A PORTABLE JAMMING SYSTEM TO EVALUATE THE PERFORMANCE OF L BAND RADIO SYSTEMS IN AN EW ENVIRONMENT

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ABSTRACT

This paper describes a system which has been developed to simulate a number of potential EW environments. The system consists of a net of portable jammers remotely controlled from a single command and control center. Each portable jammer can be adapted for ground or air utilization and each unit includes various types of noise sources, a power amplifier and an integral transmit antenna.

The paper provides a detailed description of the jammer hardware. The antenna is a specially developed conical horn back helix. An 80 Watt nominal solid state power amplifier is described along with the control system which allows precisely controlling and monitoring the RF Output power level. Circuitry to develop noise modulation is explained as well as the AC/DC Power System which allows the jammer to be used with a variety of Power Sources.

Control of the jammer via a centrally located RF transmitter addressing individual remote receivers is discussed. Overall system performance in terms of Noise Power Spectral Density, level variations and control of spectrum are described.

Finally, a description is given of the use of the portable jammer system to emulate possible jamming environments which could be encountered in tactical GPS applications.

INTRODUCTION

This paper discusses the 3dbm Model 1002 Portable L Band Jammer. The system provides a capability to simulate spot jamming at exact operating frequencies. In doing so, it provides a cost effective way to test typical communications and/or receiver operations in the presence of spot noise, barrage jamming, or set-on jammers. The mechanical configuration of this system allows the jammers to be easily transported between sites and be quickly set up. The system is rugged enough to operate in an open environment under direct sun and with normal wind loadings.

In a simulation of an EW environment, an effective technique to replicate a tactical situation is to have a number of interference sources in a coordinated jamming network. This is accomplished by having a number of jammers controlled from a central point and carefully sequenced. To implement this kind of operation, remote control has been added to the unit.

From these general situation requirements, the portable jammer described in this paper has been configured, which allows for a realistic simulation in actual field use.

OVERALL SYSTEM DESCRIPTION

Figure 3.1-1 is a block diagram of the overall system. A portable transmitter is capable of addressing each remotely located jammer and turning it on or off. Each portable jammer contains an addressable receiver which controls the DC power to the RF driver stages of the transmitter. Within the transmitter, an internal VCXO frequency source can be modulated by an internal noise source, an external baseband signal, or operated CW. For maximum flexibility, an internal VCXO based L band source or an externally supplied RF input can be selected to drive the nominal 80 Watt amplifier.

External power adjustment and monitoring allow for precision control of the RF power delivered to the antenna. Additional flexibility is available in selection of the system prime power allowing AC or DC inputs.

Finally, the RF is radiated out through a manually steerable helicone antenna which has a gain of 14.5 dbi with a 3db beam width of 35°.

Figure 3.1-2 shows the portable jammer. The jammer is contained within a cabinet 30" high by 22" wide by 22" deep with the L Band Helicone antenna mounted on top. The electronics are contained within drawers mounted in the cabinet.

Table 5.1.1 provides the overall system specifications.

ANTENNA

An optimal portable jammer has an antenna with controlled gain and beamwidth, low side lobes and convenient positioning. For this application, EMP, Inc. developed a Helicone antenna, a combination of a helical beam and a conical horn antenna as shown in Figure 4.0.1.

The resulting combination has superior gain and sidelobe characteristics compared to a simple helix of the same length while retaining the helix characteristic of a circularly symmetric, circularly polarized beam. The sidelobes of this unique antenna are lower than a conical horn excited by a circularly polarized waveguide at the throat or a conical horn excited by a short helix at the throat.

The antenna used for the present application was designed to cover the L Band frequency range of 1.2 to 1.6 GHz with a beamwidth of 35 degrees nominal and gain of 14.5 dbi nominal for the 17-inch long antenna. Sidelobes are more than 30 db down from the peak of the beam. Gain is 14.0 dbi minimum, beamwidth across the frequency range, varies from 30° to 38° and the axial ratio from 0.9 db to 1.7 db. Figure 4.0-2 shows a typical pattern.

