# Microstrip Hairpin Bandpass Filter Using Via Ground Holes for 923 MHz RFID Application

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## Abstract

This paper proposed a microstrip hairpin filter with via ground holes for 923 MHz RFID application. By adding the via ground holes, the dimension of the filter is reduced to 37% compared to the filter without ground holes. The final result shows that dimension of the filter is 76 x 40 mm. Both simulation and measurement result shows that the filter works at 923 MHz with bandwidth of 4 MHz from simulation result whereas from measurement result 7.5 MHz.

**Keyword :** microstrip filter, hairpin resonator, RFID, bandpass filter

## 1. Introduction

Radio frequency identification is a solution in the detection of an object; the application of RFID in trading system is very helpful for the process of distributing goods from one place to another. There are several working frequencies commonly used by the RFID, some of them are 13 KHz, 433 MHz and 923 MHz [1]. When we use frequency at 433 MHz and 923 MHz, we must consider the interference from other frequencies. One solution to the interference problem is using a filter for the RFID reader. The filter used is customized with the chosen standard RFID in Indonesia that is at frequency 923-925 MHz.

There are various kinds of materials and manufacturing technology for making filters. They are: lumped-element LC filters, planar filters, coaxial and dielectric filters [2]. Each filter has their advantages and disadvantages. LC filter is the simplest and has the smallest filter size, but the quality factor is very low, so the performance will be poor. Planar filter is a filter that is quite simple and easy to fabricate, it's bigger than the LC filter and will be bigger if the working frequency decreases but the quality factor is better than LC filter. Coaxial and dielectric filters have higher quality factor, but both are quite difficult to design and fabricate compared with LC and planar filters. The dimension for both filter are bigger than LC and planar filters, especially if the working frequency decreases.

Most of the researches on microstrip hairpin filter are made for frequencies above 1 GHz. Hairpin microstrip filters have been studied and were designed for various applications [3-7]. For example, Nicholas G. Toledo designed a filter for 2.54 to 2.58 GHz using FR-4 substrate [3], Carlota D. Salamat et.al. used PTFE substrate [4], Luigi Greco et.al. designed a microstrip filter at 2.6 GHz [5], Dana Brady at 3.7 to 4.2 GHz [6], while A. Hasan and A. Nadeem [7] used microstrip hairpinline with via ground holes to reduce the size of the narrowband filter .

In consideration of the small size and ease of design and fabrication, this paper will propose a microstrip hairpin resonator line filter with ground via holes for the 923 MHz RFID application.

## 2. Microstrip Hairpin Filter Design

The filter will be designed on a Taconic TLY substrate, the dielectric constant of the substrate is 2.2, the thickness of the substrate is 1.52 mm and the dissipation factor is 0.0009, which is very low and good to get a narrow bandwidth. Substrate dissipation factor plays an important role in achieving narrow bandwidth and high quality factor (Q) while maintaining small size and low cost [8]. Filters which are designed with this dielectric material and at frequency 923 MHz require quite a long resonator line; therefore the dimension of the filter becomes quite large. To minimize the dimensions of the filter, the filter will be designed with the hairpin resonator line model with via ground holes.

Hairpin resonator filters are made with lines that are no longer elongated but deflected like the U letter, so the filter dimensions become smaller. The components in designing hairpin filters are the dimensions of the resonator, coupling coefficient, slide factor, and the position of the feed line. The dimension of the resonator line consists of resonator length and width of the line. The dimensions are influenced by the value of dielectric constant and substrate height.

The coupling coefficient indicates the amount of power transferred between resonators. The value of this coupling will directly influence the bandwidth of the filter. The greater the value of the coupling is, the greater the power that is transferred, therefore the bandwidth becomes wider [9].

