Developing wireless products can have antenna pitfalls if you don't know what to look for

Roger Denker, MegiQ, on behalf of TOP-electronics

Early prototype development for IoT & 4G frequencies

Antennas are not just components, they need to be implemented with attention to their application and environment.

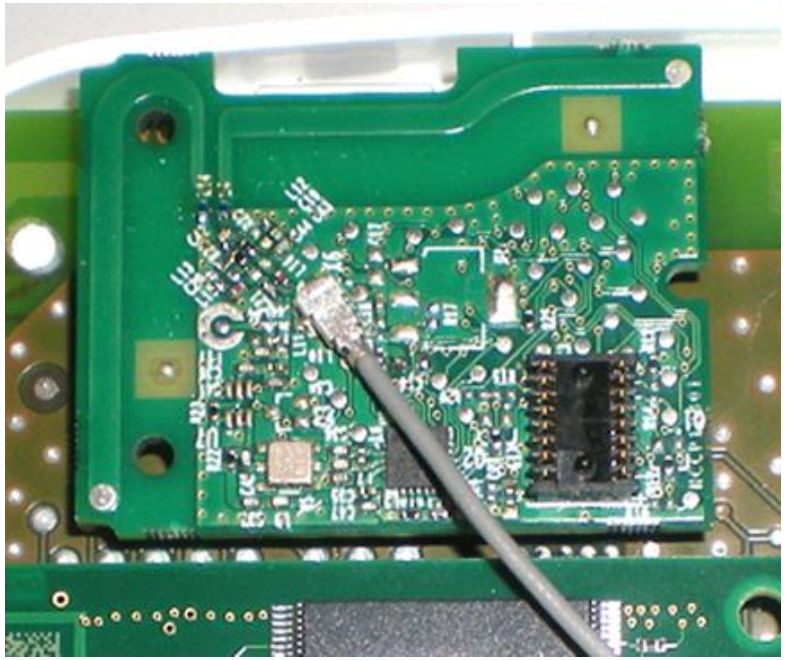
Not only should the antenna impedance be matched. The radiation pattern should also meet certain criteria.

This presentation focus on early prototype development for IoT and 4G frequencies and how to monitor the RF characteristics during the development cycle.

Antennas are not components

Internal antennas depend heavily on their direct environment.

Most antennas depend on the grounding provided by the PCB and the rest of the product.

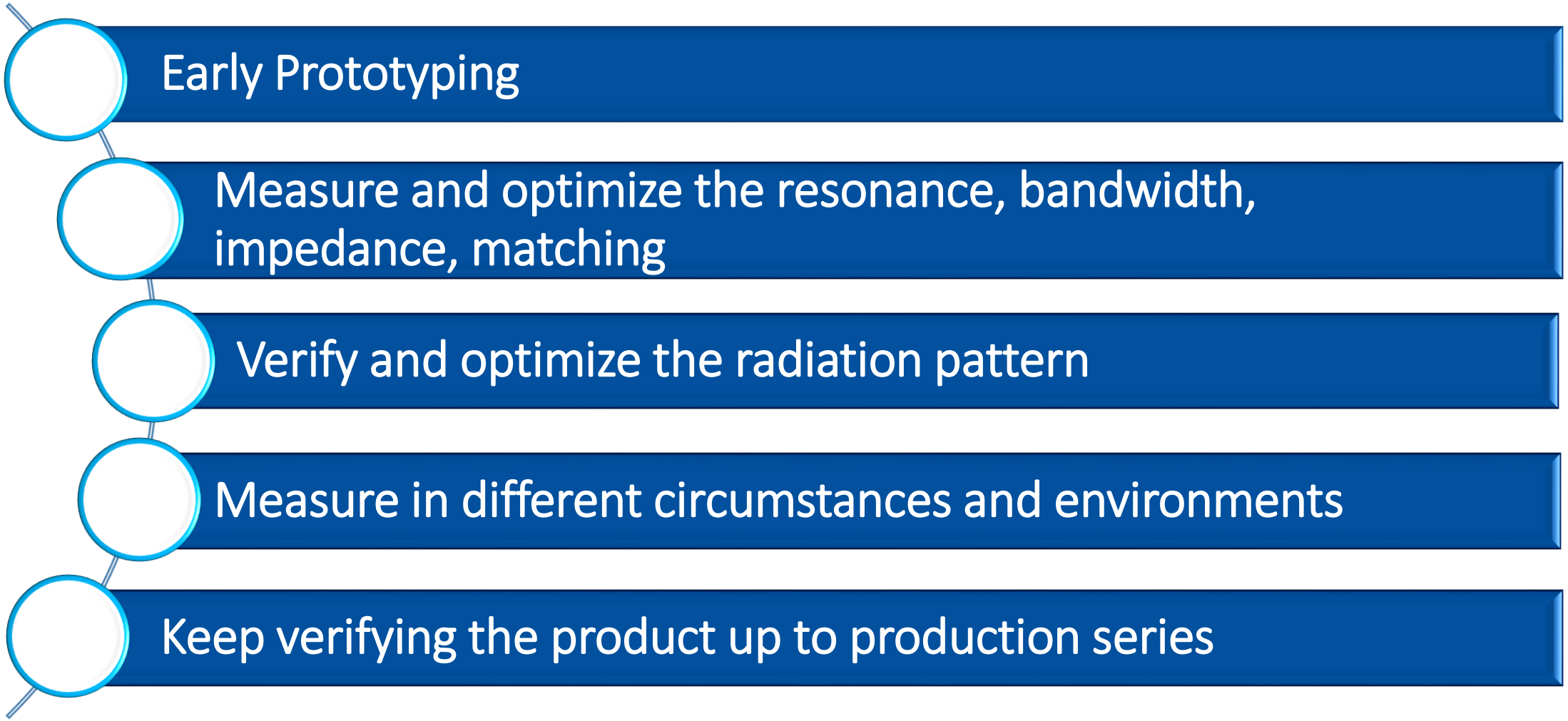


Antennas need to be designed-in and integrated in the product.

The impedance must be tuned within the device.

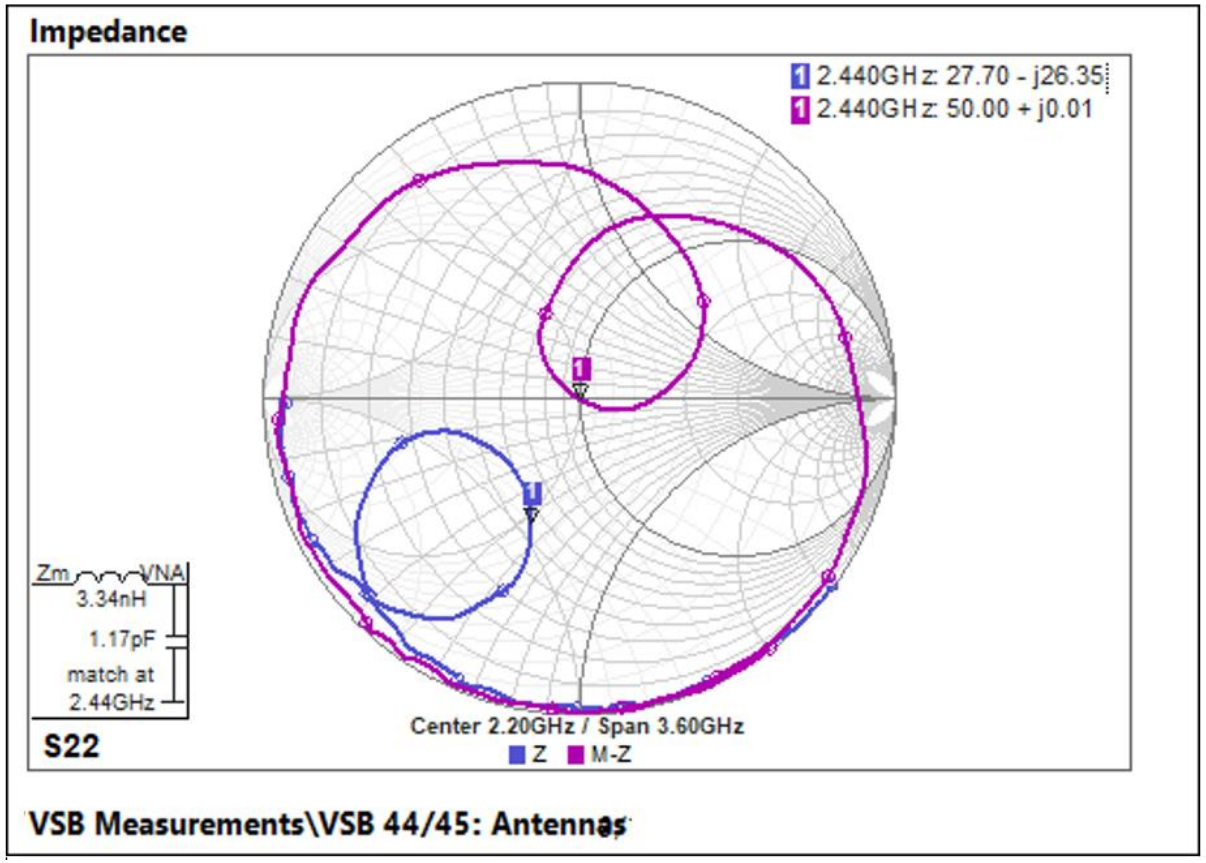
The radiation must be measured and guarded against design changes and restyling.

