iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** VI **Month of publication:** June 2022

DOI: https://doi.org/10.22214/ijraset.2022.44088

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VI June 2022- Available at www.ijraset.com

Design and Implementation of Phase Shifter for Wireless Communication

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Abstract: Phase shifters are common microwave devices that are widely used to control the phase of a microwave signal in mobile satellite systems, microwave instrumentation and measurement systems, modulators, noise cancellation systems, frequency converters, electronic beam scanning phase arrays, microwave imaging, and many other industrial applications is used for. Phase shifters are passive devices used to perform variable phase changes in the wave propagating through it. Phase shifters require compact size, low cost and low insertion loss in the desired bandwidth. The size of the phase shifters is a crucial parameter, especially in the design of portable microwave devices, due to the space constraints. The significantly higher insertion loss of phase shifters used in a transmitter causes a significant reduction in transmitting power levels, while it causes a severe drop in signal to noise ratio when the phase shifter is a part of the receiver.. Phase shifters are essential components in phased array antennas for wireless and Radio Detection And Ranging (RADAR) applications. Loaded line phase shifter, reflective line phase shifter and switched line phase shifters are the most commonly used. The electrical performance of a phase shifter is specified in terms of insertion loss, phase error, operating bandwidth and power handling capacity.. Emerging wireless systems have transceivers that require compact and cost effective phase shifters. Physical size and weight of phase shifters are the major issues in mobile and the wireless applications. Therefore, miniaturization of phase shifters has become an important objective of radio frequency (RF) designers to provide portability and affordability in wireless/mobile systems.

The present research work mainly focuses on planar phase shifter design with linear phase shift. In this a Defected Ground Structures (DGS) is proposed where as ,Monolithic Microwave Integrated Circuits (MMIC), Micro Electro Mechanical Systems (MEMS) and fractals have emerged as the possible techniques for miniaturization of RF systems and antennas. However the existence of defected cells on the ground plane may limit the use of DGS based phase shifters. MMIC technology increases the cost and complexity of manufacturing whereas MEMS based phase shifter is prone to limited life and yield. In this thesis, fractal techniques are adapted to design and develop miniaturized phase shifters for wireless applications.

Keywords: Phase Shifter, Defected Ground Surface, Gain, VSWR, Directivity

I. INTRODUCTION

The objective of this paper is to design, analyze, fabricate and characterize a DGS phase shifter with maximum phase shift per unit cell for wireless communication. A phase shifter is a component that can be inserted in series with a t-line in order to obtain a phase shift in the signal. A phase shifter is a two port network with the provision to control the phase difference between the output and the input signals by a control bias voltage (either DC or AC).

Currently, different kinds of phase shifters are invented for different applications. Phase shifters are common components in modern communication systems. They are extensively used in phased-array antenna systems as well as in antenna diversity circuits[1]

Phase arrays are typically implemented using separately produced components such as feed networks, phase shifters and antennas. Phase shifters are used to delay the phase or timing of a sinusoidal RF wave. In this case, placing a phase shifter on each radiation element allows the antenna beam to be shifted electronically without the antenna elements being physically shifted, particularly in phased array antennas for telecommunications or radar applications.

Phase shifters are passive devices used to produce phase change of the transmitted signal. This is mostly needed for tracking and sensing applications. Frequency agile systems also require phase shifters on various application bands to establish secure communication links. To meet the requirements of frequency agile systems, phase shifters deploying Defected Ground Structures (DGS) are proposed.

II. EXISTING SYSTEM

Each DGS provides its own unique characteristics depending on the geometry, with circuit functionalities such as filtering out unwanted signals and tuning higher-order harmonics can easily be accomplished by means of placing required DGS patterns, which correspond to the desired circuit operations without increasing circuit complexity.[2]

The patch and feeding line of conventional antenna are positioned on the substrate, while the ground plane is placed underneath of the substrate.[5]

There are distinct types of defective ground structures which include square, rectangular, circular, elliptic, rhombic and dumbbell shapes and there is also complex structures like U-shaped, C-shaped, H-shaped, V-shaped, interdigital, meandering and cross spiral used for suppressing common mode radiation. To overcome the difficulties in the existing structure, we modified the ground plane structure and approached the hybrid structure with two "C" and "E" heads. The etched area in this type of ground plane is more than the other structures. A solid plane is designed and fabricated on the PCB which is a hybrid of electromagnetic band gap structure and defective ground structure.

