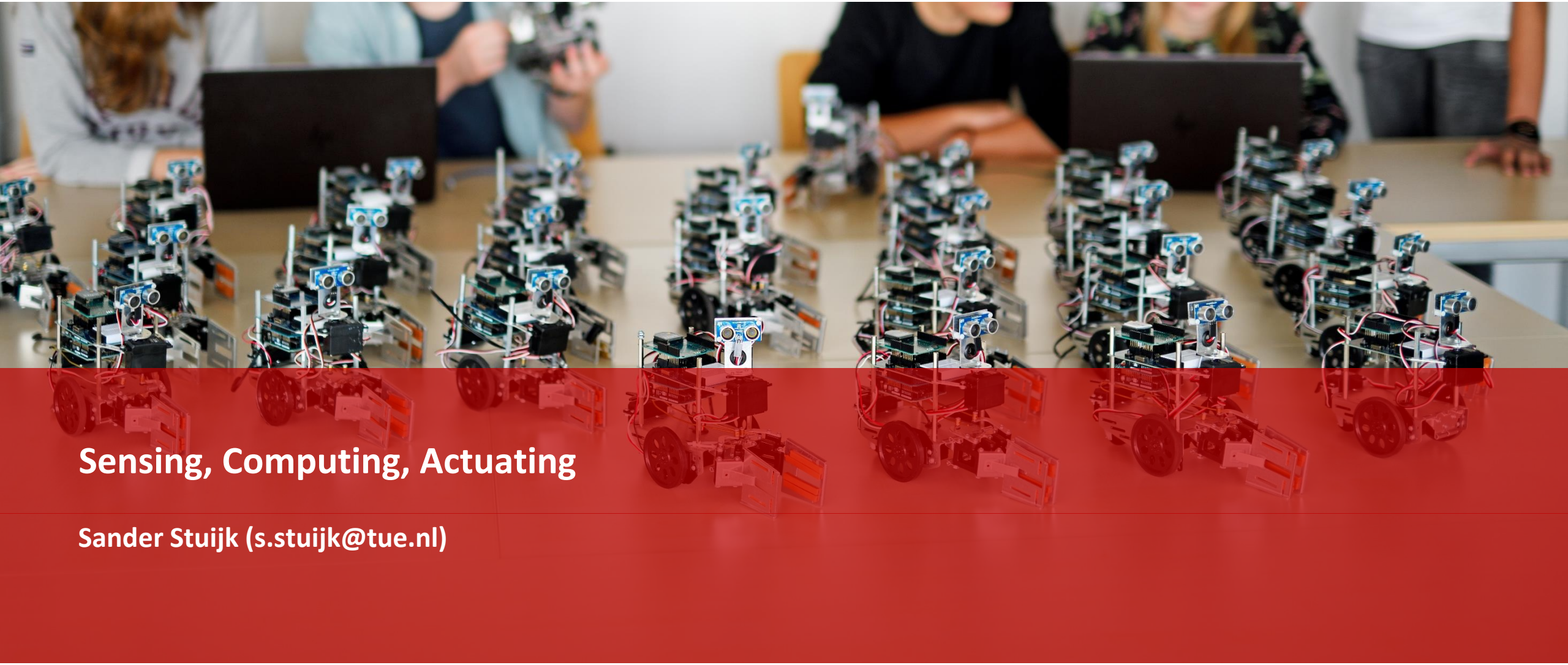

Sensing, Computing, Actuating

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