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-  mmWave modules
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-  Capacitors
-  Power inductors
-  Power
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-  Sensors

Application guide

# 5G - base station

# 5G base stations - transition from 4G

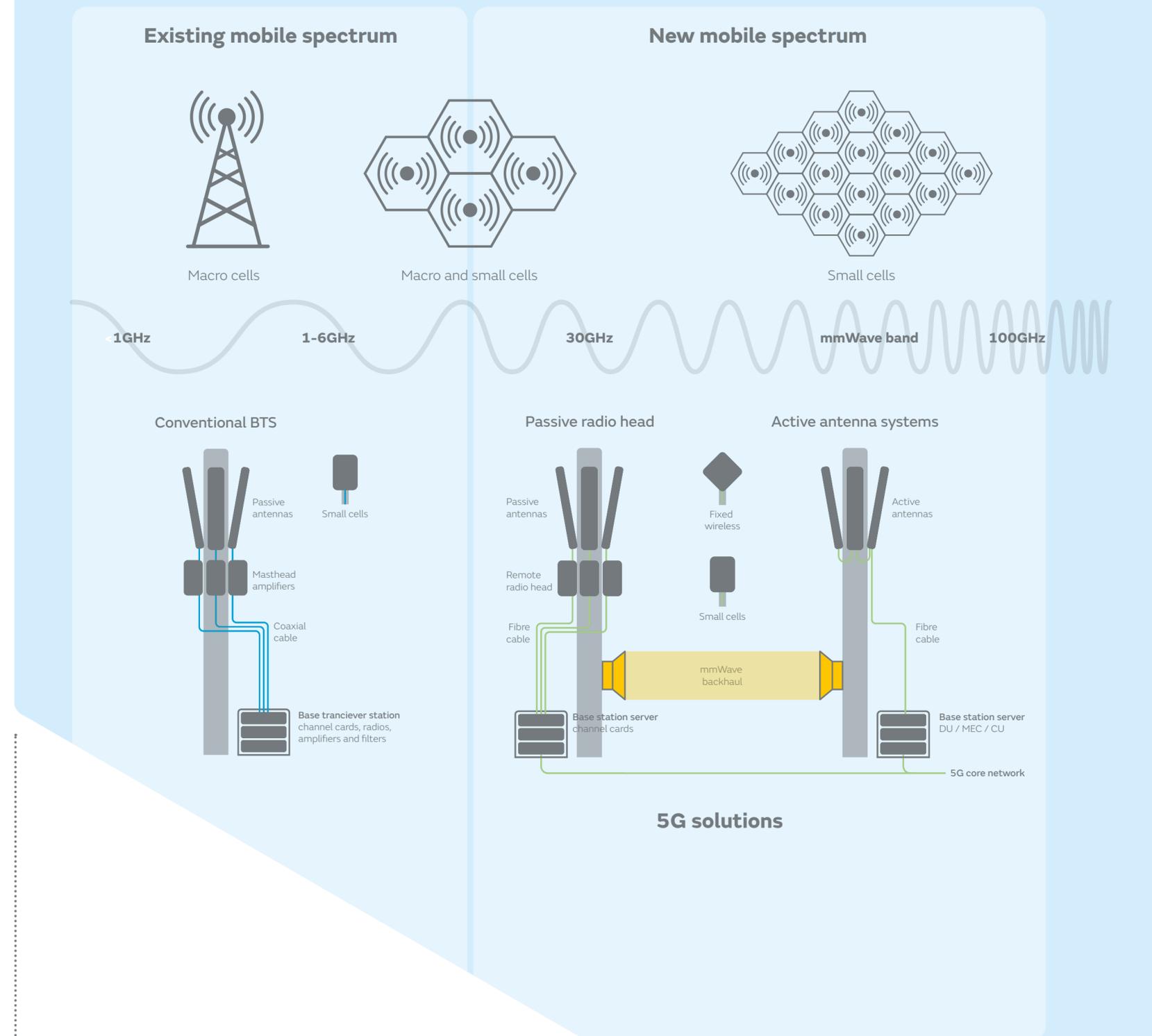
As the world transitions from 4G to 5G, the shift to these new, far more powerful networks will also require a shift in the way base stations are designed and configured.

## Moving up the mast

In the era of 4G, network installations typically relied upon heavy duty infrastructure such as large power masts and passive cables and antennas, with much of the technology concentrated around the 'shed', aka the lower ends of the base station. As we move into the 5G era, however, this structure is set to change, with a large number of active, fiber-cable antennas situated at the top of the communications tower rather than at the base of the structure.

## From few large to many small cells

Due to the higher-band frequency spectrum required by 5G, network infrastructure must make use of multiple small-cell antennas that can pick up these mmWave frequencies and allow for the rapid transfer of information. This is a significant departure from 4G, which tends to utilize a more limited number of larger-cell antennas instead.



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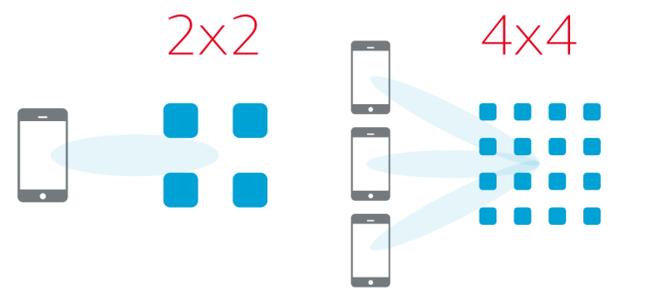
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# Massive MIMO

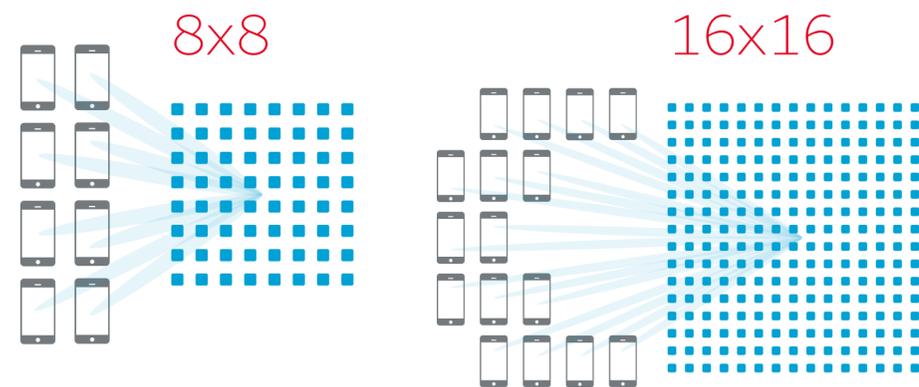
With the roll-out of next-generation networks, multiantenna technology is shifting from 4G MIMO to 5G Massive MIMO.

## How does Massive MIMO work?

Large antenna arrays – those comprising 16, 32, or 64 array elements – can be exploited by 5G networks to massively boost data capacity while maximizing energy efficiency in a process known as Massive MIMO. These large arrays are used to exploit spatial multiplexing, essentially providing a number of parallel data-streams within the same resource block. This increases the amount of data that can be sent and received on a network while avoiding the need for new towers and infrastructure.



4G MIMO



## 5G Massive MIMO

Utilises spacial multiplexing to increase capacity and data rates without additional towers and spectrum

## Benefits of Massive MIMO

With Massive MIMO in place, wireless data networks will be capable of delivering seamless connectivity at higher data rate for a much greater number of users – all while reducing the amount of power consumed.

Through Massive MIMO, beamforming techniques will allow multiple antennas to form multiple distinct connections in phased adaptive array technology. This means that beams can be formed to cater to just a single user at a time, improving connectivity and capacity without the intricate design requirements of intercell coordination. In such a setup, the network can

accommodate more users than ever before, with each user enjoying an interference-free and latency-free connection to the base station.

## Massive MIMO features

- More active antenna elements
- More focused energy
- Less interference
- More spatial multiplexing layers
- Better cellular throughput and coverage
- Large number of users served simultaneously
- Introduces 2 dimensional beamforming

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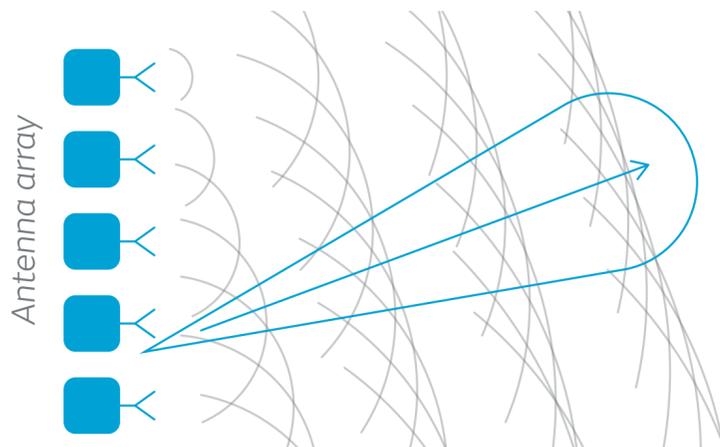
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# Beamforming

**Beamforming is set to be a cornerstone of any successful 5G Massive MIMO setup.**

This technique leverages multiple antennas to control the direction of a wavefront and target it at a specific receiving device. This is done by weighting the magnitude and phase of individual antenna signals in an array of antennas positioned at least half a wavelength apart from one another.

Overlapping waves from multiple antennas will either produce constructive or destructive interference, thereby strengthening or weakening the signal. This has the effect of directing the beam towards precise locations, delivering a much more focused connection for users. There are three sub-categories of beamforming, known as digital beamforming, analog beamforming and hybrid beamforming.



*Directional beams are created by varying the phase(delay) and amplitude of each antenna transmission.*

## Digital beamforming

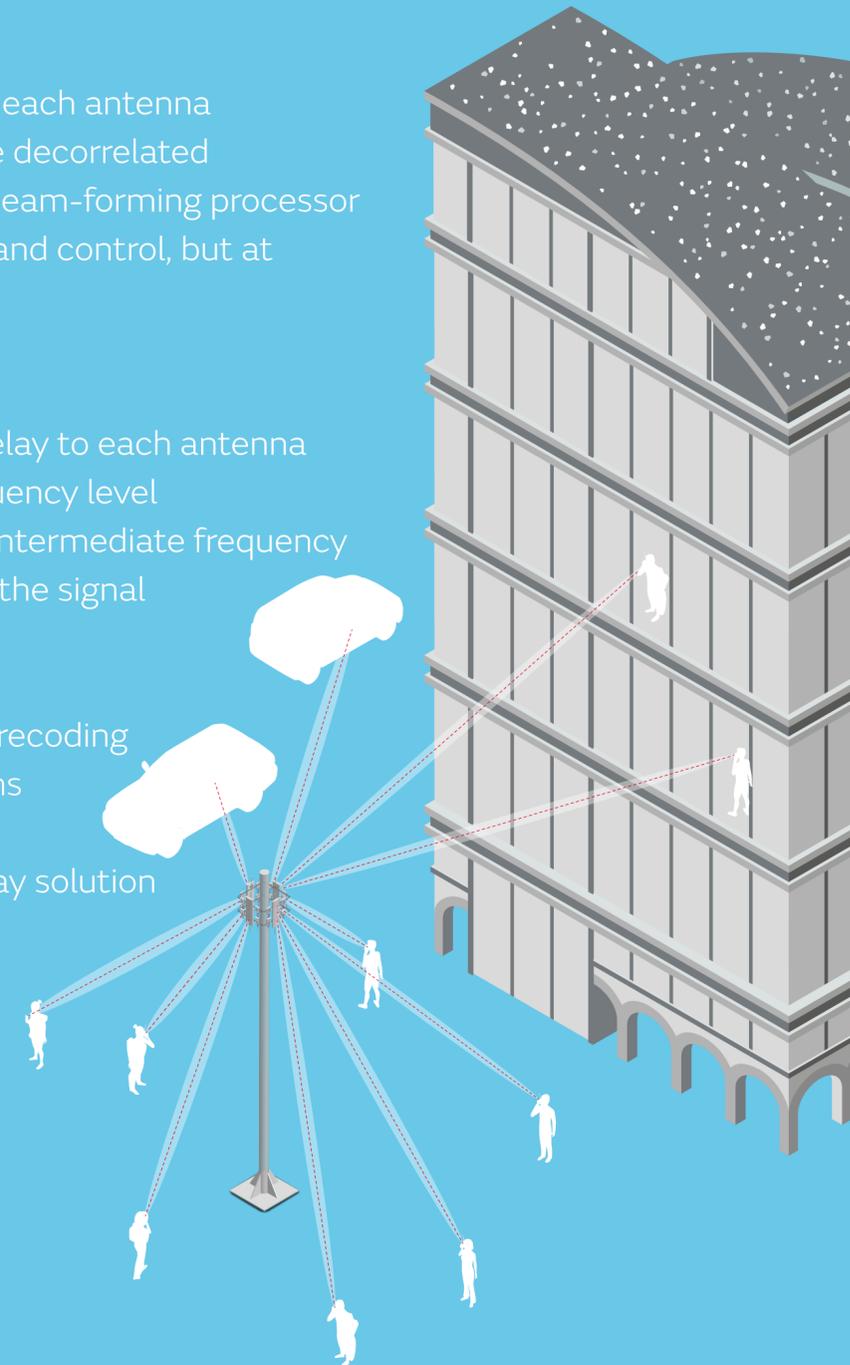
- Digital receivers are stationed at each end of each antenna
- Signal is digitized and noise and distortion are decorrelated
- Multiple beams can be formed in the digital beam-forming processor
- Offers improved range and greater precision and control, but at greater cost

## Analog beamforming

- Creates a signal beam by applying a phase delay to each antenna
- Echo signals are combined at RF carrier-frequency level
- Signals are downconverted to basic band or intermediate frequency
- An analog-to-digital converter then digitizes the signal

## Hybrid beamforming

- Combines analog beamforming with digital precoding
- Intelligently forms and receives signal patterns from a large antenna array
- Ability to create an 'off-the-shelf' phased array solution



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# 5G additional challenges

The proliferation of 5G will bring with it enormous challenges for engineers to overcome, from complex installations on unconventional structures to increased regulations and technical requirements.

## Increased complexity

Compared with the structure of an ordinary 4G base transceiver station (BTS), the architecture required for 5G is incredibly complex. As discussed earlier, small 5G cells will need to be integrated high up the mast in a modular fashion to allow for improved scalability, while the shift to mMIMO and techniques such as beamforming – using a range of antennae to control the direction of a signal beam – will add another layer of complexity to the process.

## Greater technical requirements

As the technical requirements for 5G continue to be standardised, it has become increasingly clear just how high the technical challenges are for operators. Both consumers and industry have enormous expectations for 5G, including latency of one millisecond, the ability to connect around 100x the number of devices as 4G and 1000x the bandwidth per area – not to mention reduced energy network usage and near-perfect coverage. When used for applications such as smart factories and autonomous

vehicles, it is essential that these ambitious requirements are met.

## Proliferation of technology

To meet the demand for comprehensive network coverage and enable the next generation of automated vehicles, 5G will need to be integrated across huge swathes of both the built and natural environment. Beyond traditional base station integrations, this will include complex installations on small-scale infrastructure such as lampposts and houses, which will need to appear as unobtrusive as possible and comply with local planning regulations.

### Base station quantity (RRU/AAU) forecast

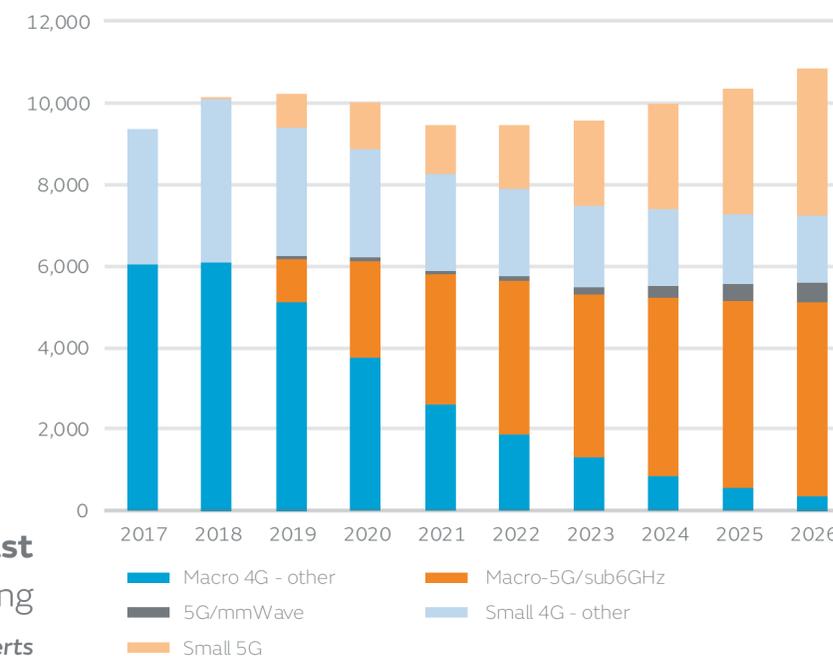
5G-compatible base stations keep increasing

Source: Murata estimation based on data from Mobile Experts

# Opportunities

## New devices and systems to address challenges

As the next phase of the 5G roll-out occurs, opportunities will arise for manufacturers and engineers with the capacity to solve some of these challenges. Until recently, 5G integration has primarily focussed on large-scale base stations and buildings, but the next stage will focus more on smaller-scale sites that can fill the gaps in network coverage. Anyone with the technical know-how to adapt 5G architecture to these less conventional sites will likely gain a strong competitive advantage.



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# Base station thermal management

An inevitable consequence of mMIMO and beamforming – and the consequence of moving hardware from the large base-station ‘shed’ to smaller assemblies at the mast head – is an increase in generated heat, making thermal management a major issue for 5G installations.

## Reasons for thermal build-up

The exponential scaling up of processing capacity and power that comes with 5G will naturally lead to increased heat generation. The transition from MIMO to Massive MIMO will create antenna arrays with up to 64 array elements, representing a huge amount of hardware with unprecedented processing power that may be at risk of overheating.

## Performance & reliability

As temperatures increase, the performance and reliability of the 5G network will go down. Antennas could start to malfunction; processing could slow, and the energy efficiency of the site could be drastically reduced. In severe cases of overheating, the lifespan of certain components could also be impeded.

## Maintenance costs

All of the negative impacts of excessive heat will inevitably have an impact on network providers’ bottom lines. While a 5G installation is intended to last around a decade with minimal upkeep, poor thermal management is likely to mean ongoing maintenance costs and high levels of expenditure, which could be passed on to the end consumer.



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# Environmental

To develop truly global 5G coverage, base stations will need to be installed across the world in some extremely inhospitable environments. This means that the new generation of base stations needs to be designed with environmental challenges and extreme weather in mind, such as the effects of humidity, heat and wind.

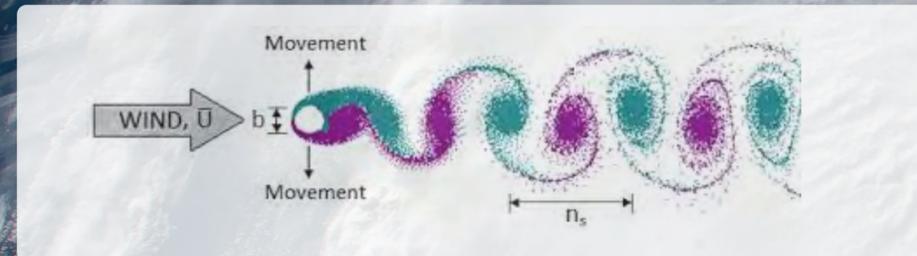
## Humidity

Base stations located in more tropical or humid climates should be engineered to withstand high levels of humidity and still maintain their performance and lifespan. Both the 5G cells and the base station should remain functional even when subjected to severely wet and humid conditions.

## Temperature

Even in extremely hot climates, 5G components must remain reliable, stable and energy efficient to prevent downtime, malfunctions and reduction in lifespan. The same applies in cold climates, where components should continue to function even at several degrees under freezing.

## Wind-induced vibration



## Weight reduction



## Wind

Since a great deal of the hardware for any 5G installation is located at the top of the mast, rather than lower down, this new era of base stations will be increasingly vulnerable to the effects of wind vibrations. Though small cells tend to be relatively light, they can nonetheless exercise a sail-like effect on the structure and weigh the towers down. For this reason, 5G components should be engineered to be as small and light as possible in order to minimise risk and reduce the need for ongoing maintenance.

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# Installation & maintenance

## Installation

A number of applications for 5G, most obviously autonomous electric vehicles, require a continuous line of sight between the 5G transmitter and the connected device. In order to attain this level of spotless coverage, a huge number of installations will be needed, which in turn will necessitate a huge amount of climbing for installation engineers. Designers of 5G components will therefore have to balance requirements for performance and reliability against the unique labour regulations that apply across various regions regarding the height of the towers, the weight of the parts and the number of workers allowed per installation. This means that the smallest and lightest configuration possible is also going to be the most cost-effective one.

## Maintenance & Monitoring

While using reliable components is the best way to reducing maintenance costs, keeping size and weight to a minimum is also advantageous when up-tower assemblies need to be replaced. In addition, a state-of-the-art monitoring system that can continuously track and analyse the condition and performance of the assembly and submit intelligence to relevant parties will be a crucial tool in the fight to reduce both costs and labour.



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# Component-level considerations

To design effective and long-lasting 5G infrastructure, the architecture of the base stations should be considered right down to the level of components. When selecting a manufacturer, the following four key factors should be taken into consideration.

## Futureproofing and innovation

5G is an area that is constantly evolving, with new engineering challenges and solutions arising at every stage of its roll-out. To keep costs to a minimum and remain on the front foot, network providers should opt for a supplier with a history of innovation and the ability to think ahead and future-proof their products. Components designed and manufactured with the future in mind will be more likely to meet the distinctive challenges that 5G presents, ensuring high performance and longevity even when integrated with new types of technology.

