# TEST REPORT # EMCC-951599BB, 2005-05-04

**EQUIPMENT UNDER TEST:**

| | |
|---|---|
| Trade Name: | 24 GHz SLR Sensor |
| Type: | MASRAU0025 |
| Serial Number: | 030002112, 030002893 |
| Equipment Category: | Vehicle Radar System, Sensor |
| Manufacturer: | Tyco Electronics M/A-COM INC. |
| Address: | 1011 Pawtucket Boulevard<br>Lowell, MA 01854<br>USA |
| Phone: | +1-978-442-5175 |
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**RELEVANT STANDARD:** 47 CFR Part 15 F - Ultra-Wideband Operation

**MEASUREMENT PROCEDURE USED:**

☒ ANSI C63.4-2003 ☐ FCC/OET MP-4 (1987) ☒ IEEE Std C95.3-1991

**TEST REPORT PREPARED BY:**

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**TEST PERSONNEL:**

Wolfgang Döring

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# 1 GENERAL INFORMATION

## 1.1 Purpose

The purpose of this report is to show compliance to the FCC regulations for devices operating under section 15.515 of the Code of Federal Regulations title 47.

## 1.2 Limits and Reservations

The test results in this report apply only to the particular Equipment Under Test (EUT) as declared in this report.
This test report shall not be reproduced except in full without the written permission of EMCC DR. RAŠEK.

## 1.3 Test Location

| | |
|---|---|
| Company Name: | EMCC DR. RAŠEK |
| Street: | Moggast 72-74 |
| City: | 91320 Ebermannstadt |
| Country: | Germany |
| Laboratory: | Test Laboratory of EMCC DR. RAŠEK<br>FCC Registration Number: 90566<br>This site has been fully described in a report submitted to the FCC, and accepted in the letter dated February 04, 2003 Registration Number 90566. |
| Phone: | +49-9194-9016 |
| Fax: | +49-9194-8125 |
| E-Mail: | emc.cons@emcc.de |
| Web: | www.emcc.de |

## 1.4 Manufacturer

| | |
|---|---|
| Company Name: | Tyco Electronics M/A-COM INC. |
| Street: | 1011 Pawtucket Boulevard |
| City: | Lowell, MA 01854 |
| Country: | USA |

| | |
|---|---|
| Name for contact purposes: | Jeff Schaefer |
| Phone: | +1-978-442-5175 |
| Fax: | +1-978-442-4600 |

## 1.5 Dates

| | |
|---|---|
| Date of receipt of EUT: | CW 07/2005 (S/N 030002112)<br>CW 11/2005 (S/N 030002893) |
| Test date: | CW 07+08/2005 (S/N 030002112)<br>CW 11/2005 (S/N 030002893) |

Mr. Hermann Henftling from Tyco Electronics M/A-COM Inc. attended all tests.

# 2 PRODUCT DESCRIPTION

## 2.1 Equipment Under Test (EUT)

| | |
|---|---|
| Description: | 24 GHz SLR Sensor |
| Device designation: | Vehicle Radar System, Sensor |
| Type: | MASRAU0025 |
| No. of units: | one |
| Serial number: | 030002112 (without mounting plate or bracket),<br>030002893 (with mounting plate and with reduced output power) |
| FCC ID: | BV8MASRAU0025 |
| Transmit Frequency: | 24.1 – 24.25 (nominal: 24.175 GHz) – (TX carrier) |
| Type of modulation: | pulse modulation |
| Duty cycle: | 15.5 µs PULS MODE ON / 56 µs OFF |
| Class of emission (ITU): | 4G0 P0N |
| Max. rated output power: | 0.1W e.i.r.p. |
| Antenna: | Integral |
| Rated input voltage: | 12.0 VDC nominal |

## 2.2 EUT Peripherals

The EUT was tested connected with
- Laptop personal computer as CAN-bus simulator for start up and initializing purposes,
- standard laboratory DC power supply.

## 2.3 Mode of Operation During Testing

The equipment under test (EUT) was operated during the tests under the four following conditions:
- SHORT PULSE mode,
- LONG PULSE mode,
- CW mode with RF switch set to its high insertion loss state (for test purposes only)
- CW mode with RF switch set to its low insertion loss state (for test purposes only) for measuring the carrier power and with adjusted carrier frequency for measuring the vertical plane transmitter emissions.

All modes were set via the CAN-bus from the PC.

## 2.4 Modifications Required for Compliance

EUT SN 030002893 with reduced output power for EIRP limit compliance.
Power alignment was made by the manufacturer.

# 3 TEST RESULTS SUMMARY

## Summary of Test Results

| Requirement | CFR Section | Report Section | Tested Sample and Result |
|---|---|---|---|
| Antenna Requirement | 15.203 | 4 | Pass |
| Operation Limitations | 15.515(a) | 5 | N.A. |
| UWB bandwidth | 15.515(b), 15.503(d) | 6 | Pass |
| Emissions Attenuation above Horizon | 15.515(c) | 7 | Pass |
| Radiated Emissions | 15.515(d) and 15.209 | 8 | Pass |
| Radiated Emissions in GPS Bands | 15.515(e) | 8 | Pass |
| Peak Emissions within a 50 MHz Bandwidth | 15.515(f) | 8 | Pass |
| Conducted Emissions | 15.207 | 9 | N.A. |
| Effect of Supply Voltage Variation | 15 | 10 | Pass |
| Radio frequency exposure | FCC OET Bulletin 65 | 11 | Pass |
| | | | |

N.A. – not applicable

The client has made the determination that EUT Condition, Characterization, and Mode of Operation are representative of production units, and meet the requirements of the specifications referenced herein.

Consistent with Industry practice, measurement and test equipment not directly involved in obtaining measurement results but having an impact on measurements (such as cable loss, antenna factors, etc.) are factored into the "Correction Factor" documented in certain test results. Instrumentation employed for testing meets tolerances consistent with known Industry Standards and Regulations.

The measurements contained in this report were made in accordance with the procedure ANSI C63.4 - 2003 and IEEE Std C95.3-1991. All requirements were found to be within the limits outlined in this report.
The test results in this report apply only to the particular Equipment Under Test (EUT) as declared in this report.

Test Personnel: Wolfgang Döring
Issuance Date: 2005-05-04

# 4 ANTENNA REQUIREMENT

Test Requirement: FCC CFR47, Part 15C

## 4.1 Regulation

15.203 An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of Part 15C. The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

## 4.2 Result

| | |
|---|---|
| Device: | 24 GHz SLR Sensor |
| Type: | MASRAU0025 |
| Serial number: | 030002112 and 030002893 |

Antenna is integral.

The EUT meets the requirements of this section.

# 5 OPERATION LIMITATIONS

Test Requirement: FCC CFR47, Part 15F

## 5.1 Regulation

**Section 15.515 Technical requirements for vehicular radar systems.**

(a) Operation under the provisions of this section is limited to UWB field disturbance sensors mounted in terrestrial transportation vehicles. These devices shall operate only when the vehicle is operating, e.g., the engine is running. Operation shall occur only upon specific activation, such as upon starting the vehicle, changing gears, or engaging a turn signal.

## 5.2 Test Equipment

Not applicable.

## 5.3 Test Procedures

Not applicable.

## 5.4 Test Results

| | |
|---|---|
| Device: | 24 GHz SLR Sensor |
| Type: | MASRAU0025 |
| Serial number: | 030002112 and 030002893 |

The EUT submitted was a sensor unit, only.
Therefore requirements concerning the vehicle dependent sensor operation control functions could not be investigated.

# 6 UWB BANDWIDTH

Test Requirement: FCC CFR47, Part 15F

## 6.1 Regulation

**Section 15.503 Definitions.**

(a) UWB Bandwidth. For the purpose of this subpart, the UWB bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission, as based on the complete transmission system including the antenna. The upper boundary is designated $f_H$ and the lower boundary is designated $f_L$. The frequency at which the highest radiated emission occurs is designated $f_M$.

(b) Center frequency. The center frequency, $f_C$, equals $(f_H + f_L)/2$.

(c) Fractional bandwidth. The fractional bandwidth equals $2(f_H - f_L)/ (f_H + f_L)$.

(d) Ultra-wideband (UWB) transmitter. An intentional radiator that, at any point in time, has a fractional bandwidth equal to or greater than 0.20 or has a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth.

(b) The UWB bandwidth of a vehicular radar system operating under the provisions of this section shall be contained between 22 GHz and 29 GHz. In addition, the center frequency, $f_C$, and the frequency at which the highest level emission occurs, $f_M$, must be greater than 24.075 GHz.

## 6.2 Test Equipment

| Type | Manufacturer/ Model No. | Serial No. | Last Calibration | Calibration Interval |
|---|---|---|---|---|
| EMI Receiver / Analyzer (1 GHz – 26.5 GHz) | Rohde & Schwarz ESIB 40 | 100126 | 2003-07 | 24 months |
| Standard Gain Horn Antenna (18 GHz – 26.5 GHz) | Mid Century MC 20/31B | 1362/86 | 2004-08 | 24 months |

## 6.3 Test Procedures

The bandwidth was measured using the analyzer with the receiving antenna located 1m from the EUT. The turn-table was rotated through 360° to obtain the highest readings.
The resolution bandwidth of the receiver was set to both 1 MHz. The frequency range was set from 21.5 GHz to 26.5 GHz.
Measurement performed with both pulse modes (SHORT and LONG) as described in Section 2.3.

## 6.4 Result

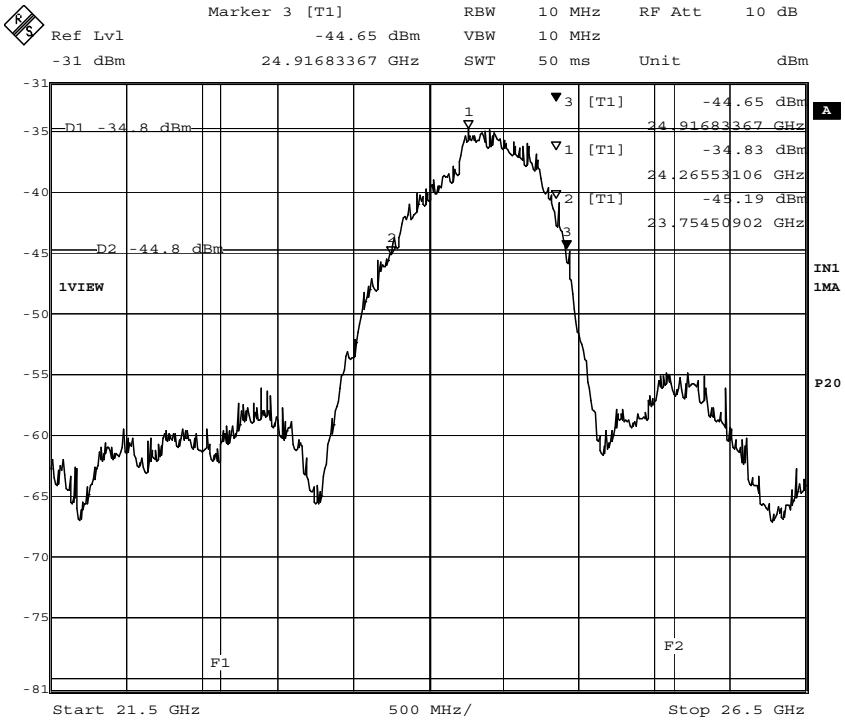
Device: 24 GHz SLR Sensor
Type: MASRAU0025
Serial number: 030002112

The bandwidth of the EUT was found to comply with the requirements of 15.515(b).
Refer to bandwidth plots located in Figures 6-1 and 6-2.

