Controlled Reception Pattern Antenna (CRPA) Technologies



Application Note

Introduction

A Controlled Reception Pattern Antenna (CRPA) is an advanced GNSS antenna system designed to improve the reliability, accuracy, and resilience of satellite-based positioning. Unlike conventional GNSS antennas that receive signals uniformly from all directions, a CRPA uses multiple antenna elements working together with sophisticated signal processing to actively manage how signals are received. By analyzing the amplitude and phase differences of signals arriving at each antenna element, a CRPA can enhance legitimate GNSS satellite signals while reducing the impact of unwanted interference. This enables GNSS receivers to maintain accurate positioning in challenging environments where traditional antennas may struggle.

Why do you need a CRPA?

A conventional GNSS antenna receives signals from nearly every direction above the horizon with approximately equal sensitivity. While this wide-field reception ensures visibility of satellites across the sky, it also means the antenna cannot distinguish between a legitimate satellite signal and an unwanted signal arriving from another direction.

CRPA technology addresses this limitation by providing spatial awareness. Instead of receiving all signals equally, a CRPA can electronically control its reception pattern, enhancing desired GNSS signals while reducing sensitivity to interference and reflections.

Conventional Antenna vs CRPA

Challenge	Conventional GNSS Antenna	CRPA Array
Jamming	Easily overwhelmed	Steers nulls toward interference
Spoofing	Limited ability to distinguish false signals	Uses spatial information to identify inconsistencies
Multipath	Difficult to separate direct and reflected signals	Suppresses unwanted low-angle signals
Reception pattern	Fixed	Dynamically controlled
Simultaneous interference sources	No spatial rejection	Up to N−1 theoretical nulls
Positioning in difficult environments	Can degrade significantly	Designed to maintain performance

How does CRPA work?

Three Key Functions That Enable CRPA Performance:

Beamforming
The processor aligns the phase of satellite signals received by each antenna element so they add constructively. This concentrates array gain toward the desired satellite directions and strengthens weak GNSS signals.

Null Steering
The processor applies carefully selected phase and amplitude weights that force interference signals from specific directions to cancel when combined. This allows the array to suppress jammers and spoofers while continuing to receive satellite signals from other directions.

Multipath Suppression
The array reduces sensitivity toward low-elevation directions where reflected signals are most common, helping the receiver focus on the direct satellite path and improving positioning accuracy.

With four antenna elements, the array theoretically provides N−1 = 3 degrees of freedom, allowing up to three simultaneous interference sources to be addressed. For a typical 4-element CRPA it requires:

- 4 total degrees of freedom
- 1 degree of freedom maintains the GNSS beam
- 3 degrees of freedom remain for null steering

Selecting the Right Array Configuration

The performance of a CRPA system depends not only on the antenna elements themselves, but also on how those elements are arranged within the array. The physical placement of each element determines the array's spatial coverage, interference rejection capability, beamforming performance, phase-centre stability, and overall system size. Different array configurations offer different advantages, making the selection process an important part of the design. In the table below we compare three different array configurations to consider four application.

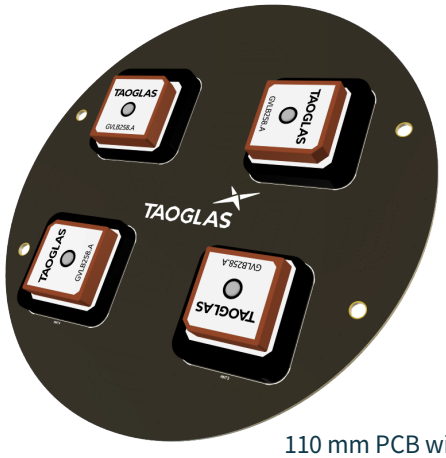
Configuration	Works Best For	Advantage	Key Consideration
2 x 2 Square Configuration	General-purpose CRPA, UAVs, automotive, compact platforms	Balanced performance with uniform beamforming and null steering coverage in all directions. Most compact and widely adopted configuration.	Adjacent elements are closely spaced, requiring more attention to isolation ad coupling management.
Cross Configuration	Defence, surveying, high-performance anti-jam systems	Larger effective aperture provides deeper nulls, higher angular resolution, and im-proved interference discrim-ination.	Requires a larger footprint and performs best when interference directions are known or predictable.
Star Configuration	High-accuracy positioning, RTK, research applications	Central element provides a stable phase reference, supporting advanced positioning and differential phase measurements.	Null depth varies with azimuth due to the three-fold symmetry of the array.

