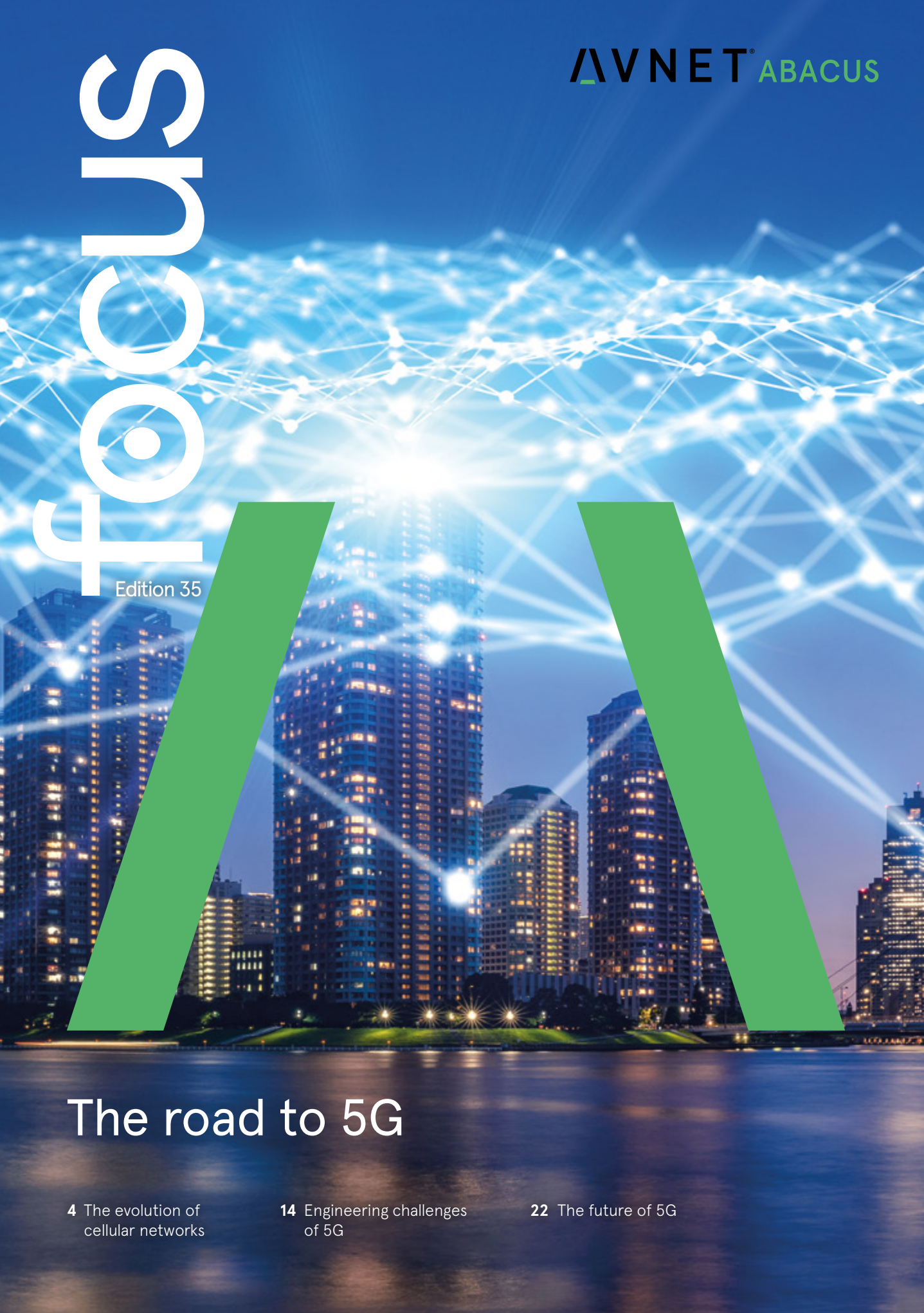

AVNET ABACUS

focus

Edition 35

The road to 5G

focus

Focus is the quarterly magazine from Avnet Abacus, featuring in-depth trend and technology reviews, new product spotlights, Avnet community news and interviews with market leaders.

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Features

Supplier technologies

Connectors

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If you have any comments or questions on the technologies featured in this edition, or wish to speak to one of our technical specialists, you can get in touch at **avnet-abacus.eu/ask-an-expert**

Editor Elinor Gorvett
Design Media Ace
Print Image Evolution

Keep up to date with the latest news, product information and technical insights via our social media channels.

Rudy Van Parijs
President, Avnet Abacus

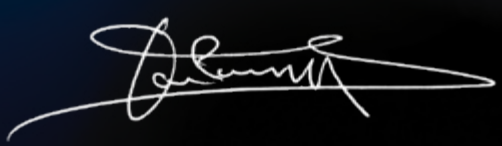
Each generation of mobile connectivity has brought significant advances in cellular networking and technology. In our 35th edition of Focus magazine we examine the journey from the emergence of analogue 1G cellular communications in Japan, to the potential of 5G and how it will transform the world of communication.

In our first article, The evolution of cellular networks, Martin Keenan, Technical Director reviews the evolution of cellular networking and discusses what is different about the fifth generation and how we expect it to deliver the many anticipated economic benefits.

Mathias Goebel, European Product Manager Connectors, surveys key hardware driving network performance and the major investments in infrastructure required to unleash the power of 5G. Also deliberated is the importance of network integrity, security and the challenges of network densification.

Finally, Adam Chidley, European Product Marketing Manager looks at The future of 5G, including the already defined capabilities of fifth generation networks and emerging applications. We anticipate the potential of further innovations in technology such as remote robotic surgery and autonomous vehicles and the benefits they may bring.

5G is not an improved version of 4G. It is a massive leap in reduced latency and requires new hardware. With analysts predicting 5G will be the next driver of global economic growth, Avnet Abacus is ready to embrace the 5G revolution and be part of the brilliant connected future ahead.



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The evolution of cellular networks

'The uptake of 5G is expected to be faster than any previous cellular generation and expectations are running high for its future impact on the global economy.'

Since the first 5G services were launched in the USA by Verizon and AT&T, 5G networks have been rolled out in a further 17 countries with South Korea, the United Kingdom, Germany, and the United States leading the charge and China catching up fast.

With analysts forecasting 2.7 billion 5G connections by 2025, (Figure 1), the uptake of 5G is expected to be faster than any previous cellular generation and expectations are running high for its future impact on the global economy.

In this review of the evolution of cellular networking, we take a brief look at previous generations of networks before examining why 5G is different and how it is expected to deliver the many anticipated economic benefits.

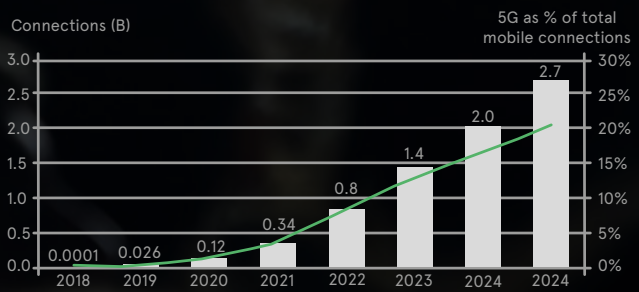

Figure 1: Forecast growth in global 5G connections (Source: CCS Insight)

Martin Keenan

Technical Director
Avnet Abacus

A trip through the generations

Since their initial arrival in the late 1970s, cellular networks and technology have evolved considerably, with successive generations, (2G through 4G) representing significant milestones in the development of mobile connectivity (Figure 2).

First Generation

Although not called 1G at the time, first generation mobile networks emerged in Japan in 1979, before rolling out to other countries such as the USA (1980), and the UK, (1985). Based on an analogue technology known as Advanced Mobile Phone System (AMPS), which used frequency division multiple access (FDMA) modulation, 1G networks offered a channel capacity of 30KHz and a speed of 2.4kbps. 1G networks only allowed voice calls to be made, suffered from reliability and signal interference issues and had limited protection against hackers.

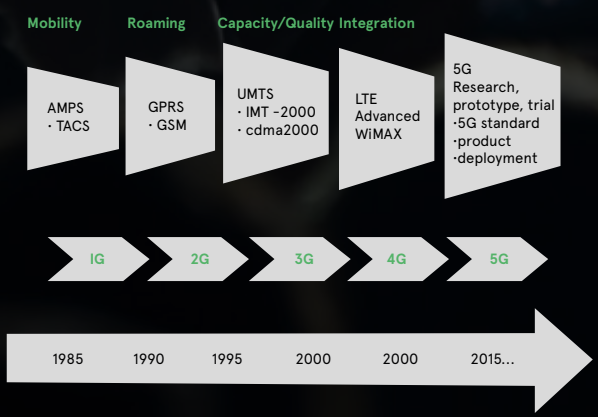

Figure 2: Cellular network evolution timeline
(Source: https://www.researchgate.net/figure/Mobile-Cellular-Network-Evolution-Timeline_fig1_263657708)

Second Generation (2G)

Despite its flaws the 1G network wasn't superseded until 1991, when 2G networks, were introduced. Based on digital signalling technology, Global System for Mobile Communication (GSM), which increased security and capacity, 2G networks offered bandwidths of 30 to 200KHz and allowed users to send SMS and MMS messages, although at low speeds, up to 64kbps. Continuous improvement of GSM technology led to the introduction of so-called 2.5G, which incorporated packet switching in the form of GPRS and also EDGE technology. 2.5G enabled data-rates up to 144kbps, enabling users to send and receive e-mail messages and browse the web.

The evolution of cellular networks

'It is only around 40 years since the birth of mobile telephony and in that time the capabilities of cellular networks have evolved at a pace which has fuelled both social change and innovation on a global scale.'

Third Generation (3G)

The arrival in the year 2000 of 3G, known as UMTS in Europe and CDMA2000 in the USA, heralded a change in the way mobile phones were used and viewed by the end user, becoming less about voice calls, more about social connectivity. Also based on GSM, the main aim of 3G was to support high-speed data and the original 3G technology allowed data-rates up to 14Mbps. With its ability to transmit greater amounts of data at higher speeds, 3G enabled users to make video calls, surf the web, share files, play online games and even watch TV online. Whereas 2G networks would enable a 3-minute MP3 song to be downloaded in around 6-9 minutes, the same file would take anywhere between 11 and 90 seconds to download on a 3G network. Today the most common use for 3G networks is as a backup for 4G.

