

NEW DUAL CASCADE LOOP CONTROLLER
WITH COLOR LCD BAR GRAPHS,
EQUIPPED WITH A MEMORY CARD

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Abstract

A new dual loop controller using color LCD bar graphs with LED back lights has been developed. An optional memory card is used to load or save the controller configuration, which may be a preprogrammed standard package or a user-programmed configuration, in addition to the built-in functions ready for user selection. The bar-graph display is selectable for single-loop or dual-loop use.

A high grade of self-tuning functions using a modeling technique is built-in as standard. The controller can accommodate optional plug-in modules for thermocouples, communication, etc. All the options are fully field upgradable.

1. Outline

As the panel-mounted DDC is used not only for control functions, but also in a measuring control room, strong demands are made in regard to readability, operation, maintenance, and reliability. Now a new controller series using a high-level microprocessor has been developed. The special feature of this architecture is the fact that the basic type can be built up to a high-level controller by adding options. A color liquid crystal display has been developed for the display panel. By display with LED back-lighting, good color readability and high reliability have been realized. A special microprocessor is used for transmissions, and conformity to various protocols is easily established. Control function loading, maintaining of configuration data, etc. can be realized easily by use of memory cards.

2. System Composition

The system composition is shown in Fig.1. The main features are listed below.

- (1) Connection to general purpose equipment via a general purpose bus
RS485 is used for the transmission bus, and connection to a general purpose sequencer or a host computer etc. is possible via this bus. The user can use his personal computer to form a system, and a system with high flexibility can be created cheaply. Package soft for measuring systems, which recently is becoming popular, also can be used, and the user himself can create monitoring screens closely connected to the site.
- (2) Versatile system builders
A graphic loader, basic loader, and hand-held terminal are provided as system builders. This is done to offer the system builder with the best cost performance to the user for system development from small to large scale. For example, when 2 or 3 controllers are used as a stand-alone type, sufficient correspondence is possible with a hand-held terminal, and when further controllers are added at a later time, the system is flexible in regard to scale expansion, and a more convenient system builder can be used.
- (3) Communication between system builders
Program uploading and downloading between system builders is possible via RS232C. For example, a program can be downloaded from the basic loader to the light and easily carried hand-held terminal, and then it can be downloaded to the controllers installed at the site. Uploading of system parameters changed at the site via the hand-held terminal to the basic loader and filing at the center etc. is possible, and it should be observed that customization is possible for the various use of the users.
- (4) Memory card writer
This system uses memory cards as the storage medium. Programs developed by the user with the system loader is transmitted via RS232C to the memory card writer for writing to a memory card. Also, when standard packages are to be modified suitably on the user

side, the program can be downloaded from the memory card writer to the system loader.

3. Functions and Features

The new controller has a basic type, with which basic functions like simple PID etc. can be realized without software, and a programmable type, with which more advanced algorithms can be realized by programs, and with which various control configurations are acceptable by use of options. Accordingly, a measuring system can be set up with minimal costs and without waste. The function outline and the special features are shown below.

(1) Functions

In addition to the functions of the conventional integrated controllers, it has been upgraded the controller with special attention to controllability, operability, reliability, and expandability.

1) Control functions

A wide range of control algorithms can be realized by a function module configuration.

As the function module has built-in practical and effective control algorithms like PID control with two degrees of freedom etc., an economical and effective control system can be composed.

Installation of two loops also is possible, and virtual operation of the two loops is also possible.

2) Autotuning function for PID with two degrees of freedom

An autotuning function for PID with two degrees of freedom, strengthened set-up function, and strengthened practicality can be realized with modules.

3) I/O functions

3 points for standard analog input, 2 points for operation output, 1 point for digital input, and 2 points for digital output can be installed. In addition, 3 points for analog input, 2 points for analog output, 2 points for digital input, and 2 points for digital output can be used virtually in the intelligence space.

An optional expanded I/O board is also available, and when the expanded type is installed, the above named virtual I/O points can be made to function as real I/O points.

Further, correspondence to pulse input, TC input, mV input, and CJC input is possible with optional input card use.

