Tactical Technologies Inc.

1701 Second Ave
PO Box 91
Folsom, PA 19033
FAX 610-522-9430
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Part 90 Testing

Echo6
16 Channel Synthesized FM Voice Repeater

FCC ID: IP9ECHO6

Performed by

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

February 13, 2002

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 IP9EHO6

(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 1940mw. @ 13.8 Volts

(7) Maximum Power Rating is 2000mw.

(8) All of the Pre-amp sections run off of regulated +5.0 Volts, and the RF Final transistor runs on 12 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 172.0125 MHz (TX) and 165.0125 MHz (RX).

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 (2.0W) = 53 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)
172.0	REFEERENCE	+33 dBm	
344.0		-65	53
516.0		-70	53
688.0		-75	53
860.5		>-75	53
1032.1		>-75	53
1204.1		>-75	53
1376.1		>-75	53
1548.1		>-75	53
1720.1		>-75	53

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 / R Where: E = electric-field intensity in Volts/meter
P = transmitted power in Watts
R = distance in meters

For this case: E = 2.02 V/M = 126.1 dBuV/m

The permissible value of spurious emissions is equal to less than 126.1 dBu/m - (50 + 10log(2) = 73.1 dBuV/m.

TABLE 2
FIELD STRENGTH OF RADIATED EMISSION

Horizontal: MHz	Height(m)	Level dbuv	Antenna Factor(db)	Cable Loss(db)	Field Strength @3m dbuv	dbc	FCC Limit
172.01	1.00	89.5	16.2	1.4	107.1 Reference		
344.02	1.85	21.0	15.0	2.0	38.0	69.1	53.0 dbc
516.03	1.95	17.0	19.0	3.0	39.0	68.1	53.0 dbc
688.05	2.67	21.0	21.5	4.0	46.5	60.6	53.0 dbc
860.06	1.50	25.0	24.0	3.0	53.0	54.1	53.0 dbc
1032.0	1.00	25.0	25.2	3.0	53.2	53.9	53.0 dbc
1720.1	1.00	13.0	27.7	4.0	44.7	62.4	53.0 dbc

Vertical: MHz	Height(m)	Level dbuv	Antenna Factor(db)	Cable Loss(db)	Field Strength @3m dbuv	dbc	FCC Limit
172.01	1.00	102.5	17.0	1.4	120.9 Reference		
344.02	1.00	38.0	15.6	2.0	55.6	65.3	53.0 dbc
516.03	1.00	26.0	18.5	3.0	47.5	73.4	53.0 dbc
688.05	1.30	25.5	21.8	4.0	51.3	69.6	53.0 dbc
860.06	1.00	22.0	23.4	4.0	49.4	71.5	53.0 dbc
1032.0	1.00	33.0	25.2	3.0	61.2	59.7	53.0 dbc
1377.3	1.00	17.0	26.4	4.0	47.4	73.5	53.0 dbc
1548.2	1.00	15.0	26.8	4.0	45.8	75.1	53.0 dbc

50 + 10log(2) = 53.0 dbc (FCC Limit)

RADIATION SCIENCES INC. — ELECTROMAGNETIC EMISSION TEST

EUT	ADDITIONAL INFORMATION	DATE:	TEST CODE
MANUFACTURER:		12/13/01	
MODEL NO. – EC H06			TECHNICIAN
SERIAL NO. – 102			ENGINEER
MODE – TX			

TEMPERATURE:	RSI EQUIPMENT NUMBERS 73, 83	TEST SPEC.
HUMIDITY:		

RADIATED ☐ HORIZ. ☐ BB ☐ NB ☐ VERT. ☐ H ☐ E
DISTANCE:
ANTENNA:

CONDUCTED ☐ BB ☐ NB
LINE:

	FREQ.	IND. LEVEL		CORRECTION FACTORS ANT.	cable		FINAL LEVEL	ANTENNA HEIGHT	EUT AZIMUTH	REMARKS
HORIZ	Hz									
	172	89.5		16.2	1.4		107.1	1	0°	
	344	21		15	2		38	1.95		
	516	17		19	3		39	1.95		
	688	21		21.5	4		46.5	2.67		
	861	25		24	4		53	1.5		
–	1.03	25		25.2	3		53.2	1		
	1.20	11 A		25.7	3	A	39.7			
	1.377	9 A		26.4	4	A	39.4			
	1.55	8 A		26.8	4	A	37.8			
	1.72	13		27.7	4		44.7	↓	↓	
VERT	172	102.5		17	1.4		120.9	1	0°	
	344	38		15.6	2		55.6	1		
	516	26		18.5	3		47.5	1		
	688	25.5		21.8	4		51.3	1.1		
	861	22		23.4	4		49.4	1.3		
	1.03	33		25.2	3		61.2	1		
	1.2	10 A		25.7	4	A	39.7			
	1.37	17		26.4	4		47.4			
	1.55	15		26.8	4		45.8			
	1.72	9 A		27.7	4	A	40.7	↓	↓	

