

EVOLUTION OF THE COMPACT CONTROLLER

Kazuyuki Kisa

1 INTRODUCTION

Even since commercializing Compact Controller F in 1979, we have expanded its family types of controllers, such as low-cost type Compact Controller E, Transmission Controller and others, serializing them as FC Series of today.

In the mean time, for process control, demand for controllers has changed from diversity of functions to easiness of use and maintenance with progress of CRT operation and totalization of process control. And controllers that realize functions required by users through simple engineering and easy installation, have come to be more in demand.

Coping with this change and as the products meeting the demand of international market, Fuji Electric has now developed a new single-loop controller, "Compact Controller S".

2 DESIGN CONCEPT

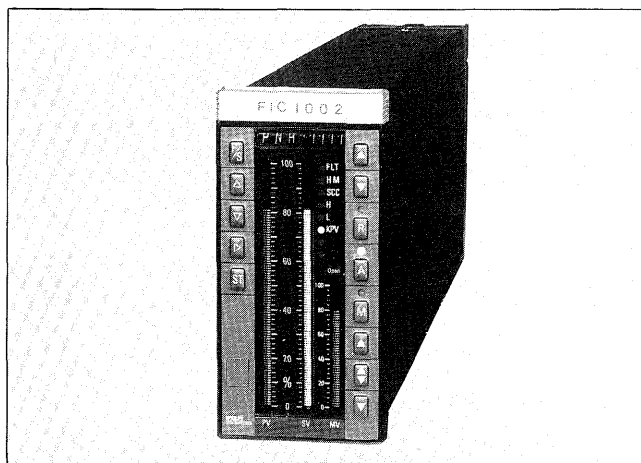
(1) Easiness of use

In single-loop controllers, it is necessary that control functions desired by users be put into practice with ease. The most processes are simple loop controllers easy to use with fixed functions are demanded rather than those with diverse functions. However, at the same time, for controls more complex and a step more advanced, programmable control functions become necessary.

Compact Controller S includes functions of both Compact Controller E (with fixed functions) and Compact Controller F (programmable functions) and they can be configured as Basic PID Controller or Programmable Controller. In Basic PID Controllers, a PID control function is fixedly provided with several other control functions to be applied to as many processes as possible.

Also, for conventional type of controllers, it was indispensable to have a specialized knowledge for adjusting PID parameters. However, as Compact Controller S is provided with auto-tuning function, tuning without need of specialized knowledge is made possible, so that engineering works are reduced. The auto-tuning function is equipped

Fig. 1 Compact Controller S



in either type of machines mentioned above.

(2) Ease of installation

It is desirable for controller that they can be installed in any environment without adding other peripheral equipment.

For Compact Controller S, power supply is DC 24V, AC 110V and AC 220V so that it can be used with ease also in overseas countries.

Also, measured value input can be selected from DC1-5V, 4-20mA (power supply possible to transmitter), thermocouple and resistance temperature detector. Cold-junction compensation for thermocouple is incorporated within the mainbody, thus ease of installation is devised.

(3) Ease of maintenance

Together with diffusion of CRT operation, there are fewer chances that front-panel operation of the controller should be made, but, still there are chances of that for emergency, and downtime of controller and processing.

In this Compact Controller S, switches for output operations are placed exclusively on its front panel. These switches can be operated even when the micro-processor fails.

Also, a manual operation unit is available in option with which output can be retained at the time of withdrawing instrument. The manual operation unit can be mounted from the front panel of the instrument so that re-

