



DATE: 21 June 2020

I.T.L. (PRODUCT TESTING) LTD.
FCC/IC Radio Test Report
for
Orpak Systems Ltd.

Equipment under test:

nWGT-W (Nano Wireless Gateway Terminal)

**nWGT-W Outdoor unit W/P.S;
nWGT-W Outdoor unit W/O P.S*;
nWGT-W (Pump, SAM x1, LAN))***

*See customer declaration on page 12

Tested by:

M. Zohar

Approved by:

D. Shidlowsky

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This report relates only to items tested.



Measurement/Technical Report for Orpak Systems Ltd.

nWGT-W (Nano Wireless Gateway Terminal)

nWGT-W Outdoor unit W/P.S

**FCC ID: W8F819527450
IC: 8264A-819527450**

This report concerns:	Original Grant: <input checked="" type="checkbox"/> X
	Class I Change: <input type="checkbox"/>
	Class II Change: <input type="checkbox"/>
Equipment type:	FCC: (DTS) Digital Transmission System IC: Spread Spectrum Digital Device (2400-2483.5)
Limits used:	47CFR15 Section 15.247 RSS 247, Issue 2, February 2017, Section 5 RSS-Gen, Issue 5, April 2018

Measurement procedure used is KDB 558074 D01 v05r01, ANSI C63.10:2013 and RSS-Gen, Issue 5, April 2018

Application for Certification prepared by:	Applicant for this device: (different from "prepared by")
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1. General Information

1.1 Administrative Information

Manufacturer: Orpak Systems Ltd.

Manufacturer's Address: 31 Lechi St. P.O. Box 1461
Bnei Brak, 5111401, Israel
Tel: +972-3-577-6868
Fax: +972-3-579-6310

Manufacturer's Representative: Yair Elul

Equipment PMN: nWGT-W (Nano Wireless Gateway Terminal)

Equipment Under Test (E.U.T): nWGT-W Outdoor unit W/P.S

Equipment HVIN: nWGT-W (Rev C)

Equipment FVIN: 09.02.40

Equipment Serial No.: Not designated

Date of Receipt of E.U.T: February 10, 2020

Start of Test: February 11, 2020

End of Test: April 30, 2020

Test Laboratory Location: I.T.L (Product Testing) Ltd.
1 Batsheva St.,
Lod
ISRAEL 7120101

Test Specifications: FCC Part 15, Subpart C
RSS 247, Issue 2, February 2017, Section 5
RSS-Gen, Issue 5, April 2018



1.2 ***List of Accreditations***

The EMC laboratory of I.T.L. is accredited by the following bodies:

1. The American Association for Laboratory Accreditation (A2LA) (U.S.A.), Certificate No. 1152.01.
2. The Federal Communications Commission (FCC) (U.S.A.), FCC Designation No. IL1005.
3. The Israel Ministry of the Environment (Israel), Registration No. 1104/01.
4. Department of Innovation, Science and Economic Development (ISED) Canada, CAB identifier: IL1002

I.T.L. Product Testing Ltd. is accredited by the American Association for Laboratory Accreditation (A2LA) and the results shown in this test report have been determined in accordance with I.T.L.'s terms of accreditation unless stated otherwise in the report.



1.3 **Product Description**

Wire infrastructure at gas station forecourt increases the cost of automating existing stations or building new ones and the TCO for the oil company and station owners. Orpak nWGT-W solution is fully wireless forecourt connecting the controller and the dispensers via Orpak's highly robust wireless network.

The Wireless Forecourt is specially designed for the gas station environment and uses unlicensed frequency band in mesh configuration with strong redundancy and encryption.

All the end line devices that are placed in the gas station Isles and near the dispensers will be connected by wires to the nWGT-W unit and all the data from these devices will be transferred via the wireless network.

Working voltage	115VAC via AC/DC adapter
Mode of operation	802.15.4 Transceiver (ZigBee)
Modulations	DSSS
Assigned Frequency Range	2400.0-2483.5MHz
Operating Frequency Range	2405.0-2470.0MHz
Transmit power(conducted)	~16.0dBm (power level code: 10)
Antenna Gain	+3.3dBi trace antenna
Modulation BW	5MHz
Bit rate (Mbit/s)	N/A

1.4 **Test Methodology**

Both conducted and radiated testing was performed according to the procedures in KDB 558074 D01 v05r01, RSS-Gen, Issue 5, April 2018 and ANSI C63.10: 2013. Radiated testing was performed at an antenna to EUT distance of 3 meters.

1.5 **Test Facility**

Emissions tests were performed at I.T.L.'s testing facility in Lod, Israel. I.T.L.'s EMC Laboratory is accredited by A2LA, certificate No. 1152.01 and its FCC Designation Number is IL1005.



1.6 ***Measurement Uncertainty***

Conducted Emission

Conducted Emission (CISPR 11, EN 55011, CISPR 22, EN 55022, ANSI C63.4)

0.15 – 30 MHz:

Expanded Uncertainty (95% Confidence, K=2):
± 3.44 dB

Radiated Emission

Radiated Emission (CISPR 11, EN 55011, CISPR 22, EN 55022, ANSI C63.4)
for open site:

30-1000MHz:

Expanded Uncertainty (95% Confidence, K=2):
± 4.96 dB

1 GHz to 6 GHz

Expanded Uncertainty (95% Confidence, K=2):
± 5.19 dB

>6 GHz

Expanded Uncertainty (95% Confidence, K=2):
± 5.51 dB



2. System Test Configuration

2.1 Justification

- 2.1.1 The E.U.T contains a standard (ZigBee) transceiver IEEE 802.15.4 consisting of 2 identical RF chains (including antenna) for diversity. The antennas do not transmit simultaneously. See customer declaration on page 12.
- 2.1.2 The E.U.T has the following 3 configurations:
 - Configuration 1** – AC version - Outdoor unit with compact Box enclosure powered by internal power supply
 - Configuration 2** - DC version - Outdoor unit with compact Box enclosure powered by External typical power supply
 - Configuration 3** – DC Version – Outdoor unit with small box enclosure powered by External typical power supply.
- 2.1.3 All the configurations have the same PCB.
- 2.1.4 Testing was performed with the same AC/DC adapter.
- 2.1.5 The unit was evaluated while transmitting at the low channel (2405MHz), the mid channel (2440MHz) and the high channel (2470MHz).
- 2.1.6 Conducted emission tests were performed with the E.U.T. antenna terminal connected by a RF cable to the Spectrum Analyzer through a 20dB external attenuator.
- 2.1.7 Final radiated emission tests were performed after exploratory emission testing that was performed in 3 orthogonal polarities to determine the “worst case” radiation for each enclosure configuration.
- 2.1.8 According to screening results on the next page, the “worst case” was Configuration 1 at the Y axis.



Orientation	Frequency	2 nd Harmonic	4 rd Harmonic	Band Edge
	(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)
X axis	2405.0	50.2(N.L)	45.9(N.L)	58.5
	2440.0	49.1(N.L)	45.6(N.L)	-
	2470.0	50.0(N.L)	45.3(N.L)	59.8
Y axis	2405.0	50.2(N.L)	46.0(N.L)	59.5
	2440.0	48.9(N.L)	45.7(N.L)	-
	2470.0	50.5(N.L)	45.9(N.L)	60.0
Z axis	2405.0	48.8(N.L)	45.6(N.L)	57.3
	2440.0	48.4(N.L)	45.5(N.L)	-
	2470.0	49.7(N.L)	45.5(N.L)	59.8

Figure 1. Configuration 1 – Exploratory Radiated Emissions Results

Orientation	Frequency	2 nd Harmonic	3 rd Harmonic	Band Edge
	(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)
X axis	2405.0	50.1(N.L)	45.4(N.L)	58.0
	2440.0	48.2(N.L)	45.1(N.L)	-
	2470.0	49.8(N.L)	45.5(N.L)	59.1
Y axis	2405.0	50.0(N.L)	45.5(N.L)	59.2
	2440.0	49.0(N.L)	45.5(N.L)	-
	2470.0	50.4(N.L)	45.7(N.L)	59.9
Z axis	2405.0	48.2(N.L)	45.0(N.L)	57.3
	2440.0	48.0(N.L)	45.1(N.L)	-
	2470.0	49.2(N.L)	45.2(N.L)	59.6

Figure 2. Configuration 2 - Exploratory Radiated Emissions Results



Orientation	Frequency	2nd Harmonic	3rd Harmonic	Band Edge
	(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)
X axis	2405.0	50.2(N.L)	46.0(N.L)	58.0
	2440.0	49.0(N.L)	45.7(N.L)	-
	2470.0	50.0(N.L)	45.1(N.L)	59.1
Y axis	2405.0	50.0(N.L)	45.7(N.L)	59.0
	2440.0	48.9(N.L)	45.6(N.L)	-
	2470.0	50.6(N.L)	45.8(N.L)	59.2
Z axis	2405.0	48.5(N.L)	45.7(N.L)	57.1
	2440.0	48.2(N.L)	45.5(N.L)	-
	2470.0	49.5(N.L)	45.5(N.L)	59.4

Figure 3. Configuration 3 - Exploratory Radiated Emissions Results

2.2 EUT Exercise Software

No special exercise software was used.

2.3 Special Accessories

Equipment	Manufacturer	Part Number	Serial Number
AC/DC adapter	MEANWELL	RS-15-24	N/A

2.4 Equipment Modifications

Initially, the E.U.T failed to meet the requirements of the following specifications:

1. Spurious emission restricted band; and
2. Band edge restricted band (2483.5-2500MHz)

The manufacturer took the following corrective actions:

Added low pass filter and deleted channels 26 &25.