Antenna Development Cycle

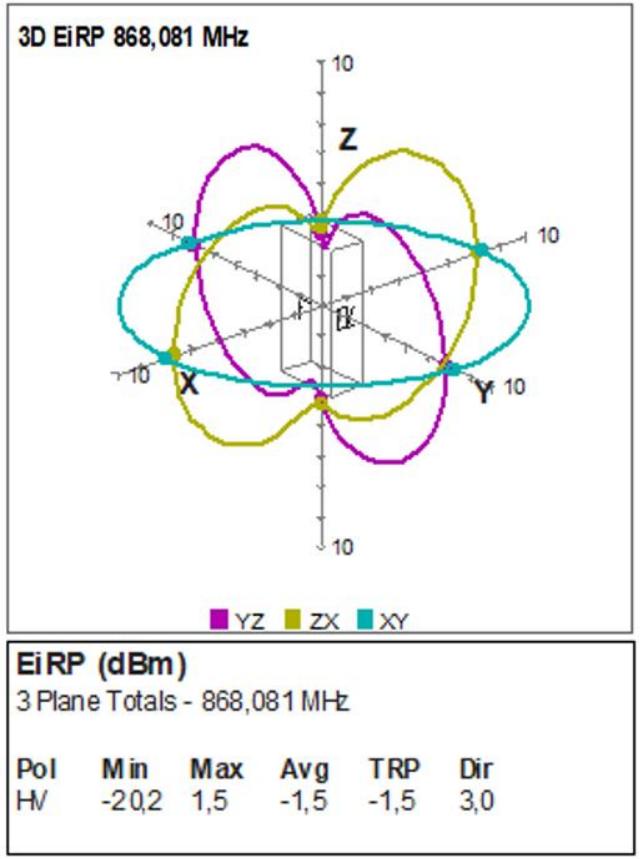


Antenna Measurements

Measure, optimize and match the antenna impedance



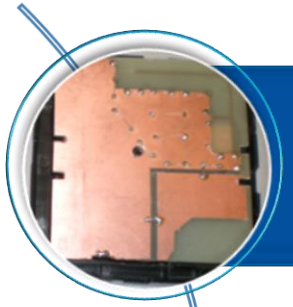
Measure and optimize the antenna radiation



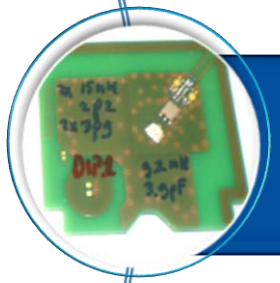
TOP ELECTRONICS

MegiQ

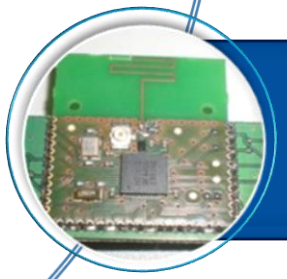
Early Prototyping



Standalone antenna on handcut PCB

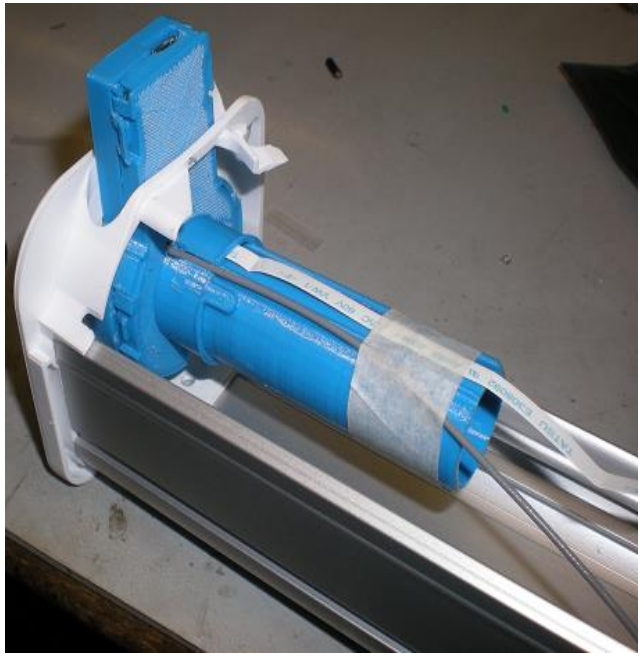


Design a PCB with only antenna and transceiver and the larger key components (battery, display, connectors)



Use an early cabinet prototype

Measure the complete device



Measure the complete device including cabinet, mounting, cables

In small devices, all parts are interacting together.

The (plastic) cabinet is an integral part of the antenna implementation.

The device as a whole acts as antenna.

Peripherals like battery, display, connectors, cables must be in place during antenna evaluation.

The cabinet must be in place and well closed.

When using SLR or printed models for prototyping, the antenna must later be re-tuned with the actual cabinet material (ABS).

