RF 2018 TECHNOLOGY DAYS

DE BASILIEK VEENENDAAL 18 APRIL 2018

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

Roger Denker, MegiQ,
namens TOP-electronics

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Early prototype development for IoT and 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 but also the radiation pattern should meet certain criteria.

Our 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.

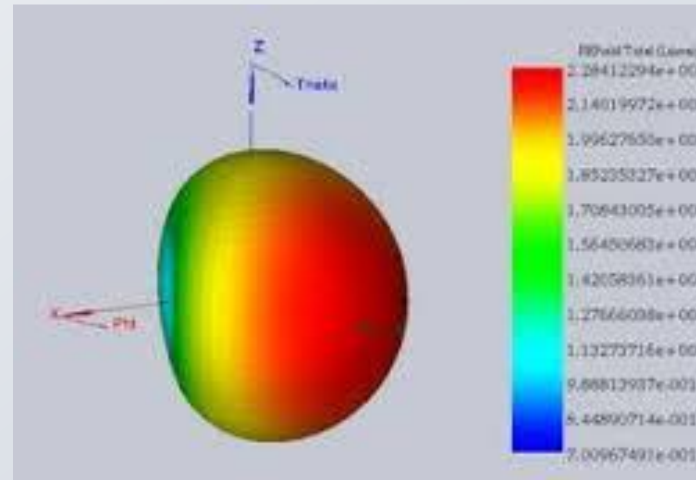
Antenna Development Cycle

- Early Prototyping
- Measure and optimize the resonance, bandwidth, impedance, matching
- Verify and optimize the radiation pattern
- Measure in different circumstances and environments
- Keep verifying the product up to production series

Antenna simulations

Simulation can be a good method to try different antenna concepts.

It provides detailed performance information.

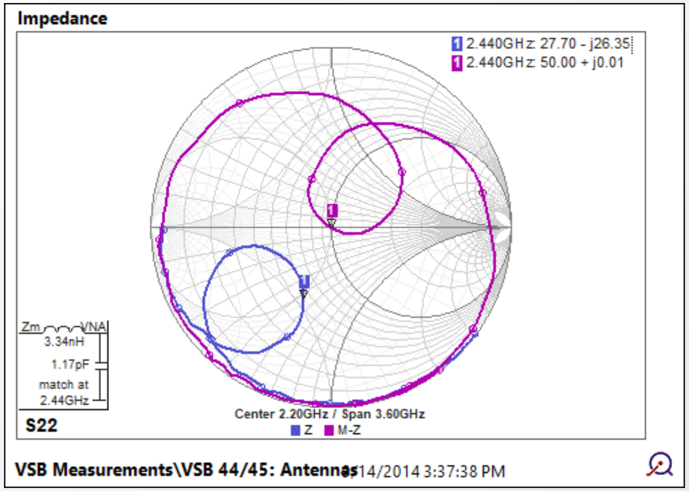


For information about the actual device, the whole device and its environment must be accurately modeled in the simulation.

With detailed models the simulation can take several hours on a high speed computer.

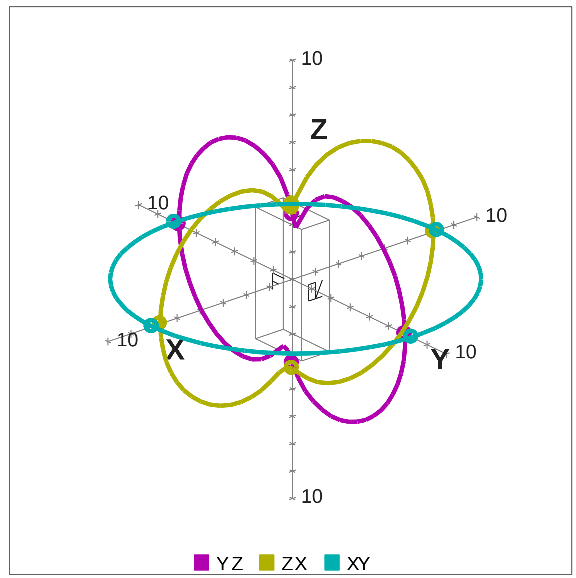
The ultimate performance should always be verified with actual measurements.