TRANSMITTER SYSTEM OVERVIEW

The Model 1002 Transmitter is an all solid state chassis containing a solid state RF Power Amplifier, a multifunction power conversion system, and an internal modulation source which allows the unit to be operated entirely internally or from external modulation. In addition, an external signal source can be used with the system.

Table 5.1.1 provides electrical specifications for the unit. The system has been designed to provide spot jamming to exactly the IF bandwidth of the receiver being tested. Broader bandwidths, while available, dilute the power spectral density.

The transmitter is contained within a 5 1/4" high transmitter drawer. Cooling of the system is achieved by forced air and convection. The efficient switching power supply dissipates heat by rear mounted cooling fins. Internal components are cooled via a fan mounted directly on the front panel, which pulls the air through a dust filter. The air is conducted over fins mounted directly on the final stage of the power amplifier. The air then passes over the cooling fins of the high current series voltage regulators.

SYSTEM BLOCK DIAGRAM

Figure 5.2-1 is a block diagram of the system. The RF path consists of a VCXO which drives a X16 Phase Lock Loop Multiplier to the L Band frequency. This RF signal passes through a front panel mounted “U” section of cable which can be removed to allow an external RF signal source to drive the output amplifier chain.

Modulation for the VCXO is developed by amplifying and filtering one of three front panel switch selectable inputs. A front panel adjustment controls the deviation signal. An external modulation signal, internal Guassian noise, or a shorting position resulting in CW operation of the source may be selected.

An L Band driver amplifier increases the 10 milliwatt nominal input drive up to 5 watts nominal. External pulse modulation can be applied on the input stages of the drive amp at rates up to 100 KHz. Because following amplification stages are Class C, the final on/off ratio is in excess of 50 db.

The output power amplifier is a 2-stage design providing a minimum of 80 watts of RF power which drives a protective isolator followed by power monitoring directional couplers. RF output power is controlled by varying the collector voltage on the last stage of amplification. RF output power is monitored by use of a thermoelectric power meter, assuring an accurate measurement over a 25 db dynamic range.

Power for the system can be either AC or DC. A 115 VAC, 47-440 Hz Power Supply allows driving the system from line or generator power. Alternatively, a back panel terminal strip allows the user to directly patch for external DC power. Because the power passes through a low pass filter with transient suppressor and is series regulated, the system is able to directly accept aircraft power.

RF ASSEMBLY INTERNAL FREQUENCY GENERATOR

The transmitter has the capability of generating a CW signal or providing FM with an internally or externally generated baseband. The internal baseband signal is generated by amplifying the output of a true Guassian solid state noise source and passing it through low pass filter. A front panel selector switch selects either this output, an external input, or zero volts (corresponding to a CW signal) and passes it through a front panel mounted potentiometer which regulates the deviation.

The internal frequency source consists of a VCXO followed by a X16 multiplier. This unit is capable of generating 10 milliwatts of RF power with a center frequency stability of ±5 KHz and a deviation of up to ±100 KHz at a DC to 20KHz baseband rate.

RF POWER AMPLIFIERS

The RF Power amplification chain consists of a driver and a final amplifier. The driver amplifier is a 3 stage design consisting of two cascaded Class A stages driving a Class C output stage. The amplifier can be pulse modulated by controlling the bias on the first Class A stage.

An external TTL input pulse drives the first stage via a front panel mounted pulse modulation input jack.

Figure 5.3.2-1 is a photograph of the output stage. The input signal is split two ways to the input of the two driver stages. The output of each driver stage then drives 2-way power splatters to drive four output devices in parallel. The outputs are recombined to a single output capable of RF output powers in excess of 80 watts.

The output power is varied by controlling the collector voltage on the 4 parallel output stages. By varying this voltage from 3 to 22 volts, the RF output power varies from 1.5 to 80 watts. Protection of the RF output stage from load VSWR is assured by use of an output isolator capable of withstanding output reflected power of 100 watts.

