PROFIBUS CONFERENCE 2010

PROFIBUS BOGAZ

Boots on Ground (A to Z)

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SENIOR ICA ENGINEER

http://www.profi-bus.co.uk/Index.asp?PageID=3%20

PRESENTATION AGENDA

- *United Utilities - Introduction*
- *UU Project Delivery Method*
- *Profibus Network Design*
- *Device Configuration*
- *Network Installation*
- *Installation Tests*
- *Profitrace Benchmarking and Waveforms*
- *Surge Protection Devices*
- *Questions*

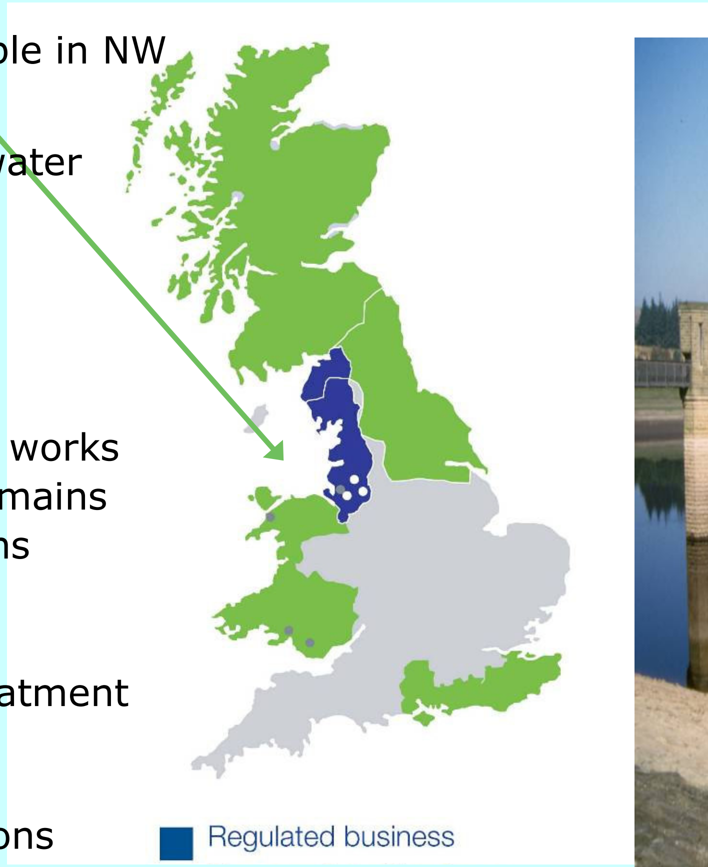
WHO ARE UNITED UTILITIES ?

- ***We are the UK's largest listed water and wastewater company***
- ***We provide services to over 27 million people worldwide***
- ***Employing over 9,000 people worldwide***
- ***£13 billion invested in the UK between 1989-2010***
- ***Between 2010-2015, £3.6 billion will be invested by United Utilities in its water and wastewater networks***

UK OPERATIONS – WATER AND WASTEWATER

United Utilities

- Serve 7 million people in NW England
- 1.9 billion litres of water everyday



WATER

- 184 reservoirs
- 59 River Intakes
- 95 Water treatment works
- 40,000+ km Water mains
- 400 Pumping stations

WASTEWATER

- 582 Wastewater treatment works
- 43,000 km Sewers
- 1800 Pumping stations
- 3000 Telemetry outstations

UU PROJECT DELIVERY METHOD

Overview

User Requirements - Solution Scope Book (aka SSB) a high level design document developed by UU Engineers (Environmental, Process, Hydraulic, Geo-Technical, Civil, Mechanical, E&ICA)

UU Framework Agreements for Detailed Design, Installation and Commissioning by our Alliance Partners, essentially a 'turnkey' contract for each project.

UU Framework Supplier Agreements for Instrumentation, Actuators, MCCs, Control Panels, PLC Hardware and PLC Software

The Alliance Partners design the control system from the SSB outline requirements and have to use Profibus devices selected from those available under the Framework Supplier Agreements.

It is a UU need that all Alliance Partners Profibus designers, installers and commissioning engineers should have attended a certified training course.

We DO NOT do detailed reviews of design and installation – we have to trust our Alliance Partners.

NETWORK DESIGN

UU Standards and Specifications

Standards

UU Company standards (S04, E110, E104, etc..) define the requirements where Profibus solutions are utilised. These are issued with project SSBs / contracts so that designers have a point of reference.

Architecture and Drawings

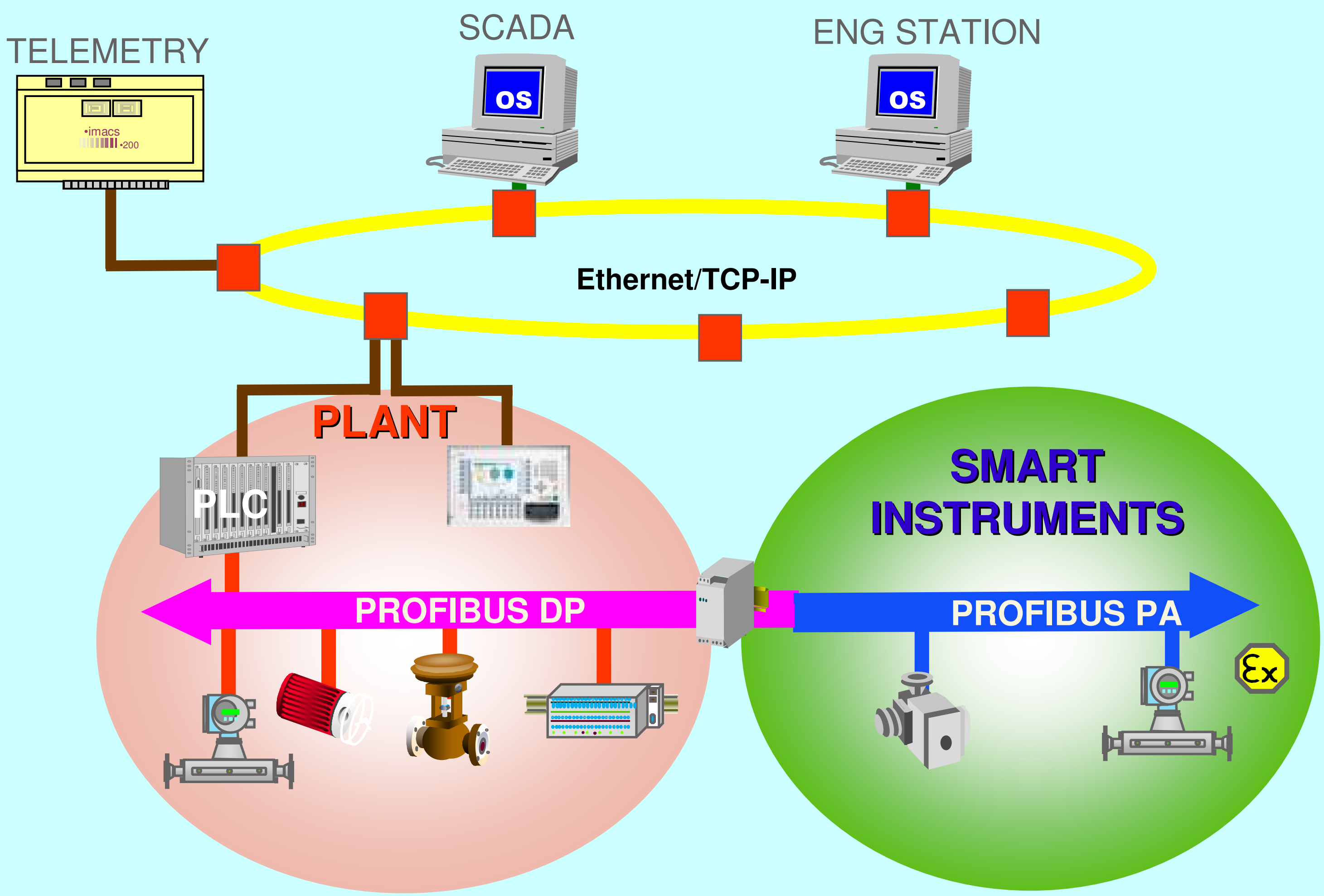
The Alliance Partners are required to provide the detailed design and must be based on the System Architecture outline provided in the SSB.
They are also responsible for the installation, testing and commissioning stages.
The system architecture should include devices names, node addresses, cable lengths etc. and are vital for continued effective maintenance.

Installers Documents

Alliance Partner developed guidance notes explaining installation and testing procedure and best practice methods with examples for their installation and commissioning teams.

