PROFIBUS • PROFINET
UNITED KINGDOM

Manchester Metropolitan University

Practical steps for a successful

PROFIBUS Project

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Manchester Metropolitan University

Content

- ⇨ 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

Basics – PROFIBUS DP and PA

⇨PROFIBUS DP - *Decentralised Periphery*

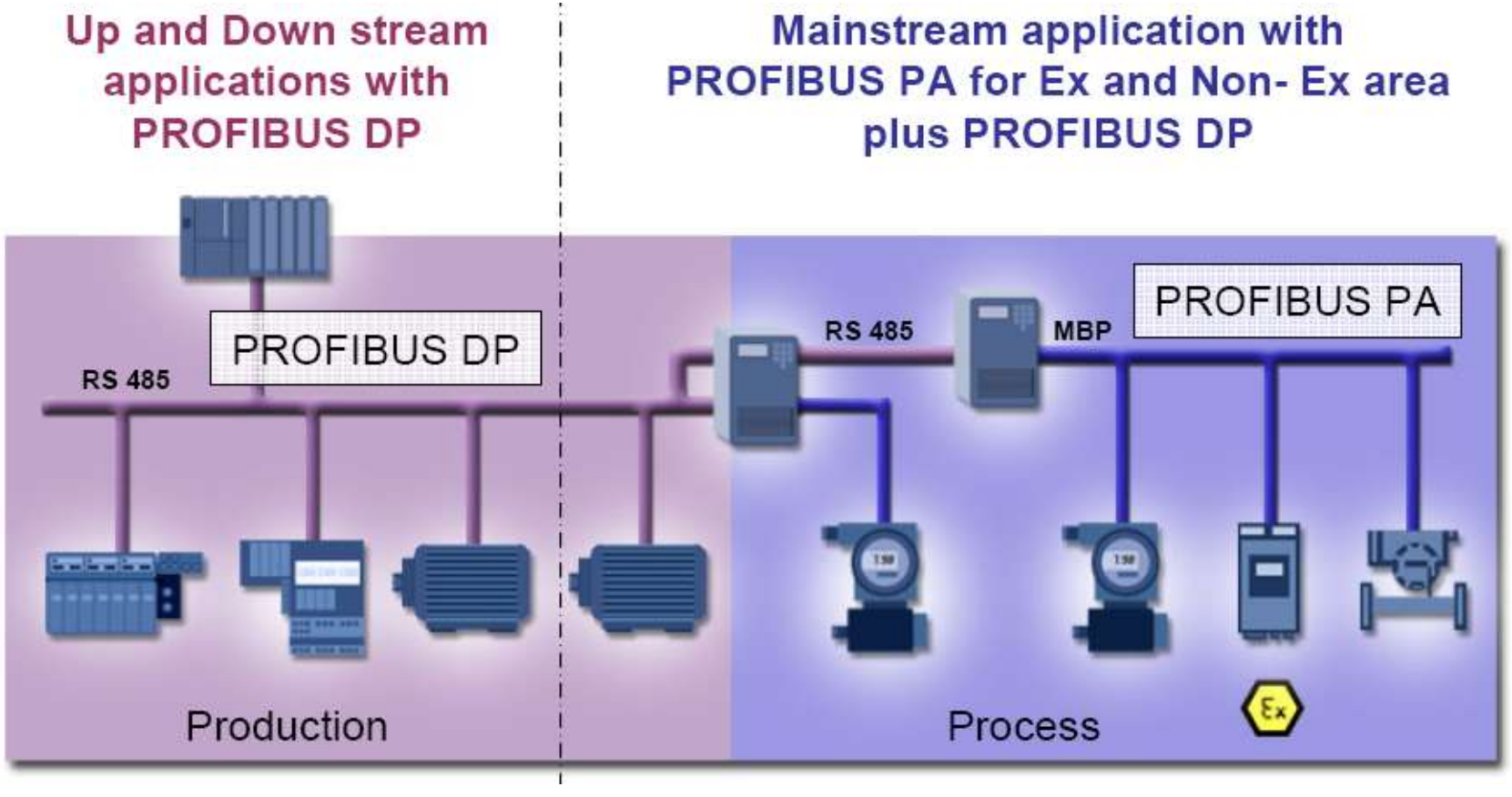
- Replacement for conventional 0- 10 V voltage transmission
- **Uses RS485 transmission**
- High speed, Low cost, very suitable for factory automation. (e.g. Electronics, Automotive, and Metal/Mining industries)
- Versions: DP-V0 (1993), DP-V1 (1997) , and DP-V2 (2002).

⇨*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.

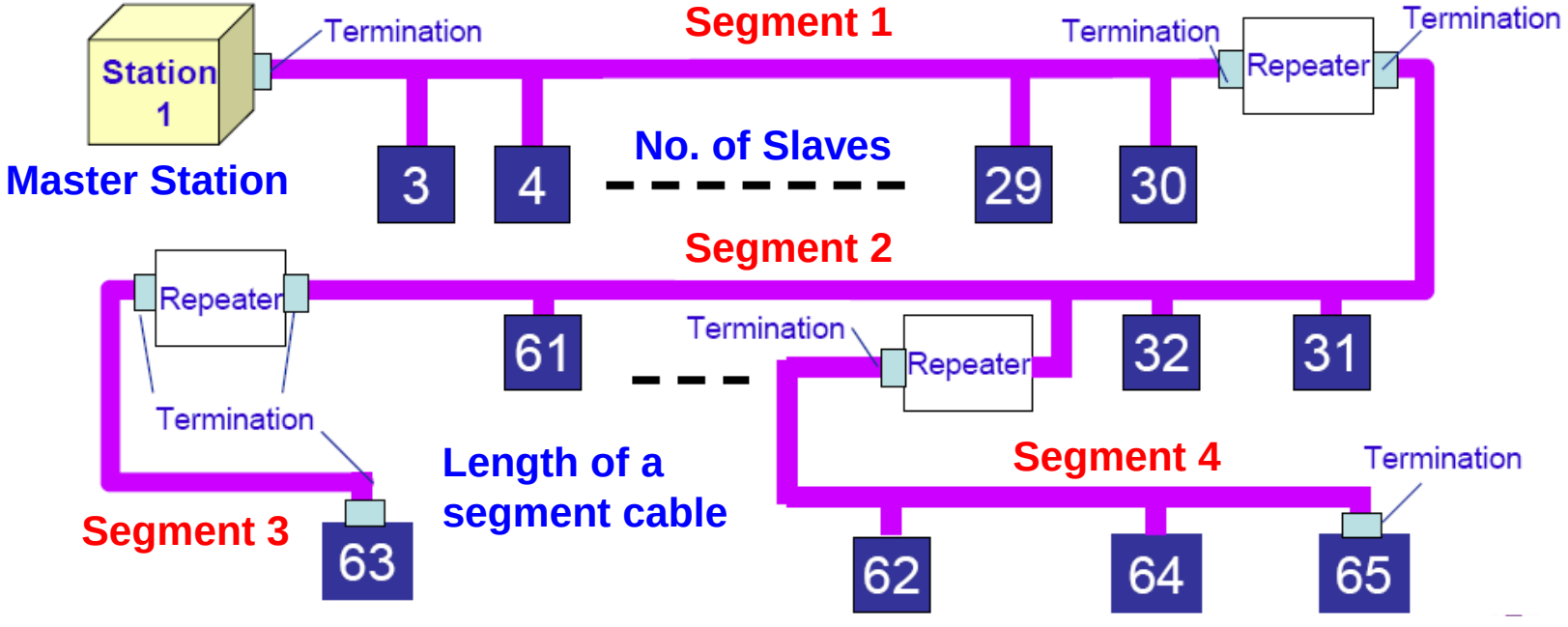
One controller for all devices

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

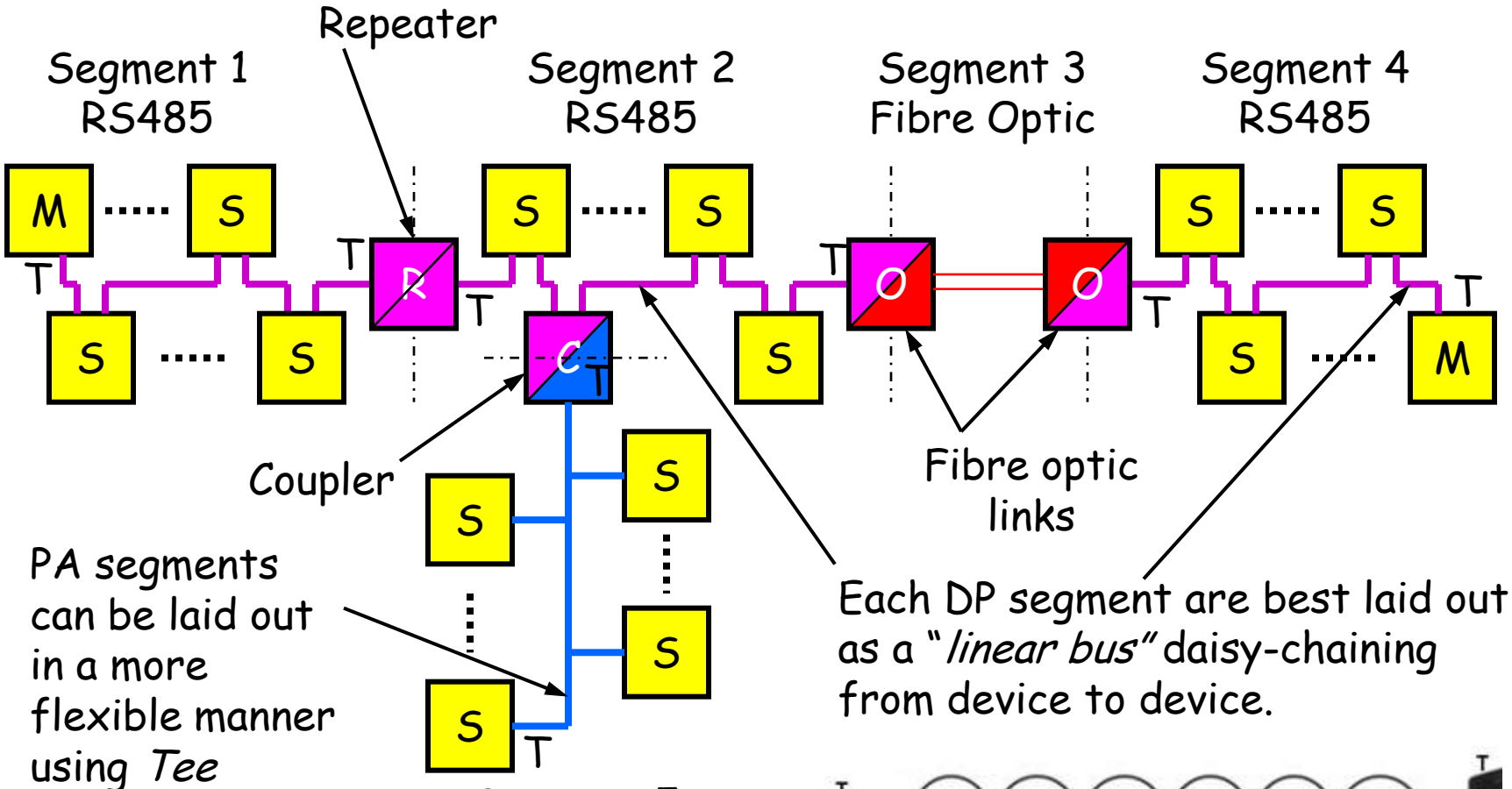


Segmentation

- On a PROFIBUS network.
  - No hubs and no switches
  - Uses Repeater, DP/PA Coupler, and OLM to expend 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	
1.5 Mbit/s	200m	
3.0 Mbit/s	100m	High speed
6.0 Mbit/s	100m	
12.0 Mbit/s	100m	

