

*Clegg*



# **FM-DX**

***2 METER FM TRANSCEIVER***

**OWNER'S MANUAL**

# SECTION 1

## GENERAL INFORMATION

### 1.1 DESCRIPTION

The FM-DX is a solid-state VHF FM transceiver offering unique features never before available to the 2-meter amateur.

The unit employs digital technology in a phase-locked loop scheme to control frequency over the full 2-meter band with additional coverage (143.5 to 148.5 MHz) for operation in the MARS and other amateur related services.

Operation features include a 6 digit, direct frequency readout with brilliant numeric LEDs. The transmitter frequency tracks with the selected receiver frequency and is programmable for either Simplex or Repeater operation. Capability is provided for all standard repeater spreads with provisions for several non-standard spreads.

A panel selector permits instant choice between more than 35 watts output and 1/2 watt output.

The receiver section employs the latest in component, circuit and solid-state device technology to yield an unprecedented marriage of sensitivity, selectivity and freedom from spurious responses. A meaningful S-Meter significantly enhances operating convenience of the FM-DX.

Reliability and servicability has been achieved by a unique extremely rugged modularized construction technique employing a solid extruded main frame.

The FM-DX is supplied with a high quality, attractive dynamic microphone and includes provisions for a wide

complement of accessory capabilities common to 2-meter FM activity.

### 1.2 SPECIFICATIONS

#### GENERAL

SUPPLY VOLTAGE: 13.5 ± 1.3 VDC;  
NEGATIVE GND ONLY

CURRENT DRAIN AT 13.8 VDC

Receive: 1.3A (typical)

Transmit: (LO) 4A (max.)

Transmit: (HI) 10A (max.); 9.5A (typical)

SEMICONDUCTOR COMPLEMENT:

3 Field Effect Transistors

28 Bipolar Transistors

18 Digital Integrated Circuits

5 Linear Integrated Circuits

6 Display LED's

DIMENSIONS: 7" Wide x 3 1/8" High x

11 1/2" Deep

NET WEIGHT: 5 1/2 pounds

SHIPPING WEIGHT: 7 1/2 pounds

ACCESSORY RECEPTACLE: 7 pin socket,  
mating plug supplied

EXTERNAL SPEAKER JACK: RCA phono  
type

OPERATING TEMP. RANGE: 0° F to 130° F

#### FREQUENCY SYNTHESIZER

TYPE: Phase locked voltage controlled oscillator with programmable digital control. Referenced to 4 MHz crystal oscillator.

CONTROL: Four panel switches provide:

1. 1 MHz Steps } 10 position

2. 100 KHz Steps } rotary

3. 10 KHz Steps }

4. 0/5 KHz (2 position toggle)

DISPLAY: Six Numeric LED display read

receive frequency directly.  
**CALIBRATION ACCURACY:**  
(25°C, 13.5 VDC supply; 15 min.  
warmup) ± .0005% typical  
Internal trimmers provided to permit  
periodic recalibration against external  
standard.

**TEMPERATURE STABILITY:**  
±500 Hz (max.) 30°F to 100°F  
±800 Hz (max.) 5°F to 120°F

**SUPPLY VOLTAGE STABILITY:**  
±200 Hz (max.) 12 to 14.8 volts

**LOOP LOCKUP TIME:**  
Virtually zero when switching between  
transmit and receive.  
Less than 100 milliseconds typical when  
changing frequency.

### RECEIVER

**TYPE:** Single conversion, 10.7 MHz IF  
with 8 pole monolithic crystal filter.  
**FREQUENCY RANGE:** 143.5 to 148.5  
MHz (full spec. performance)  
142 to 149.5 MHz (usable)  
5 KHz steps  
300 Hz typical accuracy  
**SENSITIVITY:** .25uv (max.) for 12 db  
**SINAD:** .35uv (max.) for 20 db Quieting;  
.15uv (max.) Squelch Threshold.  
**SELECTIVITY:** 14 KHz (min.) at 3 db; down  
40 db at ± 11 KHz; down 60 db at ±15 KHz;  
down 80 db at ±20 KHz  
**INTERMODULATION ATTENUATION:**  
66 db (min.)  
**IMAGE REJECTION:** 66 db (min.)  
**IF (10.7 MHz) REJECTION:** 66 db (min.)  
**AUDIO OUTPUT:** 1.3 watts (min.)  
**OUTPUT IMPEDANCE:** 4 ohms (3.2 -  
8 ohm speaker)  
**INTERNAL SPEAKER:** 4 inch, 1.2 ounce  
magnet, 8 ohms

### TRANSMITTER

**FREQUENCY RANGE:** 143.5 to 148.5  
MHz, 5 KHz Steps

**POWER OUTPUT:** (at 13.5 VDC)  
**HI POSITION:** 35 Watts (min.)  
**LO POSITION:** Approximately 500 mw.  
**FREQUENCY CONTROL:** Heterodyne  
derived from VCO in synthesizer. Panel  
selection of heterodyne crystal permits  
any Transmit Offset from 0 KHz  
(Simplex) to +5 MHz and -4 MHz. Three  
offset crystals supplied (±600 KHz and  
Simplex). Socket and switch provisions  
for three additional offsets included.  
**FREQUENCY STABILITY:** Essentially  
same as indicated for synthesizer.  
**CALIBRATION ACCURACY:** ±.00052 (typ);  
±.0001% (max.)  
**MODULATION:** 16 F3  
**MODULATION SYSTEM:** Direct FM via  
voltage variable diode in synthesizer  
VCO; internally adjustable clipping.  
**MICROPHONE:** Supplied with 350 ohm  
dynamic hand-held PTT microphone.  
**SPURIOUS OUTPUTS:** In band spurs all  
down 60 db (min.), 76 db (typ.); harmon-  
ics down 45 db (min.).  
**HUM AND NOISE MODULATION:** Above  
100 Hz; down 50 db below 3 KHz  
deviation  
Below 100 Hz; down 30 db below 3 KHz  
deviation  
**DUTY CYCLE:**  
**LO Position:** 100%  
**HI Position with heat sink; approx.**  
80% (20 minutes key down, 5 minutes  
receive)  
**HI Position with heat sink and small  
fan:** 100%  
**HI Position without heat sink; approx.**  
50% (3 minutes key down, 3 minutes  
receive)

