ENGINEERING STATEMENT

For Type Certification of

MIDLAND CONSUMER RADIO

Model No: HP-405
FCC ID: MMA80400

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 Midland Consumer Radio to make type certification measurements on the HP-405 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: February 29, 2000

A. INTRODUCTION

The following data are submitted in connection with this request for Type Certification of the HP-405 transceiver in accordance with Part 2, Subpart J of the FCC Rules.

The HP-405 is a multi-bandwidth, UHF, frequency modulated transceiver intended for hand-held, portable applications in the 450 - 480 MHz band. It operates from a 7.5-volt battery pack. Output power rating is 1-4 watts. Both 25 kHz and 12.5 kHz channel operation is provided.

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

1. Name of applicant: Midland Consumer Radio

2. Identification of equipment: MMA80400

   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: 440-480 MHz.
   c. Operating power of transmitter is fixed at the factory at 4 watts and can be reduced to 1 watt.
   d. Maximum power permitted under Part 90 of the FCC is 350 watts, and the HP-405 fully complied with those power limitations.
   e. The dc voltage and dc currents at final amplifier:

      Collector voltage: 7.4 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.
   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.

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 4.0 watts; and with internal adjustments minimum power was 1.0 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 4.0 and 1.0 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 2996 Hz, the frequency of maximum response. Measured modulation under these conditions was 3.7 kHz, or 1.7 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.

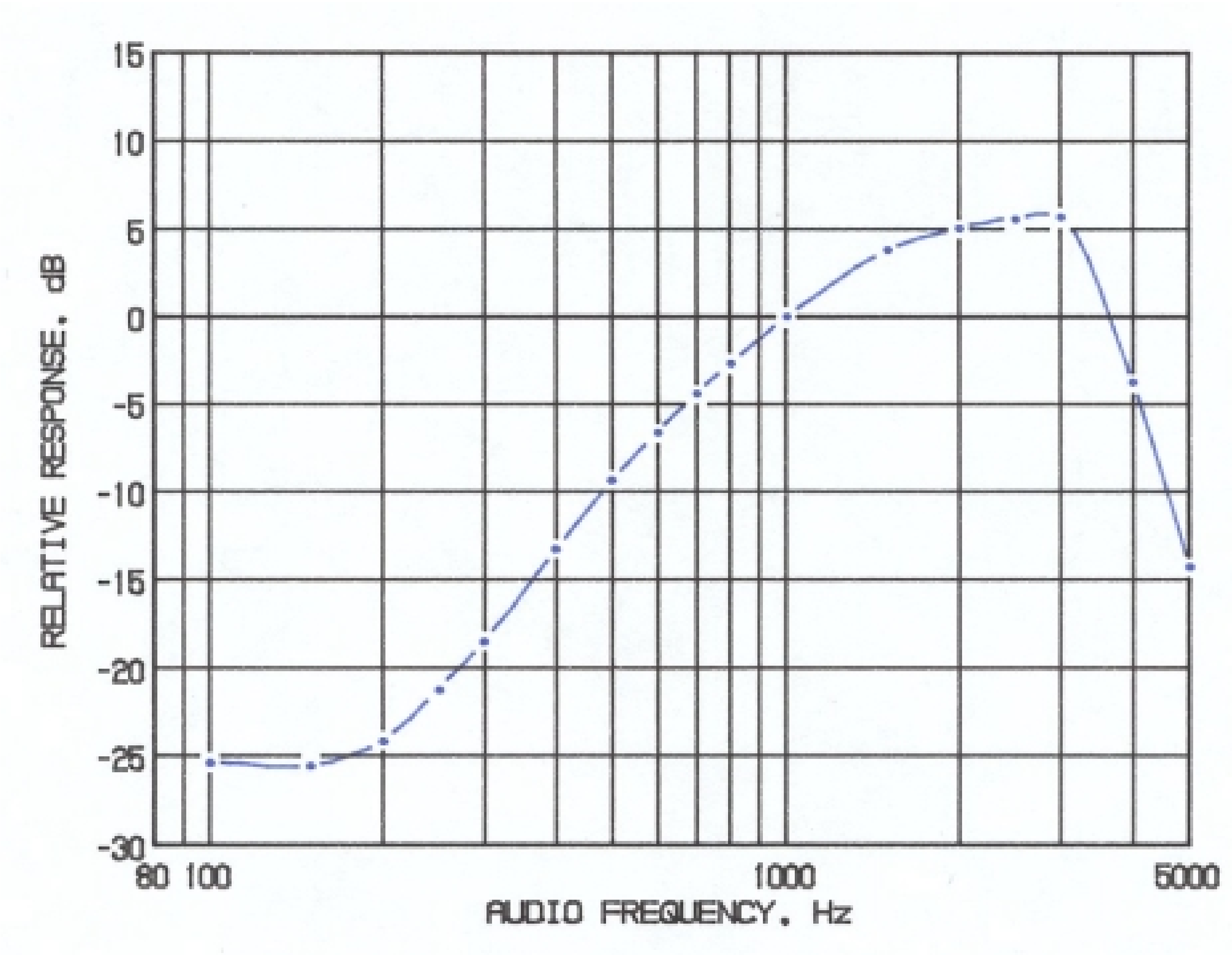
Emission designators: (2D + 2F)

25   kHz 2x5 + 2x3 = 16k0F3E
12.5 kHz 2x2.5 + 2x3 = 11k0F3E

D = rated system deviation, kHz.
F = maximum audio frequency, kHz.

