MANUAL MOBILE RADIO
OVERALL SYSTEM
BASE STATION LINEUP
TRANSMITTER FREQUENCY AND MODULATION

This section provides procedures for adjusting base station transmitters used in manual mobile radio telephone service.

It is reissued to revise the transmission levels on the land line facilities connecting the radio transmitters and receivers with the control terminal.

Transmitter Frequency Adjustment

The importance of adjusting the transmitter frequency as close as possible to the assigned frequency cannot be overemphasized. Penalties resulting from off-frequency conditions are severe in terms of impaired transmission performance. The principal transmission penalty resulting from frequency errors is an increase in audio noise and a resulting impairment in the signal-to-noise ratio.

Figure 1 illustrates noise-frequency error characteristics for 150-MHz system operation. Curve A in Fig. 1, for example, indicates that where a mobile unit is operating near the fringe of the coverage area under fairly severe impulse noise conditions, a frequency difference of 1500 Hz is enough to raise the audio noise by as much as 8 dB. The resulting decrease in the signal-to-noise ratio would be at least as great. Therefore, the original signal-to-noise ratio of 12 dB would be reduced to about 4 dB, making the circuit unusable.

A further requirement for careful frequency adjustment relates to FCC regulations. Some older type transmitters are subject to frequency drift. These transmitters should be checked and adjustments made as needed at intervals frequent enough so as to insure that they always operate within allowable FCC tolerances.

If the transmitter frequency is more than 200 hertz off the assigned frequency, it should be readjusted. It is essential that the transmitter frequency be matched perfectly with that of the frequency meter by varying the frequency adjustment in the transmitter crystal circuit.

Transmitter Deviation Adjustment

The usual method for measuring transmitter deviation calls for inserting a strong signal at 1000 hertz into the transmitter and then adjusting the modulation limiting control or instantaneous deviation control (IDC) for an indication of ± 5 kHz or slightly less as indicated on a deviation meter. This procedure should still be followed, but additional tests and a change in test methods are necessary to assure that the transmitter will not overdeviate and thus invite possible citations. The additional tests include sweeping the signal generator through the audio band to verify that frequencies other than 1000 Hz will not cause the transmitter to deviate more than the permissible ± 5 kHz. It is important that this check be performed using a deviation meter equipped with an oscilloscope that has been carefully calibrated. This will permit observation of modulation peaks and allow adjustment

