TESTS AND MEASUREMENTS

TESTS AND MEASUREMENTS

Product Description

The equipment under test (EUT) is a RELM Communications, Model GPH, handheld VHF Radio. The GPH Series Radios are self-contained VHF FM Transceivers covering the frequency range of 148 MHz to 174 MHz. The units are multi-channel, digitally syntheisized radios using a single crystal for frequency control. All models incorporate an EEPROM for the storage of channel frequency, Code Guard™ and Dual tone Multiple Frequency/Automatic Numeric Identifier (DTMF/ANI) encode information. All models also include low battery and busy channel indicators. Toggle switches control hi/low transmit power, priority scan, and multi-channel scan. Status and channel information is displayed over a liquid crystal display on Keyboard/Display models. Connectors ar eprovided on the side of the unit for external antenna, microphone, speaker, and other optional accessories. A variety of twist-off battery packs are also available.

Test Methodology

Prepared in accordance with the requirements of FCC Rules and Regulations Part 2 Subpart F, Paragraphs 2.983 through 2.999 and applicable portions of Parts 24, 74, 80 and 90. All measurements are peak unless stated otherwise. The video filter associated with the spectrum analyzer was off throughout the evaluation process. Interconnecting cables were manipulated as necessary to maximize emissions. A block diagram of the tested system is shown in Figure 1.

Test Facility

Testing was performed at US Tech's measurement facility as described to the FCC and acknowledged in their letter marked 31040/SIT/US TECH. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number IC2982.

Test Equipment

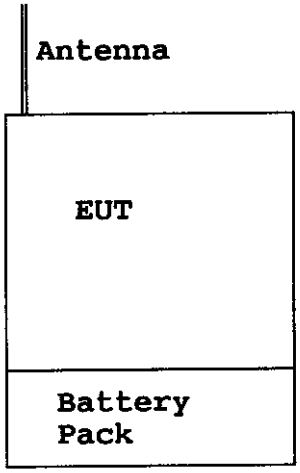
Table 1 describes test equipment used to evaluate this product.

Modifications

US Tech did not make any modifications to bring the EUT into compliance.

Test Date: August 1, 1998
UST Project: 98-352
Customer: RELM Communications
Model: GPH5102X

Figure 1
System Block Diagram



Test Date: August 1, 1998
UST Project: 98-352
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Model: GPH5102X

TABLE 1

EUT AND PERIPHERALS

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC ID:	CABLES P/D
Handheld VHF Radio RELM Communications (EUT)	GPH5102X	830006	K95GPH51 (Pending)	6" Antenna
Nickel Cadmium Rechargeable Battery Pack King Radio Corp.	LAA 105	55	None	None

TABLE 2

TEST INSTRUMENTS

TYPE	MANUFACTURER	MODEL	SN.
SPECTRUM ANALYZER	HEWLETT-PACKARD	8593E	3205A00124
SPECTRUM ANALYZER	HEWLETT-PACKARD	8558B	2332A09900
S A DISPLAY	HEWLETT-PACKARD	853A	2404A02387
COMB GENERATOR	HEWLETT-PACKARD	8406A	1632A01519
RF PREAMP	HEWLETT-PACKARD	8447D	1937A03355
RF PREAMP	HEWLETT-PACKARD	8449B	3008A00480
BICONICAL ANTENNA	EMCO	3110	9307-1431
LOG PERIODIC ANTENNA	EMCO	3146	9110-3600
HORN ANTENNA	EMCO	3115	167
THERMOMETER	FLUKE	52	5215250
MULTIMETER	FLUKE	85	53710469
DUAL OUTPUT POWER SUPPLY	HEWLETT-PACKARD	E3620A	KR41200373
PLOTTER	HEWLETT-PACKARD	7475A	2325A65394

MEASUREMENT PROCEDURE

Subpart 2.987(a) and 90.211(a)

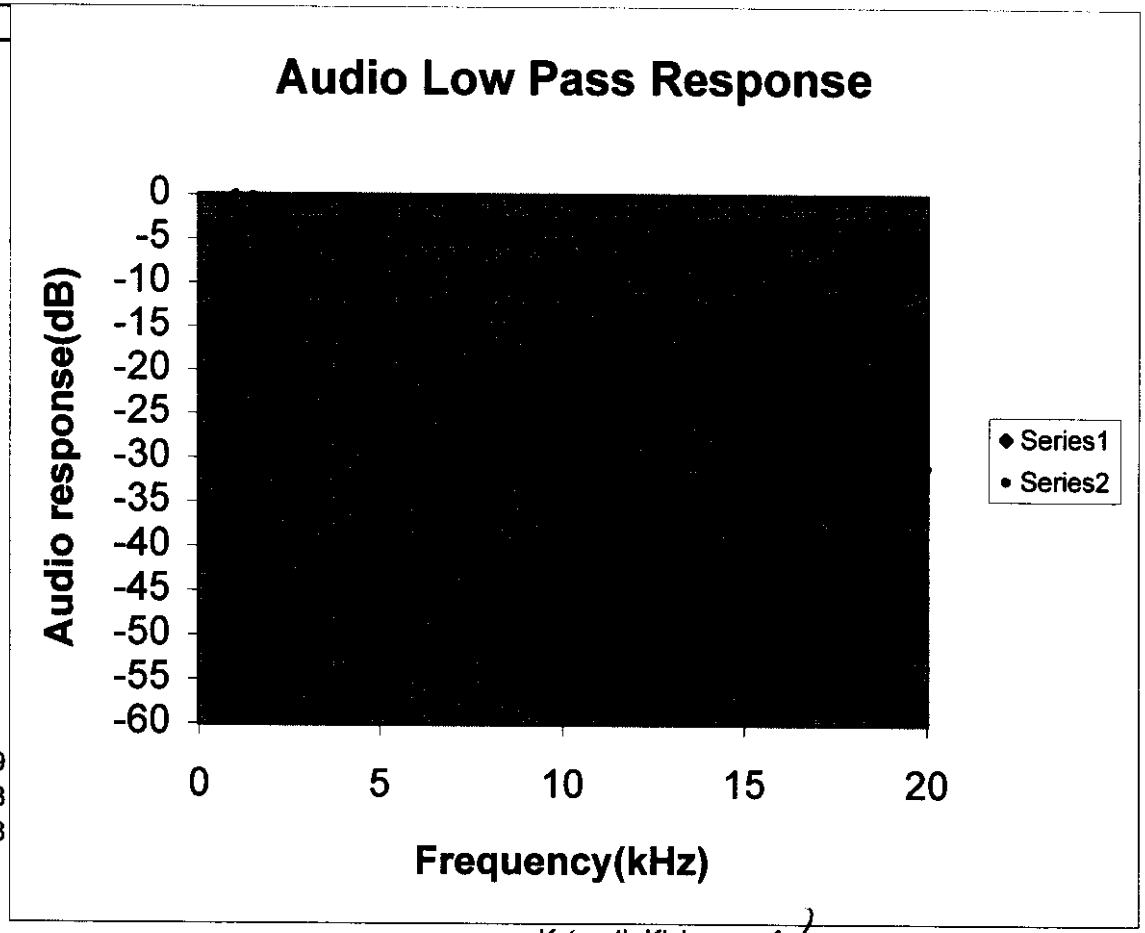
MODULATION CHARACTERISTICS

FCC Minimum Standard

The following measurement was performed by RELM Communications. The data is shown in the following figure.

