User's Manual

Model US1000 Digital Indicating Controller Functions

IM 5D1A01-02E

YOKOGAWA
Yokogawa Electric Corporation

IM 5D1A01-02E
2nd Edition

◆ Introduction

This instruction manual describes the functions of the US1000 Digital Indicating Controller in detail. Read this manual together with the separate instruction manual for the “US1000 Digital Indicating Controller” when setting up your US1000 controller.

■ Contents of This Manual

This manual contains the following:

- Examples of the US1000’s applications
- Description of each controller mode (US mode)
- Description of all the parameters

■ Intended Readers

This manual is intended for personnel in charge of instrumentation and setup of the controller.

■ Related Documents

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

- US1000 Digital Indicating Controller (IM 5D1A01-01E)
  This manual introduces the basic functions and provides instructions for the general operation of the US1000 controller.
- US1000 Digital Indicating Controller Communication Functions (IM 5D1A01-10E)
  Manual for using the US1000 communication function. Supplied with models having the optional communication function.
- LL1100 PC-based Parameters Setting Tool (IM 5G1A01-01E)
  Manual for setting US1000 parameters from a personal computer. Supplied with the LL1100 PC-based Parameters Setting Tool.
- LL1200 PC-based Custom Computation Building Tool (IM 5G1A11-01E)
  Operation manual for creating custom computations by the US1000 controller. This manual also describes examples of custom computations. The LL1200 PC-based Custom Computation Building Tool includes the LL1100 PC-based Parameters Setting Tool.
- LL1200 PC-based Custom Computation Building Tool Reference (IM 5G1A11-02E)
  This is the functions manual necessary for creating custom computations by the US1000 controller. This manual should be referred to in order to find out and understand what functions offered by the LL1200.

FD No. IM 5D1A01-02E
2nd Edition: Jun. 2004 (KP)

◆ Documentation Conventions

■ Symbolic

The following symbolic are used in this manual.

WARNING

Indicates that operating the hardware or software in a particular manner may damage it or result in a system failure.

NOTE

Draws attention to information that is essential for understanding the operation and/or features of the product.

TIP

Gives additional information to complement the present topic and/or describe terms specific to this document.

See Also

Gives reference locations for further information on the topic.

■ Description of Displays

Some of the representations of product displays shown in this manual may be exaggerated, simplified, or partially omitted for reasons of convenience when explaining them.

◆ Notice

■ This Instruction Manual

(1) This manual should be passed on to the end user. Keep at least one extra copy of the manual in a safe place.
(2) Read this manual carefully to gain a thorough understanding of how to operate this product before you start using it.
(3) This manual is intended to describe the functions of this product. Yokogawa Electric Corporation (hereinafter simply referred to as Yokogawa) does not guarantee that these functions are suited to the particular purpose of the user.
(4) Under absolutely no circumstances may the contents of this manual, in part or in whole, be transcribed or copied without permission.
(5) The contents of this manual are subject to change without prior notice.
(6) Every effort has been made to ensure accuracy in the preparation of this manual. Should any errors or omissions come to your attention however, please contact your nearest Yokogawa representative or our sales office.

■ Protection, Safety, and Prohibition Against Unauthorized Modification

(1) In order to protect the product and the system controlled by it against damage and ensure its safe use, make certain that all of the instructions and precautions relating to safety contained in this document are strictly adhered to. Yokogawa does not guarantee safety if products are not handled according to these instructions.
(2) The following safety symbols are used on the product and in this manual.

CAUTION

If this symbol is indicated on the product, the operator should refer to the explanation given in the instruction manual in order to avoid personal injury or death to either themselves or other personnel, and/or damage to the instrument. The manual describes that the operator should exercise special care to avoid shock or other dangers that may result in injury or loss of life.

Protective ground terminal:

This symbol indicates that the terminal must be connected to ground prior to operating the equipment.

Function ground terminal:

This symbol indicates that the terminal must be connected to ground prior to operating the equipment.

(3) If protection/safety circuits are to be used for the product or the system controlled by it, they should be externally installed on the product.
(4) When you replace the parts or consumables of the product, only use those specified by Yokogawa .
(5) Do not modify the product.

■ Force Majeure

(1) Yokogawa does not make any warranties regarding the product except those mentioned in the WARRANTY that is provided separately.

(2) Yokogawa assumes no liability to any party for any loss or damage, direct or indirect, caused by the use or any unpredictable defect of the product.

WARNING

Do not change the setting of the following US1000 controller parameter.

[Setup parameter] - [Main menu: USMD] - [Submenu: TEST]
Parameter: TST (Test mode)

This parameter is used to adjust a US1000 controller at the factory. If you change the setting of this parameter, the US1000 controller may not operate normally.

CAUTION

Only personnel with an understanding of the US1000 controller and custom computation functions are qualified to change the settings of the following parameters as necessary. Those using the US1000 controller for the first time and those not knowledgeable about the custom computation function, should use the default values of the following parameters assigned to the controller.

[Setup parameter] - [Main menu: CONF] - [Submenu: DO and DI]
All the parameters under the submenus above.

If you change the settings of these parameters, some of the functions assigned to each US1000 controller mode (US mode) may not work.

Contents

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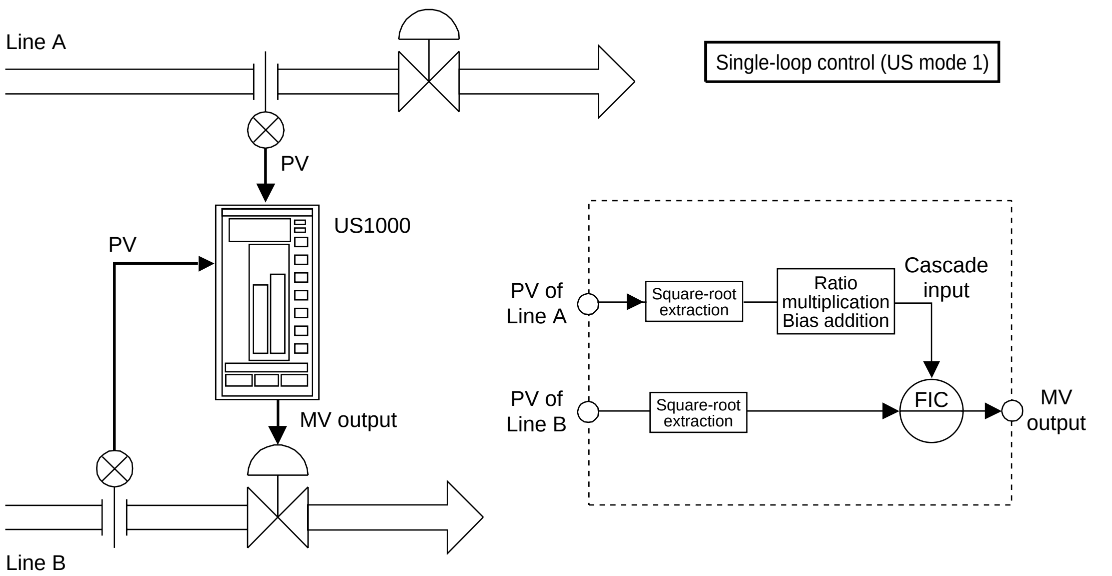
1. Examples of US1000 Applications

This chapter contains examples of applications that use each controller mode (US mode). These examples will help you to find out which controller mode is applicable for a particular control and what equipment can be included in the control.

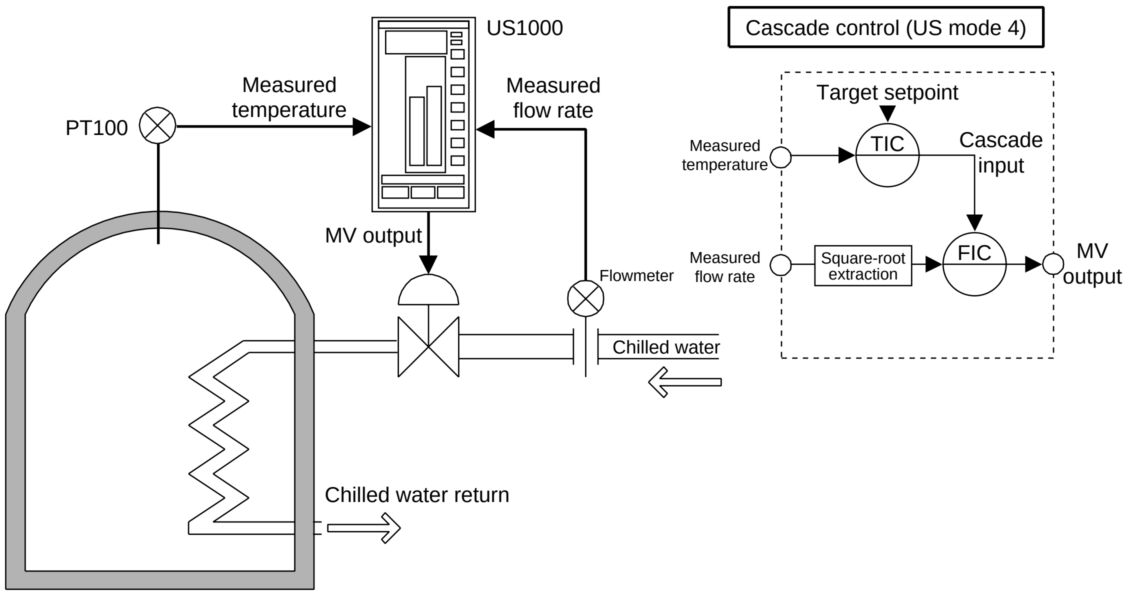
■ Flow Rate Ratio Control

The ratio of line-A and line-B flow rates is maintained at a constant value. Square-root extraction, ratio multiplication, and bias addition are carried out on the measured flow rate (differential pressure) of line A, and the result is used as the cascade input for the line-B control.



