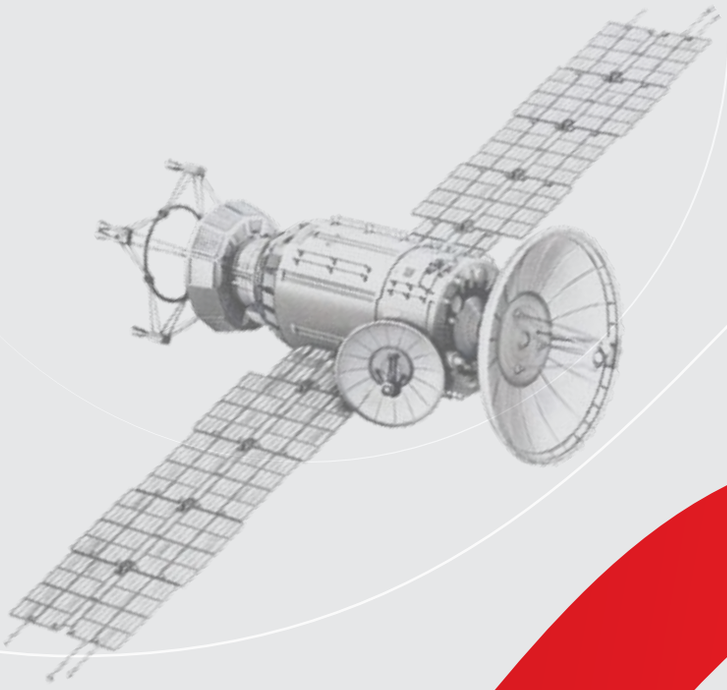
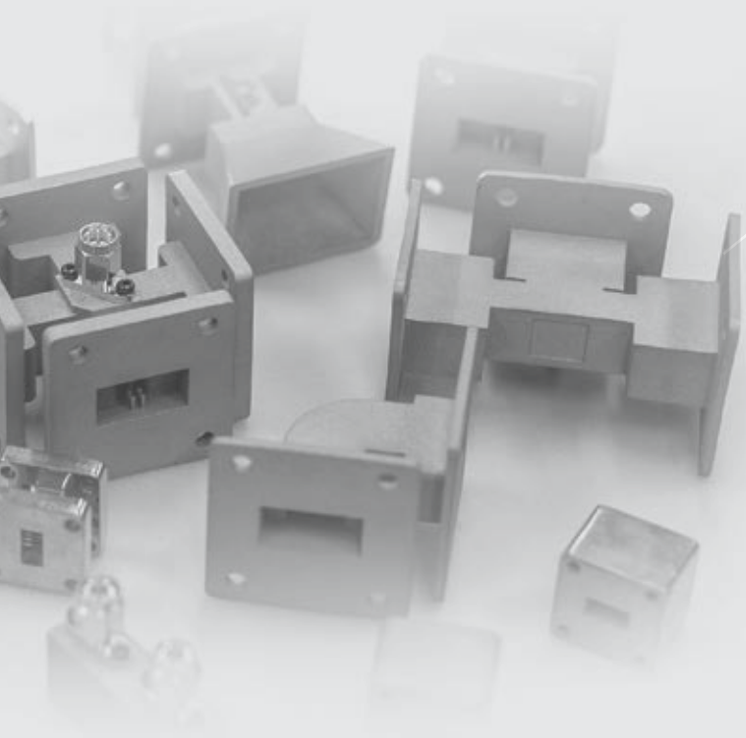


MinWave

Miniaturized Microwave Solutions



MinWave employs patented cutting-edge metamaterial technology for the development of high-performance, compact, and lightweight RF front-end (RFFE) solutions. We offer a wide range of custom or standard RFFE devices compatible with various interfaces (waveguide, surface mount, and coaxial) and applications including space and telecommunication.

