Control Systems

Subject Code: EC380

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Introduction

System – An interconnection of elements and devices for a desired purpose.

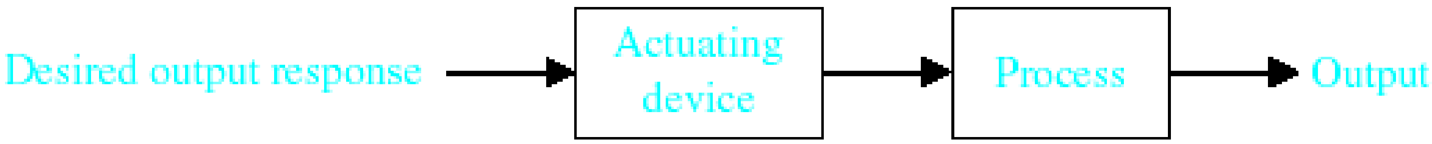
Control System – An interconnection of components forming a system configuration that will provide a desired response.

Process – The device, plant, or system under control. The input and output relationship represents the cause-and-effect relationship of the process.

Process to be controlled.

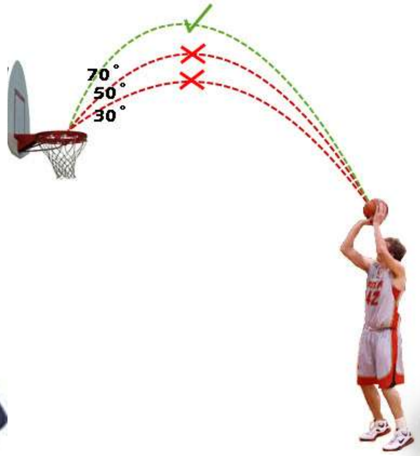
Open-Loop Control

Open-Loop Control Systems utilize a controller or control actuator to obtain the desired response.



Open-loop control system (without feedback).

e.g., Electric Hand Drier, washing machine, Toaster, microwave oven, shooting a basketball, Automatic Tea/Coffee Maker, Volume on Stereo System, etc.



Advantages of Open Loop Control System

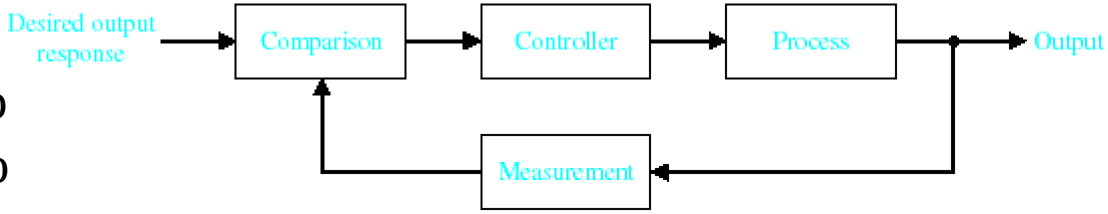
1. Simple in construction and design
2. Economical
3. Easy to maintain
4. Generally stable
5. Convenient to use as output is difficult to measure

Disadvantages of Open Loop Control System

1. They are inaccurate.
2. They are unreliable.
3. Any change in output cannot be corrected automatically.

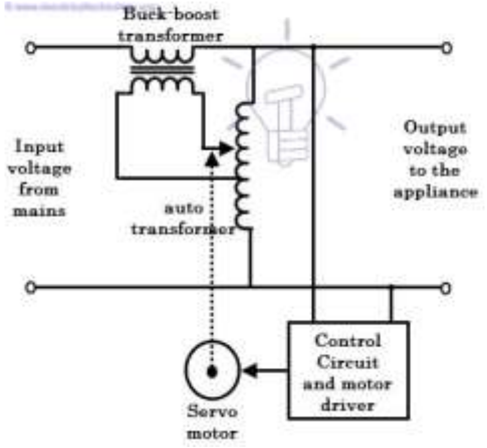
Closed-Loop Control

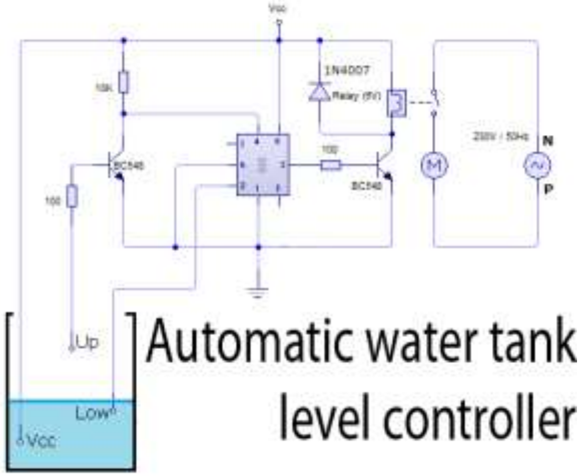
Closed-Loop Control Systems utilizes feedback to compare the actual output to the desired output response.

