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Antenna design considerations for a Smart Home

6 March 2018

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Welcome

Thank you for joining the webinar today

- Hosted by Mathias Goebel, Supplier Business Manager, Avnet Abacus
- Brief introduction to Avnet Abacus and Molex
- Presented by Savvas Valsamakis, Business Development Manager, Molex
- 40-minute technical presentation
- 10-minute Q&A session

Avnet Abacus and Molex Partnership

Avnet Abacus is part of Avnet, a leading global distributor of electronic components.

We specialise in interconnect, sensors, wireless, passive, power supplies and battery products.

Our extensive team of technical specialists offers design and solution support to engineers across Europe.

Molex is a leading global supplier of advanced electronic components and solutions.
The product range also includes a variety of switches and applications tooling.

As a one-source supplier, Molex assures worldwide coordination of its resources to meet customers' needs globally, regionally and locally, designing and manufacturing products that make life easier.

Together we bring you a portfolio of high-performing solutions and associated technologies that enable you to transform concepts into smart connected designs across a wide range of applications.

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An overview of antenna technologies, with an in-depth look at products and wireless protocols

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Introducing our Presenter

Savvas Valsamakis, Business Development Manager at Molex EMEA

- Savvas joined Molex in 2014, after eleven years in research and development
- Responsible for Molex Micro-Solution Business Unit (MSBU) capabilities in the European market
- Specifically related to Molded Interconnect Device (MID) and antenna solutions

Contents

- Internet of Things and Antennas
- Factors Influencing Antenna Design (in)
- Molex and Antennas
- Product Literature
- Q&A

The **Internet of Things (IoT)** is the internetworking of physical devices for the collection and transfer of data

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Growth in IoT will continue to be driven by:

- Ubiquitous use of the internet
- Continued build out of wireless networks
- Operational efficiencies obtained through data management

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Growth in IoT will continue to be driven by:

- Increased functionality for safety and security
- Continued increase in computing capacity
- Continued decrease in hardware costs
- Continued decrease in hardware power consumption

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IoT and Antenna Technology

Antennas allow users to gain remote access to their device of choice, eliminating the need for direct wiring between transmitting and receiving devices, giving freedom of location and movement.

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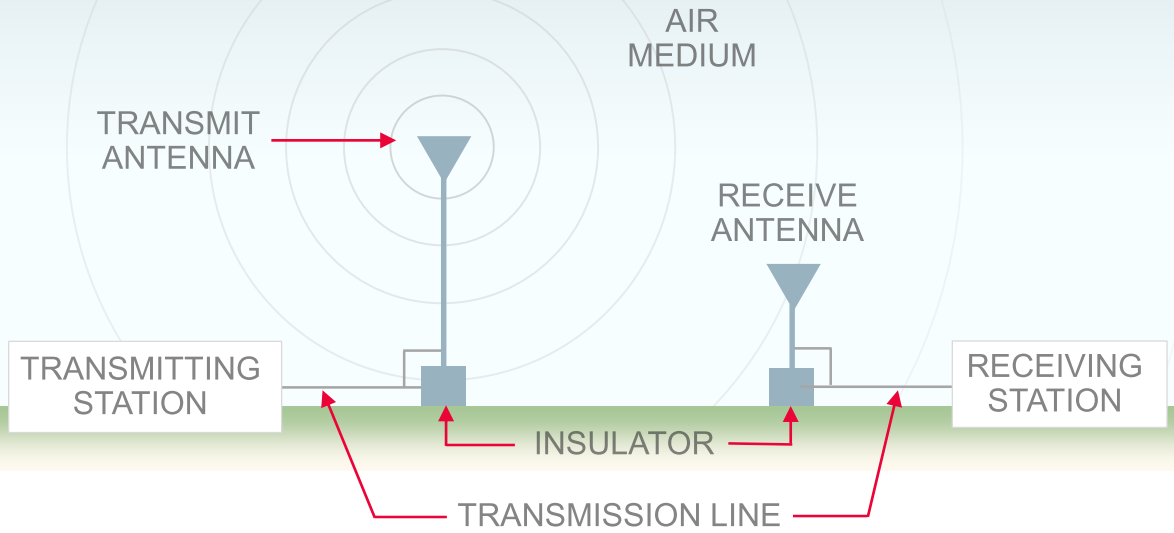
Antenna Introduction

So, what is an antenna?

An antenna is a device, or component, that converts guided electromagnetic waves to unguided electromagnetic waves and vice versa.

Any metal wire or strip could be used as an antenna.



Antenna Introduction

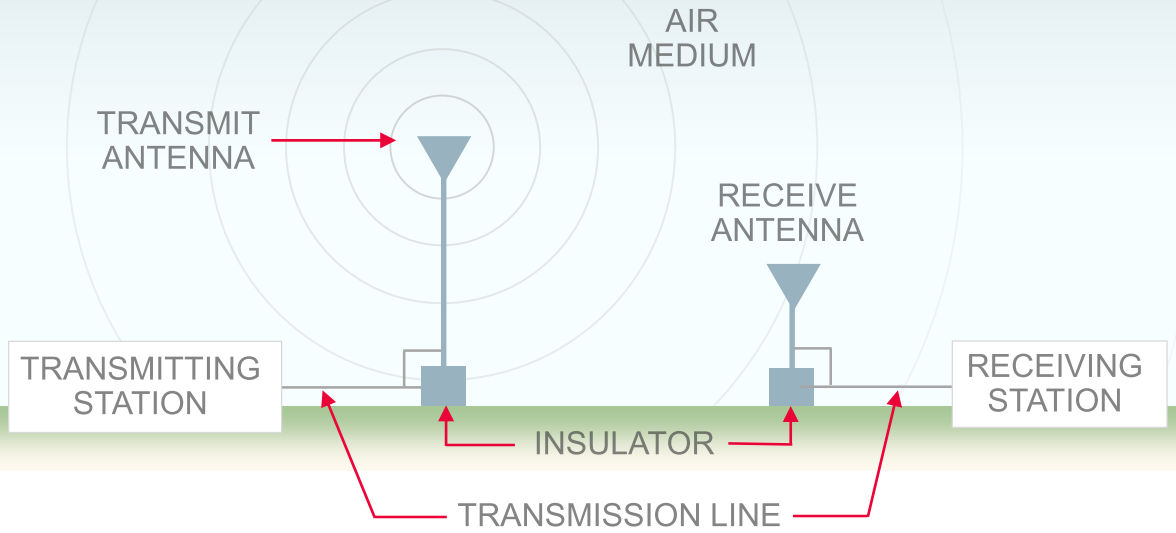
What is an antenna?

A single antenna can both transmit and receive

This is known as the *Theory of Reciprocity*

This is different to audio signals that need 2 devices (speaker and mic) to transmit and receive.

