Circular Arrays for GSM-UMTS Applications

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***ABSTRACT* -** The switched beam antenna, a smart antenna technology, consists of an array of antennas, a beam-forming network and a switching matrix. It may be used to generate *n* beams to improve the carrier to interference ratio (CIR) and the reuse of frequency in cellular systems, increasing system capacity.

1. Introduction

Several beam switching techniques in multiple beam system applications have been reported by various authors and a few of these techniques have been considered in this paper. Skahill and White [1] used a Butler Matrix and a switching matrix to excite only the sector of the circular array that contributed to formation of the desired radiation pattern. Krairiksh et al [2], developed a flat four-beam compact array antenna, designed using a circular array of four antennas and four 1-bit phase shifters. Kuga and Arai [3] introduced a flat four-beam switched array antenna and the beam switching was carried out by switching input terminals of the hybrid couplers through terminal one to terminal four. Scott et al [4] introduced a single-port adaptive antenna using switched parasitic elements, employing the concept of multiple Yagi-Uda arrays sharing the active element. The parasitic element is switched to appear as a director, reflector, or “invisible” to switch beam of the antenna.

This paper describes a simplified system composed of a circular array and a passive beam-forming network with several ports [5-7]. It includes two NxN Butler matrices, a switching matrix and a weights box, including the magnitude and phase of the excitation coefficients, which synthesize the required pattern. With the first Butler Matrix any beam may be selected and given the phase shift to deflect the pattern. Several narrow and directional beams can be generated simultaneously around 360º.

2. Design of the Array

The antenna has been designed to operate at GSM-1800, GSM-1900, PCS and UMTS bands with 2Ghz center frequency. The antenna geometries designed for fabrication are given in Fig. 1. The two layers between the ground plane and the patches (layers 2 and 3 in the Fig. 1) are air, separated 15mm and 35mm respectively, which limits the effect of surface waves and enables easy adjustment of the slot-to-patch distances.

The measured return loss for the fabricated antenna achieves a bandwidth in excess of 37.32% for S11<-10dB at port V and port H, as shown in Fig. 2 The isolation between the two ports is better than -27dB (Fig. 3). The front-to-back ratio of the antenna radiation pattern is better than -17dB (Fig. 4). Figure 5 shows the Photograph of the antenna prototype.

3. N-Beams switched array antenna with NxN Butler Matrix

The system [5-7] is composed of a circular array and a passive beam-forming network with several ports. It includes two NxN Butler matrices, a switching matrix and a weights box, including the magnitude and phase of the excitation coefficients, which synthesize the required pattern. With the first Butler Matrix any beam may be selected and given the phase shift to deflect the pattern. Several narrow and directional beams can be generated simultaneously around 360º. The system configuration is shown in Figure 6 and Figure 7 shows measured multiple beam.

Furthermore, if two adjacent beams are excited simultaneously in a circular array with directional elements arranged in a multiple beam system, a cosine amplitude taper at the outputs of the Butler Matrix can be generated. This leads to a remarkable decrease in the side lobe level as is shown in [7]

To achieve SLL and Crossover level improvement to the adjacent beams, the beams generated by the system could be increased by adding Butler matrices with several ports and increasing the number of antennas used. Nevertheless the system cost would be raised. On the other hand, if Butler matrices with few ports and antennas were used, the synthesized pattern would have poor levels of SSL and crossover. If we excite two adjacent beams simultaneously in a circular array with directional elements arranged in a multiple beam system, we can generate cosine amplitude taper at the outputs of the Butler Matrix. This leads to a remarkable decrease in the side lobe level [7].

To generate additional directional beams, the beams generated by the system described before could be modified by adding switched phase shifters at the input of the second Butler matrix. With an additional linear progression of phase shifts across the input ports of the second matrix, it would produce linear angular shifts of the resultant directional pattern [7].

4. Conclusion

We have analyzed the "Butler Matrix" beam switching technique used in multiple-beam system applications with circular arrays. It could also be an excellent candidate for base-station applications in wireless communication services.

Also, the original system configuration could be improved, by means of additional hardware components like switched phase shifters to generate additional directional beams. In the same way, by means of an additional Wilkinson power divider, we powered two adjacent beams at the same time, improving SLL and crossover levels. Similar results could be obtained in synthesizing the appropriate pattern.

