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GROUND MODIFIED ELECTRICALLY SMALL ANTENNA FOR DCS 1800 APPLICATIONS

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Abstract

A Uni-planar coplanar waveguide fed modified ground radiating structure with very compact size and simple structure, suitable for Global System for Mobile 1800 DCS application is discussed. Developed antenna offers a 2:1 VSWR bandwidth of 180 MHz ranging from 1.71 GHz to 1.89 GHz which is wider to cover both uplink and downlink bands of GSM1800. Antenna possesses linear polarization characteristics and offers a radiation pattern just like a quarter wave monopole. Developed antenna offers an average and uniform gain of 2.1 dBi with a moderate gain of 79.8% in the entire band of operation.

Keywords:

Electrically Small, CPW Fed, Monopole, Modified Ground

1. INTRODUCTION

Antenna is considered as the eye and ear of a communication system and thus has most important position in communication gadgets. As technology grows, the size of gadgets become more compact. This is a same time break and challenge to antenna design engineers. They have to design very compact antenna structure without compromising the radiation and impedance characteristics. Normally the size of antenna proportional to its wavelength of operation and if the size of the antenna is very less than that of the wavelength, we can term it as electrically small one. Compacting can be achieved through different techniques which are already discussed in literatures.

A dual mode wearable antenna with a circular patch inside a rectangular loop patch is discussed in [1] which is a triple layer structure. In [2], the authors present a wearable antenna which is also a complicated structure composing a square patch inside a ring. A compact antenna operating at 2.4 GHz ISM band is presented in [3] in which the size reduction is achieved by shorting circular slots in radiator and rectangular and polygon-shaped slots in the ground. In [4], the size reduction is achieved using a 3D spiral structure. An L and J shaped slots loaded compact planar inverted F antenna is presented in [6] which consist of two radiating elements. An antenna with two non-resonant coupling elements is presented in [7]. A defective ground meta-material based single band antenna is presented in [8] which is a double planar structure. Mokal et al. in [9] presents an X shaped antenna structure with enhanced gain. In [10] a PIFA antenna having two stacked rectangular patch is discussed. A microstrip based antenna suitable for GSM 1800 base station is explained in [11] which is a huge one with multi-layer structure.

In this paper, we are presenting a novel and electrically small antenna suitable for DCS 1800 mobile communication band. Developed antenna offers sufficient bandwidth to cover both uplink and downlink frequency bands of GSM1800, with good and uniform radiation characteristics. The linearly polarised monopole discussed here offers an apple shaped radiation pattern with good gain and moderate radiation efficiency.

2. EVOLUTION OF THE ANTENNA

Antenna structure is evolved from a conventional coplanar waveguide (CPW) fed monopole of signal strip dimension $L_s \times W_s$ and ground length L_g, whose ground plane is extended upward to form a rectangular structure of dimension $L \times W$.

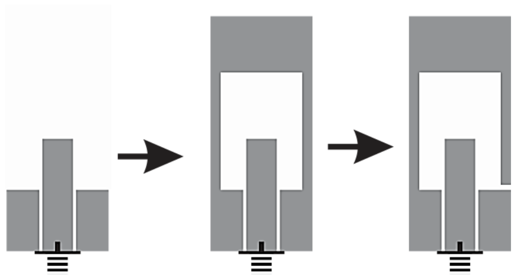

Fig.1. Evolution of the Compact Antenna

A rectangular portion of $L_1 \times W_1$ is etched off from the ground plane to create a slot in ground. To introduce a resonance at lower frequency a narrow slit of dimension s is introduced at the right bottom corner of the ground slot as shown in Fig.1. Simulated reflection characteristics of a CPW fed monopole, extended ground CPW fed antenna and extended ground CPW fed antenna with slit are depicted in Fig.2. From the plot it can be noticed that the introduction of a slit in an extended ground CPW fed monopole will introduce a resonance at well lower frequency with good impedance matching.