Basics - Network Speed

- 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

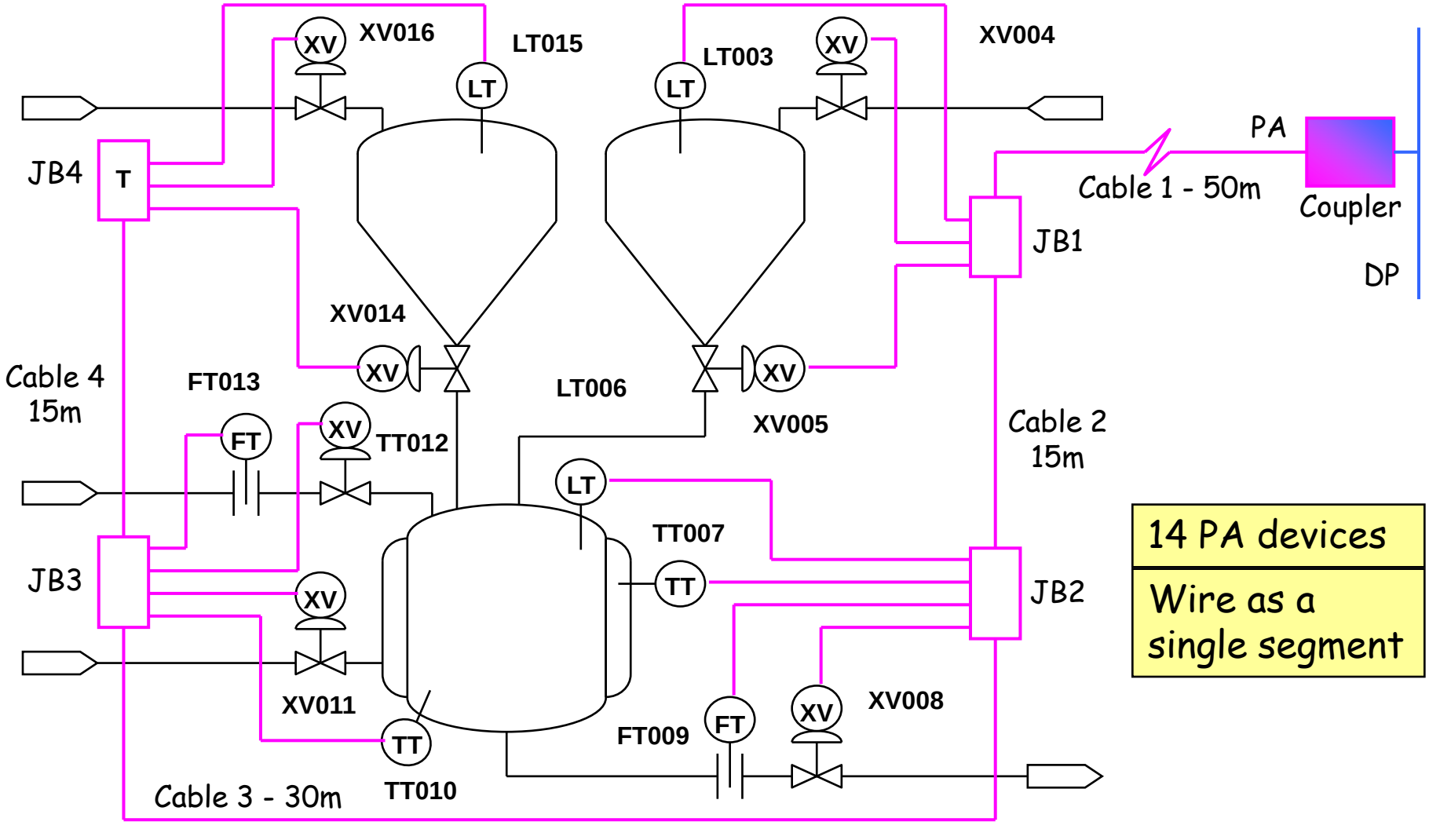
Segmentation - PA

- 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
25 to 32	1 m	1 m
19 to 24	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 x 60 = 1440m 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.

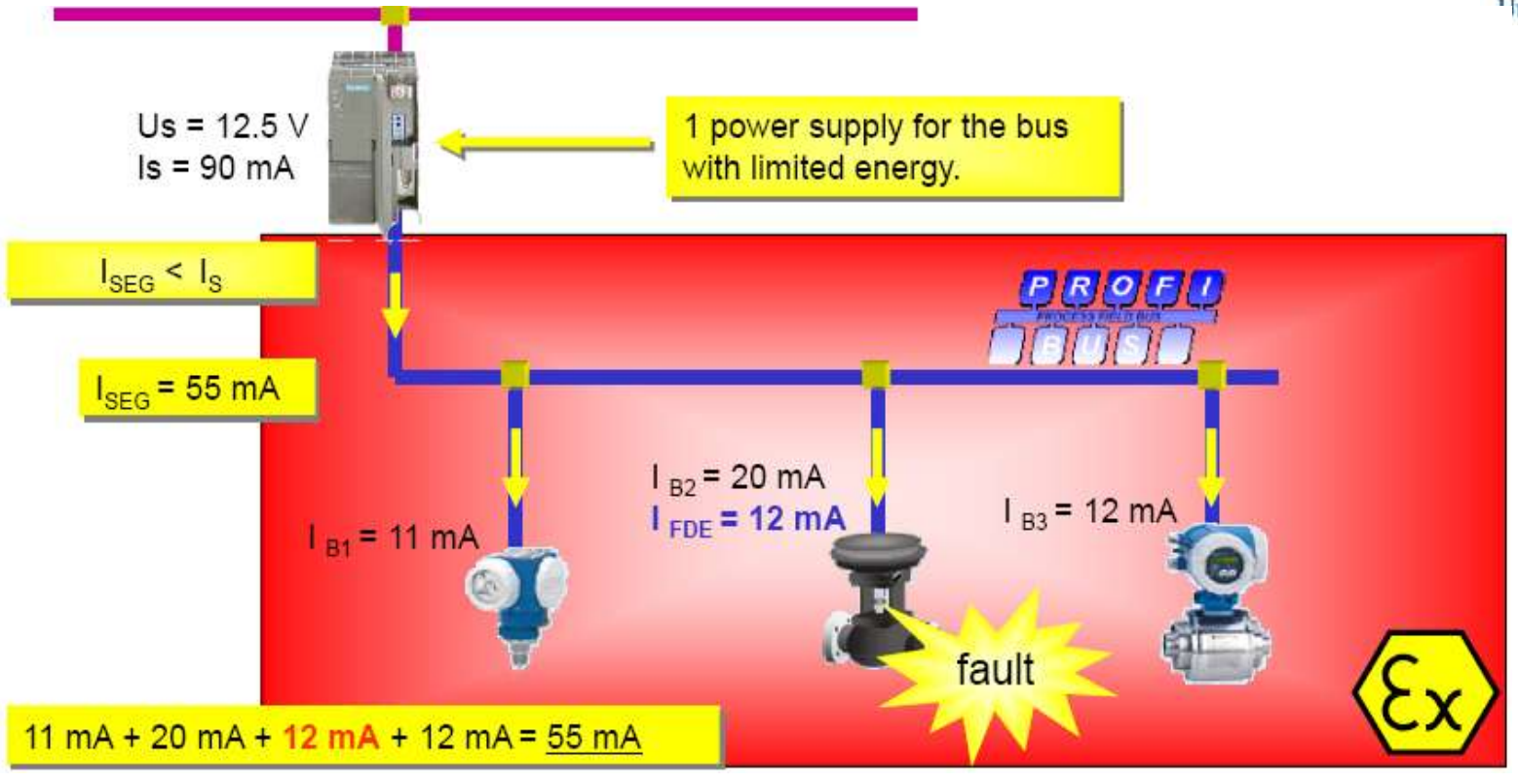
Maximum coupler output = 400 mA

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

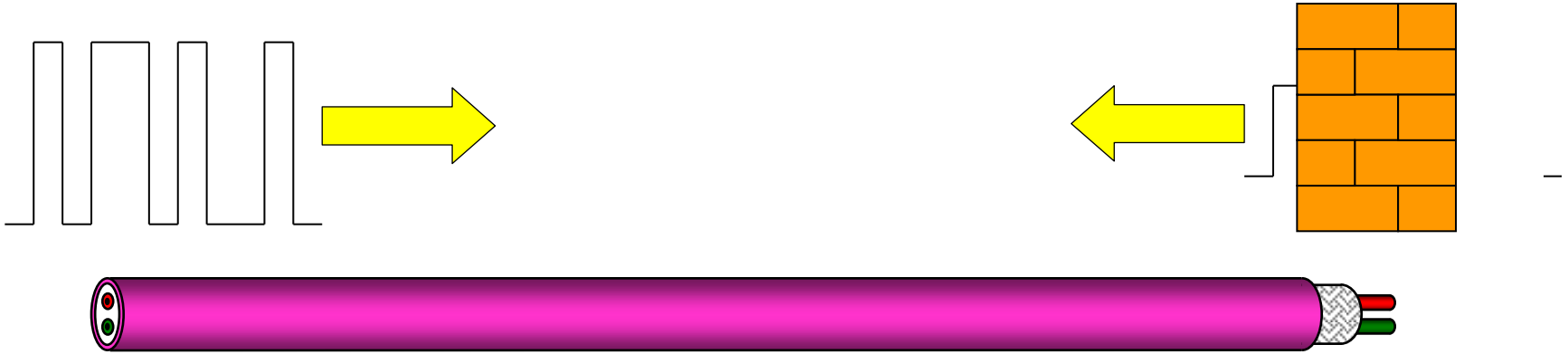
PA Segmentation – Intrinsic Safe



- ⇨ 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.

