Nemko Test Report:	10228909RUS1rev3
Applicant:	The Charles Machine Works, Inc. 1959 W. Fir Ave Perry, OK 73077 USA
Equipment Under Test: (E.U.T.)	TK/TKD/TKQ Tracker FCC ID.: ITQ-TK IC: 3598A-TK
In Accordance With:	**CFR 47 Part 90, Subpart I and Industry Canada RSS-119, Issue 11** Private Land Mobile Radio Services
Tested By:	Nemko USA Inc. 802 N. Kealy Lewisville, TX 75057-3136

TESTED BY: _____ DATE: 23 October 2012

David Light, Wireless Engineer

APPROVED BY: _____ DATE: 23 October 2012

Mike Cantwell

Total Number of Pages: 30

Table of Contents

Section 1. Summary of Test Results

Manufacturer: The Charles Machine Works, Inc.

Model No.: TK/TKD/TKQ

Serial No.: None

General: **All measurements are traceable to national standards.**

Model TK: Single receive frequency tracker (29kHz).
Model TKD – for the Standard, Dual Frequency Tracker (12 kHz and 29 kHz)
Model TKQ (tested) – TKQ, has all parts installed and all beacon frequencies, 1.5 kHz, 12 kHz, 20 kHz and 29 kHz, enabled with the software.

Variance is a software variance only to change from single frequency (TK), dual frequency (TKD) or quad frequency (TKQ)

These tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with CFR 47 Part 90, Subpart I and Industry Canada RSS-119, Issue 11.

☒ New Submission ☒ Production Unit

☐ Modification Filing ☐ Pre-Production Unit

☒ Family Listing

THIS TEST REPORT RELATES ONLY TO THE ITEM(S) TESTED.

THE FOLLOWING DEVIATIONS FROM, ADDITIONS TO, OR EXCLUSIONS FROM THE TEST SPECIFICATIONS HAVE BEEN MADE. See " Summary of Test Data".

NVLAP Lab Code 100426-0

Summary of Test Data

NAME OF TEST	PARA. NO.	RESULT
RF Power Output	90.205/5.4.1	Complies
Audio Frequency Response	TIA EIA-603.3.2.6	NA
Audio Low-Pass Filter Response	TIA EIA-603.3.2.6	NA
Modulation Limiting	TIA EIA-603.3.2.6	Complies
Occupied Bandwidth	90.210/5.8.3	Complies
Spurious Emissions at Antenna Terminals	90.210/5.8.3	Complies
Radiated Spurious Emissions	90.210/5.8.3	Complies
Receiver Spurious Emissions	5.11	NA
Frequency Stability	90.213/5.3	Complies
Transient Frequency Behavior	90.214/5.9	Complies

Footnotes:

The DUT is data only and has no audio components. Maximum deviation is +/-2.5 kHz.

The DUT is not a receiver.

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Section 2. General Equipment Specification

Supply Voltage Input:	9 Vdc
Tunable Bands:	466.0375 to 466.3625 MHz (USA) 464.625 to 464.800 MHz (Canada)

Type(s) of Modulation:

F3E (Voice)	F1D	F2D	D7W (QAM)	Other
☐	☒	☐	☐	☐

Emission Designator:	6K20F1D
Necessary BW:	(2 x 2.5 kHz dev). + 2 x (1200bps/2) = 6.20 kHz
Output Impedance:	50 ohms
RF Power Output (rated):	100 mW
Channel Spacing(s):	12.5 kHz
Operator Selection of Operating Frequency:	Dependent on receiver. Frequency selections are pre-programmed and user may only select from pre-programmed channels.
Power Output Adjustment Capability:	None

Revisions:

Revision 1: Added model TK to test report.

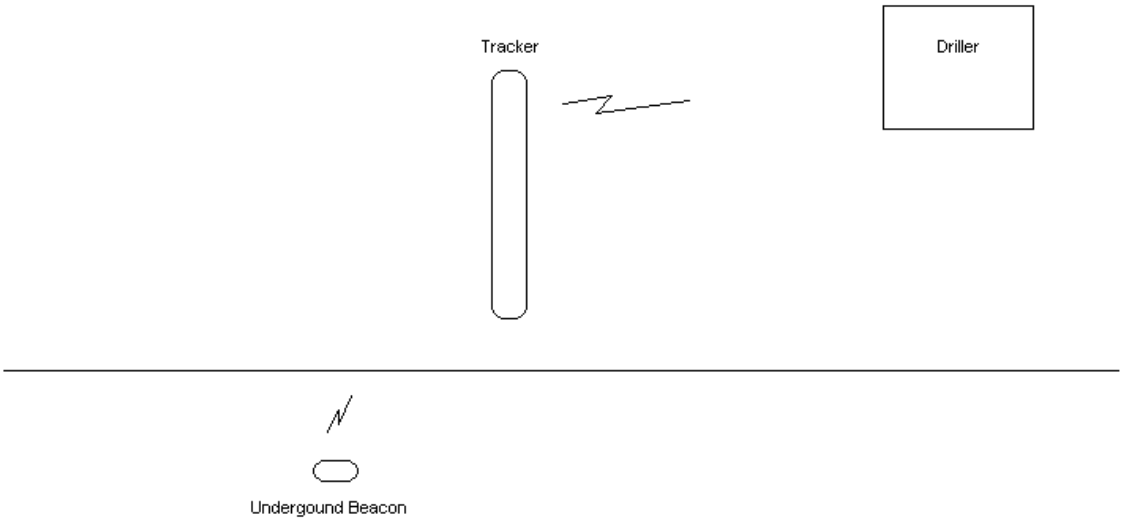
System Description

The TK/TKD/TKQ Tracker is a hand held, dual-conversion, narrow-band FM tracking device used in horizontal directional drilling applications. The tracker provides comprehensive guidance data including pitch, roll angle, depth, location, beacon temperature, battery status, etc. The data is collected and transmitted to a receiver located on the operator's station of a directional drill. The unit operates in the 450MHz-470MHz band and is powered by 4 C-cell alkaline batteries.

USA model uses RF transmitter part number TX2I-466-5-12K5-DWUS.

Canada model uses RF transmitter part number TX2I-464-5-12K5-DWCA.

System Diagram



Section 3. RF Power Output

NAME OF TEST: RF Power Output	PARA. NO.: 90.205/5.4.1
TESTED BY: David Light	DATE: 01 August 2012

Measurement Results: Complies.

Measurement Data:

Frequency (MHz)	Measured Power (dBm)	Measured Power (mW)	Rated Power (mW)
466.2125	21.37	137	125
464.7125	21.65	146	125

Spectrum Analyzer Settings:

RBW: 1 MHz
VBW: 1 MHz
Detector: Max Peak

Measurement Conditions:

Temperature: 22 °C
Humidity: 49 %

Test Equipment Used: 1036-1082-1472

Measurement Uncertainty: +/- 1.7 dB

Section 4. Occupied Bandwidth

NAME OF TEST: Occupied Bandwidth	PARA. NO.: 90.210/5.8.3
TESTED BY: David Light	DATE: 01 August 2012

Measurement Results: Complies.

