



# InterLab®

## Test Report Annex Methods of Measurements

**Test Report Reference: Annex to MDE\_UBLOX\_1502\_FCCa**

on

### TOBY-L201 Data Module

FCC ID XPYTOBYL201  
IC: 8595A-TOBYL201

**Date:** May 29, 2015

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**Note:**

The following test results relate only to the devices specified in this document. This report shall not be reproduced in parts without the written approval of the test laboratory.

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## **Description of Methods of Measurements**

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### **FCC Part 22**

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#### **RF Power Output**

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Standard      FCC Part 22, Subpart H

The test was performed according to: FCC §2.1046

#### **Test Description (conducted measurement procedure)**

- 1) The EUT was coupled to a Spectrum Analyser and a Digital Communication Tester through a Power Divider. Refer to chapter "Setup Drawings".
- 2) The total insertion losses for signal path 1 and signal path 2 were measured. The values were used to correct the readings from the Spectrum Analyser and the Digital Communication Tester.
- 3) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

#### **Important Settings:**

- Channel (Frequency): please refer to the detailed results
- 4) The transmitted power of the EUT was recorded by using a spectrum analyser.

#### **Test Description (radiated measurement procedure)**

- 1) The EUT was placed inside an anechoic chamber. Refer to chapter "Setup Drawings". The EUT was coupled to a Digital Communication Tester which was located outside the chamber via a small signalling antenna.

- 2) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

#### **Important Settings:**

- Output Power: Maximum
- Channel: please refer to the detailed results

- 3) A substitution procedure is used so that the readings from the spectrum analyser are corrected and represent directly the equivalent radiated power (related to a  $\lambda/2$  dipole).
- 4) The output power was measured in both vertical and horizontal antenna polarisation during the call is established on the lowest channel, mid channel and on the highest channel. To find the worst case power all orientations (X, Y, Z) of the EUT have been measured.
- 5) The test procedure according to TIA-603-C-2004 has been considered.

#### **Test Requirements / Limits**

##### **§2.1046 Measurements Required: RF Power Output**

- (a) For transmitters other than single sideband, independent sideband and controlled carrier radiotelephone, power output shall be measured at the RF output terminals when the transmitter is adjusted in accordance with the tune-up procedure to give the values of

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current and voltage on the circuit elements specified in § 2.1033(c)(8). The electrical characteristics of the output terminals when this test is made shall be stated.

§22.913 Effective radiated power limits

(a)(2) Maximum ERP. ... The ERP of mobile transmitters and auxiliary test transmitters must not exceed 7 Watts.

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**Emission and Occupied Bandwidth**

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Standard      FCC Part 22, Subpart H

The test was performed according to: FCC §2.1049

**Test Description**

- 1) The EUT was coupled to a Spectrum Analyser and a Digital Communication Tester through a Power Divider. Refer to chapter "Setup Drawings".
- 2) The total insertion losses for signal path 1 and signal path 2 were measured. The values were used to correct the readings from the Spectrum Analyser and the Digital Communication Tester.
- 3) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

**Important Settings:**

- Output Power: Maximum
- Channel: please refer to the detailed results

**4) Important Analyser Settings:**

- Resolution Bandwidth: >1% of the manufacturer's stated occupied bandwidth
- 5) The maximum spectral level of the modulated signal was recorded as the reference.
- 6) The emission bandwidth is measured as follows:  
the two furthest frequencies above and below the frequency of the maximum reference level where the spectrum is -26 dB down have to be found.
- 7) The occupied bandwidth (99% Bandwidth) is measured as follows:  
the occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5 percent of the total mean power.

**Test Requirements / Limits**

§ 2.1049 Measurements required: 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.