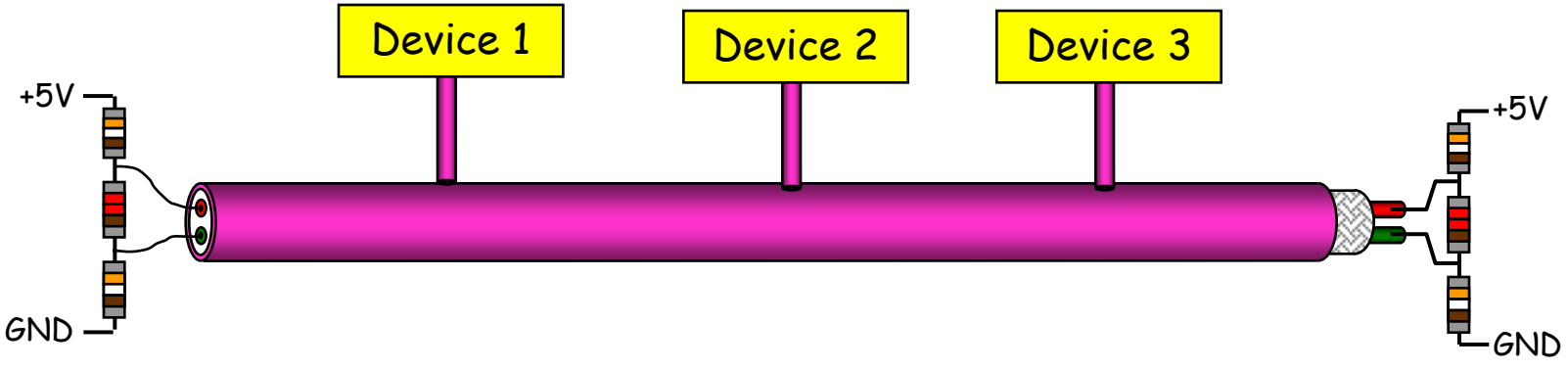
Reflections & Termination

- 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.



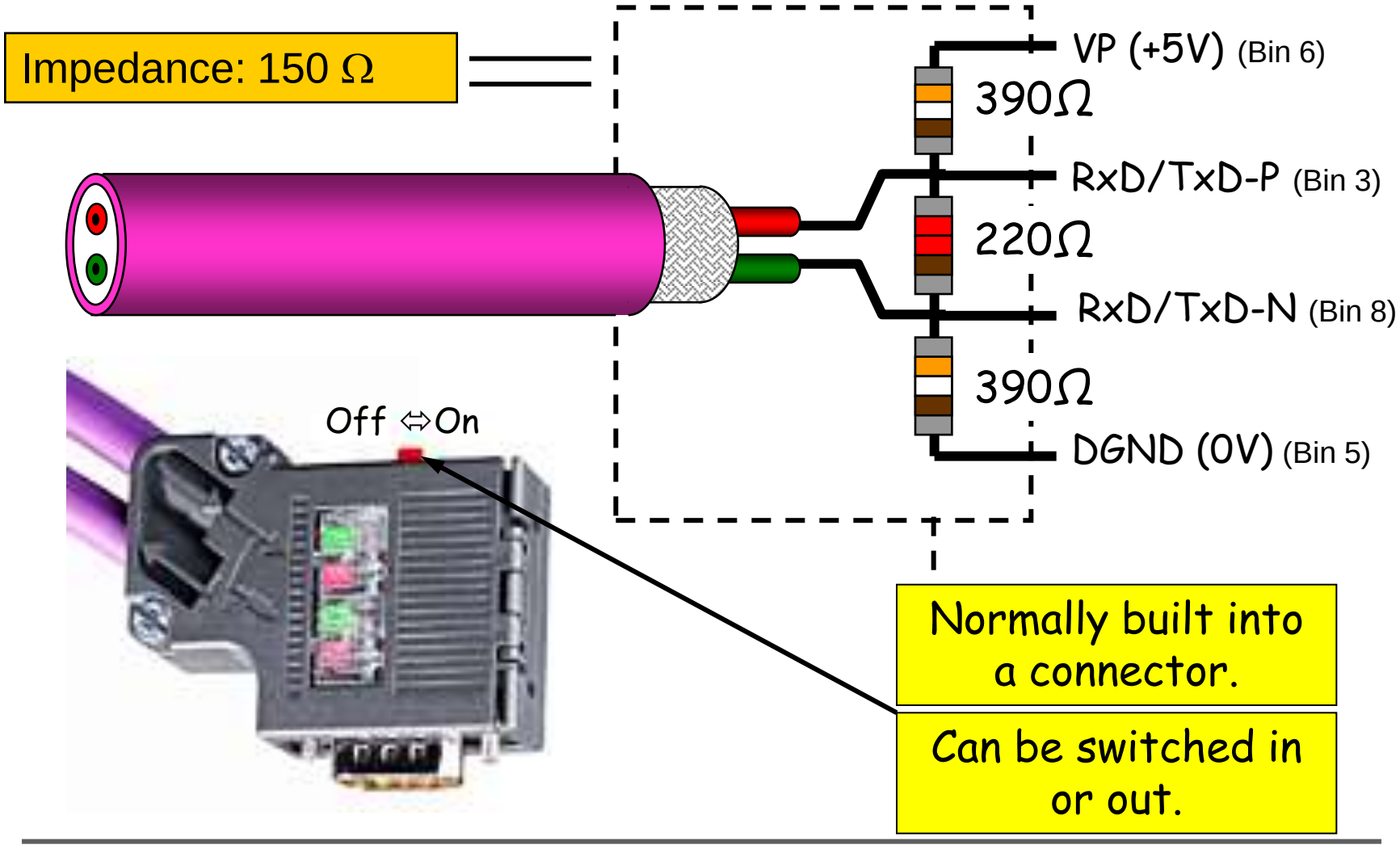
Reflections and Termination

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



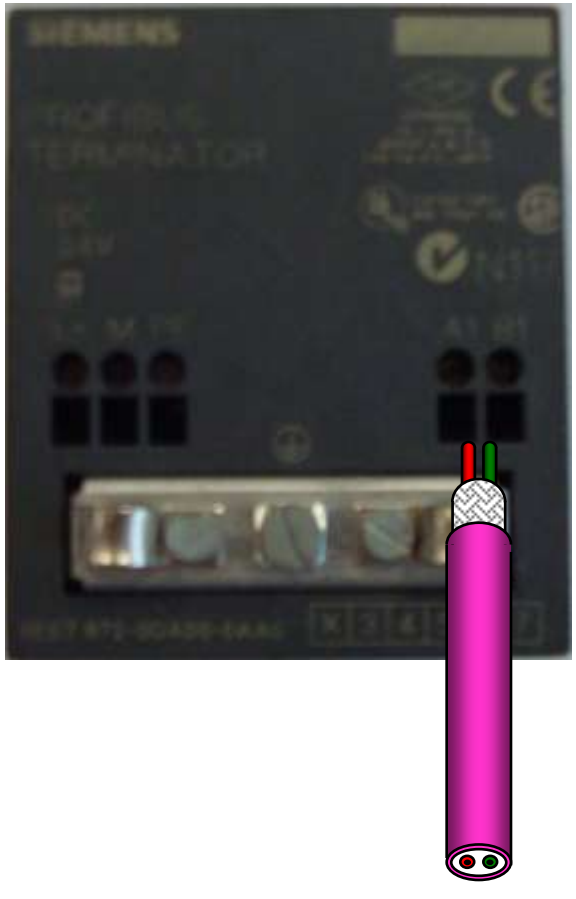
- Termination must be powered to provide the characteristic impedance and it is referred to as "active termination".