■ Cascade Control

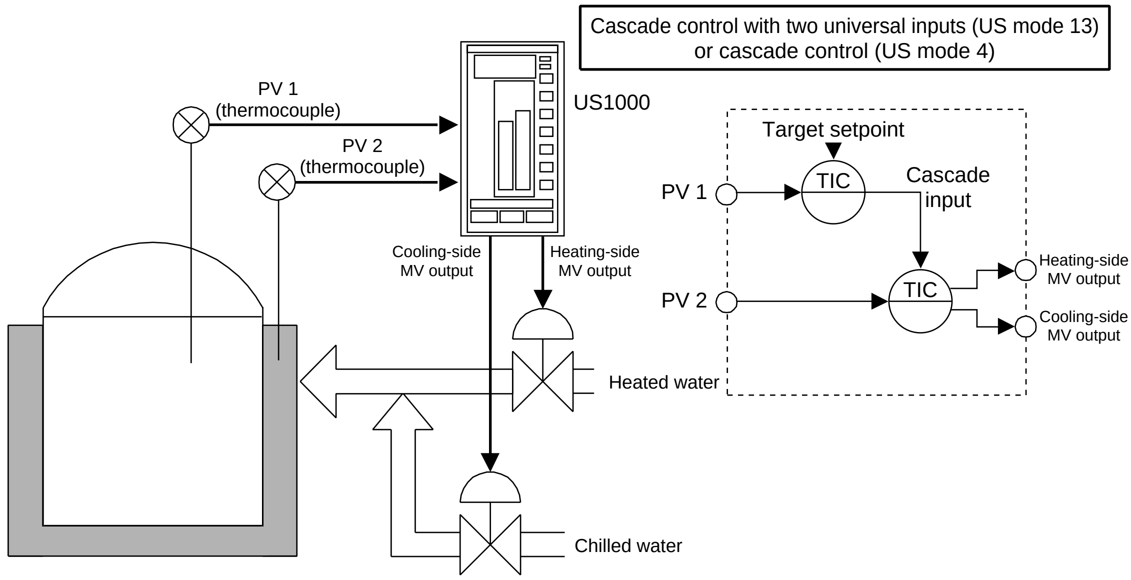
This example shows cascade control using two inputs of measured temperature and flow rate.



■ Reactor Cascade Control

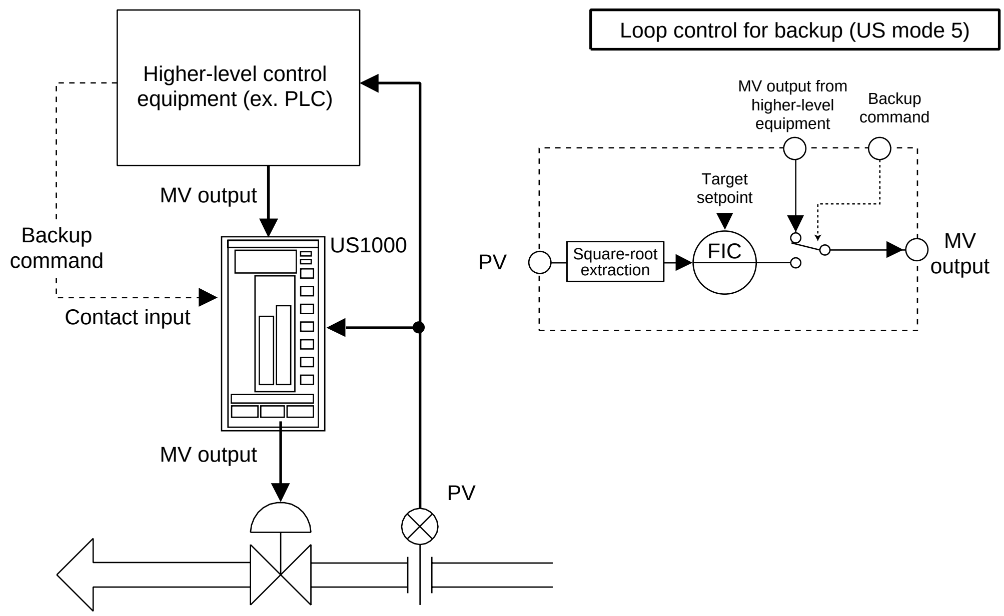
In the cascade control of a reactor, the temperature of the reactor content is raised by heated water from the start of the control process until the start of reaction. After reaction, the temperature will be controlled by chilled water. When the PID computation result does not exceed 50%, the cooling-side MV output (0 to 100%) is regulated; when the result is 50% or more, the heating-side MV output (0 to 100%) is regulated.

The controller mode for cascade control with two universal inputs (US mode 13), allows a controller to receive two points of temperature inputs directly. The cascade control mode (US mode 4), on the other hand, requires a temperature converter for one of the two inputs because this controller mode provides only a single universal input.



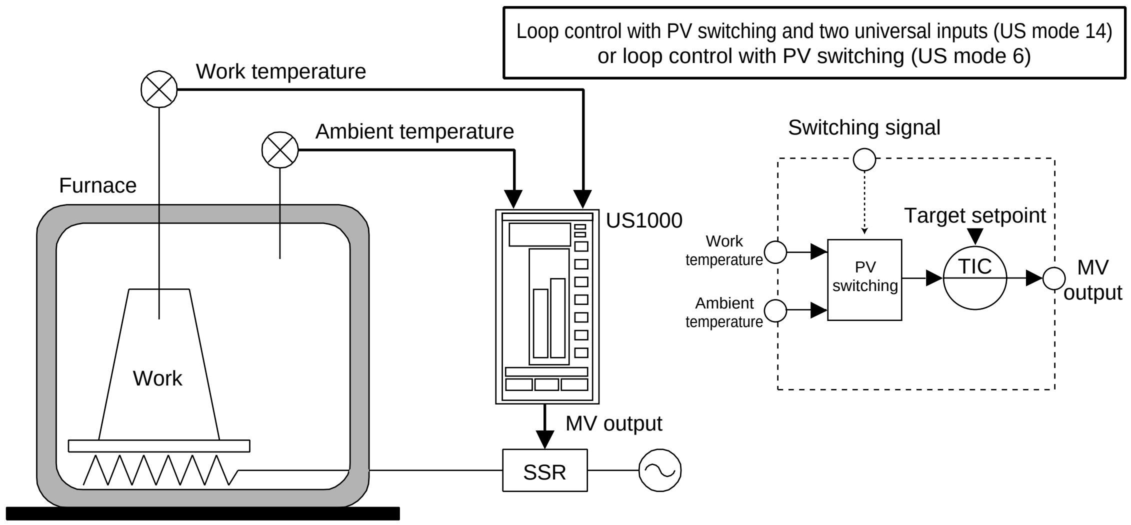
■ Loop Control for Backup

This controller mode is used to backup the MV output of higher-level control equipment such as a programmable logic controller (PLC). Normally, the process is controlled by the MV output from the higher-level control equipment through the US1000 controller. And if the equipment fails, the control is automatically switched to the PID control by the US1000 controller on receiving a backup-command contact input signal.