SYSTEM POWER

Figure 3.1-1 shows the power distribution circuits. The system has been designed to be compatible with a variety of available power sources. AC power at line frequencies of 47 to 440 Hz can be accommodated by the efficient switching regulated power supply. By removing rear panel jumpers, an external DC power source of nominal 23 to 32 volts, can be inputed to the system. The output directly drives the system cooling fan as well as two series regulators. One of the series regulators provides a constant 22 volts throughout the system. The other series regulator is used to control the collector voltage on the output transistors of the final amplifier. The regulator consists of a series regulator which is controlled via a reference IC with an external control of the reference voltage. The series regulator is a high power PNP transistor mounted on an individual heat sink to convect away the high dissipation.

TRANSMITTER PERFORMANCE

Figure 5.5-1 shows the plotted spectrum of the jamming at deviations of ±50 MHz and CW. This corresponds to the calculated RF power spectrum occuring with modulation by use of a band limited baseband Guassian Noise signal. The spectrum is independent of the RF output power level which varies from 1 to 80 watts.

REMOTE CONTROL

In order to facilitate remote operation of the portable jammer, a Communitronics Inc. matched Transmitter-Encoder/Receiver-Decoder System has been incorporated. In this system, the portable transmitter can be located up to 50 miles away. Any jammer within line of sight can be addressed and the RF turned On or Off. The individual receivers can be set for individual or group addressing. Tables 6.1, 6.2 and 6.3 provide specifications on the transmitter, receiver and antenna respectively.

OPERATIONAL DEPLOYMENT

The Navstar Global Positioning System (GPS) has utilized 3dbm equipment for jamming tests conducted at Yuma Proving Ground and SOCAL Range at San Clemente, California. Special requirements for remotely powered high temperature environments made 3dbm off-the-shelf designs a cost effective solution to the Yuma testing special needs.

Testing to date has been highly successful with equipment being rapidly deployed to remote areas. Radio control links are used to activate jammer performance provided emulation of tactical type scenarios. Special emphasis placed by the program office on low maintenance and survivability in the severe Yuma environment has been proven to be an important factor in mission success rate. No equipment malfunctions have been recorded to date, although temperature shutdown has occurred in extreme thermal conditions. It is concluded that equipment operability and survivability are key factors in the execution of a successful test and evaluation program.

TABLE 3.1.1 SYSTEM SPECIFICATIONS

Electrical Specifications

RF Output Center Frequency:	0.9 to 1.8 GHz
Bandwidth:	100 MHz Minimum
Peak Output Frequency Stability:	±10 PPM Maximum
EIRP	1500 Watts Minimum
RF Load VSWR:	Infinite at any Phase Angle (Isolator Protected)
Harmonics:	-50 dBc Maximum
EIRP Dynamic Range:	50-1500 Watts Minimum, Front Panel Screwdriver Adjust
RF Output Power On/Off Power Control:	TTL 0 is ON
Pulse Modulation	
Control:	TTL “1” is ON
Rise/Fall Time:	1 Microsecond Maximum
On/Off Ratio:	50 dB Minimum
External Drive Input:	10 dBm ±2 dB
Drive Input VSWR:	1.3:1 Maximum

Modulation:	FM
Peak Deviation:	±50 KHz, ±5 Volts
Baseband:	DC-20,000 Hz
Baseband Load Impedance:	10K Unbalanced
Baseband Source (Switch Selectable):	Internal Guassian Noise, CW, External
RF Output VSWR:	1.3:1 Maximum
AC Input:	115 VAC, 1Ø, 47-440 Hz, 7 Amps Maximum
DC Input Power:	24-32 Volts at 20 Amps Maximum
Power Meter Accuracy:	±2%
Operating Temperature Range:	0-50°C
Remote Control:	Addressable via FSK Carrier 416.6 MHz

Mechanical Specifications

Cabinet Size:	30x22x22"
Antenna:	(Per Figure 4.0-1)
Overall System Weight:	130 lbs.

