

Test Report

Report Number: F150998E3

Applicant:

WABCO Fahrzeugsysteme GmbH

Manufacturer:

WABCO Fahrzeugsysteme GmbH

Equipment under Test (EUT):

OptiTire ECU



Laboratory accredited by
Deutsche Akkreditierungsstelle (DAkkS) GmbH
in compliance with DIN EN ISO/IEC 17025

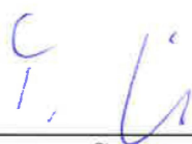
REFERENCES

- [1] **ANSI C63.10-2013** American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- [2] **FCC CFR 47 Part 15** Radio Frequency Devices
- [3] **RSS-210 Issue 8 (December 2010)** Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment
- [4] **RSS-Gen Issue 4 (November 2014)** General Requirements for Compliance of Radio Apparatus
- [6] **Publication Number 913591 (March 2007)** Measurement of radiated emissions at the edge of the band for a Part 15 RF Device

TEST RESULT

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test.

The complete test results are presented in the following.

Test engineer:	Thomas KÜHN		15 April 2015
	Name	Signature	Date
Authorized reviewer:	Bernd STEINER		15 April 2015
	Name	Signature	Date

RESERVATION

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1 Identification

1.1 Applicant

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eMail Address:	hans-juergen.frank@wabco-auto.com
Applicant represented during the test by the following person:	Mr. Hans-Jürgen FRANK

1.2 Manufacturer

Name:	WABCO Fahrzeugsysteme GmbH
Address:	Am Lindener Hafen 21 30453 Hannover
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eMail Address:	hans-juergen.frank@wabco-auto.com
Applicant represented during the test by the following person:	Mr. Hans-Jürgen FRANK

1.3 Test laboratory

The tests were carried out at: **PHOENIX TESTLAB GmbH**
Königswinkel 10
32825 Blomberg
Germany

accredited by *Deutsche Akkreditierungsstelle GmbH* in compliance with
DIN EN ISO/IEC 17025 under Reg. No. *D-PL-17186-01-02*, FCC Test site registration number
90877 and Industry Canada Test site registration IC3469A-1.

1.4 EUT (Equipment Under Test)

Test object: *	Tire pressure control system
HVIN: *	OptiTire ECU
FCC ID: *	SA4-OPTITIRE
IC: *	6970A-OPTITIRE
Article number: *	884 910 050 0
Serial number: *	000532
Hardware version: *	446 220 130
Software version: *	884 910 046 2
Lowest / highest internal frequency: *	235 kHz / 433.92 MHz

1.5 Technical data of equipment

Channel spacing: *	None (one channel operation)					
Antenna type: *	Integrated PCB antenna					
Modulation: *	ASK					
Bit rate of transmitter: *	4096 bit/s					
Supply Voltage: *	U _{Nom} =	24 V _{DC}	U _{Min} =	6 V _{DC}	U _{Max} =	32 V _{DC}
Power Supply:	External by vehicle battery					
Temperature range: *	-40 °C to +85 °C*					
Ancillaries to be tested with: *	-					

* declared by the applicant.

The following external I/O cables were used:

Identification	Connector		Length
	EUT	Ancillary	
Supply / Sensor / CAN	8-pole jack	-	1.5 m
-	-	-	-
-	-	-	-

*: Length during the test if no other specified.

1.6 Dates

Date of receipt of test sample:	04 March 2015
Start of test:	04 March 2015
End of test:	05 March 2015

2 Operational states

The EUT is part of a tire pressure control system. It is able to transmit and receive data to / from ancillary sensors. The communication frequency is 433.92 MHz. For the measurements described in this test report it was possible to enable the necessary operation mode by using a laptop PC connected via CAN to the EUT running test software "UDT". The setup is shown in the following picture.

During all tests except the measurement of the transmitter timing for calculating the average correction factor were carried out with the EUT transmits data telegrams continuously.

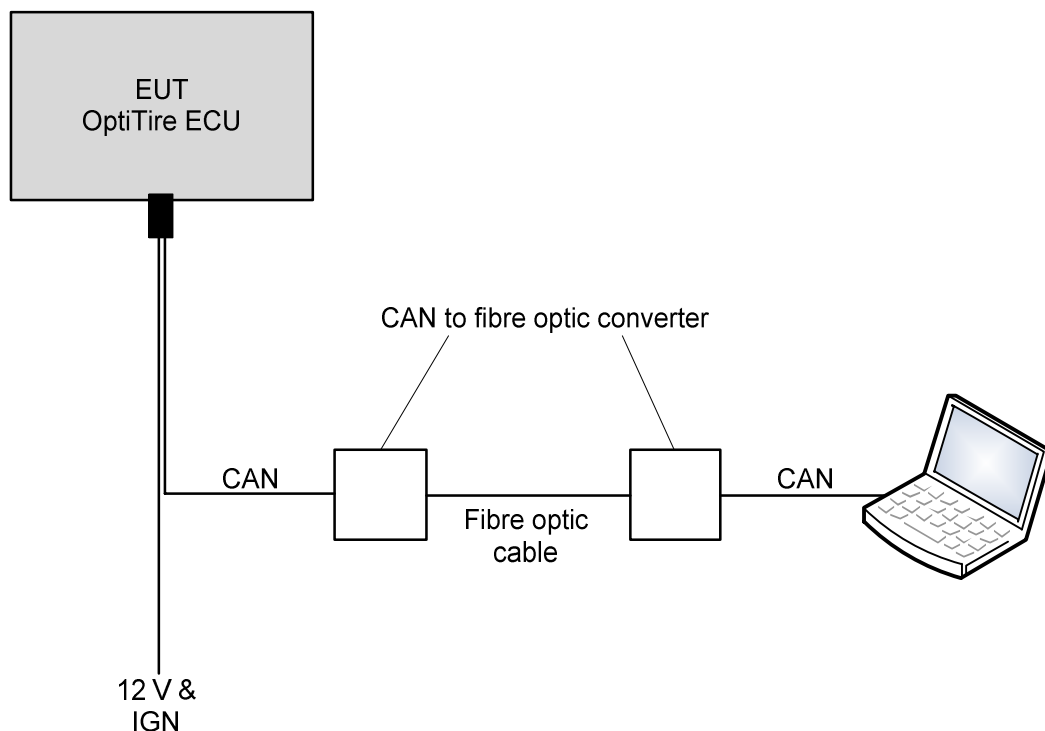
The EUT was supplied with 12 V DC by an external power supply during all measurements because of the higher current consumption.

As declared by the applicant, the EUT will be mounted in different positions. Therefore the measurements were carried out in two orthogonal directions of the EUT. These positions were defined as follows:

Position 1: Connector shows upwards, EUT lying horizontal.

Position 2: Connector shows away from the measurement antenna, EUT lying horizontal.

For details of these positions refer also the photographs in annex A of this test report.



3 Additional information

The tested sample was not labelled with a FCC-label.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS 210, Issue 8 [3] or RSS-Gen, Issue 4 [4]	Status	Refer page
Occupied bandwidth	433	15.231 (c)	A1.1.3 [3]	Passed	14 et seq.
Transmission time control	433	15.231 (a) (3)	A1.1.1 [c]	Passed	19 et seq.
Radiated emissions	0.009 – 4,500	15.231 (b) 15.205 (a) 15.209 (a)	2.5 [3] A1.1 [3] 8.9 [4]	Passed	22 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [4]	Not applicable*	-

* EUT is intended to be used in vehicular environment only.

