NOVEL, TUNABLE, MULTIBAND COMPACTMICROSTRIPANTENNA

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Abstract. In this paper, a novel, tunable, multiband compact microstrip antenna is proposed. This antenna has the advantage of reducing antenna size and at the same time by varying the number of vias and their locations, different tuneable operating frequencies are obtained. The total area of the proposed antenna is (9mm *8mm). To verify the idea one, three and six vias are implemented. The antenna configurations are fabricated on FR-4 substrate material. A TRL calibration kit was designed and fabricated using the same material to cover the frequency range from 0.4 GHz up to 3.5 GHz. Measured results were found to be in excellent agreement with the simulated data.

1. Introduction

Several techniques have been proposed to reduce the size of the patch antenna such as using high dielectric constant materials. However, poor efficiency due to surface wave excitation and narrow bandwidth has been observed [1]. A second technique is using shorting posts in different arrangements but there is a strong dependence of the input impedance on the close positioning of the shorting post with respect to the feed, and once again the narrow impedance bandwidth. To date, the recorded bandwidths of the proposed shorted patches are significantly less than that required for cordless systems.

Regarding the bandwidth enhancement of patch antennas, several techniques have been proposed, among them are: impedance matching network, multiple resonators and thick substrates. For an electrically thick substrate, coaxial feed is used, however, the increased inductance introduced by the long probe limits the bandwidth. For this reason several other methods have been suggested to solve this problem, including etching a small circular slot, cutting a U-slot on a patch and the use of an L-probe feed [2].

Recently a novel shorted microstrip antenna was presented in [3] to achieve reduction in antenna size and at the same time operating at a broadband frequency. This structure with added tuning capability is presented in this paper. The basic idea is shown in section 2, followed by the simulation and the experimental verifications.

2. Proposed structure and basic idea

Fig.1 shows the proposed geometry, this antenna is designed to operate at the Bluetooth range of frequency. The area of the antenna is much smaller than the conventional rectangular microstrip antenna (only 6.7% of it), while its bandwidth is larger.

The equivalent circuit of an antenna can be presented by an equivalent LC circuit parallel to the radiation resistance. To add the tuning capability to the structure either L or C should be variable. Since the shape of the structure is fixed, tuning is not possible. However, one or more via that connects the upper metal to the bottom ground is going to change the effective length of the radiating element and therefore this leads to change in the inductance of the antenna. The value of this inductance depends on the dimension, position and number of vias. Tuning capability can be achieved with a switch that connects the via to the antenna, hence the operating frequency will depend on the state of the switch.

Due to the technology complexity, these circuits could not be realized. However, to verify the idea one, three and six vias are implemented in positions 2,3, …,7 as shown in Fig.1. Four configurations were designed, fabricated and measured. In the first one, one via was implemented at one of two positions namely 2 and 6. In the second, three vias were implemented in positions in 3,5,6, while in the third structure six vias were implemented in positions 2,3,…,7, which appear as a shorting wall.

3. Numerical and Experimental Results

Fig.2 shows the simulated S_{11} of the three different antenna configurations. The resonant frequencies (1.8, 2.53, 2.61 GHz), respectively varies with the position and the number of vias, as predicted by the basic idea. Fig.3 shows the radiation pattern of the three structures which did not change due to the variation of the number and position of vias. The case of antenna with single via at position 6 will be introduce in section 4 (dual band antenna). The antenna configurations are fabricated on FR-4 substrate material with ε_r=4.7, h=1.5mm (about $0.012\lambda_0$) using thin film technology and photolithographic technique. An SMA connector is used to feed the antenna. The reflection coefficient is measured using the vector network analyzer. The structures are measured using both SOLT and TRL calibrations. The TRL calibration kit was designed and fabricated on the same material as shown in Fig.4 to cover the frequency range from 0.4GHz up to 3.5GHz. The advantage of the TRL is that the reference plane is transferred to the middle of the thru line, which corresponds to the edge of the antenna. This is identical to the reference plane in the simulation. Reflection coefficient measured with these two techniques, were found to be in very good agreement with simulation for the three antennas as shown in Fig.5. (a,b,c), respectively.

4. Dual Band Antenna with Single Via

Dual and multi bands were possible by implementing only one via and selecting its appropriate position between 2- 7. Different via positions were tested using IE3D simulator. Fig.6 shows how the resonant frequency of the antenna is varied by changing the position of the via. It should be noted that the number of resonances in the chosen frequency range is also changed by via position. Fig. 7 shows the measured and simulated S_{11} . Dual band antenna has been demonstrated to operate at 1.8 GHz and 4.9 GHz at via position 2, while multi band operation at 2.5, 2.95, 7.53 and 8.5 GHz, respectively, at via position 6 as shown in Fig.7(b). These two configurations were fabricated on FR4 and measured using SOLT calibration technique since the operating bandwidth is out of the range of the TRL calibration kit. Fortunately, the dual band antenna can work with a single feed by electrically shorting the radiating elements using common short pins, and the lengths of the two arms of the antenna are different in order to achieve two staggered resonances as shown in Fig.1. Results indicate that two resonances with frequency ratio of 2.7 are clearly observed as shown in Fig.7(a), and the input return loss < 15 dB at both bands has been obtained. Four resonances with frequency ratios 1.2, 3, 3.4, 2.5, 2.8 are obtained as illustrated in Fig.7(b) at via position 6. The radiation pattern of these two configurations did not change due to the variation of the via position.

