

ENGINEERING STATEMENT

For Type Certification of

MAXON AMERICA, INC.

Model No: SP-150V2
FCC ID: F3JSP150V2

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 SP-150V2 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.

Rowland S. Johnson

Dated: May 31, 2000

A. INTRODUCTION

The following data are submitted in connection with this request for Type Certification of the SP-150V2 transceiver in accordance with Part 2, Subpart J of the FCC Rules.

The SP-150V2 is a multi-bandwidth, VHF, frequency modulated transceiver intended for hand-held, portable applications in the 148 - 174 MHz band. It operates from a 7.5 volt battery pack. Output power rating is 1-5 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: F3JSP150V2
 - 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 5 watts and can be reduced to 1 watt.
 - d. Maximum power permitted under Part 90 of the FCC is 350 watts, and the SP-150V2 fully complied with those power limitations.
 - e. The dc voltage and dc currents at final amplifier:

Collector voltage: 7.3 Vdc
Collector current: 1.2 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.

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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 5.3 watts; and with internal adjustments minimum power was 1.2 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 $60\log f/3$ 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)

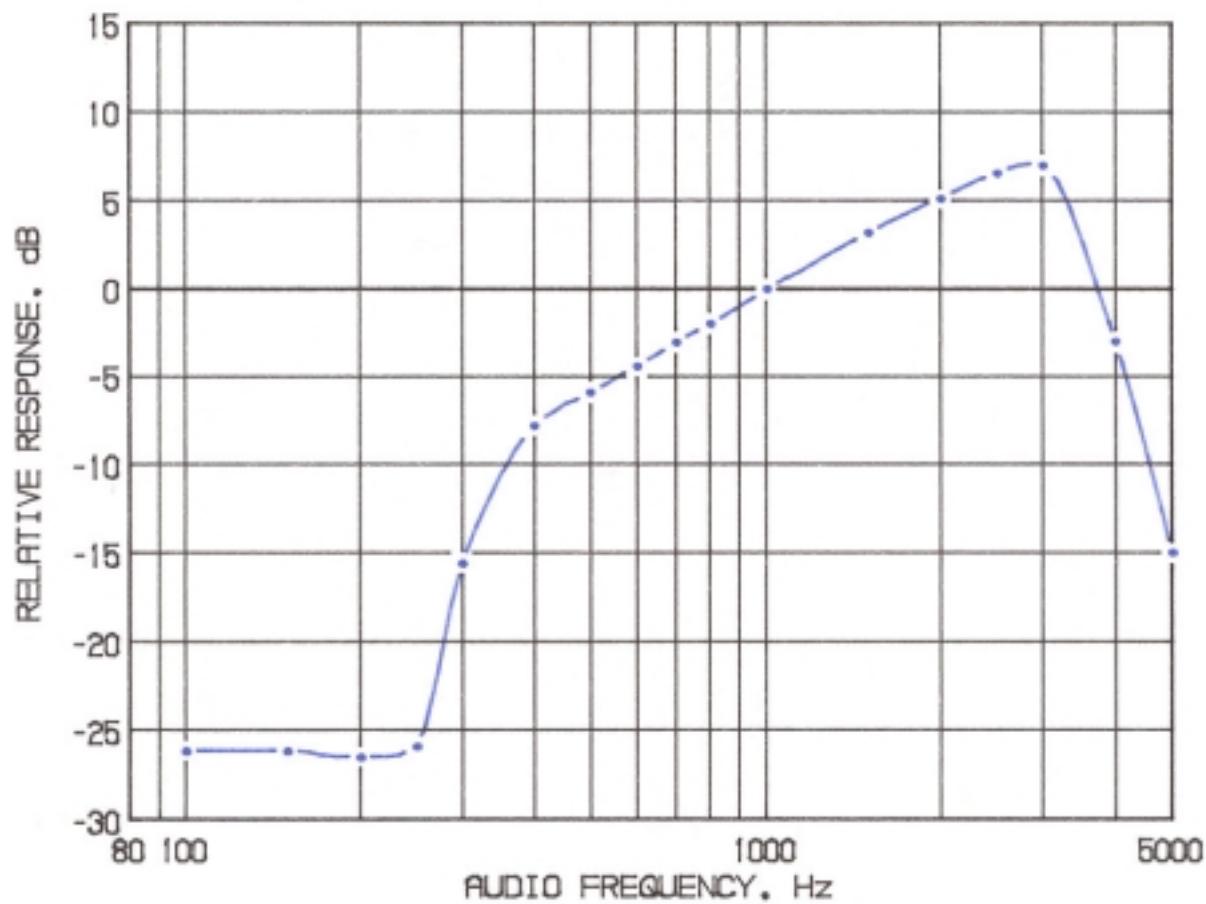
Figures 4a, 4b, 4c and 4d are plots of the sideband envelope of the transmitter for both 5.3 and 1.2 watt output taken with a Advantest R3361A spectrum analyzer. Modulation corresponded to conditions of 2.989(c)(1) and consisted of 2500 Hz tone at an input level 16 dB greater than that necessary to produce 50% modulation at 2890 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



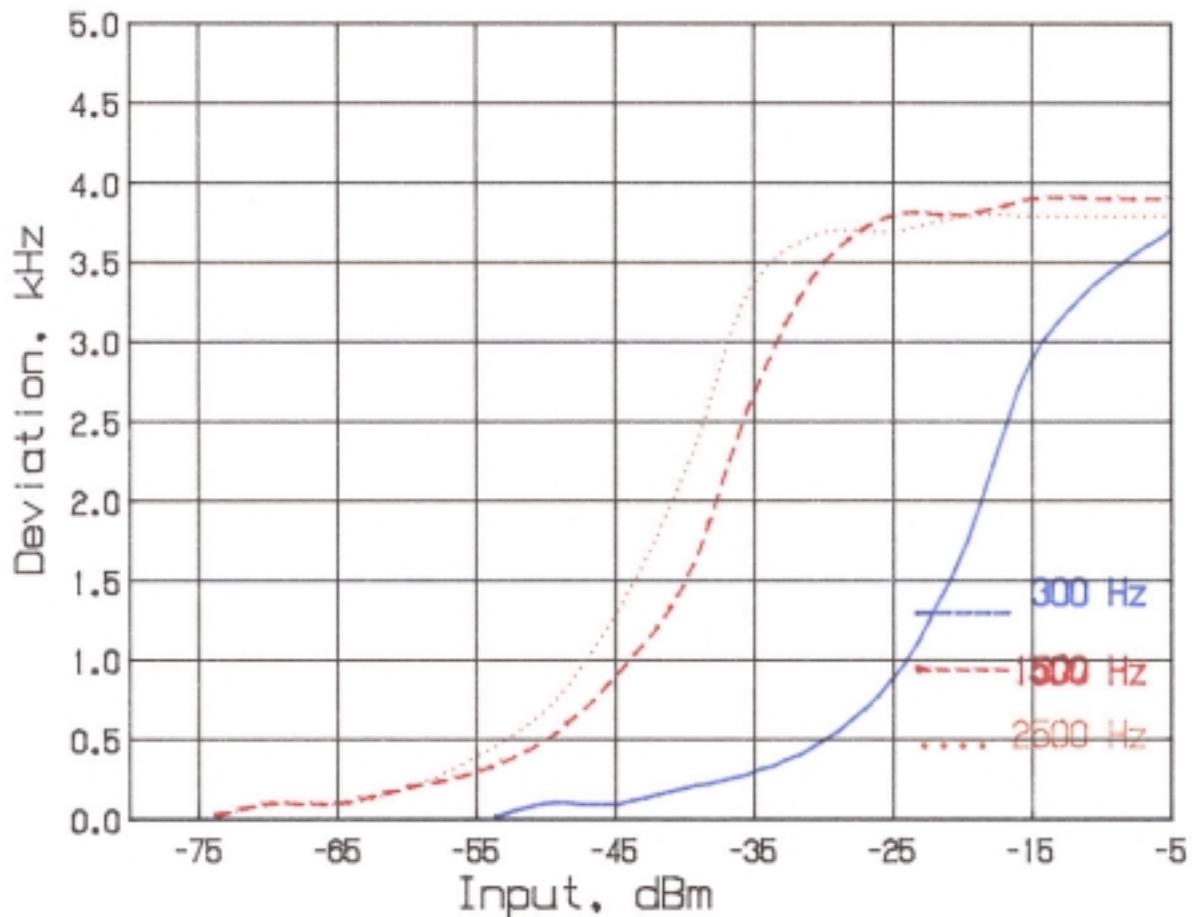
MODULATION FREQUENCY RESPONSE
FCC ID: F3JSP150V2