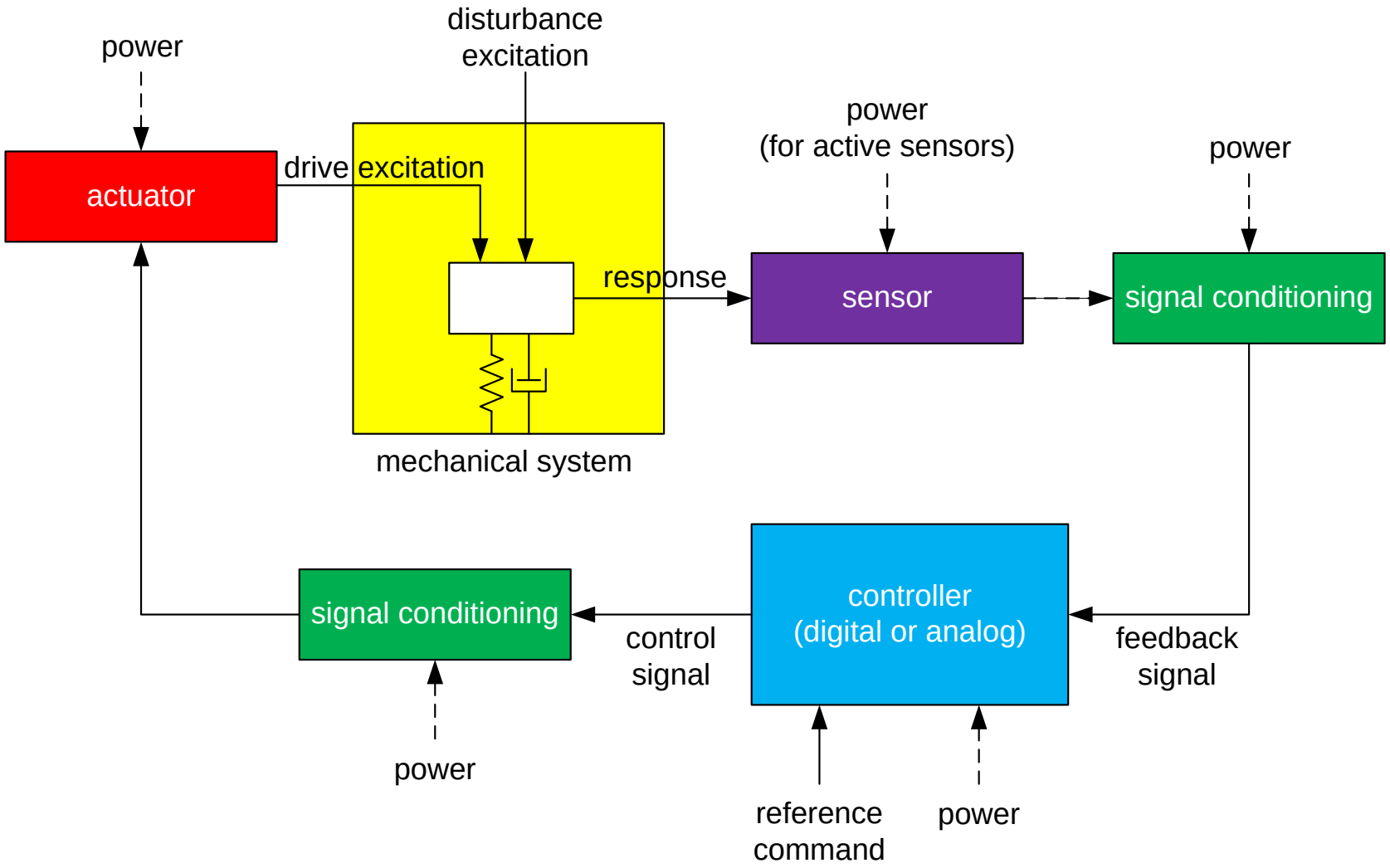
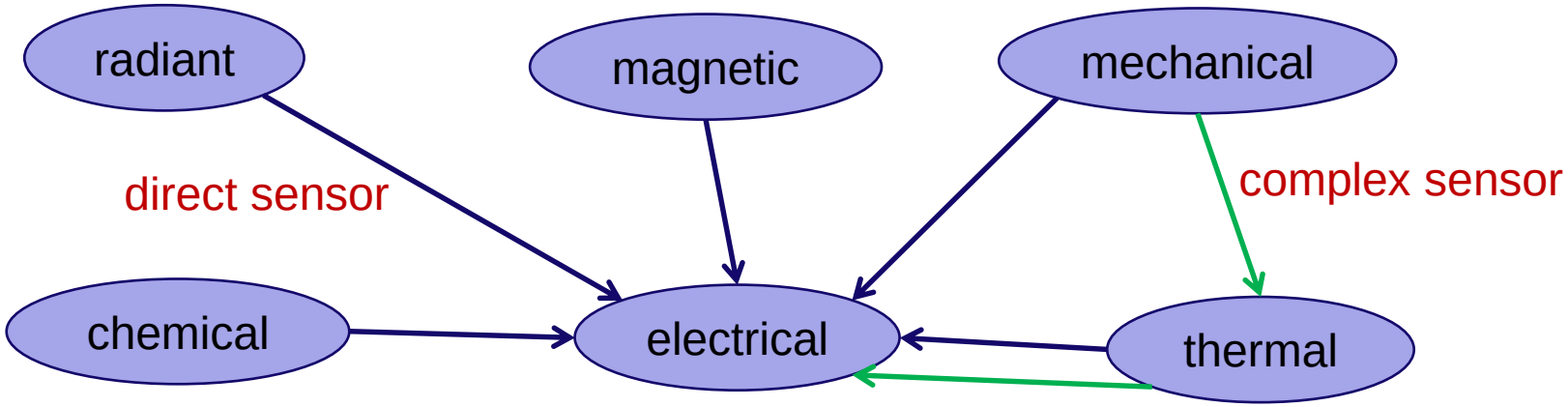
SUMMARY