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Date 03.05.2020

To whom it may concern

nWGT W – Declaration

I hereby to declare that:

1. Orpak's nWGT - W:
 - a. Contains two (2) integrated antennas for redundancy to increase the reliability of the product's wireless performances
 - b. The two RF channels with their Antennas operate one by one and not on the same time
 - c. These two Antennas identical regarding design, Antenna's pattern& Gain
2. Orpak's nWGT - W:
 - a. Had the below 3 models:
 - i. AC version - Outdoor unit with compact Box enclosure powered by internal power supply
 - ii. DC version - Outdoor unit with compact Box enclosure powered by External typical power supply
 - iii. DC Version – Outdoor unit with small box enclosure powered by External typical power supply
 - b. All three (3) models contain the same electronics hardware - PCBA
 - c. Please relate them from Radio point of view as the same product

Sincerely,

Elul Yair
Engineering Manager

2.5 Configuration of Tested System

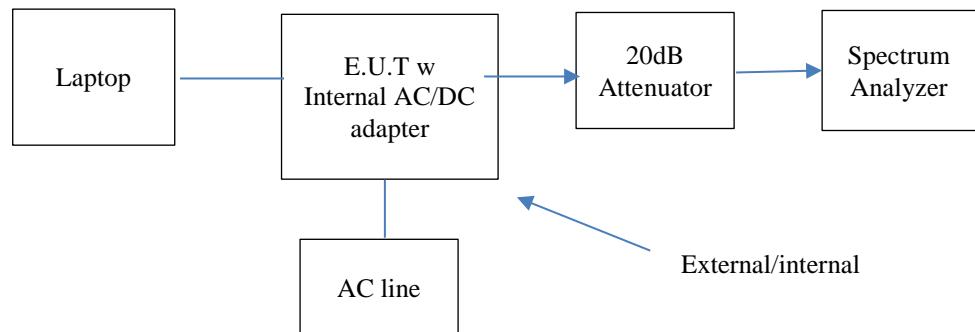


Figure 4. Configuration of Tested System Conducted

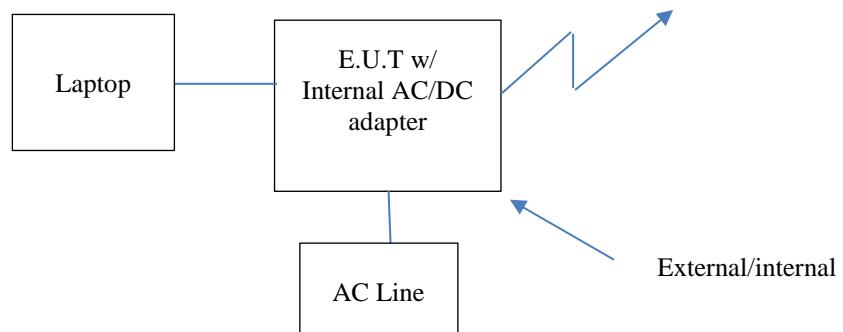


Figure 5. Configuration of Tested System Radiated

3. Conducted & Radiated Measurement Test Set-Up Photos



Figure 6. Conducted Emission from AC Line Test



Figure 7. Radiated Emission Test, 0.009-30MHz



Figure 8. Radiated Emission Test, 30-200MHz

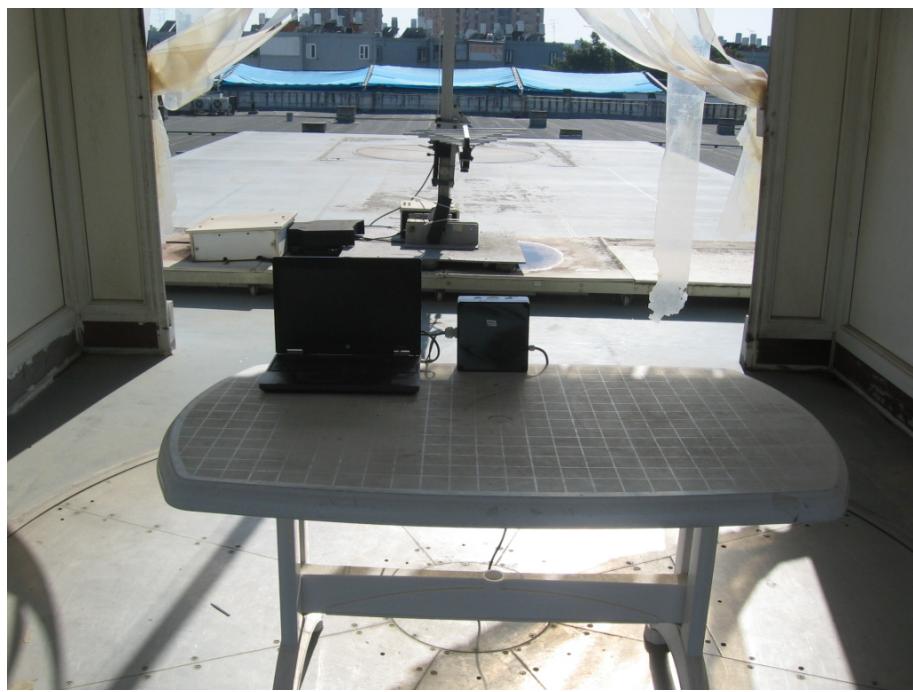


Figure 9. Radiated Emission Test, 200-1000MHz



Figure 10. Radiated Emission Test, 1-18GHz



Figure 11. Radiated Emission Test, 18-26.5GHz



4. Conducted Emission From AC Mains

4.1 Test Specification

FCC Part 15, Subpart C, Section 15.207

RSS Gen, Issue 5, Clause 8.8

4.2 Test Procedure

(Temperature (22°C)/ Humidity (56%RH))

The E.U.T operation mode and test setup are as described in Section 2 of this report. In order to minimize background noise interference, the conducted emission testing was performed inside a shielded room, with the E.U.T placed on a 0.8 meter high wooden table, 0.4 meter from the room's vertical wall. In the case of a floor-standing E.U.T., it was placed on the horizontal ground plane.

The E.U.T was powered from 115 V AC / 60 Hz via 50 Ohm / 50 μ Hn Line Impedance Stabilization Network (LISN) on the phase and neutral lines. The LISN's were grounded to the shielded room ground plane (floor), and were kept at least 0.8 meters from the nearest boundary of the E.U.T.

The center of the E.U.T.'s AC cable was folded back and forth, in order to form a bundle less than 0.40 meters and a total cable length of 1 meter.

The effect of varying the position of the cables was investigated to find the configuration that produces maximum emission.

The emission voltages at the LISN's outputs were measured using a computerized receiver, complying with CISPR 16 requirements. The specification limits are loaded to the receiver and are displayed on the receiver's spectrum display.

The E.U.T was evaluated in TX operation mode.

A frequency scan between 0.15 and 30 MHz was performed at 9 kHz I.F. band width, using peak detection.

The spectral components having the highest level on each line were measured using a quasi-peak and average detector.

4.3 Test Limit

Frequency of Emission (MHz)	Conducted Limit (dB μ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

* Decreases with the logarithm of the frequency.



4.4 **Test Results**

JUDGEMENT: Passed by 11.90 dB

The margin between the emission levels and the specification limit is, in the worst case, 11.90 dB for the phase line at 0.52 MHz and 13.67dB at 6.30 MHz for the neutral line.

The EUT met the F.C.C. Part 15, Subpart C and RSS Gen, Issue 5, Clause 8.8 specification requirements.

The details of the highest emissions are given in *Figure 12* to *Figure 15*.



Conducted Emission

E.U.T Description nWGT-W (Nano Wireless
Gateway Terminal)
Type nWGT-W Configuration 1
Serial Number: Not designated

Specification: FCC Part 15, Subpart C
 RSS Gen, Issue 5, Clause 8.8
Lead: Phase
Detectors: : Peak, Quasi-peak, Average
Power Operation AC/DC Adapter inside enclosure

EDIT PEAK LIST (Final Measurement Results)					
Trace1:	CE22BQP				
Trace2:	CE22BAP				
Trace3:	---				
	TRACE	FREQUENCY	LEVEL dB μ V	DELTA	LIMIT dB
1	Quasi Peak	194 kHz	27.68	-36.17	
2	Average	230 kHz	24.16	-28.28	
1	Quasi Peak	426 kHz	29.28	-28.04	
2	Average	426 kHz	23.66	-23.66	
2	Average	522 kHz	34.10	-11.90	
1	Quasi Peak	526 kHz	41.26	-14.73	
1	Quasi Peak	966 kHz	36.34	-19.65	
2	Average	966 kHz	30.09	-15.90	
1	Quasi Peak	1.582 MHz	31.52	-24.48	
2	Average	1.582 MHz	25.49	-20.50	
2	Average	2.202 MHz	22.98	-23.01	
1	Quasi Peak	2.35 MHz	25.93	-30.06	
2	Average	6.098 MHz	36.61	-13.38	
1	Quasi Peak	6.106 MHz	41.52	-18.47	
1	Quasi Peak	6.182 MHz	41.81	-18.18	
2	Average	6.182 MHz	36.88	-13.11	
2	Average	10.438 MHz	27.26	-22.73	
1	Quasi Peak	11.046 MHz	34.62	-25.37	
2	Average	17.694 MHz	21.14	-28.86	
1	Quasi Peak	20.81 MHz	26.10	-33.89	

Date: 4.MAR.2020 17:20:33

Figure 12. Detectors: Peak, Quasi-peak, Average

Note: QP Delta/Av Delta refers to the test results obtained minus specified requirement; thus a positive number indicates failure, and a negative result indicates that the product passes the test.

