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TRIPLE-BAND MEANDER LINE ANTENNA FOR GSM, DCS AND UTMS APPLICATIONS

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ABSTRACT

A compact triple-band meander line antenna for global system for mobile communication (GSM), distributed control system (DCS) and universal mobile telecommunications system (UMTS) applications operating at the frequencies band of 0.9 GHz, 1.8 GHz and 2.1 GHz is designed. Most demanded wireless communication bands are covered in this design for consumer electronics. The resonant frequencies are 0.9 GHz with the return loss of -21.262 dB and the corresponding radiation pattern with maximum gain of 2.09 dBi, 1.8 GHz with the return loss of -19.011 dB and the corresponding radiation pattern with maximum gain of 2.32 dBi, and 2.1 GHz with the return loss of -20.203 dB and the corresponding radiation pattern with maximum gain of 3.7 dBi. The antenna was printed on a FR4 substrate with dielectric constant of 4.7. The simulated result was verified through measurement in which a good agreement between the simulated and measured result was documented. An application example is shown for the proposed design which is an integrated system to detect the level of electromagnetic field radiation at GSM frequencies.

Keywords: global system for mobile communication, distributed control system, universal mobile telecommunications system.

INTRODUCTION

Microstrip patch antennas are extensively used in different types of applications because of their many advantages such as convenient feeding mechanisms, simple structures, low volume, low profile, light weight, low fabrication cost, ease of mounting on the host surface and convenient integration with RF devices. These types of characteristics of microstrip patch antennas have made them attractive candidates for numerous applications (Alam, M.S.; Islam 2012);(Nashaat Elsheakh *et al. 2010*).

In recent years, the need for the design of an antenna with triple-band operation has growing since such an antenna is essential for integrating more than one communication standards in a single compact system to successfully encourage the portability of a modern personal communication system. For this demand, the growing up of antenna is not only to have a triple-band frequency, but also to have a simple design, compact size, and easy integration with the circuit(Liu *et al.* 2011).

There has been a rising reliance on wireless communication to offer better functionality for products and services. This area increased the required the antennas used in wireless communication systems. In the beginning of 3G and 4G cellular communication systems, in many parts of the world, the order for a single compact antenna to support both 0.9 GHz.1.8 GHz and 2.1 GHz operation is obvious. Besides that, integration of GPS operation with the communication devices is also eligible to support intelligent transportation system, and to integrate location-finding service with mobile phones to improve user security and safety (Andrews *et al.* 2010);(Min Sze Yap *et al.* 2003).

The point to that a single, triple-resonating structure is desirable to fulfill the requirements of multiple wireless systems such as GSM, DCS and UMTS While many moveable communications system uses a simple antenna with a matching circuit (Soltani *et al.* 2011); (Lakhtakia 2006), it may result in reduced efficiency, when designed much smaller in order to suit into compact devices (Shafie *et al.* 2010); (Liao *et al.* 2010).Therefore a meander line antenna is presented here to produce a triple-band frequency without any harmonics at a resonance frequencies of 0.9 GHz, 1.8 GHz and 2.1 GHz.

Antenna design

The proposed antenna has been designed to fit in GSM, DCS and UTMS application. The next is the summary of the details of both antennas design.

Antenna geometry

The meander line antenna, as shown in Figure-1 has been designed for triple-bad frequencies at 0.9 GHz, 1.8 GHz and 2.1 GHz. This antenna design uses transmission line model where a meander line antenna of length L and width W can be viewed as a wide transmission line that is resonating with electric field varying sinusoidally along its resonant length L (Pues and van de Capelle 1984). Since the proposed designed will resonate at triple-band frequency, necessary optimizations is needed for the antenna structure in order to obtain the desired triple frequency and to get the required possible matching impedance.

In the design of this antenna, as shown in the Figure-1, the FR4 substrate is used because of its ease of fabrication, availability, low cost and it has a thickness of h=1.6 mm with loss tangent = 0.025 and a relative permittivity ε_r= 4.7. The edges along the length are called

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none radiating and along the width are called radiating edges (Girase *et al.* 2014). There are different techniques of feeding such as coaxial probe feed, microstrip line feed, aperture coupling and coplanar waveguide (CPW). In this paper, feeding line with 50 ohm feed has been used; it is considered to be the simplest methods to fabricate as it is a conducting strip connected to the meander line antenna and therefore can be considered as extension of the patch. It is also simple to model and easy to control impedance matching by controlling the inset. The dimensions were calculated based on simple rectangular microstrip path antenna and then optimized to get the desired triple-band frequencies. The antenna was designed and analyzed using CST Microwave Studio software.

