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Request for Type Acceptance of the
J-Tech On-Premise Paging System

Model Series-2600
FCC ID:HLG SERIES2600tx

Test Performed by:

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System Specifications

J-Tech, Inc. Premise Paging System Series-2600

Item	Specification
Operating Voltage	13.8 volts 1.7 amp external power supply
Power Output	.5 to 2W depending on country
Modulation	FSK 512 BPS
Protocol	POCSAG
Display	2 line by 8-character alpha numeric LCD
Keyboard	Numeric 3X4 sealed rubber tactile
Antenna port	50 ohm BNC with rotating mount
Mounting	Horizontal for desktop mounting or Vertical for wall mount
Accessory port	For factory programming
Operating frequency	UHF synthesized 450 MHz-470 MHz. 12.5 KHz splinter channels
Temperature Stability	-30C to +50C with better than 2.5 PPM frequency stability
Size	7 3/8" Long (187 mm) x 7 1/8" High (181 mm) x 0.9" Tall (23 mm)
Weight	3 lbs. 1360 g

Technical Description Overview

A. The Series 2600 desktop transmitter operates on 12.5 kHz or 25 kHz UHF assigned channels. The RF transmitter maximum output power is 2 watts and the encode data rate is 1024 bps. Emission type is 7K0F1D.

B. Series 2600 transmitter

The paging transmitter is frequency synthesized and uses a phase lock loop (PLL) design. The reference oscillator is a voltage controlled temperature compensated crystal oscillator (VC-TCXO) and determines the temperature frequency stability of the final output. The design uses a number of control elements to insure that the final transmit channel is achieved before enabling the power amplifier. Modulation of the loop requires modulating the voltage controlled oscillator (VCO) and the reference oscillator. A 2 port modulation scheme insures good fidelity modulation for the low frequency paging data. Additional circuits under control of the micro processor via an I2C bus control factory set channel frequency, RS-232-C interface.

C. Major Component and Active Devices on transmitter section

U20 Voltage regulator + 9 volts	l78scv
U1 Voltage regulator + 5 volts	lm7805
U3 Analog switch	CD4053
U4 Quad Operational Amplifier	LMC6582
U8 RS-232 Serial Interface integrated circuit	MAX232A
U6 RF Power Module Hybrid integrated circuit	RA07N4047M
U7 PLL synthesizer integrated circuit	ADF4110
U8 Buffer amp	MAV11BSM
U9 TCXO Hybrid integrated circuit	TEW TX1824M
Y3 Voltage control oscillator VCO hybrid	RTVCA450-10
Q2 Digital Transistor	BCX17
Q3 Power control voltage follower	MMBV2222

Technical Description Detail Pager Master Transmitter

Frequency Synthesizer

a. Reference Oscillator and VCTCXO

The reference oscillator provides the frequency stability vs. temperature characteristic for the transmitter. The reference element is compensated to better than 2.5 ppm and is supplied as a pre-packaged hybrid unit or equivalent. Modulation is direct FM introduced to a varactor port and provides low frequency data modulation. The output of the reference at 9.6 MHz. is applied to the synthesizer U7 where it is internally divided to provide a reference frequency of 12.5 KHz.

b. PLL Synthesizer, Data Modulation, and Loop Filter

The PLL system consists of three (3) main devices; the synthesizer IC U7, VCO Y3, and the reference oscillator. Control of the synthesizer U7 is provided by microcontroller and resident firmware. The synthesizer uses a dual modulus prescaler and is a standard indirect PLL technique. The IC U7 consists of phase/frequency detector, 1/N counter or main divider, two modulus counter and control, and reference counter. Main control of these internal circuit blocks within U7 is via control over a control bus to PINs 11-14 of U7. Data clock is provided to PIN 8. The reference oscillator operating at 9.6MHz. is divided to a fixed 12.5 kHz. Control of the 450-470 MHz VCO is via U7 phase frequency comparator and charge pump circuit with external loop filter. Appropriate value of the 1/N counter can be obtained from the 2 modulus equation with the 2 modulus count equal to $31/32$, the reference frequency at 12.5KHz. and the VCO frequency equal to the transmit channel. The loop filter is a conventional low pass with phase lead compensation provided by R12 and C60. Pre-integration of the charge pump pulses is provided by C34 and additional reference filtering of the charge pump pulses is provided by R39 and C35. Modulation fidelity is maintained by introducing the data signal at 2 points in the loop. One data signal is applied to the VCO control line voltage via the loop filter. The other is introduced to the reference oscillator. In order to modulate the VCO correctly, and introduce a summing junction for modulation and VCO control, the modulation signal voltage is converted into a current. R38 provides this function. Data shaping for the VCO modulation is provided by low pass filter R40 and 41 and C61. Data shaping for the reference oscillator and VCO modulation port is provided by a low pass data filter. U4.and U3 along with R20, R26, R28, and C47 through C49 provide a low pass filter. Additional filtering is provided by R40, 41 and C61. Since 2 point modulation is used it is necessary to control the amount of deviation contributed to each modulation port. An imbalance of signal at one port or the other will produce either excessive integration or differentiation of the modulation. Since the modulation gain of the reference is much less than the VCO, deviation adjustment is directly connected to U9 the reference oscillator and controlled by R5,R4. Deviation compensation is controlled by R54.

Transmitter Controller

c. Microcontroller

The controller 89c55 provides via an I2C interface bus programming of the synthesizer U7. In addition the microcontroller encodes the keyboard input data with additional bits for error correction and finally into pocsag data format. Microcontroller firmware also handles power management routines including switching the power amplifier on after frequency and phase lock is achieved, if no keyboard activity is The controller clock is 12 MHz. set by C10 and 11 and crystal Y1. External communication via a serial port J1 with the controller is handled by an RS-232 interface U8.

