In this paper, a coplanar waveguide fed rectangular slot antenna tuned by a patch stub is designed and presented for ultra wideband band applications. The presented antenna exhibits a small size, a wide bandwidth of 98%, and a 6 dB average gain.

Introduction

In applications where size, weight, cost, performance, ease of installation, and aerodynamic profile are constraints, low profile antennas like microstrip and printed slot antennas are required. Printed slot antennas fed by a coplanar waveguide (CPW) have several advantages over microstrip patch antennas. Slot antennas exhibit wider bandwidth, lower dispersion and lower radiation loss than microstrip antennas, and when fed by a coplanar waveguide they also provide an easy means of parallel and series connection of active and passive elements that are required for improving the impedance matching and gain [1].

A number of bow-tie slot designs were recently introduced which demonstrate wide bandwidth that ranges from 17% to 73% [2-11]. However, in order to use these antennas in phased array systems, the antenna element size must be smaller than half the wavelength at the highest operating frequency to avoid grating lobes while scanning the main beam. Thus, the separation distance between elements must be small, and such spacing results in high coupling, which causes scan blindness and anomalies within the desired bandwidth and scan volume.

Recently, the authors presented a novel wideband small-sized triangle slot antenna with a tuning stub [12]. This antenna can provide up to 50% bandwidth, and its bent version provides 57% bandwidth in the X-band for a size of only 12 mm. In this paper, a CPW fed rectangular slot antenna with a tuning rectangular patch that supports ultra wideband characteristics is presented. The numerical simulation and analysis for this class of antennas are performed using the Momentum software package of the Advanced Design System (ADS) by Agilent Technologies, which is based on the method of moments. Verifications of the ADS results are further performed by using Ansoft HFSS, which is based on the finite element method. Measurements of return loss, VSWR and radiation patterns are also conducted for verification of these new antenna designs.
Antenna Geometry

The geometry and parameters of the rectangular slot antenna with a patch stub are shown in Fig. 1, where W1 and L1 are the width and height of the rectangle, W2 and L2 are the width and height of the patch stub, and L3 is the distance between the patch stub and the CPW feedline. The antenna is supported by a dielectric substrate of a height equal to 32 mil and a relative dielectric constant of 3.38. The CPW is designed for a 50 Ω characteristic impedance with slot and feed line widths equal to 0.125 and 2 mm, respectively.

![Antenna Geometry Diagram](image)

Fig. 1. The geometry and parameters of the rectangular slot antenna with patch stub.

Antenna Characteristics

A rectangular slot antenna with a patch stub of (W1, L1, W2, L2 and L3) = (11, 7, 6, 1, and 1 mm) is simulated using HFSS to verify the results of ADS simulations. In HFSS, a finite ground plane of a size of 20×25 mm² is used. The return loss and VSWR are computed using ADS and Ansoft HFSS, and measured using a 8510 vector network analyzer as shown in Fig. 2 along with a prototype of the final antenna design. Although good agreement can be seen, there are small discrepancies between the computed and measured results, which may occur because of the effect of the SMA connector and fabrication imperfections. The measured results show that the antenna operates over a wide frequency range that extends from 8 GHz to more than 23.5 GHz, with an impedance bandwidth of more than 98%. The small size of this antenna allows for more separation distance between elements in an array environment, which in turn reduces the coupling and improves the scanning range. The radiation patterns are measured at 8, 10 and 12 GHz, and presented in Fig. 3. Good agreement is obtained between the measurements and the HFSS simulation results. The antenna gain is in the order of 6 dB as calculated using HFSS.
Fig. 2. Comparison between the measured and computed (a) return loss, and (b) VSWR, for the rectangular slot antenna of $W_1$, $L_1$, $W_2$, $L_2$ and $L_3 = 11$, $7$, $6$, $1$, and $1$ mm, respectively.

Fig. 3. Measured radiation patterns at 8, 10, and 12 GHz.

**Conclusion**

The rectangular slot antenna with the tuning patch provides 98% impedance bandwidth, 6 dB average gain, and acceptable radiation characteristics. These characteristics make it a good candidate for a variety of radar and other applications designed for frequencies between 8 GHz and 22 GHz.
References