### ACCESSORIES AVAILABLE

Model 031A Base Station Power Supply/  
Speaker  
Tone Pads and Sub-Audible Tone  
Generators  
Narrow Band IF Filters  
Consult Sales Department

Offset crystals normally stocked at Clegg for all non-standard ( $\pm 600$  KHz) repeater parrings including  $\pm 1000$  KHz,  $+4020$  KHz

(MARS), etc.  
Spare Mobile Mounting Bracket

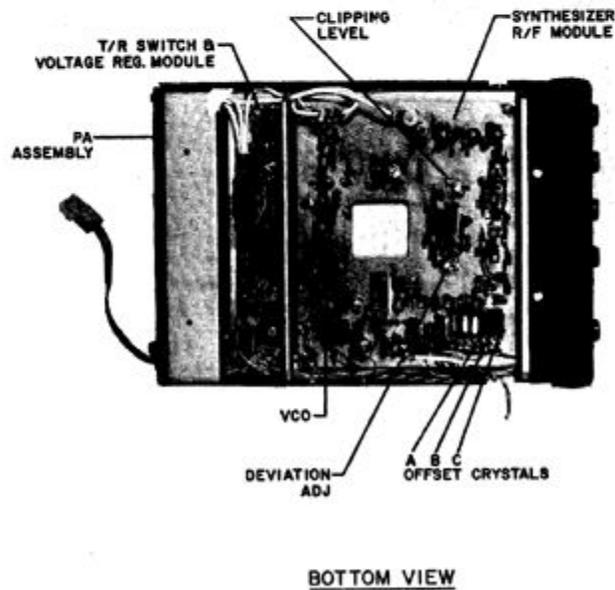
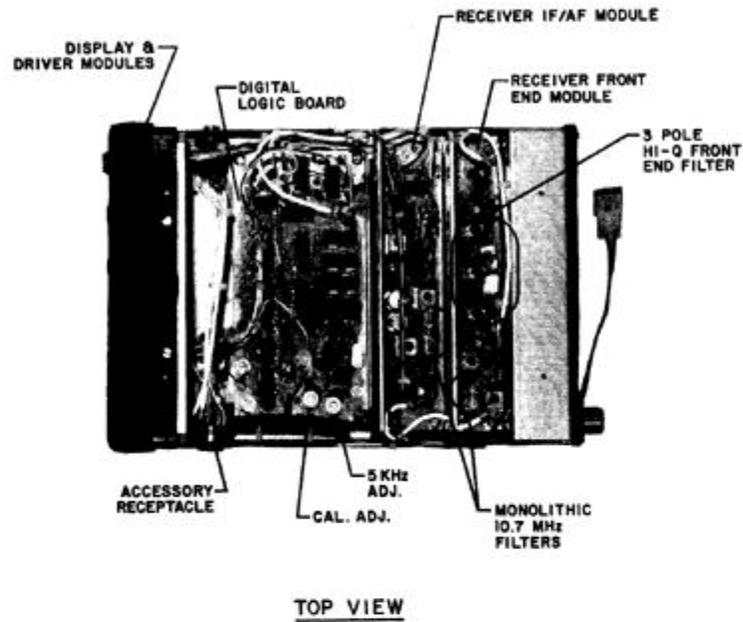


Figure 1-1. FM-DX Transceiver, Location of Major Assemblies and Components

## SECTION 2

# INSTALLATION

### 2.1 UNPACKING AND INSPECTION

Immediately upon receipt of the FM-DX transceiver inspect the packing box and the unit for signs of possible shipping damage. Ascertain if the transceiver is performing satisfactorily as outlined in the operation instructions (Section 3). If the transceiver is damaged or fails to operate properly, file immediate claim with the carrier who is responsible to deliver your shipment undamaged. Failure to check for and report damage immediately may result in monetary loss to you!

It is recommended you keep the shipping carton. In the event storage, moving, or reshipment becomes necessary, it will come in handy.

**CAUTION:** Before connecting the FM-DX to a power source, carefully observe the **NEGATIVE GROUND** precautions described below. Reversing polarity of power connection will damage the unit and void warranty.

### 2.2 POWER REQUIREMENTS

The transceiver is supplied ready to operate from any regulated 13.8V DC, 10 ampere negative ground source. An automobile, 12 volt, negative ground system is usually more than adequate. Some note must be taken, however, to the condition of the vehicle's electrical system. Problems such as low battery, worn generator/alternator, poor voltage regulator, etc., will impair operation of your transceiver as well as the vehicle.

High noise generation or low voltage delivery can be traced to these deficiencies. If an AC power supply is used with your transceiver, make certain it is adequately regulated for both voltage and current. Low voltage while under load will not produce satisfactory results from your transceiver. Receiver gain and transmitter output will be greatly impaired.