- Guided electromagnetic waves = waves being passed through the metal wire/strip
- Unguided electromagnetic waves = waves being passed through the air



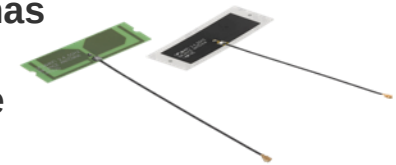
Antenna Introduction

We can categorize antennas in 4 main uses, considering their location on a device

Embedded Antennas
(inside the customer's device and mounted on the PCB)

Outdoor Antennas
(exposed to weather and harsh environments)

Internal Cabled Antennas
(inside the customer's device and coaxial cable connected to the PCB)



External Antennas
(outside the customer's device)

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Factors Influencing Antenna Design (in)

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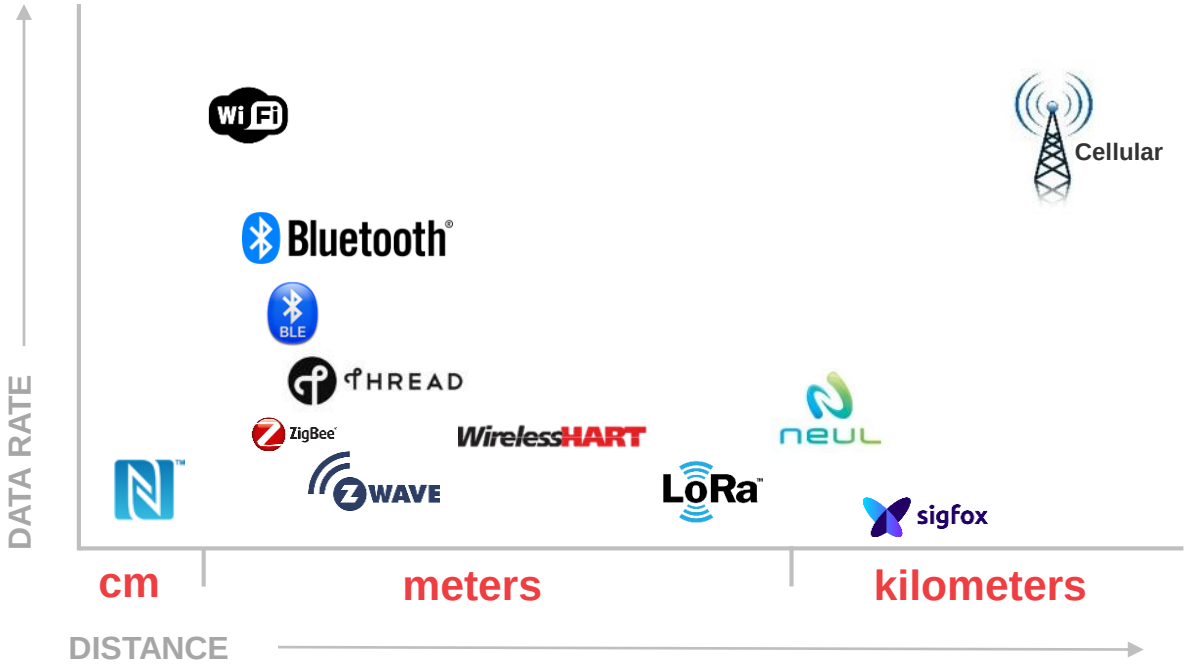
Wireless Decisions…

- How much data must be sent?
- What range is required?
- What frequencies can be used?
- How much power is available?

Wireless Protocols



Wireless protocols define the standards that allow networking devices to exchange information

Selection is **typically** driven by range and data usage requirement

For remote devices; power usage may be the driving factor

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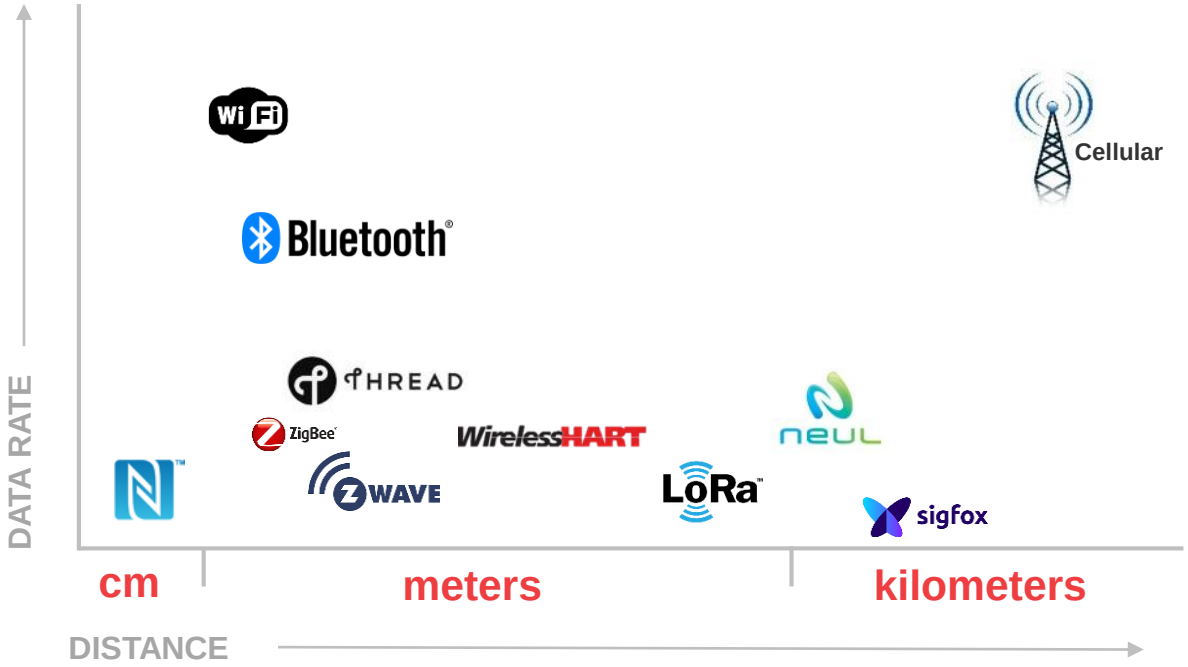
Wireless Protocols



Range

- **Long-range:** measured in kilometers e.g., Cellular
- **Medium-range:** measured in tens or hundreds of meters e.g., Wi-Fi
- **Short-range:** is generally less than 1 meter e.g., NFC (10cm)