References

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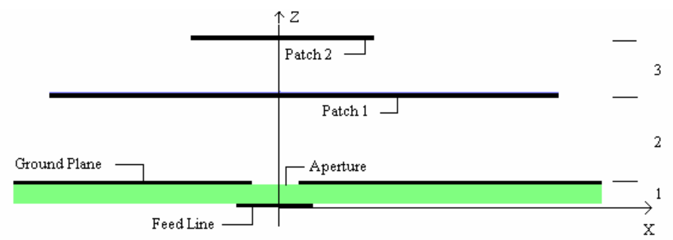

Figure. 1 Side view of the antenna

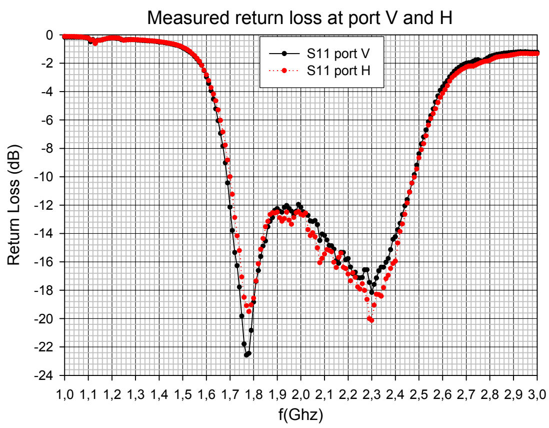

Figure. 2 Measured return loss at port V and H.

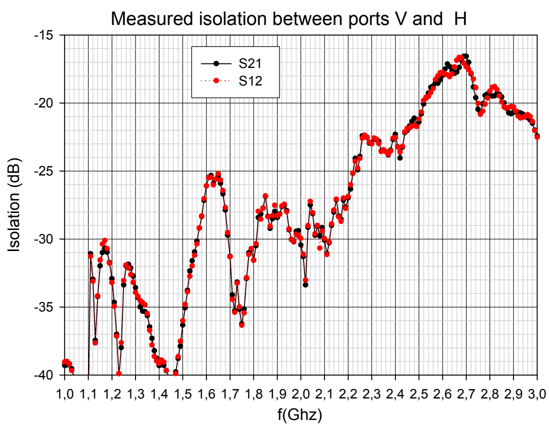

Figure. 3 Measured isolation between ports V and H

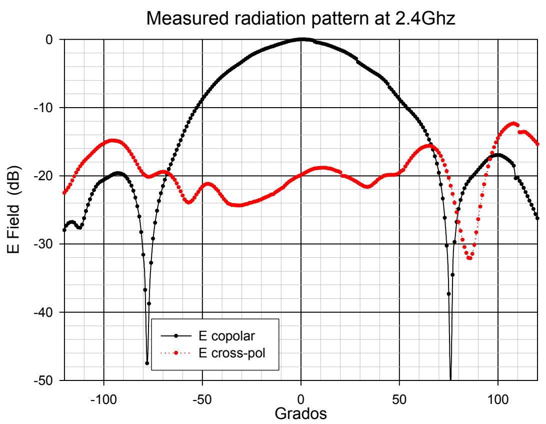

Figure. 4 Measured E plane radiation pattern at 2.4GHz, for port V.

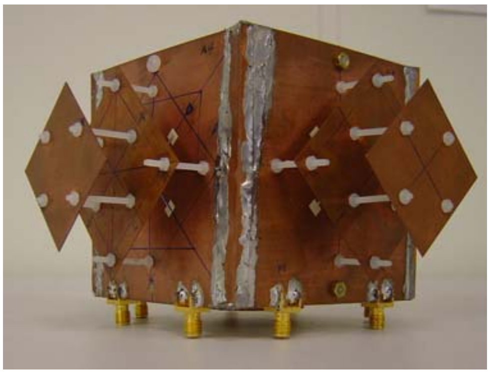

Figure. 5 Photograph of the antenna prototype

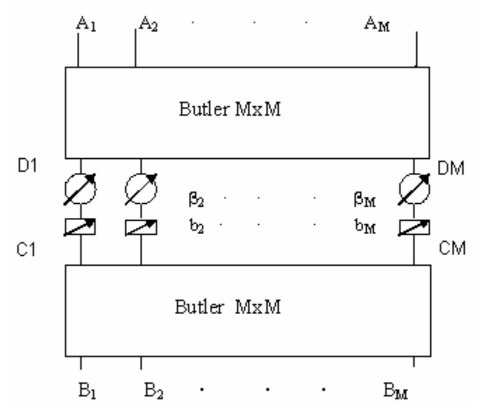

Figure 6. System Configuration

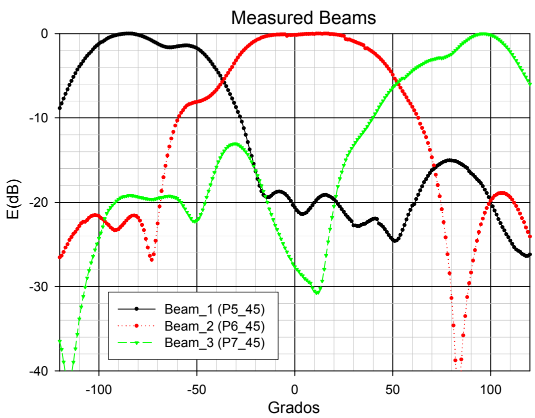

Figure. 7 Measured multiple beams.