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UWB RECTANGULAR SLOTTED MICROSTRIP PATCH ANTENNA IN PROXIMITY OF HUMAN ARM MODEL

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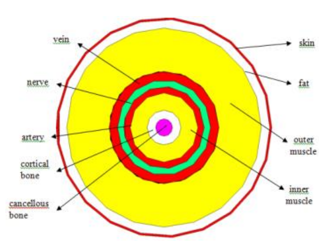
Graphical abstract



Abstract

In this paper, we study behavior of Ultra wideband antenna which is Rectangular Slotted Microstrip Patch Antenna. Then, the antenna operated in proximity of human arm model. Furthermore, the antenna is designed on a FR-4 substrate with dielectric constant of 4.3 and thickness 1.6 mm. This antenna simulated in CST Microwave Studio software. In order to test the antenna, an arm model was numerically modelled. The study shows properties and performances of antenna when it is placed in three situations which in free space, outside and inside of human arm model. The properties of UWB antenna in term of return loss, gain, directivity and radiation pattern in the three situations is simulated and discussed.

Keywords: Ultrawideband Antenna, Human Arm Model, Microstrip Patch Antenna

1.0 INTRODUCTION

Ultra wideband (UWB) communication is a promising wireless communication technology introduced by the US-Federal Communication Commission (FCC) in 2002 [1]. The requirement for high data rates wireless communication turns out to be more pressing. UWB varies from different wireless architectures in that it is not confined to utilizing a single waveband. Signs can travel close to around 10 to 20 meters, which viably precludes UWB as an opponent to the 802.11 WLAN technologies [11]. By and large, UWB strategies have been given careful consideration for some points of interest. The advantages of printed UWB antenna higher data rates, safety to multi-way cancelation, increment of correspondence operational security, low interference to legacy system, low profile, light weight, wide bandwidth, ease and great omnidirectional radiation design {2}. However, radio wires are the especially difficult part of UWB innovation [2].

UWB technology has high data rate wireless communication ability for different applications. In this manner, it has increased extraordinary notoriety in research and industrial regions. UWB antennas are a key and most passive component in UWB system. Henceforth, it has been explored by a considerable measure of specialists and generally a couple of proposals for UWB antenna design have been reported [4][10]. UWB antennas use the wide transmission capacity from 3 to 10.6 GHz for UWB application. However this wideband ought to be scored to maintain a strategic distance from the impedances with WLAN, GPS and many more. Hence, UWB antennas ought to have an indented recurrence band for its radiation. [11].UWB antenna apparatus exhibits are required for multifunctional radio frequency systems which need to bolster electronic warfare, communications interchanges, and radar applications. Notwithstanding their expansive transmission capacities, these arrays should likewise demonstrate wide checking ability, polarization and assorted qualities [5]. Moreover, UWB reception apparatuses encourage expanded unearthly proficiency and adaptability through spatial multiplexing [6].

In this paper, UWB rectangular slotted microstrip patch antenna is designed. Then, the UWB antenna will be simulate in two situations which is in free space and inside the human arm model in other to study the behavior and performances in term of return loss, gain, radiation pattern and directivity. The simulated result for the UWB antenna in free space, outside and inside a human arm model environment are compared and discussed.

2.0 HUMAN ARM MODELLING

Accomplishing equal TL circuits that represent to the human arm nerve strands included strides of procedure with the use of software. Initial step is to demonstrate or model the most straightforward type of the genuine human arm with it equal radiation source in a three dimensional simulation software known as CST Microwave Studio. At that point, the radiation force is changed over into induce source for the TL circuits.

Human arm axial perspective view representations layers of organs and tissues that construct a human arm. In common, along the human arm, peripheral layer of human arm is skin and afterward taken after by fat, external muscle, vein, nerve, artery, internal muscle and lastly cortical and cancellous bones as deepest layer [7].Hence, it can be said that human arm least difficult structure is much the same as a cylindrical solid and it additionally a mind boggling environment to model with electrical properties. Inside it, contain layers of littler round and hollow cylindrical as shown in Figure 1 with every layer express to distinctive organs and tissues. Properties of the organs and tissues are compressed in Table 1.

