Chapter One

Introduction

Fourth Academic Year

Power, E/C, and C/C

Electrical Engineering Department

College of Engineering

Salahaddin University - Erbil

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What is a Control System?

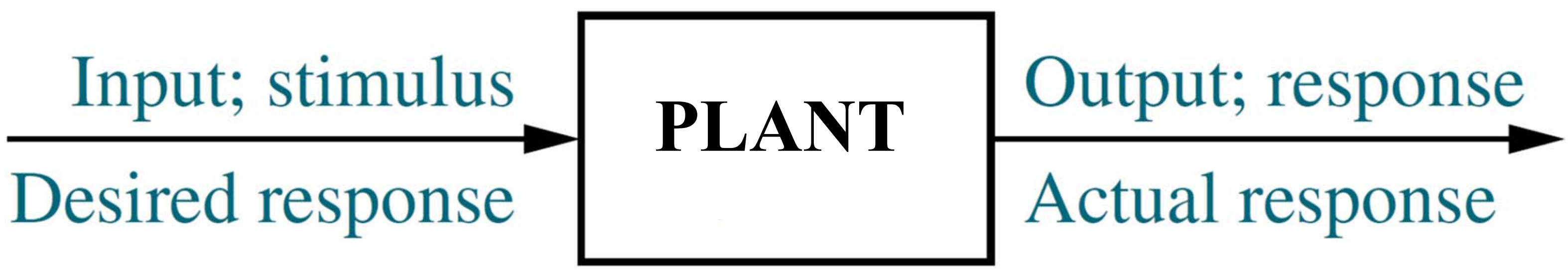
A SYSTEM is anything with inputs and outputs.

In OPTIMAL Control, there are two sets of inputs and outputs:

INPUTS: Actuators and Disturbance

OUTPUTS: Sensor Measurements and Regulated Output

The SYSTEM to be controlled is called the PLANT.

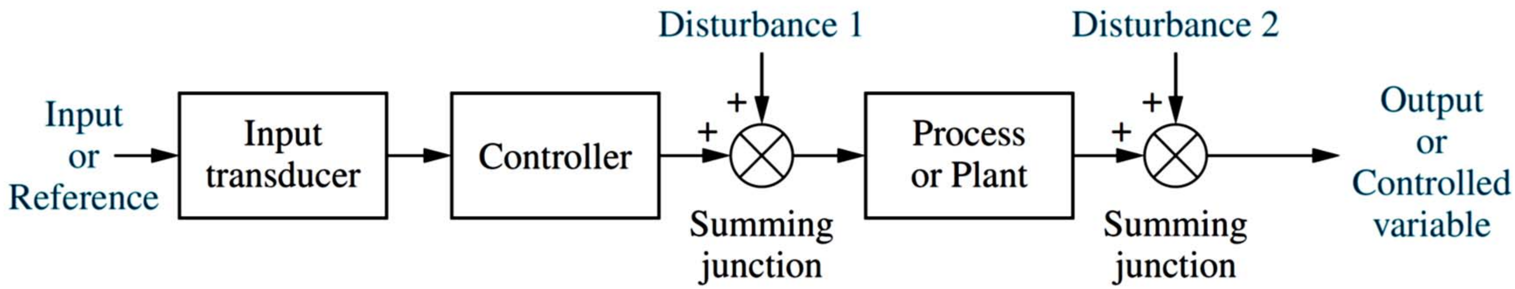


What is a Control System?

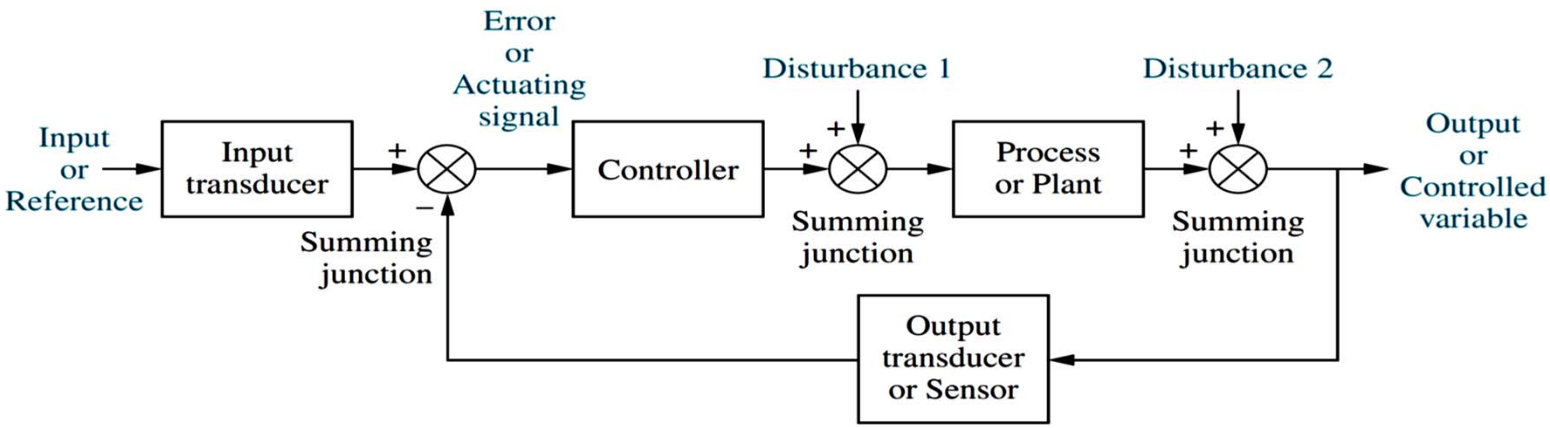
A CONTROL SYSTEM is a system which modifies the inputs to the plant to produce a desired output.