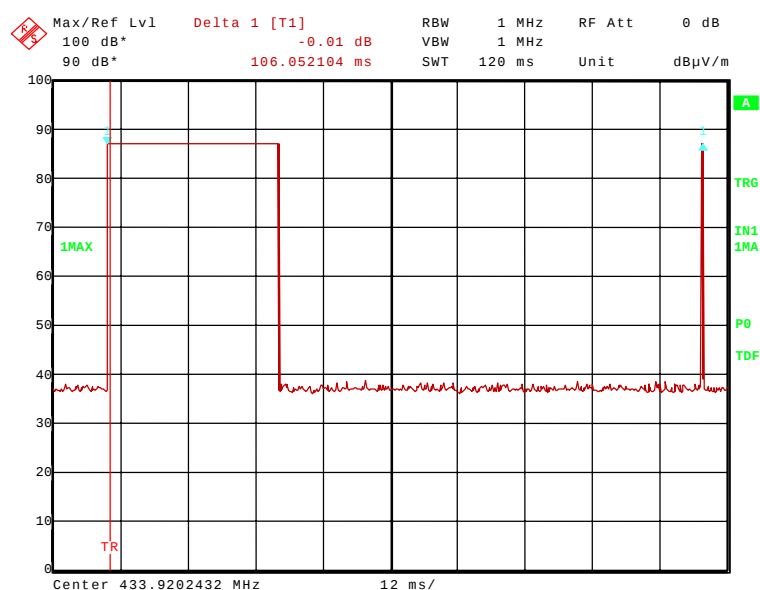
5 Test results

5.1 Average correction factor

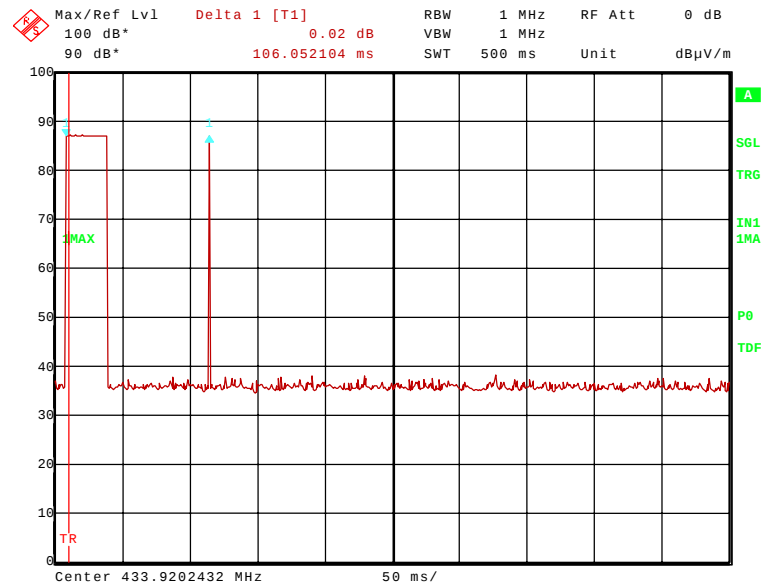
Because of a single transmission all measurements were carried out with a peak detector and the average value is calculated over the real pulse train as required in Part 15.35.

To calculate the average value a timing of the emission was measured. A detail view to the transmission pulse was recorded and the total transmitter on time was calculated.

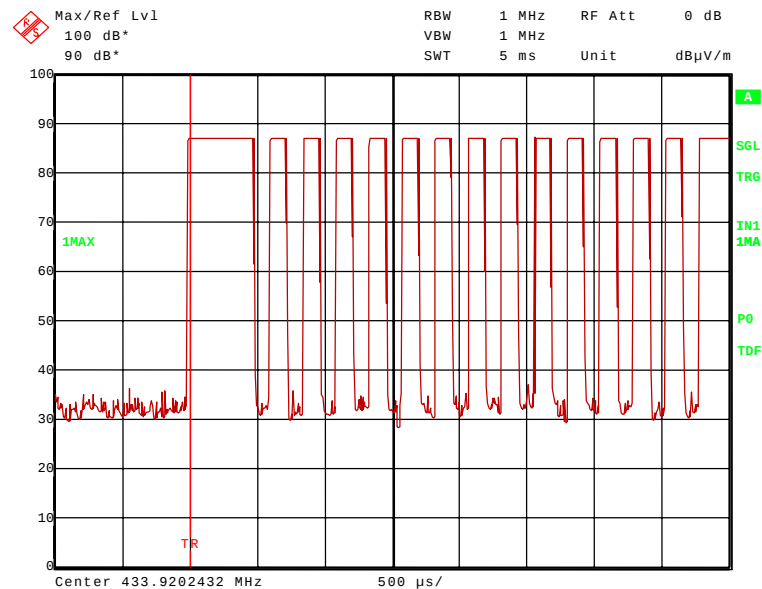
150998_3.wmf: Detail view to total pulse train:



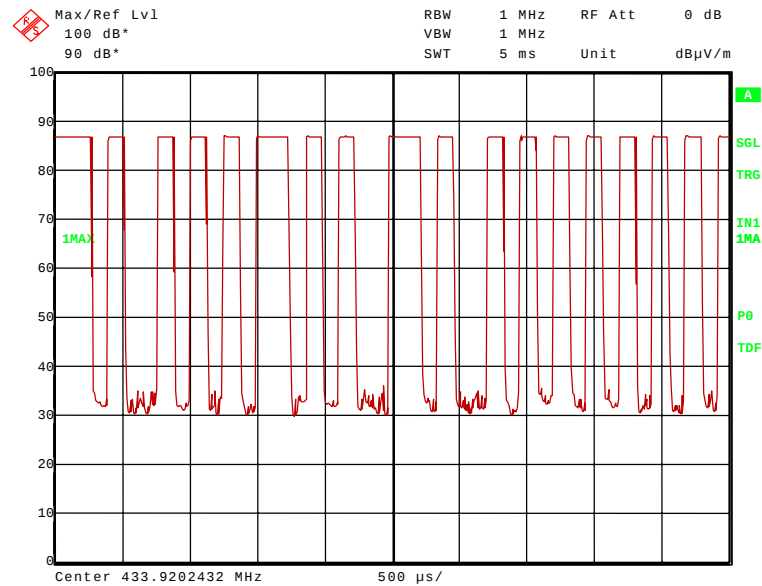
150998 4.wmf: Total pulse train:



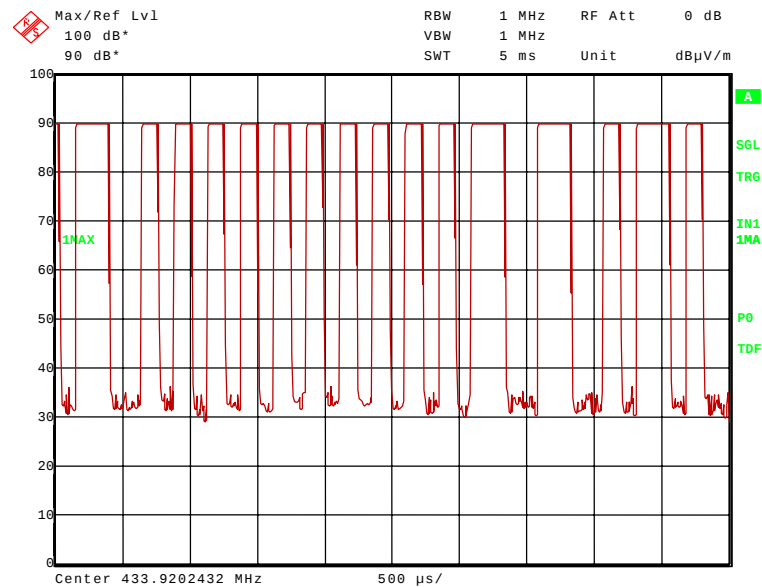
150998 5.wmf: Detail view 1 to pulse train:



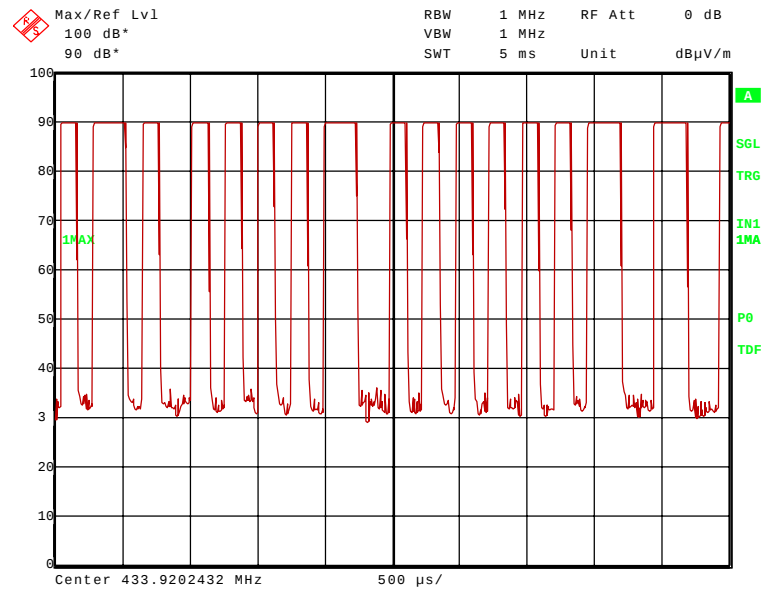
150998 6.wmf: Detail view 2 to pulse train:



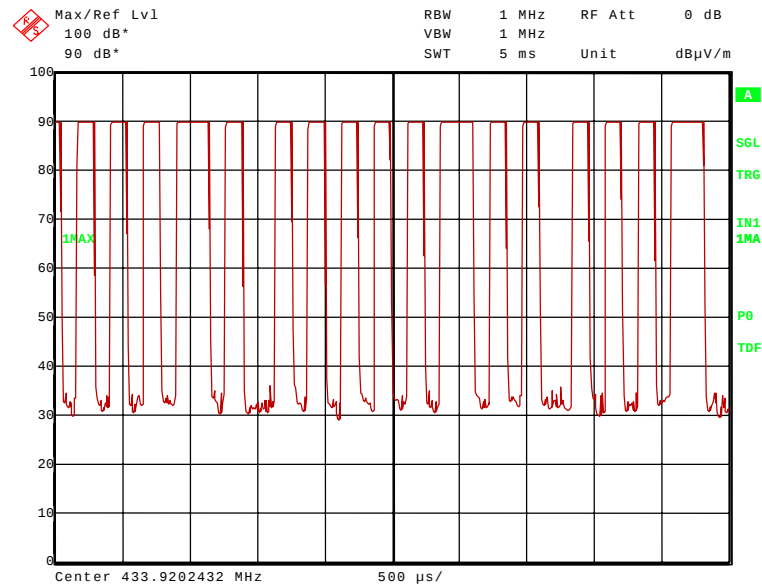
150998 7.wmf: Detail view 3 to pulse train:



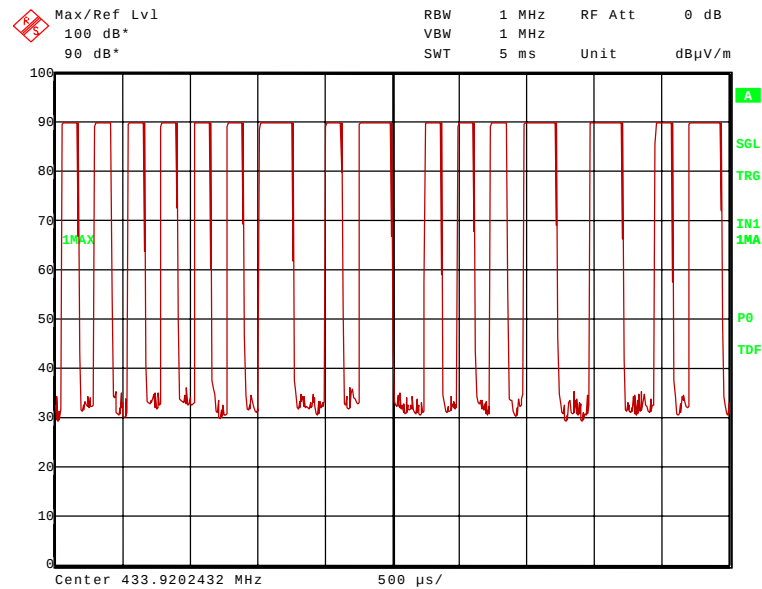
150998_8.wmf: Detail view 4 to pulse train:



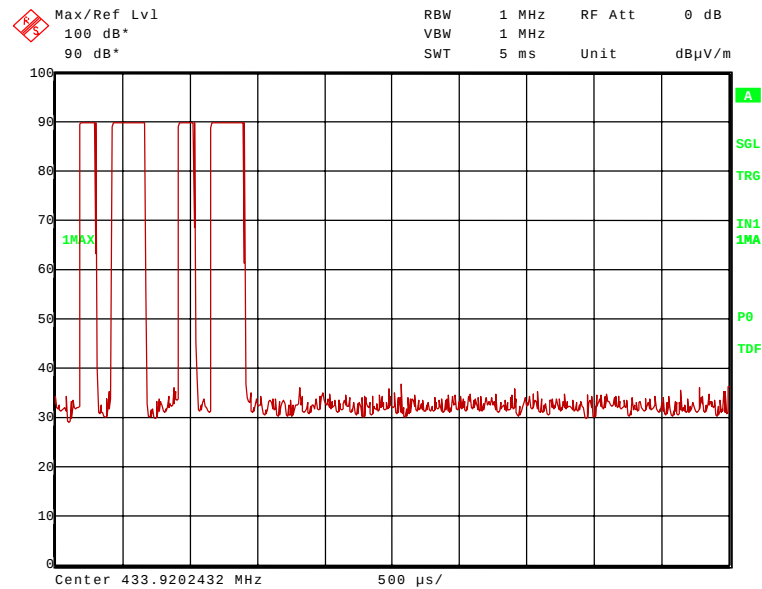
150998_9.wmf: Detail view 5 to pulse train:



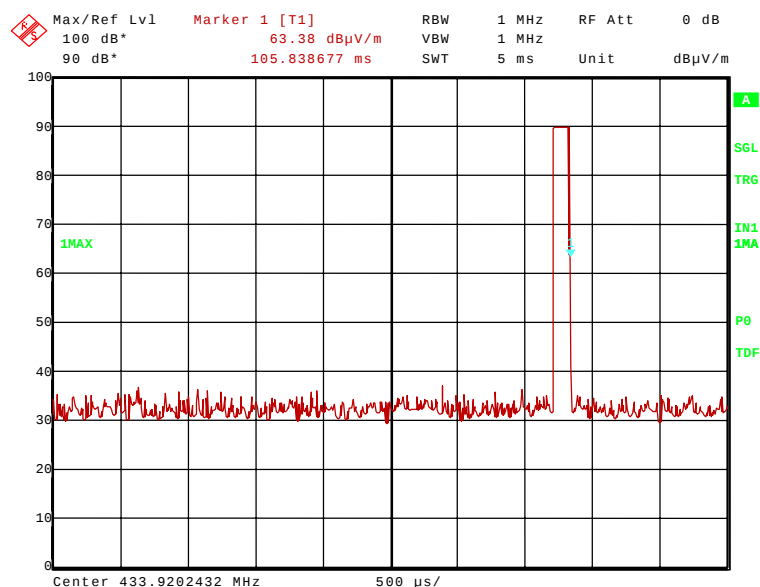
150998_10.wmf: Detail view 6 to pulse train:



150998_11.wmf: Detail view 7 to pulse train:



150998_12.wmf: Detail view 8 to pulse train:



Summary of the complete pulse train:

The pulse train consists of

2 pulses type 1: $2 * 500 \mu s = 1,000 \mu s$
 80 pulses type 2: $80 * 130 \mu s = 10,400 \mu s$
 20 pulses type 3: $20 * 250 \mu s = 5,000 \mu s$

total on time of sub pulse = 16,400 μs
 total length of one sub pulse = 30.5 ms

Duty cycle correction factor according to 15.35c

Because the pulse is longer than 100 ms the duty cycle correction factor has to be calculated with 100 ms.

$$F [dB] = 20 * \log (16,400 \mu s / 100 ms) = -15.7 dB$$

So the measured peak values were calculated with 15.7 dB down into average values.

Test equipment used (refer clause 6):

24, 26, 31

5.2 Bandwidth

5.2.1 Method of measurement (20 dB bandwidth)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed or a test fixture has to be used. The EUT has to be switched on. The transmitter shall work with its maximum data rate.

The following spectrum analyser settings shall be used:

- Span: App. 2 to 3 times the 20 dB bandwidth, centred on the actual channel.
- Resolution bandwidth: If no requirements were made, the following minimum values shall be used:
 From 9 kHz to 30 MHz: $RBW_{min} = 1 \text{ kHz}$;
 from 30 MHz to 1000 MHz $RBW_{min} = 10 \text{ kHz}$,
 and from 1000 MHz to 40 GHz $RBW_{min} = 100 \text{ kHz}$
- Video bandwidth: $\geq$ the resolution bandwidth.
- Sweep: Auto.
- Detector function: peak.
- Trace mode: Max hold.

After trace stabilisation the marker shall be set on the signal peak. If possible the 20 dB down function of the analyser shall be used, if not, the display lines of the analyser shall be used as follows: The first display line has to be set on this value. The second display line has to be set 20 dB below the first line (or the peak marker). The frequency lines shall be set on the intersection points between the second display line and the measured curve.

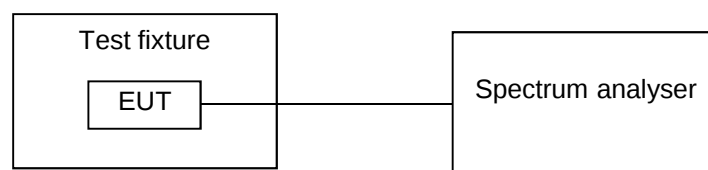
5.2.2 Method of measurement (99 % bandwidth)

The following spectrum analyser settings shall be used (99 % bandwidth):

- Span: The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts.
- Resolution bandwidth: App. 1% to 5% of the occupied bandwidth (OBW).
- Video bandwidth: 3 x RBW.
- Sweep: Auto.
- Detector function: peak.
- Trace mode: Max hold.

After trace stabilisation the marker shall be set on the signal peak. The 99 % bandwidth function of the analyser shall be used to determine 99 % bandwidth of the EUTs transmission.

