The Consumer Guide to Fieldbus Networks for Process Control

Seminar Presented by
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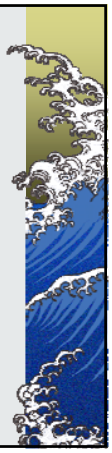

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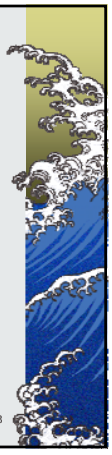

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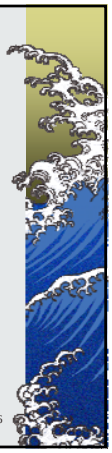

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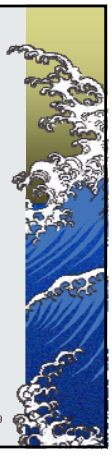
Seminar Outline

- ***Introduction***
- *Networking Fundamentals*
- *Fieldbus Technologies*
- *Fieldbus Architectures*
- *Fieldbus Functions*
- *Consumer Guide*

Introduction

- *Working Definition of a Fieldbus*
- *Why Use a Fieldbus?*



Working Definition of a Fieldbus

- *An electronic connection to a process sensor or actuator designed to carry digital data.*

Why Use a Fieldbus?

- *Serves to enable "smart" field devices*
  - *Cannot serve smart devices without bidirectional data transfer*
- *Provides access to more than a single data point of the field device*

Why Use a Smart Field Device?

- *Provide a means to calibrate and adjust remotely during operation*
  - *Hands-on access usually not required*

Why Use a Smart Field Device?

- *Enable diagnostics and performance alarms*
  - *Often possible to predict failures before they occur*
  - *Maintain local memory of calibrations and service*

Why Use a Smart Field Device?

- *Improve Accuracy*
  - *Digital transmission = no loss of accuracy*
  - *Direct digital measurement*
    - *No loss of accuracy to analog conversion*
    - *High accuracy measurements*

Why Use a Smart Field Device?

- *Signal processing in the instrument*
  - *Off-loads computations from a controller*
  - *Can use attributes only available in the field device*

Why Use a Smart Field Device?

- *Control in the field device*
  - *Restores single loop integrity*
  - *Does not depend upon control in the control room*
  - *Off-loads computations from controllers in the DCS*

Why Use a Smart Field Device?

- *Summary*
  - *Control in the field device*
  - *Signal processing in the instrument*
  - *Improve Accuracy*
  - *Enable diagnostics and performance alarms*
  - *Provide a means to calibrate and adjust remotely during operation*

Seminar Outline

- *Introduction*
- ***Networking Fundamentals***
- *Fieldbus Technologies*
- *Fieldbus Architectures*
- *Fieldbus Functions*
- *Consumer Guide*

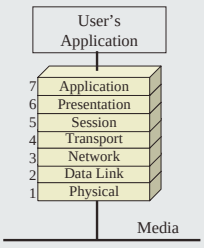
Networking Fundamentals

- ***Layer Models***
- *Network Topologies*
- *Network Media*
- *Error Detection and Recovery*
- *Laws of Physics*
- *Network Standards*
- *Hazardous Area Protection*

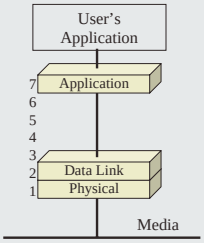
ISO/OSI Model

- *ISO = International Standards Organization*
- *OSI = Open Systems Interconnection*

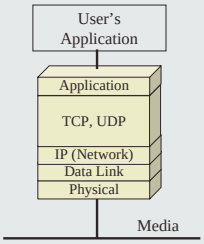
ISO/OSI 7-Layer Model



ISO/OSI Model Used for Automation



Internet Layer Model



Networking Fundamentals

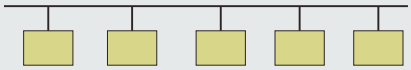
- *Layer Models*
- ***Network topologies***
- *Network media*
- *Error detection and recovery*
- *Laws of physics*
- *Network standards*
- *Hazardous area protection*

Network Topologies

- *Topology = Physical layout*
  - *Bus*
  - *Star*
  - *Tree*
  - *Mesh*

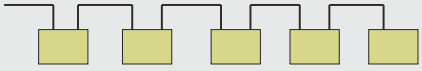
Network Topologies

- *Bus*
  - *Multidrop*



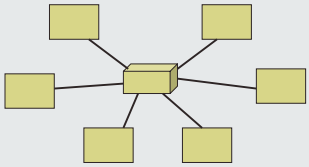
Network Topologies

- *Bus*
  - *Daisy-chain*



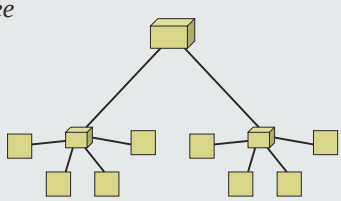
Network Technologies

- *Star*



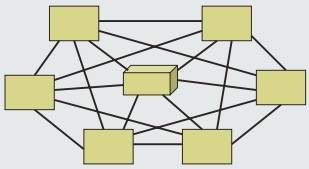
Network Topologies

- *Tree*



Network Topologies

- *Mesh*



Networking Fundamentals

- *Layer Models*
- *Network topologies*
- ***Network media***
- *Error detection and recovery*
- *Laws of physics*
- *Network standards*
- *Hazardous area protection*

Network Media

- *Copper*
- *Fiberglass*
- *Radio (Wireless)*

Network Media

- *Copper*
  - *Twisted or untwisted pair*
    - *Shielded or unshielded*
  - *Coaxial*
    - *RG specification*
    - *Twinaxial*

Network Media

- *Fiberglass*
  - *Multimode*
    - *Used for industry*
    - *LED (Light Emitting Diode) excitation*
    - *Length: up to 2 km*
    - *Core/sleeve: 62.5/125 or 50/125 microns*

Network Media

- *Fiberglass*
  - *Single mode*
    - *Used for long distance communications*
    - *Infrared Laser excitation*
    - *Length: up to 100 km*
    - *Core/sleeve: 9/125*

Network Media

- *Radio*
  - *Now called "wireless"*
  - *Modulation*
    - *Amplitude*
    - *Frequency*
    - *Phase*

Network Media

- *Radio*
  - *Narrowband*
    - *Single frequency*

Network Media

- *Radio*
  - *Broadband*
    - *Spread spectrum*
      - *Direct Sequence (DSSS)*
      - *Frequency Hopping (FHSS)*
      - *Orthogonal Frequency Division Multiplexing (ODFM)*
    - *UltraWideBand (UWB)*

Networking Fundamentals

- *Layer Models*
- *Network topologies*
- *Network media*
- ***Error detection and recovery***
- *Laws of physics*
- *Network standards*
- *Hazardous area protection*

Error Detection & Recovery

- *Error detection*
  - *Checksum*
  - *Parity*
  - *Cyclic redundancy check*

Error Detection & Recovery

- *Error recovery*
  - *Re-transmit*
  - *Ignore (do not use data)*
  - *Error correction*
    - *For deep space or other unrecoverable data*

