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A frequency domain design of PID controller for an AVR system

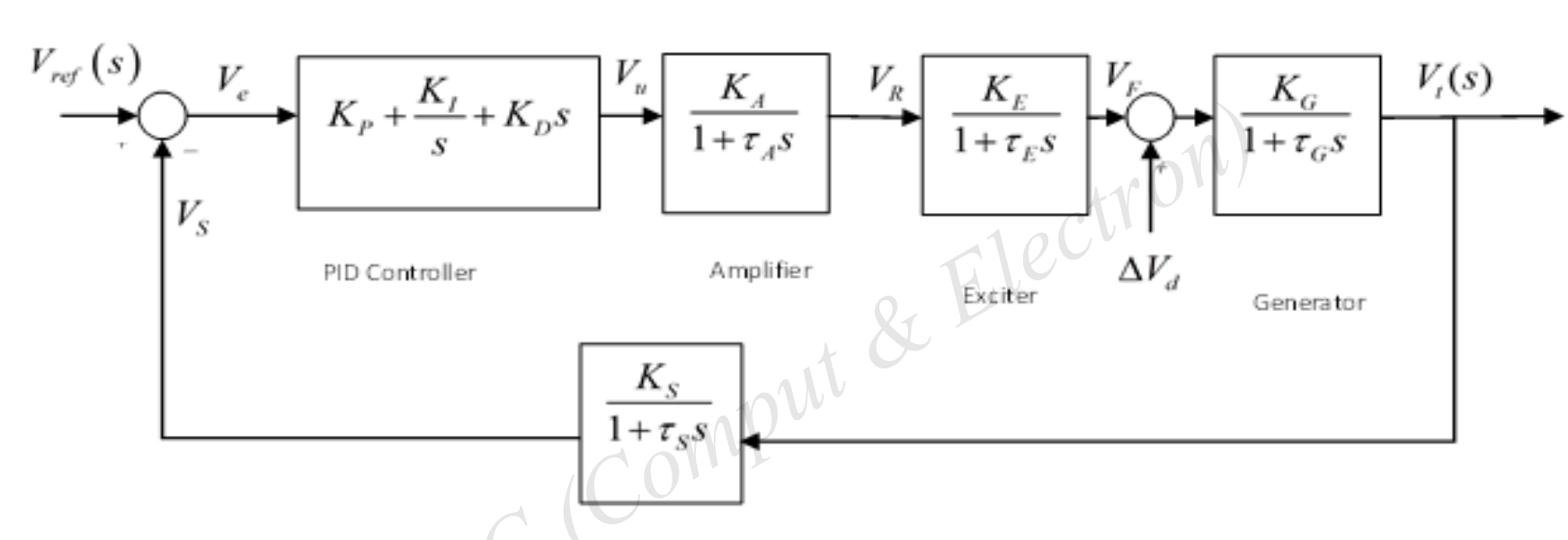
Key words: Automatic voltage regulation (AVR), PID controller, Frequency response matching

Corresponding author: Md Nishat Anwar
E-mail: nishatnith@gmail.com

Introduction

- The proportional-integral-derivative (PID) controller with its variants is the most widely accepted controller for industrial applications.
- The automatic voltage regulation (AVR) systems continuously adjust the field excitation to maintain the generator terminal voltage at a specified level.
- Numerous PID controllers for the AVR system are available in the literature.
- A new PID controller design method based on approximate frequency response matching has been presented in this paper.

Design method (I)



$$G_P(s) = \frac{K_A K_E K_G}{(1+\tau_A s)(1+\tau_E s)(1+\tau_G s)}$$

Desired reference model: $M_{r,y}(s) = \frac{P(s)}{Q(s)}$

For frequency response matching between the designed and the desired systems,

$$G_{r,y}(s)\Big|_{s=j\omega} = \frac{C(s)G_P(s)}{1+C(s)G_P(s)F(s)}\Bigg|_{s=j\omega} \cong M_{r,y}(s)\Big|_{s=j\omega}$$

Design method (II)

The controller comes out:

$$C(s)\big|_{s=\mathrm{j}\omega} \cong \left.\frac{M_{r,y}(s)}{G_P(s)[1-M_{r,y}(s)F(s)]}\right|_{s=\mathrm{j}\omega}$$

$$= \left.\frac{P(s)(1+\tau_A s)(1+\tau_E s)(1+\tau_G s)(1+\tau_s s)}{K_A K_E K_G[Q(s)(1+\tau_s s)-P(s)K_S]}\right|_{s=\mathrm{j}\omega} = H(s)\big|_{s=\mathrm{j}\omega}$$

H(*s*) is approximated by the PID controller *C*(*s*) through frequency response matching at two low frequency points ω_0 and ω_1 as given by

