K_a-band Patch Antenna Array with Integrated MEMS Phase Shifters for Satellite Communications On-The-Move Uplink Mechanism

Steven D. Keller
U.S. Army Research Laboratory, Adelphi, MD 20783, USA

As part of the Tactical Network and Communications Antennas (TNCA) Army Technical Objective (ATO), a four-element K_a-band patch antenna array with integrated MEMS phase shifters for beam steering has been designed to demonstrate a compact, efficient wafer-scale steerable transmitter mechanism for Army applications. The array utilizes a unique coplanar waveguide (CPW) slot coupled patch antenna design (K. Hettak, G. Delisle and M. Boulmalf, IEEE Trans. on Ant. and Prop., Vol. 46, No. 11, 1757-1758, 1998) adapted for present Army applications (S. Keller, ACES Journal, Vol. 23, No. 2, 177-183, 2008), in order to minimize the overall system weight and fabrication complexity without sacrificing performance.

The array was designed for functionality centered at 30 GHz on 500 μm thick RT/Duroid 6010 substrate. The patch antenna dimensions are 1.27 x 1.27 mm, with a CPW feedline center conductor width of 300 μm and slot width of 140 μm. A quarter wavelength tuning stub with length of 750 μm and width of 60 μm was incorporated at the aperture to optimize the input impedance. A Wilkinson power divider strategy was employed in order to produce equal power division and minimize mutual coupling between the antenna elements. Since the discrete 30 GHz *Raytheon* MEMS phase shifters that serve as the beam steering elements in the array contain CPW input and output ports, the feedline artwork for the array was designed using CPW architecture.

Simulations of the Wilkinson power divider indicate acceptable average insertion loss of ~0.5 dB and mutual coupling of -10 dB between 28 – 32 GHz. The return loss for each port also remains under 10 dB for the entirety of the simulated spectrum, with S_{11} = -21.4 dB, S_{22} = -16.2 dB, and S_{33} = -15.4 dB at 30 GHz. A simulation of a two-element antenna array using this power divider and the CPW slot-coupled antenna design indicates a center frequency of ~29.9 GHz and a 10 dB return loss bandwidth of ~2.2 GHz (7.4 %), from 28.5 GHz to 30.7 GHz. This bandwidth is well within the range of the desired minimum operational bandwidth for Army SOTM systems. The full four-element array should yield a comparable center frequency and bandwidth, though subtle differences are expected due to the expected increase in insertion loss and substrate-to-patch size ratio.

The details of the antenna array design and simulation process and the measured results of the fully-fabricated demonstrator array will be presented in full at the 2009 USNC/URSI NRSM.