A NEW BROADBAND CIRCULAR PATCH ANTENNA

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ABSTRACT

A simple technique to improve the impedance bandwidth of a circular microstrip patch antenna using two sectoral slots is proposed. Using this design more than 5% impedance bandwidth is obtained. The added advantage of this new antenna is that it can be fed by a 50-Ω microstrip line.

INTRODUCTION

Microstrip antennas are quickly replacing conventional antennas due to advantages such as light weight, small size, low production cost, and conformal nature. The commonly used radiating elements are rectangular and circular patches. The inherent disadvantage of these antennas is their extremely narrow impedance bandwidth. Although numerous methods are described in the literature to improve the impedance techniques are available on bandwidth enhancement of a circular microstrip patch. This is mainly due to the limited use of the circular patch antenna because of high input impedance along its circumference, which restricts the direct use of a 50-Ω microstrip line as feed. A method to overcome this constraint has already been proposed by the authors, wherein, a sectoral slot shunted with a conducting strip is made on the patch [5]. This antenna shows wide variation in input impedance along the circumference and thus can easily be matched with a microstrip line of any impedance.

One of the techniques commonly used to enhance the bandwidth of the circular patch is by using a parasitic element over the patch in a stacked fashion [6]. Another conventional method is the use of a thick dielectric substrate to improve the impedance bandwidth of the circular patch antenna [7]. Even though there is substantial improvement in the impedance bandwidth of the antennas, in both cases the structure becomes bulky and complex. In this article we report a new technique to enhance the impedance bandwidth of circular patch antenna on thin dielectric substrates.

DESIGN AND EXPERIMENTAL DETAILS

The schematic diagram of the antenna is shown in Figure 1. Two sectoral slots are made on the patch surface. The presence of the sectoral slots on the patch causes the antenna to resonate at two adjacent frequencies, which results in the enhancement of the impedance bandwidth.

As a typical example, an antenna is fabricated on a dielectric substrate having thickness $h = 0.16$ cm and dielectric constant $\epsilon_r = 4.5$. The radius r of the patch is 4.95 cm and the sectoral slot angle θ is 6°. The angular position of the 50-Ω feed point from the center of the sectoral slot ϕ is 30°.

The VSWR plot of the antenna is shown in Figure 2. The 2:1 VSWR bandwidth of the antenna is 47.66 MHz and the central frequency is at 882.7 MHz. This corresponds to a 5.4% impedance bandwidth. This is much larger than the impedance bandwidth of 1% to 2% of ordinary circular patch antennas.

The E- and H-plane radiation patterns of the antenna at the central frequency and the two end frequencies (normal-

