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# **5G Communication and Its Future**

### Dr. Thomas Cameron Analog Devices, Inc.

In mid-2018, Dr. Thomas Cameron, director of wireless technology at Analog Devices, talked about the fifth generation of Analog Devices solutions and developments for communications technology, as well as its future. Dr. Cameron has over 30 years of experience in research and development of technology for telecom networks including cellular base stations, microwave radios, and cable systems, and he shares his expertise in the following interview.

## Let us talk about 5G communications and its future.

The 5G cycle is well underway, with many field trials completed and many others in progress globally. In the recent 5G Trial Snapshot Report from the GSA, it reported that over 326 separate 5G trials and demonstrations have been identified globally to date, with some 134 mobile operators announcing 5G trials in 62 countries. While many of these trials focus on demonstrating higher throughput, 5G introduces flexibility and new features that enable new use cases, and 5G sets the stage for the wireless standard that will carry us into 2030 and beyond.

Looking forward, we see no slowing in the generation and consumption of mobile data as video sharing becomes pervasive throughout our society. But the future of connectivity is also about connecting to the world around us as we enter the coming age of machines. We are on the doorstep of an era of digital transformation that will profoundly change the way we live, the way we work, and the way we move about daily. While the current smartphone is an interface between humans and information, future devices will be actively communicating with each other independent of human interaction and monitoring the environment around us through a dense network of connected sensors. At the core of this coming digital transformation are highly capable mobile networks connecting everyone and everything with high reliability and low latency.

While we as engineers tend to focus on the emerging specifications such as bandwidth, latency, and such, one of the foundations of 5G is flexibility. If we observe how the specifications are forming, we see the waveforms being defined to enable a range of use cases currently envisioned with provisions for use cases not even yet imagined.

At a high level, 5G is motivated by the desire to enable three major use cases.

- Enhance mobile broadband (eMBB)
- Massive machine type connectivity (mMTC)
- Ultrareliable low latency communications (uRLLC)

Currently, much of the industry 5G focus is on enhanced mobile broad band, driving toward high network capacity and higher throughput that utilizes beamforming techniques in the mid band and high band spectrum. We are also beginning to see use cases emerge, such as industrial automation, that leverage the low latency features of the 5G network architecture.

# Where does radio technology best contribute to 5G?

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Enhanced mobile broadband drives a need for higher data throughput and higher network capacity. Cellular base station capacity can be increased through three major initiatives: acquiring new spectrum, increasing base station density, and improving spectral efficiency. While we continue to see new spectrum made available for mobile use globally and network density increasing though the addition of small cells, there remains a much needed improvement in the utilization of available spectrum. In recent years, massive MIMO has emerged as a technology that can provide significant improvements in spectral efficiency. Massive MIMO is based on the use of many active antenna elements that can be adapted in a coherent manner to accurately deliver a signal to an intended user in space, while controlling the interference to other users. The large number of antennae combined with signal processing algorithms enable the systems to essentially take frequency re-use to the micro scale. This introduces a new factor in the frequency re-use equation whereby space is now used to enable the base station to simultaneously deliver independent data streams to multiple users at the same time and in the same spectrum. This results in a large improvement in spectral efficiency, which in turn results in greatly improved throughput for the cell. Figure 1 illustrates such a system. The antenna physically appears as a panel, on which many radiators (antenna element) are mounted. Behind each radiator is a radio signal chain.



Figure 1. Massive MIMO.

### What is the state of massive MIMO?

Massive MIMO has been demonstrated to provide 3 to 5 times improvement in mobile data throughput with promise for further improvements. Massive MIMO trials have been completed by many mobile operators globally and it is expected that initial commercial deployment of this technology will commence in the 2019 to 2020 timeframe by early adopters to address the most congested areas in their networks. Going forward, as massive MIMO technology evolves and new features are added in the 3GPP wireless standards, we would expect this radio form factor to propagate throughout mobile networks globally.

## How is this technology bringing challenges for the engineering community?

In massive MIMO systems we add many more radio channels to the system scaling from typical 8T8R (eight transmitters, eight receivers) TDD (time division duplex) radio head to a system of 64T64R. While the massive MIMO systems provide much improvement in base station capacity, this improvement comes at the cost of higher complexity in the radio head. Historical radio deployments utilize passive antenna enclosures fed over cables by remote radio heads. The massive MIMO physical structure is based on an active antenna architecture whereby the active radio signal chains are now embedded within the antenna assembly. Given that these radio systems are typically tower or pole mounted, there are limitations on the allowed size and weight of active antenna system. While the antenna size is dictated by the antenna element spacing, dc power consumption is also a key consideration affecting the weight of the system. There are many technical challenges for the radio designer to achieve the required radio performance within the size, weight, and power consumption limits.

# How do ADI products enable 5G and what are your recent solutions for radio developments?

There are various approaches to reduce the size, weight, and power consumption of the radio system, the most common approach leveraging circuit integration and Moore's law to shrink the size and improve power efficiency. At Analog Devices, we promote a system-level approach to solve these big problems. While integration is of course the most direct path to radio shrink, integration on its own may not yield the desired dividends. However, if we partition the system and optimize the architecture for integration, we produce a much more impressive result. For example, if we build on a radio architecture that can reduce and/or eliminate large filters and other passive elements, this leads to an overall superior solution. For example, the adoption of a zero-IF radio architecture leads to the overall lowest system complexity and power consumption and is conducive to high levels of radio function integration.