NETWORK DESIGN

Typical Site Architecture



NETWORK DESIGN

A typical UU site

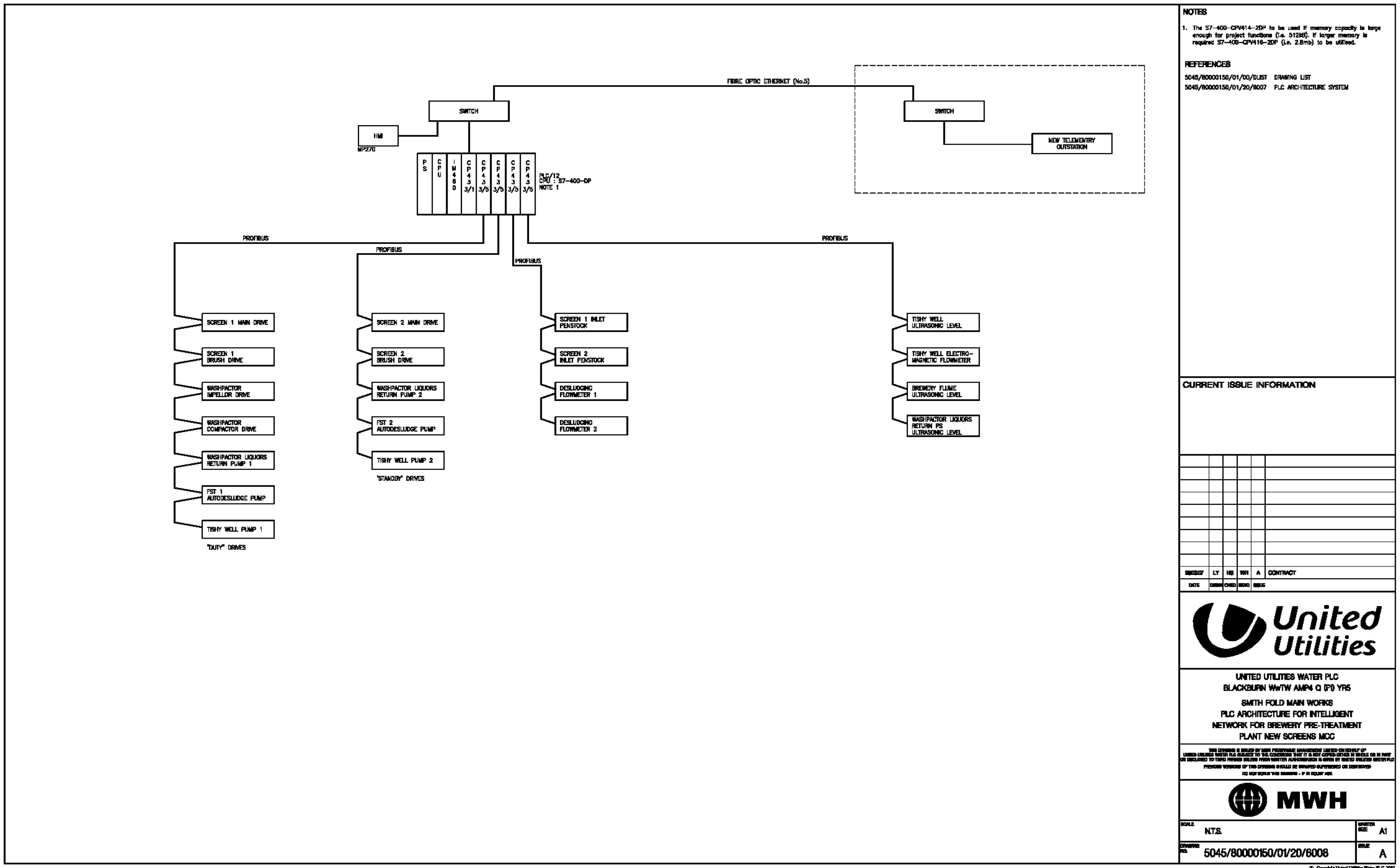
Looking to the site front end

And looking to the site back end

Our sites tend to cover a large flat areas and have 'clusters' of plant connected via pipes/channels

NETWORK DESIGN

The SSB block diagram – Produced by UU



An overall view of the required process unit network

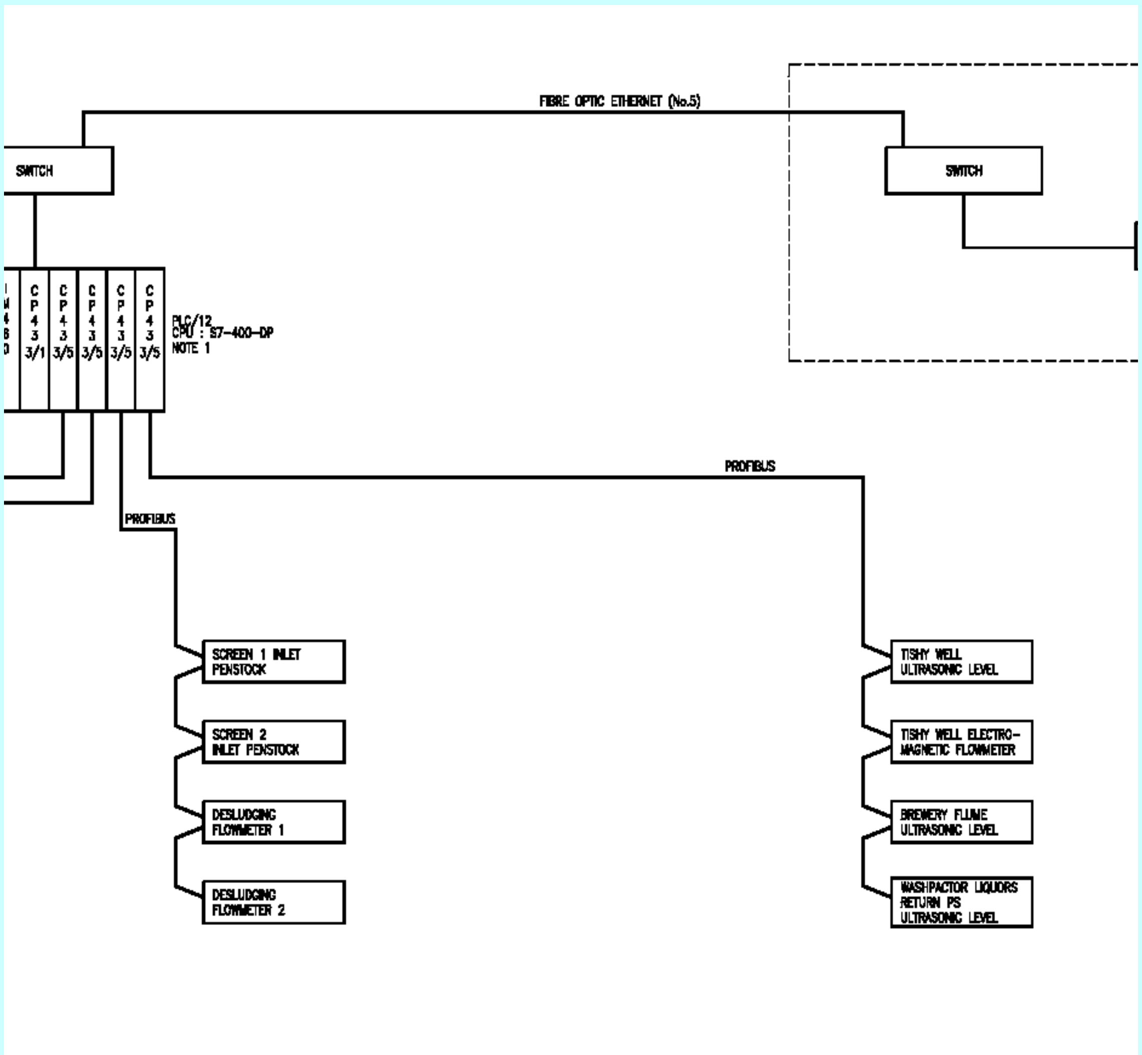
- ***Shows an Ethernet connection.***
- ***The specific PLC needs for a plant area.***
- ***Other PLCs are detailed on separate sheets***

After this SSB block diagram all detail design, installation, testing and commissioning are the responsibility of our Alliance Partners.

We do not review/inspect these activities.