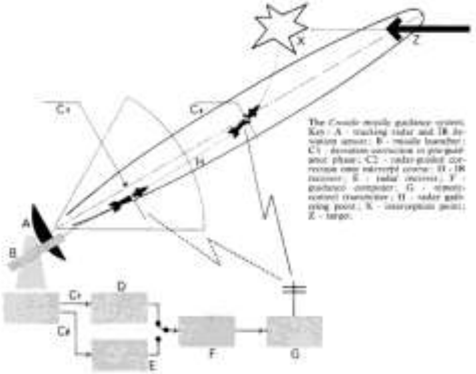


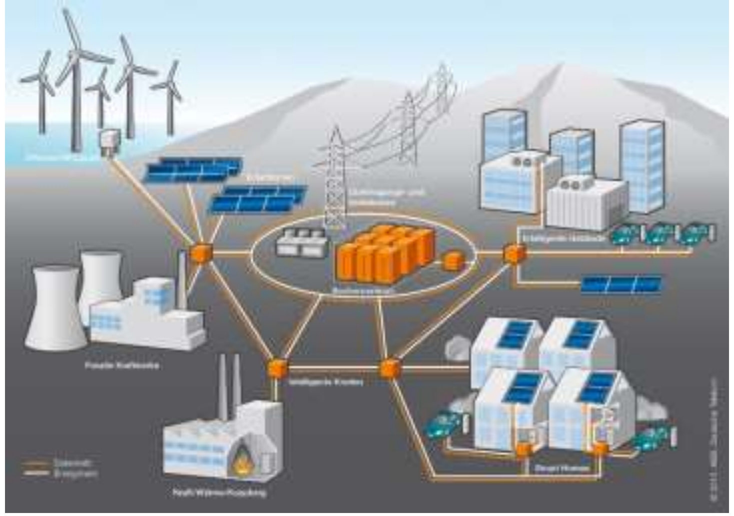
Closed-loop feedback control system (with feedback).

e.g., Servo Voltage Stabilizer, Water Level Controller, Missile Launched & Auto Tracked by Radar, Air Conditioner, Cooling System in Car, smart grid, autonomous automotive systems, process control systems, distributed robotics, and automatic pilot avionics, etc.

