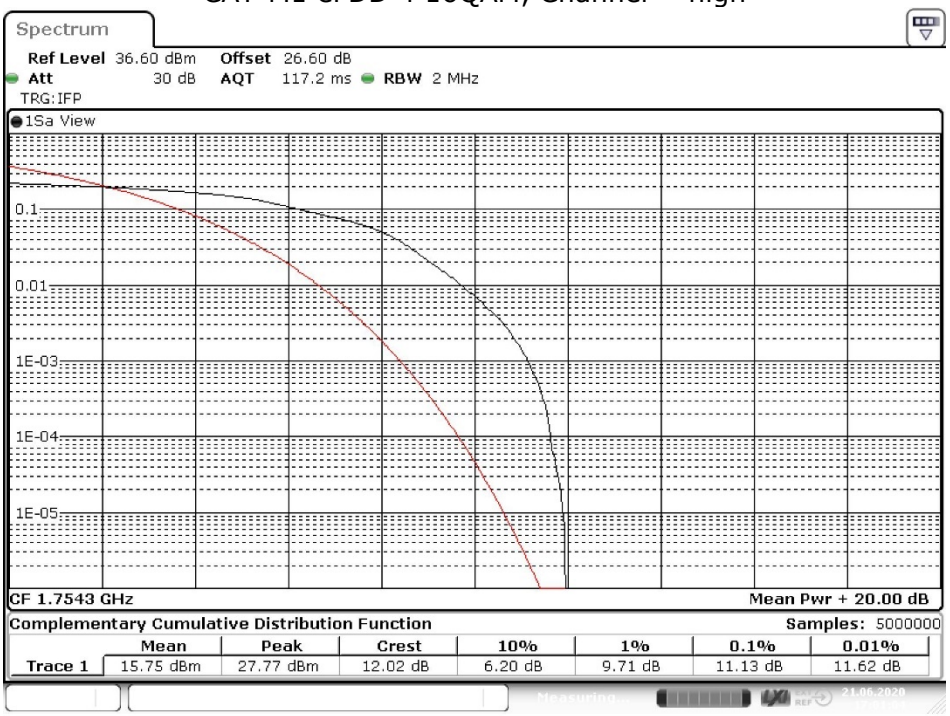
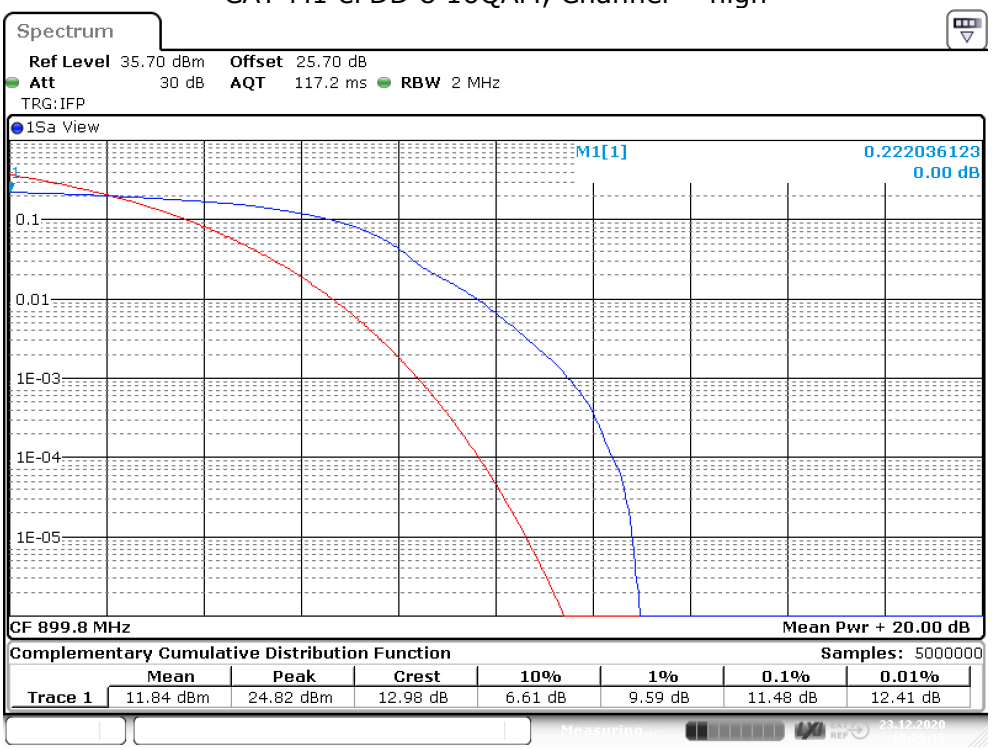
5.21.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