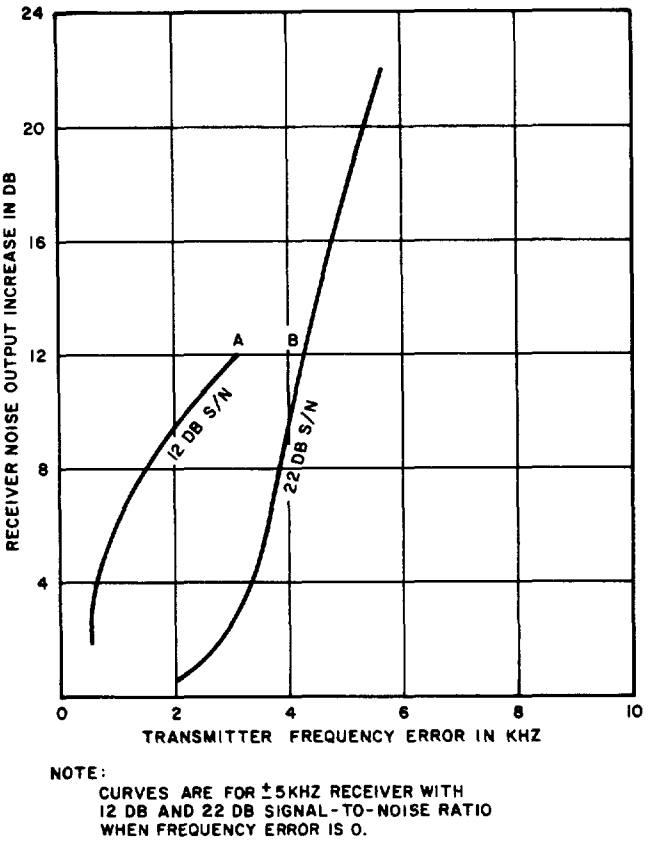

Fig. 1—Noise-Frequency Error Characteristics for 150-MHz System

to be made using the highest peak. This precaution is necessary since some transmitters do not modulate uniformly. The final check to assure proper deviation limiting and compliance with FCC regulations involves observing the deviation meter oscilloscope while the transmitter is voice-modulated from the control terminal. Modulation peaks should be observed over a period of several minutes to confirm that cycling of the crystal oven heater does not shift the zero deviation point.

This more thorough method of checking modulation deviation is important since some of the older transmitters in use have been found to have deviation characteristics that produce much wider frequency swings at the lower audio frequencies than at 1000 Hz.

APPARATUS:

ITEM	REQUIREMENT	TYPICAL APPARATUS
Audio Oscillator	Frequency: 0-3000 Hz; output: 2 volts; accuracy: ±2%	Hewlett-Packard Types 200CD or 201C, or 202C
Frequency Meter	Accuracy: 1 PPM; sensitivity: 50 mV; frequency: to 460 MHz	Hewlett-Packard 5245L E/W frequency converter; Cushman CE3 (or later)
FM Deviation Monitor	Accuracy: ±5%; frequency: to 460 MHz; deviation: 0-10 kHz; built-in or external visual presentation	Radio Speciality Co. Model 1163-1-5 Cushman CE3 E/W oscilloscope plug-in unit (or later)
AC VTVM	Minimum full scale indication: 1 V to 10 Vac; frequency range: 100-3000 Hz	Hewlett-Packard 400 Series
Adjustable "T" Attenuator	Frequency: to 460 MHz; power: to 500 watts; adjustable: 30 to 100 dB	General Radio 874 GAL; International Crystal Co. Model 150-288; DuMont 21-1CBA (where available)

STEP	PROCEDURE

A. Frequency Measurement

At the transmitter:

Note: The most accurate frequency measurement can be made by inserting the RF attenuator between the transmitter and the load. Connect a dummy load in place of the base station antenna to avoid radiation during alignment.

1 Arrange the frequency meter to measure the transmitter carrier frequency.

2 Key the transmitter and adjust the attenuator coupling to provide the proper RF level to the frequency meter.

STEP	PROCEDURE

3 Read the frequency meter.

Requirement: Transmitter frequency is within ±200 Hz of the assigned frequency (Table A).

Note: Transmitter frequency is usually adjusted either by varying an oscillator trimmer capacitor or tuning coil in the transmitter crystal circuit.

B. Deviation Measurement

At the transmitter:

4 Connect the 600-ohm output of the audio oscillator to the transmitter audio input (Fig. 2).

Note: Connect to the TRANS IN or TRS input jack of the transmitter trunk terminating circuit. If an input jack is not provided, disconnect the wire line at the input terminal strip and connect the sending test equipment to these terminals.

5 Set the line level control(s) fully clockwise for maximum input level (minimum attenuation).

6 Set the transmitter deviation control fully counterclockwise for minimum deviation.

Note: This control may be designated MOD, MODULATION, DEVIATION, or IDC on various transmitters.

7 Connect an ac voltmeter across the sending test equipment output terminals or across the transmitter input terminals if a line amplifier precedes the transmitter.

TABLE A

FREQUENCY BAND	TRANSMITTER	FCC FREQUENCY REQUIREMENTS	BELL SYSTEM RECOMMENDED MAXIMUM VARIATION
35 MHz	Base and Mobile	±0.002% or ±700 Hz	±200 Hz
150 MHz	Base and Mobile	±0.0005% or ±750 Hz	±200 Hz
450 MHz	Base	±0.00025% or ±1125 Hz	±200 Hz
	Mobile	±0.0005% or ±2250 Hz	±200 Hz

Note: FCC Rules, Part 21, Section 21.102 stipulate that transmitter frequency-measuring equipment "shall have an accuracy within one-half of the allowed frequency tolerance of the transmitter being measured." It is expected that frequency monitors used in the Bell System will have frequency stability characteristics substantially better than the FCC-imposed limits.

