Bode plot examples step by step pdf

In this post we will go on the process of sketching straight-line bode plot approximation for a simple rational transfer-function in a step-by-step fashion. See Section 7.1 for details about the estimate. We will start with the Magnitsky plot and cover the future later stage plot. Consider the following second order transaction function: $$G(s) = \0 frac {s + 2}{s ^ 2 + 11 s + 10}. The first step to producing a bod plot sketch is the points and denominator factors in terms of your poles and zeros: $$G(s) = \0 frac {s+2}{(s+1)(s+1)}$ You may need the help of a numeric calculator here for large order transfer-function. All poles and zeros in this example are real. We will consider the issue of complex poles and zero in any other post. Once the poles and zeros have been affected, normalize the digits and denominator: $$G(s) = \0 frac{2}{10} \ frac {1+s/2}{(1+s)(1+s/10)}.$This step is very important and not performing it before proceeding with the sketch is a common mistake that leads to the wrong profit. We proceed to identify the pole or zero with the smallest magnitude, which is the case $s is pole at =-1$. Such a pole will appear on the Magnitsky Bode plot such as the straight-line approximation that $\omega= $1 is $0 before and a $-20 $dB/$20.000.000/20.000.000/-20/200/2000/2000/2000/20/20/20/2000/2000/-200000/- As shown in the figure: After seeing if the next pole or zero $s is at =-2$, we can proceed to draw the sketch as a red line in the next diagram, stopping right before $\omega=2$. Calculate the value of -6 marked above a standard $\\Delta_y =\text {slope}\0 Times \Delta_x $ Argument: $\0 Delta_y = -20 \log_{10} (2)-\log_{10}(1))=-20\log_{10}(2/1)\1.$$Last $\2$, $s =-2$, but it's necessary to take into account a contribution of zero, which adds $-20 $dB/decade to the current slope of $+20$dB/decade. The resulting slope of $-20+20=0 dB/decade is the straight line in the next figure: we move along the red line until $Omega = $10, at which point $s =-10$-20 $dB/decade contribution begins, as shown next: since there is no other pole or zero, we have $20 d/s. We need to offset the diagram to take into account the $2/10 profit, which corresponds to $20 \log_{10} (2/10).\0 Approximately -13 \0 Text {d B}$$ To get the final sketch: Finally, here are some vivek checks that you should perform on your sketch: If there are no poles nor zeros in the original your magnitude will start flat at $20 log_{10} | G (0) | $. in this example $ 20 \ log_{10}| 2/10| \ Approximately -13$. It will always end with a slope of $-20 (N-M) $dB/decade, where the number of $$n poles and the number of zeros is $$m. In this example, $n = 2$, $m = 1 $, and the plot ends with a $-20 (2-1) = -20 $dB/decade slope. We will consider A sketch of the stage on a followup post. 1 (a real pole) 2 (real pole and zero) 3 (pole in origin) 4 (repeated real poles, negative constant) 5 (complex conj. poles) 6 (multiple poles in the original, complexconj zero) 7 (time delay) This document will discuss how to actually draw bode diagram. It contains most examples. The main concept - there are four steps to draw the bod diagram: a transfer function normally consists of form: as discussed in the previous document, we would like to rewrite it so that the lowest command words in the digit and denominator are both unity. Some examples will illustrate: note that the lowest (zero) command strength of the numeral and denominator polynomial in the final result is equal to unity. Note that in this example, the lowest power in the digit was 1. In this example the denominator was already factored in. In such cases, unity is needed as the lowest ordering power of each positive word s (zero in this case). 2. Separate the transfer function into its component parts. The next step is to divide the function into its component parts. There are seven types of parts: the original real poles conjugate a constant poles poles at the original zero in the real Zeros complex we can use the example above to display again. This function has a constant of 6, zero on S=-10, and complex sanjugate poles at the roots of s2+3s++50.   Complex sanjugate poles are at j6.9 (where j=sqrt(-1)) ± S=-1.5. A more common (and useful for our purposes) to express it is to use the standard notation for the second order polynomial in this case, this function has a stable of 3, zero in the original, and there are complex serious poles at the roots of S2+3s++50, in other words this function has a stable of 2. Poles on s =-10 on zero, and S=-3 and S=-50. 