Engine Room Simulator

ERS-L11 MAN B&W 5L90MC-VLCC
Version MC90-V

USER'S MANUAL

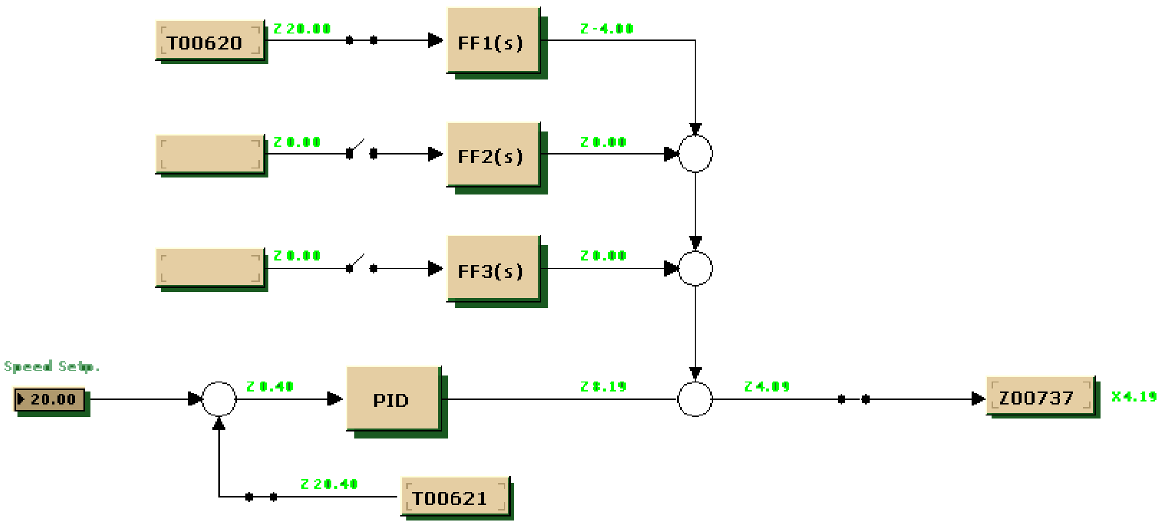
Appendix B

Controllers and Actuators

1 CONTROLLERS AND ACTUATORS - APPENDIX E

1.1 General Controller

The controller consists of a general PID controller with an addition of three possible feed forward signals to the PID output.



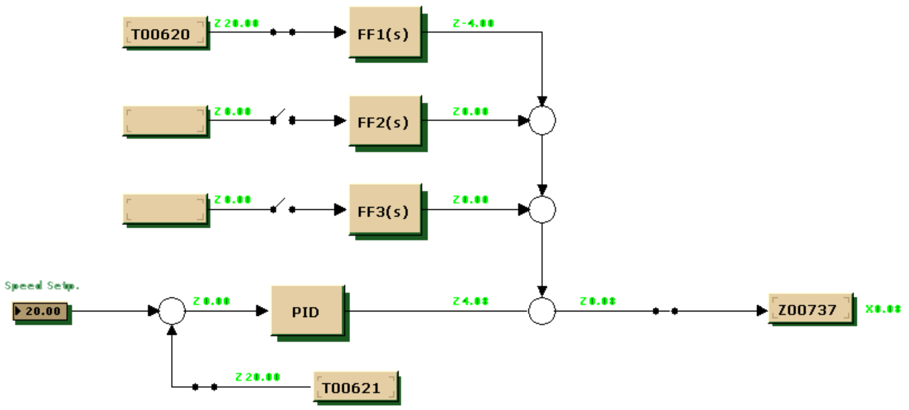
The feed back signal and the 3 feed forward signals can be taken from any variables, and the controller output can update any variable in the simulator. This gives the user a great flexibility in configuring the control system. The feed forward signal should be taken from a variable that after a while will influence the regulated process variable. In this way the controller will use this advanced information to compensate the output and improve the regulation. Each of the Feed Forward transfer functions is of the form:

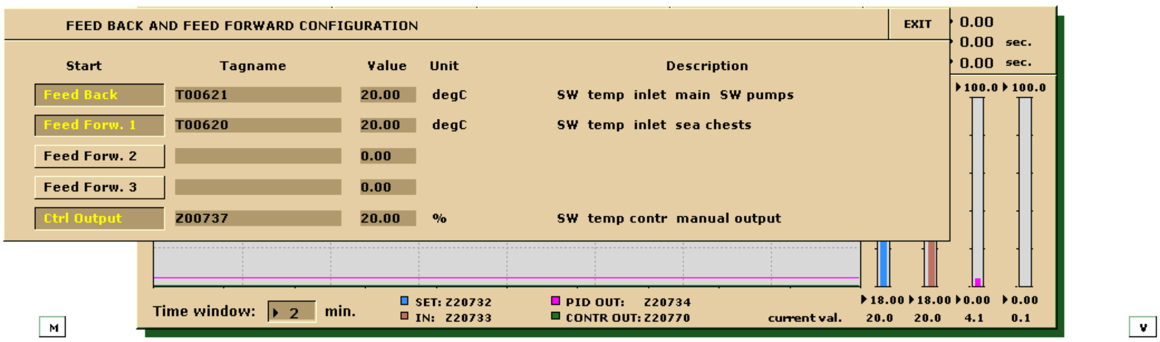
(3-1)
$$H(s) = \frac{K}{(1+T_1 s)(1+T_2 s)}$$

A feed forward signal can, for example, be taken from the difference between two variables (x_1 and x_2) by using the same transfer functions on the two variables, with opposite sign on the K:

$$K * x_1 - K * x_2 = K * (x_1 - x_2)$$

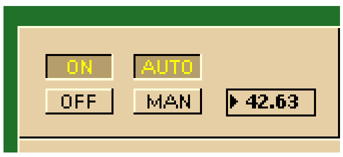
The variable for the feed back and feed forward functions can be chosen from any of the variables present within the model. By clicking on the box for the feed back signal, feed forward signals or the output signal, the configuration menu will popup. The unique tag name for these values is placed in the required feed back, feed forward and output configuration box as shown below.





Example Sea Water system:
In this example the feedback signal is the Sea Water Temp inlet main SW pumps (T00621), and one feed forward signal has been used, namely the SW temp inlet sea chest (T00620). The output signal is connected to the manual output variable of the SW temp controller (Z00737). The SW temp controller is in manual on MD01.

Put the controller in Auto on MD135 to activate.



The unit of the controller gain and feed forward gain is [% / SI-Unit]. "SI-Unit" is the unit of the connected variable. In the above example where the feed back and feed forward signals are taken from temperature measurement, the units will be [%/degC].

