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U형 좁은 스트립 구조를 갖는 UWB 패치 안테나 설계

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Design of a UWB Patch Antenna for with U-Shaped Narrow Strip Structures

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요 약

본 연구에서는 초광대역 특성을 갖는 U형 마이크로스트립 안테나를 제안하였다. 제안된 안테나는 직사각형 패치 안에 매우 좁은 스트립과 함께 U형 방사체로 구성되며, 접지평면에는 역 T 형 슬롯이 구성된다. 제안된 안테나의 면적은 18.9 × 12 ㎟ 이며, 비 대역폭은 3.06 ~ 11.6 ㎓에서 113%로 넓은 대역폭을 제공한다. 제안된 안테나의 성능은 주파수 영역에서 3D 전파 전자기장 시뮬레이션 툴 (ANSYS HFSS)를 사용하여 반사계수, VSWR 및 방사패턴으로 설명된다.

Key Words : communication, signal processing, Neutral systems, Communication Sciences, Network

ABSTRACT

In this paper a U-shaped microstrip antenna with Ultra wide band characteristics is presented. The proposed antenna consists of U-shaped radiating element along width very narrow strip and a rectangular patch inside it, where as there is inverted T-shaped slot in ground plane. The proposed antenna size is 18.9 ×12 ㎟. It provides a wide usable fractional bandwidth of 113% for 3.06 to 11.16 GHz. The performance of proposed antenna is demonstrated from Reflection coefficient, VSWR and radiation patterns by using 3D full-wave electromagnetic field simulation tool (ANSYS HFSS) in frequency domain.

Ⅰ. Introduction

Ever since, the FCC released unlicensed spectrum of 3.1㎓ at 10.6㎓ for UWB application in 2002, having power spectral density emission for transmitter is –41.3 dBm/MHz. UWB has received important interest from both industry and academia having Coexistence possibility with IEEE 802.11/b/g. The only reason why UWB technology is so important is it shows potential ability to offer low-power consumption, multipath resolution, high bit rate, and coexist with the narrow-band system. Basically in the UWB structure, the duration of the pulse is extremely quick, normally on the order of nano seconds so, this Ultra-fast impulses make it possible to solve and combine signal echoes with route length differential down to 1 feet[1-3].

Furthermore, the demand for small size antenna with very efficient result is only possible with UWB systems, antenna design parameters are explained in[4,5]. For researchers there are many important factors while designing an UWB antenna, such as

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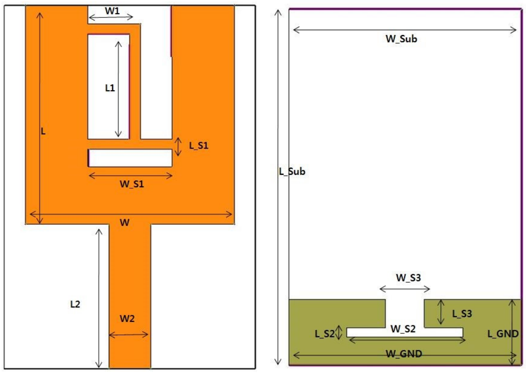
stable radiation pattern, impedance bandwidth and avoidance of interference due to other existing technologies. This is very well known fact that microstrip patch antennas are considered as most advantageous in term of light weight, compact size, easy to fabricate and compatible with printed circuits but the only limitations of patch antenna is narrow bandwidth. To minimize this problem researchers has investigated and proposed many impedance matching and feeding techniques for example microstrip patch antenna, slotted patch antenna, rectangular slot patch antenna[6-8].

However several antennas having U-shaped, H-shaped and C-shaped wide slot characteristics with excellent impedance matching and increased bandwidth over entire UWB frequency range have been reported in literature[9-11]. In addition compact UWB antenna design consist of open L-Shaped slot with asymmetric rectangular patch are introduced in[12]. Papers[13,14] shows the modified ground plane with T shaped slot and rectangular patch and double sided printed with irregular ground slot are used to make UWB antenna compact in size. But the rectangular structure U-shaped antenna with inserted narrow strip and inserted T shaped slot in ground plane are studied for reducing overall size[15-17]. The remainder of the paper is organized as follows: Section Ⅱ summarizes the architecture of our proposed antenna. Section Ⅲ illustrates the numerical results by taking very important factor i.e. return loss, standing wave ratio, radiation pattern and current distribution diagram. In Section Ⅳ, we will explain some future applications of UWB techniques in term of medical and others. Finally, conclusions are provided in Section Ⅴ.