Analog Devices' portfolio of integrated CMOS radio transceivers based on the zero-IF architecture brings forth a high level of integration providing a significant improvement in size, weight and power consumption of the overall radio system. In addition to the CMOS radio transceivers, ADI offers a broad portfolio of high performance RF components for the radio frontend signal chains, precision monitoring and control functions, and highly efficient power management circuits.

A few examples of our award-winning transceiver portfolio include the AD9375 and the recently announced ADRV9009. In 2017 we announced our AD9375, the first RF transceiver to incorporate the digital predistortion (DPD) algorithm on-chip specifically designed to optimize the transmit power efficiency for small cell radios and active antenna systems. "The repartitioning of the DPD system from the FPGA to the transceiver cuts the number of JESD204B serial data interface lanes in half, resulting in a dramatic power savings particularly as the number of antennas per base station increases."

Recently, ADI expanded our award-winning RadioVerse<sup>™</sup> technology and design ecosystem with the industry's widest bandwidth RF transceiver, the ADRV9009, which provides designers with a single radio platform to accelerate the deployment of 5G, sustain 2G/3G/4G coverage, and simplify phased array radar design. The ADRV9009 RF transceiver delivers twice the bandwidth (200 MHz) of previous generation devices and replaces as many as 20 components, cutting power in half and package size by 60%. The ADRV9009 supports multichip phase synchronization with internal LOs (local oscillators), which enables high performance digital beamforming while reducing size, weight, and power consumption.



Figure 2. Industry's widest bandwidth RF transceiver speeds development of 2G to 5G base stations and phased array radar.

# Tell us more about Analog Devices RadioVerse wireless technology and how it accelerates 5G?

RadioVerse technology is the embodiment of how we have leveraged our system-level approach to bring value our customers. Our comprehensive bits-to-antenna product portfolio plus system-level expertise enables us to become more than a vendor—we become a partner with our customers to help solve their toughest problems. For example, by engaging and leveraging the RadioVerse ecosystem on our website, customers can rapidly move from concept to prototype all the way through to production.

Whether our customers are designing with our highly integrated transceiver products or our leading-edge data converter and RF portfolio, RadioVerse technology provides extensive technical information, reference designs, software, and tools to aid in the design process. Through EngineerZone<sup>™</sup>, an active support community that includes support forums, blogs, and more, designers can interact with our technical experts and get answers to design questions quickly.

The AD9375 small cell reference design is another good example of what you can find in the RadioVerse ecosystem. The reference design in Figure 3 includes all components necessary for the small cell radio, from the SERDES interface right up to the antenna. The design is suitable for indoor small cells with 2T2R 250 mW output power per antenna. All radio components are on the board, including the AD9375 with DPD, high efficiency PAs, LNAs, filters, and a power solution. The power consumption is <10 W and it comes in a very small form factor, sitting comfortably in your hand. A single 12 V supply is all that is required to power the board and it comes with an evaluation kit that connects to a baseband subsystem directly to enable a designer to quickly prototype their system.



Figure 3. Reference design.

# Can you share the commercial reality of 5G and its adoption and growth?

At the end of 2017, the 3GPP published the first 5G NR specification (Release 15). While this non-standalone specification is the first of many steps in achieving 5G, this enabled SoC vendors to move forward with modems to support the 2019 availability of 5G handsets. Recently another millstone was announced by the 3GPP on the completion of the 5G NR standalone specification, which will enable independent deployment of 5G NR networks. While the spectrum of choice varies by region, it is expected that 5G deployments will commercially launch in 2020 and consumers will begin to experience the first benefits of the 5G technology. We expect that 5G massive MIMO will leverage midband spectrum in many regions followed by millimeter wave deployments as this technology matures. In any deployment case whether it be low band, midband, or millimeter wave, ADI provides our customers with a strong and ever evolving technology portfolio to enable them to stay Ahead of What's Possible™ in 5G.

#### References

<sup>1</sup> "Analog Devices Lays Foundation for 4G to 5G Migration with Expanded RadioVerse Wireless Technology and Design Ecosystem." Analog Devices, Inc., June 2017.

### About the Author

Dr. Thomas Cameron is the director of wireless technology at Analog Devices. In this role he contributes to industry-leading innovation in integrated circuits for cellular base station systems. He is currently working on the research and development of radio technology for 5G systems in both cellular and millimeter wave frequency bands. Prior to his current role at Analog Devices he was director of systems engineering for the Communications Business Unit.

Thomas has over 30 years of experience in research and the development of technology for telecom networks, including cellular base stations, microwave radios, and cable systems. Prior to joining Analog Devices in 2006, he led the development of a broad range of RF systems and technologies at Bell Northern Research, Nortel, Sirenza Microdevices, and WJ Communications.

Thomas holds a Ph.D. in electrical engineering from the Georgia Institute of Technology. He has seven patents in wireless technology and has authored numerous technical papers and articles. He can be reached at *thomas.cameron@analog.com*.

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