Design and Analysis of Different Types of Microstrip Low Pass Filter of The Order of Three and Five to Improve Frequency Response

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Abstract— In communication Signals have to be filtered with a specific bandwidth. In microwave region, the filters are designed on microstrip line. In this paper the designing of different types of microstrip low pass filter like: stepped impedance and by using open circuited stubs is done. These filters are of the order of three and five, to improve the frequency response characteristics of microstrip low pass filter. The development of the Micro strip low pass filters are simulated by using IE3D simulator software and analysis this result into: control manual functions, view faults and operate machine.

Key words: Low Pass Filter (LPF), Stepped Impedance, Microstrip Line, Open Circuited Stubs, Cutoff Frequency and Loss Tangent

I. INTRODUCTION

Microstrip low pass filter is that a filter which passes the microwave frequencies below the cutoff frequency and attenuated the microwave frequencies above the cutoff frequency. There must be a sharp cutoff at the cutoff frequency but practically it is considerable up to < -10 dB.

II. STEPPED-IMPEDANCE, L-C LADDER TYPE LOW PASS FILTERS

A general structure of the stepped-impedance lowpass microstrip filters, which use a cascaded structure of alternating high and low impedance transmission lines is shown in figure 2.1(a). These are much shorter than the associated guided wavelength, so as to act as semi lumped elements. The high-impedance lines act as series inductors and the low-impedance lines act as shunt capacitors. Therefore, this filter structure is directly realizing the L-C ladder type of low pass filters of figure 2.1(b) [1].

Fig. 2.1(a): General structure of the stepped-impedance low pass microstrip filter.

Fig. 2.1(b): L-C ladder type of low pass filter

It would be practical to initially fix the characteristic impedances of high and low-impedance lines by consideration of:

- \( Z_{OC} < Z_0 < Z_{OL} \) where \( Z_{OC} \) and \( Z_{OL} \) denote the characteristic impedances of the low and high impedance lines, respectively, and \( Z_0 \) is the source impedance, which is usually 50 ohms for microstrip filters.

- A lower \( Z_{OC} \) results in a better approximation of a lumped-element capacitor, but the resulting line width \( W_c \) must not allow any transverse resonance to occur at operation frequencies.

- A higher \( Z_{OL} \) leads to a better approximation of a lumped-element inductor, but \( Z_{OL} \) must not be so high that its fabrication becomes inordinately difficult as a narrow line, or its current-carrying capability becomes a limitation.

A. Stepped-Impedance, L-C Ladder Type Lowpass Filter for n=3

- In order to illustrate the design procedure for this type of filter, the design of a three-pole lowpass filter is described in follows –

- The specifications for the filter under consideration are:

- Cutoff frequency \( f_c = 1.5 \) GHz, Passband ripple 0.1 dB (or return loss = –12.0 dB), Source/load impedance \( Z_0 = 50 \) ohms

- A lowpass prototype with Chebyshev response is chosen, whose element values are:

For n=3:

- For capacitor: \( \varepsilon_{rec} = 3.714 \) & \( \lambda_{gc} = 155.67 \) mm, \( W_c = 8.8247 \) mm, \( l_2 = 8.1072 \) mm

- For inductor: \( \varepsilon_{rel} = 3.084 \) & \( \lambda_{gl} = 170.83 \) mm : \( l_1 = l_3 = 17.126 \) mm, \( W_l = 0.8 \) mm

Fig. 2.2(a): Dimensions of Stepped Impedance, L-C Ladder Type LPF (n=3)
**Fig. 2.2(b): Simulated performance of stepped impedance, L-C ladder type LPF**

**B. Stepped-Impedance, L-C Ladder Type Lowpass Filter for n = 5**

g₀=g₆=1 ; g₁=g₃=1.7058 ; g₂=g₄=1.2296 ; g₅=2.5408

Here g₁, g₃, g₅ are inductive element & g₂, g₄ are capacitive element. [3,4]

In these design we have following parameter

Relative Dielectric Constant, $\varepsilon_r = 4.4$, Cut-off frequency, $f_c = 1.5$ GHz, Height of substrate $h = 1.6$ mm

The substrate used - loss tangent $\tan\delta = 0.02$, $Z_0 = 50$ ; $Z_{oc} = 14 ; Z_{ol} = 130$ & $\Omega_c = 1$

