

# TEST REPORT

**Test Report Reference: R40448/1 Edition 2**

**Equipment under Test: TSS/RE4T**

**Applicant: BERU AG**

**Manufacturer: BERU AG**

**Test Laboratory  
(CAB)**

**accredited by  
DATech e.V.**

**in compliance with DIN EN ISO/IEC 17025  
under the**

**Reg. No. TTI-P-G071/94-11**

**and listed by  
FCC 31040/SIT1300F2**

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## 1 IDENTIFICATION

### 1.1 APPLICANT

|                                                                |                                                                |
|----------------------------------------------------------------|----------------------------------------------------------------|
| Name:                                                          | BERU AG                                                        |
| Address:                                                       | Mörikestraße 155<br>71602 Ludwigsburg                          |
| Country:                                                       | Germany                                                        |
| Name for contact purposes:                                     | Mr. Zlatan Saric                                               |
| Phone:                                                         | +49-7141-132-798                                               |
| Fax:                                                           | +49-7141-132-589                                               |
| Mail address:                                                  | <a href="mailto:Zlatan.saric@beru.de">Zlatan.saric@beru.de</a> |
| Applicant represented during the test by the following person: | -                                                              |

### 1.2 MANUFACTURER

|                                                                |                                                                |
|----------------------------------------------------------------|----------------------------------------------------------------|
| Name:                                                          | BERU AG                                                        |
| Address:                                                       | Mörikestraße 155<br>71602 Ludwigsburg                          |
| Country:                                                       | Germany                                                        |
| Name for contact purposes:                                     | Mr. Zlatan Saric                                               |
| Phone:                                                         | +49-7141-132-798                                               |
| Fax:                                                           | +49-7141-132-589                                               |
| Mail address:                                                  | <a href="mailto:Zlatan.saric@beru.de">Zlatan.saric@beru.de</a> |
| Applicant represented during the test by the following person: | -                                                              |

### 1.3 DATES

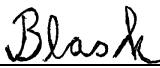
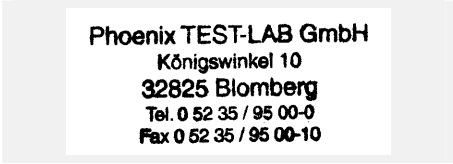
|                                 |             |
|---------------------------------|-------------|
| Date of receipt of test sample: | 17 May 2004 |
| Start of test:                  | 17 May 2004 |
| Finish of test:                 | 18 May 2004 |

## 1.4 TEST LABORATORY

The tests were carried out at:

**PHOENIX TEST-LAB GmbH**  
Königswinkel 10  
D-32825 Blomberg  
Germany

Phone: +49 (0) 52 35 / 95 00-0  
Fax: +49 (0) 52 35 / 95 00-10

|                                                                                    |               |                                                                                    |              |
|------------------------------------------------------------------------------------|---------------|------------------------------------------------------------------------------------|--------------|
| Test engineer:                                                                     | Raimund Blask |   | 14 June 2004 |
|                                                                                    | name          | signature                                                                          | date         |
| Test report checked:                                                               | Bernd Steiner |  | 14 June 2004 |
|                                                                                    | name          | signature                                                                          | date         |
|  |               |                                                                                    |              |
| stamp                                                                              |               |                                                                                    |              |

## 1.5 RESERVATION

This test report is only valid in its original form.

Any reproduction of its contents without written permission of the accredited test laboratory PHOENIX TEST-LAB GmbH is prohibited.

The test results herein refer only to the tested sample. PHOENIX TEST-LAB GmbH is not responsible for any generalisations or conclusions drawn from these test results concerning further samples. Any modification of the tested samples is prohibited and leads to the invalidity of this test report. Each page necessarily contains the PHOENIX TEST-LAB Logo and the TEST REPORT REFERENCE.

## 1.6 NORMATIVE REFERENCES

- [1] **ANSI C63.4-1992** American National Standard for Methods of Measuring of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
- [2] **FCC 47 CFR Part 15 (December 2003)** Radio Frequency Devices

## 1.7 TEST RESULTS

The requirements of this test document are fulfilled by the equipment under test. The complete test results are presented in the following.

## 2 TECHNICAL DATA OF EQUIPMENT

### 2.1 DEVICE UNDER TEST

|                              |                                       |
|------------------------------|---------------------------------------|
| Type of equipment:           | Tire pressure monitoring transmitter* |
| Type designation:            | TSS/RE4T                              |
| Serial No.:                  | 400001043                             |
| Highest operating frequency: | 433.920 MHz*                          |

\* declared by the applicant

**The following external I/O cables were used:**

| Cable | Length | Shielding | Connector |
|-------|--------|-----------|-----------|
| -     | -      | -         | -         |

### 2.2 PERIPHERY DEVICES

**The ancillary equipment mentioned below was in use:**

No ancillary equipment necessary.

### 2.3 MODIFICATIONS

No modifications necessary to fulfil the requirements.

### 3 OPERATIONAL STATES AND PHYSICAL BOUNDARIES

The transmitter was tested in normal operation mode:

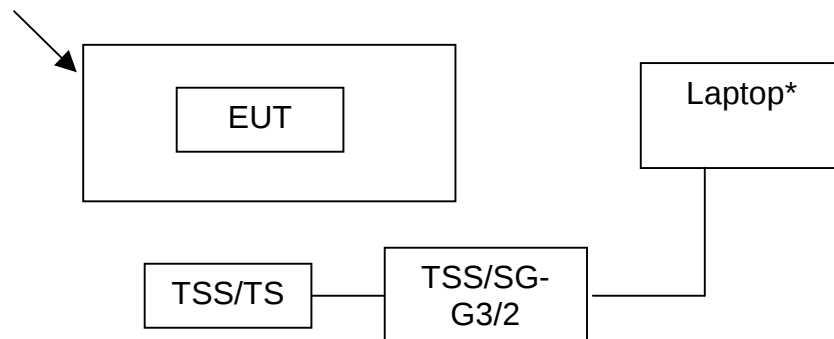
To stimulate the transmitter the EUT (TSS/RE4T) was triggered by a 125 kHz-Transmitter (Type BERU TSS/TS) to transmit every 1 second.

The transmitter was operating on the following frequency:

| Channel: | Transmit frequency: |
|----------|---------------------|
| 1        | 433.920 MHz         |

The physical boundaries of the Equipment Under Test are shown below.

Physical boundaries of the EUT:



\* Laptop with Vector Tool “CANoe” to establish CAN communication to Control Unit (TSS/SG-G3/2). Vector Tool “CANape” to stimulate the Transmitter (TSS/RE4T) transmitting every second RF-telegrams.

## 4 LIST OF TEST MODULES

### 4.1 EMISSION

| Field strength of spurious emissions FCC 47 CFR Part 15 section 15.231 (b) |                       |                                |                                                        |                    |        |        |
|----------------------------------------------------------------------------|-----------------------|--------------------------------|--------------------------------------------------------|--------------------|--------|--------|
| No.                                                                        | Application           | Frequency range                | Limits                                                 | Reference standard | Remark | Status |
| 1                                                                          | Intentional radiator  | 30 to 960 MHz<br>above 960 MHz | 60.82 dB $\mu$ V/m at 3 m<br>60.82 dB $\mu$ V/m at 3 m | ANSI C63.4 (1992)  | -      | Passed |
| Field strength of fundamental FCC 47 CFR Part 15 section 15.231 (b)        |                       |                                |                                                        |                    |        |        |
| No.                                                                        | Fundamental frequency | Transmitter frequency          | Limits                                                 | Reference standard | Remark | Status |
| 2                                                                          | 260 – 470 MHz         | 433.920 MHz                    | 10996.67 $\mu$ V/m or<br>80.82 dB $\mu$ V/m at 3 m     | ANSI C63.4 (1992); | -      | Passed |
| Bandwidth of emission FCC 47 CFR Part 15 section 15.231 (c)                |                       |                                |                                                        |                    |        |        |
| No.                                                                        | Application           | Frequency range                | Limits                                                 | Reference standard | Remark | Status |
| 3                                                                          | Intentional radiator  | 70 to 900 MHz                  | 0.25% of the center frequency<br>(20 dB-points)        | -                  | -      | Passed |

## 5 METHOD OF MEASUREMENT

### 5.1 RADIATED EMISSIONS 30 MHz TO 5 GHz

The radiated emission measurement is divided into two stages.

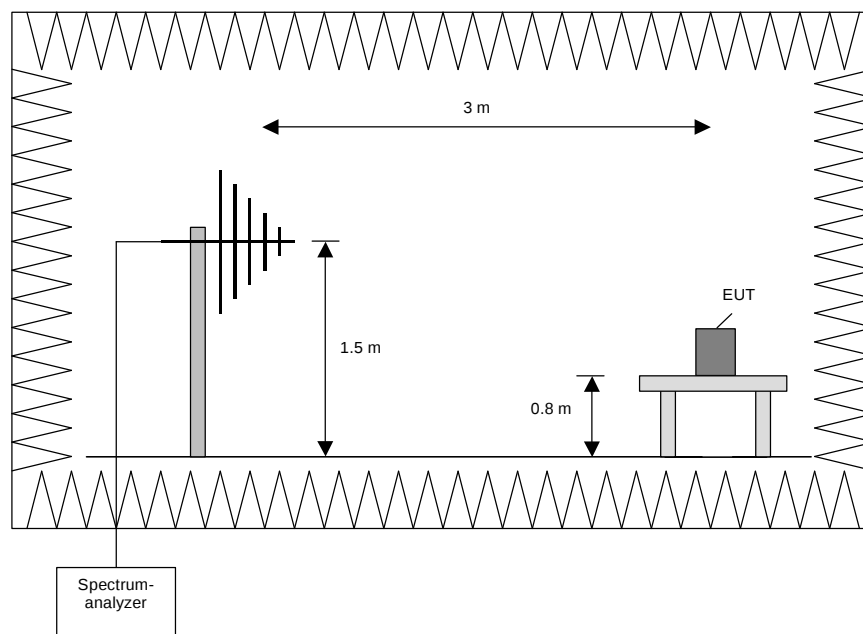
#### Preliminary measurement:

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 C63.4-1992 [1].

The frequency range 30 MHz to 5 GHz will be measured with an EMI Receiver set to MAX Hold mode. 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 1 GHz | 100 kHz              |
| 1 GHz to 5 GHz  | 1 MHz                |



#### Procedure preliminary measurement:

Prescans were performed in the frequency range 30 MHz to 200 MHz, 200 MHz to 1 GHz and 1 GHz to 5 GHz.