FIGURE 1

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FIGURE 2a

AUDIO LIMITER CHARACTERISTICS



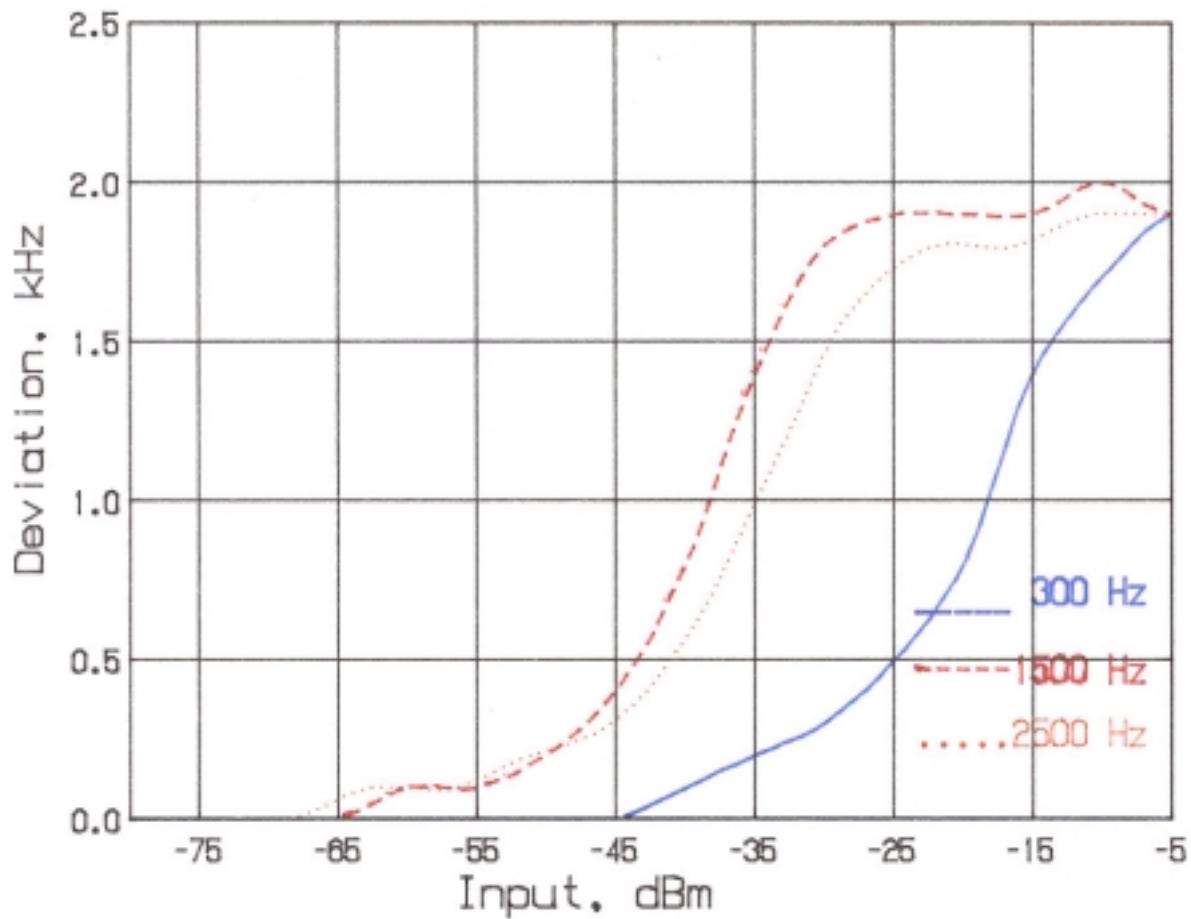
AUDIO LIMITER CHARACTERISTICS
FCC ID: F3JSP150V2

FIGURE 2a Wideband (5 kHz)