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DATA SHEET _____

table 2a _1 - original test results from Radiation Sciences

RADIATION SCIENCES INC. — ELECTROMAGNETIC EMISSION TEST

EUT
MANUFACTURER: Tactical Technologies
MODEL NO. - ECH06 Repeater
SERIAL NO. - 102
MODE - RX

ADDITIONAL INFORMATION: LO Fund. and harmonics
DATE: 11/29/01
TEST CODE: RE
TECHNICIAN:
ENGINEER: CBK

TEMPERATURE:
HUMIDITY:
RSI EQUIPMENT NUMBERS 31, 75, 80, 91, 391
TEST SPEC. FCC

RADIATED — DISTANCE: — ANTENNA: Bicon, L/P, DRWG
☒ HORIZ. ☐ BB ☒ NB
☒ VERT. ☐ H ☒ E
CONDUCTED — LINE:
☐ BB ☐ NB

FREQ.	IND. LEVEL		CORRECTION FACTORS ANT.	CORRECTION FACTORS cable Loss		FINAL LEVEL	ANTENNA HEIGHT	EUT AZIMUTH	REMARKS
MHz	dBµV		dB	dB		dBµV/m	meters	degrees	
143.813	41.3		12.2	1.4		54.9	1.2	0	HORIZ
287.60	6.9		13.5	2		22.4	1.75		
431.400	8.7		17.2	3		28.9	3.5		
575.20	32		20.1	4		56.1	1.6		
719.06	4		21.1	4		29.1	3.5		
862.87	53		23.2	4		—	—		Amb.
1.0066	9		25.2	3		37.2	1.0		
1.1505	5		25.5	3		—	—		Amb.
1.2943	9.8		26.3	3.5		39.6	1.0		
1.4381	1		26.7	4		—	—	X	Amb.
143.813	39.4		11.9	1.4		52.7	2.1	0	VERT
287.60	2		15.2	2		19.2	1.0		
431.40	16.2		19.1	3		38.3	1.0		
575.20	2		20.9	4		26.9	1.0		
719.06	5.7		22.8	4		32.5	1.79		
862.87	55		23.2	4		—	—		Amb.
1.0066	11.7		25.2	3		39.9	1.0		
1.1505	5		25.5	3		—	—		Amb.
1.2943	10.2		26.3	3.5		40.0	1.0		
1.4381	2		26.7	4		—	—	X	Amb.

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DATA SHEET _____

table 2a_2 – original test results from Radiation Sciences (continued)

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 9.0 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	172.012382
-20	172.012395
-10	172.012407
0	172.012419
+10	173.012422
+20	172.012490
+30	173.012497
+40	172.012510
+50	172.012518

The values are within 5 ppm (.000860 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	13.80	172.012490
100	12.00	172.012490
85	10.20	172.012490

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

RF Power Output 2.1046(a), 2.1033(c)(8)
OUTPUT POWER VS. VOLTAGE

Voltage	RF Output Power
10.0 v	1.47 Watt
10.5 v	1.56 Watt
11.0 v	1.64 Watt
11.5 v	1.68 Watt
12.0 v	1.76 Watt
12.5 v	1.80 Watt
13.0 v	1.89 Watt
13.5 v	1.93 Watt
13.8 v	1.94 Watt

The RF output power was measured at 10 volts through 13.8 volts into a 50 Ohm pure resistive load. The Echo6 repeater has an input and output tuning range of 450 Khz. The RF output power drops off rapidly on either side of the pass band frequency of the duplexier.

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.

