KYOCERA AVX

Your Connectivity Partner
for RF Solutions

Bluetooth Antennas & Locationing

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ADVANCED ANTENNA SOLUTIONS

Key Applications

400+

Patents issued or pending

25+

Global Measurement Systems

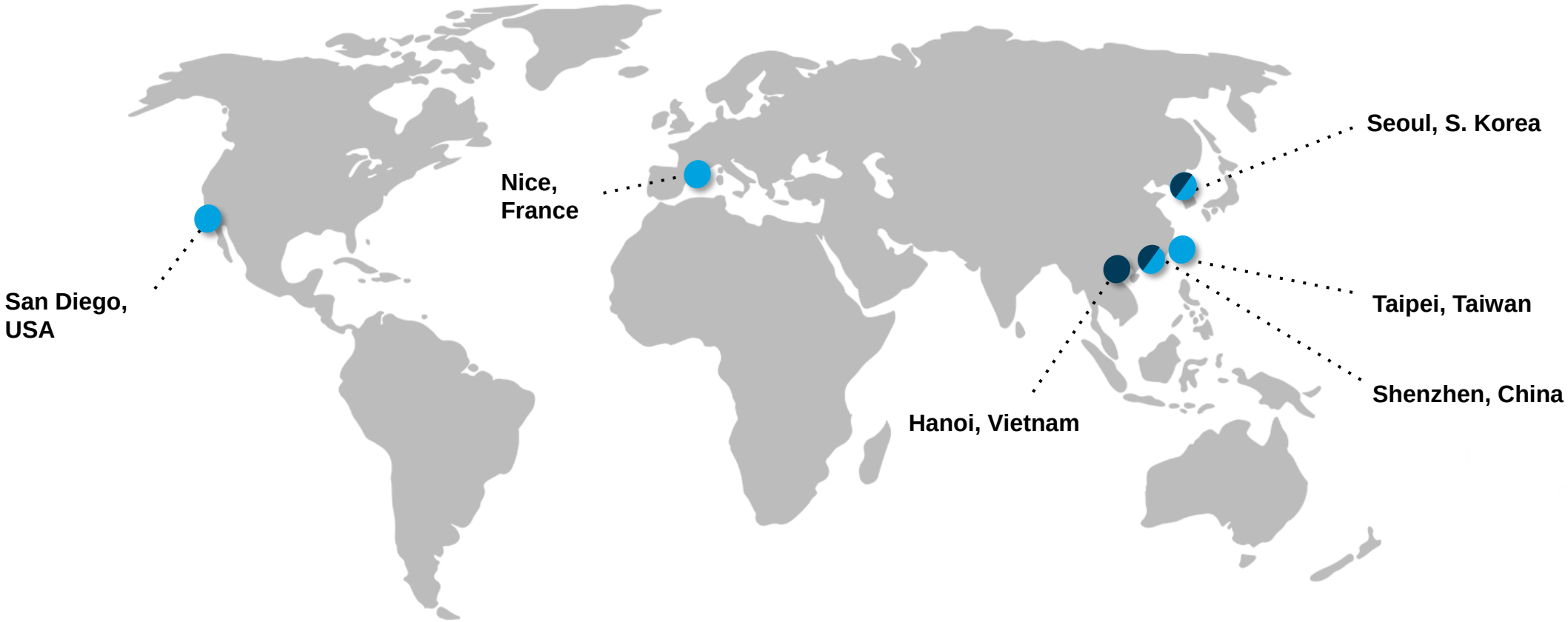
Antenna company with **state-of-the-art manufacturing technologies** and innovative solutions

- **Active Antenna Systems:** Active steering, Impedance matching, Band switching
- **Measurement Systems:** Anechoic, automotive and 5G chambers with extremely user-friendly GUI software

Unique portfolio (Standard, Custom) of **high-quality products**

Ability for **Vertical Integration** for complex systems

Global Presence for Antennas



DESIGN CENTERS

- San Diego, USA
- Nice, France
- Seoul, S. Korea
- Taipei, Taiwan
- Shenzhen, China

MANUFACTURING CENTERS

- Seoul, Korea
- Hanoi, Vietnam
- Shenzhen, China

Antennas for each Application

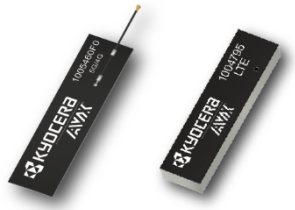
Standard Antennas

Custom Designs

Validation & Pre-certification

Industrial Gateways
External Antennas or Embedded Solutions

5G RedCap, 5G/4G, LoRa, Wi-Fi 6E/7

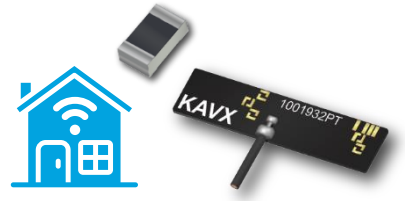


Smart Meters & Lighting
Versatile Standard Antennas or Custom Solutions

169MHz, 433 MHz, LoRa, NB-IoT,
2.4 GHz, DECT NR+, Wi-SUN

Wearables
LDS Technology for Thinner and Smaller Devices

BLE, GNSS, Cellular, Wi-Fi

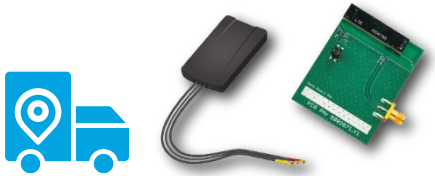


Smart Homes
Patented Antennas for
Improving AoA and Throughputs

UWB, BLE, Matter, Zigbee, Thread, Wi-Fi 6E/7

Satellite Communications
The Smallest Chip Antennas for SatCom

5G NTN, GNSS, RTK, L1/L2/L5/L6, LoRa S-band

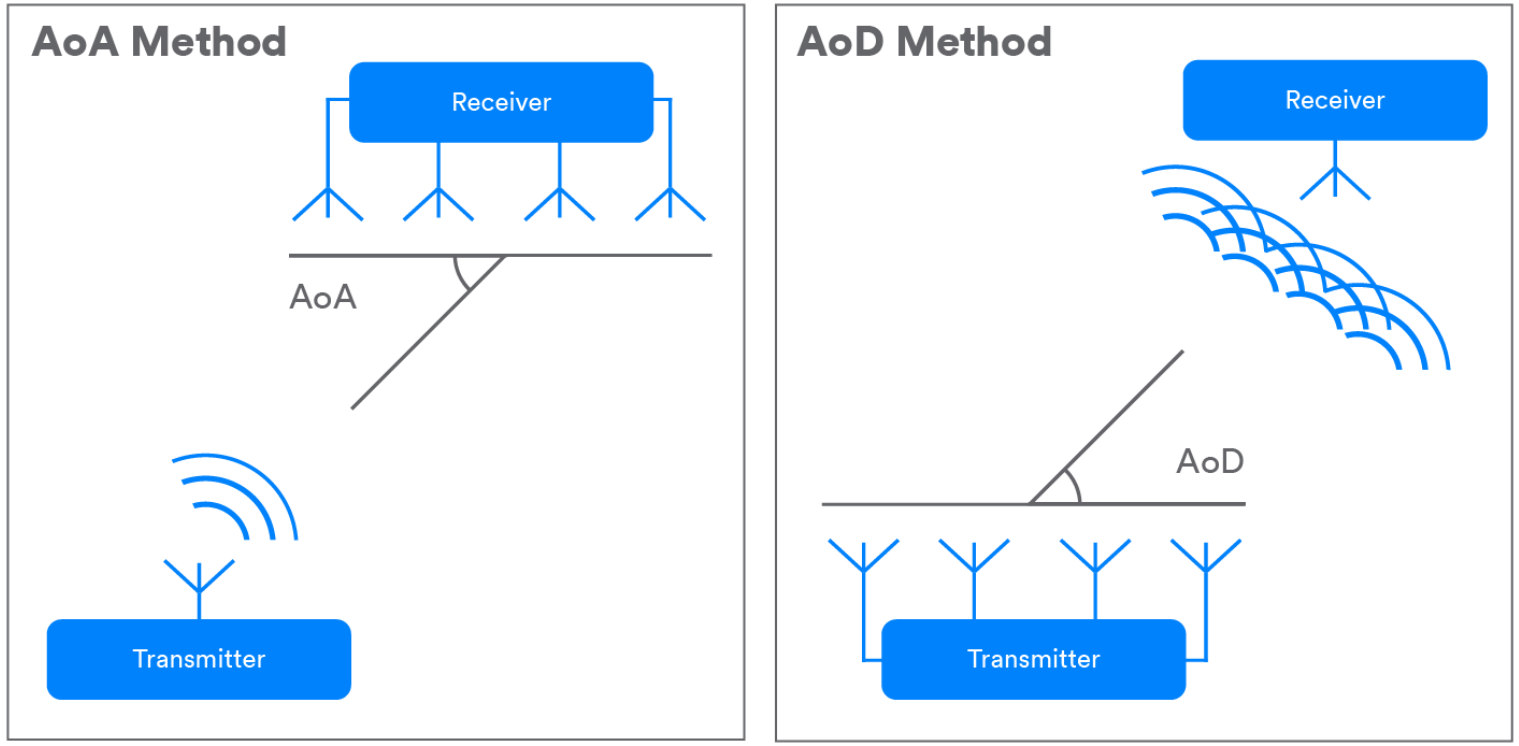


Automotive & Fleet & Asset Tracking
Active Antenna Band Switching for Small Devices
and Embedded or External Antennas

