Modelling and control summaries

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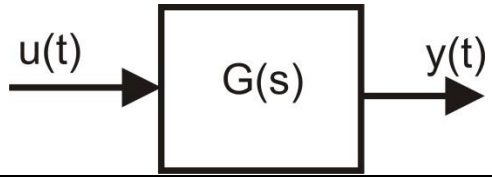
Bode 6: Introduction to plotting



SUMMARY of Frequency response

We have established that frequency response is given by the formulae:

$$gain = |G(jw)|; \quad phase = \angle G(jw)$$

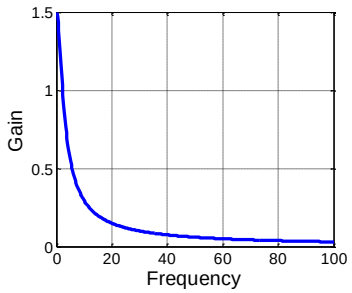
Phase normal expressed in degrees.

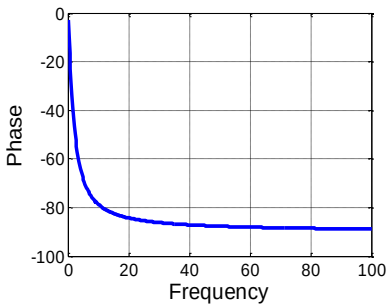
Plotting gain and phase

It is well known that graphs can lend insight and give a good overall picture. Consequently it is logical to plot the frequency response characteristics against frequency.

MATLAB can be used to save time as this is tedious.

>> [gain,phase]=bode(G,w);
>> plot(w,gain); etc.



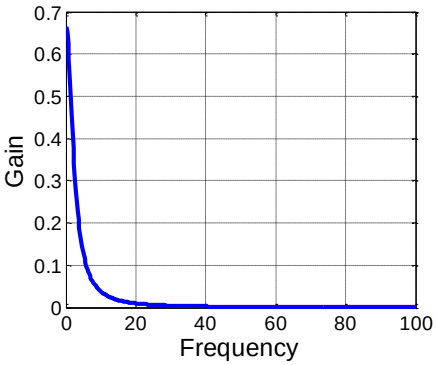


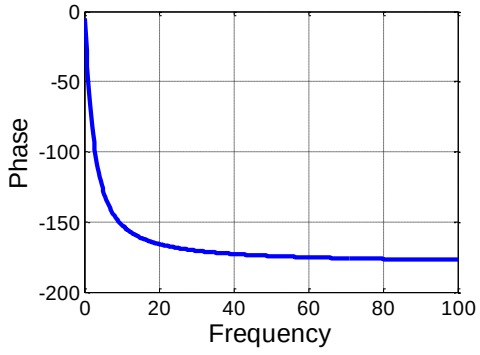
$$G(s) = \frac{3}{s+2}; \quad |G(jw)| = \frac{3}{\sqrt{w^2+2^2}}; \quad \angle G(jw) = \tan^{-1}\frac{w}{2}$$

REMARK: One can clearly see that the gain reduces as frequency increases and also the phase is zero for small frequencies and gradually reduces to -90° for large frequencies. The graphs have provided a useful insight. However, it is hard to see detail in the low frequency range (say 0-1 rad/s for figures here).

2nd order example

The insights are similar, that is gain reduces with frequency and phase also reduces with frequency, in this case to -180°. Detail poor in low frequency range.

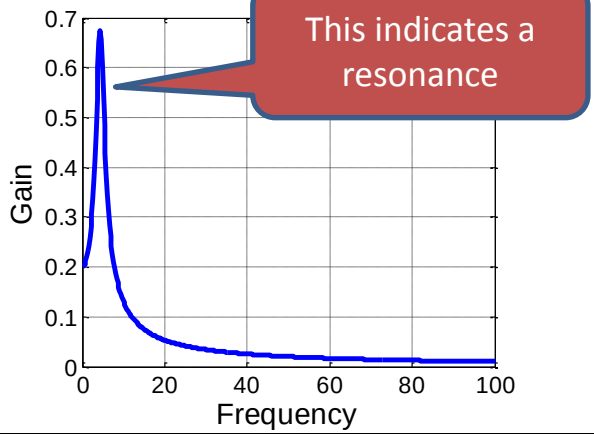


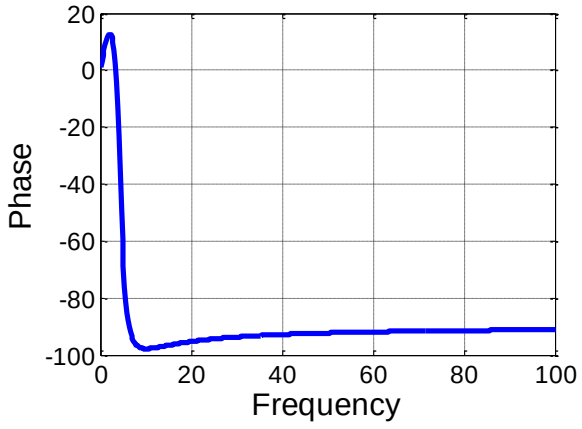


$$G(s) = \frac{4}{s^2+5s+6}; \quad |G(jw)| = \frac{4}{\sqrt{(w^2+2^2)(w^2+3^2)}}; \quad \angle G(jw) = -\tan^{-1}\frac{w}{2} - \tan^{-1}\frac{w}{3}$$

Underdamped example

The insights are similar, that is gain reduces with frequency and phase also reduces with frequency, in this case to -180^{o}. However, here is very notable that detail is poor in low frequency range. The graph does not allow a good view on low frequency information and the same time as trends in the high frequency range. The peak in gain indicates a resonance, that is for a frequency around 5, the output amplitude is significantly larger than for frequencies in the same region.





SUMMARY

1. It is straightforward to plot the frequency response parameters and hence get an overview of how gain and phase change over a range of frequencies. I advise using MATLAB or a similar tool.
2. However, all the focus is on the larger frequencies as any notable changes in the low frequency range are cramped into a small part of the graph domain. Similarly very large frequencies are excluded.
3. It is not obvious from formulae what causes the shapes and asymptotes that arise and hence how changes in poles and zeros will affect the overall shapes.

Next the notes look at alternative graphs for representing frequency response information.