**CAUTION:** Excessive voltage (above 16VDC) will damage your transceiver. Be sure to check the source voltage before connecting the power cord.

Power supply connection is made to a molded nylon polarized connector via either of two supplied power cables. **RED LEAD IS POSITIVE, BLACK LEAD IS NEGATIVE AND CASE GROUND.**

A 10 foot fused cable with mating connector provides power to the FM-DX when operating mobile. The in-line fuse is rated at 15 amperes and is a conventional 12 volt automotive part. It is best to connect cable leads directly to the battery terminals. This arrangement eliminates random noise and transient spikes sometimes arising from automotive accessory wiring. Remember, the unit operates on a negative ground system only; it cannot be used in a positive ground automobile.

If an AC power supply is used with your transceiver, make certain it is adequately regulated for both voltage and current. Low voltage while under load will not produce satisfactory results from your transceiver. Receiver gain and transmitter output will be greatly impaired. Connection to the AC supply is made via the supplied 3 foot unfused power cable.

### **2.3 ANTENNA**

The most important single item that will influence the performance of any communications system is the antenna. For that reason, a good, high-quality, gain antenna of 50 ohms impedance is recommended. For best performance it should have an SWR of less than 2 to 1. A 1/4 wave vertical plugged directly into the antenna jack on the rear panel is definitely NOT recommended.

The UHF coaxial connector on the rear chassis mates with a standard PL-259 connector. Connection may be made to this jack with a 50 ohm coaxial cable such as RG-8/U or RG-58/AU with a type PL259 coax connector attached to the cable. It is recommended that if RG-58/AU is used the length be kept to less than 50 feet or excessive loss in the feed line may result. Low loss RG-8/U will probably suffice for runs up to 100 feet. Over 100 feet, 1/2" or larger solid copper foam or air line is recommended.

### **2.4 MICROPHONE**

The FM-DX is supplied with a high quality dynamic PTT microphone fitted with a right angle, three pole male plug. The matching receptacle is located on the left side of the transceiver. Should you wish to use a different microphone, it must have a Push-to-Talk facility in which the microphone element or cartridge is shorted when in the normal (receive)

position. Microphone impedance may be from a few hundred ohms to 10,000 ohms. If a desk microphone is intended for base operation and the microphone provided with the unit used for mobile operation, the desk microphone should have adjustable gain for most convenient usage. This permits one adjustment of the internal clipping control to suffice for both mobile and base operation. Particular care should be exercised in wiring also, as the internal electronic switching system is dependent upon it. See the schematic for the proper hook up. Under no circumstances use a "gain pre-amp" type microphone. The audio system in your transceiver is more than adequate and additional pre-amplification is unnecessary. To use this class of microphone is to invite distortion and possible damage to the transceiver.

### **2.5 EXTERNAL SPEAKER**

A phono plug receptacle is located on the rear panel of the unit to accommodate an external speaker wired with a conventional phono plug. Insertion of the external speaker automatically disables the internal speaker. Speaker impedance may be from 3.2 to 8 ohms.

### **2.6 MOBILE INSTALLATION**

The FM-DX, because of its significantly higher power rating than conventional transceivers, may require more care in installation. Current drain on HIGH POWER transmit may be as high as 10 amperes. To assure full performance, the power cable between the battery source and the radio should be of sufficient conductor size to provide more than 12.3 volts at the transceiver.

Cigarette lighter adapters or alligator clip arrangements are not satisfactory for use with the FM-DX in the HIGH POWER mode. For temporary or emergency operation these expediences may be employed if the transceiver is operated

in the LOW POWER position.

The mobile mount supplied with the FM-DX provides flexibility and versatility of installation. No particular constraints on positioning the unit for operation accessibility would be the primary consideration. Where practical to do so the unit should be placed where direct sunlight is least apt to fall directly on the LED display. The speaker is located on the bottom of the unit; therefore this area should remain unobstructed.

No radio works better than the antenna to which it is connected. Many choices exist for mobile installations. Where practical roof top mounting is superior to rear deck mounting and rear deck mounting is usually superior to bumper type mounts. Fresh, new coaxial cable should be used. RG-58/U deteriorates measurable with age. If practical RG-8/U is preferable. However, for the short lengths associated with mobile installations the difference may not be significant.

Do not locate where the unit may be damaged by being struck with a gear shift level or hand brake, etc.

## **2.7 BASE STATION INSTALLATION**

The extreme frequency versatility of the FM-DX makes it an ideal unit for the FM'er who enjoys channel hopping with a base station. Unlike some earlier synthesized units, the FM-DX has characteristics ideally suited for operation with large, high gain beam antenna for Simplex DXing. Receiver design provides excellent freedom from overload and intermodulation; transmitter design provide an excellent spectrum purity.

The FM-DX should be installed in a convenient spot for the operator while making sure it receives adequate ventilation.

Base operation requires a reasonably regulated power source capable of supplying  $13.5 \pm .5$  VDC at 10 amperes. Regulation should be such that voltage does not fall below 12.3 volts at 10 amperes and does not rise above 14.5 volts at no load.

The Clegg Model 031A Power Supply provides an ideal base station power source for the FM-DX. In addition it includes an auxiliary speaker matched to the FM-DX.

Antenna selection for base station operation is very much a function of the owner's operation preferences and his geographical location. Most operation can be done with a simple omnidirectional vertical. However, a good vertically polarized beam may yield considerably expanded operating enjoyment in many cases. In addition to providing extended range for both Simplex and Repeater operation the beam permits the station which is located within range of two Repeaters on the same frequency to access one without interfering with the other!

