PROFIBUS

Course Document

Certified PROFIBUS Installer Course CPI

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PROFIBUS INTERNATIONAL

Course Title: **Certified PROFIBUS Installer**

Course Code: **CPI**

Course Duration: **1 day (including a 45min practical and a 45min theoretical examination)**

Grading Type: **Normal**

Credits: **Subject to approval**

Prerequisite: **No Formal Requirements but some experience and/or understanding of automation and relating technologies is recommended.**

Version 0.2
August 2006

Developed by the Working Group “Training” (WG9) within the Technical Committee for “Test and Certification” (TC1).

This Learning Outcome is one of a series of several courses:

4.712 Certified PROFIBUS Engineer
4.722 Certified PROFIBUS Installer
4.732 Certified PROFIBUS-PA Engineer
4.812 Certified PROFINET Engineer
4.822 Certified PROFINET Installer

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1 Aims & Objectives

It is widely accepted that a large percentage of the problems experienced on live PROFIBUS systems stem from poor layout and installation. This is often due to a lack of basic knowledge of layout and installation requirements and lack of experience in building and testing networks. Various handbooks and guidelines are available from PI describing the requirements and techniques for proper PROFIBUS network layout and installation. The objective of this course is to provide the theoretical knowledge and practical competence to layout, install, test and maintain PROFIBUS networks. The Course is suitable for those with no previous experience of fieldbus or digital communications networks. However, even experienced technicians can gain significantly from taking this course. The course provides a first stage of training course for those who are involved with the design, installation, commissioning and ongoing maintenance of PROFIBUS networks.

The course aims to give an introduction to PROFIBUS system terminology, operation and characteristics. It aims to provide a basic understanding of the problems that can occur in high speed digital communication systems, their causes and solutions. The various rules and guidelines for PROFIBUS network layout and installation are covered and practical techniques for implementing these are explored. Basic network and device testing techniques are covered; however these are limited to static methods, where the network is not operational. The course focuses on the techniques and practice of wiring for PROFIBUS DP and PA systems.

2 Learning Outcomes

The following learning outcomes specify what candidates will know or be able to do as a result of successfully completing the course. These learning outcomes are developed during the course and assessed during the tests.

On successful completion of this course candidates will be able to:	**Assessment Mode**
General PROFIBUS knowledge	
Know how PROFIBUS International is organised and know how to obtain information and support.	Theory Exam
Understand how repeaters, fibre-optic links and couplers can be used to segment a network.	Theory Exam
Understand the differences and commonalities between PROFIBUS DP and PA segments, devices and application areas. Understand where RS485, MBP and FO transmission are applied.	Theory Exam
Describe the available range of PROFIBUS addresses and know which addresses are reserved. Know how to set and check the address of a PROFIBUS device. Understand the effect of duplicate device addresses.	Theory Exam / Practical Exam

Describe the implications of using various network bit rates and understand the effects this has on network layout, performance and robustness.	Theory Exam
Appreciate the various devices that are found on PROFIBUS networks. Understand concept of network configuration and the function of GSD files and ID numbers in this process.	Theory Exam
Signal transmission and pickup	
Understand the basic mechanisms of interference pickup and apply a range of methods to avoid or reduce pickup on PROFIBUS cables.	Theory Exam
Understand the concept of balanced and unbalanced transmission and how these are affected by interference and ground currents. Understand that PROFIBUS uses balanced transmission.	Theory Exam
Understand the basic causes and effects of reflections on high speed communication systems. Recognise the many possible causes of reflections and how to avoid these. Understand the concept of “termination” and the importance of matching cable characteristic impedance.	Theory Exam
RS485 and MBP segment layout	
Describe the expected DC voltage, waveform shape and the minimum and maximum voltage levels for RS485 and MBP segments. Describe the tools that must be used for these measurements (i.e oscilloscope and volt meter).	Theory Exam
Apply the rules for RS485 and MBP segment layout in terms of cable length, spur lengths and number of devices.	Theory Exam
Know how to correctly terminate RS485 and MBP segments and recognise the many pitfalls that can lead to incorrect termination.	Theory Exam / Practical Exam
Understand the implications of device removal and know how to correctly use repeaters, isolating connectors, piggy back sockets and active terminators to build a maintainable network.	Theory Exam / Practical Exam
Understand the characteristics and limitations of DP/PA couplers and link modules. Know when to use each type of device.	Theory Exam
Understand the effect of segment isolation on the observed waveform when using repeaters, couplers and fibre optic segments.	Theory Exam
Installation practice	
Know how to correctly wire a range of PROFIBUS connectors, test an assembled cable for errors and locate any faults.	Theory Exam / Practical Exam
Understand the physical level differences between RS485 and MBP wiring. Understand the importance of using correct specification cable.	Theory Exam / Practical Exam

