Phase Margin and Damping Ratio Approximation

Asked 6 years, 1 month ago Modified 3 years, 7 months ago Viewed 16k times

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2

I have read in many texts that the closed loop system damping factor can be approximated as:

$\Phi_m = 100 * \zeta$

With Φ_m as the phase margin and ζ as the damping ratio.
The actual relation between the two is more complicated and I think requires numerical method to solve.

$$\Phi_M = 90 - \tan^{-1}\frac{\sqrt{-2\zeta^2+\sqrt{1+4\zeta^4}}}{2\zeta}$$
$$= \tan^{-1}\frac{2\zeta}{\sqrt{-2\zeta^2+\sqrt{1+4\zeta^4}}}$$

How is the approximation made in a second order control system, and when is it valid to consider the approximation (what's the range of the phase margin)?

control-system phase-margin damping-factor

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edited Jan 6, 2019 at 21:38
chossenger
103 5

asked Jun 22, 2016 at 10:54
Ashik Anuvar
708 2 12 21

Do you have a link to the assertion? – Andy aka Jun 22, 2016 at 11:06

It's a design ROT for systems that are, ostensibly, 2nd order, and should be treated as such. – Chu Jun 22, 2016 at 13:59

2 Answers

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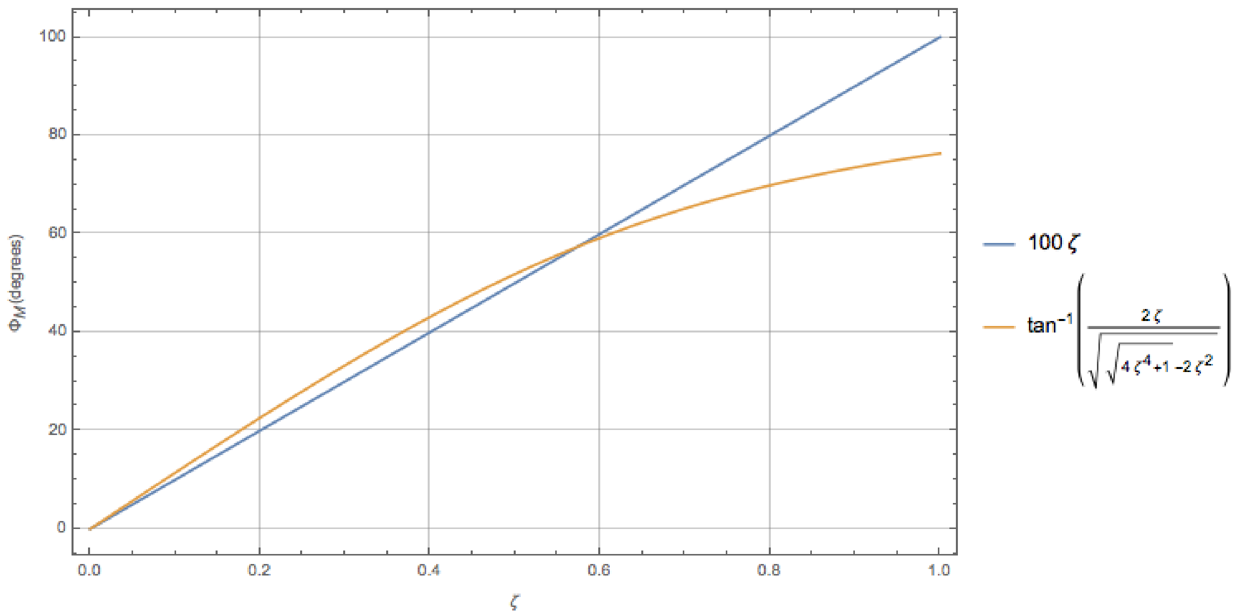
7

You can see when the approximation is good simply by plotting the two curves.



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edited Jun 22, 2016 at 14:29

answered Jun 22, 2016 at 14:24

Suba Thomas
1,234 10 20

3

The mentioned approximation for the phase margin (100*damping factor) applies to a second order system only when the damping factor is smaller than 1/SQRT(2)=0.7071 or when the phase margin is smaller than app. 65 deg. (Ref.: R.C. Dorf, Modern Control Systems, 6th edition, Addison-Wesley).

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answered Jun 22, 2016 at 12:05

LvW
22.8k 2 21 46