CAT-M1 eFDD 4 16QAM, Channel = high



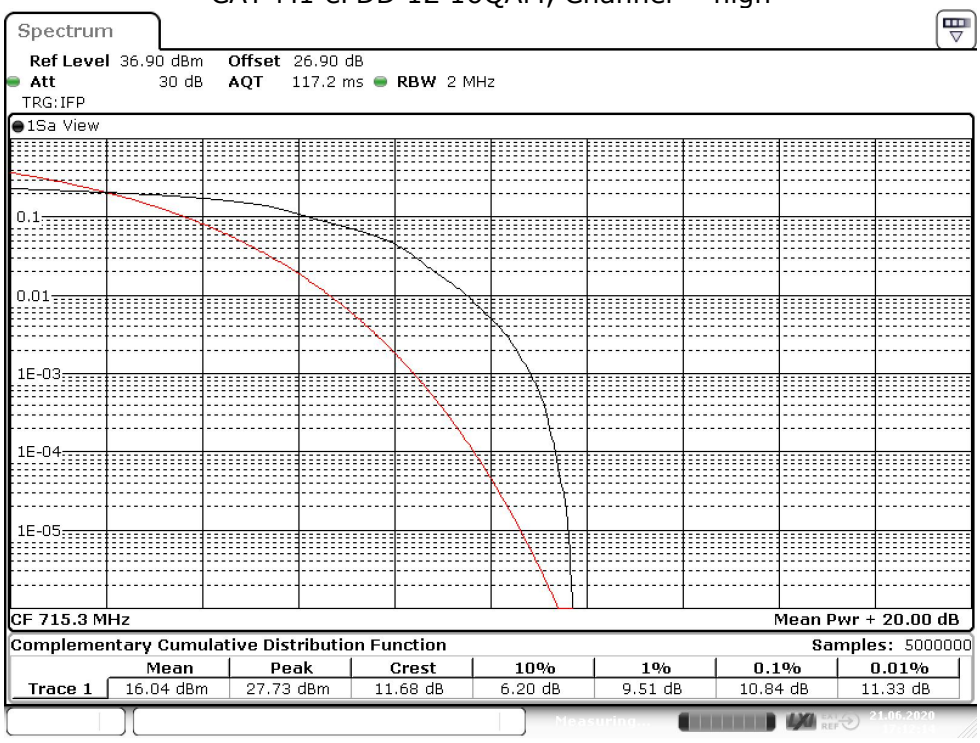
Date: 21.JUN.2020 17:01:04

CAT-M1 eFDD 8 16QAM, Channel = high



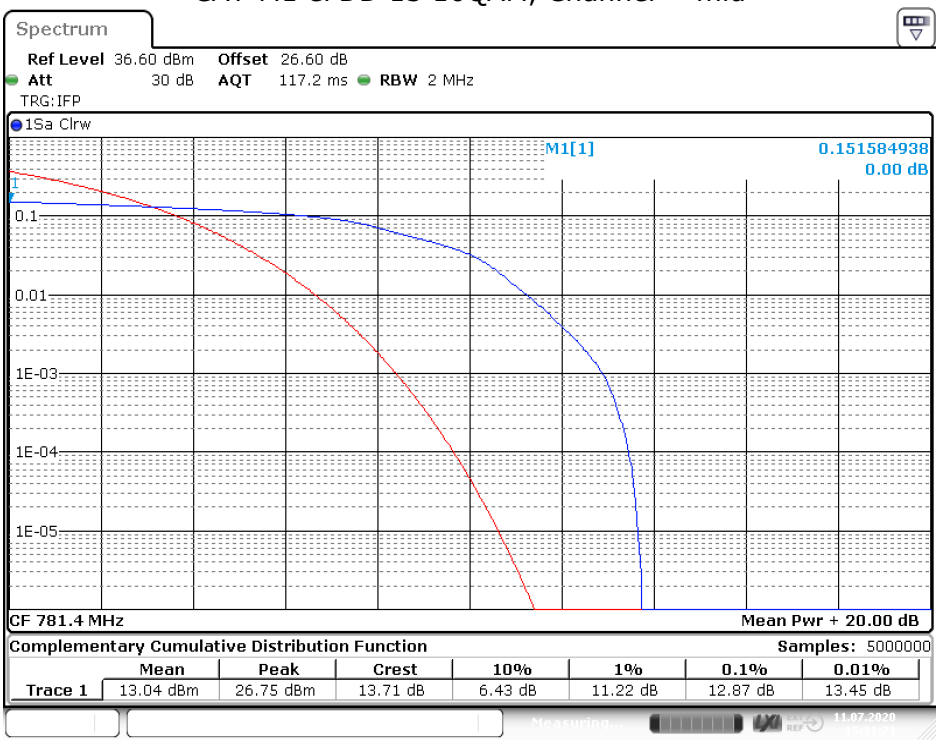
Date: 23.DEC.2020 18:29:16

CAT-M1 eFDD 12 16QAM, Channel = high



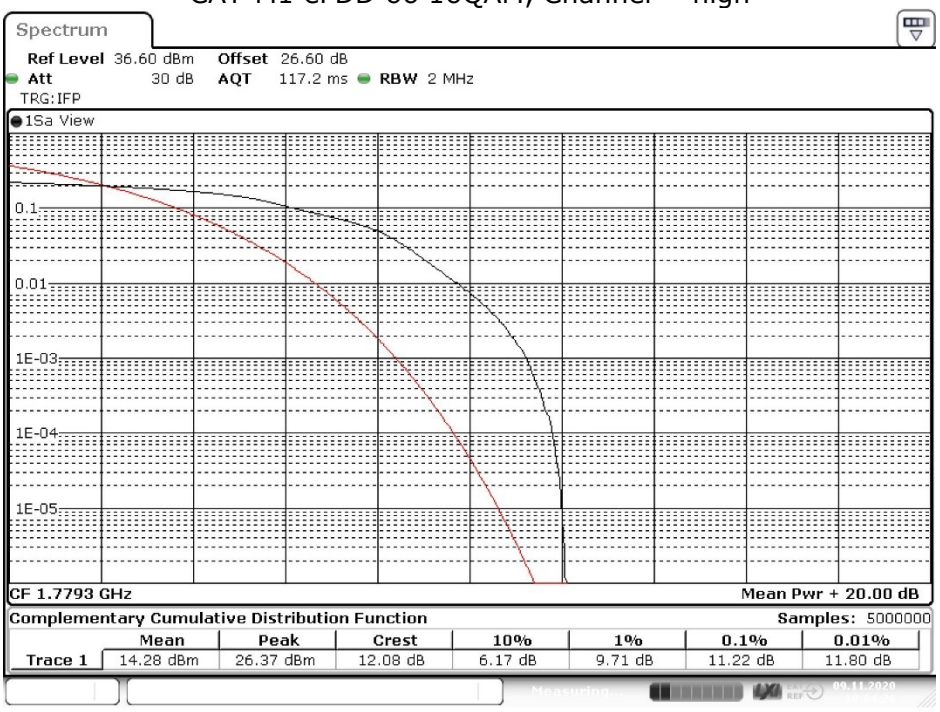
Date: 21.JUN.2020 17:12:14

CAT-M1 eFDD 13 16QAM, Channel = mid



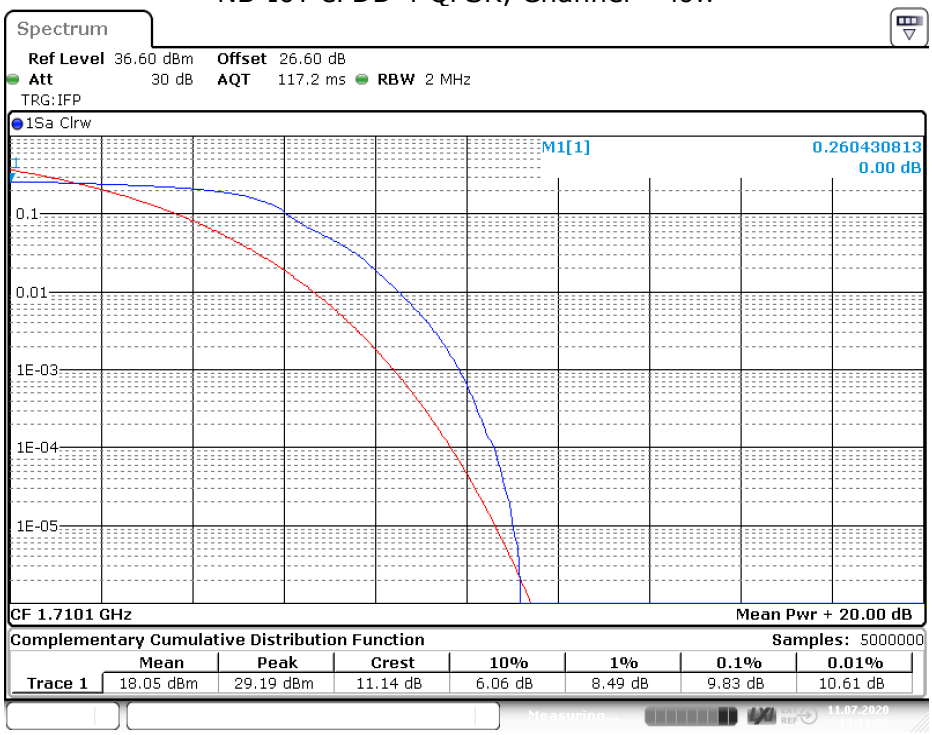
Date: 11.JUL.2020 15:31:21

CAT-M1 eFDD 66 16QAM, Channel = high



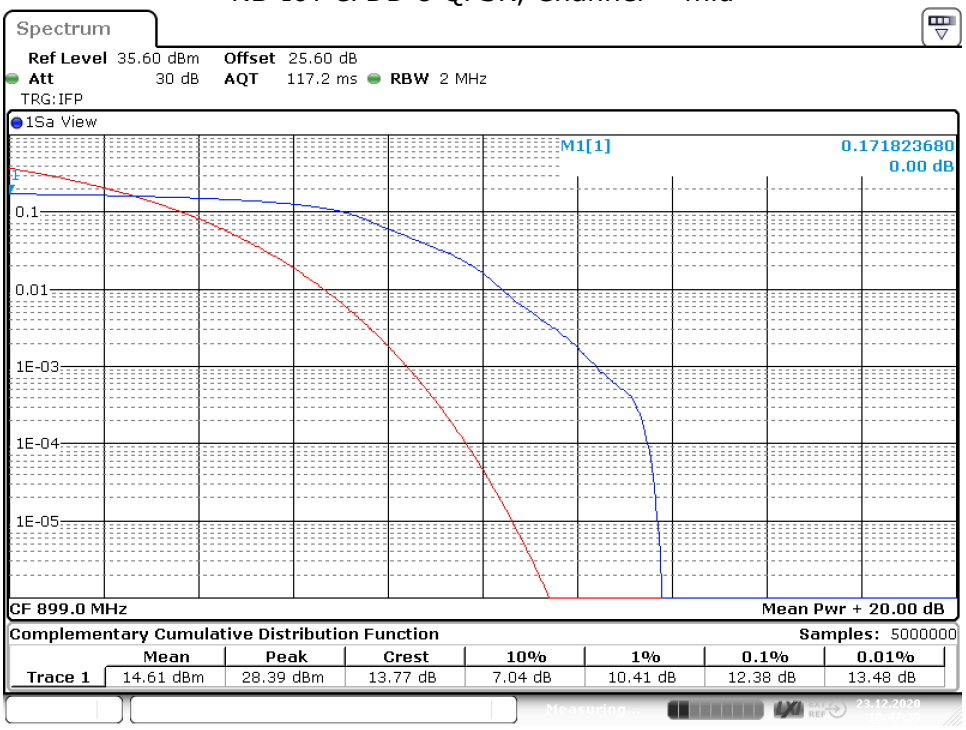
Date: 9.NOV.2020 10:04:21

NB-IoT eFDD 4 QPSK, Channel = low



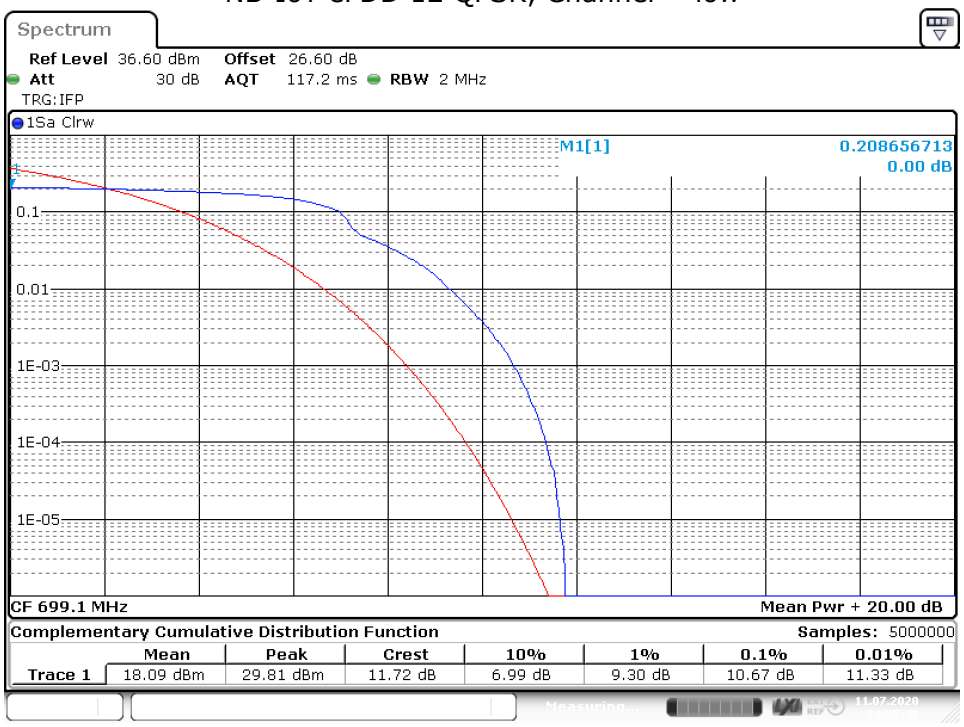
Date: 11.JUL.2020 14:11:52

NB-IoT eFDD 8 QPSK, Channel = mid



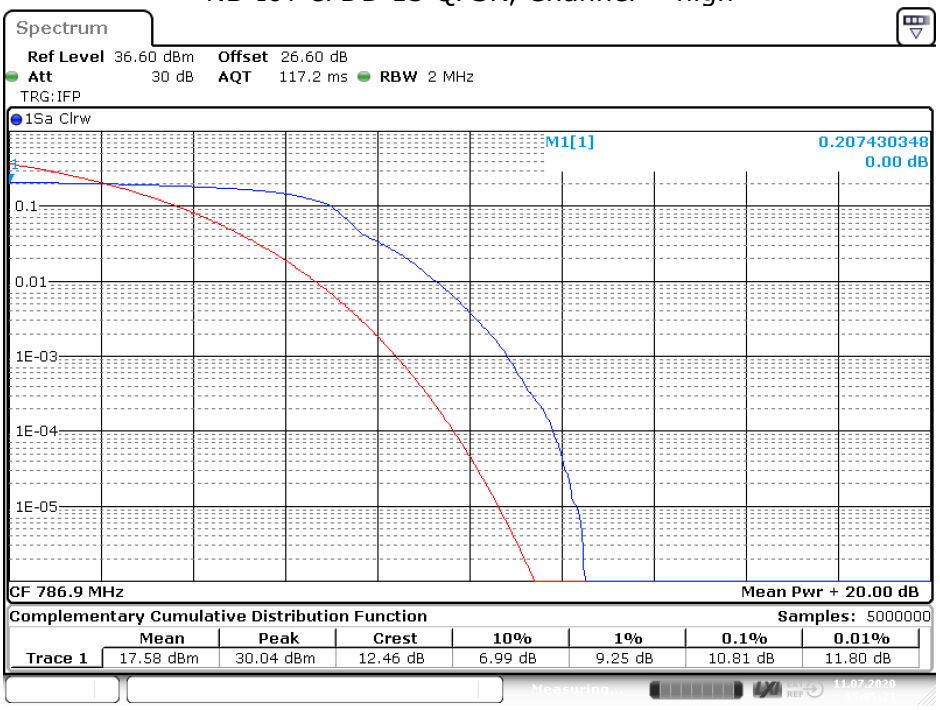
Date: 23.DEC.2020 18:47:39