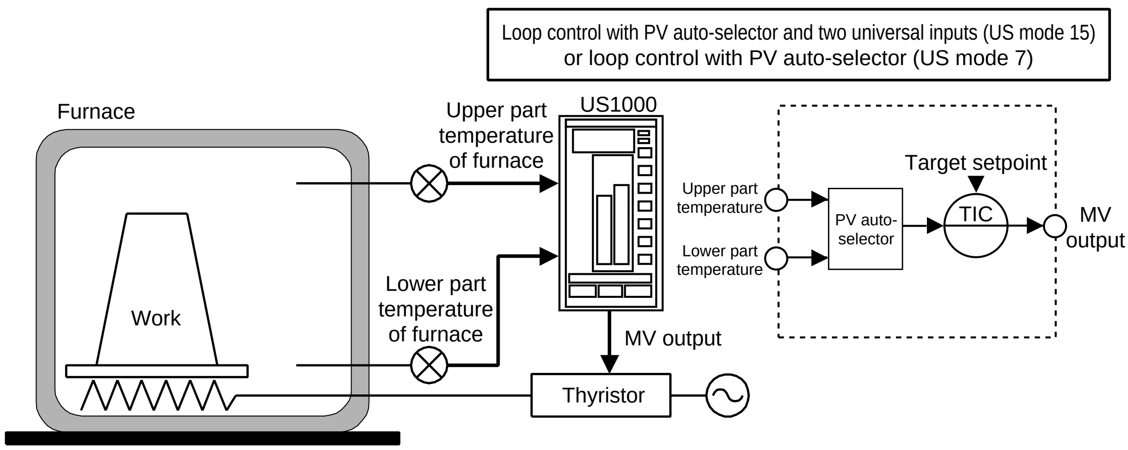
■ Loop Control with PV Switching

In this example, the furnace temperature is first controlled at ambient temperature and then gradually increased to the required work temperature, where it is then controlled.
The controller mode for loop control with PV switching and two universal inputs (US mode 14) allows a controller to receive two points of temperature inputs directly. The loop control with PV switching mode (US mode 6), on the other hand, requires a temperature converter for one of the two inputs because this controller mode provides only a single universal input.



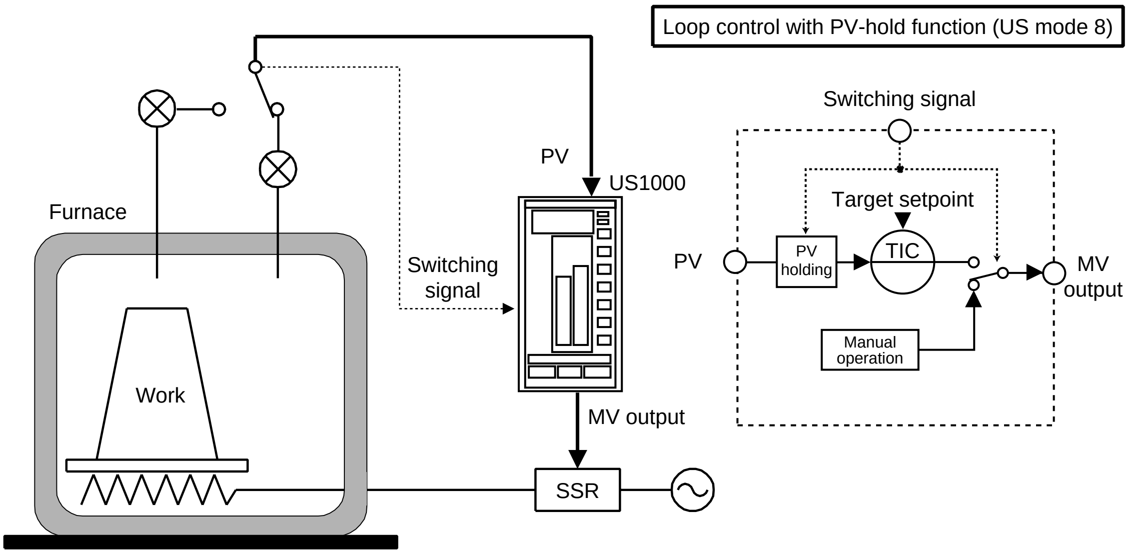
■ Loop Control with PV Auto-selector

The temperatures in the upper and lower parts of the furnace are measured, and the furnace temperature can be controlled at an average, maximum, minimum, or differential value of the two temperatures.
The controller mode for loop control with PV auto-selector and two universal inputs (US mode 15) allows a controller to receive two points of temperature inputs directly. Loop control with PV auto-selector mode (US mode 7), on the other hand, requires a temperature converter for one of the two inputs because this controller mode provides only a single universal input.



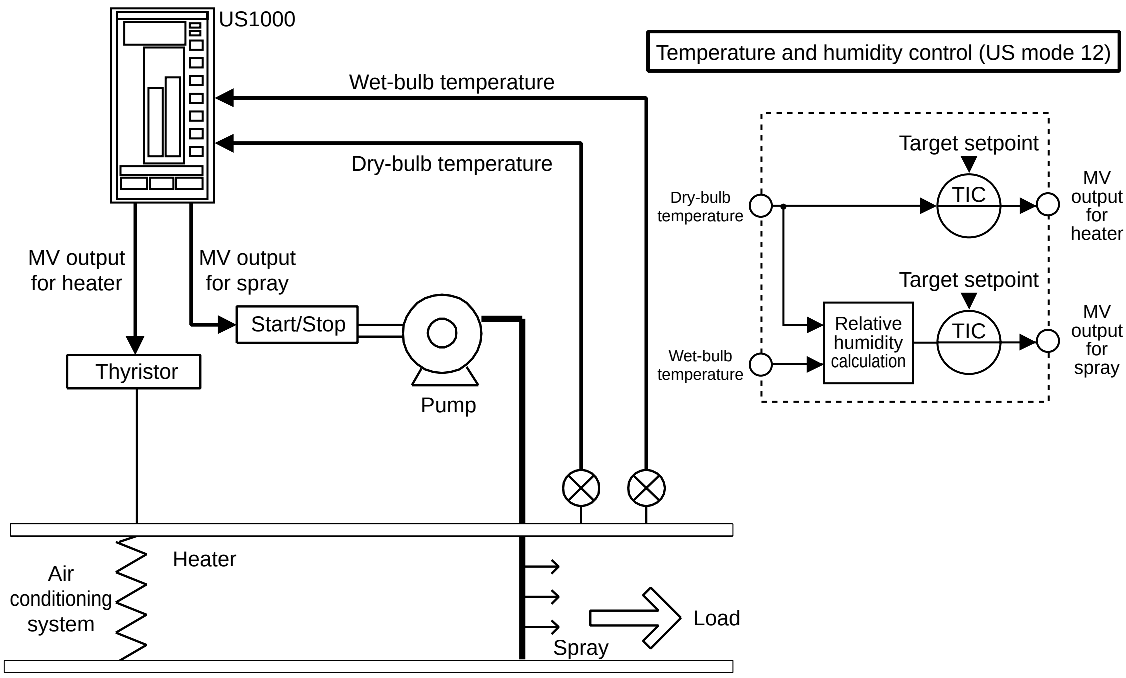
■ Loop Control with PV-hold Function

During replacing the works in the furnace, PV and MV values can be held by the contact input. So that, PV low limit alarm or MV wind-up won't occur when the temperature in the furnace decreases temporarily according to replacing the works.



■ Temperature and Humidity Control

Dry- and wet-bulb temperatures can be controlled using a single US1000 controller for an air conditioning system. (US1000-11 only)



2. Controller Mode (US Mode)

The US1000 controller has control functions to meet various kinds of control loops, as shown in Table 2.1. These control functions are called “controller modes,” or “US modes.”
The controller mode (US mode) is first set when configuring the US1000 controller functions. Table 2.2 shows the parameter for setting the controller mode (US mode). To set this parameter, refer to the separate instruction manual “US1000 Digital Indicating Controller” (IM 5D1A01-01E).

This chapter describes each controller mode function showing function block diagrams. The fundamental description is in Section 2.1, “Single-loop Control (US mode 1).” Other descriptions specific to each US mode function are in the sections dedicated to their respective US mode function.
Regarding the parameters shown in the diagrams, refer to Chapter 3, “Parameters.”

Table 2.1 Controller Mode (US Mode)

Controller mode	Setting	Description	US1000 *1		
			-00	-11	-21
Single-loop control	1	Basic PID control	○	○	○
Cascade primary-loop control	2	Operates as a primary controller in cascade control.	○	○	
Cascade secondary-loop control	3	Operates as a secondary controller in cascade control.	○	○	○
Cascade control	4	Performs cascade control with a single controller.	○	○	○
Loop control for backup	5	PID control with backup function for the suppervisory system.	○	○	○
Loop control with PV switching	6	PID control with dual-PV switching function by contact in put or PV range.	○	○	○
Loop control with PV auto-selector	7	PID control with dual-PV auto-selector function by minimum/maximum/average/difference.	○	○	○
Loop control with PV-hold function	8	PID control with a PV- and MV-hold function.	○	○	○
Dual-loop control	11	Basic PID control for independent two loops		○	
Temperature and humidity control	12	Controls temperature and relative humidity independently by PID control.		○	
Cascade control with two universal inputs	13	Performs cascade control using two universal inputs.		○	○
Loop control with PV switching and two universal inputs	14	Performs loop control with PV switching using two universal inputs.		○	○
Loop control with PV auto-selector and two universal inputs	15	Performs loop control with PV auto-selector using two universal inputs.		○	○
Custom computation control	21	Controls by user-defined control and computation functions.		○	○

*1 Some US mode functions are not available depending on the controller model. The US mode functions available are marked with ○ for US1000-00, US1000-11, and US1000-21.