NETWORK DESIGN

A partial detail from SSB block diagram – Produced by UU

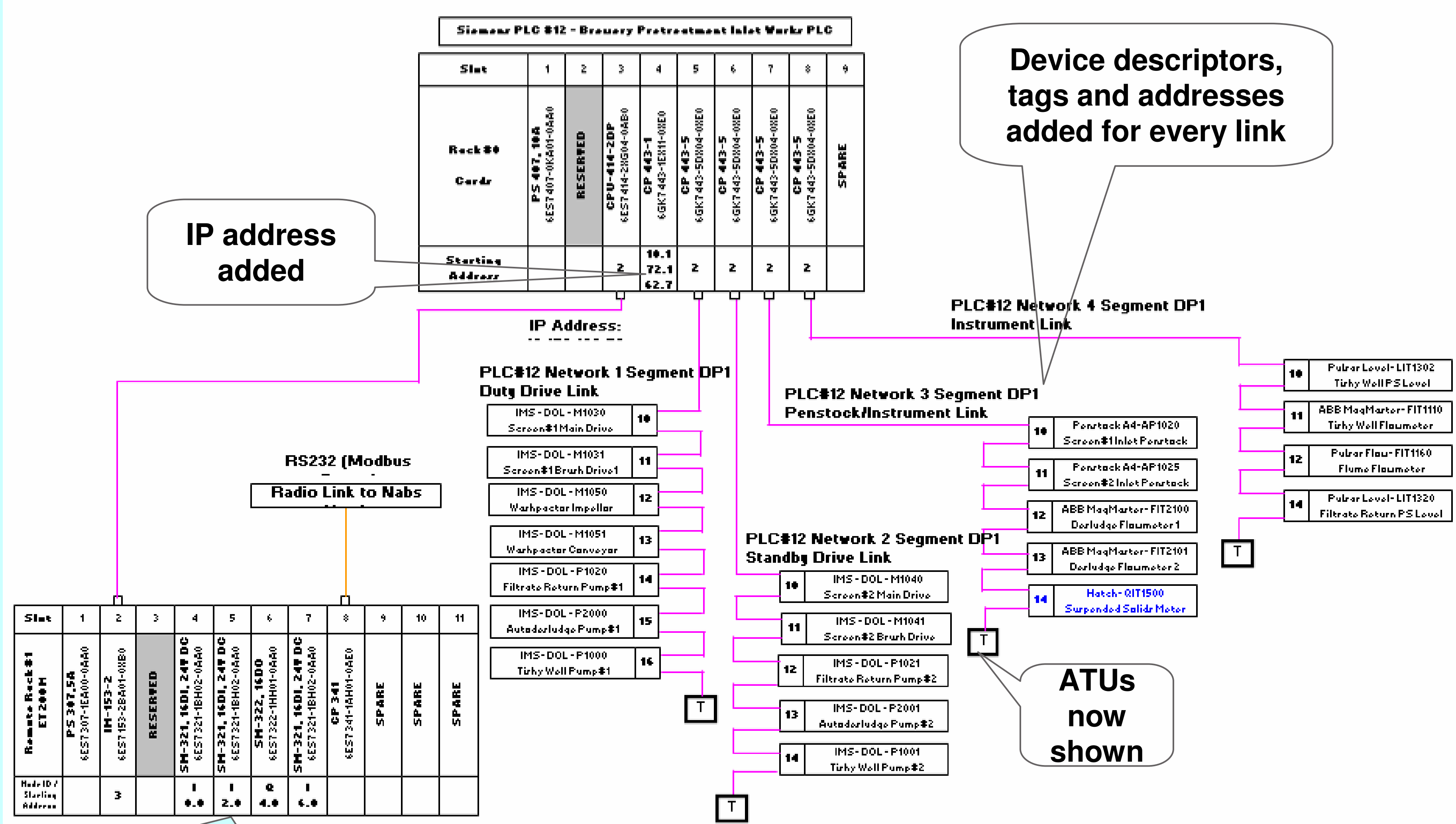


Concerned only with –

- ***Corporate high level needs.***
- ***Allocation of devices between the Profibus networks to maintain process security if a link fails.***
- ***Device descriptors only shown***
- ***The Alliance Partner has to provide all subsequent detail design work.***

NETWORK DESIGN - Detailed

Profibus network detail added by the System Integrator

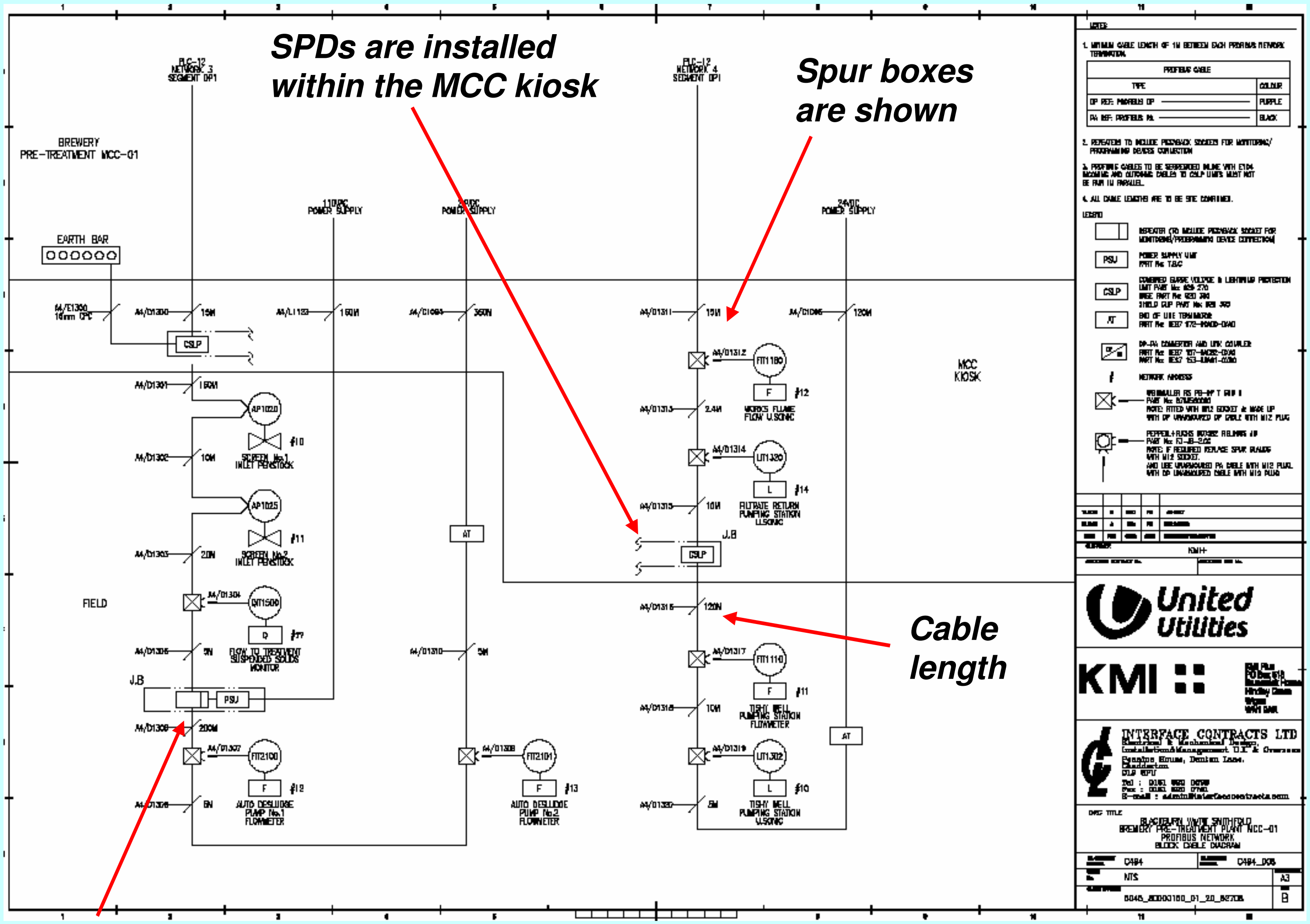


Any hard or 'special' I/O are in a remote rack connected to a CPU Profibus port

The framework System Integrator is responsible to the Alliance Partner

NETWORK DESIGN - Detailed

Profibus Network Diagram - As Built



Have only shown 2 of the networks – the other 2 networks are shown on a separate sheet

Device tags, descriptors and Profibus addresses are shown

Cable lengths are shown between each device

Repeater now included, 210m from the PLC

NETWORK DESIGN – Detailed - Draft of Profibus I/O schedule by the System Integrator – showing only the first part of one device

Profibus node	Number of bytes alloted		Addresses				Signal type	Inst / PLC Tag	Description
	Inputs	Outputs	Inputs		Outputs				
	DB21	DB22	HW Config	DB21	HW Config	DB22			
DP Master:	2		Master Port:	CP443-5 (Rack 0, Slot 5)			DP Link:	Duty Link - Drives	
10	**10**	**4**	**I 1000**	**1000**	**Q 1000**	**1000**	**Duty**	**A4M1030**	**Screen#1 Main Drive**
				DB 21.DBX1000.0			DP-DI-Duty	A4M1030_MCC_MA	Screen#1 Main Drive - MCC Mode
				DB 21.DBX1000.1			DP-DI-Duty	A4M1030_AV	Screen#1 Main Drive - Available
				DB 21.DBX1000.2			DP-DI-Duty	A4M1030_RG	Screen#1 Main Drive - Running
				DB 21.DBX1000.3			Not Used	A4M1030_SPARE	Screen#1 Main Drive - Spare
				DB 21.DBX1000.4			DP-DI-Duty	A4M1030_OL	Screen#1 Main Drive - Overload Fault
				DB 21.DBX1000.5			DP-DI-Duty	A4M1030_GEN_FLT	Screen#1 Main Drive - Device Fault
				DB 21.DBX1000.6			DP-DI-Duty	A4M1030_E_STOP	Screen#1 Main Drive - Emergency Stop
				DB 21.DBX1000.7			DP-DI-Duty	A4M1030_FLT_RST	Screen#1 Main Drive - Simocode OP Fault Reset
				DB 21.DBX1001.0			DP-DI-Duty	A4M1030_DEV_FLT	Screen#1 Main Drive - Emergency Stop
				DB 21.DBX1001.1			DP-DI-Duty	A4M1030_S_INT1	Screen#1 Main Drive - Safety Interlock 1
				DB 21.DBX1001.2			DP-DI-Duty	A4M1030_S_INT2	Screen#1 Main Drive - Safety Interlock 2
				DB 21.DBX1001.3			DP-DI-Duty	A4M1030_IMS_CFG_FLT	Screen#1 Main Drive - Drive IMS Configuration Fault
				DB 21.DBX1001.4			Not Used	A4M1030_SPARE_1	Screen#1 Main Drive - Spare
				DB 21.DBX1001.5			DP-DI-Duty	A4M1030_DP_INP1	Screen#1 Main Drive - Drive Protection Input 1
				DB 21.DBX1001.6			DP-DI-Duty	A4M1030_DP_INP2	Screen#1 Main Drive - Drive Protection Input 2
				DB 21.DBX1001.7			DP-DI-Duty	A4M1030_DP_INP3	Screen#1 Main Drive - Drive Protection Input 3
				DB 21.DBW1002			DP-AI-Duty	A4M1030_I_AMP	Screen#1 Main Drive - Motor Current
				DB 21.DBD1004			DP-AI-Duty	A4M1030_KW	Screen#1 Main Drive - Active Power
				DB 21.DBW1008			Not Used	A4M1030_SPARE_2	Screen#1 Main Drive - Spare
						DB 22.DBX1000.0	DP-DO-Duty	A4M1030_RUN_STRT	Screen#1 Main Drive - Start Command To Drive
						DB 22.DBX1000.1	DP-DO-Duty	A4M1030_SPARE	Screen#1 Main Drive - Spare
						DB 22.DBX1000.2	DP-DO-Duty	A4M1030_RUN_STP	Screen#1 Main Drive - Stop Command to Drive
						DB 22.DBX1000.3	DP-DO-Duty	A4M1030_RST	Screen#1 Main Drive - Fault Reset Command to Drive(Spare)
						DB 22.DBB1001	Not Used	A4M1030_SPARE_1	Screen#1 Main Drive - Spare
						DB 22.DBW1002	Not Used	A4M1030_SPARE_2	Screen#1 Main Drive - Spare
11	**10**	**4**	**I 1010**	**1010**	**Q 1004**	**1004**	**Duty**	**A4P1031**	**Screen#1 Brush Drive**