FIGURE 1

MODULATION FREQUENCY RESPONSE

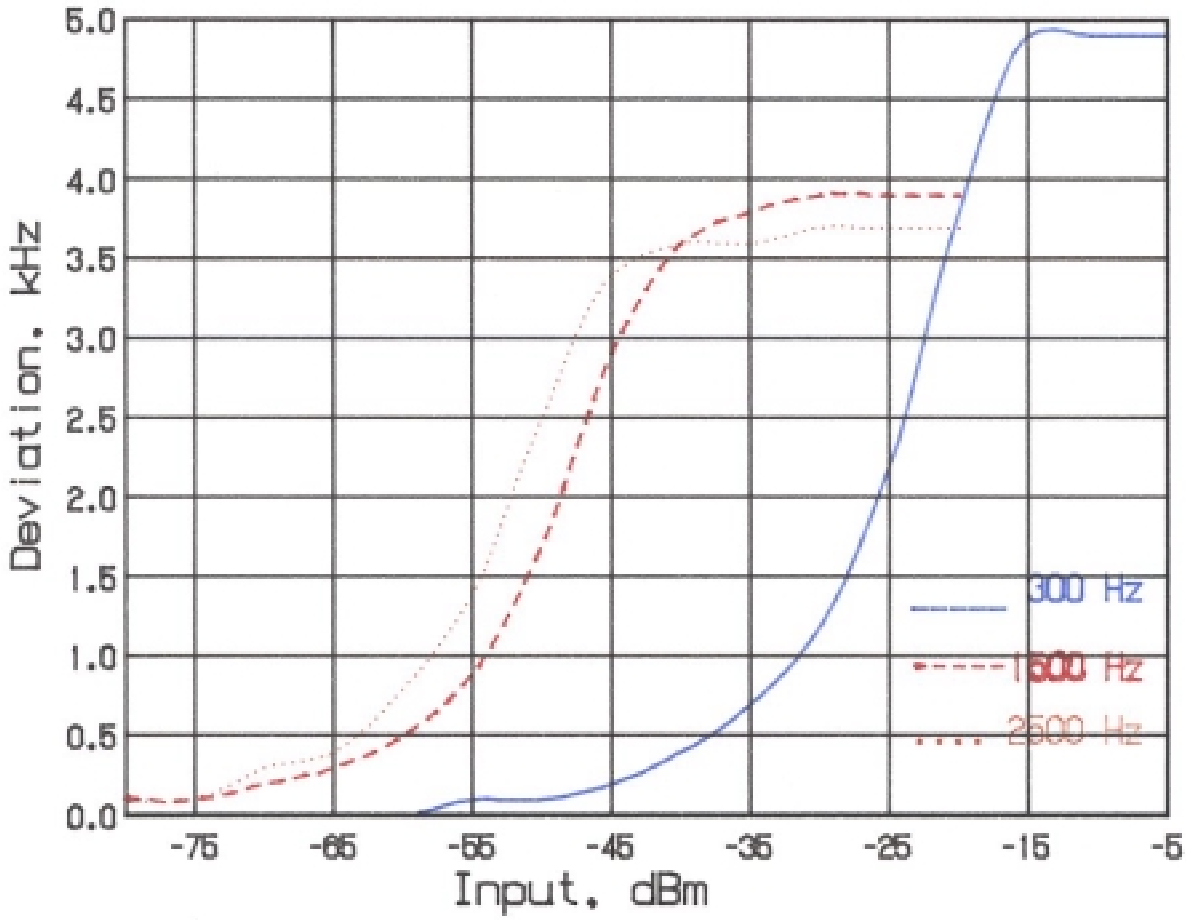


MODULATION FREQUENCY
RESPONSE
FCC ID: MMA80400

FIGURE 1

FIGURE 2a

AUDIO LIMITER CHARACTERISTICS

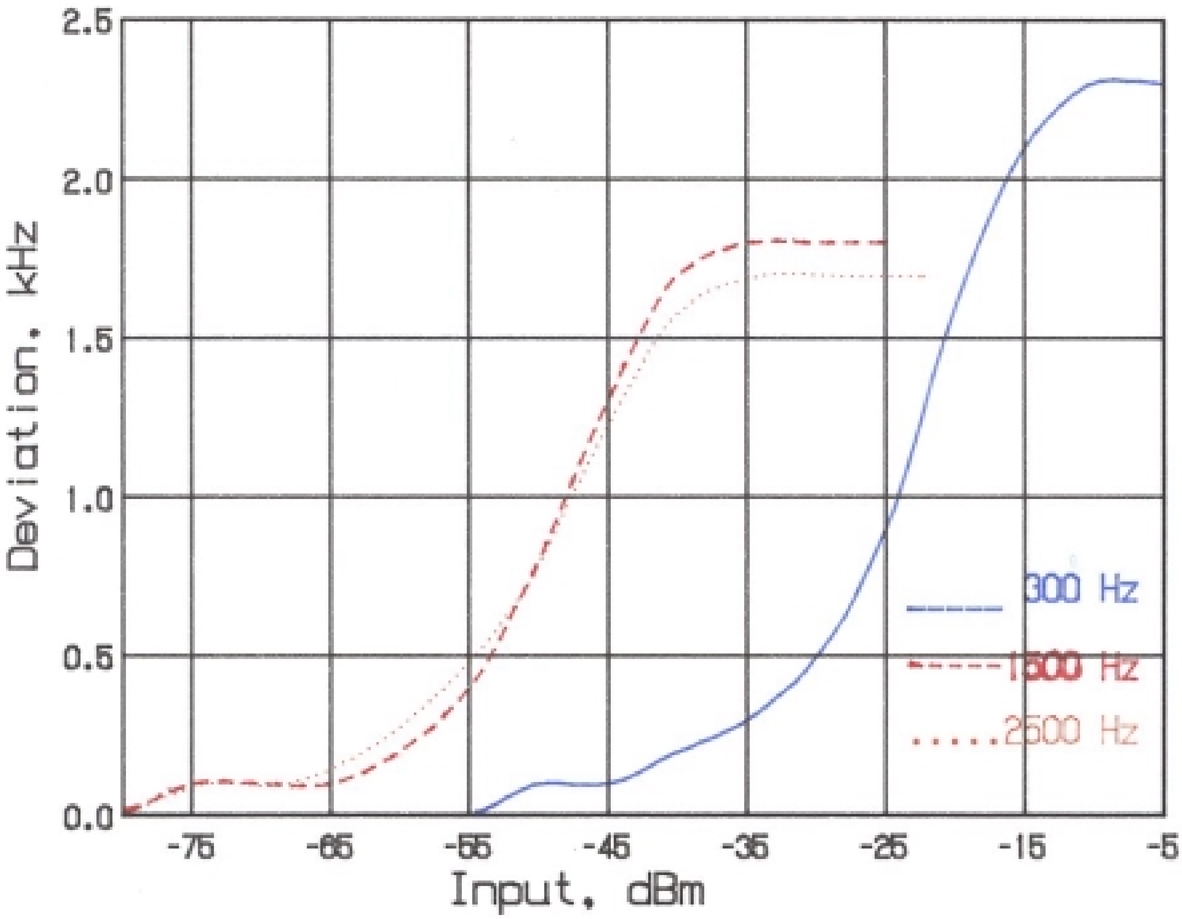


AUDIO LIMITER CHARACTERISTICS
FCC ID: MMA80400

FIGURE 2a Wideband (5 kHz)

