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DESIGN OF KEY - SHAPED MONOPOLE ANTENNA FOR UWB APPLICATIONS

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ABSTRACT
In this paper key shaped monopole antenna with and without rectangular slot inserted on feeding strip is proposed for Ultra Wide Band (UWB). This UWB antenna is etched on a 30 x 30mm^2 commercially available low cost substrate of Flame Recorded Grade 4 (FR4) with thickness of 1.6mm, relative dielectric constant ε_r = 4.4 and dielectric loss tangent = 0.02. One of the industry leading 3D EM software tools for radio frequency (RF) application known as High Frequency Structure Simulator (HFSS) was used to design this UWB antenna. The reflection coefficient S_{11} of the proposed antenna was found to be less than -10dB and Voltage Standing Wave Ratio (VSWR) is less than 2. It was found that the designed UWB antenna is operable over the entire 3.1GHz - 10.6GHz frequency range.
KEYWORDS: Key-shaped monopole antenna, rectangular slot, HFSS software, UWB antenna, flame recorded grade.

INTRODUCTION

Ultra Wide Band is short range radio technology having spectrum that occupies a bandwidth greater than 20% of the center frequency or a bandwidth of at least 0.5GHz which complements other longer range radio technologies such as Wi-Fi, WiMAX and cellular wide area communications. Thus, the center frequency f_C of the UWB bandwidth is designated as

$$f_c = \frac{f_H + f_L}{2}$$

(1)

The fractional Bandwidth BW is defined as

$$BW = 2\frac{f_H - f_L}{f_H + f_L} X100\%$$

(2)

In the United States the Federal Communications Commission (FCC) has mandated that radio transmissions can legally operate in the range from 3.1GHz up to 10.6GHz, with a maximum power emission limit of -41.3dBm/MHz .Since the Federal Communication Commission (FCC) released its report in 2002, (there is a great attention in ultra-wideband (UWB) system design and its application in personal wireless communications. Today, most of computer and consumer electronic devices require wires to record, play or exchange data, UWB eliminate these wires allowing people to unwire their lives in new and unexpected ways. Examples through UWB: All the components for an entire home entertainment center could be set up and connected to each other without a single wire; a digital camcorder could play a just – recorded video on a friend's HDTV without anyone having to fiddle with wires. A mobile computer user could wirelessly connect to a digital projector in a conference room to deliver a presentation and so on. UWB technology has gained great popularity in the field of research and industrial area due to its higher data rate and large BW. Researchers have investigated many UWB antennas (Chang and Burnside; 2000) and (Garg, 2001), which show that their design would be a big issue. Antenna play a critical role in the UWB communication systems and modern telecommunication systems require antenna with wider bandwidth and smaller dimensions than conventionally possible. This has initiated antenna research in various directions one of which is by using UWB antenna. In this paper, small size, omni directional patterns, and simple structure antenna was designed to produce low distortion with broader bandwidth and it was found to be a good candidate of UWB applications.

REVIEW

UWB wireless communications systems have many expected attractive features and advantages. There are, however many technical issues needed to be resolved. UWB antennas should cover the allocated 7500MHz of spectrum so as to utilize the spectrum.

Some antennas have been proposed for Ultra wideband applications by (Wong et al, 2005, Schantz, 2004, Siwiak et al, 2001) and (FCC, 2002). They all have wide impedance bandwidth and good radiation patterns.
A significant research effort was also conducted by antenna designers, including (Rumsey,1957 and Dyson,1959); who were developing logarithmic spiral antennas, and Ross, who applied impulse measurement techniques to the design of wideband, radiating antenna elements (Ross, 1968). With these advances, the potential for using impulse based transmission for radar and communications became clear. For nearly 40 year period from 1960-1999, over 200 papers were published in accredited IEEE journals, and more than 100 patents were issued on topics related to ultra wideband technology (Barrett). The interest seems to be growing exponentially now, precipitated by the FCC allocation in 2002 of the UWB spectrum, with several researchers exploring RF design, circuit design, system design and antenna design, all related to UWB applications.