There are two types of Control System:

1. Open Loop Control System



2. Closed Loop Control System



Control System Definition Cont.

Plant - is a piece of equipment, perhaps just a set of machine parts functions together, the purpose of which is to perform a particular operation.

Processor - a natural progressively continuing operation or development maker by a series of gradual changes that succeed on another irrelatively fixed way and lead toward a particular result or end. In other word, any operation to be controlled is a process.

Disturbance - is a signal which tends to adversary affecting the value of the output of system. If its external signal it's an input.

Feedback control - is an operation in which a disturbance tends to reduce the difference between the output of a system and the reference input (or an arbitrarily varied desired state) and which dies so on the basic of this difference.

Feedback Control System – A control system which monitors its effect on the system it is controlling and modifies its output accordingly.

Fundamentals of Control

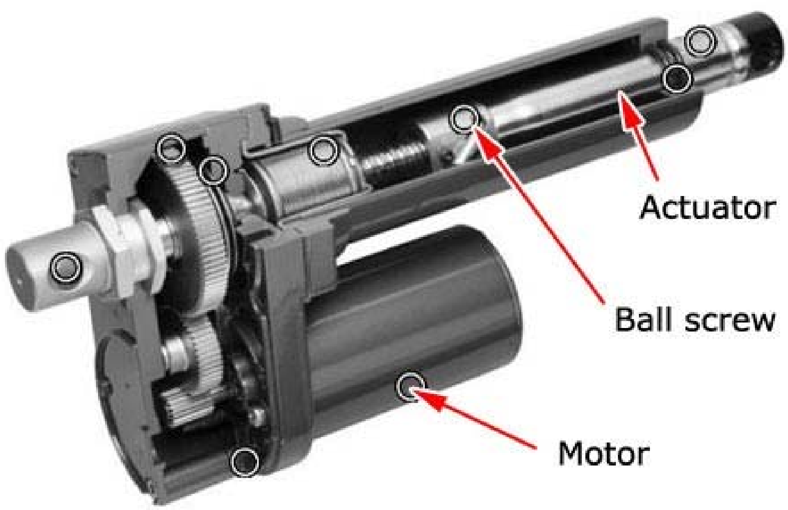
Any controller must have one fundamental part: The Actuator

The ACTUATOR is the mechanism by which the controller affects the input to the plant