Measurement Data: See attached data

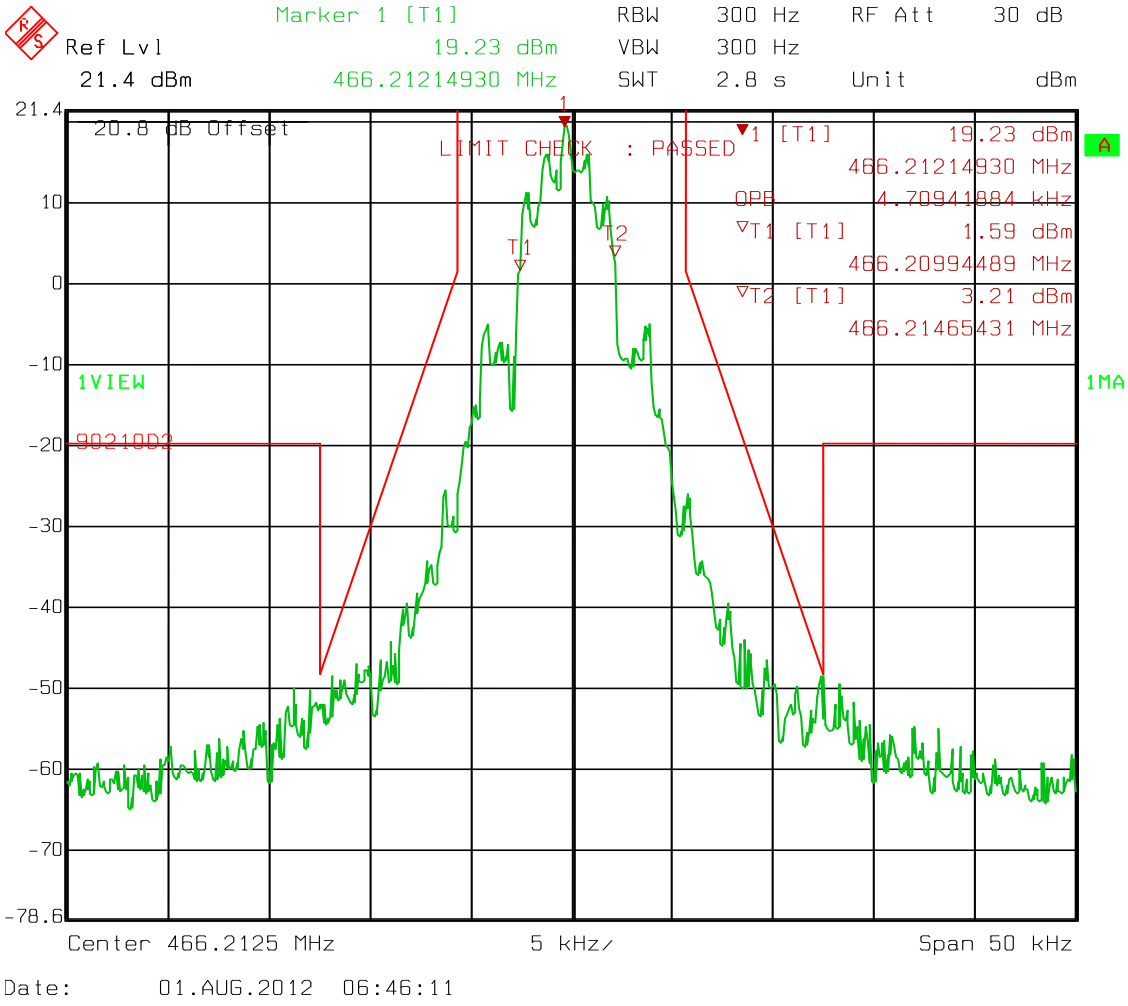
Measurement Conditions: Temperature: 22 °C
Humidity: 49 %

