# Incremental encoder

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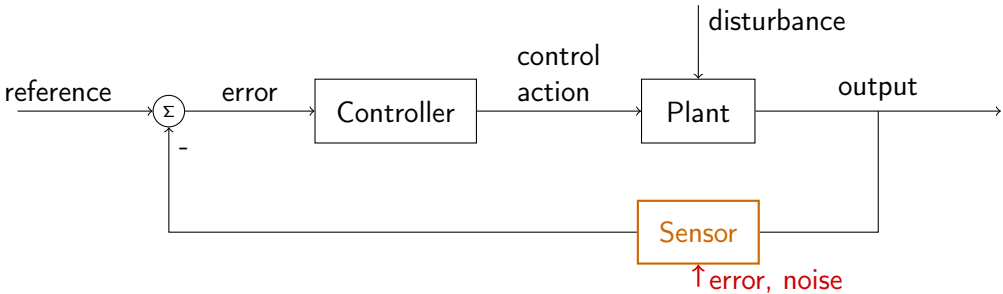
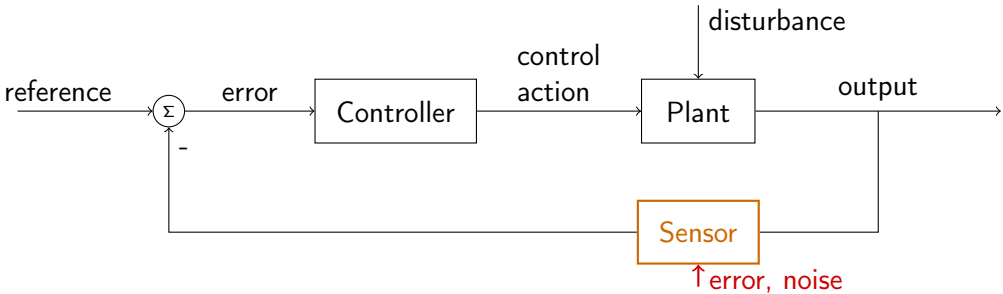
# Sensors

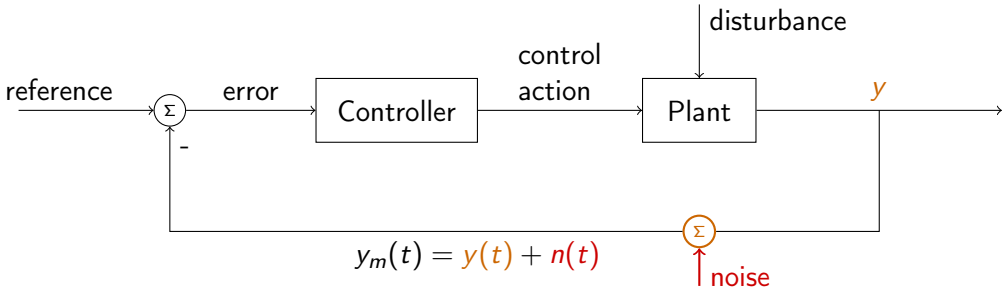

disturbance
control
action
reference
error
Controller
Plant
output
Σ
-
Sensor
error, noise

# Sensors

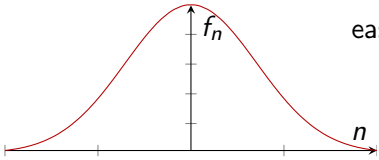



It is inevitable that sensors introduce noise into the system.

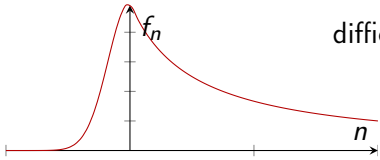
# Sensors




It is important to know the (statistical) characteristics of the measurement error!




easy




difficult

# Sensors - characteristics

- Accuracy How correct is the measurement on average
- Precision How much do the errors vary (standard deviation)
- Sensitivity/resolution The smallest change in the measured variable that can be detected
- Delay $y_m(t) = y(t - \tau) + n(t)$
- Sampling and digitalization

