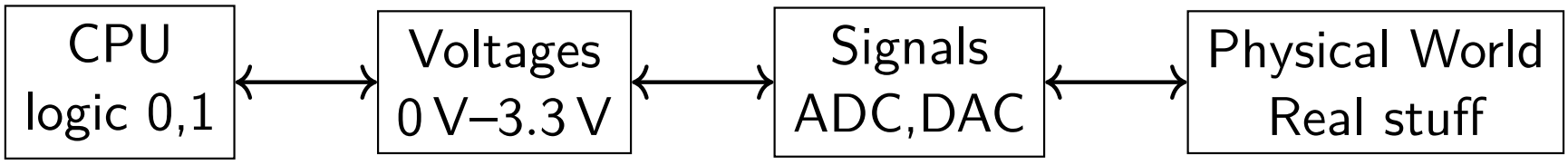
Sensors and Actuators

Control systems and Computer Networks

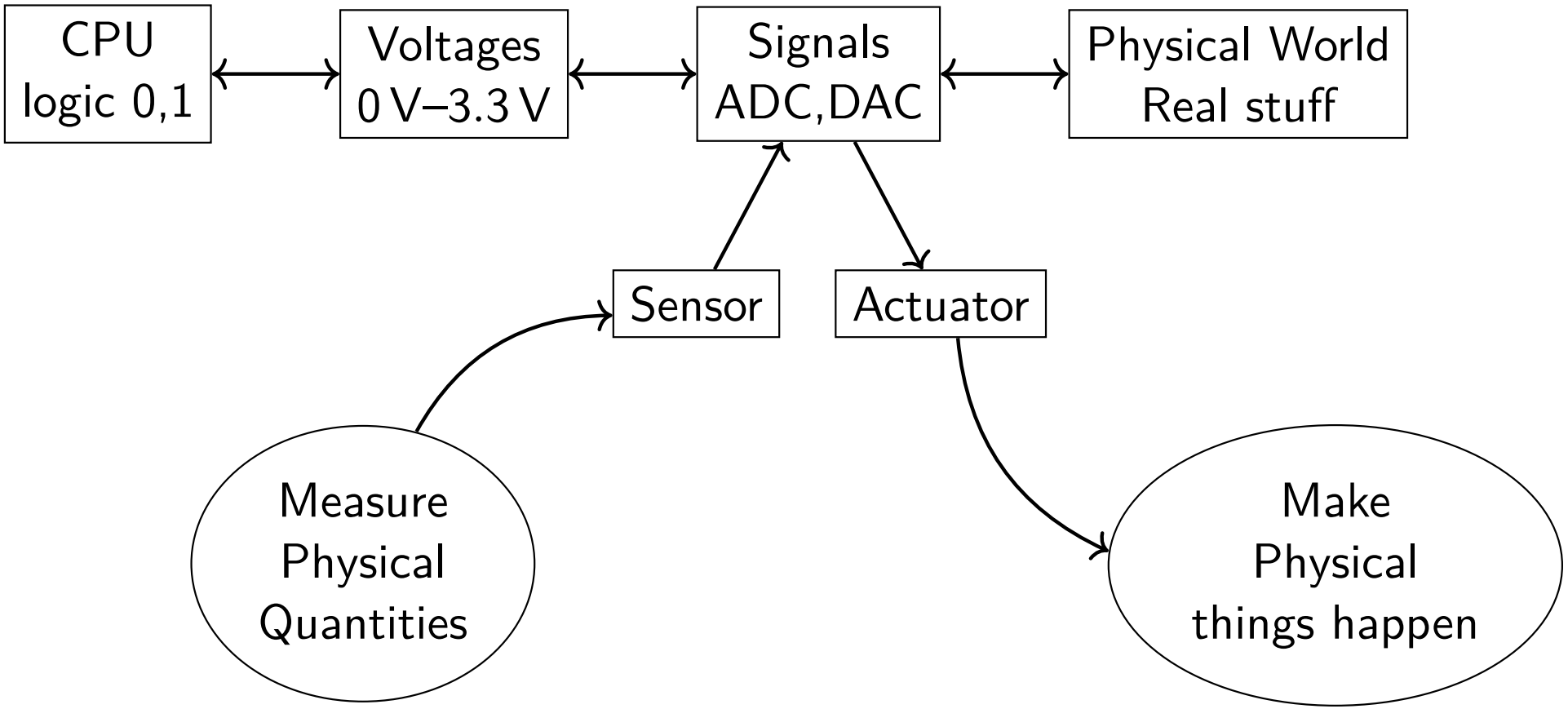
Dr Alun Moon

Lecture 4.2

Layers from Program to Physical



Layers from Program to Physical



Sensors

- Measure some value in the environment
- allow sampling of process variable
- convert changes in the physical process into electrical signals

