

# SMJE 4293 Industrial Automation

## Fieldbus

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# Previous Lecture

## Distributed Control System

- Definition
- Architecture of DCS
- Hardware of the 1<sup>st</sup> control level, operator level
- Interface to supervisory systems
- Case studies in DCS

# Outline

- Definition
- Types of fieldbus loop, devices and software
- Design of a basic fieldbus; control solution
- Configuration of a fieldbus installation
- Troubleshoot and repair of various installation problems
- Specify instrumentation and equipment for a fieldbus solution

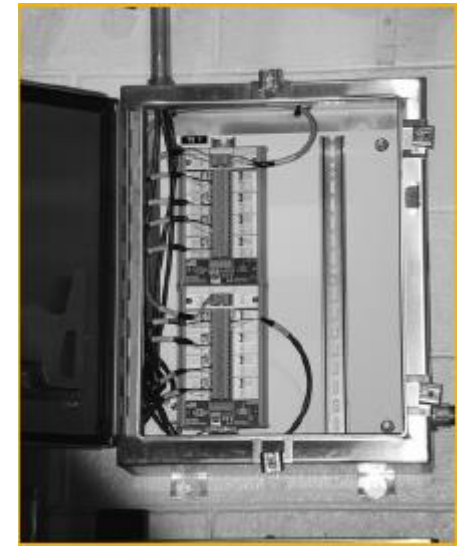
# Long time ago ...



- In analog control systems
  - instruments produce a 4-20mA output signal that travels all the way from the remote distillation column, tank or process unit to the control room, marshalling rack, remote I/O concentrator or RTU over twisted pair cables
  - 4-20mA control signals travel from the control system to valve actuators, pumps and other control devices
  - MESSY! – Hundreds, sometimes thousands, of cables snake their way through cable trays, termination racks, cabinets, enclosures and conduit

