ENGINEERING STATEMENT

For Type Certification of

MAXON AMERICA, INC.

Model No: SM-6150-V2
FCC ID: F3JSM6150V2

I am an Electronics Engineer, a principal in the firm of Hyak Laboratories, Inc., Springfield, Virginia. My education and experience are a matter of record with the Federal Communications Commission.

Hyak Laboratories, Inc. has been authorized by Maxon America, Inc. to make type certification measurements on the SM-6150-V2 transceiver. These tests made by me or under my supervision in our Springfield laboratory.

Test data and documentation required by the FCC for Type Certification are included in this report. The data verifies that the above mentioned transceiver meets FCC requirements and Type Certification is requested.

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Rowland S. Johnson

Dated: June 30, 2000

A. INTRODUCTION

The following data are submitted in connection with this request for Type Certification of the SM-6150-V2 transceiver in accordance with Part 2, Subpart J of the FCC Rules.

The SM-6150-V2 is a multi-bandwidth, VHF, frequency modulated transceiver intended for vehicular mobile applications in the 148 - 174 MHz band. It operates from a nominal 13.8 volt supply. Output power rating is 10-45 watts. Both 25 kHz and 12.5 kHz channel operation is provided.

B. GENERAL INFORMATION REQUIRED FOR TYPE CERTIFICATION (Paragraph 2.983 of the Rules)

1. Name of applicant: Maxon America, Inc.

2. Identification of equipment: F3JSM6150V2

   a. The equipment identification label is submitted as a separate exhibit.
   b. Photographs of the equipment are submitted as a separate exhibit.

3. Quantity production is planned.

4. Technical description:

   a. 16k0F3E; 11k0F3E emission
   b. Frequency range: 148-174 MHz.
   c. Operating power of transmitter is fixed at the factory at 45 watts and can be reduced to 10 watts.
   d. Maximum power permitted under Part 90 of the FCC is 350 watts, and the SM-6150-V2 fully complied with those power limitations.
   e. The dc voltage and dc currents at final amplifier:

      Collector voltage: 13.6 Vdc
      Collector current: 6.5 A

   f. Function of each active semiconductor device: See Appendix 1.
   g. Complete circuit diagram is submitted as a separate exhibit.
   h. A draft instruction book is submitted as a separate exhibit.
   i. The transmitter tune-up procedure is submitted as a separate exhibit.

j. A description of circuits for stabilizing frequency is included in Appendix 2.

B. GENERAL INFORMATION… (Continued)

k. A description of circuits and devices employed for suppression of spurious radiation and for limiting modulation is included in Appendix 3.

l. Not applicable.

5. Data for 2.985 through 2.997 follow this section.

C. RF POWER OUTPUT (Paragraph 2.985(a) of the Rules)

RF power output was measured with a Bird 4421 RF power meter and a Narda 765-20 attenuator as a 50 ohm dummy load. Maximum power measured was 45 watts; and with internal adjustments minimum power was 10 watts. (The transmitter was tuned by the factory.)

D. MODULATION CHARACTERISTICS

1. A curve showing frequency response of the transmitter is shown in Figure 1. Reference level was audio signal output from a Boonton 8220 modulation meter with one kHz deviation. Audio output was measured with a Audio Precision System One TRMS voltmeter and tracking generator.

2. Modulation limiting curves are shown in Figures 2a and 2b for wide or narrow channel operation respectively, using a Boonton 8220 modulation meter. Signal level was established with a Audio Precision System One TRMS voltmeter. The curves show compliance with paragraphs 2.987(b), and 90.211(c).

3. Figure 3 is a graph of the post-limiter low pass filter which meets the requirements of paragraph 90.211(d)(1) in providing a roll-off of 60Logf/3 dB where f is audio frequency in kHz. Measurements were made following EIA RS-152B with an Audio Precision System One selective voltmeter on the Boonton 8220 modulation meter audio output.

D. MODULATION CHARACTERISTICS (Continued)

4. Occupied_Bandwidth
(Paragraphs 2.989(c), 90.209(b)(4) and 90.210(d) of the Rules)

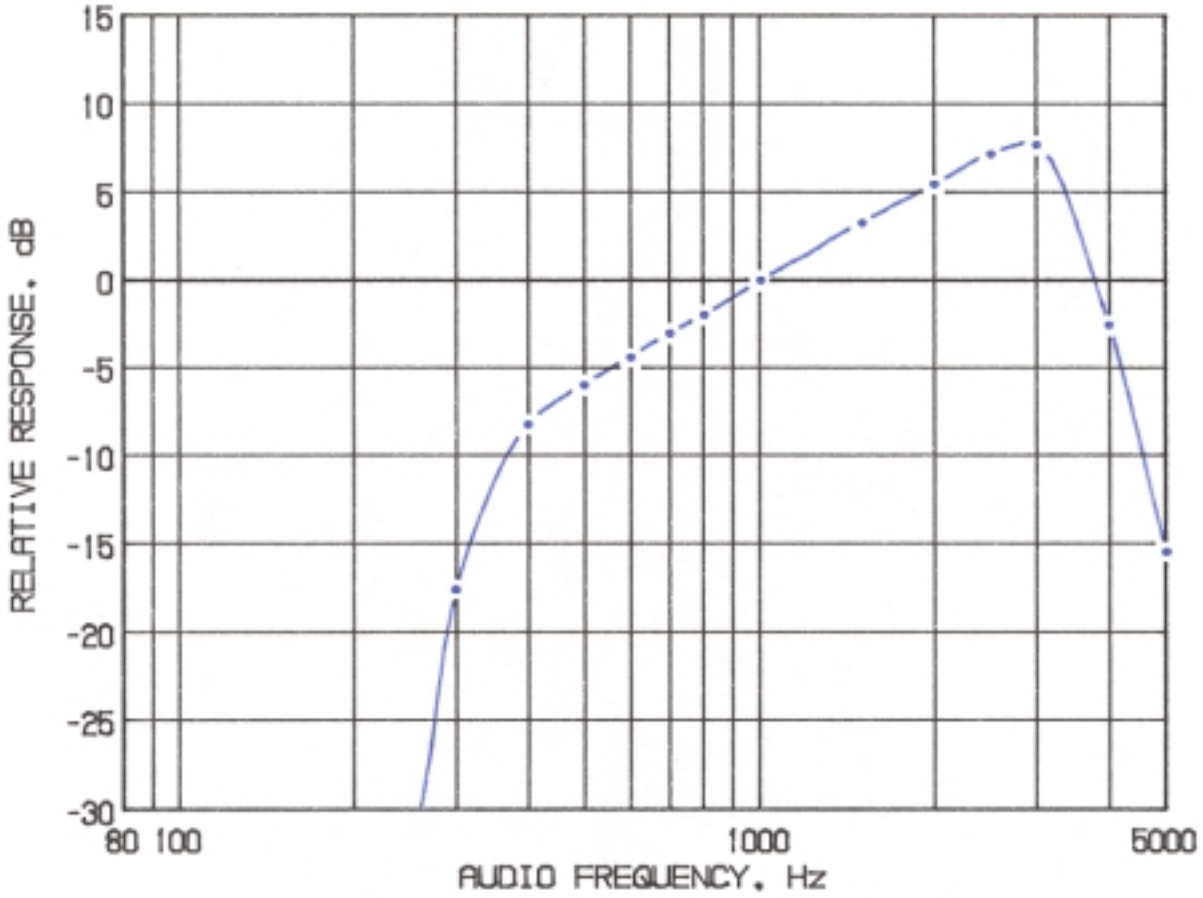
Figures 4a, 4b, 4c and 4d are plots of the sideband envelope of the transmitter for both 45 and 10 watt output taken with a Advantest R3361A spectrum analyzer. Modulation corresponded to conditions of 2.989(c)(1) and consisted of 2500 Hz tone at an input level 16 dB greater than that necessary to produce 50% modulation at 2476 Hz, the frequency of maximum response. Measured modulation under these conditions was 3.8 kHz, or 1.9 kHz for 25 or 12.5 kHz channelization respectively.

