



Compliance Testing, LLC

Previously Flom Test Lab

EMI, EMC, RF Testing Experts Since 1963

toll-free: (866) 311-3268

fax: (480) 926-3598

<http://www.ComplianceTesting.com>

info@ComplianceTesting.com

Test Report

Prepared for: FRTek

Model: FRM-DU28D / FRM-MRU28D

Description: 5G 28 GHz Optical DAS

FCC ID: 2AFEG-FRM-28

To

FCC Part 30

Date of Issue: August 5, 2020

On the behalf of the applicant:

FRTek
181 Metro Dr.
San Jose, CA 95110

Attention of:

Milla Woo, CEO
(510)390-1939
milla.woo@frtek.com

Prepared By
Compliance Testing, LLC
1724 S. Nevada Way
Mesa, AZ 85204
(480) 926-3100 phone / (480) 926-3598 fax
www.compliancetesting.com
Project No: p19c0009



Greg Corbin
Project Test Engineer

This report may not be reproduced, except in full, without written permission from Compliance Testing
All results contained herein relate only to the sample tested

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	July 9, 2020	Greg Corbin	Original Document
2.0	July 28, 2020	Greg Corbin	Added EIRP to Table on page 10 Added Table of Annexes on page 3 Added Annex H on page 29
3.0	August 5, 2020	Greg Corbin	Date of issue



Table of Contents

<u>Description</u>	<u>Page</u>
Table of Contents	3
Table of Annexes	4
Standard Test Conditions and Engineering Practices	5
Test Result Summary	7
AGC Threshold	8
Out-Of-Band Rejection	9
Input-Versus-Output Signal Comparison	10
Mean Output and Amplifier Gain	11
Out-Of-Band/Block Emission (Dual Carrier)	12
Out-Of-Band/Block Emission (Single Carrier)	13
Conducted Spurious Emissions	14
Radiated Spurious Emissions	19
Measurement Uncertainty	29
Calibration Data	29
Test Equipment Utilized	30



Table of Annexes

<u>Description</u>	<u>Page</u>
Annex A – Out of Band Rejection	9
Annex B – Input vs Output	10
Annex C – Out of Band/Block Emission (dual carrier)	12
Annex D – Out of Band/Block Emission (single carrier)	13
Annex E – Conducted Spurious Emission	18
Annex F – Radiated Spurious Emission	28
Annex G – Test Equipment Calibration Certificates	29
Annex H – Scope of Accreditation	29

FCC Site Reg. #349717

IC Site Reg. #2044A-2

Non-accredited tests contained in this report:

None

Test and Measurement Data

All tests and measurement data shown were performed in accordance with FCC Rules and Regulations, KDB 935210 D05 v01r04 Industrial Booster Basic Measurements, KDB 586862, KDB 842590 D01 Upper Microwave Flexible Use Service v01r01, ANSI C63-26-2015, and FCC Part 2, Part 30 where appropriate.

Standard Test Conditions and Engineering Practices

In accordance with ANSI/C63.4-2014, and unless otherwise indicated in the specific measurement results, the ambient temperature of the actual EUT was maintained within the range of 10° to 40°C (50° to 104°F), unless the particular equipment requirements specified testing over a different temperature range. Also, unless otherwise indicated, the humidity levels were in the range of 10% to 90% relative humidity.

Environmental Conditions		
Temp (°C)	Humidity (%)	Pressure (mbar)
24.2 – 28.5	29.0 – 37.1	961.7 – 969.7

Measurement results, unless otherwise noted, are worst-case measurements.

EUT Description

Model: FRM-DU28D / FRM-MRU28D

Description: 5G 28 GHz Optical DAS

Additional Information:

The EUT is a 5G 28 GHz Optical DAS (Distributed Amplifier System).

The frequency range for both the uplink and downlink is 27.5 – 28.35 GHz.

The EUT has separate SISO and MIMO input / outputs.

Modulation used is according to the 5G NR (New Radio Standard) 3GPP 38 (Downlink: CP-OFDM, Uplink: CP-OFDM or DFT-S-OFDM – up to 256QAM).

Channel Capacity is:

100MHz X 8FA (Continuous & Non-Continuous) or 200MHz X 4FA (Continuous & Non-Continuous) or 400MHz X 2FA (Continuous & Non-Continuous)

EUT Operation during Tests

EUT was set up for normal operating conditions.

The EUT was controlled by a GUI titled “FRTek 5G DAS GUI – version 0.22”

5G test signals with either 100 MHz or 400 MHz bandwidths were used as required.

The DU and mHU antennas were removed to provide access to the antenna ports.

Test signals were injected into the antenna ports.

The 5G 28 GHz Optical DAS contains the following individual units.

Product Name	Model Name	Serial Number	Version
28 GHz 5G mRU	FR-R5G17AFU	FRC14-198-0007	10.30
28 GHz 5G DU	FR-R5G17AFU	FRC10-198-0004	10.30
28 GHz 5G DRU	FR-R5G17AFU	FRC13-198-0004	10.30
28 GHz 5G MDU	FR-R5G17AFU	FRC11-198-0004	10.30
28 GHz 5G MHU	FR-R5G17AFU	FRC12-198-0004	10.21
28 GHz 5G MPSU	FR-R5G17AFU	FRC15-198-0007	N/A

The EUT Antenna ports are listed below.

DU	mRU
SISO Downlink Input	SISO Downlink Output
SISO Uplink Output	SISO Uplink Input
MIMO Downlink Input	MIMO Downlink Output
MIMO Uplink Output	MIMO Uplink Input

Accessories: None

Cables: manufacturer supplied interconnect cable set

Modifications: None

Test Result Summary

Specification	Test Name	Pass, Fail, N/A	Comments
KDB 935210 D05 (3.2)	AGC Threshold	Pass	
KDB 935210 D05 (3.3)	Out-of-Band Rejection	Pass	
KDB 935210 D05 (3.4)	Input-Versus-Output Signal Comparison	Pass	
2.1046 KDB 935210 D05 (3.5)	Mean Output Power and Amplifier gain	Pass	
Part 30.203(a) KDB 935210 D05 (3.6.2)	Out-Of-Band/Block Emissions Conducted	Pass	
2.1051 Part 30.203(a) KDB 935210 D05 (3.6.3)	Spurious Emissions Conducted	Pass	
KDB 935210 D05 (3.7)	Frequency Stability	N/A	Does not have Frequency translation
2.1053 KDB 935210 D05 (3.8)	Spurious Emissions Radiated	Pass	

Statements of conformity are reported as:

- Pass - the measured value is below the acceptance limit, *acceptance limit = test limit*.
- Fail - the measured value is above the acceptance limit, *acceptance limit = test limit*.

AGC Threshold

Engineer: Greg Corbin

Test Date: 5/15/2020

Test Procedure

The EUT was connected as shown in the test set-up block diagram.

The Signal Generator was configured to produce 5G signals with 100 MHz and 400 MHz bandwidth.