4) Display operation functions

Display and setting of various parameters, as well as autotuning for the above named PID with two degrees of freedom can be executed from the front panel.

5) Message functions

Various trouble and alarm messages can be displayed and confirmed from the front panel.

6) Transmission functions

RS232C is supported as standard, and RS485 is supported as an option.

Accordingly, two types of transmissions can be executed simultaneously when an RS485 transmission board is installed.

7) Self-diagnostic functions

Self-diagnostic functions are provided for ADC, MV read-back, transmission, and memory, and a hardware test program is provided as standard.

(2) Special features

This new controller has the following special features because of the above mentioned functions.

1) Excellent control performance

The control performance of the control system is realized by use of advanced algorithms and an autotuning function.

2) Decreased engineering costs

The autotuning function aims at shortened plant start-up time and work reduction. Enhancement of various engineering tools permits system construction in a short time, so that the load of the system engineer can be reduced.

3) Realization of high-speed control

Use of a 16 bit CPU permits operation with a high-speed operation, and the transmission function is supported by a special transmission board, so that the load of the control CPU is reduced, and control with a high-speed processing cycle is possible.

4) Excellent expandability

Expanded I/O cards, various input cards, and transmission cards are available as options, and system expansion is easy. For example, when the number of I/O points increases with plant expansion, it is sufficient to insert an expanded type I/O board into the existing controller.

5) Excellent cost performance

As the basic configuration is limited to a minimum, system configuration is possible with only the functions required for each plant, a system without unnecessary functions can be realized, the system overhead can be reduced, and improvement of the cost performance can be expected.

4. Memory Card Application

In recent years, memory cards have come into use for various applications in many fields. As memory cards are small in comparison to floppy disks and magnetic tapes, they have excellent portability and transportability, and as the recording data does not need to be converted to a different medium like magnetism or light, interfacing with the microprocessor is easy. The item most easily causing problems in comparison to other media is the memory capacity, but progress towards large capacities is being made, and memory cards being able to sufficiently withstand various applications are being developed one after another.

Generally, the following applications can be considered for use of the special features of such memory cards.

1. Use as expansion RAM to increase the memory capacity.
2. Expansion of fixed data for fonts, dictionaries, etc.
3. Use as recording medium for storage in the same way as floppy disks and magnetic tape.
4. Use as a function expansion module with its own program.

In this way, various developments are taking place in the general industry, and various applications also can be considered for the field of process instrumentation.

(1) Memory cards for the new controller

Differing from the above listed general applications, the following applications can be considered for the new controller.

- . Control program construction <-- 2, 3
- . Control data logging function <-- 1, 3
- . Internal program module expansion <-- 4

Application of memory cards was tried for the above 3 items.

(2) Control program construction

For the control of various physical quantities (temperature, flow volume, pressure, etc.) with a process instrumentation controller consisting mainly of a one-loop controller, a control configuration tailored to the process is required. As different control rules must be constructed

for each user control loop, most controllers are equipped with program functions which can be set by the user.

These programs are created on a personal computer or with a special tool and then transferred to the controller, and this time memory cards are being used as the transfer medium.

Until now, EPROMs were the main stream, but recently, the EEPROM is being brought into the controller, and input is made via RS232C with a tool like a hand-held terminal etc.

However, in the case of transmission, a transmission line must be led to each unit, and when a hand-held terminal is used, the contents which can be programmed at the site are rather limited.

Thus RAM-type memory cards are being used, so that program construction is possible by interfacing with a personal computer or a hand-held terminal. When the memory card then is inserted into the controller body, the program can be transmitted easily. As the memory card itself principally can be inserted and removed, it is not required to have one card for each unit, but a single memory card can be used to store the programs for several controllers, so that the cost performance is excellent.

Polygonal line tables for linearization, gain scheduling tables, etc. also can be sent to the controller in the same way.

(3) Control data logging function

When recording of the internal control data was desired in a conventional controller, it was required to convert the internal data to analog output and have them written by a recorder or to use transmission with access by a host computer to acquire the data. Generally, the internal data are desired when an abnormal condition has occurred, when an alarm has been generated, etc. With a recorder, direct reading of digital quantities is not possible, and in case of transmission, there are problems like response speed etc., and as this is considerably slow in comparison to the control period, it was not possible to catch a given moment.