## Quality and reliability

When it comes to large-scale engineering projects such as 5G integration, it's essential to build long-lasting, robust structures that are able to function continuously for several years without regular maintenance. This principle applies right down to the components that form an integral part of any next generation 5G base station. Since maintenance on communication tower assemblies can be a tricky logistical

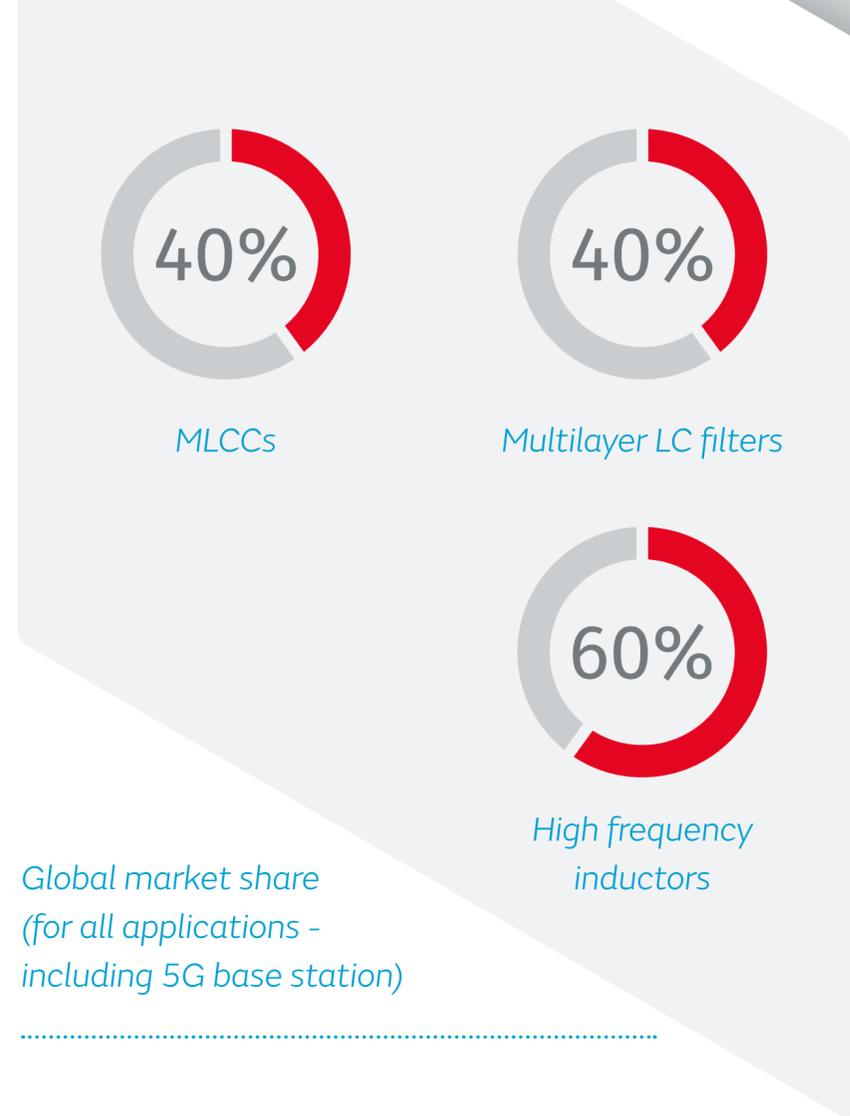
problem, it's important to look for reliable and long-lasting components, ideally with a 10-year warranty that will radically reduce ongoing maintenance costs.

## Manufacturing strength and supply

As 5G networks are built and expanded, suppliers and manufacturers who can produce components quickly and at scale are likely to be given preference over less reliable, smaller-scale suppliers. As 5G is a truly global project, companies with a presence all over the globe will also have an advantage, offering seamless supply chains into multiple regions and the manufacturing capacity to ensure that networks can continue to scale as needed without unnecessary delays.

## Industry understanding

5G is set to represent a massive leap forward in terms of the technical requirements demanded of networks, scaling up the number of connected devices exponentially with higher data rates and much lower latency. To enable this incredible



level of connectivity, a split with the network architecture of the past has been required, requiring new solutions to challenges. For these reasons, it is important to pick a components supplier who has a good grounding in 5G and can offer in-depth industry knowledge, understanding the unique requirements and options for different types of installation.

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# Components constructed to meet the 5G challenges

**Materials, manufacturing processes and construction innovation are key to optimising performance in 5G base stations.**

## Design and manufacture

With so many challenges facing the new generation of 5G network operators – balancing requirements for optimal energy efficiency against the need to support ultra-powerful networks – components in any 5G infrastructure should be fully optimized for performance and reliability.

A supplier with a deep understanding of materials and manufacturing processes can design 5G components right down to the molecular level, ensuring that every aspect of the product is fully suited its application. This careful optimization goes far beyond the initial design phase. It ensures complete oversight and control from initial conception right through to the front- and back-end development and analytics. This allows networks to meet the stringent requirements demanded of them, all while maximizing energy efficiency and minimizing wastage.



## Innovation

By utilizing the latest manufacturing processes and materials and partnering with industry innovators, components suppliers can optimize their designs for all types of 5G installation, from densely populated urban settings to smaller-scale suburban sites. They can also anticipate future developments and design their products for adaptability and versatility.

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# Miniature components

Reducing the size of base station sub-assemblies while increasing their performance requires continuous reductions in the size and weight of components.

## Environmental

The transition from traditional 'shed'-oriented BTS configurations to assemblies of small-cell antennas high up on the comms-tower has made the need for ultra-small, lightweight components an imperative. With wind vibrations exercising a particularly destabilizing effect on the towers, minimizing the weight burden of the assembly will help to secure the overall structure against these environmental conditions.

## Installation

With regulations and logistical issues surrounding 5G installations in high-up locations, having incredibly light-weight and miniaturized components will help to streamline the installation process. Legal restrictions on the weight of loads that can be carried up the mast can thereby be more easily adhered to, allowing for greater speed and, more importantly, greater safety.



*Murata's history of component miniaturization predates the invention of semiconductors.*

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# Efficiency and long-term reliability

Keeping maintenance costs down while increasing the number of 5G small cell base stations will have a huge impact on the profitability of 5G networks.

## High-temperature performance

In the initial phases of 5G expansion, installing new networks will require a careful balancing of cost-to-user against cost-to-business. This careful balancing act will require operators to consider the ongoing costs of their operations, seeking to limit ongoing maintenance and downtime to an absolute minimum.

With this in mind, sourcing components that have been deeply designed for optimal thermal management will be a major concern. Every stage of the design and manufacturing process – right from the original selection of materials – will be crucial in minimizing the adverse effects of heat generation. If components can maintain their performance in extreme thermal conditions, the overall energy efficiency of the assembly will be increased and the need for regular maintenance will be drastically reduced.



## Reliability and ease of maintenance

Integrating a 5G network requires clever logistics, a great deal of engineering expertise and a large financial investment, so it's incredibly important that, once installed, the architecture is reliable and long-lasting. With high-quality

components that can be consistently monitored for performance and condition, the burden of high maintenance costs can be reduced, ensuring that a network will continue to operate seamlessly long after the initial installation.

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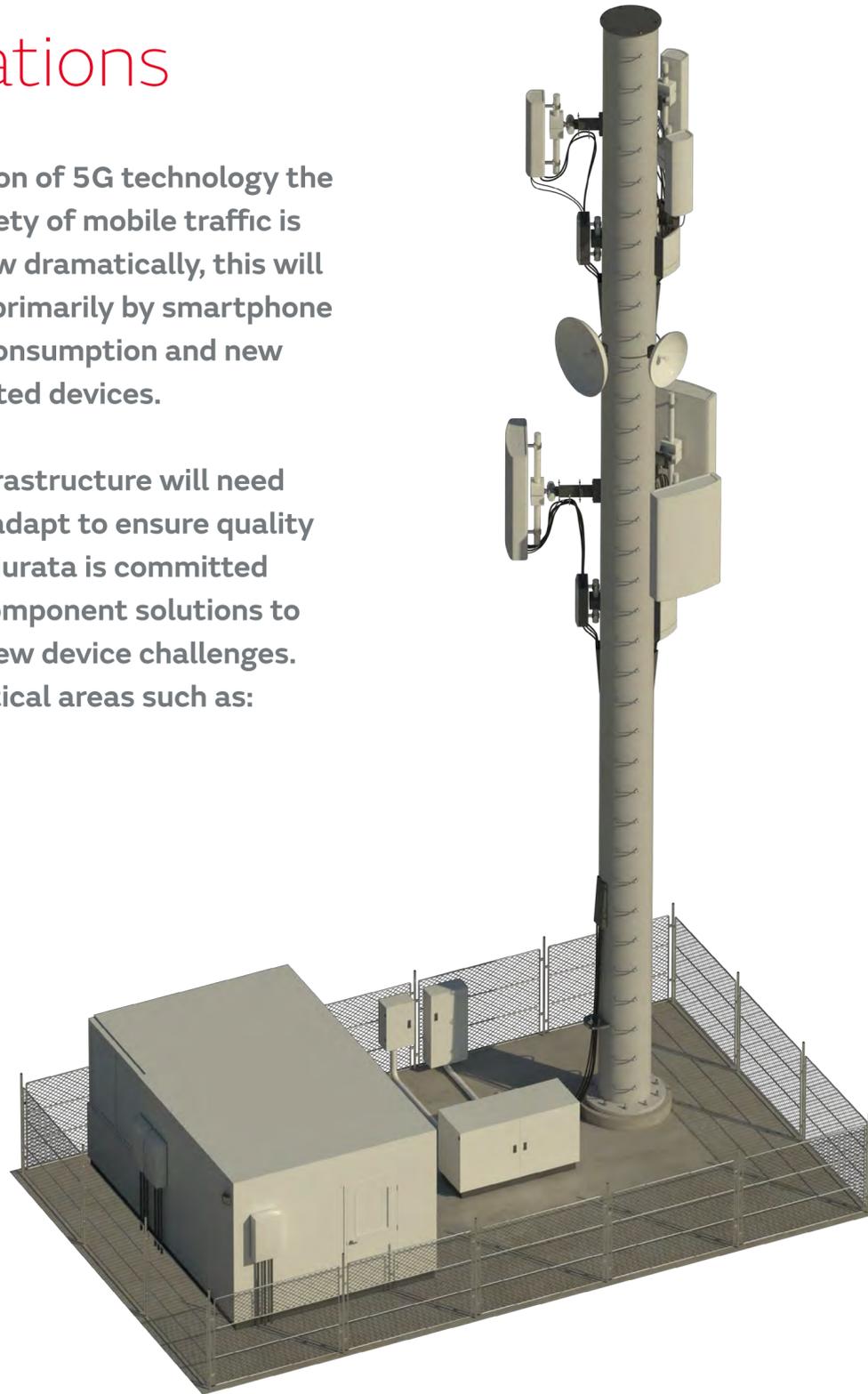
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# Applications

With the adoption of 5G technology the volume and variety of mobile traffic is expected to grow dramatically, this will be likely driven primarily by smartphone video or game consumption and new types of connected devices.

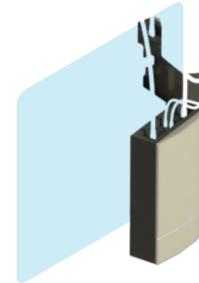
Base station infrastructure will need to significantly adapt to ensure quality of experience. Murata is committed to developing component solutions to support these new device challenges. Especially in critical areas such as:



## RRU/AAU

### Remote Radio Unit / Active Antenna Unit

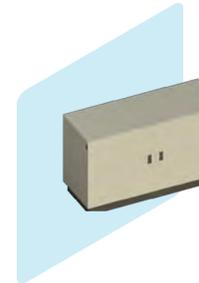
Either alongside passive antennas or within active antenna arrays.



## PA

### Power Amplifier

Power amplifier is inside of RRU. Here, We introduce individually because Murata has specific products here which support high power and efficiency.



## BBU/DU/CU

### Baseband Unit / Distributed Unit / Centralized Unit

The BBU/DU/CU is placed in the equipment room and connected with the RRU via optical fiber. These are responsible for communication through the physical interface and is in a virtualization trend.



## MEC

### Multi-access edge computing

Hardware can be located in a number of locations including Distributed Units (DUs), alongside Centralized Units or within an edge datacenter.

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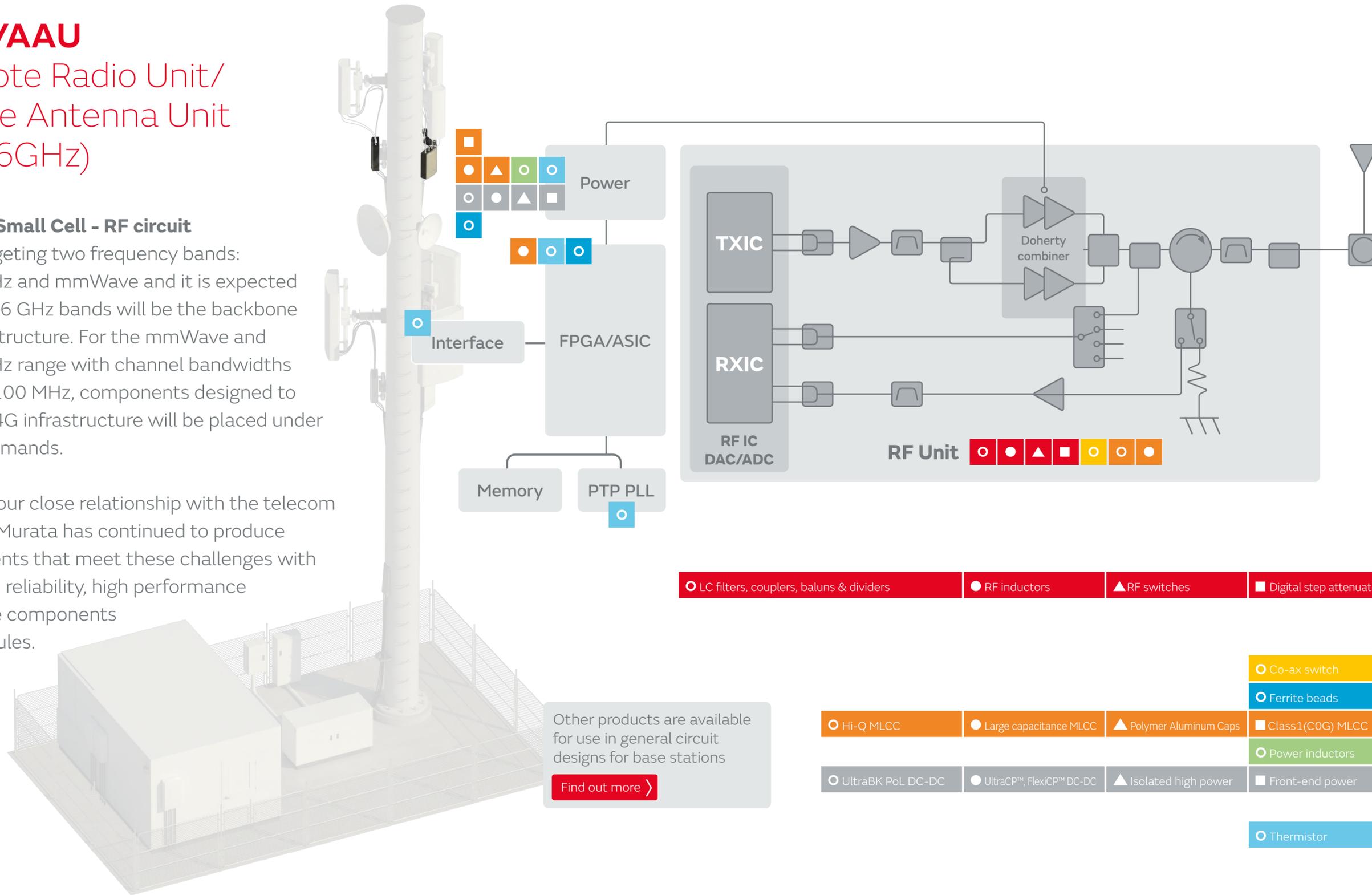
# RRU/AAU

## Remote Radio Unit/ Active Antenna Unit (sub 6GHz)

### Macro / Small Cell - RF circuit

5G is targeting two frequency bands: sub-6 GHz and mmWave and it is expected that sub-6 GHz bands will be the backbone 5G infrastructure. For the mmWave and sub-6 GHz range with channel bandwidths of up to 100 MHz, components designed to support 4G infrastructure will be placed under higher demands.

Through our close relationship with the telecom industry Murata has continued to produce components that meet these challenges with ultra high reliability, high performance miniature components and modules.



Other products are available for use in general circuit designs for base stations  
[Find out more >](#)

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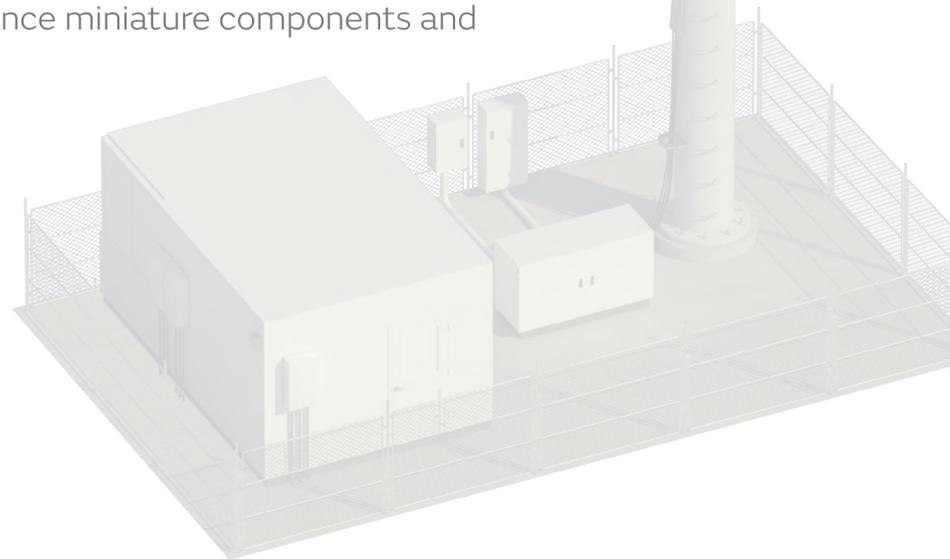
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# RRU/AAU

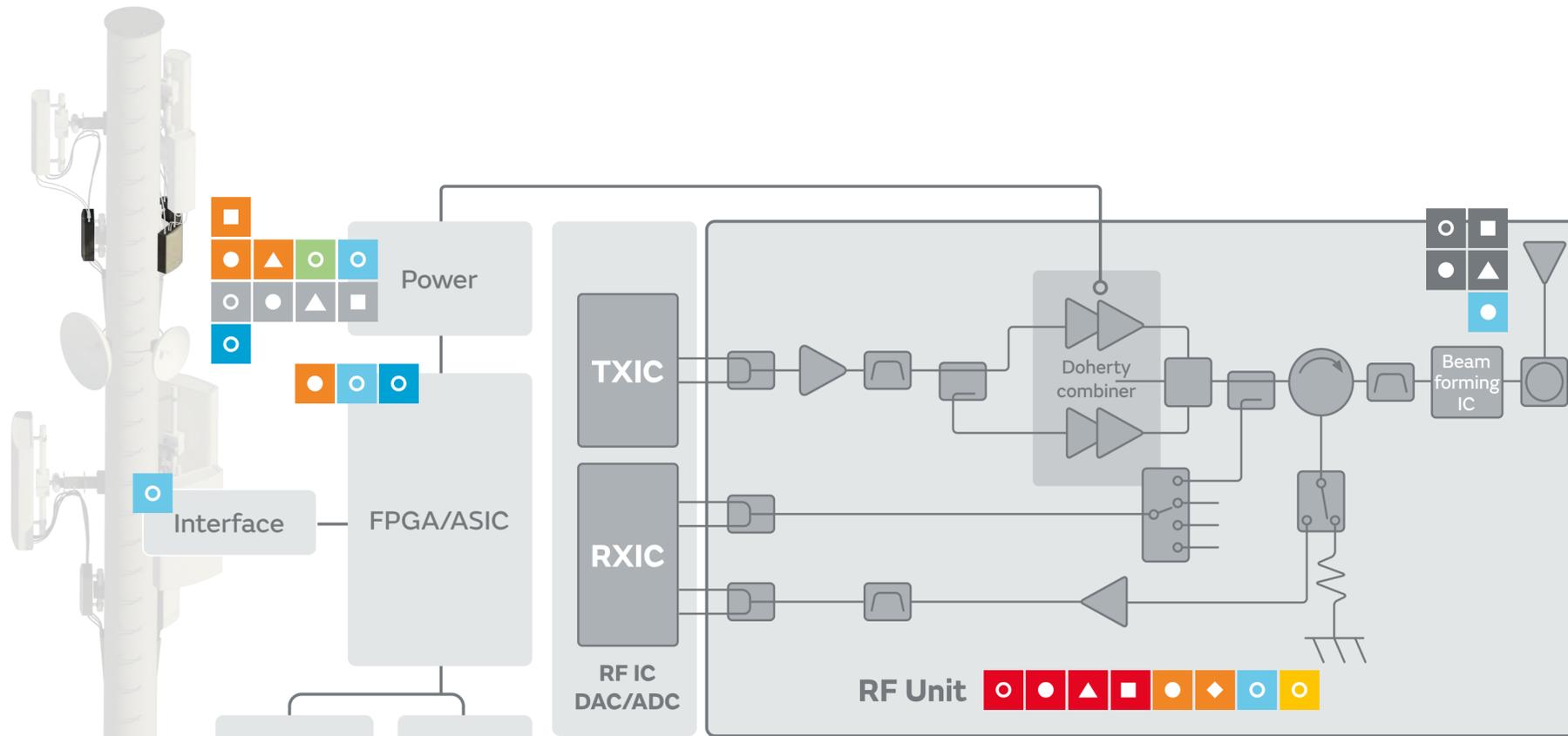
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- LC filters, couplers, baluns & dividers
- RF inductors
- ▲ RF switches
- Digital step attenuator
- 4x4 array antenna
- Beamformer IC
- ▲ Up-down converter IC
- SPDT switch
- Large capacitance MLCC
- ▲ Polymer Aluminum Caps
- Class1(COG) MLCC
- ◆ Silicon Capacitors
- UltraBK PoL DC-DC
- UltraCP™, FlexiCP™ DC-DC
- ▲ Isolated high power
- Front-end power
- Co-ax switch
- Ferrite beads
- Power inductors
- Thermistor
- MEMS inclinometers