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Spurious emissions at antenna terminals

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Standard      FCC Part 22, Subpart H

The test was performed according to FCC §2.1051

#### Test Description

- 1) The EUT was coupled to a Spectrum Analyser and a Digital Communication Tester through a Power Divider. Refer to chapter "Setup Drawings".
- 2) The total insertion losses for signal path 1 and signal path 2 were measured. The values were used to correct the readings from the Spectrum Analyser and the Digital Communication Tester.
- 3) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

#### Important Settings:

- Output Power: Maximum
- Channel: please refer to the detailed results

- 4) Important Analyser Settings
  - [Resolution Bandwidth]:
    - a) [ $\geq 1\%$  of wanted signal bandwidth] in the Span of 1 MHz directly below and above the PCS-Band,
    - b) otherwise [100 kHz] (or [1 MHz] for accelerated sweep times)
    - c) [reduced resolution bandwidth] in case the curve of the analyser IF-Filter or the wanted EUT signal leads to an exceeding of the limit, in this case a correction factor was used
  - Sweep Time: depending on the transmitting signal, the span and the resolution bandwidth

- 5) The spurious emissions peaks were measured in the frequency range from 9 kHz to 10 GHz (up to the 10th harmonic) during the call was established

#### Test Requirements / Limits

##### § 2.1051 Spurious emissions at antenna terminals

The radio frequency voltage or power 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 Sec. 2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

##### § 2.1057 Frequency spectrum to be investigated.

(a) In all of the measurements set forth in Secs. 2.1051 and 2.1053, the spectrum shall be investigated from the lowest radio frequency signal generated in the equipment, without going below 9 kHz, up to at least the frequency shown below:

(1) If the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

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(b) Particular attention should be paid to harmonics and subharmonics of the carrier frequency as well as to those frequencies removed from the carrier by multiples of the oscillator frequency. Radiation at the frequencies of multiplier stages should also be checked.

(c) The amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

(d) Unless otherwise specified, measurements above 40 GHz shall be performed using a minimum resolution bandwidth of 1 MHz.

**§ 22.917 Emission limitations for cellular equipment**

(a) The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least  $43 + 10 \log(P)$  dB. Remark of the test laboratory: This is calculated to be -13 dBm.

(b) Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kHz or greater. In the 1 MHz bands immediately outside and adjacent to the frequency block a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. A narrower resolution bandwidth is permitted in all cases to improve measurement accuracy provided the measured power is integrated over the full required measurement bandwidth (i.e. 100 kHz or 1 percent of emission bandwidth, as specified). The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.

(c) Licensees in this service may establish an alternative out of band emission limit to be used at specified band edge(s) in specified geographical areas [...].

(d) If any emission from a transmitter operating in this service results in interference to users of another radio service, the FCC may require a greater attenuation of that emission than specified in this section.

For reporting only spurious emission levels reaching to the 20dB margin to limit were noted.

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**Field strength of spurious radiation**

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Standard      FCC Part 22, Subpart H

The test was performed according to: FCC §2.1053

**Test Description**

- 1) The EUT was placed inside an anechoic chamber. Refer to chapter "Setup Drawings". The EUT was coupled to a Digital Communication Tester which was located outside the chamber via a small signalling antenna.
- 2) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

**Important Settings:**

- Output Power: Maximum
- Channel: please refer to the detailed results

- 3) A pre-calibration procedure is used so that the readings from the spectrum analyser are corrected and represent directly the equivalent radiated power (related to a lamda/2 dipole).

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4) All spurious radiation measurements were made with spectrum analyser and the appropriate calibrated antennas for the frequency range of 30 MHz to 10 GHz (up to the 10th harmonic of the transmit frequency). The frequency range from 9 kHz to 30 MHz has been examined during the conducted spurious emission measurements.

5) Important Analyser Settings

- [Resolution Bandwidth / Video Bandwidth]:
  - a) [3 kHz / 10 kHz] in the Span of 1 MHz directly below and above the Band,
  - b) [10 kHz / 30 kHz] in case the curve of the analyser IF-Filter leads to an exceeding of the limit, in this case a worst case correction factor of 20 dB (1 MHz -> 10 kHz) was used
  - c) [1 MHz / 3 MHz] otherwise
- Sweep Time: depending on the transmitting signal, the span and the resolution bandwidth

6) The spurious emissions peaks were measured in both vertical and horizontal antenna polarization during the call is established on the lowest channel, mid channel and on the highest channel. To find the worst case peaks all orientations (X, Y, Z) of the EUT have been measured.