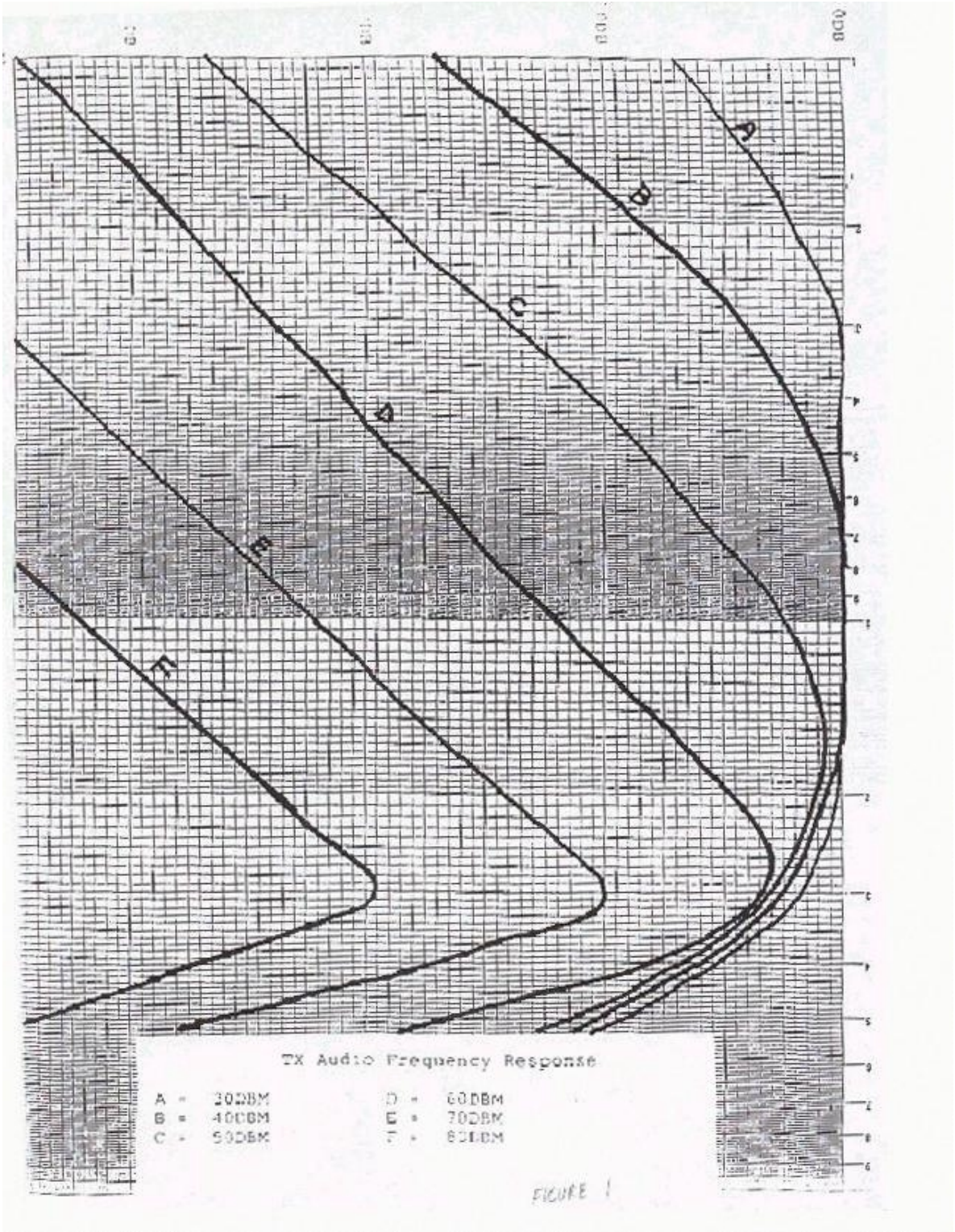


Figure 1 - Audio Frequency Response

