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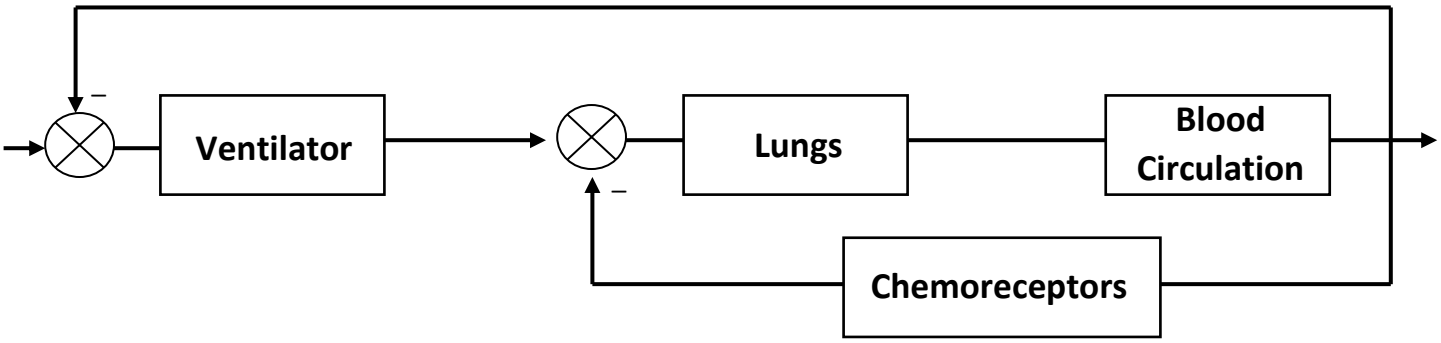
CONTROLLER DESIGN ON MATLAB PLATFORM BY ANALOG FREQUENCY RESPONSE

OBJECTIVE

- To design a cascaded ventilator transfer function for an analog respiratory system and specifications provided

TRANSFER FUNCTION AND BLOCK DIAGRAM



The transfer function for lungs is given by:

$$\frac{1}{s+1}$$

And Blood Circulation is represented with a 3rd order transfer function, as shown below:

$$0.1\frac{(s+0.2)^2}{(s+0.5)^2(s+0.15)}$$

Chemoreceptors are realised only with a gain block with K = -1.

CONSTRAINTS AND DESIGN

It is required for the CLTF to maintain a Phase Margin of 45°. Apart from that, the chemoreceptors could get flawed resulting in value ten times that of typical value and time constant of lungs could worsen up by ten times as well. So, all the effects need to be taken care of in design

Assuming the most straightforward transfer function for the ventilator taken as:

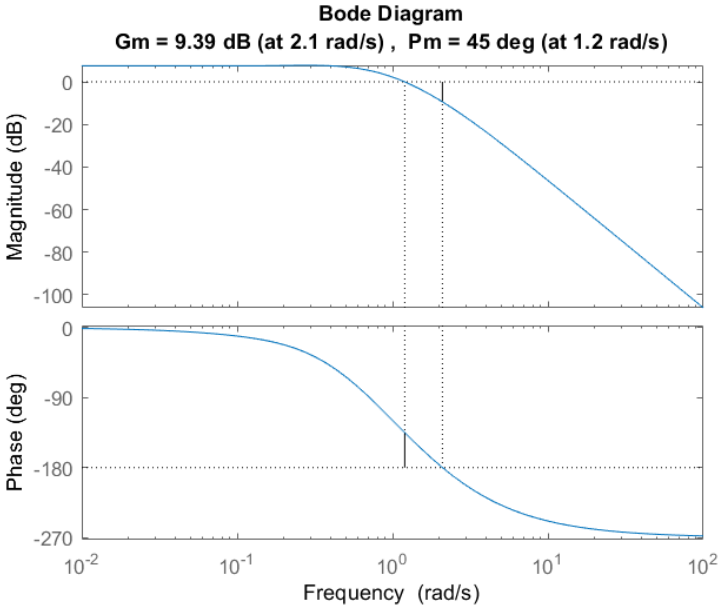
$$\frac{g}{s+2}$$

While choosing the pole is to take such that the pole of the ventilator transfer function lies away from the poles of the respiratory system. This way, the phase margin would not change arbitrarily. Thus, a simple integrator could have worked out as well. g is worked out accordingly to satisfy the constraint.