GPH5102X
FCC TYPE ACCEPTANCE
Audio Low Pass Filter Response

Audio Freq (kHz)	Response (dB)
1	0
1.5	-0.18
2	-0.39
2.5	-0.69
3	-1.21
4	-5.49
5	-12.79
6	-17.69
8	-21.17
10	-24.69
15	-31.09
20	-31.09
30	-31.09



Test Equipment	Cal Due
HP8903 Audio Analyzer	5/11/99
HP8901 Modulation Analyzer	12/29/98
F34 Function Generator	11/3/98

Kenneth Klyberg
Engineering Technician

MEASUREMENT PROCEDURE

Subpart 2.985(a), 90.205(d), and 74.461

RF Power Output

The EUT was directly connected to a spectrum analyzer with the input resistance set to 50Ω. An external 30 dB attenuation was used during the test. The maximum RF output power was measured and compared to the manufacturer's rating. The connector and cable that was used to connect the EUT to the spectrum analyzer has an unknown loss.

FCC Minimum Standard

Typically (+/-) 20 % of the manufacturer's rated output power and less than the maximum power.

Mfg. Rated Power: +37.8 dBm/6000.0 mW across 50 Ω at output terminals

Power Measured (corrected)

		Power (dBm)	Power (mW)
Figure 2A	CH. 3- 25.0 kHz Channel Spacing	38.26	6698.8
Figure 2B	CH. 6- 12.5 kHz Channel Spacing	38.35	6839.11

Example Calculation

Power in mW = antilog (38.26 /10) = 6698.8

Tester Signature: _____ **Name:** Erik D. Collins

MEASUREMENT PROCEDURE

Subpart 2.989(h), 90.210(b), 90.210(d), 80.211(f), 22.359(a), and 74.462(c)

BANDWIDTH OF FUNDAMENTAL EMISSION UNDER MODULATION

This test was performed by RELM Communications. The EUT was modulated by a 2.5 kHz tone. The following figures show the plots for 25 kHz and 12.5 kHZ channel bandwidths, respectively.