Products

Passive components:

- Filters: standard and non-standard waveguide ports, Coaxial connectors and SMT packages
- Diplexers/ Multiplexers
- Integrated modules: Ortho-mode transducers (OMT), antenna feed assemblies and feed chain
- Impedance/interface Transitions

Antennas:

- Compact array antennas
- Noise resilient GPS antenna
- ESPAR antennas
- Extremely wide-band antennas

Market

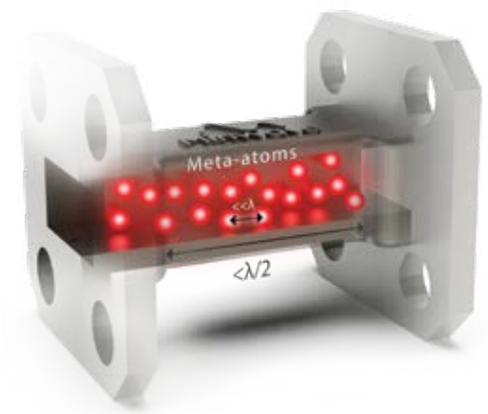
- 4G and 5G Radios in LTE, FR1 and FR2
- Satcom applications for L-band to Ka-band
- Point to point links
- mmWave consumer devices

Manufacturing

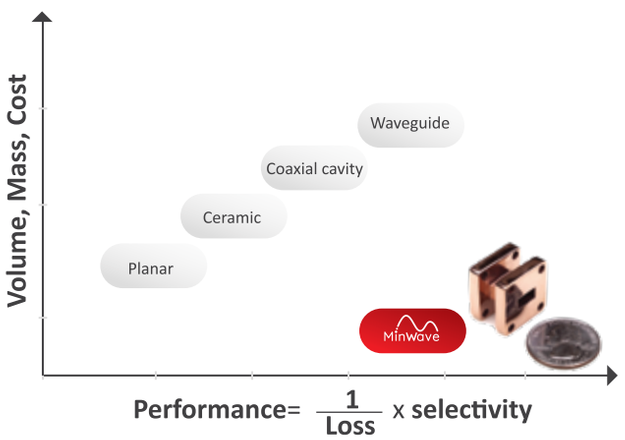
We utilize **additive manufacturing** as an effective tool for complex geometry fabrication method to address space industry needs. Furthermore, we are working with experienced partners to utilize the appropriate manufacturing method, such as micro casting, machining, injection molding and variety of surface treatments for each application.

MinWave core technology

MinWave designs and manufactures RF front-end (RFFE) solutions based on novel metamaterials. The fundamental advantage of our technology is the utilization of ε or $\mu<0$ metamaterials in a very small length (typically $<\lambda/2$) to realize devices. Negative index materials provide sharp selectivity and high rejection levels; and small length decreases loss and increases the overall quality of the filters in an unprecedented fashion.



Minwave technology = $\underbrace{\varepsilon \leq 0 \text{ or } \mu \leq 0}_{\text{Sharp selectivity}} + \underbrace{\text{sub } \lambda}_{\text{Miniaturized low loss}}$