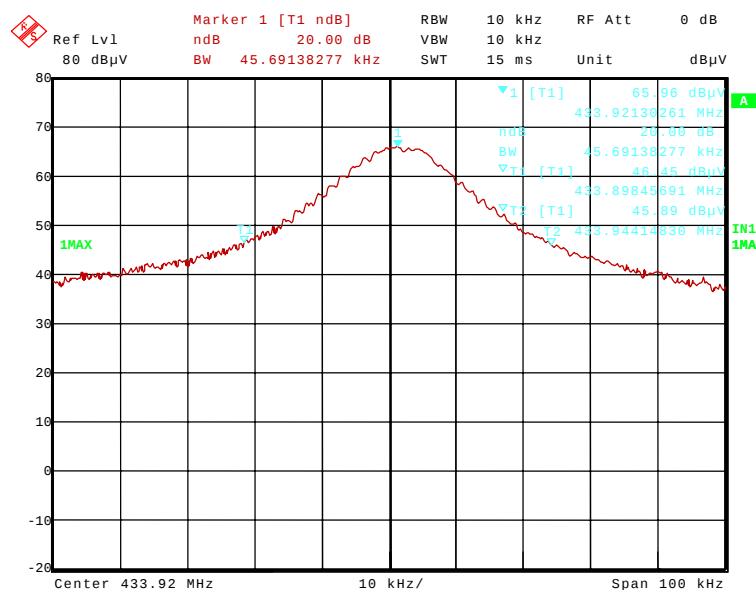
Test set-up: (20 dB and 99 % bandwidth)



5.2.3 Test results (20 dB bandwidth)

Ambient temperature	22 °C	Relative humidity	28 %
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150998 16.wmf: 20 dB Bandwidth:



Lower frequency	Upper frequency	20 dB bandwidth	LIMIT (0.25 % of the center frequency)
433.898457 MHz	433.944148 MHz	45.691 kHz	1084.135 kHz
Measurement uncertainty		< 1*10 ⁻⁷	

Test: Passed

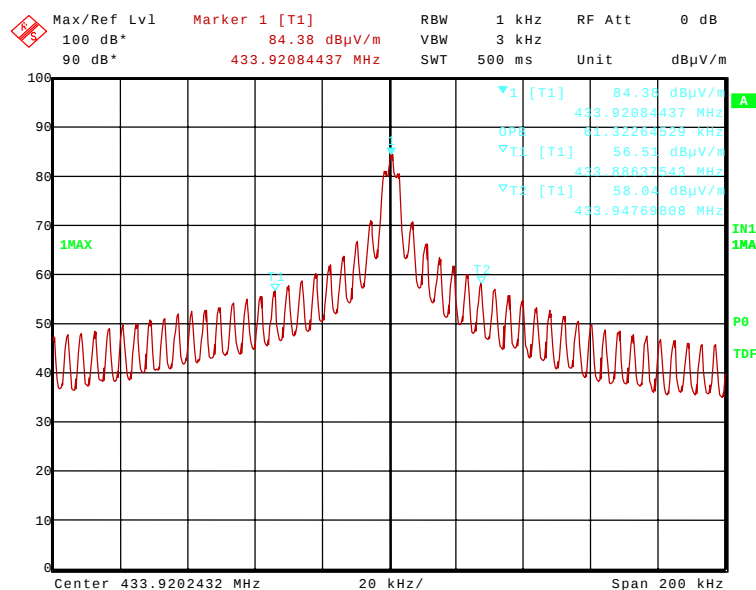
Test equipment used (refer clause 6):

24, 26, 31

5.2.4 Test results (99 % bandwidth)

Ambient temperature	22 °C	Relative humidity	28 %
---------------------	-------	-------------------	------

150998 17.wmf: 99 % Bandwidth:



Lower frequency	Upper frequency	99 % bandwidth	LIMIT (0.25 % of the center frequency)
433.886375 MHz	433.947698 MHz	61.323 kHz	1084.135 kHz
Measurement uncertainty		< 1*10 ⁻⁷	

Test: Passed

Test equipment used (refer clause 6):

24, 26, 31

5.3 Band-edge compliance

5.3.1 Method of measurement (Band-edge compliance (radiated))

The same test set-up as used for the final radiated emission measurement shall be used (refer also subclause 5.5.1 of this test report).

The following spectrum analyser settings shall be used:

- Span: Wide enough to capture the peak level of the emission on the channel closest to the band-edge, as well as any modulation products, which fall outside the assigned frequency band.
- Resolution bandwidth: 100 kHz.
- Video bandwidth: $\geq$ the resolution bandwidth.
- Sweep: Auto.
- Detector function: Peak.
- Trace mode: Max hold.

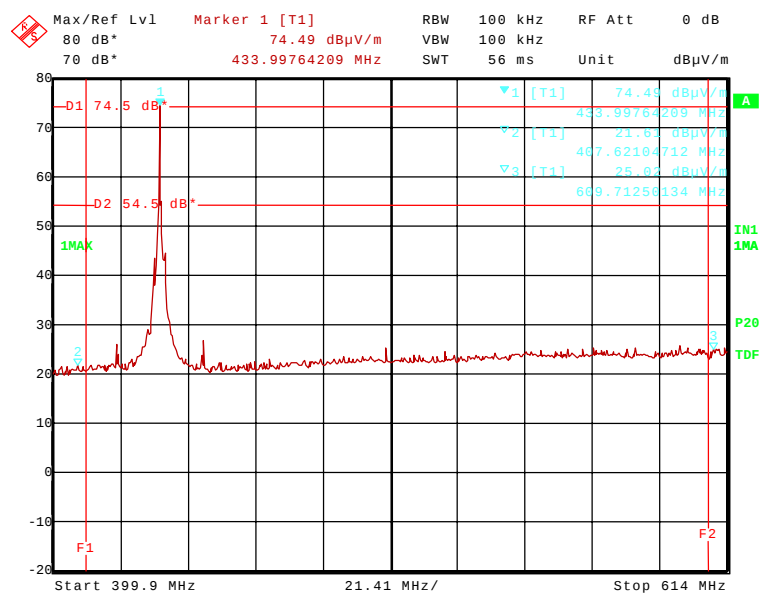
After trace stabilisation the marker shall be set on the signal peak. The first display line has to be set on this value. The second display line has to be set 20 dB below the first line (or the peak marker). The frequency line shall be set on the edge of the assigned frequency band. Set the second marker on the emission at the band-edge, or on the highest modulation product outside of the band, if this level is higher than that at the band-edge. This frequency shall be measured with the EMI receiver as described in subclause 5.5.1 of this test report, but 100 kHz resolution bandwidth shall be used.

The measurement will be performed at the upper end of the assigned frequency band if applicable.

5.3.2 Test results (Band-edge compliance (radiated))

Ambient temperature	22 °C	Relative humidity	28 %
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150998_19.wmf: Band edge compliance (radiated):



Test: Passed

Test equipment used (refer clause 6):

24, 29, 31 – 35, 142

5.4 Transmission time control

5.4.1 Method of measurement (transmission time control)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed or a test fixture has to be used. The EUT has to be switched on, the transmitter shall work with its maximum data rate.

The following spectrum analyser settings shall be used:

- Span: = 0 Hz.
- Resolution bandwidth: 1 MHz.
- Video bandwidth: $\geq$ the resolution bandwidth.
- Sweep: Sufficient to detect single transmission pulses and the gap between them.
- Detector function: peak.
- Trace mode: Max hold.

The time between two transmissions shall be measured with the delta marker function of the spectrum analyser and the total transmitter on time per hour shall be calculated.