NETWORK DESIGN – *Detailed - Draft of Profibus I/O schedule by the System Integrator – showing the second part of one device only*

State 0	State 1	Range	Eng. Unit	Reference Document Number	Document Description	Doc. Rev.	Process Unit	Model Name	GSD
					FDS			**Simocode**	**SI1180FD.GSE**
MCC Man	MCC Auto	-	-						
Unavailable	Available	-	-						
Stopped	Running	-	-						
		-	-						
Healthy	Fault	-	-						
Healthy	Fault	-	-						
Healthy	Fault	-	-						
Healthy	Fault	-	-						
Healthy	Fault	-	-						
Tripped	Healthy	-	-						
Inhibit	Healthy	-	-						
Inhibit	Healthy	-	-						
Inhibit	Healthy	-	-						
Fault	Healthy	-	-						
Fault	Healthy	-	-						
Fault	Healthy	-	-						
-	-	-	0						
-	-	-	0						
-	-	-	-						
No Action	Start	-	-						
No Action	Start	-	-						
No Action	Stop	-	-						
No Action	Fault Reset	-	-						
-	-	-	-						
-	-	-	-						

NETWORK DESIGN

In the field………

Problems have occurred when a designed network is within 20% or so of its allowable length, has been installed on site and then another device needs to be installed.

The site team then install extra DP cable along an available route from the end of the existing segment to the location of the extra device and set it to work. No extra networks tests were done as the existing network was operational

But the extra cable added causes the segment length to exceed the 400m limit for a 500kbps speed by some 90m and the network still worked fine with no problems noted.

Until someone came along to review the Profibus installations and connected Profitrace to this network and saw the signal attenuation and capacitance effects that characterise an overlong segment.

A repeater and power supply now had to be installed in the field to make the network compliant.

Watch-point – if you need to add extra devices or otherwise modify an operational network then review the original design and consider how the extra devices or modifications may affect the network before you do anything else.

Device Configuration

GSD files are important .

BUT the device configuration tools available make this a straightforward task.
Once it's done it's done – until you want to make a change later on.

The only minor problems we have had is where a SI has a slightly out of date GSD file for a specific device on his programming laptop and used this instead of checking to see if it needs a more recent version.

As UU and our framework contractors have climbed the learning curve then this doesn't happen anymore. It's possibly more likely that if it does then it's immediately spotted and rectified on site and nobody is any wiser.

We are developing a UU wide procedure to list every device on a project and it's associated GSD file and version number to assist in ongoing maintenance and future device change configuration.

NETWORK INSTALLATION

In the Field

Profibus cable tray is separate from power tray.

The Profibus DP, PA and I.S. cables are easily seen.

The site is under construction and additional DP and other cables have yet to be installed.

The installers tend to find it cost effective to mass produce all support metalwork to the same size

Try not to mix signal and power cables on the same tray.

NETWORK INSTALLATION

In the Field - DP Spur boxes

The incoming and outgoing cables are terminated in a piggy back DP connector mounted on a Weidmuller DP-IP20 T connection unit.

Note the cable bending radii are maintained and the connection unit mounted ‘off centre’.

The spur cable (approx 0.5 m long) to the instrument is ‘bought in’ ready made up and then terminated .

All spur boxes and devices are bonded to earth (the tray)

Cable markers are added asap

NETWORK INSTALLATION

In the Field - Not Good !!!!!

The spur cable is approx 2m long and is not even DP Type A !! These were installed everywhere, even though the spur box drawing told the installers the correct cable and length to use.

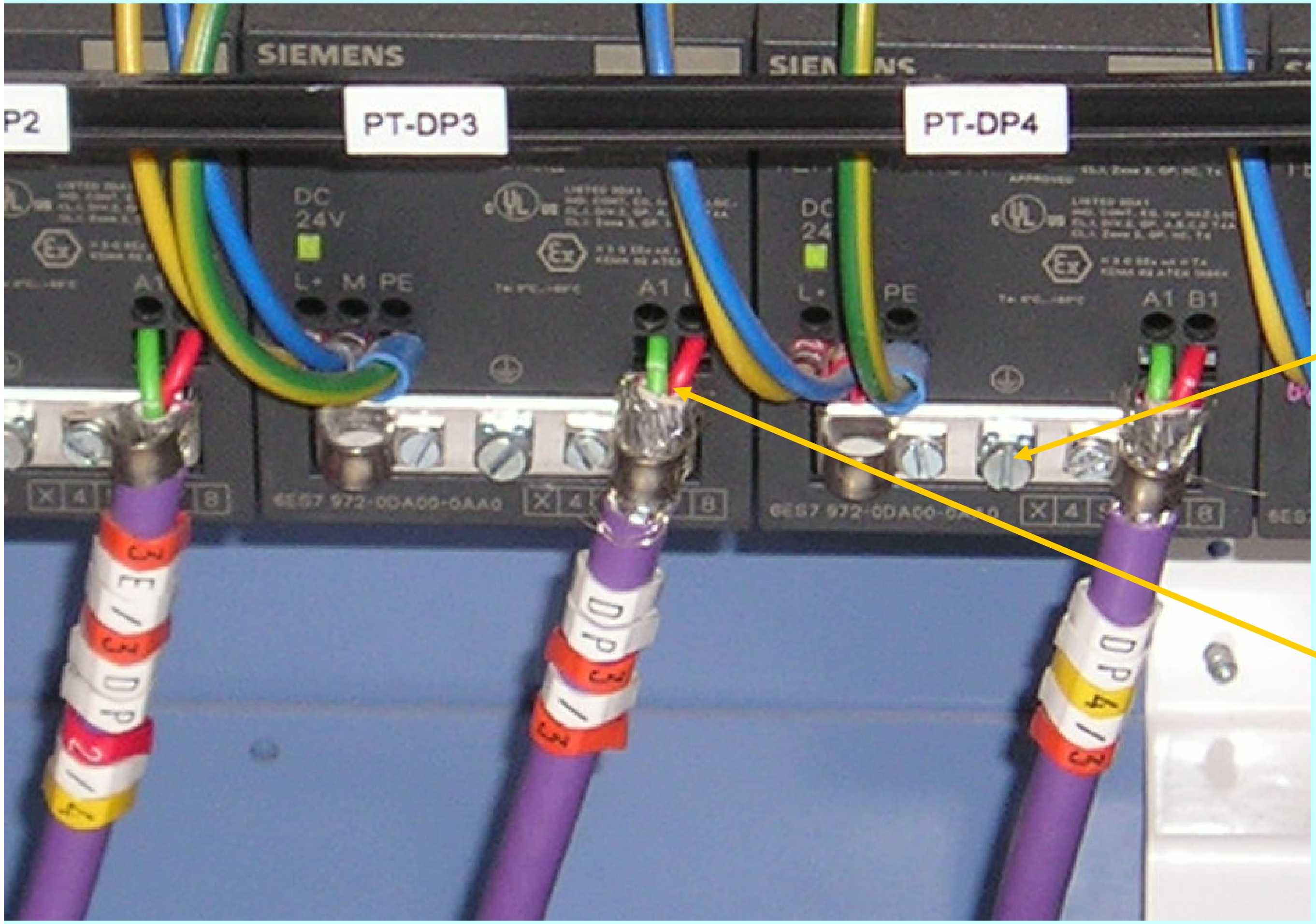
Even so the networks were all fully operational and were not experiencing any problems.

The installer had to return to site to replace every one of them and the electrical installation supervisor was

It's v.difficult to know if the black cables on the tray are power or 24VDC. Hence we prefer separate trays for signal cables.

NETWORK INSTALLATION

In the Field - Not Good !!!!!!!!



Active Termination Units

Showing 2 common problems

No earth cable connected to ground the end of the network

Knife cut terminations – the red and green cores are 'nicked' and the braid is scrappy with whiskers.