TABLE 6-1
TRANSMITTER - ENCODER (50939-02-02)
SPECIFICATIONS

Frequency:	416.600 MHz, Crystal Select
Frequency Stability:	+/-.001%, -30° to 60° C Ref. To 25° C
RF Power Output:	2 Watts, minimum, at 12 Volts
Emission Type	15F2
Tone Frequencies:	Mark: 1070 Hz, Space 1270 Hz
Data Rate:	60 Baud
Spurious and Harmonics:	Greater than 43 dB +10Log Pout
Output Impedance:	50 OHMS
Load Mismatch:	Up to 5:1 with no damage
Temperature Range:	-30 to +60 C
Operating Voltage	9.5 - 13 Volts (reduced RF Output below 11.5V)
Address Selection:	2 Decade bidirectional pushbutton code switches
Address Range:	00 to 99 Decimal (100 Codes)
Power Source:	12V 1.4AH Gel Cell
Operations/Charge:	>10,000 (1 Command/5 Seconds, Temp. between 50 and 75 F)

Charger Type:	Float/Constant Current
Keying Command:	Three position momentry rocker switch
Modulation Type	PM
Audio Distortion	Less than 1.5% THD
Hum and Noise:	Greater than 40 dB

TABLE 6-2
RECEIVER - DECODE (50939-02-01)
SPECIFICATIONS

Frequency:	416.600 MHz, Crystal Select
Frequency Stability:	+/-.001%, -30° to +60° C refer to 25° C
Sensitivity:	.35uv Max for 12 dB Sinad .50uv Max for 20 dB Quieting
Selectivity:	Greater than 70 dB @ ±30 KHz
Spurious Rejection:	Greater than 60 dB
Image Rejection:	Greater than 70 dB
Modulation Acceptance	±7 KHz Minimum
Input Impedance:	50 OHMS
Audio Output:	Greater than 1.5V P-P into 10K Load
Audio Distortion:	Less than 3% THD
DC Input Range:	24VDC ±10%
Address Selection:	8 User Programmed Straps
Address Range:	00 to 99 Decimal (100 Codes) 00 to FF Binary (256 Codes)
Temperature Range:	-30 to +60 C
Data Rate:	60 Baud
Command Output:	TTL Compatible (open collector) Logic 0: -0.3 to +0.4VDC Logic 1: +2.4V Max
Size:	3-1/2"Hx9-1/4"Wx12"D

TABLE 6-3
ANTENNA - AV-1 (50939-02-03)
SPECIFICATIONS

Frequency:	416.600 MHz
VSWR:	Less than 1.5:1
Impedance:	60 OHMS, Nominal
Power:	100 W Max
Gain:	2 dB Per RS-329

Length:	Approx. 36"
Rated Wind:	100 MPH
Radials	4 ea. Stainless Steel
Weight:	Less than 2 pounds
Cable Length:	25 ft., nominal
Connectors:	PL-259 (1) and Type N (1)