Table 1 Specification of compact controllers

Item		Specification
Type		Current output type controller (PNA) or pulse width output type controller (PNC)
Input signal	Ai	5 points: DC 1~5V × 4 points 4~20mA × 1 } Option Thermocouple × 1 } selectable RTD × 1 } 1 type
	Di	6 points: DC 24V isolated
Output signal	Ao	5 points: 4~20mA × 1 points DC 1~5V × 4
	Do	6 points: DC 24V isolated, including one fault output and two alarm output
Indicator	Process variable and set point variable	LED display (PV: red, SV: green) 1% resolution, 0 to 100% linear, scale length 100mm
	Control output	LED display (red) 2% resolution, 0 to 100% linear, scale length 50mm
Data Link		CC-Data-Line or RS422/485
Memories		PROM 32kB Program memory EEPROM 2KB Configuration memory RAM 8kB work memory
Installation	Ambient conditions	0 to 50°C, 90%RH max.
	Power requirements	24VDC (20 to 30VDC) 110VAC (85 to 132VAC) 220VAC (187 to 264VAC)
	Weight	Approx. 3 kg
	Power consumption	Approx.
	Dimension (H × W × D)	144 × 72 × 391mm, IEC (DIN) standards
Cycle time		0.1 sec min.
<p>• Transfer function of PID control</p> $MV = K_P \left(1 + \frac{1}{T_i S}\right) \cdot DV + \frac{T_d S}{1 + \frac{1}{8} T_d S} \cdot PV$ <p> <i>MV</i>: control output <i>K_P</i>: proportional gain <i>DV</i>: control deviation <i>T_i</i>: integral time <i>PV</i>: process variable <i>T_d</i>: derivative time </p> <p> Control group • PID control • ratio calculation • time cycle program control • load PID parameters </p> <p> Logic group • and • or • exclusive or • inverter • flip-flop • timer • decoder • pulse generator • PWM </p> <p> Computation group • add • subtract • multiply • divide • square root extraction • absolute • linearize (x3) • selector • limiter • compare • summation (analog or pulse width) • hysteresis • sample hold • average • lead/lag • dead time (x3) • moving average (x2) </p>		

placing of instruments can be effectuated under the condition of retaining control output.

Instrument failure and process abnormally are displayed on the instrument front panel. In order to permit a comprehension of abnormally at a glance, indicator flickering together with lamp indication can be configured. Also, in order to leave informations on momentaneous failure and abnormally, a function of retaining information until the operator will confirm the fact, is available.

(4) Step to Internationalization

Fuji Electric's single-loop controllers, from the start, are oriented toward internationalization, and Compact Controller E/F are type-approved by WIB¹⁾, UOP²⁾ and others. Compact Controller S, on basis of its technology, in measures for meeting with further demand for diversification of power supply, water-proof construction, and FCC control, and thus, it has become product that can earn a big popularity in the international market.

Also, for facilitating coupling with various types of computers, a communication interface RS422/485 is provided. By using this communication line, linking with IBM and DEC computers is made possible.

By utilizing fully highly advanced manufacturing technology, high-cost performance controllers are suppliable, and a thorough cost down is devised.

3 MANUFACTURING TECHNOLOGY

There are two PCB's inside the Compact Controller S, namely: main board and power supply unit card. Aiming at reduction of number of parts through LSI's and on basis of advanced manufacturing technology, as well as utilizing fully the surface mounting technology, two microprocessors, two gage arrays, memory, analog input/output circuit, digital input/output circuit, and transmitting interface are mounted in a compact form. Further, through auto-mounting and autotesting technologies, easy manufacturing, that is, low cost making is intended.

4 INSTRUMENT FRONT PANEL

For front panel of Compact Controller S, in order to obtain diversification of displays, LED's of two colors are adopted.

Indicator makes operator's pattern recognition easier. For that, three vertical LED indicator are provided in the central part of the instrument. Indicator normally indicates PV (process variable), SV (Set point) and MV (control output). Furthermore indication of control deviation and line segment indication are configurable.

In upper part of the front panel, 8-digit LED digital

- NOTE 1. WIB (= Working Party of Instrument Behaviour): An international users' entity established in Holland carrying out various tests on instruments.
2. UOP (= United Oil Process): Entity established in U.S.A. approving instruments used for UOP Process in petroleum refining.