Example

. Force Transducers: Servos/ Motors

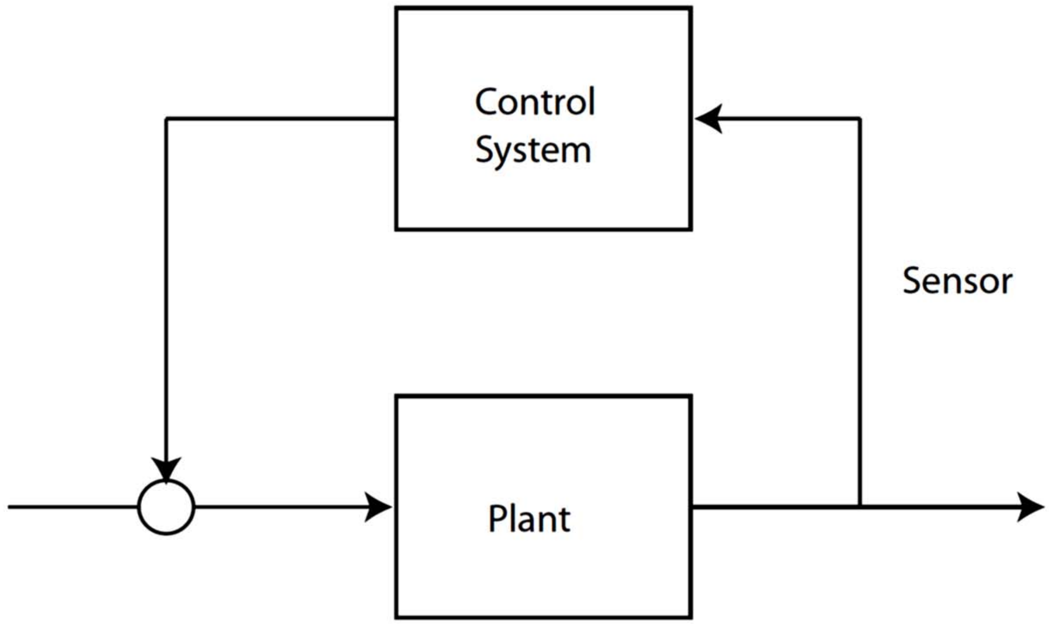
. Furnace/ Boiler



Fundamentals of Control Cont’d

An OPEN LOOP CONTROLLER has actuation but no measurement.

A CLOSED LOOP CONTROLLER uses Sensors in addition to Expatiators.



History of Feedback Control Systems

Egyptian Water Clocks 1200BC

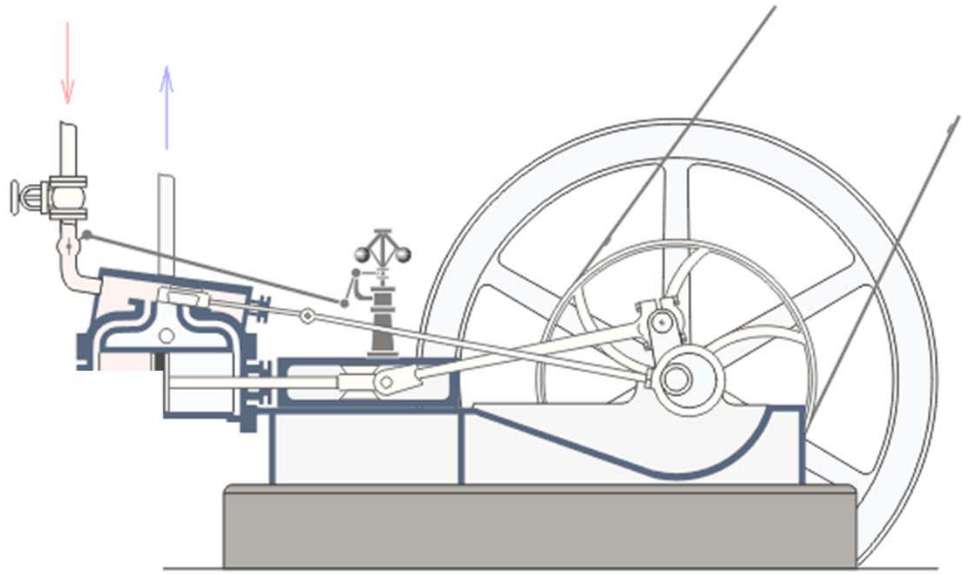
Time left is given by the amount of water left in the pot.

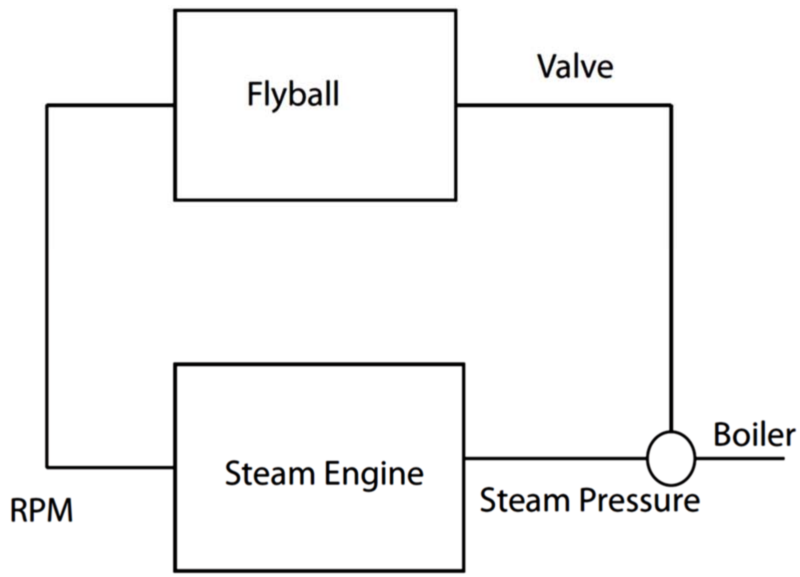
History of Feedback Control Systems Cont'd

