Test Report No. 9412320084

Applicant: *TALGIL Computing&Control Ltd.*

RF module G4.5
Model: G4.5

From The Standards Institution
Of Israel
Industry Division
Electronics & Telematics Laboratory
EMC Branch

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Table of contest

1. Applicant information

Applicant:	TALGIL Computing&Control Ltd.
Address:	Na'aman Center, Kiryat Motzkin, Israel
Sample for test selected by:	The customer
The date of tests:	9,13 July 2014

Equipment under test information

Description of Equipment Under Test (EUT):	RF module G4.5
Model:	G4.5
Hardware version:	1.0.0
Serial Number:	NA
Manufactured by:	TALGIL Computing&Control Ltd.

2. Test performance

Location:	SII EMC Branch
Purpose of test:	Apparatus compliance verification in accordance with emission requirements
Test specifications:	47CFR part 15.247, part 1 §1.1310

Reference Documents:

CFR 47 FCC:	Rules and Regulations; Part 15. "Radio frequency devices"; Subpart C: "Intentional radiators"

This Test Report contains 30 pages and may be used only in full.	This Test Report applies only to the specimen tested and may not be applied to other specimens of the same product.

3. Summary of test

The EUT was found to be in compliance with requirements of: 47CFR Part 15, §§ 15.247, 15.209.

Transmitter characteristics	Subclasses
Minimum 6 dB bandwidth	15.247(a)(2)
Maximum output power	15.247(b)(3)
Out of band spurious emissions radiated	15.205, 15.247(d)
Peak power spectral density	15.247(e)
Conducted emissions on AC power line	15.207. Not applicable. Battery option only.
Unwanted radiated emissions below 1 GHz	15.209

Electronics and
Telematics Branch

21 July 2014

Name: Eng. Yuri Rozenberg
Position: Head of EMC Branch

Name: Michael Feldman
Position: Test Technician

Measurement uncertainty.

Were relevant, the following measurement uncertainty level have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:
This uncertainty represents an expended uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

Test description	Expanded uncertainty
Radiated emissions in the open field test site at 3 m measuring distance: 30 MHz – 1.0 GHz 1.0 GHz – 18 GHz	 2 Uc (E) = ± 4.32 dB 2 Uc (E) = ± 4.47 dB

4. Equipment under test description.

*The customer provided description.

4.1 General description

The G4.5 RF transceiver module is a part of wireless control system for irrigation in agriculture. It use as a master or slave remote unit for communication in 902 – 928 MHz frequency band on one of 16 frequency channels defined by address DIP switch.
The "RF module G4.5" is based on Semtech Ltd. transceiver SX1277 patented LoRaTM (Long Range) digital modulation technique.

EUT technical characteristics

Transmitter technical characteristics.			**Note**
Stand-alone/fixed use			
Assigned frequency range	902 MHz – 928 MHz		
Operating frequency range	903.75 MHz – 926.25 MHz		
RF channel spacing	1.5 MHz		
Conducted output power	13 dBm		
Antenna connection	SMA		
Type of modulation	LoRaTM proprietary spread spectrum technique.		
Modulating test signal (baseband)	PRBS		
Antenna information			
Type	**Manufacturer**	**Model**	**Gain, dBi**
Internal Omni antenna	V.Tourch	VTGSMA-83	5

5. Environmental evaluation and exposure limit according to FCC part 1, §1.1307, §1.1310

Limit for power density for general population/uncontrolled exposure is 0.6 mW/cm^2.
The power density calculation is $S = [(Pt/0.6)/4\pi r^2]$.
Where:
Pt - The transmitted power (EIRP) (mW)
r - The distance from the unit. (cm)
The limit 0.6 mW/cm^2 can be calculated from the above based on the following data:
Pt- the transmitted power whish is equal to the maximum peak output power 12.93 dBm plus internal antenna gain 5 dBi . The maximum peak EIRP = 17.93 dBm = 62.1 mW
Maximum allowed distance "r", where RF exposure limits may not be exceeded,
r = SQRT(103.5/4π) and is more than 3 cm from the antenna main lobe.