A most significant consideration in the base station, regardless of the antenna used, is the choice of coaxial feed line. When cable lengths of more than 50 feet or so are required RG-8A/U is a must; where lengths of more than 100 feet are to be used the operator is wise to consider one of the lower loss cables. Reference is made to any of the VHF handbooks for information on the loss characteristics of available cables.

## SECTION 3 OPERATION

### 3.1 GENERAL

The FM-DX FM transceiver is designed to provide two-way voice communication in the frequency range of 143.5 to 148.5 MHz in 5 KHz steps. The transceiver covers the 2-meter amateur band as well as MARS and other amateur related services.

### 3.2 CONTROLS AND INDICATORS

Table 3-1 describes the function of all normal operating controls and indicators. Although the FM-DX is very simple to operate, it is recommended that the function of these controls and indicators be understood before operating the transceiver.

**TABLE 3-1. OPERATING CONTROLS AND INDICATORS**

CONTROL OR INDICATOR	LOCATION	DESCRIPTION
PWR Switch (3 - position toggle switch)	Front Panel	Serves the dual function of ON/OFF control and transmitter HI (35 watts) and LO (approximately 500 mw) power selection.
Frequency Control:		Four controls are used to select receive frequency within the frequency range of 143.5 to 148.5 MHz.
RECEIVE FREQUENCY controls (three 10-position rotary switches)	Front Panel	Select receive frequency in 1 MHz, 100 KHz and 10 KHz steps.
0/5 KHz Switch (2 - position toggle switch)	Front Panel	Selects receive frequency in 5 MHz steps.
Frequency Readout (6 - digit numeric LED display)	Front Panel	Directly displays selected receive frequency. The first two digits always 1 and 4; sixth digit lights for 5 KHz and blanked when zero would be displayed. Digits three through five display 1 MHz, 100 KHz and 10 KHz frequency steps, respectively.

**TABLE 3-1. OPERATING CONTROLS AND INDICATORS (Cont'd)**

CONTROL OR INDICATOR	LOCATION	DESCRIPTION
TRANSMIT OFFSET switch (6-position rotary switch)	Front Panel	Provides for five different Repeater separations in addition to Simplex. Simplex, -600 Hz and +600 Hz are supplied as standard equipment. Positions A, B and C provide the capability of adding three additional Repeater separations by adding a plug-in crystal for each offset required. No adjustments are required.
SQUELCH Control	Front Panel	Controls the squelch threshold point of the receiver. Advancing to the extreme clockwise position causes the receiver to "mute" until a signal of approximately 10 microvolts is received. When retarded (CCW) to the threshold point, the receiver will be actuated by weak signals.
VOLUME control	Front Panel	Controls audio output level of the receiver.
Meter	Front Panel	Indicates relative transmitter output power and receiver signal strength. In receive mode, signals just barely perceptible will be indicated by a visible deflection of the meter and deflection will be proportional to signal strength. Full scale deflection is achieved with an input signal strength of approximately 75 microvolts.
Phase Lock Indicator (LED)	Front panel	Normally extinguished. Illuminates to indicate unlock condition in synthesizer. May flash momentarily when large changes are made in frequency. <b>DO NOT TRANSMIT WHEN ILLUMINATED.</b>

**TABLE 3-1. OPERATING CONTROLS AND INDICATORS (Cont'd)**

CONTROL OR INDICATOR	LOCATION	DESCRIPTION
Microphone Jack	Left side of transceiver	Accepts 3 prong mike plug supplied on microphone.
Accessory Jack (7-pin socket) Note: Early production models utilized different pinout than indicated here. Consult Clegg Service.	Right side of transceiver	Provides for interconnection of accessory devices such as tone generators and remote controls. Connections are: Pin 1 - Tone input Pin 3 - +9VDC (both TX and RX) Pin 4 - Paralleled with microphone PTT control Pin 7 - Ground (Unused pins usable for other special functions.)
External Speaker Jack (phono)	Rear of transceiver	Accepts an external speaker wired with a conventional phono plug. Insertion of external speaker automatically disables the internal speaker. Speaker impedance may be from 3.2 to 8.0 ohms.
Antenna Connector (Conventional UHF type connector)	Rear of transceiver	Accepts standard PL259 coaxial connector.
Push to Talk Switch	On microphone	Mutes the receiver and activates the transmitter.

### 3.3 OPERATING INSTRUCTIONS

**CAUTION:** Do not key the transmitter unless an antenna or dummy load is connected to the antenna connector.

#### 3.3.1 Initial Operation

1. Make sure the PWR switch is in the OFF position.
2. Connect the microphone to microphone jack on left side of the transceiver.

3. Connect the antenna to antenna connector on rear of the transceiver. Make sure the coax line is of the correct impedance (50 ohms) and is neither shorted nor open circuited.

4. Turn the VOLUME and SQUELCH controls to the maximum counterclockwise position.

5. Turn the PWR switch to either LO or HI position as desired.

### 3.3.2 Frequency Selection

A total of five front panel controls are involved in the frequency selection process of the transceiver. Four of these are used to select receive frequency.

1. M Hz SELECT (10-position rotary switch).
2. 100 KHz SELECT (10-position rotary switch).
3. 10 KHz SELECT (10-position rotary switch).
4. 0 or 5 KHz SELECT (2-position toggle switch).