Termination

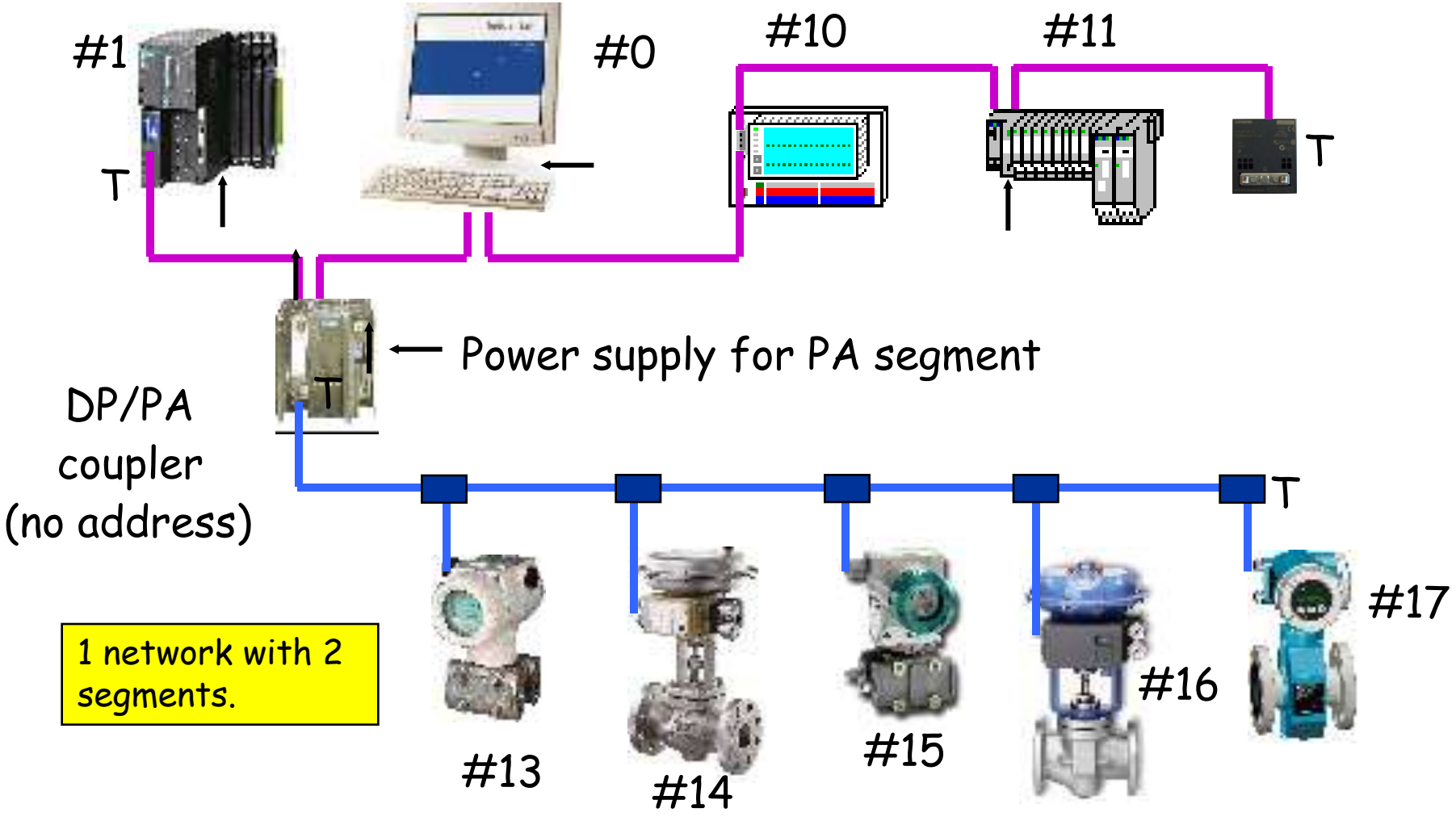


Termination

- ⇨ Standalone terminator box
- ⇨ Terminator on Repeaters



Termination



Reflections – min.1m Rule

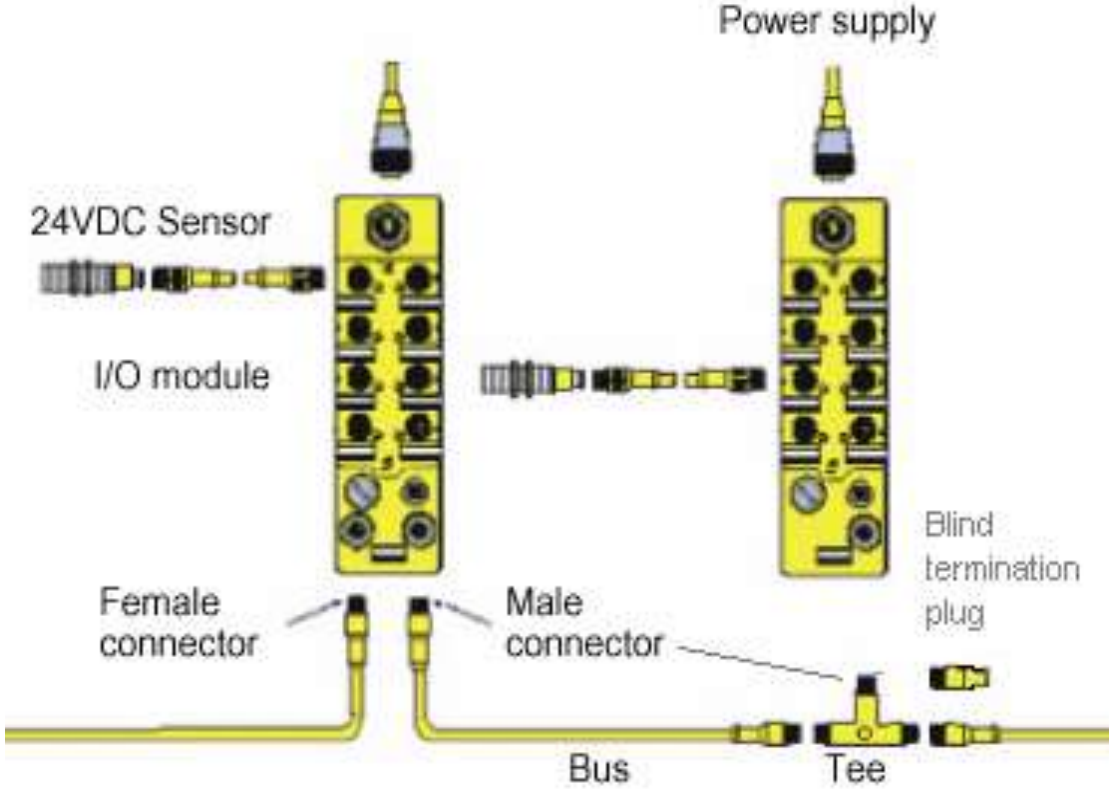
Reflections - Spurs!

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 Connectors

M12 connector systems

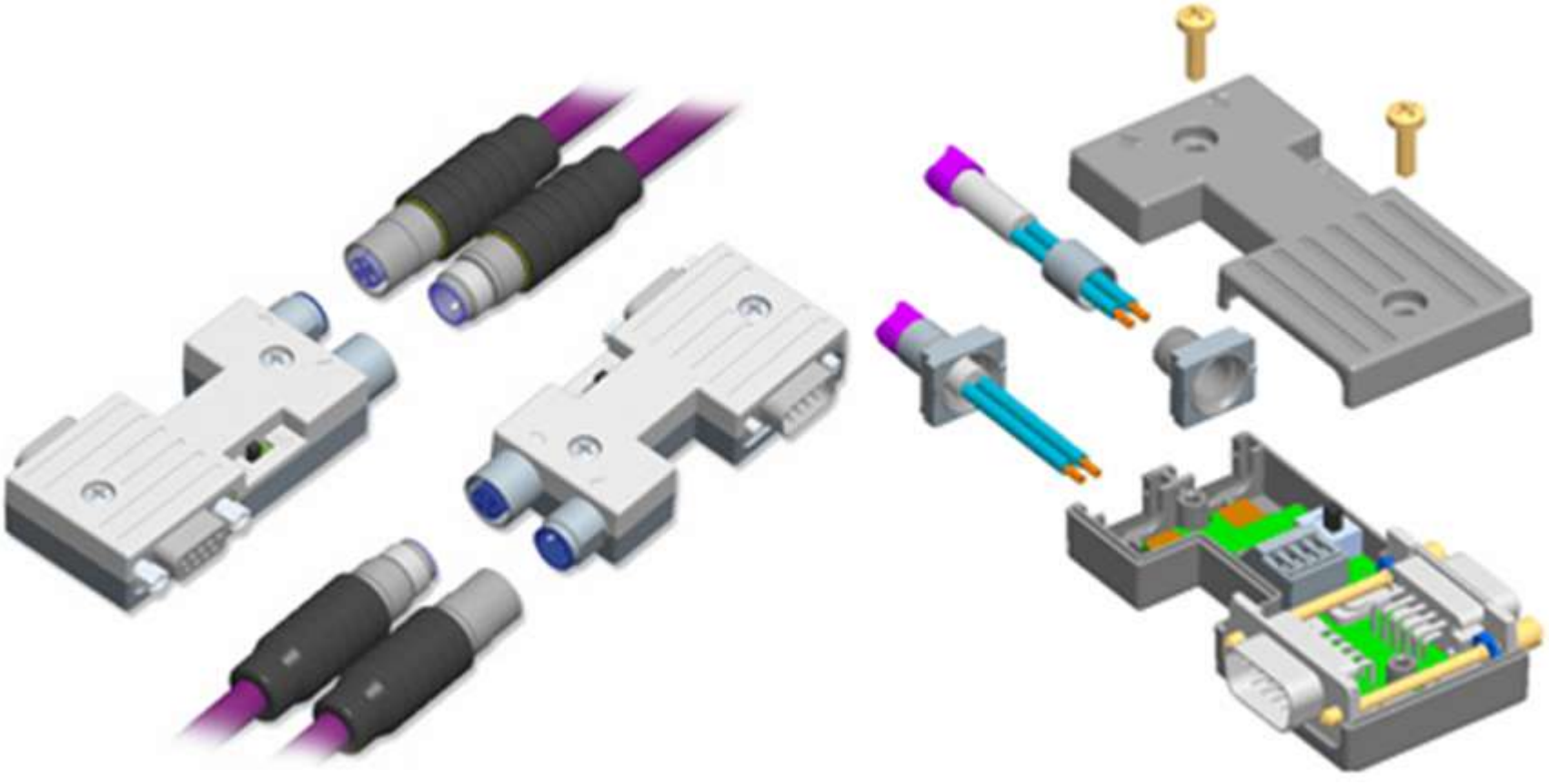


- Devices often have two sockets for incoming and outgoing PROFIBUS cables – difficult to remove device without disrupting the bus.
- Special Tee connectors which can be used to connect to devices via a short spur line (one connection) to overcome this problem.
- But do not use a spur line – plug directly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

For IP65/67

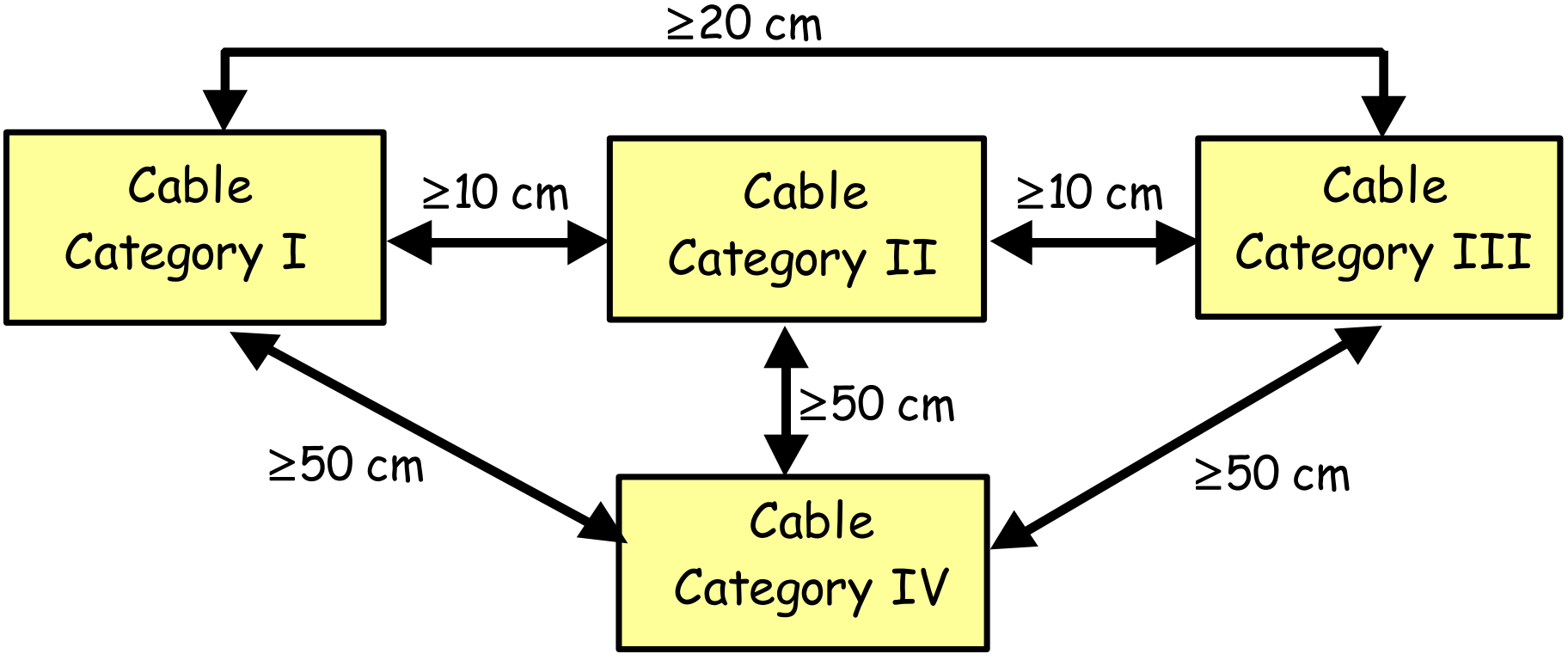
- One solution to this problem is to use a short spur line.
- However this will cause reflections and we must limit the bus bit rate.