Antenna Measurements



Measure, optimize and match the antenna impedance

3D EiRP 868,081 MHz

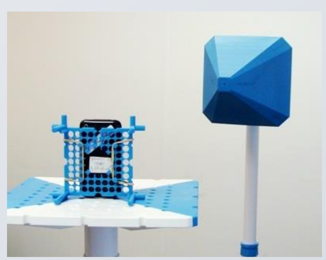


EiRP (dBm)

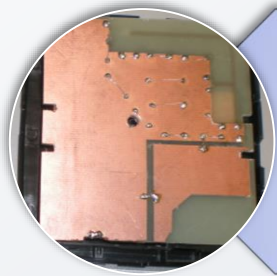
3 Plane Totals - 868,081 MHz

Pol	Min	Max	Avg	TRP	Dir
HV	-20,2	1,5	-1,5	-1,5	3,0

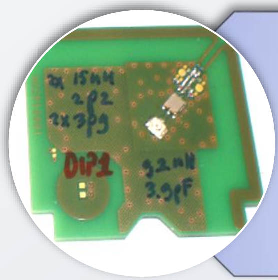
Measure and optimize the antenna radiation



Early Prototyping

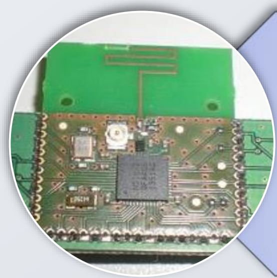


Standalone antenna on handcut PCB



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

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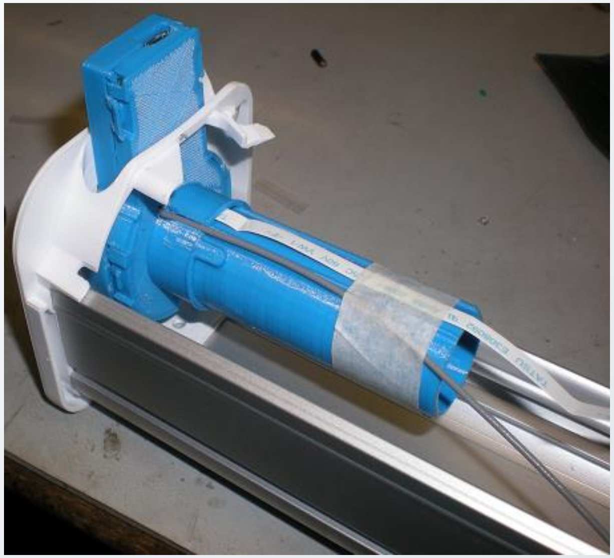

Measure the complete device including cabinet, mounting, cables

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.
- for 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.

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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

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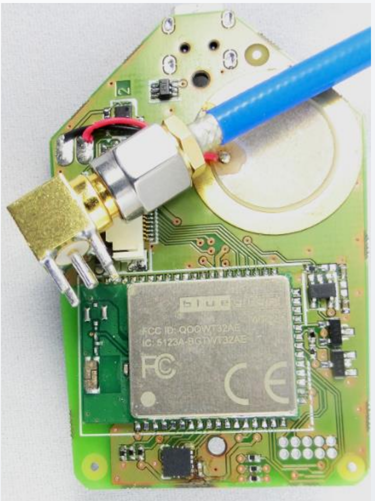
Using UFL connectors



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.