The selected frequency is read directly on the 6-digit numeric LED display. (For operating convenience the 6th digit is blanked when a zero would be displayed; the first two digits are always 1 and 4.)

For example, to set the receiver at 146.52:

1. MHz SELECT rotated until third digit is 6.
2. 100 KHz SELECT rotated until fourth digit is 5.
3. 10 KHz SELECT rotated until fifth digit is 2.
4. 0 or 5 KHz SELECT switch to 0 position.

The FM-DX Receiver will then be precisely tuned to 146.52.

The remaining frequency control (affecting Transmit Frequency only) is the TRANSMIT OFFSET. The transmitter frequency is always related to the Receive Frequency. When the TRANSMIT OFFSET is in the SIMPLEX position the Transmit and Receive frequencies are identical.

Repeater operation simply requires setting the TRANSMIT OFFSET control to the setting appropriate to the particular repeater to be used.

For example, to work with a normal 146.13/146.73 repeater the Receiver would be set to the 146.73 repeater output; 146.73 would be displayed on the LED readout. The TRANSMIT OFFSET would be set to -600; the transmitter would

then be on the repeater input frequency, 146.13.

The TRANSMIT OFFSET control provides for 5 different repeater separations (in addition to Simplex). Simplex -600 KHz and +600 KHz are supplied as standard equipment. The user can supplement this capability at any time by adding a single plug-in crystal for each additional separation required. No adjustments are required.

A PHASE LOCK indicator light is located just above the TRANSMIT OFFSET control. This indicator will normally be extinguished but may flash on briefly when changing frequency. Transmission should not be made while this lamp is illuminated or flashing!

### 3.3.3 Reception

1. Adjust the VOLUME control to a comfortable listening level of noise, if no signal is present.

2. Carefully adjust the SQUELCH control clockwise until the noise just disappears. This is the proper squelch threshold setting and must be done when no signal is received which opens the squelch. If the squelch is unstable due to the reception of weak or unstable stations, adjust the squelch control further until the proper threshold is obtained.

3. The S meter indicates the relative signal strength of the incoming stations. An input signal of approximately 5uv will provide midscale readings. Nominal meter range is .15uv to 75uv.

### 3.3.4 Transmitting

1. Push the PTT (push to talk) button on the microphone and the transceiver is set for transmitting. The Meter provides an indication of relative power output of the transmitter.

2. Hold the microphone about three inches from your mouth and speak in a

normal voice. Shouting does not increase your communication range, but a good antenna does. The microphone is of the dynamic type and provides good pickup

for all levels of the voice.