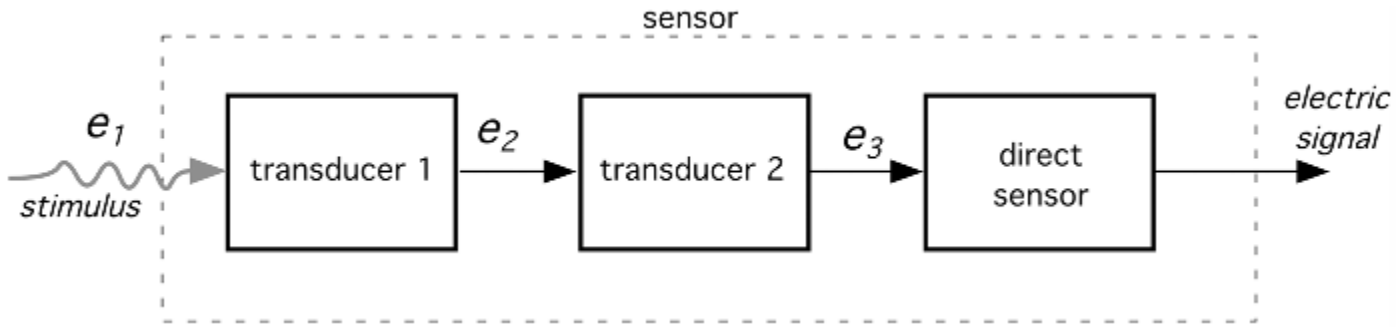
Control system



Sensors, transducers and actuators



- a transducer converts a stimulus from a signal domain to another signal domain
- a sensor receives a stimulus and responds with an electrical signal



- an actuator converts an electrical signal to another signal domain

Transducers classification – physical effect

- transducers employ physical effects to convert a stimulus from a signal domain to another signal domain