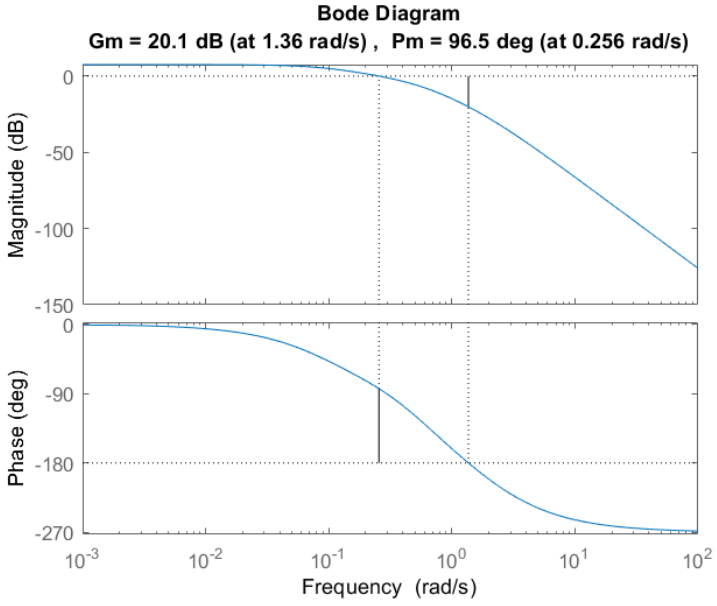
If the worst case is taken care of all the possibilities then the system would be able to perform as per the specifications. The cases, therefore, would be no variation (a time constant variation, chemoreceptor gain variation, both the effects at the same time.

This leads to a solution of 'g' as 49.55 thus transfer function becomes: $49.55/(s+2)$

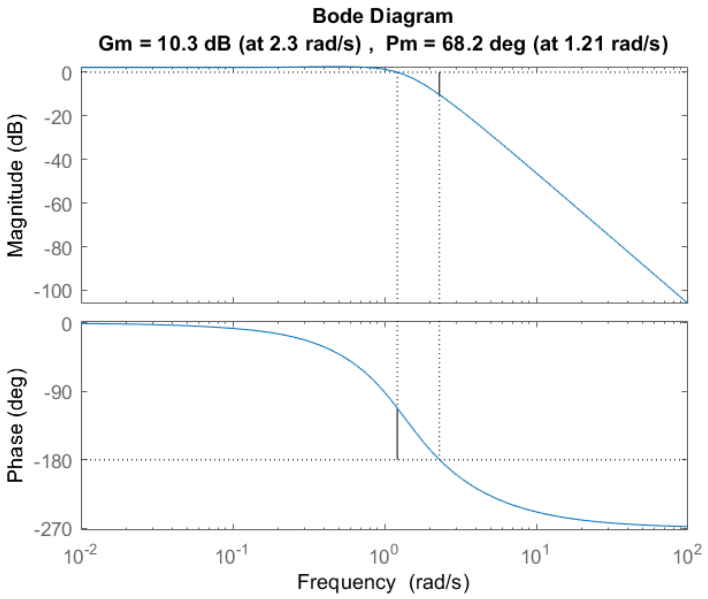
The magnitude and phase plot with no variation in any parameter thus obtained is as



