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ENGINEERING STATEMENT

For Type Certification of

MAXON AMERICA, INC.

Model No: SP-200
FCC ID: F3JSP200U2

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-200 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: February 24, 1999

A. INTRODUCTION

The following data are submitted in connection with this request for Type Certification of the SP-200 transceiver in accordance with Part 2, Subpart J of the FCC Rules.

The SP-200 is a multi-bandwidth, UHF, frequency modulated transceiver intended for hand-held, portable applications in the 450 - 470 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: F3JSP200U2

   a. The equipment identification label is shown in Appendix 1.
   b. Photographs of the equipment are included in Appendix 2.

3. Quantity production is planned.

4. Technical description:

   a. 16k0F3E; 11k0F3E emission
   b. Frequency range: 440-470 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-200 fully complied with those power limitations.
   e. The dc voltage and dc currents at final amplifier:

      Collector voltage: 7.1 Vdc
      Collector current: 1.3 A

   f. Function of each active semiconductor device: See Appendix 3.
   g. Complete circuit diagram is included in Appendix 4.
   h. A draft instruction book is submitted as Appendix 5.
   i. The transmitter tune-up procedure is included in Appendix 6.
   j. A description of circuits for stabilizing frequency is included in Appendix 7.
   k. A description of circuits and devices employed for suppression of spurious radiation and for limiting modulation is included in Appendix 8.
   l. Not applicable.

B. GENERAL INFORMATION...(Continued)

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 5.2 watts; and with internal adjustments minimum power was 1.2 watts. (The transmitter was tuned by the factory according to the procedure of Exhibit 4.)

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.

4. <u>Occupied Bandwidth</u>
(Paragraphs 2.989(c), 90.209(b)(4) and 90.210(d) of the Rules)

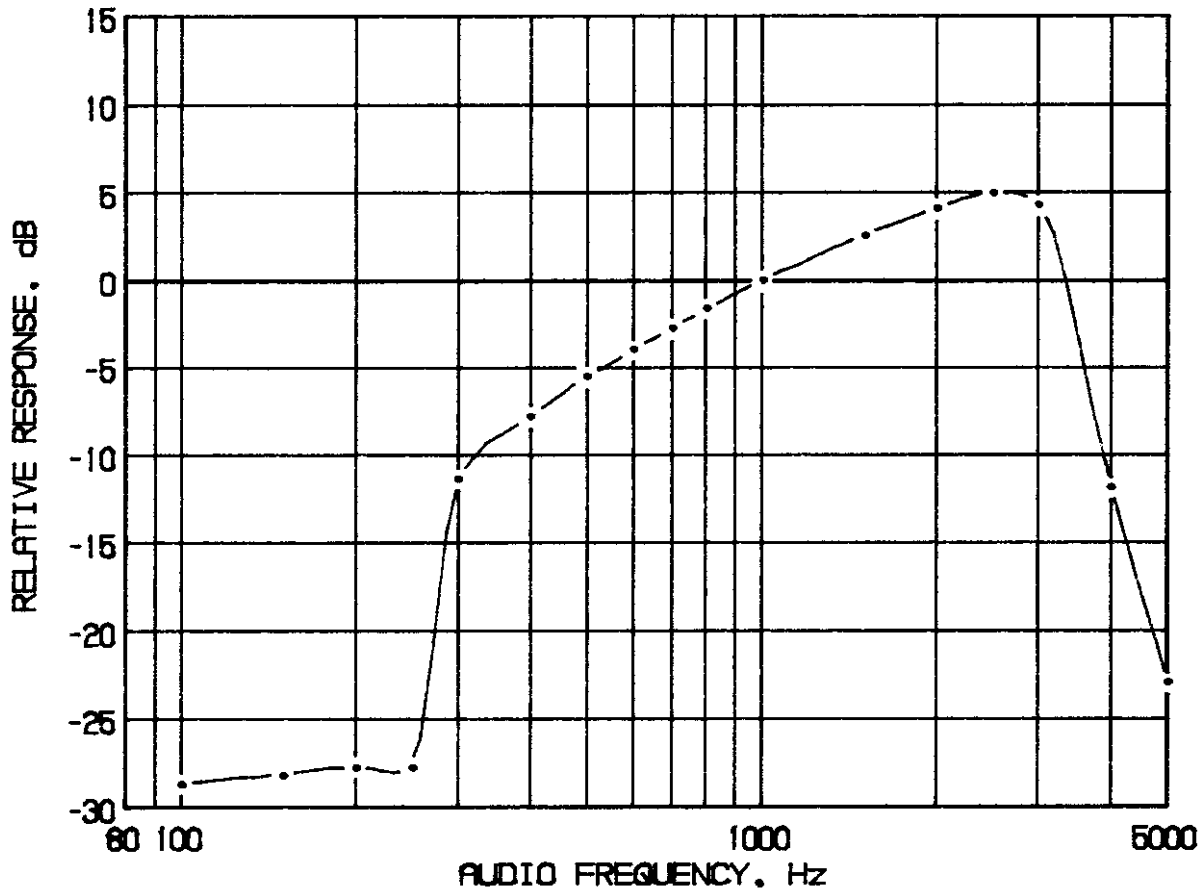
Figures 4a, 4b, 4c and 4d are plots of the sideband envelope of the transmitter for both 5.2 and 1.2 watt output taken with a Advantest R3361A spectrum analyzer. Modulation corresponded to conditions of 2.989(c)(1) and consisted of 2500 Hz tone at an input level 16 dB greater than that necessary to produce 50% modulation at 2723 Hz, the frequency of maximum response. Measured modulation under these conditions was 4.1 kHz, or 2.1 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

