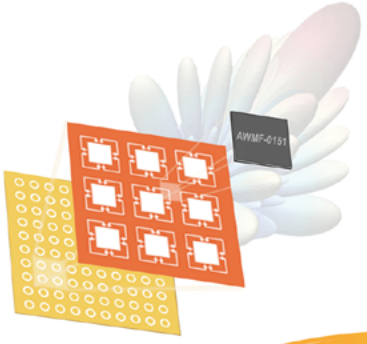
HOW IMPORTANT IS mmW TO 5G?



Enabling ICs for mmW 5G Systems

Anokiwave

mmW Solutions. Enabling a new world

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“It's being called "the future of communications”, "the greatest communications technology" that brings performance improvements demanded by the world's population that has become reliant on instant "everywhere" communications. To deliver on these promises, 5G must operate over much more frequency specturm than current 4G systems - frequency at 24 GHz or higher - or mmW bands.

How Important is mmW to 5G?

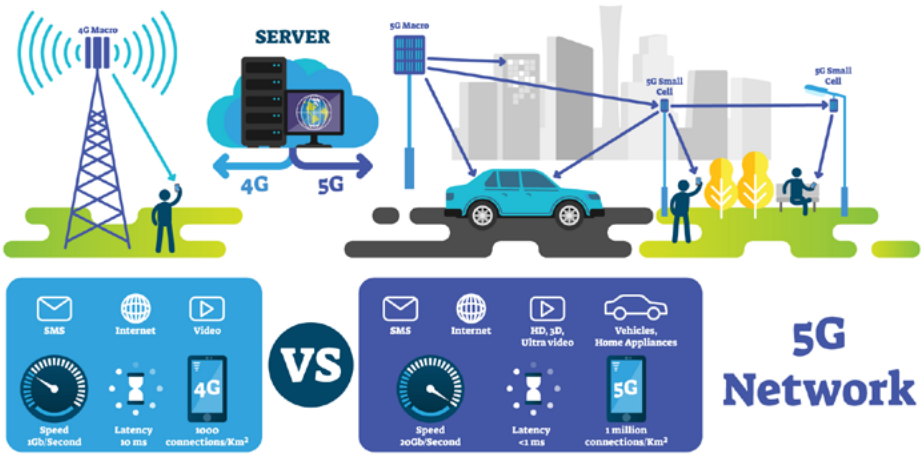
by Ke Lu, Anokiwave, Inc.

It is being called “the future of communications.” The world’s population has grown so reliant on instant “everywhere” communications that Fifth Generation (5G) cellular wireless communications networks are being hailed as the latest and greatest communications technology, bringing performance improvements above and beyond 4G LTE technology. For 5G New Radio (NR) technology to deliver these improvements, network infrastructure is needed in for form of smaller cells and base stations more closely spaced than 4G LTE network towers and it must operate across much more frequency spectrum than 4G LTE. Some of that added spectrum will be below 6 GHz while a large amount of it will be at 24 GHz and higher, through millimeter-wave (mmW) frequency bands. The wide bandwidths available at these higher frequencies will support truly high-speed, low-latency, short-range applications. 5G systems will use a variety of different frequencies, below 6 GHz and above 24 GHz, to connect users with smartphones and even machines such as autonomous “self-driving” vehicles and Internet of Things (IoT) sensors. But how much of 5G NR networks will depend on mmW frequencies?

mmW Enables 5G Performance

The real performance differences in wireless communications speed/latency between 4G LTE and 5G is due to 5G's mmW frequencies. The large available bandwidth at mmW frequencies will make it possible to download a digital two-hour movie in seconds compared to minutes for the same size file downloading over a 4G LTE network. This edge in speed and capacity comes from operating in the mmW bands. To achieve these high-performance levels at mmW frequencies, the installation of infrastructure hardware and software in additional small cells are required. Because of the propagation characteristics of mmW signals, these small cells must be closely spaced and supported by advanced technologies such as active antenna arrays capable of beam steering and massive multiple-input, multiple-output (MIMO) antenna configurations to direct energy from small mmW cells to users. 5G NR antennas in small cells focus signals between network nodes and users to make the most efficient use of available energy at higher frequencies as opposed to 4G LTE network infrastructure with omnidirectional antennas for lower-frequency communications.

To make it practical and efficient for 5G, Anokiwave has applied the essential technology of active antennas to a line of Silicon Core ICs covering the different millimeter-wave bands of 5G wireless networks with the performance required to create low-cost 5G wireless links.



5G network performance improvements are due to new mmW antenna configurations with active beam steering

Such outstanding performance will not come without investments in network infrastructure. Licensing the mmW spectrum is part of the investment, building the new infrastructure is another. Verizon, AT&T, T-Mobile, and other large telecommunications providers are already showing a clear and sustained commitment to 5G and mmW.