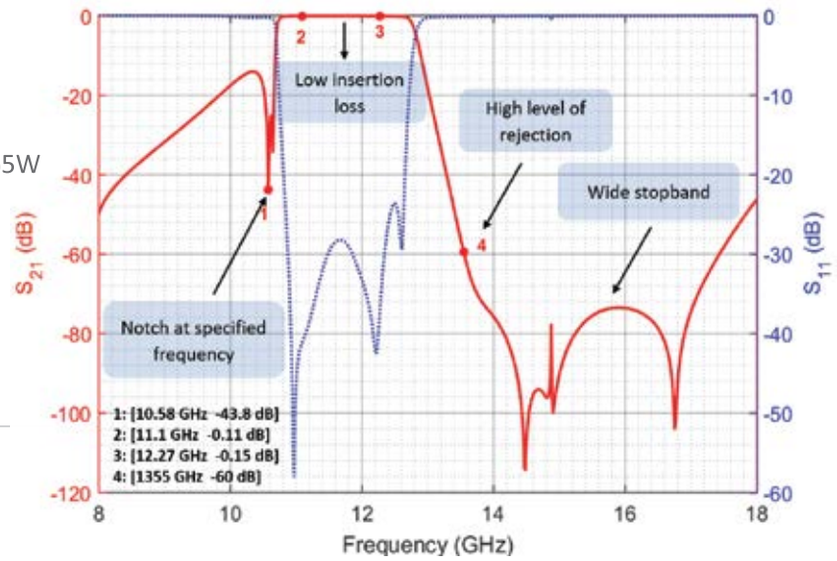


MinWave metamaterial filters

MinWave designs and manufactures RF front-end solutions from C band to Ka-band. Our technology is based on a novel metamaterial filter with low insertion loss, high selectivity, high rejection, and wide stopband. Due to the metamaterial nature of the designs, the passband has a sharp roll-off with a deep level of rejection. To improve the selectivity of the pass band and/or maximize the rejection at a specific frequency, single or stack of TZs can be added at the appropriate frequencies without increasing the footprint. Our filters are compatible with waveguide ports, and coaxial as well as surface mount interfaces.

Ku band filter

- WR75 ports
- Peak power: 230W
- Continuouspower: 65W
- Multipaction free



Product features:

- Very small footprint
- Ultra-lightweight
- Low insertion loss
- Sharp roll-off
- Wide stop band
- No tunning screws
- Customizable frequency and bandwidth
- Customizable interfaces and pipe shapes

Ku band bent filter

- WR75 ports
- Sharp bend
- Ultra-small footprint for monolithic assembly
- Low insertion loss

Double ridge Ku-band filter

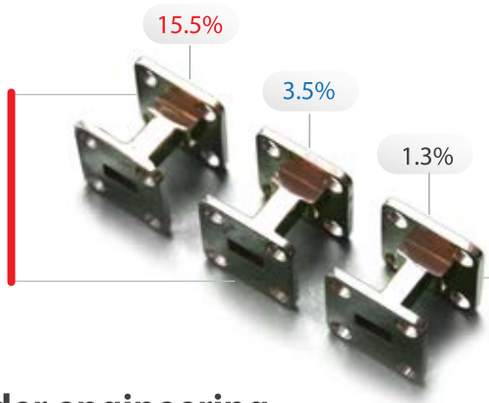
- WRD750 ports
- Low insertion loss
- Wide stopband
- Ultra-compact

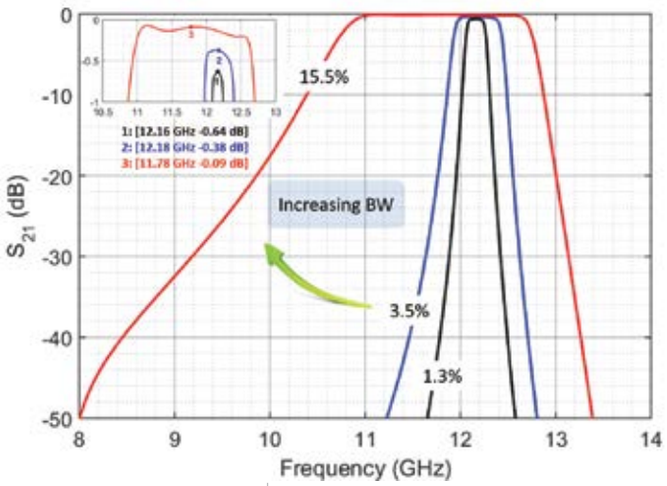
Ka band filter

- WR28 ports
- Sharp roll-off
- Low insertion loss
- Ultra-compact

Customizable bandwidth

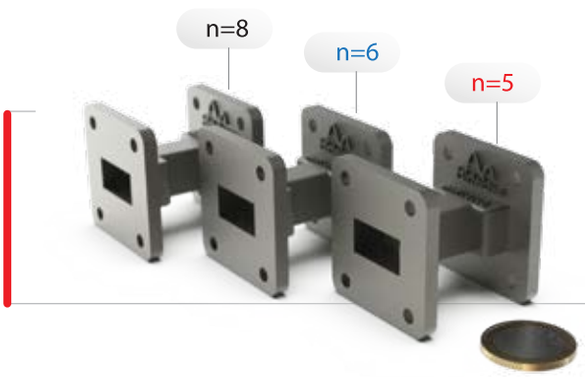
The metamaterial nature of **MinWave** designs enables customizable bandwidth (1-50%) while maintaining low insertion loss and fixed total length of the filter. The typical insertion loss in wide band filters is below 0.3 dB and in narrowband filters are bellow 0.9 dB in Ku and Ka-bands.