RF Power and Supply Distribution

e. Power amplifier and Low Pass RF Filter

The VCO output Y3 is applied to a resistive power splitter using R15, R16 and R17. This split and reduced power is input to the synthesizer prescaler and buffer amplifier. Signal from buffer amp. Is applied to power module U6 . Power Module provides rated output power and is factory set via power adjust R52. Low source impedance voltage control for PA power adjust is provided by follower Q3. Power amplifier enable is controlled by a series transistor switch Q2 switch. RF output is obtained at PIN 4 and is low pass filtered by a 7 section Chebychev filter using C36 through C38 and C42 along with L6 through L8.

f. Power Distribution

Main power supply distribution is from an 13.6 volt external power supply. This supply is rated at 2.4 amps maximum, and has built in shut down protection for short circuit protection. Reverse polarity protection is provided by D2. This could occur if incorrectly polarized DC plug or incorrect power supply is used. Supply via J2 is RFI filtered via L2, L3 and C1,C2 .

Test and Alignment Procedure

Series 2600 transmitter

The tuning of the transmitter consists of four (4) adjustments. The carrier center frequency is adjusted via a trimmer capacitor contained within TCXO reference module U9. The modulation level which controls deviation is set by R4, R5 and R54. These three adjustments also work together to control modulation fidelity of the phase lock loop. The final adjustment factory presets RF output power via setting R52.

1. The RF center frequency is adjusted by monitoring the VCO output without modulation. The operating frequency is counted and adjusted to within +/- 200 Hz.
2. The frequency deviation and modulation fidelity are measured with a nominal 250 Hz (one fourth data rate) square wave provided and the microprocessor modulation output pin. Demodulation of the transmitted data on a service monitor provides a scope readout of the deviation. Adjust R4, R5 for symmetrical deviation of 4 kHz peak.
4. Modulation fidelity, the rise and fall time of the data modulation signal, is observed on the service monitor. Adjustment of the compensation control R54 controls the undershoot and overshoot of the waveform to ensure flat response.
5. With these adjustments made, deviation is limited and held constant, since the signal level swings are limited and constant as set by the controller logic. With the data fidelity set and checked the modulation bandwidth is limited by a combination of data filters and phase lock loop bandwidth.
6. RF final output power is measured into a 50 ohm system load at antenna terminal and is adjusted by a factory preset adjustment R52. Power output is set at +33 dBm (2 watts maximum).

Test Results

Power Output

RF Power Output vs. Temperature and Line Voltage

FCC rules:2.1033(c)(6) 2.1046(a) 90.267

Specification: 2 watt maximum

Test Results: Unit tested comply with FCC specification

Test Conditions: Room Temperature (+25°C.)

Nominal DC Supply voltage 13.8 VDC (line voltage at 115 volts)

Unit under test in transmit with no modulation

Test Equipment: Variac

30 dB attenuator PAD

Spectrum analyzer

Voltmeter

Temperature chamber

Power Supply

Staco Energy Products Model 6020CT

HP 11708

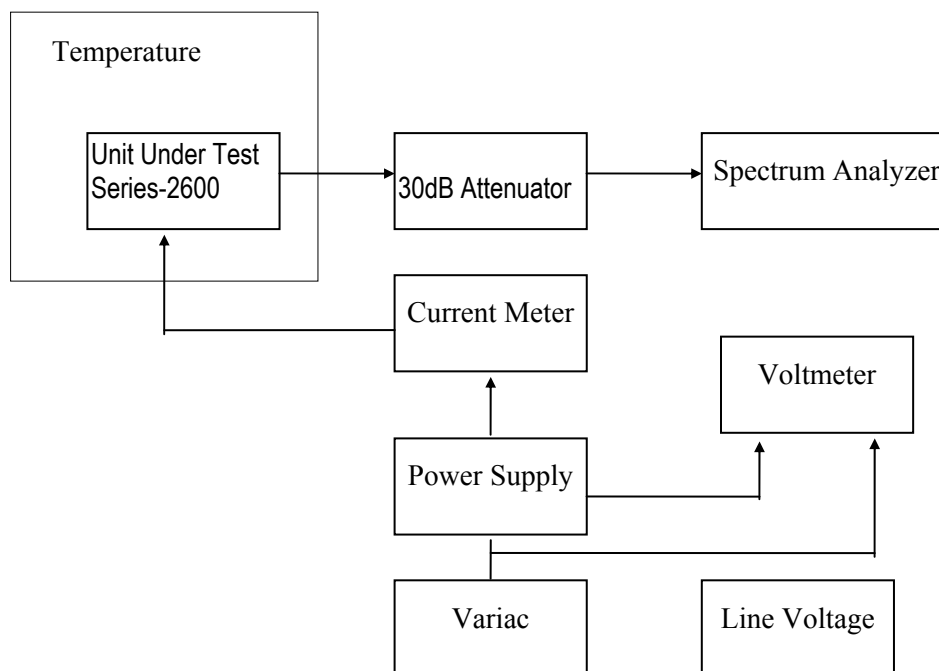
AGILENT 4407B

Fluke 77

Tenny Model Series 942

Cinon electronics Model TR36A

Test Setup:



Test Results... RF Power Output vs. Temperature and Line Voltage

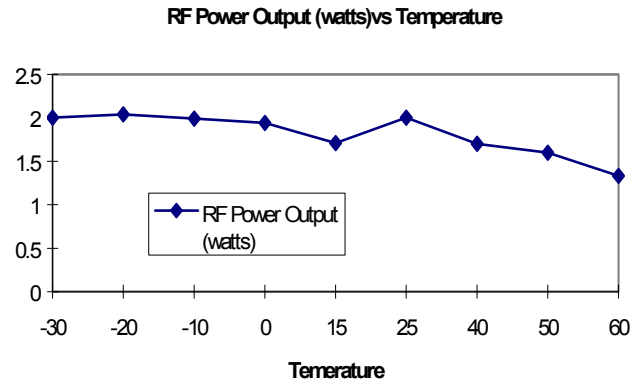
Test Transmit Frequency: 465.8875 MHz.