**LONG PULSE mode:**
Bandwidth = 1.163 GHz,
$f_L$ = 23.754 GHz, $f_H$ = 24.917 GHz, $f_M$ = 24.2655 GHz

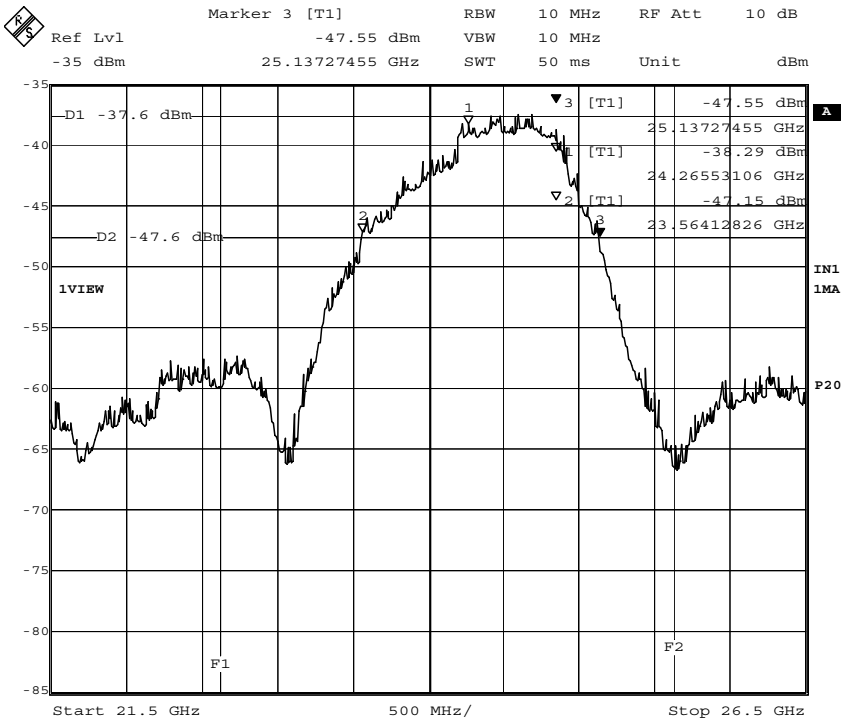
## SHORT PULSE mode:

Bandwidth = 1.573 GHz,
$f_L$ = 23.564 GHz, $f_H$ = 25.137 GHz, $f_M$ = 24.2655 GHz




Title: FCC 10dbBW, long pulse, d=1m hor. preamp.
Date: 16.FEB.2005 13:23:01

Figure 6-1: Occupied Bandwidth, LONG PULSE mode




Title: FCC 10dBBW, short pulse, d=1m hor. preamp. BW=10MHz
Date: 16.FEB.2005 13:45:09

Figure 6-2: Occupied Bandwidth, SHORT PULSE mode

# 7 EMISSIONS ATTENUATION ABOVE HORIZON

Test Requirement: FCC CFR47, Part 15F

## 7.1 Regulation

**Section 15.515(c).**

(c) Following proper installation, vehicular radar systems shall attenuate any emissions within the 23.6-24.0 GHz band that appear 38 degrees or greater above the horizontal plane by 25 dB below the limit specified in paragraph (d) of this section. For equipment authorized, manufactured or imported on or after January 1, 2005, this level of attenuation shall be 25 dB for any emissions within the 23.6-24.0 GHz band that appear 30 degrees or greater above the horizontal plane. For equipment authorized, manufactured or imported on or after January 1, 2010, this level of attenuation shall be 30 dB for any emissions within the 23.6-24.0 GHz band that appear 30 degrees or greater above the horizontal plane. For equipment authorized, manufactured or imported on or after January 1, 2014, this level of attenuation shall be 35 dB for any emissions within the 23.6-24.0 GHz band that appear 30 degrees or greater above the horizontal plane. This level of attenuation can be achieved through the antenna directivity, through a reduction in output power or any other means.

## 7.2 Test Equipment

| Type | Manufacturer/ Model No. | Serial No. | Last Calibration | Calibration Interval |
|---|---|---|---|---|
| EMI Receiver / Analyzer | Rohde & Schwarz ESIB 40 | 100126 | 2003-07 | 24 months |
| Preamplifier | Spacek Labs SL2310-20-3 | 5A27 | n.a. | n.a. |
| Standard Gain Horn Antenna | Mid Century MC 20/31B | 1362/86 | 2004-08 | 24 months |

## 7.3 Test Procedure

The antenna pattern was measured using the analyzer with the receiving antenna located 1m from the EUT. The EUT was pivoted 90° relatively to its normal position and to placed on a 1m support on the turn-table.
The EUT was operated in a continuous CW mode, setting the EUT's RF switch to its low insertion loss state. The Transmitter was successively set to the following fixed frequencies: 23.6 GHz, 23.8 GHz, 24.0 GHz.
Starting at boresight position the turntable was rotated in 1 degree steps and the analyzer reading recorded. Test performed rotation in both directions from boresight position, because the transmitter can be mounted also in upside down position.

## 7.4 Result

| | |
|---|---|
| Device: | 24 GHz SLR Sensor |
| Type: | MASRAU0025 |
| Serial number: | 030002112 (elevation pattern measurement) / 030002893 (emissions measurement) |
| Test Date: | 2005-02-18 (SN 030002112) |
| Test Personnel: | Wolfgang Döring |

The emission attenuation of the EUT was found to comply with the requirements of 15.515(c) for compliance until 2014-01-01. Refer to plot located in Figure 7-1.

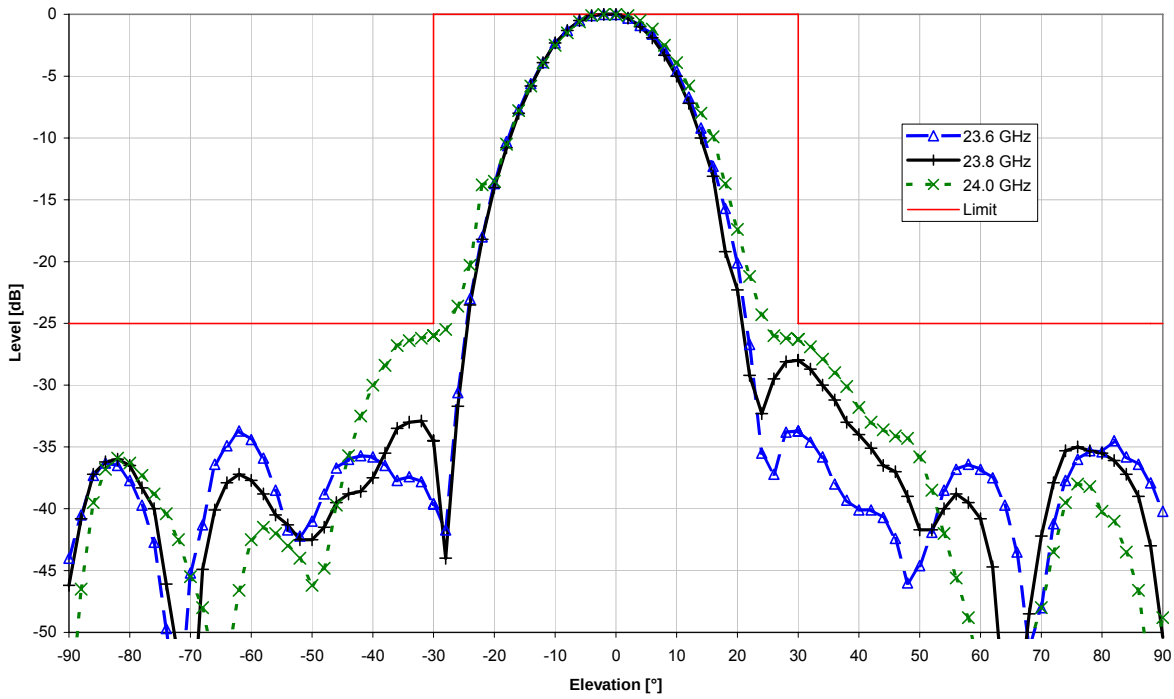



Figure 7-1: Transmit elevation pattern taken from SN 030002112.
Limit lines for compliance until 2010-01-01.

The limit in the limit line in the plot is related to the absolute emission limits according to Section 15.515(c). The pattern lines are relative values related to the boresight max. peak values. Thus the pattern plots represent the worst case situation assuming boresight emissions equal to the limit according to Section 15.515(c). The pattern plots can be lowered by the amount of margin the real emissions are below the respective limit at each frequency.

According to the emission results obtained for sample #030002893 for the worst case LONG PULSE mode this margin is about 4 dB at 24 GHz and even higher for the lower frequencies.

| **worst case sidelobe emission at 24.0 GHz (LONG PULSE mode)** | | | | | | |
|---|---|---|---|---|---|---|
| Angle | Frequency | Sidelobe attenuation | boresight emission level | sidelobe emission level | Limit | Compliance until |
| [°] | [GHz] | [dB] | [dBm] | [dBm] | [dBm] | |
| -30 | 24.0 | 26.0 | -45.7 | -71.7 | -71.3 | 2014-01-01 |

# 8 RADIATED EMISSIONS

Test Requirement: FCC CFR47, Part 15F
Test Procedure: ANSI C63.4:2003

## 8.1 Regulation

**Section 15.505 Cross reference.**

(a) Except where specifically stated otherwise within this subpart, the provisions of Subparts A and B and of Sections 15.201 through 15.204 and Section 15.207 of Subpart C of this part apply to unlicensed UWB intentional radiators. The provisions of Sections 15.35(c) and 15.205 do not apply to devices operated under this subpart. The provisions of Footnote US 246 to the Table of Frequency Allocations contained in Section 2.106 of this chapter does not apply to devices operated under this subpart.

