



Practical steps for a successful

PROFIBUS Project

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- ⇒ Basics of PROFIBUS
- ⇒ Practical steps in the design and installation stages
 - ✓ Segmentation: number of devices, length of cables
 - ✓ Reflections and Termination
 - ✓ Cabling, Interference and Reduction
 - ✓ Design Documents
 - ✓ PROFIBUS Protocol, Extensions and Profiles
- ⇒ Coming training courses at MMU

⇒ PROFIBUS DP - *Decentralised Periphery*

- Replacement for conventional 0- 10 V voltage transmission
- **Uses RS485 transmission**
- High speed, Low cost, very suitable for factory automation. (e.g. Electronics, Automotive, and Metal/Mining industries)
- **Versions: DP-V0 (1993), DP-V1 (1997) , and DP-V2 (2002).**

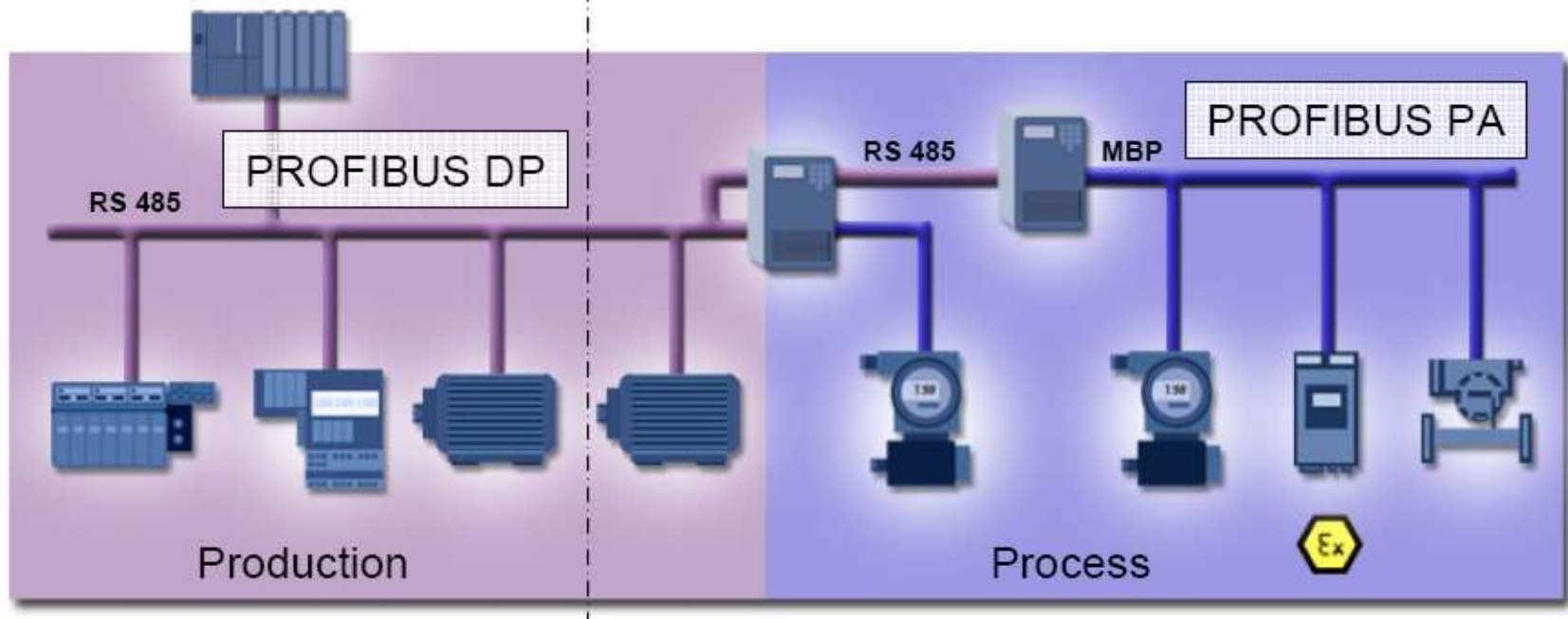
⇒ PROFIBUS PA - *Process Automation*

- Developed specifically for the process industry to replace 4-20mA transmission. (e.g. Chemicals, Refineries, and Power Stations)
- **Uses MBP transmission**
- Two-wire connection carrying both power and data.
- **Defined in DP-V1, the first extension to the basic protocol.**
- **Also defined in PA Profile.**

- ⇒ Standard protocols and PA Profile over a single cable.
- ⇒ DP/PA convertor used to convert from RS485 transmission to MBP transmission.

Up and Down stream applications with PROFIBUS DP

Mainstream application with PROFIBUS PA for Ex and Non-Ex area plus PROFIBUS DP

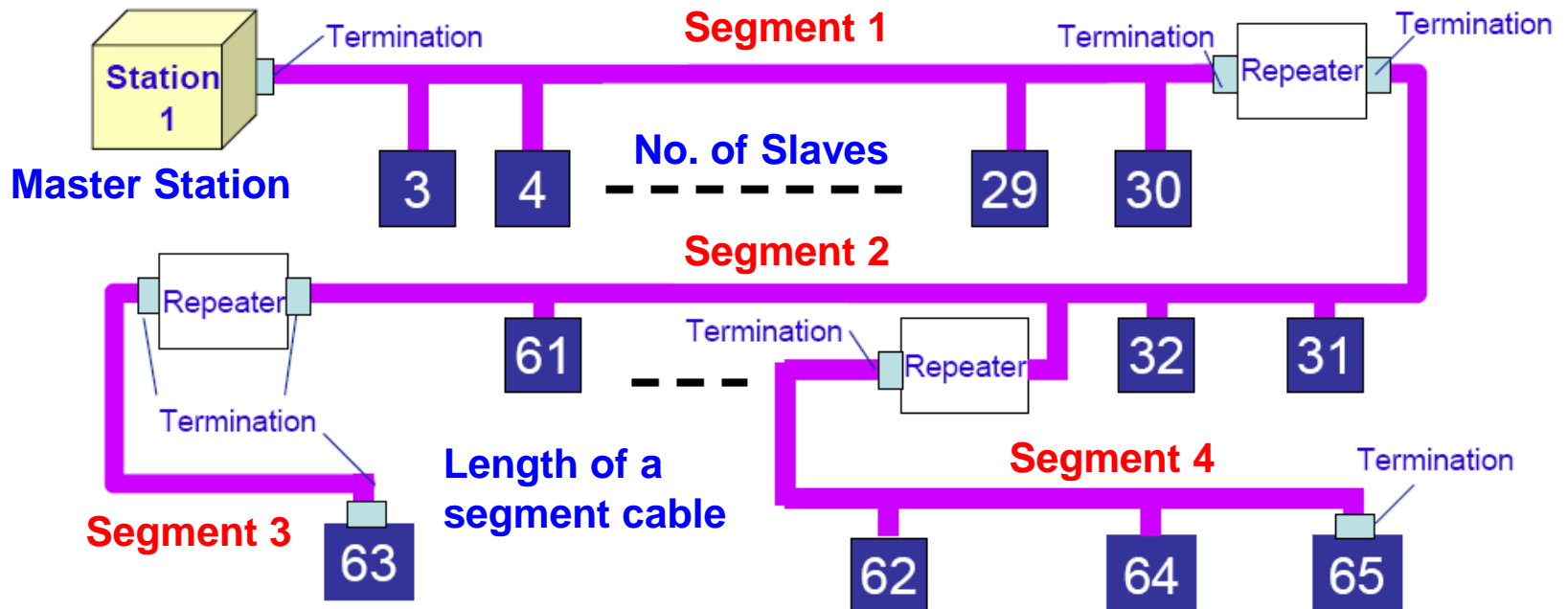


Segmentation

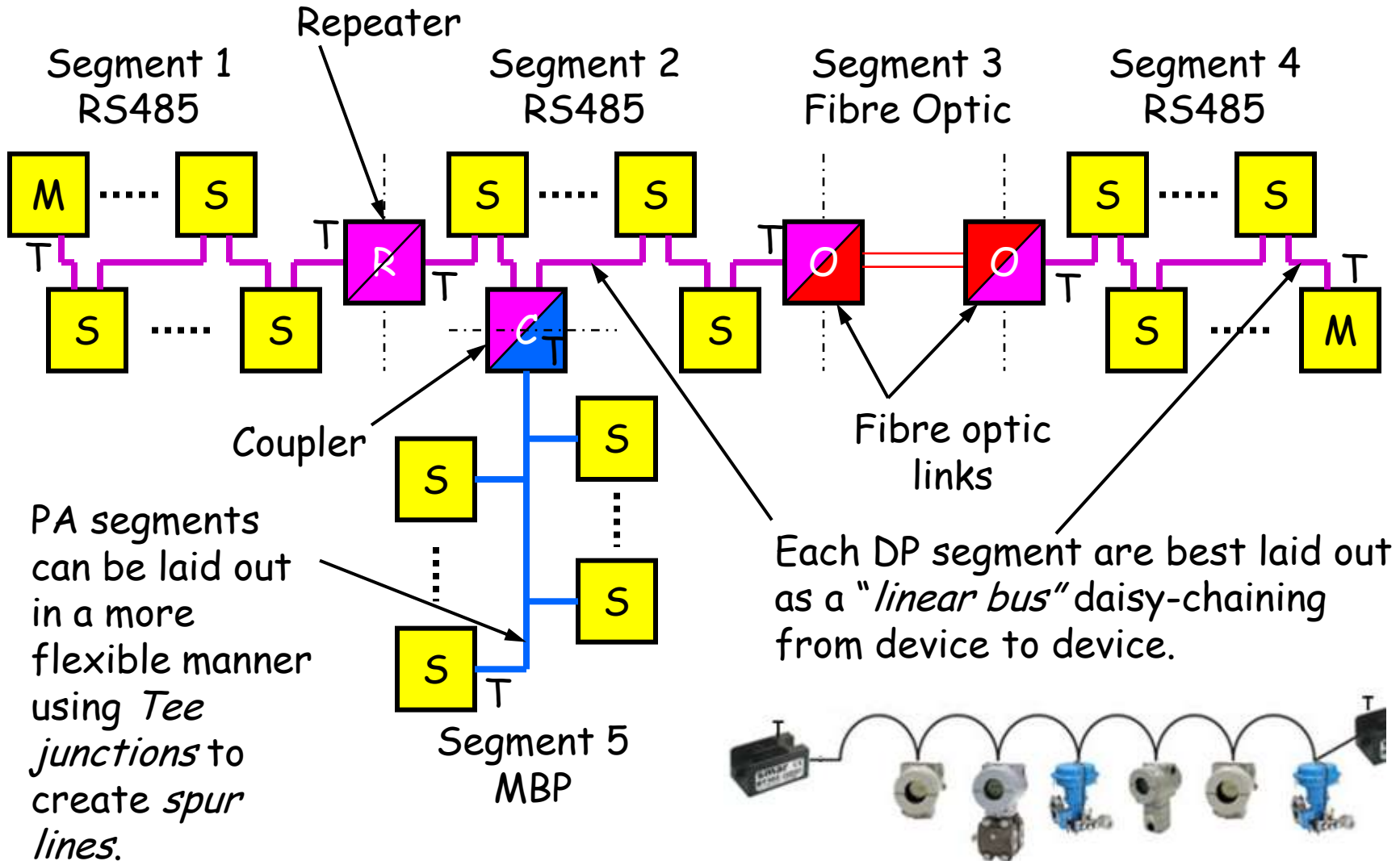
⇒ On a PROFIBUS network.

