Modelling and control summaries

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Margins 7: Effects of gain changes on PM

PHASE MARGIN:	**GAIN MARGIN**
1. Find a frequency w_g such that $\|G(jw_g)\|=1$. 2. Clockwise rotation $e^{-j\phi}$ such that $G(jw_g)\,e^{-j\phi}=-1$. 3. Phase margin $=\phi = 180+\arg(G(jw_g))$.	1. Find w_p such that $\arg(G(jw_p))=-180$. 2. Find a real number K such that $G(jw_p)K=-1$. 3. Gain margin $= K = 1/\|G(jw_p)\|$

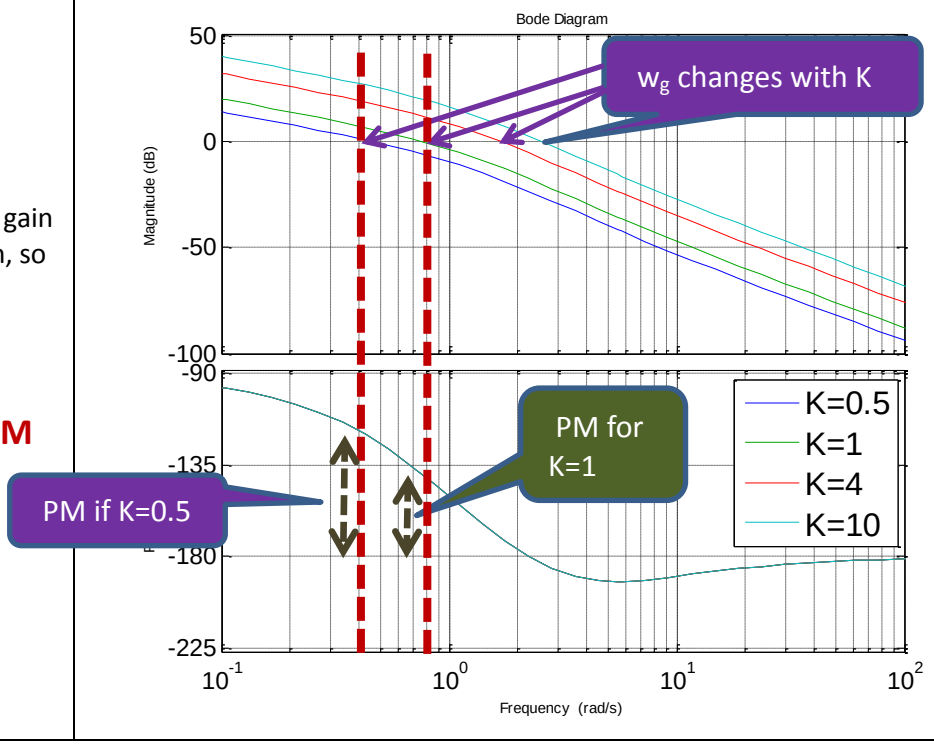
EXAMPLE

$$G(s)=\frac{0.4}{(s+2)(s+1)}$$

$$M(s)=K\frac{s+5}{s}$$

Changes in gain cause the gain plot to move up and down, so **the gain crossover frequency changes.**

Consequently, the PM is computed at a different point and changes.



In general, there is no simple analytic formulae which captures the change in the PM with K.

This is because the gain crossover frequency does not have a simple analytic dependence on K (in general).

A new computation is required for each value of K.

NEXT, DESPITE THE LACK OF EASY ANALYTIC RESULTS, WE SHOW HOW BODE DIAGRAMS CAN BE USED QUICKLY AND EFFICIENTLY TO ACHIEVE A SPECIFIED PHASE MARGIN BY JUST CHANGING THE GAIN.

ACQUIRING A SPECIFIED PHASE MARGIN

The phase margin is computed at the gain cross over frequency using $\phi = 180+\arg(G(jw_g))$. Alternatively, a specified phase margin will dictate the gain cross over frequency indirectly by specifying the phase of G(jw) where the gain cross over frequency must occur:

STEP 1: Find required w_g so that $\arg(G(jw_g))$ has desired value (ϕ -180= $\arg(G(jw_g))$.

STEP 2: Find K such that $|G(jw_g)K|=1$ – that is force w_g to be gain cross over frequency.

