PRACTICAL PROJECTS ‘PON P-NET

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Fieldbuses are beginning to be recognised by an increasing number of project designers, as a reliable and economic means of connecting sensors, actuators, drives and motion controllers together, within a single or multi-fieldbus network.

The paper describes practical implementations of P-NET, ranging from Engine management on ships, through Cement Product manufacturing plants and Textile Production, to automatic Pig Feeding systems, which have been installed during the past 10 years.

Aerial View of Neckelmann Textile Plant

INTRODUCTION

When considering the design of a measurement and control system using a fieldbus, a design team needs to address a number of specific factors.

Will the physical layout of the system be spread over a wide area, or restricted to the confines of a single machine? Aspects of measurement may include those as diverse as temperature, density, pressure, level, weight, flow. Can the fieldbus support these requirements in terms of hardware availability? Control of processes and drives may require closed loops. Does the hardware provide PID and remote programmability? Would it be convenient to divide the project into sections, each part dealing with a particular aspect of plant operation, or is a single communication path sufficient? What about the speed of measurement and control set point transfer ? How important is the response time for a binary command from one part of the system to the other. Is it necessary for a fieldbus input/output node device to respond to fast changes (>20 KHz) in sensor or control states?

PROJECT ANALYSIS

There are many types of fieldbuses available, and the system designer needs to select the appropriate type to suit the purpose. This is not necessarily an easy choice, since the designer requires to have some understanding of the attributes of the fieldbus in question.

Project Area

The advantage of a fieldbus over a central control system is that intelligence can be easily distributed to the locality of the measurement or control process, and expansion is simply undertaken by adding an autonomous control module, without necessarily disrupting the rest of the system. Take for example a pump control system, which requires both local and remote control. With a fieldbus, the pump control logic (intelligence) can be built into the local pump control panel by means of a PLC type module with a fieldbus interface. By this means, not only can this section of the system be regarded as autonomous, having perhaps its own local display or manual control facilities, but all control or measurement variables can be monitored or modified from anywhere else within the fieldbus system boundaries. This means modification to the pump control program itself can be performed remotely off line and down loaded to the pump controller, without affecting system operation. It is important to consider however, the required distance between fieldbus nodes where if necessitating repeaters, will negate some of the advantages of fieldbuses by increased costs

Speed

Some fieldbuses are designed for high speed binary value transfer, which may be required for fast machine control or robotics, where perhaps a single master requires information from a number of simple slaves. However, such a fieldbus is

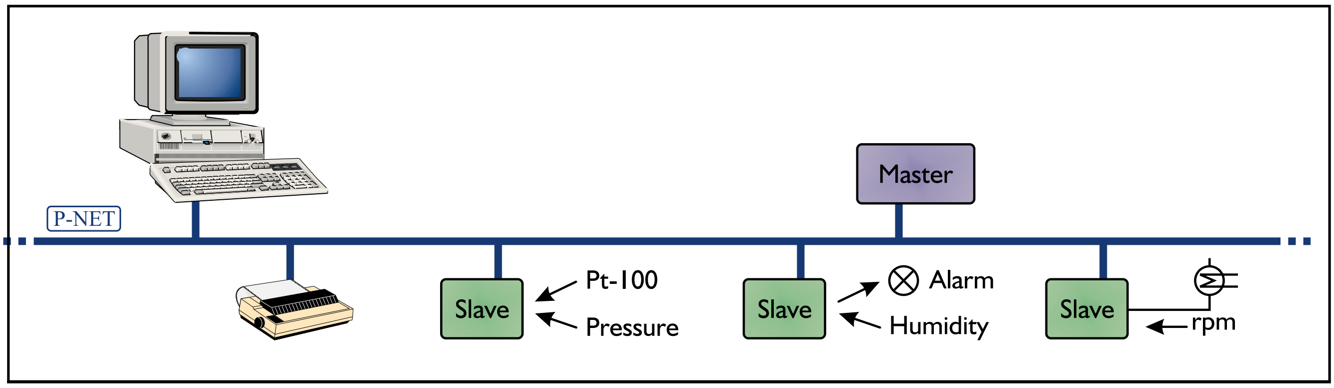

FIGURE 1. Multi-master & slave concept of P–NET

restricted to relatively short distance operation without repeaters. Therefore, if a fieldbus is required to be installed in a plant which covers a wide area, then such a high frequency fieldbus may not be appropriate.