× No hubs and no switches

× Uses Repeater, DP/PA Coupler, and OLM to expand the number of devices or cable length



DP & PA Topology



Segment Cable Length

When using best quality PROFIBUS RS485 (Type-A) cable:

Baud rate	Maximum segment length	
9.6 kbit/s	1 200m	Low speed
19.2 kbit/s	1 200m	
45.45 kbit/s	1 200m	
93.75 kbit/s	1 200m	
187.5 kbit/s	1 000m	
500.0 kbit/s	400m	High speed
1.5 Mbit/s	200m	
3.0 Mbit/s	100m	
6.0 Mbit/s	100m	
12.0 Mbit/s	100m	

- ⇒ The network runs at a certain data rate (also called the bit rate or baud rate).
- ⇒ **PA baud rate is fixed at 31.25 kbit/s.**

DP baud rate

9.6 kbit/s

19.2 kbit/s

45.45 kbit/s

93.75 kbit/s

187.5 kbit/s

500.0 kbit/s

1.5 Mbit/s

3.0 Mbit/s

6.0 Mbit/s

12.0 Mbit/s

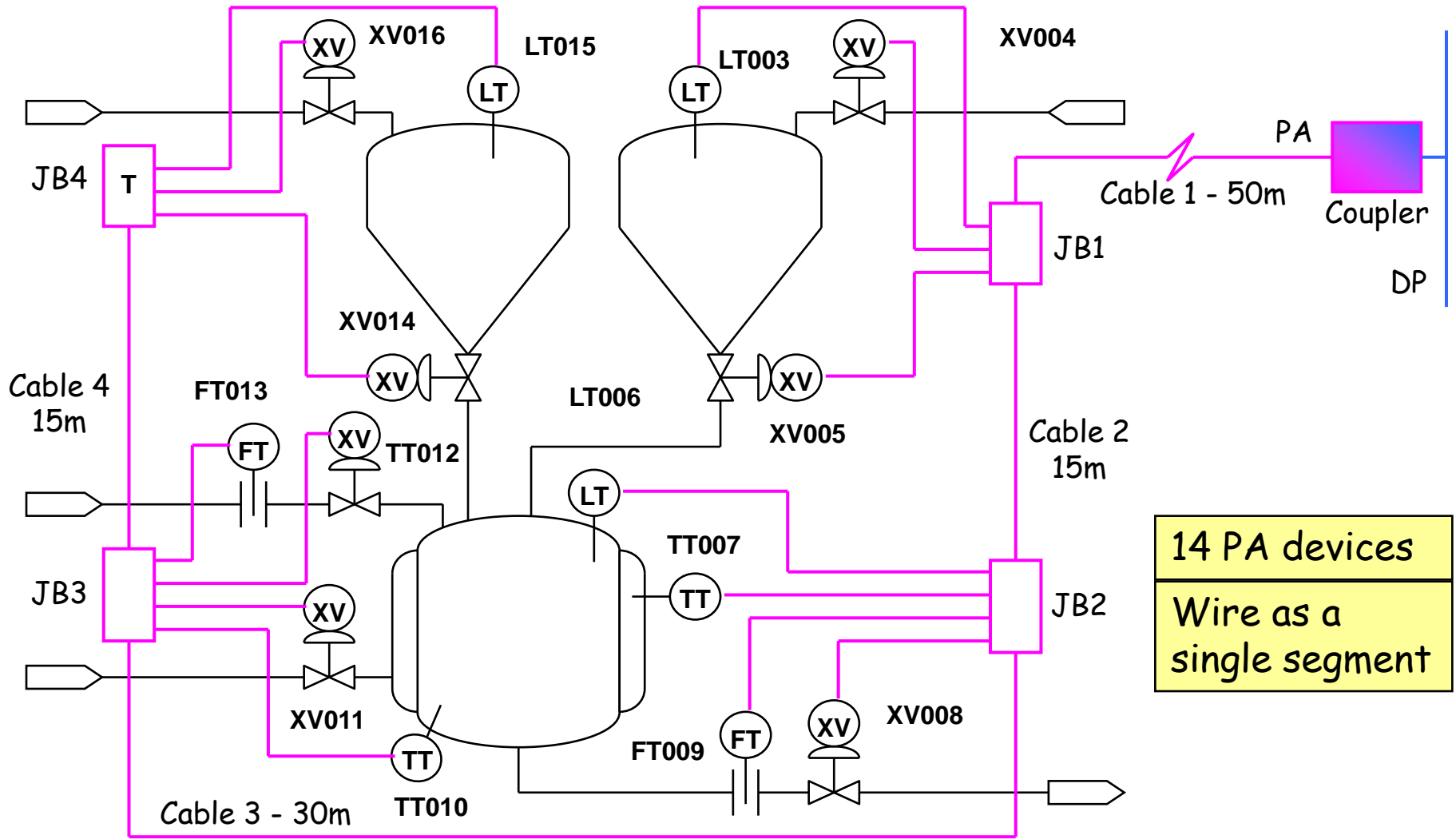
Segmentation - PA

- ⇒ Total cable length of 1900m
- ⇒ For intrinsic safe applications, 1000m.
- ⇒ The length of the **individual** spur-lines depends upon the total number of spurs used:

Number of spur-lines	Maximum spur length non-intrinsically safe	Maximum spur length intrinsically safe
<u>25</u> to 32	1 m	1 m
19 to <u>24</u>	60 m	60 m
15 to 18	60 m	60 m
13 to 14	90 m	60 m
1 to 12	120 m	60 m

- ⇒ Example (non-intrinsic safe): $24 \times 60 = 1440\text{m}$ spurs + 460m trunk line

PA Segmentation - Voltage Drop Calculation



PA Segmentation - Current Calculation

Determine the basic current and fault current for each device.

Compare the total current + max single fault current with the coupler output.

Maximum coupler output = 400 mA

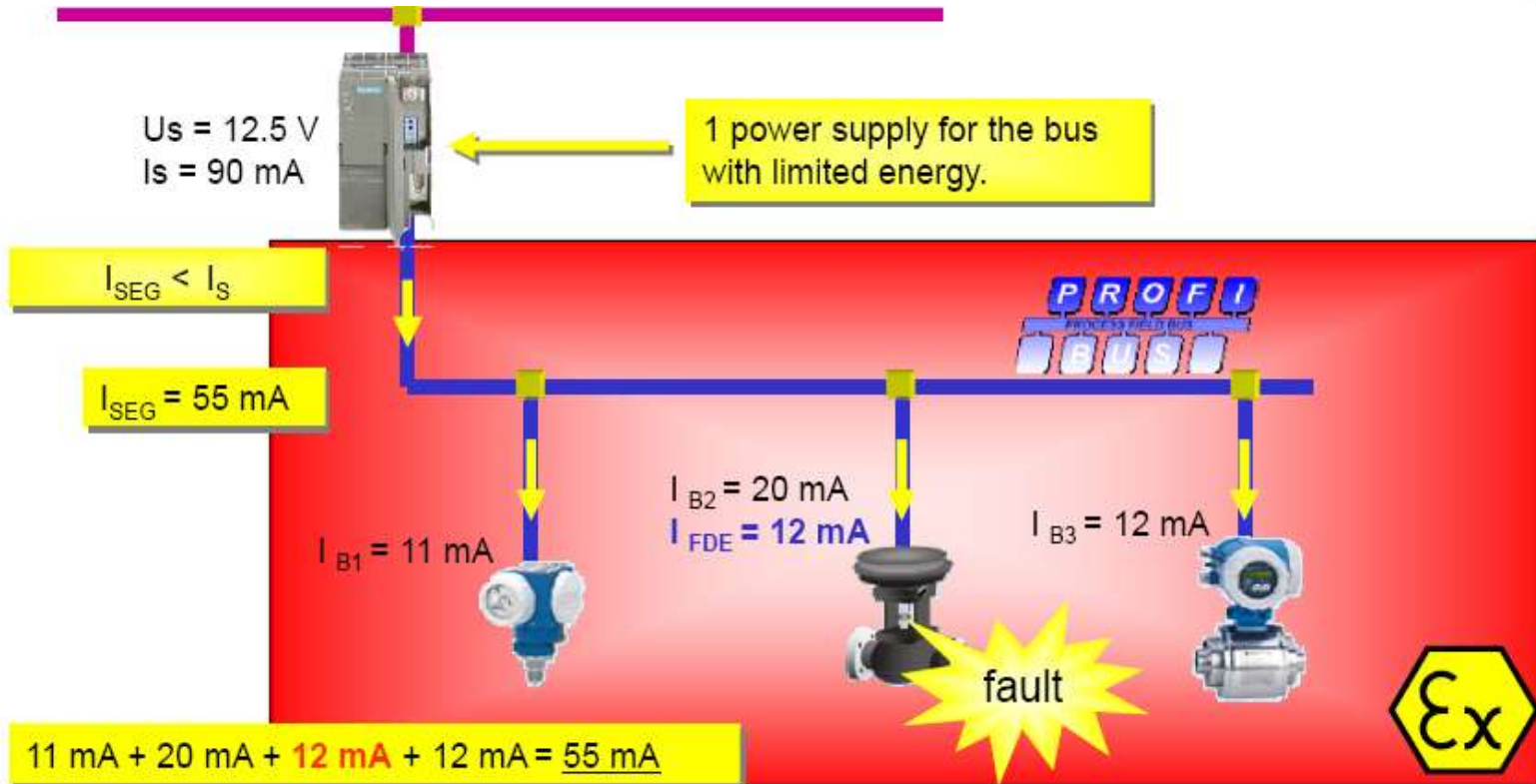
OK!