The following procedure will be used:

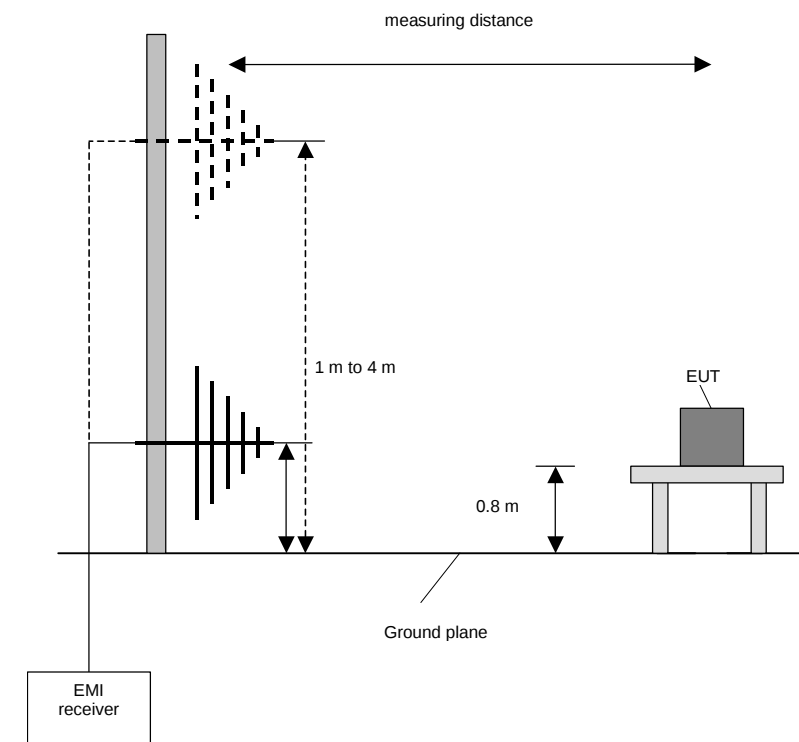
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °
2. Manipulate the system cables within the range to produce the maximum level of emission
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Make a hardcopy of the spectrum
5. Measure the frequency of 3 highest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

### Final Measurement:

In the second stage 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 (Peak) and note the value
- 11) Repeat 5) to 10) for each frequency
- 12) Repeat 1) to 11) for each orthogonal axes of the EUT if handheld equipment.

## 6 TEST RESULTS EMISSION TEST

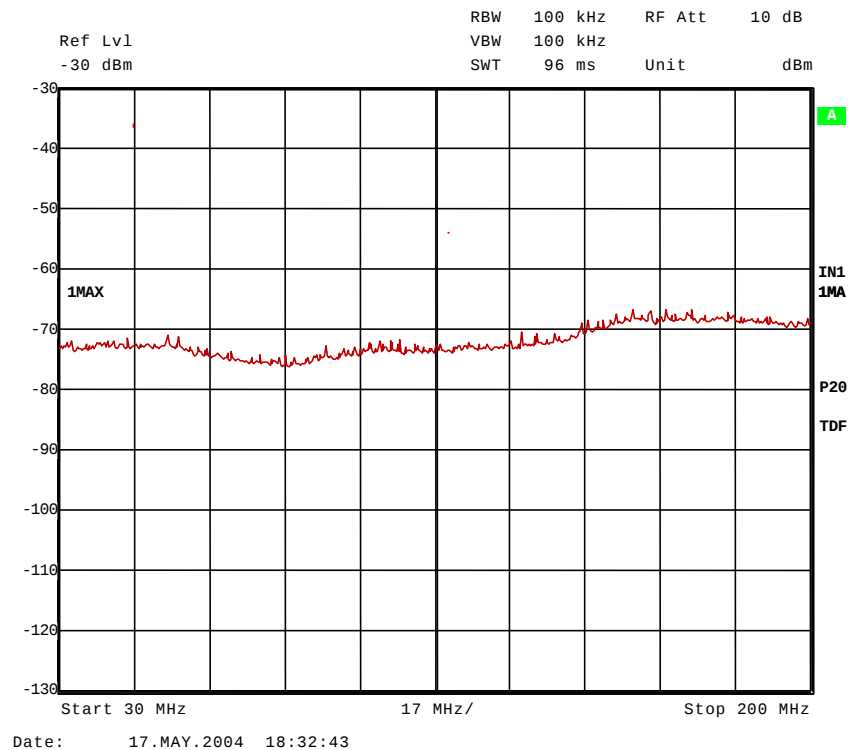
### 6.1 PRELIMINARY RADIATED EMISSION TEST (30 MHz to 1 GHz)

|                     |       |                   |      |
|---------------------|-------|-------------------|------|
| Ambient temperature | 20 °C | Relative humidity | 60 % |
|---------------------|-------|-------------------|------|

Position of EUT: The EUT was set-up on a wooden table of a height of 0.8 m.  
The distance between EUT and antenna was 3 m.

Cable guide: No cable necessary.

