

Test report No.: KES-RF-18T0122 Page (1) of (41)

# **TEST REPORT**

# Part 15 C & RSS-247 (Issue 2)

Equipment under testWireless Video Baby MonitorModel nameSEM-3049WFCC IDNLMSEM3049W

IC 21482-SEM3049W

Applicant Hanwha Techwin Co., Ltd.

Manufacturer Hanwha Techwin (Tianjin) Co.,Ltd. Hanwha Techwin Security Vietnam Co.,Ltd. D-TECH Co.,Ltd.

**Date of test(s)** 2018.11.19 ~ 2018.11.23

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**Issued** to

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# **Revision history**

Revision	Date of issue	Test report No.	Description
-	2018.12.27	KES-RF-18T0122	Initial



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# 1. General information

Applicant:	Hanwha Techwin Co., Ltd.		
Applicant address:	6, Pangyo-ro 319 Beon-gil, Bundang-gu Seongnam-si,		
	Gyeonggi-do, 13488, Korea		
Test site:	KES Co., Ltd.		
Test site address:	3701, 40, Simin-daero 365beon-gil, Dongan-gu, Anyang-si,		
	Gyeonggi-do, 14057, Korea		
	473-21, Gayeo-ro, Yeoju-si, Gyeonggi-do, Korea		
Test Facility	FCC Accreditation Designation No.: KR0100, Registration No.: 444148		
	ISED Registration No.: 23298		
FCC rule part(s):	15.247		
IC rule part(s):	RSS-247		
FCC ID:	NLMSEM3049W		
IC:	21482-SEM3049W		
Test device serial No .:	☑ Production	ıg	

# 1.1. EUT description

Equipment under test	Wireless Video Baby Monitor	
Frequency range	$2\ 409.5\ \text{Mz}\ \sim 2\ 476\ \text{Mz}$	
Model	SEM-3049W	
Modulation technique	GFSK	
Number of channels	20 ch	
Antenna specification	Antenna type : Dipole antenna, Peak gain : 1.2 dBi	
Power source	DC 3.85 V (Li-Ion Battery)	

15.247(a)(1) that the rx input bandwidths shift frequencies in synchronization with the transmitted

15.247(g): The system is designed to comply with all of the regulations in Section 15.247 when the transmitter is presented with a continuous data (or information) system.

15.247(h): The system does not coordinate it channels selection/ hopping sequence with other frequency hopping systems for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters.

# **Pseudorandom frequency hopping sequence**

The channel is represented by a pseudo-random hopping sequence hopping through the 20 RF channels.

## Equal hopping frequency use

The channels of this system will be used equally over the long-term distribution of the hopsets.

## Example of a 20 hopping sequence in data mode:

12, 14, 03, 17, 16, 02, 18, 05, 19, 10, 06, 20, 09, 01, 13, 07, 11, 08, 15, 04



# **1.2.** Test configuration

# The Hanwha Techwin Co., Ltd. Wireless Baby Monitor FCC ID: NLMSEM3049W,

**IC: 21482-SEM3049W** was tested according to the specification of EUT, the EUT must comply with following standards and KDB documents.

FCC Part 15.247 ISED RSS-247 Issue 2 and RSS-Gen Issue 5 KDB 558074 D01 v05 ANSI C63.10-2013

# **1.3.** Frequency/channel operations

Ch.	Frequency (Mb)
01	2409.5
10	2441
-	
20	2476

# 1.4. Accessory information

Equipment	Manufacturer	Model	Serial No.	Power source
-	-	-	-	-

# 1.5. Software and Firmware description

The software and firmware installed in the EUT is version 1.0

## **1.6.** Measurement results explanation example

For all conducted test items :

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator factor between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

Offset(dB) = RF cable loss(dB) + attenuator factor(dB). = 0.72 + 20 = 20.72 (dB)

## 1.7. Measurement Uncertainty

Test Item		Uncertainty	
Uncertainty for Conduction emission test		2.62 dB	
Uncertainty for Radiation emission test (include Fundamental emission)	9kHz - 30MHz	4.54 dB	
	30MHz - 1GHz	4.36 dB	
	Above 1GHz	5.00 dB	
Note. This uncertainty represents an expanded uncertainty expressed at approximately the 95%			
confidence level using a coverage factor of k=2.			

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2. Summary of tests			
Section in FCC Part 15	Section in RSS-247 & Gen	Parameter	Test results
-	RSS-Gen 6.7	99% occupied bandwidth	Pass
15.247(a)(1)	RSS-247 5.1(a)	20 dB bandwidth	Pass
15.247(b)(1)	RSS-247 5.4(b)	Output power	Pass
15.247(a)(1)	RSS-247 5.1(b)	Carrier frequency separation Pass	
15.247(a)(1)(iii)	RSS-247 5.1(d)	Number of channels Pass	
15.247(a)(1)(iii)	RSS-247 5.1(d)	Time of occupancy Pas	
15.205 15.209	RSS-247 5.5 RSS-Gen 8.9, 8.10	Radiated restricted band and emission Pas	
15.247(d)	RSS-247 5.5	Conducted spurious emission and band edge Pass	
15.207(a)	RSS-Gen 8.8	AC conducted emissions Pass	



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# Test results 99% Occupied Bandwidth

# Test procedure

ANSI C63.10-2013 clause 7.8.7

# Test setup Spectrum EUT Attenuator analyzer

# Test setting

- 1. Span = approximately 1.5 to 5 times the OBW, centered on a hopping channel
- 2. RBW = range of 1% to 5 % of the OBW
- 3. VBW = approximately 3 times RBW
- 4. Sweep = auto
- 5. Detector function = Peak
- 6. Trace = Max hold

# Limit

Not applicable

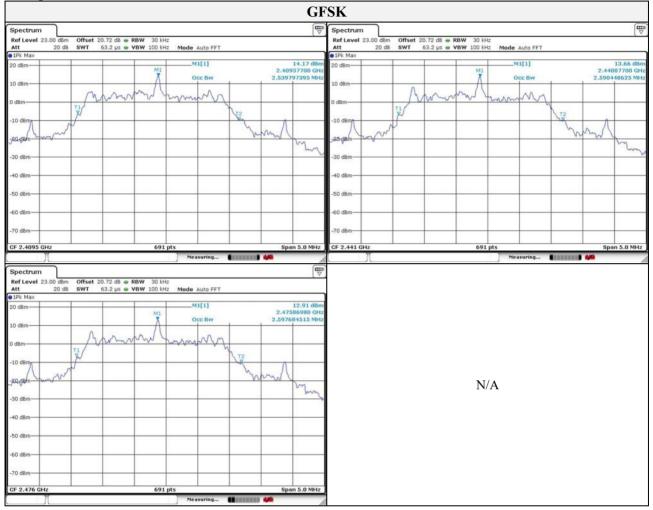
# **Test results**

Frequency(Mz)	99% occupied bandwidth(Mz)	Limit(Mb)
2 409.5	2.540	
2 441	2.590	_
2 476	2.598	