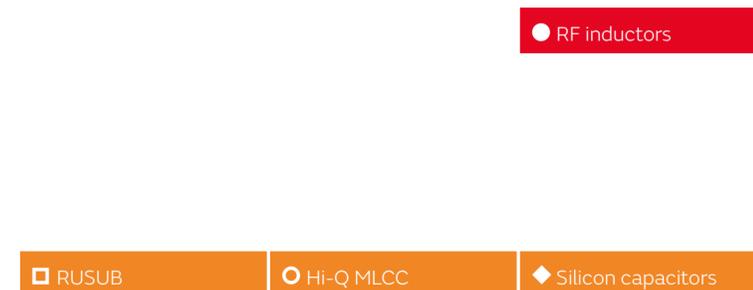
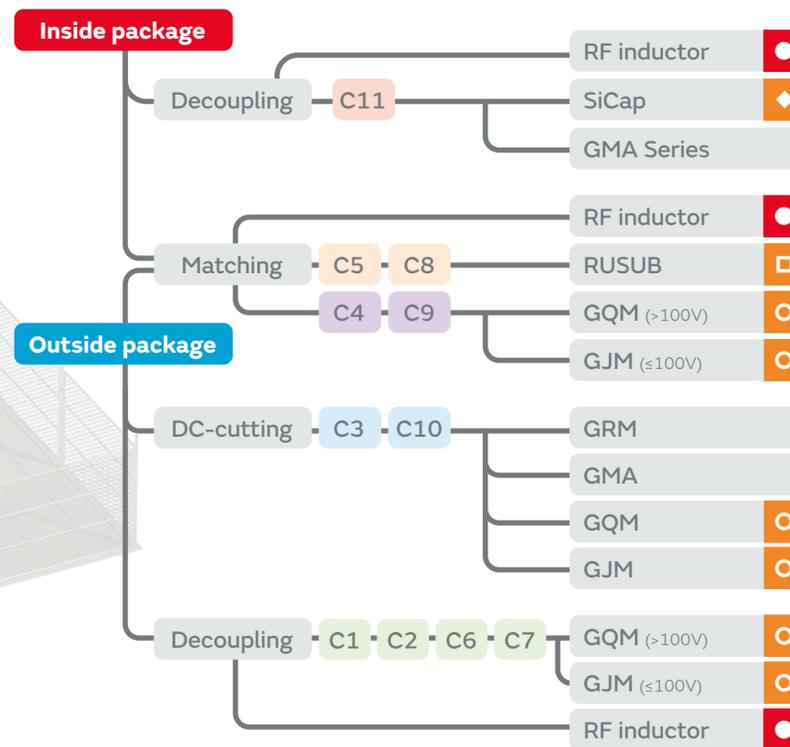
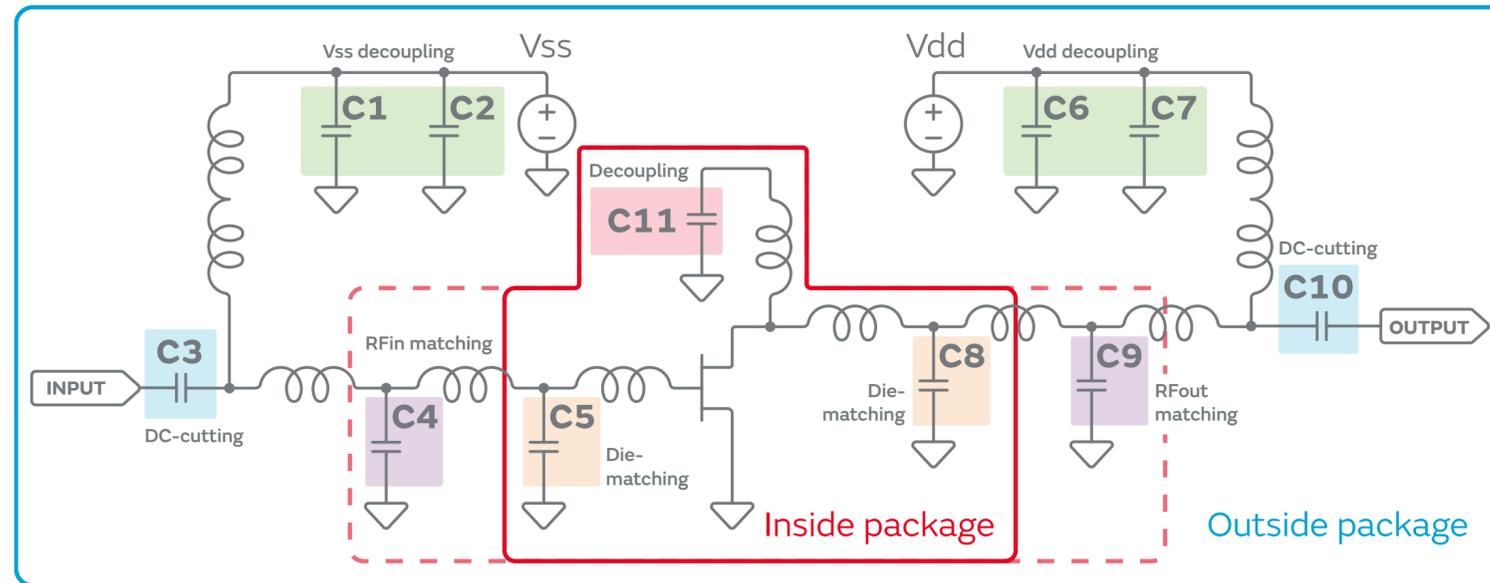
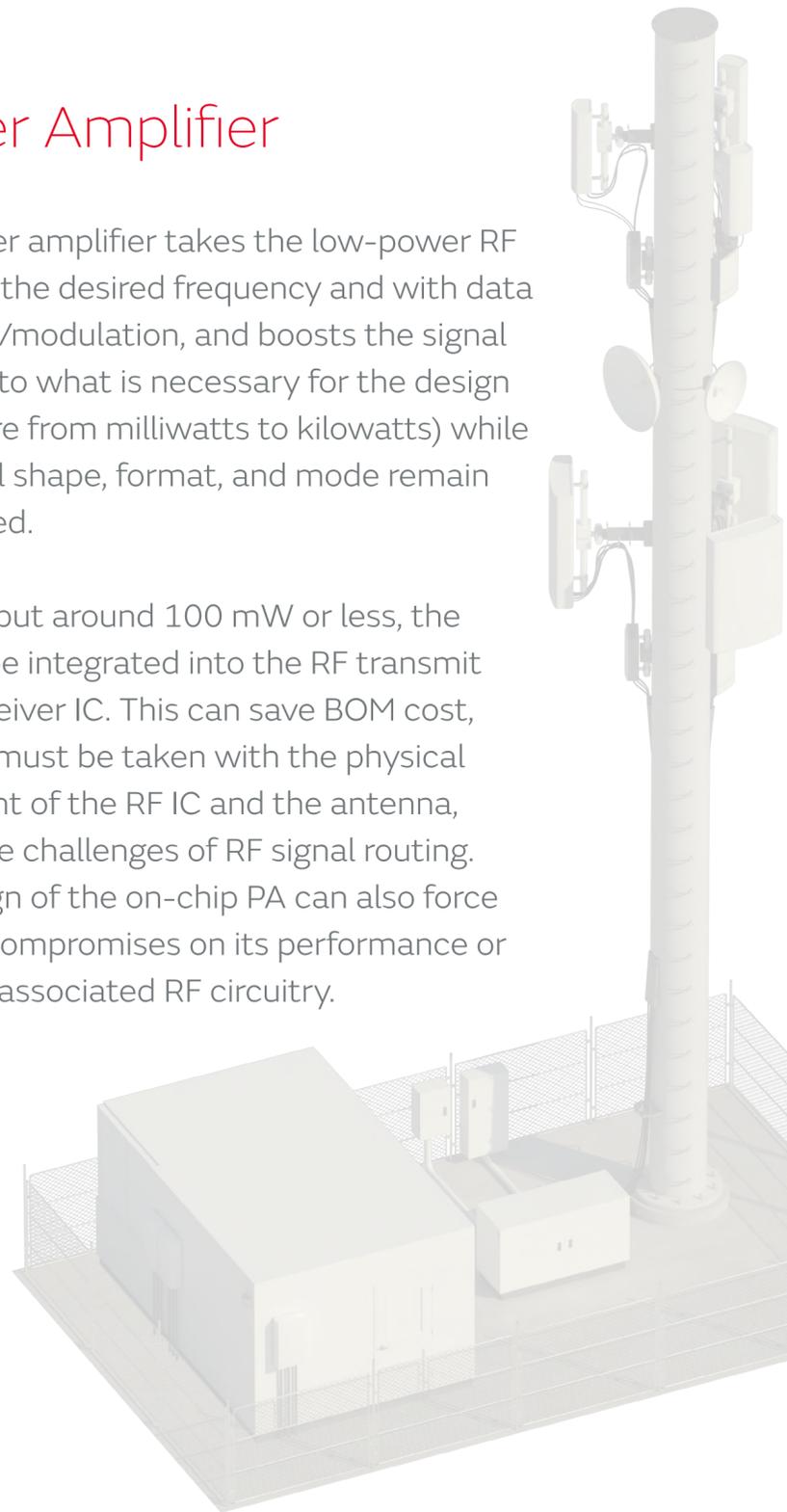
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  - Power
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  - Sensors

# PA Power Amplifier

The power amplifier takes the low-power RF signal, at the desired frequency and with data encoding/modulation, and boosts the signal strength to what is necessary for the design (anywhere from milliwatts to kilowatts) while the signal shape, format, and mode remain unchanged.

In RF output around 100 mW or less, the PA may be integrated into the RF transmit or transceiver IC. This can save BOM cost, but care must be taken with the physical placement of the RF IC and the antenna, due to the challenges of RF signal routing. The design of the on-chip PA can also force difficult compromises on its performance or th of the associated RF circuitry.



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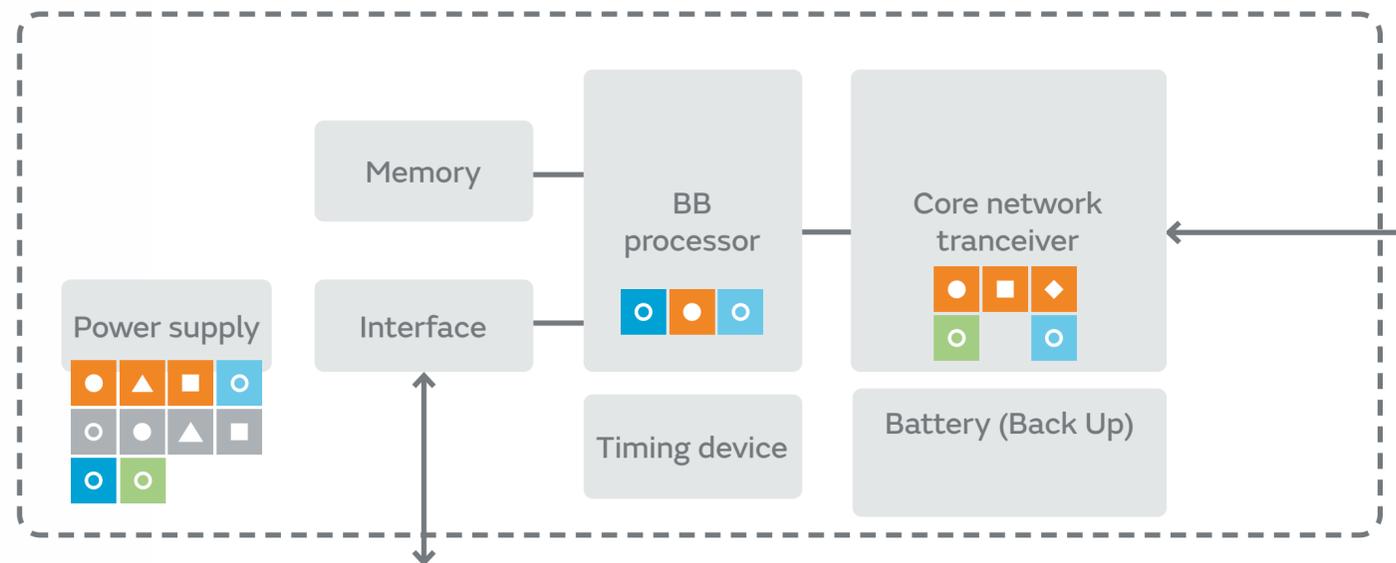
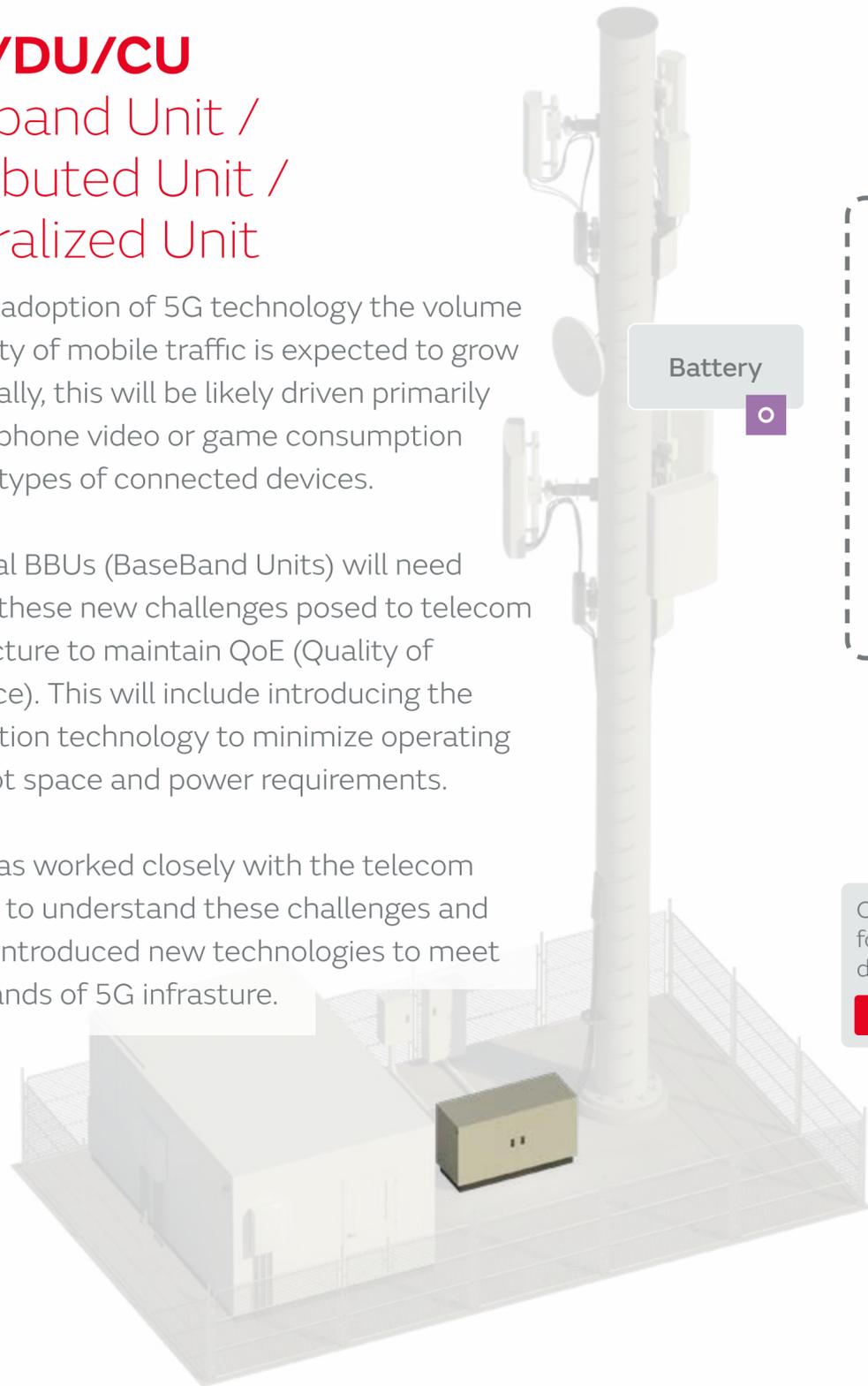
# BBU/DU/CU

## Baseband Unit / Distributed Unit / Centralized Unit

With the adoption of 5G technology the volume and variety of mobile traffic is expected to grow dramatically, this will be likely driven primarily by smartphone video or game consumption and new types of connected devices.

Traditional BBUs (BaseBand Units) will need adapt to these new challenges posed to telecom infrastructure to maintain QoE (Quality of Experience). This will include introducing the virtualization technology to minimize operating costs, foot space and power requirements.

Murata has worked closely with the telecom providers to understand these challenges and we have introduced new technologies to meet the demands of 5G infrasture.



Other products are available for use in general circuit designs for base stations

[Find out more >](#)

● Large capacitance MLCC	■ Class1(C0G) MLCC	▲ Polymer Aluminum Caps	○ Ferrite beads
○ UltraBK PoL DC-DC	● UltraCP™, FlexiCP™ DC-DC	▲ Isolated high power	◆ Silicon Capacitors
			○ Power inductors
			■ Front-end power
			○ Battery shelf
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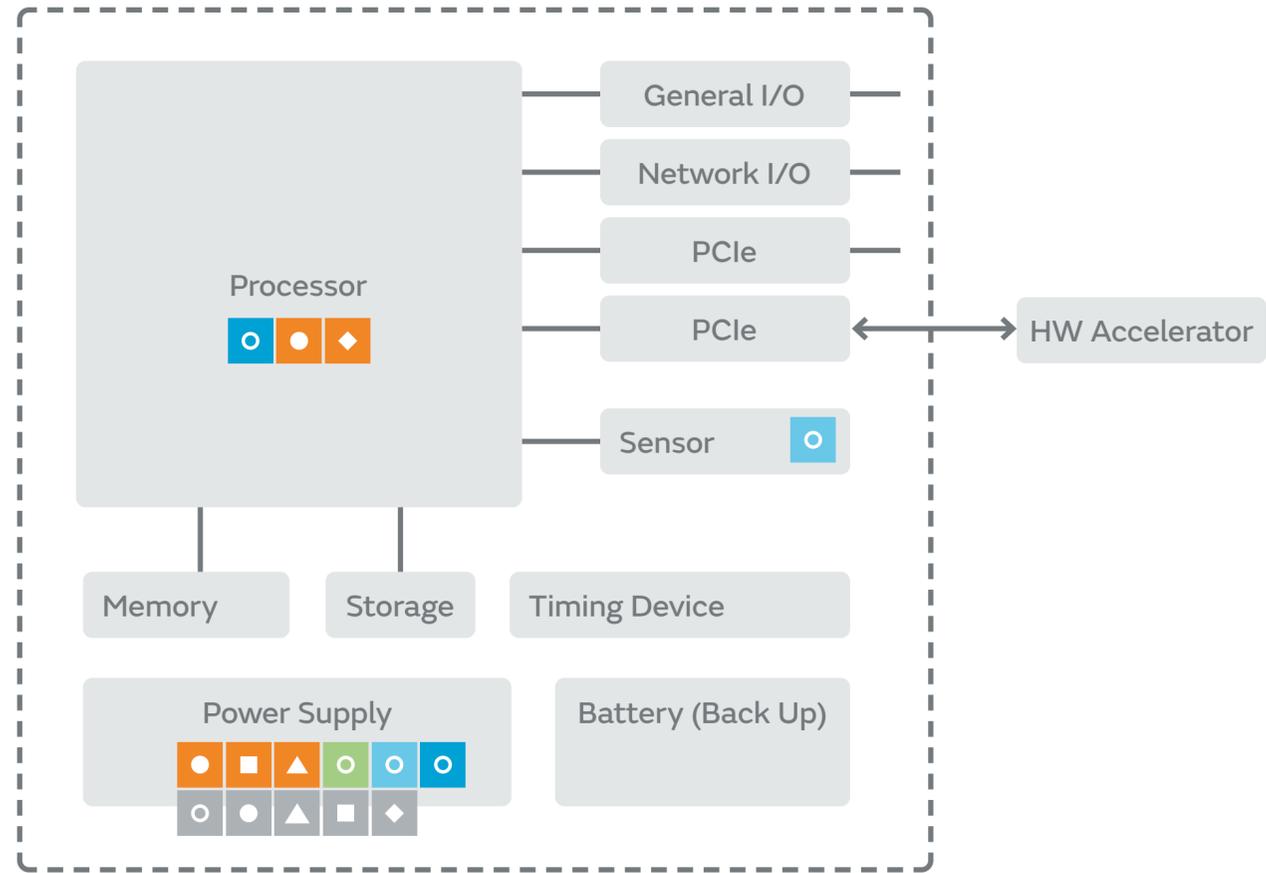
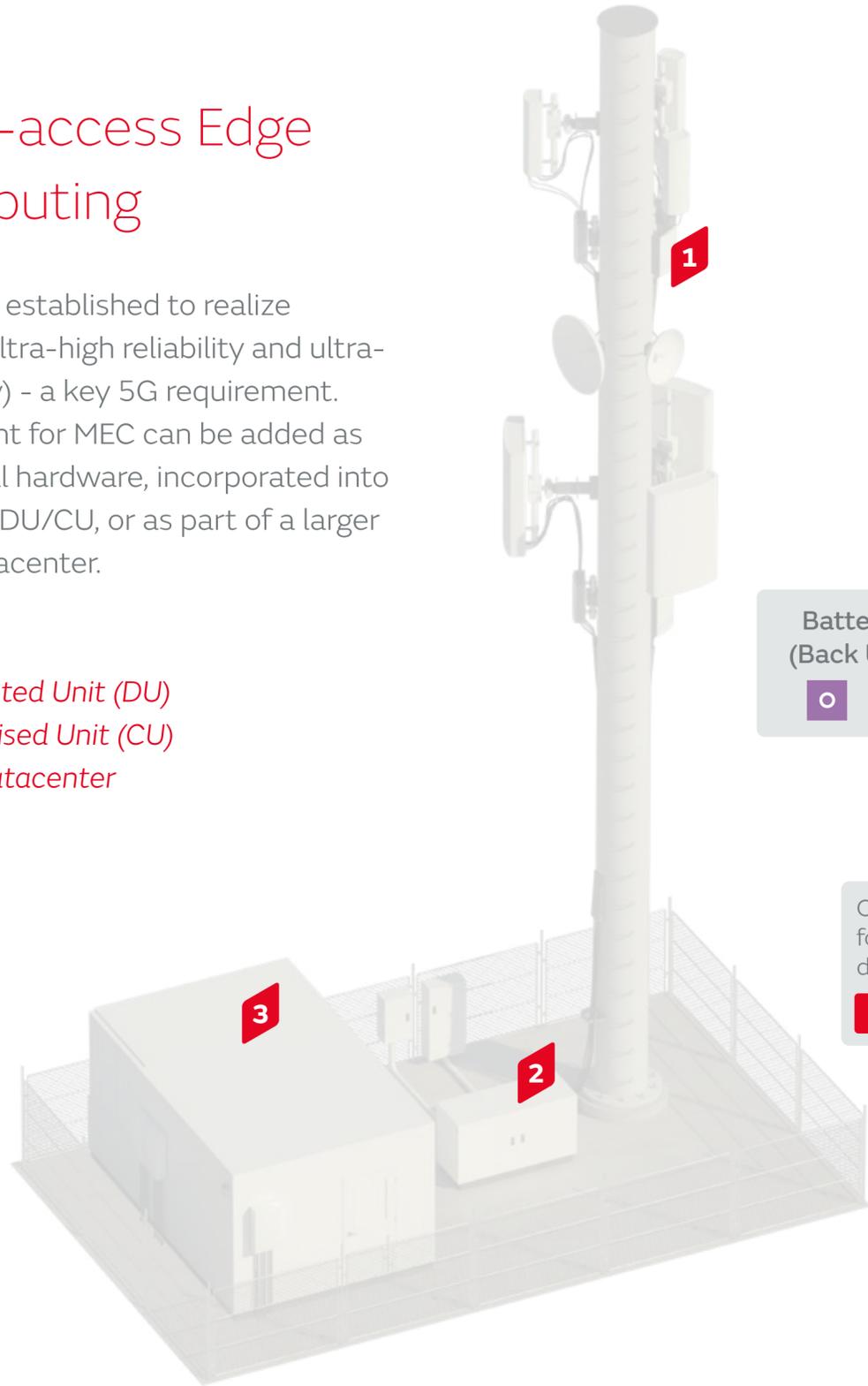
# MEC

## Multi-access Edge Computing

MEC was established to realize URLLC (ultra-high reliability and ultra-low delay) - a key 5G requirement. Equipment for MEC can be added as additional hardware, incorporated into the BBU/DU/CU, or as part of a larger edge datacenter.