3. To receive again, just release the PTT button.

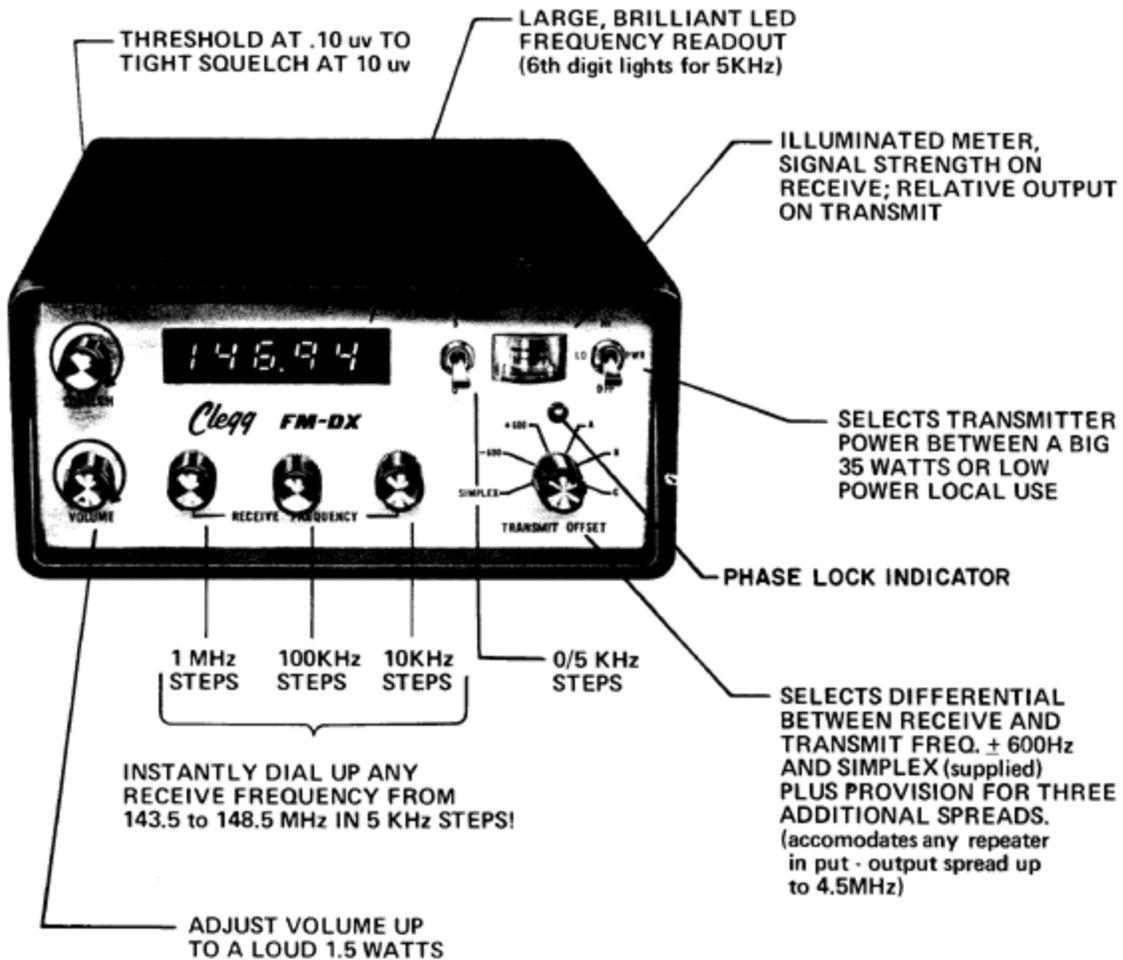


Figure 3-1. FM-DX, Location of Operating Controls and Indicators

## SECTION 4

### PRINCIPLES OF OPERATION

#### 4.1 FREQUENCY CONTROL SYSTEM

##### 4.1.1 Digital Synthesizer

The FM-DX employs digital counting technique and a phase locked voltage controlled oscillator (VCO) for direct generation of the injection signal for the receiver. The same phase locked VCO output is combined in a mixer along with the output of a switchable crystal oscillator to derive the transmitter frequency. A block diagram of this processing is shown in Figure 4-2.

The VCO operates over the range from 33.2 MHz to 34.45 MHz. The output is frequency multiplied four times to provide the required 132.8 to 137.8 MHz receiver injection frequency.

Simultaneously, the VCO frequency is divided by four to yield a signal between 8300 and 8612.5 KHz. This latter signal feeds five cascaded programmable counters. The net count of these counters can be programmed by three panel controls so that they divide the input frequency by any selected number from 13,280 to 13,780. Output from the divider string provides one of two inputs to a phase detector. The second input is a fixed 625 Hz signal derived from a precise 4000 KHz crystal oscillator and a fixed divide-by-6400 digital circuit.

The phase detector employed (a Motorola MC4044) is of the type wherein a steady state output voltage exists only when both input and output signals are identical in both frequency and phase. In this application this condition is satisfied only when the divided down VCO frequency equals the 625 Hz reference frequency.

The filter and DC amplifier circuits following the phase detector output are applied to the VCO and consequently tune the VCO to that frequency which satisfies this 625 Hz condition.

A numerical example is in order. Let us say our programmable divider is arbitrarily set to divide by 13,600. The phase detector filtered and amplified output will force the VCO to  $13,600 \times 4 \times 625$  Hz or 34.000 MHz. If the VCO tends to drift higher the 625 Hz resultant will also increase and the phase detector will respond with a corrective output voltage returning the VCO to the correct frequency. With the VCO locked on 34.000 MHz the receiver will be tuned to  $(34.0 \times 4) + 10.7$  or 146.70 MHz.

Similarly, if we wish to change from 146.70 to 146.71 MHz we merely change the divider from the previous 13,600 number to 13,601. Each change of 1 in our divide numeral results in a 10 KHz change in receive frequency. Furthermore, our receive frequency in KHz is always 10 times our divide numeral plus 1070; i.e.,  $10(N + 1070)$  KHz.

The FM-DX controls and LED display have been programmed to do the above arithmetical computation internally. Consequently when the Receive Frequency controls are switched so that 146.70 is displayed on the LED's the divider is automatically set to the corresponding 13,600 value and the receiver is tuned to 146.70.

To accommodate the 5 KHz increments controlled by the 0/5 KHz toggle switch the 4000 KHz reference oscillator is moved slightly in frequency and consequently,

the 625 Hz reference moves a proportional amount. (The 5 KHz shift which results is only precise at one frequency, 146.00 MHz. However, the error in the 5 KHz shift is less than 100 Hz at frequency extremes.)

#### 4.1.2 Transmit Synthesizer

The FM-DX is configured so that the transmit frequency is always slaved to the receive frequency. When the radio is in the Simplex mode the transmit frequency is the same as is the receive frequency. For repeater operation the transmit frequency can be above or below the selected received frequency. In addition to the normal plus or minus 600 KHz repeater spacings the FM-DX will accommodate three additional choices of spacing. The TRANSMIT OFFSET switch controls this selection. Transmit frequency is produced by combining two signals in a solid state double balanced mixer:

1. The second harmonic of the VCO.
2. The output of a switchable crystal oscillator.

The sum of these two frequencies is then doubled in frequency and becomes our transmitter output frequency.

Let us refer again to the arithmetic example used in the previous section. The receiver has been programmed to receive 146.70 MHz; our VCO is consequently on 34.00 MHz. This VCO frequency is doubled to 68.00 MHz and is applied to the double balance mixer. The crystal oscillator is on 5.35 MHz and is also applied to the mixer. The mixer output at 73.35 MHz (68.0 + 5.35) is amplified and doubled to 146.70 MHz. Similarly if we switch the crystal oscillator to 5.05 MHz the mixer output becomes 73.05 MHz and the transmitter is then on 146.10 MHz. The first example, of course, represents the simplex mode whereas the second represents the

typical 146.70 output, 146.10 input repeater mode.

A series of multi-tuned selective circuits following the balanced mixer output and between all succeeding stages assures rejection of the other potential undesired products from the balanced mixer. These selective circuits compose two band pass amplifiers. The one prior to the frequency doubler has a pass band from 71.75 to 74.25 MHz. The one following the doubler has a pass band from 143.5 to 148.5 MHz. A total of 15 filter poles are employed.

