A 2.45GHz Full-Range Phase Shifter

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The phase shifter plays an important role in phased-array antenna and smart antenna systems with beamforming capability. To obtain the maximum flexibility for antenna designer, a full-range phase shifter with good phase linearity and constant output level is required. However, it is hard for a single phase shifter to satisfy these. In this work, we cascade a 3-bit vector-sum phase shifter and an all-pass active phase shifter to construct a full-range phase shifter.

The 3-bit vector-sum phase shifter utilizes the switched attenuator instead of variable gain amplifiers in previous works. The use of the switched attenuator eliminates the dc power consumption and reduces the circuit area. Since the T-section resistor attenuator exhibits a constant insertion loss and almost zero phase shift over a very wide frequency range, the bandwidth improvement of the phase shifter can also be expected. This switched attenuator needs no input/output matching circuit between VGA and the branch-line coupler. The mismatching can cause unbalance between the two paths in the phase shifter and thus phase error can be introduced.

The all-pass active phase shifter is used to fine-tune the output phase and provide additional gain. Due to the all-pass property of the active phase shifter, the bandwidth can be retained. Since the required phase shift range of the active phase shifter is only 45X, high phase linearity can be easily achieved over the required frequency range. The control signal level has been designed between 0V and 3V, which is available in most electronic system or semiconductor process.

A 2.45GHz 3-bit vector-sum full-range phase shifter has been designed, fabricated and measured on 0.6mm FR4 PCB. The simulation results show the average phase shift between two adjacent states is 45X, standard deviation of phase shift is 3.7X, input/output return loss is greater than 20dB, average insertion loss is -15.5dB and the maximum insertion loss variation is 1.47dB at 2.45GHz. The measurement result shows good consistency with simulation. The 2.45GHz all-pass active phase shifter has also been designed at 2.45GHz using pHEMT and built on 0.6mm FR4 PCB.