6. EUT block diagram and test configuration.

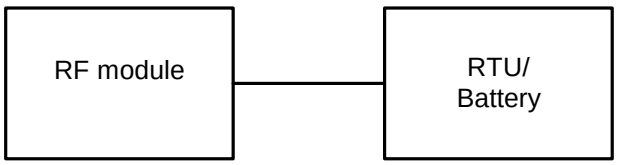


Fig. 1. EUT block diagram.

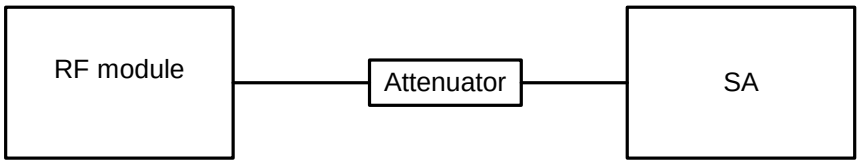


Fig. 2. Conducted measurements block diagram.

7. Test results

7.1 Transmitter characteristics

7.1.1 Occupied 6 dB bandwidth for digitally modulated systems.

Method of measurement		**558074 D01 DTS Meas Guidance. Section 8.2**			
Operating Frequency Range		**903.75– 926.25 MHz**			
Detector used		**Peak**			
Resolution bandwidth		**>1 % OBW**			
Video bandwidth		**> 3 x RBW.**			
Trace mode		**Max Hold.**			
Sweep time:		**Auto couple.**			
Ambient Temperature	**24^0 C**	**Relative Humidity**	**51%**	**Air Pressure**	**1009 hPa**

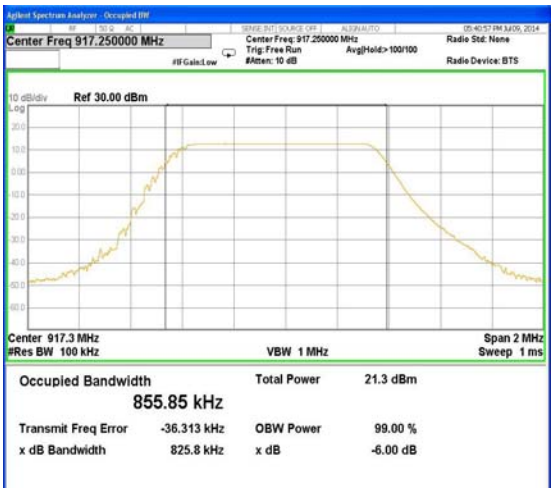
The minimum 6 dB bandwidth shall be at least 500 kHz.

Carrier frequency MHz	Measured 6 dB bandwidth, kHz	Reference to plots#
903.75	826	1
917.25	825	2
926.25	800	3

TEST EQUIPMENT USED:

1	3	5				

Plot # 1



Plot # 2

Plot # 3

7.1.2 Maximum peak conducted output power test according to §15.247 (b)(3).

Method of measurement		**558074 D01 DTS Meas Guidance. Section 9.1.1**			
Operating Frequency Range		**903.75– 926.25 MHz**			
Detector used		**Peak**			
Resolution bandwidth		**1 MHz**			
Video bandwidth		**> RBW.**			
Trace mode		**Max Hold.**			
Ambient Temperature	**24^0 C**	**Relative Humidity**	**47%**	**Air Pressure**	**1007 hPa**

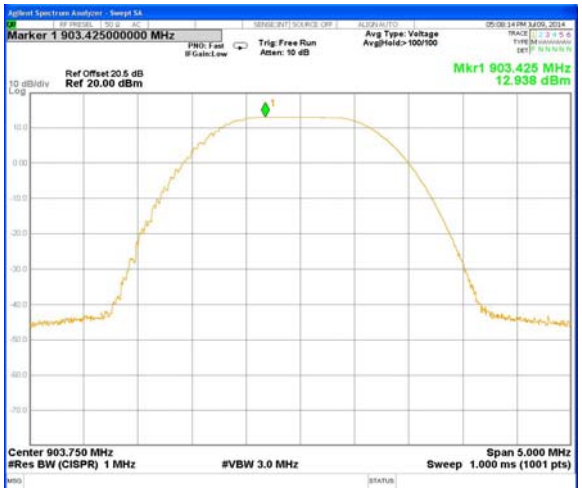
For systems using digital modulation in the 902 – 928 MHz frequency band: 1W (30 dBm).
The conducted output power limit is based on use with antennas with directional gains that do not exceed 6 dBi.

