

6 PILLARS

INDUSTRIAL COMMUNICATION SYSTEM

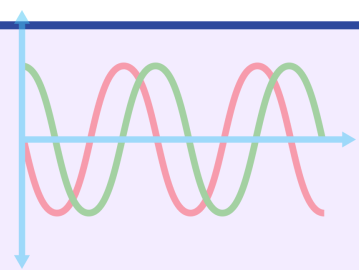
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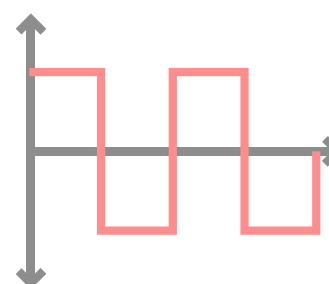
1 ANALOG FOUNDATION

- **4–20 mA** current signal
- **Point-to-point wiring**
- **Loop power, signal isolation, grounding**

“THE ERA OF ANALOG SIMPLICITY — ONE LOOP, ONE SIGNAL.”



4 mA was chosen because it represents “**live zero**” — power + signal on same loop. Still used in **99% of process plants** for safety signals. Cannot transmit multiple variables (**only one parameter per loop**).



COMMUNICATION BASICS

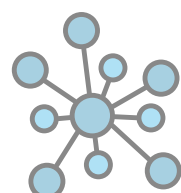
- **Serial Communication:** Data sent bit by bit over a single line.
- **Parallel Communication:** Data sent multiple bits at once, each on its own line.
- **Twisted Pair Cable:** Two wires twisted together to reduce noise and interference.
- **Cat5e / Cat6 Cable:** Ethernet cable with 4 twisted pairs for high-speed data.

4 PROFIBUS & FIELDBUS

- Digital communication for smart devices
- **Profibus DP** → Factory automation
- **Profibus PA / Foundation Fieldbus** → Process automation
- **Intrinsically safe**, two-wire powered network

“SMART FIELD NETWORKS — CONNECTING INSTRUMENTS INTELLIGENTLY.”

Reduces wiring drastically and enables smart maintenance.



Fieldbus can power and communicate over the **same cable**. Supports **multi-variable transmitters** and device diagnostics. Defined under **IEC 61158** — **open standard**.

2 SERIAL COMMUNICATION BASICS

- **RS-232** → one-to-one
- **RS-485** → multi-drop
- **Serial** = data sent bit-by-bit

“BIRTH OF DIGITAL COMMUNICATION — FEWER WIRES, MORE DATA.”

RS-485 can handle up to **32 devices** on one bus. **Typical speed:** up to 10 Mbps; **distance:** up to 1200 meters. The foundation for Modbus RTU and Profibus DP.

3 MODBUS PROTOCOL

- **Open, simple, vendor-independent**
- **Master-slave structure**
- **Modbus RTU (Serial) & Modbus TCP (Ethernet)**

“THE UNIVERSAL INDUSTRIAL LANGUAGE.”

Still the most **widely used** industrial protocol worldwide. Only needs **2 wires** (A & B). **Free and open** — anyone can implement it.

Gigabit Ethernet = **1 billion bits per second!** TCP/IP originally built for ARPANET — military communication in the 1970s. The base for **modern Profinet, Modbus TCP, and EtherNet/IP**.



SIGNAL FLOW CONCEPTS

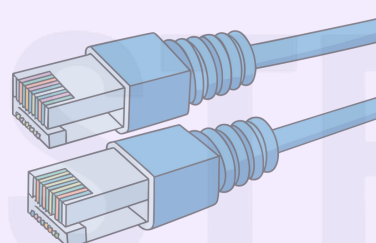
- **Master-Slave:** One controller polls multiple devices.
- **Master-Master:** Peer-to-peer communication (Ethernet).
- **Twisted Pair:** Reduces EMI; carries power + data.
- **Parallel vs Serial:** Multi-lane vs single-lane transfer.



5 ETHERNET & TCP/IP

- **High-speed data over Cat-5e/Cat-6**
- **Multiple twisted pairs** → full-duplex
- **Supports Modbus TCP, Profinet, EtherNet/IP**
- **Peer-to-peer (master-master) capability**

“THE BACKBONE OF MODERN INDUSTRIAL CONNECTIVITY.”



6 INTEGRATION & FUTURE

- **IIoT (Industrial Internet of Things)**
- **Cloud-based SCADA / OPC UA**
- **Cybersecurity & data analytics layers**

“FROM INSTRUMENTS TO INSIGHTS — THE CONNECTED PLANT OF TOMORROW.”



OPC UA can exchange data across different vendor systems securely. Future trend: **Edge computing** and **5G** industrial networks.



Type	Example	Medium	Speed
Analog	4–20 mA	Copper pair	Low
Serial	RS-485	Twisted pair	Medium
Fieldbus	Profibus PA / FF	Twisted pair (MBP)	Medium
Ethernet	Cat-5e/Cat-6	Twisted pair / Fiber	High

Type	Signal / Media	Speed	Distance
Analog	4–20 mA	Low	Long
Serial	RS-485	Medium	Long
Fieldbus	Twisted pair	Medium	Moderate
Ethernet	Cat5e/Cat6	High	Moderate
Parallel	Ribbon cable	Very high	Short

KEY TAKE AWAYS

- **4–20 mA:** Reliable analog signal, simple and robust.
- **Modbus:** Open, easy, widely used — master/slave.
- **Profibus / Fieldbus:** Digital, standardized, multi-vendor interoperability.
- **Ethernet / TCP/IP:** High-speed backbone for modern automation.
- **RS-485:** The foundation for many serial protocols.
- **Twisted pair & Cat5e:** Reduce interference, carry data reliably.
- **Serial vs Parallel:** One lane vs multi-lane — speed vs simplicity.