Fieldbus Foundation
Fieldbus Foundation – India Marketing Committee

Technology Event

ISA EXPO – 2007,
Pragati Maidan, New-Delhi

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Belden-Hirschmann (Singapore)
FOUNDATION FIELDBUS

HSE
Foundation Fieldbus HSE

- HSE for use as a control backbone
- HSE enhances access to H1 technology via Linking Devices (LD)
- HSE uses standard Fast ETHERNET (IEEE802.3u)
  - Preserve all H1 functions and carry H1 services
  - High speed transfer/huge bandwidth
  - Commercial off the shelf (COTS) Ethernet components
- Redundancy on the network level
Standard Ethernet and Automation Protocols

L5 protocol necessary for automation communication, L3 and L4 protocol necessary for realtime applications.

Application Programming Interface (API)

Middleware (5-7)
HTTP, SNMP, ??, DNS, FTP

Transport (4)
TCP, UDP, ??

Network (3)
ARP, IP, ICMP, ??

Data Link (2) Physical (1)
Ethernet IEEE 802.3

- Established standards of the IT world
- New Industrial-Ethernet protocols
Industrial Automation Protocols

- **Ethernet/IP**
  - By ODVA (Open DeviceNet Vendor Association)
  - In higher protocol layers ControlNet/DeviceNet

- **Modbus TCP/IP**
  - IDA (Interface for Distributed Automation) / modbus.org
  - Technology: compatible to ModBus/TCP

- **PROFInet**
  - By PNO (Profibus Nutzer Organisation)
  - Technology: Take-over of complete Profibus
H1 Physical Layer
## FF standard

<table>
<thead>
<tr>
<th></th>
<th>H1</th>
<th>Ethernet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>31.25 kbit/s</td>
<td>100 Mbit/s</td>
</tr>
<tr>
<td>Distance</td>
<td>1900 m</td>
<td>100 m</td>
</tr>
<tr>
<td>Two-wire</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Multidrop</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Bus power</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Intrinsically safe</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Media redundancy</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Deterministic</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
### Key Cable Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Type A Cable</th>
<th>Type B Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 61158-2 / ISA-SP 50 Standard</td>
<td>100 Ohms +/- 20</td>
<td>100 Ohms +/- 30</td>
</tr>
<tr>
<td>Impedance</td>
<td>4 nF/km</td>
<td>6 nF/km</td>
</tr>
<tr>
<td>Capacitance Unbalance</td>
<td>24 Ohms/km</td>
<td>56 Ohms/km</td>
</tr>
<tr>
<td>Conductor DC Resistance</td>
<td>3 dB/km</td>
<td>5 dB/km</td>
</tr>
<tr>
<td>Attenuation @ 39 kHz</td>
<td>1.7 us/km</td>
<td>90%</td>
</tr>
<tr>
<td>Max. Propagation Delay:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Shield Coverage</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>Conductor Size</td>
<td>18 AWG</td>
<td>22 AWG</td>
</tr>
<tr>
<td>Max network length up to</td>
<td>1900m</td>
<td>1200m</td>
</tr>
</tbody>
</table>

- **Inductance & resistance**
  - Impedance 100 Ω @ 31.25 kHz
  - Capacitance Unbalance < 4 ηF/km
  - Conductor DC Resistance < 24 Ω/km
  - Cable Shielding > 90% coverage
Bus Power

Power Budget
400 mA, 24V (non-IS)
215 mA, 13V (FNICO/Zone 2)
100 mA, 12.8V (IS FISCO, Zone 1)
70 mA, 10.6V (IS Entity)
Ethernet Physical Layer
OSI Reference Model (Physical)

- The Physical Layer defines the physics of getting a message from one device to another. It is responsible for an error-free transmission.
- Converts bits into signals for outgoing messages and signals into bits for incoming ones.
- This is the most important area in terms of troubleshooting and operations.
Network Topologies - Bus

- **Ethernet 10 Mbit/s – 10Base2**
  - Segment max. 185 m
  - BNC T-Joint
  - Transceiver
  - Min. 0.5 m
  - Terminator 50 Ω