Some fieldbuses offer multi-speed facilities, which encourage a heirachical system structure. However, this often means more complex hardware in terms of configuration and gateway software.

Multi-master

To enable a wide general use, a fieldbus needs to be multi-master, which allows the true distribution of processing power. (Fig. 1).

Multi-net

A distinct advantage, especially in sizeable plants, would be to use a fieldbus that naturally allows a system to be divided up into sections or cells, (not unlike a honeycomb), without any software overhead. That is to say, that any system programming does not need to consider how data is transferred between cells. This not only requires a multi-master facility, but also a multi-net protocol involving multi-port masters. (Fig. 3).

Cost

One of the widely accepted advantages of a fieldbus is that there is a significant saving in cabling compared with centrally controlled systems. This of course leads to a reduction in installation costs, but certain additional factors are sometimes forgotten, such as reduced maintenance, accelerated trouble shooting, and one of the most important aspects for larger systems, ease of expansion. But what of hardware and software costs? Although a project budget can perhaps withstand a small increase in the cost of distributed hardware, it starts to become a pointless exercise if this outweighs the savings already achieved. These economies must also apply to the overall cost of software development or configuration of a project, which must not be negated by a necessity to recall the integrator, every time a small modification or expansion is required.

Availability

Whilst the choice of a fieldbus type on the basis of the aforementioned factors, may have narrowed the field down somewhat. There is no point in picking a particular fieldbus if it cannot offer a full range of general purpose, or function specific equipment. Further, if a fieldbus protocol is so complex, as to discourage both current and new manufacturers to develop new products to satisfy new drives and control needs, the future proliferation of new sensors, drives and controls will be stifled.

Standards

It is as well to consider the difference between an open and standardised fieldbus type and a proprietary type. The former are, by definition, far more likely to have met certain design criteria, have conformance testing procedures laid down, be available to all that wish to obtain a copy of the standard, which will also not impose any royalty or product development subscription on its use. Proprietary types, also by definition, may boast they are open, but may not be able to satisfy those criteria laid down by national or international standards bodies.

Track Record

In keeping with any worthwhile technological development, the evolvement of a fieldbus takes many years to yield sufficient product, software, technical support and a wide range of practical project examples. It could be a very disconserting experience to find oneself using an underdeveloped fieldbus type, only to find that insufficient hardware had been produced to satisfy all the requirements of a project. Furthermore, software development tools need time to be fully debugged, and it is most annoying for a system designer or user, to find that he is inadvertently acting as a beta tester for a new product or software package.

Engine Management on Dutch Ferry

The PC Factor

The PC has become such a common part of our lives, within the areas of commerce, education and industry. It would be unthinkable to consider the choice of a fieldbus type, without establishing that it fully supports the use of PC's, in both the development and operational phases of a project. Due to its economic and common familiarity advantages, a PC will appear somewhere within a fieldbus based project. Its use is commonly for data logging because of availability of cheap memory, or as a system Man-Machine Interface (MMI) perhaps in the form of a proprietary SCADA system. However, the use of PC's within a fieldbus system, now do not have to be the control workhorses of the past, since processing power can be distributed throughout a system, ensuring that traffic within a fieldbus cell need only consist of the transfer of fully processed measurement results, the sending of set points or binary control signals. The use of the fieldbus for the transfer of files consisting of distributed control program or recipes, is also a necessary consideration in the choice of a fieldbus. However, these batch processing activities do not present time critical problems, and the system designer should not be confused into believing that the speed of a fieldbus need be any higher for these activities compared with the speed of normal operation.