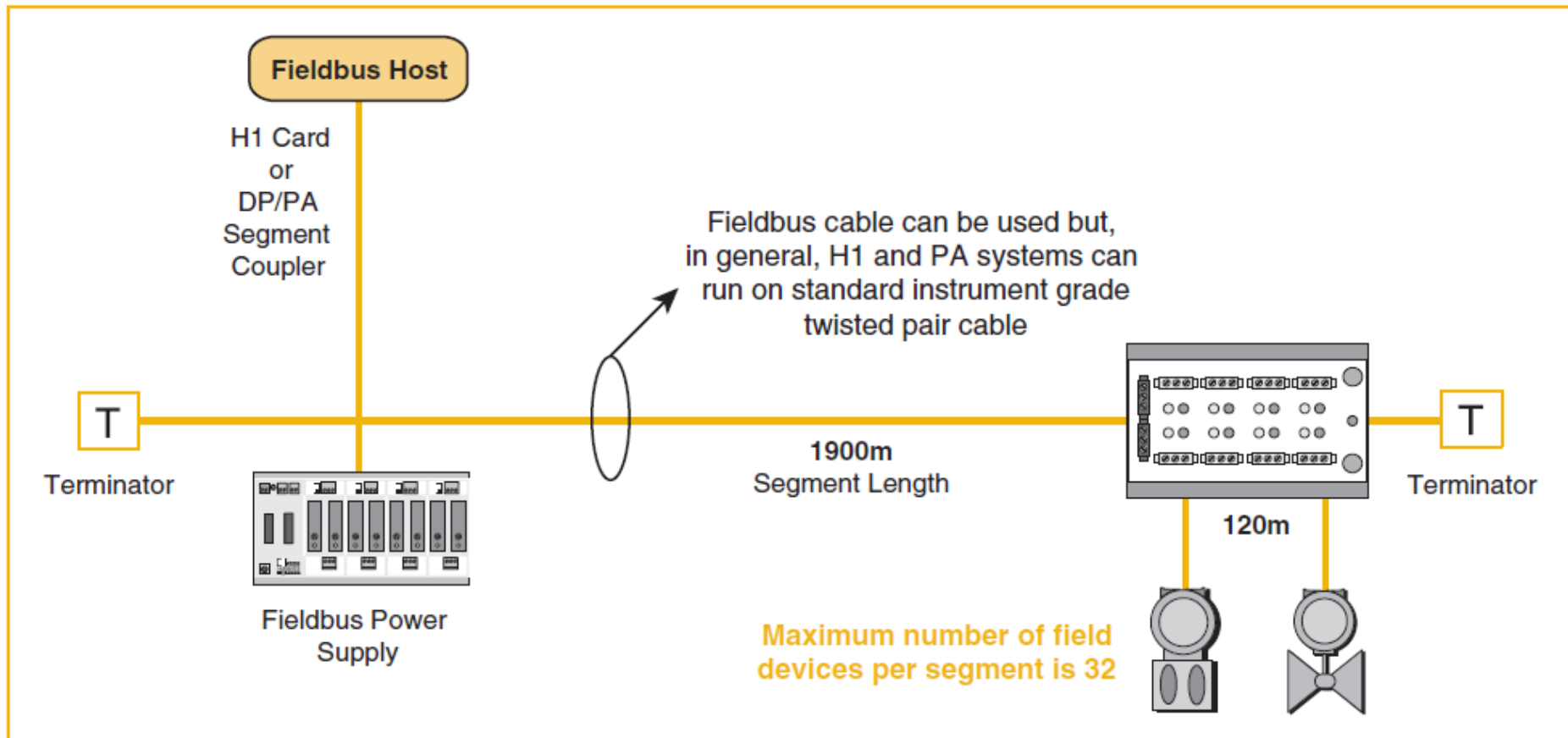
# Introduction

- FIELDBUS simplifies wiring
- fieldbus allows multiple instruments to use a single cable “trunk” or a “segment,” ;
- each instrument connects to the cable as a “drop.”
- Instruments
  - must have a fieldbus interface to connect to the segment,
  - Must have software running to provide the fieldbus communications