5G NTN, 5G/4G, NB-IoT, LTE-M, GNSS, BLE, Wi-Fi

Bluetooth Direction Finding

AoA vs. AoD



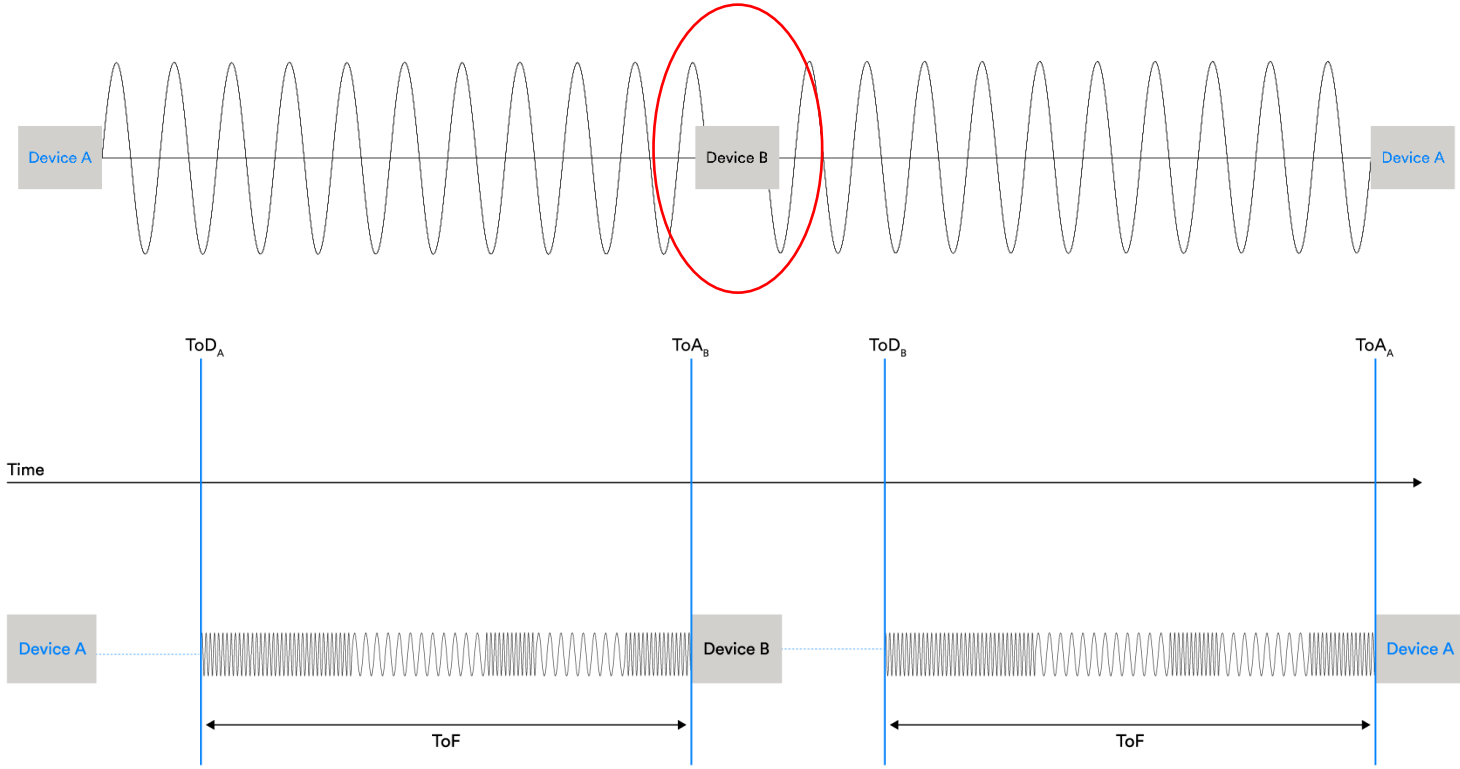
Angle of Arrival detection

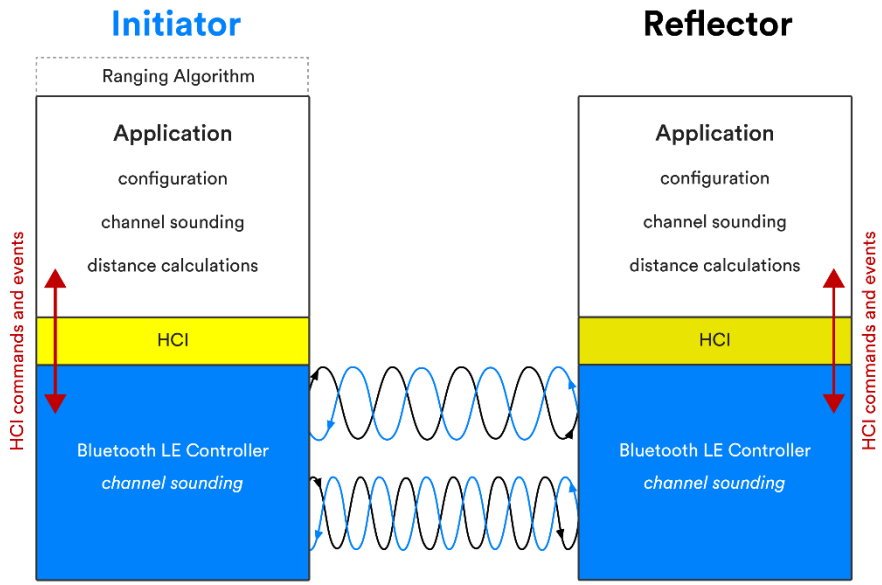
1. Antenna arrays or Active antenna with multiple radiation pattern are required
2. Phase distribution around each antenna is a key factor of merit

Source: Bluetooth SIG https://www.bluetooth.com/channel-sounding-tech-overview/?utm_source=internal&utm_medium=blog&utm_campaign=channel-sounding&utm_content=a-first-look-at-bluetooth-channel-sounding

Bluetooth Channel Sounding

Phase-based Ranging (PBR) and Round-Trip Timing (RTT)





1. Reduced number of channels + time division reducing TX/RX time requires higher reliability
2. Phase variation detection recommends multiple antennas or an Antenna Array

Source: Bluetooth SIG https://www.bluetooth.com/channel-sounding-tech-overview/?utm_source=internal&utm_medium=blog&utm_campaign=channel-sounding&utm_content=a-first-look-at-bluetooth-channel-sounding

Antenna Values for BLE

How to save power

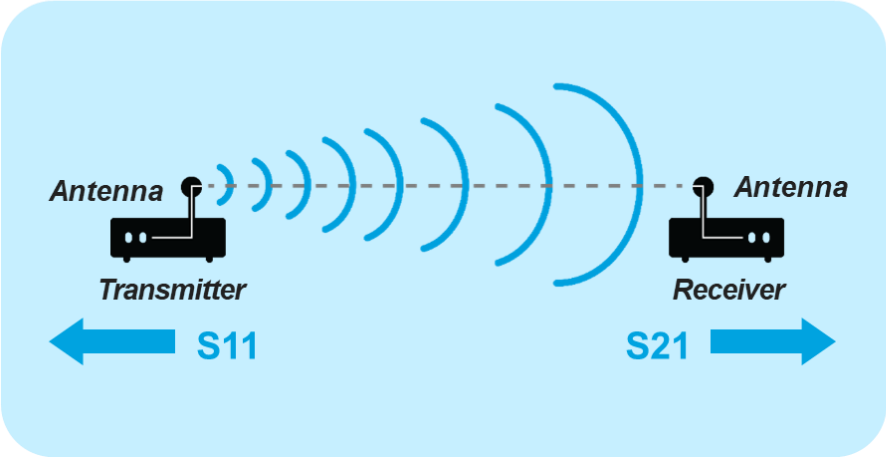
Passive Parameters

Return Loss (S11) / **Isolation** (S21)

Gain / Directivity

Efficiency (η)

Polarization



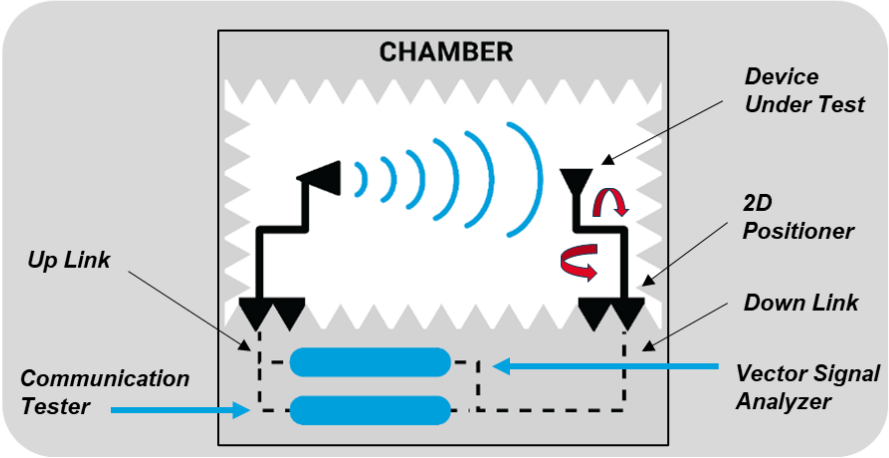
Active Parameters

TRP ***(Total Radiated Power)***

$TRP_{dBm} = Conducted\ Power_{dBm} + Efficiency\ (\eta)_{dB}$

TIS ***(Total Isotropic Sensitivity)***

$TIS_{dBm} = Conducted\ Sensitivity_{dBm} + Efficiency\ (\eta)_{dB}$
(ideally)

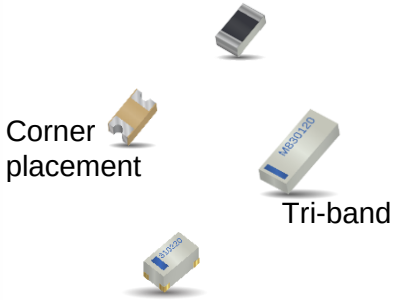


Optimizing these parameters will **save energy** and **improve accuracy!**

Standard Antenna Offering for Bluetooth

Chip Antennas

Chip antennas with different form factors



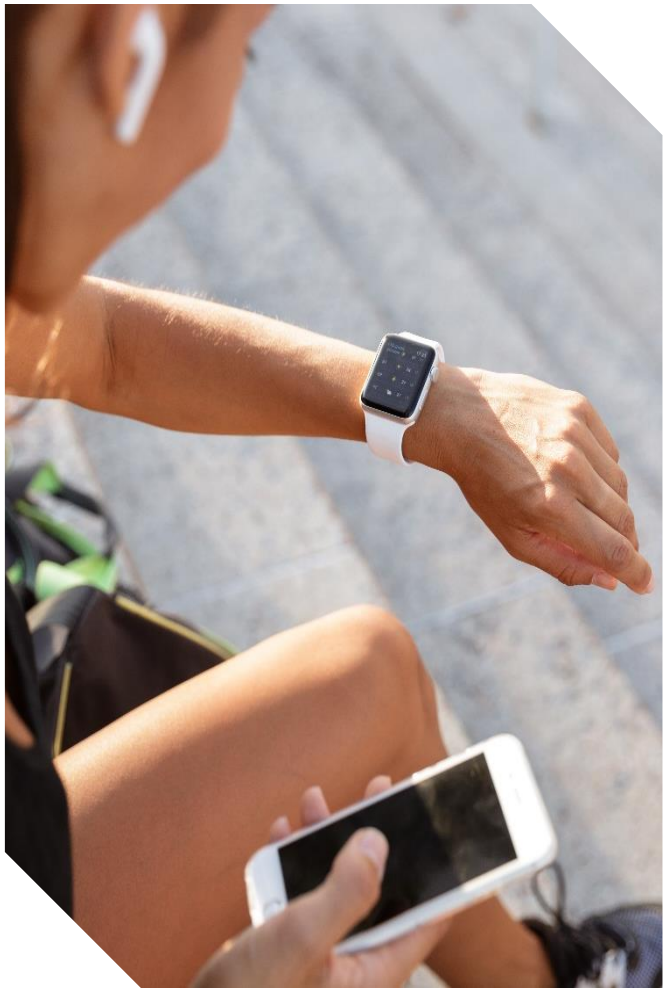
Ultra-small Chip Antennas

Benefits:

- Smallest size in the market
- Tightest tolerance
- SMT
- Corner or PCB edge placements
- Automotive versions available

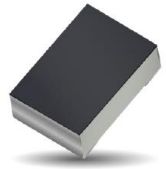
Applications:

- IoT Industrial
- Asset Tracking
- Wearables
- Telematics
- TPMS



Check Full Chip Antenna Portfolio > *Click Here*

The Smallest Chip Antennas



9001978

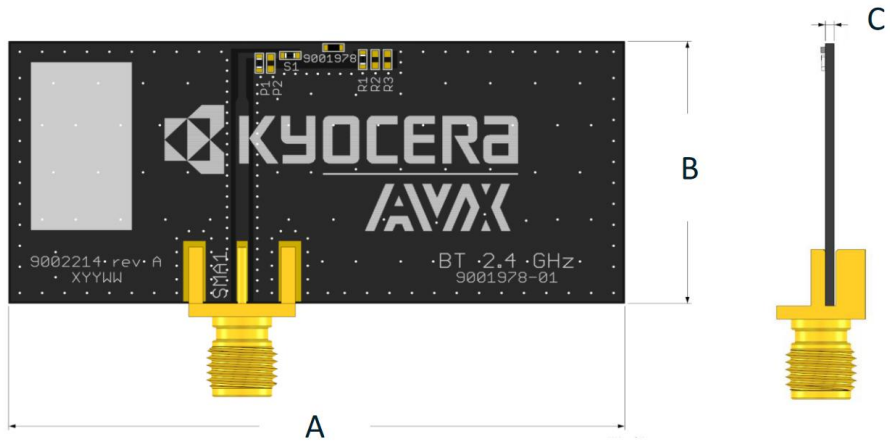
1.00 x 0.55 x 0.40 mm

Frequency	2400 – 2485 MHz	5150 – 5850 MHz	2400 – 2485 MHz (BT ONLY)
Peak Gain	3.0 dBi	2.6 dBi	Refer to Appendix 1
Average Efficiency	60%	50%	
VSWR	2.4:1 max	5.6:1 max	
Feed Point Impedance	50 ohms unbalanced		
Polarization	Linear		
Power Handling	0.5 Watt CW		

Antenna Demo Board (9001978-01)

Typical layout dimensions (mm)

Part Number	A	B	C
9001978-01	(55.0)	(25.0)	(0.80)

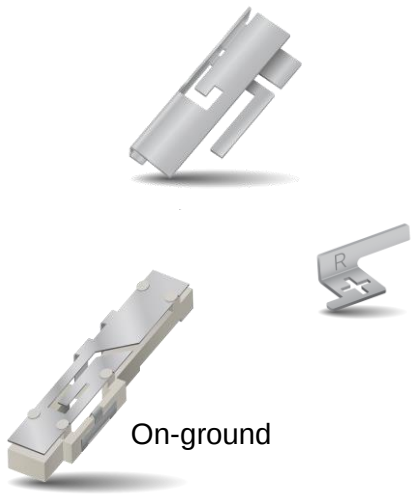


Check Full Chip Antenna Portfolio > *Click Here*

Standard Antenna Offering for Bluetooth

Stamped Metal Antennas

Stamped Metal antennas with different form factors



On-ground

Vertical Polarized Antennas

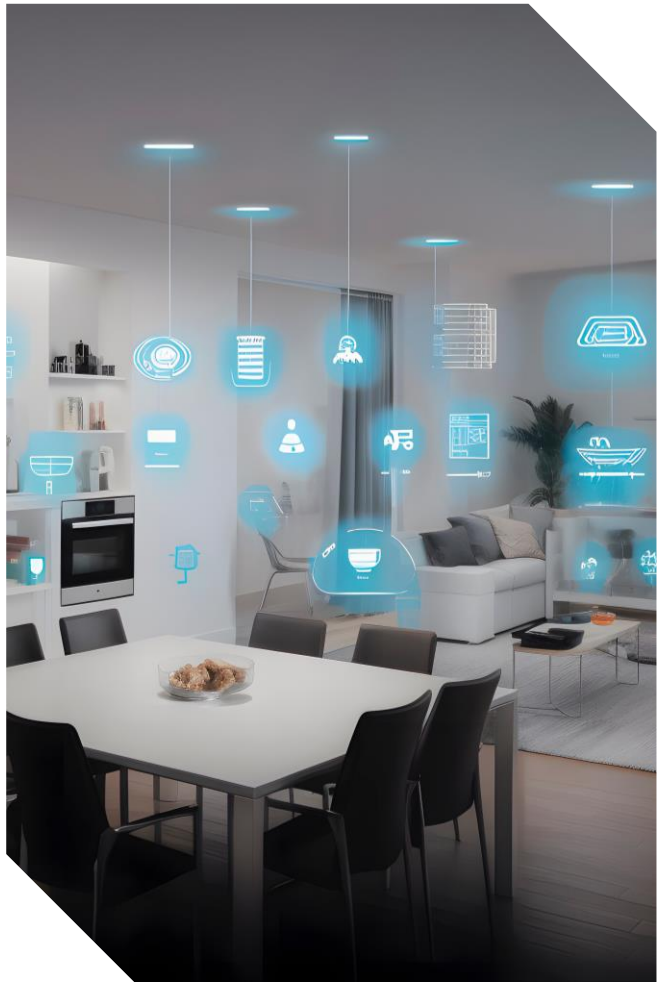
On-ground / Tri-band

Benefits:

- Tuning pads
- Low profile
- Cost Efficient
- High gain
- Vertical Polarization solutions
- Multi-band coverage
- On-ground solutions
- SMT
- Automotive versions available

Applications:

- Healthcare
- Smart Home
- Gateways
- Smart Grid
- Telematics

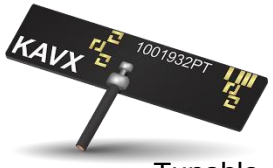


Check Full Stamped Ant. Portfolio > *Click Here*

Standard Antenna Offering for Bluetooth

PCB/FPC + Cable Antennas

PCB/FPC antennas with different form factors



Tunable

FPC Antenna for Metal Surfaces

On-ground

Lock MHF Connector for Robust Connections

Check Full PCB/FPC Ant. Portfolio

> *Click Here PCB*

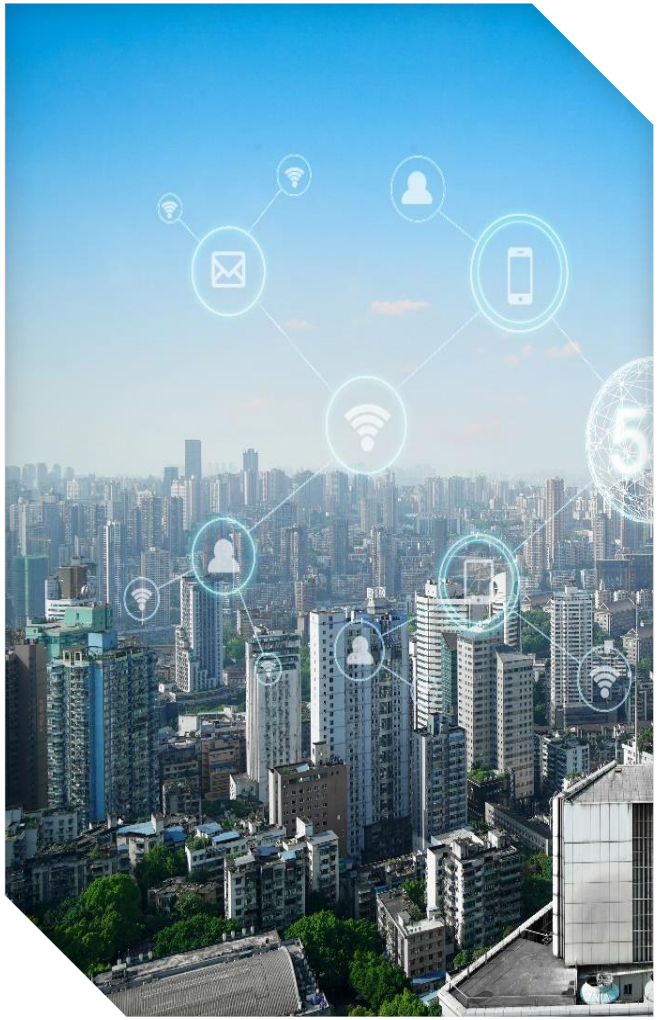
> *Click Here FPC*

Benefits:

- On ground solutions
- Ground independent solutions
- Multi-band coverage
- Dual feed options
- Foam option to minimize the detuning
- Different cable lengths and connectors available (MHF, MHF4L, MHF LK…)
- Tunable antennas

Applications:

- Smart Home
- IoT Industrial devices
- Smart Grid
- Gateways
- Robotics
- Drones



Standard Antenna Offering for Bluetooth

W-Family Antenna Solutions

W4 Family

Benefits:

- Tri-Band Wi-Fi 6E&7
- Side cable
- 2400-2485 MHz / 5150-5850 MHz / **5925-7127 MHz**
- 42.6 x 8.6 x 0.5 mm
- PCB & FPC

W5 Family

Benefits:

- Dual-Band Wi-Fi 6E&7
- 5150-5850 MHz / **5925-7127 MHz**
- 15.9 x 7.6 x 0.5 mm
- PCB & FPC

W6 Family

Benefits:

- Single Band Wi-Fi 6E&7
- **5925-7127 MHz**
- 15.9 x 7.6 x 0.5 mm
- PCB & FPC

W7 Family

Benefits:

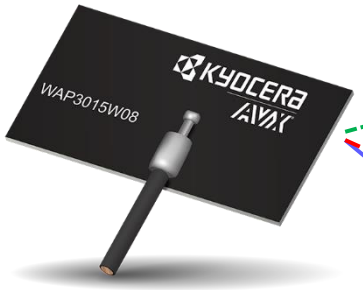
- Tri-Band Wi-Fi 6E&7
- 2400-2485 MHz / 5150-5850 MHz / **5925-7127 MHz**
- 35.2 x 8.5 x 0.5 mm
- PCB & FPC

W1 Family: 2.4 GHz (single Band)