PC Applications

On the assumption that the chosen fieldbus type can interface with the common PC, what of interfacing with standard or purpose designed PC programs? Although the use of proprietary SCADA packages is a popular means of providing a front end graphical display, the user of such a package must ensure that an easily configured interface is available between the package and the fieldbus equipment. Consideration also needs to be given to the operating system platform used by the PC. WINDOWS is probably the most familiar and widely used OS today. Wouldn't it be nice if there was a common interface between WINDOWS based PC applications and the chosen fieldbus type? Communication between WINDOWS based applications is now performed using OLE Automation (Object Linking & Embedding), the older technology being DDE (Dynamic Data Exchange). Therefore, in choosing a fieldbus type, it is worth establishing that it supports OLE. This means, that not only will the proprietary packages and tools of the chosen fieldbus type be more likely to also support OLE, but will also allow the user to use standard and globally familiar applications, such as EXCEL, ACCESS and Visual Basic. (Fig. 2). It may not be as widely known as it should be, that a relatively cheap, standard, but powerful application, such as EXCEL, traditionally used for financial spreadsheets, can be configured using simple macros, to perform most of the functions and displays of a highly expensive SCADA package. Choice of such a philosophy, can often produce huge hidden cost savings, and that the use of such a standard PC application shell would provide a user with the opportunity of not necessarily having to rely on a single provider for expansion or modification.

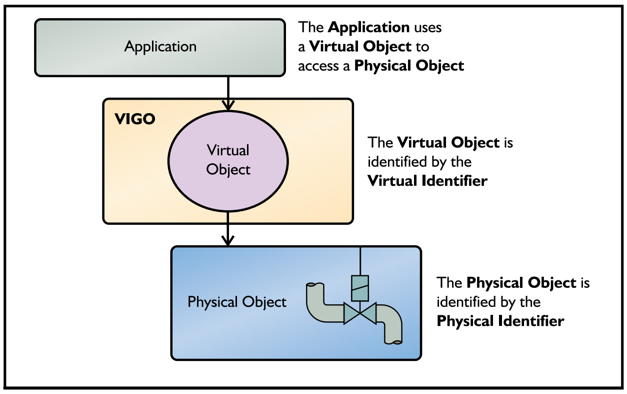

FIGURE 2. Object linking between PC applications and Fieldbus Device

Fieldbus Mix

It would be a great mistake not to recognise that there will never be a single fieldbus standard. Certainly, some manufactures will now start to adopt fully standardised fieldbus types, although through necessity, will continue support of their own proprietary serial communication systems for some time. Manufacturers who have never produced fieldbus nodes, are now in a position to start choosing a single or selection of fieldbus types for their products. Again for economic expediency, and using the same criteria of choice as that of the system designer, it is likely that manufacturers will be the influencing factor in causing the number of available fieldbus types to reduce. However, whilst one fieldbus type may have the reputation of being general purpose, others may be regarded as specialist, but there is no reason why these cannot satisfactorily live together. Some fieldbus types have evolved within themselves, using differing speeds or even protocols. Communication between these hierarchical protocols requires the use of Gateways, which by definition, requires a translation from one level to another, to ensure system intercommunication. However, it is highly unusual for such distributed gateways to consider intercommunication between differing fieldbus types. Therefore, the final criterion for consideration by the system designer needs to be the ability of the chosen fieldbus type to be capable of differing fieldbus intercommunication. This is important, where an existing part of a expanding system may already be utilising a specialised fieldbus type, which may not be appropriate for a larger, or physically scattered system. The opposite may also apply in the future, where a project may be based on single standardised protocol, but a special expansion requiring an interface to a specialised proprietary protocol may be necessary. As with the logic behind a common application interface utilising the available power within the PC, it worth considering whether the fieldbus type chosen can support fieldbus intercommunication within such a universal package.

P-NET

In making an assessment of fieldbuses, the system designer (or product manufacturer) will inevitably consider the internationally recognised P-NET fieldbus standard. By utilising the previously proposed criteria, an overview of the features of this general purpose protocol is described.

P-NET is a multi-master fieldbus. This means that processing power can be distributed throughout a system, negating the need for a single powerful computing centre that has to do everything.