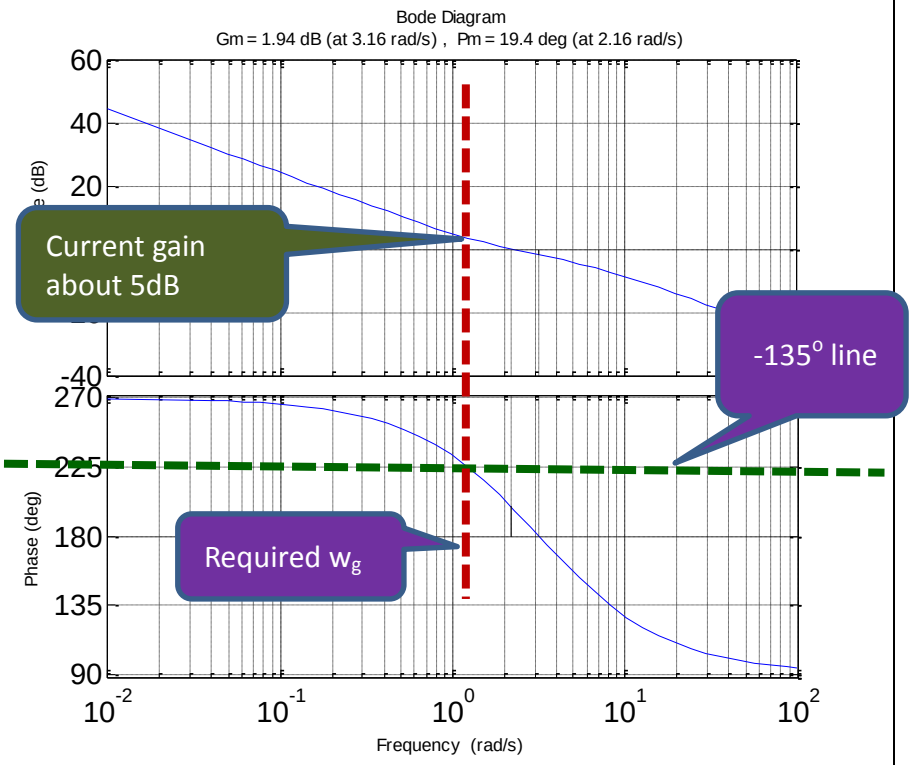
Find K so that the phase margin is 45 degrees.

STEP 1: Find the frequency where arg(G(jw))=-180+45 =-135

STEP 2: Draw a vertical line up at this frequency to find the current gain.

Use K=1/|G(jw)| in order to force this to become the gain cross over frequency – that is make |G(jw)K|=1.

Here K will be -5dB



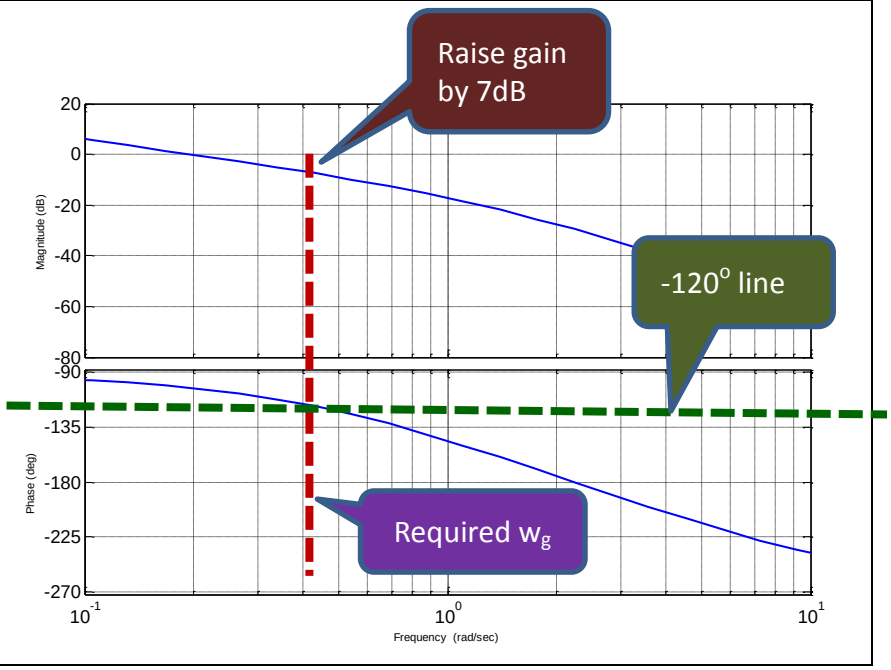
Find K to achieve a 60 degree phase margin

1. STEP 1: Find the frequency where arg(G(jw))=-180+60 =-120

STEP 2: Draw a vertical line up at this frequency to find the current gain.

Find the gain change required to make |G(jw)K|=1.

Here K will be about 7dB



Warning: Not all phase margins are possible – only those where we can satisfy ϕ -180= $\arg(G(jw_g)$.