



NORDIC®
SEMICONDUCTOR

Antenna Integration Application Note

Design and solution partners to get your wireless products to market on time, the first time



Taoglas' Cellular and GNSS Antennas

High precision GNSS and high efficiency wide-band cellular antennas

Introduction

Taoglas have partnered up with Nordic to help you in bringing your new IoT products to market on time, the first time.

We will help you on your IoT product journey, by providing integration guidelines for our cellular and GNSS antennas with the Nordic nRF9160 cellular IoT System-in-Package. By utilizing our knowledge gained on over 10,000 customer RF and IoT projects, we want to eliminate problems and risks that can arise with the RF complexities when designing small wireless devices.

GNSS & Cellular Portfolio Overview

Optimizing design can help increase RF performance and in turn extend device battery life and this application note that will show you how to achieve the best possible cellular and GNSS integration on your device PCB.

We have chosen some of our top-performing Cellular and GNSS antennas, paired them with the Nordic nRF9160, and shown the preferred board layout for optimum performance. Real-world test data is included to show the impact of the ground plane size on cellular performance.

Cellular Product Specifications and Benefits

LTE-M & NB-IoT

- Frequency range, 700 – 960 MHz & 1710 – 2200 MHz.
- nRF9160 Frequency range, 700 – 2200 MHz.

Ground Plane Size/ Antenna to metal clearance

- Works well with a ground plane length over 75mm.

Efficiency

- For a PCB longer than 107mm the antenna efficiency needs to be at least $\geq 32\%$ in the low band and $\geq 50\%$ for high bands for the USA market wherein Europe minimum recommended frequency is $\geq 20\%$.
- For a PCB shorter than 107mm USA operators have relaxed the certification requirement and can accept efficiencies $\geq 10\%$.

Impedance

- Designed for 50 ohms transmission.

Bandwidth

- Targeted minimum of -4dB return loss at the edge of the band.

Advantages

- Compact volume, minimum footprint.
- Can be machine surface mounted.
- Achieves moderate to high gain in both vertical and horizontal
- Polarization planes.
- Performance in different environments .
- Human body: up to 4dB degradation.
- Concrete/wood: up to 2dB degradation.
- Metal: 2dB to 4dB (minimum clearance to antenna should be 20mm).

PA.710.A



The Warrior PA.710, the revolutionary patent pending PA.710A is a 4G/3G/2G, High Efficiency SMD Ceramic antenna, operating at 698MHz to 960MHz and 1710MHz to 2690MHz. It uses high grade custom ceramic material and new design techniques to deliver the highest efficiencies on all bands when mounted on the device's main PCB. The exceptional wide-band response means it is the ideal antenna for all LTE applications that also need high efficiency and backward compatibility for 3G and 2G globally on all lower and upper bands.

PCS.06.A



The Havok PCS.06.A is a low profile SMD LTE/cellular 4G/3G/2G embedded antenna designed for direct SMD mount on a device PCB. It provides high efficiency in a very small factor. If tuning is required it can be tuned for the device environment, while there is no need for new tooling. Its rectangular shape and small size makes it very easy to integrate – packaged in tape and reel, it can be mounted via pick and place to reflow solder directly on the edge of the PCB board. The antenna is very suitable for lower cost LTE/cellular applications due to the ease of integration.

PCS.50.A



The Taoglas Universe PCS.50A is a patent pending active Cellular and GNSS antenna designed specifically for IoT devices with small ground planes. With an unprecedented level of integration, it combines aperture tuning and active switching technologies to provide a wideband coverage for GNSS and most 4G cellular bands, including the most challenging 700MHz bands. The PCS.50 has an RF switch to adjust the resonance frequency of the antenna depending on the device requirements.

GGBLA.01.A



The Unifier GGBLA.01.A is ceramic miniature loop antenna for GPS-GLONASS-Galileo-BeiDou applications. At 3.2*1.6*0.5mm, this antenna is a miniature edge mounted SMD antenna, designed for small space requirements. Typical applications are small sized automotive navigation or position tracking systems and hand-held devices when GNSS function is needed. The Unifier antenna series' wide bandwidth allows high efficiency, stable reception on all three GPS, GLONASS and BeiDou bands from 1555MHz to 1602MHz. With achievable efficiencies of 64% to 85% and peak gain of 3.3dBi this antenna's gain performance is placed within the range of a much larger 15mm to 18mm patch antennas.

DSGP.18.A



The DSGP.18.4.A is an 18mm square ceramic GPS L1 / GALILEO E1 passive patch antenna. With a low profile, this antenna is ideal for space constrained applications in telematics devices, vehicle tracking/fleet management systems, wearables and navigation. The antenna has been tuned on a 50*50mm ground plane, working at 1575.42MHz with a 4.20dBi gain. The radiation pattern is broadly hemispherical with a stable gain across elevations. The patch is mounted via SMT process, ideal for high volume low cost assembly.

nRF9160 cellular IoT System-in-Package

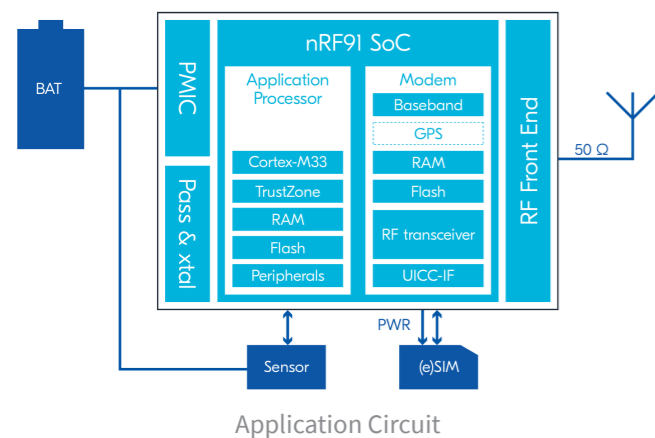
Low power SiP with integrated LTE-M, NB-IoT and GNSS wireless modem

Overview

The nRF9160 SiP is making the latest LTE technology accessible for a wide range of applications and developers. With the fully integrated SiP and pre-certification for global operation, it solves the complex wireless design challenges as well as the comprehensive set of qualifications needed to utilize cellular technology.

By integrating an application processor, multimode LTE-M/NB-IoT/GNSS modem, RF front-end (RFFE) and power management in a 10x16x1.04 mm package, it offers the most compact solution for cellular IoT (cIoT) on the market.

Targeting asset tracking applications, the nRF9160 SiP has built-in support for nRF Cloud Location Services. These services provide built in GNSS and LTE location support with assisted GPS, predicted GPS, single-cell and multi-cell location services.



Application Processor

The nRF9160 SiP offers a modern and powerful 64 MHz Arm Cortex-M33 CPU with on-chip flash and RAM exclusively for application use.

A range of analog and digital peripherals supports the powerful application processor and enables advanced single chip cIoT products.

The integrated cryptographic and security features enables the nRF9160 SiP to meet the latest requirements on internet security and authentication. By including trusted execution capability on the application processor, it takes security a step further by securing the most critical processes and peripherals in the application. In addition, the on-chip modem is its own security island.

LTE-M/NB-IoT/GNSS modem

The nRF9160 LTE modem integrates RFFE, radio and baseband. It supports worldwide operation, enabling cIoT products without regional specific variants.

The LTE modem supports half-duplex FDD operation and all power saving and coverage enhancement modes. A single pin antenna interface is available.

The LTE stack layers L1-L3, IPv4/IPv6, TCP/UDP, TLS/DTLS are all part of the modem firmware. The application processor communicates with the LTE modem through BSD secure sockets APIs and contains the application layer protocols such as HTTP(S), CoAP, MQTT and LWM2M, and the application itself.

The nRF9160 LTE modem supports both SIM and eSIM, plug-in or soldered. It provides power to the SIM and handles all communication automatically.

Designed for true low power cIoT

The nRF9160 SiP is specifically designed to take full advantage of the energy efficiency possibilities associated with the LTE-M and NB-IoT standards. Nordic designs all hardware and software, and as such offers an unparalleled, highly efficient and optimized low power cIoT solution.

It supports both the PSM and eDRX power saving features, enabling the nRF9160 SiP to sleep for longer periods of time. For both LTE-M and NB-IoT the PSM floor current is as low as 2.7 uA, and with an eDRX interval of 655 seconds the idle average current is 6 uA for LTE-M and 9 uA for NB-IoT.