(b) The requirements of Subpart F apply only to the radio transmitter, i.e., the intentional radiator, contained in the UWB device. Other aspects of the operation of a UWB device may be subject to requirements contained elsewhere in this chapter. In particular, a UWB device that contains digital circuitry not directly associated with the operation of the transmitter also is subject to the requirements for unintentional radiators in Subpart B of this chapter. Similarly, an associated receiver that operates (tunes) within the frequency range 30 MHz to 960 MHz is subject to the requirements in Subpart B of this chapter.

**Section 15.35 Measurement detector functions and bandwidths.**
(b) On any frequency of frequencies above 1000 MHz, the radiated limits shown are based upon the use of measurement instrumentation employing an average detector function. When average radiated emission measurements are specified in the regulations, including emission measurements below 1000 MHz, there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit for the frequency being investigated unless a different peak emission limit is otherwise specified in the rules in this part, e.g., see § 15.255. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. Measurement of AC power line conducted emissions are performed using a CISPR quasipeak detector, even for devices for which average radiated emission measurements are specified.

**Sections 15.515(d) and 15.209, UWB Radiated Emissions.**
Radiated emissions below 960 MHz must comply with the emission limits of Section 15.209. Emissions above 960 MHz must comply with the average limits given in the following table when measured with a 1 MHz resolution bandwidth.

| Frequency | EIRP |
|---|---|
| (MHz) | (dBm) |
| 960 - 1610 | -75.3 |
| 1610 - 22000 | -61.3 |
| 22000 - 29000 | -41.3 |
| 29000 - 31000 | -51.3 |
| Above 31000 | -61.3 |

**Section 15.515(e), UWB Radiated Emissions in GPS Bands.**
The radiated emissions of a UWB system operating under the provisions of Section 15.515 shall not exceed the following rms limits when measured with a resolution bandwidth of no less than 1 kHz:

| Frequency | EIRP |
|---|---|
| (MHz) | (dBm) |
| 1164 - 1240 | -85.3 |
| 1559 - 1610 | -85.3 |

**Section 15.515(f), UWB Peak Radiated Emissions.**
There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, $f_M$. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in Section 15.521.

**Section 15.521 Technical requirements applicable to all UWB devices.**
(d) Within the tables in Sections 15.509, 15.511, 15.513, 15.515, 15.517, and 15.519, the tighter emission limit applies at the band edges. Radiated emission levels at and below 960 MHz are based on measurements employing a CISPR quasi-peak detector. Radiated emission levels above 960 MHz are based on RMS average measurements over a 1 MHz resolution bandwidth. The RMS average measurement is based on the use of a spectrum analyzer with a resolution bandwidth of 1 MHz, an RMS detector, and a 1 millisecond or less averaging time. […]
(g) When a peak measurement is required, it is acceptable to use a resolution bandwidth other than the 50 MHz specified in this subpart. This resolution bandwidth shall not be lower than 1 MHz or greater than 50 MHz, and the measurement shall be centered on the frequency at which the highest radiated emission occurs, $f_M$. If a resolution bandwidth other than 50 MHz is employed, the peak EIRP limit shall be 20 log (RBW/50) dBm where RBW is the resolution bandwidth in megahertz that is employed. This may be converted to a peak field strength level at 3 meters using E(dBuV/m) = P(dBm EIRP) + 95.2. If RBW is greater than 3 MHz, the application for certification filed with the Commission must contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation employed in the testing.

**Sections 15.109, 15.209, 15.521 Digital Circuitry Radiated Emissions.**
Section 12.521(c) Emissions from digital circuitry used to enable the operation of the UWB transmitter shall comply with the limits in Section 15.209 of this chapter, rather than the limits specified in this subpart, provided it can be clearly demonstrated that those emissions from the UWB device are due solely to emissions from digital circuitry contained within the transmitter and that the emissions are not intended to be radiated from the transmitter's antenna. Emissions from associated digital devices, as defined in Section 15.3(k) of this chapter, e.g., emissions from digital circuitry used to control additional functions or capabilities other than the UWB transmission, are subject to the limits contained in Subpart B of Part 15 of this chapter.

As a vehicular device, all digital emissions from circuitry that are not used to enable the operation of the UWB transmitter are exempt according to Section 15.103.
Emissions from circuitry that are used to enable the operation of the UWB transmitter are subject to the emissions limits of Section 15.209.

Section 15.209 (a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

| Frequency (MHz) | Field Strength (microvolts/meter) | Measurement distance (meters) |
|---|---|---|
| 0.009–0.490 | 2400/F(kHz) | 300 |
| 0.490–1.705 | 24000/F(kHz) | 30 |
| 1.705–30.0 | 30 | 30 |
| 30–88 | 100 | 3 |
| 88–216 | 150 | 3 |
| 216–960 | 200 | 3 |
| Above 960 | 500 | 3 |

(c) The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. For intentional radiators which operate under the provisions of other sections within this part and which are required to reduce their unwanted emissions to the limits specified in this table, the limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.

**Section 15.101 Equipment authorization of unintentional radiators. (concering the receiver part of the UWB device)**

(b) Only those receivers that operate (tune) within the frequency range of 30-960 MHz, CB receivers and radar detectors are subject to the authorizations shown in paragraph (a) of this section.
However, receivers indicated as being subject to Declaration of Conformity that are contained within a transceiver, the transmitter portion of which is subject to certification, shall be authorized under the verification procedure. Receivers operating above 960 MHz or below 30 MHz, except for radar detectors and CB receivers, are exempt from complying with the technical provisions of this part but are subject to § 15.5.
The receiver part operates at 24.175 GHz, i.e. outside of the 960 MHz or below 30 MHz range. The L.O. emission is subject only to the requirement that no harmful interference is caused. [As confirmed by the FCC in the appropriate correspondence.]

## 8.2 Radiated Emissions Test

### 8.2.1 Test Equipment

| Type | Manufacturer/ Model No. | Serial No. | Last Calibration | Calibration Interval |
|---|---|---|---|---|
| Receiver (30 MHz - 1 GHz) | Rohde & Schwarz ESS | 843513/012 | 2004-01 | 18 months |
| Antenna (30 MHz - 1 GHz) | EMCO 3142 | 9601-1002 | 2002-05 | 36 months |
| EMI Receiver / Analyzer (960 MHz – 40 GHz, with external mixer up to 100 GHz) | Rohde & Schwarz ESIB 40 | 100126 | 2003-07 | 24 months |
| Harmonic Mixer Add-On (40...60 GHz, 20 dB conv. loss) | Rohde&Schwarz FS-Z60 | 1048.0620.02 | 2005-02 | 24 months |
| Harmonic Mixer Add-On (50...75 GHz, 25 dB conv. loss) | Rohde&Schwarz FS-Z75 | 1048.0720.02 | 2005-02 | 24 months |
| Harmonic Mixer Add-On (75...110 GHz, 40 dB conv. loss) | Rohde&Schwarz FS-Z110 | 1048.1110.02 | 2005-02 | 24 months |
| Antenna (test 960 MHz - 12 GHz) | Schwarzbeck BBHA 9120 D | 248 | 2004-03 | 24 months |
| Antenna (calibr. 960 MHz - 18 GHz) | Schwarzbeck BBHA 9120 D | 137 | 2004-03 | 24 months |
| Standard Gain Horn Antenna (test 12 GHz - 18 GHz) | Scientific Atlanta 12-12 | 286 | 2005-02 | 24 months |
| Standard Gain Horn Antenna (18 GHz - 26.5 GHz) | Mid Century MC 20/31B | 1362/86 | 2004-08 | 24 months |
| Standard Gain Horn Antenna (calibr. 18 GHz - 26.5 GHz) | Mid Century MC 20/31B | 1363/86 | 2004-08 | 24 months |
| Standard Gain Horn Antenna (test 26.5 GHz – 40 GHz) | Mid Century MC 22/31B | 1360/86 | 2005-02 | 24 months |
| Standard Gain Horn Antenna (cal. 26.5 GHz – 40 GHz) | Mid Century MC 22/31B | 1361/86 | 2005-02 | 24 months |
| Preamplifier (960 MHz – 8 GHz) | JCA/Telem JCA 08-415 | 101 | 2005-02 | 24 months |
| Preamplifier (8 – 18 GHz) | Avantek/Kont. AWT-18616 | F12903 | 2005-02 | 24 months |
| Preamplifier (18 – 35 GHz) | Spacek Labs SL2310-20-3 | 5A27 | 2005-01 | 24 months |
| Preamplifier (20 – 40 GHz) | Spacek Labs SP3020-22-25 | 4E06 | 2004-05 | 24 months |
| Test Generator (960 MHz – 40 GHz) | Hewlett-Pack. 83640A-4008 | 3009A00182 | 2001-11 | 48 months |
| RF Power Meter (cal. 960 MHz – 40 GHz) | Rohde & Schwarz NRVD | 843246/036 | 2004-10 | 24 months |
| Power Sensor (cal. 960 MHz – 40 GHz) | Rohde & Schwarz NRV-Z55 | 845988/003 | 2003-01 | 30 months |
| Standard Gain Horn Ant. (25dB, 39.3...59.7GHz) | FMI/Pro N 2424-25 | 30 | 2005-02 | 24 months |
| Standard Gain Horn Ant. (25dB, 50…75GHz) | Electrof./Tho WG25-25 | 001 | 2005-02 | 24 months |
| Standard Gain Horn Ant | Electrof./Tho | 001 | 2005-02 | 24 months |

| Type | Manufacturer/ Model No. | Serial No. | Last Calibration | Calibration Interval |
|---|---|---|---|---|
| (25dB, 75-110GHz) | WG27-25 | | | |
| Standard Gain Horn Ant (10dB, 75-110GHz) | FMI/ProN 25240-10 | 31 | 2005-02 | 24 months |

## 8.2.2 Test Procedures

The EUT is placed on a 1 meter high nonconductive support that sits on a flush mounted metal turntable. The turntable was rotated through 360 degrees to determine the most intense radiation lobe(s). Tests performed in both polarizations of EUT and test antenna.

The EUT was connected with CAN-bus simulator and the power supply to provide the 12 VDC operation power.