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#### **Test plots**





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# 3.2. 20 dB bandwidth

#### Test procedure

ANSI C63.10-2013 clause 6.9.2 and 6.9.3

### Test setup

FUT	Attenuator	Spectrum analyzer
EUI	Attenuator	Spectrum analyzer

#### Test setting

- 1. Span = approximately 2 to 5 times the OBW, centered on a hopping channel
- 2. RBW = range of 1% to 5 % of the OBW
- 3. VBW = approximately 3 times RBW
- 4. Sweep = auto
- 5. Detector function = peak
- 6. Trace mode = max hold

#### Limit

Not applicable

## Test results

Frequency(Mz)	20 dB bandwidth(Mz)	Limit(Mb)
2 409.5	2.388	
2 441	2.402	-
2 476	2.402	



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# Test plots

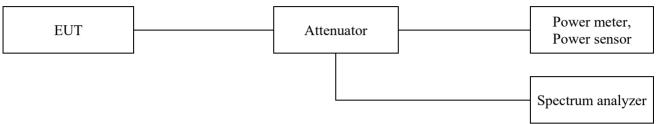
		GF	SK				
Spectrum			Spectrum				E Starten Sta
	0.72 dB 🖶 RBW 30 kHz		Ref Level 29.00 de				
Att 25 dB SWT	63.2 µs 🖷 VBW 100 kHz Mode Auto FFT		Att 25	dB SWT 63.2 µs	VBW 100 kHz Mod	e Auto FFT	
	M1[1]	14.01 dBm 2.4093700 GHz				M1[1]	13.53 dBm 2.4408700 GHz
20 dBm	M1 ndB	20.00 dB	20 dBm-		MI	ndB	20.00 dB
10 dBm	Bw Q factor	2.388000000 MHz 1009.0	10 dBm	-	A A	Bw Q factor	2.402000000 MHz 1016.0
0 dBm	Munu many		0 dBm		Month man	wh	
-10 dBm	7 8		-10 dBm	, ja		8	
Λ	we have	A	22220	Ant		June	
-20 dBm		M. A I	-20 dBm	Anno		1	la A A
-30 dBm Augur W		1 manual and	-30 dBrown	- Jure	-		me mundy 1
-40 dBm		mun mun	-40 dBm				man much
-50 dBm			-50 d8m				
1000 mg 1			00000				
-60 dBm-			-60 dBm				
CF 2.4095 GHz	691 pts	Span 10.0 MHz	CF 2.441 GHz		691 pts	_	Span 10.0 MHz
Marker			Marker	200.00	11.11 (b) (b) (c)		
Type         Ref         Trc         X-value           M1         1         2.409	e         Y-value         Function           937 GHz         14.01 dBm         ndB down	Function Result 2.388 MHz	Type Ref Trc M1 1	2.44087 GHz	Y-value F 13.53 dBm	ndB down	Function Result 2,402 MHz
T1 1 2.4081	69 GHz -5.35 dBm ndB 55 GHz -5.90 dBm Q factor	20.00 dB 1009.0	T1 1 T2 1	2.439654 GHz 2.442056 GHz	-7.29 d8m -6.31 d8m	ndB Q factor	20.00 dB 1016.0
12 1 2.4105	Measuring	1009.0	12 1	2.442050 GH2	-6.31 dBm		1018.0
		E Contraction of the second se					
Ref Level 29.00 dBm Offset 2	0.72 dB 🖷 RBW 30 kHz						
Att 25 dB SWT	63.2 µs . VBW 100 kHz Mode Auto FFT						
1Pk Max	M1[1]	12.87 dBm					
20 dBm		2.4758700 GHz					
10 d8m-	M1 ndB X Bw	20.00 dB 2.402000000 MHz					
C. State of Manual American	As manufal Q factor	1030.6					
0.dBm	T/ The State Transmith						
-10 dBm		1					
-20 d8m	and hung						
A AN		my A 1			N/A		
-30 dBm Auror		man 1			11/11		
-40 dBm		- www.					
-50 d8m							
-60 dBm							
-00 Ubil)							
CF 2.476 GHz	691 pts	Span 10.0 MHz					
Marker							
Type         Ref         Trc         X-value           M1         1         2.475	e <u>Y-value Function</u> 87 GHz 12.87 dBm ndB down	Function Result 2.402 MHz					
T1 1 2.4746	i54 GHz -7.64 dBm ndB	20.00 dB					
T2 1 2.4770	156 GHz -6.96 dBm Q factor Measuring	1030.6					
	reasuring						



#### 3.3. Output power Test procedure

ANSI C63.10-2013 - Section 7.8.5

# Test setup



# Test setting

- 1. Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel
- 2. RBW > the 20 dB bandwidth of the emission being measured
- 3. VBW  $\geq$  RBW
- 4. Sweep = Auto
- 5. Detector function = Peak
- 6. Trace = Max hold
- 7. Allow the trace to stabilize.

# Limit

According to \$15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequenci es separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

According to RSS-247 Issue 2 5.4(b), For FHSs operating in the band 2 400 - 2 483.5 Mz, the maximum peak conducted output power shall not exceed 1.0 W if the hopset uses 75 or more hopping channls; the maximum peak conducted output power shall not exceed 0.125 W if the hopset uses less than 75 hopping channls. The e.i.r.p shall not exceed 0.4 W, except as provided in section 5.4(e).



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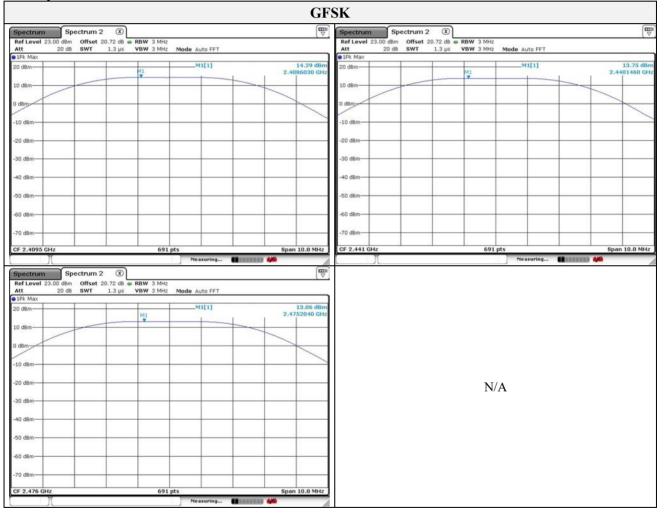
#### **Test results**

Frequency(Mb)	Channel no.	Peak Power (dBm)	Average Power (dBm) Note1	Power Limit (dBm)
2 409.5	01	14.29	14.06	20.97
2 441	10	13.75	13.45	20.97
2 476	20	13.06	12.85	20.97

Note.

1. The average power was tested using an average power meter.

#### Test plots



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# **3.4.** Carrier frequency separation

Test procedure

ANSI C63.10-2013 - Section 7.8.2

#### Test setup

EUT	Attempoten	Secondaria analyzan
EUI	Attenuator	Spectrum analyzer

#### **Test Setting**

- 1. The EUT must have its hopping function enabled. Use the following spectrum analyzer settings:
- 2. Span = wide enough to capture the peaks of two adjacent channels
- 3. RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- 4. Video (or Average) Bandwidth (VBW)  $\geq$  RBW
- 5. Sweep = auto
- 6. Detector function = peak
- 7. Trace = max hold

Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels. The limit is specified in one of the subparagraphs of this Section. Submit this plot.