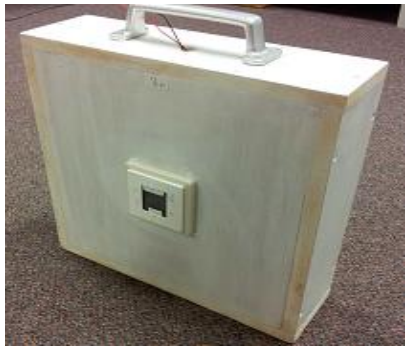
Simulating the environment

Antenna environment can seriously affect the performance.

Environment includes cabinet, metal objects, human body, mounting surface.

Simulating the human body:

⇨ for meat lovers: bacon is similar to human body



⇨ vegetarians: plant oasis soaked in 0.9% salt solution also works well

Build your own wall for testing on concrete

Submerge in water for some applications

TOP ELECTRONICS

MegiQ

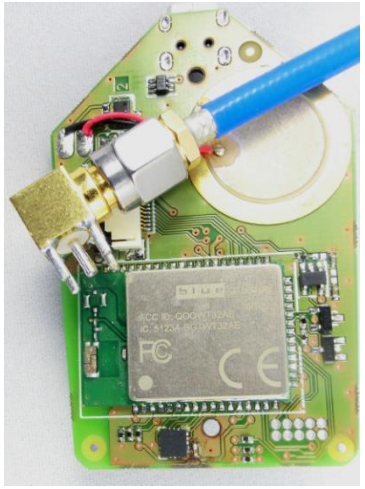
Measuring Antenna Impedance

Antenna impedance is measured with a Vector Network Analyzer (VNA).

The VNA is connected to the antenna feed point, or at the input of the antenna matching circuit.

The VNA generates an RF signal and measures the Voltage / Current ratio to determine the impedance.

Using UFL connectors



When measuring small devices, the usual High End connectors are too large and will affect the measurement.

Tools for practical measurements are provided to measure with UFL connectors because they are very small and can be incorporated in a product prototype.

UFL connectors and cables, although not the same quality as SMA or N-connectors, are very practical and can be used up to 6GHz.

The UFL imperfections are calibrated during the measurement calibration.

The VNA software can normalize them out of the results.

Impedance measurement procedure

Calibrate the VNA with UFL adapter and cable.

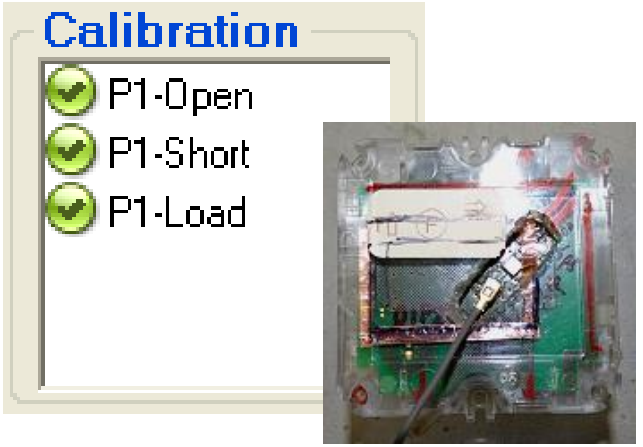
Connect the cable to the antenna input.

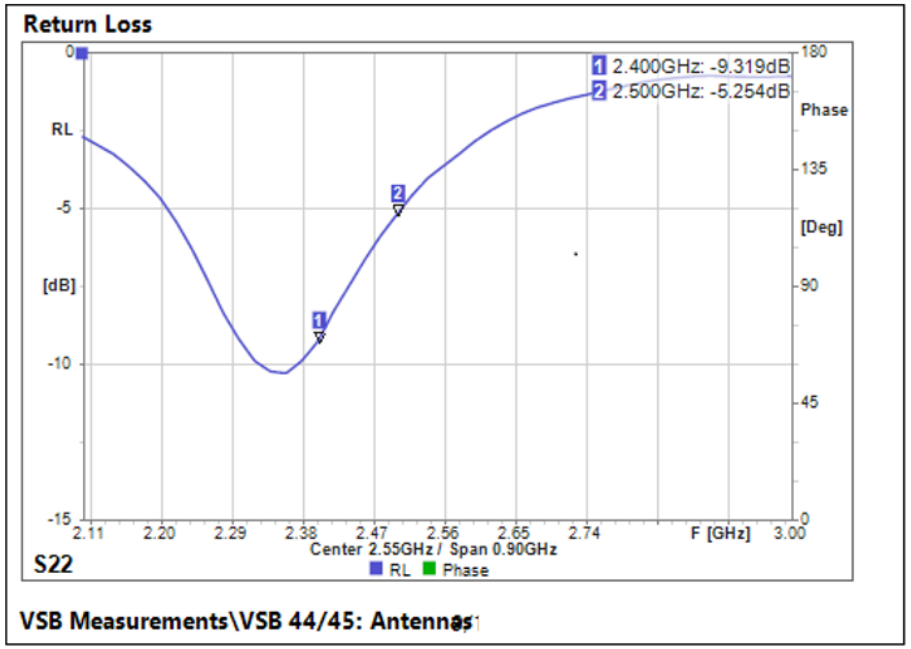
Bypass any matching circuit and disconnect the transceiver chip.

