Tactical
Technologies
Inc.

1701 Second Ave
PO Box 91
Folsom, PA 19033
FAX 610-522-9430
TEL 610-522-0106

Part 90 Testing

CST-2005/V
Crystal Controlled Voice Transmitter

FCC ID: IP92K5V

Performed by

Tactical Technologies Inc.
1701 Second Ave
Folsom, PA 19033
610-522-0106

August 24, 2001

The audio frequency response, low pass filter test, occupied bandwidth, frequency stability, transient behavior, and modulation testing in this application for FCC Type Certification have been performed under my direct supervision. To the best of my knowledge these tests were conducted in accordance with the procedures outlined in Part 2 and Part 90 of the Commission's Rules and Regulations.

I am presently employed by Tactical Technologies Inc. in Folsom, Pennsylvania as a Design Engineer. My prior experience consists of 10 years of designing and testing communications products in the VHF portion of the spectrum.

Sincerely,

Jeffrey N. Olson
Engineer
Tactical Technologies Inc.

A. INTRODUCTION

The following data are submitted in connection with this Application for Type Certification in accordance with Part 2, Subpart J, and Part 90, Subparts B,D, and I of the FCC Rules and Regulations.

B. INFORMATION REQUIRED BY PART 2

2.1003(a) See Form 731

2.1033(b) N/A

2.1003(c)

(1) The full name and address of the applicant and manufacture for certification is:
Tactical Technologies Inc.
1701 Second Ave.
P.O. Box 91
Folsom, Pa. 19033

(2) The FCC Identifier of this device is IP92K5V

(3) Operating Instructions are included in the Exhibits.

(4) Emission: NBFM Voice – 11K2F3
Emission Calculations are included in the Exhibits.

(5) Frequency Range 150 – 174 Mhz

(6) Output Power of the device is 100mw. @ 3.6 Volts

(7) Maximum Power Rating is 100mw.

(8) All of the Transmitters sections run off of regulated +5.0 Volts, and the RF Final transistor runs on 5 Volts.

(9) Tune up procedure are included in the Exhibits.

(10) Schematics are included in the Exhibits.

(11) A drawing of the equipment identification label is included in the Exhibits.

(12) Photographs of the internal and external construction of the device are included in the Exhibits.

(13) N/A

(14) Test Data required by Part 2.1046 through 2.1057, inclusive, is measured in accordance with the procedure in Part 2.1041.

(15) N/A

(16) N/A

(17) N/A

C. SUBMISSION OF EQUIPMENT FOR TESTING - Paragraph 2.943

Upon request, the test sample will promptly be made available by Radiation Science Inc.

D. DESCRIPTION OF MEASUREMENT FACILITIES - Paragraph 2.947

The open-field tests were performed on the 3 meter range maintained by Radiation Science Inc. Complete description and measurement data have been placed on file with the Commission.

E. TEST DATA

This section contains results of measurements required by Parts 2 and 90 of the rules. Data are presented in tabular and/or graphical form, and measurement procedures are described within the text of each reported test. The test sample operated on 166.2250 MHz.

1. RF POWER OUTPUT - Paragraphs [2.1046(a),2.1033(c)(8),90.205(d)]
Measurements pertaining to the power output of the transmitter were performed by the manufacturer. To the best of my knowledge, these tests were conducted in accordance with the procedures outlined in Parts 2 and 90 of the Commissions Rules and regulations.

The data presented on Table 1 demonstrates compliance with the appropriate technical standards.

2. MODULATION CHARACTERISTICS - Paragraph [2.1047(a), 90.211(a)]
Measurements pertaining to the modulation characteristics were performed by the manufacture. To the best of my knowledge, these tests were conducted in accordance with the procedures outlined in Parts 2 and 90 of the Commission's Rules and regulations. The data presented on figures 1 and 2 demonstrates compliance with the appropriate technical standards.

3. OCCUPIED BANDWIDTH - Paragraphs [2.1049, 90.211(a)]
Figures 3 and 4 contain pictures taken from a Hewlett Packard 8558B Spectrum Analyzer. The transmitter was modulated with a sine wave tone at 2500 Hz at a level 16 dB above the required to produce 50% modulation at the frequency maximum response. Paragraph 90.210(d) requires that the mean power of emissions shall be attenuated below the mean output power of the transmitter by the following amounts:

-- On any frequency removed from the center of the authorized bandwidth f0 to 5.625 khz removed from f0; Zero db.
-- On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in khz) of more than 5.625 khz but no more than 12.5 khz. At least (fd – 2.88khz)db.
-- On any frequency removed from the center of the authorized Bandwidth by a displacement frequency (fd in khz) of no more than 12.5 khz. At least 50 + log(P) or 70db, whichever is the lesser attenuation.

4. SPURIOUS EMISSIONS AT THE 50 OHM TEST POINT ON THE TRANSMITTER [2.1053, 90.209 Emission Mask D]

The transmitter was modulated per paragraph 2.1053. The spectrum was checked with the spectrum analyzer from 10 MHz to the 10th harmonic of the carrier frequency. Observed emissions not reported are attenuated more than 20 dB below the permissible value of 40 dB, i,e., 50 + log (.10W) = 40 dB given by Section 90.209. The data in Table 1 verifies that the test sample complies with Paragraph 90.209(c)(3).