Get started today

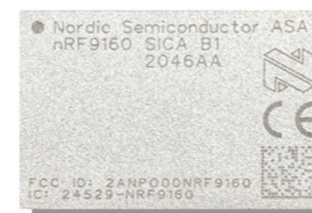
The nRF Connect SDK is the software development kit for the nRF9160 SiP, including everything needed to get started, and much more. It integrates the Zephyr RTOS, application layer protocols such as HTTP(S), CoAP, MQTT and LWM2M, and application examples covering a wide range of use cases. It also includes software for secure boot, and secure firmware over-the-air (FOTA) for both application and modem firmware. The necessary firmware for the LTE modem is offered as pre-certified and precompiled downloads.

nRF Cloud is our IoT optimized cloud that works seamlessly with the nRF9160 SiP. It enables the use of nRF Cloud Location Services, services which provide different ways of computing location data with a lower power consumption compared with regular GNSS.

The nRF9160 DK is our recommended starting point for development. It is an affordable, pre-certified single board development kit for the nRF9160 SiP, facilitating development with LTE-M, NB-IoT and GNSS.

Key Features

- Multimode LTE-M/NB-IoT modem with integrated RF front-end.
- Certified LTE bands: B1-B5, B8, B12-B14, B17-B20, B25-B26, B28 and B66
- 10x16x1.04 mm LGA package



nRF9160 SiP

Certified for global operation:

- AT&T, Bell, China Telecom, Deutsche Telekom, KDDI, Telstra, Verizon, Vodafone, etc.
- GCF, PTCRB y FCC (USA), CE (EUR), UKCA (UK), ISED (CAN), SRRC (CHN), ACMA RCM (AUS), NCC (TWN), MIC (JPN), MSIP (KOR), (IND) and more
- More info: nordicsemi.com/9160cert

Multimode LTE-M/ NB-IoT modem

- 700 - 2200 MHz LTE band support
- +23 dBm output Power
- GNSS (GPS, QZSS)
- eDRX and PSM power saving features
- Coverage enhancement modes
- Single pin 50Ω antenna interface
- UICC interface

Dedicated application processor and memory

- 64MHz Arm Cortex-M33 CPU
- Arm TrustZone for trusted execution
- Arm CryptoCell 310 for application layer security
- 1MB Flash & 256KB RAM

Applications

- Logistics and asset tracking
- Smart city & smart agriculture
- Predictive maintenance & industrial
- Wearables & medical

Key Data

LTE-M/NB-IoT modem	
Frequency range	700-2200 MHz
Throughput (DL/UL)	LTE-M: 300/375 kbps NB-IoT: 30/60 kbps
Output power	Up to 23 dBm
RX sensitivity	LTE-M: -108 dBm NB-IoT: -114 dBm GPS: -155 dBm
Mode	HD-FDD

Application Processor	
CPU	64 MHz Arm Cortex-M33 Arm TrustZone
Flash	1 MB
Output power	256 KB
Security	Arm Cryptocell 310
Peripherals	4xSPI/UART/TWI 4 x PWM, PDM, I2S 12 bit/200 ksps ADC 3xTIMER, 2xRTC, WDT

Current consumption (23 dBm TX power, 3.7 V supply)	
PSM floor current	LTE-M: 2.7 uA NB-IoT: 2.7 uA
eDRX, 655 seconds	LTE-M: 6 uA NB-IoT: 9 uA

Operating conditions and package	
Supply voltage	3.0-5.5 V
Temperature	-40 to 85 °C
Package	10x16x1.04 mm LGA



Cellular/ GPS Antenna Reference Design with Nordic - nRF9160

Taoglas PA.710.A LTE Antenna with the DSGP.18.2.A Integrated on Different PCB Dimensions

