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# Proportional directional valve based automatic steering system for tractors

**Key words:** Automatic steering system, Hydraulic circuit, Proportional directional valve, Proportional-integral-derivative (PID) control

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# Motivation

- As a key technology in farming equipment navigation, the control accuracy of an automatic steering system determines the control accuracy of the automatic navigation system.
- The traditional automatic hydraulic steering system is usually designed for oil supply systems with either constant current or constant pressure, sometimes even for a designated tractor type, making the system neither adaptable nor promotable.
- Most of the common full-hydraulic automatic steering valves lack an unloading circuit in the neutral position (Wu *et al.*, 2009; Shen *et al.*, 2014), which will result in high pressure, large energy consumption, temperature rise, and serious leaking problems during long-time operations.

# Main idea

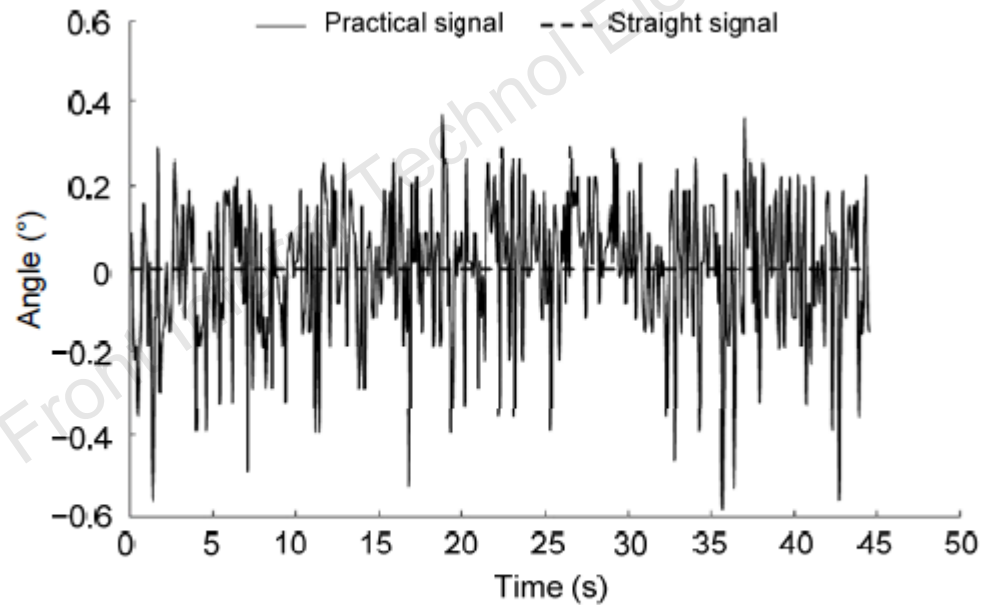
- In view of the abovementioned problems, here we present a proportional integrated control valve block for different steering hydraulic systems.
- The application of a 5-way-3-position proportional directional valve maintains the lowest pressure under load feedback and stays at the neutral position during unloading, thus meeting the requirements for steering.

# Method

1. Considering the basic characteristics of the hydraulic steering system found in most agricultural equipment and the design principles they follow, a multifunctional automatic hydraulic steering valve circuit is developed (Fig. 2).
1. Establish a controller based on the STC90C516RD and the incremental PID control algorithm.
2. Carry out straight-line tracking and sinusoidal tracking experiments on a Foton Lovol TG1254 tractor to test the response and tracking performance of the PID control valve system.

# Major results

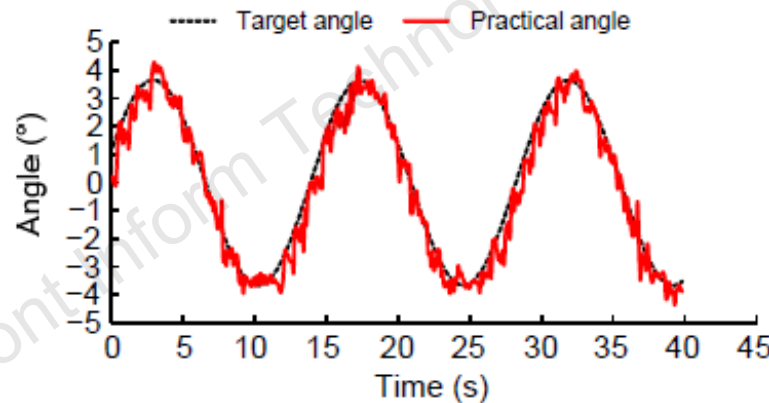
- We set the target angle at zero, and the results of straight-line tracking are shown in Fig. 10:



**Fig. 10** Graph of straight-line tracking on the concrete way

# Major results (Con'd)

- We set a sine wave at  $3.6^\circ$  amplitude for sinusoidal tracking. The results are shown in Fig. 11:



**Fig. 11** Graph of sinusoidal tracking during the tractor's walking process

# Conclusions

- The proportional integrated control valve block applicable to a variety of hydraulic steering systems has been developed.
- The tracking test results showed that the automatic steering control system has good tracking performance with a fast response, thus meeting the navigation control requirement of agricultural equipment to a certain extent.