FCC Minimum Standard

25 kHz Channel Bandwidth

10 kHz up to and including 20 kHz 25 dB

20 kHz up to and including 50 kHz 35 dB

> 50 kHz 43 + 10 log (P) dB

12.5 kHz Channel Bandwidth

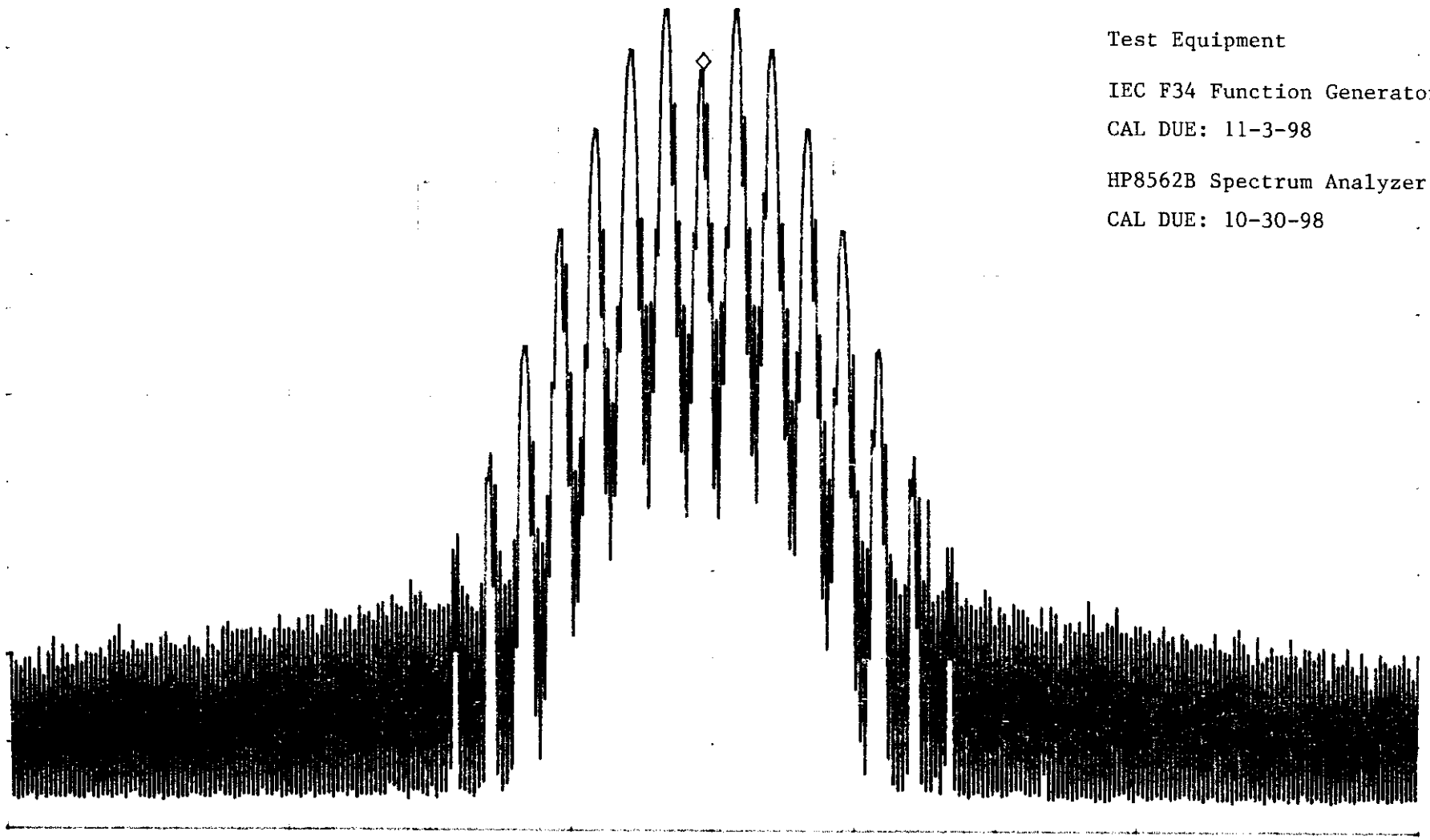
0 up to and including 5.625 kHz 0 dB

5.625 kHz up to and including 12.5 kHz

> .27 (fd -2.88 kHz) dB

> 12.5 kHz 50 + 10 log (P) dB or 70 dB which ever is the lesser attenuation

FCC ID: K95GPH31



Test Equipment

IEC F34 Function Generator

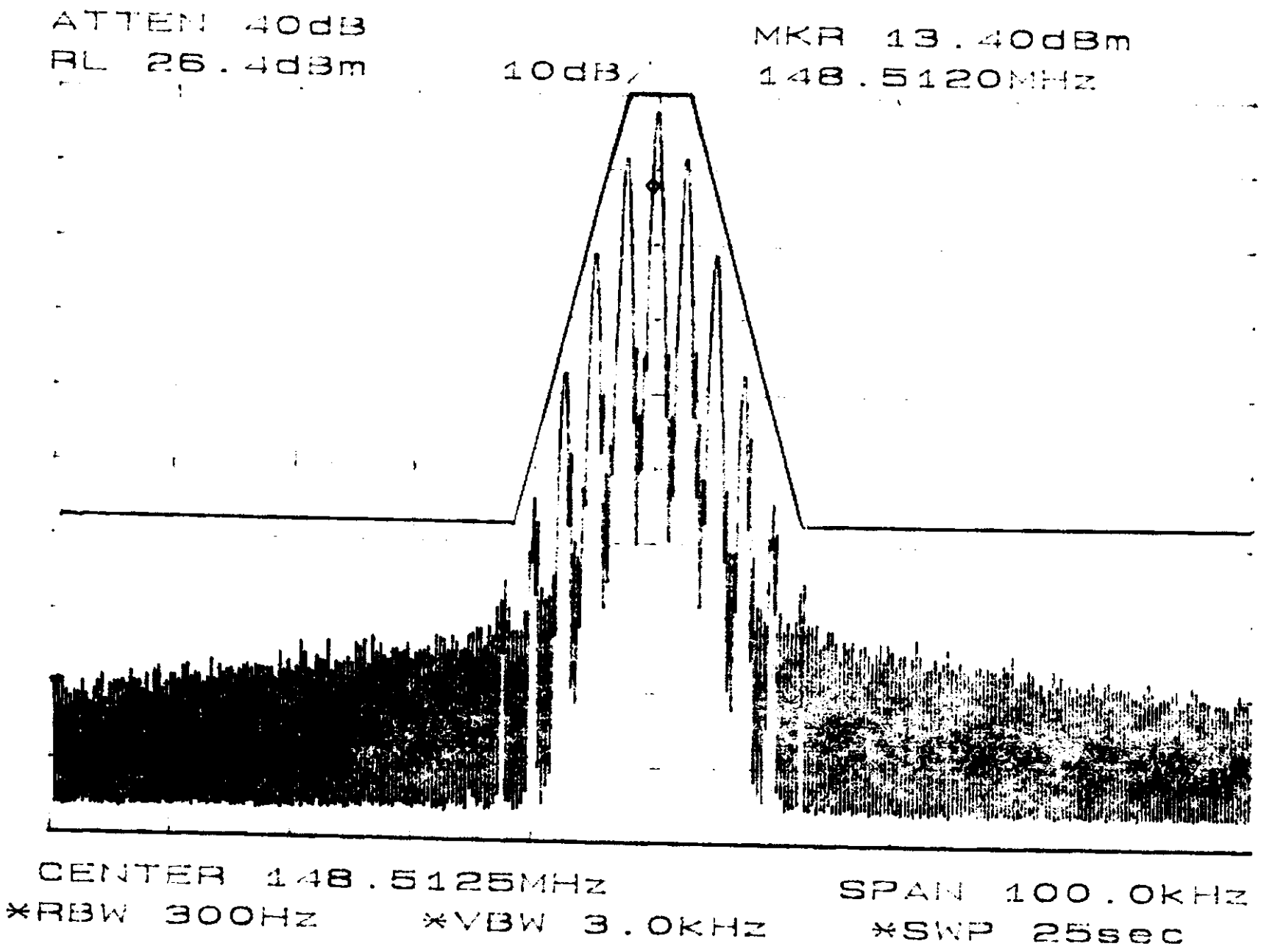
CAL DUE: 11-3-98

HP8562B Spectrum Analyzer

CAL DUE: 10-30-98

Occupied Bandwidth test Graph 25 kHz Input 2500Hz tone

Tested by: Kenneth Klyberg



Occupied Bandwidth Test Graph 12.5kHz Input 2500Hz tone

MEASUREMENT PROCEDURE

Subpart 2.991, 90.210(b), 90.210(d), 80.211(f), 22.359(a), and 74.462(c)

Transmitter Spurious Emmissions At Antenna Terminals

The following measurement was made by RELM Communications. The reference line is an indication of the FCC Limit with respect to the RF Output Power. The following tables and figures show the field strength of each spurious emission with respect to the reference line.

FCC Minimum Standard

25 kHz Channel Bandwidth

43 + 10 log (P) = dB

P = Measured Power

43 + 10 log (6.7) = 51.3 dB

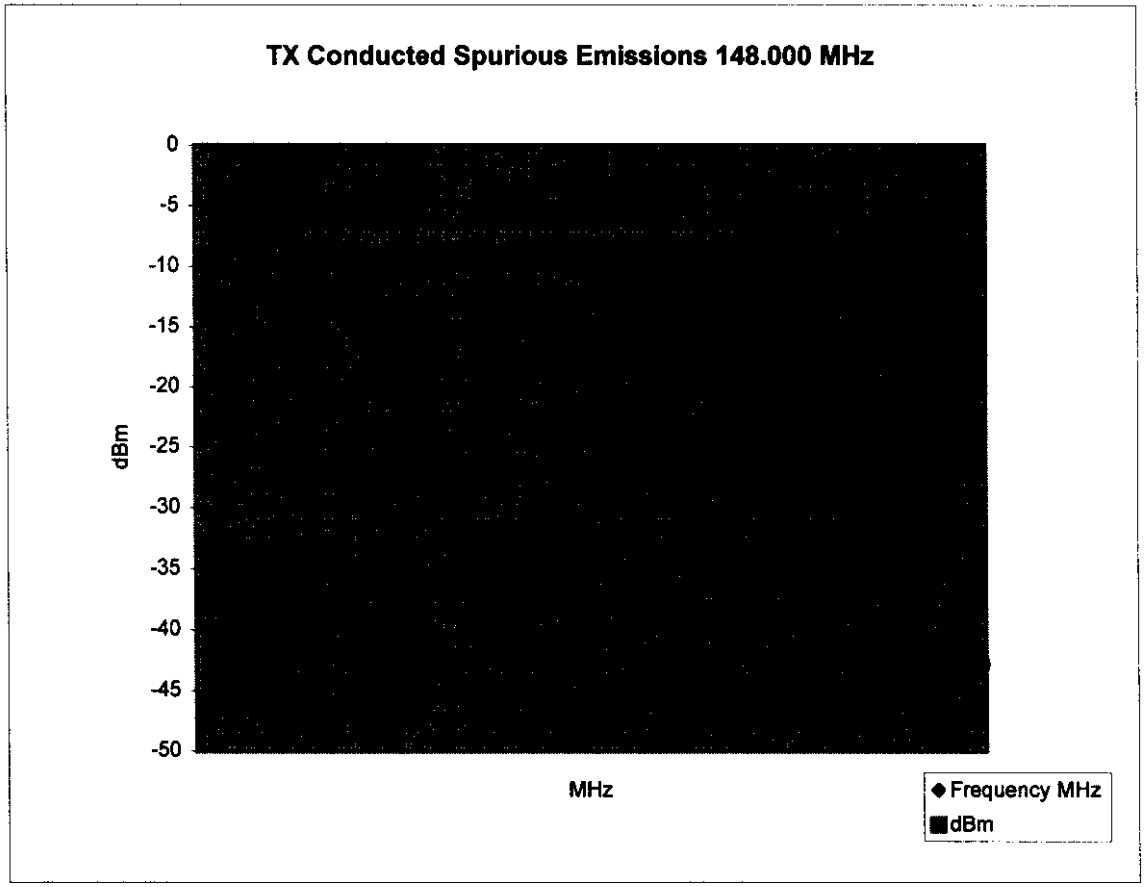
38.26 dBm - 51.3 dB = - 13.04 dBm (Reference Line)

GPH5102X

FCC TYPE ACCEPTANCE

Conducted Spurious Emmissions 148.000 MHz

Frequency MHz	dBm
296	-22
444	-40
592	-40
740	-42
888	-32
1036	-43
1184	-40
1332	-35
1480	-43



Test Equipment	Cal. Due
HP 8562B Spectrum Analyzer	10/30/98
HP 8640B Signal Generator	6/27/99
IEC F34 Function Generator	11/3/98