Since 2017, carriers have either spent or committed to spend nearly $14 billion on mmW frequencies through acquisitions or via spectrum made available by FCC auctions. Verizon's purchase of XO Communications for $1.8B, that included a large amount of mmW spectrum assets, in 2017[1] and Straight Path for $3.1B in 2018[2] started these large investments on mmW spectrum. AT&T followed suit with the acquisition of FiberTower for $207M in 2018[3]. Each of these companies owned valuable spectrum in the 28 GHz and 39 GHz bands.

Anokiwave ICs enabled mmW 5G in the majority of the network deployments in 2019. By commercially supplying 5G ICs in every mmW band, we are enabling the ecosystem for more than $14B of investments in mmW spectrum.

Auction 101 in 2018 for additional spectrum in the 28 GHz band resulted in $702M in winning bids, with Verizon winning the majority of spectrum in this auction[4]. Auction 102, for spectrum in the 24 GHz band, followed in 2019 raising $2B in bids with AT&T and T-Mobile winning the majority of these licenses[5]. Auction 103, the FCC's latest auction of mmW spectrum resulted in $7.6B in proceeds with Verizon, AT&T, and T-Mobile as top spenders.[6]

Wireless service providers are busily installing 5G mmW infrastructure equipment into existing 4G base stations as non-stand-alone (NSA) network nodes and into closely spaced small cells as stand-alone (SA) network nodes. The mmW capabilities of 5G NR networks are especially beneficial in densely populated areas where users need high-speed fixed as well as mobile wireless communications services as alternatives or replacements for cable or fiber-optic services. In densely populated areas, the large numbers of simultaneous wireless users can cause delays in overburdened 4G LTE networks. The addition of 5G NR infrastructure with mmW capabilities not only adds capacity and higher performance for users with access to it but also frees network capacity for users still operating at lower 4G LTE frequencies.

Markets for 5G mmW

Why is mmW bandwidth so important to 5G NR networks? Globally, any users wanting improved enhanced mobile broadband (eMBB) services compared to 4G LTE will want the eMBB performance possible above 24 GHz. Wireless mobile users are growing accustomed to having access to the Internet at any time, using mobile devices for access. Improved eMBB services will support downloading larger files (such as the 3-s download of a 2-h video file), gapless streaming of video, and the use of augmented-reality (AR) and virtual-reality (VR) applications such as business meetings and university educational events.[7]

Service providers such as Verizon look to the added speed and capacity of 5G NR with mmW infrastructure to avoid congestion during peak hours, especially in densely populated areas. As business users turn to an increasing number of "data-consuming" activities, such as meetings with live video, service providers must find ways to provide faster upload/download speeds without glitches or delays. In addition, the growing number of IoT devices within densely populated areas also drains wireless network capacity and requires the capacity and speeds provided by 5G NR mmW network infrastructure. Of course, achieving this added capacity requires the installation of 5G NR infrastructure with mmW bandwidth and, fortunately, densely populated cities represent areas with customer bases that can support the investment.

Service providers are installing 5G NR infrastructure with mmW bandwidth in densely populated areas around the world first because of the needed additional capacity and speed and due to the relationship of population density to network equipment and operating costs. Rural areas simply may not have the number of users on average to justify the immediate investment in 5G NR small cells. Larger numbers of users in densely populated areas explains why 5G NR service will come to highly populated areas first, such as New York City and other large cities in China, Japan, Korea, Singapore, and Taiwan.

As business users turn to an increasing number of "data-consuming" activities, mmW 5G networks provide increased speed and capacity especially in densely populated areas as service providers search for ways to provide faster upload/download speeds without glitches or delays.

China is a good example of an area with a large population density and many wireless communications device users. Wireless service in China is provided by government-owned telecom companies, such as China Mobile, China Telecom, China Unicom, and China Radio. These telecom companies work with government agencies such as the Chinese Ministry of Industry and Information Technology (MIIT) to ensure the quality of service provided by the wireless networks and they have been steadily adding 5G NR infrastructure to cities such as Beijing, Shanghai, and Shenzhen where the dense populations can benefit from the performance and the added capacity of 5G NR networks with mmW frequency. One of China's leading mobile telecommunications service providers, China Mobile, has already built more than 20,000 5G NR base stations, with more than 3500 5G NR base stations in Beijing. The mmW bands in use in China include 24 to 27 GHz and 37 to 42 GHz.[8]

South Korea has also aggressively pursued its build-up of 5G NR infrastructure, with leading local service providers, SK Telecom, LG Uplus, and KT Corp., contributing to a rapid buildup of 5G NR microcells with mmW frequency coverage along with U.S. service provider Verizon. South Korea's telecom companies have been in sync with China (since about April 2019) in offering 5G wireless services in major cities such as Seoul, with more than 5 million 5G NR customers on record as of April 2020.[9]

These Korean wireless service providers are not just connecting smartphones to each other but are providing a glimpse at how the mmW portions of 5G NR networks will be applied. The low latency of 5G at mmW frequencies (no more than 2 ms) makes 5G NR networks attractive for "self-driving" autonomous vehicles, where vehicle-to-vehicle (V2V) and vehicle-to-network communications must be instantaneous to avoid accidents. Densely populated areas are also expected to leverage 5G's increased bandwidth for interconnection of billions of Internet of Things (IoT) sensors as part of smart cities to provide control, monitoring, and automation in homes, offices, medical facilities, and factories.

