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Active Integrated Oscillator Antenna Using Microstrip-T Coupled Patch Antenna

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1. Introduction

Active integrated antennas (AIAs), which are implemented by combining microwave oscillators and radiating elements, have received much attention due to low weight, compact size, low cost, and adaptability in array antenna systems. In an application as a source generator, the antenna acts as both a resonant load for the oscillator and a radiating element, through a feedback loop. The some geometries of the AIA with feedback loop have been proposed for several years [1-3]. Especially, it can be classified into two kinds in terms of the number of substrate; AIA consisted of single- or multi-layered substrate. The former approach is to use the two port microstrip patch antenna as a feedback resonator of the oscillator on the single substrate [4]. This results into easy fabrication, but it has a drawback with an additional chip capacitor for blocking the DC current in RF path. The latter approach uses a multilayer slot coupled antenna [5]. Since the radiator is isolated from the FET source, EMI/EMC problem and DC isolation on an active circuit can be easily avoided as compared to other single-substrate. But it is expensive to be implemented on the multi-layered substrate and hard to match to active devices.

In this paper, we proposed the feedback antenna oscillator using the Microstrip-T coupled patch antenna as feedback resonator. Since this oscillating antenna is consisted of electromagnetically coupled T-shape microstrip line on both sides of rectangular patch, chip capacitors for blocking the DC current in the RF path can be avoided [6]. This means that a cost and unnecessary effort by attaching the capacitor is able to be cut down.

2. Feedback Oscillator Antenna Design

The proposed AIA configuration is shown in Figure 1. The oscillator contains an amplifier and electromagnetically coupling T-shaped patch resonator. Extra microstrip lines connecting both sides of the patch are required to adjust the loop phase for oscillation. To maintain the constant load impedance at each antenna port, the proper input and output matching circuit were designed. In order to oscillate, the closed-loop gain should be larger than 0 dB and the electrical length of the loop should be a multiple of 2π at the operating frequency. The circuit was fabricated on Duroid 5880 with thickness of

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0.508 mm and relative dielectric constant (ε_r) of 2.2. For an operating frequency of 5.8 GHz, the length (L) and the width (W) of the Microstrip-T coupled patch antenna have a same value of 16.6 mm, and place the antenna away from the active circuit to reduce the surface wave effect on the active element. The gap spacing (s) is 0.15 mm and the thickness (t) of coupled line is 2.5 mm. A bias condition for the oscillator with an ATF-13786 GaAs MESFET is V_{DS} = 2.5 V and V_{GS} = 0.1 V with a drain current (I_{DS}) of 20 mA, and the oscillator is driven using a self biasing technique.

3. Measurements

Figure 2 shows the results of the S-parameters versus frequency for the two port Microstrip-T coupled patch antenna. The characteristics of the antenna are measured with an HP8755 network analyzer. At the center frequency of 5.8 GHz, the measured return loss and coupling power is approximately -15.65 dB and -2.2 dB, respectively, similar to the simulated results. The impedance bandwidth (2:1 VSWR) of the antenna is approximately 2 % from the center frequency. In addition, to satisfy the oscillation phase requirement, the microstrip loop is fixed to the suitable electrical length in consideration of the measured phases of the amplifier and passive antenna. Figure 3 shows the radiated output power from the fabricated feedback oscillator antenna measured in anechoic chamber. This oscillation frequency is measured at 5.813 GHz, which is 0.2 % close to the frequency of 5.8 GHz. The output power is measured about -25.17 dBm using an Agilent E4440A spectrum analyzer and a double ridged horn antenna (Gain = 17 dBi) as a reference antenna away from a distance of 2 m. An EIRP (Effective Isotropic Radiated Power) correspond to the above data is 19.2 mW [7] and the total RF power divided by the input DC power yielded a DC-to-RF efficiency of 25.7 %. The simulated and measured radiation patterns for the E-plane and H-plane are shown in Figure 4. The simulated radiation patterns are calculated by using the gap source technique, in the commercial EM simulator HFSS, considering the complete feedback active antenna which has same layout except for an active transistor. Both of the radiation patterns are similar to the ordinary microstrip patch antenna's one. The received cross-polarizations in the E-plane and H-plane of the AIA are approximately -17 dB and -13 dB lower than the maximum co-polarized radiation, respectively. The measured co-polarized radiation patterns in the E- and H-plane have a similar trend with those of the simulated results. As seen in Figure 4(b), the radiation pattern in the H-plane is asymmetry due to the asymmetrically presence of the distributed oscillator-feedback circuitry..

4. Conclusions

In this paper, the feedback oscillator antenna using the Microstrip-T coupled patch antenna is proposed at 5.8 GHz. The fabricated active antenna is investigated with the comparison of the measured and simulated results. The active antenna utilizes the electromagnetic coupling between the Microstrip-T and the patch for closing the feedback loop. The oscillator antenna achieves an EIRP of 19.2 mW and the cross-polarization level in the E- and H-plane are less than -17 dB and -13 dB, respectively. Since the Microstrip-T coupled antenna shows a good DC isolation, we need no chip capacitor resulting low cost and easy fabrication in active transmitting system.