ANTENNA DESIGN GEOMETRY AND RESULT

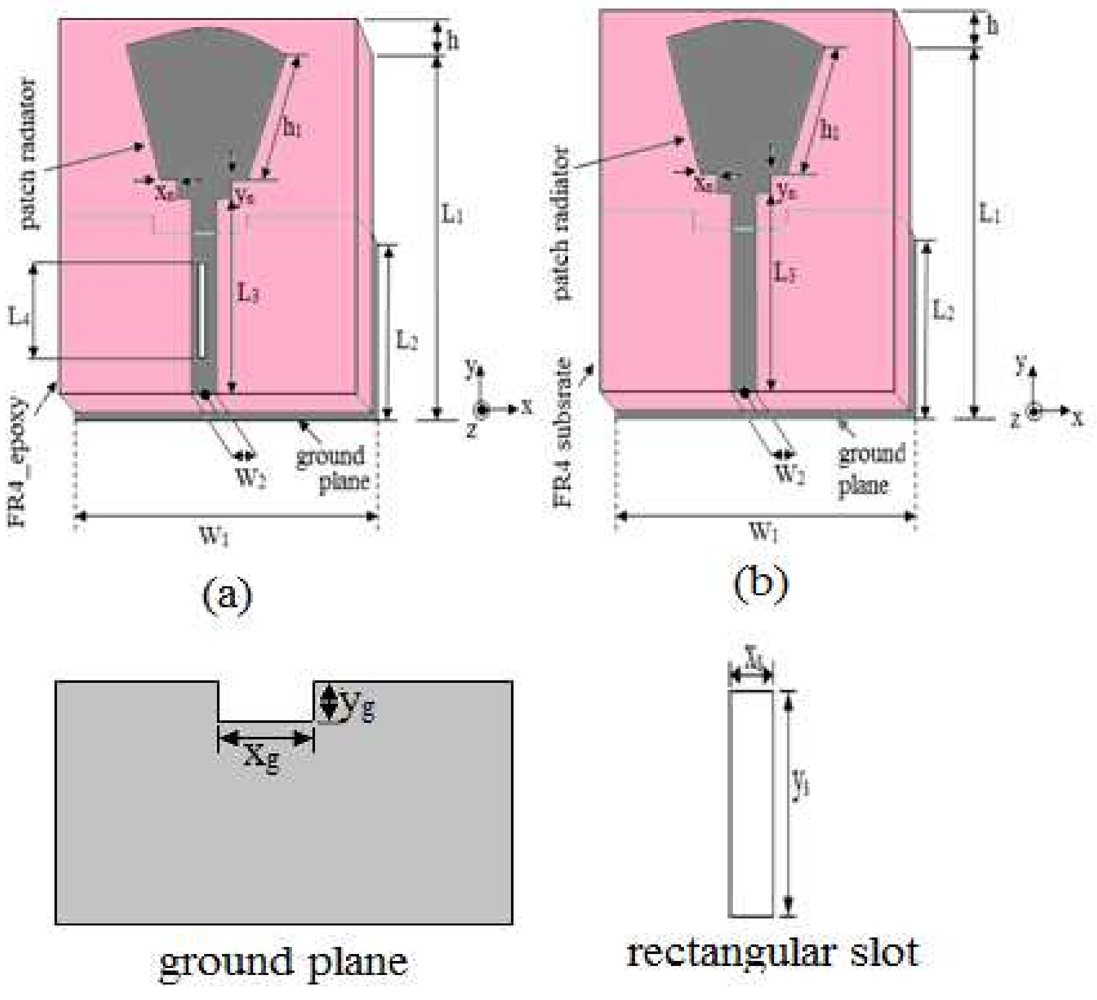


Figure1: Geometry of proposed key shaped monopole antenna

The geometry and configuration of the proposed antenna are shown in figure 1, the antenna is designed and realized on FR4_epoxy substrate with ε_r = 4.4, dielectric loss tangent = 0.02, and thickness h = 1.6mm. The excitation of the antenna is formed by a 50Ω microstrip line of width W_2 = 2mm and the Length L_3 = 16mm, L_1 is the length of the substrate equal to 30mm, and W_1 is the width which is equal to 30mm, L_2 = 15mm is the length of the ground, L_4 = y_s is the length of the rectangular slot located at the feed line, x_s = 0.4mm is the width of the rectangular slot, y_g is the length of the notch located at middle top of the ground plane with fixed x_g = 6mm, x_n and y_n are the length and the width of the notches respectively located at the bottom of the patch radiator which is made up of arc structure.