#### Limit

According to 15.247(a)(1), frequency hopping system operating in 2 400 ~ 2 483.5 Mz. Band may have hopping channel carrier frequencies that are separated by 25 kz or two-third of 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

According to RSS-247 Issue 2, 5.1(b), FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2400-2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W.



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#### **Test results**

Frequency(Mz)	Channel no.	Channel Separation (Mz)
2 441	10	2.437

		Test	plots					
	Hopping mode_GFSK							
Spectrum	pectrum 2	Spectrum 3	×					
Ref Level 32.00 dB		dB - RBW 30 kH						
1Pk Max								
			D2[1]		-0.07 dB 3.5020 MHz			
20 dBm-			M1[1]		13.30 dBm			
MI		02	1	1 1	2.4373680 GHz			
10 dBm				1 1				
. J. Mala	Ad. I.	1 Marule	Aug a 1	1 Am	have .			
0 dBm/0	Multimers	have the	mand women	nor was a	mannung			
-10 dBm	. r.							
-20 dBm								
-30 dBm			-	-				
-40 d8m								
-50 dBm								
-60 d8m								
05.0.111.011-								
CF 2.441 GHz		691	Measuring	-	Span 10.0 MHz			

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# 3.5. Number of hopping frequency

# Test procedure

ANSI C63.10-2013 - Section 7.8.3

# Test setting

- 1. The EUT must have its hopping function enabled.
- 2. Span = The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
- 4. RBW = To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- 5.  $VBW \ge RBW$
- 6. Sweep = auto
- 7. Detector function = peak
- 8. Allow the trace to stabilize.

All the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

# Limit

According to 15.247(a)(1)(iii), for frequency hopping system operating in the 2 400 ~ 2 483.5 Mz bands shall use at least 15 hopping frequencies.

According to RSS-247 Issue 2, 5.1(4), FHSs operating in the band 2400-2483.5 Mz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

## **Test results**

Frequency	Number of hopping frequency	Limit
$2 409.5 \sim 2 476$ Mz	20	≥15



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# **Test plots**

Spectrum	Spectrum 2	× Spe	ectrum 3	🛞 S	pectrum	4 🕱		V
Ref Level 26.0			V 1 MHz V 1 MHz	Mode Auto	FET			
Pk Max	1			noue aut	2111	_		
20 dBm-	_							
10 dBm	www	nor	m	m	ww	vv	ww	7
0 dBm			5 - 5 			1 A		1
-10 dBm								
-20/d8m-								6
								1
40 dBm								
50 dBm								
60 d8m								
ou asm								
-70 d8m		++					+	



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**3.6.** Time of occupancy

Test procedure ANSI C63.10-2013 - Section 7.8.4

# Test setting

- 1. The EUT must have its hopping function enabled.
- 2. Span = zero span, centered on a hopping channel
- 3. RBW shall be  $\leq$  channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
- 4. Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
- 5. Detector function = peak
- 6. Trace = max hold

# Limit

According to 15.247(a)(1)(iii), for frequency hopping system operating in the 2 400 ~ 2 483.5 Mz band, the average time of occupancy on any frequency shall not be greater than 0.4 second within a 8 second period.

According to RSS-247 Issue 2, 5.1(d), FHSs operating in the band 2 400 - 2 483.5 Mz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

A period time =  $0.4(s) \times 20 = 8(s)$ 

Frequency (Mz)	Burst time (ms)	Burst number	Time of occupancy (ms)	Limit (ms)
2 441	0.841	25	21.025	400



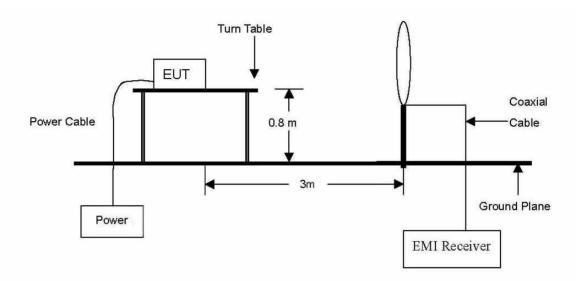
Ref Level 26.00 dBm       Offset 20.72 dB       RBW 1 MHz         Att       25 dB       SWT       20 ms       VBW 1 MHz         GL       SIL       SIL       SIL       SIL         0 IBm       01(1)       2.06 dB       SIL       SIL       SIL         0 IBm       01(1)       2.06 dB       SIL       SIL       SIL         10 dBm       01(1)       2.06 dB       SIL       SIL       SIL       SIL         20 dBm       01(1)       10(1)       10(1)       SIL       SIL       SIL       SIL         -20 dBm       -30 dBm       -40 dBm	В	urst tin	ne(ms)	= 0.8	41_Hop	oing N	lode		Bu	rst	num	ber v	with	in 8	s =	25 _	Ho	ppir	ıg N	lod	e
Att       25 dB @ SWT       20 ms       VBW 1 MHz         50.       91% Chw       00(1)       2.00 ms       00(1)       2.00 ms         10 dbm       M1[1]       -20 dbm       00(1)       2.00 ms       00(1)       00(1)         -10 dbm       M1[1]       -20 dbm       00(1)	Spectrum	Spectrum 2	× s	ectrum 3	Spectrur	n4 🕱		E	Spectrum		Spectrun	12 (2	Spe	ctrum 3	3 X	Spect	rum 4	×			
D0[1]         2.66 db           20 dBm         M1[1]           12.985 ms         20 dBm           0 dBm         M1[1]           -20 dBm         0 dBm           -10 dBm         0 dBm           -20 dBm	Att 3								Att							• 1196					
20 dBm	1Pk Clrw								● 1Pk Clrw		52				0	100				1000	
10 dBm       4.9 P25 ms         0 dBm       4.9 P25 ms         10 dBm       9 Bm         -10 dBm       9 Bm         -10 dBm       9 Bm         -20 dBm       9 Bm         -20 dBm       9 Bm         -30 dBm       9 Bm         -40 dBm       9 Bm         -50 dBm       9 Bm         -60 dBm       9 Bm         -70 dBm	20 dBm				Same and			12.9855 m	s 20 dBm			_	_			-	_			-	
0 dBm -10 dBm -20 dBm -20 dBm -20 dBm -20 dBm -20 dBm -20 dBm -20 dBm -20 dBm -20 dBm -30 dBm -30 dBm -30 dBm -30 dBm -50 dBm -70 dBm -11 dBm -50 dBm -50 dBm -50 dBm -50 dBm -70 dBm -11 dBm -50 dBm -50 dBm -50 dBm -50 dBm -70 dBm -11 dBm -12 dBm -12 dBm -12 dBm -12 dBm -10 d	10 dBm	- 7			M1[1]				5 1 4		11		1	11	11	11	11	1	1	11	11
-20 dBm -30 dBm -30 dBm -30 dBm -40 dBm -50 dBm -70 dBm -70 dBm -70 dBm -70 dBm -70 dBm -11 d 4025 ms -37.65 dBm -14 d -14 d	0 dBm					-			- Com												
-30 dBm -0 dB	-10 dBm																				
Lium funderednings and with a stand of the s	-20 dBm					+			-10 dBm												
40 dBm -50 dBm -60 dBm -70	-30 dBm	mangaetty of	hurrock	report for	A how the have been	unemedia	wanter	a lawso	ac dam												
-60 dBm0	-40 dBm								Jan sen -								Male	Juli	and the second	Щ	Juli
-50 dBm -70									-40 d8m-												
CF 2.44175 GHz         691 pts         2.0 ms/           Marker	10000000								-												
Type         Ref         Trc         X-value         Y-value         Function         Function Result           M1         1         4.9275 ms         -37.65 dBm         -70 dBm				691 pt	ts			2.0 ms/	-50 d8m												
M1         1         4.927 sms         -37.65 dBm         -70	Marker								-60 dBm		-	-	-		-	-	-		+	_	
D2         M1         1         840.6 µs         0.56 dB         -70 dBm         -70 dBm           D3         M1         1         12.9855 ms         2.66 dB         CF 2.44175 GHz         691 pts         800.0 ms/						Fun	ction Resul	t	-												
		1 8	40.6 µs	0.56 dB							2										
Ready Ready A	D3 M1	1 12.9	855 ms	2.66 dB					CF 2.4417	5 GHz				691	pts					800	.0 ms/