MEC at:

1. Distributed Unit (DU)
2. Centralised Unit (CU)
3. Edge datacenter



Other products are available for use in general circuit designs for base stations

[Find out more >](#)

○ Large capacitance MLCC	■ Class1(C0G) MLCC	▲ Polymer Aluminum Caps	○ Ferrite beads
○ UltraBK PoL DC-DC	○ UltraCP™, FlexiCP™ DC-DC	▲ Isolated high power	◆ Silicon Capacitors
		■ Front-end power	○ Power inductors
			◆ Power shelf
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			○ Thermistor

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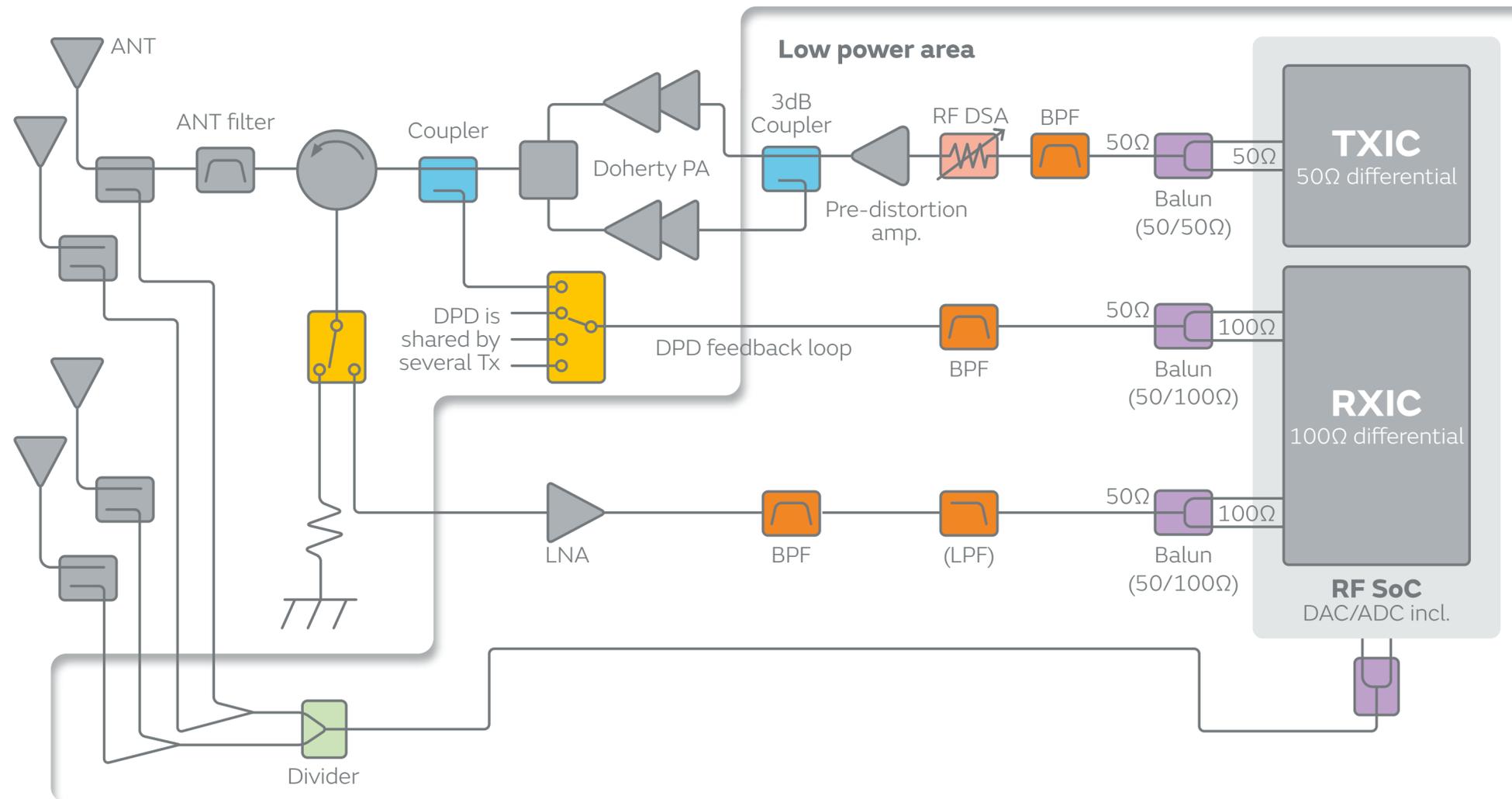
# RF components

LC filters, couplers, baluns, dividers, switches & digital step attenuators (DSAs)

Murata and pSemi, a Murata company, offer innovative solutions to 5G challenges with world-leading expertise in LTCC (Low Temperature Cofire Ceramics), multilayer construction and RFIC design.

### RF components in sub-6 m-Mimo

- LC filter
- Coupler
- Balun
- Divider
- RF Switch
- RF DSA



## Applications

- RRU/AAU

### RF components

- LC filters, couplers, baluns & dividers
- RF inductors
- ▲ RF switches ○○
- RF digital step attenuator ○○

[More about LC filters](#) >  
(membership registration is required)

[More about RF switches](#) >

[More about RF DSAs](#) >

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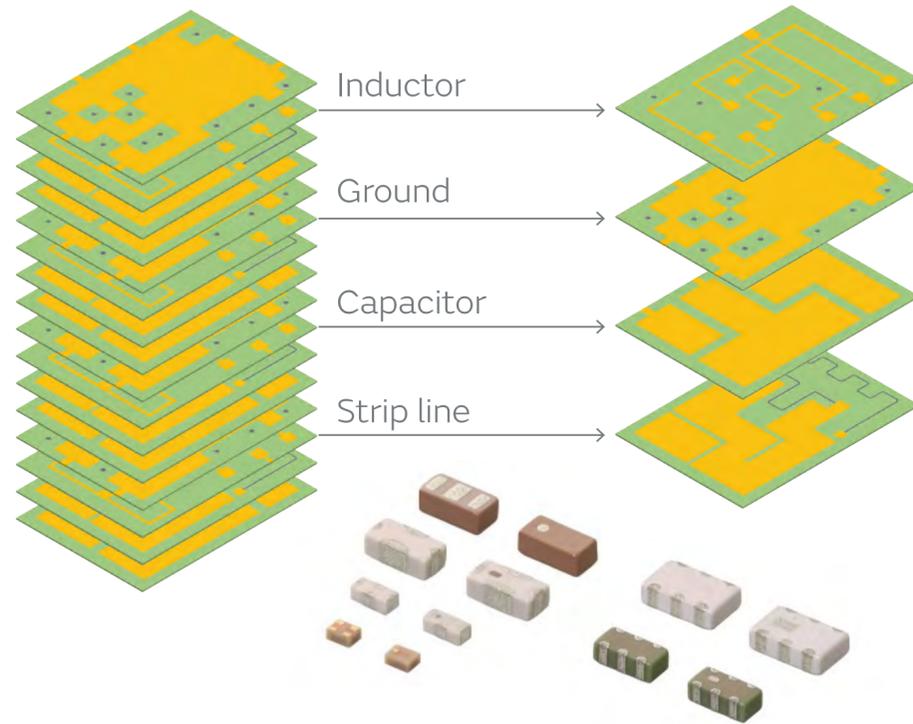
### Murata innovation

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- Sensors

# RF components

## LC filters, couplers, baluns & dividers

### LTCC technology - Low Temperature Co-fired Ceramics



**LC filters** are passive components which pass or reject a specific frequency band. These components are used for extracting the specific frequency band, or rejecting for noise reduction.

**Couplers** are RF passive devices used for coupling a specific frequency from an inputted RF signal. These products are used for power level control of transmitters.

**Baluns** are used for converting between a balanced transmission line and an unbalanced transmission line.

**Dividers** are the component function to divide one high-frequency signal into two signals.

LTCC products	Size (mm)	EIA Size (inch)	Popular packages in base stations				
			Balun	Coupler	Divider	BPF	LPF
Code type							
L**32	3.2 x 2.5	1210				○	○
L**31	3.2 x 1.6	1206			○		
L**2H	2.5 x 2.0	1008				○	
L**21	2.0 x 1.25	0805		○		○	○
L**18	1.6 x 0.8	0603	○	○	○	○	○

## Applications

- RRU/AAU
- RRU/AAU mmWave

### RF components

- LC filters, couplers, baluns & dividers
- RF inductors
- ▲ RF switches ○ ○
- RF digital step attenuator ○ ○

[More about RF switches >](#)

[More about RF DSAs >](#)

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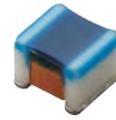
### Murata innovation

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- Sensors

# RF components

## RF inductors

Murata offers a wide range of RF inductors to address the challenges of base station circuit design.



### Wire Wound RF Inductors

To achieve the highest Q characteristics, Murata leveraged its unique winding technique to create the LQW2BAN\_00 series in the smallest possible size (2.0×1.5 mm)

- Excellent Q characteristics unique to winding-type inductors
- The industry's highest allowable current for the size
- Broad lineup - 35 items
- Compatible with a wide range of inductance (3.2 nH to 200 nH)

LQW2BAN\_00 series >



### High-Q chip inductors

Murata's LQP03HQ\_02 series of compact 0201 standard size (0.6 x 0.3 x 0.4 mm) high-frequency chip inductors have some of the highest Q characteristics in the industry.

LQP03HQ\_02 series >



### 0402-size winding type choke inductors with large rated current and low DC resistance

Designed to address the effects electromagnetic noise from communication frequency bands, the LQW15CA series of 0402-size (1.0×0.5mm) winding type inductors feature excellent Z characteristics in the communication frequency bands (700MHz to 2,700MHz bands).

LQW15CA series >



### 15µH inductor in 0402 size

The LQW15DN features a maximum inductance of 15µH in 0402 size (1.0 x0.5mm) due to our unique materials and design technology, enabling contribution to the miniaturization and high-efficiency of the circuit.

LQW15DN series >

## Applications

- RRU/AAU mmWave
- RRU/AAU
- PA

### RF components

- LC filters, couplers, baluns & dividers
- RF inductors
- ▲ RF switches ○ ○
- RF digital step attenuator ○ ○

All RF inductors >

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# RF components

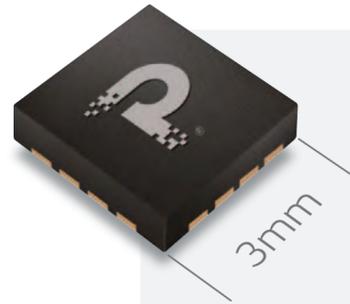
## Receiver protection SPDT switch

PE42823 is a HaRP™ technology-enhanced 50Ω SPDT RF receiver protection switch that delivers simple, repeatable and reliable receiver protection for 4G & 5G wireless infrastructure.

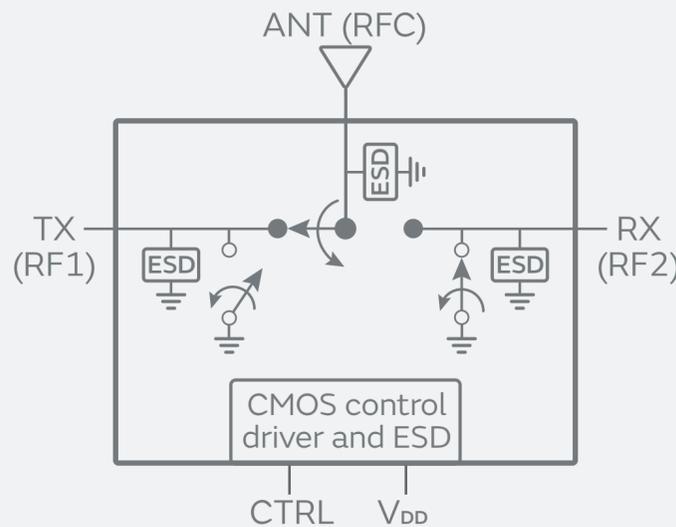
PE42823 also features high linearity and superior thermal performance in compact 16-lead 3x3 mm QFN package.

### Key features

- Excellent single-event peak power handling of 51 dBm LTE
- Exceptional linearity across all frequencies
  - IIP3: 70dBm
  - P1dB: 46dBm
- 1.8/3.3V TTL compatible
- +105°C operating temperature
- High ESD performance of 4.5 kV HBM on RF pins to ground
- Packaging – 16-lead 3 × 3 mm QFN



High reliability, small form factor receiver protection switch for 4G and 5G RRU/AAU



Part Number	Description	Frequency	IIP3	P1dB	Insertion loss	Isolation	Switching time	Package	
PE42823	Failsafe SPDT switch	700 – 6000 MHz	70 dBm	46dBm	0.68 dB	48 dB	850 ns	16L 3x3 mm QFN	<a href="#">Find out more</a>

## Applications

- RRU/AAU

### RF components

- LC filters, couplers, baluns & dividers
- RF inductors
- ▲ RF switches ● ○
- RF digital step attenuator ○ ○

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[More about RF switches](#) >

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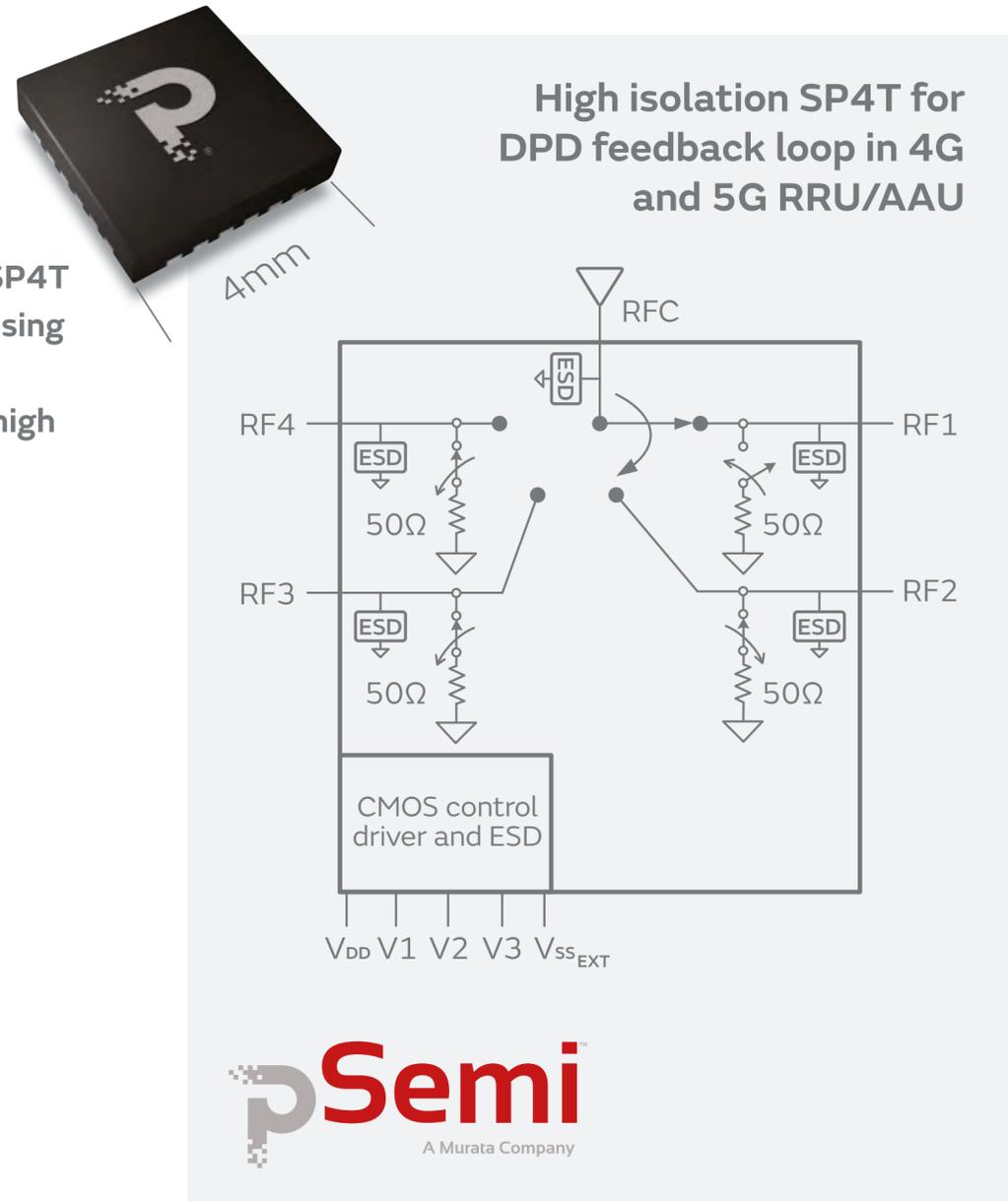
# RF components

High isolation SP4T switch for DPD feedback loop

PE42442 is a HaRP™ technology-enhanced absorptive SP4T RF switch that enables 4G & 5G infrastructure designs using advanced linearization techniques to maximize spectral efficiency and data throughput. PE42442 also features high linearity and exceptional fast switching.

### Key features

- High isolation
  - 61dB @ 900 MHz
  - 52 dB @ 2700MHz
  - 43 dB @ 4000 MHz
- High linearity
  - 97dBm IIP2
  - 58dBm IIP3
- +105°C operating temperature
- Fast switching time of 255 ns
- High ESD performance of 4kV HBM on RF pins to ground
- Packaging – 24-lead 4 × 4 mm QFN



Part Number	Description	Frequency	IIP3	PO.1dB	Insertion loss	Isolation	Switching time	Package
PE42442	High Isolation SP4T switch	30 – 6000 MHz	58 dBm	35 dBm	1.25 dB	61 dB	255 ns	24L 4 x4 mm QFN

[Find out more](#)

## Applications

- RRU/AAU

### RF components

- LC filters, couplers, baluns & dividers
- RF inductors
- RF switches**
- RF digital step attenuator

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[More about RF switches](#)

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# RF components

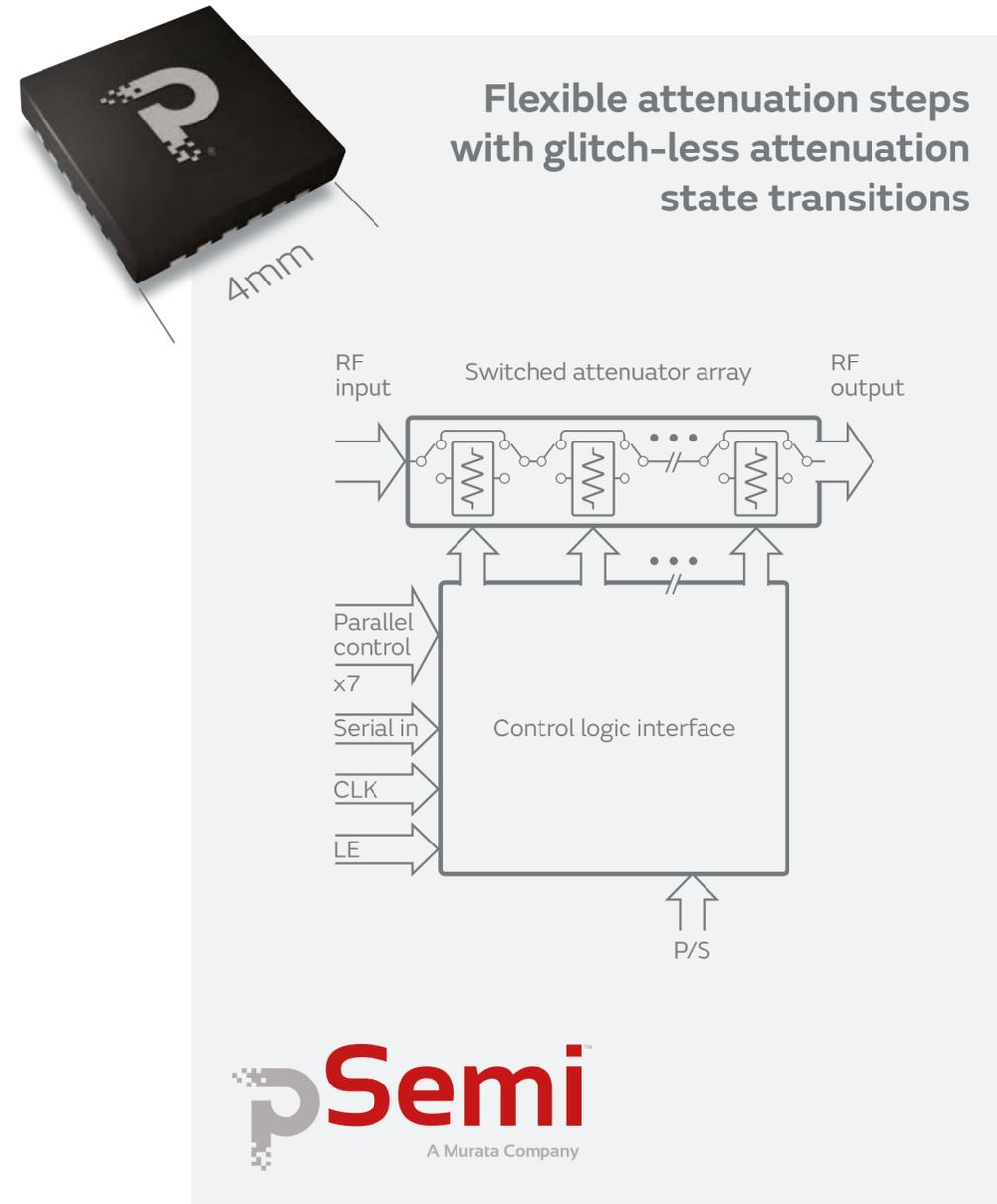
## RF digital step attenuator

The PE43711 is a 50Ω, HaRP™ technology-enhanced, 7-bit RF digital step attenuator (DSA) that supports a broad frequency range from 9 kHz to 6 GHz.