Heron's Aeolipile 10-70 AD

History of Feedback Control Systems Cont'd

Steam Engines : Flyball Governor





Rovers

Rovers on Mars:

Opportunity Rover: 2004 - 2019

Spirit Rover : 2004 to 2010

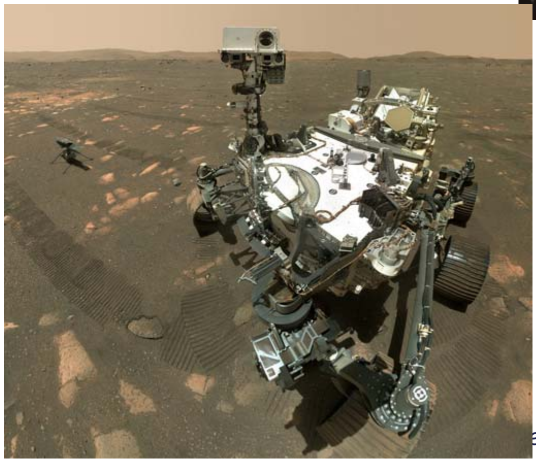
Both rovers were designed with an expected 90 sols (92 Earth days) lifetime, but each lasted much longer than expected

Curiosity Rover: Active since 2012

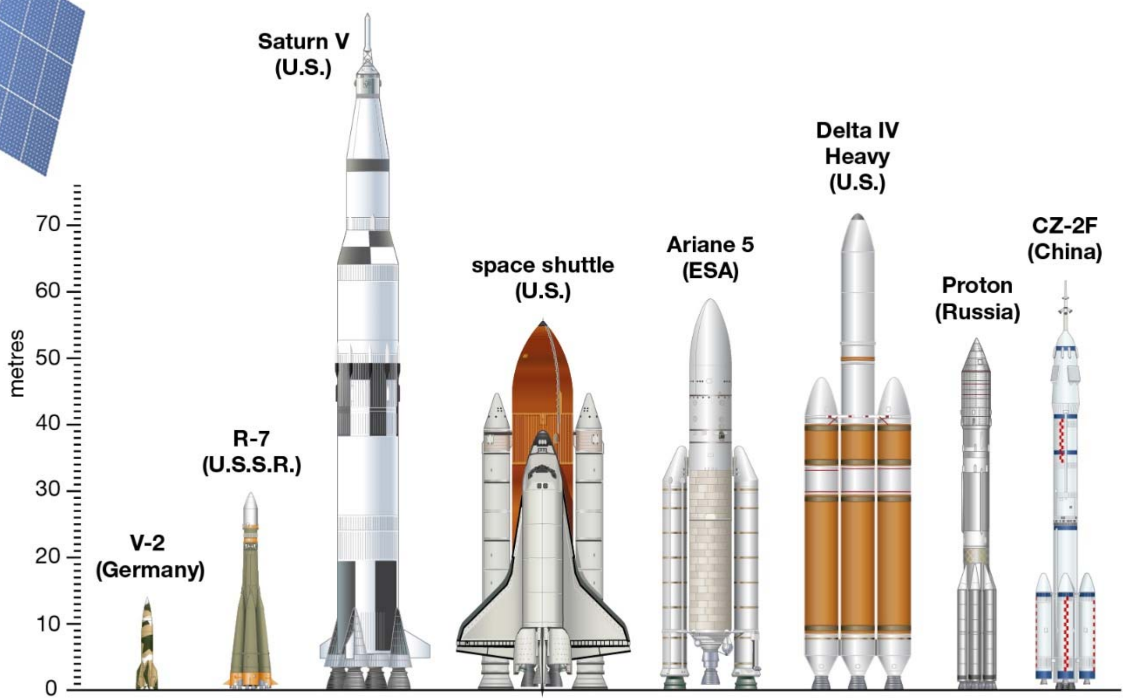
A two mission years rover

Perseverance Rover:

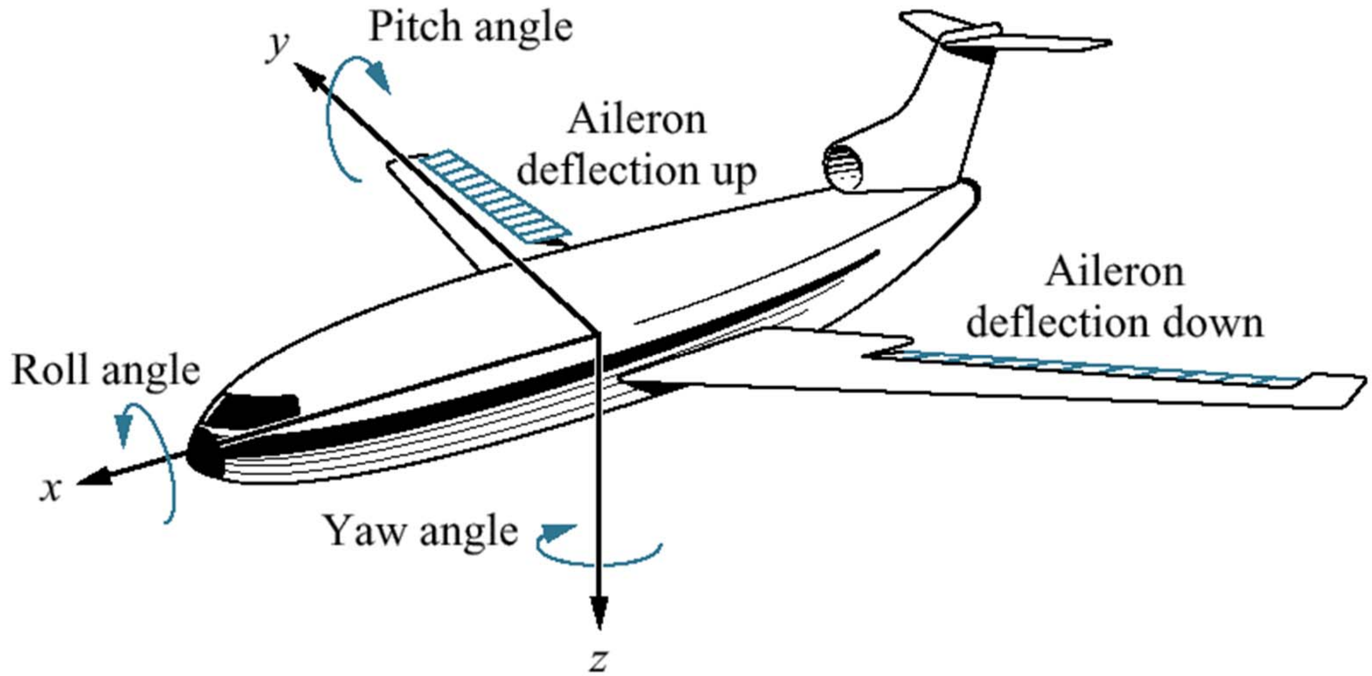
Active since Feb. 2020



Satellite and Launch Vehicles



Airplane System



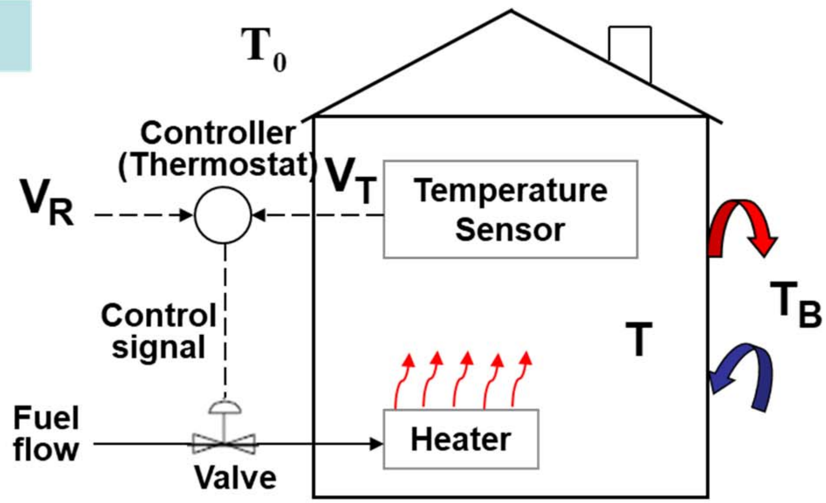
Heating System

Home Heating Control System

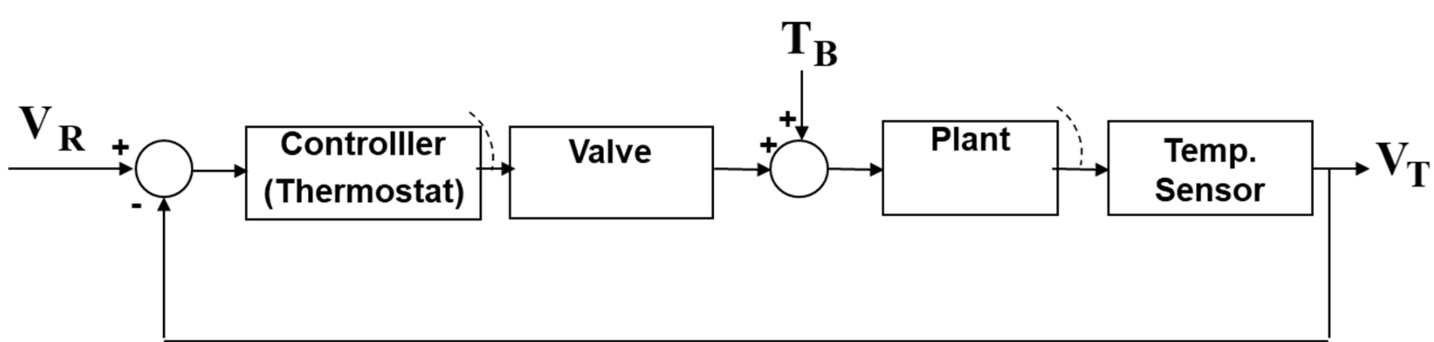
V_R : Reference temp.

V_T : Measured temp.

T_B : Disturbance (heat transfer: door, window, wall, etc.)

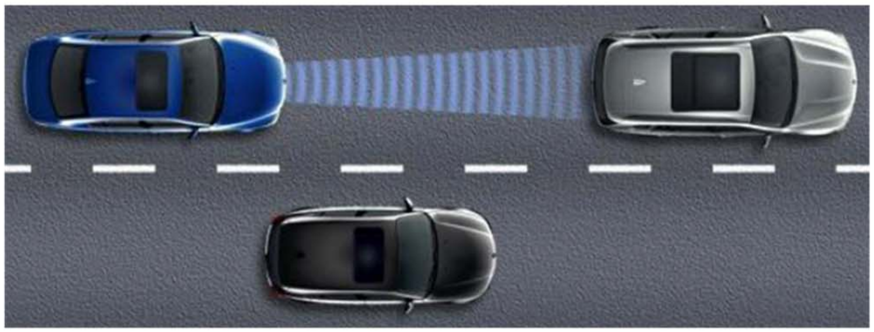


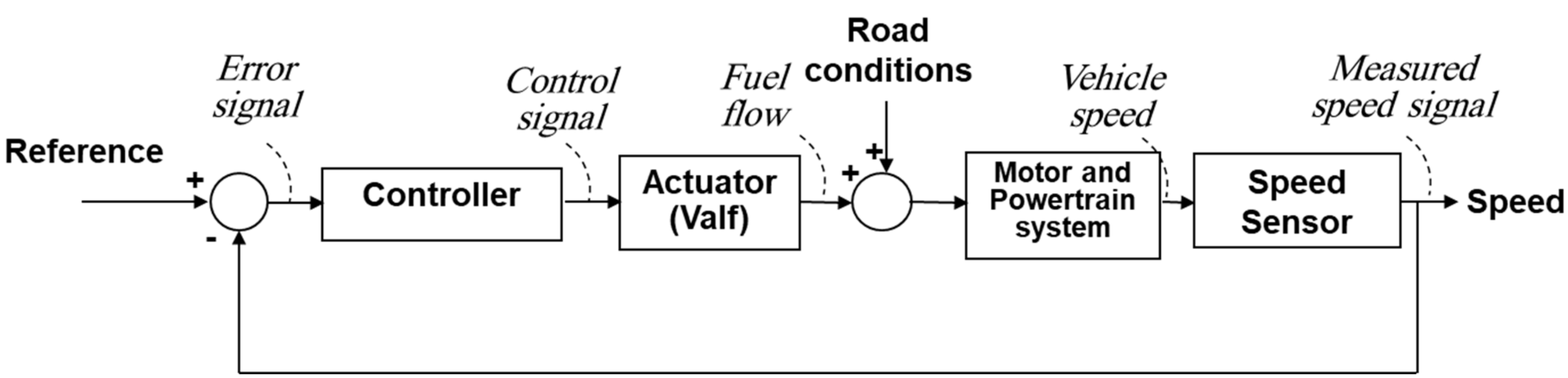
Error		Status		Control action
$V_R - V_T > 0$	→	Cold	→	Open valve
$V_R - V_T < 0$	→	Hot	→	Close valve



Vehicle Controller

Cruise Control System





Role of Control Systems

September 11, 1916: Quebec Bridge, Canada

Tacoma Narrows Bridge, Washington, USA, 1940

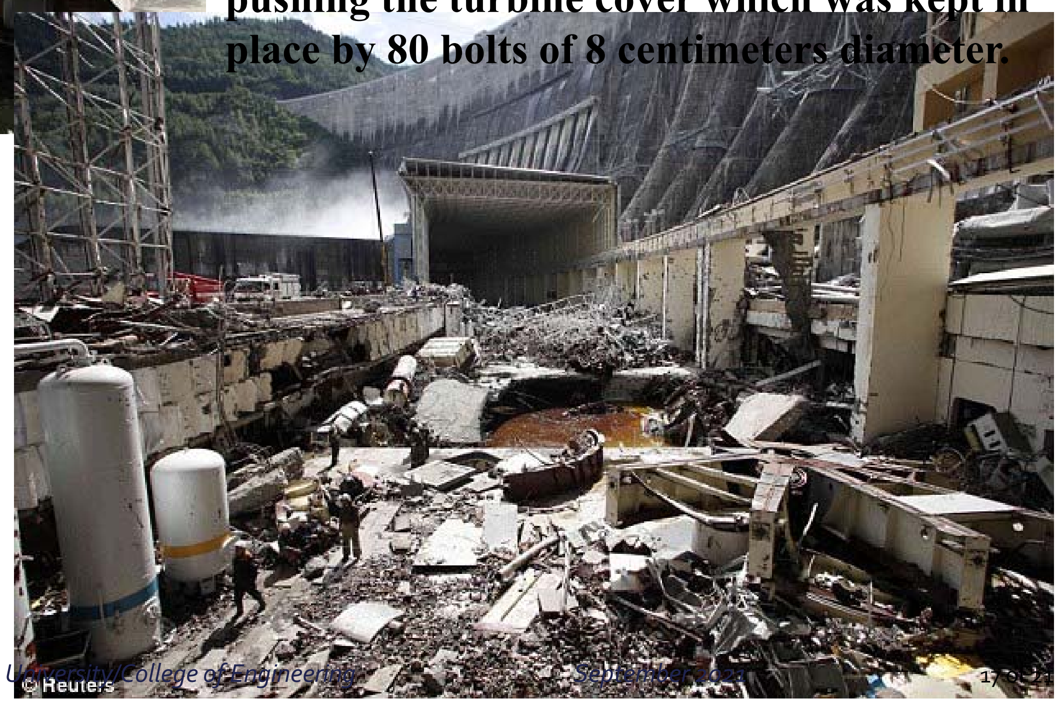
Role of Control Systems Cont'd

A wind turbine near Dalry and Ardrossan in North Ayrshire caught fire during Scotland's extreme weather on Dec 8th 2011.

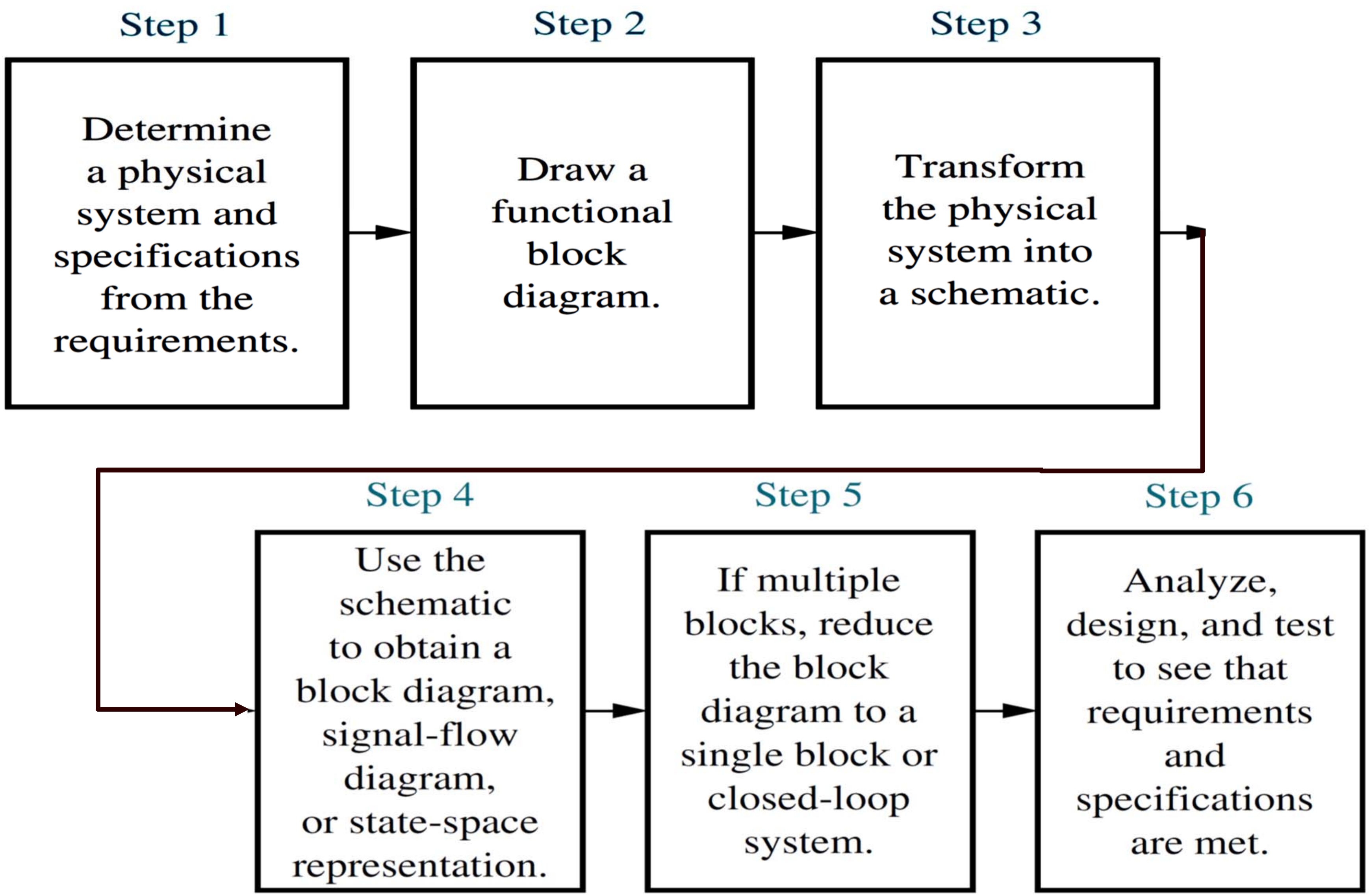
Fire: The wind turbine in North Ayrshire went up in flames on Thursday. Pic: © Stuart McMahon