FIGURE 2b

AUDIO LIMITER CHARACTERISTICS

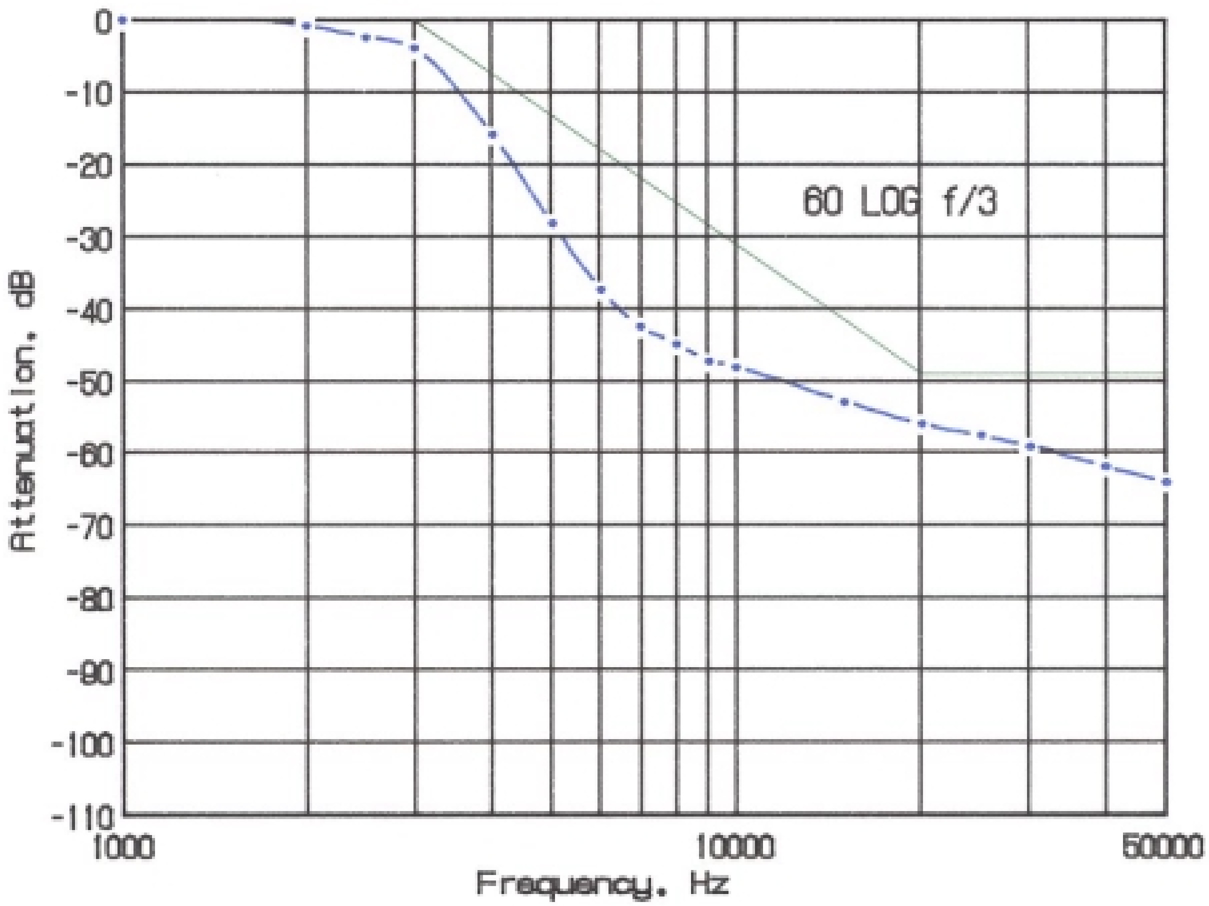


AUDIO LIMITER CHARACTERISTICS
FCC ID: MMA80400

FIGURE 2b Narrow band (2.5kHz)

FIGURE 3

AUDIO LOW PASS FILTER RESPONSE

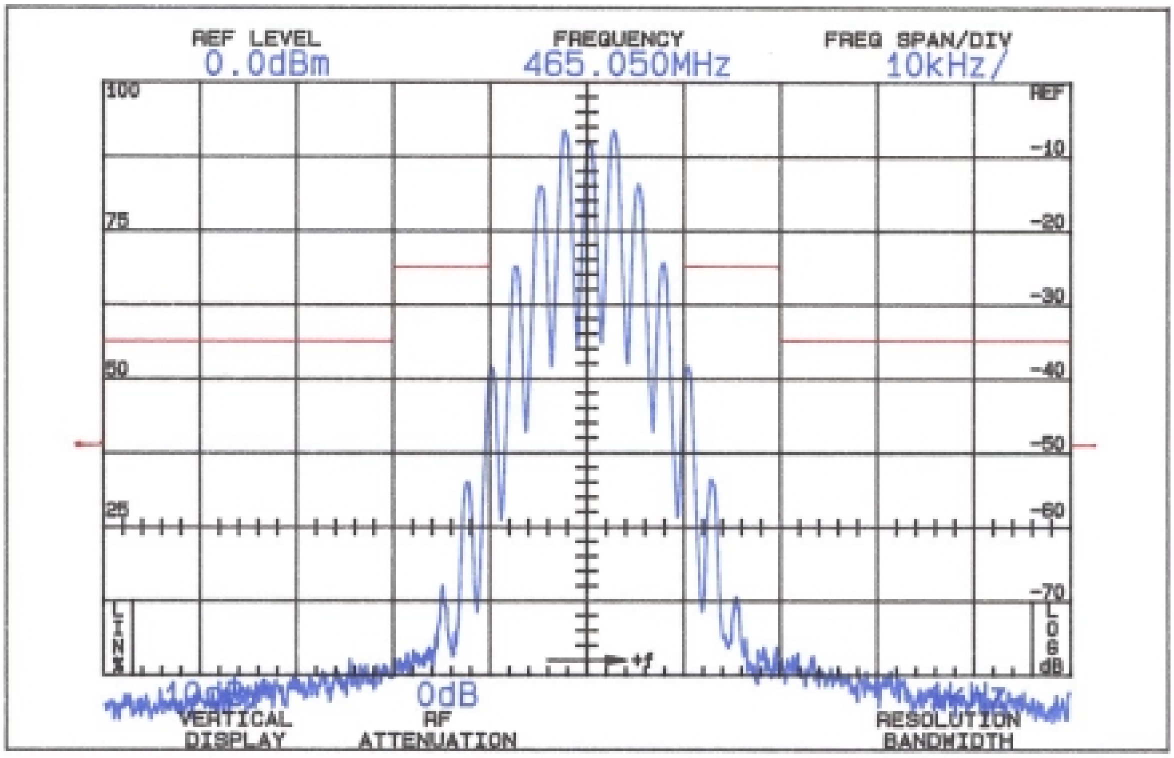


AUDIO LOW PASS FILTER RESPONSE
FCC ID: MMA80400

FIGURE 3

FIGURE 4a

OCCUPIED BANDWIDTH



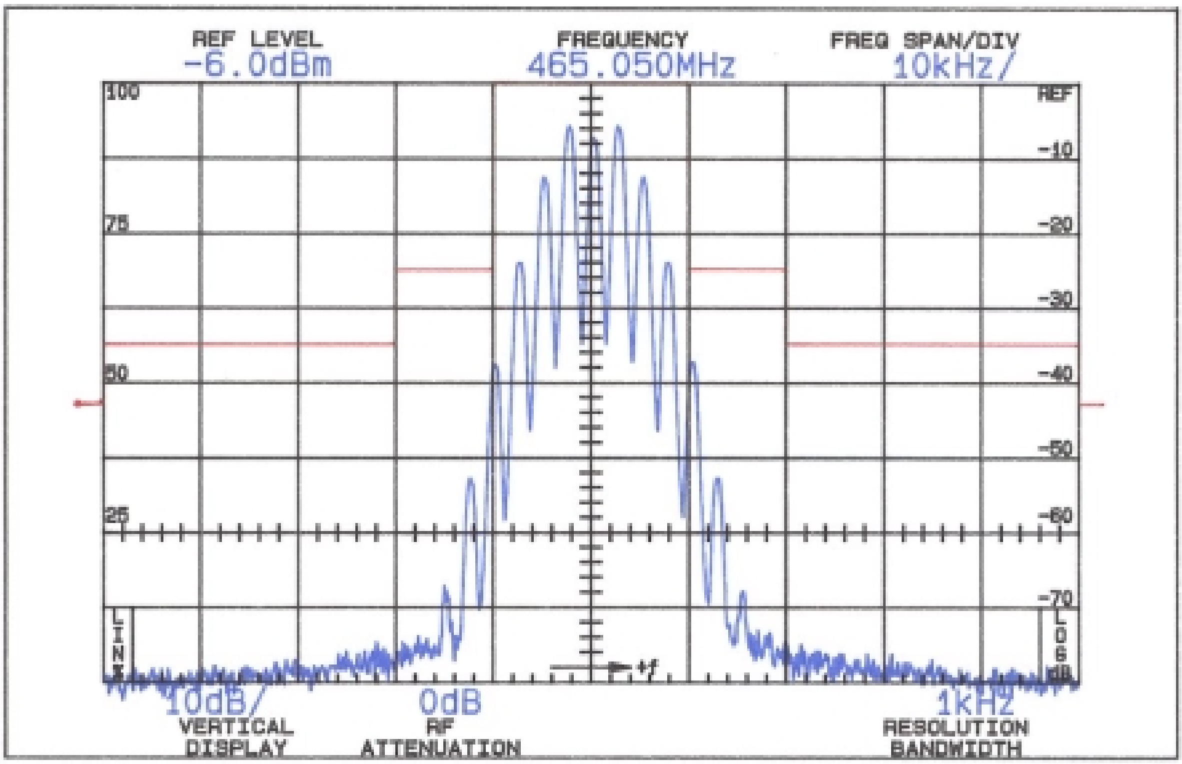
	ATTENUATION IN dB BELOW MEAN OUTPUT POWER Required
On any frequency more than 50% up to and including 100% of the authorized bandwidth, 20 kHz (10-20 kHz)	25
On any frequency more than 100%, up to and including 250% of the authorized bandwidth (20-50 kHz)	35
On any frequency removed from the assigned frequency by more than 250% of the authorized bandwidth (over 50 kHz)	43+10LogP = 49 (P = 4.0 W)