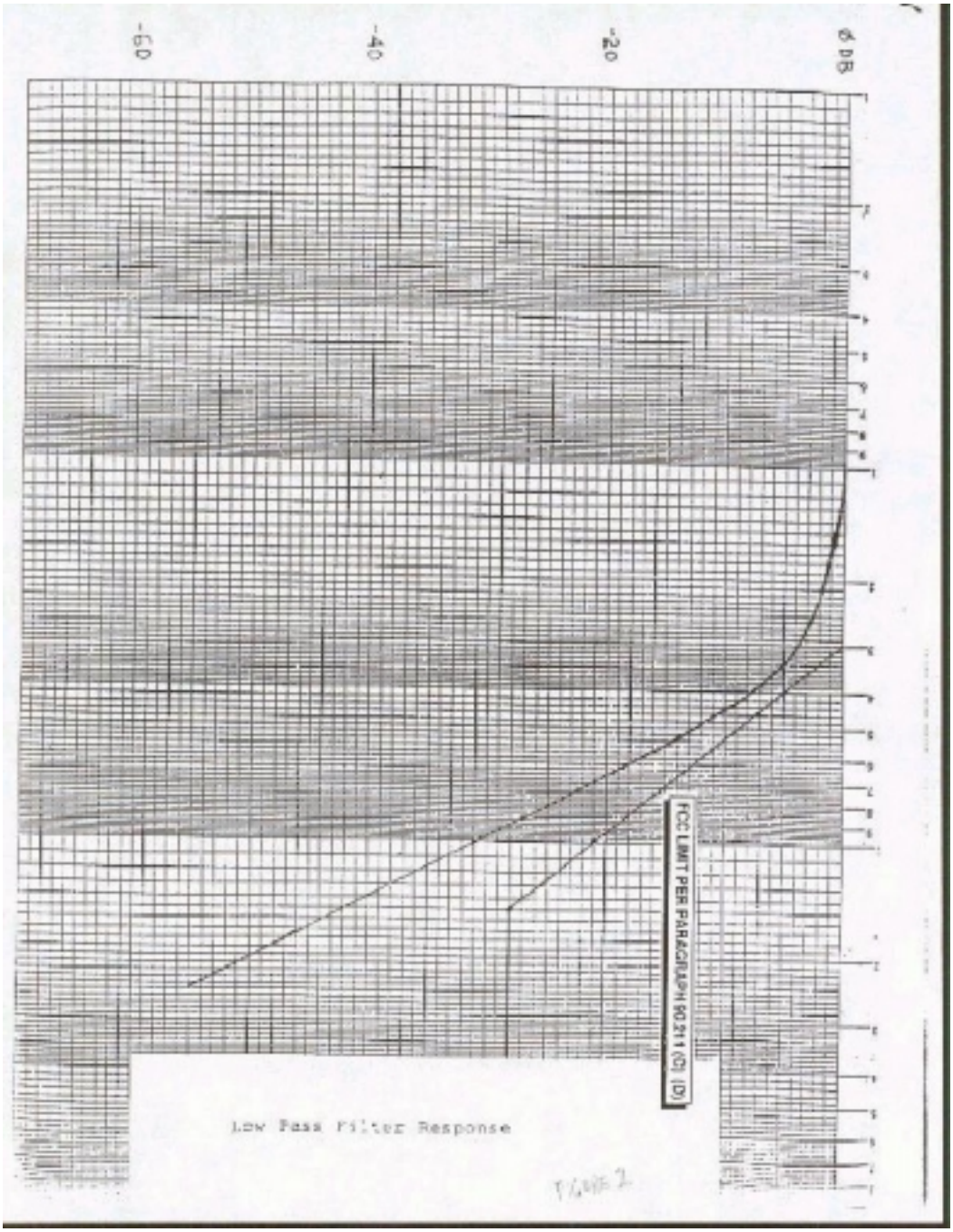


Figure 2 - Low Pass Filter Response

