A dual band FR4 PCB antenna

[1] Lin Hao, [2] Xingping Peter Lin
[1] Department of Electrical Engineering, Tsinghua University
Room 104, Building 28, Tsinghua University, Beijing, China, fantasyforest@163.net
[2] 9104 Department, TRW Automotive
24175 Research Drive, Farmington Hills, MI 48335, U.S.A, Peter.Lin@TRW.COM

Abstract

A PCB antenna structure modified from F antenna with different resonating frequency loads were used to create the dual band and wide band antennas. The method of improving the dual band bandwidth has been elaborated. By adding numbers of resonating loads of different branch length, the wide bandwidth was achieved. A structure with loads concentred around two different frequencies was simulated and 3GHz and 5.2GHz dual bands antenna was achieved. Another wide band structure with different loads has been simulated and results has shown 4.09 GHz bandwidth at SWR=4 centred around 4.5GHz (or 90% bandwidth) was achieved. The principle shown here can be applied to different applications by adjusting the matching tapping point, matching loop size, number of the arm loads and their length or resonating points.

1. Introduction

Many dual band and wide band antenna designs have been published [1] [2]. Stacked patch antenna [3] and dual frequency planar inverted-F antenna [4] have been reported. FR4 PCB antenna is cost saving and it is easy to be fabricated. Most F antennas have the short pin after the feeding. Based on the F antenna structure, this paper changes the short pin location. It places the short post which actually behaves like an inductor here (called the inductor load) before the feeding point. The low impedance antenna is transferred to 50 ohm high impedance through inductor tapping. When arranging the tapping point properly and using different antenna arms, dual band antennas can be achieved. To achieve a wideband antenna, use multiple-antenna arms with different lengths. The CST microwave studio was used for simulation. Dual band and wide band antennas have been simulated and demonstrated the principle.

2. Analysis

The basic structure is illustrated in fig.1. The antenna L_arm is close to ¼ wavelength of the operating frequency (the exact length depends on the tapping point). There are three elements that can be adjusted: length of the vertical arm La, the short horizontal arm Lb and arm connected to GND Lc. The higher the La, the higher the radiating resistance becomes, but this number is restricted by the package size. The simple form for the impedance transfer is the ratio: k= (La+Lb+Lb')/Lc. The smaller the real impedance of the L_arm, the larger ratio k required (shorter Lc or longer Lb). In the smith chart, the antenna L_arm impedance is a few ohms (depending on the distance away from the PCB GND) at the frequency close to the resonating frequency (¼ wavelength) and is close to the left side of the smith chart. The short arm Lc behaves like a parallel inductor and pulls the antenna impedance down along admittance curve to the right open side on the smith chart. The series (La+Lb+Lb') behaves like a series inductor to pull the impedance to 50 ohm. Thus is illustrated in fig. 2.