# How does it work?

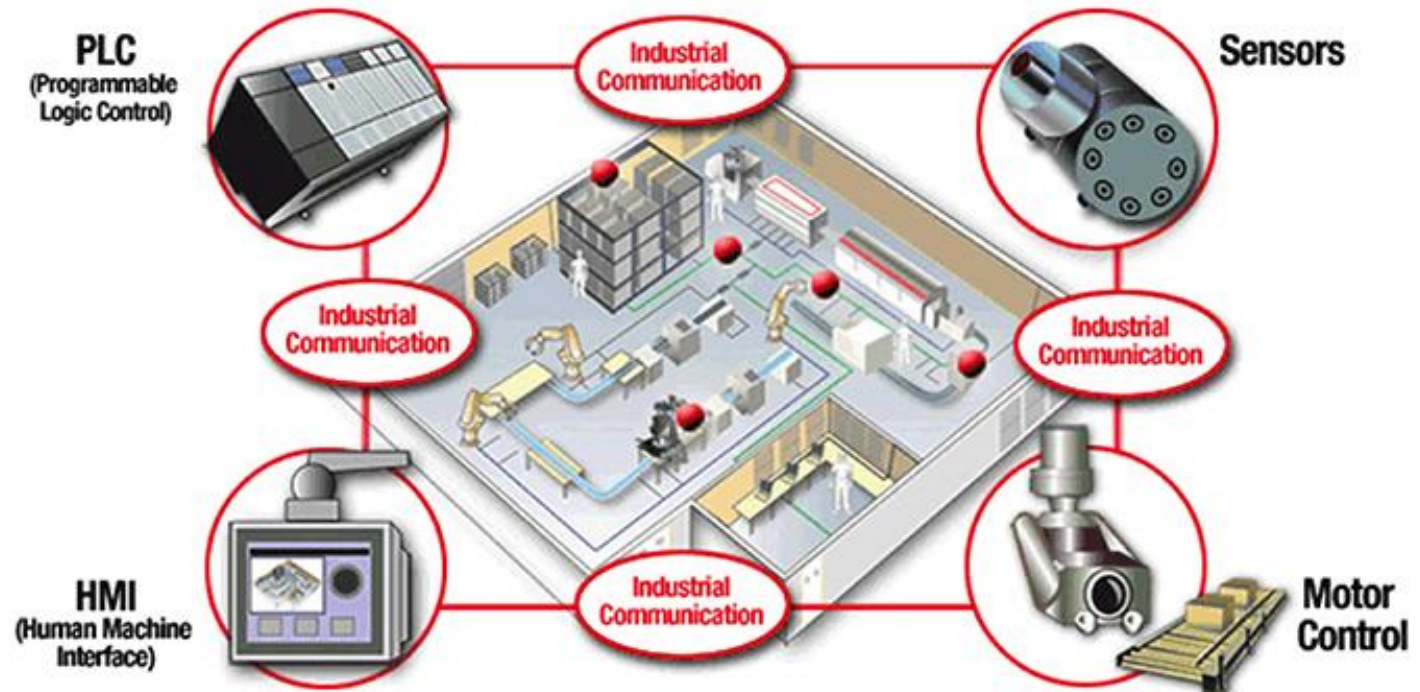
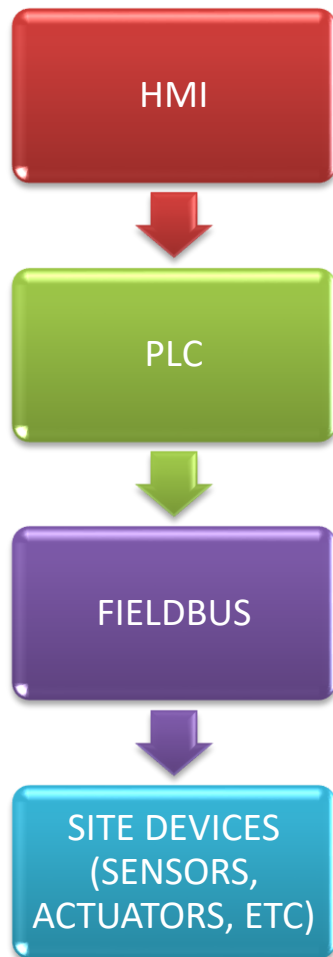
**Figure 3.** A fieldbus segment starts with an H1 interface card and a power supply for FOUNDATION fieldbus or a segment coupler for PROFIBUS. Up to 32 devices can be supported on a single segment. The boxes with a "T" in them indicate the location of the segment terminators.





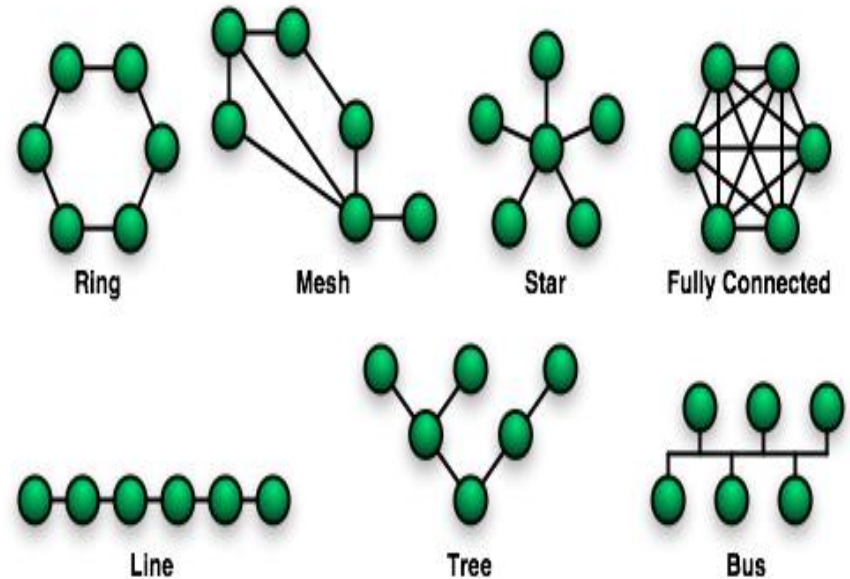


# Fieldbus



# Definition

- Fieldbus = name of a family of industrial computer network protocols used for real-time distributed control - IEC 61158.
- links the PLCs to the components
- Network structures →