The FM-DX is supplied with Simplex and +600 KHz crystals. Other offsets up to ±5.0 MHz can be added at any time by merely inserting the appropriate frequency crystal in the sockets provided. Crystal frequency is determined as follows:

$$\text{Freq. in KHz} = \frac{10,700 + f_o}{2}$$

Where  $f_o$  is the desired offset frequency in KHz. For example if a crystal is required for a repeater with high input, low output and 1000 KHz spacing the correct crystal frequency is

$$\frac{10,700 + 1000}{2} = 5850 \text{ KHz}$$

Most commonly used repeater, MARS, and CAP offset crystals are stocked at Clegg.

#### 4.2 RECEIVER DESIGN

The receiver section of the FM-DX has been designed to afford fractional micro-volt sensitivity combined with immunity from undesirable spurious responses.

The receiver physically occupies two individual printed circuit board modules. The first contains a dual gate MOSFET RF amplifier with 4 poles of high Q band pass filtering and a MOSFET mixer to the 10.7 MHz intermediate frequency. The first

4 poles of IF filtering with monolithic crystal filters complete the first module.

The second module includes two 10.7 MHz amplifier stages followed by 4 additional poles of crystal filtering. Further 10.7 amplification and limiting are provided by a type CA3089E integrated circuit which also performs as a discriminator and audio preamplifier. This IC is followed by Squelch gated audio stage which drives an LM380 IC to produce 1.5 watts audio output. Five additional transistors provide a wide dynamic range squelch control system on this module. Signal strength meter output is derived from internal functions of the CA3089E.

### 4.3 TRANSMITTER DESIGN

The transmitter section of the FM-DX has been designed with great emphasis on special purity of the output signal. All transmit functions up to the .7 watts level are contained on the Main RF P/C module which is shared with the nondigital portion of the frequency synthesizer. A functional block diagram of the transmitter is shown in Figure 4-3.

The VCO is phase locked to a frequency in the 34 MHz region as determined by the desired RECEIVE FREQUENCY set by the panel controls and displayed by the LED's. The VCO frequency is doubled and filtered and applied at one input to a solid state double balanced mixer.

The other input to this mixer is provided by the TRANSMIT OFFSET XLO which is at 5.35 MHz for Simplex and between 4.6 and 6.1 MHz for useable Repeater offsets.

The Sum output of the balanced mixer in the 73 MHz region is band pass filtered with 8 poles of filtering and amplified in two transistor stages providing an extremely pure spectrum free from undesired mixer products. This signal, in the 71.75 to 74.25 MHz range is applied to a frequency double followed by two amplifier stages. Four additional band pass poles are provided in these stages which yield an output of about 1.5 watts in the 143.5 to 148.5 MHz range for driving the Power Amplifier Module.

The PA Module consists of a three-stage, fixed tuned microstrip band pass amplifier with approximately 18 db gain and an output power capability of 35 watts or more.

Modulation is achieved by the use of a voltage variable diode capacitor across the VCO tank circuit. A single 4 stage IC operational amplifier and a pair of diodes constitute the audio system. The stages preceeding the clipper diodes and following diodes serve as low pass amplifiers. Gain controls are provided both before and after the diodes. The post-clipper control adjusts deviation; the other establishes the amount of speech clipping.

