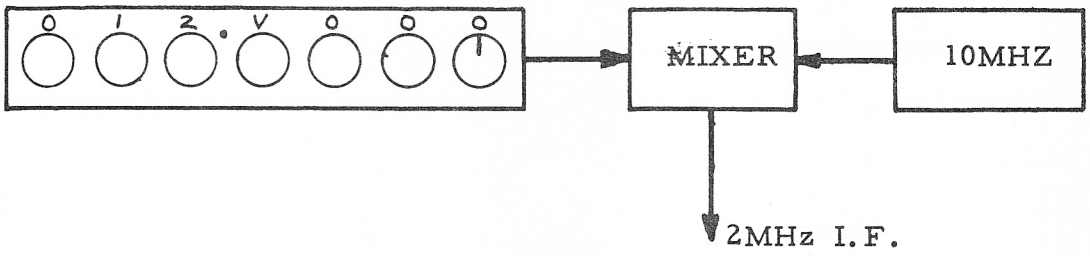


Figure 4-4: I. F. Generation

Since the frequency controls have been set for 12.000 MHz, the 0-1 KHz control will be in the zero position. However, when the frequency controls are finally re-set to 197.8325 MHz, the 0-1 KHz control will be in the 8.3 position. It is therefore necessary to refer to the deviation correction chart (Figure 3-1). Find the correction factor corresponding to a setting of 8.3 which is 2.33 and divide it into the desired deviation of 14 KHz.

$$14 \text{ KHz} \div 2.33 = 6 \text{ KHz}$$

The MDM should therefore be set for a corrected deviation range on the meter of 6 KHz. When the 10 MHz signal is removed and the frequency controls are re-set from 12 MHz

to 197.8325 MHz the 0-1 KHz control will be set to 8.3 and the deviation generated will be 14 KHz.

SECTION 5

TO BE ISSUED AT A LATER DATE