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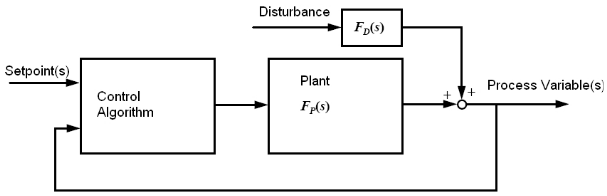
What does a Feedback Controller do?

Nowadays, in almost all Electronic Control Units so-called feedback controllers are integrated. Other than open-loop systems, the feedback controller in a closed-loop system manipulates the inputs to a system to obtain the desired effects on the output of the system.



Control design and the parameter tuning in technical systems is often difficult and time-consuming. Reasons for this are system dynamics which may result in different effects like undesirable delays, dead-time, oscillations or even instabilities.
In addition to these negative effects, nonlinearities in actuators and sensors increase the level of difficulty enormously. To manipulate the system input in an optimal way, the system dynamics have to be taken into account when designing the suitable controller.
Using theoretical control design methods for real life technical systems often seems to be very difficult, so the only way out for engineers is to apply trial & error methods. Unfortunately this means trying to find the suitable controller structure and controller parameters by merely applying them and observing how the system behaves. The benefit of trial & error methods is avoiding theoretical methods. However, trial & error methods do have at least the following disadvantages:

1. Impossible to know if the optimal parameters and structures are already found
2. Often time-consuming
3. Always an "open end scenario" which is only limited by time frame and budget available or simply whether it will work at all

Conclusion: As soon as a deviation between setpoint and output is being detected, e.g. because of disturbances, the feedback controller's task is to manipulate the system input (actuator) such that the desired setpoint is maintained and the transition dynamics are acceptably smooth and fast at the same time.

Difficulties of Feedback Control

- Control design is un-precise and/or time-consuming when applying:
  - Design by trial & error method
  - Design by tuning methods (Ziegler/Nichols, Chien/Hrones/Reswick)
  - Design by Bode diagram
- When control design is based on measured data and carried out with traditional software tools:
  - Almost no assistance and support
  - Limited design flexibility due to the underlying theory
- When control design is based on available model descriptions and carried with traditional software tools:
  - Different system dynamics between model and real system
  - Almost no assistance and support
  - Limited design flexibility due to the underlying theory
- Controller behavior either setpoint or disturbance optimized, both seems not to work
- Specific and independent transition times for setpoint and disturbance seem not to be achievable
- Design of state controllers for time-variant, non-linear, dead-time effected MIMO (multiple input/output) systems is very time-consuming, expensive and very complex.
- Different system dynamics in different operating points seem to be required to be covered by one feedback controller only.
- Classical controller structures (up to PID) cannot be used if
  - The system contains multiple resonances
  - High quality requirements have to be fulfilled when the system needs to follow ramp signals without tracking errors

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ExpertControl´s Solutions for Feedback Control Systems

ecICP Fully automatic control design software
ecCST Adaptive high-tech control algorithm with controller switching technology

Difficulties of Feedback Control	**Solution with ecICP and ecCST**	**ecICP**	**ecCST**
Control design is difficult	Control design with ecICP is easy because ecICP calculates the controllers fully automatic. All you have to do is to specify your desired transition time.	✓	
Control design is time-consuming	ecICP calculates the optimal controller within few seconds	✓	
Designing a controller by taking the system dynamics into account is difficult	Measured data includes the system dynamics and the nonlinear effects of actuator, sensor and plant. From this ecICP calculates a dynamic model and again from this the suitable feedback controller	✓	
Controller behavior is either setpoint or disturbance optimized, both seems not to work	If the controller hardware offers the flexibility to use ecICP´s controller parameters and controller structures, a setpoint <u>and</u> disturbance optimized closed-loop behavior can always be achieved	✓	
Specific and independent transition times for setpoint and disturbance seem not to be achievable	ecICP designs the controller according to the specified transition times (technical feasibility prerequisite).	✓	
Design of state controllers for time-variant, nonlinear, dead-time effected MIMO systems is very time-consuming, expensive and complex.	Designing optimal state controllers with ecICP and ecCST does not require more expertise or more time than designing a simple P-controller.	✓	✓
Different system dynamics in different operating points seem to be required to be controlled with one feedback controller only.	(1) Define with ecICP your individual operating points in your measured data. (2) Run ecICP and let ecICP automatically calculate the optimal controller for each operating point. (3) Finally ecCST will use these individual controllers to run the application. ecCST will switch between these individual controllers while the system is running. The result is an optimal system behavior in the different operating areas.	✓	✓
Classical controller structures (up to PID) cannot be used if ○ The system contains multiple resonances ○ High quality requirements have to be fulfilled when the system needs to follow ramp signals without tracking errors	ecICP calculates the optimal controller structures and controller parameters automatically even for systems with multiple resonances and MIMO systems. The necessary controller structures are already integrated in ecCST as well as a ramp controllers, position controllers, state controllers, observers, sine sweep controllers and many more…	✓	✓