



MODEL FM-20E FM EXCITER

INSTRUCTION BOOK

May 1975



**A** **M** **E** **L** **A** **M** **E** **R** **I** **C** **A** **N** **E** **L** **E** **C** **T** **R** **O** **N** **I** **C** **L** **A** **B** **O** **R** **A** **T** **O** **R** **I** **E** **S**

P.O. Box 552, Lansdale, Pa. 19446 • (215) 822-2929 TWX: 510-661-4976

## DESCRIPTION

The American Electronic Laboratories' Model FM-20E Exciter is a solid state, direct FM modulation exciter for use in Commercial FM Broadcast Transmitters in the 88 to 108 MHz band. The design utilizes the latest developments in circuitry and components to achieve the utmost in performance, reliability and long term, as well as short term, operating stability.

The AEL FM-20E is a unit of modular construction with plug-in modules that facilitate replacement and ease of service with the minimum "off-air" time possible. The basic modules are as follows:

1. System Frame/Rack
2. Power Supply
3. Frequency Modulated Oscillator
4. Power Amplifier
5. Monaural Module
6. Stereo Generator
7. SCA Generator

### 1. System Frame/Rack

The system frame is a 8-3/4" high (5 panel spaces) 19" rack panel wired to accept all modules and equipped with the necessary tracks and hardware to facilitate sliding the modules in and out with ease.

The back panel of the system frame has the necessary inputs and outputs well insulated so that RFI will not get into the system and enable the user to install the exciter inside an AEL transmitter cabinet. Although the exciter will operate inside an AEL transmitter cabinet within its specifications, installing the exciter inside a transmitter cabinet places the exciter in

undue RFI. The connectors on the back panel are as follows:

- a. SCA -- A BNC connector supplied to feed SCA signal directly to the FMO.
  - b. Stereo Composite Input -- A BNC connector supplied to feed composite signal directly to the FMO.
- NOTE: The two inputs above are identical with insulation between them. Also note that the internal inputs to the FMO are also isolated and do not interfere amongst each other. These inputs will also serve as outputs if any internal plug-in module is used.
- c. Low Level RF/Mon. Out -- A BNC connector supplies an output out of the FMO and before the power amplifier intended for hook-up of a monitor or frequency counter.
  - d. Hi-Level Output -- A BNC connector located on the power amplifier sub-assembly provides the RF output of the exciter. (5-20 watts)
  - e. Power Amplifier -- A four pin connector supplies dc power to the power amplifier.
  - f. Control Circuits -- A six pin connector provides for all the connections for the control circuitry.
  - g. Mono/Stereo Left -- This connector is provided for the left channel stereo, if using the stereo generator, or the mono signal, if using the monaural module.
  - h. Stereo Right -- A connector which provides an input for the right channel stereo is only active when using the stereo generator.
  - i. SCA 1 -- A connector which provides an input for feeding audio to the first SCA module.

j. SCA 2 -- A connector which provides an input for feeding audio to the second SCA module. This input is not active if a stereo generator is used.

k. AC Power -- A male connector is provided to plug-in the power cord.

NOTE: Extreme care should be taken to prevent RFI from getting inside the system frame/rack, especially when used in a transmitter cabinet. All shields are to be grounded to the metal cover of all connectors and no ground wires are to be connected through the panel.

## 2. Power Supply

The power supply module of the AEL FM-20E supplies all the necessary d.c. voltages for all modules and also contains two meters on the front panel.

The left hand meter labeled kHz Deviation is calibrated 0-10 and by means of a small toggle switch located under it, it can be made to directly read 0-10 kHz and 0-100 kHz. The right hand meter is for standard metering with a function rotary switch located under it.

By means of this rotary switch one can monitor:

- a. Forward power into load.
- b. Reflected power from load.
- c. The three voltages (+24V, +15V and +5V) necessary to power all modules.
- d. The AFC voltage.
- e. The FMO RF oscillator.
- f. The local oscillator providing the reference frequency standard.

NOTE: More information in regards to the above functions can be found in the Theory of Operation section of this manual.

### 3. Frequency Modulated Oscillator

The Frequency Modulated Oscillator (FMO) of the AEL FM-20E generates a full, completely linear signal at the carrier frequency. An Automatic Frequency Control holds the frequency of the Carrier Oscillator within the specified limits. A unique "phase locked loop" AFC circuit offers exceptional reliability and stability within the specified environmental and electrical parameters. Use of monolithic digital circuitry (ICs) and a special cut on the reference oscillator crystal further enhance the reliability and stability of the FMO. Special control circuitry is provided for off frequency shut down. The digital design concept of the FMO reduces all the adjustments for alignment to a particular frequency down to two adjustments.

### 4. RF Power Amplifier

The RF Amplifier module of the FM-20E exciter is located on the back side of the 19" rack mounting cage and it is built around a large and specially constructed heat dissipator. The broadband design eliminates the need of any alignment and its power is continuously variable from 5W to 20W by means of a single control. The amplifier is designed to withstand a short or open circuit output for an indefinite time with no adverse effects.

This all solid state power amplifier provides the broadcaster with the latest in FM exciter concept and manufacturing technology.

### 5. Monaural Module

The Monaural Module of the FM-20E exciter (FM-20EM) provides the necessary circuitry for driving the FMO with a signal 30-15000 Hz  $\pm$  5 db. It also has built into it the necessary isolation transformer and pre-emphasis network (normally supplied with 75 usec pre-emphasis, it has provision for altering it to any value that can be desired).

6. Stereo Generator (FM-20SG)

The AEL FM-20SG stereo generator exceeds its specifications by a considerable margin. These specifications are by far more stringent than the minimum FCC requirements.

The AEL FM-20SG utilizes an all silicon monolithic design which offers unprecedented reliability and performance. A special digital chain for the sub-channel carrier offers the most in stability of frequency as well as phase. A modulation scheme assures a separation in excess of 40 db at any frequency from 50 Hz to 15,000 Hz.

7. SCA Generator (FM-20SC)

The AEL FM-20SC SCA Generator provides an SCA carrier for the exciter. A special monolithic circuitry provides excellent stability, performance and reliability. The AEL FM-20SC comes standard providing a 67 kHz sub-carrier (10% modulation,  $\pm 6.7$  kHz); a 41 kHz version can also be obtained, if specified.

## THEORY OF OPERATION

The FM-20E AEL Exciter was designed with the Broadcaster's needs in mind. The modular construction facilitates selection of the optional modules as well as eases replacement in the event of failure and decreases "off the air" time to a minimum.

### 1. Power Supply

The power supply module supplies all the necessary voltages for all modules and also contains the necessary circuitry to display functional data of the various circuits on the two meters that appear on its front panel.

A bridge rectifier is followed by short circuit proof regulators and 5V volt regulator chip to provide the necessary +24V and +5V DC outputs. The +15 VDC is provided by a regulator in the FMO module.

The metering circuitry has adjustment potentiometers for the precise calibration of the meter indication and a rotary selector switch which enables the right hand meter to select the indication desired. The left hand meter is connected permanently to read deviation 0-10 and 0-100 kHz and the scale is selectable by means of a toggle switch.

### 2. Frequency Modulated Oscillator (FMO)

The plug-in FMO contains a very stable oscillator, operating at carrier frequency and which utilizes varactors for its frequency control. The output of this oscillator is fed into a solid state amplifier which feeds the LOW LEVEL RF/MON OUT jack in the back of the System Frame/Rack and the input of the RF Power Amplifier Module. It is also fed into the input of a digital divider chain which divides the carrier frequency by 2000. The output of this divider chain is then fed into one of the inputs of a phase/frequency detector (Fig. #1).

A "secondary" frequency standard (the primary standard considered as WWV of N.B.S.) consists of a special extremely stable crystal oscillator. This oscillator utilizes a special monolithic circuit and special cut crystal and requires no constant temperature chamber (oven). The secondary frequency output is fed into a digital divider chain which divides its frequency by 80 and then it is fed into the second input of the phase/frequency detector (Fig. #1).

The phase/frequency detector compares the two signals which are approximately 50 kHz and the resulting "error" voltage out of the phase/frequency detector is then fed back into the carrier oscillator frequency control and results in keeping its frequency stable to well beyond the specified limits.

Three LED devices are fed by a special monitoring circuit and display the condition under which the AFC is performing. A green LED indicates "on frequency lock"; "off lock high" and "off lock low" is indicated by the other two led's. A toggle switch allows the "off frequency" detector to also shut down the RF power amplifier whenever the oscillator is not locked.

The FMO is provided with three separate and isolated inputs. One is 600 ohm and is fed by the monaural plug-in module. The other two inputs are 4000 ohm and are fed, one from the plug-in stereo generator and the other from the plug-in SCA generator. These inputs are also paralleled to the SCA and Composite inputs on the back panel of the system frame.

### 3. The Monaural Module

This module contains an audio insulation transformer, preceded by an isolation pad and followed by the pre-emphasis network. An operational amplifier follows with a gain control and an emitter follower at its output. The output of the emitter follower is fed into a low pass filter of which the output then drives the FMO.



4. RF Power Amplifier

This module is mounted on the rear of the system frame.

