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TEST REPORT

Part 90

Equipment under test Pager Transmitter

Model name PS-3500N

FCC ID Q6OPS-3500N

Applicant WELINK

Manufacturer Lee Technology Korea Co., Ltd.

Date of test(s) 2012.10.04 ~ 2012.10.11

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Revision history

Revision	Date of issue	Test report No.	Description
-	2012.10.11	KES-RF-120070	Initial



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1.0 General product description

Equipment under test	Pager Transmitter
Model name	PS-3500N
Serial number	N/A
Frequency Range	450.025 0 MHz ~ 469.975 0 MHz
Type of emission	10K2F1D
Channel separation	12.5 kHz
Maximum output power	1.901 W
Power Source	AC Adaptor 120 V(Output : DC 12V)
Antenna type	Connector type(BNC) // Dipole antenna
Antenna gain	-2.61 dBi

1.1 Test frequency

	Low channel	Middle channel	High channel
Frequency (MHz)	450.025 0	457.575 0	469.975 0

1.2 Information about variant model

N/A

1.3 Device modifications

N/A

1.4 DC input into the final stage

Frequency (MHz)	Voltage(V)	Current(A)	Power(W)
450.012 5	12	0.593	7.116
457.575 0	12	0.626	7.512
469.975 0	12	0.712	8.544



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1.4 Test facility

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477-6, Hageo-ri, Yeoju-eup, Yeoju-gun, Gyeonggi-do, 469-803, Korea

The open area test site is constructed in conformance with the requirements ANSI C63.4-2003/2009.

1.5 Laboratory accreditations and listings

Country	Agency	Scope of accreditation	Certificate No.
USA	FCC	3 & 10 meter Open Area Test Sites and one conducted site to perform FCC Part 15/18 measurements.	343818
KOREA	KC	EMI (10 meter Open Area Test Site and two conducted sites) Radio (3 & 10 meter Open Area Test Sites and one conducted site)	KR0100
CANADA	IC	3 & 10 meter Open Area Test Sites and one conducted site	4769B-1



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2.0 Summary of tests

Section	Parameter	Status
90.205	RF output power	C
90.209	Bandwidth limitation	C
90.210(d)	Emission mask	C
90.210(d)	Conducted spurious emissions	C
90.213	Frequency stability	C
90.214	Transient frequency behavior	C
90.210(d)	Radiated spurious emissions	C

Note 1: C=Complies NC=Not complies NT=Not tested NA=Not applicable

2.1 Test data

2.1.1 RF output power

Test setup



Test procedure

1. The transmitter output was connected to the spectrum analyzer through an attenuator
2. Use the following spectrum analyzer setting

Span = 2 MHz

RBW = 100 kHz

VBW = 100 kHz (\geq RBW)

Sweep = auto

Detector function = peak

Trace = max hold

Limit

According to FCC 90.205(h) 450 ~ 470 MHz. (1) The maximum allowable station effective radiated power (ERP) is dependent upon the station's antenna HAAT and required service area and will be authorized in accordance with table 2. Applicants requesting an ERP in excess of that listed in table 2 must submit an engineering analysis based upon generally accepted engineering practices and standards that includes coverage contours to demonstrate that the requested station parameters will not produce coverage in excess of that which the applicant requires.

Table 2. 450 ~ 470 MHz—Maximum ERP/Reference HAAT for a Specific Service Area Radius

	Service area radius (km)									
	3	8	13	16	24	32	40 ⁴	48 ⁴	64 ⁴	80 ⁴
Maximum ERP (W) ¹	2	100	2500	2500	2500	2500	2500	2500	2500	2500
Up to reference HAAT (m) ³	15	15	15	27	63	125	250	410	950	2700

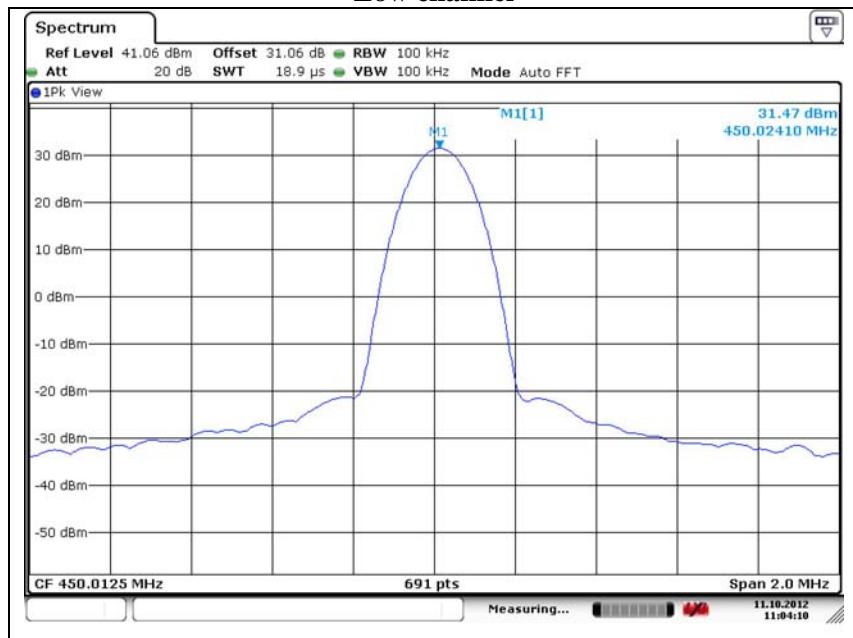
¹Maximum ERP indicated provides for a 39 dBu signal strength at the edge of the service area per FCC Report R-6602, Fig. 29 (See §73.699, Fig. 10 b).

²Maximum ERP of 500 watts allowed. Signal strength at the service area contour may be less than 39 dBu.

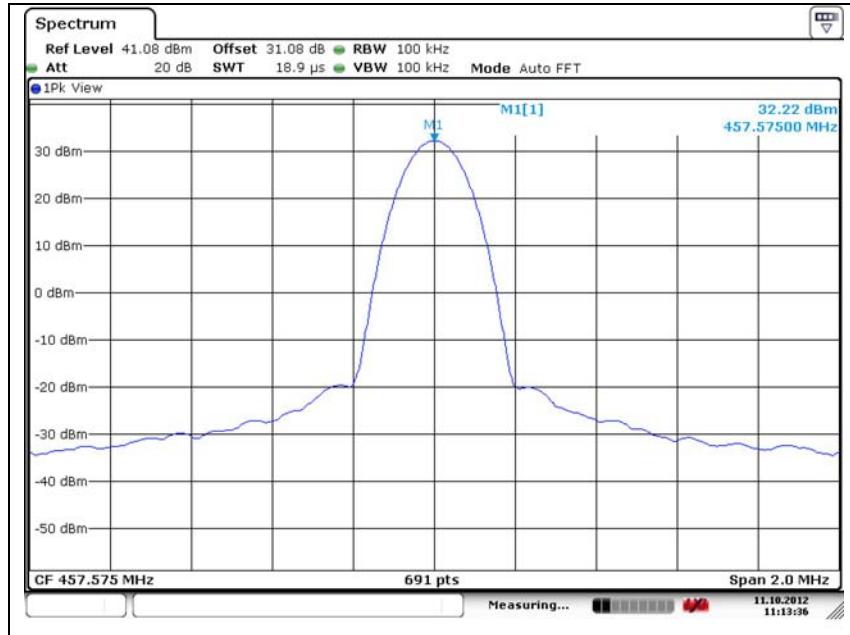
- ³When the actual antenna HAAT is greater than the reference HAAT, the allowable ERP will be reduced in accordance with the following equation: $ERP_{allow} = ERP_{max} \times (HAAT_{ref}/HAAT_{actual})^2$.
- ⁴Applications for this service area radius may be granted upon specific request with justification and must include a technical demonstration that the signal strength at the edge of the service area does not exceed 39 dBu.