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FIGURE 2b

AUDIO LIMITER CHARACTERISTICS

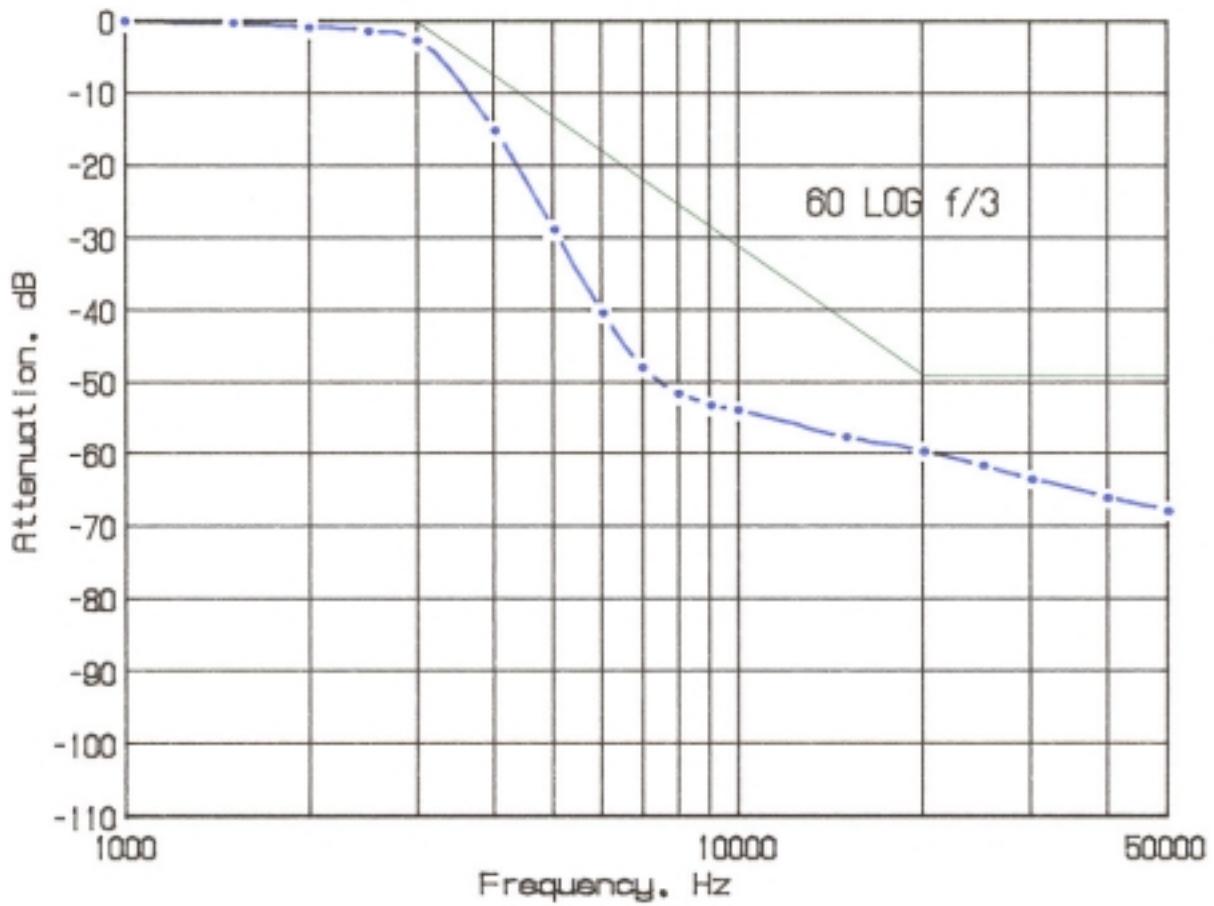


AUDIO LIMITER CHARACTERISTICS
FCC ID: F3JSP150V2

FIGURE 2b Narrow band (2.5 kHz)

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FIGURE 3

AUDIO LOW PASS FILTER RESPONSE

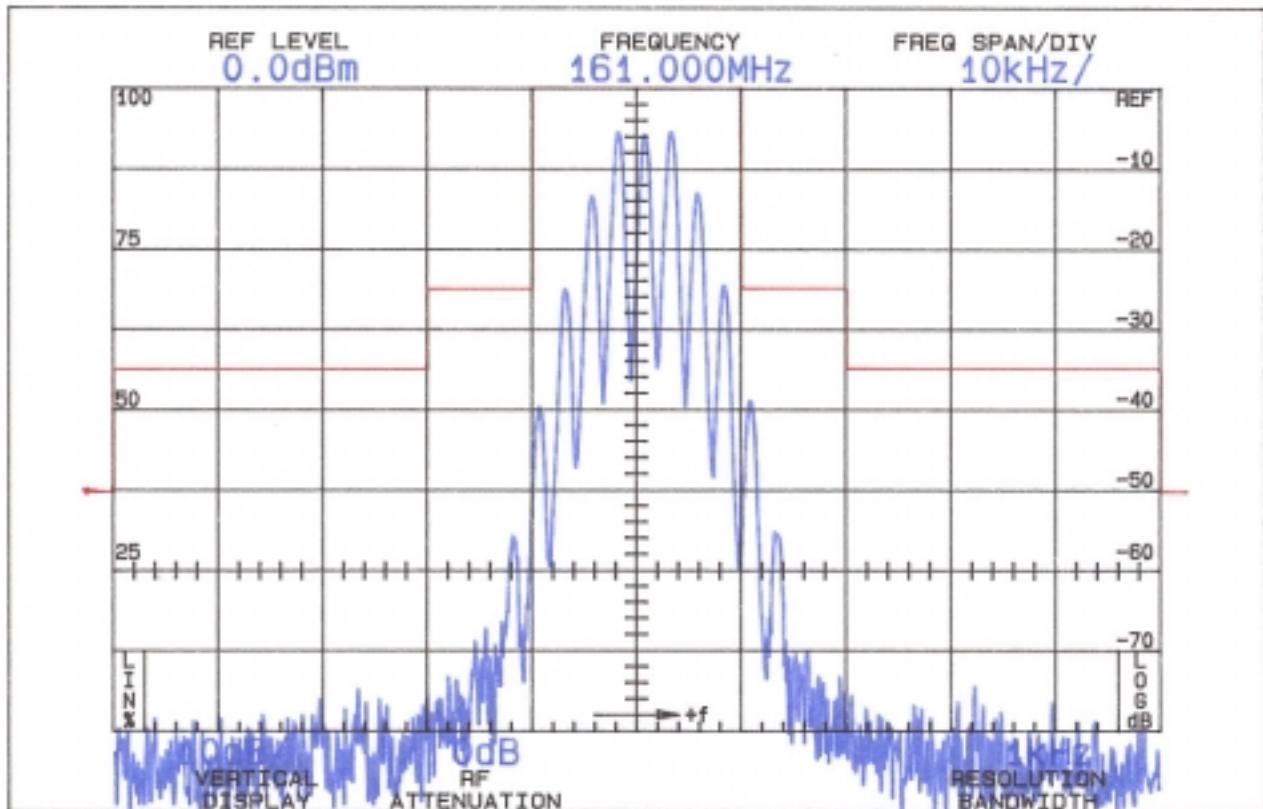


AUDIO LOW PASS FILTER RESPONSE
FCC ID: F3JSP150V2

FIGURE 3

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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
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)

