Based on an article published in
IEE Computing & Control Engineering Journal - Dec 95

Fieldbus Trials at BP, Sunbury-on-Thames

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Introduction

The development of a communications standard, and the testing of it, are essential parallel elements in evolving a system that users and vendors will be happy to implement in both products and systems.This is especially true for a Fieldbus standard, where systems carry measurement and control data that can be crucial to the safe operation of a plant, and the safety of the people in the surrounding areas. It is therefore essential to gather evidence of a system's robustness and its reliable operation when it has been designed to comply with the requirements of a new standard.

Stable drafts of the physical layer of the IEC Fieldbus standard, IEC 1158-2 (the ISA standard S50.02 has identical English text) covering wire media systems emerged from committee work in 1991. At that time some initial physical layer testing work was carried out at an Exxon plant in the USA (at Linden, NJ), involving five international companies including Measurement Technology Ltd. (MTL). This produced the first practical evidence that the physical layer standard could meet the criteria laid down in the standard, including continued operation in the presence of a wide selection of electrical interference sources typically found in an industrial process environment. It also demonstrated the ability of the standard to support hazardous area systems using Intrinsic Safety.

A more comprehensive and systematic test programme was obviously required, and BP offered a site for this work.This site had formed part of BP's Research and Engineering facility, based at Sunbury-on-Thames, and the plant equipment had originally been used to test valve performance when subjected to various abrasive and corrosive fluids. The close proximity of Sunbury to London's Heathrow airport made it a convenient location for visitors, and the siting of such a significant trials centre in the UK proved very helpful in raising the profile of Fieldbus generally, including its effect on potential manufacturers and users, both here and in other European countries. Sunbury became the major world site for Fieldbus testing throughout this period.

Objectives of the trials

Fieldbus testing at the Sunbury site took place in two phases:

Phase I : Equipment for this was installed, tested and demonstrated during 1993. It concentrated entirely on the physical layer interconnection features of Fieldbus systems, with subsets of the other (incomplete) IEC Fieldbus layers sufficient to ensure device inter-working. Fifty companies participated in this phase, testing and demonstrating both low (31.25kbit/s) and high (1.0Mbit/s) data rate systems.

Phase II : This was completed during 1994. It extended the testing of practical cabling architectures, and demonstrated the capability of Function Blocks in a real control environment. Twenty-five companies took part in this second phase of the work, demonstrating devices that included a subset of the draft IEC Data Link layer. These were based on components and software tools that had become available since the first phase of testing.

The overall programme had several key objectives:-

- to devise specific tests for each part of the standard as they developed;
- to demonstrate inter-working and interchangeability of prototype Fieldbus devices from different suppliers;
- the demonstration of complex control systems based on multiple Fieldbus segments and multiple prototype devices;
- to share the results of each stage with the standards making body;
- co-operation with the EEMUA (Engineering Equipment & Materials Users Association) User Group for Fieldbus.

Publicity for the testing work, and the results emerging from it, was also an important aspect. Specific Visitor Days were scheduled for both phases in order to promote better understanding of the status of the work, and the potential of Fieldbus systems among people in industry and those on related standards committees. During the programme several hundred visitors from industry, education and the media took the opportunity to visit the site and hear presentations on the work. This had a major influence on people's awareness, appreciation and understanding of Fieldbus.

The Sunbury trial site

The test rig at Sunbury comprised a pipe loop with an in-line pump, a liquid storage tank and a heat exchanger. There were numerous positions for installing typical process control and measurement devices and at least four control loops were required to operate the rig. Control room equipment was housed in a portable cabin with connections to the outdoor devices made via several junction boxes. Figures 1 and 2 show conditions both inside and outside the cabin during the Phase II testing.