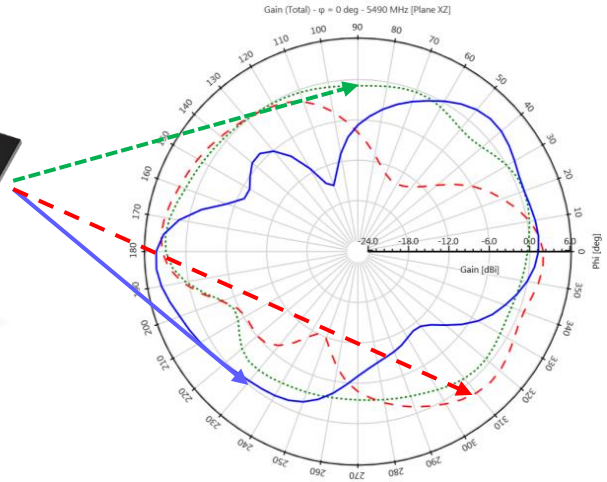
W2 Family: 5 GHz (single Band)

W3 Family: 2.4 / 5 GHz (Dual-Band) or Tri-Band 2.4 / 5 / 6 GHz (Low Peak Gain)

WX-Family: Tri-Band. One fixed mechanic size, 3 different pattern options



30.0 x 15.5 x 0.80 mm



Standard Antenna Offering for Bluetooth

External Antennas

External antennas with different form factors

IP67

Small Form Factor Wi-Fi 7 Antenna

84 x 9.35 mm

Accessories - Cables

RP-SMA to MHF4L

Check Full External Ant. Portfolio

> *Click Here* ***Indoor***

> *Click Here* ***Outdoor***

Benefits:

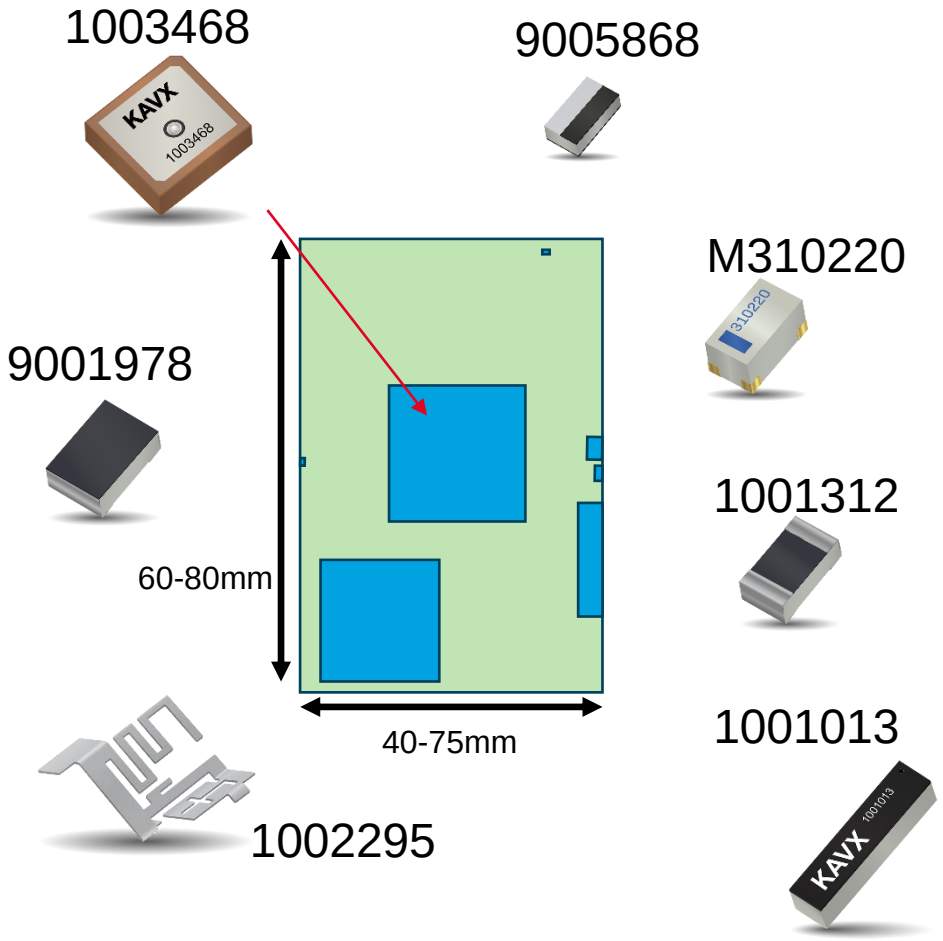
- Several mounting types (adhesive, screws, magnet…)
- Multi-band coverage
- Different cable lengths and types available (RG-174, LMR…)
- Different connectors available (SMA, RP-SMA, MHF, MMCX…)
- Indoor and Outdoor

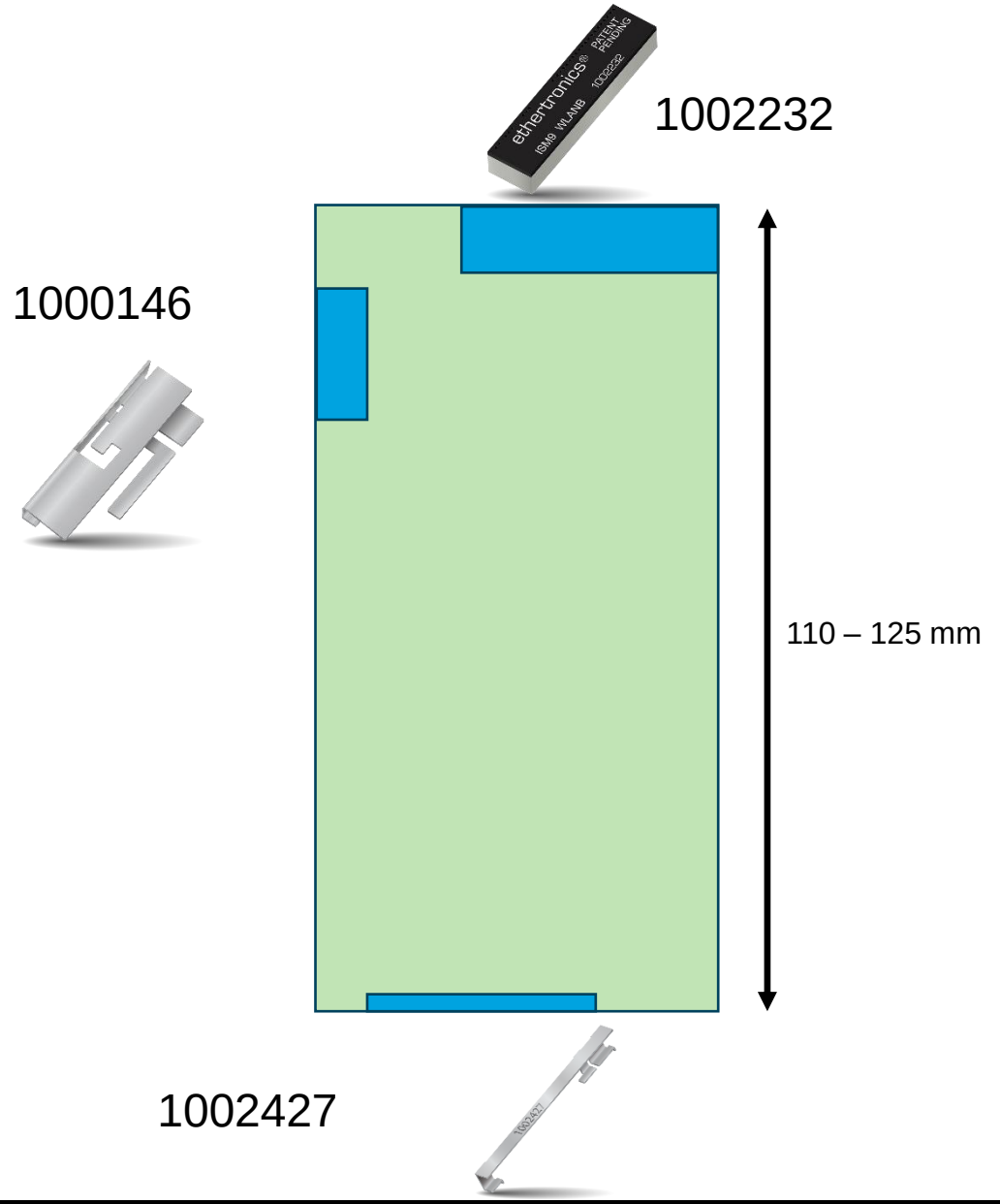
Applications:

- Transportation
- IoT Industrial devices
- Gateways
- Smart Grid
- Agriculture

Antenna Position

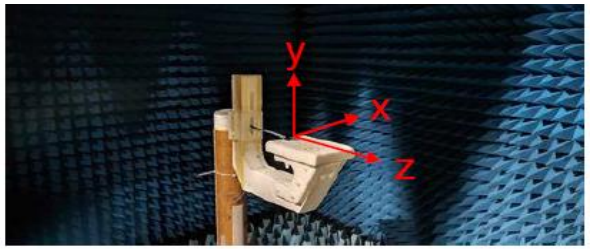
Solutions for Every Layout





Phase Variation

- Phase variation in XZ cut is around 360 degree.
- That is related to the shape of the EVB, creating nulls in some directions