Assemble the complete device, drill a hole in the cabinet to feed the UFL cable.

Place the device on a neutral platform (styrofoam).

Perform a VNA measurement, store the result for later reference.





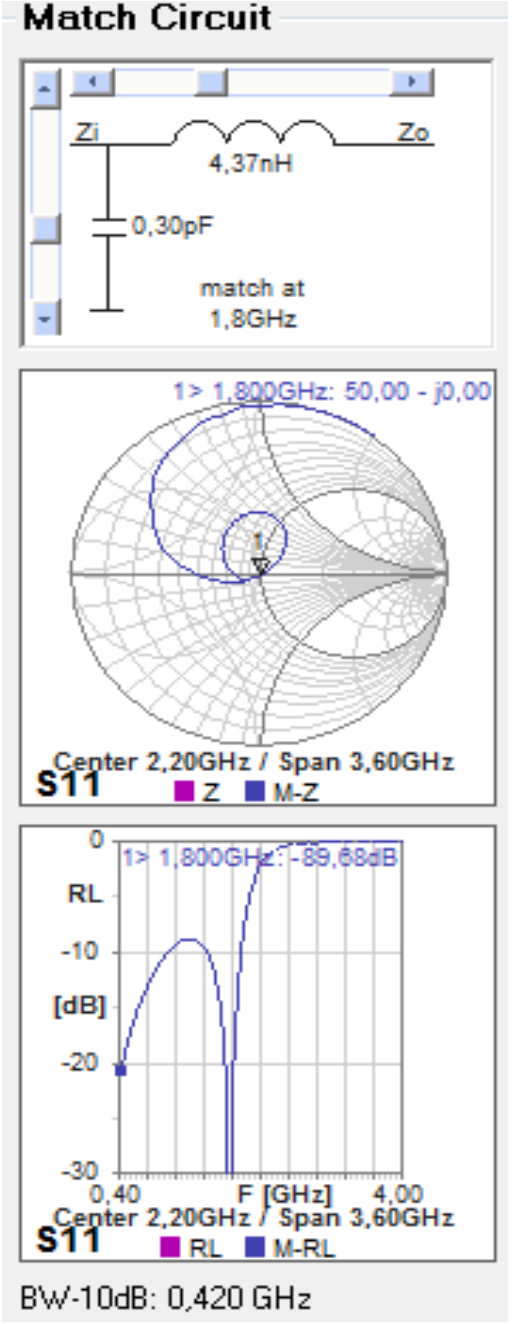
Optimizing the Impedance

Tuning
If necessary, cut or extend the antenna length to get a resonance at the desired frequency.

Matching
The VNA software provides a function to calculate a matching circuit automatically.

Bandwidth
The matching circuit can be adjusted to optimize the antenna bandwidth.

For multiband antennas the data can be exported and used by Atyune matching software.



Sandbox, UFL and Balanced Cal Kit's

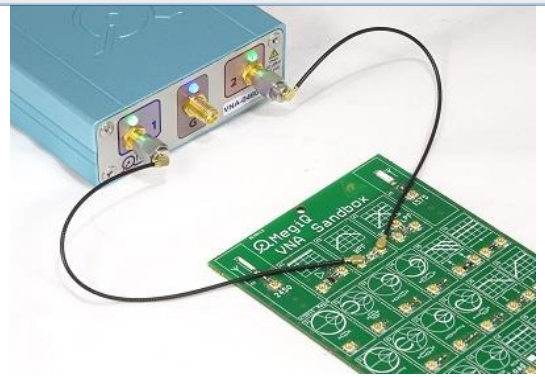
VNA Sandbox

UFL OSLT calibration-kit and

example circuits to get a feel for VNA measurements.

The Cal-kit on the sandbox allows

measurements on other UFL boards and prototypes.



