CONCLUSIONS AND PERSPECTIVES

The realization of a 4 × 4 Butler matrix in the millimeter frequency band is possible with microstrip technology. It can be manufactured without any crossing on a single layer, but the parasitic radiations of the feeding network (which is the Butler matrix) slightly affect the antenna radiating patterns by an increase of the sidelobes levels in the H-plane and thus narrower beams. However, the principle is validated because pointings are observed.

Regarding the parasitic radiation patterns, the use of multilayer circuits is essential. A second 4 × 4 Butler matrix will be isolated from the antenna array, which will be fed by slots in the ground plane and thus will be realized.

Afterwards, and 8 × 8 Butler matrix may be perfected on a bi-layer circuit by using, for example, microstrip/slot/microstrip transitions.

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SLOT ANTENNA FED BY A CPW LINE WITH TAPERED TRANSITION

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ABSTRACT: *A tapered coplanar waveguide (CPW) transition is proposed in order to facilitate the connection between a slot antenna and coaxial connector. The broadband bow-tie slot antenna is considered as an example in this design. The tapered transition is utilized to optimize the connection of two 50Ω CPW lines with different widths. A narrow CPW line is connected to the slot-antenna feed point and the wide CPW line is connected to the coaxial SMA connector for measurement purposes. The tapered transition proposed here results in a negligible reflection in the CPW feed when its length is approximately λ/20.* © 2003 Wiley Periodicals, Inc. Microwave Opt Technol Lett 38: 465–467, 2003; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.11091

Key words: *slot antenna; coplanar waveguide feed; tapered transition*

INTRODUCTION

Coplanar waveguide (CPW) transmission lines have been widely used in recent years as feeding networks with slot antennas. CPW lines have many useful design characteristics such as low radiation loss, less dispersion, and uniplanar configuration. They can also be used for RF frequency applications, where their easy mounting and integration with other microwave circuit components significantly simplifies the antenna design [1]. Usually, the CPW line is designed with 50Ω systems. For X-band applications, the antenna size is very small and requires a narrow CPW feed line. However, the narrow CPW line is not easily connected to an SMA connector for measurement purposes. Therefore, it is necessary to have a tapered 50Ω CPW line as a transition between the narrow-conductor CPW feed line (connected to the antenna) and the wider CPW line (attached to the SMA connector) in order to obtain a good transition between transmission lines. Unlike microstrip transmission lines, the CPW can be designed as a tapered CPW with a 50Ω characteristic impedance over a uniform thickness of a dielectric substrate [2]. The CPW is similar to a coaxial transmission line in terms of the potential design of transmission lines that have constant characteristic impedance, yet different dimensions of the inner and outer radii of the coaxial line (corresponding to the center conductor and aperture widths for the CPW). In order to examine these characteristics, a wide bandwidth antenna is considered. The bow-tie slot antenna [3] has been recently studied and has shown a wide bandwidth approaching 40% [4]. For the present work, the antenna has been first redesigned to achieve a wideband performance when the antenna port is considered to be at the center of the slot. The performance for different tapered CPW transitions is then investigated. The analysis is performed numerically using Momentum from the Agilent Advanced Design System [5].

DESCRIPTION OF THE ANTENNA FED BY THE CPW

The configuration of the bow-tie slot antenna fed by a CPW line is shown in Figure 1. The ground plane (not shown in the figure) in which the slot antenna is cut is infinite, as is the supporting dielectric substrate with permittivity $\varepsilon_r = 2.94$ and thickness $t = 1.57$ mm. First, it is important to design the bow-tie slot antenna

