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SECTION I

1.0 INTRODUCTION

1.1 General

This report contains data required for certification of the EMCEE Model TTV500ES VHF Low Power Television Transmitter. This externally diplexed unit, which will be manufactured in quantity, is rated to provide 500 watts peak visual and 50 watts average aural on any FCC specified VHF television channel extending from 54 to 216MHz (Ch.2 to Ch.13). The TTV500ES is completely solid state and comprised of six different assemblies. The RF sections begin with a standard television modulator which supplies separate visual and aural modulated IF carriers (45.75MHz visual/ 41.25MHz aural) to the 2 watt Exciter drawer. Here the carriers are converted to the desired VHF frequencies, filtered and amplified to the 2W level. The television carriers are then sent to the Visual IPA/Aural Final Amplifier drawer where the signals are further amplified to the 25 watt visual and 75 watt aural levels. The 25 watt visual carrier is delivered to the Visual Final Amplifier drawer for final amplification while the 75 watt aural signal is brought to the Visual/Aural diplexer for combining with the 500 watt visual output signal. Other assemblies in the TTV500ES transmitter include the Power Supply/Control Status drawer which checks various transmitter circuits and distributes DC power throughout the transmitter. To separately supervise the output power of the visual and aural carriers, a Meter Panel is provided for monitoring and power calibration.

The data contained in this report was obtained from tests performed on an EMCEE production unit having an output frequency of VHF channel 9 (186-192MHz) using an EMCEE EM1 Modulator. However, to better serve our customers, EMCEE also wishes to use the Catel ATM1600 and the Scientific Atlanta 6340 as appropriate substitutes for the EM1. These modulator models, which also comply with Part 74, are used in all current EMCEE LPTV, MMDS and ITFS type accepted equipment requiring modulators. Also, we are requesting that the high stability (0.5PPM) Vectron CO-254D57 oscillator with a X2 or X4 multiplier be used in the TTV500ES. This oscillator, replacing the standard synthesizer, will provide the customer with optional precision offset capability. Tests on both the oscillator and synthesizer are also found in this report.

In order to meet the requirements of Section 74.750(c)(5) of the FCC Rules, the TTV500ES switches to a nonradiating condition in the absence of a modulating video signal. Additionally, an optional Code Identification Unit, capable of shifting the frequency of the transmitted carriers, may also be included to satisfy 74.750(c)(7) of the Rules.

A complete list of the test equipment utilized to obtain the certification data can be found in Section 1.3 of this report. Information relating to the description, operation and maintenance of the transmitter can be found in the TTV500ES, EM1, ATM1600, and SA6340 Instruction Manuals.

1.2 Personnel Qualifications

The certification tests were conducted by Robert Nash, EMCEE VP/Director of Engineering. Mr. Nash has more than 23 years of experience in the development and testing of television transmitters and translators.

1.3 Test Equipment

1. Antenna, Adjustable Dipole Set, 30MHz to 1GHz, Model 3121, EMCO
2. Antenna, Conical Helix, 1-11GHz, Model ALN108B, AEL
3. Attenuator, 10dB, Model 766-10, Narda
4. Attenuator, 20dB, Model 766-20, Narda
5. Attenuator, 30dB, Model 766-30, Narda
6. Distortion Measurement Set, Model 339A, Hewlett Packard
7. Demodulator, Model 1450, Tektronix
8. Directional Coupler, 30dB, Model 3020-30, Narda
9. Diode Detector, 50 ohm, Model 423A, Hewlett Packard
10. Dummy Load, 50 ohm, 500 Watt, Model 785-30, Narda
11. Envelope Delay Measuring Set, Model 201/1, Shibasoku
12. Environmental Chamber, Tenny Jr., Tenny Engineering
13. Frequency Counter, Model 5386A, Hewlett Packard
14. Mixer, Model ZAD-2, 37023, Mini Circuits
15. Modulator, Model EM1, EMCEE
16. Multimeter, Digital, Model E2378A, Hewlett Packard
17. NTSC Vectorscope, Model 520, Tektronix
18. Power Meter, Model 435A, Hewlett Packard
19. NTSC Video Generator, Type 149A, Tektronix
20. Spectrum Analyzer, Model 8595E, Hewlett Packard
21. Waveform Monitor, Model 1485R, Tektronix
22. 500 Watt VHF Television Transmitter, Model TTV500ES, EMCEE

1.4 Active Device List

The following is a complete listing of all the active devices used in the EMCEE Model TTV500ES VHF Television Transmitter. The devices are grouped together as seen on each specific schematic or interconnection diagram. Given with each device is its schematic designator, EMCEE part number and function.

DEVICE	PART #/DESIGNATOR	FUNCTION
IF AGC AMPLIFIER Schematic Diagram C331-37		
Diode	1B70/CR1, CR2, CR4, CR9	RF Attenuator
Diode	1B05/VR1	Voltage Regulator
Transistor	2B28/Q1	RF Amplifier
Transistor	2B06/Q2, Q3	RF Amplifier
LINEARIZER Schematic Diagram 30367078		
Diode	1B162/CR1-CR8	RF Switch
Transistor	2B08/Q2, Q4, Q5	RF Amplifier
Transistor	2B09/Q1, Q3	RF Amplifier
POWER ADJUST Schematic Diagram 10331255		
Diode	1B142/CR1, CR2, CR3	RF Attenuator
REFERENCE OSCILLATOR Schematic Diagram 10368037		
TCXO	RTX0771AD/G1	Oscillator
Integrated Circuit	3B130/U1	RF Amplifier

DEVICE	PART #/DESIGNATOR	FUNCTION
VHF SYNTHESIZER Schematic Diagram 30362427 (Band I)		
Integrated Circuit	3B160/U4	Reference Divider
Integrated Circuit	MC12028AD/U2	Dual Prescaler
Integrated Circuit	3B161/U1	Synthesizer
Integrated Circuit	3B149/U3	Loop Filter
Integrated Circuit	3B181/U6	Feedback Amplifier
Integrated Circuit	SNA586/U5	RF Amplifier
VCO	V110SC01/G1	Oscillator
VHF SYNTHESIZER Schematic Diagram 30362003 (Band III)		
Integrated Circuit	3B160/U4	Reference Divider
Integrated Circuit	3B190/U2	Dual Prescaler
Integrated Circuit	3B161/U1	Synthesizer
Integrated Circuit	3B149/U3	Loop Filter
Integrated Circuit	3B181/U6	Feedback Amplifier
Integrated Circuit	3B151/U5	RF Amplifier
VCO	V220S015/G1	Oscillator
X2 MULTIPLIER (With Vectron Oscillator - Band I) Schematic Diagram B280-35		
Integrated Circuit	3B09/LL1	Voltage Regulator
Transistor	2B03/Q1	RF Amplifier
Transistor	2B06/Q2	RF Amplifier
X4 MULTIPLIER (With Vectron Oscillator - Band III) Schematic Diagram C331-24		
Integrated Circuit	3B09/U1	Voltage Regulator
Transistor	2B03/Q1	RF Amplifier
Transistor	2B06/Q2, Q3	RF Amplifier

DEVICE	PART #/DESIGNATOR	FUNCTION
LO SPLITTER/AMPLIFIER Schematic Diagram 30362024		
Diode	SBL1-2MH/MX1, MX2	Mixer
Integrated Circuit	3B192/U3, U4	RF Amplifier
Integrated Circuit	3B185/U1, U2	RF Amplifier
2 WATT VHF AMPLIFIER Schematic Diagram 30362257		
Integrated Circuit	MAR7SM/U1	RF Amplifier
Integrated Circuit	MAV11SM/U2	RF Amplifier
Integrated Circuit	BGX885/U3	RF Amplifier
Transistor	MRF342/Q1	RF Amplifier
Transistor	MJE371/Q2	Current Regulator
50W VHF AMPLIFIER Schematic Diagram 30362252 (Band I) Schematic Diagram 30362046 (Band III)		
Transistor	DU28200M(2B146)/Q1	RF Amplifier
Transistor	MJE371(2B25)/Q2, Q3	Voltage Regulator
AURAL DRIVER AMPLIFIER Schematic Diagram 30362035		
Transistor	MRF173CQ/Q1	RF Amplifier
Transistor	2N3906/Q2	Voltage Regulator
AURAL FINAL AMPLIFIER Schematic Diagram 20362269 (Band I) Schematic Diagram 30362014 (Band III)		
Transistor	DU28200M(2B146)/Q1	RF Amplifier
300 WATT FINAL VISUAL AMPLIFIER Schematic Diagram 20362275 (Band I) Schematic Diagram 30362367 (Band III)		
Integrated Circuit	MC1723CD/U1	Voltage Regulator
Transistor	MRF151G/Q1, Q2	RF Amplifier

1.5 Certification of Data

Having supervised the tests and compilation of information in this report, I certify that all statements and test results submitted for certification of the EMCEE TTV500ES are true and correct to the best of my knowledge.

Robert G. Nash
VP/Director of Engineering

SECTION II
TEST PROCEDURES AND DATA

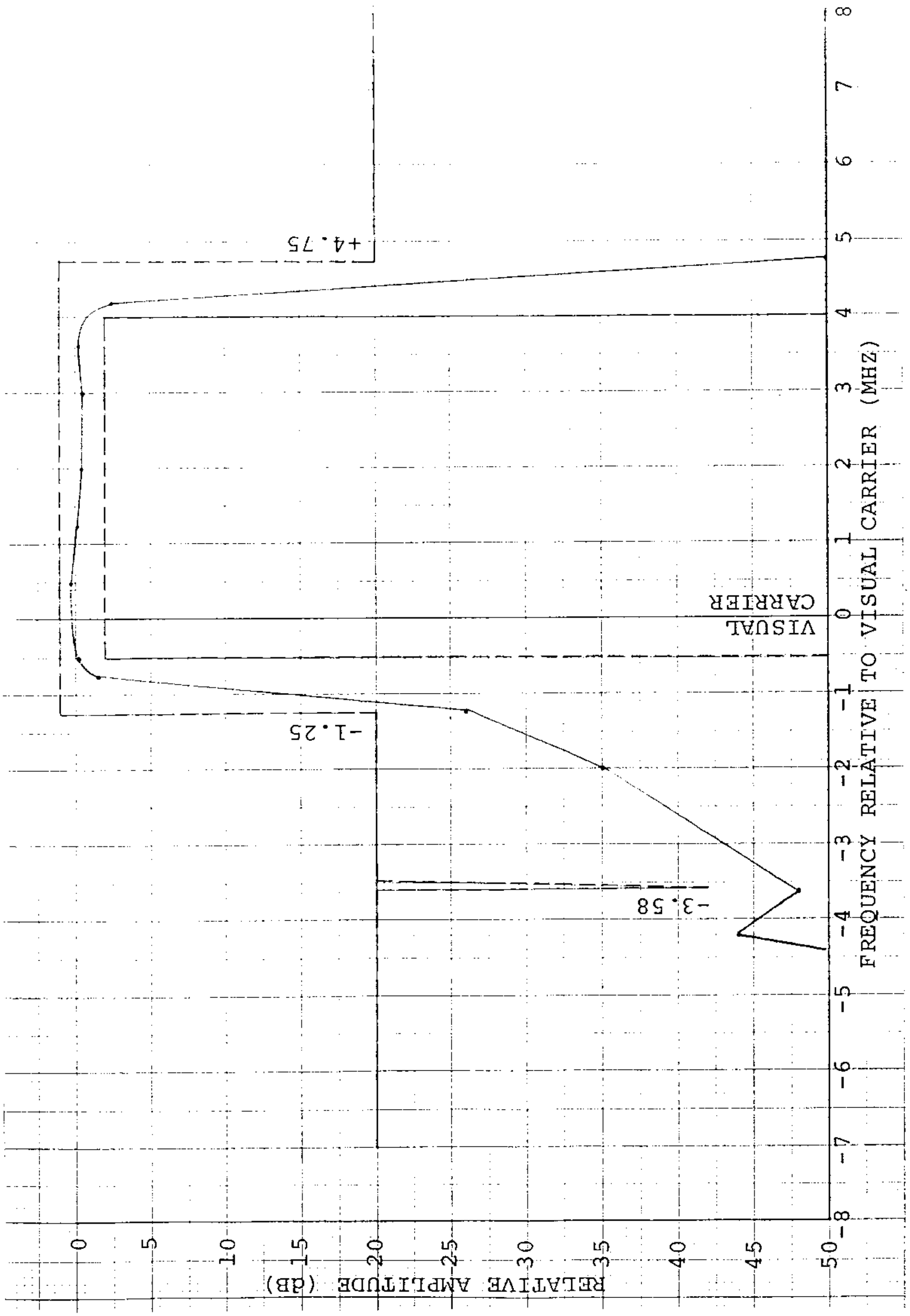
2.1 Frequency Response [73.687(a)(3)]

Test Equipment Setup	Figure 2–1A
Visual Output Power	500 watts peak sync
% Video Modulation	87.5%
Type Video Modulation	Standard sync with a variable frequency sine wave occupying the interval between pulses. Sine-wave axis was maintained at 50% of the peak sync amplitude. Sine-wave amplitude was held constant at less than 75% of the peak output voltage.
Aural Output Power	0 watts
Method of Measurement	Sine-wave frequency was varied through the video range. The data recorded was relative to the 200kHz sideband amplitude designated as 0dB.

FREQUENCY RESPONSE DATA

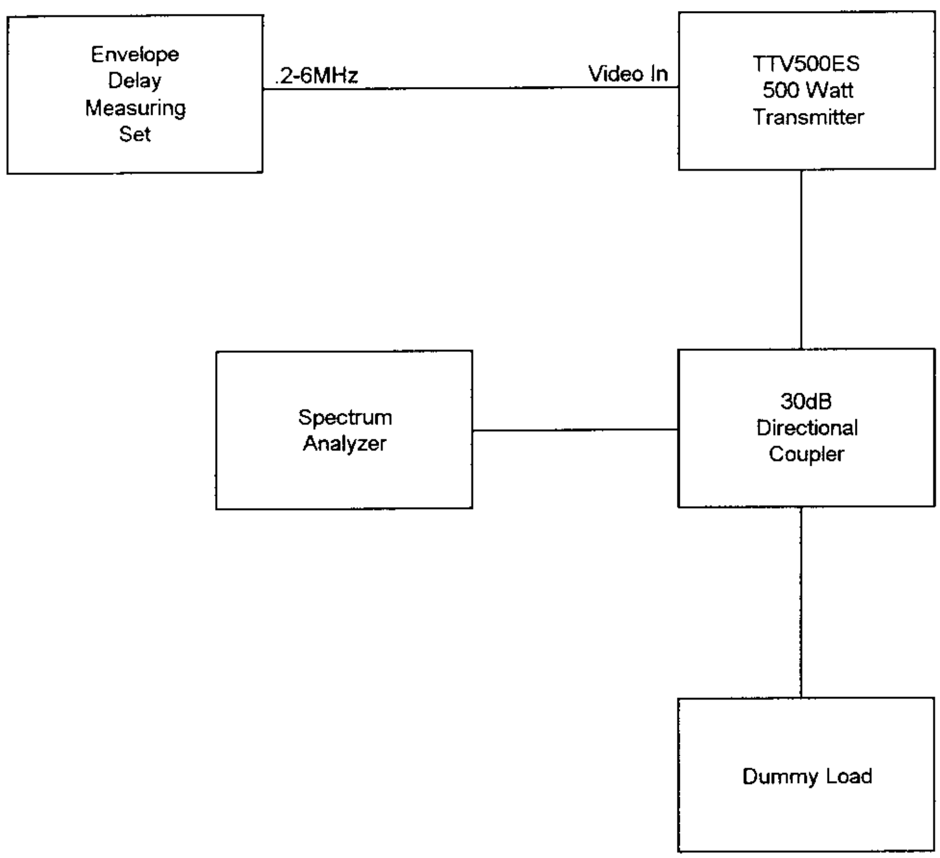
REFERENCE LEVEL: 0dB = 200kHz sideband amplitude

OUTPUT FREQ. (MHz) CHANNEL 9	SIDEBANDS	RELATIVE OUTPUT (dB) CHANNEL 9
182.50	-4.75MHz	-58.0
183.07	-4.18MHz	-44.0
183.67	-3.58MHz	-48.0
185.25	-2.00MHz	-35.0
186.00	-1.25MHz	-26.0
186.50	-750kHz	-1.6
186.75	-500kHz	-0.2
187.25	VISUAL CARRIER	
187.45	REFERENCE SIDEBAND	0.0
187.75	+500kHz	+0.4
188.50	+1.25MHz	-0.2
189.25	+2.00MHz	-0.4
190.25	+3.00MHz	-0.5
190.83	+3.58MHz	-0.3
191.43	+4.18MHz	-2.5
192.00	+4.75MHz	-50.0



AMPLITUDE VS. FREQUENCY CHARACTERISTICS

Figure 2–1



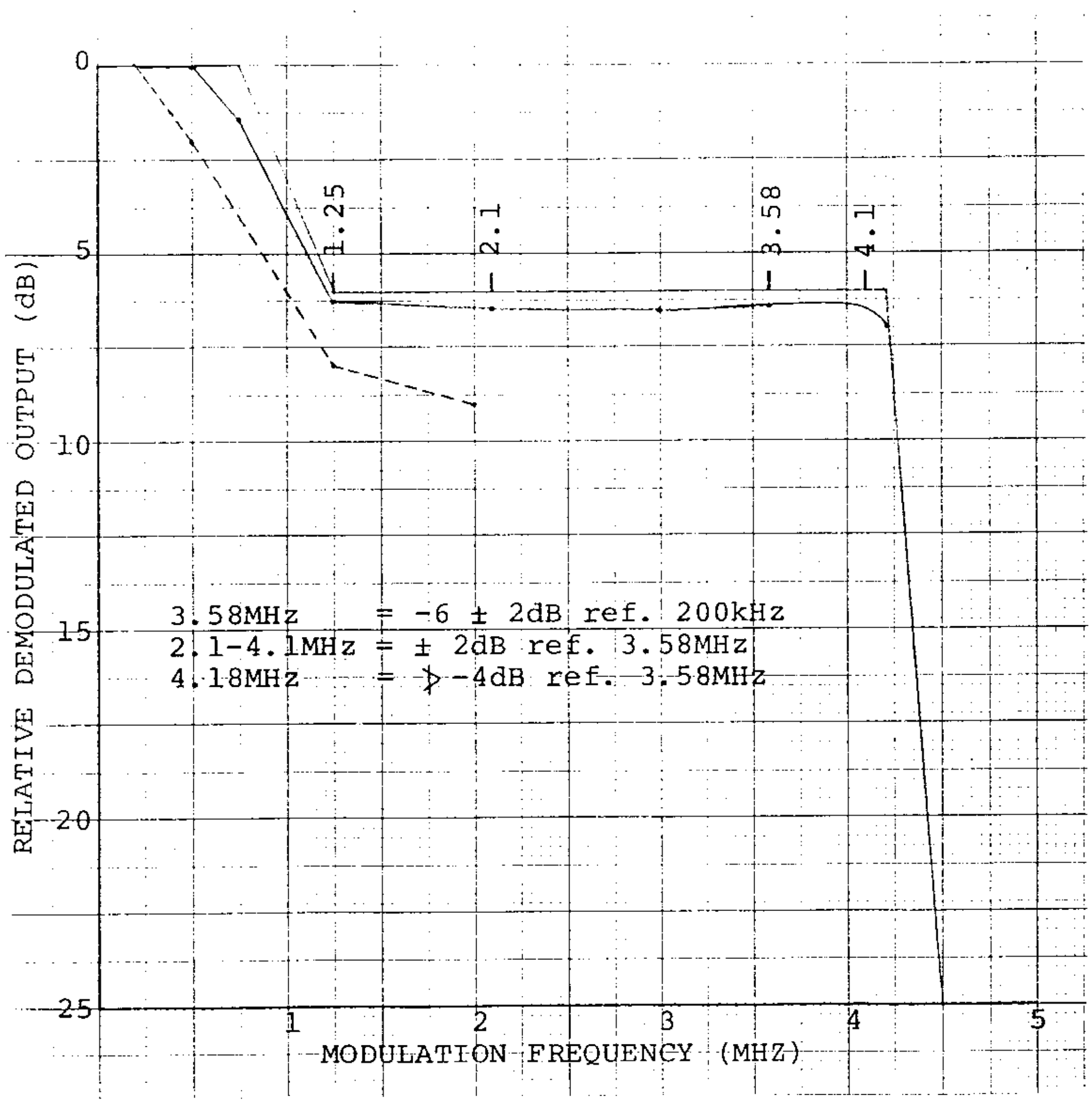
FREQUENCY RESPONSE TEST SETUP
Figure 2-1A

2.2 Attenuation Characteristics [73.687(a)(2)]

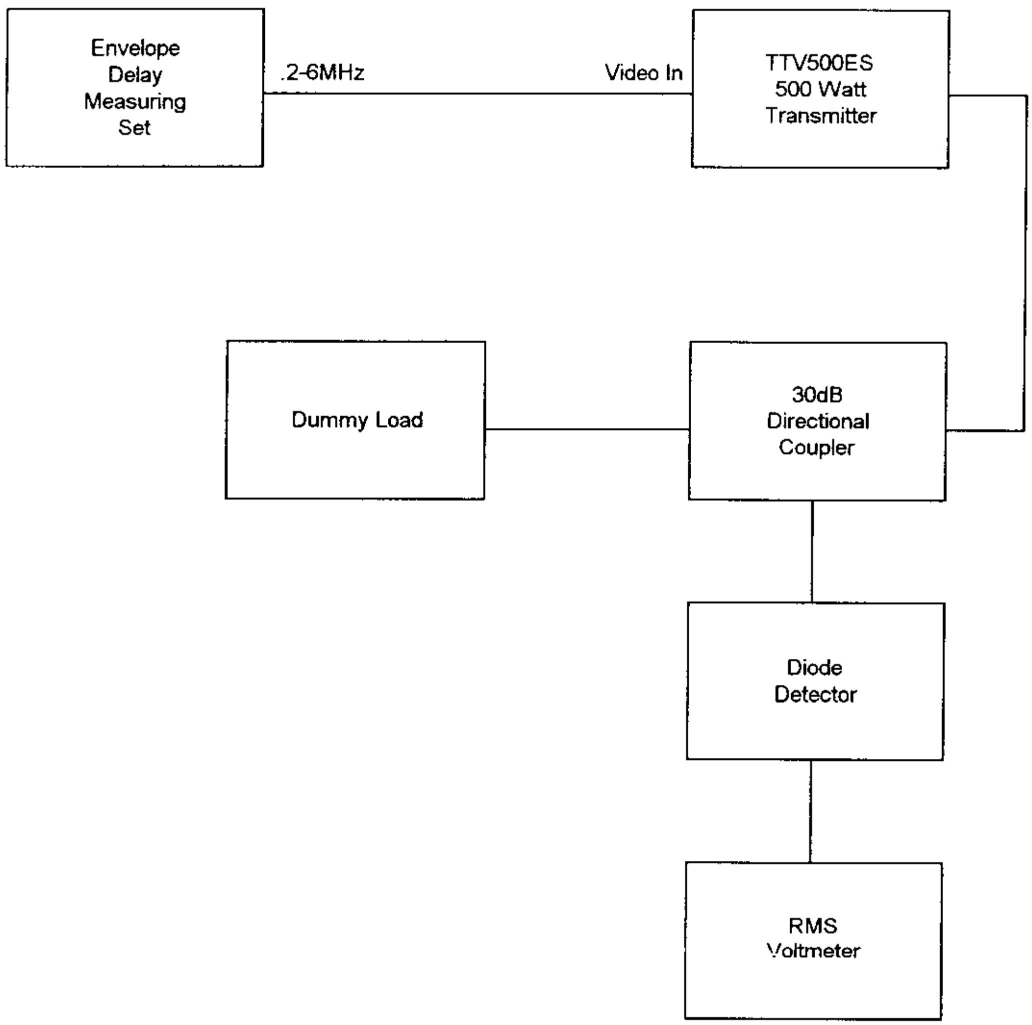
Test Equipment Setup	Figure 2–2A
Visual Output Power	500 watts peak
% Video Modulation	87.5%
Type Video Modulation	Standard sync with a variable frequency sine wave occupying the interval between pulses. Sine-wave axis was maintained at 50% of the peak sync amplitude. Sine-wave amplitude was held constant at less than 75% of the peak output voltage.
Aural Output Power	0 watts
Method of Measurement	Sine-wave frequency was varied through the video range. The data recorded was relative to the 200kHz sideband amplitude designated as 0dB.