Note: Longer distance requires lower frequency and more power

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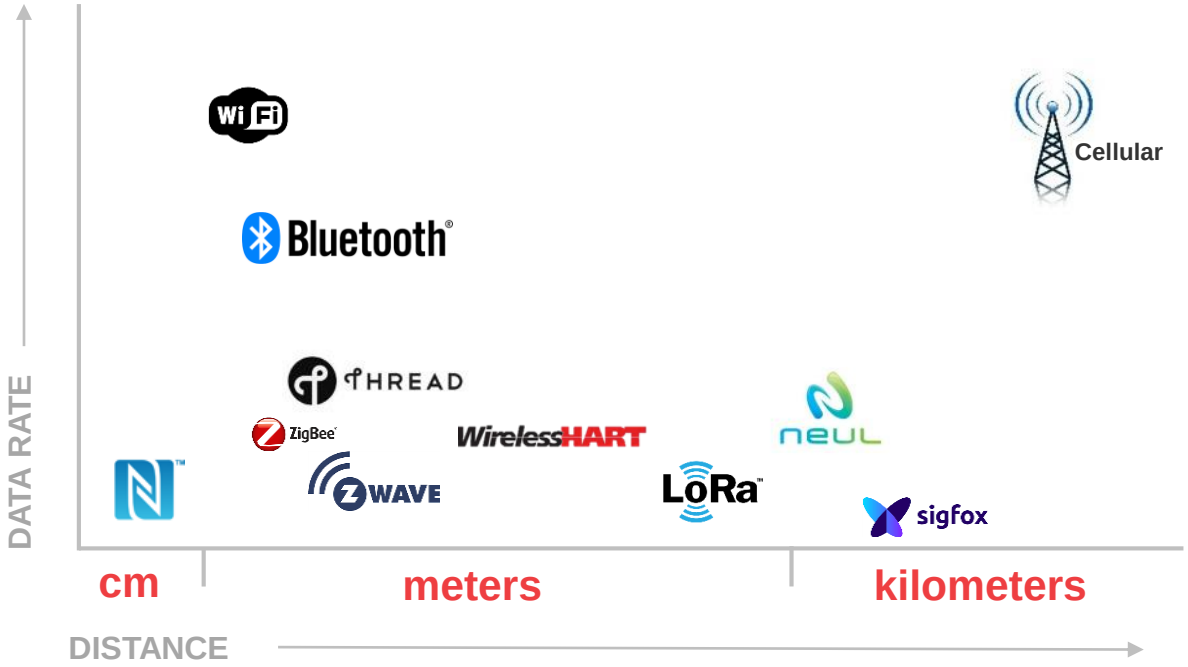
Wireless Protocols



Data Rate

- This can be anywhere from a single bit per second (1 bps) to over 1 Gbps
- Data rate (channel capacity) is a function of protocol, frequency and power
- Higher data rates require more power and higher frequency (bandwidth)

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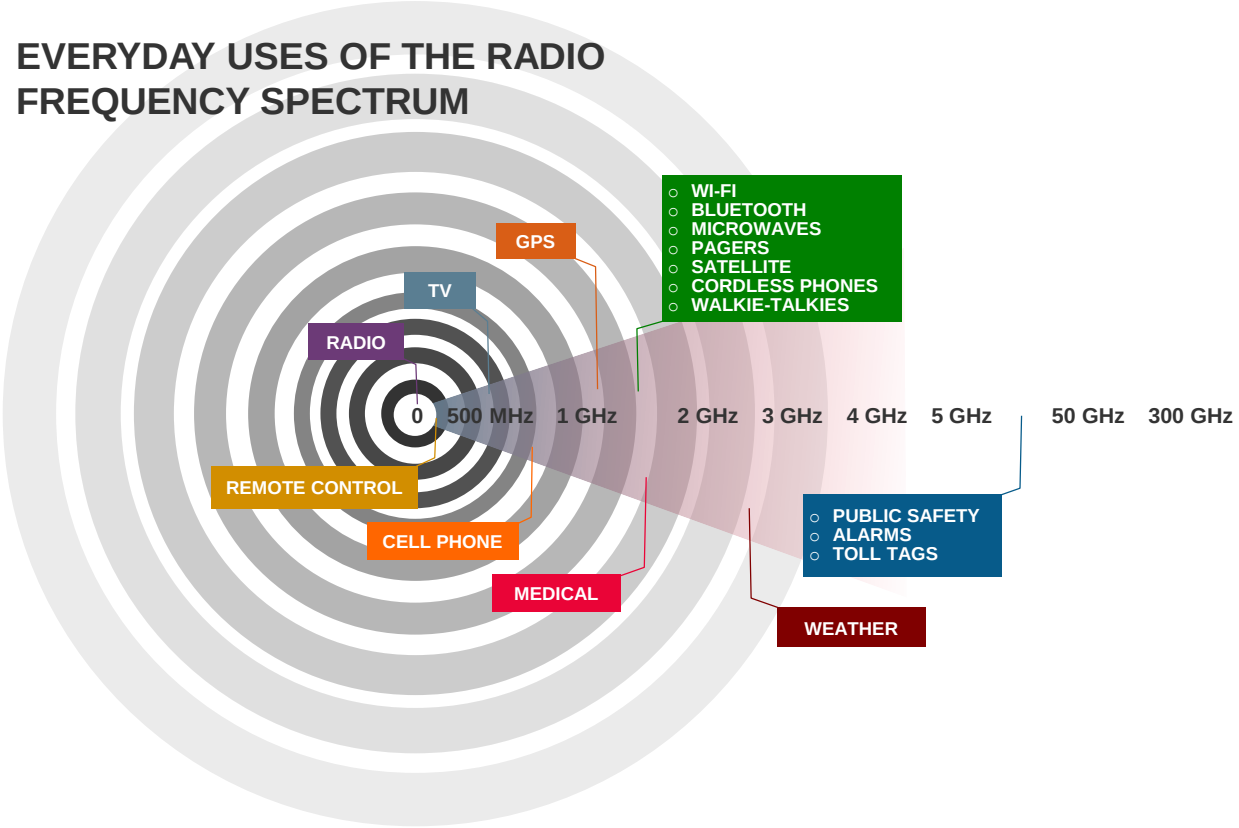
Wireless Protocols



Frequency

- Data rate (channel capacity) is a function of protocol, ***frequency*** and power. The higher the frequency, the greater the amount of data that can be transferred
- Additionally, the different types of communications use different frequencies to avoid colliding with each other

