CS1011：數位電子導論

Actuators

Outline

- Introduction
- Heat Actuators
- Light Actuators
- Force, Displacement and Motion Actuators
- Sound Actuators
- Actuator Interfacing

Introduction

- In order to be useful, an electrical or electronic system must be able to affect its external environment. This is done through the use of one or more actuators
- As with sensors, actuators are a form of transducer which convert one physical quantity into another
- Here we are interested in actuators that take electrical signals from our system and vary some external physical quantity

Heat Actuators

- Most heat actuators are simple resistive heaters
- For applications requiring a few watts, ordinary resistors of an appropriate power rating can be used
- For higher power applications, there are a range of heating cables and heating elements available

Floor heating cables

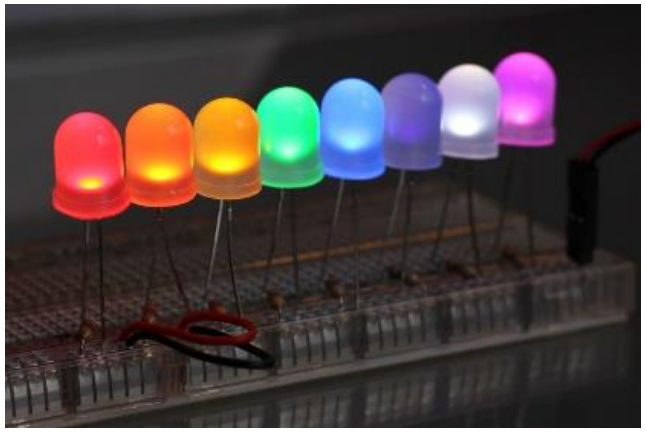
Heating elements

Light Actuators (1/4)

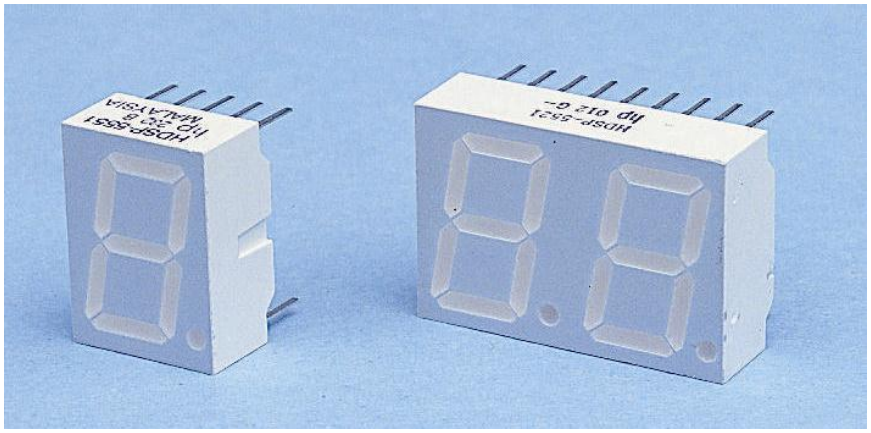
- For general illumination, it is normal to use conventional incandescent light bulbs (白熾燈) or fluorescent lamps (螢光燈)
  - Power ratings range from a fraction of a watt to perhaps hundreds of watts
  - Easy to use but relatively slow in operation
  - Unsuitable for signalling and communication applications

Light Actuators (2/4)

- **Light-emitting diodes (LEDs)**
  - Produce light when electricity is passed though them
  - A range of semiconductor materials can be used to produce light of different colors
  - Can be used individually or in multiple-segment devices such as the seven-segment display