Reference Temperature: 25°C

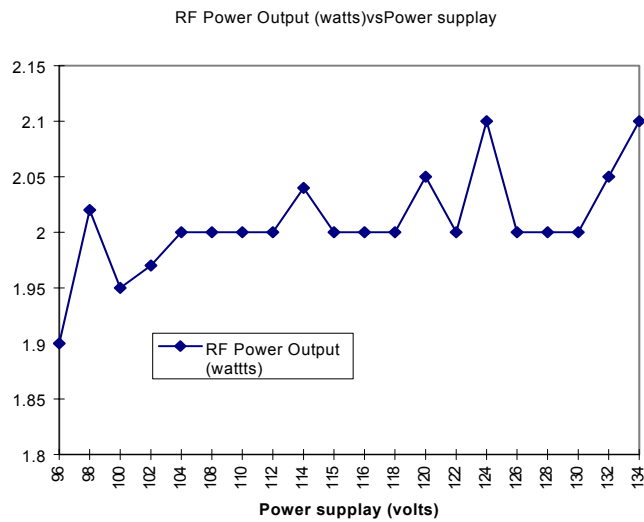
Reference Line Voltage: 115 volts

Power Output: 33dBm Supply Voltage: 13.5 volts Supply Current: 890 mA.

Temperature (degrees C)	RF Power Output (watts)
-30	2
-20	2.04
-10	1.99
0	1.94
15	1.71
25	2
40	1.7
50	1.6
60	1.33



Line Voltage (volts)	RF Power Output
96	1.9
98	2.02
100	1.95
102	1.97
104	2
108	2
110	2
112	2
114	2.04
115	2
116	2
118	2
120	2.05
122	2
124	2.1
126	2
128	2
130	2
132	2.05
134	2.1



Frequency Stability vs. Line Voltage

FCC rules: 2.1055, ; 90.213 (a), (b)

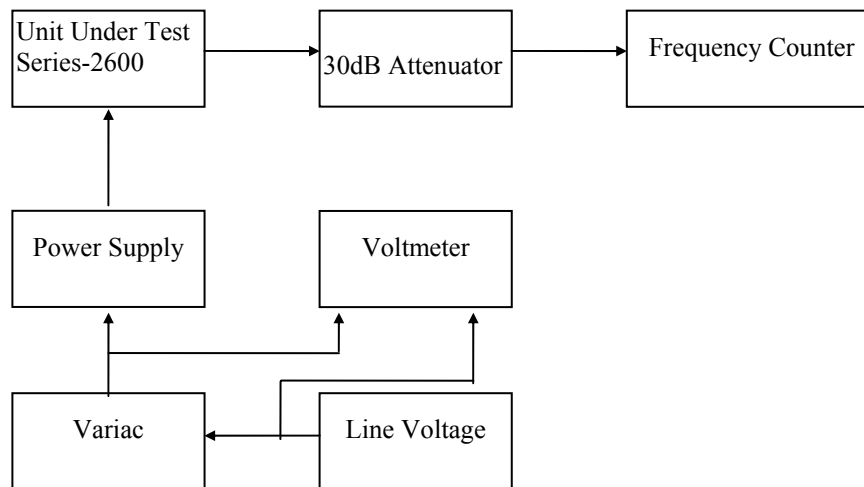
Specification: +/- .00025% (2.5ppm) from minimum line voltage to maximum line voltage (+/- 15%)

Test Results: Unit tested comply with FCC specifications

Test Conditions: Room temperature (+25°C) Unit Under Test in Transmit

Test Equipment: Power Supply	Cinon electronics Model TR36A
30dB attenuator pad	HP 11708
Voltmeter	Fluke 77
Frequency counter	HP 8920a
Variac	Staco Energy Products Model 6020CT

Test Setup:



Test Results... Frequency Stability vs. Line Voltage

Test Frequency: 465.8875 MHz.

Frequency Stability vs. Temperature

FCC rules: 2.1055 , 90.213

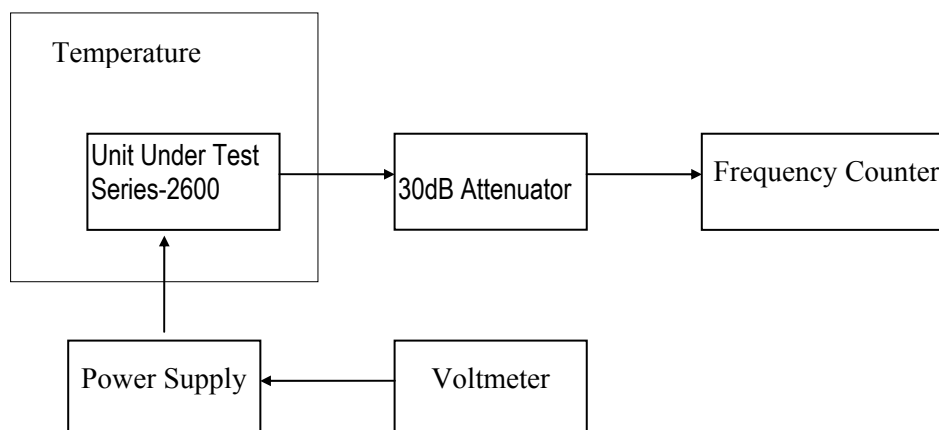
Specification: +/- .00025 % (2.5 ppm) from -30°C to +50°C

