An Introduction to 5G and How MPS Products Can Optimize a Base Station's AAU and BBU

Introduction

5G is a cellular network technology that is often referred to in conversation as a technological breakthrough that will make everything easier — from robot-driven surgeries, to videocalls, to the ongoing developments in AI. However, it is not always clear in these conversations what makes 5G so unique compared previous iterations, except for its faster speed.

The article will provide a look at 5G: its definition, the network architecture that makes it possible, as well as the benefits and challenges with implementing 5G in more areas. It will also introduce MPS solutions that address some of the issues faced in 5G applications, such as those related to power supplies.

What Is 5G?

5G is a global wireless standard that was released in 2019, and it is the fifth generation for cellular network technology, with previous generations being 1G through 4G. In 5G, service areas are divided into geographic areas called cells. Service areas are based around the location of a base station, which handles the reception, processing, and transmission of signals between wireless devices (such as your cell phone) and the network.

5G wireless devices communicate via radio waves sent to and received from cellular base stations (also called nodes) using fixed antennas. These devices communicate across specific frequencies assigned by the node. For example, as you travel with your phone, your phone seamlessly transfers communication between nodes to ensure that you are always connected to data. If you have reduced service or lose it entirely, you are no longer within a node's radius, and there is no other operational node nearby.

Because it is the latest standard, 5G is significantly faster and more efficient than previous generations; in addition, it can operate across three frequency ranges (low-band, mid-band, and high-band) to provide widespread coverage and speed for consumers.

Table 1 shows the main differences between the five generations of cellular network technology.

Table 1: Cellular Network Generations

Generation	Average Data Speed (Mbps)	Applications
1G	0.024	Voice calls over wireless phones
2G	0.1	Improved quality and SMS messages
3G	2	Email and video streaming, mobile data
4G	30	Social media, high-definition streaming, apps
5G	60 to 1,000	Fast internet, AI networks, sensors

5G Network Architecture

The base station is a critical component for 5G operation. The base station is comprised of two main components: the active antenna unit (AAU) and the baseband unit (BBU) (see Figure 1).

The AAU receives and transmits the radio signals that facilitate communication between wireless devices and the base station. The AAU includes the antenna, which receives the radio frequencies, and the remote radio unit (RRU), which connects wireless devices to the wireless network.

The BBU is connected to the RRU and controls data traffic and data processing. The BBU is split into the centralized unit (CU) and distributed unit (DU). The CU supports high-level functions like resource management, while the DU handles functions like signal processing and modulation.

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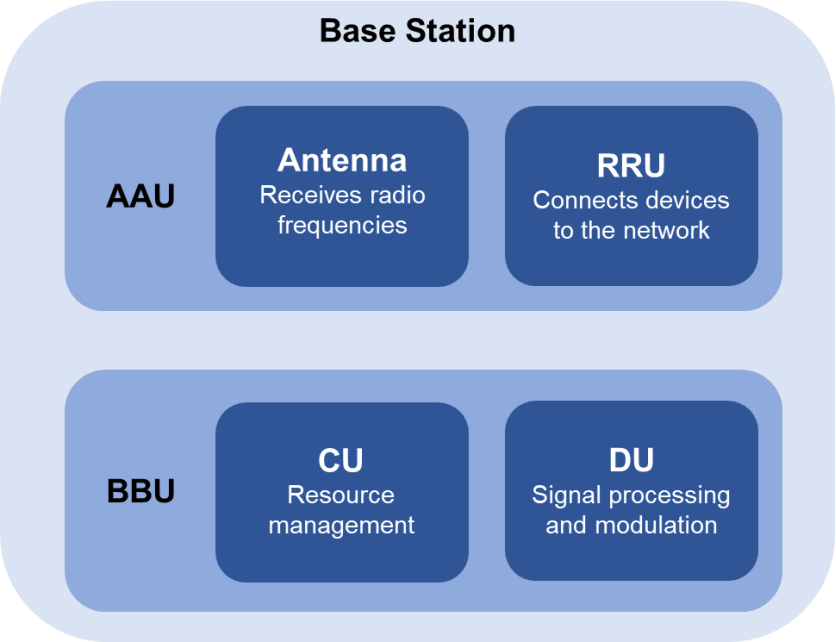

Figure 1: Base Station Architecture

Consider your phone. When you try to videocall a friend for a conversation, your phone will send a signal to closest base station within your cell. The base station will receive that signal via the antenna in the AAU. This signal is processed and transmitted to a satellite by the AAU. The satellite receives the signal from your closest base station, then the satellite sends a new signal to the base station closest to your friend's device, such as a smartwatch. When your friend's device receives the signal, they can accept the call, and you can begin communication.

What Are the Benefits of 5G?

Compared to 4G, an immediately obvious benefit with 5G is its faster download and upload speeds, which enable users to communicate with one another almost instantaneously. Faster download and upload speeds make it easier to connect online and join internet discussions, send text messages, and send pictures.

In addition, 5G has a lower latency, which reduces the time it takes for data to travel between devices. This means that when you video call your friend, the video will not lag as often, and you will consistently see them respond in real time. The enhanced mobile broadband also allows you to watch videos at a higher definition and interact with virtual reality.