Light-emitting diodes



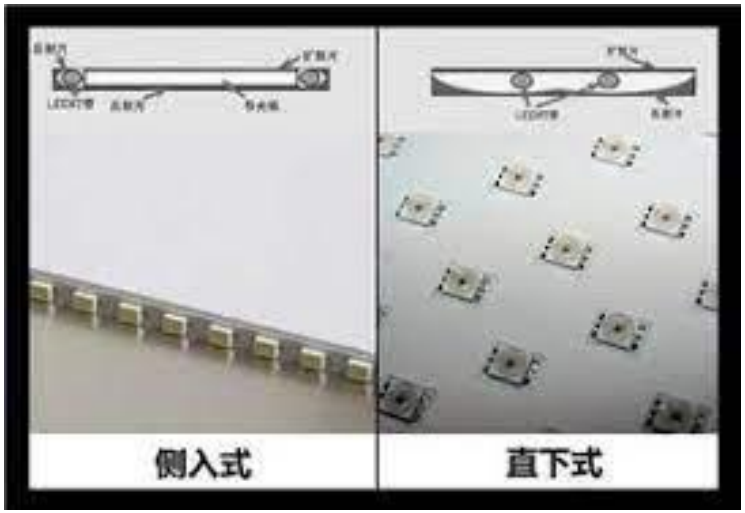
LED seven-segment displays

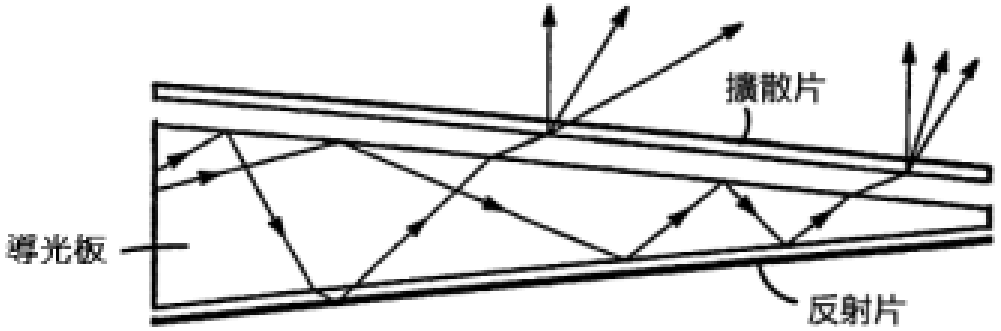
Light Actuators (3/4)

- **LED light bulbs**
  - **In addition to their use in electronic applications, LEDs are increasingly being used in domestic and industrial lighting**
  - **They are considerably more efficient than incandescent (白熾燈) and fluorescent (螢光燈) lights and have a much greater life**

An LED light bulb

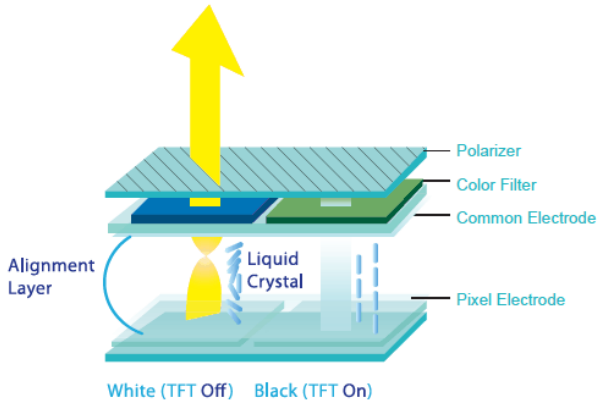
Accessories for LED Lighting





Light Actuators (4/4)

- **Liquid crystal displays**
  - Consist of 2 sheets of polarised glass with a thin layer of oily liquid sandwiched between them
  - An electric field rotates the polarization of the liquid making it opaque
  - Can be formed into multi-element displays (such as 7-segment displays)
  - Can also be formed into a matrix display to display any image or character



