ECE 4455

Biomedical Systems Analysis

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1 Biomedical Modeling

1.1 Types of System Models

There are a few types of models, ther exist **black-box models** which contain a transfer function relating inputs to outputs. There are also **structural/parametric models** these models are dervied from physical laws, applied to known antomy or physiiological processes, these models often rely on **physical system analogies**. More often than not the latter is preferred

1.2 Transfer Functions

Over this course several notations will be used, these also represent the different ways to represent transfer fucntions

- Time Domain: $y(t) = h(t)\text{conv}x(t)$
- Frequency Domain: $Y(\omega) = H(\omega) \cdot X(\omega)$
- Complex Frequency Domain: $X(s) = H(s) \cdot X(s)$

We will also consider the functions $h(t)$, $H(\omega)$, and $H(s)$ to be the impulse response of a system.

Recall the following relationships, these are only applicable for **linear time-invariant systems**:

$$H(\omega) = \text{FT}\left[h(t)\right] = H(s)|_{s=j\omega}$$
$$H(s) = \text{LT}\left[h(t)\right]$$

1.3 Lumped Parameter Models

A **lumped-parameter model** is a network of 1-D connections among elements representing import physical properties of a system The elements are treated as *spatially compact*, so spatial veriation of parameters is neglected This leads to systems yielding Ordinary Differentialy Equations (ODEs).

Type of System	"Effort"	"Flow"
Electrical	Voltage (v)	Current (i)
Solid Mechanics	Net Force (F)	Velocity (v)

Type of System	"Effort"	"Flow"
Fluid Mechanics	Pressure (P)	Flow Rate (Q)
Chemical Diffusion	Conecntration (ϕ)	Mass flux (Q)

These components of lumped-parameter models can be combined into a circuit either in series or parallel, analogies between different types of systems are established by connecting elements such that the *flow* quantity behaves identically in both systems.

Going forward the generalized effort variable will be denoted as ψ, and the flow variable will be denoted as ζ

1.4 Resistor Equivalents

1.5 Capactior Equivalents

1.6 Inductor Equivalents

1.7 Compartmental Models