

Technology of Distance Measurement and Monitoring for Power Conversion and Intelligent motion

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Abstract:

Technology of distance measurement for simple laboratory conditions as well as industrial processes is described in the paper. Laboratory experiments can be controlled with the use of a simple GPIB card or other measurement cards and with the use of a dedicated software. Industrial processes on the other side use sophisticated fieldbusses. In the paper different solutions are suggested and compared.

1. Introduction

Distance measurement of Power electronic and Intelligent Motion systems is used for several reasons. Internet as well as local (LAN) computer network intranet makes it possible to create solutions useful for industry as well as education. Industrial applications differ from the laboratory in the amount of data transferred, number of connected devices, length of bus (cable length) and number of measured signals.

The possibilities of using distance measurement in laboratory application are: PXI or VXI systems, GPIB interface or Data Acquisition Card. The card consists of several A/D converter coupled with an interface that allows a personal computer to control the actions of the A/D, as well as to capture the digital output information from a conversion.

Solutions used for laboratory applications and described below can use only limited number of measurement instruments and number of controlled processes. Information transferred is usually simple. The GPIB interface (which is used in presented solution of distance laboratory) can connect max. 15 devices to the bus. The speed is up to 1MB/s and max length of the cable is 20m. Therefore industrial solutions are based on different principles. As an example of industrial bus (fieldbus) is Profinet described with the speed of bus of 10/100/1000 MB/s and number of connected devices unlimited.

In the first part of the paper a distance measurement application for educational purposes is described. In the second part monitoring and industrial applications are studied.

2. Online distance laboratories

Online distance laboratories are the latest trend also in education. The same technology can be used for measurement on distance of simple

power conversion and intelligent motion equipment. For educational purpose the hardware experiment should therefore be adapted in such a way that it can also be accessed from the Web. In this way the advances in ICT will be combined with the real world.

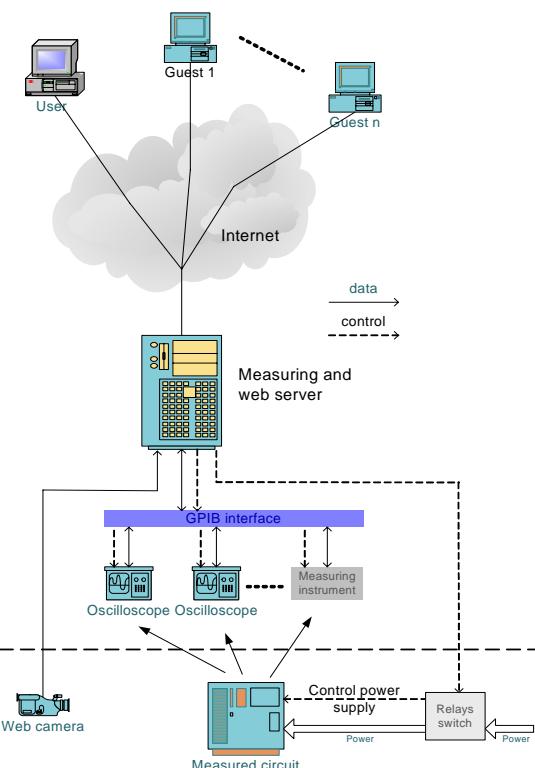


Figure 1. Principle structure of distance laboratory

The proposed virtual (distance) laboratory is not a web-based simulation. It is a real electro-technical experiment conducted in the laboratory, but it is remotely controlled and monitored by

web-based tools. It is even possible to visualize the measuring instrument, the electronic components and many more factors such as layout, for example. This facility is useful to fulfill today's requirements for teaching over the Internet.

An example of such a system is given next. The system includes a number of subparts. The principle functionality is showed in Figure 1. There are several parts of the system. The main part is the 'Measuring and web server'.

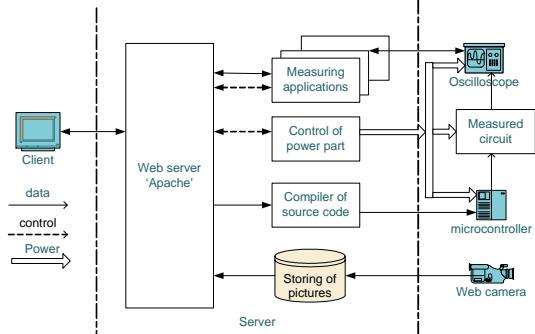


Figure 2. Principle of server functionality

The services: communication with the measurement instrument, the control of the power supplies of all the components and the displaying of the web pages with measured values, are provided by the computer. The measuring instruments, which are connected to the server, will be described later. The users are divided into groups: the authorized users and the guests. Only authorized users can control the measurement. The guests can observe measured values but they can't control any part of system.