Fourth Generation (4G)

The introduction of 4G really ushered in the era of the smartphone and hand-held mobile device. 4G is the first generation to use Long-Term Evolution (LTE) technology to deliver theoretical download speeds of between 10Mbps and 1Gbps, offering end users better latency (less buffering), improved voice quality, instant messaging services and social media, quality streaming and faster download speeds. 4G is also the first IP-based mobile network, handling voice as just another service and the technology is being developed to accommodate the Quality of Service (QoS) and rate requirements required by applications including wireless broadband access, Multimedia Messaging Service (MMS), video chat, mobile TV, HDTV content, Digital Video Broadcasting (DVB).

In the relatively short time since their introduction however, 4G networks are already struggling to cope with the demands placed upon them. Driven by emerging technologies such as Augmented Reality (AR), autonomous vehicles and the exponential growth of the Internet of Things (IoT), global demand for mobile bandwidth is growing at an explosive rate. Technology giant Ericsson predicts a compound annual growth rate (CAGR) of 39 per cent in global mobile data traffic between now and 2023, equating to a total of 107 exabytes (EB) per month. As well as being bandwidth hungry, emerging applications need higher speeds and lower latencies and the growing number of IoT devices is fuelling demand for ever higher numbers of connections – to over 29 billion by 2022, according to Ericsson.

Realising that 4G/LTE networks will ultimately reach capacity, the International Telecommunications Union, (ITU), in 2015, defined the requirements specification for 5G.

The 5G revolution

The ITU specification for 5G, contained in the document, ITU-R IMT-2020 (5G), is summarised in Figure 2. The ambitious specification represents a step-change in performance over 4G and aims to address the requirements of the emerging applications, described above. Throughputs up to 10Gbps (100 times faster than 4G networks) aim to satisfy the growing hunger for bandwidth; latencies of 1mSec (cf. 30 - 50mSec for 4G) will enable near-real-time response rates; and connection densities of 1000 devices per square kilometre (100 times more than 4G) will support the growing numbers of IoT devices and sensors.

Having completed the 5G specification, the ITU delegated the definition of the 5G technical specifications to the global standards body, the 3rd Generation Partnership Project (3GPP). Founded in 1998, 3GPP is a global cooperation of independent standardisation committees (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC), and has been responsible for the definition of technical specifications for wireless standards since the introduction of 3G. 3GPP prioritises and groups specifications into releases, based on the sequence in which new functionality will be deployed in wireless networks. 5G specifications have been integrated into 3GPP releases 15 and 16 (Figure 3), with release 16 scheduled for completion in time for the ITU's 2020 deadline. Completion of these specifications ensures that operators and manufacturers of 5G technology can have confidence in their designs and investments.

Full deployment of all of the 5G capabilities defined in IMT-2020G requires implementation of totally new networks, significant investments by operators and considerable elapsed time to enable a full roll-out. To ease the migration path and enable operators to get to market early with 5G services, 3GPP defined 5G NR Non-stand Alone (NSA), (NSA) technology in release 15 (Figure 4).

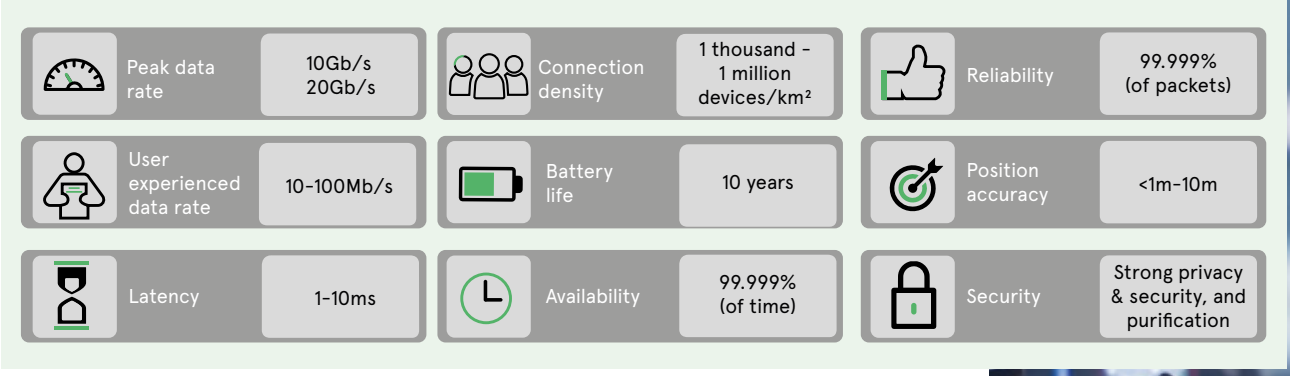

Figure 2: Selected key performance indicators of 5G according to ITU-R
(Source: "5G for Connected Industries and Automation", 2nd edition, White Paper, 5GACIA, November 2018)

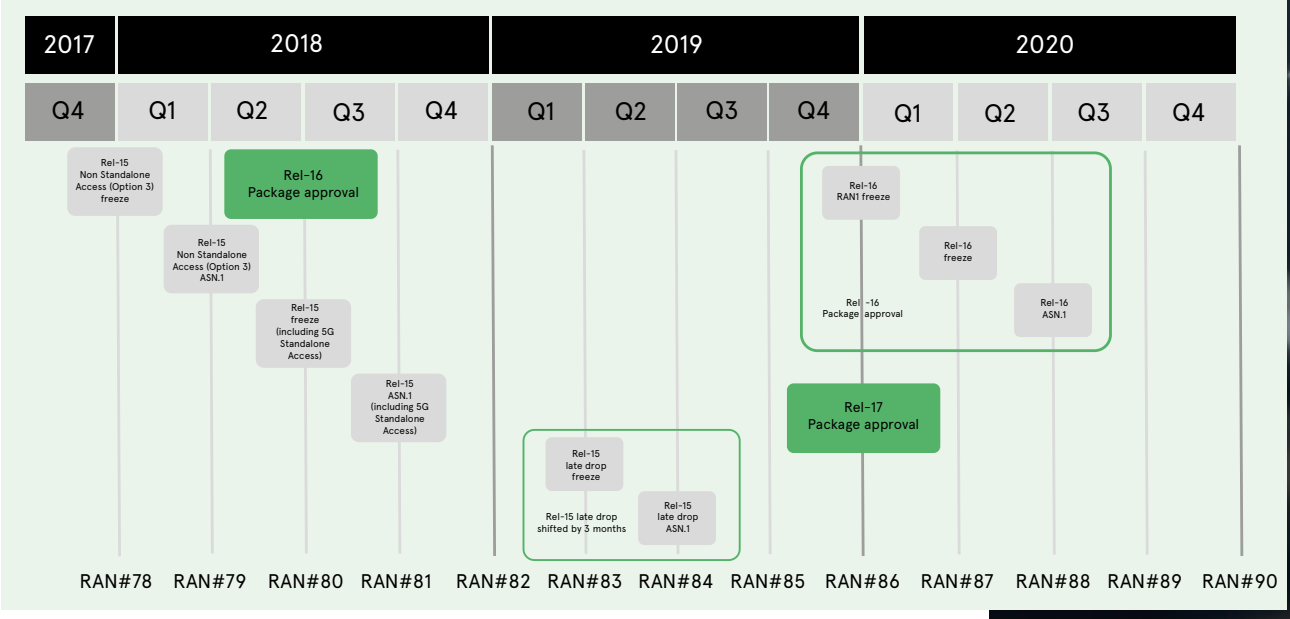

Figure 3: 3GPP release 15 and 16 schedule
(Source: 3GPP)

The evolution of cellular networks

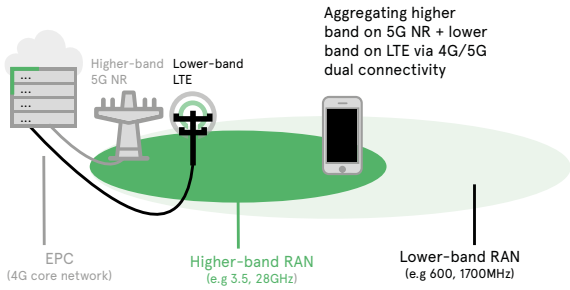

Figure 4: 5G NR non stand-alone (Source: Qualcomm)

5G NSA enables 5G services to be provided by leveraging existing LTE infrastructure. The throughput of existing macro cells can be increased by adding extra MIMO layers and operators can use existing spectrum in the so-called "MIMO sweet spot", around 3.5GHz to offer a mainly consumer proposition, providing faster services to new 5G handsets.

Release 15 also includes the specifications for 5G NR Stand-alone (SA) technology and release 16, scheduled for completion in early 2020, addresses the specifications for mmWave technology, based on spectrum allocation decisions due to be taken following the ITU's World Radio Conference in October of 2019.

A review of 5G launch announcements (Table 1), confirms that the NSA route is popular with many operators around the world, with key exceptions being AT&T and Verizon who are using their mmWave licences to provide Fixed Wireless Access (FWA) services to consumers.

5G is poised to change the way we live

It is only around 40 years since the birth of mobile telephony and in that time the capabilities of cellular networks have evolved at a pace which has fuelled both social change and innovation on a global scale. The capabilities of 3G then 4G networks were developed in response to demands for a mobile internet and have led to the smartphone and tablet becoming everyday accessories. However, the inexorable rise of the IoT and the demands of emerging applications such as AR/AI and self-driving cars have stretched the capabilities of 4G networks to their limits leading to the development of the next generation of cellular networking, 5G.

Whereas 3G and 4G networking were focused on voice and data services and are mainly associated with the smartphone, 5G offers much more, promising to enable the inter-connection of billions of devices of almost any kind. More than a faster wireless capability, 5G promises to transform existing consumer, business and industrial processes, unlocking new levels of productivity and innovation and driving the next wave of global economic growth. The 5G roll-out has only just begun but, with operators poised to invest in the infrastructure required to unlock the full power of 5G, the global economy stands on the verge of the next wave of growth.

OPERATOR	FREQUENCIES	SERVICES
AT&T	39GHz	Home Broadband
Verizon	28/39GHz	Home Broadband
T-Mobile (USA)	600MHz	Consumer, handsets, tablets, etc.
EE	3.4GHz	Consumer, handsets, tablets, etc.
Vodafone	3.4GHz	Consumer, handsets, tablets, etc.
China Unicom	3.5 – 3.6GHz	Consumer, handsets, tablets, etc.
South Korea (all 3 operators)	3.5GHz	Consumer, handsets, tablets, etc.