PA.710.A Features and Benefits

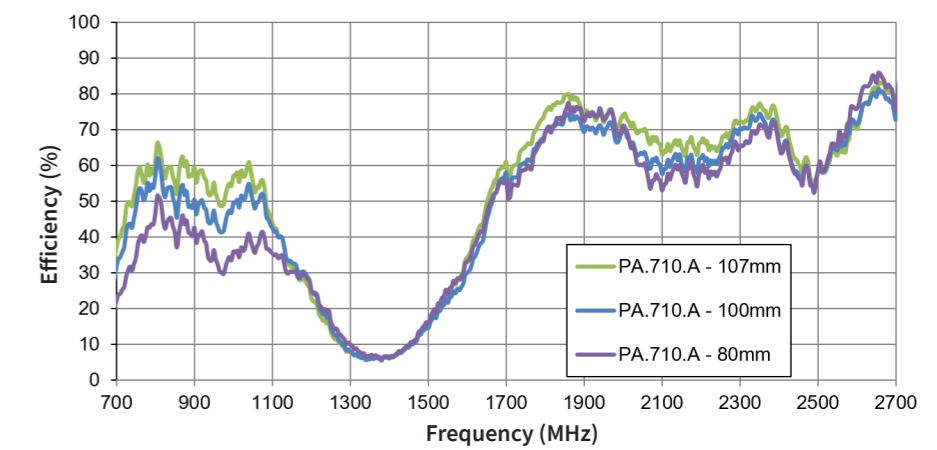
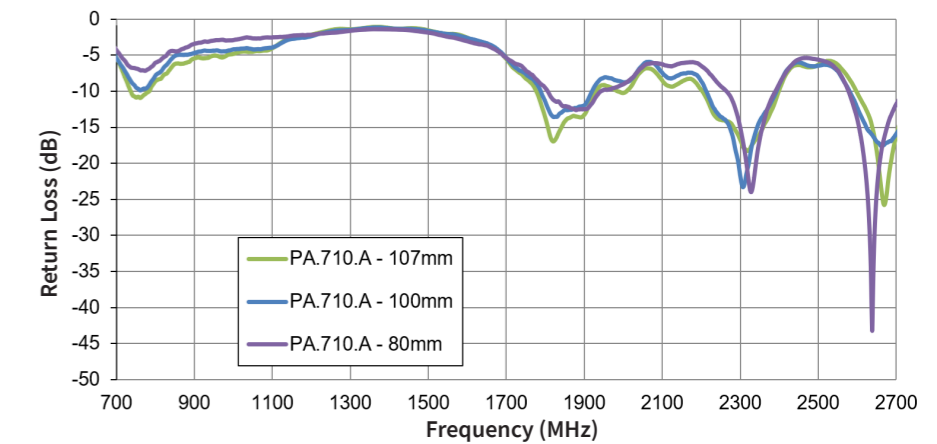
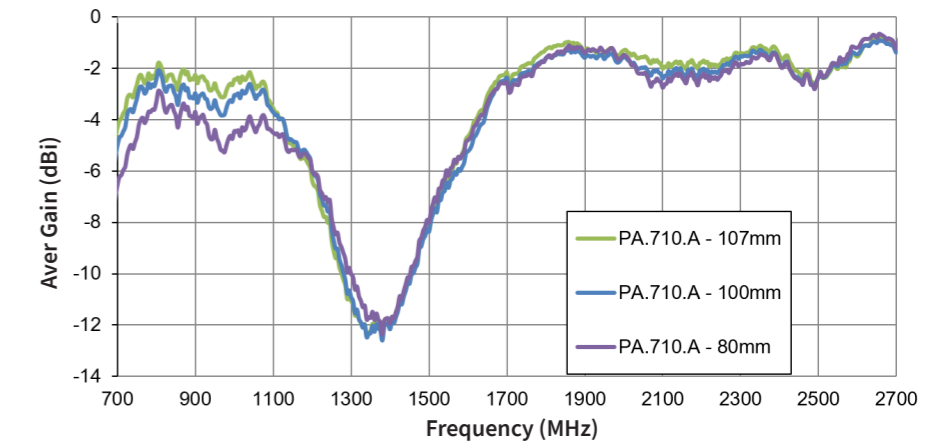
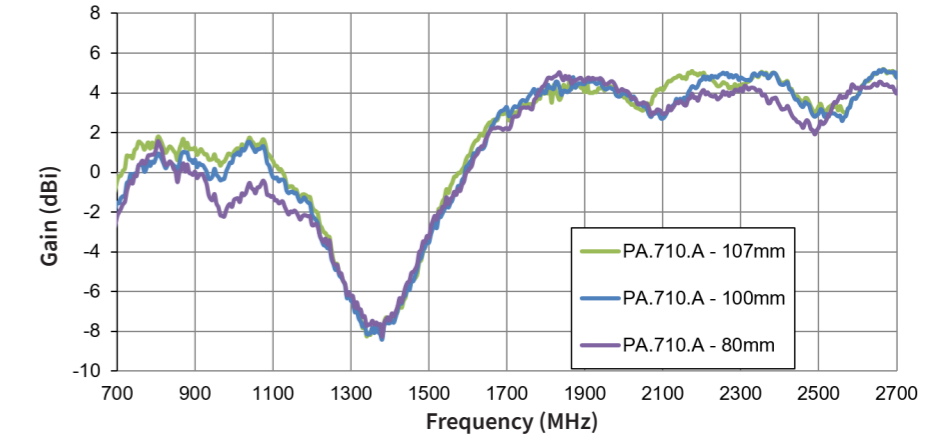
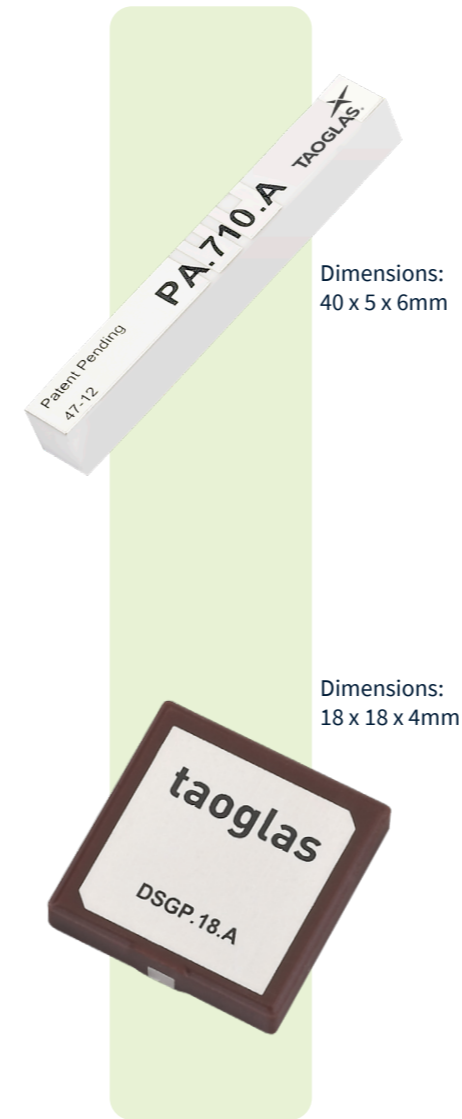
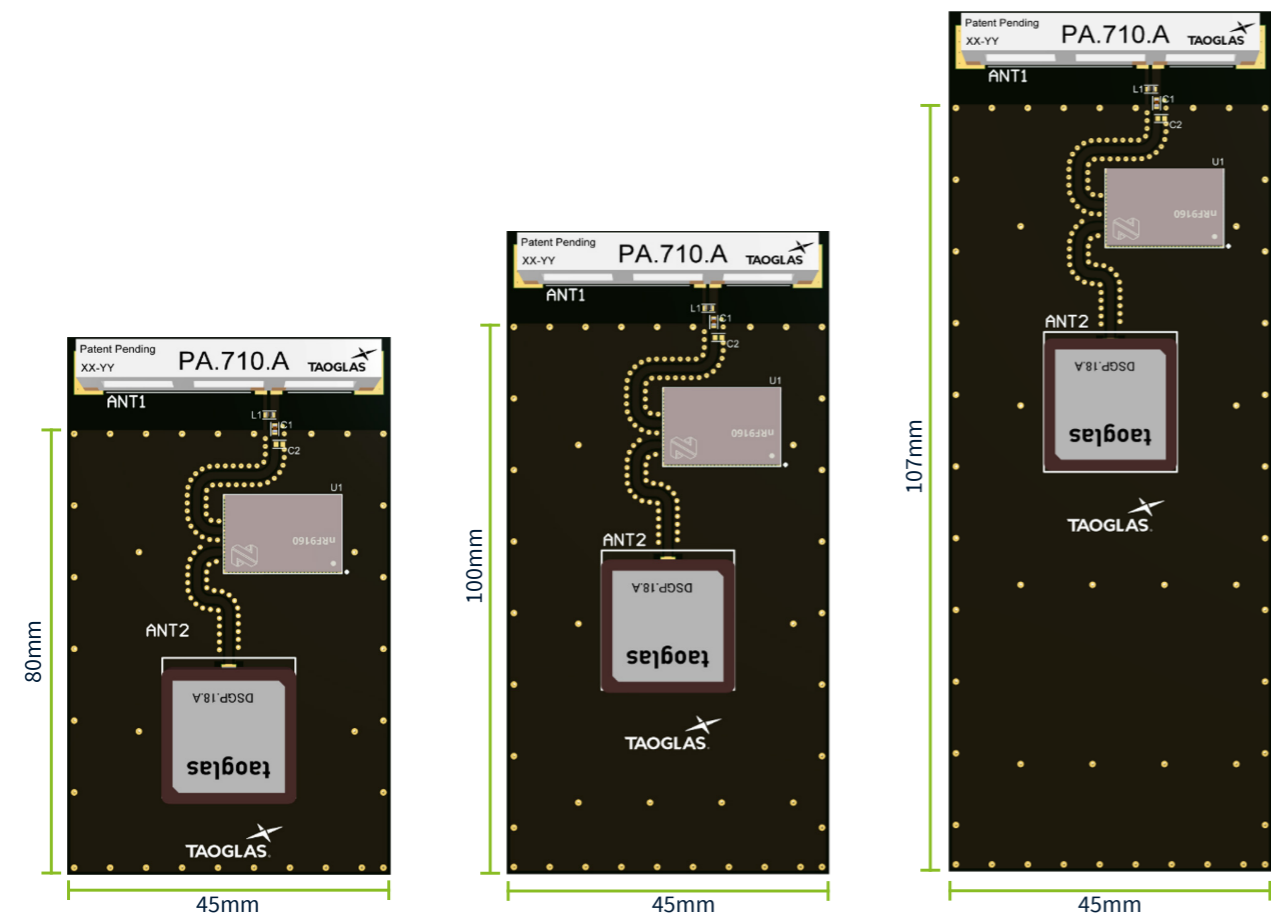
- High efficiency, high grade custom, SMD ceramic antenna.
- Wide-band response is ideal for all LTE applications.
- Backward compatibility for 3G and 2G globally on all lower and upper bands.
- Operates with great efficiency on worldwide NB-IoT and CAT-M frequency bands.

[Click Here to View the PA.710.A Product Page](#)

DSGP.18 Features and Benefits

- High RHCP gain.
- Short TTFF (Time to first fix), excellent carrier to noise values.
- High positional accuracy.
- Multipath mitigation capabilities.

[Click Here to View the DSGP.18 Product Page](#)



Cellular/ GPS Antenna Reference Design with Nordic - nRF9160

Taoglas PA.710.A LTE Antenna with the GGBLA.01.A Integrated on Different PCB Dimensions