7) After this initial test, a final test according to TIA-603-C 2.2.12 Unwanted Emissions is performed on signals which are identified as being close to the limit. For any emissions found to be within 10 dB of the limit, a specific signal substitution measurement is performed at the frequency of the emission to determine the exact e.i.r.p. value.

**Test Requirements / Limits****§ 2.1053 Measurements required: Field strength of spurious radiation.**

Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data shall be supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph (c) of Sec. 2.1049, as appropriate. For equipment operating on frequencies below 890 MHz, an open field test is normally required, with the measuring instrument antenna located in the far-field at all test frequencies. In the event it is either impractical or impossible to make open field measurements (e.g. a broadcast transmitter installed in a building) measurements will be accepted of the equipment as installed. Such measurements must be accompanied by a description of the site where the measurements were made showing the location of any possible source of reflections which might distort the field strength measurements. Information submitted shall include the relative radiated power of each spurious emission with reference to the rated power output of the transmitter, assuming all emissions are radiated from halfwave dipole antennas.

(b) The measurements specified in paragraph (a) of this section shall be made for the following equipment:

(2) All equipment operating on frequencies higher than 25 MHz.

**§ 2.1057 Frequency spectrum to be investigated.**

(a) In all of the measurements set forth in Secs. 2.1051 and 2.1053, the spectrum shall be investigated from the lowest radio frequency signal generated in the equipment, without going below 9 kHz, up to at least the frequency shown below:

(1) If the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

(b) Particular attention should be paid to harmonics and subharmonics of the carrier frequency as well as to those frequencies removed from the carrier by multiples of the

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oscillator frequency. Radiation at the frequencies of multiplier stages should also be checked.

(c) The amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

(d) Unless otherwise specified, measurements above 40 GHz shall be performed using a minimum resolution bandwidth of 1 MHz.

**§ 22.917 Emission limitations for cellular equipment**

(a) The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least  $43 + 10 \log(P)$  dB. This is calculated to be -13 dBm (effective radiated power) which corresponds to 84.6 dB $\mu$ V/m (field strength) in a distance of 3 m.

(b) Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kHz or greater. In the 1 MHz bands immediately outside and adjacent to the frequency block a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. A narrower resolution bandwidth is permitted in all cases to improve measurement accuracy provided the measured power is integrated over the full required measurement bandwidth (i.e. 100 kHz or 1 percent of emission bandwidth, as specified). The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.

(c) Licensees in this service may establish an alternative out of band emission limit to be used at specified band edge(s) in specified geographical areas [...].

(d) If any emission from a transmitter operating in this service results in interference to users of another radio service, the FCC may require a greater attenuation of that emission than specified in this section.

For reporting only spurious emission levels reaching to the 20dB margin to limit were noted.

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**Frequency stability**

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Standard      FCC Part 22, Subpart H

The test was performed according to FCC §2.1055

**Test Description**

- 1) The EUT was placed inside a temperature chamber.
- 2) The EUT was coupled to a Digital Communication Tester. Refer to chapter "Setup Drawings".
- 3) The climatic chamber was cycled down/up to a certain temperature, starting with the EUT minimum temperature.
- 4) After the temperature was stabilized the EUT was switched on and a call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

**Important Settings:**

- Output Power: Maximum
- Mid Channel

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5) The frequency error of the EUT was recorded by using an internal measurement function of the Digital Communication Tester immediately after the call was established, five minutes after the call was established and ten minutes after the call was established.

6) This measurement procedure was performed for temperature variation from -30°C to +50°C in increments of 10°C, if not otherwise stated in the detailed results.

When the EUT did not operate at certain temperature levels, these measurements were left out.

**Test Requirements / Limits****§2.1055 Measurements required: Frequency stability**

(a) The frequency stability shall be measured with variation of ambient temperature as follows:

(1) From -30° to +50° centigrade for all equipment except that specified in paragraphs (a) (2) and (3) of this section.

(b) Frequency measurements shall be made at the extremes of the specified temperature range and at intervals of not more than 10° centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stabilizing circuitry need be subjected to the temperature variation test.