Ⅱ. Antenna Configuration

The configuration of proposed antenna fed by 50 Ω microstrip feed line is shown in Figure 1. All geometric parameters of the proposed antenna which includes shape, length, width, thickness of rectangular patch, length and width of slots are described in Table 1. The FR4 substrate is used for antenna having thickness of 1.6㎜ and relative permittivity of 4.4.



(a) (b)

그림 1. 제안된 안테나의 구조 (a) 전면, (b) 후면
Fig. 1. Geometry of Proposed Antenna (a) front side, (b) back side

표 1. 제안된 안테나의 파라미터 (㎜)
Table 1. Parameters of the proposed Antenna (㎜)

L_Sub	18.9	W_Sub	12
L	11.5	W	10
L_Gnd	3.45	W_Gnd	12
L1	6.1	W1	2
L_S1	1	W_S1	4
T1	3	T2	3
L2	7.45	W2	2
L_S2	0.55	W_S2	6
L_S3	1.45	W_S3	2

The radiation patch is formed on the top side, a narrow strip of 0.5㎜ is inserted along with rectangular patch of 1 × 4㎜ inside the U-shaped patch antenna. It has a microstrip feeding line where as the inverted T shape slot is made on the ground plane. All radiating elements are using copper as a conducting material.

First of all because of U-shaped patch antenna size is made small , but form literature it has observed , this modified patch makes the impedance mismatch at different frequencies. That's why a narrow strip is added along with rectangular patch to generate additional resonance which produced more current path in the sides of rectangular patch and good reflection coefficient value for entire UWB. The purpose of inverted T shape slot in ground is also same.

The length of ground has major role in controlling the coupling between ground plane and patch because this coupling causes spread of the impedance bandwidth. Thus ground plane with a inverted T-Shaped slot plays a significant role in wide band characteristics of antenna.

As mentioned above, this proposed design consist of different dimensions of slots used in patch and ground plane, which has removed impedance mismatch along with desired output bandwidth which must be within UWB range.

2.1 Effect of Parametric Variation

There are so many different parameters which effects the proposed antenna design , but here only effect of length of L_S1 has been observed to give brief idea. Figure 2 shows the when the length of L_S1 was 0mm , the proposed geometry was covering only some range of higher frequencies varying from 8 to 10GHz. But as the value of length has been increased , corresponding effects on output is very clear. So perfect value for L_S1 chosen is 1 mm to avoid impedance mismatch.

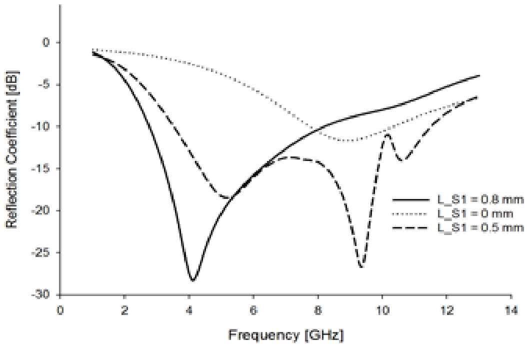


그림 2. L_S1의 길이 VS 주파수 [㎓]
Fig. 2. Length of L_S1 VS Frequency [GHz]

Ⅲ. Numerical Results and Discussions

The simulated results are obtained by using a 3D full-wave electromagnetic field simulation tool (ANSYS HFSS).

The return loss /reflection coefficient of the antenna is shown in Figure 3. At 3.06㎓ the value of this parameter is -10.1㏈ and it remains less

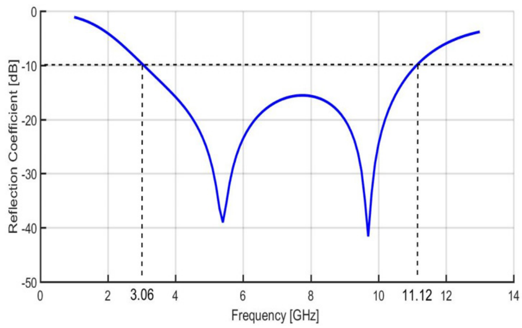


그림 3. 제안된 안테나의 S11 파라미터
Fig. 3. S11 Parameter for proposed design

though out whole UWB till 11.1㎓ by taking reference frequency 9.6㎓. From the Figure it clear that maximum gain achieved is -41.62㏈ at 9.7 GHz whereas second peak of -39.1㏈ is at 5.4㎓. The Proposed antenna provides a wide useable fractional bandwidth of more than 113 % over very low reflection coefficient value.