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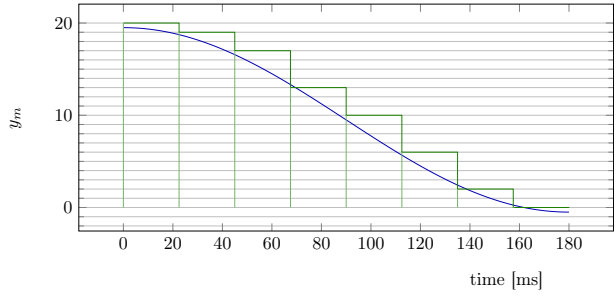
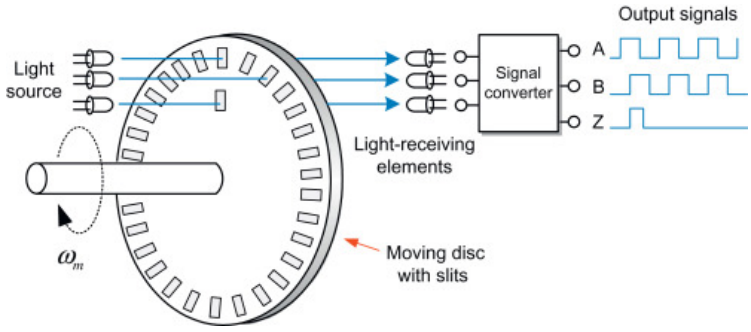


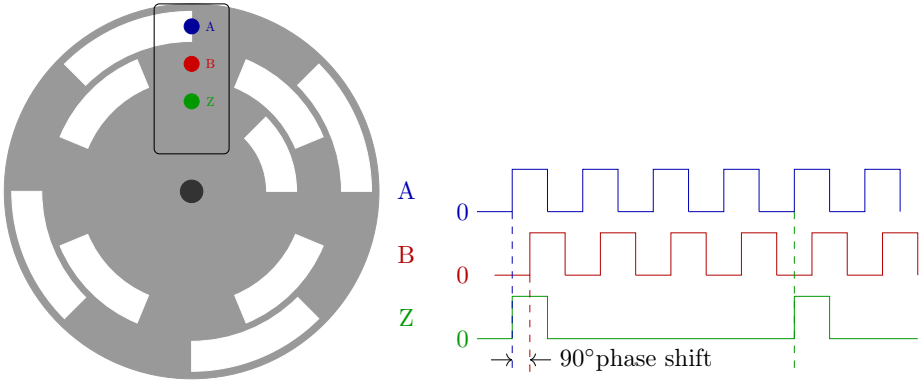
# Incremental encoder




Source:

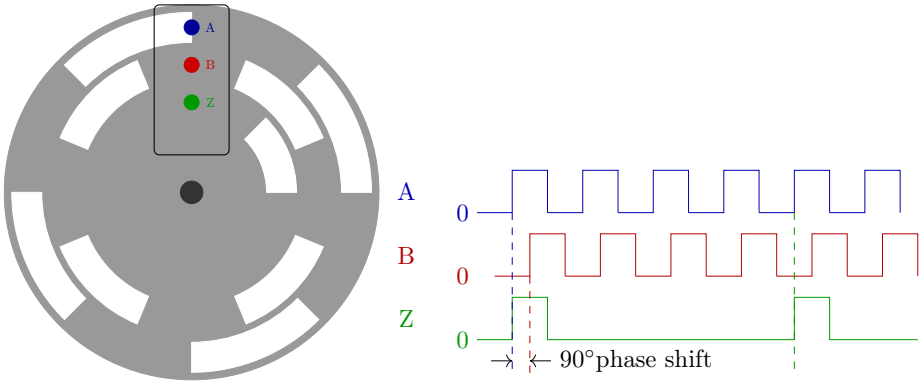
https://www.sciencedirect.com/topics/engineering/incremental-encoder

# Incremental encoder



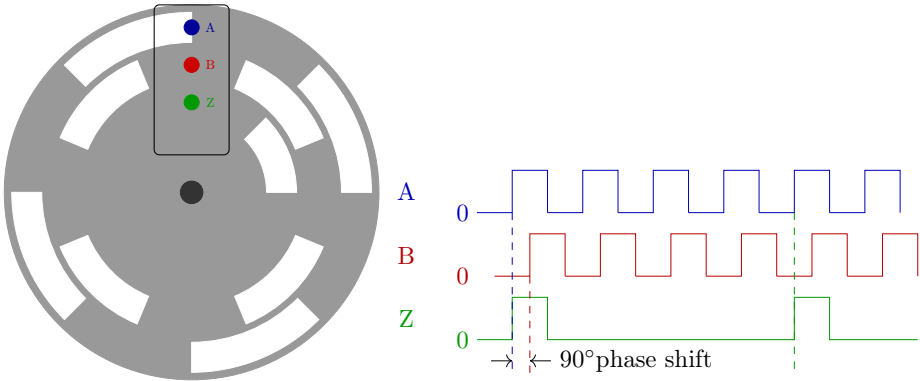

*Pulses Per Revolution (PPR)* is 4 en the example. Each aperture covers a sector of $\frac{360°}{2 \times PPR} = 45°$.