Test results: Unit tested comply with FCC specification

Test conditions: Line voltage 115 volt supply voltage 13.8ts DC
Unit under test in transmit with no modulation

Test Equipment:	Power Supply	Cinon electronics Model TR36A
	30 dB attenuator	HP 11708
	Voltmeter	Fluke 77
	Frequency counter	HP 8920a
	Temperature chamber	Tenny Model Series 942

Test Setup:

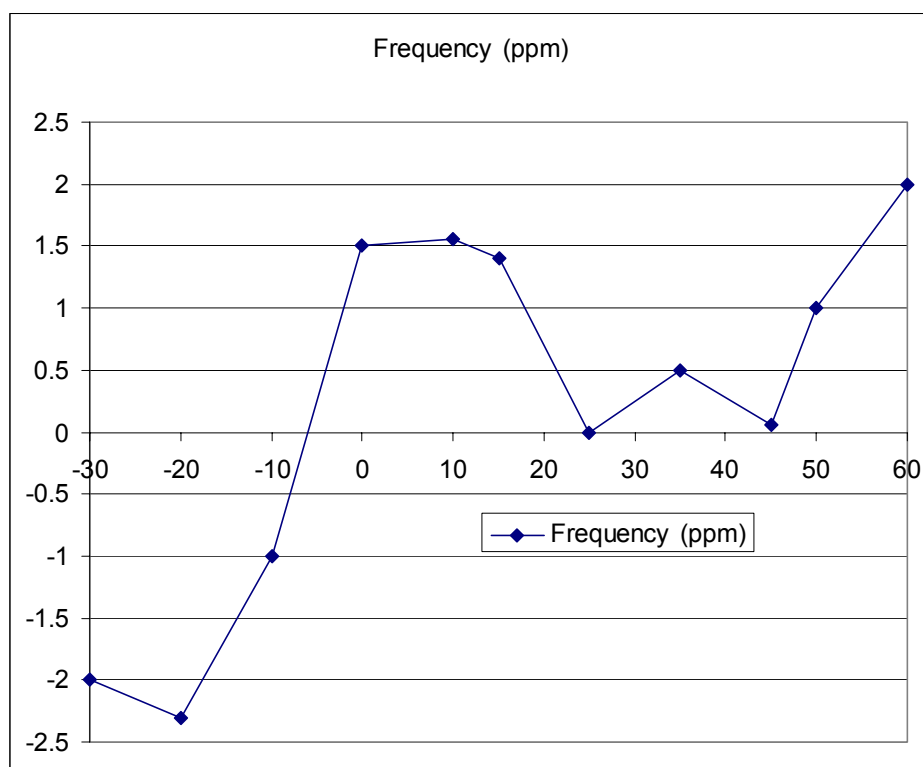


Test Results... Frequency Stability vs. Temperature

Test Frequency: 465.8875MHz.

Reference Temperature: 25°C

Temperature (degrees C)	Frequency (ppm)
-30	-2
-20	-2.3
-10	-1
0	1.5
10	1.56
15	1.4
25	0
35	0.5
45	0.06
50	1
60	2



Modulation Characteristics/ Occupied Bandwidth

FCC Rules: 2.1047, 90.210 (d), Emission Mask D for 12.5Khz channel bandwidth equipment

Specification: Fo to 5 KHz. Zero (0)dB

From 5.625KHz but more the 12.5KHz less then 7.27(Fd-2.88Khz)dB

Greater then 12.5Khz less 50 +10log(P) dB or 70 whichever is the lesser

Test Results: Unit tested comply with FCC specification

Test Conditions: Room temperature (+25°C)

Line voltage 115 volts, supply voltage 13.8 volts DC

Unit under test in transmit with 1024 Hz modulation

Test Equipment: Power Supply

Cinon electronics Model TR36A

30 dB attenuator pad

HP 11708

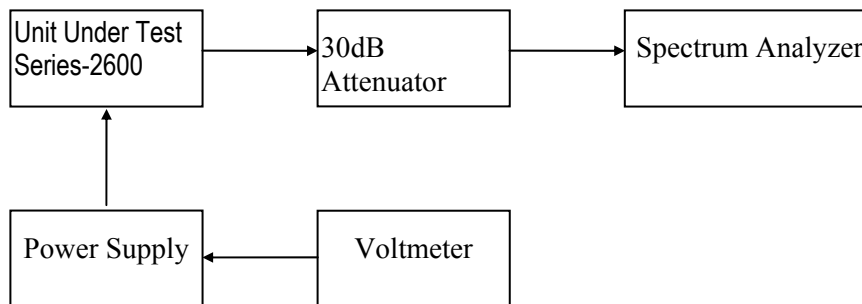
Spectrum Analyzer

AGILENT 4407B

Voltmeter

Fluke 77

Test Setup:



Test Results... Modulation Characteristics/ Occupied Bandwidth

Nominal Transmit Frequency: 465.0 MHz

RF Carrier Level: +33 dBm

Zero and up to 5.625Khz from carrier and more then 5.625Khz and no more then 12.5 Khz from the carrier