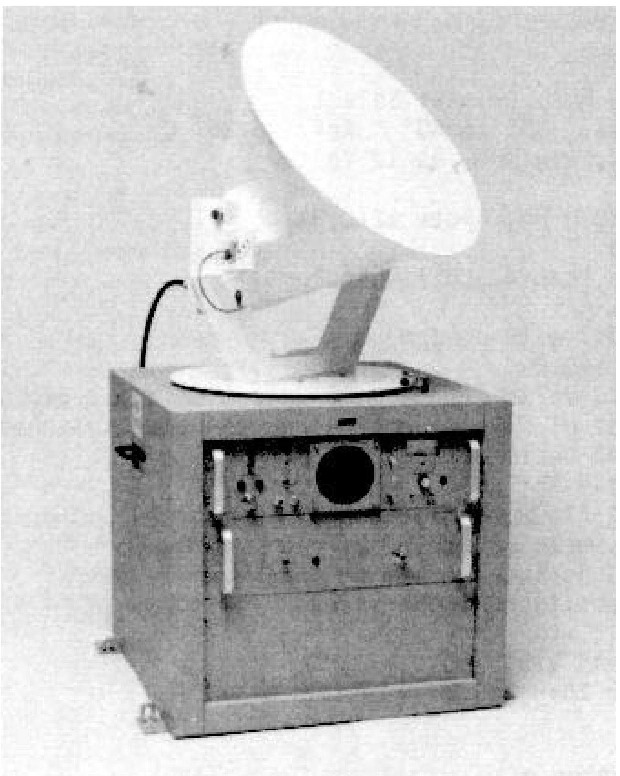


Figure 3.1-2
Model 1002 Portable
L Band Jammer System

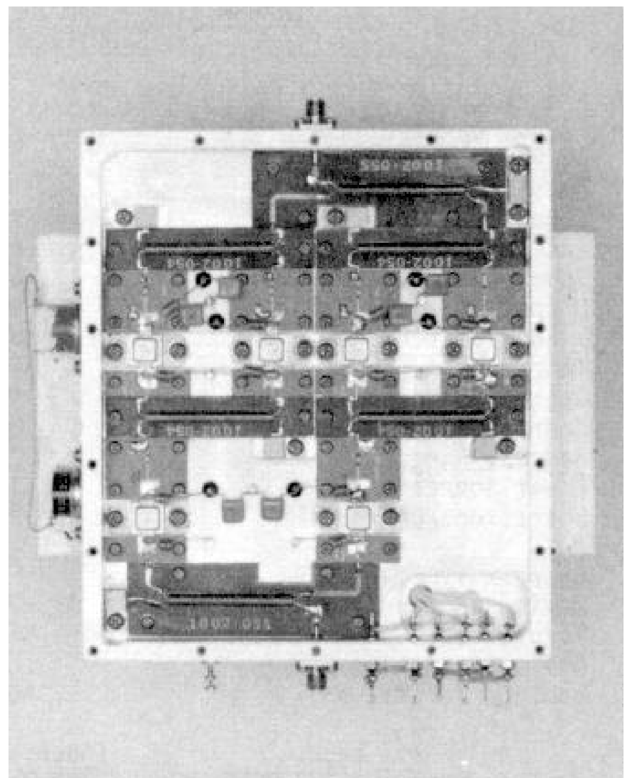