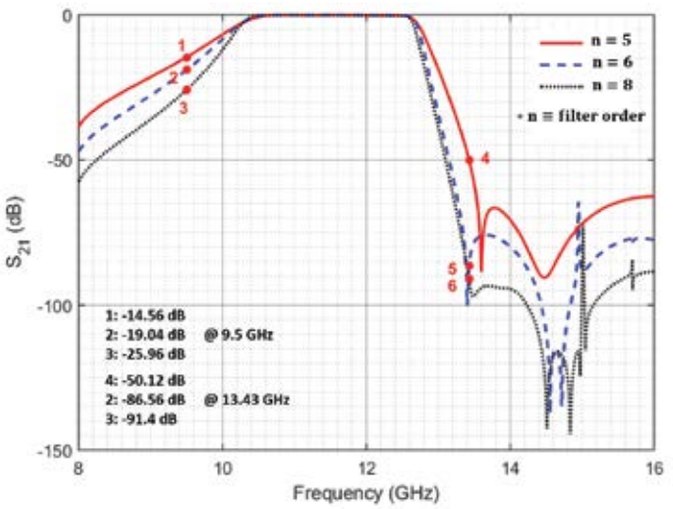




Filter order engineering

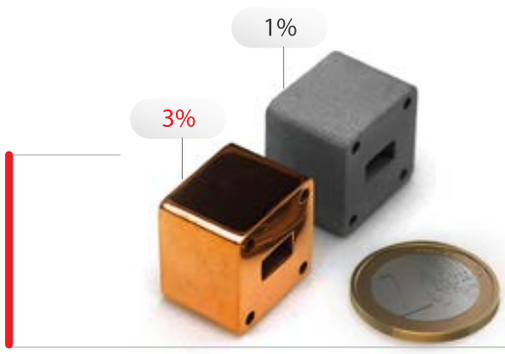
Increasing the order of filter is obtained by adding a deep subwavelength length, e.g. few millimeters in Ku-band to the size, resulting in enhanced rejection.