Enquiries indicated that the 8 off electricians on site shared 1 off Profibus cable stripper.

INSTALLATION TESTS

UU specifications require that all installations are tested on completion and before power up; a late addition to these specs now require that signal waveforms are also checked and recorded for ‘benchmarking’.

Our Alliance Partners developed an ‘installation check list’ to encapsulate all Profibus networks checks.

The UU PLC hardware framework supplier is Siemens - so for practical reasons we use the Siemens BT200 test unit.

For waveform analysis purposes we use the Procentec Profitrace equipment. This is not an endorsement as they were bought by a non-technical buyer who was influenced by one of our field service engineers. However this equipment has proven itself reliable and accurate.

INSTALLATION TESTS

INSTRUMENTATION
TESTING COMMISSIONING

Ref:
Issue: A
Date: Dec 2006

PROFIBUS DP Network and Segment Installation Check Sheet						
Plant identification:						
Network identification:						
Plant state:						
Bit rate:						
Number of masters:		Number of slaves:			Number of segments:	
Segment identification						
Number of masters:		Number of slaves:			No of diag. Sockets:	
Total no. of RS485 drivers:						

Visual checks	Checked	Comments
Minimum cable bend radius		
Minimum 1m cable between devices		
Separation from power cables, or		
Enclosure in earthed steel trunking		
Termn. on at trunk line ends and nowhere else		

Cable continuity (BT200/Nettest II)	Checked	Comments
Shorts/open cct/crossed wires		
2 terminations only		
Segment cable length		

Analyser/Oscilloscope check									
Device/address									
Data exchange									
Repeat/corrupted telegrams									
Reflections									
Ringing									
Device/address									
Data exchange									
Repeat/corrupted telegrams									
Reflections									
Ringing									
Device/address									
Data exchange									
Repeat/corrupted telegrams									
Reflections									
Ringing									

Inspected by:		Date:		Signature	

AX4 Instrument Test Procedure.doc Annexe C

Our Alliance Partners ‘installation check list’ covers

- **Visual checks**
- **BT200 tests**
- **Profitrace tests**

in a single sheet and confirms that all checks have been successfully completed.

The BT200 and Profitrace test results are also placed in the Site Operations and Maintenance Manual for reference.

These test results effectively benchmark and ‘fingerprint’ the installation and give visual evidence that the networks performed satisfactorily prior to handover.

It is intended that UU Maintenance will periodically check the networks and compare against the ‘fingerprints’.

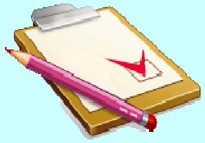
Profibus Defect Analysis

Over a 2 year installation period from more than 40 projects

PROFIBUS INSTALLATIONS

All snags/defects reported are due to installation and/or documentation issues - There are no recorded instances of any device configuration issues.

Check on the network cabling and Profibus device installation as it progresses - It is far easier and cheaper to catch and rectify errors as they arise rather than at the end of the job.



Check that each network has been BT200 (or otherwise) tested and any defects found rectified by the installer <u>before</u> setting the network to work. Get and keep hardcopies of the BT200 test results.

Check that all network drawings are at 'as built' status and include descriptors, tag numbers, node addresses, accurate cable lengths and that all cable markers are affixed on site.

Check that all network drawings are consistent with each other. E.g. those produced by the SI and the panel manufacturer and the field installers are all consistent and any changes are reflected on all drawings – it's probably better to have an overall Profibus network drawing for each PLC system.

WATCH-POINT SUMMARY

Rules
Develop a set of rules that meet your requirements, document these and educate across your design, installation and maintenance teams. Refine from lessons learnt. You know what works for your sites. Use available publications as a basis.

Designers and Installers
Use certified designers and installers. From UU experience - more than 90% of issues are down to incorrect or poor installation, the rest being drawings and documentation. Where possible use certified devices.

Testing and Maintenance
Always design with testing and maintenance in mind. Easily maintainable systems tend to get maintained.

Equipment
Invest in test and commissioning equipment, it reduces commissioning and maintenance times and provides confidence in solutions.

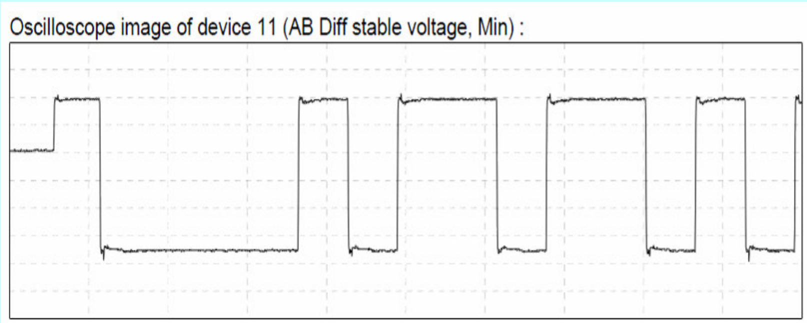
Documentation
Vital at all stages. From design and installation guides to drawings showing architecture, routes, lengths nodes etc… Develop test sheets to benchmark systems at project handover and to provide future maintenance.

Training
At all levels, use external and internal means, involve all concerned in the project lifecycle and the future owners and maintainers of the system (vital).

PROFITRACE BENCHMARKING

What do we look for?

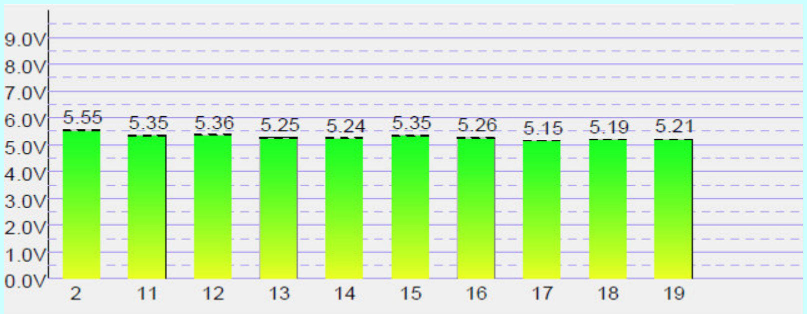
I mentioned earlier (Installation Tests) why we do this - so what do we look for using Profitrace for benchmarking.



+3v

-3v

Signal Waveforms – shows signal 'quality' and if reflections are present; any significant deviations from the 'ideal' should be investigated



7v

4v

Signal Bar-graphs – indicates average signal voltage profile along the network cable.

A voltage drop along the network is expected and is roughly proportional to network length.

A signal voltage < 4 v for a DP device should be investigated

PROFITRACE BENCHMARKING

What do we look for?

6 Tested subjects:

6.1 Slaves that have been lost at least one time:	None ✓
6.2 Slaves that generated diagnostics while in data exchange:	None ✓
6.3 Devices that have caused illegal responses:	None ✓
6.4 Device found on reserved address 126:	None ✓
6.5 Slaves that caused retries:	None ✓
6.6 Slaves that caused syncs:	None ✓
6.7 Parameters have been sent to the following slaves:	None ✓

Diagnostics Summary – network is monitored for a reasonable period; to catch the 'slow' errors.

If no problems noted in that time then high probability that all is OK

3 Network properties

Transmission speed:	500 kbps
Number of Masters:	1
Number of slaves:	5
Cycle time:	Min: 6.81 ms, Avg: 8.23 ms, Max: 9.65 ms

Message Cycle Times – does it look right for the number of slaves.

A cycle time can be estimated at the design stage or in the field and compared with the site actuality.

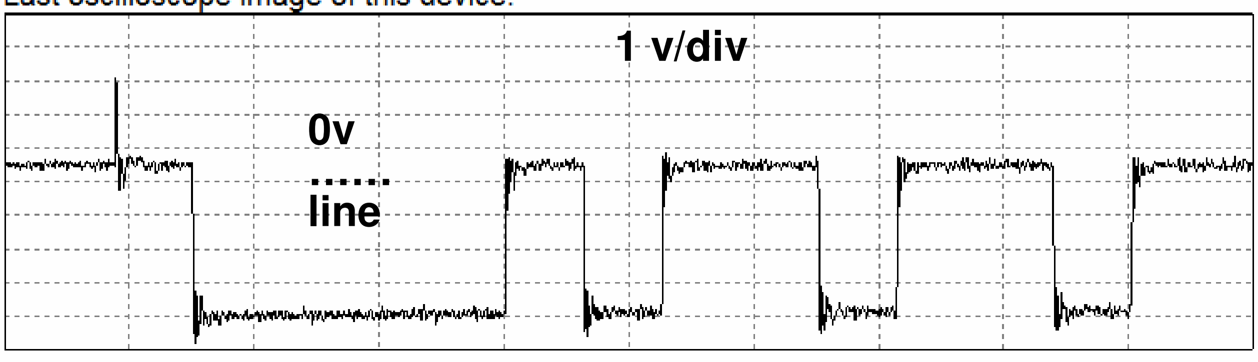
PROFITRACE BENCHMARKING

A poor example

Address: **15**

IdentNo:	Unknown
Manufacturer:	Unknown
Model name:	Unknown
Bytes I/O length:	8 inputs, 4 outputs
Signal voltage:	Min: 4.34 V, Max: 4.48 V, Last: 4.45 V
Diag count while DX:	0
Total retry count:	0
Times lost:	0

