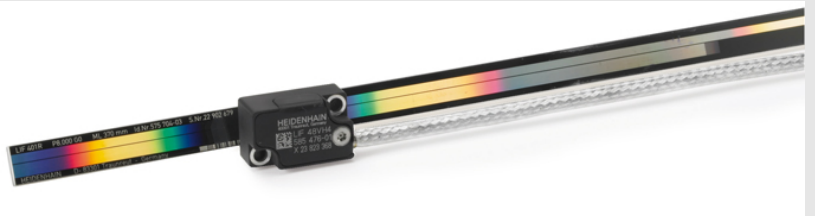
Introduction to Encoders

Or

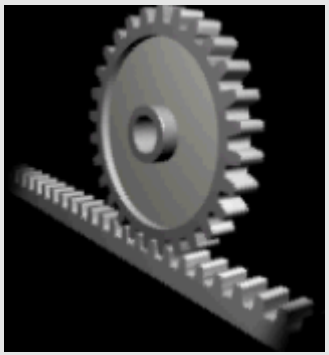
You spin me right 'round, baby, right 'round

Encoders: Linear versus Rotary

- Linear encoders measure linear motion
  - A coded linear scale moves past sensor head(s) to detect motion
  - Resolution is typically defined as pulses per linear measurement, e.g. pulses per millimeter

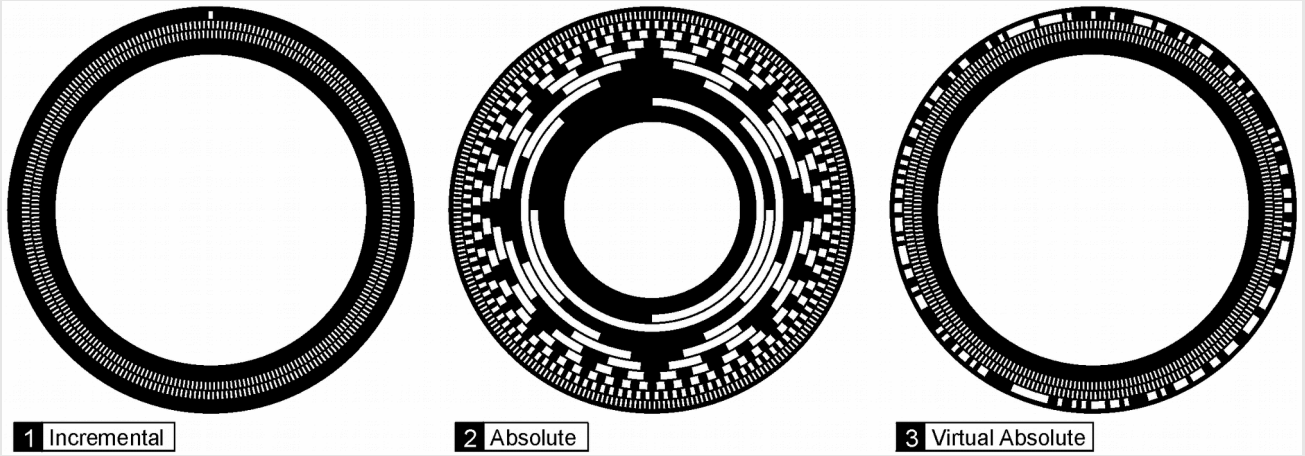


- Rotary encoders measure rotational motion
  - A coded wheel scale moves past sensor head(s) to detect motion
  - Resolution is typically defined as pulses per revolution (PPR)
  - Through the use of a rack and pinion gear system, rotary encoders can provide linear encoding