Thin-film-transistor LCD

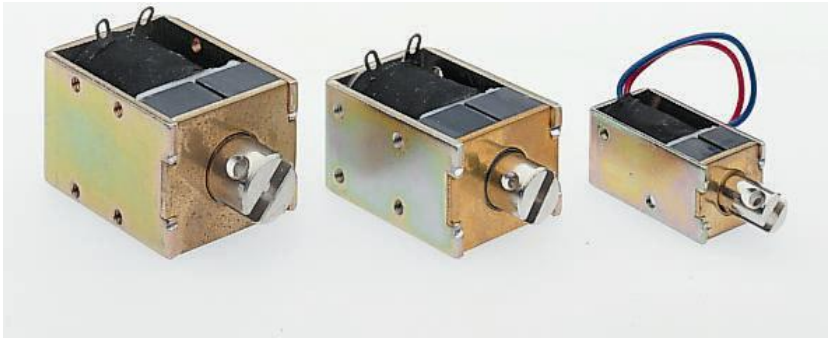
A custom LCD display

How LCD works: https://www.youtube.com/watch?v=0B79dGR19Tg

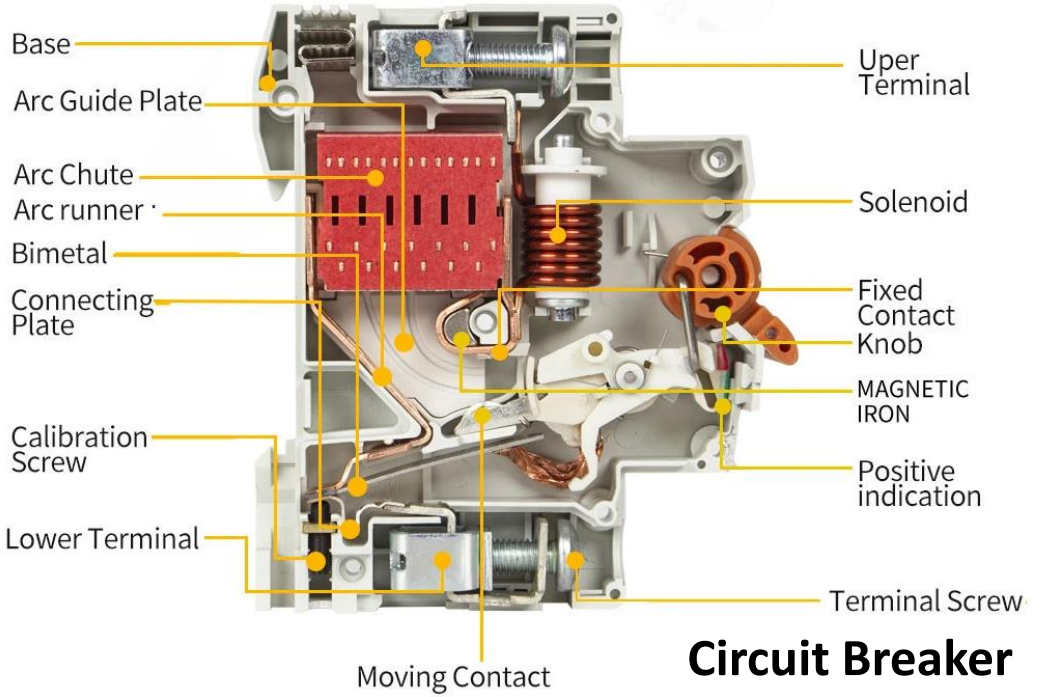
Force, Displacement & Motion Actuators

▣ Solenoids (螺線管)

- Basically a coil and a ferromagnetic ‘slug’
- When energized, the slug is attracted into the coil
- Force is proportional to current, often used in an ON/OFF mode
- Can produce a force, a displacement or motion
- Can be linear or angular