Carrier frequency MHz	Measured Peak output power, dBm	Power limit dBm	Margin, dBm	Reference to plot #
903.75	12.93	30	17.07	4
917.25	12.55	30	17.45	5
926.25	12.27	30	17.73	6

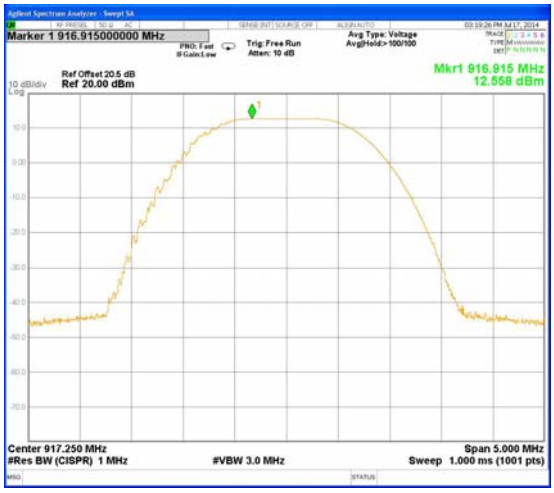
TEST EQUIPMENT USED:

1	3	5				

Peak output power results



Plot # 4



Plot # 5

Plot # 6

Insertion loss of external attenuator and cable = 20.5 dB.

7.1.3 Radiated emissions out of band test according to §15.247(d), 15.205

Method of measurement		**558074 D01 DTS Meas Guidance. Section 11.3, 12.2.5.1**			
Operating Frequency Range		**903.75– 926.25 MHz**			
Detector used		**Trace 1 – peak; Trace 2 – RMS (power averaging).**			
Resolution bandwidth		**120 kHz/1 MHz**			
Video bandwidth		**> RBW.**			
Trace mode		**Max Hold.**			
Ambient Temperature	**24^0 C**	**Relative Humidity**	**47%**	**Air Pressure**	**1007 hPa**

In any 100 kHz bandwidth outside the frequency band the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below in band highest level desired power.
Radiated emissions, which fall in the restricted bands, must comply with the radiated emissions limit specified in section 15.205(c).

Carrier frequency 903.75 MHz.

Frequency, MHz	Radiated emissions, dBµV/m	Avg limit, dBµV/m	Margin, dB	Note	Reference to plot#
2751.9	36.7	54	16.9	Restricted Band	12
3669.2	41.1	54	12.9	Restricted Band	13

Carrier frequency 917.25 MHz

Frequency, MHz	Radiated emissions, dBµV/m	Avg limit, dBµV/m	Margin, dB	Note	Reference to plot#
2751.9	36.7	54	17.3	Restricted Band	18
3669.2	42.1	54	11.9	Restricted Band	19

Carrier frequency 926.25 MHz

Frequency, MHz	Radiated emissions, dBµV/m	Avg limit, dBµV/m	Margin, dB	Note	Reference to plot#
2778.9	37.5	54	16.5	Restricted Band	25
3704.9	41.6	54	12.4	Restricted Band	26

TEST SAMMARY

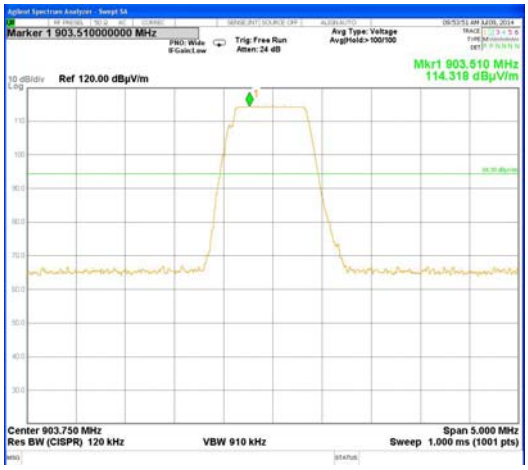
All emissions outside of the 902 – 928 MHz frequency band were found below 15.247(d) limits.