Table 2.2 Parameter to Set Controller Mode (US Mode)
[Setup parameter]

Main menu	Submenu	Parameter	Description	Range of setting	Default
USMD	MD	USM	Controller mode (US mode)	See the table above.	1

2.1 Single-loop Control (US mode 1)

This controller mode provides the basic control functions with a single control computation unit. Following is a description of how to read the function block diagram for single-loop control (US1000-00). The numbers in parentheses correspond to the numbers in the diagram. Most of these descriptions can also be applied to the function diagrams for other US modes.

(1) PV input section

A series of computations can be performed on the PV input from the AIN1 terminal. The AIN1 terminal is a universal analog input terminal that can receive direct signals from a thermocouple or RTD, or voltage signal. For information about the computations provided on the PV input, refer to Section 3.2, “Parameters for Analog Input,” and Section 3.3, “Parameters for PV Computation.”

(2) Cascade input section (Optional communication function)

Cascade input is used in control such as the flow rate ratio control introduced in Chapter 1.
The RS-485 terminal is the communication input terminal for the RS-485 and is provided for controllers with optional communication functions.
In CAS operation mode, the US1000 controller performs control using the cascade input from the RS-485 or AIN3 terminal as the target setpoint instead of using the value set with the parameter n.SV.
Whether to use RS-485 or AIN3 terminal for cascade input can be specified using the parameter CMS.
For information about the CMS parameter and cascade input, refer to Section 3.4, “Parameters for Cascade Input.”

(3) Cascade input section (AIN3 terminal)

The AIN3 terminal is an analog input terminal for voltage input. Like the RS485 terminal mentioned above, the input from the AIN3 terminal can be used as a cascade input, and computations can be performed on the input. For information about the computations on inputs, refer to Section 3.2, “Parameters for Analog Input.”
The input from AIN3 terminal can also be used as a feedforward input by setting the parameter FFS to AIN. In this case, the parameter CMS must be set to CPT. The feedforward input value will be added to the result of PID computation. For information about feedforward input, refer to Section 3.5, “Parameters for Feedforward Input.”

(4) Contact input section

Two contact input terminals DI1 and DI2 are provided. At the time of shipping, the functions for switching between RUN/STOP and to switch the operation mode to MAN are assigned to DI1 and DI2 terminals, respectively. For detailed information about the functions assigned to contact inputs, refer to Table 2.3.
The assigned function can be changed to other functions (e.g., switching to AUTO mode). Refer to Section 3.15, “Parameters for Contact Input,” for how to change.

Table 2.3 Functions of Contact Input

Function	Contact status and US1000 controller action
RUN/STOP switchover	STOP when the contact is ON; RUN when OFF
CAS/AUTO/MAN mode selection	Operation mode changes to CAS, AUTO, and MAN when the corresponding contact changes from OFF to ON. Operation mode does not change from ON to OFF.
Tracking switching	The tracking input from AIN2 or AIN3 is valid when the contact is ON; the tracking input is invalid when OFF.
OPEN/CLOSE switchover	Cascade open when the contact is ON; cascade close when OFF.
‘PV-hold and MAN mode’ or ‘AUTO mode’	PV is held in MAN mode when the contact is ON; AUTO mode when OFF.

(5) PID computation unit

The PID computation unit, which represents the core of the control. For information about the PID computation unit, refer to Section 3.9, “Parameters for PID Computation.”

(6) RUN/STOP and operation mode switching section

The controller operates when the signal from DI1 terminal is off, and stops when the signal is on. When the controller is stopped, the preset MV value is set with the parameter n.PM or n.PMc output as MV output. For information about the parameter n.PM and n.PMc, refer to subsection 3.12.4, “Preset MV.”

Operation mode can be switched to CAS, AUTO, and MAN using the [C], [A], and [M] keys on the controller’s front panel, respectively.

In MAN mode, the MV output can be operated using the [<], [<<>>], and [>] keys on the controller’s front panel. For information about the operation mode and operations, refer to Chapter 6, “Operation,” in the separate instruction manual “US1000 Digital Indicating Controller” (IM 5D1A01-01E).

(7) MV output section

The result of control computation is output to the OUT1A terminal as an MV output. The type of MV output can be selected from voltage pulse and current using the MVS1 parameter. For information about MV outputs, refer to Section 3.8, “Parameters for Control Computation,” and Section 3.12, “Parameters for MV.”

(8) Retransmission output section

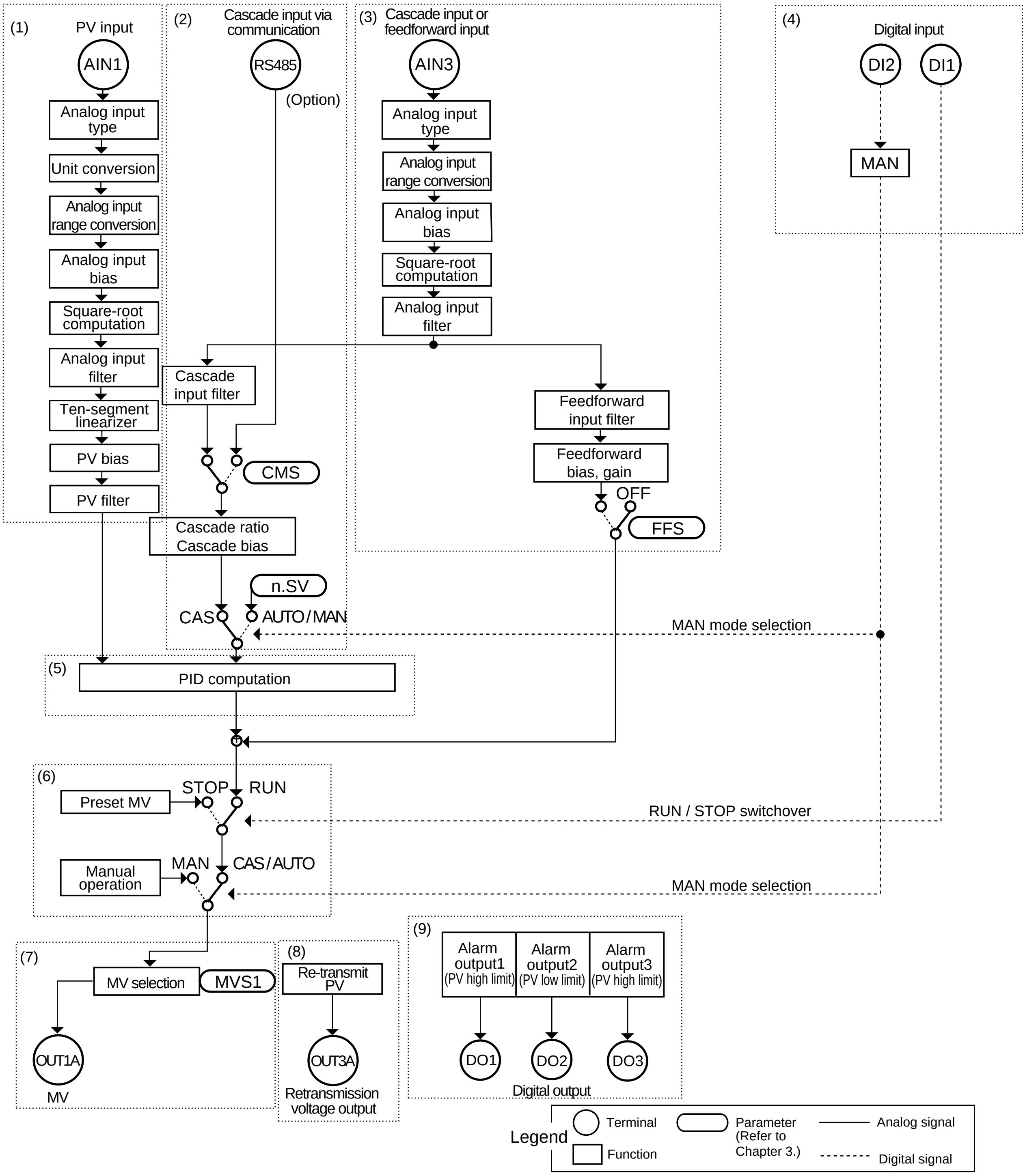
The OUT3A terminal is used solely for retransmission output. Retransmission output is the function for retransmitting the signal of PV, SV, or MV data in the controller to a device such as a recorder. At the time of shipping, the function is set to retransmit PV. For information about the retransmission output, refer to Section 3.13, “Parameters for Retransmission Output.”

(9) Contact output section

Three contact output terminals DO1, DO2, and DO3 are provided. At the time of shipping, the PV high limit, PV low limit, and PV high limit (to be used as the high-high limit) alarms are assigned to the respective terminals. For information about alarm functions, refer to Section 3.14, “Parameters for Alarm Output.”

■ Single-loop Control (US1000-00)

One universal input terminal (AIN1) is provided. Voltage pulse or current output can be selected for the MV output by setting the MVS1 parameter (OUT1A terminal).