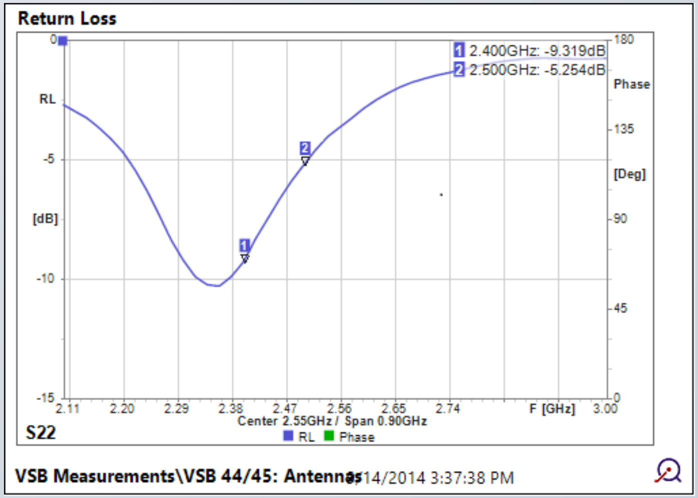
Connect the cable to the antenna input.

Bypass any matching circuit and disconnect the transceiver chip.

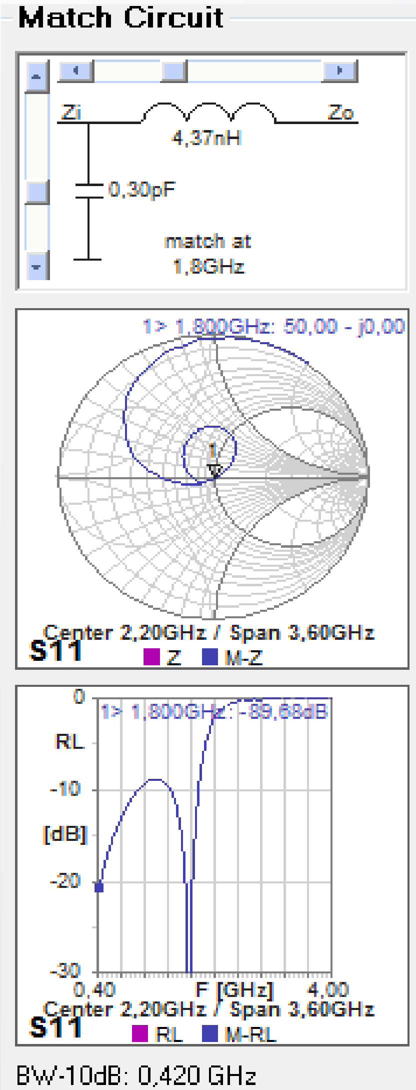
Assemble the complete device, drill a hole in the cabinet to feed the UFL cable.

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.