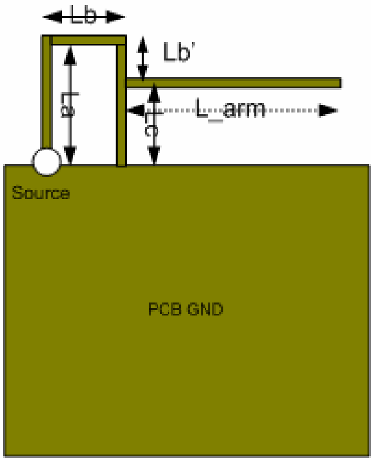

Fig. 1: Basic structure. A source behind inductor leg (Lc) shorted to GND

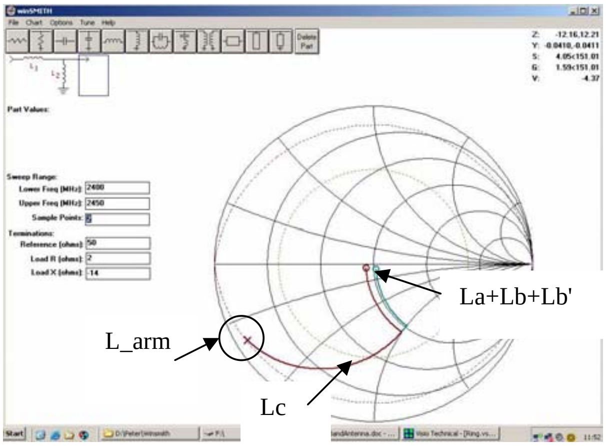

Fig.2 Impedance match

To achieve a dual band antenna, two arms can be arranged as shown in fig. 3. The distance Ld can be chosen as one half of the second resonating frequency's wavelength ($\lambda_{2g}/2$) (presented as open). The second arm length can be adjusted to achieve impedance match. To improve the bandwidth, multiple arms can be used to replace these two arms.

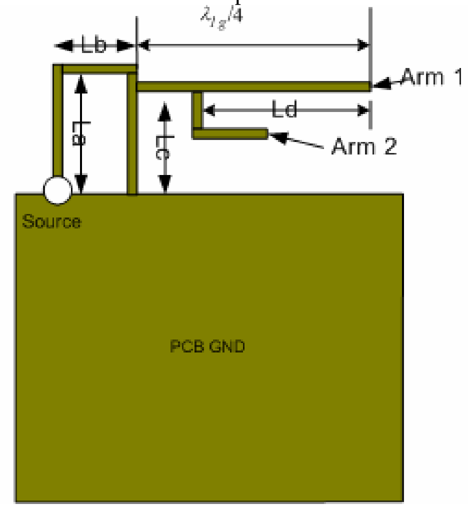

Fig. 3 Dual band structure

There are basically two groups of arms. One group of arms with slight different lengths are resonating around frequency 1 and the other group of arms with slight different lengths are resonating around frequency 2. This is illustrated in fig. 4

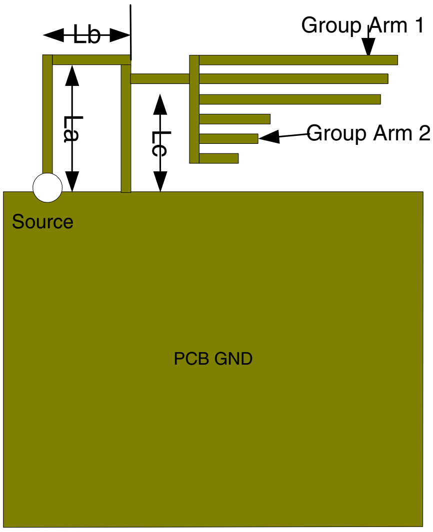

Fig. 4 Dual wide band structure

If move these two groups of arms closer, the wider bandwidth will be achieved around one frequency. The single frequency wide bandwidth antenna can be achieved. This kind of structure is shown in fig.5.

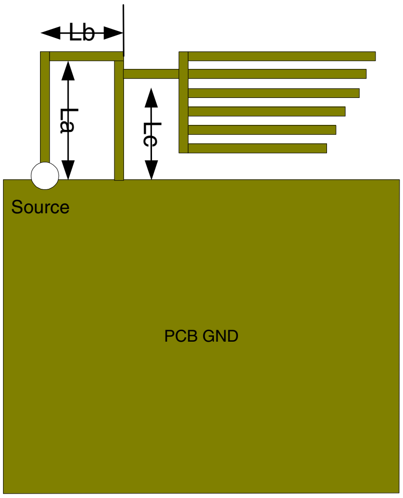

Fig.5. Single frequency wide band

These are just principles. Since two groups affect each other, the proper tuning of Lb, La, Lc and arm lengths may be required. In some cases, the wide bandwidth can be achieved by setting two groups apart.

