WHITE PAPER

Beamforming EMI Effects on a DDR4 Bus of a 5G Smartphone

This application brief examines potential electromagnetic interference (EMI) issues associated with an integrated phased array antenna on a DDR4 bus of a 5G smartphone.

Electromagnetic interference (EMI) affects the performance of electronics and is a critical consideration in the design of new 5G user equipment (UE). To illustrate this, we examined potential EMI issues associated with an embedded phased array antenna on a DDR4 bus within a 5G smartphone. A 5G phone has beamforming capabilities to improve the capacity and data rates for wireless applications. For specific scan angles, the embedded antenna system can affect digital signals in the printed circuit board (PCB). Noise generated by beamforming techniques at specific scan angles can degrade the signal integrity of the memory bus in the user equipment.

/ Simulation Method

A complete simulation of a 5G smartphone comprising the antenna array system, the PCB and the housing was performed in Ansys HFSS. Figure 1 shows the HFSS model detailing the antenna array system, controller and DDR4 modules. It also calls out a data net (DQ7) that transmits a pseudo random binary sequence (PRBS) signal between the two components.

The HFSS model is coupled to the Nexxim circuit solver in Ansys RF Option through a dynamic link — to control the magnitude and phase of each antenna in the system for beamforming, as well as the IBIS models used for the signal integrity analysis of the DDR4 bus.

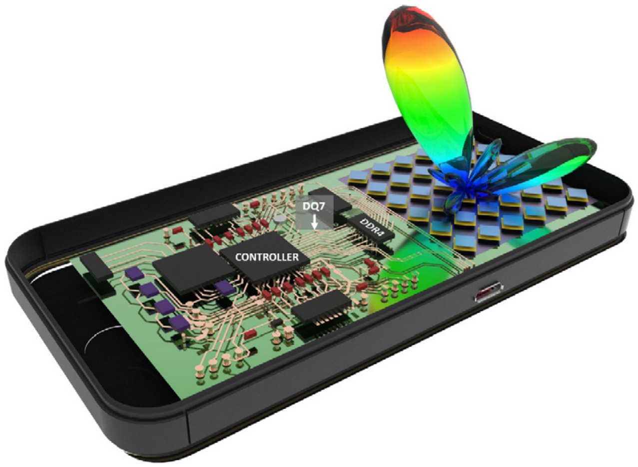


Figure 1. 5G generic device model and radiation pattern.

/ Results

Figure 2 shows the far-field radiation pattern of the antenna array system for $\theta = 0$ degrees (red) and $\theta = 60$ degrees (blue), both for the same value of $\phi = 270$ degrees. The change of the radiation pattern was achieved by changing the phase of each individual antenna in the array.

When the antenna array system is configured to scan at $\theta = 60$ degrees, the radiation is directed toward the PCB (blue radiation pattern). We investigated a data line (DQ7) that connects the memory module closer to the antenna array and the main controller in the center of the board. For the simulation, we used a generic DDR4 IBIS model writing data at 2133 Mbps signal to the memory module.