It features glitch-less attenuation state transitions and supports 1.8V control voltage and an extended operating temperature range to +105 °C, making this device ideal for many broadband wireless applications.

### Key features

- Flexible attenuation steps of 0.25 dB, 0.5 dB and 1 dB up to 31.75 dB
- Glitch-less attenuation state transitions
- Monotonicity: 0.25 dB up to 4GHz, 0.5 dB up to 5 GHz and 1 dB up to 6 GHz
- Extended +105°C operating temperature
- Parallel and serial programming interfaces
- Packaging—24-lead 4 × 4 mm QFN



## Applications

- RRU/AAU mmWave
- RRU/AAU

### RF components

- LC filters, couplers, baluns & dividers
- RF inductors
- ▲ RF switches ○ ○
- RF digital step attenuator ● ○

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[More RF DSAs >](#)

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Part Number	Description	Frequency	IIP3	PO.1dB	Insertion loss	Attenuation Accuracy	Switching time	Package
PE43711	RF DSA	9 kHz – 6 GHz	57 dBm	31 dBm	1.9 dB	±(0.15 + 1.5% of setting)	275 ns	24L 4x4 mm QFN

[Find out more](#)

# RF components

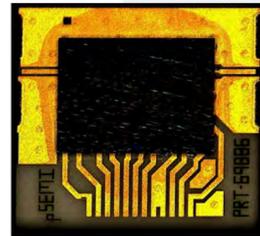
## RF digital step attenuator

The PE43508 is a 50Ω, HaRP™ technology-enhanced, 6-bit RF digital step attenuator (DSA) that supports a wide frequency range from 9k to 55 GHz.

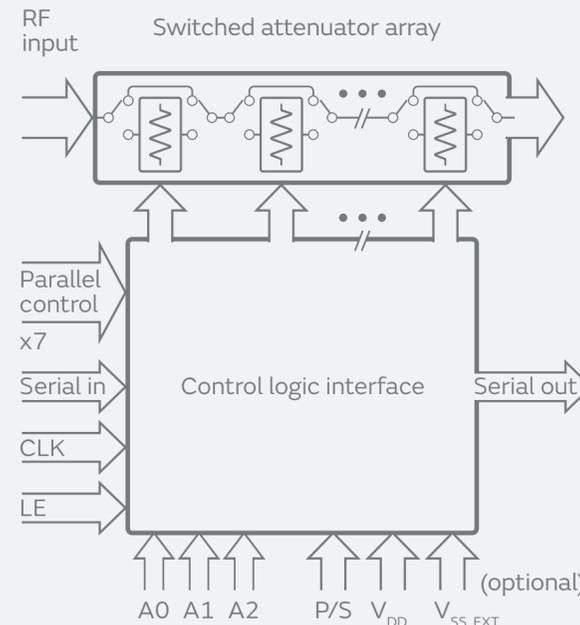
The PE43508 features glitch-safe attenuation state transitions, supports 1.8V control voltage and optional VSS\_EXT bypass mode to improve spurious performance, making this device ideal for test and measurement, point-to-point communication systems, and very small aperture terminals (VSAT).

### Key features

- Wideband support up to 55 GHz
- Glitch-safe attenuation state transitions
- Flexible attenuation steps of 0.5 dB and 1 dB up to 31.5 dB
- Extended +105°C operating temperature
- Parallel and serial programming interfaces with serial addressability
- Flip-chip die



Provides an integrated digital control interface that supports both serial addressable and parallel programming of the attenuation.



Part Number	Description	Frequency	Typ. IL	IIP3	Attn range	Attn step	Interface	Bits	Package
PE43508	RF DSA	9 kHz – 55 GHz	5.90 dB max. 2.20 dB min.	50 dBm	31.50 dB	0.5/1.0 dB	Parallel (latched, direct), serial addressable	6	Flip Chip

[Find out more](#)

## Applications

- RRU/AAU mmWave
- RRU/AAU

### RF components

- LC filters, couplers, baluns & dividers
- RF inductors
- ▲ RF switches
- RF digital step attenuator

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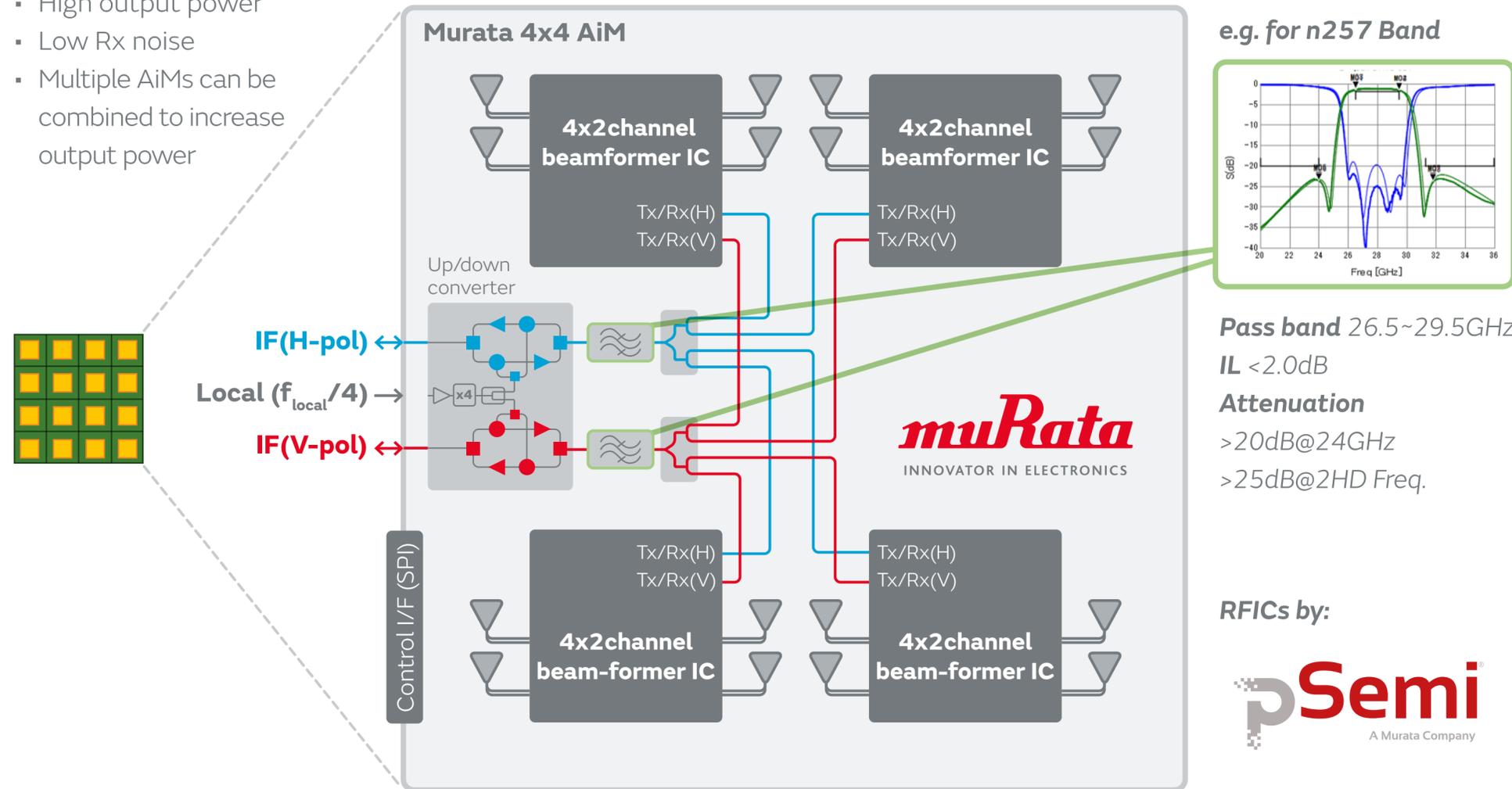
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# mmWave modules

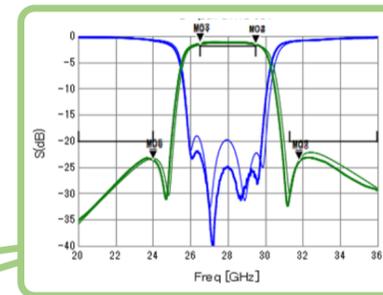
AiM: Antenna integrated Module (4x4 array antenna)

## Key features

- High output power
- Low Rx noise
- Multiple AiMs can be combined to increase output power



e.g. for n257 Band



Pass band 26.5~29.5GHz

IL < 2.0dB

Attenuation

> 20dB@24GHz

> 25dB@2HD Freq.

RFICs by:



## Applications

- RRU/AAU mmWave

### mmWave modules

- 4x4 array antenna module
- mmWave Beamformer IC
- ▲ mmWave up-down converter IC
- mmWave SPDT switch

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Array config.	Tx				Rx				Control I/F
	4x4 EIRP	Gain	EVM	Pdiss	NF	Gain	Rx IIP3	Pdiss	
4x4 /module Up to 256array	38dBm@CP-OFDM	>40 dB	<-27dBc (4.4%)	<240mW/ch	<4.5 dB	>24 dB	>-17 dBm	<50m W/ch	SPI

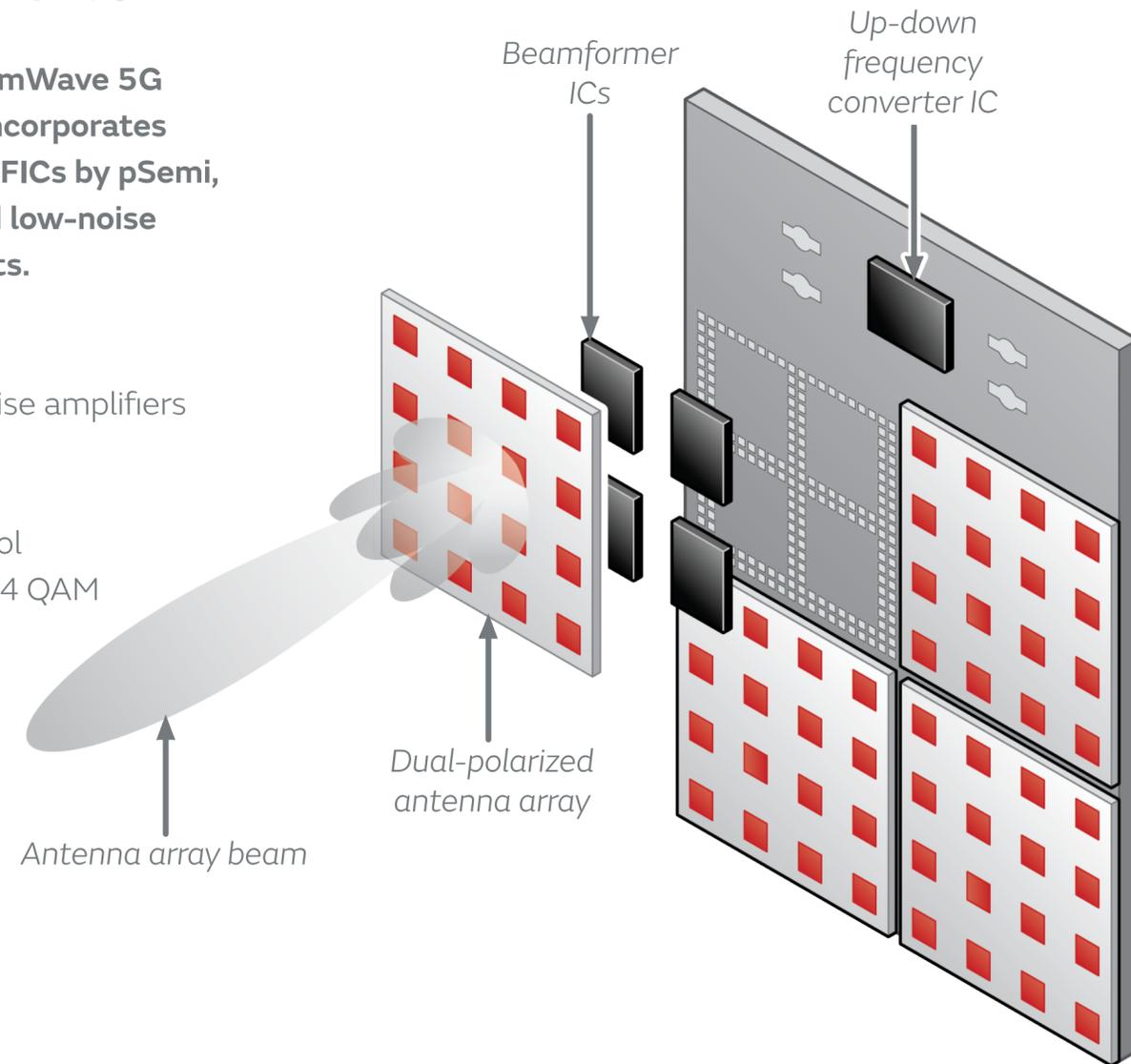
# mmWave modules

## 5G mmWave beamformer IC

pSemi and Murata have co-designed a mmWave 5G antenna-integrated module (AiM) that incorporates multi-channel, beamforming front-end RFICs by pSemi, offering high-efficiency transmitters and low-noise receivers for advanced mmWave products.

### Key features

- Integrated power amplifiers and low-noise amplifiers
- Supports four dual-polarity antennas
- 50Ω impedance at RF ports
- 6-bit phase and 6-bit attenuation control
- Linear POUT +11 dBm with CP-OFDM 64 QAM
- Fast beam switching
- On-chip memory for 512 beams
- Independent control via SPI of all paths



Part Number	Description	Frequency	Tx			Rx		
			Gain	OP1dB	Power consumption	Gain	IIP3	Power consumption
PE188100	n257 8 ch beamformer	24.25 – 27.5 GHz	27 dBm	21 dBm	295mW /CH	27 dB	-17 dBm	45 mW /CH
PE188200	n258 8 ch beamformer	26.5 – 29.5 GHz						

## Applications

- RRU/AAU mmWave

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### mmWave modules

- 4x4 array antenna module
- mmWave Beamformer IC
- ▲ mmWave up-down converter IC
- mmWave SPDT switch

[Find out more](#)

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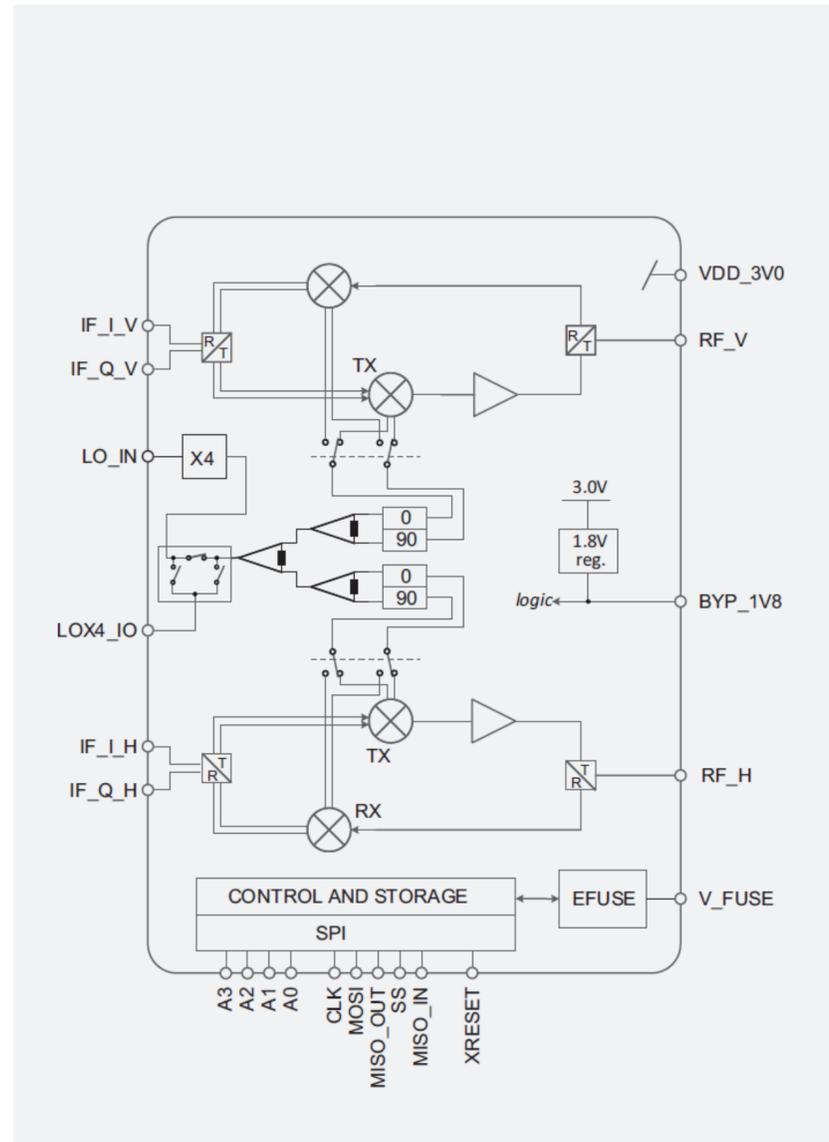
# mmWave modules

## 5G mmWave up-down converter IC

pSemi and Murata have co-designed a mmWave 5G antenna-integrated module (AiM) that incorporates multi-channel, beamforming front-end and up-down converter RFICs by pSemi, offering high-efficiency transmitters and low-noise receivers for advanced mmWave products.

### Key features

- Compatible with PE188100/200 8-channel beamforming front end
- Fast TDD switching in <400 ns
- Separate V and H channels use a single X4 LO multiplier
- Image reject up- and down-converters with I/Q balance adjustment
- IF I/Q phase and amplitude adjustment
- LO I/Q phase adjustment
- TX OP1dB = +15 dBm, RX IIP3 = +8 dBm, RX NF = 5.0 dB
- Independent control via SPI of all paths



Part Number	Description	Frequency	Up Conversion			Down Conversion		
			Gain	Linear Pout	Power consumption	Gain	IIP3	Power consumption
PE128300	n257 & n258 up-down converter	24.25 – 29.5 GHz	17 dBm	7 dBm	1.5 W	4 dB	8 dBm	1.1 Wy

## Applications

- RRU/AAU mmWave

For some customers, pSemi products have a different sales channel from Murata Sales. Please confirm with [sales@psemi.com](mailto:sales@psemi.com)

### mmWave modules

- 4x4 array antenna module
- mmWave Beamformer IC
- mmWave up-down converter IC
- mmWave SPDT switch

Find out more >

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### Overview

- 4G-5G progression
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- Beamforming

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- Environmental
- Installation/maintenance

### Component solutions

- Construction
- Miniaturization
- Efficiency & reliability

### Applications

- RRU/AAU: sub 6GHz mmWave
- Power amplifier
- BBU/DU/CU
- MEC

### Murata innovation

- RF components
- mmWave modules
- Substrates
- Connectors
- EMI
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- Power inductors
- Power
- Batteries
- Sensors

# mmWave modules

## 5G mmWave SPDT switch

PE42525/PE426525 deliver excellent high frequency RF performance accompanied by high reliability of SOI in a monolithic solution.

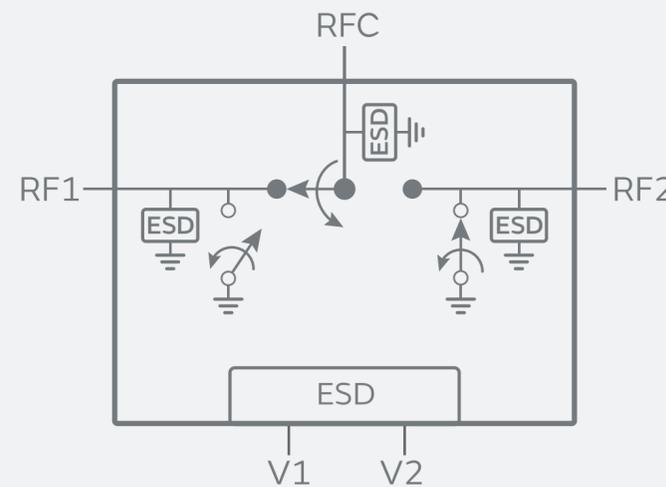
These products also support a wide frequency band range up to 60GHz and deliver low insertion loss, fast switching time and high isolation performance.

### Key features

- Low Insertion Loss
  - 1.7dB @ 45 GHz
  - 2.7dB @ 60 GHz
- Fast switching time of 3 ns
- High isolation
  - 38 dB @ 45 GHz
  - 36 dB @ 60 GHz
- High linearity
  - 48dBm IIP3



RF SOI switches from  
**9-60 GHz**  
at operating temperatures  
from **-55°C to +125°C**



Part Number	Description	Frequency	IIP3	PO.1dB	Insertion loss	Isolation	Switching time	Package
PE42525/PE426525	Wide band SPDT switch	9kHz – 60GHz	48 dBm	35 dBm	1.7 dB	38 dB	3 ns	Flip-chip die

[Find out more](#)

## Applications

- RRU/AAU mmWave

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### mmWave modules

- 4x4 array antenna module
- mmWave Beamformer IC
- ▲ mmWave up-down converter IC
- mmWave SPDT switch

[More about RF switches](#)

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# Substrates

## Metrocirc

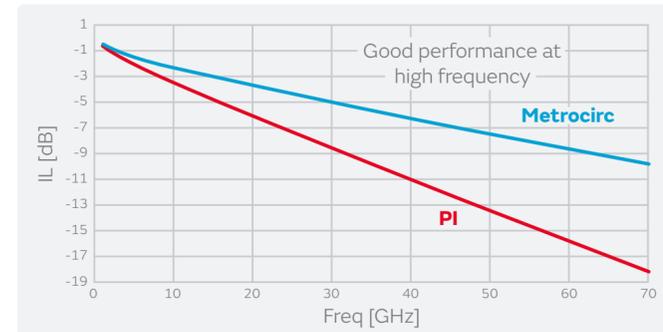
**MetroCirc™ is a thinner multilayer resin substrate comprising LCP (liquid crystal polymer) sheets.**

It is characterized by exceptional RF characteristics, low water absorption, and the ability to handle a flexible bending process because it does not require an adhesive layer, and high multiple layers are possible by using Murata's multilayer technology.

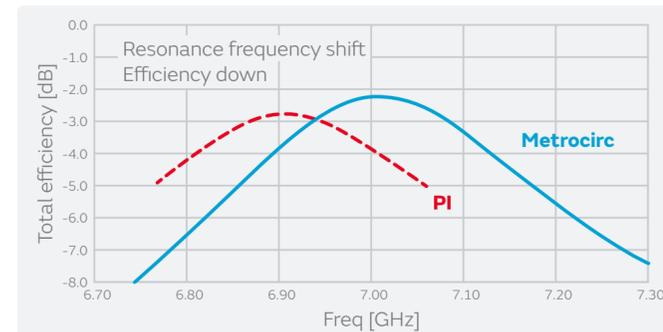
It is possible to design circuits by inserting copper foil sheets between LCP sheets, and these circuits are used as transmission wires, coils, and other functional components in base stations, contributing to smaller, thinner, and higher performance devices.