The peak frequency from the Out of Band Rejection was used unless the frequency was too close to the band edge in which case the next highest peak was selected that allowed bandwidth of the signal to remain within the passband. This same signal was used for the Mean Output Power test.

The input power level was increased in 1 dB increments until the power no longer increased.

The input levels were recorded in the table below.

The spectrum analyzer channel power tool was used to monitor the output power level.

Test Setup



AGC Threshold Test Results

Downlink

Tuned Frequency (MHz)	Channel Configuration	AGC Threshold (dBm)	
		100 MHz BW	400 MHz BW
27925	SISO	-52	-50
27970.9	MIMO	-51	-51

Uplink

Tuned Frequency (MHz)	Channel Configuration	AGC Threshold (dBm)	
		100 MHz BW	400 MHz BW
27925	SISO	-52	-50
27970.9	MIMO	-51	-51

Out-Of-Band Rejection

Engineer: Greg Corbin

Test Date: 5/15/2020

Test Procedure

The EUT was connected as shown in the test set-up block diagram.

A signal generator was utilized to produce a swept CW signal with the RF input level set to 3 dB below the AGC Threshold level.

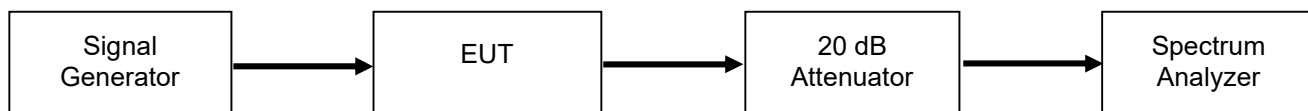
The Uplink and Downlink filter response and the -20 dB bandwidth were measured.

The marker table function of the spectrum analyzer was used to show the peak amplitude in the passband and the -20 dB bandwidth of the pass band filter.

RBW = 1 MHz

Video BW = 3 MHz

Test Setup



-20 dB Bandwidth Test Results

Channel Configuration	-20 dB Bandwidth (MHz)
SISO Downlink	1077.2
SISO Uplink	1052.3
MIMO Downlink	1065.2
MIMO Uplink	1052.7

Annex A Out of Band Rejection

Refer to Annex A for Out of Band Rejection plots

Input-Versus-Output Signal Comparison

Engineer: Greg Corbin

Test Date: 5/22/2020

Test Procedure

The EUT was connected as shown in the test set-up block diagram.

The amplitude was set to be just below the AGC threshold level but not more than 0.5 dB.

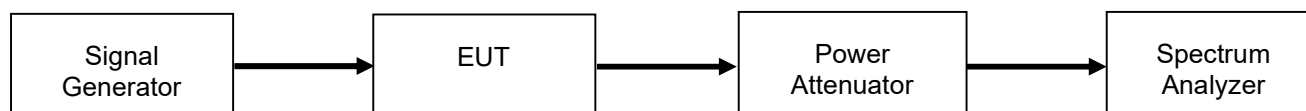
The Occupied BW tool on the spectrum analyzer was used to measure the -26 dB BW for both the input and output signals.

The 99% bandwidth was compared between the input and the output of the EUT.

The input level was then increased by 3 dB above and the comparison repeated.

The Input and Output signal comparison was performed with 100 MHz and 400 MHz BW signals.

Test Setup



Annex B – Input vs Output

Refer to Annex B for Input vs Output plots.

Mean Output and Amplifier Gain

Engineer: Greg Corbin

Test Date: 5/22/2020

Test Procedure

The EUT was connected as shown in the test set-up block diagram.

The peak frequency from the Out of Band Rejection was used unless the frequency was too close to the band edge in which case the next highest peak was selected that allowed bandwidth of the signal to remain within the passband.

The output power test was performed with 100 MHz and 400 MHz test signals.

The channel power tool on the spectrum analyzer was used to measure output power.

The input power level was increased in 1 dB increments until the power no longer increased.

The input and output levels were recorded in the table below.

The amplifier gain was determined from the delta between the input and output levels.

The input level was increased 3 dB and the output power was recorded.

Test Setup



Output Power and Gain Test Results

Channel Configuration	Bandwidth (MHz)	Tuned Frequency (MHz)	Input Power (dBm)	Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	Gain (dB)	(Input Power +3 dB) Output Power (dBm)
SISO Downlink	100	27925	-52	18.5	8	26.5	70.5	20.8
SISO Uplink	100	28034	-52	18.8	10	28.8	77	21.6
MIMO Downlink	100	27970.9	-52	18.2	8	26.2	70.2	20.6
MIMO Uplink	100	27925	-57	18.6	10	28.6	75.6	20.9
SISO Downlink	400	27925	-52	19.8	8	27.8	71.8	22.5
SISO Uplink	400	27925	-57	19.2	10	29.2	76.2	21.7
MIMO Downlink	400	27970.9	-52	18.4	8	26.4	70.4	20.8
MIMO Uplink	400	27925	-57	19.1	10	29.1	76.1	21.7

EIRP = Output Power + Antenna Gain

Gain = Output Power – Input Power

Out-Of-Band/Block Emission (Dual Carrier)

Engineer: Greg Corbin

Test Date: 5/21/2020

Test Procedure

This test was performed using test signals with 100 MHz bandwidth.

For Band edge OOBE, the measurement is performed for 10% of the emission BW, for 100 MHz BW signal, the OOBE is measured for 10 MHz from the band edge.

The Lower Band Edge is 27490 - 27500 MHz

The Upper Band Edge = 28350 - 28360 MHz

The limit is -5 dBm/MHz in the OOBE region

Part 30 section 203_Emission Limits_

(a) The conductive power or the total radiated power of any emission outside a licensee's frequency block shall be -13 dBm/MHz or lower. However, in the bands immediately outside and adjacent to the licensee's frequency block, having a bandwidth equal to 10 percent of the channel bandwidth, the conductive power or the total radiated power of any emission shall be -5 dBm/MHz or lower

The input power was set by measuring the output power with the integration BW set to 200 MHz, the input power was increased until just below the AGC (ALC) point

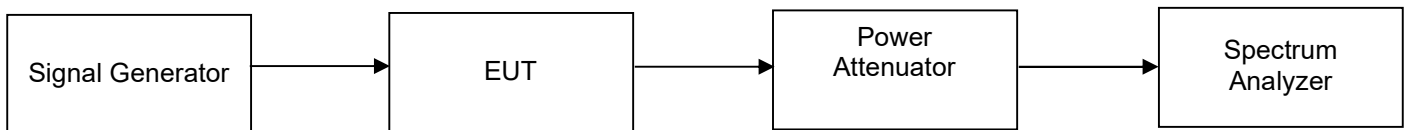
The test was performed at the lower and upper band edge.

RBW = 1 MHz

VBW = 3 MHz

The test was performed with the input level 0.2 dB below the AGC level and at 3 dB above the AGC level. A wideband plot was also included to show the dual carriers.