NB-IoT eFDD 12 QPSK, Channel = low



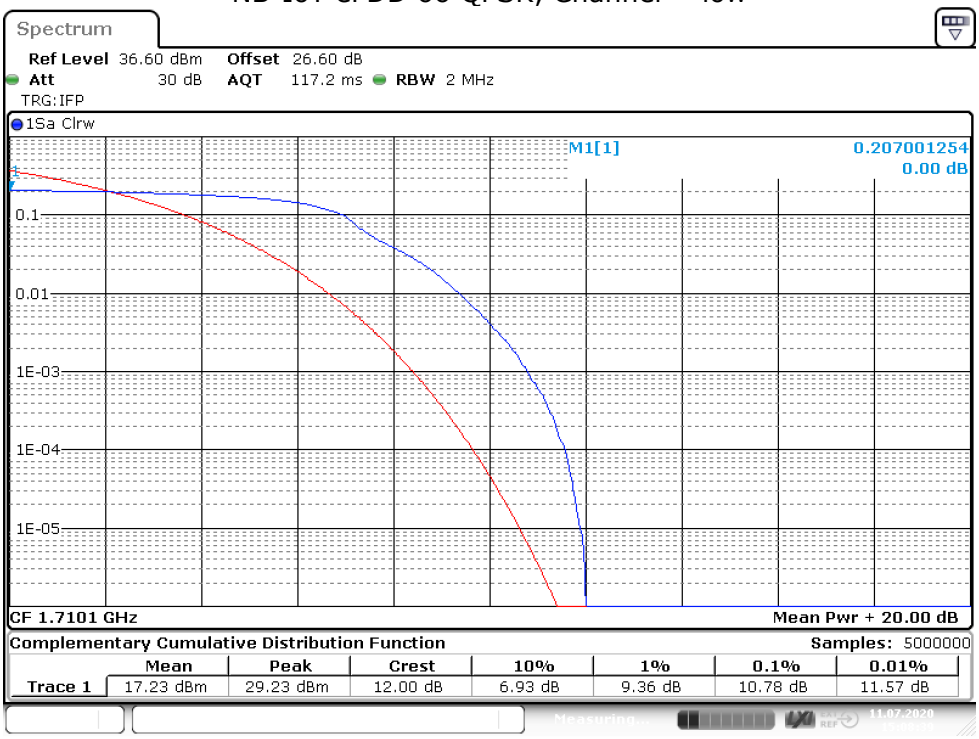
Date: 11.JUL.2020 14:25:47

NB-IoT eFDD 13 QPSK, Channel = high



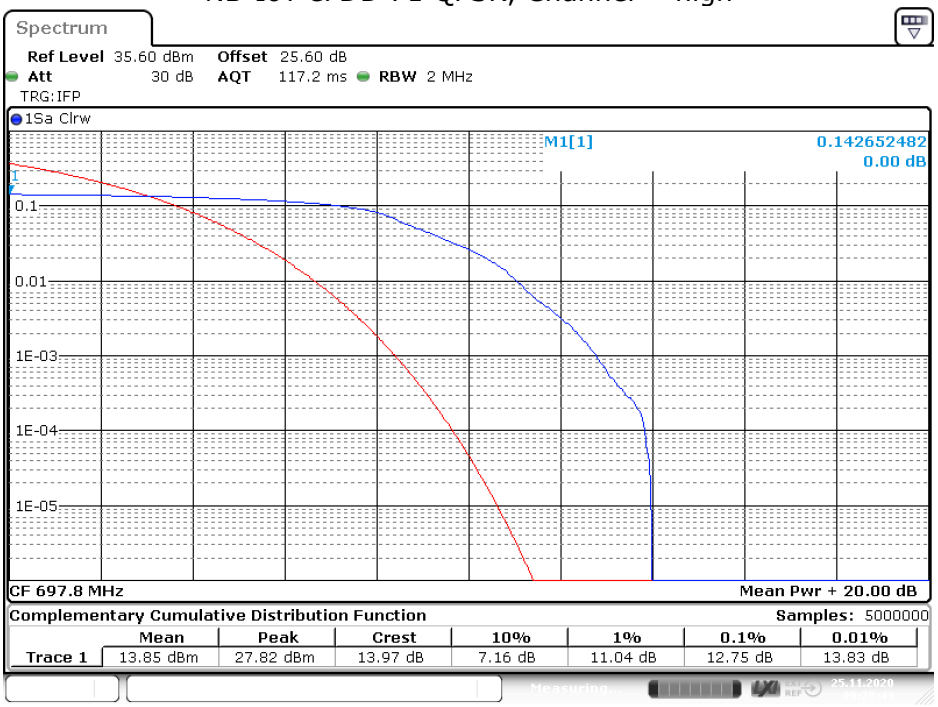
Date: 11.JUL.2020 15:05:21

NB-IoT eFDD 66 QPSK, Channel = low



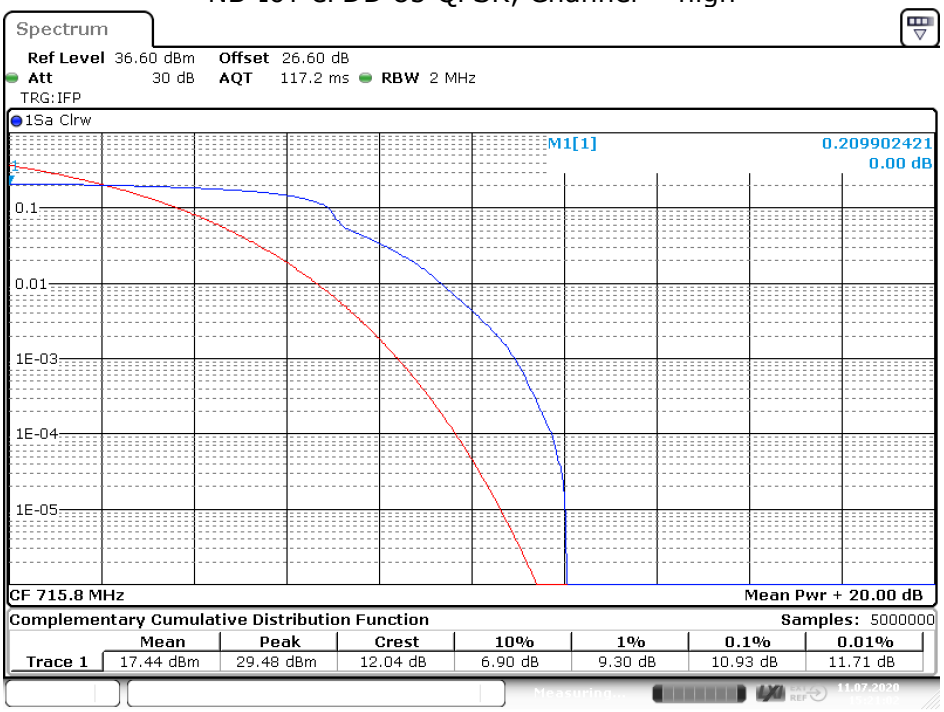
Date: 11.JUL.2020 15:08:39

NB-IoT eFDD 71 QPSK, Channel = high



Date: 25.NOV.2020 09:28:44

NB-IoT eFDD 85 QPSK, Channel = high



Date: 11.JUL.2020 15:21:03

5.21.5 TEST EQUIPMENT USED

- Radio Lab

5.22 RF OUTPUT POWER

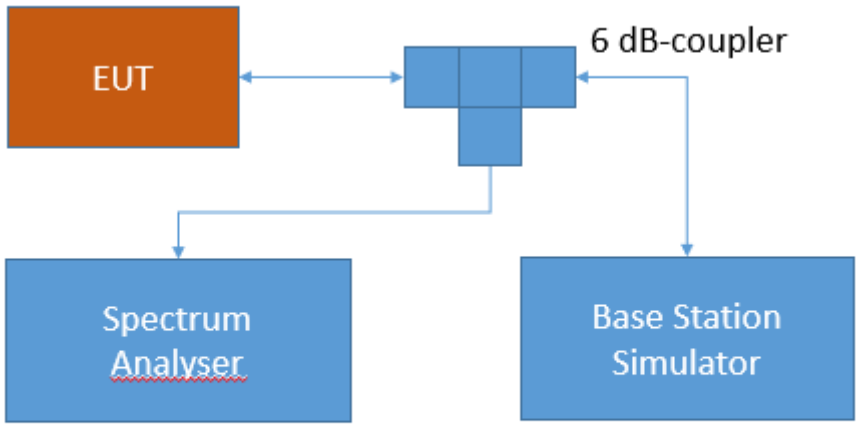
Standard **FCC PART 90 Subpart S**

The test was performed according to:
ANSI C63.26: 2015

5.22.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the applicable RF Output power test case per § 2.1046. The limit and the requirements come from the applicable rule part for the operating band of the cellular device.