Test results

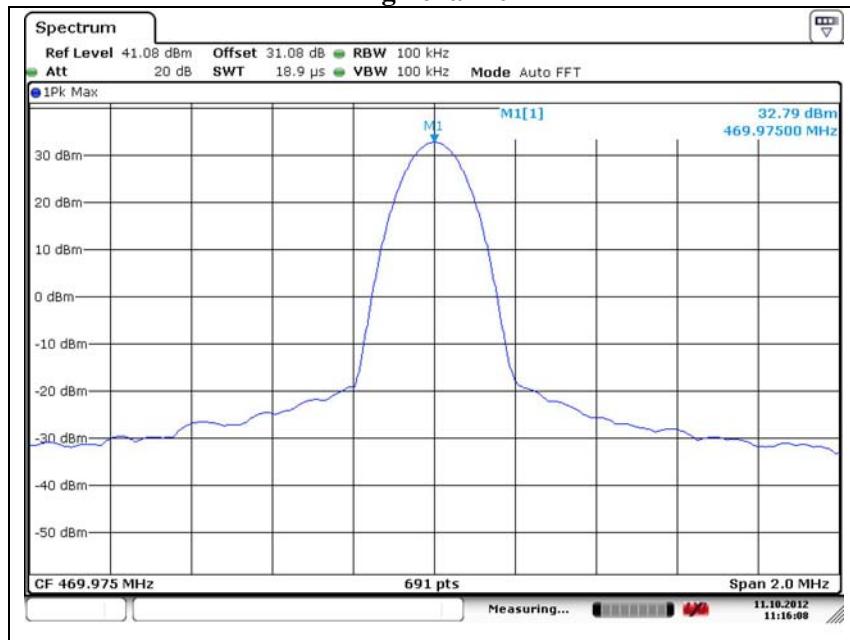
Frequency (MHz)	Output power(dBm)	Output power(W)	Limit(W)
450.0125	31.47	1.402	2
457.5750	32.22	1.667	
469.9750	32.79	1.901	

Low channel


Middle channel



High channel



2.1.2 Bandwidth limitation

Test setup



Test procedure

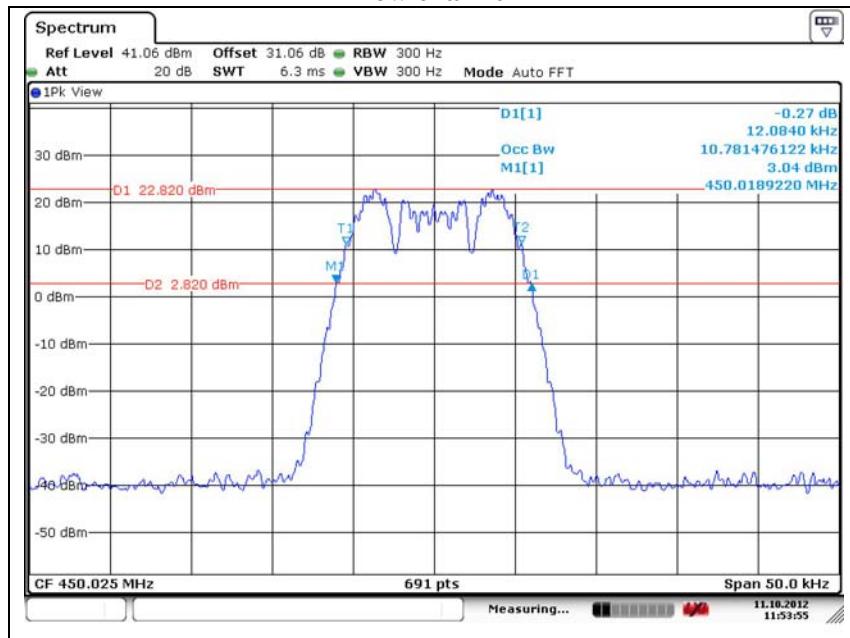
1. The transmitter output was connected to the spectrum analyzer through an attenuator
2. Use the following spectrum analyzer setting
 - Span = 50 kHz
 - RBW = 300 Hz
 - VBW = 300 Hz (\geq RBW)
 - Sweep = auto
 - Detector function = peak
 - Trace = max hold
3. Mark the peak frequency and -20 dB(Upper and lower) frequency.

