TOOL: The Bode plot rules for a real zero at s_z involve approximating the zero term at low frequency as $\left|\frac{s}{s_z}+1\right| \approx 1$ for $s << s_z$ and at high frequency as $\left|\frac{s}{s_z}+1\right| \approx \frac{s}{s_z}$ for $s >> s_z$.

The next step is to take the $\log_{10}$ of the approximation.

$$\log_{10} 1 = 0 = \text{horizontal line} \quad \text{for } s << s_z$$

$$\log_{10}\left|\frac{s}{s_z}+1\right| \approx \log_{10}\left(\frac{s}{s_z}\right) = \text{straight line sloping up} \quad \text{for } s >> s_z$$

After taking the $\log_{10}$ we will be adding the approximate terms to get the $\log_{10}$ of the product. That is, $\log_{10} a*b = \log_{10} a + \log_{10} b$.

We draw the two straight lines and discover that they intersect at $\omega = \omega_z$ where we have defined $s_z \equiv j\omega_z$.

Our final step is to multiply y values by 20. We call this a "dB" (for "decibel") scale. This vertical scaling factor is just for convenience of the values we get for $20\log_{10} x$.

$$20\log_{10} \mathbf{1} = \mathbf{0} \qquad 20\log_{10} \sqrt{2} \approx 3 \qquad 20\log_{10} \mathbf{2} \approx \mathbf{6} \qquad 20\log_{10} \mathbf{5} \approx \mathbf{14} \qquad 20\log_{10} \mathbf{10} = \mathbf{20}$$

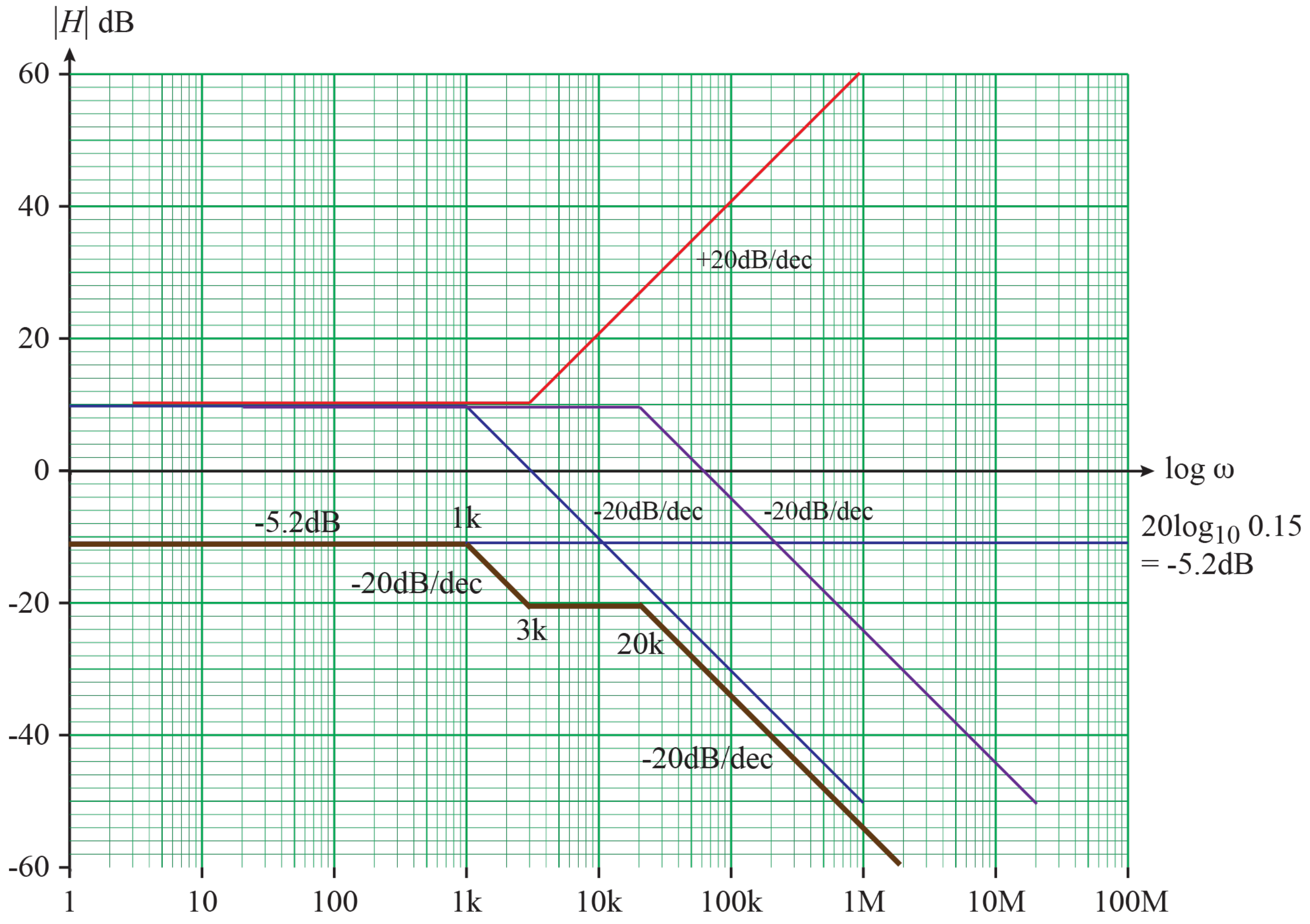
The graph below shows the Bode magnitude plot of the following transfer function:

$$|H(s)| = \left|\frac{s+3\text{k}}{(s+1\text{k})(s+20\text{k})}\right| = \frac{3\text{k}}{1\text{k}\cdot 20\text{k}} \cdot \frac{\left|\frac{s}{3\text{k}}+1\right|}{\left|\frac{s}{1\text{k}}+1\right|\left|\frac{s}{20\text{k}}+1\right|}.$$

Using $s = j\omega$ and converting to dB, we have

$$|H(s)|\text{dB} = 20\log_{10} 3/20 + 20\log_{10}\left(\frac{s}{3\text{k}}+1\right) - 20\log_{10}\left(\frac{s}{1\text{k}}+1\right) - 20\log_{10}\left(\frac{s}{20\text{k}}+1\right).$$

We plot each term and sum the curves (meaning we sum the values at a given frequency ω and then repeat the process for every ω).


|H| dB
60
40
20
0
-20
-40
-60
+20dB/dec
log ω
-5.2dB
1k
-20dB/dec
-20dB/dec
20log10 0.15
= -5.2dB
-20dB/dec
3k
20k
-20dB/dec
1
10
100
1k
10k
100k
1M
10M
100M