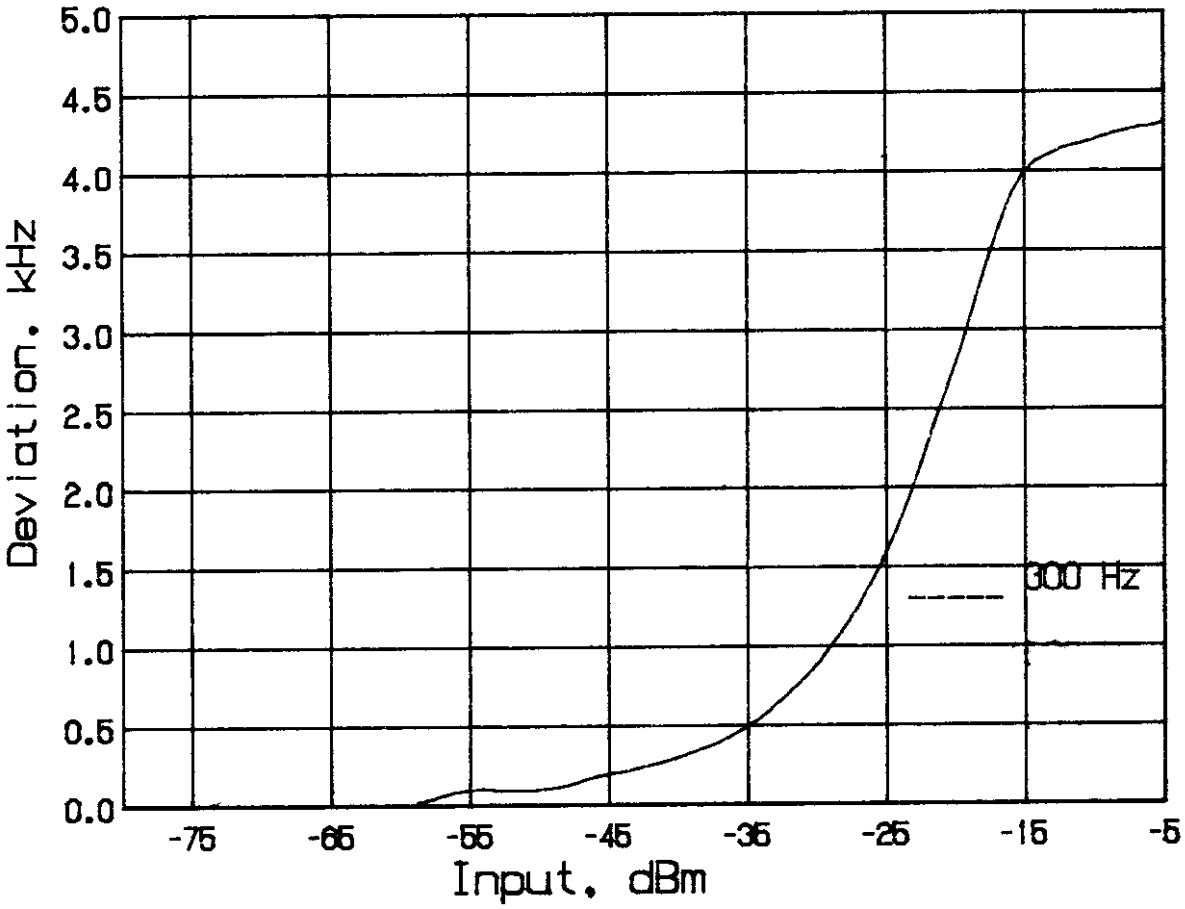


MODULATION FREQUENCY RESPONSE
FCC ID: F3JSP200U2

FIGURE 1

FIGURE 2a

AUDIO LIMITER CHARACTERISTICS

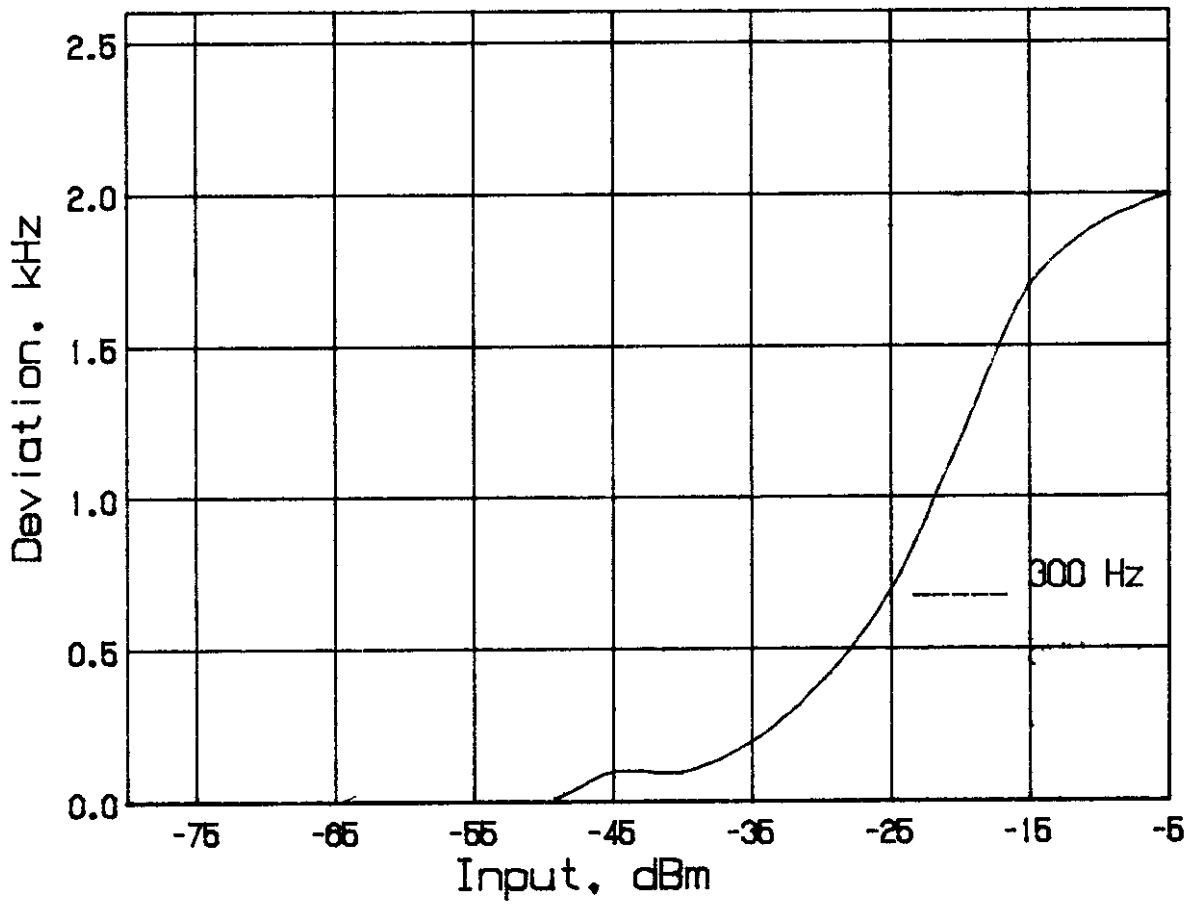


AUDIO LIMITER CHARACTERISTICS
FCC ID: F3JSP200U2

FIGURE 2a Wideband (5 kHz)