Emission Freq.	Measured Level	dBc	FCC Specification
1024 Hz.	-19dBm		22 0dBc
2048 Hz.	-18.dBm	21	0dBc
4096 Hz.	-4dBm	7	0 dBc
5120 Hz.	-38 dBm	41	0 dBc
6144 Hz	-50 dBm	53	23.73 dBc
7168 Hz.	-58.dBm	61	31.17 dBc
8192 Hz.	-60 dBm	63	38.62dBc
9216 Hz.	-62dBm		65 46.06dBc
10024 Hz.	-64 dBm	67	51.94 dBc
11264 Hz.	-68 dBm	71	60.95 dBc
12288 Hz	-72 dBm	75	68.40dBc

Emission Freq.	Measured Level	dBc	FCC Specification
13312 Hz.	-69 dBm	72	53 dBc
14336 Hz	-69 dBm	72	53 dBc
15360 Hz	-68dBm		71 53 dBc
16384 Hz	-72 dBm	75	53 dBc
17408 Hz	-72 dBm	75	53 dBc
18432 Hz	-73 dBm	>75	53 dBc
19456 Hz	do	>75	do
20480 Hz	do	>75	do
beyond 20 KHz.	do	>75	do

Emission Freq.	Measured Level	dBc	FCC Specification
Beyond 20 KHz.	>-70 dBm	>75	53dBc

Ref 0 dBm

Atten 10 dB

Peak

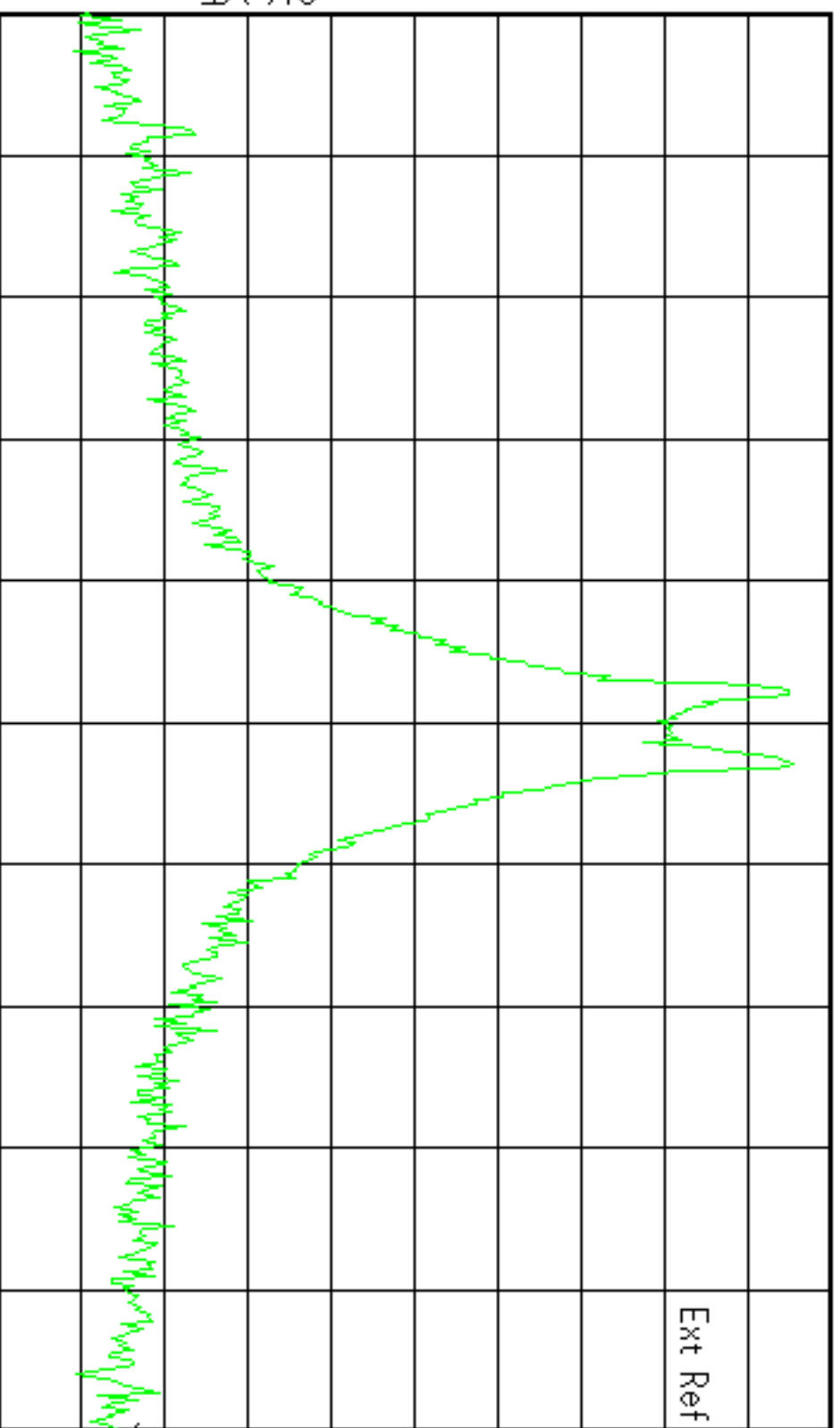
Log

10

dB/

Ext Ref

M1 S2
S3 FC
AA



Center 465 MHz
#Res BW 100 Hz

VBW 100 Hz

Span 100 kHz
Sweep 5.665 s (401 pts)