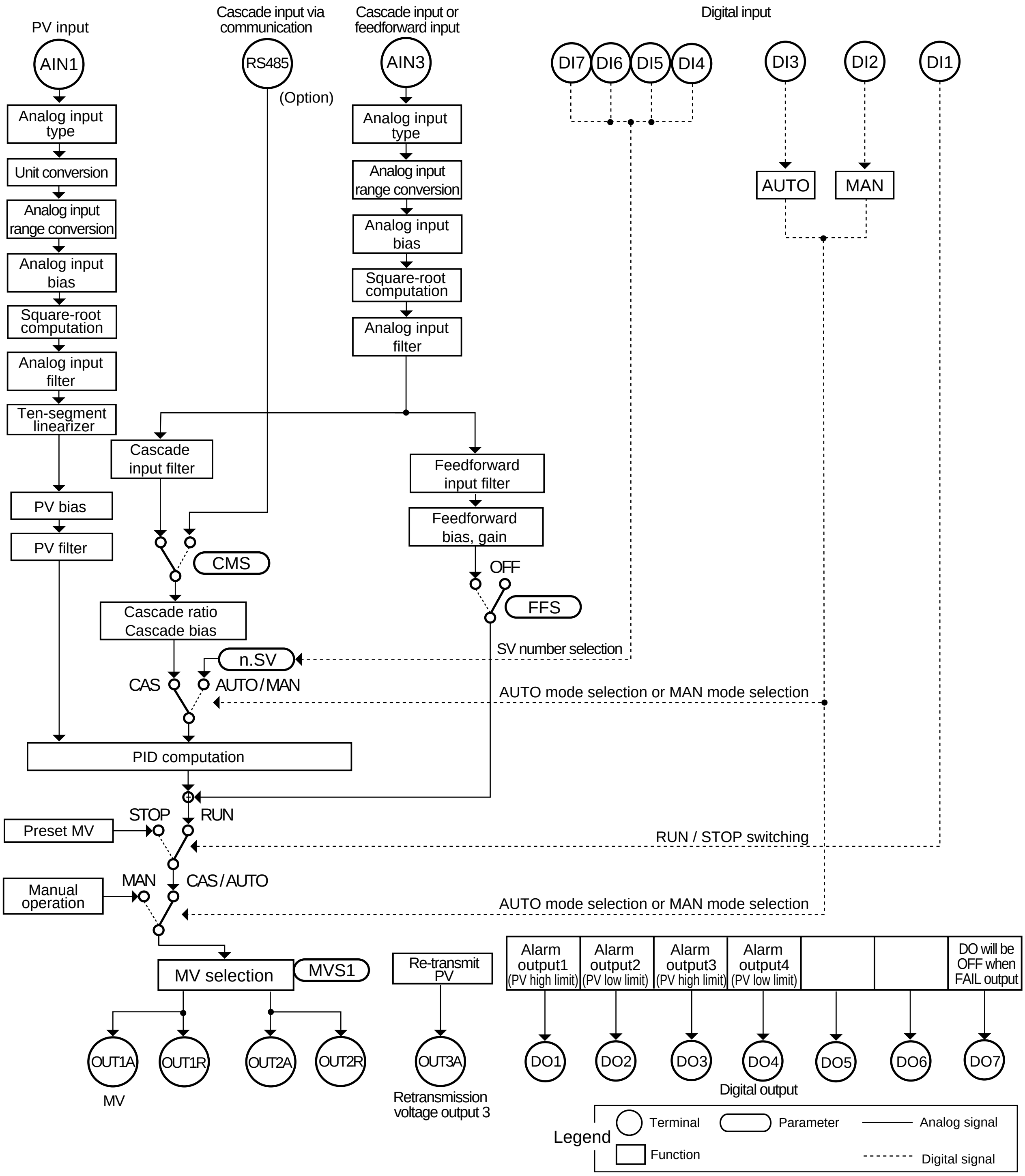
■ Single-loop Control (US1000-11)

One universal input terminal (AIN1) is provided. The type of MV output can be selected from those in the table below by setting the MVS1 parameter.

Table 2.4 MV Output for US1000-11

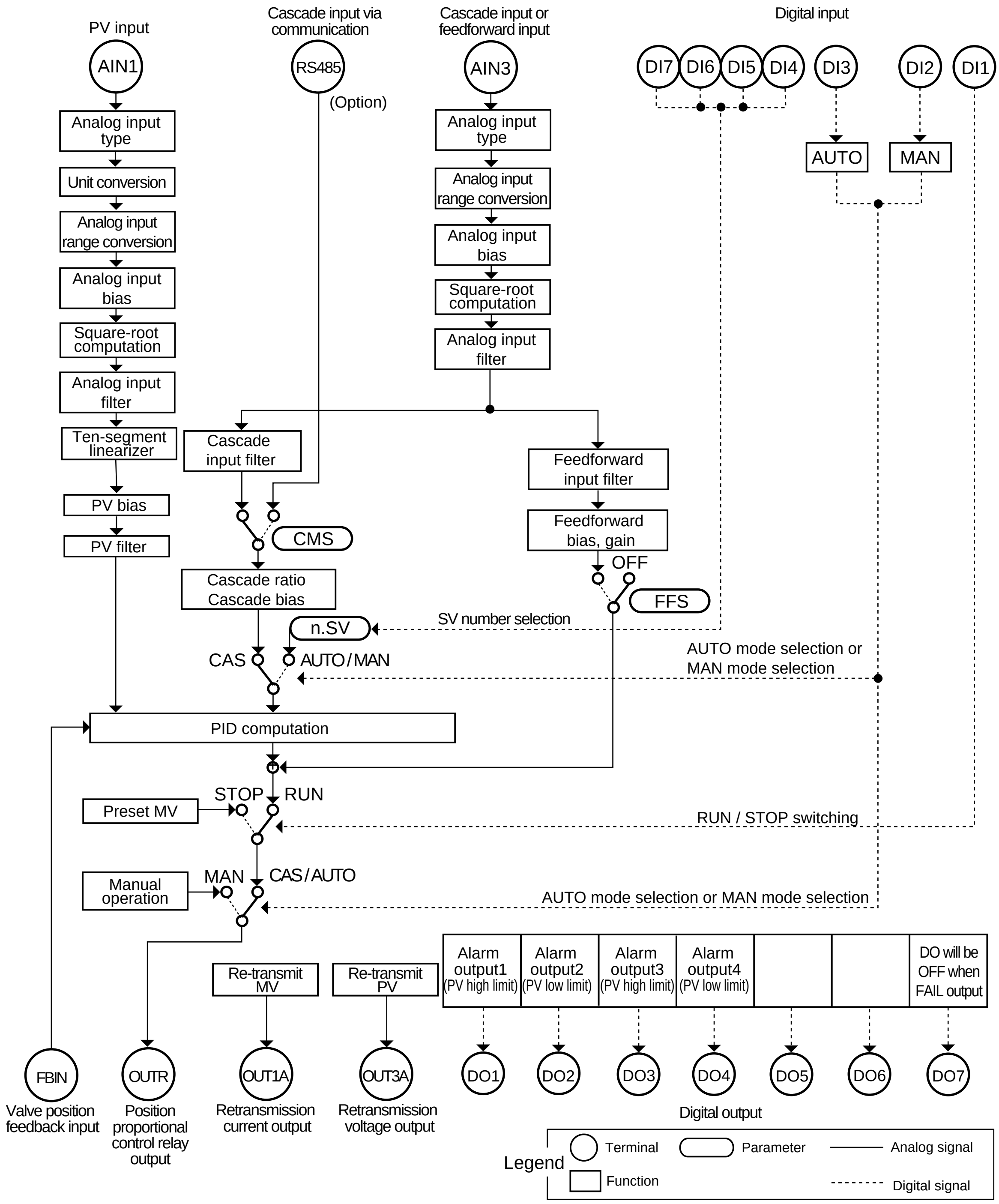
Terminal code	Terminal No.	Type of control computation (Value of MVS1 *1)			
		Time proportional PID (0, 1) Continuous PID (2) ON/OFF computation (3)	Heating/cooling computation (4 to 6)	Heating/cooling computation (7 to 9)	Heating/cooling computation (10 to 12)
OUT1A	16, 18	Retransmission output (0, 3) Voltage pulse output (1) Current output (2)	Retransmission output (4) Heating pulse output (5) Heating current output (6)	Retransmission output (7) Heating pulse output (8) Heating current output (9)	Retransmission output (10) Heating pulse output (11) Heating current output (12)
OUT1R	55 to 57	Control relay output (0, 3) Alarm output 4 (1, 2)	Heating control relay output (4) Alarm output 4 (5, 6)	Heating control relay output (7) Alarm output 4 (8, 9)	Heating control relay output (10) Alarm output 4 (11, 12)
OUT2A	49, 50	Retransmission output 2	Retransmission output 2	Cooling pulse output	Cooling current output
OUT2R	58 to 60	Alarm output 3	Cooling control relay output	Alarm output 3	Alarm output 3

*1 Value of MVS2 for cascade control and cascade control with two universal inputs.