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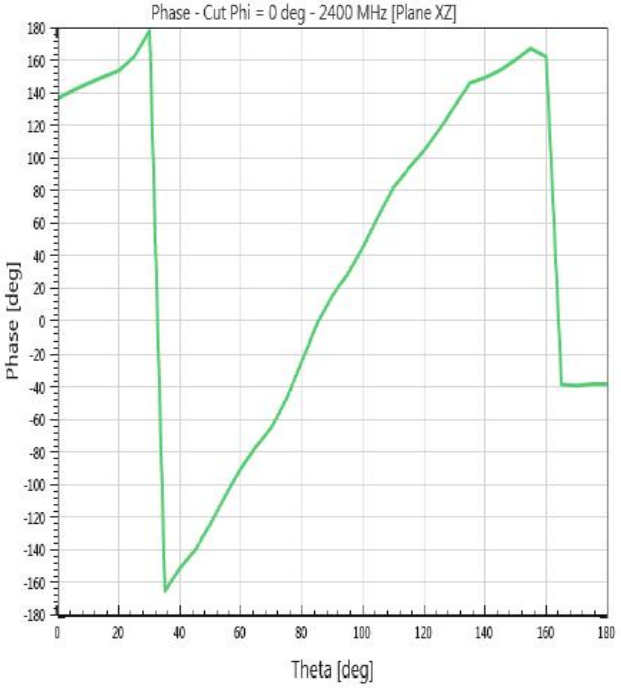
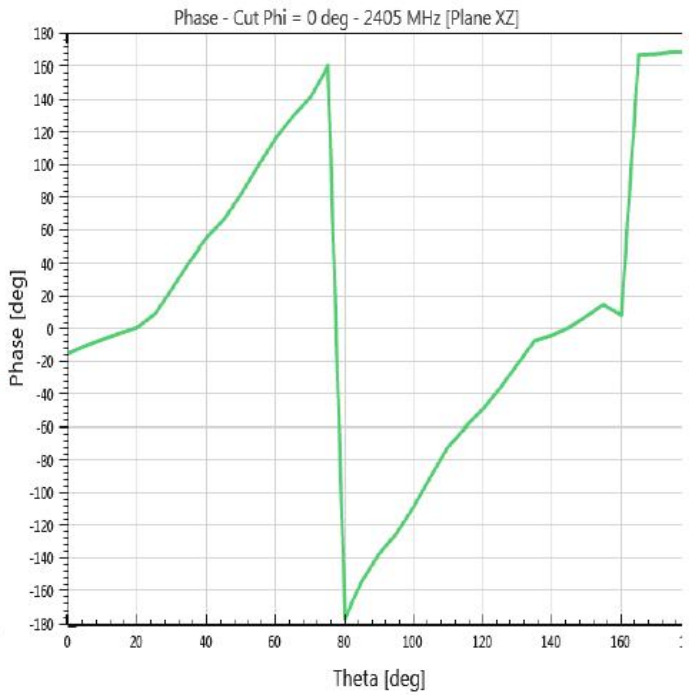
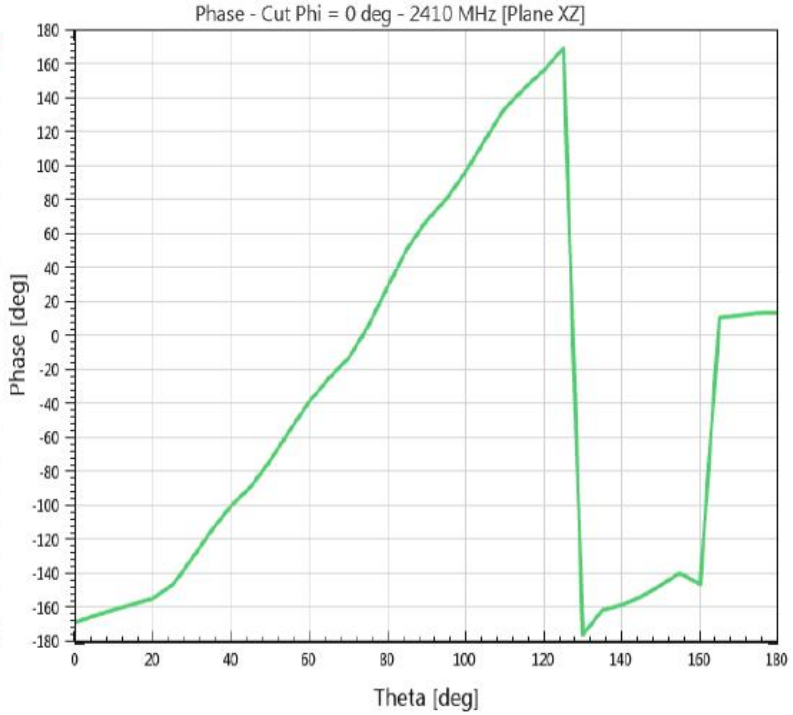




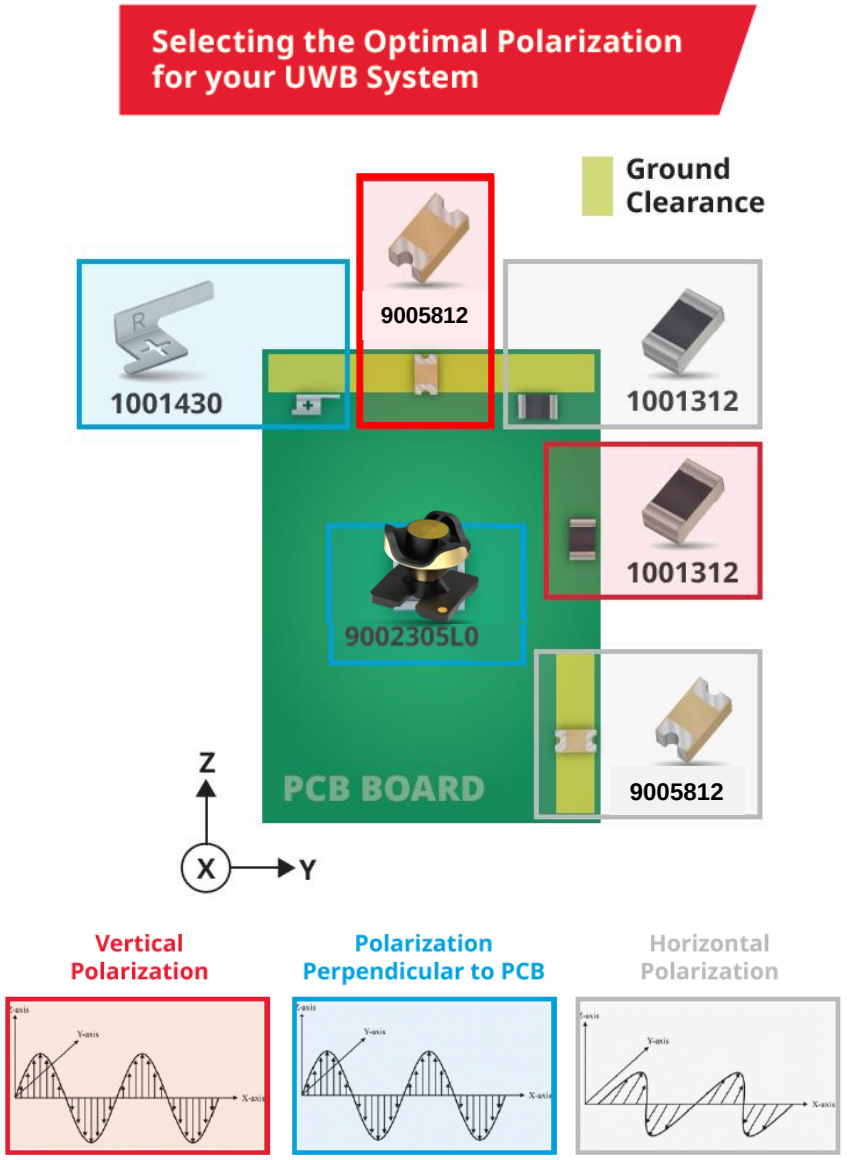


One single antenna can´t cover a 360° phase variation

Polarization

Vertical vs. Horizontal Polarization

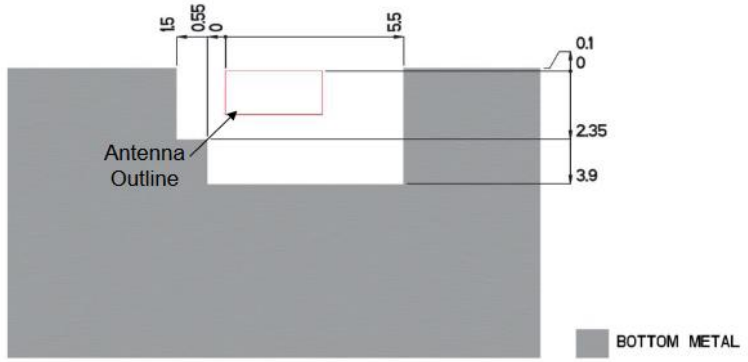
- Similar to our UWB studies we can offer antenna solutions for different polarization requirements



Clearance Area

The Smallest Antenna is not always the Smallest Solution

M310220



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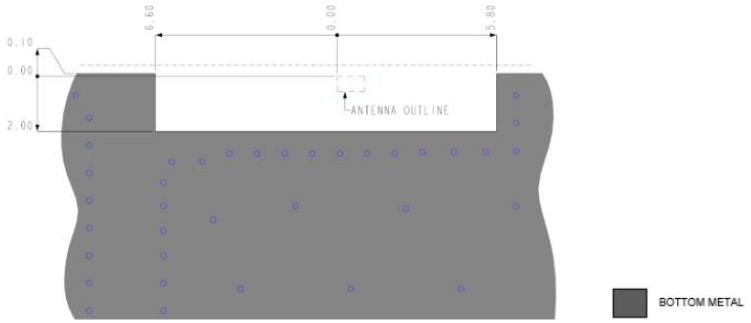

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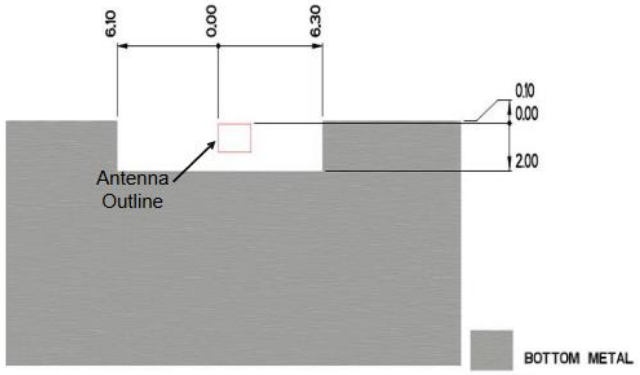

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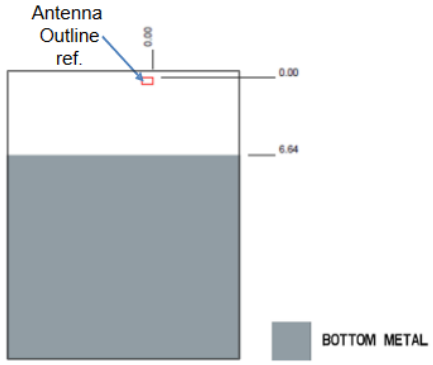

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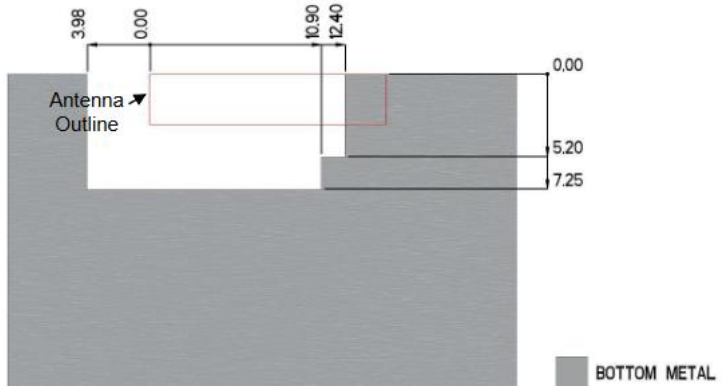
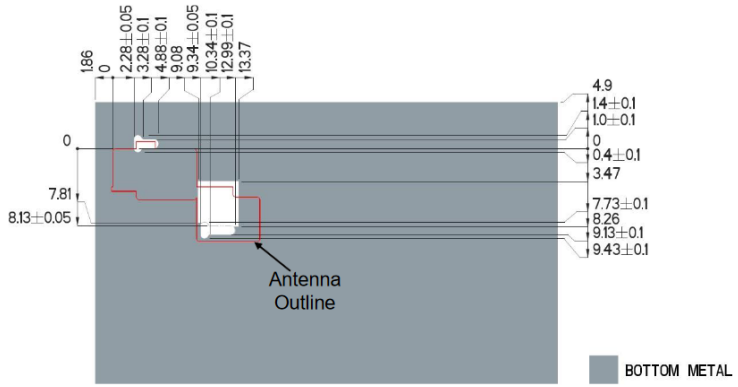


images not in scale!