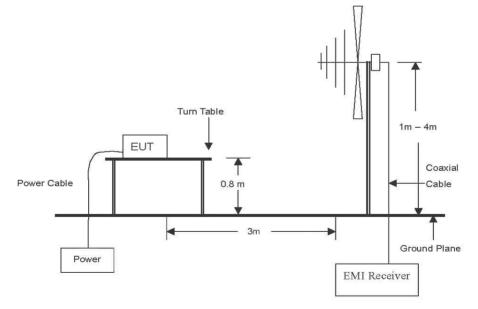
# 3.7. Radiated restricted band and emissions

# Test setup

The diagram below shows the test setup that is utilized to make the measurements for emission from 9 kHz to 30 MHz Emissions.



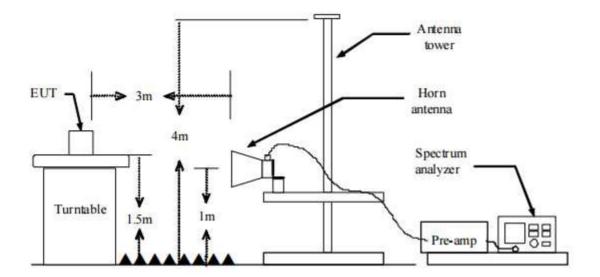
The diagram below shows the test setup that is utilized to make the measurements for emission from 30 Mz to 1 Gz emissions.





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The diagram below shows the test setup that is utilized to make the measurements for emission from 1  $\mathbb{G}\mathbb{Z}$  to the tenth harmonic of the highest fundamental frequency or to 40  $\mathbb{G}\mathbb{Z}$  emissions, whichever is lower.





# **Test procedure**

- 1. The EUT is placed on a turntable, which is 0.8 m above ground plane.
- 2. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
- 3. EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
- 4. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
- 5. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
- 6. Repeat above procedures until the measurements for all frequencies are complete.
- 7. Spectrum analyzer settings for f < 1 GHz:

Span = wide enough to fully capture the emission being measured

RBW = 100 kHz  $VBW \ge RBW$  Sweep = auto Detector function = quasi peakTrace = max hold

- 8. Spectrum analyzer settings for  $f \ge 1$  GHz: Peak
  - Span = wide enough to fully capture the emission being measured

RBW = 1 Mbz  $VBW \ge RBW$  Sweep = auto Detector function = peak Trace = max hold

- 9. Spectrum analyzer settings for  $f \ge 1$  GHz: Average
  - ① Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
  - 2 RBW = 1 ML
  - (3)  $VBW \ge 3 \times RBW$
  - (4) Detector = RMS, if span/(# of points in sweep)  $\leq$  (RBW/2). Satisfying this condition may require increasing the number of points in the sweep or reducing the span. If this condition cannot be satisfied, then the detector mode shall be set to peak.
  - (5) Averaging type = power(i.e., RMS)
    - 1) As an alternative, the detector and averaging type may be set for linear voltage averaging.
    - 2) Some instruments require linear display mode in order to use linear voltage averaging. Log or dB averaging shall not be used.
  - 6 Sweep = auto
  - $\bigcirc$  Trace = max hold
  - 8 Perform a trace average of at least 100 traces.
  - (9) A correction factor shall be added to the measurement results prior to comparing to the emission limit in order to compute the emission level that would have been measured had the test been performed at 100 percent duty cycle. The correction factor is computed as follows:
    - 1) If power averaging (RMS) mode was used in step (5), then the applicable correction factor is  $10 \log(1/x)$ , where x is the duty cycle.
    - 2) If linear voltage averaging mode was used in step (5), then the applicable correction factor is 20 log(1/x), where x is the duty cycle.
    - 3) If a specific emission is demonstrated to be continuous ( $\geq$  98 percent duty cycle) rather than turning on and off with the transmit cycle, then no duty cycle correction is required for that emission.

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# Note:

- 1. The spectrum is measured from 9 kHz to the 10th harmonic of the fundamental frequency of the transmitter using CISPR quasi peak detector below 1 GHz. Above 1 GHz, average and peak measurements were taken using linearly polarized horn antennas. The worst-case emissions are reported however emissions whose levels were not within 20 dB of the respective limits were not reported.
- 2. Emissions below 18 GHz were measured at a 3 meter test distance while emissions above 18 GHz were measured at a 1 meter test distance with the application of a distance correction factor.
- 3. Average test would be performed if the peak result were greater than the average limit.
- 4. Field strength( $dB\mu N/m$ ) = Level( $dB\mu N$ ) + CF(dB) + or F<sub>d</sub>(dB) + or DCF(dB)
- 5. CF(Correction factors(dB)) = Antenna factor(dB/m) + Cable loss(dB) + or Amp. gain(dB)
- 6. Margin(dB) = Limit(dB $\mu$ V/m) Field strength(dB $\mu$ V/m)
- 7. To get a maximum emission level from the EUT, the EUT was moved throughout the XY, XZ and YZ planes.
- 8. f < 30 MHz, extrapolation factor of 40 dB/decade of distance.  $F_d = 40 \log(D_m / D_s)$
- $f \ge 30$  MHz, extrapolation factor of 20 dB/decade of distance.  $F_d = 20\log(D_m / D_s)$

Where:

- $F_d$  = Distance factor in dB
- D<sub>m</sub> = Measurement distance in meters
- D<sub>s</sub> = Specification distance in meters
- DCF = duty cycle correction factor
- 9. According to exploratory test no any obvious emission were detected from 9 klz to 30 Mlz. Although these tests were performed other than open area test site, adequate comparison measurements were confirmed against 30 m open are test site. Therefore sufficient tests were made to demonstrate that the alternative site produces results that correlate with the ones of tests made in an open field based on KDB 414788.