Understand the effects of using damaged cable. Understand the limitations of bend radius on PROFIBUS cable and the effect of exceeding this.	Theory Exam
Recognise the importance of cable segregation. Determine the required cable separation distances for a range of applications.	Theory Exam
Understand that trunking or conduit can be used to improve pickup performance.	Theory Exam
Describe the special requirements for networks operating at high-speed (>1.5Mbit/s).	Theory Exam
Understand and apply the grounding rules for DP and PA segments. Understand the problem of ground currents and the various ways to solve the problem.	Theory Exam
Intrinsically safe considerations	
Understand the need for intrinsically safe protection and the basic terminology and methods associated with this. Understand that both MBP and RS485 segments can be designed to be instrinsically safe. Understand that some aspects of these segments may differ from non-hazardous segments (for example: voltage, cable length and number of devices on PA and active terminations on RS486 IS segments etc.)	Theory Exam
Understand the additional rules that apply to IS installations (may be country dependent) and that uncertified test equipment must not be used in IS segments (e.g. multimeters, analysers or oscilloscopes)	Theory Exam
Fibre optics	
Understand the various benefits of using fibre optic segments.	Theory Exam
Understand that optical signals are attenuated by optical fibre and connectors and that this can limit the optical segment length.	Theory Exam
Understand that fibre optic segments must be installed and tested by trained and qualified people.	Theory Exam
Compare the cost and relative characteristics of plastic and glass, single and multi-mode fibres.	Theory Exam
Appreciate that optical segments can be used to implement line, ring, tree and star topologies and redundant systems.	Theory Exam

3 Instructors

The instructor(s) must have passed the Certified PROFIBUS Engineer Course as a minimum and must be registered with PI.

4 Training and assessment methods

The training should cover the topics listed in the syllabus below and must cover the required learning outcomes. An example slide-set in English is provided by PI as a guideline. The delivery may be customised and formatted to suit the desires

of the instructor and the needs of the candidates. The training must include a significant practical element in which the candidates build and test a small network and practice finding faults on pre-made test cables.

It is a good idea to include a short tutorial session in which revision/practice questions are answered and checked with the aid of the instructor. The tutorial questions should generally be open-ended to promote discussion and explore any weaknesses or misunderstandings the candidate(s) may have. If possible, pictures of poorly installed networks and wiring errors from real installations should be included to give realism to the training.

5 Syllabus

5.1 General Overview [1 hour]

- ☐ The concept of fieldbus and the differences between analogue and digital communication and networked and non-networked communications.
- ☐ The PI Organisation and support: RPAs, PICCs and Test Centres. Finding the PI web site.
- ☐ Basic characteristics and operation of PROFIBUS networks and its application areas. The position of fieldbus and Ethernet in the control system hierarchy.
- ☐ Overview of FMS, DP and PA and the 7-layer OSI model. Differences and commonalities between DP and PA solutions. Application of RS485, MBP and FO transmission.
- ☐ The concept of a network and segmentation using repeaters, fibre-optic links and couplers.
- ☐ Master and slave devices, Class I and Class II masters. Concept of cyclic communication with multi-master systems.
- ☐ Device addressing, available and reserved addresses. Methods for setting the device address.
- ☐ Concept of bit rate (Baud rate). Standard PROFIBUS bit rates. Bit rate setting and automatic detection.
- ☐ Basic principle of PROFIBUS network configuration. GSD files and ID numbers.

5.2 Signal transmission and pickup concepts [45 min]

- ☐ The basic mechanisms of interference pickup on signal cables: electrostatic and electromagnetic coupling. How to avoid or reduce each type of pick up.
- ☐ The concept of balanced and unbalanced transmission and how these are affected by interference and earthing. Use of balanced transmission within PROFIBUS and the importance of proper screening and earthing.
- ☐ Causes and effects of reflections within communication systems.
- ☐ The concept of cable characteristic impedance and matching end of segment terminations. The PROFIBUS RS485 active termination network.
- ☐ Effects of stub-lines, mismatched or damaged cable, missing and additional terminations, un-powered terminations and uncertified devices.

5.3 RS485 wiring [1 hour]

- ☐ Waveform shape and minimum, maximum voltage level requirements.

- ☐ Basic RS485 segment layout rules, device loading, cable lengths and permitted stub line lengths. Use of repeaters and hubs.
- ☐ Termination rules and pitfalls (multiple and hidden terminations, un-powered termination no termination on stub lines etc.)
- ☐ Standard PROFIBUS connectors for RS485 (9-pin sub-D and 5-pin M12). Optional and mandatory pin allocation. M12 termination schemes.
- ☐ Correct wiring of connectors. Use of piggy-back sockets and isolating connectors. Connectors for stranded and solid core cables.
- ☐ Special requirements for bit rates greater than 1.5Mbit/s.
- ☐ Maintenance issues: device removal, test tool access, use of isolating connectors and separate active terminators.
- ☐ Cables for PROFIBUS RS485. Cable specification (type A only).
- ☐ Hand-held cable test tools. Features and operation. Techniques for locating errors due to shorts and open circuits. Cable length and reflection measurements. Bus scan and device test facilities.

5.4 MBP wiring [45 min]

- ☐ DC voltage requirements and waveform shape and minimum, maximum voltage level requirements.
- ☐ Basic segment layout, device loading, cable lengths and permitted stub line lengths.
- ☐ MBP termination and rules.
- ☐ Wiring options for MBP; junction boxes and 4-pin M12 connectors.
- ☐ DP/PA Links and Couplers; limitations and characteristics.
- ☐ MBP segment and spur line length rules.
- ☐ Cables for MBP. Cable specifications.

