2.4GHZ倒F及弯曲线PCB蓝牙天线

设计指导

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1 Introduction

This document outlines two types of Printed Circuit Board (PCB) antennas used by CSR, which can be used with 2.4GHz radios.

- Inverted-F
- Meander Line

In addition, this document discusses the effect of placing metallic or dielectric materials near an antenna.

2 Inverted-F Antenna

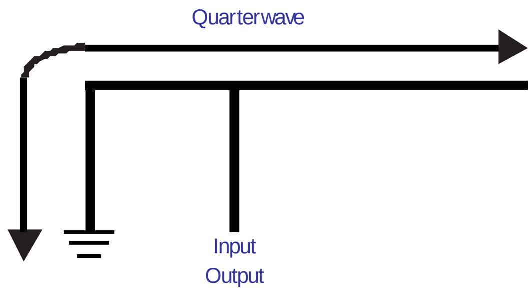

Figure 2.1: Inverted-F Antenna

The inverted-F is a quarterwave antenna. It is bent into an L-shape. The shorter side is connected to earth. The longer side is left open-circuit at the end. The feed point is located somewhere between the earth end and the open end. The resulting structure resembles the letter *F* and possesses the properties of both a loop antenna due to the circulating current from the feed point to ground and a whip antenna due to the open circuited straight section.

In the PCB version, the antenna is printed on the top layer and a ground plane is placed near the antenna on the top layer. There must not be a ground plane underneath the antenna.

The aim is to make the quarterwave section resonate at the midband frequency (which is 2441MHz for 2.4GHz ISM radios). The feed point (which is the input/output connection) is connected to the L-Shape at the point corresponding to 50Ω. Experiment with measurement to determine the correct location for the feed point and length of this antenna.

3 Meander Line Antenna

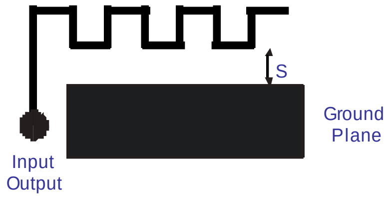

Figure 3.1: Meander Line Antenna

The length of the meander line antenna is difficult to predict. It is usually a bit longer than a quarterwave but dependent on its exact geometry and proximity to the ground plane.

Note:

In Figure 3.1 the ground plane is shown in black. S is the distance from the ground plane. See Figure 4.2 for approximate dimensions.

This type of antenna is always a PCB version. The antenna is printed on the top layer and a ground plane is placed near the antenna on the top layer. There must be no ground plane underneath the radiating section of the antenna.

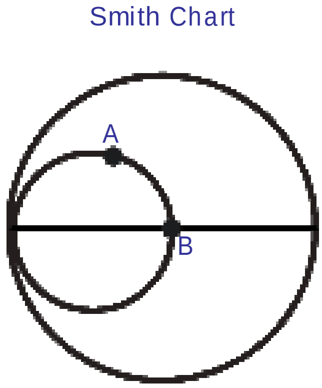

Figure 3.2: Input Impedance of Two Meander Line Antennas

The real part of the impedance of this antenna is about 15Ω to 25Ω, depending on geometry and proximity to the ground plane. The impedance matching is done by adjusting the length of the antenna until the input impedance is at the unity conductance circle (when normalised to 50Ω), in the top half of the Smith chart (Point A). A shunt capacitor is then connected between the antenna input and ground to match to 50Ω (Point B). Experimental measurement is used to determine the correct design.