3. SIMULATION

CST Microwave Studio Software was used for simulation. The PCB with loss FR4 as substrate was used. The substrate height is 1.6 mm. The PCB ground is 36 mm wide and 40 mm long. La=8 mm. Lb=3.5 mm. Lc=6.5 mm. The top arm of Group1 is 21.5 mm long and the top arm of bottom group 2 is 17 mm (only includes the horizontal arm) (fig. 6). The return loss and smith chart are shown in fig.7 and fig.8

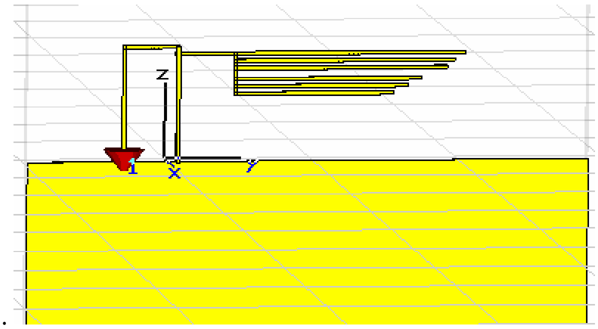

Fig. 6 Dual band structure

The bandwidth of 740Mz. is achieved around the frequency 3GHz and the bandwidth of 500 MHz is achieved around 5.2GHz. The current distributions at three different frequencies are plotted in fig. 9, fig. 10 and fig.11.