Spurious Emissions at Antenna Terminals

FCC rules: 2.1051 90.209

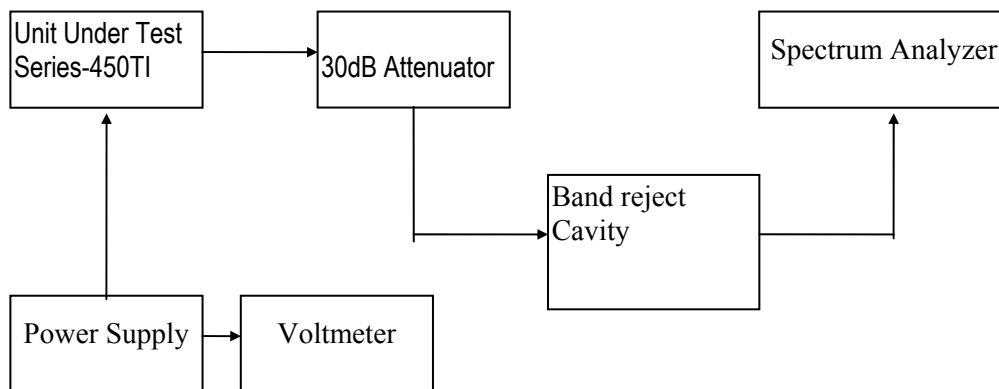
Specification: 50 to 100 % of authorized BW, 25 dB below carrier
100 to 250 % of authorized BW, 35 dB below carrier
> 250 % of authorized BW, $43 + 10\log_{10}(\text{Power Out})$

Test Results: Unit tested comply with FCC specification

Test conditions: Room temperature (+25°C)
Line voltage 115 volts, supply voltage 13.8 volts DC
Unit under test in transmit with no modulation

Test Equipment: Power supply	Cinon electronics Model TR36A
30 dB attenuator pad	HP 11708
Spectrum analyzer	AGILENT 4407B
Voltmeter	Fluke 77
Bandreject cavity filter	Microwave Filter Co, Inc. Model 6367-5

Test setup:



Test Results... Spurious Conducted Emissions at Antenna Terminal

Nominal Transmit Frequency: 465.8875 MHz.

Carrier level: +33.1 dBm.

50 to 100 % of authorized BW, 25 dB below carrier

All spurious emissions in this range were greater than 60 dB below carrier reference level.

100 to 250 % of authorized BW, 35 dB below carrier

All spurious emissions in this range were greater than 60 dB below carrier reference level.

> 250 % of authorized BW = $43 + 10\log(\text{Power Output})$ dB

All spurious emissions in this range were greater than 60 dB below carrier reference level.

Per the attached spectral plot, no emissions were noted that exceeded the required limits