PA.710.A Features and Benefits

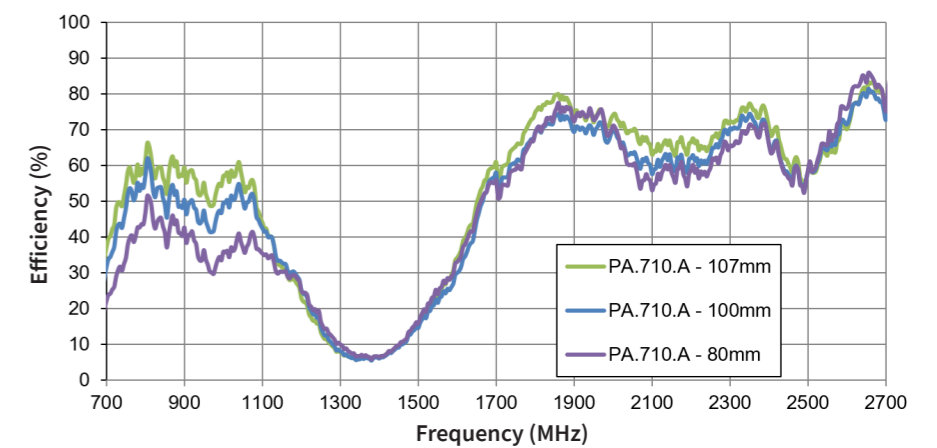
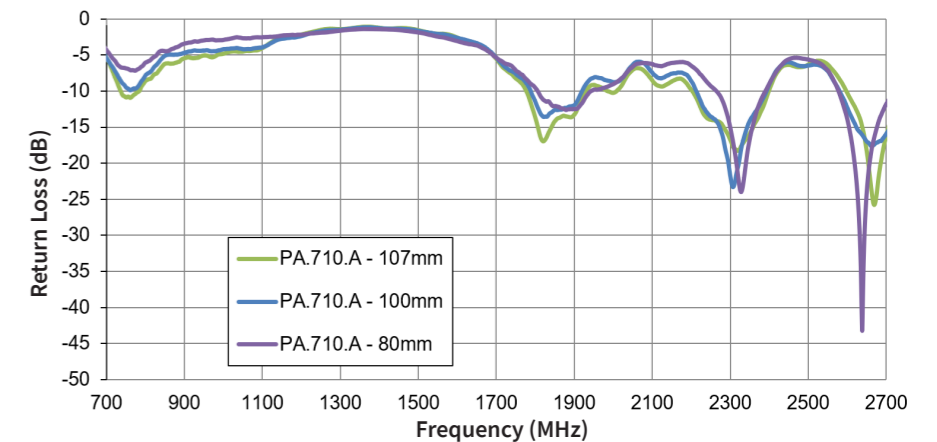
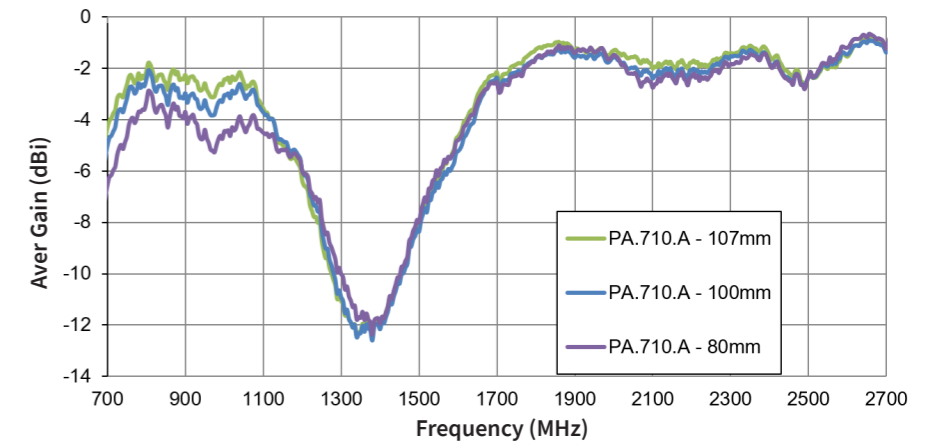
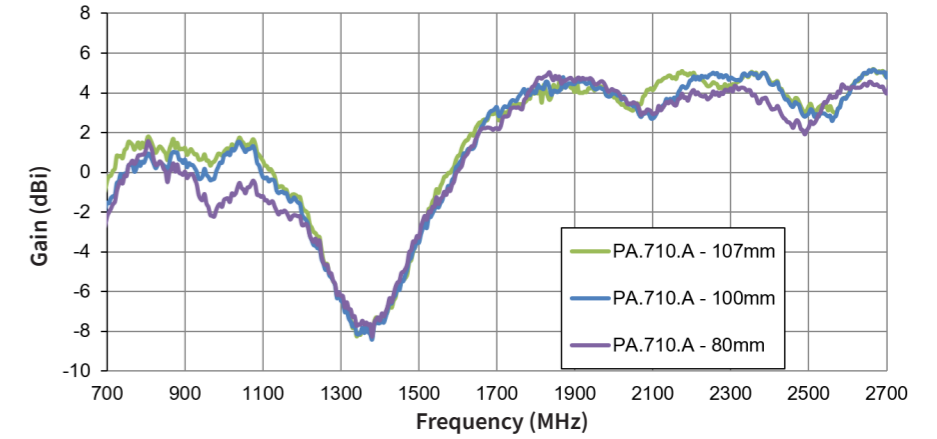
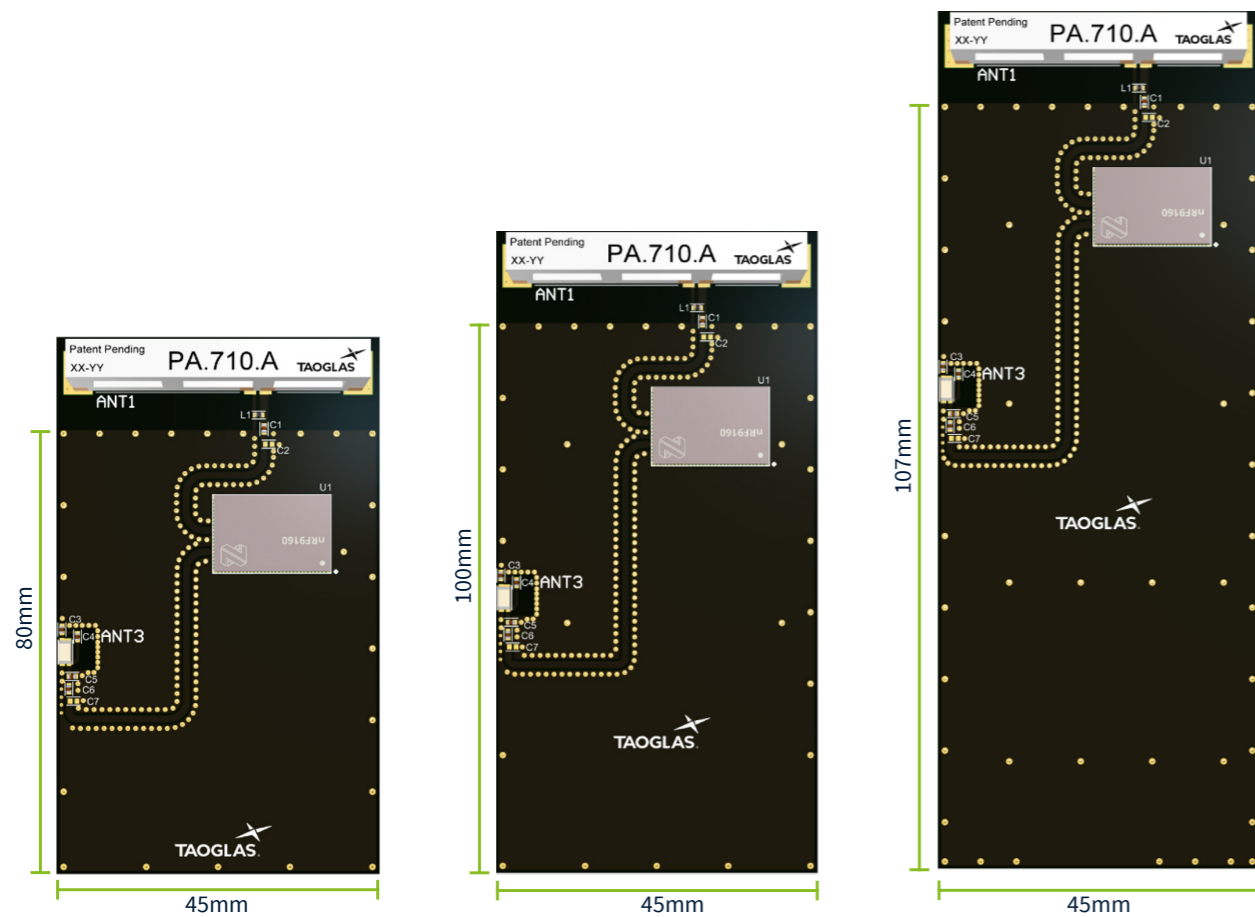
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- Operates with great efficiency on worldwide NB-IoT and CAT-M frequency bands

[Click Here to View the PA.710.A Product Page](#)

GGBLA.01 Features and Benefits

- Small form factor is suitable for small spaces.
- High positional accuracy.
- High efficiency, stable reception on GPS, GLONASS and BeiDou.
- Omnidirectional radiation pattern.