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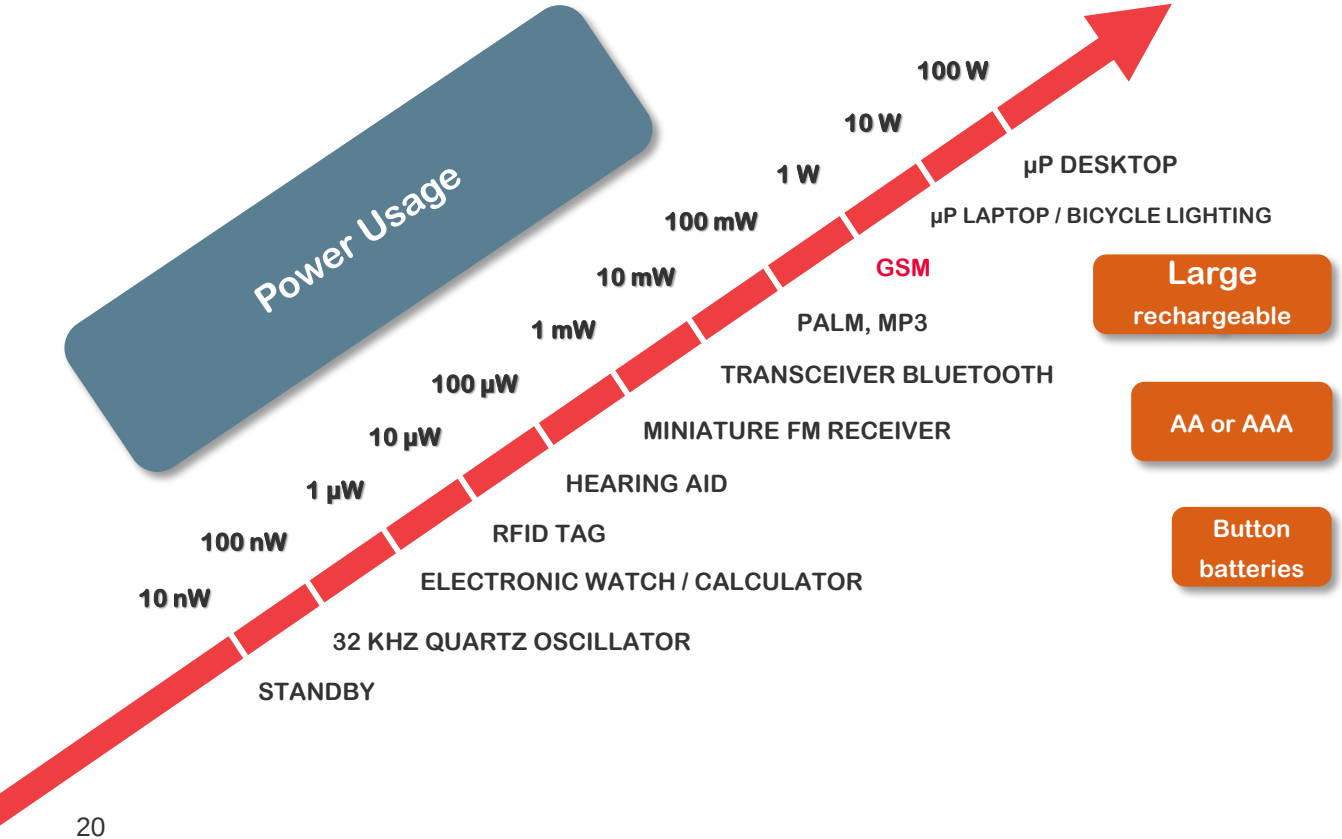
Wireless Protocols



Power

- Power usage is how much power the device is using for its function and is dependent on the protocol, frequency, range requirement and data rates
- Higher data rates will require more power
- Power usage is more of a concern for devices that do not have access to an external power source and are dependent on battery rates

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Wireless Protocols and Antennas

- **Frequencies** are the same
- **Range** varies
- **Data rates** are completely different

	ZigBee	Bluetooth	Wi Fi
FREQUENCY	2.4 GHz	2.4 GHz	2.4 GHz
RANGE	0-100m	0-100m	0-50m
DATA RATE	250 kbps	1 Mbps	Up to 1 Gpbs
	Home alarm system: Door open / closed	**Audio / Music transfer**	**Video / Movie transfer / Streaming / Download**

Wireless Protocols and Antennas

- *Why not just use Wi-Fi for all?*
- Battery management!
- Module Cost!

	ZigBee	Bluetooth	Wi Fi
FREQUENCY	2.4 GHz	2.4 GHz	2.4 GHz
RANGE	0-100m	0-100m	0-50m
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Wireless Protocols and Antennas

- Antennas work **independently** of the Wireless Protocol
- Antennas work across a defined set of frequencies (bandwidth)
- One antenna can support more than one protocol

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FREQUENCY	2.4 GHz	2.4 GHz	2.4 GHz
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Other Factors Which Influence Antenna Design (in)

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Frequency Needed for Communication

- Patterns/shape are designed to match a specific frequency or bandwidth

Area/Size/Shape Available for the Antenna

- Space issues impact the antenna material and shape
- Desired location of the antenna is dictated by whether an embedded or internal cabled assembly can be used

Location of the Antenna

- Embedded in the device
- External to the device
- Outdoor

Customer Use Condition

- How the antenna is used and the surrounding environment can impact the design to ensure optimum performance

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Molex Antennas

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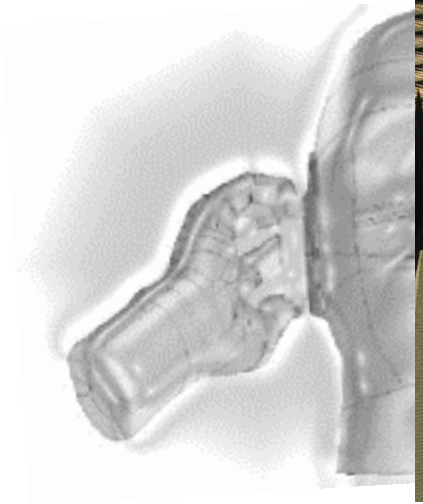
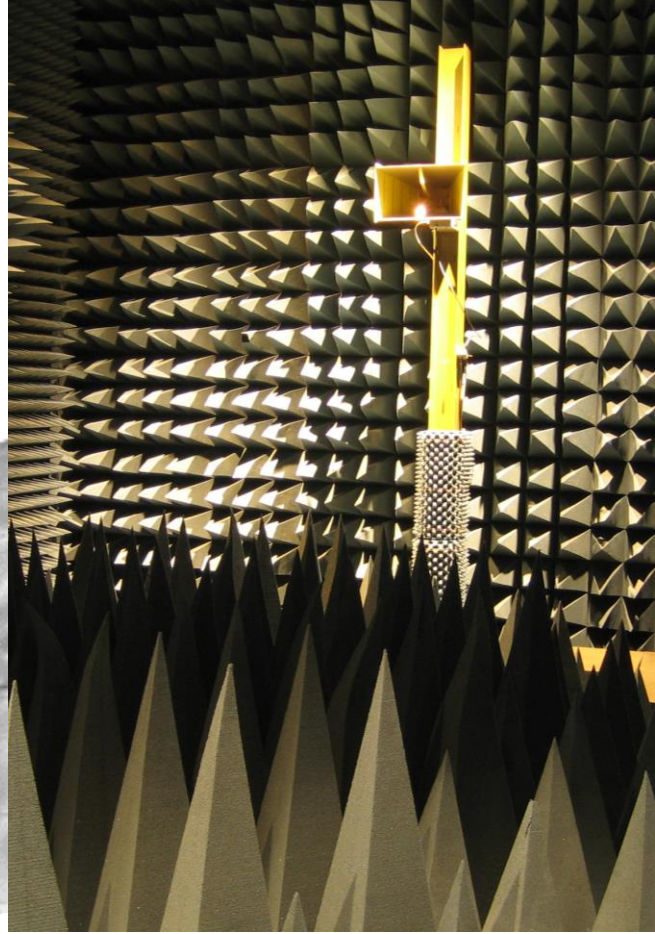
Molex Antenna Technology

