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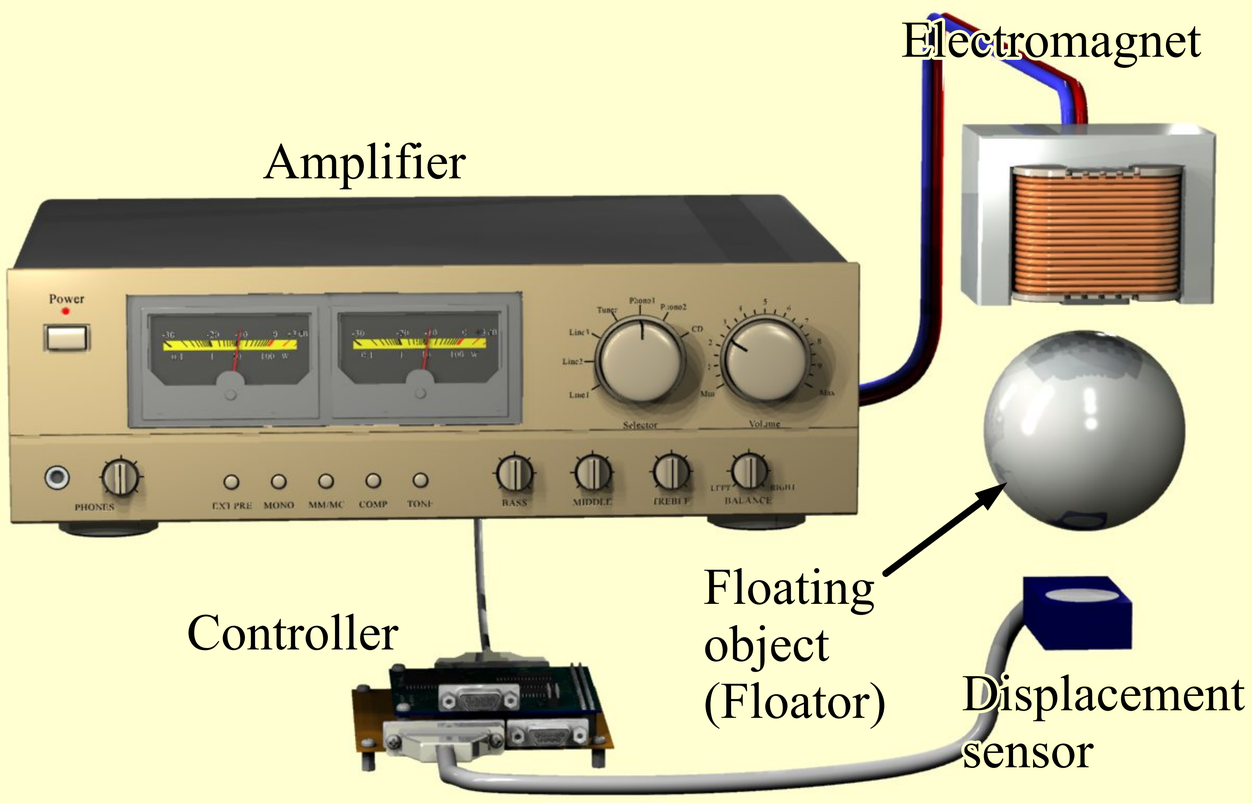
Stabilization of magnetic suspension system by using First-Order Reset Element

in Classical Control

Magnetic suspension systems have unstable and no-damping characteristics.

At least, PD feedback is necessary to stabilize the system.



PD control: Proportional and Derivative feedback
Proportional element produces: restoring force.
Derivative element produces: damping effect.

+With Integrator: PID or Zero-power control

However, when the gain of derivative element is set too high, the robustness of system is deteriorated.