Measurement Uncertainty: +/- $1X10^{-7}$ ppm

Test Equipment Used: 1036-1082-1472

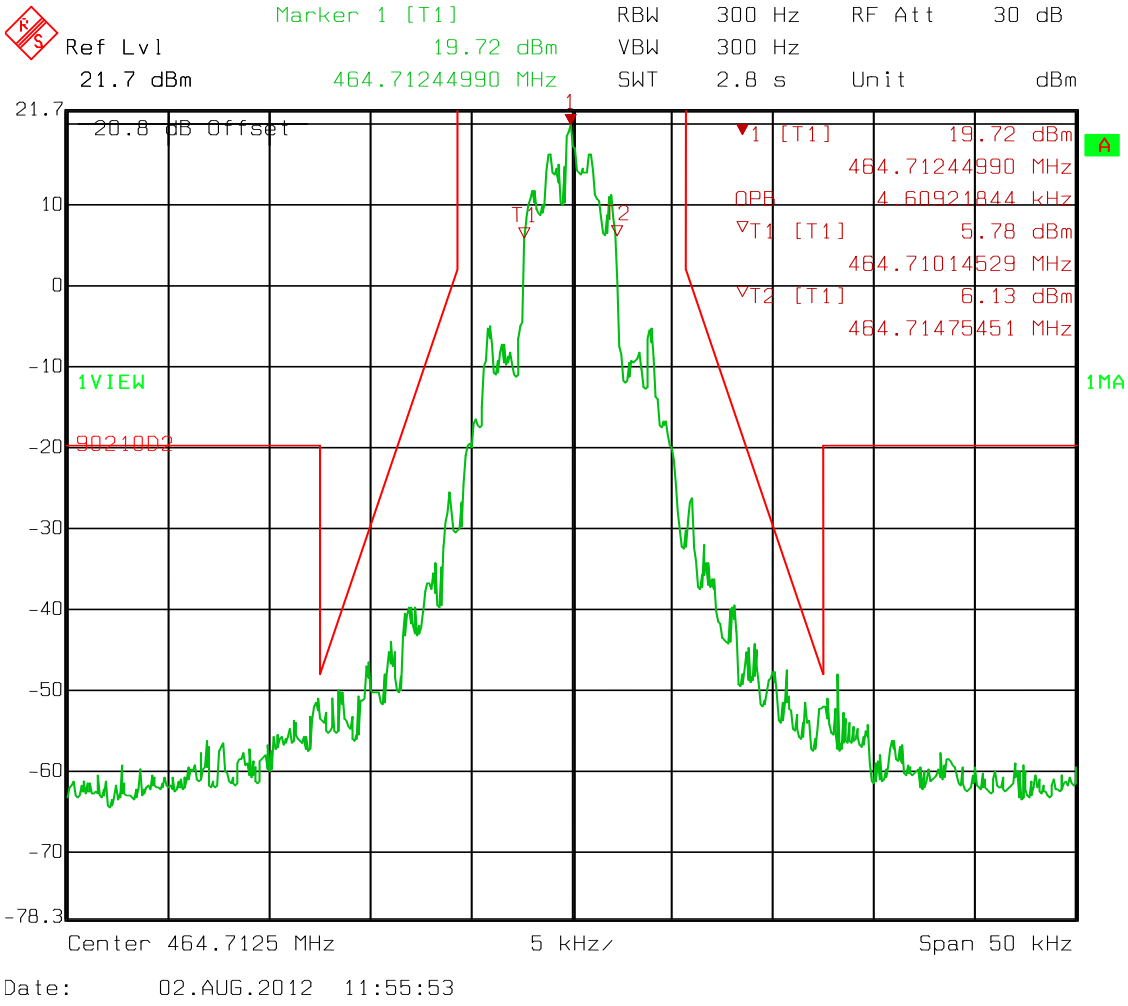
Test Data – Occupied Bandwidth

USA



Test Data – Occupied Bandwidth

Canada



Section 5. Spurious Emissions at Antenna Terminals

NAME OF TEST: Spurious Emissions @ Antenna	PARA. NO.: 90.210/5.8.3
TESTED BY: David Light	DATE: 01 August 2012

Measurement Results: Complies.

Measurement Data: See attached data

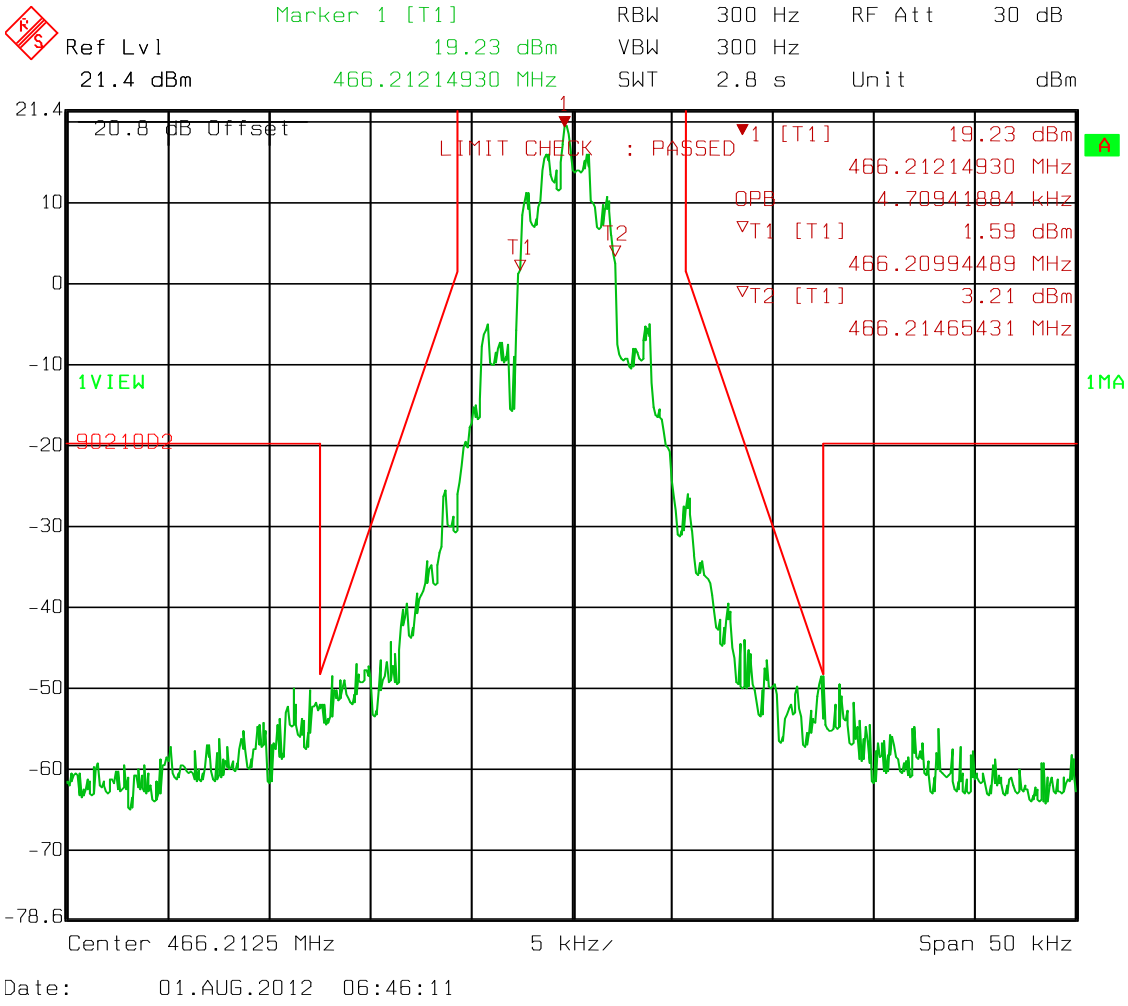
Measurement Conditions: Temperature: 22 °C
Humidity: 49 %