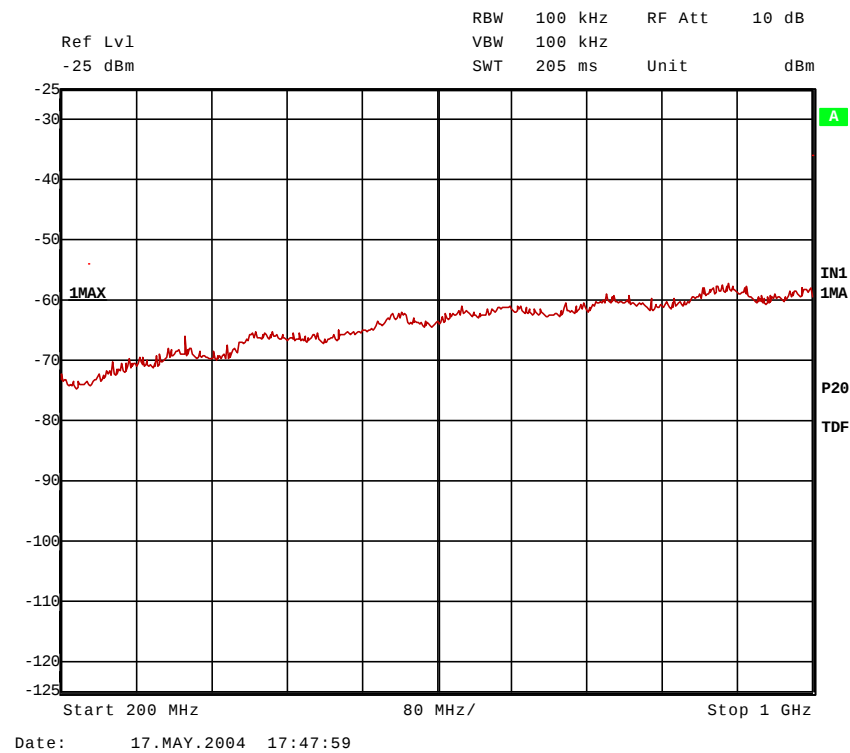
Test record: The test was carried out in normal operation-mode.



40448tx3.wmf: 30 MHz to 200 MHz



TEST REPORT REFERENCE: R40448/1\_Edition 2



40448tx4.wmf: 200 MHz to 1000 MHz

The following significant frequencies were found during the preliminary radiated emission test:

433.920 MHz, 867.840 MHz

These frequencies have to be measured on the open area test site.

TEST EQUIPMENT USED FOR THE TEST:

29, 31 – 35, 37

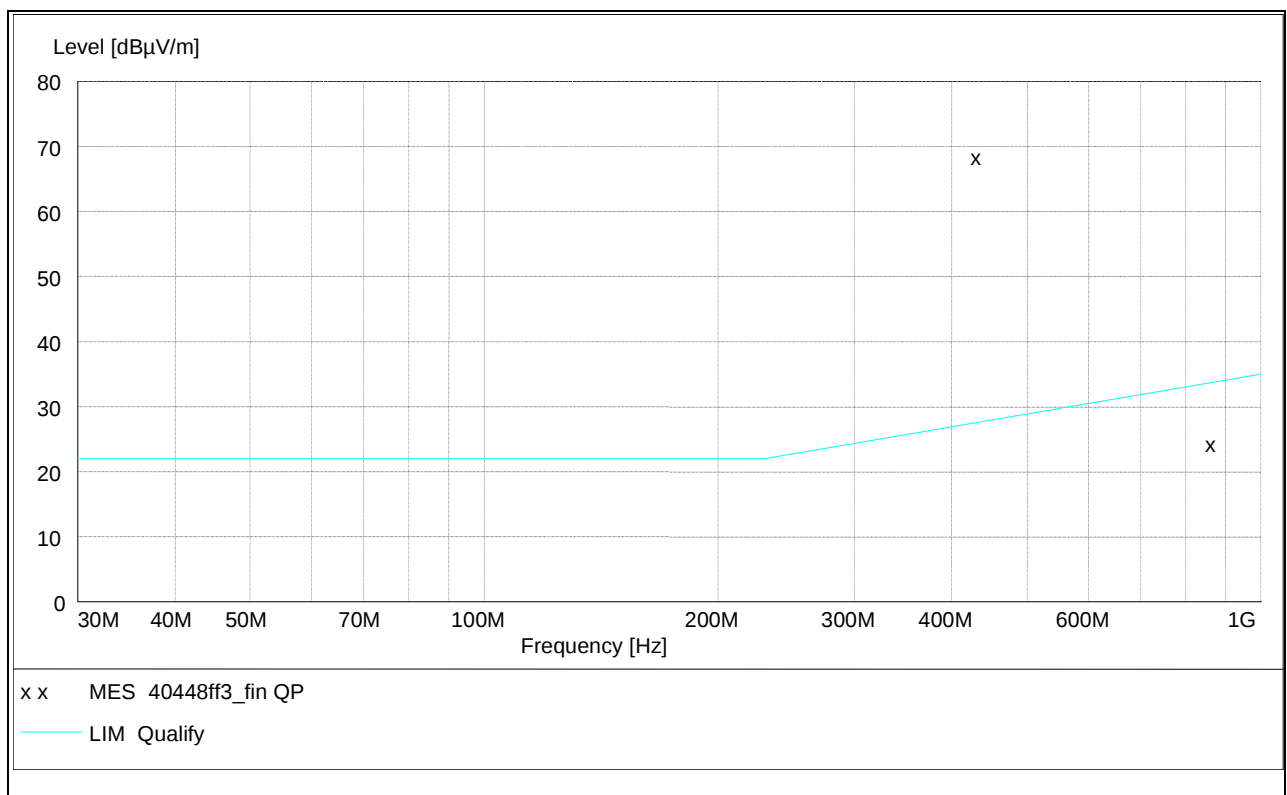
## 6.2 FINAL RADIATED EMISSION TEST (30 MHz to 1 GHz)

|                     |       |                   |      |
|---------------------|-------|-------------------|------|
| Ambient temperature | 20 °C | Relative humidity | 60 % |
|---------------------|-------|-------------------|------|

Position of EUT: The EUT was set-up on a wooden table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

Cable guide: No cable necessary.

Test record: The test was carried out in normal operation-mode.



