Zynq RFSoC DFE Solves 5G Mass Deployment Challenges

David Brubaker, Sr. Product Line Manager at Xilinx

5G has transitioned from concept to reality with deployments of 5G infrastructure and enabled devices; it is apparent that the 5G economy will not be a repeat of 3G or 4G.

New challenges require adaptive solutions that can address diverse requirements, while evolving with market needs. The Zynq® UltraScale+™ RFSoC DFE meets these challenges due to its architecture that integrates more hard IP logic than traditional soft logic, making it cost and power competitive with a custom ASIC while also retaining the Xilinx adaptable DNA.

Challenges on the 5G Frontier

Increasing Radio Performance and Complexity

The need for wider bandwidth in the radio unit (RU) is not just about increasing data rates; operators need to meet complex radio configurations for existing and new bands. To meet these requirements, radios are designed to support the widest possible instantaneous bandwidth (iBW). For instance, early 5G radios supported bandwidths up to 200MHz, but future radios require up to 400MHz.

Even though 5G is the default wireless standard, 4G shipments will continue in significant volume for years. When upgrading or installing a 5G network, operators must provide 4G coverage and since tower space is rented by the unit and weight, a multi-mode RU with both 4G and 5G reduces both CAPEX and OPEX.

Another complexity in 5G radios is the distributed unit (DU) interface. The typical splits are 7.1, 7.2, and 7.3; the RU must support all of these.

5G Diverse Use Cases and Evolving Standards

3G was about voice and texting; operators sold talk time minutes and number of texts. 4G had one use case: mobile data, which enabled the rise of the smart phone with operators selling data in GB per month.

5G, on the other hand, has three main use cases as shown in Figure 1: Enhanced Mobile Broadband (eMBB), Ultra-Reliable Low-Latency Communication (URLLC), and Massive Machine Type Communication (mMTC). Optimizing each of these use cases separately would lead to very different radio solutions; 5G blends them into one standard.

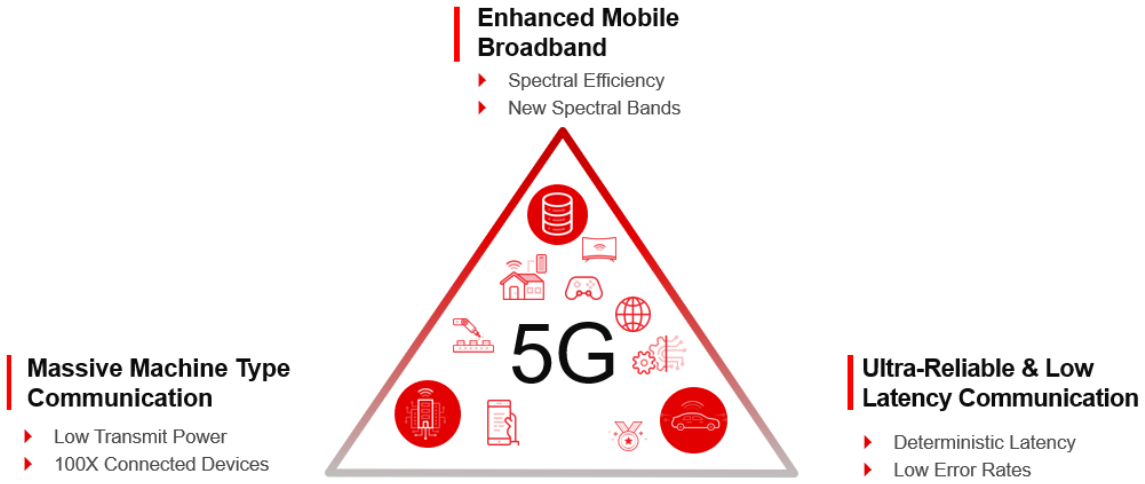

Figure 1. 5G Use Cases

Today's 5G is all about eMBB. Operators race to deploy 5G in order to lure customers to the fastest network.

Since URLLC and mMTC are new, there is no developed market or economy implementing them. The main application touted for URLLC is autonomous driving, but the 5G network will not assume a significant role in this area. That process will operate *in situ.* A viable URLLC use case is vehicle or machine operation in situations too dangerous for onboard control, like mining and disaster operations.

For the mMTC use case, metrics of up to 1 million connected devices per sqKm are presented. For smart home devices, WiFi works just fine, and 5G will not replace it. The mMTC use case will be more important for industrial, commercial, and government applications, e.g., smart factories and smart cities.