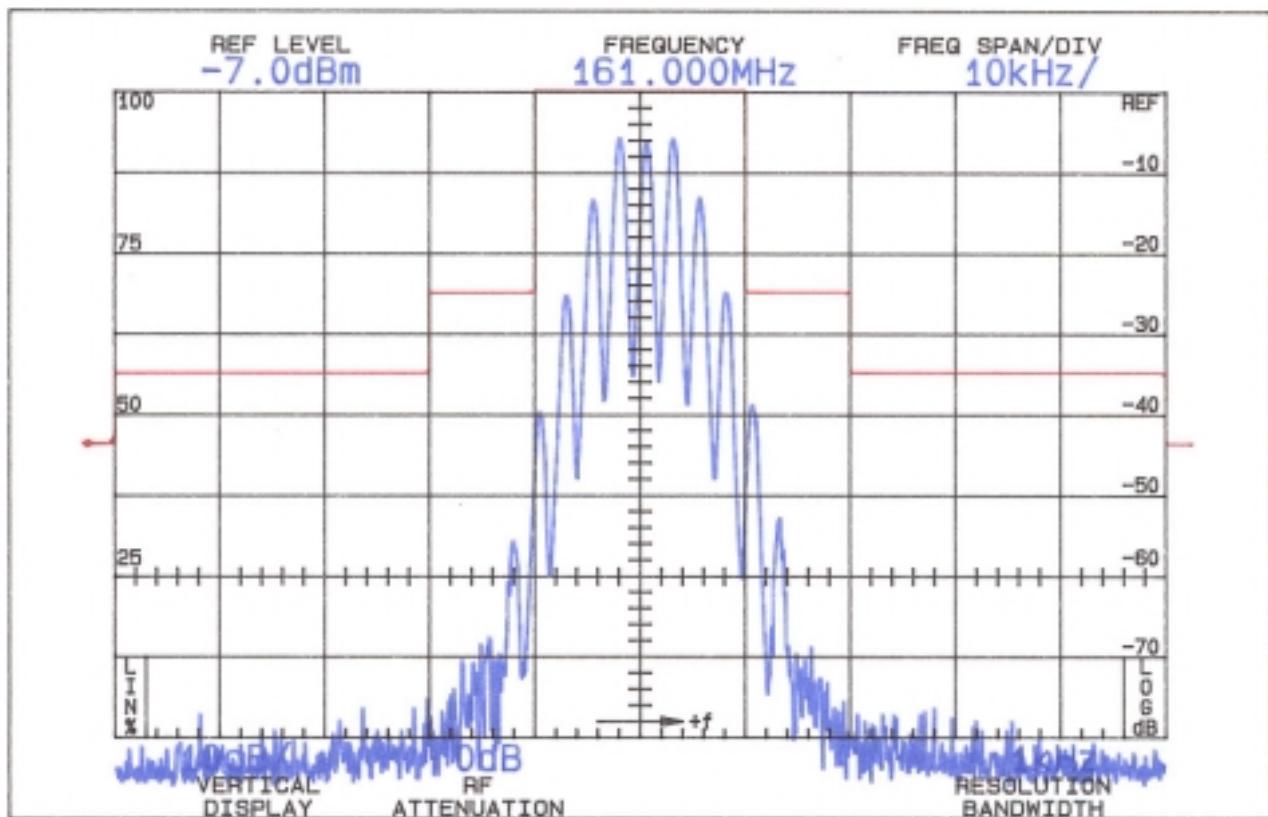
$$43 + 10 \log P = 50$$
$$(P = 5.3 \text{ W})$$

OCCUPIED BANDWIDTH (5.3 W)
FCC ID: F3JSP150V2

FIGURE 4a (5 kHz)

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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

25

(10-20 kHz)

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)

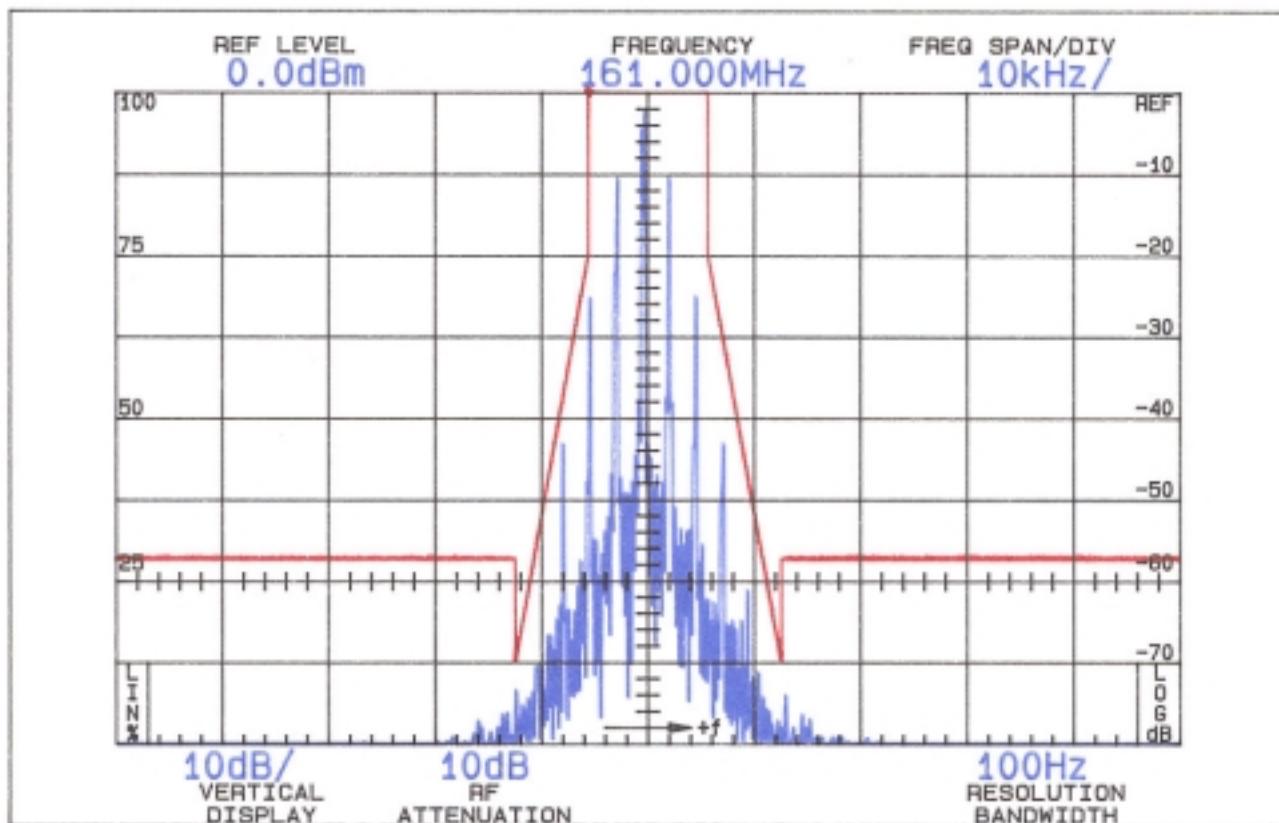
$$43 + 10 \log P = 44 \\ (P = 1.2 \text{ W})$$

OCCUPIED BANDWIDTH (1.2 W)
FCC ID: F3JSP150V2

FIGURE 4b (5 kHz)

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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.