3. Draw bod diagram for each part. The rules for drawing bod diagrams for each part are summarized on a separate page. Examples of each are given later. 4. Draw the overall bod diagram by adding results from step 3. After preparing the personal terms, linking them together is a simple matter. See example, below. Example: Draw bod diagrams for the following transfer tasks These examples are compiled on the next page. A simple pole full solution combines multiple poles and zero-full solution a pole and zero-full solution on the original and poles repeated poles, a zero on the original, and a negative continuous full solution complex poles complete solution Change a complex task complete solution Reference 1. BEE-502 Automati Unit-4, B Ditterm et ver all oth preliminary lot L magnit compa that now, W (i) T T A (ii) T C Control Cyst Bod plot Supp minnation y low frek er termes h slope db log is less than tide in G20 this e is the slope we consider type - 0 s thus, initia nd initial m type - 1 s plementary No of Initial quencies, th have neglig nly determi the corner is given b ( ) (G j Hω equation w −20n dB/d are the cases System: n log G20 al part of t magnitude System: n lo20 tes (Ele l Slope of he type te gible contr ined by th r frequenci ( )G jω by: ( )j M ω = = − 20 with the eq dec. for variou n = 0 ( ) (G j H jω the Bode p is 20 log K n = 1 ( )og G j Hω Diploma in E ectrical/ Instr. 5th Semes f Bode Pl rm / (jω1 ribution to is term, an ies can be a) ( )H jω ≈ ( ) log log n K j n ω ω 0 20 quation of us system 't)jω = = 20 20 plot of a ty K. ( )H jω = = Engg. Ster ot)n ω domina wards the nd the tran approxima () n k jω ≈ log log n K = + 20 20 straight lin type'. } Log log of J K ω 0 ype - 0 sy (J K ω 20 of log log log as a gain mag nsfer funct ated on 20 cyst intru ates: GK N K − 20 ne y = mx log = 20 stem is a) Log K ω ω − 20 tem euctor: Mohd. U date pag all other te nitude, he can call ion on freq log (n ω x + c, we g k 1 a slope 0 dω Umar Rahman E: 7.11.2017 GE 1 as 8 erms quencies dB/dec, 2. BEE-502 Automati Unit-4, B T (III) T T EQ C Control Cyst Bod plot in EQ the initial ntersection quation type-2s initial p nter qusectionation to tems plementary zero with no part of th. System: Part of N Log20 with zero. TES (Ele he Bode p 0 db axis log ω 0 20 n = 2() GJ Hω E Bod Plot 0 DB Axis Logakωω 2 0 20 Diploma in E Ectrinal/E. Instra. 5th Semes plot An SF log log can be Kω = 0 20 20 ()H jω== T A slope sf can be Kω of log log = 2 0 20 20 Engg. and control) Ster Slope found by E G Lo G − 20 (Ω− 20 20 PE−40 E G Lo G found by ω − 2 20 Instra −20 d equal thω) ω − 2 20 d/Dec of the log. A likeness th ogω uctor: mohammad u det pag december, p he rhs o ω2 again, p he rhs o umar rahman e: 7.11. 2017 GE 2 of 8 point of f of point of 3 above F. Beee-502 Automatic Control System Unit-4, Bod Plot Supplementary Notes Diploma in Engg. (Electrical/ Instrail & Control) 5th Semester Instructor: Mohammad Umar Rahman Date: 7.11. 2017 page 3 of 8 Let us see some examples on the bod plot. Example 1: Draw bode plot of unity response system with further advantage()) (SGS=++200 2 20 also determine the profit margin, phase margin and stability of the system. Solution: Step-1: First change the given transfer function to time conference form. } s = ⎛ ⎞⎛ ⎞ + ⎜ ⎟⎜ ⎟ ⎜ ⎟ ⎜ ⎟× × + + ⎜ ⎟ ⎜ ⎟⎜ ⎟ ⎜ ⎟ ⎜ ⎟⎜ ⎟ ⎝ ⎠⎝ ⎠ = + 200 200 2 1 1 2 2 2 5 1 0 5 1 0 5 1 0 5 0 05 Step-2: Determine the sinusoidal transfer function()(). GJJ ωωωω ω = +++5 1 0 5 1 0 05 Step-3: Identify different parts of the bod plot (i) consecutive term: K = 5 (ii) Of the system: 1, this means that the initial slope − is 20 dB/Dec, and the intersection of the initial part of the plot with 0 dB axis is at red/sKω = = 5. (iii) Corner frequency: c1 c2 rad/s, rad/s. . ω = 1 1 2 20 0 0 05 Step-4: Draw reference slopes on the top left corner of the semi log graph paper. Plots for magnitude draw 0 dB axis line, above it are positive values like 20 dB, 40 dB etc. and negative values below it such as −20 dB, 40 dB etc. For step plot, drag an −180 degree axis line. The values above will be −150°, −120°, −90°, etc., and the values below it will be −210°, −240°, −270°, etc. Beee-502 Automatic Control System Unit-4, Bod Plot Supplementary Notes Diploma in Engg. (Electrical/ Instrail & Control) 5th Semester Instructor: Mohammad Umar Rahman Date: 7.11. 