5 CONTROL FUNCTIONS

(1) Basic PID controller

In this type, the following control functions, besides

- Linearization on process variable.
- Square root extraction of process variable
- Delay filtering on process variable
- Functioning as a process variable limiter.
- Non-linear control
- Limiter of change rate of control output
- Control output limiter
- Tracking of set value by process variable (PV-TRK)
- Tracking of control output by external command (EX-MV)

(2) Programmable controller

In programmable controller, more complex and more

Fig. 2 Functional block diagram of basic PID controller

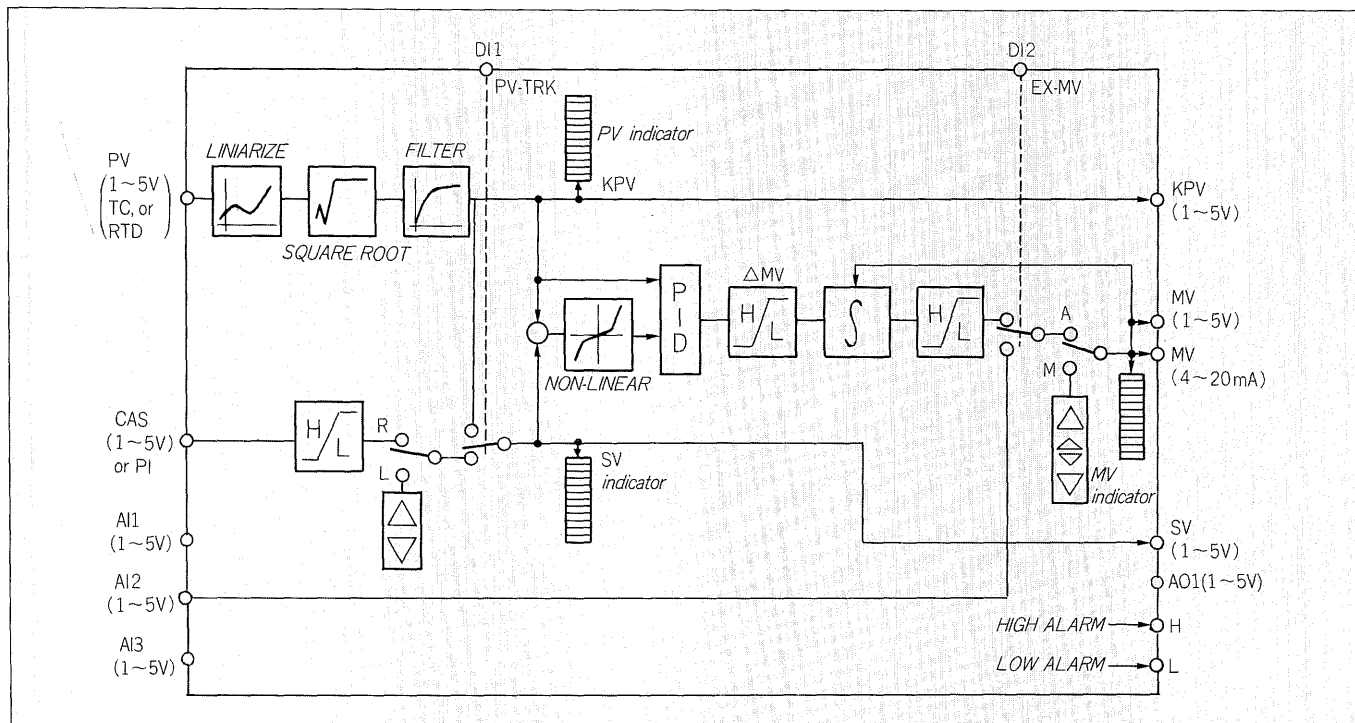
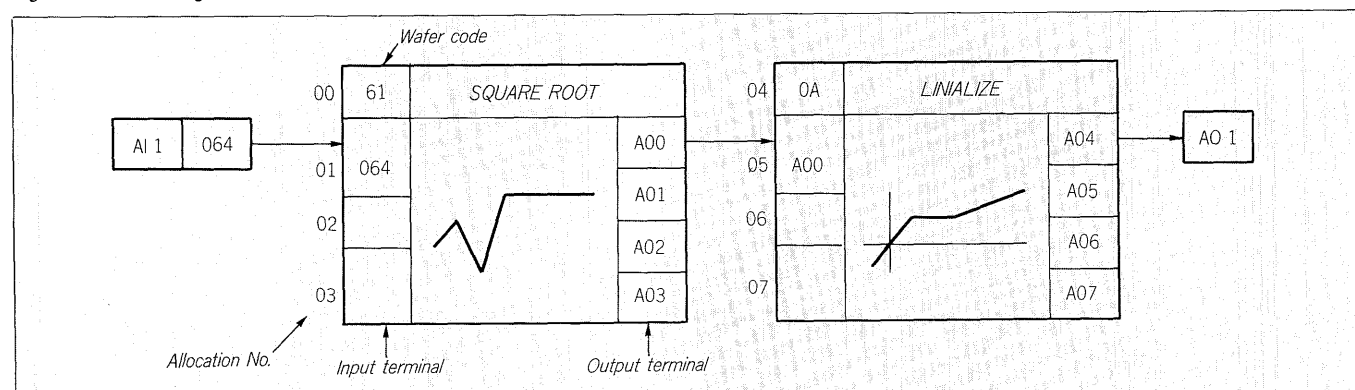