$50 + 10 \log P = 57$ (>12.5 kHz)
($P = 5.3W$)

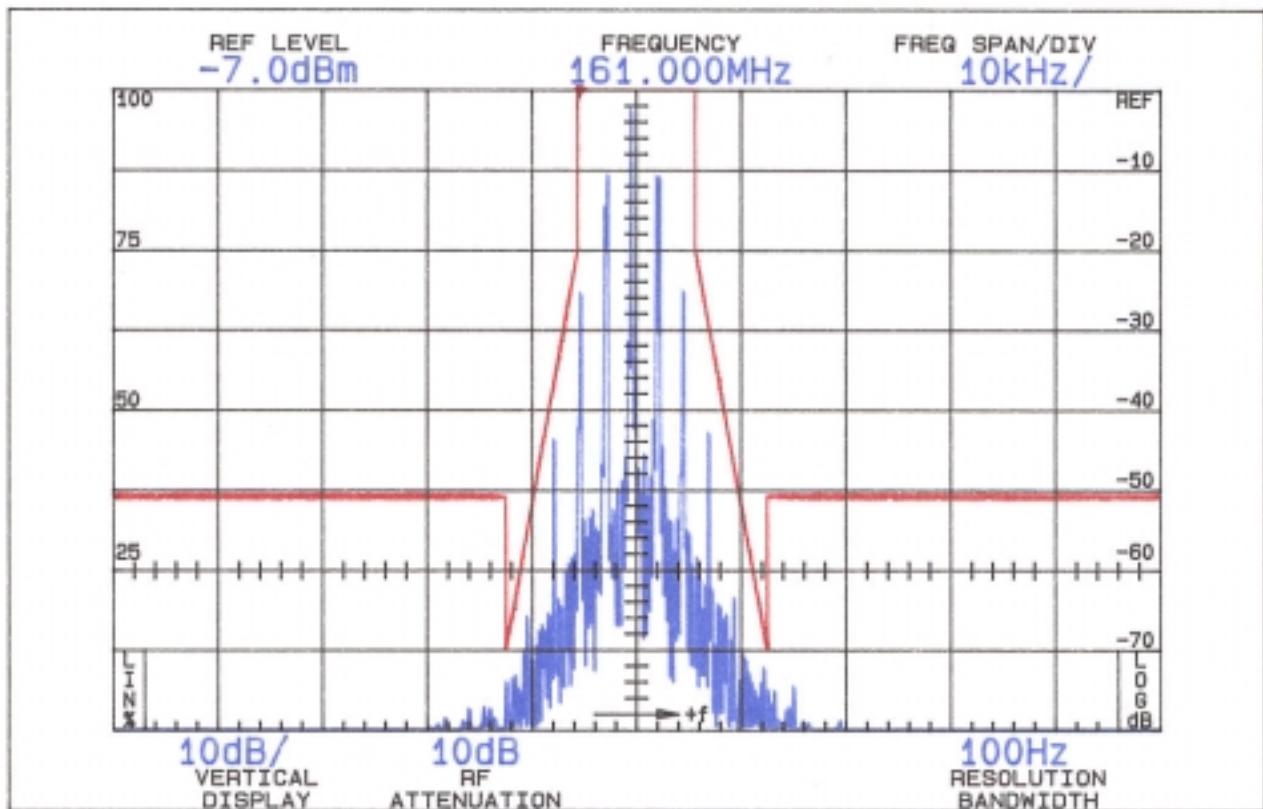
OCCUPIED BANDWIDTH (F3E 5.3W)
FCC ID: F3JSP150V2

FIGURE 4c (2.5 kHz)

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FIGURE 4d

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. $50 + 10 \log P = 51$ (>12.5 kHz)
($P = 1.2W$)

OCCUPIED BANDWIDTH (F3E 1.2W)
FCC ID: F3JSP150V2

FIGURE 4d (2.5 kHz)

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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 SP-150V2 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 2890 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 7.5 volts throughout the tests.

Spurious emissions were measured at 5.3 and 1.2 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.

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TABLE 1

TRANSMITTER CONDUCTED SPURIOUS
161.000, 7.5 Vdc Input

Spurious Frequency <u>MHz</u>	<u>dB Below Carrier Reference</u>
5.3 W	
322.000	91
483.000	96
644.000	86
805.000	90
966.002	92
1127.000	>100
1288.000	>100
1449.000	>100
1610.000	>100

Required:

50 (57) 90.210(d)

1.2 W

322.000	88
483.000	93
644.000	93
805.000	93
966.000	92
1127.000	>100
1288.000	>100
1449.000	>100
1610.000	>100

Required:

44 (51) 90.210(d)

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

*Reference data only, more than 20 dB below FCC limit.

NOTE: Carrier notch filter used to increase dynamic range.

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G. FIELD STRENGTH MEASUREMENTS OF SPURIOUS RADIATION

Field intensity measurements of radiated spurious emissions from the SP-150V2 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 7.5 Vdc.

Output power was 5.3 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 5.3 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 $E = \frac{(49.2 \times 5.3)^{1/2}}{3} = 5.4 \text{ V/m}$

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

$$5.4 \text{ volts/meter} = 5.4 \times 10^6 \text{ uV/m}$$

$$\begin{aligned} \text{dBu/m} &= 20 \log_{10}(5.4 \times 10^6) \\ &= 135 \text{ dBu/m} \end{aligned}$$

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

$$135 - 107 = 28 \text{ dBm}$$

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

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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, 7.5 Vdc, 5.3 watts

Spurious	dB Below
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Frequency MHz	Carrier Reference ¹
322.000	81H*
483.000	97V*
644.000	84V*
805.000	91H*
966.000	84H*
1127.000	91V*
1288.000	93V*
1449.000	93H*
1610.000	84V*
Required:	50 (57) 90.210(d)

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

* Reference data only, more than 20 dB below FCC limit.

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

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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 $\pm 2^\circ$ 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 7.5 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; 7.5 Vdc; 5.3 W

<u>Temperature, °C</u>	<u>Output_Frequency,_MHz</u>	<u>p.p.m.</u>
-29.5	161.000057	0.4
-19.7	161.000120	0.7
-10.0	161.000116	0.7
- 0.2	161.000097	0.6
10.3	161.000057	0.4
20.0	161.999939	-0.4
30.4	161.999872	-0.8
40.2	161.999840	-1.0
49.7	161.999942	-0.4
Maximum frequency error:	161.999840 <u>161.000000</u>	
	- .000160 MHz	

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

High Limit	161.000403 MHz
Low Limit	161.999598 MHz

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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 $\pm 15\%$ above the nominal 7.5 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, 7.5 Volts Nominal, 5.3 W