Test Setup



Annex C – Out of Band/Block Emission (dual carrier)

Refer to Annex C for Out of Band/Block emission plots (dual Carrier)

Out-Of-Band/Block Emission (Single Carrier)

Engineer: Greg Corbin

Test Date: 5/21/2020

Test Procedure

This test was performed using a test signal with 100 MHz bandwidth.

For Band edge OOBE, the measurement is performed for 10% of the emission BW, for 100 MHz BW signal, the OOBE is measured for 10 MHz from the band edge.

The Lower Band Edge is 27490 - 27500 MHz

The Upper Band Edge = 28350 - 28360 MHz

The limit is -5 dBm/MHz in the OOBE region

Part 30 section 203_Emission Limits_

(a) The conductive power or the total radiated power of any emission outside a licensee's frequency block shall be -13 dBm/MHz or lower. However, in the bands immediately outside and adjacent to the licensee's frequency block, having a bandwidth equal to 10 percent of the channel bandwidth, the conductive power or the total radiated power of any emission shall be -5 dBm/MHz or lower

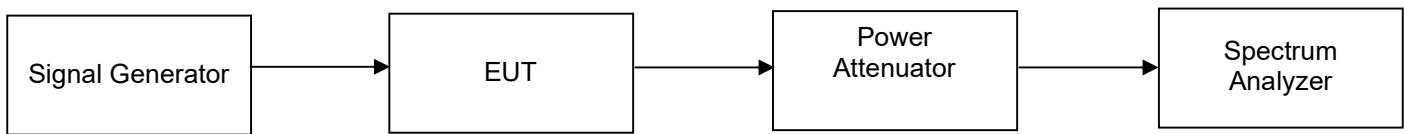
The test was performed at the lower and upper band edge.

RBW = 1 MHz

VBW = 3 MHz

The test was performed with the input level 0.2 dB below the AGC level and at 3 dB above the AGC level.

Test Setup



Annex D – Out of Band/Block Emission (single carrier)

Refer to Annex D for Out of Band/Block emission plots (single carrier)

Conducted Spurious Emissions

Engineer: Greg Corbin

Test Date: 6/25/2020

Test Procedure

This test was performed using 5GNR test signals with 100 MHz bandwidth.

Raw data was recorded, with no correction factors were input to the spectrum analyzer.

The peak emission was recorded and the final value was calculated in the table below.

Conducted spurious emissions were measured from 30 MHz to 110 GHz.

From 30 MHz to 40 GHz the EUT output was connected directly to the spectrum analyzer and raw data was recorded.

From 30 MHz to 40 GHz the only correction factor was the cable loss from the EUT output to the spectrum analyzer input.

From 40 – 110 GHz, external mixers were used and raw data was recorded with all correction factors applied manually in the table below.

RBW = 100 kHz for measurements below 1 GHz.

RBW = 1 MHz for measurements above 1 GHz.

VBW = 3 X RBW.

The tests were performed with the test signal set to the low, mid, and high channels of the band, with the output power level set to just below the AGC point.

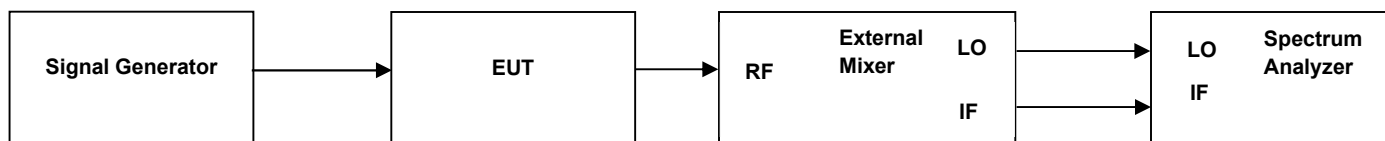
Part 30 section 203_Emission Limits_

(a) The conductive power or the total radiated power of any emission outside a licensee's frequency block shall be -13 dBm/MHz or lower.

Test Setup_30 MHz to 40 GHz



Test Setup_40 GHz to 110 GHz



Calculations:

30 MHz – 40 GHz_ Direct connection to spectrum analyzer

Final Data = Raw Data + Cable Insertion Loss

40 GHz – 110 GHz_ EUT output connected to external mixer with the IF/LO ports going to a diplexer then connected to spectrum analyzer

Final Data = Raw Data + Diplexer Insertion Loss + Cable/Conn Insertion Loss + Mixer Conversion Loss

SISO Downlink Conducted Spurious Test Data

Test Frequency	Spectrum Analyzer span	Conducted Spurious (raw data)		RBW	Diplexer Insertion Loss @ 311 MHz	Cable/Conn Insertion Loss_ EUT output to Mixer input	Receive Mixer Conversion Loss	Conducted Spurious Emissions_ Final Data	Limit	Margin
		Frequency	Amplitude							
GHz	GHz	GHz	dBm	kHz	dB	dB	dB	dBm	dBm	dB
27.550	0.03 - 1	61.1	-33.00	120	0	-0.7	0.00	-32.30	-13	-19.30
27.550	1 - 18	25.925	-20.60	1000	0	-3.8	0.00	-16.80	-13	-3.80
27.550	18 - 40	28.351	-29.00	1000	0	-4	0.00	-25.00	-13	-12.00
27.550	40 - 50	45.872	-53.90	1000	-1	-3.2	-22.70	-27.00	-13	-14.00
27.550	50 - 75	55.109	-65.60	1000	-1	-1.7	-33.90	-29.00	-13	-16.00
27.550	75 - 110	82.628	-89.00	1000	-1	-2.05	-40.60	-45.35	-13	-32.35
27.925	0.03 - 1	61.5	-36.10	120	0	-0.7	0.00	-35.40	-13	-22.40
27.925	1 - 18	25.925	-20.60	1000	0	-3.8	0.00	-16.80	-13	-3.80
27.925	18 - 40	28.361	-29.30	1000	0	-4	0.00	-25.30	-13	-12.30
27.925	40 - 50	46.484	-49.50	1000	-1	-3.2	-22.40	-22.90	-13	-9.90
27.925	50 - 75	55.85	-62.80	100	-1	-1.7	-33.50	-26.60	-13	-13.60
27.925	75 - 110	98.969	-91.30	1000	-1	-2.05	-42.00	-46.25	-13	-33.25
28.300	0.03 - 1	61.5	-36.50	120	0	-0.7	0.00	-35.80	-13	-22.80
28.300	1 - 18	25.925	-20.70	1000	0	-3.8	0.00	-16.90	-13	-3.90
28.300	18 - 40	28.358	-25.80	1000	0	-4	0.00	-21.80	-13	-8.80
28.300	40 - 50	47.114	-56.40	1000	-1	-3.4	-22.40	-29.60	-13	-16.60
28.300	50 - 75	56.6	-62.90	1000	-1	-1.7	-33.30	-26.90	-13	-13.90
28.300	75 - 110	83.231	-83.20	1000	-1	-2.05	-40.50	-39.65	-13	-26.65