The EUT was connected to the test setup according to the following diagram:



Test Setup FCC Part 22/24/27/90 Cellular;
RF Output power

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams.

5.22.2 TEST REQUIREMENTS / LIMITS

Part 90; PRIVATE LAND MOBILE RADIO SERVICES

Subpart S—Regulations Governing Licensing and Use of Frequencies in the 806-824, 851-869, 896-901, and 935-940 MHz Bands

§90.635 Limitations on power and antenna height.

(b) The maximum output power of the transmitter for mobile stations is 100 watts (20 dBw).

5.22.3 TEST PROTOCOL

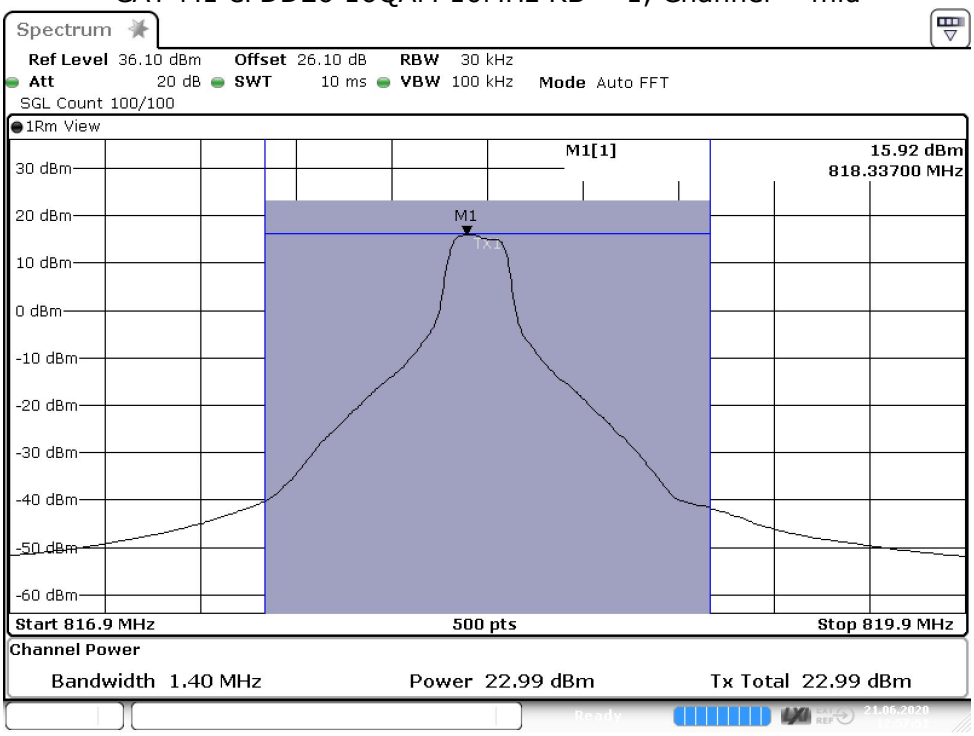
Ambient temperature: 20 - 25 °C
Relative humidity: 30 - 40 %