The tests were performed in the modes as described above.
The initial step in collecting radiated data is a peak scan of the measurement range with an EMI test receiver under closer distances as given in the rule. The significant peaks are then measured with the appropriate distance and detectors.
Worst case radiated emissions are listed under chapter: test results.
Above 40 GHz additional external mixers have to be used.
Due to high mixer loss at very high frequencies the distance between the EUT and the test antenna was reduced to very low values (some mm) to detect any emissions.
**Calibration:** All EIRP measurements up to 40 GHz performed using true EIRP power calibration set-ups consisting of the calibrated HP test generator and calibrated antennas, measuring the supplied to the substitution antenna power by means of the R&S power meter with the appropriate measuring head.

| **Radiated Emissions Test Characteristics** | |
|---|---|
| Frequency range | 30 MHz - 100,000 MHz |
| Test distance | 3 m, below 3 m* |
| Test instrumentation resolution bandwidth | 120 kHz (30 MHz - 1,000 MHz) |
| | 1 MHz (1,000 MHz - 26,500 MHz) |
| Test instrumentation detector | QP (30 MHz - 1,000 MHz) |
| | PEAK, RMS (1,000 MHz - 40,000 MHz) |
| Receive antenna polarization | Vertical/Horizontal |

* According to Section 15.31 (f)(1): At frequencies at or above 30 MHz, measurements may be performed at a distance other than what is specified provided: measurements are not made in the near field except where it can be shown that near field measurements are appropriate due to the characteristics of the device; and it can be demonstrated that the signal levels needed to be measured at the distance employed can be detected by the measurement equipment. (...) When performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade (inverse linear-distance for field strength measurements; inverse-linear-distance-squared for power density measurements).

### 8.2.3 Calculation of Field Strength Limits

Calculation: microvolts/meter to dBµV/m

| Frequency | Section 15.209 Field Strength Limit | | Measurement distance | Remarks |
|---|---|---|---|---|
| (MHz) | (microvolts/meter) | (dBµV/m) | (meters) | |
| 30–88 | 100 | 40 | 3 | |
| 88–216 | 150 | 43.5 | 3 | |
| 216–960 | 200 | 46 | 3 | |
| 960-100,000 | 500 | 54 | 3 | |

### 8.2.4 Average Correction Factor

NOTE: All AV measurements were performed using the test receiver's average detector and the max. hold facility; the average value measured directly without the necessity of additional correction factor.

### 8.2.5 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF
where
FS = Field Strength in dBµV/m
RA = Receiver Amplitude in dBµV
AF = Antenna Factor in dB(1/m)
CF = Cable Attenuation Factor in dB

Assume a receiver reading of 23.5 dBµV is obtained. The Antenna Factor of 7.4 dB(1/m) and a Cable Factor of 1.1 dB are added, giving a field strength of 32 dBµV/m. The 32 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 23.5 + 7.4 + 1.1 = 32 [dBµV/m]

Level in µV/m = Common Antilogarithm (32/20) = 39.8

For test distance other than what is specified, but fulfilling the requirements of Section 15.31 (f)(1) the field strength is calculated by adding additionally an extrapolation factor of 20 dB/decade (inverse linear-distance for field strength measurements). The basic equation with a sample calculation is as follows:

FS = FST + DF
where
FS = Field Strength in dBµV/m
FST = Field Strength at test distance in dBµV/m
DF = Distance Extrapolation Factor in dB,
where DF = 20 log (Dtest/Dspec) where Dtest = Test Distance and Dspec = Specified Distance

Assume the tests performed at a reduced Test Distance of 1.5 m instead of the Specified Distance of 3 m giving a Distance Extrapolation Factor of DF = 20 log(1.5m/3m) = -6 dB.

Assuming a measured field strength level of 32 dBµV/m is obtained. The Distance Factor of -6 dB is added, giving a field strength of 26 dBµV/m. The 26 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 23.5 + 7.4 + 1.1 - 6 = 26 [dBµV/m]
Level in µV/m = Common Antilogarithm (26/20) = 20

### 8.2.6 EIRP Substitution and Calculation

According to the FCC requirements all EIRP calculations shall be performed using a 20 dB/decade far field attenuation rate (= distance correction factor) for all measurement ranges.

**EIRP Substitution**
In the frequency range up 40 GHz all EIRP measurements the readings were related to substituted EIRP calibrations, no distance correction factor was necessary.
The appropriate EIRP limit reading and / or the test EIRP reading was re-established in a substitution set-up, the supplied into the substitution antenna power and the antenna gain were used for calculation of the EIRP.

EIRP = Pant + gi [dBm]
with
Pant = Pgen - Katt - Kcable
where
Pant = Power into the substitution antenna in dBm
gi = Antenna gain in dBi
Pgen = Substitution generator output power in dBm
Katt = Attenuator in dB
Kcable = Cable loss in dB

Assume a generator output power of -14.7 dBm (measured with the power meter using the same RF cable → including cable loss) and a attenuator of 80 dB. The resulting power into the substitution antenna is -94.7 dBm. The isotropical antenna gain of 20 dB is added, giving an EIRP of -74.7 dBm.

A substitution measurement performed in particular for the applicable limit values, i.e. setting the generator and attenuator for an EIRP equal to the limit, the resulting analyzer reading Palim was recorded.
Comparing the reading Pa caused by EUT emissions with the recorded Palim, the EUT emissions EIRP will be computed:
EIRP = Limit - Palim + Pa [dBm]

Assume a reading Palim = - 63.9 dBm for the - 41.3 dBm limit and a reading of - 65.72 dBm, the EIRP will be EIRP = -41.3 + 63.9 - 65.72 = - 43.12 [dBm].

Alternatively the substitution was also performed directly for the measurement reading; i.e. the EIRP from the substitution measurement was equal to the EUT's EIRP.

**EIRP Calculation**
In the frequency range above 40 GHz the receive antennas were connected directly to the external mixers. The emissions readings were corrected by the mixer conversion loss and the cable loss.

E = Pa + 107 + Km + AF [dBµV/m]
with
Pa = analyzer reading in dBm
Km = mixer conversion loss including cable loss in dB
AF = antenna factor; calculated for horn antennas according to the formula: AF = 30.25 + 20 log f - gi

with gi = isotropical gain in dB and f = frequency in GHz
→ E = 137.25 + Pa + Km + 20 log f - gi [dBµV/m]

To convert the measured fieldstrength into EIRP the following formula was used:

EIRP = E - 90 - 10 log 30 + 20 log Dtest [dBm]
with
E = measured fieldstrength in dBµV/m
Dtest = Test Distance

The resulting complete formula is as follows:

EIRP = Pa + 107 + Km + 30.25 + 20 log f - gi - 90 - 10 log 30 + 20 log Dtest [dBm]
→ EIRP = 32.48 + Pa + Km + 20 log f - gi + 20 log Dtest [dBm]

For an analyzer reading of -86.8 dBm at 48.4 GHz measured with a 25 dB Horn antenna and 20 dB mixer conversion and cable loss at 0.5m distance the resulting fieldstrength at 3m distance and the EIRP will be:
E = 137.25 - 86.8 + 20 + 20 log 48.4 - 25 + 20 log (0.5/3) = 137.25 - 86.8 + 20 + 33.7 - 25 -16
E = 79.15 [dBµV/m]

EIRP = 32.48 - 86.8 + 20 + 20 log 48.4 - 25 + 20 log 0.5 = 32.48 - 86.8 + 20 + 33.7 - 25 - 6
EIRP = - 31.62 [dBm]

## 8.2.7 Test Results

### 8.2.7.1 UWB Spurious Emissions below 960 MHz

Device: 24 GHz SLR Sensor
Type: MASRAU0025
Serial number: 030002112
Test Date: 2005-02-17
Test Personnel: Wolfgang Döring
The spurious emissions of the EUT below 960 MHz were found to comply with the requirements of 15.515(d).

| PRODUCT EMISSIONS DATA BELOW 960 MHz | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Emission Frequency [MHz] | Receiver Mode and Bandwidth [kHz] | Test Distance [m] | Receiver Reading RA [dBµV] | Correction Factor AF+CF [dB(1/m)] | Distance Extrapola-tion Factor DF [dB] | Result = Corrected Reading FS [dBµV/m] | Spec Limit [dBµV/m] | Polari-zation Ant | Margin [dB] | Remark |
| | | | | | | | | | | | |
| | no emissions above noise floor found. all emissions more than 20 dB below limit. | | | | | | | | | | 1 |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

[1] Where the PK result kept below the AV limit, no AV detector measurement were performed.

### 8.2.7.2 UWB Radiated Emissions 960 MHz to 40 GHz, excluding operating band

Device: 24 GHz SLR Sensor
Type: MASRAU0025
Serial number: 030002112
Test Date: 2005-02-16+21
Test Personnel: Wolfgang Döring

The spurious emissions of the EUT in the 960 MHz to 40 GHz range, excluding the operating band, were found to comply with the requirements of 15.515(d).

| PRODUCT EMISSIONS DATA (Section 15.515(d)) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No | Emission Frequency f [MHz] | Receiver Mode and Bandwidth [kHz] | Test Distance Dtest [m] | Receiver Reading Pa [dBm] | Limit EIRP [dBm] | Receiver Reading for Limit Palim [dB] | EIRP Result FS [dBm] | Margin [dB] | Polari-zation Ant | Remark |
| 1 | 1125 | 1000; RMS | 0.5 | -60.6 | -75.3 | -58.9 | -77.0 | 1.7 | h | |
| 2 | 1375 | 1000; RMS | 0.5 | -60.2 | -75.3 | -59.2 | -76.3 | 1.0 | h | |
| 3 | 26630 | 1000; Pk | 1 | -69 | -41.3 | -50 | -60.3 | 19 | h | |
| 4 | 26731 | 1000; Pk | 1 | -68.8 | -41.3 | -50 | -60.1 | 18.8 | h | |
| | | | | | | | | | | |

The spurious emissions of the EUT in the GPS bands, were found to comply with the requirements of 15.515(e).

| PRODUCT EMISSIONS DATA (Section 15.515(e)) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Emission Frequency f [MHz] | Receiver Mode and Bandwidth [kHz] | Test Distance Dtest [m] | Receiver Reading Pa [dBm] | Test Generator Output Psub [dBm] | Attenua-tion [dB] | Antenna Gain [dB] | EIRP Result FS [dB] | EIRP Limit [dBm] | Margin [dB] | Polari-zation Ant | Remark |
| 1 | 1562.5 | 1; RMS | 0.5 | -69.3 | -14.7 | 80 | 8.8 | -85.9 | -85.3 | 0.6 | v | SP |
| 2 | 1575 | 1; RMS | 0.5 | -70.2 | -15.6 | 80 | 8.9 | -86.7 | -85.3 | 1.4 | v | LP |
| 3 | 1587.5 | 1; RMS | 0.5 | -70.8 | -16.6 | 80 | 9 | -87.6 | -85.3 | 2.3 | v | SP |
| 4 | 1600 | 1; RMS | 0.5 | -69 | -15 | 80 | 9.1 | -85.9 | -85.3 | 0.6 | v | SP |
| | | | | | | | | | | | | |