MetroCirc™ is ideal for use in substrates for millimeter wave modules, millimeter wave transmission lines, and other applications that utilize the low transmission loss properties at high frequencies that is a feature of MetroCirc™.

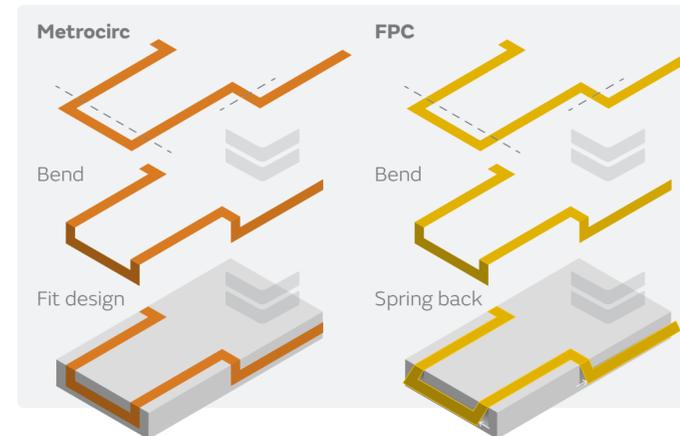
### High frequency transmission loss



### Low water absorbability

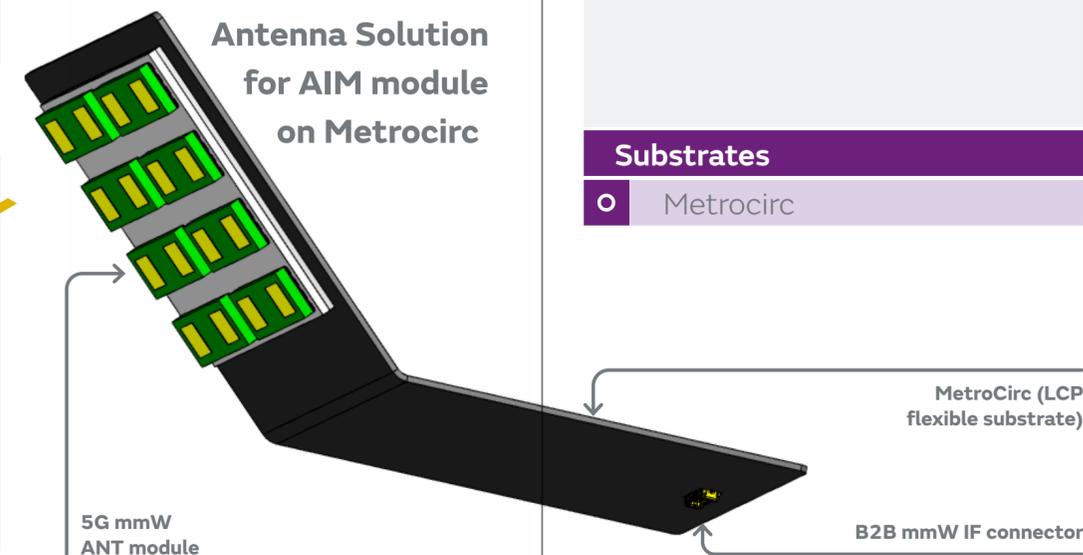


### Pre-formable



*This folded substrate can be used to create 5G mmWave modules that provide wider antenna coverage.*

*This also reduces the number of heat generators.*



## Applications

- RRU/AAU mmWave
- RRU/AAU
- PA

### Substrates

- Metrocirc

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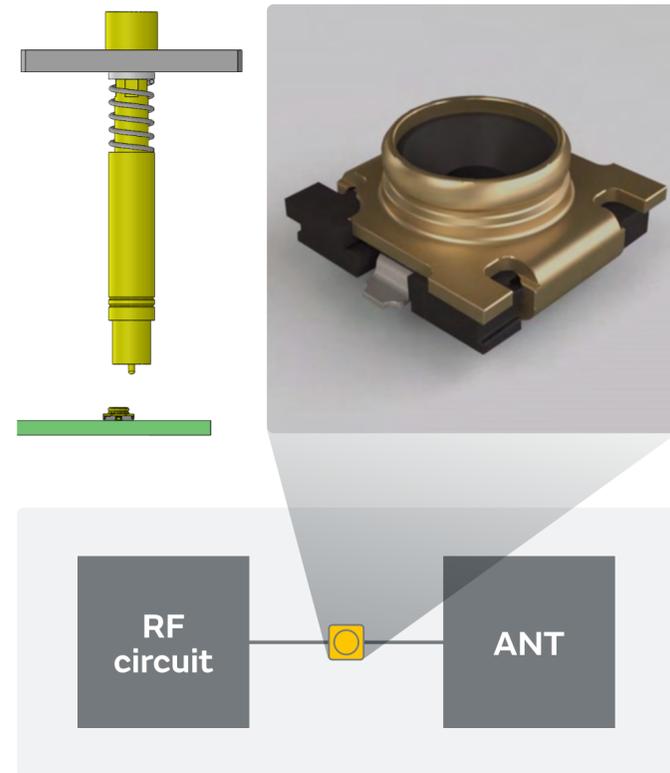
# Connectors

Microwave coaxial switch connectors and test probes

Microwave coaxial switch connectors are very useful for electrical characteristics measurement of microwave circuits in base stations.

The RF circuit and ANT characteristics can be measured by mounting in an RF transmission line.

The built-in mechanical switch separates the RF circuit and ANT circuit, so that the circuit can be measured without any mutual effect using a dedicated probe made by Murata. Except when measuring with probe, internal mechanical switch is connected, so the RF circuit and antenna circuit remain connected.



## Manual probe with cable



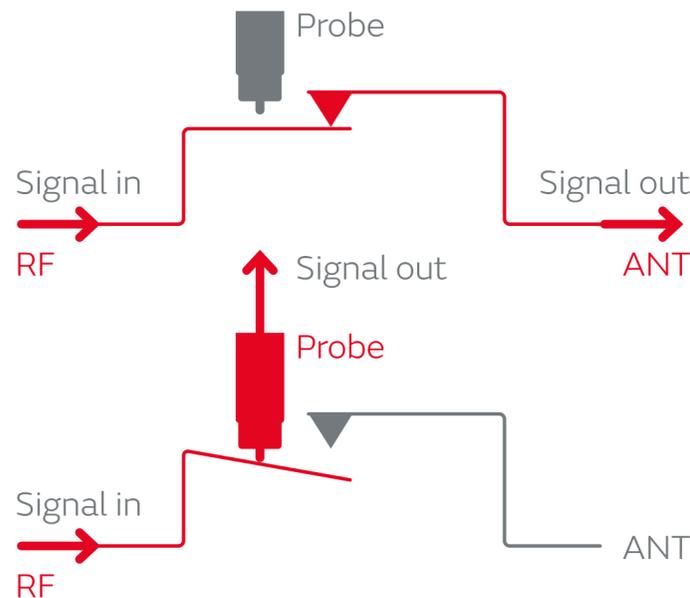
Used for evaluation in the lab, this probe stands by itself after mating is completed, because it has claw at the contact point with connectors.

## Automatic test probe



Used for inspection in mass production process, these probes are built into the measurement fixture, and pressed at connectors.

Murata can advise test fixture design and setting of probes on the measurement fixture.



## Applications

- RRU/AAU mmWave
- RRU/AAU
- PA

### Caution

The product shall not be used in any application which requires especially high reliability for the prevention of such defect as may directly cause damage to the third party's life, body or property. You acknowledge and agree that, if you use our products in such applications, we will not be responsible for any failure to meet such requirements.

### Connectors

- Coax switch connectors

[Coax switches & probes video](#)

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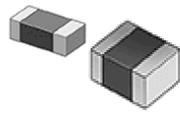
- RRU/AAU: sub 6GHz mmWave
- Power amplifier
- BBU/DU/CU
- MEC

### Murata innovation

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# EMI filters

## Ferrite beads

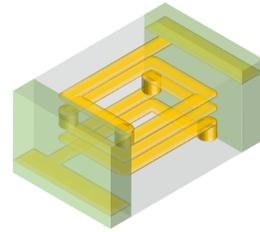


### Key features

- Small size
- High performance
- Wide temperature range
- Extensive product range

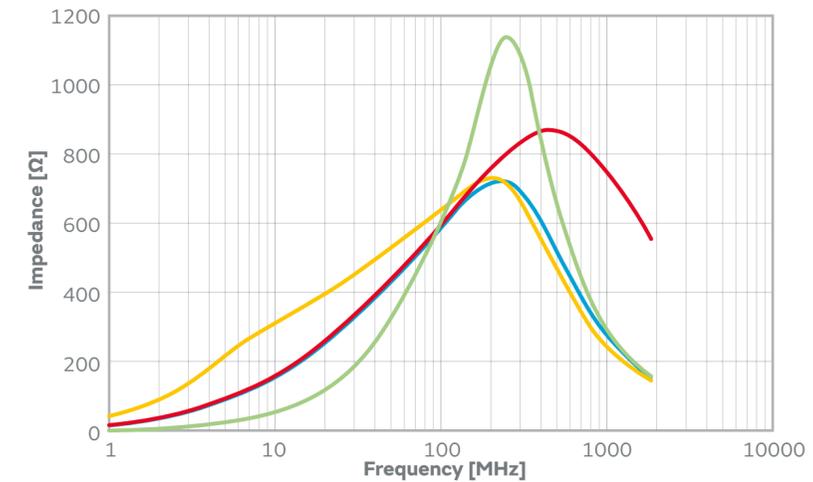
Noise suppression has become an important issue, particularly with regard to electromagnetic interference (EMI) and electromagnetic compatibility (EMC)

Ferrite beads are Inductive EMI suppression filters that are effective from several MHz to several GHz. They can be widely used as general purpose noise suppression components. Inductive EMI filters work as inductors at low frequencies, but impedance caused by resistance increases at high frequencies. When inserted in series into the noise conduction path, this resistance component prevents and absorbs noise conduction.



**Low frequency**  
Dominant factor of impedance is **inductance**

**High frequency**  
Dominant factor of impedance is **resistance**  
Noise energy is changed into heat



— **A type:** For general type (low frequency signals) / BLM18AG601SN1  
 — **P type:** For DC power line  
 — **R type:** For low distortion type (digital interfaces) / BLM18RK601SN1  
 — **B type:** For high speed signals / BLM18BD601SN1  
 — **H type:** For GHz noise suppressions / BLM18HG601SN1

Size (mm)	1608	1005	0603	0402
Size (inch)	0603	0402	0201	01005
<b>Power line Lowest DCR High current</b>	<b>BLM18KG</b> Lowest DCR in 0603 size 6A rated current available	<b>BLM15PX</b> Lowest DCR in 0402 size 3A rated current available	<b>BLM03PX</b> Lowest DCR in 0201 size	<b>BLM02PX</b>
	<b>BLM18SG/PG</b> Other low DCR options	<b>BLM15AX/AG</b> Up to 1000Ω @100MHz AX series: Low DCR version	<b>BLM03AX/AG</b> Up to 1000Ω @100MHz AX series: Low DCR version	<b>BLM02AX</b> Up to 120Ω @100MHz Low DCR
<b>GHz signal Rx sensitivity improvement</b>	<b>BLM18BA BLM18BB BLM18BD</b> Sharpnes of impedance curves: BA>BB>BD Many options for specific GHz frequencies	<b>BLM15BA BLM15BB BLM15BC BLM15BD</b> Sharpnes of impedance curves: BA>BC>BB>BD Many options for specific GHz frequencies	<b>BLM03BB BLM03BC BLM03BD</b> Sharpnes of impedance curves: BC>BB>BD Many options for specific GHz frequencies	<b>BLM02BX BLM02BC BLM02BB</b>
<b>High impedance at high frequency</b>	<b>BLM18EG/HE</b> High Z @ high frequency + low DCR	<b>BLM15EG/EX</b> High Z @ high frequency + low DCR	<b>BLM03EB</b> High Z @ high frequency + low DCR	
	<b>BLM18HG/HD BLM18HB/HK</b> Highest Z @ high frequency	<b>BLM15EG/EX</b> Highest Z @ high frequency	<b>BLM03HG/HD/HB</b> Highest Z @ high frequency Over 2KΩ @1GHz	
	<b>BLM18GG</b> Ultra-high GHz with high Z	<b>BLM15GG/GA</b> Ultra-high GHz with high Z		

A wide range of package sizes and styles is available across a full range of impedance and current values

## Applications

- RRU/AAU
- RRU/AAU mmWave
- BBU/DU/CU
- MEC

### EMI filters

- Ferrite beads

See Murata chip ferrite beads >

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- Efficiency & reliability

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### Murata innovation

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# Capacitors

## High-Q



## High-Q (GQM/GJM series)

### 5G has requirements for

- Reduced base station size
- Reduced heat sinks
- Providing multiple outputs (Tx)
- Higher frequencies



### These requirements result in

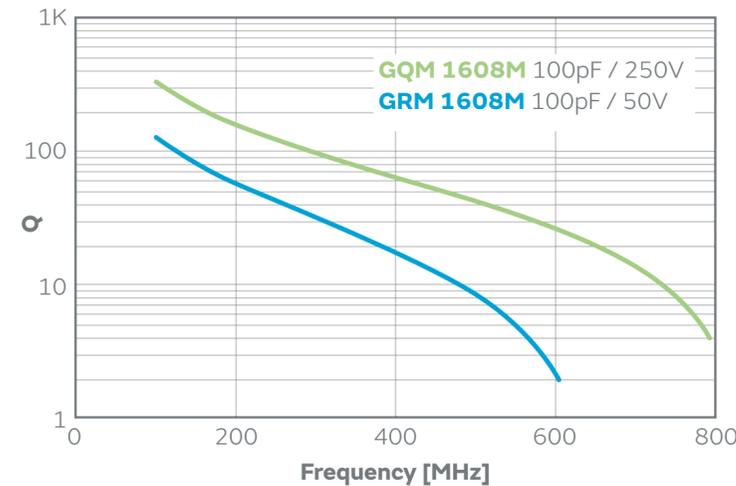
- Increased ambient temperatures
- Increased heat generation of the capacitors
- Reduced space for components

To help meet the demands of 5G applications, Murata offers a range high-Q, high temperature capacitors in small package sizes.

### Key features

- Higher Q value
- High temperature (up to 150°C)
- High voltage (up to 500V)
  - GJM series <=100Vdc
  - GQM series >100Vdc
- Low ESR = high current
- Smaller case size
- Internal Electrodes Cu
- Stable supply (by using internal base metal electrodes)

### Q data



Temperature	Rated voltage [Vdc]	Size code [mm]	Capacitance range [pF]				
			1	10	100	1000	
125°C	100	0603	■	■	■	■	0.2-15pF
	200	1005	■	■	■	■	0.1-33pF
	250	1608-2012	■	■	■	■	0.1-150pF
150°C	100	0603	■	■	■	■	0.2-22pF
	200	0603	■	■	■	■	0.2-22pF
	250	1005	■	■	■	■	0.1-33pF
	250	1608	■	■	■	■	0.1-30pF
	250	2012	■	■	■	■	0.2-82pF
	500	2012	■	■	■	■	0.2-22pF

*Note: The 150°C 100V 0603 0.2-22pF and 150°C 200V 0603 0.2-22pF cells are highlighted with a red box and labeled 'NEW'.*

## Applications

- RRU/AAU mmWave
- RRU/AAU
- PA

### Capacitors

- High-Q MLCC
- Large capacitance MLCC ○○
- ▲ Polymer Aluminum Caps
- Class1 (COG) MLCC
- ◆ Silicon Capacitors
- RUSUB

GQM series >

GJM series >

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# Capacitors

## MLCC

Murata has a range of large capacitance/125°C suitable for applications requiring a high-temperature warranty.

Using our unique technological capabilities, we will continue to extend this range to meet the growing need for higher temperatures.

## Large capacitance + 125°C operation

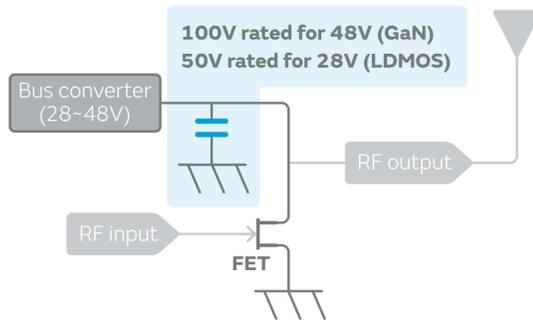
### Technology for realizing high capacity and high reliability

- Thinner dielectric layers
- Increased number of dielectric layers
- Improved efficiency of effective area (increased area)

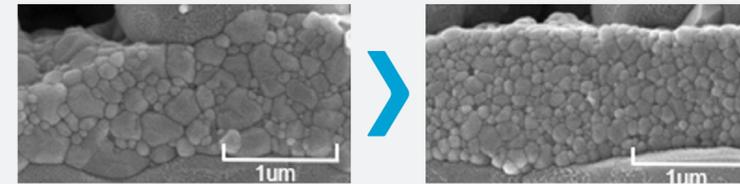
$$C = \frac{\epsilon \times \epsilon_0 \times S_0 \times n}{t}$$

Capacitance formula

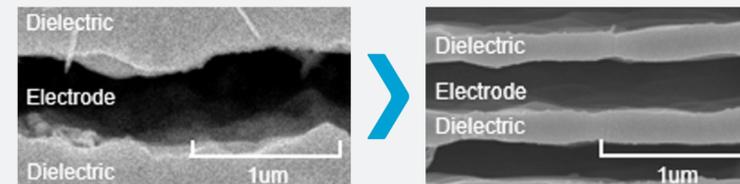
- $\epsilon$  Relative permittivity of dielectric
- $\epsilon_0$  Permittivity of vacuum  $8.854 \times 10^{-12}$  (F/m)
- $S_0$  Effective area per layer
- $n$  Number of dielectric layers
- $t$  Dielectric layer thickness



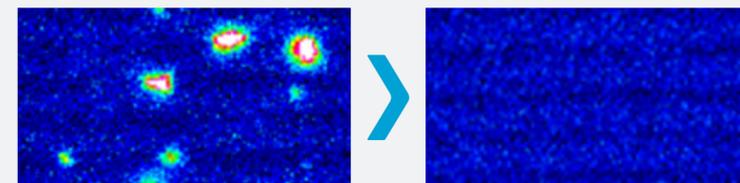
### Fine-grained ceramics



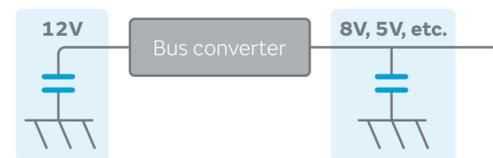
### Thining of electrode and dielectric



### Uniform dispersion



Length [mm]	Width [mm]	Rated Voltage [V]	Capacitance value				
			1µF	2.2µF	4.7µF	10µF	22µF
2	1.25	50					
3.2	1.6						
3.2	2.5						
2	1.25	100					
3.2	1.6						
3.2	2.5						



Size code [mm]	Rated Voltage [V]	Capacitance value					
		1µF	2.2µF	4.7µF	10µF	22µF	47µF
1005-3225	10						
1005-3225	16						
1608-3225	25						

## Applications

- RRU/AAU
- RRU/AAU mmWave
- BBU/DU/CU
- MEC

### Capacitors

- High-Q MLCC
- Large capacitance MLCC
- Polymer Aluminum Caps
- Class1 (COG) MLCC
- Silicon Capacitors
- RUSUB

Base station capacitor selection

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# Capacitors

Large capacitance

By adding polymer Al cap (the ECAS series) to our line of multilayer ceramic capacitor (MLCC) products, we have further broadened the range of options available to customers.

As electronic devices gain ever-more-sophisticated functionality, stricter voltage control is needed for the power lines of the CPU, etc. Maintaining voltage line stability sometimes requires large capacitance. In the past we would have suggested using multiple MLCCs, but now in many cases we can propose combining ECAS series capacitors with MLCCs in order to reduce both the quantity and cost of components.