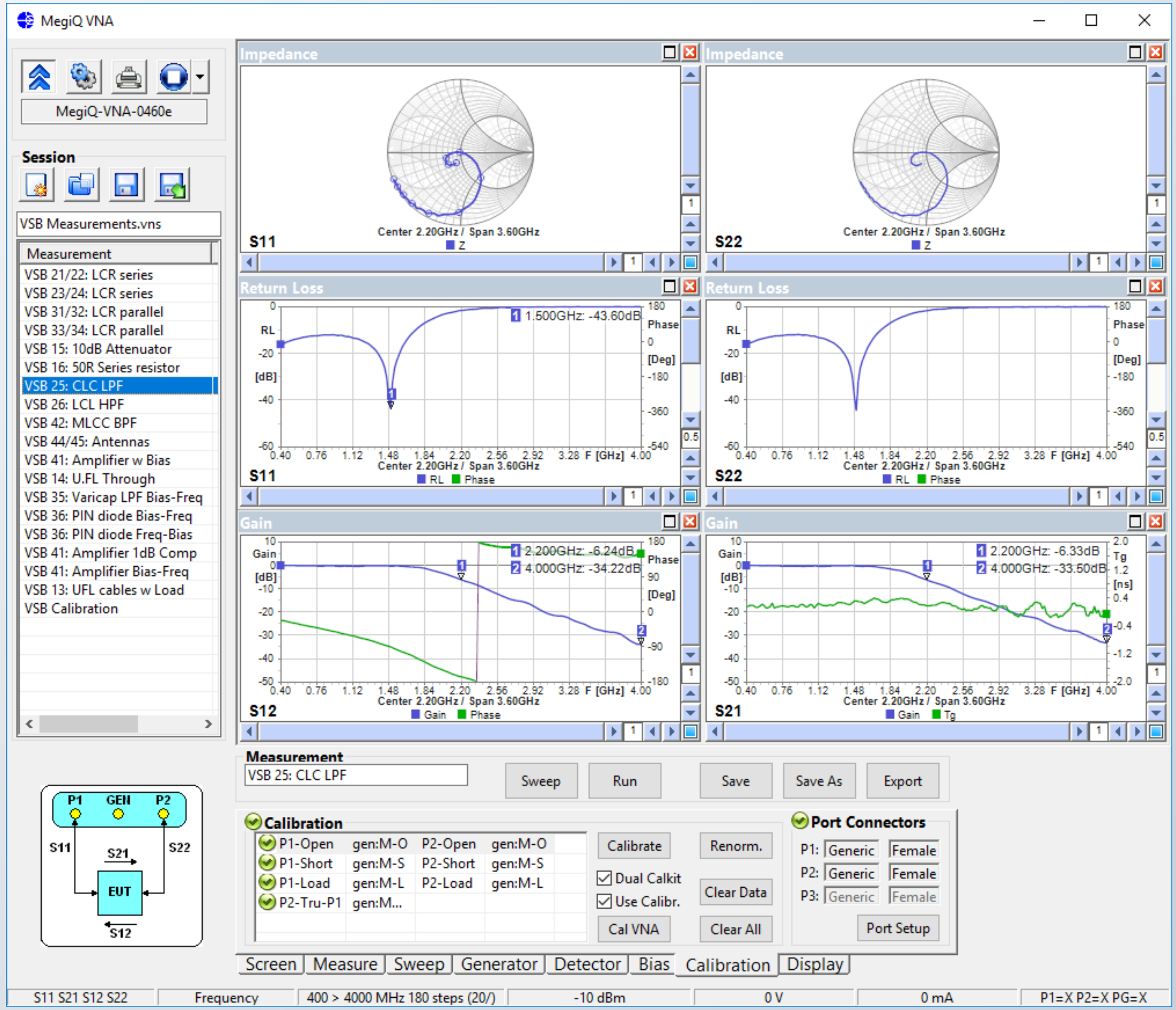
Matching: the VNA software provides a function to calculate a matching circuit automatically.

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.

VNA software

- Presets for easy test setup
- Allows combined sweep of different system settings
- Session manager to organize measurements
- Report Generator for clear reporting
- Software API for automated testing



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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.

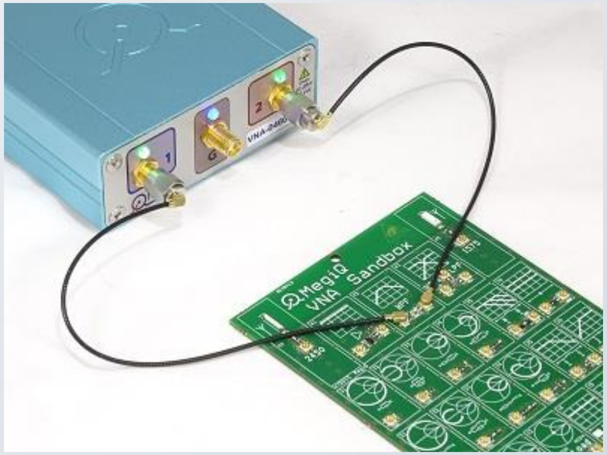
UFL and Balanced Cal Kit

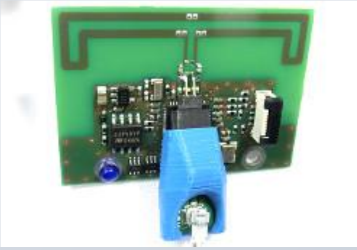
For more elaborate UFL calibration and balanced measurements.