[Click Here to View the GGBLA.01.A Product Page](#)



Cellular/ GPS Antenna Reference Design with Nordic - nRF9160

Taoglas PCS.06.A LTE Antenna with the DSGP.18.2.A Integrated on Different PCB Dimensions

PCS.06.A Features and Benefits

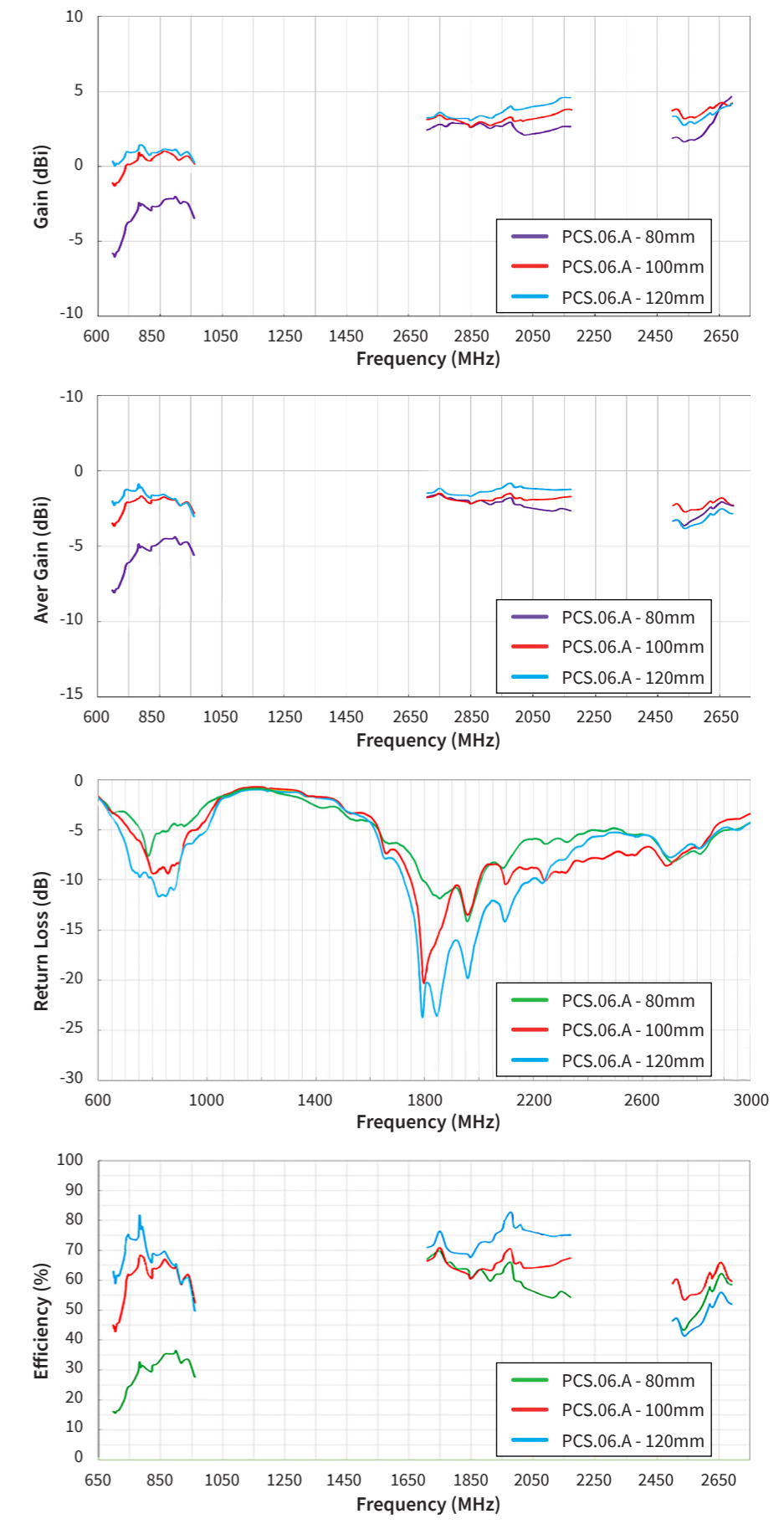
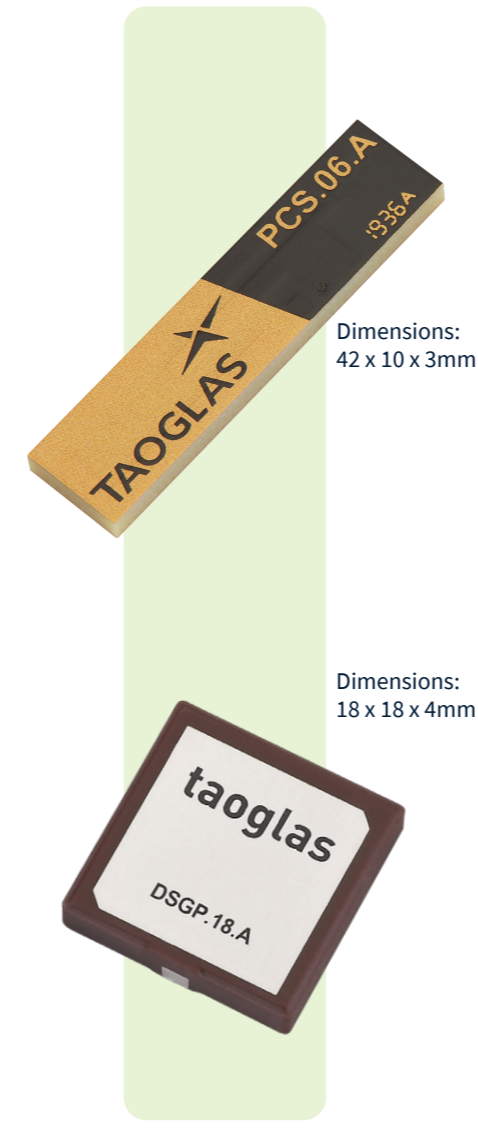
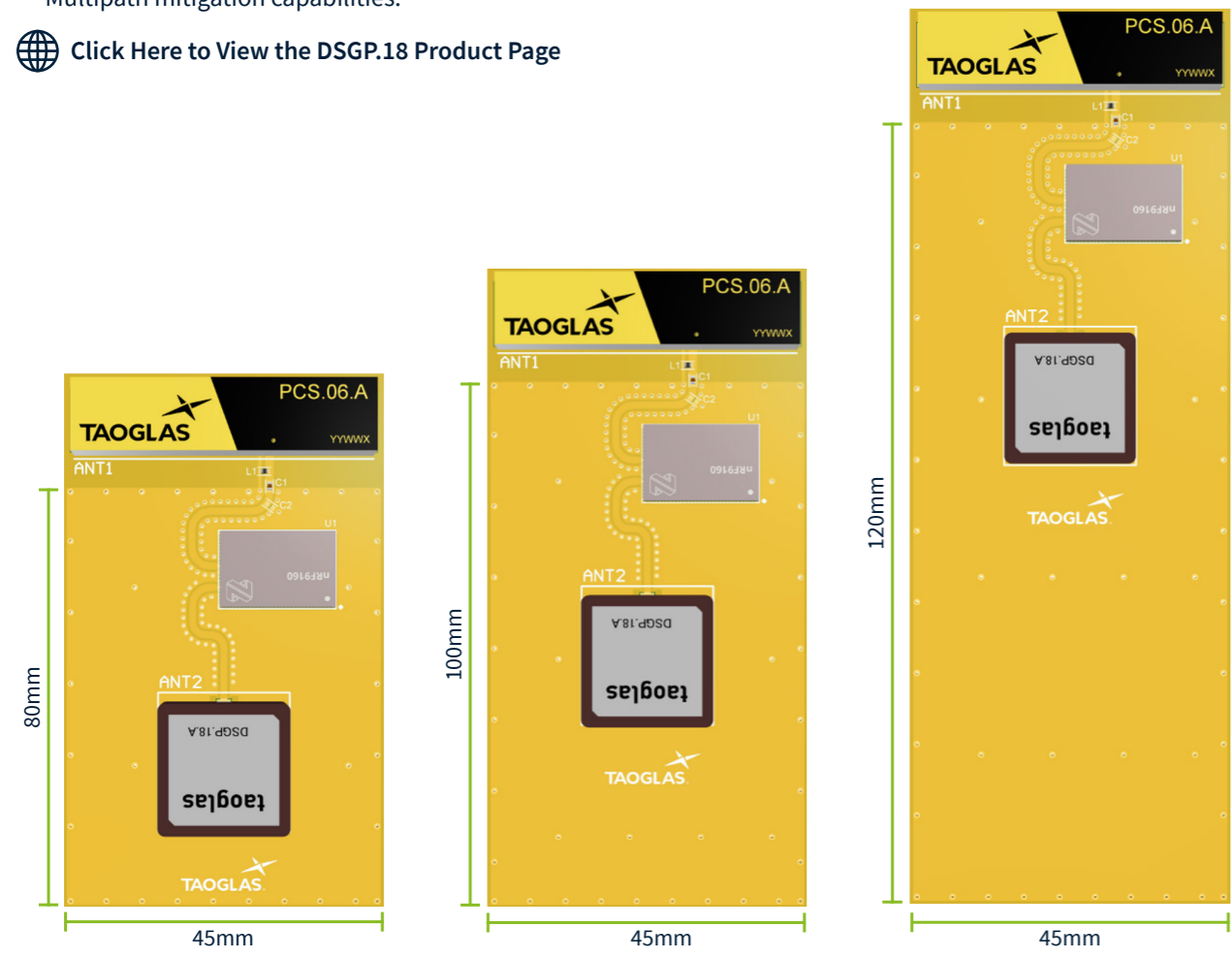
- Active Cellular and GNSS antenna.
- Designed to suit IoT devices with small ground planes.
- Combines aperture tuning and active switching technologies to provide a wideband coverage for GNSS and most 4G cellular bands.
- RF switch to adjust the resonance frequency of the antenna.

