DUAL BAND F-ANTENNA FOR EUROPE AND NORTH AMERICA

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ABSTRACT

A single antenna for multiple bands are always beneficial from the design point of view. Here a single antenna which is fundamentally inverted F antenna is used, the uniqueness of the design is that , it uses trap technique to produce dual resonance from a single inverted F antenna . The trap used to block the current due to some frequencies and passes the current contributed by other frequencies. So in short , this trap is like a RF filter which has some passband as well as stop band. This trap approach uses a LC network to achieve this design goal .The two bands of interest are 865-870 MHz and 902-928 MHz .. The challenge of this design is that the frequency separation of the two bands is very small. In this case, and also the extra section for low frequency band is too small. Then, the influence of trap LC component variation due to tolerance to the two resonant frequencies is big, and so it is difficult to achieve good in band return loss within the LC tolerance. This is the main difficulty of this design. This issue is resolved by placing the low band section away from the end of the antenna. The antenna is designed on FR4 substrate material having thickness of 1.6 mm and hence it is a low cost solution which could use in various commercial applications which follows these bands.

KEYWORDS

Trap , SubGHz , inverted F antenna, FR4 substrate , LC Component

1. INTRODUCTION

Adding traps on antenna is a commonly used method to make multiband antennas. In [1], this method was used to design Dual-Band PIFA. In [2], traps were added to wires to make Dual-Band Quadrifilar Helix Antenna. In [3], the trap method was used not just to design multiband antenna, but to design broad band antenna. In this paper, the trap method is used to design a dual band printed F-Antennas. The design consists of an inverted F antenna, with a trap for creating the dual bands. The two bands are 865-870 MHz and 902-928 MHz. The design goal is that, the return loss for the two bands is under -10dB within the trap LC component tolerance. For trap F-antenna, a straight forward configuration of the antenna is shown in Fig. 1. A), where the low band section is at the end of the antenna. But this configuration will not work for this antenna design, because the separation of the two bands is small, and thus that section is small. And because this section is small, the influence of trap L and C components variation due to tolerance to the two resonant frequencies is big. Actually, it is too big. It is not possible to achieve the design goal, which is, the return loss for the two bands is under -10dB within trap LC component tolerance. To solve this problem, the low band section is placed away from the end of the antenna as shown in Fig. 1. B), so it becomes bigger. When it is bigger, the LC tolerance's influence is smaller, then the design goal is achieved. The first part of the paper describes the design of the trap, second part will present the inverted F-Antenna design. The antenna is designed to be printed on FR-4 material to minimize space and cost of the board. For all simulations, the software used in the designs is CST (Computer Simulation Technology).

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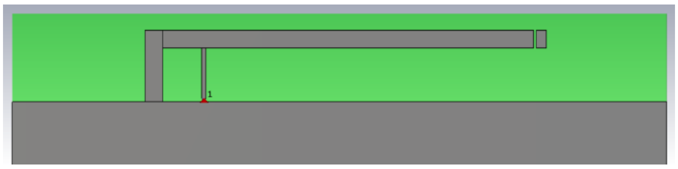
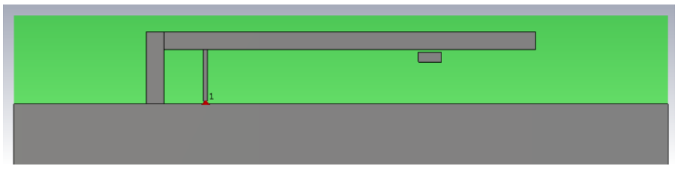


a) Low band section is at the antenna end.



6) Low band section is away from the antenna end

Figure 1. Two congurations of trap antenna

2. THE TRAP DESIGN

The Trap used in the design are as follows. It consists of one capacitor and two inductors connected in parallel which acts as a band stop filter for high band. The reason of using two inductors in parallel is for getting the required value.

LC selection: the readily available tolerance for C is +-0.05pF but up to the value 9.1pF in a popular source. For the percentage reason, the highest value 9.1pF is selected. The L value is selected to make the LC trap resonating at 915MHz. The readily available tolerance for L is +-2%.