The RF power amplifier uses 3 stages of amplification to produce 20 watt output (gain of +23 db). The power amplifier is built on a printed circuit board with all stages isolated. Output level is controlled by limiting the gain of the first driver stage.

The RF power amplifier may be shut off by either a phase-frequency control loop failure signal or a remote command.

5. Stereo Generator

A complete instruction manual is available with each stereo generator.

6. SCA Generator

A complete instruction manual is available with each SCA generator.

## OPERATION AND ALIGNMENT

### 1. Power Supply

Check to see that each of the power supply voltages are correct. The front panel meter can be calibrated to correspond to power supply voltages measured with a VTVM. Since the power supply employs solid state regulators, there are no adjustments.

### 2. FMO

Since the FMO is basically a digital system, there are only two adjustments and they are the Carrier Oscillator Frequency control and the crystal trimmer capacitor. Follow these simple steps:

a. If the carrier frequency is lower than 100 MHz, insert a ferrite slug in the carrier oscillator coil. If the frequency is higher than 100 MHz, use a brass slug.

b. Insert crystal in holder and plug in pins. To figure crystal frequency:

$$F_{\text{crystal}} = \frac{F_{\text{carrier}}}{25}$$

c. Switch meter selector of P.S. to AFC. Turn on "off frequency" disabling switch and turn RF amplifier power to min. by turning potentiometer counterclockwise.

d. Turn on exciter and wait approximately 5 minutes or until the AFC voltage rises to its maximum indication.

e. Turn carrier oscillator coil until the AFC voltage indication is at the center of the scale (middle of green range).

f. Turn power output control of RF amplifier until desired power is achieved.

- g. Wait until exciter unit warms up to stable temperature.
- h. Touch up AFC voltage again to maintain indicator as mentioned above.
- i. Adjust frequency trimmer for proper output frequency.

Please note that the indicator will move slightly back and forth as the AFC circuit corrects the carrier oscillator frequency.

3. Power Amplifier

Set power output to that necessary for the particular transmitter in use by adjusting the pot on the final amplifier assembly. The amplifier requires no further adjustment.

4. Monaural Module

The input level should be adjusted for the proper modulation level on the station monitor.

5. Alignment instructions for the stereo and SCA modules are included with their respective instruction books.

ELECTRICAL PERFORMANCE (with Model FM-20E/SG Stereo Generator, Model FM-20E/SC Generator)

1. Frequency 88 MHz to 108 MHz, factory set to customer's operating frequency.
2. Power Output 5 to 20 watts, continuously adjustable.
3. Output Impedance 50 ohms (BNC connector)
4. VSWR (Load) Can tolerate any VSWR up to infinity without damage to output stage.
5. AM Noise -60 db maximum
6. Incidental AM -60 db maximum
7. Harmonic & Spurious Exceeds all FCC requirements
8. Power Source 120/240 VAC  $\pm 10\%$  single phase  
50/60 hertz @ 150 watts.
9. Deviation Capability  $\pm 100$  kHz
10. Frequency Stability  $\pm 500$  Hertz
11. Monaural Specifications
  - a. Input Impedance 150/600 ohms, balanced or unbalanced
  - b. Input Level 0 to +20 dbm for 100% modulation
  - c. Response 30 to 15,000 Hz  $\pm .5$  db
  - d. Pre-emphasis 75 Microsecond standard
  - e. Distortion .5% Total Harmonic Distortion
  - f. FM Noise -70 db (max.)
12. Stereo Specification (with AEL Stereo Generator Model FM-20E/SG)
  - a. Input Impedance 600 ohms balanced
  - b. Input Level +10 dbm  $\pm 2$  db for 100% modulation
  - c. Stereo Response 50 to 15,000 Hz  $\pm 1$  db
  - d. Stereo Pre-emphasis 75 microsecond standard
  - e. Distortion .5% Total Harmonic Distortion
  - f. FM Noise -63 db (max.)

- g. Stereo Pilot Stability                    19 kHz  $\pm$  1 Hz
  - h. Cross Talk  
    (Ref: 100% Mod)
    - L + R to L - R                            -45 db maximum
    - L - R to L + R                            -45 db maximum
  - i. Separation                                -40 db maximum, 30 Hz - 15 kHz
13. SCA Generator (Model FM-20E/SC)
- a. Frequency Range                        30 to 75 kHz
  - b. Frequency Stability                     $\pm$ 400 Hz
  - c. Audio Input Impedance                600 ohms balanced or 10K unbalanced
  - d. Audio Input Level                      -15 dbm to +10 dbm adjustable
  - e. Muting Delay                            0.5 to 5 seconds adjustable
  - f. FM Noise                                 -63 db maximum
  - g. Pre-emphasis                            75 microsecond standard
  - h. Distortion                                less than 1%