# Limit

According to 15.209(a), for an intentional radiator devices, the general required of field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values :

Frequency (Mz)	Distance (Meters)	Radiated (µV/m)
$0.009 \sim 0.490$	300	2400/F(kHz)
0.490 ~ 1.705	30	24000/F(kHz)
1.705 ~ 30.0	30	30
30 ~ 88	3	100**
88~216	3	150**
216 ~ 960	3	200**
Above 960	3	500

\*\*Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands  $54 \sim 72$  Mb,  $76 \sim 88$  Mb,  $174 \sim 216$  Mb or  $470 \sim 806$  Mb. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

According to RSS-Gen, Except when the requirements applicable to a given device state otherwise, emissions from licence-exempt transmitters shall comply with the field strength limits :

Frequency (MHz)	Distance (Meters)	Radiated ( $\mu$ /m)
$0.009 \sim 0.490$	300	2 400 / F(kHz)
$0.490 \sim 1.705$	30	24 000 / F(kHz)
1.705 ~ 30.0	30	30
30 ~ 88	3	100
88~216	3	150
216~960	3	200
Above 960*	3	500

\* Unless otherwise specified, for all frequencies greater than 1 GHz, the radiated emission limits for licenceexempt radio apparatus stated in applicable RSSs (including RSS-Gen) are based on measurements using a linear average detector function having a minimum resolution bandwidth of 1 MHz. If an average limit is specified for the EUT, then the peak emission shall also be measured with instrumentation properly adjusted for such factors as pulse desensitization to ensure the peak emission is less than 20 dB above the average limit.

Note: Transmitting devices are not permitted in restricted frequency bands unless stated otherwise in the specific RSS.



# **Duty cycle**

Test mode	T <sub>on</sub> time	Period	Duty cycle	Duty cycle	Duty cycle correction factor
	(ms)	(ms)	(Linear)	(%)	(dB)
GFSK	100.00	100.00	1	100	0

Duty cycle (Linear) = T<sub>on</sub> time/Period

Spectrum	Spectrum 2	×	Spectrum 3	X Spe	ctrum 4	×	4
Ref Level 26.0 Att SGL	0 dBm Offset 25 dB e SWT	20.72 dB 4 100 ms	RBW 5 MHz VBW 5 MHz				
1Pk Clrw							 
20 dBm-					-		 
10 d8m-					-		
0 dBm							
-10 dBm							 
-20 dBm			+ +				 
-30 d8m							 
-40 dBm			-				 
-50 dBm	_		+ +				 
-60 dBm							
-70 dBm							
CF 2.441 GHz		1	691 p	ts			 10.0 ms/
1					Ready	REAR	

Note.

1. Radiated test is performed with Non hopping Mode

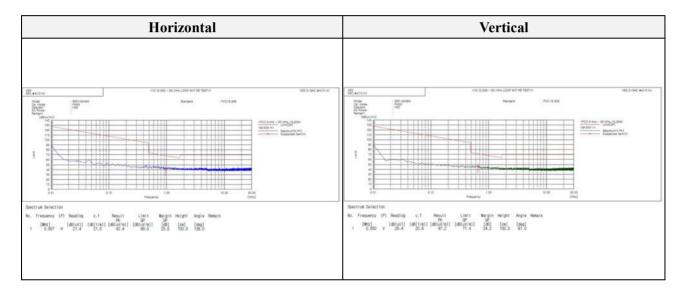


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<b>Test resul</b>	ts (Below 3	0 M⊞z)
-------------------	-------------	--------

Mode:	GFSK
Distance of measurement:	3 meter
Channel:	01 (Worst case)

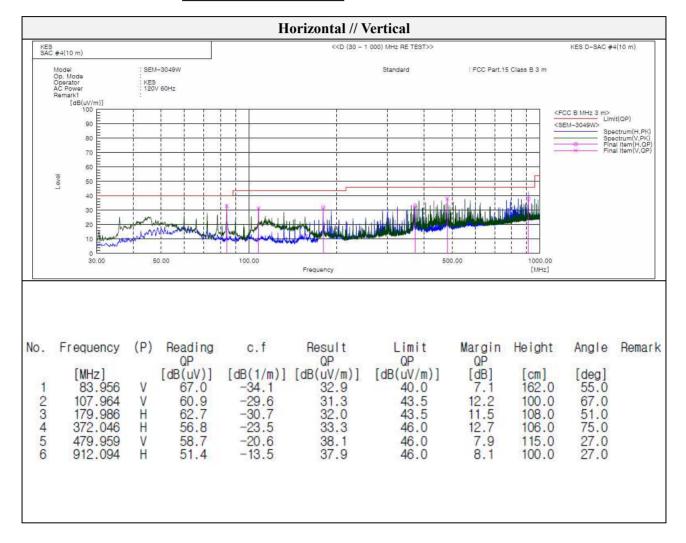
- Spurious	5						
Frequency (Mbz)	Reading (dBµN)	Ant. Pol. (H/V)	CF (dB)	Distance factor (dB)	Field strength (dBµN/m)	Limit (dBµN/m)	Margin (dB)
0.957	21.40	Н	21.00	- 40.00	2.40	27.98	25.58
0.650	26.40	V	20.80	- 40.00	7.20	31.34	24.14





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Test results (Below 1 000 Mz)					
Mode:	GFSK				
Distance of measurement:	3 meter				
Channel:	01 (Worst case)				





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# Test results (Above 1 000 Mz)

Mode:	GFSK
Distance of measurement:	3 meter
Channel:	01

- Spurio	us							
Frequency (畑)	Level (dBµN)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBµV/m)	Limit (dBµV/m)	Margin (dB)
1 843.70	52.71	Peak	Н	-2.62	-	50.09	74.00	23.91
2 639.70	52.17	Peak	V	0.49	-	52.66	74.00	21.34
4 813.00	49.23	Peak	Н	7.66	-	56.89	74.00	17.11
4 813.00	34.68	Average	Н	7.66	-	42.34	54.00	11.66
3 814.00	43.18	Peak	V	3.23	-	46.41	74.00	27.59

# Band edge

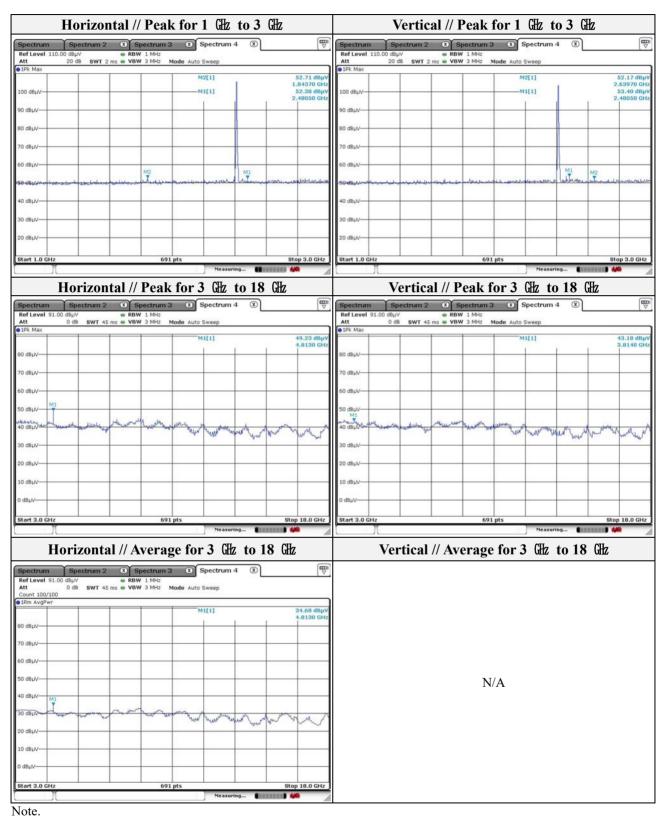
- Danu C	uge							
Frequency (Mz)	Level (dBµN)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2 332.04	51.43	Peak	Н	-0.33	-	51.10	74.00	22.90
2 345.59	50.09	Peak	V	-0.30	-	50.60	74.00	23.40