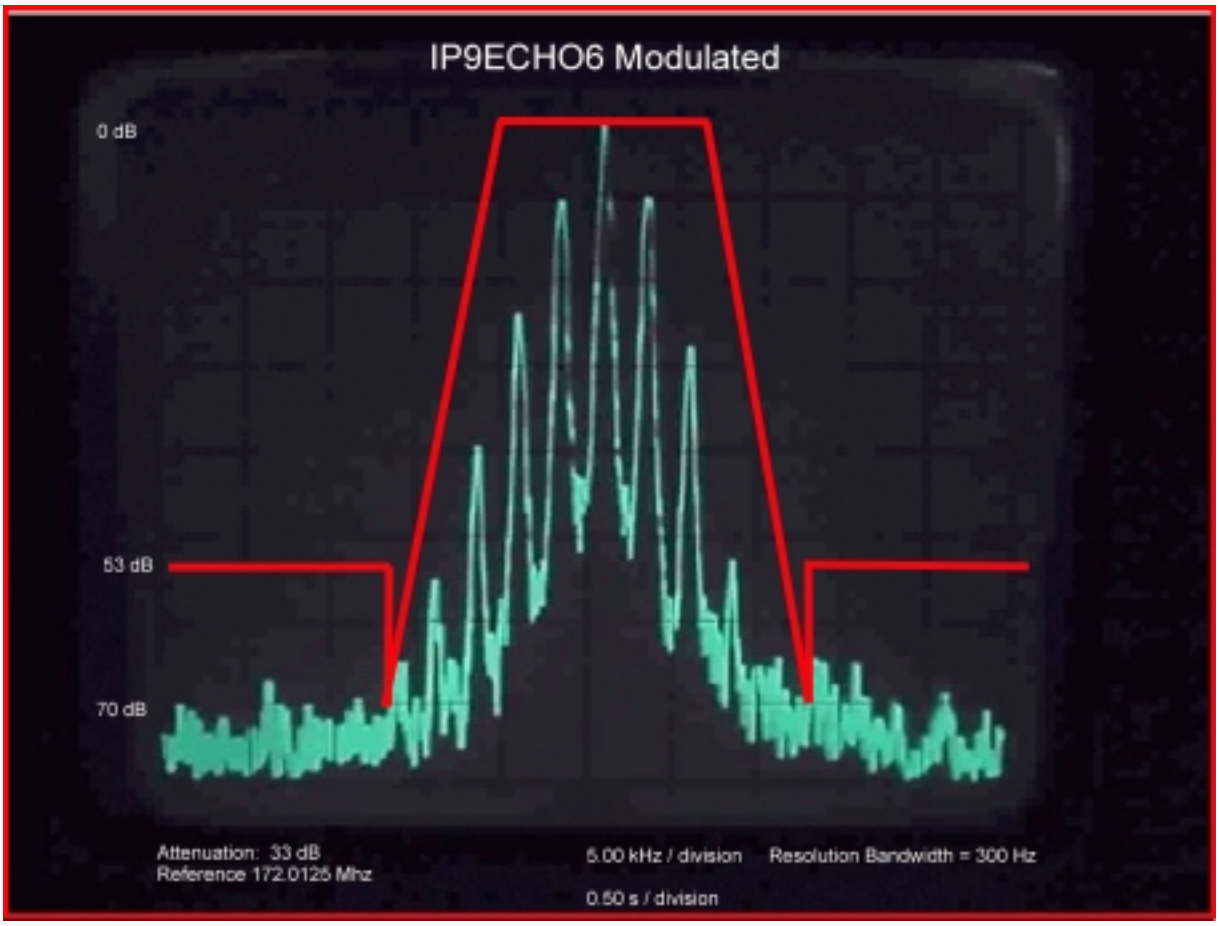


Figure 3
Modulated Bandwidth