STEP	PROCEDURE

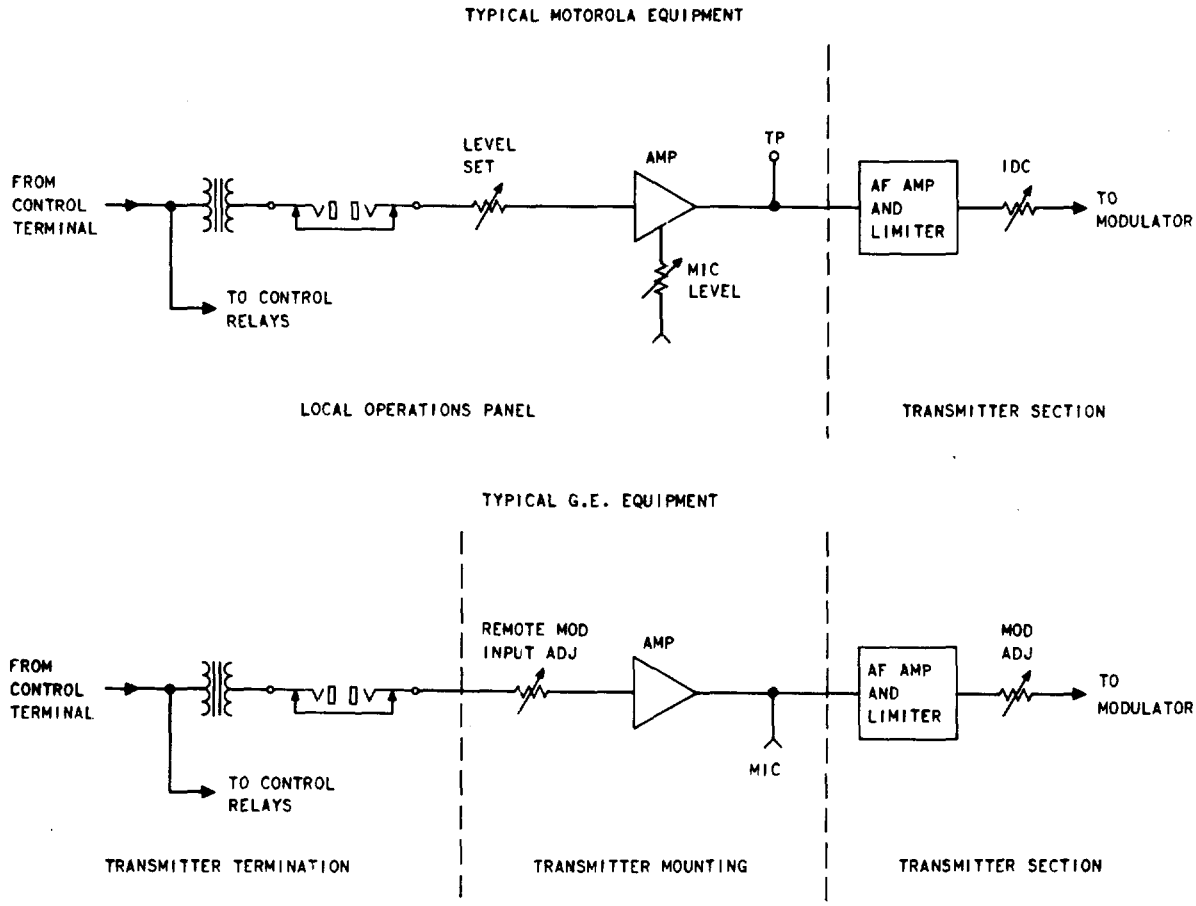

Fig. 2—Typical Transmitter Input Arrangements

8 Adjust the audio oscillator to produce an indication of 1.0 volt on the ac voltmeter at 1000 Hz.

9 Connect the deviation meter equipped with an oscilloscope to the transmitter through the RF attenuator. Refer to the manufacturer's instruction manual for proper calibration.

