OPTIMAL 5G DESIGN WITH VIRTUAL PROTOTYPING
EXCLUSIVE SUMMARY

Current mobile data technology is being pushed to its limit. The increase in bandwidth-heavy apps for streaming, the need for high-speed internet in territories where infrastructure is limited and the development of smart and autonomous vehicles are all increasing demand for high-speed and reliable data. Additional industry trends such as the rise of cloud computing, the introduction of the Internet of Things (IoT), remote tele-surgery and precision manufacturing all require a completely new approach for cellular networks. The Fifth Generation New Radio, commonly known as 5G NR, promises download speeds of gigabits per second, with much lower latency, higher reliability and support for far more connected devices in a given area.

Original equipment manufacturers (OEMs) and suppliers must develop 5G capable devices and networks to remain competitive, but there is a significant increase in complexity compared to previous generations. For example, 5G has two major operating frequency bands, the sub 6 GHz spectrum and 24-52 GHz in the millimeter wave (mm-wave) spectrum. 5G standards include support for massive MIMO (Multiple Input Multiple Output) communication, and antenna arrays with beamforming technology, to increase network capacity and communication quality even in dense urban environments with many users. Of course support for previous generation telecommunications standards must be maintained. For the fixed form factors of the smartphone market, this will typically require a complete redesign to accommodate the new technology while maintaining current capabilities.

5G devices require redesign of components, circuits, antennas and even materials used, to ensure effective performance, regulatory compliance, long term robustness as well as effective deployment in emerging applications. Careful consideration needs to be given to higher data rates and the associated challenge of ensuring signal and power integrity as well as limiting heating, radiated emissions and susceptibility to outside interference. The effect of proximity to the human body, where even a finger can block a signal in the mm-wave 5G range, needs to be carefully studied. All this means that effective parametric analysis is required to consider these complex and difficult to predict effects, both individually and in combination with each other.

Deploying a data driven, model based approach such as that embodied by the 3DEXPERIENCE® platform from Dassault Systèmes, allows companies to manage the complexity of 5G across the development value chain from ideation, requirements, design, simulation and optimization through to manufacturing and delivery. Virtual prototyping, deployed as a strategic part of a company’s development platform, can help reduce the risk of late delivery or failure and safeguard the substantial investment in 5G development.

CHALLENGES OF DESIGNING FOR 5G

With every new generation of mobile communication, new antennas and components must be integrated into existing form factors. In every electronic device, component placement is critical in order to achieve key performance indicators (KPIs) relating to performance specifications and compliance, but the increased complexity of mobile design for 5G inherently introduces more failure points. Therefore, it is more important than ever to identify potential issues, such as the presence of the human body has a major impact on the performance of mobile devices.
potential failure to meet an electromagnetic interference (EMI) standard, as early as possible given the extremely short design cycles faced by the mobile device industry. The emergence of Advanced Driver-Assistance Systems (ADAS) and the Industrial Internet of Things (IIoT) require 5G applications to operate reliably in constrained and dynamic environments. More extensive use of simulation earlier in the design cycle will be critical in achieving KPIs and safety standards, in both consumer and industrial 5G applications.

Since 5G is a broadcast technology, it is subject to government regulations including:

- Electromagnetic Compatibility (EMC), the susceptibility of a device to outside radio frequency signals
- Electromagnetic Interference (EMI) generated by the device itself
- Specific Absorption Rate (SAR), quantifying the amount of radiated power absorbed by human tissue

Ensuring on-device Signal Integrity (SI) and Power Integrity (PI) is also a major concern if reliable high-speed communication between components is to be maintained. SI/PI and EMC/EMI become more critical at the higher frequencies and data rates associated with 5G. Preventing desensitization (desense) of critical electronic systems in close proximity to many other systems becomes a challenging engineering task. High frequencies and component density mean that in 5G product design, full-wave 3D electromagnetic simulation is needed to capture many of the interactions that can cause EMC/EMI, SI/PI and desense issues. The increased number of systems means there is a higher risk of SAR issues, and moreover, public trust issues surrounding 5G proliferation mean that manufacturers need to be able to demonstrate clearly that the technology does not pose a health risk and meets regulatory standards. At mm-wave frequencies new standards for human exposure are in development which must be considered and will require new simulation approaches such as hybrid techniques.

5G enduser devices must work reliably in challenging environments including densely populated and complex urban settings containing many possible obstacles to the signal, such as other people, buildings and other mobile devices. To operate reliably, 5G devices will make use of massive Multiple Input, Multiple Output (MIMO) technology to effectively exploit multipath effects where signals bounced from buildings, for example, can help fill in dead spots and increase network capacity. This means that more antennas are needed in one device, reducing space and increasing EMC/EMI, SAR and thermal management issues.

In order to integrate future millimeter-wave antennas within mobile devices, new approaches to product design will be required. At mm-wave frequencies, geometrically thin structures—like a smartphone case—have a significant thickness compared to the wavelength of propagating electromagnetic waves, and substantially influence a signal passing through them. Radome design techniques pioneered in the aerospace industry may be used to engineer smartphone covers to allow radio signals to pass through unimpeded, ensuring high antenna radiation efficiency and fine control over beam behavior.

**SOLVING 5G DESIGN CHALLENGES WITH VIRTUAL PROTOTYPING**

Specific absorption rate (SAR) simulation calculates power absorbed by the body to ensure that the device meets legal regulations.
Many companies who are developing mobile devices, IoT products and cellular infrastructure are using the realistic simulation tools developed by the SIMULIA brand of Dassault Systèmes to overcome these industry challenges. With a realistic 3D virtual prototype, integrated antenna engineering, device EMC/EMI performance, Printed Circuit Board (PCB) performance and device structural and thermal performance can all be rapidly, and accurately, modelled, analyzed and optimized.