SP – SHORT PULSE mode, LP – LONG PULSE mode

### 8.2.7.3 UWB Radiated Emissions, UWB fundamental band

Device: 24 GHz SLR Sensor
Type: MASRAU0025
Serial number: 030002893
Test Date: 2005-03-14
Test Personnel: Wolfgang Döring

The emissions of the EUT in the UWB fundamental band, excluding the L.O. emissions as per Section 15.101(b), were found to comply with the requirements of 15.515(d).

| PRODUCT EMISSIONS DATA (Section 15.515(d), 15.101(b)), SHORT PULSE mode | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No | Emission Frequency f [MHz] | Receiver Mode and Bandwidth [kHz] | Test Distance Dtest [m] | Receiver Reading Pa [dBm] | Limit EIRP [dBm] | Receiver Reading for Limit Palim [dB] | EIRP Result FS [dBm] | Margin [dB] | Polari-zation Ant | Remark |
| 1 | 24175 | 1000; RMS | 1 | -69.9 | -41.3 | -64.2 | -47 | 5.7 | h | |
| *2* | *24181.5* | *1000; RMS* | *1* | *-49.1** | *-41.3** | *-64.2** | *-26.2** | *-15.1** | *h* | *L.O. ** |
| 3 | 24254 | 1000; RMS | 1 | -69.4 | -41.3 | -64.2 | -46.5 | 5.2 | h | |
| 4 | 24387 | 1000; RMS | 1 | -68.2 | -41.3 | -64.2 | -45.3 | 4 | h | |
| 5 | 24487 | 1000; RMS | 1 | -68.3 | -41.3 | -64.2 | -45.4 | 4.1 | h | |
| 6 | 24557 | 1000; RMS | 1 | -69.1 | -41.3 | -64.2 | -46.2 | 4.9 | h | |
| 7 | 24642 | 1000; RMS | 1 | -69.4 | -41.3 | -64.2 | -46.5 | 5.2 | h | |

**** narrowband emissions caused by L.O. of the homodyne receiver (exempt as per Section 15.101(b))***

| PRODUCT EMISSIONS DATA (Section 15.515(d), 15.101(b)), LONG PULSE mode | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No | Emission Frequency f [MHz] | Receiver Mode and Bandwidth [kHz] | Test Distance Dtest [m] | Receiver Reading Pa [dBm] | Limit EIRP [dBm] | Receiver Reading for Limit Palim [dB] | EIRP Result FS [dBm] | Margin [dB] | Polari-zation Ant | Remark |
| 1 | 23867 | 1000; RMS | 1 | -68.9 | -41.3 | -64.2 | -46 | 4.7 | h | |
| 2 | 24095 | 1000; RMS | 1 | -68.3 | -41.3 | -64.2 | -45.4 | 4.1 | h | |
| *3* | *24174* | *1000; RMS* | *1* | *-49.5** | *-41.3** | *-64.2** | *-26.6** | *-14.7** | *h* | *L.O. ** |
| 4 | 24249.5 | 1000; RMS | 1 | -65.7 | -41.3 | -64.2 | -42.8 | 1.5 | h | |
| 5 | 24282.5 | 1000; RMS | 1 | -67.4 | -41.3 | -64.2 | -44.5 | 3.2 | h | |
| 6 | 24336 | 1000; RMS | 1 | -67.7 | -41.3 | -64.2 | -44.8 | 3.5 | h | |
| 7 | 24442.5 | 1000; RMS | 1 | -66.9 | -41.3 | -64.2 | -44 | 2.7 | h | |
| 8 | 24500.5 | 1000; RMS | 1 | -67.5 | -41.3 | -64.2 | -44.6 | 3.3 | h | |
| 9 | 24570 | 1000; RMS | 1 | -68.6 | -41.3 | -64.2 | -45.7 | 4.4 | h | |
| 10 | 24625.5 | 1000; RMS | 1 | -68.1 | -41.3 | -64.2 | -45.2 | 3.9 | h | |

**** narrowband emissions caused by L.O. of the homodyne receiver (exempt as per Section 15.101(b))***

The peak emissions of the EUT in the UWB fundamental band were found to comply with the requirements of 15.515(f).

| PRODUCT EMISSIONS DATA (Section 15.515(f)) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No | Emission Frequency f [MHz] | Receiver Mode and Bandwidth [MHz] | Test Distance Dtest [m] | Receiver Reading Pa [dBm] | Limit EIRP [dBm/10MHz] | Receiver Reading for Limit Palim [dB] | EIRP Result FS [dBm/10MHz] | Margin [dB] | Polari-zation Ant | Remark |
| 1 | 24486 | 10; Peak | 1 | -41.0 | -14 | -37.2 | -17.8 | 3.8 | h | SP |
| 2 | 24476 | 10; Peak | 1 | -39.2 | -14 | -37.2 | -16 | 2 | h | LP |

SP – SHORT PULSE mode, LP – LONG PULSE mode

### 8.2.7.4 UWB Radiated Emissions 40 GHz to 100 GHz

Device: 24 GHz SLR Sensor
Type: MASRAU0025
Serial number: 030002112
Test Date: 2005-02-17
Test Personnel: Wolfgang Döring

The spurious emissions of the EUT in the 40 GHz to 100 GHz range, excluding the L.O. emissions as per Section 15.101(b), were found to comply with the requirements of 15.515(d).

| PRODUCT EMISSIONS DATA (Section 15.515(d), 15.101(b)) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Receiver Mode: RMS; Bandwidth: 1000 kHz; Polarization of antenna: h, v (worst case noted) | | | | | | | | | | |
| No | Emission Frequen-cy f [GHz] | Test Distan-ce Dtest [m] | Receiver Reading Pa [dBm] | Mixer Loss Km [dB] | Antenna gain gi [dB] | calcul. Field strength for 3 m distance [dBµV/m] | EIRP Result [dBm] | EIRP Limit [dBm] | Margin [dB] | Remark |
| **narrowband emissions caused by L.O. of the homodyne receiver (exempt as per Section 15.101(b))** | | | | | | | | | | |
| 1 | 48.4 | 0.5 | -86.8 | 20 | 25 | 63.6 | -31.7 | n.a. | n.a. | L.O. harmonic, RMS, LONG PULSE mode |
| 2 | 48.4 | 0.5 | -87.6 | 20 | 25 | 62.8 | -32.4 | n.a. | n.a. | L.O. harmonic, RMS, SHORT PULSE mode |
| 3 | 72.6 | 0.03 | -92.1 | 25 | 10 | 57.4 | -37.9 | n.a. | n.a. | L.O. harmonic, RMS, residual carrier |
| 4 | 72.6 | 0.03 | -92.1 | 25 | 10 | 57.4 | -37.8 | n.a. | n.a. | L.O. harmonic, RMS, LONG PULSE mode |
| 5 | 72.6 | 0.03 | -93.5 | 25 | 10 | 56.0 | -39.2 | n.a. | n.a. | L.O. harmonic, RMS, SHORT PULSE mode |
| **broadband UWB emissions** | | | | | | | | | | |
| 6 | 40 | 0.01 | -100 | 20 | 25 | 14.8 | -80.5 | -61.3 | 19.2 | LONG PULSE mode + SHORT PULSE mode tested |
| 7 | 48.8 | 0.01 | -100 | 20 | 25 | 16.5 | -78.8 | -61.3 | 17.5 | |
| 8 | 60 | 0.01 | -100 | 20 | 25 | 18.3 | -77.0 | -61.3 | 15.7 | |
| 9 | 73.2 | 0.01 | -100 | 25 | 25 | 25.0 | -70.2 | -61.3 | 8.9 | |

PRODUCT EMISSIONS DATA (Section 15.515(d), 15.101(b))

Receiver Mode: RMS; Bandwidth: 1000 kHz; Polarization of antenna: h, v (worst case noted)

| No | Emission Frequen-cy f [GHz] | Test Distan-ce Dtest [m] | Receiver Reading Pa [dBm] | Mixer Loss Km [dB] | Antenna gain gi [dB] | calcul. Field strength for 3 m distance [dBµV/m] | EIRP Result [dBm] | EIRP Limit [dBm] | Margin [dB] | Remark |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 75 | 0.01 | -100 | 25 | 25 | 25.2 | -70.0 | -61.3 | 8.7 | |
| 11 | 97 | 0.003 | -100 | 40 | 25 | 32.0 | -63.2 | -61.3 | 1.9 | |
| 12 | 100 | 0.003 | -100 | 40 | 25 | 32.2 | -63.0 | -61.3 | 1.7 | |
| **NOTE: no broadband emissions found above noise over the whole frequency range** | | | | | | | | | | |
| | | | | | | | | | | |

*Remark: The used standard gain horn antennas may not see the entire device at close range. Therefore, the DUT was rotated through all axes and angles in front of the antenna, keeping the separation distance listed. A 20dB/decade far-field attenuation rate was applied for all calculations as per FCC.*