Sub-D and M12 Combined

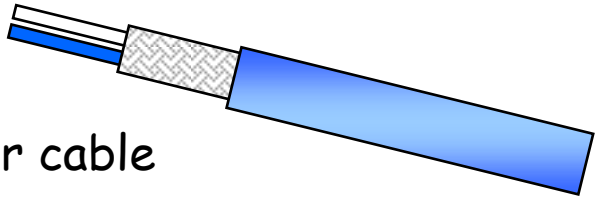


Cabling – Cable Segregation

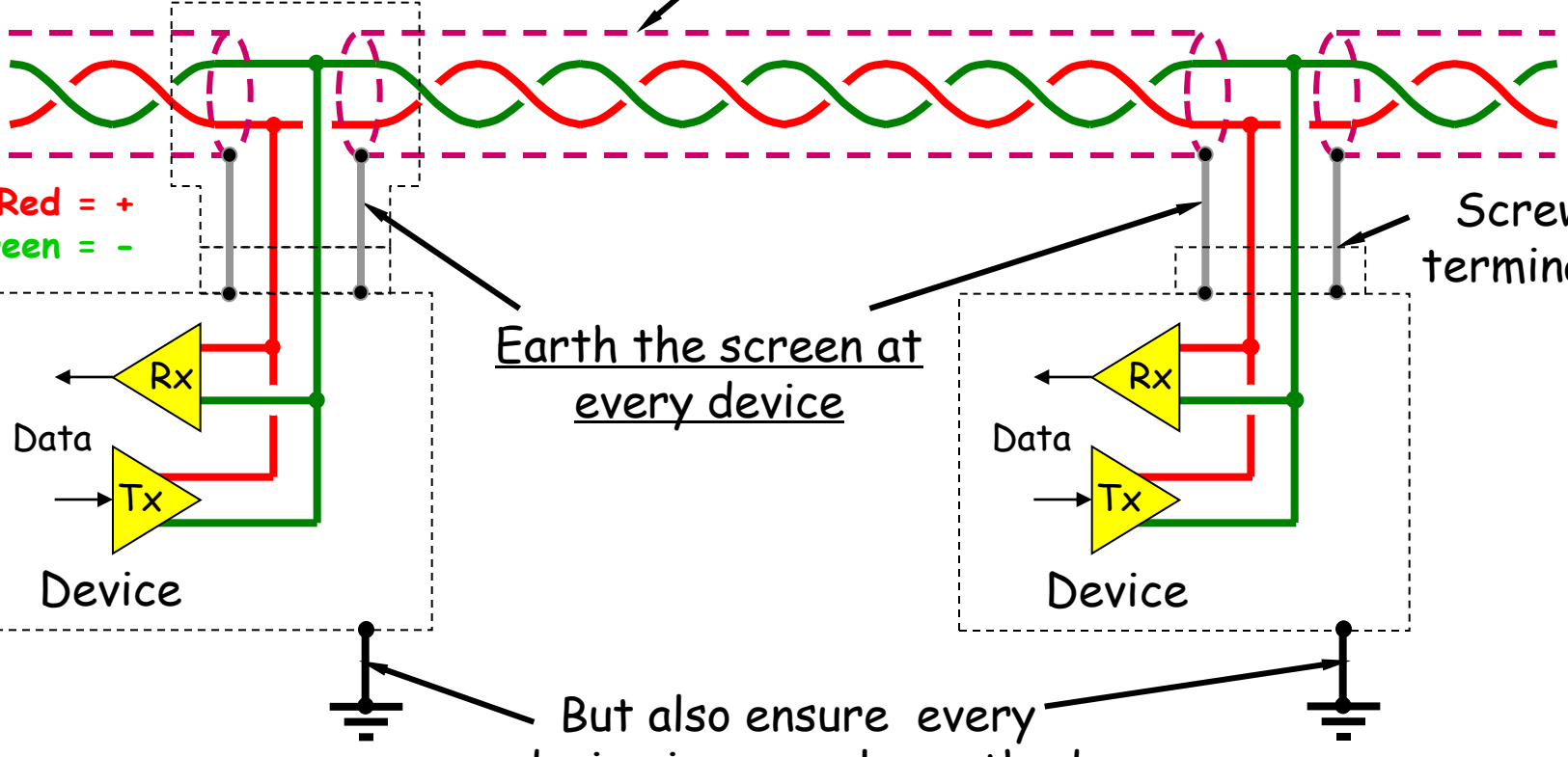
⇨ **Recommended cable separation distances:**