FIGURE 2b

AUDIO LIMITER CHARACTERISTICS

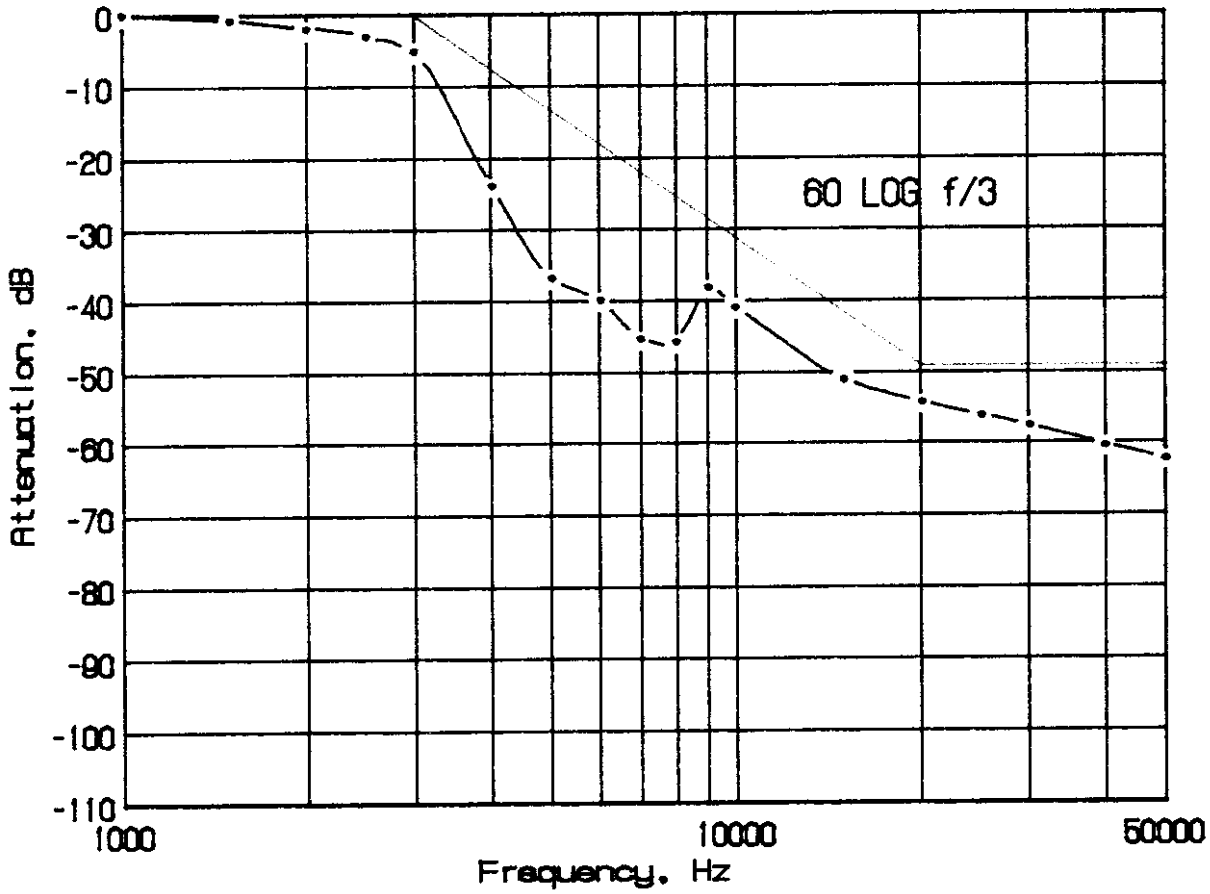


AUDIO LIMITER CHARACTERISTICS
FCC ID: F3JSP200U2

FIGURE 2b Narrow band (2.5 kHz)

FIGURE 3

AUDIO LOW PASS FILTER RESPONSE



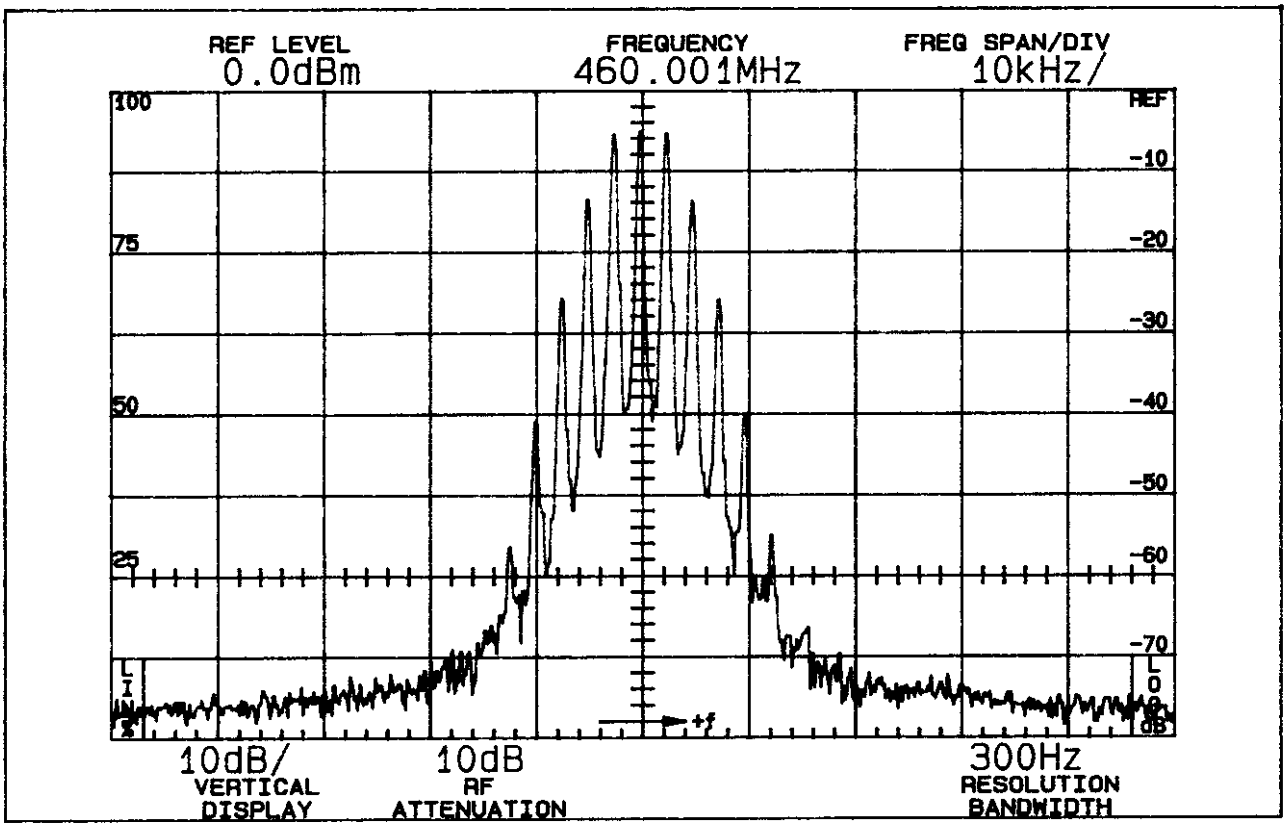
AUDIO LOW PASS FILTER RESPONSE
FCC ID: F3JSP200U2

