Bandwidth Enhancement of rectangular microstrip patch antenna using T-slot inside U-slot shape

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Abstract
The bandwidth of microstrip antennas is usual small due the thickness of the substrate is very thin in terms of wavelengths. To enhance the bandwidth, a new design of rectangular microstrip patch antenna is presented. The proposed geometry consists of a rectangular shaped ground plane structure which has T-slot inside a U- slot loaded patch layer. The antenna is simulated using ADS, advanced design system software. A bandwidth of 44.64 % was a archived with return loss of -44dB.The resultant bandwidth of our antenna is compared with the results of non-slotted rectangular microstrip patch antenna.

KEYWORDS: Microstrip antenna, Feed point, Bandwidth, return loss.

الملخص

عادة ما يكون عرض النطاق الترددي للهوائيات الشريطية صغيرا جدا نظرا لصغر عرض الركيزة مقارنة للطول الموجي. لتحسين عرض النطاق الترددي ثما اقتراح تصميم جديد لهوائي شريطي مستطيل الرقعة. يحتوي الشكل الهندسي المقترح على هيكل مستوى ارضي مستطيل الشكل يحتوي فتحة على شكل حرف U بداخله فتحه اخرى على شكل حرف T موجودة على طبقة الرقعة. تما محاكاة الهوائي باستخدام برنامج (ADS). انجز عرض نطاق ترددي بنسبة تصل الى 44.64%. مع فقد مرتد بنسبة 44dB− . تمت مقارنة عرض النطاق الترددي الناتج من الهوائي المقترح مع نتائج الهوائي الشريطي ذو الرقعة المستطيلة الذي لا يحتوي على أي فتحة بداخله.

Introduction
In wireless communication Microstrip patch antenna plays a major role. It has many advantages such as low profile, compactness, easy to fabricate, easy installation, low cost etc but it has a major a weak point of small bandwidth which proved to be a challenge for engineers to meet high data rate for various broadband application [1][2]. Now-a-days, antennas with multiband capabilities have been widely required in satellite and mobile communication systems to meet the growing system complexity [3]. Bandwidth of antenna can be increased by various methods such as cutting slot in patch layer [4]. Some researchers also combined several methods together to planes [5]. In reference [1], the design was T-slot and H-solt separately on rectangular microstrip antenna. In this research, our design is rectangular shape that contains T-slot inside U-slot shape. A basic structure of microstrip patch antenna was taken under design consideration. Microstrip patch antenna uses a radiation patch of perfectly conducting material

separated from the copper ground plane using dielectric substrate material. Coaxial probe feed is easy and flexible where it can be placed at any desired location to match the impedance.

Design procedure

The basic design is using rectangular T inside U-slot microstrip patch antenna. The new antenna was a probe-fed rectangular microstrip patch antenna on a permittivity substrate with an internal U and T- slot as shown in Figure 1.