## Polymer aluminum cap & >100µF MLCC

### Comparison table

Product type	MLCC	Polymer Al capacitor (PAC)
Appearance		
Low ESR	★ ★ ★	★ ★
Long-term reliability	★ ★ ★	★ ★
Temperature characteristics	★ ★	★ ★ ★
DC bias characteristics	★	★ ★ ★
Large capacitance	★ ★	★ ★ ★
High voltage	★ ★ ★	★
Compact & thin	★ ★ ★	★

### Over 100µF capacitor line-up

Rated voltage [V]	Type	L x W [mm]	Capacitance value (µF)			
			100	220	330	470
2.5	MLCC	3.2 x 2.5		■	■	
	PAC	7.3 x 4.3			■	■
4	MLCC	2.0 x 1.25	■			
		3.2 x 1.6	■	■		
6.3	MLCC	3.2 x 2.5		■		
		3.2 x 1.6	■			
	PAC	7.3 x 4.3	■	■	■	

### Applications

- RRU/AAU
- RRU/AAU mmWave
- BBU/DU/CU
- MEC

### Capacitors

- High-Q MLCC
- Large capacitance MLCC ○ ○
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Polymer >

>100µF MLCC >

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# Capacitors

## Polymer Aluminum Capacitor (PAC)



### Key features

- Higher capacitance than MLCC
- No acoustic noise
- Resistant to substrate bending and mechanical stress
- Capacitance stability against DC-bias, temperature
- Open mode failure

Rated voltage [Vdc]	Capacitance value (μF)									
	15	22	33	47	68	100	150	220	330	470
2 0D								D4 9		
2.5 0E						ESR (mΩ)	105°C	125°C	D4 (*1)	D6 (*2)
						(*1)	6	9		
						(*2)	4.5	6		
6.3 0J						D4 15	D4 15	D4 10	D6 9	
10 1A					D3 40	D4 40	D6 10			
16 1C				D3 40	D4 40	D6 12				
20 1D				D4 40						MP
25 1E	D3 40	D3 40	D4 40				D4 Case Size 6 ESR (mΩ)		105°C 125°C	105°C only

### Case dimensions: mm (inch)

Size code	L	W	T (max.)
D3			1.5 (0.059)
D4	7.3 ± 0.3 (0.287 ± 0.012)	4.3 ± 0.2 (0.169 ± 0.008)	2.0 (0.079)
D6			3.1 (0.122)

## Applications

- RRU/AAU
- RRU/AAU mmWave
- BBU/DU/CU
- MEC

### Capacitors

- High-Q MLCC
- Large capacitance MLCC ○ ○
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Base station capacitor selection >

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# Capacitors

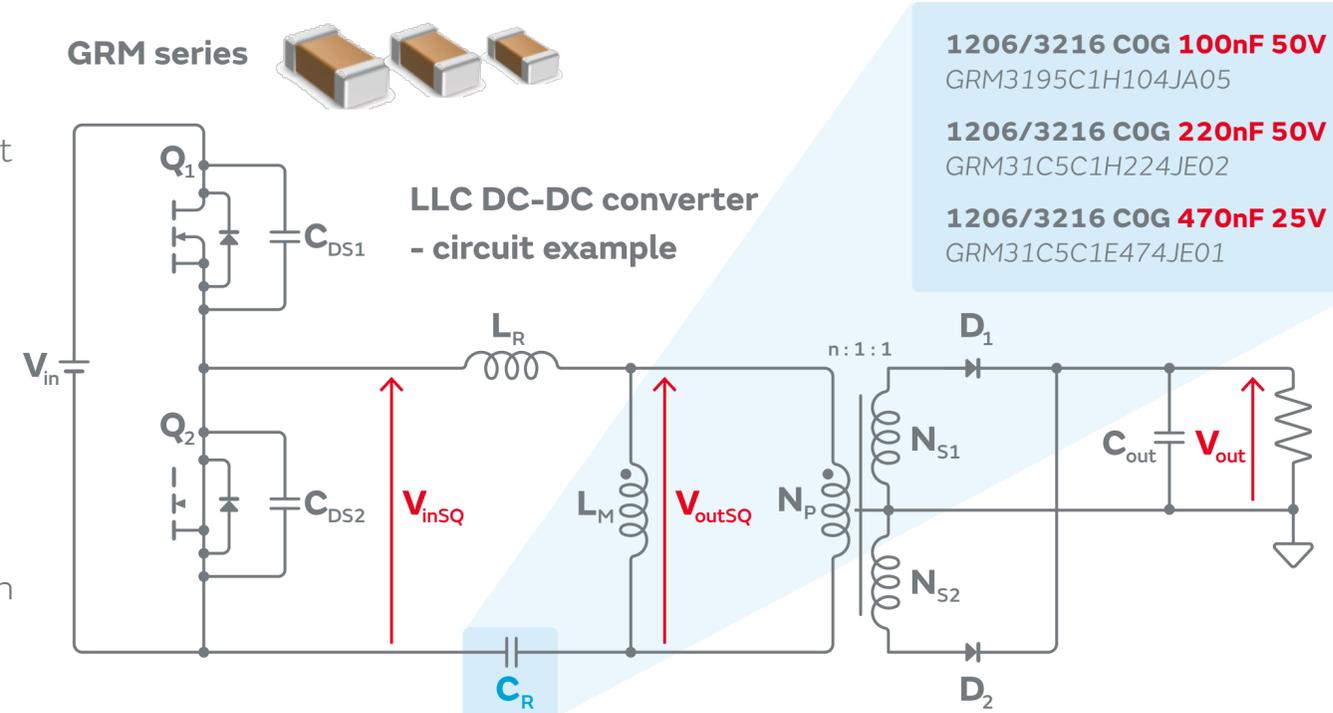
## MLCC

Since base station antennas consume considerable power, the key to power design is how to design a highly efficient power supply. Among them, the power source of LLC resonance system attracts attention.

### Key features

- No change in capacitance due to temperature or voltage
- Small case size
- large capacitance allows for reduction in the number of MLCCs

## Class1 (COG)/large capacitance



### For other applications....

Loop filter for PLL frequency synthesizer IC

To optimize the PLL loop bandwidth, the optimum design of the loop filter is required, but the loop band is changed by the capacitance change of the loop filter capacitor.

### Applications

- RRU
- RRU mmWave
- BBU/DU/CU
- MEC

### Capacitors

- High-Q MLCC
- Large capacitance MLCC ○ ○
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- Class1 (COG) MLCC
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Base station capacitor selection >

Length [mm]	Width [mm]	Rated voltage [V]	Capacitance range [pF]		
			1000pF	0.01μF	0.1μF
3.2	1.6	25			NEW
1.6	0.8	50	■	■	
2	1.25			■	■
3.2	1.6	630	■	■	NEW
2	1.25			■	■
3.2	1.6	1K	■	■	NEW
	2.5			■	■

## Contents

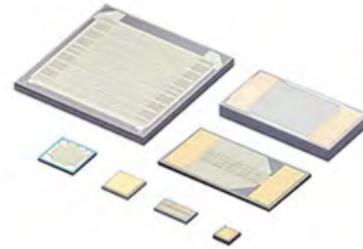
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  - EMI
  - Capacitors
  - Power inductors
  - Power
  - Batteries
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# Capacitors

## Silicon capacitors (Si-Cap)

### Key features

- Small size
- High voltage - up to 450V
- Operation up to 250°C
- High frequency - up to 110GHz



To realise smaller package sizes and higher capacitance, Murata Si-Caps feature deep trenches and tripod pillars to provide 100 times more electrode surface area than a planar structure. In addition, a temperature compensating material is used as the dielectric of the Si-Cap, maintaining capacitance even in actual usage conditions, enabling maximum capacitance density in small and vertical capacitors.

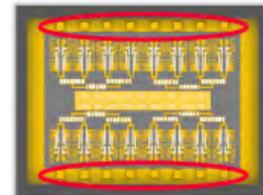


3D structure proves 100x more electrode surface area

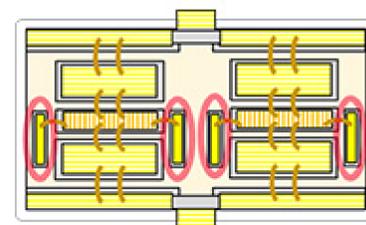
## Application for base station RFPA

### Signal-frequency broadband expansion and issues associated with 5G high-speed large capacity communications

When a broadband signal is output at a high power, an Inter Modulation Distortion (IMD) is generated in the Power Amplifier Module (PAM), reducing signal integrity. IMD frequency is a proportional function of the bandwidth, and the affected frequencies in Second-Order IMD are up to 400 MHz with Sub 6 GHz or several GHz with mmWave.



MMIC

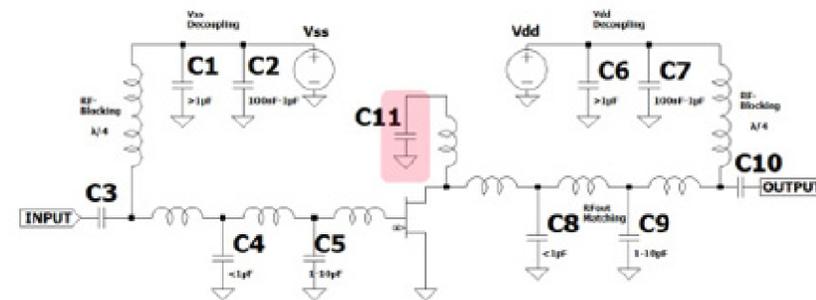


Installation image

### The Si-Cap solution

The low frequency band of IMD can be removed using a bias circuit connected to an FET drain. However, the high frequency band of IMD is difficult to remove outside of the PAM due to the influence of the microstrip line for RF-Blocking. In the method described here, the silicon capacitor (Si-Cap) is installed directly onto the metal substrates of the PAM, and the FET and Si-Cap are connected by a wire.

This method uses a small Si-Cap that maintains a high capacity under actual usage conditions, enabling the removal of the IMD in the limited space inside the PAM.



PAM circuit with Si-Cap solution

## Applications

- PA

### Capacitors

- High-Q MLCC
- Large capacitance MLCC
- ▲ Polymer Aluminum Caps
- Class1 (COG) MLCC
- ◆ Silicon Capacitors
- RUSUB

See Murata silicon capacitors >

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- Installation/maintenance

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- Miniaturization
- Efficiency & reliability

### Applications

- RRU/AAU: sub 6GHz mmWave
- Power amplifier
- BBU/DU/CU
- MEC

### Murata innovation

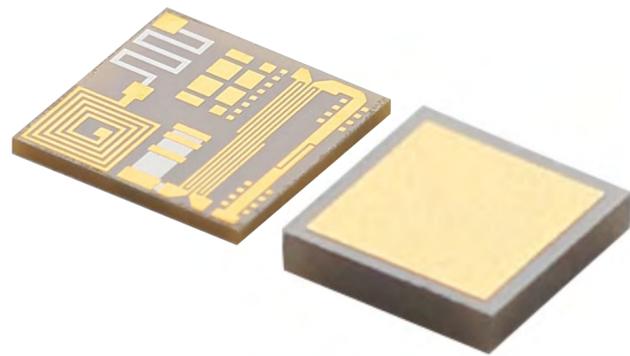
- RF components
- mmWave modules
- Substrates
- Connectors
- EMI
- Capacitors
- Power inductors
- Power
- Batteries
- Sensors

# Capacitors

Thin film circuit substrates (RUSUB)

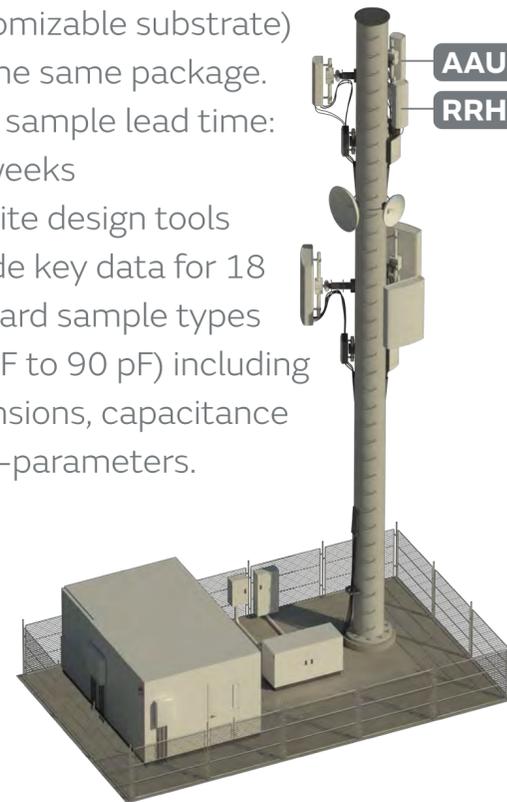
## Key features

- High Q and high dielectric constant materials.
- Gold electrodes for wire bonding with gold wire.
- Customized CR composite products with high dielectric Single Layer Capacitor (SLC) and thin film resistor.

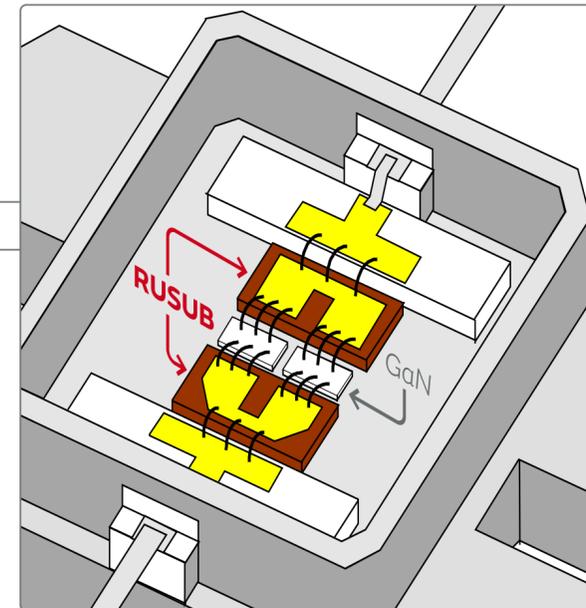


## Internal matching power GaN/GaAs FET for base stations

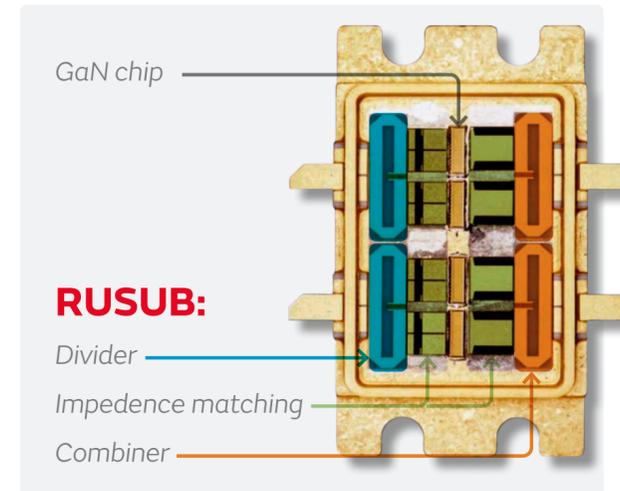
- Possible to mount both GaN chip and RUSUB (customizable substrate) into the same package.
- Short sample lead time: 2-4 weeks
- Website design tools provide key data for 18 standard sample types (1.0 pF to 90 pF) including dimensions, capacitance and S-parameters.



For base station



GHz high power FET



## Under improvement for GaN FET

- **High current:** Increasing bonding wire diameter from 25µm to 50µm.
- **High DC rated voltage:** Increasing rated DC voltage from 100V to 200V.
- **High Q factor:** Increasing Q factor from 100 (@1MHz) to 1000 (@1MHz).

## Applications

- PA

### Capacitors

- High-Q MLCC
- Large capacitance MLCC ○ ○
- ▲ Polymer Aluminum Caps
- Class1 (COG) MLCC
- ◆ Silicon Capacitors
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### Murata innovation

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# Power inductors

Metal alloy, chip-coil & molded metal inductors

## Key features

- Small size
- High performance
- Wide temperature range
- Extensive product range

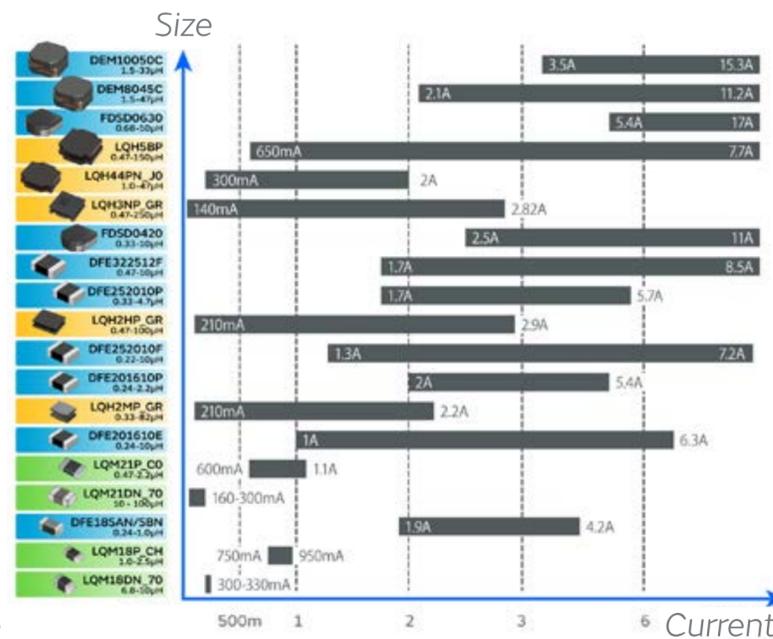
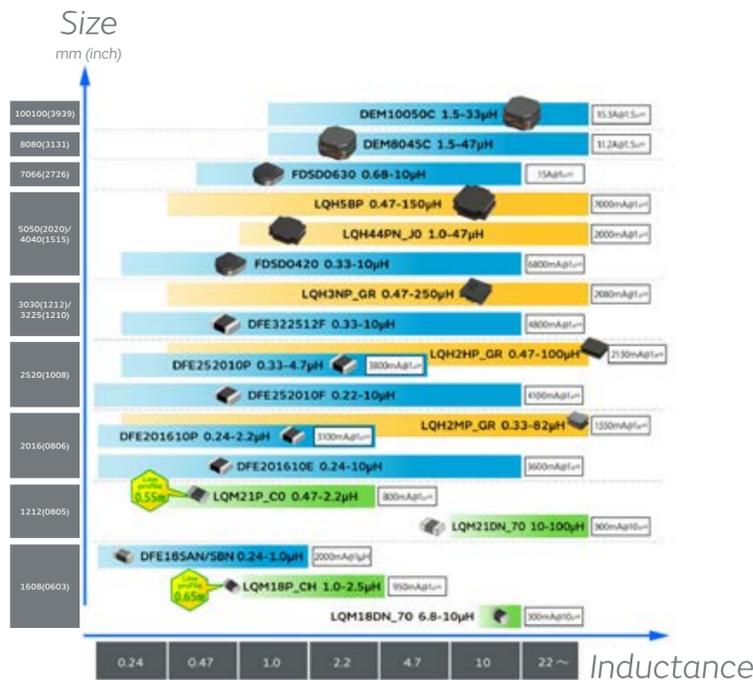
Murata's inductors are optimally designed (making full use of multiple construction techniques such as multilayer, film, and wire wound) to meet the requirements of the application, while also achieving size reductions and increased performance.

A wide range of package sizes and styles is available across a full range of inductance and current values



Inductors for power supply circuits pose challenges that require improving multiple aspects of the product simultaneously. These aspects include high-current capability, DC superimposition

characteristics, and miniaturization. To better meet these challenges, Murata has prepared a lineup of inductors that incorporate metal alloy materials in addition to the ferrite materials used up to now.



## Applications

- BBU/DU/CU
- RRU/AAU mmWave
- RRU/AAU
- MEC

## Power inductors

- Metal alloy, chip-coil & molded metal

[See all Murata inductors](#)

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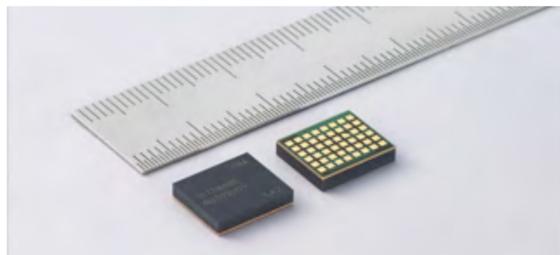
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# Power

## UltraBK™

### Features

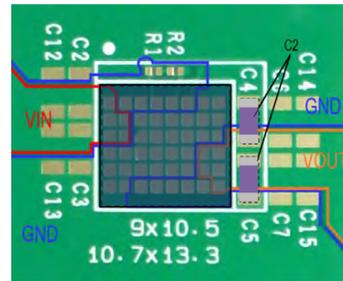
- Ultra-high efficiency
- Low profile - 2.1mm
- Smallest overall solution footprint
- 0.5-2MHz switching frequency
- I<sup>2</sup>C programmable with telemetry
- 5x lower input ripple
- Fast transient performance
- Low conducted & radiated EMI



## World's highest efficiency & smallest PSiP

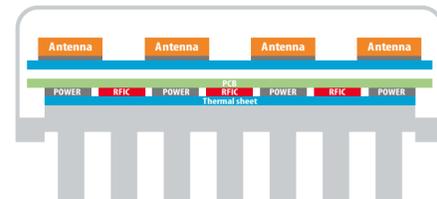
### 143mm<sup>2</sup> solution size

(package size: 9 x 10.5 x 2.1 mm)  
This converter enables a power solution in only 143mm<sup>2</sup> including two external output capacitors only (no external input capacitors required).



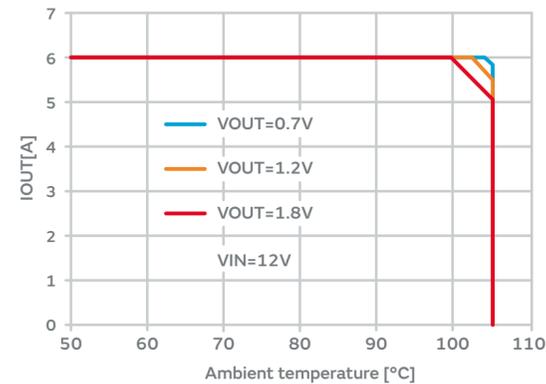
Only 2 external output capacitors required

### Low profile



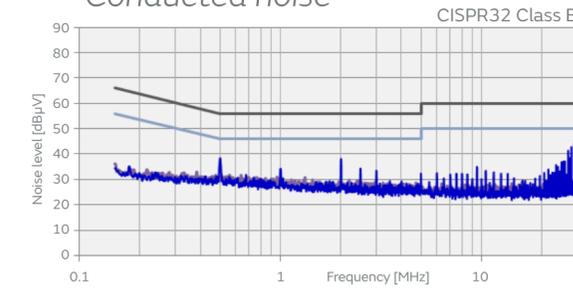
Low profile construction enables better performance at higher temperatures

### Excellent thermal derating

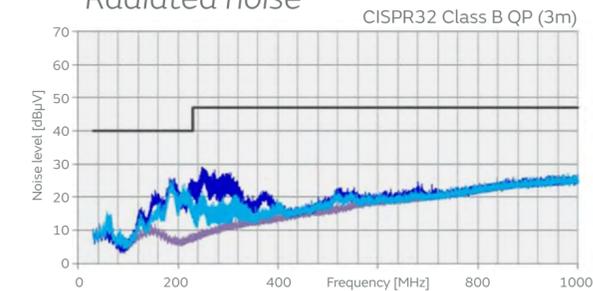


### Low EMI

#### Conducted noise



#### Radiated noise



Measurement conditions: Vin: 12V, Vout: 1V, Iout: 6A, Cin:10uFx2 (MLCC), Cout:100uFx2 (MLCC)

### Applications

- BBU/DU/CU
- RRU/AAU mmWave
- RRU/AAU
- MEC

#### Power

- UltraBK™ PoL DC-DC
- UltraCP™, FlexiCP™ DC-DC
- ▲ Isolated high power DC-DC
- Front-end power
- ◆ Power shelf

Part Number	Input voltage V	Output voltage V	I <sub>o</sub> max A	f <sub>SW</sub> MHz	Telemetry	Peak efficiency 12V <sub>IN</sub> 1V <sub>OUT</sub>	Solution size mm <sup>2</sup>	MP Rel	Package size W x L x H mm
MYTNA1R86RELA2RA MYTNC1R86RELA2RA	6.0-14.4V 7.0-14.4V 9.6-14.4V	0.7-1V 0.7-1.35V 0.7- 1.8V	6	1	N/A VI/Io/Vo/Temp	87%	143	Available	9 x 10.5 x 2.1 LGA
MYTNA1R84RELA2RA MYTNC1R84RELA2RA	6.0-14.4V 7.0-14.4V 9.6-14.4V	0.7-1V 0.7-1.35V 0.7- 1.8V	4	1	N/A VI/Io/Vo/Temp	87.3%	143	Available	9 x 10.5 x 2.1 LGA
MYT0424	9.6-14.4V	0.7- 1.8V	4x4	1	VI/Io/Vo/Temp	88%	TBD	Q1.22	12.1 x 11.6 x 2.1 LGA

Find out more

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### Murata innovation

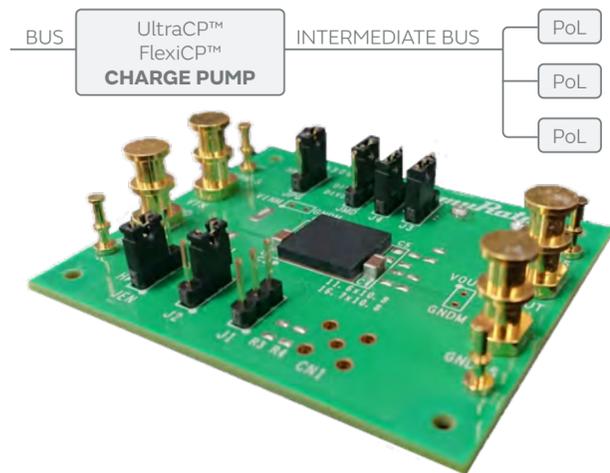
- RF components
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- Sensors

# Power

## UltraCP™ FlexiCP™

### Features

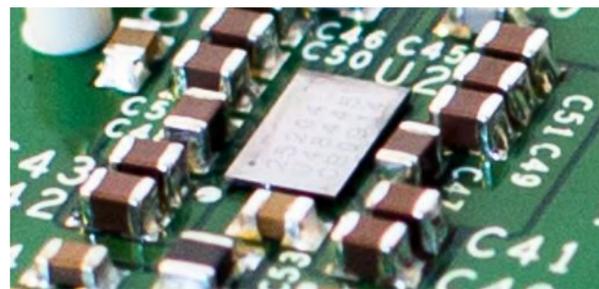
- Virtually lossless - 98% DC transformer
- Phase interleaved, soft switching architecture
- Integer ratio (2,3 & 4) step-down
- Parallel capable with synchronization
- Available in IC or PSiP form



## Ultra-high efficiency, integrated capacitor divider for intermediate bus conversion

The FlexiCP™ PE252xx series of ultra-high efficiency, capacitor divider products is based on Murata's proprietary adiabatic - or lossless - charge pump technology.