- **Ethernet 10 Mbit/s – 10Base5**
  - Segment max. 500 m
  - Transceiver
  - Min. 2.5 m
  - Transceiver cable max. 50 m
  - Terminator 50 Ω
Network Topologies - Star
Network Topologies - Tree
Network Topologies - Ring
Network Topologies - Mesh
Twisted Pair

- Categorization of TP cable:
  - Cat. 3: min. transmission frequency 20 MHz
  - Cat. 5: min. transmission frequency 125 MHz
  - Cat. 6: min. transmission frequency 250 MHz
  - Cat. 7: min. transmission frequency 600 MHz
Twisted-Pair – Industrial Connectors

- Currently no industry suitable connector standardized by IEEE
- Demands: mechanical stability, IP protection (IP64 or IP67), stable against vibrations
- Proprietary solutions:
  - DB-9: large installed base
  - M12: suggested by IAONA for Ethernet, well-known in fieldbus area
  - VS-RJ45: RJ45 adapted
  - RJ Lnxx: sleeve nut over RJ45
Fiber-Optic Cable

- Rodent protection and strain relief
- Strain relief made of aramide fiber
- Filler
- Supporting element (GFRP)
- PE sheath
- PE intermediate sheath
- Single/multiple fiber with water repelling filler
- Glass fibers with primary coating with single fiber or multiple fibers

Primary coating 250 µm

Cladding 125 µm

Core
Fiber Optic transmission

- Fiber optic cable has huge advantages over copper
  - It’s immune to Electromagnetic Interference
  - Support of long distances

- Fiber is made from
  - Glass – High quality, used for long distances or high speed
  - Plastic – Cheaper, used for short distances and low speed
  - Glass core + plastic cladding – compromise, fieldbusses only

- There are 3 basic light sources
  - LEDs – low cost, used for MMF
  - ELEDs - medium cost, used for SMF, cheaper than LDs, no Laser protection measures needed
  - Laser, Laser Diodes LD – used with SMF over long distances
Fiber types 1: Multimode Fiber

- Because of the high dispersion, multimode fiber is only used for short distances.
- LEDs for glass fiber use either 850 nm or 1300 nm wavelength for transmission.
Fiber types 2: Singlemode Fiber

- Capable of transmission rates of several Tbit/s
- Use of ELEDs at 1300 nm wavelength till about 30 km, for longer distances lasers/LDs with 1550 nm as transmitters
- Quoted as between 8/125 µm and 10/125 µm cable, depending on manufacturer
Ethernet Data Link Layer
OSI Reference Model (Data Link)

- The Data Link Layer provides the rules for converting electrical signals to data, error checking, physical addressing and media access control.
- Handles the delivery of frames from sender to receiver through the physical layer.

![Diagram showing the OSI model with a focus on the Data Link layer.](image-url)
MAC and LLC Layer

- **2b: Logical Link Control (LLC)**
  - Link make and break, packet traffic control, packet sequencing, packet acknowledgement
  - LLC offers link control independent of medium.

- **2a: Medium Access Control (MAC)**
  - Functions in send direction
  - Functions in receive direction
Switches

- The switch is a device in layer 2 of the ISO/OSI reference model. Each port of a switch can operate in half-duplex or full-duplex mode. This means each port comprises its own segment (collision domain).
- Erroneous packets or collisions in connected segments are not forwarded by a switch and do not reach other connected segments.
Industrial Ethernet
ETHERNET: The Present

ETHERNET today is not the same when it was invented 30 years ago

What’s the improvements?

- Higher bandwidth - 10Mbit/100Mbit/1Gbit/10G
- Full-duplex communication → without collisions
- Switching
- Prioritization and flow control
- VLANs - Virtual Local Area Networks
Why Industrial ETHERNET?

- The fieldbuses available on the market use different types of physical transmission; as a result bus-specific infrastructure components are necessary and the interface to the higher level networks requires so-called “gateways”.

- Ethernet offers a dramatic increase in bandwidth compared to fieldbuses (e.g. Profibus DP up to 12 Mbit/s – Ethernet up to 10Gigabit/s).

- Ethernet makes vertical integration possible (From ERP down to the station controller).