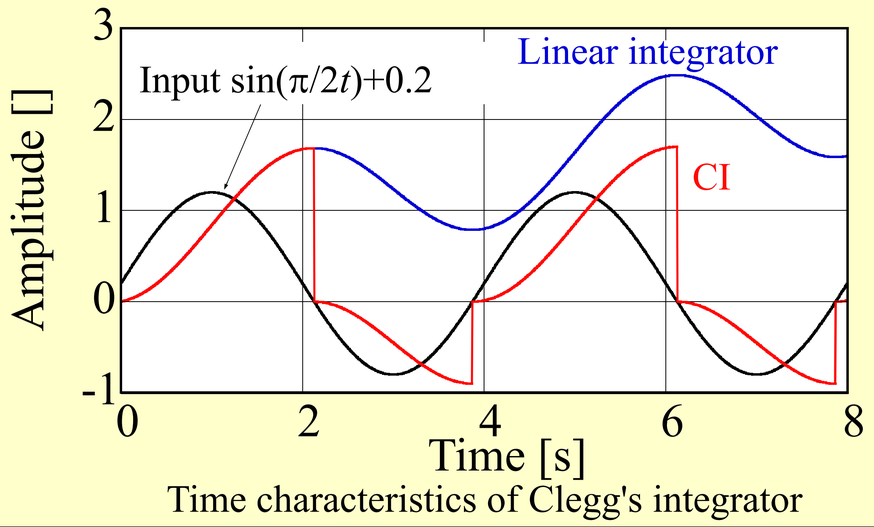
In real system
Included noise in high frequency region.

Producing the damping without the derivative feedback element is desirable.

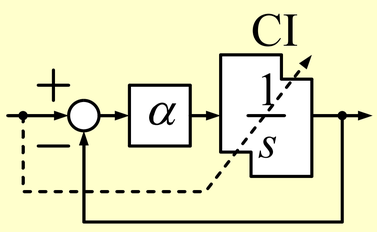
Reset Elements

Output of element jumps to target when condition is met.

Clegg's integrator or first-order reset element are famous reset element.
The output of Clegg's integrator is jumped to zero when input crosses 0.
The FORE is first order low pass filter using a linear integrator replaced with CI.