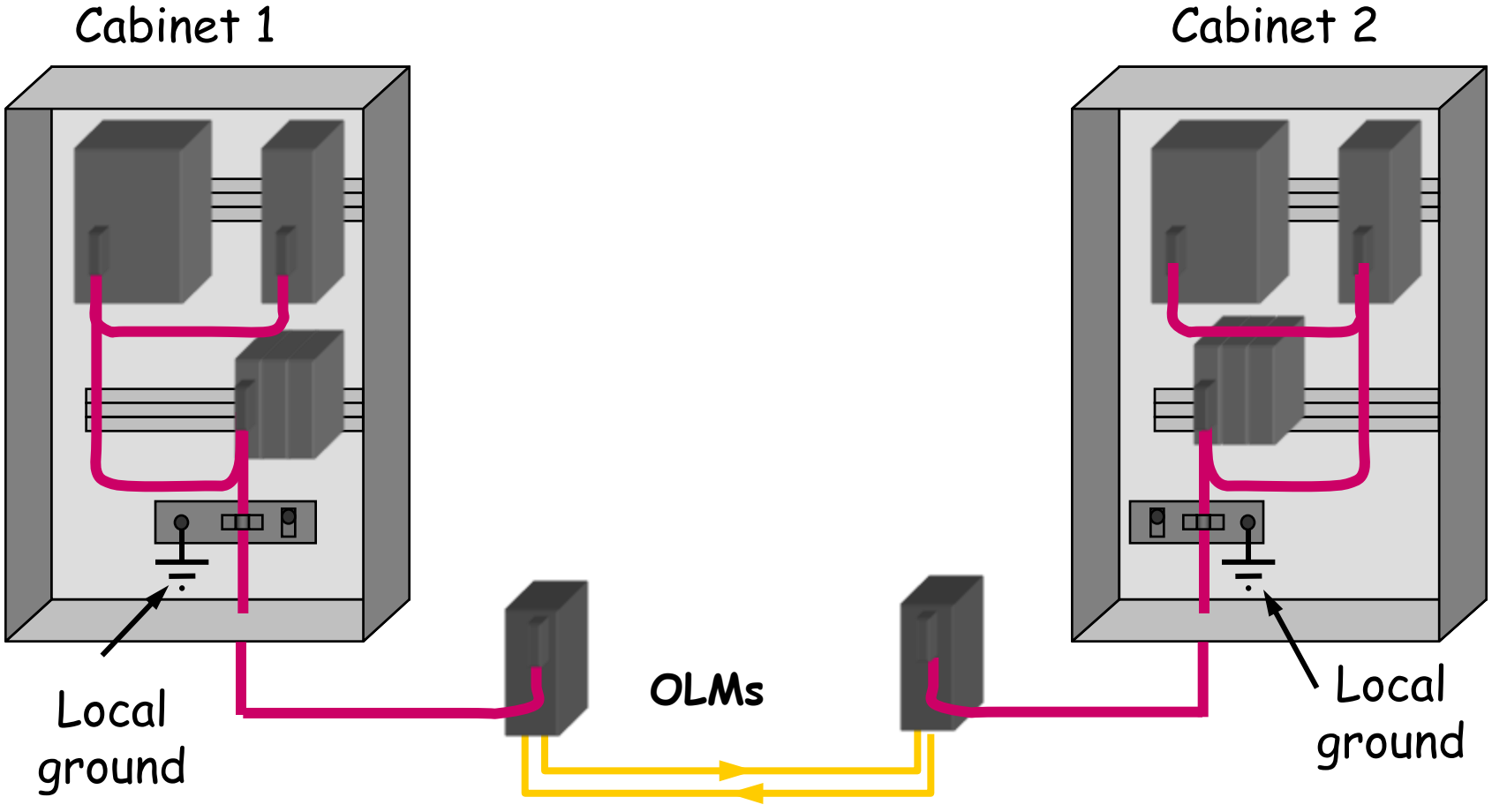
Shielding and Twisting



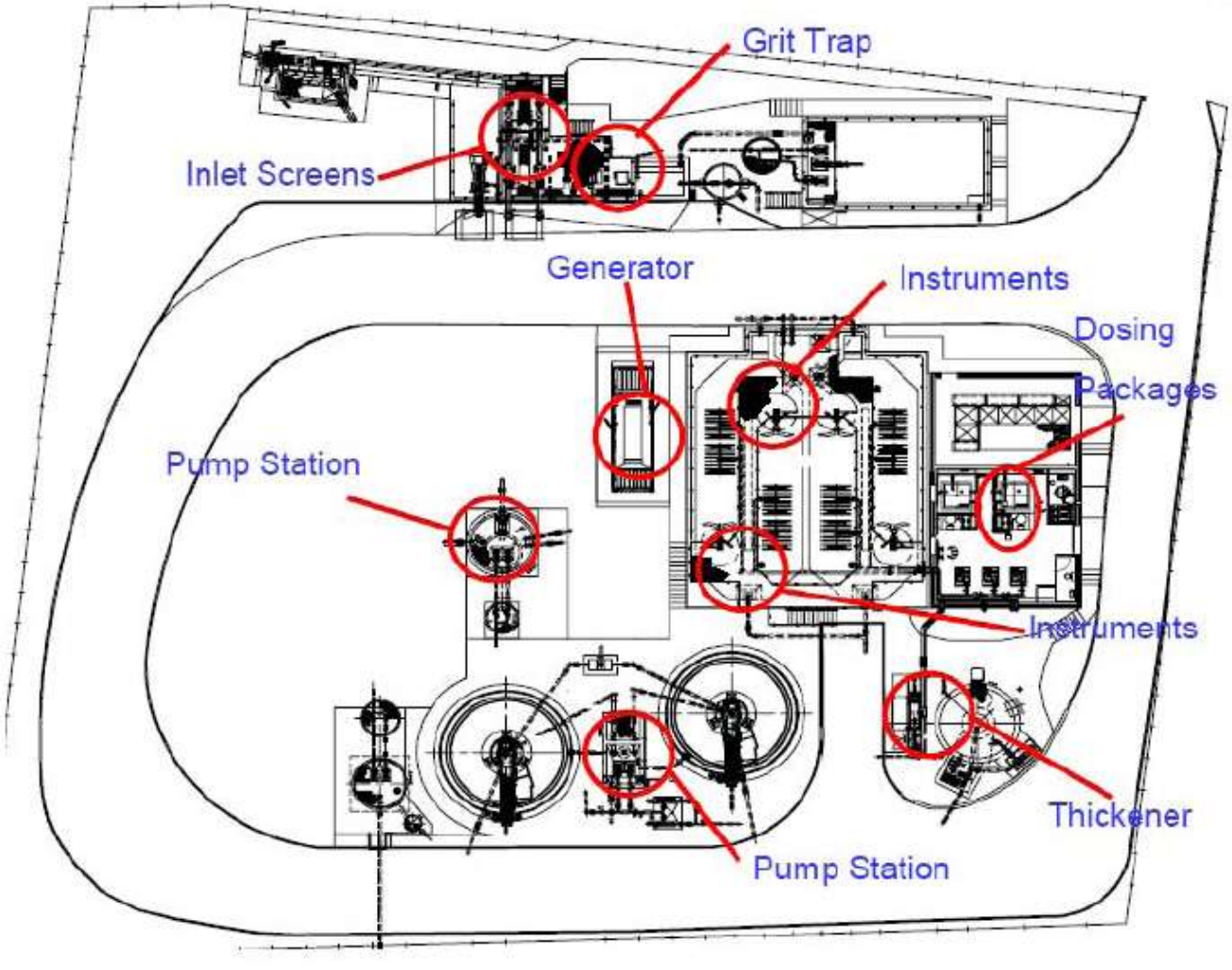
Shielded, twisted-pair cable



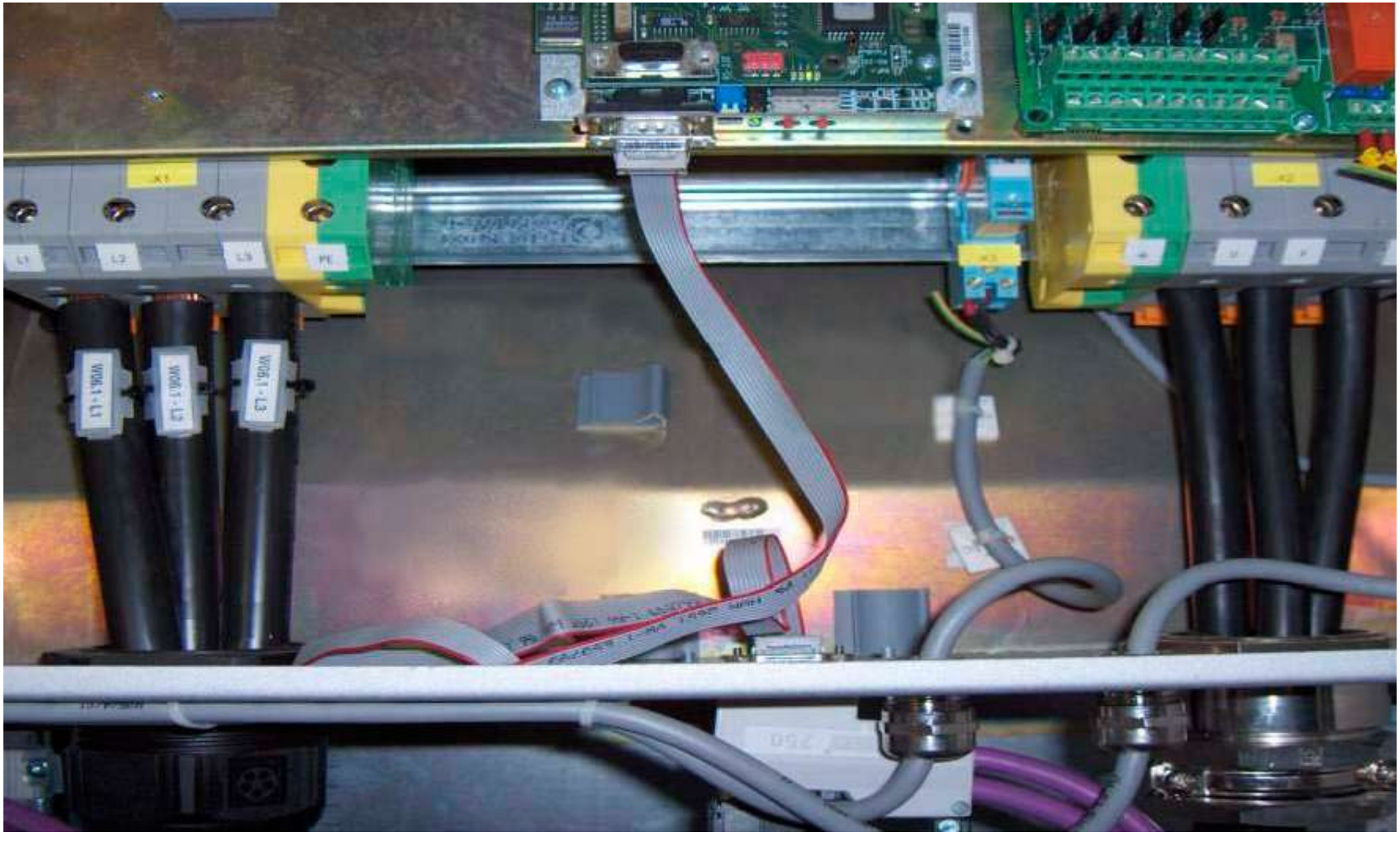
Earthing Issues - Optic Fibres



Design - Plant Layout



Space for Connectors?



Basics - Station Types

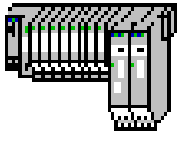
#1 

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

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

#0 

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

#21 

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


#22

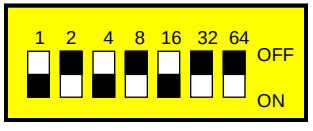

#23

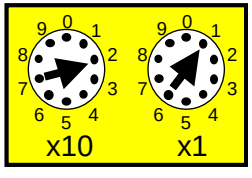

#24

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

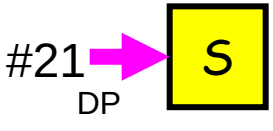
Basics - Addressing

- 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:

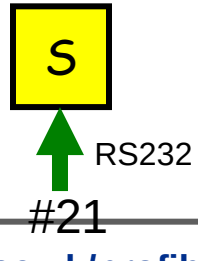




  - A local switch on the device (binary dip switch or rotary switch).



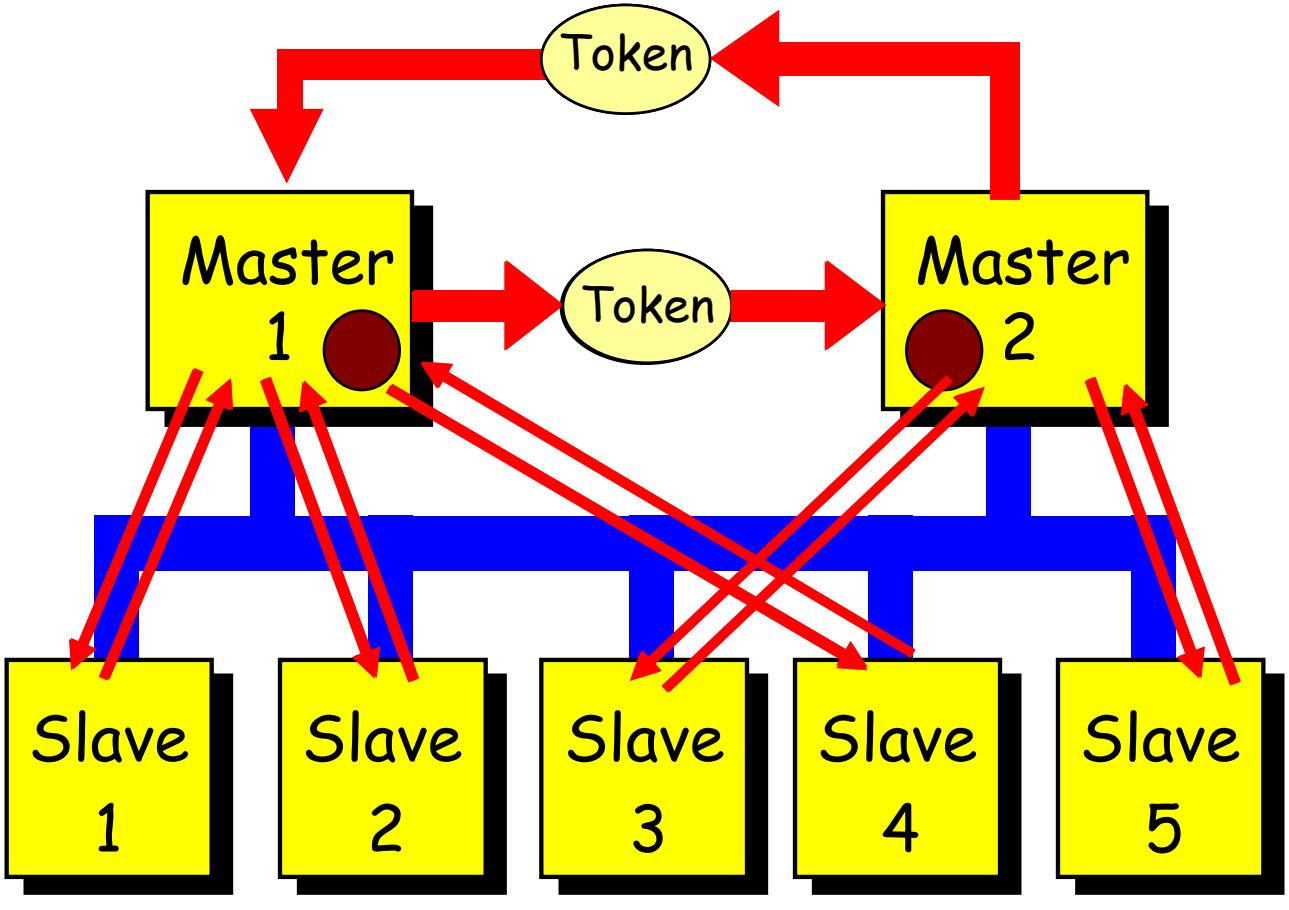
  - Software setting of device address over the PROFIBUS network using a configuration tool (called a *class 2 master, change from #126 to #21*).
  - Finally, some devices may use special software and a serial link or hand-held tool to set the device address (e.g. some PLCs, drives or HMI devices.