UFL and Balanced Cal Kit

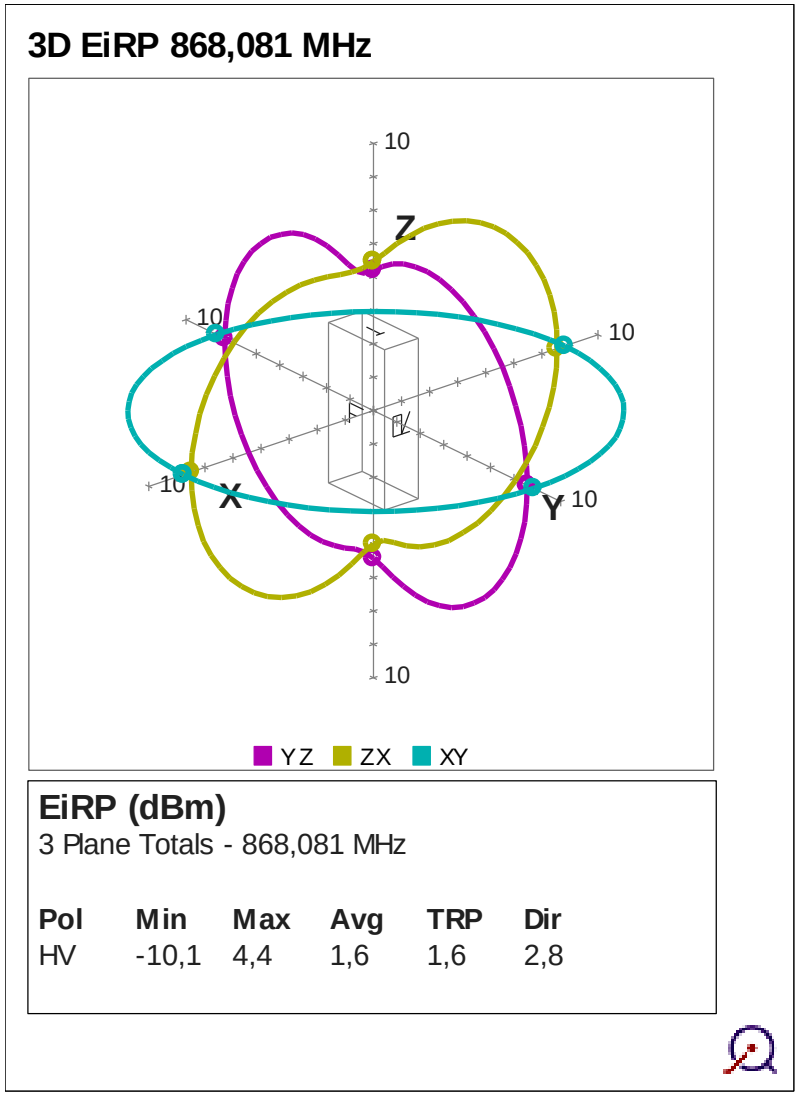
For more elaborate UFL calibration and balanced measurements.

UFL Measurement to 6GHz

Dual UFL OSLT Cal Kits for different layer stackings

Balanced Measurement to 3GHz

Antenna Radiation



Ultimately, the wireless performance is determined by the antenna radiation.

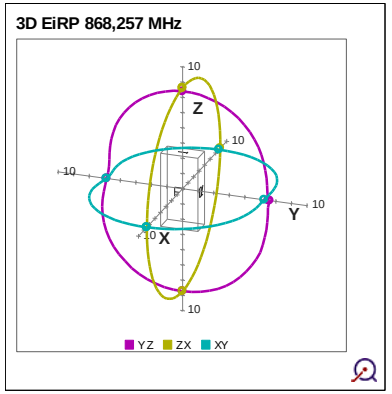
Verifying the radiation performance shows whether the device is suited for a wireless system or not.

It is best to evaluate the radiation performance early in the development, preferably by testing different antenna concepts.

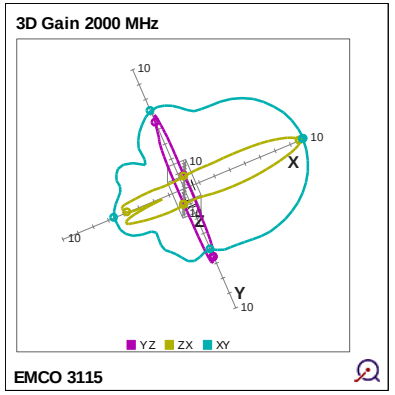
The antenna radiation should be guarded throughout the development process to make sure that it has not deteriorated by changes in the product.

Different Radiation patterns

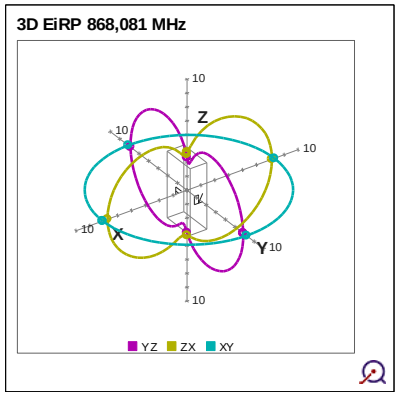
Which direction and polarization do we need?



