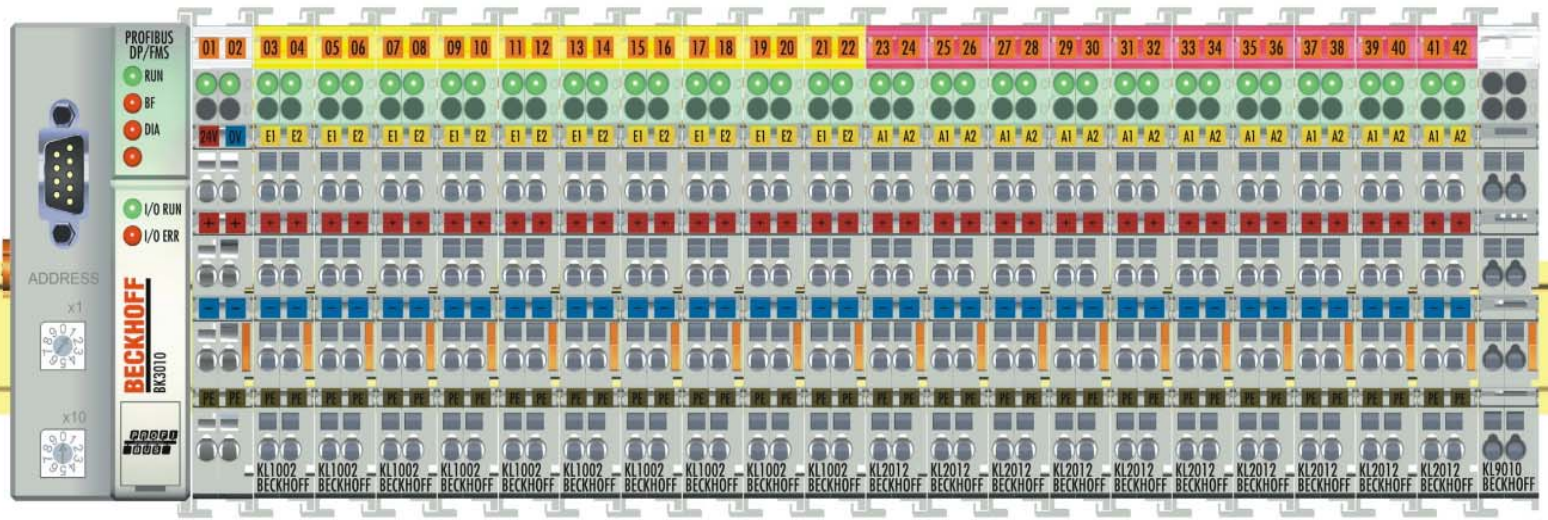
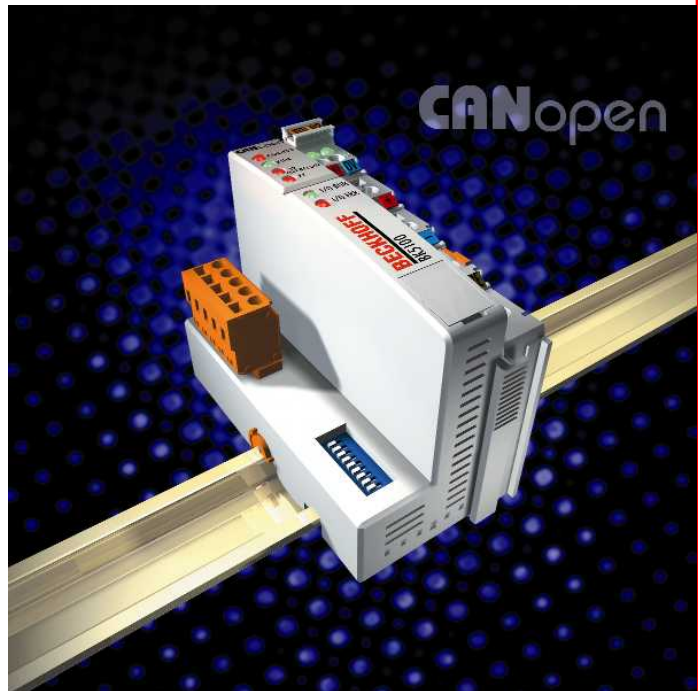
Fieldbus Overview

Profibus

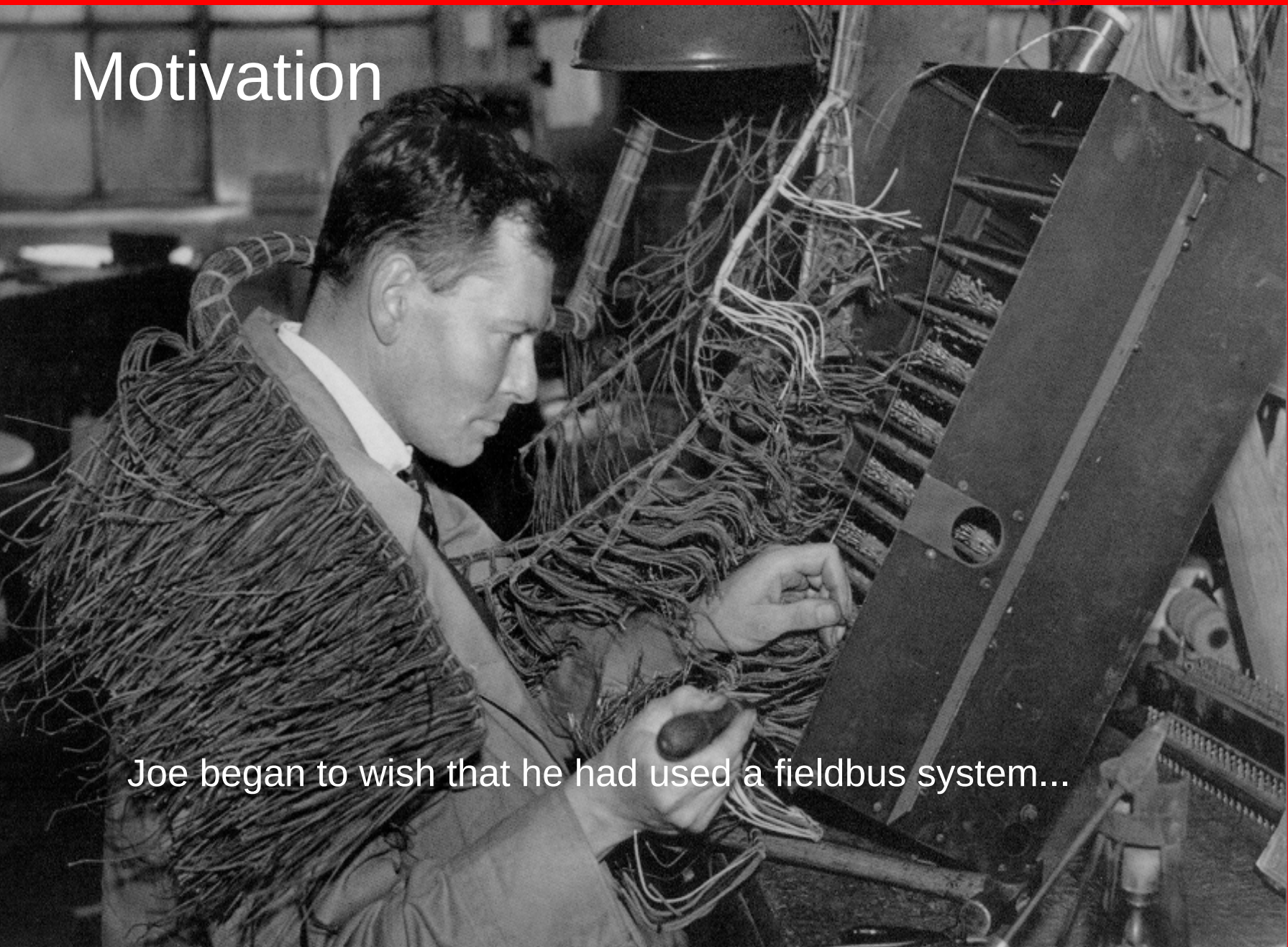


Content

- Motivation
- Features of Fieldbus Systems
- Profibus
- Performance Comparison



Motivation



Joe began to wish that he had used a fieldbus system...

Why select a Fieldbus System?

- Independent of proprietary solution
- Vendor independent
- Cost savings
- Increase of productivity in terms of
  - faster
  - more flexible
  - easy expandable
  - customized

What a Fieldbus system needs to offer?