PV input
AIN1
Analog input type
Unit conversion
Analog input range conversion
Analog input bias
Square-root computation
Analog input filter
Ten-segment linearizer
PV bias
PV filter
Cascade input via communication
RS485
(Option)
Cascade input or feedforward input
AIN3
Analog input type
Analog input range conversion
Analog input bias
Square-root computation
Analog input filter
Cascade input filter
CMS
Cascade ratio
Cascade bias
Feedforward input filter
Feedforward bias, gain
OFF
FFS
Digital input
DI7
DI6
DI5
DI4
DI3
DI2
DI1
AUTO
MAN
SV number selection
n.SV
CAS
AUTO / MAN
AUTO mode selection or MAN mode selection
PID computation
Preset MV
STOP
RUN
RUN / STOP switching
Manual operation
MAN
CAS / AUTO
AUTO mode selection or MAN mode selection
MV selection
MVS1
Re-transmit PV
Alarm output1 (PV high limit)
Alarm output2 (PV low limit)
Alarm output3 (PV high limit)
Alarm output4 (PV low limit)
DO will be OFF when FAIL output
OUT1A
OUT1R
OUT2A
OUT2R
MV
OUT3A
Retransmission voltage output 3
DO1
DO2
DO3
DO4
DO5
DO6
DO7
Digital output
Legend
Terminal
Parameter
Analog signal
Function
Digital signal

■ Single-loop Control (US1000-21)

Control is performed based on a position-proportional PID computation so as to ensure that the MV output and control valve opening always match. One universal input terminal (AIN1) is provided. The MV output is a position-proportional control relay output (OUTR terminal). A valve position feedback input is provided.



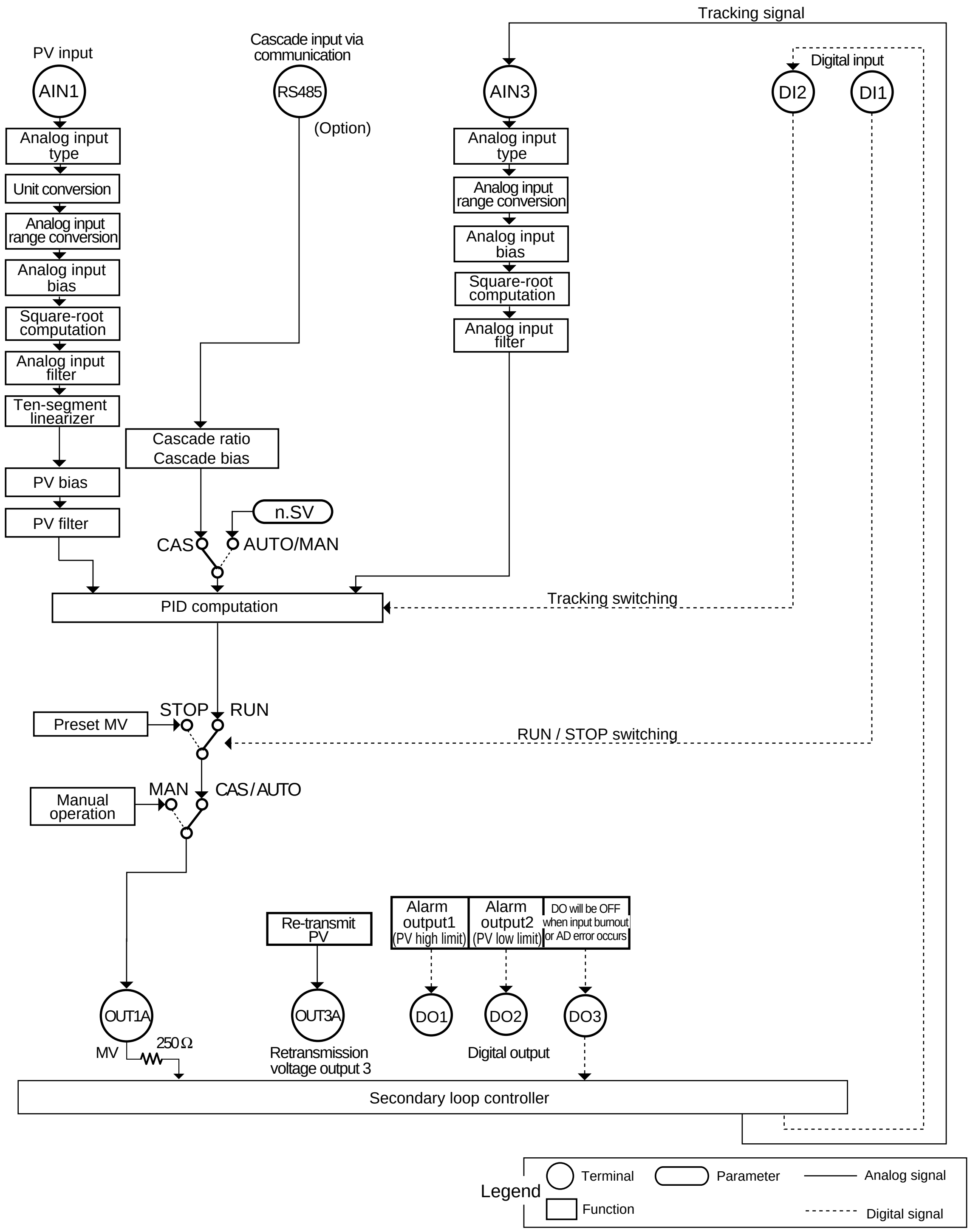
2.2 Cascade Primary-loop Control (US mode 2)

This US mode sets up a controller as the primary loop controller when cascade control is to be performed using two controllers.

The mode provides an output tracking function and an error signal output to the secondary loop controller, both of which are required for a cascade primary loop.

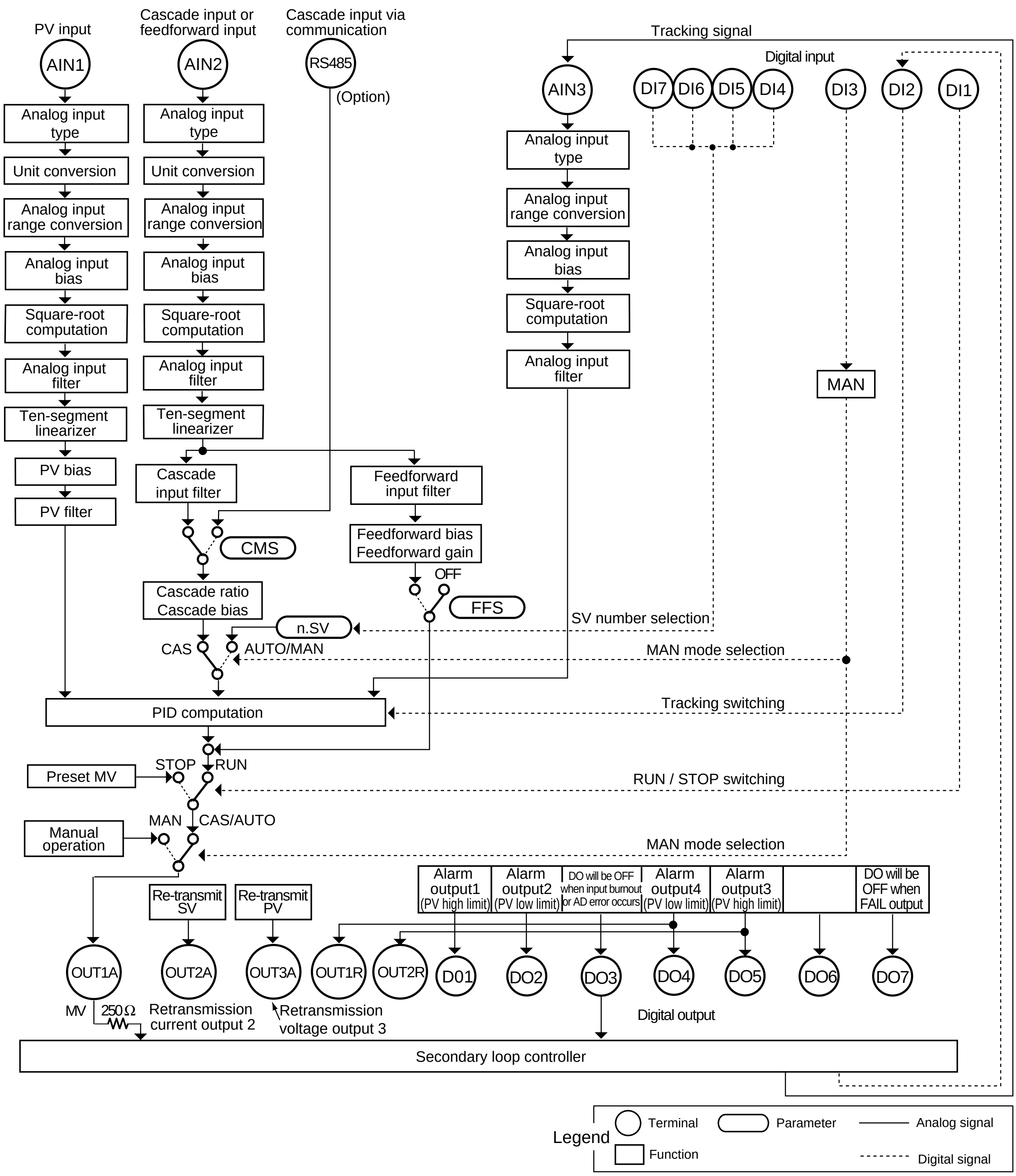
■ Cascade Primary-loop Control (US1000-00)

One universal input terminal (AIN1) is provided. The MV output is a current output (OUT1A terminal). Leave the MVS1 parameter setting at the default value (2).