Table 1: Summary of global 5G launch plans

Amphenol ICC Octis™ outdoor I/O system for high reliability applications

The versatile OCTIS™ I/O system, using multiple industry standard interfaces, features high speed signal and power, lightning protection, EMI shielding, and ease of installation for outdoor, compact and harsh environments. Lightning protection, EMI shielding features, and a rugged weather proof design make it ideal for use in harsh environment applications. Blind mate, float mount, colour and physical coding features make it easy to use and avoids mismating.

FEATURES AND APPLICATIONS

- Field termination or factory certified cable assembly options are available
- Use of standard small form factor interfaces for greater port to port density. Ideal for outdoor applications like small cells, macro cells, smart radios and RRU/RRH
- Suitable for various applications with standard connector interfaces like SFP/SFP+, QSFP, signal, PoE (Power over Ethernet), MDR26, power, hybrid of signal & Power and RJ45

For more information visit
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The need for high frequency connectors in 5G communications from Cinch

As the global 5G roll-out gathers pace, new product announcements are appearing on a daily basis across the industry value-chain. Network operators are competing with a variety of service offerings, including higher-speed consumer propositions, Fixed Wireless Access (FWA) offerings and NB-IoT services. Device manufacturers such as Qualcomm are releasing 5G modems, test equipment manufacturers are updating their portfolios and companies such as Huawei, Nokia and Ericsson are developing innovative network infrastructure such as Advanced Antenna Systems (AAA).

The electrical connector is a key component in all of the above areas, and with increasing 5G frequencies, precision of connector design becomes critical to the performance of the 5G system, subsystem or component. As a key player in the mobile eco-system, Cinch Connectivity-Johnson understands the challenges designers are facing from evolving 5G technologies. The company's 50 years of RF experience, coupled with a deep knowledge of mobile technologies, ensures that the Johnson product portfolio constantly adapts to the unfolding demands of 5G. Here we look at these demands and how Johnson is responding with new product launches.

MMWAVE – THE KEY TO 5G NETWORK PERFORMANCE

5G's three major use cases - eMBB, mMTC and URLLC - are supported by three distinct spectrum bands (Figure 1) but it is the higher frequencies, particularly at 30GHz and above – the mmWave frequencies - which unlock the step change in speeds and available bandwidth.

eMBB	HIGH FREQUENCIES **Super data layer**	Addressing specific use cases requiring extremely high data rates	ABOVE 6GHz 800MHz assignments (contiguous)
eMBB, URLLC,mMTC (wide-area but no deep average)	MEDIUM FREQUENCIES **Coverage & capacity layer**	Best compromise between capacity and coverage	2-6GHz 100MHz assignments (contiguous)
mMTC, eMBB, URLLC	LOW FREQUENCIES **Coverage layer**	Wide-area and deep indoor coverage	BELOW 2GHz (up to 20MHz paired/unpaired)

Figure 1: 5G spectrum bands allocated to 5G use cases (source Huawei.com)

Signal propagation characteristics at mmWave frequencies, present a number of challenges for 5G network designers, and a range of innovative techniques, including MU-MIMO, beamforming and network densification have been developed to address these challenges.

THE CRITICAL ROLE OF THE CONNECTOR

The transmission characteristics of mmWave signals also place specific demands on the electrical connector. At these frequencies conductors effectively become transmission lines and RF connectors must transfer electromagnetic energy from one line to another while ensuring minimum losses and reflections, making the precision of their design critical.

RF connector design must meet constraints based on geometry, size and transmission characteristics while ensuring that the connector impedance matches that of the rest of the transmission line. As the frequency increases, maintaining the impedance becomes more complex, and the electrical, mechanical, (Figure 2), and environmental characteristics of RF connectors all have a vital role to play in ensuring their performance.

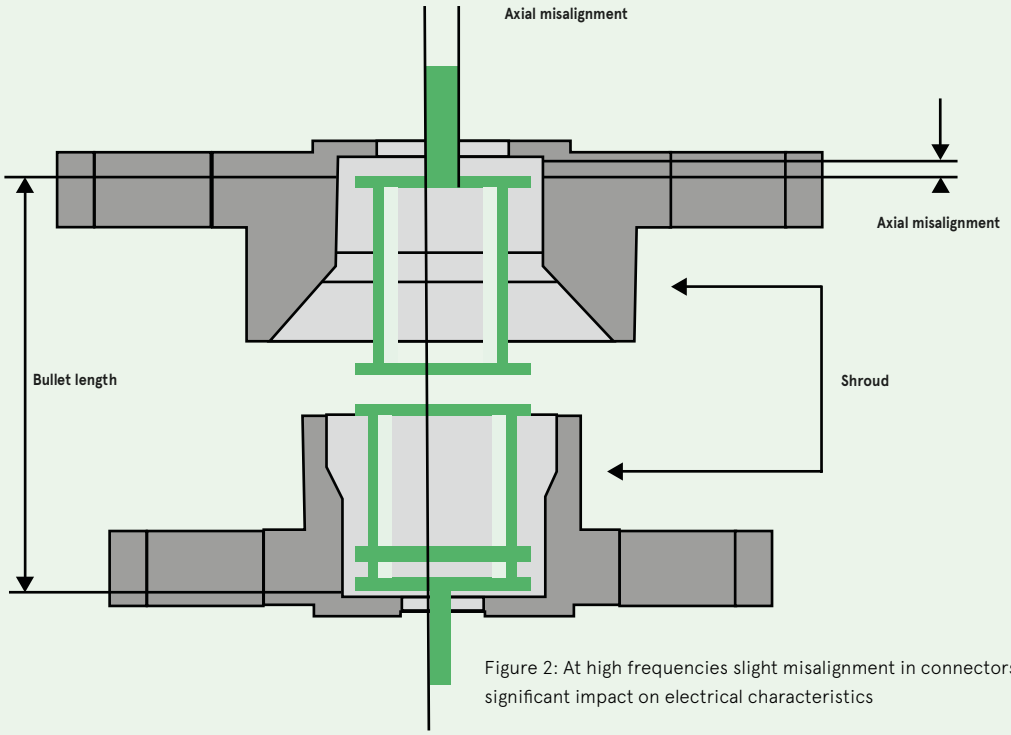


Figure 2: At high frequencies slight misalignment in connectors can have a significant impact on electrical characteristics

Johnson offers one of the most comprehensive ranges of RF connectors on the global market and has been leveraging its 50+ years of experience and resources to develop and extend its product range to meet the evolving demands of 5G. Johnson's 50Ohm SMA connectors are rated up to 26.5GHz and are available in brass or stainless steel, with support for various configurations including PC board mount (thru-hole and surface mount), end launch, bulkhead flange mount and cable.

In response to changing market needs, driven by the 5G roll-out, Johnson has been actively launching several new products to support higher frequencies and smaller sizes, including:

- 2.92mm family up to 40GHz
- 2.4mm family up to 50GHz
- 1.85mm family up to 67GHz
- SMP family expansion up to 40GHz
- SMPM family expansion up to 65GHz
- Ganged SMP 4-port up to 40GHz

Johnson has sales, design and manufacturing centres in the United States and China, is ideally placed to support the requirements of the emerging 5G market and will continue to invest in its product portfolio to support the emerging needs of 5G networks.

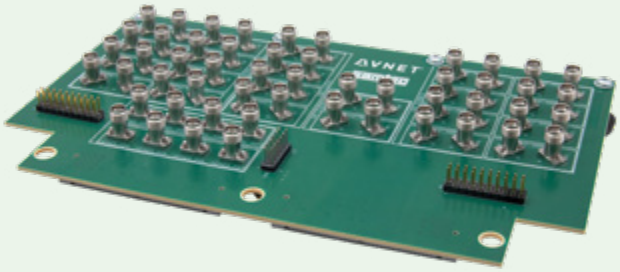
For more information visit
avnet-abacus.eu/cinch-connectivity-solutions

Samtec high performance interconnects for 5G design challenges

The heart of any 5G-enabled device remains the mmWave Silicon IC transmitting and receiving data from bits to antenna. 5G system development typically links multiple RF signal chain and digital IC development boards mimicking end applications.

System testing of next-generation 5G systems must validate sub-6GHz and mmWave radio solutions supporting governmental, industry and carrier standards.

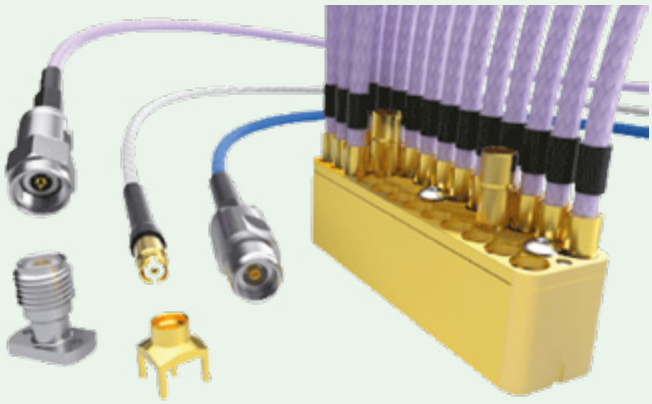
Samtec's broad product portfolio and high-performance interconnect expertise enable 5G system prototyping and connectivity between test and measurement equipment alike.



DIFFERENTIAL BREAKOUT CARD FOR ZYNQ ULTRASCALE+ RFSOC

As a daughtercard for the Xilinx Zynq UltraScale+ RFSoC ZCU111 Evaluation Kit, the AES-LPA-502-G routes the RF-ADCs and RF-DACs of the RFSoC device to external test equipment via Samtec high-performance interconnect at carrier frequencies ≥ 20 GHz.

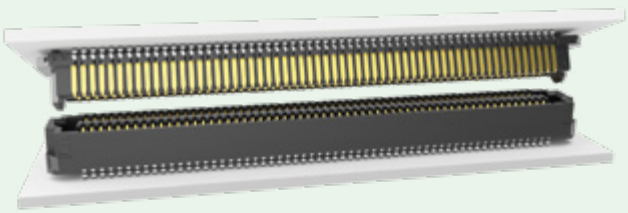
- Contains Samtec LP Array™ high-speed low profile connectors for RFMC carriers and daughter cards
- Eight DACs and eight ADCs routed to RF connectors
- Four pairs of external input clocks for ADCs routed to RF connectors
- Two pairs of external input clocks for DACs routed to RF connectors
- Leverages Samtec RSP-208784-01 screw-mount, straight SMA plug



PRECISION RF INTERCONNECTS

Increasing complex systems with escalating bandwidths and shrinking footprints drive Samtec to continually engineer, develop and expand our portfolio of Precision RF interconnects.