Limit

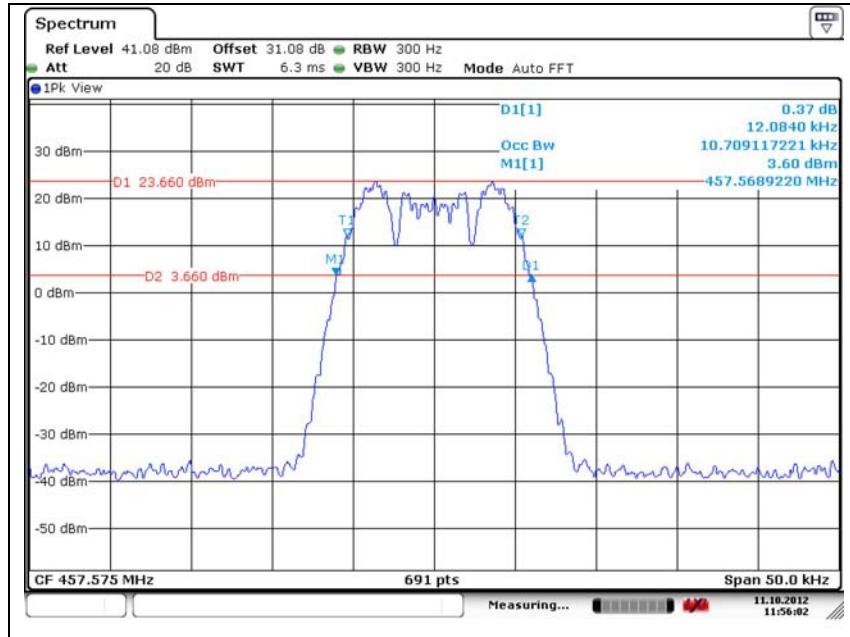
N/A

Test results

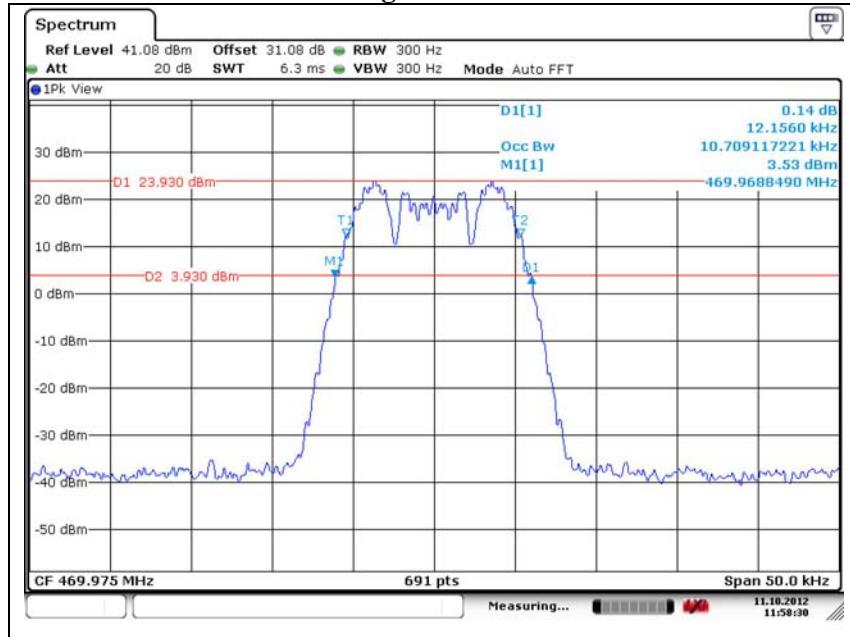
Low channel



Middle channel



High channel



2.1.3 Emission mask

Test setup



Test procedure

1. The transmitter output was connected to the spectrum analyzer through an attenuator
2. Use the following spectrum analyzer setting
 - Span = 120 kHz
 - RBW = 100 Hz
 - VBW = 100 Hz (\geq RBW)
 - Sweep = auto
 - Detector function = peak
 - Trace = max hold
3. Mark the peak frequency with maximum peak power as the center of the display of the spectrum analyzer.
4. Record the power spectrum analyzer and compare to the mask.

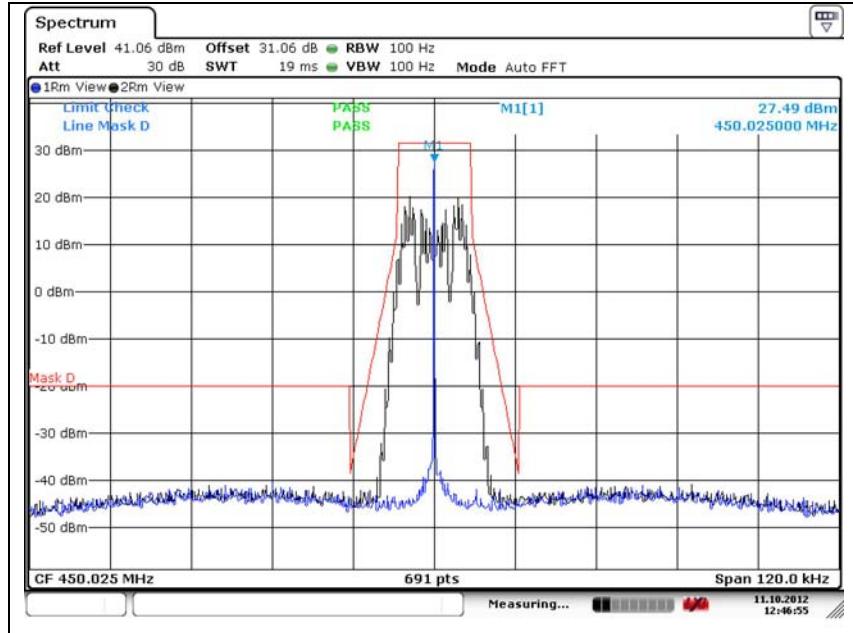
Limit

According to FCC part 90.210(d) Emission Mask D – 12.5 kHz channel bandwidth equipment. For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power(P) of the highest emission contained within the authorized bandwidth as follows:

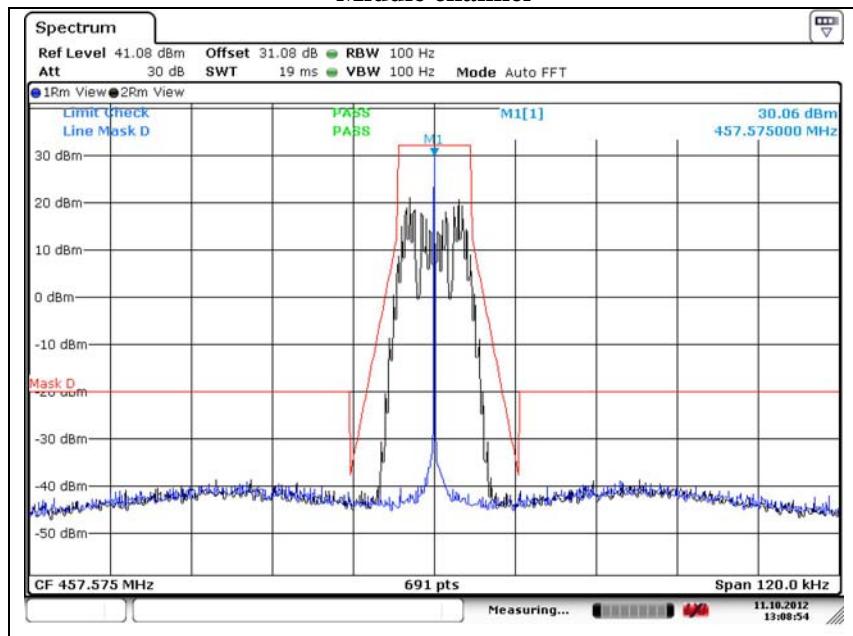
- (1) On any frequency from the center of the authorized bandwidth f_0 to 5.625 kHz removed from f_0 : Zero dB.
- (2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.625 kHz, but no more than 12.5 kHz: At least $7.27(f_d - 2.88)$ dB.
- (3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: At least $50 + 10\log(P)$ dB or 70 dB, whichever is the lesser attenuation.

Test results

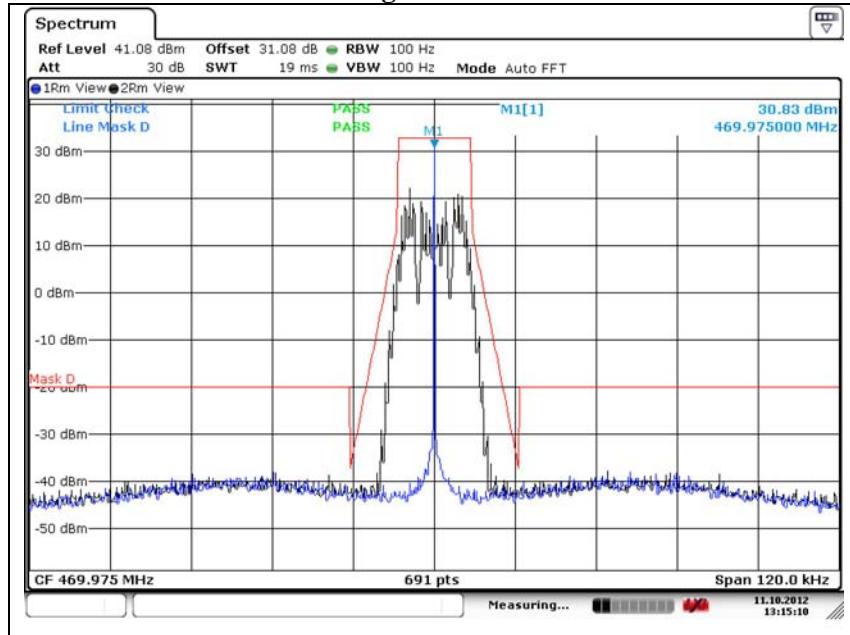
Low channel



Middle channel



High channel



2.1.4 Conducted spurious emissions

Test setup



Test procedure

1. The transmitter output was connected to the spectrum analyzer through an attenuator
2. Use the following spectrum analyzer setting