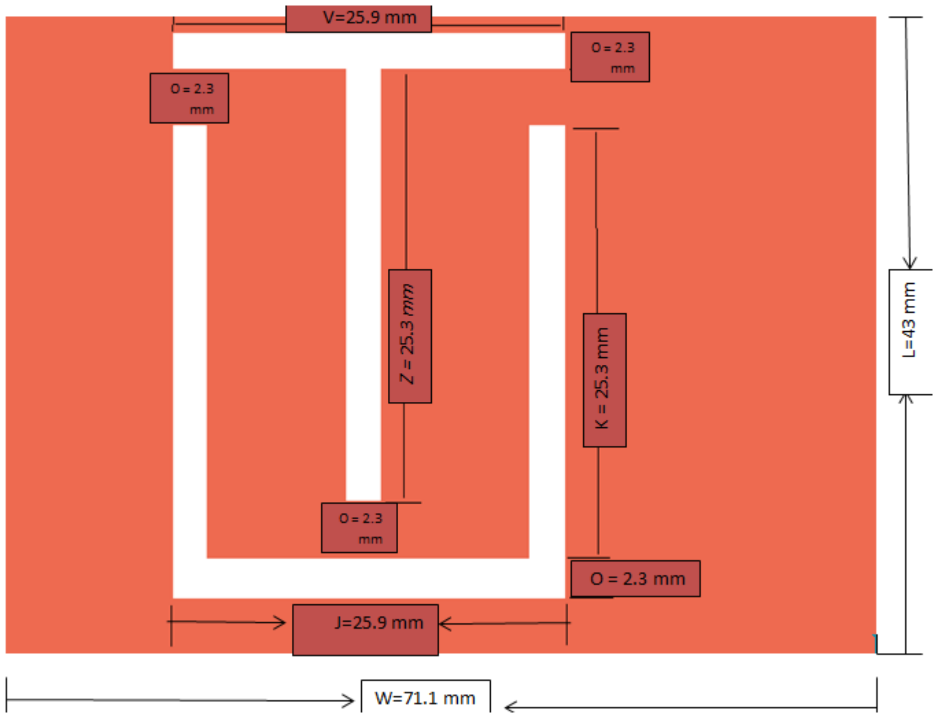

Figure 1. Geometry of the rectangular T-U-slot microstrip patch antenna

Specify the center frequency (f_c), and select a substrate permittivity (ε_r) and a substrate thickness h. According to the following relationship [2][6][7]:

$$h \geq 0.06 \frac{\lambda_{res3}}{\sqrt{\varepsilon_r}} \qquad (1)$$

Where λ_{res3} wavelength at the center frequency in air.

Calculate W as:

$$W = \frac{c}{2.f_{r3}} \sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (2)$$

Where c = speed of light in free space.

Calculate ε_{eff} as:

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1+\frac{12h}{W}\right)^{-1/2} \quad (3)$$

$$\Delta L = 0.824h\frac{(\varepsilon_r+0.3)\left(\frac{W}{h}+0.262\right)}{(\varepsilon_r-0.258)\left(\frac{W}{h}+0.813\right)} \quad (4)$$

Calculate the value of L

$$L = \frac{c}{2f_{r3}\sqrt{\varepsilon_{eff}}} - 2\Delta_L \quad (5)$$

The antenna works at resonant frequency of 5.6 Ghz, dielectric constant of 2.20, and substrate Height of 6.35 mm. Table 1 summarize all the computed results.

TABLE 1. Dimensions of single U slot antenna

L (mm)	**W (mm)**	**h (mm)**	ε_r	**f_c (Ghz)**
71.0	**43.0**	**6.35**	**2.20**	**5.6**

The Bandwidth (BW) % can be calculated as follow:

$$BW = \frac{f_H - f_L}{f_c}$$

Results and Discussion

Figure 2 illustrates rectangular microstrip patch antenna design using ADS . Figure 3 shows the simulated results of the variation of return loss versus the frequency is shown in figure 3.

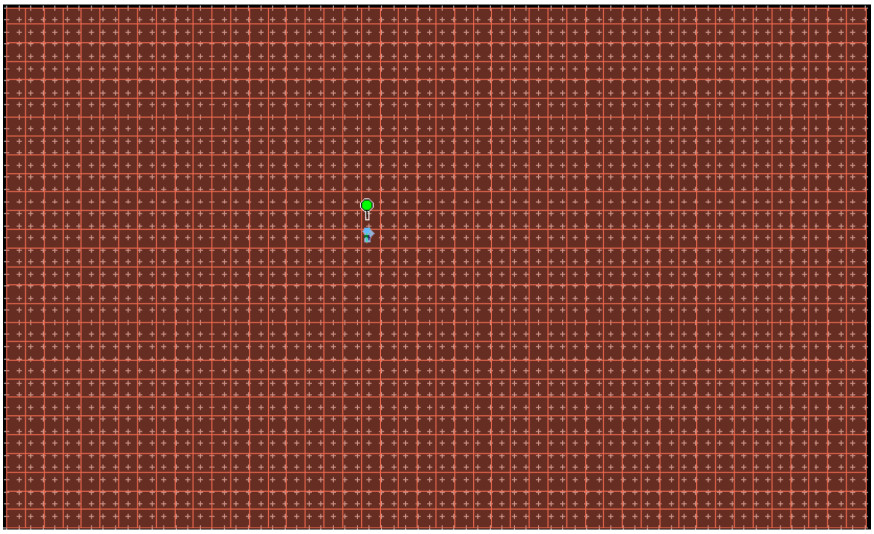

Figure 2. Rectangular microstrip patch antenna design using ADS

From the Figure 3, we observe that a resonant frequency is located at the desired values of 5.6 GHz with return loss of -39 dB for WLAN. Hence the bandwidth was found 25%.

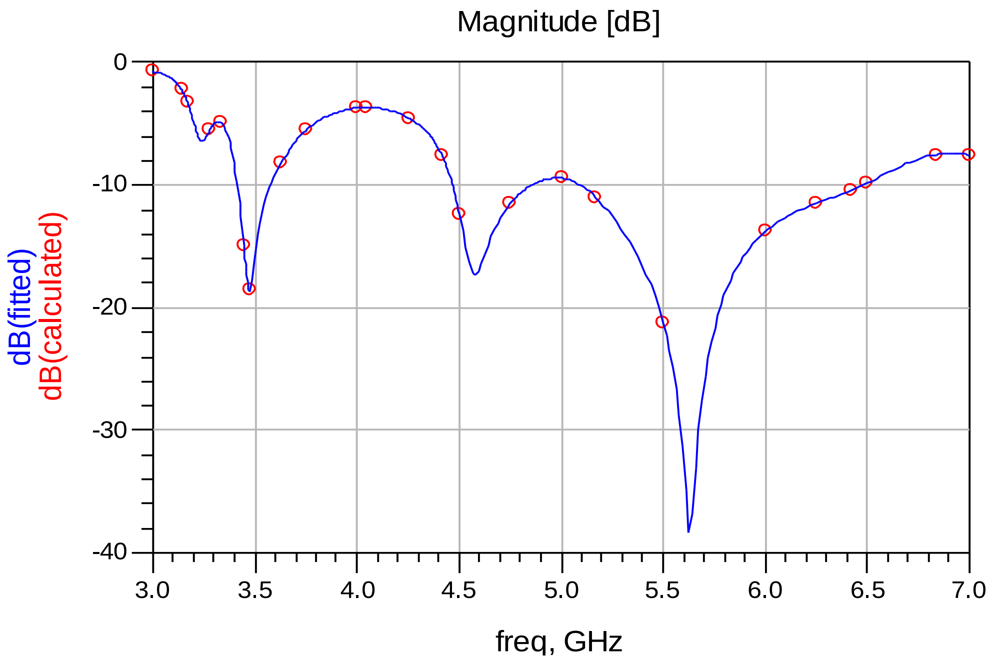

Figure 3. simulated return loss for rectangle microstrip patch antenna

The figure 4 shows the proposed annten simulated using ADS. The Figure 5 shows the resonant frequency at 5.6 GHz with return loss of -44 dB. a bandwidth with 44.64% was achieved**.**