TABLE 1

CONDUCTED SPURIOUS EMISSIONS DATA

EMISSION FREQUENCY (MHz)	EMISSION LEVEL (dBc)	FCC LIMIT (dBc)
166.2	REFEEERENCE +20 dBm	40
332.4	-52	40
498.6	-58	40
664.8	-75	40
831.1	>-75	40
997.3	>-75	40
1163	>-75	40
1329	>-75	40
1495	>-75	40
1662	>-75	40

5. FIELD STRENGTH OF SPURIOUS RADIATION - Paragraphs [2.1053,90.209]

Measurements were made on the three meter range maintained by Radiation Science Inc. to quantify spurious emission level that] are radiated directly from the cabinet, control circuits, power leads and intermediate circuit elements under normal conditions of installation and operation. Particular attenuation was paid to harmonics of the carrier frequency as well as those frequencies removed from the carrier by multiples of the oscillator frequency.

Data is submitted in Table 2 showing the magnitude of harmonics and other spurious emissions from 30 MHz through the 10th harmonic. The test sample was placed on a non-conductive table one meter above the ground plane in order to determine the maximum level at each emission. Both horizontal and vertical site antenna polarization were employed. The antenna was raised 1 to 4 meters in height and the equipment under test was rotated 360 degrees to minimize the emission. An average factor of 20 db was applied to the level of the fundamental Emission when compared to the FCC limit. The reference level for spurious radiation was taken as a ideal dipole excited by the measured output power according to the following relationship:

E = (49.2 P)1/2 / Where: E = electric-field intensity in Volts/meter
P = transmitted power in Watts
R = distance in meters

For this case: E = 1.17 V/M = 121.4 dBu/m

The permissible value of spurious emissions is equal to less than 121.4 dBu/m - (50 + 10log(.1) = 64.4 dBu/m. Any observed spurious emissions not reported were more than 20 db below the permitted level.

TABLE 2

FIELD STRENGTH OF RADIATED EMISSION

Vertical: MHz	Height(m)	Level dbuv	Antenna Factor(db)	Cable Loss(db)	Averaging Factor(db)	Field Strength @3m dbm	dbc	FCC Limit
166.22	1.00	75.8	12.0	1.0	-20	-38.2	Reference	40.0 dbc
332.44	1.00	14.7	14.0	2.0	-20	-96.3	58.1	40.0 dbc
498.66	1.00	19.9	17.0	2.5	-20	-87.6	49.4	40.0 dbc
664.88	1.00	5.3	20.0	3.0	-20	-98.7	60.5	40.0 dbc
831.1	1.00	10.0	21.4	3.5	-20	-92.1	53.9	40.0 dbc
997.3	1.00	11.7	24.0	3.5	-20	-87.8	49.6	40.0 dbc

Horizontal: MHz	Height(m)	Level dbuv	Antenna Factor(db)	Cable Loss(db)	Averaging Factor(db)	Field Strength @3m dbm	dbc	FCC Limit
166.22	1.00	79.3	13.0	1.0	-20	-33.7	Reference	40.0 dbc
332.44	1.00	36.3	14.0	2.0	-20	-74.7	41.0	40.0 dbc
498.66	1.00	29.0	17.5	2.5	-20	-78.0	44.3	40.0 dbc
664.88	1.00	12.5	20.0	3.0	-20	-91.5	57.8	40.0 dbc
831.1	1.00	26.8	22.0	3.0	-20	-75.2	41.5	40.0 dbc
997.3	1.00	19.1	24.0	3.5	-20	-80.4	46.7	40.0 dbc
1163.0	1.00	26.8	23.0	2.0	-20	-75.2	41.5	40.0 dbc
1329.0	1.00	22.3	24.0	2.0	-20	-78.7	45.0	40.0 dbc

50 + 10log(.1) = 40.0 dbc (FCC Limit)

RADIATION SCIENCES INC. — ELECTROMAGNETIC EMISSION TEST

EUT
MANUFACTURER: Tactical Tech, Inc.
MODEL NO. – CST2005
SERIAL NO. – 180
MCOS –

ADDITIONAL INFORMATION:
DATE: 8/24/01
TEST CODE: RE
TECHNICIAN:
ENGINEER: CBK
FREQ. RANGE:

TEMPERATURE:
HUMIDITY:
RSI EQUIPMENT NUMBERS
TEST SPEC.: FCC

RADIATED
DISTANCE: 3 meter
ANTENNA:
[X] HORIZ. [ ] BB [ ] NB
[X] VERT. [ ] H [X] E

CONDUCTED
LINE:
[ ] BB
[ ] NB

FREQ.	IND. LEVEL		CORRECTION FACTORS ANT.			FINAL LEVEL	ANTENNA HEIGHT	EUT AZIMUTH	REMARKS
Hz	Vert		Horiz						
166.22	75.8		79.3				1m	0°	
332.44	14.7		36.3				↓	↓	
498.66	19.9		29.0				↓	↓	
664.88	5.3		12.5				↓	↓	
831.10	10.0		26.8				↓	↓	
997.30	11.7		19.1				↓	↓	
1.1632	14 A		26.8				↓	↓	
1.3296	14 A		22.3				↓	↓	
1.4952	13.8A		19.5A				↓	↓	
1.6620	14.5A		14 A				↓	↓	

RSI-TF-046
24 MAR 99

DATA SHEET ______

Table 2a - original test results from Radiation Sciences

Table 2a measurements were made by Radiation Science Inc. They calculated them out for Part 15 not Part [90.209].