A key feature of both trial phases was testing the limits of the cable performance, and up to 50% beyond, as defined in the Fieldbus Physical layer standard for each cable type. Changes to

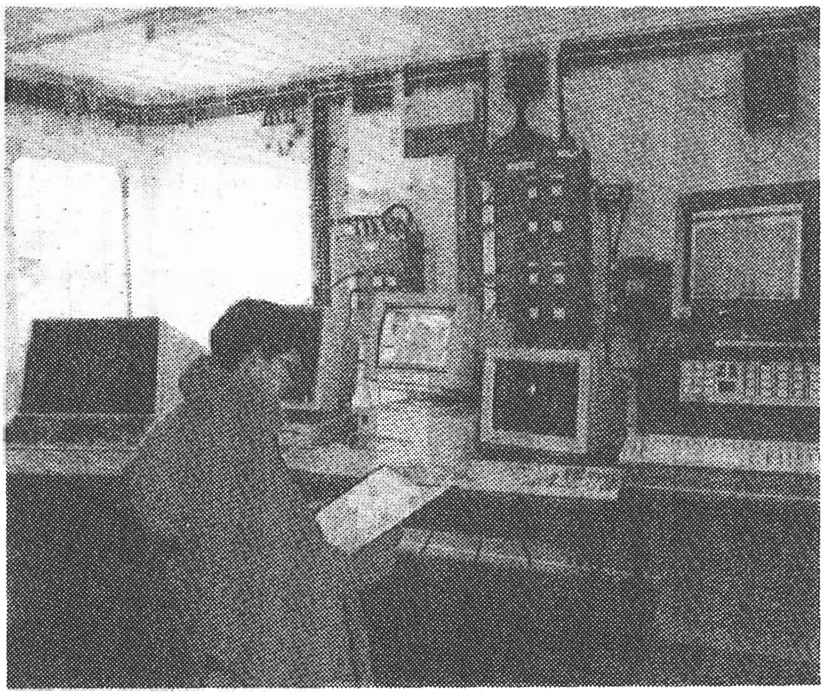

Figure 1 : View Inside Cabin

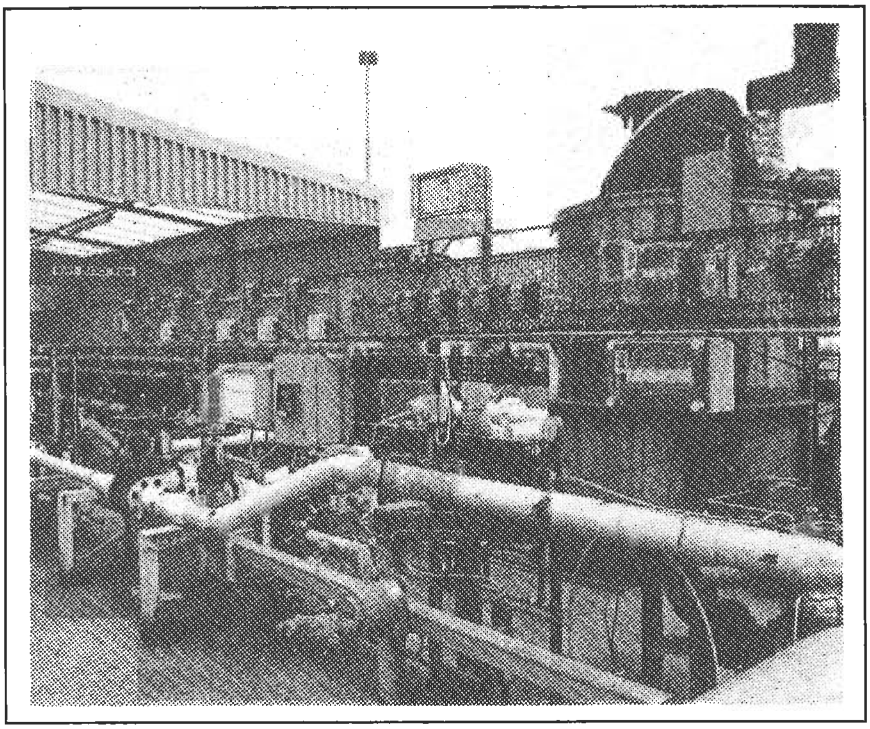

Figure 2 : View Outside Cabin

bus lengths and topologies were easily achieved using a number of patch panels within the cabin. Six different grades of cable were available for testing, making a total length of almost 7km.

