* -> Why are ratings important? Characterize speed of performance, stability, accuracy; used in modelling to predict system performance and the effects of interconnection.
* -> What if an analytical model is not possible? A linear system is one that can be expressed by a linear analytical model; if error or non-linear phenomena cause the system to be non-linear, linearize (according to the textbook)
  + Also: analyze system, create model, simulate system, design, test
* Applications of instrumentation: process monitoring, testing and qualification, product quality assessment, fault prediction, detection and diagnosis, warning generation, surveillance, model identification, control
* Sensor = measures unknown signals and parameters of a plant and its environment
* Sensor system = 1) many sensors, sensor fusion, 2) sensor + accessories (signal processing, DAQ, display,…)
* Examples of sensors:
  + Motion – potentiometer, LVDT, magnetostrictive, tachometer, resolver, ultrasound ranger
  + Force/torque – strain gauge, motor current sensor
  + Flow – pitot tube, rotameter, orifice flow meter
  + Pressure – manometer, bourdon tube, diaphragm type
    - Pressure and flow can be correlated; sensors can be interchanged
  + Temperature – thermocouple, thermistor, RTD
* Kinds of impedance
  + Across variable / Thru variable
  + Electrical: voltage/current
  + Mech: velocity/force, called MOBILITY
* Problems with signals
  + Noise: filter it
  + Drift (stable conditions but signal shifts): condition it
  + Low signal level/power: amplify it
  + Other fixes: signal modification (filtering), modulation (overlay signal on carrier waveform), error detection and encoding, signal conversion (ADC, DAC)
* Instrumentation = adding/integrating devices into a system so that you achieve desired system performance
* -> Benefits/drawbacks of mech compared to elec components? Weight, inertia, cost, size, obviousness of hazards (electrocution)
* MEMS Devices: small size and light weight (negligible loading errors), high speed (high bandwidth), convenient for mass production (low cost)
* Characteristics of a mechatronic system
  + Electromechanical
  + Has sensors, actuators, controllers
  + Multiphysics, multidomain, and designed with all domains/components considered simultaneously
  + Optimized and designed through the mechatronics approach
* Mechatronics approach key points: electromechanical (de Silva expands to multi-physics) products and systems, integrated design, and a bunch of other bullshit
* Instrumentation is an integral part of design
* Terminology
  + Most of the stuff on the slide is obvious
  + Feed-forward control: control signal is determined according to plant excitation (or model) without knowing actual output
* Steps: 1) study system, 2) identify and group components based on domain, 3) develop a preliminary system architecture, 4) create model, 5) get performance requirements of system
* Based on what components are actually found, model and system architecture may need to be revised.
* Design process: 1) identify basic components in conceptual design, 2) determine sensor parameter values in detailed design, optimize
* Design process may indicate a commercially unavailable product needs to be developed
* Dynamic coupling = connecting components changes their behavior compared to when they operate independently
* Generalized impedance = across / through
  + Across variables: voltage, velocity, pressure, temperature
  + Through variables: force, current, fluid flow rate, heat transfer rate
* Goal of impedance matching:
  + Source and Load matching for max power transfer
  + Power transfer at maximum efficiency
  + Reflection prevention in signal transmission
  + Loading reduction
* All components of system have effect on signals (sensors, signal conditioning circuits, actuators, cables, support structure, etc.)
  + Ex. Mechanical power flow – involves angular velocity, torque, …  
     Electrical power flow – involves voltage and current
  + Impedance matching may be needed to reach desired operating conditions; type of matching depends on goal and system

Note: at max power, efficiency=50%

|  |  |
| --- | --- |
| **DC (pure resistance)**  Power absorbed by load:  Max power if:  Occurs when |  |
| **General Impedance**  (resistive and reactive parts can be adjusted independently)  Max power if:  Max power | Note: z=a+bi, z\*=a-bi |
| **Power transfer at max efficiency**  Eff=absorbed/total power  As |  |

Impedance matching to prevent signal reflection

* Abrupt change in impedance reflects signals
* Reflection deteriorates signal (magnitude and phase), and dissipates power
* Match impedance on transmission lines to prevent reflection

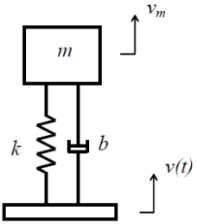
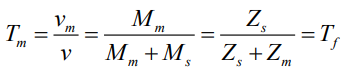
|  |  |
| --- | --- |
| **Reflection coefficient:**  , want =0  Incident , reflected |  |

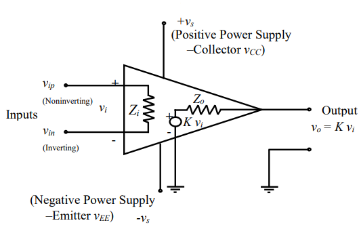
Impedance Matching for Loading Reduction

|  |  |
| --- | --- |
| Input Impedance  rated input voltage/input current (open circuit output) | Output Impedance  open circuit output voltage/s.circuit output current |
|  | |

* Sensor should not significantly change system behavior; loading error is one of the biggest errors
* Ex. Force or motion isolation for stuff sensitive to vibration

|  |  |  |  |
| --- | --- | --- | --- |
| Element | Time Domain | Impedance | Mobility |
| Mass *m* |  |  |  |
| Spring *k* |  |  |  |
| Damper *b* |  |  |  |

* Force transmissibility=velocity of mass under investigation/driving velocity = force   
  
* Maximum power transfer when the forcing is at natural frequency (resonance), but amplitude is not at max; max power transfer implies max motion and force transmissibility
  + , for small , peak transmissibility at
  + As increases, peak shifts to lower r
  + “isolation” after resonance peak, when |Tf|<1 which occurs when r>sqrt(2); after this |Tf| increases with
  + Percent isolation

Part 4: Op-amps (s6)

* ideally, K=infinity, Zi=infinity, low Zo
* With negative feedback, inputs to op-amp are ~equal