The above measurements in Table 2 were copied from their test result paper (table 2a) and calculated for Part [90.209(c)(3). The data from Table 2 verifies that the test sample complies with Paragraph 90.209(c)(3).

6. FREQUENCY STABILITY - Paragraphs 2.1055, 90.213, 90.214

Measurements of the frequency stability versus temperature was made at temperatures ranging from -30 degrees C to +50 degrees C. At each temperature, the unit was exposed to the test chamber ambient for a minimum of 30 minutes after the temperature had stabilized within plus or minus one degree of the desired temperature. Following a 30 minute "soak" at each temperature, the frequency was measured within one minute after application of power. The test temperature was sequenced in the order shown in Table 3 starting at -30 degrees Celsius. The nominal primary power supply voltage of 3.60 vdc was used, and the frequency was measured with a Hewlett Packard 5253B Frequency Counter.

TABLE 3
FREQUENCY STABILITY VS. TEMPERATURE

TEMPERATURE C	FREQUENCY MHz
-30	166.224655
-20	166.224964
-10	166.224667
0	166.224690
+10	166.225104
+20	166.225370
+30	166.225694
+40	166.225670
+50	166.225665

The values are within 5 ppm (.000831 MHz) of the assigned frequency as stated in Paragraph 90.213. Thus, the test sample complies with Paragraph 90.213.

The output frequency as a function of supply voltage was measured, and the results are given below in Table 4.

TABLE 4

FREQUENCY STABILITY
POWER SUPPLY VOLTAGE VS. OUTPUT FREQUENCY

POWER SUPPLY VOLTAGE (%)	(Vdc)	OUTPUT FREQUENCY (MHz)
115	4.14	166.225370
100	3.6	166.225370
85	3.06	166.225370

These values are within 5 ppm of the assigned frequency. The test sample complies with Paragraph 90.213.

Table 5

Audio Pre-Emphasis and Low Pass Filter vs. Input Signal

Input Signal Level -60 dBm

Frequency Hz	Output Level		Pre-Emphasis 6Dbm/Octive Scaled +1/-3	Low Pass Filter 12 dBm/Octave
300	400mvpp	-15.3Dbm	-10.24Dbm	.
500	600mvpp	-11.7Dbm	-6.71Dbm	.
750	1100mvpp	-6.5Dbm	-1.45Dbm	.
1000	1300mvpp	-5.1Dbm	0.00Dbm	.
1500	1800mvpp	-2.3Dbm	+2.82Dbm	.
2000	2000mvpp	-1.3Dbm	+3.74Dbm	.
2500	3250mvpp	+2.8Dbm	+7.95Dbm	.
2700	4000mvpp	+4.7Dbm	+9.76Dbm	.
3000	3500mvpp	+3.5Dbm	+8.60Dbm	.

Low Pass Filter

4000	-9.00Dbc
5000	-16.00Dbc
6000	-22.00Dbc
7000	-27.00Dbc
8000	-31.00DBC
9000	-35.00Dbc
10000	-38.00Dbc
15000	-50.00Dbc
20000	-60.00Dbc

All audio distortion measurements at the above frequencies were less than 10%. Distortion measurements were made with a B&W Model 400 Distortion Meter. Audio output measurements were made with a Tektronix Oscilloscope OS-245 and a Hewlett Packard 3551A Audio generator. All low pass filter measurements were made applying an audio generator to the microphone input, and monitoring the output of the transistor on a Hewlett Packard 8558B Spectrum Analyzer at 5 kHz bandwidth.