Rest	tricted band //	/ Horizontal /	// Peak		Restri	cted ban	d // Vertica	al // Pe	ak	
Spectrum         Spectrum           Ref Level 110.00 dBµV         Att         20 dB           Att         20 dB         Att         20 dB		Mode Auto FFT		Spectrum Ref Level 1 Att		· RBW 1 M	Hz Hz Mode Auto FFT			<b>₽</b>
(AP) Max     (0) dBuV     (0) dBuV	M3	M3[1] M1[1]	51,43 dBµV 2,35240 GHz 40,41 dBµV 2,510600 GHz 2,510600 GHz 40,41 dBµV 2,510600 GHz 7,10600 GHZ	100 dBµV 90 dBµV 80 dBµV 70 dBµV 60 dBµV		w w w	M3(1) M1(1)	M2 M2 P2	2.3	50.90 dBµV 45590 GHz 48.44 dBµV 10000 GHz
Start 2.3 GHz	69	11 pts	Stop 2.42 GHz	Start 2.3 GH	z		691 pts		Stop	2.42 GHz
Marker         Type         Ref         Trc           M1         1         1           M2         1         1           M3         1         1	X-value         Y-value           2.31 GHz         49.61 d           2.39 GHz         49.24 d           2.33204 GHz         51.43 d	ВµV ВµV	Function Result	Marker Type Ref M1 M2 M3	1 2	2.31 GHz 48.4 2.39 GHz 49.1	4 dBµV 8 dBµV 0 dBµV		ction Result	

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1. Average test would be performed if the peak result were greater than the average limit.

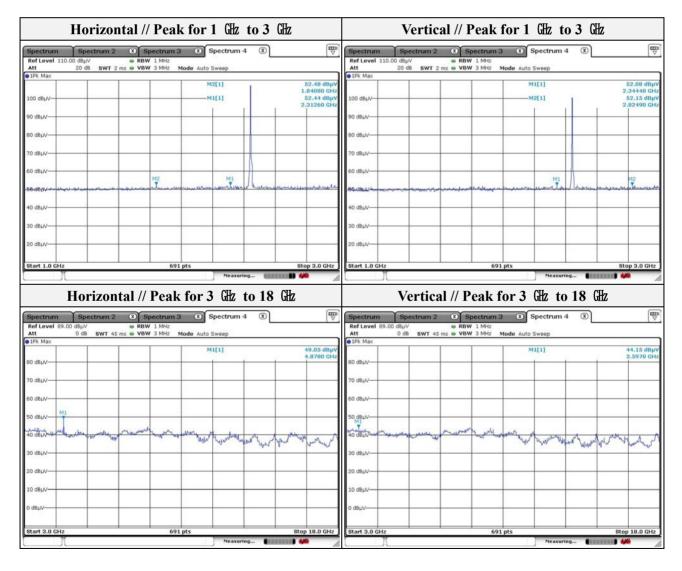
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Mode:	GFSK
Distance of measurement:	3 meter
Channel:	10

<u>- Spurio</u>	us							
Frequency (Mbz)	Level (dBµV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBµN/m)	Limit (dBµV/m)	Margin (dB)
1 840.80	52.48	Peak	Н	-2.65	-	49.83	74.00	24.17
2 824.90	52.15	Peak	V	1.17	-	53.32	74.00	20.68
4 878.00	49.05	Peak	Н	8.17	-	57.22	74.00	16.78
4 878.00	36.27	Peak	Н	8.17	-	44.44	54.00	9.56
3 597.00	44.15	Peak	V	2.14	-	46.29	74.00	27.71



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Horizontal // A	Average for 3 GHz to	18 GHz	Vertical // Average for 3 GHz to 18 GHz
Ref Level 89.00 dBµV 😐 RE	Spectrum 3 Spectrum 4 3 W 1 MHz 3W 3 MHz Mode Auto Sweep		
80 dBµV	M1[1]	36.27 dBµV 4.8780 GHz	
70 dBµV-			
60 dBµV			
50 dBµV			N/A
40 dBµV M1	muser and and		
20 dBµV	and manufacture warden of	man	
10 dBµV			
0 dBµV			
Start 3.0 GHz	691 pts	Stop 18.0 GHz	
1	Measuring	BREERE MARKEN	

Note.

1. Average test would be performed if the peak result were greater than the average limit.



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Mode:	GFSK
Distance of measurement:	3 meter
Channel:	20

- Spurio	us							
Frequency (Mbz)	Level (dBµN)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBµN/m)	Limit (dBµN/m)	Margin (dB)
1 936.30	53.37	Peak	Н	-1.64	-	51.73	74.00	22.27
1 947.90	51.77	Peak	V	-1.52	-	50.25	74.00	23.75
8 980.00	44.37	Peak	Н	13.15	-	57.52	74.00	16.48
8 980.00	32.64	Average	Н	13.33	-	45.97	54.00	8.03
8 915.00	43.39	Peak	V	13.29	-	56.68	74.00	17.32
8 894.00	32.55	Average	V	13.33	-	45.88	54.00	8.12

- Band e	edge							
Frequency (Mbz)	Level (dBµV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBµN/m)	Limit (dBµN/m)	Margin (dB)
2 483.75	58.20	Peak	Н	-0.05	-	58.15	74.00	15.85
2 483.50	49.10	Average	Н	-0.05	-	49.05	54.00	4.95
2 483.85	53.44	Peak	V	-0.05	-	53.39	74.00	20.61