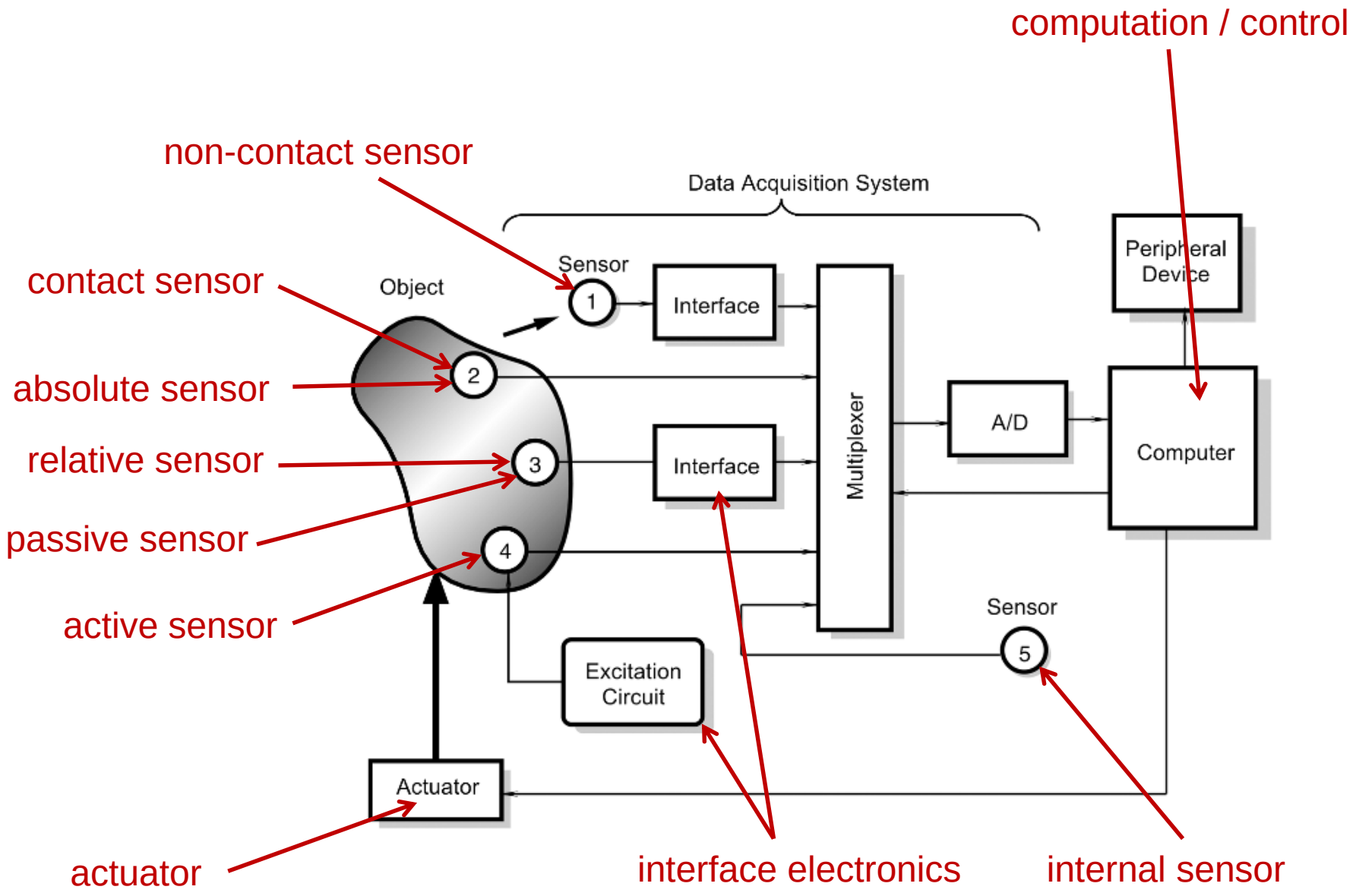
in \ out	radiation	mechanical	thermal	electrical	magnetic	chemical
radiation	photo luminance	radiation pressure	radiation heating	photo-conduction	photo-magnetic	photo-chemical
mechanical	photo-elastic effect	conservation moment	friction heat	piezo-electric	magneto-strict.	pressure induced explosion
thermal	incandescence	thermal expansion	heat conduction	Seebeck effect	Curie-Weiss law	endothermic reaction
electrical	inject luminance	piezo-electric	Peltier effect	pn-junction effect	Ampere's law	electrolysis
magnetic	Faraday effect	Magneto-striction	Ettinghausen effect	Hall effect	Magnetic induction	
chemical	Chemo-luminance	Explosive reaction	Exothermal reaction	Volta effect		Chemical reaction

