Design and Development of SIR based Microstrip filter for GPS Applications

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***Abstract*—A Microstrip filter for GPS L1 band (1.575 GHz) application is designed and simulated in Agilent® ADS software. The design is based on Stepped Impedance Resonator (SIR) approach. The designed filter is fabricated in FR4 substrate and an insertion loss of 7 dB and return loss of 30 dB is observed, at the required frequency .**

***Keywords*—Stepped impedance resonator (SIR), micro strip filter, GPS, L1 Band, ADS.**

I. INTRODUCTION

In modern wireless and mobile communication systems, RF/microwave filters play an important role. Recently, GPS has become an essential component in many mobile communication applications [1]. This paper describes a stepped impedance resonator (SIR) approach based on non-uniform transmission line resonator, to implement a micro strip band pass filter [2]. The SIR scheme enables to achieve good harmonic suppression by making the central frequency of second band far apart from the fundamental [2]. In this study, a Microstrip Bandpass filter for GPS L1 band [3] (1.575 GHz) is designed and simulated using ADS software. The layout generated is used to develop the filter in FR4 substrate and its characteristics such as S_{11}, S_{21}, group delay and impedance are determined.

II. STEPPED IMPEDANCE RESONATOR

The Stepped impedance resonator (SIR) is symmetrical and has two different characteristic impedance lines, Z_1 and Z_2, of admittance Y_1 and Y_2. The basic structure of the $\lambda_g/2$ SIR is shown in fig 1, where λ_g is the wavelength.

Whereas, θ_1 and θ_2, are their corresponding electrical lengths. For the ease of the analysis, a new parameter R_Z is introduced, which is defined as the ratio of the line impedances Z_1 and Z_2, ($R_z = Z_2/Z_1$).

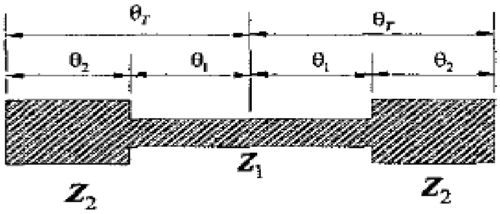

Fig. 1. Basic structure of half wavelength type SIR [2]

The resonance condition can be analyzed by using the input admittance. The input admittance of the half wavelength SIR is given as [2]

$$Y_i = jY_2 \frac{2(R_z \tan\theta_1 + \tan\theta_2)(R_z - \tan\theta_1 \tan\theta_2)}{R_z(1-(\tan\theta_1)^2)(1-(\tan\theta_2)^2) - 2(1-R_z^2)\tan\theta_1 \tan\theta_2} \quad (1)$$

The resonance condition is achieved at $Y_i = 0$, and this is realized by the following equation

$$(R_z \tan\theta_1 + \tan\theta_2)(R_z - \tan\theta_1 \tan\theta_2) = 0 \quad (2)$$

If we assume $\theta_1 = \theta_2 = \theta_0$, equation (2) can be rewritten as

$$(R_z \tan\theta_0 + \tan\theta_0)(R_z - (\tan\theta_0)^2) = 0 \quad (3)$$

From (3), we obtain the following solution,

$$\theta_0 = \tan^{-1}\sqrt{R_z} \quad (4)$$

The relationship between fundamental and spurious frequencies is given by [1]

$$\frac{f_{SB1}}{f_0} = \frac{\theta_{s1}}{\theta_0} = \frac{\pi}{2\tan^{-1}\sqrt{R_z}}$$

$$\frac{f_{SB2}}{f_0} = \frac{\theta_{s2}}{\theta_0} = 2\left(\frac{f_{SB1}}{f_0}\right) - 1$$

$$\frac{f_{SB3}}{f_0} = \frac{\theta_{s3}}{\theta_0} = 2\left(\frac{f_{SB1}}{f_0}\right) \qquad (5)$$

Thus the spurious frequencies can be controlled by impedance ratio R_z.

III. FILTER SCHEMATIC AND DESIGN

A filter with a second order Chebychev response is considered for the design. By taking $\frac{f_{SB1}}{f_0} = 2.5$ [2], hence, the value of R_Z is obtained as 0.5. From the value of R_Z, and considering $Z_2 = 50\ \Omega$, then Z_1 is obtained as 100 Ω.

