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TECHNICAL TREND OF MEASUREMENT AND CONTROL SYSTEM

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1 INTRODUCTION

In the context of recent stable growth and internationalization of the industries, the trends toward rationalization and for higher technological informations express themselves in the following movements in those concerned with measurement and control.

(1) Rationalization and total systematization
- Rationalization of process for energy and resource saving
- Improvement of efficiency of processing and working
- Rationalization including production control as a part of the total system
- Replacing of the plant constructed before 60's.
- Through rationalization of works down to the small-scale facilities.

(2) Coping with new processes and research and investigation
- Measurement and control coping with introduction of new materials, new process, fine chemicals and high-technology products into new sectors of industries.
- Investment for studies, research and investigation

(3) Internationalization
- Plant export
- OEM supply of equipment and system or technological interchange

For these social tendency, we can enumerate as the main items of the measurement and control technology the following.

(1) Distributed control system with CRT operations that has started from 1975 due to the development of electronics including micro-processor come to establish.
(2) Apparition on and from 1983 of intelligent sensor (smart transmitter) aiming at higher precision and higher functionality in process sensors.
(3) High-precision measuring instruments and analytic equipment for LA (Laboratory Automation) including those for laboratories and line inspection.
(4) Utilization of telecommunications technology for LAN (Local Area Network) and public channels by use of optical fiber technology.
(5) Introduction of advanced control utilizing control theory and knowledge engineering mainly expert system, and its practical use.

With this background, Fuji Electric concentrates its efforts for developing instruments and devices in the sector of measurement and control for these PA, FA, and LA, namely:

(1) Distrubuted control system with Digital Process Control System MICREX-P as central system covering everything from PA (Process Automation) to total FA (Factory Automation).
(2) Industrial use personal computer L-300 and general use temperature controller Z series that propel small-scale PA-FA and rationalization in the field of machinery industry.
(3) FC Series constituting internationalized products in process sensors to optical fiber type field instrumentation system FFI with optical fiber transmission and intelligent sensor.
(4) High-functional and high-performance measuring equipment as microparticle counter, Fourier transform infrared spectrometer (FT-IR) mainly for LA.

This article in the special issue introduces technological trends in the field of measurement and control in Fuji Electric at their latest phase. This report in particular presents a perspective of sensor technology and instrumentation control system as well as system construction as the background to these trends.

2 TRENDS IN SENSOR TECHNOLOGY

2.1 Trends in sensor technology

Together with a rapid progress in information processing capacity as seen in micro-computers, personal computers and large-scale computers, the importance of sensors as their input devices has come to be stressed more and more everyday in their quality and quantity. On the other hand, thanks to full utilization of the new processing technology, sensors of lower cost and higher functionality have come to the reality.

The following are the most remarkable points in the

Table 1 List of Sensors in Fuji Electric.

Element technology	Main sensors and measuring instruments	Main field of application
Semi-conductor application technology	Silicone diffusion strain gauge type pressure sensor	Public (car electronics)
	Silicone radiation detector	Nuclear power st. PA
	Amorphous silicone linear image sensor	Public
Optic measurement and analysis technology	Fourier transformat infrared spectrometer (FT-IR)	LA, PA (semi-conductor, biotechnology)
	Microparticle counter	PA, LA
	Non-dispersion infrared gas analyzer	PA
	Luminescent oxygen analyzer	PA
	Infrared film thickness measuring meter	PA, FA
	Ultraviolet organic turbidimeter	Water treatment
Optical fiber application technology	Optical-application electric and magnetic field sensor	Electric power st.
	Optical-type temperature sensor	PA
	Optical fiber transmission sensor (FFI)	PA
Image sensing technology	General-purpose video sensor (multi-window)	FA
	Robot vision sensor	FA
	Bill validating	OA
Ultrasonic application technology	Ultrasonic flowmeter (portoflow)	PA
	Ultrasonic level meter	PA
	Ultrasonic switch	FA
	Ultrasonic defect detector	Preventive maintenance
Electromagnetics and electrostatics application technology	Static capacity pressure and differential pressure tramsmitter (FC)	PA
	Electromagnetic flowmeter	PA
	Approximation switch	FA
	Vibration sensor	FA
	Conductometer	PA, water treatment
	Magnetic oxygen analyzer	PA
	Heat conduction type gas analyzer	PA
Radio-isotope application technology	Various types of radiation sensor	Nuclear, PA
	Radio-isotope thickness gauge	PA
	Radio-isotope level gauge	PA
	Radio-isotope densitometer	PA
Ceramics application technology	Zirconia oxygen analyzer	PA, Public
	Zirconia humidity meter	PA
Electro-chemistry application technology	pH-meter	Water treatment
	Solved oxygen	Water treatment
	Residual chlorine meter	Water treatment
	Lithium chloride humidity meter	PA
Biochemistry application technology	Immobilized enzyme membran	Medical, PA (food)
	Immobilized enzyme, micro hybrid sensor	PA (food)
Medium application technology	Catalytic combustion gas sensor	Public
	Medium-applied gas analyzer	PA
Fluid measuring technology	Various types of temperature sensor (thermoelectric meter, resistance-bulb, thermistor)	PA, FA
	Various types of differential pressure type flow and level meter	PA
	Kárman vortex air flowmeter	Public (Car electronics)