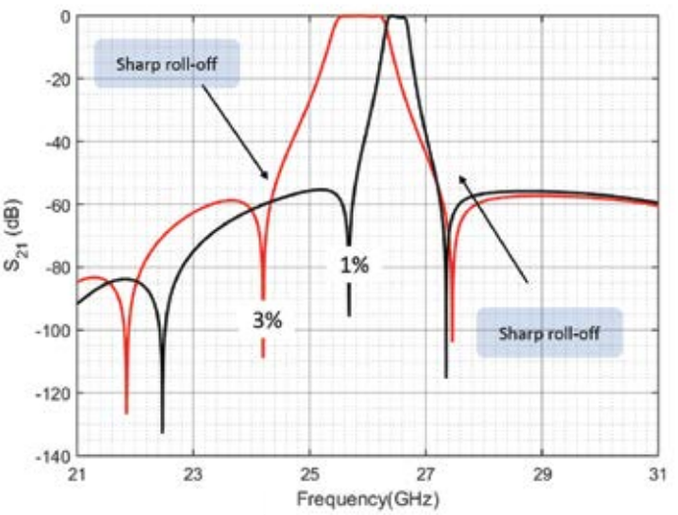




Frequency selectivity

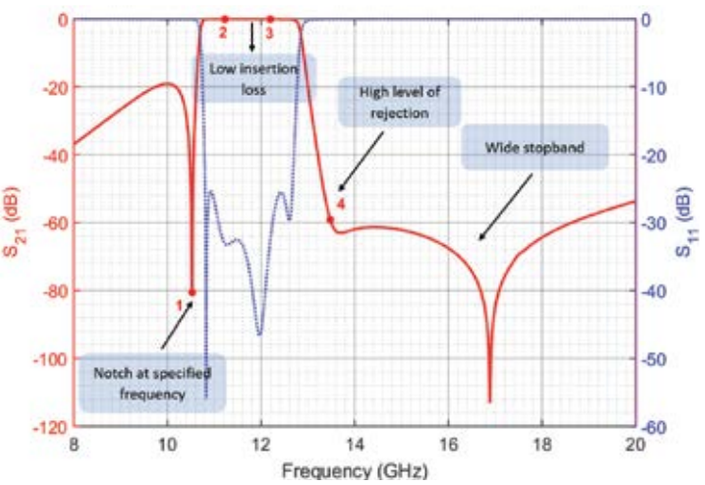
Our metamaterial designs introduce a stack of zeros on the right side of the passband, which makes sharp selectivity on the upper side. By properly engineering these transmission zeros, the selectivity of the filter in the lower side can also be engineered.





Connectorized solutions

MinWave team have developed connectorized version of filters with smaller footprint specially for 4G and 5G telecommunications. However custom solutions from C band to Ka-band are available, which are considerably smaller and lighter than conventional coaxial filters and more power efficient than ceramic filters. As in waveguide versions, the sharp roll-off of Minwave filter can improve spectral efficiency, required by telecom. operators.



Ku band

- SMA ports
- Low insertion loss
- Sharp roll-off
- Ultra-compact

Diplexers/ Multiplexers

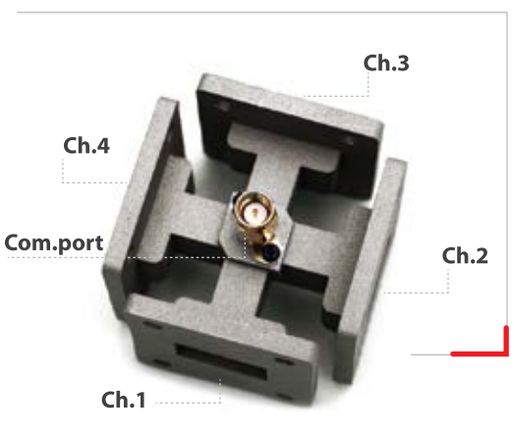
Taking advantage of our miniaturized lightweight filters novel designs, we develop other passive devices and RF front end modules such as diplexers and multiplexers in wide range of frequency bands. Thanks to the use of the additive manufacturing method, complex integrated miniaturized geometries are fabricated at **MinWave.**

Product Features:

- Magnified miniaturization
- Monolithic assemblies
- Less dissipation
- Custom interfaces