Span = 30 MHz to 5 GHz

RBW = 100 kHz

VBW = 100 kHz (\geq RBW)

Sweep = auto

Detector function = peak

Trace = max hold

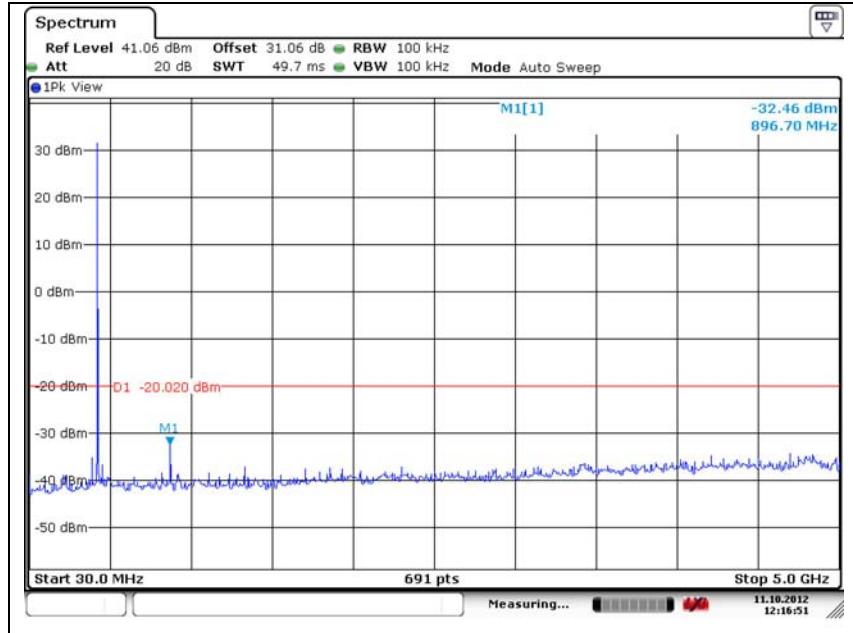
Limit

According to FCC part 90.210(d) Emission Mask D – 12.5 kHz channel bandwidth equipment. For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power(P) of the highest emission contained within the authorized bandwidth as follows:

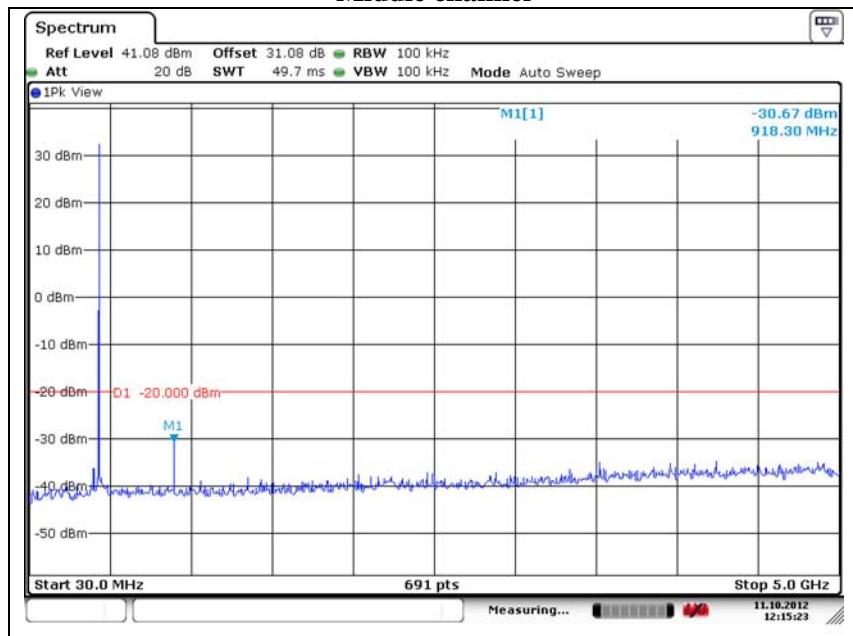
(3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: At least $50 + 10\log(P)$ dB or 70 dB, whichever is the lesser attenuation.

Test results

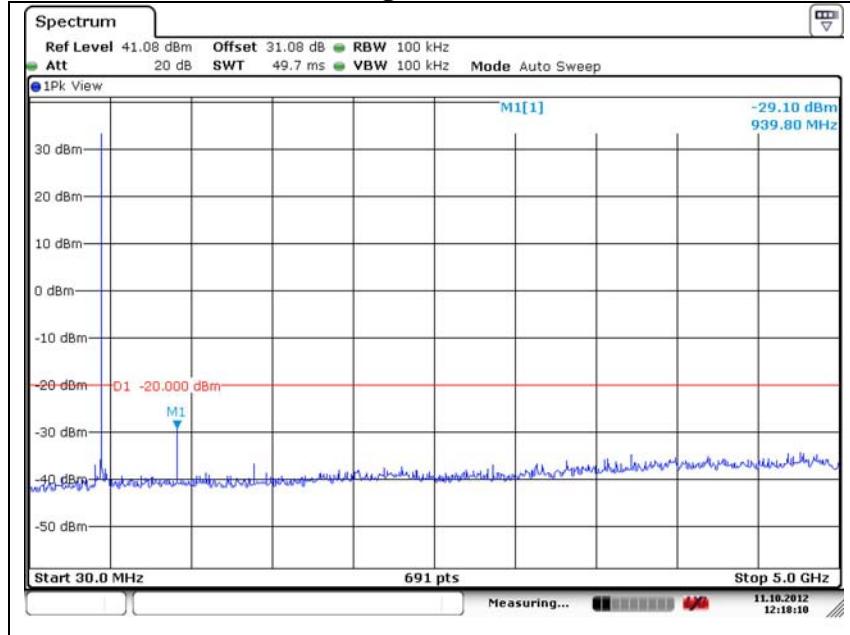
Low channel



Middle channel

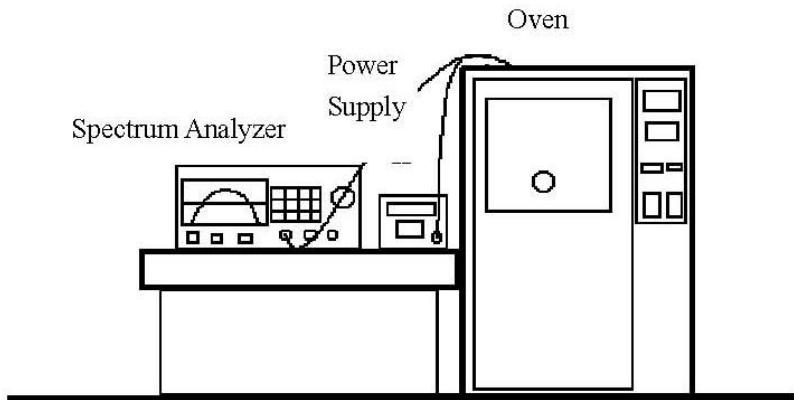


High channel



2.1.5 Frequency stability

Test setup



Test procedure

1. The transmitter output was connected to the spectrum analyzer through an attenuator.
2. The transmission time was measured with the spectrum analyzer using $RBW=1$ kHz, $VBW=1$ kHz.
3. Set the temperature of chamber to -30°C . Allow sufficient time (approximately 30 min) for the temperature of the chamber to stabilize. While maintaining a constant temperature inside the chamber, turn the EUT on and measure the EUT operating frequency.
4. Repeat step 2 with a 10°C decreased per stage until the highest temperature 50°C is measured, record all measured frequencies on each temperature step.