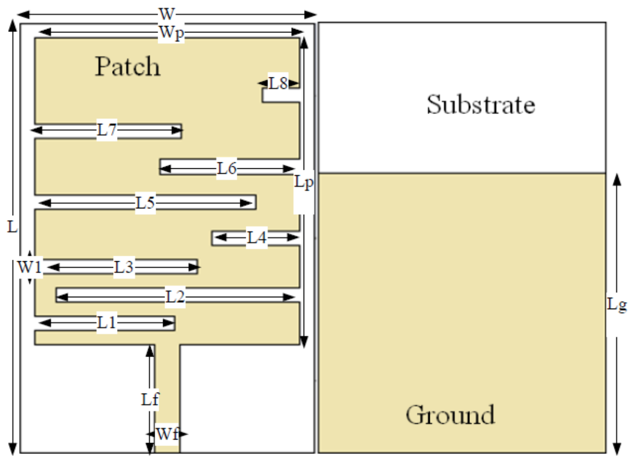

Figure-1. Geometry of the proposed design.

For that purpose, meander line antenna with partial ground plane has been designed to reduce the overall size of the antenna. Besides that, it helps to obtain a smooth triple desirable resonant frequency. The optimized dimensions are shown in Table-1. The structure is fabricated on the one side of the substrate and ground is on the other side of the substrate as shown in Figure-2.

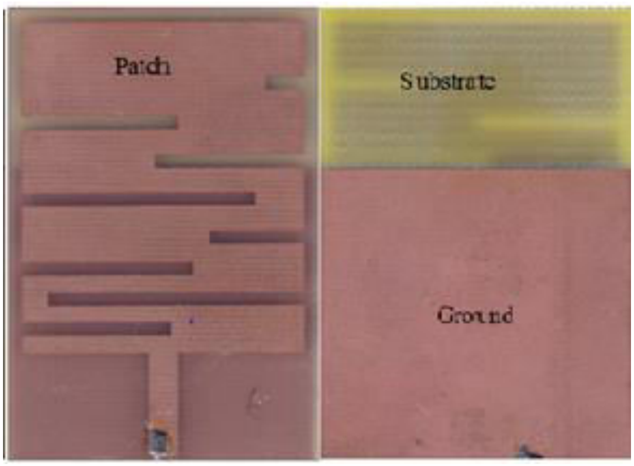

Figure-2. Prototype of the fabricated meander line antenna.

Table-1. Antenna geometry dimensions.

Parameter	Dimension (mm)
W	40
L	60
Wp	18
Lp	43
Lg	39
L1	19
L2	33
L3	22
L4	12
L5	30
L6	19
L7	20
L8	5
W1	2
Wf	3.37
Lf	15

RESULTS AND DISCUSSIONS

The simulations were carried out in CST Microwave Studio, which is commercial electromagnetic software. This software uses Finite Integration Technique (FIT) for simulations.

A. Return loss

The simulated return loss magnitude of the meander line antenna is shown in Figure-3. The desirable triple frequency has been obtained with smooth resonant frequency which shows that the antenna's response to be good for the three different bands. The operating bands are 0.9 GHz, 1.8 GHz and 2.1 GHz with return loss of -21.262 dB, -19.011 dB and -20.203 dB respectively. These bands are used under different wireless applications as mentioned before. It is significant to note that the return loss at all these frequencies is below -15dB and this is satisfactory for effective power radiation at the chosen frequencies. This obviously shows that the patch is perfectly matched to the 50 ohm input feed.

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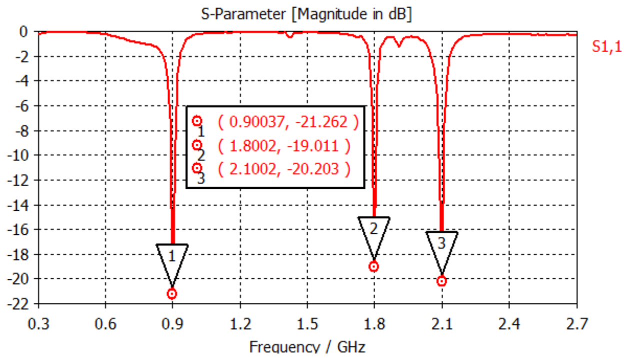

Figure-3. Simulated S_{11} parameter of meander line antenna.

B. Input impedance

Since the input impedance of the antenna must be identically matching in order to achieve maximum energy transfer between the transmission line and the antenna to achieve higher efficiency. Hence, a consideration has been taken in order to achieve desired matching for the proposed meander line antenna. It can be seen that from the Figure-4 the design result with acceptable matching of 50 Ohm.