Radio Technology	Channel	Re-source Blocks	Band-width [MHz]	RMS Cond. Power [dBm]	FCC EIRP Limit [W]	IC EIRP Limit [W]	Max. Antenna Gain FCC [dBi]	Max. Antenna Gain IC [dBi]
CAT-M1 eFDD 26 QPSK	low	1	1.4	22.59	100	-	27.41	-
CAT-M1 eFDD 26 QPSK	low	3	1.4	21.68	100	-	28.32	-
CAT-M1 eFDD 26 QPSK	low	6	1.4	20.59	100	-	29.41	-
CAT-M1 eFDD 26 QPSK	mid	1	1.4	22.80	100	-	27.2	-
CAT-M1 eFDD 26 QPSK	mid	3	1.4	21.81	100	-	28.19	-
CAT-M1 eFDD 26 QPSK	mid	6	1.4	20.71	100	-	29.29	-
CAT-M1 eFDD 26 QPSK	high	1	1.4	22.77	100	-	27.23	-
CAT-M1 eFDD 26 QPSK	high	3	1.4	21.56	100	-	28.44	-
CAT-M1 eFDD 26 QPSK	high	6	1.4	20.47	100	-	29.53	-
CAT-M1 eFDD 26 16QAM	low	1	1.4	21.78	100	-	28.22	-
CAT-M1 eFDD 26 16QAM	low	5	1.4	20.49	100	-	29.51	-
CAT-M1 eFDD 26 16QAM	mid	1	1.4	21.85	100	-	28.15	-
CAT-M1 eFDD 26 16QAM	mid	5	1.4	20.63	100	-	29.37	-
CAT-M1 eFDD 26 16QAM	high	1	1.4	21.16	100	-	28.84	-
CAT-M1 eFDD 26 16QAM	high	5	1.4	20.59	100	-	29.41	-
CAT-M1 eFDD 26 QPSK	low	1	3	22.57	100	-	27.43	-
CAT-M1 eFDD 26 QPSK	low	3	3	21.54	100	-	28.46	-
CAT-M1 eFDD 26 QPSK	low	6	3	20.52	100	-	29.48	-
CAT-M1 eFDD 26 QPSK	mid	1	3	22.75	100	-	27.25	-
CAT-M1 eFDD 26 QPSK	mid	3	3	21.64	100	-	28.36	-
CAT-M1 eFDD 26 QPSK	mid	6	3	20.66	100	-	29.34	-
CAT-M1 eFDD 26 QPSK	high	1	3	22.68	100	-	27.32	-
CAT-M1 eFDD 26 QPSK	high	3	3	21.44	100	-	28.56	-
CAT-M1 eFDD 26 QPSK	high	6	3	20.49	100	-	29.51	-
CAT-M1 eFDD 26 16QAM	low	1	3	21.91	100	-	28.09	-
CAT-M1 eFDD 26 16QAM	low	5	3	20.54	100	-	29.46	-
CAT-M1 eFDD 26 16QAM	mid	1	3	21.85	100	-	28.15	-
CAT-M1 eFDD 26 16QAM	mid	5	3	20.63	100	-	29.37	-
CAT-M1 eFDD 26 16QAM	high	1	3	21.71	100	-	28.29	-
CAT-M1 eFDD 26 16QAM	high	5	3	20.52	100	-	29.48	-
CAT-M1 eFDD 26 QPSK	low	1	5	22.54	100	-	27.46	-
CAT-M1 eFDD 26 QPSK	low	3	5	21.47	100	-	28.53	-
CAT-M1 eFDD 26 QPSK	low	6	5	21.54	100	-	28.46	-
CAT-M1 eFDD 26 QPSK	mid	1	5	22.71	100	-	27.29	-
CAT-M1 eFDD 26 QPSK	mid	3	5	21.69	100	-	28.31	-
CAT-M1 eFDD 26 QPSK	mid	6	5	21.76	100	-	28.24	-
CAT-M1 eFDD 26 QPSK	high	1	5	22.74	100	-	27.26	-
CAT-M1 eFDD 26 QPSK	high	3	5	21.58	100	-	28.42	-
CAT-M1 eFDD 26 QPSK	high	6	5	21.63	100	-	28.37	-
CAT-M1 eFDD 26 16QAM	low	1	5	22.95	100	-	27.05	-
CAT-M1 eFDD 26 16QAM	low	5	5	20.44	100	-	29.56	-
CAT-M1 eFDD 26 16QAM	mid	1	5	23.10	100	-	26.9	-
CAT-M1 eFDD 26 16QAM	mid	5	5	20.61	100	-	29.39	-
CAT-M1 eFDD 26 16QAM	high	1	5	22.65	100	-	27.35	-
CAT-M1 eFDD 26 16QAM	high	5	5	20.59	100	-	29.41	-
CAT-M1 eFDD 26 QPSK	mid	1	10	22.64	100	-	27.36	-
CAT-M1 eFDD 26 QPSK	mid	3	10	22.56	100	-	27.44	-
CAT-M1 eFDD 26 QPSK	mid	6	10	21.53	100	-	28.47	-
CAT-M1 eFDD 26 16QAM	mid	1	10	22.99	100	-	27.01	-
CAT-M1 eFDD 26 16QAM	mid	5	10	21.48	100	-	28.52	-

Remark: Please see next sub-clause for the measurement plot.

5.22.4 MEASUREMENT PLOT

CAT-M1 eFDD26 16QAM 10MHz RB = 1, Channel = mid



Date: 21.JUN.2020 12:57:51

5.22.5 TEST EQUIPMENT USED

- Radio Lab

5.23 SPURIOUS EMISSIONS AT ANTENNA TERMINALS

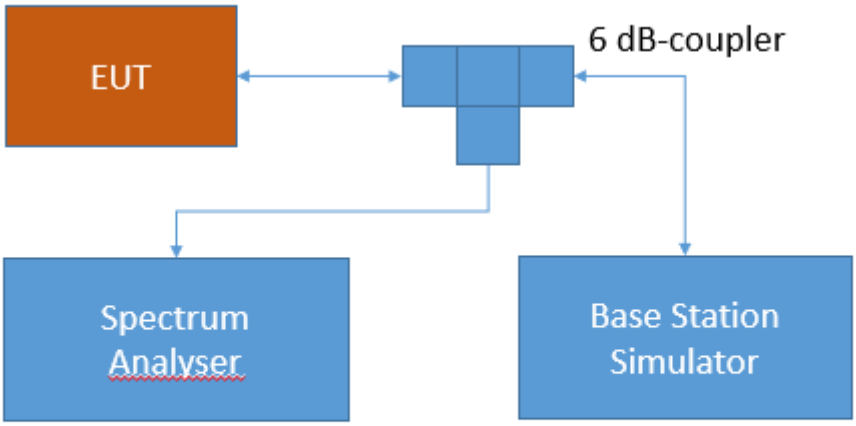
Standard **FCC PART 90 Subpart S**

The test was performed according to:
ANSI C63.26: 2015

5.23.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the applicable conducted spurious emission test case per § 2.1051. The limit comes from the applicable rule part for the operating band of the cellular device.

The EUT was connected to the test setup according to the following diagram:



Test Setup FCC Part 22/24/27/90 Cellular;
Spurious Emissions at antenna terminal

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams.

5.23.2 TEST REQUIREMENTS / LIMITS

FCC Part 2.1051; Measurement required: Spurious emissions at antenna terminal:

The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of each harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in §2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

Part 90; PRIVATE LAND MOBILE RADIO SERVICES

Subpart R—Regulations Governing the Licensing and Use of Frequencies in the 763-775 and 793-805 MHz Bands

§90.543 – Emission limitations.

(a) The adjacent channel power (ACP) requirements for transmitters designed for various channel sizes are shown in the following tables. Mobile station requirements apply to handheld, car mounted and control station units. The tables specify a value for the ACP as a function of the displacement from the channel center frequency and measurement bandwidth. In the following tables, "(s)" indicates a swept measurement may be used.

5.23.3 TEST PROTOCOL

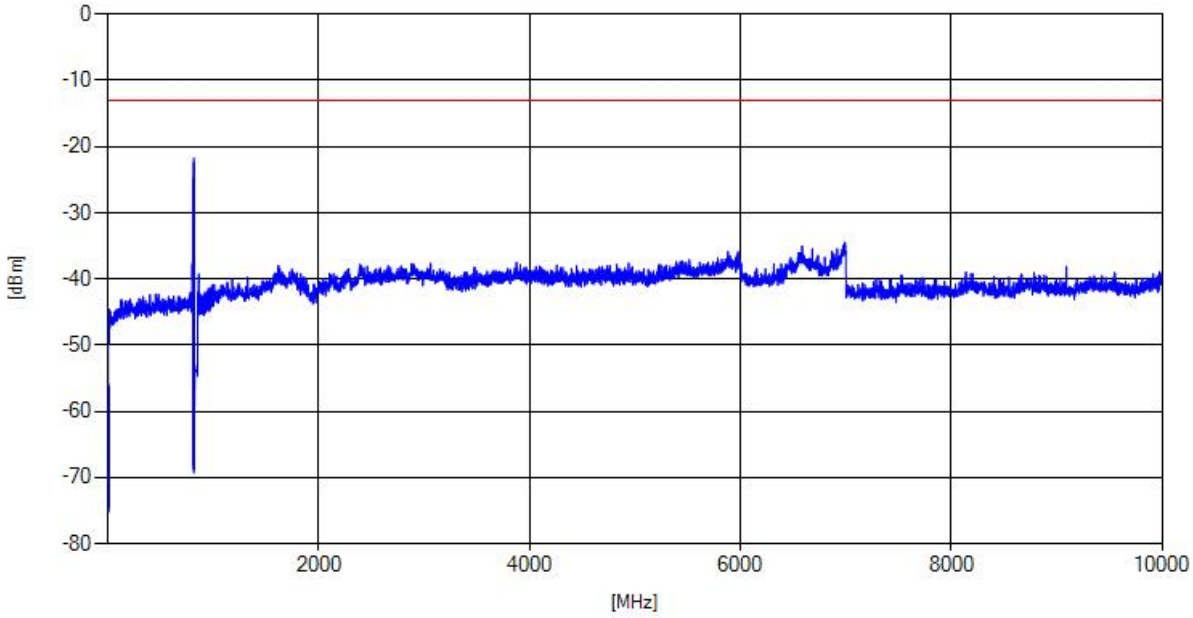
Ambient temperature: 20 - 25 °C
Relative humidity: 30 - 40 %

Radio Technology	Channel	Detector	Trace	Resolution Bandwidth /kHz	Frequency /MHz	Peak Value /dBm	Limit /dBm	Margin to Limit /dB
CAT-M1 eFDD26	low	rms	maxhold	20	814	-22.36	-13	9.36
CAT-M1 eFDD26	mid	rms	maxhold	100	813.6	-25.1	-13	12.1
CAT-M1 eFDD26	mid	rms	maxhold	100	824.1	-25.89	-13	12.89
CAT-M1 eFDD26	high	rms	maxhold	20	824	-24.6	-13	11.6

Remark: Please see next sub-clause for the measurement plot.