The simulated VSWR of proposed antenna in Figure 4 illustrates very low value for complete UWB bandwidth. Whereas for best performance the VSWR should be < 2. Thus this shows the proposed antenna could be very good candidate for UWB applications.

Figure 5 shows the simulated surface current distribution planes in order to demonstrate the concept of resonance.

It has been observed that the current concentrated on the exterior of the inverted T shaped slot in ground and in the feed line at the resonance

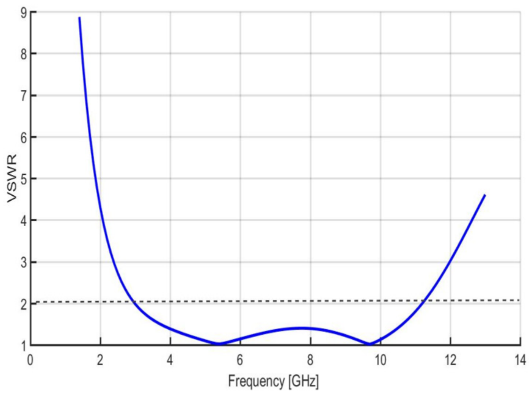


그림 4. VSWR vs. 주파수
Fig. 4. VSWR vs. FREQUENCY

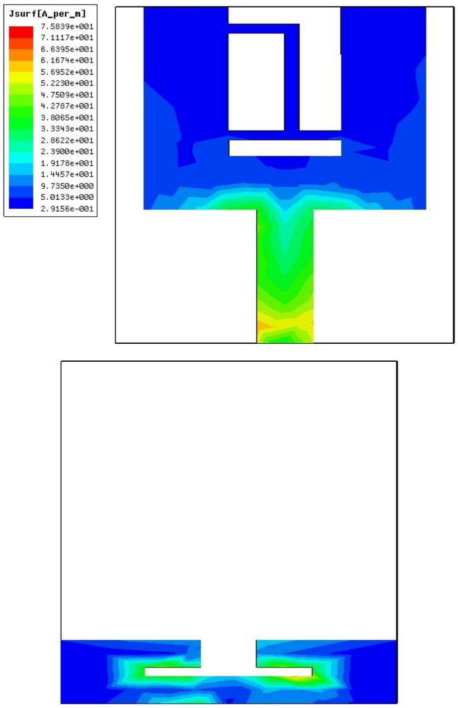


그림 5. 공진 주파수 9.6 ㎓에서의 시뮬레이션 표면 전류 분포
Fig. 5. Simulated surface current distribution at resonance frequency of 9.6 GHz

frequency of 9.6GHz.

Results of the calculation using HFSS software indicates that the proposed antenna features a good efficiency, being greater than 80% in the entire radiating band

As shown in figure 6 the group delay value varies between 0 to 2ns , which is acceptable for UWB applications. It conforms the capability of the proposed antenna to operate as a UWB antenna.

Figure 7 shows the simulated radiation pattern of the proposed antenna in two principle planes (H-Plane and E-Plane) at 3.1, 5.5, 7.5 and 10.6GHz respectively.

They are referred as E-plane (YZ- Plane) and H-Plane (XZ- Plane). Omni directional pattern (Purpal color) is observed on the H-Plane for all four frequencies while monopole-like patterns (Red color) or bidirectional pattern are shown on the E-plane for same frequencies respectively.

The comparison between proposed design and other antennas are summarized in Table 2. The

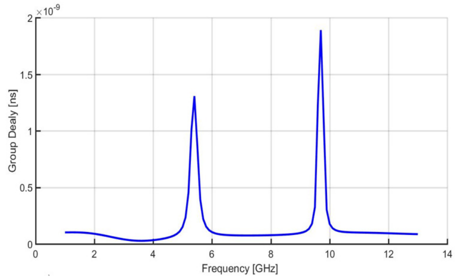


그림 6. 군 지연 [ns] vs. 주파수 [㎓]
Fig. 6. Group Delay [ns] vs. Frequency [GHz]

