Research of Miniaturized Phased Array Antennas for Microwave Sensors

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In recent years, the electrically scannable microwave (MW) array antenna for security system in consumer market is demanded in order to obtain two-dimensional and positional information of the target. The aim of this research is to develop the phased array antennas with small size and reasonably low cost. Three approaches are proposed and their research results are reported.

I. The phase shifter composed of high permittivity materials: $Ba_x Sr_{(1-x)} TiO_3$(BST), which have been attracting an attention as a key material for electrically tunable device is studied. The measurement and evaluation method of the dielectric characteristics for BST ceramic substrate is investigated first, because the evaluation technique of material parameters that is directly applicable for practical design is not established on that time. A novel evaluation method with coplanar waveguide (CPW) on high permittivity substrate is proposed for the solution. The dielectric characteristics are obtained accurately by the measurement and analysis of S-parameter of CPW fabricated on the substrate. The variation of the permittivity versus bias voltage applied to BST samples is confirmed by using this evaluation method, and then the figure of merit for the phase shifter application is evaluated. As the result, it is found out that BST's are useful for the small angle phase shifter, but still need some more break through for a wider range scanning MW sensing system.

II. Novel bi-directional feeding method; the signal is fed into radiator alternately through the both ports of serially connected phase shifters is studied. The miniaturization and cost reduction of phase shifters, which is most expensive in the system, can be achieved by this feeding method, because the required phase shift for phase shifters is reduced in one half of that in the conventional method. In this method, the variable impedance phase shifter (VIPS), of which impedance changes automatically along with the direction of signal flow, is required. New type VIPS is developed with π-type low-pass filter accompanying with three varactor diodes. Bi-directionally fed phased array antenna system combining three VIPSs and array of four patch antennas is designed, fabricated and then the radiation characteristics is measured. The characteristics of this system is ±30° in beam steering angle, 24° in beam width, -9 dB in side lobe, and the size of the feeding circuit is 20 (H) × 38 (W) × 2 (T) mm.

III. The small antenna that can select one of three discrete directions is studied, and novel two feeding circuits are developed. The first one consists of three switches and two hybrid couplers (HTBM). The second one consists of five switches and the matrix circuit with λ/4 transmission lines instead of hybrid couplers in HTBM, the phase differences of ±90° and 0° between antenna elements are created by these feeding circuits. The over all size of latter is smaller than the former. HTBM and the array of four patch antennas are fabricated and the radiation characteristics are measured. The performance are ±34° in beam steering angle, 30° in beam width, -11dB in side lobe. And the size of HTBM is 46 (H) × 68 (W) × 3 (T) mm.

The results and approaches in this research are meaningful and applicable to the development and designing of the miniaturized and less expensive phased array antennas for a consumer use security system.