Small linear solenoids

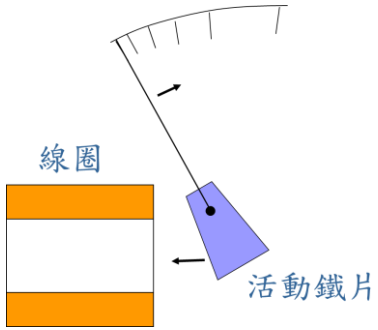


Circuit Breaker

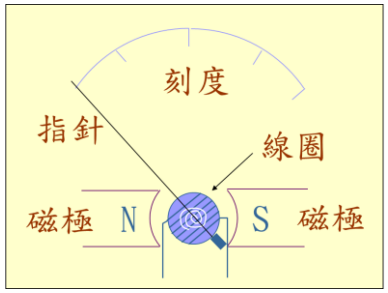
Force, Displacement & Motion Actuators

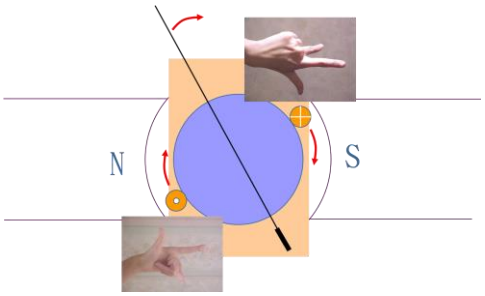
Meters

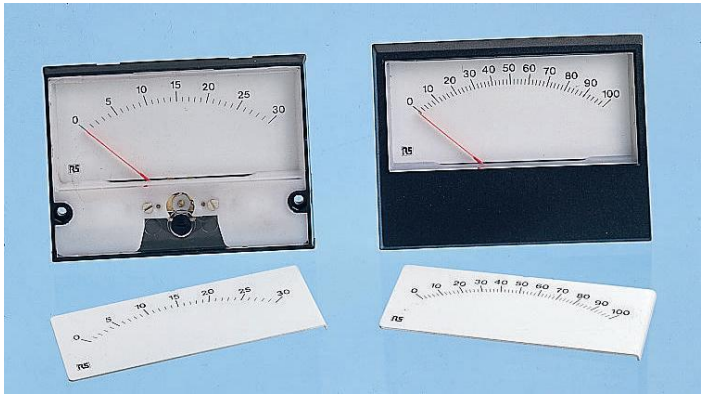
- **Moving-iron**
  - Effectively a rotary solenoid + spring
  - Can measure DC or AC



- **Moving-coil**
  - Most common form
  - Deflection proportional to average value of current (rectified required for AC)
  - Full-scale deflection: typically 50 μA – 1 mA
  - Used in voltmeters and ammeters







Moving-coil meters

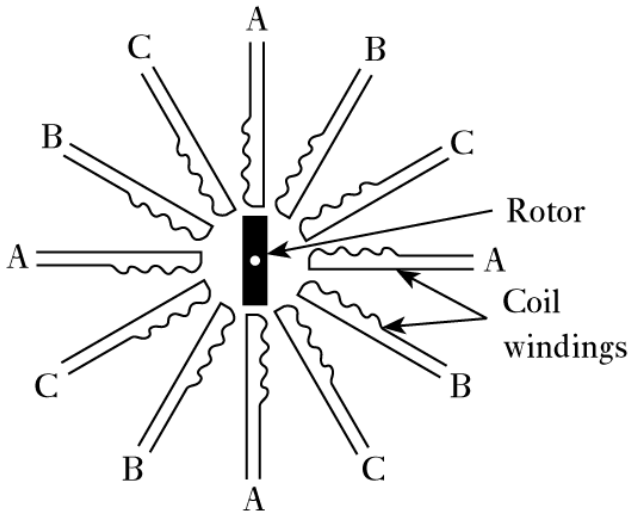
Reference: ETEAHK/ATS

Force, Displacement & Motion Actuators

- **Motors**
  - **AC motors**
    - Primarily used in high-power applications
  - **DC motors**
    - Used in low-power precision position-control applications
  - **Stepper motors**
    - A digital (discrete) actuator used in position control applications