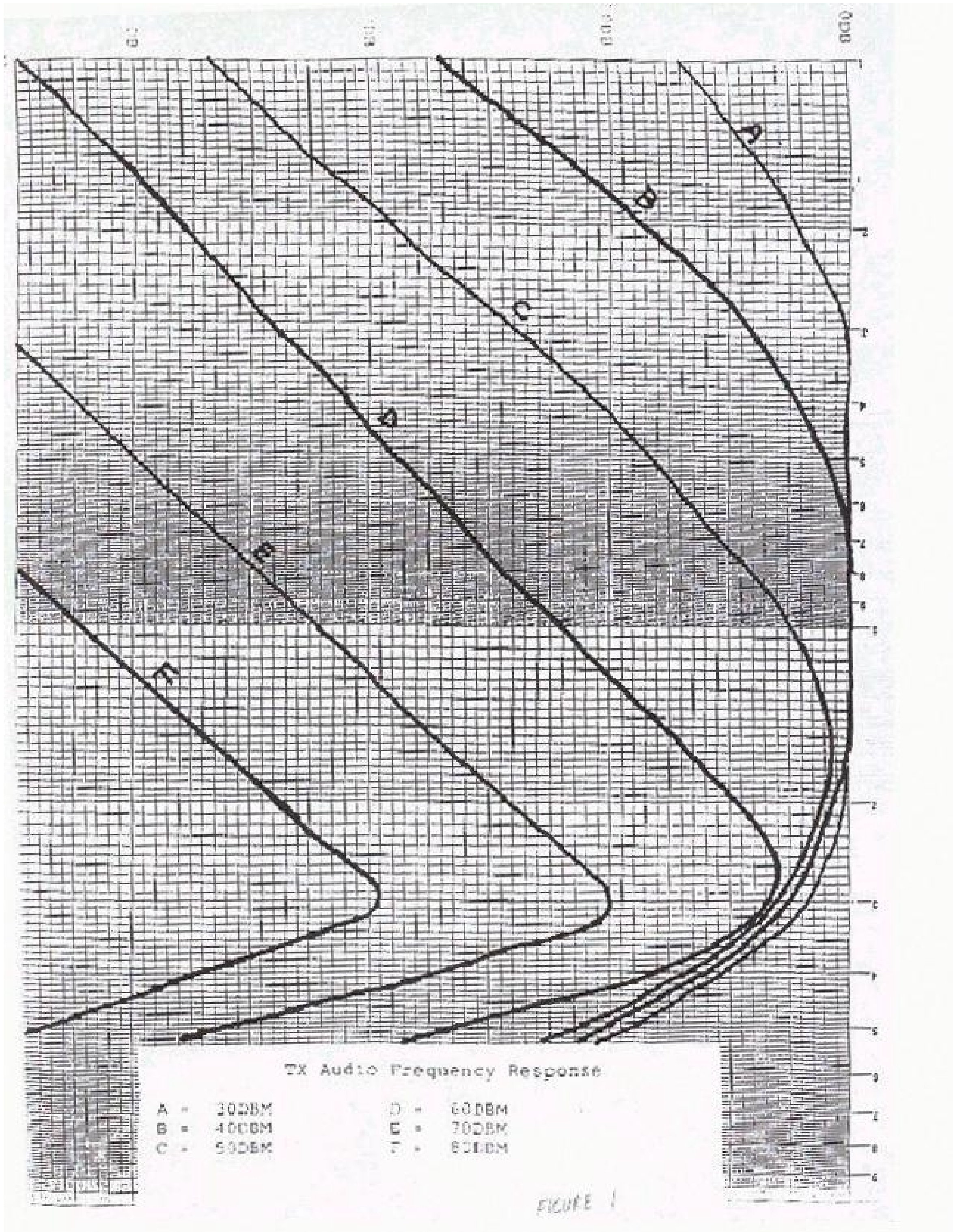


Figure 1 - Audio Frequency Response

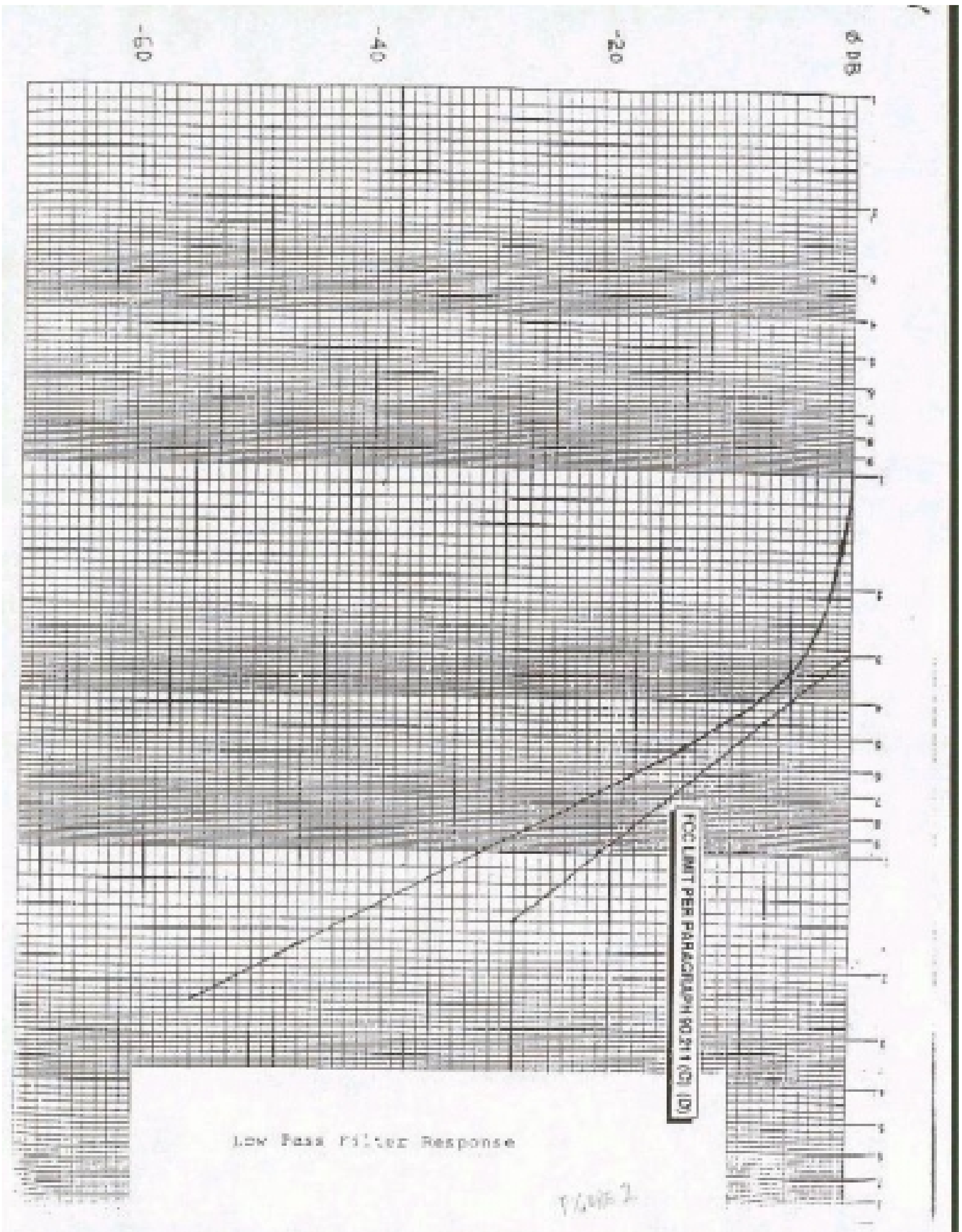