FIGURE 3

A: \SPSCOMM1.CSV

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+10LogP = 50 (P = 5.2 W)

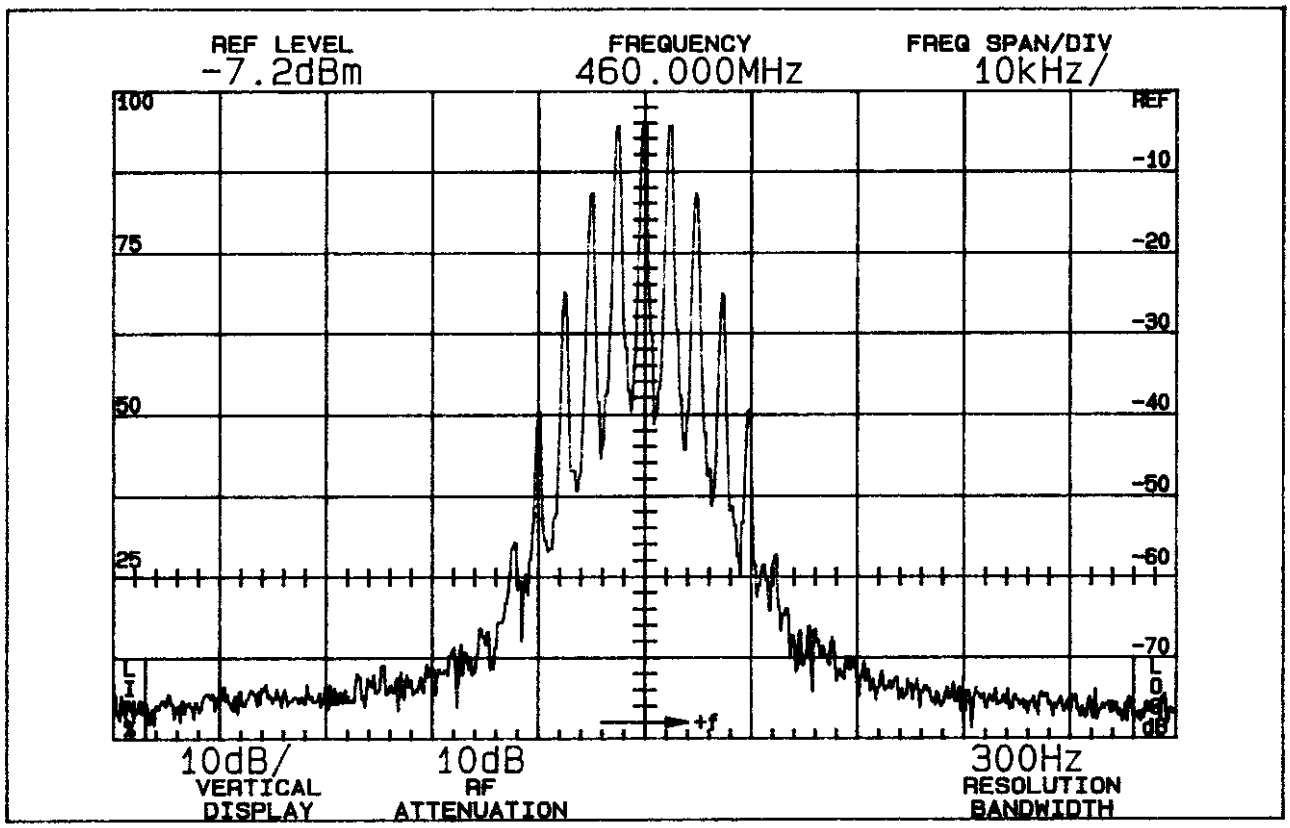
OCCUPIED BANDWIDTH (5.2 W)
FCC ID: F3JSP200U2

FIGURE 4a (5 kHz)

A: \SPSCOBWL.CSV

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 = 44 (P = 1.2 W)

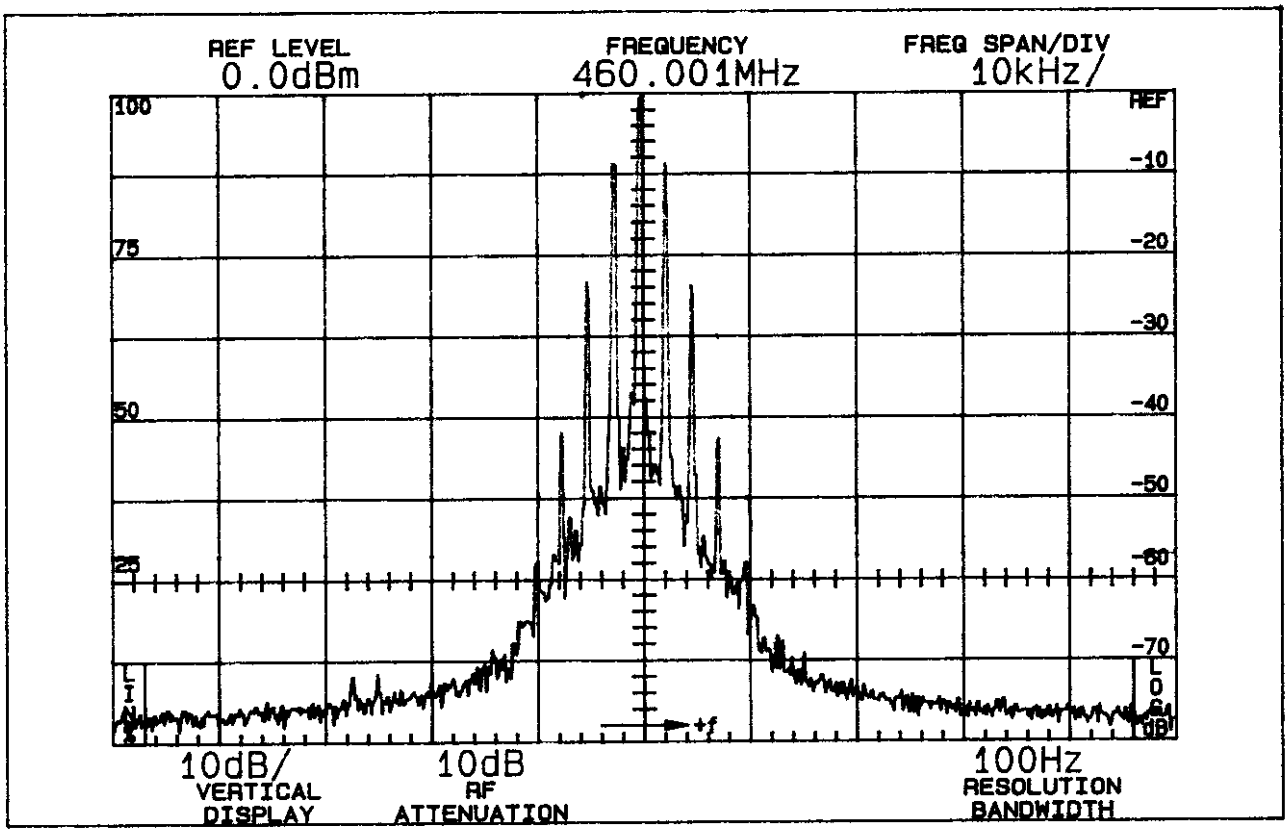
OCCUPIED BANDWIDTH (1.2 W)
FCC ID: F3JSP200U2