In addition, 5G is better for densely populated areas because it can support simultaneous connections, which will be vital as smart homes continue to add more Internet of Things (IoT) devices, such as video doorbells, electronic smart locks, and smart thermostats that can be controlled via your phone.

Not only is 5G beneficial for consumers, but it is also invaluable for certain markets. 5G enables the development of AI and machine learning, with speeds fast enough for chatbots such as ChatGPT to quickly organize our questions to give us cohesive answers. The medical field benefits from 5G because it enables telemedicine, and can serve as a reliable communication network between someone who has been in an accident and operators who need to send rescue services.

It is estimated that 5G will continue to expand industries and provide us with new technologies that are faster, more reliable, and higher quality.

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What Are the Challenges of 5G?

One of 5G's biggest issues is its inefficient energy consumption. The infrastructure for 5G requires a dense network of cells and base stations, which can be expensive and require a long development time due to coordination between construction teams and regulation. Although 5G is designed to be more energy efficient than previous generations, it still requires a much more complex architecture with additional stations. This leads to a higher overall energy consumption, which is expensive and could ultimately create more environmental issues than it solves.

5G systems demand high power to meet incredibly fast data transmission standards, which creates a tradeoff between environmental friendliness and speed. To ensure that 5G does not harm the environment, it is necessary to innovate the hardware used in substations. Utilizing 5G's impressive transmission rates requires a new generation of technology that is small, highly efficient, and capable of dissipating heat or optimizing power sequencing.

5G is also difficult to transmit through obstacles such as buildings and trees. Significant interference slows down the data speed because the high-frequency bands have limited coverage. This also makes 5G unideal for rural areas, since implementing 5G is neither cost-effective nor environmentally friendly. Not only is 5G less likely to reach sparsely populated areas, but certain consumers may also not be able to afford devices that support 5G. This reduced accessibility will make it difficult for all devices to use 5G.

Lastly, 5G raises security concerns due to its ability to connect so many devices together. For example, if your phone is connected to a video doorbell, which is also connected to a smart lock, which is connected to your security system, it could be possible for a cyberattack to come through any one of these devices and provide access to all of the devices due to their interoperability and connectivity.

Power Solutions for 5G (AAU)

The AAU consists of a series of power supply devices to ensure that all signals are received, processed, and transmitted. For the receivers and transmitters, it is vital to have a powerful and efficient device that can produce a high output current (I_{OUT}) and optimized output voltage (V_{OUT}).

The MPQ8645 is a synchronous step-down converter that ensures the receivers and transmitters do not receive a dangerously high voltage from the intermediate bus converter (IBC), which powers a significant portion of the AAU. The MPQ8645 is fully integrated and has an adjustable V_{OUT} to meet specific application requirements. Its switching frequency (f_{SW}) is maintained at about 800kHz regardless of the input voltage (V_{IN}) or V_{OUT}, which results in a high efficiency across a dynamic range of conditions.

Not only is the MPQ8645 available in a tiny TQFN-25 (4mmx5mm) package, but this converter is also simple to use and does not require complicated configuration to operate within a system. It can be easily controlled and tuned with minimal external components for a complete solution for applications that benefit from small size.

In addition, because the MPQ8645 is an automotive-grade converter, it can operate effectively under harsh environments, which would benefit base stations in areas with unpredictable weather conditions.

To further protect receivers and transmitters, this device features over-voltage protection (OVP), over-current protection (OCP), and over-temperature protection (OTP) to protect the AAU from operating under suboptimal or even dangerous conditions.

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Figure 2 shows where the MPQ8645 would be used best in an AAU.

