TEST REPORT

Part 90

Equipment under test	Coaster Transmitter
Model name	LTK-2008TE
FCC ID	QBTLTK-2008TE
Applicant	Lee Technology Korea Co., Ltd.
Manufacturer	Lee Technology Korea Co., Ltd.
Date of test(s)	2011.12.14 ~ 2011.12.20
Date of issue	2011.12.20

Issued to

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Issued by

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Test and report completed by :	Report approval by :
Jeff Do Test engineer	Gyu-cheol Shin Technical manager

Revision history

Revision	Date of issue	Test report No.	Description
-	2011.12.20	KES-RF-110060	Initial

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1.0 General product description

Equipment model name	:	Coaster Transmitter
Serial number	:	Prototype
EUT condition	:	Pre-production, not damaged
Antenna type & gain	:	Helical antenna
Frequency Range	:	457.575 ㎒
Type of emission	:	20K0F2D
Channel separation	:	25 ㎑
Maximum output power	:	0.011 19 W
Power Source	:	DC 3.0 V

1.1 Test frequency

	Low channel	Middle channel	High channel
Frequency (㎒)	457.575	-	-

1.2 Model differences

N/A

1.3 Device modifications

N/A

1.4 Test facility

C3701 Dongil Techno Town, 889-1, Gwanyang 2-dong, Dongan-gu, Anyang-si, Gyeonggi-do, 431-716, Korea
477-6, Hageo-ri, Yeoju-eup, Yeoju-gun, Gyeonggi-do, 469-803, Korea

The sites are constructed in conformance with the requirements of ANSI C63.7, ANSI C63.4 and CISPR Publication 22.

1.5 Laboratory accreditations and listings

Country	Agency	Scope of accreditation	Logo
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

2.0 Summary of tests

Section in FCC Part 90 & 1	Parameter	Status
90.205	RF output power	C
90.209	Bandwidth limitation	C
90.210	Emission mask	C
2.1057	Transmitter spurious conducted emission	C
90.213	Frequency stability	C
90.214	Transient frequency behavior	C
90.210	Field strength of spurious radiation	C
1.1307(b)	RF exposure	C
Note 1: C=Complies NC=Not complies NT=Not tested NA=Not applicable		
Note 2: The data in this test report are traceable to the national or international standards.		
Note 3: The sample was tested according to the following specification: FCC Part 90, ANSI C63.4-2003		

2.1 Technical characteristic test

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 = 500 ㎑
   RBW = 30 ㎑
   VBW = 100 ㎑ (≥ RBW)
   Sweep = auto
   Detector function = peak
   Trace = max hold

Limit

According to FCC 90.205(h) 450 ~ 470 ㎒. (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 ㎒—Maximum ERP/Reference HAAT for a Specific Service Area Radius

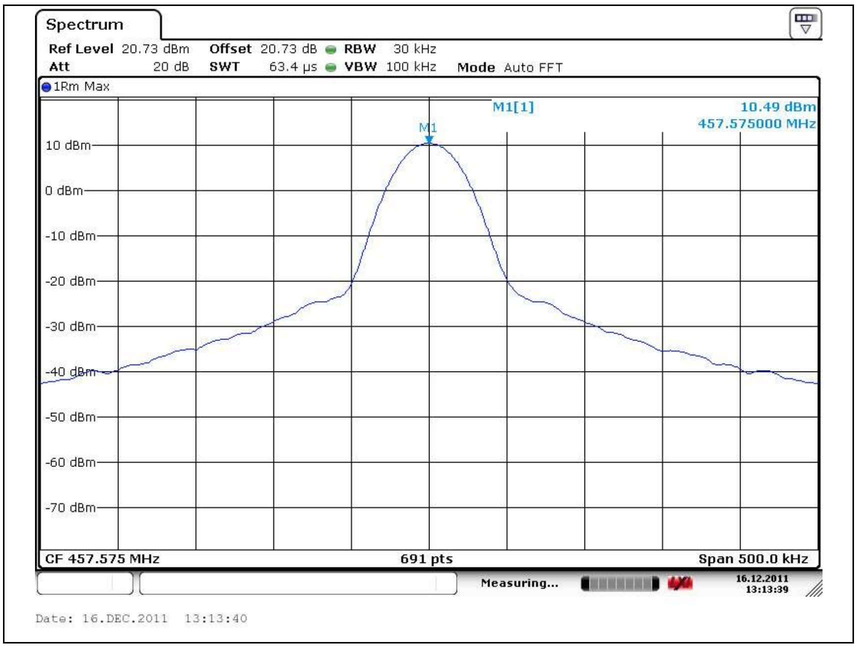
	Service area radius (km)									
	3	8	13	16	24	32	40[4]	48[4]	64[4]	80[4]
Maximum ERP (W)[1]	2	100	[2]500	[2]500	[2]500	[2]500	[2]500	[2]500	[2]500	[2]500
Up to reference HAAT (m)[3]	15	15	15	27	63	125	250	410	950	2 700