The E-plane and H-plane radiation patterns located at yz – plane and xz - plane respectively at frequencies 3GHz, 6GHz, and 7.8GHz are shown in figure 7. The radiation in the E-plane exhibits a dipole – like radiation patterns while in the H-plane it exhibits a good Omni- directional radiation patterns. But at 7.8GHz the radiation pattern is distorted. The size of the slot and the notches are critically affecting the impedance bandwidth of the proposed antenna as shown in figure 3. The voltage standing wave ratio (VSWR), of the proposed antenna is shown in figure 4.

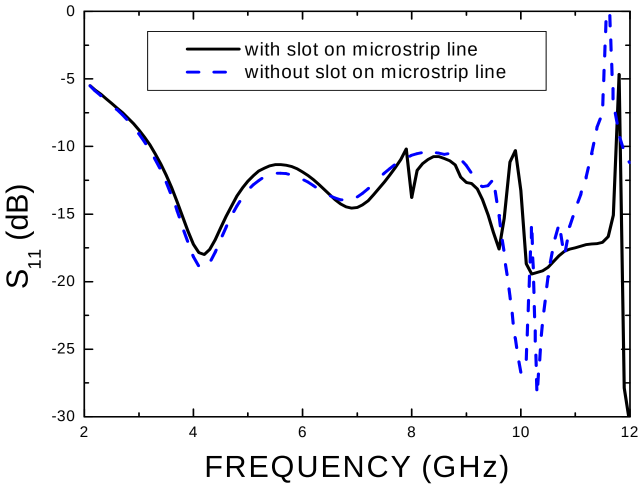


Figure 3: The simulated return loss of the key shaped antenna

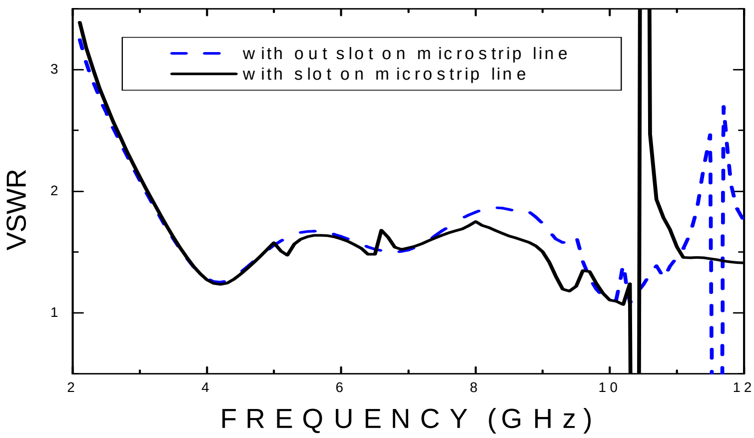


Figure 4: The VSWR of the key shaped antenna

The simulated Reflection coefficient or return loss (S_{11} < -10dB) of the key shaped antenna shown in Fig. 3 shows that antenna with rectangular slot on microstrip line is having 5-resonating frequencies 4.3GHz, 6.9GHz, 8.0GHz, 9.6GHz, and 10.3GHz. Antenna without slot on microstrip line also have 5 - resonating frequencies 4.2GHz, 6.9GHz, 10.0GHz, 10.3GHz, and 9.3GHz. So these proposed antennas are capable of supporting multiple of resonance modes distributed across the spectrum which leads to UWB characteristics. The calculated impedance bandwidth of these two proposed antenna designs for reflection coefficient S_{11} (dB) less than -10dB ranges from 11.32GHz to 3.17GHz with fractional BW of 113% for antenna without rectangular slot and 11.74GHz to 3.23GHz with fractional BW of 114% for antenna with rectangular slot. The change of rectangular slot y_s = L_4 with x_s = 0.4mm shown in figure 1 affect the impedance bandwidth of the antenna as seen in figure 5 and figure 6 shows its VSWR.