Molex is leading antenna development and manufacturing in the mobile industry

The collected experience and developed know-how is now leveraged to create innovative solutions for IoT applications





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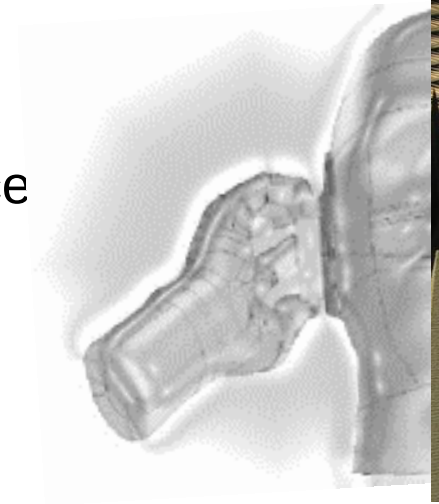
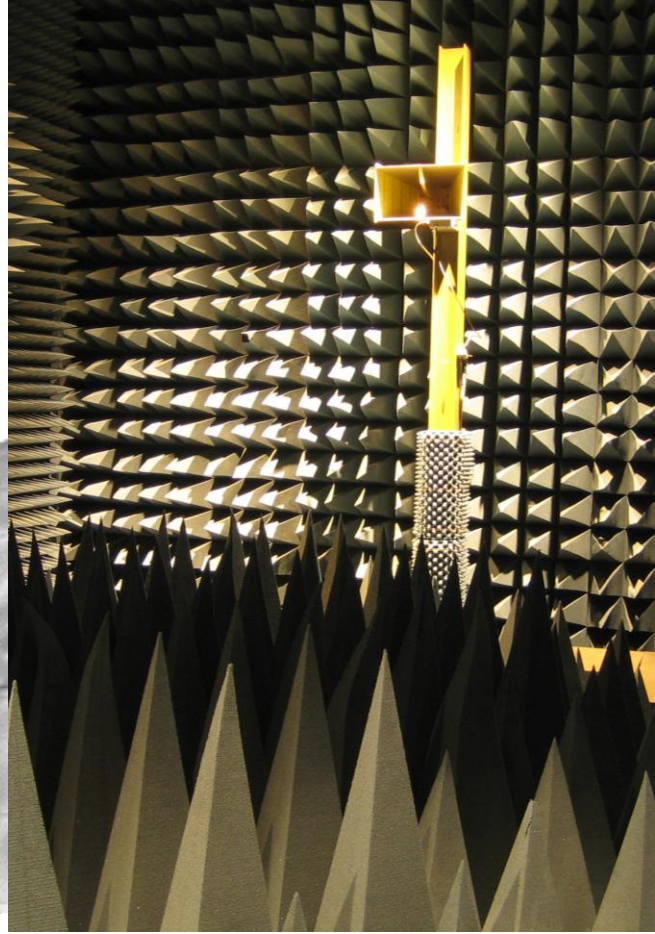
Molex Antenna Technology

From conception to validation, **Molex Antenna RF engineering** is using state-of-the-art simulation software and measuring equipment for the development of high-performance antennas, featuring patented technologies





Protocols that Molex Antennas Support

Bluetooth		Standard: Bluetooth 4.2 core specification **Frequency: 2.4GHz (ISM)** Range: 50-150m (Smart/BLE) Data Rates: 1Mbps (Smart/BLE)
Zigbee		Standard: ZigBee 3.0 based on IEEE802.15.4 **Frequency: 2.4GHz** Range: 10-100m Data Rates: 250kbps
Thread		Standard: Thread, based on IEEE802.15.4 and 6LowPAN **Frequency: 2.4GHz (ISM)** Range: N/A Data Rates: N/A
WiFi		Standard: Based on 802.11n (most common usage in homes today) **Frequencies: 2.4GHz and 5GHz bands** Range: Approximately 50m Data Rates: 600 Mbps maximum, but 150-200Mbps is more typical, depending on channel frequency used and number of antennas (latest 802.11-ac standard should offer 500Mbps to 1Gbps)
6LowPAN	6LoWPAN	Standard: RFC6282 **Frequency: (adapted and used over a variety of other networking media including Bluetooth Smart (2.4GHz) or ZigBee or low-power RF (sub-1GHz)** Range: N/A Data Rates: N/A

Z-Wave		Standard: Z-Wave Alliance ZAD12837 / ITU-T G.9959 **Frequency: 900MHz (ISM)** Range: 30m Data Rates: 9.6/40/100kbit/s
Sigfox		Standard: Sigfox **Frequency: 900MHz** Range: 30-50km (rural environments), 3-10km (urban environments) Data Rates: 10-1000bps
Neul		Standard: Neul **Frequency: 900MHz (ISM), 458MHz (UK), 470-790MHz (White Space)** Range: 10km Data Rates: Few bps up to 100kbps
Cellular		Standard: GSM/GPRS/EDGE (2G), UMTS/HSPA (3G), LTE (4G) **Frequencies: 900/1800/1900/2100MHz** Range: 35km max for GSM; 200km max for HSPA Data Rates (typical download): 35-170kps (GPRS), 120-384kbps (EDGE), 384Kbps-2Mbps (UMTS), 600kbps-10Mbps (HSPA), 3-10Mbps (LTE)
NFC		Standard: ISO/IEC 18000-3 **Frequency: 13.56MHz (ISM)** Range: 10cm Data Rates: 100–420kbps
LoRaWAN		Standard: LoRaWAN **Frequency: Various** Range: 2-5km (urban environment), 15km (suburban environment) Data Rates: 0.3-50 kbps