Basics - GSD Files

- 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.

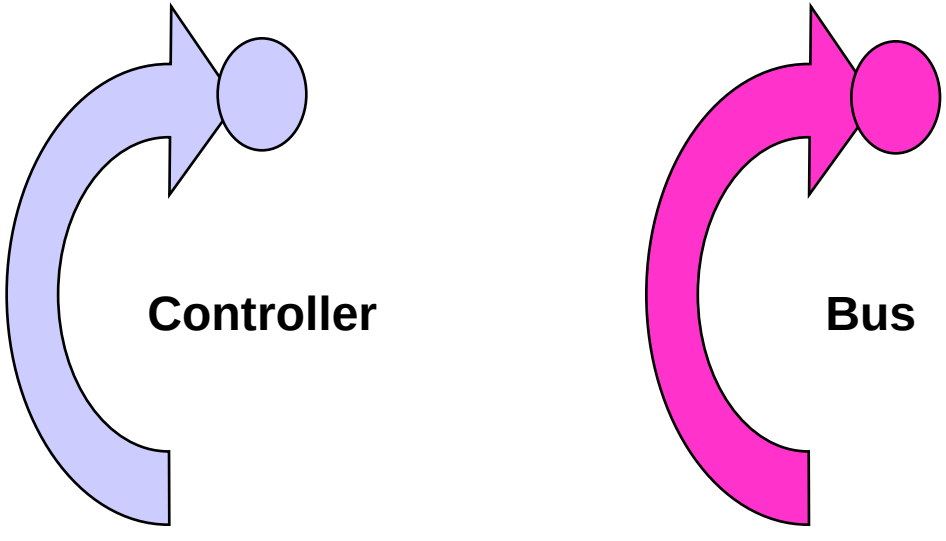
Token passing and Master-slave communication



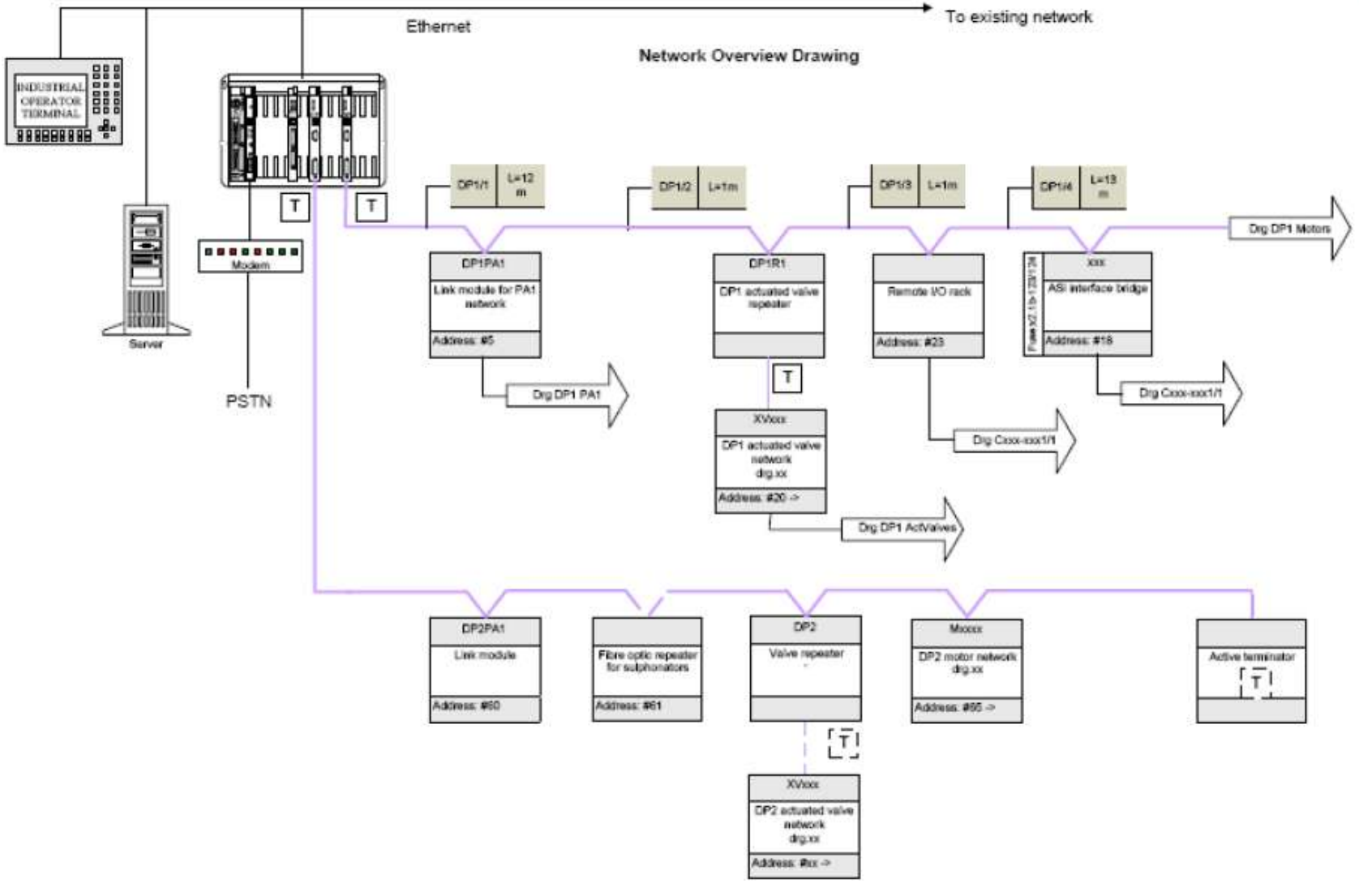
Cyclic operation:
M1→S1, S1→M1
M1→S2, S2→M1
M1→S4, S4→M1
M1→token→M2
M2→S3, S3→M2
M2→S5, S5→M2
M2→token→M1
M1→S1, S1→M1
M1→S2, S2→M1
etc.

Basics - Timing

- ⇨ PLC cycle time.
- ⇨ Bus cycle time.



Documentation – Network Drawings

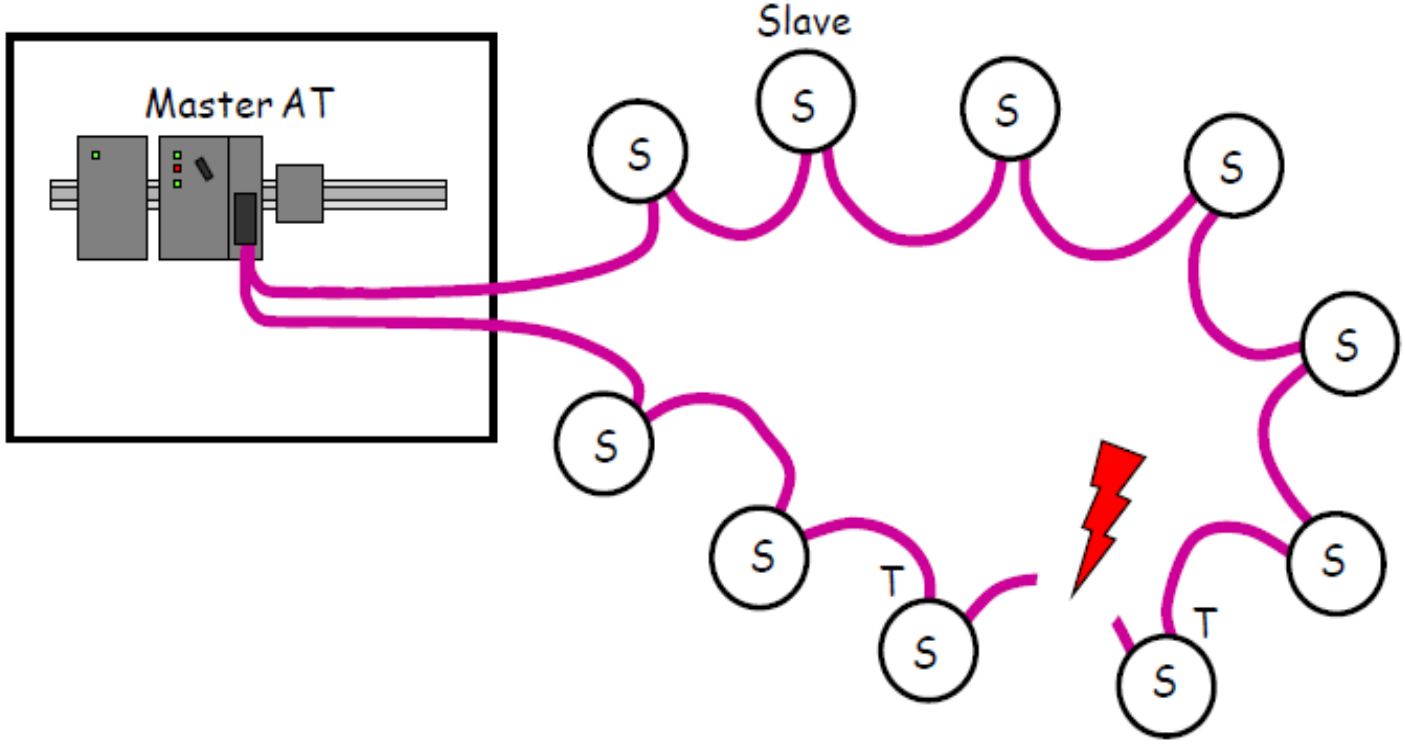


Design - An Example

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

Design - An Example

- 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.