trend of sensor technology:

(1) Expansion of application field of sensors

Up to now, the domain covered under the name of automation has been, mainly, PA field, but now, it is much more. It means FA, LA and now HA (Home Automation) plus OA. That is, sensors play an important role in public use also.

(2) Improvement in sensor quality

It is the diversification of input/output informations that has come to develop, so to say, from points to lines, and from lines to areas, that propels the improvement of quality of products from the mass-produced low-cost sensors to high-precision measurement instruments with advanced electronics technology.

As mentioned above, the sensor technology has a wide area of needs and its expansion is expected to be limitless with the progress of the information processing equipment.

2.2 Sensor technology in Fuji Electric

Fuji Electric as general electric equipment manufacturer responds the wide needs from each field of industries and, in particular as to the manufacture of sensors, has come to develop their production on the basis of its well found technical background.

Table 1 shows a list of element technology regarding sensors and main line of sensors produced, as well as the fields of their application and use.

(1) Semi-conductor application technology is a field of technology that mass-production sensors can utilize to the full their physical features.

In particular, silicone diffusion type strain gauge pressure sensors are produced in an enormous quantity to be used for automobiles.

Future of semi-conductor sensors is bright: through application of miniaturization technology, they are expected to be demanded more and more in the world market.

(2) Optic measuring and spectrometric technologies are represented by measuring and spectrometric equipment utilizing the physical properties of light (reflexion, absorption and transmission), for which Fuji Electric has traditionally strong series of products as non-dispersion type infrared gas analysis instruments that has been manufactured long time. But now, through application of laser and electronics technologies, new series of instruments as spectrometer and micro-particle counters and others.

(3) As for the image sensing technology, by combination of optic sensor (CCD, silicone array sensors, etc.), magnetic sensor array technologies, which constitute important factors of pattern recognition technology, it will be come the locomotive for development of FA in future, and it registers a steady progress.

(4) Ultrasonic wave application technology is one of the most excellent measuring technologies that FUJI ELECTRIC has and it is represented by the products of TLL type ultrasonic flowmeter that are widely used.

(5) For electro-magnetic, electrostatics application tech-

nologies, radiation application technology and fluid measuring technology various types of sensors are already manufactured and commercialized, among which the electrostatic capacity type pressure and differential pressure transmitter (FC series) and various types of radio-isotope sensors constitute one of the most characteristic sensors of Fuji Electric products.

(6) For the future, much is expected for ceramic application technology, biochemistry application technology (bio-sensor). For these, part of these technologies have laready been put into practice, and they are expected to grow in the future.

Their field of application is, mainly, for PA as well as FA and LA, and furthermore, they can be used for public use and for OA. The field of application is increasing.

Among the sensor technologies of Fuji Electric mentioned above, a brief description is made on the theme recently developed and introduced in this feature issue of our brochure.

The Fourrier transformat infrared spectrometer (FT-IR) can, through combination of precision-class optics and high-function electronics techniques, carry out higher speed and higher resolution analyses, that may not have been possible with conventional dispersion type infrared spectrometer. The new types of ours can also carry out surface analysis on semi-conductors and ceramics. Further application is under development.

Air flowmeter for automobiles has been developed as air flowmeter for engine control (EFI) that has been a main theme of particular study for car electronics. Many featured sensors, those having wider range of measurement due to Kárman vortex and quick response, have come to be produced and manufactured now. A high-precision engine control can be expected with these sensors.

A combined type electromagnetic flowmeter (Compact Flow) was developed for measuring the liquid flow for PA, which has feature of compacting its size and reduction in weight as well as making it of higher functionality compared with the conventional type of flowmeters, and has become next popular instrument to FC sensor for PA of FUJI ELECTRIC.

3 TREND IN INSTRUMENTATION & CONTROL SYSTEM

3.1 Progress in instrumentation & control system

Instrumentation & control system of Fuji Electric has seen systematic development in each level of computer system, distributed digital instrumentation & control system and electronic measurement control system. This report describes the latest topics in this progress.

(1) Progress of distribution (single loops)

First single-loop controller "Compact Controller" according to IEC (DIN) size was commercialized in 1979. In 1983, MICREX-P system Process Station "PCS-100" for rack mount type CRT operation was added. It was another addition of single loop system to the multi-loop system that has existed before.

The following are the characteristics of single loop control in contrast to multi-loop.

(a) Improvement in reliability due to distribution of risks

(b) Improvement in expansibility and maintainability through loop to loop integrity.

(c) Fast calculation operating speed.

(2) Increase of CRT operation (serialization of CRT operator stations)

Through improvement of MICREX-P in 1983 and succeeding development, CRT operator stations were serialized as 20-inch OCS-1100 for large-scale, 20-inch OCS-200 for medium-scale and 14-inch OCS-150 for small scale. And the system development was devised so that CRT operations can be adopted according to the scale of the plant.

(3) From PA to total FA (Integration of instrumentation, electric control and computers)

In 1983, by connecting controlleer PCS-100 for process control (instrumentation) to programmable controller HDC-100 for sequence control (electric control) by common data way DPCS-E, the system was made so that it can be controlled and supervised by CRT operator station, and can be integrated into Computer U-1000 Series and S-3000 Series. This is a unique system taking full advantage of Fuji Electric's total capability. In 1985, super micro-computer FASMIC G was also added.

(4) Integration to sensor (FF1 System)

In 1985, for the first time in the world, optical fiber type instrumentation system FF1 was announced and commercialized as a system. FF1 is a new-generation instrumentation system that would take over the place of conventional pneumatic and electronic systems (DC4-20 mA). This is integrated with MICREX-P.

(5) Impact caused by Personal Computer (L-300)

Together with the rapid pace of progress and their diffusion, with an aim of utilizing their merit in the industry, Fuji Electric has, commercialized L-100 in 1982, and L-300 in 1984, for industrial use personal computer and now they are in full operation in various applications mainly for small-scale FA.

(6) Advanced control put into practical use

For MICREX-P system, an auto-tuning function was added in a practical way since 1978, and many control theory were put into practice. In 1985, general purpose fuzzy controller, expert system was announced and that drew much attention of users.

3.2 Fuji Electric's Total Control System

Fig. 1 shows the total control system of Fuji Electric. Features of this system are:

(1) Global instrumentation control system including from sensor to digital instrumentation control system, process computer, and computers for production control.

Fig. 1 Fuji Electric's total process control system

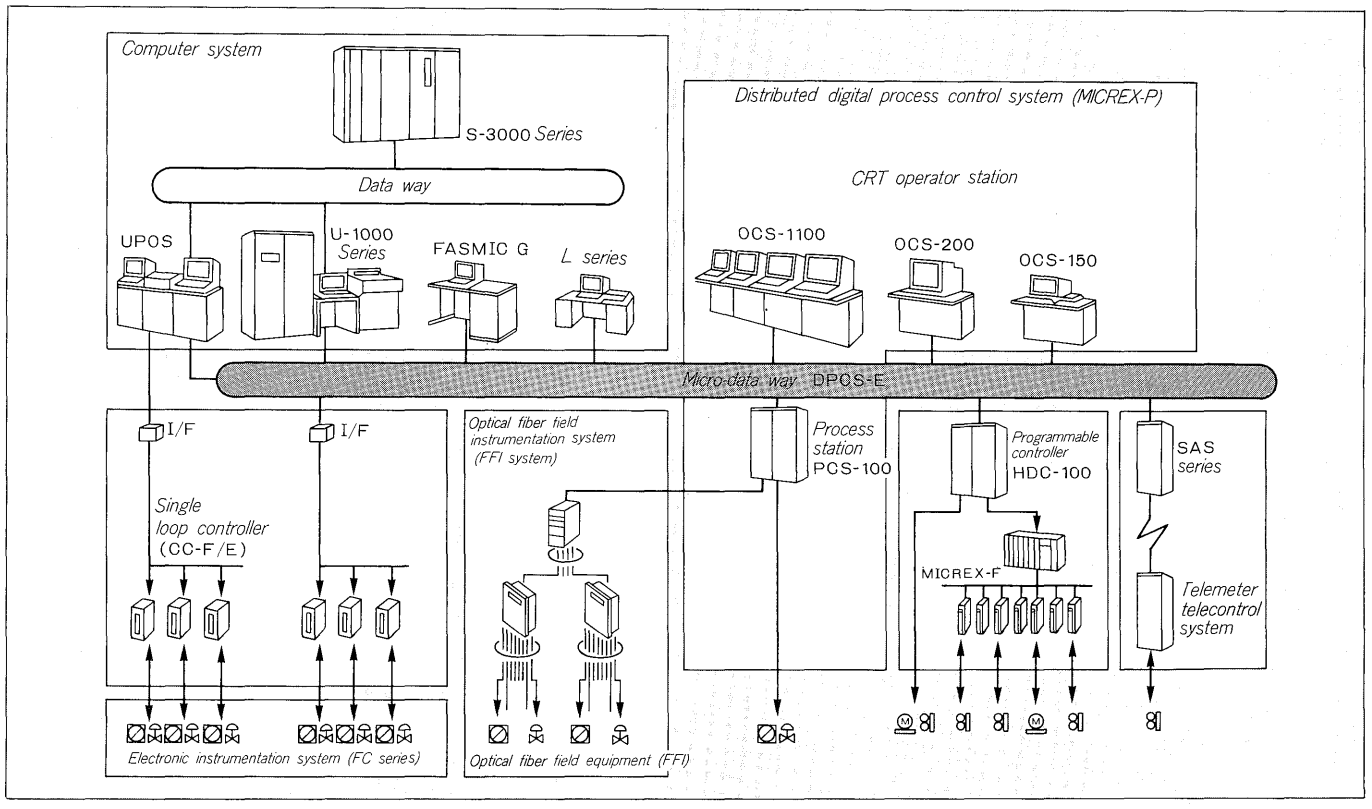
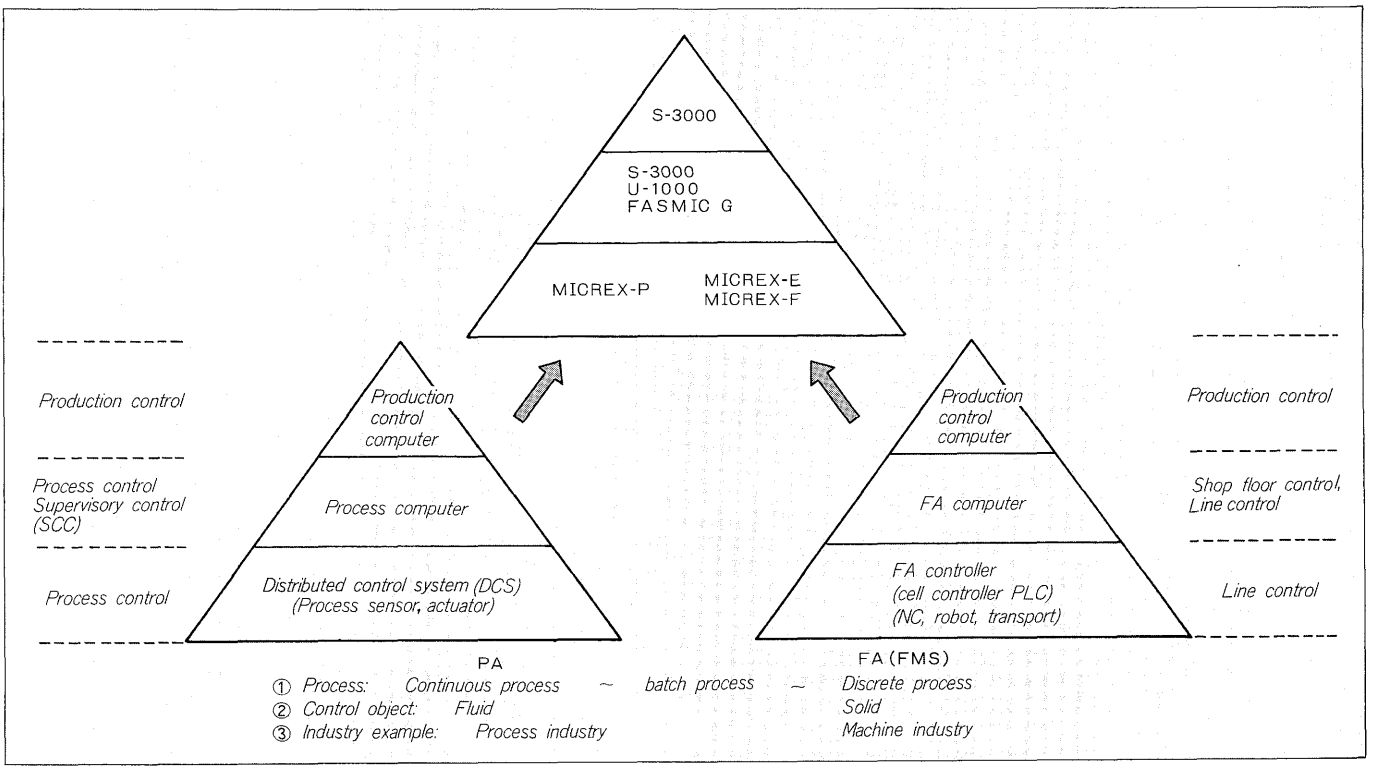


Fig. 2 Integration of PA-FA hierarchy composition



(2) Total FA system for entire plant integration programmable controller including electronic control and mechatronics equipment with instrumentation & control system.

(3) General use temperature controller that can cope with detailed demands of small-scale PA-FA and small-scale plant control using such devices as general use instrumentation, simplified instrumentation and industrial personal computers.

In brief, as mentioned above, the system features in a

standard system developing from sensor to total PA-FA system responding to all requests from users.

Fig. 2 shows a concept of hierarchy composition of PA and FA (FMS). MICREX-P is for PA while MICREX-E and MICREX-F can be said to be mainly for FA. These are desired to be integrated from the following necessities:

(a) Process of material flow in the process industry.
(b) Production control in the batch process.
(c) Loop control of temperature as in machine industry.

Fuji Electric's total control system takes into consideration of the following items

(a) Unified data way as one of the MICREX series.
(b) Supervising operation in the identical man-machine interface (OCS).
(c) Link with computers.

Also, the system is serialized so that it can be matched with various versions for controllers and computers.

3.3 Confugiration method of instrumentation & control system

Fig. 3 shows the composition of the instrumentation & control system, contents of control, operational method, plant scale and computer function, as well as the method of selecting those functions.

3.3.1 CRT Operation system: MICREX-P

(1) Small-scale system: OCS-150 + PCS-100
(2) Medium-scale system: OCS-200 + PCS-100
(3) Large-scale system: OCS-1100 + PCS-100 + HDC-100

A system among the above-mentioned (1), (2) and (3) will be selected according to the system scale (plant scale) in the CRT operation system. When there are many sequence control functions in the contents of control, use HDC-100 with PCS-100 as controller at the same time. (*Fig. 4*)

These systems, small-, medium- and large scale ones, use the same data way and have the system configuration serialized according to the scale of CRT and, further, have the following characteristics:

(a) Possibility of expanding from small and medium scale systems to large-scale system.
(b) Possibility of co-existence of small and medium scale systems among the large-scale system.

Also, though OCS-200 is of 20-inch graphic, it is of disk-top type and its adaptability is very high.

(4) Small-scale supervision and control equipment: EPEC-10

The stand alone package FPEC-10 as small-scale supervision and control equipment is a system coupling 14-inch desk top CRT equivalent to OCS-150 with general purpose programmable controller MICREX-F PIO capsule (T capsule) by an IO link (T link) and is a very light composition. Users will have no difficulty at all without the need of any modifications for using both its hardware and software, and in particular, the system is optimum for the small-scale batch process.

Fig. 3 Selecting procedures of instrumentation control system

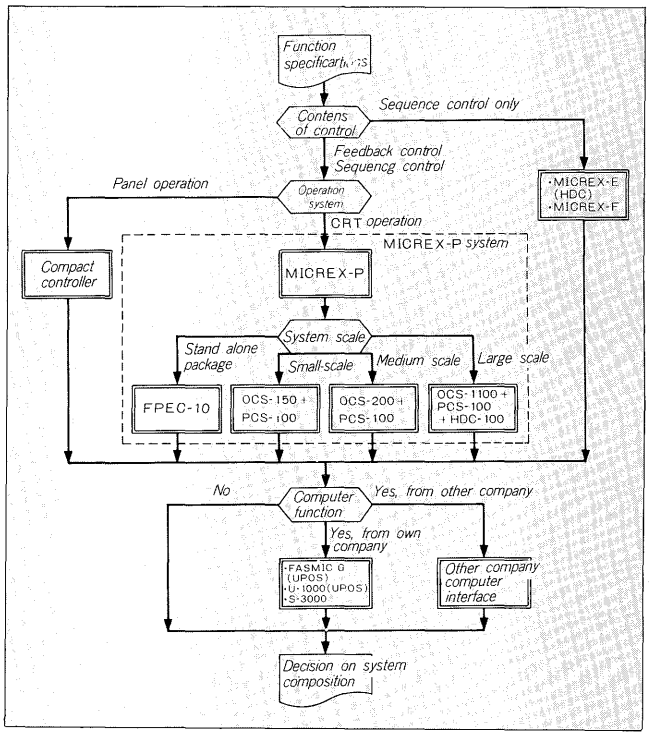
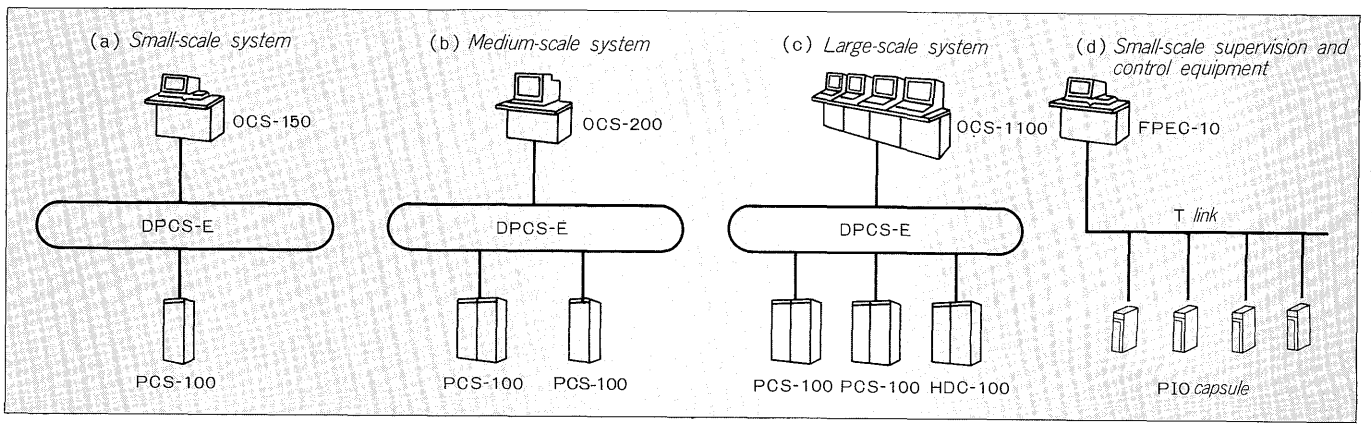


Fig. 4 CRT operation system composition



3.3.2 Panel operation system: compact controller

Panel instrumentations still have stronghold in both markets, domestic and overseas and in particular, they are adopted for small and medium scale system as well as local instrumentation system.

3.3.3 General purpose instrumentation system: Z series

Z-series are used for general-purpose instrumentation and simple instrumentation in particular for temperature control in the machinery industry. Those are available small-sized controller of 48 mm□, 72 mm□ and 96 mm□. and temperature program controller

3.3.4 Optical fiber field instrumentation system: FFI

A new generation optical fiber instrumentation system having various features as explosion proof, anti-noise, remote maintenance, etc. can be constructed by suing optical fiber for the field equipment mentioned in paragraphs 3.3.1 and 3.3.2. This new system exerts an excellent performance for petrochemical and chemical explosion-proofing process.

3.3.5 Computer system

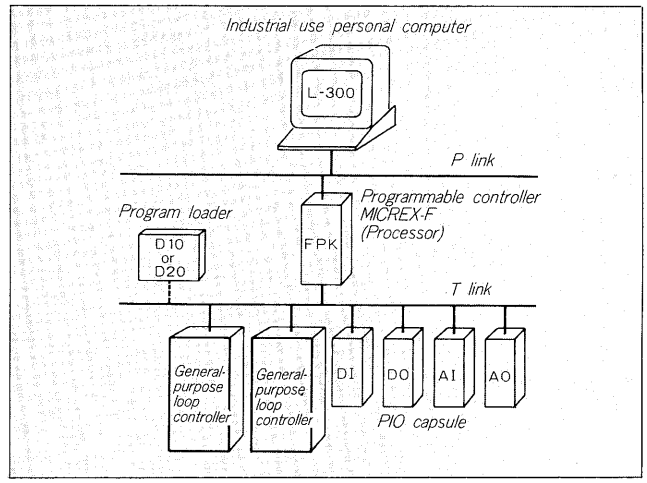
A 32-bit super mini-computer S-3000 series and 16-bit mini-computer U-1000 series having a rich and vaste experience as process computers including a function of product control, can be used by coupling them to the system as the higher hierarchy system. In the small and medium scale systems, super micro-computer FASMIC G can be used as process package UPOS. This UPOS can include additionally supervisory and control functions, so that it can constitute a system including computer function and CRT operation function.

3.3.6 PA and FA total control system

(1) Total FA system

In addition to PA, this system aims at FA that carries out automatization and product control on material flow which is the up- and down-stream procedures of the process at the same time, and is directed to total FA system combined with administration information. For these, system construction is effectuated by integrating (1), (2) and (3) MICREX-P of Paragraph 3.3.1 with computer system of Paragraph 3.3.5 above.

Fig. 5 Small-scale PA-FA system



(2) Small-scale FA system

For small scale PA-FA system for machinery industry, industrial personal computer L-300 and general purpose programmable controller MICREX-F, as well as Z series as temperature controller and used. With these, a system with a good cost performance can be constructed. This makes a good use of economicity and ease of handling of general-purpose instrumentation and programmable controller as well as personal computers, for constituting a system.

4 CONCLUSION

In this technological perspective, FUJI ELECTRIC is determined to keep going on with bold introduction of the fruits of latest technological progress such as micro-electronics, light fiber, new materials, micro-processing technology and artificial intelligence technology with harmony, and to offer our users the measurement and control equipment/system that are perfect match with the users' need. Fuji Electric sincerely requests instructions and suggestions, assistance and encouragement from our users.