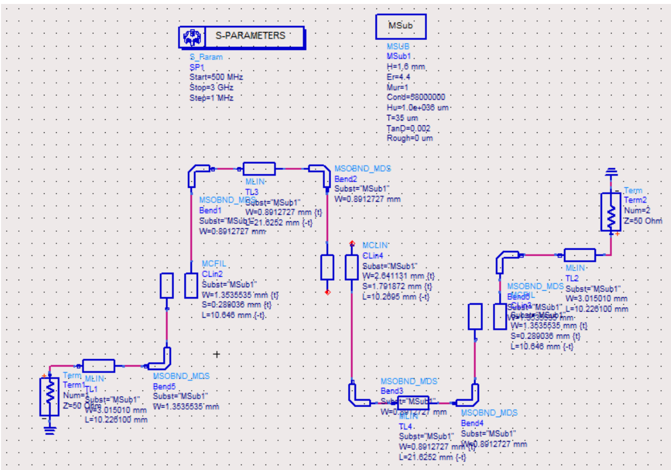

Fig. 2. Schematic of the filter

The filter is implemented in FR4 substrate with dielectric thickness 1.6 mm, dielectric constant 4.4 and conductor thickness of 0.035 mm. The filter is simulated in ADS tool. Fig 2 shows the schematic of the filter in ADS.

The layout corresponding to the filter schematic is obtained in ADS, and shown in Fig.3. In the layout, the dark areas denote the conducting strip and background denotes the substrate.

IV. RESULTS AND DISCUSSION

The layout is simulated in ADS- Momentum and the S parameter characteristics are obtained as shown figure 4. The insertion loss in the pass band is found to be 1.013 dB. The return loss (S_{11}) in the pass band is obtained as 21.137 dB.

From the S_{21} characteristics, The 3 dB bandwidth of the filter is calculated around 60 MHz. The response is shown in the fig. 5. The 20dB bandwidth of the filter is found to be 230 MHz (Fig. 6).

