Introduction

This Technical Information gives an outline of the functions of the US1000 Digital Indicating Controller. For the latest information on this product, please see our home page located at: http://www.yokogawa.co.jp/MCC/

Structure of Technical Information

This Technical Information introduces the US1000 and its functions under the following topics:

- Features and outlines
- Custom computation
- Hardware
- Controller functions and applications
- Communication
- Setting up functions
- Appendices

Intended Readers

This Technical Information is intended for people who wish to learn about the functions of the US1000 controller.

Related Documents

The following documents all relate to the US1000 Digital Indicating Controller. Read them as necessary. The codes enclosed in parentheses are their document numbers.

- US1000 Digital Indicating Controller — Operation (IM 5D1A01-01E)
  Introduces the basic functions and explains the general operation of the US1000.

- US1000 Digital Indicating Controller — Functions (IM 5D1A01-02E)
  Explains the functions of the US1000 in detail.

- US1000 Digital Indicating Controller — Communication Functions (IM 5D1A01-10E)
  Explains the communication specifications and commands used when the US1000 communicates with a higher-level computer.

- LL1100 PC-based Parameters Setting Tool (IM 5G1A01-01E)
  Explains how to install and operate the LL1100, the software tool which allows you to set the parameters of the US1000 from a personal computer.

- LL1200 PC-based Custom Computation Building Tool (IM 5G1A11-01E)
  Explains how to install and operate the LL1200, the software tool used to create US1000 custom computations on a personal computer. This manual also presents some examples of custom computation.

- LL1200 PC-based Custom Computation Building Tool User’s Reference (IM 5G1A11-02E)
  Explains the functions of the individual computation modules that are used to configure a custom computation function. Refer to this manual if you are not familiar with the types of functions available or how these functions work.
Features of US1000 (1)

- Suitable for a variety of process control types.
  - Single PID, cascade, and dual loops
  - Custom computation
- Simple human-machine interface
  - Three bar displays for PV, SV, and MV
  - Two digital displays
- Universal I/Os with isolation
  - Analog inputs: 3 (two universal inputs)
  - Analog outputs: 3 (two current & one voltage)
  - DI/DO: 7 of each

Figures 8 to 28 present various applications of US1000.
For US1000 monitoring and operation functions, see Figures 5 and 6.
For US1000 I/O signal specifications, see Figures 3, 4, 32, and 33.

Features of US1000 (2)

- Versatile & Compact Hardware
  - Versatile power supply of 100 V to 240 V AC
  - Unit depth of 150 mm (about 5.9 inch)
  - An additional power supply of 25.5 V DC for the two transmitters
- Easy Maintenance
  - No battery required for memory backup
  - Control output relays can be changed
  - Capacitors have a long 7- to 10-year life

Figures 3, 4, and 34 show the US1000 hardware specifications.
For the safety and explosion-proof standards to which US1000 conforms, see Figure 35.
For information on the US1000 communications function, see Figure 31.
Three Models for Various Applications

There are three types of controllers for various applications:
- Standard type: For single-loop control
- Enhanced type: For complex single-loop or dual-loop control with custom computation
- Position proportional PID type: All functions are the same as those of the enhanced type, except that the MV is for motor valve control.

<table>
<thead>
<tr>
<th>Model</th>
<th>Suffix Code</th>
<th>Description</th>
<th>Analog Input</th>
<th>LPS</th>
<th>MV</th>
<th>RET</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Universal</td>
<td>1-5 V or 0-10 V dc</td>
<td>24 V dc</td>
<td>Current or Pulse</td>
<td>Relay 1-5 V or 0-5 V dc</td>
</tr>
<tr>
<td>US1000</td>
<td>-00</td>
<td>Standard type</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>-11</td>
<td>Enhanced type</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>-21</td>
<td>Enhanced type* with position proportional PID</td>
<td>1/(v) + 1(sw)*</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>set</td>
</tr>
<tr>
<td>Option</td>
<td>A10RS485</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: 1. Enhanced type has a custom computation function
2. US1000-21 has one voltage input and one slide wire input for valve position feedback.
LPS: Power supply function for two-wire transmitter
RET: Retransmission output for another controller or recorder.

To use the custom computation function on US1000-11 or -21, you will need the PC-based Custom Computation Building Tool (model LL1200) and a personal computer with Windows 95 or NT4.0.
You can add the optional communications function to any model with the -00, -11, or -21 suffix.
You can set a communication protocol (PC-link or MODBUS) on location (at customer’s site).