3. Web and measuring server

The main part of the system is the web server, which is responsible for all the web services, web pages and the correct functionality of the user interface. The web server also communicates with other applications (Figure 2) which can access the other parts such as the measured data. The parts, which cooperate with web server, are:

Measurement application: Most of the similar applications use LabView [7]. In the case described here the measurement application communicates with measurement instruments via a GPIB interface. This application was written in a Matlab environment and finally compiled / built as an executable application. Matlab has to be installed together with its "Instrument Control Toolbox" to provide communication via the GPIB interface. This toolbox is a general programming

interface, controlling all instruments equipped with a GPIB interface.

Control of power part: There is an application, programmed in C++ language, which controls the on and off switching of the power supply of the measuring instruments and the measuring board. The data bits of a parallel port are used as a control signal. A built in remote controller controls the power switches by means of radio waves (see Figure 3).

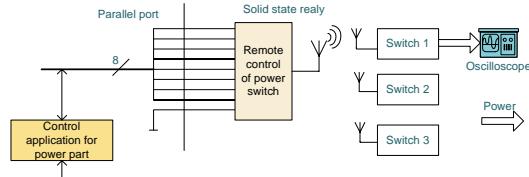


Figure 3. Principle of power controlling.

Compiler of the source code: The source-code compiler for the XC866 microcontroller is also included in this system. The usage of the compiler will be explained later. The selected microcontroller is a XC866 from Infineon [8]. This 8-bit microcontroller features a system on chip that has been developed for all kinds of motion control using PWM based schemes. The microcontroller used in this system is commercially available in an evaluation kit. The PC is connected to this starter kit via the communications port, COM1. After the user sends the source code to the microcontroller, it is compiled and translated to a hexadecimal-executable file and then loaded in the microcontroller. The programming language used for the microcontroller is C. Users can use all the available features of the C language and in addition they can also use the special registers as variables.

Software

The main functional part is the connection between the web server and the measuring applications which in turn communicate with the measuring devices themselves. In Figure 4 (left) a simple state diagram of the web page is shown. The 'DelftWebLab page' bubble represents the web page with measured data. From this page the user can run the measuring application (dash line). The two arrows pointing away from the "DelftWebLab page" bubble represent some events which might occur. The first event, namely the 'On change settings of the measurement instruments', occurs when some parameters are changed e.g. the vertical scale of the scope, etc. The second event occurs periodically, refreshing the web page to show the latest measured data.

On the right side of this figure, there is a block diagram of a measurement cycle. The grey lines represent the cooperation between the functionality of the web page and the measuring application. When the measuring application is launched, the program periodically controls the measuring instrument, reads the measured data and stores the measured data to a file.

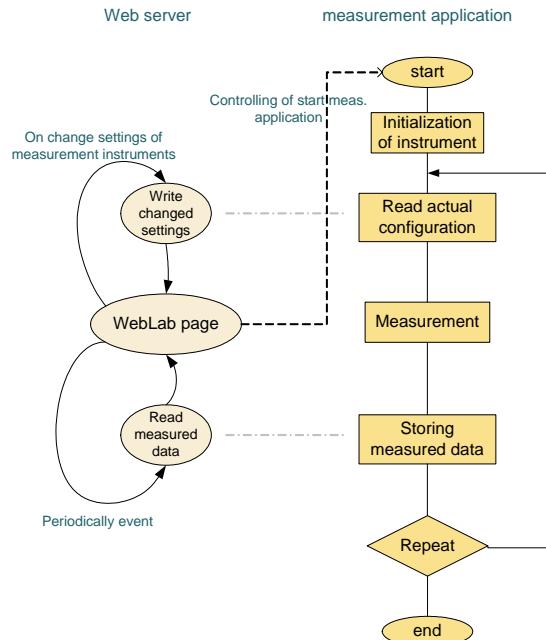


Figure 4. Cooperation of web server and measuring application

4. Monitoring and Industrial Applications.

In typical industrial application is the need to monitor and control many processes (up to 100). All of these nodes of network are plugged to one bus – fieldbus. There are many types of fieldbus. The using of particular fieldbus depends on many factors as are required transfer rate, length of fieldbus, and number of plugged nodes (Table 1). The differences between laboratory buses (see chapter I – GPIB) and industrial buses is the number of plugged nodes, level of noise, operational environment, complexity of measurement system, etc.