5.23.4 MEASUREMENT PLOT

CAT-M1 eFDD26, Channel = low



5.23.5 TEST EQUIPMENT USED

- Radio Lab

5.24 FIELD STRENGTH OF SPURIOUS RADIATION

Standard **FCC PART 90 Subpart S**

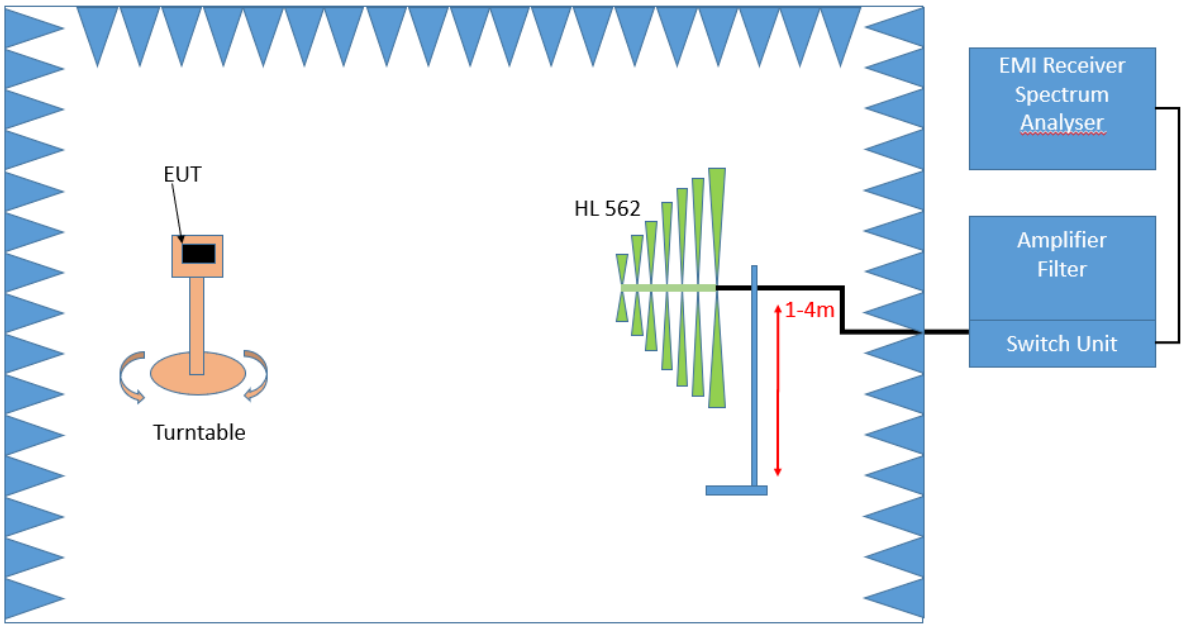
The test was performed according to:
ANSI C63.26: 2015

5.24.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the applicable radiated spurious emission measurements per § 2.1053. The limit and requirements come from the applicable rule part for the operating band of the cellular device.

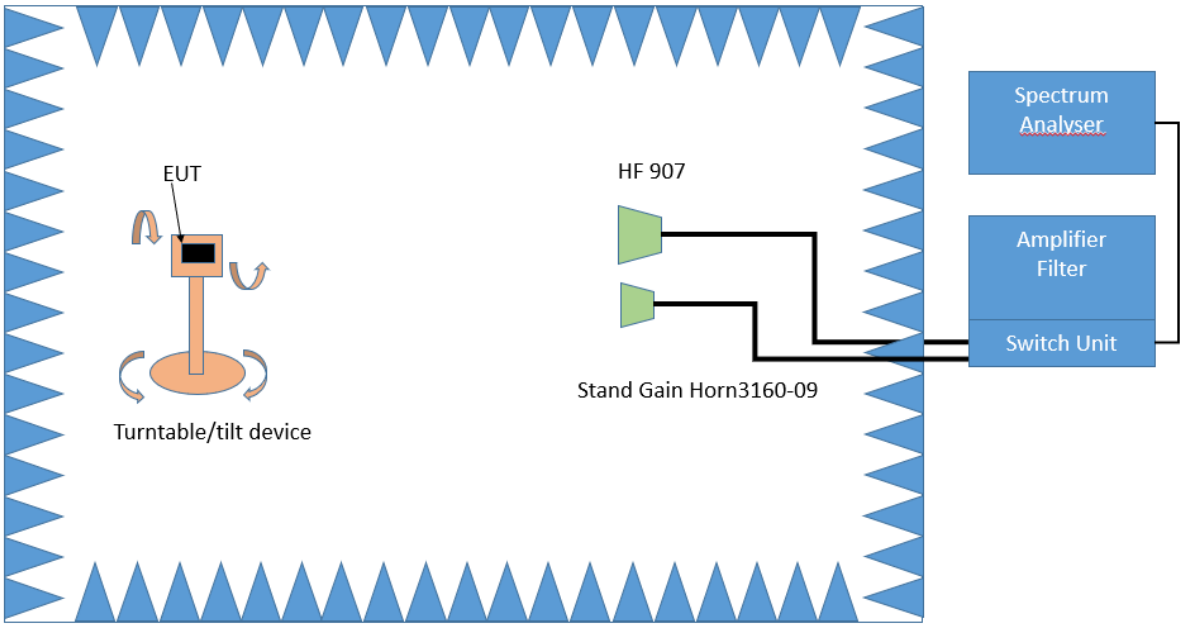
The EUT was connected to the test setup according to the following diagram:

Frequency Range: 30 MHz – 1 GHz:



Test Setup; Spurious Emission Radiated (SAC), 30 MHz- 1GHz

Frequency Range: 1 GHz – 26.5 GHz



Test Setup; Spurious Emission Radiated (FAC), 1 GHz-26.5 GHz

The test set-up was made in accordance to the general provisions of ANSI C63.26 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 m² in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.
The measurement procedure is implemented into the EMI test software EMC32 from R&S. Exploratory tests are performed at 3 orthogonal axes to determine the worst-case orientation of a body-worn or handheld EUT. The final test on all kind of EUTs is also performed at 3 axes. A pre-check is performed while the EUT is powered from a DC power source.

1. Measurement above 30 MHz and up to 1 GHz

Step 1: Preliminary scan
This is a preliminary test to identify the highest amplitudes relative to the limit.
Settings for step 1:
- Antenna distance: 3 m
- Detector: Peak
- RBW: 100 kHz
- VBW: 300 kHz
- Sweep time: coupled
- Turntable angle range: –180° to 90°
- Turntable step size: 90°
- Height variation range: 1 – 4 m
- Height variation step size: 1.5 m
- Polarisation: Horizontal + Vertical

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: Adjustment measurement
In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.
For each frequency, which was determined the turntable azimuth and antenna height will be adjusted. The turntable azimuth will slowly vary by 360°. During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the antenna height will also slowly vary by 1 – 4 m.

During this action, the value of emission is also continuously measured. The antenna height of the highest emission will also be recorded and adjusted.
- Detector: Peak
- Measured frequencies: in step 1 determined frequencies
- RBW: 100 kHz
- VBW: 300 kHz
- Sweep time: coupled
- Turntable angle range: 360°
- Height variation range: 1 – 4 m
- Antenna Polarisation: max. value determined in step 1

Step 3: Final measurement with RMS detector
With the settings determined in step 3, the final measurement will be performed:
EMI receiver settings for step 4:
- Detector: RMQ
- Measured frequencies: in step 1 determined frequencies
- RBW: 100 kHz
- VBW: 300 kHz
- Sweep time: 1 s

After the measurement a plot will be generated which contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement.