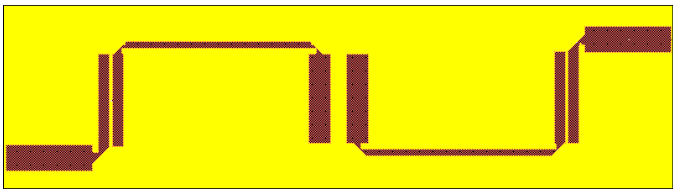

Fig.3. Layout of the filter

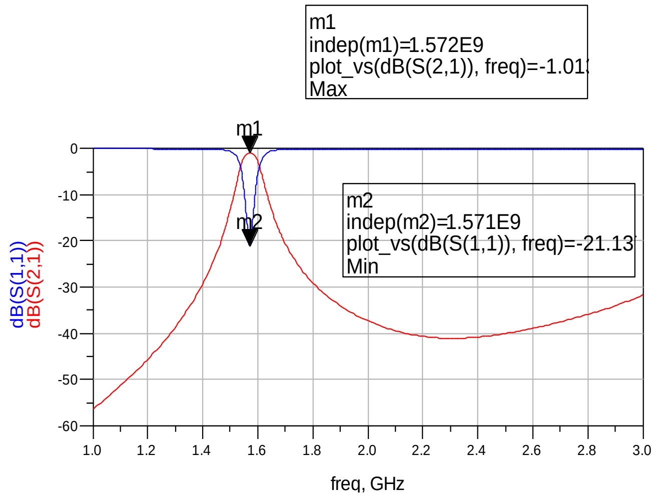

Fig.4. S-parameter characteristics

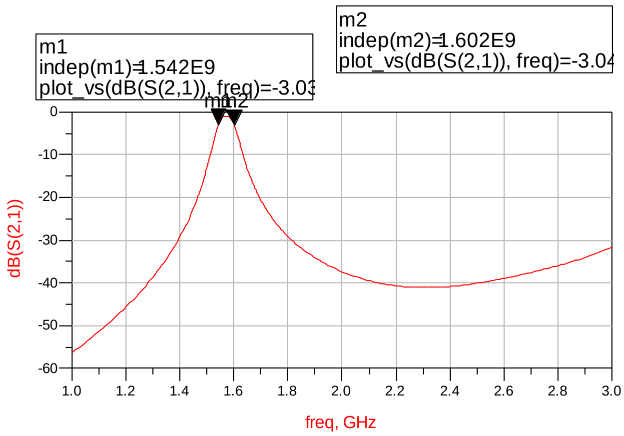

Fig.5. 3 dB bandwidth

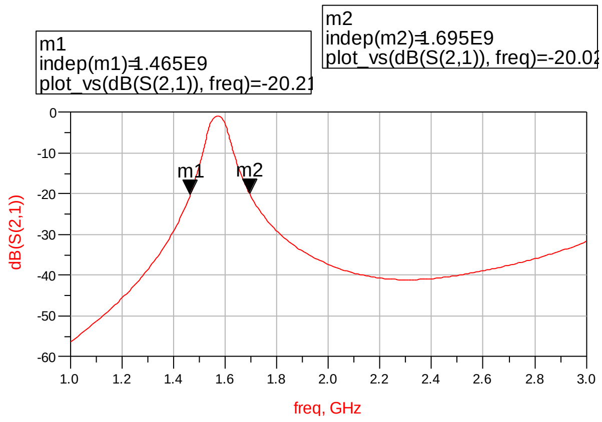

Fig. 6. 20 dB bandwidth

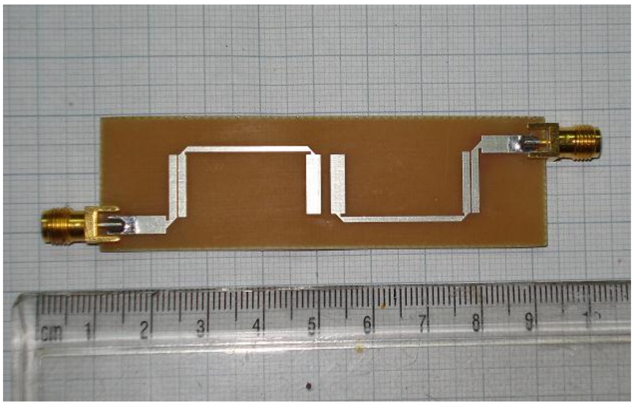

Fig.7. Photograph of the fabricated filter

The photograph of the fabricated filter is shown in fig.7.An Agilent E5071C Network analyzer (8 GHz) is used to measure the filter characteristics. The measured S_{21} and S_{11} response of the filter are shown in fig.8 and fig.9 respectively. The insertion loss is found to be 7dB.The return loss is found to be 30 dB. A higher value of insertion loss is seen in the measurement owing to the non uniformities of the substrate material. Fig.10 shows the group delay of the filter which is almost constant around 5.6 ns, in the pass band.

The impedance and SWR of the filter is shown in fig.11 and fig.12 respectively. They indicate an SWR value of 1.2 and impedance value of 48.5 Ohms. These values are close to the ideal values and will lead to better filter performance.