Error Detection & Recovery

- *Alarm limit checking*
  - *Range alarm*
  - *Hi-Hi limits*
  - *Lo-Lo limits*
  - *Hi/Lo limits*
  - *Deviation limits*

Networking Fundamentals

- *Layer Models*
- *Network topologies*
- *Network media*
- *Error detection and recovery*
- ***Laws of physics***
- *Network standards*
- *Hazardous area protection*

Laws of Physics

- *Ohm's Law*
  - *E=IR*
- *Signal degradation in fiber optics*
- *Near-field loss for radio*
- *Far-field loss for radio*
- *Signal-to-noise ratio*

Laws of Physics

- *Ohm's Law*
  - *4-20 mA for long distance communication*
  - *Varying current flow is slow-acting*
    - *Inductive effects*

Laws of Physics

- *Signal degradation in fiber optics*
  - *Little loss of signal strength*
  - *Distortion of waveform*
  - *Multipath distortion*

Laws of Physics

- *Near-field antenna loss*
  - *Near-field is wavelength/10*
  - *Inside loop antennas*
  - *Constant with distance in the near-field*

Laws of Physics

- *Far-field antenna loss*
  - *Inverse square law applies*

$$signal\_strength_2 = signal\_strength_1 * \sqrt{\frac{d_1}{d_2}}$$

Laws of Physics

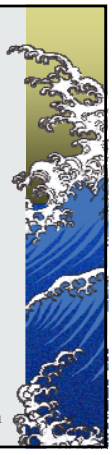
- *Signal-to-noise ratio (SNR)*
  - *Ability to detect a valid signal is usually given by the ability of the receiver to extract data from the noise received.*

Networking Fundamentals

- *Layer Models*
- *Network topologies*
- *Network media*
- *Error detection and recovery*
- *Laws of physics*
- ***Network standards***
- *Hazardous area protection*

Network Standards

- *EIA/TIA (RS) 232C*
- *EIA/TIA (RS) 485*
- *Bellcore 202*
- *IEC 61158 (Fieldbus)*
- *Ethernet*
- *IETF (Internet)*



RS 232C

- *Commonly called "serial interface"*
  - *Becoming obsolete on PCs*

RS 232C

- *2-10 meters*
- *Single-ended voltage level interface*
- *2 to 100 Kbps*
- *Asynchronous*

RS 232C

- *Start/stop bits*
- *Byte parity*
- *LRC/Checksum*

Serial Data Communications

- *New serial communications on PCs*
  - *USB*
  - *IEEE 1394 Firewire*
  - *Ethernet*
  - *Wireless*

HART/Bellcore 202

- *HART*
- *Telegraph*

HART/Bellcore 202

- *20 mA current loop*
- *Phase-coherent FSK*
- *1200 bps*
- *LRC/Checksum*
- *May pass through an intrinsic safety barrier*

RS 485

- *Modbus*
- *PROFIBUS-DP*
- *Other*

RS 485

- *2 Kbps at 5 Km*
- *12 Mbps at 10 meters*
  - *Only with special shielded cable*

RS 485

- *Balanced differential voltage level interface*
- *Synchronous*
- *LRC/Checksum*

Foundation Fieldbus H1 & PROFIBUS-PA

- *IEC 61158 Type 1*
- *31.25 Kbps*
- *Up to 1600 meters*

Foundation Fieldbus H1 & PROFIBUS-PA

- *Manchester encoded*
- *Trapezoidal waveform*
- *CRC-16*
- *May pass through an intrinsic safety barrier*

Ethernet

- *IEEE 802.3 and ISO/IEC 8802-3*
- *EIA/TIA 568B Category 5, 5e, 6 cable*
  - *10/100/1000BaseTx*

Wireless

- *IEEE 802.11a/b/g*
  - *Wireless LAN*
- *IEEE 802.15.1*
  - *Bluetooth PAN*
  - *…also Bluetooth Alliance*

Wireless

- *IEEE 802.15.4 PAN*
  - *ZigBee Alliance*
- *IEEE 802.15.3 PAN*
  - *UltraWideBand (UWB)*

Networking Fundamentals

- *Layer Models*
- *Network topologies*
- *Network media*
- *Error detection and recovery*
- *Laws of physics*
- *Network standards*
- ***Hazardous area protection***

Hazardous Area Protection

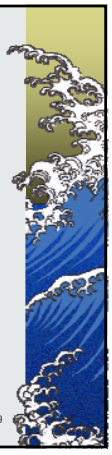
- *Explosion-proof*
- *Purged case*
- *Intrinsic safety*

Intrinsic Safety

- *Not capable of igniting an explosive gas mixture*
  - *No sparking or low energy sparking*
    - *No inductive or capacitive circuits*
  - *Barrier to energy conducted on the communications wire*
    - *IS Barrier*

Intrinsic Safety

- *4-20 mA ANSI/ISA 50.1 (1972)*
- *HART*
- *Foundation Fieldbus H1*
- *PROFIBUS-PA*



Seminar Outline

- *Introduction*
- *Networking Fundamentals*
- ***Fieldbus Technologies***
- *Fieldbus Architectures*
- *Fieldbus Functions*
- *Consumer Guide*

Fieldbus Technologies

- ***HART***
- *PROFIBUS-PA*
- *Foundation™ Fieldbus*
- *Foundation™ Fieldbus HSE*

HART

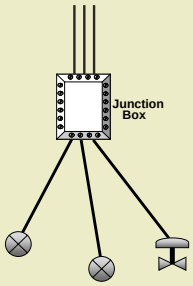
- *Evolved from early Fieldbus committee work*
- *Backwards compatible with 4-20 mA*

HART

- *PV analog*
- *Bellcore 202 modem standard*
- *All other data digital*
- *DDL*

HART

- *Wiring*



EDDL

- *Electronic Data Definition Language*
  - *IEC 61804-2 Specification of Function Block concept and Electronic Device Description Language (EDDL)*
    - ***HART***
    - *PROFIBUS-PA*
    - *Foundation Fieldbus*

HART

- *Digital data limited 1200 bps by Bell 202 modem standard*
- *Analog PV is fast enough for control*

HART

- *Range change*
  - *Remote zero and span setting*
  - *Wide-range sensors*
  - *Manufacturer stocks one model for many ranges*
  - *User: fewer spares*

HART

- *Most popular fieldbus*
- *Is it a "fieldbus"??*
- *Replaced pure analog*
  - *Less expensive than analog*

HART

- *User Benefits*
  - *Diagnostics*
  - *Rangeability*
    - *Reduce spare parts inventory*

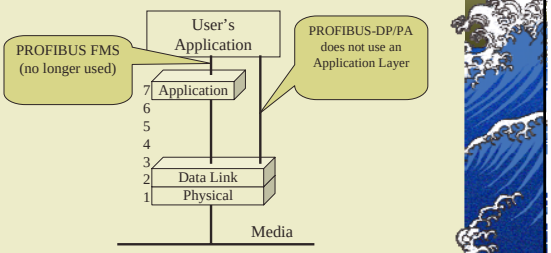
HART

- *HART6 digital PSK*
  - *Higher speed phase shift keying*
  - *Same 2-wire*
  - *Use 4-20mA analog*
  - *Up to 9,600 bps digital*
  - *Not yet available*
    - *Don't count on it*