*** Always expanding – Please ask!**

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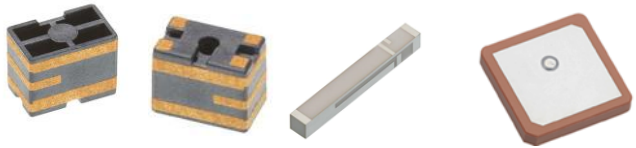
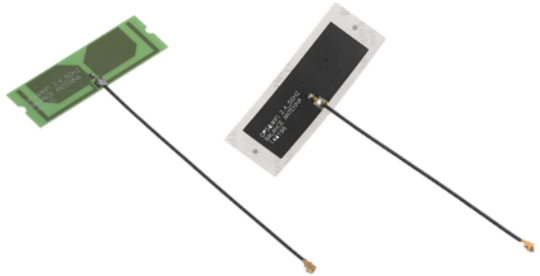
Molex and Antennas

Today Molex designs and sells antennas for use as:

Embedded Antennas
Inside the customer's device and mounted on the PCB



Internal Cabled Antennas
Inside the customer's device and coaxial cable connected to the PCB



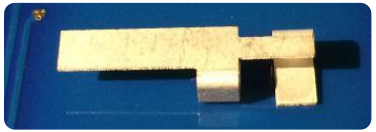
Molex and Antennas

Embedded Antennas (inside the device)

Chip Type 1:
Plastic housing and laser direct structuring

Chip Type 2:
Ceramic

Stamped metal



- Embedded antennas are directly SMT'd or soldered onto the device's PCB
- They are small and typically used when general space inside a device is a premium but space exists on the PCB

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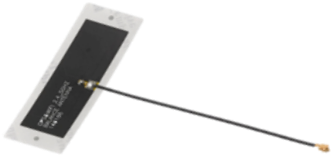
Molex and Antennas

Internal Cabled Assembly Antennas (inside the device)

Printed circuit board



Flexible printed circuit

Stamped metal

Internal cabled assemblies are typically used when:

- The user wants to optimize performance of the antenna by placing it closer to the outside of the device
- There is no space for an embedded antenna on the PCB
- Gives the PCB designer more freedom for design

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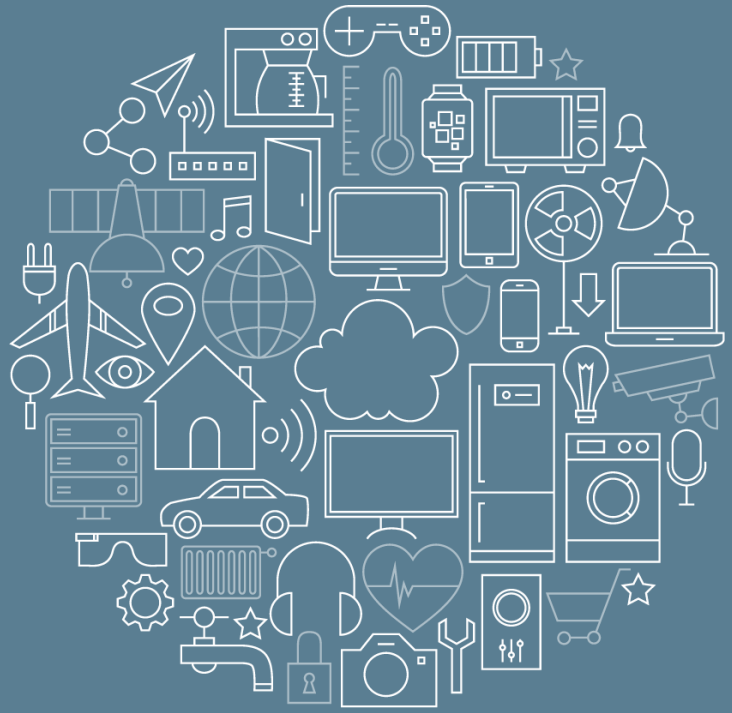
Molex Antenna Technology



Utilizing a variety of manufacturing technologies from MID to flexible circuits and stamping, **Molex can provide the appropriate antenna solution** for each application.

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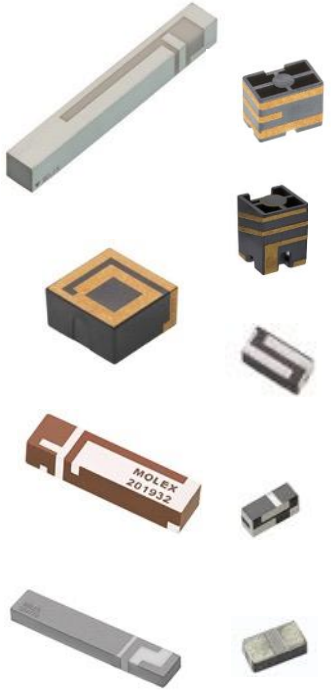

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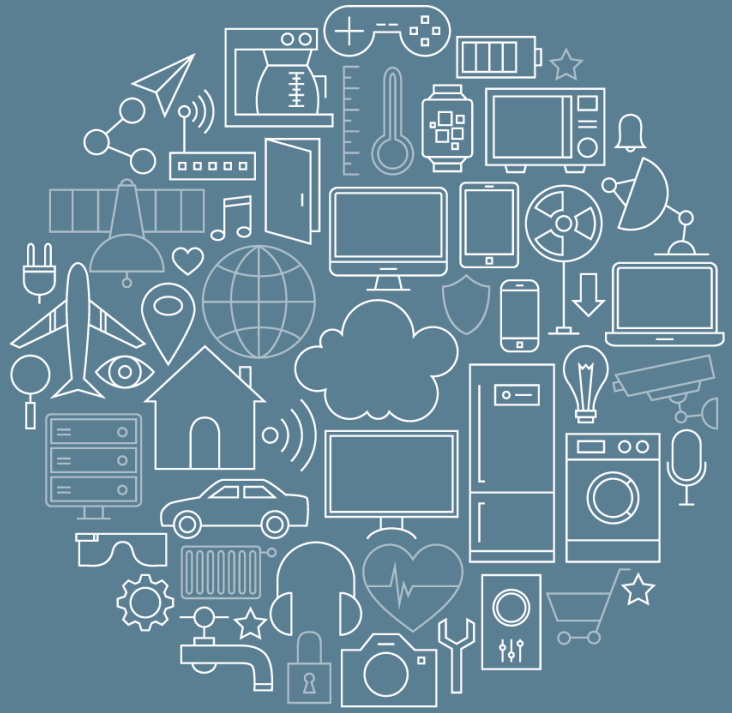
Molex Antenna Technology



From custom solutions to overcome conventional design and production method restrictions, to standard solutions for the most common applications.

Innovative antenna products supporting multiple protocols are being created to enable best-in-class IoT devices.