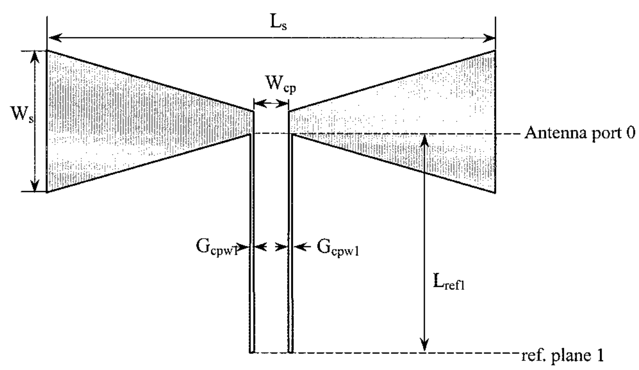

Figure 1 Bow-tie slot antenna fed by the CPW line and different reference planes

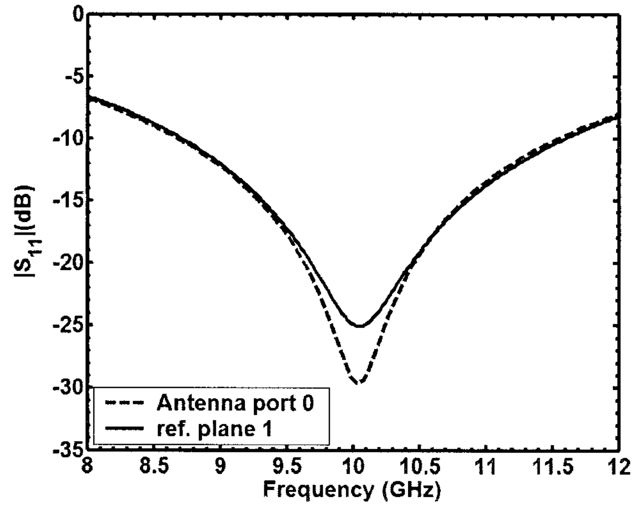

Figure 2 Reflection coefficient at the antenna port and reference plane 1 for the bow-tie slot antenna fed with the 50Ω CPW

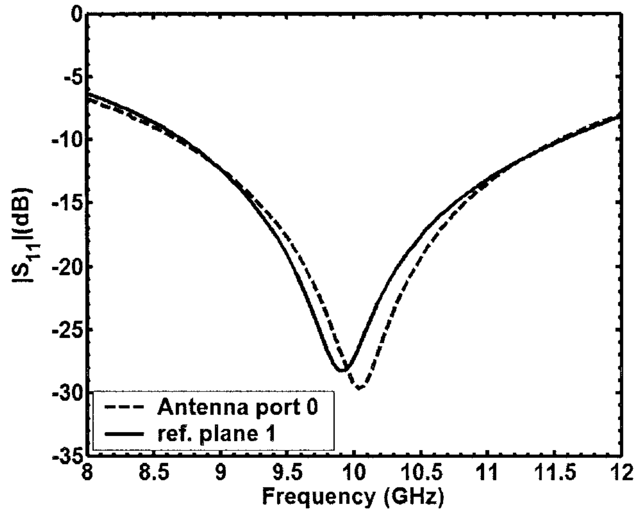

Figure 4 Reflection coefficient calculated at the antenna port and reference plane 1 for the bow-tie slot antenna fed with the 50Ω tapered CPW transition

with a 50Ω port impedance at its center. The 50Ω CPW line is designed with parameters $W_{cpw1} = 1.6548$ mm and $G_{cpw1} = 0.1$ mm. It is connected to the slot antenna with parameters $L_s = 20.64$ mm and $W_s = 6.3$ mm. The reflection coefficient is computed at the antenna port and at reference plane 1 with $L_{ref1} = 25$ mm, as shown in Figure 2. It can be seen that the antenna achieves a wide bandwidth of approximately 30%, and that the magnitude of the reflection coefficient is the same for the two different reference planes, except near the frequency, where the antenna is matched. Thus, we have established the performance of the antenna with the 50Ω CPW feed. Note, however, that the magnitude of the reflection coefficient calculated at the antenna port (labeled as "Antenna port 0" in Fig. 1) at the resonant frequency of 10 GHz differs by approximately 5 dB from the one calculated at reference plane 1. This occurs because small variations in the value of characteristic impedance of the CPW, near the resonant frequency, significantly affect the reflection coefficient of the antenna. If the CPW were designed to have exactly a 50Ω impedance, then the reflection coefficient at the antenna port and at reference plane 1 would be the same.

