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Probe-Fed Rectangular Microstrip Patch Antenna Using Crystal Substrate for Wideband Applications

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Abstract

In this paper, a new microstrip rectangular patch antenna is proposed for wideband applications which can achieve a bandwidth of 2.2 GHz. The crystal ‘gallium arsenide’ is used as the dielectric substrate material of the proposed design. The radiation pattern and return loss obtained from simulation show a good impedance matching across the operating band.

Keywords: Microstrip Patch Antennas, Gain, Bandwidth, Radiation Pattern, Ansoft HFSS, Feeding Techniques, Crystal Substrate

1. INTRODUCTION

In wireless world, wideband communication is an attractive field. In recent years, broadband and ultra-wideband (UWB) antennas have received much attention in wireless communication and radar systems [1]. A bandwidth from 3.1 GHz to 10.6 GHz is allocated for UWB systems by Federal Communication Commission (FCC) of USA in 2002[2]. But the main challenges behind designing the antenna for UWB applications are the tasks for achieving wide bandwidth, high gain and compact size of the antenna as microstrip patch antenna normally gives narrow bandwidth and poor gain. At present there are many microstrip antennas for wide band and UWB applications where the mentioned challenges are met by applying different methods like changing shapes of antenna, uses of different feeding techniques, different probe locations and uses of different dielectric substrate material with different substrate thickness. In this work, we have used a crystal as the substrate material which is gallium arsenide and for the feeding we have chosen probe feed mechanism. On the other hand as a substrate material crystal plays the vital role for increasing the bandwidth. The utilization of a crystal substrate, instead of the original bulk substrate, has shown to reduce the excitation of surface wave modes, and as a consequence improves the antenna radiation efficiency, reduces the side lobe level and mitigates the problems related to coupling [3]. The gain of patch antennas can be increased by using multiple patches connected to an array or by reducing the surface wave which can create ripples in the radiation pattern. [4]. One approach suggested is the synthesized substrate that lowers the effective dielectric constant of the substrate either under or around the patch [5-6]. Other approaches are to use parasitic elements [7-8] or to use a reduced surface wave antenna [9-11]. Electromagnetic band gap (EBG) structures, also known as photonic crystal [12], are also used to improve the antenna performance [13-21]. In our paper, a new design has been proposed with improved performance.

This paper is organized as follows. In section II, analysis and design of the proposed rectangular patch antenna is presented. In section III the simulated result is shown. Finally in section IV concluding remarks are given.

2. ANTENNA DESIGN AND ANALYSIS

One of the most promising technologies for short-range high data rate wireless communication application is Ultra Wide Band technology. For many years much investigation has been done for

UWB. It has excited antenna designers for challenging design of low cost and low profile UWB antennas. However, for the mobile healthcare applications, antenna with frequency range covered Bluetooth, WiFi and UWB is well suited to short-distance applications, such as PC peripherals, the efficient transfer of data from digital camcorders, wireless printing of digital pictures from a camera without the need for a personal computer and the file transfer between cell phone handsets and handheld devices such as portable media players. It is also used for real-time location system and well-suited for radio-frequency-sensitive environments, such as hospitals and in “see-through-wall” precision radar-imaging technology.

For UWB antenna, printed antennas have been receiving considerable attention due to their low cost, lightweight and ease of fabrication. Here we present a rectangular patch antenna which covers UWB band.

The proposed antenna is constructed with gallium arsenide substrate with relative permittivity $\varepsilon_r = 12.9$ and thickness = 0.32 cm which is shown in Fig.1. The rectangular patch has a size of 9 cm X 4 cm.

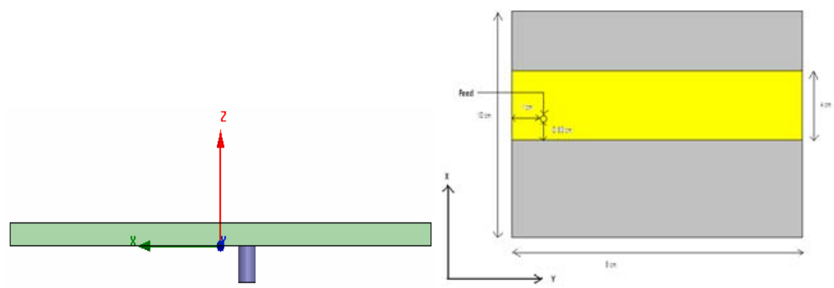

Fig. 1: (a) Proposed antenna (side view) (b) top view

3. SIMULATED RESULT

The proposed design was simulated using Ansoft HFSS software. As the antenna is probe fed, the peak of the electric current on the probe occurred at the feed point. The maximum magnetic current of the slot is at the centre and decreased as the sinusoidal distribution until became zero at the ends of the slot.

The simulated return loss curve for the antenna is shown in Fig. 2. This return loss curve shows that the antenna achieves an impedance bandwidth ranging from 2.8 GHz to 5 GHz with a return loss below -10 dB. The antenna has impedance bandwidth of 2.6 GHz i.e. the fractional bandwidth is 65%.

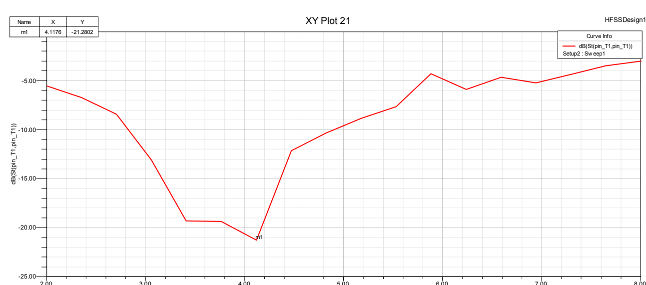

Fig. 2: Return loss of proposed design

The VSWR curve, gain and the radiation pattern of the antenna are also shown in the Fig. 3 and Fig. 4 respectively:

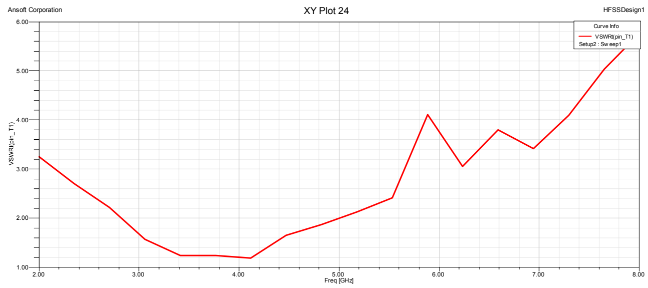

Fig. 3: VSWR vs. frequency

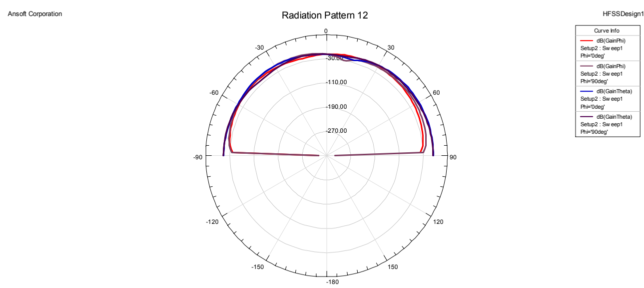

Fig. 4: Radiation Pattern of the antenna at 4 GHz

4. CONCLUSION

A newly designed wideband antenna is presented. The proposed antenna yields an impedance bandwidth of 2.8 to 5 GHz with S11 ≤ -10 dB. The simulated results show the broadband impedance matching with good radiation pattern.

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