The selected capacitor and inductor nominal values and tolerances are C=9.1pF+-0.05pF, L=6.8nF+-0.02%. The trap S21 with the nominal values, and the two ends of tolerances are shown in Figure . 2. Trap S21 variation due to tolerance is clearly seen.

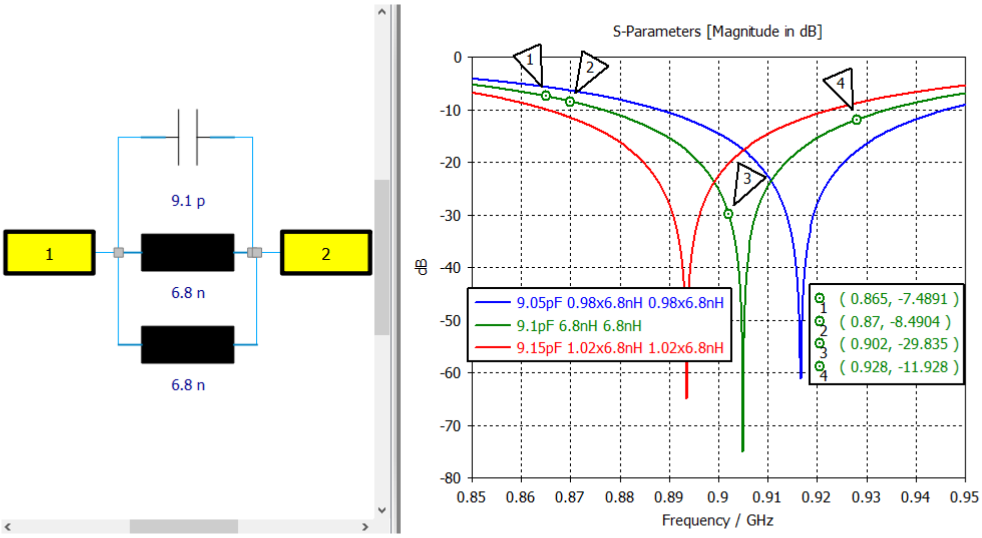
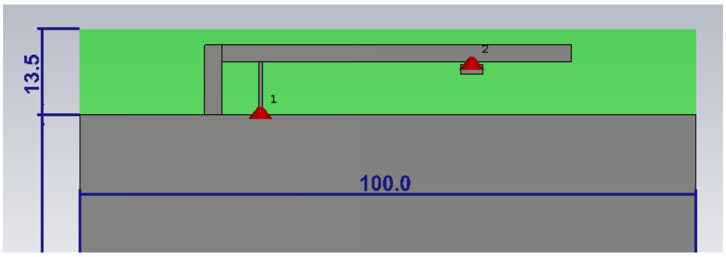


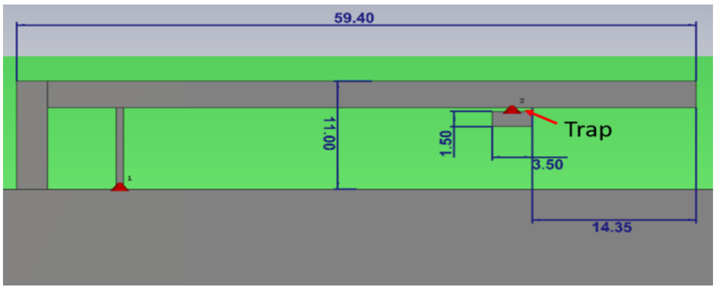
Figure 2 . Trap used in the design

3. THE F-ANTENNAS DESIGN WITH TRAP

The inverted F antenna design, as shown in Figure . 3, combines a single inverted F antenna with a trap. The ground plane is modeled as 1.6 mm thick,100x100mm PEC. The antenna area is 13.5 mm wide FR4 (Er 4.3, LossTan 0.025). The antenna dimensions are 59.4x11 mm, antenna trace is 2.7 mm wide, feed width is 0.65 mm, antenna PEC thickness is 0.035 mm. Fig. 5 shows the antenna return loss with trap LC nominal values, and the two ends of tolerances. As can be seen, the design goal is achieved, which is, under -10dB for all cases.