Figure 2 - Low Pass Filter Response

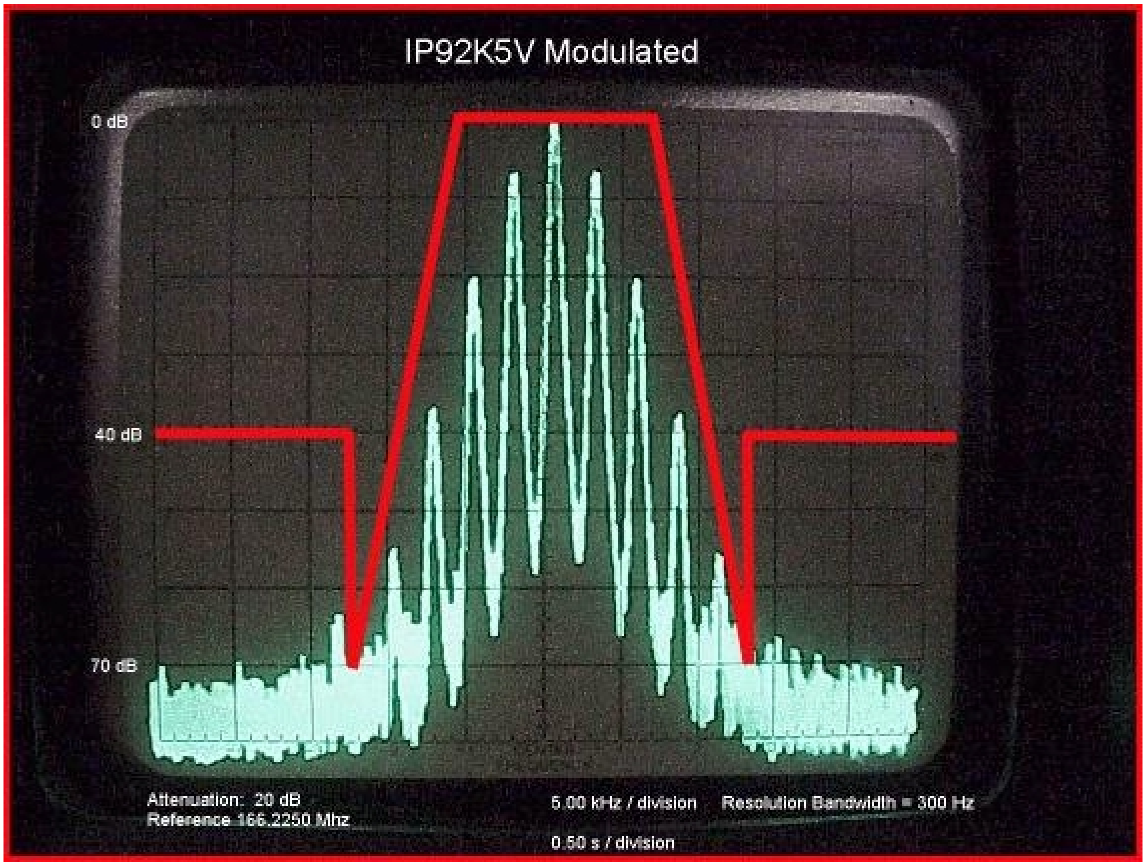


Figure 3