Details of the Phase I test programme and its results have been published elsewhere (Ref. 1), with particular emphasis on the Intrinsically Safe systems tested for hazardous area applications. These results are not repeated here. Instead, further details of the second phase will be presented.

Phase II test programme

Figure 3 lists the companies that tested equipment in the Phase II trial. The original Phase I trial was directed by the IFC (International Fieldbus Consortium), which is a group of interested Fieldbus developers and users committed to test the evolving IEC standard. By the time work commenced on the Phase II work, two competing protocols and their supporting organisations were in existence, both based on the developing IEC standard but incompatible with each other. These were WorldFIP, which evolved internationally from the original French Club FIP organisation, and ISP (Interoperable Systems Project), a group formed initially by Fisher-Rosemount, Siemens and Yokogawa using, largely, a development from the German Profibus protocol. Equipment from particular participating companies generally conformed to either of these, as indicated in figure 3, although some items were independent of the protocol differences. Sunbury offered the opportunity for these groups to work co-operatively on a common installation, an experience which proved entirely harmonious and forged important links that assisted the later, September 1994, merger of these organisations (apart from the European region of WorldFIP) into Fieldbus Foundation (FF).

The Phase II testing objectives had to be reduced somewhat following the formation of FF, as their specifications would involve a change to the communication protocol in devices. This was a change whose costs most participants were not prepared to accept while the FF specification was in its early formation stage. Therefore the Data-Link layer testing of features, services and inter-working in a real control environment had to be curtailed.

The publicity arising from the Phase I Physical layer test programme and its results had, however, raised further detailed questions in the minds of potential users about how Fieldbus could be installed and operated to suit their applications. The existence and involvement of the EEMUA group mentioned above was particularly useful in this respect. The contribution of Graham Loose of BP in this should be recognised; his continuous enthusiasm and efforts to involve this group in defining the testing objectives for Phase II was crucial.

This second phase of testing, therefore, covered areas arising from these further inputs, and investigated the effects of:

- devices installed in a tree or "chicken foot" topology (see Figure 4);
- open circuit in a spur or of the main bus trunk;
- crosstalk in multicore cables;
- connection and disconnection of devices during normal operation;
- removal of one bus terminator;
- an increase in connector resistance;
- intrinsically safe networks.

Two systems were installed during July and August 1994, the first Fieldbus segment operating at 31.25kbit/s using the ISP protocol and the second communicating with WorldFIP protocol via a 1.0Mbit/s voltage mode bus. Work was completed with few problems, using a combination of BP staff and the manufacturers themselves. Most devices in the trial were bus powered (i.e., all the power for the device was provided via the Fieldbus). This greatly simplified electrical connections.

The "chicken foot" topology is primarily applicable to low speed Fieldbus systems. The 31.25kbit/s bus was configured with five devices concentrated at the end of a 600m long bus trunk, each device being connected via a 125m spur cable. Communication continued without errors, even when two of the spur cables were open circuited. These tests highlighted the need for careful design of the Medium Attachment Unit (MAU) - the transmission and reception circuits connected directly to the bus cables - in this configuration. Some prototype devices exhibited internal instabilities when connected to the high frequency resonant circuit presented by a long spur cable. The 1.0Mbit/s bus was tested with a 1125m linear bus topology (see figure 4), without producing errors.

Crosstalk testing was performed on both Fieldbus systems. Each was run over a 600m length using a cable having two twisted pairs and an overall shield. The Fieldbus system was connected to the first twisted pair and a 100kHz square wave signal switching between 4mA and 20mA to the other pair. Fieldbus communication was not affected at either data rate. Fieldbus signals and HART protocol signals (HART is a communications protocol used for "smart" field devices in the process industries) were also able to operate satisfactorily together. Connection and disconnection of devices while the Fieldbus was operating caused no errors other than corruption of a few frames while the operation was taking place. These errors were always correctly detected and the data re-transmitted.