ATTENUATION CHARACTERISTICS DATA

MODULATION FREQ. (MHz)	RECTIFIED OUTPUT (dB)
0.20	0
0.50	0
0.75	-1.4
1.25	-6.3
2.10	-6.5
3.00	-6.5
3.58	-6.4
4.18	-7.0



ATTENUATION CHARACTERISTIC CURVE
Figure 2–2



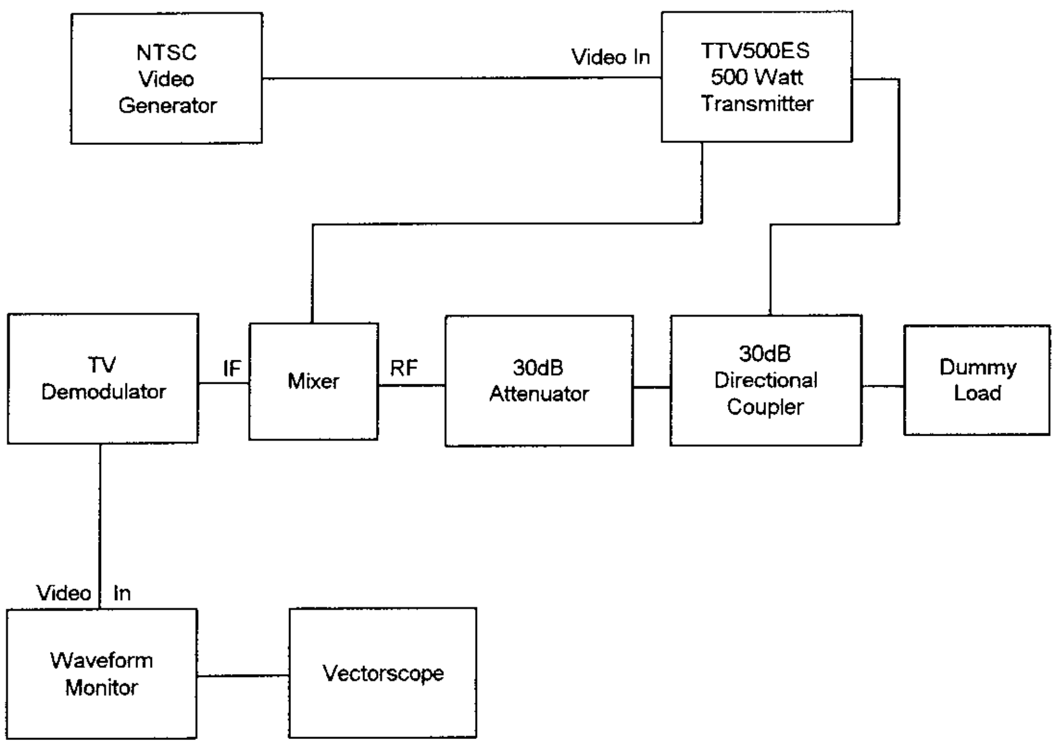
<u>ATTENUATION CHARACTERISTICS TEST SETUP</u>
Figure 2-2A

2.3 Differential Phase and Gain [73.682(a)(20)(vii)]

Test Equipment Setup	Figure 2–3A
Visual Output Power	500 watts peak
% Video Modulation	87.5%
Type Video Modulation	Standard 5-riser stairstep modulated with 3.58MHz color subcarrier
Aural Output Power	50 watts average
% Aural Modulation	0%
Method of Measurement	Data was taken from the demodulated output viewed on a vectorscope after passing through an internal chroma filter.

DIFFERENTIAL PHASE AND GAIN DATA

Differential Phase	=	+2.3°
Differential Gain	=	+2.5%



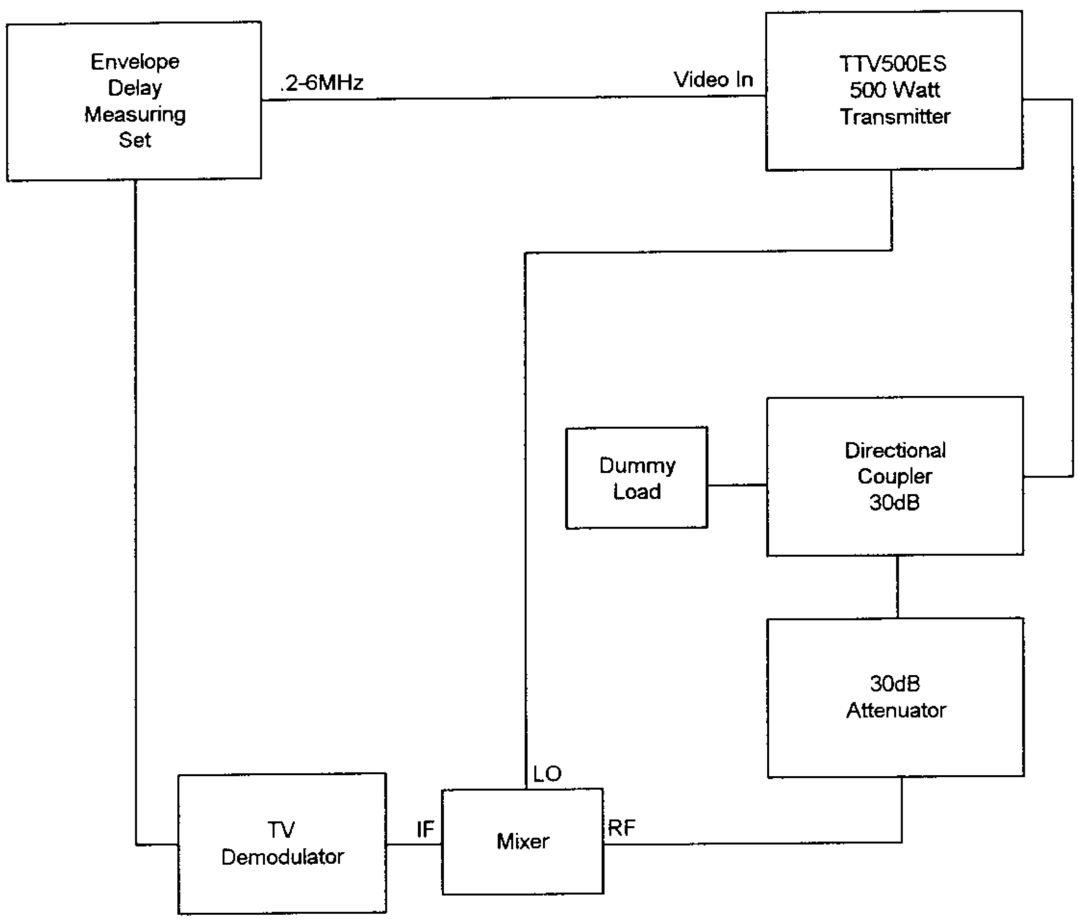
DIFFERENTIAL PHASE AND GAIN TEST SETUP
Figure 2-3A

2.4 Envelope Delay [73.687(a)(5)]

Test Equipment Setup	Figure 2–4A
Visual Output Power	500 watts peak
% Video Modulation	87.5%
Type Video Modulation	A variable frequency constant amplitude sine-wave with a 200kHz reference signal provided by the envelope delay test equipment
Aural Output Power	0 watts
Method of Measurement	The sine-wave was varied through the video range and the delay data was read from the CRT display of the Envelope Delay Measuring Set.

ENVELOPE DELAY VERSUS FREQUENCY DATA

FREQUENCY	ENVELOPE DELAY (ns)
200kHz	0
500kHz	+10
1.0MHz	0
1.5MHz	+5
2.1MHz	+8
2.5MHz	+40
3.0MHz	-15
3.2MHz	-80
3.4MHz	-105
3.58MHz	-215
4.0MHz	-255
4.18MHz	-260



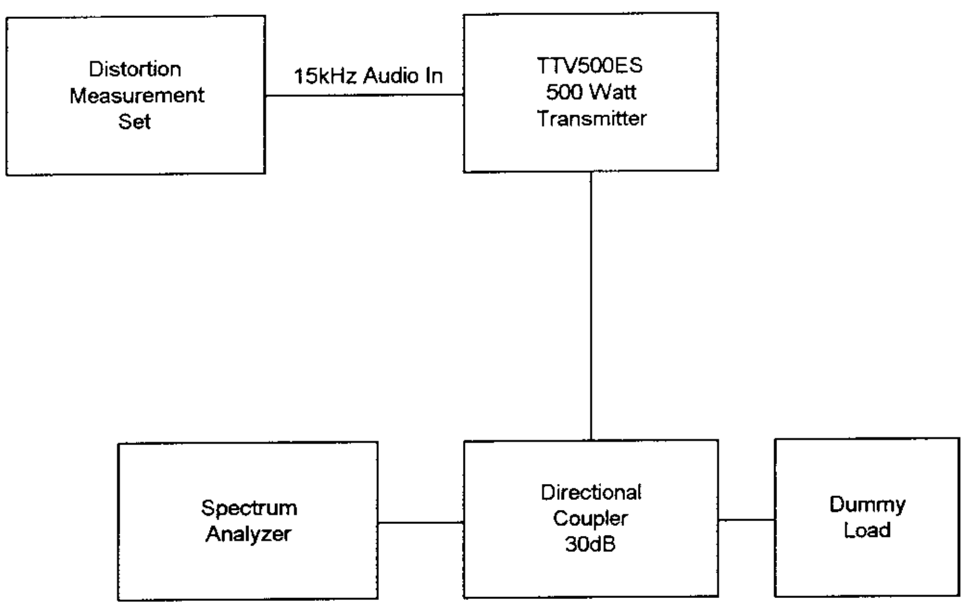
ENVELOPE DELAY TEST SETUP
Figure 2-4A

2.5 Aural Occupied Bandwidth [2.989(e)(5)]

Test Equipment Setup	Figure 2-5A
Visual Output Power	500 watts peak
% Video Modulation	0%
Aural Output Power	50 watts average
% Aural Modulation	85% (21.25kHz)
Aural Modulation Signal	15kHz
Method of Measurement:	Spectrum Analyzer set at 3kHz resolution, 15kHz/division frequency span and 5ms/division sweep speed. Bandwidth was read at 0.5% (-23dB) of mean power.

AURAL OCCUPIED BANDWIDTH DATA

Bandwidth ≈ 90kHz



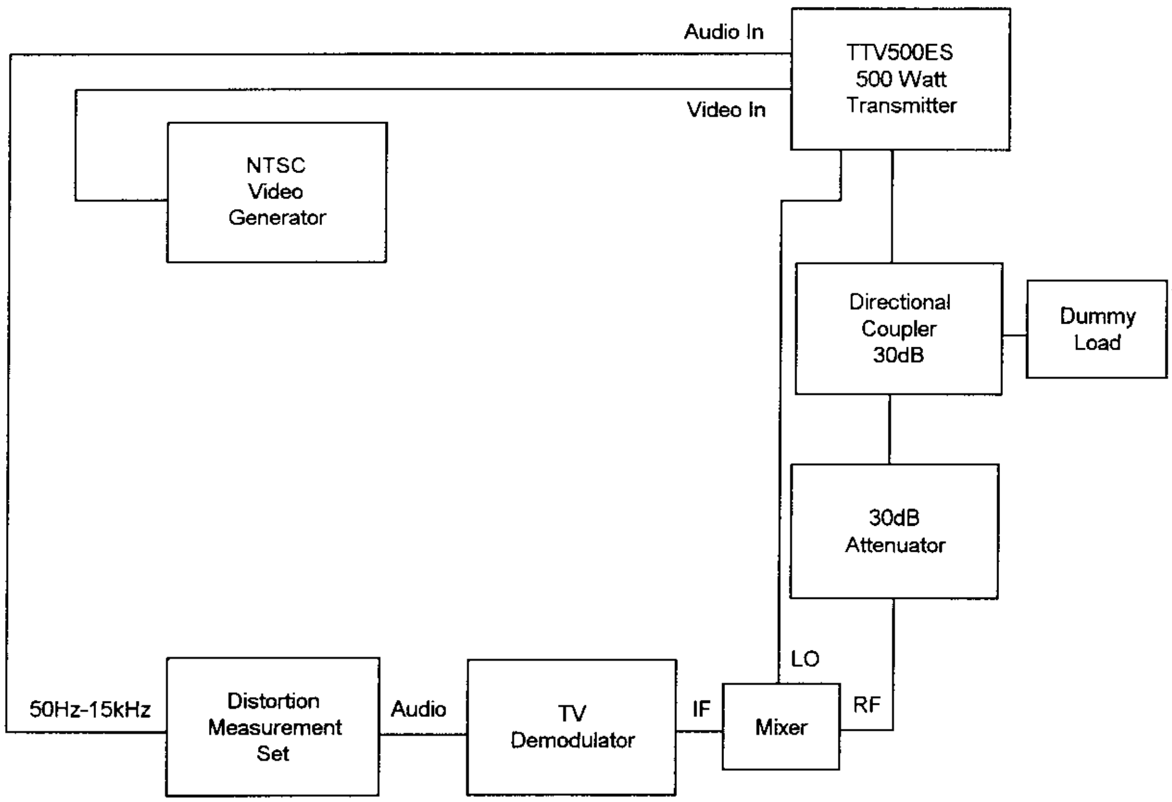
<u>AURAL OCCUPIED BANDWIDTH TEST SETUP</u>
Figure 2-5A

2.6 Aural Distortion [73.687(b)(3)]

Test Equipment Setup	Figure 2–6A
Visual Output Power	500 watts peak
% Video Modulation	87.5%
Type Video Modulation	Standard 10-riser stairstep
Aural Output Power	50 watts average
% Aural Modulation	100%, 50%, 25%
Aural Modulation Signal	Variable audio sine-wave from 50Hz to 15kHz
Method of Measurement	The aural modulation frequency was varied at three different % modulation levels and a distortion measurement was noted for each frequency-modulation combination.

AURAL DISTORTION DATA

FREQUENCY	% DISTORTION		
Hz	100% MOD	50% MOD	25% MOD
50	0.36	0.39	0.42
100	0.30	0.31	0.34
400	0.26	0.28	0.34
1,000	0.21	0.25	0.27
5,000	0.25	0.31	0.34
7,500	0.37	—	—
10,000	0.44	—	—
15,000	0.47	—	—



AURAL DISTORTION TEST SETUP
Figure 2-6A

2.7 Aural Frequency Response [73.687(b)(2)]

Test Equipment Setup — Figure 2–7A

Visual Output Power — 500 watts peak

% Video Modulation — 87.5%

Type Video Modulation — Standard 10-riser stairstep

Aural Output Power — 50 watts average

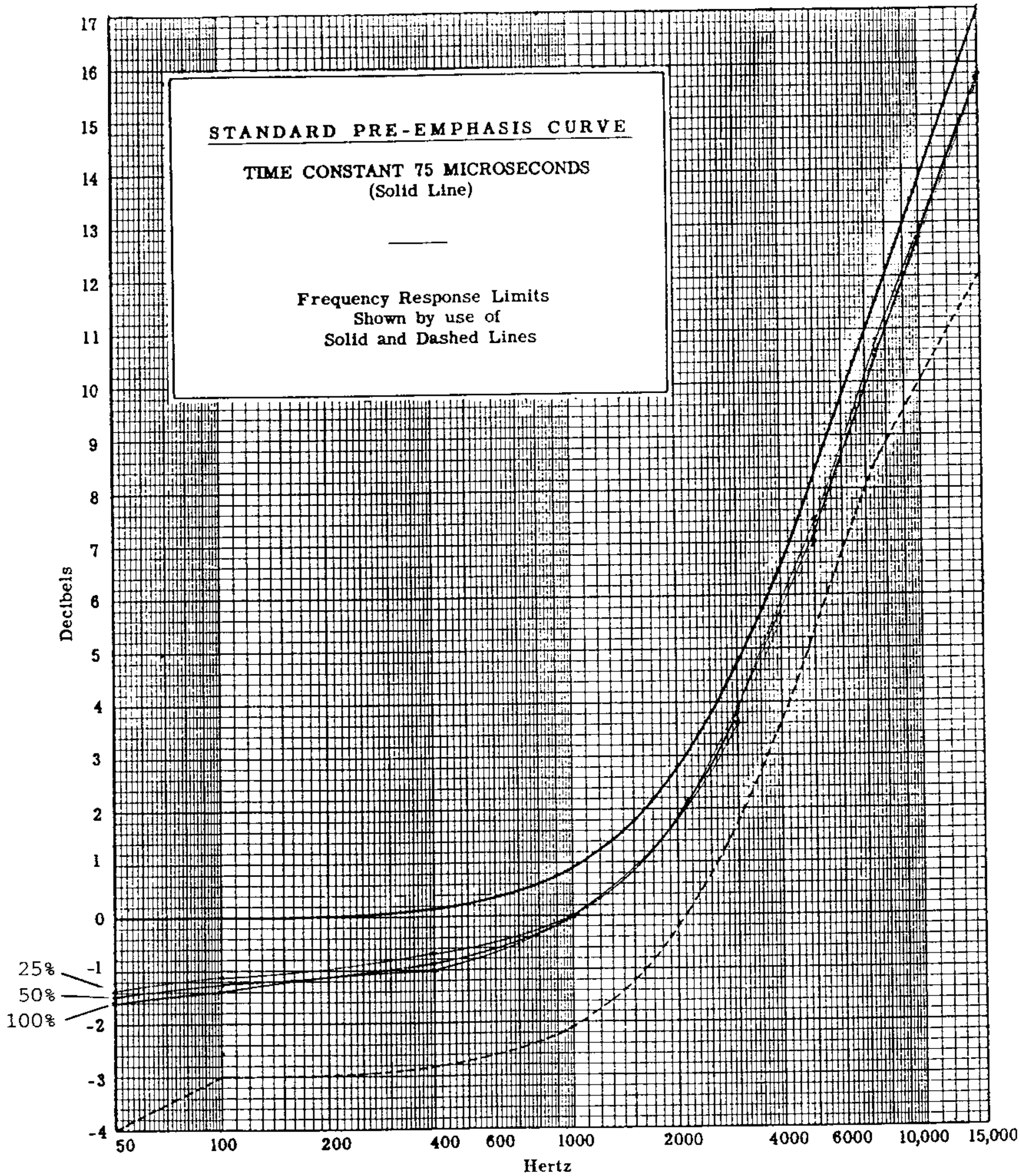
% Aural Modulation — 100%, 50%, 25%

Aural Modulation Signal — 50 to 15,000Hz

Method of Measurement — The audio input was adjusted at each audio frequency to maintain a constant modulation level. Modulation input variations were plotted directly from the dB scale of the Distortion Test Set Meter.

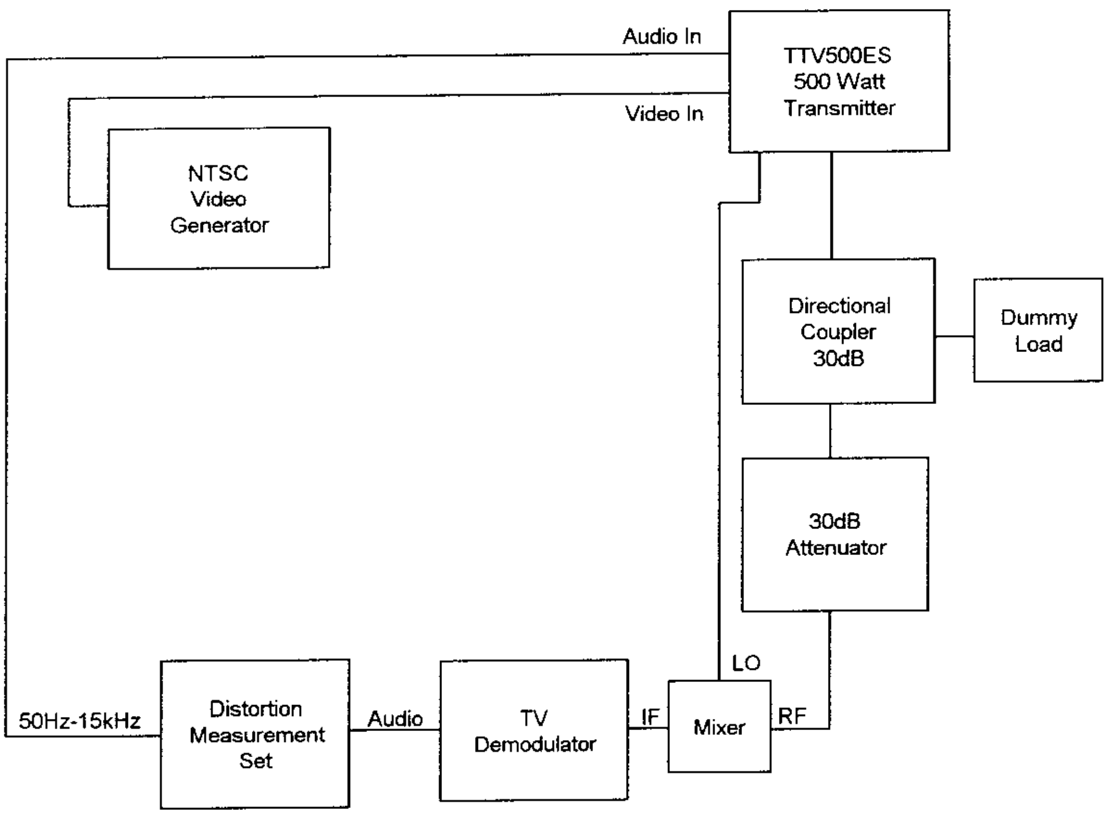
AURAL FREQUENCY RESPONSE DATA

FREQUENCY	OUTPUT LEVEL RELATIVE TO 1000Hz (dB)		
Hz	100% MOD	50% MOD	25% MOD
50	-1.6	-1.5	-1.4
100	-1.4	-1.3	-1.1
400	-1.0	-0.9	-0.7
1000	0	0	0
3000	+3.6	+3.8	3.9
5000	+7.0	+7.2	+7.4
7500	+10.5	+10.6	+10.8
10000	+12.6	+12.7	+12.9
15000	+15.7	+15.7	+15.8



AURAL FREQUENCY RESPONSE

Figure 2–7



AURAL PREEMPHASIS TEST SETUP

Figure 2-7A

2.8 Amplitude Modulation Noise [73.687(b)(5)]

Test Equipment Setup	Figure 2–8A
Visual Output Power	0 watts
Aural Output Power	50 watts average
% Aural Modulation	100%
Aural Modulation Signal	400Hz
Method of Measurement	AC RMS and DC readings were taken to compute the signal to noise ratio shown below. An RC network was used with the RMS voltmeter to roll off noise above 15kHz.

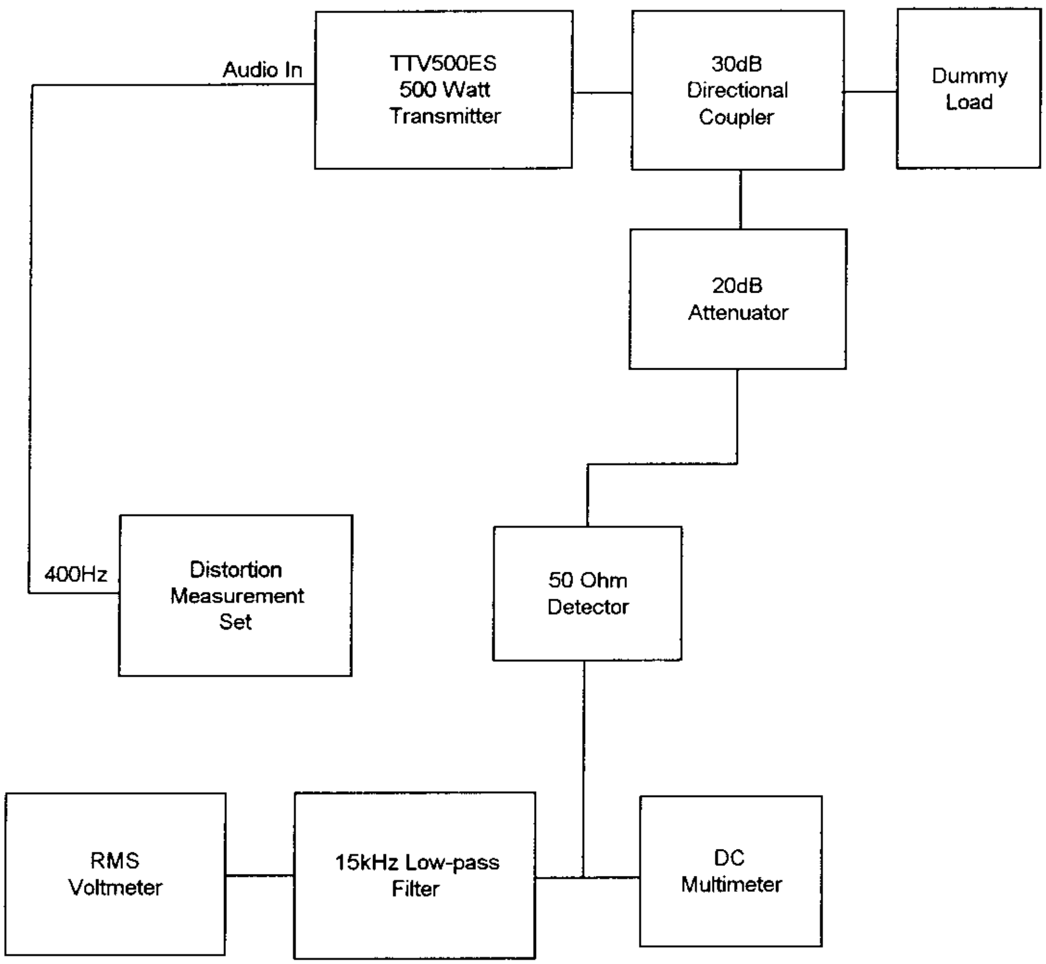
AM NOISE DATA

AC Output = 3.0mV

DC Output = 2.3V

$$\text{AM Noise} = 20 \log \frac{\text{AC Output}}{\text{DC Output}} = \frac{.003\text{V}}{2.3\text{V}}$$

AM Noise = -57.7dB



AM NOISE TEST SETUP
Figure 2-8A

2.9 Frequency Modulation Noise [73.687(b)(4)]

Test Equipment Setup	Figure 2–9A
Visual Output Power	0 watts
Aural Output Power	50 watts average
% Aural Modulation	100% and 0%
Aural Modulation Signal	400Hz
Method of Measurement	With aural modulation applied, a reading was obtained from the Distortion Measurement Set RMS voltmeter. With modulation removed, a new reading was recorded. The signal to noise calculation was checked against the dB scale of the RMS voltmeter.