Fieldbus Technologies

- *HART*
- ***PROFIBUS-PA***
- *Foundation™ Fieldbus*
- *Foundation™ Fieldbus HSE*

PROFIBUS-PA



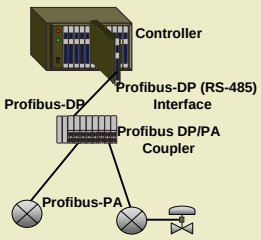
PROFIBUS-PA

- *Physical layer*
  - *IEC 61158-Type 1*
  - *Identical with Foundation Fieldbus H1*
    - *31.25 Kbps*
    - *Up to 1600 meters*
    - *Manchester encoded*
    - *Trapezoidal waveform*
    - *CRC-16*
    - *Intrinsic safety*

PROFIBUS-PA

- *Data Link Layer*
  - *IEC 61158-Type 3*
  - *Identical with PROFIBUS-DP*
    - *Master-slave polling*
    - *RS-485*

PROFIBUS-DP/PA Coupling



PROFIBUS-PA

- *Device data*
  - *GSD (Gerätestammdaten: equipment master data)*

PROFIBUS-PA

- *Application data*
  - *EDD (Electronic Device Description)*

EDDL

- *Electronic Data Definition Language*
  - *IEC 61804-2 Specification of Function Block concept and Electronic Device Description Language (EDDL)*
    - *HART*
    - ***PROFIBUS-PA***
    - *Foundation Fieldbus*

PROFIBUS-PA

- *Profiles: Measurement Function Blocks*
  - *EDD signal processing (only) for:*
    - *Pressure*
    - *Temperature*
    - *Flow*
    - *Level*

PROFIBUS-PA

- *User Benefits*
  - *Diagnostics*
  - *Rangeability*
    - *Reduce spare parts inventory*
  - *Off-load controller*
    - *Signal processing*

Fieldbus Technologies

- *HART*
- *PROFIBUS-PA*
- ***Foundation™ Fieldbus H1***
- *Foundation™ Fieldbus HSE*

Foundation Fieldbus H1

- *Physical layer*
  - *IEC 61158-Type 1*
  - *Identical with PROFIBUS-PA*
    - *31.25 Kbps*
    - *Up to 1600 meters*
    - *Manchester encoded*
    - *Trapezoidal waveform*
    - *CRC-32*
    - *Intrinsic safety*

Foundation Fieldbus H1

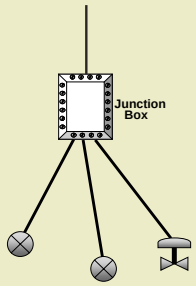
- *Data Link Layer*
  - *Bus mastership*
    - *Arbitrated via LAS (Link Active Scheduler)*
    - *Token passing*
    - *Master-Slave Polling*

Foundation Fieldbus H1

- *Bus Termination*
  - *Controller interface card*
  - *Foundation Fieldbus HSE Linking Device*

Foundation Fieldbus H1

- *Chickenfoot Wiring*



Foundation Fieldbus H1

- *Signal Processing*
  - *Alarm limit testing*
    - *Span high*
    - *High-high*
    - *High*
    - *Low*
    - *Low-low*
    - *Span low*
    - *Rate of change*
    - *Deviation*

Foundation Fieldbus H1

- *Signal Processing*
  - *Conversion*
    - *Engineering units*
      - *Mathematical PV=a+bRawValue*
      - *Table lookup*
      - *Functions PV=sqrt(a+bRawValue)*

Foundation Fieldbus H1

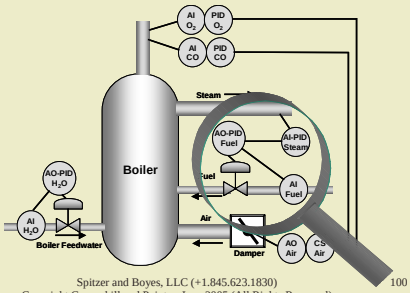
- *Diagnostics*
  - *Internal temperature*
  - *Vibration*
  - *Drift*

Foundation Fieldbus H1

- *Field Control*
  - *Function Blocks*
    - *Feedback loop control*
    - *Cascade control*
    - *Feedforward control*
    - *Loop computations*

Foundation Fieldbus H1

- *Field Control Example*



Foundation Fieldbus H1

- *How Can This be Done?*
  - *Real-time Publish/Subscribe*
  - *Distributed Real-Time Clock*
  - *LAS (Link Active Scheduler)*

EDDL

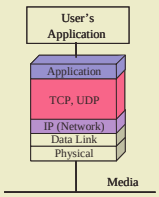
- *Electronic Data Definition Language*
  - *IEC 61804-2 Specification of Function Block concept and Electronic Device Description Language (EDDL)*
    - *HART*
    - *PROFIBUS-PA*
    - ***Foundation Fieldbus***

Fieldbus Technologies

- *HART*
- *PROFIBUS-PA*
- *Foundation™ Fieldbus*
- ***Foundation™ Fieldbus HSE***

Foundation Fieldbus HSE

- *Defined with Internet protocols*
  - ***Off-the-shelf Ethernet Physical Layer***
  - ***Based on use of UDP/IP***



Foundation Fieldbus HSE

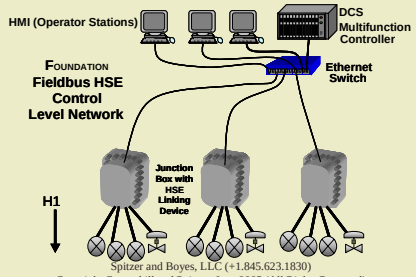
- *Uses identical Application Layer as H1*
  - ***EDDL Function Blocks***

Foundation Fieldbus HSE

- *Uses identical Application Layer as H1*
  - ***Spans multiple H1 segments***

Foundation Fieldbus HSE

- ***Spans multiple H1 segments***



Foundation Fieldbus

- ***Advantages of Field Control***
  - *Lower cost control systems*
    - *Initial installed cost*
    - *TCO (Total Cost of Ownership) - 10 years*

Foundation Fieldbus

- ***Advantages of Field Control***
  - *More responsive control*
    - *It's all in the field*

Foundation Fieldbus

- ***Advantages of Field Control***
  - *Single loop integrity*
    - *All devices in the field*

Foundation Fieldbus

- ***Advantages of Field Control***
  - *More reliable control*
    - *Field devices built to last*

Foundation Fieldbus

- ***Advantages of Field Control***
  - *Modular redundancy for critical controls*
    - *Multiple technology sensors*
    - *Control in more than one device*
    - *Auto-select function block*

Foundation Fieldbus

- ***Advantages of Field Control***
  - *Can be incrementally enhanced*
    - *Add feedforward controls*
    - *Add decoupling logic*

Foundation Fieldbus

- ***Advantages of Field Control***
  - *Not dominated by a single supplier*

Foundation Fieldbus

- ***Advantages of Field Control***
  - *Only the field equipment is proprietary*
    - *Standard network devices*
    - *Commercial PCs*