OCCUPIED BANDWIDTH (4.0W)
FCC ID: MMA80400

FIGURE 4a (5 kHz)

FIGURE 4b

OCCUPIED BANDWIDTH



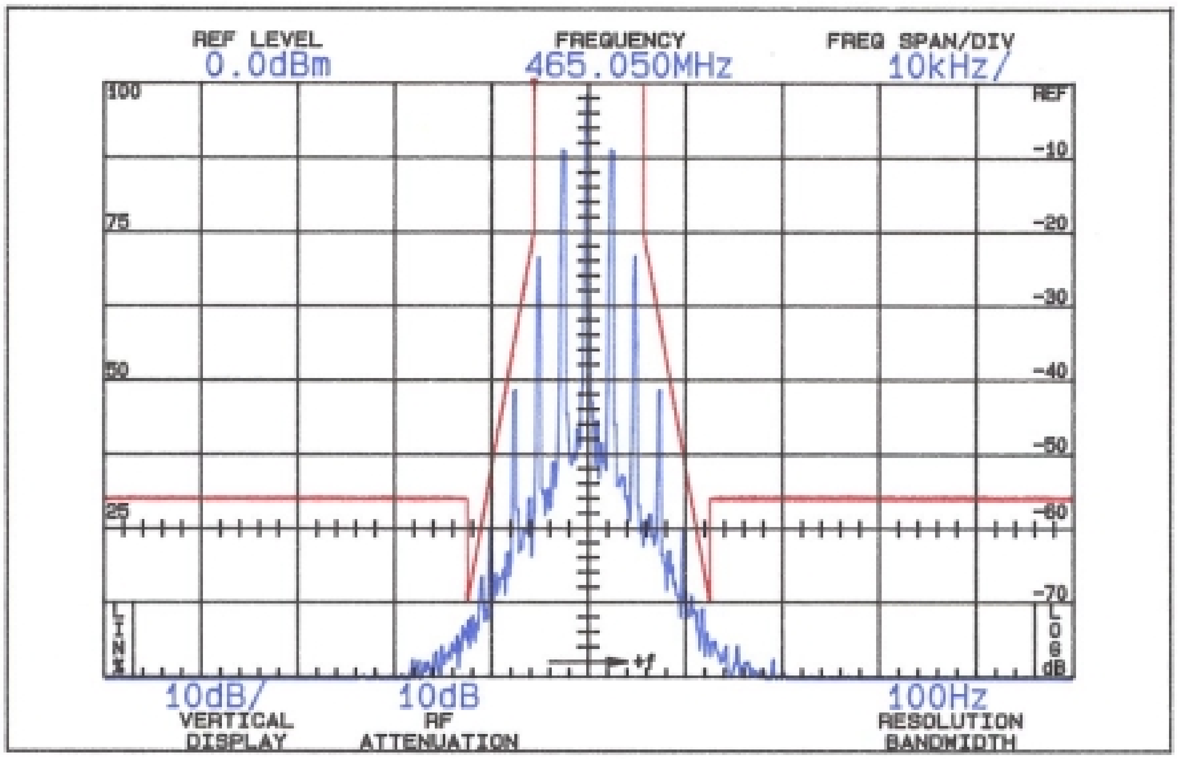
	ATTENUATION IN dB BELOW MEAN OUTPUT POWER Required
On any frequency more than 50% up to and including 100% of the authorized bandwidth, 20 kHz (10-20 kHz)	25
On any frequency more than 100%, up to and including 250% of the authorized bandwidth (20-50 kHz)	35
On any frequency removed from the assigned frequency by more than 250% of the authorized bandwidth (over 50 kHz)	43+10LogP = 43 (P = 1.0 W)

OCCUPIED BANDWIDTH (1.0W)
FCC ID: MMA80400

FIGURE 4b (5 kHz)

FIGURE 4c

OCCUPIED BANDWIDTH



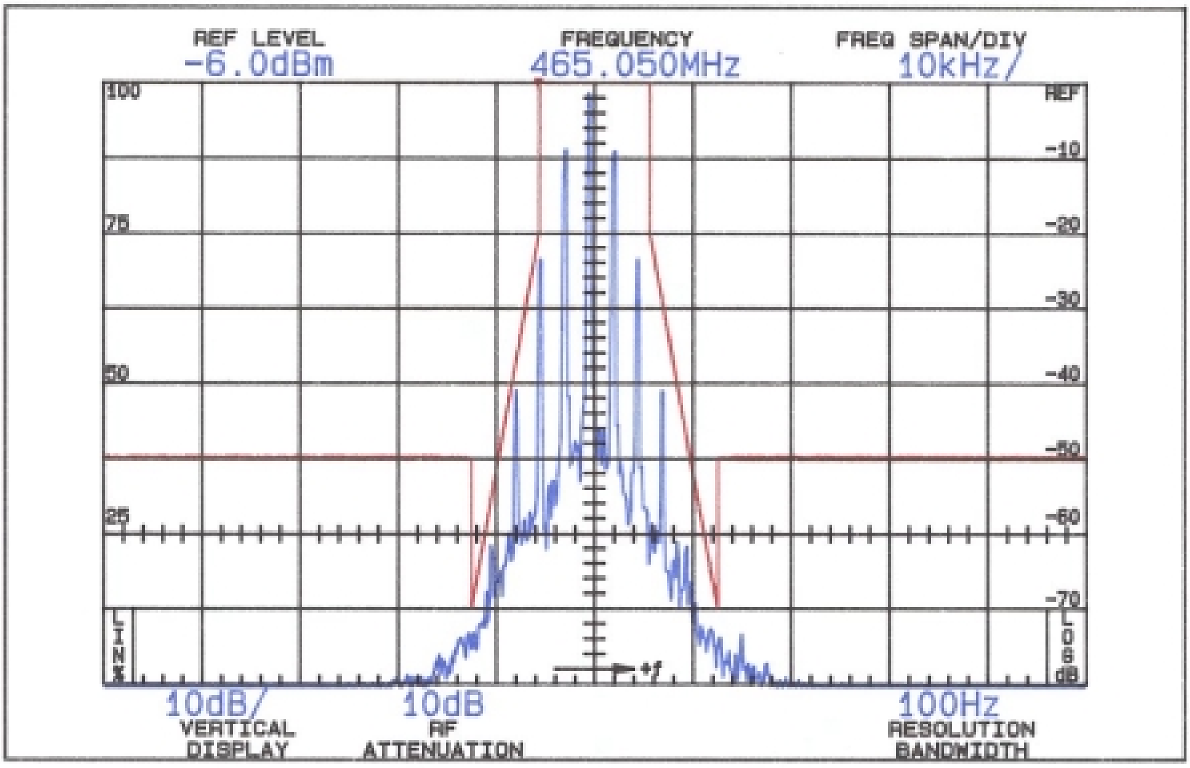
	ATTENUATION IN dB BELOW MEAN OUTPUT POWER Required
On any frequency from the center of the authorized bandwidth f_o to 5.625 kHz removed from f_o.	0 (>5.625 kHz)
On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.625 kHz but no 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 = 56 (>12.5 kHz) (P = 4.0W)