[1]Maximum ERP indicated provides for a 39 ㏈u signal strength at the edge of the service area per FCC Report R-6602, Fig. 29 (See §73.699, Fig. 10 b).
[2]Maximum ERP of 500 watts allowed. Signal strength at the service area contour may be less than 39 ㏈u.

- [3]When the actual antenna HAAT is greater than the reference HAAT, the allowable ERP will be reduced in accordance with the following equation: $ERP_{allow}=ERP_{max}\times(HAAT_{ref}/HAAT_{actual})^2$.
- [4]Applications 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 ㏈u.

Test results

Frequency (㎒)	Output power(㏈m)	Output power(W)	Limit(W)
457.575	10.49	0.011 19	2



2.1.2 Bandwidth limitation

Test setup

EUT	Attenuator	Spectrum analyzer

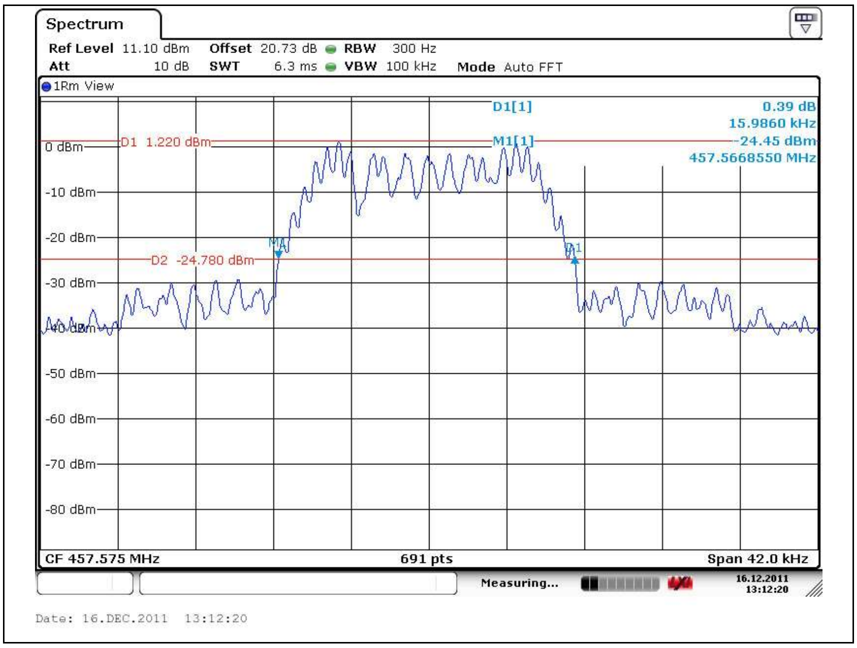
Test procedure

1. The transmitter output was connected to the spectrum analyzer through an attenuator
2. Use the following spectrum analyzer setting
   Span = 50 ㎑
   RBW = 300 ㎐
   VBW = 1 ㎑ (≥ RBW)
   Sweep = auto
   Detector function = peak
   Trace = max hold
3. Mark the peak frequency and -26 ㏈(Upper and lower) frequency.

Limit

N/A

Test results



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 = 50 ㎑
   RBW = 300 ㎐
   VBW = 1 ㎑ (≥ 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.

