Schaumann: Design of Analog Filters
Chapter 1 : Introduction

Introduction 1-1

1.1 The gain $G = 20\log(V_2/V_1) = 20\log(5.34) = 14.55$ dB
Phase shift $\Delta\theta = (180/\pi)(4.87 - 2.68) = 125.5°$

1.2 At 12 kHz, the gain of the filter is $G = 10^{-78/20} = 1.259\times10^{-4}$
∴ The amplitude of output signal is $V_o = V_{in} \cdot G = 1\times1.259\times10^{-4} = 125.9$ μV.

1.3 $\alpha = 20\log[(45\times10^{-6})/(100\times10^{-3})] = 20\log(4.5\times10^{-4}) = -66.94$ dB

1.4 The gain is $G = 10^{35/20}\angle-42° = 56.23\angle-42°$, hence the output signal is
$V_{out} = V_{in} \cdot G = 2.4\angle45° \times 56.2\angle-42° = 135.0\angle3°$
∴ $v_{out}(t) = 135.0\cos(\omega_1 t + 3°)$

1.5 (a) Lowpass. Transition bandwidth $BW_{TB} = 9.6 - 3.4 = 6.2$ kHz
(b) Bandpass. Transition bandwidths $BW_{TB1} = 12.5 - 7 = 5.5$ kHz, $BW_{TB2} = 40 - 24 = 16$ kHz
(c) Bandstop. Transition bandwidths $BW_{TB1} = 12.5 - 7 = 5.5$ kHz, $BW_{TB2} = 40 - 24 = 16$ kHz
(d) Highpass. Transition bandwidth $BW_{TB} = 40 - 24 = 16$ kHz
(e) Lowpass. Transition bandwidth $BW_{TB} = 600 - 360 = 240$ kHz
(f) Bandpass. Transition bandwidths $BW_{TB1} = 1000 - 730 = 270$ kHz,
$BW_{TB2} = 7.8 - 2.4 = 5.4$ MHz

1.6 At dc, $s = 0$, hence the gain is $20\log|T(s)|_{s=0} = 20\log(2\times9.32/1) = 20\log(18.64) = 25.41$ dB
At high frequencies $|T(j\omega)|_{\omega\to\infty} \approx \omega^{-2}$, attenuation $\alpha(\omega) = 20\log(1/\omega^2) = -40\log(\omega)$ increases 40 dB per decade.

When $\omega = \infty$ (infinite), attenuation is infinite.

1.7 In this problem's solution, denormalized component values are denoted by a "–".
Denormalized parameters are $\overline{R_1} = R_1 \cdot R_0$, $\overline{L} = \frac{R_0}{\omega_0}L$, and $\overline{C} = C/(\omega_0 R_0)$, therefore $\overline{R_1} = 300$ Ω, $\overline{R_L} = 300$ Ω, $\overline{L_1} = 5.547$ μH, $\overline{L_2} = 4.365$ μH, $\overline{L_3} = 3.875$ μH, $\overline{C_1} = 126.0$ pF, $\overline{C_2} = 77.44$ pF

1.8 In this problem's solution, denormalized component values are denoted by a "–". Since denormalized capacitance is $\overline{C_1} = C_1/(\omega_0 R_0)$, where R_0 is the normalization resistor, we have
$R_0 = \frac{1}{\omega_0}\frac{C_1}{\overline{C_1}} = \frac{1}{2\pi\times360\times10^3}\frac{0.765}{0.05\times10^{-9}} = 6.764$ kΩ
therefore the denormalized resistances are
$\overline{R_1} = R_1 \cdot R_0 = 1.243\times6.764\times10^3 = 8.408$ kΩ
$\overline{R_2} = \overline{R_3} = R_2 \cdot R_0 = 1.677\times6.764\times10^3 = 11.343$ kΩ
$\overline{R_4} = R_4 \cdot R_0 = 6.888\times6.764\times10^3 = 46.59$ kΩ

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