UFL Measurement to 6GHz

Dual UFL OSLT Cal Kits for different layer stackings

Balanced Measurement to 3GHz





Antenna Radiation

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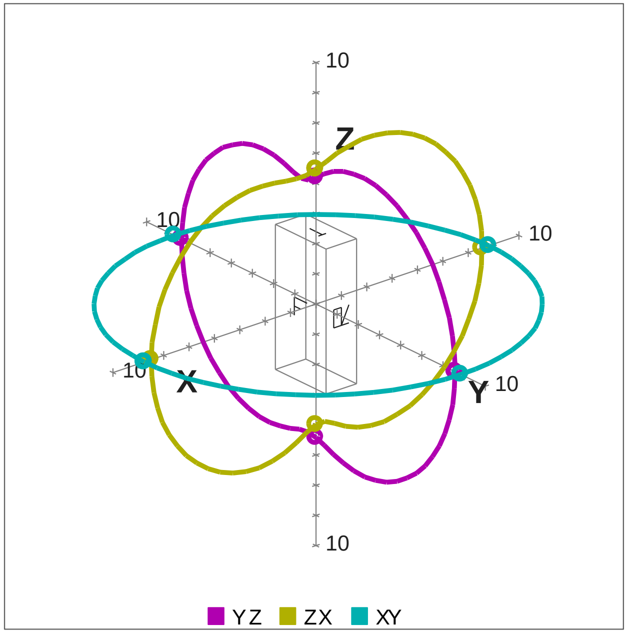
Ultimately, the wireless performance is determined by the antenna radiation.

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.

3D EiRP 868,081 MHz



EiRP (dBm)

3 Plane Totals - 868,081 MHz

Pol	Min	Max	Avg	TRP	Dir
HV	-10,1	4,4	1,6	1,6	2,8

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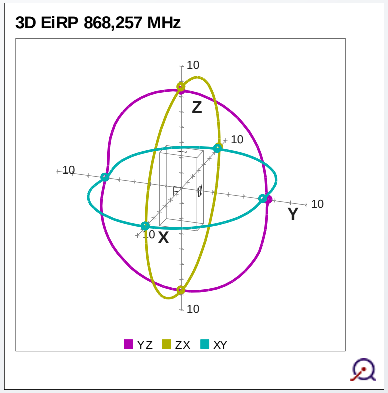
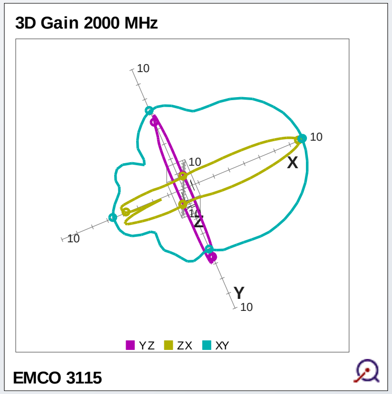
Different Radiation patterns

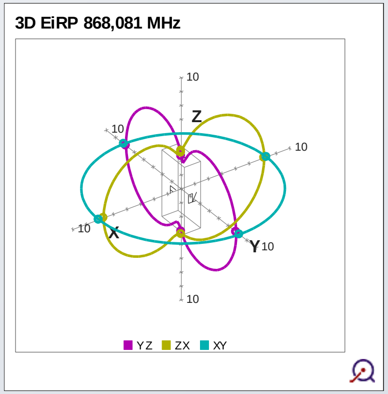
Which direction and polarization do we need?



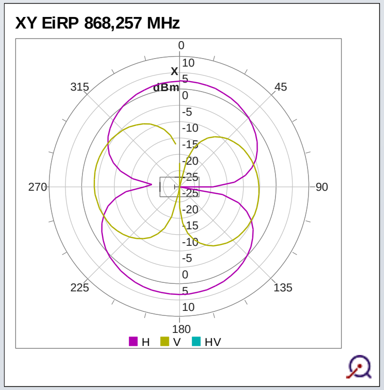
Omni-directional



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.

Gain, Efficiency and TRP

An antenna can have Gain when it bundles the energy in a certain direction.

Since an antenna does not create energy, the overall gain must be <= 0 dB.