2017 Page 4 of 8 Step-5: Start the plot of magnitude plot by drawing a line along the initial slope of −20 dB/DEC separating 0 db axis from each other on 5 red/s. The slope continues to the first corner frequency of 2 red/s. Since the frequency of the corner is due to a pole, an additional slope of −20 dB/Dec will be added, so the slope will now be −40 dB/Dec. The slope will continue until the second corner frequency of 20 red/s. Since the second corner frequency is also due to a pole, an additional slope of −20 dB/Dec will be added, and hence the slope will now be −60 dB/Dec. This slope will continue for all values ahead ω. Step-6: Step Count: Only denominator conditions will contribute to the step angle. The expression for the step angle is given: tan() () (tan.) GJJ ω ωφ ω ω −−− ==1 90 0 5 0 0 05 Using this expression, we tabulate some of the values of φ WR. t. ω Is as follows: 0.1 1 2 10 20 40 ∞ φ −93.15°−119.42°−140.7°−1 95.29° − 219.28° −240.58°−270° Step-7: Set the value of frequency at which the magnitude plot crosses the 0 dB axis. This price gain is crossover frequency GC ω. Step leave a vertical line at this value of frequency on the plot and read the step angle value. Here, GC. rad/sω = 2 85 and this value has a phase angle at () GC φ ω =−−° 153. Next, determine the value of the frequency at which the magnitude plot crosses the −180° axis. This frequency phase is the crossover frequency PC ω. Leave a vertical line on the PC ω on the magnitude plot and read the corresponding value of magnitude. PC here . Red/sω = 6 3 and magnitude() PC M ω = −13 dB. Step-8: Calculate the stability margin gain margin, ()) GM M ω ==−==0 13 13 dB. Phase margin, () GC() PM φ ω = =−= 180 180 153 27 Since both margins are positive, the system is stable. A bod plot prepared by the software is shown here and all the values given here are for reference only. The closer your values are to these values, the more accurate your Bode plot Maybe. 5. BEEE-502 Automatic Control System Unit-4, Bod Plot Supplementary Notes Diploma in Engg. (Electrical/ Instrail & Control) 5th Semester Instructor: Mohammad Umar Rahman Date: 7.11. 2017 Page 5 of 8 Fig 1. Bode plot of example 1 Example 2: ())()) Bode plot draw of unity response system with further advantages such as (SGS++40 2 5) also determine the profit margin, phase margin and stability of the system. Workaround: Repeat the steps in previous example step-1: Change the transfer function to static form at a time (() ()(). (S.H.S.=++40 4 2 5 1 0 5 1 0 2 Step-2: Convert to Sinusoidal Form. GJJ ωωω ω ω + + = 0 5 01 2 4 1 6. Beee-502 Automatic Control System Unit-4, Bod Plot Supplementary Notes Diploma in Engg. (Electrical/ Instrail & Control) 5th Semester Instructor: Mohammad Umar Rahman Date: 7.11. 2017 Page 6 of 8 Phase-3: Different parts of the plot (i) Continuous Duration: K = 4 (ii) Type of system: 0, this means the initial slope is 0 dB/Dec, and the initial magnitude is 20 log k = 20 log 4 = 12.04 dB (iii) Corner frequency: c1 c2 rad/s rad, . ω ω = 1 1 2 5 0 5 0 2 Step-4: Draw reference slopes and axes. Step-5: Draw the magnitsky plot. Step-6: Draw Phase Plot, Tan Tan (() (.) G J H Jφ ω −1 1 0 5 0 2 Using this expression, tabulation some values of φ WR. t. ω Is As follows: 0.1 1 2 5 10 20 ∞ φ −40.08°−37.87°−66.80°−11 3.2° − 142.1° −160.25°−180° Step-7: Get cross-over and phase cross-over frequencies and corresponding values of phase and magnitude. } GC GC PC PC. Red/S, Red/S, DBM ω φ ωω ω = ∞ = ∞ 5 18 115 Step-8: Stability Margin Gain Margin, () GM M ω = −∞ = +∞0 0 dB phase margin, () GC PM φ ω = 180 180 115 65 phase plot curve is the symbol for −180 degree axis at high frequencies and the profit on high crossover is negative that GM +∞. Since both PM and GM are positive, the system is stable. Also GM is infinite, therefore, the system is naturally stable. 7. BEEE-502 Automatic Control System Unit-4, Bod Plot Supplementary Notes Diploma in Engg. (Electrical/ Instrail & Control) 5th Semester Instructor: Mohammad Umar Rahman Date: 7.11. 2017 Page 7 of 8 Figs 2. Example 2 Bod plot of Example 3: Determine the open loop transfer function of a system whose magnitude bod plot is shown below.   Figure 2. Example 3 Bode plot of solution: We see that the initial slope of the Magnitsky Bode plot is 0 d/2. At the same time, its initial intensity is 20 dB. Therefore, the log log of K = ⇒ = ⇒ = 20 120 10 20 8. Beee-502 Automatic Control System Unit-4, Bod Plot Supplementary Notes Diploma in Engg. (Electrical/ Instrail & Control) 5th Semester Instructor: Mohammad Umar Rahman Date: 7.11. 8 of 2017 Page 8 ω1 = 10 Red/S and second corner frequency being zero is the frequency of one corner due to the pole ω2 = 1000 is the frequency of a corner due to zero at red/s. Therefore, we can write as TF: () ST GS ω ω − ⎛ ⎞⎜ ⎟ ⎜ +⎟ ⎜ ⎟ ⎜ ⎟⎜ + ⎝ ⎠ = = ⎛ ⎞ + ⎜ ⎟ ⎜ +⎟ ⎜ ⎟ ⎜ ⎟⎜ ⎝ ⎠ ++22 3 1 1 1 1 10 10 10 10101010* End of unit - 4 *

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