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Product Literature

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Product Webpage

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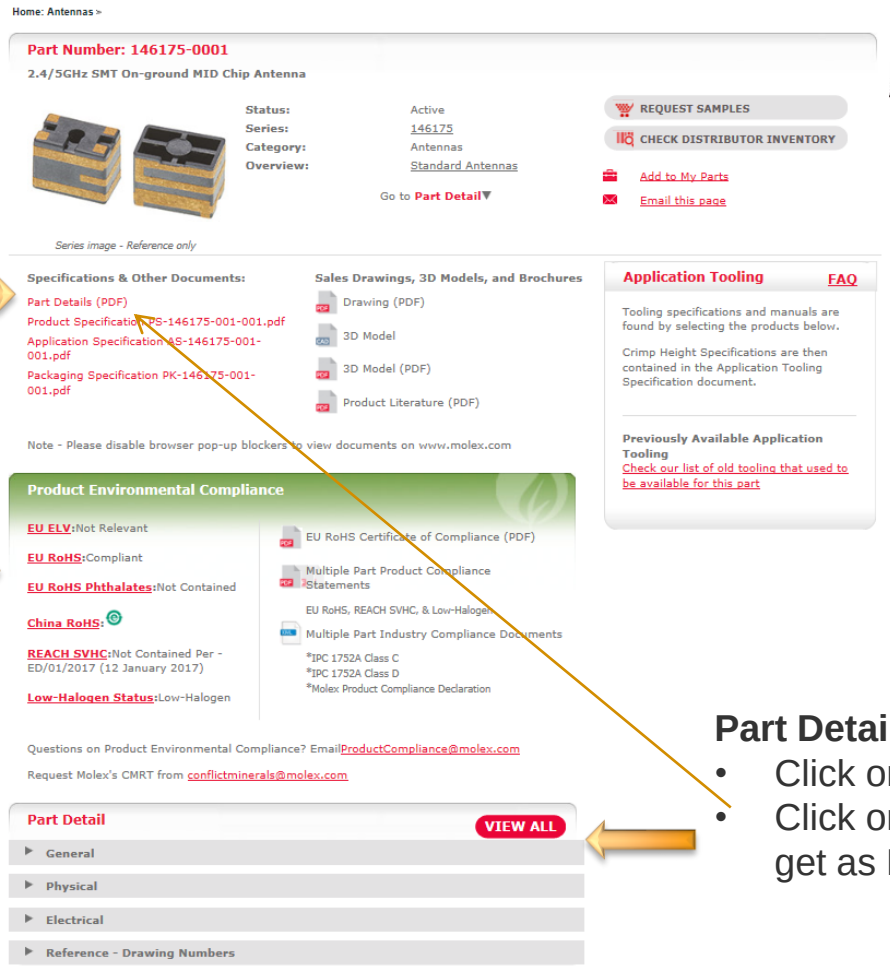
Product Literature

- Product spec
- Application spec
- Packaging spec
- Drawings and CAD models

Product Certification



Part Details Overview

- Click on VIEW ALL to expand
- Click on Part Details (PDF) get as PDF download

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Application Specification

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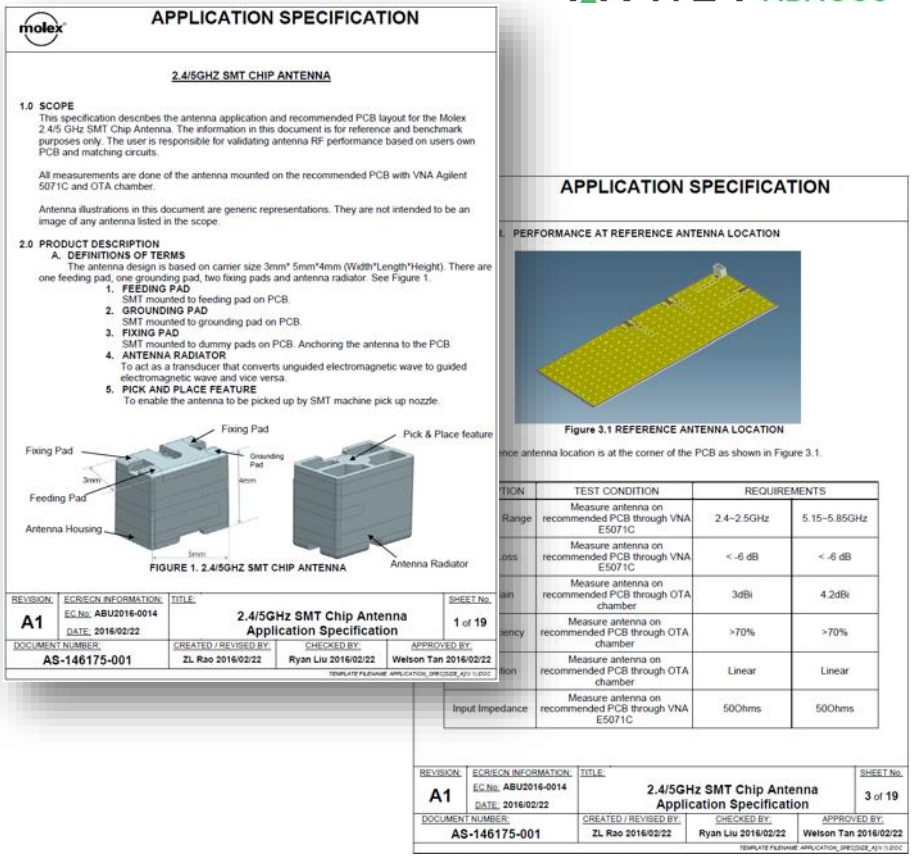


APPLICATION SPECIFICATION

2.4/5GHZ SMT CHIP ANTENNA

1.0 SCOPE

This specification describes the antenna application and recommended PCB layout for the Molex 2.4/5 GHz SMT Chip Antenna. The information in this document is for reference and benchmark purposes only. The user is responsible for validating antenna RF performance based on users own PCB and matching circuits.

All measurements are done of the antenna mounted on the recommended PCB with VNA Agilent 5071C and OTA chamber.

Antenna illustrations in this document are generic representations. They are not intended to be an image of any antenna listed in the scope.

2.0 PRODUCT DESCRIPTION

A. DEFINITIONS OF TERMS

The antenna design is based on carrier size 3mm* 5mm*4mm (Width*Length*Height). There are one feeding pad, one grounding pad, two fixing pads and antenna radiator. See Figure 1.

1. FEEDING PAD — SMT mounted to feeding pad on PCB.
2. GROUNDING PAD — SMT mounted to grounding pad on PCB.
3. FIXING PAD — SMT mounted to dummy pads on PCB. Anchoring the antenna to the PCB
4. ANTENNA RADIATOR — To act as a transducer that converts unguided electromagnetic wave to guided electromagnetic wave and vice versa.
5. PICK AND PLACE FEATURE — To enable the antenna to be picked up by SMT machine pick up nozzle.