Conducted Emission

E.U.T Description nWGT-W (Nano Wireless
Gateway Terminal)

Type nWGT-W Configuration 1

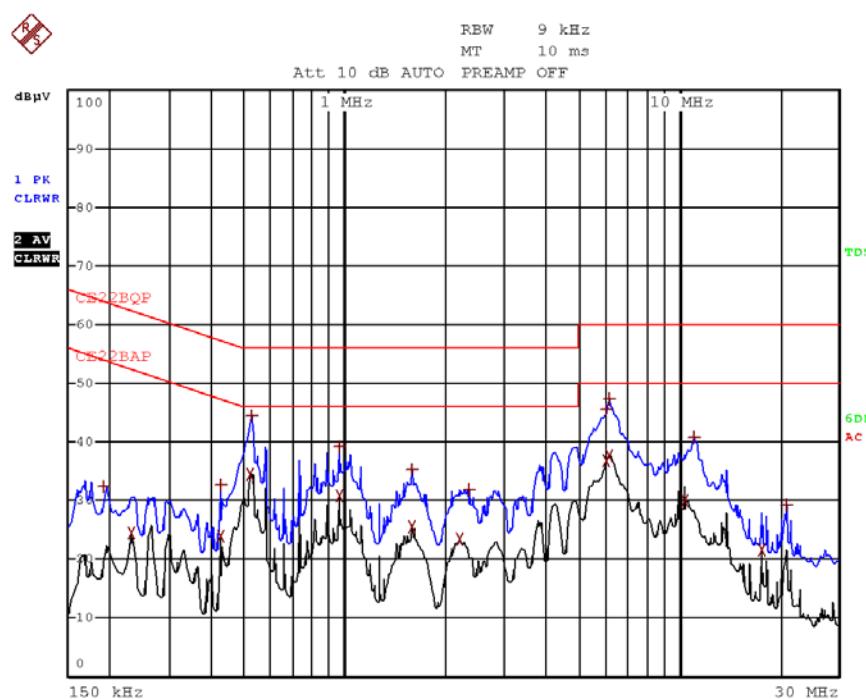
Serial Number: Not designated

Specification: FCC Part 15, Subpart C
RSS Gen, Issue 5, Clause 8.8

Lead: Phase

Detectors: Peak, Quasi-peak, Average

Power Operation AC/DC Adapter inside enclosure



Date: 4.MAR.2020 17:19:34

Figure 13. Detectors: Peak, Quasi-peak, Average



Conducted Emission

E.U.T Description nWGT-W (Nano Wireless
Gateway Terminal)

Type nWGT-W Configuration 1

Serial Number: Not designated

Specification: FCC Part 15, Subpart C
RSS Gen, Issue 5, Clause 8.8

Lead: Neutral

Detectors: Peak, Quasi-peak, Average

Power Operation AC/DC Adapter inside enclosure

EDIT PEAK LIST (Final Measurement Results)					
Trace1:	CE22BQP				
Trace2:	CE22BAP				
Trace3:	---				
TRACE	FREQUENCY	LEVEL dB μ V	DELTA	LIMIT	dB
2	Average 230 kHz	22.95	-29.49		
1	Quasi Peak 234 kHz	26.57	-35.73		
2	Average 262 kHz	24.25	-27.11		
1	Quasi Peak 426 kHz	25.10	-32.22		
1	Quasi Peak 518 kHz	38.97	-17.02		
2	Average 522 kHz	32.22	-13.77		
1	Quasi Peak 966 kHz	31.83	-24.16		
2	Average 966 kHz	25.41	-20.58		
1	Quasi Peak 1.582 MHz	28.76	-27.23		
2	Average 1.582 MHz	22.68	-23.31		
2	Average 2.202 MHz	21.23	-24.76		
1	Quasi Peak 2.742 MHz	25.81	-30.19		
1	Quasi Peak 6.082 MHz	40.56	-19.44		
2	Average 6.094 MHz	36.09	-13.90		
2	Average 6.214 MHz	36.32	-13.67		
1	Quasi Peak 6.298 MHz	41.41	-18.59		
2	Average 10.578 MHz	28.18	-21.82		
1	Quasi Peak 11.238 MHz	34.59	-25.40		
2	Average 17.694 MHz	23.41	-26.59		
1	Quasi Peak 20.81 MHz	26.61	-33.38		

Date: 4.MAR.2020 17:14:52

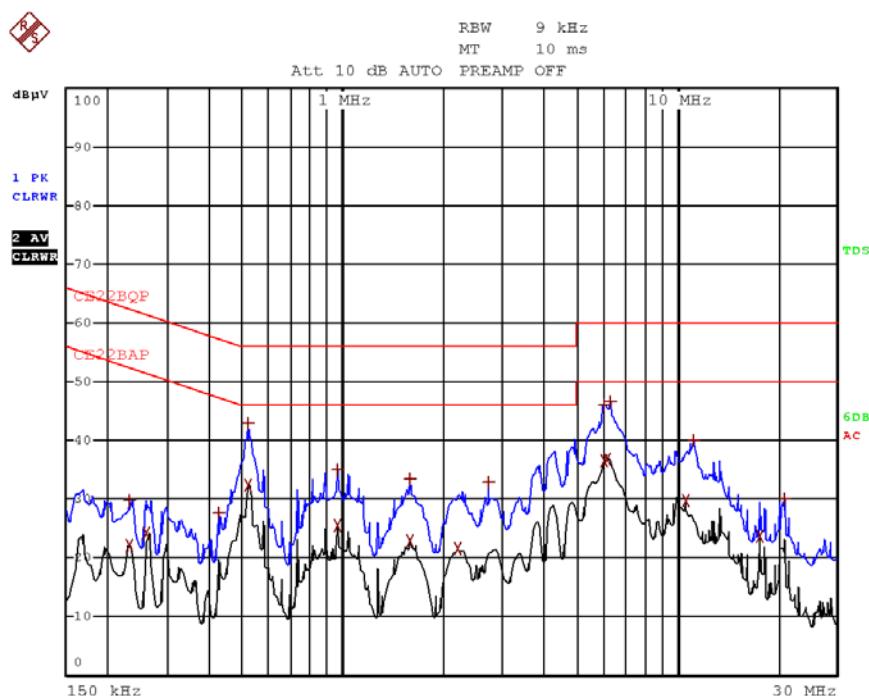
Figure 14. Detectors: Peak, Quasi-peak, Average

Note: *QP Delta/Av Delta refers to the test results obtained minus specified requirement; thus a positive number indicates failure, and a negative result indicates that the product passes the test.*

Conducted Emission

E.U.T Description: nWGT-W (Nano Wireless Gateway Terminal)
Type: nWGT-W Configuration 1
Serial Number: Not designated

Specification: FCC Part 15, Subpart C
RSS Gen, Issue 5, Clause 8.8
Lead: Neutral
Detectors: Peak, Quasi-peak, Average
Power Operation: AC/DC Adapter inside enclosure



Date: 4.MAR.2020 17:13:49

Figure 15 Detectors: Peak, Quasi-peak, Average



4.5 **Test Equipment Used; Conducted Emission***

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Next Calibration Due
LISN	Fischer	FCC-LISN-25A	127	September 8, 2019	September 30, 2020
Transient Limiter	HP	11947A	3107A01308	September 16, 2019	September 30, 2020
EMI Receiver	Rohde & Schwarz	ESCI7	100724	February 27, 2019	March 31, 2020
Cable CE Chamber 3M + 3M	Testline 18 + RJ214	11556	-	March 31, 2019	March 31, 2020

*Testing performed March 4, 2020

Figure 16 Test Equipment Used

5. 6 dB Minimum Bandwidth

5.1 Test Specification

FCC Part 15, Subpart C, Section 247(a)(2)

RSS 247, Issue 2, Section 5.2(a)

5.2 Test Procedure

(Temperature (22°C)/ Humidity (52%RH))

The E.U.T operation mode and test set-up are as described in Section 2 of this report.

The E.U.T. antenna terminal was connected to the Spectrum Analyzer through an external attenuator and an appropriate coaxial cable (total loss=21.0 dB). Special attention was taken to prevent Spectrum Analyzer RF input overload.

The spectrum bandwidth of the E.U.T. at the point of 6 dB below maximum peak power was measured and recorded. The RBW was set to 100 kHz.

5.3 Test Limit

Systems using digital modulation techniques may operate in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

5.4 Test Results

Protocol Type	Operation Frequency	Reading	Limit
	(MHz)	(kHz)	(kHz)
ZigBee	2405.0	1417.0	>500.0
	2440.0	1497.0	>500.0
	2470.0	1557.0	>500.0

Figure 17 6 dB Minimum Bandwidth

JUDGEMENT: Passed

For additional information see *Figure 18* to *Figure 20*.