10 Key the transmitter and adjust the attenuator for a satisfactory indication.

11 With the transmitter keyed, adjust the deviation level control of the transmitter.

STEP	PROCEDURE

Requirement:

MAXIMUM DEVIATION	DEVIATION INDICATION	SYMMETRY OF MODULATION BETWEEN POSITIVE AND NEGATIVE PEAKS
±5 kHz	±5 kHz	Within 0.5 kHz

Note: All transmitters do not deviate uniformly; that is, some may deviate more in a positive direction than in a negative direction from the zero level point. It is important, therefore, to observe both positive and negative peaks on the oscilloscope and adjust the modulation deviation limiter controls so that the highest peak does not exceed the allowable limit of ±5 kHz. If excessive nonuniformity is observed, realignment of the transmitter may be required.

12 While keying the transmitter, vary the frequency of the audio oscillator over the range of 100 to 3000 Hz while maintaining the output level at 1.0 volt RMS. Observe the deviation peaks on the oscilloscope and readjust the modulation control, if necessary, to assure that the maximum allowable deviation limits are not exceeded at any frequency.

13 Readjust the audio oscillator to 1000 Hz. Key the transmitter and observe the maximum peak deviation.

◗***Requirement:***

MAXIMUM DEVIATION	MINIMUM DEVIATION
5 kHz	±4.5 kHz◖

Note: Transmitters not meeting this requirement should be removed from service for repair. Proceed in accordance with local instructions.

14 If the transmitter is equipped with a crystal oven heater, cycling of the heater may shift the zero deviation point. Therefore, it is important to recheck the requirements of Steps 11 and 13 while the heater cycles to insure that the requirements will be met.

Note: A final check of deviation using voice modulation is called for below. Do not consider the transmitter properly adjusted without performing this check.

15 Arrange to transmit a 1000-Hz test signal at ◗−4 dBm◖ from the control terminal on the appropriate circuit to the transmitter location. Jack designations will vary with the type of control terminal.

At the transmitter:

16 With a 1000-Hz test signal sent from the control terminal, key the transmitter and adjust the line level control(s) to provide the proper deviation. Do not change the setting of

STEP	PROCEDURE

deviation limiting controls set above. Where two line level controls are provided, it will usually be satisfactory to adjust only one and leave the other set for maximum gain.

Requirement: Adjust the line level control for a transmitter deviation of ±3.3 kHz as indicated by the deviation measuring device.

At the control terminal:

17 Adjust the selective signaling oscillator for the proper output level. (Refer to Section 404-205-500.)

At the transmitter:

18 Key the transmitter (with the control terminal in the signaling mode) and observe the deviation for each signaling frequency.

Requirement:

MAXIMUM DEVIATION	DEVIATION AT 600 HZ	DEVIATION AT 1500 HZ
±5 kHz	2.0 ±0.5 kHz	4.5 ±0.5 kHz

Note: The difference in deviation per various frequencies is due to the phase modulation characteristics of the transmitters. For example, 1500 Hz approximates full modulation of ±5 kHz and 1000 Hz = 1000/1500 of 5 kHz, or 3.3 kHz. Therefore, 600 Hz applied at the same level will be approximately 600/1500, or 2.0 kHz.

19 As a final check, arrange for voice modulation of the transmitter from the control terminal. Observe the oscilloscope on the deviation meter and verify that voice modulation peaks do not deviate the transmitter more than ±5 kHz.

20 Repeat these frequency and deviation measurements for all other transmitters in the system. Each test or standby transmitter must also be checked for correct frequency and deviation. When a test transmitter is equipped with more than one frequency, each operating frequency must be checked.