Foundation Fieldbus

- ***Disadvantages of Field Control***
  - *Not all DCS suppliers support it*
  - *You lose "one supplier" support*

Seminar Outline

- *Introduction*
- *Networking Fundamentals*
- *Fieldbus Technologies*
- ***Fieldbus Architectures***
- *Fieldbus Functions*
- *Consumer Guide*

Fieldbus Architectures

- ***HART***
- *PROFIBUS-PA*
- *Foundation™ Fieldbus H1*
- *Foundation™ Fieldbus HSE*

HART Architecture

- *Adds digital data to 4-20mA transmission*
  - *2-wire*
  - *Loop power*
  - *Intrinsic safety*

HART Architecture

- *First multi-ranging device*
  - *Wide ranging sensors*
  - *Software controlled zero and span*
    - *Affects the meaning of 4 and 20 mA*
    - *Dynamically set*
      - *Via handheld terminal*
      - *Control system*

HART Architecture

- *Advantages of multiranging*
  - *One transmitter replaces several models*

HART Architecture

- *Advantages of multiranging*
  - *One transmitter replaces several models*
    - *Lowers cost of manufacturing*
      - *Reduces manufacturer inventory*
      - *Improves inventory turnover*

HART Architecture

- *Advantages of multiranging*
  - *One transmitter replaces several models*
    - *Lowers user's cost*
      - *Fewer units in spare parts inventory*
      - *Allows in-line range change*

Fieldbus Architectures

- *HART*
- ***PROFIBUS-PA***
- *Foundation™ Fieldbus*
- *Foundation™ Fieldbus HSE*

PROFIBUS-PA

- *Higher speed digital data transmission*
  - *2-wire*
  - *Loop power*
  - *Intrinsic safety*

PROFIBUS-PA

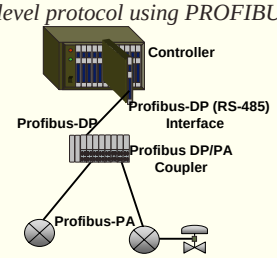
- *Digital data transmission*
  - *Can use same wire type as analog/HART*
    - *Cannot share wiring with analog/HART*

PROFIBUS-PA

- *Noise rejection*
  - *Trapezoidal waveform*
  - *Manchester Bi-phase encoding*
    - *Two phase-shifts per symbol*

PROFIBUS-DP/PA

- *Digital data transmission*
  - *2-level protocol using PROFIBUS-DP*



PROFIBUS-PA

- *GSD*
  - *Gerätestammdaten: equipment master data*
  - *Defines details of the network node*

PROFIBUS-PA EDDL

- *Electronic Data Definition Language*
  - *IEC 61804-2 Specification of Function Block concept and Electronic Device Description Language (EDDL)*
    - *HART*
    - ***PROFIBUS-PA***
    - *Foundation Fieldbus*

PROFIBUS-PA

- *Electronic Data Definitions*
  - *Signal conditioning*
    - *Filtering/smoothing of raw data*
    - *Alarm limit testing*
    - *Conversion to engineering units*

PROFIBUS-PA

- *FDT (Field Device Tools)*
  - *Configuration tools*
    - *Used to define EDDs*
    - *Not unique to PROFIBUS-PA*
    - *DTM (Device Type Manager)*
      - *XML files supplied to configuration software*

PROFIBUS-PA

- *Control in the controllers*
- *No synchronized data path for control in field devices*
- *Control may be in field devices if they do their own sensing*

Fieldbus Architectures

- *HART*
- *PROFIBUS-PA*
- ***Foundation™ Fieldbus H1***
- *Foundation™ Fieldbus HSE*

Foundation Fieldbus H1

- *Digital data transmission*
  - *Can use same wiring type as analog/HART*
    - *Cannot share wiring with analog/HART*

Foundation Fieldbus H1

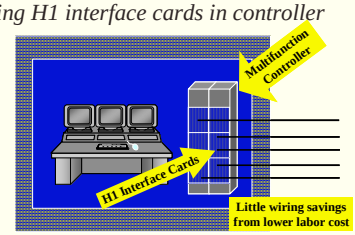
- *Digital data transmission*
  - *Uses the same wiring and signaling as PROFIBUS-PA*

Foundation Fieldbus H1

- *Digital data transmission*
  - *Different protocol than PROFIBUS-PA*
    - *Cannot share wiring with PROFIBUS-PA*

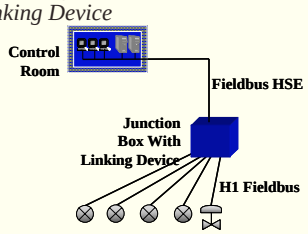
Foundation Fieldbus H1

- *Control system connection*
  - *Using H1 interface cards in controller*



Foundation Fieldbus H1

- *Control system connection*
  - *Using H1 interface in Foundation Fieldbus HSE Linking Device*



Foundation Fieldbus H1

- *How many connections on one H1 segment?*
  - *Entity concept*
  - *FISCO*
  - *FNICO*

Foundation Fieldbus H1

- *Entity concept*
  - *Original standard*
  - *Worst case loading conditions*
  - *Intrinsic safety margins*
  - *About 8-10 devices*

Foundation Fieldbus H1

- *FISCO*
  - *Fieldbus Intrinsic Safety Concept*
  - *Not all devices transmit at all times*
  - *About 12-14 devices*

Foundation Fieldbus H1

- *FNICO*
  - *Fieldbus Non-incendive Concept*
  - *Not all areas are Class 1, Division 1*
  - *For Class 1, Division 2 areas only*
    - *Flammable gases not normally present*
    - *Non-sparking or low intensity spark*
  - *Maybe 12-16 devices*

Foundation Fieldbus H1

- *Energy Barrier is still required*
- *Applies to PROFIBUS-PA*
  - *PROFIBUS-PA usually has need for more devices per segment since there is no Field Control and no need for single loop integrity*

Foundation Fieldbus H1

- *Noise rejection*
  - *Trapezoidal waveform*
  - *Manchester Bi-phase encoding*
    - *Two phase-shifts per symbol*

Foundation Fieldbus H1

- *Transducer Blocks*
  - *Defines hardware connection information*
  - *Similar to GSD of PROFIBUS-PA*

Foundation Fieldbus H1

- *Function Blocks*
  - *Defined using DDL*
  - *Migration to IEC 61804-2 EDDL*

Foundation Fieldbus H1

- *Function Blocks*
  - *Signal conditioning*
  - *Computations*
  - *Feedback loop control*

Foundation Fieldbus H1

- *Single loop integrity*
  - *Limits number of devices per H1 segment*
  - *Loss of one loop is **acceptable***
    - *Analog tradition*
  - *May include miscellaneous measurements*

Foundation Fieldbus H1

- *Mobility of control*
  - *Function blocks locations*
    - *Field transmitter*
    - *Control valve positioner*
    - *Controller*

Foundation Fieldbus H1

- *Mobility of control*
  - *Function blocks may be relocated*
    - *Field transmitter*
    - *Control valve positioner*
    - *Controller*

