CMA / Flodyne Drive for Technology

Linear Position Measurement Technologies

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What Are We Talking About Today?

• General Applications for Linear Position Sensors

• Linear Feedback Terminology

• Linear Feedback Technologies, Products, and Applications

• Basic Network Connectivity
Three Primary Applications for Linear Position Feedback

- **Controlling** linear motion
  - Acceleration, deceleration, i.e., dynamic control, closed-loop feedback

- **Monitoring** linear motion
  - Linear transducer monitors position
  - May be used to automate machine functions
  - Open-loop feedback

- **Measuring** linear motion
  - Linear transducer is used to provide accurate measurement
  - “Electronic yardstick”
Application Examples

- **Controlling** linear motion
  - Closed-loop servohydraulics
Application Examples

- **Monitoring** linear motion
  - E-brake performance monitoring on stamping press
Application Examples

- **Measuring** linear motion
  - Product measurement on cut-off saw
Linear Position Sensor Terminology

Accuracy
Non-linearity
Hysteresis

Resolution
Repeatability

Absolute
Incremental
Linear Position Sensing Technologies

Resolution
Smallest change sensor can detect

Repeatability
Accuracy after returning to same point

Linearity
Deviation through range

Accuracy?
Incremental vs. Absolute

Incremental
• Provides *relative* position feedback from a known reference position

• Examples:
  • rotary optical encoders
  • Magnetically encoded scales

• Advantages:
  • Typically lower cost
  • Easy to interface

• Disadvantages:
  • Requires re-homing after power interruption
Incremental vs. Absolute

**Absolute**
- Provides a unique output for a given position

- Examples:
  - Magnetostrictive LDT's
  - Inductive analog sensors
  - Inductive optical sensors

- Advantages:
  - No need to re-home after power interruption
  - Easy to interface

- Disadvantages:
  - Can be more costly
Market Forces: Why Continuous Position Sensors?

– Reduce scrap
  • Inspection of components
  • In-process monitoring
– Increase quality
  • Measurements in difficult locations
  • 100% inspection
– Adjust for machine wear
  • Collect actual feedback
  • Continuous Measurement in tough environments

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What can you do with measurement information?

- Measure thickness
- Position feedback
- Measure tool wear
- Null out machine wear
- Null out thermal expansion
- Verify die position
- Verify bend radius
- Part profiling
- Stack height
MagneTostrictive Linear Displacement Transducers (LDT's)

- Range: 1" to 300"
- Rugged
- Absolute
- Non-contact measurement technology
- Wide variety of housing styles / form factors
  - Rod-style for in cylinder feedback
  - Aluminum "profile" housings for external mount
- Wide variety of electrical output options
  - Analog (0-10V, 4-20 mA, etc.)
  - Digital timing pulse
  - Synchronous Serial Interface (SSI)
  - Integrated fieldbus interfaces
MagnetostRICTIVE LINEAR DISPLACEMENT TRANSUDCERS

Operating Principle = Magnetostriiction

Waveguide

Initial pulse

Mechanical wave

Damping

Electromagnetic field

Position marker (magnet)

Signal converter (Balluff patented process)

Copper conductor

Receiver
Magnetostrictive Linear Displacement Transducers

- Applications:
  - Hydraulic cylinder feedback
  - Sawmill machinery
  - Off-road equipment
  - Plastic injection molding machinery
  - Tire manufacturing
  - Metal stamping
  - Energy
  - Packaging
Magnetostrictive Linear Displacement Transducers

- Gun-drilled cylinder rod
- Hydraulic Cylinder
- Rod-style LDT
- Magnet ring attached to piston face
**Magnetostrictive Linear Displacement Transducers**

**Industry:** Die Casting / Metal Forming  
**Application:** Die Casting Trim Press  
**Product(s) Used:** Externally mounted rod-style LDT  
**Benefits to Customer:**  
- Retraction distance can be customized based on part being worked  
- Increased machine throughput
Magnetostrictive Linear Displacement Transducers