TEST EQUIPMENT USED:

1	8	10	15			

Carrier frequency – 903.75 MHz

Plot # 7



Plot # 8

Plot # 9

Plot # 10

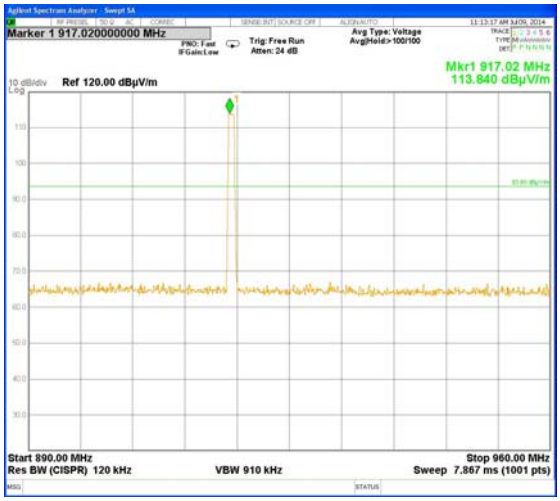
Plot # 11

Plot # 12

Plot # 13.

Carrier frequency – 917.25 MHz

Plot # 14



Plot # 15

Plot # 16

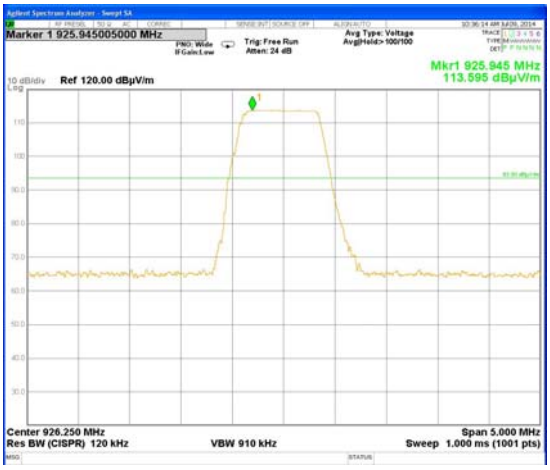
Plot # 17

Plot # 18

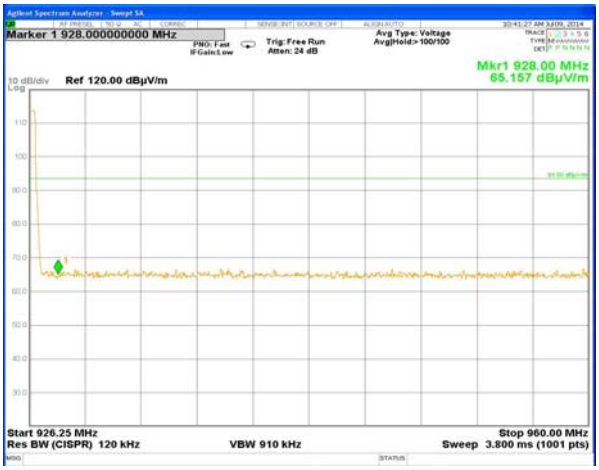
Plot # 19

Carrier frequency – 926.25 MHz.

Plot # 20



Plot # 21



Plot # 22

Plot # 23

Plot # 24

Plot # 25


Agilent Spectrum Analyzer - Swept SA
Marker 1 3.704225000000 GHz
PREAMP
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 2 dB
Avg Type: RMS
Avg|Hold:>100/100
Mkr1 3.704 225 GHz
51.080 dBµV/m
10 dB/div
Ref 68.99 dBµV/m
Log
Center 3.705000 GHz
Res BW (CISPR) 1 MHz
VBW 2.0 MHz*
Span 5.000 MHz
Sweep 1.000 ms (1001 pts)
1 N 1 f 3.704 225 GHz 51.080 dBµV/m
2 N 2 f 3.704 920 GHz 41.627 dBµV/m
3
4
MSG
STATUS

Plot # 26.