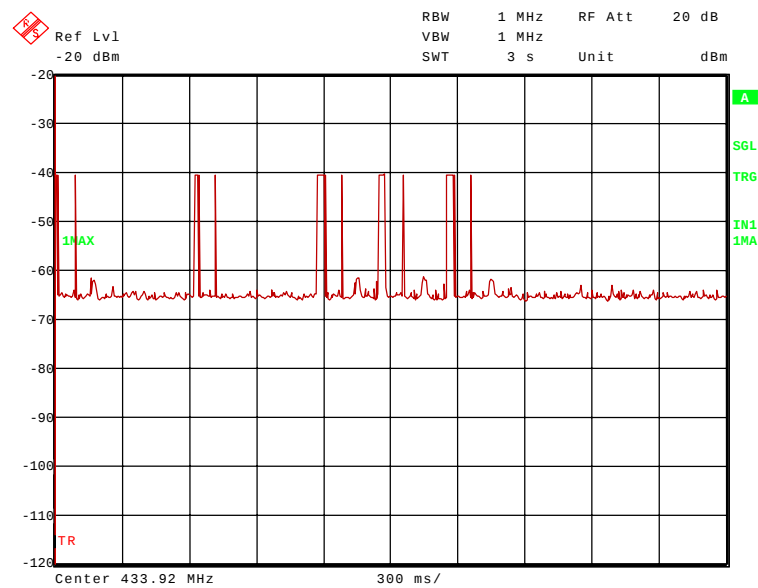
Test set-up:



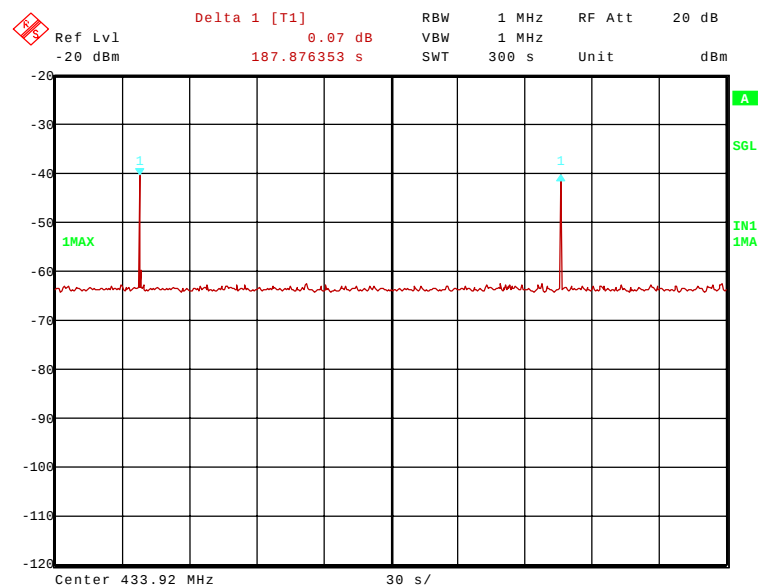
5.4.2 Test results (transmission time control)

Ambient temperature	22 °C	Relative humidity	28 %
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150998_20.wmf: Start sequence:



150998_21.wmf: Time between two transmissions:



Calculation of the total transmission time per hour:

During the normal operation mode of the EUT, the following behavior occurs:

After turning on the vehicle ignition a start sequence with five pulses will be transmitted. After that start sequence one pulse will be transmitted every 188 s. So during one hour 24 pulses will be transmitted. For details of the transmission pulse refer also clause 5.1 of this test report.

As declared by the applicant, in alarm mode one additional message is transmitted.

Number of pulses per hour	Pulse length	Total transmission time per hour	Limit	Result
24	16.4 ms	393.6 ms	2000 ms	Passed
Measurement uncertainty		$<10^{-7}$		

Test equipment used (refer clause 6):

24, 26, 31

5.5 Radiated emissions

5.5.1 Method of measurement (Radiated emissions)

The radiated emission measurement is subdivided into four stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 150 kHz to 1 GHz.
- A final measurement carried out on an open area test site with reflecting ground plane and various antenna heights in the frequency range 30 MHz to 1 GHz.
- A preliminary measurement carried out in a fully anechoic chamber with a variable antenna distance and height in the frequency range 1 GHz to 5 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 1 GHz to 5 GHz.

Preliminary measurement (9 kHz to 30 MHz):

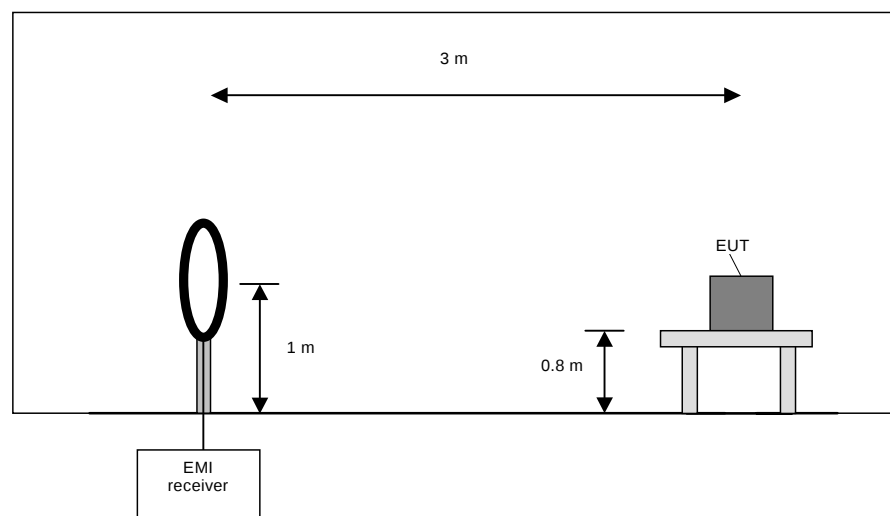
In the first stage a preliminary measurement will be performed in a shielded room with a measuring distance of

3 meters. Tabletop devices will be set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The set up of the Equipment under test will be in accordance to ANSI C63.4-2009 [1].

The frequency range 9 kHz to 30 MHz will be monitored with a spectrum analyser while the system and its cables will be manipulated to find out the configuration with the maximum emission levels if applicable. The EMI Receiver will be set to MAX Hold mode. The EUT and the measuring antenna will be rotated around their vertical axis to find the maximum emissions.

The resolution bandwidth of the spectrum analyser will be set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	10 kHz



Preliminary measurement procedure:

Prescans were performed in the frequency range 9 kHz to 150 kHz and 150 kHz to 30 MHz.

The following procedure will be used:

- 1) Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
- 2) Manipulate the system cables within the range to produce the maximum level of emission.
- 3) Rotate the EUT by 360 ° to maximize the detected signals.
- 4) Make a hardcopy of the spectrum.
- 5) Measure the frequencies of highest detected emission with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
- 6) Repeat steps 1) to 5) with the other orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).
- 7) Rotate the measuring antenna and repeat steps 1) to 5).

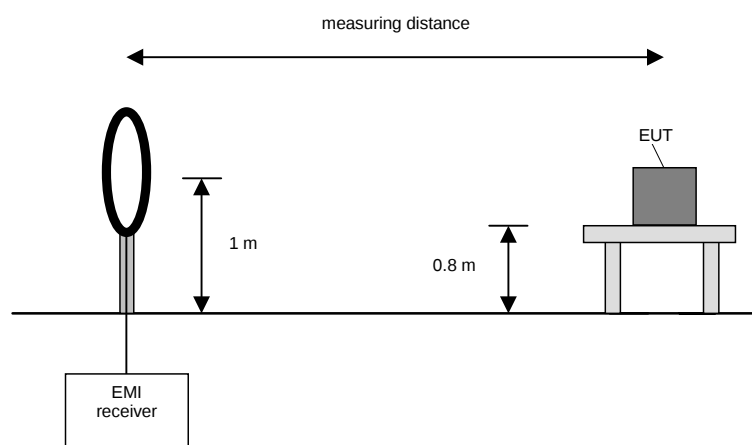
Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in measuring distances of 3 m, 10 m and 30 m. In the case where larger measuring distances is required the results will be extrapolated based on the values measured on the closer distances according to Section 15.31 (f) (2) [2]. The final measurement will be performed with a EMI Receiver set to Quasi Peak detector except for the frequency bands 9 kHz to 90 kHz and 110 kHz to 490 kHz where an average detector will be used according Section 15.209 (d) [2].

On the during the preliminary measurement detected frequencies the final measurement will be performed while rotating the EUT and the measuring antenna in the range of 0 ° to 360 ° around their vertical axis until the maximum value is found.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	9 kHz



Final measurement procedure:

The following procedure will be used:

- 1) Monitor the frequency range with the measuring antenna at vertical orientation parallel to the EUT at an azimuth of 0 °.
- 2) Rotate the EUT by 360 ° to maximize the detected signals and note the azimuth and orientation.
- 3) Rotate the measuring antenna to find the maximum and note the value.
- 4) Rotate the measuring antenna and repeat steps 1) to 3) until the maximum value is found.
- 5) Repeat steps 1) to 4) with the other orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).