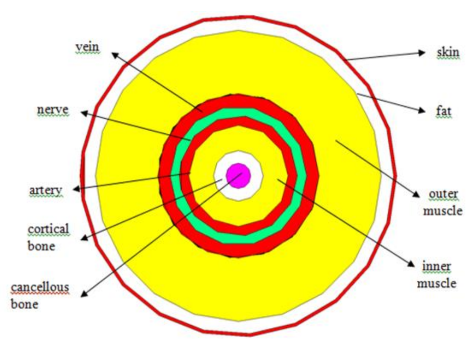


Figure 1 Simplest form of human arm in axial view

Table 1 Human arm organs and tissue properties

Organs	Thickness (mm)	Relative permittivity at 6.8GHz [8]	Conductivity at 6.8GHz (S/m) [8]
Skin	1	37.39200	4.62530
Fat	4	4.865200	0.35987
Outer Muscle	20	47.137000	6.20190
Vein	4	36.888000	5.42600
Nerve	3	26.382000	3.63060
Artery	3	36.888000	5.42600
Inner Muscle	8	47.137000	6.20190
Cortical Bone	4	9.587420	1.39510
Cancellous Bone	4	14.64300	2.56770

Figure 2 shows free view of the constructed human arm model. Beside the human arm model is an Ultra wideband antenna [9].The Ultra wideband antenna is placed as near to the human arm model without overlapping each other. The human arm is located in the near field region of the antenna because this paper concentrating on the performance of the Ultra wideband antenna when being placed in and out of the human arm model. Figure 3 and Figure 4 shows the UWB antenna outside and inside of human arm model.

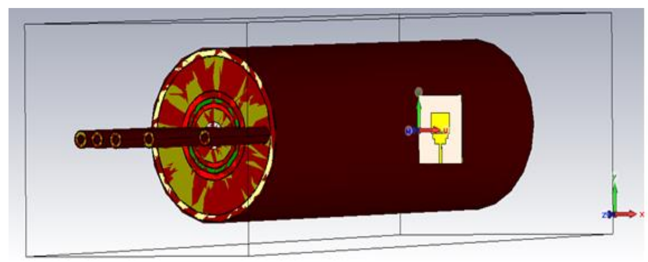


Figure 2 Human arm model with a UWB antenna in horizontal orientation

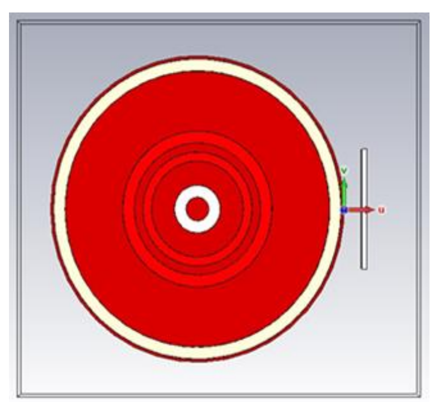


Figure 3 UWB antenna outside of human arm model

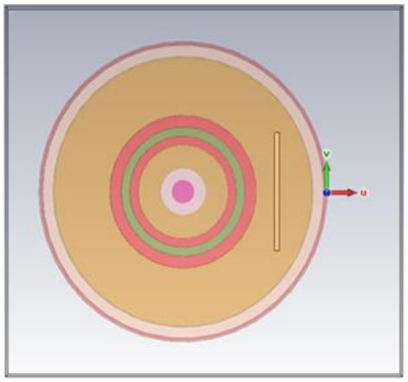
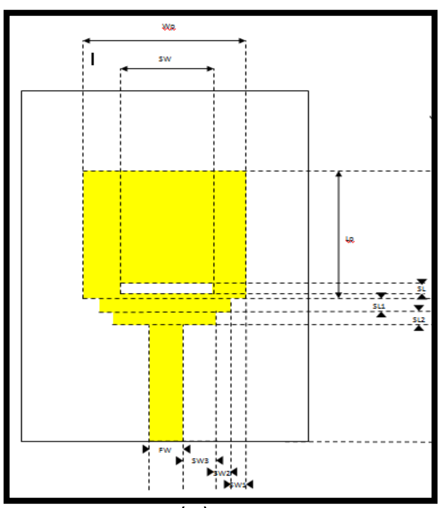


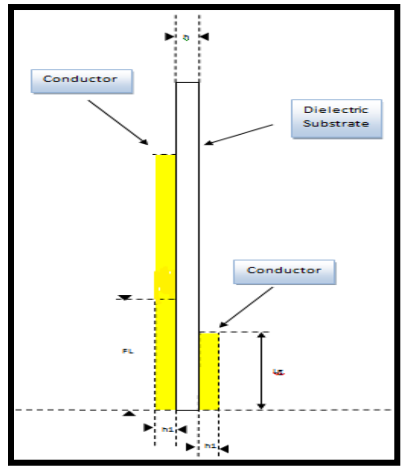
Figure 4 UWB antenna inside of human arm model.

