Active Integrated Beam Scanning Microstrip Array

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Research on active integrated transmitting antenna arrays (AITAA) is a multidisciplinary endeavor because it requires expertize in antenna theory, electronic device modeling and nonlinear dynamics. Due to the highly nonlinear behavior of the system of coupled oscillators, AITAA have interesting properties that can be exploited in practical applications. One such application is in the area of active integrated phased arrays (Stephan, *IEEE Trans. Microwave Theory and Techniques*, **34**, 1017-1025, 1986, and York, *IEEE Trans. Microwave Theory and Techniques*, **41**, 1799-1809, 1993). Unlike traditional phased array design, where phase shifters are used for phase control of the array elements, the phase profile of the active integrated phased array can be manipulated by using nonlinear locking techniques. Hence, the amount of phase shifters used in the array can be significantly reduced.

Previous proposed schemes often suffer from a small beam scanning range and/or the array performance is sensitive to environmental changes. In this paper, an active integrated phased array scheme consisting of a phase-locked loop (PLL), an array of coupled VCO-antennas (voltage-controlled-oscillator active integrated antennas) and phase delay elements is presented. Rectangular microstrip antennas, which function as radiators and resonators, are integrated with transistors and voltage control varactors to form the VCO-antenna elements. The coupling structure between the two outer elements at each edge of a one dimensional array consists of two circulators and one phase shifter to provide non-reciprocal coupling, whereas, the inner VCO-antenna elements are coupled to their nearest neighbor with a reciprocal resistively loaded microstrip transmission line.

The basic idea of the scheme is that a phase-locked loop is employed to enhance stability of the array operating frequency while beam scanning is done by adjusting the delay elements. Design procedures, detail analysis and experimental results of the array will be presented. Recently, it came to the authors' attention that Hwang and Myung (*IEEE Microwave and Guided Wave Letters*, **8**, 191-193, 1998) had proposed a similar beam scanning technique. Their technique is also based on controlling the coupling angle of the coupling element at each of the two edges in a coupled oscillator array. However, their coupling structure is different from ours, because their coupling scheme at the two edges is reciprocal. In addition, they only have antenna elements for the inner oscillators and the antennas act as radiators only.