Dejan Filipovic tells us about his group at the University of Colorado Boulder and their work on applied electromagnetics, including Schiffman phase shifters and their applications

Tell us about your research group

The Antenna Research Group at the University of Colorado Boulder focuses on applied electromagnetics research where, for example, we demonstrated an antenna-based interconnect system for multi-core communications over 170–220 THz. We are funded by the Office of Naval Research to work on small antennas for vehicle-based HF communications, compact directed energy antennas, concealed antenna integration techniques, entire passive suites for millimetre-wave towed decoys, and single aperture and array based direction finding systems for wideband millimetre wave electronic support measures.

Results of the work presented in our Letter will further the development of not only the electronic support systems, but also wireless communications deep into (sub)millimetre waves.

What have you presented in this issue?

In our Letter, we have shown that Schiffman phase shifters can now be designed and fabricated to work over a 15–45 GHz range with very low loss (<0.6 dB) and imbalances (<0.25 dB and <2.5°). The device is designed and built for the emerging surface micromachining technology PolyStrata™ (trademark of Nuvotronics, LLC; developed under the DARPA-MTO funded program 3-d MERFS by Nuvotronics, BAE Systems, and University of Colorado Boulder).

Schiffman phase shifters were first introduced over 50 years ago by an inventor whose name they carry to date. It is a component that provides the required phase difference between the multi-port transmission lines or channels. This feature is achieved by carefully engineering and controlling coupling in one or more signal paths while delaying the signal in others. Narrowband and wideband configurations have been demonstrated through the Ku-band both as individual devices and integral parts of more complex matching networks. While typically built and implemented in microstrip or stripline, other transmission line technologies have also been exploited for their implementation.

What are Schiffman phase shifters used for?

Schiffman phase shifters are most commonly used in phased arrays as integral parts of their analogue fixed beam or beam steering networks. They have also found use in single aperture RF systems, where excitation of multiple modes is necessary to achieve functionality such as direction finding. Wideband Butler matrix beamforming networks are examples of complex systems to which they naturally lend themselves. For example, most of the multi-arm spiral or sinusoidal antennas use Schiffman as part of their beamforming and/or modeforming network.

The recent boom in personal communications has provided a renewed interest in low-cost implementations of these devices.

What processes allowed you to achieve these results and how will you develop them?

The use of surface micromachining technology, specifically the PolyStrata process, was critical for our work. Since we were a major part in the development thereof, we relied on our intimate knowledge of the process and its ability to transform the ideal circuit models into fully functional devices. Another key to successful demonstration of the Schiffman phase shifter was the full understanding of process sensitivity on the layer thickness variations and its impact on the performance of the device. It is seen that the device will still work quite well even if the fabrication worked out to the limit of its capabilities.

Only time will show the impact of the research presented here. We are moving very fast into the millimetre wave spectrum so devices like this and technologies like PolyStrata will enable unprecedented levels of personal connectivity. Along with commercial applications, the defence related research will follow even in the time of continuing budgetary cuts. While as engineers we may foresee great technical advancement across the disciplines, we must not lose sight of the impact they may have on personal liberties. Achieving a balance between the two may never be reached but it is worth pursuing.