Foundation Fieldbus H1

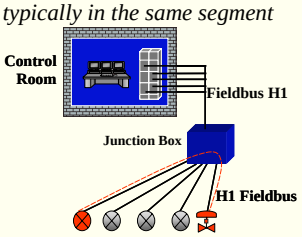
- *Control in Controllers*
  - *No device savings over analog/HART*
  - *Wiring savings from shared H1*

Foundation Fieldbus H1

- *Field Control*
  - *Wiring savings from shared H1*
  - *Reduced number of Controllers*

Foundation Fieldbus H1

- *Field Control*
  - *Measured variables and the controlled variable typically in the same segment*



Foundation Fieldbus H1

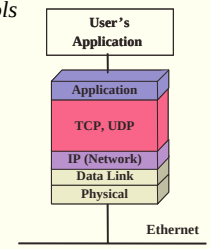
- *Field Control*
  - *Often regarded as "new" or experimental*
  - *Standardized by several major users*
  - *Experience says no increased risk*

Foundation Fieldbus HSE

- *High Speed Ethernet*
  - *Inappropriately named*
  - *Should have been HSI (High Speed Internet)*

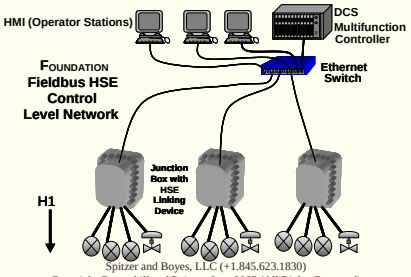
Foundation Fieldbus HSE

- *High Speed Ethernet*
  - *Uses Internet protocols*



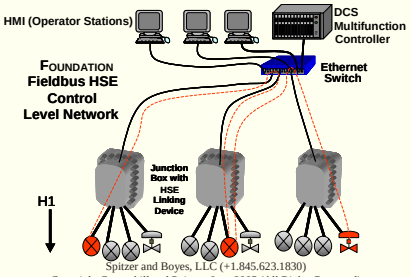
Foundation Fieldbus HSE

- *2-Level bus structure*



Foundation Fieldbus HSE

- *Enhanced Field Control*



Foundation Fieldbus HSE

- *Can I use HSE without DCS support?*
  - *Technically - YES*

Foundation Fieldbus HSE

- *Can I use HSE without DCS support?*
  - *Strategically – No*
    - *Problems **not** resolved by*
      - *DCS supplier*
      - *Linking Device supplier*
      - *Instrument supplier*

Foundation Fieldbus HSE

- *Can I use HSE without DCS support?*
  - *Configurations untested by DCS supplier*
    - *User becomes both*
      - *Tester*
      - *Systems integrator*

Foundation Fieldbus HSE

- *Foundation Fieldbus HSE field instruments*
  - *None currently available*

Foundation Fieldbus HSE

- *Foundation Fieldbus HSE field instruments*
  - *Intrinsic Safety currently not available with Ethernet wiring*
    - *Not impossible, just not available*

Foundation Fieldbus HSE

- *Foundation Fieldbus HSE field instruments*
  - *Powering field instruments*
    - *IEEE 802.3af – Power on Ethernet (PoE)*
    - *Currently calls for 48 vDC*
    - *No products available for 24 vDC*

Foundation Fieldbus HSE

- *Foundation Fieldbus HSE field instruments*
  - *Higher speed, costs less (than H1)*
    - *Ethernet chip costs less than H1 chip*
    - *Category 5, 5e, 6 wiring costs less than H1 instrument cable*

Foundation Fieldbus HSE

- *Foundation Fieldbus HSE field instruments*
  - *Basis for wireless field instruments*
    - *Wi-Fi a/b/g (wireless Ethernet)*
    - *Not available*
    - *Not likely soon*

Wireless Foundation Fieldbus

- *No plans*
- *Candidate technologies*
  - *ZigBee*
    - *Direct sequence spread spectrum*
    - *2.4 GHz and 868/915 MHz*
    - *Mesh network*
    - *Very low power*

Wireless Foundation Fieldbus

- *Candidate technologies*
  - *Bluetooth*
    - *Frequency hopping spread spectrum*
    - *2.4 GHz*
    - *Low power*

Wireless Foundation Fieldbus

- *Candidate technologies*
  - *UWB (UltraWideBand)*
    - *IEEE 802.15.3*
    - *3-10 GHz*
    - *Very low power*

Wireless Foundation Fieldbus

- *Candidate technologies*
  - *Something else*
    - *Frequency hopping spread spectrum*
    - *915 MHz*
    - *Very low power*

Seminar Outline

- *Introduction*
- *Networking Fundamentals*
- *Fieldbus Technologies*
- *Fieldbus Architectures*
- ***Fieldbus Functions***
- *Consumer Guide*

Fieldbus Functions

- *Intelligent signal processing*
- *Alarming*
- *Control*

In the field device itself.

HART Functions

- *Highway Addressable Remote Transducer*
  - *Analog 4-20 mA signal*
  - *1200 bps digital overlay*

HART Functions

- *Integrated HART/AI interface*
  - *New*
  - *Brings HART digital into DCS*
  - *Previously digital data only via handheld terminal*

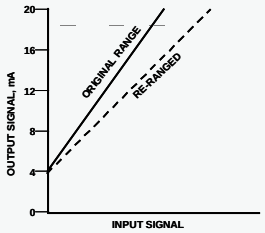
HART Functions

- *Device Descriptions (DDs)*
  - *Lower Range*
  - *Upper Range*

Determine the meaning of 4 and 20 mA

HART Functions

- *Range Values*



HART Functions

- *Benefits of re-ranging*
  - *Reduced cost of manufacturing*
    - *Fewer products*
    - *Less inventory*
    - *Faster turnover*

HART Functions

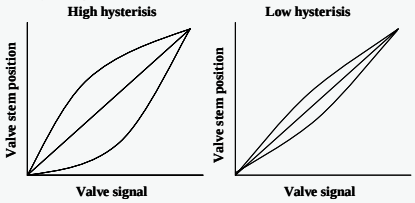
- *Benefits of re-ranging*
  - *Users also benefit —*
    - *Fewer out-of-range problems*
    - *Fewer units in inventory*
    - *Common spare parts*
    - *Lower labor cost for re-ranging*

HART Functions

- *Benefits for control valve positioners*
  - *Monitor control valve stem position*
    - *No extra wiring cost*
    - *Better determine limit-stops*

HART Functions

- *Benefits for control valve positioners*
  - *Analysis for hysteresis*



HART Functions

- *Benefits for control valve positioners*
  - *Causes of hysteresis*
    - *Valve stem wear*
    - *Valve stem deposits*

HART Functions

- *Benefits for control valve positioners*
  - *Problems resulting from high hysteresis*
    - *Poor control loop performance*

HART Functions

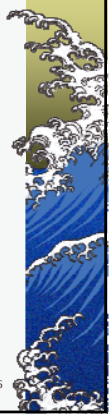
- *Benefits of HART*
  - *Asset Management*
    - *Readable device data*
    - *Readable service data*

HART Functions

- *Device Descriptions (DDs)*
  - *Text definitions describing the transaction with the internal device database*
    - *Interface definition*
    - *DDL (Device Description Language)*