(d) The frequency stability shall be measured with variation of primary supply voltage as follows:

(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.

(2) For hand carried, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.

(3) The supply voltage shall be measured at the input to the cable normally provided with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

**§22.355 Frequency tolerance**

...the carrier frequency of each transmitter in the Public Mobile Service must be maintained within the tolerances given in table C-1 of this section.

**Table C-1.- Frequency Tolerance for Transmitters in the Public Mobile Services**

Frequency range (MHz)	Base, fixed (ppm)	Mobile up to 3 watts (ppm)	Mobile above 3 watts (ppm)
25 to 50	20.0	20.0	50.0
50 to 450	5.0	5.0	50.0
450 to 512	2.5	5.0	5.0
821 to 896	1.5	2.5	2.5
928 to 929	5.0	n/a	n/a
929 to 960	1.5	n/a	n/a
2110 to 2220	10.0	n/a	n/a

For the mid channel (836.6 MHz) the frequency tolerance is 2.5 ppm (2091.5 Hz).

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Band edge compliance

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Standard      FCC Part 22, Subpart H

The test was performed according to: FCC §22.913

**Test Description**

- 1) The EUT was coupled to a Spectrum Analyser and a Digital Communication Tester through a Power Divider. Refer to chapter "Setup Drawings".
- 2) The total insertion losses for signal path 1 and signal path 2 were measured. The values were used to correct the readings from the Spectrum Analyser and the Digital Communication Tester.
- 3) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

**Important Settings:**

- Output Power: Maximum
- Channel: please refer to the detailed results

- 4) Important Analyser Settings:

- Resolution Bandwidth = Video Bandwidth: >1% of the manufacturer's stated occupied bandwidth

**Test Requirements / Limits**

§ 22.917 Emission limitations for cellular equipment

Refer to chapter "Field strength of spurious radiation".

**TEST REPORT REFERENCE:****Annex to MDE\_UBLOX\_1502\_FCCa****FCC Part 24**

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**RF Power Output**

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Standard: FCC Part 24, Subpart E

The test was performed according to: FCC §2.1046

**Test Description (conducted measurement procedure)**

- 1) The EUT was coupled to a Spectrum Analyser and a Digital Communication Tester through a Power Divider. Refer to chapter "Setup Drawings".
- 2) The total insertion losses for signal path 1 and signal path 2 were measured. The values were used to correct the readings from the Spectrum Analyser and the Digital Communication Tester.
- 3) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

**Important Settings:**

- Channel (Frequency): please refer to the detailed results

- 4) The transmitted power of the EUT was recorded by using a spectrum analyser.

**Test Description (radiated measurement procedure)**

- 1) The EUT was placed inside an anechoic chamber. Refer to chapter "Setup Drawings". The EUT was coupled to a Digital Communication Tester which was located outside the chamber via a small signalling antenna.
- 2) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

**Important Settings:**

- Output Power: Maximum
- Channel: please refer to the detailed results

- 3) A substitution procedure is used so that the readings from the spectrum analyser are corrected and represent directly the equivalent radiated power (related to a lamda/2 dipole).
- 4) The output power was measured in both vertical and horizontal antenna polarisation during the call is established on the lowest channel, mid channel and on the highest channel. To find the worst case power all orientations (X, Y, Z) of the EUT have been measured.
- 5) The test procedure according to TIA-603-C-2004 has been considered.

**Test Requirements / Limits****§2.1046 Measurements Required: RF Power Output**

(a) For transmitters other than single sideband, independent sideband and controlled carrier radiotelephone, power output shall be measured at the RF output terminals when the transmitter is adjusted in accordance with the tune-up procedure to give the values of current and voltage on the circuit elements specified in § 2.1033(c)(8). The electrical characteristics of the output terminals when this test is made shall be stated.

**§24.232 Power and antenna height limits**

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(c) Mobile/portable stations are limited to 2 watts EIRP peak power and the equipment must employ means to limit the power to the minimum necessary for successful communications.