Ku band Diplexer

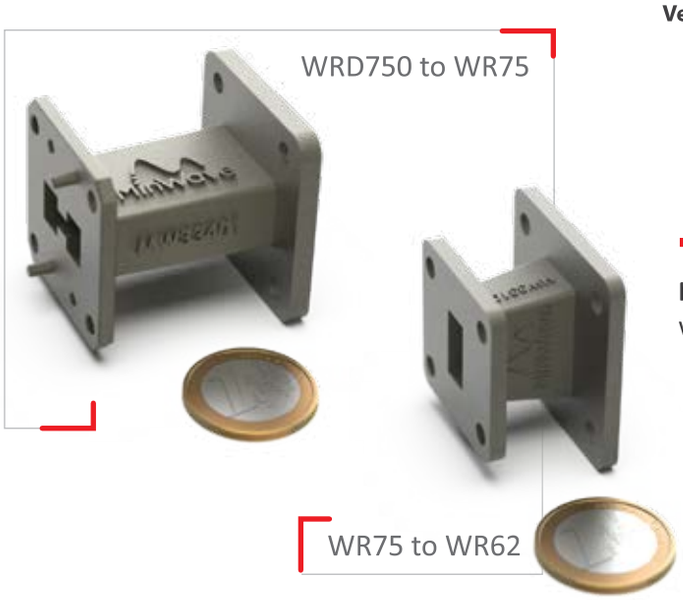
Ku band Multiplexer



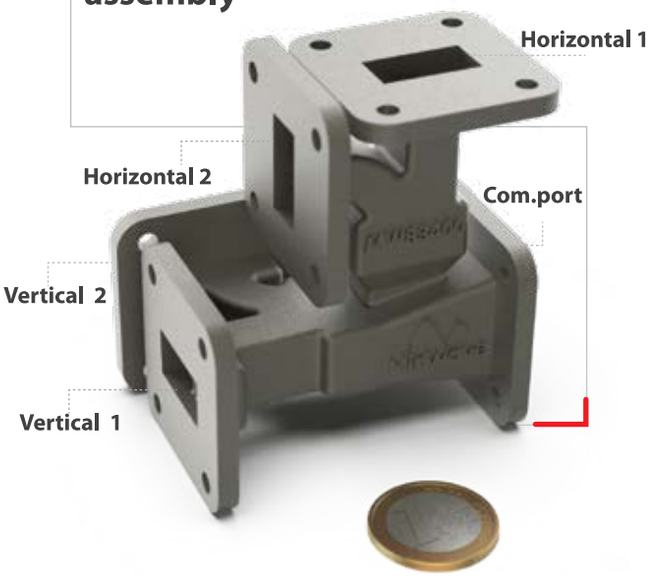
Integrated modules

MinWave's design group designed different options of integrated modules including OMT, feed assemblies and feed chain. Since these modules are integrated in one single device, they offer less power dissipation and passive inter modulation (PIM) levels while they are very compact in size and are lightweight.

- WR75 ports
- Monolithic assembly
- Ultra-Compact
- Less dissipation
- Dual-polarized
- Double frequency band



Miniaturized TX/RX monolithic feed assembly



Transitions

MinWave offers various types of ultra-compact transitions with low loss including:

- Standard waveguide to standard waveguide
- Non -standard waveguide to standard waveguide
- SMA to standard waveguide
- SMA to non-standard waveguide

Antennas

MinWave antenna design group designed various antenna types with different functionalities and applications including:

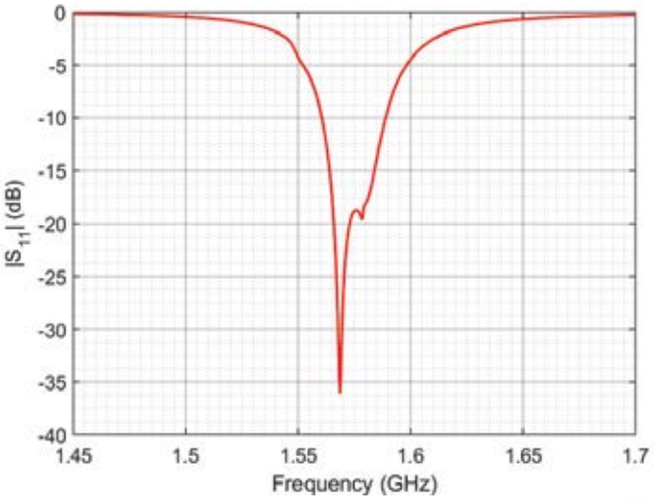
- GPS antenna
- Compact 5G MIMO antenna
- Extremely wide band Blade antenna

GPS antenna

A well-known problem in GPS receivers arises from the system's vulnerability to deliberate or unintentional interference. **MinWave** introduces a new passive GPS antenna with improved suppression of unwanted waves.