# Types

- IEC 61158 standard with eight different protocol sets called "Types" as follows:
  - Type 1 Foundation Fieldbus H1
  - Type 2 ControlNet
  - Type 3 PROFIBUS
  - Type 4 P-Net
  - Type 5 FOUNDATION Fieldbus HSE (High Speed Ethernet)
  - Type 6 SwiftNet (a protocol developed for Boeing, since withdrawn)
  - Type 7 WorldFIP
  - Type 8 Interbus
- Recent additions or planned additions to IEC 61158 include but are not limited to:
  - Type 10 PROFINET IO
  - Type 12 EtherCAT
  - Type 13 Ethernet Powerlink
  - Type 14 EPA
  - Type 16 SERCOS\_interface

# EtherCAT

**BECKHOFF** New Automation Technology

# PROFINET



# PROFINET



# PROFINET









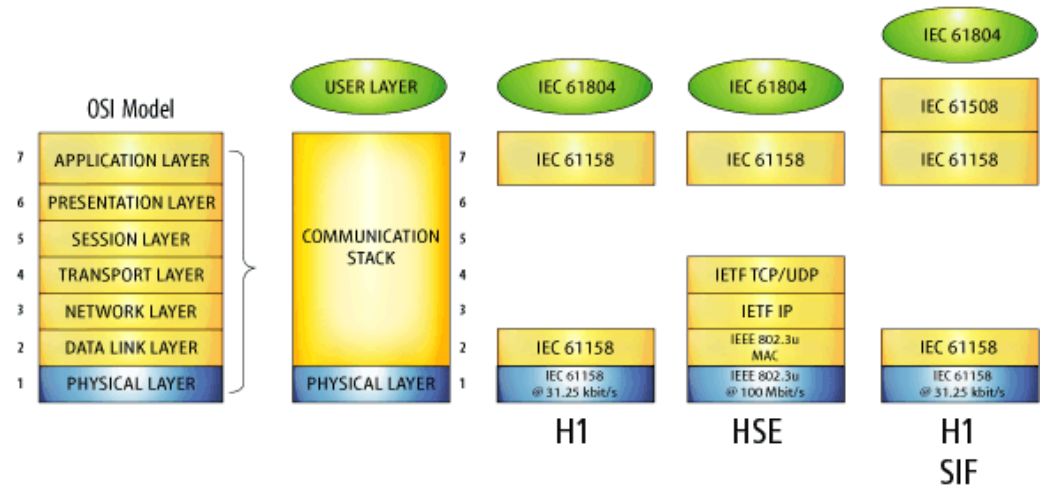






# Design of a Basic Fieldbus and Control Solution

- 4 layers
  - Physical layer - OSI
  - Data link layer - OSI
  - Application layer - OSI
  - User layer



# Advantages of Fieldbus

- Initial Savings

- Less wiring → less cost for equipment installation
- Each process cell requires only one wire to be run to the main cable, with a varying number of cells available.
- Fieldbus is a multi-drop rather than point-to-point system → multidrop network can offer a 5:1 reduction in field wiring expense. The simpler system design implies that fewer system drawings will be needed in order to develop a fieldbus system. → less complex and faster bus systems.