<b>Restricted band // Horizontal // Peak</b>	Restricted band // Vertical // Peak
Spectrum 2 🗴 Spectrum 3 🗴 Spectrum 4 🗶	Spectrum Spectrum 2 (X) Spectrum 3 (X) Spectrum 4 (X)
Ref Level 108.00 dBµV         RBW 1 MHz           Att         20 dB         SWT 5.7 µs         VBW 3 MHz         Mode Auto FFT           DFM Max         DFM Max         Mode Auto FFT         DFM Max	Ref Level         108.00         dBµV         ■ RBW         1 MHz           Att         20 dB         SWT 5.7 µs         ■ VBW         3 MHz         Mode         Auto FFT           6 µFK Max         60 µs         1 MHz         1 MHz
M3[1]         SB.20 dBµV           100 dBµV         M1[1]         2.4837480 GHz           90 dBµV         M1[1]         2.4835000 GHz           80 dBµV         2.4835000 GHz         2.4835000 GHz           90 dBµV         90 dBµV         90 dBµV         90 dBµV           50 dBµV         90 dBµV         90 dBµV         90 dBµV           60 dBµV         90 dBµV         90 dBµV         90 dBµV           50 dBµV         90 dBµV         90 dBµV         90 dBµV	M3[1] 53.44 dBµ 100 dBµV- M1[1] 52.94 dBµ M1[1] 52.94 dBµ
20 dBµV F1 F2	20 dBµV F1 F2
Start 2.47 GHz 691 pts Stop 2.51 GHz	Start 2.47 GHz 691 pts Stop 2.51 GHz
Marker         Yupe         Ref         Trc         X-value         Y-value         Function         Function Result           M1         1         2.4835 GHz         57.19 dBµV </td <td>Marker         Type         Ref         Trc         X-value         Y-value         Function         Function Result           M1         1         2.4835 GHz         52.84 dBµV  <!--</td--></td>	Marker         Type         Ref         Trc         X-value         Y-value         Function         Function Result           M1         1         2.4835 GHz         52.84 dBµV </td



Test report No.: KES-RF-18T0122 Page (32) of (41)

Restricted band // Horizontal // Average	Restricted band // Vertical // Average
Spectrum         Spectrum 2         Spectrum 3         Spectrum 4         The sector of the secto	N/A
M3 1 2.4835 GHz 49.10 dByV Horizontal // Peak for 1 GHz to 3 GHz	Vertical // Peak for 1 GHz to 3 GHz
Spectrum         Spectrum 2         Spectrum 3         Spectrum 4         Image: Control of the sector of the	Spectrum         Spectrum 2         Spectrum 3         Spectrum 4         2         min           Ref Level 110.00 dBµ/ Att         € RBW 1 MHz         Ref Level 110.00 dBµ/ Att         € RBW 1 MHz         min         Im
19k Max         M2[1]         53.37 dbyv           100 dbyv	
Spectrum         Spectrum 2         Spectrum 3         Spectrum 4         Tmp           Ref Level 69.00 dB/V <ul></ul>	Spectrum         Spectrum 2         Spectrum 3         Spectrum 4         Imm           Ref Level 89.00 dBµV         ← R8W 1 MHz         ■ R8W 1 MHz         Imm         Imm
	0 dBµV Stort 3.0 GHz 691 pts Stop 18.0 GHz Measuring

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Spectrum Sp			spectrum 4 🛞		Spectrum	Spectrum 2	× Spec				E .
Ref Level         89.00         dBµ^           Att         0         d8           Count         100/100         0			Sweep	1	Ref Level 89.0 Att Count 100/100		■ RBW 11 ms ■ VBW 31		uto Sweep		
1Rm AvgPwr		1975-A			1Rm AvgPwr			1000.0	0.000		
80 dBuV		1	41[1]	32.64 dBµV 8.8940 GHz	80 dBµV				M1[1]		32.55 dBp 8.8940 GF
NO GODA					00 0000						
70 dBµV					70 dBµV			-		+	
50 dBµV					60 dBµV						
50 dBµV					50 dBµV	-		-			
10 dBµV	M				40 dBµV	_	MI	-		-	
SO dBu	a at				30 dBuy		a and				
20 dBµV	man and an	man and when	man have bury	man	20 dBuV	and many		a many	whenewh	and my	mon
LO dBµV					10 dBµV						
0 dBµV				· · · · ·	0 dBµV				2		
Start 3.0 GHz		691 pts		Stop 18.0 GHz	Start 3.0 GHz			691 pts			Stop 18.0 GHa

Note.

1. Average test would be performed if the peak result were greater than the average limit.



Test report No.: KES-RF-18T0122 Page (34) of (41)

Test results (18 GHz to 30	GHz)
Mode:	GFSK
Distance of measurement:	3 meter
Channel:	01(Worst case)

Frequency	Level	Ant. Pol.	CF	F <sub>d</sub>	Field strength	Limit	Margin
(Mz)	(dBµN)	(H/V)	(dB)	(dB)	(dBµN/m)	(dBµN/m)	(dB)
		No spurious er	nissions were c	letected within	20 dB of the limi	t	

	Vertical
Spectrum         Spectrum 3         Spectrum 4         C           tef Level 90.00 dbµV	Spectrum         Spectrum 2         Spectrum 3         Spectrum 4         T           Ref Level 90.00 dBµV <ul></ul>
D dBuV	ВО dBuV 70 dBuV 60 dBuV 50 dBuV 40 dBuV 40 dBuV 10 dBuV 10 dBuV 10 dBuV
dBµV tart 18.0 GHz 691 pts Stop 30.0 GHz	0 d8µV

Note.

1. No spurious emission were detected above 18 GHz.



# 3.8 Conducted spurious emissions & band edge





# **Test procedure**

ANSI C63.10-2013 - Section 7.8.6 and 7.8.8

## Test setting

- 1. Span = Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products that fall outside of the authorized band of opera tion.
- 2. Reference level: As required to keep the signal from exceeding the maximum instrument input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level.
- 3. Attenuation: Auto (at least 10 dB preferred).
- 4. RBW = 100 kHz
- 5. VBW  $\geq$  300 kHz
- 6. Detector = Peak
- 7. Sweep time = auto couple
- 8. Allow the trace to stabilize.

## Limit

According to 15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph(b)(3) of this section , the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in section 15.209(a) is not required. In addition, radiated emission which in the restricted band, as define in section 15.205(a), must also comply the radiated emission limits specified in section 15.209(a) (see section 15.205(c))

According to RSS-247 issue 2 5.5, In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shal

1 be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided

that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a t ime interval, as permitted under Section 5.4(d), the attenuation required shall be 30 dB instead of 2 0 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

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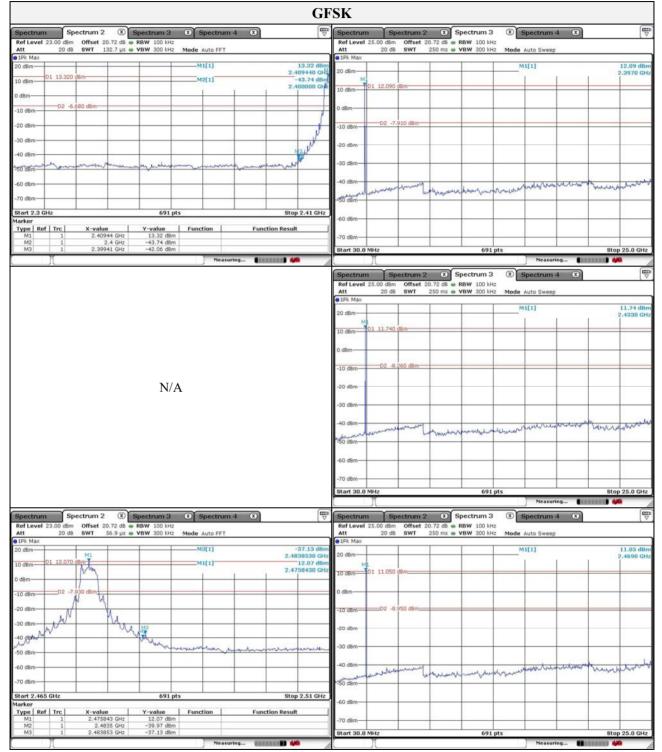
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## Test results