Clearance Area

Metal Stamp Antennas

1002295



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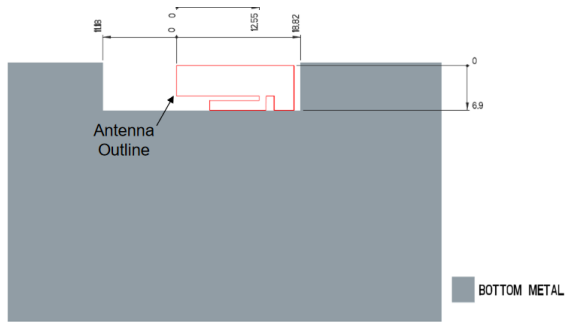

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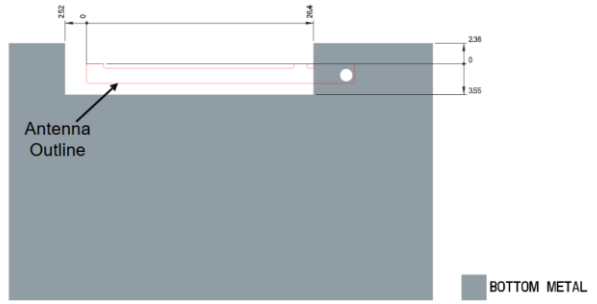
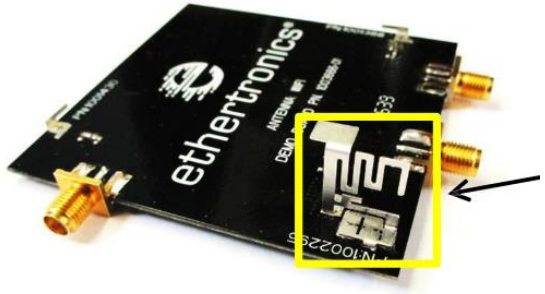


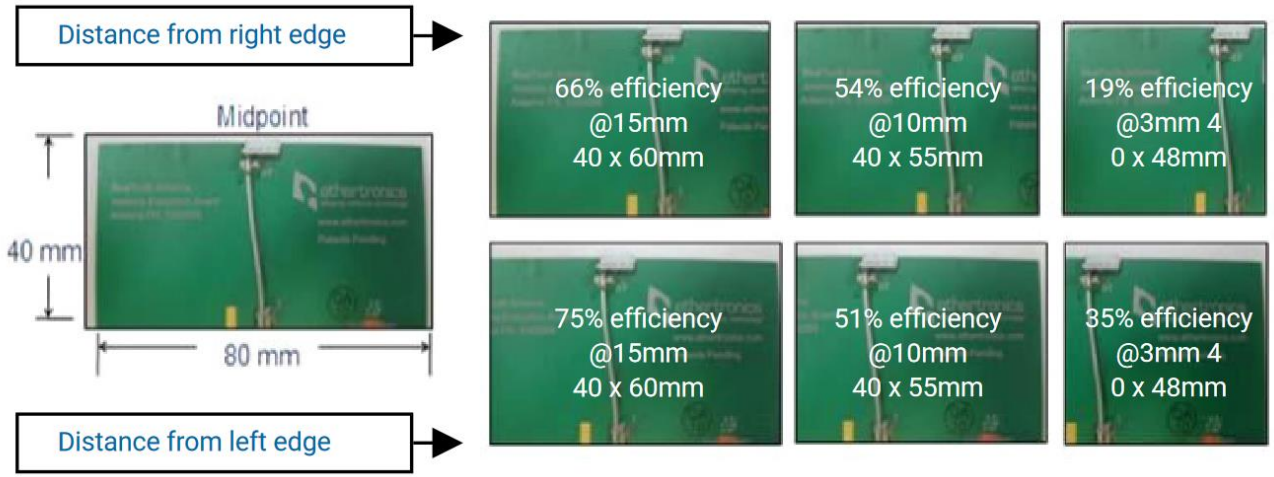


Dual Band antenna layout
(ISM and BT)

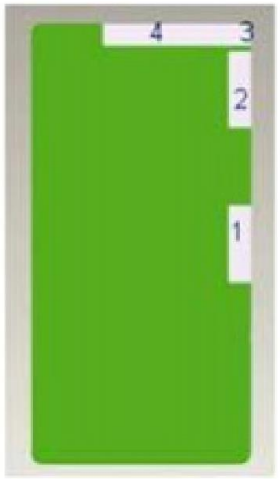
images not in scale!

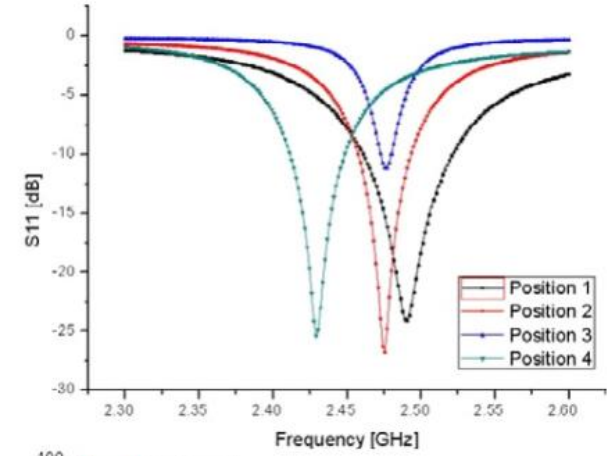
Antenna Position

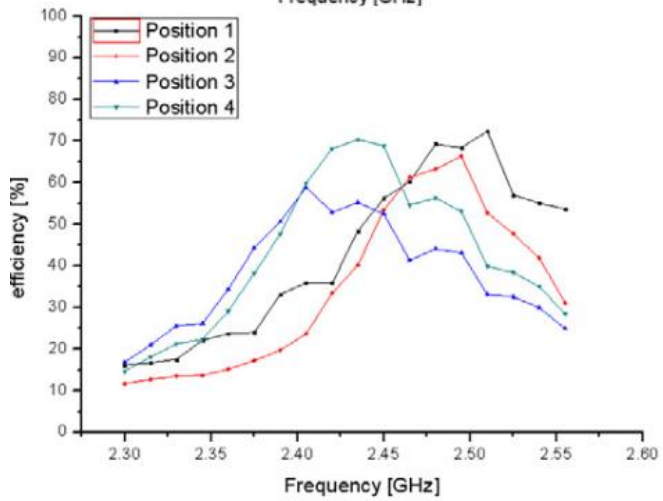
Distance from the Corners vs. Efficiency



Position on the PCB vs. S.11 & Efficiency



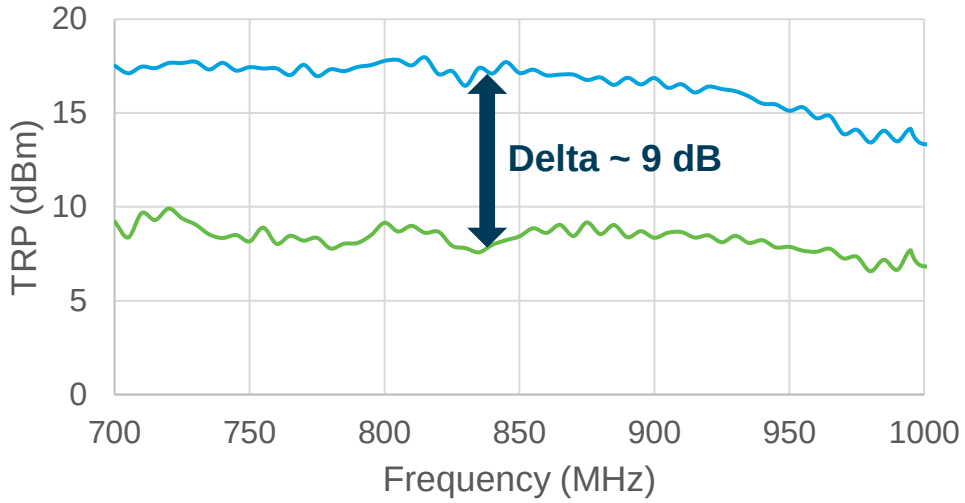




Other Effects of the Environment

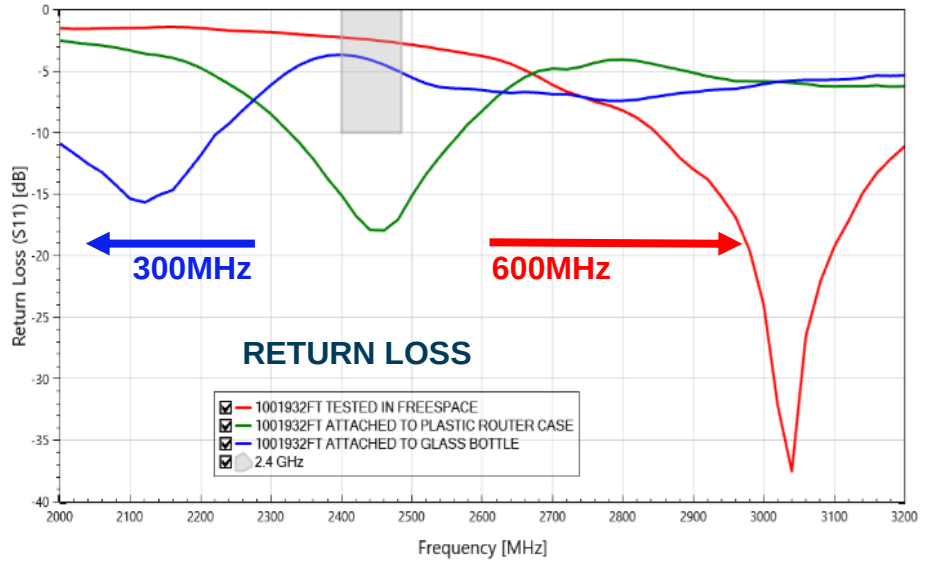
Human Body Absorption

Antenna performance in free space has **9dB** of **TRP gap** with the antenna placed beside the head of the human body



