SWITCHING POLARISATION DIVERSITY COMMUNICATION SYSTEM
APPLICATION OF RECTANGULAR DIELECTRIC RESONATOR ANTENNAS

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ABSTRACT

In this paper a new application of a Rectangular Dielectric Resonator Antenna (RDRA) is presented. The experimental and simulation results of an RDRA show that the difference between the co- and cross-polarization radiation levels is at least 15dB. Using a single RDRA exciting by two probes at two modes TE\textsubscript{x111} and TE\textsubscript{y111}, an antenna to receive two orthogonal polarization waves is made. A communication system including a transmitter with two orthogonal dipoles and correspondence switching polarization diversity receiver at 2.36GHz was designed and implemented to demonstrate the application of polarization diversity of an RDRA as the receiver antenna.

Keywords: Dielectric Resonator, Antenna and Polarization Diversity

1- Introduction

Dielectric Resonators (DRs) made of low-loss and high relative dielectric constant have been widely studied in the past decades for designing miniaturized microwave components and devices, which have been well used in microwave circuits such as filters and oscillators. On the other hand, the use of DRs for antenna application received less attention even though the first study of dielectric resonator antennas (DRAs) was made in 1983 [1]. However, in recent years DRAs have received increased interest and a significant amount of research activities have been reported [2-6].

DRAs can be in a few geometries including cylindrical, rectangular, spherical, half-split cylindrical and hemispherical shaped. Among them, rectangular DRAs are more attractive for easier fabrication. Their radiation characteristics such as the resonance frequency,
patterns and impedance bandwidth could also be more conveniently adjusted by tuning the two aspect ratios. Simulations and experimental studies of RDRAs have been reported in the literature [6,9].

In this paper, the study of the use of an RDRA for switching polarization diversity is presented, which includes the design and implementation of a dual polarized RDRA, a transmitter with two dipole antennas for transmitting waves of orthogonal polarization and a receiver for diversity reception at 2.36 GHz.

2- Probe-fed Rectangular Dielectric Resonator Antenna

Figure 1-a shows the structure of a single probe-fed RDRA. The DR with dimensions $a=b=18$mm, $h=9$mm and $\varepsilon_r=37$ is placed at the centre of a circular ground plane of a diameter $d=10$cm with an operation frequency of 2.36GHz. The rectangular DR is excited by a small probe located at $x=a/2$, $\phi=0^\circ$ at the fundamental mode of the DR $TE_{111}^\circ$ [8].

The simulated co- and cross-polarization radiation patterns of the RDRA for the E- and H-plane using the HFSS [10] are shown in Figure 2 and the measured radiation patterns are shown in Figure 3. It can be seen that the RDRA antenna excited by a probe on $x$-axis radiates as predominantly a $x$-polarized wave in $xy$-plane, but with an orthogonal or cross polarization which is along $y$-direction, with a cross polarization level [11] at least 15 dB.

Hence, when two probes are used to feed the RDRA as shown in Figure 2 with probes located at $x=a/2$, $\phi=0^\circ$ and $y=a/2$, $\phi=90^\circ$, a dual polarized RDRA is obtained, with polarization in $x$- and $y$-direction. When this RDRA is used as a receiver antenna, each polarization can be selected using a switching circuit, thus provided polarization diversity. The return loss at each selected probe including the effect of the switch is shown in Figure 4 against frequency. The antenna is well matched at 2.36 GHz for both polarizations.

![Figure 1: a) Single probe-fed RDRA excited by a probe located along x-axis, b) Probe-fed RDRA using two probes along x and y-axis for polarization diversity](image-url)
Figure 2: The simulated co- and cross-polarization radiation patterns of the RDRA

Figure 3: The measured co- and cross-polarization radiation patterns of the RDRA
Figure 4: The measured reflection coefficient of the RDRA for two modes TE\textsubscript{x111} and TE\textsubscript{y111}.

5- Transmitter and Switching Polarisation Diversity Receiver

Figure 5-a and b show the schematic diagram of the transmitter and switching polarization diversity receiver operating at 2.36GHz. The frequency of the signal source in the transmitter can be adjusted between 2.0 and 2.5GHz. The polarization of the wave radiated by two orthogonal dipoles in the transmitter is controlled manually using a SPDT microwave switch. At the receiver, the outputs of the dual polarised RDRA are connected to another SPDT microwave switch. The switch is further controlled by the level of the carrier detected at the output of the RF detector. A low noise amplifier is used to amplify the received signal of the selected polarization. A mixer and a local oscillator are used to down-converted the signal with an IF frequency around 100 MHz. After amplification, the level of the IF signal detected by an RF detector. The detected DC signal is proportional to the amplitude of the carrier. This is compared with a pre-set reference voltage. If the DC level is less than the reference value, the switch will then be activated through a digital controller. Hence, a reception with a satisfactory level takes place.

Table 1 shows the levels of the output of Mixer at IF and RF detector when the transmitting and receiving antennas are separated by a distance of 2m, and the dipoles are switched to produce either horizontally or vertically polarized waves, which corresponds to TE\textsubscript{x111} and TE\textsubscript{y111} modes of the RDRA respectively during testing. The co- and cross-polarization outputs are significantly different. The polarization diversity can be automatically realized when the reference V\textsubscript{R} is set 1V, which has been experimentally demonstrated.
5- Discussion and Conclusion

In this paper a new application of the RDRA has been described. A single RDRA has been shown to be able to receive orthogonal polarized waves for polarization diversity. Simulation and experimental results show that the difference between co- and cross- polarization radiation is at least 20dB. The polarization diversity using the RDRA has been demonstrated with a transmitter capable of transmitting two orthogonally polarized waves and a receiver for signal amplification and switching control. For simplicity, the receiver has been designed to make use of a reference voltage for switching control. Using two channels, one corresponding to each polarization, and making an amplitude comparison of these two channels for switching control would, however, can improve this.
Table 1: The measured value of signals at the output of down converter and RF detector for different matched modes between transmitter and receiver.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Horizontal Dipole Radiation</th>
<th>Vertical Dipole Radiation</th>
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<tbody>
<tr>
<td></td>
<td>TE_{x_{111}} mode</td>
<td>TE_{y_{111}} mode</td>
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<tr>
<td>Mixer out at IF (dBm)</td>
<td>-18.75 -26.5</td>
<td>-25.45 -19.25</td>
</tr>
<tr>
<td>RF Detector (V)</td>
<td>2.25 0.35</td>
<td>0.45 2.15</td>
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5- References: