Fieldbus Trends and Fuji Electric's Related Activities

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1. Introduction

Efforts to develop practical applications for the Fieldbus, expected to become the next generation control system, have recently been strengthened.

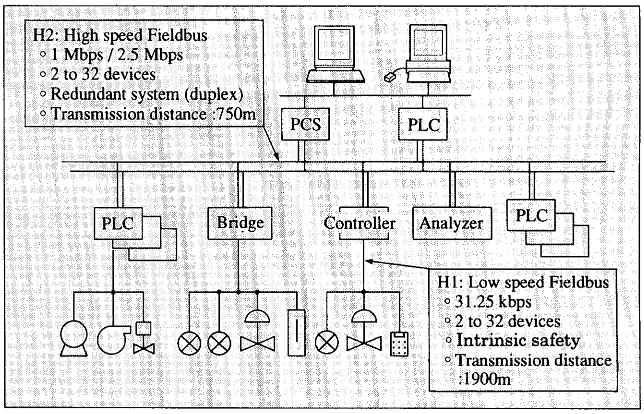
Fuji Electric's contribution to the Fieldbus started in 1985 when we marketed FFI (Fiber optic Field Instrumentation) and proposed FFI as an optical Fieldbus to the IEC (Electrotechnical Commission) and the ISA (International Society for Measurement and Control) internationally promoting the standardization of the Fieldbus. Later, we also proposed a low-power signaling technique for the electrical Fieldbus and have taken part in its field test, in Japan. Currently, as an executive member of the Fieldbus Foundation, founded by approximately 100 overseas and domestic manufacturers of control devices and systems to put the Fieldbus into practice, we are actively promoting the development of Fieldbus applications. This paper describes related Fuji Electric activities.

2. Fieldbus Trends

The Fieldbus provides a dataway to connect field devices for bidirectional digital communications, e.g. sensors and actuators (Refer to Fig. 1). It will become a central dataway for field instrumentation in the future. The Fieldbus makes it possible to integrate management and control information, to lower maintenance costs, to promote intelligent sensors and to configure interoperable multivendor systems, such as various environment-friendly control systems, which were not feasible with conventional analog transmission.

The Fieldbus is expected not only to transmit more information than before but also to change engineering, control, operation and maintenance in the control system. Moreover, field devices from different manufacturers, which are to be connected to each other through the Fieldbus in the plant, will have to pass field tests under actual connected conditions to prove their effectiveness and safety. In addition to having an effect on conventional device development, the Fieldbus also has a significant effect on the product development of field devices, systems and their connection methods.

Fig. 1 Fieldbus system configuration



Ever since the initial stage of international standardization and product development, all associated manufacturers have been involved world-wide to realize a common Fieldbus. The Fieldbus Foundation currently leads these missions. The Fieldbus Foundation has been established since September 1994 for the purpose of product development and practical application of the Fieldbus. Fuji Electric has taken part in these activities, especially in the development of product specifications and associated hardware, and in popularization and publicity.

The Fieldbus Foundation is scheduled to develop a low-speed Fieldbus product by autumn 1996 and a high-speed Fieldbus product by 1997. Fuji Electric is keeping pace with this schedule by developing associated devices and systems.

In these effort to develop Fieldbus products, the various manufacturers inevitably have to collaborate to determine specifications, verify connections and ensure conformance thereof, thus being coworkers rather than the competitors at present. Under these circumstances, it is important for us to be able to propose and supply devices and systems that have unique Fuji Electric features.

Fuji Electric's effort and their results will be described in the following chapters.

3. Electrical Fieldbus

3.1 Proposal for the low-power signaling system

One of the problems of the electrical Fieldbus is that the current supply from the powered bus limits the number of the devices that can be connected to it. This issue has been raised when discussing the associated standards and testing the system in the field.

Conventional analog transmission technology is well suited to transmit power and signal to the devices through two wires. However, in the Fieldbus, the number of devices that can be connected is limited due to an intrinsic safety barrier. This is because the minimum current powered to the device is limited to a constant value, regardless of the actual current that is consumed.

To solve this problem, Fuji Electric has proposed a low-power signaling system. (Refer to Fig. 2). The Fieldbus Foundation has formally adopted this new system. Since 1993, the IEC has held ongoing discussions to compile a committee draft of the MAU (Medium Attachment Unit) 31.25 kbps, voltage mode, wire medium, with low-power option Clause 24, in which new proposals for applications of external power type field devices are added.

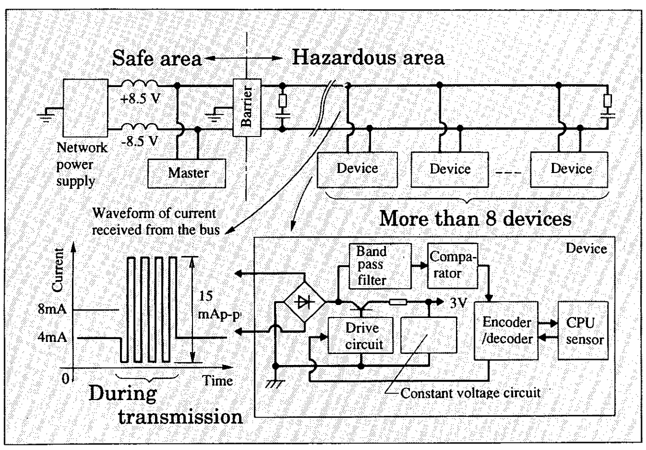
In addition, the Fieldbus Foundation has compiled a profile, that prescribes regulations for device assemblies which were insufficiently specified in the standard.

3.2 Product development

The factors essential to accelerate and expand development of the Fieldbus and the associated devices are development tools, stack software and chip materials, which various vendors will supply.

Fuji Electric has also developed the Fieldbus IC, FRONTIER-1 (Fuji Electric Fieldbus Interface Control Device with Transceiver-1) and has supplied engineering samples to approximately 10 overseas and domestic manufacturers of control devices and systems. The FRONTIER-1 already conforms with the physical layer specified in the standard, and supports the low-power signaling system.

Fig. 2 Block diagram of low power MAU system



The features of the FRONTIER-1 are described below.

(1) IC chip comprised digital and analog circuits

The digital circuitry (modem) and analog circuitry (driver, receiver) are integrated into one chip, using high-voltage Bi-CMOS technology to reduce the number of parts.

(2) Low power consumption

With 3V operation, the FRONTIER-1 consumes low power, and is compatible with the powered bus, (the bus that supplies power through signal wire).

The powered bus is a feature of the electrical Fieldbus. (wire medium, voltage mode, 31.25 kbps)

(3) Compact

The FRONTIER-1, having a 64 pins SQFP (Small Quadra Flat Package) structure, has been downsized so that it may be mounted on transmitters and actuators.

(4) Environment-friendly design

The circuit and interface have been designed to meet the severe environmental conditions required for the outdoor operation of field devices and the intrinsic safety required hazardous areas, such as encountered in the petro-chemical fields. Figure 3 shows the external view of the FRONTIER-1.

3.3 Development of the electrical Fieldbus device

To verify the actual performance of the Fieldbus, field trial tests were performed at two domestic sites in 1994. The IFC-J (International Fieldbus Consortium-Japan), which has been organized by 13 users and manufacturers, presided over the test.

As a member of the IFC-J, Fuji Electric developed a prototype pressure transmitter for the Fieldbus, which is composed of a transmission board equipped with an IC, FRONTIER-1 and the associated protocol software. It was connected to a conventional electrical transmitter. The external view of this prototype is shown in Fig. 4.

Fig. 3 FRONTIER-1

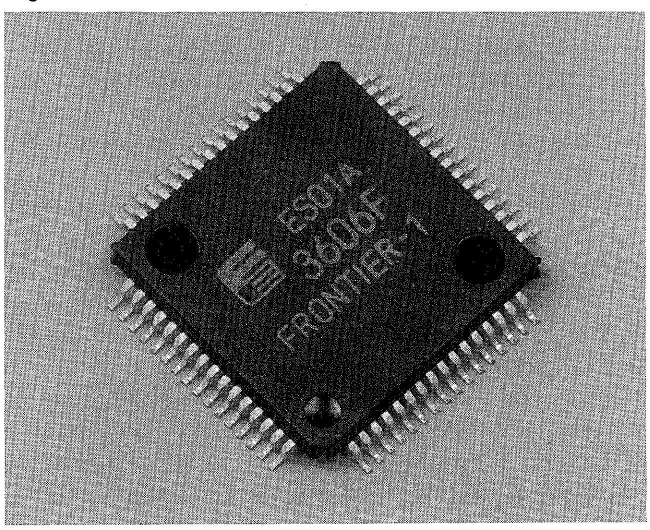


Fig. 4 Fieldbus transmitter

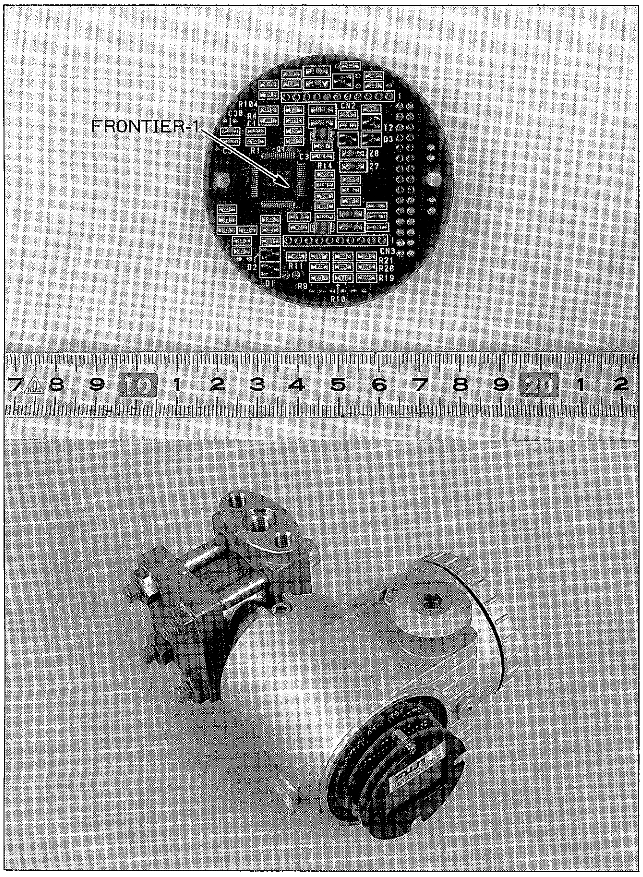


Fig. 5 Optical Fieldbus configuration

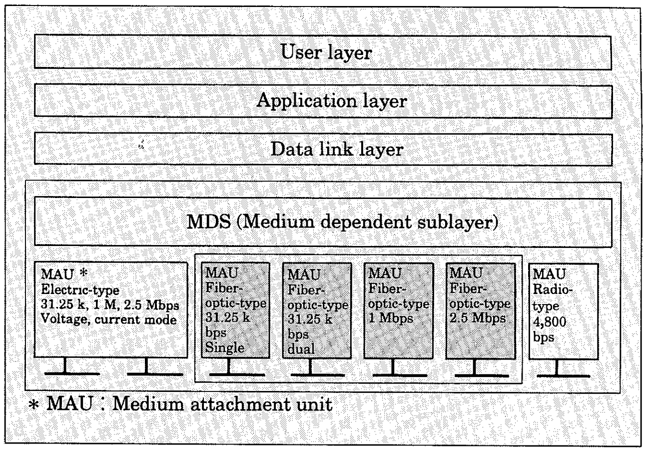


Table 1 Specifications of IEC optical Fieldbus (DIS)

Item	IEC optical Fieldbus
Topology	Star topology
Number of devices	Max. 32
Transmission length	Not specified
Bit rate	31.25 kbps
Wave length	850±30 nm
Transmit power level	−13.5±1.0 dBm
Connector	FC or ST connector
Cable	100/140 μm SI

In the field test of this transmitter, we measured and identified the signal waveforms, the effects of various cables and noise, with special emphasis on the standard for physical layers. In addition, we loaded a common function block to verify the compatibility with devices from other manufacturers.

4. Optical Fieldbus

4.1 Proposal for the optical Fieldbus standard

We proposed the optical Fieldbus based on technology and experience with the FFI system, which Fuji Electric was the first to market. The FFI system is a digital transmission network, which connects various field devices, such as transmitters and controllers of differential pressure, flow rate and temperature via a single line optical fiber cable and an optical star coupler. Protect against noise and lightning impulses as well as superior intrinsic safety characteristics have been proven. A vast amount of practical experience in actual plants has been accumulated.

The optical Fieldbus standard applies to a part of the MAU (medium attachment unit) and specifies the media for the physical layer. (Refer to Fig. 5). This MAU concerns the topology, bit rate, and such hardware as optical fibers and optical star couplers.

The MDS (medium dependent sublayer) is located above the MAU in the physical layer. The MDS mainly processes encoding, and decoding signals to the data link and higher layers. Since the MDS of the optical Fieldbus is the same as that of the electrical Fieldbus, the upper layers above the physical layer are compatible with each other. Table 1 shows a draft of the IEC standard and lists fiber diameter, signal wave length and bit rate. For conformity, both the optical Fieldbus and electrical Fieldbus are specified with the same maximum number of connectable devices and transmission rate.

4.2 Development of optical Fieldbus devices

Fuji is currently developing the second generation FFI system according to the optical Fieldbus standard. A comparison between the current FFI system and the next generation FFI system is shown in **Fig. 6**. A major change in system configuration is the use of a reflective star coupler instead of the transmittive star coupler. The conventional transmittive star coupler works only between the upper system and the field devices. As in the case of the electrical Fieldbus, the reflective star coupler makes it possible for the field devices to transmit signals to each other. By installing the reflective star coupler (passive type) which requires no power supply, the optical Fieldbus can also realize a field distributed control system.

The transmission rate of the next generation optical Fieldbus system will be changed to 31.25 kbps in order to comply with the standard. At the same time,

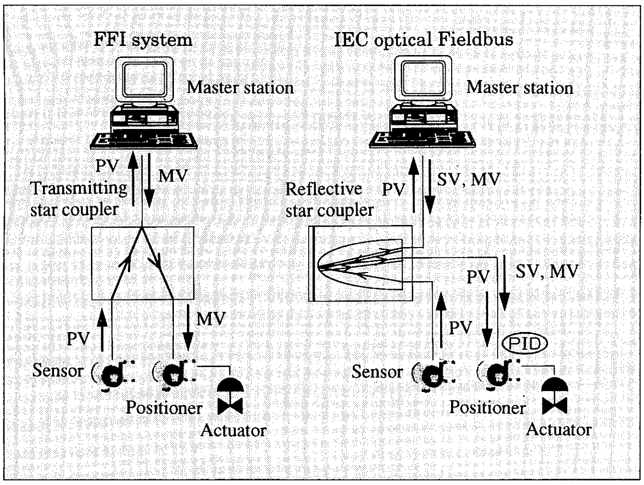


Fig. 6 Comparison between FFI system and IEC optical Fieldbus

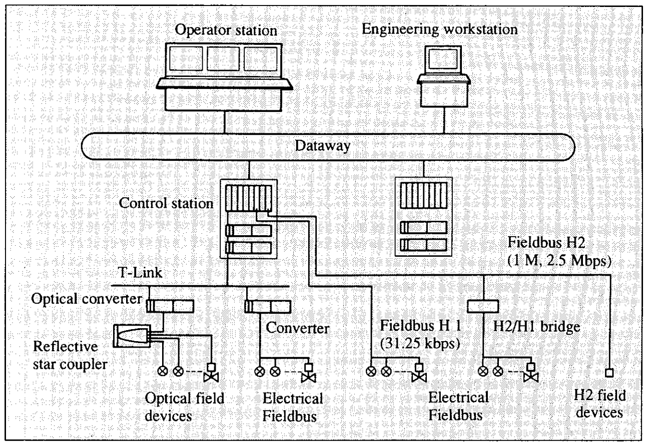


Fig. 7 Example of Fieldbus system with DCS

Fuji Electric intends to prolong the battery life of battery-powered field devices by reducing power consumption.

Moreover, by installing the same protocol as that of the electrical Fieldbus in the data link and higher layers, the optical Fieldbus devices will be compatible with the electrical ones.

5. Fieldbus System Configuration

How large should the scale of the Fieldbus be ? To what host system will the Fieldbus be connected? The answer to these questions will depend on the future line-up of associated products, their variety and reliability, the availability of peripheral devices, including maintenance tools, and the accumulation of practical knowledge and experience. In this sense, the field tests scheduled in the future will have a considerable affect on the direction of the Fieldbus.

During testing of the Fieldbus, a small-scale monitoring system connected to personal computers may extend its applications, or a field distributed system may be introduced for trial by some leading users. Further, the Fieldbus may promote downsizing of the DCS and cause control systems to evolve.

Compared to the conventional control systems, the Fieldbus isa field network in which FA and PA are combined, and contains one or more wire, optical fiber or wireless media that replace the standard 4 to 20mA analog signals.

The following problems must be solved, utilizing advantages of the above characteristics, before the Fieldbus can be used widely.

Broken wires, misconnections and short circuits during operation will fatally affect all of the field devices. It will be better in the initial stage to limit the number of the field devices that are connected in order to disperse the risk.

Since multiple field devices are connected to the Fieldbus, it is necessary to identify and locate transmission error and device faults, to analyze their causes and to take measures against these malfunctioms and faults.

As for the intrinsic safety, the field device and barrier were connected in pairs in conventional systems. With the Fieldbus, since one or more devices are connected to a single barrier, it is necessary to design and verify field device current consumption and the connecting methods in each Fieldbus, and in addition, to establish a judgement criteria for the above.

Therefore, until the Fieldbus is widely used and experience is accumulated in practical applications, the bus topology and number of the field devices connected must be designed carefully.

On the other hand, the optical Fieldbus is free not only from noises that affects electrical performance, but also from engineering problems, such as topology of the Fieldbus and the number of field devices that may be connected. Field devices with internal batteries will be suitable for use in field distributed systems due to their self-support capability. Both the electrical and optical systems have features and advantages. These should be the basis on which the respective Fieldbus systems are developed and configured.

The DCS connections for both systems are shown in Fig. 7.

6. Conclusion

This paper has presented Fuji Electric's activities concerning the Fieldbus. The Fieldbus Foundation plans to preside over field tests in 1996. These tests will be the last step of verification in the Fieldbus product development, the largest milestone in Fieldbus standardization for the past 10 years. The author will devote himself to further development of Fieldbus products in the coming Fieldbus era.