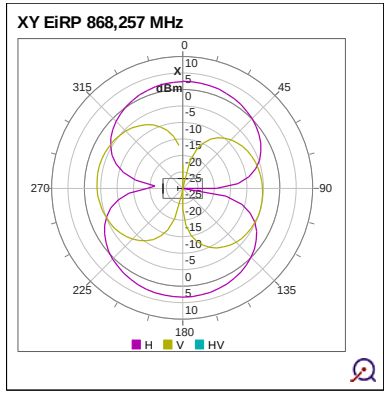
Omni-directional



Directional



Planar



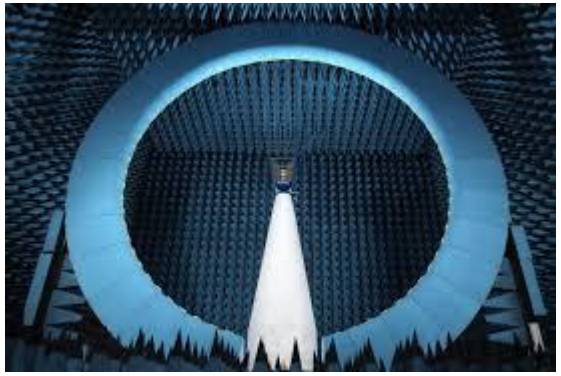
Polarization

For domestic applications it is often assumed that reflections will disperse the polarization, so that it can be mostly ignored.

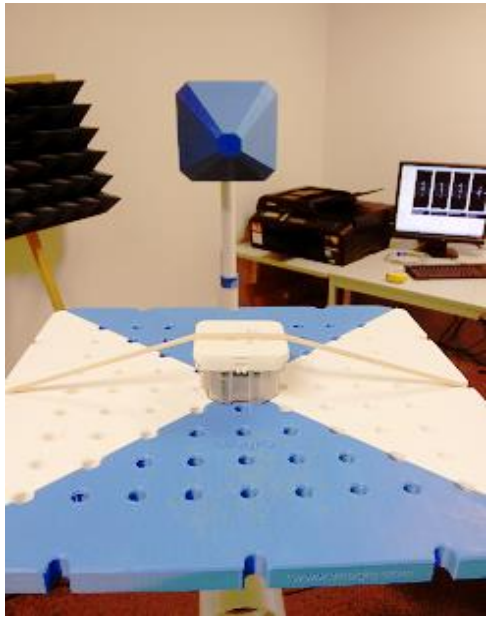
For domestic and handheld applications the orientation of the device can usually not be controlled. It is usually best to have an omni-directional pattern.

Systems for measuring Radiation

Anechoic Chamber



Satimo Starlab



MegiQ RMS-0660

Frequency range 600 to 6000 MHz.

Can be used without anechoic chamber.