- Design, fabrication and assembly of RF solutions
- Offering cable connectors, cable assemblies and board-level mates
- Interconnect components to 110GHz
- Full cable assemblies to 70GHz
- Vertical integration enables industry-leading customer service and design-in support



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Innovative design provides hundreds of I/Os in a compact footprint, while providing excellent signal integrity at 56Gbps PAM4 data rates.

- Incredibly dense up to 400 total I/Os
- Ultra-slim 5 mm width
- Open-pin-field design for maximum routing and grounding flexibility
- Supports 56Gbps PAM4 applications
- Rugged Edge Rate® contacts designed for high-speed and high-cycles

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THE 5G ECOSYSTEM

EXPERTS say that there will be over 75 billion connected devices by 2025, and most will use wireless networks. 4G simply won't be able to keep up. TE Connectivity is enabling the next level of connectivity with solutions that support speeds up to 100 times those of 4G networks. With broader bandwidth and super-low latency, 5G will be integrated into infrastructure, connecting your devices to the world around you with greater speed and reliability.

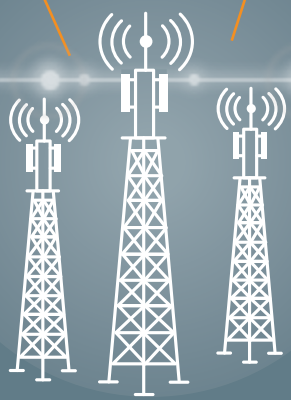
Because of 5G's greatly expanded bandwidth, users will be able to download, upload, and access huge amounts of data. Virtual and augmented reality, connected cars, and smarter cities will all be possible - and reliable - with 5G.

Ruggedised (FullAXS connectors & RF)

Antennas & RF

EDGE DEVICES will enable a complete ecosystem of interactive edge devices from smart home controls to vertical horticulture and from cellphones to connected streetlights.

Antennas, sensors and USB Type-C connectors

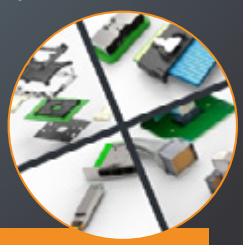


5G SMALL CELLS small cell technology is optimised for short-range, data-rich applications. Small cells are essentially miniaturised cell towers (think the size of a wifi router) for use in urban areas dense with edge devices using high amounts of data. Small cells will play a critical role in the infrastructure and roll-out of 5G networks.

5G ANTENNAS will distribute data with innovative techniques like beamforming and MIMO, allowing 5G networks to be reliable and scalable. Small cell and edge computing processes will further enhance network performance.

CLOUD COMPUTING will bring the efficiency and power of enormous data centers to even the most compact of 5G devices, enabling artificial intelligence and machine learning.

5G EDGE COMPUTING will provide greater capacity, lower latency, more mobility and accuracy, and increased reliability and availability.



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Engineering challenges of 5G

The technology driving 5G network performance

The enhanced capabilities of 5G offer exciting benefits for a wide spectrum of applications across multiple sectors but, in order to unlock these benefits, network operators will have to make significant investments in new technologies and hardware. This article looks at the key elements of 5G's infrastructure including small cell deployment, active antenna systems and massive Multiple Input Multiple Output (MIMO) technology, and discusses the components and equipment being developed to meet 5G's demands, with a focus on key engineering challenges of increased density, functionality and power efficiency.

Meeting the challenging requirements defined in ITU-R IMT-2020 (5G), has required a transformational approach to network design, resulting in the development of a completely new radio interface, 5G NR (New Radio), which uses a range of highly sophisticated, state-of-the-art technologies, including:

- Orthogonal Frequency Division Multiplexing (OFDM) is a signal modulation technique where a large number of closely spaced subcarrier signals, each carrying low data rates, are transmitted in parallel. OFDM enables RF transmissions to make extremely efficient use of radio spectrum and is compatible with high data rates/wide bandwidths.

- 5G will use a wide range of radio spectrum and three distinct layers are defined (Figure 1), based on the needs of various use cases:

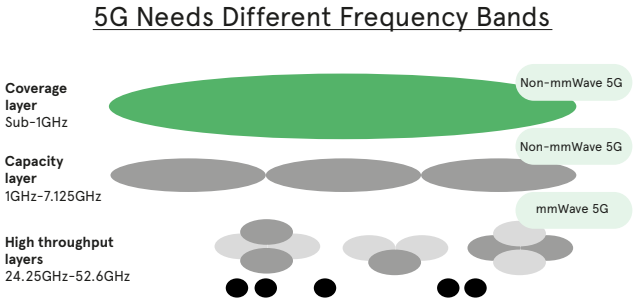


Figure 1: 5G frequency layers
(Source: https://www.slideshare.net/3G4GLtd/beginners-5g-spectrum-long-version)

- The 'coverage layer', with frequencies below 1GHz, provides wide area and deep indoor coverage.
- The 'coverage and capacity layer', between 1GHz-6GHz, delivers the optimum capacity-coverage compromise and includes the C-band spectrum, around the 3.5GHz mark.
- The 'super data layer', from 6GHz up to the mmWave frequencies of 30GHz and above, delivers the large quantities of bandwidth and high data rates required by the IMT2020 specification.

- Beamforming and Multi-User MIMO (MU-MIMO) techniques (Figure 2), are core components of 5G NR and together will enable 5G to support over 1,000 more devices per square-metre than 4G, transmitting ultra-fast data to many more users, with high precision and low latency.

Mathias Goebel

Supplier Business Manager, European Product Marketing
Avnet Abacus

Beamforming is a relatively new technology which enables the beam from the 5G base station to be directed towards the end-user mobile device, ensuring optimum transmission levels whilst minimising interference to other, nearby mobile devices.

MIMO uses spatial multiplexing to transmit independent and separately encoded data signals, known as 'streams', reusing the same time and frequency resource. Single-User MIMO (SU-MIMO), where both the UE and the base station have multiple antennas, was first introduced to improve throughput of legacy LTE networks. Spectral efficiency and capacity can be improved by adding more streams or layers up until a point where power sharing and interference between users result in diminishing gains and, eventually, losses.

Current 4G LTE networks use 4×4 MIMO - four antennas for four simultaneous data streams, whereas 5G NR will employ MU-MIMO, which uses a large number of antennas (32 in 3GPP release 15, rising to 64 or more in future releases) in the base station. MU-MIMO uses a complex algorithm and spatial information gained from a Channel State Information Reference Signal (CSI RS) to enable the 5G base station to communicate with multiple devices concurrently and independently.

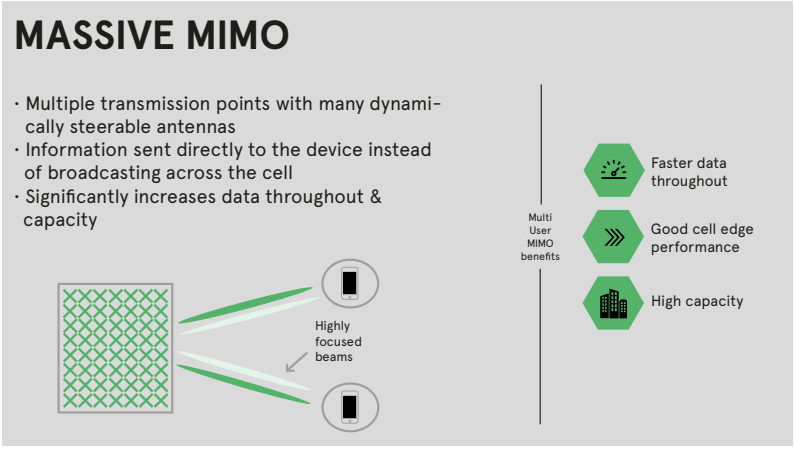


Figure 2: Massive MIMO and beamforming
(Source: Ericsson)

- Advanced Antenna Systems (AAS) have been evolving in parallel with the development of MIMO and beamforming technology (Figure 3). An AAS is a combination of an AAS radio and a set of AAS features, including beamforming and MIMO. The AAS integrates an antenna array with the necessary RF transmission hardware and software and also includes the signal processing algorithms required by beamforming and MIMO. As the antenna arrays required for

'Emerging applications, many of them mission critical, will rely on 5G networks, placing huge importance on network security and stability.'

MU-MIMO multiply, conventional antennas struggle to support them due to weight and space limitations.

AAS addresses this problem, enabling state-of-the-art beamforming and MIMO techniques and significantly enhancing network performance in both uplink and downlink.

- Network slicing is one of a number of enhanced network management features of 5G, enabling operators to tailor services according to needs of the application. Remote tele-surgery, for example, requires extremely fast, low latency connections, but for many IoT sensors, battery conservation and low-data rate long distance communications are a priority.
- Cloud implementation and edge computing brings the benefits of the cloud to radio networks, satisfying the ultra-low latency requirement by bringing the content closer to the network, providing local break out and Multi-access Edge Computing (MEC).