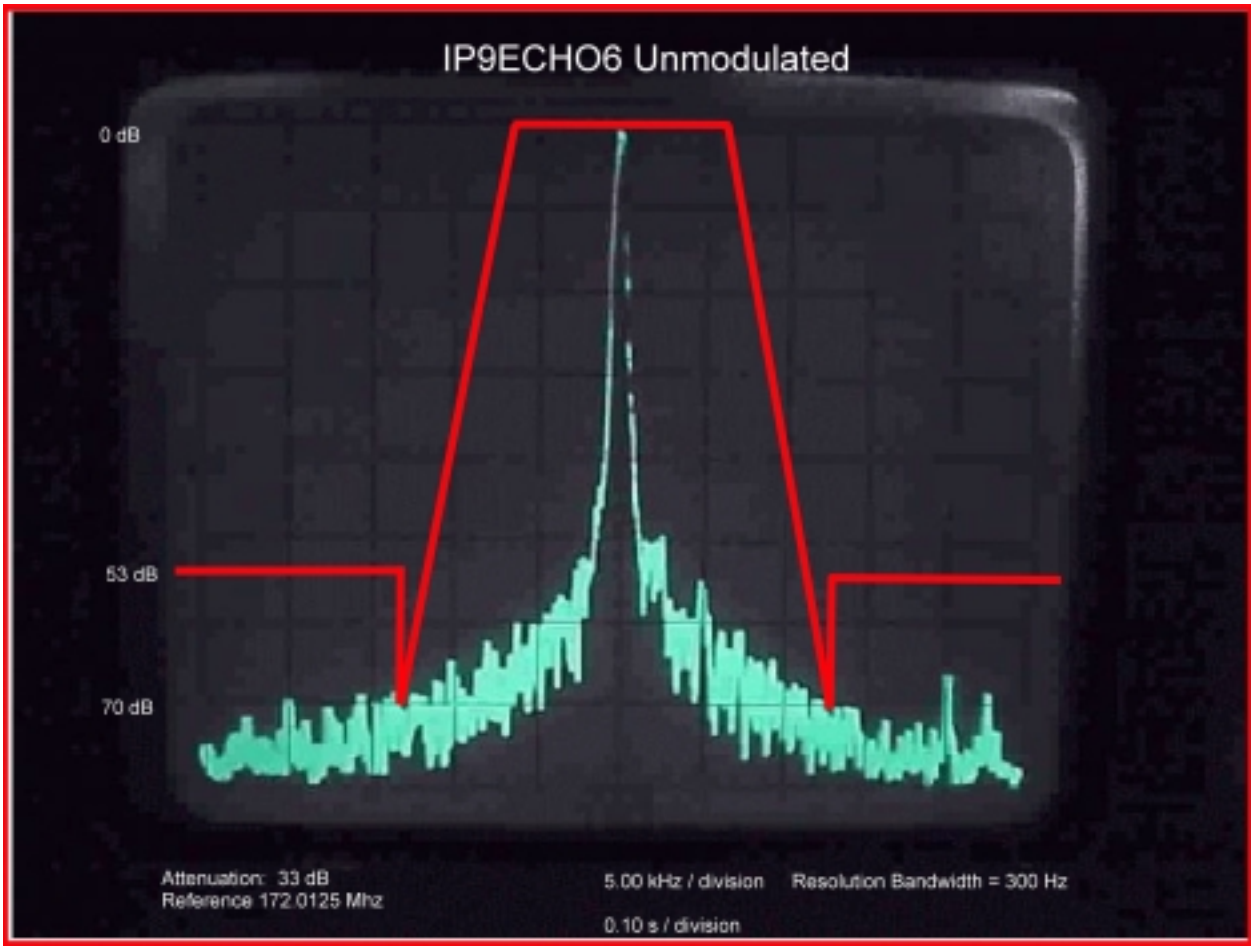
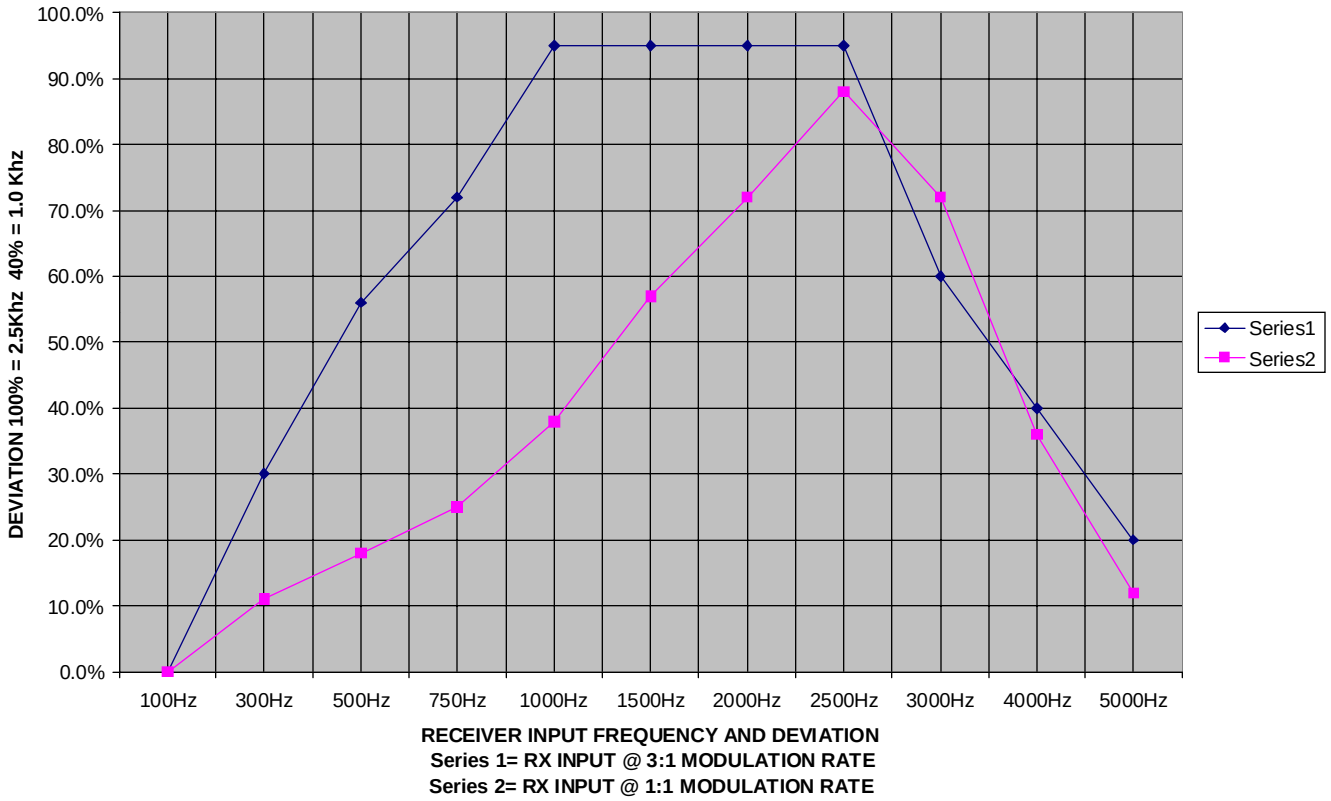