Tested by undersigned

Kenneth Klyberg

Engineering Technician

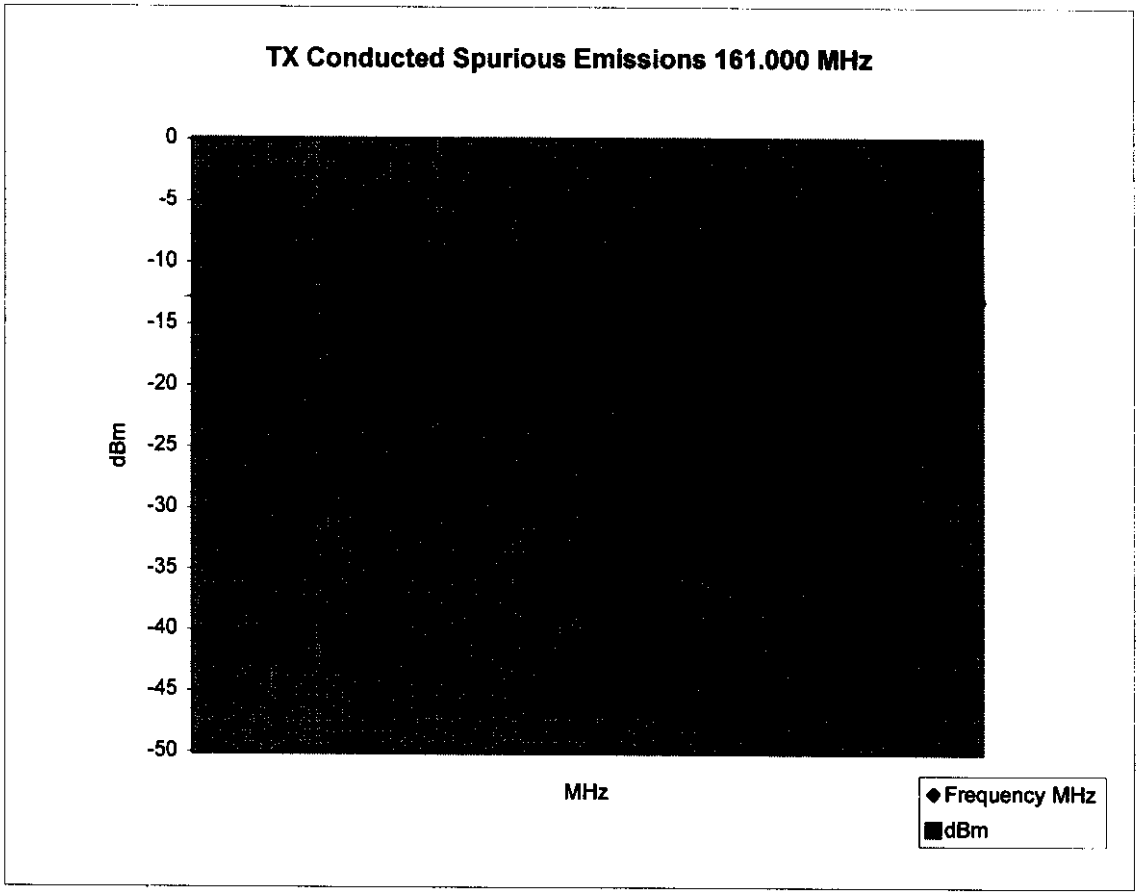
GPH5102X

FCC TYPE ACCEPTANCE

Conducted Spurious Emmissions 161.000 MHz

Frequency MHz	dBm
322	-25
483	-23
644	-39
805	-40
966	-30
1127	-43
1288	-43
1447	-43
1608	-43

Test Equipment	Cal. Due
HP 8562B Spectrum Analyzer	10/30/98
HP 8640B Signal Generator	6/27/99
IEC F34 Function Generator	11/3/98



Tested by undersigned

Kenneth Klyberg

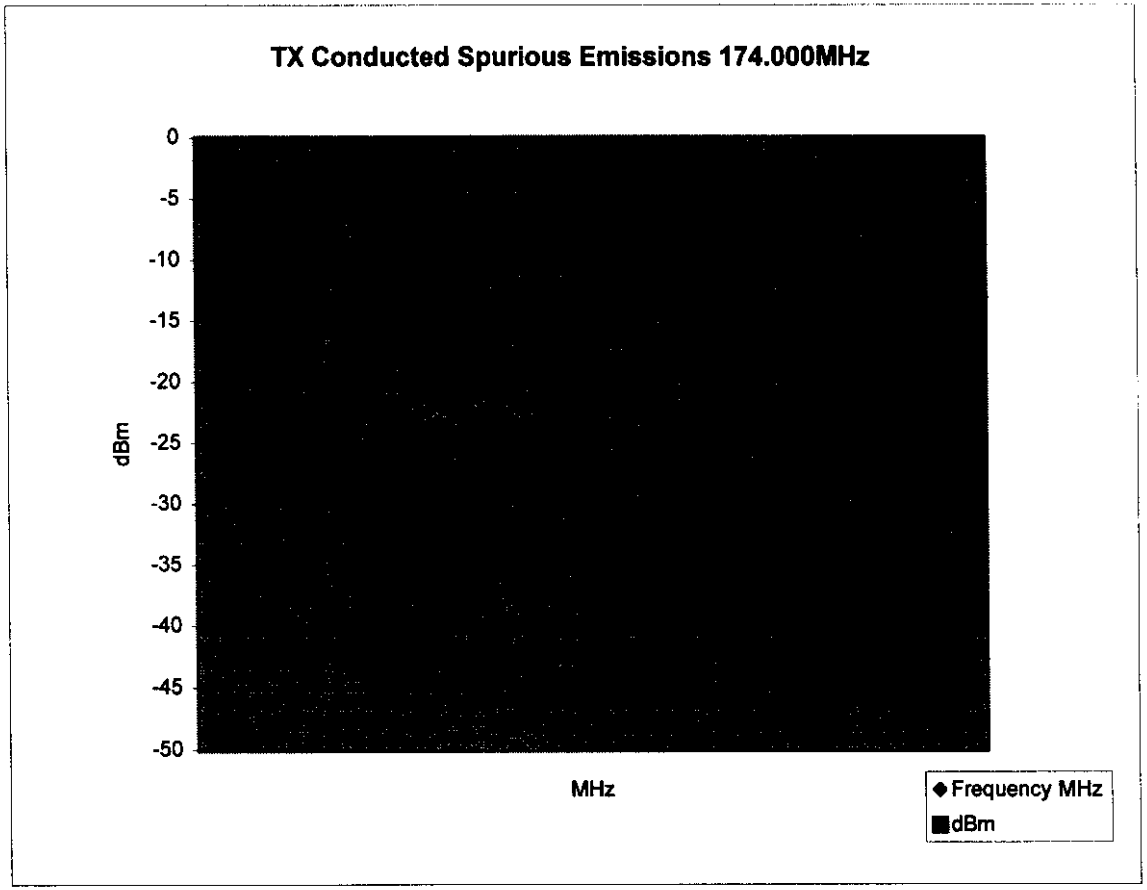
Engineering Technician

GPH5102X

FCC TYPE ACCEPTANCE

Conducted Spurious Emmissions 174.000 MHz

Frequency MHz	dBm
348	-25
522	-23
696	-39
870	-40
1044	-30
1218	-43
1492	-43
1666	-43
1840	-43



Test Equipment	Cal. Due
HP 8562B Spectrum Analyzer	10/30/98
HP 8640B Signal Generator	6/27/99
IEC F34 Function Generator	11/3/98

Tested by undersigned

Kenneth Klyberg

Engineering Technician

MEASUREMENT PROCEDURE

Subpart 2.993(a), 90.211(c), 80.211(f), 22.359(a), and 74.462(c)

Field Strength of Spurious Radiation

Spurious emissions were evaluated from 30 MHz to 2.0 GHz at an EUT to antenna distance of 3 meters. The handset was tested with a new battery. Measurements for 30 to 1000 MHz were made with the analyzer's bandwidth set to 120 kHz. Measurements above 1000 MHz were made with the analyzer's bandwidth set to 1 MHz. Since the EUT is part of a portable handheld configuration, the EUT was rotated through three orthogonal axis to produce the highest emission relative to the limit.