ROLE OF ACTIVE VS. PASSIVE ANTENNAS

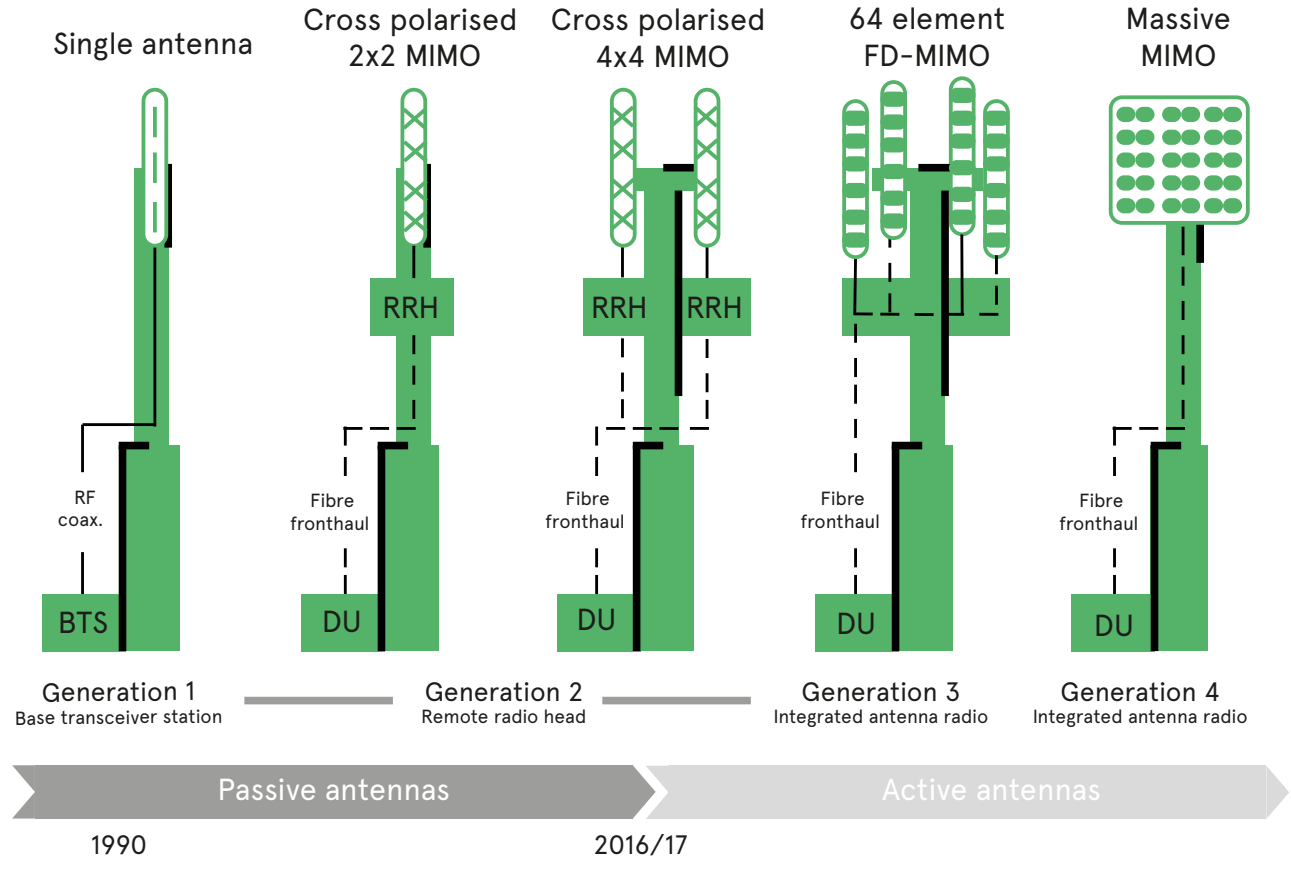
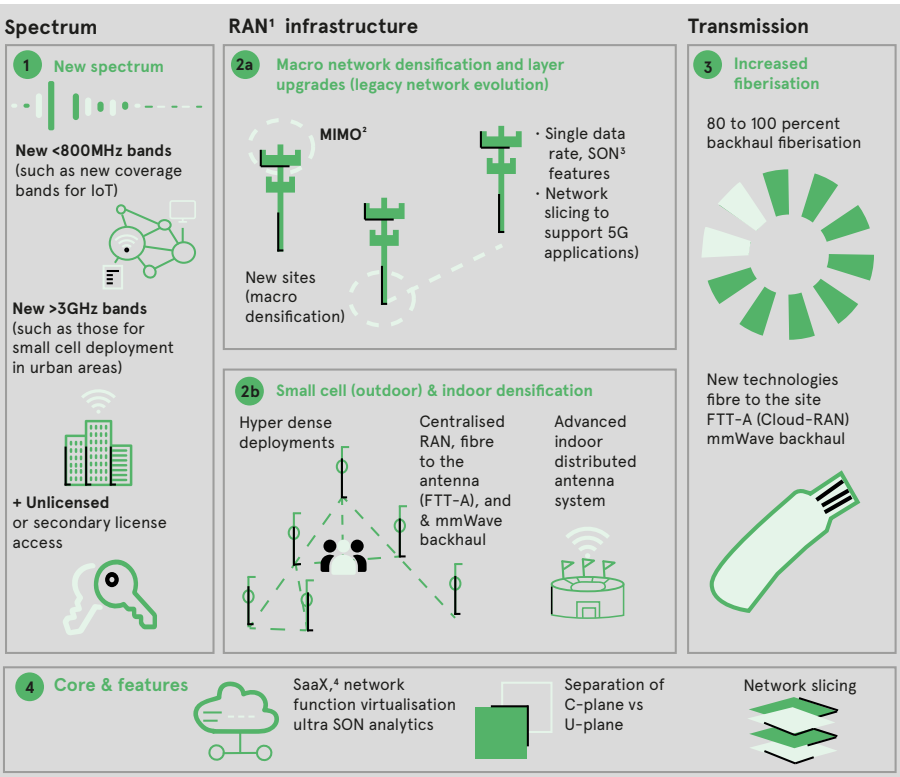


Figure 3: Evolution of antennas
(Source: https://www.rcrwireless.com/20180624/wireless/analyst-angle-the-rise-and-outlook-of-antennas-in-5g)



1 RAN = Radio access network
2 MIMO = Massive-Multiple Input and Multiple Output
3 SON = Self Organizing Network
4 SaaX = Software as a...

Source: Expert interviews; McKinsey analysis

Figure 4: Areas for network capital expenditure (Source: McKinsey)

5G Roll-out demands major infrastructure investment

Although the future 5G opportunity may be huge, network operators will have to invest across all network domains (Figure 4), before new revenue streams start to flow. According to a recent report by the GSMA, a trade association representing the interests of global mobile network operators, global capex spend by mobile operators will reach $1.3 trillion over the period 2019 to 2025, with 75% of that related to 5G.

This may be a challenge for many operators who are still building out 4G/LTE networks, with many seeing revenues dip as existing services become commoditised. 5G NR Non Stand-Alone, technology defined in 3GPP release 15 offers a migration path, enabling operators to leverage their existing 4G/LTE infrastructure by using MU-MIMO technology to improve throughput and offer 5G services in the capacity and coverage layer. This is a transitory situation, however, as the available bandwidth in the coverage layer is finite, and also the full capabilities of 5G will only be delivered over mmWave infrastructure. Key areas of investment required to enable and support mmWave transmission include:

Network densification

The short propagation distances of mmWaves and need for line of sight communication will drive huge network densification, particularly in urban areas, meaning more base stations in the global network. Network densification involves increasing the capacity and throughput of macro cells by increasing levels of MU-MIMO and also adding small cell sites and in-building or pico sites. MU-MIMO requires multi-antenna arrays, placing size and weight pressure on existing tower sites, driving the need for a higher proportion of AAS, in the network.

Fibre

Mobile operators will also be required to invest heavily in fibre connectivity, both to improve capacity and latency of existing backhaul networks to make them 5G-ready and also to support the deployment of additional small cells in urban environments.

It is estimated that 5G technology dictates fiberisation levels of 70%, compared to current levels of around 25% - 30%, and according to the International Telecommunications Union (ITU - Trends in Telecommunication Reform), $144.2 billion was invested in fibre infrastructure globally, in the five years from 2014, with 5G responsible for a significant proportion of this.

Power supplies

In the absence of any efficiency measures, more base stations with more antennas will lead to higher power requirements for 5G networks. A typical 4G base station with two transmitters has an input power requirement of 300 watts, which would translate to 1500 watts for a 5G station with 64 transmitters. However, with operators' energy costs running at around 15% of opex, this increase will not be sustainable and innovative efficiency measures must be incorporated in the design of 5G networks. This drive to reduce power consumption is leading to a demand for highly efficient, advanced digital power supplies and DC-DC converters. This demand will also manifest itself in the datacentre, which will be required to process higher volumes of data as remote IoT devices and applications take advantage of 5G network performance to offload computation-intensive tasks.

Connectors

The characteristics of mmWave frequencies place specific demands on electrical connectors, for example within the base station. The smaller sizes linked to high frequencies place constraints on the mechanical and electrical design and manufacture, the precision of which is critical to ensure effective, loss-free transfer of electromagnetic energy.

Test equipment

Existing and emerging applications, many of them mission critical, will rely on 5G networks, placing huge importance on network security and stability. Additionally, a plethora of devices will be connected, potentially threatening network integrity and security. Network management tools and systems must therefore be developed to mitigate against these and other such threats.

Conclusion

Although the 5G roll-out has begun, initial service launches are predominantly based on the capacity-coverage spectrum region, with operators mainly offering faster data speeds to consumer customers.

The real promise of 5G will only be unlocked when infrastructure supporting mmWave frequencies is deployed, requiring significant investments across most network domains. Operators will be forced to make strategic choices as they decide where to place their bets, and the next few years will see a variety of strategies based upon local and regional market opportunities as well as the constantly evolving regulatory landscape.

Hirose DF40 series 0.4mm pitch FPC to board connectors

HIROSE Electric Co. Ltd, a world-class manufacturer in connectors, has introduced the DF40 series, a high-speed transmission, flexible printed-circuit (FPC) to board connector.

BENEFITS

- Ideal for wearable, medical and small portable devices.
- Can handle 10Gbps high-speed transmission and supports USB3.2 Gen. 2 standards.
- The housing incorporates robust shock absorbing ribs to prevent damage to the housing walls for applications requiring drop impact resistance.
- A clear tactile click can be felt when mating to confirm correct engagement and secure connection.
- A minimised depth of only 3.38mm reduces the required mounting area, creating additional board space to optimise the design.
- Wide stacking heights are available from 1.5mm – 4mm allowing design flexibility.
- The guide ribs allow a wide self-alignment range of ±0.33mm in XY directions to simplify the mating operation.
- The user-friendly connector offers an effective mating length of 0.45mm providing high contact reliability.

FEATURES

- Number of contacts: 10–100 (most sizes)
- Contact pitch: 0.4mm
- Current rating: 0.3A
- Rated voltage: AC-DC 30V
- Halogen-free
- RoHS compliant

For more information visit avnet-abacus.eu/hirose

HIROSE ELECTRIC EUROPE B.V.

How automotive Ethernet and 5G will power autonomous driving

THE NERVOUS SYSTEM OF THE CONNECTED VEHICLE

Human beings are complex creatures: Our brains transmit signals via our nervous systems to our muscles. At the same time, impulses that we perceive through our sensory organs are transmitted by our nerves to our brains. This enables us to communicate, act and react in and with our environment. Autonomous driving works in much the same manner: the car must react to outside influences while simultaneously communicating with its environment.

The key requirements needed by such a vehicle are a brain, in the form of powerful computers installed throughout the vehicle, tactile sense in the form of sensors, automotive Ethernet and high-performance 5G communication systems. The automotive Ethernet will form the nervous system and the antenna(s) the ears and the mouth, so to speak. In the process, they will help turn the future of autonomous driving into a reality.