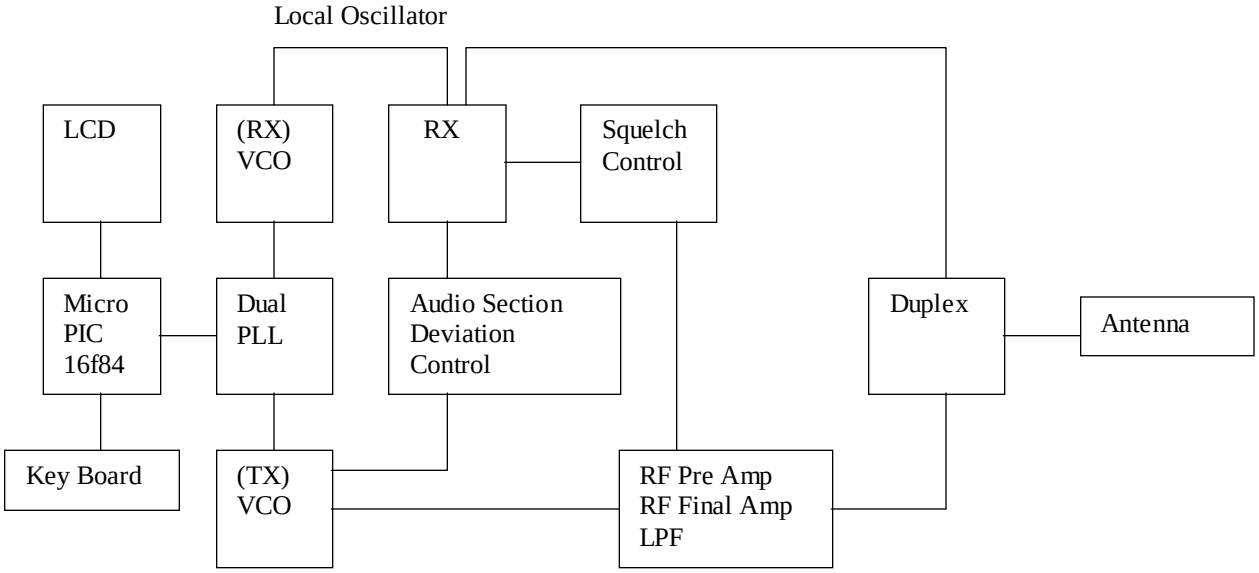
Figure 4
Unmodulated Bandwidth

OUTPUT DEVIATION AND MODULATION LIMITING ECHO6 FCC ID # IP9ECHO6



RECEIVER INPUT FREQUENCY AND DEVIATION
Series 1= RX INPUT @ 3:1 MODULATION RATE
Series 2= RX INPUT @ 1:1 MODULATION RATE

EHCO6
FCC ID# IP9ECHO6
Block Diagram



ECHO6
Frequency Range 150 - 174 MHz
16 Channel Synthesized Repeater
FCC ID# IP9ECHO6
Circuit Description

The Echo6 repeater circuitry consists of a TXCO (X2), Dual Phase Lock Loop (U1), and a micro controller (U11). The micro controller sends data to the PLL; the PLL outputs a voltage to both VCO's (U7 & U8) to the desired Frequencies. The RF output from each of the vco pre-amplifiers is ~10mw (Q9 & Q10). The one vco output connects to the receiver mixer (DBM1). (Q1) is the RF front-end amplifier and band pass filter, the output of the mixer (IF) connects to the 8 pole xtal filter. The recovered audio from the IF amplifier and de-modulator (U4) is de-emphasized and amplified by (U2). The audio is pre-emphasized by (U10A/B) and applied to the modulation varactor (V2) R64 is adjusted for maximum deviation (2.5Khz). The RF vco output is applied to another pre-amplifier (Q1) and then (Q2) the final amplifier. The output of (Q2) connects to a low pass filter L7 and L8 which attenuates all the harmonics of the transmitter > 60 Dbc.

ECHO6
Frequency Range 150 - 174 MHz
16 Channel Synthesized Repeater
FCC ID# IP9ECHO6
Tuning Procedure

1. Receiver Tuning:
   Apply 13.8 volts to the receiver unit

2. Connect a RF Signal Generator to the receiver RF input. Using a Communication Receiver measure The receiver Local Oscillator (RX freq – 21.4 Mhz) Adjust the TXCO to the desired frequency +/- 50 Hz. Adjust the receiver front end (Q1) , and the Image Frequency inductors (L5 & L6) to achieve .18 uV sensitivity @ 12 dbm SineAd.

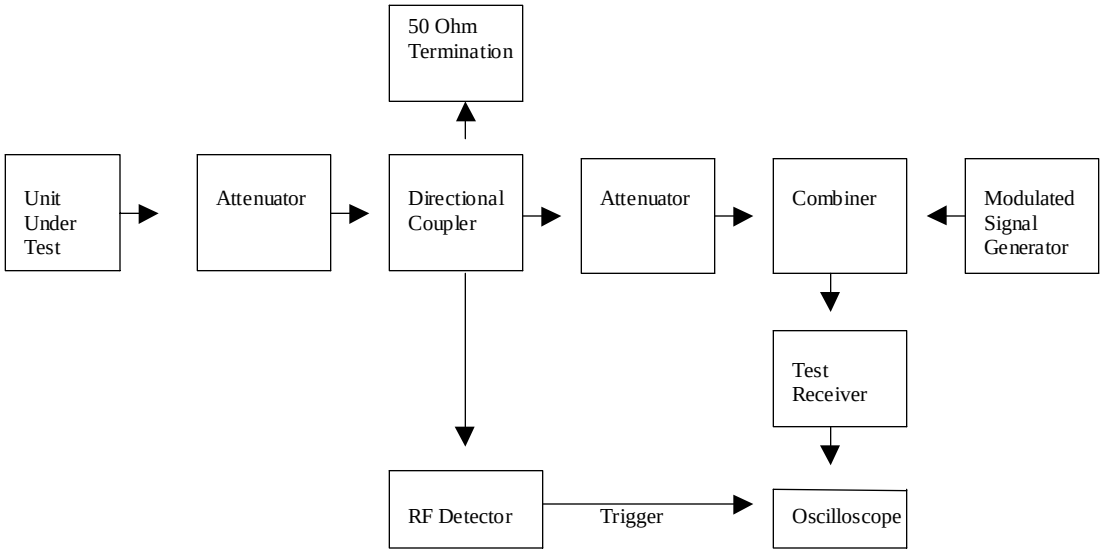
3. Transmitter Tuning:
   Apply 13.8 volts to the repeater, connect a T tap connector to the 30 Dbm pad from the RF output BNC Connector into a watt meter. Open the receivers squelch pot to turn On the transmitter.

4. Using a Spectrum Analyzer probe the collector of (Q10), output power should be ~ +10dbm Monitoring the transmit frequency with a Communications receiver the desired frequency should be +/- 50 Hz. Connect the Spectrum Analyzer into the T tap connector, adjust (C3,C4,C5,C7,C12) while monitoring the power into the Watt Meter and monitoring the desired frequency and all its harmonics to achieve 2 watts @ 650 mA (total repeater current) and attenuating all the harmonics > 65Dbc.