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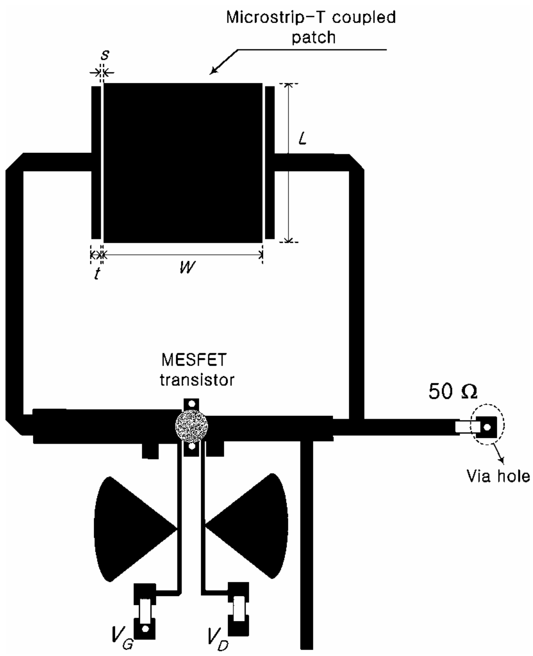
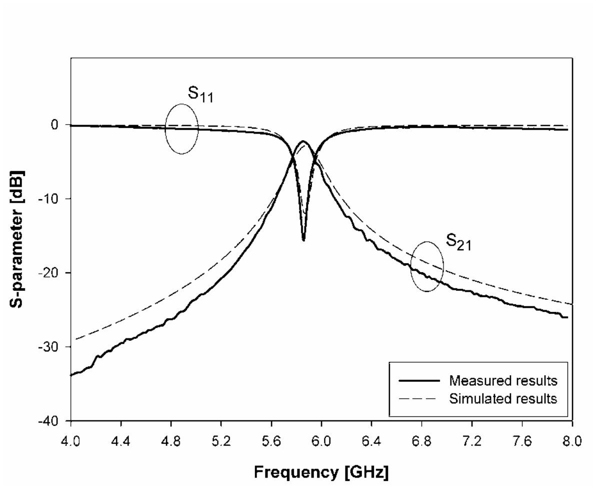


Figure 1. Configuration of active feedback antenna



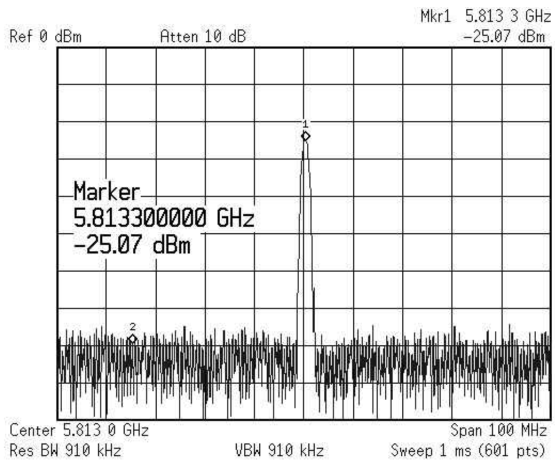
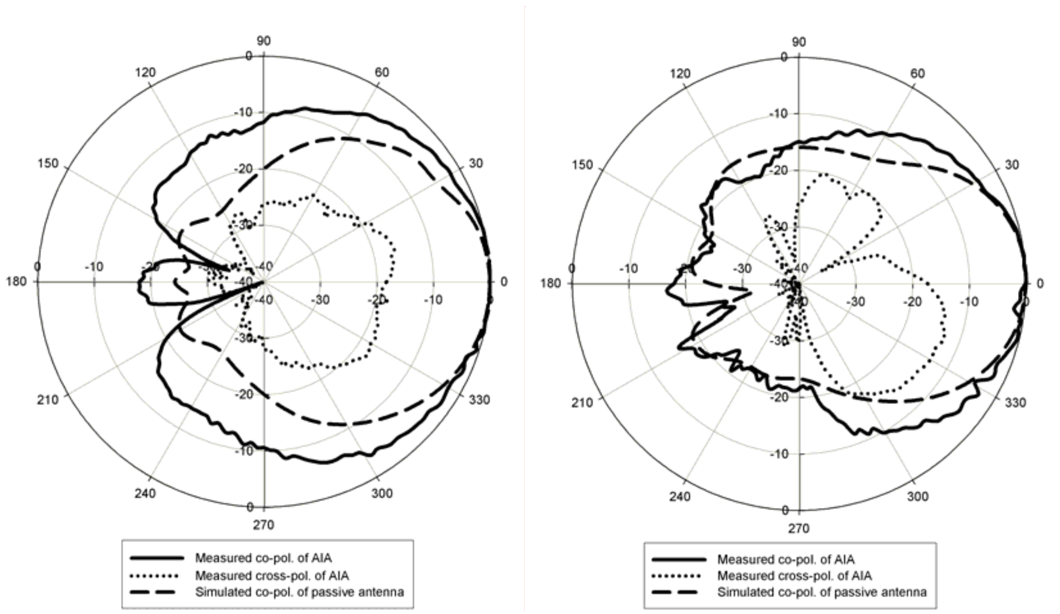


Figure 2. S-parameters for Microstrip-T coupled patch antenna

Figure 3. Measured output power radiated from active feedback oscillator antenna



(a) E-plane

(b) H-plane

Figure 4. Radiation patterns in E-plane and H-plane