Overview

• Need for digital output transducers
• Types of digital transducers
  – shaft encoders
  – tachometers
  – etc.
• Measuring digital signals
  – counter/timer basics
  – applications
Digital Sensors

- With computers being used more often in measurement applications, it is attractive to have sensors that can produce digital output directly.
- Digital “sensors” or transducers generate discrete-level output signals such as pulse trains or encoded data that can be read directly by a control processor.
- Motion is easily detected using different “digital” sensing mechanisms, but using this as a basis it is possible to build digital sensors to detect force, pressure, torque, etc.
- A counter is commonly used to count output pulses or clock cycles over a pulse duration.

Advantages of Digital Transducers

- Ease of generating, manipulating, and storing digital signals
- need for high measurement accuracy and discrimination
- relative immunity of a high-level digital signal to external disturbances (noise), especially in transmitting signals over long distances
- simplified data presentation
Types of Digital Transducers

- Transducers with A/D
  - integrated with any signal conditioning
  - saves need to convert to digital later
  - need to send “n” wires
- Frequency Domain Transducers
  - transducers that utilize a frequency output which is then used as the measurement through a counting circuit
  - e.g., a turbine flow meter or tachometer
- Direct Digital Transducers
  - nowhere is there any analog form
  - on-off, mechanically-switched, etc.
  - rotary encoders


Shaft Encoders

- An encoder is a device that provides a coded reading of a measurement.
- Shaft encoders provide digital output measurements of angular position and velocity.
- Applications are found in: robotics, machine tools, mirror positioning systems, rotating machinery controls (fluid and electric), etc.
- Two types: incremental, absolute
Incremental Encoders (1)

- The output is a pulse signal generated when a disk rotates as a result of motion being measured.
- The pulses are counted or the pulse width is timed using a clock signal, and both velocity and displacement can be measured.
- Displacement must be measured relative to some reference point.

Incremental Encoders (2)

Offset sensors provide two signals.

You can detect direction of rotation by measuring both signals.
Incremental Encoders (3)

Functional diagram.

Hewlett-Packard
HEDS-9000

Incremental Encoders (4)

Incremental encoder attached to a PMDC motor shaft.
Incremental Encoders (5)

Incremental encoder measurement issues:

- Signal measurement - use counter
- Computing displacement and velocity from count
- Displacement resolution: \( 360\text{deg}/(4\times N) \) (“uncertainty”)?
  - number of windows, \( N \)
  - number of bits of the buffer (counter), \( r \)
  - if you use two signals, you can get \( 4\times N \) counts per cycle (detect rising and falling)

Absolute Encoders

- Absolute encoders directly generate coded data to represent angular positions using a series of pulse signals.
- No pulse counting is necessary since a code pattern is put on the disk.

Can be 2 times more expensive than incremental.

No reliance on counting.
No problem missing pulses.
No need to re-initialize.
Digital Tachometers

Pulse tachometers use a toothed wheel. Magnetic probes are used and pulses are generated.

Hall effect sensor can be used in similar applications.

Digital Signal Measurement: Counter

• A **counter** is a sequential device that counts and stores the number of input pulses it receives.

• Counters are a common subsystem on most modern data acquisition boards.

• Example: The NI PCI-6023E board has two 24-bit time/counters.
Counter/Timer Basics (1)

- In a digital circuit, a pulse is a change of levels from low to high (0 to 1) and back to low (positive pulse) or high to low and back (negative pulse).
- Each pulse has a duration called a **pulse width**.
- When a series of pulses is used as a timing device, it is called a **clock**, and each pulse has a frequency of occurrence over time.
- A clock is used to synchronize two or more circuits that operate together or in parallel. Many operations may be combined and synchronized by a clock timing system.

![](image)

Counter/Timer Basics (2)

- The source or clock input counts signal transitions.
- The count register can be preset, but for each count it increments or decrements.
- The gate input controls when counting occurs or is initiated.
- The out(put) may generate TTL pulses or pulse trains.

![](image)
Counter/Timer Basics (3)

How do you use the gate input?

This is the signal to be counted.

Here, counting starts with a rising edge on the gate.

Here, counting only takes place if the gate is high. Note, the count register stays at 4 after the gate drops.

Counter/Timer Board Applications

- Generate a Delayed Pulse
- Generate a Continuous Pulse Train
- Generate a Finite Pulse Train
- Measure a Pulse Width
- Measure Frequency
- Measure Period
- Count Events
- Count Time