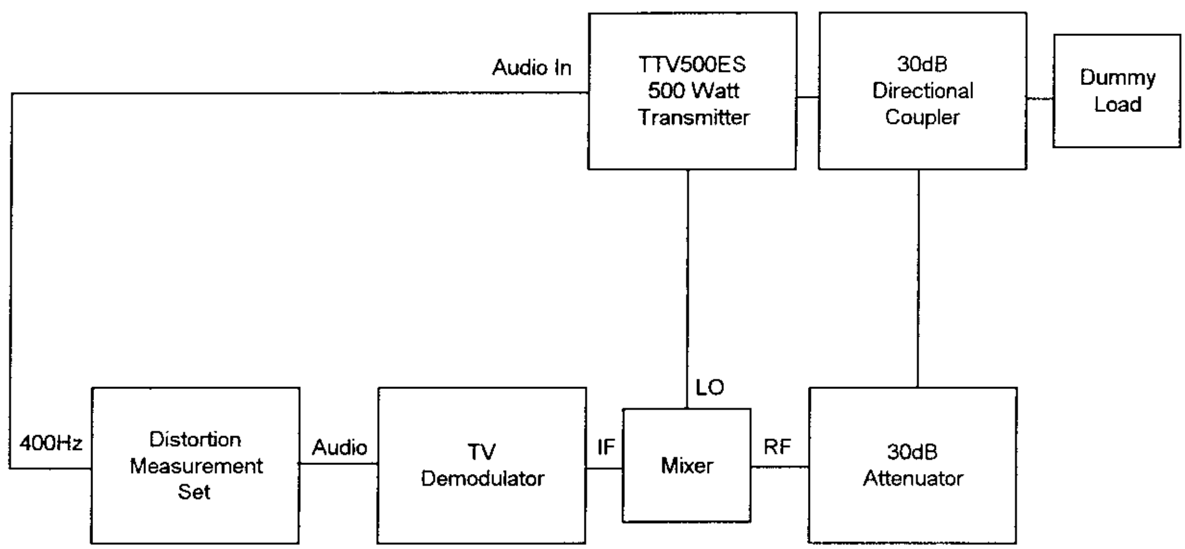
FM NOISE DATA

Detected Output w/o modulation = 1.9mV

Detected Output w/modulation = 2.5V

$$\text{FM Noise} = 20\log\frac{\text{Output w/o modulation}}{\text{Output w/modulation}} = \frac{.0019\text{V}}{2.5\text{V}}$$

FM Noise = -62.4dB



<u>FM NOISE TEST SETUP</u>
Figure 2-9A

2.10 Antenna Terminal Radio Frequency Voltage [74.936(c)(iii)]

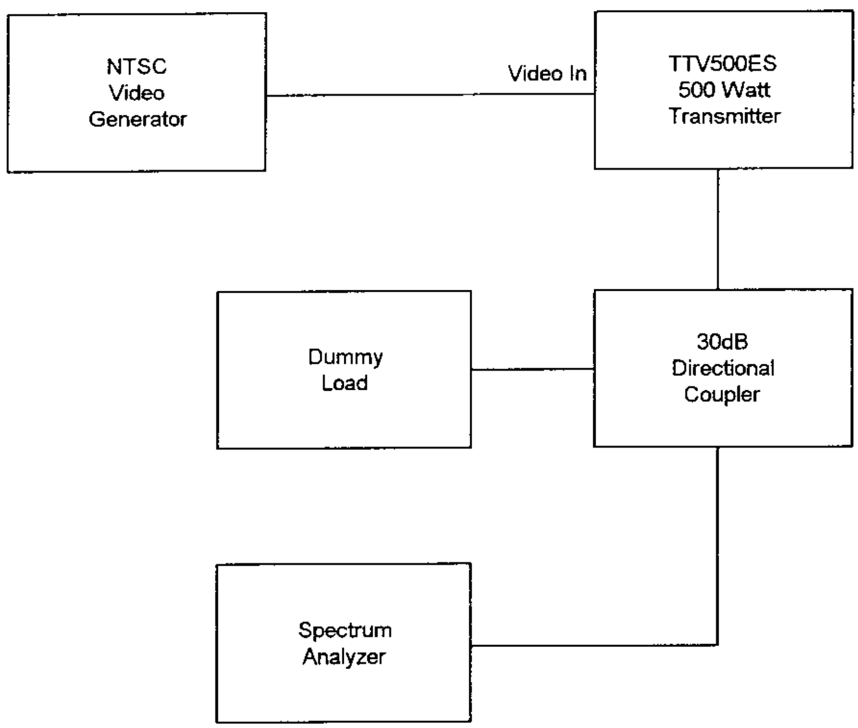
Test Equipment Setup	Figure 2–10A
Visual Output Power	500 watts peak
% Video Modulation	87.5%
Type Video Modulation	Standard 10-riser stairstep
Aural Output Power	50 watts average
% Aural Modulation	0%
Method of Measurement	The spectrum analyzer display was adjusted for a zero reference level at the visual carrier using the following settings:

Frequency Span/Division	–	1MHz
Resolution Bandwidth	–	30kHz
Time/Division	–	20ms
Input Attenuation	–	30dB
Reference Level	–	-4dBm
Video Filter	–	Off

All emissions were checked relative to peak sync from 0 to 10.0GHz. Those emissions below -80dB were not noted.

ANTENNA TERMINAL RF VOLTAGE DATA

FREQUENCY (MHz)	LEVEL (dB relative to peak visual)	
187.25	0dB	Visual Carrier
191.75	-10dB	Aural Carrier
182.75	-68dB	Visual Carrier -4.5MHz
196.25	-75dB	Aural Carrier +4.5MHz
179.25	——	Visual Carrier -9.0MHz
200.75	——	Aural Carrier +9.0MHz
233.00	-66dB	Visual Carrier +45.75 (LO)
374.50	-65dB	Visual 2nd Harmonic
383.50	-75dB	Aural 2nd Harmonic



ANTENNA TERMINAL RF VOLTAGE TEST
Figure 2-10A

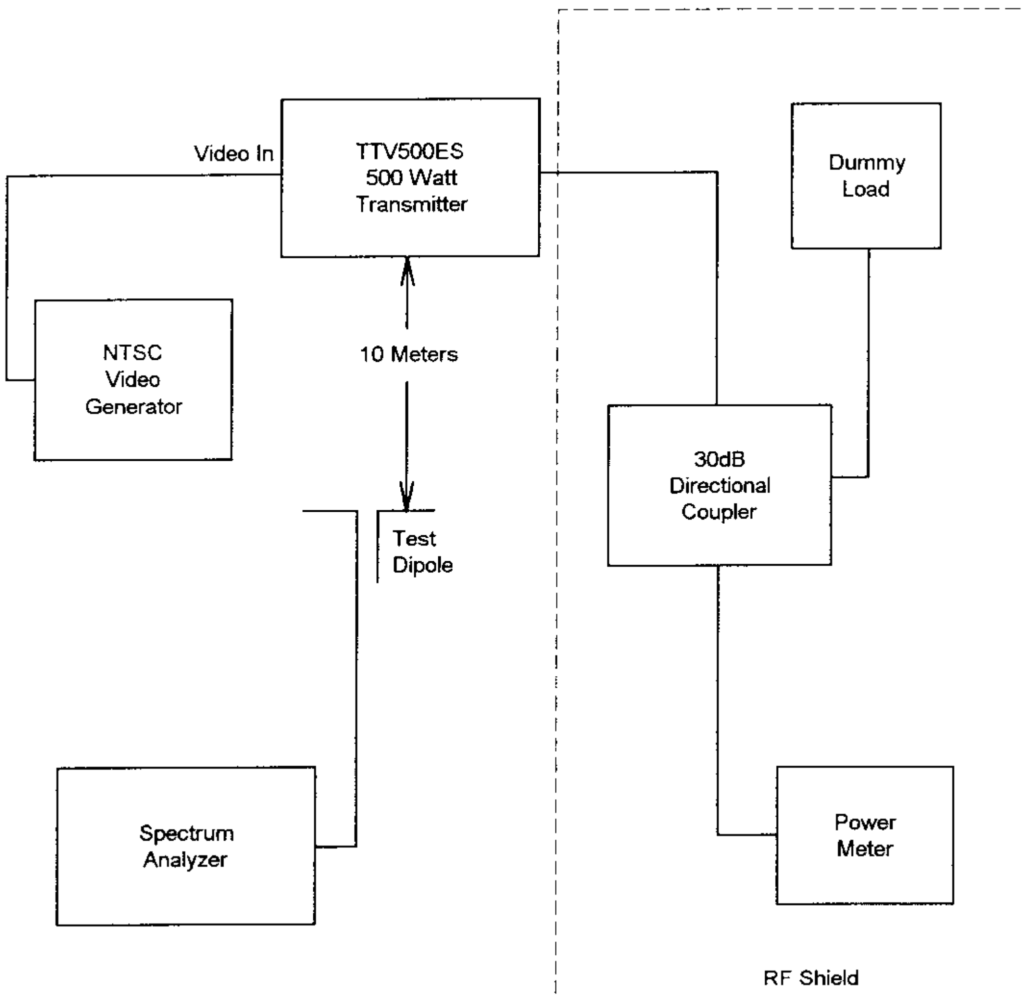
2.11 Spurious Radiation Field Strength [2.993]

Test Equipment Setup	Figure 2-11A
Visual Output Power	500 watts peak
% Video Modulation	87.5%
Type Video Modulation	Standard 10-riser stairstep
Aural Output Power	50 watts average
% Aural Modulation	0%
Method of Measurement	The broadband receive antennas were moved horizontally and vertically around the unit to maximize receive level. Absolute power level of each spurious radiation was measured on a calibrated spectrum analyzer and converted to an equivalent field strength by finding the power density (absolute power divided by the antenna area). The relative field strength of the spurious radiation was then calculated with respect to the unit's rated output power. The field strength of the rated output was found using $\sqrt{49.2P}/R$ (P = rated output, R = distance). All emissions were assumed to be radiated from half-wave dipoles. Frequencies scanned extended from 20MHz to 10.0GHz.

SPURIOUS RADIATION FIELD STRENGTH DATA

$$E\ Output = \sqrt{49.2P}/R = \sqrt{(49.2)(500)}/10 = 15.7\ Volts/Meter$$

FREQUENCY (MHz)		POWER MEASURED (dBm)	EQUIVALENT FIELD STRENGTH (VOLTS/METER)	RELATIVE FIELD STRENGTH (dB)
Visual	187.25	-48	4.23×10^{-3}	-71.4dB
Aural	191.75	-60	1.09×10^{-3}	-83.2dB
LO	233.00	Not Visible	————	———
2nd Harmonic	374.50	Not Visible	————	———



<u>SPURIOUS CABINET RADIATION TEST SETUP</u>
Figure 2-11A

2.12 Power Output Meter Calibration [2.985]

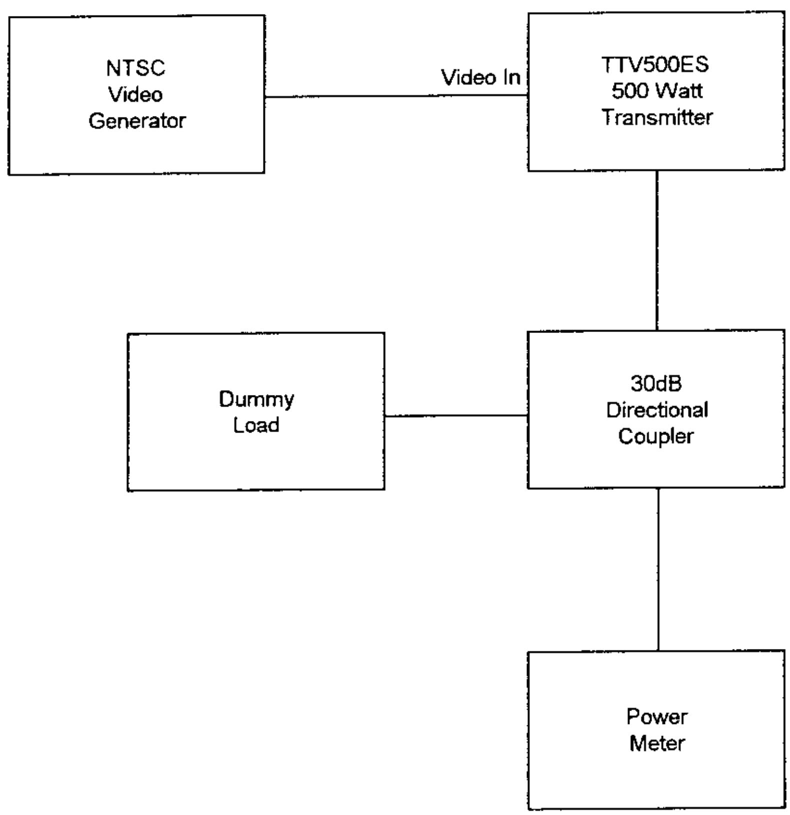
Test Equipment Setup	Figure 2–12A
Visual Output Power	500 watts peak
% Video Modulation	87.5%
Type Video Modulation	Standard sync with blanking level set at 75% of peak sync and maintained through the interval between pulses (0% APL).
Aural Output Power	50 watts average
% Aural Modulation	0%
Method of Measurement	The 2W Exciter was adjusted to obtain a 298mW average visual reading from the transmitter. This power level corresponds to 500 watts peak power when using the factor of 1.68 and compensating for the output attenuation as shown:

$$\underset{\text{meter reading}}{[298\text{mW}]} \times \underset{\text{attenuation}}{[10^3]} \times \underset{\text{power factor}}{[1.68]} = 500\text{W}$$

The FWD control of the VISUAL Metering Detector, located behind an access hole on the transmitter Metering panel, was adjusted to provide a 100% indication on the VISUAL % POWER meter with the meter switch set to FWD. The % POWER meter and meter switch are also located on the Metering panel.

The Exciter's aural level was then adjusted to obtain a 348mW indication on the external power meter (298W average visual + 50W average aural -30dB = 348mW).

The FWD Control of the AURAL Metering Detector, located behind an access hole on the transmitter's Metering panel, was adjusted to provide a 100% indication on the AURAL % POWER meter with its meter switch set to FWD. The % POWER meter and meter switch are also located on the Metering panel.



POWER OUTPUT METER CALIBRATION SETUP
Figure 2-12A

2.13 Frequency Stability [2.995]

Test Equipment Setup: Figure 2–13A

Method of Measurement: The EMCEE VHF Synthesizer, with its B+ lines intact, was removed from the transmitter and placed in an environmental chamber. The synthesizer's stability was first tested with ±15% variations in the AC line voltage. The chamber's internal temperature was then changed and the oscillator frequency was noted at every 10°C increment. The results of both tests are shown in the following tables.

LINE VOLTAGE	EMCEE FREQUENCY SYNTHESIZER	CHANNEL ERROR (Hz)
95	233.000025	+25
115	233.000026	+26
135	233.000026	+26

TEMP C°	EMCEE FREQUENCY SYNTHESIZER	CHANNEL ERROR (Hz)
+50	232.999855	-145
+40	232.999939	-61
+30	233.000009	+9
+20	233.000021	+21
+10	233.000049	+49
0	233.000086	+86
-10	233.000104	+104
-20	233.000123	+123
-30	233.000155	+155

Test Equipment Setup	Figure 2–13A
Method of Measurement	To provide the customer with our optional precision offset, the Vectron CO-254D57 oscillator with an EMCEE X2 or X4 Multiplier will be used as a direct replacement for the EMCEE VHF synthesizer in the TTV500ES Transmitter.

The Vectron CO-254D57 oscillator was tested using the same method as for the EMCEE synthesizer.

LINE VOLTAGE	EMCEE OSCILLATOR (MHz)	X4 MULTIPLIER (MHz)	CHANNEL ERROR (Hz)
95	58.250010	233.000010	+10
115	58.250010	233.000010	+10
135	58.250012	233.000012	+12

TEMP C°	EMCEE OSCILLATOR (MHz)	X4 MULTIPLIER (MHz)	CHANNEL ERROR (Hz)
+50	58.249983	232.999930	-70
+40	58.249915	232.999966	-34
+30	58.250000	233.000002	+2
+20	58.250004	233.000015	+15
+10	58.250006	233.000024	+24
0	58.250010	233.000041	+41
-10	58.250017	233.000068	+68
-20	58.250021	233.000085	+85
-30	58.250026	233.000103	+103

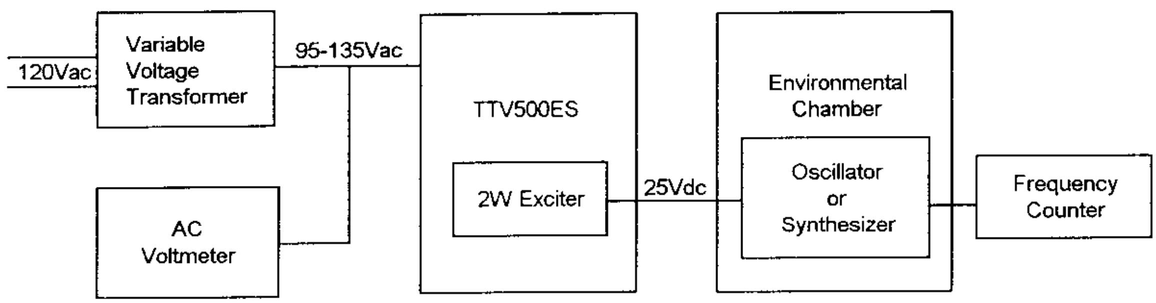
Test Equipment Setup — Figure 2–13B

Method of Measurement — The EMCEE EM1 Modulator was placed in an environmental chamber and the frequency stability of the visual and aural carriers was monitored during variations in line voltage and ambient temperature. The results of both tests are recorded in the tables below.

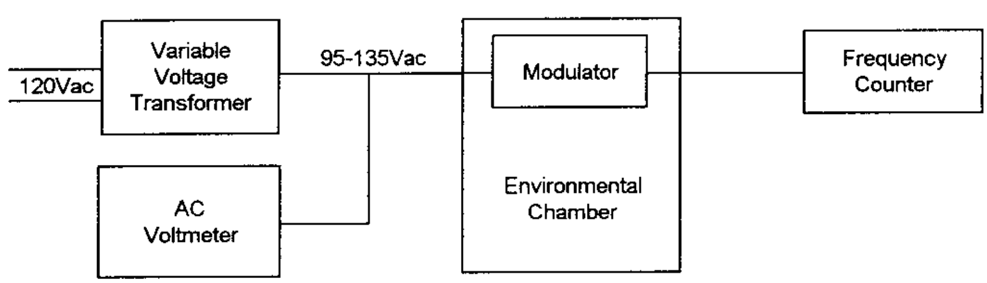
LINE VOLTAGE	VISUAL CARRIER (MHz)	AURAL CARRIER (MHz)	4.5MHz ERROR (Hz)	CHANNEL ERROR (Hz)
95	45.750064	41.250076	-12	+64
115	45.750064	41.250077	-13	+64
135	45.750063	41.250078	-15	+ 63

TEMP C°	VISUAL CARRIER (MHz)	AURAL CARRIER (MHz)	4.5MHz ERROR (Hz)	CHANNEL ERROR (Hz)
+50	45.749888	41.249920	-32	-112
+40	45.749901	41.249929	-28	-99
+30	45.749976	41.249998	-22	-24
+20	45.750065	41.250080	-15	+ 65
+10	45.750123	41.250130	-7	+123
0	45.750185	41.250180	+ 5	+185
-10	45.750256	41.250249	+ 7	+256
-20	45.750332	41.250321	+11	+332
-30	45.750297	41.250288	+ 9	+297

Adding the worst instances of frequency variations for the modulator and VHF Synthesizer, the TTV500ES carrier frequencies are well within the .002% FCC specifications for Low Power Television Transmitters and within the ±1kHz requirement for zero frequency offset . When using the Vectron high stability CO254D57 oscillator and X2 or X4 Multiplier, the transmitter's frequency stability also falls within the ±1000Hz necessary for ±10kHz precision offset.



FREQUENCY STABILITY TEST SETUP
Figure 2-13A



FREQUENCY STABILITY TEST SETUP
Figure 2-13B

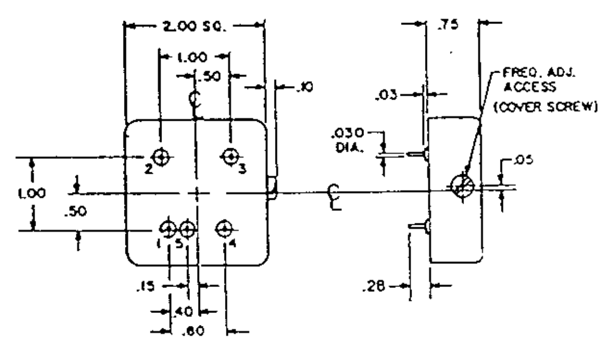
Series CO-252 and CO-254 offer the highest stability alternatives and broadest range of options within Vectron's line of TCXOs. The TCXOs on the adjacent pages are more limited in input/output alternatives and other options, but are smaller in size.

	50 kHz to 20 MHz CO-252 SERIES	20.1 MHz to 140 MHz CO-254 SERIES
FREQUENCY	Sine: 1 MHz to 20 MHz TTL: 200 kHz to 20 MHz CMOS: 50 kHz to 15 MHz HCMOS: 50 kHz to 20 MHz	Sine: 20.01 MHz to 140 MHz TTL: 20.01 MHz to 100 MHz CMOS: 20.01 MHz to 50 MHz HCMOS: 20.01 MHz to 140 MHz ECL: 20.01 MHz to 140 MHz
STABILITY Temperature (Temp. Range A) +15°C to +35°C:	CO-252A17: $\pm1 \times 10^{-7}$ CO-252A58: $\pm5 \times 10^{-8}$	CO-254A57: $\pm5 \times 10^{-7}$ CO-254A17: $\pm1 \times 10^{-7}$
(Temp. Range B) 0°C to +50°C:	CO-252B57: $\pm5 \times 10^{-7}$ CO-252B27: $\pm2 \times 10^{-7}$ CO-252B17: $\pm1 \times 10^{-7}$	CO-254B16: $\pm1 \times 10^{-6}$ CO-254B57: $\pm5 \times 10^{-7}$ CO-254B27: $\pm2 \times 10^{-7}$
(Temp. Range C) 0°C to +70°C:	CO-252C16: $\pm1 \times 10^{-6}$ CO-252C57: $\pm5 \times 10^{-7}$ CO-252C37: $\pm3 \times 10^{-7}$	CO-254C36: $\pm3 \times 10^{-6}$ CO-254C16: $\pm1 \times 10^{-6}$ CO-254C37: $\pm3 \times 10^{-7}$
(Temp. Range D) -20°C to +70°C:	CO-252D16: $\pm1 \times 10^{-6}$ CO-252D57: $\pm5 \times 10^{-7}$	CO-254D56: $\pm5 \times 10^{-6}$ CO-254D16: $\pm1 \times 10^{-6}$ CO-254D57: $\pm5 \times 10^{-7}$ ←
(Temp. Range E) -40°C to +75°C:	CO-252E56: $\pm5 \times 10^{-6}$ CO-252E26: $\pm2 \times 10^{-6}$ CO-252E16: $\pm1 \times 10^{-6}$	CO-254E56: $\pm5 \times 10^{-6}$ CO-254E26: $\pm2 \times 10^{-6}$ CO-254E16: $\pm1 \times 10^{-6}$
(Temp. Range F) -55°C to +85°C:	CO-252F56: $\pm5 \times 10^{-6}$ CO-252F26: $\pm2 \times 10^{-6}$ CO-252F16: $\pm1 \times 10^{-6}$	CO-254F56: $\pm5 \times 10^{-6}$ CO-254F26: $\pm2 \times 10^{-6}$ CO-254F16: $\pm1 \times 10^{-6}$
(Temp. Range G) -55°C to +105°C:	CO-252G56: $\pm5 \times 10^{-6}$	CO-254G56: $\pm5 \times 10^{-6}$
(Temp. Range H) -55°C to +125°C:	CO-252H15: $\pm1 \times 10^{-5}$	CO-254H15: $\pm1 \times 10^{-5}$
Aging Rate	≤5 MHz: 5×10^{-7}/year (3×10^{-9}/day avg) >5 MHz: 1×10^{-6}/year (5×10^{-9}/day avg)	
Short Term (Allan Variance)	1×10^{-9}/second under constant conditions	
Frequency vs Supply	2×10^{-6} per percent in supply with 10 to 28 Vdc input; 1×10^{-7} per percent change in supply for 5 to 9 Vdc input	

OUTLINE/INSTALLATION DRAWINGS

CO-252, CO-254 SERIES

PCB mount (standard)



Pin	WITH SINGLE SUPPLY: No "V" Option	WITH SINGLE SUPPLY: "V" Option	WITH SEPARATE TTL SUPPLY: No "V" Option	WITH SEPARATE TTL SUPPLY: "V" Option
1	Output	Output	Output	Output
2	Supply (+)	Supply (+)	Supply (+)	Supply (+)
3	0 Volt/case	0 Volt/case	*0 Volt/case	*0 Volt/case
4	0 Volt/case	VCXO in	+5V	VCXO in
5	*rf return	*rf return	*rf return	+5 Vdc

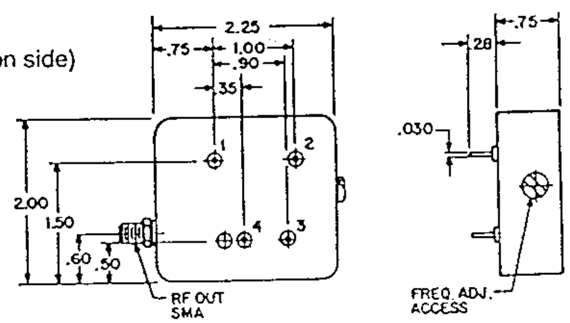
*Internally connected (except pin 5 is not internally connected with sine output in CO-252 series)

RF Connector options

Option SW
(SMA connector on side)

Pin	Function
1	Supply (+)
2	0 volts, case
*3	Case
4	Case

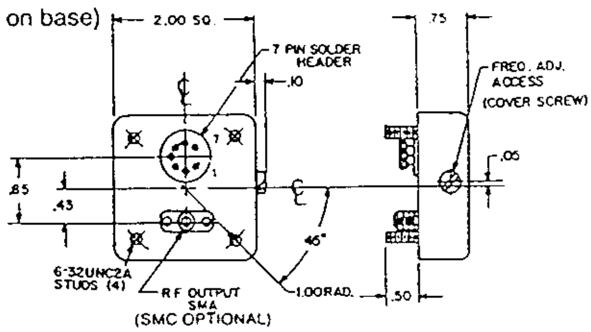
*In units with electronic tuning ("V" option), control voltage is applied from pin 3 to pin 2.



Option W
(SMA connector on base)

Pin	Function
1	Supply (+)
2	N/C
3	0 volts, case
4	N/C
5	Case
6	N/C
*7	N/C

*In units with electronic tuning ("V" option), control voltage is applied from pin 7 to pin 3.



EMCEE

MODEL EM1
SOLID STATE
FREQUENCY AGILE MODULATOR

BROADCAST PRODUCTS

P.O. Box 68 • Susquehanna St. • White Haven, PA 18661 • 570-443-9575 • FAX 570-443-9257

12/94

IMPORTANT

Transient Overvoltage Protection

Transient overvoltage of micro- and nano-seconds durations are a continuous threat to all solid-state circuitry. The resulting costs of both equipment repairs and system downtime make preventative protection the best insurance against these sudden surges. Types of protection range from isolation transformers and uninterruptible power supplies to the more cost effective AC power line protectors. As transient culprits are most often lightning induction and switching surges, AC power line protectors are the most practical solution. An effective AC power line protector is one capable of dissipating impulse energy at a low enough voltage to ensure the safety of the electronic components it is protecting. The protection unit should be across the AC line at all times even during periods of total blackout. It should also reset immediately and automatically to be 100% ready for repeated transients.

TABLE OF CONTENTS

SECTION I

THE EM1 MODULATOR

1.1 Introduction:

The EMCEE EM1 is a solid-state high performance modulator that can be used in many applications where baseband video and audio need to be converted to AM television signals. This unit can provide a modulated RF signal on any channel from 2 to 61 (YY), as well as 5A, and A minus 1 to A minus 5, with an output level of at least 6.25dBm. The desired channel is easily chosen using the front panel selector, which is equipped with a positive lock to prevent inadvertent channel changes. Where channels are subject to FCC mandated frequency control, offsets of ±12.5kHz or ±25kHz can be selected from the rear panel.

The EM1 has dual IF loops with output levels in excess of -13.5dBm that are accessed from the rear panel. The IF output can be used directly by a transmitter (e.g., the TTS10HS) or can be looped back into the modulator to provide an RF output. Either way the modulator is set up, the IF loops provide a connection that is compatible with any IF scrambling system.

The EM1 modulator is a self-contained unit and requires only 1.75 inches of height clearance in a standard 19 inch rack.

1.2 Specifications:

Video Input

Type	Composite NTSC video, sync negative
Level	0.5 to 2.5 V p-p, front panel adjustable (0.5V p-p minimum for 87.5% modulation)
Impedance	75 ohms, unbalanced (Type F Connector)
Frequency Response	±0.5dB, 30Hz to 4.0MHz +0/-1.5dB, 4.0MHz to 4.2MHz
Differential Phase	2° maximum
Differential Gain	2% maximum
Visual Signal-to-Noise	>60dB @ 87.5% modulation
AM Hum and Noise	60dB minimum below 87.5% modulation
Group Delay	Meets FCC requirements (-170, ±60ns max.)
Field Time Distortion	2% maximum, 60Hz, 50% square wave

Line Time Distortion	2% maximum
White Clip Level	95%, ±2% modulation

Audio Input

Type	Baseband Monaural
Level	-10 to +10dBm
Impedance	600 ohms, unbalanced (RCA Phono Jack)
Frequency Response	±1dB, 40Hz to 15kHz with 75μsec pre-emphasis
Harmonic Distortion	1% maximum (1kHz with 25kHz deviation)
Hum and Noise	-50dB minimum at 25kHz deviation
Over Deviation Threshold	25kHz

4.5MHz Input

Input	4.5MHz modulated FM signal, monaural or BTSC stereo
Impedance	75 ohms, unbalanced (Type F Connector)
Level	-13.5 to 1.25dBm

IF Input/Output

Impedance	75 ohms, unbalanced (Type F Connector)
Operating Level	>-13.5dBm with normal setup (all IF input/output ports)
Frequency Accuracy	±1.0kHz of 45.75MHz visual or 41.25MHz aural IF

RF Output

Frequency Range	54-450MHz, 66 Channels (Channel 2 to Channel 61 [YY]) (Channel 5A, A Minus 1 to A Minus 5)
FCC Offset	0, ±12.5kHz and ±25kHz, selectable
Frequency Stability	Within ±5kHz of selected frequency
Impedance	75 ohms, unbalanced (Type F Connector)

Level	>6.25dBm
Level Range	>10dB, front panel adjustable
Level Stability	±1dB
Return Loss	16dB
Aural Control Range	-10 to -20dB (front panel adjustable)
Spurious Outputs	60dB below visual carrier, 50-450MHz at 6.25dBm output
Sideband Response	-20dB at channel edge; -40dB at adjacent channel visual and aural carrier frequency
RF Test	-20dB, type F connector

Mechanical

Power Requirements	115Vac ± 8% Vac @ 50-60Hz, 27W
Ambient Temperature	-30°C to +50°C
Mechanical Dimensions	19"W x 1.75"H x 12.75"D
Weight	10.5 lb.

1.3 Installation:

The connectors and terminals mentioned in the following instructions are located on the rear of the equipment.

1. After unpacking the modulator, a thorough inspection should be conducted to reveal any damage which may have occurred during shipment. If damage is found, immediately notify the shipping agency and advise EMCEE Broadcast Products (Customer Service) or its field representative. Also check to see that any connectors, cables or miscellaneous equipment, which may have been ordered separately, are included.

2. Place the modulator in a clean, weatherproof environment with an air gap around the unit to provide adequate ventilation. It is important to maintain the ambient operating temperature within the -30°C and +50°C limits.

3. Place the modulator in its permanent location near a receptacle that supplies 115Vac at 50-60Hz. The ac source should have a minimum power capacity of 30W.

4. Set all circuit breakers and switches, including the incoming ac mains breakers, to the off position. Place an appropriate ac power line protector (surge suppressor) across the ac supply line.

5. Connect the input video signal to the F connector labeled VIDEO IN. The video signal level should be 1.0V p-p.

6. Connect the audio input signal to the 600 ohm RCA phono jack labeled AUDIO IN. This signal should be at a level of 0dBm. When using this input, make sure the last switch in the frequency offset group of switches is in the INT (down) position.

7. If using an external 4.5MHz input, connect it to the AURAL 4.5MHz IN F connector. The level of this signal should be -8dBm. To use this input, the last switch in the frequency offset group must be set to the EXT (up) position.

   If the modulator is packaged in a cabinet with a transmitter, go to step #10. Otherwise, continue with step #8.

8. If the transmitter is going to use a direct IF input, then connect the VISUAL IF OUT and AURAL IF OUT of the modulator to the visual and aural IF IN of the transmitter. Refer to the transmitter manual for correct interconnections.

9. For RF operation, the short coaxial jumpers supplied with the modulator must be connected as follows: Connect the VISUAL IF OUT to the VISUAL IF IN, and connect the AURAL IF OUT to the AURAL IF IN. Once the jumpers are installed, the output channel must be selected using the procedure below. (If unsure of the channel, refer to Table 1-1.)

   a. The output channel is chosen with the CHANNEL selector located on the right of the front panel. The tabs above and below the CHANNEL display must be opened to operate the selector. This is done by gently lifting them away from the front panel.

      The tabs below the display increase the digit directly above by one for each time they are pressed. The tabs above the display decrease their respective digit by one. Each display digit ranges from 0 to 9, allowing any combination from 00 to 99 to be selected.

   b. Set the first digit to the desired value. For channels lower than 10, this will be zero. Set the second digit to the correct value. The display indicates the channel currently selected.

   c. Once the selection is completed, fold the tabs back down. This locks the CHANNEL selector and prevents an unintentional change.

   d. To verify channel frequency and selection, refer to Table 1-1, EM1 OUTPUT CHANNEL/FREQUENCY.

      The modulator is now installed and ready for use. Proceed to section 1.4.

10. Verify that all cabling is correctly connected.

11. If the modulator is providing an RF output, check the channel indicator for correct output channel. If the channel is incorrect, see above step 9.

1.4 Operation:

Once the EM1 is installed in the rack with cabling and channel selection completed, make the following signal level adjustments.

1.4a RF Output Level:

1. Visual Carrier - Disconnect the video source from the Video In connector on the rear of the EM1. Connect a suitable level meter (Field Strength Meter or Spectrum Analyzer) to the RF TEST connector on the EM1 front panel. (Remember the signal at this point is 20dB less than the actual output.) Tune the meter to the visual carrier frequency.

2. Set the RF output to the desired level by adjusting the RF LEVEL VISUAL CARRIER control on the front panel. This control simultaneously adjusts both the visual and aural carriers. The aural carrier is factory set at 15dB below the visual carrier. If this ratio is incorrect or a different ratio is required, proceed to step 3.

3. Aural Carrier - Adjust the RF LEVEL AURAL CARRIER control on the front panel to set the aural carrier 16dB below the visual carrier, or to the desired ratio.

1.4b Video Modulation:

1. Connect a known video source to the Video In connector on the rear of the EM1. A standard signal of 1.0V p-p, such as stairstep or color bars is preferred. The unit is factory adjusted for this input and should not require adjustment.

2. Check the WHITE CLIP indicator on the front panel. If it is lit, reduce the video level by adjusting the VIDEO MOD control on the front panel until the indicator is extinguished. When operating with a video signal which is not static, such as the video from a camera or VCR, an occasional flash of the WHITE CLIP indicator is acceptable.

   (An alternative method of checking the video level is to observe it on a TV set, tuned to the operating channel. If the picture appears to be too low, increase the video level by adjusting the VIDEO MOD control on the front panel. The WHITE CLIP indicator should not be lit after the adjustment.)

1.4c Audio Deviation:

1. Connect a known audio source to the Audio In connector on the rear of the EM1. A standard signal at 0dBm, such as a 1kHz tone from an audio generator is preferred. The unit is factory adjusted for this input and should not require adjustment.

2. Check the OVER DEV indicator on the front panel. The indicator should not be lit. If it is, reduce the audio level by adjusting the AUDIO DEV control on the front panel until the indicator is extinguished.

In operation, the OVER DEV indicator should flash only very briefly during the loudest portions of speech or music. If the indicator flashes frequently, additional reduction in audio level must be made.

(An alternative method of checking the audio level is to listen to the sound from a TV set, tuned to the operating channel. If the sound level appears to be low compared to other TV channels, increase the audio level by adjusting the AUDIO DEV control on the front panel. The OVER DEV indicator should not be lit after the adjustment.)

1.4d 4.5MHz Modulated FM Carrier:

1. There are no modulator adjustments for operation with a 4.5MHz modulated carrier.
2. When operating with a 4.5MHz modulated carrier, the modulation depth is controlled by the unit originating the carrier. The AUDIO DEV control and OVER DEV indicator do not function in this mode of operation.
3. If sound modulation bars appear in the picture, this is an indication the level of the 4.5MHz carrier is too high and should be reduced. This is accomplished by reducing the level at the originating equipment. If this equipment is not accessible, the signal can be attenuated by using a fixed attenuator at the input of the EM1.

1.4e Theory of Operation:

All modulator functions are consolidated on three printed circuit boards in the EM1. The IF section generates the visual and aural IF carriers and modulates them with processed video and audio or 4.5MHz modulated aural carrier signals. The Converter section converts the IF signals to the final RF frequency, and the RF Amplifier section amplifies the signal to the final output level.

Within the IF section, the video signal is amplified and clamped. It enters the white clip circuit which provides signal limiting and indication of overmodulation. The signal then modulates a stable 45.75MHz IF frequency. After modulation, the signal is amplified and passes through a SAW filter. The audio signal is first pre-emphasized and then frequency modulates a 4.5MHz oscillator. A buffer amplifier with a preset comparator provides indication of over deviation of the audio. When the unit is operated with an external 4.5MHz subcarrier, the audio processing and modulation sections are bypassed and the external signal is substituted. The 4.5MHz modulated subcarrier and the 45.75MHz visual carrier create the 41.25MHz modulated aural IF carrier.

The IF carriers separately loop through the rear panel of the unit and are then combined into a composite IF which is sent to the Converter section. The PLL Converter section is controlled through the front panel channel selector and the rear panel frequency offset switches. The composite IF is then converted to the selected RF output frequency.

The output of the Converter section is passed to an RF amplifier which provides the necessary gain for the final output signal.

1.4f Indicators and Controls:

This list gives the title and a brief description of the controls, indicators and connections located on the front and rear panels.

Front Panel

POWER:	This indicator illuminates yellow when the modulator is receiving ac power.
WHITE CLIP:	This red LED will light if the video modulation level exceeds 95%.
VIDEO MOD:	The control labeled VIDEO MOD adjusts the amount of modulation of the visual carrier.
OVER DEV:	When this indicator is illuminated red, it means that the aural carrier is overmodulated. This corresponds to an audio deviation in excess of 25kHz.
AUDIO DEV:	The AUDIO DEV control adjusts the audio modulation to achieve the correct deviation.
RF LEVEL - AURAL CARRIER:	This control changes the amplitude of the aural carrier with respect to the visual RF carrier.
RF LEVEL - VISUAL CARRIER:	This adjustment alters the level of both the visual and aural carriers simultaneously.
CHANNEL:	The CHANNEL selector/indicator controls the selection of the output RF channel and also provides a readout of the currently selected channel.
RF TEST:	The F type connector labeled RF TEST provides a sample of the output RF channel that is 20dB below the actual output.

Rear Panel

RF OUTPUT:	The composite, modulated RF signal is accessed at this 75 ohm F connector.
AURAL IF - IN:	This port is driven by the IF signal returned from the AURAL IF - OUT.
AURAL IF - OUT:	The IF signal from this port can be used to drive a transmitter, or can be looped back into the AURAL IF - IN port. With either configuration the IF signal can be passed through any IF scrambler.

VISUAL IF - IN:	The VISUAL IF signal is returned to this port from the VISUAL IF - OUT.
VISUAL IF - OUT:	Like the AURAL IF - OUT, this output can be used as the input to a transmitter or be looped into the VISUAL IF - IN. This signal can also be scrambled.
FREQUENCY OFFSET:	The FREQUENCY OFFSET switch group allows for a choice between five different offset options: No offset, +12.5kHz, -12.5kHz, +25kHz, and -25kHz. The last switch in this group selects either an Audio Input (INT.) or a 4.5MHz AURAL CARRIER (EXT.).
AUDIO IN:	A 600 ohm RCA jack is provided to accept the monaural baseband audio signal. For this input the last switch of the FREQUENCY OFFSET group must be set to INT.
AURAL 4.5MHz IN:	This option is provided to allow for the input of an externally modulated MONO or BTSC audio subcarrier. To use this option, connect the 4.5MHz externally modulated signal to the F connector and set the last switch in the FREQUENCY OFFSET group to EXT.
VIDEO INPUT:	This 75 ohm F connector accepts the baseband video signal that is to be modulated.
FUSE 250V 1A:	This fuse provides protection against overloads to the circuitry of the modulator.
117AC:	This ac line cord supplies the ac power to the modulator. The three-pronged plug is intended to be used with a properly grounded outlet.

1.5 Warranty and Parts Ordering:

Warranty - EMCEE warrants its equipment to be free from defects in material and workmanship for a period of one year after delivery to the customer. Equipment or components returned as defective (prepaid) will be, at our option, repaired or replaced at no charge as long as the equipment or component part in question has not been improperly used or damaged by external causes (e.g., water or lightning). Semiconductors are excepted from this warranty and shall be warranted for a period of not more than ninety (90) days from date of shipment. Equipment or component parts sold or used by EMCEE, but manufactured by others, shall carry the same warranty as extended to EMCEE by the original manufacturer.

Equipment Returns - If the customer desires to return a unit, drawer, or module to EMCEE for repair, follow the procedure described below:

1. Contact EMCEE Customer Service Department by phone or fax for a Return Authorization Number.

2. Provide Customer Service with the following information:

   Equipment model and serial numbers.
   Date of purchase.
   Unit input and output frequencies.
   Part number (PN) and Schematic Diagram designator if a module is being sent.
   Detailed information concerning the nature of the malfunction.

The customer shall designate the mode of shipping desired (e.g., Air Freight, UPS, Fed Ex, etc.). EMCEE will not be responsible for damage to the material while in transit. Therefore, it is of utmost importance that the customer insure the returned item is properly packed.

Parts Ordering - If the customer desires to purchase parts or modules, utilize the following procedure:

1. Contact EMCEE Customer Service by phone or fax indicating the customer's purchase order number. If the purchase order number is provided by phone, written confirmation of the order is required.

2. Also provide:

   The equipment model and serial number.
   The unit input and output frequencies.
   The quantity, description, vendor, number, and designation of the parts needed as found in the Parts Lists subsection of this manual.
   If a module is required, give the part number (PN) and Schematic Diagram designator (e.g., 30368014).
   Designate the mode of shipping desired (e.g., Air Freight, UPS, Fed Ex, etc.).
   Shipping and billing addresses.

For EMERGENCY technical assistance, EMCEE offers a toll free, 24-hour, 7-day-a-week customer service hot line: 1-800-233-6193.

EM1 OUTPUT CHANNEL/FREQUENCY

TV CH	CHANNEL DISPLAY	VISUAL FREQUENCY (MHz)	AURAL FREQUENCY (MHz)	TV CH	CHANNEL DISPLAY	VISUAL FREQUENCY (MHz)	AURAL FREQUENCY (MHz)
2	02	55.250	59.750	7	07	175.250	179.750
3	03	61.250	65.750	8	08	181.250	185.750
4	04	67.250	71.750	9	09	187.250	191.750
5A	01	73.250	77.750	10	10	193.250	197.750
5	05	77.250	81.750	11	11	199.250	203.750
6	06	83.250	87.750	12	12	205.250	209.750
				13	13	211.250	215.750
A-5	95	91.250	95.750				
A-4	96	97.250	101.750	J	23	217.250	221.750
A-3	97	103.250	107.750	K	24	223.250	227.750
A-2	98 **	109.250	113.750	L	25 *	229.250	233.750
A-1	99 **	115.250	119.750	M	26 *	235.250	239.750
				N	27 *	241.250	245.750
A	14 *	121.250	125.750	O	28 *	247.250	251.750
B	15 *	127.250	131.750	P	29 *	253.250	257.750
C	16 *	133.250	137.750	Q	30 *	259.250	263.750
D	17	139.250	143.750	R	31 *	265.250	269.750
E	18	145.250	149.750	S	32 *	271.250	275.750
F	19	151.250	155.750	T	33 *	277.250	281.750
G	20	157.250	161.750	U	34 *	283.250	287.750
H	21	163.250	167.750	V	35 *	289.250	293.750
I	22	169.250	173.750	W	36 *	295.250	299.750

* FCC mandated ±12.5kHz offset required, where applicable.
** FCC mandated ±25.0kHz offset required, where applicable.

TABLE 1–1

EM1 OUTPUT CHANNEL/FREQUENCY

TV CH	CHANNEL DISPLAY	VISUAL FREQUENCY (MHz)	AURAL FREQUENCY (MHz)	TV CH	CHANNEL DISPLAY	VISUAL FREQUENCY (MHz)	AURAL FREQUENCY (MHz)
AA	37 *	301.250	305.750	WW	59	433.250	437.750
BB	38 *	307.250	311.750	XX	60	439.250	443.750
CC	39 *	313.250	317.750	YY	61	445.250	449.750
DD	40 *	319.250	323.750				
EE	41 *	325.250	329.750	---	00/62-94	451.250	455.750
FF	42 **	331.250	335.750				
GG	43 *	337.250	341.750				
HH	44 *	343.250	347.750				
II	45 *	349.250	353.750				
JJ	46 *	355.250	359.750				
KK	47 *	361.250	365.750				
LL	48 *	367.250	371.750				
MM	49 *	373.250	377.750				
NN	50 *	379.250	383.750				
OO	51 *	385.250	389.750				
PP	52 *	391.250	395.750				
QQ	53 *	397.250	401.750				
RR	54	403.250	407.750				
SS	55	409.250	413.750				
TT	56	415.250	419.750				
UU	57	421.250	425.750				
VV	58	427.250	431.750				

* FCC mandated ±12.5kHz offset required, where applicable.
** FCC mandated ±25.0kHz offset required, where applicable.

TABLE 1–1

SECTION II

MAINTENANCE AND TROUBLESHOOTING

2.1 Maintenance:

The EM1 requires very little maintenance. Once it is set up and adjusted correctly, it should require no further attention aside from an occasional visual inspection of the cables. The cables should be checked to be sure that all connections are tightly secured, there are no cuts or tears in the cable covering, and there is no tension in the cables that could cause them to break or damage the connectors on the modulator. The EM1 and its cables should also be periodically cleaned and dusted.

2.2 EM1 Troubleshooting Chart:

PROBLEM	CAUSE	SOLUTION
Power Indicator does not light.	AC power cord is not plugged in.	Plug power cord into a properly grounded, 117Vac outlet.
	Fuse is blown or improperly inserted.	Check fuse and make sure it is properly inserted. If fuse is blown, replace with a 250V 1A fuse (an SOC MQ4 or other compatible fuse).
	Circuit breaker of ac supply is tripped.	Identify and correct problem before resetting the circuit breaker.
No RF output	Cable not connected or improperly connected.	Check cable connection to RF output port. Make sure that the center conductor of the coaxial cable is properly inserted into the F connector.
Poor Video contrast	Modulation depth not set correctly.	Adjust the VIDEO MOD for best contrast. (See Section 1.4b.)
Poor Audio quality	Deviation level is incorrect.	Adjust the AUDIO DEV control for correct deviation level. (See Section 1.4c.) [If using a 4.5MHz AURAL Input, Audio deviation adjustments must be made at the remote modulator.]
Adjacent Channel has beat	Aural carrier level is too high.	Using the RF LEVEL - AURAL CARRIER control, adjust the level of the carrier until the beat interference disappears.

If the above chart has not identified the problem, or an internal fault is suspected, contact an EMCEE service representative.

TABLE 2–1

emcee Broadcast Products
P.O. Box 68, White Haven, PA 18661 Phone: (570) 443-9575 FAX: (570) 443-9257

TTV500ES

SOLID STATE
500W VHF TRANSMITTER

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IMPORTANT

Transient Overvoltage Protection

Transient overvoltage conditions are a continuous threat to all solid-state circuitry. The resulting costs of both equipment repairs and system downtime make preventative protection the best insurance against these sudden surges. Types of protection range from isolation transformers and uninterruptible power supplies to the more cost effective AC power line protectors. As transient culprits are most often lightning induction and switching surges, AC power line protectors are the most practical solution. An effective AC power line protector is one capable of dissipating impulse energy at a low enough voltage to ensure the safety of the electronic components it is protecting. The protection unit should be across the AC line at all times even during periods of total blackout. It should also reset immediately and automatically to be 100% ready for repeated transients.

CAUTION

Transmitter Cooling

The top covers found on most drawers of this transmitter are an integral part of the amplifier cooling within each drawer. Do not operate this transmitter for an extended period without all the drawer covers properly installed.

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SECTION I

THE TTV500ES TRANSMITTER

SECTION I

THE TTV500ES TRANSMITTER

1.1 Introduction:

The EMCEE TTV500ES Transmitter is rated to provide 500 watts of peak visual and 50 watts of average aural power on any FCC or CCIR specified channel extending from 54MHz to 230MHz. The TTV500ES is completely solid-state providing maximum performance and reliability. Comprised of a Modulator, a 2 Watt VHF Exciter, a Visual IPA/Aural Final Amplifier drawer, a Visual Final Amplifier drawer, a Power Supply/Control Status drawer, a Visual/Aural Diplexer/-3.58MHz Notch Filter assembly, and a panel for power metering, the TTV500ES is easy to service and maintain with practically nonexistent RF alignment. A number of front panel visual indicators are provided to aid the operator during turn-on, operation and maintenance of the transmitter.

1.2 Specifications:

Output Power	500W peak visual 50W average aural
Emissions	5M75C3F visual 250KF3E aural
Color Transmission	NTSC, PAL, or SECAM
Output Frequency Range	54-230MHz (FCC – Ch.2-13) (CCIR – Ch.E3-E12)
Frequency Stability	Visual Carrier ±1kHz Aural Carrier +4.5MHz ± 100Hz (relative to visual)
Visual Output Power Stability	±0.5dB
Spurious Products	60dB below peak sync
Harmonics	60dB below peak sync
Intermodulation Products (IM_3)	60dB below peak sync
Differential Gain	5%
Differential Phase	5°
Low Frequency Linearity	5%
Visual Frequency Response	Better than FCC 73.687(a)(1)
Envelope Delay	Better than FCC 73.687(a)(3)

Output Impedance	50 ohms / 7/8" EIA flange
Video Input Level	1 volt peak-to-peak nominal
Video Input Impedance	75 ohms unbalanced/SO239 UHF
Video Signal to Noise	-55dB
Audio Input Level	0dBm nominal
Audio Input Impedance	600 ohms balanced/3-pin Cannon
Audio Distortion	<1%
Aural FM Noise	<-60dB
Ambient Temperature	0°C to +50°C
Power Requirements	230Vac ± 15% @ 50/60Hz, 4.0kW
Mechanical Dimensions	36"H x 23"W x 29"D
Weight	400 lb.

1.3 Installation:

Except where otherwise noted, the connectors mentioned in the following instructions are located on the rear of the transmitter.

1. After unpacking the transmitter, a thorough inspection should be conducted to reveal any damage which may have occurred during shipment. If damage is found, immediately notify the shipping agency and advise EMCEE Broadcast Products Customer Service or its field representative. Also check to see that any connectors, cables or miscellaneous equipment, which may have been ordered separately, are included.

2. Place the transmitter in a clean, weatherproof environment providing adequate ventilation for the exhaust fans at the rear of the transmitter. It is important to maintain the transmitter's ambient temperature within the 0°C and +50°C limits. Cooler ambient temperatures will provide increased reliability. Also insure that the rear of the transmitter is far enough from any obstruction so that the transmission line to the antenna can be easily connected to the transmitter's 7/8" RF OUT connector. This is located in the upper left corner of the cabinet's rear opening. The transmitter's permanent location should be near a single-phase receptacle that supplies 220Vac at 50/60Hz with a minimum power capacity of 5.0kW.

> IMPORTANT
>
> Do not apply ac power to the transmitter at this time since its RF output must be properly loaded before being placed in operation.

3. Set all circuit breakers and switches, including the local incoming AC line breaker, to the OFF position. Place an appropriate ac power line protector (surge suppressor) across the ac line that supplies the transmitter.

4. Connect the video and audio cables (customer supplied) to the transmitter's VIDEO IN and AUDIO IN connectors located on the upper rear panel of the transmitter cabinet.

5. Using a 7/8" EIA flange connector, connect the transmitting antenna cable to the transmitter's RF OUT connector located in the upper left corner of the cabinet's rear opening.

6. Verify that the power cords of the Modulator and the Exciter drawer are plugged into the receptacle at the bottom of the transmitter cabinet. Also check the rear of each drawer to insure that all RF cables and AC or DC wire harness plugs are secure.

7. Connect the female end of the three-wire, twist-lock power cord into the rear AC connector of the Power Supply/Control Status drawer. Connect the other end into an appropriate 208/220Vac electrical outlet.

1.4 Operation:

Assuming the installation instructions of Section 1.3 have been completed and the transmitter is receiving baseband video and audio signals, proceed with the following steps to place the transmitter in operation. Except where otherwise noted, the controls, switches, and indicators mentioned in these steps are located on the front of the transmitter.

1. Turn the Exciter's VISUAL and AURAL POWER ADJUST controls fully counterclockwise and place its OPERATE/ALIGN switch to OPERATE, its OUTPUT AGC switch to OFF, and its meter switch to VISUAL. Place the Power Supply drawer OPERATE/STANDBY switch to STANDBY. Place both the Power Supply and Exciter AC POWER circuit breakers to the on/up position. Then verify the following responses of the transmitter.

    a. All the external fans of the transmitter should be operating. The Exciter, Visual IPA/ Aural Final and 500W VHF Amplifier fans all exhaust air out the rear while drawing air through the front panel. (The Power Supply drawer contains internal fans which cannot be visually checked without opening the drawer. These fans are not activated at this time and do not need to be checked during transmitter turn-on.)

    b. The Exciter's front panel OPERATE indicator should be illuminated yellow, its SYNTH LOCK indicator should be illuminated green, and its CARRIER PRESENT and FINAL RF indicator should be extinguished.

    c. The Power Supply front panel VISUAL DRIVER, AMPL 3, AMPL 4 and AURAL DRIVER LED indicators should be green. All other indicators on this drawer will be extinguished.

    d. The Power Supply front panel voltmeter will read 5V with the +5VDC button depressed.

2. Place the modulator's power switch to ON and verify that it is providing 87.5% video modulation. If necessary, vary the VIDEO MODULATION adjustment for the correct indication as described in the modulator instruction manual. Also check for correct audio modulation and adjust the modulator accordingly. The Exciter's CARRIER PRESENT indicator should now be green.

3. Place the Power Supply OPERATE/STANDBY switch to OPERATE and verify the following transmitter responses.

   a. The Exciter OPERATE, CARRIER PRESENT and SYNTH LOCK indicators should remain illuminated while the FINAL RF indicator turns green.

   b. The Power Supply VISUAL BIAS and AURAL BIAS lights should now be illuminated green in conjunction with the EXCITER ON light.

   c. The Power Supply front panel voltmeter will show a 28V or 48V reading with the +28VDC or +48VDC button pushed in.

NOTE: There is a time delay of approximately 10 seconds before the 2 Watt Exciter supplies RF drive to the transmitter.

4. Place the Meter Panel VISUAL meter switch to FWD and turn the Exciter's VISUAL POWER ADJUST control clockwise until a 100% indication appears on the Meter Panel's VISUAL % POWER meter.

5. Wait for 15 to 30 minutes and then place the Exciter's OUTPUT AGC switch to ON and verify that the VISUAL % POWER meter still reads 100%. If necessary, slowly vary the Exciter's OUTPUT AGC ADJUST for a 100% indication. Be careful not to overadjust the AGC as this circuit is very slow.

6. Place the Meter Panel AURAL meter switch to FWD and adjust the Exciter AURAL POWER ADJUST for a 100% indication on the Meter Panel AURAL % POWER meter. As the transmitter warms up, readjustment of the aural power may be necessary.

7. Place the Meter Panel VISUAL and AURAL meter switches to REFLD and verify that each % POWER meter indicates no more than 10% returned power. If the reflected power is more than 10%, shut down the transmitter and check the VSWR of the transmitting antenna and its associated cable. Also insure that no shipping damage has occurred to the Visual/Aural Diplexer at the top of the cabinet.

8. Place the Meter Panel VISUAL and AURAL meter switches to FWD for constant monitoring of the transmitter's visual and aural output power.

The transmitter is now in operation providing 500 watts of peak visual and 50 watts (-10dB) of average aural power to the antenna transmission line. If the operator wishes to transmit a -13dB (5%) visual/aural ratio, turn the AURAL POWER ADJUST so that the AURAL % POWER meter reads 50%.

Check the transmitter's coverage area for clean, sharp television reception. If the reception or picture quality is unsatisfactory, examine the amount of power delivered to the transmitting antenna (see Section 3.5) and, if necessary, examine the antenna orientation, antenna VSWR and transmission line VSWR to insure maximum radiation in the proper direction.

1.5 Warranty and Parts Ordering:

Warranty – EMCEE warrants its equipment to be free from defects in material and workmanship for a period of one year after delivery to the customer. Equipment or components returned as defective (prepaid) will be, at our option, repaired or replaced at no charge as long as the equipment or component part in question has not been improperly used or damaged by external causes (e.g., water or lightning). Semiconductors are excepted from this warranty and shall be warranted for a period of not more than ninety (90) days from date of shipment. Equipment or component parts sold or used by EMCEE, but manufactured by others, shall carry the same warranty as extended to EMCEE by the original manufacturer.

Equipment Returns – If the customer desires to return a unit, drawer, or module to EMCEE for repair, follow the procedure described below:

1. Contact EMCEE Customer Service Department by phone or fax for a Return Authorization Number.

2. Provide Customer Service with the following information:

   Equipment model and serial numbers.
   Date of purchase.
   Unit input and output frequencies.
   Part number (PN) and Schematic Diagram designator if a module is being sent.
   Detailed information concerning the nature of the malfunction.

The customer shall designate the mode of shipping desired (e.g., Air Freight, UPS, Fed Ex, etc.). EMCEE will not be responsible for damage to the material while in transit. Therefore, it is of utmost importance that the customer insure the returned item is properly packed.

Parts Ordering – If the customer desires to purchase parts or modules, utilize the following procedure:

1. Contact EMCEE Customer Service by phone or fax indicating the customer's purchase order number. If the purchase order number is provided by phone, written confirmation of the order is required.

2. Also provide:

   The equipment model and serial number.
   The unit input and output frequencies.
   The quantity, description, vendor, number and designation of the parts needed as found in the Parts Lists subsection of this manual.
   If a module is required, give the part number (PN) and Schematic Diagram designator (e.g., 10331255).
   Designate the mode of shipping desired (e.g., Air Freight, UPS, Fed Ex, etc.).
   Shipping and billing addresses.

Spare and Replacement Modules and Components – The Spare Modules and Components section of this manual provides a listing of the modules and some discrete components contained within the transmitter. This list contains those modules or components considered to be essential bench-stock items and should be available to the maintenance technician at all times. The Schematic or Interconnection Diagram is the governing document of this manual. Should there be a discrepancy between a modules or components list and a diagram, the diagram takes precedence. Such a discrepancy is possible since manufacturing changes cannot always be incorporated immediately into the instruction manual.

Component Referencing – The transmitter consists of a modulator as well as a number of modules and components mounted in a drawer. Components mounted in a module take the drawer number and the module number in addition to a component number. Thus the reference designator A2A1Q1 means transistor Q1 in module A1 of drawer A2. Components mounted in a drawer take only the drawer number and a component number (e.g., A2M1 designates meter M1 of drawer A2). Components mounted directly to the cabinet take only a component number.

For EMERGENCY technical assistance, EMCEE offers a toll free, 24-hour, 7-day-a-week customer service hot line: 1-800-233-6193.

SECTION II

CIRCUIT DESCRIPTION

SECTION II

CIRCUIT DESCRIPTION

2.1 Modulator:

Catel ATM-1600 ⋆ A1
EMCEE EM1 ⋆ A1

VISUAL IF OUT	-8dBm peak visual
AURAL IF OUT	-8dBm average aural

The modulator processes baseband video and audio information to provide an IF output consisting of a visual IF carrier at 45.75MHz with 5M75C3F visual modulation as well as an aural IF carrier at 41.25MHz with 250KF3E aural modulation. For CCIR B/G operation the visual carrier frequency will be 38.9MHz with the aural carrier at 33.4MHz. The modulator's video sense circuit indicates whether the modulator is receiving baseband video (i.e., logic high = video present/logic low = video loss). This voltage is used by the Power Supply/Control Status drawer (A9) to place the transmitter in an on-the-air condition with the presence of video.

2.2 Exciter Drawer:

Interconnection Diagram 40362004/Rev J ⋆ A2

VISUAL IF IN (J1)	-8dBm peak visual
AURAL IF IN (J2)	-8dBm average aural
VISUAL RF OUT (J3)	≈+27dBm peak visual
AURAL RF OUT (J4)	≈+24dBm average aural

The Exciter drawer separately upconverts the modulator's visual and aural IF carriers to the selected VHF channel providing approximately 0.5 watts of peak visual and 250mW of average aural power at the output. Visual IF signal processing and upconversion are accomplished by a Linearizer (A2), an IF AGC Amplifier (A1), a Power Adjust (AT1) and an LO Splitter/Amplifier (A6), in conjunction with a local oscillator chain consisting of a Reference Oscillator (A4A2), and a VHF Synthesizer (A4A1). Aural IF processing and upconversion are provided by a Power Adjust (AT2) and the LO Splitter/Amplifier (A6) in conjunction with the local oscillator chain. Selection of the visual and aural VHF carriers is performed by separate VHF Bandpass Filters (FL1/FL2). The carriers are then individually amplified by parallel 2 Watt VHF Amplifiers (A3/A7). Two Directional Couplers (DC1, DC2) provide samples of the visual and aural VHF carriers to the power detection/metering circuitry which consists of Metering Detector A8, meter switch S3, and % POWER meter M1. Automatic gain control and diagnostic circuitry includes a Limiter/Output AGC board (PC1), the OPERATE/ALIGN switch (S1), an OUTPUT AGC switch (S2), an OUTPUT AGC ADJUST control (R3), an OPERATE indicator (DS1), a CARRIER PRESENT indicator (DS2), a SYNTHESIZER LOCK indicator (DS4) and a FINAL RF indicator (DS3). Power Supply circuitry includes a +28V Power Supply (PS1), a ±15V/+5V Power Supply (PS2), a contactor (K1), an AC POWER circuit breaker (CB1) and a rear panel circuit breaker (CB2) for the +28V Power Supply.

2.2a Linearizer:

Schematic Diagram 30367078/Rev 60 ★ A2A2

Gain w/S1 OFF (J1-J2)	3dB min./6dB max.
Gain w/S1 ON (J1-J2)	6dB min./12dB max.
Emitter of Q1/Q2	+4.8Vdc @ 13mAdc/+13Vdc @ 30mAdc
Emitter of Q3/Q4	+3.3Vdc @ 11mAdc/+15Vdc @ 45mAdc
Emitter of Q5	+8.7Vdc @ 22mAdc

The Linearizer is a five-stage circuit which compensates for linearity distortions generated by the transmitter's Class AB visual amplifiers. Transistors Q1 through Q5 are all amplifier stages with the Q1/Q2 combination providing approximately 20dB of gain. 8dB of gain is provided by transistors Q3/Q4. Q2, Q4, and Q5 are used as low impedance emitter followers. Variable gain expansion networks which provide linearity correction are centered around diodes CR1 through CR8, slope potentiometers SL1 through SL4 (i.e., R10, R11, R21, R22), unity gain inverting amplifiers U1 and U2, threshold potentiometers TH1 through TH4 (i.e., R37, R38, R39, R40), and switch S1. When S1 is in the OFF position, each diode pair is continuously reverse biased throughout the positive and negative cycles of the visual IF carrier. Due to the high reverse resistance provided by CR1 through CR8, each network essentially represents a resistive L-pad with the visual IF carrier attenuated by a fixed amount. As a result, no linearity correction is provided. However, when S1 is in the ON position and the Linearizer is properly adjusted, the four diode pairs form a nonlinear circuit where each diode pair is biased to turn on at different points of the positive and negative cycles of the visual IF carrier envelope. Each diode pair is initially reverse biased by equal but opposite polarity dc voltages established by U1 and U2. L1 through L8, shunted by R29 through R36, isolate the visual IF carrier from the diode biasing circuitry. When the positive and negative peaks of the visual IF carrier are sufficient to forward bias a diode pair, the diode pair turns on placing the resistance of its respective slope potentiometer either in parallel or in shunt to ground with its respective series arm resistance. As a result of switching additional resistance in parallel or shunt with the series arm of the L-pad, the attenuation of the visual IF carrier is reduced. Threshold potentiometers TH1 through TH4 determine the turn-on point of each diode pair while slope potentiometers SL1 through SL4 vary the amount of gain expansion achieved during the turn-on period of each diode pair. Threshold controls TH1, TH2, and TH3 are used to adjust the differential gain of the white to black region while TH4 adjusts the sync amplitude (see Figure 3–6). When properly adjusted, the Linearizer provides sync amplitude and differential gain correction to the visual IF carrier.

2.2b IF AGC Amplifier:

Schematic Diagram C331-37/Rev G ★ A2A1

IF IN (J1)	OdBm peak visual
IF OUT (J2)	≈OdBm peak visual
Gain (J1-J2)	40 to OdB
Collector of Q1	+23Vdc @ 5mAdc
Collector of Q2	+28Vdc @ 30mAdc
Collector of Q3	+26.2Vdc @ 67mAdc

The IF AGC Amplifier provides amplification and automatic gain control for the visual IF carrier so that the transmitter's visual output power is held at its rated value. The circuitry of this module consists of three sections:

(1) IF Amplifier Section
(2) AGC Section
(3) IF Limiter Section

The IF amplifier section consists of three cascaded RF transistor amplifier stages Q1, Q2 and Q3 with the second and third stages separated by a 9dB matching pad formed by R22, R23 and R24. The module gain is adjustable by varying the amount of emitter bypass for Q1 via GAIN ADJ potentiometer R15. Q3's collector feedback network, consisting of C12, L2 and TILT ADJ potentiometer R31, compensates for the module's overall frequency characteristics (lower gain at higher frequencies). R31 controls the module's frequency response by varying the amount of Q3 negative feedback.

The AGC section, in conjunction with the transmitter's Metering Detector (A2A9) and the Limiter/ Output AGC circuit (A2PC1), automatically compensates for visual gain variations up to and including the IF AGC Amplifier (input AGC) as well as after the IF AGC Amplifier (output AGC). The AGC section consists of five stages. The first stage is an IF level detector consisting of diode CR8, capacitors C13, C14, C18, tapped coil L3 and resistor R29. C18 couples a portion of the visual IF carrier while L3 and C14 form an adjustable tank circuit which is tuned to the visual IF carrier. Detection of the sampled visual carrier is accomplished by CR8 along with R29 and C13 which form a time constant of 1.27 milliseconds. The detector produces a negative dc voltage proportional to the peak value of the visual IF carrier. The second stage is a buffer amplifier consisting of U1B, R27 and R28. This stage buffers the detected IF level while providing a voltage gain of 1.2V/V. The negative dc voltage from this buffer amplifier is used by the third stage, integrator R7, R9 and C29, as well as the Limiter/Output AGC's limiter circuit. The integrator stage removes any remaining high frequency components from the AGC voltage. The fourth stage is an AGC comparator centered around U1A. The two signals compared at pins 2 and 3 of U1A are the input AGC voltage from the integrator stage and the output AGC voltage from the Limiter/ Output AGC board. The AGC comparator produces a positive dc control voltage which is applied to the fifth stage, a variable attenuator centered around pin diodes CR1, CR2 and CR4. This circuit automatically controls the attenuation of the visual IF carrier so that the transmitter's visual output power is held to its rated value. The amount of attenuation is determined by the magnitude of the positive dc control voltage applied to the cathode of CR4 from the AGC comparator. This voltage varies directly with changes in the visual IF level as well as changes in the transmitter's visual output power. For example, if the visual gain increases, the output power will increase above its rated value. This condition results in an increase in voltage applied to the cathode of pin diode CR4 which causes a decrease in current through CR2 and an increase of current drawn by CR1 and CR4. Consequently, the attenuation to the visual IF carrier is increased thereby maintaining the transmitter's visual output power.

The purpose of the IF limiter section, composed of PIN diode CR9 and transistor Q4, is to prevent the transmitter's visual amplifiers from being overdriven due to the Exciter's AGC circuits not being able to respond quickly enough to control the incoming IF signal. This condition can occur when the visual input to the IF AGC Amplifier is temporarily lost or attenuated, and then reappears after the gain of the amplifier increases substantially due to undeveloped AGC voltage. As the output of the amplifier attempts to exceed +3dBm, the limiter circuit on the Limiter/Output AGC board provides a negative voltage at J3-4, reverse biasing transistor Q4 and PIN diode CR9. As a result, the visual IF carrier is attenuated by approximately 20dB until the level detector (CR8) provides enough AGC voltage to control the module's output at 0dBm.

A second overdrive situation is possible during turn-on when AC is first applied to the Exciter drawer. During this period of stabilizing AGC and power supply voltages, the timer circuit, designed around transistors Q5 and Q6, is activated. As 15Vdc appears at the junctions of diodes CR10 and CR11, transistors Q5 and Q6 conduct, placing a low on the base of Q4. With Q4 and PIN diode CR9 reverse biased, the signal from the IF AGC Amplifier is again attenuated by 20dB. Over the next ten seconds, capacitor C2 will charge through R40, increasing the voltage on the base of Q6. Eventually transistors Q6 and Q5 will be shut off, forward biasing Q4 and CR9 and returning the IF visual signal to its proper 0dBm level.

NOTE: When the transmitter is to be aligned, the front panel OUTPUT AGC switch (S2) is placed to OFF and the OPERATE/ALIGN switch (S1) is placed to ALIGN. As a result, the OPERATE indicator (DS1) is extinguished and the IF AGC Amplifier's primary AGC voltage is replaced by +5Vdc from the ±15V/+5V Power Supply (PS2). This +5Vdc level facilitates the alignment process by replacing the lost primary AGC voltage that disappears during a loss of the visual IF carrier. In this way, the IF AGC Amplifier's variable attenuator is kept in operation during alignment of the transmitter.

2.2c Power Adjust:

Schematic Diagram 10331255/Rev A ⋆ A2AT1/A2AT2

Range of Attenuation (J1-J2)	20dB
Minimum Attenuation (J1-J2)	3dB

The Power Adjust is a variable attenuator used to set the transmitter's visual and aural output power by providing manual control of the visual and aural IF carriers. This module is made up of POWER ADJUST potentiometer R5, transistor Q1, and pin diodes CR1, CR2 and CR3. The amount of attenuation is determined by the setting of R5 which controls the bias of Q1. As the bias of Q1 increases, its emitter voltage increases which causes a decrease in current through CR2 and an increase of current drawn by CR1 and CR3. Consequently, the attenuation to the visual or aural IF carrier is increased. However, as the bias of Q1 decreases, the current through CR2 increases while the current through CR1 and CR3 decreases, providing less attenuation to the IF carrier.

2.2d LO Splitter/Amplifier:

Schematic Diagram 30362024/Rev 53 ⋆ A2A6

Visual Conversion (J4-J1)	-8dB
Aural Conversion (J6-J3)	+6dB
LO Input (J2)	+13dBm min.
LO Sample (J5)	0dBm

The LO Splitter/Amplifier is essentially a dual mixer circuit used to convert the visual and aural IF carriers up to the transmitted VHF channel frequencies. The IF carriers enter this module from each Power Adjust (AT1/AT2) at VISUAL IF IN connector J4 and AURAL IF IN connector J6. The visual signal is brought directly to mixer MX1 while monolithic amplifier U4 provides the aural carrier 13dB of gain before mixer injection. At the LO IN connector J2, the unmodulated mixing signal from the synthesizer enters the module where it is evenly split and attenuated (-13dB) by resistors R1, R2, R3 and R4, providing isolation between the mixers and synthesizer. Each LO signal is then amplified 12dB by monolithic circuits U1 and U2 before being coupled into MX1 and MX2. The mixers are double balanced circuits which combine each IF carrier with the CW signal from the synthesizer. The resulting sum and difference frequencies at the output of each mixer are then brought to the module's VISUAL and AURAL RF out connectors J1 and J3. The visual and aural difference frequencies are then selected by the VHF Bandpass Filters (A2FL1/A2FL2). Monolithic amplifier U3 in conjunction with attenuator R9/R10 provides further isolation and amplification for the LO signal to be monitored at the LO SAMPLE connector on the Exciter's front panel.

2.2e Reference Oscillator:

Schematic Diagram 10368037/Rev B ⋆ A2A4A2

10MHz REF. OUT (J1, J2)	3.5V P/P square wave

The Reference Oscillator provides a 10MHz reference signal for the VHF Synthesizer (A4A1). This module is centered around a 10MHz temperature-compensated crystal oscillator (G1). The output from G1 is applied to two exclusive-OR gates used as inverting buffers. The output signal from each gate is a 10MHz low-level square wave with a frequency stability of 3 parts per million (PPM).

2.2f VHF Synthesizer:

Schematic Diagram 30362003/Rev D ⋆ A2A4A1 (Band III)
Schematic Diagram 30362427/Rev C ⋆ A2A4A1 (Band I)

10MHz REF. IN (J1)	3.5V P/P square wave
LO OUT (J2)	+15dBm min. (see Table 2–1 for freq.)
SYNTH. LOCK (Pin A of J4)	logic high (locked) logic low (unlocked)

The VHF Synthesizer uses one of the 10MHz reference signals from the Reference Oscillator (A4A2) and develops a programmable LO signal for each Mixer (MX1, MX2) in the LO Splitter/ Amplifier (A6). The frequency of the LO signal is calculated as the sum of the visual IF carrier and the visual VHF carrier of the specified output channel. The LO signal's frequency is programmed by switches S1 through S4 which are accessible through the top cover of the module. The relationship between the settings of these switches and the resulting LO frequency is provided in Table 2–1 for each channel.

2.2g VHF Bandpass Filter:

Schematic Diagram 20362428/Rev 51 ⋆ A2FL1, A2FL2 (BAND I)
Schematic Diagram 10362113/Rev 53 ⋆ A2FL1, A2FL2 (BAND III)

1dB Bandwidth (J1-J2)	7MHz
Insertion Loss (J1-J2)	3dB

The Band I visual and aural VHF Bandpass filter consists of discrete, tunable inductors and capacitors. The Band III visual and aural VHF Bandpass Filters consist of four tunable resonant cavities. Each filter is adjusted to provide the optimum frequency response for the selected VHF carrier. FL1 selects the visual carrier from the lower sideband of the signal at the VIS RF OUT (J1) of the LO Splitter/Amplifier (A2A6), and FL2 is tuned to select the aural carrier at J3 of A6.

2.2h 2W VHF Amplifier:

Schematic Diagram 30362257/Rev 52 ⋆ A2A3, A2A7

Gain (J1-J2)	50dB
Power Out (J2)	≈+27dBm Peak Visual ≈+23dBm Average Aural
Flatness (J1-J2)	±1dB
U1, PIN 3	+3.9Vdc @ 29mA
U2, PIN 3	+5.3Vdc @ 58mA
U3, PIN 4	+20Vdc @ 100mA
Q1, Collector	+25Vdc @ 1A

The two 2 Watt Amplifiers provide 50dB of gain to the visual and aural carriers. These amplifiers cover both Band I and Band III without requiring any switching or retuning. The Band III amplifier is a four-stage, class A, microstrip design. The Band I amplifier has three stages and is identical to the Band III amplifier except that U1 and its bias circuitry is removed.

The first three stages of the amplifier are broadband monolithic amplifier circuits, U1 through U3, that have a combined gain of approximately 40dB. U1 is biased by R1, U2 is biased by R2, and U3 is biased by R3. L1 and L2 provide impedance matching for the outputs of the first two amplifiers. C1 through C4 are coupling capacitors, while C7 to C16 are all RF bypasses.

Q1 provides the final amplification of the signal in this amplifier, supplying about 12dB of gain to the carrier. It is biased by a DC regulator consisting of Q2 and R6 to R10. This circuit maintains Q1's collector voltage and current over a wide load and temperature range. Capacitors C5, C6, C17 to C19, C28 and C29, along with R11, R12, L3 and L7 form an input matching network for Q1. The output matching circuit is made up of L8, L9 and C36 to C39. The remaining inductors (L10-L13) are RF chokes and the rest of the capacitors (C20-C26, C30-C34) are RF bypasses. These components serve to prevent RF from leaking into the DC supply, and also to prevent RF feedback from the output of Q1 to its input.

2.2i Directional Couplers:

Schematic Diagram 10362314/Rev 51 ⋆ A2DC1, A2DC2

Insertion Loss (J1-J2)	0.15dB max.
FWD Coupling (J1-J3)	-24dB

The Directional Couplers are three-port circuits that pass the visual and aural carriers with minimal loss, while providing a -24dB sample of each carrier to the Metering Detector. The output of the couplers appears at the VISUAL and AURAL RF OUT ports at the rear of the Exciter drawer.

2.2j Metering Detector:

Schematic Diagram 30368024/Rev P ⋆ A2A8

The Metering Detector contains separate but similar circuitry for monitoring the peak visual and average aural power at the output of the Exciter drawer. Samples of these two RF signals are supplied by the two Directional Couplers mentioned above.

The front end or detector portion of each circuit is basically the same. Diodes CR2 and CR3, together with their surrounding components, convert the sampled on-channel RF signals to positive dc voltages proportional to the detected RF power. Detection of the sampled visual output carrier is accomplished by CR2 in conjunction with R4 and C2 which form a time constant of 1 second. R4 is the dc load while C1 and C11 form the RF ground of the visual power detector. Detection of the sampled aural output carrier is the same using diode CR3 with capacitors C3, C13, C14 and resistor R13. The positive dc voltages from the visual and aural power detectors are processed by buffer amplifiers U1 and U2 which provide voltage gains of 1V/V and 2V/V, respectively. These buffer amplifiers also provide isolation between the % POWER meter (A2M1) and the detectors. The settings of potentiometers R9 and R18 determine the voltage level applied to the % POWER meter when the meter switch (A2S3) is in its VISUAL or AURAL position. The reflected portion of the Metering Detector is not used in the 2W VHF Exciter.

2.2k Limiter/Output AGC:

Schematic Diagram B331-34/Rev C ⋆ A2PC1

The Limiter/Output AGC board provides various monitoring and control functions for the transmitter. This board consists of a limiter circuit, an input carrier monitoring circuit, and an output AGC circuit.

The <u>limiter circuit</u> is made up of LIMITER ADJ potentiometer R13 and an exponential amplifier formed by U2A, U2C, U2D and surrounding components. This circuit, in conjunction with the IF limiter section of the IF AGC Amplifier (A2A1), prevents the transmitter's visual amplifiers from being overdriven whenever the visual IF carrier from the AGC Amplifier exceeds a specific level. This condition could occur if the carrier returned to normal amplitude after a period of significant reduction during which the AGC Amplifier's gain increases significantly. With a reappearance of the visual carrier, the AGC section cannot respond quickly enough to prevent overdrive. This deficiency is overcome by the limiter circuit which monitors and quickly responds to the AGC Amplifier's limiter reference voltage. R13 is set to activate the limiter circuit when the visual carrier from the AGC Amplifier reaches approximately +3dBm. When activated, the limiter circuit provides a -14Vdc limiter enable voltage to the AGC Amplifier's IF limiter section which causes a pin diode (CR9) to reverse bias, reducing the visual IF by approximately 20dB. After the AGC Amplifier's AGC section has had enough time to respond to the increase in the visual carrier, the limiter circuit is deactivated. As a result, the limiter enable voltage returns to +14Vdc, disabling the AGC Amplifier's limiter section.

The <u>input carrier monitoring circuit</u> is centered around comparator U2B, CR4, and Q3. This circuit uses the IF AGC Amplifier's limiter reference voltage to control the operation of the CARRIER PRESENT indicator (A2DS2). When a visual carrier of appropriate level is detected by the AGC Amplifier, its limiter reference voltage will be less than -0.7Vdc. As a result, U2B saturates in the positive mode, Q3 turns on, and the CARRIER PRESENT indicator illuminates green.

The remaining circuitry of the Limiter/Output AGC forms the output AGC circuit. This circuit has two modes of operation—AGC active and pre-AGC. The AGC active mode occurs when the OPERATE/ALIGN switch (A2S1) is placed to OPERATE, the OUTPUT AGC switch (A2S2) is placed to ON, and the limiter circuit is not active. In this mode, the output AGC circuit monitors the transmitter's visual power reference voltage developed by the output Metering Detector (A2A8) and produces an output AGC voltage proportional to the transmitter's visual output power. This voltage is applied to the IF AGC Amplifier's AGC section in order to complement its input AGC circuitry by compensating for visual gain variations that occur after the IF AGC Amplifier. In the AGC active mode, the limiter enable voltage is +14Vdc, diodes CR1 and CR2 are turned off, transistors Q1 and Q2 are turned on, and relay K1 is energized thereby applying the visual power reference voltage to inverting summing amplifier U1B. This voltage is controlled by the front panel OUTPUT AGC ADJUST potentiometer (A2R3), buffered by U1A, and applied to U1B along with an AGC reference voltage set by AGC REF ADJ potentiometer R8. U1B produces an output AGC voltage which is used by the IF AGC Amplifier (at pin 3 of U1A). The pre-AGC mode occurs either when the transmitter is first turned on or when the limiter circuit is activated. When the transmitter is first turned on, relay K1 is deenergized thereby applying a pre-AGC reference voltage to U1B set by PRE-AGC REF ADJ potentiometer R25. This voltage is summed with the AGC reference voltage set by R8. An initial turn-on delay allows the output from U1B to stabilize at a constant value proportional to the pre-AGC reference voltage. K1 remains deenergized for approximately four seconds following turn-on while C2 charges to +0.7Vdc. After C2 has charged, CR1 and CR2 turn off, Q1 and Q2 turn on, and K1 energizes placing the output AGC circuit in its active AGC mode. When the limiter circuit is activated, the output AGC circuit is placed in its pre-AGC mode with the output AGC voltage replaced by a constant value proportional to the pre-AGC reference voltage. Therefore, the IF AGC Amplifier's input AGC circuitry is allowed to respond to a significant increase in the visual carrier without interference from the output AGC circuit. In the pre-AGC mode, the limiter enable voltage is negative, CR1 and CR2 are turned on, Q1 and Q2 are turned off, and a pre-AGC reference voltage set by R25 is applied to U1B replacing the visual output power reference voltage.

2.2l +28V Power Supply:

Schematic Diagram N/A ⭑ A2PS1

Voltage	28Vdc
Current	4A max.

The +28V Power Supply is a single output, linear, regulated power supply with a rated output current of 4Adc. This supply provides +28Vdc to circuitry in the VHF 2 Watt Exciter drawer. When energized, the contactor (A2K1) provides +28Vdc switched to the 2W VHF Amplifiers (A2A3, A2A7) and the FINAL RF indicator (A2DS3) illuminates green.

2.2m ±15V/+5V Power Supply:

Schematic Diagram N/A ⭑ A2PS2

Voltage/Current	±15Vdc @ 400mA max. +5Vdc @ 2A max.

The ±15V/+5V Power Supply is a fully regulated, multiple output, linear power supply. Each 15Vdc output is rated to provide 400mA of current with the +5V output able to supply 2A.

2.2n X2 Multiplier:

Schematic B280-35/Rev E ⋆ A2A4 (Ch.2-6)

	Q1	Q2	J2	J3
Collector V	+25V	+15Vdc		
Output Power			10-30mW	
Output Freq.			2nd Harmonic of Crystal Oscillator	
LO SAMPLE				≈1mW (0dBm)

The X2 Multiplier is used in the Exciter drawer with a Ch.2-6 output. The purpose of the X2 Multiplier is to amplify and multiply by two the frequency of oscillation provided by the Vectron Oscillator (A2G1). The output of the X2 Multiplier is applied to the LO port of the LO Splitter/ Amplifier (A2A6).

The X2 Multiplier consists primarily of an amplifier stage and a frequency doubler stage fed by the fundamental frequency of the crystal oscillator (A2G1). Transistor Q1 and surrounding components form an untuned class A VHF amplifier. The output of this amplifier is coupled to a resonated idler loop (series circuit L3 and C7) tuned to the fundamental frequency of the oscillator. Transistor Q2 and surrounding components form a class AB frequency doubler that feeds a LC series circuit (L5, C12) tuned to the second harmonic of the oscillator. Capacitors C13 through C17 and inductors L6 through L8 comprise a three-section bandpass filter which passes only the second harmonic. Resistors R9 and R10 supply an attenuated LO SAMPLE of the second harmonic for convenient monitoring on the front panel of the Exciter drawer.

2.2o X4 Multiplier:

Schematic C331-24/Rev D ⋆ A2A4 (Ch.7-13)

	Q1	Q2/Q3	J2	J3
Collector V	+25Vdc	+15Vdc		
Output Power			10-30mW	
Output Freq.			4th Harmonic of Crystal Oscillator	
LO SAMPLE				≈1mW (0dB)

The X4 Multiplier is used in the Exciter drawer with a Ch.7-13 output. The purpose of the X4 Multiplier is to amplify and multiply by four the frequency of oscillation provided by the Vectron oscillator. The output of the X4 Multiplier is applied to the LO port of the LO Splitter/Amplifier (A2A6).

The X4 Multiplier consists primarily of an amplifier stage and two frequency doubler stages fed by the fundamental frequency of the Vectron oscillator (A2G1). Transistor Q1 and surrounding components form an untuned class A VHF amplifier. The output of this amplifier is coupled to a resonated idler loop (series circuit L3 and C7) tuned to the fundamental frequency of the high stability oscillator. Transistor Q2 and surrounding components form a class AB frequency doubler that feeds a LC series circuit (L5, C12) tuned to the second harmonic of the oscillator. Capacitors C13 through C17 and inductors L6 through L8 comprise a three-section bandpass filter which passes only the second harmonic. Transistor Q3 and surrounding components form a class C frequency doubler with both input and output tuning. Tuning consists of a second harmonic idler circuit (L9 and C19) at the input and an output network (L12, C22 and C23) that is tuned to the 4th harmonic of the oscillator. Capacitors C26 through C29 and inductors L13 and L14 comprise a two-section bandpass filter tuned to pass the oscillator's fourth harmonic. Resistors R13, R14, and R15 form a 50 ohm-to-50 ohm, 3dB attenuator, which maintains the impedance match between the output of the X4 Multiplier and the LO input of the LO Splitter/Amplifier (A2A6). Resistors R16 and R17 supply an attenuated LO SAMPLE of the fourth harmonic for convenient monitoring on the front panel of the Exciter drawer.

2.3 Visual IPA/Aural Final Amplifier Drawer:

Interconnection Diagram 30362006/Rev A ⋆ A3

VISUAL RF IN (J1)	≈+27dBm peak
AURAL RF IN (J2)	≈+24dBm average
VISUAL RF OUT (J3)	≈+44dBm peak
AURAL RF OUT (J4)	≈+50dBm average
Visual Gain (J1-J3)	+17dB
Aural Gain (J2-J4)	+26dB

This drawer contains two driver amplifiers, one for the visual signal and one for the aural, and an aural final amplifier. The 50W Visual Driver Amplifier provides 17dB of gain to the visual carrier, resulting in a peak output of approximately 44dBm. Due to an excess of gain when operating in Band I, a 6dB attenuator is typically installed at the drawer's visual output reducing the level to approximately 38dBm peak at the input of the Visual Final Amplifier drawer. The Aural Driver Amplifier in conjunction with the Aural Final Amplifier provides a total minimum gain of 26dB for an approximate output power level of 50dBm.

2.3a Visual Driver Amplifier:

Schematic Diagram 30362252/Rev 54 ⋆ A3A1 (BAND I)
Schematic Diagram 30362046/Rev 56 ⋆ A3A1 (BAND III)

Gain (J1-J2)	+17dB
Power Output (J2)	≈+44dBm peak
Drain of Q1	26Vdc @ 4ADC (both sides)

The Visual Driver Amplifier is a class A microstrip design with push-pull transistor Q1 providing the gain. Q1 is biased by two DC current regulators that maintain the drain voltage and current over a wide range of temperatures and input levels. Each regulator is made up of a PNP transistor (Q2, Q3) along with a potentiometer (R16, R4) to achieve proper bias. Resistors R1 to R16 are also part of the regulator and biasing circuitry. The input signal is converted from an unbalanced to a balanced signal of equal magnitude and opposite polarity, by microstrip balun Z1. In the Band III Driver, the signal is fed through an impedance matching transformer (T1) and then ac coupled to Q1 by C1 and C2, with parallel capacitors providing load matching. AC coupling connects Q1's output to an impedance matching transformer (T1 in the Band I Driver and T2 in the Band III Driver). The balanced output of this transformer is converted to an unbalanced output by balun Z2. C6, C9, and C30 are load matching capacitors, while all the remaining components of PC1 and PC2 provide RF isolation for the +28Vdc power supply.

The circuitry of PC3 will detect either an open or a short in the push-pull transistor. Normally the drain voltage of both sides of the push-pull transistor is +26Vdc. When this is the case, Q1 through Q3 of PC3 are on, diodes CR2 and CR3 are off, while the diodes connected to pins 1/14 and 7/8 of CR1 are on. The other two diodes of CR1 are off at this time, and the FAULT line is set to a logic low (0 to 0.5Vdc). If either side of the push-pull transistor develops an open circuit, its drain voltage would rise to about +27.5Vdc causing the diode at pins 1 and 3 of either CR2 or CR3 to turn on. This results in Q3 and Q2 turning off, along with the diode at pins 7 and 8 of CR1. In this case, the diode at pins 3 and 12 of CR1 turns on, placing a logic high (+4.5 to +5Vdc) on the FAULT line. A fault would also be indicated if either side of the push-pull transistor shorted. If this occurred, the drain of the affected side would drop to approximately +0.2Vdc, causing the diode at pins 2 and 3 of CR2 or CR3 to turn on. Then Q1 would turn off, and so would the diode at pins 1 and 14 of CR1. Once this has happened, the diode connected to pins 2 and 13 of CR1 would turn on, supplying a high to the FAULT line. The data from the FAULT line is processed by the fault monitoring section of the Power Supply/Control Status drawer (A4).

2.3b Aural Driver Amplifier:

Schematic Diagram 30362035/Rev 55 ⋆ A3A2

Gain (J1-J2)	+12dB min.
Power Output	≈+35dBm average
Drain of Q1	+26.8Vdc @ 1Adc

The Aural Driver, which operates in both Band I and Band III, consists of FET amplifier Q1 with impedance matching networks at its input and output and a DC current regulator. The input matching network is made up of C1 to C4, L1 and R1, while the output network is formed by C13 to C15, C9 and wide band matching transformer, T1. RF transistor Q1 is biased by the DC current regulator made up of Q2, R6 and R7. The regulator maintains the correct bias for Q1 over a wide variation of temperature and signal level. R2 to R4, L2, L3 and C5 are also part of the biasing circuitry. All remaining capacitors on PC1 are RF bypasses.

The Fault Circuit board (PC2) detects the presence of either an open or a short in the amplifier's RF transistor. Under normal operation, the drain voltage on the transistor is typically +26.8Vdc. Under this condition, Q1 through Q3 of the fault circuit are turned on, both diodes of CR2 are turned off, and the diodes identified by pins 1/14 and 7/8 of CR1 are conducting while those identified by pins 2/13 and 3/12 are not. Hence, for normal operation of the RF transistor, the FAULT line (pin C of connector J3) is set at a logic low (approximately 0Vdc). However, if the transistor opens, its drain voltage rises from +26.8Vdc to about +27.4Vdc causing the diode identified by pins 1 and 3 of CR2 to turn on. This action results in biasing Q3 and Q2 off as well as the diode identified by pins 7 and 8 of CR1. With these components turned off, the diode identified by pins 3 and 12 of CR1 is based on applying a logic high (approximately +4.7Vdc) to the FAULT line. On the other hand, if the RF transistor shorts, the drain falls from +26.8Vdc to about +0.2Vdc causing the diode identified by pins 2 and 3 of either CR2 or CR3 to forward bias. This action results in turning off Q1 and the diode identified by pins 1 and 14 of CR1. With these components reverse biased, the diode identified by pins 2 and 13 of CR1 turns on applying a logic high to the FAULT line. The information on the FAULT line is processed by the fault monitoring/ display section of the Power Supply/Control Status drawer A4.

2.3c Aural Final Amplifier:

Schematic Diagram 20362269/Rev 54 ⋆ A3A3 (BAND I)

Gain (J1-J2)	+15dB min.
Power Output (J2)	≈+50dBm
Drain of Q1	28Vdc @ 1Adc

This Band I amplifier is a class AB, push-pull FET design that supplies a minimum of 15dB of gain to the aural carrier. The input to the amplifier drives transformer T1, which acts as a balun, converting the unbalanced input signal to a balanced signal. C1 and C2 ac couple the signal to T2 and T3, which form an impedance matching transformer. C3 through C5 furnish load matching. At the Drains of Q1, load matching is accomplished by C9 to C11. T4 and T5 form an impedance matching transformer. Capacitors C12 through C15 provide ac coupling to T4, a balun that returns the signal to an unbalanced state. Q1 is biased by resistors R1 through R4, while the remaining components provide RF isolation to the +28Vdc power supply.

Schematic Diagram 30362014/Rev 56 ⋆ A3A3 (BAND III)

Gain (J1-J2)	+14dB min.
Power Output (J2)	≈53dBm
Drain of Q1	28Vdc @ 1Adc

This Band III amplifier is a class AB, push-pull FET design that supplies a minimum of 14dB of gain to the aural carrier. The input to the amplifier drives transformer T1, which acts as a balun, converting the unbalanced input signal to a balanced signal. T2 and T3 form an impedance matching transformer. This signal is AC coupled to the gates of push-pull transistor Q1 by capacitors C1 and C2, with C3 through C5 furnishing load matching. At the Drains of Q1, load matching is accomplished by C15 to C18, C32 to C34, and C21. Capacitors C19, 20, 22, and 23 ac couple to T4, a balun that returns the signal to an unbalanced state. Additional load matching is given by C24 and C25. Q1 is biased by resistors R1 through R8, while the remaining components provide RF isolation to the +28Vdc power supply.

2.4 Visual Final Amplifier Drawer:

Interconnection Diagram N/A ⋆ A5 (BAND I)

Gain (J1-J2)	+20dB
Power Out (J2)	≈+58dBm peak
Power In (J1)	≈+38dBm peak

Interconnection Diagram 30362473/Rev 52 ⋆ A5 (BAND III)

Gain (J1-J2)	+14dB
Power Out (J2)	≈+58dBm peak
Power In (J1)	≈+44dBm peak

The Visual Final Amplifier drawer consists of a power splitter (PC1), two amplifier modules (A3, A4), a power combiner (PC2), and two thermostats (TS1, TS2). The input splitter is a 2-way Wilkinson design that supplies each of the amplifier modules an equal part of the input signal with an insertion loss of less than 0.25dB. Each amplifier module in the Band I drawer provides +20dB of gain to its portion of the visual signal, while the Band III amplifier pallets provide a gain of +14dB each. The combiner is also a 2-way Wilkinson type with an insertion loss of no more than 0.25dB.

In the event of an overheating problem, two thermostats signal the Power Supply/Control Status drawer. If the temperature in the drawer rises above 160°F, the first thermostat opens, causing the Control Status board to reduce the gain of the transmitter's AGC circuit. If the temperature continues to rise past 175°F, the other thermostat will open. When this occurs, the Control Status board puts the transmitter in a standby condition until the amplifiers cool down.

2.4a 300W Final Visual Amplifier (BAND I):

Schematic Diagram 20362275/Rev A ⋆ A5A3, A5A4

Gain (E1-E2)	+20dB

The VHF Band I, 300W Final Visual Amplifier is a class AB microstrip design that provides +20dB of gain to the visual carrier. The gain is derived from a matched, n-channel, enhancement mode MOSFET transistor pair (Q1) operating on +48Vdc.

The RF signal enters at E1/IN, and is applied to balun T1 which provides two signals proportional to the input and opposite in polarity. This balanced signal is then ac coupled to an impedance matching transformer, formed by T2 and T3, to drive the gates of Q1. T4 and T5 provide impedance matching for the amplified signal, which are then ac coupled to balun T6. The unbalanced amplified signal is provided on E2/OUT.

The gate-source bias voltage for Q1 is generated by U1. R7 and VR1 drop the +48Vdc supplied to the amplifier module to +27Vdc for use by U1. Potentiometer R2 controls the output of U1. Thermistor RT1 provides thermal compensation by reducing the output of U1 as the temperature of the module increases.

2.4b Combiner Fault Circuit (BAND I):

Schematic Diagram N/A ⋆ A5PC2

The Combiner Fault Circuit detects imbalances between Final Visual Amplifiers A3 and A4 on ports E3 and E4. Any imbalance appears as a voltage across R5 which is then coupled by T2 to the 50 ohm resistor R8. CR2 and C2 form a peak detector which produces a voltage on E7 that is proportional to the imbalance. Therefore, a fault in either Visual Final Amplifier pallet A3 or A4 will illuminate both VISUAL AMPL 3 and VISUAL AMPL 4 Power Supply/Control Status drawer indicators red.

2.4c 300W Final Visual Amplifier (BAND III):

Schematic Diagram 30362367/Rev 54 ⋆ A5A3, A5A4

Gain (E1-E2)	+14dB

The VHF, Band III, 300W Final Visual Amplifier is a class AB, FET design that provides +14dB of gain to the visual carrier. The gain is derived from two matched, n-channel, enhancement mode MOSFET transistor pairs (Q1, Q2) operating on +48Vdc.

The RF signal enters at E1/IN and is split by a sage wire line 90° hybrid, CP1. Each unbalanced signal is then applied to baluns T1 and T4, which provide two signals that are proportional to the input and opposite in polarity. These balanced signals are then ac coupled to the appropriate impedance matching transformer, T2 and T3 or T5 and T6, to drive the gates of Q1 or Q2, respectively. T7/T8 and T9/T10 provide impedance matching for the amplified signals, which are then ac coupled to baluns T11 and T12. CP2, a sage wire line 90° hybrid, combines the unbalanced signals from T11 and T12, providing the combined, amplified signal at E2/OUT.

The gate-source bias voltage for Q1 and Q2 is generated by U1. R12 and VR1 drop the +48Vdc supplied to the amplifier module to +27Vdc for use by U1. Potentiometer R9 controls the output of U1. Thermistor RT1 provides thermal compensation by reducing the output of U1 as the temperature of the module increases. Potentiometers R2 and R3 provide individual fine tuning of the gate-source biases of Q1 and Q2, respectively.

In the event that either RF transistor Q1 or Q2 fails, the unbalanced energy created in CP2 will be coupled to the 50 ohm resistor (R19) at the isolation (B) port on the output side of the hybrid. CR1 and C50 convert this RF energy to a dc level that is provided on E5, the FAULT line, to be monitored by the Control/Status board (A4PC1).

2.5 Metering Couplers:

Schematic Diagram N/A ⋆ DC1, DC2

	DC1	DC2
Insertion Loss	<0.2dB	<0.2dB
FWD Coupling	-50dB	-40dB
REFLD Coupling	-50dB	-40dB

The visual and aural Metering Couplers (DC1/DC2) are four-port circuits that perform two functions. The first function is to separately pass the amplified visual and aural carriers with minimal insertion loss. These carriers are then separately applied to the Diplexer's visual and aural input ports. The second function of each coupler is to provide a sample of each RF signal used by the Metering Detectors. These RF signal samples include the forward and reflected visual carrier from DC1 and the forward and reflected aural carrier from DC2.

2.6 Metering Detector:

Schematic Diagram 30368024/Rev P ⋆ A7, A8

The Metering Detector contains separate but similar circuitry for monitoring the peak visual, average aural, visual reflected, and aural reflected power at the output of the transmitter. Samples of these four RF signals are supplied by the visual and aural Metering Couplers (DC1, DC2).

The front end or detector portion of each circuit is basically the same. Diodes CR2 and CR4, together with their surrounding components, convert the sampled on-channel RF signals to positive dc voltages proportional to the detected RF power. Detection of the sampled visual output carrier is accomplished by CR2 in conjunction with R4 and C2 which form a time constant of 1 second. R4 is the dc load while C1 and C11 form the RF ground of the visual power detector. Detection of the other RF signal is the same except for a faster time constant, R22/C6 have a time constant of 1 millisecond. The positive dc voltage from the visual detector is processed by buffer amplifiers U1 and U2 which provide voltage gains of 1V/V and 2V/V, respectively. Similarly, the positive dc voltage from the reflected power detector is processed by U1 and U2 with voltage gains of 1V/V and 1.47V/V, respectively. These buffer amplifiers also provide isolation between the % POWER meters (A6M1, A6M2) and the detectors. The settings of potentiometers R9 and R27 determine the voltage level applied to the visual % POWER meter when the VISUAL meter switch (A6S1) is in its FWD or REFL position, respectively.

A dc voltage proportional to the transmitter's visual output power is applied to pin 5 of connector J4, designated VISUAL POWER REFERENCE. This voltage is fed back to the Limiter/Output AGC (A2PC1) in the 2W Exciter drawer. When the OUTPUT AGC switch (A2S2) is in its ON position, this voltage ultimately controls the attenuation of the visual IF carrier so that the transmitter's visual output power is automatically maintained at its rated value.

A dc voltage proportional to the transmitter's reflected output power is fed to pin 10 of comparator U2. This voltage is compared to a reference voltage at pin 9 whose magnitude is determined by the setting of potentiometer R30. With R30 properly set, the voltage on pin 10 will be greater than the reference voltage whenever the transmitter's reflected power is at least 10% of its rated forward power. As a result, the output of the comparator saturates in the positive mode applying approximately +4Vdc to pin 7 of connector J4, designated VSWR OVLD. This voltage instructs the Control Status that a VSWR overload condition has been detected. However, when the transmitter's reflected power is less than 10% of its rated forward power, the voltage on pin 10 of comparator U2 will be less than the reference voltage. As a result, the comparator saturates in the negative mode with diode CR1 forward biased and approximately -0.7Vdc is applied to pin 7 of connector J4. This voltage instructs the Control Status that no VSWR overload condition exists.

The aural Metering Detector (A7) is identical to the visual detector except that the forward aural sample is connected to the AURAL IN (J2) instead of the VISUAL IN (J1).

2.7 Visual/Aural Diplexer:

Schematic Diagram N/A ⋆ CP1

Insertion Loss	Visual	0.3dB max.
	Aural	2dB max.

The Diplexer combines the visual and aural VHF carriers provided from the Visual Final Amplifier and Aural Final Amplifier via Directional Couplers DC1 and DC2. The composite signal is then applied to the transmitter's RF OUT connector.

2.8 Notch Filter:

Schematic Diagram N/A ⋆ FL1

Insertion Loss 0.15dB

FL1 is a single-cavity notch filter with a maximum insertion loss of 0.15dB and a minimum notch attenuation of 15dB.

2.9 Meter Panel:

Schematic Diagram N/A ⋆ A6

The Meter Panel consists of a VISUAL % POWER meter (M1), a VISUAL meter switch (S1), an AURAL % POWER meter (M2), and an AURAL meter switch (S2). This circuitry is used in conjunction with the Metering Detectors (A7, A8) to provide visual and aural output power measurement information.

2.10 Power Supply/Control Status Drawer:

Interconnection Diagram 30362341/Rev 55 ⋆ A4

The Power Supply/Control Status drawer consists of a Control/Status board (PC1), a ±15V/+5V Power Supply (PS1), a +28V Power Supply (PS2), a +48V Power Supply (PS3) and a voltmeter (M1) with a Metering Switch (PC2). This drawer provides power to all the other assemblies in the transmitter.

2.10a Control Status Board:

Schematic Diagram 40362435/Rev 53 ⋆ A4PC1

The Control/Status board provides various monitoring and control functions for the transmitter while displaying the results on several front panel indicators. The circuitry of this PC board can be divided into two sections:

(1) Interlock and VSWR Monitoring
(2) Amplifier Fault Monitoring

The interlock and VSWR section monitors the transmitter's output VSWR, the position of the Control/Status drawer's OPERATE/STANDBY switch (S2) and the status of the Auto-On relay (A2PC2-K1) located in the 2W Exciter drawer. Results of this monitoring are displayed by the

FINAL BIAS (DS1), AURAL FINAL BIAS (DS10), EXCITER ON (DS2), and VSWR OVLD (DS3) indicators. Assuming that the transmitter is operational with the OPERATE/STANDBY switch in OPERATE, with the AUTO-ON relay energized and acceptable VSWR levels at the transmitter's output, the FINAL BIAS, AURAL FINAL BIAS and EXCITER ON LED's will be illuminated with the VSWR OVLD indicator extinguished.

However, if the OPERATE/STANDBY switch or Auto-On relay conditions change, the transmitter will proceed to standby with the FINAL BIAS, AURAL FINAL BIAS and EXCITER ON indicators shut off. The transmitter will also go to the standby mode if the VSWR overload circuits in the Metering Detectors (A7, A8) initiate a shutdown. In this case, the VSWR OVLD indicator will illuminate and the DS1/FINAL BIAS and DS2/EXCITER ON indicators will shut off.

Under normal operation, the Metering Detector's VSWR OVLD voltage of -0.7Vdc is applied to the base of Control Status transistor Q1 which is turned off, resulting in a logic high applied to the negative edge-TRIGgered inputs of timers U1A and U1B as well as to the positive edge-triggered clock (CLK) inputs of D-type flip-flops U2A and U2B. With U1A and U1B disabled, a logic low is applied to pin 8 of NOR gate U5C and pin 9 of AND gate U4C. A logic low will then occur at pin 8 of U4C which is applied to the positive edge-triggered clock (CLK) input of D-type flip-flop U3A resulting in a logic low at its Q output. This logic low is applied to pin 9 of U5C while Q2 is turned off and the VSWR OVLD indicator is extinguished. With pins 8 and 9 of U5C at a logic low and Temp Sensor #1 closed, highs are present at both inputs and the output of U15C. Therefore, with the OPERATE/STANDBY switch to OPERATE and the Automatic-On's relay energized, a logic high is applied to pins 4 and 5 of U4B resulting in a high at pin 6 of U4B.

This high is applied to transistor Q3, causing the FINAL BIAS indicator to illuminate green while supplying a logic low to Q4, turning on the +48V power supply by providing a logic high on its sense line (J1-5). When the +48V Power Supply (A4PS3) activates, the voltage divider formed by R68 and R67 converts the +48V on J1-8 to a logic high at input pin 1 of AND gate U15A. This high, along with the high at the output of U4B, produces a high at the output of U15A, turning on Q12. Q12 causes DS10 to illuminate green and Q5 to conduct providing a logic high on J1-3 enabling the +28V power supply A4PS2. The high output from U15A is also applied to transistors Q10 and Q11 via the RC network of R24 and C9. After a 3-second delay, Q10 and Q11 turn on causing the EXCITER ON indicator to illuminate green while supplying a ground to pin 26 of connector J1. As a result, the Exciter's contactor (A2K1) energizes, supplying +28Vdc to the visual and aural 2W Amplifiers (A2A3, A2A7) which provide drive signals to the remaining amplifiers in the transmitter.

For the transmitter to be placed in the STANDBY mode, one of four situations must occur. The first is to place the OPERATE/STANDBY switch of the Control/Status section to the STANDBY (open) position. This action removes the 5Vdc from AND gate U4B pin 5 which in turn places a low on the bases of transistors Q3 and Q12/Q10 via U15A. FINAL BIAS and AURAL FINAL LEDs will extinguish as a high is placed on pins 5 and 3 of connector J1, shutting off the 28V and +48V power supplies. At the same time, the 2 watt VHF Amplifiers of the Exciter drawer (A2) are turned off via contactor A2K1 due to the high on the Exciter Control line at J1-26. This high appears with the low placed on the base of transistor Q10 which also extinguishes EXCITER ON LED DS2.

A second situation to place the transmitter in STANDBY is to remove video from the modulator input. The video loss will deactivate the Exciter's Auto-On relay (A2PC2-K1) removing 5Vdc from the interlock line at Control Status PCB plug J1 pin 27. This, in effect, will provide the same sequence as explained above when opening the OPERATE/STANDBY switch.

The third circumstance to bring the transmitter into STANDBY is the occurrence of high VSWR at the transmitter's output. In this situation, the unit will shut down temporarily and, after ten seconds, the Control Status circuits will place the transmitter back on the air. If the problem persists and the unit shuts down twice more within a five-minute period, the transmitter will then shut down permanently requiring manual reactivation. Under normal operating conditions, the Metering Detector's VSWR OVLD circuit, which continually monitors output VSWR through the Visual and Aural Metering Couplers, places a low on the base of transistor Q1 of the Control Status circuit. However, if the standing wave ratio of the transmitter's load increases beyond the 1.9:1 point (50 watts reflected power as dictated by the setting of Metering Detector potentiometer R9), the detector's VSWR OVLD circuit will place a 4Vdc high on the base of Q1 which in turn provides a low at its collector to trigger timers U1A/U1B and flip-flops U2A/U2B. At the output (pin 5) of 10-second clock U1A, a high appears which is applied to pin 8 of NOR gate U5C. The resulting lows at the outputs of U5C, U15C, and U4B shut off transistors Q3, Q12, and Q10. As explained previously, this operation will shut down the power amplifier drawer and the 2 watt amplifiers of the Exciter. FINAL BIAS (DS1), AURAL FINAL (DS10), and EXCITER ON (DS2) indicators are also turned off and the voltage applied to the base of Q1 is removed due to the lack of output power. At this point, the Q outputs of flip-flops U2A (pin 5) and U2B (pin 9) are providing a count of 1 and 0 to pins 12 and 13 of AND gate U4D. However, the U4D output at pin 11 and U4C output at pin 8 stay low as before and are of no consequence at this time even though the output of 5-minute timer U1B has switched high at U4C pin 9. After ten seconds, the output pin 5 of U1A will reset to a low to bring the transmitter back on-line. If the VSWR problem still exists as the transmitter's output power increases, the aforementioned sequence will repeat. The high from the Metering Detector VSWR overload circuit will again be applied to the base of Q1 retriggering the 10-second timer which again delivers a high to U5C pin 8 subsequently placing the transmitter back in standby. The count of the output of flip-flops U2A and U2B are now reversed to 0 and 1 which are applied to pins 12 and 13 respectively at the input of U4D but again affecting no change at the U4D output (pin 11). However, during the beginning of the third 10-second VSWR overload shutdown, the count from U2A-5 and U2B-9 will be 1 and 1, switching the output state of U4D from low to high. If the 011 count of U2A occurs before 5-minute timer U1B times out (removing its high from pin 9 of U4C), then pin 8 of U4C will go high to latch the output of flip-flop U3A high. With a continuous high at the pin 3 input of NOR gate U5C, its pin 10 output goes negative to permanently shut down the transmitter and light the VSWR OVLD indicator.

The transmitter is now in a permanent overload condition due to the logic high present on the output (pin 5) of flip-flop U3A. Under these conditions, the transmitter can only be reactivated by removing the high from NOR gate U5C. This can be accomplished by pushing up the VSWR OVLD RESET momentary switch located on the front panel of the Control Status drawer.

If the Visual Final Drawer overheats, the transmitter will also be put into standby mode. When the temperature on the Visual Final Drawer heat sink exceeds 160°F, thermostat TS2 will open, causing the input of U7C to go negative. A low appears at the output of U7C which causes A2PC1U1B in the Exciter drawer to reduce the gain of the AGC circuit. If this does not correct the problem and the temperature rises above 175°F, thermostat TS1 will open driving U7D's input negative and its output low. This low appears at the input of U15C, which will cause the transmitter to shut down as explained above.

The amplifier fault portion of the Control Status board monitors the operation of the various power amplifiers in the transmitter and displays the resulting information on the front panel of the drawer. The information on the FAULT lines from the two 300W Visual Final Amplifiers is fed into two comparators (U8A and U8D) along with a reference voltage from R55 and 56. The outputs of the comparators simultaneously drive two buffers (U9D and U9E) and two inverters (U10A and U10H). The output of each buffer is connected to the green side of bi-colored LEDs, while the output of the inverters are each connected to the red sides. When no fault is detected, the outputs of the comparators are high. Under this condition the output of the buffer is high and the output of the inverter is low. This allows the green segment of the LED to light while the red is extinguished. If a fault is detected, the above conditions reverse, the green portion goes out and the red illuminates.

The outputs of the inverters also serve as the inputs for the OR gates U6A through U6D. When any of the visual amplifier modules indicate a fault, a high will appear at the output of U6C. This high turns on A1PC1Q4 in the Exciter drawer, thus turning off the transmitter's AGC circuit. This prevents the remaining amplifiers from being overdriven by the AGC circuit attempting to compensate for the malfunctioning amplifier by increasing the IF gain.

The visual and aural driver amplifiers are also monitored individually by the Control Status circuit but in a more simplified fashion. Under normal operating conditions the fault circuit of each driver amplifier in the Visual IPA/Aural Final drawer provides a logic low directly to buffers U10E, U10F, U9G and U9H which dictate whether indicators DS8 and DS9 are red or green. If a problem occurs, for example, in the Visual Driver Amplifier, the logic level from its fault circuit will go high, turning the output of U9G positive while the output of U10F shifts negative. With diode CR14 forward biased, the green portion of VISUAL DRIVER indicator DS8 shuts off while output of U9G turns positive reverse biasing CR15 to turn LED DS8 red.

2.10b ±15V/+5V Power Supply:

Schematic Diagram N/A ⋆ A4PS1

The ±15V/+5V Power Supply is a multioutput, linear supply that provides ±15Vdc for the Metering Detectors (A7, A8) as well as +15Vdc to both the Visual Final Amplifier Drawer (A5) and the Control Status board. +5Vdc is also supplied to the Control Status board. This Power Supply is not field repairable, and should be returned to EMCEE for repair or replacement if found defective.

2.10c +28V and +48V Power Supplies:

Schematic Diagram N/A ⋆ A4PS2, A4PS3

Output	+28Vdc ± 5%; 29Adc max. +48Vdc ± 5%; 48Adc max.

Both of these units are single output switching supplies that operate with a minimum efficiency of 80%. They are furnished with internal current limiting circuits that provide overload protection to both the supply and the load. The +28V module powers the three amplifiers in the Visual IPA/Aural Final Drawer (A3). The +48V unit is hardwired to the two amplifier modules in the Visual Final Amplifier Drawer (A5). Neither supply is field repairable and if either of them is found to be defective, it should be returned to EMCEE for repair or replacement.

VHF CHANNEL	BAND LIMIT (MHz)	VIS/AUR Freq. (MHz)	LO OUT Freq. (MHz)	STEP LOOP SWITCH			
				S4	S3	S2	S1
2	54-60	55.25-59.75	101	0	3	F	1
3	60-66	61.25-65.75	107	0	4	2	7
4	66-72	67.25-71.75	113	0	4	6	5
5	76-82	77.25-81.75	123	0	4	C	7
6	82-88	83.25-87.75	129	0	5	0	5
7	174-180	175.25-179.75	221	0	4	5	1
8	180-186	181.25-185.75	227	0	4	6	F
9	186-192	187.25-191.75	233	0	4	8	D
10	192-198	193.25-197.75	239	0	4	A	B
11	198-204	199.25-203.75	245	0	4	C	9
12	204-210	205.25-209.75	251	0	4	E	7
13	210-216	211.25-215.75	257	0	5	0	5

SYNTHESIZER CHART FOR TTV500ES

Table 2-1

SECTION III

MAINTENANCE

SECTION III

MAINTENANCE

3.1 Periodic Maintenance Schedule:

OPERATION	RECOMMENDATION
ALIGNMENT	Upon installation and at one-year intervals thereafter (see Section 3.4).
OUTPUT POWER CALIBRATION	Same as above (see Section 3.5).
FANS	Inspect as often as possible (at least monthly) and clean when necessary. No lubrication needed.

3.2 Recommended Test Equipment:

EQUIPMENT	MANUFACTURER	MODEL #
Digital Multimeter	HEWLETT PACKARD	E2378A
Oscilloscope	TEKTRONIX	2232
VHF Sweep Generator	WAVETEK	2001
50 Ohm RF Detector	TELONIC BERKELEY	8553
20dB Attenuator	NARDA	766-20
30dB Directional Coupler	NARDA	3020A-30
50 Ohm, 1000W Dummy Load	BIRD	8833
Power Meter	HEWLETT PACKARD	435B
Frequency Counter	HEWLETT PACKARD	5386A
Spectrum Analyzer	HEWLETT PACKARD	8594E
NTSC Video Generator	TEKTRONIX	TSG100

switch should be in the ALIGN position (down) while performing sweep alignment of the Exciter Drawer and the Visual or Aural Driver Amplifiers. This switch position supplies a false AGC to the IF AGC Amplifier and Auto-On circuits while turning the OPERATE indicator off.

2. The CARRIER PRESENT indicator signifies that a visual IF carrier is present from the modulator, creating an AGC voltage within the IF AGC Amplifier which activates this LED. This green indicator will extinguish when there is loss of the IF carrier.

3. The green SYNTH LOCK indicator turns on if the Exciter's frequency synthesizer is properly locked. If not, the indicator will turn off and, if the problem persists, the synthesizer should be replaced.

4. The FINAL RF LED monitors the status of the Exciter's contactor K1 and illuminates when the contactor distributes voltage to the visual and aural 2 Watt VHF Amplifiers. Contactor K1 is energized by a low on the Driver Control line from the Power Supply/Control Status drawer. This low indicates that the transmitter's final and driver amplifiers are powered and ready for a drive signal from the Exciter. The FINAL RF DRIVE indicator will turn off with loss of video to the modulator, during a VSWR overload shutdown when the Control/Status OPERATE/STANDBY switch is open or when the Exciter circuit breaker is off.

TTV500ES TROUBLESHOOTING CHART

The following chart is meant as an aid to uncovering faults that have developed in the TTV500ES Transmitter. During normal operation, all indicator LEDS are green except for the VSWR LED which is extinguished. When a problem develops with the transmitter, note the LEDs that are RED or extinguished and compare these to the chart.

TTV500ES TROUBLESHOOTING CHART

PROBLEM	INDICATORS	CAUSE	SOLUTION
NO OUTPUT POWER	No LED Indicates a Fault	+48V Power Supply Failure	Check reading of +48V meter on Power Supply drawer (A4). Replace supply if defective.
		+28V Power Supply Failure	Check +28V meter on Power Supply drawer (A4). Replace supply if defective.
	CARRIER PRESENT LED is extinguished	Modulator Failure	Replace modulator.
		Modulator is not connected or is connected with a faulty cable.	Check cabling and replace cable if necessary.
	FINAL BIAS AURAL FINAL BIAS EXCITER ON FINAL RF DRIVE LEDs are extinguished	Operate/Standby switch on Standby	Place switch to Operate.
		No Video going into the modulator	Check Video and Audio inputs to modulator.
		Overheated Visual Final Drawer	Check fans to make sure they are operating. Make sure ambient temperature is within the 0°C to 50°C range. If problem persists, replace Visual Final Drawer.
	FINAL BIAS AURAL FINAL BIAS EXCITER ON FINAL RF DRIVE SYNTH LOCK LEDS are extinguished	Synthesizer Failure	Check Synthesizer output for correct level and frequency. Replace if defective.
		Reference Oscillator Failure	Check for correct level and frequency. Replace if faulty.

TTV500ES TROUBLESHOOTING CHART

PROBLEM	INDICATORS	CAUSE	SOLUTION
NO OUTPUT POWER	FINAL BIAS AURAL FINAL BIAS EXCITER ON FINAL RF DRIVE LEDs extinguished VSWR OVLD LED is RED	VSWR Overload condition	Check Diplexer, TX Line and Antenna for VSWR. Repair or replace faulty component before placing transmitter back on the air.
	VISUAL AMPL 3 AND VISUAL AMPL 4 LEDs are Red	Defective 300W Visual Final Amplifier pallets	Replace module corresponding to Red indicator.
	VISUAL DRIVER OR AURAL DRIVER LED is Red	Failed Driver Module	Replace malfunctioning module.
LOW OR DISTORTED OUTPUT SIGNAL	No Fault is indicated	Output Power Calibration is incorrect Linearizer is adjusted incorrectly Transmitter is out of Alignment Modulator Malfunction	See Section 3.5. See Section 3.6. See Section 3.4. Replace modulator.
	OPERATE/ALIGN LED is unlit	Operate/Align switch is on Align	Place switch to Operate.
	VISUAL AMPL 3 OR VISUAL AMPL 4 LED is Red	Failed 300W Visual Final Amplifier pallet	Replace defective module.

3.4 Alignment:

1. Assuming the transmitter is operating, place the Control/Status OPERATE/STANDBY switch to STANDBY and the Exciter's OUTPUT AGC switch to OFF. Remove the four cables from the rear panel and the four screws on the front panel of the Exciter drawer. Carefully pull out the drawer and remove its top cover. Leave the VISUAL and AURAL POWER ADJ controls as they would be under normal operation and place Linearizer switch A2S1 to OFF.

2. Visual Alignment:

   a. Set up the test equipment with the Exciter drawer as shown in Figure 3–4. Connect the VHF sweep generator's RF output to the VIS IF IN connector (J1) and attach the attenuator/detector combination to J3, the VIS RF OUTput. Set the VHF generator to sweep from approximately 36 to 50MHz using 45.75MHz and 41.25MHz markers if available.

   b. Place the OPERATE/STANDBY switch to OPERATE. Adjust the visual VHF Bandpass Filter (FL1) tuning screws designated C1, C2, C3 and C4 to obtain the appropriate frequency response shown in Figure 3–5.

3. Aural Alignment:

   a. Place the OPERATE/STANDBY switch to STANDBY. With the test equipment set up as shown in Figure 3–4, connect the VHF sweep generator's RF output to the AUR IF IN connector (J2) and attach the attenuator/detector to J4, the Aural RF OUT connector. Set the VHF generator to sweep from approximately 36 to 50MHz using a 41.25MHz marker if available.

   b. Repeat step #2b for the aural VHF Bandpass Filter (FL2) but with the frequency response centered on the 41.24MHz aural marker.

4. Place the OPERATE/STANDBY switch to STANDBY and remove the test equipment. Reconnect the modulator's coaxial cables to the VIS IF IN and AUR IF IN connectors and the Visual IPA/Aural Final drawer cables to the VIS RF OUT and AUR RF OUT connectors. Place the Linearizer's precorrection switch to ON.

3.5 Output Power Calibration:

To insure correct transmission parameters, the output power level and % POWER meter calibration of the transmitter should be checked at least once every year. With the VISUAL meter switch in the FWD position, the VISUAL % POWER meter has been factory calibrated for 100% with the transmitter providing 500 watts of peak visual power. With the AURAL meter switch in the FWD position the AURAL % POWER meter is calibrated for 100% with the transmitter providing 50 watts of average aural power. The following calibration procedure assumes that the composite signal from the transmitter has the aural carrier 10dB below the visual with the visual carrier consisting of 87.5% video modulation and 0% average picture level (APL). Power levels at 50% APL (Gray) are included in brackets following the power levels at 0% APL (Sync only).

3.5a Forward Power:

1. With the Control/Status OPERATE/STANDBY switch in STANDBY, set up the test equipment as shown in Figure 3–6.

2. Place the modulator's power switch to ON (if applicable) and verify 87.5% video modulation with 0% APL. Place the VHF 2W Exciter POWER circuit breaker to ON, its OPERATE/ALIGN switch to OPERATE, its OUTPUT AGC switch to OFF, and its % POWER switch to VISUAL. Turn the AURAL POWER ADJUST control fully counterclockwise to disable the aural carrier.

3. To set the transmitter's visual output power, turn the VISUAL POWER ADJ control for a power reading of 297.5 [170] watts as seen on the external average power meter. (Note that 500 watts peak visual with 0% APL is equal to 297.5 watts average power. However, when using a 30dB coupler, the average meter will actually read 297.5mW.)

4. With the power meter reading correctly, place the VISUAL meter switch to FWD and check the % POWER meter for a 100% indication. If this reading is not obtained, adjust potentiometer R9 of Metering Detector A8 for a 100% indication. A8R9 is accessible through the hole marked VIS CAL on the front of the transmitter's meter panel.

5. Place the 2W Exciter AGC switch to ON and verify that the VISUAL % POWER meter still reads 100%. If necessary, slowly vary the AGC ADJ control for a 100% indication.

6. To set the transmitter's aural output power, rotate the AURAL POWER ADJ control for a combined external power meter reading of 347.5W [220W]. (Note that 50 watts of average aural power plus 297.5 watts of average visual equals 347.5 watts total average power or 347.5mW at the 30dB port of the directional coupler.)

7. With the external power meter reading the correct composite output power, place the AURAL meter switch to FWD and check the % POWER meter for a 100% indication. If this reading is not obtained, adjust potentiometer R18 of Metering Detector A7 for a 100% indication. A7R18 is accessible through the hole marked AUR CAL on the front of the transmitter's meter panel.

3.5b Visual Reflected Power (Optional):

8. Place the 2W Exciter AGC switch to OFF and disable the transmitter's aural carrier [e.g. Remove the aural IF modulator cable from the AURAL IF INPUT connector (J2) on the Exciter's rear panel].

9. Adjust potentiometer R30 of the Visual Metering Detector (A8) fully clockwise to disable the VSWR overload detection circuit. A8R30 is accessible through the hole marked VISUAL METER ADJUST/VSWR OVLD SET on the front of the transmitter's meter panel.

10. Remove and reverse the coaxial cables connected to the INCIDENT and REFLECTED ports of the Visual Metering Coupler DC1. The Metering Detector's reflected power circuit will now monitor the transmitter's forward visual power simulating an open circuit (total returned power) at the transmitter's visual output.

11. Place the VISUAL meter switch to REFLD and check the % POWER meter for a 100% indication (70% for 50% APL). If this reading is not obtained, adjust potentiometer R27 of Metering Detector A8 for the correct indication. A8R27 is also accessible through the transmitter's front panel at the hole marked VISUAL METER ADJUST/REFLD CAL.

12. Decrease the transmitter's output power to 10% by setting the VISUAL POWER ADJ control for an external power meter reading of 30W [17W]. This average power level is used for setting the "trip point" of the VSWR overload detection circuit. Adjust potentiometer R30 of the Visual Metering Detector slowly counterclockwise until the VSWR OVLD indicator illuminates red. A8R30 is accessible through the hole marked VISUAL METER ADJUST/ VSWR OVLD SET on the front of the transmitter's meter panel. Leave the potentiometer at this setting.

13. Remove the coaxial cables connected to the Visual Metering Coupler INCIDENT and REFLECTED ports and connect them to their original positions. Since 10% reflected power is no longer present, activate the VSWR OVLD reset switch and verify that the VSWR OVLD indicator extinguishes.

14. Increase the transmitter's visual output power from 10% back to 100% by resetting the VISUAL POWER ADJ for an external power meter reading of 297.5W [170W]. Place the VISUAL meter switch to FWD for constant monitoring of the transmitter's visual output power. Place the AGC switch to ON and, if necessary, reset the AGC ADJ for a 100% indication on the % POWER meter.

15. Bring the aural carrier back on line by reattaching the modulator's aural cable to the AURAL IF INPUT connector on the rear panel of the Exciter drawer.

3.5c Aural Reflected Power (Optional):

16. Place the Exciter's AGC switch to OFF and disable the visual carrier by removing the modulator's IF cable from the VISUAL IF INPUT on the rear of the Exciter drawer.

17. Adjust potentiometer R30 of the Aural Metering Detector (A7) fully clockwise to disable the aural VSWR overload detection circuit. A7R30 is accessible through the hole marked AURAL METER ADJUST/VSWR OVLD SET on the front of the transmitter's meter panel.

18. Remove and reverse the coaxial cables connected to the INCIDENT and REFLECTED ports of the Aural Metering Coupler DC2. The Metering Detector's reflected power circuit will now monitor the transmitter's forward aural power simulating an open circuit (total returned power) at the transmitter's aural output.

19. Place the AURAL meter switch to REFLD and check the % POWER meter for a 100% indication when measuring 50 watts of aural power on the external power meter. If this reading is not obtained, adjust potentiometer R27 of the Aural Metering Detector (A7) for the correct indication. A7R27 is accessible through the transmitter's front meter panel at the hole marked AURAL METER ADJUST/REFLD CAL.

20. Decrease the transmitter's aural output power to 30% by setting the AURAL POWER ADJ control for an external power meter reading of 15W. This average power level is used for setting the "trip point" of the VSWR overload detection circuit. Adjust potentiometer R30 of the Aural Metering Detector (A7) slowly counterclockwise until the VSWR OVLD indicator

illuminates red. A7R30 is accessible through the hole marked AURAL METER ADJUST/ VSWR OVLD SET on the front of the transmitter's meter panel. Leave the potentiometer at this setting.

21. Remove the coaxial cables connected to the Metering Coupler's INCIDENT and REFLECTED ports and connect them to their original positions. Since 10% reflected power is no longer present, activate the VSWR OVLD RESET momentary switch and verify that the VSWR OVLD indicator extinguishes.

22. Increase the transmitter's aural output power from 30% back to 100% by resetting the AURAL POWER ADJ control for an external power meter reading of 50W. Place the AURAL meter switch to FWD for constant monitoring of the transmitter's aural output power.

23. Place the Control Status OPERATE/STANDBY switch to STANDBY and disconnect the test equipment from the transmitter. Reconnect the modulator's visual cable to the VISUAL IF INPUT connector on the Exciter's rear panel and reapply regular programming to the modulator's baseband video and audio inputs.

24. Reconnect the transmitting antenna cable to the transmitter's RF OUT connector (J3). Place the OPERATE/STANDBY switch back to OPERATE to place the transmitter on the air.

3.6 Linearizer Adjustment:

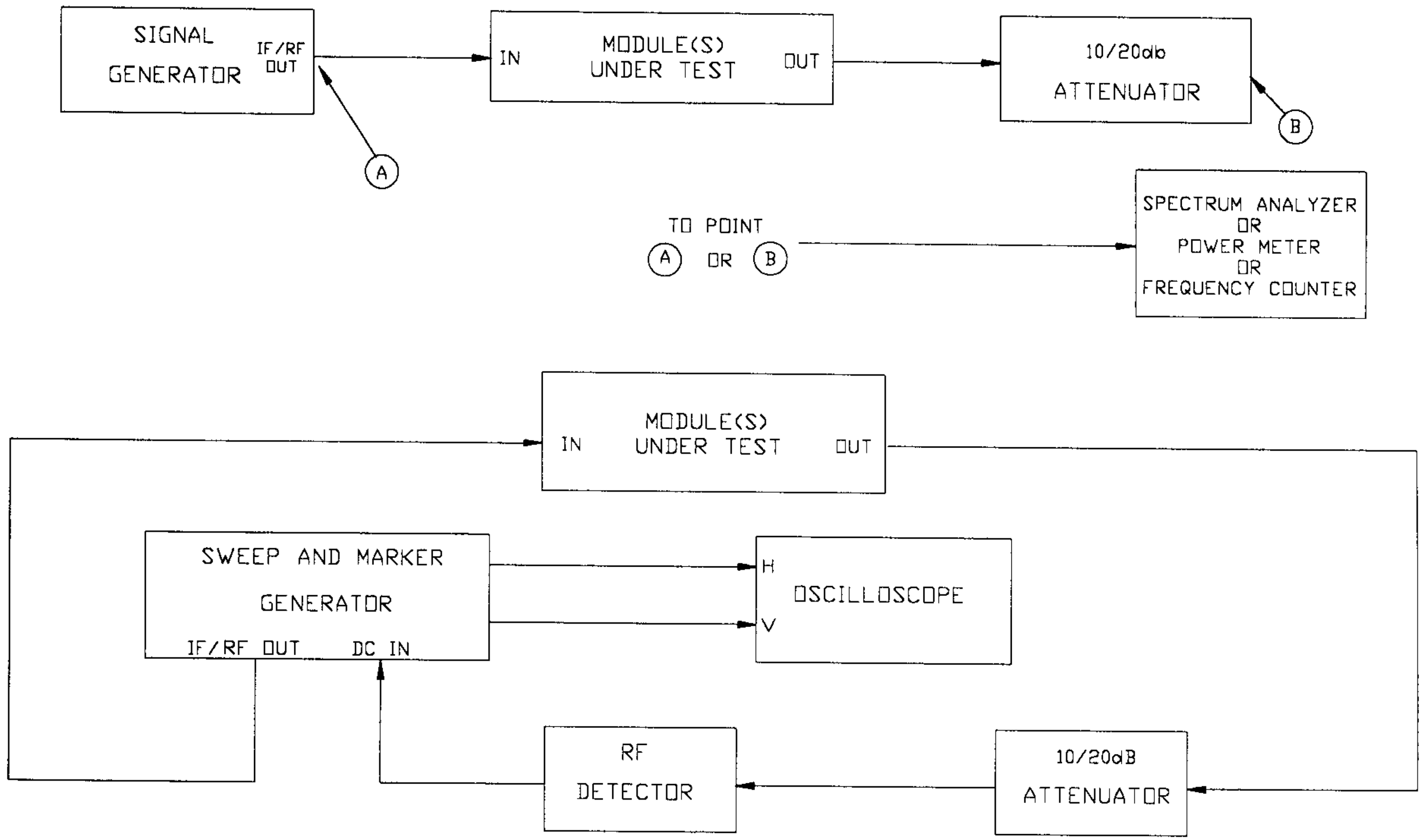
Adjustment of the Exciter's Linearizer is limited to eight potentiometers which should not be realigned unless absolutely necessary. (The Linearizer can produce unwanted distortion if adjusted incorrectly.) The test equipment which should be available for readjustment of the Linearizer is a spectrum analyzer for measurement of sync or a waveform monitor and television demodulator for sync and differential gain measurements. Acquire as much of this test equipment as possible since the amount of linearity correction will depend on equipment versatility. The transmitter should be aligned and have its output power properly calibrated before any adjustments are done on the Linearizer.

1. To the output of the transmitter connect the test equipment available for monitoring sync amplitude and differential gain.

2. Remove the four screws on the front panel of the Exciter drawer, pull out the drawer, and remove its top cover. Insure switch S1 of the Linearizer is in the ON position.

3. Place the transmitter in an operating condition with the system providing its rated output. Slowly adjust potentiometers R37 through R40, R10, R11, R21 and R22. Normally, differential gain will improve as the sync amplitude reaches 100%.

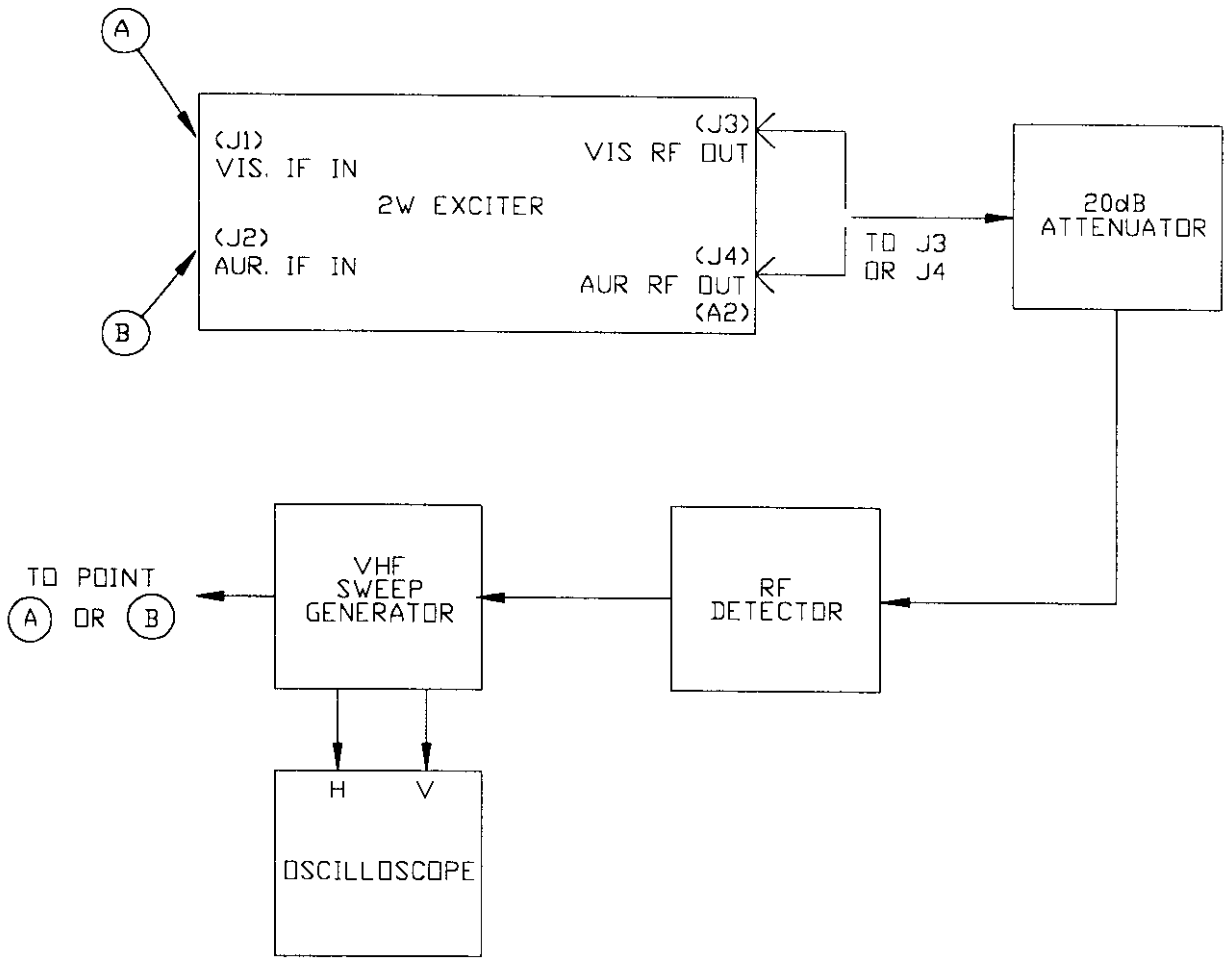
4. Reinstall the top cover to the Exciter drawer, slide the drawer back into the cabinet, and secure it properly.



TEST EQUIPMENT SETUPS FOR MEASURING THE GAIN OR LOSS OF THE MODULES COMPRISING THE RF AMPLIFIER CHAIN

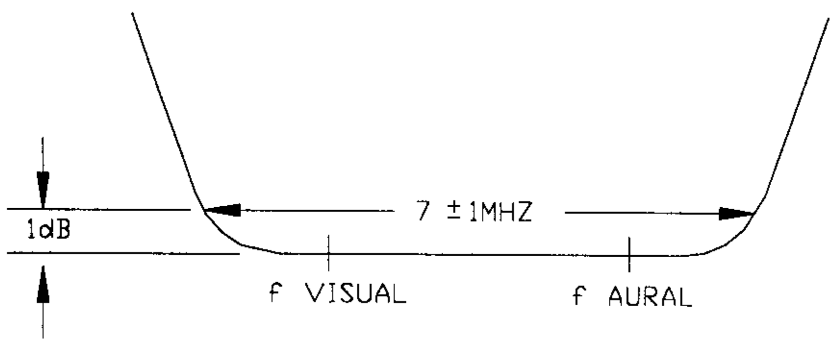
FIGURE 3-1

10129783



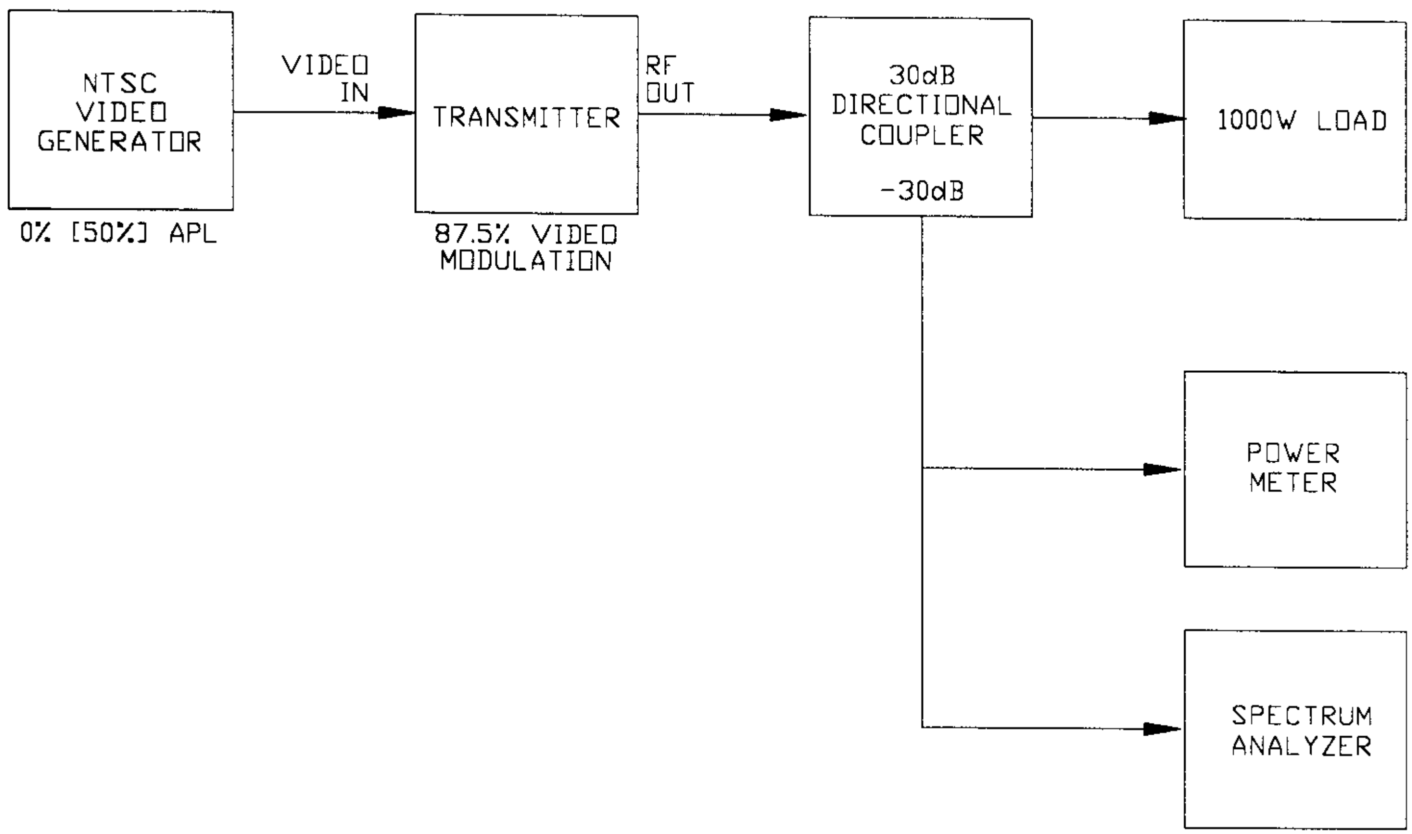
ALIGNMENT OF RF AMPLIFIER CHAIN
FIGURE 3-4

BANDPASS FILTER ALIGNMENT



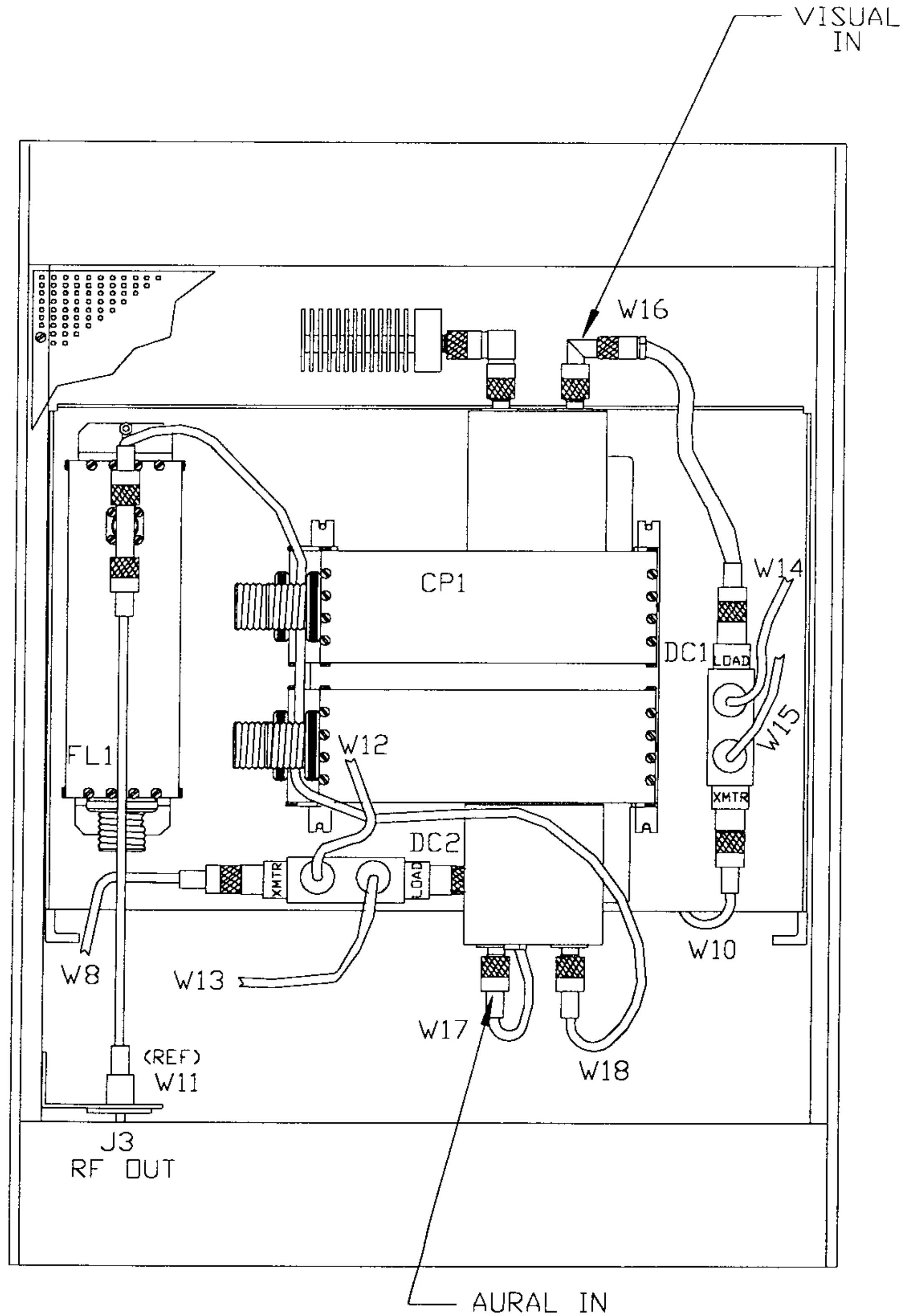
FREQUENCY RESPONSE OF RF AMPLIFIER CHAIN
FIGURE 3-5

00223



OUTPUT POWER CALIBRATION
FIGURE 3-6

00288



BAND III VISUAL/AURAL DIPLEXER

FIGURE 3-7

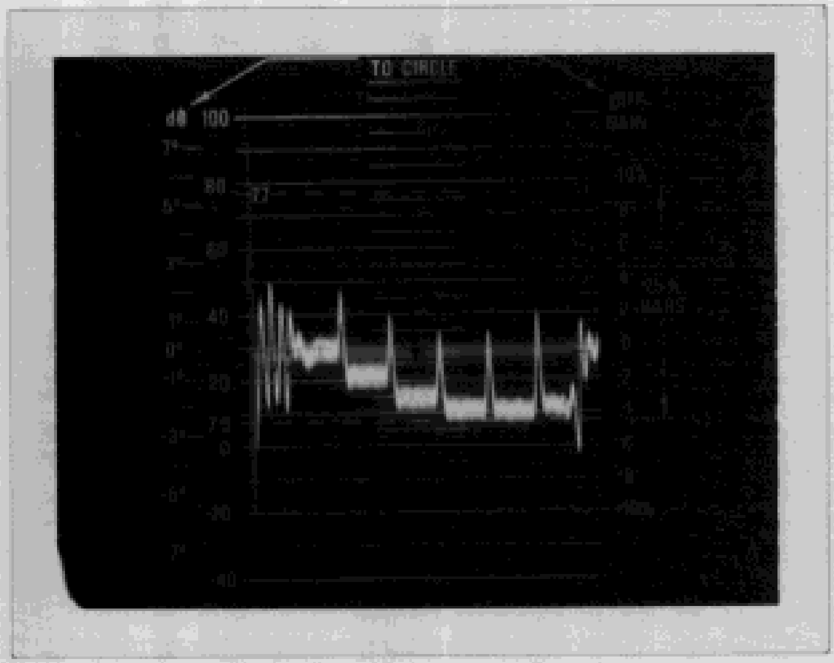
00290

3.7 Spare Modules and Components:

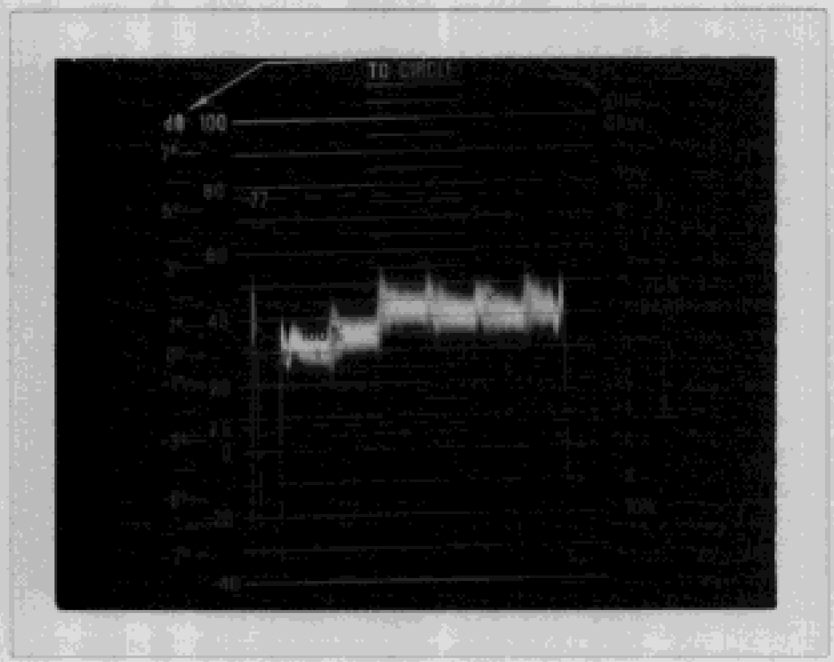
The following is the description, vendor, part number, and designator of each module found in the TTV500ES Transmitter that EMCEE considers to be essential bench-stock items. These modules should be available to the technician at all times.

INTERCONNECTION DIAGRAM 40362475 (REV 52)

DESCRIPTION	VENDOR/PART #	DESIGNATOR
Linearizer	EMCEE/60367083-1	A2A2
IF AGC Amplifier	EMCEE/B331-42-1	A2A1
Power Adjust	EMCEE/B331-295-1 & 2	A2AT1, A2AT2
LO Splitter/Amplifier	EMCEE/60362030-1	A2A6
Reference Oscillator	EMCEE/60368055-1	A2A4A2
VHF Synthesizer (BAND III)	EMCEE/60367103-2	A2A4A1
OR		
VHF Synthesizer (BAND I)	EMCEE/60367103-3	A2A4A1
2W VHF Amplifier	EMCEE/70362260-1	A2A3, A2A7
Limiter/Output AGC	EMCEE/B331-36-1	A2PC1
+28V Power Supply	EMCEE/60319220-1	A2PS1
±15V/±5V Power Supply	Deltron/W300A	A2PS2, A4PS1
Visual Driver Amplifier (BAND I)	EMCEE/80362096-2	A3A1
Visual Driver Amplifier (BAND III)	EMCEE/80362096-1	A3A1
Aural Driver Amplifier	EMCEE/70362095-1	A3A2
Aural Final Amplifier (BAND I)	EMCEE/80362313-1	A3A3
Aural Final Amplifier (BAND III)	EMCEE/80362094-1	A3A3
Fault Circuit	EMCEE/60370023-1	A3A1PC3, A3A2PC2
Visual Final Amplifier (BAND I)	EMCEE/80362308-1	A5A3, A5A4
Visual Final Amplifier (BAND III)	EMCEE/40362372-1	A5A3, A5A4
Control Status	EMCEE/40362437-1	A4PC1
+28V Power Supply	UNIPOWER/001-1770-050	A4PS2
+48V Power Supply	HC/HC2511-B	A4PS3
Metering Detector	EMCEE/60368050-1	A7, A8, A2A8

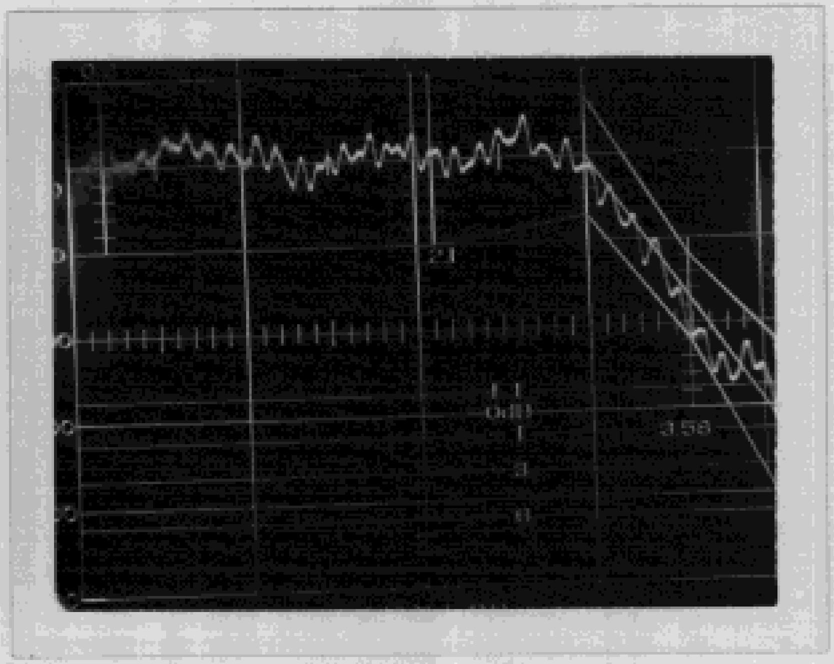


DIFFERENTIAL PHASE – +2.3°



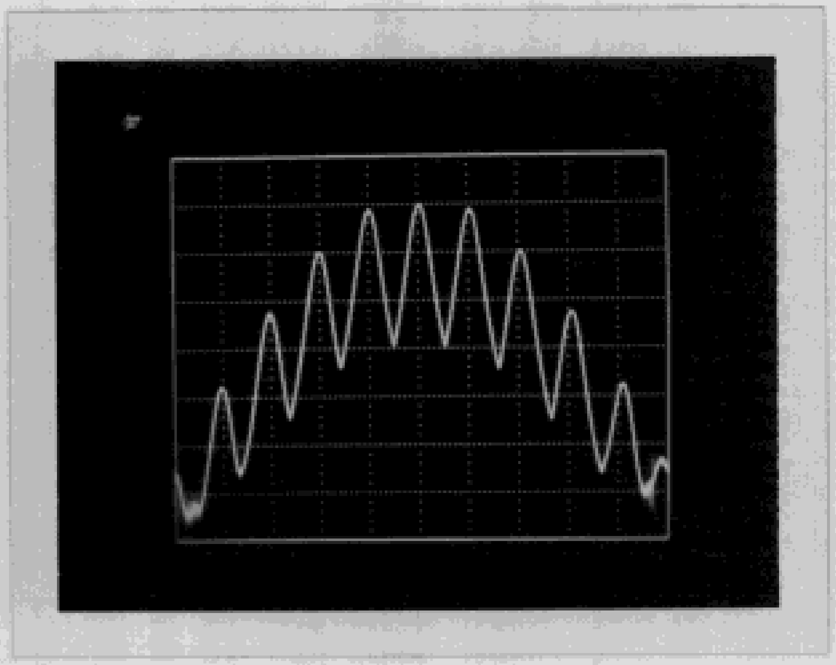
DIFFERENTIAL GAIN – 2.5%

Figure 2–3



ENVELOPE DELAY

Figure 2–4



AURAL OCCUPIED BANDWIDTH
Figure 2–5