3.0 ANTENNA CONCEPT

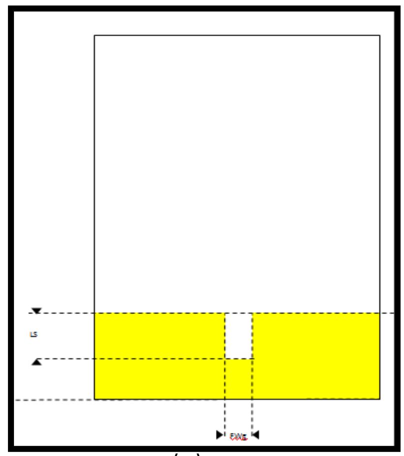
Figure 5 (a, b and c) shows the design structure of rectangular slotted microstrip patch antenna for UWB. FR4 substrate with the thickness of 1.6mm and dielectric constant of 4.3 has been used in designing this antenna. This antenna consists of rectangular patches with steps and a rectangular slot is etched. This design also consists of fiddling which is the small patch and partially defected the ground plane. For the ground plane, it is designed with a rectangular patch at the bottom with a rectangular slot in the middle. The antenna structure for the patch has been designed on different side with the ground plane. Figure 6 shows the reflection coefficient of UWB Rectangular Slotted Microstrip Patch Antenna



(a)



(b)



(c)

Figure 5 Design Structure (a) Front View (b) Side View (c) Ground Plane

Table 2 The dimensions of the UWB antenna

Basic Configurations	Variable	Dimensions (mm)
Patch	Lp	12
	Wp	15
	sw2	1.5
	sw1	1.5
	sl1	1.5
	sl2	3
	Fl	11.5
	Fw	2
	H	0.035
Slot	Sl	1
	Sw	10
Ground plane	Fwg	2
	Lg	6
Substrate	Wo	35
	Lo	40
	h1	1.6

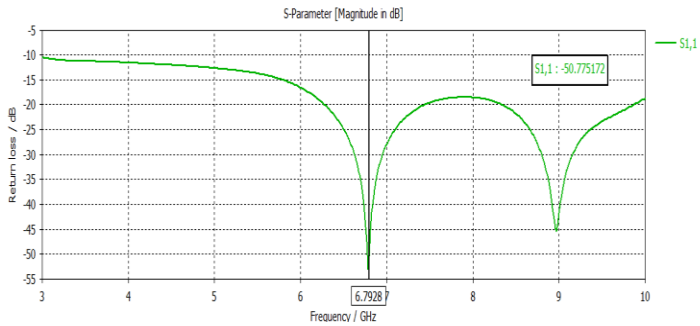


Figure 6 Reflection coefficient of UWB Rectangular Slotted Microstrip Patch Antenna

4.0 RESULTS AND DISCUSSION

Figures 7 show the simulated return loss of UWB antenna in free space, out and in human arm model. The return loss is shifted when UWB antenna is placed near the arm model due to the interaction between UWB antenna and the arm model. However, the return loss of antenna when it being placed in the arm model is slightly worse compare to other situation. This is due to the dielectric properties of the lossy tissue that strongly affect the behavior of antenna lowering the resonant frequency compared to the free space performance of an antenna.

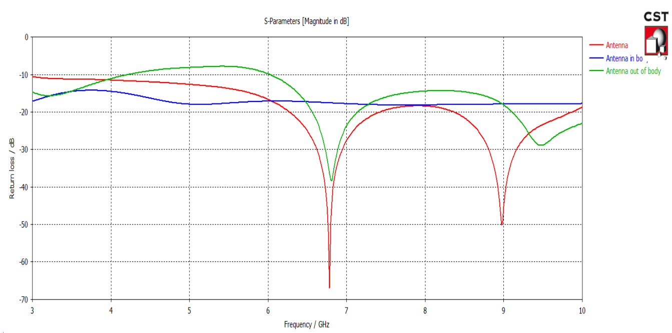


Figure 7 Simulated return loss of UWB antenna in free space, out and in human arm model

Figure 8 show the directivity of UWB antenna in free space, out and in human arm model.It can be observed that, the directivity of UWB antenna in three situation is more than 0 dB,which is acceptable for short range UWB communications. This is due to the directivity of the antenna is correlated to its radiation pattern and does not be influenced by on the lossy tissue or the antenna.