[Click Here to View the PCS.06.A Product Page](#)

DSGP.18 Features and Benefits

- High RHCP gain.
- Short TTFF (Time to first fix), excellent carrier to noise values.
- High positional accuracy.
- Multipath mitigation capabilities.

[Click Here to View the DSGP.18 Product Page](#)



Cellular/ GPS Antenna Reference Design with Nordic - nRF9160

Taoglas **PCS.06.A** LTE Antenna with the **GGBLA.01.A** Integrated on Different PCB Dimensions

PCS.06.A Features and Benefits

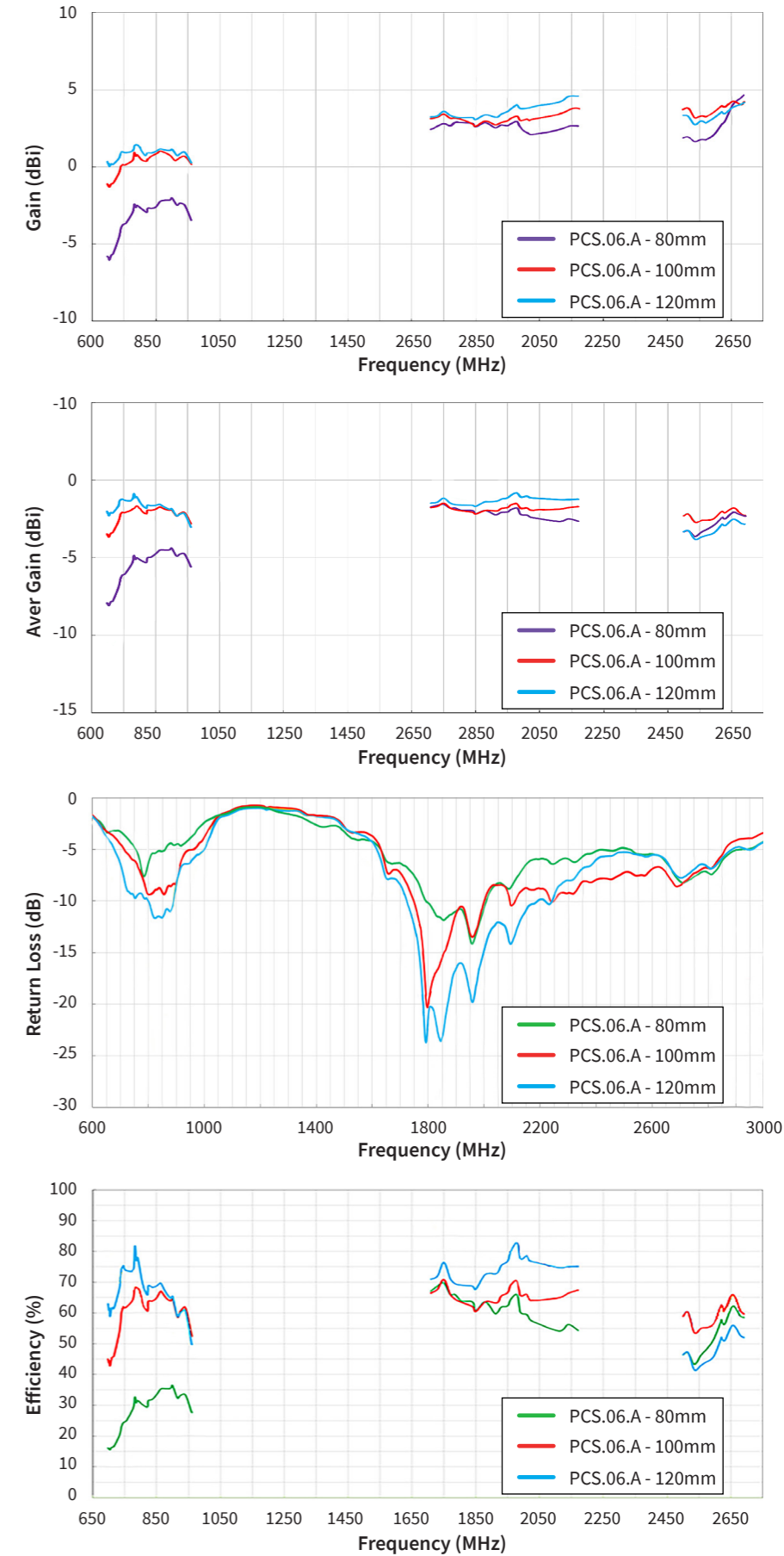
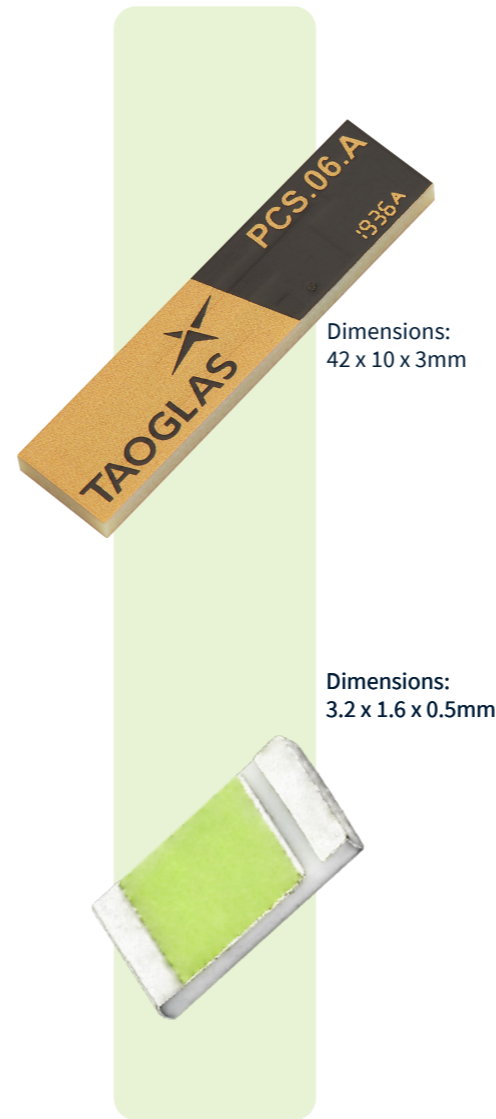
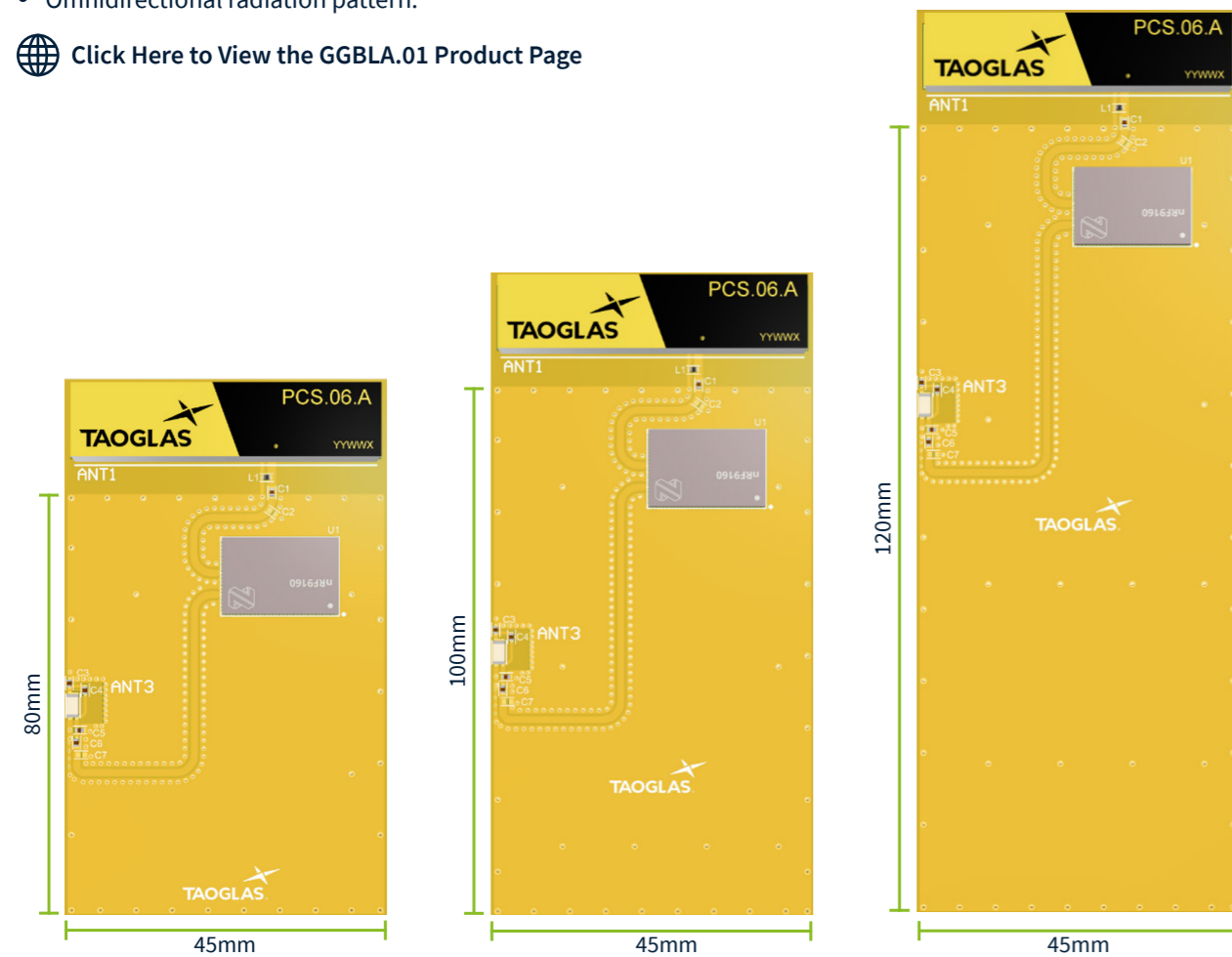
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- Designed to suit IoT devices with small ground planes.
- Combines aperture tuning and active switching technologies to provide a wideband coverage for GNSS and most 4G cellular bands.
- RF switch to adjust the resonance frequency of the antenna.