Industry: Packaging
Application: Automated size changing on conveyor line
Product(s) Used: Externally mounted magnetostrictive LDT
Benefits:
• Allows use of low-cost actuators
• Recipe-driven automatic changeover
• Easy to implement and cost effective
Magnetostriective Linear Displacement Transducers

Application: Gate Cutoff Saw

Product(s) Used: Externally mounted LDT with floating marker magnet

Benefits:

- Continuous feedback automates process
- Quick and easy setup and changeover
- Floating magnet able to withstand harsh environment = Increased reliability, reduced scrap
Magnetic Linear Encoders

- Range: up to 150 ft. +
- Flexible magnetic tape is easy to apply
- Non-contact sensor head
- Position resolution to 0.00004"
- Fast response time
- Incremental output
  - A, B, Z, quadrature
  - Analog Sine/Cosine
- Integrated limit switches
Magnetic Linear Encoders

Count

Pole width
Magnetic Linear Encoders

- Applications:
  - X-Y-Z position measurement
    - example: water-jet cutting
  - Pick-and-place machinery
  - Position measurement for overhead gantries
  - Direct position measurement on linear drives and actuators
Inductive Analog Sensors (tubular)

- Basic operation similar to standard inductive proximity sensor
- Form factor same as typical inductive proximity switch
- Detects metal target
- Outputs: 0-10V, 4-20 mA
- Short range
  - typically < 1"
- Excellent resolution and repeat accuracy
- High pressure versions for in-cylinder feedback
- Integrated, user-programmable setpoints
- Simple 3-wire operation
- Non-contact operation
Inductive Analog Sensors (tubular)
Inductive Analog Sensors (tubular)

- Applications:
  - Non-contact position feedback of metal targets over short distances
  - Distance measurement
  - Thickness measurement
  - Runout measurement
  - Position monitoring
  - Soft-stop in hydraulic cylinders
Inductive Analog Sensors (block-style)

- Rugged, compact housing
- Excellent housing length-to-stroke length ratio
- Fully encapsulated electronics
- Range: up to ≈ 4", user-scalable
- Detects steel target
- Non-contact
- Absolute
- Outputs:
  - Analog (0-10V, 4-20 mA, etc.)
  - IO-Link
Inductive Analog Sensors (block-style)

Technology

- Individual inductive coils are dampened by metal target
- Algorithm is used to calculate a damping curve
- Output is relative to the lateral position of metal target
Inductive Analog Sensors (block-style)

- Applications / Markets:
  - Machine tools (spindle position)
  - Grippers
  - Material handling
  - Automated assembly
Optical Sensors

- Triangulation or Time-of-Flight (TOF)
- Working range: ≈ 2" up to ≈ 240"
- Small beams for small targets
- Output: 0-10V, 4-20 mA
- Integrated, teachable discrete setpoints
- Non-contact, wear-free
Optical Sensors

Triangulation Technology
Optical Sensors

Time-of-Flight (TOF) Technology

- Emitter sends out pulses of light
- Sensor determines measurement based on time it takes light to bounce off target “electronic clock”

Greater sensing ranges at a high level of accuracy are achievable.
Optical Analog Sensors

• Applications:
  • Distance measurement
  • Thickness measurement
  • Part contour measurement
  • Stack height
  • Spool diameter
  • Liquid level
  • Flatness measurement
Network Connectivity

Direct Connection to Network

- CANopen
- DeviceNet
- PROFIBUS DP
Network Connectivity

Machine-Mount I/O Block

- Allows connection of up to 4 magnetostrictive linear transducers
- And, up to 8 discrete sensors
- Or, up to 4 analog sensors
- Economical solution for connecting magnetostrictive transducer to Profibus network
Network Connectivity Example

Balluff BTL\_\_P-111/ M1 Transducers

Balluff BTL5- T.... Profibus Transducers
Additional Network Connectivity Options

Distributed Modular I/O
• Allows for connection of analog sensors to higher-level networks
Questions?
Thank You for Your Time and Attention!