(a) whole PCB



(b) Antenna details

Figure 3 . The design. (a) whole PCB (b) Antenna details

4. IMPEDANCE MATCHING FOR THE DUAL BAND F ANTENNA :

Most common wireless circuits are matched to 50 ohm at the antenna input .When RF engineers think about the impedance of their project's transmission lines, they may automatically assume that these lines all have a nominal impedance of 50 ohms (Ω). That makes sense, as so much of today's RF design work is based around that value. It's not an arbitrary number; there are good technical reasons for using 50 Ω.

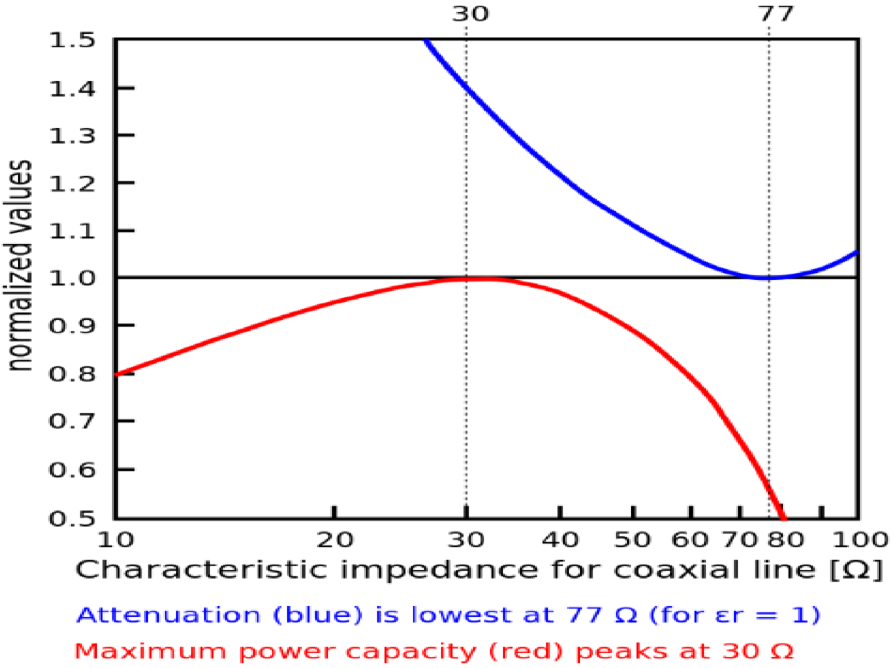


Figure 4 : Comparison of characteristics impedance for max power, low attenuation

As in figure 4, Their analysis looked at the performance of three characteristics as a function of impedance and they found:

1: *Attenuation (loss)* is largely a function of the dielectric in the cable. For the air-filled coaxial cable which they analyzed, the lowest loss was at about 77 Ω (it is around 50 Ω for some dielectrics, but such cables did not yet exist).

2: The *voltage maximum* is a function of the intensity of the electric field between the coaxial outer conductor and the inner conductor. For coaxial cable supporting RF signals in the TE_{10} electromagnetic (EM) field waveguide mode, the e-field has its maximum at around 60 Ω.

3: The *power handling capability* is determined by the breakdown field and impedance (V^2/Z). For air-filled coaxial cables operating below the TE_{11} mode cutoff frequency, the power transfer is at its maximum at around 30 Ω.

In this design , the antenna input impedance is matched to 50 ohm for maximum power transfer and thereby achieving better efficiency of radiation . The Figure 7 below shows the Smith Chart representation of the impedance matching at two frequency points 866 MHz & 901 MHz , which are in the Europe & NA bands .