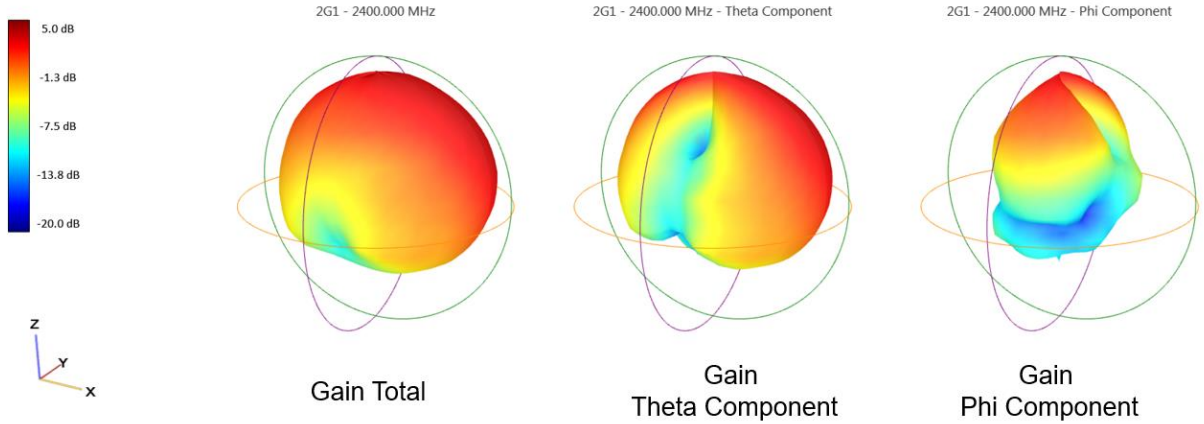
FS: Free space **BHH:** Beside Head Hand

Material Detuning



Radiation Pattern – Composite Gain Measurements

Radiation Pattern – 2G1 – 3D Patterns at 2400MHz



Gain Total

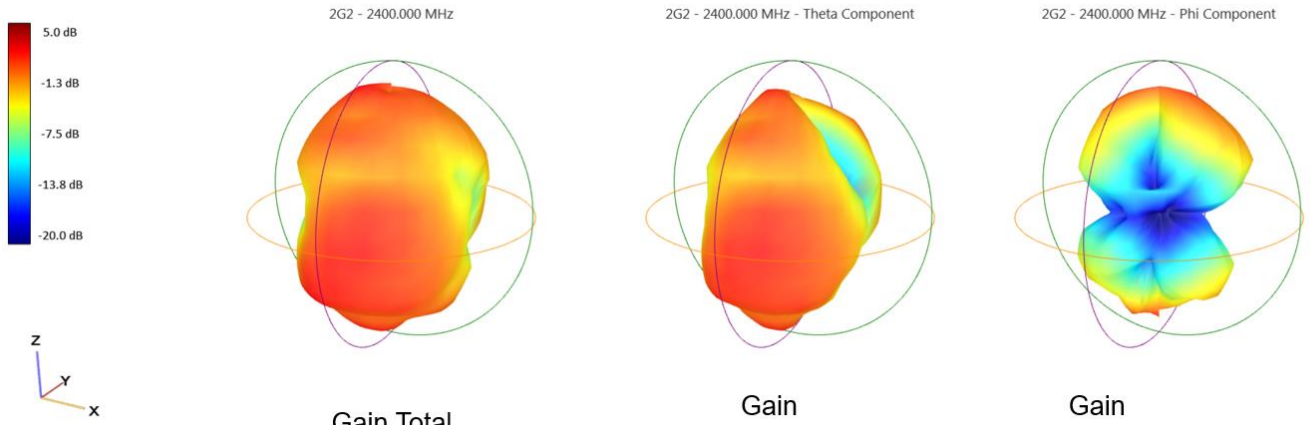
Gain
Theta Component

Gain
Phi Component

← Radiation Pattern of Antenna 1

Radiation Pattern of Antenna 2 →

Radiation Pattern – 2G2 – 3D Patterns at 2400MHz



Gain Total

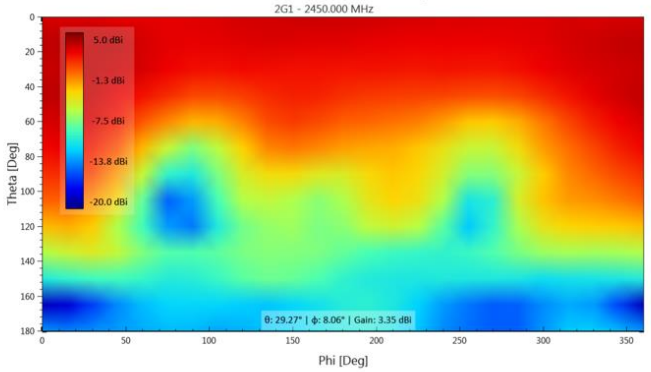
Gain
Theta Component

Gain
Phi Component

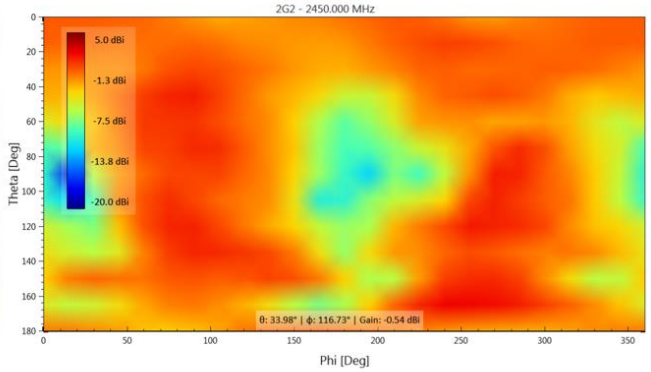
Radiation Pattern – Composite Gain Measurements

Composite Gain – 2.4 GHz antennas

2G1 Antenna gain



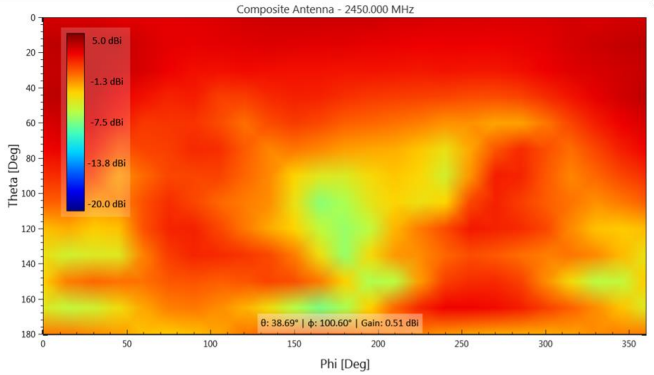
2G2 Antenna gain



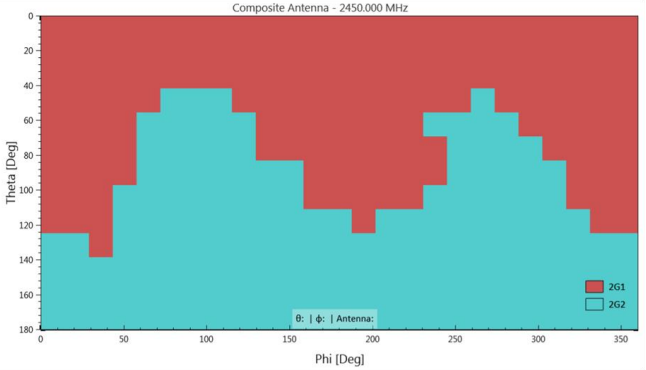
Note: This plot is a 2D map of the radiation pattern.

Composite Gain – 2.4 GHz antennas

Composite gain (max gain of 2G1 and 2G2 antennas)



Map color of which antenna has more gain in which direction



- The position and the orientation of the two antennas 2G1 and 2G2 have been optimized in order to optimized the overall coverage around the device, leading to a much more uniform gain composite distribution.
  ⇒ That will maximize the connectively between the AP and the devices

Antenna Arrays and Test Set-Ups

Example:

We do custom Eval-Kits and Arrays since every product has specific requirements

Standard parts on our Roadmap!

From Design to Manufacturing

- Review customer requirements
- Free-of-charge recommendations and layout review
- RF simulation on free space and phantom (optional)
- Custom antenna design (optional)

- Proof of concept – building a mock-up
- Mechanical antenna design (custom antenna) or PCB layout (standard antenna)

- Test mock-up in RF chamber
- Tuning & optimization
- Passive testing (Gain, Eff, RL)
- Active testing (TRP/TIS)
- FCC/CE pre-check (EMC/EMI)

- Build factory samples
- Validate performance of antenna
- Perform tuning & optimization

- Final test report
- Engineering package for antenna and final assembly

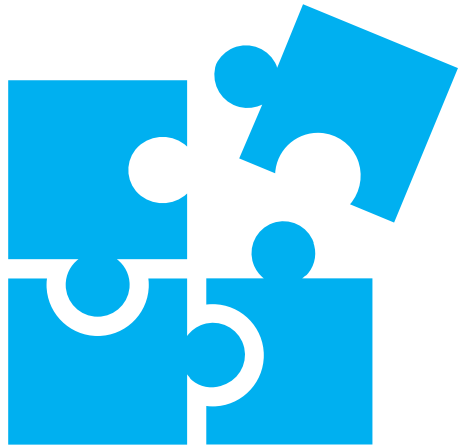
- Tool build for custom designs
- Qualification for mass production

Antenna Selection Process

Antenna Selection Check-list

What type of antenna is required?

- ✓ How many technologies must be integrated in the device?
- ✓ What frequency bands must be covered?
- ✓ What's the size of the PCB?
- ✓ What's the space available for the antennas (on-board or off-board)?
- ✓ What are the antenna surroundings (e.g. metal or potting material)?
- ✓ What is the end-user environment (e.g. body worn)?



