Microwave Planar Non-linear Phase Shifter in microstrip geometry

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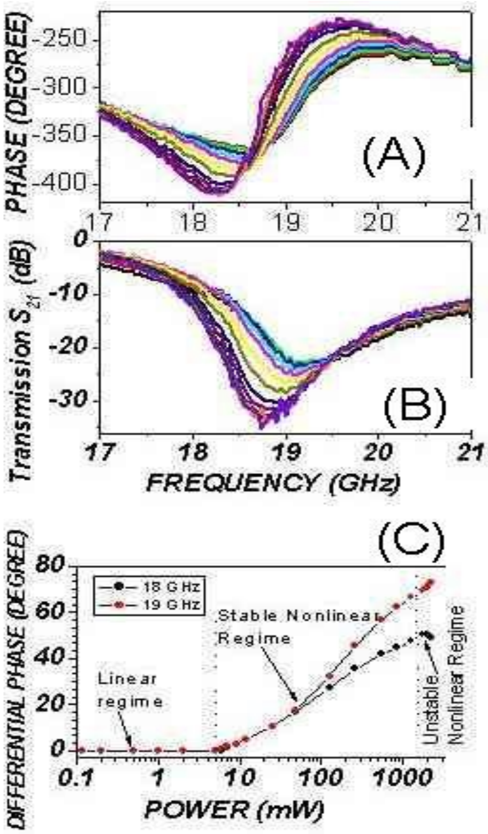
Phase shifters are used to introduce a phase shift in the passing electromagnetic (em) wave and are modern day requirement for most of the civilian and military uses. A high power microwave nonlinear phase shifter is fabricated and tested using iron as active element in microstrip geometry.To the best of our knowledge, our device is a proper planar/integrated microwave structures which is light weight in microstrip geometry [Alexey B. Ustinov and Boris A. Kalinikos, Applied Physics Letters Vol.**93**, pp.102504 (2008)].

We examine nonlinear ferromagnetic dynamics in ribbons of iron (Fe). We observed a huge differential phase shift ($\delta\phi = \phi_{HP} - \phi_{LP}$) because of microwave power for the same length of transmission line [A]. 2 GHz below resonance frequency (at 14 GHz) the differential phase shift is $\delta\phi = 55^o$ and 4 GHz above resonance frequency (at 22 GHz) the differential phase shift is $\delta\phi = 34^o$. Phase shift is the highest at the 3 dB half-power points, 150^o at 19.2 GHz. Fig.C shows that increase of power from 1 mW to 1 W shifts the phase of the device from 5^o to 80^o. The origin of this phase shift is referred to "the non-linear phase shift" associated with the reduction of static magnetization vector (M) and increase in the dynamic component (m). The characteristic did not change its shape and frequency position for P_{in} from −10 (0.1 mW) to −2 dBm (0.63 mW). For P_{in} above -2 dBm the amplitude-frequency-characteristic began to shift toward the higher frequencies [Fig.B].



The obtained experimental results show that three different operating regimes with respect to the power level of the input microwave signal could be distinguished for the nonlinear phase shifter [Fig.C]: (1) *a linear regime* for a low signal power in the range from −10 (0.1 mW) to +8 dBm (6.3 mW), (2) *a stable nonlinear regime* for the power levels from +8 dBm, and above (3) *an unstable nonlinear regime* for the power levels of more than +32 dBm. We note that the second regime can be used for microwave signal processing. In the third regime the development of second-order instability threshold effect restricts the stable performance of nonlinear phase shifter. The model provides a good description for the experimentally obtained performance characteristics of the device.