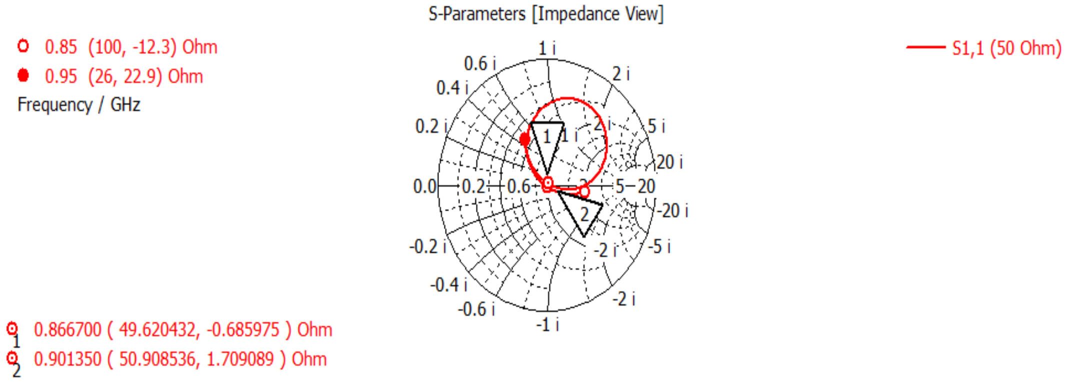


Figure 5 : Smith Chart for impedance matching 866 MHz & 901 MHz

As in Figure 5 , the complex impedance is (49.6-j0.685) ohm for 866 Mhz and (50.9+j1.7) ohm . Thus it can be concluded that the two frequency points in the band of interest are very closely matched to 50 ohm impedance and the return loss is well below -10 dB standard .

5. Results & Analysis

This section deals with the results of the propsoed Dual band Sub GHz antenna . It mainly includes the Surface current distribution, Return Loss (dB) , 3D Radiation pattern & Antenna efficiency (dB).

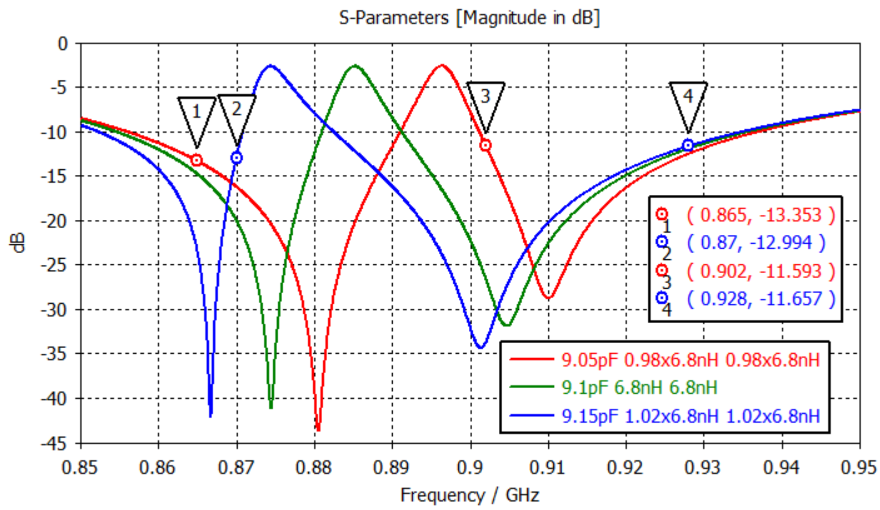


Figure 6. Antenna return loss

The Antenna return loss plot in Figure 6., shows the bandwidth numbers, which is more than 20 MHz for the 868 MHz band (Europe) &approx.. 50 MHz for 915 MHz which is well beyond the bandwidth requirements .