To increase the width of the CPW for matching to SMA or *N*-type connectors, the configuration shown in Figure 3 is proposed. A linearly tapered transition is used between the narrow and wide CPW lines. Both sides of the CPW are designed to have a 50Ω characteristic impedance. The CPW characteristic impedance is a function of dielectric permittivity of the substrate and the ratio a/b, where a is the width of the central strip line and b is the distance between the two ground planes [6, 7]. Here, $a = W_{cpw}$ and $b = W_{cpw} + 2 \cdot G_{cpw}$. These quantities correspond exactly to the diameters of the inner conductor and outer conductor of a coaxial transmission line. Therefore, if the permittivity of the substrate and the ratio a/b are kept the same, then by varying the parameter a (and consequently, the parameter b), the characteristic impedance is kept constant. The reflection coefficient shown in Figure 4 is computed at the antenna port and reference plane 1 with the following parameters (dimensions in millimeters): $W_{cpw2} = 3$, $G_{cpw2} = 0.1650$, $L_t = 10$, $W_{cpw1} = 1.6548$, $G_{cpw1} = 0.1$, $L_s = 20.64$, $W_s = 6.3$, and $\alpha = 45°$.

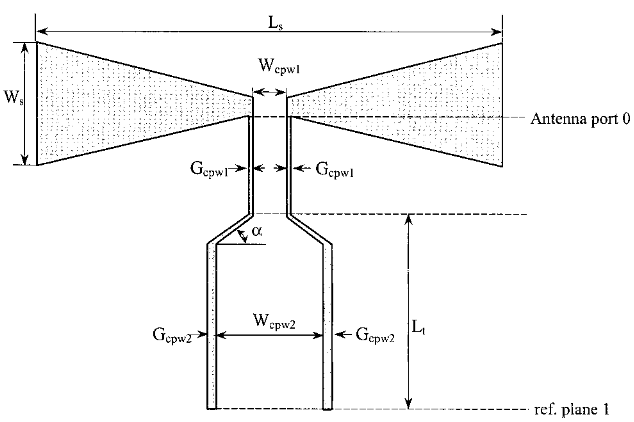

Figure 3 Bow-tie slot antenna fed with the tapered CPW transition with $W_{cpw2} = 3$, $G_{cpw2} = 0.1650$, $L_t = 10$, $W_{cpw1} = 1.6548$, $G_{cpw1} = 0.1$, $L_s = 20.64$, $W_s = 6.3$, and $\alpha = 45°$ (dimensions in millimeters)

As can be seen in Figure 4, the difference in the magnitude of the reflection coefficient is less than 5 dB as the reference plane changes from the antenna port to reference plane 1. This shows a very good match between the two CPW transmission lines used in the design. To further study this CPW transition, tapered transitions with different lengths were used. Three different tapered transitions of lengths 0.78 mm, 0.95 mm, and 1.34 mm, with the associated tapered transition angles of 30°, 45°, and 60°, respectively, were studied to optimize the reflection coefficient of the antenna. The reflection coefficient of the bow-tie slot antenna fed with the tapered 50Ω CPW with different lengths of the tapered transition is computed at the reference plane of a generator (reference plane 1) and is shown in Figure 5. One observes from Figure 5 that all of the transitions perform satisfactorily. The transition length of 0.78 mm ($\alpha = 30°$) results in the smallest reflection coefficient and is in better agreement with the results obtained at the antenna port, shown in Figure 2. This is contrary to the expectation that the longer transition should provide the better match. In this case, however, the shorter transition appears to compensate for the mismatch introduced by the non-ideal CPW, which does not have exactly a 50Ω impedance.