Summary of Specifications

<table>
<thead>
<tr>
<th></th>
<th>US1000-00</th>
<th>US1000-11 and -21*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog inputs</td>
<td>1 x universal, 1 x voltage</td>
<td>2 x universal, 1 x voltage</td>
</tr>
<tr>
<td>Loop power supplies for transmitter</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Control output</td>
<td>1 x current or voltage pulse</td>
<td>2 x current or voltage pulse, 2 x relay contact</td>
</tr>
<tr>
<td>Analog output</td>
<td>1 x voltage</td>
<td>1 x voltage</td>
</tr>
<tr>
<td>Digital inputs</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Digital outputs</td>
<td>3 x relay</td>
<td>7 (3 x relay, 4 x transistor)</td>
</tr>
<tr>
<td>Control function</td>
<td>8 types of control functions (Single, cascade loop)</td>
<td>14 types of control functions (Single, cascade, dual loop)</td>
</tr>
<tr>
<td>Custom computation</td>
<td>None</td>
<td>Available</td>
</tr>
<tr>
<td>Control period</td>
<td>50, 100, 200, 500 ms (200 or 500 ms when custom computation is carried out)</td>
<td></td>
</tr>
<tr>
<td>Communication (option)</td>
<td>MODBUS or PC-link (RS485 from 0.6 to 38.4 kbps)</td>
<td></td>
</tr>
<tr>
<td>Power supply</td>
<td>100 to 240 VAC ±10%</td>
<td></td>
</tr>
<tr>
<td>Dust and water protection</td>
<td>IP65 (Dust-tight, waterproof)</td>
<td></td>
</tr>
<tr>
<td>Safety standards</td>
<td>CE (Europe), FM (application pending), CSA (North America)</td>
<td></td>
</tr>
<tr>
<td>Hazardous area classification</td>
<td>FM (application pending), CSA non-incendive</td>
<td></td>
</tr>
<tr>
<td>Signal connection</td>
<td>M3.5 screw terminals (for signal, power supply, and grounding connections)</td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>72 (W) x 144 (H) x 148 (D) mm (inclusive of the 180-mm deep terminal cover)</td>
<td></td>
</tr>
</tbody>
</table>

* The specifications of US1000-21 are the same as those of US1000-11 except for the control output.

If you do not wish to use the current or pulse output signal as the control output for US1000-11 or -21, you can use the signal for retransmission output. US1000-11 and -21 both have 3 points of relay contacts and 4 points of transistor contacts. The dust and water protection, safety standards, and hazardous area classification are standard specifications that apply to all models.
Easy-to-Read Faceplate

SV is indicated as a cursor on the right-side bar. You can perform all kinds of controller operations < from setting up of functions to operation > through the front faceplate. The light loader interface communicates with the LL1100 Parameter Setting Tool or LL1200 Custom Computation Building Tool by emitting and receiving light signals.

A Variety of Digital Operation Displays

The two digital displays in the upper part of the faceplate can display various data.
You can call up desired operating parameters with a few operations by assigning the frequently changed operating parameters to the USER display or SELECT display.
For USER displays, choose from among the pre-selected parameters.
For SELECT displays, you can register up to 5 from the whole range of operating parameters.
14 Types of Controller Modes

<table>
<thead>
<tr>
<th>Single Loop</th>
<th>Controller Modes</th>
<th>Mode Code</th>
<th>-00</th>
<th>-11</th>
<th>-21</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single-loop control</td>
<td>1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Cascade primary-loop control *</td>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Cascade secondary-loop control</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Loop control for backup*</td>
<td>5</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Loop control with PV switching *</td>
<td>6</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Loop control with PV switching and two universal inputs</td>
<td>14</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Loop control with PV auto-selector *</td>
<td>7</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Loop control with PV auto-selector and two universal inputs</td>
<td>15</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Loop control with PV-hold function</td>
<td>8</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Cascade</td>
<td>Cascade control *</td>
<td>4</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Cascade control with two universal inputs</td>
<td>13</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Dual</td>
<td>Dual loop control</td>
<td>11</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Temperature and humidity control</td>
<td>12</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Custom</td>
<td>Custom computation control</td>
<td>21</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* When these controller modes (US modes) are used with US1000-00, the controller cannot accept cascade input signals because of the limited numbers of inputs. Before you can set up controller functions, you must first set the controller mode.

Single Loop Control

- Full range of computation functions available for computing PV and SV.
- A power supply of 25.5 V DC for the two transmitters.
- Example: Flow rate control
  - Square root extraction and ratio computation for remote SV.
  - Square root extraction for PV.
  - Model US1000-21 can drive the motor valve as an actuator.

US mode = 1
Power supply for transmitter: US1000-11 and -21 have 2 points, US1000-00 has 1 point. Expression of ratio computation: Cascade setpoint = ratio × cascade input signal + bias
As shown above, single-loop control (US mode=1) incorporates various functions.

Figure 10

Computation Input Signals

- Nine computation blocks for PV input.
  - Six blocks are used for the setup of the universal input.
  - The input computation blocks are dependent on the controller mode.
  - The PV bias and filter blocks are used to tune the optimum control condition.

You can set the setup parameters that are to be set in the earlier stage of function setup and the input computation blocks only when you set up the controller functions. You cannot change the function or time constant during operation.

On the other hand, you can set the bias value and time constant during operation as long as they are operating parameters.
Universal Control Outputs

There are five types of control outputs that relate to control computation:

- **PID Control**
  - Current (4 to 20 mA, 0 to 20 mA)
  - Time-proportional voltage pulse (which uses the same output terminal as current output)
  - Time-proportional relay contact (N.C, N.O, COM)

- **Position-proportional PID Control (US1000-21 only)**
  - Relay output for motor valve (H = direct rotation, L = reverse rotation, COM)

- **ON/OFF Control**
  - On/off relay contact (N.C, N.O, COM)

Any control outputs not in use (for example, current output signal when control output is a time-proportional relay contact) can be used for any of the following:

Current output signal: PV/SV retransmission output
Relay contact signal: Alarm output or status output

### Basic Function: Preset PID Parameter Function

- Process characteristics (gain) often change with the temperature.
- The US1000 has 8 sets of PID parameters that it automatically switches between according to PV. Switching according to control deviation is also possible.
- It is also possible to switch between the PID parameter sets using custom computation or digital input.

Two methods are provided to switch between the 8 sets of PID parameters:

1) Zone PID: As shown in the figure above.
2) SV No. selection: The PID parameter of the same No. as the selected SV No., is switched to.
Heating and Cooling Control

- Process characteristics are different in the heating and cooling stages.
- The controller has two set of PID parameters each for heating control and cooling control.

Heating and cooling control is available on the enhanced type controller (US1000-11). Heating-output and cooling-output types are also available as options. For example, you can set a 4 to 20 mA current output, which needs to be controlled precisely, for the heating process; and a relay-contact pulse-output, for which rough control is satisfactory, for the cooling process.

Single-loop Control with Feed-forward Signal

- Easy to minimize the deviation of the tank’s pH level, by measuring the flow of waste water and the amount of compensation.
- F.F. compensation
  - Gain, bias
  - First-order lag

Expression of feed forward computation
Feed forward signal = (Feed forward input + FBI) × FGN + FBO
FGN (feed forward gain): -9.999 to 9.999
FBI (internal bias): -100.0 to 100.0% of input signal
FBO (external bias): -999.9 to 999.9% of input signal
Time constant of feed forward input signal filter: 0 to 120 seconds
Auto-tuning Function

- Uses the open-loop response to calculate the PID parameters.
- Automatically changes the MV from 0% to 100% (and vice versa) during step response.
- Calculates the PID parameters by the Ziegler and Nichols method.

You must carefully monitor the response when carrying out auto-tuning on the following processes: • fast-response processes such as flow rate and pressure; • processes in which a severe change in output, even if temporarily, is undesirable; • processes in which any severe stress on the actuator is undesirable; and • processes in which product quality can be adversely affected if PV fluctuates beyond its allowable limits.

Basic Functions: 29 Types of Alarm Functions

- The alarm type can be changed via key operation.
- The waiting action turns off the alarms from the start of operation until a stable condition is achieved.
- Alarm setting at the factory depends on the controller mode.

<table>
<thead>
<tr>
<th>Alarm type</th>
<th>Setting</th>
<th>Alarm type</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV high limit</td>
<td>1</td>
<td>PV high limit</td>
<td>11</td>
</tr>
<tr>
<td>PV low limit</td>
<td>2</td>
<td>PV low limit</td>
<td>12</td>
</tr>
<tr>
<td>High-limit deviation</td>
<td>3</td>
<td>High-limit deviation</td>
<td>13</td>
</tr>
<tr>
<td>Low-limit deviation</td>
<td>4</td>
<td>Low-limit deviation</td>
<td>14</td>
</tr>
<tr>
<td>High-limit deviation passive</td>
<td>5</td>
<td>High-limit deviation passive</td>
<td>15</td>
</tr>
<tr>
<td>Low-limit deviation passive</td>
<td>6</td>
<td>Low-limit deviation passive</td>
<td>16</td>
</tr>
<tr>
<td>High- and low-limit deviation</td>
<td>7</td>
<td>High- and low-limit deviation</td>
<td>17</td>
</tr>
<tr>
<td>Dev. between high &amp; low limits</td>
<td>8</td>
<td>Dev. between high &amp; low limits</td>
<td>18</td>
</tr>
<tr>
<td>PV high-limit passive</td>
<td>9</td>
<td>PV high-limit passive</td>
<td>19</td>
</tr>
<tr>
<td>PV low-limit passive</td>
<td>10</td>
<td>PV low-limit passive</td>
<td>20</td>
</tr>
<tr>
<td>SV high limit</td>
<td>21</td>
<td>PV velocity alarm</td>
<td>25</td>
</tr>
<tr>
<td>SV low limit</td>
<td>22</td>
<td>PV velocity alarm passive</td>
<td>26</td>
</tr>
<tr>
<td>MV high limit</td>
<td>23</td>
<td>Self-diagnostic alarm</td>
<td>27</td>
</tr>
<tr>
<td>MV low limit</td>
<td>24</td>
<td>Self-diagnostic alarm passive</td>
<td>28</td>
</tr>
</tbody>
</table>

The US1000 has 4 points for alarm functions (AL1 to 4), which are made effective by assigning the alarm types in the table above. At the time of shipping, the assignment is as follows: DO1=AL1=PV high (=1); DO2=AL2=PV low (=2); DO3=AL3=PV high (=1, Not the same as DO1.) For example, to assign the alarm for “deviation of high & low limits” to DO4, set AL4 = 7 and DO4 = 5693 (address of AL4).
Loop Control for Backup

- When the condition of the PLC/DCS is normal, the US1000 outputs an MV from the PLC/DCS.
- When the condition of the PLC/DCS is abnormal, the US1000 performs PID control totally isolated from the PLC/DCS's output signal.
- In MAN mode, MV can be manipulated manually regardless of the conditions of the PLC/DCS.

US mode = 5
In AUTO mode, the US1000 can perform backup control for a PLC or DCS. MV transfers bumplessly when the control switches to PID control for backup. When the US1000 is in MAN mode, it is necessary to make PLC/DCS's output track the MV of US1000 by making PLC/DCS read the MV feed-back signal.

Loop Control with PV Auto-Selector

- Selects a maximum, minimum, average or temperature differential value automatically from two or three inputs, and then controls them.
- Application: selects a maximum value from among the furnace inlet temperature, internal temperature and outlet temperature, and then controls it.
- The US1000-11 can connect up to three inputs: two universal inputs, the other a DC voltage input.

US mode=7  US1000-00: Auto-selector between a universal input (IN1) and a voltage input (IN3).
US mode=15 US1000-11, -21: Auto-selector between two universal inputs (IN1,2) and a voltage input (IN3).
The measurement ranges of the PV inputs (2 or 3) must partially overlap.
The temperature differential input is calculated as follows.
US1000-00: PV = IN3 - IN1,  US1000-11, -21: PV = IN2 - IN1
Loop Control with PV Switching

- Switches to and carries out control from either one of the two measured input signals by contact input.
- Example: Switches to either the temperature of an upper furnace or that of a lower furnace according to certain conditions.
- There are two universal inputs (US1000-11) available.

US mode = 6  US1000-00: PV switching between a universal input (IN1) and a voltage input (IN3).
US mode = 14 US1000-11,-21: PV switching between two universal inputs (IN1, 2).
You can assign sensors of different type and measurement range to the two temperature inputs (measurement ranges must partially overlap, however). At sensor switching, control is performed so that the MV does not change suddenly even when the two inputs do not match.

Loop Control with PV Hold Function

- Useful for batch heat treatment processes.
- Temporarily holds the PV value and control output MV when the US1000 receives the PV hold signal.
- During the PV hold condition, PV is held constant at the operation temperature and the PV alarm does not occur.

US mode = 8
Under loop control with PV hold function, the controller hold PV and MV when the contact input signal (PV hold signal) turns on in the AUTO mode. Accordingly, the PV low-limit alarm is not activated and a stable state achieved soon after temperature control is resumed following product replacement.
Cascade Control using Two Controllers

- Uses two controllers for cascade loop control.
- The primary loop controller has an output tracking function and a fail output function.
- The secondary loop controller has an SV output function, a CAS/AUTO status output function, and a CAS/AUTO switching function that is based on a discrete input.

Cascade primary-loop control: US mode = 2
Cascade secondary-loop control: US mode = 3
Use these controller modes when configuring a cascade loop using 2 controllers. The advantage is that the primary and secondary loops can be monitored and operated independently.

Cascade Control

- Cascade-loop heating and cooling control can be performed on a single controller.
- Two temperature PVs can be input.
- US1000 can display both loops simultaneously.
  Left bar graph: Primary loop
  Right bar graph: Secondary loop

US mode = 4 US1000-00: PV1 = universal input 1 (IN1), PV2 = voltage input 3 (IN3).
US mode = 13 US1000-11,-21: PV1 = universal input 1, PV2 = universal input 2 (IN2).
When the inside cascade loop is closed, the PV/SV bar shows loop-1 value and the MV bar shows loop-2 value. When the inside cascade loop is open, the left and right bars show the PV/SV of loop-1 and 2 respectively, as shown right. The MV bar shows the loop-2 MV. SV is shown as a flashing cursor when the control deviation exceeds the set value.
Dual Loop Control

- Controls two independent loops in a single controller.
- Example: Controls two stages of a multi-stage cooling device.
- A TC and RTD can be directly connected to US1000-11 in order to measure the PV of each loop.
- The US1000 can display both loops simultaneously.
  Left bar graph: Primary loop
  Right bar graph: Secondary loop

US mode = 11 (US1000-11 only)
Under dual-loop control, the controller always shows the dual-loop display as shown right.
SV is shown as a flashing cursor when the control deviation exceeds the set value.
While loop-2 is selected, the LP2 lamp in the upper right is lit.
CAS/AUTO/MAN mode switching is carried out for the selected loop.

Temperature & Humidity Control

- Controls the dry-bulb and wet-bulb relative humidity and temperature in a US1000.
- Suitable for air-conditioning control during coating processes.
- The US1000 can display both loops simultaneously.
  Left bar graph: Primary loop
  Right bar graph: Secondary loop

US mode = 12 (US1000-11 only)
The dry-bulb and wet-bulb signals from the temperature sensors can either be thermocouple, RTD, or DC voltage signals. The dry-bulb temperature range is from 0 to 100°C.
Display and operation are the same as for “dual-loop control.”
Custom Computation

Temperature & Pressure Compensation of Flow Rate

- Executes complicated signal computations and sequence logic operations.
- Both temperature and pressure compensation can be carried out by combining the temperature compensation and pressure compensation modules, and adding a sum module to calculate the resulting flow rate.
- The AUTO/MAN modes can be switched between by connecting the two contact inputs with an AND operation.

The US1000-11 and -21 are capable of custom computation. The custom computation function can carry out complicated computations and sequence logic control that are not possible in standard controller modes as well as the general built-in calculations. Custom computation is created using a personal computer.

Configuration of Custom Computation

- Custom computation is configured by connecting several computation modules
  - 30 modules for input computation
  - 30 modules for output computation
  - Single-loop, cascade or dual-loop control can be selected.
- Various computation modules
  - Mathematical calculation
  - Logical computation
  - Dynamic computation

To configure custom computation, computation modules need to be connected. For the control function section, you can select from single-loop PID, cascade, and dual-loop. Furthermore, if you use custom
computation, you can switch between operation modes (e.g., CAS/AUTO/MAN, and tracking on/off) and output control statuses (e.g., operation mode, alarm status) using contact signals.

**Various Computation Modules & Control Cycle**

- **Calculation modules**
  - +, -, *, /, absolute value, square root extraction, ratio, first order lag, dead time, moving average, fluid temp. compensation, fluid press. compensation, sum, flow sum, temp. & humidity calculation, constant, limits, rate of change limit, auto selector, switching between two inputs, multi-selector, max/min value hold, range conversion, reciprocal, switch, 10-seg. linearizer 1/2, curve linearizer 1/2, inverse 10-seg. linearizer 1/2, detection of change, MV selection 1/2, output terminal configuration, edge counter

- **Logical computation modules & display modules**
  - AND, OR, NOR, NOT, <, >, equal, not equal, counter, decremental counter, timer, latch, range, display, long word AND, word shift, display data unit conversion, parameter, data display, edge-triggered timer, detection of change in edge

- **Control cycle**
  - 200 ms when up to 30 modules are used.
  - 500 ms when over 30 modules are used.

To use the custom computation function, set US mode = 21.
For details about the computation modules, read the following document.
LL1200 PC-based Custom Computation Building Tool User's Reference (IM 5G1A11-02E)

**Combustion Control -Cross Limit Method**

The cross-limit method of air-fuel ratio control, which is commonly used for combustion control, is also possible. Custom computation is used for the limit calculation in both the air-flow and the fuel-flow controllers. The master controller is set up in standard single-loop control.
How to Create a Custom Computation Function

- Select the US mode you would like to use.
- Determine how the input and output computation is to be changed and which computation modules are to be connected.
- Create a custom computation function using the LL1200 Windows-Based Custom Computation Building Tool.
- Write the custom computation data to the US1000 and confirm the functions.

The LL1200 package consists of five FDCs, a dedicated cable, an optical adapter, and instruction manuals. The LL1200 includes the entire functionality of the LL1100.

Example of Custom Computation screen

In the screen above, the flow-rate input (analog input 1 = AIN1) is converted into an engineering unit (EUCONV) and then subjected to temperature compensation (TCOMP) using a temperature input (analog input 3 = AIN3). The result of that compensation is then subjected to pressure compensation (PCOMP) using the pressure input (analog input 2 = AIN2). A window then appears for registering those modules that contain data for square-root extraction.
Communication

Communication with a PC or PLC

- US1000 can communicate with a PC or PLC via either the MODBUS or PC-Link Communication Protocol.
- MODBUS
  - RTU (binary) mode, ASCII mode
  - MODBUS is very popular in the US and Europe.
- PC-Link
  - YOKOGAWA’s proprietary communication protocol.
  - UT.UP controllers can be easily connected to the same PC-Link communication line.

The MODBUS protocol is supported by many SCADA software products (operation and monitoring software) and PLCs. You can easily connect US1000 to these products or PLCs. If you use the PC-link protocol, US1000 can be connected along a communication line of Green Series temperature controllers.

Hardware

Universal Inputs with Isolation

- Universal Inputs
  - The following input signals must be connected directly.
  - RTD: Pt100 and JPt100
  - DC voltage: 0.4 to 2 V, 1 to 5 V, 0 to 2 V, 0 to 10 V, -10 to 20 mV, 0 to 100 mV
- Built-in 25.5 V DC power supply function for one or two 2-wire transmitters.
- Input types and measurement ranges can be set via key operation.

Loop power supply for two-wire transmitter: The basic type model (US1000-00) can support one transmitter. The enhanced and position-proportional type models (US1000-11, -21) can support two transmitters. Transmitters that have communication functions, such as Yokogawa EJA, can also be connected. Both universal input 1 and 2 are isolated from other signals and internal circuits. Voltage input 3 and the power supply for transmitter 1 and 2 are also isolated from internal circuits but not isolated between signals.
Isolation System

- Isolated universal inputs means that there is no need to worry about the lack of isolation among sensors or the effects of complicated wiring.

- The I/O contacts and communication terminals are also isolated to achieve trouble-free products.

Withstanding voltage:
2300 V AC for 1 min. (between a primary & secondary terminal, & between a primary terminal & ground)
1500 V AC for 1 min. (between a secondary terminal and ground)
500 V AC for 1 min. (between secondary terminals)
Isolation resistance: 100 MΩ at 500 V DC (between power supply and ground terminal)
Primary terminals: power supply, relay output, Secondary terminals: other I/O signals.

IP65 Dust and Water Protection

- The faceplate of the US1000 has dust and water protection (in compliance with IP65).

  IP6_ : Dust-tight
  No ingestion of dust

  IP_5 : Protected against a jet of water.
  Diameter of the water nozzle: 6.3 mm
  Flow rate: 12.5 l/min.
  Distance from nozzle: 2.5 to 3 m

Dust & water protection are only effective on US1000 controllers.
IP Code : IEC529 specifies the degree of protection provided by enclosures.
Compliance with FM, CSA and CE

- Factory Mutual Research Co. USA (application pending)
- “Non-Incendive” Class 1, Div. 2, Gr. A, B, C & D
- General safety standards.
- Canadian Standards Association, Canada
  - “Non-Incendive” and general safety standards.
  - No electrical instrument can be sold in Canada without the CSA General Safety Standard.
- Conformite Europeenne, European Union
- Safety standards, EMC standards
  - No electrical instrument can be sold in Europe without the CE mark.

Groups A, B, C & D of Class 1, Div. 2, are all hazardous area classifications in North America, that are mainly used in the petroleum refining, petrochemical and chemical industries. The standard US1000 products conform to the standards above at no extra cost.

Setting up Functions

Setup

- Easy setup
- All control functions can be specified using the keys on the front panel.
- The initial parameters are set for simple PID control with current outputs.
- A PC is required only for creation of custom computation.

Simple PID Loop Control with 4-20 mA Control Output

Various Types of Loop Control

Loop Control with Custom Computation

Select controller mode

Create the custom computation (PID)

Define universal inputs

Define universal inputs

Output type, range, burnout, etc.

Define control outputs

Output type, D/R action, heating/cooling, etc.

Set other parameters

Alarm function, password, communication, etc.

Set operating parameters

PID parameters, alarm setpoints, MV limiter setpoints, etc.

Operation

Operation

At the time of shipping, the US1000 is set up for general use. Users can start using the controller after all of the required setting modifications have been performed. To perform a sophisticated control such as cascade or dual-loop control, set up the required functions according to the proper procedure.
# US1000 Factory-set Defaults

<table>
<thead>
<tr>
<th>Item</th>
<th>Factory-set default for US1000-00</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV input signal, range and unit</td>
<td>1 to 5 V DC, 0.0 to 100.0 (No unit setting)</td>
</tr>
<tr>
<td>Input computation</td>
<td>OFF (filter, bias, burnout, square-root computation, 10-segment linearizer)</td>
</tr>
<tr>
<td>Loop power supply for 2-wire transmitter</td>
<td>Enabled</td>
</tr>
<tr>
<td>Alarm function</td>
<td>PV high limit (2 points: DO1, DO3), PV low limit (1 point: DO2)</td>
</tr>
<tr>
<td>Cascade input signal</td>
<td>1 to 5 V DC (CAS mode key is disabled, however)</td>
</tr>
<tr>
<td>Controller mode (US Mode) &amp; MV output</td>
<td>Single-loop control (US mode=1), 4 to 20 mA</td>
</tr>
<tr>
<td>Auto-tuning and SUPER function</td>
<td>OFF</td>
</tr>
<tr>
<td>PID control Direct/reverse action</td>
<td>Reverse action</td>
</tr>
<tr>
<td>PID parameters, Preset MV</td>
<td>P =999.9%; I =1000sec.; D =off, MV = 5.0%</td>
</tr>
<tr>
<td>Output limiter</td>
<td>Upper limit =100%, Lower limit =0%</td>
</tr>
<tr>
<td>Control period</td>
<td>200 ms</td>
</tr>
<tr>
<td>Mode switching by external contacts</td>
<td>RUN/STOP switchover, MAN mode selection</td>
</tr>
<tr>
<td>Password, Key lock</td>
<td>No password, CAS mode key disabled</td>
</tr>
<tr>
<td>Action upon power recovery</td>
<td>Less than 2 sec: Starts in the state prior to power failure 2 sec or longer: Starts in the MAN mode.</td>
</tr>
</tbody>
</table>

The table above shows that US1000s configured with their factory-set defaults, are ready for simple PID control. It may however be necessary to change the measurement range (factory-set default is 0.0 to 100.0) depending on the particular use.

## Setting Data on a PC

- All of the parameters of US1000 can be specified using the keys on its front panel.
- Moreover, with the LL1100 Parameter Setting Tool, all of the following functions can be performed on your PC:
  - Parameter setting
  - Writing/reading of parameters to/from US1000
  - Saving of parameters to disk
  - Printouts
  - Tuning

1) Setting parameters 2) Setting parameters using front panel keys on a PC with LL1100.  

The LL1100 package consists of 5 FDCs, a dedicated cable, an optical adapter, and an instruction manual. Operating environment for LL1100 PC-based Parameters Setting Tool:

- OS: Windows 95 or Windows NT 4.0
- Min. memory: 16 MB for Win95; 24 MB for NT4
- Display: 800 x 600 pixels or superior, 256 colors
- FDD: One 3.5-inch drive
- CPU: Pentium of 90 MHz or more
- Hard disk: 8 MB or more
- Communication port: One channel of RS232C
- Printer: Necessary for printing
Prevention of Wrong Operation

- **Password**
  - Configuration data can be protected by a password that restricts access to the setup parameters.
  - Only those who know the four-digit password can access and change the configuration data.

- **Key lock security**
  - Changes to PID parameters and use of operation keys can be prohibited using the key lock function.
  - Users can prohibit or allow changes by contact input signals or parameter setting via communication.

Once you set a password, you must input the password every time you wish to display/change the setup parameters (no password set at shipping). You can however still carry out operation and change the operation parameter such as PID without the password. If you lose the password, you must return the US1000 to Yokogawa Engineering Service Corporation for password cancellation. The key lock function disables the operation keys and prohibits the display of operating parameter on a menu basis.

Actions upon Power Recovery and During Failure

- **Upon Power Recovery**
  - The US1000 does not detect power failures of less than 20 ms.
  - Following power failures of less than 2 seconds:
    - Starts in the state prior to power off.
  - Following power failures of 2 seconds or longer:
    - HOT => Starts in the state prior to power off.
    - COLD => Starts in MAN mode and outputs the preset MV.

- **During Failure**
  - Display: Indicates the cause of failure.
  - Output signal:
    - Analog outputs: Off-scale becomes 0% or less
    - Digital outputs: Open (same as when power fails)
    - Transmitter power supply: Normal

The controller detects an error using a self-diagnosis function and displays the cause of abnormality on the digital display. For detailed information, read the instruction manual. In the event of failure, the analog output (current/voltage output) shoots down to 0% or undershoots past the 0% level.
### Appendices

For Reference

### Types of Universal Input

<table>
<thead>
<tr>
<th>Input type</th>
<th>Setting</th>
<th>Instrument Range(°C)</th>
<th>Instrument Range(°F)</th>
<th>Accuracy for % of instrument range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermocouple</td>
<td>K</td>
<td>1 -270.0 to 1370.0°C</td>
<td>-450.0 to 2500.0°F</td>
<td>0°C and over: ±0.1% of F.S.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 -270.0 to 1000.0°C</td>
<td>-450.0 to 2300.0°F</td>
<td>Below 0°C: ±0.2% of F.S.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 -200.0 to 500.0°C</td>
<td>-200.0 to 1000.0°F</td>
<td>K (below -200°C): ±2% of F.S.</td>
</tr>
<tr>
<td></td>
<td>J</td>
<td>4 -200.0 to 1200.0°C</td>
<td>-300.0 to 2300.0°F</td>
<td>T (below -200°C): ±1% of F.S.</td>
</tr>
<tr>
<td></td>
<td>T</td>
<td>5 -270.0 to 400.0°C</td>
<td>-450.0 to 750.0°F</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 0.0 to 400.0°C</td>
<td>-200.0 to 750.0°F</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>7</td>
<td>0.0 to 1800.0°C</td>
<td>32 to 3300°F</td>
<td>400°C and over: ±0.1% of F.S.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Below 400°C: ±5% of F.S.</td>
</tr>
<tr>
<td>S</td>
<td>8</td>
<td>0.0 to 1700.0°C</td>
<td>32 to 3100°F</td>
<td>±0.15% of F.S.</td>
</tr>
<tr>
<td>R</td>
<td>9</td>
<td>0.0 to 1700.0°C</td>
<td>32 to 3100°F</td>
<td>±0.1% of F.S.</td>
</tr>
<tr>
<td>N</td>
<td>10</td>
<td>-200.0 to 1300.0°C</td>
<td>-300.0 to 2400.0°F</td>
<td>±0.1% of F.S.</td>
</tr>
<tr>
<td>E</td>
<td>11</td>
<td>-270.0 to 1000.0°C</td>
<td>-450.0 to 1800.0°F</td>
<td>0°C and over: ±0.1% of F.S.</td>
</tr>
<tr>
<td>L</td>
<td>12</td>
<td>-200.0 to 900.0°C</td>
<td>-300.0 to 1600.0°F</td>
<td>Below 0°C: ±0.2% of F.S.</td>
</tr>
<tr>
<td>U</td>
<td>13</td>
<td>-200.0 to 400.0°C</td>
<td>-300.0 to 750.0°F</td>
<td>E (below -200°C): ±1.5% of F.S.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 0.0 to 400.0°C</td>
<td>-200.0 to 1000.0°F</td>
<td>±0.2% of F.S.</td>
</tr>
<tr>
<td>W</td>
<td>15</td>
<td>0.0 to 2300.0°C</td>
<td>32 to 4200°F</td>
<td>±0.2% of F.S.</td>
</tr>
<tr>
<td>Platinel 2</td>
<td>16</td>
<td>0.0 to 1390.0°C</td>
<td>32 to 2500°F</td>
<td>±0.1% of F.S.</td>
</tr>
<tr>
<td>PR20-40</td>
<td>17</td>
<td>0.0 to 1900.0°C</td>
<td>32 to 3400°F</td>
<td>800°C and over: ±0.5% of F.S.</td>
</tr>
<tr>
<td></td>
<td>W97Re3</td>
<td>18 0.0 to 2000.0°C</td>
<td>32 to 3600°F</td>
<td>±0.2% of F.S.</td>
</tr>
<tr>
<td>W75Re25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTD</td>
<td>Jp100</td>
<td>30 -200.0 to 500.0°C</td>
<td>-300.0 to 1000.0°F</td>
<td>±0.1% of F.S.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>31 -150.0 to 150.0°C</td>
<td>-200.0 to 300.0°F</td>
<td>±0.2% of F.S.</td>
</tr>
<tr>
<td>Pt100 (ITS90)</td>
<td>35</td>
<td>-200.0 to 850.0°C</td>
<td>-300.0 to 1560.0°F</td>
<td>±0.1% of F.S.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36 -200.0 to 500.0°C</td>
<td>-300.0 to 1000.0°F</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>37 -150.0 to 150.0°C</td>
<td>-200.0 to 300.0°F</td>
<td>±0.2% of F.S.</td>
</tr>
<tr>
<td>Standard signal</td>
<td>40</td>
<td>0.4 to 2.0V</td>
<td>0.400 to 2.000</td>
<td>±0.1% of F.S.</td>
</tr>
<tr>
<td></td>
<td>41</td>
<td>1.00 to 5.000</td>
<td>1.000 to 5.000</td>
<td></td>
</tr>
<tr>
<td>DC voltage</td>
<td>50</td>
<td>0.00 to 2.000</td>
<td>0.000 to 2.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>0.00 to 10.000</td>
<td>0.000 to 10.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-10 to 20mV</td>
<td>-10.00 to 20.00</td>
<td>-10.00 to 20.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>56</td>
<td>0.00 to 100.0</td>
<td>0.000 to 100.0</td>
<td></td>
</tr>
</tbody>
</table>