7.1.4 Power spectral density of digitally modulated systems according to § 15.247(e)

Method of measurement		**558074 D01 DTS Meas Guidance. Section 10.2**				
Operating Frequency Range		**903.75– 926.25 MHz**				
Detector used		**Peak**				
Resolution bandwidth		**3 kHz**				
Video bandwidth		**> 3 x RBW.**				
Trace mode		**Max Hold.**				
Sweep time		**Auto couple**				
Ambient Temperature	**24^0 C**	**Relative Humidity**	**47%**	**Air Pressure**		**1007 hPa**

For digitally modulated systems the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

Carrier frequency MHz	Measured PSD dBm	Specified limit dBm	Margin, dB	Reference to plot #
903.75	-0.10	8	7.9	27
917.25	-0.56	8	7.44	28
926.25	-0.74	8	7.26	29

TEST EQUIPMENT USED:

1	3	5				

Plot # 27

Plot # 28

Plot # 29

8. Radiated emissions test according to § 15.209

Method of measurement		ANSI C63.4 §13.4			
Operating Frequency Range		903.75 – 926.25 MHz			
Ambient Temperature	22^0 C	Relative Humidity	58%	Air Pressure	1009 hPa

TEST DESCRIPTION:

The measurements were performed at the Anechoic chamber at a 3 m test distance. EUT was arranged on a polystyrene table 0.8 m height placed on the turn - table. The Active Loop antenna 1.0 - 30 MHz frequency range was used. The frequency range was investigated from 0.15 MHz to 30 MHz and the measurements were performed at each frequency at which the signal was 10 dB below the limit or less. The level was maximized by initially rotating turntable through 360°.

REQUIREMENTS:

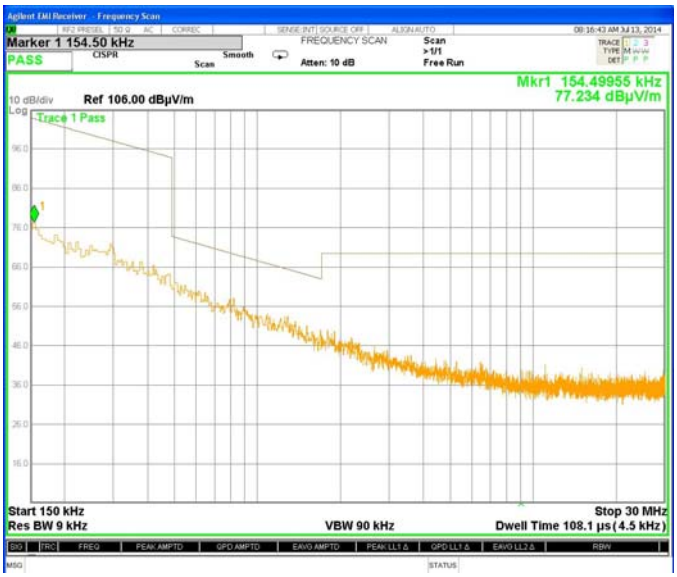
EUT radiated emission shall not exceeds value required in section 15.209

TEST RESULT:

Test result is presented in the Plot# 30.

TEST EQUIPMENT USED:

1	15	17				


Agilent EMI Receiver - Frequency Scan
Marker 1 154.50 kHz
PASS
CISPR
Scan
Smooth
FREQUENCY SCAN
Atten: 10 dB
Scan
>1/1
Free Run
Mkr1 154.49955 kHz
77.234 dBµV/m
10 dB/div
Log
Ref 106.00 dBµV/m
Trace 1 Pass
Start 150 kHz
Res BW 9 kHz
VBW 90 kHz
Stop 30 MHz
Dwell Time 108.1 µs (4.5 kHz)

Plot # 30.

9. Conducted emissions test according to § 15.207

Method of measurement		ANSI C63.4 §13.3			
Operating Frequency Range		903.75 – 926.25 MHz			
Ambient Temperature	23^0 C	Relative Humidity	56%	Air Pressure	1009 hPa

Frequency, MHz	Class B equipment, dB (μV)	
	QP	AVRG
0.15 - 0.5	66 - 56*	56 - 46*
0.5 - 5	56	46
5 - 30	60	50

* Decreases with the logarithm of the frequency.