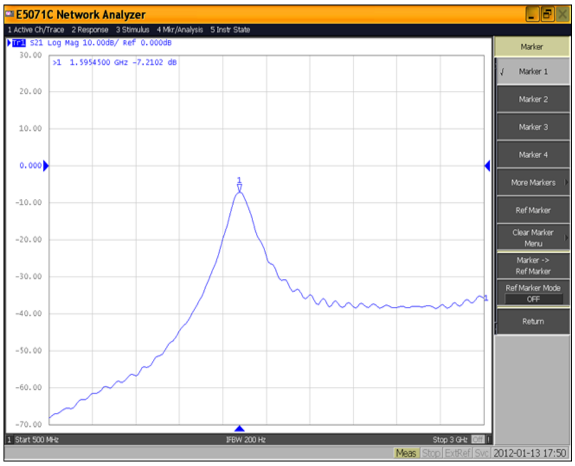

Fig.8. Measured S_{21} response

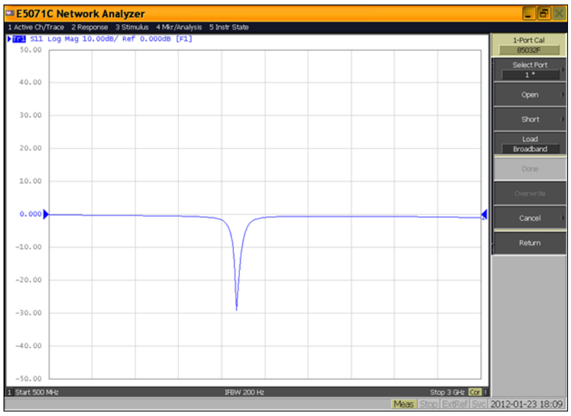

Fig.9. Measured S_{11} response

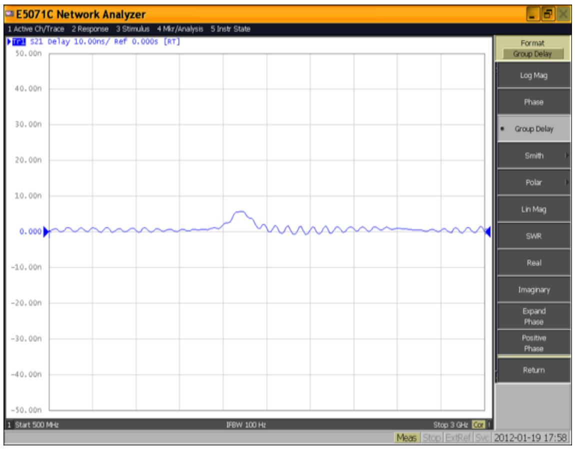

Fig.10. Measured Group Delay of the filter.

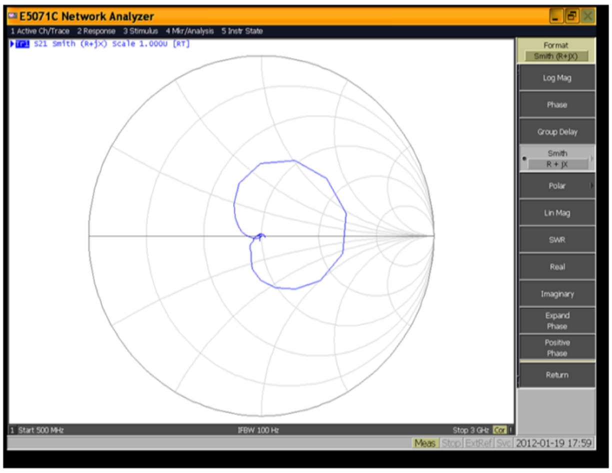

Fig.11. Measured Impedance of the filter

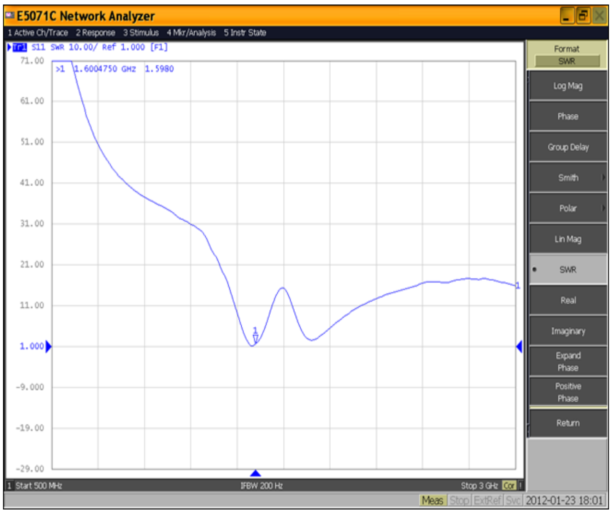

Fig.12. Measured SWR of the filter.

V. CONCLUSION

A method of designing a BPF suitable for GPS L1 band with SIR is established, and a microstrip bandpass filter using stepped-impedance resonator has been proposed, designed and fabricated .Measurement shows an insertion loss of 30 dB, impedance of 48 Ohms and SWR of 1.2 at the desired frequency .

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