Measurement Uncertainty: +/- 1.7 dB

Test Equipment Used: 1036-1082-1472

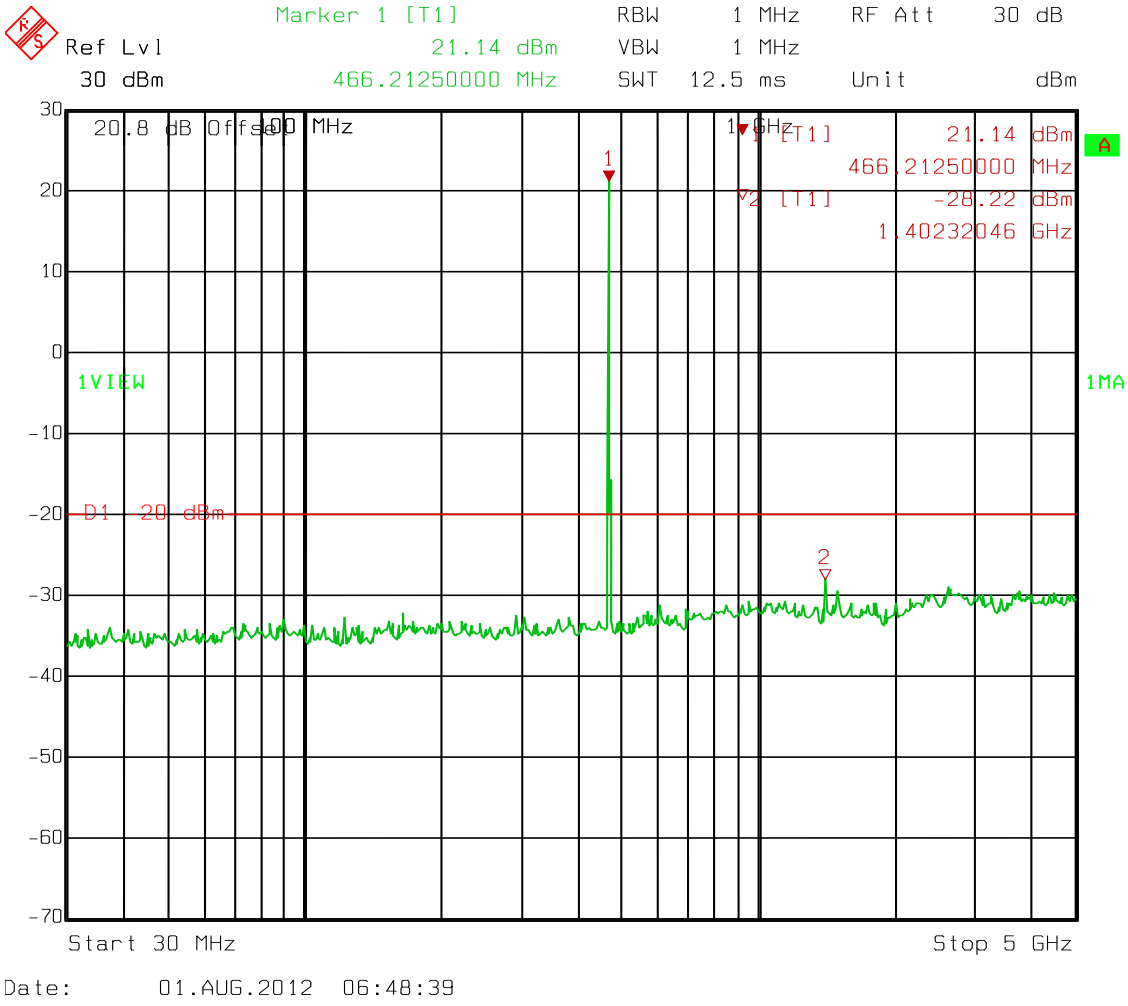
Test Data – Spurious Emissions at Antenna Terminals

USA



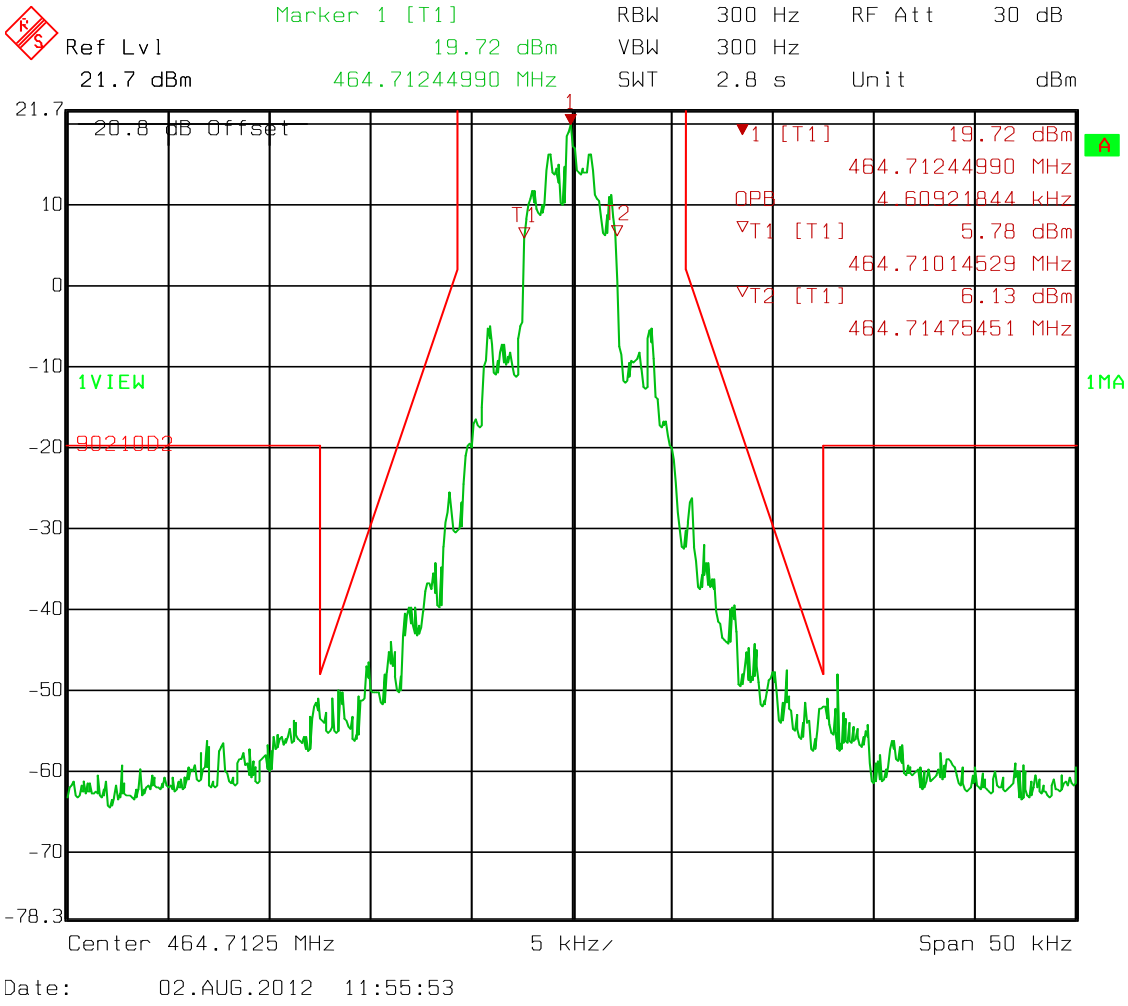
Test Data – Spurious Emissions at Antenna Terminals