Figure 3 : Equipment Installed in Phase II of the BP, Sunbury Trial

Company	Protocol	Equipment
BICC - Brand Rex	WorldFIP/ISP	Cable
Cegelec	WorldFIP	PLC, variable speed driver, bus analyser
DDC/ShipStar	ISP	Bus analyser
Endress + Hauser	ISP	Ultra-sonic level meter
Fisher-Rosemount	ISP	DCS, differential pressure and temperature transmitters
Foxboro	ISP	DCS, level meter
ITT Canon	WorldFIP/ISP	Connectors
Leeds & Northrup	ISP	pH meter
MTL	ISP	Digital remote I/O, IS barriers, terminators
Pepperl + Fuchs	ISP	IS barriers, terminators
Siemens	ISP	Pressure, differential pressure and temperature transmitters
Telemecanique	WorldFIP	PLC, digital remote I/O
Weidmuller	WorldFIP/ISP	Taps, terminators, analogue I/O
Yokogawa	ISP	Vortex flow meter

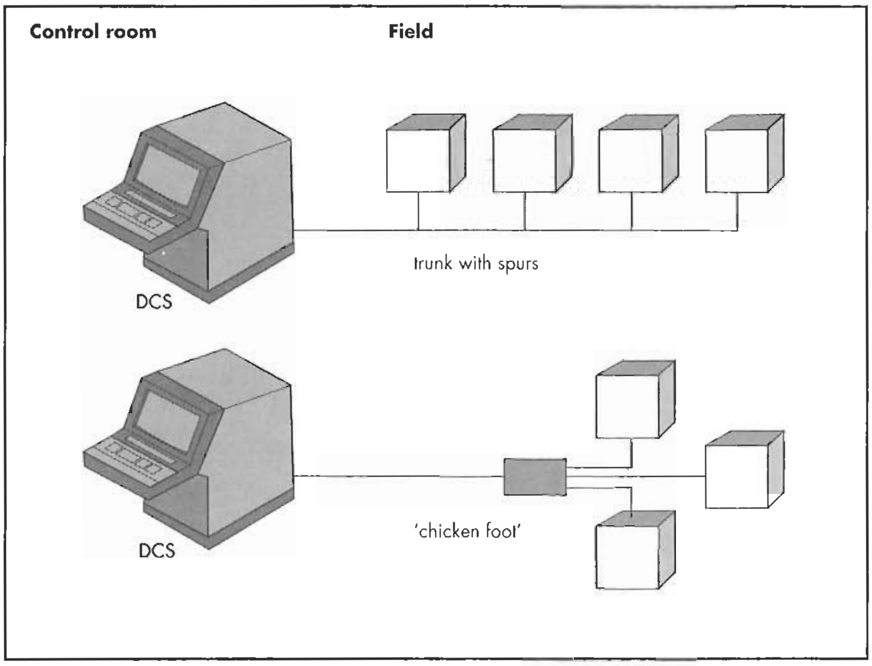

Figure 4 : Linear Bus and "Chicken Foot" Topologies

The effects of removing one Fieldbus terminator were different between the two bus data rates. The high speed bus could not tolerate removal of a bus terminator (as would be the case in a bus open circuit) for bus lengths above 250m. The low speed bus was more tolerant and continued operating correctly up to 950m with one terminator removed.

An unbalanced resistance of up to 50Ω (representing a high resistance on one connector pin) in one Fieldbus line could be tolerated on the low speed bus operating with a 950m trunk cable. Equivalent tests were not carried out on the high speed fieldbus.

Neither Fieldbus could continue operating with a short circuit applied to the main bus trunk as both are voltage operating buses, with devices connected in parallel across the bus cables. However, devices returned to normal operation within a few seconds following the removal of a direct short circuit from the bus. Most prototype devices in the trials each consumed about 30mA from the Fieldbus, this is probably three times the consumption expected from silicon chip-sets when they become available, and this limited the number of devices that could be connected to simulate hazardous area operation under Intrinsic Safety conditions. A maximum of two devices could be connected in this situation, but various configurations were tested satisfactorily to confirm and extend the performance found during Phase I testing. Tests were also carried out with Intrinsic Safety barriers and galvanic isolators. The MTL prototype Intrinsic Safety units installed in Phase II are shown in figure 5.

In order to examine the limits of correct operation as the bus length increased, the 31.25kbit/s bus was tested at distances considerably beyond the 1900m specified for conformance in the IEC standard. A single field device continued to operate successfully while connected through 3450m of cable.