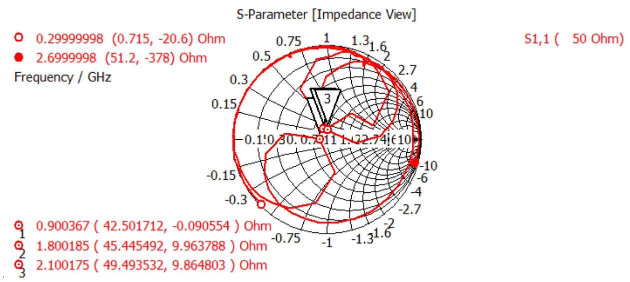

Figure-4. Simulated results for input impedance (smith chart).

C. Radiation pattern with maximum gain

The radiation pattern with maximum gain of the proposed meander line antenna has been simulated at the triple-band frequency. It can be seen from Figure-5, Figure-6 and Figure-7 that the radiation pattern with maximum gain achieved for the triple-band frequencies 0.9 GHz, 1.8 GHz and 2.1 GHz is 2.09 dBi, 2.320 dBi and 3.706 dBi respectively.

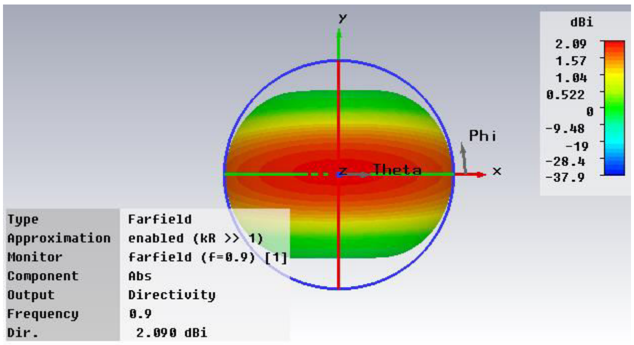

Figure-5. Radiation pattern with maximum gain of the meander line antenna at 0.9 GHz.

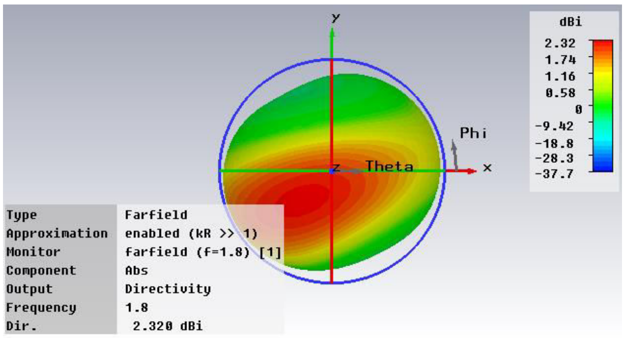

Figure-6. Radiation pattern with maximum gain of the meander line antenna at 1.8 GHz.

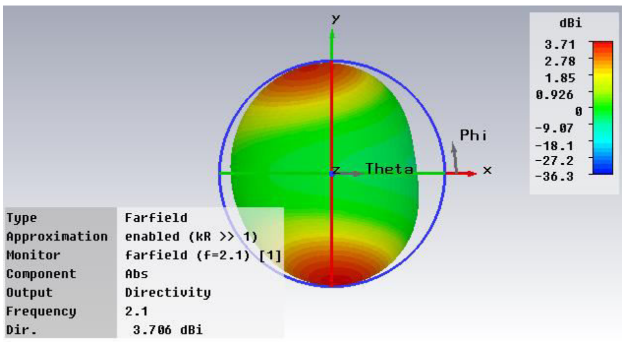

Figure-7. Radiation pattern with maximum gain of the meander line antenna at 2.1 GHz.

The performance of meander line antenna has been measured using the network analyzer. Return losses have been carried out at the required triple-band resonant frequencies of 0.9 GHz ,1.8 GHz and 2.1 GHz. Figure-8 illustrates the comparison of the simulated and measured S_{11} parameter of proposed antenna design at free space. It shows that the resonant measured frequency at 0.9 GHz and 1.8 GHz has a good agreement. However, the frequency at 2.1 GHz is slightly shifted from the simulation result. This is something that is expected to occur, since a change in the measured result compared to the simulated result could happen due to conductive or copper losses and dielectric losses. In addition, improper PCB printing and soldering during fabrication process

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might cause some errors to the small geometries of the antenna in a millimeter difference. Besides that, the size of the width and length of the patch may not be exactly the value used in the simulation software, since the patch shape is printed on a dry film before fabrication using a paper printer and not accurate enough to match the exact dimensions. It is observed from measurements that the proposed antenna shows acceptable impedance matching, which indicates that the antenna has a good efficiency as shown in Figure-9.