3. Measurement above 1 GHz
The following modifications apply to the measurement procedure for the frequency range above 1 GHz:
Step 1:
The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.
All steps were performed with one height (1.5 m) of the receiving antenna only.
The EUT is turned during the preliminary measurement across the elevation axis, with a step size of 45 °.
The turn table step size (azimuth angle) for the preliminary measurement is 45 °.
- Antenna distance: 3 m
- Detector: Peak
- RBW: 1 MHz
- VBW: 3 MHz
- Sweep time: coupled
- Turntable angle range: –180° to 135°
- Turntable step size: 45°
- Polarisation: Horizontal + Vertical

Step 2:
Due to the fact, that in this frequency range the test is performed in a fully anechoic room, the height scan of the receiving antenna instep 2 is omitted. Instead of this, a maximum search with a step size ± 45° for the elevation axis is performed.
The turn table azimuth will slowly vary by ± 22.5°.
The elevation angle will slowly vary by ± 45°
EMI receiver settings (for all steps):
- Detector: Peak,
- RBW: 1 MHz
- VBW: 3 MHz
- Sweep time: coupled

Step 3:

Spectrum analyser settings for step 3:
- Detector: RMS
- Measured frequencies: in step 1 determined frequencies
- RBW: 1 MHz
- VBW: 3 MHz
- Sweep Time: 1 s

5.24.2 TEST REQUIREMENTS / LIMITS

FCC Part 2.1051; Measurement required: Spurious emissions at antenna terminal:

The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of each harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in §2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

Part 90; PRIVATE LAND MOBILE RADIO SERVICES

Subpart R—Regulations Governing the Licensing and Use of Frequencies in the 763-775 and 793-805 MHz Bands

§90.543 – Emission limitations.

(a) The adjacent channel power (ACP) requirements for transmitters designed for various channel sizes are shown in the following tables. Mobile station requirements apply to handheld, car mounted and control station units. The tables specify a value for the ACP as a function of the displacement from the channel center frequency and measurement bandwidth. In the following tables, "(s)" indicates a swept measurement may be used.

Subpart S—Regulations Governing the Licensing and Use of Frequencies in the 806-824, 851-869, 869-901 and 935-940 MHz Bands

§90.543 – Emission limitations.

(a) On any frequency in an MTA licensee's spectrum block that is adjacent to a non-MTA frequency, the power of any emission shall be attenuated below the transmitter power (P) by at least 43 plus 10 log10(P) decibels or 80 decibels, whichever is the lesser attenuation.

Note: The measurements of emission power can be expressed in peak or average values, provided they are expressed in the same parameters as the transmitter power.

(b) When an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in this section.

5.24.3 TEST PROTOCOL

Ambient temperature: 20 - 25 °C
Relative humidity: 30 - 40 %

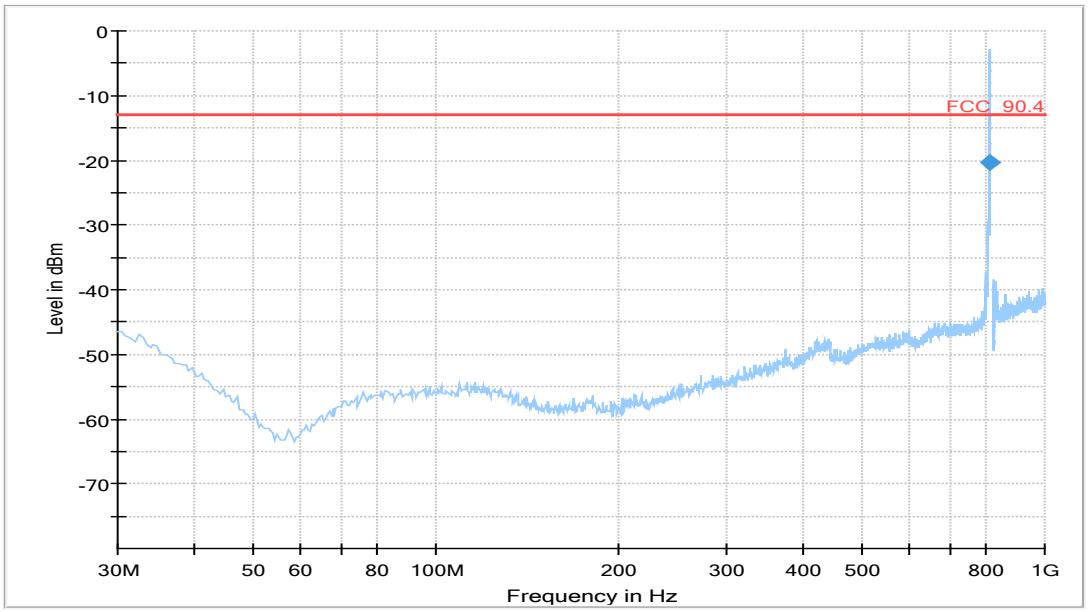
Radio Technology	Channel	Detector	Trace	Resolution Bandwidth /kHz	Frequency /MHz	Peak Value /dBm	Limit /dBm	Margin to Limit /dB
eFDD26	low	rms	maxhold	-	-	-	-13	>20
eFDD26	mid	rms	maxhold	-	-	-	-13	>20
eFDD26	high	rms	maxhold	-	-	-	-13	>20

Remark: Please see next sub-clause for the measurement plot.

5.24.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

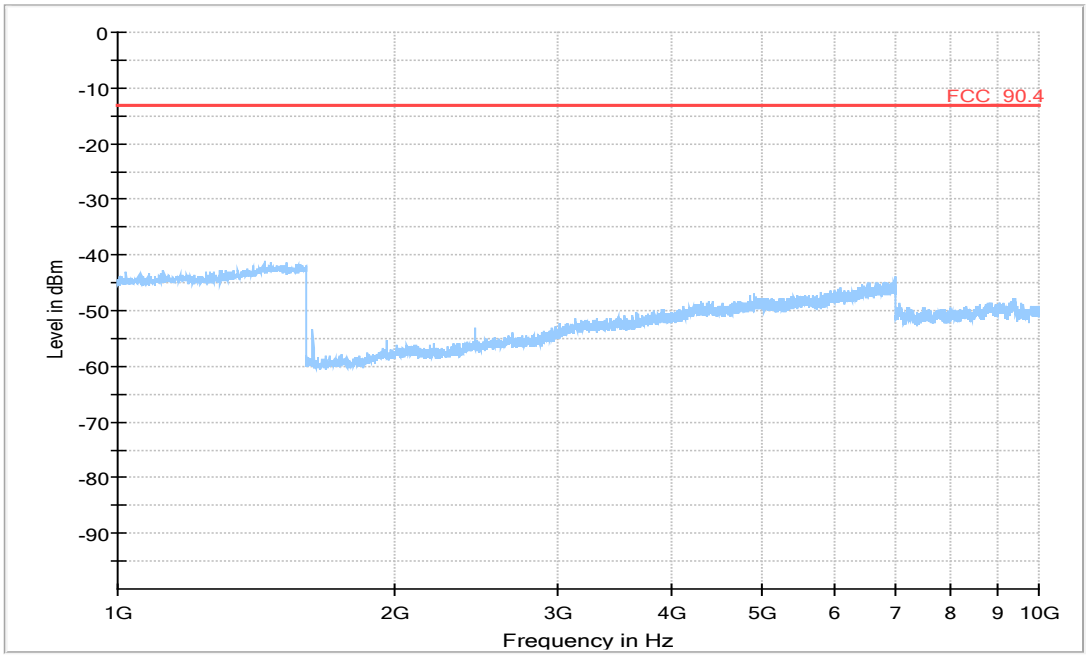
CAT-M1 eFDD26, Channel = low

30 MHz – 1 GHz



Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
813.998000	-20.27	-13.00	7.27	1000.0	100.000	108.0	V	80.0	-74.2