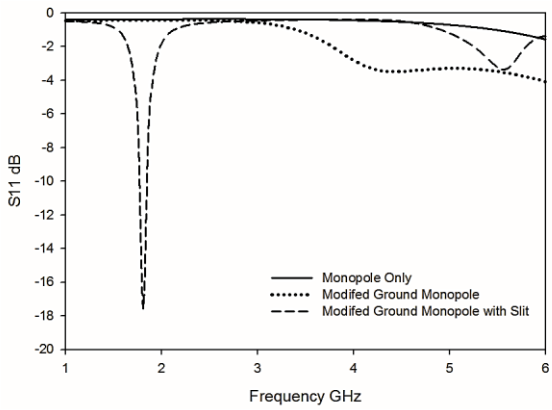

Fig.2. S_{11} of CPW fed monopole, extended ground CPW fed Monopole and extended ground CPW fed monopole with slit

Detailed structure with dimensional notation of the proposed single band antenna is depicted in Fig.3.

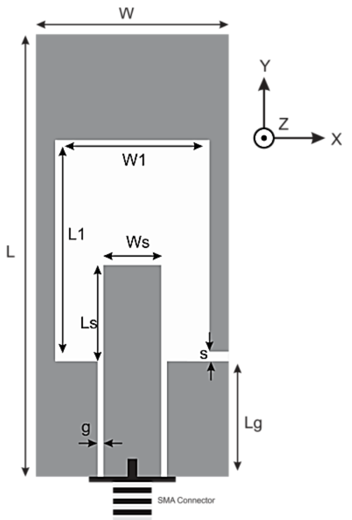

Fig.3. Antenna structure with SMA Connector

Signal strip width W_s and gap g of the structure is selected to meet an input impedance of 50Ω standard, for noiselessly incorporating an SMA connector as input feed.

3. PARAMETRIC OPTIMIZATION

To optimize the dimensional parameters, parametric analyses of the antenna for various dimensions are performed. The results obtained are discussed as follows.

Effect of the slit *s* on resonance is analysed first and it is found to be crucial in this antenna design. The result obtained is given in Fig.4 and from that it can be noticed that when there is no slit, no resonance is found at lower frequencies. On introducing a very narrow slit, a heavily matched resonance is introduced. The resonance is found to be shifting towards right when s increases. This is due to reduction of length of right portion of extended ground with 's'.

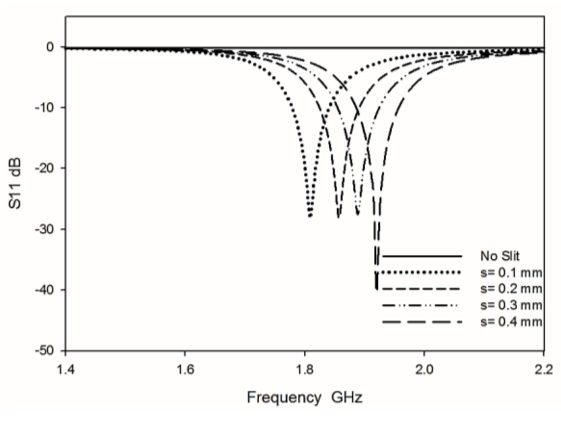

Fig.4. Effect of slit on Resonance

As next step, the effect of total length of structure on resonance is analysed. This length has only feeble effect on resonance. The resonant frequency slightly lowering with this parameter but the matching increases. S parameters obtained for various L is depicted in Fig.5.

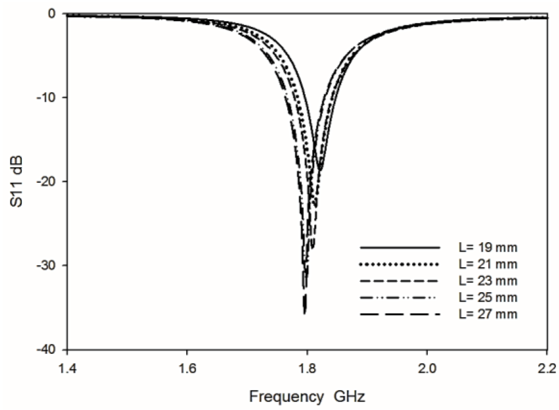

Fig.5. Effect of *L* on Resonance

Effect of monopole length *Ls* is analysed and is depicted in Fig.6. Resonance is found to be lowering with increase in monopole length. This may be due to the increase in surface current path length.