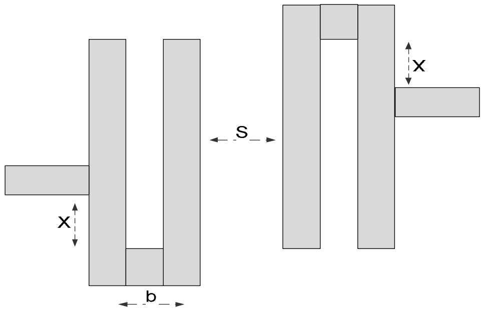


Figure 1: Configuration of resonators

In Fig. 1, the distance between two resonators is denoted by s, the slide factor is denoted by b while feedlines position is denoted by x. The distances between resonators (s) influence the coupling coefficient of the filter. The wider s is, the smaller the coupling will be influenced. The slide factor is the line that is not coupled in the hairpin filter. If the width of the slide factor is too long, it will cause the increase of the filter attenuation, but if the slides are too short, it will lead to the coupling between resonators at the same line [8]. So the optimum width of the slide factor is 1 to 3 times of the resonator width, or 2 to 2.5 times the distance between the resonators itself. The position of feedlines (x) influences the external quality factor of the filter.

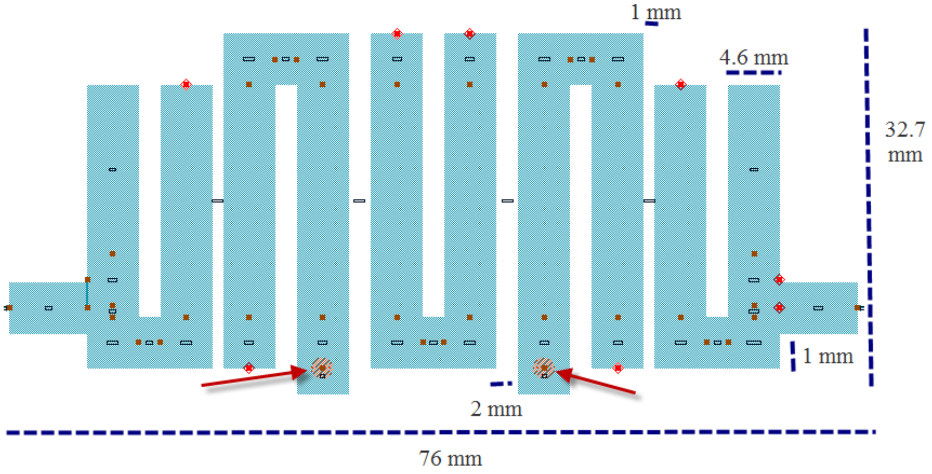


Figure 2: Via Ground Holes

To create a filter with narrow bandwidth, we have to widen the distance between the resonators, however this can cause higher insertion loss, therefore to prevent that, we use ground via holes in the second and fourth resonator as shown in the Fig. 2. The via ground holes is pointed by red arrows.

## 3. Simulation and Measurement

The filter design proposed in this paper shows simulation results as depicted in Fig. 3. From the simulation result, the insertion loss from S21 is -6.65 dB. The insertion loss is still high, this can occur because the signal from the input has been dissipated before reaching the output of the filter. It is dissipated by the substrate and the copper. The bandwidth of the filter is 4 MHz from 920 MHz to 924 MHz.