- Maintenance Savings

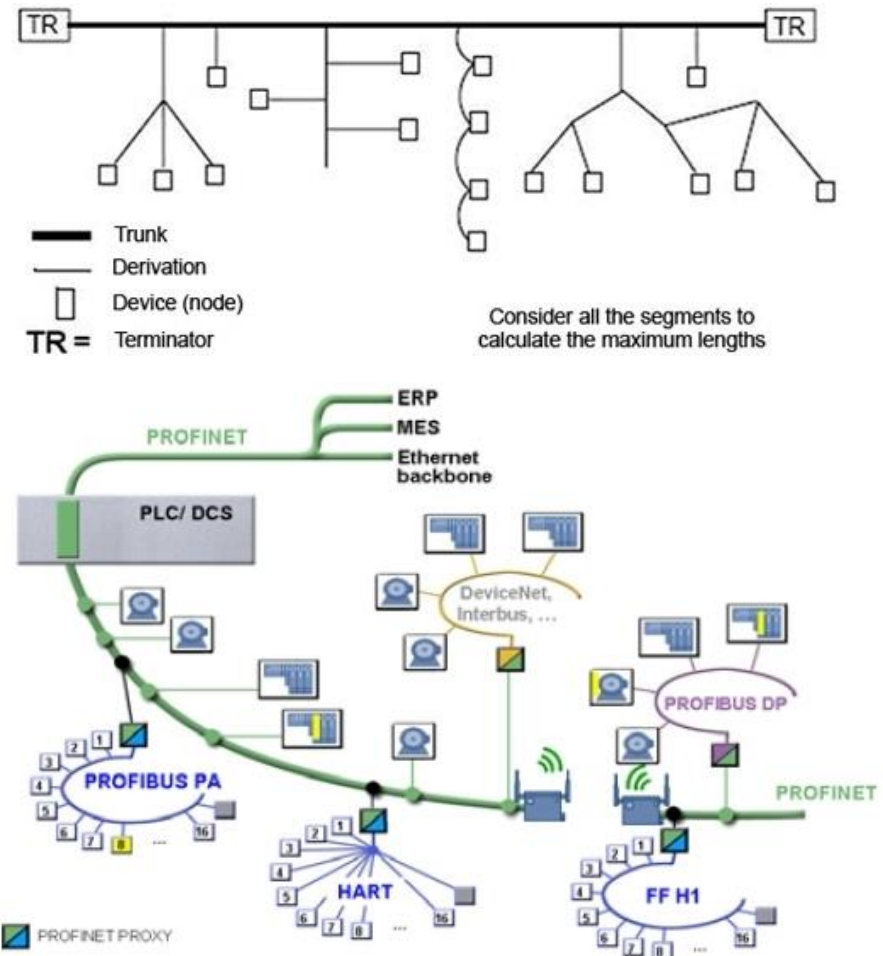
- Less complex → less overall need for maintenance.
- Increased long term reliability of the bus
- Possible for the operators to easily see all of the devices included in the system and to also easily interpret the interaction between the individual devices → Simpler discovery of the source of any problems & maintenance much simpler → reduce overall debugging time.
- Fieldbus enables online diagnostics to be carried out on individual field devices e.g. open wire detection and predictive maintenance → simplify tasks such as device calibration.

# Advantages of Fieldbus

- Improved System Performance
  - Fieldbus allows the user increased flexibility in the design of the bus system.
  - Control programs reside in the individual field devices → reducing the overall size of the main control system → reduces the overall systems cost → future expansion a simpler prospect.
  - simplification of the collection of information from field devices instead of converting raw data into the required units → Measurement and device values will be available to all field and control devices in engineering units → will free the control system for other more important tasks.
  - Two-way communication between field devices and the control system is possible, rather than via control system → enables several related field devices to be combined into one device.

# Configuration of Fieldbus Installation

- Fieldbus network's shared wiring carries power to devices and signals between devices.
- 2 terminators → avoid distorting signals & allow the twisted-pair cable to carry digital signals.
- A power supply and a power conditioner are needed to provide fieldbus power.
- A twisted-pair trunk cable connects control room equipment with a number of devices in the field
- The field devices → connected with spur or drop cables to a common terminal block, called the chickenfoot, in a junction box.
- Generally, there are less than 16 devices on any single fieldbus segment, a single network. In a large process plant there may be several hundred segments.