The overall gain is called the efficiency. It is also expressed as Total Isotropic Gain (TIG).

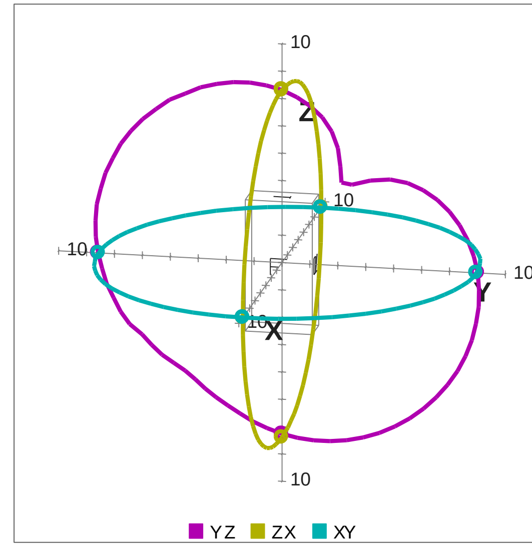
100% Efficiency = 0 dB TIG.

The antenna gain pattern causes a certain Effective Radiated Power (ERP) pattern.

The ERP Pattern follows the Antenna Gain pattern.

The overall ERP is called the Total Radiated Power (TRP). It is the most meaningful figure of an omni-directional device.

3D EiRP 868,083 MHz



EiRP (dBm)

3 Plane Totals - 868,083 MHz

Pol	Min	Max	Avg	TRP	Dir
HV	-11,4	6,5	4,3	4,3	2,2

Measuring Antenna Radiation

There are two methods for measuring radiation: Rotation and Scatter.

A Rotation system rotates a sensor around the device, or rotates the device around its axes.

Rotation systems can measure around 3 axes (XYZ) to create a semi-3D pattern or measure many points to create a full-3D pattern.

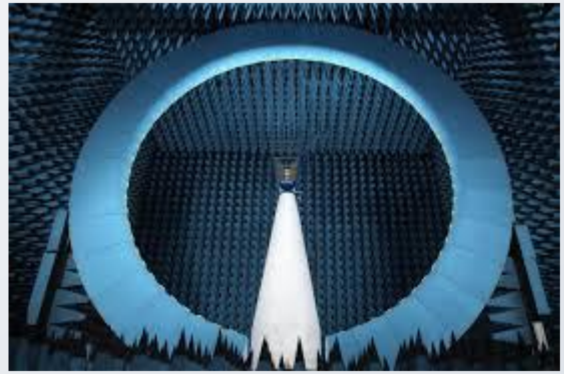
Rotation systems must work in an anechoic environment or otherwise attenuate reflections.

A Scatter system is a fully reflective chamber with a metal fan that 'stirs' the energy and measures a statistical signal at a sensor. This is called 'Stirred Chamber' or 'Reverberation Chamber'.

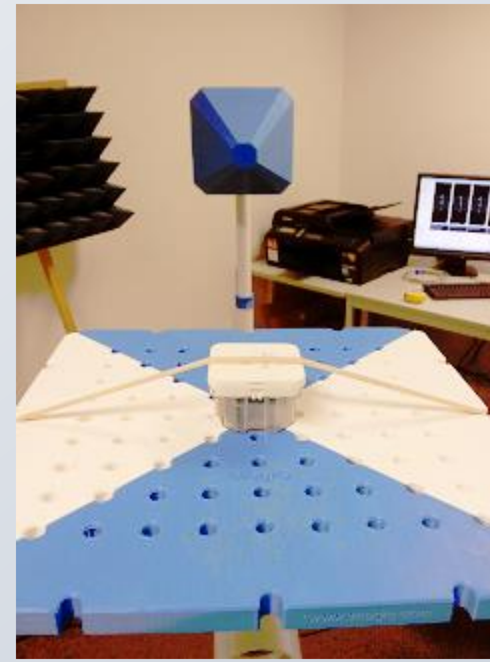
The scatter measurement only yields a TRP value, there is no radiation pattern.