(e) Peak transmit power must be measured over any interval of continuous transmission using instrumentation calibrated in terms of an rms-equivalent voltage. The measurement results shall be properly adjusted for any instrument limitations, such as detector response times, limited resolution bandwidth capability when compared to the emission bandwidth, sensitivity, etc., so as to obtain a true peak measurement for the emission in question over the full bandwidth of the channel.

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**Emission and Occupied Bandwidth**

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Standard: FCC Part 24, Subpart E

The test was performed according to: FCC §2.1049

**Test Description**

- 1) The EUT was coupled to a Spectrum Analyser and a Digital Communication Tester through a Power Divider. Refer to chapter "Setup Drawings".
- 2) The total insertion losses for signal path 1 and signal path 2 were measured. The values were used to correct the readings from the Spectrum Analyser and the Digital Communication Tester.
- 3) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

**Important Settings:**

- Output Power: Maximum
- Channel: please refer to the detailed results

**4) Important Analyser Settings:**

- Resolution Bandwidth: >1% of the manufacturer's stated occupied bandwidth
- 5) The maximum spectral level of the modulated signal was recorded as the reference.

**6) The emission bandwidth is measured as follows:**

the two furthest frequencies above and below the frequency of the maximum reference level where the spectrum is -26 dB down have to be found.

**7) The occupied bandwidth (99% Bandwidth) is measured as follows:**

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

**Test Requirements / Limits****§ 2.1049 Measurements required: 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

**TEST REPORT REFERENCE:****Annex to MDE\_UBLOX\_1502\_FCCa**

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.

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Spurious emissions at antenna terminals

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Standard: FCC Part 24, Subpart E

The test was performed according to FCC §2.1051

**Test Description**

- 1) The EUT was coupled to a Spectrum Analyser and a Digital Communication Tester through a Power Divider. Refer to chapter "Setup Drawings".
- 2) The total insertion losses for signal path 1 and signal path 2 were measured. The values were used to correct the readings from the Spectrum Analyser and the Digital Communication Tester.
- 3) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

**Important Settings:**

- Output Power: Maximum
- Channel: please refer to the detailed results

- 4) Important Analyser Settings
  - [Resolution Bandwidth]:
    - a) [ $>=1\%$  of wanted signal bandwidth] in the Span of 1 MHz directly below and above the Band,
    - b) otherwise [1 MHz]
    - c) [reduced resolution bandwidth] in case the curve of the analyser IF-Filter or the wanted EUT signal leads to an exceeding of the limit, in this case a correction factor was used
  - Sweep Time: depending on the transmitting signal, the span and the resolution bandwidth

- 5) The spurious emissions peaks were measured in the frequency range from 9 kHz to 20 GHz (up to the 10th harmonic) during the call was established

**Test Requirements / Limits****§ 2.1051 Spurious emissions at antenna terminals**

The radio frequency voltage or power 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 Sec. 2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

**§ 2.1057 Frequency spectrum to be investigated.**

(a) In all of the measurements set forth in Secs. 2.1051 and 2.1053, the spectrum shall be investigated from the lowest radio frequency signal generated in the equipment, without going below 9 kHz, up to at least the frequency shown below:

**TEST REPORT REFERENCE:****Annex to MDE\_UBLOX\_1502\_FCCa**

- (1) If the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.
- (b) Particular attention should be paid to harmonics and subharmonics of the carrier frequency as well as to those frequencies removed from the carrier by multiples of the oscillator frequency. Radiation at the frequencies of multiplier stages should also be checked.
- (c) The amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.
- (d) Unless otherwise specified, measurements above 40 GHz shall be performed using a minimum resolution bandwidth of 1 MHz.

**§ 24.238 Emission limitations for Broadband PCS equipment**

- (a) The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least  $43 + 10 \log(P)$  dB. Remark of the test laboratory: This is calculated to be -13 dBm.
- (b) Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 1 MHz or greater. However, in the 1 MHz bands immediately outside and adjacent to the frequency block a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. A narrower resolution bandwidth is permitted in all cases to improve measurement accuracy provided the measured power is integrated over the full required measurement bandwidth (i.e. 1 MHz or 1 percent of emission bandwidth, as specified). The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.
- (c) Licensees in this service may establish an alternative out of band emission limit to be used at specified band edge(s) in specified geographical areas [...].
- (d) If any emission from a transmitter operating in this service results in interference to users of another radio service, the FCC may require a greater attenuation of that emission than specified in this section.