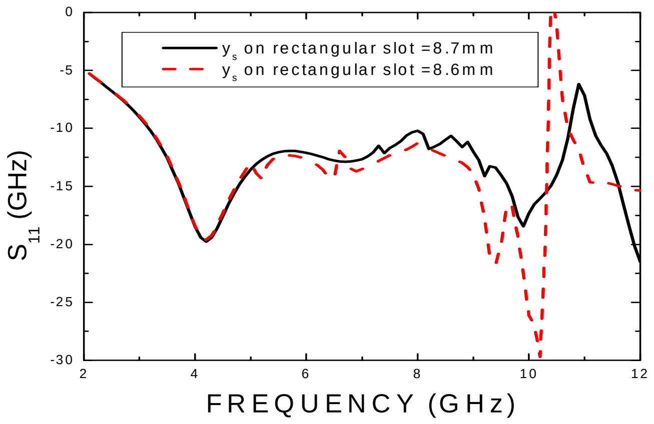


Figure 5: Simulated return loss of the proposed antenna with rectangular slot

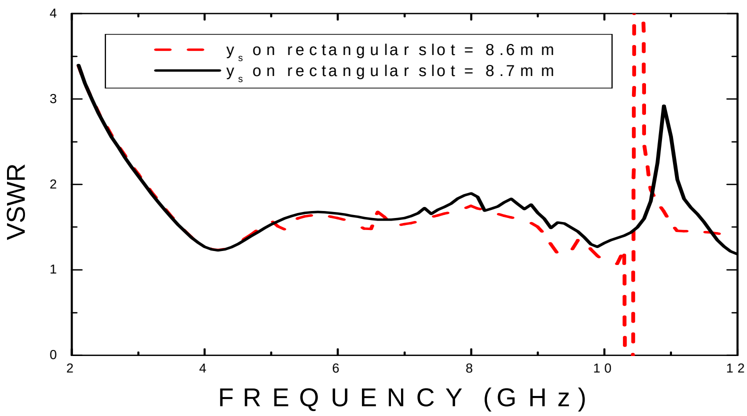
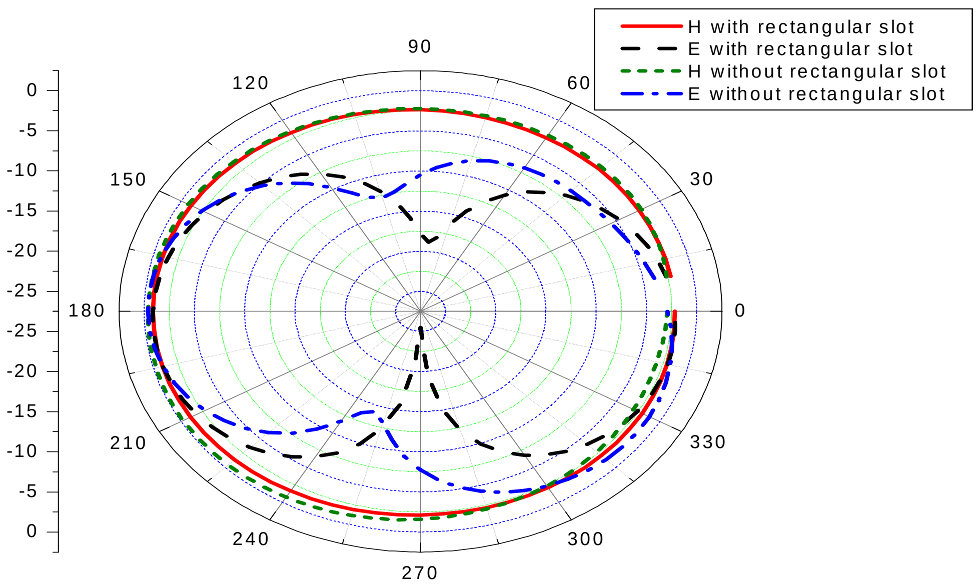
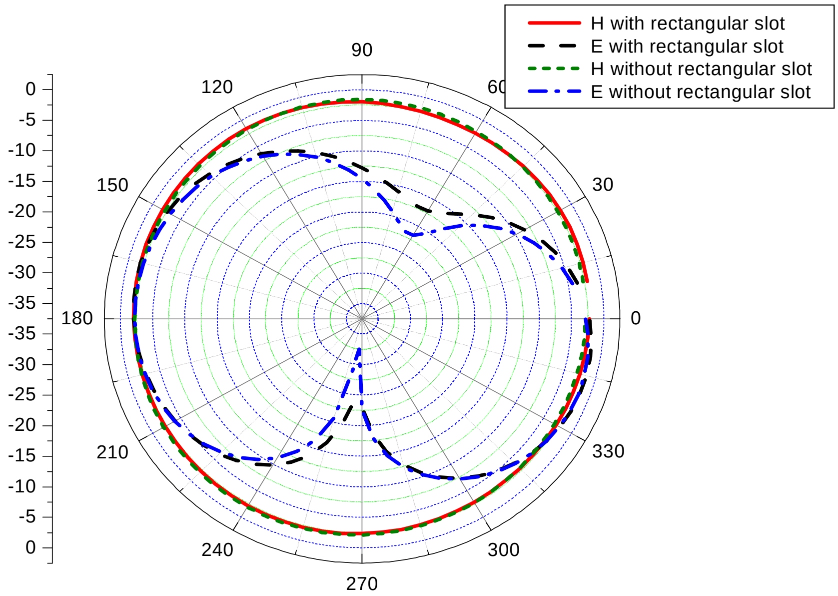