The idea of this chapter is to show how is able to monitor and control processes connected to a fieldbus over the Internet. The principle of web monitoring is in Figure 5.

From many types of fieldbus (e.g. Profibus, AS-interface, Profinet, Foundation Fieldbus, CAN ...) was chosen two fieldbus: Foundation Fieldbus and Profinet.

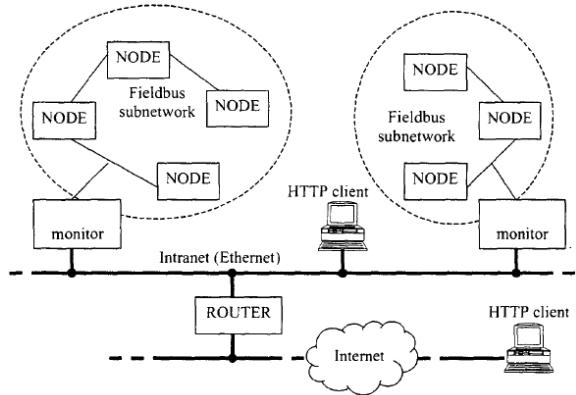


Figure 5. Web monitoring and controlling of fieldbus

Fieldbus

Fieldbus is a generic term used to describe a common communications protocol for control systems and/or field instruments. Although some standard forms have been agreed for instruments, the DCS (Distributed Control System) industry as a whole has so far no agreed fieldbus.

The main function of fieldbus is to create information networks, which interconnect the devices. The intelligent sensors and devices, which have implemented certain degree of independency, are used in modern industrial production. There are several types of fieldbusses: Sensorbus (sensor bus), Devicebus (which interconnect the devices) and Fieldbus (higher level of complexity). Detailed description of these busses in following Table 1:

Table 1. Division of fieldbus

	Senzorbus	Devicebus	Fieldbus
Application area	Discrete systems	Discrete systems	Industrial process
Typical control system	PLC	PLC	Distributed control
Typical data size	1 Byte	Up to 100 Byte	Up to 1 000 Byte
Application of microprocessors	No	Yes	Yes
Implemented intelligence	No	Partially	Yes
Diagnostic	No	Simple	Sophistic
Time response	Up to 5 ms	Up to 5 ms	Up to 1s
Distance of bus	Short	Short	Long
Example of used device	Simple sensor	Sensor with auto test	Intelligent valve with PID control
Implementations	CAN, Seriplex, ASI, LonWorks	CAN, DeviceNet, ProfibusDP, SDS, Interbus-S	IES/SP50, Fieldbus Foundation, Profibus PA, WorldFTP

Hierarchy of fieldbus

The hierarchy of fieldbus illustrate following picture. As it shown, the Industrial Ethernet is situated above other fieldbuses and over the Industrial Ethernet is Ethernet. This view of hierarchy allows monitor or control single processes (on the lowest level) by the Ethernet. The communication through Ethernet includes the intranet/Internet communication.

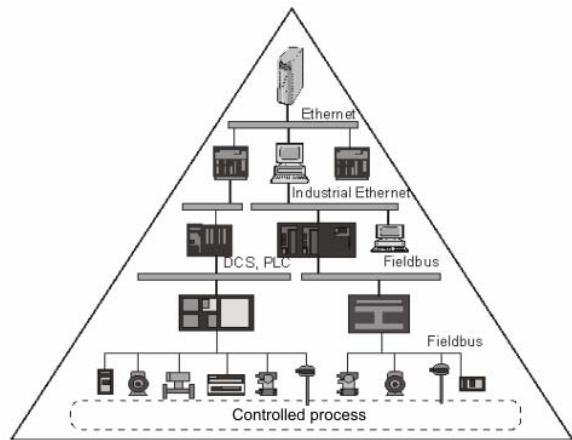


Figure 6. Hierarchy of fieldbus

4.1 Foundation Fieldbus

The open, nonproprietary Foundation architecture provides a communications protocol for control and instrumentation systems in which each device has its' own "intelligence" and communicates via an all-digital, serial, two-way communications system.

