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A differential control method for the proportional directional valve

Key words: Differential control method, Frequency response, Proportional directional valve, Spool displacement feedback

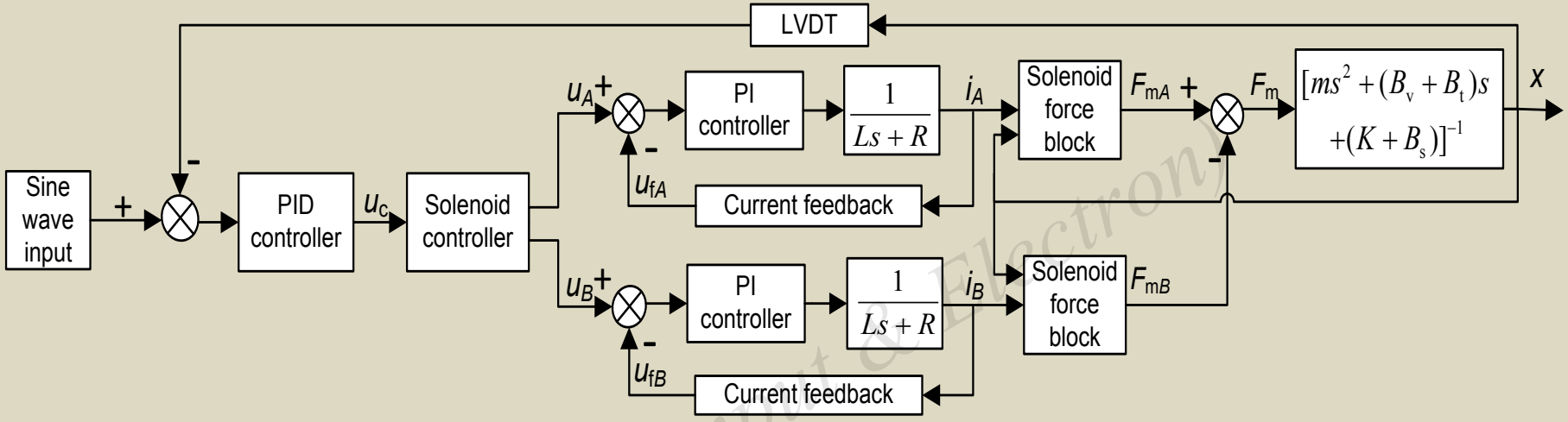
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Introduction

- Electro-hydraulic proportional valves have been widely used in contamination prevention, failure maintenance, etc., including some high-precision applications.
- The performance of the proportional valve is improved by improving hardware of the valve including mechanical structure and electronic devices.
- We develop a control strategy to energize two solenoids simultaneously by differential signals, which obviously enhances the response of the proportional valve.

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Design method (I)



The composition of the solenoid forces:

$$F_{\mathrm{m}}(i(t),x(t)) = F_{\mathrm{m}A}(i_A(t),x(t)) - F_{\mathrm{m}B}(i_B(t),x(t)),$$

The solenoid controller:

$$u_A(t) = u_0 + u_{\mathrm{c}}(t),\quad u_B(t) = u_0 - u_{\mathrm{c}}(t).\quad i_A(t) = i_0 + i_{\mathrm{c}}(t),\quad i_B(t) = i_0 - i_{\mathrm{c}}(t).$$

The composition of solenoid forces is

$$F_{\mathrm{m}}(i,x) = F_{\mathrm{m}A}(i_0 + i_{\mathrm{c}}(t),x(t)) - F_{\mathrm{m}B}(i_0 - i_{\mathrm{c}}(t),x(t)).$$

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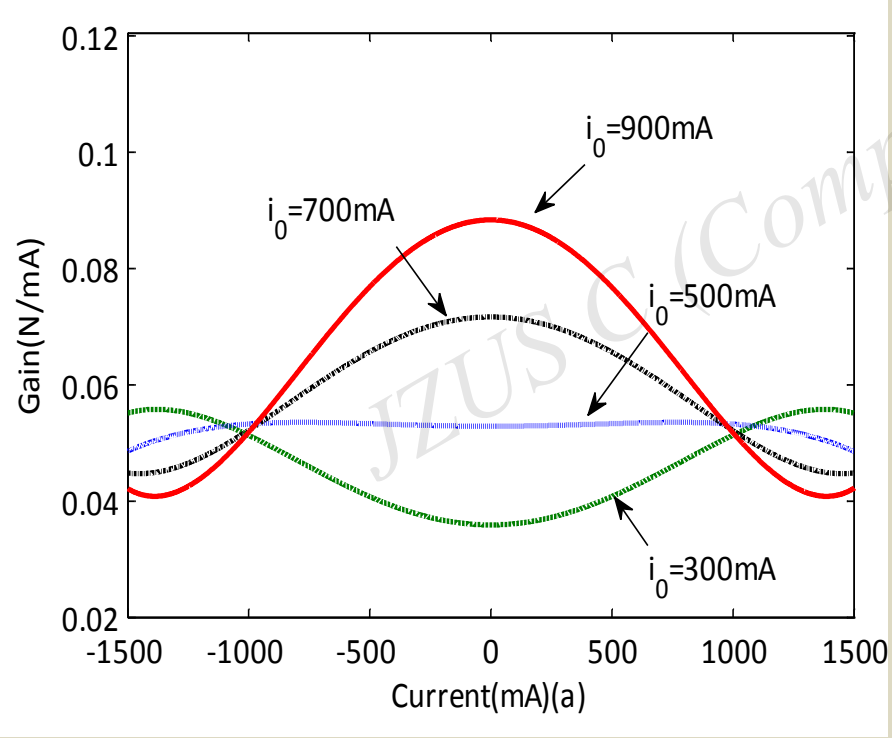
Design method (II)