As in Figure 7 , the surface current distribution shows strong current distribution along the antenna traces , at both the SubGHz bands , 866 MHz & 915 MHz respectively

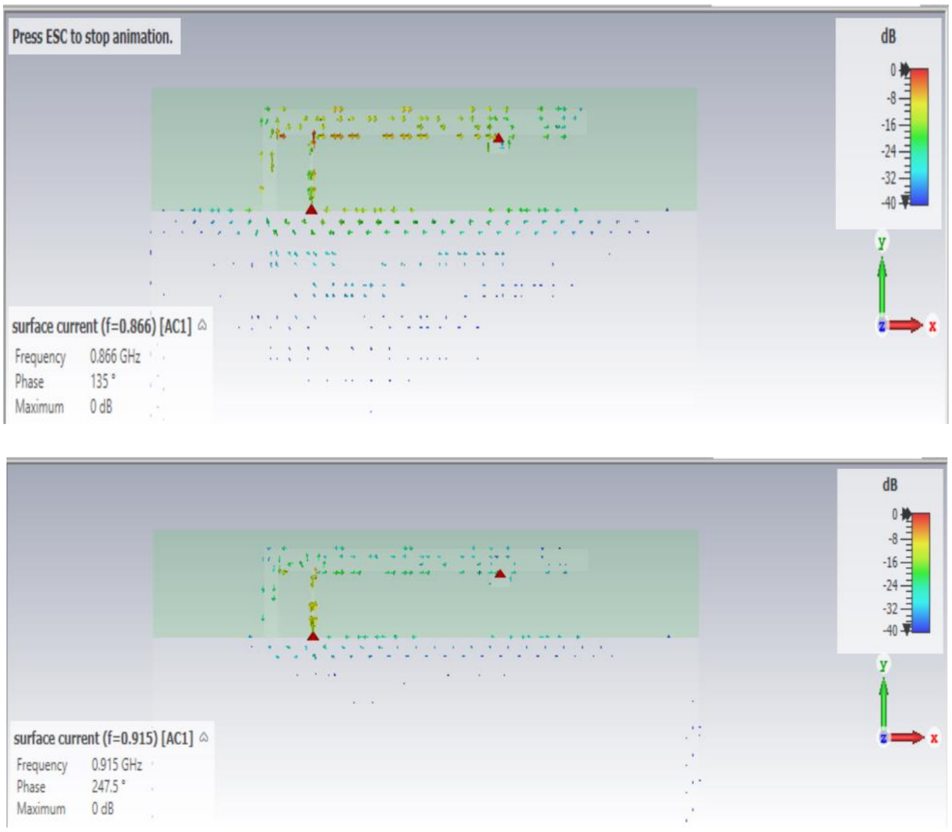
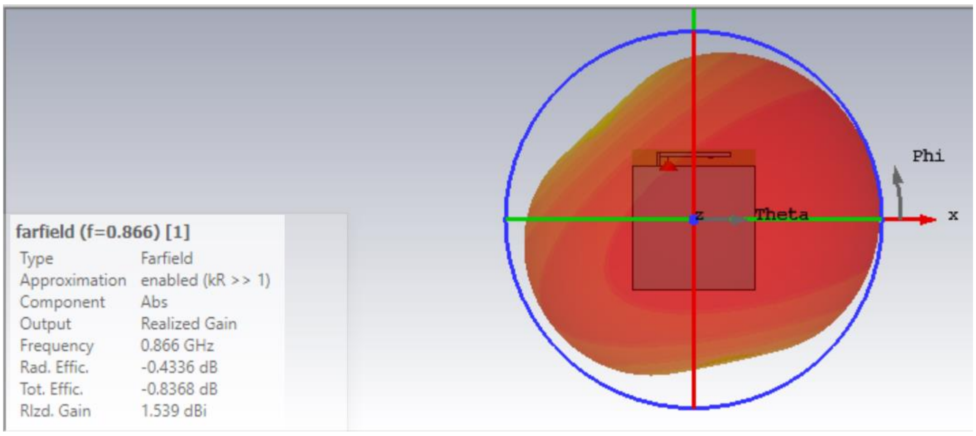