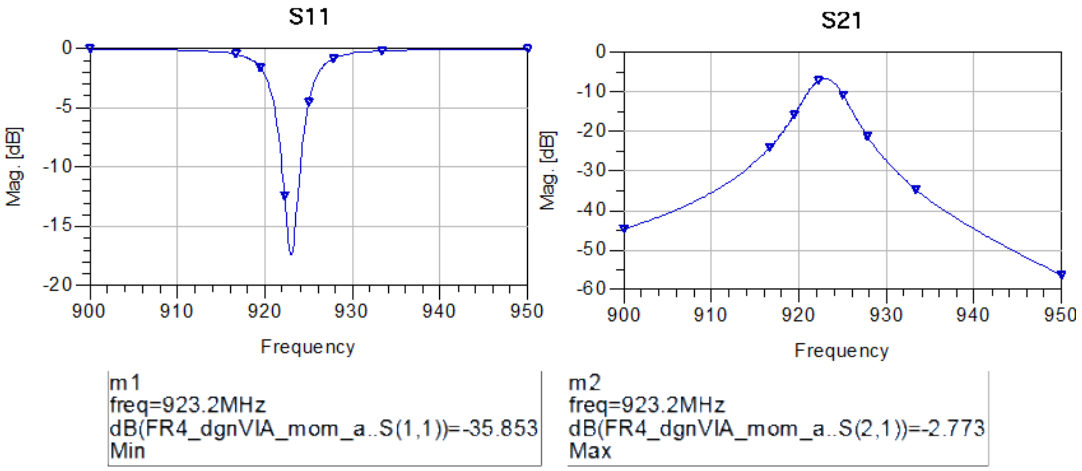


Figure 3 : Simulation Result

The fabricated filter is shown in Fig. 4 and the measurement results are shown in Fig. 5. From Fig. 4, we can see that the dimension of filter is quite small. The dimension of the filter with ground holes is 76 X 40 mm, while without via ground holes are 80.5 X 60. This means, this proposed filter design has reduced the conventional filter to 37%.

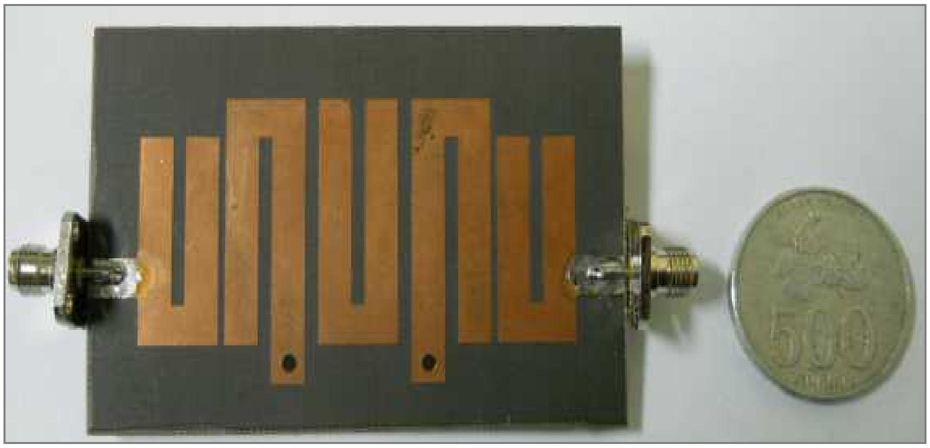
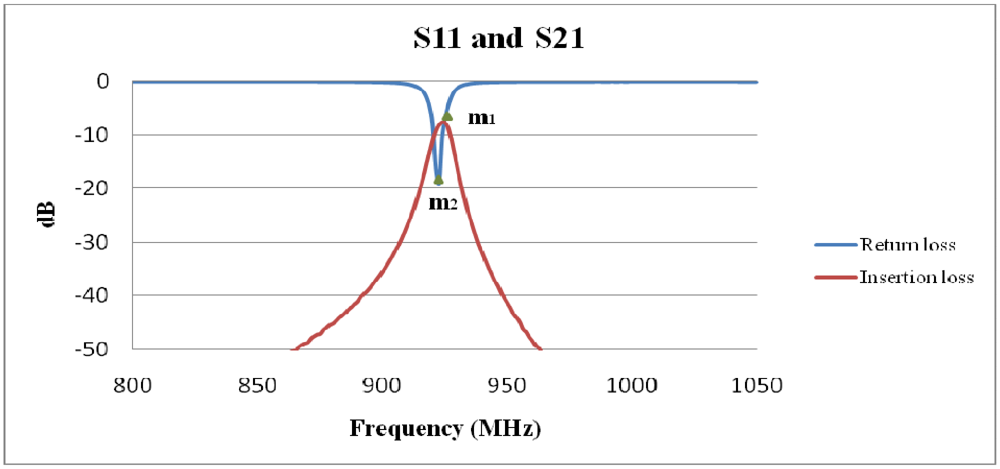


Figure 4: Snapshot of Fabricated Filter



m1 =923.75 MHz; -7.7 dB m2 = 922.5 MHz; -18.9 dB

Figure 5: Measurement Result

From the measurement result, the insertion loss from S21 is -7.7 dB. The bandwidth of the filter is 7.5 MHz from 920.3 MHz to 927.8 MHz. Both simulation and measurement results show the the proposed filter design can be used for the 923 MHz RFID application. The slight difference between simulation and measurement result is due to imperfect fabrication of the filter.

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