Tag	Address	Device	Basic current/mA	Fault current/mA
LT 003	3	Ultrasonic level	13	0
XV 004	4	Valve positioner	13	4
XV 005	5	Valve positioner	13	6
LT 006	6	Ultrasonic level	13	0
TT 007	7	Temperature	13	0
XV 008	8	Valve positioner	13	4
FT 009	9	Mass flow meter	12	0
TT 010	10	Temperature	13	0
XV 011	11	Valve positioner	13	4
XV 012	12	Valve positioner	13	4
FT 013	13	DP cell + orifice	11	0
XV 014	14	Valve positioner	13	6
LT 015	15	Ultrasonic level	13	0
XV 016	16	Valve positioner	13	4

Total current: 179

Max fault current: 6

Total current + max single fault current: **185** mA

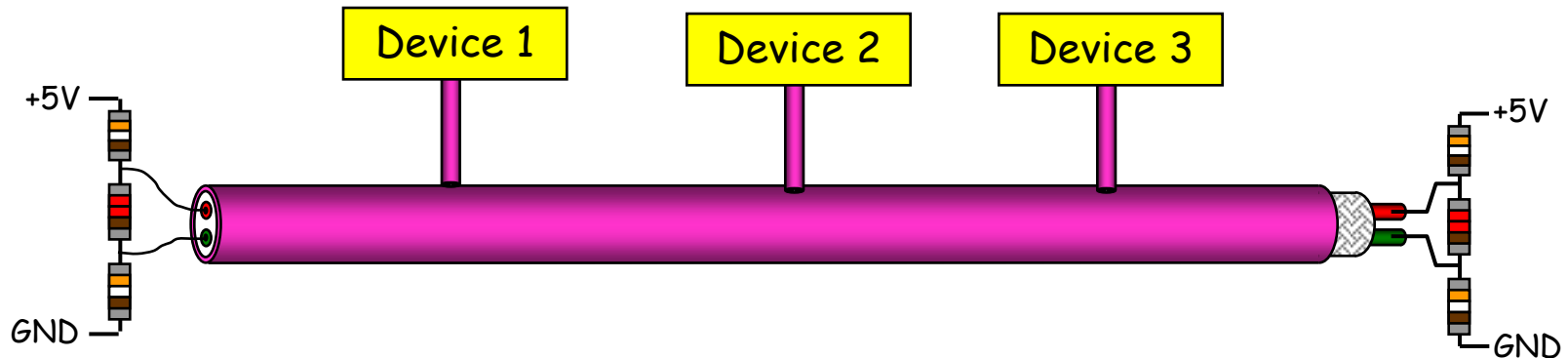


- ⇒ We must use FISCO certified coupler and field devices.
- ⇒ We must not use more than 1000m of cable (total) within a segment.
- ⇒ Number of devices in a segment is dependent on the current that the coupler can supply.
- ⇒ Spur lines must not be longer than 60m.

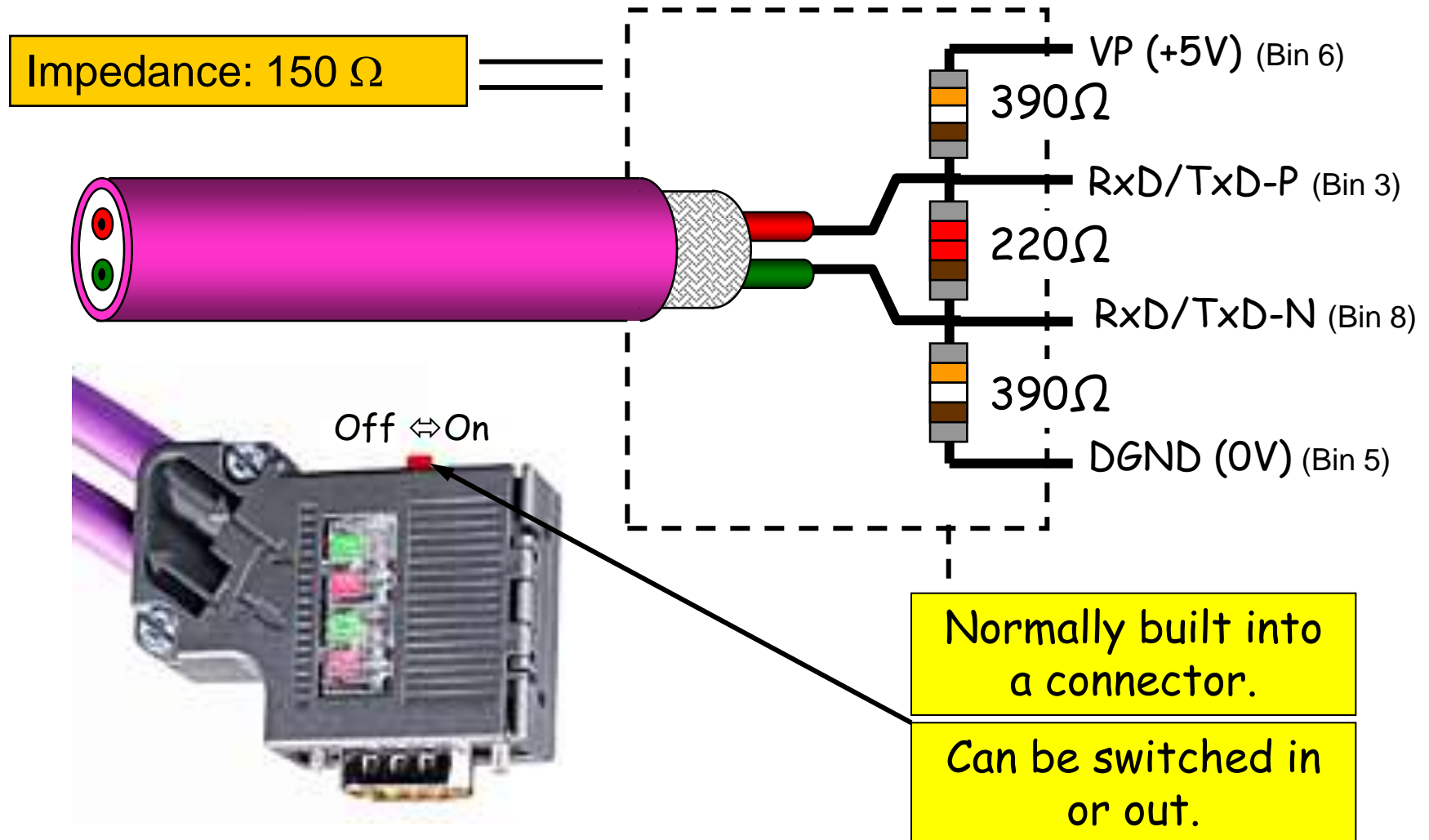
- ⇒ Reflections happen when signals travel down a cable and hit the discontinuity.
- ⇒ Any change in resistance, capacitance or inductance causes discontinuity. In particular, the end of a wire is a major discontinuity where the resistance suddenly increases to infinity and the end becomes open circuit.



⇒ The technique is simple - terminate the two ends of a cable with resistance that matches the cable "characteristic impedance".



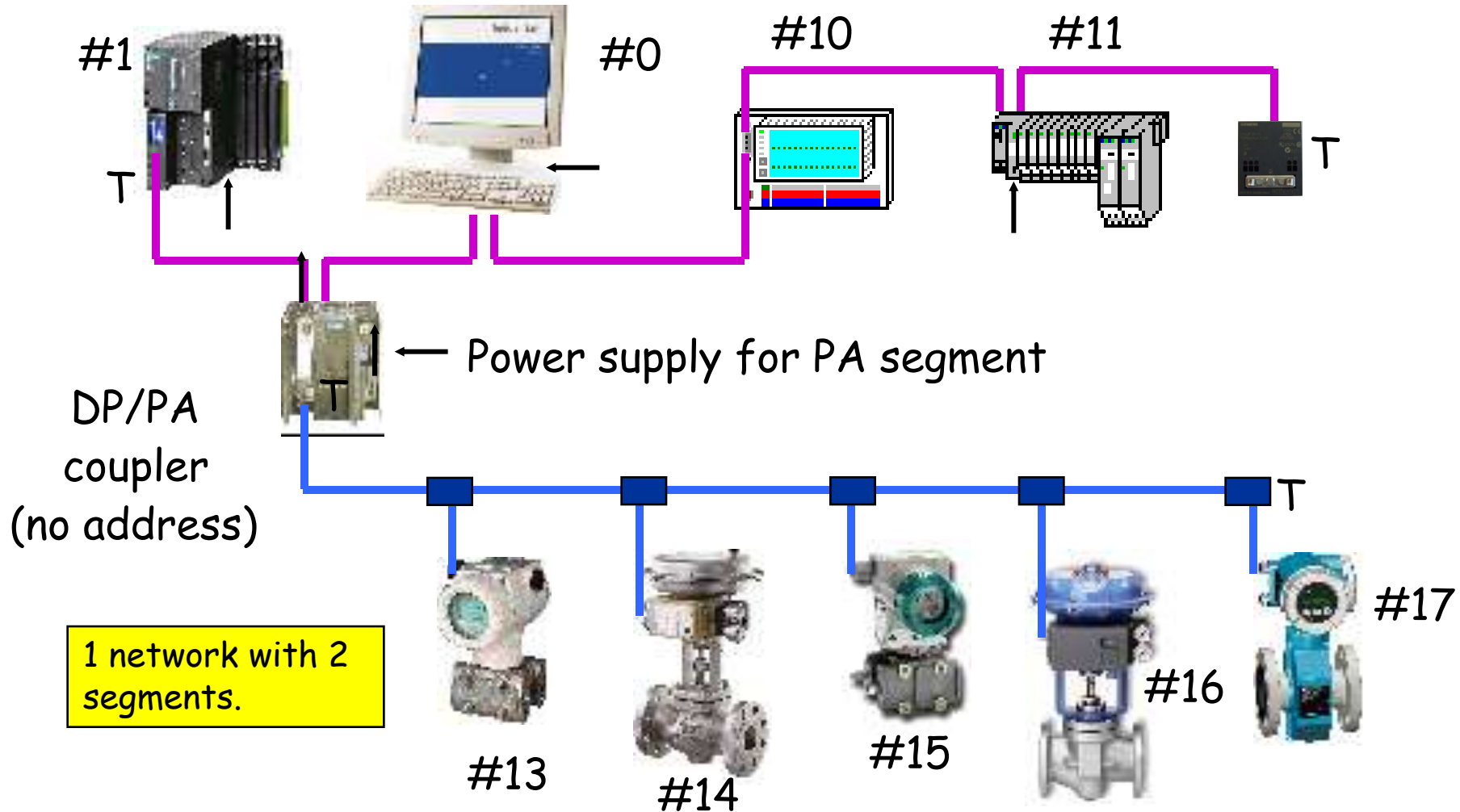
⇒ Termination must be powered to provide the characteristic impedance and it is referred to as "active termination".