USA



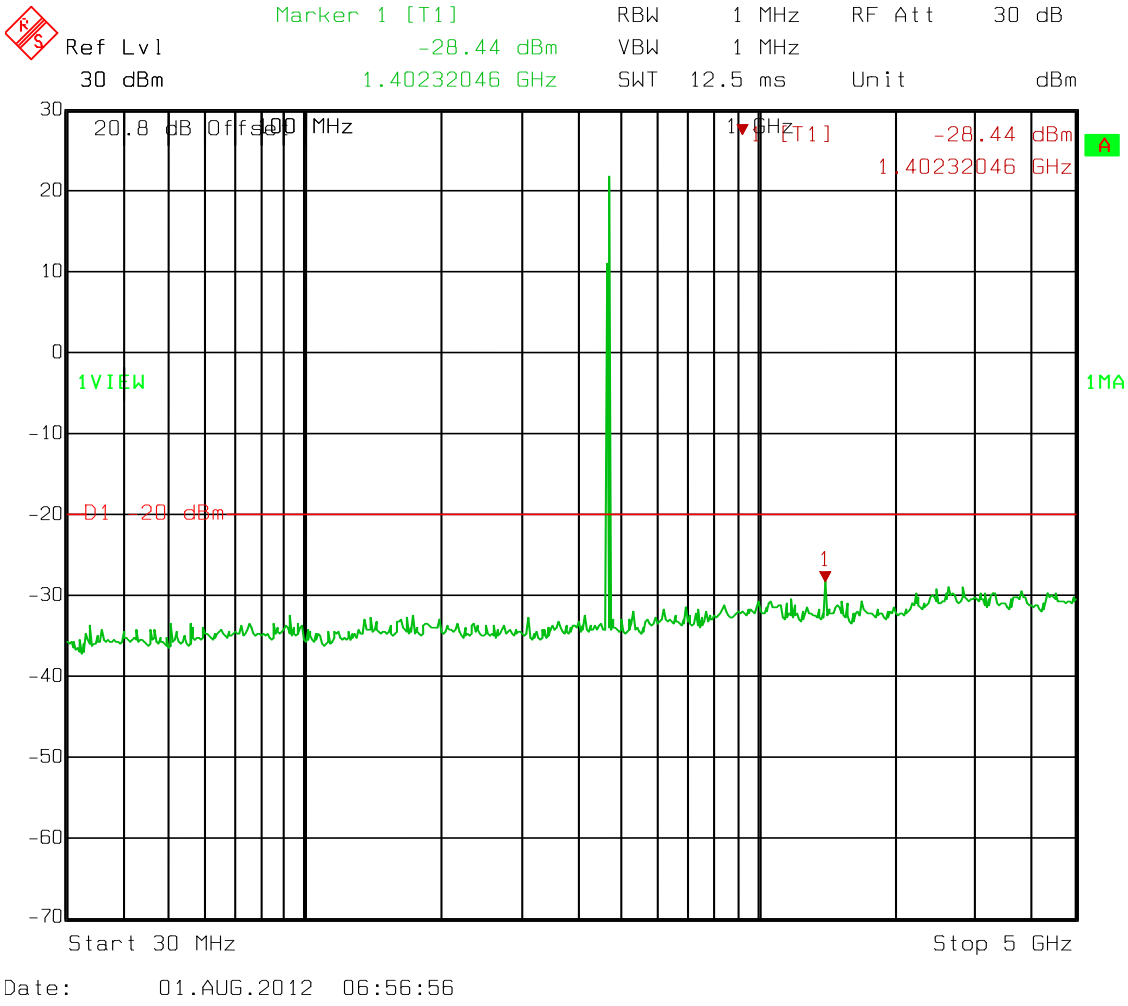
Test Data – Spurious Emissions at Antenna Terminals

Canada



Test Data – Spurious Emissions at Antenna Terminals

Canada



Section 6. Field Strength of Spurious Emissions

NAME OF TEST: Field Strength of Spurious Emissions	PARA. NO.: 90.210/5.8.3
TESTED BY: David Light	DATE: 02 August 2012

Test Results: Complies.

Test Data: There were no emissions detected above the noise floor which was at least 20 dB below the specification limit. The spectrum was searched from 30 MHz to 5 GHz.

Equipment Used: 1464-1016-993-1480-1025-1783

Measurement Uncertainty: +/-1.7 dB

Temperature: 22 °C

Relative Humidity: 49 %

Note: See page A5 for applicable limit.

Section 7. Frequency Stability

NAME OF TEST: Frequency Stability	PARA. NO.: 90.213/5.3
TESTED BY: David Light	DATE: 01 August 2012

Measurement Results: Complies.

Measurement Data: See attached data

Measurement Conditions: Temperature: 22 °C
Humidity: 49 %

Test Equipment Used: 1036-1082-1472

Measurement Uncertainty: +/- $1X10^{-7}$ ppm

Test Data – Frequency Stability

USA

Temp (°C)	Measured Frequency (MHz)		Test Voltage	Freqeuncy Error (Hz)	Limit (+/-Hz)	Error (ppm)	Comment
20	466.212630		6 Vdc	130	2331.1	0.3	Nominal
20	466.212733		6.9 Vdc	233	2331.1	0.5	
20	466.212668		2.8 Vdc	168	2331.1	0.4	Battery cutoff
50	466.212870		6 Vdc	370	2331.1	0.8	
40	466.212790		6 Vdc	290	2331.1	0.6	
30	466.212660		6 Vdc	160	2331.1	0.3	
10	466.212560		6 Vdc	60	2331.1	0.1	
0	466.212610		6 Vdc	110	2331.1	0.2	
-10	466.212480		6 Vdc	-20	2331.1	0.0	
-20	466.212600		6 Vdc	100	2331.1	0.2	
-30	466.212650		6 Vdc	150	2331.1	0.3	
Notes:							

Canada

Nominal Test Frequency = 464.7125 MHz

Temp (°C)	Measured Frequency (MHz)		Test Voltage	Freqeuncy Error (Hz)	Limit (+/-Hz)	Error (ppm)	Comment
20	464.712350		6 Vdc	-150	2323.6	-0.3	
20	464.712247		6.9 Vdc	-253	2323.6	-0.5	
20	464.712312		2.8 Vdc	-188	2323.6	-0.4	Battery cutoff
50	464.712110		6 Vdc	-390	2323.6	-0.8	
40	464.712190		6 Vdc	-310	2323.6	-0.7	
30	464.712320		6 Vdc	-180	2323.6	-0.4	
10	464.712420		6 Vdc	-80	2323.6	-0.2	
0	464.712370		6 Vdc	-130	2323.6	-0.3	
-10	464.712500		6 Vdc	0	2323.6	0.0	
-20	464.712380		6 Vdc	-120	2323.6	-0.3	
-30	464.712330		6 Vdc	-170	2323.6	-0.4	
Notes:							

Limit +/- 5.0 ppm

Section 8. Transient Frequency Behavior

NAME OF TEST: Transient Frequency Behavior	PARA. NO.: 5.9
TESTED BY: David Light	DATE: 01 August 2012

Measurement Results: Complies.

Measurement Data: See attached data

Frequency deviation: +/- 2847 Hz
Maximum frequency drift: +/- 982 Hz

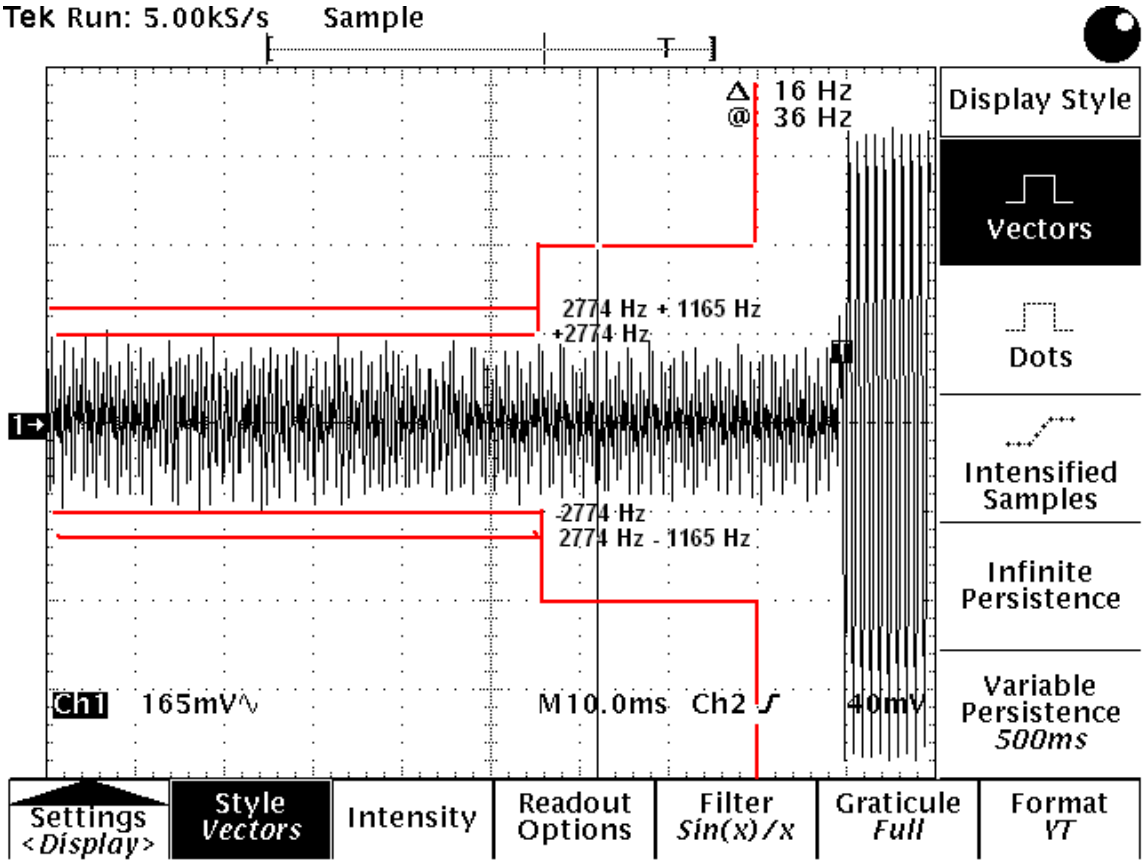
Measurement Conditions: Temperature: 22 °C
Humidity: 49 %

Test Equipment Used: 1463-1082-1054-1093

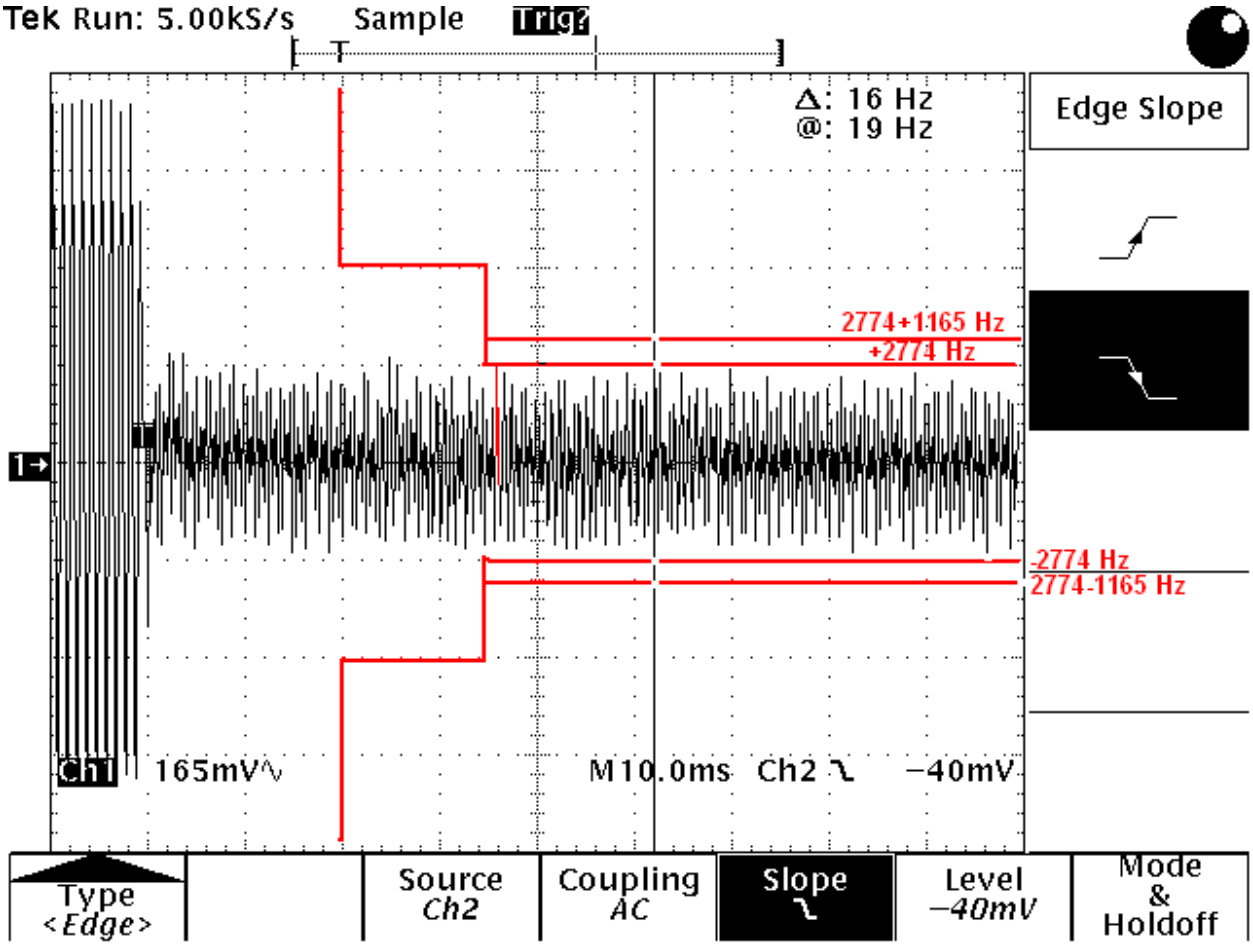
Measurement Uncertainty: +/- $1X10^{-7}$ ppm