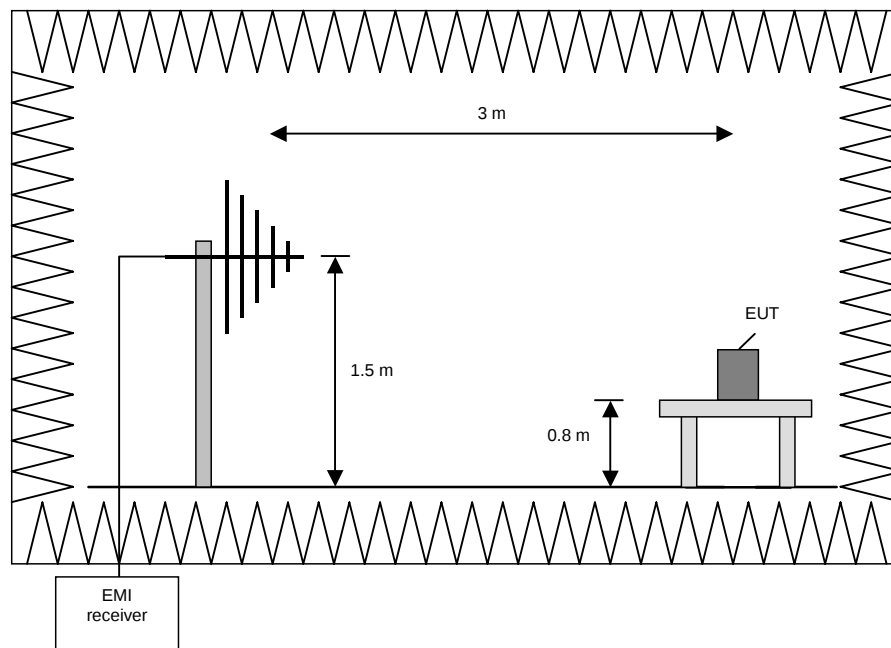
Preliminary measurement (30 MHz to 1 GHz)

In the first stage a preliminary measurement will be performed in a fully anechoic chamber with a measuring distance of 3 meter. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The set up of the Equipment under test will be in accordance to ANSI C63.4-2009 [1].

The frequency range 30 MHz to 1 GHz will be measured with an EMI Receiver set to MAX Hold mode and a resolution bandwidth of 100 kHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
30 MHz to 230 MHz	100 kHz
230 MHz to 1 GHz	100 kHz



Procedure preliminary measurement:

Prescans were performed in the frequency range 30 MHz to 230 MHz and 230 MHz to 1 GHz.

The following procedure will be used:

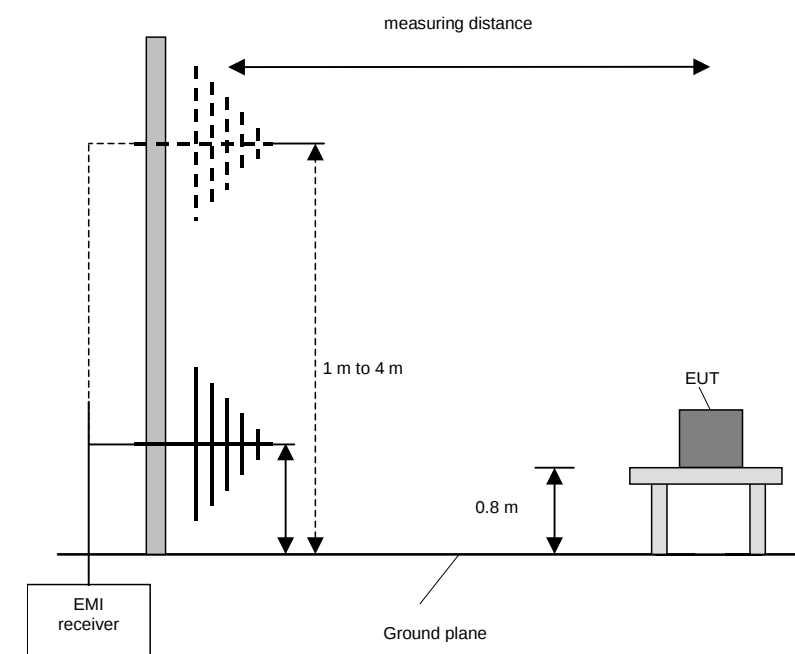
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Make a hardcopy of the spectrum.
5. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
6. Repeat 1) to 4) with the other orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).
7. Repeat 1) to 5) with the vertical polarisation of the measuring antenna.

Final measurement (30 MHz to 1 GHz)

A final measurement on an open area test site will be performed on selected frequencies found in the preliminary measurement. During this test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be set to horizontal and vertical polarisation and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
30 MHz to 1 GHz	120 kHz



Procedure final measurement:

The following procedure will be used:

- 1) Measure on the selected frequencies at an antenna height of 1 m and a EUT azimuth of 23 °.
- 2) Move the antenna from 1 m to 4 m and note the maximum value at each frequency.
- 3) Rotate the EUT by 45 ° and repeat 2) until an azimuth of 337 ° is reached.
- 4) Repeat 1) to 3) for the other orthogonal antenna polarization.
- 5) Move the antenna and the turntable to the position where the maximum value is detected.
- 6) Measure while moving the antenna slowly +/- 1 m.
- 7) Set the antenna to the position where the maximum value is found.
- 8) Measure while moving the turntable +/- 45 °.
- 9) Set the turntable to the azimuth where the maximum value is found.
- 10) Measure with Final detector (QP and AV) and note the value.
- 11) Repeat 5) to 10) for each frequency.
- 12) Repeat 1) to 11) for each orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).

Preliminary and final measurement (1 GHz to 40 GHz)

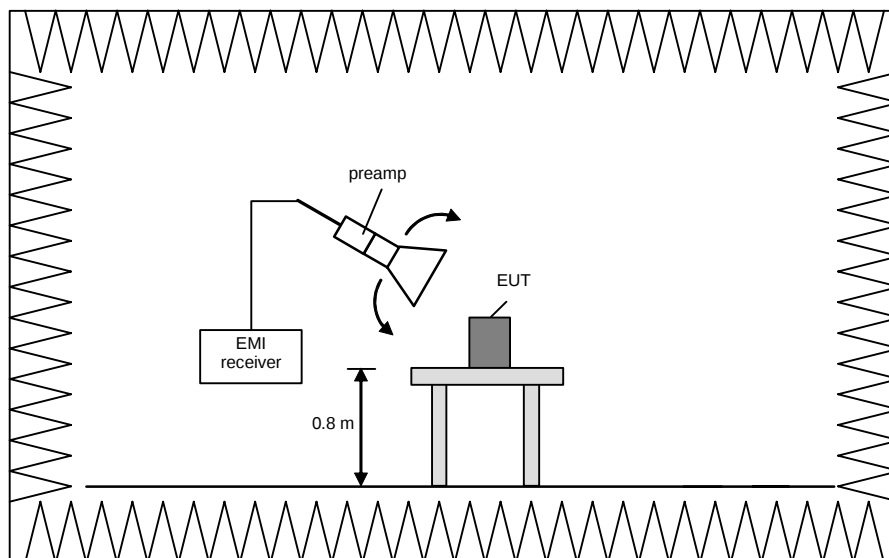
This measurement will be performed in a fully anechoic chamber. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The set up of the Equipment under test will be in accordance to ANSI C63.4-2009 [1].

Preliminary measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The spectrum analyser set to MAX Hold mode and a resolution bandwidth of 100 kHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna, the antenna close to the EUT and while moving the antenna over all sides of the EUT. With the spectrum analyser in CLEAR / WRITE mode the cone of the emission should be found and than the measuring distance will be set to 3 m with the receiving antenna moving in this cone of emission. At this position the final measurement will be carried out.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	100 kHz
4 GHz to 12 GHz	100 kHz
12 GHz to 18 GHz	100 kHz
18 GHz to 25 / 26.5 GHz	100 kHz
26.5 GHz to 40 GHz	100 kHz

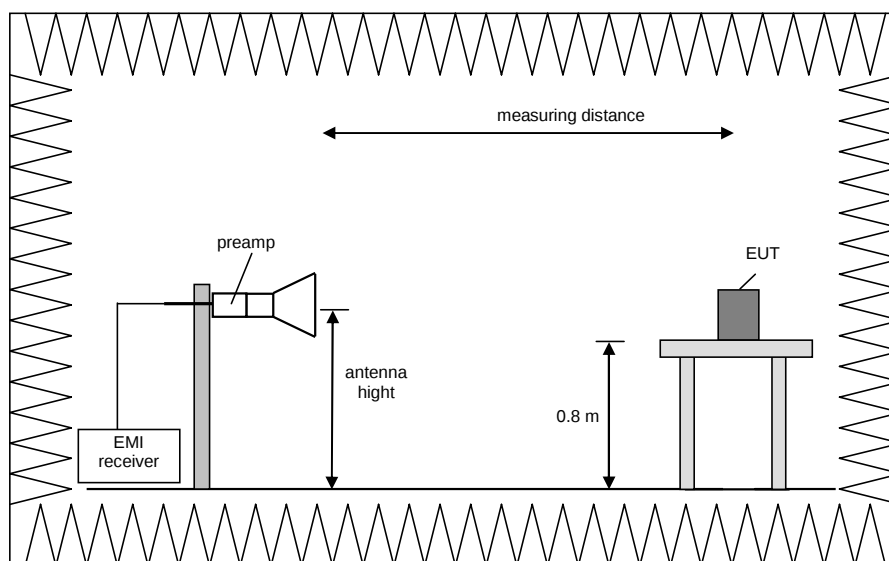


Final measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The EMI Receiver set to peak and average mode and a resolution bandwidth of 1 MHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 ° in order to have the antenna inside the cone of radiation.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	1 MHz
4 GHz to 12 GHz	1 MHz
12 GHz to 18 GHz	1 MHz
18 GHz to 25 / 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz



Procedure of measurement:

The measurements were performed in the frequency ranges 1 GHz to 4 GHz, 4 GHz to 12 GHz, 12 GHz to 18 GHz, 18 GHz to 25 /26.5 GHz and 26.5 GHz to 40 GHz.