FIGURE 4b (5 kHz)

A: \SPSKGBNH.GBW

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 = 57 (>12.5 kHz) (P = 5.2W)

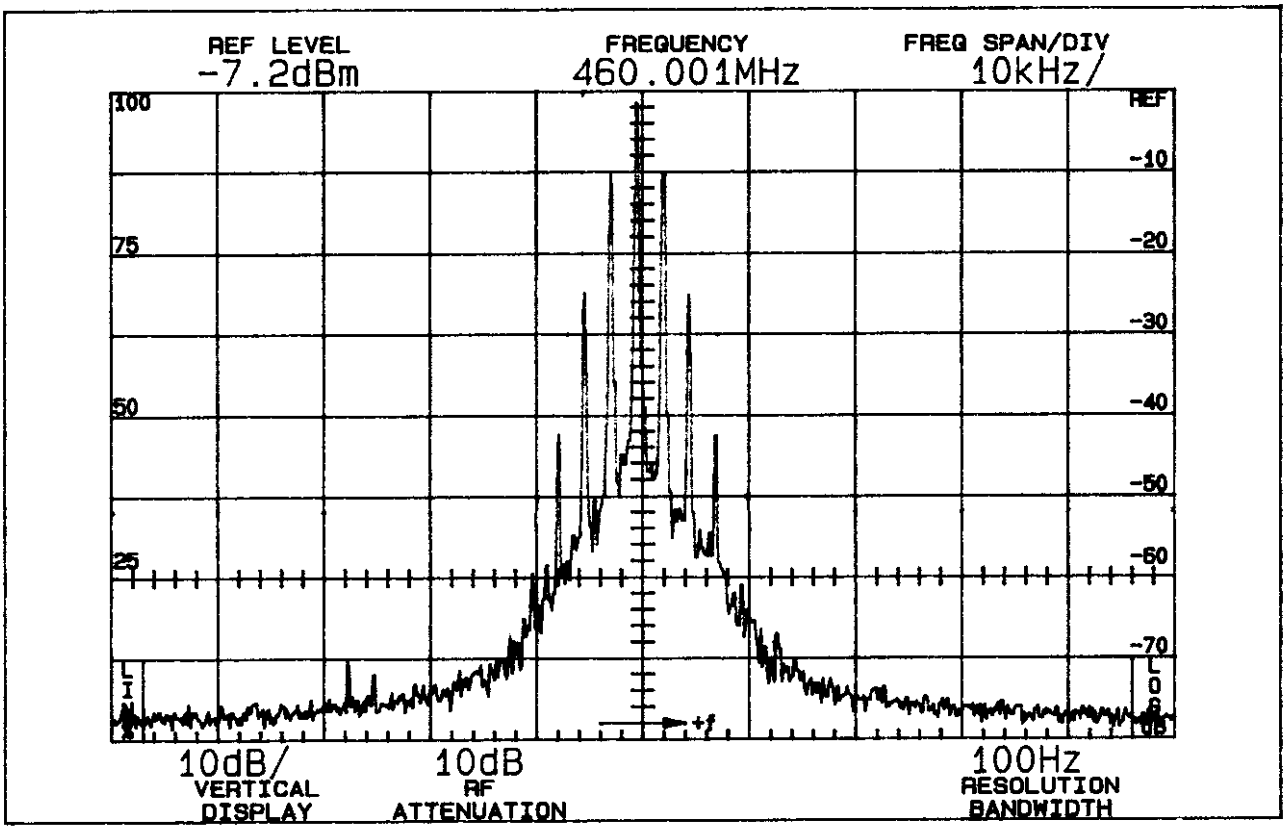
OCCUPIED BANDWIDTH (F3E 5.2W)
FCC ID: F3JSP200U2

FIGURE 4c (2.5 kHz)

A: \SPSKOSNL.OSN

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+10LogP = 51 (>12.5 kHz) (P = 1.2W)

OCCUPIED BANDWIDTH (F3E 1.2W)
FCC ID: F3JSP200U2

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 SP-200 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 2723 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 5.2 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.

TABLE 1

TRANSMITTER CONDUCTED SPURIOUS
460.000, 7.5 Vdc Input

	Spurious Frequency MHz	dB Below Carrier Reference	
5.2 W			
	920.002	65	
	1380.000	97	
	1840.000	96	
	2300.000	>100	
	2760.000	>102	
	3220.000	>102	
	3680.000	>102	
	4140.000	>102	
	4600.000	>102	
	Required:	50	(57) 90.210(d)
1.2 W			
	460.000	63	
	920.002	97	
	1380.002	>101	
	1840.000	>101	
	2300.000	>102	
	2760.000	>102	
	3220.000	>102	
	3680.000	>102	
	4600.000	>101	
	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.

G. FIELD STRENGTH MEASUREMENTS OF SPURIOUS RADIATION

Field intensity measurements of radiated spurious emissions from the SP-200 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 5.2 watts at 460.000 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 5.2 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 $E = \frac{(49.2 \times 5.2)^{1/2}}{3} = 5.3$ V/m

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

5.3 volts/meter = 5.3×10^6 uV/m

dBu/m = $20 \log_{10}(5.3 \times 10^6)$

= 135 dBu/m

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

135 - 107 = 28 dBm

*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

460.000 MHz, 7.5 Vdc, 5.2 watts

Spurious Frequency MHz	dB Below Carrier Reference[1]	
920.000	63V*	
1380.000	82V*	
1840.000	91H*	
2300.000	78V*	
2760.000	88H*	
3220.000	89H*	
3680.000	93V*	
4140.000	95V*	
4600.000	87V*	
Required:	50	(57) 90.210(d)

[1]Worst-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.