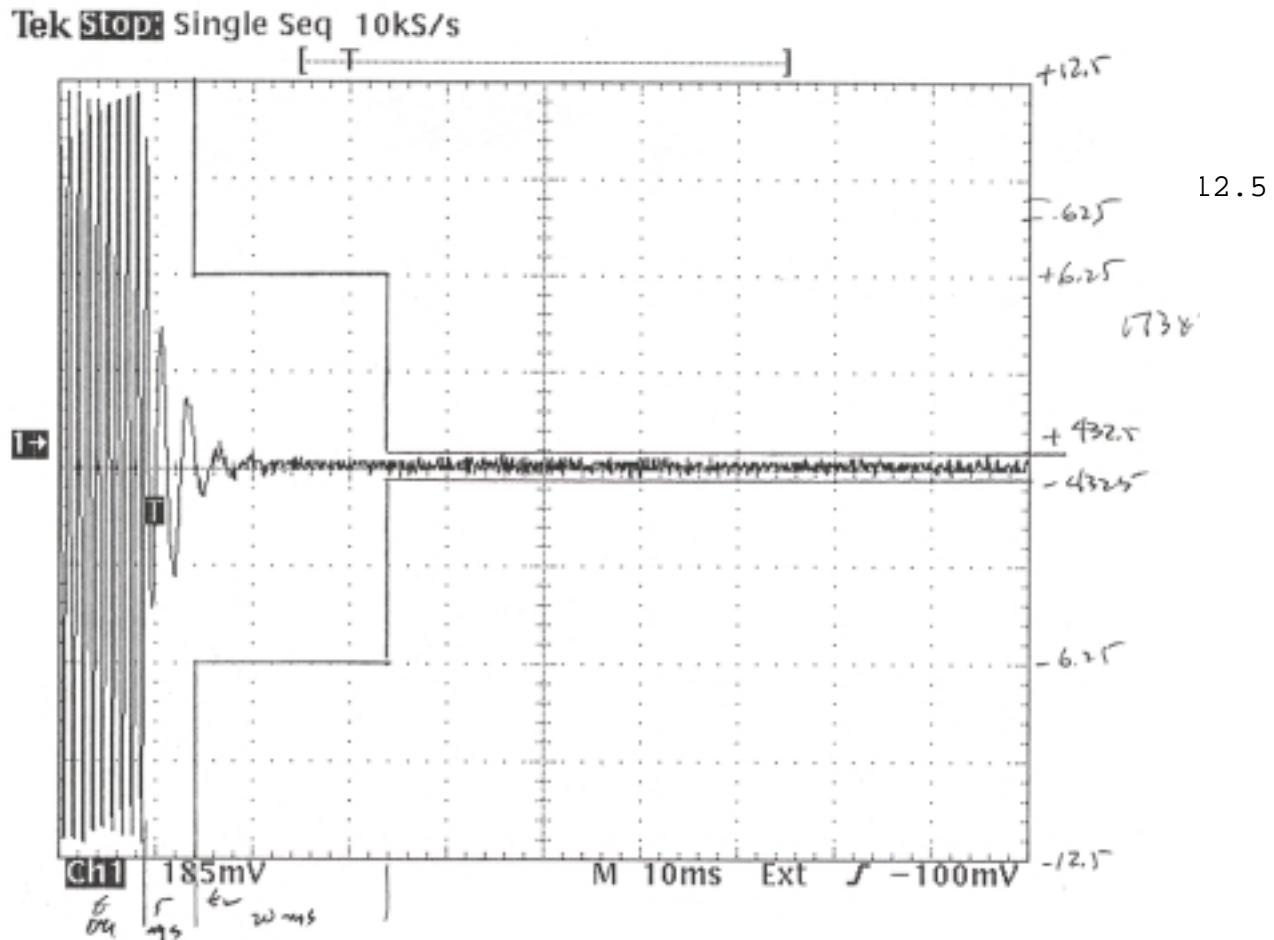
<u>%</u>	<u>Supply_Voltage</u>	<u>Output_Frequency,_MHz</u>	<u>p.p.m.</u>
115	8.63	161.999980	-0.1
110	8.25	161.999956	-0.3
105	7.88	161.999946	-0.3
100	7.50	161.999939	-0.4
95	7.13*	**	N/A
90	6.75	**	N/A
85	6.38	**	N/A
80	6.00	**	N/A
Maximum frequency error:		161.999939	
		<u>161.000000</u>	
- .000061 MHz			

*MFR rated battery end-point

** No RF output, processor shut-down.

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

High Limit 161.000403 MHz
Low Limit 160.999597 MHz

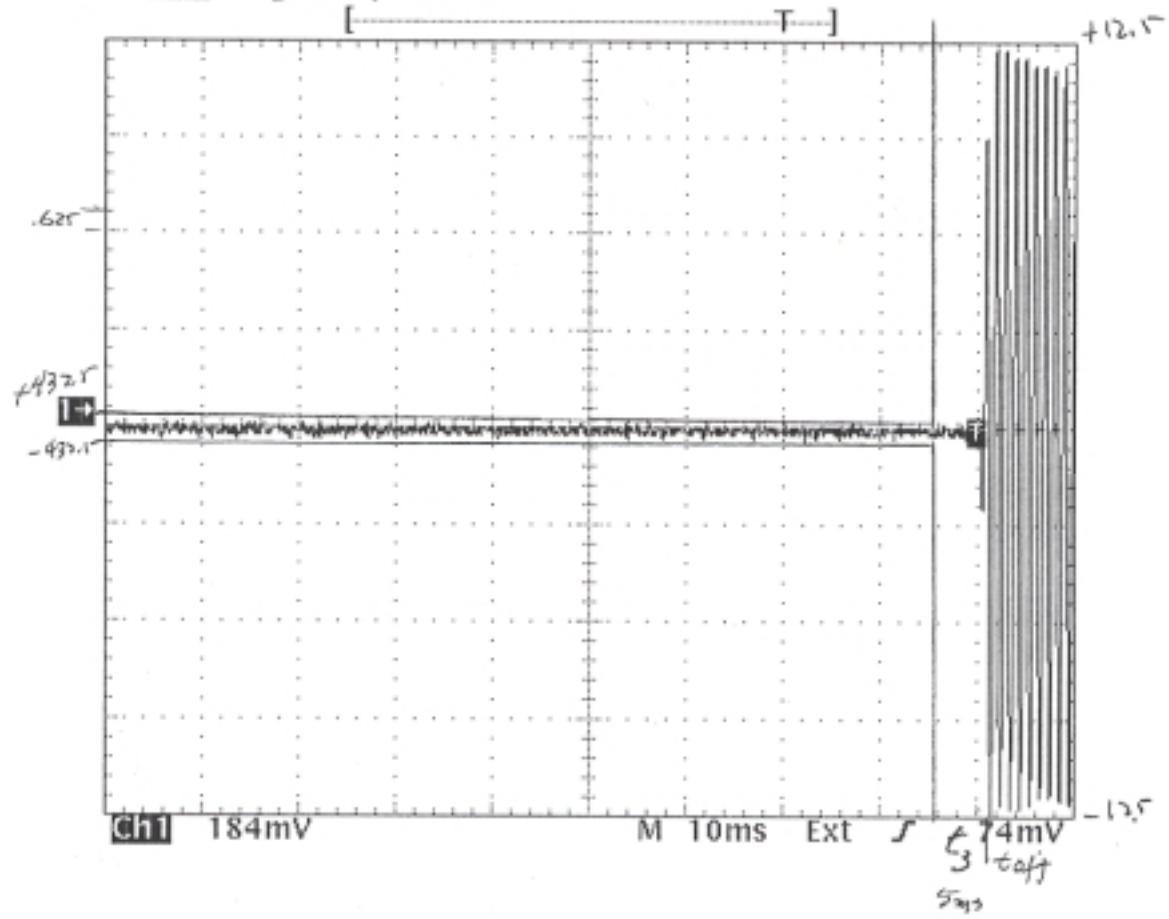


TRANSIENT FREQUENCY BEHAVIOR
FCC ID: F3JSP150V2

FIGURE 5 (12.5 kHz Turn-on)