The following procedure will be used:

- 1) Monitor the frequency range at horizontal polarisation and move the antenna over all sides of the EUT (if necessary move the EUT to another orthogonal axis).
- 2) Change the antenna polarisation and repeat 1) with vertical polarisation.
- 3) Make a hardcopy of the spectrum.
- 4) Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
- 5) Change the analyser mode to Clear / Write and found the cone of emission.
- 6) Rotate and move the EUT, so that the measuring distance can be enlarged to 3 m and the antenna will be still inside the cone of emission.
- 7) Measure the level of the detected frequency with the correct resolution bandwidth, with the antenna polarisation and azimuth and the peak and average detector, which causes the maximum emission.
- 8) Repeat steps 1) to 7) for the next antenna spot if the EUT is larger than the antenna beamwidth.

Step 1) to 6) are defined as preliminary measurement.

5.5.2 Test results (radiated emissions)

5.5.2.1 Preliminary radiated emission measurement (150 kHz to 5 GHz)

Ambient temperature	22 °C	Relative humidity	28 %
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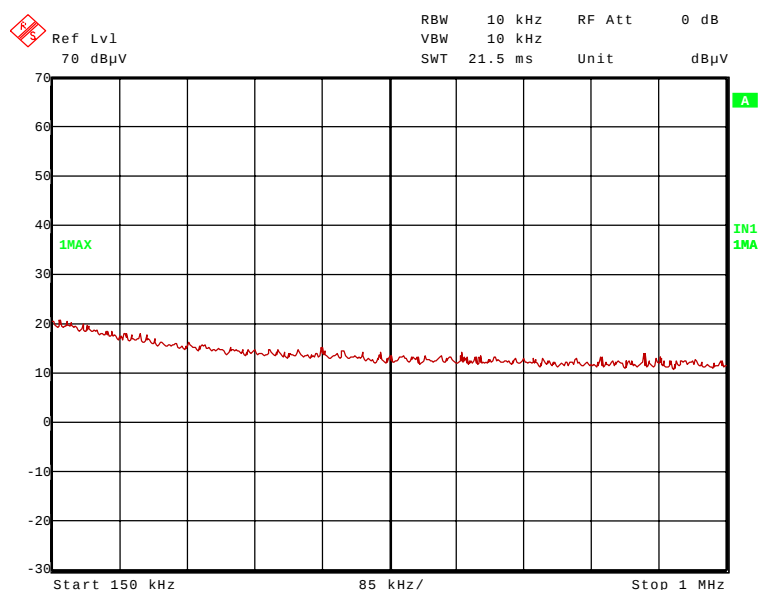
Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

Cable guide: The cable of the EUT runs vertically to the false floor. For detail information of test set-up and cable run refer to the photographs in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied by 12.0 V DC by an external power supply.

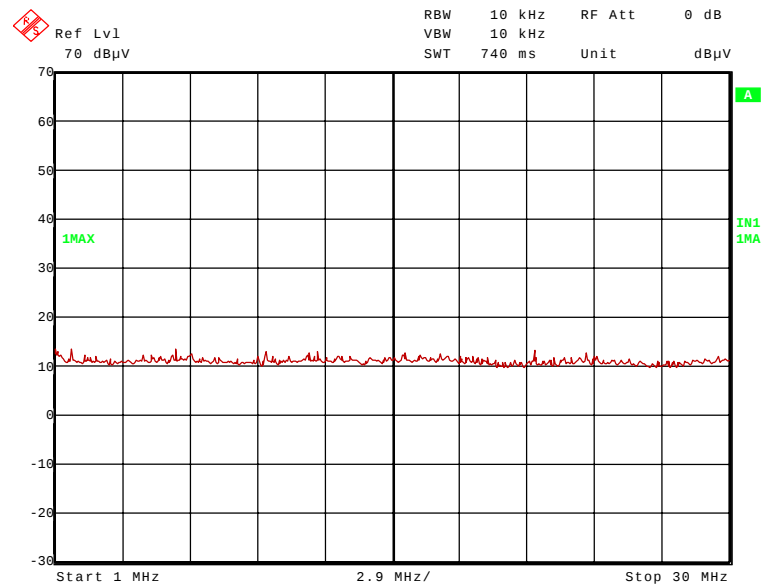
150998_14.wmf: Spurious emissions from 150 kHz to 1 MHz:



Test equipment used (refer clause 6):

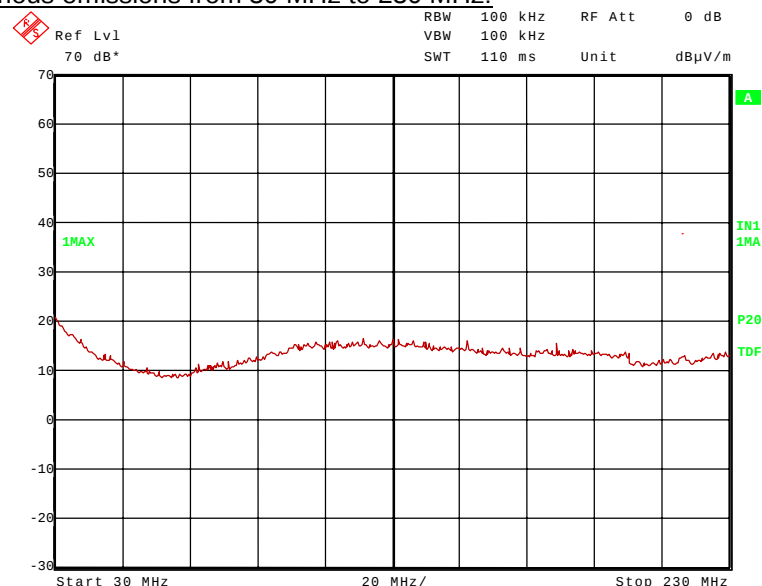
24, 29, 31 – 36, 133, 142 - 144

150998 18.wmf: Spurious emissions from 1 MHz to 30 MHz:

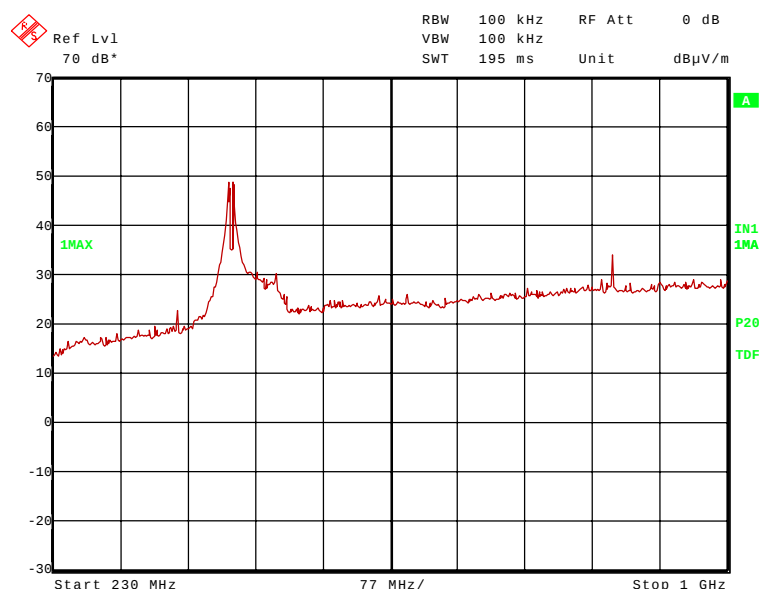


No frequencies were found during the preliminary measurement, so no final measurement on the outdoor test site was carried out.