1.2 Control System

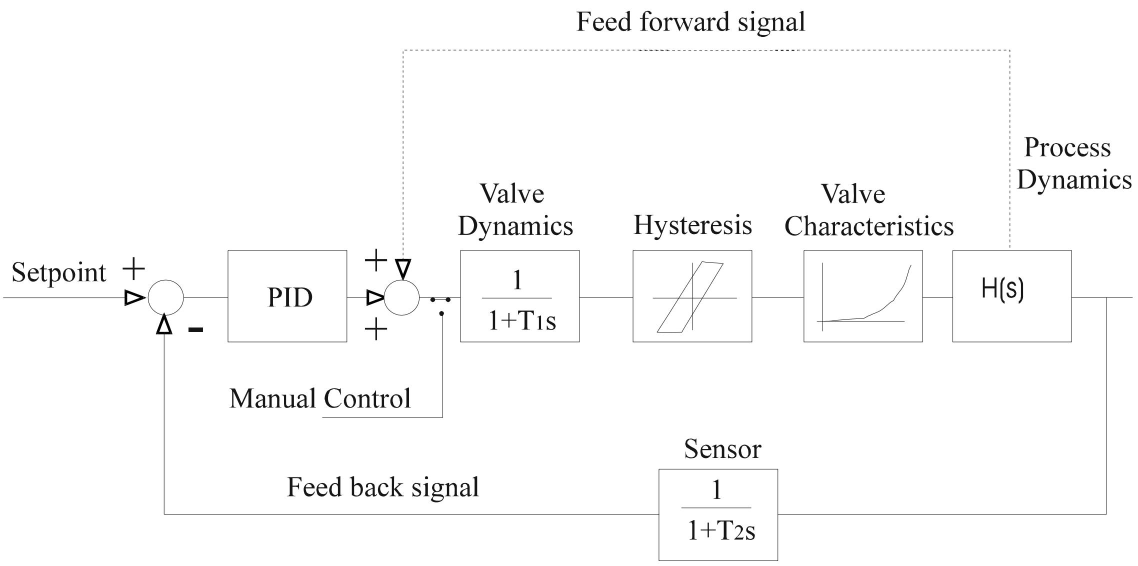
A standard single controller loop consists of the following parts:

- PID controller
- Actuator
- Process
- Sensor

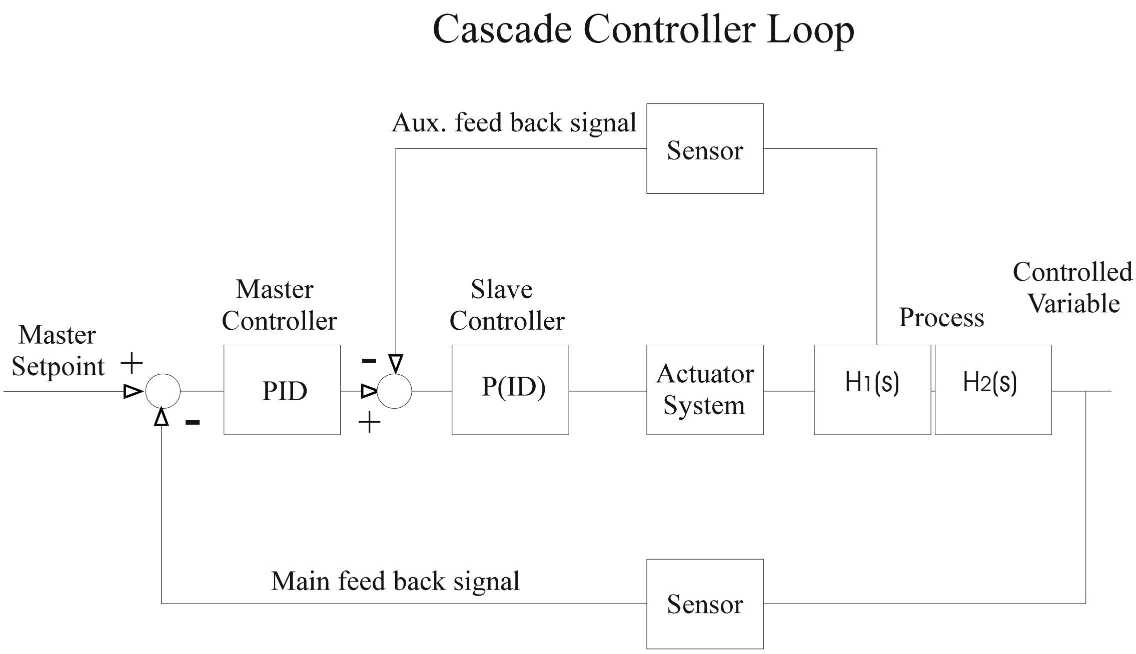
1.2.1 PID Controller

The basic PID controller action can be modified by including "feed forward" signal(s). This is another efficient way of improving control functions. These "modifications" are found in the Steam system. See figure below.

