**Homework 3**



**P14.2.7** Determine *ω*0 and *Q* in Figure P14.2.7.

**Solution:** The circuit in the frequency domain is as shown. The voltage across the capacitor is 0.1*VI*(*jω*), so that *IC*(*jω*) = *jω*C×0.1*VI*(*jω*) = *jω*(0.1*C*)*VI*(*jω*), which means that the effective capacitance in the capacitive branch is 0.1*C* = 0.1 μF. Alternatively, using the source absorption theorem, the dependent source is equivalent to an admittance of *jω*C×0.1*VI*(*jω*)/0.9*VI*(*jω*) = *jωC*/9, which is corresponds to a capacitance of *C*/9. This in series with *C*, gives a capacitance of 0.1*C*, as before.



 rad/s ≡ 100 krad/s; .



**P14.2.11** If a 4 MΩ resistor is connected in parallel with *L* and *C* in Figure P14.2.8, determine the percentage change in the bandwidth.

**Solution:** BW. When a 4 MΩ resistor is connected in parallel with *L* and *C*, *Rp* is reduced from 1 MΩ to  MΩ. The BW increases from  to , that is, an increase of 25%.

**P14.2.12** For the circuit of Figure P14.2.12, determine: (a) *ω*0; (b) *Q*; (c) *VO*(*jω*0) if *VSRC*(*jω*0) = 1 V.



**Solution:** (a) The circuit is bandstop, having   rad/s.

(b) When the independent source is set to zero, the circuit is a parallel circuit having *Rp* = kΩ; .

The 3-dB bandwidth is not defined because the output at *ω*0 does not fall to of its maximum value.

(c) When *ω* = *ω*0*, L* and *C* behave as an open circuit, so that  0.8. Hence, if *VSRC*(*jω*0) = 1 V, *VO*(*jω*0) = 0.8 V.

**P14.2.13** (a) Show that the response *VO*(*jω*)/*VSRC*(*jω*) in Figure P14.2.13 is an allpass response. (b) Determine the frequency at which the phase shift is 180°, assuming *R* = 10 kΩ, L = 1 μH, and C =



1 μF.

**Solution:** (a) The transfer function for the response across *L* and *C* is:

. The transfer function for the response across *R* is: . The transfer function *H*(*s*) = *H*1(*s*) – *H*2(*s*) = , where .

(c) The phase shift is 180° at *ω* = *ω*0, when *H*(*s*) = -1.  = 1 Mrad/s. Alternatively, if the phase shift is to be determined directly from the transfer function,  hence, ; ; .



**P14.2.14** Determine the frequency at which the response *VO*(*jω*)/*VSRC*(*jω*) in Figure P14.2.14 is a maximum.

**Solution:** The linear transformer is replaced by its T-equivalent circuit, as shown, where *L*2 – *M* = 0. Maximum response occurs when *sM* is in parallel resonance with 1/*sC*, so that *V*1(*s*) = *VI*(*s*) and *VO*(*s*) is maximum. Parallel resonance occurs when *ωM* = 1/*ωC*, or rad/s.



**P14.2.16** Determine  and  in Figure P14.2.16 so that the magnitude of the transfer function *VO*(*jω*)/*VI*(*jω*) is unity at 1 Mrad/s and zero at 0.5 Mrad/s.



**Solution:** *VO*(*jω*)/*VI*(*jω*) = 1 when *L*1 is in series resonance with the 10 nF capacitor; hence *L*1 H ≡ 0.1 mH. *VO*(*jω*)/*VI*(*jω*) = 0 when the reactance of *L*1  and *C* is capacitive and is in parallel resonance with *L*2. The reactance of *L*1 and *C* at 0.5 Mrad/s is 0.5×106×10-4 –  = 50 – 200 = -150 Ω; hence, 0.5×106× *L*2 = 150, or *L*2 =  = 300×10-6 = 0.3 mH.

**P14.3.5** Given . Determine the maximum response in dB.

**Solution:** . The response is the sum of a bandstop response  and a bandpass response . *H*1(*s*) = 0 at ω = 5 rad/s, and *H*2(*s*) is a maximum at this frequency, having a value of (4×2.5)/5 = 2. This also the maximum value of *H*(*s*) and is equivalent to 20log10(2) = 6 dB.

**P14.3.7** Given the



asymptotic

Bode magnitude plot of Figure P14.3.7. Determine: (a) the *X* dB level; (b) the transfer function represented by this asymptotic plot.

**Solution:** (a) The slope is -20 dB/decade, and the

starting point is +20 dB at 104 rad/s. a decade further in frequency the response drops by 20 dB to 0 dB. Hence, *X* = 0 dB.



(b) The response can be built up from individual responses as follows:

1. Start with a line of slope 20 dB/decade that passes through the point (20 dB, 100 rad/s). The 20 dB is a gain of 10, so that the expression for the magnitude of this line is *ω*/10 and as a transfer function is *s*/10.
2. To have corner at *ω* = 102 rad/s so that the plot continues horizontally, a lowpass response of the form 102/(*s*+102) is to be added on the vertical log scale to the line *ω*/10. This lowpass response has a the 0 dB line as a low frequency asymptote and a high frequency asymptote that is 20log10(100) – 20log10*ω*. This is a line of slope -20dB/decade that crosses the 0dB line at *ω* = 102, as shown by the orange lines. Adding this to the line *ω*/10 on a logarithmic scale corresponds to multiplication of the expressions for the two functions. The transfer function becomes: .
3. To have a corner frequency at *ω* = 104 rad/s and the plot continue with a negative slope of -20 dB/decade, the same procedure is followed. A response of the form 104/(*s*+104) is added on the vertical log scale to the preceding transfer function. This response has the 0 dB line as a LF asymptote and the line 20log10(104) – 20log10*ω* as the HF asymptote, as shown by the red lines. The new transfer function becomes: .
4. To have a corner frequency at *ω* = 105 rad/s and the plot continue with a positive slope of +20 dB/decade, a response of the form (*s*+105)/105 is added on the vertical log scale to the preceding transfer function. This response has the 0 dB line as a LF asymptote and the line 20log10*ω* – 20log10(104) as the HF asymptote, as shown by the blue lines. The new transfer function becomes: .
5. To have a corner frequency at *ω* = 106 rad/s and the plot continue with a negative slope of -20 dB/decade, a response of the form 106/(*s*+106) is added on the vertical log scale to the preceding transfer function. This response has the 0 dB line as a LF asymptote and the line 20log10(106) – 20log10*ω* as the HF asymptote, as shown by the green lines. The new transfer function becomes:  .