Sensors, Signals and Control

Course info

- AENG31300
  - Core unit
  - 20 CP, 2 semesters, 2 hours pw
- 1st semester
  - Sensors and Signals, Steve Burrow, Danielle Fiscaletti
- 2nd semester
  - Control, Andres Marcos

Assessment

- 70% 3 hour examination in May/June

- 15% Sensors & signals
  - Simulink coursework

- 15% Control Coursework
  - Quanser laboratory

What prior teaching do we draw upon?

- Electronics
- Linear systems theory
- Fourier transforms
- Laplace transforms
- Transfer functions

Sensors, Signals and Control

Why?

“The art of measurement is a wide discipline in both engineering and science encompassing detection, acquisition and analysis of data…

…and plays a vital role in every branch of scientific research and industrial process”

Adapted from RANGAN, “Instrumentation”

Topics

- Sensing basics
- Static sensor characteristics
- Analogue and digital signals
- Sensor systems
- Transducers
- Mathematical Modelling
  - Signals
  - System

Structure

Tuesdays (mostly) Thursdays (mostly)

	theory	*practical*
1	Signals theory - Time domain measures	Intro - measuring basics
2	Signals theory - Complex Exponential signal, Visualising signals	Health and Usage Monitoring Sytems
3	Signals theory - Discrete time signals	Review of magnetics; Temperature sensing
4	Signals theory - Correlation, Fourier and Laplace transforms	Foil strain gauges and measurement bridges
5	Signals theory - DTF, DTFT and FFT	Guest lecture - strain gauging for helicopter testing
6	Systems theory - LTI impulse response and convolution	Static sensor performance
7	Systems theory - Frequency domain, Transfer functions	Static Behaviour, Quantities, Decibels, Interference, Connections
8	Systems theory - Poles, Zeros, Bode plots, 1st & 2nd order systems	Sensor fusion
9	Theory examples class	Piezo electric devices
10		Transduction mechanisms
11		modelling piezo

Traditional 'Linear systems' type material

More knowledge based, useful-to-know type material

What are signals?

- Signals are some phenomenon that can be described quantitatively.
- They carry information; sometimes transfer energy.
- In a block diagram they are the link between system blocks.
- They may be physically measurable, or not!
- Many signals are time varying; although some we experience as frequencies.
- The information in a signal can be transferred into a different domain.
- We almost always process signals in the electrical domain.

- In these lecture you will likely hear reference to: ‘function’, ‘wave’, ‘waveforms’ as well as ‘signals’

Signals - Field and Power Quantities

- ‘Field ’ is a term used to describe a quantity whose square is proportional to power in linear system
  - Velocity
  - Force
  - Current
  - Voltage
  - Pressure

- ‘Power ’ is a used to describe just that, quantities that are power (i.e. SI units of Watts) or proportional to power

  - power per unit area e.g. Luminous intensity or sound intensity are proportional quantities.

What’s a linear system?

Do they exist?