- ⇒ Standalone terminator box
- ⇒ Terminator on Repeaters



Termination



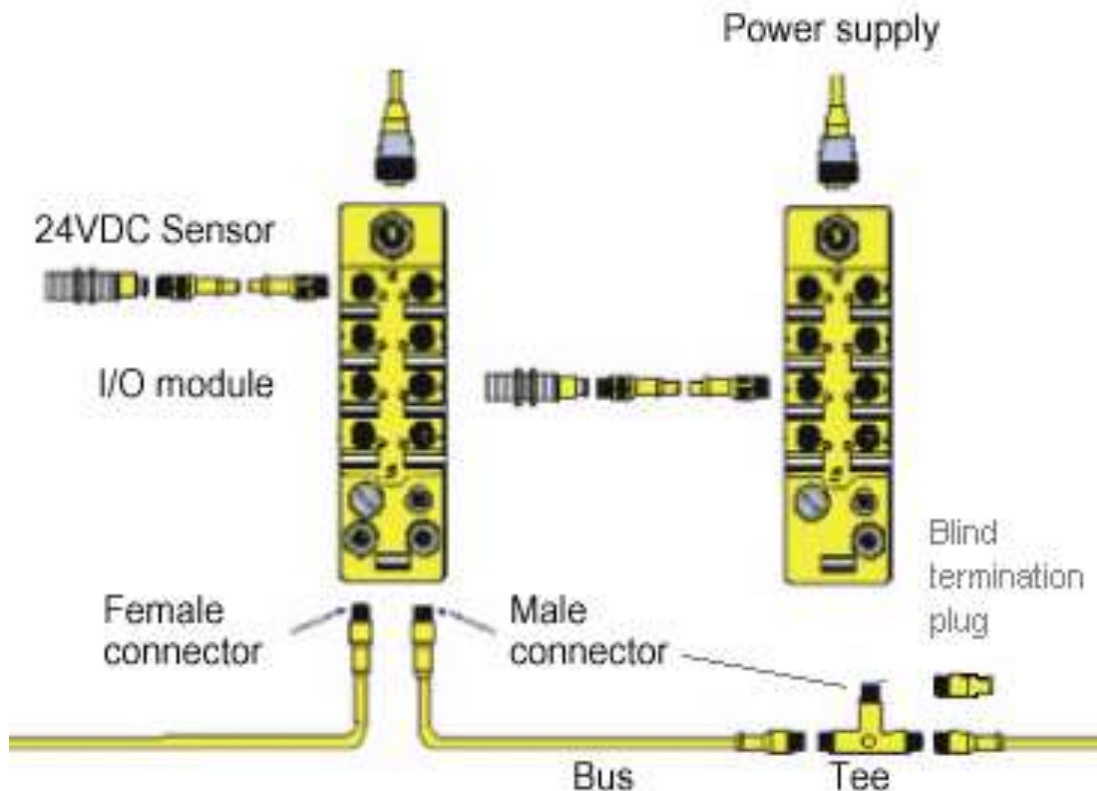


Reflections - Spurs!

Baud rate	Total allowable spur capacitance	Total Spur cable length/segment*
>1.5 Mbit/s	None	None
1.5 Mbit/s	0.2 nF	6.7 m
500 kbit/s	0.6 nF	20 m
187.5 kbit/s	1.0 nF	33 m
93.75 kbit/s	3.0 nF	100 m
19.2 kbit/s	15 nF	500 m

* Calculated for PROFIBUS cable type A at 30pF/m

M12 connector systems

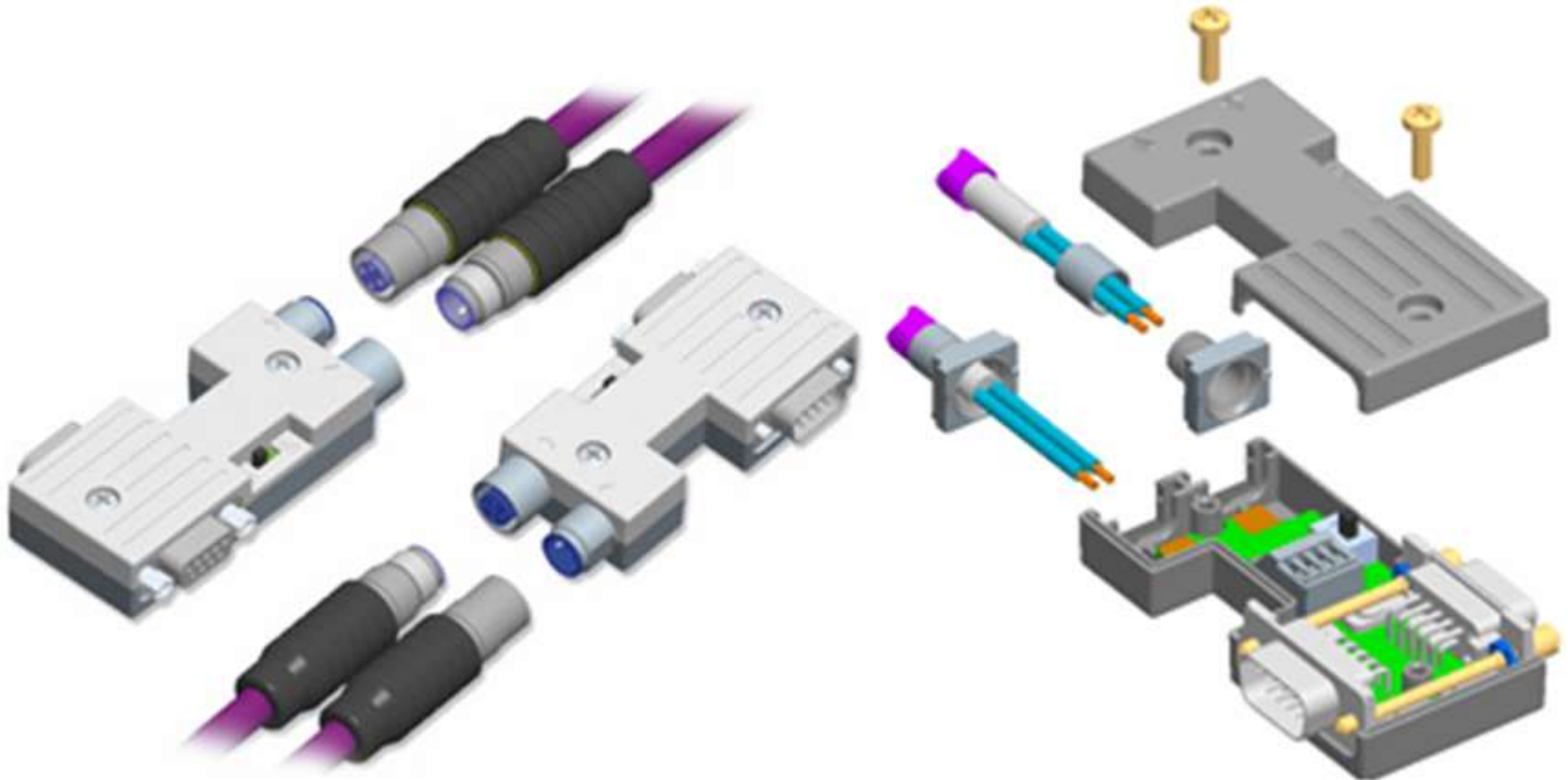


- Devices often have two sockets for incoming and outgoing PROFIBUS cables - **difficult to remove device** without disrupting the bus.
- Special Tee connectors which can be used to connect to devices via a short spur line (one connection) to overcome this problem.
- But do not use a spur line - plug directly into device.
- Termination can be provided by special blind termination plugs.

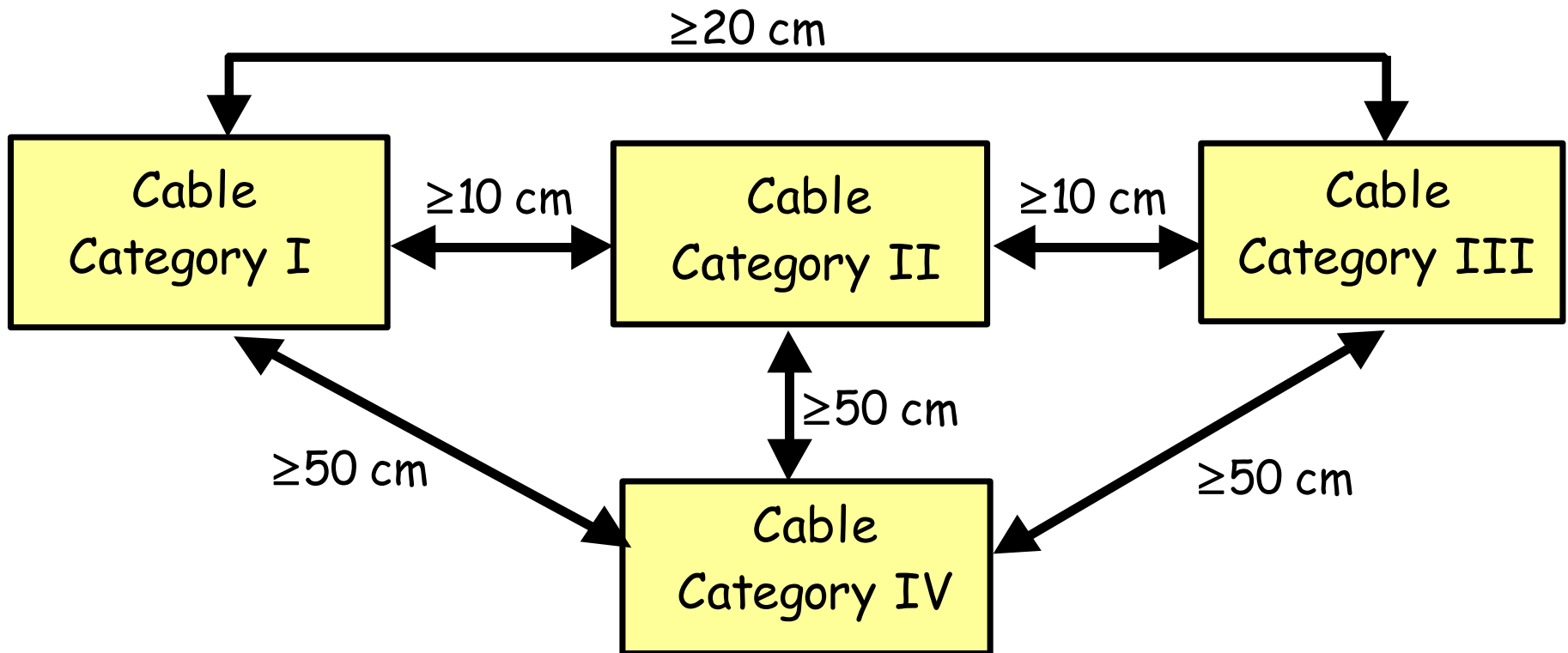
- ⇒ One solution to this problem is to use a short spur line.
- ⇒ However this will cause reflections and we must limit the bus bit rate.