Modulated Bandwidth

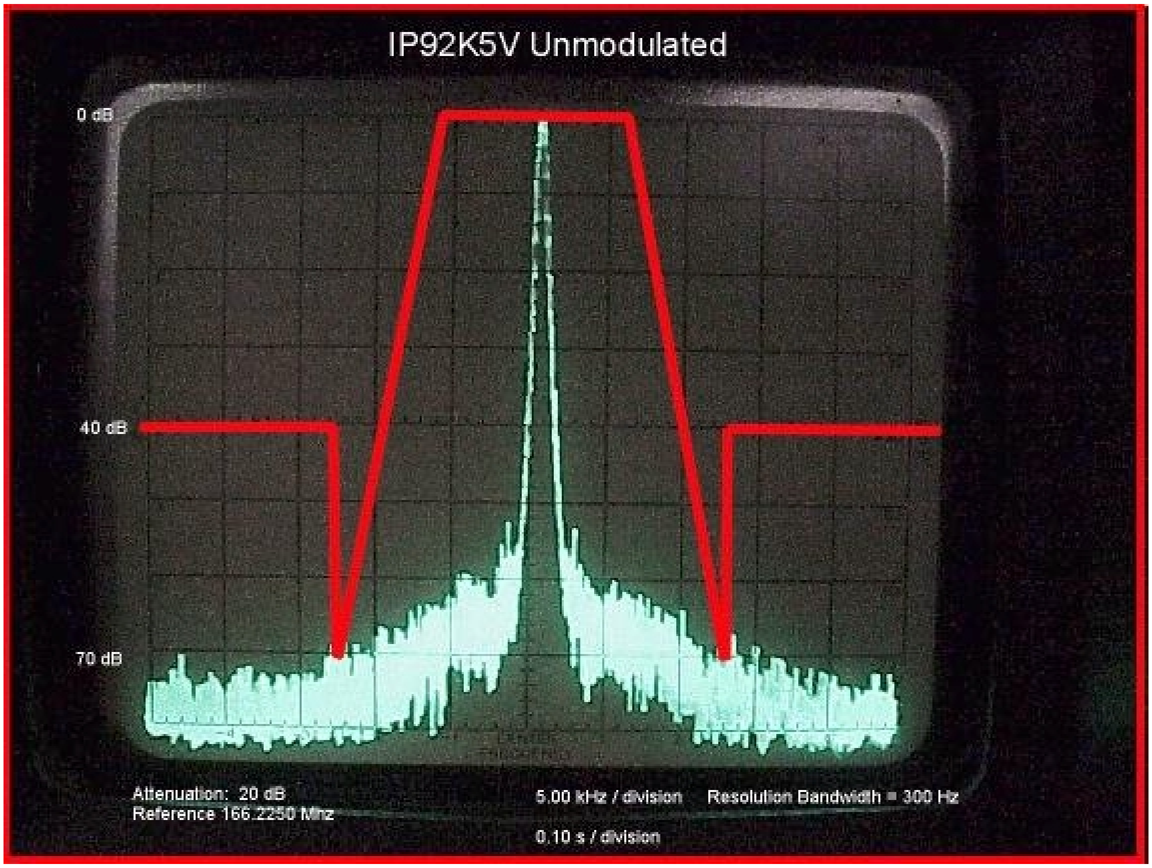
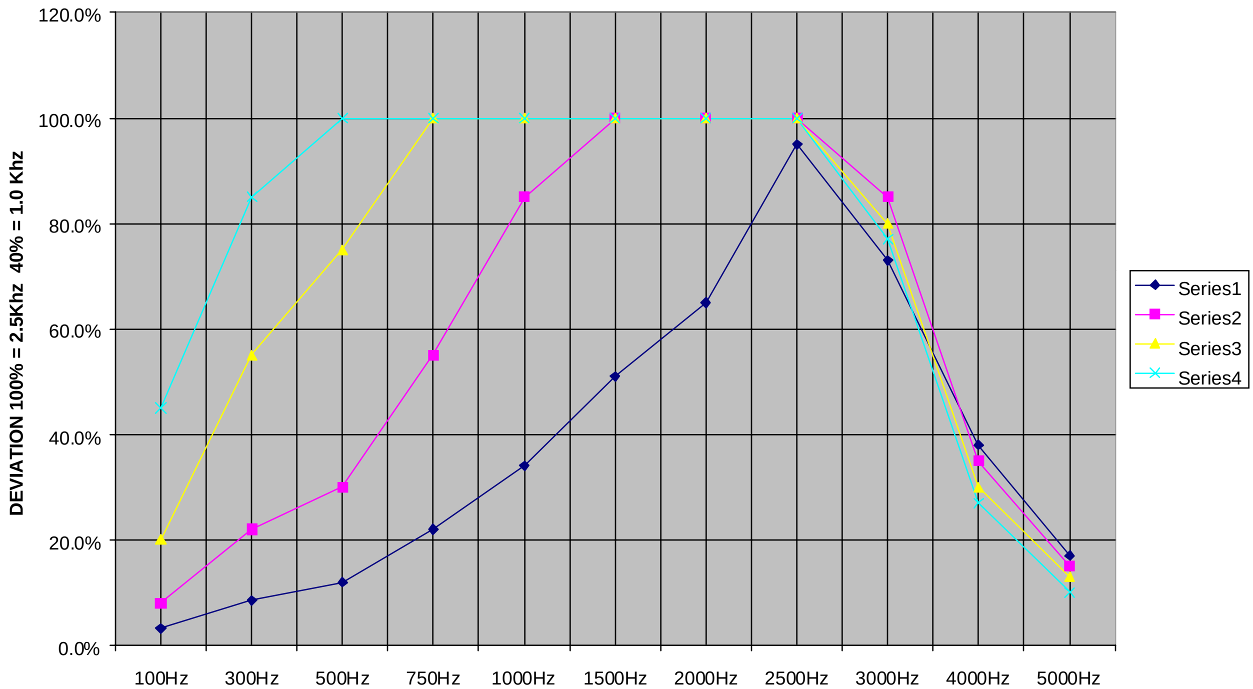


