Modelling and control summaries

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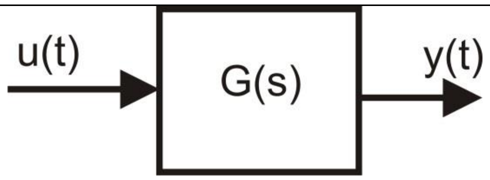
Bode 11: Sketching using asymptotes b



SUMMARY of Frequency response

We have established that Bode diagram comprises two plots (gain in dB, phase in degrees):

$gain = 20\log_{10}|G(jw)|; \quad phase = \angle G(jw)$

Summary of key observations and techniques for sketchin Bode diagrams for systems with real poles and zeros

Using asymptotic approximations for a single factor (s+a)	
If w<a approx. factor as (jw+a)=a If w>a approx. factor as (jw+a)=jw If w=a then have jw+a=ja+a If w=a/10 or 10a	Gain is a, phase is zero Gain is w (or 20dB/dec), phase is 90 Gain is a√2 (or 3dB up), phase is 45. Error between phase and asymptote is 6^o.
FINAL SKETCH: Sketch a line that follows the asymptotic approximations and also passes through key points.	**Key points:** Compute exact value of phase at 1-2 key points near expected bandwidth (likely around -120^o to -180^o)

USEFUL QUICK RULES

If frequency crosses a zero: gain asymptote goes up by 20dB/dec, phase asymptote up by 90^o.
If frequency crosses a pole: gain asymptote goes down by 20dB/dec, phase asymptote down by 90^o.

INITIALISATION OF GAIN AND PHASE ASYMPTOTES WITH INTEGRATORS

An integrator has a constant phase (-90^o) so is easy to include within phase plots.

The gain of an integrator is (1/w) so this means there is a slope of -20dB/dec even at low frequencies. Begin asymptote at smallest corner frequency, using the normal asymptotic approximations.

EXAMPLE BELOW:

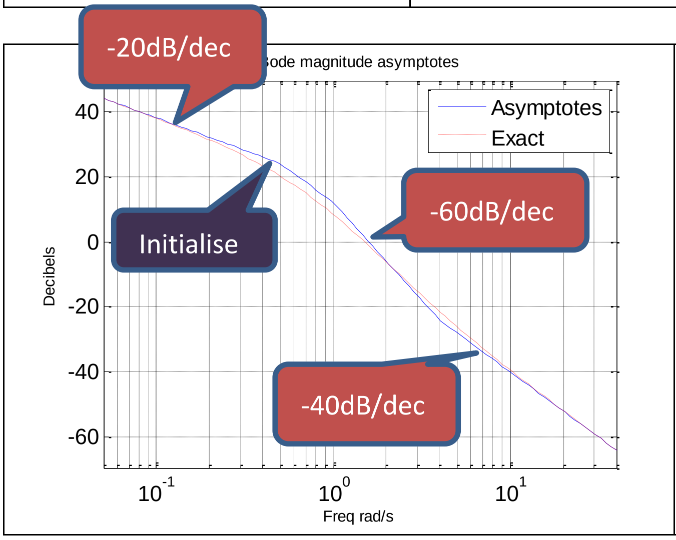
Smallest corner frequency

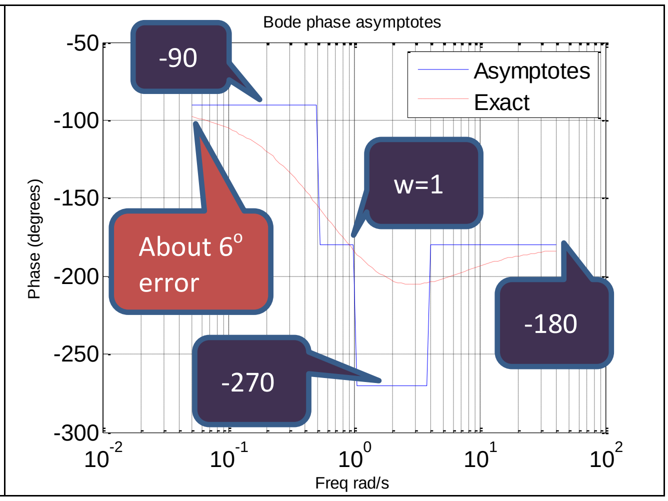
Asymptotic approximation

Substitute w=0.5

$$G = \frac{s+4}{s(s+1)(s+0.5)} \quad \Rightarrow \quad \left\{ w = 0.5 \quad \Rightarrow \quad G(jw) \approx \frac{4}{jw(1)(0.5)} \quad \Rightarrow \quad |G(j0.5)| \approx \frac{4}{0.25} \right\}$$

<u>EXAMPLE of quick rules</u> $G = \dfrac{s+4}{s(s+1)(s+0.5)}$	1. Initialise gain asymptote at w=0.5 as above 20log10(4/0.25)=24dB 2. If w<0.5, gain slope is -20dB/dec and phase is -90 3. At w=0.5 pass a pole, so gain slope goes to -40 and phase to -180. 4. At w=1 pass a pole, so gain slope goes to -60 and phase to -270. 5. At w=4 pass a zero, so gain slope goes to -40 and phase to -180. 6. **ADD** exact computation around w=1 to phase plot. 7. **Note that errors in phase from asymptotes at high and low frequency are around 6^o when a decade from nearest pole/zero.**





USING MATLAB	An exact plot can be obtained use bode.m where G is a transfer function object. >> G=tf([1 4],poly([0 -1 -0.5])) >>bode(G)
I have provided a file which also does the asymptotes as long as system has only simple poles/zeros (no complex roots)	>> bodeasymptote(G)

<u>EXAMPLES for students to try</u> [Use MATLAB to test your answers]

$$G = \frac{4}{s(s+5)}; \quad H = \frac{s+2}{(s+5)^2}; \quad K = \frac{s+4}{s^2(s+8)(s+10)}$$

$$M = \frac{2(s+10)}{s(s+1)(s+4)}; \quad P = \frac{3}{(s-1)(s+6)}$$