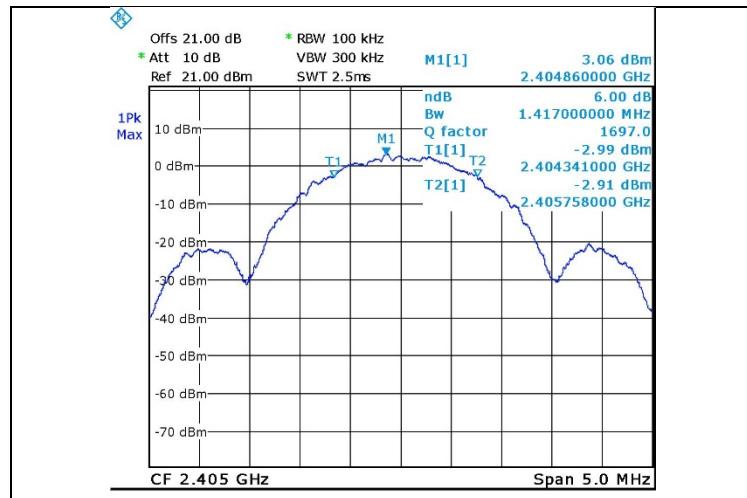


Figure 18. 2405.0 MHz

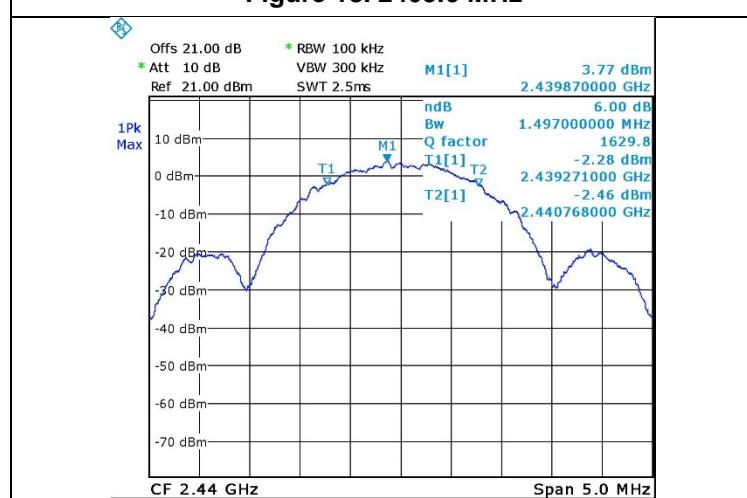


Figure 19. 2440.0 MHz

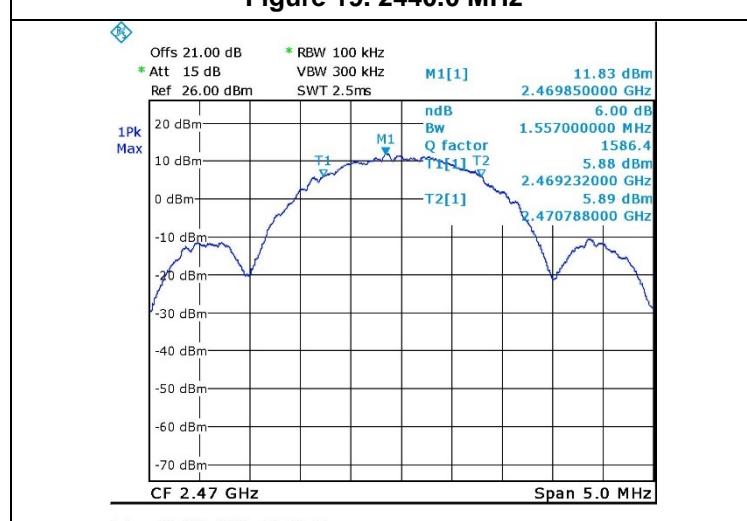


Figure 20. 2470.0 MHz



5.5 **Test Equipment Used; 6dB Bandwidth**

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Next Calibration Due
Spectrum Analyzer	R&S	FSL6	100194	March 10, 2020	March 31, 2021
20dB Attenuator	Midwest Microwave	ATT-0217-20-NNN-02	-	December 24, 2018	December 31, 2020
RF Cable	1m low loss coax cable	EIM	705A0093 01EIM	December 24, 2018	December 31, 2020

Figure 21 Test Equipment Used



6. Maximum Conducted Output Power

6.1 Test Specification

FCC, Part 15, Subpart C, Section 247(b)(3)

RSS 247, Issue 2, Section 5.4(d)

6.2 Test Procedure

(Temperature (20°C)/ Humidity (51%RH))

The E.U.T operation mode and test set-up are as described in Section 2 of this report.

The E.U.T. antenna terminal was connected to the Spectrum Analyzer through an external attenuator and an appropriate coaxial cable (total loss=21.0dB). Special attention was taken to prevent Spectrum Analyzer RF input overload.

6.3 Test Limit

The maximum peak conducted output power of the intentional radiator for systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt.

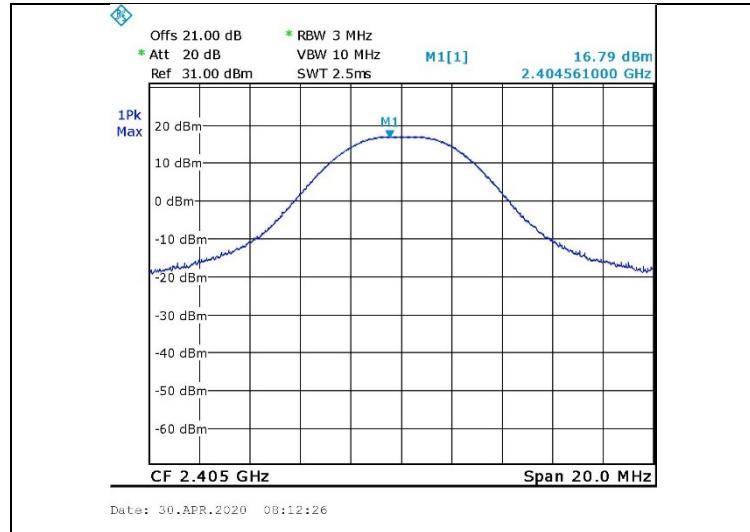
6.4 Test Results

Protocol Type	Operation Frequency	Power	Power	Limit	Margin
	(MHz)	(dBm)	(mW)	(mW)	(mW)
ZigBee	2405.0	16.8	47.9	1000.0	-952.1
	2440.0	16.2	41.7	1000.0	-958.3
	2470.0	14.7	29.5	1000.0	-970.5

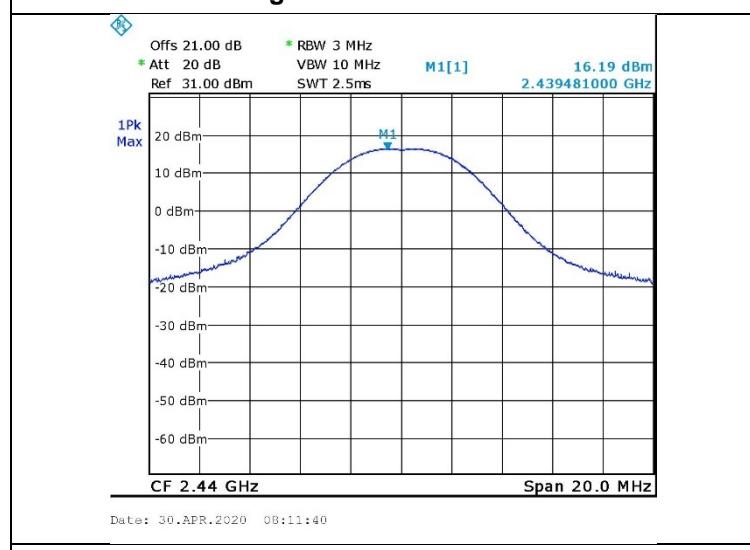
Figure 22 Maximum Peak Power Output

JUDGEMENT: Passed by 952.1 mW

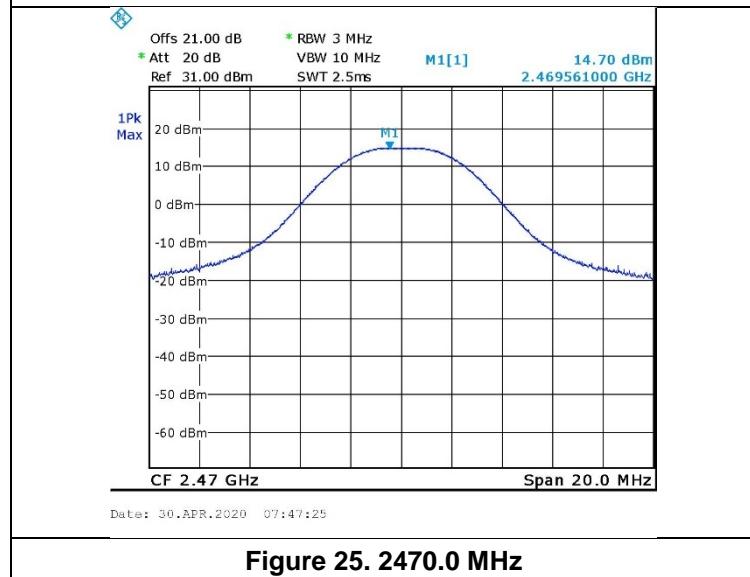
For additional information see *Figure 23* to *Figure 25*.



Date: 30.APR.2020 08:12:26

Figure 23. 2405.0 MHz

Date: 30.APR.2020 08:11:40

Figure 24. 2440.0 MHz

Date: 30.APR.2020 07:47:25

Figure 25. 2470.0 MHz



6.5 **Test Equipment Used; Maximum Peak Power Output**

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Next Calibration Due
Spectrum Analyzer	R&S	FSL6	100194	March 10, 2020	March 31, 2021
20dB Attenuator	Midwest Microwave	ATT-0217-20-NNN-02	-	December 24, 2018	December 31, 2020
RF Cable	1m low loss coax cable	EIM	705A00930 1EIM	December 24, 2018	December 31, 2020

Figure 26 Test Equipment Used



7. Band Edge Spectrum

7.1 Test Specification

FCC, Part 15, Subpart C, Section 247(d)

RSS 247, Issue 2, Section 5.5

7.2 Test Procedure

(Temperature (20°C)/ Humidity (49%RH))

The E.U.T operation mode and test set-up are as described in Section 2 of this report.