Figure 4
Unmodulated Bandwidth

INPUT SIGNAL LEVEL VS. DEVIATION CST-2005/V FCC ID # IP92K5V



INPUT VOLTAGE VS. FREQUENCY Series 1 = -60Dbm Series 2= -50Dbm Series 3 = -40Dbm Series 4 = -30Dbm

CST-2005/V
FCC: IP92K5V
Block Diagram

```
 Battery  ******** DC - DC (5v)
3.6 Volts         Converter
                      *
                      *
                      *
                      *
   ********************************************
   *              *               *           *
   *              *               *           *
   *              *               *           *
Varactor ***** Crystal ******** Pre-Amp **** Final *** Antenna
Modulator      Oscillator X6                Amp
   *
   *
   *
Microphone amp
Pre-emphasis audio  ********* Microphone
Low pass filter
AGC
```

CST2005/V
Frequency Range 150 - 174 MHz
One Channel Crystal Controlled Transmitter
FCC ID# IP92K5V
Circuit Description

The CST2005/V transmitter circuitry consists of a crystal (X1) witch is a devide by six, the transistor oscillator output of (Q1) is tuned to the sixth harmonic which is the desired frequency of the crystal. The output of the Double tuned filter is applied to a pre-amp (Q2) the output of the pre-amp is 10 mw. The final amp (Q3) amplifies the signal to 100mw or +20Dbm. The harmonic filter (L5, C12, and C30) attenuates the frequencies above 174 MHz.

The audio section consists of 4 transistors (Q4, Q5, Q6, and Q7) the audio from the Microphone is amplified by (Q5) and pre-emphasized and amplified in (Q7). The low pass filter to attenuate all frequencies after 2700 Hz is handled in (Q6). The output (Q6) emitter is applied to the deviation pot (R30) and also is connected to the AGC circuitry where the diode (A7) rectifies the audio to produces a dc voltage which then turns off and on the transistor (Q4) which shorts some off the audio to ground to prevent over deviation.

CST2005/V
Frequency Range 150 - 174 MHz
One Channel Crystal Controlled Transmitter
FCC ID# IP92K5V
Tuning Procedure

1. Apply 3.5 volts to the unit

2. Using a Spectrum Analyzer probe the base of Q2 and peak the sixth harmonic (C4 and C5)

3. Using a Spectrum Analyzer probe the base of Q3 and peak the sixth harmonic (L4)

4. Connect a BNC connector to the junction of L5 and C20 install a 20 Dbm attenuater in series with a wattmeter. Adjust C12 and C30 to obtain 100mw while monitoring the harmonics so that they are 50 Dbc.

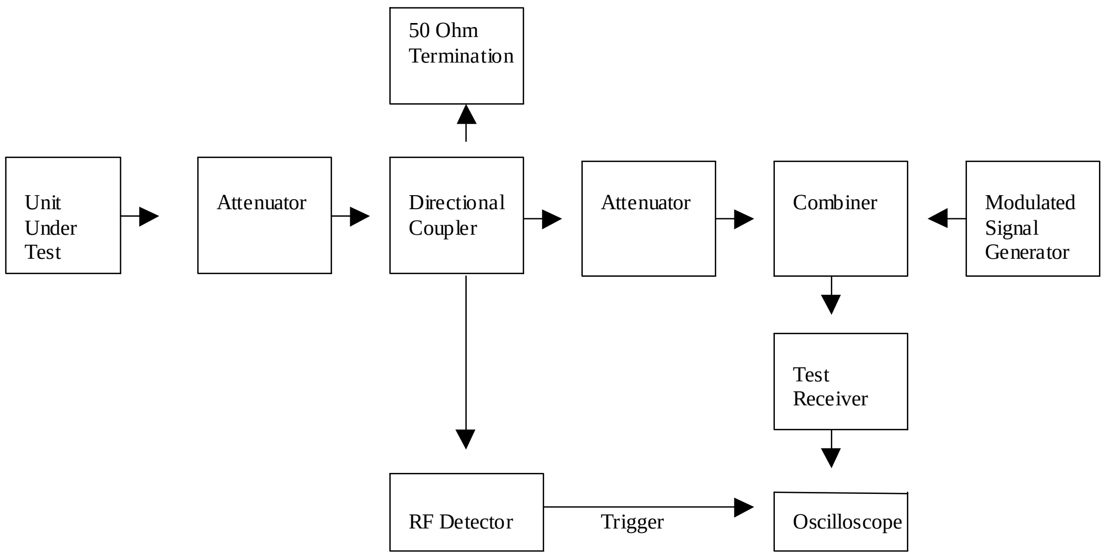
5. Using a Communications Receiver adjust R27 to the desired frequency +/- 100Hz