4 Real Designs

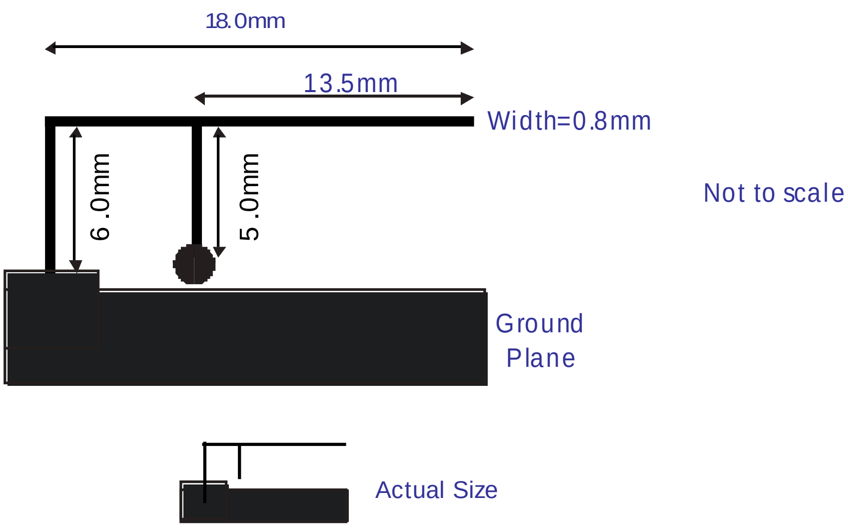

Figure 4.1: Approximate Dimensions of Inverted-F Antenna

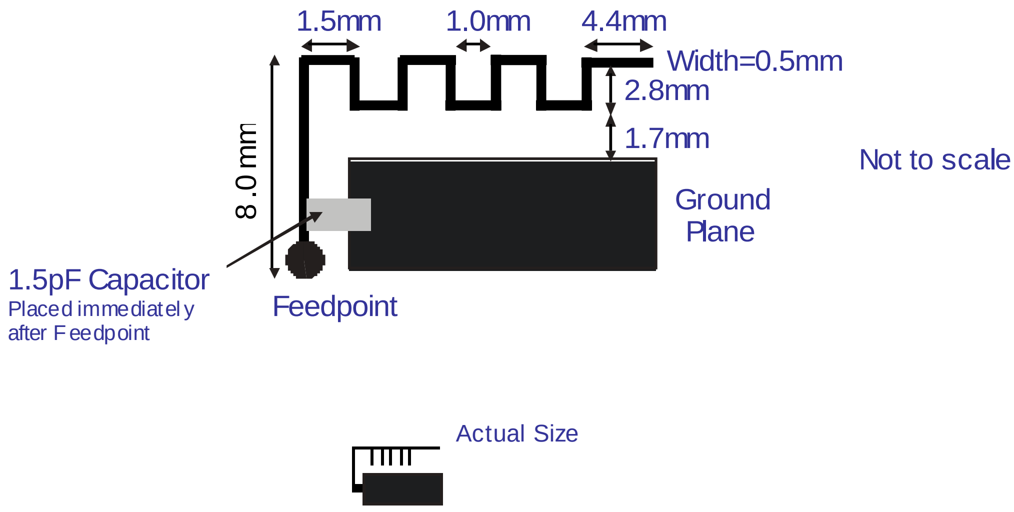

Figure 4.2: Approximate Dimensions of Meander Line Antenna

5 Proximity to Metal Objects

CSR recommends keeping metal objects as far away from the antenna as possible. Keeping metallic objects out of the near field is usually adequate.

Near Field = $2D^2/\lambda$

D is the largest dimension of the antenna. In the case of these antennas, this is approximately a quarterwave ($\lambda/4$).

Notes:

λ is the wavelength of the signal in freespace.

In the 2.4GHz ISM band, λ=122mm in freespace.

Substituting D=$\lambda/4$ into the Near Field equation gives Near Field = $\lambda/8$.

Near Field = 122/8 mm = 15.25mm.

6 Proximity to Dielectric Materials

Dielectric materials (like plastic or FR-4) detune an antenna by lowering its resonant frequency. The effect is not as serious as placing an antenna next to metal objects and can be corrected by reducing the length of the antenna. Therefore, it is important to tune the antenna when it is in the product. This is done during the development of the product.