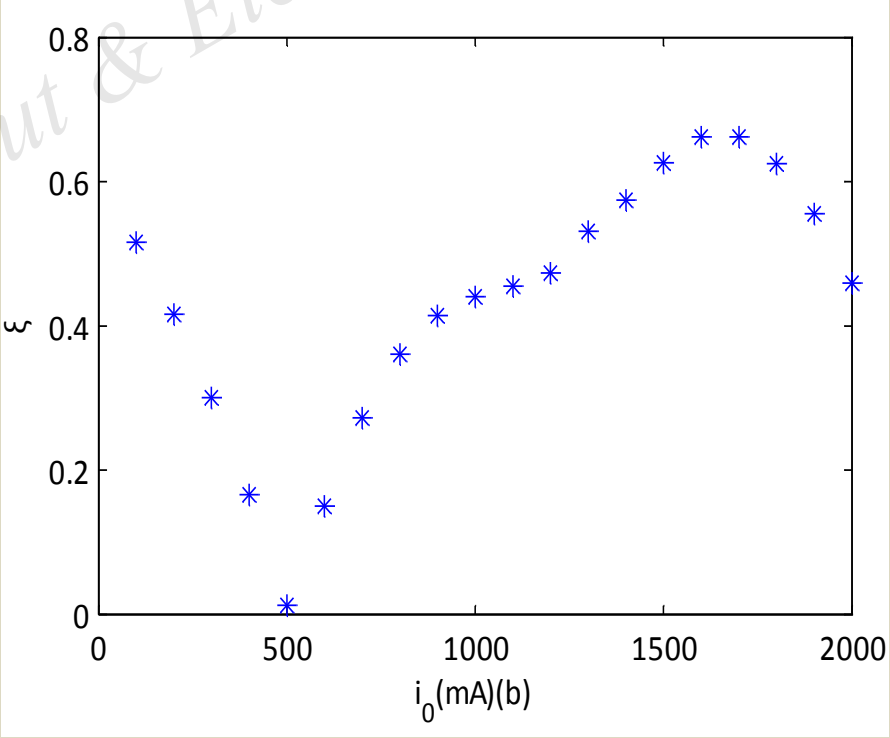
The current force gain is

$$g(i)=\frac{\partial F_{\mathrm{Dm}}(i,x)}{\partial i}.$$

The variation of the gain is

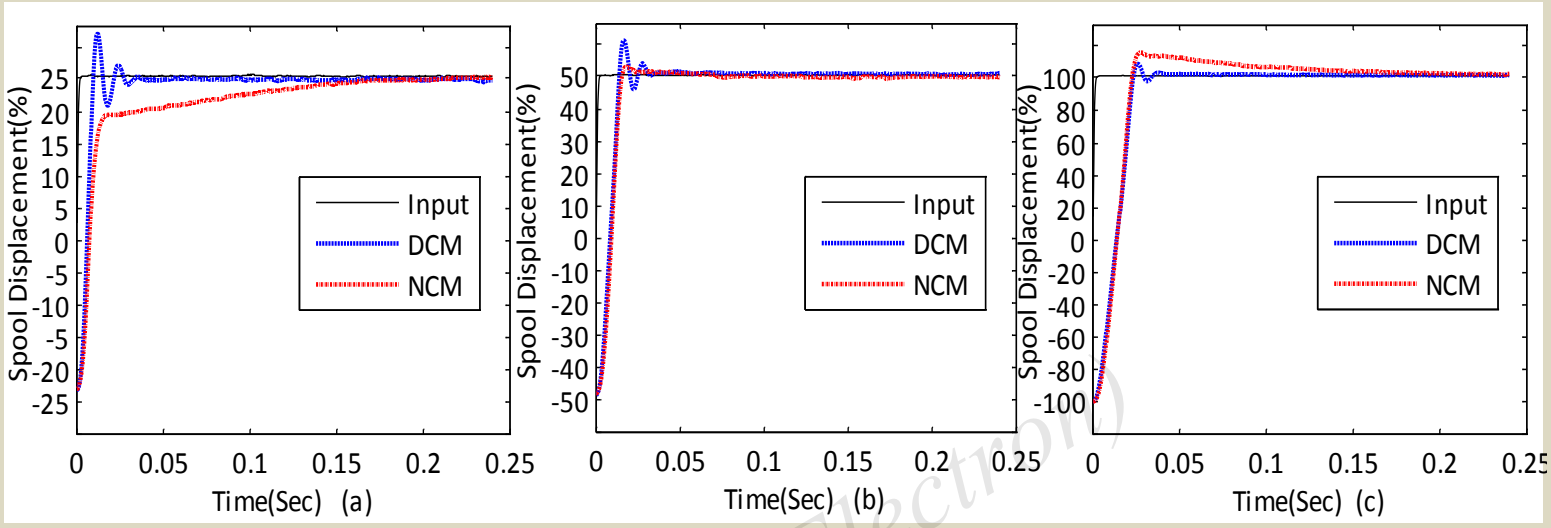
$$\xi=\frac{\max(g(i))-\min(g(i))}{\max(g(i))}.$$