Last oscilloscope image of this device:



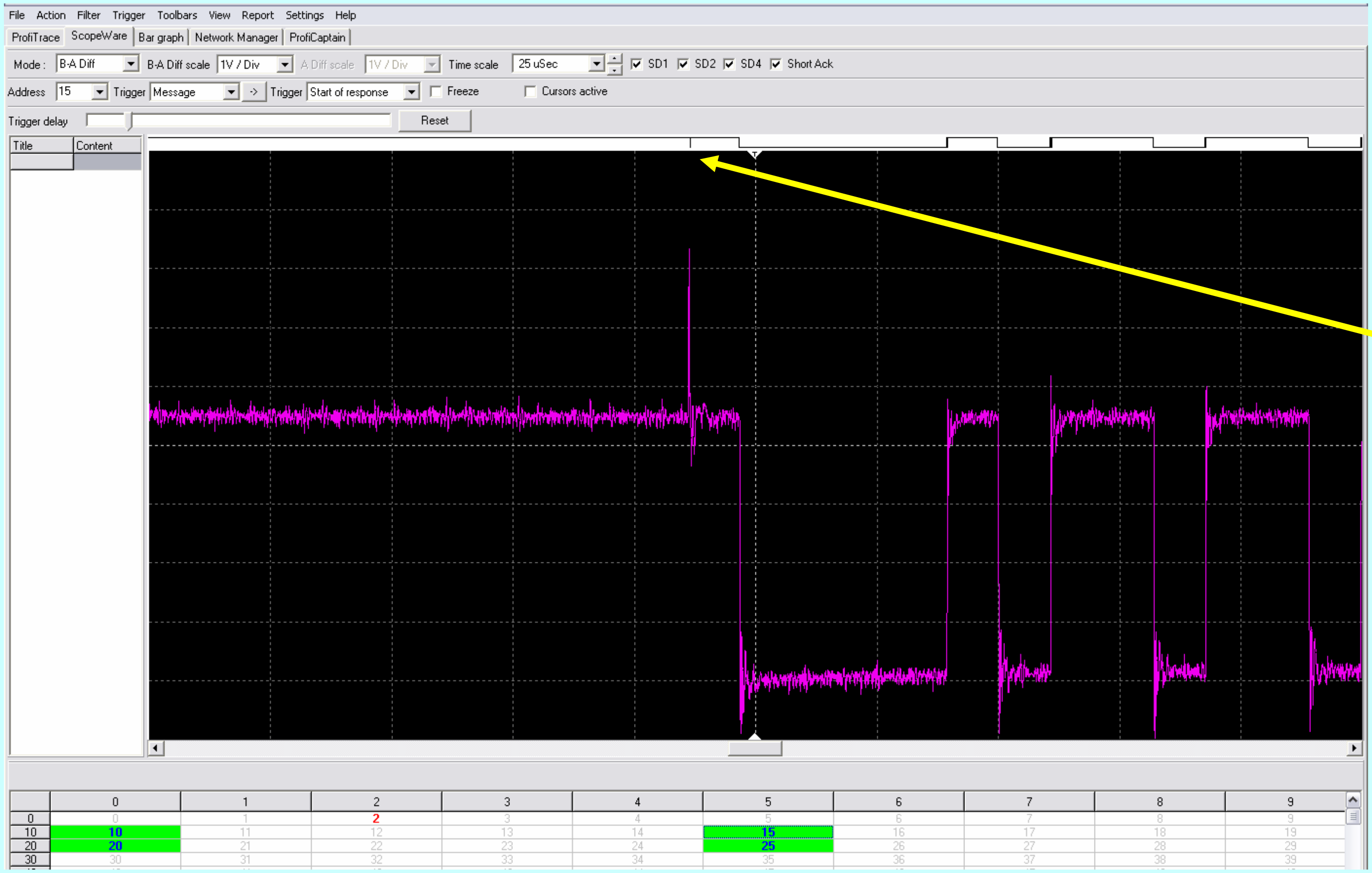
Probably the worst waveform I have ever seen

There is something radically wrong; I expect to see the signal top at about +3 v and the bottom around -3v

Signal top is at +0.5v and the bottom is about -4v

PROFITRACE BENCHMARKING

A poor example



A screen print of the bad waveform

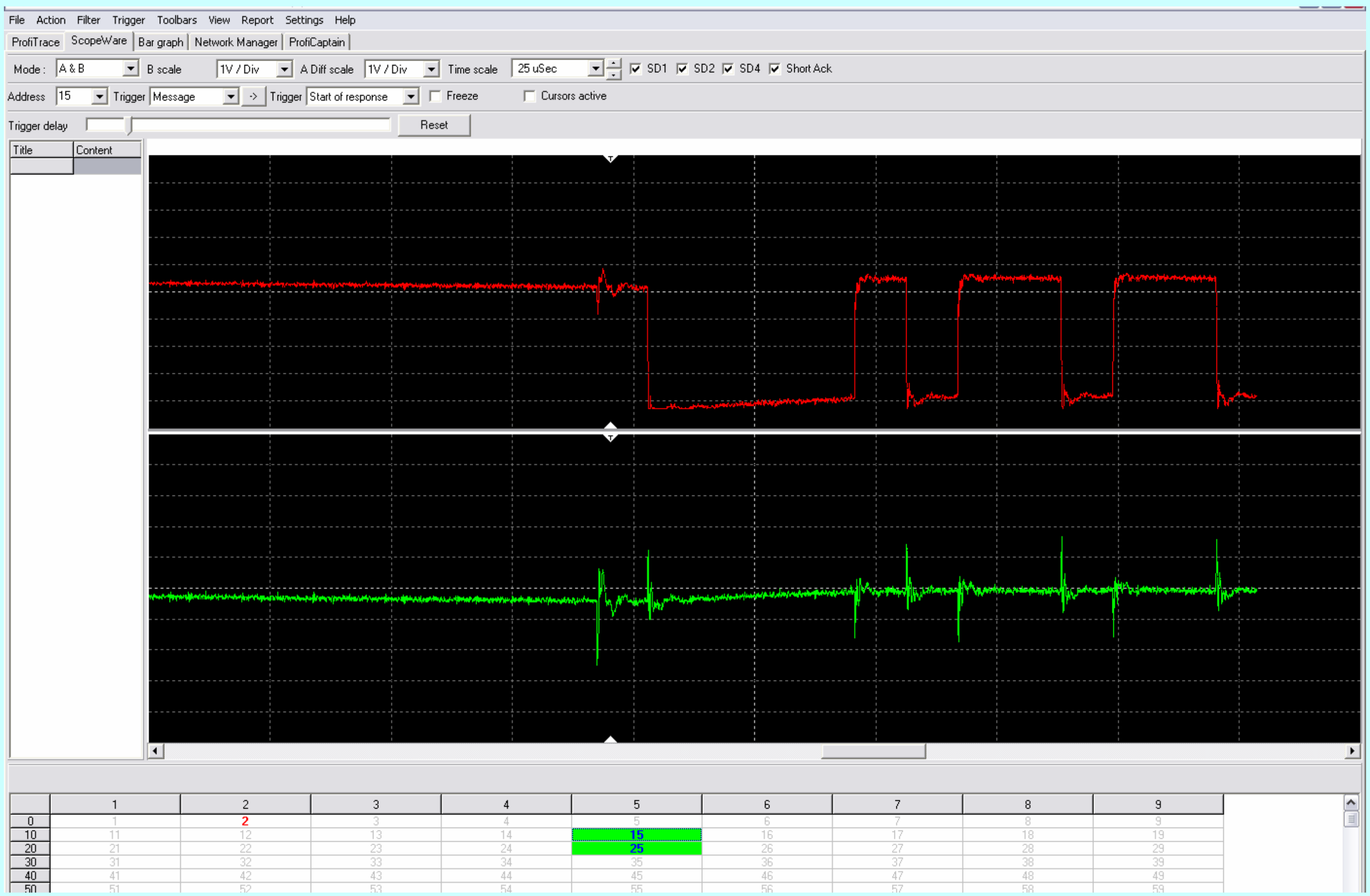
We can see a glitch – in this case it's in the 'quiescent period'

Multiple glitches were also seen in the message 'packet'

I found it amazing that the network still worked and only suffered occasional device 'drop-outs'

PROFITRACE BENCHMARKING

A poor example



As before but showing the waveforms on each cable core

The red signal (Data B) should be about +4v to +1v and not -ve

The green signal (Data A) should be about +4v to +2v and anti-phase to Data B.