III.PROPOSED METHOD

The design of linear planar phase shifter deployed with DGS over a Microstrip line with E-shaped patch is implemented to enhance the phase characteristics. The design is targeted for a frequency in the 2 to 5 GHz frequency band that is used for commercial multimedia communications, digital television and local public security networks in regulated channels.

The proposed models are simulated, fabricated and tested to analyze the phase changing characteristics. Figure 1 shows the fabricated models of the proposed prototype of the modified microstrip delay line with different DGS structures and the modified CPW structure.

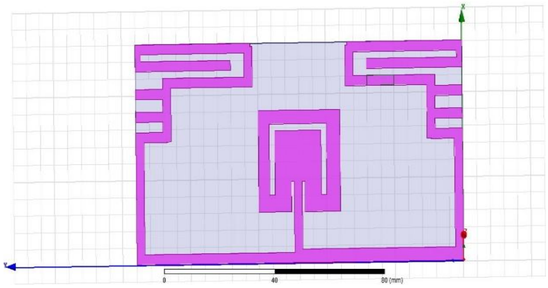

Fig.1 Proposed prototype models

A microstrip – CPW – microstrip transition analysis for phase shifting application is thus performed. The proposed microstrip – CPW - microstrip transition system shows a gradual phase shift with gradual change in the dimension of the DGS. With the proposed prototypes, 5^o, 20^o and 30^o phase shifts are achieved with acceptable reflection and transmission coefficients over the entire operating band. The negative slope values indicate the phase lagging characteristics of the proposed phase shifter. As the proposed model provides phase shift over a single band, the prototype is limited to use in the particular band only. To overcome the limitation, the design of dual, triband and penta band phase shifters are given. It can be used in many target sensing and tracking applications.

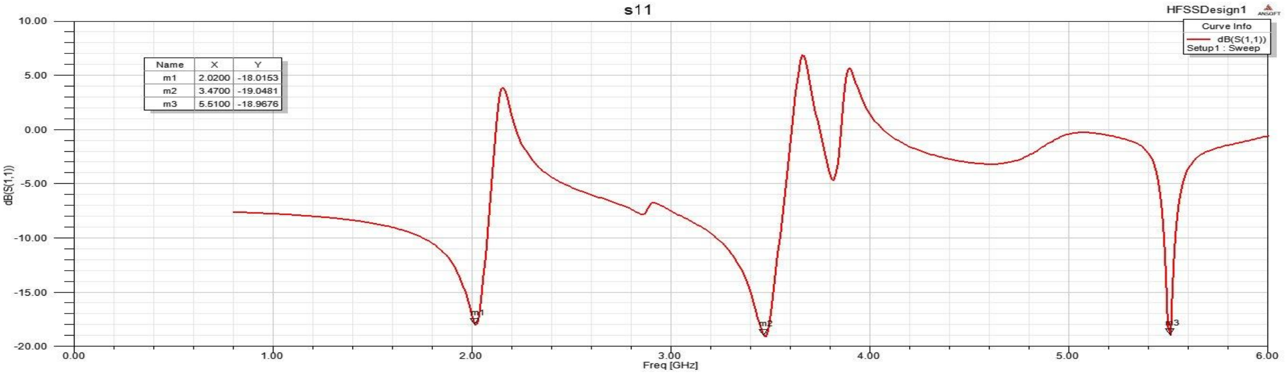

Fig.2 Simulated reflection coefficient vs. frequency characteristics of phase shifter with different configurations