SAFETY IN THE CONNECTED CAR WILL COME FROM WITHIN

Like humans, an autonomous vehicle must produce safety from within and function on its own. Fully and highly automated vehicles must be able to independently manage safety issues with their own sensory and actuating systems. And they must do so without relying on data produced by other vehicles on the road or the infrastructure. For this reason, the vehicle needs data from sensors and an agile nervous system that will pass on the data to all computing units installed throughout the vehicle. This is where automotive Ethernet comes into play. Ethernet can serve as the nervous system for car manufacturers because the technologies that have arisen from IT have already proven themselves there. They meet the needs of the automotive industry in terms of transmission speeds, fault tolerance and, above all, safety. Furthermore, Ethernet is considered to be future-proof, a feature that is vital to autonomous driving.

HIGH DATA RATES AND RELIABILITY AS KEY CRITERIA

Automotive Ethernet will make it possible to achieve high data speeds within the car. At the moment, automobile data networks have speeds of up to 10Gbps.

The high bandwidth and fast signal processing are essential to autonomous driving. In addition, the Ethernet must be fail-safe and reliable. To make this happen, cars will be equipped with redundant wiring harnesses that can make up for a partial failure and facilitate the continued operation of the entire system. Another way to boost Ethernet reliability is to use a ring-shape arrangement of cables. With this system, individual components can continue to communicate with one another if a complete failure occurs at one point in the ring. One critically important job that the Ethernet will have to perform is to quickly and reliably supply the safety-related data produced by vehicle sensors to the computing units. This will enable the vehicle to autonomously operate in urban traffic. Other data will be needed for autonomous driving, in particular to increase riding comfort.

5G COMMUNICATION SYSTEMS FOR INCREASED COMFORT IN AUTONOMOUS VEHICLES

Antennas are already a key component of connected driving. They are used to supply signals received from other vehicles or the infrastructure via the Ethernet and a connectivity platform to the car's computing brains. This so-called preprocessing sensor system is something like the voice of the connected vehicle, with which

the vehicle communicates with its environment and can send and receive signals. The received signals are designed to increase comfort. One such scenario would occur when the vehicle applies the brakes earlier than expected and, thus, more gently because the vehicle ahead of it has wirelessly reported a braking manoeuver. Or an ambulance would announce its presence wirelessly to vehicles ahead so that they could form a corridor in time.

Today, sensor data is transmitted in a heavily preprocessed state because of the lack of bandwidth. The currently available bandwidth per vehicle amounts to just a few hundred kilobits. This will do for right now, but it is not enough for autonomous driving. Vehicles will have to be able to receive more sensor data, some of which is unprocessed. Such requirements make bigger bandwidth unavoidable. The ideal vision is that a vehicle would be able to receive raw sensor data in an amount equal to its own already available data. Other scenarios in which tremendous amounts of data are transferred are also important to autonomous driving. This includes the downloading of current, high-resolution maps that show current construction sites and obstacles to which the vehicle will have to react.

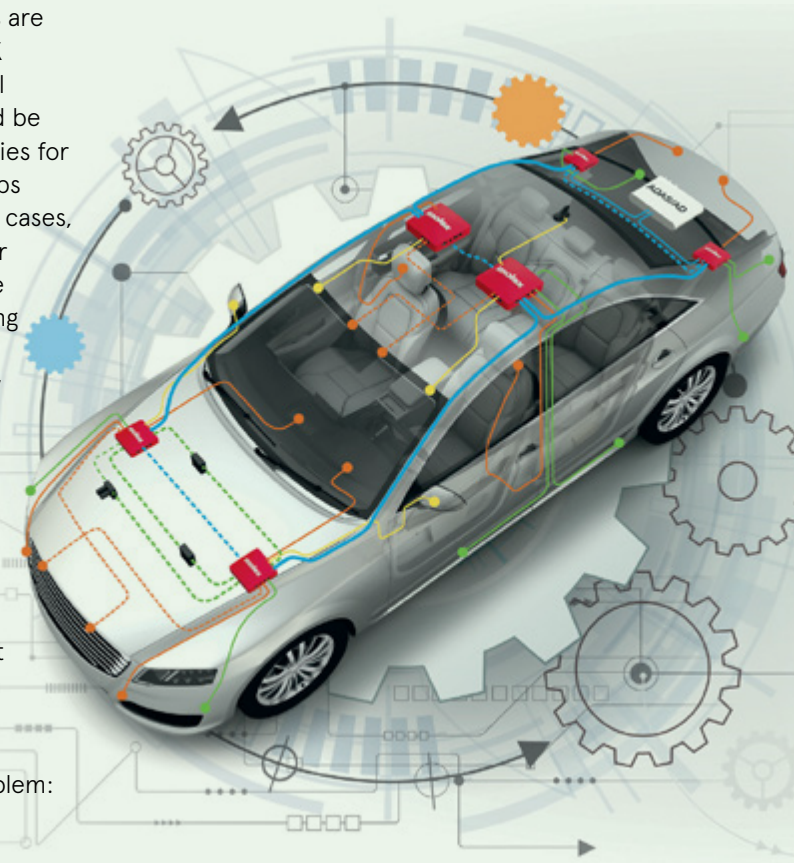
FREQUENCY RANGE MUST BE EXPANDED

To be able to offer this bandwidth, antennas will have to cover a larger frequency range. This will require a new standard, something that a number of groups are currently developing. This new standard — 5G V2X — should facilitate several 100MBits, ideally several gigabit/s, of bandwidth. As a result, vehicles would be able to receive and send the relevant data quantities for increased comfort. Because standardisation groups are currently meeting and are defining application cases, experts forecast that the first products will appear on the market at the beginning of the next decade and will support fully and highly autonomous driving beginning about 2025. An important question that still must be answered involves the frequency range that should be used for 5G V2X. After all, there is no available and gratis frequency range below 60 GHz around the world that could carry this amount of data. There is also a physical problem in the area of 60 GHz, an issue that involves the resonant frequency of the oxygen molecule. If this molecule begins to oscillate, it will withdraw energy from radio waves and restrict their range to just a few metres. Applications such as communications among vehicles and the infrastructure would be impossible as a result. Antenna technology offers a way to solve this problem: Instead of using an omnidirectional antenna that sends out radio waves in a ring-shaped form, several directed antennas would be used. These antennas could continuously beam their waves in one direction and increase the range during the trip in the process. They will be needed to receive the signals of other vehicles on the road and to send their own signals as well. They will also have to be connected to one another as well as with the vehicle's computers. This, in turn, will require the automotive Ethernet to quickly transmit the data.

THE FUTURE BEGINS NOW

Car manufacturers are already testing automated cars in field trials. Initial results show that drivers accept the autonomous cars and are willing to turn over control to them. The autonomous car acts like a human being: Sensors receive a signal, transmit it via the nervous system and communication systems to the brain and communicate over (directed) antennas with other vehicles on the road.

By Guido Dornbusch, VP Product management Molex Connected vehicle solutions and Alex Bormuth, Director Business development Molex Connected mobility solutions



For more information visit avnet-abacus.eu/molex

The future is 5G

'The explosive growth of the IoT shows no signs of abating, with Gartner forecasting 20.8 billion connected "things" by 2020, and IHS Markit predicting that this number will rise to 125 billion by 2030.'

Whilst we are still early in its deployment cycle, 5G's characteristics and performance capabilities are well defined and its potential to enable new and improved applications is already clear. Beyond those applications which have already emerged, however, it is widely anticipated that 5G will transform many areas of our lives by enabling further levels of innovation across multiple vertical segments, including healthcare, automotive, smart cities and industrial automation.

Most analysts and industry commentators are united in their view that 5G will underpin the next wave of growth in global GDP and a recent report, commissioned by the GSMA, a trade association representing the interests of global mobile network operators, concluded that 5G will contribute $2.2 trillion to the global economy over the next 15 years (Figure 1), with the biggest beneficiaries being the manufacturing, utilities, and professional and financial services sectors.

5G Enables a powerful set of use-case scenarios

5G's network capabilities were specified to address the requirements of three broad use-case scenarios, as illustrated in the diagram published by the ITU (Figure 2) and summarised on the next page.

Enhanced Mobile Broadband, (eMBB)

With extremely high data-rates, up to 20Gbps, eMBB provides an improved consumer experience and also supports high bandwidth applications such as Augmented Reality (AR), Artificial Intelligence (AI), and Virtual Reality (VR).

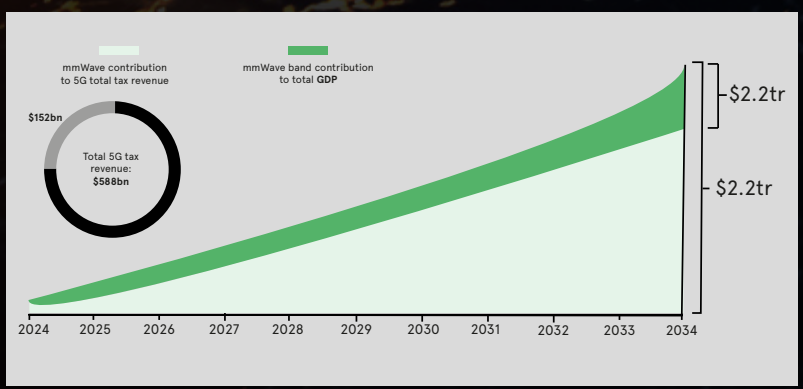


Figure 1: Estimated impact of 5G on the global economy (Source: GSMA)

Adam Chidley

Marketing Manager, European Product Marketing
Avnet Abacus

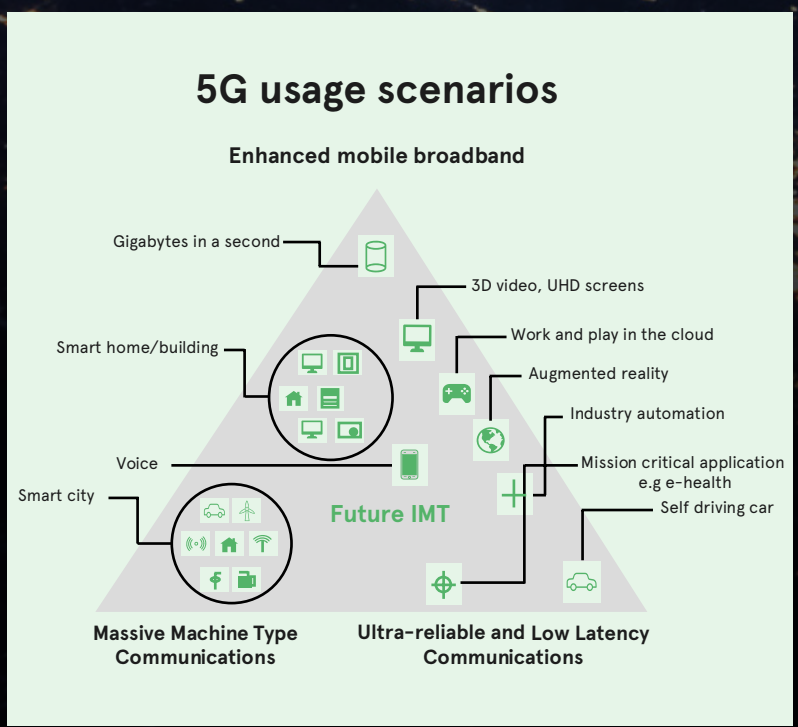


Figure 2: Broad 5G use cases
(Source: (ITU)

Massive Machine Type Communications (mMTC)

mMTC provides wide-area coverage and deep indoor penetration for an extremely large number – up to 1 million per square kilometre - of connected devices. This use-case addresses the requirements of the rapidly growing mobile IoT, by providing Low-Power-Wide-Area, (LPWA) technologies which enable low power consumption, improved coverage and optimised transmission for small and intermittent blocks of data.

