mm-Wave Varactor Reconfigurable Microstrip Patch Antennas using GaN on Sapphire Technology

Mohammod Ali*(1), Brown Mattox (1), MVS Chandrashekhar (1), and Grigory Simin(1)
(1) University of South Carolina, Columbia, SC 29208

Frequency, pattern, and polarization reconfigurable antennas have drawn tremendous interests in the research community because of their inherent advantages since a single aperture can be used to achieve multiple functionality. Reconfiguration, namely frequency reconfiguration has been proposed for antennas where different parts of an antenna geometry are connected or disconnected using switches. A variety of switching mechanisms have been proposed e.g. PIN diode, RF MEMS, varactors, liquid metal, vanadium dioxide, mechanical etc. Key metrics include switch size, voltage and current requirement, power dissipation, ESD sensitivity, insertion loss, isolation, RF power handling ability etc. Some switches perform better than others. We have reported the study and design of reconfigurable pixelated antennas using RF MEMS switches (A MEMS reconfigurable pixel patch antenna, Ali et al., IEEE APS Symp. Dig. 2014). The reported antennas included discrete MEMS switches.

Literature reports of other reconfigurable antennas also primarily include antennas with discrete PIN diode or MEMS switches. The growing interest in mm-wave technology calls for reconfigurable antenna design using monolithically integrated switches. GaN devices are highly desirable for their high power handling and high temperature operation capability. Moreover, if fabricated on low cost sapphire substrates they prove to be very viable for commercial applications from a cost benefit point of view. GaN varactors on sapphire can be switches of choice for mm-Wave reconfigurable antennas.

In this paper we present the simulation studies of a mm-Wave reconfigurable patch antenna. The aperture coupled patch antenna is reconfigured within the frequency range of 28-60 GHz with the help of several GaN varactor switches. The patch antenna and the GaN varactor switches reside on a 400 micron thick sapphire substrate. Underneath the sapphire is a Duroid 6010 substrate which contain a slot and a microstrip feed line. The patch antenna consists of a center patch that is surrounded by a ring. The center patch and the ring are connected using four varactor diodes. Since unlike MEMS switches varactors are capacitive switches their behavior is entirely governed by the ON versus OFF capacitance ratios. Typically high capacitance is desirable for ON state while low capacitance is needed for OFF state. Yet a very large CON/COFF ratio may not be attainable due to device limitations. The device will also contain a series resistance that will add to the loss. The varactor switches are modeled using capacitances and resistances in HFSS for both the ON and OFF states and their effects are studied on the antenna frequency reconfiguration, pattern and gain. Finally the effects of antenna conductor thickness on antenna gain are also investigated. The findings obtained in this study would guide us in the fabrication and testing of the GaN varactor reconfigurable patch antennas for mm-Wave applications. The detailed antenna performance characteristics as function of varactor parameter variation will be presented.