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UWB Microwave Signal Components Estimation in Various Mediums

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Abstract:

Microwave radar signal in various ranges have found a wide application in this era in the various field like defence, surveillance, emergency and scientific .The multidisciplinary application of this technology has attracted the attention of many researches, scientists and academicians to contribute their effort. However, the ultra wide band (UWB) with its feature like range and resolution has found applicable in through the wall imaging system where the other sensors like infrared etc, could not solve the purpose because of their non penetration capability through the wall. Similarly in the ground penetrating system, to detect the buried objects the microwave radar signal with UWB are significant as compared to the other sensors. The major challenge for a researcher is to calculate and measure the parameters of microwave signal .The present paper is an endeavour to estimate the major parameters like reflection coefficient, speed of propagation though the wall of various materials with different dielectric constant in the simulation environment.

Keywords – **Dielectric constant, reflection coefficient, relative permittivity, resolution, ultra wide band.**

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INTRODUCTION :

Human being always desirous to know what's happening behind the wall and beneath the ground. So with the growth of need there starts development of technology sensors like infrared and optical though found useful carrying Signal to a long range, however their poor capability to penetrate into the solid surface confines their applications. Millimetre and micrometer radars took edge over due to its numerous advantages as range and resolution is an important and useful feature of it. The major challenge to be faced is to know the exact location of the target behind the wall in through wall imaging radar system and to locate the exact position of buried and hidden object in the ground penetrating radar system. The important characteristic of microwave radar signal like speed of propagation in the solid surface, reflection coefficients, and transmission coefficients with UWB is a preliminary requirement prior locating the hidden object. Many researchers have put their effort to estimate the parameters of microwave signals in the air and in the medium too as M.Aftanas [1] with M sequence radar estimated the time of arrival of the microwave signal also estimated the other parameters like the dielectric constant and thickness of the wall has been estimated, however the approach is bit tedious and complex. Fauzia Ahmad [2] uses non coherent approach target location and imaging of the target. Different researchers and academicians are using different techniques for the measurement of the range and identification of the object such as living or non-living through wall imaging technology and ground penetrating GPR technology with the help of the radar. There are several studies and journals on TWRI to detect targets behind walls with the known wall parameters such as thickness and dielectric constant [3-4]. An electromagnetic wave, which can pass through a dielectric wall, can be transmitted and received at several locations along with a synthetic array and combined into a two-dimensional image. In order to achieve high-resolution image, a wide band signal should be

used. The frequency band is typically implemented with the several contiguous narrowband signals such as step-frequency signal. In turn, a very wide bandwidth of several Mega-Hertz, as in the case of indoor imaging, requires a large number of narrowband signals [5-6].Digital signal processing techniques have been used[7] for estimation of wall parameters also an overview has been presented[8]. The present paper has been divided into five sections, as section2 depicts the theory and the model used,section3 elaborates the necessary equations and calculations,section4 depicts results and observation table ,section5 concludes the paper,

1. THEORY

Microwave radar signal with UWB due to its characteristics like range and resolution is highly applicable in detecting the object behind the wall and also to detect the buried objects. Also the image of the object may be generated. Many researchers apply techniques to extract the feature of hidden object after the generation of image It is very important to analyse the characteristics and the behaviour of microwave signals in the various mediums like air, solid surface made of various materials with different dielectric constant .The characteristics like speed of propagation, time delay etc through various medium. Found useful in order to analyse the microwave signals for various applications. As shown in Fig 1

A. Simulink model

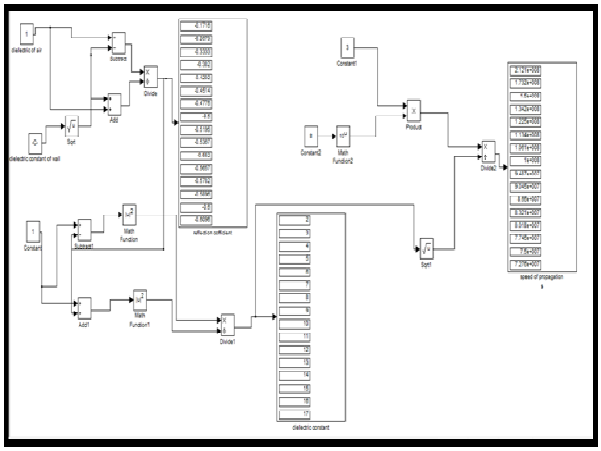
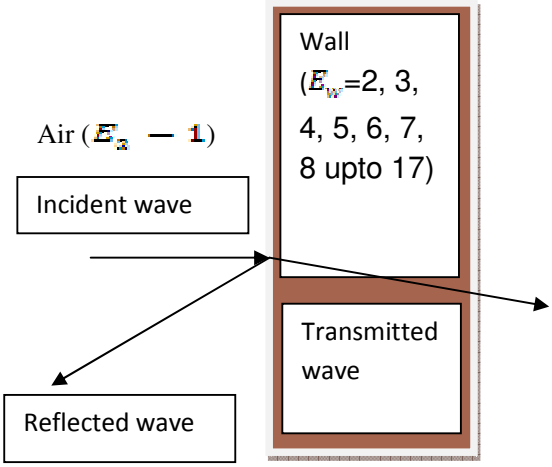


Fig.1 Simulink model

In order to analyse the characteristic of microwave signal, the Simulink model has been designed as in figure1 based to the below mentioned equations.

$$\check{R}=(\sqrt{E_a}-\sqrt{E_w})/(\sqrt{E_a}+\sqrt{E_w}) \qquad (1)$$

Where Ř is the refection coefficient of the solid surface like wall also, $E_a - 1$, E_w are the dielectric constants of air and wall respectively. Here we have considered E_w=2, 3, 4, 5, 6, 7,8upto 17 i.e. are assuming here the solid surface like wall made of different materials so with different dielectric constant .as the microwave signal propagate from one medium to another i.e. From air to the solid surface like wall, part of the signal is reflected and transmitted through the solid medium in the direction of propagation so the reflection and transmitting confidents are to be taken into the consideration. As shown in the figure 2.