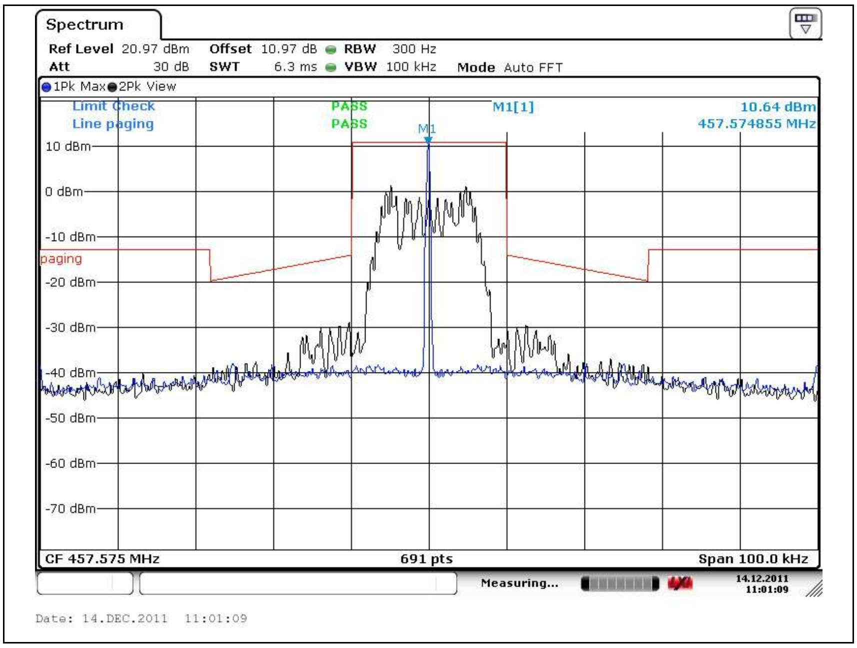
Limit

According to FCC part 90.210(g) Emission Mask G. For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier power (P) as follows:

(1) On any frequency removed from the center of the authorized bandwidth by a displacement frequency ($f_d$in ㎑) of more than 10 ㎑, but no more than 250 percent of the authorized bandwidth: At least 116 log (f_d/6.1) ㏈, or 50 + 10 log (P) ㏈, or 70 ㏈, whichever is the lesser attenuation;

(2) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) ㏈.

Test results



2.1.4 Transmitter spurious conducted emission

Test setup

EUT	Attenuator	Spectrum analyzer

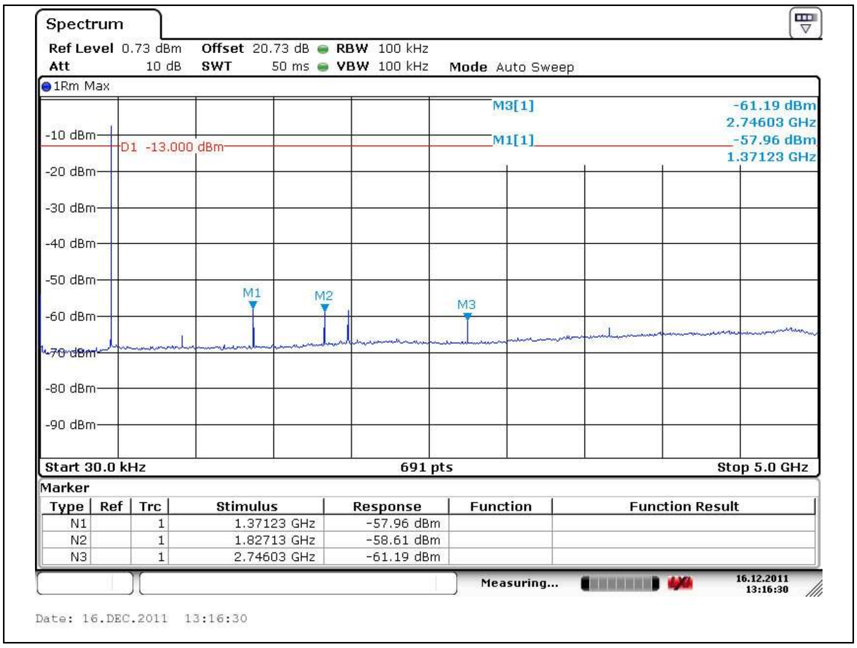
Test procedure

1. The transmitter output was connected to the spectrum analyzer through an attenuator
2. Use the following spectrum analyzer setting
   Span = 30 ㎒ to 5 ㎓
   RBW = 100 ㎑
   VBW = 100 ㎑ (≥ RBW)
   Sweep = auto
   Detector function = peak
   Trace = max hold

Limit

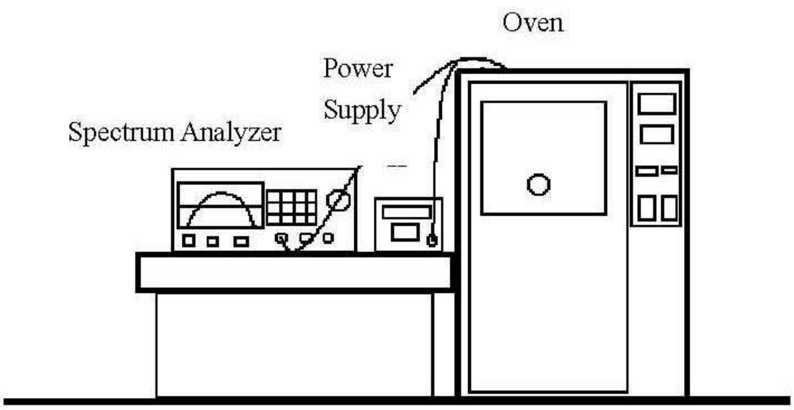
According to FCC part 90.210(g),
On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) ㏈.
Alternatively, an equivalent absolute level of -13 ㏈m is taken.