Conclusions

The trials at BP, Sunbury, described in this report, have been crucial to the development of Fieldbus technology. They demonstrated publicly, in an industrial situation, that Fieldbus systems will offer substantial savings in cost and quantity of installed cables and equipment as well as enhanced system performance. It was important to demonstrate these aspects, especially during a period when delays in the completion of an international Fieldbus standard and rivalries between the various competing groups were causing frustration for both potential users and equipment manufacturers. These trials demonstrated that those parts of the standard already completed do perform reliably under a number of the conditions of most interest to potential Fieldbus users in the process control industry. The testing programme initially envisaged for Phase II could not be completed in full due to these delays but, nevertheless, it provided valuable experience of a large number of manufacturers working together to achieve important practical objectives. The educational aspects of these trials, in promoting a greater general understanding of Fieldbus amongst potential users, will continue to benefit UK industry for some time to come.

Plans for further field trials are not yet defined. FF is currently conducting laboratory trials using silicon chips and software which implement its protocol specifications. These will be followed, later this year, by trials at a Monsanto plant in Texas, USA. 1996 will see extensive field trials on three continents. The past success of BP, Sunbury as a base for such trials may lead to the selection of the UK, once again, as the venue for other steps in the development of Fieldbus.

Acknowledgements

The Phase II testing work which is the subject of this article was carried out by a small test sub-group, and the testing procedures and results were detailed in a report to an assembly of BP Phase II participants. The author gratefully acknowledges the work of this sub-group and use of the information contained in their report.

References

1. Practical solutions for Fieldbus in hazardous areas by R. W. Squires. Paper presented by the author at Fieldbus '93 - an imposed or logical choice conference in Milan, October 1993. A reprint of this paper is available on request from MTL (ref.TP1108).

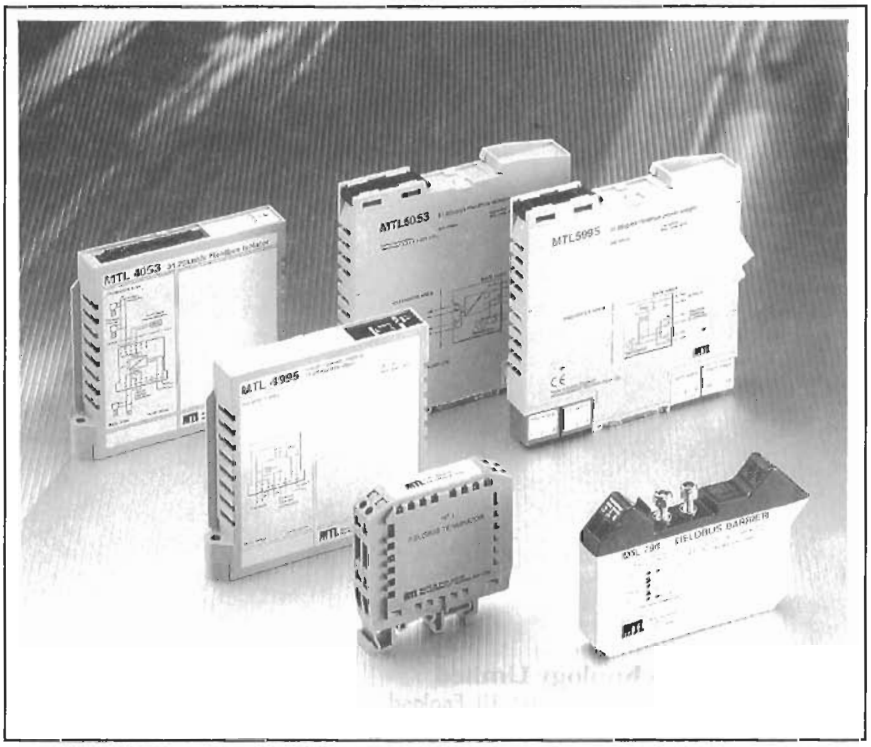

Figure 5 : MTL Intrinsically Safe Fieldbus Units.

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2/97 Printed in the EU