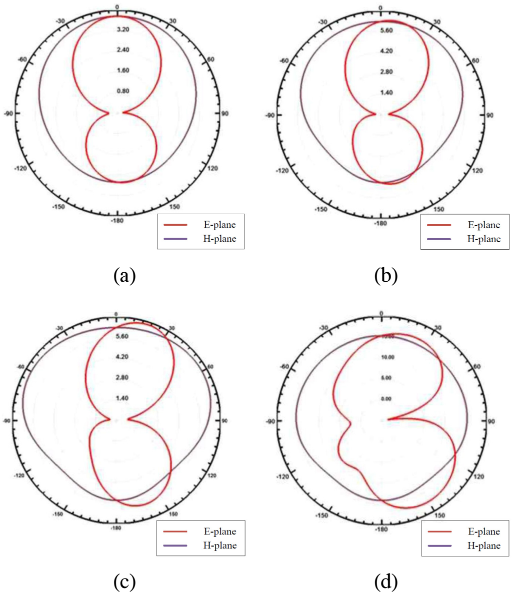


그림 7. 제안된 UWB 안테나의 방사패턴 (a) 3.1 ㎓, (b) 5.5 ㎓, (c) 7.5 ㎓, (d) 10.6 ㎓
Fig. 7. Radiation pattern of proposed UWB antenna (a) 3.1 ㎓, (b) 5.5 ㎓, (c) 7.5 ㎓, (d) 10.6 ㎓

antenna performance such as size, footprints, bandwidth and fractional bandwidth is listed as well. Reference[14] has more bandwidth with respect to proposed antenna, but the difference in size is also very clear. It is noticeable, that proposed design has small size covering more bandwidth with fractional bandwidth of 113%.

Ⅳ. Ultra Wide Band Applications

UWB technology has various uses including communication for various type of imaging and vehicular applications. It is a viable positioning

표 2. 안테나 특성 비교
Table 2. Antenna characteristics comparisons

Reference	Size (㎜)	Footprints ㎟	BW (S11 〈 -10 ㏈)	FBW (%)
[3]	46 × 38	1748	4.5 ~ 5.6	21.7
[4]	21 × 18	378	3.2 ~ 11.2	111
[8]	38 × 25.5	969	3 ~ 12	120
[10]	18.9 × 12	227	3.1 ~ 10.75	110
[11]	30 × 22	660	2.9 ~ 16	138
This work	18.9 × 12	227	3.06 ~ 11.16	113

technology can meet the many industrial requirements in term of health care, workplace/smart offices, public buildings, security, defense training, public transportation, entertainment, level gauging, professional ground and wall probing, manufacturing assembly language, logistics, warehouses and road & rail vehicles sensor networks.

CEPT/ECC, EC and ETSI standards have divided the whole allocated UWB frequency band for different applications. Location tracking below 10 ㎓ is divide to two parts, LT type 1 (6 to 9㎓), LT type 2 (3.1 to 4.8㎓) depending on applications. Furthermore research and development of ultrawide band for more dependable and secure smart society has goal is to create next generation end to end real time model, where every small machine be communicate able to each other by using tiny sensor and small antennas.

Indoor positioning systems: High frequency and Low power spectral density makes it Capable to determine location with a high level of precision. By applying signal processing function like correlation UWB can be used to measure distances with in centimeters. A fixed station which will use UWB to transmit data, a mobile station (user) and a monitoring system is required for this. This will enhance security for various issues as well as for credit card transactions.

Health care radar technologies: UWB radar that can monitor the respiration and heart beat of a person by reading UWB signals reflected of them.

Wearable and implantable wireless biosensors: small wearable Ban devices such as a Bracelet , belt to measure heart beat and blood oxygen saturation levels, that will gather the data of heart activities to produce electro cardiogram, measure body movement as well as the device that are connected to monitoring computer. Each device uses UWB to transmit data to the belt attached , which also send the accumulated data to the computers where the data is further monitored in real time and other factors , an alarm will be triggered in case of emergency. Medical staffs can immediately response to the situation.

New UWB positing hope to develop a new business model like smart wall, 3-D printed food, in home body pods, under water cities and personal drones. That will be technological smart and intelligent to more dynamic economy and happier society where we can all be assured with the safety of our children's and elderly.

Ⅴ. Conclusion

In this paper simulation of our proposed UWB antenna which has size of 18.9 ×12㎟ is observed. It exhibits good characteristics such as broad impedance bandwidth, stable radiation pattern and VSWR for entire UWB frequency band.

Many future applications of UWB is explained. Thus study suggests small size and efficient antenna having good potential for real time applications. CEPT/ECC, EC and ETSI standards should be kept in mind while designing antenna for different kind uses.

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