Test results



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 ㎑, VBW=1 ㎑.
3. Set the temperature of chamber to -30 ℃. 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 ℃ decreased per stage until the highest temperature 50 ℃ 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 -20 ℃ to + 50 ℃ 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 overned by this part must have a minimum frequency stability as specified in the following table.

Minimum Frequency Stability [Parts per million (ppm)]

Frequency range (㎒)	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 2 450[10]			

[1]Fixed 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.

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

[3]Travelers information station transmitters operating from 530 ~ 1 700 ㎑ 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 ㎐ of the authorized frequency.

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

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

[6]In the 150 ~ 174 ㎒ band, mobile stations designed to operate with a 12.5 ㎑ 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 ㎑ channel bandwidth must have a frequency stability of 2.0 ppm.

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

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

[9]Fixed stations with output powers above 120 watts and necessary bandwidth less than 3 ㎑ 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.

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

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

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

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

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

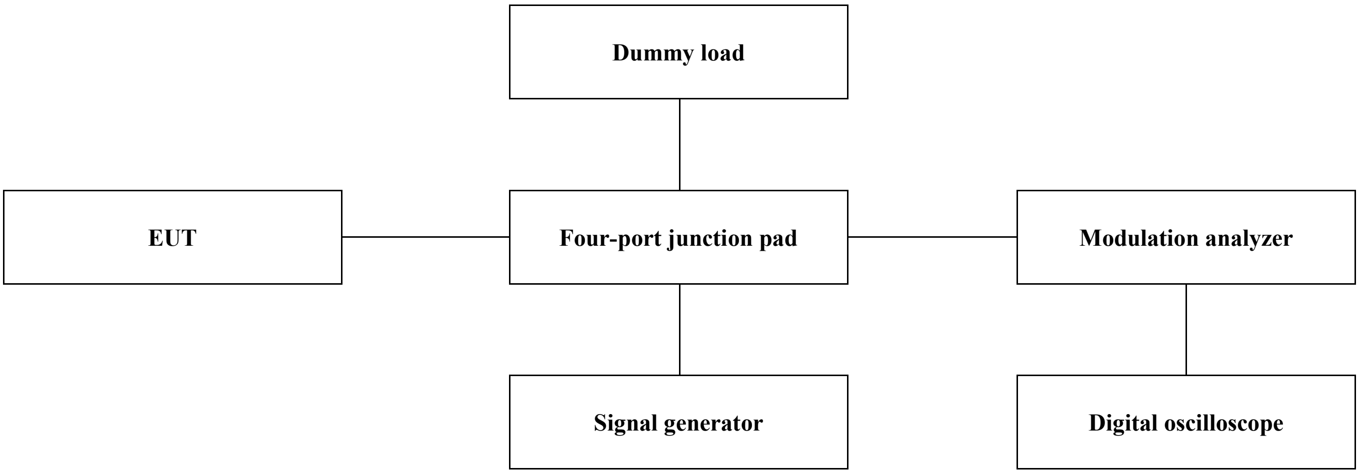
(b) For the purpose of determining the frequency stability limits, the power of a transmitter is considered to be the maximum rated output power as specified by the manufacturer.

Test results

Test voltage (%)	Test voltage (V)	Temperature (℃)	Measure frequency (㎒)	Frequency deviation (㎐)	Frequency deviation (ppm)	Limit (ppm)
100 %	DC 3.0 V	-30	457.574 446 7	-553.3	-1.21	2.5
100 %		-20	457.574 449 3	-550.7	-1.20	2.5
100 %		-10	457.574 451 2	-548.8	-1.20	2.5
100 %		0	457.574 543 3	-456.7	-1.00	2.5
100 %		10	457.574 541 2	-458.8	-1.00	2.5
100 %		20	457.574 840 0	-160.0	-0.35	2.5
100 %		30	457.574 849 8	-150.2	-0.33	2.5
100 %		40	457.574 947 4	-52.6	-0.11	2.5
100 %		50	457.574 818 3	-181.7	-0.40	2.5
115%	DC 3.45 V	20	457.574 840 0	-160.0	-0.35	2.5
85%	DC 2.55 V	20	457.574 840 0	-160.0	-0.35	2.5