One of the unique and most advantageous features of P-NET is that it is also a multi-net protocol. (Fig. 3). In technical terms, P-NET is specified for layers 1, 2, 3, 4 and 7. (Most fieldbuses are specified in terms of layers 1, 2 and 7). This means that a system can be divided up into logical sections or cells, within which independent communication between nodes can take place. Due to this cellular philosophy, a system can theoretically be spread

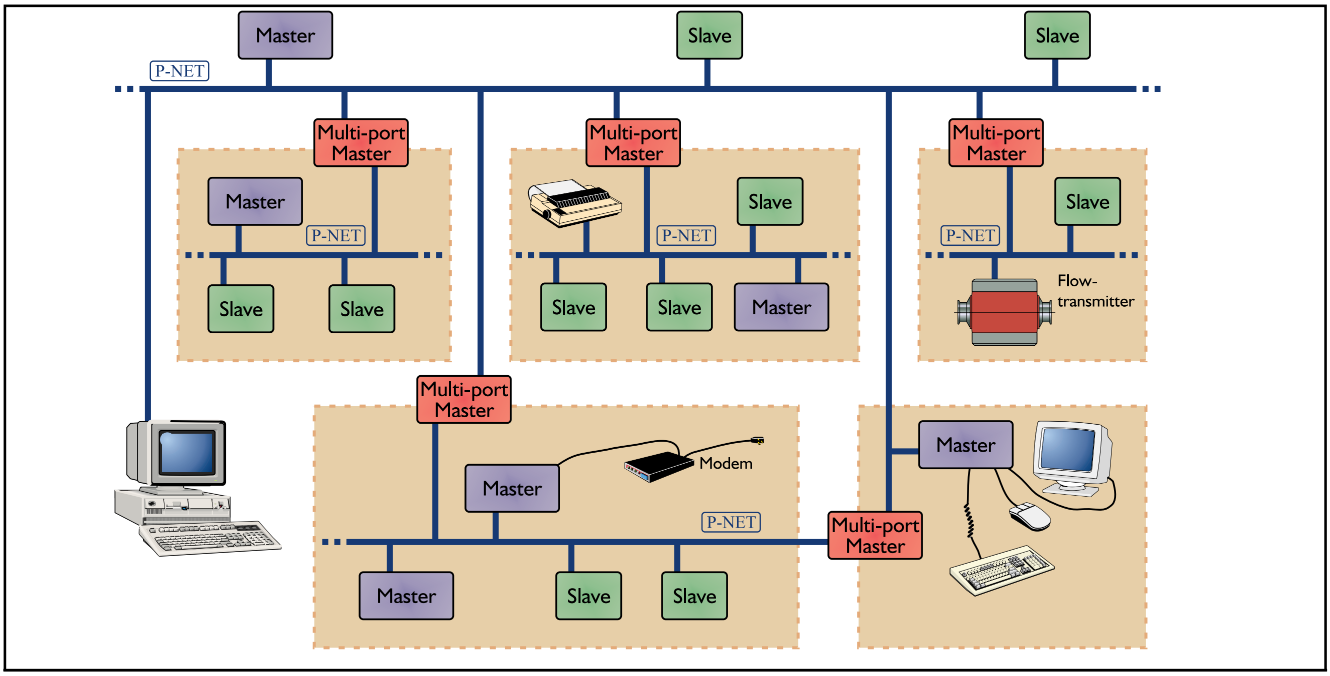

FIGURE 3. The Multi–net structure of the P–NET Fieldbus

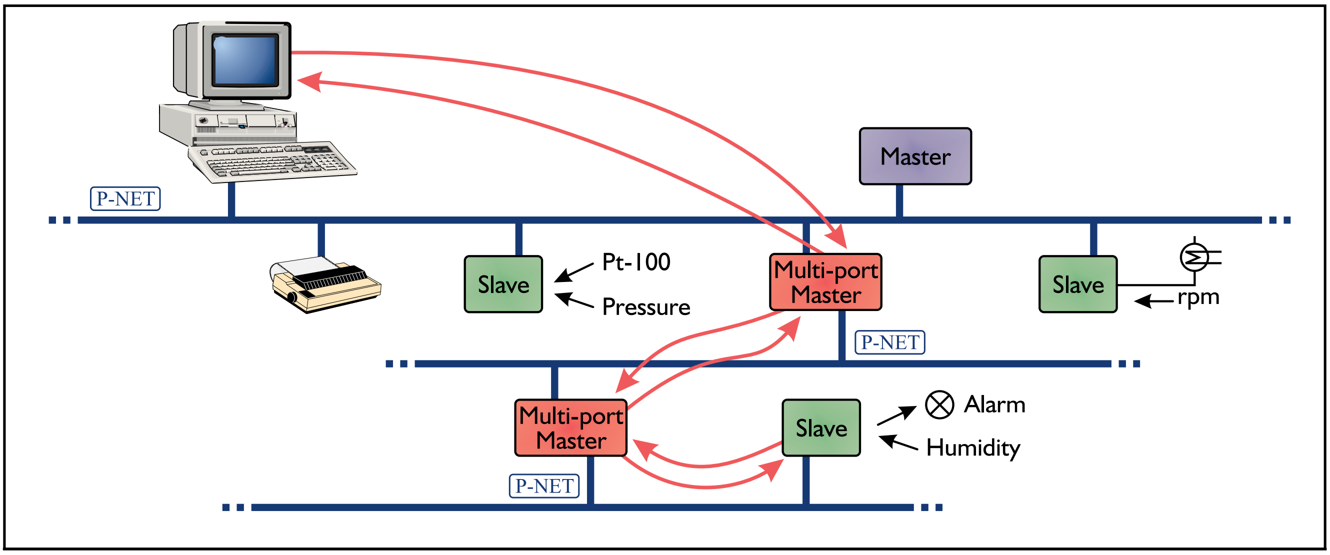

FIGURE 4. Transparent access through multi-port masters to other bus segments

over a virtually infinite area and can be designed with redundant communication paths. In practice however, all this means is that P-NET can be used over as wide an area as required.

The standardised single speed of P-NET communication can be defined in terms of bits per second or baud rate, which is 76.8 Kbps. Although it should be mentioned that this is a direct multiple of standard comms rates (4800, 9600, 19,200 .. 76,800), this does not convey the useful throughput of data, which as far as P-NET is concerned, allows up to 300 fully processed and confirmed messages (4 bytes) to be transferred per second, within a single cell. Due to the efficiency of the protocol, this exceeds data transfer rates of other fieldbuses operating at similar bit rates and in a lot of cases is comparable with fieldbuses having many times the bit rate of P-NET. The cellular functionality of P-NET also means that each cell transfers its own data independently and in parallel with other cells. The effect from an overall system point of view, is that the system data transfer rate increases as the number of cells are increased. (Fig. 4).

One of the reasons behind the choice of a single bit rate of 76.8 kbps for P-NET, is that standard and readily available components can be used for both slave and master nodes. Manufacturers can utilise standard multi-source micro-controllers which normally have built in serial communication