For added engineering and business value, Dassault Systèmes provides the 3DEXPERIENCE platform, which enables companies to leverage realistic simulation fully integrated with 3D design, process automation, design exploration, and information intelligence within a collaborative, interactive environment. The 3DEXPERIENCE platform allows companies to manage the complexity of 5G across the development value chain from ideation, requirements, design, simulation and optimization through to manufacturing and delivery. When development activities take place within this data-driven, model based environment, all stakeholders—including designers and simulation experts—leverage a single model. Every modification to this digital model is automatically propagated and every simulation is automatically associated with the right model. As a result, there is digital traceability between the final design and the final tested and released version of the product.

**ROBUST ELECTROMAGNETIC DESIGN**

SIMULIA CST Studio Suite is the part of SIMULIA’s multiphysics simulation portfolio dedicated to electromagnetic (EM) simulation. This proven EM simulation software provides a complete range of electromagnetic and supporting multiphysics solvers, as well as the powerful automatic meshing and optimization tools needed to meet the design and engineering challenges of 5G product development. The flagship transient solver can simulate extremely large and complex problems with minimal model preparation, and is able to leverage GPUs, cluster and cloud computing to accelerate simulations further.

The software also enables compliance tests to be performed virtually, as some quantities, such as electric fields inside the human body, cannot be physically measured and can only be characterized with simulation. CST Studio Suite comes with CTIA certified hand and head models which can be used for virtual SAR testing. This can help reduce the risk of late delivery or test failure, and thus safeguard the substantial investment in 5G development.

Typical mobile device KPIs that can be generated with CST Studio Suite include:

- Total Radiated Power (TRP)
- Effective Isotropic Radiated Power (EIRP)
- Total Isotropic Sensitivity (TIS)
- Cumulative Distribution Function (CDF)
- Specific Absorption Rate (SAR)

The automated post-processing in CST Studio Suite allows these KPIs to be produced from simulation results at the push of a button. These powerful capabilities, connected with the collaboration and data management capabilities of the 3DEXPERIENCE platform, enable engineers from different disciplines to collaborate effectively while optimizing the performance of designs, which is critical in the face of ever-decreasing product design lifecycles.

With multiple antennas on a single device, co-site interference or co-existence between antennas and desensitization are important considerations. The CST Studio Suite Interference Task allows virtual testing of multiple component configurations and automatic flagging of potential interference issues. Since simulation offers a full 3D visual representation of the electromagnetic fields and currents inside the device, engineers can directly identify the sources of interference and the path that stray currents follow through the device, allowing easy mitigation of problems. Potential sources of crosstalk between communication channels, and other SI/PI and EMC/EMI issues on the PCB, can be also simulated and resolved with CST Studio Suite.

Antenna Magus, the unique antenna design tool which is also part of SIMULIA’s electromagnetic simulation portfolio, helps engineers quickly find the correct initial antenna or array type for a 5G device. Antenna Magus is a fully documented library of than 350 designable antennas.
When given frequency bands and a form factor, the software automatically generates a suitable design as well as a fully parameterized simulation model. This design and simulation automation helps engineers make better antenna design decisions, especially when faced with the new 5G constraints and specifications. For base station design, additional SIMULIA electromagnetic design tools such as FEST3D and Filter Designer 3D can be used to synthesize the waveguide components, filters and multiplexers found in antenna feed systems.

**ACHIEVING A COMPETITIVE ADVANTAGE**

CST Studio Suite is the industry standard electromagnetic simulation solution for designing, analyzing and optimizing cellular devices. It provides the high-performance solvers and specialized features needed to meet the challenges of designing for 5G. In addition, the SIMULIA brand delivers a deep portfolio of proven multiphysics / multiscale simulation technology used by world-leading companies to simulate material behavior, thermal effects, drop, impact, vibration and full system performance. These simulation applications are interoperable with a broad-range of third party 3D modelling and simulation tools, as well as Electronic Design Automation (EDA) tools.

Dassault Systèmes’ 3DEXPERIENCE platform enables companies to manage the complexity of 5G design by providing a digital thread which captures functional requirements, design variants, simulation models and analysis results, related to the product throughout the development process. By leveraging realistic multiphysics simulation, fully integrated with 3D design, process automation, design optimization and decision analytics on the platform, organizations are able to capture and share best practices, maintain a single source of truth, and accelerate design space exploration. When employed early and continuously throughout each phase of development, virtual prototyping helps teams decide on the correct design path early, when it’s less expensive and easier to make changes.

5G is not simply an evolution of existing standards, but requires an entirely new approach to cellular device and infrastructure design. Many manufacturers are competing to bring 5G enabled devices to market first, since the potential rewards are high. Development costs for 5G technology are substantial and the risk of failure is high due to the complex engineering challenges involved. Virtual prototyping can help cut design time and costs, and achieve regulatory compliance while reducing risk of failure. Companies that can best make use of digitally connected virtual prototypes will overcome the challenges of end-to-end 5G system design and have significant advantages over their competitors in the race to take 5G mainstream.
Our 3DEXPERIENCE® platform powers our brand applications, serving 11 industries, and provides a rich portfolio of industry solution experiences.

Dassault Systèmes, the 3DEXPERIENCE® Company, provides business and people with virtual universes to imagine sustainable innovations. Its world-leading solutions transform the way products are designed, produced, and supported. Dassault Systèmes’ collaborative solutions foster social innovation, expanding possibilities for the virtual world to improve the real world. The group brings value to over 250,000 customers of all sizes in all industries in more than 140 countries. For more information, visit www.3ds.com.