This level is interpolated to 30 meters using:

dBm @ 3 meters + 20 log(3/30) = dBm @ 30 meters

this level is compared to the level a transmitter would produce at 30 meters if connected to a 1/2 wave dipole using:

$$E = \frac{(30\ Pt\ Gt)^{1/2}}{d} \text{ volts per meter}$$

E = Field intensity (volts per meter)

Pt = Power output of transmitter (watts)

Gt = Gain of antenna (1.64 for 1/2 wave dipole)

d = distance (meters)

Example: A 25 watt transmitter would produce

$$\frac{[(30)(25)(1.64)]^{1/2}}{30.0} \text{ volts per meter}$$

= 1,150,635 microvolts per meter @ 30 meters

FCC Minimum Standard

25 kHz Channel Bandwidth
$43 + 10 \text{ Log}_{10} (P)$ = attenuation below carrier (dB)
Table 3A 43 + 10 log (6.7) = 51.3 dB

12.5 kHz Channel Bandwidth
$50 + 10 \text{ Log}_{10} (P)$ = attenuation below carrier (dB)
Table 3B 50 + 10 log (6.8) = 58.3 dB

FIELD STRENGTH OF SPURIOUS RADIATION

Test Date: August 1, 1998
UST Project: 98-352
Customer: RELM Communications
Model: GPH5102X

25 kHz Channel Bandwidth
FCC Minimum Standard: 43 + 10 log (6.7) = 51.3 dB
Fundamental = Corrected Reading in Far Field (30m) = 8.6 dBm

TABLE 3A

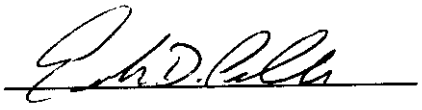
FREQ (MHz)	MEASUREMENT @ 3 m (dBm)	CORRECTION AF + CL + AMP GAIN	CORRECTED MEASUREMENT @ 30 m (dBm)	ATTENUATED LEVEL BELOW CARRIER POWER (dB)
348.0	-53.3*	19.1	-54.2	62.8
522.0	-59.1*	23.9	-55.2	63.8
696.0	-65.2	27.5	-57.7	66.3
870.0	-68.9	30.4	-58.5	67.1
1043.95	-24.7	-6.9	-51.6	60.2
1217.95	-35.8	-6.4	-62.2	70.8
1391.98	-33.6	-5.9	-59.5	68.1
1565.90	-42.3	-5.2	-67.5	76.1
1739.93	-41.6	-4.2	-65.8	74.4

SAMPLE CALCULATION:
Results dBm @ 30 m:

-53.3 + 19.1 - 20 = -54.2

CONVERSION FROM 3 METERS TO 30 METERS = 20 dB

*** = Measurments were made with a 50Ω termination connected to the antenna port. All other measurements were made with a rubber flex antenna provided by RELM Communications.**

Tester Signature:  **Name: Erik D. Collins**

FIELD STRENGTH OF SPURIOUS RADIATION

Test Date: August 1, 1998
UST Project: 98-352
Customer: RELM Communications
Model: GPH5102X

12.5 kHz Channel Bandwidth
FCC Minimum Standard: 50 + 10 log (6.8) = 58.3 dB
Fundamental = Corrected Reading in Far Field (30m) = 8.7 dBm

TABLE 3B

FREQ (MHz)	MEASUREMENT @ 3 m (dBm)	CORRECTION AF + CL + AMP GAIN	CORRECTED MEASUREMENT @ 30 m (dBm)	ATTENUATED LEVEL BELOW CARRIER POWER (dB)
348.0	-54.1*	19.1	-55.0	63.7
522.0	-57.6*	23.9	-53.7	62.4
696.0	-65.7	27.5	-58.2	66.9
870.0	-66.9	30.4	-56.5	65.2
1043.95	-25.1	-6.9	-52.0	60.7
1217.95	-36.1	-6.4	-62.5	71.2
1391.98	-34.2	-5.9	-60.1	68.8
1565.90	-38.9	-5.2	-64.1	72.8
1739.93	-41.2	-4.2	-65.4	74.1

SAMPLE CALCULATION:
Results dBm @ 30 m:

-54.1 + 19.1 - 20 = -55.0

CONVERSION FROM 3 METERS TO 30 METERS = 20 dB

*** = Measurments were made with a 50Ω termination connected to the antenna port. All other measurements were made with a rubber flex antenna provided by RELM Communications.**

Tester Signature: Erik D. Collins **Name:** Erik D. Collins

MEASUREMENT PROCEDURE

Frequency Stability

Subpart 2.995, 90.213, 80.209, 22.355, and 74.464

The frequency tolerance of the carrier signal was measured by RELM Corporation while ambient temperature was varied from -33 to 65 degrees centigrade. The frequency tolerance was verified at 5 degree increments. The EUT was tested with fully charged batteries. The supply voltage was varied from 8.5 Volts to 11.5 Volts. The data is shown in the following tables and figures.

FCC Minimum Standard

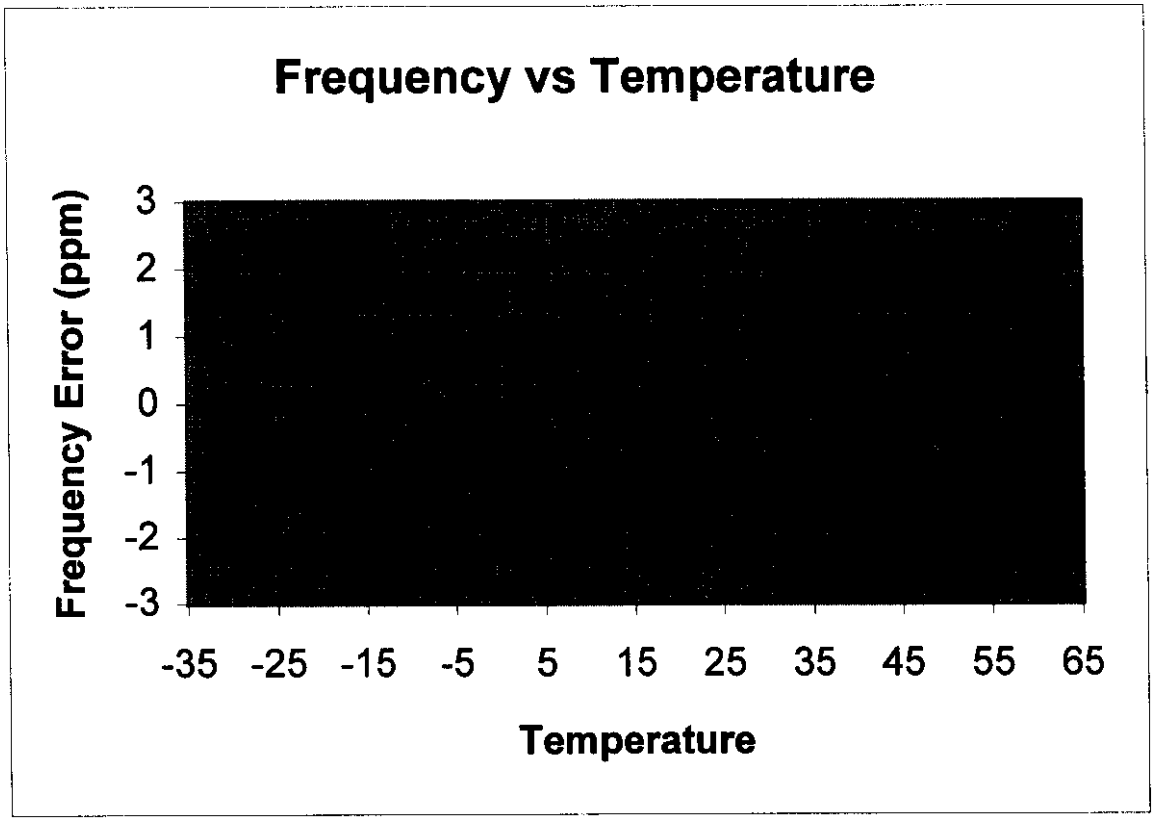
< 5 ppm

GPH5102X

FCC TYPE ACCEPTANCE

Frequency stability vs. Temperature

Temperature	PPM error
Temp (C)	PPM
65	-0.05
60	-0.52
55	-0.67
50	-0.86
45	-0.99
40	-0.85
35	-0.68
30	-0.24
25	-0.15
20	-0.23
15	0.20
10	0.23
5	-0.21
0	0.24
-5	0.24
-11	0.26
-16	0.25
-21	0.21
-25	0.19
-28	0.20
-33	0.20