The low-latency of mmW 5G enables increased bandwidth for autonomous vehicles and interconnection of billions of IoT sensors for control, monitoring, and automation in homes, offices, medical facilities, and factories.

For example, SK Telecom is working with a 5G factor alliance group to create smart factories based on IoT technology and 5G NR network capacity. KT Corp., Korea's largest wireless service provider, is exploring expanded use of 5G's capabilities, in such applications as "cloud" computing, advanced security for home and office, artificial intelligence (AI), and for zero-latency autonomous driving. The company sees a bright future for the many uses for 5G NR technology not just in Korea but in hundreds of countries in terms of data roaming and has committed $400 million in 5G research and development (R&D) through 2023.[10]

Of course, not to be outdone by these 5G NR efforts around the world, leading U.S. service providers such as Verizon are making major investments, in the amount of $18B in just in 2020, covering 5G expansion, upgrading 4G LTE base stations to 5G NR service in densely populated areas of the U.S, and adding fiber.[11] Network customers will retain 4G LTE service with these upgrades and, as new user equipment (UE) for 5G, such as the Samsung Galaxy smartphone, become available, those customers will gradually experience the improved service of 5G NR networks, especially at mmW frequencies.

Practical Solutions

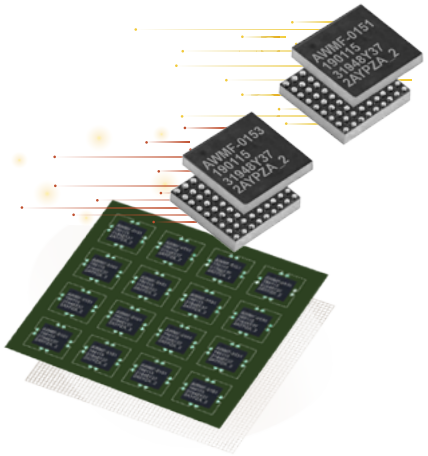
To speed and simplify the design and development of the many small cells and even customer premises equipment needed for 5G NR coverage, Anokiwave applies advanced 300-mm silicon (Si) CMOS semiconductor technology to the fabrication of its highly integrated beamformer integrated circuits (BFICs) and intermediate-frequency integrated circuits (IFICs). Provided in packages that fit within the small mmW lattice spacings, these devices serve as the core components of multiple-element active antenna arrays at all key 5G NR mmW frequency bands: 24/26, 28, and 37/39 GHz. They are also ideal for mmW satellite communications (SATCOM) and radar applications.

Anokiwave ICs enable intelligent, scalable antenna arrays that can be configured for different power levels and frequency bands. This is important as the flexibility to optimize the array for different use cases - infrastructure, small cells, and CPE - is important as the needs vary from application to application.

