Band-Pass Nonreciprocal Switch Based on Asymmetric Nonlinearities for Radar Applications

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Radio detection and ranging systems (radars) are important for a wide range of applications, e.g., for remote sensing, air traffic control and ground traffic control. In a conventional radar system, a high power-short pulse is emitted into the space by the transmitter. The scattered pulse is then received by the antenna so that it can be processed by a highly sensitive receiver. Typically, nonreciprocal devices such as circulators and switches enable the proper routing of transmitted and received signals through the same antenna. Magnetic bias is the common approach to implement this operation, with the downside of costly and heavy devices. Active switches can be used to replace the need for a magnetic bias, however resulting in degradation of the receiver operation by increasing the noise figure.

Recently, fully passive, nonlinearity-based nonreciprocal devices have been proposed based on asymmetrically coupled nonlinear resonators (Sounas, D.L., Soric, J. & Alù, A. Nat Electron 1, 113–119 (2018)). In these devices, a nonlinear Lorentzian resonator is coupled to a nonlinear Fano resonator resulting in either low-pass or high-pass filtering response. In this work, we explore different approaches to obtain a band-pass response by asymmetrically coupling two Fano resonators with reversed filtering response (high-pass and low-pass Fano resonators in order to obtain larger transmission contrast and low insertion loss, ideally suited for pulsed radar applications.

We optimized the system for chirp radar applications realizing multiple nonlinearity-based nonreciprocal stages that can replace high-selective bandpass filters, relaxing the design specifications on the receiver by improving the noise figure, and yielding multiple narrowband receivers that simplify the system layout.