5. Conclusion

In this paper, a miniature microstrip antenna was simulated, fabricated and characterized. This antenna has the advantage of small size and at the same time by varying the number of vias and their positions, the operating frequency can be changed. The total area of the proposed antenna is only 6.7% of the conventional rectangular microstrip antenna. Dual and multi band antenna were achieved by varying the via position. To obtain very accurate measurements, different calibration techniques were implemented. Simulated results obtained by the IE3D were found to be in good agreement with measured results.

References

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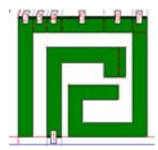


Fig.1 The layout of the antenna showing possible via positions. Via was placed either at a single position from position 2 to position 7 or simultaneously.

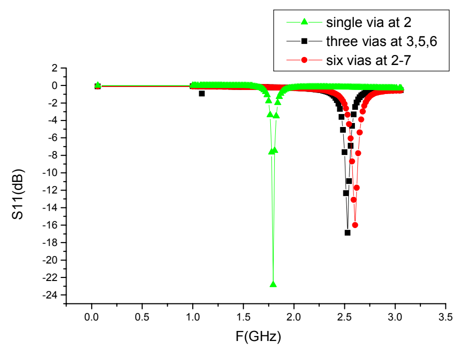


Fig.2 Simulated results of one, three and six vias at positions 2, (3,5,6) and (2-7), respectively .

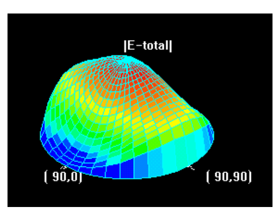
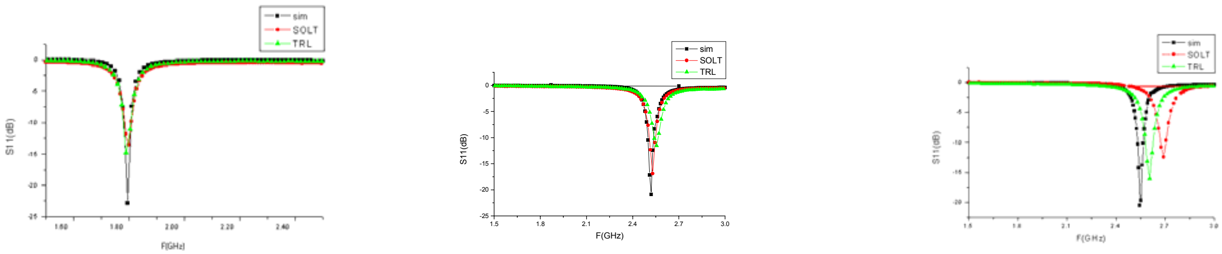


Fig.3 Simulated radiation Patteren for one,three and six vias at position 2, (3,5,6), (2-7) ,respectively.

Fig.4 TRL calibration kit for FR-4 substrate.



(a) **(b)** **(c)**

Fig.5 Reflection coefficient against frequency(a) at via position 2,(b) at via position 3,5,6, (c) at via position 2-7.

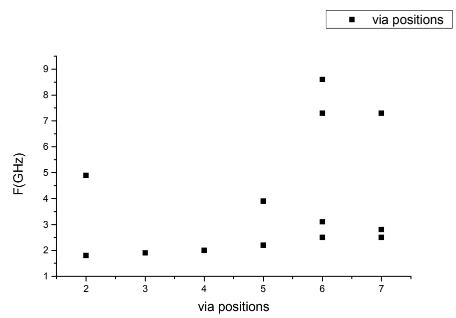
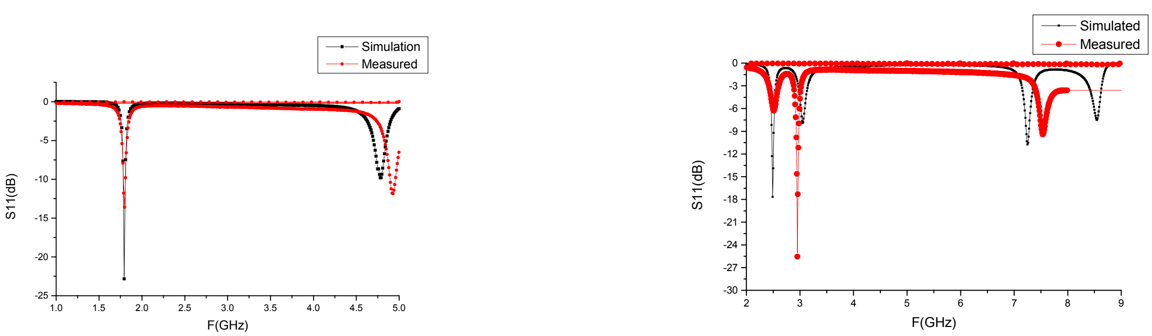


Fig.6 Via positions against frequency.



(a) **(b)**

Fig.7 Reflection coefficient of the antenna
(a) Via at position 2, (b) Via at position 6.