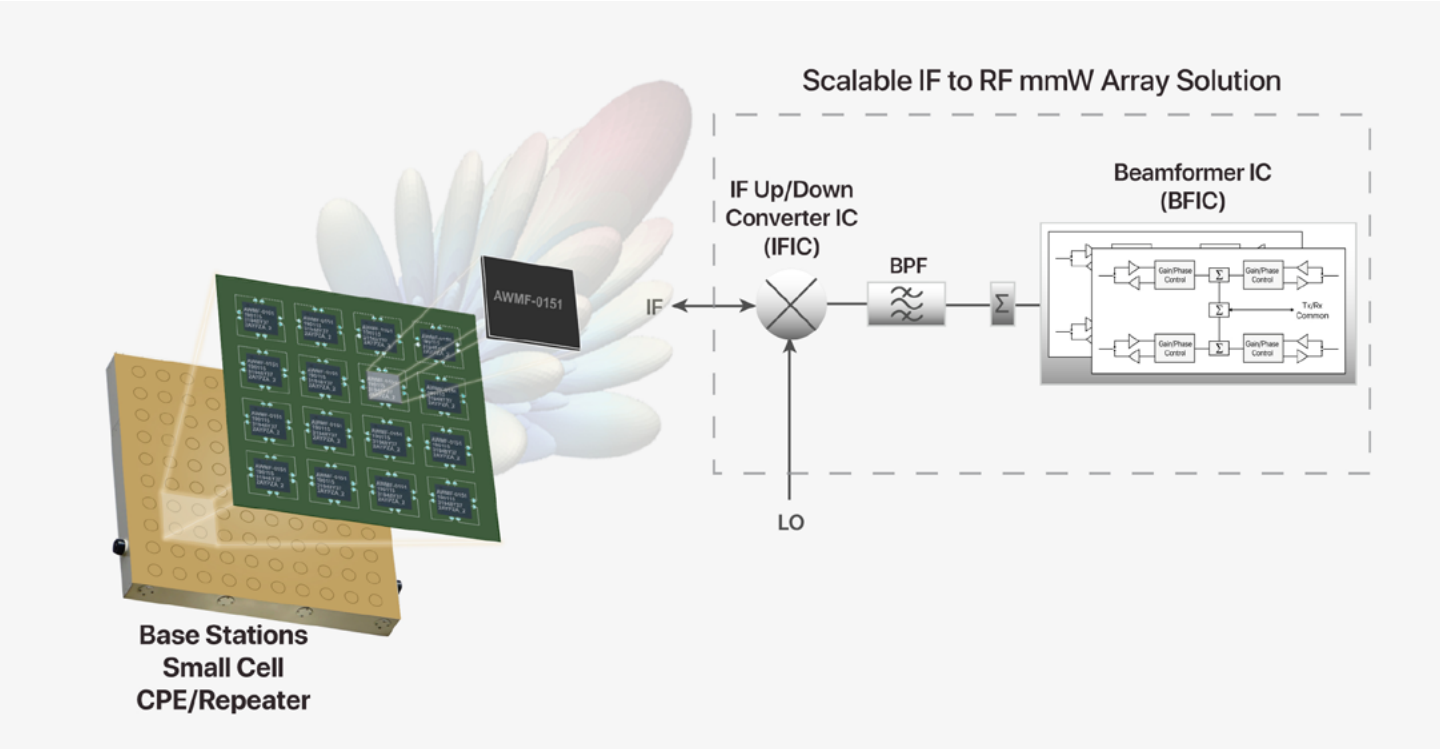
Leveraging the knowledge and design experience gleaned from two earlier generations, Anokiwave recently launched several third generation (Gen 3) BFICs and IFICs for 5G: AWMF-0165 and AWMF-0170 for the 24/26 GHz band, AWMF-0151 and AWMF-0153 for the 28 GHz band, and AWMF-0159 and AWMF-0161 for the 37/39 GHz band. Each IC is supplied in a compact wafer level chip scale package (WLCSP) ideal for planar antenna designs. The beamformer ICs provide horizontal and vertical polarization and transmit and receive functions by controlling the gain and phase of four antenna elements in a phased array. In addition to excellent gain and dynamic range, the ICs incorporate many useful features to ensure high reliability, such as ESD protection on all package pins and over-heating detection.

Housed in the same type of package, the IFICs are transmit/receive frequency up/downconverter ICs for moving mmW signals from mmW to and from a lower-frequency IF range for digital conversion and signal processing. They include all the components needed for frequency conversion in one IC, including amplifiers, local oscillators (LOs), and frequency multipliers. They cover the mmW 5G NR frequency ranges specified by Third Generation Partnership Program (3GPP) standards, offering system designers a low-cost, practical solution for frequency conversion in small cells and other 5G NR infrastructure equipment.

Anokiwave ICs deliver the maximum number of options for performance, cost, and functionality for mmW 5G. By harnessing the appropriate level of integration, three generations of active antenna IC learning, and cost structures only available on 300 mm diameter silicon processes, Anokiwave has enabled the total cost of ownership for base-stations and small cells to resemble Wi-Fi access points.



Anokiwave's family of mmW 5G ICs deliver the maximum number of options for performance, cost, and functionality enabling the total cost of ownership for base-stations and small cells to resemble Wi-Fi access points.



Anokiwave offers a complete RF signal chain solution for 5G mmW arrays with system level performance optimized for each 5G use case

Conclusion

Expectations for 5G are massive; It is being called “the future of communications.” For 5G to deliver on these expectations, it must operate across wide contiguous frequency spectrum - only available at mmW frequencies. The frequency bands in the spectrum above 24 GHz can support large bandwidths and high data rates, ideal for increasing the capacity of wireless networks. Anokiwave saw this market coming years ago and was the first to offer commercial 5G mmW ICs. Today, after multiple generations of learning, Anokiwave offers the industry's most complete portfolio of Silicon ICs for mmW 5G and is the trusted choice of Tier-1 and -2 OEMs worldwide.

Anokiwave powers the 5G link with the industry’s most complete portfolio of Silicon mmW ICs with real 3GPP compliant commercial deployment - enabling intelligent, scalable 5G antenna arrays.

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