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 7.5 volts. Frequency was measured with a HP 5385A frequency counter connected to the transmitter through a power attenuator. Measurements were made at 460.000 MHz. No transient keying effects were observed.

TABLE 3

FREQUENCY STABILITY vs. TEMPERATURE

460.000 MHz; 7.5 Vdc; 5.2 W

Temperature, °C	Output Frequency, MHz	p.p.m.
-29.5	460.000314	0.7
-19.8	459.999945	-0.1
- 9.6	459.999725	-0.6
- 0.1	460.000037	0.1
10.5	460.000325	0.7
20.1	460.000128	0.3
30.0	459.999919	-0.2
40.5	459.999861	-0.3
49.9	460.000135	0.3

Maximum frequency error: 460.000325
460.000000

\+ .000325 MHz

FCC Rule 90.213(a) specifies .00025% or a maximum of ± .001150 MHz, which corresponds to:

High Limit	460.001150 MHz
Low Limit	459.998850 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 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

460.000 MHz, 7.5 Volts Nominal, 5.2 W

%	Supply Voltage	Output Frequency, MHz	p.p.m.
115	8.63	460.000277	0.6
110	8.25	460.000241	0.5
105	7.88	460.000190	0.4
100	7.50	460.000128	0.3
95	7.13	460.000068	0.1
90	6.75	460.000014	0.0
85	6.38	459.999971	-0.1
80	6.00*	459.999941	-0.1
	Maximum frequency error:	460.000146	
		460.000000	
		+ .000146 MHz	

*MFR rated battery end-point

FCC Rule 90.213(a) specifies .00025% or a maximum of ± .001150 MHz, corresponding to:

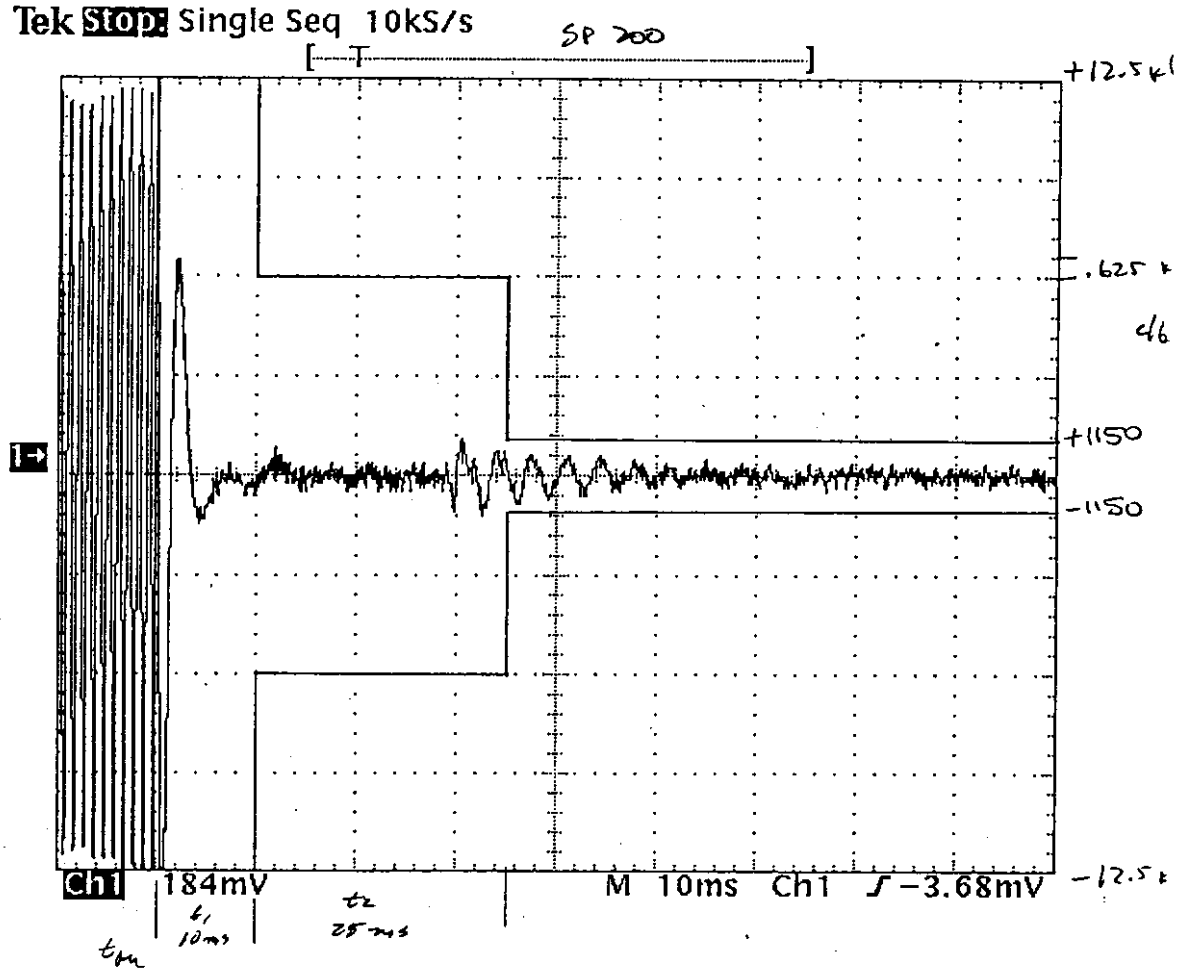
High Limit	460.001150 MHz
Low Limit	459.998850 MHz

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

Plots identified as Figures 5 through 7 demonstrate TFB for 12.5 kHz or 25 kHz channel operation.