Limit

1. According to FCC part 2 section 2.1055(a)(1), the frequency stability shall be measured with variation of ambient temperature from -30 °C to +50 °C centigrade.
2. According to FCC part section 2.1055(d)(2), for battery powered equipment the frequency stability shall be measured with reducing primary supply voltage to the battery operating end point, which is specified by the manufacture.
3. According to FCC part 90 section 90.213, (a) Unless noted elsewhere, transmitters used in the services governed by this part must have a minimum frequency stability as specified in the following table.

Minimum Frequency Stability [Parts per million (ppm)]

Frequency range (MHz)	Fixed and base stations	Mobile stations	
		Over 2 watts output power	2 watts or less output power
Below 25	1,2,3,100	100	200
25–50	20	20	50
72–76	5		50
150–174	5, ¹¹ 5	⁶ 5	^{4,6} 50
216–220	1.0		1.0
220–222 ¹²	0.1	1.5	1.5
421–512	7, ^{11,14} 2.5	⁸ 5	⁸ 5
806–809	¹⁴ 1.0	1.5	1.5
809–824	¹⁴ 1.5	2.5	2.5
851–854	1.0	1.5	1.5
854–869	1.5	2.5	2.5
896–901	¹⁴ 0.1	1.5	1.5
902–928	2.5	2.5	2.5
902–928 ¹³	2.5	2.5	2.5
929–930	1.5		
935–940	0.1	1.5	1.5
1427–1435	⁹ 300	300	300
Above 2450 ¹⁰			

¹Fixed and base stations with over 200 watts transmitter power must have a frequency stability of 50 ppm except for equipment used in the Public Safety Pool where the frequency stability is 100 ppm.

²For single sideband operations below 25 MHz, the carrier frequency must be maintained within 50 Hz of the authorized carrier frequency.

³Travelers information station transmitters operating from 530 ~ 1 700 kHz and transmitters exceeding 200 watts peak envelope power used for disaster communications and long distance circuit operations pursuant to §90.242 and §90.264 must maintain the carrier frequency to within 20 Hz of the authorized frequency.

⁴Stations operating in the 154.45 to 154.49 MHz or the 173.2 to 173.4 MHz bands must have a frequency stability of 5 ppm.

⁵In the 150 ~ 174 MHz band, fixed and base stations with a 12.5 kHz channel bandwidth must have a frequency stability of 2.5 ppm. Fixed and base stations with a 6.25 kHz channel bandwidth must have a frequency stability of 1.0 ppm.

⁶In the 150 ~ 174 MHz band, mobile stations designed to operate with a 12.5 kHz channel bandwidth or designed to operate on a frequency specifically designated for itinerant use or designed for low-power operation of two watts or less, must have a frequency stability of 5.0 ppm. Mobile stations designed to operate with a 6.25 kHz channel bandwidth must have a frequency stability of 2.0 ppm.

⁷In the 421 ~ 512 MHz band, fixed and base stations with a 12.5 kHz channel bandwidth must have a frequency stability of 1.5 ppm. Fixed and base stations with a 6.25 kHz channel bandwidth must have a frequency stability of 0.5 ppm.

⁸In the 421 ~ 512 MHz band, mobile stations designed to operate with a 12.5 kHz channel bandwidth must have a frequency stability of 2.5 ppm. Mobile stations designed to operate with a 6.25 kHz channel bandwidth must have a frequency stability of 1.0 ppm.

⁹Fixed stations with output powers above 120 watts and necessary bandwidth less than 3 kHz must operate with a frequency stability of 100 ppm. Fixed stations with output powers less than 120 watts and using time-division multiplex, must operate with a frequency stability of 500 ppm.

¹⁰Except for DSRCS equipment in the 5 850 ~ 5 925 MHz band, frequency stability is to be specified in the station authorization. Frequency stability for DSRCS equipment in the 5 850 ~ 5 925 MHz band is specified in subpart M of this part.

¹¹Paging transmitters operating on paging-only frequencies must operate with frequency stability of 5 ppm in the 150 ~ 174 MHz band and 2.5 ppm in the 421 ~ 512 MHz band.

¹²Mobile units may utilize synchronizing signals from associated base stations to achieve the specified carrier stability.

¹³Fixed non-multilateration transmitters with an authorized bandwidth that is more than 40 kHz from the band edge, intermittently operated hand-held readers, and mobile transponders are not subject to frequency tolerance restrictions.

¹⁴Control stations may operate with the frequency tolerance specified for associated mobile frequencies.

(b) For the purpose of determining the frequency stability limits, the power of a transmitter is considered to be the maximum rated output power as specified by the manufacturer.



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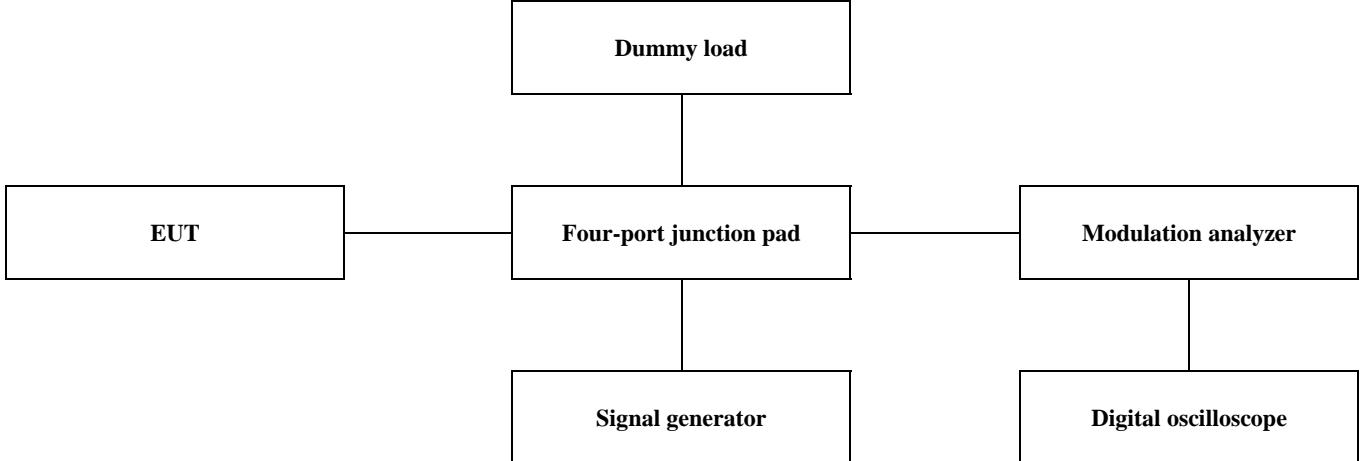
Test results