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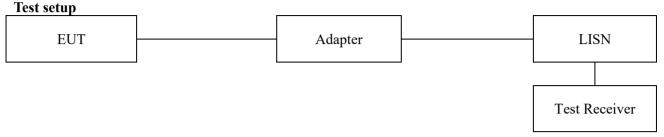
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							GFSK_I	Hoppir	ıg								
Spectrum	Υ	Spectrum 2	×s	Spectrum 3	Spectrur	n 4 🛞		Spectrum	Sp	ectrum 2	× S	pectrum 3	3 (8) 5	Spectrum	4 X		
Ref Level 30 Att	0.00 d			RBW 100 kHz VBW 300 kHz	Mode Auto FFT			Ref Level 2 Att	5.00 dBm 20 dB			RBW 100 k		Auto Sweep			
1Pk Max			Acto po e	1011 000 1112	House Autority			• 1Pk Max		0.111		1011 000 1	ie inoue	Nato Sheep			1111
20 dBm					M4[1]		-26.17 dBm 2.483840 GHz	20 d8m					M	1[1]			11.94 dBn 2.4330 GH
	13.3		W IL L	A MA MA	M1[1]		-38.33 dBm 2.400000 GHz	10 d8m D	1 11.940	dBm		-					
0 dBm	-02	-6.660 dBm	A.M.A	M.N.AV	14444V	wark	4	0 dBm									
-10 dBm	N	C. C.C.C. GLANT					4	-10 d8m-	-D2 -8.	060 dBm							
-30 dBm	V	-					W.	-20 dBm									
10,48M		-					Videdas	-30 d8m									
50 d8m								-40 dBm									
CF 2.441 GH	7			691 p	ts	8	pan 100.0 MHz	NS0 dem	and the second	mission	man	hourself	uppenabl	wenne	mun	Luchter	when
larker				051 p		0	Poil Toolo Mile	-SU OBIN									
Type Ref	Trc	X-valu	e 2.4 GHz	Y-value -38.33 dBm	Function	Function R	esult	-60 d8m				-					-
M2 M3	1	2.399	28 GHz 35 GHz	-30.69 dBm -32.83 dBm													
M3 M4	1	2.483	84 GHz	-26.17 dBm	1			-70 dBm									
M5	1	2.411	91 GHz	13.34 dBm			0	Start 30.0 M	Hz			69)	pts			Sto	25.0 GHz
	-				Meas	uring			1					Measur	ing 🚺		4



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# 3.9. AC conducted emissions



# Limit

According to 15.207(a), for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50uH/50 ohm line impedance stabilization network (LISN). Compliance with the provision of this paragraph shall on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower applies at the boundary between the frequencies ranges.

According to RSS-Gen Issue 5, 8.8, a radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in Table 3. Unless the requirements applicable to a given device state otherwise, for any radio apparatus equipped to operate from the public utility AC power supply either directly or indirectly (such as with a battery charger), the radio frequency voltage of emissions conducted back onto the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in Table 3 below. The more stringent limit applies at the frequency range boundaries.

The conducted emissions shall be measured in accordance with the reference publication mentioned in Section 3.

Execution of Emission (Mg)	Conducted li	mit (dBµN/m)
Frequency of Emission (Mb)	Quasi-peak	Average
0.15 - 0.50	66 - 56*	56 - 46*
0.50 - 5.00	56	46
5.00 - 30.0	60	50

## Note:

1. All AC line conducted spurious emission are measured with a receiver connected to a grounded LISN while the EUT is operating at its maximum duty cycle, at maximum power, and the appropriate frequencies. All data rates and modes were investigated for conducted spurious emission. Only the conducted emissions of the configuration that produced the worst case emissions are reported in this section.

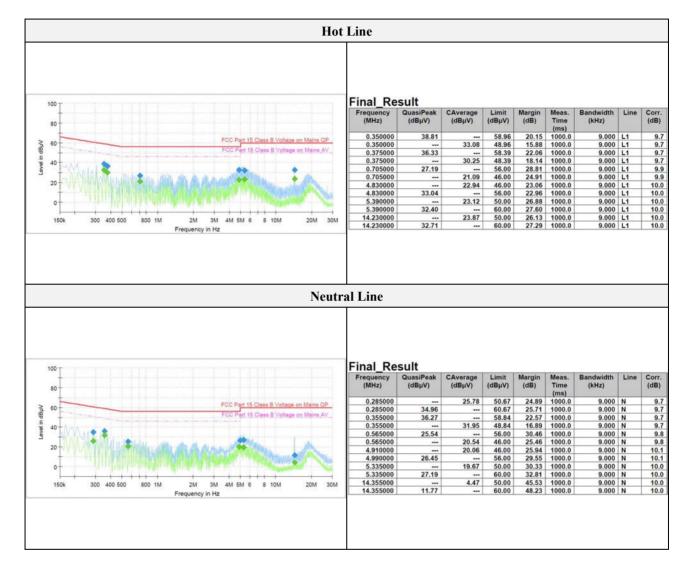
3. Both Cable loss and LISN factor are included in measurement level(QP Level or AV Level).

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# Test results





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Equipment	Manufacturer	Model	Serial No.	Calibration interval	Calibration due.
Spectrum Analyzer	R&S	FSV30	100736	1 year	2019.06.28
Spectrum Analyzer	R&S	FSV40	101002	1 year	2019.06.29
8360B Series Swept Signal Generator	HP	83630B	3844A00786	1 year	2019.01.22
Power Meter	Anritsu	ML2495A	1438001	1 year	2019.01.25
Pulse Power Sensor	Anritsu	MA2411B	1339205	1 year	2019.01.25
Attenuator	KEYSIGHT	8493C	82506	1 year	2019.01.22
Loop Antenna	Schwarzbeck	FMZB1513	225	2 years	2019.05.10
Trilog-broadband antenna	SCHWARZBECK	VULB 9163	9168-714	2 years	2020.11.26
Horn Antenna	A.H	SAS-571	414	2 years	2019.02.15
Horn Antenna	SCHWARZBECK	BBHA9170	BBHA 9170550	2 years	2019.02.15
High Pass Filter	Wainwright Instrument Gmbh	WHJS3000-10TT	1	1 year	2019.06.29
Low Pass Filter	Wainwright Instrument Gmbh	WLK1.0/18G-10TT	1	1 year	2019.06.29
Preamplifier	R&S	SCU01	100603	1 year	2019.11.26
Preamplifier	AGILENT	8449B	3008A01742	1 year	2019.01.11
EMI Test Receiver	R&S	ESR3	101783	1 year	2019.04.25
EMI Test Receiver	R&S	ESU26	100551	1 year	2019.04.11
LISN	R&S	ENV216	101137	1 year	2019.01.31

# Appendix A. Measurement equipment

#### **Peripheral devices**

Device	Manufacturer	Model No.	Serial No.
-	-	-	-