## Example plots to chapter 8:

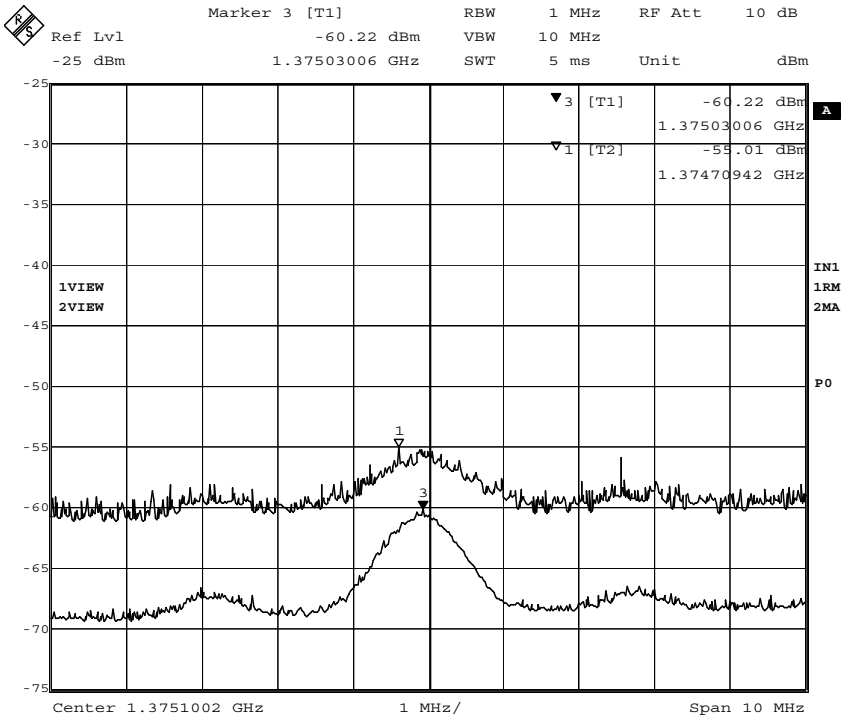



Figure 8-1: UWB radiated emissions, SHORT PULSE mode; RMS and PEAK reading

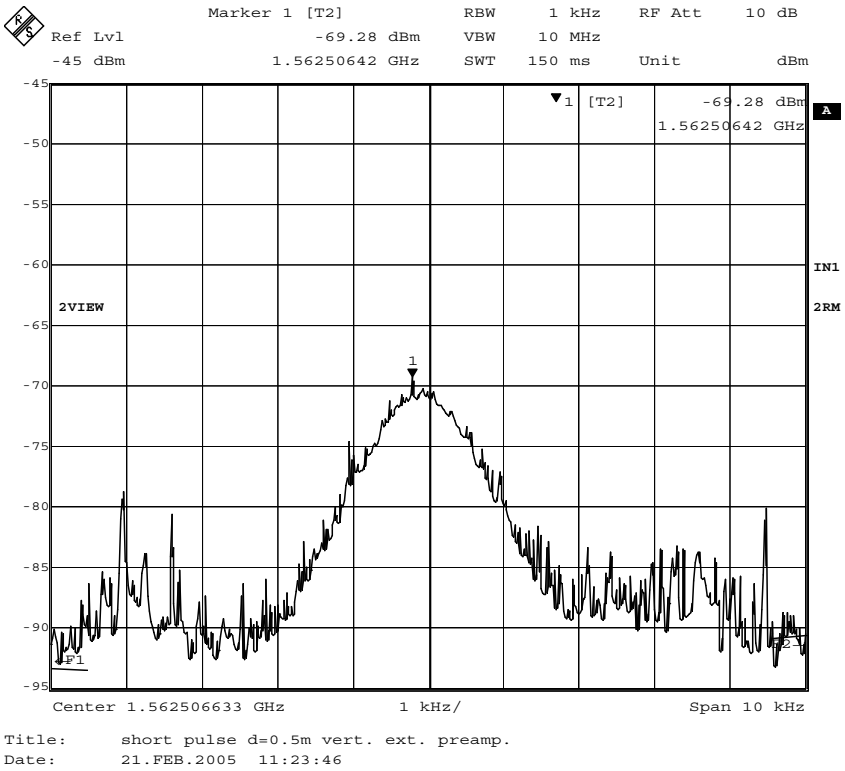
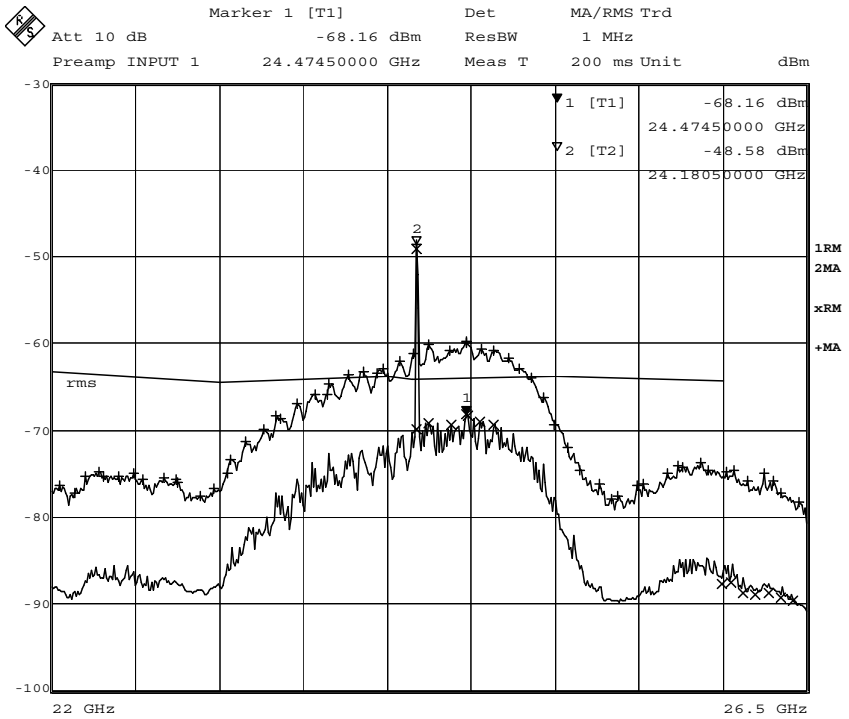
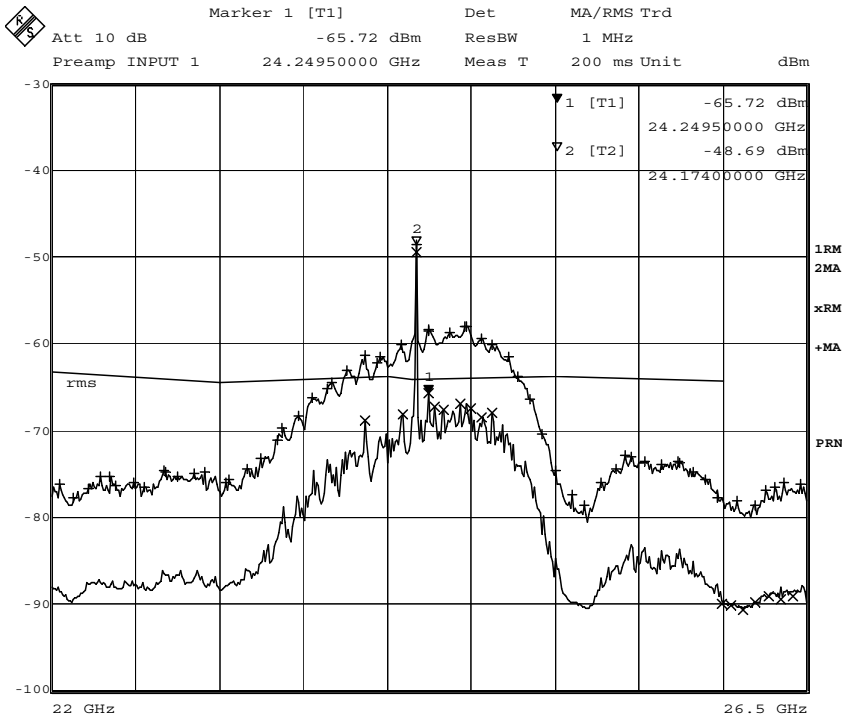



Figure 8-2: UWB radiated emissions within GPS band, SHORT PULSE mode; RBW=1kHz



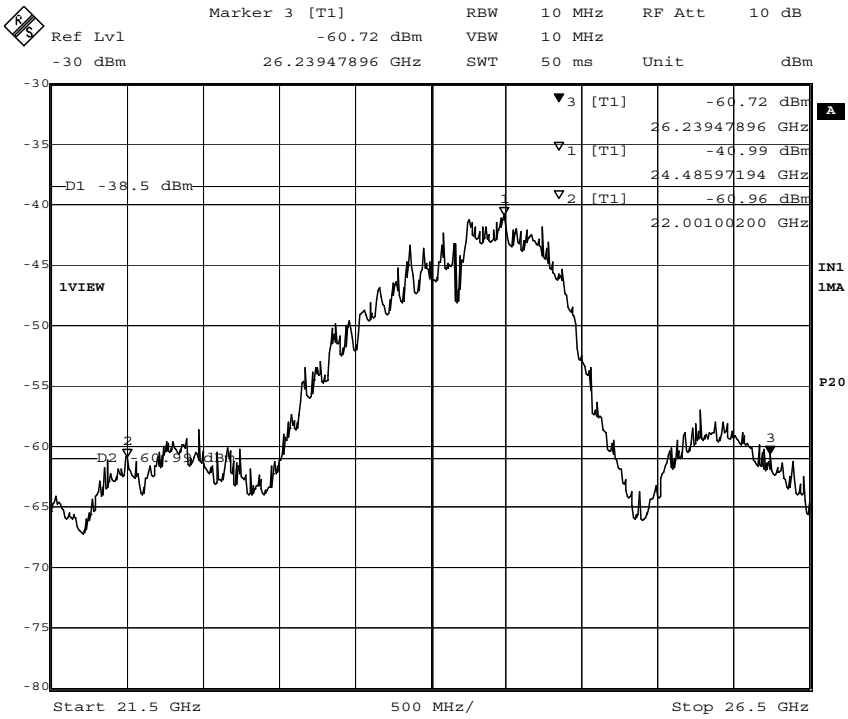

Title: Average Power Density EUT2893, 21deg,12V; short pulse
Date: 14.MAR.2005 15:17:59

Figure 8-3: UWB fundamental band emissions, SHORT PULSE mode; RMS and PEAK reading
Trace 1: RMS detector, Trace 2: PEAK detector; step rate: 500kHz, 0.5ms/step