HART Functions

- *Device Descriptions (DDs)*
  - *In transition to IEC 61804-2 (EDDL)*
    - *Function Blocks for Process Control*
    - *Same as for PROFIBUS-PA and Foundation Fieldbus*



HART Functions

- *Transition from DD to EDD*
  - *Example:*

"input block Lower Range Value"

"Input_Block_Lower_Range_Value"

PROFIBUS-PA Functions

- *GSD (Gerätestammdaten: equipment master data)*
  - *Network node information*
    - *Supplier's model number*
    - *Hardware characteristics*
    - *"Plug-and-play"*

PROFIBUS-PA Functions

- *GSD (Gerätestammdaten: equipment master data)*
  - *Available from device supplier*
  - *Available on www.profibus.com*

PROFIBUS-PA Functions

- *EDD (Electronic Device Description)*
  - *Attributes of PROFIBUS-PA function block objects*
  - *Derived from PROFIBUS-PA "profiles"*
  - *Not yet available*

PROFIBUS-PA Functions

- *Profiles*
  - *As used by PROFIBUS:*
    - *Device application classes*
  - *Examples*
    - *Pressure transmitter*
    - *Temperature transmitter*
    - *Differential pressure flow transmitter*

PROFIBUS-PA Functions

- *Profiles*
  - *Not well understood*
  - *Not well supported*
  - *Decided to wait for EDD agreement*

PROFIBUS-PA Functions

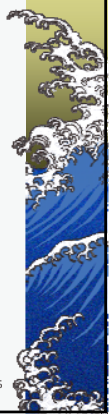
- *Profiles*
  - *Now being replaced by Function Block concept and use of EDD*
  - *Working project of PROFIBUS International*

PROFIBUS-PA Functions

- *FDT/DTM (Field Device Tools/Device Type Manager)*
  - *Developed by ABB*
  - *PROFIBUS International assumed development and support*

PROFIBUS-PA Functions

- *FDT*
  - *Engineering tools used in host systems*
  - *Always define attributes of field devices in the same way*
    - *HART*
    - *PROFIBUS-PA*
    - *Foundation Fieldbus*



PROFIBUS-PA Functions

- *DTM*
  - *Defined by field device manufacturers*
  - *Translates DD and GSD attributes to terminology of FDT*

PROFIBUS-PA Functions

- *Problems with FDT/DTM*
  - *Well supported by ABB, Yokogawa, and Foxboro*
  - *Not supported by Emerson, Honeywell, and Siemens*

PROFIBUS-PA Functions

- *Problems with FDT/DTM*
  - *Claims to "augment not replace" EDDL*
  - *Good host support of standardized EDDL*
    - *Makes FDT/DTM unnecessary*

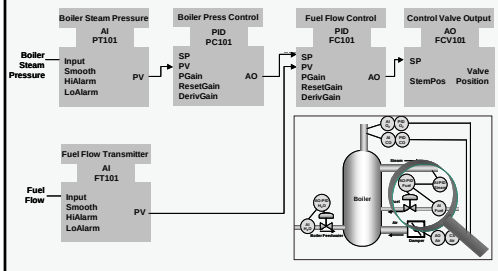
FDT/DTM not likely to survive!

Foundation Fieldbus Functions

- *Function Block support*
  - *All applications of Foundation Fieldbus are based on use of function blocks*
  - *Function block cascades*
    - *Method of inter-block communications*
    - *Based on classical feedback control methods*

Foundation Fieldbus Functions

- *Function Block example:*



Foundation Fieldbus Functions

- *Function Block Modes*
  - *Dynamic state of the block*
  - *"State" refers to:*
    - *Source of the Setpoint*
      - *Operator input*
      - *An upstream block*
      - *A "host" system (DCS)*
    - *Activity – is the block calculating its output?*
      - *Yes*
      - *No*

Foundation Fieldbus Functions

- *Function Block Modes (ordinary)*
  - *OOS – Out of Service*
  - *MAN – Manual*
  - *AUTO – Automatic*
  - *CAS - Cascade*

Foundation Fieldbus Functions

- *Function Block Modes (networked)*
  - *IMAN – Initialization Manual (transitional)*
  - *LO – Local Override*
  - *RCAS – Remote Cascade*
  - *ROUT – Remote Output*

Foundation Fieldbus Functions

- *Critical block scheduling*
  - *LAS (Link Active Scheduler)*
    - *In every loop structure*
    - *Resident in any Foundation Fieldbus device*
    - *Allows relocation of function block to any network device*
    - *Redundancy*
    - *Schedules the function block activity*
      - *In control loop order*

Foundation Fieldbus Functions

- *Standard Function Blocks*

Symbol	Function Block Name
AI	Analog Input
AO	Analog Output
BG	Bias/Gain
CS	Control Selector
DI	Discrete Input
DO	Discrete Output
ML	Manual Loader
PD	Proportional/Derivative
PID	Proportional/Integral/Derivative
RA	Ratio

Foundation Fieldbus Functions

- *Extended Function Blocks*

Symbol	Function Block Name
DC	Device Control
OS	Output Splitter
SC	Signal Characterizer
LL	Lead-Lag
DT	Deadtime
IT	Integrator (Totalizer)
SPG	Setpoint Ramp Generator
IS	Input Selector
AR	Arithmetic
TMR	Timer
AAL	Analog Alarm
FFB	Flexible Function Block

Foundation Fieldbus Functions

- *Resource Block*
  - *Container for hardware properties*
    - *Manufacturer's ID*
    - *Model number*
    - *Hardware characteristics*

Foundation Fieldbus Functions

- *Transducer Block*
  - *Defined for each device type*
    - *TT, PT, FT, LT, DI, FCV, etc.*
  - *Makes I/O ports visible to software*
  - *Supports sensor calibration*
  - *Somewhat like PROFIBUS-PA profiles*

Foundation Fieldbus Functions

- *Device Descriptions*
  - *Modeled after HART DDs and DDL*
  - *DDs define function block attributes or parameters*
  - *DDs distributed with devices*
    - *CDROM, Floppy Disk*
    - *Usually available for download*
  - *DDs used by host system (DCS)*

Foundation Fieldbus Functions

- *Device Descriptions*
  - *Will be changed to conform to IEC 61804*
    - *"Over the next few years"*
  - *Common with*
    - *HART*
    - *PROFIBUS-PA*

Seminar Outline

- *Introduction*
- *Networking Fundamentals*
- *Fieldbus Technologies*
- *Fieldbus Architectures*
- *Fieldbus Functions*
- ***Consumer Guide***

Fieldbus Field Devices

- *Most suppliers offer the same field device*
  - *HART*
  - *PROFIBUS-PA*
  - *Foundation Fieldbus H1*
- *But*
  - *Few supply Analog-only (no HART)*
  - *None supply Foundation Fieldbus HSE*

Fieldbus Devices

- *Regional preferences*
  - *North, South, and Central America, Asia, and Middle East*
    - *HART*
    - *Foundation Fieldbus*
  - *Europe and countries with German engineering*
    - *HART*
    - *PROFIBUS-PA*