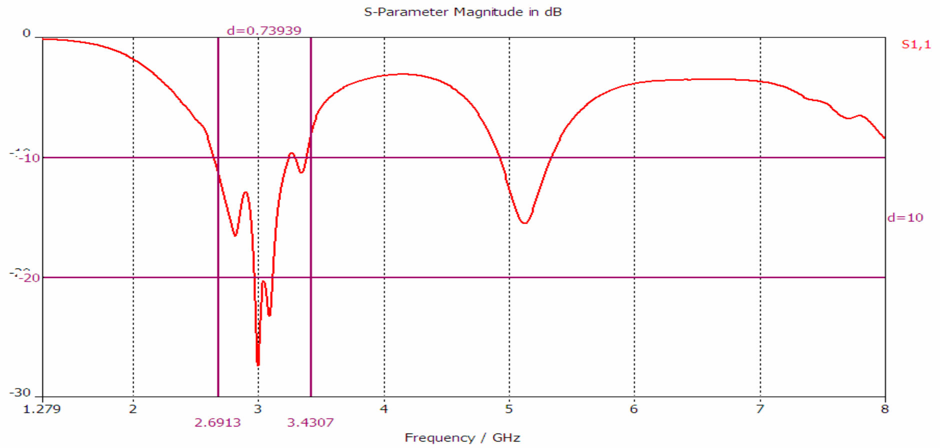

Fig. 7 Return loss

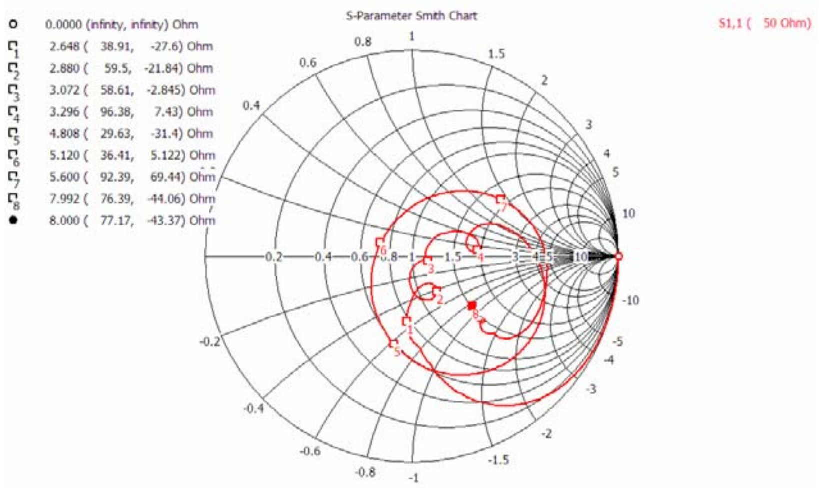

Fig. 8 Impedance

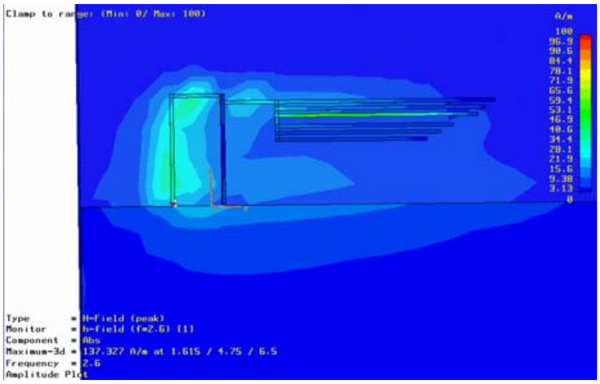

Fig. 9 Current distribution at 2.6 GHz

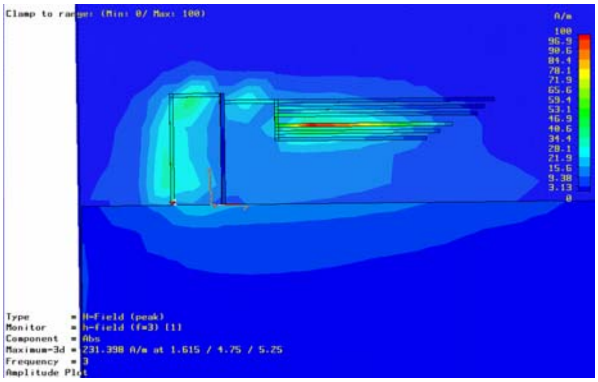

Fig.10 Current distribution at 3GHz

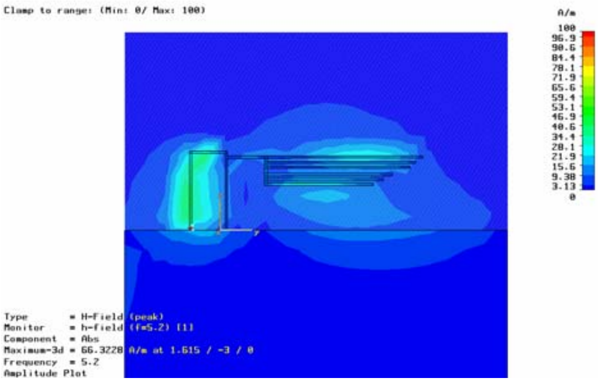

Fig. 11 Current distribution at 5.2GHz

Most current is concentrated around vertical arm for all the frequencies. The resonating frequency is mainly determined by horizontal arm L_arm. At the lower frequency, 2.6GHz, more current concentrated at upper long arms. As the frequency increases, the concentrated current moves down towards the short arm. The radiating efficiency is 73% at 2.6 GHz and 83% at 5.2GHz (fig. 12 and 13)