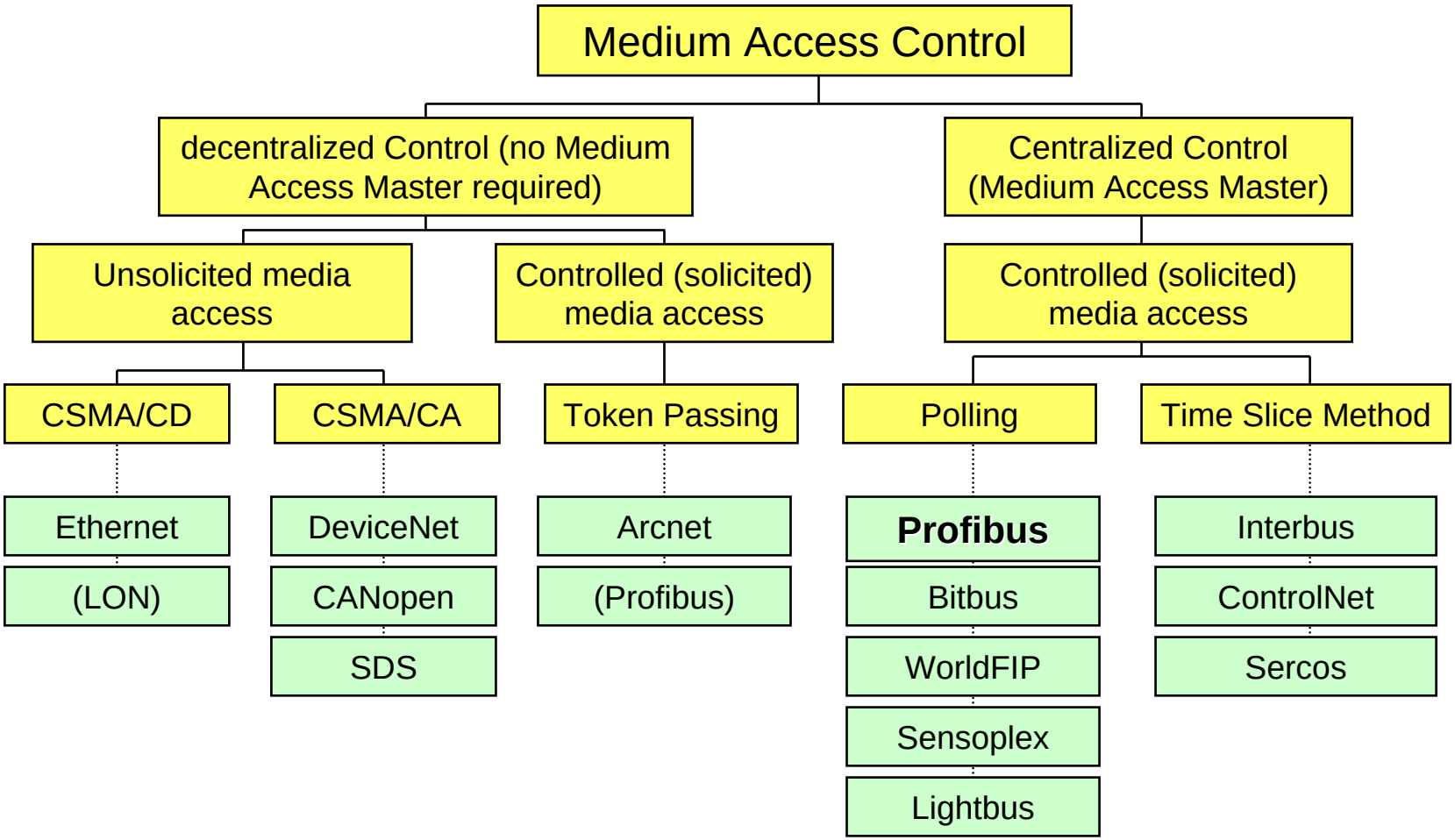
- Deterministic
  (since parallel wiring will be replaced)
- Flexible
- Multi-vendor use
- Cost efective (installation, startup, service)
- Reliable and safe
- Easy to use
- Solution for all your automation needs

Standardization

Basic Features of Fieldbus Systems

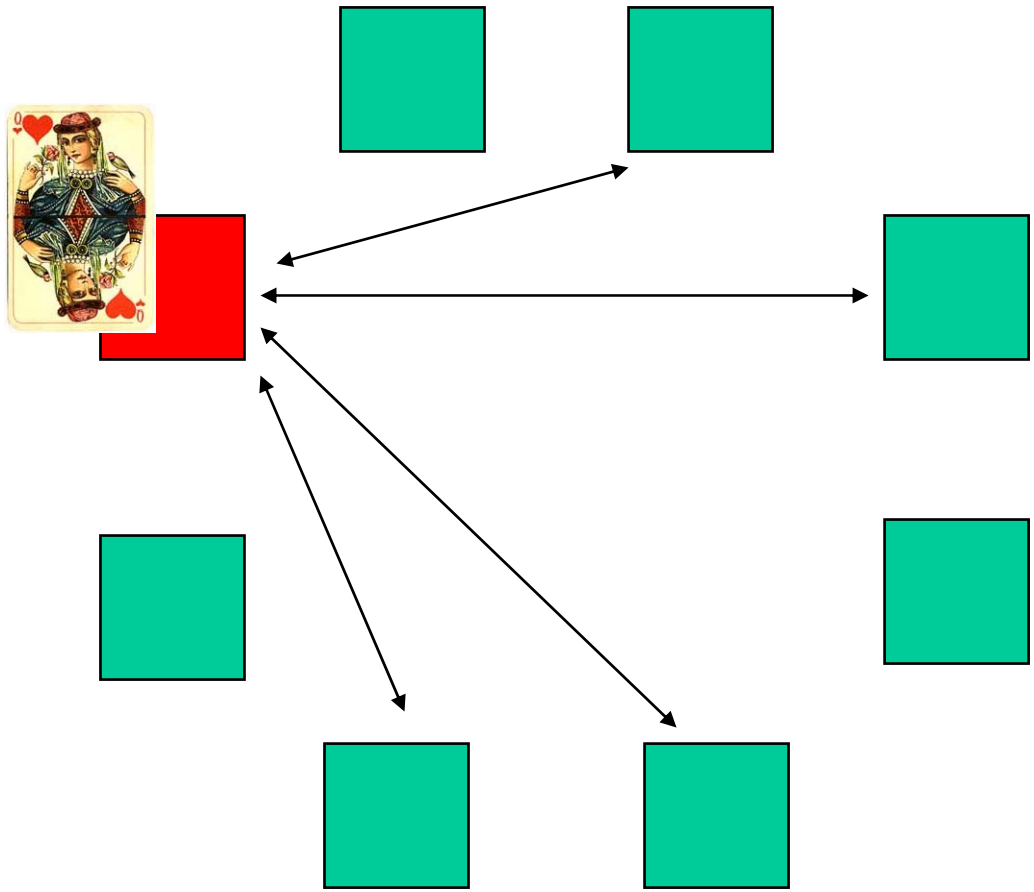
- MAC: Medium Access Control
- Addressing
- Transmission Media
- Topology
- Node Hierarchy