Figure 5.3.2-1
Photograph of Power
Amplifier Stage

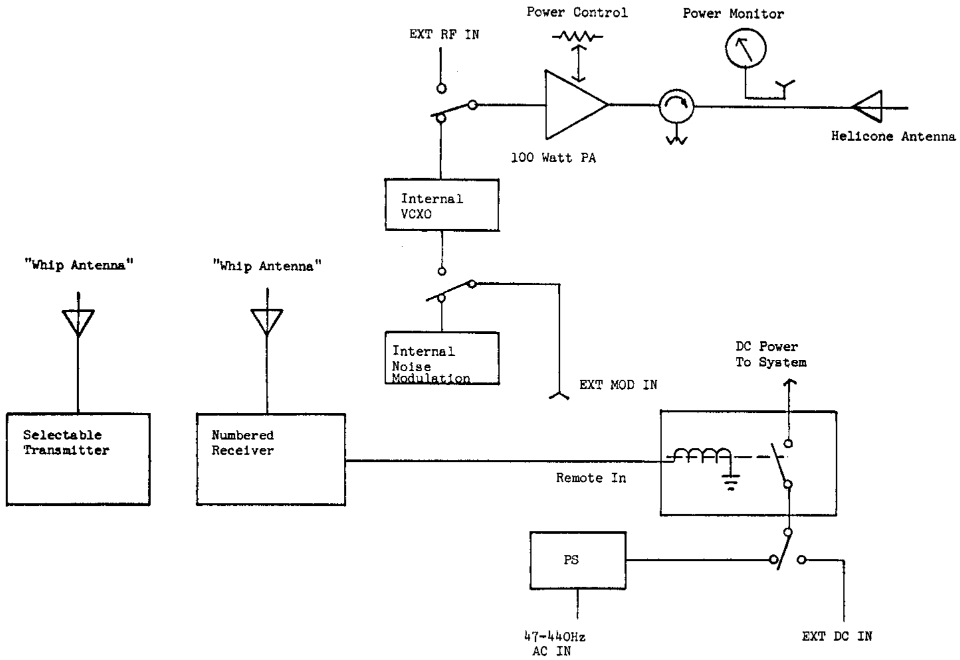
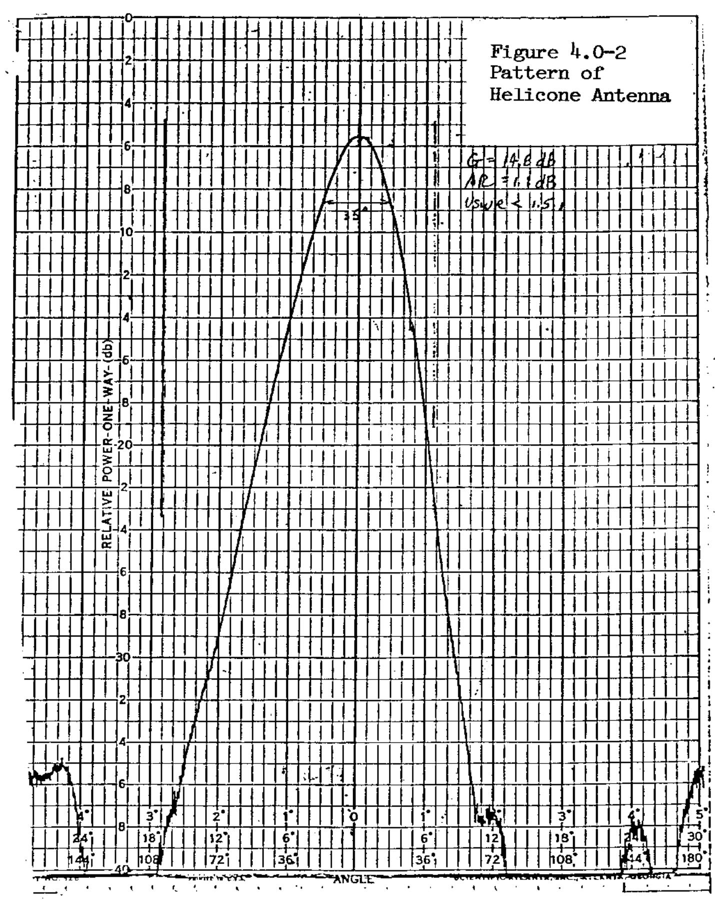