SISO Uplink Conducted Spurious Test Data

Test Frequency	Spectrum Analyzer span	Conducted Spurious (raw data)		RBW	Diplexer Insertion Loss @ 311 MHz	Cable/Conn Insertion Loss_ EUT output to Mixer input	Receive Mixer Conversion Loss	Conducted Spurious Emissions_ Final Data	Limit	Margin
		Frequency	Amplitude							
GHz	GHz	GHz	dBm	kHz	dB	dB	dB	dBm	dBm	dB
27.550	0.03 - 1	61.1	-33.00	120	0	-0.7	0.00	-32.30	-13	-19.30
27.550	1 - 18	25.925	-20.60	1000	0	-3.8	0.00	-16.80	-13	-3.80
27.550	18 - 40	28.351	-29.00	1000	0	-4	0.00	-25.00	-13	-12.00
27.550	40 - 50	45.872	-53.90	1000	-1	-3.2	-22.70	-27.00	-13	-14.00
27.550	50 - 75	55.109	-65.60	1000	-1	-1.7	-33.90	-29.00	-13	-16.00
27.550	75 - 110	82.628	-89.00	1000	-1	-2.05	-40.60	-45.35	-13	-32.35
27.925	0.03 - 1	61.5	-36.10	120	0	-0.7	0.00	-35.40	-13	-22.40
27.925	1 - 18	25.925	-20.60	1000	0	-3.8	0.00	-16.80	-13	-3.80
27.925	18 - 40	28.361	-29.30	1000	0	-4	0.00	-25.30	-13	-12.30
27.925	40 - 50	46.484	-49.50	1000	-1	-3.2	-22.40	-22.90	-13	-9.90
27.925	50 - 75	55.85	-62.80	1000	-1	-1.7	-33.50	-26.60	-13	-13.60
27.925	75 - 110	98.969	-91.30	1000	-1	-2.05	-42.00	-46.25	-13	-33.25
28.300	0.03 - 1	61.5	-36.50	120	0	-0.7	0.00	-35.80	-13	-22.80
28.300	1 - 18	25.925	-20.70	1000	0	-3.8	0.00	-16.90	-13	-3.90
28.300	18 - 40	28.358	-25.80	1000	0	-4	0.00	-21.80	-13	-8.80
28.300	40 - 50	47114	-56.40	1000	-1	-3.4	-22.40	-29.60	-13	-16.60
28.300	50 - 75	56.6	-62.90	1000	-1	-1.7	-33.30	-26.90	-13	-13.90
28.300	75 - 110	83.231	-83.20	1000	-1	-2.05	-40.50	-39.65	-13	-26.65



MIMO Downlink Conducted Spurious Test Data

Test Frequency	Spectrum Analyzer span	Conducted Spurious (raw data)		RBW	Diplexer Insertion Loss @ 311 MHz	Cable/Conn Insertion Loss_ EUT output to Mixer input	Receive Mixer Conversion Loss	Conducted Spurious Emissions_ Final Data	Limit	Margin
		Frequency	Amplitude							
GHz	GHz	GHz	dBm	kHz	dB	dB	dB	dBm	dBm	dB
27.550	0.03 - 1	61.5	-45.20	120	0	-0.7	0.00	-44.50	-13	-31.50
27.550	1 - 18	25.925	-7.80	1000	0	-3.8	0.00	-4.00	-13	9.00
27.550	18 - 40	28.359	-32.80	1000	0	-4	0.00	-28.80	-13	-15.80
27.550	40 - 50	45.878	-57.30	1000	-1	-3.2	-22.70	-30.40	-13	-17.40
27.550	50 - 75	55.094	-68.70	1000	-1	-1.7	-39.90	-26.10	-13	-13.10
27.550	75 - 110	91.281	-91.30	1000	-1	-2.05	-41.00	-47.25	-13	-34.25
27.925	0.03 - 1	59.1	-36.60	120	0	-0.7	0.00	-35.90	-13	-22.90
27.925	1 - 18	25.925	-8.40	1000	0	-3.8	0.00	-4.60	-13	8.40
27.925	18 - 40	28.359	-32.70	1000	0	-4	0.00	-28.70	-13	-15.70
27.925	40 - 50	46.546	-67.30	1000	-1	-3.2	-22.40	-40.70	-13	-27.70
27.925	50 - 75	55.851	-66.60	1000	-1	-1.7	-33.50	-30.40	-13	-17.40
27.925	75 - 110	83.556	-91.50	1000	-1	-2.05	-40.60	-47.85	-13	-34.85
28.300	0.03 - 1	64	-43.90	120	0	-0.7	0.00	-43.20	-13	-30.20
28.300	1 - 18	25.925	-8.00	1000	0	-3.8	0.00	-4.20	-13	8.80
28.300	18 - 40	28.351	-29.20	1000	0	-4	0.00	-25.20	-13	-12.20
28.300	40 - 50	47.153	-54.20	1000	-1	-3.4	-22.40	-27.40	-13	-14.40
28.300	50 - 75	56.602	-65.10	1000	-1	-1.7	-33.30	-29.10	-13	-16.10
28.300	75 - 110	84.931	-90.50	1000	-1	-2.05	-40.40	-47.05	-13	-34.05

MIMO Uplink Conducted Spurious Test Data

Test Frequency	Spectrum Analyzer span	Conducted Spurious (raw data)		RBW	Diplexer Insertion Loss @ 311 MHz	Cable/Conn Insertion Loss_ EUT output to Mixer input	Receive Mixer Conversion Loss	Conducted Spurious Emissions_ Final Data	Limit	Margin
		Frequency	Amplitude							
GHz	GHz	GHz	dBm	kHz	dB	dB	dB	dBm	dBm	dB
27.550	0.03 - 1	64	-38.30	120	0	-0.7	0.00	-37.60	-13	-24.60
27.550	1 - 18	25.925	-22.60	1000	0	-3.8	0.00	-18.80	-13	-5.80
27.550	18 - 40	28.352	-23.30	1000	0	-4	0.00	-19.30	-13	-6.30
27.550	40 - 50	45.684	-58.50	1000	-1	-3.2	-22.70	-31.60	-13	-18.60
27.550	50 - 75	55.098	-68.60	1000	-1	-1.7	-33.90	-32.00	-13	-19.00
27.550	75 - 110	82.604	-76.10	1000	-1	-2.05	-40.60	-32.45	-13	-19.45
27.925	0.03 - 1	59.1	-34.30	120	0	-0.7	0.00	-33.60	-13	-20.60
27.925	1 - 18	25.925	-22.60	1000	0	-3.8	0.00	-18.80	-13	-5.80
27.925	18 - 40	28.354	-26.10	1000	0	-4	0.00	-22.10	-13	-9.10
27.925	40 - 50	46.484	-50.80	1000	-1	-3.2	-22.40	-24.20	-13	-11.20
27.925	50 - 75	55.853	-59.00	1000	-1	-1.7	-33.50	-22.80	-13	-9.80
27.925	75 - 110	83.79	-82.30	1000	-1	-2.05	-40.70	-38.55	-13	-25.55
28.300	0.03 - 1	61.5	-38.90	120	0	-0.7	0.00	-38.20	-13	-25.20
28.300	1 - 18	25.925	-22.60	1000	0	-3.8	0.00	-18.80	-13	-5.80
28.300	18 - 40	38.351	-17.70	1000	0	-4	0.00	-13.70	-13	-0.70
28.300	40 - 50	47106	-59.90	1000	-1	-3.4	-22.40	-33.10	-13	-20.10
28.300	50 - 75	56.601	-67.10	1000	-1	-1.7	-33.30	-31.10	-13	-18.10
28.300	75 - 110	84.895	-84.40	1000	-1	-2.05	-42.60	-38.75	-13	-25.75