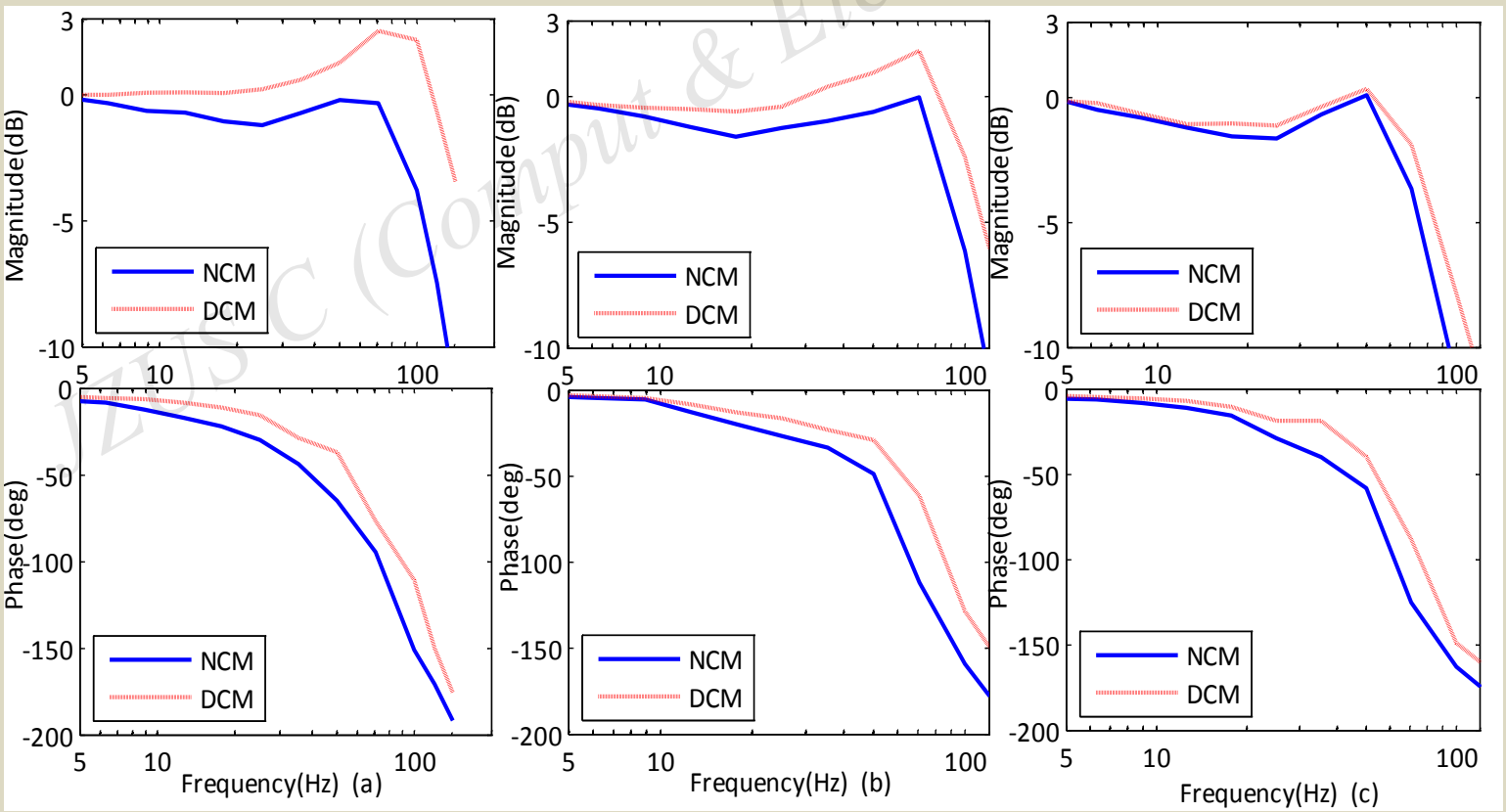




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Experiment validation





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Conclusions

- This paper mainly presents a new control strategy named the differential control method for the proportional directional valve with spool position feedback, to improve the dynamic and static characteristics.
- Comparisons of DCM and NCM in a nonlinear model were made. Experiments proved that our method is practical and effective.
- Using the proposed method, the frequency response of the valve can be enhanced, and the waveform distortion can be greatly reduced. The proportional valve can be used in applications requiring better frequency response and higher precision.

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