Sensor classification – type / quantity measured

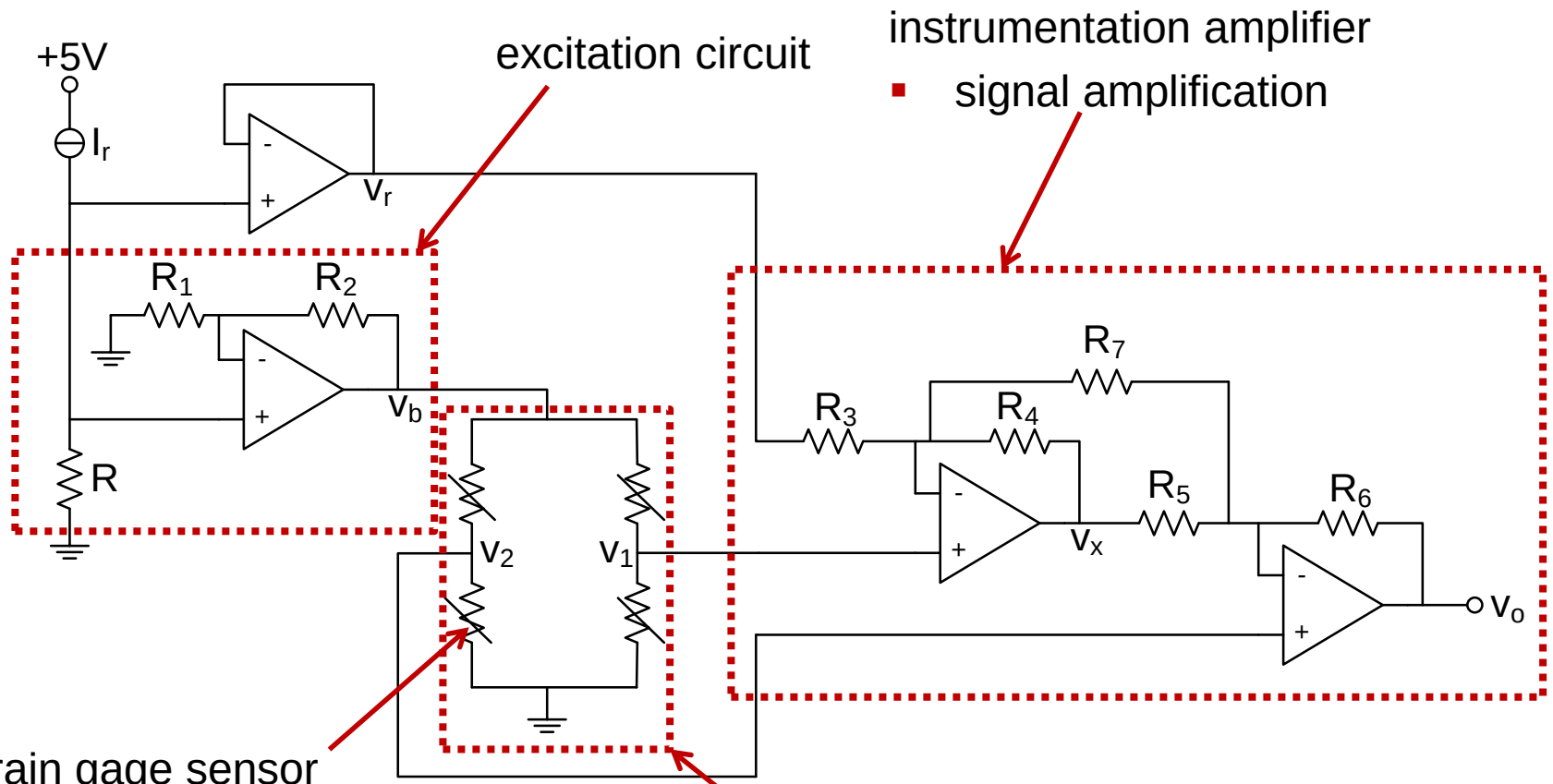
Sensor type	Quantity: Position, distance, displacement	Flow rate / Point velocity	Force	Temperature
Resistive	Magnetoresistor	Thermistor	Strain gage	RTD
	Potentiometer			Thermistor
Capacitive	Differential capacitor		Capacitive strain gage	
Inductive and electro-magnetic	Eddy currents	LVDT	Load cell + LVDT	
	Hall effect		Magnetostriction	
	LVDT			
	Magnetostriction			
Self-generating		Thermal transport + thermocouple	Piezoelectric sensor	Pyroelectric sensor
				Thermocouple
PN junction	Photoelectric sensor			Diode
				Bipolar transistor
Digital	Position encoder			Quartz oscillator
Optic				
Ultrasound	Travel time	Doppler effect		

- there are many other interesting quantities: acceleration, vibration, humidity, level, pressure, velocity, ...