Annex E – Conducted Spurious Emission

Refer to Annex E for Conducted Spurious Emission plots.

Radiated Spurious Emissions

Engineer: Greg Corbin

Test Date: 7/7/2020

Test Procedure

This test was performed using 5GNR test signals with 100 MHz bandwidth.

Raw data was recorded, with no correction factors were input to the spectrum analyzer, except for the IF cable insertion loss of -1.9 dB when external mixers are used from 40 – 110 GHz. The -1.9 dB is shown on the plots.

The peak emission was recorded and the final value was calculated in the table below.

Radiated spurious emissions were measured from 30 MHz to 110 GHz.

The tests were performed with the test signal set to the low, mid, and high channels of the band, with the output power level set to just below the AGC point.

All measurements are field strength at 1 meter, except for 30 - 1000 MHz and 1 - 18 GHz, which were measured at 3 meters.

For 30 - 1000 MHz and 1 - 18 GHz, a distance correction factor was used to convert the measurement to 1 meter.

Distance Correction Factor: $DCF (dB) = 20 \cdot \log(D1/D2)$

Field Strength (calculated) = Measured Data + Distance Corr Factor + Cable Insertion Loss + Rcv Mixer Corr Factor + Rcv Ant Corr Factor - Ext Amp Gain

Convert field strength (dBuV/m) to EIRP (dBm).

$EIRP(dBm) = \text{Field strength (dBuV/m)} - 107$

Compare result to -13 dBm EIRP limit.

BW Correction Factor = $10 \cdot \log(B1/B2)$

For the Horn antennas used with the external mixers above 40 GHz, the data supplied from manufacturer is transmit gain data. The TX gain data needs to be converted to Antenna factor data with the following formula:

Antenna Gain to Antenna Factor, $ACF(dB) = 20 \cdot \log(\text{freq, MHz}) - \text{Antenna gain (dBi)} - 29.79$

For measurements above 40 GHz, the RX antenna was moved to 0.1 meter and a distance correction factor was used to convert the measurement to 1 meter distance.

For 30 - 1000 MHz, all correction factors were input to the spectrum analyzer before recording final measurement.

All measurements were made with a peak detector set to max hold.

For any signals over the limit, the measurement was repeated with an average detector.

From 30 - 1000 MHz, RBW = 100 kHz, VBW = 300 kHz

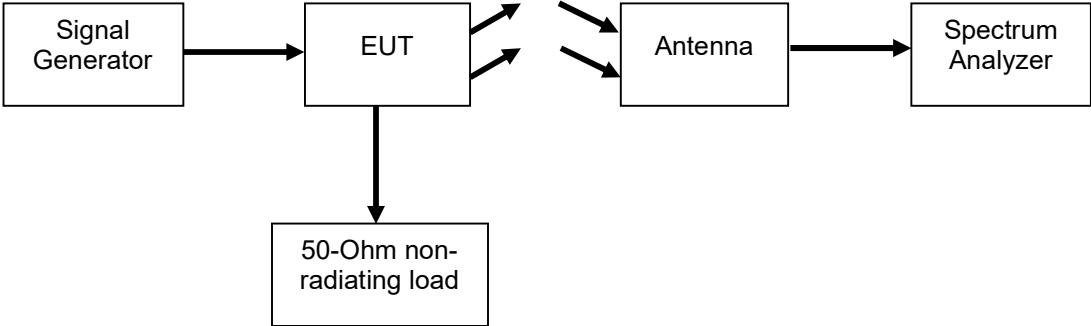
From 1 - 110 GHz, RBW = 1 MHz, VBW = 3 MHz

For 1 - 40 GHz, Amplifier Asset # i00555 was used.

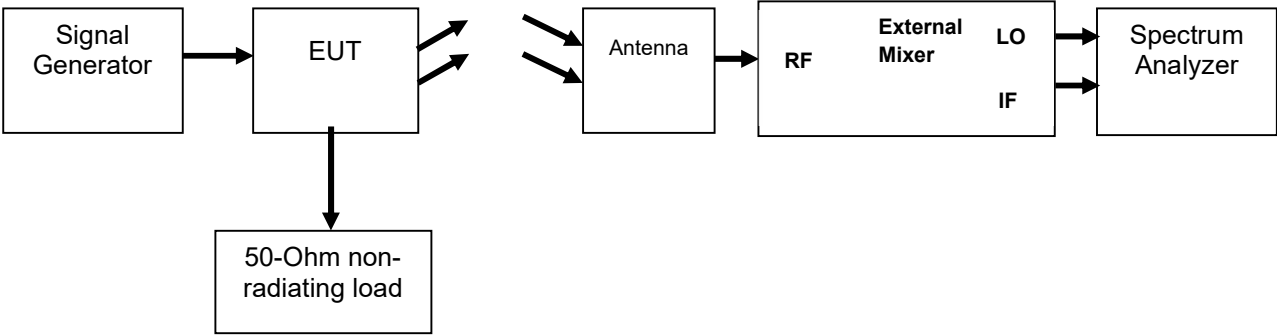
Part 30 section 203_Emission Limits_

(a) The conductive power or the total radiated power of any emission outside a licensee's frequency block shall be -13 dBm/MHz or lower.