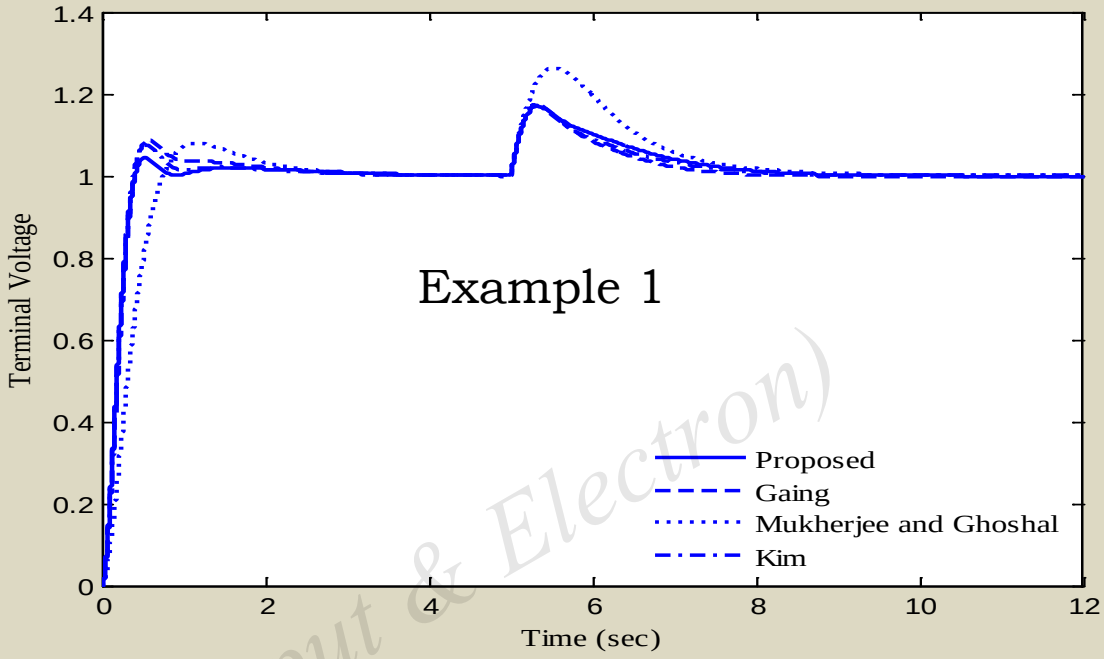
$$\boldsymbol{A}\bar{\boldsymbol{x}} = \bar{\boldsymbol{b}} \qquad \boldsymbol{A} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1/\omega_0 & \omega_0 \\ 1 & 0 & 0 \\ 0 & -1/\omega_1 & \omega_1 \end{bmatrix},$$

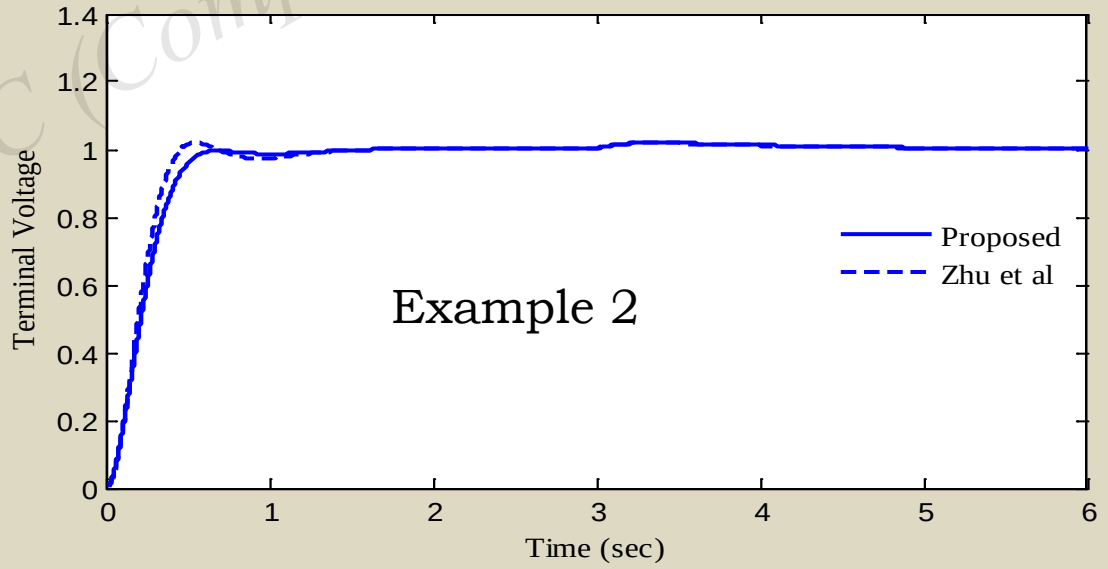
$$\bar{\boldsymbol{x}} = \begin{bmatrix} K_\mathrm{P} & K_\mathrm{I} & K_\mathrm{D} \end{bmatrix}^\mathrm{T}$$

$$\bar{\boldsymbol{b}} = \begin{bmatrix} H_\mathrm{R}(\omega_0) & H_\mathrm{I}(\omega_0) & H_\mathrm{R}(\omega_1) & H_\mathrm{I}(\omega_1) \end{bmatrix}^\mathrm{T}$$

where $H_\mathrm{R}(\omega) + \mathrm{j}H_\mathrm{I}(\omega) = H(s)\big|_{s=\mathrm{j}\omega}$

Simulation results





Conclusions

- A new frequency domain model matching method has been described for the design of a PID controller for an AVR system.
- The method does not require any elaborate frequency response analysis or mathematically involved optimization technique.
- The method is mathematically simple and its computational burden is very small.