AUTOMATICS and AUTOMATIC CONTROL

LECTURE 5

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TRANSFORMATIONS OF BLOCK DIAGRAM

In the case of more complicated systems, which consists of many elements and several feedback loops it is advisable to use the transformations of block diagrams in order to simplify them.

1. **In series connection:**

2. **Parallel connection:**

3. **Feedback:**

4. **Shifting a summing junction before an element:**

5. **Shifting a summing junction after an element:**

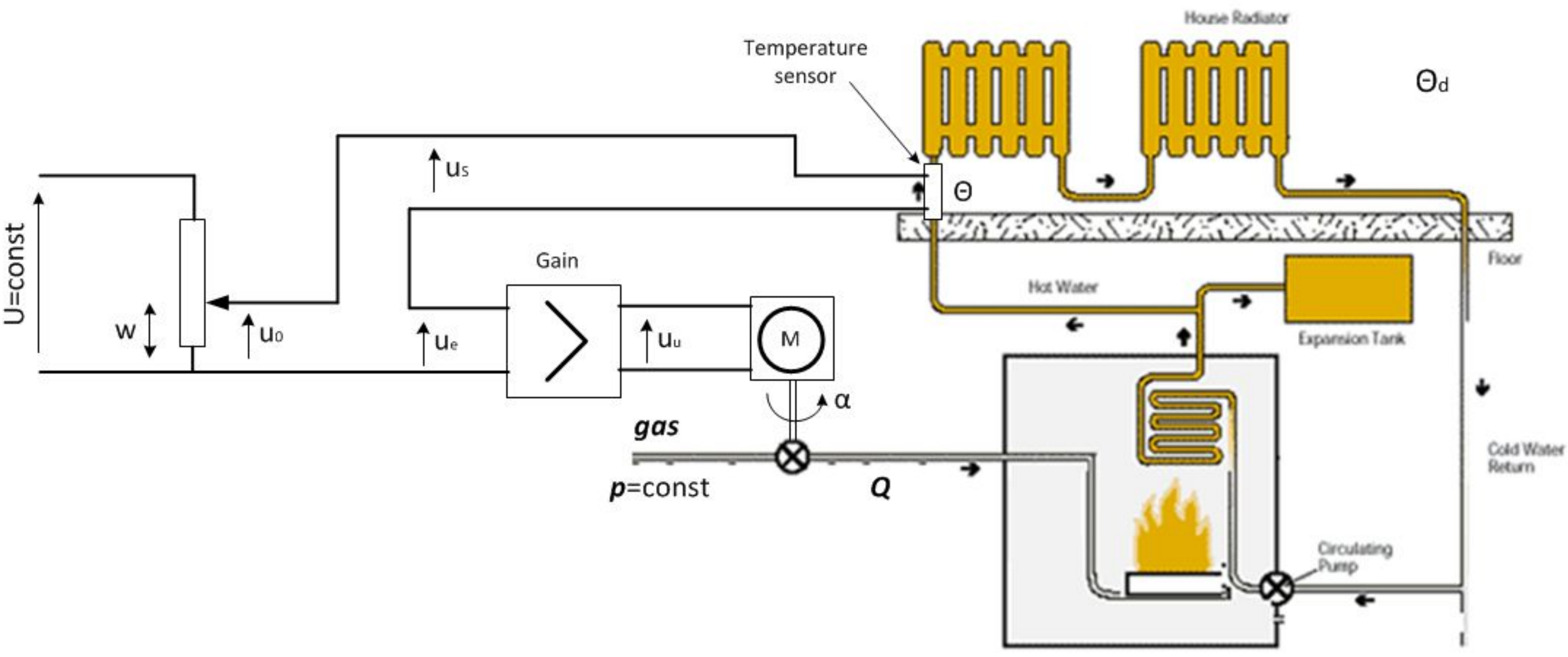
6. **Shifting a branching before an element:**

7. **Shifting a branching after an element:**

STRUCTURE OF CLOSED-LOOP CONTROL SYSTEMS

Example of closed-loop control system:

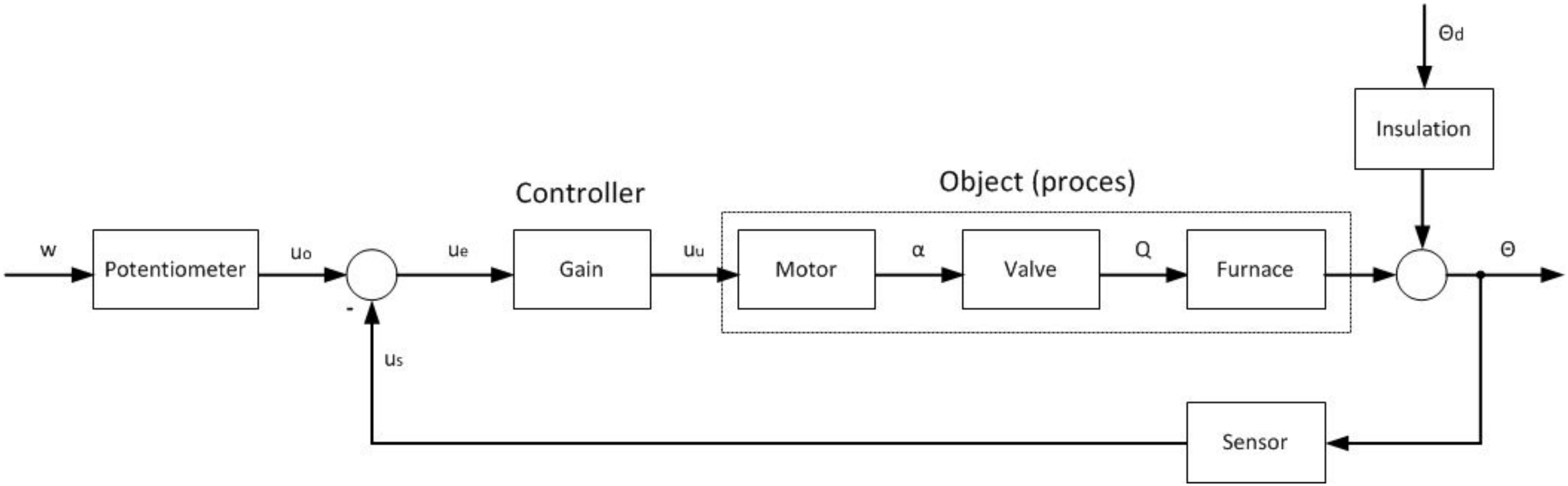
Gas furnace (temperature control in central heating system) :



STRUCTURE OF CLOSED-LOOP CONTROL SYSTEMS

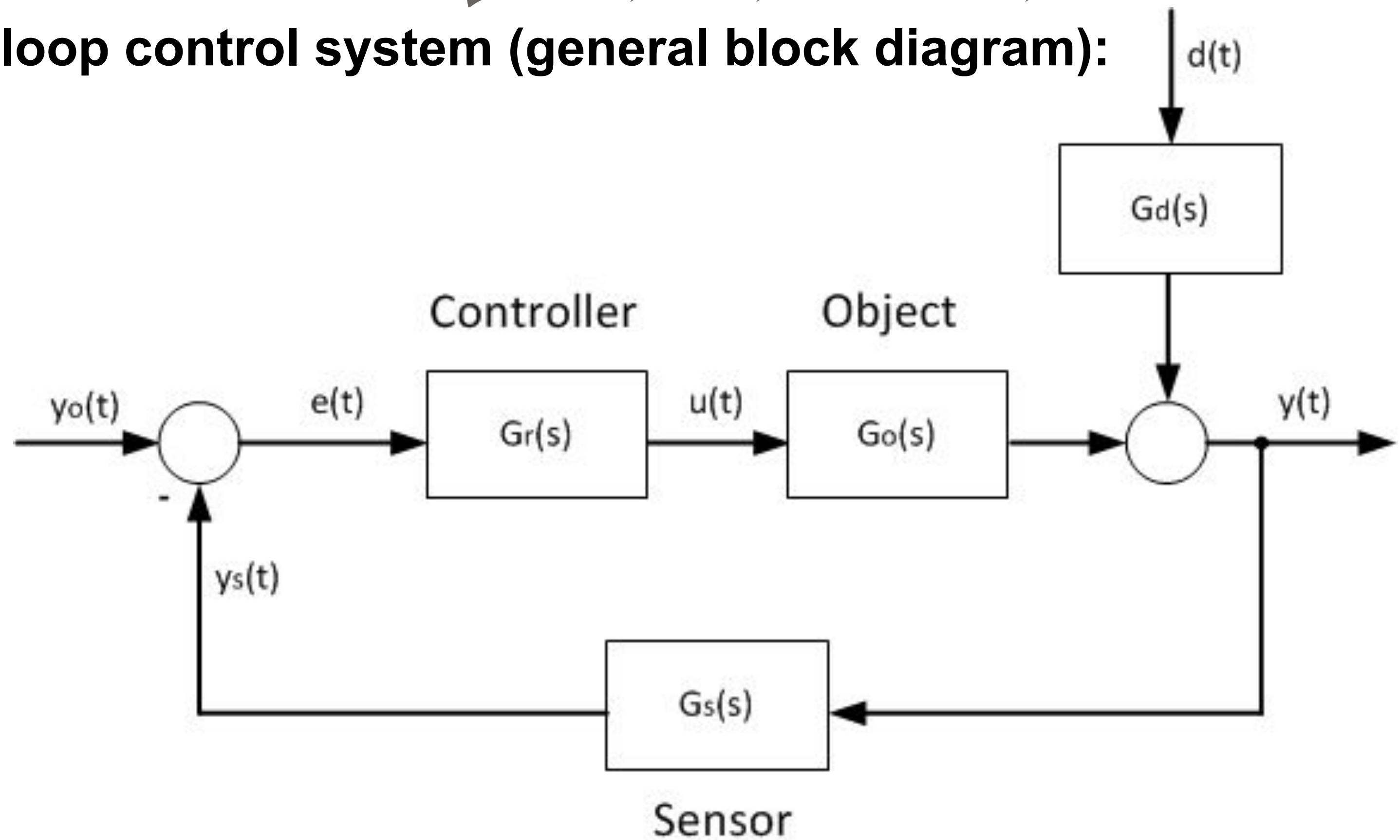
Example of closed-loop control system:

Gas furnace (block diagram) :



STRUCTURE OF CLOSED-LOOP CONTROL SYSTEMS

Closed-loop control system (general block diagram):



$y_o(t)$ – reference (set point, input signal) $u(t)$ – control signal

$y(t)$ – controlled signal (output signal) $d(t)$ - disturbance

$y_s(t)$ – measured controlled signal ($y_s(t) \approx y(t)$)

$e(t)$ - error $e(t) = y_o(t) - y_s(t)$

STRUCTURE OF CLOSED-LOOP CONTROL SYSTEMS

Closed-loop control system (general equations):

$$Y(s) = G_r(s) \cdot G_o(s) \cdot E(s) + D(s) \cdot G_d(s)$$

$$E(s) = Y_0(s) - Y_S(s) = Y_0(s) - Y(s) G_S(s)$$

$$Y(s) = G_r(s) \cdot G_o(s) \cdot \left(Y_0(s) - Y(s) G_S(s)\right) + D(s) \cdot G_d(s)$$

$$Y(s) = \frac{G_r(s) G_o(s)}{1 + G_r(s) G_o(s) G_S(s)} \cdot Y_0(s) + \frac{G_d(s)}{1 + G_r(s) G_o(s) G_S(s)} \cdot D(s)$$

$$E(s) = Y_0(s) - \left(G_r(s) \cdot G_o(s) \cdot E(s) + D(s) \cdot G_d(s)\right) G_S(s)$$

$$E(s) = \frac{1}{1 + G_r(s) G_o(s) G_S(s)} \cdot Y_0(s) - \frac{G_d(s) G_s(s)}{1 + G_r(s) G_o(s) G_S(s)} \cdot D(s)$$

STRUCTURE OF CLOSED-LOOP CONTROL SYSTEMS

Output-reference response transfer function:

$$G(s) = \frac{Y(s)}{Y_0(s)} \Big/ D(s) = 0 = \frac{G_r(s)G_o(s)}{1 + G_r(s)G_o(s)G_S(s)}$$

Output-disturbance response transfer function:

$$G_D(s) = \frac{Y(s)}{D(s)} \Big/ Y_0(s) = 0 = \frac{G_d(s)}{1 + G_r(s)G_o(s)G_S(s)}$$

Error-reference response transfer function:

$$G_E(s) = \frac{E(s)}{Y_0(s)} \Big/ D(s) = 0 = \frac{1}{1 + G_r(s)G_o(s)G_S(s)}$$

THANK YOU