Assigned frequency (MHz): 469.975

Test voltage (%)	Test voltage (V)	Temperature (°C)	Measure frequency (MHz)	Frequency deviation (Hz)	Frequency deviation (ppm)	Limit (ppm)
100 %	120	-30	469.974 840	-160	-0.34	2.5
		-20	469.974 869	-131	-0.28	
100 %		-10	469.974 862	-138	-0.29	
100 %		0	469.974 913	-87	-0.19	
100 %		10	469.974 949	-51	-0.11	
100 %		20	469.974 927	-73	-0.16	
100 %		30	469.974 927	-73	-0.16	
100 %		40	469.974 942	-58	-0.12	
100 %		50	469.974 942	-58	-0.12	
115 %	138	20	469.974 927	-73	-0.16	
85 %	102	20	469.974 927	-73	-0.16	

2.1.6 Transient frequency behavior of the transmitter

Test setup



Test procedure

1. Set the signal generator to the assigned transmitter frequency and modulate it with a 1 kHz tone at ± 12.5 kHz deviation and set its output level to -15 dBm.
2. Key the transmitter.
3. Supply sufficient attenuation via the RF attenuator to provide an input level to the test receiver that is 40 dB below the test receiver maximum allowed input power when the transmitter is operating at its rated power level.
4. Unkey the transmitter.
5. Adjust the RF level of the signal generator to provide RF power into the RF power meter equal to the level this signal generator RF level shall be maintained throughout the rest of the measurement.
6. Connect the output of the RF combiner network to the input of the Modulation analyzer.
7. Set the horizontal sweep rate on the storage oscilloscope to 10 milliseconds per division and adjust the display to continuously view the 1 000 Hz tone. Adjust the vertical amplitude control of the oscilloscope to display the 1 000 Hz at ± 4 divisions vertically centered on the display.
8. Key the transmitter and observe the stored display. once the modulation Analyzer demodulator has been captured by the transmitter power, the display will show the frequency difference from the assigned frequency to the actual transmitter frequency versus time. The instant when the 1 kHz test signal is completely suppressed (including any capture time due to phasing) is considered to be t_{on} . The trace should be maintained within the allowed divisions during the period t_1 and t_2 . See the figure in the appropriate standards section.
9. During the time from the end of t_2 to the beginning of t_3 the frequency difference should not exceed the limits set by the FCC in 47 CFR 90.214 and outlined in 3.2.2. The allowed limit is equal to the transmitter frequency times its FCC frequency tolerance times ± 4 display divisions divided by 12.5 kHz.
10. Key the transmitter and observe the stored display. The trace should be maintained within the allowed divisions after the end of t_2 and remain within it until the end of the trace. See the figure in the appropriate standards sections.
11. To test the transient frequency behavior during the period t_3 the transmitter shall be keyed.

12. Adjust the oscilloscope trigger controls so it will trigger on a decreasing magnitude from the Modulation analyzer, at 1 division from the right side of the display, when the transmitter is turned off. Set the controls to store the display. The moment when the 1 kHz test signal starts to rise is considered to provide to t_{off} .
13. The transmitter shall be unkeyed.
14. Observe the display. The trace should remain within the allowed divisions during period t_3 . See the figures in the appropriate standards section.

Limit

According to FCC 90.214, Transmitters designed to operate in the 150 ~ 174 MHz and 421 ~ 512 MHz frequency bands must maintain transient frequencies within the maximum frequency difference limits during the time intervals indicated:

Time intervals ^{1,2}	Maximum frequency difference ³	All equipment	
		150 to 174 MHz	421 to 512 MHz
Transient frequency behaviour for equipment designed to operate on 25 kHz channel			
t_1^4 -----	±25.0 kHz	5.0 ms	10.0 ms
t_2 -----	±12.5 kHz	20.0 ms	25.0 ms
t_3^4 -----	±25.0 kHz	5.0 ms	10.0 ms
Transient Frequency Behaviour for Equipment Designed to Operate on 12.5 kHz Channel			
t_1^4 -----	±12.5 kHz	5.0 ms	10.0 ms
t_2 -----	±6.25 kHz	20.0 ms	25.0 ms
t_3^4 -----	±12.5 kHz	5.0 ms	10.0 ms
Transient Frequency Behaviour for Equipment Designed to Operate on 6.25 kHz Channel			
t_1^4 -----	±6.25 kHz	5.0 ms	10.0 ms
t_2 -----	±3.125 kHz	20.0 ms	25.0 ms
t_3^4 -----	±6.25 kHz	5.0 ms	10.0 ms

¹ t_{on} is the instant when a 1 kHz test signal is completely suppressed, including any capture time due to phasing.

² t_1 is the time period immediately following t_{on} .

³ t_2 is the time period immediately following t_1 .

⁴ t_3 is the time period from the instant when the transmitter is turned off until t_{off} .

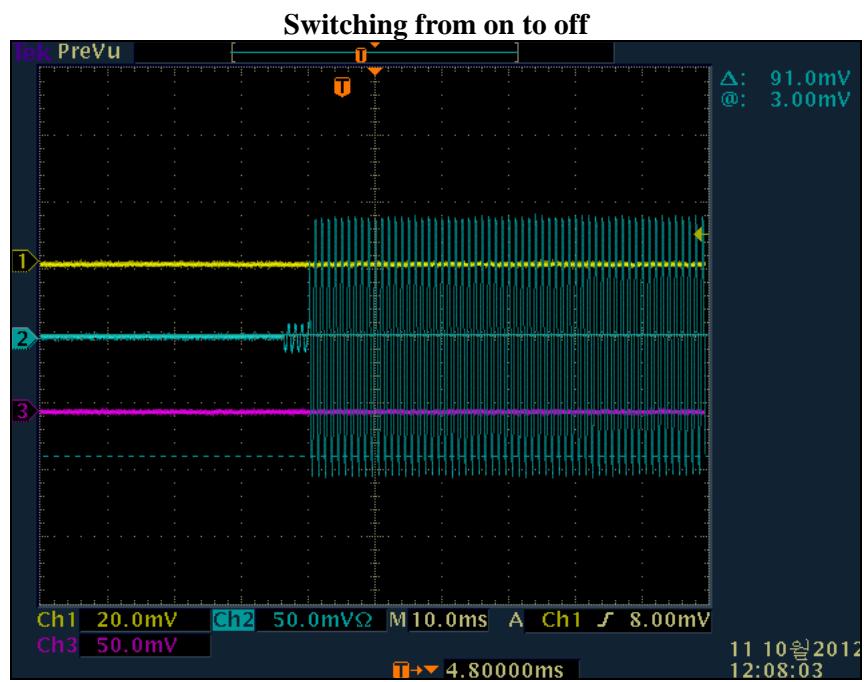
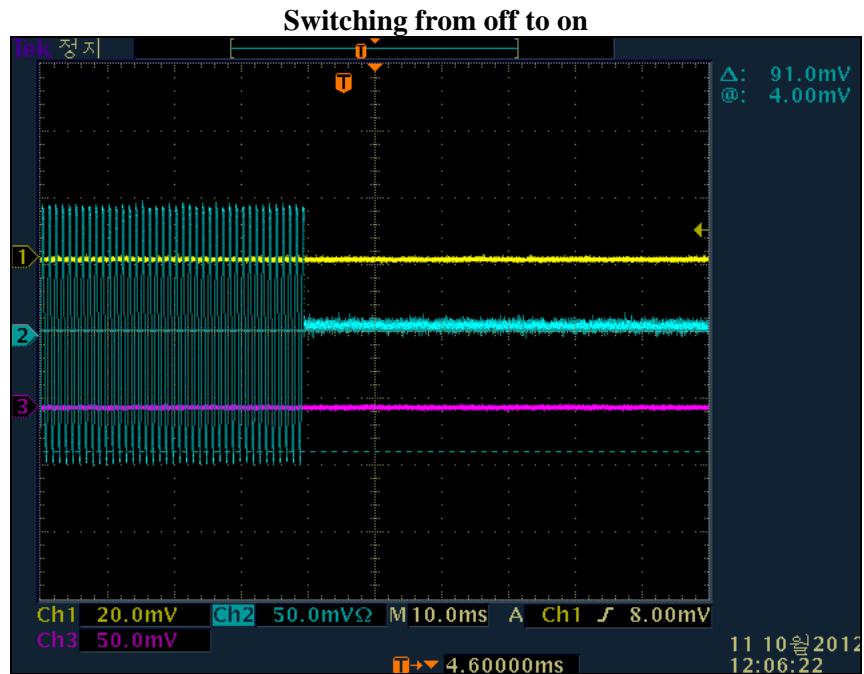
⁵ t_{off} is the instant when the 1 kHz test signal starts to rise.