Test Equipment:	Cal. Due
HP8920A	8/2/98
Newport Electronics 269-J-C	3/25/99
Ratelco Power Supply	N/A
Fluke Model 77	7/15/99

Tests were performed by the undersigned

Fred Carrigan-Technician

Bud Simciak-R&D Manager

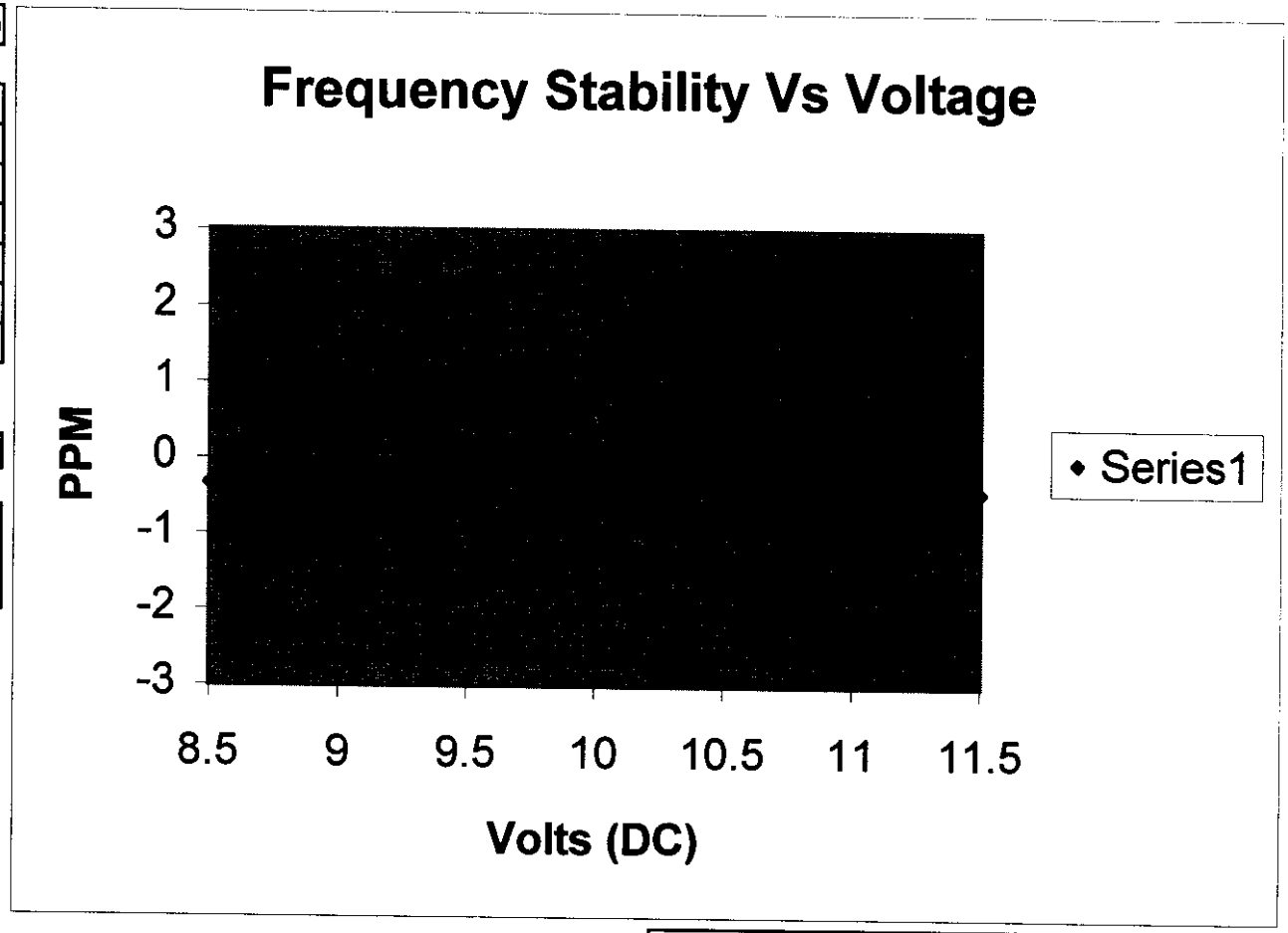
GPH5102X

FCC TYPE ACCEPTANCE

Frequency Stability Vs Voltage

Voltage (DC)	Freq. Error (PPM)
8.5	-0.337
9	-0.317
9.5	-0.28
10	-0.28
10.5	-0.44
11	-0.44
11.5	-0.44

Test Equipment	Cal. Due
HP 8920A	8/2/98
Ratelco power supply	N/A
Fluke Model 77	7/15/99