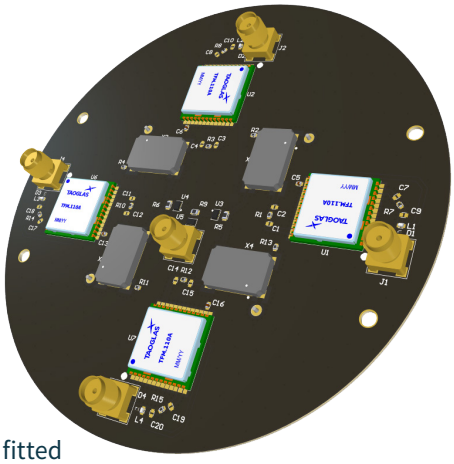
PCB Size and Element Spacing

In a CRPA design, the PCB serves not only as a mounting platform for the antenna elements but also as the ground plane that shapes antenna performance. A larger ground plane provides a more stable electromagnetic environment, improving radiation efficiency and gain, particularly at lower GNSS frequencies such as L5. Conversely, a ground plane that is too small can increase edge diffraction effects, distort radiation patterns, and reduce overall antenna performance.

Element spacing determines how effectively the array can distinguish signals arriving from different directions. When antenna elements are separated in space, each receives an incoming signal with a slightly different phase. These phase differences provide the information needed for beamforming and interference suppression. Below are three different PCB sizes with various element spacing.