² During the time from the end of t_2 to the beginning of t_3 , the frequency difference must not exceed the limits specified in §90.213.

³ Difference between the actual transmitter frequency and the assigned transmitter frequency.

⁴ If the transmitter carrier output power rating is 6 watts or less, the frequency difference during this time may exceed the maximum frequency difference for this period.

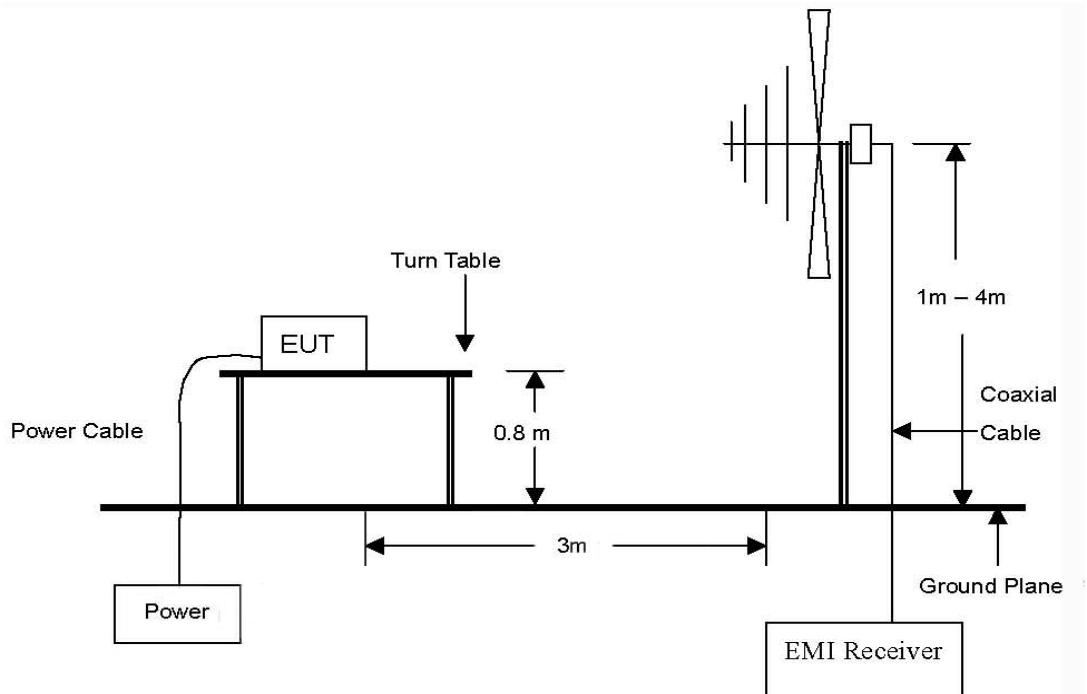
Test results



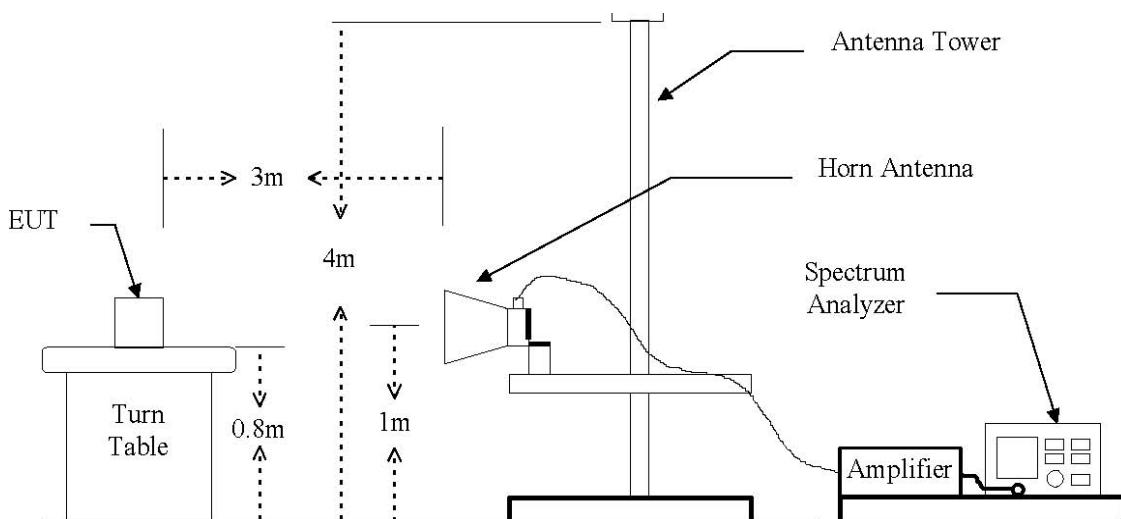
2.1.7 Radiation spurious emissions

Test setup

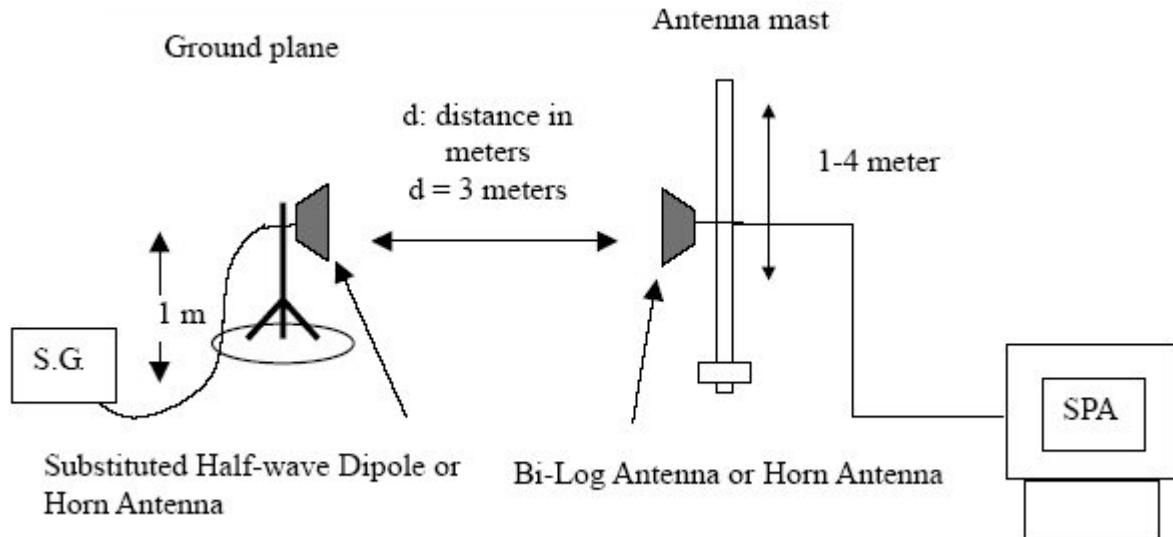
The diagram below shows the test setup that is utilized to make the measurements for emission from 30 MHz to 1 GHz Emissions.



