Control of a configurable D-Band IRS

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How to control a configurable D-Band IRS? What effects should be considered for the D-Band?

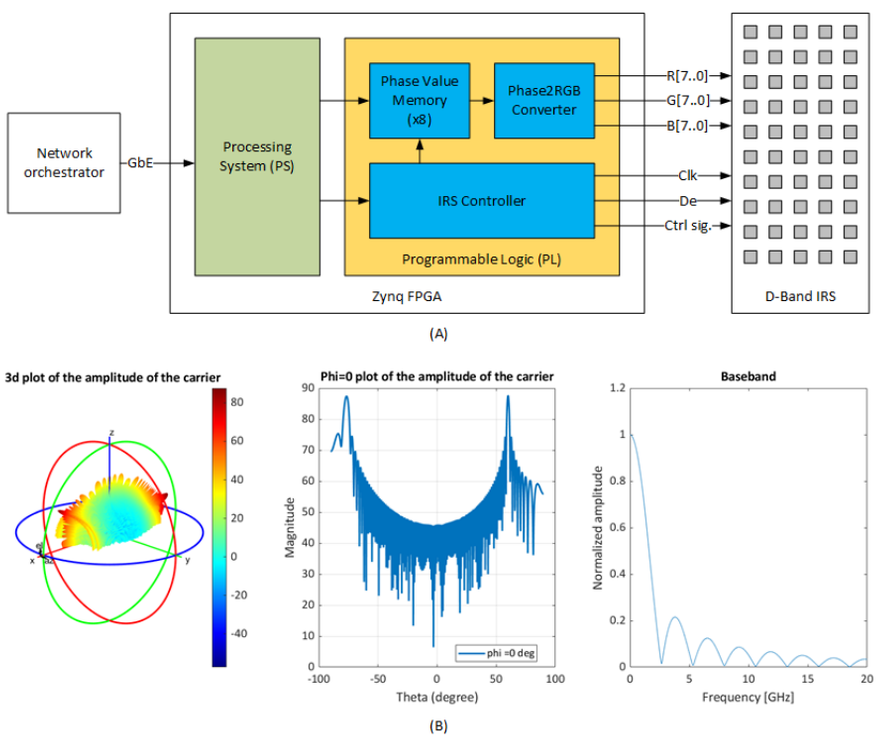

Figure (A) shows the simplified FPGA design controlling the IRS. The values of the IRS can be updated 60 times per second. Figure (B) shows a typical simulation result of our MATLAB raytracing model for a 200x120 D-Band IRS (Tx position: (2m, 0°, 0°), Rx position: (2m, 60°, 0°)). The left and the middle subfigure show the resulting amplitude gain of the carrier signal relative to a single antenna element. The right subfigure shows the normalized amplitude of a wideband signal caused by the beam squint effect.

KEY FINDINGS

Using the electronic components of liquid crystal displays is a cost-effective way to implement configurable D-Band IRS with more than 20000 elements. The programming of the phase values is identical to displaying LCD images. In our design, up to 8 configurations can be preloaded into the internal FPGA memories enabling fast switching between them. Finding the optimal phase values for every IRS antenna element is one of the challenges. For simple antennas and for IRS phase shifters that can be configured between 0° and 360°, our MATLAB raytracing model finds a solution maximizing the amplitude of the carrier signal at the receiver. We observe that the large number of IRS antenna elements results in a focused beam in the desired direction. Since it is not possible to implement true time delays, the path differences cannot be compensated completely. As a result, the amplitude of the radiated signal is frequency dependent, including some cancellations. To overcame this issue, there are two solutions: (1) deploying true time delays instead of phase shifters or (2) reducing the number of the IRS elements. Since (1) seems to be unrealistic for the near future, the challenge will be to find a good compromise between achievable gain and directivity, size of the IRS, and signal bandwidth.