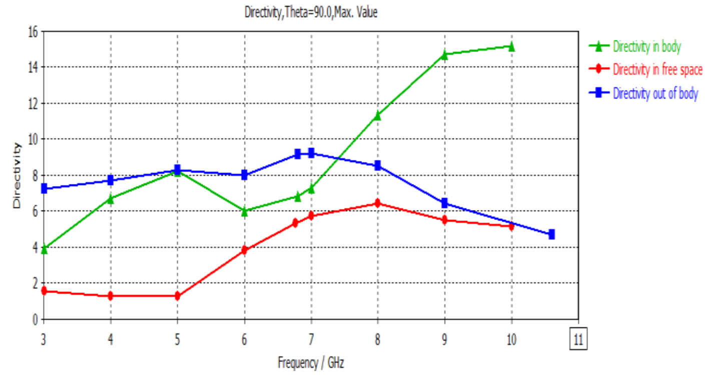


Figure 8 Directivity of UWB antenna in free space, out and in human arm model

In Figure 9, the graph show the realized gain of UWB antenna in free space, out and in human arm model. However, the gain of the antenna is depending on the losses and directivity. It can see that, the gain of UWB antenna in body is negative compared to other situations which is positive which is above 0 dB.

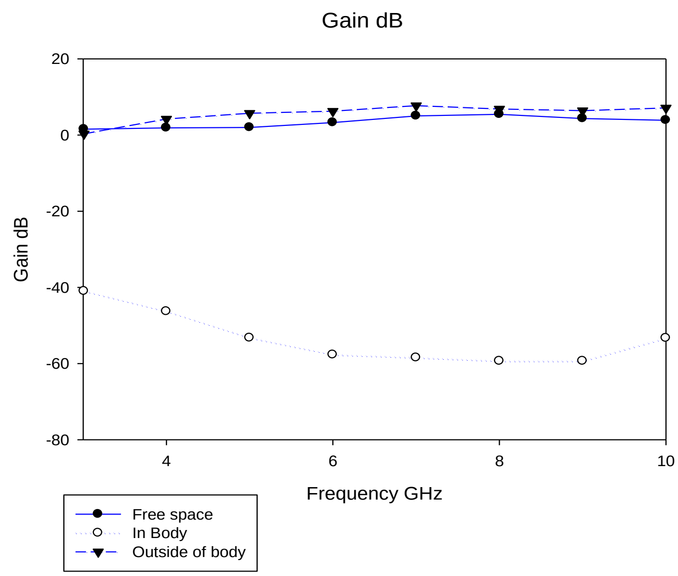


Figure 9 Gain of UWB antenna in free space, out and in human arm model

Figure 10 show the radiation pattern of UWB antenna at 3, 5, 10 GHz in three different situation. When the frequency increases, it clearly seen that, the radiation patterns of UWB antenna when it is located in body became worse compared to other situation. This is due to the radiation patterns of an antenna in proximity of human body model are strongly influenced by lossy dielectric objects, which absorb and reflect the radiated electromagnetic field of the antenna. Besides that, human body is complex, highly lossy characteristics and also dispersive, hence affect the performance of an antenna.

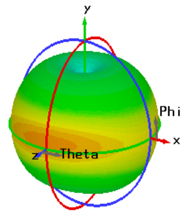
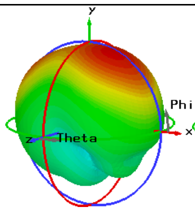
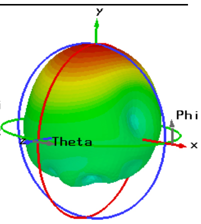
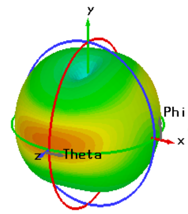
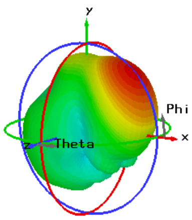
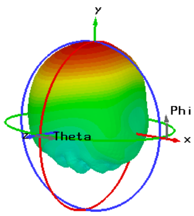
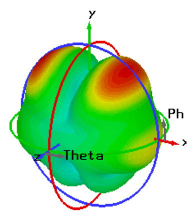
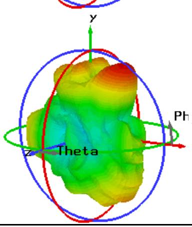
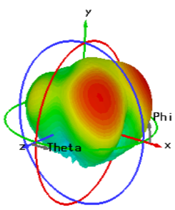
Frequency (GHz)	Free Space	In Body	Out of Body
3			
5			
10			

Figure 10 Radiation Pattern of UWB Rectangular Slotted Microstrip Patch antenna at 3, 5, 10 GHz

5.0 CONCLUSION

In this study, the properties of UWB antenna in term of return loss, gain, directivity and radiation pattern in the three situations is simulated and discussed. The modeling of the simplest human arm model in layers of cylindrical solid has been successfully achieved. It can observe that, the performance of antenna will be decrease if it being simulate and placed in the lossy tissue or media. Therefore in the near future, biocompatible insulating layer can be used around the antenna in other to increase the antenna performance.

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