Fig. 3 Wafer configuration



advanced control functions are carried out by wafer programming. Wafer is a schematization of the minimum function block necessary for process control.

Fig. 3 shows a form of wafer. The wafer is provided with three input terminals and four output terminals. Data inputted to input terminal are calculated and outputted from one or more than one output terminals. Output of a wafer can freely be connected to other wafer input. Among about 60 kinds of wafer, the maximum of 24 sheets of wafers are registered and by interconnecting among them, the following controls are possible:

- Cascade PID control
- Ratio control
- Time cycle program control
- Dead-time compensation control
- Auto-selector
- Gain scheduling control, and others

Wafer connection can, besides being able to connect from the instrument front panel, be connected from higher hierarchy personal computer via the Transmission line.

6 AUTO-TUNING

Compact Controller S carries out PID parameter tuning by using start-up tuning and self-tuning.

Start-up tuning starts operating by tuning command. This tuning is carried out with an open loop, and grasping the process characteristic mainly in a form of area of a pulse response waveform, then computes the optimal parameter. Operator will confirm the optimal value computed and will proceed to tuning again, if necessary, then can set the optimal parameter.

In self-tuning, the parameter computed by the startup tuning will be further optimized. By detecting hunting condition of the process, through its periodicity and damping, the optimal parameter will be computed and modifies the parameter automatically. Consequently, it can cope with modifications of process characteristic after installing the instrument.

7 SELF-DIAGNOSIS FUNCTION

Compact Controller S is provided with the following self-diagnosis functions. When some failure is detected, FLT lamp will be lit on the front panel and, at the same time, FLT contact will be set ON. The details of the failure will be digitally displayed on the instrument front panel.

- Watch dog timer
- Memory check (in the initial phase)

- Timer interruption check
- A/D converter abnormally check
- Analog input over-range check
- Current output leadback check
- Operation cycle-over check

8 TRANSMISSION FUNCTION

FC series existing up to now in Fuji Electric is using transmission interface (CC data line) which is purely our original system, however, in our new Compact Controller S, aiming at conformity with international standards and coupling with more computers, RS422/485 interface is added. Host stations (computers) acquired access not only to control parameters but also to various internal data of the instrument. By being linked with personal computers and other control systems, process monitoring, operation, and DDC control can be realized.

(1) CC data line

Compact Controller S is connected to Transmission Controller of FC series through CC data line. The transmission controller collects and administrates the data of 15 instruments as the maximum, and sends them to the host.

Transmission speed:	19.2 KBPS
Transmission distance:	500 m., max.
Transmission line:	Multi-drop twist pair
Code format:	Binary 12 bits

(2) RS422/485

This is a versatile interface and in order that it can be connected to as much as possible hosts, the transmission speed and code formats are made variable.

Transmission speed:	2400, 4800, 9600 or 19200 BPS
Transmission distance:	500 m, max.
Number of connect- able stations:	31 max.
Code format:	Binary 10, 11 or 12 bits

9 CONCLUSION

Compact Controller S is a new-generation single-loop controller developed by Fuji Electric, and it has attained an excellent cost performance through use of the most advanced technology and micro-processor applied technology. And, as its capability can easily be taken out in either case of configuring a small-scale control system or a large-scale hierarchy system, Fuji Electric is convinced with its utility as an interface with processes.