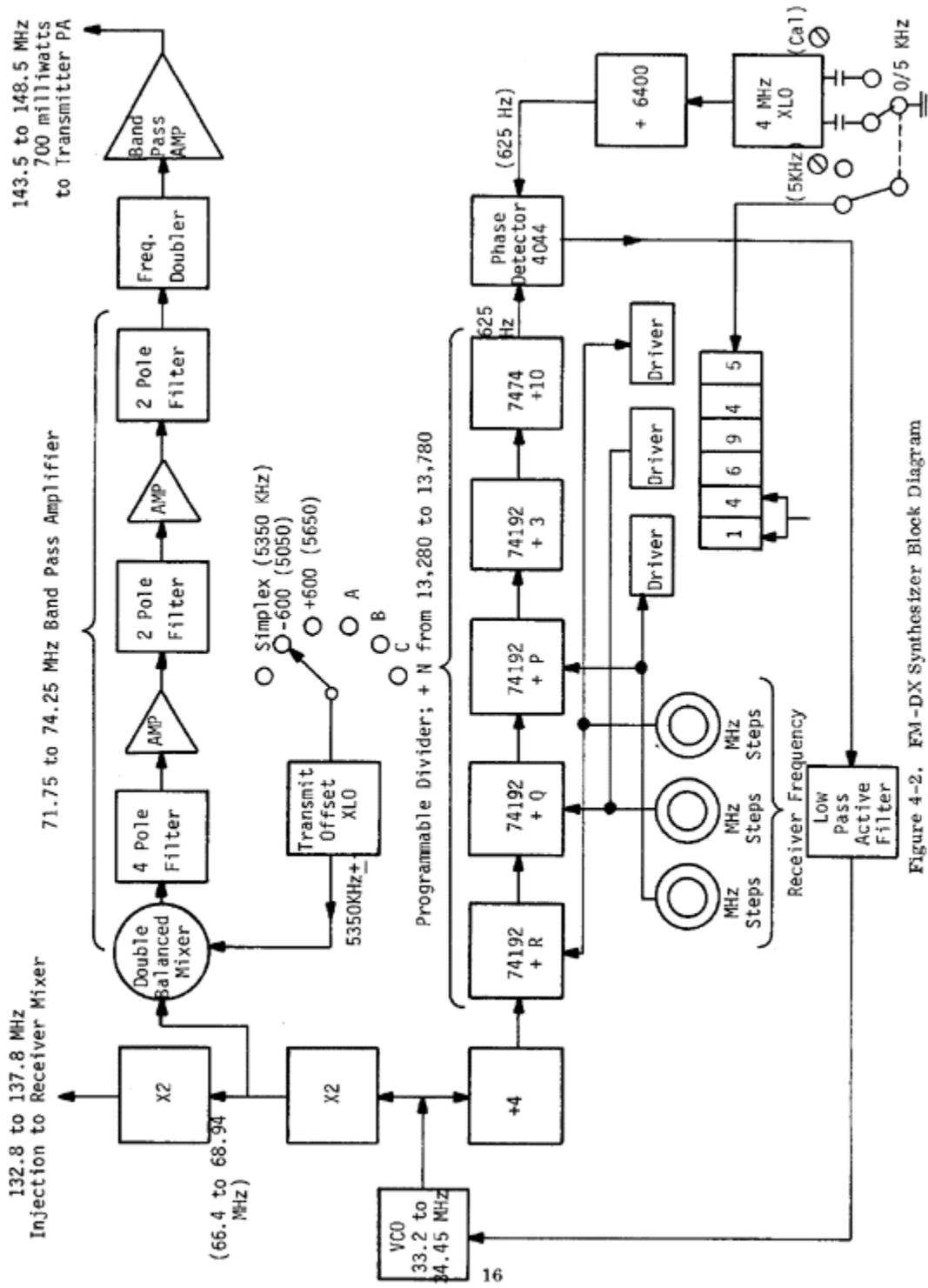


Figure 4-2. FM-DX Synthesizer Block Diagram

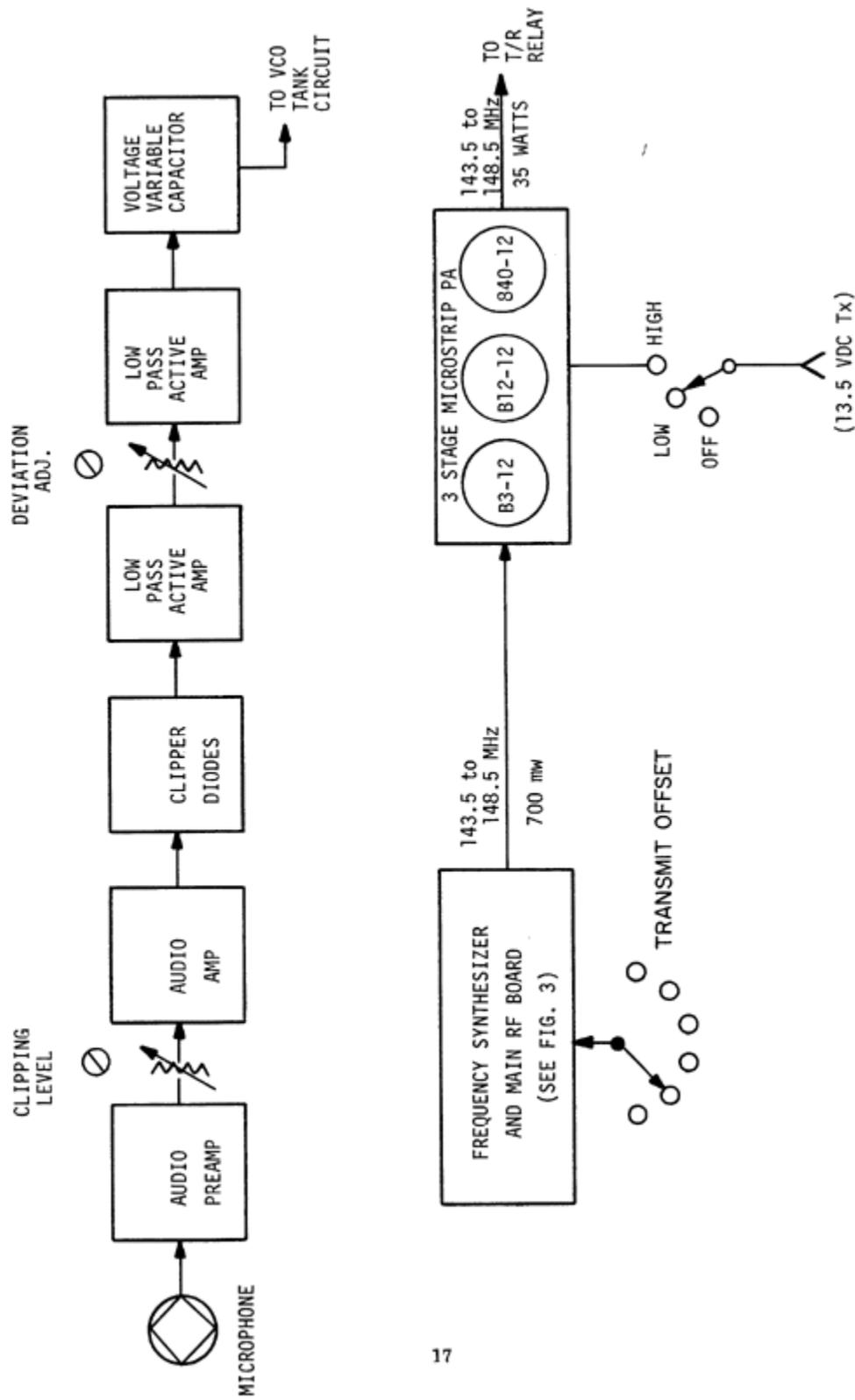


Figure 4-3. FM-DX Transmitter Block Diagram