Test Setup_30 MHz to 40 GHz



Test Setup_40 to 110 GHz



Radiated Spurious Test Data
MIMO Downlink_27.550 GHz

Test Frequency GHz	Spectrum Analyzer span GHz	Radiated Spurious (raw data)		Measurement distance per standard meter	Measurement distance meter	Distance Correction Factor dB	RBW MHz
		Frequency GHz	Amplitude dBuV				
27.550	0.030 - 1	0.03841	58.90	1	3	9.54	0.120
27.550	1 – 18	2.5	62.00	1	3	9.54	1000
27.550	18 – 40	25.925	61.80	1	1	0.00	1000
27.550	40 – 50	47.884	18.20	1	0.1	-20.00	1000
27.550	50 - 75	74.057	16.50	1	0.1	-20.00	1000
27.550	75 - 110	82.281	17.10	1	0.1	-20.00	1000

3 meter Chamber Cable Insertion Loss dB	Ext Amplifier Gain dB	Receive Mixer Correction Factor dB	Receive Antenna Correction Factor dB	Field Strength (calculated) dBuV/m	Convert Field Strength (dBuV/m) to EIRP (dBm) dBm	Limit dBm	Margin dB
0.0	0	0.00	0.00	68.44	-36.33	-13	-23.33
5.7	42	0.00	28.60	63.84	-40.93	-13	-27.93
17.8	31.94	0.00	46.20	93.83	-10.94	-13	-1.24
0.0	0	22.50	40.51	61.21	-43.56	-13	-30.56
0.0	0	36.10	44.40	77.00	-27.77	-13	-14.77
0.0	0	40.50	45.42	83.02	-21.75	-13	-8.75

Test Frequency GHz	Spectrum Analyzer span GHz	Radiated Spurious (raw data)		Measurement distance per standard meter	Measurement distance meter	Distance Correction Factor dB	RBW MHz
		Frequency GHz	Amplitude dBuV				
27.925	0.030 - 1	0.38515	57.60	1	3	9.54	120
27.925	1 – 18	2.5	62.10	1	3	9.54	1000
27.925	18 – 40	25.925	62.40	1	1	0.00	1000
27.925	40 – 50	47.884	23.10	1	0.1	-20.00	1000
27.925	50 - 75	54.191	16.80	1	0.1	-20.00	1000
27.925	75 - 110	84.352	17.50	1	0.1	-20.00	1000

3 meter Chamber Cable Insertion Loss dB	Ext Amplifier Gain dB	Receive Mixer Correction Factor dB	Receive Antenna Correction Factor dB	Field Strength (calculated) dBuV/m	Convert Field Strength (dBuV/m) to EIRP (dBm) dBm	Limit dBm	Margin dB
0.0	0	0.00	0.00	67.14	-37.63	-13	-24.63
5.7	42	0.00	40.00	75.34	-29.43	-13	-16.43
17.8	31.94	0.00	46.20	94.43	-10.34	-13	-1.24
0.0	0	22.50	40.51	66.11	-38.66	-13	-25.66
0.0	0	34.20	41.59	72.59	-32.18	-13	-19.18
0.0	0	40.50	45.33	83.33	-21.44	-13	-8.44



Test Frequency GHz	Spectrum Analyzer span GHz	Radiated Spurious (raw data)		Measurement distance per standard meter	Measurement distance meter	Distance Correction Factor dB	RBW MHz
		Frequency GHz	Amplitude dBuV				
28.300	0.030 - 1	0.03936	60.10	1	3	9.54	120
28.300	1 - 18	2.5	62.40	1	3	9.54	1000
28.300	18 - 40	25.925	61.90	1	1	0.00	1000
28.300	40 - 50	48.689	24.30	1	0.1	-20.00	1000
28.300	50 - 75	55.017	17.10	1	0.1	-20.00	1000
28.300	75 - 110	76.214	16.80	1	0.1	-20.00	1000

3 meter Chamber Cable Insertion Loss dB	Ext Amplifier Gain dB	Receive Mixer Correction Factor dB	Receive Antenna Correction Factor dB	Field Strength (calculated) dBuV/m	Convert Field Strength (dBuV/m) to EIRP (dBm) dBm	Limit dBm	Margin dB
0.0	0	0.00	0.00	69.64	-35.13	-13	-22.13
5.7	42	0.00	38.30	73.94	-30.83	-13	-17.83
17.8	31.94	0.00	46.20	93.93	-10.84	-13	-1.24
0.0	0	22.50	40.66	67.46	-37.31	-13	-24.31
0.0	0	33.90	41.72	72.72	-32.05	-13	-19.05
0.0	0	41.00	44.45	82.25	-22.52	-13	-9.52



**Radiated Spurious Test Data
MIMO Uplink**

Test Frequency	Spectrum Analyzer span	Radiated Spurious (raw data)		Measurement distance per standard	Measurement distance	Distance Correction Factor	RBW
		Frequency	Amplitude				
GHz	GHz	GHz	dBuV	meter	meter	dB	MHz
27.550	0.030 - 1	0.38539	59.10	1	3	9.54	120
27.550	1 – 18	2.5	62.00	1	3	9.54	1000
27.550	18 – 40	25.925	63.60	1	1	0.00	1000
27.550	40 – 50	47.883	23.20	1	0.1	-20.00	1000
27.550	50 - 75	71.307	16.60	1	0.1	-20.00	1000
27.550	75 - 110	91.197	16.80	1	0.1	-20.00	1000

3 meter Chamber Cable Insertion Loss	Ext Amplifier Gain	Receive Mixer Correction Factor	Receive Antenna Correction Factor	Field Strength (calculated)	Convert Field Strength (dBuV/m) to EIRP (dBm)	Limit	Margin
dB	dB	dB	dB	dBuV/m	dBm	dBm	dB
0.0	0	0.00	0.00	68.64	-38.36	-13	-25.36
5.7	42	0.00	39.60	74.84	-32.16	-13	-19.16
17.8	31.94	0.00	46.20	95.63	-11.37	-13	-3.27
0.0	0	22.50	40.51	66.21	-40.79	-13	-27.79
0.0	0	35.20	44.07	75.87	-31.13	-13	-18.13
0.0	0	41.00	46.31	84.11	-22.89	-13	-9.89

Test Frequency	Spectrum Analyzer span	Radiated Spurious (raw data)		Measurement distance per standard	Measurement distance	Distance Correction Factor	RBW
		Frequency	Amplitude				
GHz	GHz	GHz	dBuV	meter	meter	dB	MHz
27.925	0.030 - 1	0.3855	59.40	1	3	9.54	120
27.925	1 – 18	2.5	61.90	1	3	9.54	1000
27.925	18 – 40	25.925	63.00	1	1	0.00	1000
27.925	40 – 50	48.689	23.90	1	0.1	-20.00	1000
27.925	50 - 75	55.242	16.90	1	0.1	-20.00	1000
27.925	75 - 110	95.71	17.40	1	0.1	-20.00	1000

3 meter Chamber Cable Insertion Loss	Ext Amplifier Gain	Receive Mixer Correction Factor	Receive Antenna Correction Factor	Field Strength (calculated)	Convert Field Strength (dBuV/m) to EIRP (dBm)	Limit	Margin
dB	dB	dB	dB	dBuV/m	dBm	dBm	dB
0.0	0	0.0	0	0.00	0.00	68.94	-38.06
5.7	42	5.7	42	0.00	40.80	75.94	-31.06
17.8	31.94	17.8	31.94	0.00	46.20	95.03	-3.17
0.0	0	0.0	0	22.50	40.66	67.06	-39.94
0.0	0	0.0	0	33.70	41.76	72.36	-34.64
0.0	0	0.0	0	41.40	46.43	85.23	-21.77