Ref 0 dBm

Atten 10 dB

Mkr1 460 MHz
-31.41 dBm

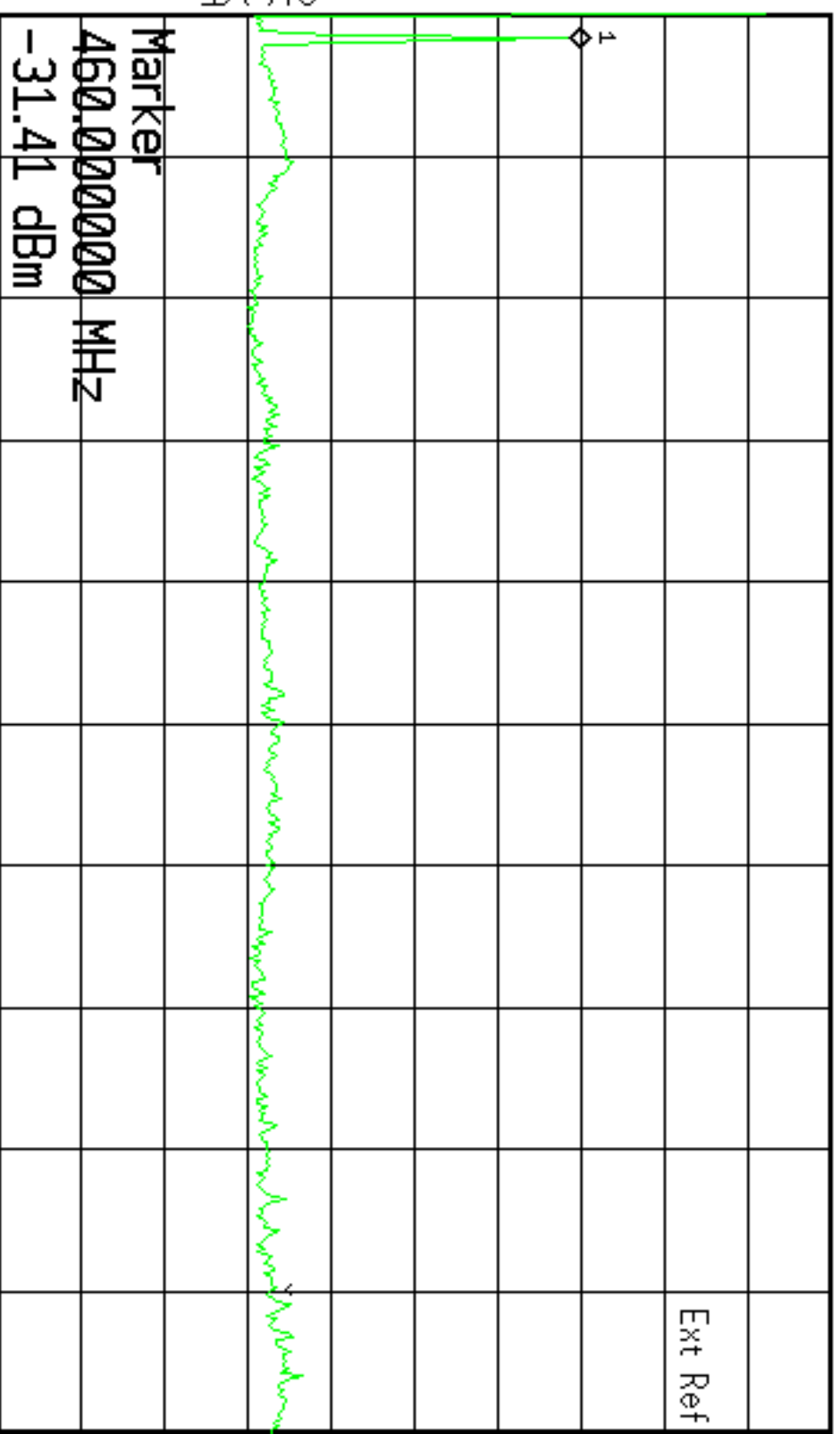
Peak

Log

10

dB/

Ext Ref



Center 13.25 GHz
#Res BW 120 kHz

VBW 300 kHz

Span 26.5 GHz
Sweep 4.237 s (401 pts)

Marker
460.000000 MHz
-31.41 dBm

Field Strength of Spurious Radiated Emissions at Antenna Terminal

FCC rules: 2.1051, 90.209

Specifications:

Nominal Transmit Frequency: 465.8875 MHz.

Carrier level: +33.1 dBm.

50 to 100 % of authorized BW, 25 dB below carrier

100 to 250 % of authorized BW, 35 dB below carrier

> 250 % of authorized BW = $43 + 10\log_{10}(\text{Power Output})$ dB

Test Conditions: Room temperature (+25°C)

Line voltage 115 volt, supply voltage 12 volts DC

Unit under test in transmit with no modulation

Test Equipment: FCC Approved Test Site and see attached report which follows:

Test Setup: see attached report which follows:

Test Results... conducted and radiated emission Requirements

RF Power and Frequency Transient vs. Time

FCC rules: 90.214

Specification: In the 421-512 MHz frequency band, transient frequencies must be within the maximum frequency difference limits during the following time intervals:

From 0 to 10 msec: within +/- 12.5 kHz at a detected ON threshold power of -30dBm.

From 10 to 35 msec: within +/- 6.25 kHz.

From 35 to 45 msec: within +/- 12.5 kHz. at a detected OFF threshold power of -30dBm.

Test Results:

0-10msec <8 kHz

10 to 35 msec <+/- 5kHz

35 to 45 msec <2.5ppp

Unit tested comply with FCC specifications

Test Conditions: Line voltage 115 volts, supply voltage 13.8volts DC

Test Equipment: Power Supply

30 dB attenuator pad

*Signal generator

*Combining network

*Test discriminator receiver

*Storage oscilloscope

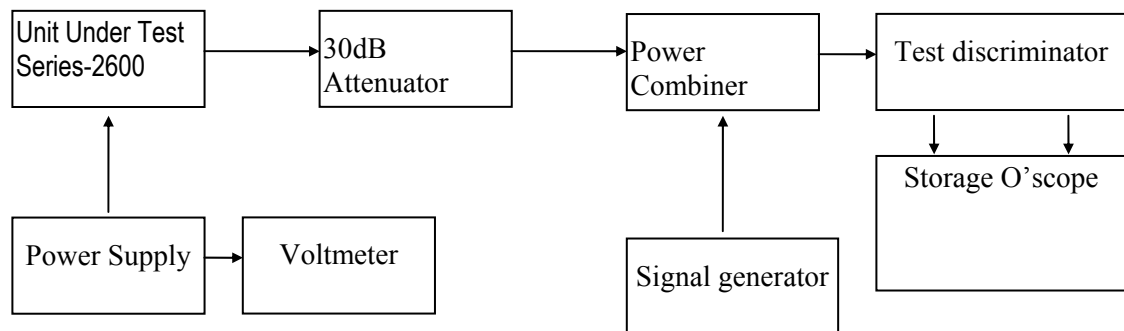
Cinon electronics Model TR36A

HP 11708

*HP8920A

* These devices are combined in the test discriminator receiver Hp 8920a

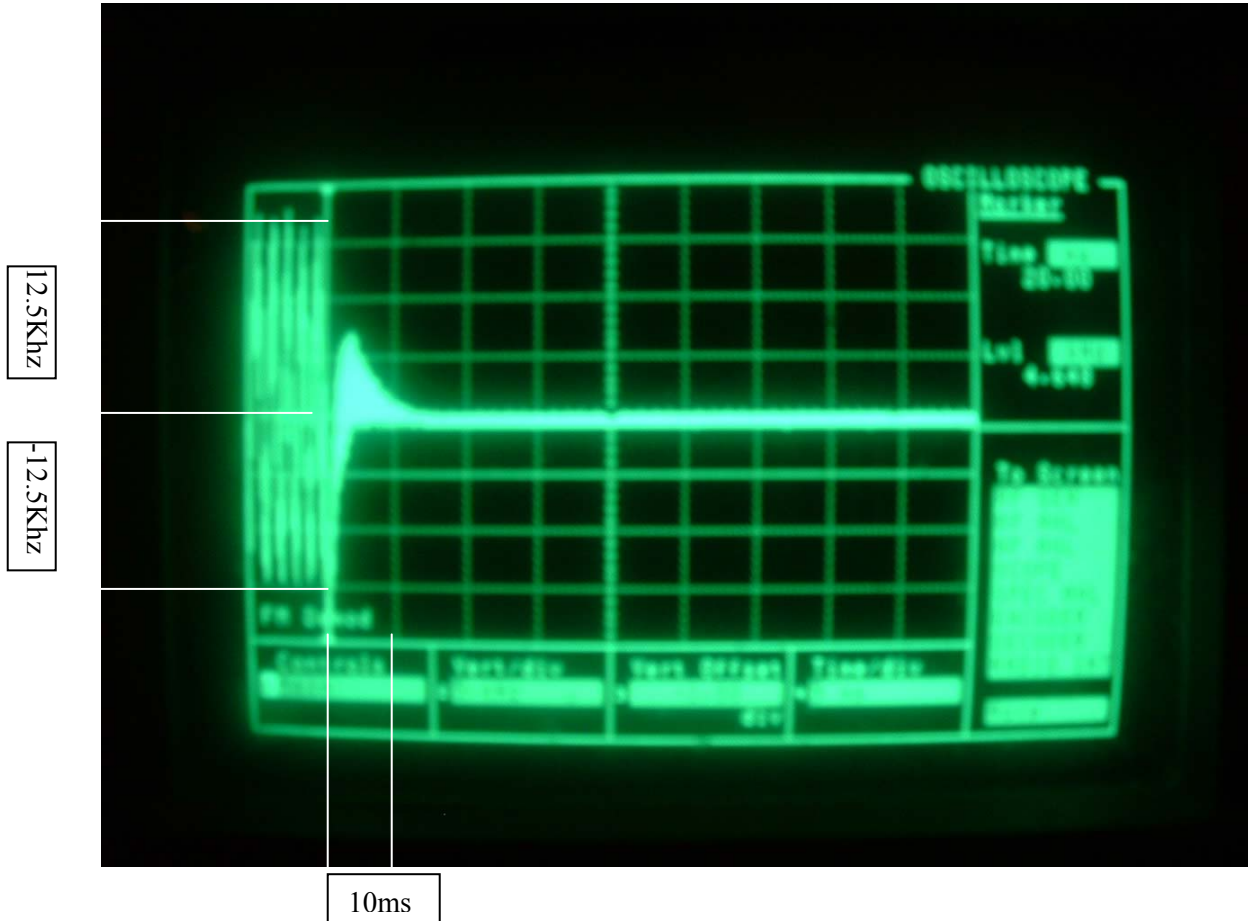
Test Setup:

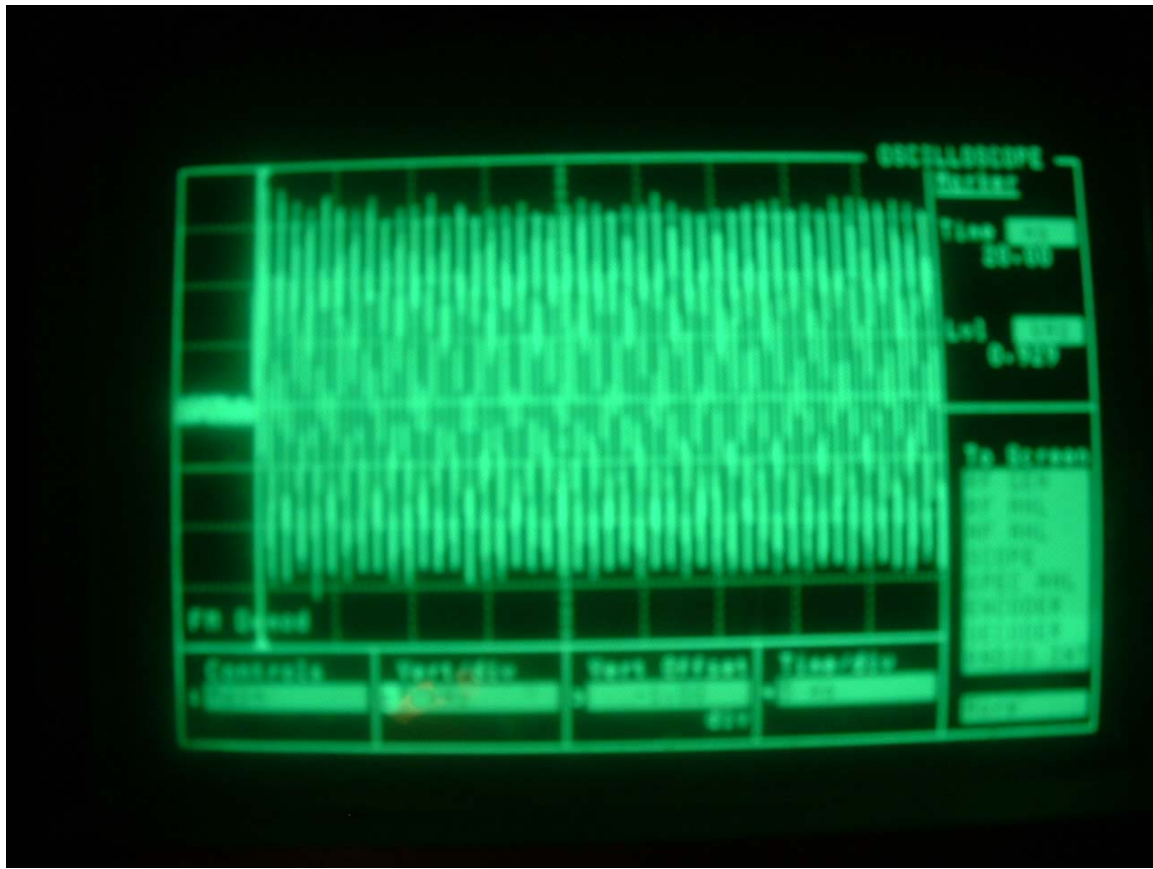


Test Results... RF Power and Frequency Transient vs. Time

Time on transient

12.5Khz





Time off transient