Evolving Standards

The 4G LTE standard was finalized with Release 9 in 2009 and then evolved over the next eight years with 5 3GPP releases to 4G LTE Advanced.

The first and second phases of 5G have been defined in release 15 and 16 and cover the eMBB, mMTC, and URLLC basics. Work has started on release 17, and release 18 is in planning. The 5G standard will evolve with market needs over the next decade.

5G Market Disruption

Another challenge for 5G can be broadly captured as market disruption. Looking back at the 4G market, it is rigid. 4G had one use case, and the market consisted of traditional operators selling data to consumers and buying network infrastructure from traditional hardware OEMs.

Today, both the O-RAN Alliance and the Telecom Infra Project are disrupting established business models by enabling diverse suppliers. Disruptive 5G operators, like Dish, Rakuten, and RJIO, are challenging their peers and incumbent operators.

Disruption and true innovation will happen in private networks that use mMTC and URLLC features to provide complete enterprise solutions.

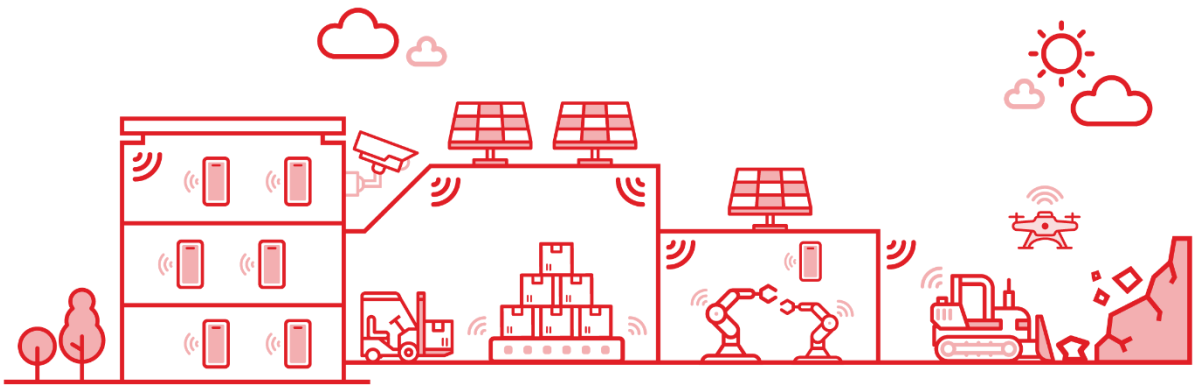

Figure 2. 5G will Enable Innovation in Private Networks

The result is a dynamic 5G economy with new operators and suppliers shown in Figure 3.

Figure 3. 5G: New Business Models, Markets, and Competition

The Zynq RFSoC DFE Meets Current and Future 5G Needs

The Zynq RFSoC DFE implements known and compute intensive DFE functions in a hardened or ASIC-like structure, which are configurable for both 4G and 5G new radio (NR) standards.

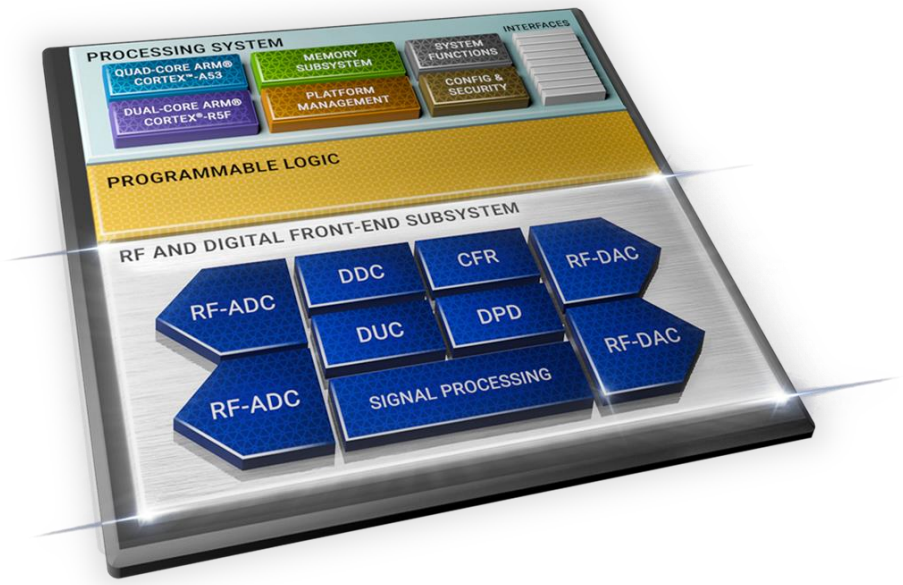

Figure 4. Zynq RFSoC DFE Integrates a Complete DFE Subsystem with Hard IP

These hardened cells occupy less silicon area and can reduce power consumption by up to 80% compared to traditional FPGA soft logic as shown in Figure 5. Since each hard IP core is physically smaller than soft logic, additional cores are added to provide 2X DFE processing capability compared to Zynq UltraScale+ RFSoC Gen 3 devices.