Test Frequency GHz	Spectrum Analyzer span GHz	Radiated Spurious (raw data)		Measurement distance per standard meter	Measurement distance meter	Distance Correction Factor dB	RBW MHz
		Frequency GHz	Amplitude dBuV				
28.300	0.030 - 1	0.38539	59.30	1	3	9.54	120
28.300	1 - 18	2.331	66.50	1	3	9.54	1000
28.300	18 - 40	25.925	63.00	1	1	0.00	1000
28.300	40 - 50	47.883	24.90	1	0.1	-20.00	1000
28.300	50 - 75	59.1	16.40	1	0.1	-20.00	1000
28.300	75 - 110	91.904	16.50	1	0.1	-20.00	1000

3 meter Chamber Cable Insertion Loss dB	Ext Amplifier Gain dB	Receive Mixer Correction Factor dB	Receive Antenna Correction Factor dB	Field Strength (calculated) dBuV/m	Convert Field Strength (dBuV/m) to EIRP (dBm) dBm	Limit dBm	Margin dB
0.0	0	0.0	0	0.00	0.00	68.84	-38.16
5.7	42	5.7	42	0.00	38.70	78.44	-28.56
17.8	31.94	17.8	31.94	0.00	46.20	95.03	-3.27
0.0	0	0.0	0	22.50	40.51	67.91	-39.09
0.0	0	0.0	0	33.80	42.34	72.54	-34.46
0.0	0	0.0	0	41.20	46.08	83.78	-23.22



**Radiated Spurious Test Data
SISO Downlink**

Test Frequency	Spectrum Analyzer span	Radiated Spurious (raw data)		Measurement distance per standard	Measurement distance	Distance Correction Factor	RBW
		Frequency	Amplitude				
GHz	GHz	GHz	dBuV	meter	meter	dB	MHz
27.550	0.030 - 1	0.04018	59.80	1	3	9.54	120
27.550	1 - 18	2.5	62.10	1	3	9.54	1000
27.550	18 - 40	25.925	62.60	1	1	0.00	1000
27.550	40 - 50	47.883	25.80	1	0.1	-20.00	1000
27.550	50 - 75	74.059	16.30	1	0.1	-20.00	1000
27.550	75 - 110	85.481	17.20	1	0.1	-20.00	1000

3 meter Chamber Cable Insertion Loss	Ext Amplifier Gain	Receive Mixer Correction Factor	Receive Antenna Correction Factor	Field Strength (calculated)	Convert Field Strength (dBuV/m) to EIRP (dBm)	Limit	Margin
dB	dB	dB	dB	dBuV/m	dBm	dBm	dB
0.0	0	0.00	0.00	69.34	-35.43	-13	-22.43
5.7	42	0.00	28.60	63.94	-40.83	-13	-27.83
17.8	31.94	0.00	46.20	94.63	-10.14	-13	-3.14
0.0	0	22.50	40.51	68.81	-35.96	-13	-22.96
0.0	0	36.10	44.40	76.80	-27.97	-13	-14.97
0.0	0	40.40	45.75	83.35	-21.42	-13	-8.42

Test Frequency	Spectrum Analyzer span	Radiated Spurious (raw data)		Measurement distance per standard	Measurement distance	Distance Correction Factor	RBW
		Frequency	Amplitude				
GHz	GHz	GHz	dBuV	meter	meter	dB	MHz
27.925	0.030 - 1	0.03983	58.80	1	3	9.54	120
27.925	1 - 18	2.5	62.10	1	3	9.54	1000
27.925	18 - 40	25.925	60.60	1	1	0.00	1000
27.925	40 - 50	48.689	24.10	1	0.1	-20.00	1000
27.925	50 - 75	58.749	16.70	1	0.1	-20.00	1000
27.925	75 - 110	96.995	16.70	1	0.1	-20.00	1000

3 meter Chamber Cable Insertion Loss	Ext Amplifier Gain	Receive Mixer Correction Factor	Receive Antenna Correction Factor	Field Strength (calculated)	Convert Field Strength (dBuV/m) to EIRP (dBm)	Limit	Margin
dB	dB	dB	dB	dBuV/m	dBm	dBm	dB
0.0	0	0.00	0.00	68.34	-36.43	-13	-23.43
5.7	42	0.00	28.60	63.94	-40.83	-13	-27.83
17.8	31.94	0.00	46.20	92.63	-12.14	-13	-3.14
0.0	0	22.50	40.66	67.26	-37.51	-13	-24.51
0.0	0	33.70	42.29	72.69	-32.08	-13	-19.08
0.0	0	41.60	46.54	84.84	-19.93	-13	-6.93



Test Frequency GHz	Spectrum Analyzer span GHz	Radiated Spurious (raw data)		Measurement distance per standard meter	Measurement distance meter	Distance Correction Factor dB	RBW MHz
		Frequency GHz	Amplitude dBuV				
28.300	0.030 - 1	0.03936	59.20	1	3	9.54	120
28.300	1 - 18	2414	63.20	1	3	9.54	1000
28.300	18 - 40	25925	61.90	1	1	0.00	1000
28.300	40 - 50	47.883	23.80	1	0.1	-20.00	1000
28.300	50 - 75	66.988	16.40	1	0.1	-20.00	1000
28.300	75 - 110	103.268	16.50	1	0.1	-20.00	1000

3 meter Chamber Cable Insertion Loss dB	Ext Amplifier Gain dB	Receive Mixer Correction Factor dB	Receive Antenna Correction Factor dB	Field Strength (calculated) dBuV/m	Convert Field Strength (dBuV/m) to EIRP (dBm) dBm	Limit dBm	Margin dB
0.0	0	0.00	0.00	68.74	-36.03	-13	-23.03
5.7	42	0.00	28.60	65.04	-39.73	-13	-26.73
17.8	31.94	0.00	46.20	93.93	-10.84	-13	-3.14
0.0	0	22.50	40.51	66.81	-37.96	-13	-24.96
0.0	0	34.60	43.43	74.43	-30.34	-13	-17.34
0.0	0	42.10	47.09	85.69	-19.08	-13	-6.08



**Radiated Spurious Test Data
SISO Uplink**

Test Frequency	Spectrum Analyzer span	Radiated Spurious (raw data)		Measurement distance per standard	Measurement distance	Distance Correction Factor	RBW
		Frequency	Amplitude				
GHz	GHz	GHz	dBuV	meter	meter	dB	MHz
27.550	0.030 - 1	0.3855	58.30	1	3	9.54	120
27.550	1 - 18	2.5	62.30	1	3	9.54	1000
27.550	18 - 40	25.925	56.10	1	1	0.00	1000
27.550	40 - 50	46.228	23.10	1	0.1	-20.00	1000
27.550	50 - 75	50.092	16.40	1	0.1	-20.00	1000
27.550	75 - 110	106.865	17.10	1	0.1	-20.00	1000