Fieldbus Devices

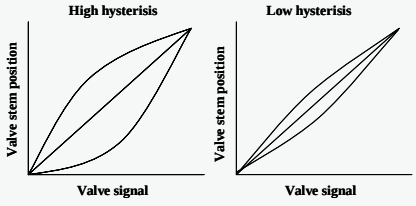
- *New plant construction schedule*
  - *Decision on Field Control*
    - *Yes*
      - *Use Foundation Fieldbus instrumentation*
      - *Co-engineer control system with instrumentation*
      - *Order fewer multifunction controllers*
    - *No*
      - *Use HART or PROFIBUS-PA*
      - *Engineer control system and order*
      - *Order HART or PROFIBUS-PA instrumentation later*

Fieldbus Devices

- *New plant construction cost*
  - *PROFIBUS-PA and Foundation Fieldbus reduces*
    - *Cost of field wiring*
  - *PROFIBUS-PA/DP and Foundation Fieldbus HSE reduces*
    - *Cost of homerun cabling*
  - *Field Control reduces*
    - *Number of multifunction controllers required*

Control Valve Positioners

- *Benefits of fieldbus*
  - *Local device diagnostics*
    - *Detect hysteresis*



Control Valve Positioners

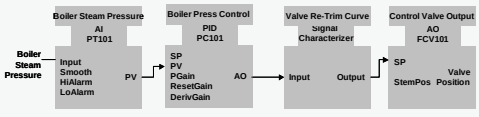
- *Benefits of fieldbus*
  - *Limit detection*
    - *Valve full open*
    - *Valve full closed*
    - *DI ports for external limit switches*
    - *Intrinsic detection within the positioner is not currently available for commercial control valve positioners*

Control Valve Positioners

- *Benefits of fieldbus*
  - *Software selection of valve characteristic*
    - *Equal percentage*
    - *Quick opening*
    - *Linear*
  - *Equivalent to changing a mechanical cam*
  - *Not currently offered on commercial control valve positioners*

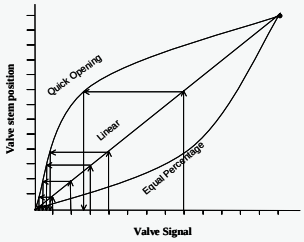
Control Valve Positioners

- *Benefits of Foundation Fieldbus*
  - *Function block compensation for valve characteristic*
    - *Equal percentage*
    - *Quick opening*
    - *Linear*
  - *Equivalent to changing a mechanical cam*



Control Valve Positioners

- *Benefits of Foundation Fieldbus*
  - *Function block compensation for valve characteristic*



Variable Speed Drive

- *A final control element*
  - *Variable speed pump to replace…*
    - *Fixed speed pump*
    - *Control valve with positioner*

Variable Speed Drive

- *Benefits of the variable speed drive to replace fixed speed pump and control valve*
  - *Smaller pump*
    - *Less head for same capacity*
    - *Less expensive*
  - *Smaller drive motor*
    - *Less power consumption*
    - *Less expensive*

Variable Speed Drive

- *Not currently offered with Foundation Fieldbus H1 or HSE interface*
- *Available with PROFIBUS-DP interface*
  - *No PROFIBUS profiles*
- *Little user experience as a replacement for a control valve*

Linking Devices

- *Network gateways*
  - *PROFIBUS DP/PA Coupler*
    - *Couples PROFIBUS-PA networks to PROFIBUS-DP*
  - *Foundation Fieldbus HSE Linking Device*
    - *Links Foundation Fieldbus H1 networks to Foundation Fieldbus HSE*

Choosing a Network

- *Fieldbus choices*
  - *HART*
  - *PROFIBUS*
  - *Foundation Fieldbus H1*
  - *Foundation Fieldbus HSE*

Choosing a Network

- *HART*
  - *Familiar*
  - *Wide range of devices*
  - *Lowest initial cost*
  - *Fast analog connection for PV*
  - *Slow digital network*

Choosing a Network

- *PROFIBUS*
  - *Reduces cost of field wiring installation*
  - *Requires use of PROFIBUS-DP for control system connection*
    - *Moderate digital network performance*
  - *Limited range of field devices*
  - *Supported by a limited number of control systems*

Choosing a Network

- *Foundation Fieldbus H1*
  - *Reduces cost of field wiring installation*
  - *Reduces number/cost of controllers required*
  - *Wide range of field devices*
  - *Supported by a wide range of control systems*
  - *Moderate digital network performance*

Choosing a Network

- *Foundation Fieldbus HSE*
  - *Reduces cost of field wiring installation*
  - *Reduces cost of homerun cabling*
  - *Reduces number/cost of controllers required*
  - *Requires use of Foundation Fieldbus H1 instruments and Linking Devices*
    - *Moderate field network performance*
    - *High-speed backbone network performance*
  - *Supported by a limited number of control systems*

Choosing a Network

- *Effect on control system performance*
  - *HART*
    - *Same as analog instrumentation*
    - *Improved maintenance and calibration*

Choosing a Network

- *Effect on control system performance*
  - *PROFIBUS*
    - *All control in control system controllers*
      - *Does NOT support Field Control*
    - *Can off-load signal processing to field devices*
      - *Currently not widely available*

Choosing a Network

- *Effect on control system performance*
  - *Foundation Fieldbus H1*
    - *Supports Field Control*
      - *Reduces number of controllers required*
      - *Limited to cascades within a single H1 segment*
    - *High performance*
      - *Local control*
      - *Parallel computations*
      - *Timing from distributed schedulers*

Choosing a Network

- *Effect on control system performance*
  - *Foundation Fieldbus HSE*
    - *Supports Field Control*
      - *Reduces number/cost of controllers required*
      - *Cascades may be anywhere in the network*
    - *High performance*
      - *Local control*
      - *Parallel computations*
      - *Timing from distributed schedulers*

Choosing a Network

- *Effect on control system performance*
  - *Correction for hysteresis in control valve positioner*
    - *Can be supported by*
      - *HART*
      - *PROFIBUS*
      - *Foundation Fieldbus*
      - *Foundation Fieldbus HSE*
    - *Not currently supported by any positioner*

Supplier Claims

- *Control system performance*
  - *Better control loop performance*
    - *Function of PID algorithm*
    - *Frequency of sampling and control*
    - *Automatic loop tuning*

Supplier Claims

- *Control system performance*
  - *Maximum number of control loops*
    - *With Field Control*
      - *Unlimited*
    - *Without Field Control*
      - *Limited by the number of controllers*

Supplier Claims

- *Interchangeability of field instruments*
  - *HART*
    - *PV analog signal*
      - *Always interchangeable*
    - *HART digital signals*
      - *Depends on instrument features*

Supplier Claims

- *Interchangeability of field instruments*
  - *PROFIBUS*
    - *Interchangeable with same profile instruments*

Supplier Claims

- *Interchangeability of field instruments*
  - *Foundation Fieldbus H1*
    - *Interchangeable*
      - *Support of Fieldbus Foundation function blocks*
      - *Standard DDs*
    - *Non-interchangeable*
      - *Custom function blocks*
      - *Custom functions with DDs*