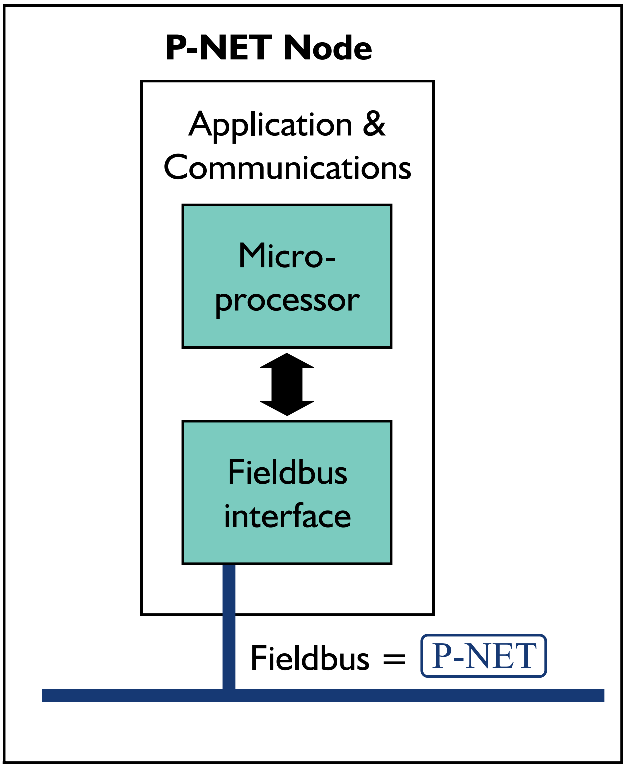

FIGURE 5. Typical P–NET Node structure

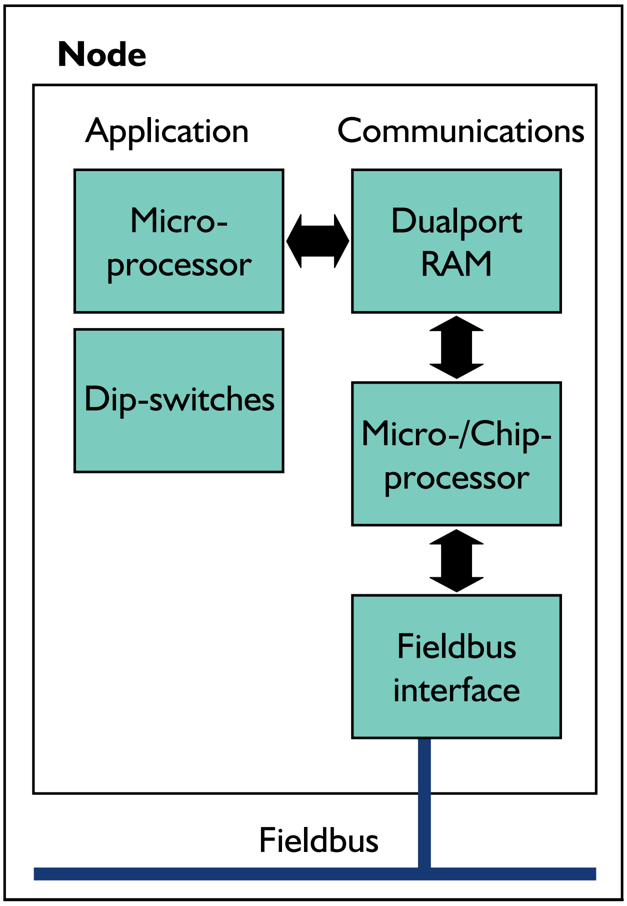

FIGURE 6. Consequence of using additional comms chip

facilities. There is no need for any special chips, which seems to be fashionable with many other fieldbus types. (Fig. 5). The consequence of additional chips, is that they need to be interfaced with the application's host micro-processor. (Fig. 6). This means extra cost in terms of both hardware and software development. The P-NET protocol can be integrated within the devices application software in as little as 6 Kbytes, and there is therefore a tendency for such devices to be of lower cost.

Since the P-NET fieldbus has been utilised within some 4000 - 5000 applications over many years, there has been sufficient time for a wide variety of proven equipment, devices and systems to have evolved. General purpose devices, such as digital I/O, analogue I/O, single and multi-port controllers and PC interface cards, provide the basis for general system design. More specialist devices covering all sorts of aspects of measurement and control provide facilities for flow, weight, thermocouples, power measurement, often integrated together with programmable logic, high speed counting and PID channels.

P-NET has attained national and European standard status. If nothing else, this conveys that certain important criteria have been met in terms of operation, documentation, support, validation, and implementation.

The history of P-NET has seen life before the PC, through the many phases of DOS, Windows and PC Networking. Many PC tools have been developed over the years, including P-NET controller compilers, programmable node assemblers, and a myriad of utilities for monitoring, configuration, download, back-up, graphics etc. The recognition that the PC in industry is here to stay, and a realisation that platforms such as Windows are likely to continue to be a de facto standard, has lead to the development of VIGO - a Common PC programming interface for fieldbus applications. This provides a means for any Windows application supporting OLE Automation to communicate with P-NET, Novell, and other standardised fieldbus types, providing an inherent multi-path gateway between fieldbuses and PC applications.

PRACTICAL PROJECTS

The proof of the pudding is in the eating, so they say. The proof of a good fieldbus is in the number and diversity of applied implementations.

