ULTRA WIDEBAND BANDPASS FILTER DESIGN

Prateek Gantayat, Dr. K.J. Vinoy

Department of Electrical Communication Engineering
Indian Institute of Science, Bangalore-Karnataka, 560012-India
E-mail: prateek@caos.iisc.ernet.in, kjvinoy@ece.iisc.ernet.in

Abstract: A technique has been devised, in order to realize an UWB bandpass filter by cascading a lowpass filter and a highpass filter; the bandwidth of the bandpass filter comes to around 3 GHz. The lowpass section is realized using sections of microstrip lines by applying Richard’s Transformation and the Highpass section has been realized using short circuited stubs of microstrip lines.

Index Items: Lowpass filter, Bandpass filter, UBW filters, microstrip filters

I. INTRODUCTION
Ultra Wideband Communications has become very popular now a days because for the need to have low power and high bandwidth short range communication. The transmission in a way does not interfere with conventional narrow band and the carrier wave uses in the same frequency band (like spread spectrum) but unlike spread spectrum it does not use frequency hopping. In case of UWB filters the bandwidth exceeds 500 MHz. For realizing such a bandpass filter a strong coupling is required considering the traditional coupled line approach. The tolerance of the microstrip line however sets an upper limit for the coupling levels. Implementation of high coupling levels is also limited due to the resolution of the fabrication process. Alternatively, a bandpass filter can be realized by cascading a lowpass filter and a highpass filter. In this paper, a bandpass filter has been simulated by cascading a lowpass filter of order 3 and a highpass filter of order 3 and also the measured characteristics of the fabricated filter have been presented.

II. LOWPASS FILTER DESIGN
Richard’s transformation is used to approximate lumped components in terms of sections of transmission lines. The characteristic impedances for the sections have been selected as 130 ohms and 30 ohms respectively from [1] and the cutoff frequency has been selected as 8.5 GHz. The schematics can be shown as follows:

![Lowpass filter schematics](image1)

Figure 1: Lowpass filter schematics

The filter characteristics are as follows:
- Filter impedance = 50 ohms.
- Length of the open circuited stubs = 14.22 mm
- Width of the open circuited stubs = 4.44 mm
- Width of the microstrip line of characteristic impedance 130 ohms = 0.31 mm
- Length of the microstrip line of characteristic impedance 130 ohms = 15.38 mm
- Substrate used = ARLON 250; \( \varepsilon_r = 2.5 \); substrate thickness = 30 mils

The schematics were generated by using ADS (Advanced Design System) 2009 (Main).

III. HIGHPASS FILTER DESIGN
The governing equations for getting the short circuited stub impedances for designing the highpass filter are shown as follows:

\[
\begin{pmatrix}
A & B \\
C & D
\end{pmatrix}_{\text{stub}} = \begin{pmatrix}
\cos \left( \frac{\pi f}{2 f_c} \right) & j Z_{\text{stub}} \sin \left( \frac{\pi f}{2 f_c} \right) \\
-j Y_{\text{inv}} \sin \left( \frac{\pi f}{2 f_c} \right) & \cos \left( \frac{\pi f}{2 f_c} \right)
\end{pmatrix}
\]

\[
\begin{pmatrix}
A & B \\
C & D
\end{pmatrix}_{\text{line}} = \begin{pmatrix}
1 & 0 \\
-j Y_{\text{inv}} Z_{\text{stub}} & 1
\end{pmatrix}
\]

\( Z_{\text{stub}} \) = short circuited stub impedance.
\( Y_{\text{inv}} \) = admittance of inverter.

From [1] and [2] the impedance was chosen to be 46 ohms and the inverter impedance was chosen to be 130 ohms. The schematics can be shown as follows:

![Highpass filter schematics](image2)

Figure 2: Highpass filter schematics

Filter characteristics are as follows:
- Width of the stubs = 0.31 mm
- Cutoff frequency = 5 GHz
- Length of the stubs = 6.35 mm
- Width of the inverter = 2.46 mm
Length of the inverter = 14.53 mm
Substrate and the software were the same as it was for the lowpass filter.

IV. BANDPASS FILTER DESIGN

The bandpass filter was then realized by directly cascading the lowpass and highpass sections and the schematics and layout of the bandpass filter has been shown below:

![Figure 3: Bandpass filter schematics](image)

![Figure 4: Layout of the bandpass filter](image)

V. RESULTS

The simulation results have been presented below:

![Figure 5: Simulated S11](image)

![Figure 6: Simulated S21](image)

As it can be inferred from the above figure the passband is from 5.3 GHz to 8.2 GHz i.e. around 3.1 GHz.

![Figure 7: Picture of the fabricated bandpass filter](image)

![Figure 8: Measured S11](image)
As it can be inferred from the position of the 2 markers from the above figure the passband is from 5.8 GHz to 8.5 GHz.

V. CONCLUSION

The UWB bandpass filter for 5-8 GHz has been fabricated and tested. The bandwidth is around 3 GHz. The main advantage of this kind filter is low insertion loss and high attenuation outside the passband. Also, the simulation results almost show an agreement with the measured results. Instead of using microstrip implementation using Richard’s transformation we can used stepped impedance design and it is expected that the drop in the cutoff region will be less steep. The size of the filter came to be less than 2 X 6 inch^2.

VI. REFERENCES

1. Microstrip Bandpass Filters for UWB wireless Communications Ching-Luh Hsu, Fu-Chieh Hsu and Jen-Tsai Kuo.