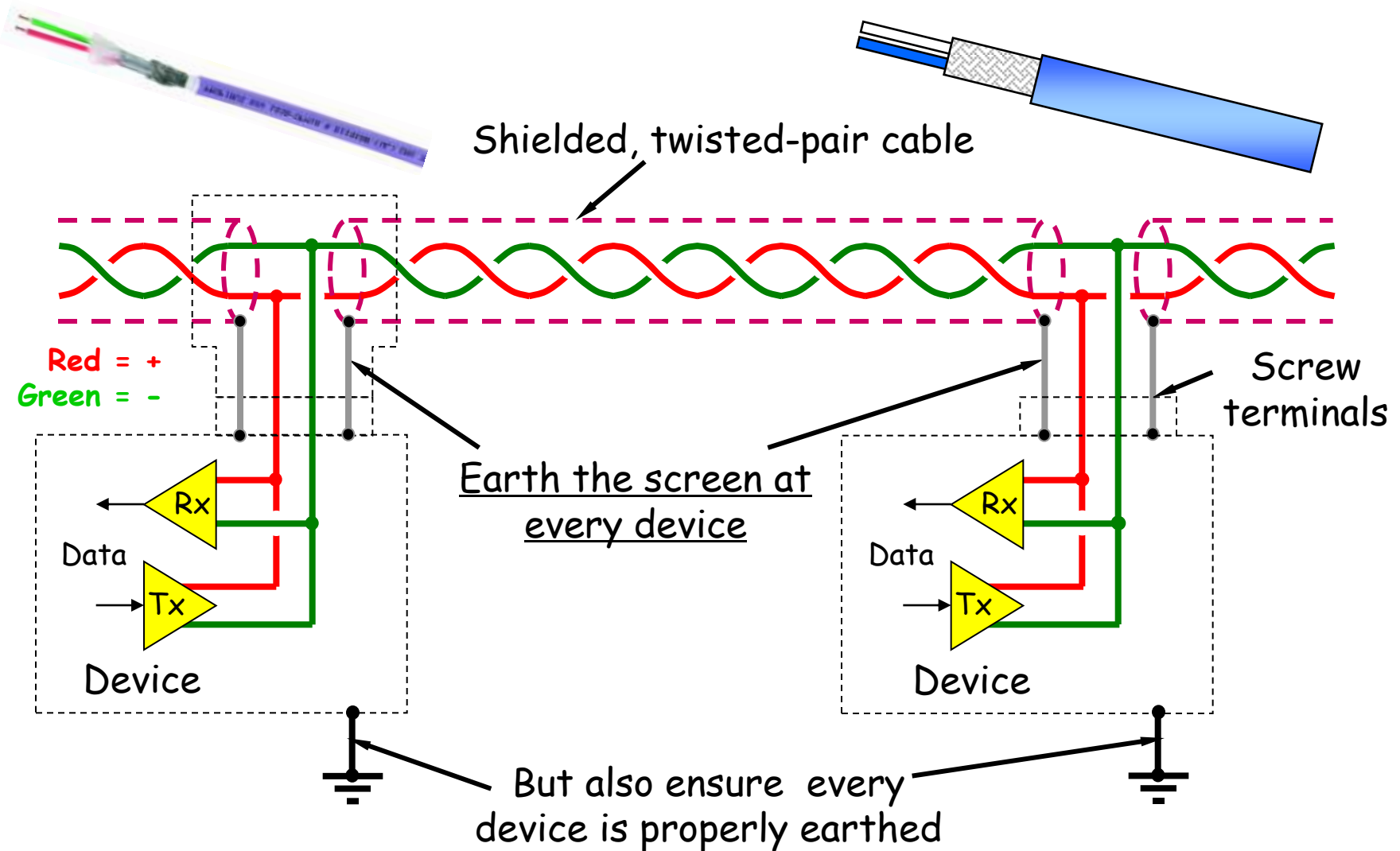
Sub-D and M12 Combined

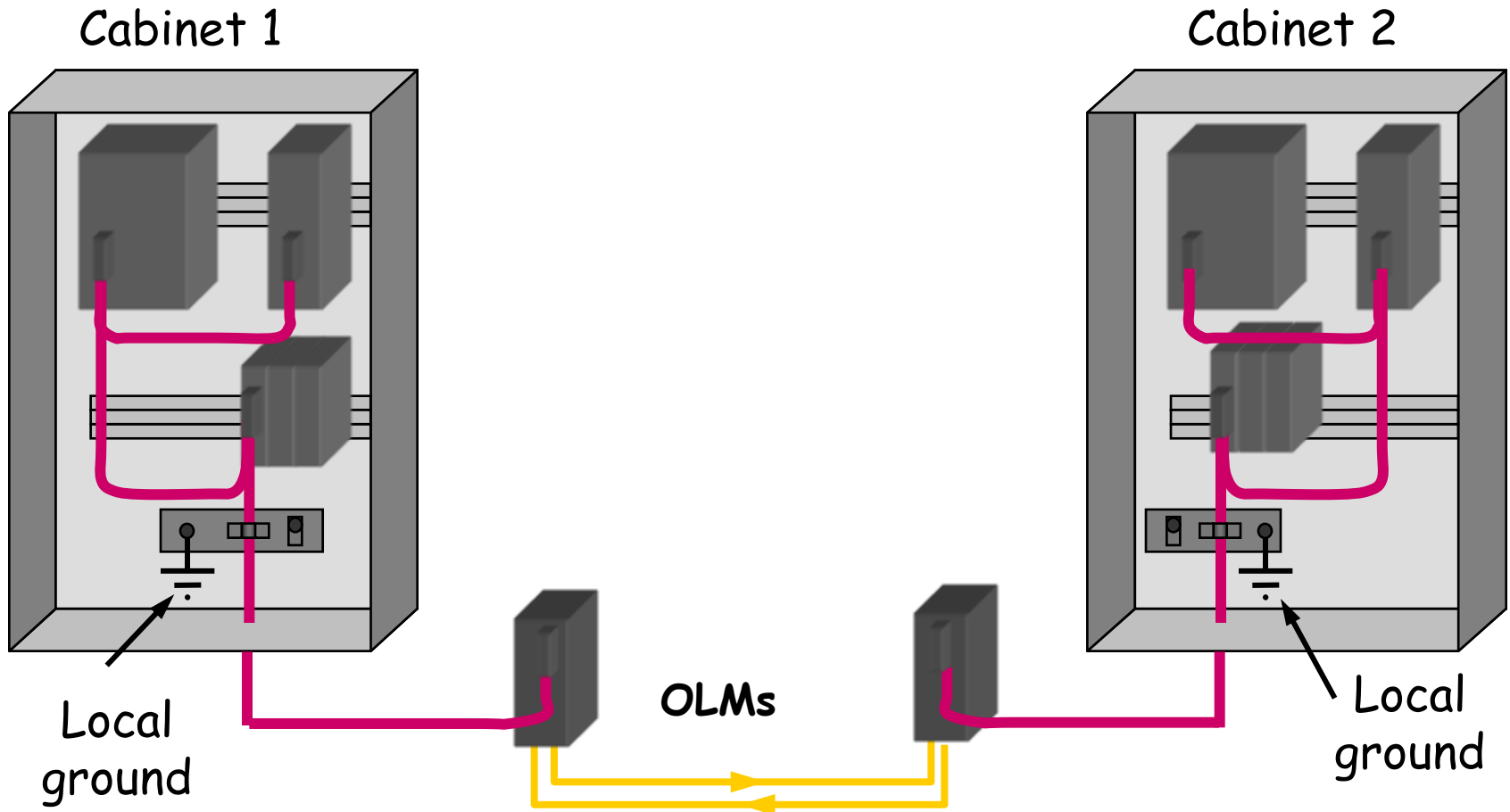


⇒ Recommended cable separation distances:

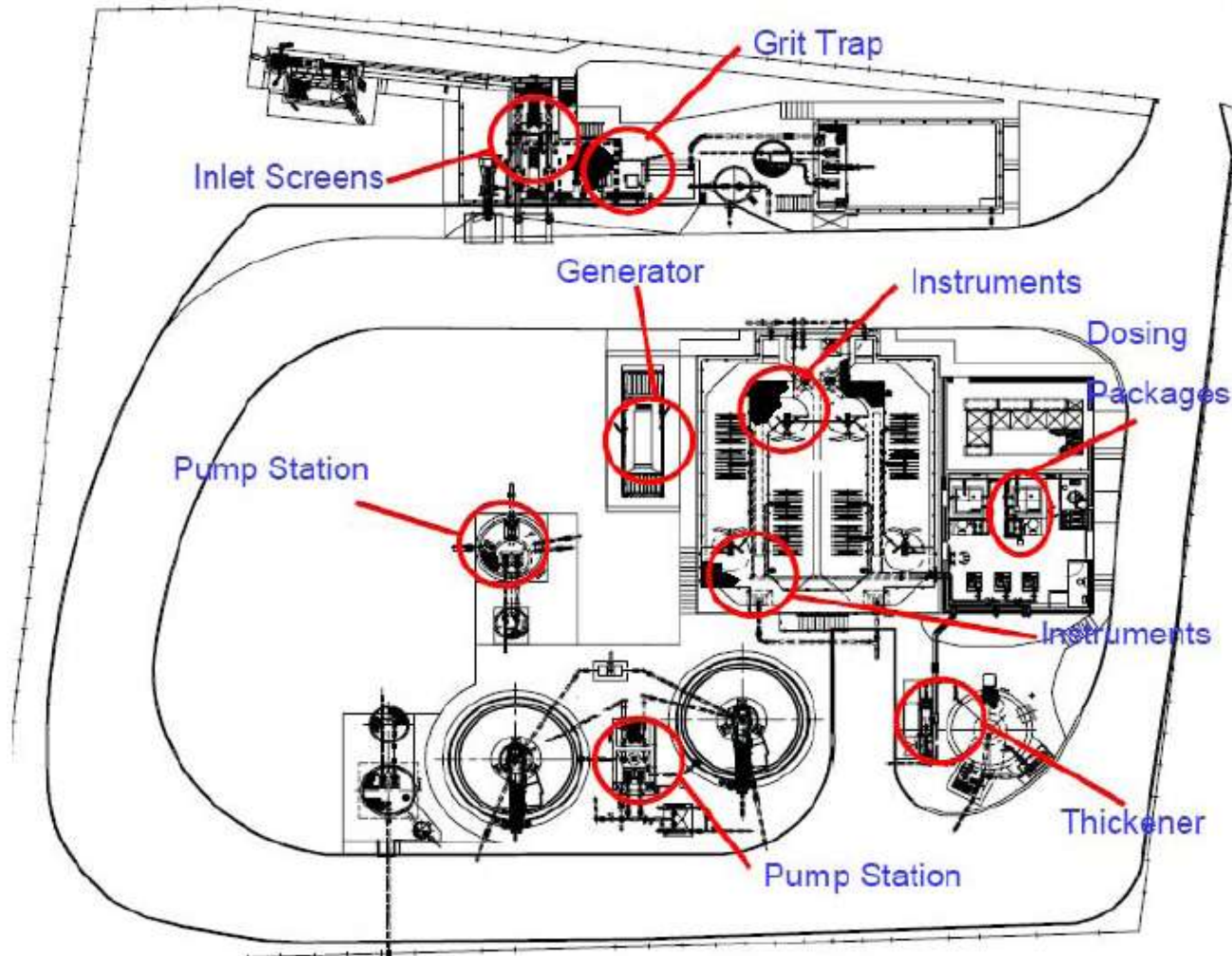


Shielding and Twisting

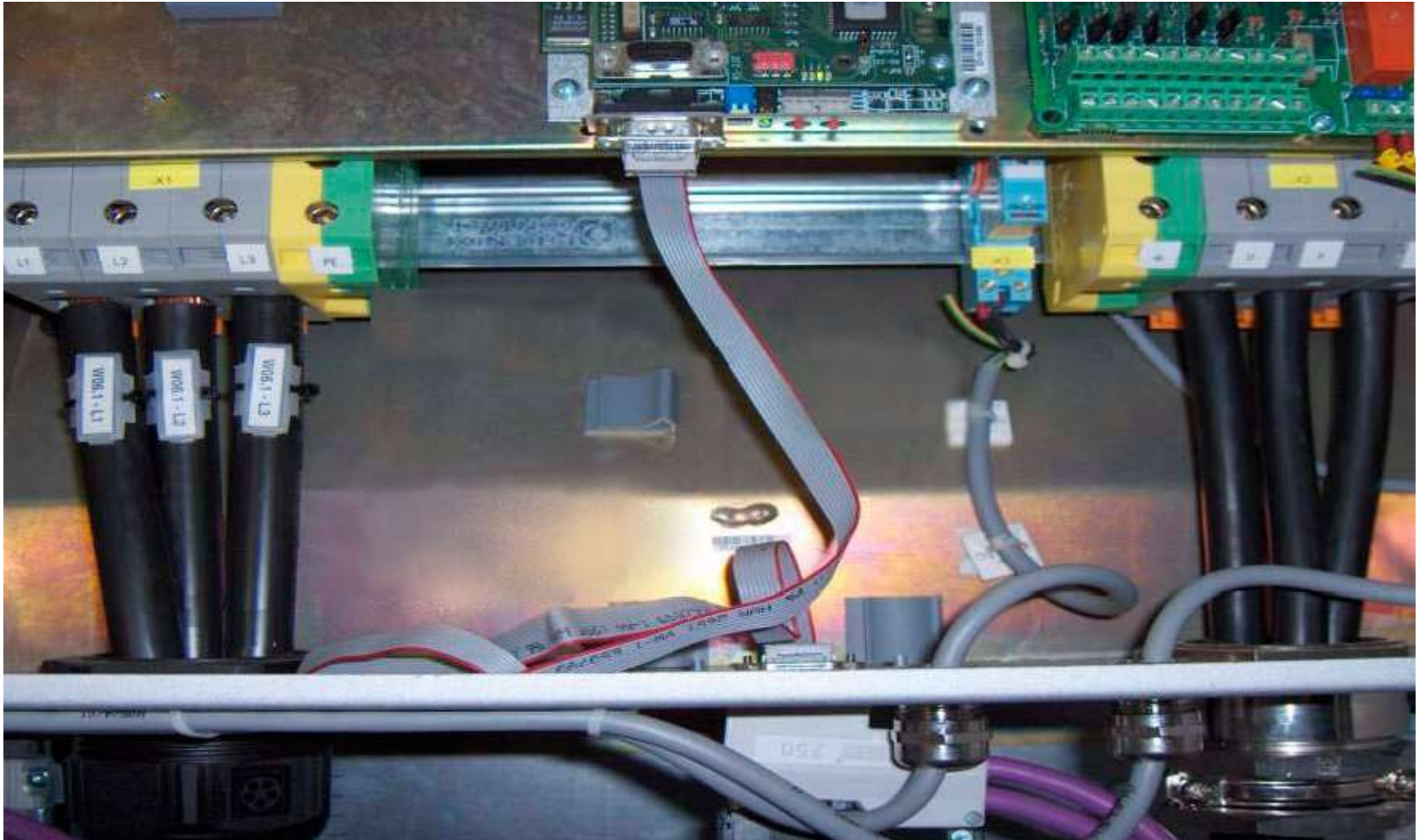




Design - Plant Layout



Space for Connectors?



⇒ Master devices (also called active stations) control the bus and initiate requests.

#1



✓ **Class 1 masters** - e.g. PLCs, controllers, some SCADA stations, etc.

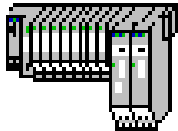
#0



✓ **Class 2 masters** - e.g. engineering tools, certain diagnostic tools, etc.

⇒ **Slave devices** (also called passive stations) respond to Master requests.

#21



✓ e.g. I/O devices, transmitters, sensors, actuators, valves, and drives, etc.



#22



#23

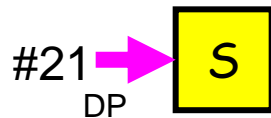
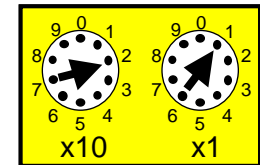
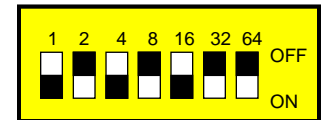


#24

Basics - Addressing

- ⇒ Within a network, every PROFIBUS device or station is given an *address* through which communication is directed.
- ⇒ The address must not overlap. Every station must have a unique address.
- ⇒ Station addresses can be set in several ways:

- A local switch on the device (binary dip switch or rotary switch).



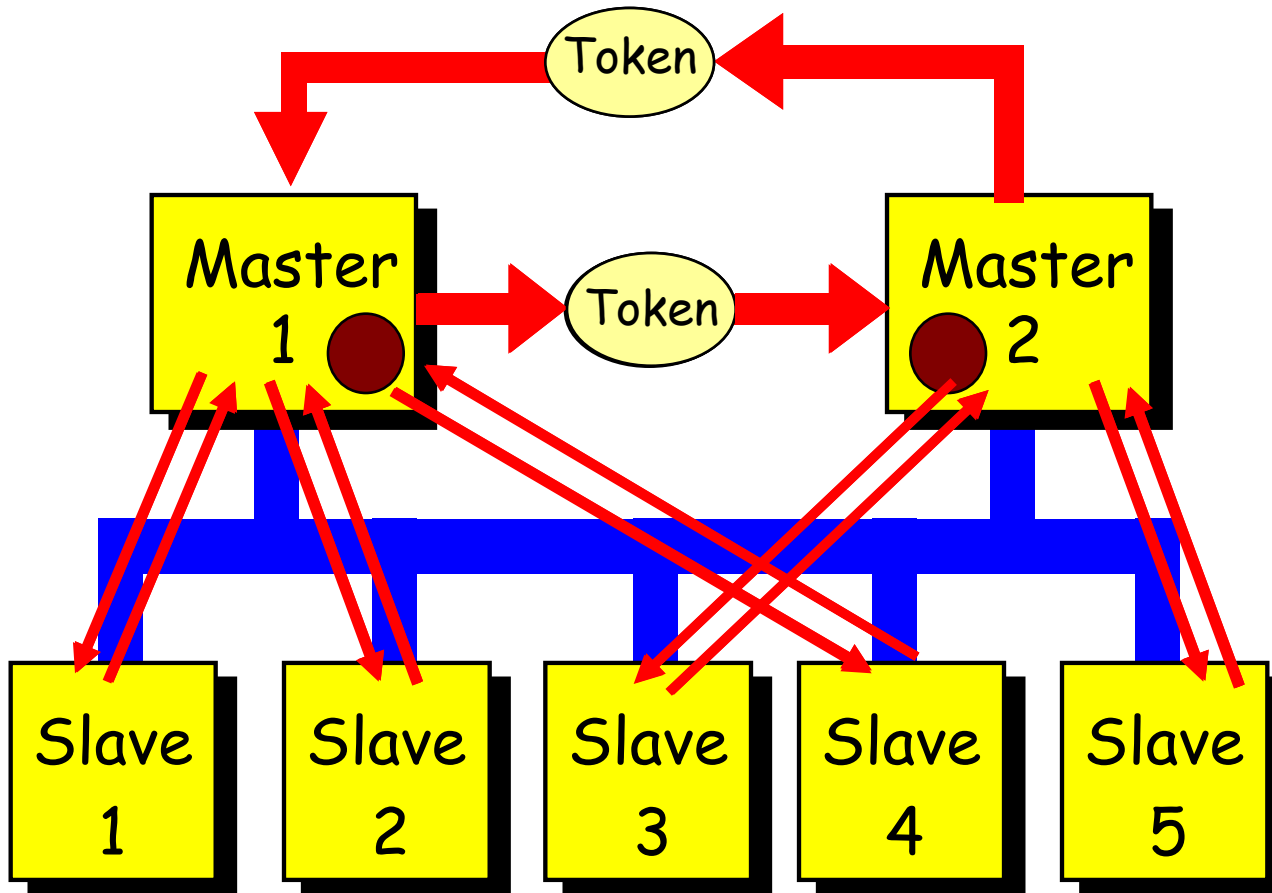
- Software setting of device address over the PROFIBUS network using a configuration tool (called a *class 2 master*, change from #126 to #21).