7 Network Analyser

Use a vector network analyser (VNA) to perform the initial tuning of the antenna:

1. Cut the PCB track (trace) just before the antenna matching network to isolate the filter and previous stages from the measurement.
2. Connect a coaxial cable between the VNA and the PCB of the product. The coaxial cable must have ferrite beads fitted over its outer sleeve. The ferrite beads help to prevent RF currents from flowing on the outer sleeve, which would disturb the measurement. Solder the outer sleeve of the coaxial cable to the ground plane of the PCB as close as possible to the input of the antenna-matching network.
3. Perform a One-Port calibration on the VNA with Open, Short, Loads connected at the end of the coaxial cable inside the product.
4. Solder the inner conductor of the coaxial cable to the input of the antenna-matching network.
5. Tune the antenna by adjusting the values of any "matching network" components, the feed point of the antenna or the length of the antenna until the S11 trace (displayed on the VNA) is at the centre of the Smith chart at the midband frequency 2441MHz.
6. Repair the cut track by putting a small amount of solder over the cut.

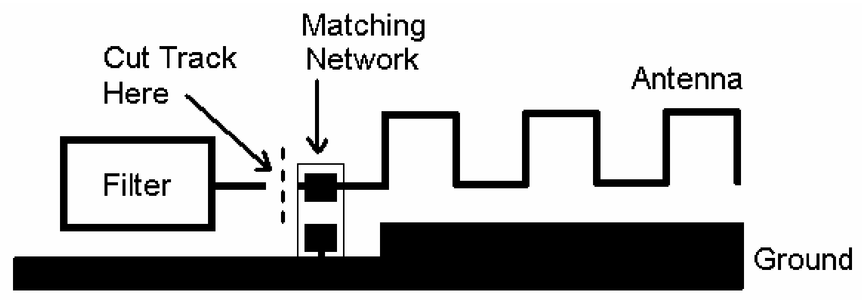

Figure 7.1: Preparation Before Measurement

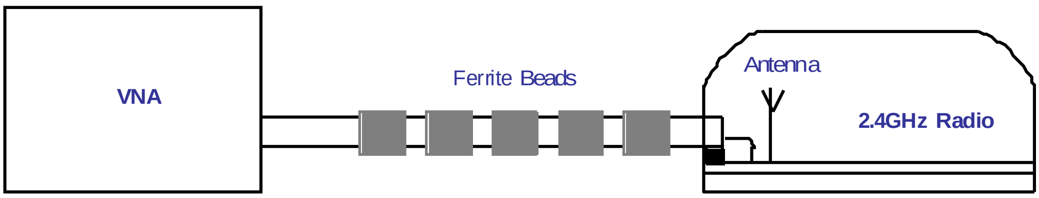

Figure 7.2: Assembled System Ready to Measure

8 Final Tuning

After tuning the antenna using the VNA procedure, it is necessary to perform fine-tuning. This yields a small improvement and is the final optimisation of the antenna. It is best to perform this procedure in an anechoic chamber, but when this is not possible, an indoor or outdoor test range can be used. It is important to minimise radio signal reflections. Avoid metallic objects such as lab-benches, filing cabinets, lampposts and cars.

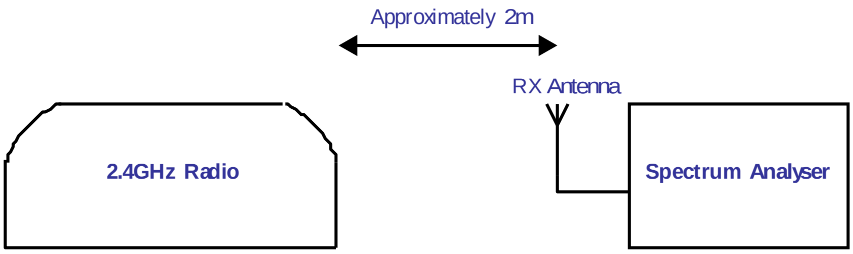

Figure 8.1: Locating Product in Far Field of Antenna

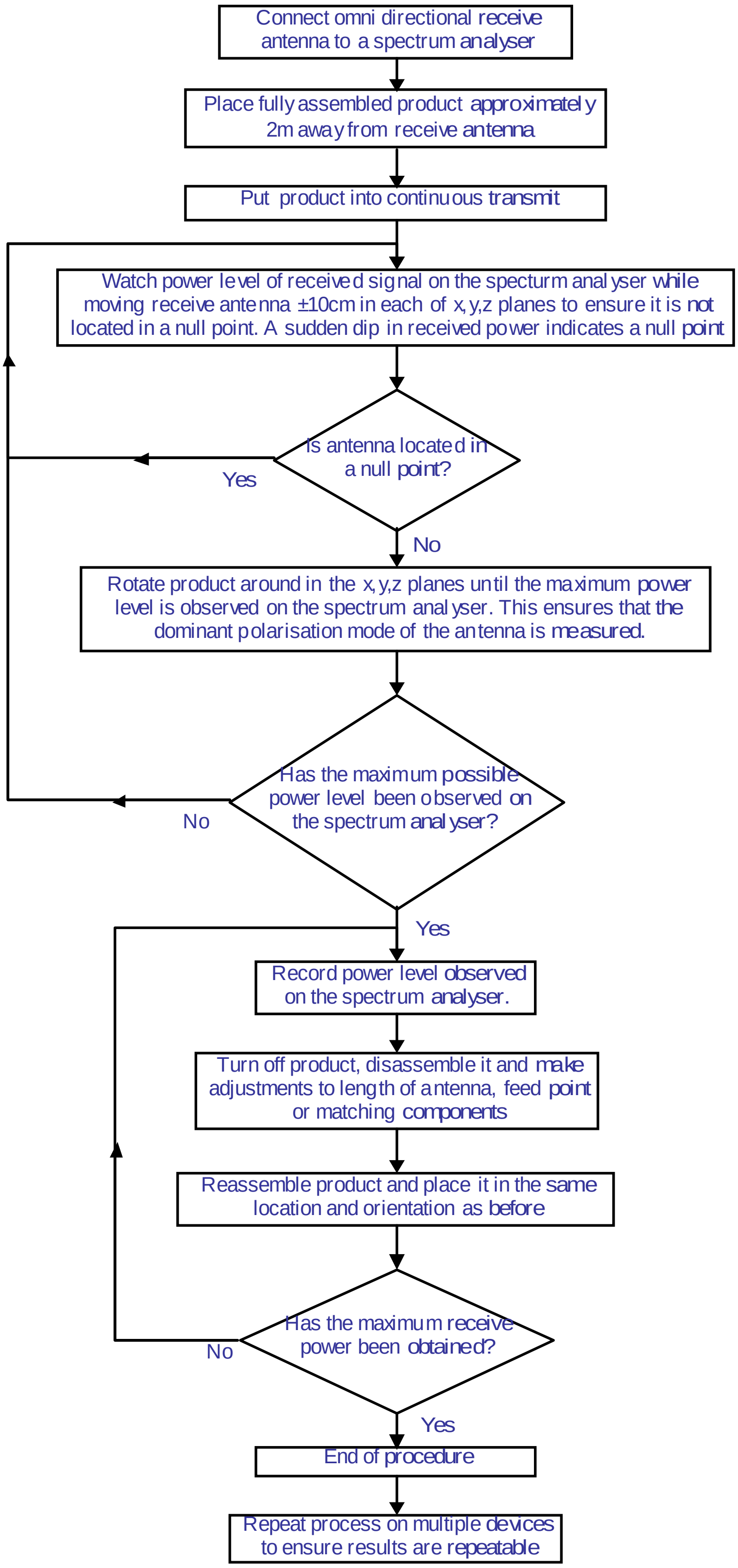

Figure 8.2: Final Tuning Procedure

9 Conclusion

Metal objects should be kept at least 15.25mm away from the Inverted-F and Meander Line types of antennas in the 2.4GHz ISM band for the antenna to work efficiently. If that is not possible, experiment to determine an acceptable trade-off between antenna performance and product size.

Even by following these rules, antenna detuning can occur. This usually results in lowering the resonant frequency of the antenna. Correct this by reducing the length of the antenna

Terms and Definitions

ISM	Industrial, Scientific and Medical
PCB	Printed Circuit Board
RF	Radio Frequency
VNA	Vector Network Analyser