IEEE 802.15 WNG

Total Radiated Power spectral density ($TRP_{sd}$) by JRC

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<table>
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Summary of $TPR_{sd}$ measurement in 2023 by JRC, ISPRA

11.03.2024

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Introduction

• These slides present a summary of the measurement results contained in the $TRP_{sd}$ measurement report from the JRC in Ispra

• The Joint Research Centre (JRC) is part of the EU commission and supports the regulation activities in Europe

• “Report on Measurement Campaigns for Total Radiated Power of UltraWideBand (UWB) device to support EU RF spectrum regulation”
  • [https://publications.jrc.ec.europa.eu/repository/handle/JRC134860](https://publications.jrc.ec.europa.eu/repository/handle/JRC134860)

• Results should be used for the future simulation in the band extension WI in SE24

• Further measurements are planned in 2024
Total Radiate Power spectral density ($TRP_{sd}$)

- Total Radiated Power (TRP) is a Radio Frequency (RF) engineering term used to describe the sum of all power radiated by an antenna connected to a transmitter.
- $TRP_{sd}$ represent the overall power emitted by a device in the given bandwidth (typically 1MHz).
- $TRP_{sd}$ represents an average value for the interference potential of a device in all directions.
  - In contrast to the e.i.r.p in dBm/MHz value which represents the worst case of the interference potential into one dedicated direction.
- For any kind of aggregated interference investigations, the $TRP_{sd}$ value is the more appropriate value.
Definition of $TRP_{sd}$

\[
TRP_{sd} = \int_{\Theta=0}^{\pi} \int_{\Phi=0}^{2\pi} \frac{P_{psd,\Theta,\Phi}}{A_r} \times r^2 \times \sin(\Theta) \, d\Theta \, d\Phi
\]  

(A.10)

Where:

- Radiated mean power spectral density $P_{psd,\Theta,\Phi}$, measurement in 1 MHz (recorded) one point of the sphere depending $\Theta$ and $\Phi$ and frequency
- $r$ is the radius of the sphere/measurement distance
- $\Theta$ is the elevation angle
- $\Phi$ is the azimuth angle
- $A_r$ is the effective area of the receiving antenna (measurement antenna)

Reference: ETSI TR 103 750 V1.1.1
Basic measurement setup

Experiments were carried out in the JRC's Shielded Anechoic Chamber (SAC) of the DG JRC of the European Commission, located in Ispra, Italy. The device under test (DUT) was a UWB module development kit, Qorvo DWM3001CDK (described more in detail in section 2.3.2), placed in the quiet zone of the chamber on a two-axis positioner as shown on the picture of Figure 1. On the left in the foreground, appears a double-ridged horn antenna used as probe antenna to measure the radiation emitted by the DUT.

A schematic of the measurement setup is shown in Figure 2. The DUT was placed on a two-axis system consisting of a compact table providing rotation around the vertical axis and a turn unit for the rotation around the horizontal axis. The aperture of the probe antenna was placed at a distance $d$ from the centre of the DUT antenna. Measurements were performed at two different distances, i.e. $d=1$ m and $d=3$ m. Absorbers were removed from the floor for the measurements at $d=1$ m because there was not enough space between the compact table and the probe antenna tripod whereas twelve pieces of absorbers were present for the measurements at $d=3$ m in the full anechoic configuration of the chamber.

A low noise amplifier (LNA) was connected to the probe antenna, followed by a series of coaxial cables linked to a spectrum analyser situated in the laboratory below the chamber. A computer was used to acquire the spectrum trace and to control the axes.

Figure 1: Over The Air (OTA) measurement set up in the Shielded Anechoic Chamber (SAC) in full anechoic configuration.
Setup: technical details

The terminology and coordinate system are taken from the CTIA Test Plan for Wireless Device Over-the-Air Performance [4]. A spherical coordinate system is linked to the DUT as shown in Figure 3. The phi axis is defined as being along the Z-axis. As the phi axis rotates, the orientation of the theta axis varies with respect to the DUT. The green arrow identifies the direction of the probe antenna (Horn antenna).

The two polarizations of the measured electric field are defined in terms of the two rotation axes:

- $\phi$-polarization is along the direction of motion when the phi axis rotates
- $\Theta$-polarization is along the direction of motion when the theta axis rotates

In the same manner as the combined-axes system shown in Appendix A of the CTIA test plan and reproduced in Figure 4, our Z-axis is in fact the horizontal axis. Therefore, the phi polarization is measured when the polarization of horn antenna is orientated vertically. The horn antenna was rotated by 90° to measure the theta polarization.

This referential differs from the one described in clause 5.6 of EN 303883 [2] where $\theta$ is the elevation angle and is independent of phi. In the present report, phi and theta are combined axes.

Figure 2: Measurement setup
Device under test

Figure 3: Coordinate system associated with the DUT

The compact table was rotated around the vertical axis (theta axis) from 5° to 175° in steps of 10°. For each theta angle, the turn unit, holding the DUT, was rotated from 0° to 360° in steps of 10°. In total, radiation patterns were measured for 18 values of theta and 37 values of phi.
Measurement procedure

Figure 3: Coordinate system associated with the DUT

Figure 4: Typical setup for a combined-axes system as shown in Appendix A of the CTIA test plan [4].
Example 3D radiation pattern

Figure 13: Example of 3D radiation pattern
Measurement results

Table 9: Measurement results

<table>
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<tr>
<th>UWB channel</th>
<th>Distance (m)</th>
<th>EIRP (dBm)</th>
<th>EIRP_{SD} (dBm/MHz)</th>
<th>TRP (dBm)</th>
<th>TRP_{SD} (dBm/MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1</td>
<td>-13.15</td>
<td>-38.25</td>
<td>-20.16</td>
<td>-45.57</td>
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<tr>
<td>9</td>
<td>1</td>
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<td>-45.28</td>
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<tr>
<td>5</td>
<td>3</td>
<td>-12.93</td>
<td>-37.95</td>
<td>-19.9</td>
<td>-45.2</td>
</tr>
</tbody>
</table>
Some comments to measurements

- Duty Cycle of the device has been set to the maximum possible without changing the default power settings leading to a slightly higher TX power
  - Maximum mean e.i.r.p. > -41.3dBm/MHz
  - Not fully conform to regulation
  - Simplification of measurements and increased measurement accuracy

- In all channels the $TRP_{sd}$ levels are significantly below the maximum mean e.i.r.p. value

- More directive antennas or absorbing material will increase the difference between maximum mean e.i.r.p. and $TRP_{sd}$

- Assumption of fully omnidirectional emissions is very worst case and not realistic
Summary and outlook

- Slides presented a summary of the JRC $TRP_{sd}$ measurements
- An isolated UWB device reaches an $TRP_{sd}$ level which is 7dB below the maximum mean e.i.r.p. value
  - -48.3dBm/MHz ($TRP_{sd}$) versus -41.3dBm/MHz (maximum e.i.r.p.), mitigating factor of 7dB
- Additional gains can be assumed in real deployment scenarios for
  - Body worn devices
  - Fixed installed access point with directive antennas
  - Wall mounted device
- Additional measurements to confirm this assumptions are planned
- Future regulation should include maximum mean e.i.r.p. value and $TRP_{sd}$
- More details: https://publications.jrc.ec.europa.eu/repository/handle/JRC134860
Acknowledgment

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• The author of the reports are
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