Customized Solutions - for Challenging Mechanics




Custom Designs Manufactured in a Wide Array of Materials

- Injection Molding
- CNC
- LDS
- FPC (Flexible PCB)
- Stamped Metal
- 3D Printing
- PCB
- Insert Molding

Vietnam (2 factories), South Korea and China

Key Benefits of LDS

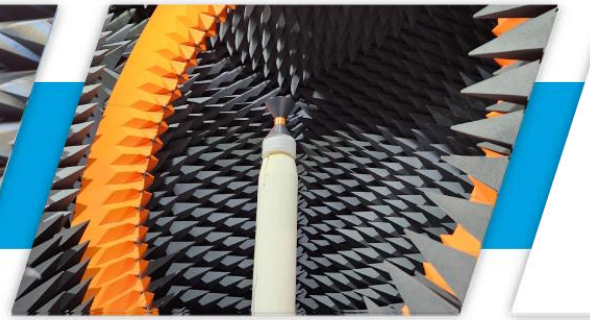
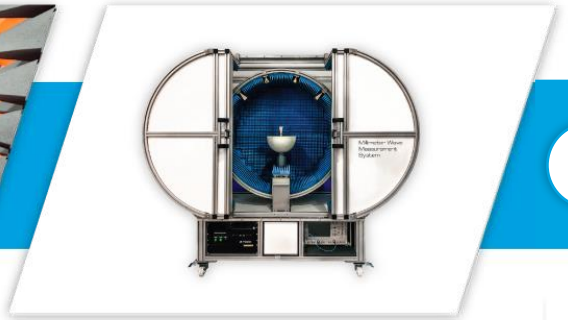
Antennas directly on the plastic carrier or housing

- 3D technology
- Design flexibility
- Smaller and thinner devices

Check how LDS works > *Click Here*

Design & Test Services



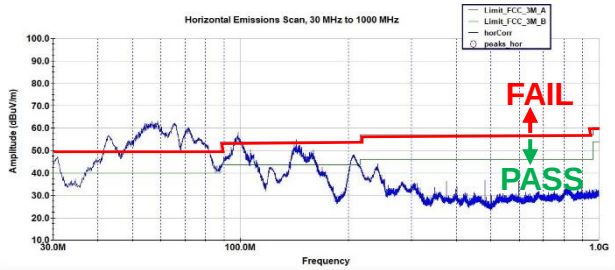



> Click Here

5	25+	1	400 MHz – 68 GHz
Design Centers	Testing Capabilities	Leading Automotive Chamber	Frequency Range

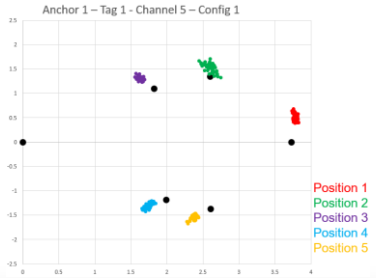
FCC/CE Regulatory Pre-Check

- TRP/TIS for 5G / LTE-M / NB-IoT and LoRa
- EMC/EMI
- SAR



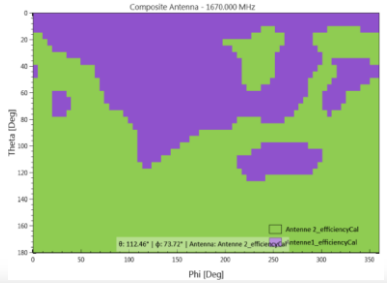
Specialty Testing

- AoA for UWB and BLE 5.1
- Phase center for GNSS receivers
- mmWave



In-house post-processing tools

- 2D/3D Radiation Patterns
- Composite Gain
- MIMO system optimization

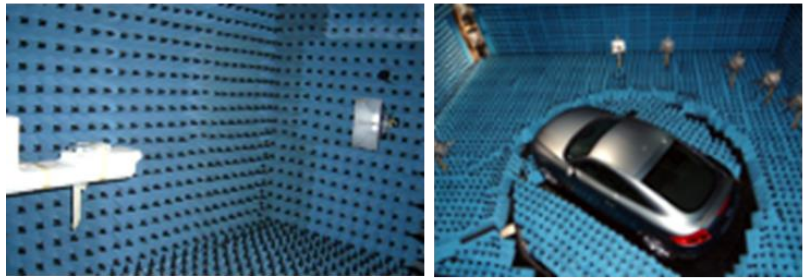


Coming back to the Main Parameters:

Return Loss (S11) / Isolation (S21)
Gain / Directivity
Efficiency (ŋ)
Polarization

Measurement Equipment

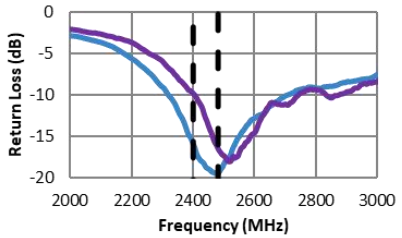
Vector Network Analyzer



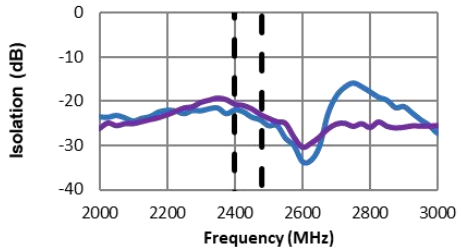
Anechoic Chambers

Test Results

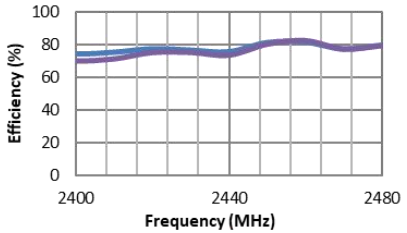
Return Loss



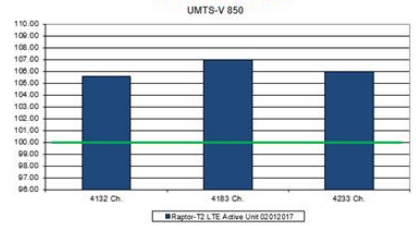
Isolation



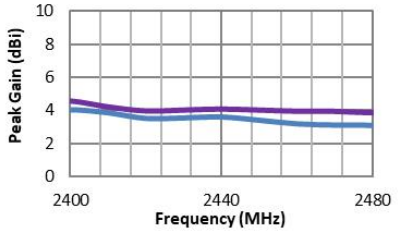
Efficiency



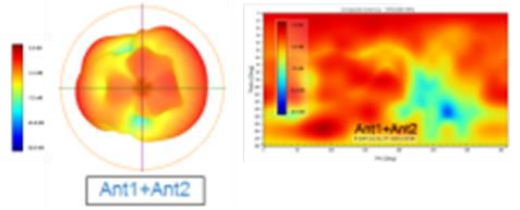
TRP & TIS



Peak Gain



2D/3D Radiation Pattern & Composite Gain



Case Study - Harmonics

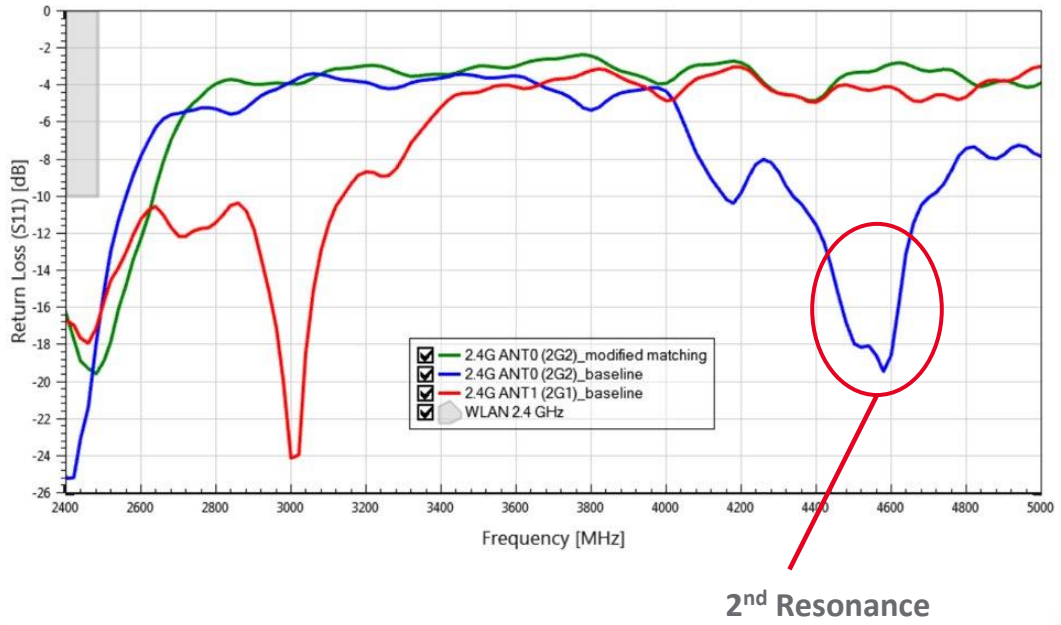
Problem
Customer encountered a pre-certification issue, which was linked to the 2nd harmonic resonance of the antenna

Root Cause
KYOCERA AVX indicated that the antenna's 2nd harmonic resonance can contribute to an FCC 2nd harmonic problem

Solution
Updates on the antenna matching circuit, to remove the resonance and resolve the harmonic concerns while maintaining the antenna performance

Outcome
2nd harmonic issue was resolved and the certification succeeded

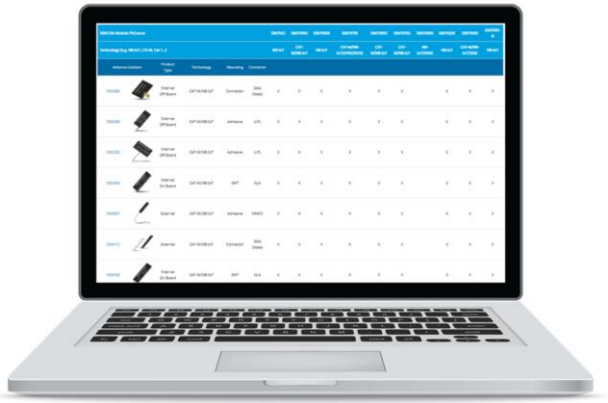
Certification test: Radiated emissions



Online Tools & Resources

> Click Here **Check Tools & Resources**

Online Component Search



Antenna Reference vs. chip/RF Module

NORDIC SEMICONDUCTOR
Fibocom
Telit Cinterion
SIMCom
u-blox
SEQUANS
Panasonic

Sample kits & lab boxes

IoT Solution Optimizer

Design Tools

Application notes

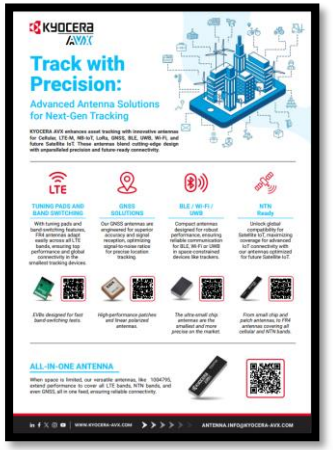
DXF/gerber files

Simulation files

3D FIT files

Technical Resources

- Videos
- White papers
- Case Studies
- One pagers
- Product Catalogs



KYOCERA AVX Benefits

- RF Knowledge and Extensive Experience
- Customized Solutions for Challenging Mechanics
- Validation and Pre-certification
- Innovative Roadmap with industry partners

THANK YOU.

KYOCERA-AVX.com