The E.U.T. antenna terminal was connected to the Spectrum Analyzer through an external attenuator and an appropriate coaxial cable (loss=21.0 dB). Special attention was taken to prevent Spectrum Analyzer RF input overload.

The RBW was set to 100 kHz.

7.3 Test Limit

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.

7.4 Test Results

Protocol Type	Operation Frequency	Band Edge Frequency	Spectrum Level	Limit	Margin
	(MHz)	(MHz)	(dBm)	(dBm)	(dB)
ZigBee	2405.0	2400.0	-25.6	-6.0	-19.6
	2470.0	2483.5	-43.9	-8.4	-35.5

Figure 27 Band Edge Spectrum

JUDGEMENT: Passed by 19.6dB

For additional information see *Figure 28* and *Figure 29*.

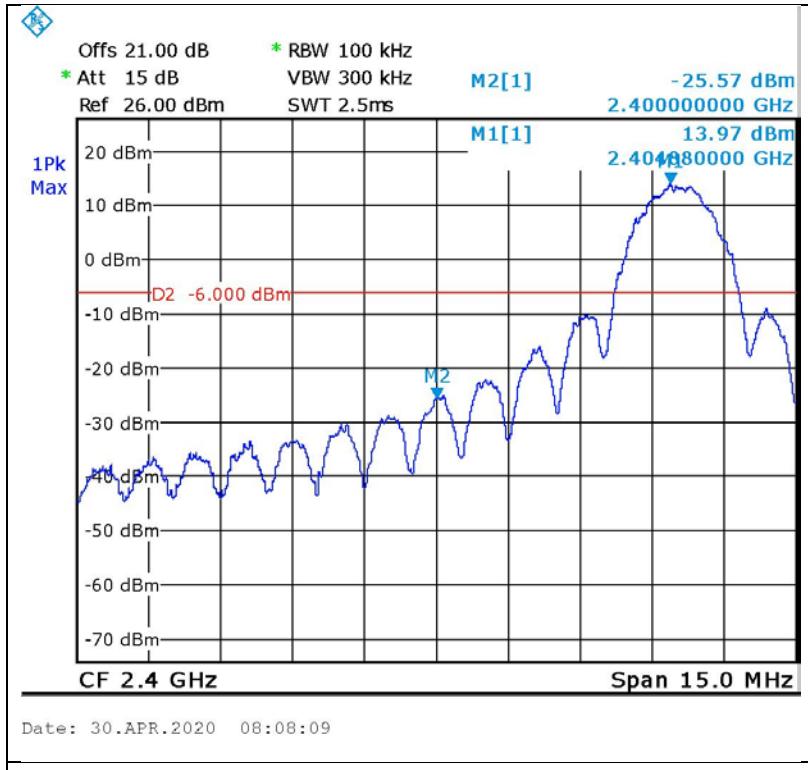


Figure 28. 2405.0 MHz

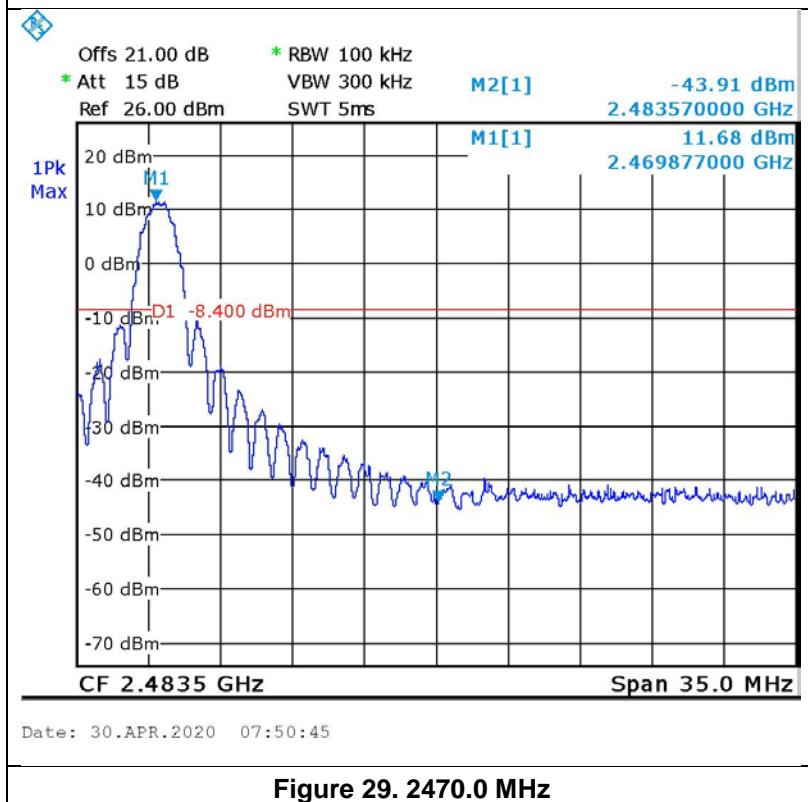


Figure 29. 2470.0 MHz



7.5 **Test Equipment Used; Band Edge**

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Next Calibration Due
Spectrum Analyzer	R&S	FSL6	100194	March 10, 2020	March 31, 2021
20dB Attenuator	Midwest Microwave	ATT-0217-20-NNN-02	-	December 24, 2018	December 31, 2020
RF Cable	1m low loss coax cable	EIM	705A00930 1EIM	December 24, 2018	December 31, 2020

Figure 30 Test Equipment Used

8. Transmitted Power Density

8.1 Test Specification

FCC, Part 15, Subpart C, Section 247(e)

RSS 247, Issue 2, Section 5.2(b)

8.2 Test Procedure

(Temperature (20°C)/ Humidity (50% RH))

The E.U.T operation mode and test set-up are as described in Section 2 of this report.

The E.U.T. antenna terminal was connected to the Spectrum Analyzer through an external attenuator and an appropriate coaxial cable (total loss= 21.0dB). Special attention was taken to prevent Spectrum Analyzer RF input overload.

The spectrum analyzer was set to 3 kHz RBW.

8.3 Test Limit

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.

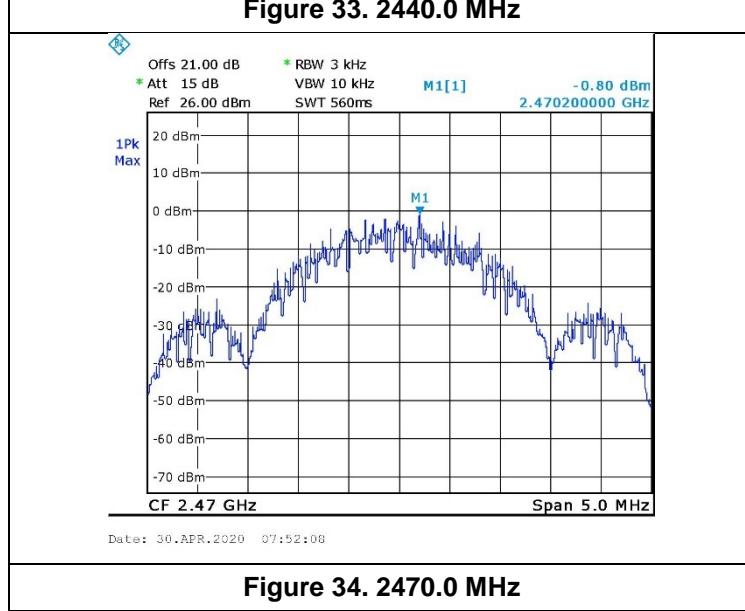
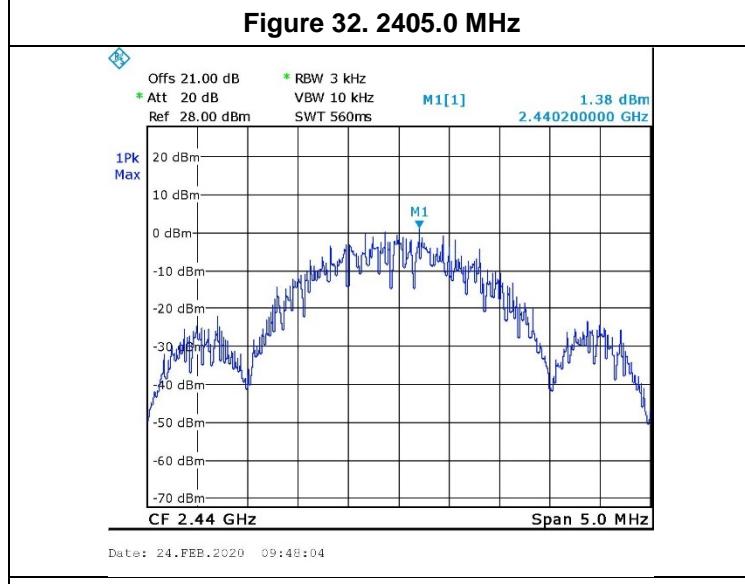
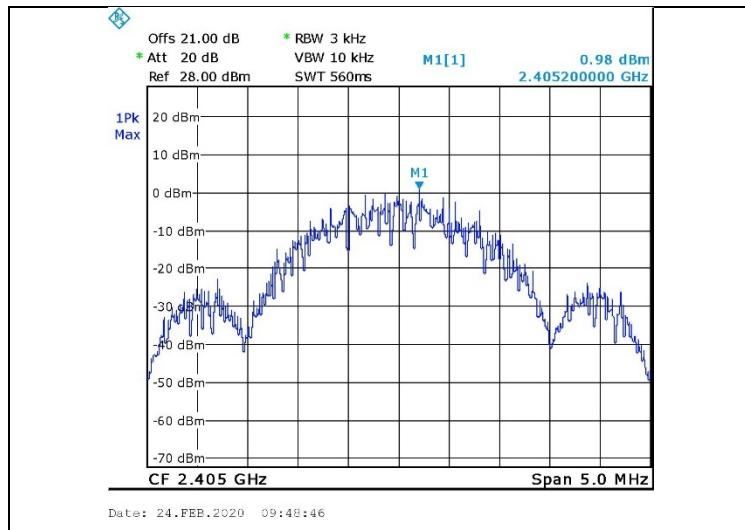
8.4 Test Results