Medium Access Control



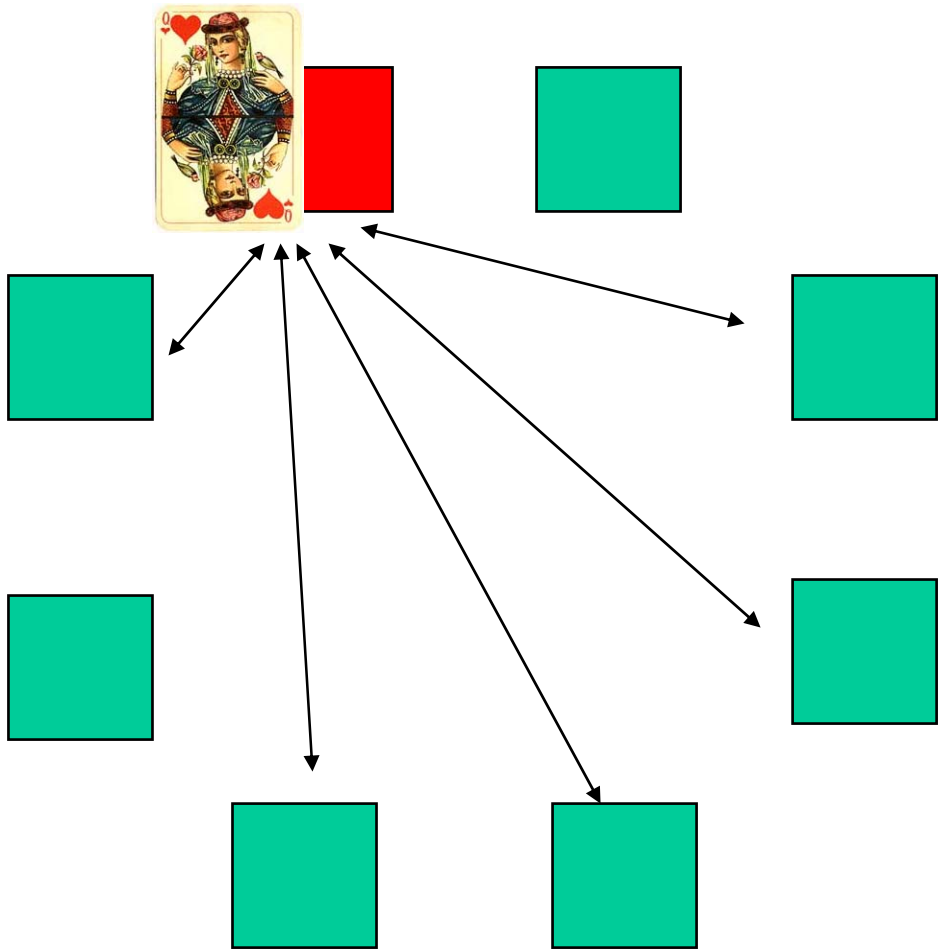
Medium Access Control: Token Passing

The node that holds the token controls the network traffic



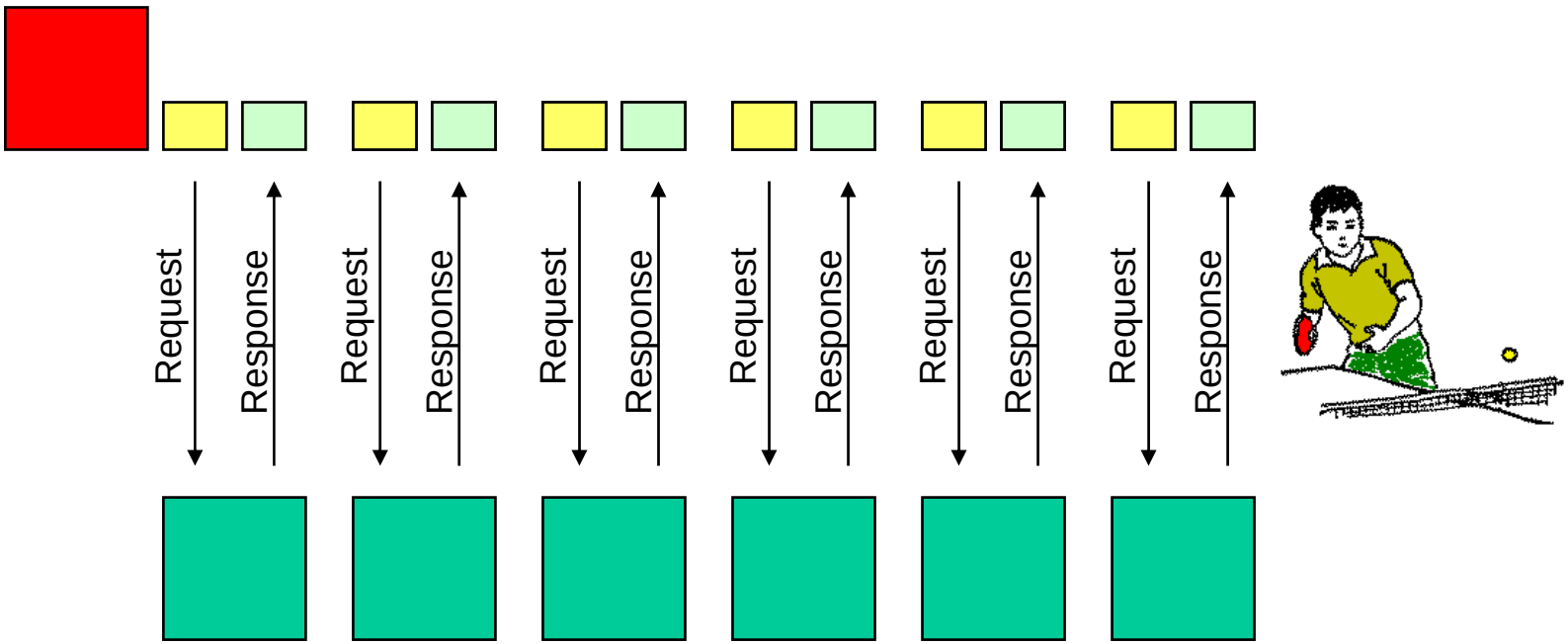
Medium Access Control: Token Passing

The node that holds the token controls the network traffic



Medium Access Control: Polling

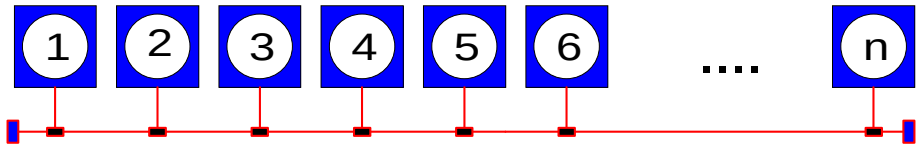
One master node polls the slave nodes



Addressing

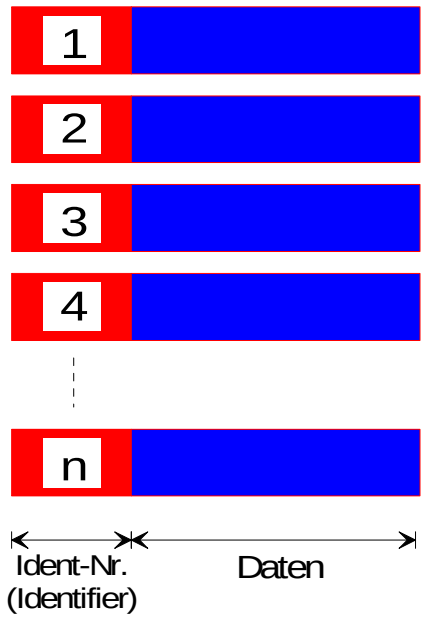
Node-Addressing

- Node processes
  Data with its destination address



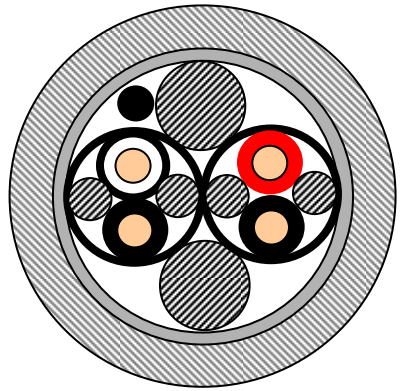
Telegram-Addressing

- Node processes
  Data with the Ident-Number that he is interested in



Transmission Media (Examples)

Copper:



- RS 485, 2/3/5-Wire

  (**Profibus-DP**, Interbus-S, LON, Bitbus...)
- ISO 11898, 2-Wire (+ GND)

  (CAN "High Speed„)
- Power Supply Line

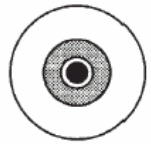
  (AS-Interface, LON, Interbus-Loop)
- Unshielded Twisted Pair (UTP)

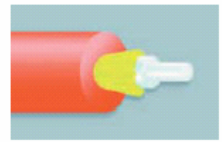
  (Ethernet 10BaseT)
- Koax-Wire

  (Arcnet, Ethernet 10Base5, 10Base2)

Transmission Media (Examples)

Fiber Optics:





- Plastic Optical Fibre (POF) + HCS (hard clad silica)

(Beckhoff-Lightbus, Sercos, Interbus-S, Profibus)

- Glass Fibre (Single Mode + Multi Mode)

Type	Peak Wave Length	Damping	Max Length
POF	640...675nm	~2000 dB/km	40m
HCS	640..675nm	~7 dB/km	300m
Multi Mode	790..910nm	~3dB/km	1700m
Single Mode	1260..1380nm	~0,4 dB/km	10000m

POF: Made of PMMA (Polymethylmethacrylate)

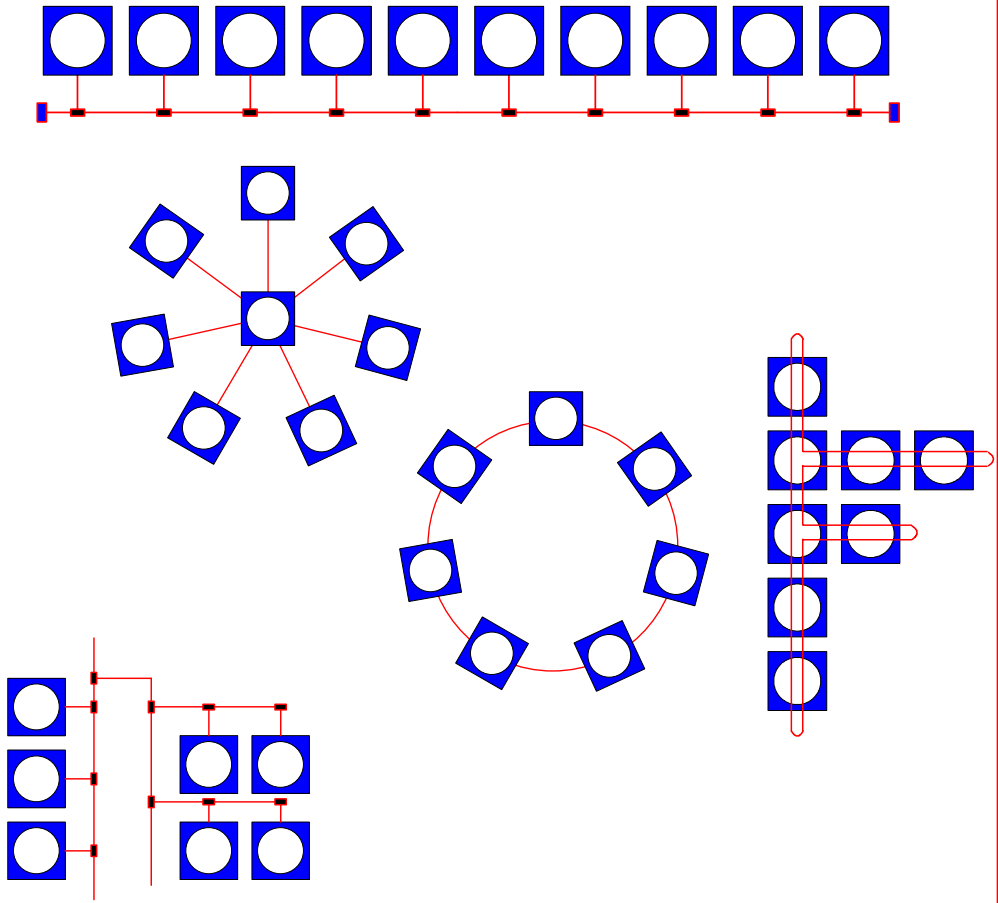
Topology

Bus / Line
- (electrical)

Star
- (electrical and optical)

Ring
- (electrical and optical)
- With special types

Tree
- (electrical)



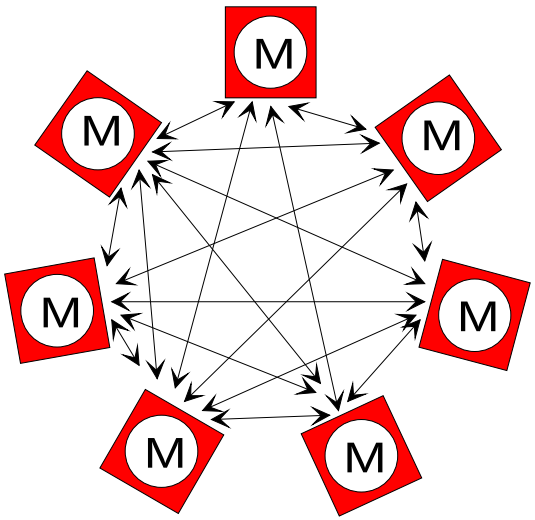
Node Hierarchy

Definitions:

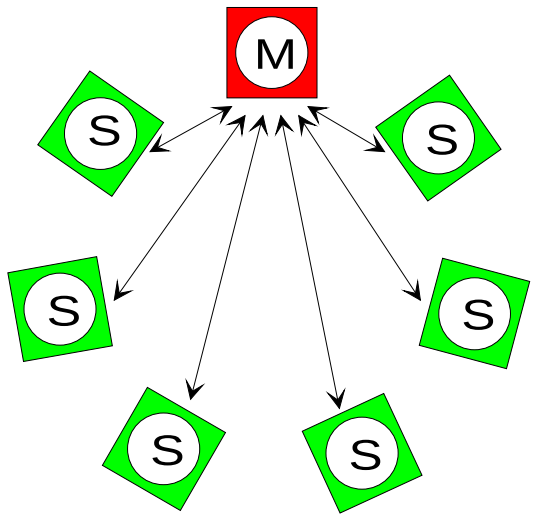
Master: Node that controls the bus access and bus communication

Slave: Can only communicate with Master

Multi-Master System



Master-Slave-System



PROFIBUS - Technical Overview

PROcess FIeld BUS

Norm

European Fieldbus Standard EN50170

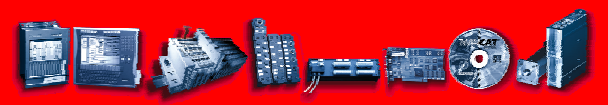
DP	Decentralized Pheriphery
	- for Factory Automation
	- fast data exchange; efficient and cost effective
	- plug and play
MC	Motion Control
FMS	File Message Service
	- for General Purpose Automation
	- universal; large variety of applications
	- Multi-Master communication
PA	Process Automation
	- application orientated

PROFIBUS - Technical Overview

Variety

European Fieldbus Standard EN50170

- Drives (AC, DC)
- Controllers (PLC/NC, Workstation)
- Decentralized I/O (Binary, Analog, Timer)
- Valves (Pneumatic, Magnetic)
- HMI (Operator Panels, Text Displays)
- Instruments (Pressure, Temperature)
- Network Components (Repeater, Cables)
- Tools (Configurator, Bus Monitor)

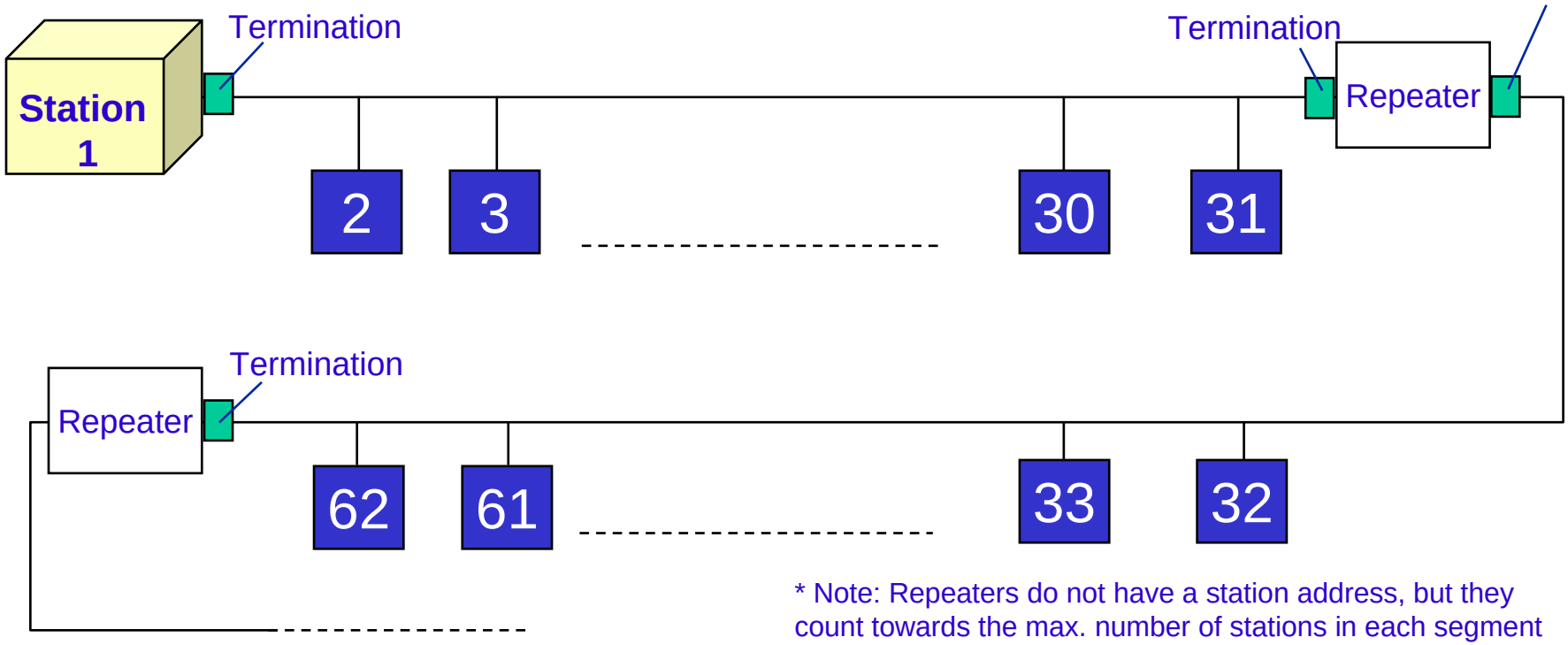


PROFIBUS-DP - Technical Overview

speed	min. 9.6 kBaud - max. 12 MBaud
based on	RS485 – twisted pair cable + ground/shielding (opt.: fibre optics); always terminated on the end
devices (stations)	32, with repeater 125
communication	Master/Slave (polled mode); Master/Master (token)
topology	line or tree or combination
cable length	depends on speed (12MBaud=100m, 32 stations)
error detection	CRC - Hamming Distance: 4 Up to 3 transmission failures at a time can be detected

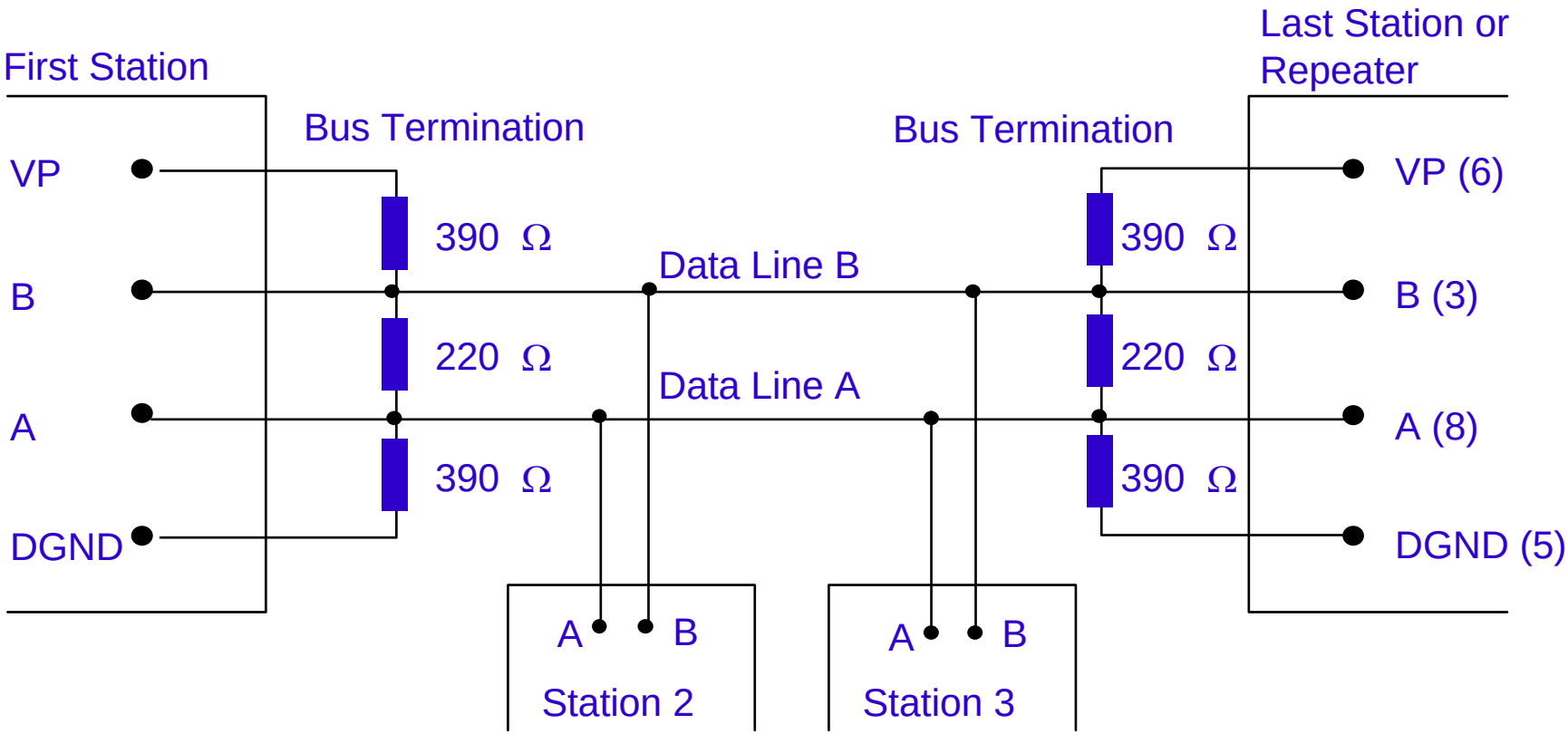
Baudrate (kbit/s)	9.6/19.2/93.75/187.5	500	1500	3000/6000/12000
Max. Segment length (m)	1000	400	200	100
Max. Expansion (m)	10.000	4.000	2.000	1.000

Profibus-DP: Topology



* Note: Repeaters do not have a station address, but they count towards the max. number of stations in each segment

PROFIBUS – Termination



Pin 3	B-Line = TxD/RxD positive; red wire
Pin 8	A-Line = TxD/RxD negative; green wire
Pin 5	Shielding (connected to housing)

If possible, terminate at the master!
Each segment needs to be terminated at both ends!
Termination needs to be powered at all time!