Time characteristics of Clegg's integrator

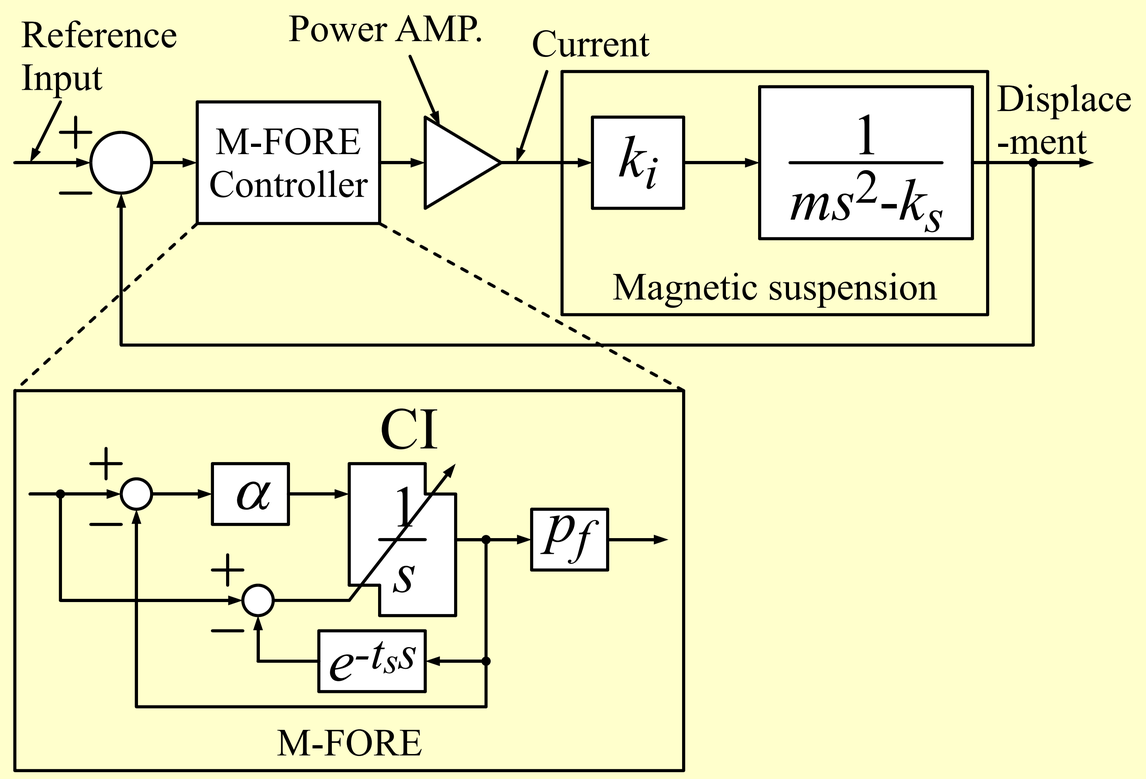


FORE
Input crosses 0
CI reset to 0

Stabilized by FORE

The magnetic suspension system can not be stabilized and damped by the conventional CI or FORE controller.

The reset condition is modified.
(called M-FORE in this poster)



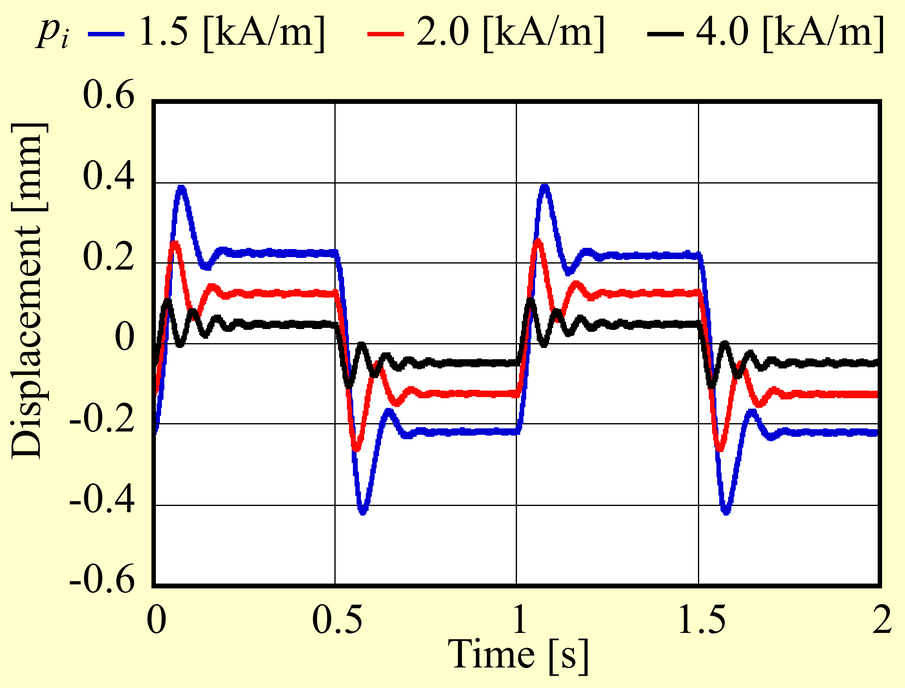
Transfer function of M-FORE in linear operation is:

$$p_f \frac{\alpha}{s+\alpha}$$

The magnetic suspension system can not be stabilized by the linear first-order low-pass filter feedback.

Magnetic suspension controller consist of one M-FORE can produce restoring force and damping.

One M-FORE is equivalent to two elements of P and D.
Derivative element unnecessary!
Use with integrator: "PID like" or "Zero-power like"
When the reset target is changed to the negative value of input, the damping effect is increased.



Time characteristics of displacement in step disturbance input

Proposed a "new" classical control method
using FORE feedback control.

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