Foundation H1 is intended primarily for process control, field-level interface and device integration. Running at 31.25kbit/s, the technology interconnects devices such as transmitters and actuators on a field network. H1 is designed to operate on existing twisted pair instrument cabling with power and signal on the same wire.

Foundation H1 devices comprise a function block application, act as a publisher and subscriber of process variables, transmit alarms and trends, and provide server functionality for host access and management functions. Devices can act as a scheduler and time master for regulating communication on a fieldbus segment. They are also used for bus interfaces in process control systems or in linking devices. Capable of controlling bus communications and many connections to multiple devices, they support both client and server applications.

A characteristic of the Foundation architecture ensuring device interoperability is its use of a fully specified, standard User Layer based on "Blocks" and Device Descriptions (DDs).

Blocks are incorporated into fieldbus devices to achieve the desired device functionality, as well as to define a wide range of features and behaviors that must work in a standard way for devices to interoperate.

Each block's parameters are represented by object descriptions that define how the parameters are communicated on the fieldbus network. The Function Block Application Process (FBAP) represents a very comprehensive application model that, in conjunction with the protocol, provides the technology that allows devices from different manufacturers to interoperate. As specified by the FBAP, a fieldbus device must have a Resource Block and at least one Function Block with input and/or output parameters that link to other function blocks, either in the same device or in separate devices by means of the bus. The "link object" defines the connection. Each input/output parameter passed will have a value and a status. The status portion of each parameter carries information on the quality of each value, of good, uncertain or bad.

Foundation HSE

High Speed Ethernet (HSE) is ideally suited for use as a control backbone. Running at 100 Mbit/s, the technology is designed for device, subsystem and enterprise integration. HSE supports complex logic functions, such as those performed by Programmable Logic Controllers (PLCs), or data-intensive process devices, such as analyzers and gateways to other networks. HSE enhances access to H1 fieldbus technology via linking devices.

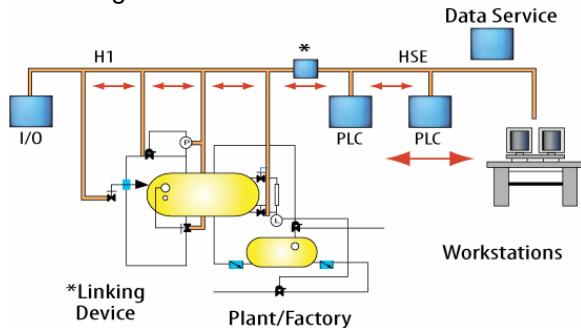


Figure 7. Fieldbus topology

HSE provides the same benefits as H1, but at the subsystem integration level instead of the field device level. It supports interoperability between disparate controllers and gateways in the same way that H1 supports interoperability between transmitters and actuators from different suppliers. FFBs in HSE devices can be set up using programming languages such as those found in the international standard IEC 61131-3.

4.2 Profinet

In today's automation technology, Ethernet and information technology (IT) is increasingly calling the shots with established standards like TCP/IP and XML. Integrating information technology into automation allows significantly better communication options between automation systems, extensive configuration and diagnostic possibilities, and network-wide service functionality. These functions have been an integral part of PROFINET from day one.

PROFINET uses Ethernet as well as TCP, UDP, and IP as the basis for communications. TCP/IP is the de-facto standard for communication protocols in the IT arena.

Distributed I/O with PROFINET IO

Distributed I/O (Remote I/O) is connected through PROFINET IO. Here, the familiar I/O view of PROFIBUS is retained, in which the user data from the field devices are periodically transmitted into the process model of the control system.

PROFINET IO describes a device model, consisting of places of insertion (slots) and groups of I/O channels (subslots). The technical characteristics of the field devices are described by the GSD (General Station Description) on an XML basis.

Configuration of PROFINET devices

The decentralized field buses are assigned to one or more control systems during configuration. During engineering the IO-Device is to be configured to the actual system expansion based on the content in the GSD file. The IO-Device is simultaneously integrated, appropriately parameterized and configured into the PROFINET topology (1) – see Figure 7.