OCCUPIED BANDWIDTH (F3E 4.0W)
FCC ID: MMA80400

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 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 = 50 (>12.5 kHz) (P = 1.0W)

OCCUPIED BANDWIDTH (F3E 1.0W)
FCC ID: MMA80400

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 HP-405 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 2996 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 4.0 and 1.0 watts output throughout the RF spectrum from 14.4 (lowest frequency generated in the transmitter) 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
465.050, 7.5 Vdc Input

Spurious Frequency MHz	dB Below Carrier Reference

4.0 W

465.050	89	
930.100	>100	
1395.150	>100	
1860.200	>100	
2325.250	>100	
2790.300	>100	
3255.350	>100	
3720.400	>100	
4185.450	>100	
4650.500	>100	
Required:	49	(56) 90.210(d)

1.0 W

465.050	87	
930.100	>100	
1395.150	>100	
1860.200	>100	
2325.250	>100	
2790.300	>100	
3255.350	>100	
3720.400	>100	
4185.450	>100	
4650.500	>100	
Required:	43	(50) 90.210(d)

All other emissions from 14.4 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 HP-405 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 4.0 watts at 465.050 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 4.0 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 $$E = \frac{(49.2x4.0)^{1/2}}{3} = 4.7 \text{ V/m}$$

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

4.7 volts/meter = $4.7x10^6$ uV/m

dBu/m = 20 $Log_{10}(4.7x10^6)$

= 133 dBu/m

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

133 - 107 = 26 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 polarizations 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 (14.4 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

465.050 MHz, 7.5 Vdc, 4.0 watts

Spurious Frequency MHz	dB Below Carrier Reference[1]	
930.100	72H	
1395.150	78V*	
1860.200	78H*	
2325.250	73H	
2790.300	81V*	
3255.350	85V*	
3720.400	88V*	
4185.450	86H*	
4650.500	95V*	
Required:	49	(56) 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 14.4 MHz to 4.7 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 S1.0 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 465.050 MHz. No transient keying effects were observed.

TABLE 3

FREQUENCY STABILITY vs. TEMPERATURE

465.050 MHz; 7.5 Vdc; 4.0 W

Temperature, °C	Output Frequency, MHz	p.p.m.
-30.1	465.049989	0.0
-19.7	465.049892	-0.2
- 9.4	465.050005	0.0
0.3	465.049987	0.0
10.1	465.049992	0.0
20.1	465.050022	0.0
29.8	465.049989	0.0
39.9	465.049968	-0.1
49.7	465.049875	-0.3

Maximum frequency error: 465.049875
465.050000
- .000125 MHz

FCC Rule 90.213(a) specifies .00025% or a maximum of ± .001163 MHz, which corresponds to:

High Limit 465.051163 MHz
Low Limit 465.048837 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
465.050 MHz, 7.5 Volts Nominal, 4.0 W

%	Supply Voltage	Output Frequency, MHz	p.p.m.
115	8.63	465.050030	0.1
110	8.25	465.050026	0.1
105	7.88	465.050024	0.1
100	7.50	465.050022	0.0
95	7.13	465.050017	0.0
90	6.75	465.050010	0.0
85	6.38	465.050005	0.0
80	6.00*	465.049984	0.0

Maximum frequency error: 465.050030
465.050000
+ .000030 MHz

*MFR rated battery end-point

FCC Rule 90.213(a) specifies .00025% or a maximum of ± .001163 MHz, corresponding to:

High Limit	465.051163 MHz
Low Limit	465.048837 MHz

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

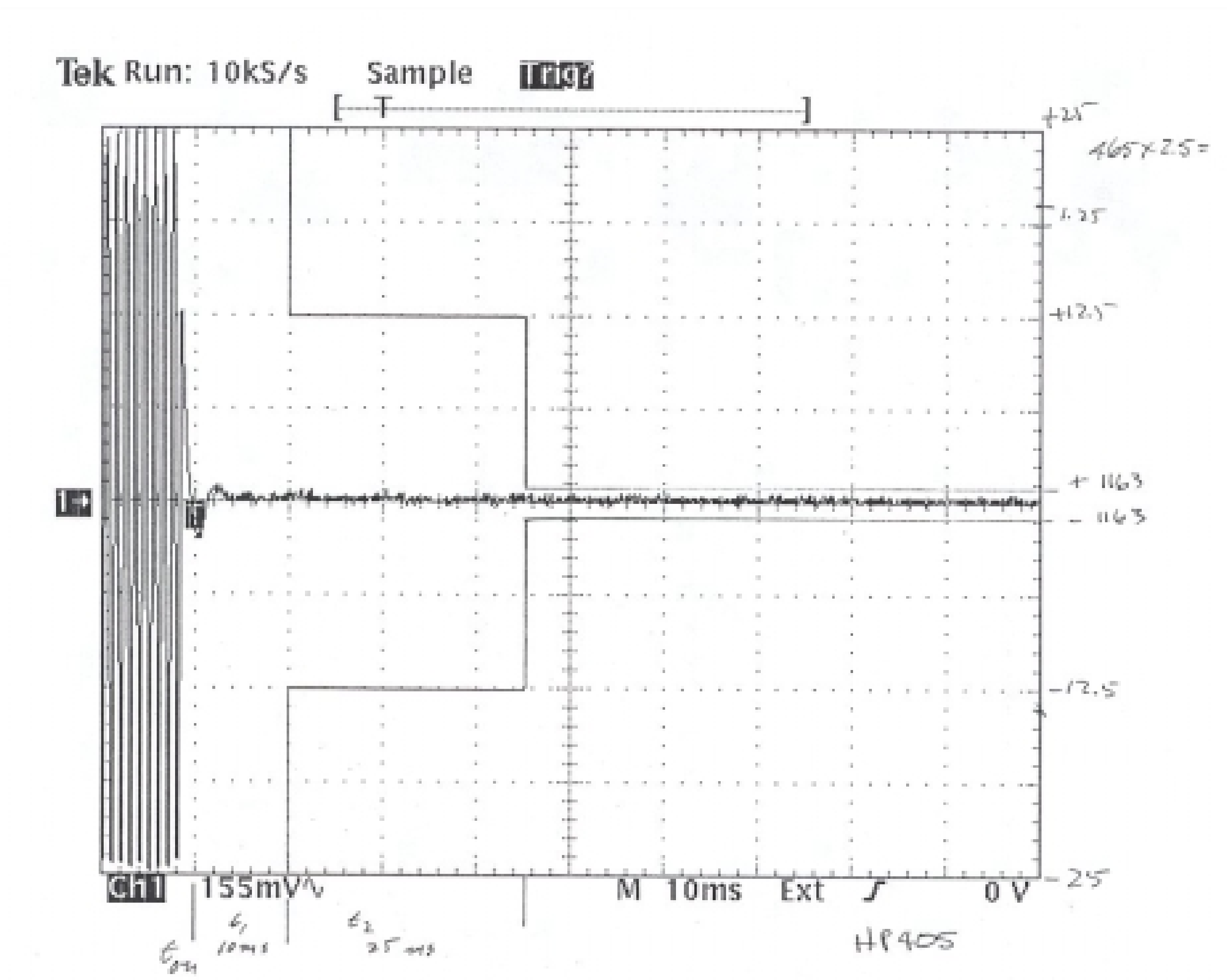
Plot identified as Figure 5 through 8 demonstrate TFB for 12.5 kHz or 25 kHz channel operation.