Sr no.	Assumed Dielectric constant of wall	Reflection constant values
1.	2	0.1716
2.	3	0.2679
3.	4	0.3333
4.	5	0.382
5.	6	0.4202
6.	7	0.4514
7.	8	0.4776
8.	9	0.5
9.	10	0.5195
10.	11	0.5367
11.	12	0.552
12.	13	0.5657
13.	14	0.5782
14.	15	0.5896
15.	16	0.6
16.	17	0.6096

Fig 2. Propagation of EM wave in various mediums

$$E_{rw}=(1-\hat{R})^2/(1-\hat{R})^2 \quad (2)$$

$$V_w=c/\sqrt{E_{rw}} \quad (3)$$

Where V_w the speed of propagation of the EM wave when enters from air to the second medium(wall)so it gets refracted while propagated through the second medium (wall) surface here E_{rw} is the dielectric constant of the wall.

2. OBSERVATIONS:

It has been analysed and observed that the signal gets refracted the moment it enters in the wall and also the speed of propagation is affected due to the variation in the dielectric constant as equation (3).The simulation environment as in figure1. has been made in MATLAB based on the equations (2) (3) and hence the following observation table has been obtained.

TABLE1.DIELECTRIC CONSTANT vs. REFLECTION CONSTANT

From table 1, it is observed that with the increase of the dielectric constant the reflection coefficient of the sold surface is increased as fig 3

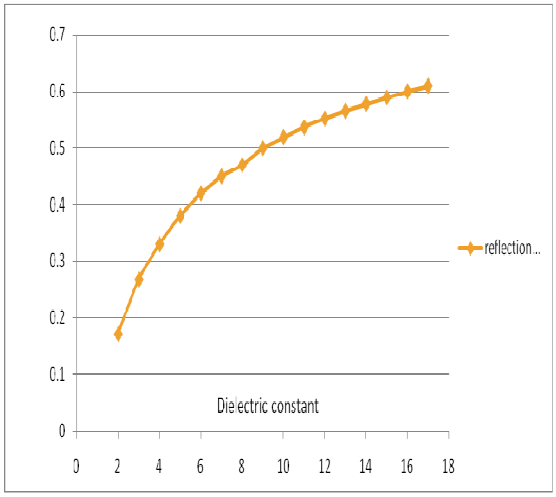


Figure 3 Graphical results (dielectric constant vs. Solid surface reflection coefficient)

The next step is to estimate the speed of propagation of EM signal within the sold surface

Table2.
DIELECTRIC CONSTANT vs. SPEED OF PROPOGATION

Sr no.	DIELECTRIC CONSTANT	SPEED OF PROPOGATION($msec^{-1}$)
1.	2	2.121
2.	3	1.732
3.	4	1.5
4.	5	1.342
5.	6	1.225
6.	7	1.134
7.	8	1.061
8.	9	1
9.	10	0.9
10.	11	0.9
11.	12	0.8
12.	13	0.8321
13.	14	0.8018
14.	15	0.746
15.	16	0.75
16.	17	0.726

GRAPH BETWEEN DIECTRIC CONSTANT vs. SPEED OF PROPOGATION.

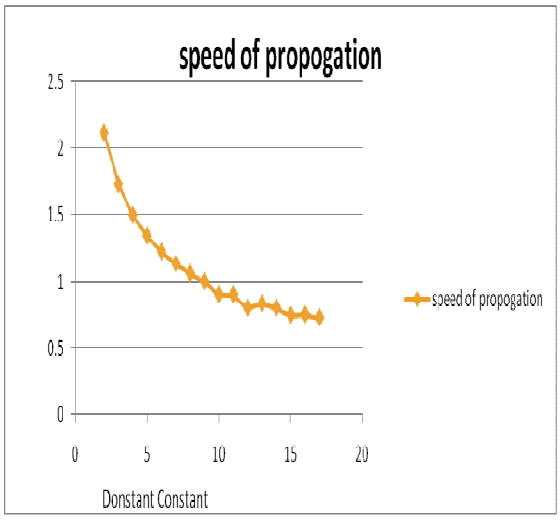


Fig. 4 Graphical results (dielectric constant vs. speed of propagation within solid surface)

3. CONCLUSION:

The present work is an endeavour to put across the behaviour of microwave signal in various environments, The effort has been made to estimate the speed of propagation of the microwave signal within the solid surface like wall made of any material and so with different dielectric constant, As a part of the signal is reflected after striking with the solid surface so the reflection coefficient of the solid surface has been estimated accordingly in the simulation environment. These parameters estimations are applicable for further analysis of microwave signal.

4. Future work:

Analysis of the nature of microwave signal within the solid surface is quite useful as effort has been in the present work and is a bench mark for the researchers to estimate the angle of refraction during the signal propagates within the solid surface like wall etc and also to estimate the delays .

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