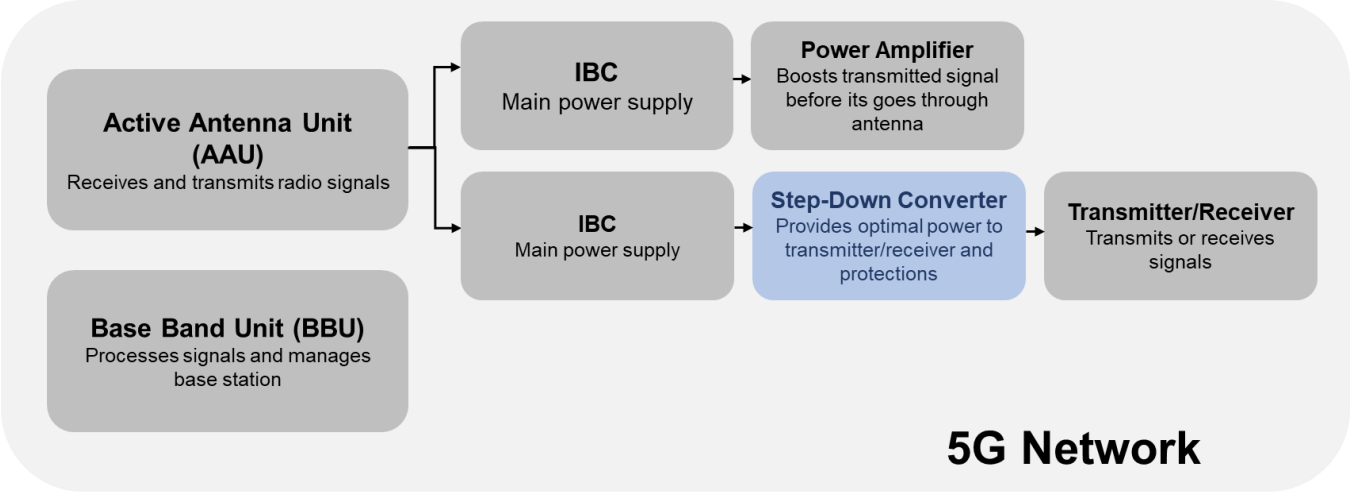

Figure 2: The MPQ8645 in an AAU

Power Solutions for 5G (BBU)

For the BBU, the DU uses field-programmable gate arrays (FPGAs) that can implement basic baseband processing functions, such as modulation and demodulation. FPGAs are excellent at handling algorithms in 5G networks. For high-speed data processing, the DU can benefit from an application-specific integrated circuit (ASIC), which is simply a circuit designed for a particular purpose.

The MP87190 is an integrated driver and MOSFET (DrMOS) solution with Quiet Switcher™ technology (QST™). QST™ uses a proprietary circuit design within a monolithic architecture to suppress voltage ringing. It also lowers EMI emissions and reduces sensitivity to PCB layout, which improves device reliability.

The MP87190 is a powerful DrMOS in a tiny TLGA-41 (5mmx6mm) package, and it can operate with tri-state pulse-width modulation (PWM) signal controllers for additional flexibility (see Figure 4). Its high 90A I_{OUT} ensures that FPGAs and ASICs are able to receive the amount of power that they require to function. In addition, it can operate across a wide 3V to 16V V_{IN}, which allows it to work under varying conditions. This device provides high efficiency and is well-suited for outdoor 5G environments due to its wide -40°C to +105°C temperature range.

Figure 3: MP87190 Package

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Intelli-Phases™ can provide power to the FPGAs and ASICs. Their high efficiency and small footprint make them ideal for these space-constrained applications, and their accurate current-sensing and temperature-sensing optimize power management by ensuring the system does not operate under over-current (OC) or over-temperature (OT) conditions. Both OC and OT conditions can result in overheating, which may damage not only the FPGA and ASIC, but can also damage neighboring components within the application.

Figure 4 shows a summary of these parts and functions, as well as where the Intelli-Phase™ would be placed within this application.

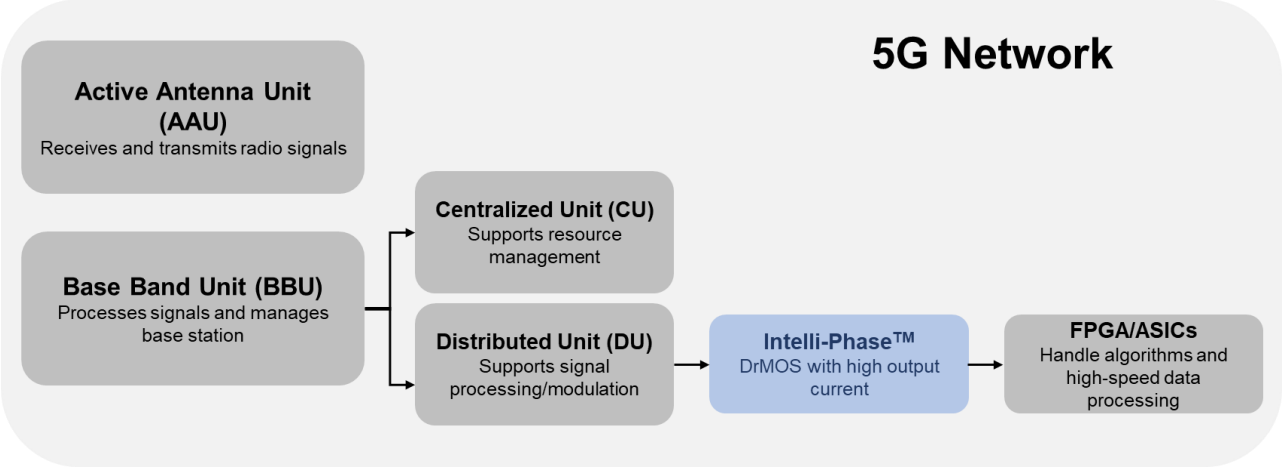

Figure 4: 5G Application with Intelli-Phases™

Conclusion

5G has and will continue to transform how we are able to connect to our devices and connect with others worldwide. Although this latest generation of technology is incredibly innovative, 5G poses challenges such as widespread adoption and efficiency.

This article described the basics of 5G and introduced two MPS parts — the MPQ8645 and MP87190 — that can be used to improve the AAU or BBU architecture within a 5G base cell station. To see other options that can meet your design needs, explore MPS's robust portfolio of high-power converters and Intelli-Phase™ devices for other applications.

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