Test Data – Transient Frequency Behavior

RF ON CONDITION



RF OFF CONDITION



Section 9. Test Equipment List

Asset Tag	Description	Manufacturer	Model	Serial #	Last Cal	Next Cal
993	Antenna, Horn	A.H. Systems	SAS-200/571	162	22-Sep-2011	22-Sep-2013
1016	Preamplifier	Hewlett Packard	8449A	2749A00159	23-Jul-2012	23-Jul-2013
1025	Preamplifier, 25dB	Nemko USA, Inc.	LNA25	399	27-Feb-2012	27-Feb-2013
1036	Spectrum Analyzer	Rohde & Schwartz	FSEK30	830844/006	23-Dec-2011	23-Dec-2013
1054	Directional Coupler, Dual	Narda	3020A	34366	N/R	
1082	Cable, 2m	Astrolab	32027-2-29094-72TC		N/R	
1093	Combiner	Mini Circuits	ZFSC-3-4		N/R	
1463	Color 4 Ch Digitizing Oscilloscope	Tektronix	TDS684A	B010460	11-Jul-2012	11-Jul-2013
1464	Spectrum Analyzer	Hewlett Packard	8563E	3551A04428	16-May-2011	16-May-2013
1472	Attenuator, 20dB, DC 18 Ghz	Omni Spectra	20600-20db		N/R	
1480	Antenna, Bilog	Schaffner-Chase	CBL6111C	2572	07-Feb-2012	07-Feb-2013
1783	Cable Assy, 3m Chamber	Nemko	Chamber		26-Sep-2011	26-Sep-2012

ANNEX A - TEST METHODOLOGIES

NAME OF TEST: RF Power Output PARA. NO.: 90.205 / 5.4

Minimum Standard: Typical transmitter output powers are 110 watts for base and/or fixed stations (paging transmitters excepted), and 30 watts for mobiles stations. Higher powers may be certified, but it should be noted that mobile stations are normally only licensed up to 30 watts.

Method Of Measurement:

Detachable Antenna:
The peak power at antenna terminals is measured using a spectrum analyzer with the IF bandwidth filter set to a level greater than the 20 dB bandwidth of the measured rf waveform. Power output is measured with the maximum rated input level.

Integral Antenna:
If the antenna is not detachable from the circuit then the Peak Power Output is derived from the peak radiated field strength of the fundamental emission by using the plane wave relation $GP/4\pi R^2 = E^2/120\pi$ and proceeding as follows:

$$P = \frac{E^2 R^2}{30G} = \frac{E^2 3^2}{30G}$$

where,

P = the equivalent isotropic radiated power in watts
E = the maximum measured field strength in V/m
R = the measurement range (3 meters)
G = the numeric gain of the transmit antenna in relation to an isotropic radiator

NAME OF TEST: Occupied Bandwidth PARA. NO.: 90.210 / 5.8

Minimum Standard: See table 1 below for applicable mask.

Table 1

Frequency Band (MHz)	Mask for equipment with Low Pass Filter	Mask for equipment without Low Pass Filter
Below 25	A or B	A or C
25 - 50	B	C
72 - 76	B	C
150 - 174	B, D or E	C, D or E
150 Paging only	B	C
220 - 222	F	F
421 - 512	B, D or E	C, D or E
450 paging only	B	H
806 - 821/ 851 - 866	B	G
821 - 824/ 866 - 869	B	H
896 - 901/ 935 - 940	I	J
902 - 928	K	K
929 - 930	B	G
Above 940	B	C
All other bands	B	C

Test Method:

RBW: 100 Hz
VBW: $\Rightarrow$ RBW

The spectrum is search up to 10 times the fundamental frequency.

NAME OF TEST: Frequency Stability PARA. NO.: 90.213 / 5.3

Minimum Standard: The transmitter carrier frequency shall remain within the assigned frequency below in ppm.

Table 2

Frequency Band (MHz)	Fixed And Base Stations	Mobile Stations	
		> 2 Watts o/p pwr	< 2 Watts o/p pwr
Below 25	100	100	200
25 - 50	20	20	50
72 - 76	5	-	50
150 - 174	5	5	5
220 - 222	0.1	1.5	1.5
421 - 512	2.5	5	5
806 - 821	1.5	2.5	2.5
821 - 824	1.0	1.5	15
851 - 866	1.5	2.5	2.5
866 - 869	1.0	1.5	1.5
869 - 901	0.1	1.5	1.5
902 - 928	2.5	2.5	2.5
929 - 930	1.5	-	-
935 - 940	0.1	1.5	1.5
1427 - 1435	300	300	300
Above 2450	-	-	-

NAME OF TEST: Transient Frequency Behavior PARA. NO.: 90.214 / 5.9

Minimum Standard:

Transient Frequency Behavior for Equipment Designed to Operate on 25 kHz Channels

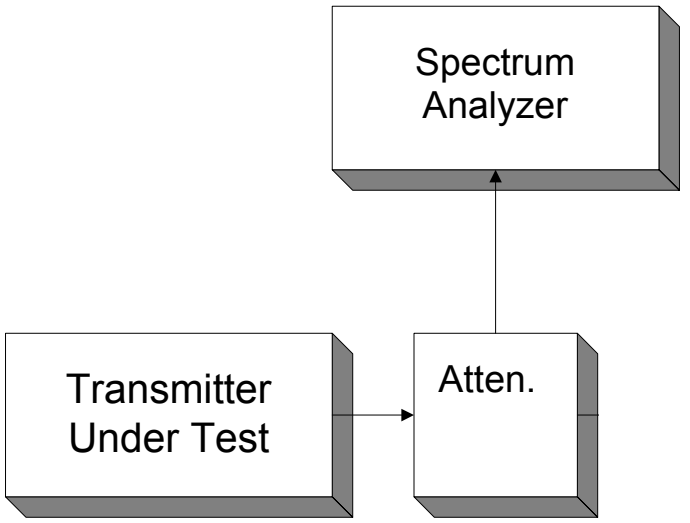
		Frequency ranges (MHz) All equipment					
	Maximum	Base station and portable radios			Mobile Radios		
Time intervals [1,2]	Frequency difference[3] (kHz)	150 - 174 (ms)	450 - 500 (ms)	500 - 512 (ms)	150 - 174 (ms)	450 - 500 (ms)	500 - 512 (ms)
t_1[4]	± 25	5.0	10.0	20.0	5.0 10.0		5.0
t_2	± 12	20.0	25.0	50.0	20.0 25.0		20.0
t_3[4]	± 25	5.0	10.0	10.0	5.0 10.0		5.0

Transient Frequency Behavior for Equipment Designed to Operate on 12.5 kHz & 6.25 kHz Channels