These problems can be solved by use of memory cards. With a normal control program, a function module method is used for control construction, where the user connects modules with input and output to a given function.

As one of these function modules, a data logging module is constructed. The data given as input to this function module are entered sequentially into the memory card as they are. This makes it

possible to log the data at the time of occurrence of a given operation inside the control program. Because the data during the control can be acquired as the internal digital codes in control period units, clear differentiation from operation abnormalities, input abnormalities is possible.

For example, when a memory card is installed and acquisition of the next 200 data from occurrence of an alarm is specified, only the data exceeding the normal range will be logged automatically. Then the user can remove the memory card at a later date to connect it to a personal computer or a tool for trouble analysis or trouble history management.

Recent controllers also have a function for on-line autotuning, and the data during tuning can be acquired, and they can be used freely by the user program itself. At a later time, the user can remove the memory card and utilize it on a personal computer or with a tool for failure analysis or historical control. In addition, if the user purchases a database program or statistic program off the shelf, it would be of great help for managing controllers or plant operation.

(4) Internal program module expansion

With the above mentioned function module method, selective connection of functions matching the user needs is possible from a module already incorporated in the controller, but special function modules become required for realization of special control. Such special function modules can be supplied by memory cards.

Normally, operation is executed by modules inside the controller, but when an expansion module is called from inside the program, control operation is executed by execution of sub-routines on the memory card.

For example, in the case of autotuning, new theories and tuning methods are being thought up all the time, and in such a case, handling in the same way as with a internal module becomes possible by using a memory card with a built-in module of the new advanced tuning method. Expansion macro modules containing a certain degree of functions, signal generator modules generating program waveforms, etc. also can be handled like built-in modules.

As described above, use of memory cards not only improves the programmability of the controller, but use of logger or other special operation functions differing from the conventional controller use methods also will be possible. As the demands made for controllers are becoming diver-

sified, it will become necessary to release display, operation, and internal algorithms to the users in the form of memory cards.

5. System-building Tool

With the new controller, the following three tool types can be selected according to the application.

(1) Graphic loader

This is an interactive loader using graphic display running on an IBM PC or a compatible machine (J-3100 etc.). System build-up is possible by interaction with the screen without any computer or special knowledge.

(2) Basic loader

This is an interactive loader using a format which can be run on an IBM PC or a compatible machine (J-3100 etc.). System build-up is possible by interaction with the screen without any computer or special knowledge.

(3) Hand-held terminal

This is a portable small loader. Interactive system build-up is possible. This permits simple program changes at the site as the main application. A controller data monitoring function is also provided.

(4) Supply of standard software packages as memory cards

By loading to the controller from memory cards, function build-up can be executed easily. An abundant variety of memory card packages can be prepared for a large number of process instrumentations.

6. Prospects

As described above, the new controller has many special features. It has been developed with special attention to easy handling. For example, from the viewpoint of engineering, five types of control functions have been included as standard equipment, so that use is possible immediately by selecting one of them. Further, up to 200 function blocks with original user functions also can be created in combination. The hardware permits a wide power supply range, and as an input signal module is built-in, sensor signals like T/C, RTD, etc. can be connected directly to the controller.

Controllers have developed from the conventional pneumatic, electric, and other types of analog controllers to digital controllers with micro-processor use. The controller described here is also a digital type, and it permits complicated

and high-level control operations which hardly permit any comparison with conventional analog controllers. Even a simple comparison of PID operation shows standard inclusion of an auto-tuning function, a PID operation function with two degrees of freedom, various alarm and limit functions, etc.

However, even with complicated and high-level functions, measures have been taken for easy handling. Display, operation, etc. can be done in the same way as with conventional controllers.

The development of hardware and software is progressing so rapidly that predictions are impossible. Accordingly, new display and operation methods probably will be entered one after another while maintaining the conventional image of a controller.

We intend to enhance the functions of this controller so that it becomes still easier to use.