Tests Performed by undersigned

Kenneth Klyberg

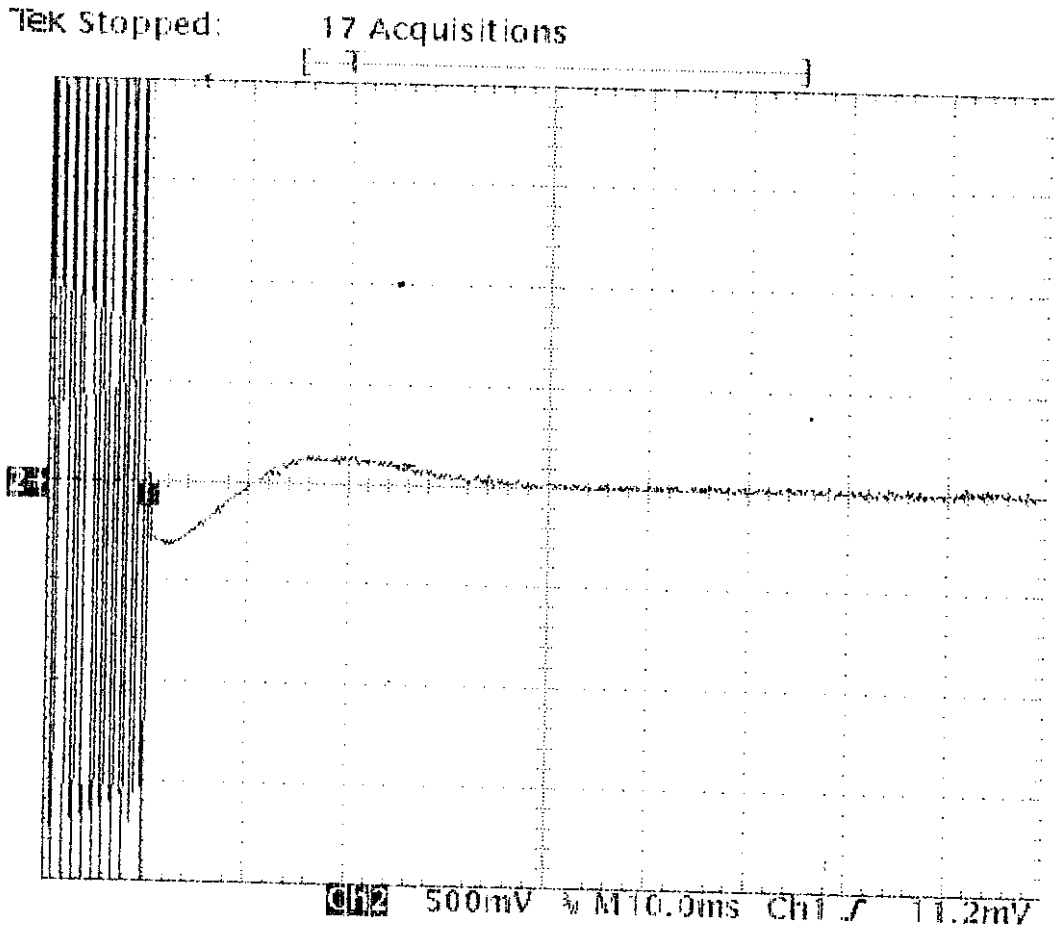
Kenneth Klyberg
Engineering Technician

MEASUREMENT PROCEDURE

Subpart 90.214

TRANSIENT FREQUENCY BEHAVIOR

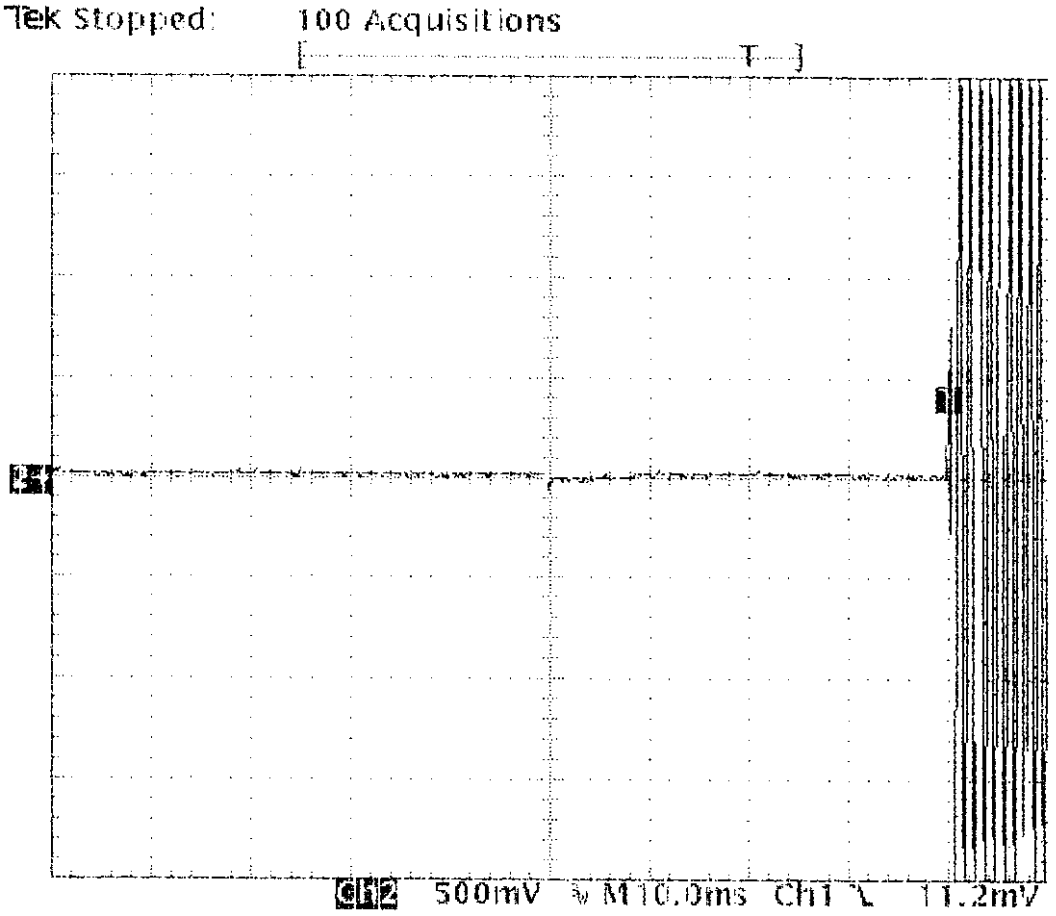
Information regarding this requirement has been supplied by RELM Communications. Plots are provided for both 25 kHz and 12.5 kHz Channel Bandwidths in the following figures.



Test Equipment	Cal Due
Tektronix TDS 420	6-16-99
HP8901B	12-29-98
HP8640B	6-27-99