5. Audio Tuning:
   Apply a 2500 Hz signal at a 1:1 modulation rate into the receiver RF input, adjust R14 for 2 volts p-p At the output of (U2) pin 5.
   Monitor the output of (U10) pin 7, adjust R70 and R68 so that the output of (U10) pin 7 is starting to Clip symmetrically at the output rails of the op-amp. Adjust (R64) the deviation pot while monitoring the Transmitters output with a Communications Receiver to 2.5 Khz deviation.

BLOCK DIAGRAM
Echo6
FCC ID: IP9ECHO6

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).

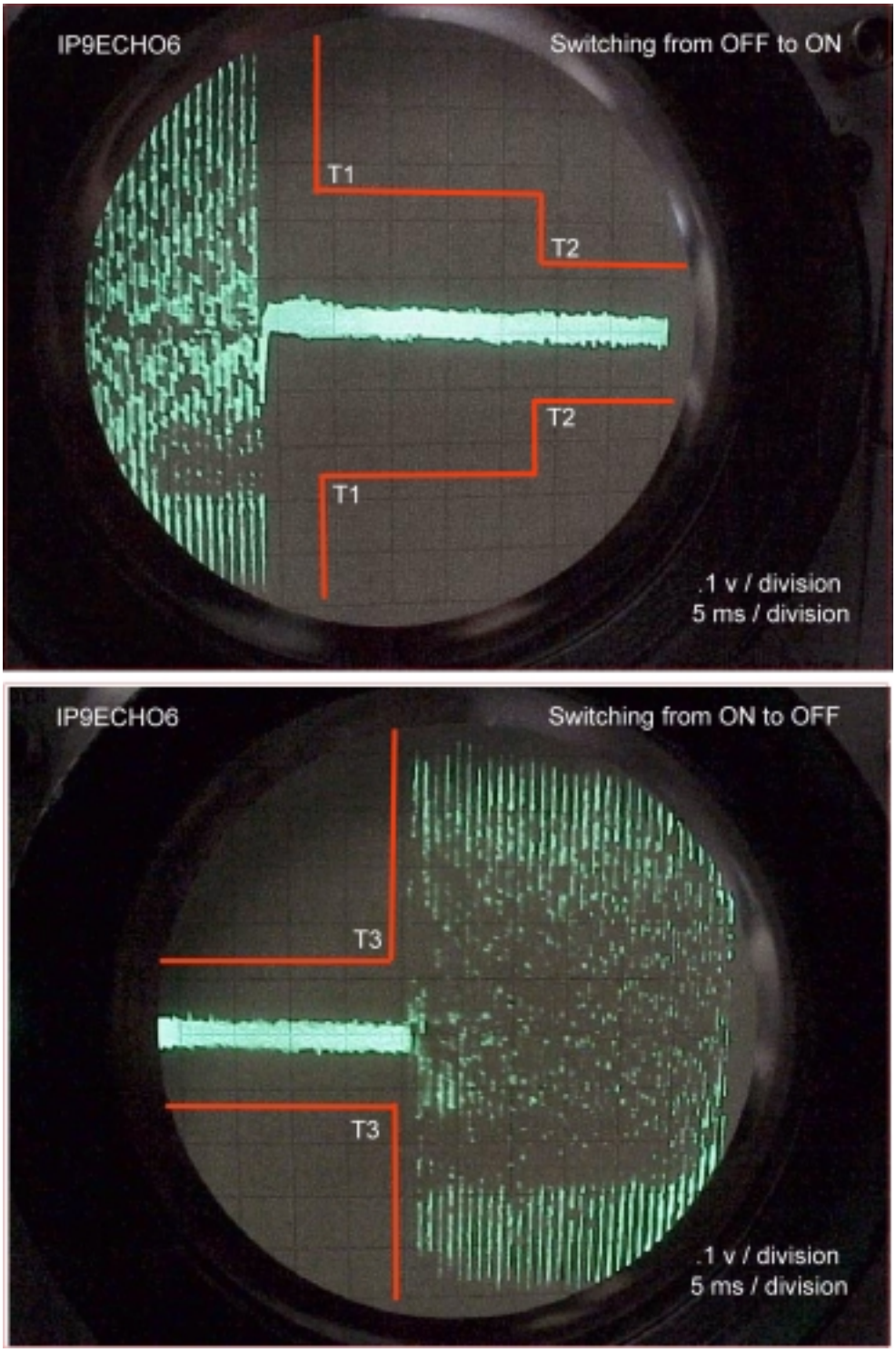


Figure 5
Transient Frequency Behavior

FCC ID# IP9ECHO6

TACTICAL TECHNOLOGIES INC
FOLSOM, PA.
MODEL – ECHO6
FCC ID – IP9ECHO6