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 ㎑ tone at ±25 ㎑ deviation and set its output level to -100 ㏈m.
2. Key the transmitter.
3. Supply sufficient attenuation via the RF attenuator to provide an input level to the test receiver that is 40 ㏈ 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 ㎐ tone. Adjust the vertical amplitude control of the oscilloscope to display the 1 000 ㎐ 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 ㎑ 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 t1 and t2. See the figure in the appropriate standards section.
9. During the time from the end of t2 to the beginning of t3 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 25 ㎑.
10. Key the transmitter and observe the stored display. The trace should be maintained within the allowed divisions after the end of t2 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 t3 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 ㎑ 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 t3. See the figures in the appropriate standards section.

Limit

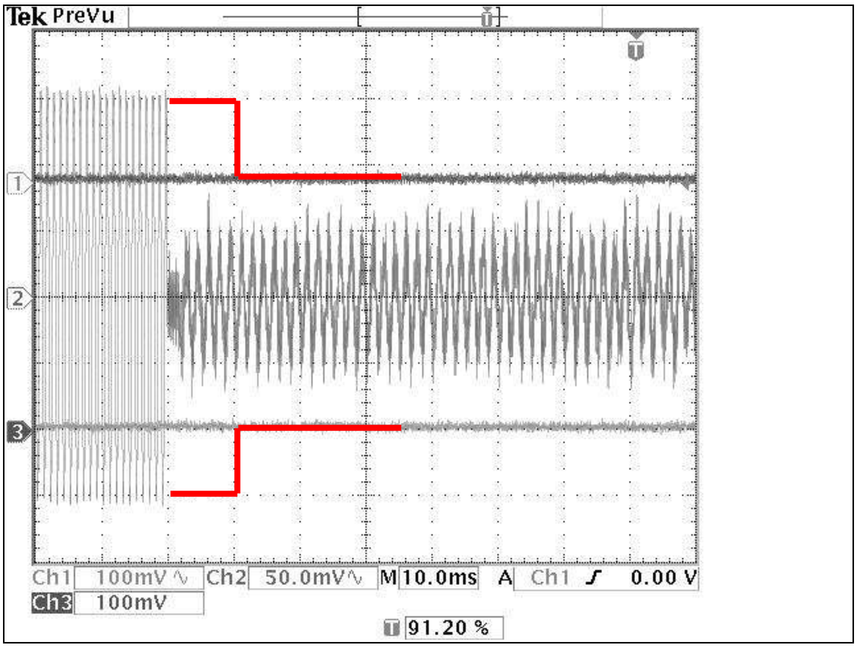
According to FCC 90.214, Transmitters designed to operate in the 150 ~ 174 ㎒ and 421 ~ 512 ㎒ frequency bands must maintain transient frequencies within the maximum frequency difference limits during the time intervals indicated:

Time intervals [1, 2]	Maximum frequency difference [3]	All equipment	
		150 to 174 ㎒	421 to 512 ㎒
Transient frequency behavior for equipment designed to operate on 25 ㎑ channel			
t1[4] ---------------------------	±25.0 ㎑	5.0 ㎳	10.0 ㎳
t2 ----------------------------	±12.5 ㎑	20.0 ㎳	25.0 ㎳
t3[4] ---------------------------	±25.0 ㎑	5.0 ㎳	10.0 ㎳
Transient Frequency behavior for equipment designed to operate on 12.5 ㎑ Channel			
t1[4] ---------------------------	±12.5 ㎑	5.0 ㎳	10.0 ㎳
t2 ----------------------------	±6.25 ㎑	20.0 ㎳	25.0 ㎳
t3[4] ---------------------------	±12.5 ㎑	5.0 ㎳	10.0 ㎳
Transient Frequency behavior for equipment designed to operate on 6.25 ㎑ Channel			
t1[4] ---------------------------	±6.25 ㎑	5.0 ㎳	10.0 ㎳
t2 ----------------------------	±3.125 ㎑	20.0 ㎳	25.0 ㎳
t3[4] ---------------------------	±6.25 ㎑	5.0 ㎳	10.0 ㎳