TEST PROCEDURE

EUT was placed on a wooden table in a shielded chamber at a height of 80 cm from the floor and 40 cm from the vertical reference plane. The measurements were performed at mains terminals by means of LISN, connected to spectrum analyzer in the frequency range as referred to in the table above. The measurements were made with quasi-peak (CISPR) and average detectors. The position of the EUT cables was varied to determine maximum emission level.

TEST RESULT:

Test not applicable. EUT has battery power option only.

TEST EQUIPMENT USED:

10	11	12				

10. APPENDIX A

Photo 1. RF conducted emission test.

Photo 2. Radiated emissions test.

Photo 3. Radiated emissions test.

11. APPENDIX B

Test equipment used

No	Description	Manufacturer information			Due Calibration date
		Name	Model	Serial No	
1	MXE EMI Receiver 20 Hz -26.5 GHz	Agilent	N9038A	SII 650114	Feb. 2015
2	EXA Signal Analyzer 10 Hz - 26.5 GHz	Agilent	N9010A	MY51250920	April 2015
3	Attenuators 20 dB DC – 12 GHz	HP	8491A	50480	June 2015
4	Power splitter 1.7 – 9.0 GHz	Mini-Circuits	ZN2PD-9G-S+	SF900801038	May 2015
5	Cable RF 1.0m	ENP Connectivity Solutions	X116LCX10040	10-11-002	October 2014
6	EPM Series Power Meter	HP	E4418A	US38261895	May 2015
7	E-Series Avg. Power Sensor 10 MHz – 6.0 GHz	Agilent	E9301A	MY41498740	May 2015
8	Double Ridged Guide Antenna 0.75 – 18 GHz	ETS-Lindgren	3115	00143138	September 2014
9	Broadband Horn antenna 15 – 40 GHz	Schwarzbeck Mess-Electronik	BBHA 9170	9170-341	Jan.2015
10	Antenna Biconilog 26 – 6000 MHz	ETS-Lindgren	31142D	0146490	Dec. 2014
11	Spectrum analyzer 20 Hz-40 GHz	Rohde&Schwarz	ESU 40	100168	Nov. 2014
12	EMI Receiver 9 kHz-6.5 GHz	HP	8546A+85460A	SII 4068	May 2015
13	LISN 9 kHz – 30 MHz	FCC	LISN 250-32-4-16	SII5023	October 2014
14	Transient limiter 0.009-200 MHz	HP	11947A	3107105	Aug. 2014
15	Cable RF 4m	Huber-Suhner	Sucoflex 104PE	21328/4PE	October 2014
16	Cable RF 0.5m	Huber-Suhner	Multiflex 141	520201	October 2014
17	Active Loop antenna 1.0 kHz – 30 MHz	ETS-Lindgren	6507	00144641	Jan. 2015

Cable Loss (Mast RG-214 6 m cable.)

Point	Frequency (MHz)	Cable Loss (dB)	Point	Frequency (MHz)	Cable Loss (dB)
1	30	0.3	21	1000	2.5
2	50	0.4	22	1100	2.6
3	100	0.6	23	1200	2.8
4	150	0.8	24	1300	2.9
5	200	1.0	25	1400	3.1
6	250	1.1	26	1500	3.2
7	300	1.2	27	1600	3.3
8	350	1.3	28	1700	3.5
9	400	1.5	29	1800	3.6
10	450	1.6	30	1900	3.7
11	500	1.7	31	2000	3.9
12	550	1.8	32	2100	4.0
13	600	1.9	33	2200	4.1
14	650	1.9	34	2300	4.2
15	700	2.0	35	2400	4.4
16	750	2.1	36	2500	4.6
17	800	2.1	37	2600	4.7
18	850	2.2	38	2700	4.8
19	900	2.3	39	2800	4.9
20	950	2.4	40	2900	5.0

Cable Loss
Type: Sucoflex 104PE; Ser.No.21328/4PE; 4 m length

Point	Frequency (GHz)	Cable Loss (dB)
1	0.0-1.0	1.7
2	1.0– 3.5	3.2
3	3.5– 5.5	4.0
4	5.5 – 7.5	4.7
5	7.5 – 9.5	5.3
6	9.5 – 10.5	5.6
7	10.5 – 12.5	6.2
8	12.5 – 14.5	6.8
9	14.5 – 16.5	7.5
10	16.5 – 18.0	8.1

Antenna factor
Biconilog Antenna, ETS-Lindgren mod. 31142D, S/N: 0146490 3m calibration.