FIGURE 5

TRANSIENT FREQUENCY BEHAVIOR

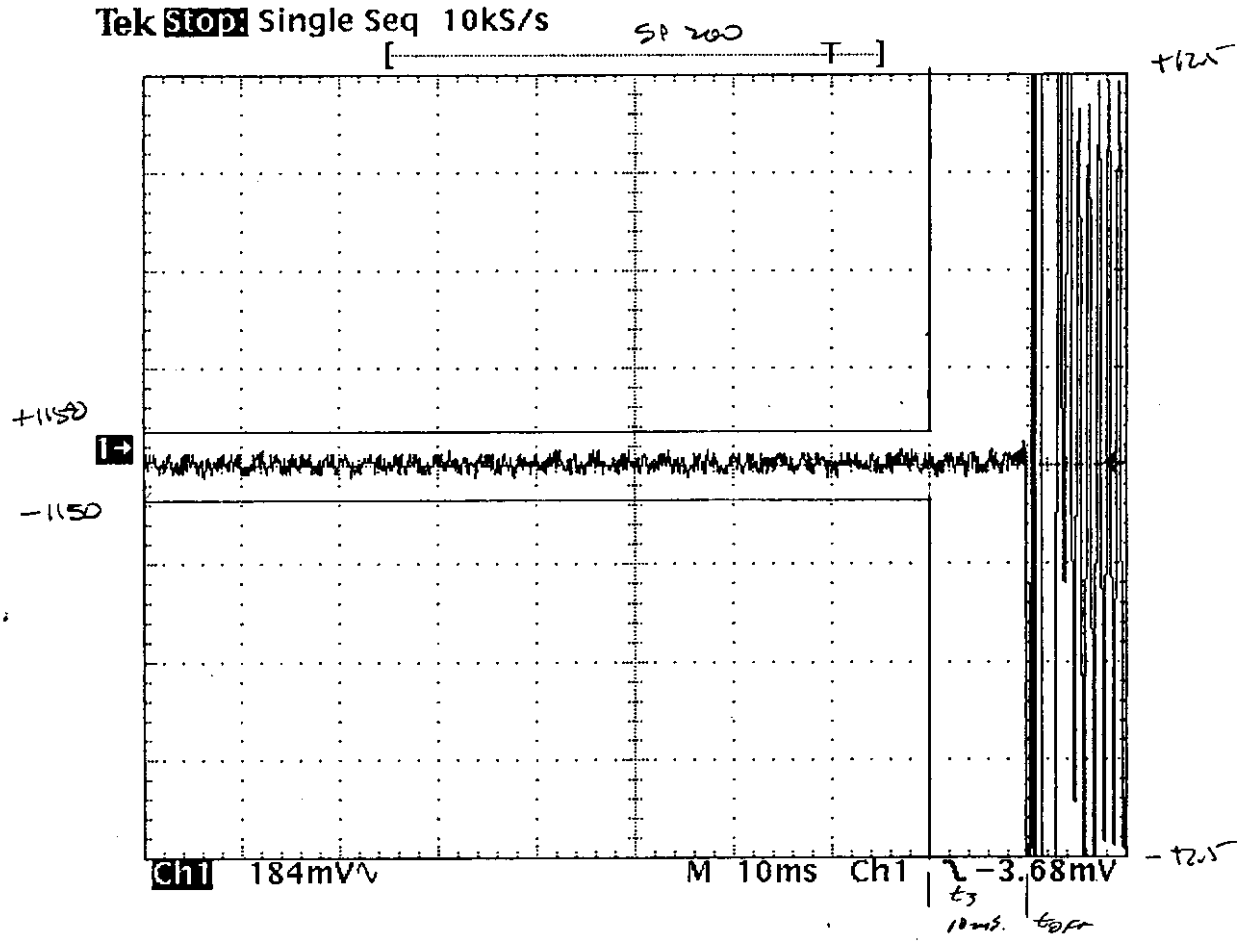


TRANSIENT FREQUENCY BEHAVIOR
FCC ID: F3JSP200U2

FIGURE 5 (12.5 kHz Turn-on)

FIGURE 6

TRANSIENT FREQUENCY BEHAVIOR

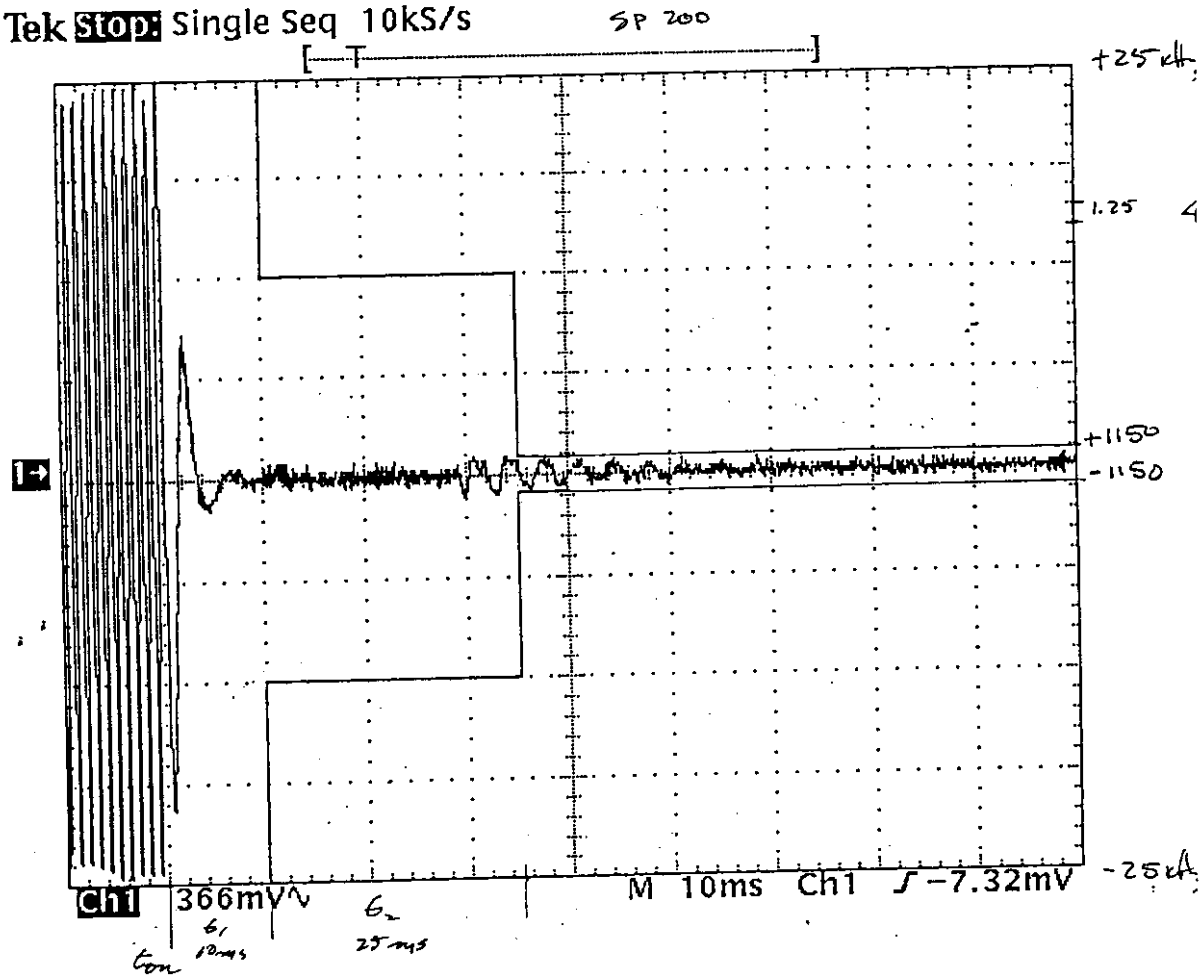


TRANSIENT FREQUENCY BEHAVIOR
FCC ID: F3JSP200U2

FIGURE 6 (12.5 kHz Turn-off)