Role of Control Systems Cont'd

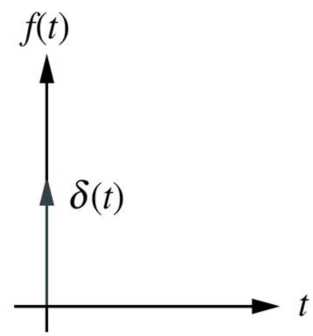
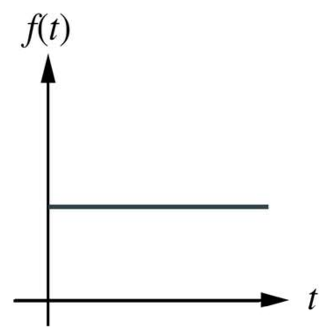
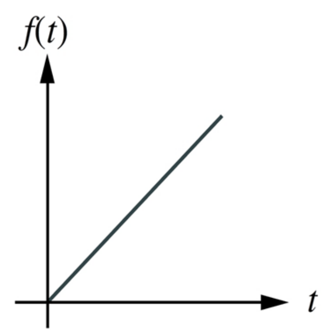
The Sayano–Shushenskaya Dam is located on the Yenisei River, near Sayanogorsk in Khakassia, Russia. It is the largest power plant in Russia and the 9th-largest hydroelectric plant in the world, ts average annual production is 23.5 TWh, which peaked in 2006 at 26.8 TWh. But on the 17th of august 2009, despite all these attempts, the vibration increased a lot (four times more than the other turbines) pushing the rotor inside the turbine up, thereby pushing the turbine cover which was kept in place by 80 bolts of 8 centimeters diameter.



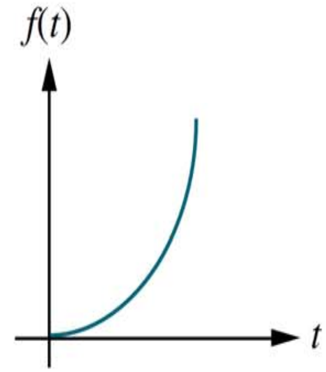
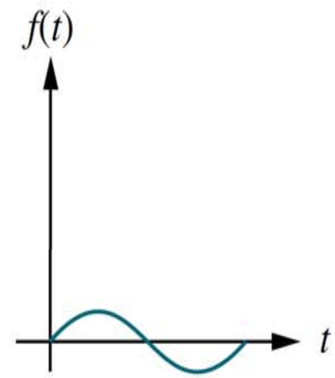
The Design Process



Testing Signals

Input	Function	Description	Sketch	Use
Impulse	$\delta(t)$	$\delta(t) = \infty$ for $0- < t < 0+$ $= 0$ elsewhere $\int_{0-}^{0+} \delta(t)dt = 1$		Transient response Modeling
Step	$u(t)$	$u(t) = 1$ for $t > 0$ $= 0$ for $t < 0$		Transient response Steady-state error
Ramp	$tu(t)$	$tu(t) = t$ for $t \geq 0$ $= 0$ elsewhere		Steady-state error

Testing Signals Cont'd

Parabola	$\frac{1}{2}t^2u(t)$	$\frac{1}{2}t^2u(t) = \frac{1}{2}t^2$ for $t \geq 0$ $= 0$ elsewhere		Steady-state error
Sinusoid	$\sin \omega t$			Transient response Modeling Steady-state error

End of Chapter One!