For reporting only spurious emission levels reaching to the 20dB margin to limit were noted.

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Field strength of spurious radiation

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Standard: FCC Part 24, Subpart E

The test was performed according to: FCC §2.1053

**Test Description**

- 1) The EUT was placed inside an anechoic chamber. Refer to chapter "Setup Drawings". The EUT was coupled to a Digital Communication Tester which was located outside the chamber via a small signalling antenna.
- 2) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

**Important Settings:**

- Output Power: Maximum
- Channel: please refer to the detailed results

**TEST REPORT REFERENCE:****Annex to MDE\_UBLOX\_1502\_FCCa**

- 3) A pre-calibration procedure is used so that the readings from the spectrum analyser are corrected and represent directly the equivalent radiated power (related to a lamda/2 dipole).
- 4) All spurious radiation measurements were made with spectrum analyser and the appropriate calibrated antennas for the frequency range of 30 MHz to 20 GHz (up to the 10th harmonic of the transmit frequency). The frequency range from 9 kHz to 30 MHz has been examined during the conducted spurious emission measurements.
- 5) Important Analyser Settings
  - [Resolution Bandwidth / Video Bandwidth]:
    - a) [3 kHz / 10 kHz] in the Span of 1 MHz directly below and above the Band,
    - b) [10 kHz / 30 kHz] in case the curve of the analyser IF-Filter leads to an exceeding of the limit, in this case a worst case correction factor of 20 dB (1 MHz -> 10 kHz) was used
    - c) [1 MHz / 3 MHz] otherwise
  - Sweep Time: depending on the transmitting signal, the span and the resolution bandwidth
- 6) The spurious emissions peaks were measured in both vertical and horizontal antenna polarisation during the call is established on the lowest channel, mid channel and on the highest channel. To find the worst case peaks all orientations (X, Y, Z) of the EUT have been measured.
- 7) After this initial test, a final test according to TIA-603-C 2.2.12 Unwanted Emissions is performed on signals which are identified as being close to the limit. For any emissions found to be within 10 dB of the limit, a specific signal substitution measurement is performed at the frequency of the emission to determine the exact e.i.r.p. value.

**Test Requirements / Limits****§ 2.1053 Measurements required: Field strength of spurious radiation.**

Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data shall be supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph (c) of Sec. 2.1049, as appropriate. For equipment operating on frequencies below 890 MHz, an open field test is normally required, with the measuring instrument antenna located in the far-field at all test frequencies. In the event it is either impractical or impossible to make open field measurements (e.g. a broadcast transmitter installed in a building) measurements will be accepted of the equipment as installed. Such measurements must be accompanied by a description of the site where the measurements were made showing the location of any possible source of reflections which might distort the field strength measurements. Information submitted shall include the relative radiated power of each spurious emission with reference to the rated power output of the transmitter, assuming all emissions are radiated from halfwave dipole antennas.

(b) The measurements specified in paragraph (a) of this section shall be made for the following equipment:

(2) All equipment operating on frequencies higher than 25 MHz.

**§ 2.1057 Frequency spectrum to be investigated.**

(a) In all of the measurements set forth in Secs. 2.1051 and 2.1053, the spectrum shall be investigated from the lowest radio frequency signal generated in the equipment, without going below 9 kHz, up to at least the frequency shown below:

(1) If the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

**TEST REPORT REFERENCE:****Annex to MDE\_UBLOX\_1502\_FCCa**

- (b) Particular attention should be paid to harmonics and subharmonics of the carrier frequency as well as to those frequencies removed from the carrier by multiples of the oscillator frequency. Radiation at the frequencies of multiplier stages should also be checked.
- (c) The amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.
- (d) Unless otherwise specified, measurements above 40 GHz shall be performed using a minimum resolution bandwidth of 1 MHz.

