**UWB Miniaturized Band Pass Filter with Five Pole Stub for Wireless Communication**

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**Abstract:**

In this paper an UWB band pass filter with five pole open circuited stub is designed for use in wireless communication. The proposed filter uses only a single layer miniaturize structure and can be easily mass-produced with low cost. The fabricated UWB BPF has a 3 dB pass band which covers the range of 5.5–10.5 GHz and it has a fractional bandwidth of 63%. The measured insertion loss is found to be less than 1dB at the center frequency of the wideband pass band. The computations are done by MATLAB and the performances are observed by the way of simulation with the help of HFSS. The structure is miniaturized based on the LTCC fabrication technology.

**Keywords:** temperature expansion; microstrip line; band pass filter

**I. INTRODUCTION**

The U.S. federal communication committee (FCC) authorized the unlicensed use of the ultra-wideband (UWB) (3.1–10.6 GHz) frequency range for indoor and hand-held wireless communications in early 2002. Since then academic and industrial research into ultra wideband (UWB) technology has risen dramatically [1]. Recently, different methods and structures based on multiple-mode resonators (MMRs) have been used to develop new UWB band-pass filters which have compact size, low insertion loss, good selectivity and out-of-band rejection performance [2]–[7]. To achieve good filtering performance, stepped-impedance stub loaded resonator was used. In this paper a microstrip pass band filter of stub loaded is designed using five pole (n=5) Chebyshev low pass prototype with a 0.1 dB pass band ripple and a fractional bandwidth FBW=0.63 at a mid-band frequency \(f_0=7.5\)GHz.

![Figure: 1. Transmission line band pass filter with half-wavelength open circuited stub.](image)

The transmission line band pass filter with half- wavelength open circuited stub is shown in Figure 1. The pass band response of the simulated structure of this filter is almost same as measured values. The structure is miniaturized based on the LTCC fabrication technology.

**II. FILTER DESIGN AND CONFIGURATION**

Band pass filters can be designed to have a form in Figure 1, which is comprised \(\lambda_{gp}/2\) open-circuited stubs, where \(l_a\) and \(l_b\) are both \(\lambda_{gp}/4\) and \(\lambda_{gp}\) is the guided wavelength in the medium. For a given filter degree \(n\), the stub band pass filter characteristic will then depend on the characteristic admittances of the stub lines denoted by \(Y_i (i=1 \text{ to } n)\) and the characteristic admittances of the connecting lines denoted by \(Y_{i,i+1}(i=1 \text{ to } n-1)\). If \(Yib = Yi\alpha\) for each \(\lambda_{gp}/2\) stub, then the stop band will have attenuation poles at the frequencies \(f_b/2\) and \(3f_b/2\). If \(Yib = a\alpha Yi\) with a \(\alpha\) constant, then the attenuation poles can be made to occur at frequencies other than \(f_b/2\) and \(3f_b/2\). This type of filter will have additional pass bands in the vicinity of \(f_a = 0\) and \(f = 2f_0\), and at other corresponding periodic frequencies. These types of filter can be rapidly designed by a modified design equations [8] in Eqn. (1).

\[
\theta = \frac{\pi}{2} \left( 1 - \frac{FBW}{2} \right)
\]

\[
h = \frac{2}{\lambda_{gp}}
\]

\[
\frac{J_{i+1}}{Y_0} = g_0 \sqrt{\frac{h g_1}{g_2}}
\]

\[
\frac{J_{i,i+1}}{Y_0} = \frac{h g_0 g_{i+1}}{g_i g_{i+1}}, \quad \text{for } i=2 \text{ to } n-2
\]

\[
N_{i,i+1} = \sqrt{\left( \frac{J_{i+1}}{Y_0} \right)^2 + \left( \frac{h g_0 g_i \tan \theta}{2} \right)^2} \quad \text{for } i=1 \text{ to } n-1
\]

\[
Y_i = g_0 Y_0 \left( 1 - \frac{h}{2} \right) g_i \tan \theta + Y_0 \left( N_{i,1} - \frac{J_{i+1}}{Y_0} \right)
\]

\[
Y_a = Y_0 \left( g_a g_{i+1} - g_0 g_1 \frac{h}{2} \right) \tan \theta + Y_0 \left( N_{i,1} - \frac{J_{i+1}}{Y_0} \right)
\]

\[
Y_i = Y_0 \left( N_{i,1} + N_{i,i+1} \frac{J_{i+1}}{Y_0} + \frac{J_{i,i+1}}{Y_0} \right) \quad \text{for } i=2 \text{ to } n-1 \quad \ldots \quad (1)
\]
The design is carried out first to give a filter with desired pass band characteristics and bandwidth. Then $Y_i$ is replaced shunt, half wavelength as shown in Figure. 1, open circuited stub having an inner quarter- wavelength portion with a characteristic admittance.

$$Y_i = \frac{\gamma_1 \tan^2 \theta - 1}{(\gamma_1 + 1) \tan^2 \theta} \quad \ldots(2)$$

And outer quarter wavelength portion with the characteristic admittance

$$Y_o = \alpha Y_i \quad \ldots(3)$$

Where $\theta$ has been defined in equation (1), and the parameter $\alpha_i$ is given by

$$\alpha_i = \cot \left( \frac{\pi f_i}{2 f_0} \right) \quad \text{for } f_i < f_0 \quad \ldots(4)$$

Where $f_i$ is the low band-edge frequency of the pass band, and $f_o$ is a frequency at which the shunt open-circuited stub presents a short circuit to the main line and causes a transmission zero or attenuation pole. Although using the same $f_i$ for all the stubs should give the best pass band response, it may be permissible to stagger the $f_i$ points of the stubs slightly to achieve broader regions of high rejection. The modified design equations of (2) to (4) are constrained to yield half-wavelength, open-circuited stubs that have exactly the same susceptances at the band-edge frequency $f_i$ as did the quarter-wavelength short-circuited stubs that they replace; both kinds of stubs have zero admittance at the mid-band frequency $f_0$.

The layout of the proposed UWB band pass filter is shown in Figure: 2. it consists of five pole half- wavelength open circuited stub.

Figure: 2. Layout of the designed microstrip band pass filter with half wavelength open circuited stubs in an soft HFSS tool. Assuming 50$\Omega$ terminal line impedance the initial design parameters obtained using equation (1), choosing $f_o=4$GHz for all the stubs, then gives $\alpha_i=1$ from equation (4). Using eqn. (3) & (4) yields the characteristics admittance of open-circuited stubs. The fabricated UWB BPF is shown in Figure 4.

Figure: 3. Photograph of the realized UWB BPF

The micro strip band pass filter designed with a relative dielectric constant of 4.4 and a thickness of 1.59mm. Where the effect of microstrip open end on each stub has been taken into account so that each stub is slightly shorter then $\lambda_o/2$. The EM simulated and measured frequency responses of the filter are plotted in Figure: 4. Filters of this type should be particularly useful where there is a relative narrow band of signals near the desire pass band to be rejected.

Figure: 4. Full wave EM simulation and measurement results of the filter.

III. CONCLUSION

The computations are done by MATLAB and the performances are observed by the way of simulation with the help of HFSS. The structure is miniaturized based on the LTCC fabrication technology. The fabricated UWB BPF has a 3 dB pass band which covers the range of 5.5–10.5 GHz and it has a fractional bandwidth of 63%. The measured insertion loss is found to be less than 1dB at the center frequency of the wideband pass band. The measured return loss is better than 13.2 dB over the whole pass band.

IV. REFERENCES