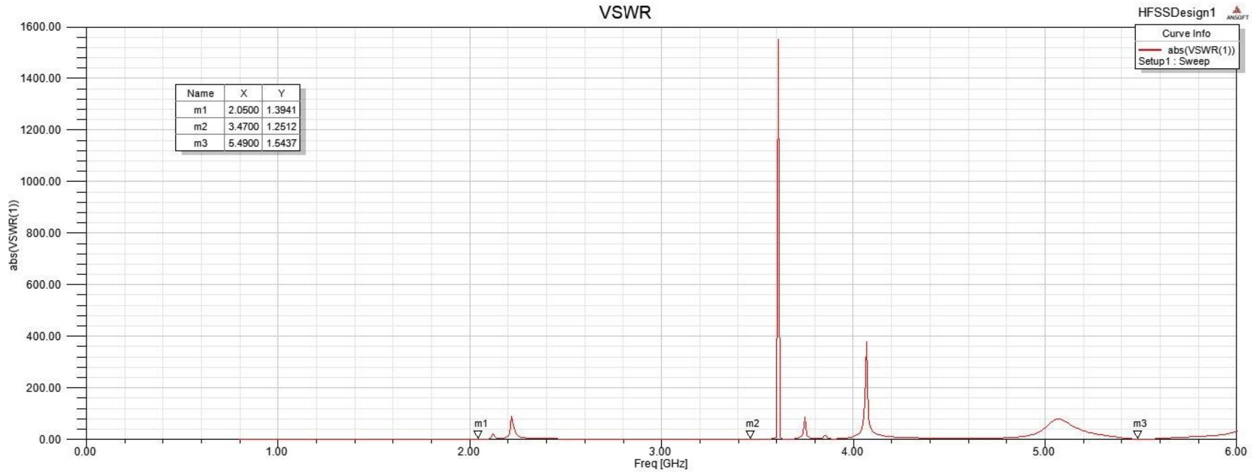

Fig.3 Simulated transmission coefficient vs. frequency characteristics of phase shifter with different configurations

The S11 simulation coefficient of s-parameter with frequency and transmission reflection coefficient is configuration provided with maximum phase component while modified adjacent CPW ground provided the least, as there is higher amount of controlled dispersion in microstrip line and least amount of dispersion in CPW.

Fig.4 Simulated Directivity

Fig.5 Simulated Gain

Fig.6 Simulated Radiation pattern

IV. RESULT

The below picture represents the prototype of the simulated structure. The hardware implementation of the structure is done by using the FR-4 substrate. The ground structure of the antenna is denoted with copper substrate that represents the rectangular reconfigurable patch with slots. The slots are implanted in the prototype to ensure the return loss is reduced.

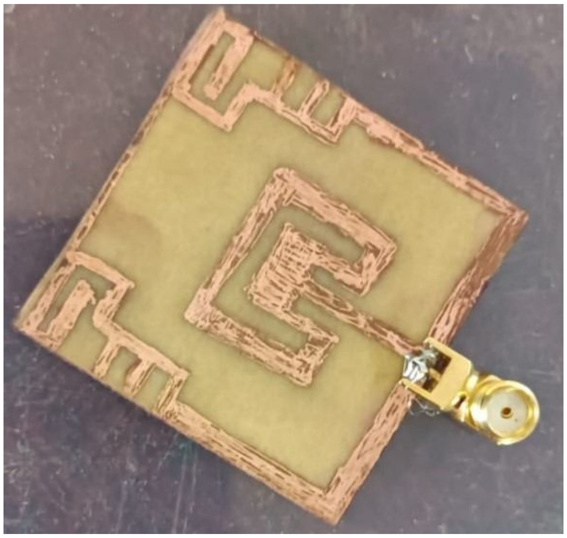

Fig.6 Hardware of the system.

TABLE I
COMPARISON OF BASE AND PROPOSED WORK

Structure	S-parameter	Gain	VSWR	Directivity
Base Work	3.9 to 5 GHz	3.6 dBi	2	3.6dBi
Proposed work	2 to 5 GHz	9.7 dBi	1.3(improved)	8.47 dBi

From the above table we can see that the gain value has increased as compared to the base work. And we get a better VSWR.

V. CONCLUSION

In this thesis report, the effects of defecting the shape of the patch, defecting the ground, namely Defected Ground Structures (DGS) and employing Electromagnetic Band Gap (EBG) structures are extensively studied. By defecting the patch, substrate and ground the enhancement of bandwidth was studied extensively. Initially, the work starts with designing Defective Ground shaped structure using that the antenna is designed for operate at triple band.

By controlling the width of the middle arm, and structure modified with phase shifter, that's is introducing slot between design will exhibits the single resonant frequency at 2.24GHz. By optimizing the probe location and the square of the patch with that phase shifter in the E shaped structure frequency is achieved at the frequencies 2 GHz, 3.4GHz and 5.5GHz. The Return loss values are -18.5B, 19dB and 14=8.7dB respectively.

Directivity has achieved as 9.7dBi.Second, the design of Square microstrip antenna with phase shifter is designed by etching the e shaped structure as introducing a slot of Variable capacitor in the patches.The designed antenna exhibits 2 to 5 GHz improvement in bandwidth.The gain of the square patch variable phase shifter is improved with 9.7 dBi.Stable radiation pattern and consistent gain were obtained in the UWB band.The simulation results of the designed antenna show a good agreement in terms of the VSWR, antenna gain, and radiation pattern.

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