Transient Behavior 25 KHz

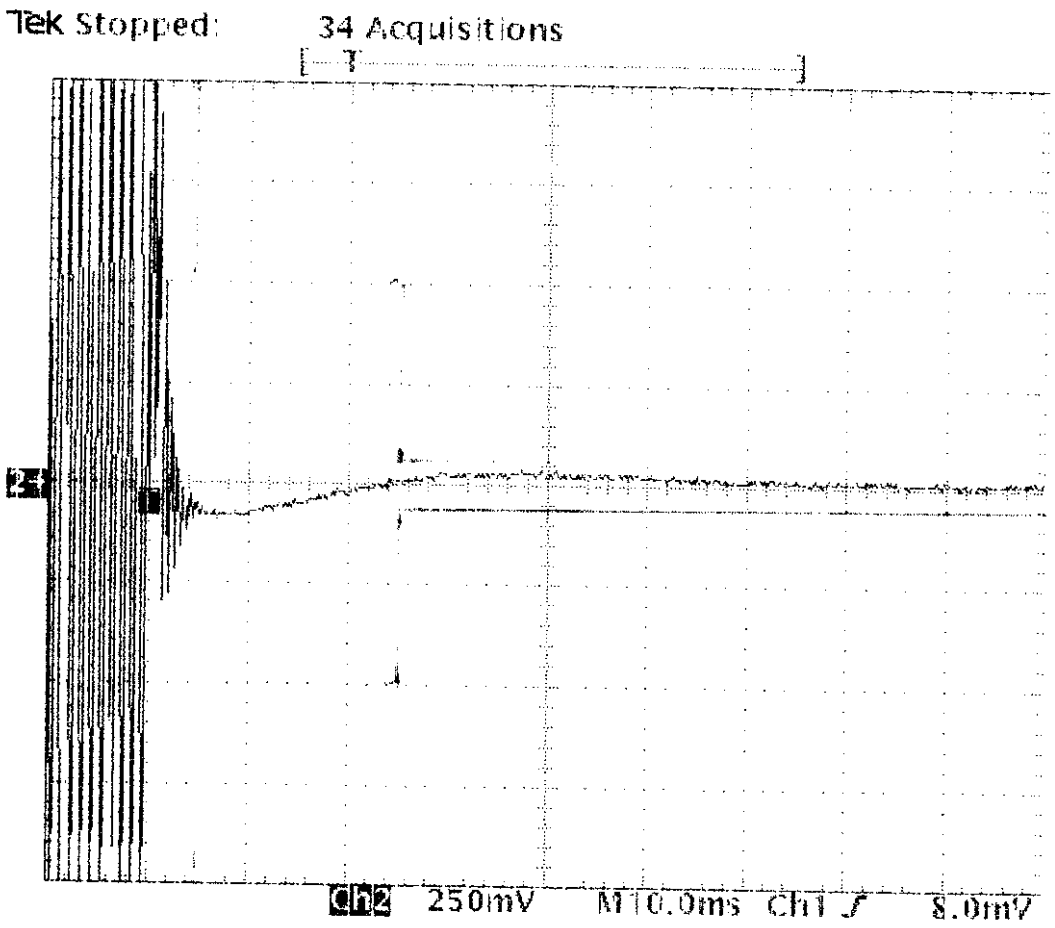
Tested By Ken Klyberg
Engineering Tech



Test Equipment	Cal Due
Tektronix TDS420	6-16-99
HP8901B	12-29-98
HP8640B	6-27-99

Transient Behavior 25KHz

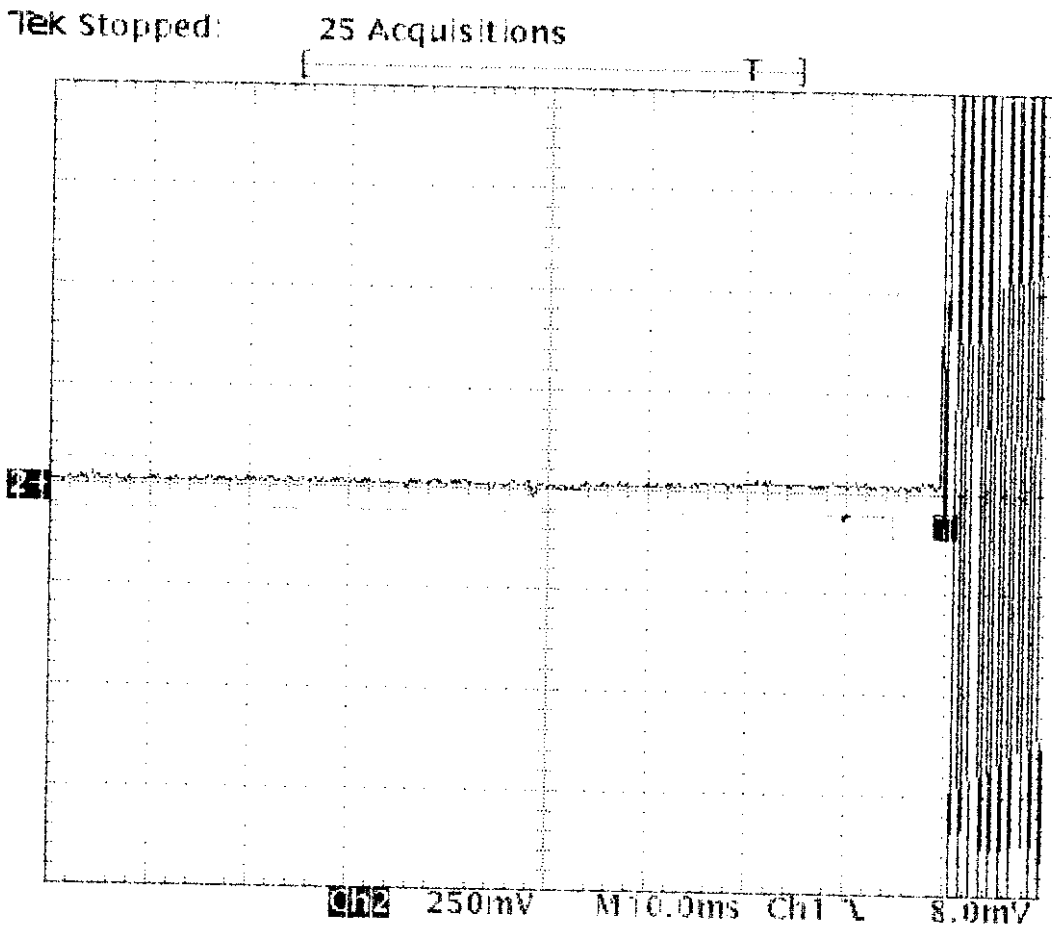
Tested By Ken Klyberg
Engineering Tech



Test Equipment	Cal Due
Tektronix TDS 420 Oscilliscope	6-16-99
HP8901B Modulation Analyzer	12-29-98
HP8640B Signal Generator	6-27-99

Transient Behavior 12.5 KHz

Test performed by
Kenneth Klyberg
Engineering Tech



Test Equipment	Cal Due
Tektronix TDS 420	6-16-99
HP8901B	12-29-98
HP8640B	6-27-99

Transient Behavior 12.5KHz

Tested By Ken Klyberg
Engineering Tech

Figure 2A
RF Output Power @ CH. 3 - 25.0 kHz Channel Spacing

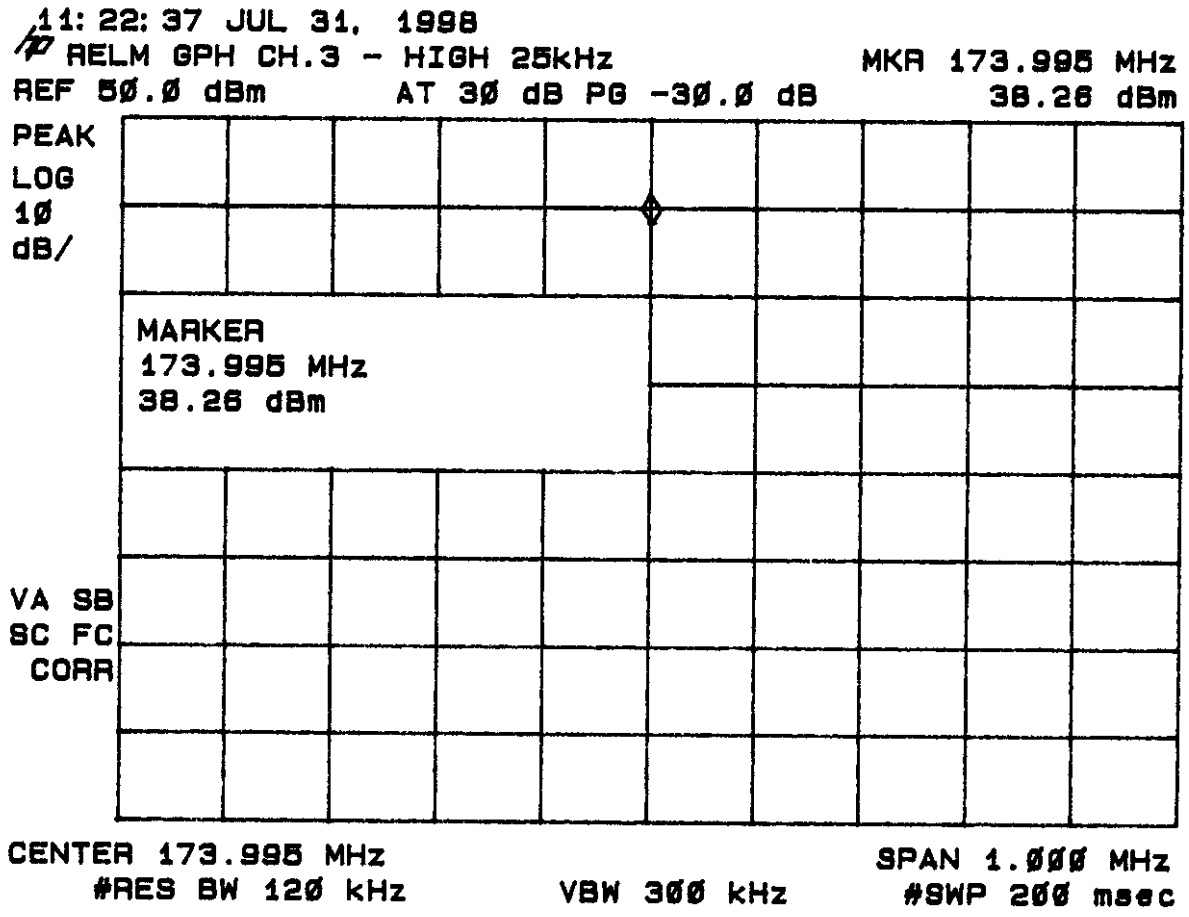


Figure 2B
RF Output Power @ CH. 6 - 12.5 kHz Channel Spacing