Supplier Claims

- *More function blocks*
  - *Only for Foundation Fieldbus*
  - *Basic function blocks required*
  - *Extended function blocks usually downloadable*
  - *Custom function blocks*
    - *Useful for YOUR application?*

Supplier Claims

- *Easy to use*
  - *HART*
    - *Same as analog*
  - *PROFIBUS*
    - *Additional features must be configured*
  - *Foundation Fieldbus*
    - *Complex configuration*
    - *Reduces configuration of control system*

Supplier Claims

- *Wiring Savings*
  - *HART*
    - *Same as analog (no wiring savings)*
  - *PROFIBUS*
    - *Reduces field wiring and homerun cabling*
  - *Foundation Fieldbus H1*
    - *Reduces field wiring*
  - *Foundation Fieldbus HSE*
    - *Reduces field wiring and homerun cabling*

Supplier Claims

- *Control System Cost Reduction*
  - *Foundation Fieldbus H1 and HSE*
    - *Field Control enables reduction in controllers*
    - *Proven: you don't need 100 percent controller backup*

Supplier Claims

- *Engineering Cost Reduction*
  - *PROFIBUS and Foundation Fieldbus*
    - *Detailed point-to-point field wiring drawings not needed*
    - *Wide-range instruments can be used*
    - *Marshalling panels not required*

Installation Considerations

- *One fieldbus architecture per plant*
  - *Pick the fieldbus supported by control system selected*
  - *Do not use different fieldbuses just to save a few $$$*

Installation Considerations

- *Field Wiring*
  - *Do not run in same cable trays/conduit with AC power wiring*
  - *Use instrument-grade cable*
    - *Twisted-shielded pair cable*
    - *Certified for Fieldbus*

Installation Considerations

- *Homerun Wiring*
  - *PROFIBUS*
    - *Use shielded twisted-pair certified for PROFIBUS-DP*
  - *Foundation Fieldbus HSE*
    - *Use Category 5E or Category 6 unshielded twisted pair (UTP)*
    - *Industrial Ethernet cable (Shielded Twisted Pair)*
    - *Use preterminated cable*
    - *…or use fiber optic Ethernet cable*

Installation Considerations

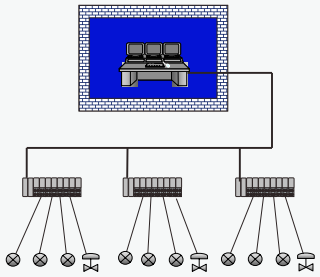
- *Field Junction Boxes*
  - *Termination for field instruments*
  - *Power supply for field instruments*
  - *Location for PROFIBUS DP/PA coupler*
  - *Location for Foundation Fieldbus HSE Linking Device*

Installation Considerations

- *DCS or PLC?*
  - *DCS more familiar configuration for continuous processes*
  - *PLC often lower cost*
    - *Use of Field Control*
      - *No integration with function blocks of PLC*
      - *May be better for batch processes*

Installation Considerations

- *Save wiring cost with HART*



Installation Considerations

- *Hazardous area wiring*
  - *High and low temperatures*
    - *Maximum industrial temperature rating 65 °C (150 °F)*
    - *Minimum industrial temperature rating -40 °*

Installation Considerations

- *Hazardous area wiring*
  - *High vibration*

Installation Considerations

- *Hazardous area wiring*
  - *Moisture*
    - *Typical ratings are 0 to 95 percent relative humidity*
    - *Non-condensing*

Installation Considerations

- *Hazardous area wiring*
  - *Flammable gases*
    - *Explosion-proof*
    - *Intrinsic safety*
    - *Non-incendive*

Installation Considerations

- *Hazardous area wiring*
  - *Must keep energy in control room from propagation to the field*
    - *Barrier*
    - *Fiber optics*
    - *Wireless*

Installation Considerations

- *Hazardous area wiring*
  - *Chemical corrosion*
    - *Acid*
    - *Chemical reaction*
    - *Organic solvent*

Installation Considerations

- *Wiring accessories*
  - *Profibus and Foundation Fieldbus H1*
    - *Short circuit protectors*
    - *Intrinsic safety barriers*
    - *DC Power for field instruments*
      - *Redundant power supplies*

Installation Considerations

- *Wiring accessories*
  - *HART*
    - *Junction boxes in the field*
    - *Marshalling cabinets for control rooms*
      - *Intrinsic safety barriers*
      - *DC power for field instruments*
    - *Wire terminations*
      - *Gas-tight bare wire connections*
      - *Pre-formed patch cables*

Installation Considerations

- *Wiring accessories*
  - *Bus protocol conversions*
    - *4-20 mA analog to FOUNDATION™ Fieldbus H1 or PROFIBUS-PA*
    - *3-15 psig pneumatic analog to FOUNDATION™ Fieldbus H1 or PROFIBUS-PA*
    - *FOUNDATION™ Fieldbus H1 or PROFIBUS-PA to 4-20 mA analog*
    - *FOUNDATION™ Fieldbus H1 or PROFIBUS-PA to 3-15 psig pneumatic analog*

Installation Considerations

- *Wiring accessories*
  - *HART Multiplexer*
    - *Multiple HART in*
    - *4-20mA continues on discrete wire pair*
    - *Digital signal available*
      - *Modbus*
      - *Modbus TCP*

Installation Considerations

- *Foundation Fieldbus HSE or PROFInet*
  - *Industrial Ethernet switches*
    - *Deterministic connection of multiple Ethernet segments*
    - *Environmentally protected*
      - *Temperature*
      - *Vibration*
    - *DIN rail mounted*
    - *Not protected for moisture or chemical corrosion*

Consumers Guide

- *Control Valve Positioners*
  - *Fieldbus supported*
  - *Supplier*
  - *Model Number*
  - *Field Control supported*
  - *FDT/DTM supported*

Consumers Guide

- *Variable Speed Drives*
  - *Fieldbus supported*
  - *Supplier*
  - *AC (PWM) or DC drive*
  - *Motor HP*
  - *Model Number*
  - *Field Control supported*

Consumers Guide

- *Fieldbus Wiring Termination Assemblies*
  - *Fieldbus supported*
  - *Supplier*
  - *Model Number*
  - *Function*
  - *Number of ports supplied*

Consumers Guide

- *Fieldbus Interface Cards for Control Systems*
  - *Fieldbus supported*
  - *System supported*
  - *Model No.*
  - *Number of fieldbus segments supported*

Consumers Guide

- *Fieldbus Gateways*
  - *Fieldbus*
  - *Supplier*
  - *Model Number*
  - *Number of segments*

Consumers Guide

- *Signal/Fieldbus Conversion Devices*
  - *Input*
  - *Output*
  - *Supplier*
  - *Model*
  - *Number of Ports*

Consumers Guide

- *Industrial Ethernet Switches*
  - *Supplier*
  - *Model Number*
  - *Local Ports*
  - *Management*

Review and Questions

- *Introduction*
- *Networking Fundamentals*
- *Fieldbus Technologies*
- *Fieldbus Architectures*
- *Fieldbus Functions*
- *Consumer Guide*

The Consumer Guide to Fieldbus Networks for Process Control

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