FIGURE 7

TRANSIENT FREQUENCY BEHAVIOR

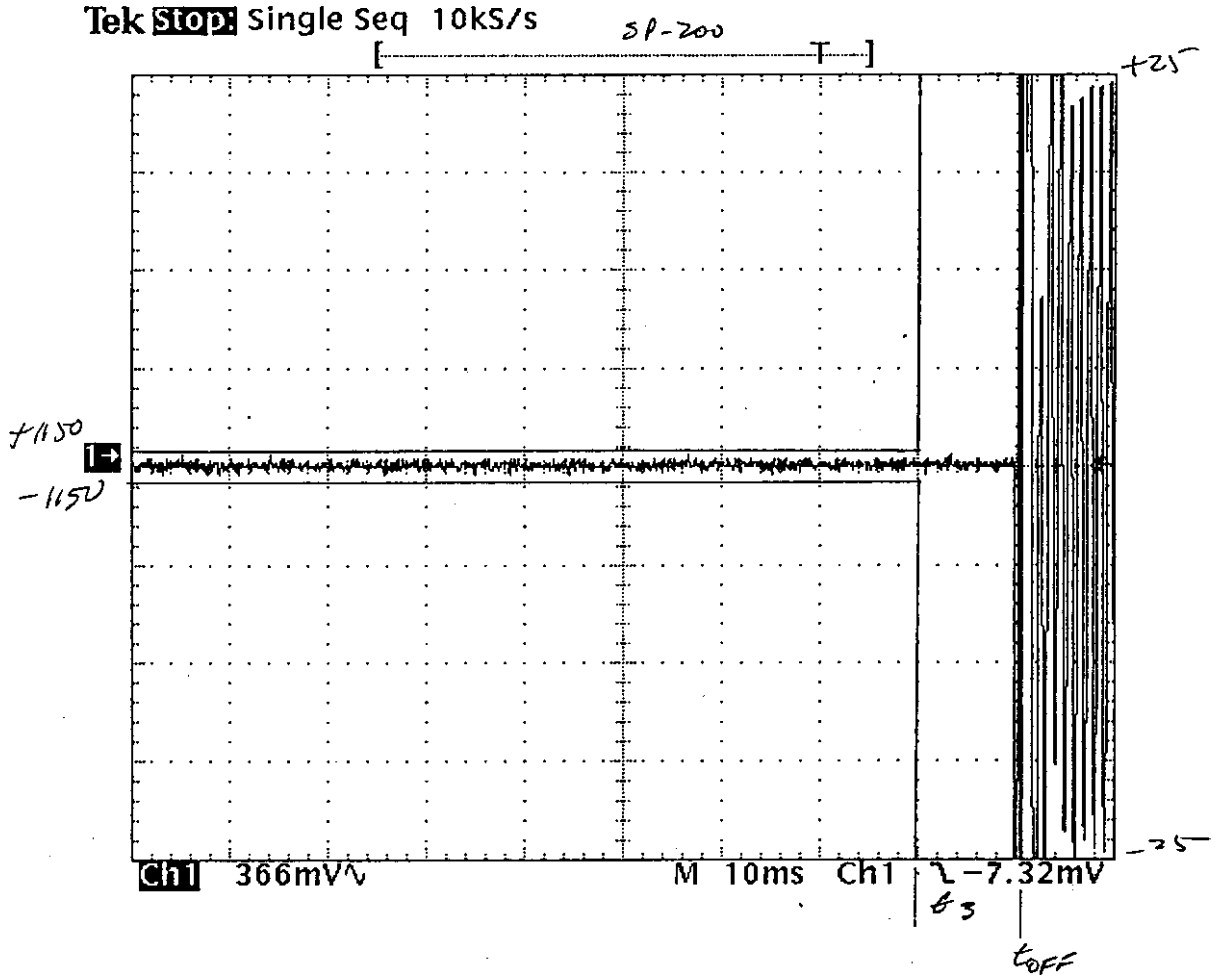


TRANSIENT FREQUENCY BEHAVIOR
FCC ID: F3JSP200U2

FIGURE 7 (25 kHz Turn-on)

FIGURE 8

TRANSIENT FREQUENCY BEHAVIOR

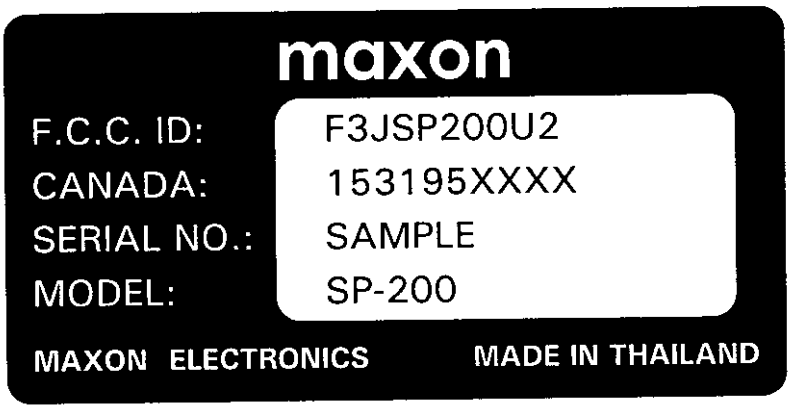


TRANSIENT FREQUENCY BEHAVIOR
FCC ID: F3JSP200U2

FIGURE 8 (25 kHz Turn-off)

APPENDIX 1

EQUIPMENT IDENTIFICATION LABEL



SEE PHOTO (APPENDIX 2) FOR LABEL PLACEMENT

APPENDIX 2

PHOTOGRAPHS

THIRTEEN (13) PHOTOGRAPHS FOLLOW THIS SHEET