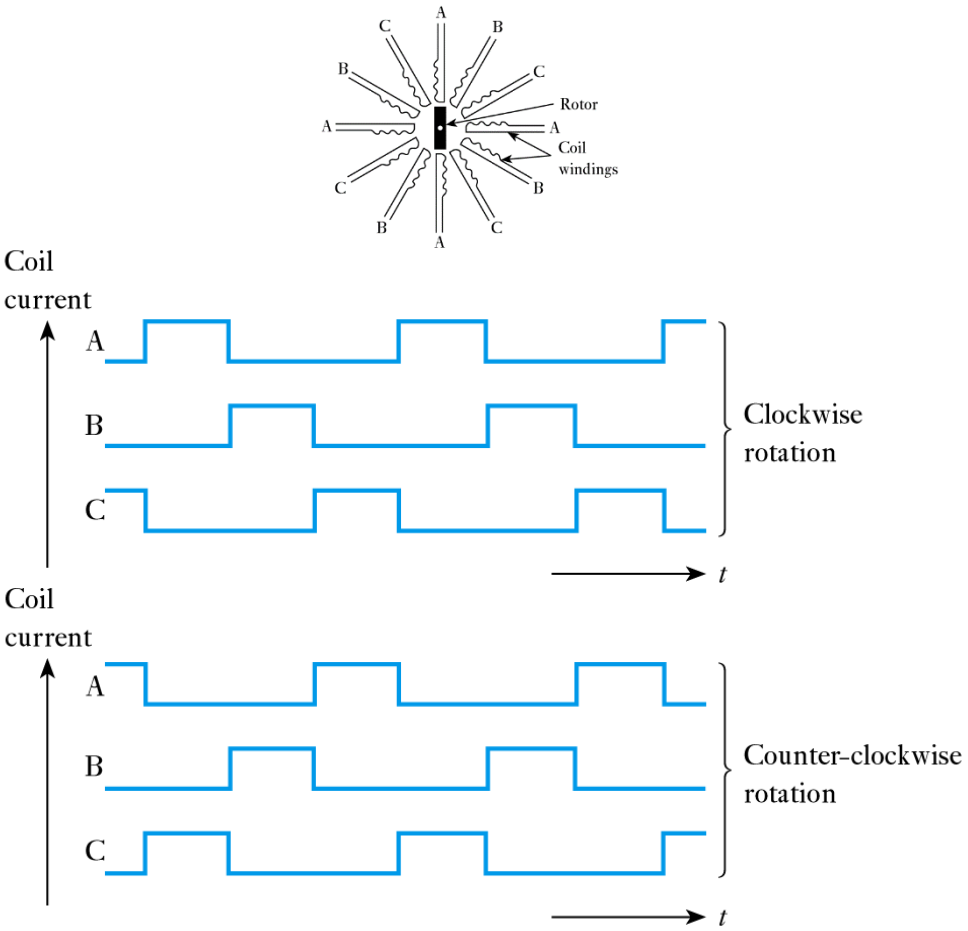
Stepper Motors (1/2)

- A central rotor surrounded by a number of coils (or windings)
- Opposite pairs of coils are energized in turn
- This ‘drags’ the rotor round one ‘step’ at a time
- Speed proportional to frequency
- Typical motor might require 48-200 steps per revolution



A simple stepper motor

Stepper Motors (2/2)



Stepper-motor current waveforms

A typical stepper-motor

Sound Actuators

Speakers

- Usually use a permanent magnet and a movable coil connected to a diaphragm (隔板)
- Input signals produce current in the coil causing it to move with respect to the magnet

Ultrasonic transducers

- At high frequencies, speakers are often replaced by piezoelectric (壓電) actuators
- Operate over a narrow frequency range

Actuator Interfacing (1/2)

Resistive devices

- Interfacing involves controlling the power in the device
- In a resistive actuator, power is related to the voltage
- For high-power devices, the problem is in delivering sufficient power to drive the actuator
- High-power actuators are often controlled in an ON/OFF manner
- These techniques use electrically operated switches
  - Discussed in later lectures

Actuator Interfacing (2/2)

- **Capacitive and inductive devices**
  - **Many actuators are capacitive or inductive (such as motors and solenoids)**
  - **These create particular problems – when using switching techniques**
  - **These hard topics will be discussed in power electronics (not covered in our course)**

Key Points

- Systems affect their environment using actuators
- Most actuators take power from their inputs in order to deliver power at their outputs
- Some devices consume only a fraction of a watt while others consume hundreds or perhaps thousands of watts
- In most cases the efficiency of the energy conversion is less than 100%, in many cases it is much less
- Some circuits resemble resistive loads while others have considerable capacitance or inductance
- The ease or difficulty of driving actuators varies with their characteristics