A Low Profile Zeroth Order Resonator Antenna for 80 GHz Chip-to-Chip Communication

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Development of a wireless communication system at the millimeter-wave band has become one of the hottest research topics in RF and antenna societies. Multi-gigabit data transfer is possible by means of this with a compact RF front-end and antenna footprint allowing the whole system to be integrated in a single package. High definition video transfer systems have been developed and commercialized at 60 GHz via alliances such as WiGig and WirelessHD. Automotive radar sensors utilizes 77 GHz frequency band to realize high-performance sensing functions to prevent unforeseen accidents. Short range chip-to-chip communication is another promising application at the millimeter-wave band. Wireless communication between chips may solve problems with wired interconnections, for instance, limitations in bandwidth and PCB manufacturability, losses in substrates and metal wires.

In this presentation, we discuss a wideband antenna design for chip-to-chip communication at 80 GHz. The target bandwidth is 8 GHz (S11<-10dB from 76 GHz to 84 GHz). A low profile antenna is needed for this application since the antenna is supposed to be integrated in the same PCB (printed circuit board) as the chip is located on. However, designing a low profile antenna that radiates in the end-fire direction (horizontal to the PCB surface) turns out to be very difficult due to the nearby PCB ground plane ($\lambda/20$ apart from the antenna aperture). Conventional wideband end-fire antennas such as tapered slot antennas and Yagi-antennas are not applicable as they tend to radiate in the broadside direction (vertical to the PCB surface).

In order to design an end-fire antenna with such extremely low profile configuration, we adopt a novel design strategy of metamaterial antennas, more specifically, the zeroth order resonator (ZOR) antenna. With this, a monopole-like radiation pattern can be generated by properly aligning periodic unit cells and by inducing the ZOR mode. The ZOR antenna is inherently low profile in that the unit cells are in the form of a microstrip patch with vias connected to the PCB ground. On the other hand, the bandwidth of the ZOR antenna is rather narrow. To overcome this, the microstrip line feeding section is carefully designed to support wideband impedance transformation while maintaining the ZOR mode excitation.

The proposed antenna was optimized using a 3D simulation tool (Ansys HFSS), and then fabricated on the top 3 layers of a 10-layer PCB. That is, the height between the antenna ground and the aperture is only 180 μm. The antenna is composed of 4 rectangular unit cells whose total foot print is $1.96 \times 1.6\ mm^2$. The detailed design process, simulation, and measurement results will be included in the presentation.