Protocol Type	Operation Frequency	PSD Reading	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dB)
ZigBee	2405.0	1.0	8.0	-7.0
	2440.0	1.4	8.0	-6.6
	2470.0	-0.8	8.0	-8.8

Figure 31 Test Results

JUDGEMENT: Passed by 6.6dB

For additional information see *Figure 32* to *Figure 34*





8.5 **Test Equipment Used; Transmitted Power Density**

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Next Calibration Due
Spectrum Analyzer	R&S	FSL6	100194	March 10, 2020	March 31, 2021
20dB Attenuator	Midwest Microwave	ATT-0217-20-NNN-02	-	December 24, 2018	December 31, 2020
RF Cable	1m low loss coax cable	EIM	705A00930 1EIM	December 24, 2018	December 31, 2020

Figure 35 Test Equipment Used

9. Occupied Bandwidth

9.1 Test Specification

FCC, Part 2, Sub part J, Section 2.1049

RSS-Gen, Issue 5: 2014, Section 6.6

9.2 Test Procedure

(Temperature (20°C)/ Humidity (50%RH))

The E.U.T. operation mode and test set-up are as described in Section 2 of this report.

The E.U.T. antenna terminal was connected to the Spectrum Analyzer through an external attenuator and an appropriate coaxial cable (total loss= 21.0dB). Special attention was taken to prevent Spectrum Analyzer RF input overload.

The RBW set to the range of 1% to 5% of the OBW.

The span was set between 1.5 to 5 times of the OBW.

99% occupied bandwidth function was set on.

9.3 Test Limit

N/A

9.4 Test Results

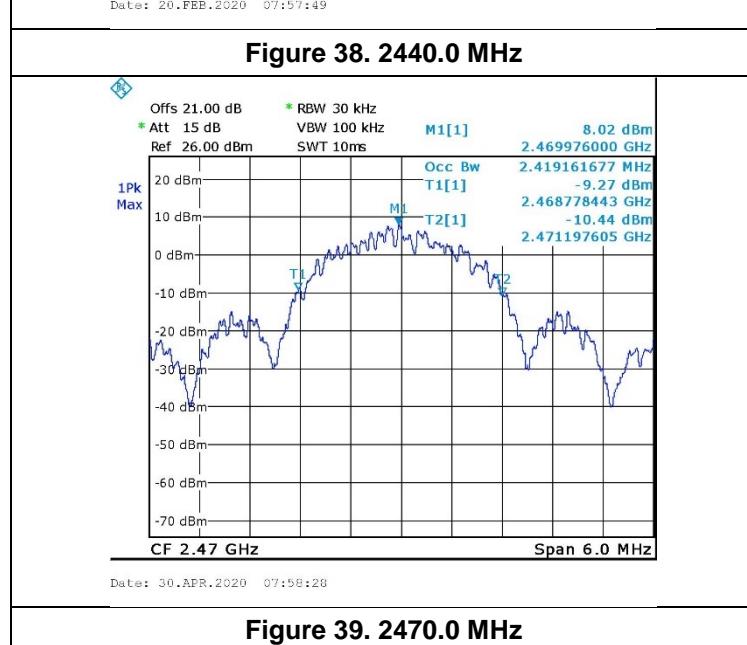
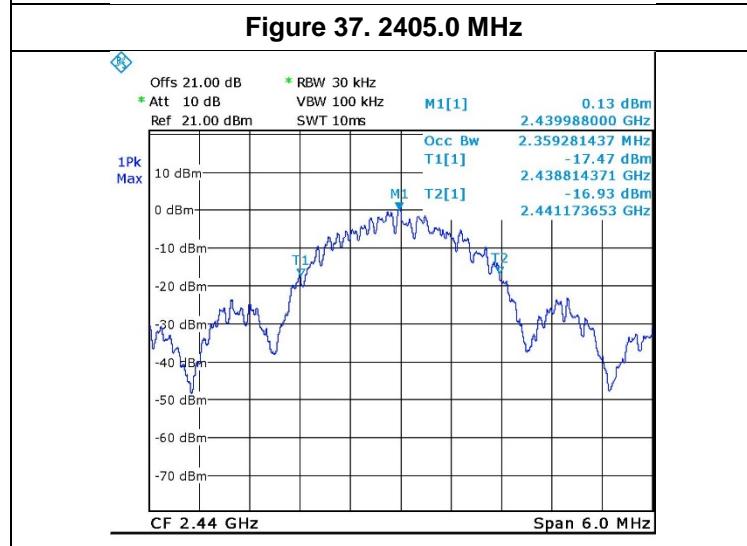
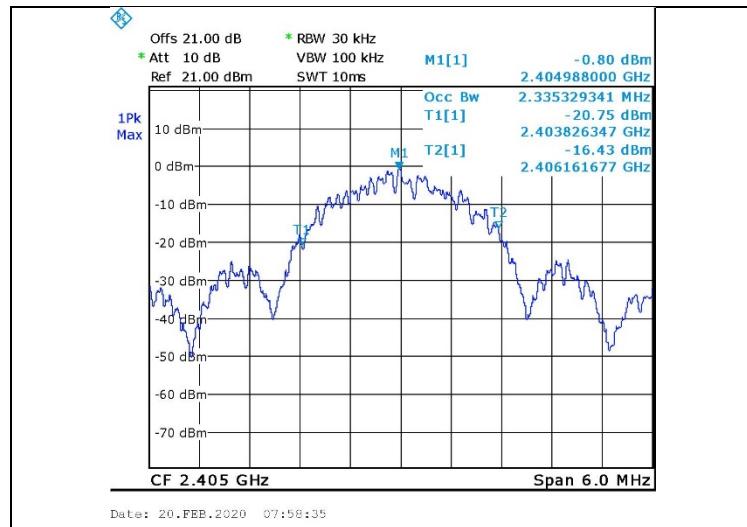
Protocol Type	Operation Frequency	Reading
	(MHz)	(MHz)
ZigBee	2405.0	2.335
	2440.0	2.359
	2470.0	2.419

Figure 36. Bandwidth Test Results

JUDGEMENT: N/A

See additional information in *Figure 37* to *Figure 39*.

Occupied Bandwidth





9.5 **Test Equipment Used; Bandwidth**

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Next Calibration Due
Spectrum Analyzer	R&S	FSL6	100194	March 10, 2020	March 31, 2021
20dB Attenuator	Midwest Microwave	ATT-0217-20-NNN-02	-	December 24, 2018	December 31, 2020
RF Cable	1m low loss coax cable	EIM	705A00930 1EIM	December 24, 2018	December 31, 2020

Figure 40 Test Equipment Used



10. Emissions in Non-Restricted Frequency Bands

10.1 Test Specification

FCC, Part 15, Subpart C, Section 247(d)

RSS 247, Issue 2, Section 5.5

10.2 Test Procedure

(Temperature (19°C)/ Humidity (48%RH))

The E.U.T. operation mode and test set-up are as described in Section 2 of this report.

The E.U.T. antenna terminal was connected to the Spectrum Analyzer through an external attenuator and an appropriate coaxial cable (max total loss=34.0 dB).

Special attention was taken to prevent Spectrum Analyzer RF input overload.

RBW was set to 100kHz, detector set to max peak and trace to “max hold”.

10.3 Test Limit

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.

10.4 Test Results

JUDGEMENT: Passed

The EUT met the requirements of the F.C.C. Part 15, Subpart C, Section 247(d) and RSS 247, Issue 2, Section 5.5 specification.

For additional information see *Figure 41* to *Figure 43*.