Control system



Example – pressure sensor



strain gage sensor

- active sensor
- absolute sensor
- contact sensor

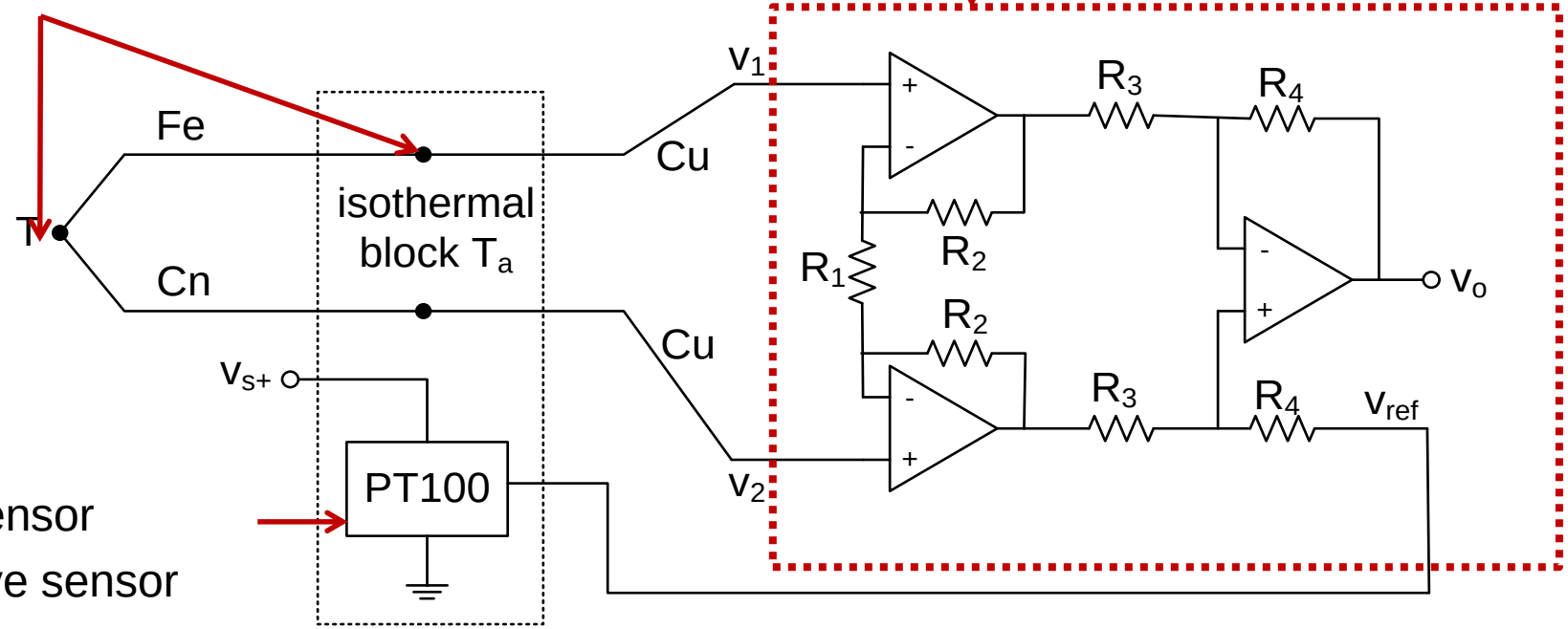
signal processing circuit

- bridge circuit
- remove error sources (e.g. temperature)
- remove offset voltage
- improve linearity
- improve sensitivity