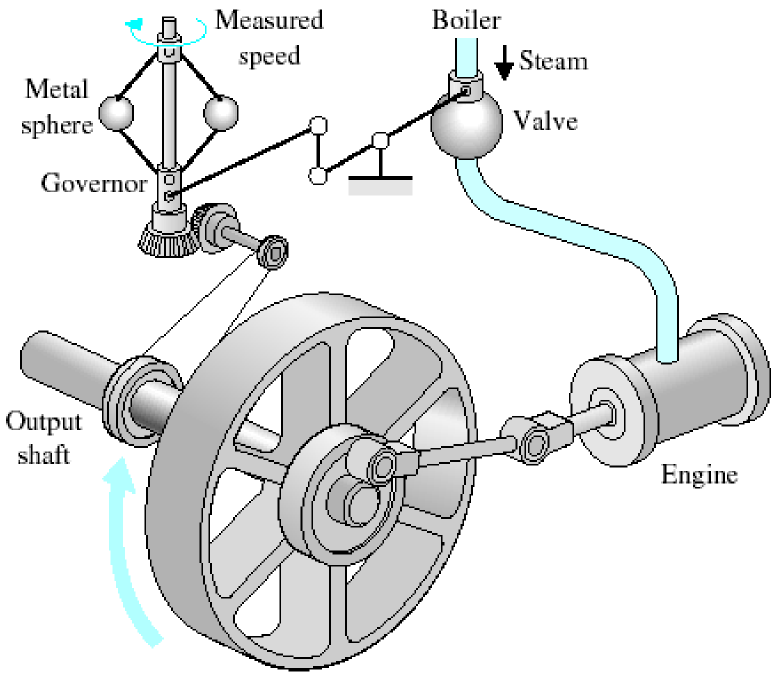








Watt's Flyball Governor



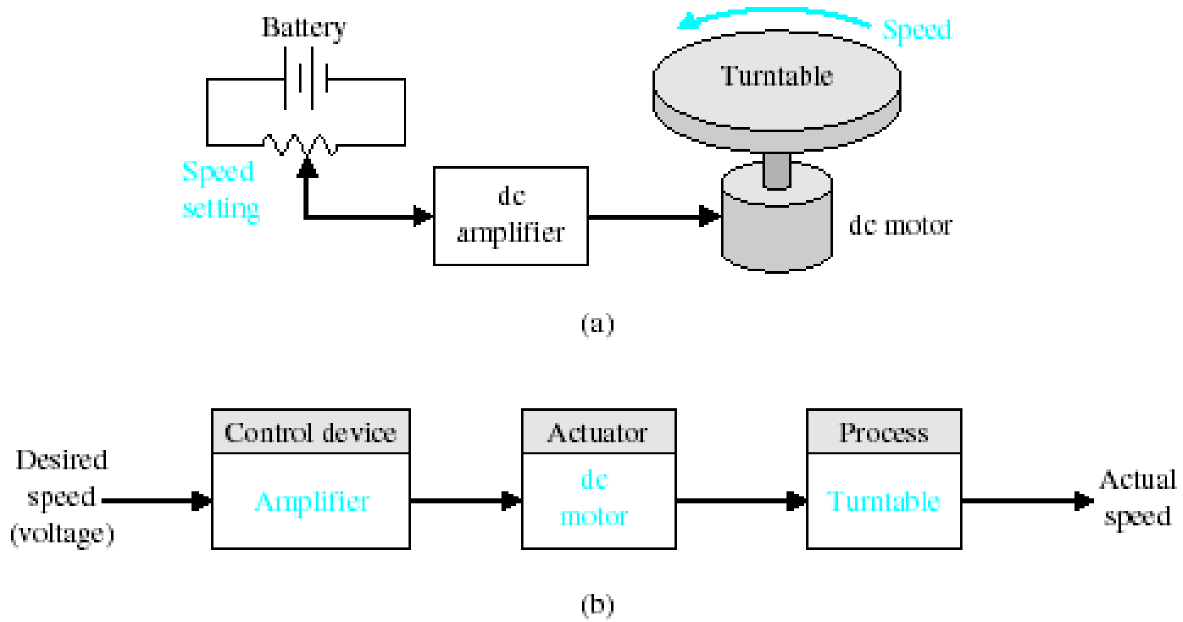
Advantages of Closed Loop Control System

1. Closed loop control systems are more accurate even in the presence of non-linearity.
2. Highly accurate as any error arising is corrected due to presence of feedback signal.
3. Bandwidth range is large.
4. Facilitates automation.
5. The noise sensitivity of system may be made small to make system more stable. This system is less affected by noise.