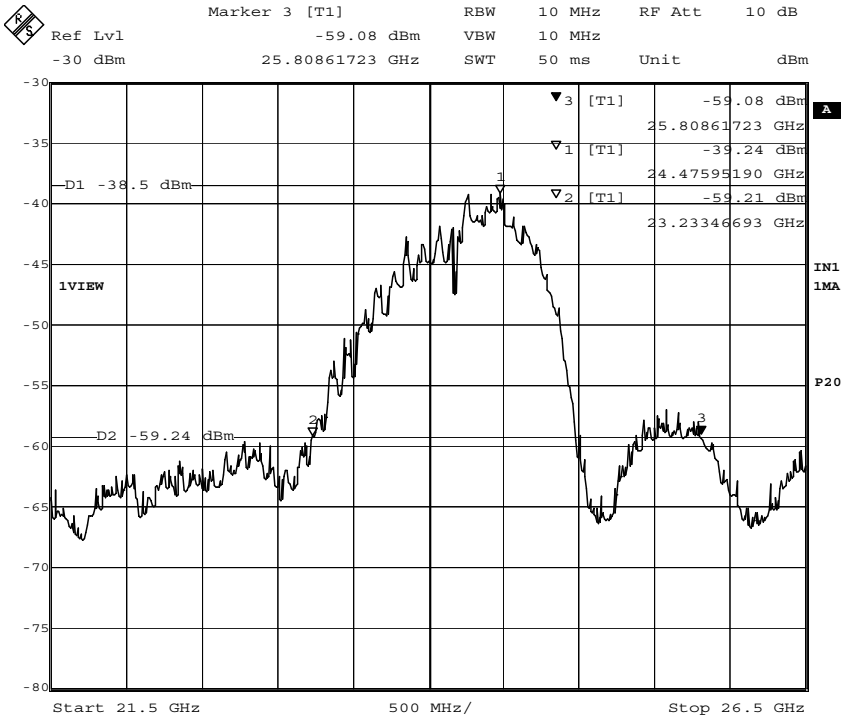

Title: Average Power Density EUT2893, 21deg,12V; long pulse
Date: 14.MAR.2005 15:12:30

Figure 8-4: UWB fundamental band emissions, LONG PULSE mode; RMS and PEAK reading
Trace 1: RMS detector, Trace 2: PEAK detector; step rate: 500kHz, 0.5ms/step



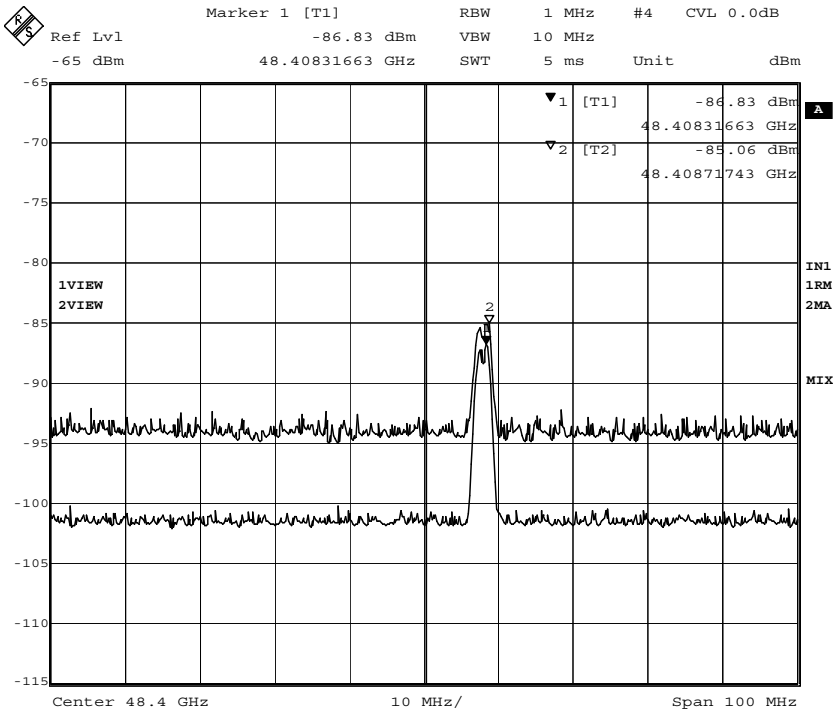

Title: Peak Power Density EUT2893, 21deg,12V; short pulse
Date: 14.MAR.2005 15:26:56

Figure 8-5: UWB fundamental band emissions, SHORT PULSE mode; PEAK reading with 10 MHz bandwidth



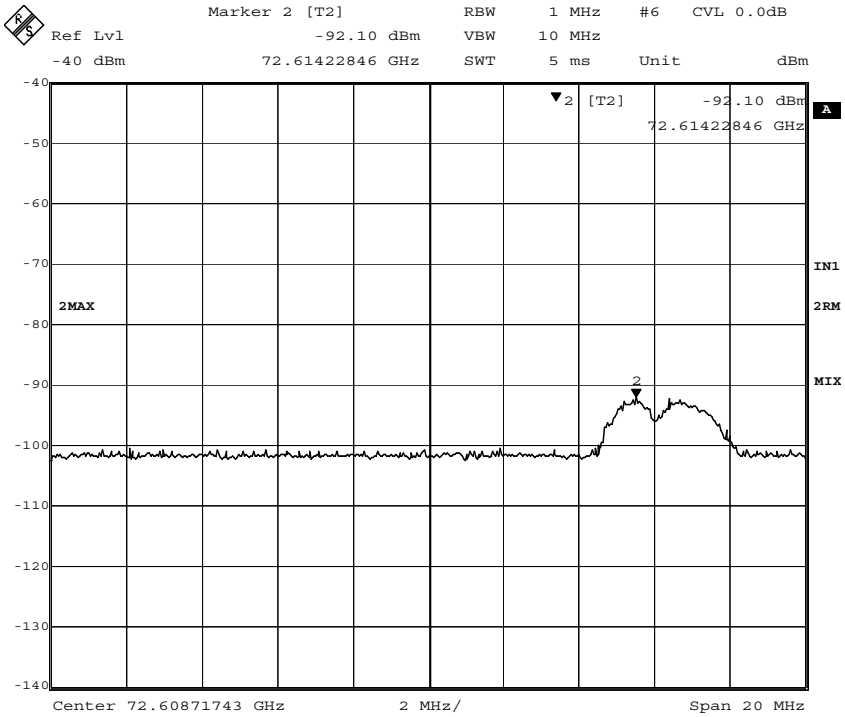

Title: Peak Power Density EUT2893, 21deg,12V; long pulse
Date: 14.MAR.2005 15:31:04

Figure 8-6: UWB fundamental band emissions, LONG PULSE mode; PEAK reading with 10 MHz bandwidth



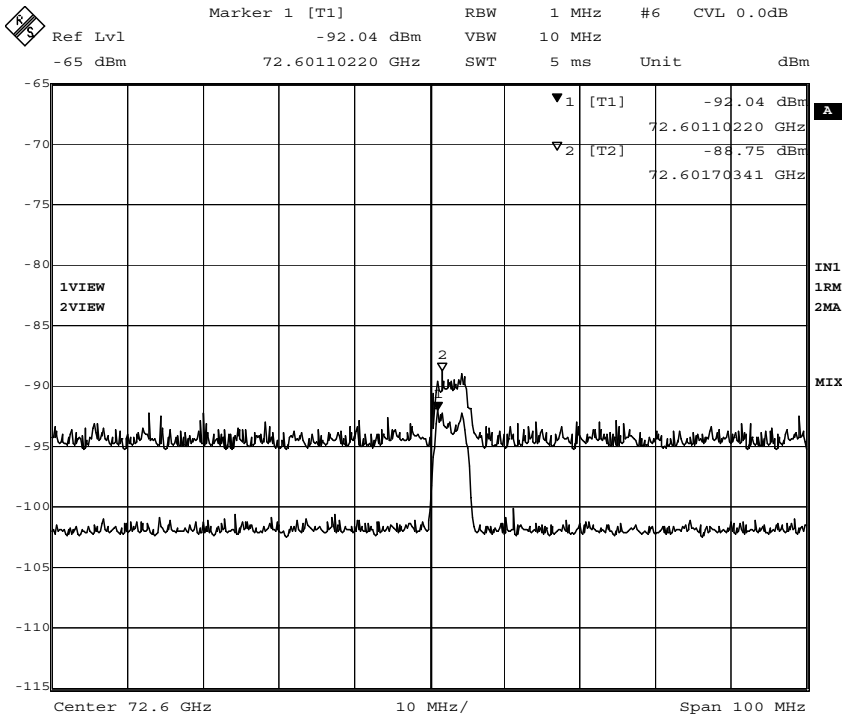

Title: Spurious at d=50cm hor. 25dB Horn long pulse
Date: 17.FEB.2005 16:58:45

Figure 8-7: UWB radiated emissions, LONG PULSE mode; PEAK and RMS reading




Title: Spurious at d=3cm hor. (residual carrier) 10dB Horn
Date: 17.FEB.2005 15:36:43

Figure 8-8: UWB radiated emissions, CW mode with RF switch set to its high insertion loss state; RMS reading




Title: Spurious at d=3cm hor. 10dB Horn long pulse
Date: 17.FEB.2005 16:18:52

Figure 8-9: UWB radiated emissions, LONG PULSE mode; PEAK and RMS reading

# 9 CONDUCTED EMISSIONS

Test Requirement: FCC CFR47, Part 15C

Test Procedure: ANSI C63.4:2003

## 9.1 Regulation

**Section 15.207 (a)** For an intentional radiator which is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 450 kHz to 30 MHz shall not exceed 250 microvolts. Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminals.

**Section 15.207 (d)** Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provision for, the use of battery chargers which permit operating while charging, AC adaptors or battery eliminators or that connect to the AC power lines indirectly, obtaining their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.

## 9.2 Test Equipment

Not applicable.

## 9.3 Test Procedures

Not applicable.

## 9.4 Test Results

| | |
|---|---|
| Device: | 24 GHz SLR Sensor |
| Type: | MASRAU0025 |
| Serial number: | 030002112 and 030002893 |

The EUT is intended to be powered from a vehicle battery, only.
Therefore - according to Section 15.207 (d) - conducted emissions measurements to demonstrate compliance with the conducted limits are not required.

# 10 EFFECT OF SUPPLY VOLTAGE VARIATION

Test Requirement: FCC CFR47, Part 15C
Test Procedure: ANSI C63.4:1992

## 10.1 Regulation

**Section 15.215 Additional provisions to the general radiated emission limitations.**
(c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in Sections 15.217 through 15.255 and in Subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the 20 dB bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

There is no particular specification for UWB devices in the Rules; the relative radiated emissions were recorded at the fundamental frequency $f_M$.

## 10.2 Test Equipment

| Type | Manufacturer/ Model No. | Serial No. | Last Calibration | Calibration Interval |
|---|---|---|---|---|
| EMI Receiver / Analyzer (960 MHz – 40 GHz, with external mixer up to 100 GHz) | Rohde & Schwarz ESIB 40 | 100126 | 2003-07 | 24 months |
| Standard Gain Horn Antenna (test 26.5 GHz – 40 GHz) | Mid Century MC 22/31B | 1360/86 | 2004-08 | 24 months |
| Preamplifier (18 – 35 GHz) | Spacek Labs SL2310-20-3 | 5A27 | 2005-01 | 24 months |
| Programmable Power Source | R&S NGPE40 | 451292/0529 | n.a. | n.a. |
| Digital Multimeter | CONRAD ME-42 | CC344177 | 2004-06 | 24 months |

## 10.3 Test Procedures

The supply voltage was varied from 9 to 16 V.