See Appendix 4 for test description.

FIGURE 5

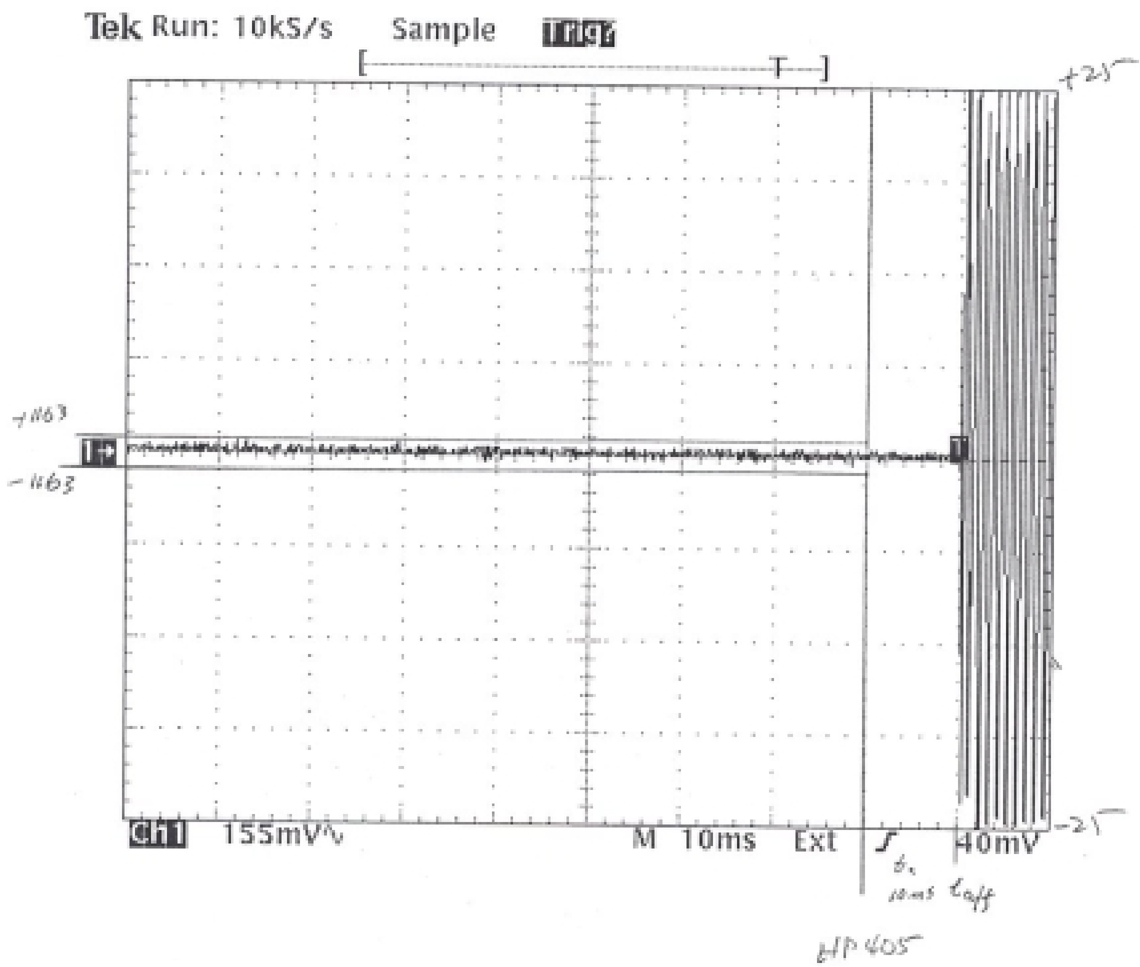
TRANSIENT FREQUENCY BEHAVIOR

25 kHz Turn On



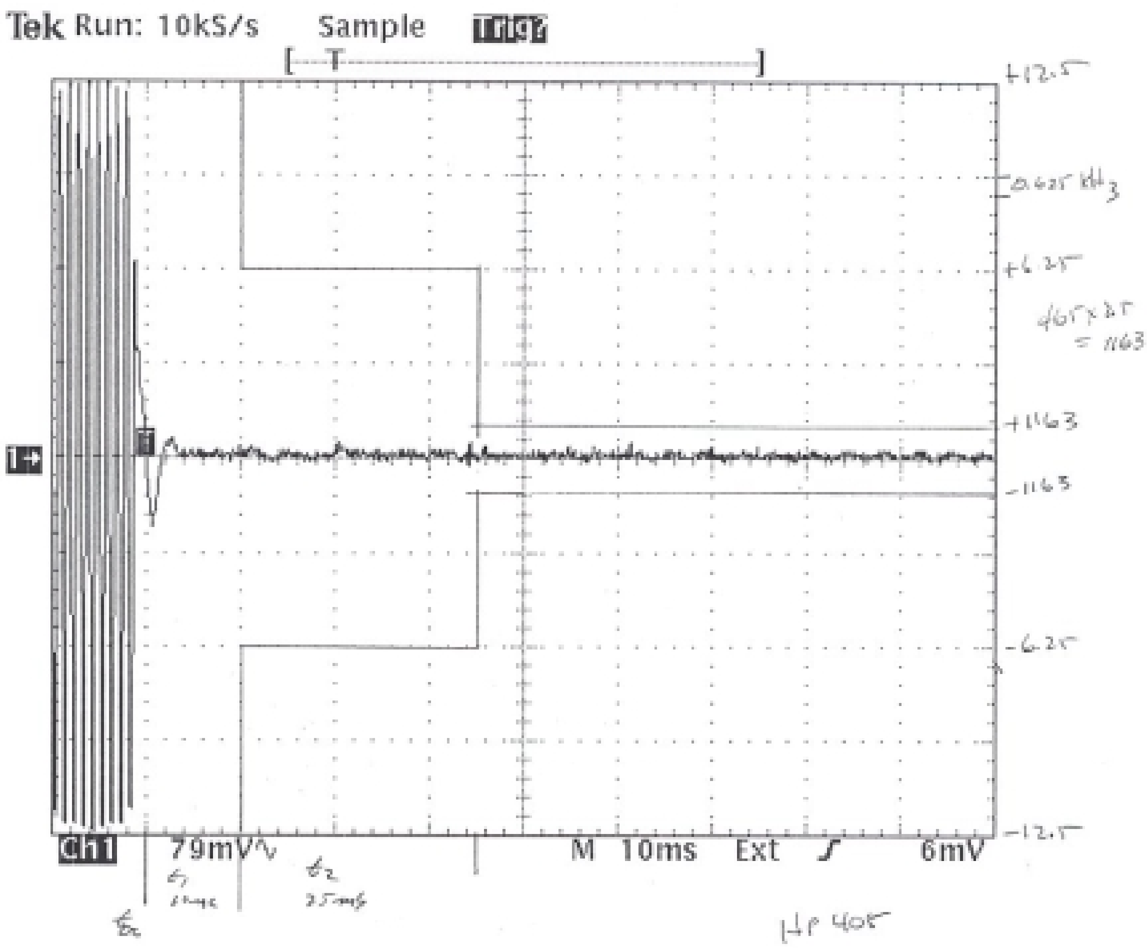
TRANSIENT FREQUENCY BEHAVIOR

25 kHz Turn Off



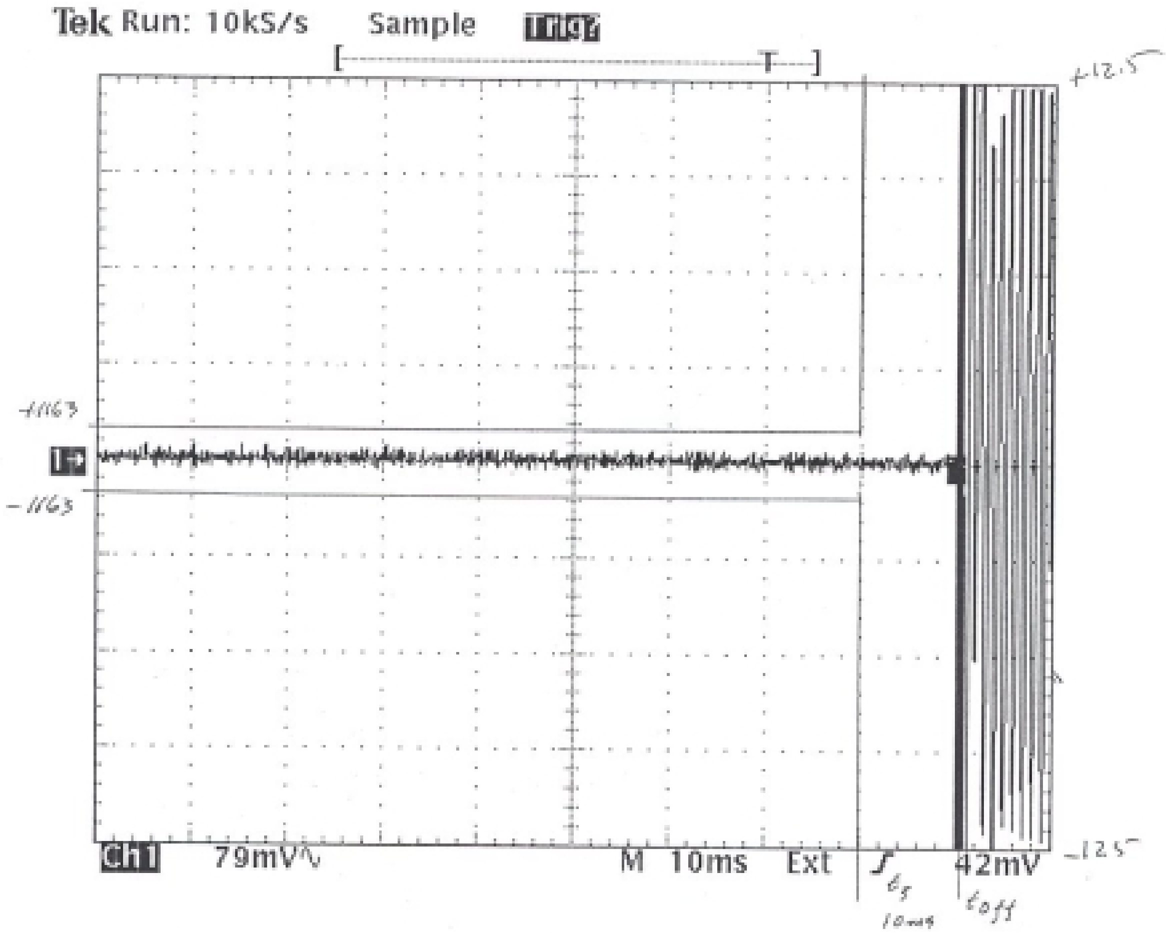
TRANSIENT FREQUENCY BEHAVIOR

12.5 kHz Turn On



TRANSIENT FREQUENCY BEHAVIOR

12.5 kHz Turn Off



TRANSIENT FREQUENCY BEHAVIOR
FCC ID: MMA80400

FIGURE 5

List of Active Devices and Functions
ALAN HP405 / 80-400

Reference	Device	Type	Function
Q101	M38223M4M	IC	MCU
Q102	CAT24WC08J	IC	EE-PROM
Q103	RN5VL45CA	IC	PWR on reset
Q110	DTC114EEA	Digital Transistor	Mic Mute (Sch: 2SJ243)
Q111	2SA1586GR	Transistor	PTT
Q112	DTC114EEA	Digital Transistor	PTT
Q116	UMH6N	Digital Transistor	LED Driver,TX/BUSY
Q201	TA31136FN	IC	Integrated FM Receiver
Q205	DTC114EEA	Digital Transistor	12.5/25kHz RX filter switch
Q206	2SJ144Y	FET	Squelch gate