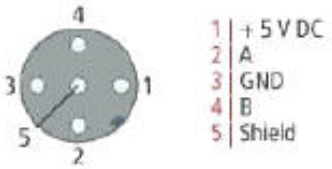
PROFIBUS Cabeling

PROFIBUS Connection

M12 circular connector

The M12 socket is inverse coded, and has five pins. Pin 1 is 5 V_{DC} and 3 is GND for the active termination resistor. These must never be misused for other functions, as this can lead to destruction of the device. Pin 2 and pin 4 are the Profibus signals. These must never be swapped over, as this will prevent communication. Pin 5 is the shield, and this is capacitatively coupled to the Fieldbus Box chassis.

M12 socket pin assignment



Nine pole D-Sub

Pin 6 is 5 V_{DC} und Pin 5 is GND for the active termination resistor. These must never be misused for other functions, as this can lead to destruction of the device. Pin 3 and pin 8 are the Profibus signals. These must never be swapped over, as this will prevent communication. Shield is connected to the D-Sub housing that is coupled with low-resistance to the mounting rail.

D-Sub socket pin assignment

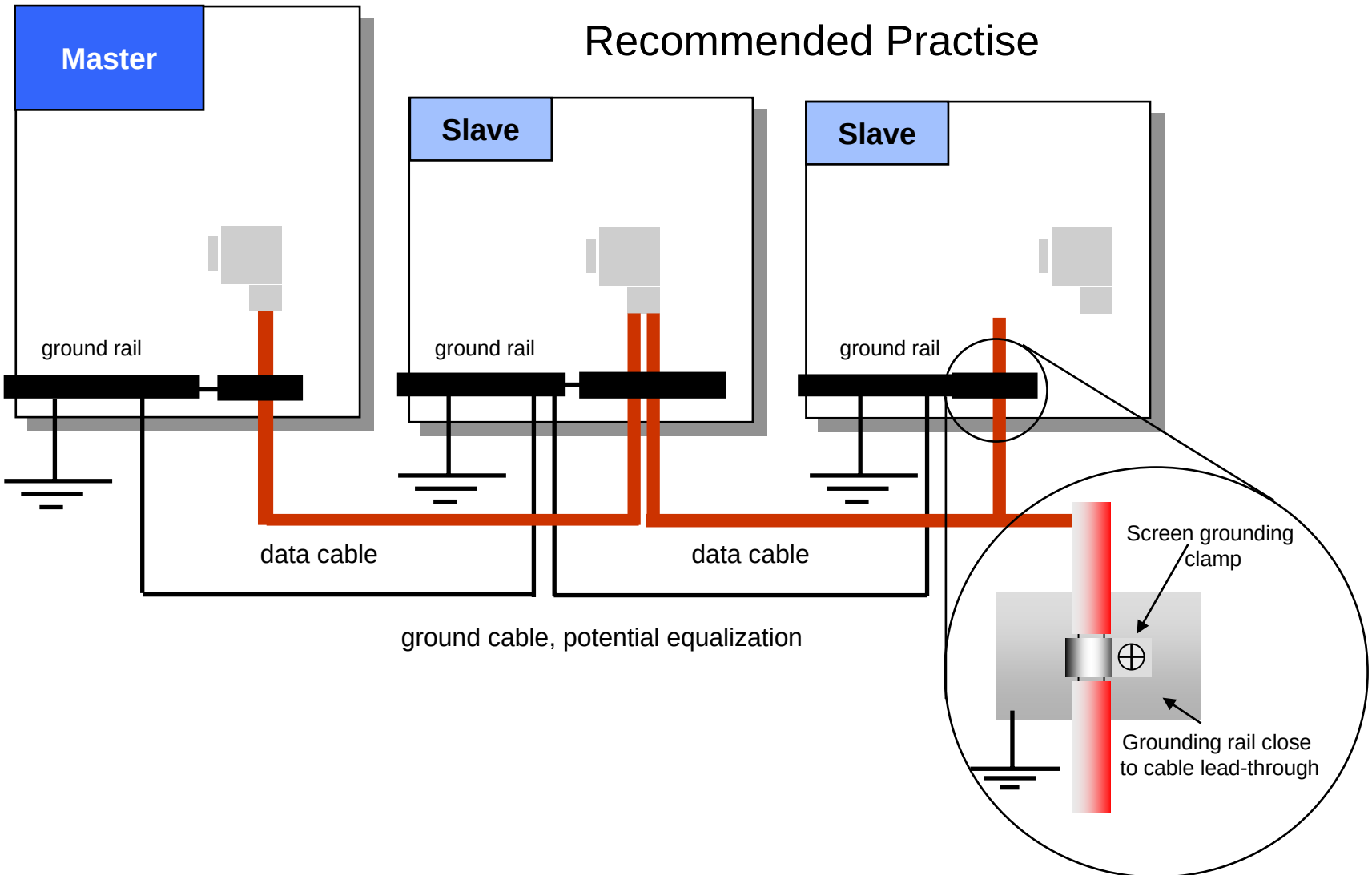
Profibus conductor colours

Profibus conductors	M12	D-Sub
B red	Pin 4	Pin 3
A green	Pin 2	Pin 8

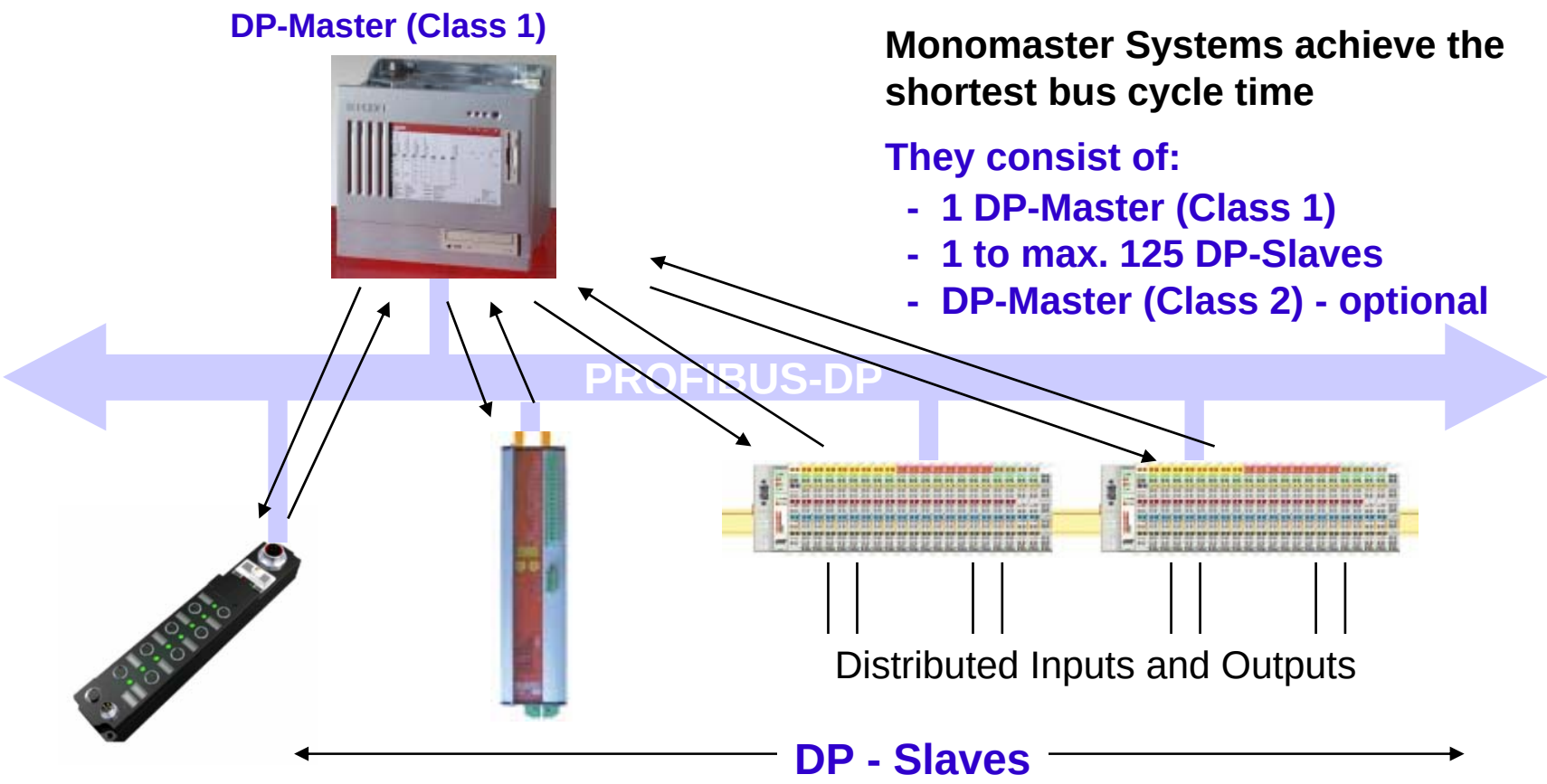
PROFIBUS – Termination

1 Schirm	Schirm
2 M24	Masse der 24V Ausgangsspannung
3 RxD/TxD-P	Empfangs-/Sende Daten Plus
4 CNTR-P	Steuersignal fuer Repeater
5 DGND	Masse zu 5V
6 VP	Versorg.Sp. fuer Terminator (5V)
7 P24	24V Ausgangsspannung
8 RxD/TxD-N	Empfangs-/Sende Daten Minus
9 CNTR-N	Repeater Steuersignal