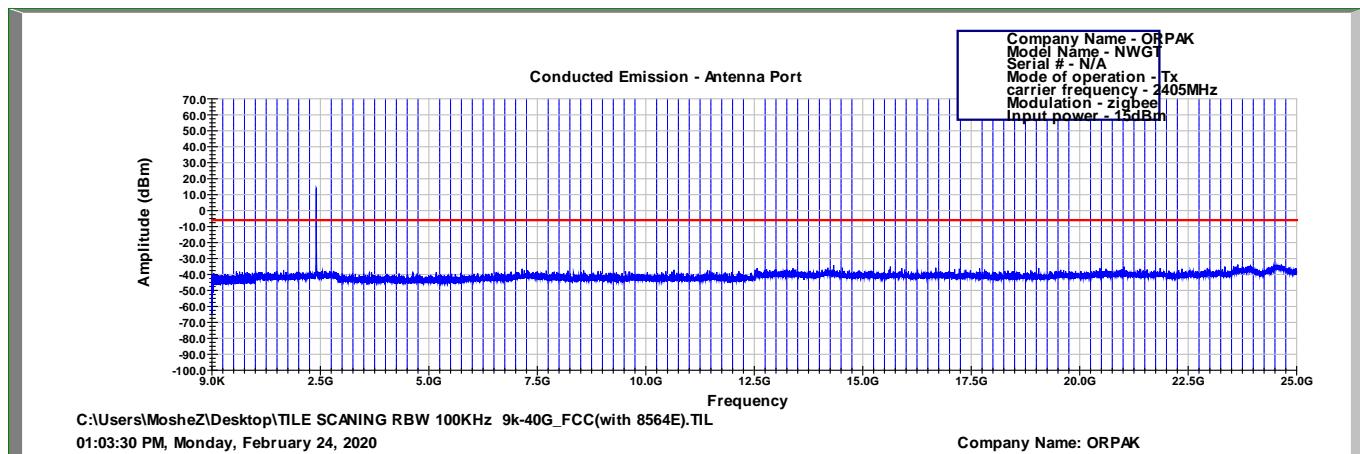


Figure 41 2405.0 MHz

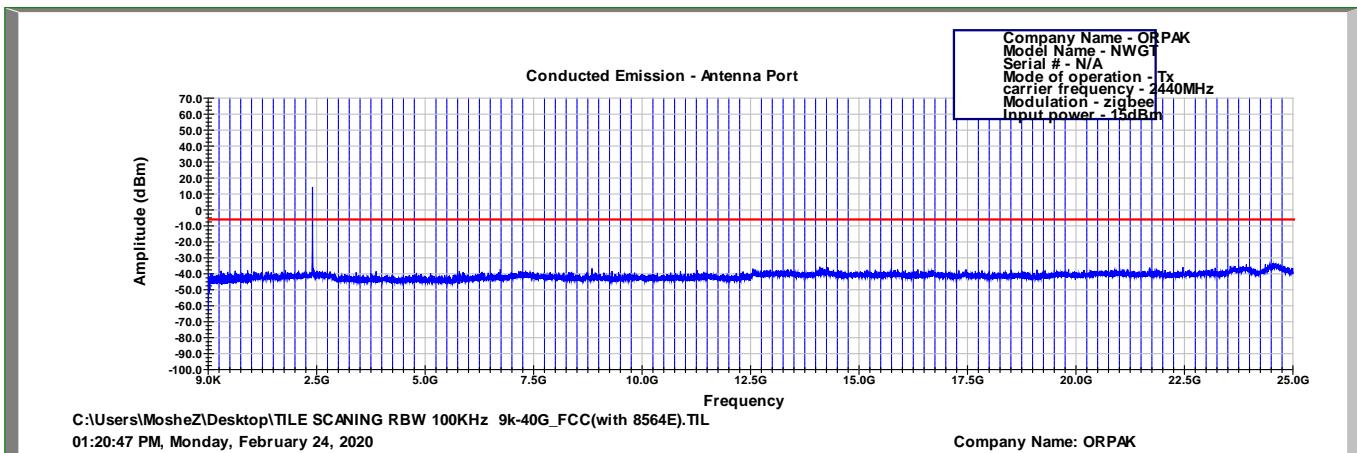


Figure 42 2440.0 MHz

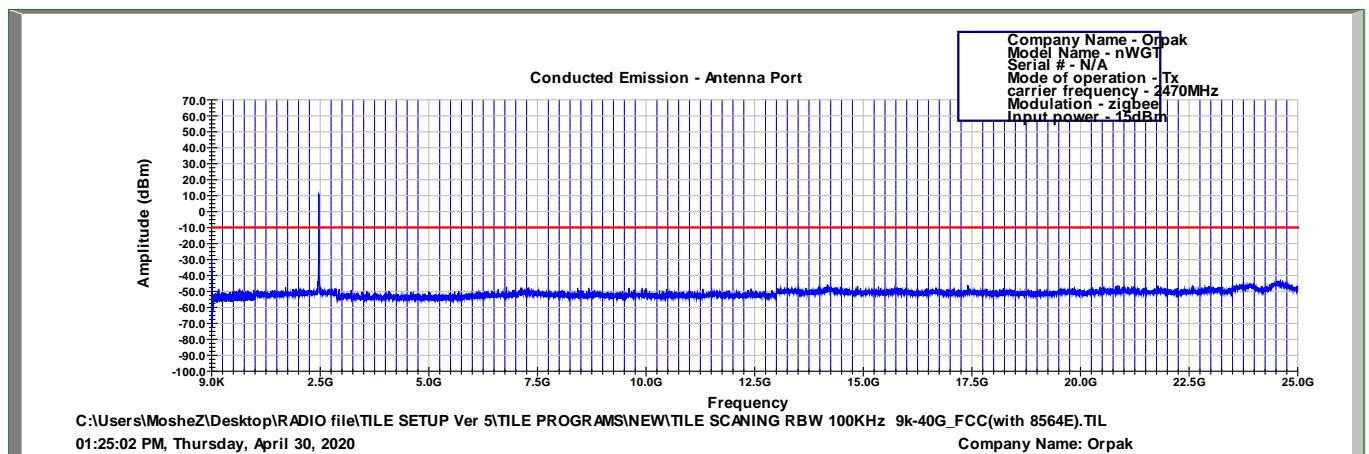


Figure 43 2470.0 MHz

Note: All peaks in plots are the fundamental transmission frequency.



10.1 ***Test Instrumentation Used, Emission in Non Restricted Frequency Bands****

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Next Calibration Due
Spectrum Analyzer	HP	8564E	3442A00275	March 11, 2020	March 31, 2021
30dB Attenuator	MCL	BW-S30W5	533	December 24, 2018	December 31, 2020
RF Cable	1m low loss coax cable	EIM	705A009301 EIM	December 24, 2018	December 31, 2020

*Testing performed on February 24, 2020 & April 30, 2020.

Figure 44 Test Equipment Used



11. Emissions in Restricted Frequency Bands

11.1 ***Test Specification***

FCC Part 15, Subpart C, Sections 15.209, 15.205, 15.247(d)

RSS 247, Issue 2, Section 3.3

RSS Gen, Issue 5, Section 8.10

11.2 ***Test Procedure***

(Temperature (23°C)/ Humidity (65%RH))

The E.U.T. operation mode and test set-up are as described in Section 2 of this report.

For measurements between 0.009-30MHz:

The E.U.T was tested inside the shielded room and placed on a non-metallic table, 0.8 meters above the ground. The emissions were measured at a distance of 3 meters. The readings were maximized by the turntable azimuth between 0-360°, and the antenna polarization.

The frequency range 0.009MHz-30MHz was scanned.

For measurements between 30-1000MHz:

A preliminary measurement to characterize the E.U.T was performed inside the shielded room at a distance of 3 meters, using peak detection mode and broadband antennas. The preliminary measurements produced a list of the highest emissions. The E.U.T was then transferred to the open site, and placed on a remote-controlled turntable. The E.U.T was placed on a non-metallic table, 0.8 meters above the ground. The emissions were measured at a distance of 3 meters. The readings were maximized by adjusting the antenna height between 1-4 meters, the turntable azimuth between 0-360°, and the antenna polarization. The frequency range 30MHz -1000MHz was scanned and the list of the highest emissions was verified and updated accordingly.

For measurements between 1GHz-25GHz:

The E.U.T was tested inside the shielded room and placed on a non-metallic table, 1.5 meters above the ground. The emissions were measured at a distance of 3 meters. The readings were maximized by the turntable azimuth between 0-360°, and the antenna polarization.

The frequency range 1GHz -25GHz was scanned.

Tests done for all “worst case”, each protocol type. The highest radiation describes in the tables below

The levels of the emissions within the frequency ranges of the restricted bands (Section 15.205 of FCC Part 15) were compared to the limits of the table in Section 15.209 (a), General Requirements.

11.3 FCC Test Limit

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement distance (meters)	Field Strength* (dB μ V/m)	Field Strength* (dB μ V/m)@3m
0.009-0.490	2400/F(kHz)	300	48.5-13.8	128.5-73.8
0.490-1.705	24000/F(kHz)	30	33.8-23.0	73.8-63.0
1.705-30.0	30	30	29.5	69.5
30-88	100	3	40.0	40.0
88-216	150	3	43.5	43.5
216-960	200	3	46.0	46.0
Above 960	500	3	54.0	54.0

*The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector. For average radiated emission measurements above 1000 MHz, there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

Figure 45 FCC Table of Limits

11.4 IC Test Limit

The emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Magnetic Field strength (microampere/meter)	Measurement distance (meters)	Magnetic Field strength (dB μ A/m)	Magnetic Field strength* (dB μ A/m)@3m
0.009-0.490	6.37/F(kHz)	300	-3.0-(-37.7)	77.0-42.2
0.490-1.705	63.7/F(kHz)	30	-17.7-(-28.5)	22.3-11.4
1.705-30.0	0.08	30	-21.9	18.0
Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)	Field strength (dB μ V/m)	Field strength* (dB μ V/m)@3m
30-88	100	3	40.0	40.0
88-216	150	3	43.5	43.5
216-960	200	3	46.0	46.0
Above 960	500	3	54.0	54.0

*The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector. For average radiated emission measurements above 1000 MHz, there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

Figure 46 IC Table of Limits



11.5 **Test Results**

JUDGEMENT: Passed by 2.7 dB

For the operation frequency of 2405 MHz, the margin between the emission level and the specification limit is in the worst case 2.7dB at the frequency of 2390.0 MHz, vertical polarization.

For the operation frequency of 2440 MHz, the margin between the emission level and the specification limit is in the worst case 23.3dB at the frequency of 4880.0 MHz, vertical polarization.

For the operation frequency of 2470 MHz, the margin between the emission level and the specification limit is in the worst case 2.8 dB at the frequency of 2483.5 MHz, vertical polarization.