[Click Here to View the PCS.06.A Product Page](#)

GGBLA.01 Features and Benefits

- Small form factor is suitable for small spaces.
- High positional accuracy.
- High efficiency, stable reception on GPS, GLONASS and BeiDou.
- Omnidirectional radiation pattern.

[Click Here to View the GGBLA.01 Product Page](#)



Cellular/ GPS Antenna Reference Design with Nordic - nRF9160

Taoglas PCS.50.A LTE Antenna with the SGGP.18.A Integrated on Different PCB Dimensions

PCS.50.A Features and Benefits

- Active Cellular and GNSS antenna.
- Designed to suit IoT devices with small ground planes.
- Combines aperture tuning and active switching technologies to provide a wideband coverage for GNSS and most 4G cellular bands.
- RF switch to adjust the resonance frequency of the antenna.

[Click Here to View the PCS.50.A Product Page](#)

DSGP.18 Features and Benefits

- High RHCP gain.
- Short TTFF (Time to first fix), excellent carrier to noise values.
- High positional accuracy.
- Multipath mitigation capabilities.

[Click Here to View the DSGP.18 Product Page](#)

LTE-M & NB-IoT

Frequency range, 700 – 960 MHz & 1710 – 2200 MHz.
nRF9160 Frequency range, 700 – 2200 MHz.

Impedance

Designed for 50 ohms transmission.

Bandwidth

Targeted minimum of -4dB return loss at the band edge.

Ground Plane Size/ Antenna to metal clearance

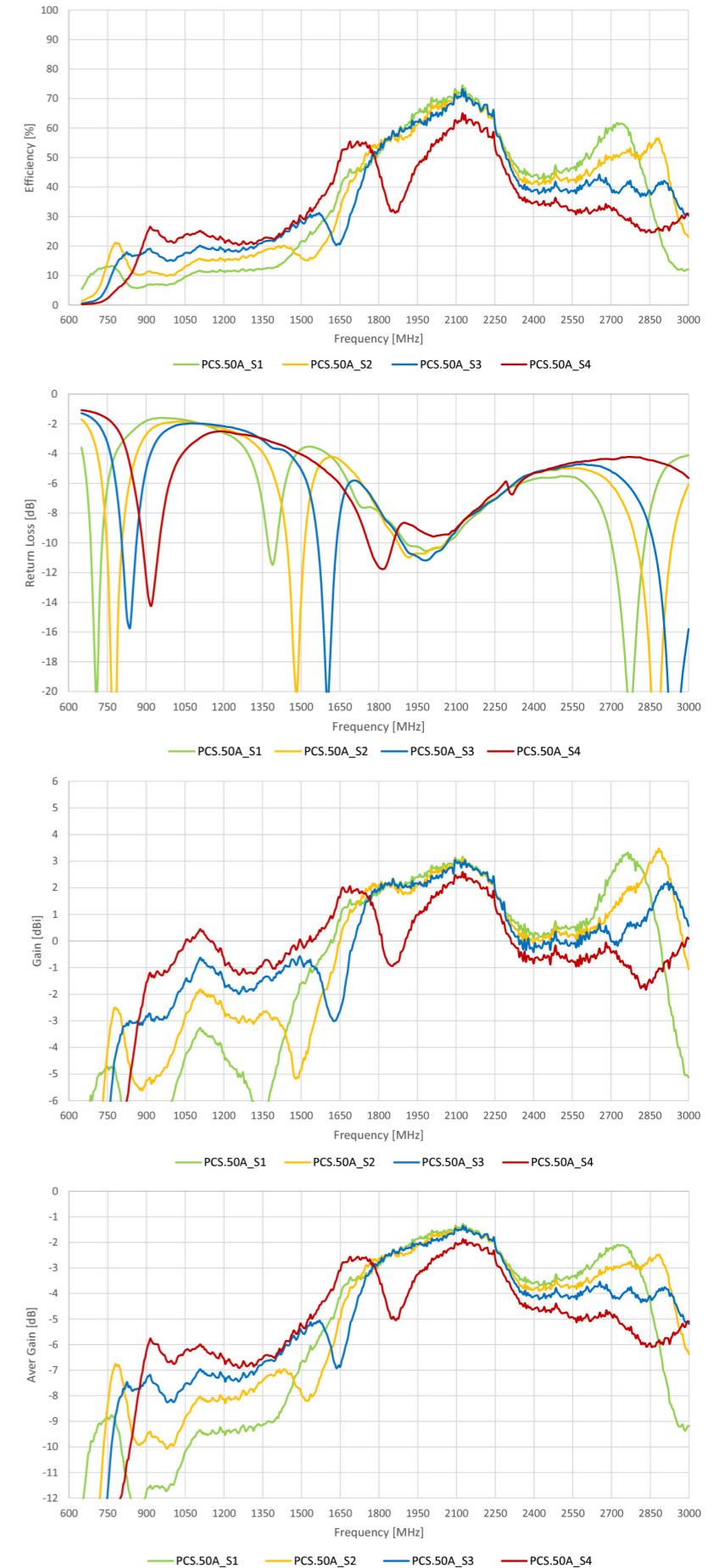
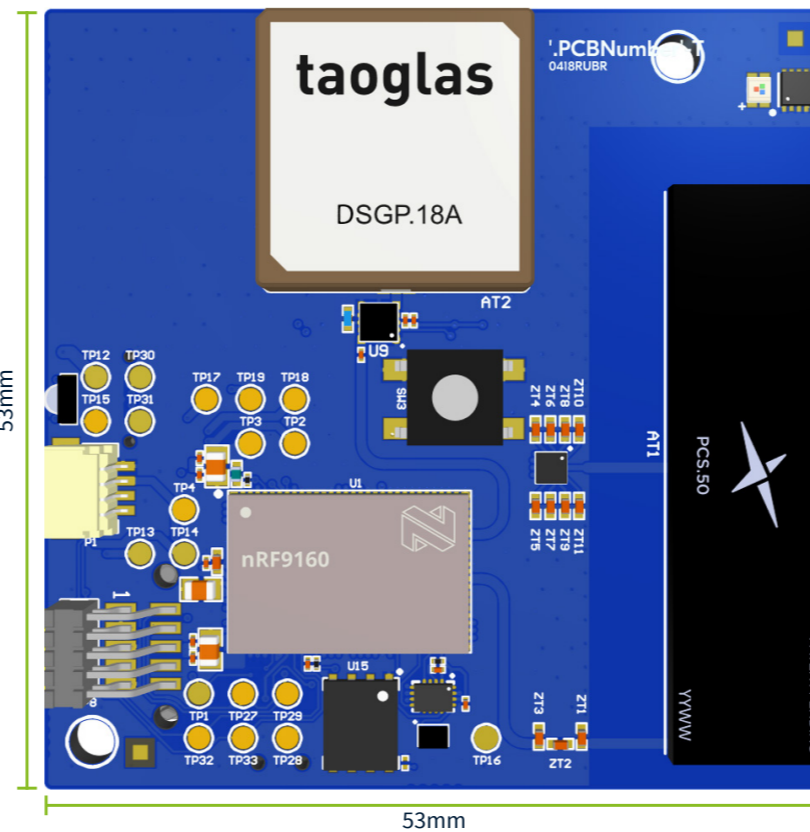
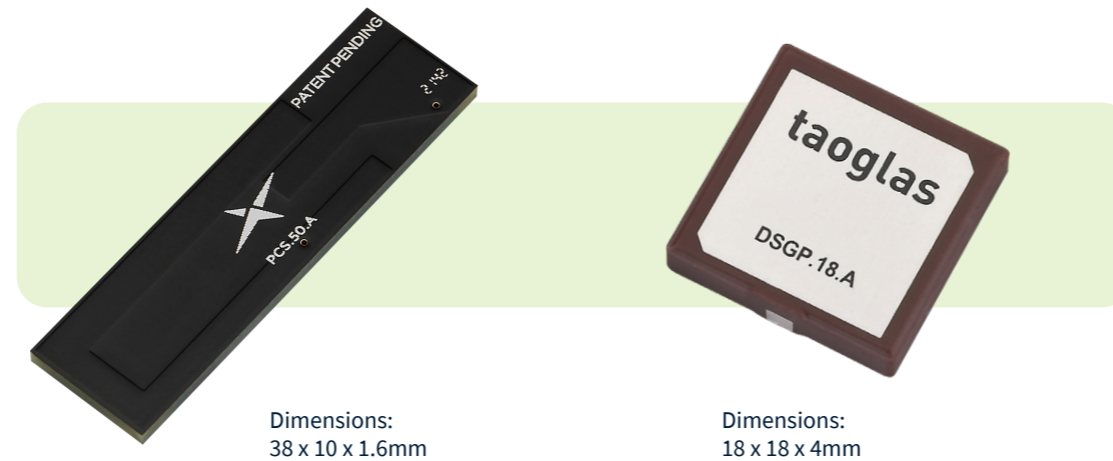
Works well with a ground plane length >50mm and <75mm.
Recommended clearance to metal is 20mm from each side of the antenna.