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Tek Stop: Single Seq 10ks/s

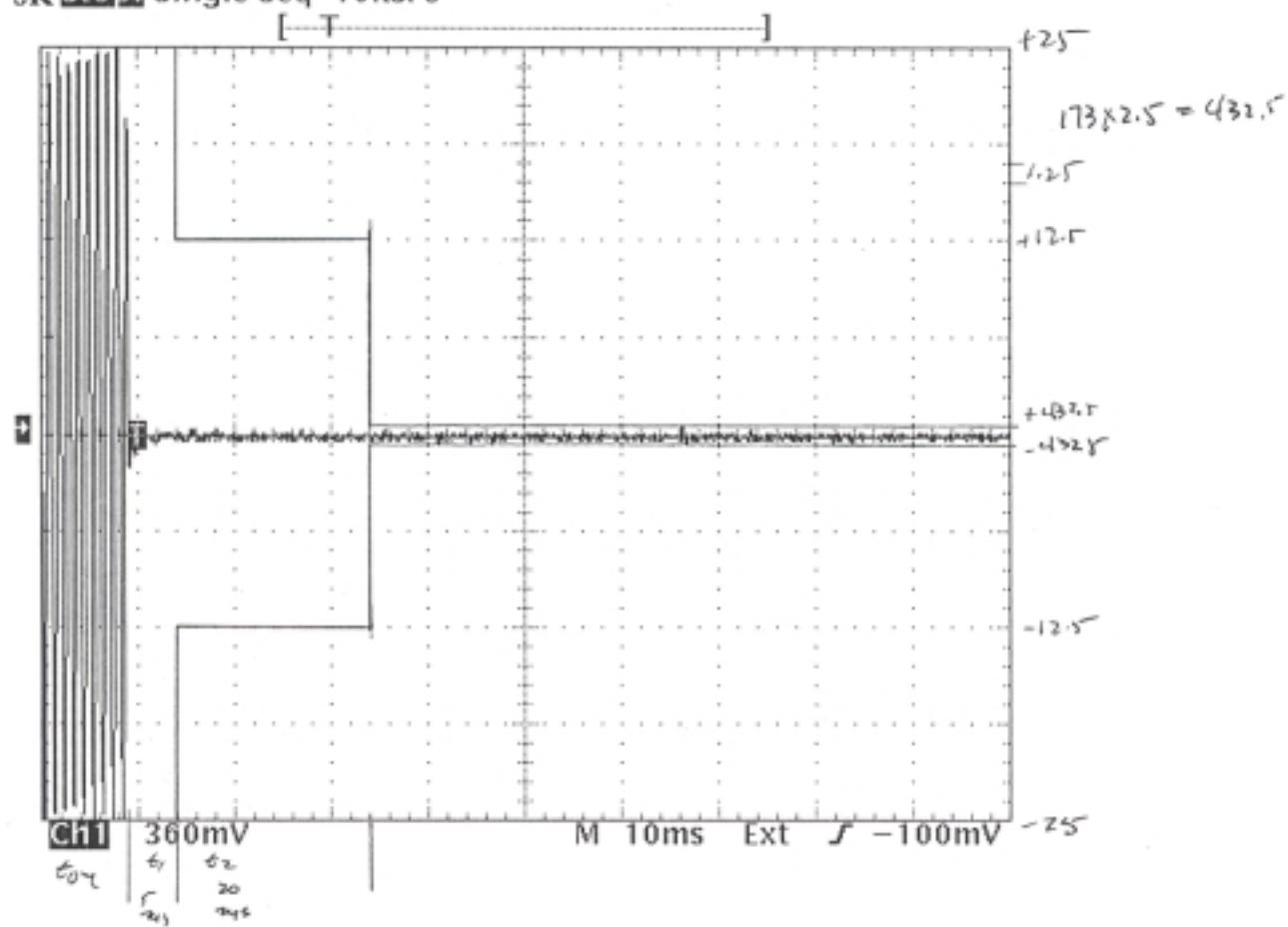


TRANSIENT FREQUENCY BEHAVIOR
FCC ID: F3JSP150V2

FIGURE 6 (12.5 kHz Turn-off)