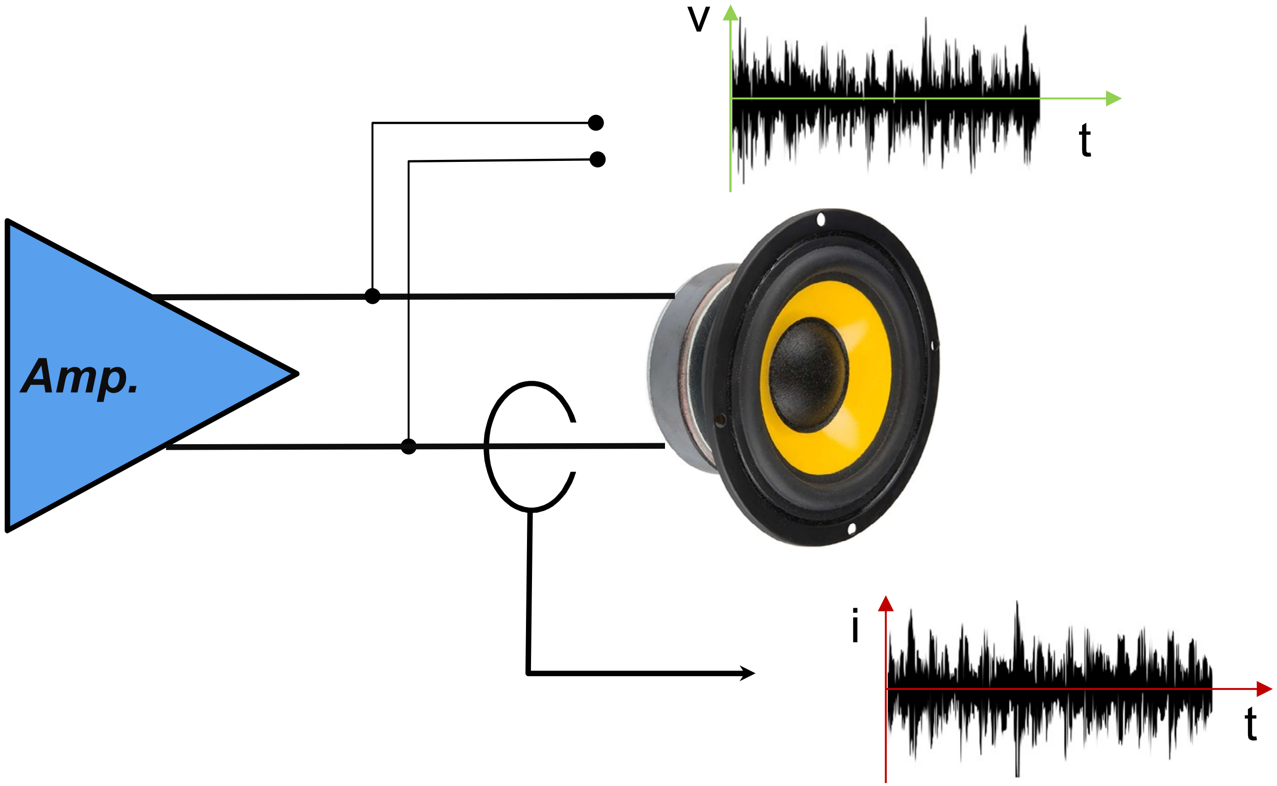
- ‘A linear system is a mathematical model of a system based on the use of a linear operator.’

- ‘As a mathematical abstraction or idealization, linear systems find important applications in automatic control theory, signal processing, and telecommunications.’

Wikipedia

Loudspeaker signals

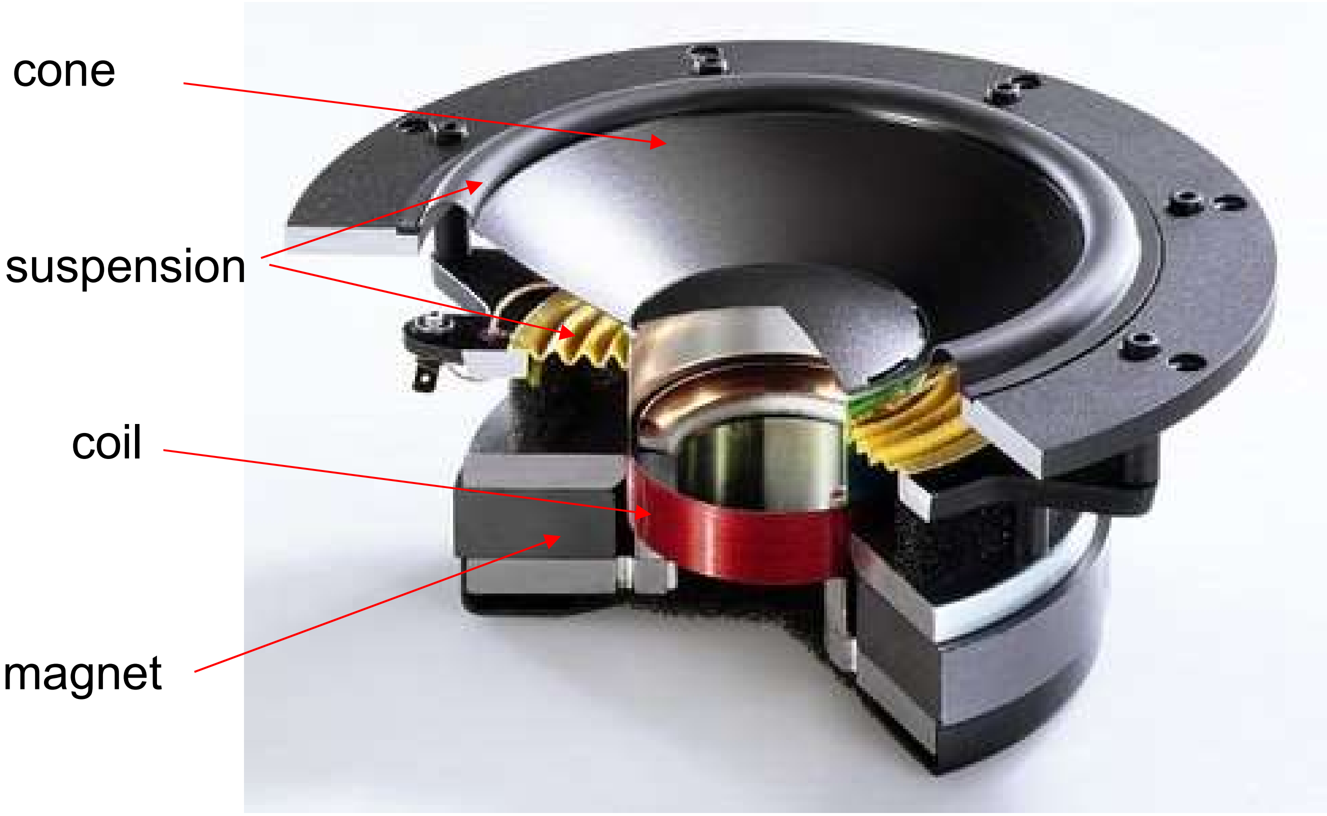
- What does a music signal look like?



There are lots of different signals and several sub-systems that we can identify. We would like to be able to model this so we can design better solutions.

Loudspeaker

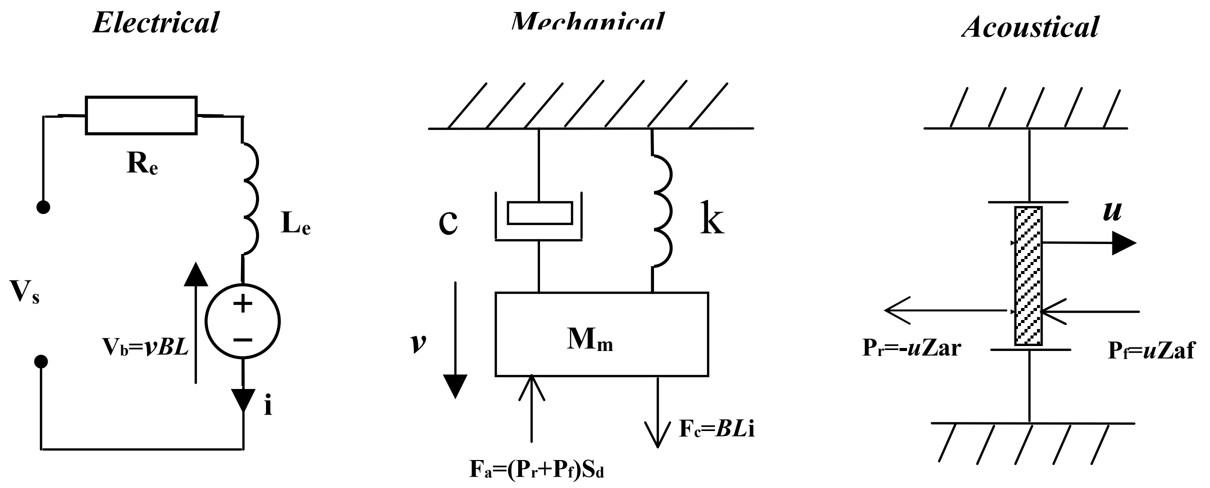
Electrical



Mechanical

Acoustical

Modelling **-** Loudspeaker example



R_e = Resistance.
L_e = Inductance.
e_b = Back emf.
i = Coil current.
e_s = Input signal.
BL = Tesla/metre product.

c = Mechanical loss.
k = Suspension stiffness
m = Moving mass.
v = Cone velocity.
F_c = Force from voice coil.
F_a = Force reflected back through cone.
S_d = Cone surface area.

u = Volume velocity.
P = Pressure created on speaker cone from volume velocity
Z_{ar} = Radiation impedance acting on rear of cone.
Z_{af} = Radiation impedance acting on front of cone.

Loudspeaker represented in 3 domains

Modelling - Loudspeaker example

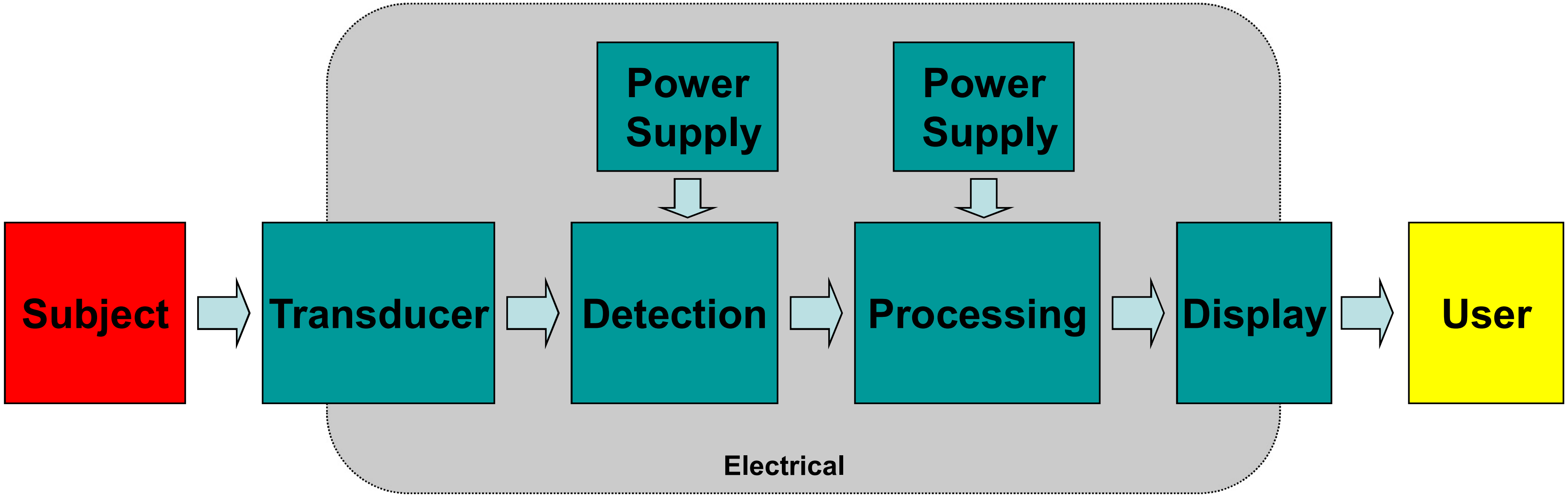
$$e_s = Ri + L\frac{di}{dt} + vBL$$

$$BLi = M\frac{dv}{dt} + Cv + \frac{1}{K}\int vdt + S_d(p_r + p_f)$$

- We can start by writing out the differential equations describing the system. They are linear differential equations.
- Imagine how unwieldy they would become as the system became more complex. OK for numerical solutions, not so good for analytical approaches.

- *Question: Do you normally solve circuits from differential equations?*

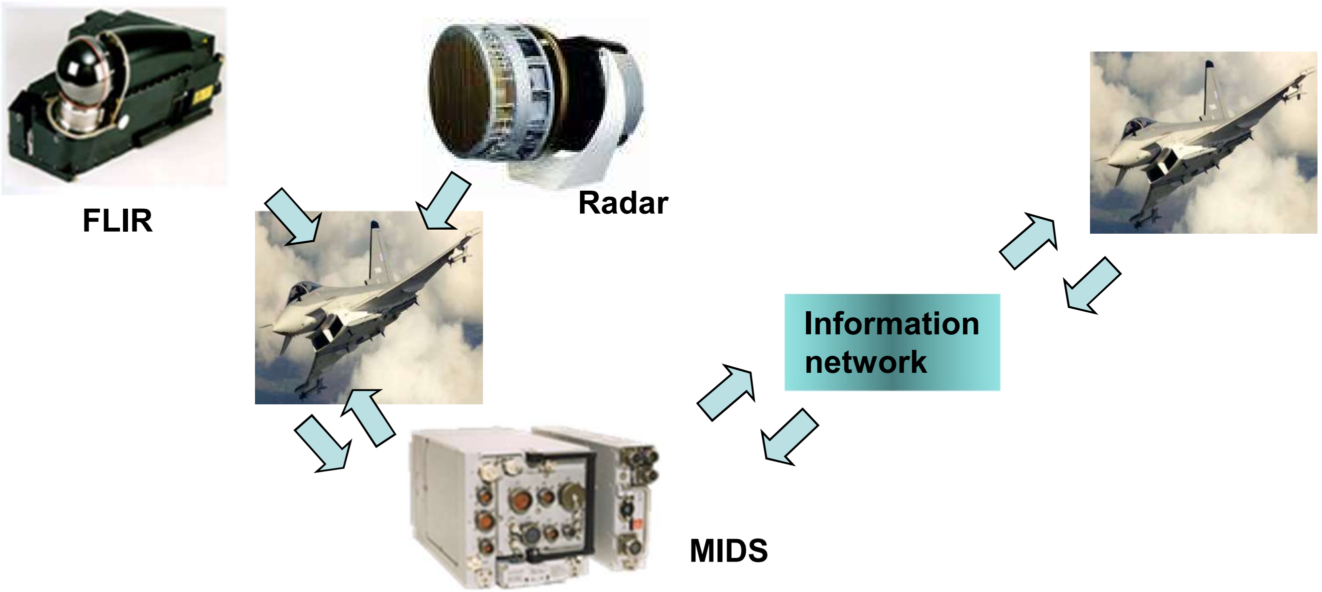
Sensor Systems - Simple Sensor



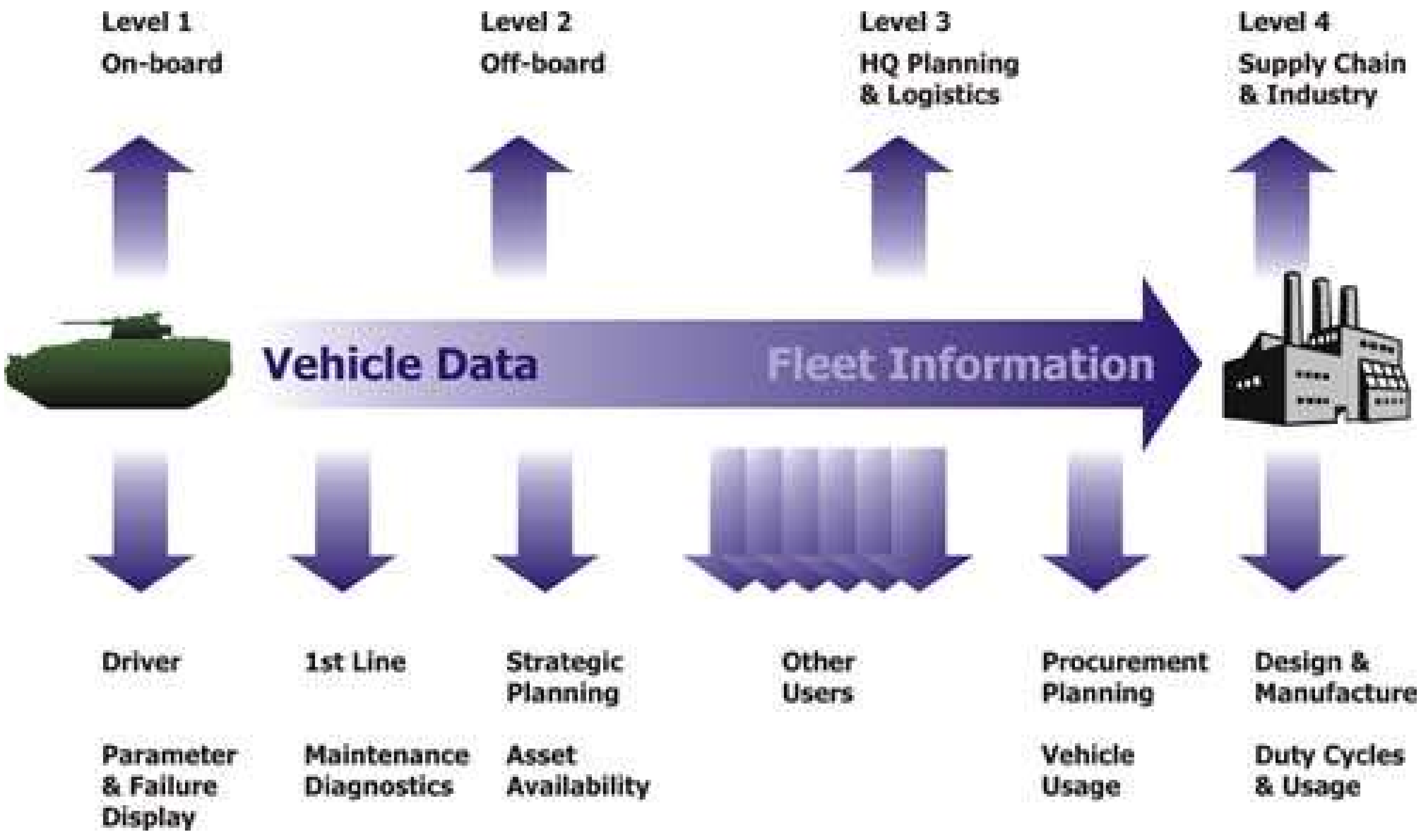
The simplest implementation of a sensor system consists of a chain of operations from a single subject through to an end user. Increasingly systems are departing from this model and there is considerable research activity in developing new sensor systems for increased capability, reliability and flexibility.

Sensor Systems - Avionics applications

Sensor fusion is a key technology on the electronic battlefield. This fusion occurs on several levels – the Typhoon fuses data from the FLIR and the Radar locally for search and track operations but can also integrate its own systems within a larger information sharing network or MIDS (Multi-Function Information Distribution System).



Sensor Systems - Advantages of HUMS



Picture: Syen

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