Standard PID Controller Loop



It is also possible to improve the quality of control further by introducing “cascade control”. The control function is then carried out in two steps. The slave controller controls the front part of the process and the master controller checks the final result and sends correction signal as a setpoint command to the slave controller. See figure below.



1.2.2 Controller Tuning

The controllers can be tuned according to “Siegler Nichols” procedure:

a. Remove the reset action by putting the Integral (I) = 0

b. Remove the derivate action by putting Derivat (D) = 0

c. Increase the gain (P) until the control loop is oscillating

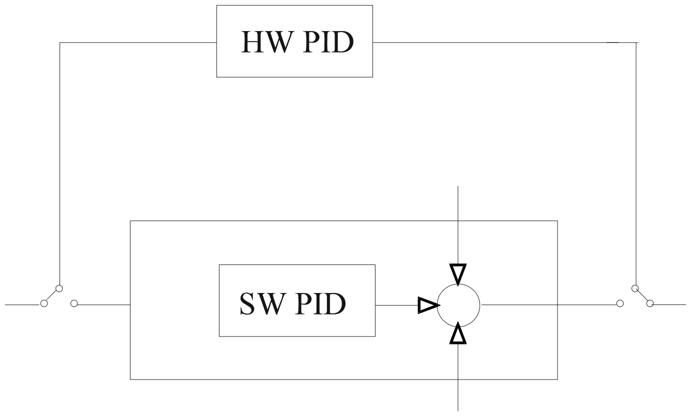
d. Note the gain (GO) and the period of oscillation (TO)

A usable controller setting is then found by:

P = 1.7 * GO, I = 0.5 * TO, D = 0.12 * TO

Low gain gives slow control action. Short integration time gives fast reset action but reduced stability. Too high derivate function gives nervous, unsteady controller action.

Changing from SW PID to HW PID: Note that feed forward signals are not included when using the HW PID. See figure below.



1.2.3 Actuator

The control valves are assumed to be positioned by valve actuators driven by air via electric-pneumatic converters (I/P).

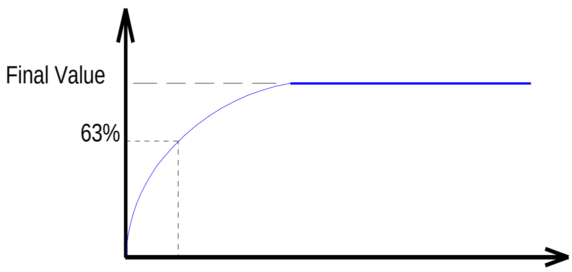
The actuator system is divided into three subsystems;

- Valve Dynamics
- Valve Hysteresis
- Valve Characteristics

The variables for actuators and the time response for sensors can be changed by the instructor from variable pages.

1.2.4 Valve Dynamics

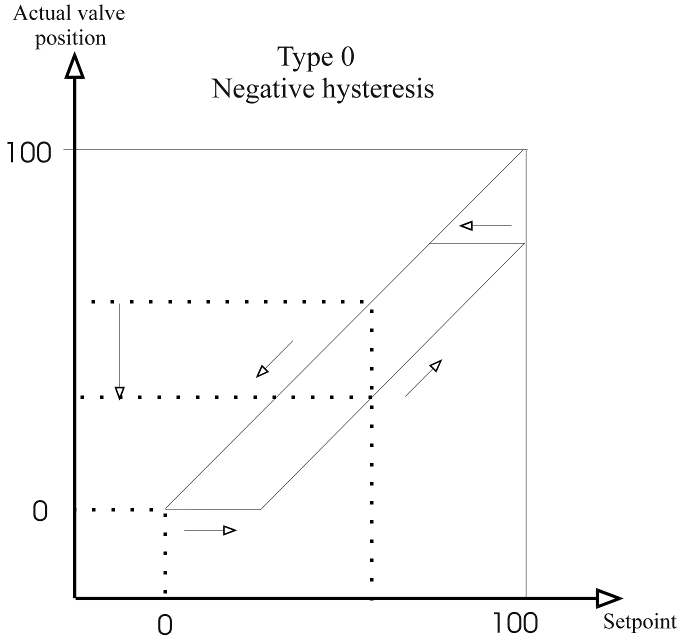
The Time Constant (TC) can be changed from the variable page. The Time Constant is defined as the time it takes for the valve to reach 63 % of the controller output signal.



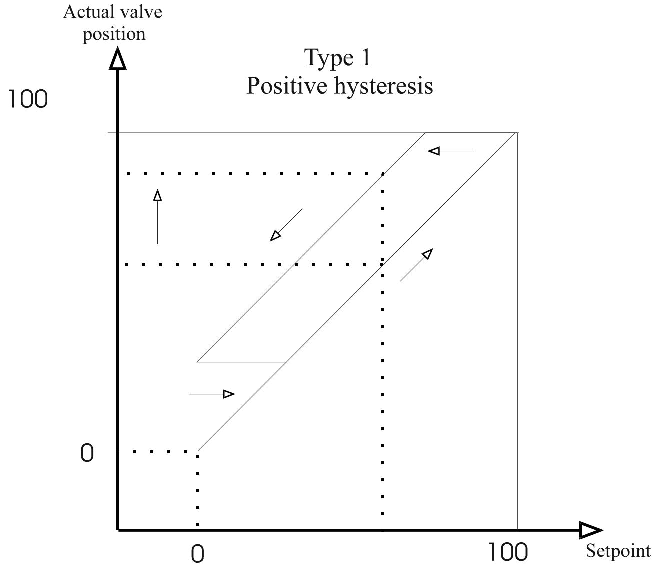
1.2.5 Hysteresis / Stiction

A "hysteresis element" is included in the description of all main control valves, to account for unlinear dynamic effects so often encountered in real life control problems.

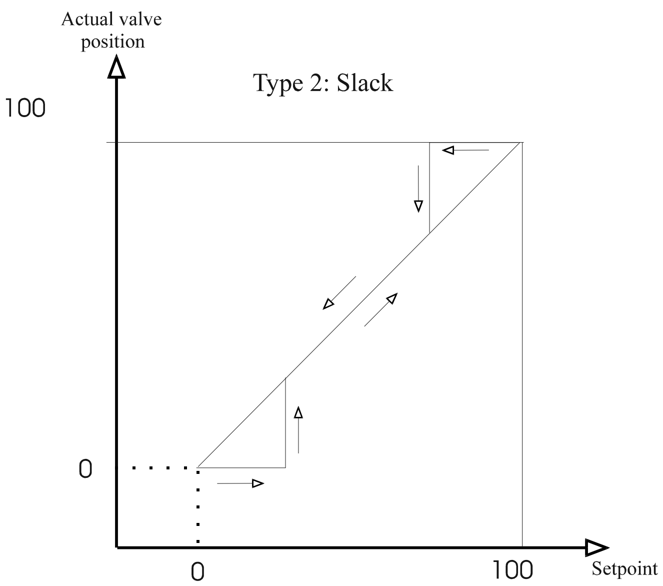
The unlinear effect can be of 3 kinds: Negativ, positiv and stiction. Type of unlinearity and the value of it can be selected from the variable page.



Negative hysteresis: The actual valve position will be less or equal to the setpoint (controller output).



Positiv hysteresis: The actual valve position will be greater or equal to the setpoint (controller output).



The actual valve position is "frozen" until the setpoint is greater than the "slack" value. In other words we can say that the valve has to "tighten up the slack" before the valve moves (both ways). When the controller output signal changes direction, the valve has to "tighten up" the slack again before the valve moves. The value of the slack can be set from the variable page.

1.2.6 Valve Characteristics

A valve usually has different gain in different working ranges, which can be seen when drawing the valve's characteristics. In other words; the connection between the in signal to the valve and the flow through the valve.

Valve characteristics to be selected from the variable page.