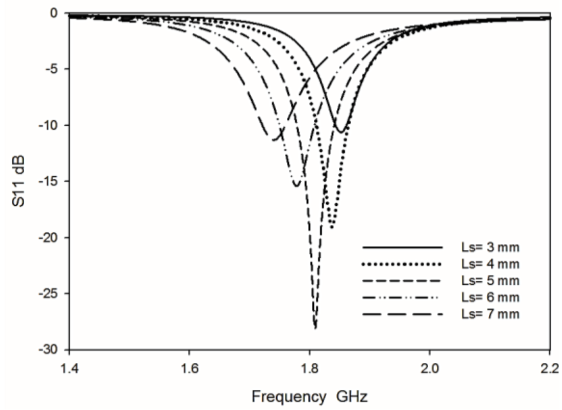

Fig.6. Effect of L_s on Resonance

Another important parameter of the antenna is length of the slot L_1. The variation of S11 with increase in L_1 is depicted in Fig.7. Here also the resonance gets drastically lowered with L_1.

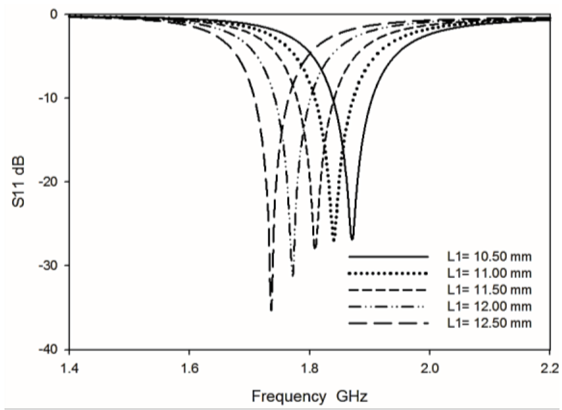

Fig.7. Effect of L_1 on Resonance

4. RESULTS AND DISCUSSIONS

From the parametric analysis performed, a prototype of the proposed antenna resonating at 1.8 GHz with excellent radiating characteristics is fabricated and tested with VNA HP8510C. The optimized physical parameters of the antenna are depicted in Table.1 Overall dimension of the antenna is found to be $0.206\lambda_g\times 0.095\lambda_g\times 0.015\lambda_g$ which is very compact on comparing with existing antennas and make this an electrically small structure.

Table.1. Optimized structural specifications of Antenna

L	W	L_s	W_s	L_1	W_1
21 mm	10 mm	5 mm	3 mm	11.5mm	8 mm
L_g	s	g	h	**tan** δ	ε
6 mm	0.1 mm	0.3 mm	1.6 mm	0.002	4.4

Measured and simulated reflection characteristics of the antenna are found to be similar and are depicted in Fig.8. Antenna is oscillating at 1.80GHz with a bandwidth of 180MHz ranging from 1.71GHz to 1.89GHz which is wide enough to cover both Uplink (1710-1785MHz) and Downlink (1805-1880MHz) frequency bands of GSM 1800 application band.

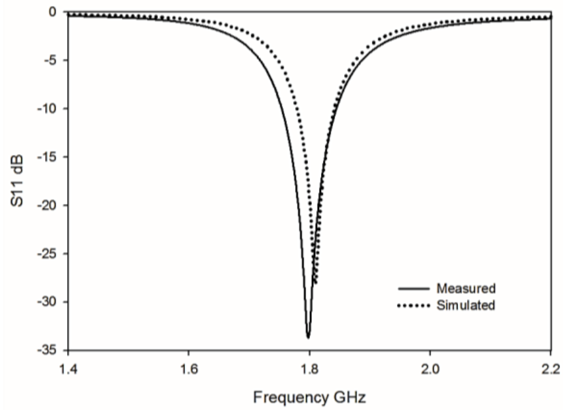

Fig.8. Simulated and Measured S11

Measured and simulated spatial energy distribution (Radiation pattern) of the antenna is given in Fig.9 and Fig.10 respectively. From the figures, the polarization of the structure is inferred to be linear, and oriented in Y direction. The Boresight direction of the antenna is lying in positive X direction with figure of 8 pattern in E plane and isotropic pattern in H plane. A cross polar purity of 25dB is present in E plane while that of H plane is nearly 15dB.