3 meter Chamber Cable Insertion Loss	Ext Amplifier Gain	Receive Mixer Correction Factor	Receive Antenna Correction Factor	Field Strength (calculated)	Convert Field Strength (dBuV/m) to EIRP (dBm)	Limit	Margin
dB	dB	dB	dB	dBuV/m	dBm	dBm	dB
0.0	0	0.00	0.00	67.84	-36.93	-13	-23.93
5.7	42	0.00	42.80	78.34	-26.43	-13	-13.43
17.8	31.94	0.00	46.20	88.13	-16.64	-13	-9.54
0.0	0	22.50	40.21	65.81	-38.96	-13	-25.96
0.0	0	35.00	41.01	72.41	-32.36	-13	-19.36
0.0	0	42.60	47.69	87.39	-17.38	-13	-4.38

Test Frequency	Spectrum Analyzer span	Radiated Spurious (raw data)		Measurement distance per standard	Measurement distance	Distance Correction Factor	RBW
		Frequency	Amplitude				
GHz	GHz	GHz	dBuV	meter	meter	dB	MHz
27.925	0.030 - 1	0.3855	59.00	1	3	9.54	120
27.925	1 - 18	2.5	62.00	1	3	9.54	1000
27.925	18 - 40	25.925	56.00	1	1	0.00	1000
27.925	40 - 50	48.69	25.00	1	0.1	-20.00	1000
27.925	50 - 75	53.296	17.40	1	0.1	-20.00	1000
27.925	75 - 110	83.266	16.90	1	0.1	-20.00	1000

3 meter Chamber Cable Insertion Loss	Ext Amplifier Gain	Receive Mixer Correction Factor	Receive Antenna Correction Factor	Field Strength (calculated)	Convert Field Strength (dBuV/m) to EIRP (dBm)	Limit	Margin
dB	dB	dB	dB	dBuV/m	dBm	dBm	dB
0.0	0	0.00	0.00	68.54	-36.23	-13	-23.23
5.7	42	0.00	40.80	76.04	-28.73	-13	-15.73
17.8	31.94	0.00	46.20	88.03	-16.74	-13	-10.04
0.0	0	22.50	40.66	68.16	-36.61	-13	-23.61
0.0	0	34.50	41.44	73.34	-31.43	-13	-18.43
0.0	0	40.60	45.22	82.72	-22.05	-13	-9.05

Test Frequency GHz	Spectrum Analyzer span GHz	Radiated Spurious (raw data)		Measurement distance per standard meter	Measurement distance meter	Distance Correction Factor dB	RBW MHz
		Frequency GHz	Amplitude dBuV				
28.300	0.030 - 1	0.3855	58.00	1	3	9.54	120
28.300	1 - 18	2.5	62.10	1	3	9.54	1000
28.300	18 - 40	25.925	56.70	1	1	0.00	1000
28.300	40 - 50	47.883	26.30	1	0.1	-20.00	1000
28.300	50 - 75	50.236	16.20	1	0.1	-20.00	1000
28.300	75 - 110	78.941	16.50	1	0.1	-20.00	1000

3 meter Chamber Cable Insertion Loss dB	Ext Amplifier Gain dB	Receive Mixer Correction Factor dB	Receive Antenna Correction Factor dB	Field Strength (calculated) dBuV/m	Convert Field Strength (dBuV/m) to EIRP (dBm) dBm	Limit dBm	Margin dB
0.0	0	0.00	0.00	67.54	-37.23	-13	-24.23
5.7	42	0.00	41.60	76.94	-27.83	-13	-14.83
17.8	31.94	0.00	46.20	88.73	-16.04	-13	-9.94
0.0	0	22.50	40.51	69.31	-35.46	-13	-22.46
0.0	0	35.00	40.93	72.13	-32.64	-13	-19.64
0.0	0	40.30	44.76	81.56	-23.21	-13	-10.21

Annex F – Radiated Spurious Emission

Refer to Annex F for Radiated Spurious Emission plots.

Measurement Uncertainty

Measurement Uncertainty for Compliance Testing is listed in the table below.

The reported expanded uncertainty has been estimated at a 95% confidence level (k=2)

Measurement Type	Expanded Uncertainty
Conducted Emissions, AC Powerline	± 3.28 dB
Radiated Emissions_30 MHz – 18 GHz	± 4.8 dB
Radiated Emissions_18 – 40 GHz	± 5.9 dB
Frequency Error	± 22 Hz
Conducted RF Power	± 0.98 dB
Conducted Spurious Emission	± 2.49 dB
AC Voltage	± 2.3 %
DC Voltage	± 0.12 %
Temperature	± 1.0 deg C
Humidity	± 4.32 %

Calibration Data

Annex G – Test Equipment Calibration Certificates

Refer to Annex G for test equipment calibration certificates

Scope of Accreditation for Part 30

Annex H – Scope of Accreditation

Refer to Annex H for Part 30 Scope of Accreditation

Test Equipment Utilized

Description	Manufacturer	Model #	CT Asset #	Last Cal Date	Cal Due Date
EMI Receiver	Keysight	N9038A	i00552	9/9/2019	9/9/20
Vector Signal Generator (rental equipment)	Rohde and Schwarz	SMW200A	Electrorent Asset 1778667D	7/22/2019	7/22/22
Harmonic Mixer, 33 – 50 GHz	Hewlett Packard	11970Q	i00465	6/29/18	6/29/21
Harmonic Mixer, 50 – 75 GHz	Agilent	11970V	i00463	6/29/18	6/29/21
Harmonic Mixer, 75 - 110 GHz	Hewlett Packard	11970W	i00464	6/29/18	6/29/21
Horn Antenna, 1 – 18 GHz	EMCO	3115	i00103	2/28/19	2/28/21
Horn Antenna, 18 – 40 GHz	EMCO	3116	i00085	2/28/19	2/28/21
Horn Antenna, 33 – 50 GHz	Custom Microwave	HO22R	i00484	Verify when used	
Horn Antenna, 50 – 75 GHz	Custom Microwave	HO15R	i00477	Verify when used	
Horn Antenna, 75 – 110 GHz	Custom Microwave	HO10R	i00476	Verify when used	
Bi-Log Antenna	Schaffner	CBL 6111D	i00349	1/17/19	1/17/21
Attenuator, 20 dB	Weinschel Corp	54-20	I00538.8	Verify when used	
Pre-amplifier	RF-Lambda	RLNA00M45GA	I00555	Verify when used	
Millimeter Wave Source Module, 50 – 75 GHz (rental equipment)	OML	S15MS-AG KT-E8257DS15	Electrorent Asset 1608082A	NCR	NCR
Millimeter Wave Source Module, 75 - 110 GHz (rental equipment)	OML	S10MS-AG KT-E8257DS10	Electrorent Asset 1320457C	NCR	NCR

In addition to the above listed equipment standard RF connectors and cables were utilized in the testing of the described equipment. Prior to testing these components were tested to verify proper operation.

END OF TEST REPORT