■ Cascade Primary-loop Control (US1000-11)

Two universal input terminals (AIN1 and AIN2) are provided. The MV output is a current output (OUT1A terminal). Leave the MVS1 parameter setting at the default value (2).

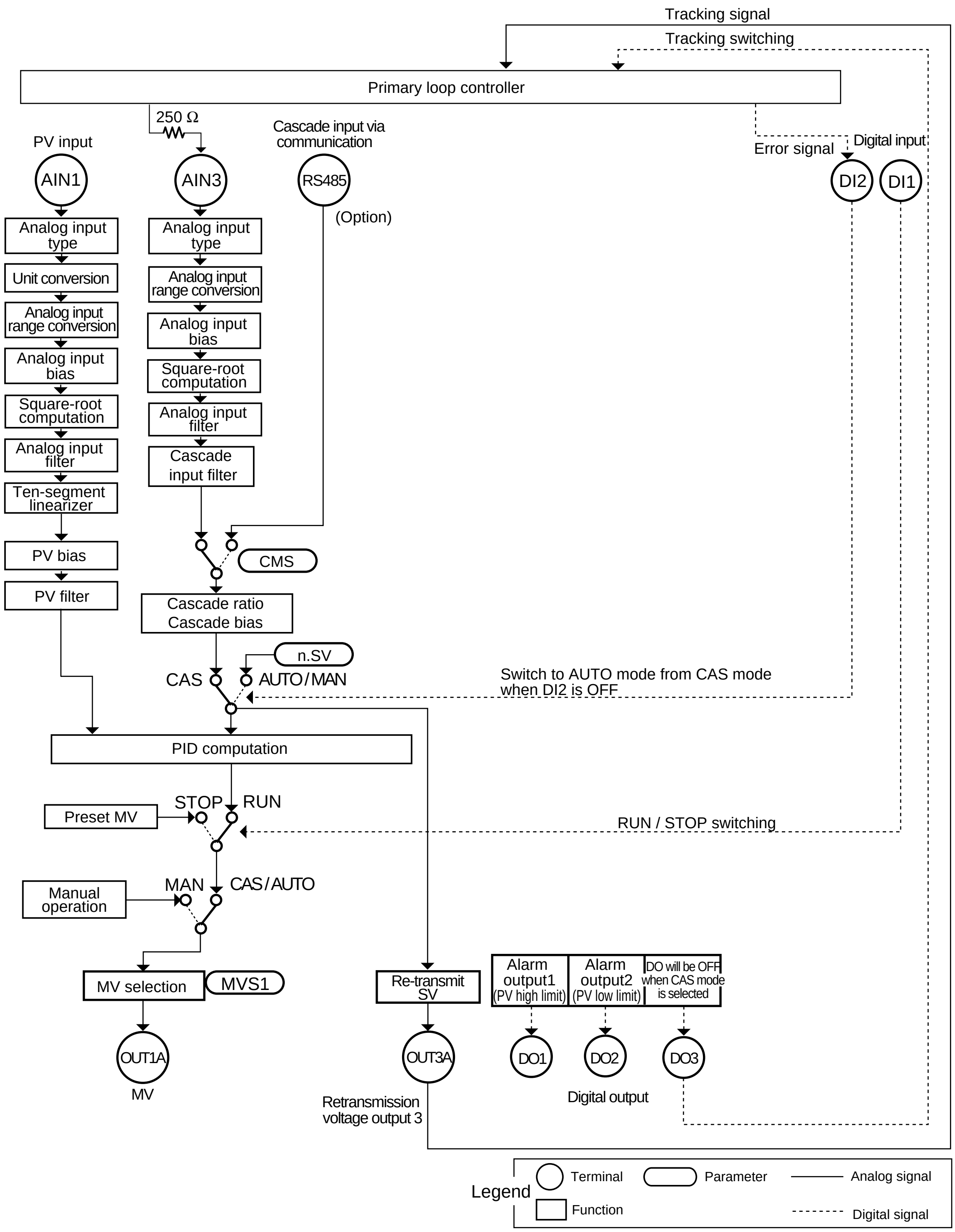


2.3 Cascade Secondary-loop Control (US mode 3)

This US mode sets up a controller as the secondary loop controller when cascade control is to be performed using two controllers.
The mode provides a setpoint output function and a signal tracking output to the primary loop controller, both of which are required for a cascade secondary loop.

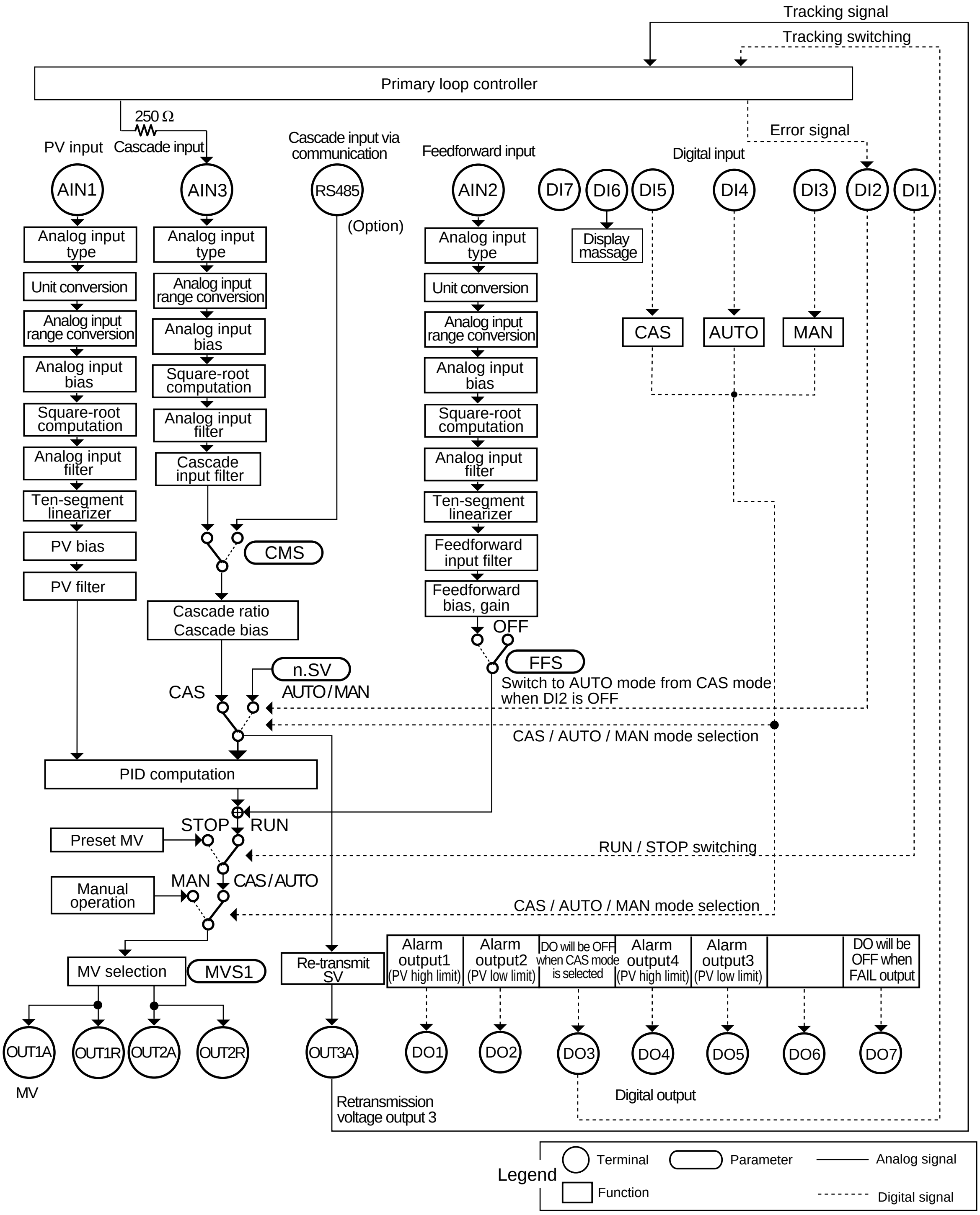
■ Cascade Secondary-loop Control (US1000-00)

One universal input terminal (AIN1) is provided. Voltage pulse or current output can be selected for the MV output by setting the MVS1 parameter (OUT1A terminal).