It is also said that a picture is worth a 1000 words, although no-one has calculated what a moving picture is worth!

This section of the paper is based around a visual record taken of a selection of diverse projects, which all fully utilise the advantages of the P-NET fieldbus. Due to both time and space constraints, not all projects recorded can be featured, nor have all projects known to exist been recorded. However, the fact that so many instances of successful practical projects can be cited, can only give confidence to system designers considering the use of fieldbus technology, that P-NET is likely to satisfy all but the most specialist implementation.

MD Foods Cheese Plant

General View of Plant

One of the largest Feta cheese plants in Europe was completed in 1989, in conjunction with Alpha Laval and Satt Control. The manufacturing process is monitored and controlled throughout by P-NET.

Pasteurisation Section including Cell Controller

Project attributes:
- 2300 Digital I/O
- 130 Analogue inputs
- 40 Controllers (masters)
- 50 Magnetic flow meters
- 27 Weight transmitters
- 10,000 meters of P-NET cable.

British Rail

Fuelling and Servicing Area

A number of Fuel Monitoring and Inventory Management systems have been installed by B.R. in their maintenance depots, scattered throughout the UK. The systems control the fuelling of trains and monitor and control the inventory of fuel oil, lubrication oil and glycol - for antifreeze.

1 of 17 Fuelling Controllers

Project attributes:
45 Digital I/O
16 Analogue inputs
24 Controllers
24 Intelligent turbine flowmeters
21 sub-networks
1 P-NET colour graphic system
1500 meters of P-NET cabling

Building Control

Security and Identification Point

Ultrakust Electronic, whose headquarters are in the Bavarian region of Germany, installed a Building Management and Control system throughout their manufacturing plant. The system integrates personnel movements, building security, environmental control of windows, lighting, heating and ventilation, and extends into stock control and component movements. Due to the diversity of operations, this system is a fine example of a project utilising P-NET equipment produced by a number of manufacturers.

Building Heating Control

Project attributes:
2500 Digital I/O
108 Analogue Inputs
6 Controllers
2 Magnetic flow meters
15 RS232 - P-NET convertors
1 P-NET colour graphics system
2000 meters of P-NET cabling

Pig Feeding

Lunch Time!

Skiold Datamix is a company who export animal feeding systems throughout Europe. This particular project deals with the control of pig feeding and climatic control on a farm dealing with 4000 pigs. It involves aspects of silo storage of feeding products, weighing, mixing and controlled distribution of foodstuff via 400 feeding valves. Only 3 operators are required to manage the complete system. The first system was installed in 1990 and an estimated 480 systems have now been installed.

Food Preparation and Mixing

Project attributes:
- 20 Silos
- 1 Controller
- 4 Mixers
- 3 Magnetic Flow Meters
- 4 Weight Transmitters
- 1400 meters of feeding pipes

Fuel Oil Distribution

Oil Delivery Vehicle

This vehicle mounted and PTB approved domestic heating oil delivery system, is an example of of the use of P-NET in a small measurement and control system. Individual temperature compensated metered deliveries of oil are recorded, and an immediate printed invoice is produced. All data is stored in a removable solid state memory, which is connected to a PC based inventory management system at the depot.

P-NET linked Metering Equipment

Project attributes:
- 2 Controllers
- 1 invoice printer
- 1 temperature sensor
- 1 flow meter
- 1-24 Digital I/O

Ship Engine Management and Ballast Control

Diesel Electric Generators

A car ferry travelling between Dutch ports, provides one of a number of examples of maritime measurement and control systems. The system was designed and installed by IPH Marine Automation, and consists of redundant P-NET paths to meet Lloyds registry approval. P-NET I/O modules and controllers monitor, control and event alarm the operation of 4 diesel electric generators, together with monitoring levels and list in the ship's fuel and ballast tanks. To date, some 107 ships have been fitted with variations of this system.