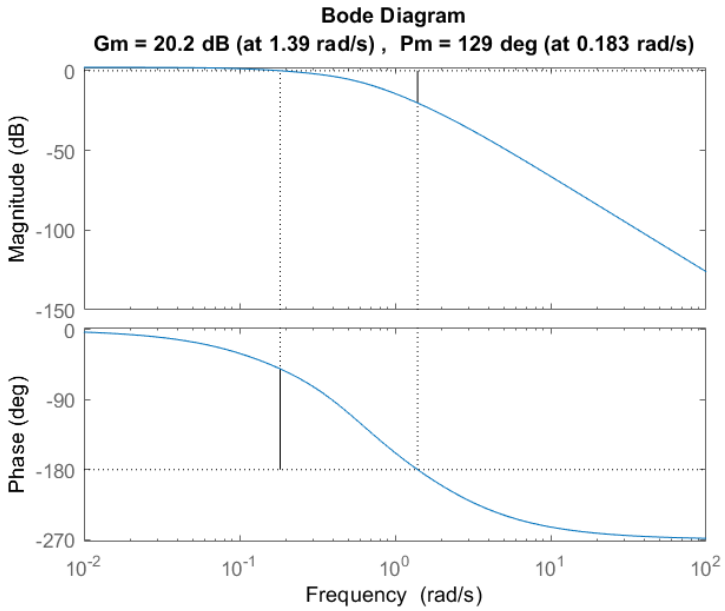
No variation of any parameter



Lungs' time constant worst case



Chemoreceptor's worst case



Both variations at their worst case

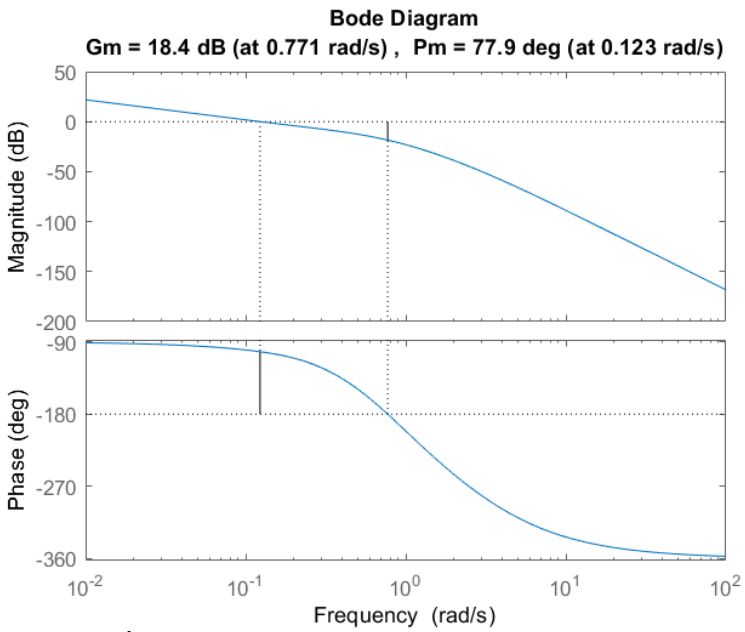
This shows that the chemoreceptor's gain causes a lower change in Phase crossover frequency however for Lung's time variation it changes by a significant amount as well as the change in behaviour of phase plot is visible too. It mostly pulled back the pole stretching the phase plot.

However the gain for the ventilator thus designed is high compared to others. We could make another transfer function with two poles and analyse the same.

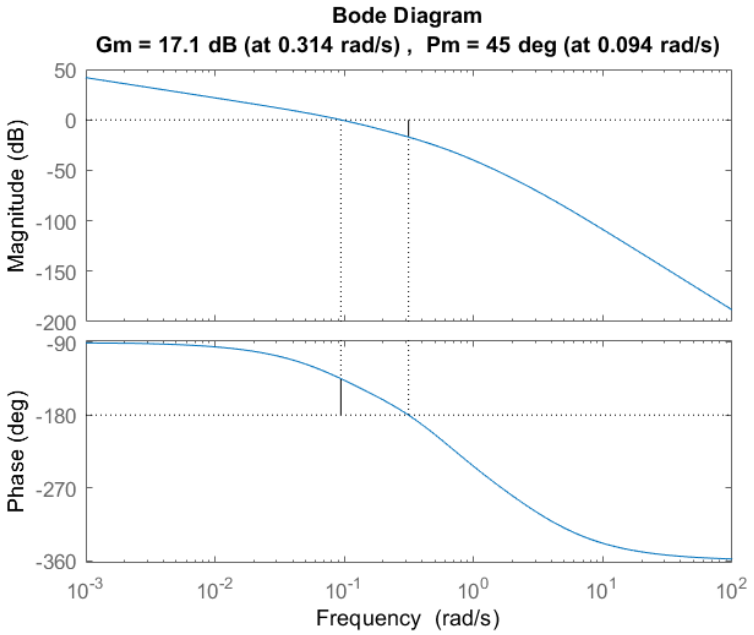
The bode plot for the ventilator transfer function given by:

$$\frac{3.837}{s^2 + 3s}$$

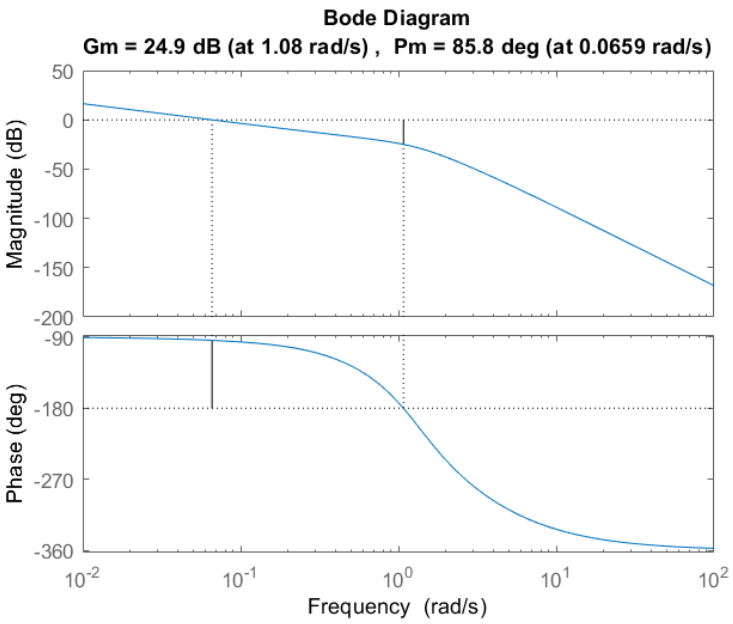
Where we have a pole at origin and another far away across the poles of the respiratory system.



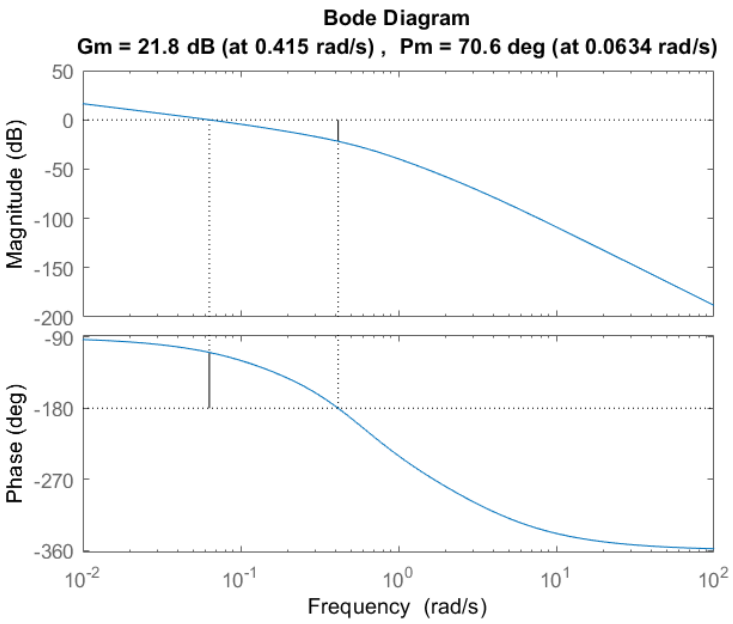
No variation of any parameter



Lungs' time constant worst case



Chemoreceptor's worst case



Both variations at their worst case

Along with decreased gain, the variations about Phase crossover frequency are better. Apart from that, Gm also stays more or less constant. This time the limiting case was created by Lungs' time constant thus is designed accordingly to be at 45°.

The ventilator was designed for a zero and a pole as well however no significant improvements were observed in terms of Pm variations.