Figure 3.3-1
Block Diagram of Remotely Controlled Portable L Band Jammer



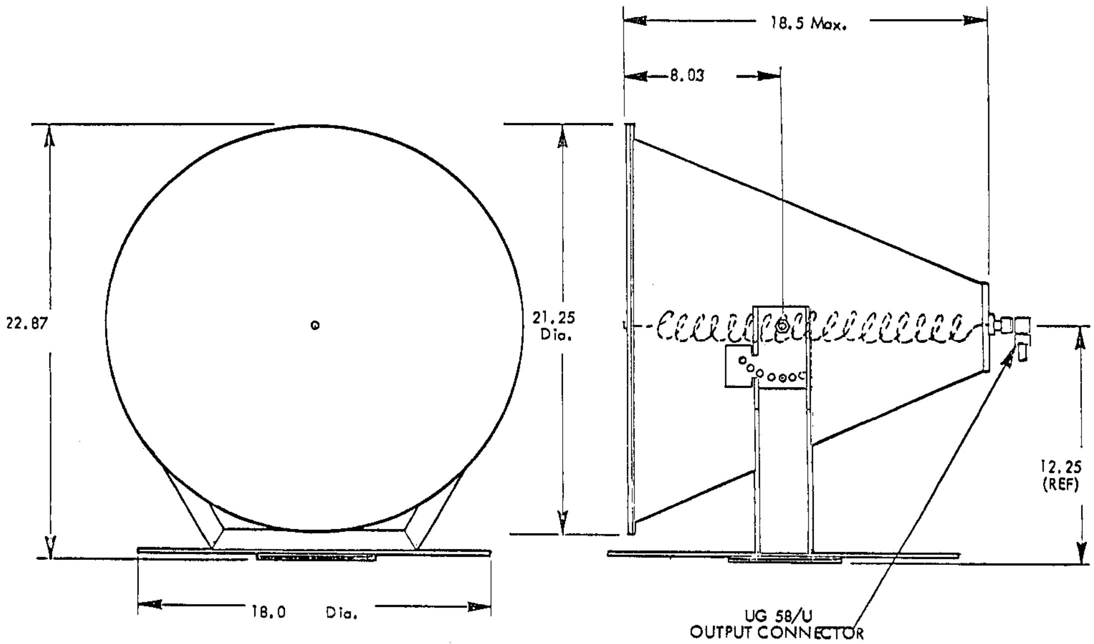


Figure 4.0-1
Outline of EMP Helicone Antenna

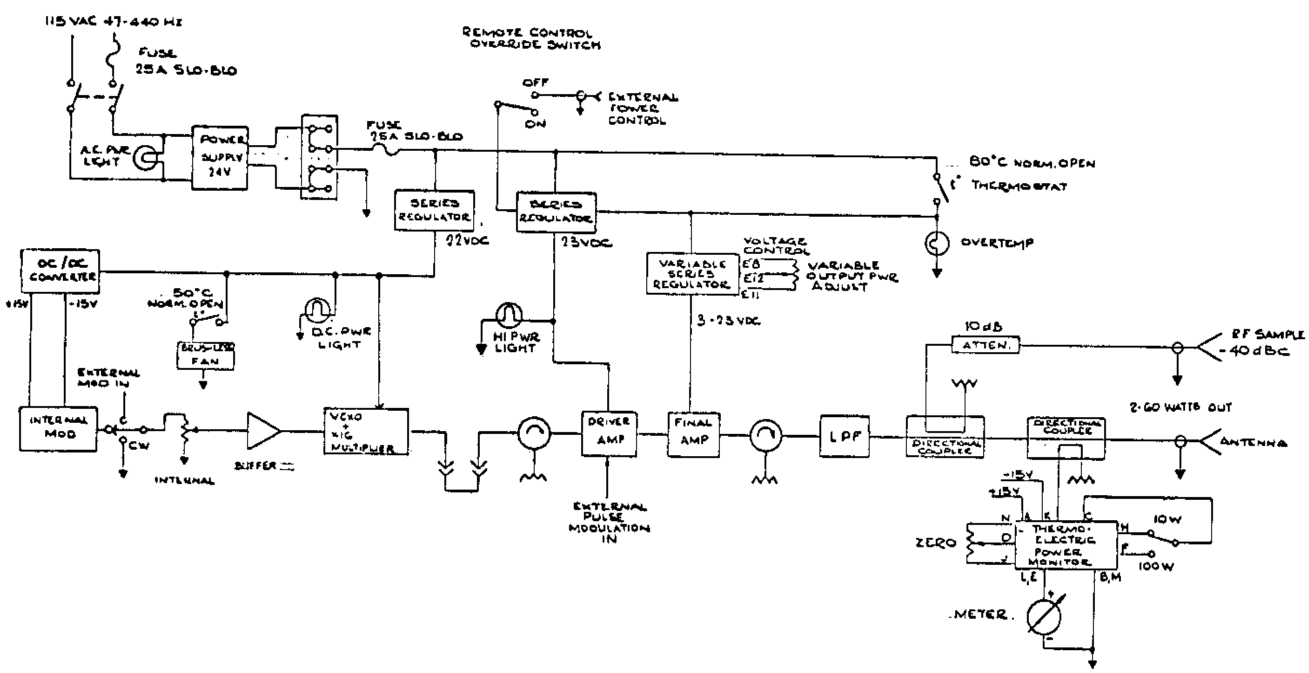


Figure 5.2-1
Block Diagram of Transmitter