**§ 24.238 Emission limitations for Broadband PCS equipment**

- (a) The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least  $43 + 10 \log(P)$  dB. This is calculated to be -13 dBm (effective radiated power) which corresponds to 84.6 dB $\mu$ V/m (field strength) in a distance of 3 m.
- (b) Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 1 MHz or greater. However, in the 1 MHz bands immediately outside and adjacent to the frequency block a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. A narrower resolution bandwidth is permitted in all cases to improve measurement accuracy provided the measured power is integrated over the full required measurement bandwidth (i.e. 1 MHz or 1 percent of emission bandwidth, as specified). The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.
- (c) Licensees in this service may establish an alternative out of band emission limit to be used at specified band edge(s) in specified geographical areas [...].
- (d) If any emission from a transmitter operating in this service results in interference to users of another radio service, the FCC may require a greater attenuation of that emission than specified in this section.

For reporting only spurious emission levels reaching to the 20dB margin to limit were noted.

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Frequency stability

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Standard: FCC Part 24, Subpart E

The test was performed according to FCC §2.1055

**Test Description**

- 1) The EUT was placed inside a temperature chamber.
- 2) The EUT was coupled to a Digital Communication Tester. Refer to chapter "Setup Drawings".
- 3) The climatic chamber was cycled down/up to a certain temperature, starting with the EUT minimum temperature.
- 4) After the temperature was stabilized the EUT was switched on and a call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

**Important Settings:**

- Output Power: Maximum

**TEST REPORT REFERENCE:****Annex to MDE\_UBLOX\_1502\_FCCa**

- Mid Channel

5) The frequency error of the EUT was recorded by using an internal measurement function of the Digital Communication Tester immediately after the call was established, five minutes after the call was established and ten minutes after the call was established.

6) This measurement procedure was performed for temperature variation from -30°C to +50°C in increments of 10°C, if not otherwise stated in the detailed results.

When the EUT did not operate at certain temperature levels, these measurements were left out.

**Test Requirements / Limits****§2.1055 Measurements required: Frequency stability**

(a) The frequency stability shall be measured with variation of ambient temperature as follows:

(1) From -30° to +50° centigrade for all equipment except that specified in paragraphs (a) (2) and (3) of this section.

(b) Frequency measurements shall be made at the extremes of the specified temperature range and at intervals of not more than 10° centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stabilizing circuitry need be subjected to the temperature variation test.

(d) The frequency stability shall be measured with variation of primary supply voltage as follows:

(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.

(2) For hand carried, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.

(3) The supply voltage shall be measured at the input to the cable normally provided with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

**§24.235 Frequency stability**

The frequency stability shall be sufficient to ensure that the fundamental emission stays within the authorized frequency block.

7Layers interpretation of limit:

To ensure that the frequency stability shall be sufficient to ensure that the fundamental emission stays within the authorized frequency block following limit was used:

+/- 2.5 ppm = 4700 Hz for a frequency of 1880.0 MHz

in accordance with FCC Part 22, Subpart H, §22.355, table C-1: Frequency tolerance for the carrier frequency of mobile transmitters in the Public Mobile Service in the frequency range 821 to 896 MHz.

**TEST REPORT REFERENCE:****Annex to MDE\_UBLOX\_1502\_FCCa**

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Band edge compliance

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Standard: FCC Part 24, Subpart E

The test was performed according to: FCC §24.238

**Test Description**

- 1) The EUT was coupled to a Spectrum Analyser and a Digital Communication Tester through a Power Divider. Refer to chapter "Setup Drawings".
- 2) The total insertion losses for signal path 1 and signal path 2 were measured. The values were used to correct the readings from the Spectrum Analyser and the Digital Communication Tester.
- 3) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

**Important Settings:**

- Output Power: Maximum
- Channel: please refer to the detailed results

- 4) Important Analyser Settings:

- Resolution Bandwidth = Video Bandwidth: >1% of the manufacturer's stated occupied bandwidth

**Test Requirements / Limits**

§ 24.238 Effective radiated power limits

Refer to chapter "Field strength of spurious radiation".