Disadvantages of Closed Loop Control System

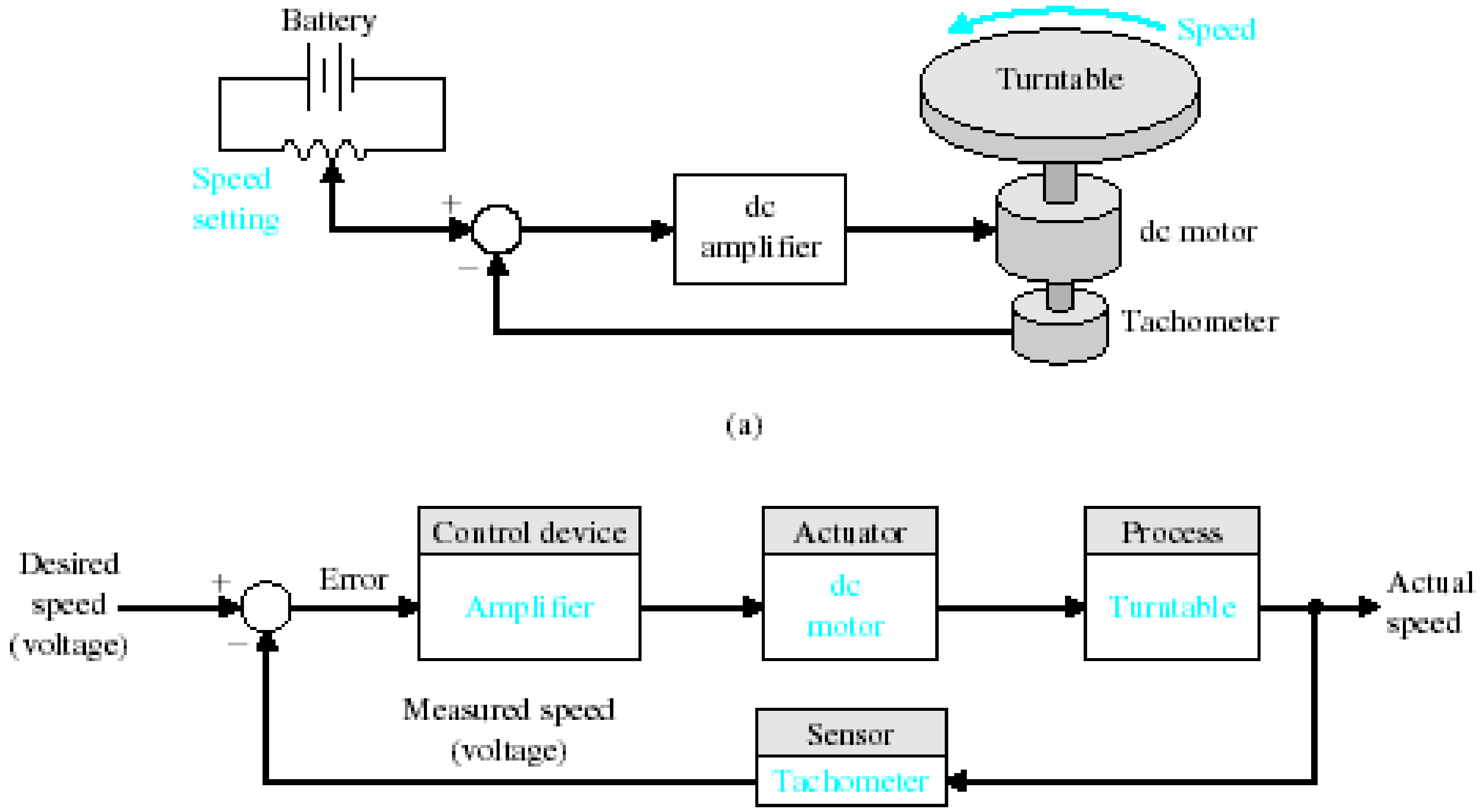
1. They are costlier.
2. They are complicated to design.
3. Required more maintenance.
4. Feedback leads to oscillatory response.
5. Overall gain is reduced due to presence of feedback.
6. Stability is the major problem and more care is needed to design a stable closed loop system.

Open Loop Design Example



(a) Open-loop (without feedback) control of the speed of a turntable.
(b) Block diagram model.

Closed Loop Design Example

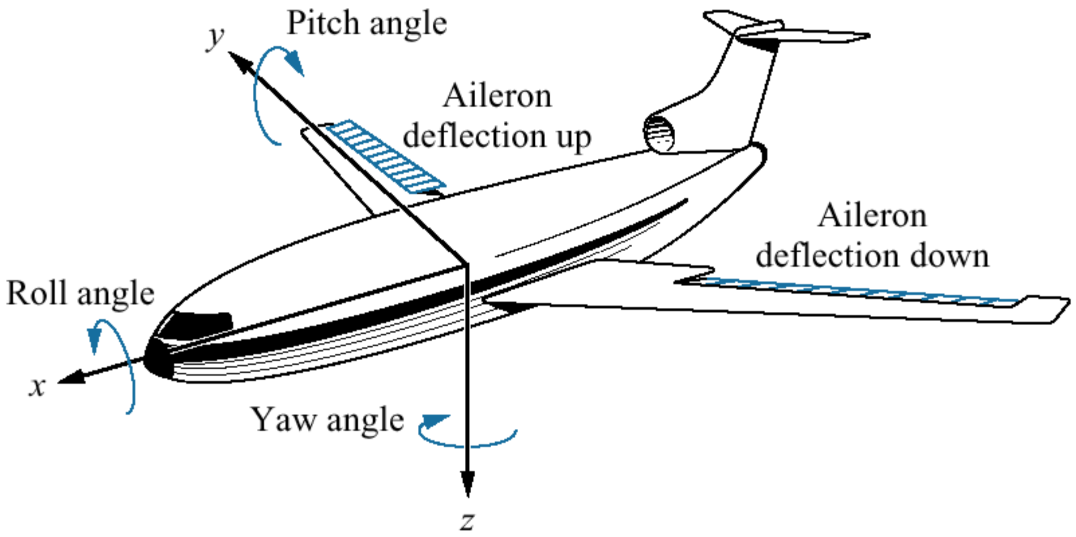


(a) Closed-loop control of the speed of a turntable.
(b) Block diagram model.