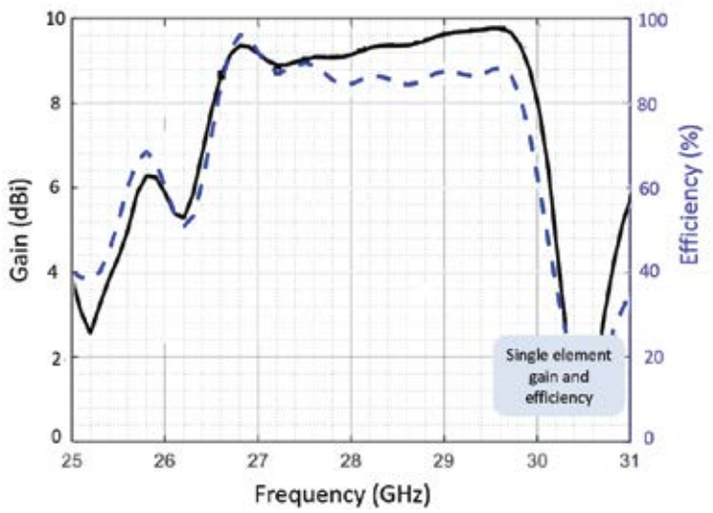
GPS antenna performance

Gain (dBi)	Efficiency (%)	HPBW (degree)	AR (dB)
8.4	> 95	> 55^0	< 3
Suppression (dB)	**Unwanted Signal Polarization**	**Unwanted Signal Azimuth Angle (Degree)**	**Unwanted Signal Elevation Angle (Degree)**
≥ 30 dB	Insensitive	0-360	< ±30



Compact 5G MIMO antenna

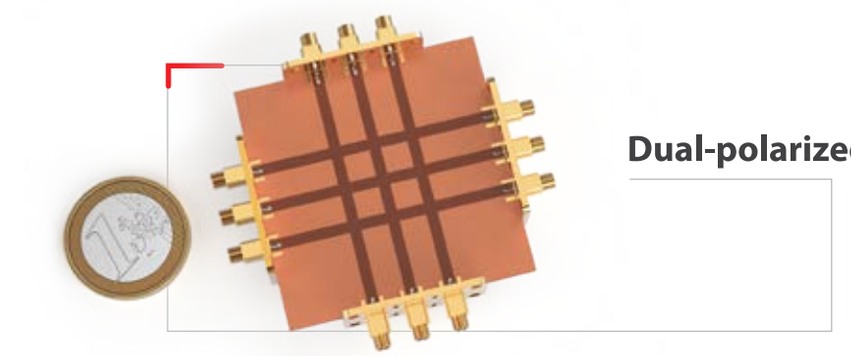
MinWave presents a wideband guided wave structure with a frequency-independent phase velocity greater than the vacuum speed of light. Using such a guided structure, **MinWave** designed a leaky-wave antenna (LWA) with a stable beam angle through a broad frequency band.



5G antenna performance

	Gian (dBi)	Efficiency (%)	Impedance BW (%) |S11|<-10 dB
Single element	10	85	13.1
Array*	19.5	85	13.1

* The scan angle and beam scan gain change are $\pm 26^0$ and 0.8 dB, respectively.

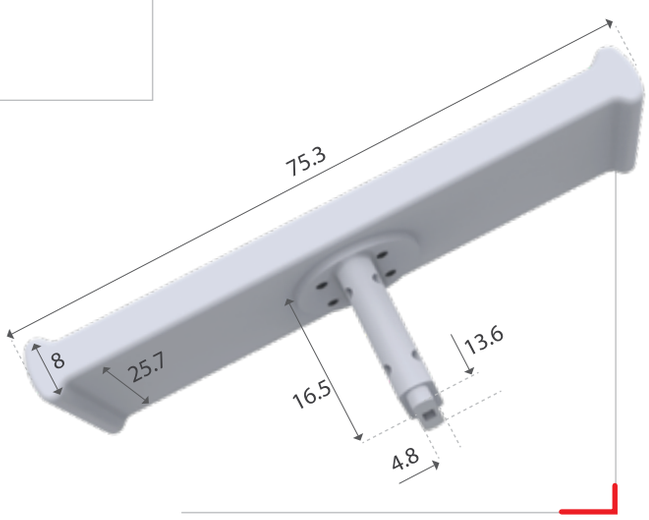


Dual-polarized array antenna

Extremely wide band Blade antenna

Blade antenna is an aerodynamic shaped antenna used in unmanned aerial vehicles (UAV) platforms. **MinWave** presents a novel broadband blade antenna with the impedance bandwidth ranging from 20 MHz to 1200 MHz.

- Frequency range: 20 to 1200 MHz
- Gain (dBi): -15 to +2
- Polarization: vertical
- RF connection: SMA
- Power (Watt): 25
- VSWR < 3.5:1



* All dimensions are in cm.

MinWave

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