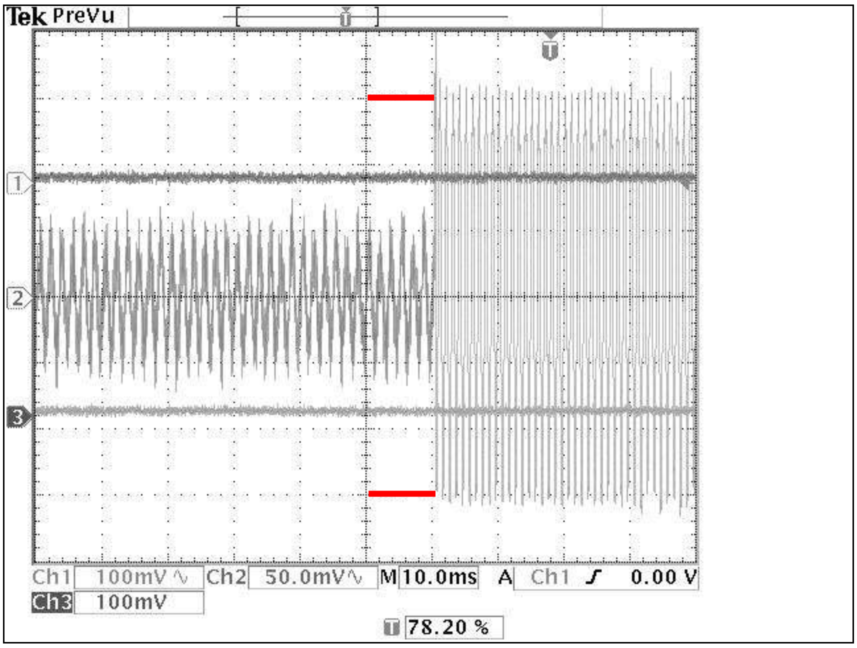
[1] $_{on}$ is the instant when a 1 ㎑ test signal is completely suppressed, including any capture time due to phasing.
t_1 is the time period immediately following t_{on}.
t_2 is the time period immediately following t_1.
t_3 is the time period from the instant when the transmitter is turned off until t_{off}.
t_{off} is the instant when the 1 ㎑ 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