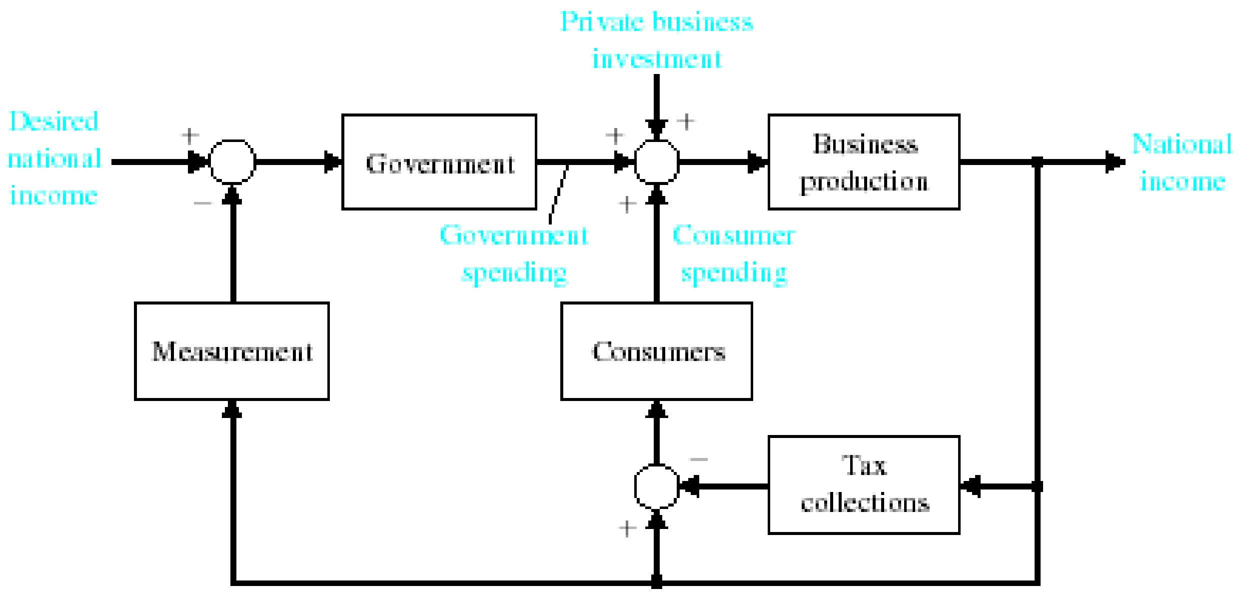
Applications on Control Sytems

Application areas include, and not limited to, aerospace systems, automotive systems, communication networks, cyber-physical systems, manufacturing, micro/nano systems, power grids, process control, robotics, smart communities, systems and synthetic biology, epidemic control, etc.

Flight Control

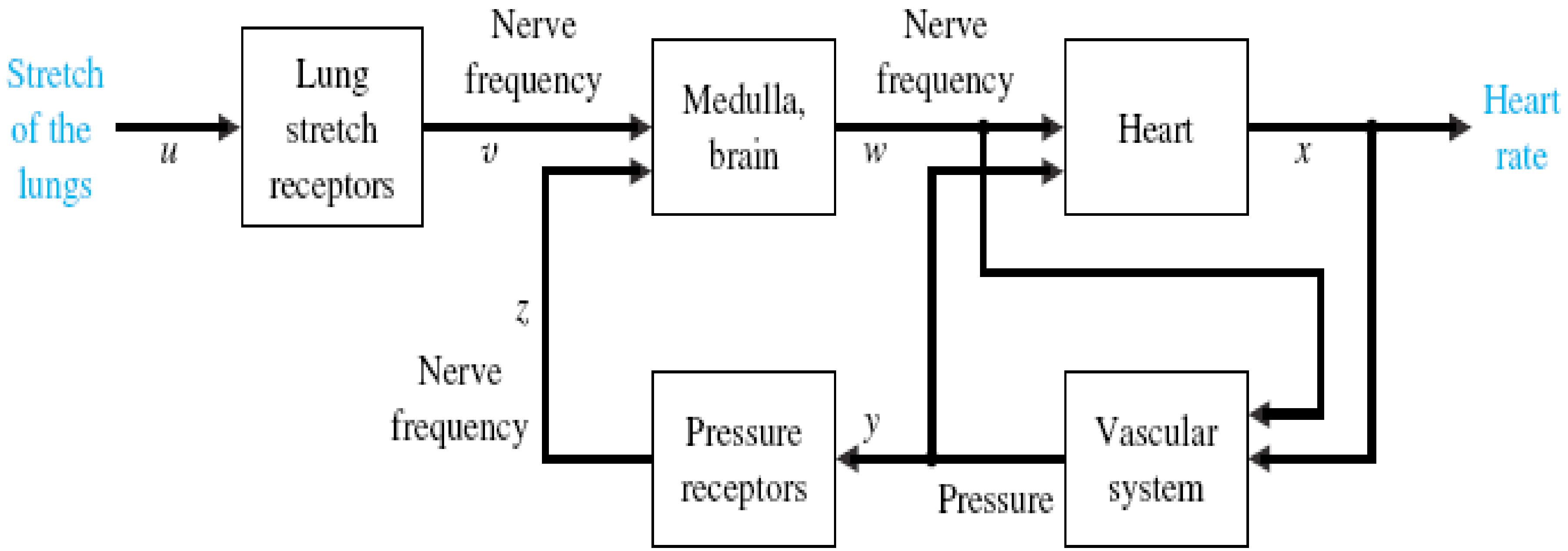


Examples of Modern Control Systems

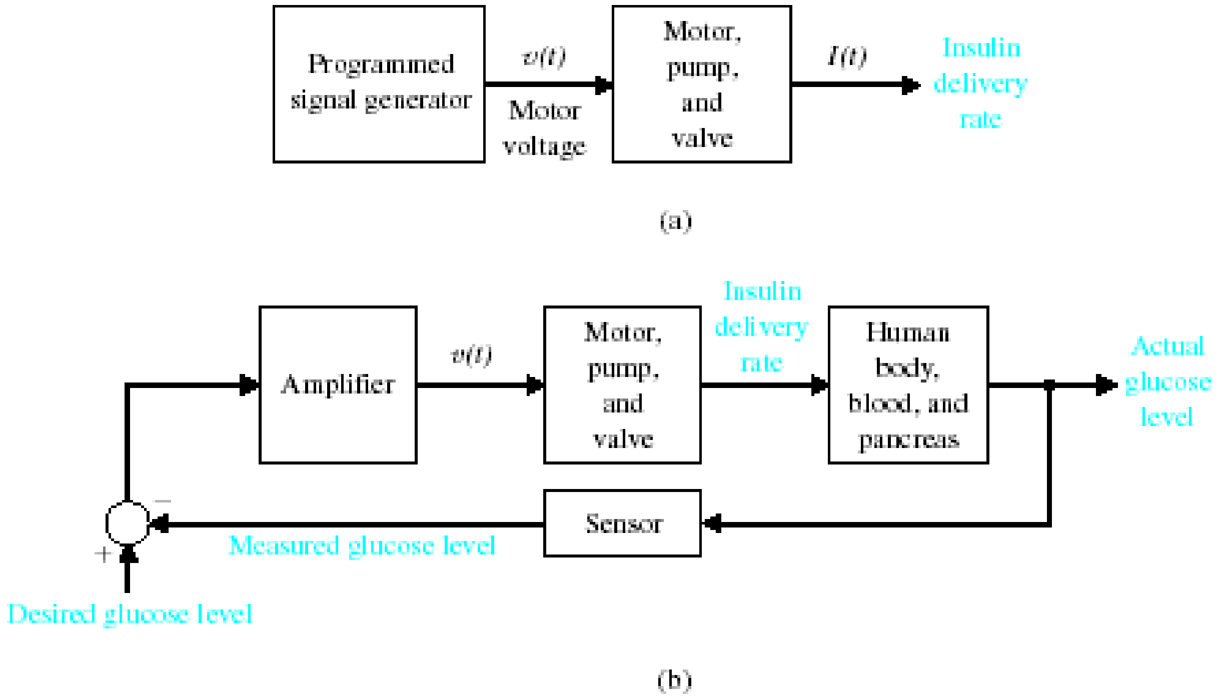


A feedback control system model of the national income.

Heart-rate Control



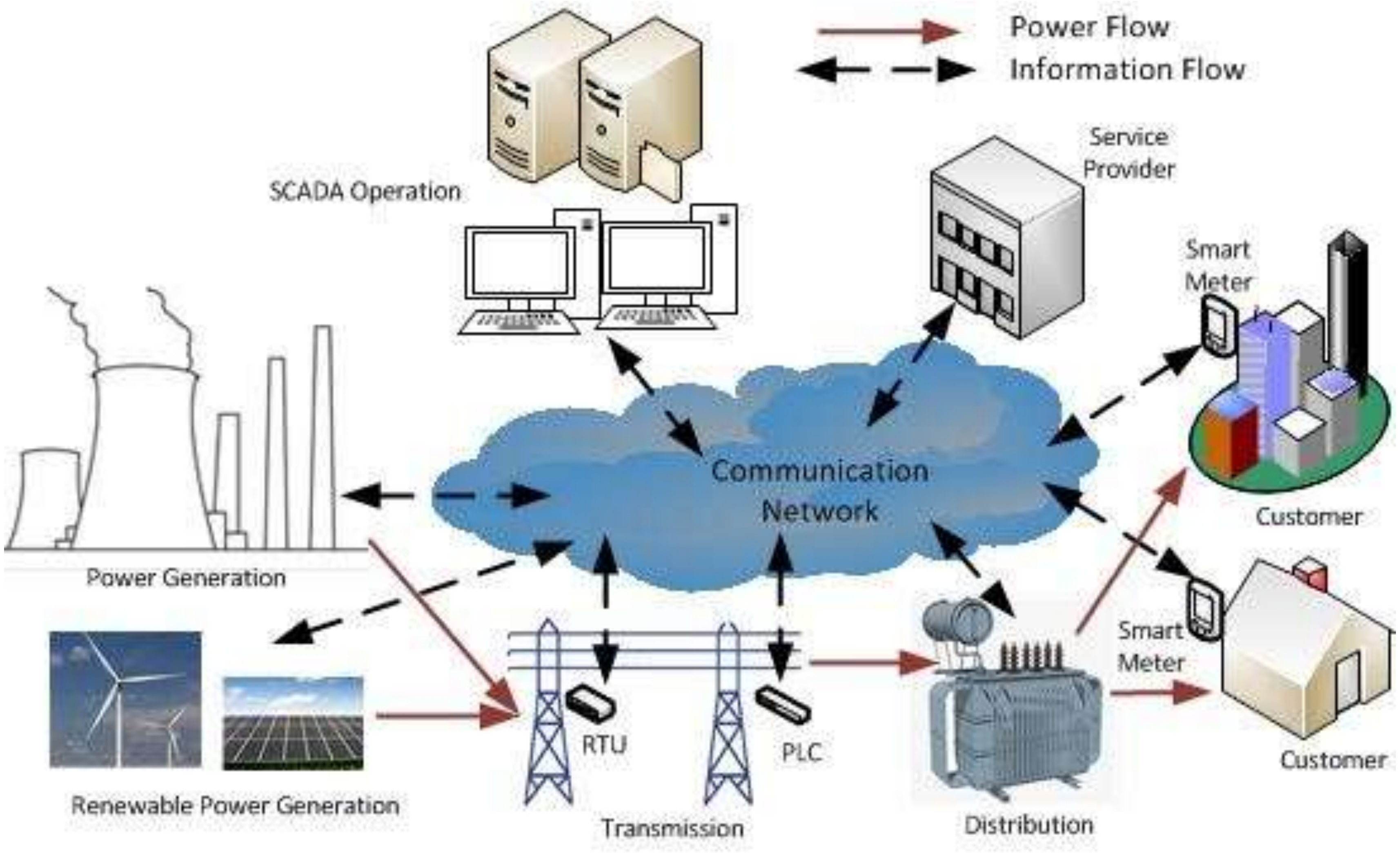
Design Example

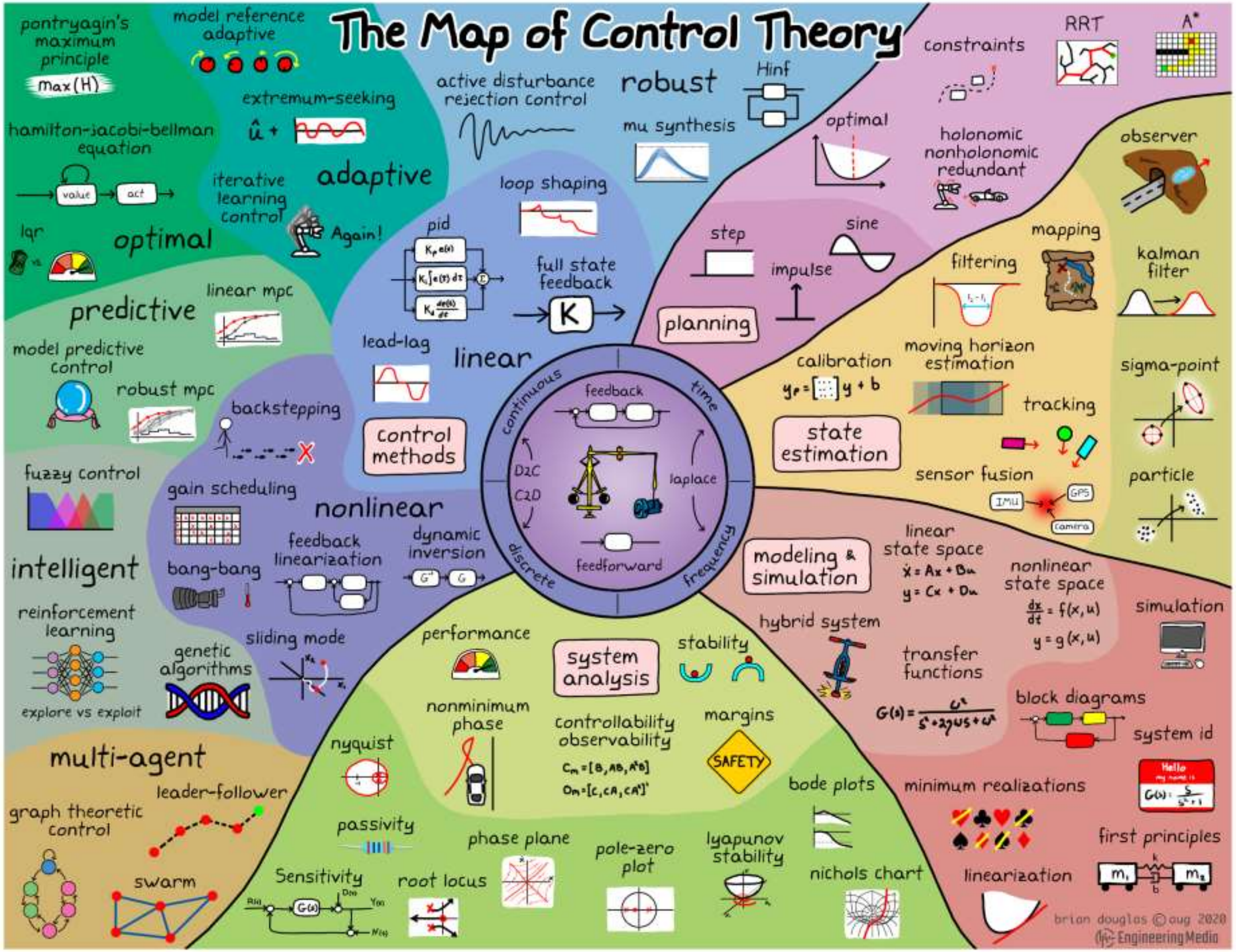


(a) Open-loop (without feedback) control and
(b) closed-loop control of blood glucose.

GREEN ENGINEERING

Cyber Physical Systems





Designed by Brian Douglas

https://engineeringmedia.com/

Course Information

Course Description:

UNIT-1: Mathematical models of physical systems: differential equations of physical systems, state-space models, transfer functions, block diagram algebra, signal flow graphs.

UNIT-2: Time-domain techniques: response of second-order systems, characteristic-equation and roots, Routh-Hurwitz criteria, Root-Locus.

UNIT-3: Frequency-domain techniques: frequency responses, Bode-plots, gain-margin and phase-margin, Nyquist plots.

UNIT-4: Compensator design: proportional, PI and PID controllers, lead-lag compensator.

UNIT-5: Modern control system techniques: state-space representations of transfer functions, controllability, observability, pole placement by state feedback, observer and observer based state feedback control, Linear Quadratic Regulator (LQR).

Objective: By the end of this course students will be able to

1. understand the dynamics of a physical system and modeling it mathematically
2. analyse stability and performance of a system
3. understand the performance specifications in the time-domain and frequency-domain
4. design controller for stability and/or desired performance of linear time invarient systems

Course Information

Text:

1. K. Ogata, *Modern Control Engineering*, Prentice Hall India, 2010.

References:

1. J. P. Hespanha, Linear Systems Theory, USA, NJ, Princeton:Princeton Univ. Press, 2009.
2. P. Antsaklis and A. N. Michel, *Linear Systems*, 1st ed. New York, NY, USA: Birkhauser, 2006.
3. R. C. Dorf and R. H. Bishop, *Modern Control Systems*, Prentice Hall, 2010.
5. I. J. Nagrath and M. Gopal, *Control Systems Engineering*, New Age Publishers, 2010.
6. https://engineeringmedia.com/

Prerequisites: Calculus, Laplace Transform, Linear Algebra