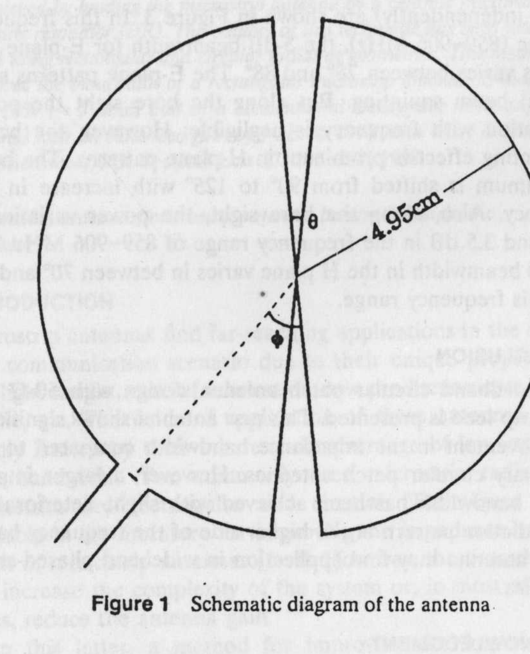

Figure 1 Schematic diagram of the antenna

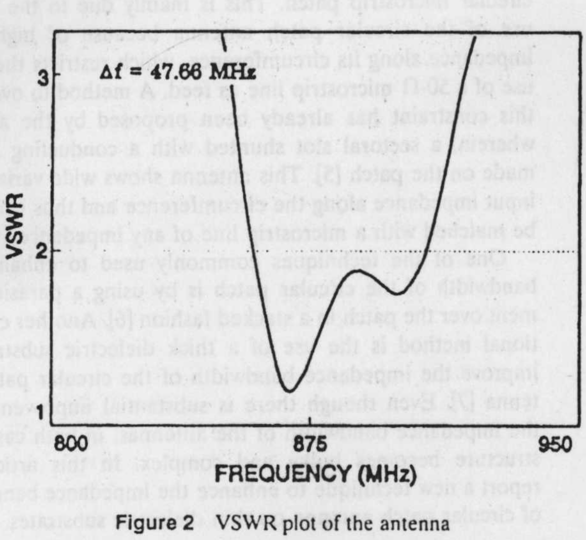

Figure 2 VSWR plot of the antenna

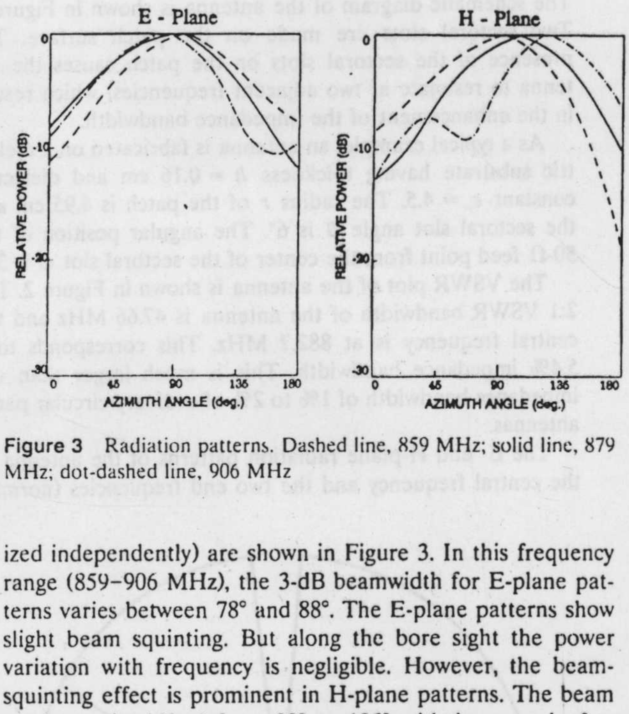

Figure 3 Radiation patterns. Dashed line, 859 MHz; solid line, 879 MHz; dot-dashed line, 906 MHz

ized independently) are shown in Figure 3. In this frequency range (859–906 MHz), the 3-dB beamwidth for E-plane patterns varies between 78° and 88°. The E-plane patterns show slight beam squinting. But along the bore sight the power variation with frequency is negligible. However, the beam-squinting effect is prominent in H-plane patterns. The beam maximum is shifted from 90° to 125° with increase in frequency. Also, along the bore sight, the power variation is around 3.5 dB in the frequency range of 859–906 MHz. The 3-dB beamwidth in the H plane varies in between 70° and 80° in this frequency range.

CONCLUSION

A broadband circular patch antenna design with 50-Ω microstrip feed is presented. This new antenna shows significant improvement in the impedance bandwidth compared to the ordinary circular patch antennas. However, a larger impedance bandwidth has been achieved with slight deterioration in radiation pattern at the higher side of the frequency band. This antenna may find application in wideband phased-array systems.

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tion capacitance model can be used to describe this process:

$$C_{\mathrm{ramp}} = \frac{m}{(1 - V/\phi)^n} \tag{5}$$

where m and n are constants which can be determined by using the continuity conditions for the beginning and end of this process, i.e.,

$$C_{\mathrm{ramp}} = C_1, \qquad \text{when } V = V_1$$
$$C_{\mathrm{ramp}} = C_2, \qquad \text{when } V = V_2. \tag{6}$$

Using Eqs. (5) and (6), we obtain

$$n = \frac{\log\left(\dfrac{C_1}{C_{21}}\right)}{\log\left(\dfrac{\phi - V_2}{\phi - V_1}\right)} \quad \text{and} \quad m = C_2\left(1 - \frac{V_2}{\phi}\right)^n. \tag{7}$$

Combining Eqs. (2), (3), and (5), we obtain the complete C–V model of the SRD as

$$C = \begin{cases} \dfrac{C_0}{(1 - V/\phi)^\gamma}, & V \le V_1 \\ \dfrac{m}{(1 - V/\phi)^n}, & V_1 < V < V_2 \\ C_{f0}\exp\left(\dfrac{qV}{\eta kT}\right), & V \ge V_2. \end{cases} \tag{8}$$

V. DISCUSSION

Through the measured C–V result, we have modeled the SRD using Eq. (8). This model can be easily implemented in a circuit simulator. The R_s–V characteristic is more complicated. Just before conduction of the diode starts, R_s first decreases, then in the transition region rapidly increases, reaching a peak value, and finally drops again. However, R_s does not vary much with the voltage. So, the values of R_s extracted through dc measurements may still be used to model the diode.

VI. CONCLUSION

This paper has presented a fast and accurate technique for the characterization of microwave step recovery diodes. A simple transmission line test fixture is designed for the characterization of SRD chips. Two SRD chips are measured by using this technique. Based on the measured results, a more accurate model of the step recovery diode has been developed.

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