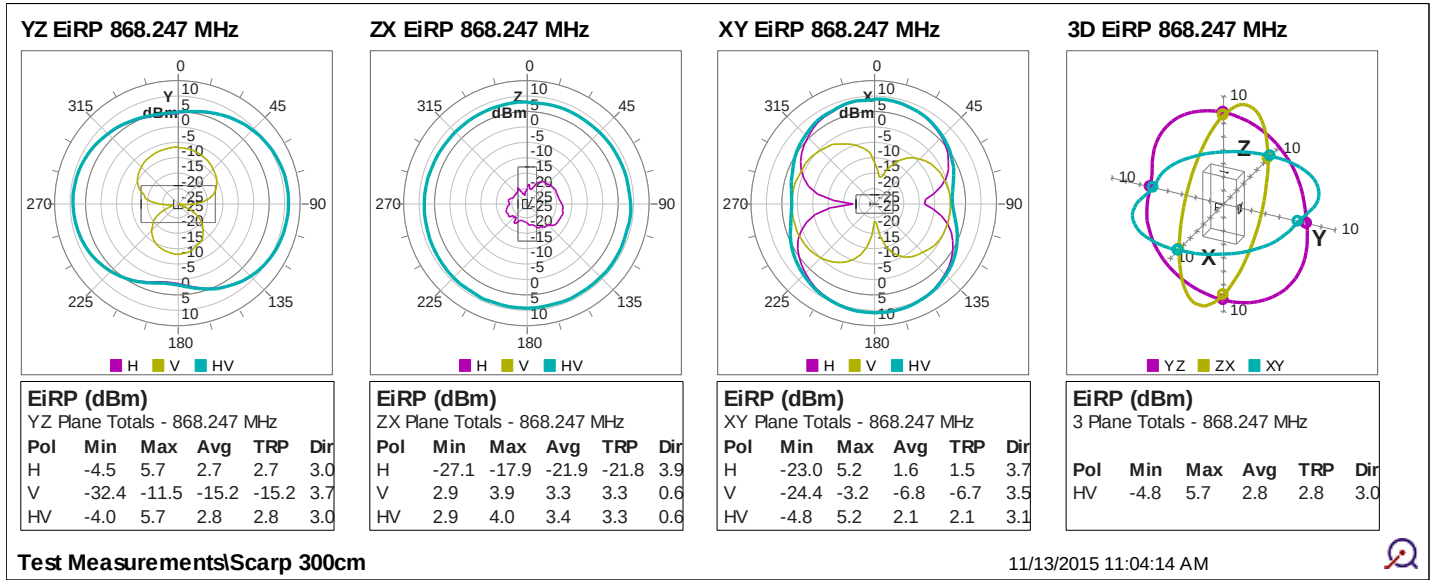
Reverberation Chamber

Bluetest Rev. Chamber

TOP ELECTRONICS

MegiQ

Radiation measurement results



EiRP (dBm)
YZ Plane Totals - 868.247 MHz

Pol	Min	Max	Avg	TRP	Dir
H	-4.5	5.7	2.7	2.7	3.0
V	-32.4	-11.5	-15.2	-15.2	3.7
HV	-4.0	5.7	2.8	2.8	3.0

EiRP (dBm)
ZX Plane Totals - 868.247 MHz

Pol	Min	Max	Avg	TRP	Dir
H	-27.1	-17.9	-21.9	-21.8	3.9
V	2.9	3.9	3.3	3.3	0.6
HV	2.9	4.0	3.4	3.3	0.6

EiRP (dBm)
XY Plane Totals - 868.247 MHz

Pol	Min	Max	Avg	TRP	Dir
H	-23.0	5.2	1.6	1.5	3.7
V	-24.4	-3.2	-6.8	-6.7	3.5
HV	-4.8	5.2	2.1	2.1	3.1

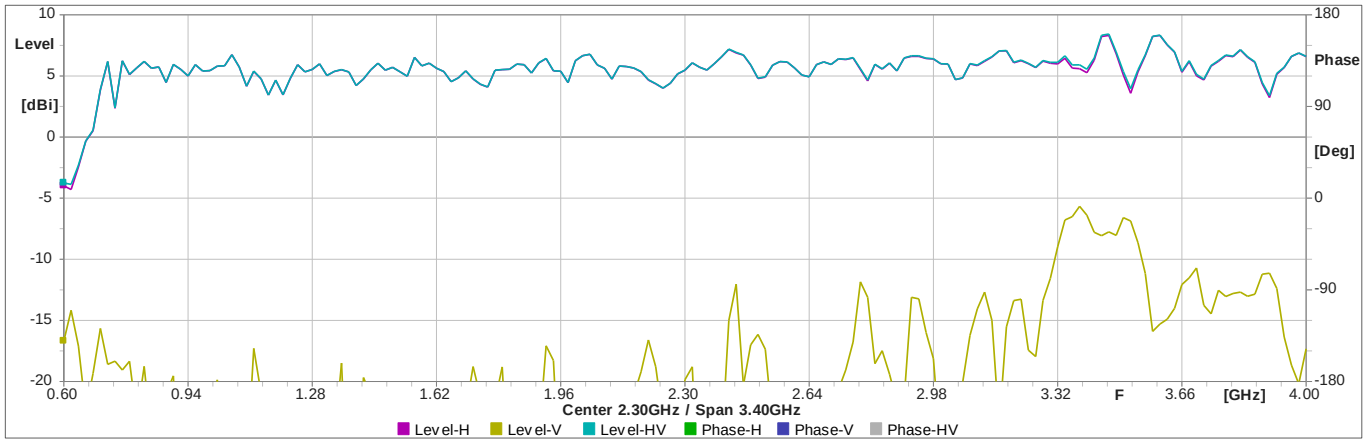
EiRP (dBm)
3 Plane Totals - 868.247 MHz

Pol	Min	Max	Avg	TRP	Dir
HV	-4.8	5.7	2.8	2.8	3.0

Test Measurements\Scarp 300cm 11/13/2015 11:04:14 AM

3-Ax Rotation: 72 Steps Frequency: 868.247 MHz
Measure: Rotation 3 Axes; EUT Distance: 3.00 meter

Sweep Gain



Test Measurements\Gain LogPer Hor 11/13/2015 3:40:36 PM

Sweep: Frequency: 600 > 4000 MHz 170 steps (20/)
Measure: Sweep; RMS Distance: 2.85 meter

- Radiation Patterns
- Frequency Sweeps
- Calculation of TRP and other statistics
- Accuracy similar to anechoic test chambers and Reverberation chambers

TOP ELECTRONICS

MegiQ

Live measurements at the booth

Learn more about

- Gain, Efficiency and TRP
- VNA impedance and gain measurements
- RMS radiation pattern measurements (rotation and scatter)
- New developments coming soon

Let us help you get started

TOP-electronics is ...

distributor and representative of electronic components, modules and special solutions;

focused on Wireless and IoT, Motion Control, Displays, Test and Measurement, Sensors and more

MegiQ ...

creates the technology to facilitate the development of wireless hardware;

provide professional turnkey tools that verify and optimize your hardware right out-of-the-box