Engineer's Monitoring Panel

Project attributes: 1020 Digital I/O
480 Analogue inputs
23 Controllers
19 sub-networks with dual redundancy
2 PC SCADA systems
14 PC's
700 meters of P-NET cabling

Textile Manufacture

Spinning Area with Sector Controller

Neckelmann of Jutland manufacture all sorts of yarn for the textile industry. Probably the most well known sector of use for the material is within the car industry for all types of upholstery. This involves dying and spinning using a wide selection of modern materials, to achieve the variety and colours of the required product. P-NET was first used in 1988, and has now been used throughout the plant to control the boilers, dying architraves, spinning and finishing machinery. The project was completely designed programmed and installed internally by Neckelmann engineers.

Digital I/O Modules linked by P-NET

Project attributes: 4000 Digital I/O
200 Analogue input
30 Controllers
400 meters of P-NET cabling

Dishwashing Machine Manufacture

The Testing Line Conveyor

The Bosch Siemens dishwashing machine manufacturing plant in Germany, have installed P-NET monitoring and control equipment on the final operational testing lines. Machines are powered and filled, and the P-NET system measures the results of each operation. The fact that the tests are performed using a moving conveyer, necessitates the use of an infra-red P-NET link to transfer control and recorded data to the factory central database.

Infra-red P-NET Transmitter/Receiver

Project attributes:
- 97 measuring stations
- 169 Digital I/O
- 390 Analogue
- 97 P-NET CRT modules
- 4 PCS with P-NET interfaces
- 19 Bar code readers
- 21 Infra-red P-NET transmitters
- 800 meters of P-NET cabling

Concrete Manufacturing

Mixer Assembly

This highly automated, machine orientated project, is one of hundreds of complete plants now installed throughout Europe. Designed for Haarup by Proces-Data, the system takes base stock of cement, sand, water together with various additives, weighs and transports the correct quantities of materials from recipes, and then mixes these to make concrete. This is then used for moulding into blocks and slabs, which are put to many familiar uses. The variation in type of such plants is quite large, so in order not have to redesign each plant individually, object orientated programming techniques have been used. By use of “pipe diagrams”, the base program is transformed into configured specific system software, to meet the customers requirements.

Material Control and Transport

Project attributes:
- 100 Digital I/O
- 2 Analogue input
- 1 Controller with data screen
- 2 Magnetic flow meters
- 8 Communication units
- 10 Weight Transmitters
- 800 meters of P-NET cabling

Milk Collection

Roadside Collection Point

Another vehicle mounted system, demonstrates the ruggedness and versatility of P-NET based systems. This Ultrakust designed equipment, sucks milk from roadside churns or farm tanks, eliminates any entrained air, makes a temperature compensated volumetric measurement, measures the pH, diverts a small sample via peristaltic pump, into a stepper motor controlled carousel of sample bottes, for later analysis. The system produces a printed receipt for the farmer, while at the same time storing records in solid state memory. At the time of video recording (1992), over 1000 systems had been installed.

Lifting and Sampling the Milk

Project attributes:
- 1 Controller with keyboard
- 1-2 printers
- 1-2 temperature sensors
- 1-2 pH sensors
- 1-2 Magnetic flow meters
- Up to 24 Digital I/O
- 1 magnetic strip reader

All the above projects are included within a 40 minute video. However, the contents do not reflect all projects implemented at the time of recording, or since, but is also worth highlighting some of the UK projects which have not been able to be discussed in detail.

Beer Barrel filling lines system - Ind Coope
Pasteurising System - Whitbread
Medical sensor manufacturing - Medisense
Fruit Juice processing - Gerba Foods
Milk Processing Plants - Dairy Crest

CONCLUSION

This hopefully illustrative presentation, has been designed to convey that not only does the P-NET fieldbus meet the required criteria for a confident choice to be made by a system or project designer, but is also backed up by the fact that many other system designers and manufacturers have also made that same considered choice during the last 10 years, and have successfully created plenty of projects using P-NET.

The full 40 minute video, on which this paper has been based, is available from the International P-NET User Organisation.

An explanatory booklet - "The P-NET Fieldbus for Process Automation", from which some diagrams have been extracted, is available free of charge from the International P-NET User Organization.

Details on the above – and about IPUO membership – can be obtained by telephoning 01491 828200, faxing 01491 828201, or by sending a request by email to: pnet@easynet.co.uk