LoRaWAN® The Power of Testing

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Market Segment Manager IoT - Rohde & Schwarz
Rohde & Schwarz: Innovation is in our DNA

Rohde & Schwarz started as a two-man laboratory 85 years ago and grew into a global group of companies standing for innovation in the fields of safe, secure and reliable communication.

11,000+ Employees worldwide

€ 2.0+ Bn Annual revenue

70+ Global presence
Rohde & Schwarz: some of our latest products

**Plane Wave Converter**
Enable 5G network deployments by effective base station testing solution

**Quick Personnel Security Scanner**
Extremely fast scans generate billions of data points analyzed by AI

Test and Measurement solutions from R&D to production for LoRaWAN®
Every technology has some limitations, but finally the implementation matters.
Challenges of our IoT customers

Technology choices

Design complexity

Myth of certification

LoRa Alliance®

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Design challenges to meet specific IoT requirements

- Quality & reliability
- Low power
- Deep coverage
LoRaWAN® in a nutshell

- Chirped Spread Spectrum (125/250/500 kHz)
- Multiple gateways simultaneously receiving
- Pseudo–random frequency hopping (after each TX)
- Data rate adaption (spreading factor/bandwidth)
- Different RX mode options (Class A/B/C)

**LoRaWAN**

**Object (Sensor)**

**Gateway**

**Network Server**

**LoRa Alliance**

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Don’t underestimate the basics of RF design

Matching
Ground plane
Housing
Interference

Bandwidth
Directivity
Gain

Return loss (S11)
TRP/TIS
Tx Power / Spectrum
Error Vector Magnitude
Receiver Sensitivity

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LoRaWAN® RF measurements for verification and regulatory conformance testing

**RF Transmitter-Test**
- Spectrum analyzer
- Test Tool
- Measuring parameters:
  - Tx bandwidth
  - Emission output power
  - Spectral density
  - FM Time Domain

**RF Receiver-Test**
- Signal Source
- Vector signal generator
- Test Tool
- Measuring PER under different signal conditions:
  - Frequency drift
  - Offset
  - Timing errors

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# Regulatory Requirements for example ETSI & FCC

**ETSI EN 300 220-1**
Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz; Part 1: Technical characteristics and methods of measurement

**FCC Title 47: Telecommunication**
PART 15—RADIO FREQUENCY DEVICES
§15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

## For example:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Emissions in Non-restricted bands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective radiated power</td>
<td></td>
</tr>
<tr>
<td>Power spectrum density</td>
<td></td>
</tr>
<tr>
<td>Out of band emission</td>
<td></td>
</tr>
<tr>
<td>Duty cycle</td>
<td></td>
</tr>
</tbody>
</table>

## e.g. for Systems employing Digital Modulation

<table>
<thead>
<tr>
<th>Parameter</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6 dB Tx bandwidth</td>
<td>Emission Output Power</td>
</tr>
<tr>
<td>Emission Output Power</td>
<td>Power Spectral Density</td>
</tr>
<tr>
<td>Emissions in Non-restricted bands</td>
<td></td>
</tr>
</tbody>
</table>
Antennas – often overlooked, but most critical in wireless design

Check antenna performance (gain, BW, frequency) and tune

\[ |S_{11}|^2 = \frac{P_{\text{ref}}}{P_S} \]

Check overall RF performance of final design (TRP, TIS, directivity)

Source: Fabien Ferrero Antenna workshop at Things conference see Github
RF Performance evaluation procedure

- Requested by many LoRaWAN® Operators in order to ensure required/expected RF performance
- Created by the LoRa Alliance™ certification committee to have a harmonize approach to the measurement of **Transmit and Receive performance** of LoRaWAN® products
  - **Transmission performance** is measured as EIRP in a full 3D radiation power pattern with maximum segmentation of 10 degrees in both theta- and phi planes
  - **Received performance** is measured by detecting the point that the product reached a packet error rate of 10% (performed in RX1 & RX2)
- Requests to make these test MANDATORY! So far manufactures are free to declare the results e.g. on the LoRa Alliance™ webpage

https://lora-alliance.org/lorawan-rf-certified-products
Example: TRP measured by the EIRP at several points around the sphere

- Measured on one channel, in case of EU region at 863.1 MHz with a continuous wave (CW),
- In addition for the TIS calculation on 868.3 MHz (RX1 window) and 869.525 MHz (RX2 window)
- For the full 3D pattern the EIRP(\(\phi, \theta\)) is measured with both orthogonal polarizations for every direction of the sphere using a maximum segmentation of 10 degrees (264 points)
- The TRP corresponds to a spatial average of EIRP

\[
TRP = \frac{1}{4\pi} \int \left\{ EIRP_\phi(\Omega, f) + EIRP_\theta(\Omega, f) \right\} d\Omega
\]

\(f\) – frequency; \(\Omega\) – solid angle of direction, \(\theta/\phi\) – polarization
Verification of the electronic design

- Power consumption
- Power Integrity
- Interference
- DC rail tolerance (Vpp)
- Unwanted signals
- Power consumption
- Digital channel analysis
- Multi-domain analysis

- Conformance
- Signal integrity
- Crosstalk

LoRaWAN
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Low power design is more than just using low power hardware and LPWAN technologies.
LoRa Alliance™ certification focusing on interoperability and performance

All certification testing is performed by independent, LoRa Alliance member company laboratories for LoRa Alliance™ members only!

https://www.lora-alliance.org/certification-overview

Test items
- Device activation
- Test application functionality
- Over the Air activation
- Packet Error Rate
- Cryptography
- Download window timing
- Frame sequence number
- MAC commands
- Confirmed packets
- Uplink transmission
- **Optional OTA performance**

LoRa Alliance™ Authorized Test Houses

**European**
- EU 863-870 MHz Region End Device Cert. (V1.5)

**US + Canada**
- US902-928 MHz Region End Device Cert. (V1.3)

**Asia**
- AS 923 MHz Region End Device Certification Requ. (V1.1)

**South Korea**
- 920-923 MHz Region End Device Cert. Requ. (V1.2)

**India**
- 865-867 MHz Region End Device Cert. Requirements (V1.1)

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LoRaWAN® device and gateway testing needs

Design verification
- RF Performance testing
- Antenna Design Verification
- Low power design

Certification
- MANDATORY
- Being MANDATED
- Operator Certification
  MANDATORY

End-of-line testing
- Output power
- Frequency
- Receiver Sensitivity

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