The technology is ideally suited to providing 'lossless' step-down voltage conversion from 48V (PE25204) or 12V (PE25200) intermediate bus



systems to support downstream Point-of-Load converters to enable highest system level efficiency.

The ICs are based on an interleaved charge pump control architecture with integrated FETs capable of delivering up to 72W of power. The devices can be connected in parallel for higher power system requirements and synchronized to eliminate noise issues. The divider products are available in IC form and in high density PSiP module form - UltraCP™ (MYCxx series) - for ease of use and placement in space constrained applications.

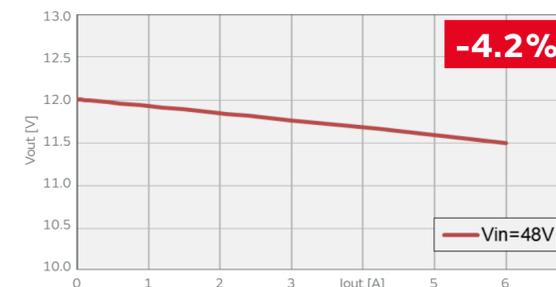
Part Number	Input voltage V	Output voltage V	Io max A	Efficiency	MP Rel	Package size W x L x H mm
MYC0300	8.2-15V (3s cell or 12VBUS)	Vin/3	10	96.5% at Peak, 96% at FL (12Vin/4Vo)	Q3,21	11.8 x 10.8 x <b>2.1 LGA</b>
	5.5-10V	Vin/2				
MYC0409	20-60V (48VBUS)	Vin/4	6	96.5% at Peak, 95% at FL (48Vin/12Vo)	Q3,21	11.5 x 9.5 x <b>2.1 LGA</b>
PE25200	8.2-15V	Vin/3	10	97% at Peak, 96.5% at FL (12Vin/4Vo)	Q3,21	4.45 x 6.85 x <b>0.492 BGA</b>
	5.5-10V	Vin/2				
PE25204	18-60V	Vin/4	6	97.5% at Peak, 97% at FL (48Vin/12Vo)	Available	3.6 x 5.8 x <b>0.492 BGA</b>
	18-45.4V	Vin/3				

[Find out more](#)

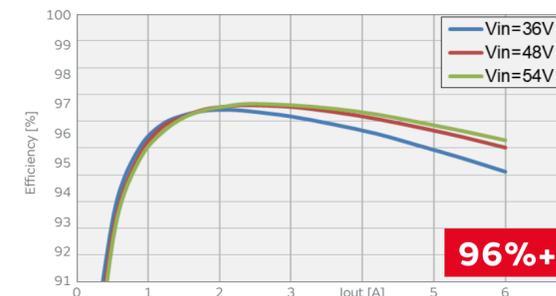
[Find out more](#)

### MYC0409 evaluation data

#### Load regulation



#### Efficiency



## Applications

- RRU/AAU
- RRU/AAU mmWave
- BBU/DU/CU

### Power

- UltraBK™ PoL DC-DC
- UltraCP™, FlexiCP™ DC-DC
- ▲ Isolated high power DC-DC
- Front-end power
- ◆ Power shelf

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### Murata innovation

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# Power

## Isolated high power DC-DC converters



### High reliability with high power density

- Industry Standard DOSA PMBus compliant
  - DSE - DOSA, W / PMBus, sense & trim
  - DAE - DOSA, W / sense & trim
  - DCE - DOSA 5 Pin IBC
- 2:1 Input voltage range: 36-75V
- High efficiency: typ. 95.5%
- 2250Vdc I/O isolation, with basic insulation
- Optional load sharing of two or more modules
- Configurable soft start/stop
- Precision delay and ramp-up
- Voltage sequencing and margining
- Voltage/current/temperature monitoring
- Wide output voltage trim range
- Telecom and wireless applications



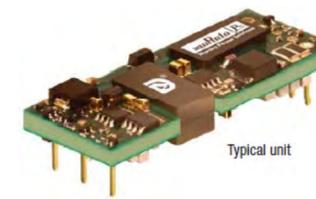
### DSE 400W Eighth Brick

- Single outputs: 12V/33A
- With baseplate



### UWS 54W Sixteenth Brick

- Single outputs:
  - 3.3V/15A, 5V/10A,
  - 12V/4.5A, 15V/3.3A, 24V/2A
- Open frame, light weight



### UWE 120W Eighth Brick

- Single outputs:
  - 5V/24A, 12V/24A,
  - 15V/8A, 24V/5A
- Optional baseplate



### DBE 300W Eighth Brick

- Single outputs:
  - 12V/25A, 5V/40A, 3.3V/40A
- Optional baseplate



### DSQ 600W Quarter Brick

- Single outputs: 12V/50A
- With baseplate



### DBQ 420W Quarter Brick

- Single outputs:
  - 12V/35A, 5V/60A, 3.3V/60A
- Optional baseplate

- RRU
- RRU mmWave
- BBU/DU/CU
- MEC

## Applications

- RRU/AAU
- RRU/AAU mmWave
- BBU/DU/CU
- MEC

Part Number	Package	Output power W	Input voltage		Output voltage V typ.	Output current A	Efficiency % typ.	Dimensions (mm)			Find out more
	Brick-type		V Range	V typ.				V typ.	W	L	
<b>DBE series</b>	Eighth	300	36-75	48	3.3, 5, 12	40, 40, 25	95.5	58.4	22.9	13.2	Find out more
<b>DSE series</b>	Eighth	400	36-75	48	12	33	95.5	58.4	22.9	14.0	Find out more
<b>DBQ series</b>	Quarter	420	36-75	48	3.3, 5, 12	60, 60, 35	95.5	58.4	36.8	13.2	Find out more
<b>DSQ series</b>	Quarter	600	36-75	48	12	50	95.5	58.4	36.8	13.2	Find out more
<b>UWS series</b>	Sixteenth	54	9-36 18-75	24 48	3.3, 5, 12, 15, 24	15, 10, 4.5, 3.3, 2	91	33	22.9	9.1	Find out more
<b>UWE series</b>	Eighth	120	9-36 18-75	12 48	5, 12, 15, 24	20, 24, 8, 5	92	58.4	22.9	13.2	Find out more

Power	
○	UltraBK™ PoL DC-DC
●	UltraCP™, FlexiCP™ DC-DC
▲	Isolated high power DC-DC
■	Front-end power
◆	Power shelf

Search isolated DC-DCs >

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# Power

## Front-end power supplies

### High efficiency

- 15 Titanium efficiency designs
- 800W -2200W
- Industry standard form factors (54mm, 74mm, 86mm)



### D1U54 Series – 2kW AC-DC

- **Input** 180 to 264Vac
- **Output** 12Vdc @ 166A  
12Vdc @ 233A  
(1.4x Peak, 100ms)
- **Standby** 12Vdc/3A
- **Power** 2000W
- **Efficiency** Platinum & Titanium
- **Ride through** 10ms (11ms at 75% load)
- **Cooling** Variable speed
- **Redundant** N+1, OR-ing FETs
- **Operating temp** 0°C to 50°C
- **Density** 46.8W/in<sup>3</sup>
- **Mechanical** 321.5mm(L) x 54.5mm(W) x 40.0mm(H)
- **Other** PMBus Interface

### High power density

- Up to 78W/in<sup>3</sup>
- Common CRPS formfactor
- 2,600W reached the highest density & efficiency in the industry



### 2600W CRPS-185 AC-DC

- **Input** 180 to 264Vac
- **Output** 12Vdc @ 166A  
12Vdc @ 233A  
(1.4x Peak, 100ms)
- **Power** 2600W
- **Efficiency** Titanium
- **Redundant** N+1, OR-ing FETs
- **Density** 78W/in<sup>3</sup>
- **Mechanical** 74mmX185mmX1U
- **Other** PMBus Interface

### Modular and slim

- Compatible DC input (40-72Vdc) variants in same form factor as AC (90-264V)
- Configurable solutions to 30KW
- Multi input AC (90-277Vac or 380Vdc)



### D1U54T Short & Slim Series – 1200W AC-DC Titanium

- **Input** 180 to 264Vac
- **Output** 12Vdc
- **Standby** 12Vdc
- **Power** 1200W
- **Efficiency** Titanium
- **Ride through** 20ms (at 50% load)
- **Cooling** Variable speed, exits at latch
- **Redundant** N+1, OR-ing FETs
- **Operating temp** 0°C to 50°C
- **Density** 39W/in<sup>3</sup>
- **Mechanical** 228.6mm(L) x 54.5mm(W) x 40.0mm(H)
- **Other** PMBus Interface

## Applications

- BBU/DU/CU
- MEC

Power	
○	UltraBK™ PoL DC-DC
●	UltraCP™, FlexiCP™ DC-DC
▲	Isolated high power DC-DC
■	Front-end power
◆	Power shelf

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### Murata innovation

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# Power

## Power shelf - Open Compute

### Features

- Up to 15kW/16kW N+1 output power @ 12Vout
- Up to 18kW N+1 output power @ 54Vout
- 12.3V or 54V main output
- 12.2V AUX output
- PSU conversion efficiency higher than 96% at 50% of load (80 PLUS Titanium class)
- Available input configurations – Single phase AC, 3-Phase AC; HVDC

### Components

- 12V and 54Vout, 21" 10U Power Shelf
- 19"/21" 2RU Power Shelf
- 54V, 3.6kW Titanium Efficiency Power Supply 12V, 3kW - 3.2kW Titanium Efficiency Power Supplies
- ATS (Automated Transfer Switch) Modules
- RMU (Remote Management Unit)
- Battery Backup Solution



### 2RU Power Shelf

The MWOCES-19x Series of 19" (convertible to 21") 2RU power shelves accommodate up to six 3kW PSUs and two ATS modules. Each shelf provides up to 15kW total output power, configured for N+1 redundancy.

Part Number	Height	Input configuration	Output power(W)	AC Outlets	Support BBU	Busbar connect	Applicable PSU	
MWOCES-192-A	2U	3phase Delta	15kW (N+1)	6	Yes	Kit	MWOC74-3000-A-RM	<a href="#">Find out more</a>
MWOCES-211-B	10U	3phase Wye	15kW (N+1)	2	No	Direct	MWOC74-3000-A-RM	<a href="#">Find out more</a>
MWOCES-211-F	10U	3phase Wye	15kW (N+1)	2	No	Direct	MWOC74-3000-A-RM	<a href="#">Find out more</a>
MWOCES-211-G	10U	3phase Wye	15kW (N+1)	2	Yes	Kit	MWOC74-3000-A-RM	<a href="#">Find out more</a>
MWDCES-191-C	1U	3phase Wye/Delta, Single phase	12kW (N+1)	2	Yes	Kit	MWOC74-3000-A-RM	<a href="#">Find out more</a>
MWDCES-191-D	1U	HVDC	12kW (N+1)	0	Yes	Kit	MWOC74-3000-A-RM	<a href="#">Find out more</a>

## Applications

- Virtualized BBU/DU/CU
- MEC

Power	
○	UltraBK™ PoL DC-DC
●	UltraCP™, FlexiCP™ DC-DC
▲	Isolated high power DC-DC
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# Batteries

## Battery shelf

### Features (shelf)

- Fits into the 21" OCP open rack standard
- Up to 16kW total power per shelf (4 BBUs)
- Battery Shelf (600×537×87 mm)
- Four battery slots; each BBU provides 12Vdc, 4kW (max.)
- One battery control unit for management of BBUs
- Communicates with Murata Power Shelf (see page 38)
- Three battery shelves can be connected in parallel

### Features (BBU)

- 4kW maximum output power
- 12V input and output voltage
- 120 seconds hold up time
- Adjustable charging power
- Active current sharing on 12V output
- ORing FET isolation
- Hot swap available
- Overvoltage, overcurrent, over temperature protection and reporting

### Murata offers 21" OCP and EIA 19" rack mountable battery backup solutions to support high reliability architectures.

We utilize Murata's best in class Lithium Ion battery cell technology for our BBU (Battery Backup Unit). With a compact form factor, each BBU is capable of supplying 4kW for up to two minutes. The 21" OCP Battery Backup Shelf (BBS) has 4 slots for BBUs and can supply up to 16kW for two minutes in the event of an AC power loss.

**Murata's battery backup solution is lighter and smaller than traditional lead acid batteries, improving your business in terms of maintenance, OPEX and total cost of ownership.**

[Find out more](#)

## Applications

- Virtualized BBU/DU/CU
- MEC

### Batteries

Battery shelf

[See all Murata batteries](#)



The BCU (Battery Control Unit) in the shelf communicates with each BBU and the power shelf to implement intelligent power system control via our Remote Management Unit (RMU).

## Contents

### Overview

- 4G-5G progression
- Massive MIMO
- Beamforming

### Challenges

- Thermal
- Environmental
- Installation/maintenance

### Component solutions

- Construction
- Miniaturization
- Efficiency & reliability

### Applications

- RRU/AAU: sub 6GHz mmWave
- Power amplifier
- BBU/DU/CU
- MEC

### Murata innovation

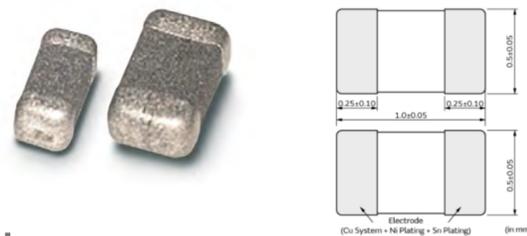
- RF components
- mmWave modules
- Substrates
- Connectors
- EMI
- Capacitors
- Power inductors
- Power
- Batteries
- Sensors

# Sensors

## SMD thermistor

### Key features

- SMD type (reflow OK)
- 10kΩ, 47kΩ, 100kΩ resistance
- 1005mm (0402inch) or 1608mm (0603inch)
- -40°C to 125°C/150°C operating temperature



### Use case

- Temperature sensing and compensation in 5G antenna systems
- Alarm
- Fan start/stop
- Over-temperature cutout

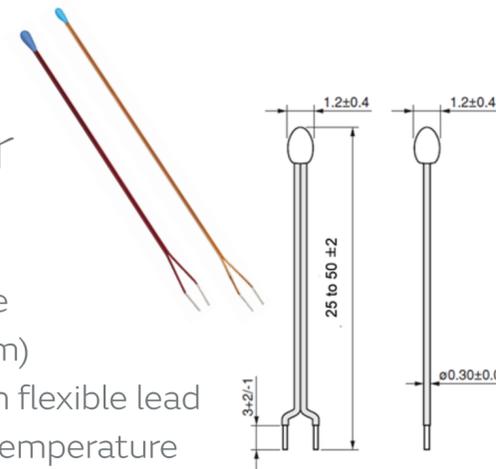
Part Number	Resistance & B-Constant					Size		Package	Find out more
	Resistance (25°C)	10kΩ	47kΩ	100kΩ					
NCU15 series	Resistance (25°C)	10kΩ	47kΩ	100kΩ	1.0x0.5mm	0.4x0.2inch	SMD	Find out more	
	B-Constant	(25/50°C)	3380K	4050K					4250K
		(25/85°C)	3434K	4108K					4311K
NCU18 series	Resistance (25°C)	10kΩ	47kΩ	100kΩ	1.6x0.8mm	0.6x0.3inch	SMD	Find out more	
	B-Constant	(25/50°C)	3380K	4050K					4250K
		(25/85°C)	3434K	4108K					4311K
NXFT series	Resistance (25°C)	10kΩ	47kΩ	100kΩ	1.2 x 1.2mm x various lead lengths	Lead	Find out more		
	B-Constant	(25/50°C)	3380K	4050K				4250K	
		(25/85°C)	3434K	4108K				4311K	

# Sensors

## Lead-type thermistor

### Key features

- 3kΩ, 10kΩ, 47kΩ, 100kΩ resistance
- Small head sensing element (1.2mm)
- Assembled our chip thermistor with flexible lead
- -40°C to 125°C/150°C operating temperature



### Why Murata?

As the world's No.1 manufacturer of PTC and NTC thermistors, Murata consistently meets the market's expectations for high quality, best value, top-class service and reliable delivery.

<b>PTC type</b>	for overheat sensing
<b>NTC type</b>	for temperature sensing and compensation

## Applications

- BBU/DU/CU
- RRU/AAU mmWave
- RRU/AAU
- PA
- MEC

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- RRU/AAU: sub 6GHz mmWave
- Power amplifier
- BBU/DU/CU
- MEC

### Murata innovation

- RF components
- mmWave modules
- Substrates
- Connectors
- EMI
- Capacitors
- Power inductors
- Power
- Batteries
- Sensors

### Sensors

- Thermistors
- MEMS inclinometers

[See all Murata thermistors](#)

# Sensors

## MEMS inclinometers

### Active stabilization systems for 5G antennas

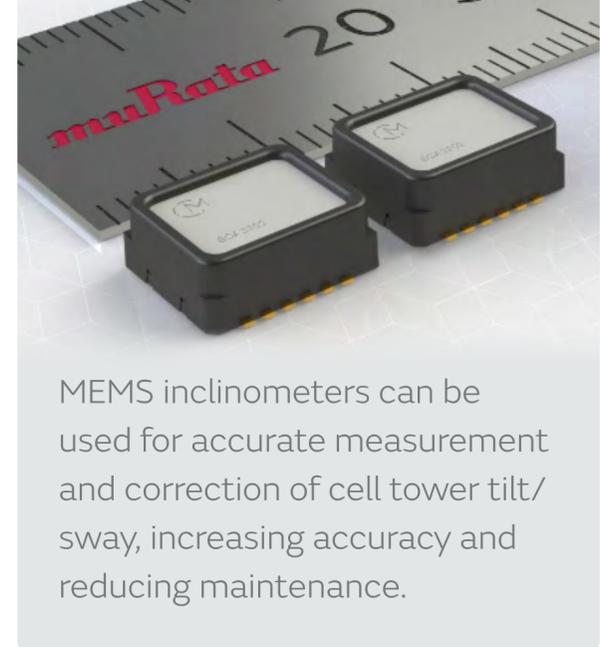
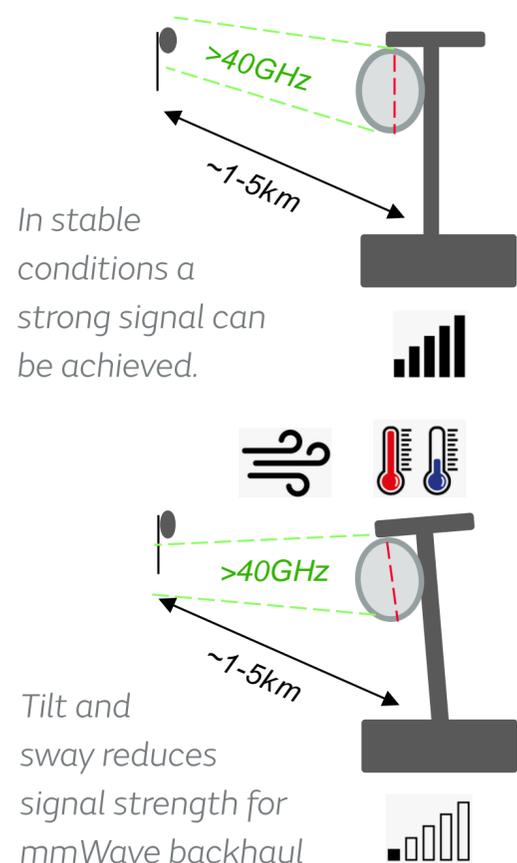
The purpose of stabilization is to ensure signal strength & link stability in backhaul high frequency links (>40GHz) by compensating for antenna tilt/sway due to:

- Wind
- Temperature deformations of antenna tower
- Other environmental disturbance

### Inclinometers can be used to detect the environment-induced tilt and sway.

After enabling the accurate measurement of abnormal motion, this motion can be compensated for by the use of:

- Beam steering
- Mechanical antenna control



MEMS inclinometers can be used for accurate measurement and correction of cell tower tilt/sway, increasing accuracy and reducing maintenance.

### Features

- low noise, making detection of smallest movements possible
- stability over time, minimizing the need for calibration in field
- stability over temperature, maintaining the accuracy in all conditions
- automotive grade reliability

Part Number	Axis	Measurement mode option	Maximum range	Amplitude response	Offset temperature characteristic	Operating temperature	Output type
SCL3300-D01	3	1	±1.8g/±90°	40Hz	±0.005%/°C	-40°C to +125°C	Digital SPI
		2	±3.6g/±90°	70Hz			
		3, 4	Inclination mode/±10°	10Hz			

[Find out more](#)

## Applications

- RRU/AAU mmWave

### Sensors

- Thermistors
- MEMS inclinometers

[See all Murata sensors](#)

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