Figure 7 . Surface current distribution at 866 MHz& 915 MHz



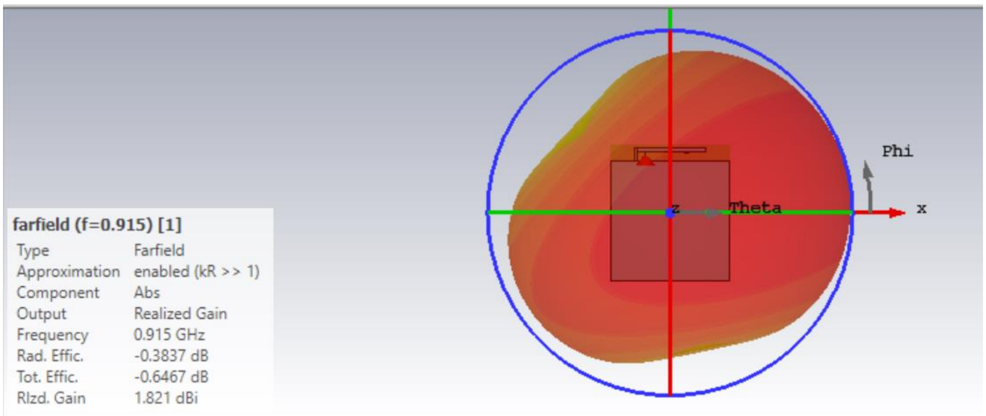


Figure 8. 3D Radiation Patterns

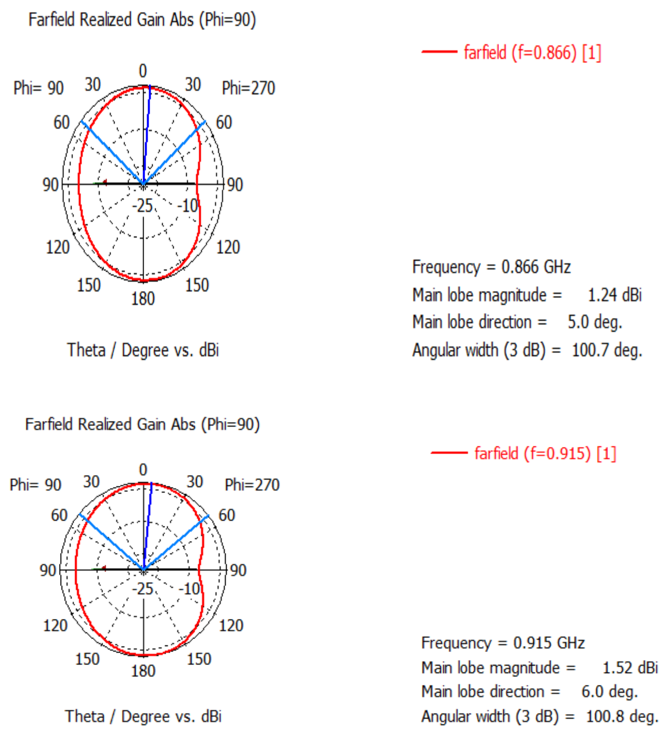


Figure 9 : 2 D Radiation Patterns

The three dimensional Radiation patterns shown in Figure 8 ., states that the antenna radiates a quasi omni directional pattern and having an efficiency of above 82 % for both the Sub GHz bands . The Figure 9 shows the corresponding two dimensional antenna radiation patterns at 866 MHz and 915 MHz respectively .

6. Conclusion

In this paper, inverted F-antenna with trap is used to design dual band (860-870 MHz & 902-928 MHz) F-antenna, with partial omni directional pattern. The antenna is printed on FR4 board for low cost. Normally the low band section of a trap antenna is placed at the end of the antenna. But it does not work when the two bands separation is small due to LC value tolerance. The problem is solved by placing the low band section away from the end of the antenna. This design meets the bandwidth, efficiency and radiation pattern requirements. It offers the design benefits like low cost , small form factor which could potential aid the commercial designs.

References

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Authors

Prasad Samudrala has master's degree in Information and communications engineering from Anna University, Chennai. He has over 19 years of experience in Industrial and building automation, IoT, Wireless and Embedded product development. He has over 25 patents and 3 trade secrets to his name. Currently he is in a Principal System Architect position in Honeywell building automation division. His area of interest include Low power wireless technologies, 5G.

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