# Troubleshooting

- List the symptoms
  - Gather all of the information.  
During the course of listing the symptoms a pattern may be noticed or clues revealed that lead to the problem
- Collect data & measurements of:
  - Voltage
  - Signal level
  - Noise
  - Retransmits
  - Shield shorts
- Look up likely [causes](#)
- Inspect the physical layer for the problem
  - Connectors not securely plugged in
  - Loose wires
  - Damaged cable or wires
  - Stray wire strands at wire terminations
  - Screw terminal and hold-down screws are not tight (use a torque screwdriver)
  - Cable shield grounded at more than one location or not grounded
  - Cable bend radius too small
  - Tie wraps too tight

# Instrumentation & Equipment

- Digital Multimeter
- Oscilloscope
- FBT-3 Fieldbus monitor
- FBT-6 Fieldbus monitor
- Torque Screwdriver



# Instrumentation & Equipment

- Digital Multimeter
  - take resistance, voltage, current, and capacitance measurements.
  - Measurements of bus voltage and shield resistance to ground (continually) can be taken any time.
  - Resistance between wires and shield can only be made when the network is without power, so they are only used when the segment is initially setup or down for maintenance



# Instrumentation & Equipment

- Oscilloscope
  - Displays what the signals in the fieldbus look like
  - Can disrupt fieldbus communications if not used properly.
  - Once a signal is captured, it must be interpreted by an experienced and knowledgeable person.



# Instrumentation & Equipment

- FBT-3 Fieldbus Monitor
  - hand-held electronic device specifically made to help determine the health of fieldbus segments and troubleshoot segments with problems.
  - The bus powered FBT-3 passively listens to the device communications when connected to the fieldbus.
  - Measures bus voltage, noise, and indicates the lowest device signal level detected as well as the signal level of the Link Active Scheduler (LAS).
- Indicates when devices are added or removed from a network, indicates the number of devices on the segment, and more. Note that the FBT-3 will add 10mA load to the bus.





# Instrumentation & Equipment

- FBT-6 Fieldbus monitor
  - the follow-on to the FBT-3
  - noise measurement is split into 3 bands:
    - the fieldbus frequency band (9kHz to 40kHz)
    - below it (50Hz to 4kHz)
    - above it (90kHz to 350kHz)
  - counts retransmissions to devices (resent pass token frames)
  - checks for the presence of shield shorts to the (+) or (-) fieldbus wires



- specifies the address and signal level of each device
- identifies which device is the Link Active Scheduler (LAS). The data collected from a segment can be saved in memory, and then downloaded to a PC via a USB port

# Instrumentation & Equipment

- Torque screwdriver
  - To make sure screw terminals are adequately tightened.
  - Without a torque screwdriver, screw terminals are often under- or over-torqued.
  - Often products use screw terminals that should be tightened to 5 in-lbs (0.57 Nm) of torque.



# SUMMARY

- Fieldbus (or field bus) is the name of a family of industrial computer network protocols used for real-time distributed control, now standardized as IEC 61158.
- Fieldbus is an industrial network system for real-time distributed control. It is a way to connect instruments in a manufacturing plant. Fieldbus works on a network structure which typically allows daisy-chain, star, ring, branch, and tree network topologies.
- There are four layers of fieldbus which are Physical Layer, Data Link Layer, Application Layer and User Layer.
- The major advantage of the fieldbus is the reduction in capital costs. The savings attained by the user stem from three main areas, initial savings, maintenance savings, and savings due to improved systems performance.
- Fieldbus network's shared wiring carries power to devices and signals between devices. Two terminators are required. A power supply and a power conditioner are needed to provide fieldbus power.
- The basic trouble-shooting approach of fieldbus are list the symptoms, collect data, look up likely causes and inspect the physical layer for the problem.
- There are many tools that can help to determine the health of a fieldbus such as digital multimeter, oscilloscope, FBT-3 fieldbus monitor, FBT-6 fieldbus monitor and torque screwdriver.