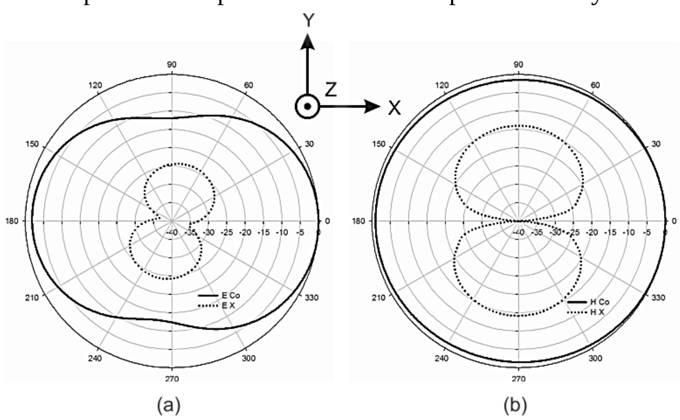

Fig.9. Measured (a) E plane and (b) H plane pattern

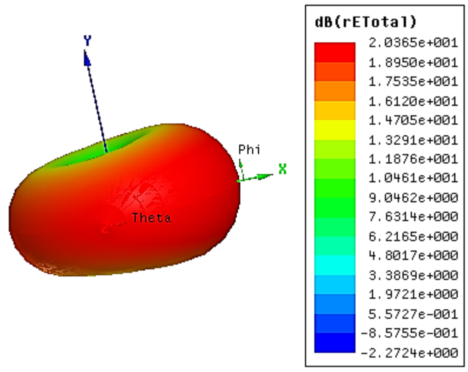

Fig.10. 3D Radiation Pattern

Simulated Surface Current distribution of the antenna at centre frequency is analysed to reveal the reason behind resonance. From the plot given in Fig.11, it is clear that entire part of the structure is contributing in radiation a half wavelength long current variation is found through the modified ground and signal strip. At the vicinity of top edge of the modified ground, the current density is minimum and this is the reason for negligible shifting of resonant frequency with L depicted in Fig.5.

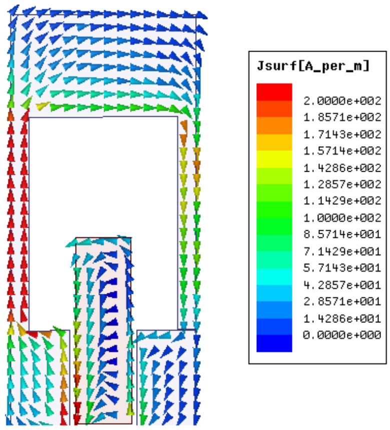

Fig.11. Current pattern of the antenna at resonance

Standard horn testing method is used for measuring antenna gain while wheeler cap method is used to calculate antenna efficiency. Antenna offers an average gain of 2.1dBi in the operating band. The radiation efficiency is found to be slightly less with an average value of 79%. Both the curves are depicted in Fig.12.

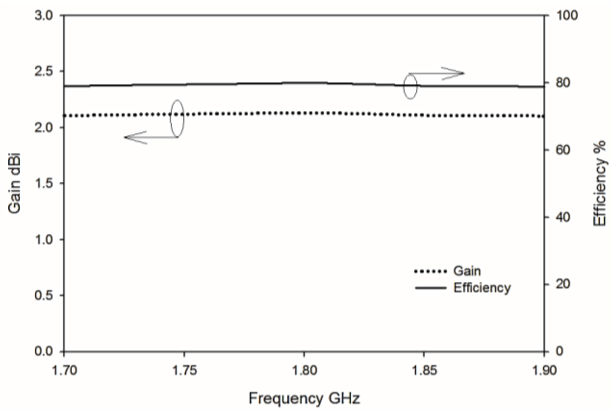

Fig.12. Gain and Efficiency plot

5. CONCLUSION

A very simple and electrically small radiating structure suitable for GSM1800 DCS application is developed. Antenna offers a 2:1 VSWR bandwidth of 180 MHz ranging from 1.71 GHz to 1.89 GHz with uniform radiation characteristics in the entire band of operation. Just like a monopole, spatial energy distribution of the antenna is isotropic in H plane while figure of 8 shaped in E plane. Developed antenna has liner polarization with good gain and moderate radiation efficiency.

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