Data record name: 40448ff3

of 18 May 2004

Continued next page:

TEST REPORT REFERENCE: R40448/1\_Edition 2

Continued:

The field strength E was calculated as follows:

Peak E-field:  $F = U + k$  (k = antenna factor + cable loss – amplifier gain)  
Duty cycle correction factor:  $D = 20 \log (10 \text{ ms} / 920 \text{ ms}) = -39.7 \text{ dB}$  (Maximum 20 dB)  
Calculated averaged field:  $E = F + D$

| Freq.:<br>MHz | Peak-<br>reading U:<br>dBμV | Trans-<br>ducer k:<br>dB/m | Peak-<br>E-field F:<br>dBμV/m | Duty<br>Cycle D:<br>dB | Calculated<br>averaged<br>field E:<br>dBμV/m | Limit:<br>dBμV/m | Margin:<br>dB | Result: |
|---------------|-----------------------------|----------------------------|-------------------------------|------------------------|----------------------------------------------|------------------|---------------|---------|
| 433.920       | 68.5                        | 18.7                       | 87.2                          | -20                    | 67.2                                         | 80.8             | 13.6          | Passed  |
| 867.840       | 24.0                        | 25.5                       | 49.5                          | -20                    | 29.5                                         | 60.8             | 31.3          | Passed  |

TEST EQUIPMENT USED FOR THE TEST:

14 – 20

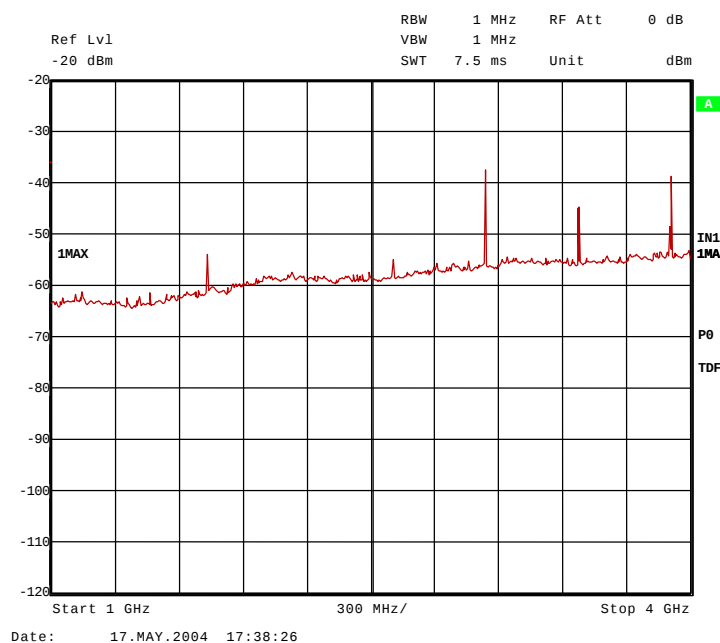


### 6.3 RADIATED EMISSION TEST (1 GHz to 5 GHz)

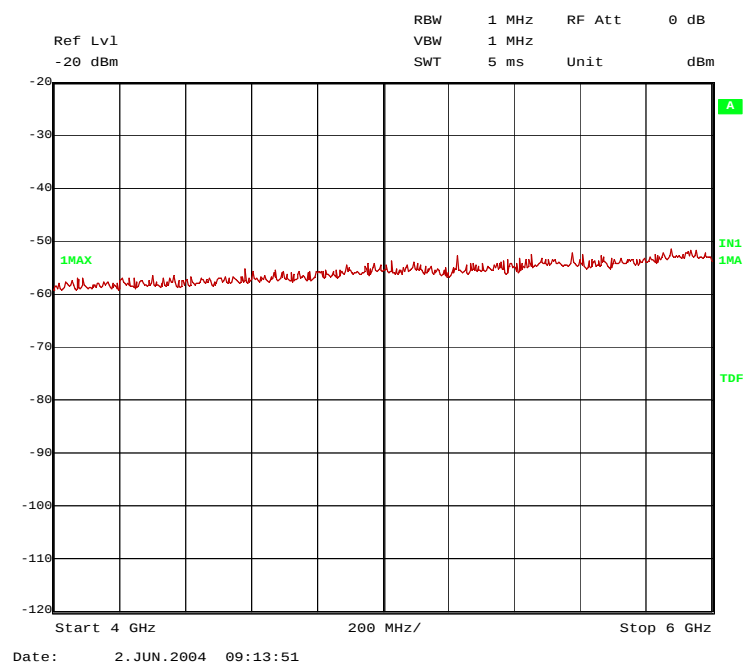
|                     |       |                   |      |
|---------------------|-------|-------------------|------|
| Ambient temperature | 20 °C | Relative humidity | 50 % |
|---------------------|-------|-------------------|------|

Position of EUT: The EUT was set-up on a wooden table of a height of 0.8 m.  
The distance between EUT and antenna was 3 m.

Test record: The test was carried out in normal operation-mode.