5.5 Shielding, grounding, segregation and installation [45 min]

- ☐ Basic rules for grounding RS485 and MBP segments.
- ☐ Cable segregation for avoidance of pickup.
- ☐ Use of trunking and cable trays.
- ☐ The earth loop problem and solutions. Potential equalisation, capacitive grounding, fibre optics.
- ☐ Special requirements for internal cabinet wiring; cable screen grounding on entry and exit, segregation, wiring devices in close proximity, problems due to excessive cable bending.
- ☐ The importance of accurate documentation, i.e. “as installed”, not “as designed”.

5.6 Intrinsic safety considerations [20 min]

- ☐ Basic Intrinsic safety considerations. Terminology and basic techniques.
- ☐ Overview of FISCO rules and effects on network layout. Use of certified devices.
- ☐ Shielding & grounding rules, special requirements for intrinsic safety (may be country dependent).
- ☐ The Certified Installer should be aware of the existence of RS485-IS solution; however the details of this are outside the scope of this course.

5.7 Fibre Optic and other transmission methods [15 min]

- ☐ Overview of fibre optic transmission and advantages over copper.

- ☐ Characteristics and limitations of plastic and glass fibres; single and multi-mode transmission; dual and single channel optical links.
- ☐ Redundant rings, star and line topologies. Awareness that optical links must be setup for the correct topology.
- ☐ The Certified Installer should understand the concept of optical signal attenuation and know that long fibre runs, splices and fibre optic connectors can increase attenuation. Attenuation must be measured before fibre segments can be used.
- ☐ The Certified Installer should be aware that the making and testing of glass fibre optical cabling is a highly skilled job requiring expensive specialised equipment; however the details of this are outside the scope of this course.
- ☐ The Certified Installer should be aware that other types of transmission are possible (e.g. Infra-Red, RF etc); however the details of this are outside the scope of this course.

6 Typical Practical Work

- ☐ Correctly connect and test an RS-485 cable with at least three isolating connectors.
- ☐ Terminate the cable properly and check with a hand-held tester to confirm the termination settings.
- ☐ Explore the effects of excess and missing terminations on the cable tests
- ☐ Scan network for attached devices.
- ☐ Set slave addresses to new required values and observe the requirement for cycling the slave power, Check the slave addresses.
- ☐ Check the station termination voltage level.
- ☐ Diagnose and locate a fault on a pre-made test cable.

7 Training Equipment

The following description of training equipment represents a minimum requirement and is included as a guide only. Each PITC (PROFIBUS International Training Centre) is free to decide on the precise type of equipment and its configuration. The practical setup must be suitable for the teaching and practice exercises and for the practical test.

Example set-up:

A typical training kit should meet the following minimum requirements:

- It should have at least two slave devices with standard connectors. Ideally one slave should be a modular device and one compact. If possible the slaves should incorporate two different methods of setting the address (i.e. one with rotary switches and one with binary or DIP switches).
- The slaves should be mounted together with a suitable power supply. Note that manufacturer's electrical safety instructions should apply to the power supply wiring.
- Sufficient cable, connectors and installation tools should be provided to allow the slaves to be wired into a single segment.
- No more than two candidates should share a training kit.
- Each pair of candidates will require a hand-held test tool.

- Optionally a class 1 master or master simulator can be included to exercise the network; however this is not a course requirement.
- A set of pre-made test cables each with at least four connectors and a single defined built-in fault (e.g. short circuit, open circuit, crossed wires etc). The test cables should be easily identifiable and the connectors should be numbered.

8 Assessment Scheme

The assessment is a combination of practical and theory examinations. Candidates must pass both components to pass the course. A score of 70% is required to pass each component. All testing is “open book”, that is the candidate can use the course notes and other reference material freely during the test.

Practical Test (45mins)

Build and test a PROFIBUS cable	50%
Set device addresses to the required new values. (Note that the instructor/examiner should check the correct wiring and setting of the slave addresses when complete.)	20%
Locate and describe the fault in a given (unseen) test cable.	30%

Theory Test: (45mins)

The exam questions are to be picked from a central database of questions. This database is set up and administered by PI. Each question in the database is given a percentage weight. Each PITC should select appropriate number of questions from each section to achieve the approximate breakdown given bellow.

General PROFIBUS knowledge:	15%
Signal transmission and pickup:	25%
RS485 and MBP segment layout	10%
Termination requirements and pitfalls	15%
Installation practice	10%
Intrinsic safety considerations	10%
Fibre optics	15%

9 Text Books and references

1. PI PROFIBUS Installation Guide for Cabling & Assembly, Order No: 8.022
2. PI Installation Guideline for PROFIBUS-DP/FMS, Order No: 2.112
3. PI PROFIBUS PA User and Installation Guideline, Order No. 2.092
4. PI PROFIBUS Interconnection Technology Guideline, Order No. 2.142