A. Switching from off to on



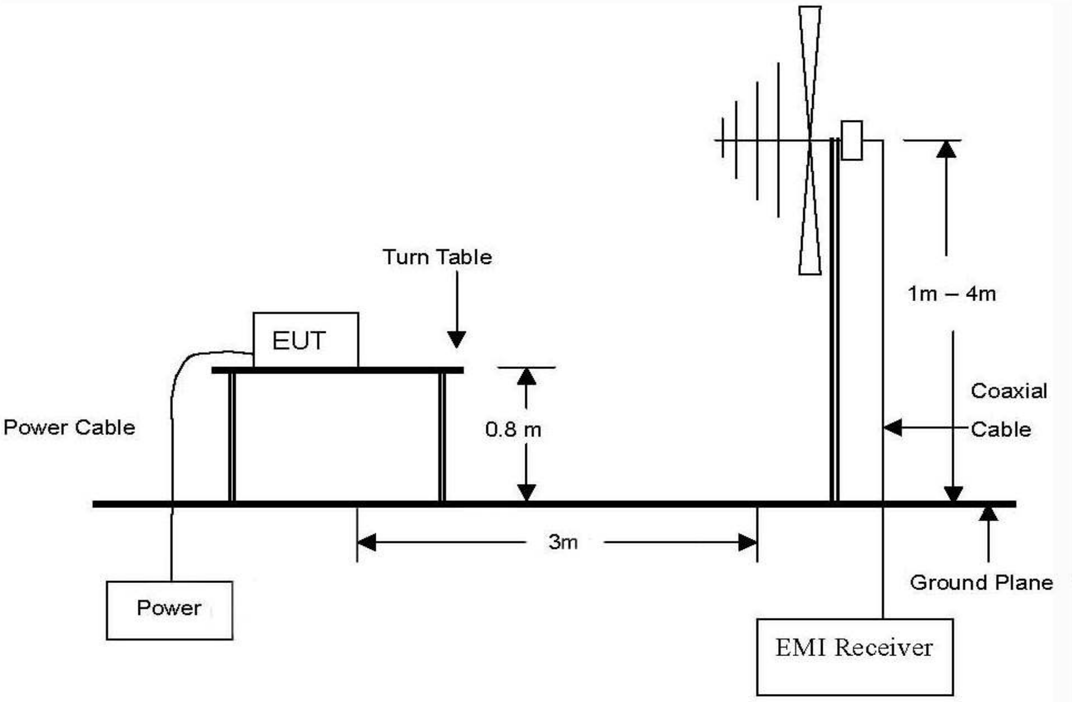
B. Switching from on to off



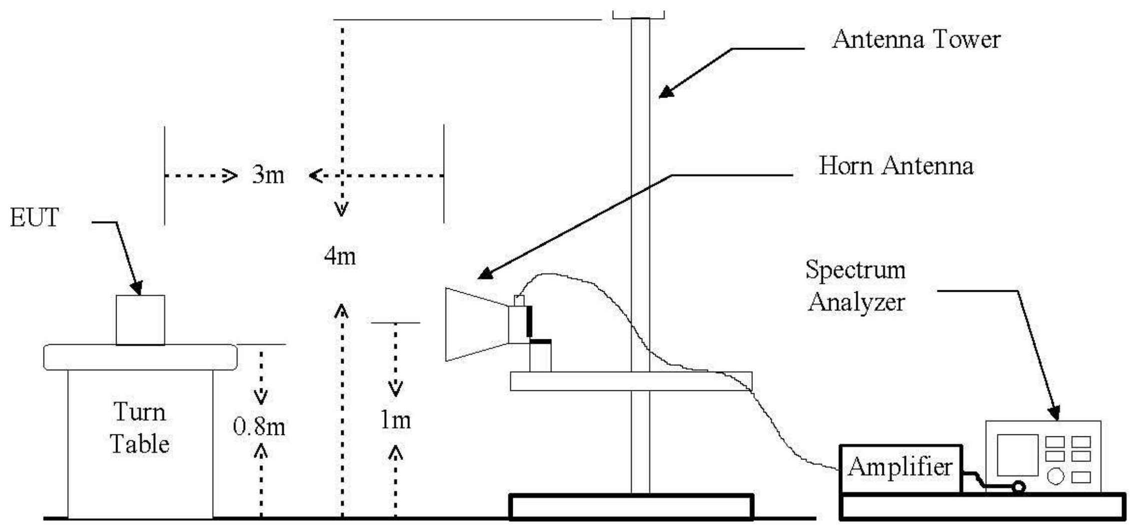
2.1.7 Field strength of spurious radiation

Test setup

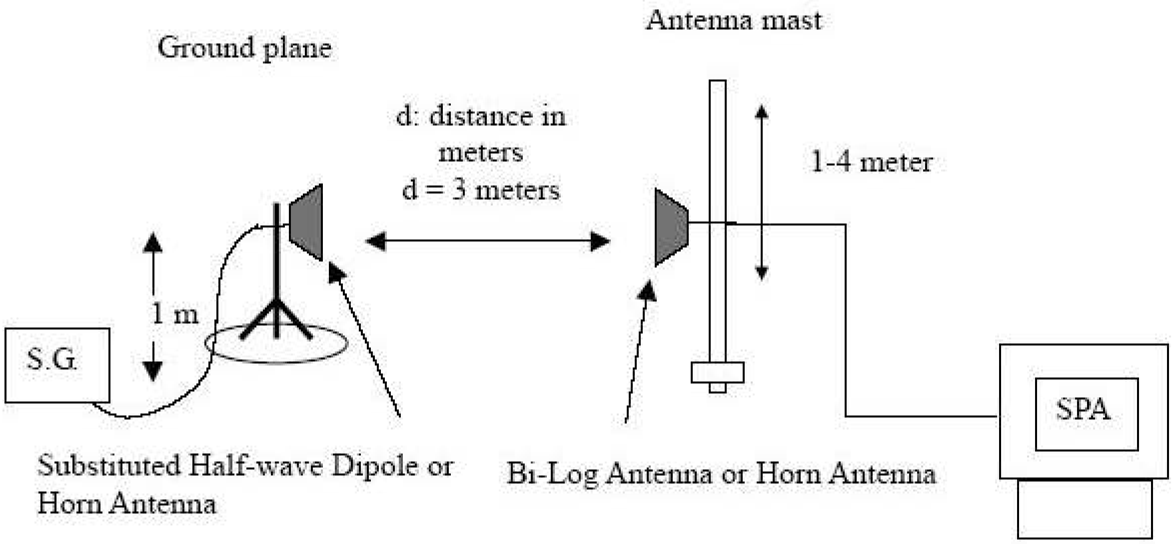
The diagram below shows the test setup that is utilized to make the measurements for emission from 30 ㎒ to 1 ㎓ Emissions.