It seems that there is no Data A signal

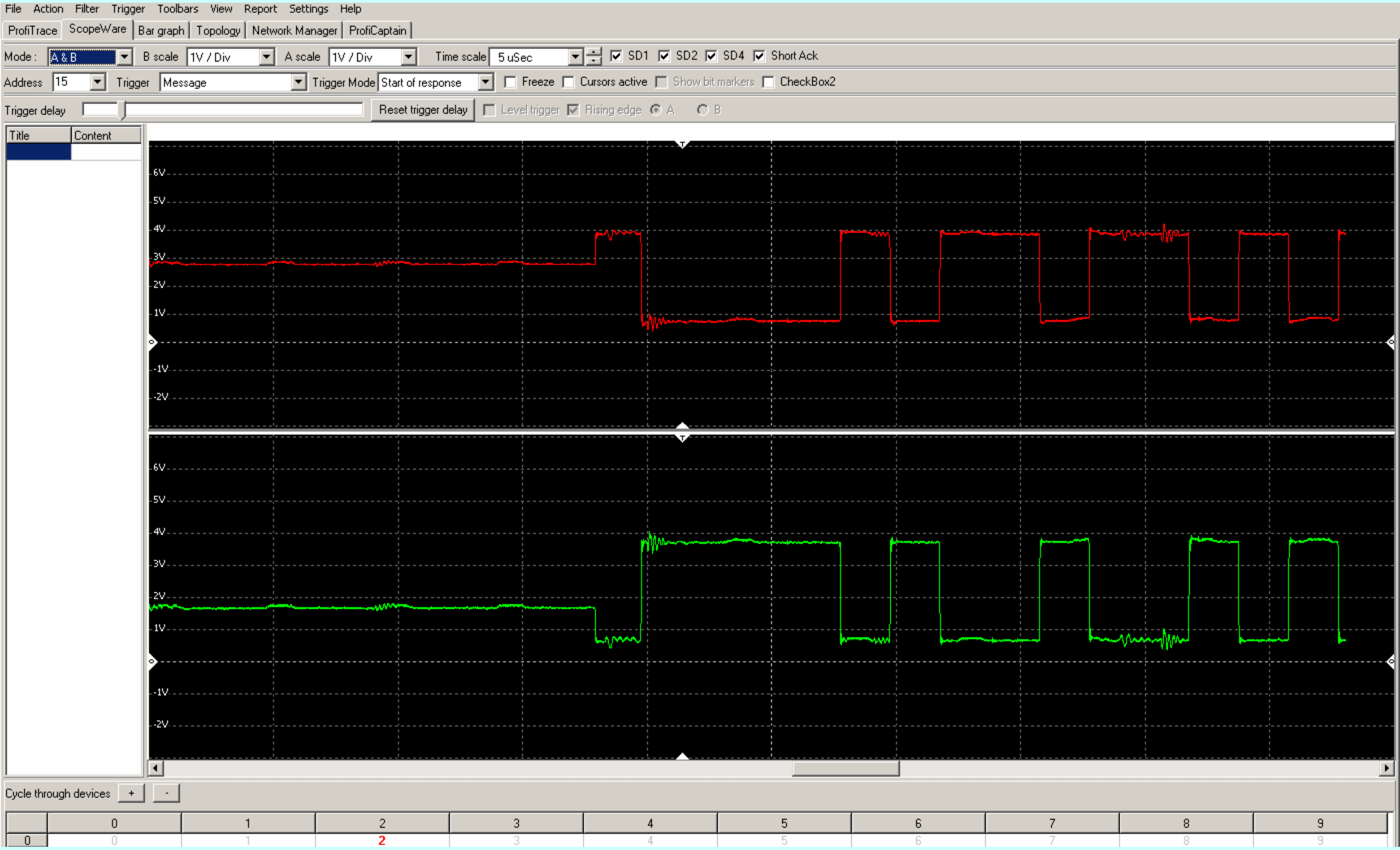
So what was wrong?

The installers had also connected a 4-20mA output signal to the valve actuator because they weren't sure what was needed !!

And it still worked !!

PROFITRACE BENCHMARKING

showing a good split (B&A) waveform



Both the B and A signal tops are at about +4v, with the bottoms at about +1v
The B signal is at about +3v in the 'quiet period' and the A signal is at about +2v
The two signals are clearly anti-phase.

SURGE PROTECTION DEVICES

aka Lightning Protection Devices

It is a Profibus need that wherever a network cable enters or exits a building then SPDs shall be installed because these cables are subject to lightning effects hence any attached devices are at risk.

UU sites tend to be large, on flat ground and in exposed locations.

This site is about 550mx220m = 12 hectares

Has 9 off installed PLCs, each fitted with between 2 and 6 off Profibus networks.

Each network has attached instrumentation and actuator devices located outside the local area control buildings.

To minimise plant failures and possible breach of regulations we install SPDs on all external Profibus cabling on all our sites.

SURGE PROTECTION DEVICES

What UU install

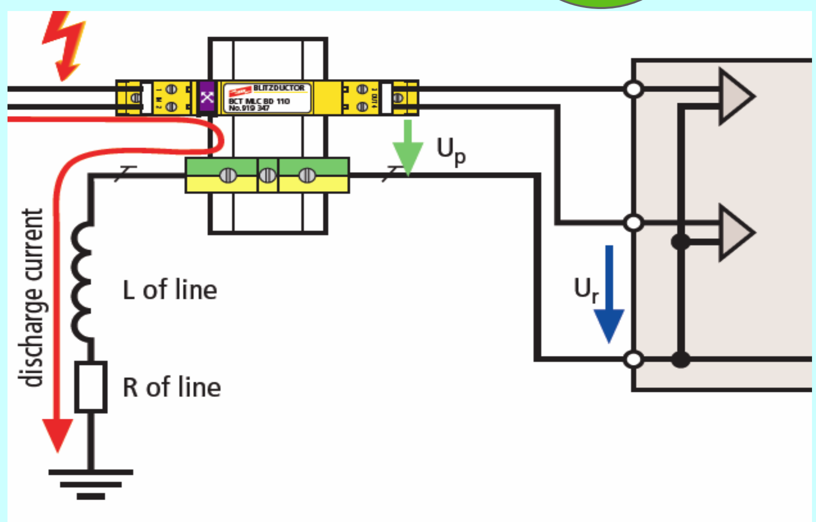
Because they are specified within the Siemens SIMATIC NET Profibus Networks Manual

We use the SPDs as provided by DEHN

Why DEHN?

DEHN provide different combined lightning current and surge arrester units for DP, PA and PA (IS) cabling

MTL also provide equivalent units as per the DEHN units



L and R of the line have no effect on U_r out of $U_r = U_p$

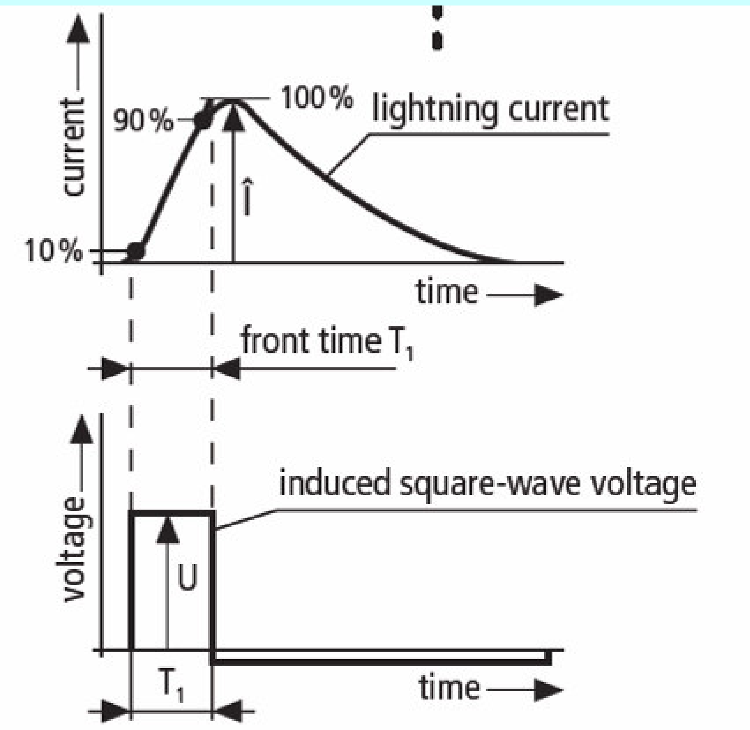
U_p = voltage protection level
U_r = residual voltage

Understanding and mitigating the effects of lightning on a system is a specialist and complex subject and we rely on the SPD manufacturer expertise and advice.

SURGE PROTECTION DEVICES

What are UU concerned about?

High voltages induced in Profibus cables caused by nearby lightning strikes (<1000 metres away)



Current reaches a peak in about 8 µS and falls to 50% of peak in about 20 µS

Induced surge voltage V= mL $\Delta i/\Delta t$

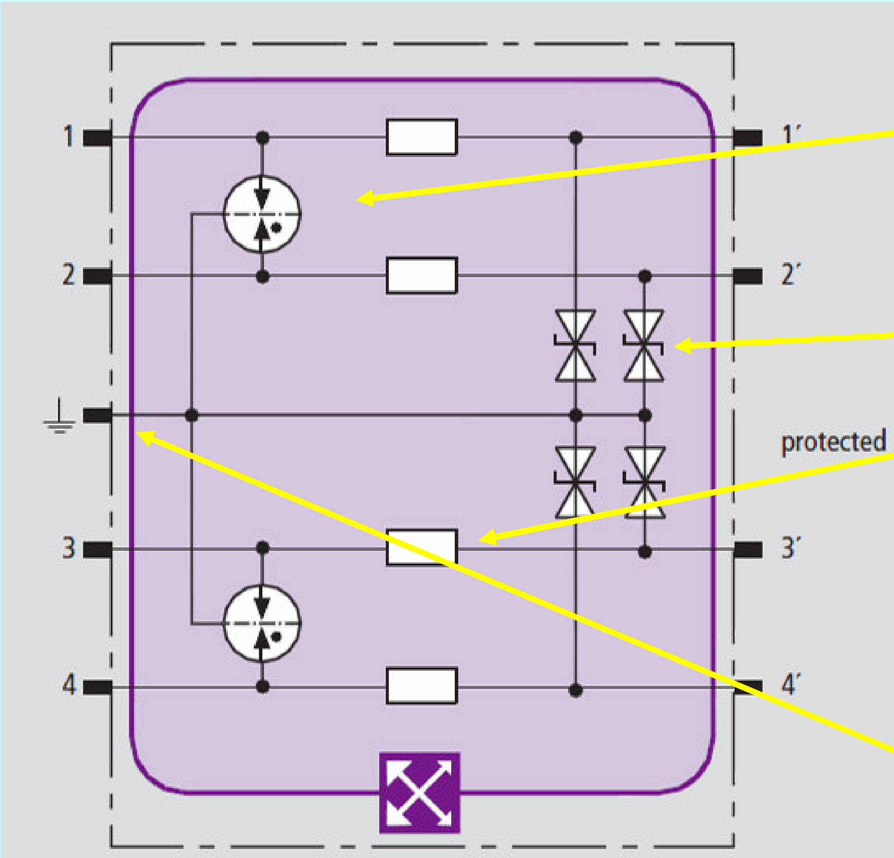
A surge voltage is in the order of kVs to a few 10s of KVs and is a high frequency (tens of kHz) pulse.

