Instrumentation Systems*

Revision sheet

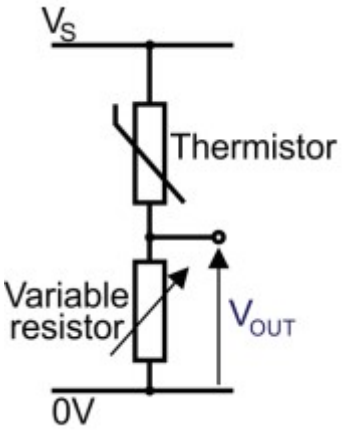
1 Analogue Instrumentation

There are two key types of analogue instrumentation systems:

- Potential divider circuit
- Wheatstone bridge.

1.1 Potential divider circuit

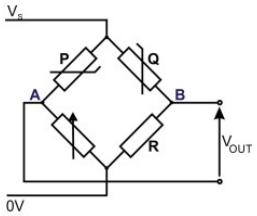
For example, this is a temperature sensing subsystem.

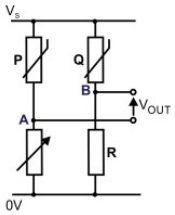


There are a number of issues with the potential divider circuit, all of which can be overcome by using a Wheatstone bridge.

- Affected by supply voltage fluctustions
- Resistance is affected by factors other than intended (eg, humidity)

1.2 Wheatstone bridge





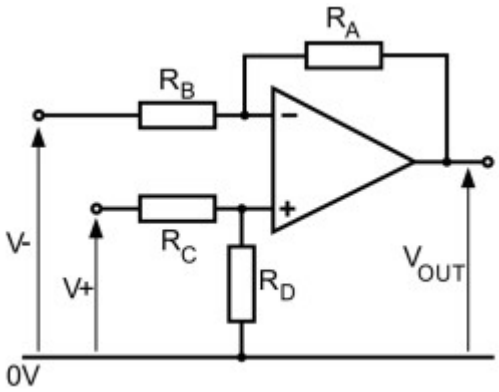
Both diagrams are of the same circuit, however the one on the right is easier to understand. The fundamentals of this circuit can be defined in the following equation:
If $\frac{P}{VR} = \frac{Q}{R}$ (ratio of resisotrs is the same on both sides of the bridge)
$V_P = V_Q$
$Vout = 0V$ (This means the bridge is balanced, which is what we want!)
If V_S increases, V_Q and V_P both increase proportionally therefore the bridge stays balanced. Both P and Q are subjected to the same environment, however only Q is attached to the temperature being measured. This compensates against voltage changes due to unwanted environmental changes.

*Images from Wjec E-book

1.3 Measure-y things

- Thermistor
- Light Dependant resisotrs
- Strain gauge

1.4 Instrumentation amplifier

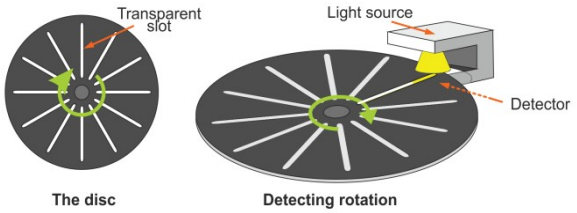


The output from the Wheatstone bridge is tiny, we have to amplify it. The amplifier has to have a high CMRR and a high input impedance.
$R_F = R_D$
$R_1 = R_2$
$Vout = (V_+ - V_-) \times \frac{R_F}{R_1}$

2 Digital Instrumentation

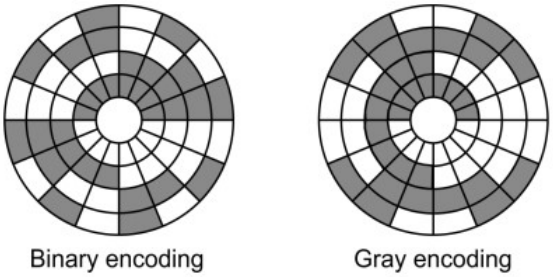
The simplest form of input is a button.
Digital inputs can either be on (1) or off (0).

2.1 Slotted Disc



The disc spins around inside a reader where a beam of light is shone through and where there is a slot in the disc, it hits the detector. The light is quite often infra-red light. It is only useful to measure speed/number of rotations as it doesn't show direction.

2.2 Encoded disc



The position is measured using opto-switches which shine a light down to the disc and record the reflection which comes back from it.

2.2.1 Binary encoded disc

This is better than a slotted disc as each sector tells us exactly which part of the disc it is on therefore we can measure absolute position. There are still problems with this disc: when the disc advances from 000 to 111, it isn't registerd cleanly there are intermediary false readings which is bad. To fix this problem, we can us Gray Code.

2.2.2 Gray Encoding

This is the same as binary however, only one bit changes per segment. It is calculated like so:

1. Change the LSB
2. If the new state already occured, switch it back and change the next one instead
3. Repeat

This now gives us no false readings.

2.3 Resolution of discs

Resolution: the minimum change in angle that can be detected.
$Resolution = \frac{360}{2^n}$