40448tx5.wmf: 1 GHz to 4 GHz

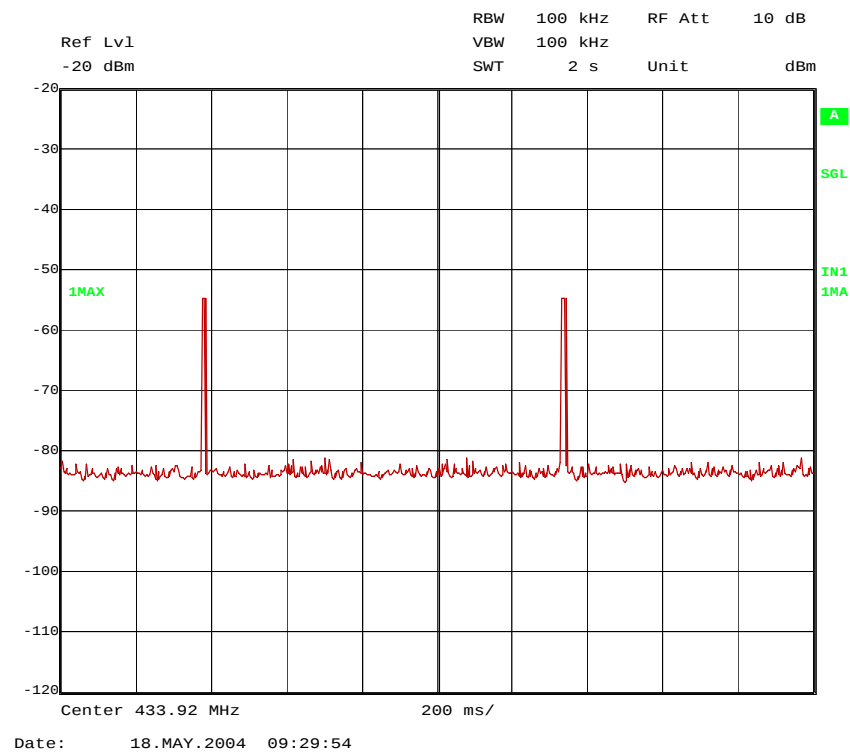


40448tx6.wmf: 4 GHz to 6 GHz

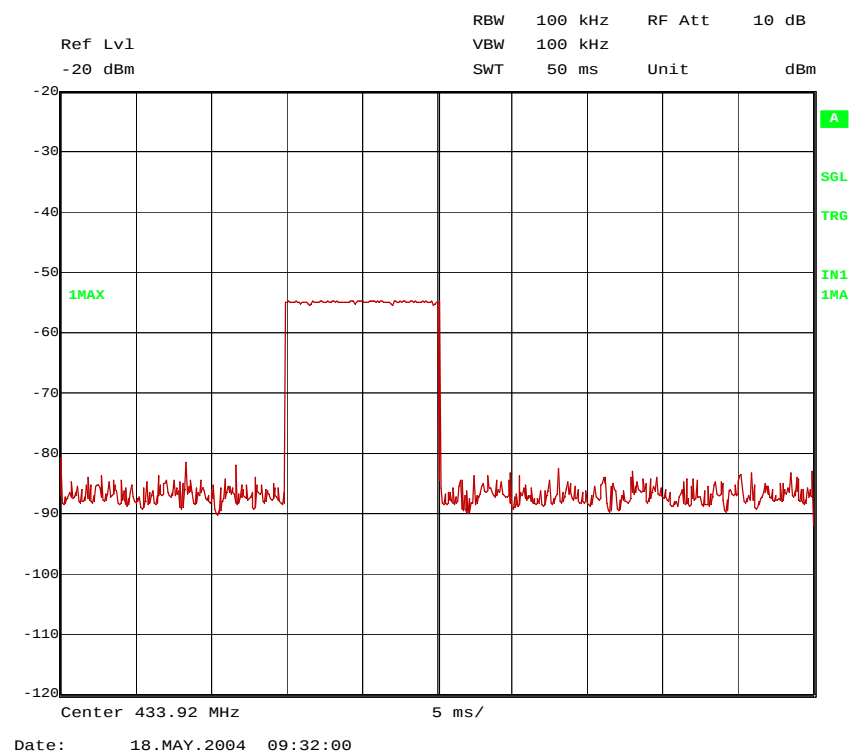


TEST REPORT REFERENCE: R40448/1\_Edition 2

Measurement results: Duty cycle



40448duty1.wmf: Transmitter on / off - time: t (off-time) = 920 ms



40134\_6duty1.wmf: Transmitter on time: t (on-time) = 10 ms

TEST REPORT REFERENCE: R40448/1\_Edition 2

The field strength E was calculated as follows:

Peak E-field:  $F = U + k$  (k = antenna factor + cable loss – amplifier gain)  
 Duty cycle correction factor:  $D = 20 \log (10 \text{ ms} / 920 \text{ ms}) = -39.7 \text{ dB}$  (Maximum 20 dB)  
 Calculated averaged field:  $E = F + D$

3 highest spurious frequencies:

| Freq.:<br>MHz | Peak-<br>reading U:<br>dBμV | Trans-<br>ducer k:<br>dB/m | Peak-<br>E-field F:<br>dBμV/m | Duty<br>Cycle D:<br>dB | Calculated<br>averaged<br>field E:<br>dBμV/m | Limit:<br>dBμV/m | Margin:<br>dB | Result: |
|---------------|-----------------------------|----------------------------|-------------------------------|------------------------|----------------------------------------------|------------------|---------------|---------|
| 1735.000      | 39.7                        | 2.5                        | 42.2                          | -20.0                  | 22.2                                         | 60.8             | 38.6          | Passed  |
| 3037.440      | 49.2                        | 8.0                        | 57.2                          | -20.0                  | 37.2                                         | 60.8             | 23.6          | Passed  |
| 3471.360      | 42.2                        | 9.0                        | 51.2                          | -20.0                  | 31.2                                         | 60.8             | 29.6          | Passed  |

