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سبتمبر

الجمعة

Friday

December 27

an IEEE paper

25 Jumada-II 1446 H

watch filter design  
requirements

$$f_c = 2.4 \text{ GHz}, f_{s_1} = 2.425 \text{ GHz}, f_{s_2} = 2.375 \text{ GHz}$$

$$\text{BW} = 50 \text{ MHz} = 50 \times 10^6 \text{ Hz} = 2.08\% = FBW$$

$$\text{min attenuation} = 30 \text{ dB} = AS, Z_o = 50 \Omega$$

We will design for a passband BW =  $2 \times \text{BW} = 100 \text{ MHz}$

$$S_0, f_{P_1} = 2.425 \text{ GHz}, f_{P_2} = 2.375 \text{ GHz}$$

For a 0.5 dB equal ripple

$$AS = 10 \log \left( 1 + \varepsilon^2 \operatorname{csh}^2(u \operatorname{cosh}^{-1}(r)) \right)$$

$$\text{as } \varepsilon = \sqrt{10^{AS/10} - 1} \quad (\text{ripple factor}), r = \frac{\omega_s}{\omega_p} \approx 2$$

$$S_{LPs} \frac{BW}{f_{P_1} - f_{P_2}} = 1, S_{LS} \frac{BW}{f_{s_1} - f_{s_2}} = 2$$

$$u \geq \operatorname{cosh}^{-1} \sqrt{\frac{10^{AS/10} - 1}{\varepsilon^2}} = 3.947$$

$$\operatorname{cosh}^{-1}(r)$$

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.	Mon.	Tue.							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31



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So  $n \approx 4$  (order)

$$Z_{on} = \frac{4 Z_0}{\pi g_n D}, \quad Z_0 = 50 \Omega$$

	$n$	$g_n$	$Z_{on}$
1	1.6703	1832.408	
2	1.1926	2566.386	
3	2.3661	1293.55	
4	0.8419	3635.434	
5	1.9841	1542.599	

$$Q = \frac{F_0}{BW} = \frac{2.4 \times 10^9}{50 \times 10^6} = 48 \#$$

We will choose a substrate with  $\epsilon_r = 4.4$   
 $h = 1.6 \text{ mm}$

we assume  $\frac{w}{d} < 2$

For  $Z_0 = 50 \Omega$  As  $Z_0 = \sqrt{\frac{\epsilon_r + 1}{2}} + \frac{\epsilon_r - 1}{\epsilon_r + 1} \left( 0.23 + \frac{0.11}{\epsilon_r} \right)$

$$\approx 1.5298$$

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$$\frac{W}{d} = \frac{8e^A}{e^{2A} - 1} = 1.91185$$

$$L_s = \lambda_{eff} \cdot \frac{C}{4f_o \sqrt{\epsilon_{eff}}}$$

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \frac{1}{\sqrt{1 + 12d/W}}$$

$$= \frac{4.4 + 1}{2} + \frac{4.4 - 1}{2} \frac{1}{\sqrt{1 + \frac{12}{1.91185}}} = 1.2$$

$$= 3.33$$

$$L_s = \frac{3 \times 10^8}{4 \times 24 \times 10^9 \times \sqrt{3.33}} = 17.11 \text{ mm}$$

$$W_s d \times 1.91185 = 1.6 \times 1.91185 = 3.05876 \text{ mm}$$

For the smallest  $Z_0$  of a stub hence ( $\epsilon_r$ )

$$As \frac{1293.55}{60} \sqrt{\frac{4.4 + 1}{2}} + \frac{4.4 - 1}{4.4 + 1} (0.23 + \frac{0.11}{\epsilon_r}) \\ = 35.5844$$

$$\frac{W}{d} = 2.8116 \times 10^{-15} \Rightarrow W_s = 4.3 \times 10^{-18} \text{ m} \quad \therefore$$

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using Coupled line (as shown before)  
 $n \leq 4$

$$Z_{oe} = Z_o \left[ 1 + \sqrt{Z_o} + (\sqrt{Z_o})^2 \right]$$

$$Z_{oo} = Z_o \left[ 1 - \sqrt{Z_o} + (\sqrt{Z_o})^2 \right]$$

Knowing that

$$Z_o J_1 = \sqrt{\frac{\pi \Delta}{2 g_1}}, \quad Z_o J_n = \frac{\pi \Delta}{2 \sqrt{g_{n-1} g_n}}, \quad Z_o J_{N+1} = \sqrt{\frac{\pi \Delta}{2 g_N g_{N+1}}}$$

$$\Delta = 0.0208$$

$n$	$g_n$	$Z_o J_n$	$Z_{oe}$	$Z_{oo}$	$h(\text{mm})$	$W(\text{mm})$
1	1.6703	0.13986	57.97	43.983	1.6	3.069
2	1.1926	0.02315	51.184	48.869	"	3.057
3	2.3661	0.01944	50.79	49.047	"	3.058
4	0.8419	0.02314	51.184	48.869	"	3.057
5	1.9841	0.13985	57.97	43.983	"	3.009