Actuators

- Change something in the environment
- Under computer control
- provide feedback to physical process to maintain some condition
- convert electrical signals into physical changes

Sensor Examples

Physical quantities measurable

- Temperature
- Pressure
- Distance and Displacement
- Velocity
- Acceleration
- Fluid Flow
- Light intensity
- Voltage
- Current
- Resistance
- Force
- Liquid levels
- Torque
- pH

And many more...

Part I

Sensors

Switches

Binary Devices

- Position – close contacts – confirm position of mechanism
- Human hands – keyboards
- Conditions – pressure, temperature (thermostat)
- Medium
  - electrical
  - pneumatic
  - hydraulic

Pressure measurement

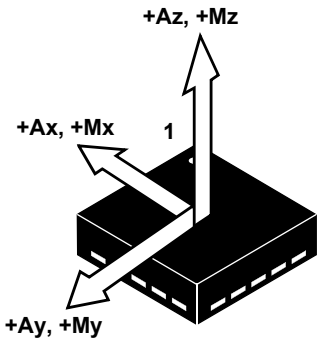
- Pressure bends an elastic element such as a diaphragm, tube, bellows or piston
- The displacement in turn moves a needle, change an electrical impedance or resistance
- Piezoelectric pressure sensors
- Rapid changes in pressure are difficult to measure – why?
- High pressure transducers are costly

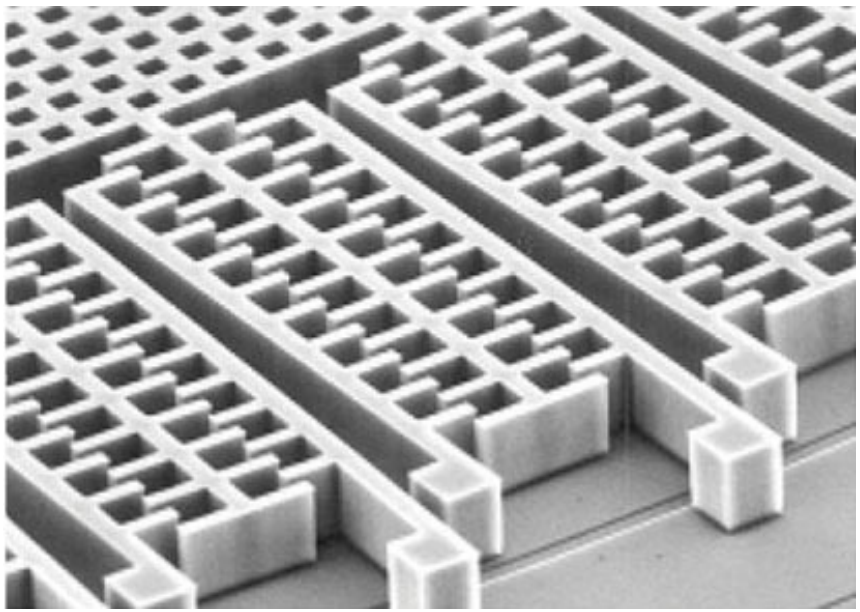
Temperature

- Expansion of solids, liquids or gases
- Pressure or movement changes can be measured
- Thermocouples – junction between dissimilar metals – generate small voltages
- Other solid state devices are available such as thermistors