W = 0.8 mm (for inductor)

for capacitor

$\varepsilon_{re} = 3.921$ & $\lambda_{eg} = 101$ mm, $W = 8.8247$ mm, $l_2 = l_4 = 10.5$ mm

for inductor

$\varepsilon_{re} = 2.934$ & $\lambda_{gl} = 116.762$ mm, $L = 13.4862 \times 10^{-9}$ henry, $l_1 = l_3 = 9.5$ mm, $l_5 = 18.5$ mm

**Fig. 2.3(a): Dimensions of Stepped impedance, L-C ladder type LPF (n=5)**

**Fig. 2.3(b): Simulated performance of stepped-impedance, L-C ladder type LPF**

**III. L-C LADDER TYPE OF LOW PASS FILTERS USING OPEN-CIRCUITED STUBS**

For n =3:

g₀=g₁=g₃=1.0316 ; g₂= 1.1474 & $\Omega_c = 1$

here g₁ & g₃ are inductive elements & g₂ is the capacitive element. [1]

for capacitor:

$\varepsilon_{re} = 3.788$ & $\lambda_{eg} = 102.76$ mm, $C_2=2.44 \times 10^{-12}$ farad, $W = 11.0$ mm

for inductor:

$\varepsilon_{re} = 3.069$ & $\lambda_{gl} = 114.165$ mm, $L_2 = L_4= 7.278 \times 10^{-9}$ henery

$l_1 = l_5 = 6.5$ mm, $l_2 = l_3 = 12.60$ mm, $C_1=C_3= 2.435 \times 10^{-12}$ farad, $C_5 = 4.1932 \times 10^{-12}$ farad.

**C. For Inductor:**

$\varepsilon_{re} = 3.069$ & $\lambda_{gl} = 114.165$ mm, $L_2 = L_4= 7.278 \times 10^{-9}$ henery

$l_1 = l_5 = 12.16$ mm, $W = 0.8$ mm

**Fig. 3.1(a): Dimensions of L-C ladder type LPF Using open-circuited stubs for n=3**

**Fig. 3.1(b): Simulated performance of L-C ladder type of LPF Using open-circuited Stubs**

**A. L-C Ladder type of Lowpass Filter using Open Circuited stubs for n = 5**

g₀=g₆=1 ; g₁=g₃=1.1568 ; g₅=1.975 ; g₂=g₄=1.1474

here g₁, g₃ & g₅ are capacitive elements & g₂,g₄ is the inductive element. [1]

**B. For Capacitor:**

$\varepsilon_{re} = 3.888$ & $\lambda_{eg} = 102.76$ mm, $W = 11.0$ mm, , $l_1 = l_5 = 6.5$ mm, $l_2 = l_3 = 12.60$ mm, $C_1=C_3= 2.435 \times 10^{-12}$ farad, $C_5 = 4.1932 \times 10^{-12}$ farad.

**C. For Inductor:**

$\varepsilon_{re} = 3.069$ & $\lambda_{gl} =114.165$ mm, $L_2 = L_4= 7.278 \times 10^{-9}$ henery

$l_1 = l_5 = 12.16$ mm, $W = 0.8$ mm

**Fig. 3.2(a): Dimensions of L-C ladder type, LPF using open-circuited stubs n=5**

**Fig. 3.2(b1): Simulated performance of L-C ladder type of LPF Using open-circuited Stubs (n=5)**

**Fig. 3.2(b2): Simulated performance of L-C ladder type of LPF Using open-circuited Stubs (n=5)**
IV. CONCLUSION

Figure 2.2, 2.3, 3.1 & 3.2 shows the design & simulated response of the proposed Stepped-Impedance, L-C Ladder Type Low pass Filter & L-C ladder type of low pass filters Using open-circuited stubs, for n=3 & 5 respectively. The graph is plotted by taking gain (dB) on the Y-axis and frequency in GHz on the X-axis. From the graph it is clear that the cut-off frequency is found to be 1.5 GHz. Hence the filters are capable of passing the frequency less than 1.5 GHz & reject the frequency after 1.5 GHz. All these filters are chebyshev in nature, we can see that L-C ladder type of low pass filters Using open-circuited stubs, for n=5 response have better stop band than stepped impedance L-C ladder type low pass filter . We can see that this filter have reflection coefficient is up to -38 dB, whereas for Stepped-Impedance, L-C Ladder Type Low pass Filter it is only -33 dB. Here figure 2.6 fabricated structure & measured graph of L-C ladder type of low pass filters Using open-circuited stubs, for n=5, in which the measured & simulated performance looking similar to each other.

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REFERENCES