No.	f / MHz	AF / dB/m	f / MHz	AF / dB/m	f / MHz	AF / dB/m
1	30	18.7	250	12.0	2750	31.0
2	35	15.7	300	13.8	3000	31.2
3	40	12.9	400	16.2	3250	32.7
4	45	10.6	500	18.6	3500	34.5
5	50	9.0	600	20.2	3750	34.3
6	60	7.3	700	21.8	4000	34.5
7	70	7.7	800	22.9	4250	35.3
8	80	8.2	900	24.1	4500	35.5
9	90	9.2	1000	24.8	4750	36.1
10	100	9.4	1250	26.9	5000	37.4
11	120	8.5	1500	30.2	5250	38.4
12	140	8.5	1750	28.5	5000	39.9
13	160	9.1	2000	28.9	5750	38.2
14	180	10.5	2250	29.8	6000	39.1
15	200	10.9	2500	32.5		

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Model: G4.5 **FCC ID: 2AC2T-RF-MODULE-45**

Antenna Factor
Double Ridged Guide Antenna mfr ETS-Lindgren model 3115 1m calibration

Point	Frequency (MHz)	Antenna Factor (dB/m)
1	1000	23.7
2	1500	25.5
3	2000	28.5
4	2500	28.1
5	3000	29.6
6	3500	31.1
7	4000	32.5
8	4500	32.5
9	5000	33.5
10	5500	34.7
11	6000	36.1
12	6500	36.5
13	7000	37.3
14	7500	38.0
15	8000	37.3
16	8500	37.9
17	9000	38.1
18	9500	38.5
19	10000	38.7
20	10500	38.8
21	11000	38.6
22	11500	38.8
23	12000	38.9
24	12500	39.3
25	13000	40.2
26	13500	40.6
27	14000	40.6
28	14500	40.4
29	15000	39.6
30	15500	39.5
31	16000	39.8
32	16500	40.4
33	17000	41.3
34	17500	42.6
35	18000	43.2

Antenna Factor
Broadband Horn Antenna model BBHA 9170 1m calibration

Point	Frequency (GHz)	Antenna Factor (dB/m)
1	15.0	38.5
2	16.0	37.7
3	17.0	38.1
4	18.0	37.9
5	19.0	38.0
6	20.0	38.0
7	21.0	37.9
8	22.0	38.2
9	23.0	39.6
10	24.0	39.6
11	25.0	39.3
12	26.0	39.5
13	27.0	39.6
14	28.0	39.6
15	30.0	40.1
16	32.0	41.2
17	34.0	41.5
18	35.0	41.9
19	36.0	42.2
20	38.0	43.8
21	40.0	43.2

12. APPENDIX C

Abbreviations and acronyms

The following abbreviations and acronyms are applicable to this test report:

AC	alternating current
cm	centimeter
dB	decibel
dBm	decibel referred to one milliwatt
dB(μV)	decibel referred to one microvolt
dB(μV/m)	decibel referred to one microvolt per meter
EBW	emission bandwidth.
EMC	electromagnetic compatibility
EUT	equipment under test
GHz	gigahertz
H	height
Hz	hertz
kHz	kilohertz
L	length
LNA	low noise amplifier
m	meter
Mbps	megabit per second
MHz	megahertz
NA	not applicable
OFDM	Orthogonal Frequency Division Multiple Access
PRBS	pseudo random binary sequence
QP	quasi-peak
RF	radio frequency
RE	radiated emission
SA	spectrum analyzer
rms	root mean square
W	width

Specification references

47 CFR part 15: 2014	Radio Frequency Devices
ANSI C63.4: 2009	American National Standard for Method of Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz