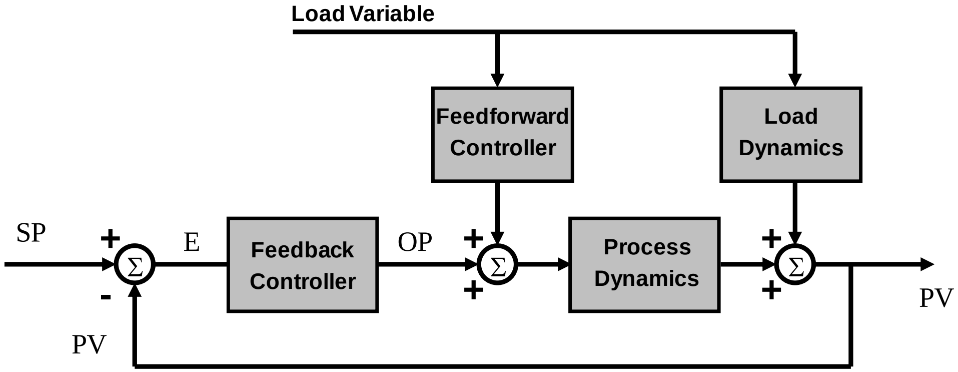
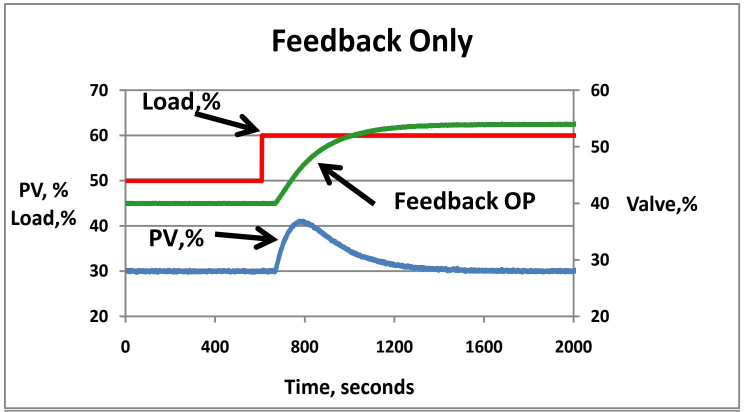
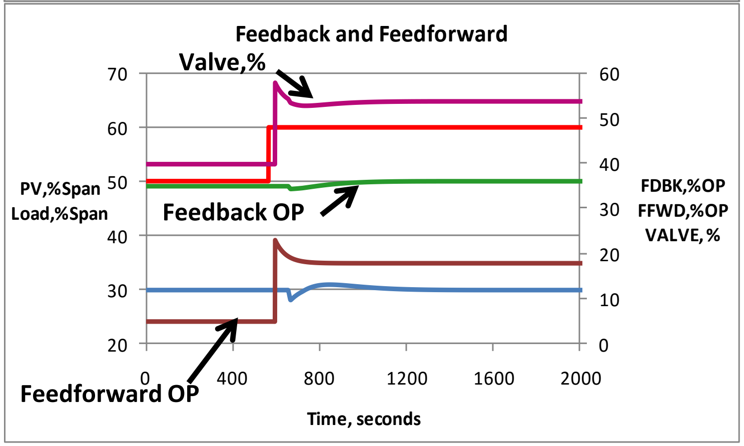
Opportunities for Feedforward

How does it Work?

The basic idea of the feedforward strategy is to measure an important load variable and take corrective action before the process is disturbed. In the most common configuration, the *sum* of the feedforward controller and the feedback controller is sent to the manipulated variable. *Ideally* the corrective action taken by the feedforward controller exactly compensates for the load disturbance and the PV is not affected. The job of the feedback controller is to compensate for unmeasured disturbances, load measurement errors, and inaccuracies in the process and load models.







Benefits

Unlike the feedback controller, it does not wait until the controlled variable is disturbed to take control action. As such it has the potential to more completely attenuate the effects of a load variable. The benefits of feedforward control can be particularly high if the feedback control capability is severely limited by a high amount of process deadtime and process lag time.

Pit-Falls – 3 issues

1. Inaccuracy in the load measurement will produce inappropriate control action.
2. It is often difficult to measure the load dynamics accurately, resulting in less than optimum feedforward controller tuning.
3. A high degree of non-linearity in the load dynamics or process dynamics will degrade feedforward performance, potentially increasing process variation. Installing a slave loop to minimize the impact of control valve related non-linearity is usually a good investment.

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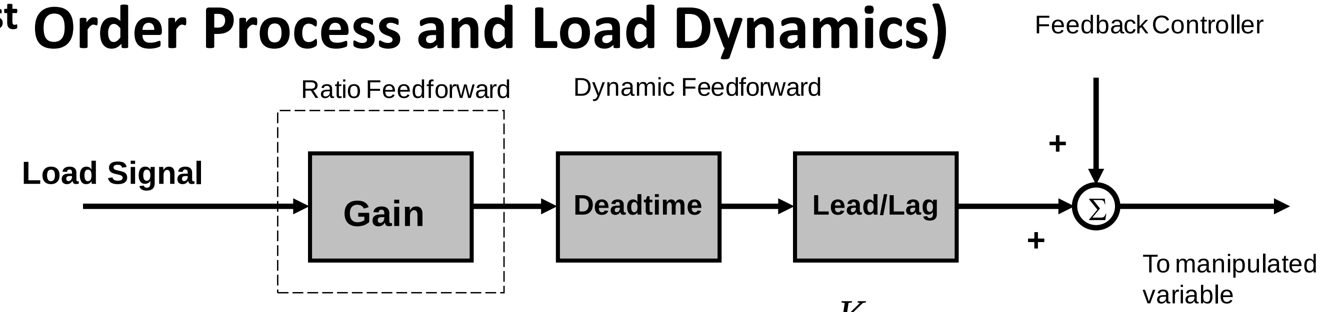
Details of the Feedforward Controller (1st Order Process and Load Dynamics)

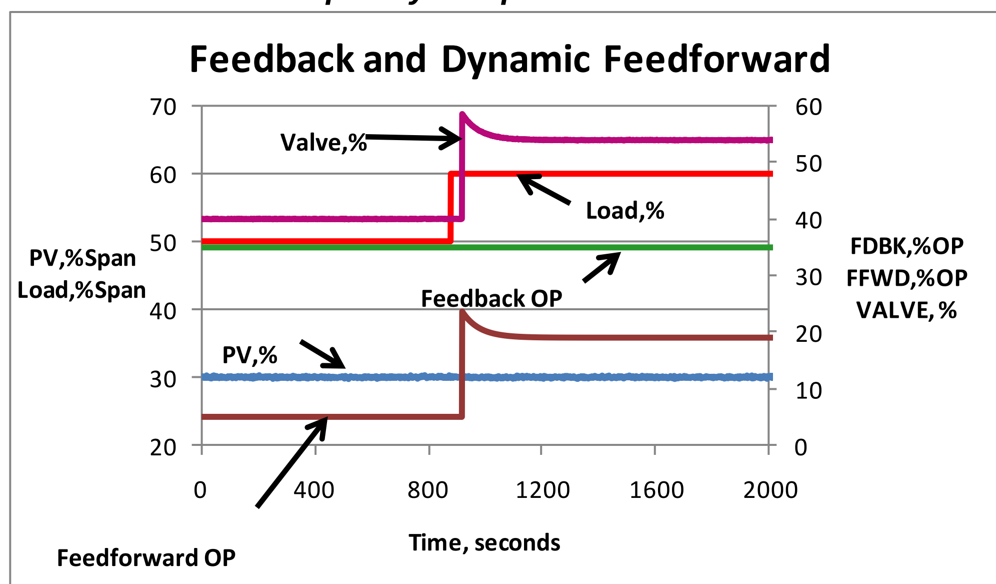


The Load signal is multiplied by a gain term equal to $\frac{-K_{Load}}{K_{Process}}$

The load signal is then passed through a delay block equal to the *Load deadtime minus the process deadtime*. The benefits of feedforward control are greater when the load deadtime is higher than the process deadtime. In this case, the control action can be delayed to match the load impact. If the process deadtime is higher than the load deadtime, the feedforward action will be too late to completely compensate for the load change.

The signal is then passed through a lead lag block. The *lead value is equal to the process time constant* and the *lag value is equal to the load time constant*.

Shows ideal case where Feedforward action completely compensates for load disturbance



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Identifying Good Candidates for Feedforward Control

Control loops that exhibit some or all of the following characteristics may be good candidates for a feedforward control strategy.

- The load variable under consideration contributes a significant amount of variability to the controlled process.
- Even after optimizing the tuning, the feedback controller is unable to attenuate the major external disturbances and the process variability targets are not being achieved.
- The load variable under consideration can be accurately measured.

Implementing the Strategy

- Ensure that the load sensor has been calibrated accurately and is well maintained
- Conduct bump tests to measure the process dynamics and load dynamics over a range of operating conditions.
- Understand the non-linearities in the load dynamics and the process dynamics. It is prudent to choose a conservative feedforward gain to account for non-linearities in the load and process dynamics.
- Install a slave loop if necessary to minimize the impact of control valve related non-linearity. A slave loop is often an important part of feedforward success.