# Incremental encoder



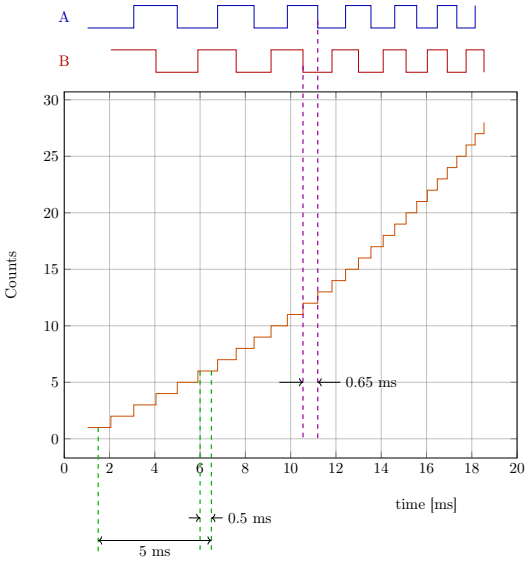

Activity If both rising and falling edges of both signals A and B, what is the smallest change in angle that can be detected (*sensitivity* of the sensor)?

# Incremental encoder



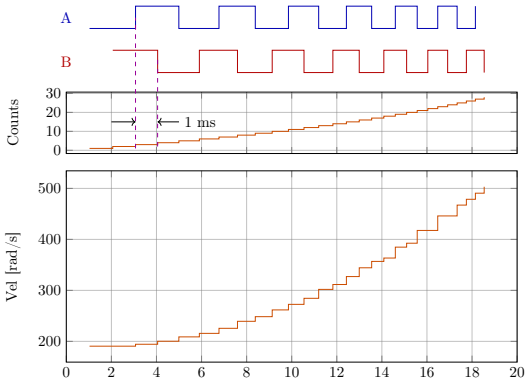

Activity In the above example, does the encoder turn clockwise (CW) or counter-clockwise (CCW)?

# Incremental encoder - velocity




We want to find the angular velocity at the time-instant $t = 6.5$ ms. For the encoder we have PPR=8, and both rising and falling edges of both signals A and B are counted, resulting in 32 counts per revolution.
Activity Calculate the angular velocity in rad/s for case (a) using a sampling period of $\Delta t = 0.5$ ms, and for case (b) using a sampling period of $\Delta t = 5$ ms.

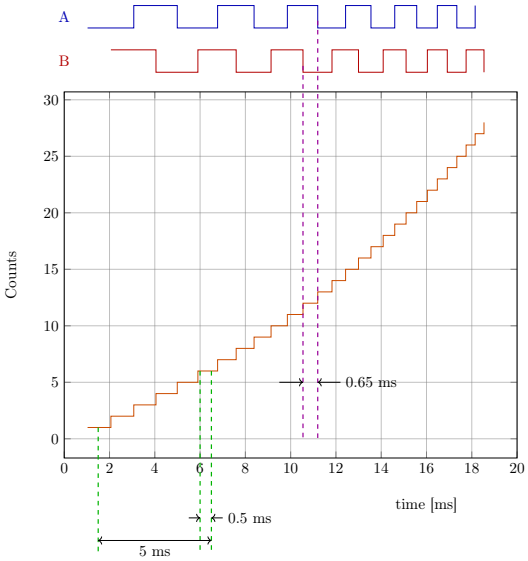
# Incremental encoder - Velocity from frequency of the counts




The velocity can be measured by the inverse of the time between subsequent pulses. In the example there is an interval of $1\ \mathrm{ms}$ between the two pulses. The velocity becomes

$$v = 1\,\text{pulses/ms} = \frac{1/32\,\text{revolutions}}{10^{-3}\ \mathrm{s}}$$
$$= \frac{2\pi}{32} \times 1000\ \mathrm{rad/s} = 196.3\ \mathrm{rad/s}$$

# Incremental encoder - Velocity from frequency of the counts




Activity Calculate the velocity!

# Simulink exercise - decoder

Complete the simulink diagram so that the angular velocity is correctly estimated.