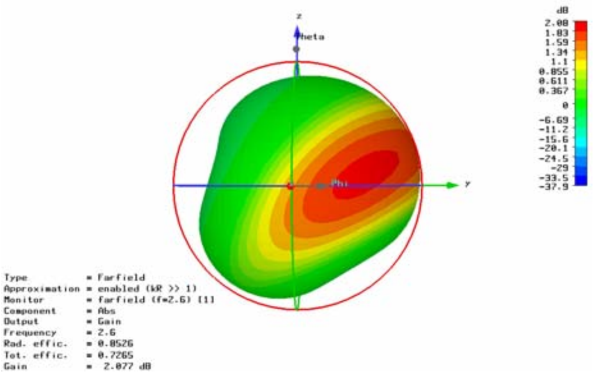

Fig.12 Radiation pattern and gain at 2.6GHz

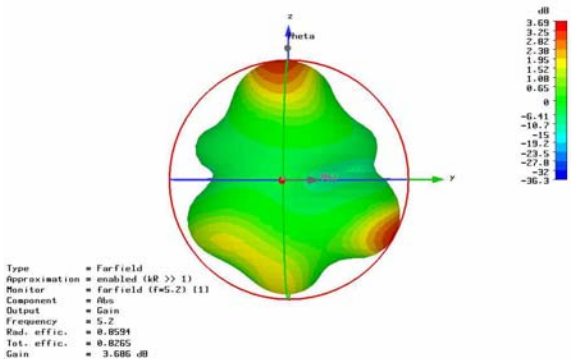

Fig. 13 Radiation pattern and gain at 5.2GHz

Another structure was simulated. The structure is shown in Fig.14. To widen the bandwidth, Lb was adjusted to be 3.mm and the top arm of the lower group is 8 mm. The impedance on the smith chart and SWR are plotted in fig15 and fig. 16

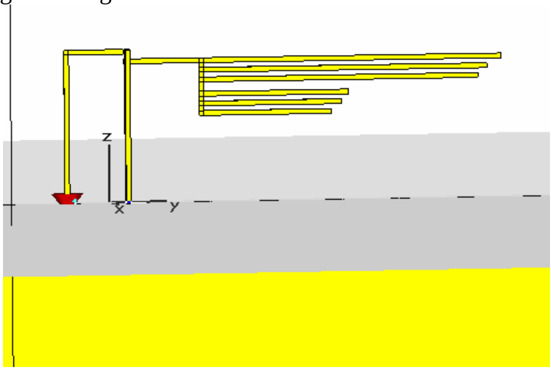

Fig.14 Wide band structure

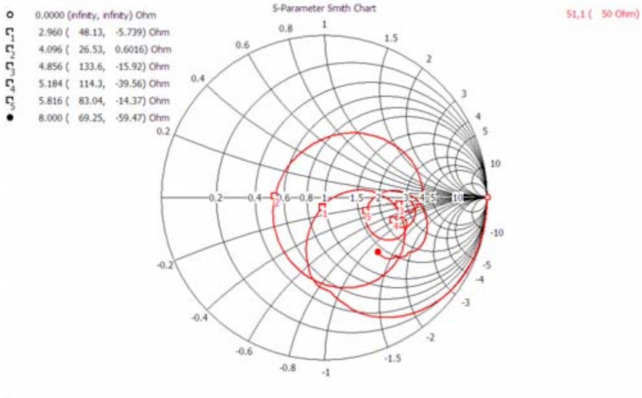

Fig. 15. Impedance Smith Chart

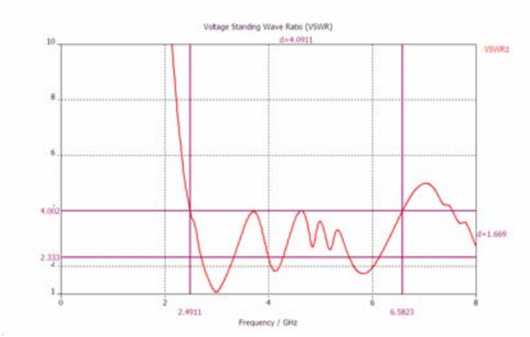

Fig.16 4.09GHz bandwidth with SWR=4

It has shown that the bandwidth of 4.09GHz was achieved with SWR=4, which is 90% bandwidth. It is believed that SWR can be reduced with more arms and proper adjustment of all the parameters. Since it takes long time for each simulation, no further simulation has been done.

4. CONCLUSION

The paper presents structure of achieving wide band dual frequency PCB antenna. It has shown by adjusting tapping position, tapping loop length, the number of load arms and arm lengths, the wide band PCB antenna and dual frequency wide band PCB antenna can be realized. The simulation has demonstrated the principle and it can be applied for different application and frequency.

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