How to set the input range: For example, to set the thermocouple type T and a range = 0 to 300°C, set the input type to 6 (the narrowest range that includes your desired range). Then, set the setup parameters, i.e., the "maximum/minimum value of analog input (RH, RL)" as RH = 300.0, RL = 0.0.
### Specifications

<table>
<thead>
<tr>
<th>Control functions</th>
<th>Single-loop, cascade primary-loop, cascade secondary-loop, loop control for backup, loop control with PV switching, loop control with PV auto-selector, loop control with PV-hold function, cascade control, dual-loop control, temperature &amp; humidity control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control computational functions</td>
<td>PID, ON/OFF, heat &amp; cool, zone PID, position-prop. PID, feed forward, output &amp; PV tracking, etc.</td>
</tr>
<tr>
<td>MV output</td>
<td>4-20 mA, voltage pulse, ON/OFF relay, direct/reverse rotation relay for motor valve</td>
</tr>
<tr>
<td>Signal computation</td>
<td>Filter, bias, square root extraction, 10-segment linearizer, limiters</td>
</tr>
<tr>
<td>Custom computation</td>
<td>Executes data computation and logical operations by combining 58 types of computation modules (available on US1000-11, -21 only)</td>
</tr>
<tr>
<td>Alarm function</td>
<td>22 types of alarms including PV high/low limit and deviation alarms</td>
</tr>
<tr>
<td>Control period</td>
<td>50 or 100ms (without custom computation), 200 or 500ms (with custom computation)</td>
</tr>
<tr>
<td>Communication</td>
<td>RS485 communication interface; MODBUS or PC-link communication protocol; communication distance = 1200 m; number of connectable units = 31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of signals</th>
<th>Input</th>
<th>LPS</th>
<th>MV</th>
<th>RET</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Universal</td>
<td>Voltage</td>
<td>Valve Position</td>
<td>Current or Pulse</td>
<td>Relay</td>
</tr>
<tr>
<td>US1000-00</td>
<td>1</td>
<td>1</td>
<td>—</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>US1000-11</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>US1000-21</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1 set</td>
</tr>
</tbody>
</table>

| Accessories       | Mounting bracket, terminal cover, tag label, number/unit labels, instruction manual |
| Terminal          | M3.5 screw (for signal, power supply, and grounding terminals) |
| Power supply      | 100 to 240 V AC ±10%, 50/60 Hz |
| Safety standards and dust & water protection | Safety = CE, CSA, FM(pending), dust & water protection = IP65 |
| Hazardous area classification | FM(application pending) and CSA non-incendive (Class1, Div2, Gr.A,B,C,D) |

**US1000 External Dimensions**

Unit: mm (approx. inch)

**Panel Cutout Dimensions**

- General mounting: 64 (2.5) or more
- Side-by-side close mounting: 137 (5.4) or more
- Mounting bracket: Leave at least 5 (0.20) between units
- Terminal cover: Leave at least 5 (0.20) between units
- Panel thickness: 1 (0.04) to 10 (0.38)

L = (72 × n) mm
## Revision Record

**Title:** Information on US1000 Digital Indicating Controller  
**Manual No.:** TI5DA01-01E

<table>
<thead>
<tr>
<th>Edition</th>
<th>Date</th>
<th>Revised Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>January 1999</td>
<td>Newly published</td>
</tr>
<tr>
<td>Second</td>
<td>July 2004</td>
<td>Change of company name</td>
</tr>
</tbody>
</table>

Subject to change without notice.