This is more than enough to destroy a Profibus ASIC chip

Even very low surge voltages can over-stress electronic components and cause eventual premature failure.

SURGE PROTECTION DEVICES

How they work



Gas Discharge Tube – slow to start but can handle very high surge currents

Suppressor Diode – fast voltage clamping but can only handle low surge currents

Series Impedance – approx 1Ω

When a surge current occurs then voltage rises rapidly

The suppressor diode quickly clamps the voltage and diverts surge current to earth.

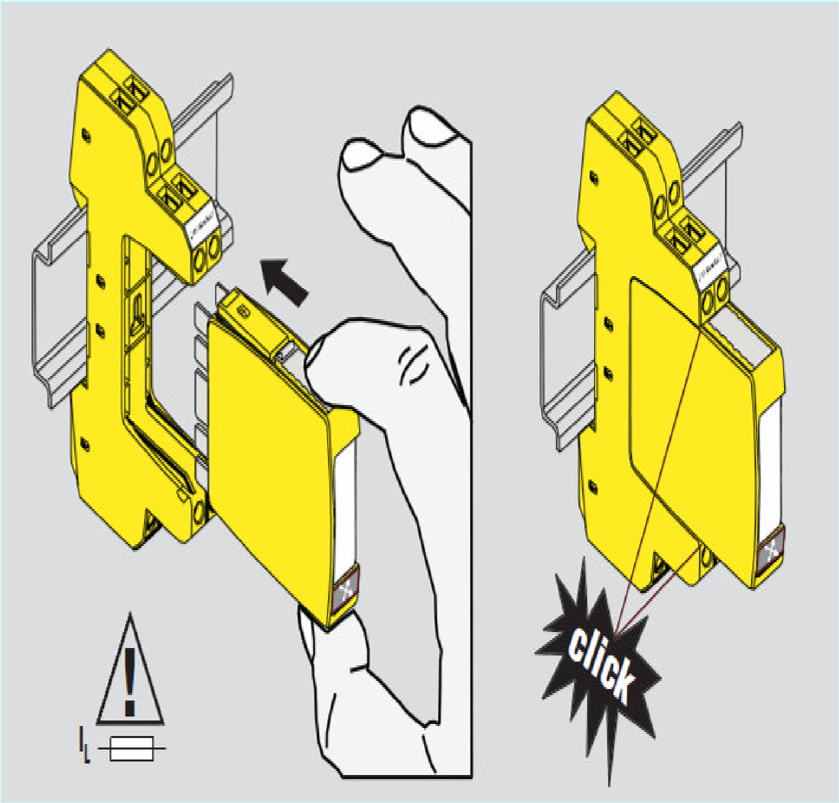
The GDT now fires and diverts large surge currents to earth.

When the surge disappears then the SPD automatically reverts to normal operation

Can handle about 10kA peak surge current – hence can withstand many lightning induced currents of about 125 A

SURGE PROTECTION DEVICES

Installation



The SPD base carrier is DIN rail mounted and provides the path to earth.

The SPD unit plugs into the carrier

For DP cable both the Red and Green cores and the braid shield are connected to the SPD

If the SPD is unplugged (or totally destroyed !) then the base carrier automatically provides a continuous signal path.

All SPD illustrations used are provided by kind permission of Dehn UK

Note – there is an insertion loss of about 20m DP cable length equivalent for each unit so must be allowed for in the segment length design

SURGE PROTECTION DEVICES

Installation Watch-points

They are supplied with an installation leaflet that highlights the major points – the installers must follow this.

Note the cable loops – the installers like to do this because it gives them room for error when terminating the cables

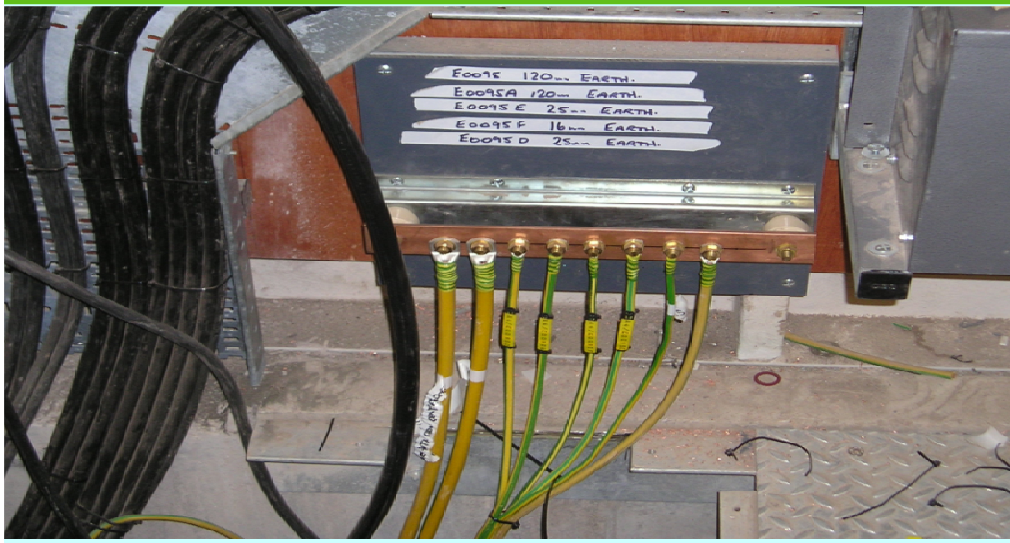
Mount them in a dedicated enclosure (ideally metallic) and no other equipment should be mounted in this enclosure.

The field cables and protected side cables must NOT be run in parallel at any point – else the surge voltage on the field cable may be coupled into the protected side cable.

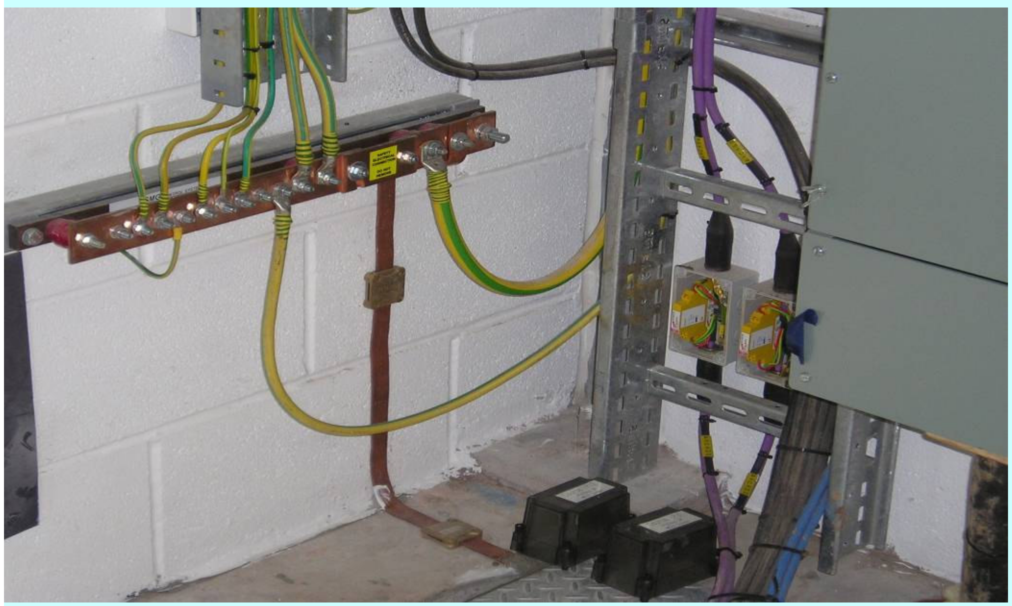
The metallic DIN rail MUST be bonded to the MET

SURGE PROTECTION DEVICES

Installation Watch-points



Mount them as close as possible to the MET for the building – to keep the earth bonding cable (min. 6mm^2 - we ask for min. 10 mm^2) as short as possible.



Almost right !!

2 off SPDs with no earth bonding cable installed even though only about 0.5m away from the MET.

QUESTIONS…….

Thank You…..

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