Example – temperature sensor

instrumentation amplifier
- signal correction
- e.g. convert relative temperature to absolute temperature

thermocouple sensor
- passive sensor
- relative sensor
- contact sensor



RTD sensor
- active sensor
- absolute sensor
- internal sensor

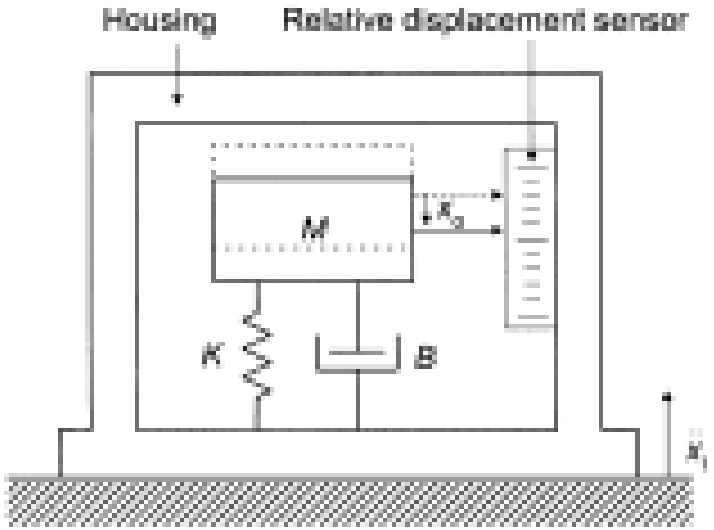
Static and dynamic characteristics

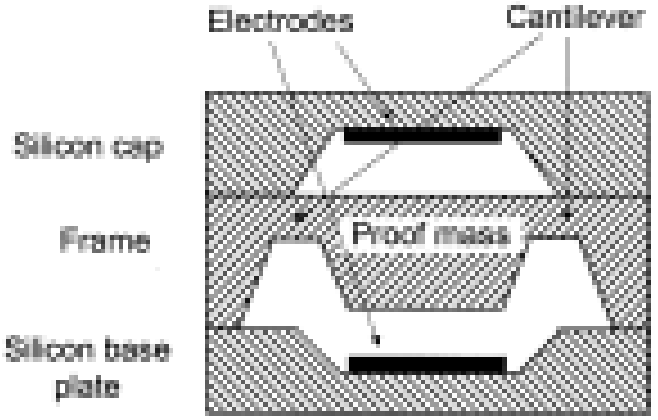
- static characteristics
  - values given for steady state measurement
- dynamic characteristics
  - values of the response to input changes
- many systems have a time-dependent behavior
- output signal needs time to adapt to change in input

Simulink example – second-order system

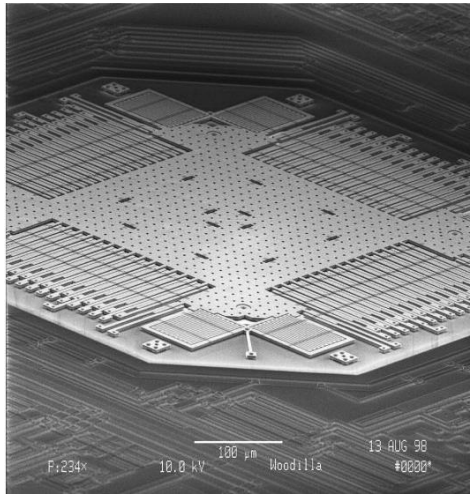
- second-order system contains two energy storing elements

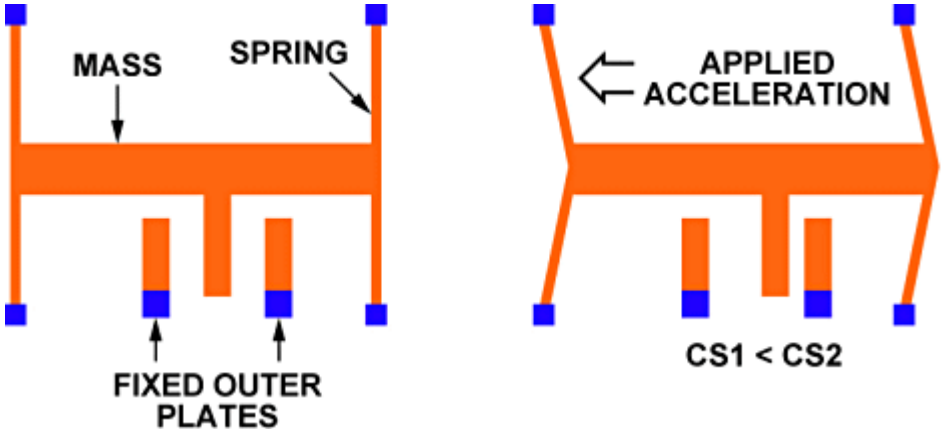
- examples – mass-spring system, micromachined accelerometer