The EUT met the requirements of the F.C.C. Part 15, Subpart C Sections 15.209, 15.205, 15.247(d) specifications.

The details of the highest emissions are given in *Figure 47*.



Radiated Emission

E.U.T Description: nWGT-W (Nano Wireless
Gateway Terminal)
Type: nWGT-W Configuration 1
Serial Number: Not designated

Specifications: FCC, Part 15, Subpart C, Sections 15.209, 15.205, 15.247(d)
RSS 247, Issue 2, Section 3.3; RSS Gen, Issue 5, Section 8.10

Antenna Polarization: Horizontal/Vertical
Protocol Type: ZigBee

Frequency Range: 9kHz to 25.0 GHz
Detector: Peak, Average

Operation Frequency	Freq.	Pol	Peak Reading	Peak Limit	Peak Margin	Average Reading	Average Limit	Average Margin
(MHz)	(MHz)	(H/V)	(dB μ V/m)	(dB μ V/m)	(dB)	(dB μ V/m)	(dB μ V/m)	(dB)
2405.0	2390.0	V	59.4	74.0	-14.6	51.3	54.0	-2.7
	2390.0	H	58.8	74.0	-15.2	50.6	54.0	-3.4
	4810.0	V	50.1(N.L.)	74.0	-23.9	-	54.0	-
	4810.0	H	50.2(N.L.)	74.0	-23.8	-	54.0	-
2440.0	4880.0	V	50.7(N.L.)	74.0	-23.3	-	54.0	-
	4880.0	H	50.5(N.L.)	74.0	-23.5	-	54.0	-
	4880.0	V	50.3(N.L.)	74.0	-23.7	-	54.0	-
	4880.0	H	50.5(N.L.)	74.0	-23.5	-	54.0	-
2470.0	4950.0	V	50.2(N.L.)	74.0	-23.8	-	54.0	-
	4950.0	H	50.4(N.L.)	74.0	-23.6	-	54.0	-
	2483.5	V	60.2	74.0	-13.8	51.2	54.0	-2.8
	2483.5	H	57.9	74.0	-16.1	48.8	54.0	-5.2

Figure 47. Radiated Emission Results

Margin refers to the test results obtained minus specified requirement; thus a positive number indicates failure, and a negative result indicates that the product passes the test.

“Peak Amp” includes correction factor.

* “Correction Factor” = Antenna Factor + Cable Loss- Low Noise Amplifier Gain



11.6 *Test Instrumentation Used; Emissions in Restricted Frequency Bands**

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Next Calibration Due
EMI Receiver	R&S	ESCI7	100724	February 27, 2019	March 31, 2020
EMI Receiver	HP	8542E	3906A00276	March 11, 2020	March 31, 2021
RF Filter Section	HP	85420E	3705A00248	March 11, 2020	March 31, 2021
Spectrum Analyzer	HP	8593EM	3536A00120 ADI	February 26, 2019	February 28, 2020
Active Loop Antenna	EMCO	6502	9506-2950	February 5, 2019	February 28, 2021
Biconical Antenna	EMCO	3110B	9912-3337	May 21, 2019	May 30, 2020
Log Periodic Antenna	EMCO	3146	9505-4081	May 31, 2018	May 31, 2020
Horn Antenna	ETS	3115	29845	May 31, 2018	May 31, 2021
Horn Antenna	ARA	SWH-28	1007	December 31, 2017	December 31, 2020
MicroWave System Amplifier	HP	83006A	3104A00589	December 24, 2018	December 31, 2020
Low Noise Amplifier 1GHz-18GHz	Miteq	AFSX4-02001800-50-8P	-	December 24, 2018	December 31, 2020
RF Cable Chamber	Commscope ORS	0623 WBC-400	G020132	December 24, 2018	December 31, 2020
RF Cable Oats	EIM	RG214-11N(X2)		May 26, 2019	May 30, 2020
Filter Band Pass 4-20 GHz	Meuro	MFL040120H50	902252	December 24, 2018	December 31, 2020
Semi Anechoic Civil Chamber	ETS	S81	SL 11643	NCR	NCR
Antenna Mast	ETS	2070-2	9608-1497	NCR	NCR
Turntable	ETS	2087	-	NCR	NCR
Mast & Table Controller	ETS/EMCO	2090	9608-1456	NCR	NCR

*Testing performed February 24, 2020

Figure 48 Test Equipment Used



12. Antenna Gain/Information

The antenna gain is 3.3dBi, type: integral.

Design Note DN0007

2.4 GHz Inverted F Antenna



SWRU120B



13. R.F Exposure/Safety

The typical placement of the E.U.T. is in a gas station. The typical distance between the E.U.T. and the user is at least 20cm.

Calculation of Maximum Permissible Exposure (MPE)

Based on 47CFR1 Section 1.1307(b)(1) and RSS 102 Issue 5, Table 4 Requirements

(a) FCC Limit at 2405 MHz is: $1 \frac{mW}{cm^2}$

Using Table 1 of 47CFR1 Section 1.1310 limit for general population/uncontrolled exposures, the above levels are an average over 30 minutes.

(b) ISED Limit: $300-6000MHz = 0.02619f^{0.6834} W/m^2 = 0.02619 \times 2405^{0.6834} = 0.02619 \times 204.48 = 5.36 W/m^2 = 0.536 mW/cm^2$

(c) The power density produced by the E.U.T. is:

$$S = \frac{P_t G_t}{4\pi R^2}$$

P_t = Conducted Transmitted Power 16.8 dBm = 47.9mW

G_t = Antenna Gain 3.3dBi = 2.14 numeric

R = Distance From Transmitter 20 cm

(d) The peak power density produced by the E.U.T. is:

$$S = 47.9 * 2.14 / 4\pi(20)^2 = 0.020 mW/cm^2$$

(e) This is below the FCC/ISED limit.



14. APPENDIX A - CORRECTION FACTORS

14.1 *Correction factors for RF OATS Cable 35m ITL #1911*

Frequency (MHz)	loss (dB)
30.0	1.3
50.0	1.7
100.0	2.6
200.0	3.7
300.0	4.7
400.0	5.5
500.0	6.3
600.0	7.0
700.0	7.6
800.0	8.4
900.0	9.0
1000.0	9.6



14.2 Correction Factors for RF Cable for Anechoic Chamber

ITL #1840

FREQ (MHz)	LOSS (dB)
1000.0	1.5
2000.0	2.1
3000.0	2.7
4000.0	3.1
5000.0	3.5
6000.0	4.1
7000.0	4.6
8000.0	4.9
9000.0	5.7
10000.0	5.7
11000.0	6.1
12000.0	6.1
13000.0	6.2
14000.0	6.7
15000.0	7.4
16000.0	7.5
17000.0	7.9
18000.0	8.1
19000.0	8.8
20000.0	9.1

NOTES:

1. The cable is manufactured by Commscope
2. The cable type is 0623 WBC-400, serial # G020132 and 10m long



14.3 Correction Factors for Active Loop Antenna

ITL # 1075

F(MHz)	AF(dB/m)
0.01	18.4
0.02	14.3
0.03	13.3
0.05	11.7
0.1	11.4
0.2	11.2
0.3	11.2
0.5	11.2
0.7	11.2
1	11.4
2	11.5
3	11.5
4	11.4
5	11.3
6	11.1
7	11.1
8	11.1
9	11
10	11
20	10
30	8



14.4 Correction Factors for Biconical Antenna
ITL #1356, EMCO 3110B 9912-3337

Frequency [MHz]	AF [dB/m]
30	13.00
35	10.89
40	10.59
45	10.63
50	10.12
60	9.26
70	7.74
80	6.63
90	8.23
100	11.12
120	13.16
140	13.07
160	14.80
180	16.95
200	17.17



14.5 *Correction Factors for Log Periodic Antenna*
ITL # 1349, EMCO 3146 s/n 9505-4081

Frequency [MHz]	AF [dB/m]
200	11.58
250	12.04
300	14.76
400	15.55
500	17.85
600	18.66
700	20.87
800	21.15
900	22.32
1000	24.22



14.6 Correction Factors for Double – Ridged Waveguide Horn
ANTENNA 3 meter range;
ITL # 1352, ETS 3115 s/n 29845

FREQUENCY (GHz)	AFE (dB/m)	FREQUENCY (GHz)	AFE (dB/m)
0.75	25.0	9.5	38.0
1.0	23.5	10.0	38.5
1.5	26.0	10.5	38.5
2.0	29.0	11.0	38.5
2.5	27.5	11.5	38.5
3.0	30.0	12.0	38.0
3.5	31.5	12.5	38.5
4.0	32.5	13.0	40.0
4.5	32.5	13.5	41.0
5.0	33.0	14.0	40.0
5.5	35.0	14.5	39.0
6.0	36.5	15.0	38.0
6.5	36.5	15.5	37.5
7.0	37.5	16.0	37.5
7.5	37.5	16.5	39.0
8.0	37.5	17.0	40.0
8.5	38.0	17.5	42.0
9.0	37.5	18.0	42.5

**14.7 Correction Factors for Horn Antenna Model
SWH-28 ITL # 1353****CALIBRATION DATA****3 m distance**

Frequency, MHz	Measured antenna factor, dB/m ¹⁾
18000	32.4
18500	32.0
19000	32.3
19500	32.4
20000	32.3
20500	32.8
21000	32.8
21500	32.7
22000	33.1
22500	33.0
23000	33.1
23500	33.8
24000	33.5
24500	33.5
25000	33.8
25500	33.9
26000	34.2
26500	34.7

¹⁾ The antenna factor shall be added to receiver reading in dB μ V to obtain field strength in dB μ V/m.