For the 12.5 kHz channelization, RBW was 100 Hz, VBW 100 Hz, max hold, multiple scan per 90.210(d)(4).

All plots have unmodulated carrier as 0 dBm reference.

FIGURE 1

MODULATION FREQUENCY RESPONSE

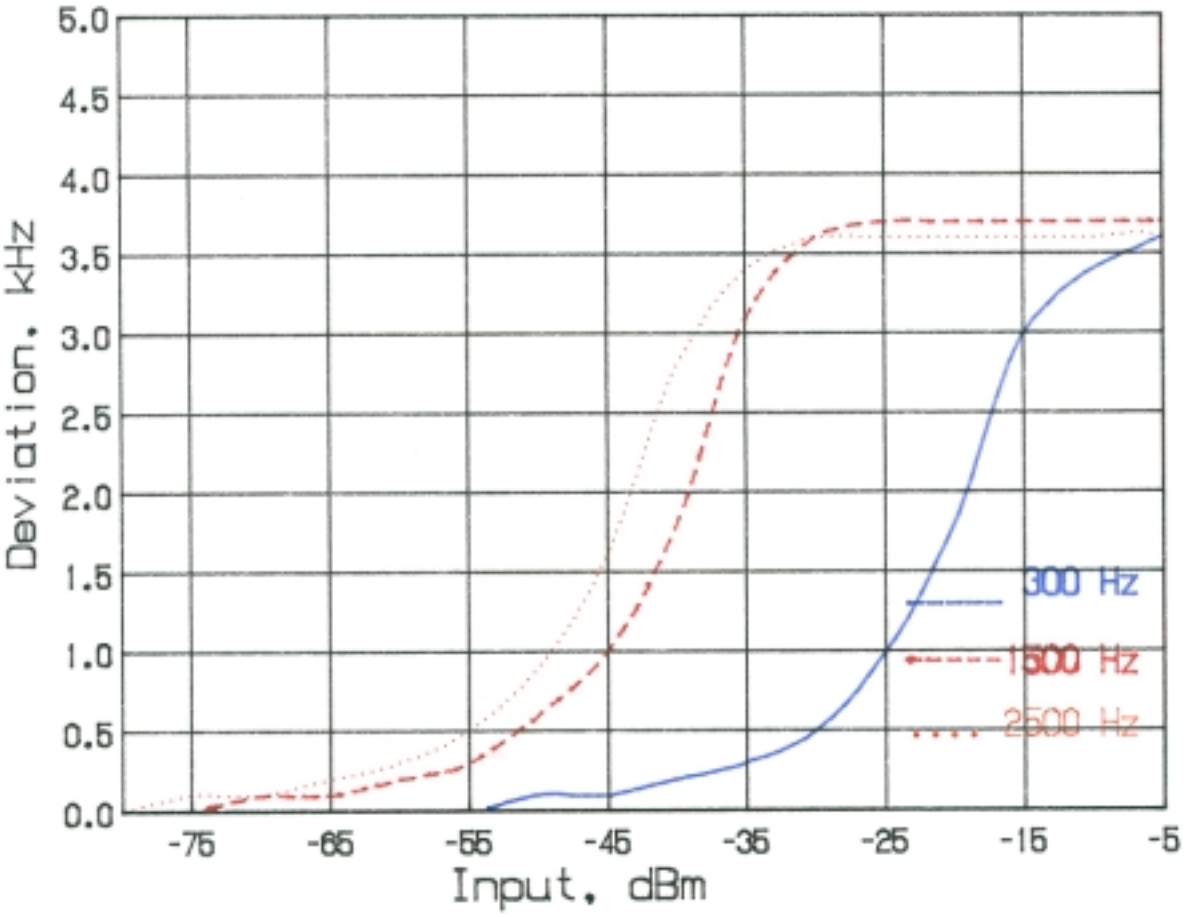


MODULATION FREQUENCY RESPONSE
FCC ID: F3JSM6150V2

FIGURE 1

FIGURE 2a

AUDIO LIMITER CHARACTERISTICS

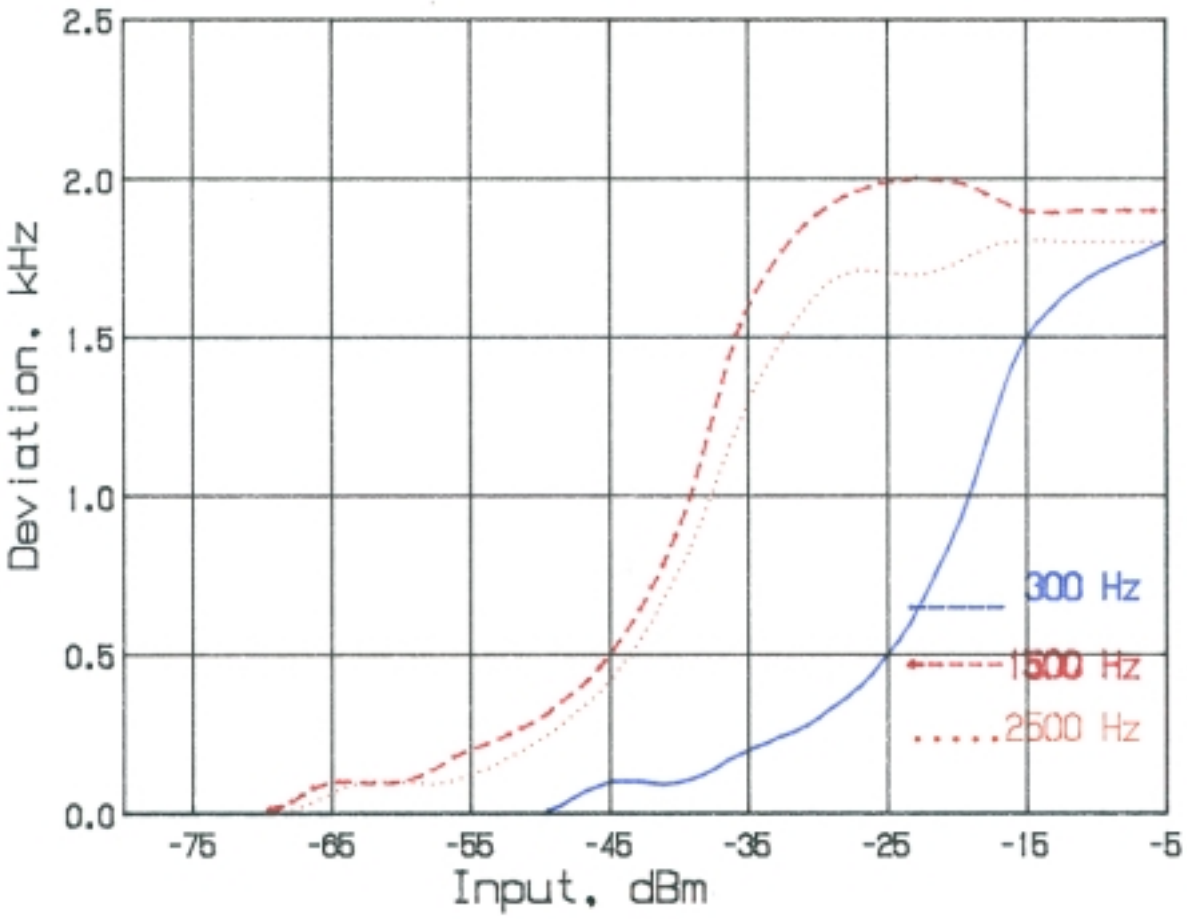


AUDIO LIMITER CHARACTERISTICS
FCC ID: F3JSM6150V2

FIGURE 2a Wideband (5 kHz)

FIGURE 2b

AUDIO LIMITER CHARACTERISTICS

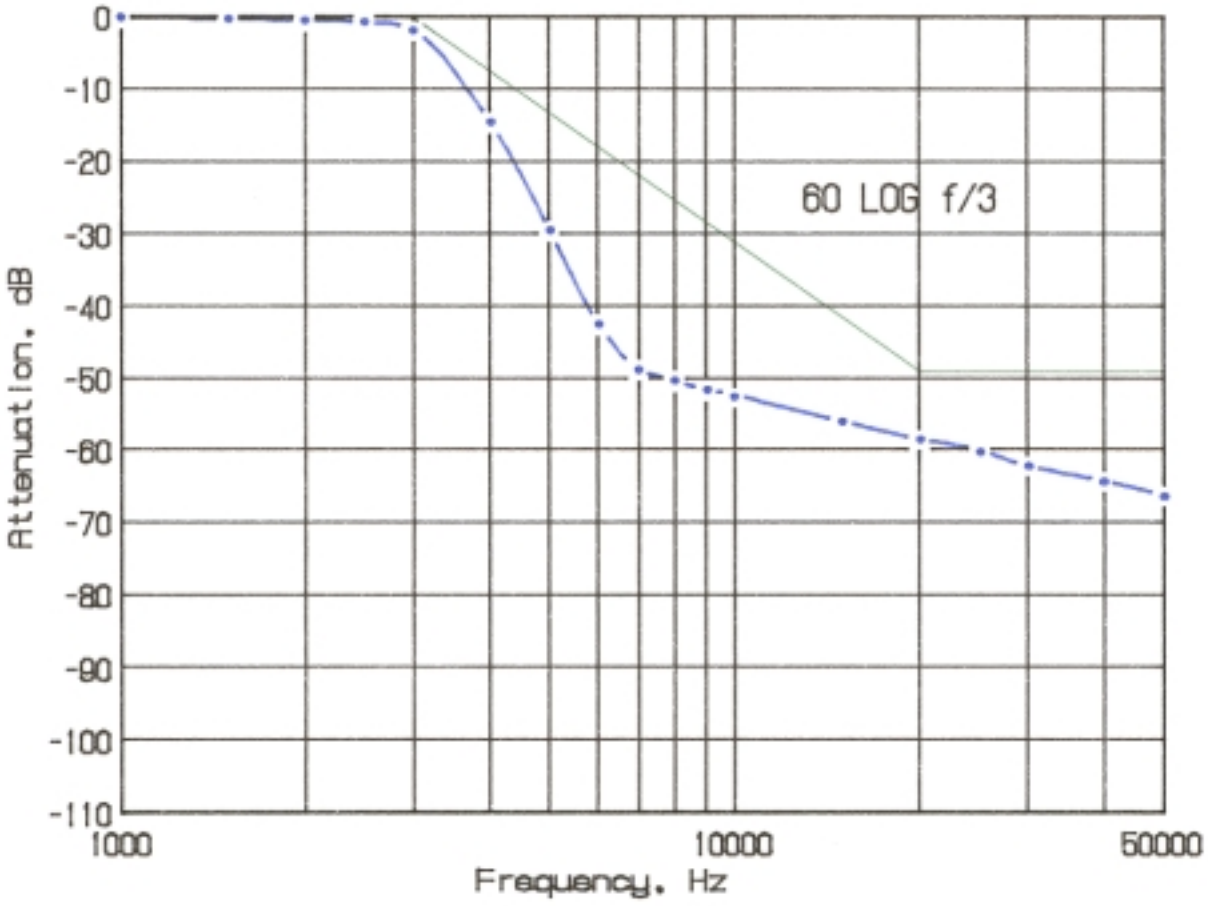


AUDIO LIMITER CHARACTERISTICS
FCC ID: F3JSM6150V2

FIGURE 2b Narrow band (2.5 kHz)