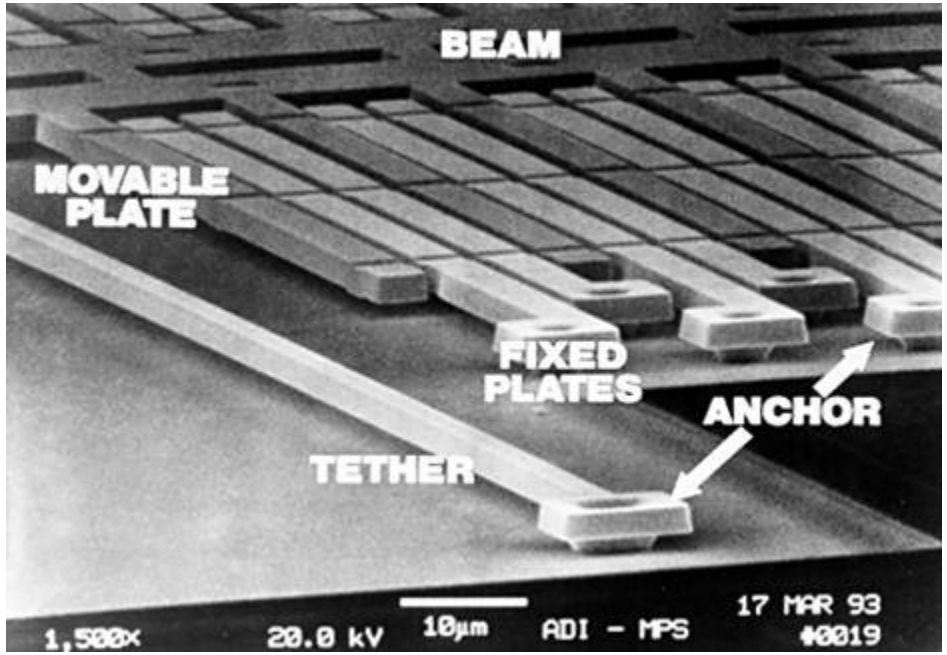


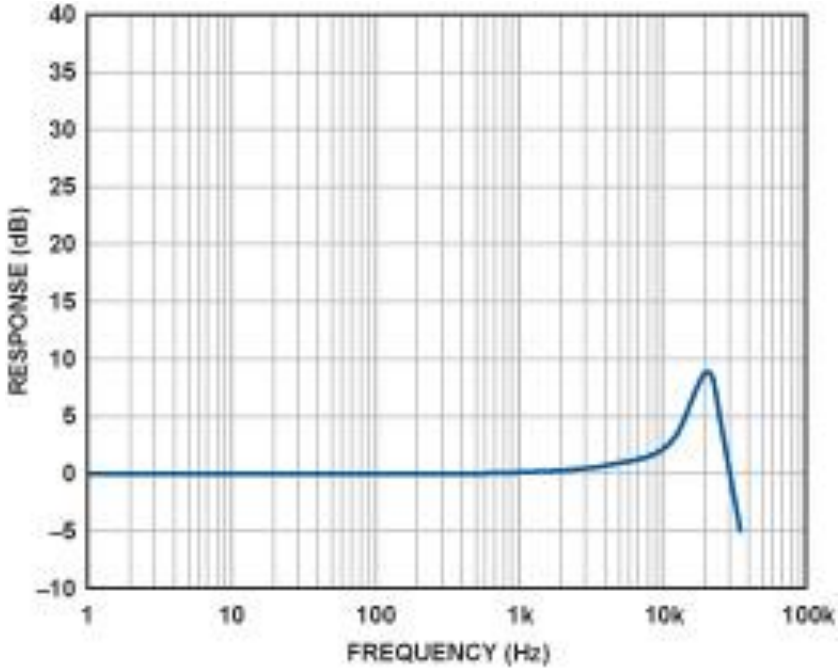


Dynamic characteristics









Dynamic characteristics