Q208	NJM324V	IC	RX Audio processing
Q212	NJM324V	IC	Audio processing/CTCSS,DCS
Q213	NJM2904V	IC	Audio processing/CTCSS,DCS
Q214	NJM2058V	IC	TX Audio processing
Q215	DTC114EEA	Digital Transistor	12.5/25kHz Mod switch
Q216	UMH6N	Digital Transistor	signaling mod
Q219	UMW1N	Digital Transistor	RX Audio switch
Q220	2SA1362GR	Transistor	RX Audio switch
Q221	NJM2070M	IC	Audio amplifier
Q222	S81350HG	IC	Voltage Regulator
Q223	UMA9N	Digital Transistor	Power control/Power save
Q224	UMG2N	Digital Transistor	Power control/Power save
Q225	DTC144EA	Digital Transistor	Power control/Power save
Q226	DTA123YEA	Digital Transistor	Power control/Power save
Q229	DTC114EEA	Digital Transistor	12.5/25kHz Mod switch
Q235	2SJ144Y	FET	TX Audio MUTE
Q240	NJM2072M	IC	VOX Amp
Q241	DTA114EEA	Digital Transistor	VOX Control
Q242	DTA114EEA	Digital Transistor	VOX Sensitiviy Switch
Q245	DTC114EEA	Digital Transistor	
Q246	UMH6N	Digital Transistor	

List of Active Devices and Functions
ALAN HP405 / 80-400

Reference	Device	Type	Function
Q404	2SC3356-T1B	Transistor	RX RF amp
Q405	HSMS-2817	DBM	RX mixer
Q406	2SC4215Y	Transistor	1st IF Amp
Q407	PF0350	Integtrated Amp	TX PA
Q408	NJM2904V	IC	TX Power control
Q409	DTC114EEA	Digital Transistor	TX Power control
Q410	DTA144EEA	Digital Transistor	TX Power control
Q411	DTC144EEA	Digital Transistor	TX Power control
Q412	MMBR951L	Transistor	TX Pre-driver
Q413	MRF947AT1	Transistor	VCO TX Buffer
Q414	MRF947AT1	Transistor	VCO RX Buffer
Q425	2SA1586GR	Transistor	Charge Pump
Q426	2SC4116GR	Transistor	Charge Pump
Q427	2SC4116GR	Transistor	VCO DC Isolator
Q429	MB15A02PFV1	IC	Synthesizer
Q430	2SB798-T1	Transistor	TX Enable
Q431	UMW1N-TL	Digital Transistor	T/R
Q434	DTA114EEA	Digital Transistor	T/R
Q435	DTA123YEA	Digital Transistor	Low Voltage inhibit
Q436	UMW1N-TL	Digital Transistor	Low Voltage inhibit
Q437	DTC144EEA	Digital Transistor	T/R
Q450	DTC144EEA	Digital Transistor	Pwr Control, H/L TX
Q915	MRF947AT1	Transistor	VCO Buffer
Q916	2SK508-T1	FET	TX VCO
Q919	2SJ243-T1	FET	VCO control
Q920	UMC4N-TL	Digital Transistor	VCO control
Q922	2SK508-T1	FET	RX-VCO
X401	DSA751HA	VC-TCXO	14.400MHz Synthesizer ref.

FUNCTION OF DEVICES
FCC ID: MMA80400

APPENDIX 1

APPENDIX 2

CIRCUITS AND DEVICES TO STABILIZE FREQUENCY

A 14.4 MHz referenced TCXO PLL circuit establishes and stabilizes output frequency.

APPENDIX 3

CIRCUITS TO SUPPRESS SPURIOUS RADIATION, LIMIT MODULATION AND CONTROL POWER

TRANSMITTER STAGE HARMONIC FILTER

The output of the final is applied to a low-pass filter (C451, C452 and L413) and then to the transmit/receive switch Q402. RF power is then fed to the antenna via the output low-pass filter consisting of C401, C405, C408, L401 and L402.

AUTOMATIC POWER CONTROL

Output power is controlled via the dual Op-Amp (Q408), which is used as a differential amplifier and comparator. Current is sensed by the voltage drop across R421 and R422. This voltage is compared to the one set by the 4 watt adjustment RV401. The power output is then reduced or increased by varying the Q410;s output voltage applied to the power amplifier Q407’s pin 2.

MICROPHONE AUDIO CIRCUIT

Transmit speech audio is provided by either the internal electric microphone N101 or the external microphone. The microphone audio is applied to MIC MUTE SW Q235, and Lo-pass filter Q214A, Q214B. The audio is pre-emphasized by 6 dB per octave by C236 and R284, and then signal amplification. The gain is such that when a signal 20 dB greater than limiting the peak-to-peak output. Under these conditions, the MOD, ADJ. Pot RV201 configured as a four-pole active low-pass filter. The resulting signal is then limited when respect to side band splatter, and has an 18 dB per octave roll-off above 3 kHz.

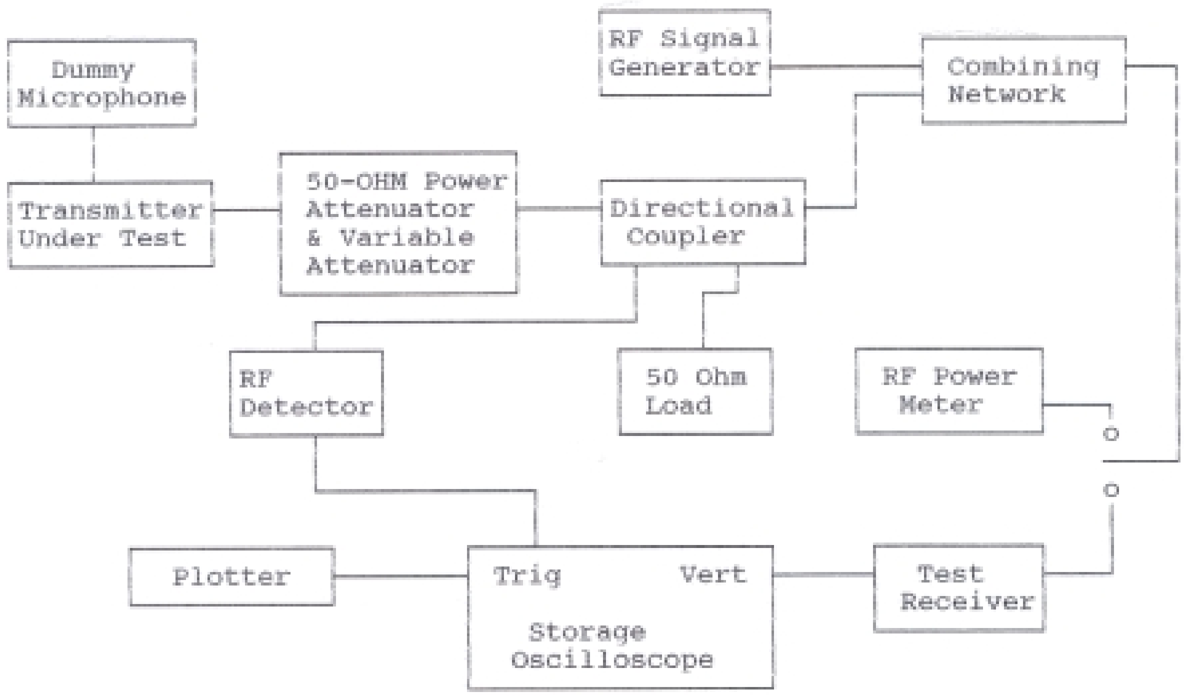
The audio is then applied through the 25 kHz/12.5 kHz channel spacing SW Q215 to transmit VCO. By varying the voltage on the varactor diode Q921 at an audio rate. The resonant frequency of VCO is varied. The result is an oscillator output that is frequency modulated at the audio frequency.

APPENDIX 4

TRANSIENT FREQUENCY BEHAVIOR (90.214) TEST PROCEDURE

Para. 2.995(a)(b)(d) <u>Frequency stability</u>

90.214 (continued) Transient Frequency Behavior



90.214 TRANSIENT FREQUENCY BEHAVIOR

REQUIREMENTS: In the 300 - 500 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 300 - 500 MHz
t_1	±25.0 kHz	10.0 ms
t_2	±12.5 kHz	25.0 ms
t_3	±25.0 kHz	10.0 ms

End of t_2 to beginning of t_3: 2.5 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.