FIGURE 3

AUDIO LOW PASS FILTER RESPONSE

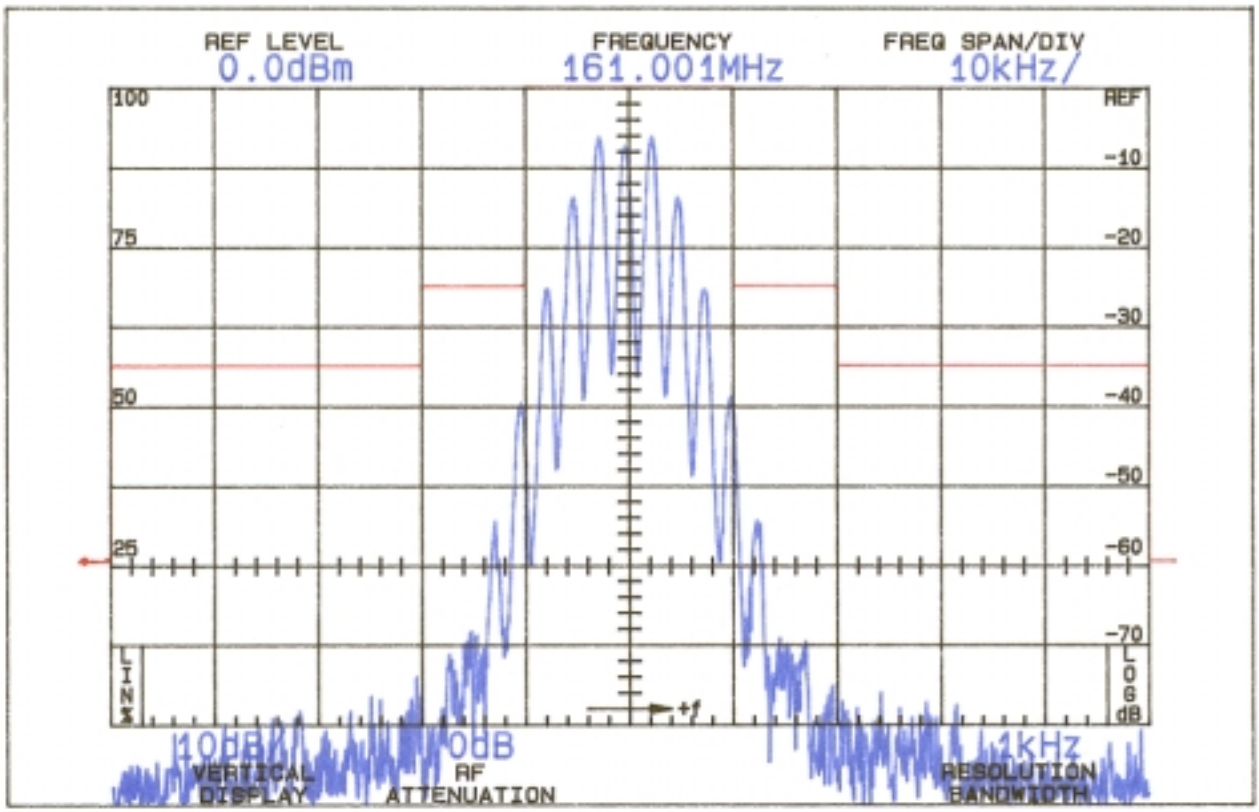


AUDIO LOW PASS FILTER RESPONSE
FCC ID: F3JSM6150V2

FIGURE 3

FIGURE 4a

OCCUPIED BANDWIDTH



	ATTENUATION IN dB BELOW MEAN OUTPUT POWER Required
On any frequency more than 50% up to and including 100% of the authorized bandwidth, 20 kHz (10-20 kHz)	25
On any frequency more than 100%, up to and including 250% of the	35

authorized bandwidth (20-50 kHz)

On any frequency removed from the assigned frequency by more than 250% of the authorized bandwidth (over 50 kHz)

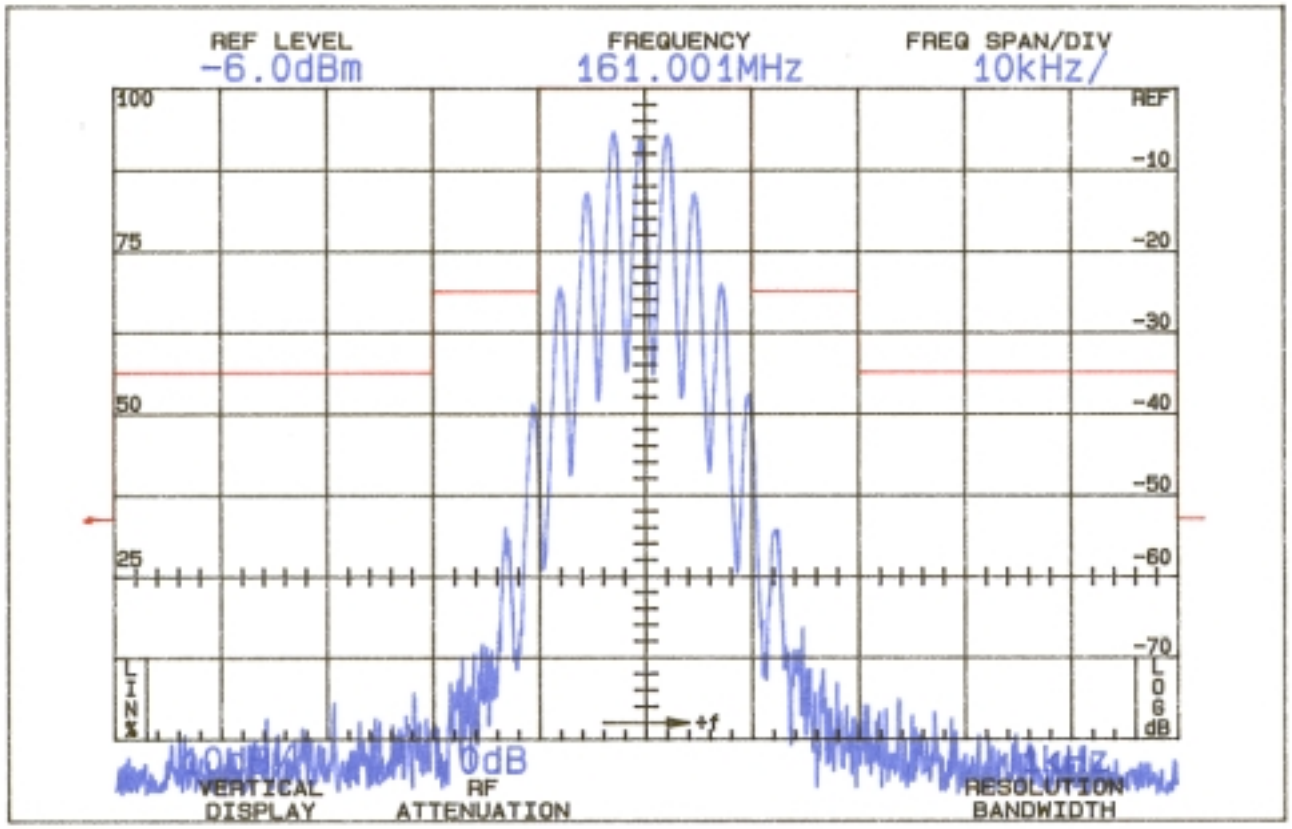
43+10LogP = 60
(P = 45 W)

OCCUPIED BANDWIDTH (45 W)
FCC ID: F3JSM6150V2

FIGURE 4a (5 kHz)

FIGURE 4b

OCCUPIED BANDWIDTH



ATTENUATION IN dB BELOW MEAN OUTPUT POWER Required

On any frequency more than 50% up to and including 100% of the authorized bandwidth, 20 kHz (10-20 kHz)

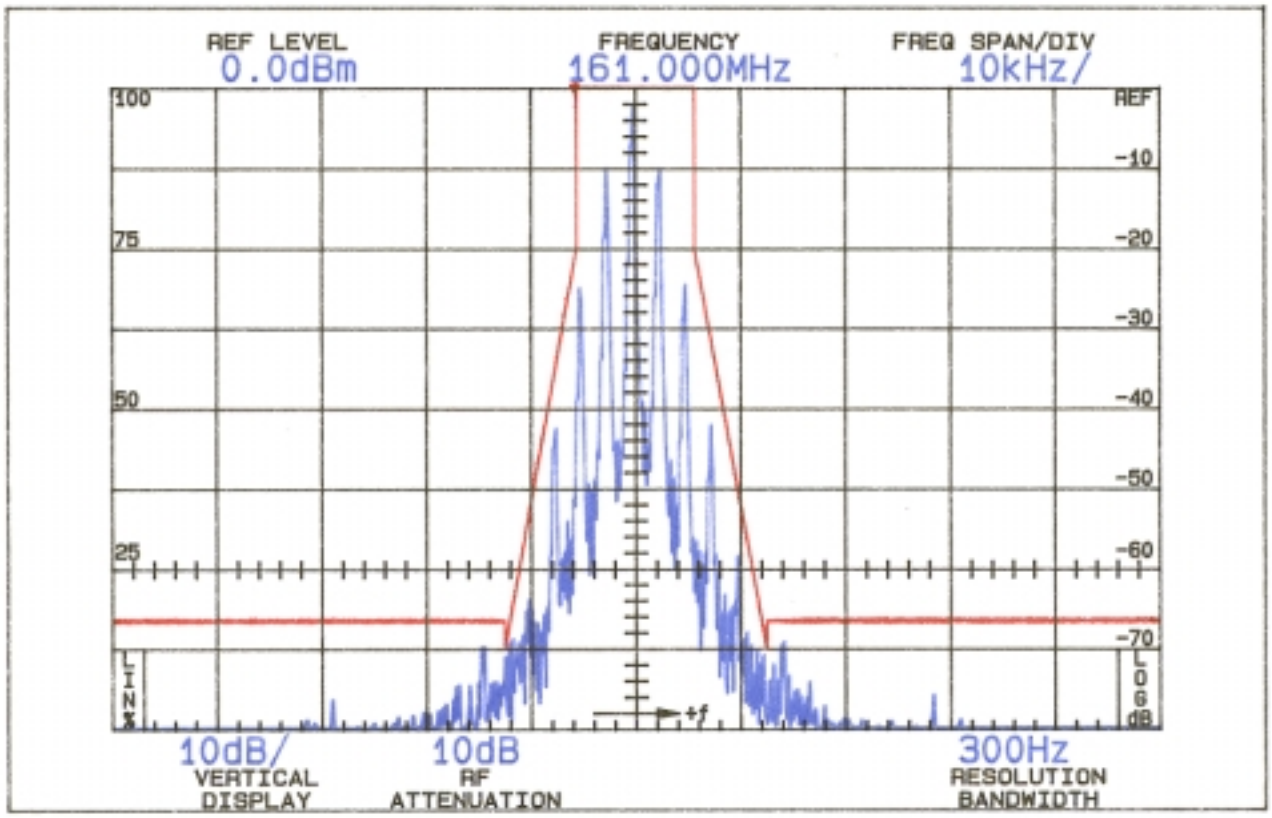
25

On any frequency more than 100%, up to and including 250% of the authorized bandwidth (20-50 kHz)	35
On any frequency removed from the assigned frequency by more than 250% of the authorized bandwidth (over 50 kHz)	43+10LogP = 53 (P = 10 W)

OCCUPIED BANDWIDTH (10 W)
FCC ID: F3JSM6150V2

FIGURE 4b (5 kHz)

FIGURE 4c
OCCUPIED BANDWIDTH



	ATTENUATION IN dB BELOW MEAN OUTPUT POWER Required
On any frequency from the center of the authorized bandwidth f_o to 5.625 kHz removed from f_o.	0 (>5.625 kHz)
On any frequency removed from the	

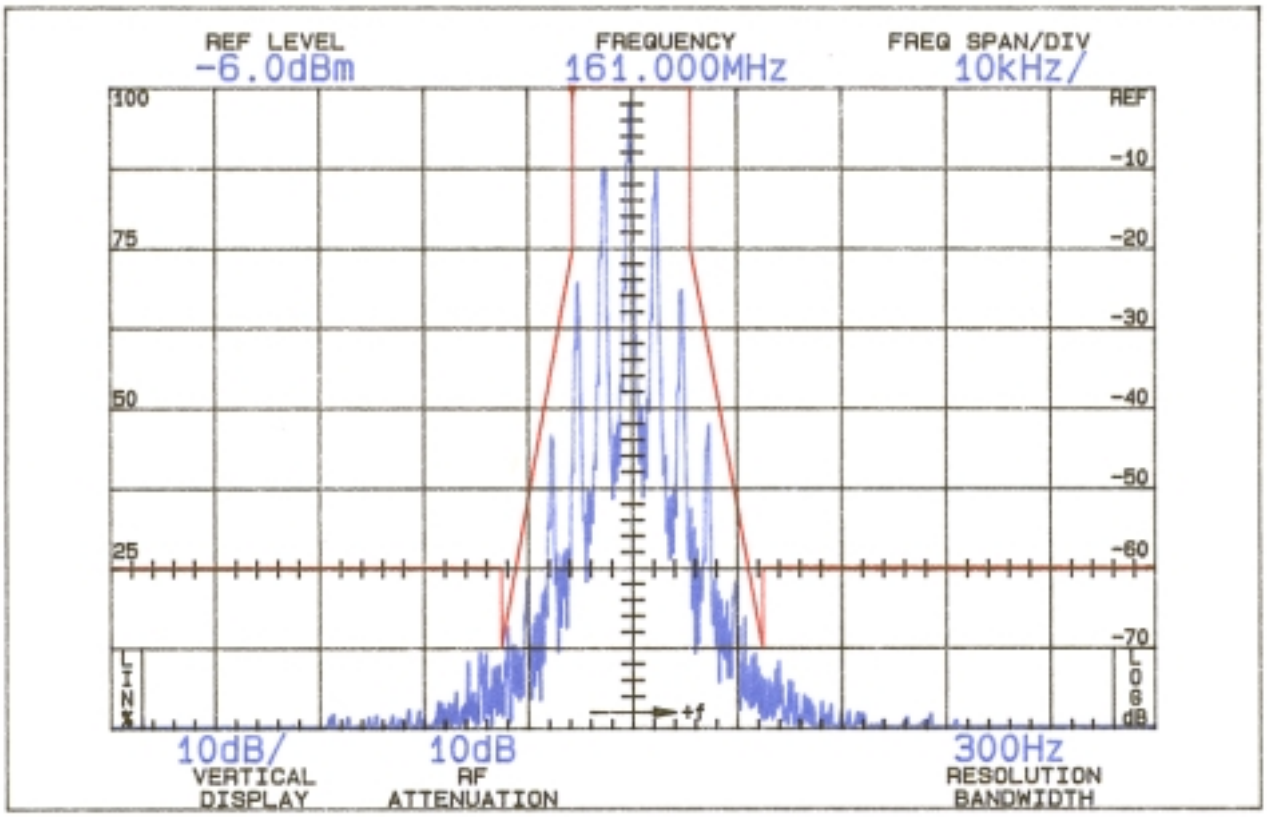
center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.625 kHz but no more than 12.5 kHz: at least 7.27 (f_d - 2.88 kHz) dB.	70 (@ 12.5 kHz)
On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz.	50+10LogP = 67 (>12.5 kHz) (P = 45W)

OCCUPIED BANDWIDTH (F3E 45W)
FCC ID: F3JSM6150V2

FIGURE 4c (2.5 kHz)

FIGURE 4d

OCCUPIED BANDWIDTH



	ATTENUATION IN dB BELOW MEAN OUTPUT POWER Required
On any frequency from the center of the authorized bandwidth f_o	0 (>5.625 kHz)

to 5.625 kHz removed from f_o.

On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.625 kHz but no more than 12.5 kHz: at least 7.27 (f_d - 2.88 kHz) dB.	70 (@ 12.5 kHz)
On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz.	50+10LogP = 60 (>12.5 kHz) (P = 10W)

OCCUPIED BANDWIDTH (F3E 10W)
FCC ID: F3JSM6150V2
FIGURE 4d (2.5 kHz)

D. MODULATION CHARACTERISTICS (Continued)

The plots are within the limits imposed by Paragraph 90.211(c) for frequency modulation. The horizontal scale (frequency) is 10 kHz per division and the vertical scale (amplitude) is a logarithmic presentation equal to 10 dB per division.

Resolution bandwidth was 100 Hz; video bandwidth 1 kHz; max store display; 20 second scan time.

E. SPURIOUS EMISSIONS AT THE ANTENNA TERMINALS
(Paragraph 2.991 of the Rules)

The SM-6150-V2 transmitter was tested for spurious emissions at the antenna terminals while the equipment was modulated with a 2500 Hz signal, 16 dB above minimum input signal for 50% (2.5 kHz deviation) modulation at 2476 Hz, the frequency of highest sensitivity.

Measurements were made with Tektronix 494P spectrum analyzer coupled to the transmitter output terminal through a Narda 765-20 power attenuator. A notch filter was used to attenuate the carrier.

During the tests, the transmitter was terminated in the 50 ohm attenuator. Power was monitored on a Bird 43 Thru-Line wattmeter; dc supply was 13.8 volts throughout the tests.

Spurious emissions were measured at 45 and 10 watts output throughout the RF spectrum from 12 (lowest frequency generated in the transmitter is 12.8 MHz) to the tenth harmonic of the carrier.

Any emissions that were between the required attenuation and the noise floor of the spectrum analyzer were recorded. Data are shown in Table 1.

F. DESCRIPTION OF RADIATED SPURIOUS MEASUREMENT FACILITIES

A description of the Hyak Laboratories' radiation test facility is a matter of record with the FCC. The facility meets ANSI 63.4-1992 and was accepted for radiation measurements from 25 to 1000 MHz on October 1, 1976 and is currently listed as an accepted site.

TABLE 1

TRANSMITTER CONDUCTED SPURIOUS
161.000, 13.8 Vdc Input

	Spurious Frequency MHz	dB Below Carrier Reference	
45 W			
	322.000	77	
	483.000	82	
	644.000	84	
	805.000	78	
	966.002	98	
	1127.000	85	
	1288.000	>100	
	1449.000	>100	
	1610.000	>100	
	Required:	60	(67) 90.210(d)
10 W			
	322.000	70	
	483.000	77	

644.000	80	
805.000	74	
966.000	94	
1127.000	88	
1288.000	>100	
1449.000	>100	
1610.000	>100	
Required:	53	(60) 90.210(d)

All other emissions from 12 MHz to the tenth harmonic were 20 dB or more below FCC limit.

NOTE: Carrier notch filter used to increase dynamic range.

G. FIELD STRENGTH MEASUREMENTS OF SPURIOUS RADIATION

Field intensity measurements of radiated spurious emissions from the SM-6150-V2 were made with a Tektronix 494P spectrum analyzer using Singer DM-105A calibrated dipole antennas below 1 GHz, and Polarad CA-L, and CA-S or EMCO 3115 from 1-5.0 GHz.

The transmitter and dummy load were located in an open field 3 meters from the test antenna. Supply voltage was a power supply with a terminal voltage under load of 13.8 Vdc.

Output power was 45 watts at 161.000 MHz operating frequency. The transmitter and test antennas were arranged to maximize pickup. Both vertical and horizontal test antennae polarization were employed.

Reference level for the spurious radiations was taken as an ideal dipole excited by 45 watts, the output power of the transmitter according to the following relationship:*

$$E = \frac{(49.2P_t)^{1/2}}{R}$$

where E = electric-field intensity in volts/meter

P_t = transmitter power in watts

R = distance in meters

for this case $E = \frac{(49.2 \times 45)^{1/2}}{3} = 15.7$ V/m

Since the spectrum analyzer is calibrated in decibels above one milliwatt (dBm), a conversion, for convenience, was made from dBu to dBm.

15.7 volts/meter = 15.7×10^6 uV/m

dBu/m = $20 \log_{10}(15.7 \times 10^6)$

= 144 dBu/m

Since 1 uV/m = -107 dBm, the reference becomes

144 - 107 = 37 dBm

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*Reference Data for Radio Engineers, Fourth Edition, International Telephone and Telegraph Corp., p. 676.

G. FIELD STRENGTH MEASUREMENTS (Continued)

The transmitter and test antennae were arranged to maximize pickup. Both vertical and horizontal test antenna polarization were employed.

The measurement system was capable of detecting signals 95 dB or more below the reference level. Measurements were made from the lowest frequency generated within the unit (12 MHz), to 10 times operating frequency. Data after application of antenna factors and line loss corrections are shown in Table 2.

TABLE 2

TRANSMITTER CABINET RADIATED SPURIOUS

161.000 MHz, 13.8 Vdc, 45 watts

Spurious Frequency MHz	dB Below Carrier Reference[1]
322.000	75H

483.000	67H	
644.000	68H	
805.000	72V	
966.000	88H	
1127.000	77V	
1288.000	89V	
1449.000	90H	
1610.000	99V	
Required:	60	(67) 90.210(d)

[1]Worst-case polarization, H-Horizontal, V-Vertical.

All other spurious from 12 MHz to 4.6 GHz were 20 dB or more below FCC limit.

H. FREQUENCY STABILITY
(Paragraph 2.995(a)(2) and 90.213 of the Rules)

Measurement of frequency stability versus temperature was made at temperatures from -30°C to +50°C. At each temperature, the unit was exposed to test chamber ambient a minimum of 60 minutes after indicated chamber temperature ambient had stabilized to within ±2° of the desired test temperature. Following the 1 hour soak at each temperature, the unit was turned on, keyed and frequency measured within 2 minutes. Test temperature was sequenced in the order shown in Table 3, starting with -30°C.

A Thermotron S1.2 temperature chamber was used. Temperature was monitored with a Keithley 871 digital thermometer. The transmitter output stage was terminated in a dummy load. Primary supply was 13.8 volts. Frequency was measured with a HP 5385A frequency counter connected to the transmitter through a power attenuator. Measurements were made at 161.000 MHz. No transient keying effects were observed.

TABLE 3

FREQUENCY STABILITY vs. TEMPERATURE

161.000 MHz; 13.8 Vdc; 45 W

Temperature, °C	Output_Frequency,_MHz	p.p.m.
-29.6	161.999955	-0.3
-20.2	161.000129	0.8
- 9.9	161.000191	1.2
0.1	161.000192	1.2
9.9	161.000159	1.0
19.9	161.000050	0.3
30.1	161.999971	-0.2
39.9	161.999922	-0.5
50.0	161.999981	-0.1

Maximum frequency error: 161.000192
161.000000

+ .000192 MHz

FCC Rule 90.213(a) specifies .00025% or a maximum of ±.000403 MHz, which corresponds to:

High Limit	161.000403 MHz
Low Limit	161.999598 MHz

I. FREQUENCY STABILITY AS A FUNCTION OF SUPPLY VOLTAGE
(Paragraph 2.995(d)(2) of the Rules)

Oscillator frequency as a function of power supply voltage was measured with a HP 5385A frequency counter as supply voltage provided by an HP 6264B variable dc power supply was varied from +_15% above the nominal 13.8 volt rating. A Fluke 197 digital voltmeter was used to measure supply voltage at transmitter primary input terminals. Measurements were made at 20°C ambient.

TABLE 4

FREQUENCY STABILITY AS A FUNCTION OF SUPPLY VOLTAGE

161.000 MHz, 13.8 Volts Nominal, 45 W

%	Supply_Voltage	Output_Frequency,_MHz	p.p.m.

115	15.87	161.000090	0.6
110	15.18	161.000082	0.5
105	14.49	161.000067	0.4
100	13.80	161.000050	0.3
95	13.11*	161.000034	0.2
90	12.42	161.000019	0.1
85	11.73	161.000006	0.0

Maximum frequency error: 161.999939
161.000000

- .000061 MHz

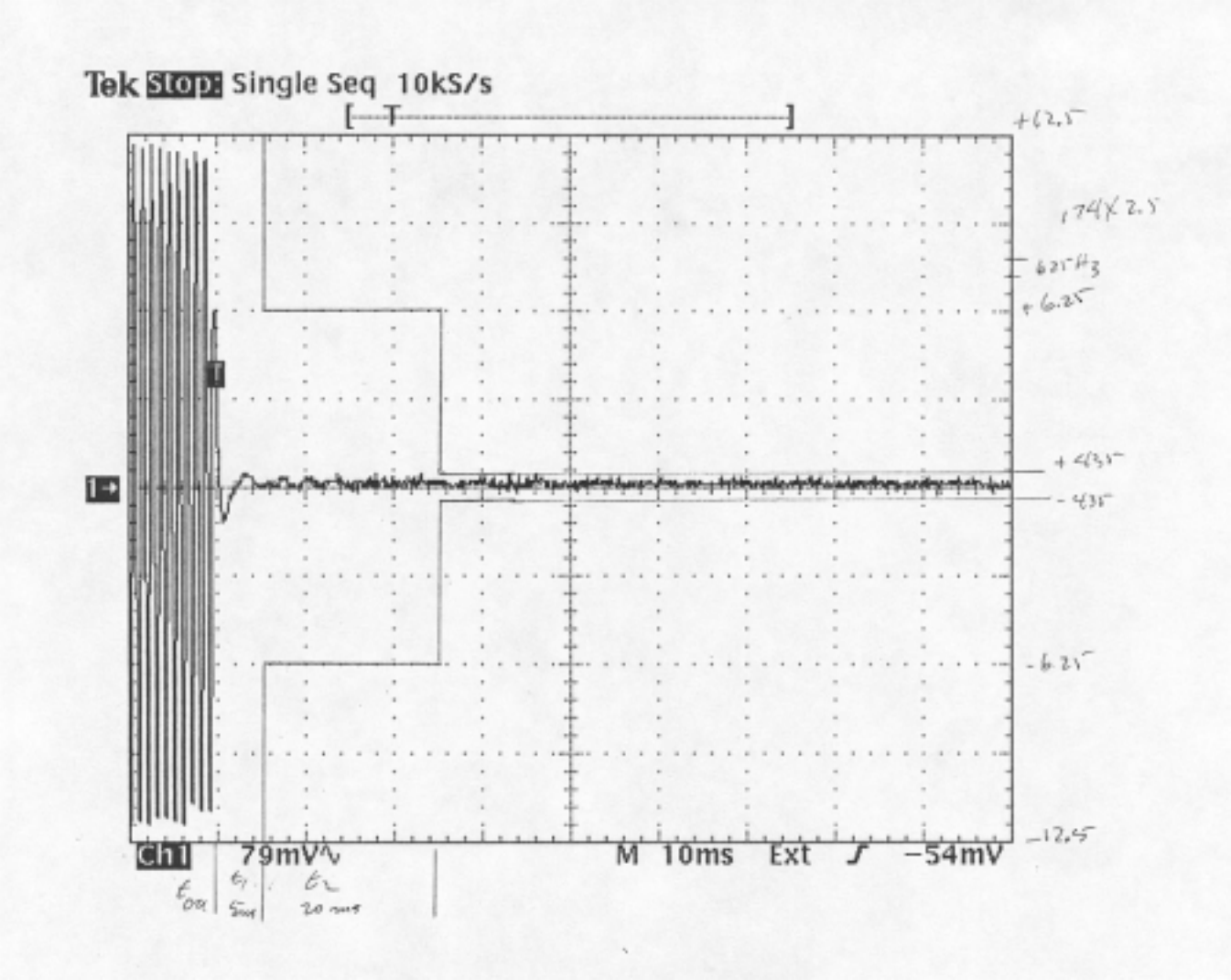
FCC Rule 90.213(a) specifies .00025% or a maximum of ±.000403 MHz, corresponding to:

High Limit	161.000403 MHz
Low Limit	161.999598 MHz

J. TRANSIENT FREQUENCY BEHAVIOR
(Paragraph 90.214 of the Rules)

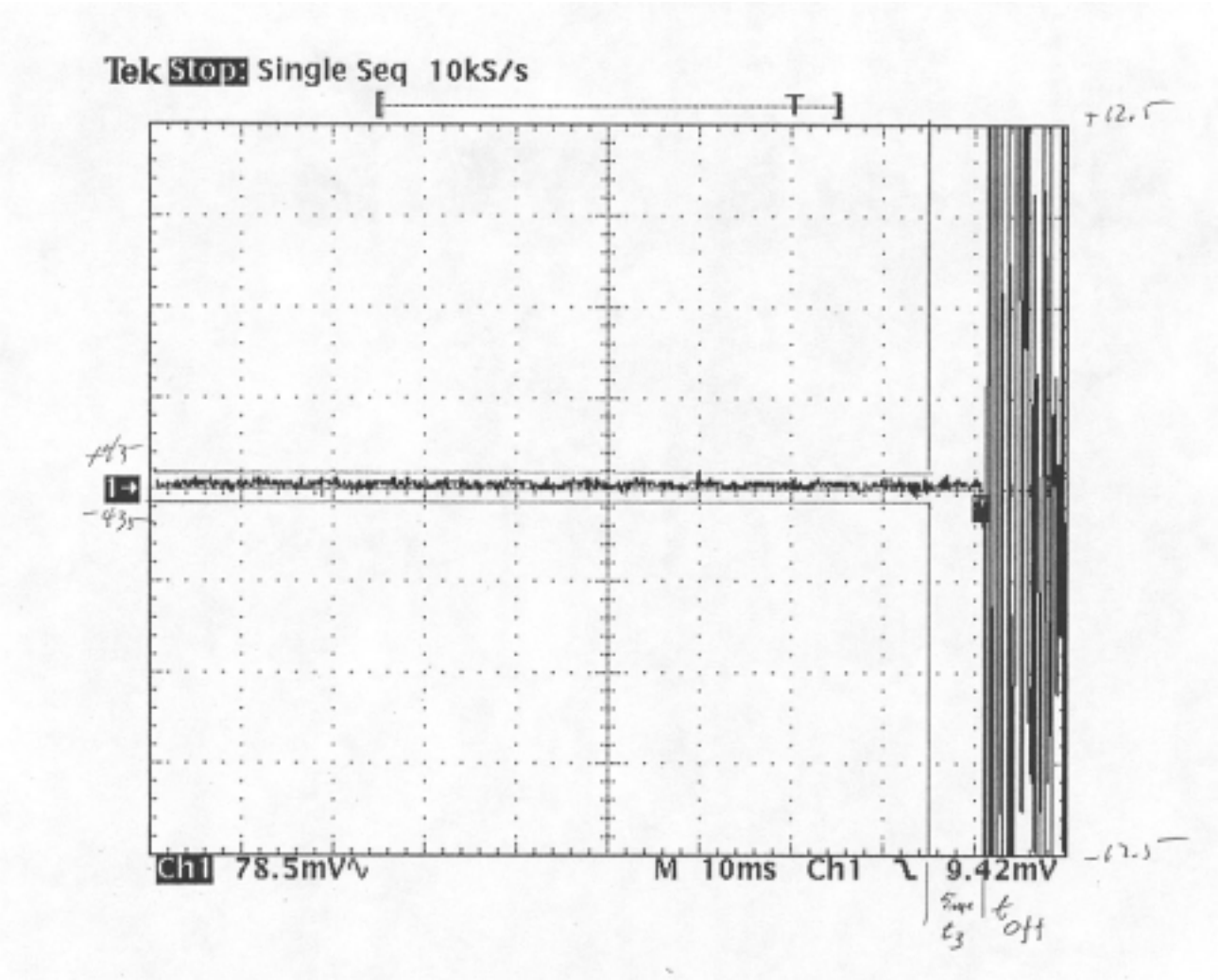
Plots identified as Figures 5 and 6 demonstrate TFB for 12.5 kHz (worst case) channel operation.

See Appendix 4 for test description.



TRANSIENT FREQUENCY BEHAVIOR
FCC ID: F3JSM6150V2

FIGURE 5 (12.5 kHz Turn-on)



TRANSIENT FREQUENCY BEHAVIOR
FCC ID: F3JSM6150V2

FIGURE 6 (12.5 kHz Turn-off)

APPENDIX 1

FUNCTION OF DEVICES
SM-6150-V2

REFERENCE NUMBER	TYPE	FUNCTION
Y2	TEW Model TTS01 V2IC (14.95 MHz)	VCTCXO
Q24	KTC3880S (KEC) or LMMBT9426 (Motorola)	TRIPLER
Q30	BFR92A	TX BUFFER
Q31	MMBR951	TX AMP
Q36	MMBR951	RX LO BUFFER
U1	MSIMXA (Mixed Signal Integration)	AUDIO ASIC (MIC AMP, LIMITER, FILTER)
U3	MC68HC11FX32	CPU
U8	MC145190F (Motorola)	PLL IC
U11	TA31136FN (Toshiba)	Rx 2nd IF & DETECTOR
Q202, Q203	2SC5084	VCO
Q501	MMBR951	TX AMP
Q502	BLT50	TX DRIVER
Q503	BLT52	TX PA

APPENDIX 2

CIRCUITS AND DEVICES TO STABILIZE FREQUENCY

A 14.95 MHz VCTCXO referenced PLL circuit establishes and stabilizes output frequency.

CIRCUITS AND DEVICES TO
STABILIZE FREQUENCY
FCC ID: F3JSM6150V2

APPENDIX 2

APPENDIX 3

CIRCUITS TO SUPPRESS SPURIOUS RADIATION,
LIMIT MODULATION AND CONTROL POWER

TRANSMITTER STAGE HARMONIC FILTER

C133, C134, L7, C135, C136, L8, C137, C138, L9, C139 make up a 6th order, Elliptic, low pass filter suppressing unwanted harmonics by ≤ -65 dBc.

AUTOMATIC POWER CONTROL

The APC keeps the current constant to the final PA stage. The current into the PA Module is sensed across resistor R164. The voltage difference across R164 is amplified through U14 by the ratio of R169 to R165. The U18 Op Amp acts as a lead/lag loop filter comparing the output of U14 to the radio's output power setting from the ASIC DA2 port (U1-10). The U19 Op Amp mimics a VCO as an integrator and the U20 Op Amp is a voltage follower, which generates the supply current to the 2nd stage amplifier in the PA.

MICROPHONE AUDIO CIRCUIT

The TX audio from the internal mic or external mic is fed into Multiplexer U2B-5 and then to the ASIC MICAUDIN port (U1-29). The combined TX audio and data exits the ASIC at the MOD1 (U1-1) and MOD2 (U1-32 for UHF) or MOD3 (U1-31 for VHF) output ports to directly control the VCO and TCXO FM modulation.

CIRCUITS TO SUPPRESS SPURIOUS
RADIATION, LIMIT MODULATION-
AND CONTROL POWER

FCC ID: F3JSM6150V2

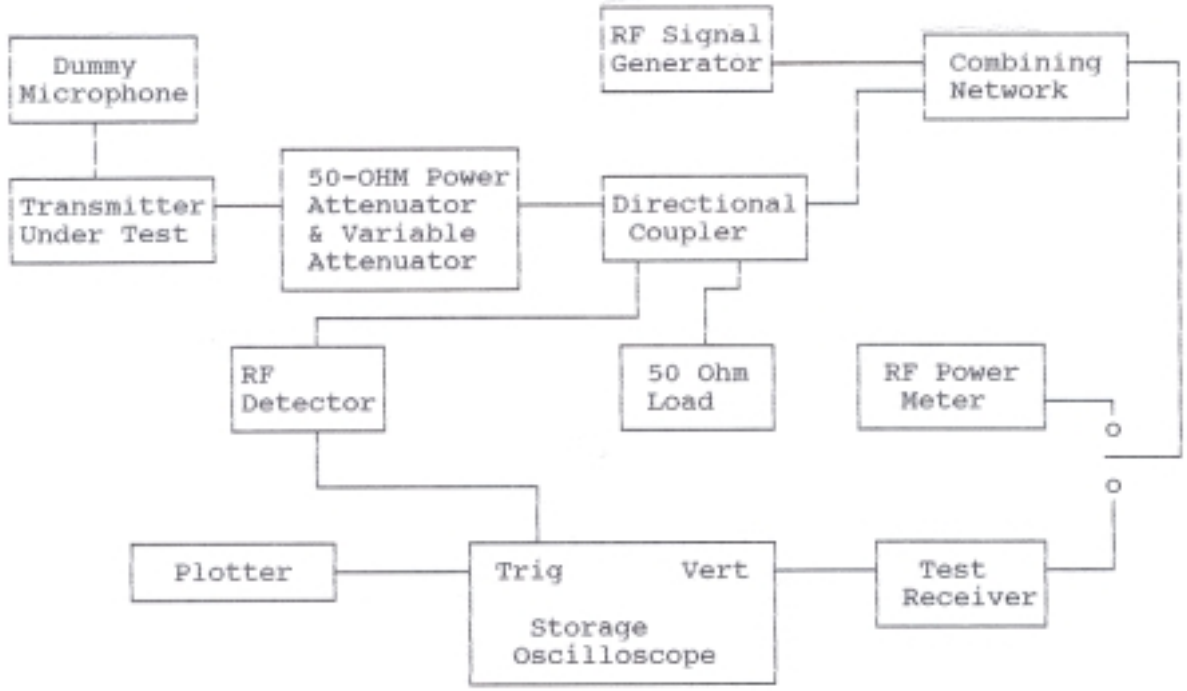
APPENDIX 3

APPENDIX 4

TRANSIENT FREQUENCY BEHAVIOR (90.214) TEST PROCEDURE

Para. 2.995(a)(b)(d) Frequency stability

90.214 (continued) Transient Frequency Behavior



TRANSIENT FREQUENCY BEHAVIOR
TEST PROCEDURE
FCC ID: F3JSM6150V2

APPENDIX 4