The peak power reading was measured for the LONG PULSE mode at the fundamental frequency with a bandwidth of 3 MHz.

## 10.4 Test Results

Device: 24 GHz SLR Sensor
Type: MASRAU0025
Serial number: 030002893
Test Date: 2005-03-15
Test Personnel: Wolfgang Döring

The EUT meets the requirements of this section.

| Relative Radiated Power versus Supply Voltage at $f_M$ = 24.25 GHz | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Voltage [V] | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Power Reading [dBm] | -49.56 | -49.56 | -49.68 | -49.68 | -49.81 | -49.68 | -49.56 | -49.56 |

# 11 RADIO FREQUENCY EXPOSURE

Test Requirement: FCC CFR47, Part 15C
Test Procedure: IEEE Std C95.3-1991

## 11.1 Regulation

**Section 2.1091 Radiofrequency radiation exposure evaluation: mobile devices.**
(a) Requirements of this section are a consequence of Commission responsibilities under the National Environmental Policy Act to evaluate the environmental significance of its actions. See subpart I of part 1 of this chapter, in particular § 1.1307(b).
(b) For purposes of this section, a mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons. In this context, the term ''fixed location'' means that the device is physically secured at one location and is not able to be easily moved to another location. Transmitting devices designed to be used by consumers or workers that can be easily relocated, such as wireless devices associated with a personal computer, are considered to be mobile devices if they meet the 20 centimeter separation requirement.

(c) Mobile devices that operate in the Cellular Radiotelephone Service, the Personal Communications Services, the Satellite Communications Services, the General Wireless Communications Service, the Wireless Communications Service, the Maritime Services and the Specialized Mobile Radio Service authorized under subpart H of part 22 of this chapter, part 24 of this chapter, part 25 of this chapter, part 26 of this chapter, part 27 of this chapter, part 80 of this chapter (ship earth stations devices only) and part 90 of this chapter are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use if they operate at frequencies of 1.5 GHz or below and their effective radiated power (ERP) is 1.5 watts or more, or if they operate at frequencies above 1.5 GHz and their ERP is 3 watts or more. Unlicensed personal communications service devices, unlicensed millimeter wave devices and unlicensed NII devices authorized under §15.253, § 15.255, and subparts D and E of part 15 of this chapter are also subject to routine environmental evaluation for RF exposure prior to equipment authorization or use if their ERP is 3 watts or more or if they meet the definition of a portable device as specified in § 2.1093
(b) requiring evaluation under the provisions of that section. All other mobile and unlicensed transmitting devices are categorically excluded from routine environmental evaluation for RF exposure prior to equipment authorization or use, except as specified in §§ 1.1307(c) and 1.1307(d) of this chapter. Applications for equipment authorization of mobile and unlicensed transmitting devices subject to routine environmental evaluation must contain a statement confirming compliance with the limits specified in paragraph (d) of this section as part of their application. Technical information showing the basis for this statement must be submitted to the Commission upon request.
(d) The limits to be used for evaluation are specified in § 1.1310 of this chapter. All unlicensed personal communications service (PCS) devices and unlicensed NII devices shall be subject to the limits for general population/uncontrolled exposure.
(1) For purposes of analyzing mobile transmitting devices under the occupational/controlled criteria specified in § 1.1310 of this chapter, timeaveraging provisions of the guidelines may be used in conjunction with typical maximum duty factors to determine maximum likely exposure levels.
(2) Timeaveraging provisions may not be used in determining typical exposure levels for devices intended for use by consumers in general population/uncontrolled environments as defined in § 1.1310 of this chapter. However, ''sourcebased'' timeaveraging based on an inherent property or dutycycle of a device is allowed. An example of this is the determination of exposure from a device that uses digital technology such as a timedivision multipleaccess (TDMA) scheme for transmission of a signal. In general, maximum average power levels must be used to determine compliance.

(3) If appropriate, compliance with exposure guidelines for devices in this section can be accomplished by the use of warning labels and by providing users with information concerning minimum separation distances from transmitting structures and proper installation of antennas.
(4) In some cases, e.g., modular or desktop transmitters, the potential conditions of use of a device may not allow easy classification of that device as either mobile or portable (also see § 2.1093). In such cases, applicants are responsible for determining minimum distances for compliance for the intended use and installation of the device based on evaluation of either specific absorption rate (SAR), field strength or power density, whichever is most appropriate.

**Section 1.1307 Actions that may have a significant environmental effect, for which Environmental Assessments (EAs) must be prepared.**
(b) In addition to the actions listed in paragraph (a) of this section, Commission actions granting construction permits, licenses to transmit or renewals thereof, equipment authorizations or modifications in existing facilities, require the preparation of an Environmental Assessment (EA) if the particular facility, operation or transmitter would cause human exposure to levels of radiofrequency radiation in excess of the limits in §§ 1.1310 and 2.1093 of this chapter. Applications to the Commission for construction permits, licenses to transmit or renewals thereof, equipment authorizations or modifications in existing facilities must contain a statement confirming compliance with the limits unless the facility, operation, or transmitter is categorically excluded, as discussed below. Technical information showing the basis for this statement must be submitted to the Commission upon request.

Section 1.1310 Radiofrequency radiation exposure limits.

| TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE) | | | | |
|---|---|---|---|---|
| Frequency range (MHz) | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density (mW/cm²) | Averaging time (minutes) |
| 1500–100,000 | - | - | 1.0 | 30 |

## 11.2 Test Equipment

| Type | Manufacturer/ Model No. | Serial No. | Last Calibration | Calibration Interval |
|---|---|---|---|---|
| Preamplifier (18 – 35 GHz) | Spacek Labs SL2310-20-3 | 5A27 | 2005-01 | 24 months |
| Test Generator (960 – 40 GHz) | Hewlett-Pack. 83640A-4008 | 3009A00182 | 2001-11 | 48 months |
| RF Power Meter (cal. 960 MHz – 40 GHz) | Rohde & Schwarz NRVD | 843246/036 | 2004-10 | 24 months |
| Power Sensor (cal. 960 MHz – 40 GHz) | Rohde & Schwarz NRV-Z55 | 845988/003 | 2003-01 | 30 months |
| Standard Gain Horn Antenna (18 GHz - 26.5 GHz) | Mid Century MC 20/31B | 1362/86 | 2004-08 | 24 months |
| Standard Gain Horn Antenna (calibr. 18 GHz – 26.5 GHz) | Mid Century MC 20/31B | 1363/86 | 2004-08 | 24 months |

## 11.3 Test Procedures

The radiation in the fundamental band 22 GHz to 26.5 GHz was measured with standard gain horn connected via a wideband amplifier to a True RMS power meter.
The test was performed at antenna distances of 1 m and 0.2 m to the surface of the EUT.
The test set-up was calibrated using substitution methods:

a) For the 0.2 m distance measurement: substituting the receive horn antenna by a calibrated generator and measuring the generator level required for the same power meter reading as recorded for the EUT emissions, adding the antenna factor to this generator level the field strength was calculated.
b) For the 1m distance measurement: performing an EIRP substitution as described in chapter 8.2.6.

Two operation modes were checked:
- SHORT PULSE mode,
- LONG PULSE mode.

The surface of the EUT was scanned with the antenna. Max. levels were detected in the co-polarized plane of the antenna of EUT.
Emissions outside the band are negligible.

## 11.4 Calculations of Power Density Limits

$S = E^2 /3770$ [mW/cm$^2$]
$S = EIRP/4\pi R^2$ [mW/cm$^2$]
with
E = Field strength in V/m
EIRP in mW
R = Distance in cm
→ $E = (S * 3770)^{0.5}$ [V/m]

→ $EIRP = 4\pi SR^2$ [mW]

For S = 1 mW/cm$^2$ the corresponding field strength is 61.4 V/m; for a distance of 1m the EIRP limit is 125.7 W.

| Frequency | Power Density | | Field Strength | EIRP |
|---|---|---|---|---|
| (MHz) | mW/cm² | dBm/cm² | V/m | W |
| 1,500 to 100,000 | 1.0 | 0 | 61.4 | 125.7 |

## 11.5 Test Results

Device: 24 GHz SLR Sensor
Type: MASRAU0025
Serial number: 030002112
Test Date: 2005-02-17
Test Personnel: Wolfgang Döring

The EUT was found to comply with the requirements of this section.

| PRODUCT EMISSIONS DATA | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mode | Test Distance [m] | Power Reading PA [dBm] | Substi. Generator level Psub [dBm] | Antenna Factor AF [dB] | Field Strength [dBµV/m] | Field Strength [V/m] | EIRP [dBm] | EIRP [mW] | Power Density [mW/cm²] | Spec Limit [m/Wcm²] | Margin [dB] |
| SP | 0.2 | -22.9 | -41.7 | 38 | 103.3 | 0.146 | - | - | 0.0000056 | 1 | 52.5 |
| SP | 1 | -35 | - | - | - | - | -13 | 0.05 | 0.0000004 | 1 | 64 |
| LP | 0.2 | -22.2 | -41 | 38 | 104 | 0.158 | - | - | 0.0000066 | 1 | 51.8 |
| LP | 1 | -34 | - | - | - | - | -12 | 0.066 | 0.0000005 | 1 | 63 |
| | | | | | | | | | | | |

SP – SHORT PULSE mode, LP – LONG PULSE mode

**Sample calculation (0.2 m):**

E = AF + Psub +107 = 38 – 41 +107 = 104 [dBµV/m]

$E = 10^{(E(dB\mu V/m)/20 - 6)} = 10^{(104/20 - 6)} = 10^{(-0.8)} = 0.158$ [V/m]

$S = E^2 /3770 = 0.158^2 / 3770 = 0.0000066$ [mW/cm$^2$] = 6.6 [nW/cm$^2$]

**Sample calculation (1 m):**

$S = EIRP/4\pi R^2$ [mW/cm$^2$]

$S = 0.066/4\pi 100^2 = 0.0000005$ [mW/cm$^2$] = 0.5 [nW/cm$^2$]

## 12 MISCELLANEOUS COMMENTS AND NOTES

None.

## 13 LIST OF ANNEXES

Following annexes are separated parts from this test report.

| Description | Pages |
|---|---|
| Annex 1: Photographs of test setups | 5 |
| Annex 2: Photographs of equipment under test (EUT), external views | 4 |
| Annex 3: Photographs of equipment under test (EUT), internal views | 3 |
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