Can be fabricated  
 with short circuit  
 needed for each  
 Coupler @ Port 4  
 Open Circuit @ Port 3

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Tuesday

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Planar notch Filter

8:00 requirements  $F_{\text{c}} = 2.4 \text{ GHz}$

9:00

10:00 BW @  $A_{\text{ss}} = 30 \text{ dB} \Rightarrow 25 \text{ MHz} \rightarrow F_{S_1} = 2.3875 \text{ GHz}$

11:00

$F_{S_2} = 2.4125 \text{ GHz}$

12:00

1:00 BW @  $A_p = 0.5 \text{ dB} \Rightarrow 50 \text{ MHz} \rightarrow F_{P_1} = 2.375 \text{ GHz}$

2:00

$F_{P_2} = 2.425 \text{ GHz}$

3:00

chebyshev (equal ripple)  $Z_0 = 50 \Omega$

4:00

5:00 Substrate requirements  
(Roger RO4350B)

$\Sigma_{\text{rs}} = 3.48$ ,  $d_s = 1.524 \text{ mm}$

$\tan \delta_s = 37 \times 10^{-4}$

6:00

Conductor  $"$   $T = 35 \text{ Min}$ ,  $b_c = 5.813 \times 10^{-7}$

7:00

$F_{\text{BW}} = \Delta = \frac{\text{BW}}{F_c} = \frac{50 \times 10^6}{2.4 \times 10^9} = 0.02083 \approx 2.083\%$

8:00

Calculate order for equal ripple = 5

First method (quarter wave resonator o.c.)

n

$J_n$

$Z_{\text{on}} = (4Z_0 / \pi)^n \Delta$

1

1.7058

1791.69

2

1.2296

2485.5757

3

2.5408

1202.87

4

1.7296

2485.5757

5

1.7658

1791.69

6

1

3056.26

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.	Mon.	Tue.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

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Monday

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second method (coupled lines)

n	$g_n$	$Z_o J_n$	$Z_o$	$Z_{oo}$
1	1.7058	0.1385	57.884	44.034
2	1.2296	0.02259	51.155	48.896
3	2.5468	0.0185	50.942	49.092
4	1.2296	0.0185	50.942	49.092
5	1.7058	0.02259	51.55	48.896
6	1	0.1385	57.884	44.034

as  $Z_o J_1 = \sqrt{\frac{\pi\Delta}{2g_1}}$ ,  $Z_o J_n = \frac{\pi\Delta}{2\sqrt{g_{n-1}g_n}}$ ,  $Z_o J_{N+1} = \sqrt{\frac{\pi\Delta}{2g_N g_{N+1}}}$

$$Z_o = Z_o [1 + J Z_o + (J Z_o)^2], Z_{oo} = Z_o [1 - J Z_o + (J Z_o)^2]$$

third method (L-R-C Resonator)

n	$g_n$	$Z_o$	$Z_{oo}$
1	1.7058	27.89	
2	1.2296	16.61	
3	2.5468	17.6	
4	1.2296	40.65	
5	1.7058	27.89	

## مذکرات

### Notes

1<sup>st</sup> method For  $F_{P_1} = 2.3 \text{ GHz}$ ,  $F_{P_2} = 2.3 \text{ GHz}$   
 $F_{S_1} = 2.33 \text{ GHz}$ ,  $F_{S_2} = 2.43 \text{ GHz}$

BW is 200 MHz

$$\Delta = FBW = \frac{0.2}{2.4} = 0.0833 = 8.33\%$$

n	$g_n$	$Z_{on} = Z_0 / \pi g_n \Delta$
1	1.7058	448.0299
2	1.2296	621.54
3	2.5408	300.79
4	1.2296	621.54
5	1.7058	448.0299

### 2<sup>nd</sup> method

n	$g_n$	$Z_{on} g_n$	$Z_{oc}$	$Z_{oo}$
1	1.7058	0.27696	67.68	39.987
2	1.2296	0.0903	54.9255	45.89
3	2.5408	0.074	53.975	46.57
4	1.2296	0.074	53.975	46.57
5	1.7058	0.0903	54.9255	45.89
6	1	0.27696	67.68	39.987

### 3<sup>rd</sup> method

n	$g_n$	$Z_{on} = Z_0 / g_n \Delta$
1	1.7058	351.8818
2	1.2296	448.1588
3	2.5408	256.24
4	1.2296	448.1588
5	1.7058	351.8818