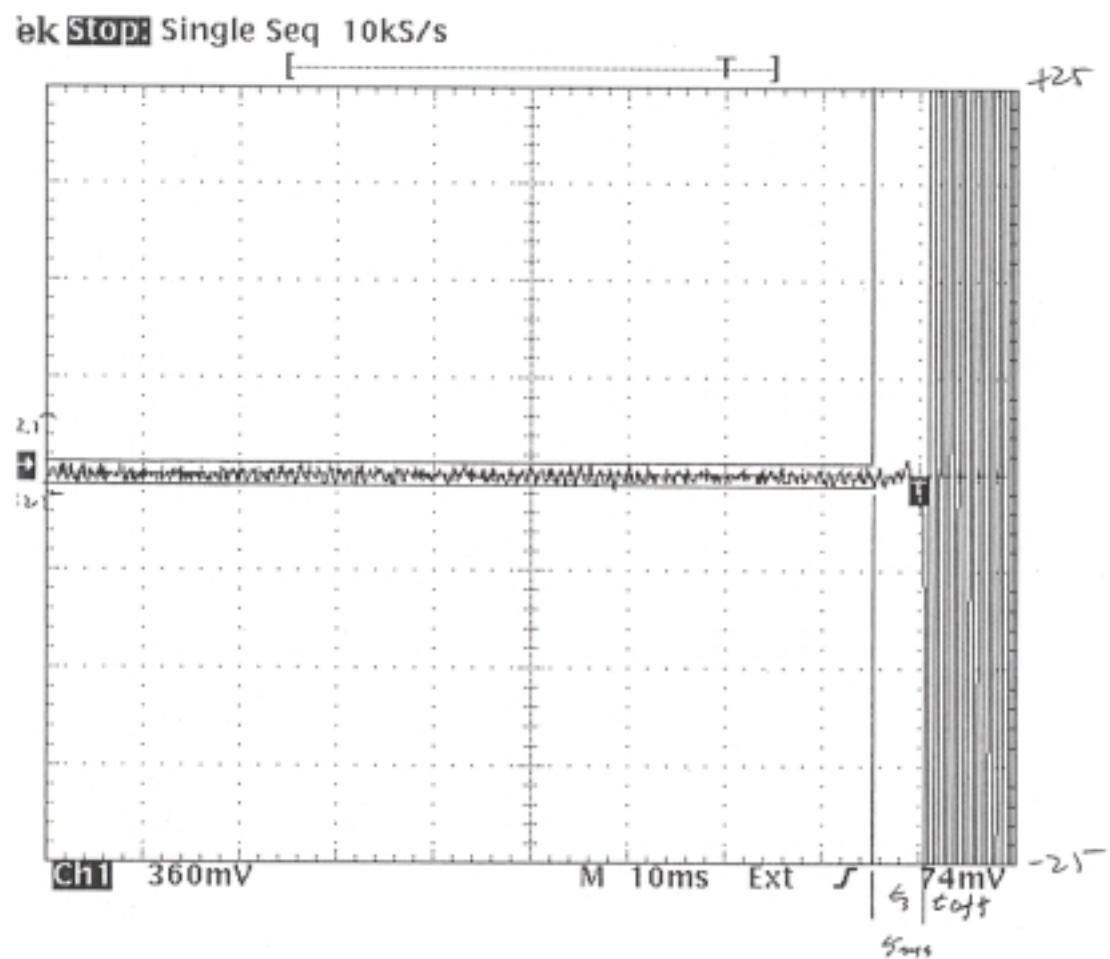
20

ek STOP: Single Seq 10kS/s



TRANSIENT FREQUENCY BEHAVIOR
FCC ID: F3JSP150V2

FIGURE 7 (25 kHz Turn-on)



TRANSIENT FREQUENCY BEHAVIOR
FCC ID: F3JSP150V2

FIGURE 8 (25 kHz Turn-off)

APPENDIX 1

FUNCTION OF DEVICES
SP-150V2

<u>REFERENCE NUMBER</u>	<u>TYPE</u>	<u>FUNCTION</u>
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 2 nd 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 12.8 MHz referenced TCXO PLL circuit establishes and stabilizes output frequency.

CIRCUITS AND DEVICES TO
STABILIZE FREQUENCY
FCC ID: F3JSP150V2

APPENDIX 2

APPENDIX 3

CIRCUITS TO SUPPRESS SPURIOUS RADIATION,
LIMIT MODULATION AND CONTROL POWER

TRANSMITTER STAGE HARMONIC FILTER

L7, L8, L11, C73, C74, C75 and C76 form a 7th order Chebyshev low pass filter. Unwanted harmonics are reduced by -65 dBc.

AUTOMATIC POWER CONTROL

The APC circuit consists of the R109, variable resistor RV1, IC3, and transistor Q19, Q21, and Q22. The supply current is monitored by difference voltage on R109 (0.1 ohm) which is through for it. If the current is varied by RF power output or other reasons, it produces some bias voltage by IC3A and Q19. The differential signal at the output of IC3 is passed to Q21 and Q22 that produces a constant power output to the antenna. RV1 is used to adjust the RF power level.

MICROPHONE AUDIO CIRCUIT

The TX audio from the internal mic or external mic is applied to ASIL (Audio Signal Processor) IC406 that performs the audio gain limiter and low-pass filter functions.

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

FCC ID: F3JSP150V2

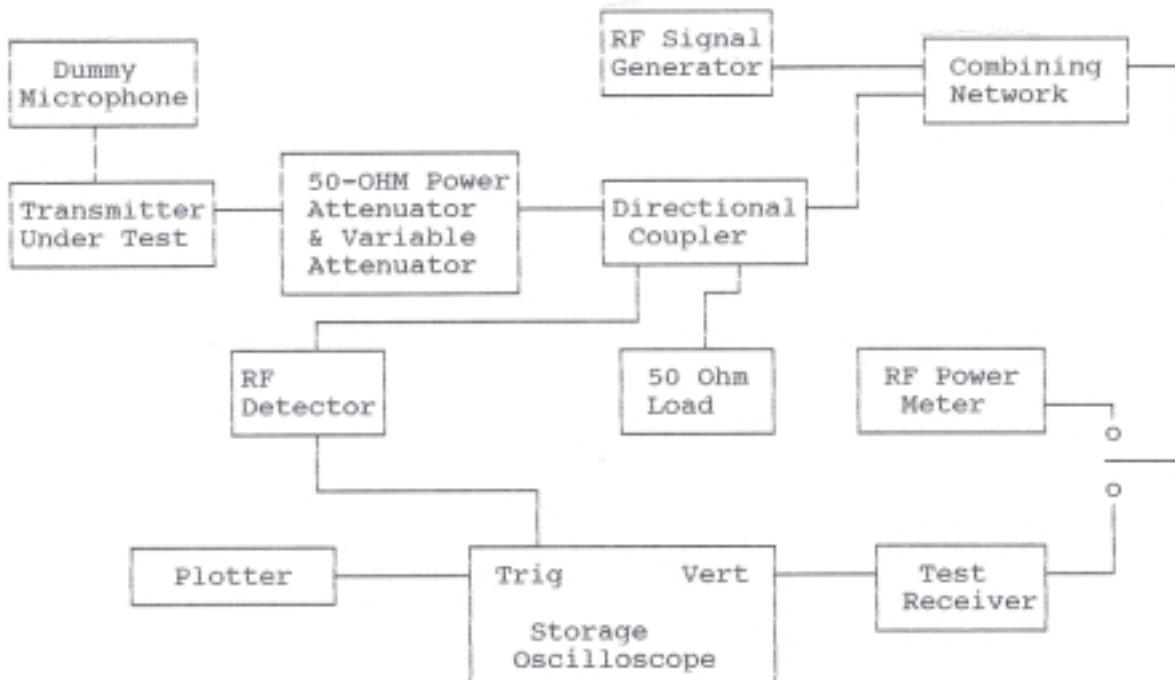
APPENDIX 3

APPENDIX 4

TRANSIENT FREQUENCY BEHAVIOR (90.214) TEST PROCEDURE

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

90.214 Transient Frequency Behavior
(continued)



90.214 TRANSIENT FREQUENCY BEHAVIOR

REQUIREMENTS: In the 150 - 174 MHz frequency band, transient frequencies must be within the maximum frequency difference limits during the time interval indicated below for 25 kHz channels:

Time Interval	Maximum Frequency	Radios 150 - 174 MHz
t_1	± 25.0 kHz	5.0 ms
t_2	± 12.5 kHz	20.0 ms
t_3	± 25.0 kHz	5.0 ms

End of t_2 to beginning of t_3 : 5 ppm.

TEST PROCEDURE: TIA/EIA TS603, PARA. 2.219, the levels were set as follows:

1. Using the variable attenuator, the transmitter level was set to 40 dB below the test receivers maximum input level, then the transmitter was turned off.
2. With the transmitter off, the signal generator was set 20 dB below the level of the transmitter in the above step (this level was maintained with the signal generator throughout the test).
3. Reduce the attenuation between the transmitter and the RF detector by 30 dB.
4. With the levels set as above the transient frequency behavior was observed & recorded.