6. Using a Communications Receiver whistle or speak loudly into the microphone and adjust R30 for 2.5KHz max. deviation.

7. Using a Spectrum Analyzer with a VHF antenna adjust C100 for maximum radiated power.

BLOCK DIAGRAM
CST-2005/V
FCC ID: IP92K5V

Transient Frequency Behavior 90.214



The unit under test (IP92K5V) was connected to a Directional Coupler. The two outputs from the coupler were connected to a RF Detector Diode and the other output from the coupler was combined with a 25kHz FM modulated test signal. The output from the combiner was connected to a test receiver, the demodulated audio from the receiver was connected to the oscilloscope input and the external trigger input on the oscilloscope was connected to the output of the RF diode detector. Power was applied to the test unit from a power supply, and the unit was turned OFF/ON manually with a test lead applied to the positive terminal of the power supply.

Three time periods were captured on the storage oscilloscope and recorded. The two pictures below (Figure 5) show the turn on and turn off points and the related frequency displacement. The t1 and t2 mask limits are superimposed on the TOP photograph (ON to OFF), and the t3 mask limit is superimposed on the BOTTOM photograph (OFF to ON).

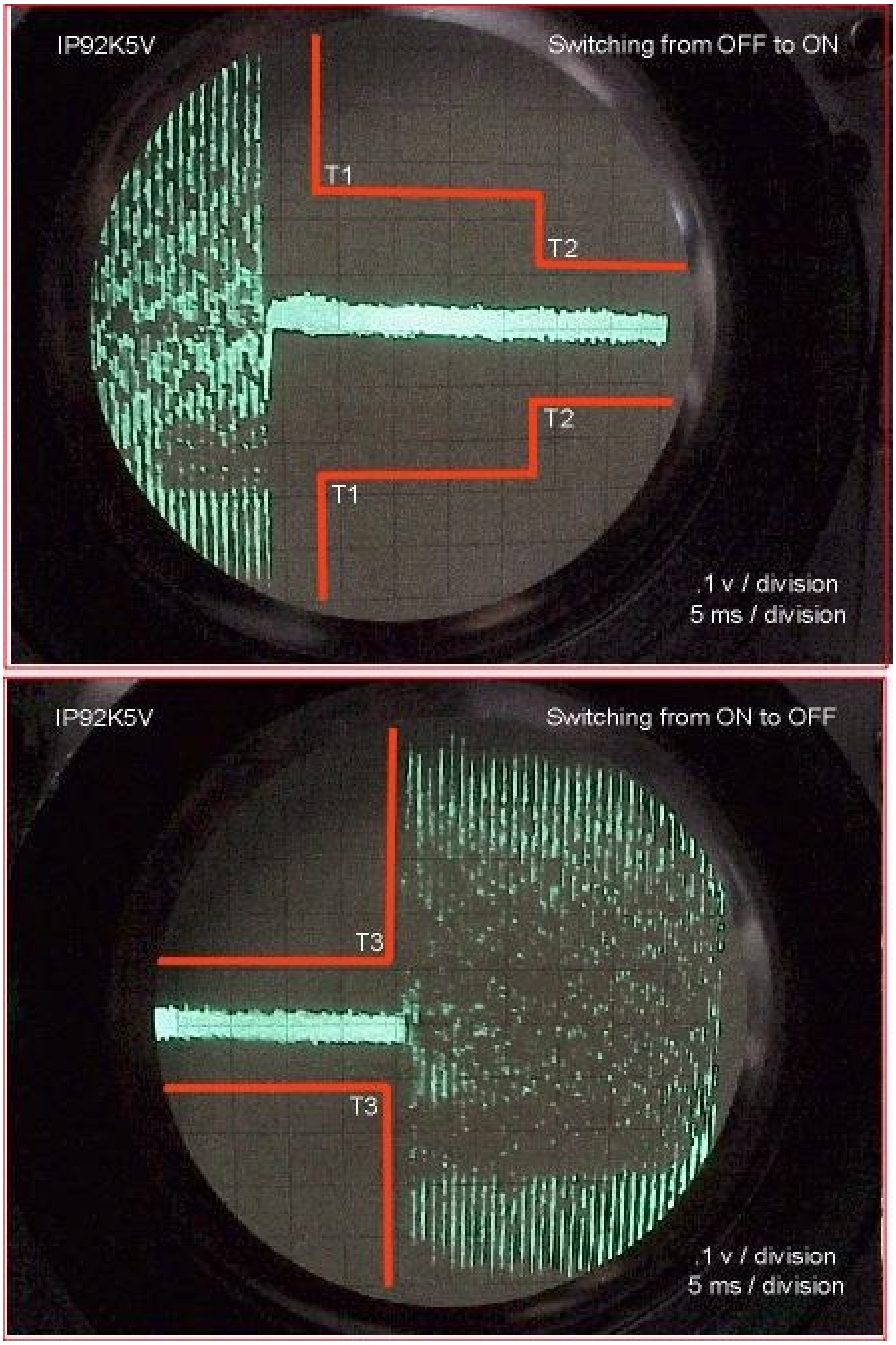


Figure 5
Transient Frequency Behavior