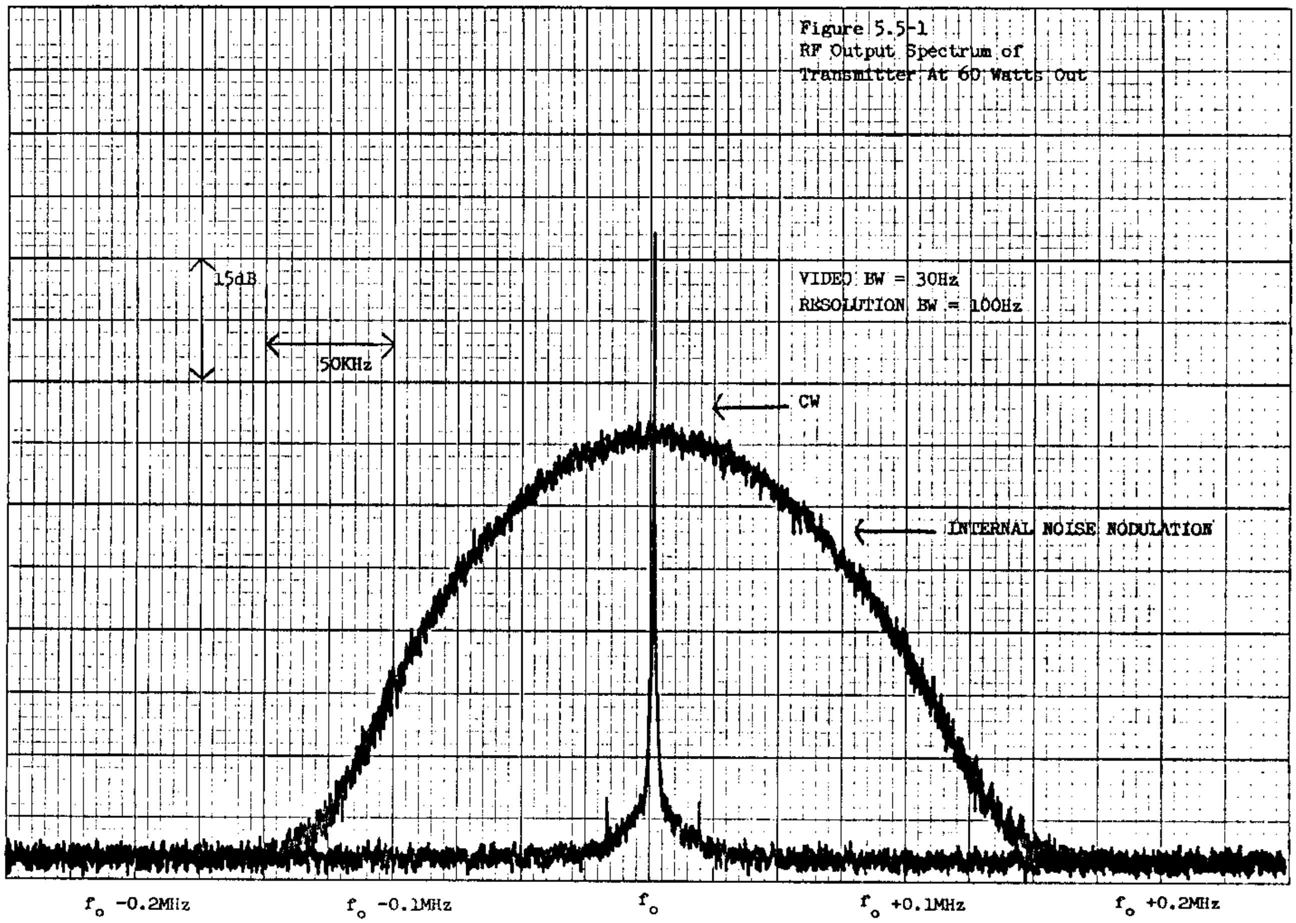


Figure 5.5-1
RF Output Spectrum of
Transmitter At 60 Watts Out
15dB
50KHz
VIDEO BW = 30Hz
RESOLUTION BW = 100Hz
CW
INTERNAL NOISE MODULATION
f_o -0.2MHz
f_o -0.1MHz
f_o
f_o +0.1MHz
f_o +0.2MHz