Front

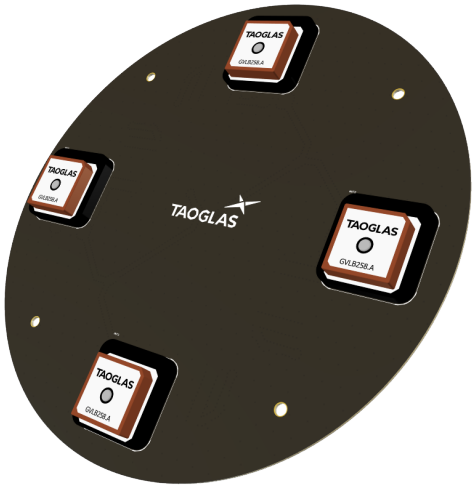


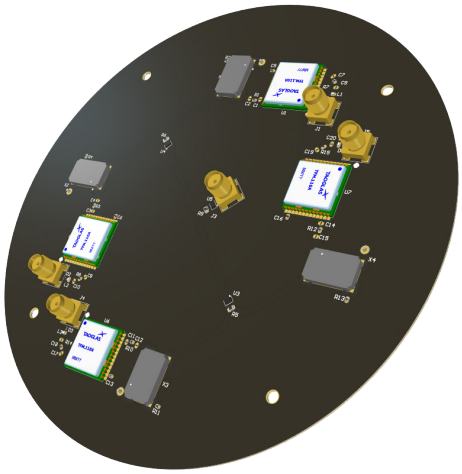


Back

110 mm PCB with the GVLB258 fitted

Front

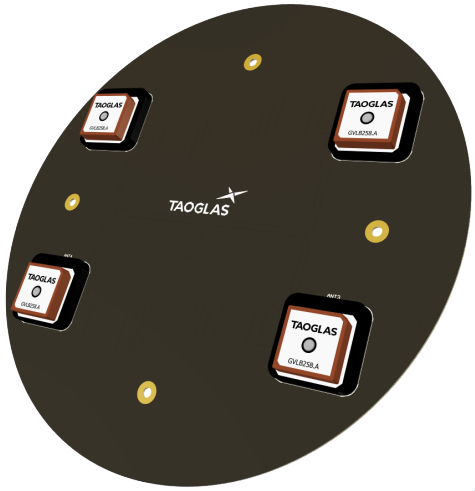


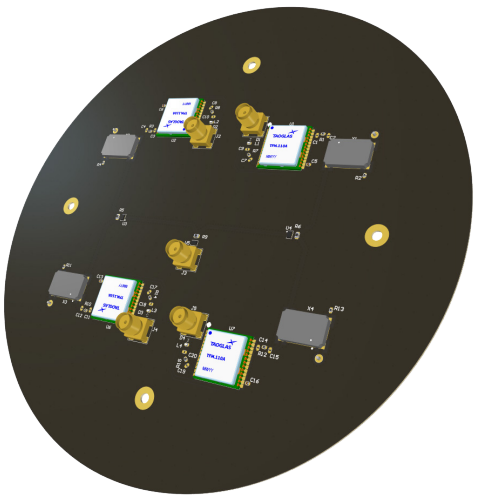


Back

150 mm PCB with the GVLB258 fitted

Front





Back

170 mm PCB with the GVLB258 fitted

PCB Datasheet Links

110 mm PCB Datasheets

- CRPA.110.G25.A
- CRPA.110.H22.A
- CRPA.110.H25.A

150 mm PCB Datasheets

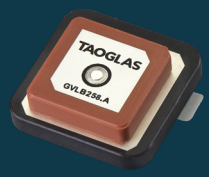
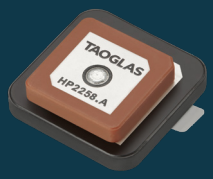
- CRPA.150.G25.A
- CRPA.150.H22.A
- CRPA.150.H25.A

170 mm PCB Datasheets

- CRPA.170.G25.A
- CRPA.170.H22.A
- CRPA.170.H25.A

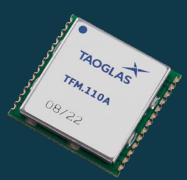
Taoglas CRPA Antenna Elements

Taoglas offers a range of high-performance GNSS patch antennas that can serve as the building blocks of CRPA arrays, supporting modern multi-constellation and multi-frequency GNSS receivers. These elements are designed to provide the wide bandwidth, stable radiation characteristics, and circular polarization required for precision positioning and advanced anti-jam GNSS applications.

Antenna Element	Key Characteristics	Typical Use Case
GVLB258.A 	Wideband stacked-patch design supporting modern L1/L5 GNSS constellations with RHCP polarization and strong efficiency characteristics.	Compact CRPA arrays, precision positioning, next-generation GNSS receivers
HP2258.A 	Multi-band (L1/L2) GNSS patch antenna option suitable for array integration.	General-purpose CRPA development
HP25258.A 	Tri-band (L1/L2/L5) GNSS patch used extensively throughout the example CRPA array designs and evaluations within this application note.	Multi-frequency CRPA systems, anti-jam and high-accuracy applications

Taoglas CRPA Module Elements

The Taoglas TFM.110A multi-band GNSS front-end module complements Taoglas' GNSS antenna elements within the CRPA design, forming part of the RF signal chain between the individual antenna channels and subsequent CRPA processing. The design uses multiple TFM.110A modules as part of its four-element architecture, providing a practical foundation for developing and evaluating resilient multi-band GNSS systems.

Module Element	Key Characteristics	Typical Use Case
TFM.110A 	Multi-band GNSS front-end module used within the Taoglas CRPA reference design.	Provides the GNSS RF front-end associated with the individual antenna channels as part of the overall CRPA signal chain. The 110 mm uses four TFM.110A modules together with four antenna elements.

CRPA Applications

CRPA technology can be applied across a wide range of GNSS-dependent systems, including:

- Defence and military
- Autonomous vehicles
- Infrastructure timing
- UAVs and drones
- Survey and geodesy
- High-precision navigation
- Precision agriculture
- Maritime systems

The required performance targets vary according to the application. Defence and survey applications, for example, typically demand greater isolation, higher efficiency, deeper nulls and tighter phase-centre tolerances than less demanding applications.

Summary

CRPA performance is highly dependent on the complete antenna, PCB and system environment. Taoglas can support the development process from antenna selection and array configuration through to simulation, optimisation and testing. The choice of antenna element, array geometry, PCB size, element spacing and isolation strategy all contribute to the final system performance. With multi-band GNSS antenna elements, engineering expertise and simulation and measurement capabilities, Taoglas can help develop CRPA solutions tailored to the requirements of your application.