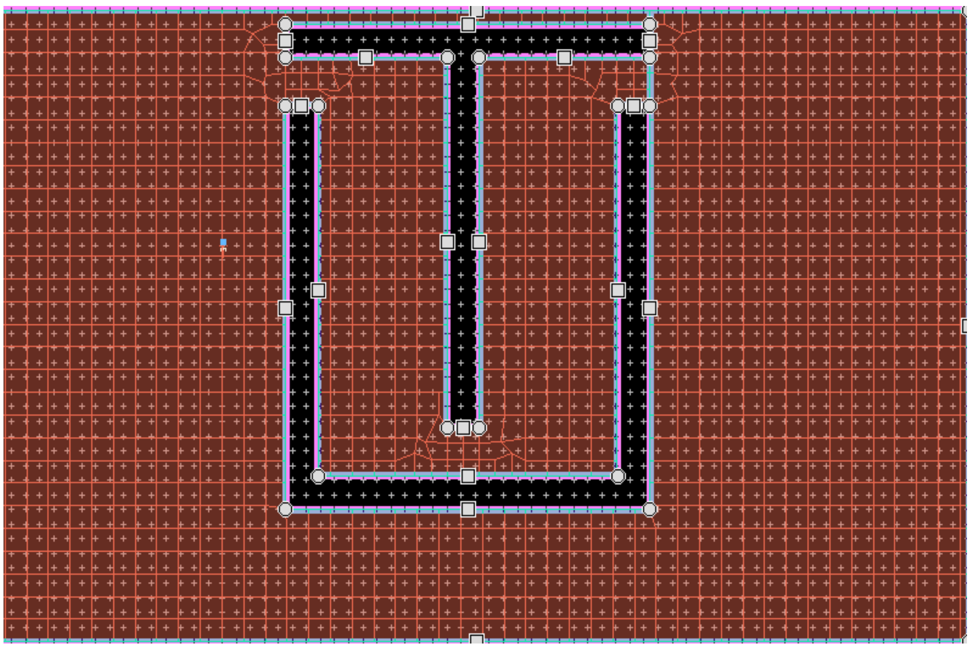

Figure 4. T-U-slot rectangular microstrip patch antenna design using ADS

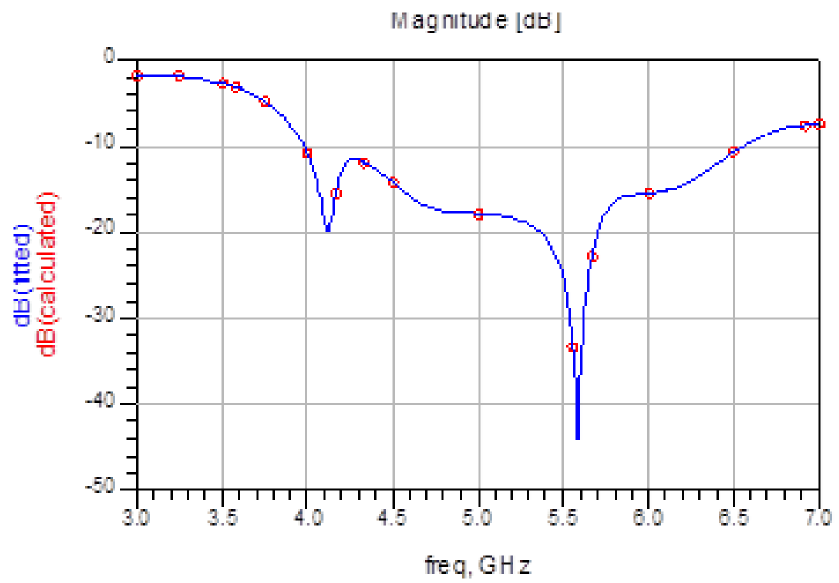

Figure 5. simulated return loss for T-U-slot rectangular microstrip patch antenna

The comparison of return loss and bandwidth enhancement values for our designs is shown in The Table 2. It is clear that there is improvement after using slots in microstrip anntena. It should be considered that the bandwidth specification is changing according to the feed point location.

TABLE 2. summarizes the data from all designs

Microstrip antenna	Resonant frequency	Return loss	Bandwidth
without any slot	5.6GHz	-39 dB	25%
With T and U-slot	5. 6 GHz	-44 dB	44.64%

Conclusions

The purpose of this paper is to increase the bandwidth of the microstrip patch antenna, by creating T inside U slots togather in rectangular microstrip patch antenna. The antenna was designed and simulated using the Advanced Design System software ADS. The antennas operate at frequency of 5.6 GHz. From the results, it is clear that slotted antenna have better performance up to 44.64% than non-slotted rectangular microstrip patch antenna.

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