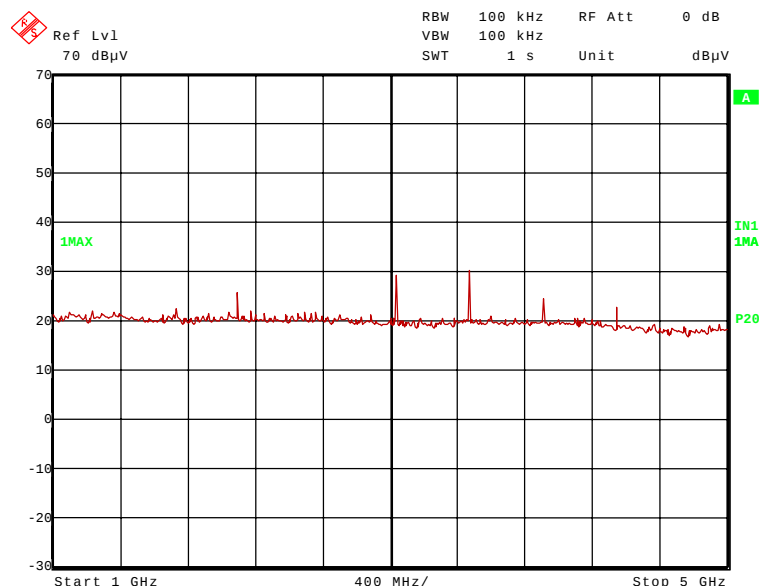
150998 1.wmf: Spurious emissions from 30 MHz to 230 MHz:



150998_2.wmf: Spurious emissions from 230 MHz to 1 GHz (carrier notched):



150998_13.wmf: Spurious emissions from 1 GHz to 5 GHz:



The following frequencies were found inside the restricted bands during the preliminary radiated emission test:

- 3905.280 MHz and 4339.200 MHz.

The following frequencies were found outside the restricted bands during the preliminary radiated emission test:

- 433.920 MHz, 485.206 MHz, 867.840 MHz, 2169.600 MHz, 3037.440 MHz and 3471.360 MHz.

These frequencies have to be measured in a final measurement. The results were presented in the following.

5.5.2.2 Final radiated emission measurement (30 MHz to 1 GHz)

Ambient temperature	20 °C	Relative humidity	32 %
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Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

Cable guide: The cable of the EUT runs vertically to the false floor. For detail information of test set-up and cable run refer to the photographs in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied by 12.0 V DC by an external power supply.

The results of the standard subsequent measurement on the open area test site are indicated in the table below. The limits as well as the measured results (levels) refer to the above mentioned standard while taking account of the specified requirements for a 3 m measuring distance.

The measurement time with the peak detector is 1 second.

Result measured with the peak detector and corrected to average:

Spurious emissions outside restricted bands											
Frequency MHz	Result dBμV/m	Limit dBμV/m	Margin dB	Readings dBμV	Antenna factor dB/m	Cable loss dB	Average correction factor [dB]	Height cm	Azimuth deg	Pol.	Pos.
433.920	79.9	80.8	0.9	76.8	16.4	2.4	-15.7	227	270	Hor.	1
485.206	16.2	60.8	44.6	12.3	17.1	2.5	-15.7	204	283	Hor.	2
867.840	29.2	60.8	31.6	19.4	22.1	3.4	-15.7	100	270	Hor.	2
Measurement uncertainty				+2.2 dB / -3.6 dB							

The test results were calculated with the following formula:

Result [dBμV/m] = reading [dBμV] + cable loss [dB] + antenna factor [dB/m] + average correction factor [dB].

Test: Passed

Test equipment used (refer clause 6):

14 – 20, 24

5.5.2.3 Final radiated emission measurement (1 GHz to 5 GHz)

Ambient temperature	22 °C	Relative humidity	28 %
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Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

Cable guide: The cable of the EUT runs vertically to the false floor. For detail information of test set-up and cable run refer to the photographs in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied by 12.0 V DC by an external power supply.

Resolution bandwidth: For all measurements a resolution bandwidth of 1 MHz was used.

Result measured with the peak detector and converted to average:

Frequency MHz	Result dBμV/m	Limit dBμV/m	Margin dB	Readings dBμV	Antenna factor 1/m	Preamp dB	Cable loss dB	Average correction factor [dB]	Height cm	Pol.	Pos.	Restr. Band
2169.600	23.4	60.8	37.4	34.6	27.7	26.0	2.8	-15.7	150	Vert.	1	No
3037.440	25.4	60.8	35.4	33.2	30.3	25.8	3.4	-15.7	150	Hor.	2	No
3471.360	28.4	60.8	32.4	35.3	31.1	25.9	3.6	-15.7	150	Hor.	1	No
3905.280	26.9	60.8	33.9	31.3	32.8	25.3	3.8	-15.7	150	Hor.	2	Yes
4339.200	26.7	60.8	34.1	31.7	32.0	25.4	4.1	-15.7	150	Vert.	1	Yes
Measurement uncertainty					+2.2 dB / -3.6 dB							

The test results were calculated with the following formula:

Result [dBμV/m] = reading [dBμV] + cable loss [dB] + antenna factor [dB/m] – preamp. [dB] + average correction factor [dB]

Test: Passed

Test equipment used (refer clause 6):

24, 29, 31 - 34, 36, 73, 143, 144

6 Test equipment and ancillaries used for tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. due
14	Open area test site	-	Phoenix Test-Lab	-	480085	Weekly verification (system cal.)	
15	Measuring receiver	ESIB7	Rohde & Schwarz	100304	480521	03/02/2015	03/2017
16	Controller	HD100	Deisel	100/670	480139	-	-
17	Turntable	DS420HE	Deisel	420/620/80	480087	-	-
18	Antenna support	AS615P	Deisel	615/310	480086	-	-
19	Antenna	CBL6111 D	Chase	25761	480894		
20	EMI Software	ES-K1	Rohde & Schwarz	-	480111	-	-
24	Power supply	TOE 8752	Toellner	480009	31569	Not applicable	
26	Test fixture	-	Phoenix Test-Lab	-	410160	Not applicable	
29	Fully anechoic chamber M20	-	Albatross Projects	B83107-E2439-T232	480303	Weekly verification (system cal.)	
31	Measuring receiver	ESI 40	Rohde & Schwarz	100064	480355	03/02/2015	03/2017
32	Controller	MCU	Maturo	MCU/043/971107	480832	-	-
33	Turntable	DS420HE	Deisel	420/620/80	480315	-	-
34	Antenna support	AS615P	Deisel	615/310	480187	-	-
35	Antenna	CBL6112 B	Chase	2688	480328	04/14/2014	04/2017
36	Horn Antenna	3115 A	EMCO	9609-4918	480183	11/10/2014	11/2017
73	High Pass Filter	WHJS1000C11/6 OEF	Wainwright Instruments GmbH	1	480413	Monthly verification (system cal.)	
82	Band Reject Filter	WRCA 432.9/434.9-431/437-50/6EE-1000	Wainwright Instruments GmbH	6	480474	Monthly verification (system cal.)	
133	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	02/18/2014	02/2016
142	RF-cable No. 36	Sucoflex 106B	Huber + Suhner	-	480865	Weekly verification (system cal.)	
143	RF-cable No. 3	Sucoflex 106B	Suhner	0563/6B	480670	Weekly verification (system cal.)	
144	RF-cable No. 40	Sucoflex 106B	Suhner	0708/6B	481330	Weekly verification (system cal.)	

7 Report history

Report Number	Date	Comment
F150998E3	15 April 2015	Document created
-	-	-
-	-	-

8 List of annexes

ANNEX A	TEST SET-UP PHOTOGRAPHS	7 pages
	150998_e.JPG: OptiTire ECU, test set-up fully anechoic chamber, pos. 1	
	150998_a.JPG: OptiTire ECU, test set-up fully anechoic chamber, pos. 2	
	150998_h.JPG: OptiTire ECU, test set-up fully anechoic chamber	
	150998_d.JPG: OptiTire ECU, test set-up fully anechoic chamber	
	150998_g.JPG: OptiTire ECU, test set-up fully anechoic chamber	
	150998_i.JPG: OptiTire ECU, test set-up open area test site, pos. 1	
	150998_j.JPG: OptiTire ECU, test set-up open area test site, pos. 2	
ANNEX B	EXTERNAL PHOTOGRAPHS	4 pages
	150998_7.JPG: OptiTire ECU, 3-D-view 1	
	150998_5.JPG: OptiTire ECU, 3-D-view 2	
	150998_6.JPG: OptiTire ECU, type plate view	
	150998_1.JPG: OptiTire ECU, top view	
ANNEX C	INTERNAL PHOTOGRAPHS	3 pages
	150998_10.JPG: OptiTire ECU, internal view	
	150998_3.JPG: OptiTire ECU, PCB, top view	
	150998_4.JPG: OptiTire ECU, PCB, bottom view	