Profibus-DP: Shielding/Grounding (CHECK)



Profibus-DP: Monomaster System

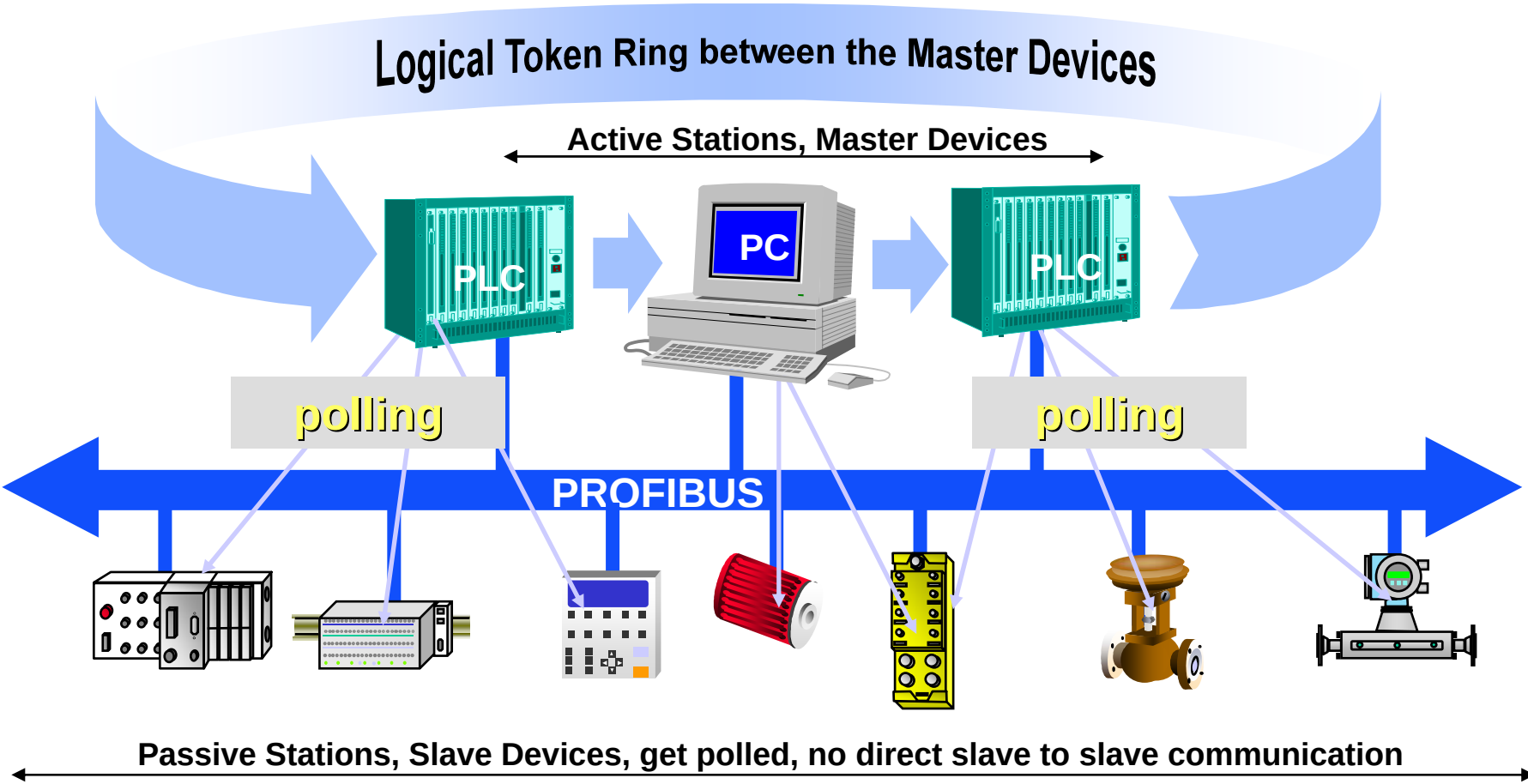


Monomaster Systems achieve the shortest bus cycle time

They consist of:

- **1 DP-Master (Class 1)**
- **1 to max. 125 DP-Slaves**
- **DP-Master (Class 2) - optional**

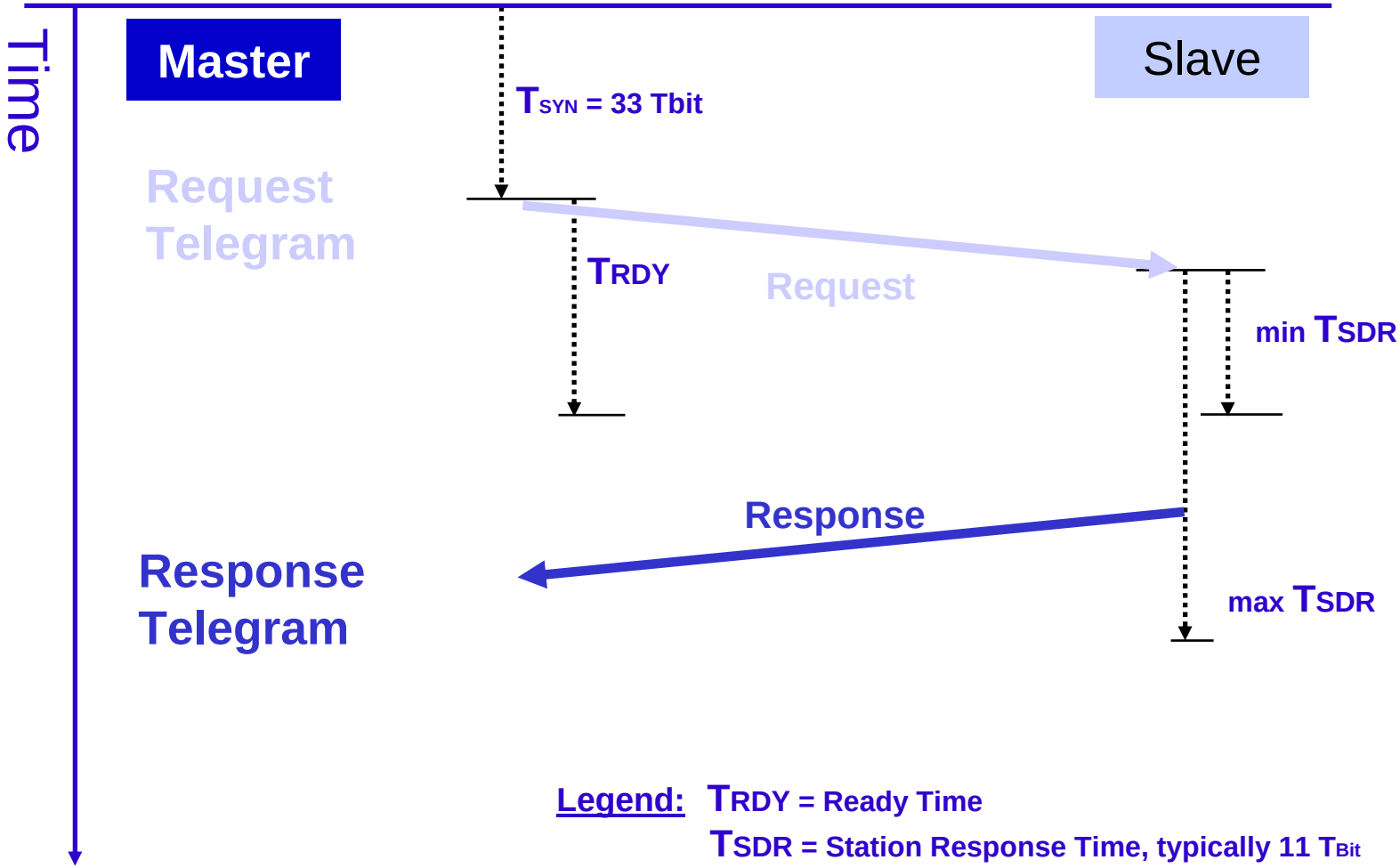
Profibus-DP: Multi Master Media Access



Profibus Protocol Classes

DPV0	**Cyclic Process Data Communication**	BK3000, **BK3100**, AX2000 BK3010, **BK3110**, **BK3120**, BK3500, BK3520, LC3100, BC3100, **FM3312**, **FM3332**, IPxxxx-B310, ILxxxx-B310, ILxxxx-C310 AH2001, **AH2003**, **FC3101**, FC3102
DPV1	**Alarm and acyclic Services (e.g. Parameter data)**	BK3010, BK3110, **BK3120**, BK3500, BK3520, LC3100, BC3100, **FM3312**, **FM3332**, IPxxxx-B310, ILxxxx-B310, ILxxxx-C310 AH2001, **AH2003**, **FC3101**, FC3102
DPV2	**Slave to Slave Communication (via Master), Equidistance (Motion Control)**	AH2001, **AH2003** (equidistance), **FC3101**, FC3102

Profibus-DP: Timing



Legend: TRDY = Ready Time
TSDR = Station Response Time, typically 11 TBit
TSYN = Synchronization Time, typically 22 TBit

Profibus-DP: Calculation of Cycle Time

$$T_{MC} = (T_{SYN} + T_{ID1} + T_{SDR} + Header + I \times 11TBit + O \times 11TBit) \times Slaves$$

T_{MC}	=	Message Cycle Time in Bit Times
T_{ID1}	=	Idle Time at the Master = typically 75 TBit
T_{SDR}	=	Station Delay Time at the Slave = typically 11TBit
Header	=	Telegram Overhead in Request and Response Frame = 198 TBit
I	=	Number of Input Data Bytes per Slave
O	=	Number of Output Data Bytes per Slave
Slaves	=	Number of Slaves

Example: PROFIBUS-DP System consisting of 1 Master and 20 Slaves each with 2 Byte Input and 2 Byte Output Data.