1 GHz – 10 GHz



5.24.5 TEST EQUIPMENT USED

- Radiated Emissions

5.25 EMISSION AND OCCUPIED BANDWIDTH

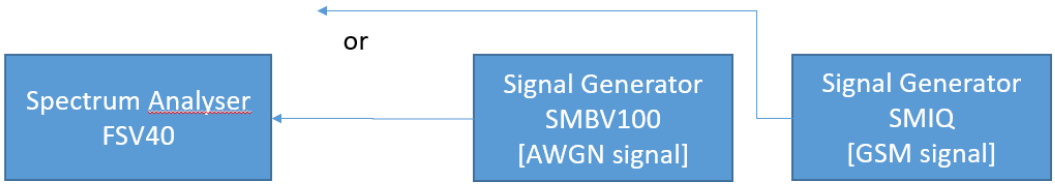
Standard **FCC PART 90 Subpart S**

The test was performed according to:
ANSI C63.26: 2015

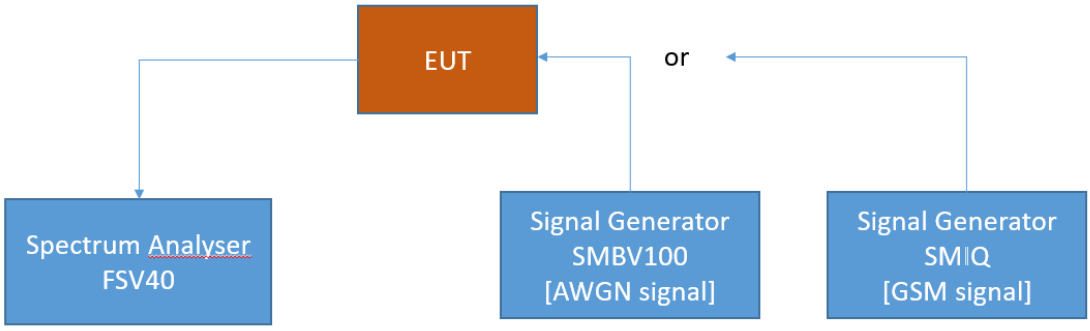
5.25.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the applicable conducted spurious emission test case per FCC §2.1049. The limit and the requirements come from the applicable rule part for the operating band of the cellular device.

The EUT was connected to the test setups according to the following diagram:



FCC Part 22/24/27/90; Industrial Signal Booster
Test Setup step 1: Measuring characteristics of test signals



FCC Part 22/24/27/90; Industrial Signal Booster
Test Setup step 2; Occupied Bandwidth/Input-versus-output spectrum

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams.

5.25.2 TEST REQUIREMENTS / LIMITS

FCC Part 2.1049; Occupied Bandwidth:

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total

mean power radiated by a given emission shall be measured under the following conditions as applicable:

(h) Transmitters employing digital modulation techniques—when modulated by an input signal such that its amplitude and symbol rate represent the maximum rated conditions under which the equipment will be operated. The signal shall be applied through any filter networks, pseudo-random generators or other devices required in normal service. Additionally, the occupied bandwidth shall be shown for operation with any devices used for modifying the spectrum when such devices are optional at the discretion of the user.

(i) Transmitters designed for other types of modulation—when modulated by an appropriate signal of sufficient amplitude to be representative of the type of service in which used. A description of the input signal should be supplied.

The trace data points are recovered and are directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded.
The difference between the two recorded frequencies is the 99% occupied bandwidth.

5.25.3 TEST PROTOCOL

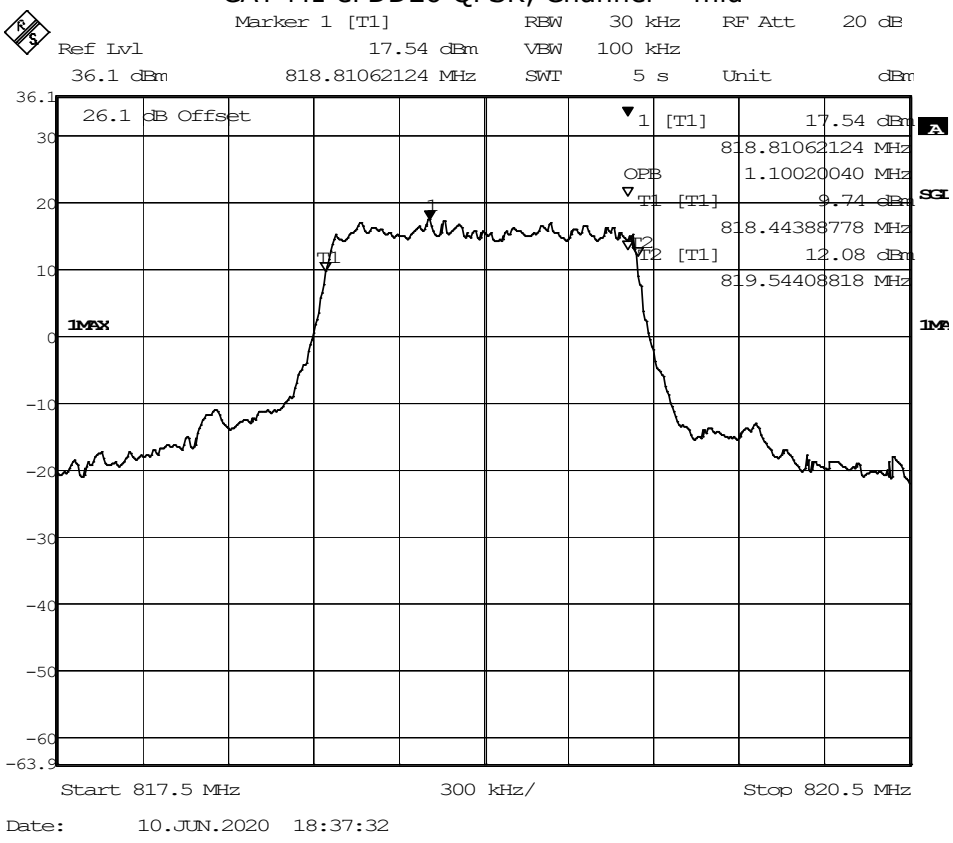
Ambient temperature: 20 - 25 °C
Relative humidity: 30 - 40 %

Radio Technology	Channel	Resource Blocks	Bandwidth [MHz]	Nominal BW [MHz]	99 % BW [kHz]
CAT-M1 eFDD 26 QPSK	low	6	1.4	1.4	1100.2
CAT-M1 eFDD 26 QPSK	mid	6	1.4	1.4	1100.2
CAT-M1 eFDD 26 QPSK	high	6	1.4	1.4	1100.2
CAT-M1 eFDD 26 16QAM	low	5	1.4	1.4	931.86
CAT-M1 eFDD 26 16QAM	mid	5	1.4	1.4	937.88
CAT-M1 eFDD 26 16QAM	high	5	1.4	1.4	937.86

Remark: Please see next sub-clause for the measurement plot.

5.25.4 MEASUREMENT PLOT

CAT-M1 eFDD26 QPSK, Channel = mid



5.25.5 TEST EQUIPMENT USED

- Radio Lab

5.26 BAND EDGE

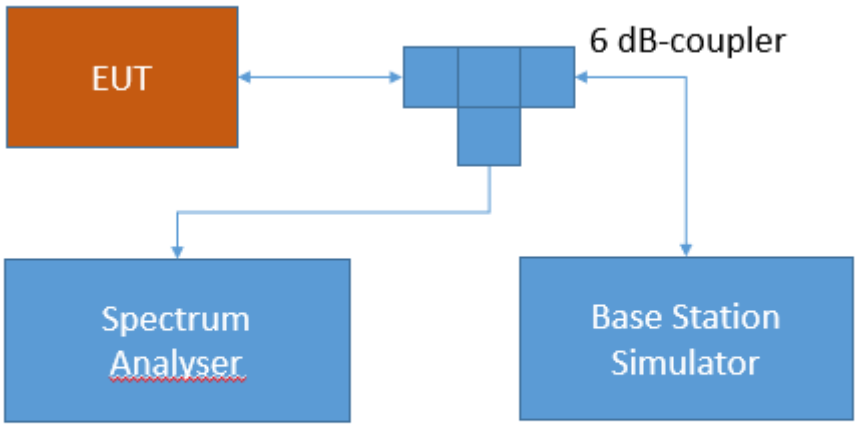
Standard **FCC PART 90 Subpart S**

The test was performed according to:
ANSI C63.26: 2015

5.26.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the applicable conducted spurious emission test case per § 2. 1051. The limit comes from the applicable rule part for the operating band of the cellular device.

The EUT was connected to the test setup according to the following diagram:



Test Setup FCC Part 22/24/27/90 Cellular;
Band edge compliance

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams.

5.26.2 TEST REQUIREMENTS / LIMITS

FCC Part 2.1051; Measurement required: Spurious emissions at antenna terminal:

The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of each harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in §2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

Part 90; PRIVATE LAND MOBILE RADIO SERVICES

Subpart R—Regulations Governing the Licensing and Use of Frequencies in the 763-775 and 793-805 MHz Bands

§90.543 – Emission limitations.

(a) The adjacent channel power (ACP) requirements for transmitters designed for various channel sizes are shown in the following tables. Mobile station requirements apply to handheld, car mounted and control station units. The tables specify a value for the ACP as a function of the displacement from the channel center frequency and measurement bandwidth. In the following tables, "(s)" indicates a swept measurement may be used.