Highest spurious frequencies in the restricted bands:

| Freq.:<br>MHz | Peak-<br>reading U:<br>dBμV | Trans-<br>ducer k:<br>dB/m | Peak-<br>E-field F:<br>dBμV/m | Duty<br>Cycle D:<br>dB | Calculated<br>averaged<br>field E:<br>dBμV/m | Limit:<br>dBμV/m | Margin:<br>dB | Result: |
|---------------|-----------------------------|----------------------------|-------------------------------|------------------------|----------------------------------------------|------------------|---------------|---------|
| 3905.280      | 45.2                        | 11.0                       | 56.2                          | -20.0                  | 36.2                                         | 54               | 17.8          | Passed  |

Test: Passed

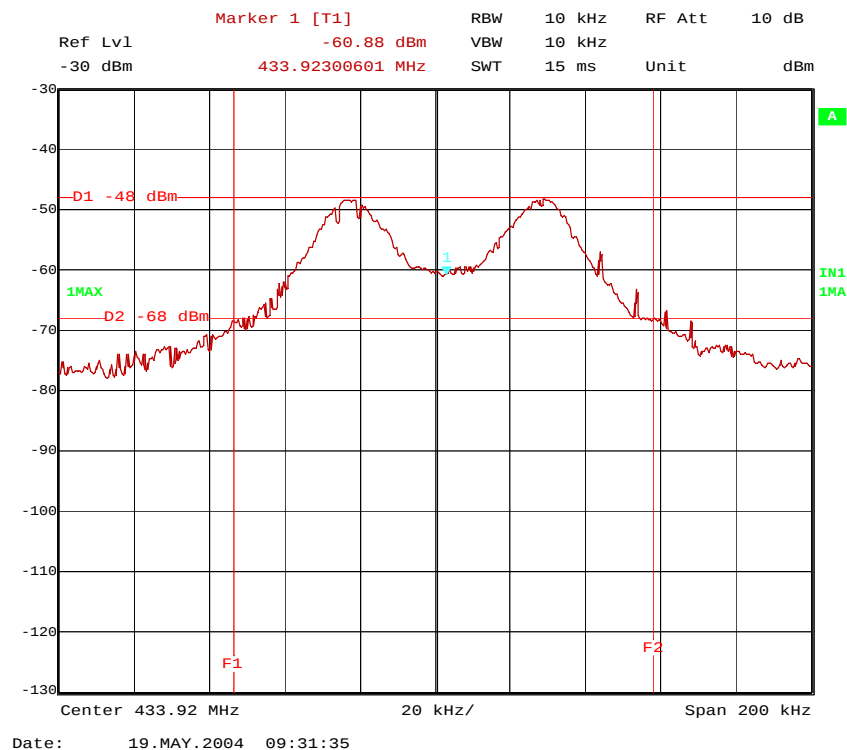
TEST EQUIPMENT USED FOR THE TEST:

14 – 20, 42 – 44, 47

## 6.4 BANDWIDTH OF EMISSION

|                     |       |                   |      |
|---------------------|-------|-------------------|------|
| Ambient temperature | 20 °C | Relative humidity | 50 % |
|---------------------|-------|-------------------|------|

Test record: The test was carried out in normal operation-mode.



40448obw1.wmf: Bandwidth of emission

| f (low)<br>Lower frequency:<br>(- 20 dB-point) | f (high)<br>Higher frequency:<br>(- 20 dB-point) | Bandwidth of<br>emission:<br>$B = f(\text{high}) - f(\text{low})$ | Limit:     | Result: |
|------------------------------------------------|--------------------------------------------------|-------------------------------------------------------------------|------------|---------|
| 433.866 MHz                                    | 433.978 MHz                                      | 112 kHz                                                           | 1.0848 MHz | Passed  |

Test: Passed

## TEST EQUIPMENT USED FOR THE TEST:

|            |
|------------|
| 31, 46, 47 |
|------------|

## **7 TEST EQUIPMENT AND ANCILLARIES USED FOR TESTS**

| Emission measurement at AC mains and DC in / out ports at M4 |                     |                |                 |                          |                  |
|--------------------------------------------------------------|---------------------|----------------|-----------------|--------------------------|------------------|
| No.                                                          | Test equipment      | Type           | Manufacturer    | Serial No.               | PM-No            |
| 1                                                            | Shielded chamber M4 | -              | Siemens         | B83117S1-X158            | 480088           |
| 2                                                            | Measuring receiver  | ESAI           | Rohde & Schwarz | 831953/001<br>833181/018 | 480025<br>480026 |
| 3                                                            | LISN                | NSLK8128       | Schwarzbeck     | 8128155                  | 480058           |
| 4                                                            | DC-filter           | B84266-A21-E13 | Siemens         | 940164525                | 480099           |
| 5                                                            | AC-filter           | B84299-D87-E3  | Siemens         | 930262292                | 480097           |
| 6                                                            | EMI-Software        | ES-K1          | Rohde & Schwarz | -                        | 480111           |

| Radiated emission measurement at M5 |                           |          |                 |                |        |
|-------------------------------------|---------------------------|----------|-----------------|----------------|--------|
| No.                                 | Test equipment            | Type     | Manufacturer    | Serial No.     | PM-No  |
| 7                                   | Fully anechoic chamber M5 | -        | Siemens         | B83177-S1-X156 | 480073 |
| 8                                   | Measuring receiver        | ESVS30   | Rohde & Schwarz | 829673/012     | 480024 |
| 9                                   | Controller                | HD100    | Deisel          | 100/324        | 480067 |
| 10                                  | Antenna support           | MA240    | Deisel          | 228/314        | 480069 |
| 11                                  | Turntable                 | DS412    | Deisel          | 412/317        | 480070 |
| 12                                  | Antenna                   | CBL6112C | Chase           | 2689           | 480327 |
| 13                                  | EMI Software              | ES-K1    | Rohde & Schwarz | -              | 480111 |