- Ethernet is an open protocol.

- The majority of fieldbus manufacturers have developed their own protocols that build on standard Ethernet: Modbus/TCP, EtherNet/IP, ProfiNet, FF HSE, Powerlink.
# ETHERNET: Office vs Industry

<table>
<thead>
<tr>
<th></th>
<th>Office</th>
<th>Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Installation</strong></td>
<td>Basic installation: Fixed basic installation in the building,</td>
<td>Cabling depends on industrial installation</td>
</tr>
<tr>
<td></td>
<td>flexible installation of devices at the workplace</td>
<td>Top hat rail / clamp</td>
</tr>
<tr>
<td></td>
<td>Connectors: No specific requirements</td>
<td>IP20, IP30, IP67 with confection in the field</td>
</tr>
<tr>
<td></td>
<td>Topology: Mostly star networks at the tertiary level; hierarchical</td>
<td>Redundant, often ring topologies</td>
</tr>
<tr>
<td></td>
<td>trees</td>
<td>Bus topologies for fieldbuses</td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td>Temperature: Normal</td>
<td>Extended range from -40→+70°C, natural convection</td>
</tr>
<tr>
<td></td>
<td>Humidity: Normal</td>
<td>Rel. humidity up to 95% (non-condensing)</td>
</tr>
<tr>
<td></td>
<td>Dust: Low</td>
<td>Possible</td>
</tr>
<tr>
<td></td>
<td>Mechanical: Low</td>
<td>Shock and vibration:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SPS standards IEC 1131-2, IEC 60068</td>
</tr>
<tr>
<td></td>
<td>Chemical: No specific requirements</td>
<td>Possible</td>
</tr>
<tr>
<td></td>
<td>Electrical: No specific requirements</td>
<td>EMI: EN50022, EN50082-2, FCC part15 (Class B),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IEC 1000-4-2, IEC 1000-4-6, IEC 1000-4-4,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EN61000</td>
</tr>
<tr>
<td></td>
<td>EMC: Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Data</strong></td>
<td>Size of data packets: Short</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td>Availability: Medium</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>MTBF: medium</td>
<td>20→100 years</td>
</tr>
<tr>
<td></td>
<td>Transmission: Mostly acyclic</td>
<td>Cyclic &amp; acyclic</td>
</tr>
<tr>
<td></td>
<td>Real-time capability: Mostly not required</td>
<td>Required</td>
</tr>
</tbody>
</table>
Industrial Requirement (1/2)

Secure mounting
Rapid mounting of robust devices by means of simple clipping onto a standard DIN-Rail.

24/48VDC power supply (redundant)

Different application fields
Robust design suitable for industrial applications.

Ambient conditions
Extended temperature range -40 ~ +70°C
Conformal coating
IP 20/IP30/IP67
Rel. atmospheric humidity up to 95% (non-condensing)
Industrial Requirement (2/2)

**Mechanical stability**

**Electrical requirement**
EMI: EN 50022, EN 50082-2, FCC Part 15 (Class B)
IEC 1000-4-2, IEC 1000-4-6, IEC 1000-4-4, EN 61000.

**Certifications / Approvals**
CE, cUL 60950, cUL 508
cUL 1604 Class 1 Div 2 (A, B, C, D) or FM 3611 Class I Div 2
ATEX 100a Zone 2
Maritime applications, e.g., GL (Germanischer Lloyd), DNV Substation IEC61850

**High MTBF** (Mean Time Between Failure)
Approx. from 20 to >100 years, in comparison with office devices with typically 3 to 5 years.
(Fan-less design)
ETHERNET: Office vs Industry

Home/Office product
- Link status LED not visible
- 110/230 V AC
- Unprofessional mounting using cable ties

Industrial-graded product
- Link status easily monitored
- 24 V DC
- DIN-rail mounting
Industrial Ethernet Products

Product Overview

- **Field Level Switches/Repeaters**
- **Control Level Switches**
- **Backbone Switches**
- **Control Room Switches**
- **Security System Firewall/VPN**
- **Wireless LAN Router**
- **Special Applications**
- **Network Management Software**
Control Level Switches / Openrail Compact
Thank you for your attention!