CONCLUSION

A tapered CPW feeding transition for a bow-tie slot antenna was proposed and studied. It was found that the tapered transition

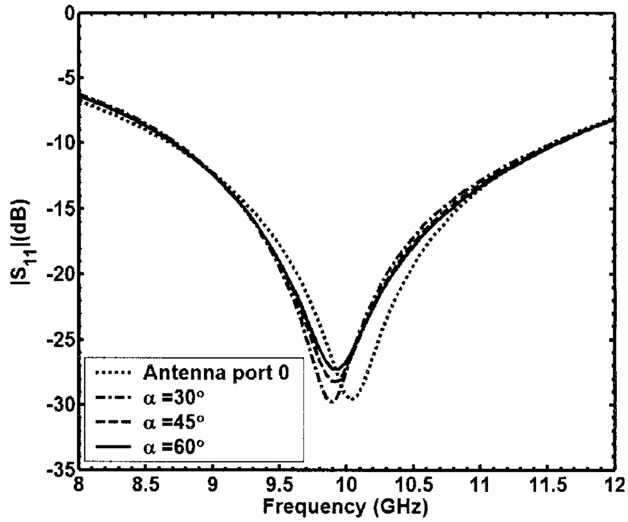

Figure 5 Reflection coefficient of the bow-tie slot antenna fed with the tapered 50Ω CPW for different lengths of the tapered transition

performance is excellent and that it is relatively independent of the taper angle. The use of this transition can facilitate measurements of the antenna characteristics when connection to a coaxial connector is required.

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NOVEL PROBE-FEEDING ARCHITECTURES FOR STACKED MICROSTRIP PATCH ANTENNAS

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ABSTRACT: *Dual-band stacked microstrip patch antennas are a popular choice for wireless and other vehicular communication applications. They are also being considered for use in feed arrays for reflector antennas. In this paper, novel center-feeding schemes to achieve the desired dual-band response will be presented. Also, novel side-feeding schemes for a potential application in arrays have been investigated. L-band frequencies were chosen to test the concept. For the stacked patch configuration, the primary objective was to get the antenna to resonate at two frequencies—1.575 GHz for the upper patch and 1.228 GHz for the lower patch—with a shared aperture and two independent excitations. Return-loss, isolation, and pattern measurements for several antenna prototypes are presented. The measured results are compared with the simulation results from an FDTD code developed at UCLA. Extension of the concept for dual-polarization and array configurations has been explored.* © 2003 Wiley Periodicals, Inc. Microwave Opt Technol Lett 38: 467–475, 2003; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.11092

Key words: *microstrip antennas; FDTD; dual-polarization*

1. INTRODUCTION

When more than one antenna is used in a dual-frequency application, the space needed for mounting and isolation becomes a problem. Potential remedies include having a broadband antenna cover the frequency range of interest, or providing independent antennas with a shared aperture. In [1–4] the authors discuss various methods for obtaining dual-frequency characteristics, such as placing shorting pins for separating the two frequency bands, simply stacking the patches together, or using genetic algorithms to design dual-frequency patches. Dual-frequency stacked patches have two patch radiators with intervening dielectric layers. Two popular configurations commonly used for stacked patches are: (i) single feed for the two frequencies and different feeds for each polarization, and (ii) separate feeds for each frequency and polarization. In [5], the authors have tabulated the various advantages

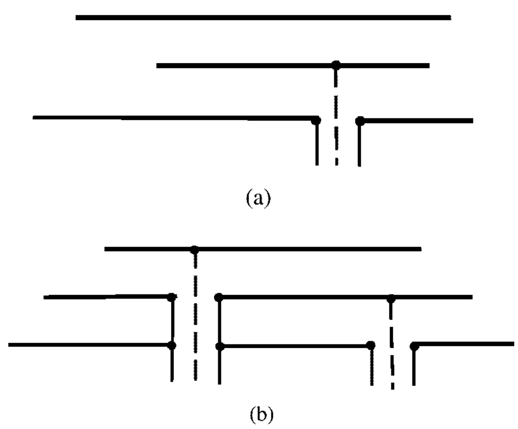

Figure 1 (a) Single-feed stacked patch antenna for dual-frequency; (b) two-feed stacked patch antenna for dual-frequency