Automation Industries

⇨ FA and PA

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

- **Manufacturing Automation**
  - Car manufacturing
  - Bottling systems
  - Storage systems
- **Building Automation**
  - Traffic automation
  - Heating, air-conditioning
- **Process Automation**
  - Purification plants
  - Chemical and petrochemical plants
  - Paper and textile plants
- **Power Generation and Power Distribution**
  - Power plants
  - Switch Gear

Breweries

Waste Water Purification

Lime Production

Glue Production

Polymer Storage

Bottling Plants

Building Automation

Food Production

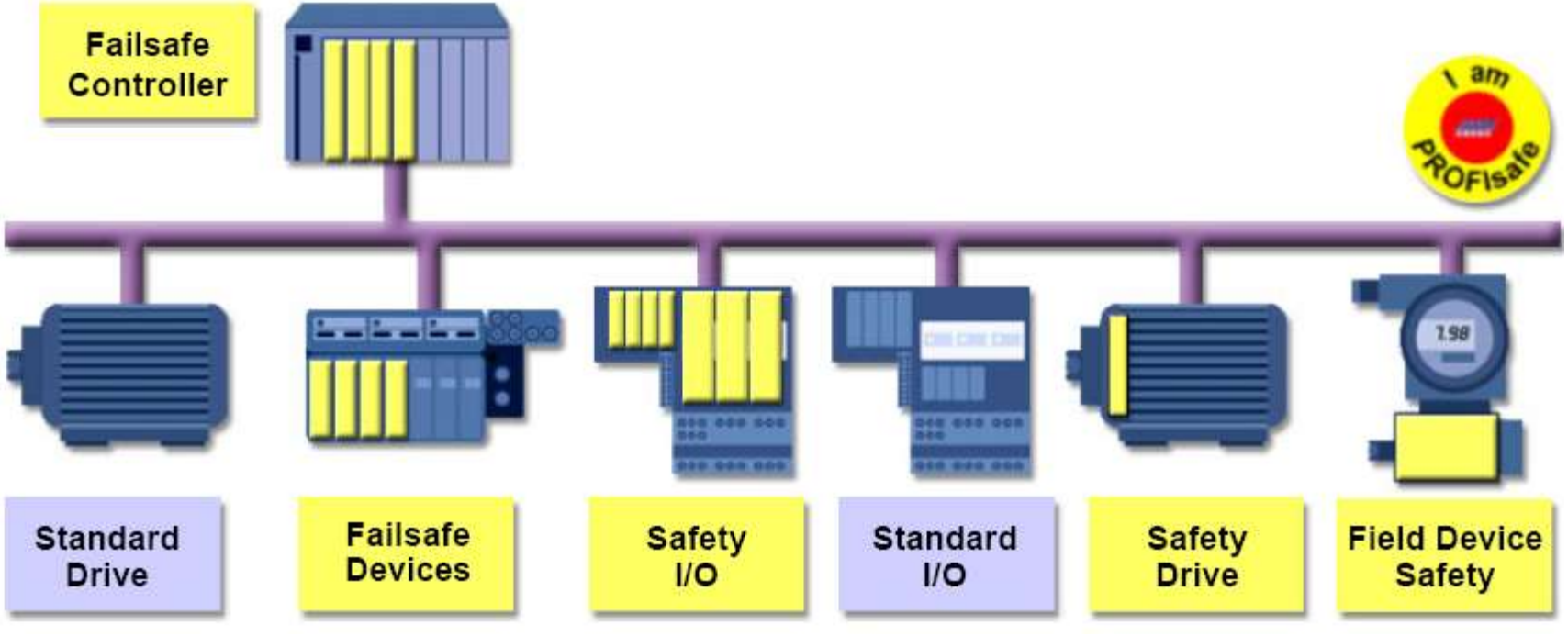
The PROFIBUS Family

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

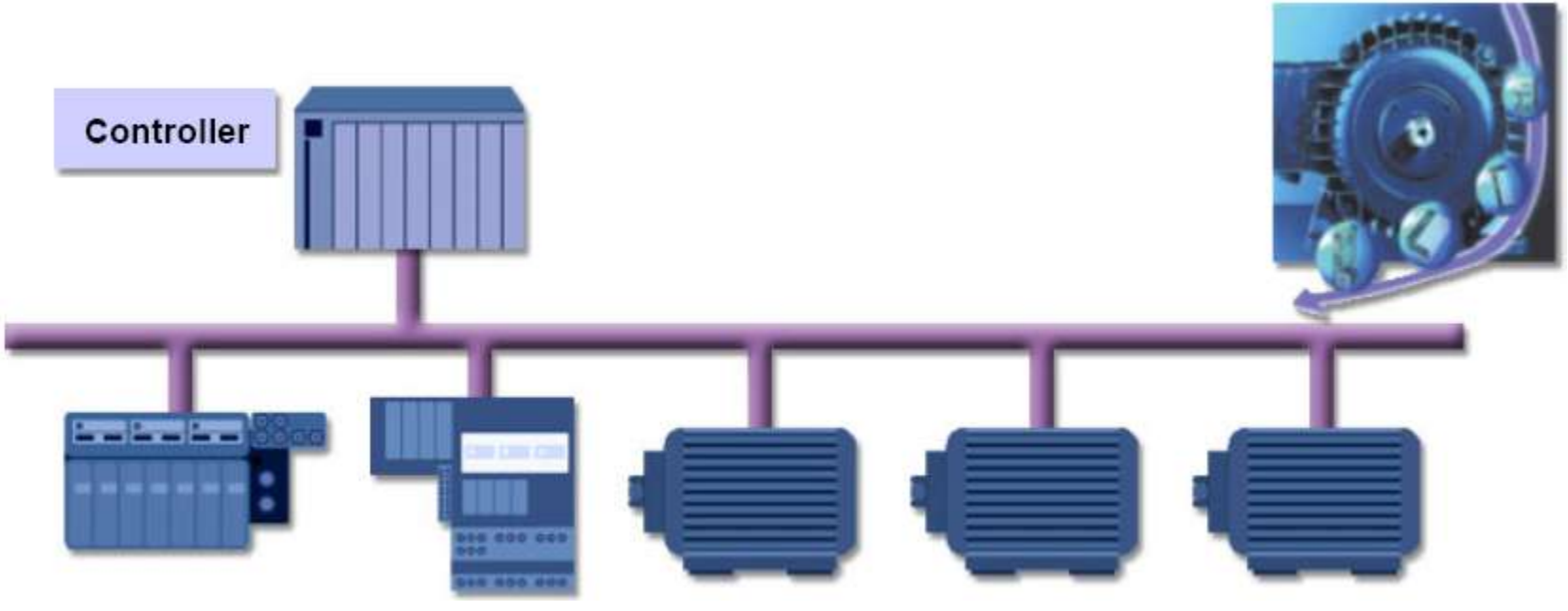
One controller for all devices

- 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.



Applications and Communication Protocol Versions

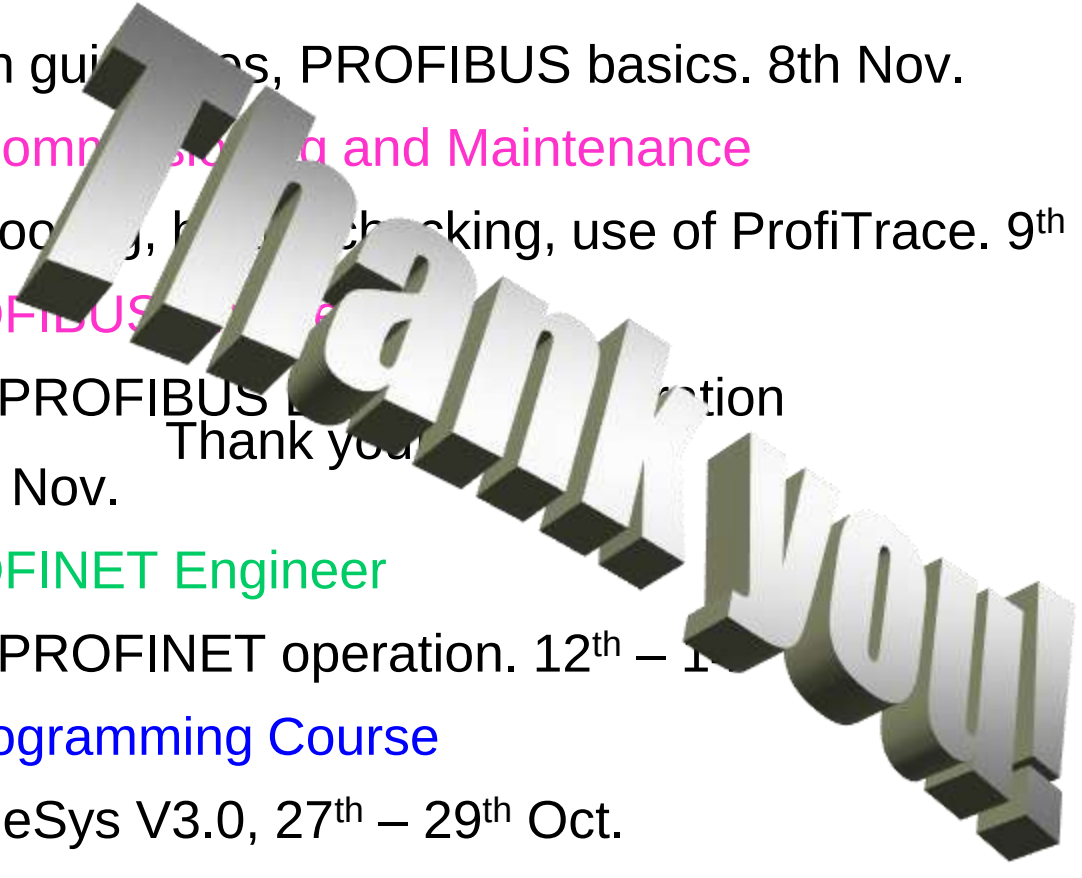
- DP devices or PA devices?
- Safety systems?
- High speed drives and synchronised motions?
- PROFIBUS Versions, DP-V0, DP-V1, or DP-V2?
- Latest Profile versions
  - ✓ PA Profile 3.02
  - ✓ PROFIsafe Profile 2.4
  - ✓ PROFIdrive Profile 4.1.
- Newer versions are backwards compatible with older versions!

Conclusion

- ⇨ 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!

Training Courses at MMU

- Certified PROFIBUS Installer
  - ✓ Installation gui[illegible]s, PROFIBUS basics. 8th Nov.
- PROFIBUS Comm[illegible]g and Maintenance
  - ✓ Troubleshoo[illegible]g, h[illegible]cking, use of ProfiTrace. 9th Nov.
- Certified PROFIBUS [illegible]
  - ✓ Details of PROFIBUS [illegible]tion
  - ✓ 10th – 12th Nov.
- Certified PROFINET Engineer
  - ✓ Details of PROFINET operation. 12th – 1[illegible]
- 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**



Thank you