- Finally, some devices may use special software and a serial link or hand-held tool to set the device address (e.g. some PLCs, drives or HMI devices).



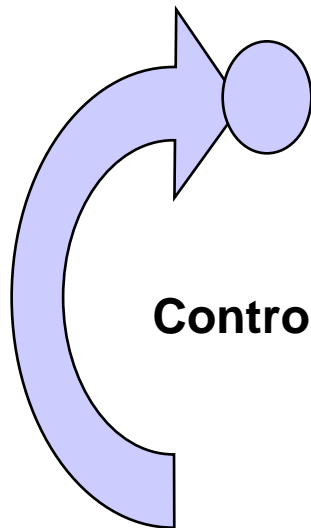
- ⇒ Every PROFIBUS device must have a GSD file (General Station Description).
- ⇒ A GSD file contains a unique *Identification Number*, which defines a type of device and issued by PI.
- ⇒ The ID is expressed as a four digit hexadecimal number using the digits 0 to 9 and A to F. (e.g. 802D).
- ⇒ The GSD is a text file and filename is in the format of manufacturer's short name and the hex. ID number, e.g. SIEM802D and WAGOD730.
- ⇒ If you know the ID or GSD filename, you can search for the GSD file on the Internet and then be able to configure the device.

Token passing and Master-slave communication

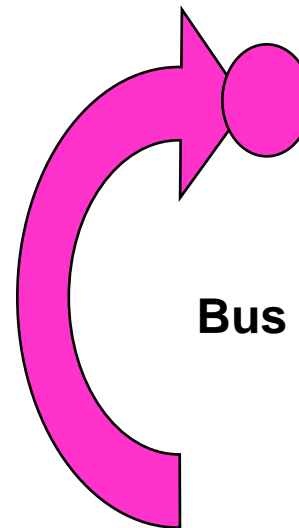


Cyclic operation:
M1 → S1, S1 → M1
M1 → S2, S2 → M1
M1 → S4, S4 → M1
M1 → token → M2
M2 → S3, S3 → M2
M2 → S5, S5 → M2
M2 → token → M1
M1 → S1, S1 → M1
M1 → S2, S2 → M1
etc.

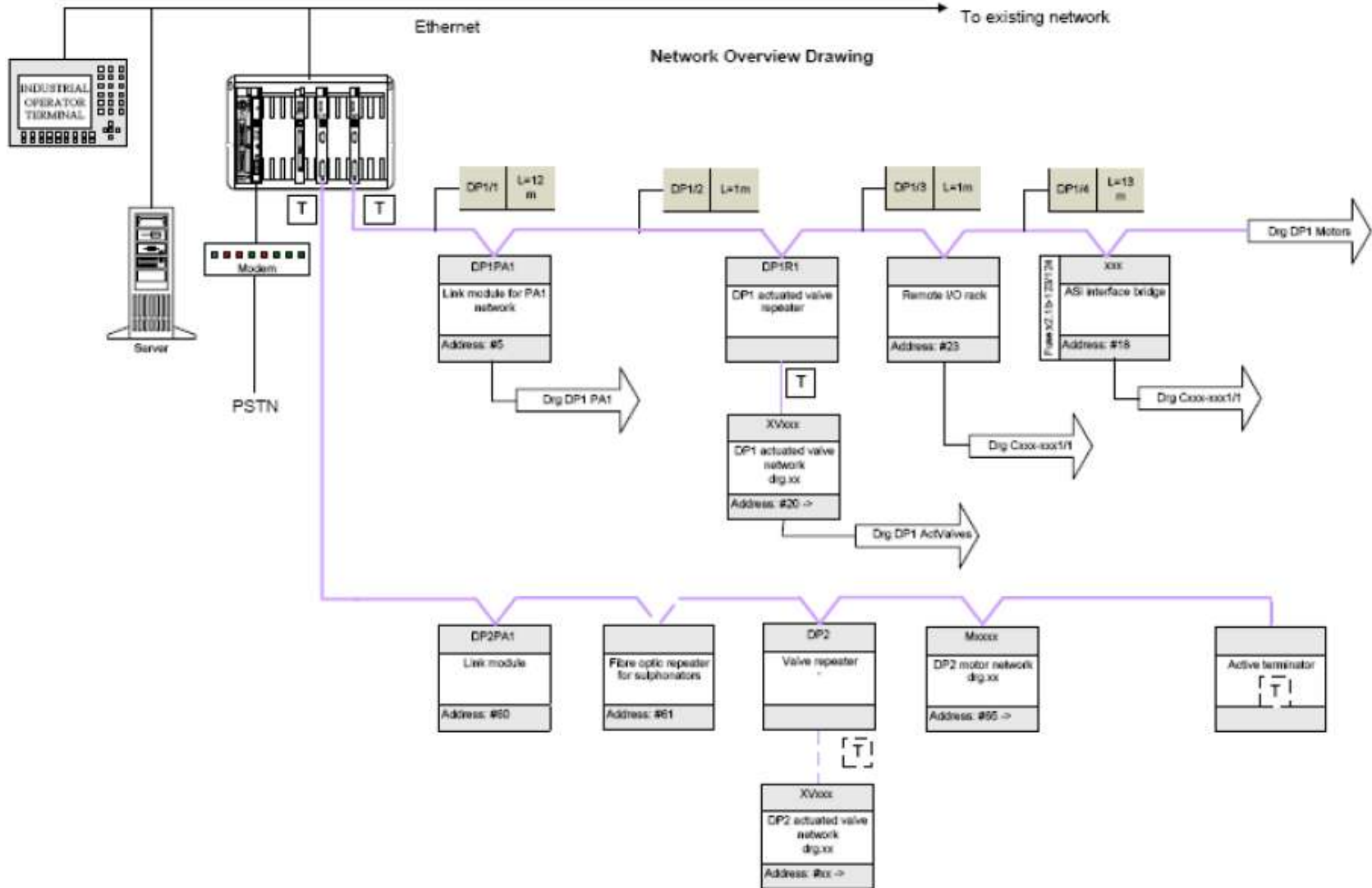
- ⇒ PLC cycle time.
- ⇒ Bus cycle time.



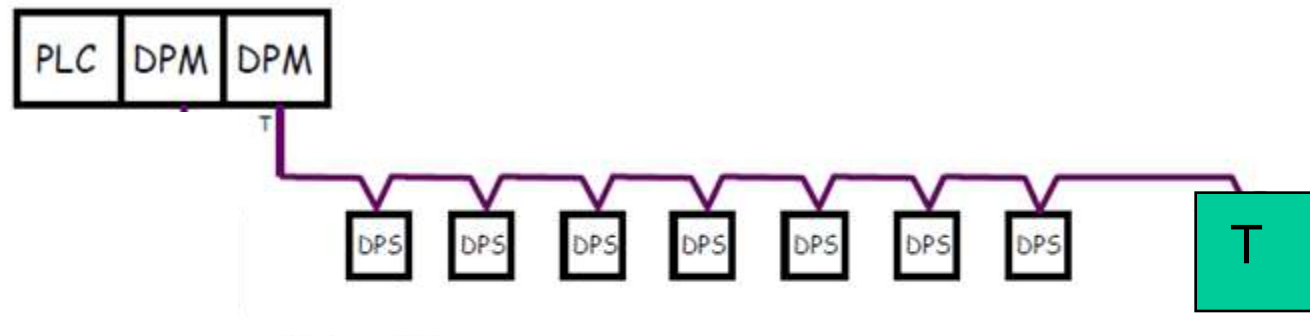
Controller



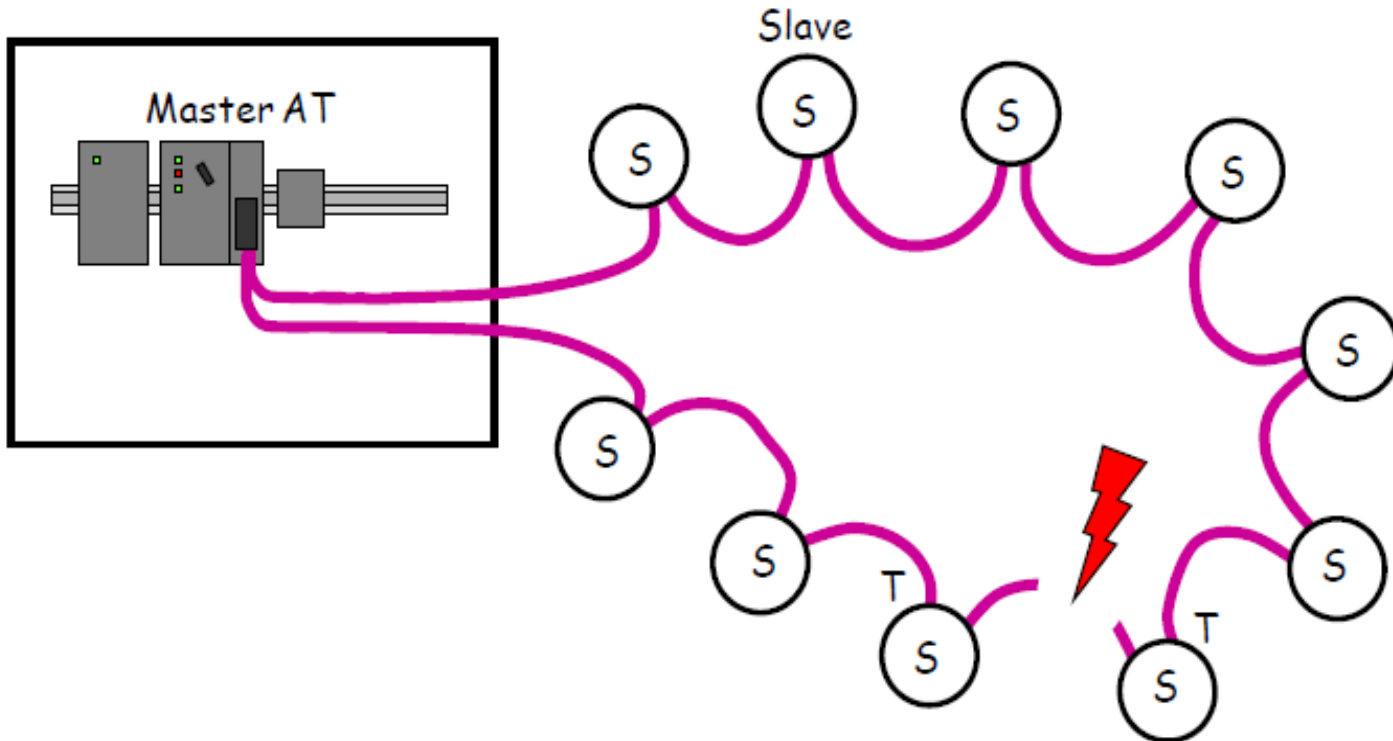
Bus



- ⇒ Multiple DP Master cards to create multiple networks
- ⇒ DP/PA couplers to create PA segments



- ⇒ Should the cable be damaged anywhere in the field, a quick repair can be made using the layout.
- ⇒ Terminating the cable either sides of the damage, and
- ⇒ Connecting the end of the cable from the AT to the master and removing the terminator at the master.



⇒ FA and PA



Car manufacturing, at General Motors, BMW, Ford, FIAT....

■ Manufacturing Automation

- Car manufacturing
- Bottling systems
- Storage systems



Breweries



Waste Water Purification

■ Building Automation

- Traffic automation
- Heating, air-conditioning



Lime Production

■ Process Automation

- Purification plants
- Chemical and petrochemical plants
- Paper and textile plants



Glue Production



Polymer Storage

■ Power Generation and Power Distribution

- Power plants
- Switch Gear



Bottling Plants



Building Automation



Food Production

There are variant solutions to meet different requirements in automation applications.

⇒ **PROFIBUS DP - Decentralised Periphery**

- ✓ General factory automation
- ✓ Low cost, fast speed, replacement for 0 - 10 V voltage transmission

⇒ **PROFIBUS PA - Process Automation**

- ✓ Designed for replacement of 4 - 20 mA transmission
- ✓ Carries power over the cable, also applied in Ex areas

⇒ **PROFIsafe - for functional safety**

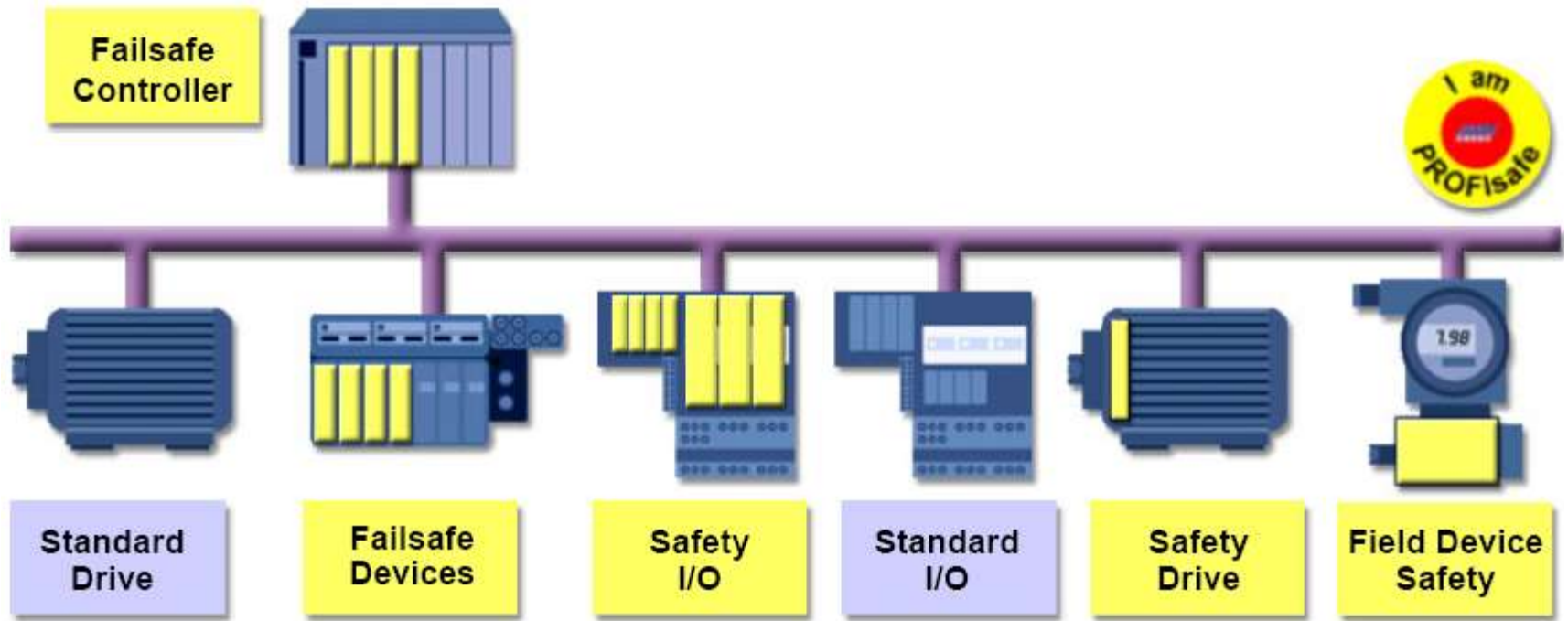
- ✓ Safeguarding, interlocking, emergency stopping, SIL 3
- ✓ When used in drives, provides significant benefits through controlled stop functions compared to switch off power

⇒ **PROFIdrive - for motion controls**

- ✓ High speed, synchronised drive & motion controls

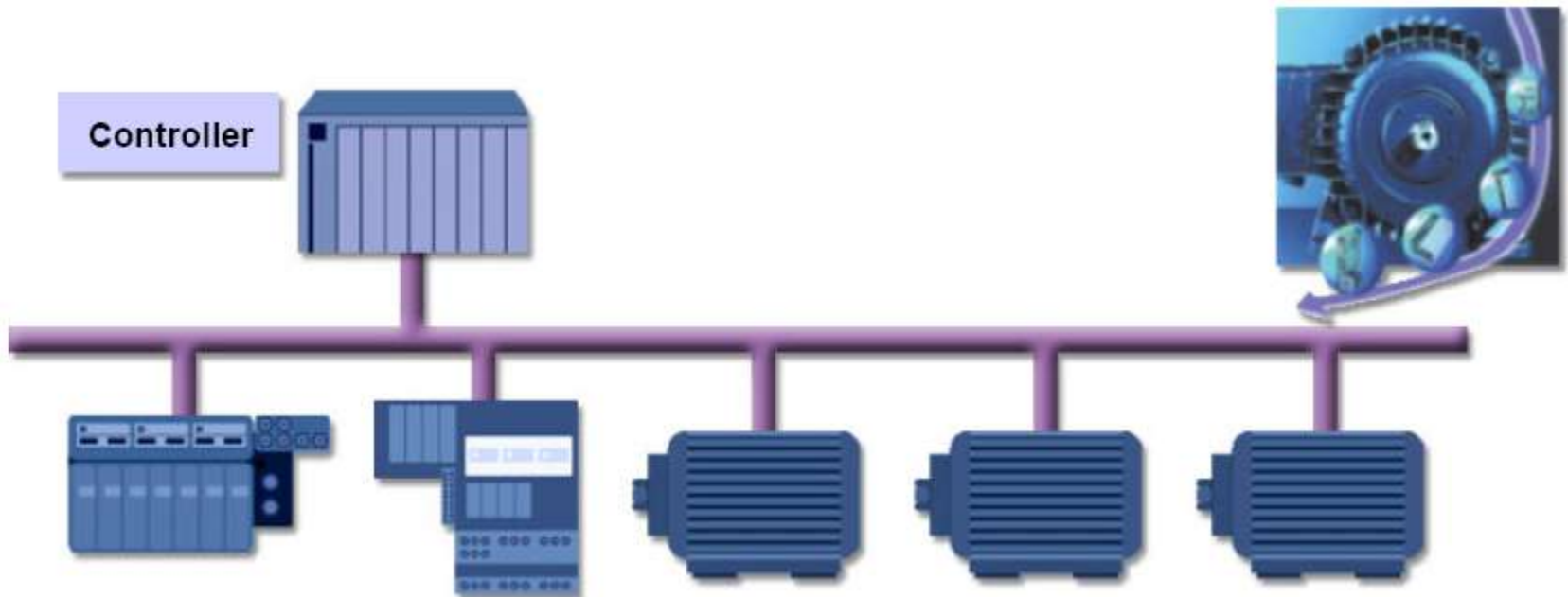
One controller for all devices

- ⇒ Standard Protocol and failsafe functions over a single cable.
- ⇒ Cost cutting - no need for special bus; only one engineering environment.



One controller for all devices

- ⇒ Standard Protocol and Drive Profile over a single cable.
- ⇒ Exact synchronization of different drives.



- ⇒ DP devices or PA devices?
- ⇒ Safety systems?
- ⇒ High speed drives and synchronised motions?
- ⇒ PROFIBUS Versions, DP-V0, DP-V1, or DP-V2?
- ⇒ Latest Profile versions
 - ✓ PA Profile 3.02
 - ✓ PROFIsafe Profile 2.4
 - ✓ PROFIdrive Profile 4.1.
- ⇒ Newer versions are backwards compatible with older versions!

- ⇒ For a successful PROFIBUS project:
- ✓ Good design with proper segments and detailed network drawings
 - ✓ Good installation with reflections eliminated and interference reduced to minimum.
- ⇒ To achieve this:
- ✓ Training!

⇒ **Certified PROFIBUS Installer**

- ✓ Installation guidelines, PROFIBUS basics. 8th Nov.

⇒ **PROFIBUS Commissioning and Maintenance**

- ✓ Troubleshooting, bus checking, use of ProfiTrace. 9th Nov.

⇒ **Certified PROFIBUS**

- ✓ Details of PROFIBUS operation
- ✓ 10th – 12th Nov.

⇒ **Certified PROFINET Engineer**

- ✓ Details of PROFINET operation. 12th – 14th Nov.

⇒ **Open PLC programming Course**

- ✓ New! CoDeSys V3.0, 27th – 29th Oct.
- ✓ Basic and certified Open PLC Courses, 22nd – 26th Nov.

⇒ **Ann Squirrell, admin@uk.profibus.com**