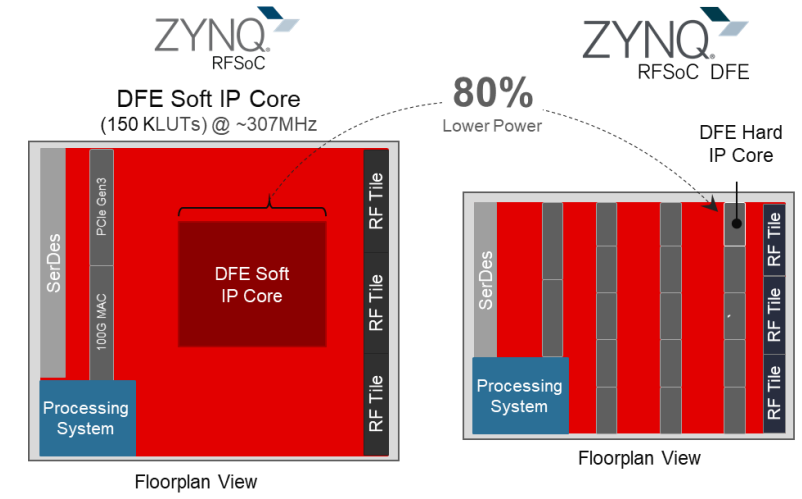

Figure 5. Benefits of Hard IP Implementation

When fully utilizing the DFE hard IP blocks, power consumption of a Zynq RFSoC DFE is about 50% lower than an equivalent implementation in a Zynq RFSoC Gen 3 device.

The hard IP blocks, as shown in Figure 6, are placed physically in the Zynq RFSoC DFE consistent with the data flow. Each IP function is composed of multiple instantiations, enabling the device to scale up or down depending on the application. To provide the most flexibility, the user can bypass any block and add logic at any point in the datapath.

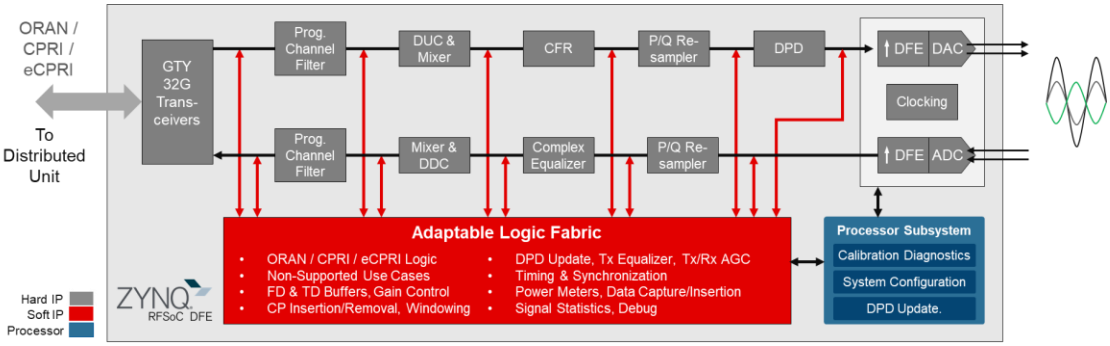

Figure 6. Functional Block Diagram of the Zynq RFSoC DFE

The Zynq RFSoC DFE supports multi-band, and multi-mode radios up to 400MHz iBW in FR1 (up to 7.125GHz) and up to 1600MHz iBW when used as an IF transceiver for FR2.

In summary, the Xilinx Zynq UltraScale+ RFSoC DFE, based on the successful Zynq UltraScale+ RFSoC, includes all the critical and compute intensive digital processing blocks in a hardened, standard-compliant configuration, providing the benefits of an ASIC yet maintaining its adaptable and time-to-market Xilinx DNA by including adaptable logic for unknown future requirements and market needs.

For more information, go to www.xilinx.com/rfsoc-dfe.