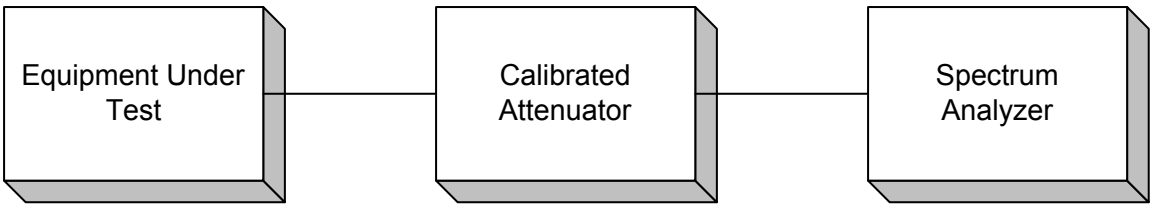
	Maximum	Frequency ranges (MHz) All equipment		
Time intervals [1,2]	Frequency difference[3] (kHz)	150 - 174 (ms)	450 - 500 (ms)	500 - 512 (ms)
t_1[4]	± 12.5 / ± 6.25	5.0	10.0	20.0
t_2	± 6.25 / ± 3.125	20.0	25.0	50.0
t_3[4]	± 12.5 / ± 6.25	5.0	10.0	10.0

ANNEX B - TEST DIAGRAMS

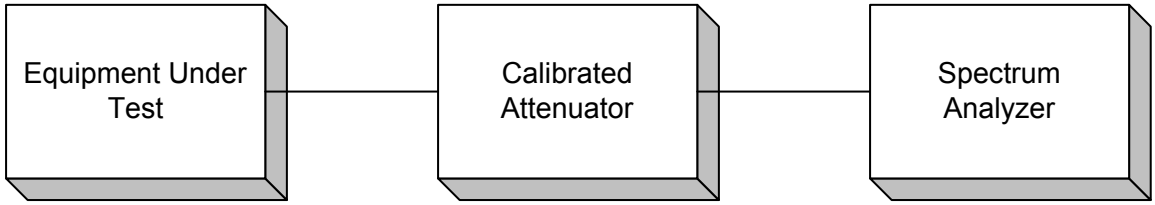
R.F. Power Output



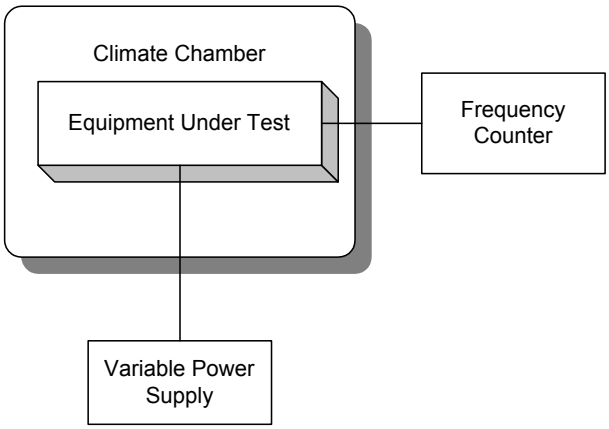
Occupied Bandwidth



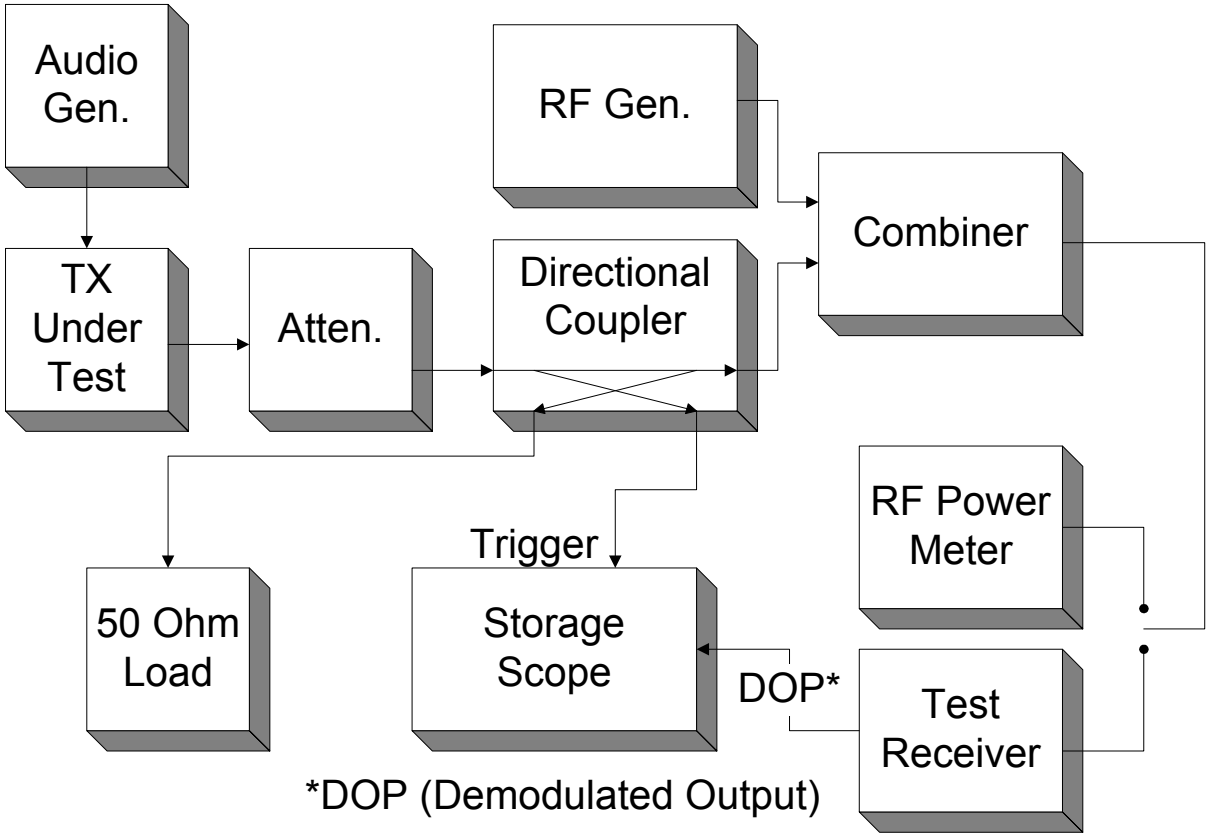
Spurious Emissions at Antenna Terminals



Frequency Stability



Transient Frequency Behavior



Voice

This measurement was made using measurement procedure TIA/EIA Land Mobile FM or PM Communications Equipment Measurement and Performance Standards TIA/EIA-603 February 1993 Telecommunications Industry Association (American National Standard ANSI/TIA/EIA-603-1992 Approved: October 27, 1992) Para. no. 2.2 Methods of Measurement for Transmitters
Para. no. 2.2.19 Transient Frequency Behavior (page no. 83).

Data

This measurement was made using measurement procedure TIA/EIA Digital C4FM/CQPSK Transceiver Measurement Methods TSB102.CAAA Para. no. 2.2.17 Transient Frequency Behavior