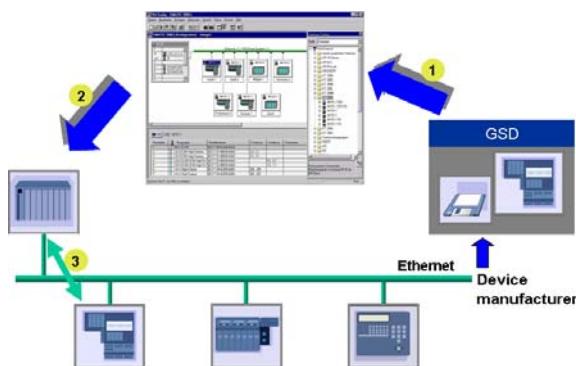


Figure 8. Principle of the Profinet solution

After completion of the engineering process, the installer loads the data for the expansion into the

IO-Controller (2). The IO-Controller independently takes over data exchange with the IO-Device (3).

Profinet cooperate with "PROFINET IO Controller Software" which can enhance a product (controllers, application software) with an Ethernet connection to include PROFINET IO Controller functionality

PROFINET CBA is a groundbreaking concept for industrial automation which fulfills the requirements of plant builders and operators for a system-wide and manufacturer-spanning engineering process. The PROFINET component model sees its real use in distributed automation systems. It is ideally suited for intelligent field devices with programmable functionality as well as controllers.

PROFINET CBA is based on the object-oriented modeling of technological modules. Based on the object model, machines and installations are structured in PROFINET in the form of technological modules. The functionality of the technological modules is encapsulated in uniform PROFINET components. From the outside, PROFINET components are accessed through uniformly defined interfaces. They can be arbitrarily connected in this way.

PROFINET based on a component model is described using a PCD (PROFINET Component Description). It is XML-based and can be generated either by the Component Generator or a manufacturer-specific configuration tool.

A vendor-independent engineering concept was created for the user-friendly configuration of PROFINET CBA systems. The engineering differentiates between the programming of the control logic of the individual technological modules (component generation using manufacturer-specific configuring tools) and the plant configuration which determines the communication relationships between the technological modules (using a PROFINET Connection Editor). As last engineering step, the connection information and configuration data are downloaded to the PROFINET

4.3 Web Integration

A PROFINET station can also be accessed by an application using Web clients based on standard technologies from the Internet sector, like HTTP, XML, HTML, and scripting.

The data is transmitted in a standardized format (HTML or XML) and displayed using standard front ends (browsers like Netscape, MS Internet Explorer, Opera, etc.) This enables the integration of information from PROFINET

components into modern multimedia-supported information systems.

The basic component of Web integration is the Web server. It forms the interface between PROFINET and the basic technologies for Web integration.

Possible usage scenarios for Web integration in the areas of commissioning and maintenance are, among others, testing and commissioning, an overview of device master data, device diagnostics, and installation and device documentation.

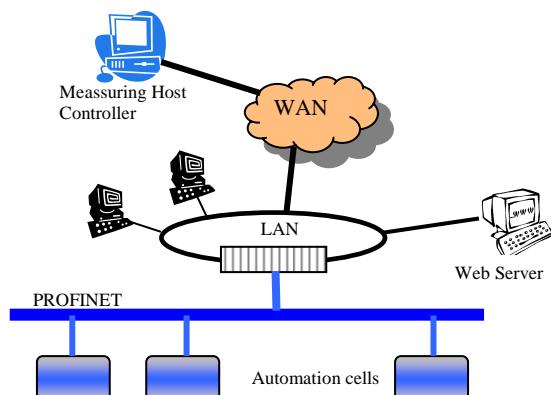


Figure 9. web integration in Profinet

Web integration in PROFINET can scale up with the performance and characteristics of the Web server. This means that even simple PROFINET devices, equipped only with an "embedded Web server", have equal rights with a PROFINET device with an "MS Internet Information Server" or the "Apache Web server" when participating in Web integration.

Web integration in PROFINET is designed in such a way that it can optionally be available for each device. Certain functions are optional and can be added according to the capabilities of the device. This makes scalable solutions realizable which are configured as perfectly as possible for the current application case. The PROFINET-specific elements can be integrated seamlessly into the existing Web implementation of a component.

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