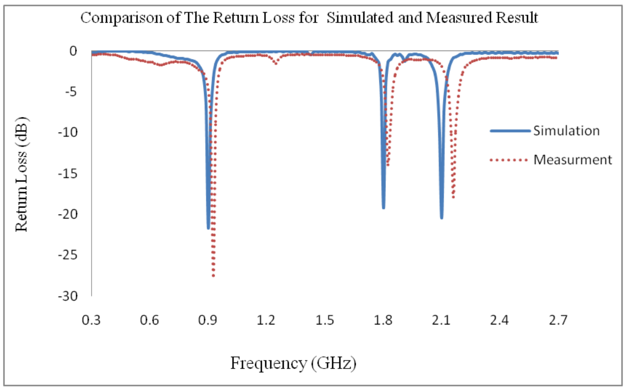

Figure-8. Measured and simulated S_{11} parameter of meander line antenna.

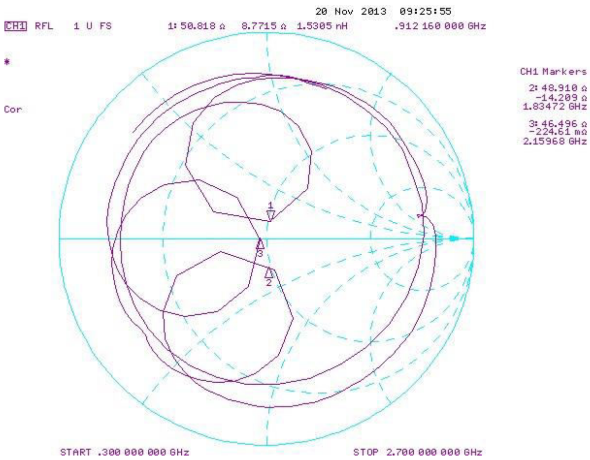

Figure-9. Measured meander line antenna impedance (Smith Chart).

The operating frequencies at 0.9 GHz, 1.8 GHz and 2.1 GHz have values of VSWR that are less than 2. As shown in Figure-10, the VSWR for the achieved frequencies reaches a magnitude of 1.2. Besides that, simulated and measured results shows a good agreement which indicates that the proposed antenna has good performance at these frequencies.

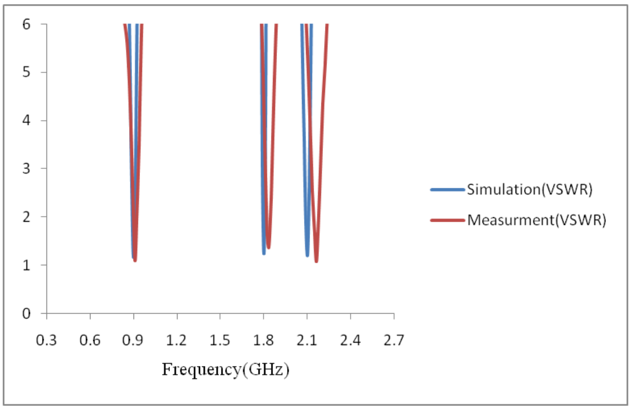

Figure-10. Measured and simulated of VSWR parameter of meander line antenna.

Application example

The proposed antenna has been applied to this application as shown in Figure-11 which is an integrated system to detect the level of electromagnetic field radiation (in volts/meter) at the GSM frequencies of 0.9 GHz, 1.8 GHz and 2.1 GHz. There are 3 sensor units each comprising of antenna, detector, microcontroller and LED displays. The output voltage of the detector is calibrated and compared with the limits set by International Committee on Non-Ionizing Radiation Protection (ICNIRP) and the decision is displayed by the LEDs to indicate the severity of radiation. Green color is safe; orange is critical and red is danger. The status of the LEDs is monitored remotely using a computer. By this way it is possible to locate the sensors at various places and monitored at a central location. This system is designed to help human in daily life to avoid the exposure to electromagnetic radiation especially for those who do not have knowledge regarding electromagnetic effects. This application has IP Protection of the system is 2012004915.

Figure-11. Integrated electromagnetic detection system.

CONCLUSIONS

Printed triple-band meander line antenna structures has been presented with simulated and measured results for GSM / DCS / UTMS applications are analyzed. A triple- band with a smooth return loss of frequencies of 0.9 GHz, 1.8 GHz and 2.1 GHz and a good matching is observed with a corresponding of radiation pattern with maximum gain designed has been shown in the proposed design. A simple feeding line type feed mechanism is used for design. The antenna has been designed by using CST software. The important parameter of the designed has been studied.

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