Systems for measuring Radiation

Anechoic Chamber



Satimo Starlab



MegiQ RMS-0740

Reverberation Chamber

Bluetest Rev. Chamber

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Radiation Measurement System

Measurement of RF device Constant Carrier and Modulated signal radiation patterns.

Frequency range 600 to 6000 MHz.

Narrow antenna beamwidth for non-anechoic environments.

Narrow receiver bandwidth for non shielded environments

Measuring distance 0.8 to 3 meter.

Simultaneous Horizontal and Vertical polarization measurement.

Simultaneous measurement of harmonic radiation.

3-axis measurements (1 turn per axis)

RMS Software

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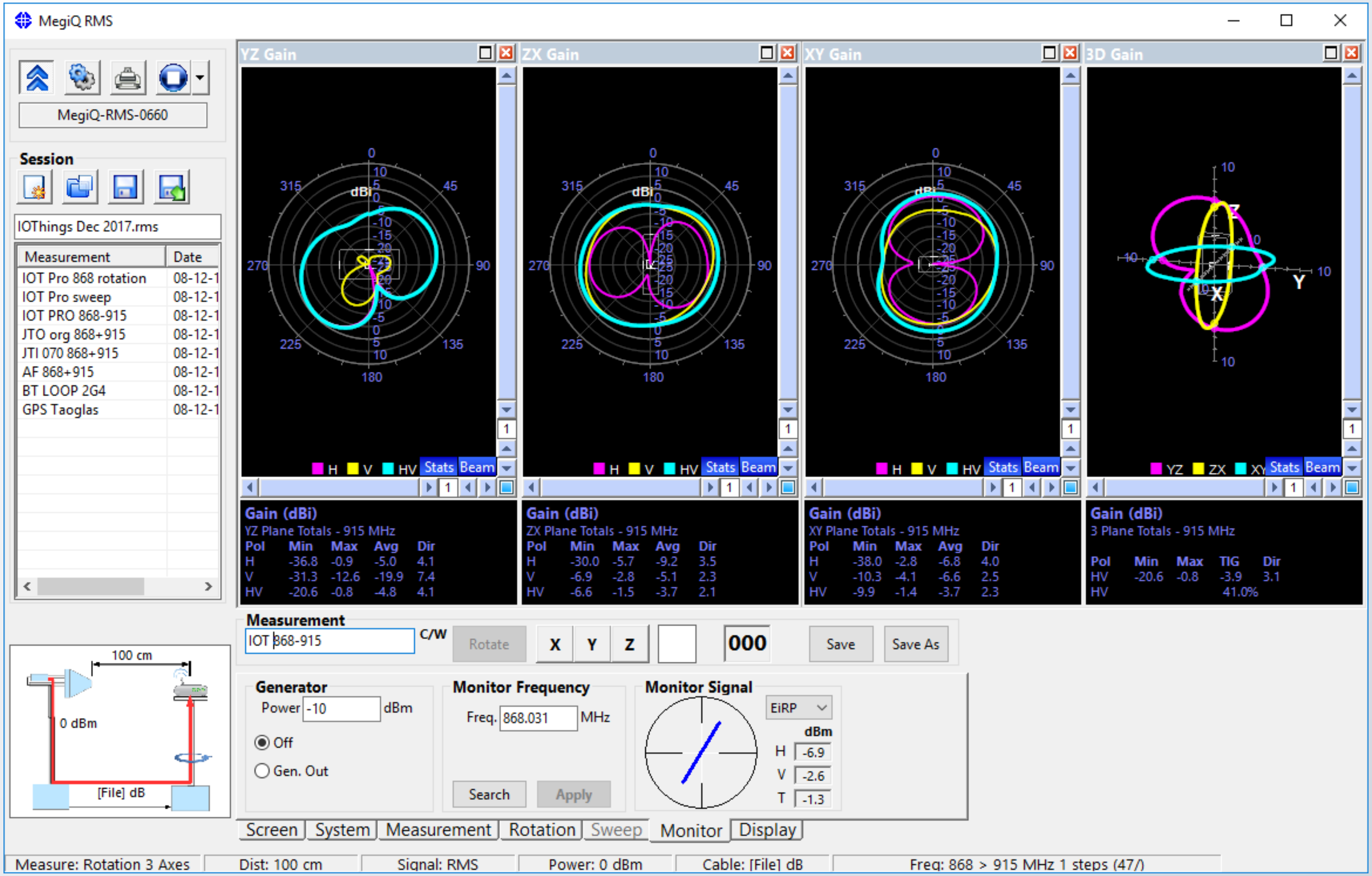