Acceleration

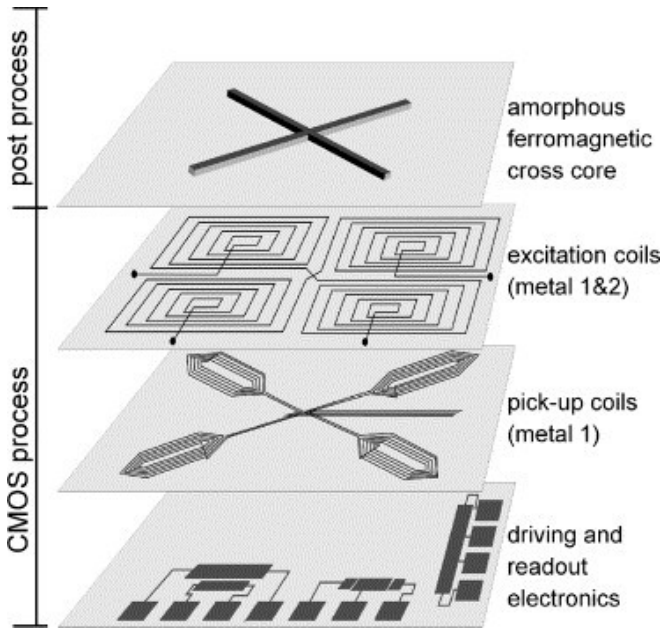
- Typically MEMS devices
- Silicon chip scale mechanism
- Moving mass
  - flexes strain gauge – measure resistance
  - changes air gap – measure capacitance
  - piezoelectric – strain crystal, generates voltage

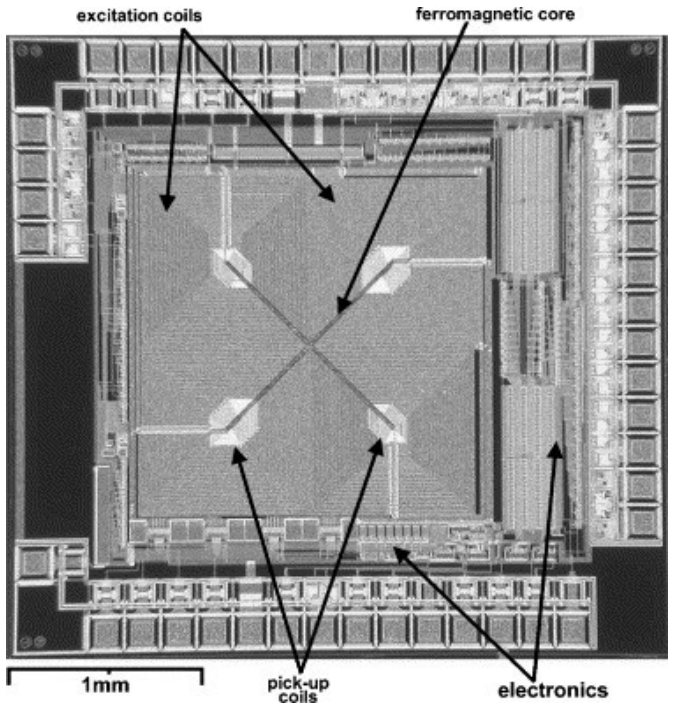




Magnetometer

- Senses magnetic fields
  - 1D
  - 2D





Part II

Actuators

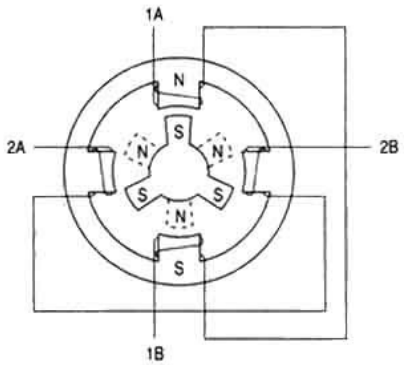
DC Motors

DC motors are employed very widely in industry, appliances, automobiles, etc.

- Used to provide continuous rotation or no rotation - position
- Inexpensive and efficient
- Can use PWM for speed control - noisy
- Geared for more torque

Stepper Motors

- Digitally controlled
- Discrete positioning
- Useful where accurate control is required
- Lower torque than DC
- Pulses cause the motor to rotate in steps - perhaps 1.8° per pulse
- Positional feedback is not required (unless the motor slips)



RC Servos

Used in Radio Control applications, and widely used in small scale systems

- 3-pin connections Signal, Voltage, Ground
- PWM controlled
  - Pulse width determines position
  - 1.5 ms “neutral” position
  - 1.0 ms sets to 0°
  - 2.0 ms sets to 90°

Part III

Limitations

Limitations

Devices have some built in limitations on how they operate

Accuracy the total of all deviations between a measured value and the actual value - sum of non-linearity, repeatability and hysteresis.

Non-linearity the maximum difference in measured value or output from a straight line between calibration points

Repeatability the max difference in a measured value or output when a set point is approached multiple times from above or below

Hysteresis the max difference in measured value or output when a set value is approached from above, and then below the value.

Accuracy and Precision

Accuracy How close to the actual value (related to repeatability)

Precision How fine a measurement can you make – how close can two values be and till be distinguished.