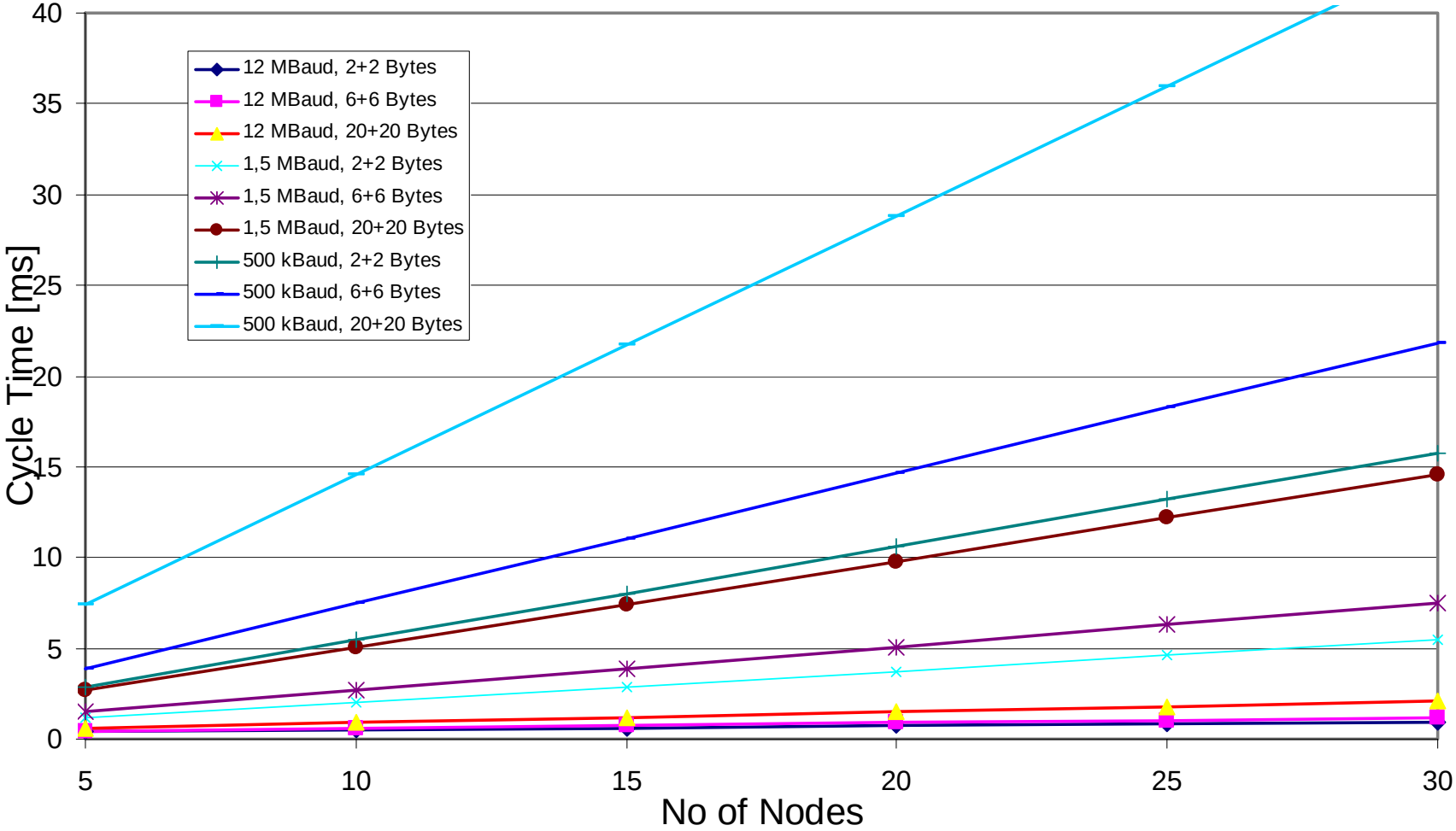
T_{MC} = (33 + 75 + 11 + 198 + 22 + 22) x 20 = 7220 TBit

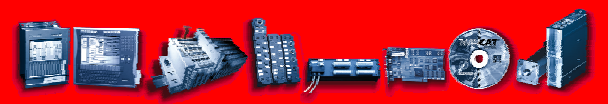
7220 TBit (1.5 MBaud) = (TBit = 0.66 µs) = 4.8 ms

7220 TBit (12 MBaud) = (TBit = 0.83 ns) = 0.6 ms

In practice, a safety margin of approx 10 to 20% should be added for bus administration, diagnostic messages and retries (after bit errors).

Profibus: Cycle Times

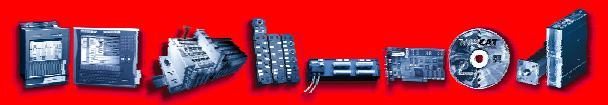




Profibus-DP: Troubleshooting

Simple test for eliminating the most common wiring errors:

- Data cable swapped over
- Open circuit of one of the data cables
- Open circuit of the cable shield
- Short circuit between the data cables
- Short circuit between data cables and cable shield
- Additional bus terminating resistors inserted unintentionally



Profibus-DP: Troubleshooting

Test each segment after installing cables and attaching bus connectors, but:

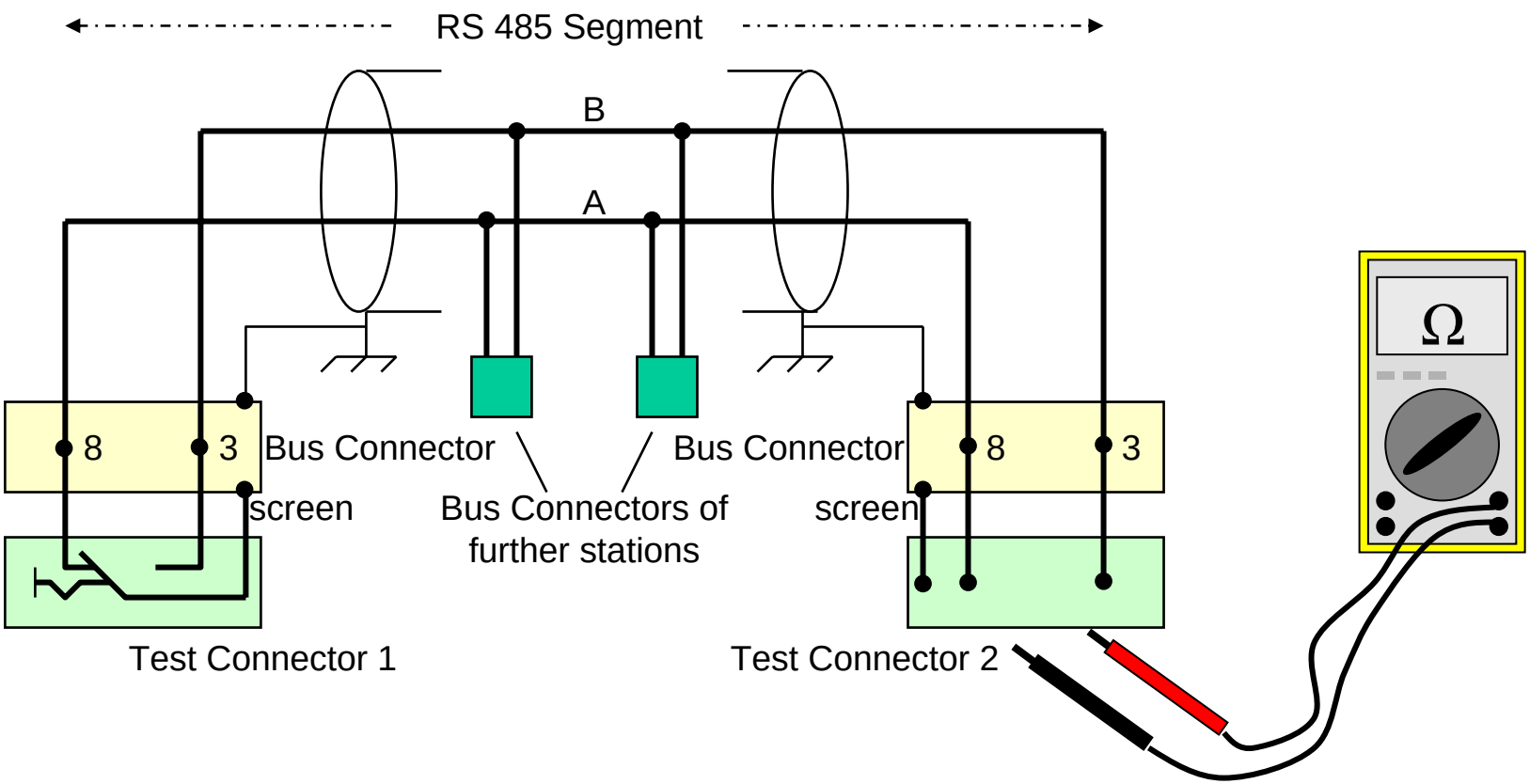
- bus connectors must not be connected to Profibus devices
- bus terminating resistors must be removed or disabled

Test equipment: 2 test connectors DB9, 1 Ohmmeter

• Connector 1 with single pole changeover switch; moving contact connected to shield (case) of the test connector. Fixed contacts connected to pin 3 (data wire B) and pin 8 (data wire A).

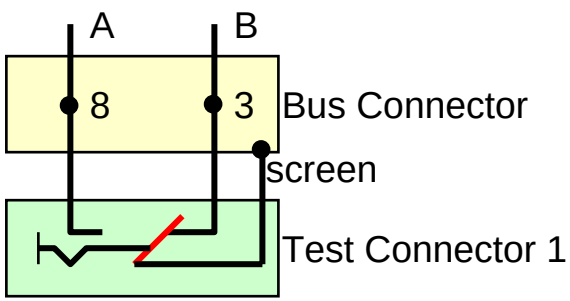
• Connector 2 used to connect the Ohmmeter to the bus

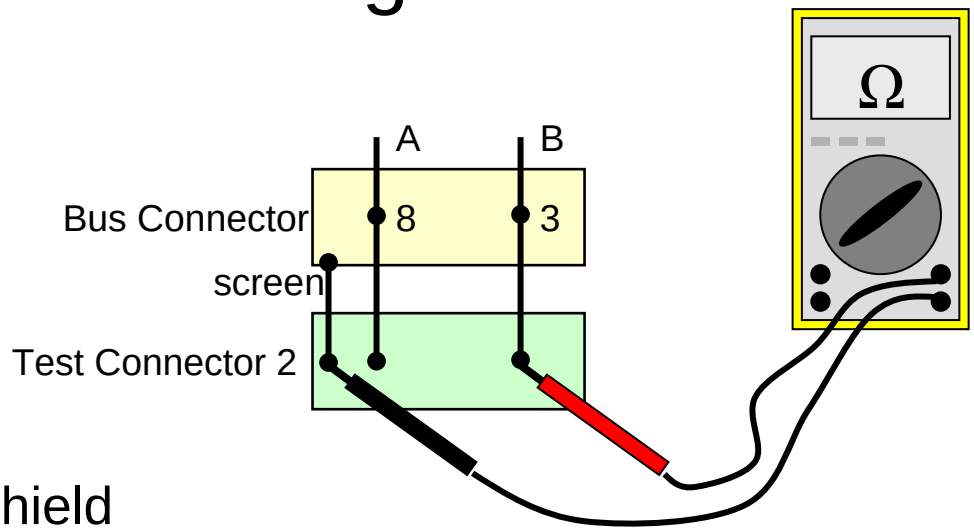
Profibus-DP: Troubleshooting



Wiring Test Setup

Profibus-DP: Troubleshooting





TC1: first connect pin 3 and shield

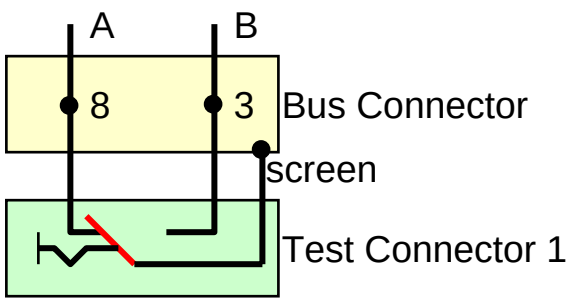
TC2: measure resistance R between pin 3 and shield

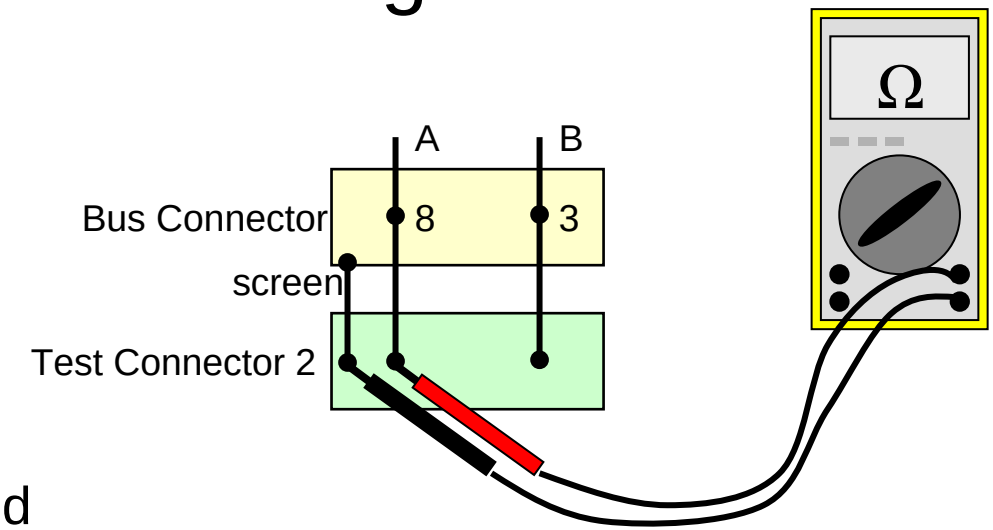
If R < 10 Ω: Data B and shield connection o.k.
If R = infinity: Data B or shield open circuit

Then disconnect pin 3 and shield at TC1

Resistance R now has to be infinite.
If not: short circuit between data B and shield or
Data A and Data B swapped over

Profibus-DP: Troubleshooting





TC1: connect pin 8 and shield

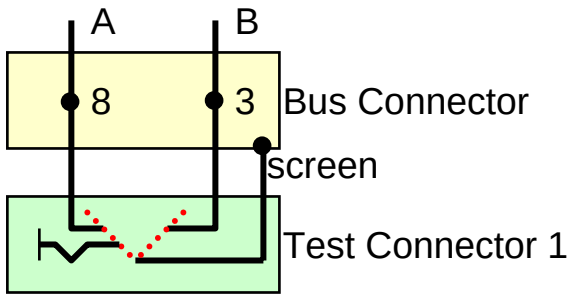
TC2: measure resistance R between pin 8 and shield

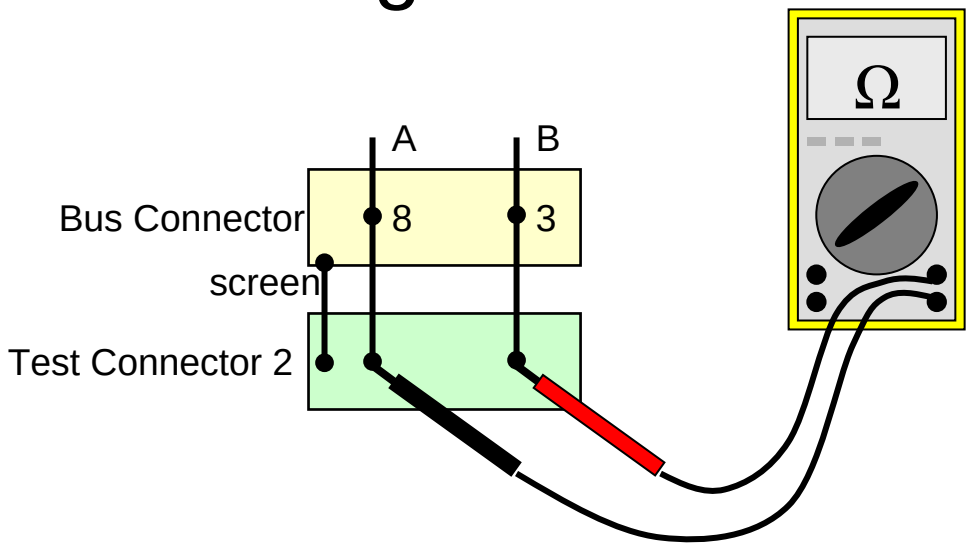
If R < 10 Ω: Data A and shield connection o.k.
If R = infinity: Data A or shield open circuit

Then disconnect pin 8 and shield at TC1

Resistance R now has to be infinite
If not: short circuit between data B and shield or
Data A and Data B swapped over

Profibus-DP: Troubleshooting

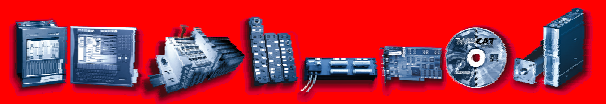




TC1: switch position is not important

TC2: measure resistance R between pin 3 and pin 8

If R = infinite: o.k., if no terminating Resistors connected
If R = 220..230 Ω: 1 Terminating Resistor connected, 1 missing
If R = 110..120 Ω: 2 Terminating Resistors connected (GOAL)
If R = <110 Ω: too many Terminating Resistors



Profibus-DP: Installation Guidelines (RS485)

Profibus cables and cables for...	must be laid...
- Bus signals, e.g. PROFIBUS - Data signals for PC´s, programming devices, printers etc. - Screened analog inputs - Unscreened DC voltages (<= 60V) - Screened process signals (<= 25 V) - Unscreened AC voltages (<= 25V) - Coaxial cables for monitors	in the same cable loom or cable duct.
- DC voltages from 60V... 400V (unscreened) - AC voltages from 25V... 400V (unscreened)	in separate cable looms or cable ducts without minimum spacing requirements
- DC and AC voltages > 400 V (unscreened) - Telephone cables - For areas with explosion hazard	inside control cabinet: in separate cable looms or cable ducts without minimum spacing requirements outside control cabinets: In seperate cable runs spaced at least 10cm (4“) apart

Bus Cycle Times