Fixing Pad, Fixing Pad, Pick & Place feature, Grounding Pad, 3mm, 4mm, Feeding Pad, Antenna Housing, 3mm, Antenna Radiator

FIGURE 1. 2.4/5GHZ SMT CHIP ANTENNA

REVISION:	ECR/ECN INFORMATION:	TITLE:	SHEET No.
A1	EC No: ABU2016-0014 DATE: 2016/02/22	2.4/5GHz SMT Chip Antenna Application Specification	1 of 19
DOCUMENT NUMBER:	CREATED / REVISED BY:	CHECKED BY:	APPROVED BY:
AS-146175-001	ZL Rao 2016/02/22	Ryan Liu 2016/02/22	Welson Tan 2016/02/22

APPLICATION SPECIFICATION

PERFORMANCE AT REFERENCE ANTENNA LOCATION

Figure 3.1 REFERENCE ANTENNA LOCATION

nce antenna location is at the corner of the PCB as shown in Figure 3.1.

TION	TEST CONDITION	REQUIREMENTS	
Range	Measure antenna on recommended PCB through VNA E5071C	2.4~2.5GHz	5.15~5.85GHz
oss	Measure antenna on recommended PCB through VNA E5071C	< -6 dB	< -6 dB
ain	Measure antenna on recommended PCB through OTA chamber	3dBi	4.2dBi
ency	Measure antenna on recommended PCB through OTA chamber	>70%	>70%
tion	Measure antenna on recommended PCB through OTA chamber	Linear	Linear
Input Impedance	Measure antenna on recommended PCB through VNA E5071C	50Ohms	50Ohms

REVISION:	ECR/ECN INFORMATION:	TITLE:	SHEET No.
A1	EC No: ABU2016-0014 DATE: 2016/02/22	2.4/5GHz SMT Chip Antenna Application Specification	3 of 19
DOCUMENT NUMBER:	CREATED / REVISED BY:	CHECKED BY:	APPROVED BY:
AS-146175-001	ZL Rao 2016/02/22	Ryan Liu 2016/02/22	Welson Tan 2016/02/22

Application Specification

2.0 PRODUCT DESCRIPTION

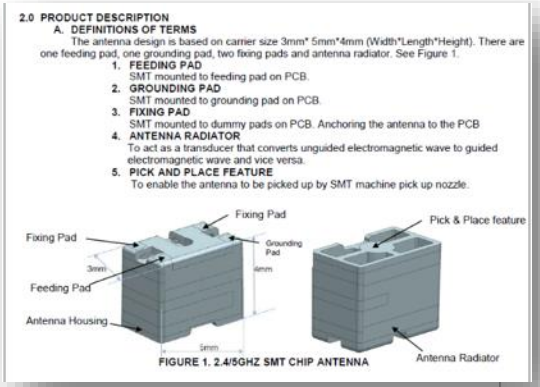
A. DEFINITION OF TERMS

→ explains the basic terminology

B. REFERENCE IMPLEMENTATION

→ provides information on the reference PCB and its layout

→ indicates the antenna performance at the reference location



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   To act as a transducer that converts unguided electromagnetic wave to guided electromagnetic wave and vice versa.
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   To enable the antenna to be picked up by SMT machine pick up nozzle.

FIGURE 1. 2.4/5GHZ SMT CHIP ANTENNA

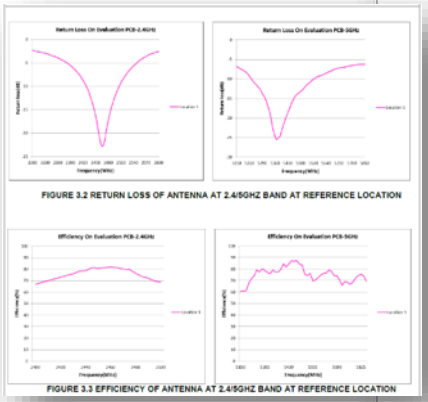
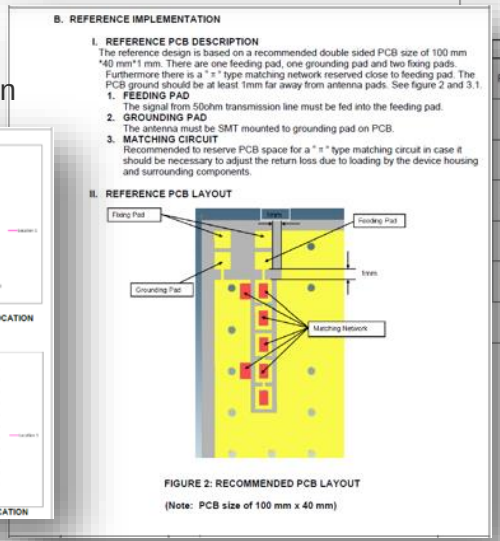


FIGURE 3.2 RETURN LOSS OF ANTENNA AT 2.4/5GHZ BAND AT REFERENCE LOCATION

FIGURE 3.3 EFFICIENCY OF ANTENNA AT 2.4/5GHZ BAND AT REFERENCE LOCATION



B. REFERENCE IMPLEMENTATION

I. REFERENCE PCB DESCRIPTION

The reference design is based on a recommended double sided PCB size of 100 mm *40 mm*1 mm. There are one feeding pad, one grounding pad and two fixing pads. Furthermore there is a " π " type matching network reserved close to feeding pad. The PCB ground should be at least 1mm far away from antenna pads. See figure 2 and 3.1.

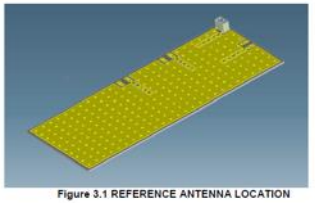
1. FEEDING PAD
   The signal from 50ohm transmission line must be fed into the feeding pad.
2. GROUNDING PAD
   The antenna must be SMT mounted to grounding pad on PCB.
3. MATCHING CIRCUIT
   Recommended to reserve PCB space for a " π " type matching circuit in case it should be necessary to adjust the return loss due to loading by the device housing and surrounding components.

II. REFERENCE PCB LAYOUT

FIGURE 2: RECOMMENDED PCB LAYOUT

(Note: PCB size of 100 mm x 40 mm)

III. PERFORMANCE AT REFERENCE ANTENNA LOCATION



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DESCRIPTION	TEST CONDITION	REQUIREMENTS	
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Return Loss	Measure antenna on recommended PCB through VNA E5071C	< -6 dB	< -6 dB
Peak Gain	Measure antenna on recommended PCB through OTA chamber	3dBi	4.2dBi
Total Efficiency	Measure antenna on recommended PCB through OTA chamber	>70%	>70%
Polarization	Measure antenna on recommended PCB through OTA chamber	Linear	Linear
Input Impedance	Measure antenna on recommended PCB through VNA E5071C	50Ohms	50Ohms

Q&A and further resources

There will now be a 10-minute Q&A

Further resources – visit avnet-abacus.eu/molex to:

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- share the on-demand webinar with your colleagues
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