The diagram below shows the test setup that is utilized to make the measurements for emission from 1 ㎓ to 5 ㎓ 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 ㎝ 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 ㎑(< 1㎓), 1 ㎒(> 1 ㎓).
   2) VBW: 100 ㎑(< 1㎓), 1 ㎒(> 1 ㎓).
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 the 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 ㎒) or horn antenna(above 1 000 ㎒) 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 received, 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 ㏈m, 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, Spurious attenuated in dB = 43 + 10log(Power output in watts)
Alternatively, an equivalent absolute level of -13 ㏈m is taken.

Test results

Frequency (㎒)	Ant. Pol. (H/V)	S.G. Level (dBm)	Correction factor (dB)	E.R.P. (dBm)	Limit (dBm)
915.150	H	-38.00	4.22	-33.78	-13
915.150	V	-38.00	6.28	-31.72	-13
1 372.725	H	-35.00	5.29	-29.71	-13
1 372.725	V	-28.00	7.66	-20.34	-13
1 830.300	H	-25.00	8.86	-16.14	-13
1 830.300	V	-20.00	5.64	-14.36	-13
2 287.875	H	-37.00	7.69	-29.31	-13
2 287.875	V	-41.00	6.88	-34.12	-13
2 745.450	H	-34.00	7.96	-26.04	-13
2 745.450	V	-34.00	9.82	-24.18	-13
3 203.025	H	-46.00	9.30	-36.70	-13
3 203.025	V	-34.00	8.29	-25.71	-13
3 660.600	H	-34.00	10.67	-23.33	-13
3 660.600	V	-36.00	9.89	-26.11	-13
4 118.175	H	-52.00	8.09	-43.91	-13
4 118.175	V	-53.00	9.86	-43.14	-13
4 575.750	H	-47.00	12.10	-34.90	-13
4 575.750	V	-47.00	11.15	-35.85	-13

Remark;
1. Correction factor: Substitution antenna gain - Tx cable loss
2. E.R.P. & E.I.R.P = S.G. Level + correction factor
3. The E.R.P. & E.I.R.P was measured in three orthogonal EUT position(x-axis, y-axis and z-axis). Worst cases are x-axis.

2.1.8 RF exposure

According to FCC part 1.1310 : The criteria listed in the following table shall be used to evaluate the environment impact of human exposure to radio frequency (RF) radiation as specified in § 1.1307(b)

Limits for Maximum Permissible Exposure (MPE)

Frequency range (㎒)	Electric field strength(V/m)	Magnetic field strength (A/m)	Power density (㎽/㎠)	Average time
(A) Limits for Occupational /Control Exposures				
300 ~ 1 500	--	--	F/300	6
1 500 ~ 100 000	--	--	5	6
(B) Limits for General Population/Uncontrol Exposures				
300 ~ 1 500	--	--	F/1 500	6
1 500 ~ 100 000	--	--	1	30

Friis transmission formula: $Pd = (Pout \times G) / (4 \times pi \times R^2)$

Where,

Pd = power density in ㎽/㎠

Pout = output power to antenna in ㎽

G = gain of antenna in linear scale

Pi = 3.1416

R = distance between observation point and center of the radiator in cm

Pd the limit of MPE, f/300 ㎽/㎠. If we know the maximum gain of the antenna and the total power input to the antenna, through the calculation, we will know the distance where the MPE limit is reached.

Results

Frequency (㎒)	Peak output power (dBm)	Antenna gain (dBi)	Power density at 20 ㎝(㎽/㎠)	Limit (㎽/㎠)
457.575	10.49	-2.15	0.001 36	1.53

Appendix A – Test equipment used for test

Equipment	Manufacturer	Model	Calibration due.
Spectrum Analyzer	R&S	FSV30	2012-01-07
Vector Signal Generator	R&S	SMBV2100A	2012-01-07
Modulation Analyzer	HP	8901B	2012-05-04
DC Power Supply	Agilent	6632B	2012-05-06
DC Power Supply	Provice	PWS-5006D	2012-11-16
Attenuator	HP	8491B	2012-05-04
Amplifier	HP	8447F	2012-05-09
Amplifier	A.H.	PAM-0118	2012-05-09
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	UHAP	2013-04-29
High pass filter	Mini-circuits	NHP-800+	2012-03-30
Oscilloscope	Tektronix	TDS305413	2012-01-07
Four - Port Junction Pad	ANRITSU	6502	2012-03-30

Test setup photo