Encoders: Absolute versus Incremental

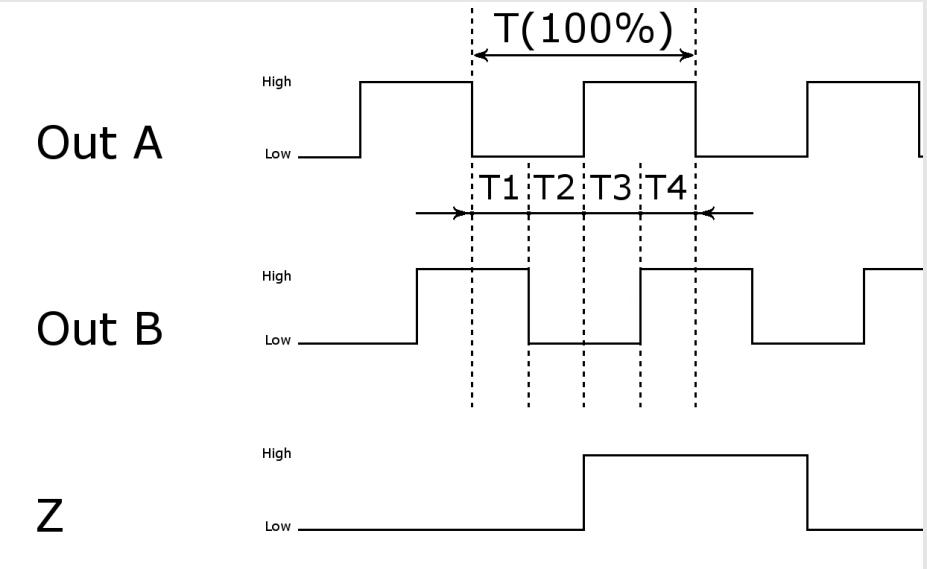
- Absolute encoders
  - Scales, wheel or linear, have discrete, unique measurement positions spaced equally on the scale
  - At each measurement point, sensor heads read the position of the scale in Gray code
  - When an absolute encoder powers on, the sensor heads read the current position of the scale
  - Resolution of an absolute encoder is 0.5 of a measurement position
- Incremental encoders
  - Sensor head(s) read code spots on the scale providing information on the relative motion of the scale
  - At each pass of a code position, the incremental encoder produces a pulse
  - An incremental encoder does not read the absolute position of the scale
  - Tracking position or determining speed requires external electronics



Decimal	Binary	Gray
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100

Quadrature Encoding

- Quadrature encoding uses two (2) different sets of code positions on the scale offset by 90 degrees of phase shift
- These two (2) sets of code positions can be either high or low, which allows four (4) different states for each period, hence quadrature
- Benefits of quadrature encoding
  - Doubles the resolution of the encoder
  - Allows determination of the direction of rotation
- A Z index on an incremental encoder provides a one (1) per revolution indication of scale location



Encoder: Sensing Techniques

- There are four (4) sensing techniques commonly used by encoders
  - Mechanical/electrical
  - Magnetic
  - Capacitive
  - Optical
- Mechanical encoding uses physical contact between sensor heads and circuit paths on the scale to measure motion
  - One of the oldest sensing techniques
  - Limited resolution due to the requirement to establish sustained physical contact with the code points to produce the signal
  - Resistant to electromagnetic interference (EMI) and many environmental contaminants
  - Life limited by wear of the mechanical surfaces
- Magnetic encoding use the poles of magnets and Hall effect to measure motion
  - Each pass of the magnet(s) induce a voltage/current in the sensing head
  - Space required for each magnet on the scale limits the resolution of the encoder
  - Resistant to environmental contaminants
  - Susceptible to EMI

Encoder: Sensing Techniques, continued

- Capacitive encoding uses changes in capacitance to sense motion
  - Capacitance changes as a function of the distance between the capacitor's conductive surface
  - Changes in capacitance change the current produced by the circuit containing the capacitor.
  - Capacitive encoders use an alternating current and changes in gap between the conductive surfaces, code points, to measure motion
  - Capacitive encoders can provide very good resolution
  - Resistant to EMI and environmental contaminants
  - Relatively new technology, but is becoming increasingly common and cheaper
- Optical encoding uses slots or alternating areas of varying reflectance to interrupt, transmit, or reflect incident light at each code position
  - Light is typically provided by an LED, laser, or incandescent bulb and focused into a narrow beam
  - A light sensitive sensor turns incident light into an electrical signal
  - Optical encoders provide very good resolution
  - Highly resistant to EMI, but sensitive to environmental contamination
  - Optical encoders are the most common form of motion encoding

Encoder: Considerations

- Each encoder will have a maximum allowable speed
  - Bandwidth and response of the encoder electronics set the maximum speed at which the encoder maintains specification resolution and accuracy
  - Mechanical speed limit is the maximum speed the encoder can spin without reducing the life of the encoder or coming apart
  - Maximum encoder speed is the lower of mechanical and electrical speed
- Encoder signals are susceptible to signal degradation and electromagnetic interference
  - Limit encoder signal cable length to the maximum recommended length for the encoder output signal type
  - Route encoder signal cables away from power cables
  - Use twisted, shielded cable pairs where possible
  - Ground the encoder signal cable at the control module end of the signal cable not the encoder end

Questions