| Radiated emission measurement at M6 |                     |           |                  |            |        |
|-------------------------------------|---------------------|-----------|------------------|------------|--------|
| No.                                 | Test equipment      | Type      | Manufacturer     | Serial No. | PM-No  |
| 14                                  | Open area test site | -         | Phoenix Test-Lab | -          | 480085 |
| 15                                  | Measuring receiver  | ESVS30    | Rohde & Schwarz  | 829673/012 | 480024 |
| 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 A | Chase            | 1643       | 480147 |
| 20                                  | EMI Software        | ES-K1     | Rohde & Schwarz  | -          | 480111 |

| Radiated emission measurement at M8 |                           |      |                 |                   |        |
|-------------------------------------|---------------------------|------|-----------------|-------------------|--------|
| No.                                 | Test equipment            | Type | Manufacturer    | Serial No.        | PM-No  |
| 21                                  | Fully anechoic chamber M8 | -    | Siemens         | B83117-E7019-T231 | 480190 |
| 22                                  | Measuring receiver        | ESMI | Rohde & Schwarz | 843977/001        | 480179 |

|    |                    |           |                 |            |        |
|----|--------------------|-----------|-----------------|------------|--------|
| 23 | Measuring receiver | ESCS 30   | Rohde & Schwarz | 828985/014 | 480270 |
| 24 | Controller         | HD100     | Deisel          | 100/427    | 480181 |
| 25 | Turntable          | DS420     | Deisel          | 420/435/97 | 480186 |
| 26 | Antenna support    | AS615P    | Deisel          | 615/310    | 480187 |
| 27 | Antenna            | CBL6112 A | Chase           | 2034       | 480185 |
| 28 | EMI Software       | ES-K1     | Rohde & Schwarz | -          | 480111 |

| Radiated emission measurement at M20 |                            |           |                    |                          |                  |
|--------------------------------------|----------------------------|-----------|--------------------|--------------------------|------------------|
| No.                                  | Test equipment             | Type      | Manufacturer       | Serial No.               | PM-No            |
| 29                                   | Fully anechoic chamber M20 | -         | Albatross Projects | B83107-E2439-T232        | 480303           |
| 30                                   | Measuring receiver         | ESMI      | Rohde & Schwarz    | 843977/001<br>843530/018 | 480179<br>480180 |
| 31                                   | Measuring receiver         | ESI 40    | Rohde & Schwarz    | 100064                   | 480355           |
| 32                                   | Controller                 | HD100     | Deisel             | 100/670                  | 480326           |
| 33                                   | Turntable                  | DS420HE   | Deisel             | 420/620/80               | 480315           |
| 34                                   | Antenna support            | AS615P    | Deisel             | 615/310                  | 480187           |
| 35                                   | Antenna                    | CBL6112 B | Chase              | 2688                     | 480328           |
| 36                                   | Antenna                    | 3115 A    | EMCO               | 9609-4918                | 480183           |
| 37                                   | RF-cable No. 30            | RTK 081   | Rosenberger        | -                        | 410141           |
| 38                                   | EMI Software               | ES-K1     | Rohde & Schwarz    | -                        | 480111           |
| 39                                   | RF-cable No. 5             | RTK 081   | Rosenberger        |                          | 410097           |

| Ancillary equipment used for testing |                                     |           |                  |            |        |
|--------------------------------------|-------------------------------------|-----------|------------------|------------|--------|
| No.                                  | Test equipment                      | Type      | Manufacturer     | Serial No. | PM-No  |
| 40                                   | Outdoor test site                   | -         | Phoenix Test-Lab | -          | 480293 |
| 41                                   | Loop antenna                        | HFH2-Z2   | Rohde & Schwarz  | 832609/014 | 480059 |
| No.                                  | Test equipment                      | Type      | Manufacturer     | Serial No. | PM-No  |
| 42                                   | Power supply                        | TOE 8852  | Toellner         | 51712      | 480233 |
| 43                                   | EMI test receiver                   | ESPC      | Rohde & Schwarz  | 843756/006 | 480150 |
| 44                                   | Signal generator                    | SMHU      | Rohde & Schwarz  | 844170/017 | 480266 |
| 45                                   | Climatic chamber                    | GTS500.40 | GTS              | 1660       | 490073 |
| 46                                   | Loop Antenna $\varnothing = 225$ mm | -         | Phoenix Test-Lab | -          | 410085 |
| 47                                   | RF-cable No. 11                     | RG223     | Phoenix-Test-Lab | -          | 410103 |

All used measurement equipment was calibrated (if necessary). The calibration intervals and the calibration history will be given out on request.

## 8 LIST OF ANNEXES

|                |                                                       |                |
|----------------|-------------------------------------------------------|----------------|
| <b>ANNEX A</b> | <b>PHOTOGRAPHS OF THE TEST SET-UPS:</b>               | <b>2 pages</b> |
|                | Test set-up preliminary radiated emission measurement | 40448emi2.jpg  |
|                | Test set-up final radiated emission measurement       | 40448emi28.jpg |
| <b>ANNEX B</b> | <b>EXTERNAL PHOTOGRAPHS OF THE TEST SAMPLE:</b>       | <b>1 page</b>  |
|                | EUT, front view                                       | 40448eut1.jpg  |