The diagram below shows the test setup that is utilized to make the measurements for emission from 1 GHz to 5 GHz Emissions.



The diagram below shows the test setup for substituted method



Test procedure: Based on ANSI/TIA 603C: 2004

1. On a test site, the EUT shall be placed at 80 cm height on a turn table, and in the position closest to normal use as declared by the applicant.
2. The test antenna shall be oriented initially for vertical polarization located 3m from EUT to correspond to the fundamental frequency of the transmitter.
3. The output of the test antenna shall be connected to the measuring receiver and the peak detector is used for the measurement.
4. During the measurement of the EUT, the bandwidth of the fundamental frequency was measured with the spectrum analyzer using
 - 1) RBW : 100 kHz(< 1 GHz), 1 MHz(> 1 GHz).
 - 2) VBW : 100 kHz(< 1 GHz), 1 MHz(> 1 GHz).
5. The transmitter shall be switched on, the measuring receiver shall be tuned to the frequency of the transmitter under test.
6. The test antenna shall be raised and lowered through the specified range of height until a maximum signal level is detected by the measuring receiver.
7. The transmitter shall then be rotated through 360° in the horizontal plane, until the maximum signal level is detected by the measuring receiver.
8. The test antenna shall be raised and lowered again through the specified range of height until a maximum signal level is detected by the measuring receiver.
9. The maximum signal level detected by the measuring receiver shall be noted.
10. The EUT was replaced by half-wave dipole(below 1 000 MHz) or horn antenna(above 1 000 MHz) connected to a signal generator.
11. In necessary, the input attenuator setting of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver.
12. The test antenna shall be raised and lowered through the specified range of height to ensure that the maximum signal is received.
13. The input signal to the substitution antenna shall be adjusted to the level that produces a level detected by the measuring receiver, which is equal to the level noted while the transmitter radiated power was measured, corrected for the change of input attenuator setting of the measuring receiver.
14. The input level to the substitution antenna shall be recorded as power level in dBm, corrected for any change of input attenuator setting of the measuring receiver.
15. The measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarization.

Limit

According to §90.210(d), Spurious attenuated in dB = $50 + 10\log(\text{Power output in watts})$

Test results
Low channel

Frequency (MHz)	Ant. Pol. (H/V)	S.G. Level (dBm)	Correction factor (dB)	Absolute level (dBm)	Spurious attenuation (dBc)	Limit (dBc)	Margin (dB)
900.050 0	H	-33.00	1.70	-31.30	56.76	45.46	11.30
900.050 0	V	-36.00	2.07	-33.93	59.39	45.46	13.93
1 350.075 0	H	-39.00	5.80	-33.20	58.66	45.46	13.20
1 350.075 0	V	-41.00	6.00	-35.00	60.46	45.46	15.00
1 800.100 0	H	-51.00	6.44	-44.56	70.02	45.46	24.56
1 800.100 0	V	-51.00	6.06	-44.94	70.40	45.46	24.94
2 250.125 0	H	-51.00	6.50	-44.50	69.96	45.46	24.50
2 250.125 0	V	-47.00	7.27	-39.73	65.19	45.46	19.73

Middle channel

Frequency (MHz)	Ant. Pol. (H/V)	S.G. Level (dBm)	Correction factor (dB)	Absolute level (dBm)	Spurious attenuation (dBc)	Limit (dBc)	Margin (dB)
915.150 0	H	-39.00	1.11	-37.89	62.92	45.03	17.89
915.150 0	V	-35.00	1.64	-33.36	58.39	45.03	13.36
1 372.725 0	H	-37.00	5.91	-31.09	56.12	45.03	11.09
1 372.725 0	V	-32.00	6.07	-25.93	50.96	45.03	5.93
1 830.300 0	H	-47.00	6.21	-40.79	65.82	45.03	20.79
1 830.300 0	V	-39.00	6.31	-32.69	57.72	45.03	12.69
2 287.875 0	H	-44.00	8.52	-35.48	60.51	45.03	15.48
2 287.875 0	V	-34.00	7.19	-26.81	51.84	45.03	6.81



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Test results

High channel

Frequency (MHz)	Ant. Pol. (H/V)	S.G. Level (dBm)	Correction factor (dB)	Absolute level (dBm)	Spurious attenuation (dBc)	Limit (dBc)	Margin (dB)
939.950 0	H	-30.80	1.33	-29.47	55.18	45.71	9.47
939.950 0	V	-34.00	0.84	-33.16	58.87	45.71	13.16
1 409.925 0	H	-41.00	5.98	-35.02	60.73	45.71	15.02
1 409.925 0	V	-42.00	6.57	-35.43	61.14	45.71	15.43
1 879.900 0	H	-45.00	6.17	-38.83	64.54	45.71	18.83
1 879.900 0	V	-45.00	5.45	-39.55	65.26	45.71	19.55
2 349.875 0	H	-56.00	6.96	-49.04	74.75	45.71	29.04
2 349.875 0	V	-47.00	6.92	-40.08	65.79	45.71	20.08

※ Remark;

1. Correction factor: Substitution antenna gain - Tx cable loss
2. E.R.P. or E.I.R.P = S.G. Level + correction factor



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Appendix A. Test equipment used for test

Equipment	Manufacturer	Model	Calibration due.
Spectrum Analyzer	R&S	FSV30	2013.01.10
Vector Signal Generator	R&S	SMBV2100A	2013.01.10
Trilog-Broadband Antenna	Schwarzbeck	VULB 9168	2013.04.28
Horn Antenna	A.H.	SAS-571	2013.03.22
Horn Antenna	A.H.	SAS-571	2013.03.22
Dipole Antenna	R&S	VHAP	2013.04.29
Dipole Antenna	R&S	VHAP	2013.04.29
Dipole Antenna	R&S	UHAP	2013.04.29
Dipole Antenna	R&S	UHAP	2013.04.29
High pass filter	Mini-circuits	NHP-800+	2013.08.02
Oscilloscope	Tektronix	TDS3014B	2012.12.20
Four - Port Junction Pad	ANRITSU	6502	2013.03.30
AC POWER SOURCE ANALYZER	HP	6813A	2013.07.06
DC Power Supply	HP	6674A	2012.12.05

Peripheral devices

Device	Manufacturer	Model No.	Serial No.
N/A			

Appendix B. Test setup photo**Radiated field emissions**

N/A