Efficiency

For a PCB longer than 75mm, the antenna efficiency needs to be at least $\geq 32\%$ in the low band and $\geq 50\%$ for high bands for the USA market wherein Europe minimum recommended efficiency is $\geq 20\%$. For a PCB shorter than 50mm USA operators have relaxed the certification requirement and can accept efficiencies $\geq 10\%$.

Advantages

- Compact volume, minimum footprint.
- Can be machine surface mounted.
- Achieves moderate to high gain in both vertical and horizontal polarization planes.
- Performance in different environments .
- Human body: up to 4dB degradation.
- Concrete/wood: up to 2dB degradation.
- Metal: 2dB to 4dB (minimum clearance to antenna should be 20mm).



Summary

A Comparison of the Taoglas Cellular Antennas to Best Suit Your Application

Cellular Antenna Benchmark

The PCB ground plane size determines the appropriate antenna to use. For ground plane sizes >75mm, the PCS.06.A or the PA.710.A would be most suitable. The minimum targeted return loss of 4dB can be achieved at the band edges with these antennas. These antennas are suitable for all LTE applications that also need high efficiency and backward compatibility to 3G globally on all lower and upper bands. These antennas also operate with great efficiency on worldwide NB-IoT and CAT-M frequency bands.

For ground plane sizes >50mm and <75mm, the PCS.50.A would be the optimum antenna choice for use with the nRF9160. This antenna is designed specifically to take advantage of smaller ground planes typically found with IoT devices. The PCS.50, tuned for PCBs to a size of just 40mm x 50mm, makes it suitable for even the smallest of IoT and CAT-M devices. Typical applications include IoT devices such as smart sensors requiring cellular and GNSS connectivity, wearables or asset tracking. The antenna itself measures just 38 x 10 x 1.6mm and as it is manufactured from high grade FR4 PCB, it is lightweight, yet robust and it is supplied on tape and reel.

Key Products



PA.710.A

[Click here for the PA.710.A Datasheet](#)



PCS.50.A

[Click here for the PCS.50.A Datasheet](#)



PCS.06.A

[Click here for the PCS.06.A Datasheet](#)



GGBLA.01

[Click here for the GGBLA.01 Datasheet](#)



DSGP.18.A

[Click here for the DSGP.18.A Datasheet](#)

Design Services and Custom Antenna Design

Custom Antenna Design and Engineering Design Services

The Taoglas team of world class engineers are on hand to help you design and optimize RF and antenna performance, whether you're looking to initial system requirements or final optimized board design ready for carrier certification.

We share our expertise and innovative proprietary designs with many antenna types including monopole, dipole, loop, ceramic patch, PCB, flex PCB antennas, Laser Direct Structuring (LDS), and beam steered MIMO antenna arrays.

With a full suite of service offerings, we will work with you on your;

- Custom antenna design
- Off-the-shelf antenna selection, optimization, and pre-certification.

In the event that an off-the-shelf antennas cannot be used, Taoglas offer full antennas and RF design services to analyse your design or device, and design an antenna to suit you specific requirement. For a full list of offerings, visit our Design and Test Services page:

<https://www.taoglas.com/design-test-service/antenna-and-rf-services/>

Integration

To help with designing Taoglas antennas into your device, we have made integration files available to download from the individual product pages from our website.

Choose from 2D Drawings, 3D STEP Models, PCB Altium Files, RF Simulation CST files.

We are continuously adding files to the Taoglas website on a regular basis, so if the antenna model you require is not available online, please contact us.



LDS Antennas

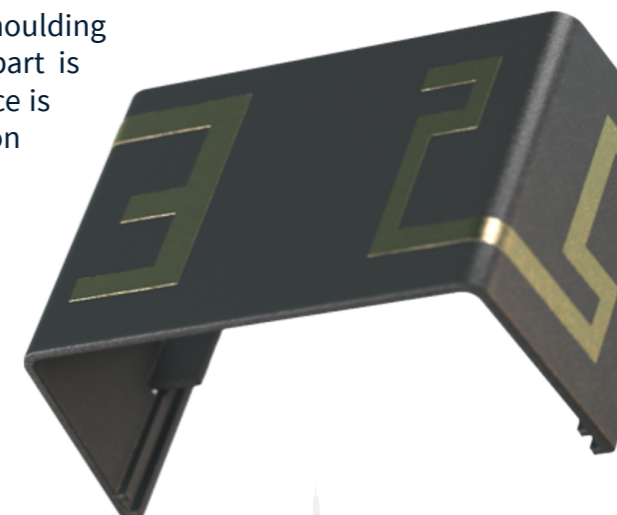
One antenna option becoming more common for small IoT devices is LDS or Laser Direct Structuring, a process whereby an antenna can be designed and produced onto a 3-dimensional plastic carrier. This carrier can be a separate plastic entity or an existing integral part of the customer's product's housing. LDS is an excellent alternative to metal stamped or flexible adhesive antenna designs where the shape of the antenna is too complex or when the space allowed for placement is limited.

The plastic housing or carrier is produced using the injection moulding process with a specially modified polymer. Following this, the part is mounted to the LDS laser application machine where the laser trace is etched onto the part. These parts are then transferred for metalization in a plating bath.

Once plated, the parts are then transferred to our quality department where each part is tested to verify both electrical performance and mechanical properties. Following this, the components are carefully packed and dispatched to the you.

To find out more about the process and to read some case studies, visit our LDS page on the Taoglas website here:

<https://www.taoglas.com/lds-antenna-technology/>





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