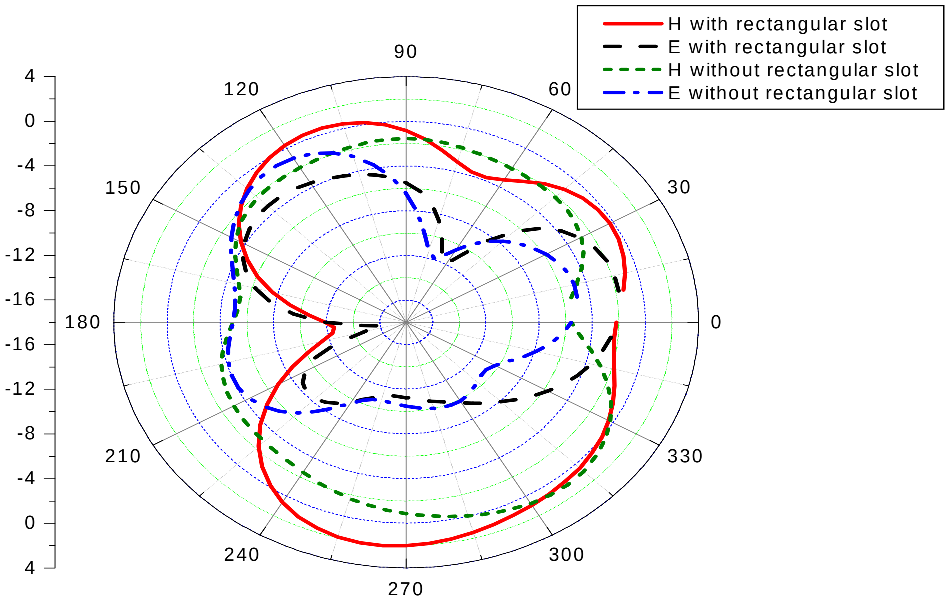
Figure 6: VSWR of the proposed antenna with rectangular slot



(a) 3GHz



(b) 6GHz



(c) 7.8GHz

Figure 7: Radiation Pattern of the proposed antenna with and without rectangular slot at different frequencies

CONCLUSION

In this paper the ultra wide bandwidth, omni - directional radiation pattern and small size antenna were obtained by using slot on the feed line and the notches at the bottom of the patch, and at the middle top of the ground plane making the two proposed antenna to operate over the whole UWB frequency band. These proposed antenna with and without rectangular slot on the feed line is considered good candidates for UWB applications. And it was found that the impedance bandwidth covers the whole UWB frequency spectrum (3.1-10.6GHz) with stable radiation patterns across the whole desired band.

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