Real time signal and polarization monitoring

Measure up to 35 frequencies per rotation

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RMS results

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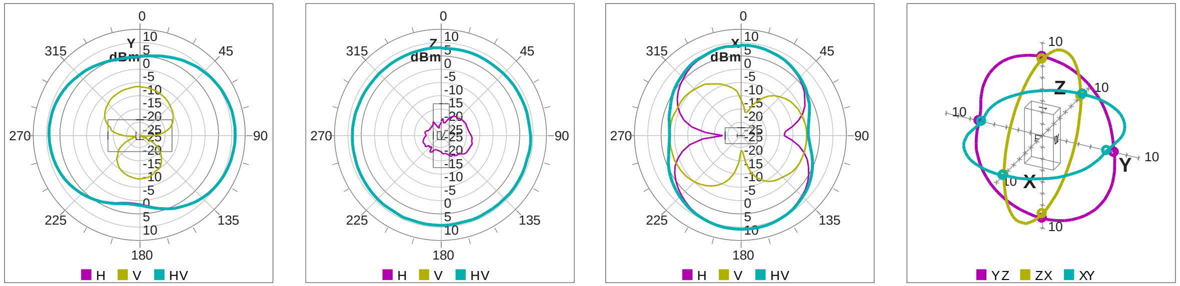
Radiation Patterns

Frequency Sweeps

Calculation of TRP
and other statistics

Accuracy similar to anechoic test chambers and Reverberation chambers

YZ EiRP 868.247 MHz | ZX EiRP 868.247 MHz | XY EiRP 868.247 MHz | 3D EiRP 868.247 MHz



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

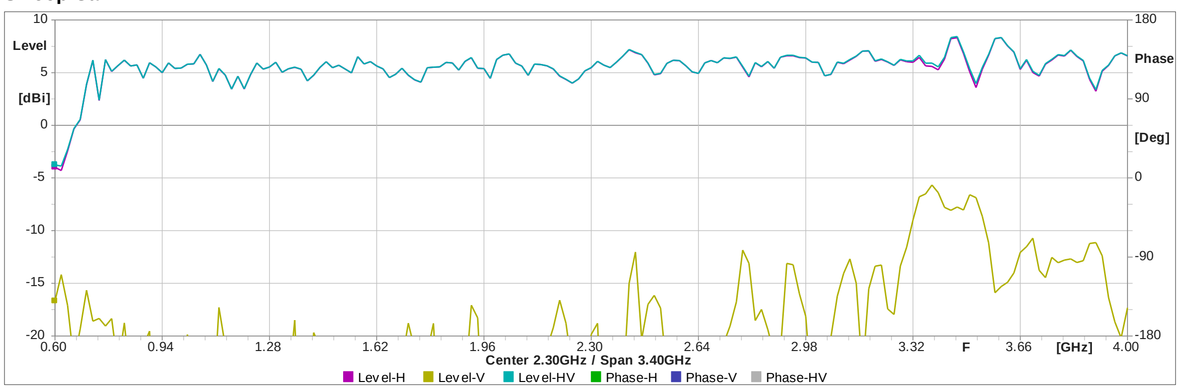
EiRP (dBm)
3 Plane Totals - 868.247 MHz

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

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Life demo measurements at the TOP-electronics booth

VNA impedance and gain measurements

RMS radiation pattern measurements

Visit our booth for the life demo measurements and for more product information, news and background information on RF measurements.

Or let us help you get started.