Ultra-Reliable and Low Latency Communications (URLLC)

URLLC supports highly mission-critical applications which are heavily dependent on extremely low end-to-end (E2E) latencies (one millisecond or less), along with high reliability and availability.

BENEFIT AREA	EXAMPLES	SERVICES
Improved connectivity	Faster and more reliable connectivity for a wide range of users in environments such as road and rail, dense areas and at home	Increased consumer value and productivity gains
New consumer devices and services	Smart devices and services including immersive media and entertainment, healthcare wearables, and autonomous vehicles	Variety of consumer and business benefits, driven by innovation
Smarter infrastructure and public services	Examples include advanced asset tracking, remote control, predictive maintenance and sensor-enabled processes across multiple sectors	Increased productivity
Smarter infrastructure and public services	Street lighting, traffic management, energy grids	More efficient and secure service delivery, environmental benefits

Table 1: Summary of anticipated 5G benefits

In practice, not all applications will need to use all of 5G's capabilities, whilst others may require different combinations, as illustrated in Figure 2, often varying dynamically. A remote IoT sensor, for example, will have a consistent need for low battery usage, low power and low data rate communications, placing it firmly in the mMTC use case. Remote robotic surgery will, as we will see later, require a combination of eMBB and URRL capabilities, as the application must transfer large quantities of sensor data from the robotic device to the surgeon whilst also enabling near real-time responses during the operation.

This changing mix of requirements is handled by 5G's network slicing functionality which enables the allocated network resources to change dynamically, in-line with the application's needs.

Emerging applications give insight into the power of 5G

As discussed earlier, there are significant expectations on the contribution that 5G will make to future global economic prosperity. Although much of this contribution will come from applications which are yet to emerge, 5G's potential benefit areas can be classified as described in Table 1 and the remainder of this section considers a sample of current, high profile applications which are already integrating 5G capabilities.

Autonomous vehicles

The driverless car is a leading example of a current, high-profile technological development, with vehicles such as Google's Waymo, BMW's Vision iNext and Tesla's models frequently featuring in headlines. Although these vehicles are still very much at the development stage, analysts are predicting strong growth in this sector over the next five years, with widespread availability of 5G networks being seen as a fundamental pre-requisite to this growth.

Reliable and safe operation requires that the autonomous vehicle must continuously interact with its environment, communicating with other vehicles, roadside infrastructure, pedestrians, and other entities, such as remote data centres. This interaction will draw heavily on 5G's capabilities: URLCC enables the vehicle to respond and react in real-time; eMBB supports the transfer of large amounts of data – as much as 2 million Gbps - as the vehicle senses and communicates with its environment; and mMTC enables an extensive network of roadside sensors. The subset of cellular technologies required to support autonomous vehicles has been termed vehicle to everything (V2X) and 3GPP has been building progressive cellular support for V2X into its releases (Figure 3).

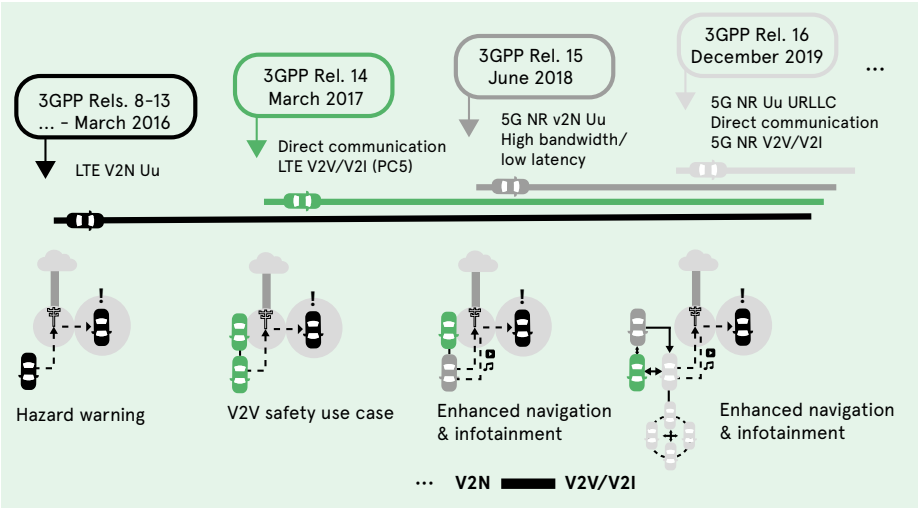


Figure 3: Evolution of 3GPP V2X standards (Source: 5GAA, Timeline for deployment of c-V2X – Update)

Remote robotic surgery

Another application capitalising on early 5G deployments is remote robotic surgery. Haptic, as well as visual, feedback is critical in surgery and the surgeon must react to both types of stimuli in under 10 mSecs – a response time which has previously presented a barrier to remote surgery. Because of this, robotic surgical devices have until now had to be directly controlled by a surgeon within the same physical environment as the patient.

Now, however, a collaboration between telecommunications giant Ericsson and King's College London (KCL) is working on the application of 5G technology to remote telesurgery. Ericsson has developed specialised haptic gloves, enabling a surgeon to operate on a patient using a robotic device, with no loss of sense of touch. The eMBB capabilities of 5G are used to stream the haptic data from the advanced sensor arrays on the robotic device, along with video from the operating theatre. The URLCC capabilities of 5G are crucial in enabling the data to be streamed from the remote operating theatre to the surgeon within the required 10 mSec delay.

5G networks have already enabled real world operations using remote tele-surgery when, in March 2019, People's Liberation Army General Hospital (PLAGH) chief physician Ling Zhipei performed brain surgery on a Parkinson's disease patient in Beijing from the PLAGH Hainan Hospital 3,000km away.

The IoT

The explosive growth of the IoT shows no signs of abating, with Gartner forecasting 20.8 billion connected "things" by 2020, and IHS Markit predicting that this number will rise to 125 billion by 2030. IoT applications span most sectors, including the Industry 4.0 factory, smart cities, agricultural monitoring, pipeline monitoring, aircraft maintenance and many more, with the intelligent sensor or 'thing' as the common denominator. A significant proportion of these applications require LPWAN technologies which are characterised by enhanced indoor, outdoor and underground coverage and enable battery-powered devices, which transmit data only occasionally, to achieve battery lives of up to 10 years. Many operators have been developing LPWAN offerings based on either NB-IoT or LTE-M networks, both of which were defined in 3GPP Release 13, with the GSMA reporting 89 NB-IoT networks and 34 LTE-M launches as of October 2019. Recognising this investment, 3GPP has confirmed that both technologies meet the 5G specifications and will underpin the mMTC capability as the 5G standard continues to evolve, guaranteeing a smooth migration path for existing solutions.

The 5G journey is just beginning

The roll-out of 5G is just over one year old but, even before the first network was deployed, expectations of 5G were exceptionally high, with analysts predicting that it will be the next driver of global economic growth, enabling significant future value creation across multiple sectors. 5G's real value will be based upon enablement of emerging applications rather than on faster handsets, and this article has considered how 5G's capabilities are enabling a sample of these current applications. We are clearly only at the beginning of a long road with 5G, but the pace of innovation can only be expected to accelerate as operators embrace the full opportunities offered by investing in fully functional 5G networks.

Panasonic Industry Bluetooth® Low Energy modules

The PAN1740A and the PAN1780 extend Panasonic Industry's wireless connectivity product portfolio. The Bluetooth® 5.0 modules reduce complexity, costs and eliminate the need for certification in comparison to a chip solution. Fast implementation and reliable performance mean that adding wireless connectivity to your design has never been easier.

PAN1740A

The new PAN170A is the optimised version and the successor of the PAN1740 Bluetooth® module, offering a quicker boot time and supporting up to eight connections to allow greater flexibility to create more advanced applications. It can be used as a standalone application processor or as a data pump in hosted systems. Next to it's Bluetooth® 5.0 core features it also supports high duty cycle and efficient non-connectable advertising. The device is optimised for Remote Control Units (RCU) requiring support for voice commands and motion/gesture recognition. The PAN1740A offers a very small form factor of 9.0 x 9.5 x 1.8mm. The module is designed to connect small applications to each other or your smartphone.