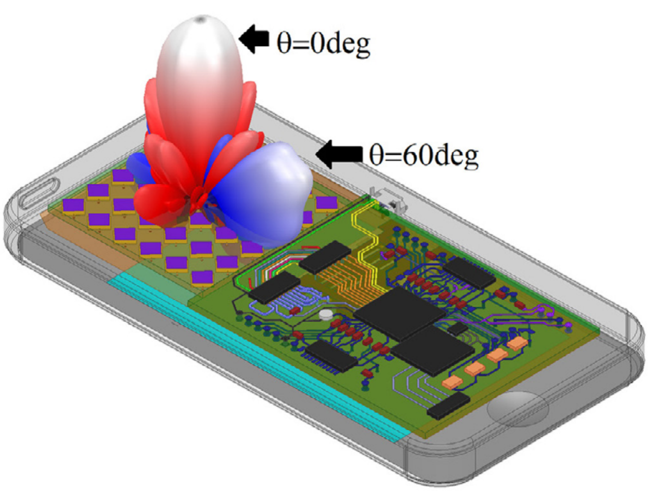
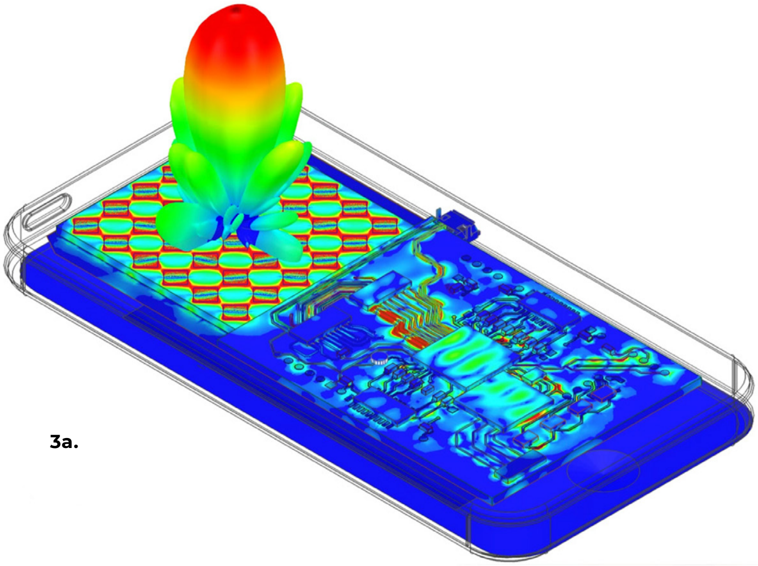
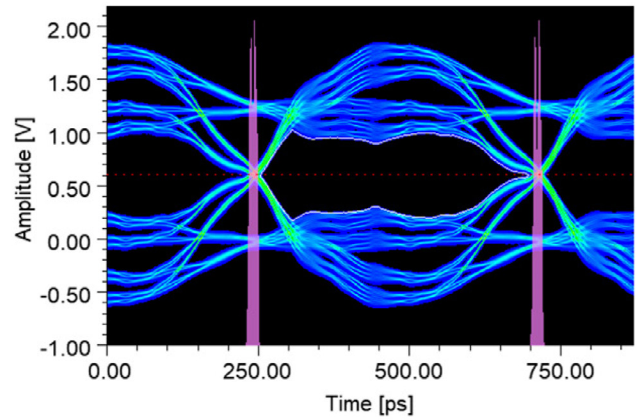
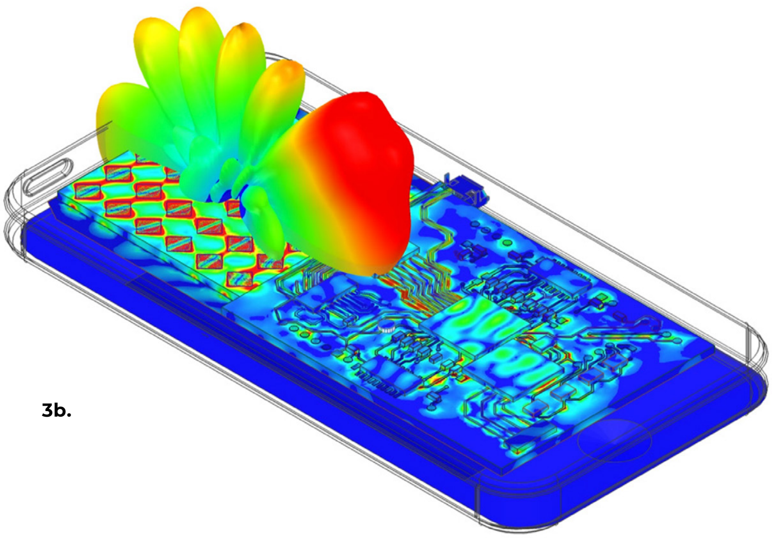


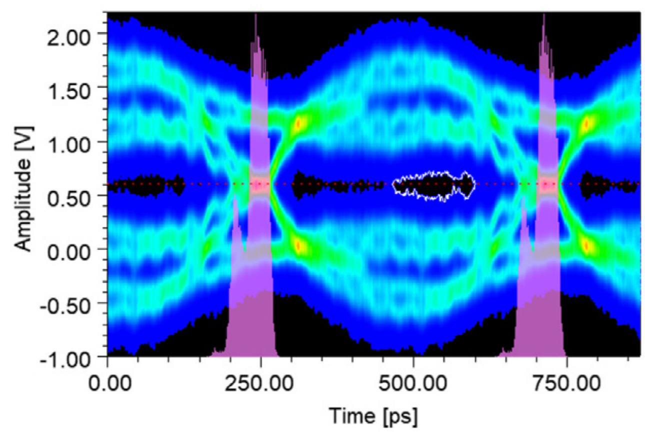
Figure 2. 5G generic device model and radiation pattern.





3a.





3b.

Figures 3a and 3b. DDR4 eye diagram when the phased array system scans at angles of ϴ = 0 degrees (a) and ⌀ = 60 degrees (b).

When each individual antenna of the system is excited with the same magnitude and phase, the beamforming creates a radiation pattern that points toward ϴ = 0 degrees and ⌀ = 270 degrees. In this situation, as observed in Figure 3a, there is barely any interference on the eye diagram of the DDR4 signal. However, when the antenna system scans at ϴ = 60 degrees and ⌀ =270 degrees, the eye diagram is closed due to the noise of the antenna system (Figure 3b).

Now that phased array antenna systems are an integral part of 5G devices, a complete workflow must be considered for radio-frequency Interference (RFI). This includes analysis of signal integrity with real IBIS models and full RF antenna array systems including the circuit to generate the beamforming. HFSS provides this complete workflow using cutting- edge solver technology that enables the user to solve complex 5G system models with unmatched accuracy.

Conclusion

5G-capable smartphones and other user equipment will provide a large amount of real-time broadband data access to customers on the go. At frequencies of interest in 5G applications, for instance, say 28 GHz, these smartphones and user equipment can make use of advanced phased-array beamsteering technologies to provide uninterrupted and superior cellular service in congested environments. When several miniaturized radios, digital systems, components and wireless assemblies are packed in a compact area such as a smartphone, the device could become susceptible to electromagnetic interference problems.

Accurate simulation tools such as Ansys HFSS and Ansys RF Option help engineers diagnose and mitigate sources of electromagnetic interference in these devices early in the design cycle. The workflow in this application brief is beneficial for engineers designing efficient and robust electronic devices in 5G. It helps increase the immunity of the devices and minimize radiated emissions to meet stringent regulatory standards and maintain electromagnetic compatibility (EMC) — a critical step for bringing 5G products to market.

References

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