CHARACTERISTICS	PAN1740A	PAN1780
RF Category	Bluetooth®5.0	Bluetooth® 5.0, IEEE® 802.15.4 & NFC-A
Software & drivers	SDK by Dialog	SDK by Nordic
Integrated circuit	DA14585	nRF52840
Size [mm]	9.0 x 9.5 x 1.8	15.6 x 8.7 x 2.0
Rx sensitivity [dBm]	-93 @ 1 Mb/s	-95 @ 1Mb/s -103 @ 125kb/s
Tx power (max.) [dBm]	+0	+8
Power supply [V]	2.2 to 3.3	1.7 to 5.5
Current consumption	Tx: 4.9mA @0dBm Rx: 4.9mA	Tx: 4.8mA @0dBm Rx: 4.8mA
Microcontrollers & memory	ARM® Cortex® -M0 96kB SRAM, 64kB OTP	ARM® Cortex® -M4F 256kB RAM, 1MB Flash

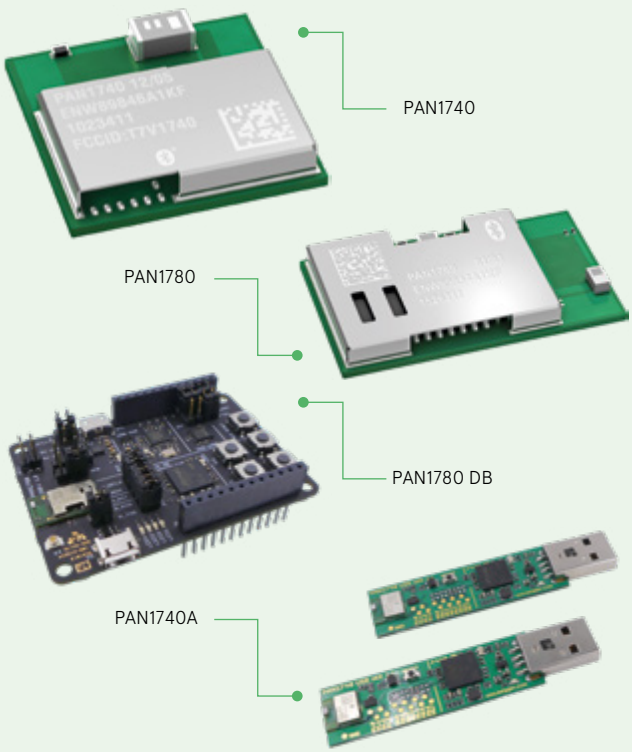
For more information visit avnet-abacus.eu/panasonic

PAN1780

The PAN1780 is a Bluetooth® 5.0 Low Energy module based on the Nordic nRF52840 single-chip controller. Besides Bluetooth® 5.0 with the qualified Bluetooth® mesh profile stack it supports 802.15.4 and NFC-A. With its Cortex™ M4F processor, 256kB RAM and the built-in 1MB flash memory it can easily be used in standalone mode, thereby eliminating the need for an external processor. An output power of up to +8dBm and the high sensitivity of the nRF52840 in combination with the LE coded PHY make the module very attractive in applications where a long range is required. In addition the ultra-low current consumption of the PAN1780 makes the module an ideal choice for battery powered devices.

The PAN1780 takes smart home efficiency to the next level: it enables the operation of various control systems and mesh networks at a very low power consumption. Possible applications could be intelligent lighting or access control. Furthermore, it opens the door for a wide range of interconnected applications.

Besides the above, the PAN1780 proves to also be an appropriate option for Industrial IoT applications like sensor hubs or factory automation. In general, it is the technology of choice wherever there is need for a maximum performance (1MB Flash and 256kb RAM) at a minimum power consumption (4.8mA in transceiving data).



Panasonic INDUSTRY

Omron G6K series miniature surface mounted high frequency relays

Omron

The G6k relay from Omron is compact and ideal for high density mounting. The unique terminal structure ensures excellent soldering properties and the light weight of 0.7g allows for higher speed mounting.

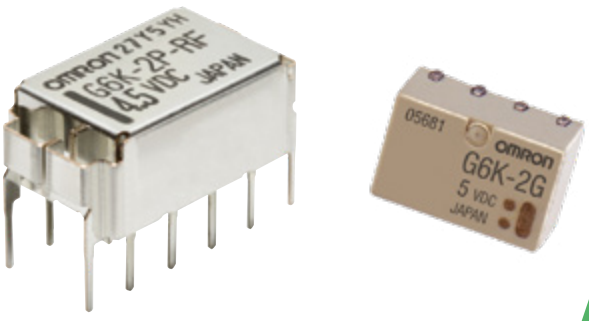
FEATURES

- Subminiature model as small as 10 x 6.5 x 5.2mm (L x W x H) ideal for high density mounting (G6K(U)-2F(-Y))
- 5.2mm low profile improves mounting efficiency (G6K(U)-2F(-Y)).
- Dielectric strength of 1,500VAC and conforms to FCC Part 68
- -Y models can withstand impulse voltage of 2,500V for 2x10μs
- Standard model conforms to UL/CSA standards, certified by BSI (EN62368-1)
- Models available with a 2.54mm terminal pitch
- Rated carry current: 2A

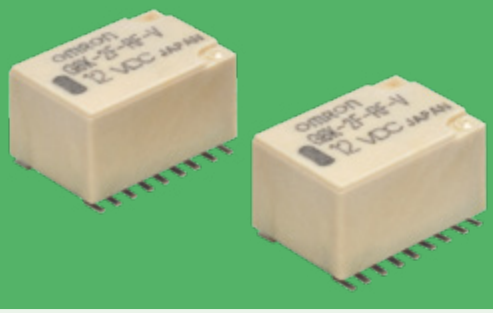
APPLICATIONS

- Telecommunications
- Office automation
- Test and measurement equipment
- Building automation
- Security
- Industrial
- Amusement equipment
- Home appliances

G6K-RF RELAYS



G6K-RF-V RELAYS



The two high frequency versions, the G6K-RF (3GHz) and the G6K-RF-V (8GHz) are specifically suited for telecommunication and communication applications.

G6K-RF RELAYS

- High-frequency characteristics (insertion loss of 0.2dB max. at 1GHz)
- Compact size 10.3 x 6.9 x 5.4mm (L x W x H)
- Rated power consumption of 100mW with high sensitivity
- Single-side stable and single-winding latching models are available
- Models with a smaller footprint (G6K(U)-2F-RF-S) are available to help save space
- G6K(U)-2F-RF-T models for 3GHz band join the lineup with a downsized footprint
- New PCB terminal models are available

G6K-RF-V RELAYS

- Superior high-frequency characteristics (insertion loss 3dB or less at 8GHz)
- Compact size 11.7 × 7.9 × 7.1mm (L × W × H)
- Rated power consumption of 100mW with high sensitivity

For more information and to download the white paper visit avnet-abacus.eu/omron

OMRON

Murata thermistors for 5G network applications

Murata

NTC THERMISTOR (NCU SERIES)

The Murata NCU series of chip type NTC thermistors can be used for wide temperature sensing and compensation, and are ideal for high reliability applications in the automotive market.

NTC Thermistor (NCU series)

FEATURES

- Highest standard QCDS from various line up
- Highly accurate R Tolerance: +/-1%, +/- 0.5%
- UL/cUL approved item: 1005, 1608mm

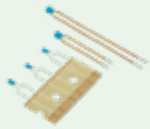
LEAD NTC THERMISTOR (NXF, NXR SERIES)

The NXF series of thermal string type NTC thermistors with flexible leads is a series of electronic components for detecting and measuring temperature.

FEATURES

- Small sensing head containing Murata's NTC chip
- High accuracy and response
- Flexible lead, self standing

NTC Thermistor (NXF series)



NTC Thermistor (NXR series)

PTC THERMISTOR (PRF, PTF SERIES)

Exploiting the PTC characteristic (a sharp increase in resistance above a certain temperature), the PRF series chip PTC thermistors are used for overheat sensing in FETs, power ICs, and other heat generating areas.

PTC Thermistor (PTF series)

FEATURES

- Miniaturisation of electronic circuit
- Great thermal responsiveness
- Mechanical vibration and shock-resistant
- Non-contact operation
- Non-noise generating

PTC Thermistor (PTF series)

PTC Thermistor (PRF series)

For more information visit avnet-abacus.eu/murata

muRata
INNOVATOR IN ELECTRONICS

The future is 5G with Bourns

Bourns

While we are still early in the 5G deployment cycle, its characteristics are defined and much of the potential for new and improved applications is already clear. With 5G taking the Internet of Things to the next level, Bourns offers a wide range of products to support relevant applications.

POWER

- GMOV™ hybrid protection components for AC input protection
- Fully shielded inductors for Point of Load DC-DC converters
  - SRR, SRU and SRP moulded
- Stacked GDTs for DC supply protection
  - 2033
- Chip resistor shunts for DC power monitoring
  - CSS shunt and CRF current sense
- TVS diodes for DC supply protection
  - PTVS2, PTVS1 and PTVS3/6/10

Stacked GDTs for DC supply protection: model 2033

GMOV™ hybrid components for AC input protection

Fully shielded inductors for Point of Load DC/DC converters

CSS shunt

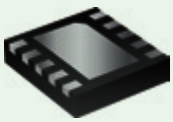
CRF current sense

Chip resistor shunts for DC power monitoring

SIGNAL

- Chip LAN transformers and common mode chokes for >1Gb Ethernet
- Chip beads for EMI filtering
  - MG, MU, MZ and MH
- TVS diode arrays for signal port ESD protection
  - CDDFN10-3304NA
- Power over Ethernet (PoE) transformers
  - SM51589PEL

ChipLAN transformers and CMC for >1Gb Ethernet: model SM453229



TVS diode arrays for signal port ESD protection: model CDDFN10-3304NA

Power over Ethernet (PoE) transformers: model SM51589PEL 5kV

Chip Beads for EMI filtering

BOURNS®

For more information visit avnet-abacus.eu/bourns

Engineers' Insight: the Avnet Abacus blog

Solving design challenges

Avnet Abacus' technical blog, Engineers' Insight, is designed to help you solve key challenges across the breadth of markets and technologies we serve.

From electronics phenomena such as equivalent series resistance in electrolytic capacitors, to discussions on the best approaches to new wireless technologies, to in-depth design guides for power solutions, this is a blog written for engineers, by engineers.

Where to read?
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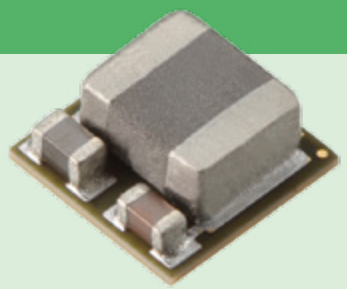

TDK µPOL DEVICES OFFER BEST PERFORMANCE AND CURRENT SIZE/DENSITITY

IC+DRIVER+ MOSFET + INDUCTOR + LOCAL BYPASS + EMBEDDED PACKAGE (SESUB) =

Easy-to-use, fully integrated and highly efficient 6A, 4A and 3A micro-point-of-load (µPOL™) voltage regulator

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- SESUB mounted controller with I2C digital communication
- Integrated MOSFETs
- Incorporated inductor and capacitors deliver an extremely compact, low noise and accurate regulation
- Plug & play (no external compensation required)
- Compact, low-profile package 3.3 x 3.3 x 1.5mm
- Multi ready-to-use design macros
- Comprehensive software tools
- Multi device design boards
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- Wide input voltage range (2.5-16V)
- Adjustable output voltage, ±0.5% initial accuracy
- -40°C to 125°C operating temperature

POWER SYSTEM OPTIONS

- Output voltage trimming +/-5mV steps
- Overvoltage/undervoltage/overcurrent set points
- I2C/PMBus advanced power

EASE OF DESIGN

Xilinx:	Artix 7, Spartan 7, Zynq 7, UltraScale+
Intel/Altera:	Cyclone, Arria
Microchip:	Microsemi PolarFire
Others:	NXP i.Mx8, Marvell/Cavium, ARM, Generic5W to 150W

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