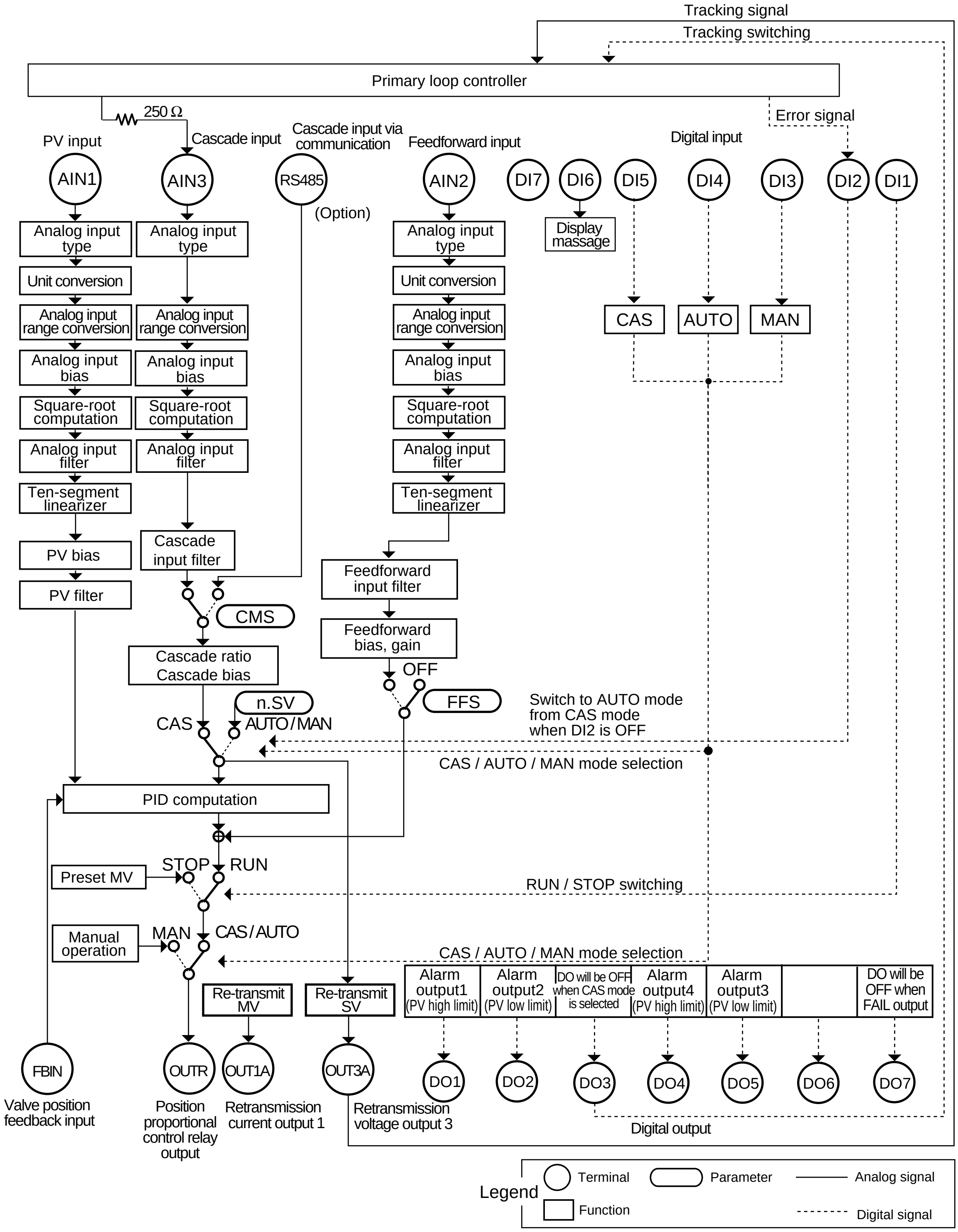
■ Cascade Secondary-loop Control (US1000-11)

Two universal input terminals (AIN1 and AIN2) are provided. The type of MV output can be selected from those in Table 2.4 in Section 2.1 by setting the MVS1 parameter.



■ Cascade Secondary-loop Control (US1000-21)

Control is performed based on a position-proportional PID computation so as to ensure that the MV output and control valve opening always match. Two universal input terminals (AIN1 and AIN2) are provided. The MV output is a position-proportional control relay output (OUTR terminal). A valve position feedback input is provided.

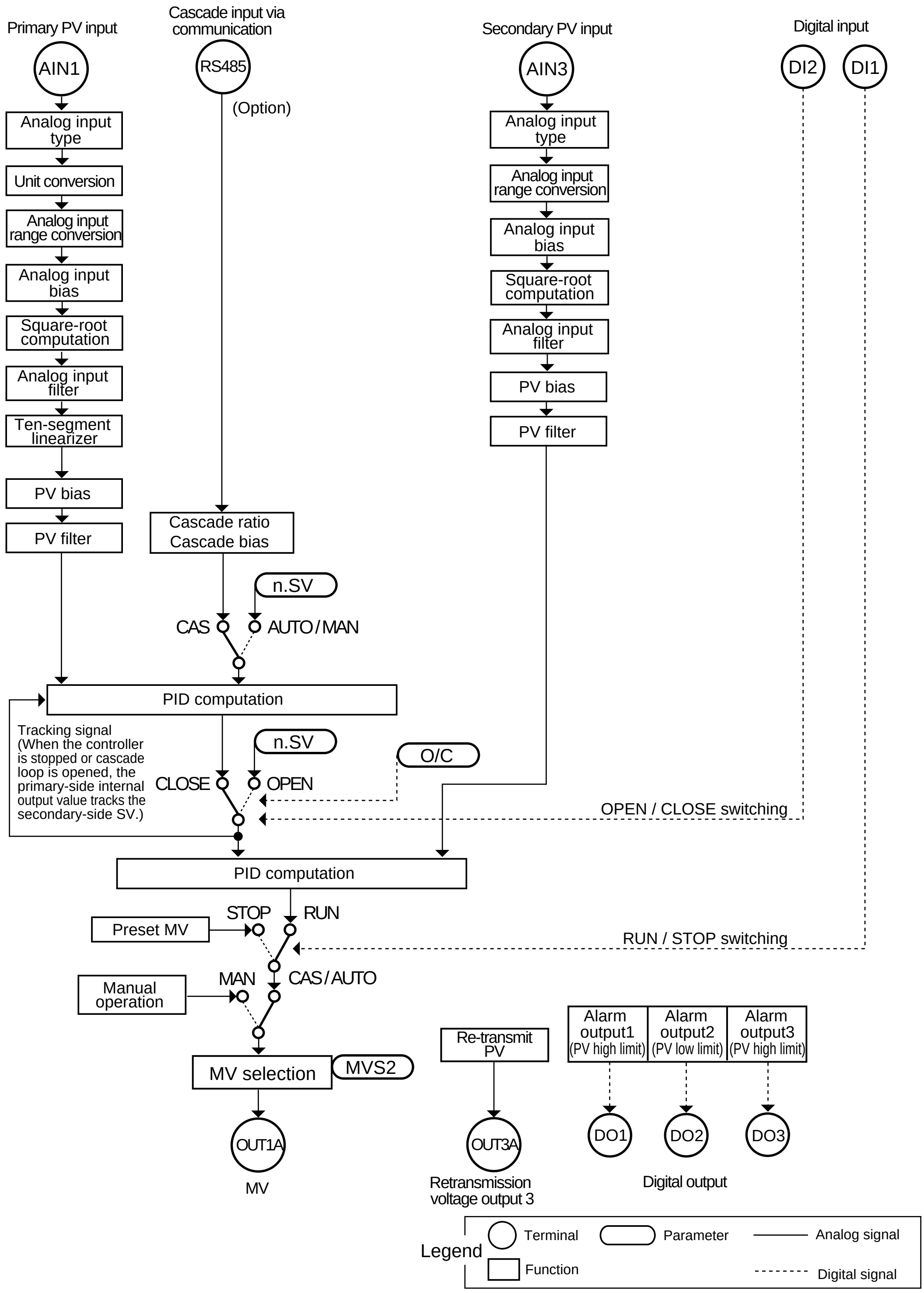


2.4 Cascade Control (US mode 4)

This US mode provides two control computation units and enables cascade control using just a single controller. Open/close switching of the cascade loop is carried out by either a contact input (DI2) or the O/C parameter. For information about open/close switching of the cascade loop, refer to Section 3.15, “Parameters for Contact Input.”

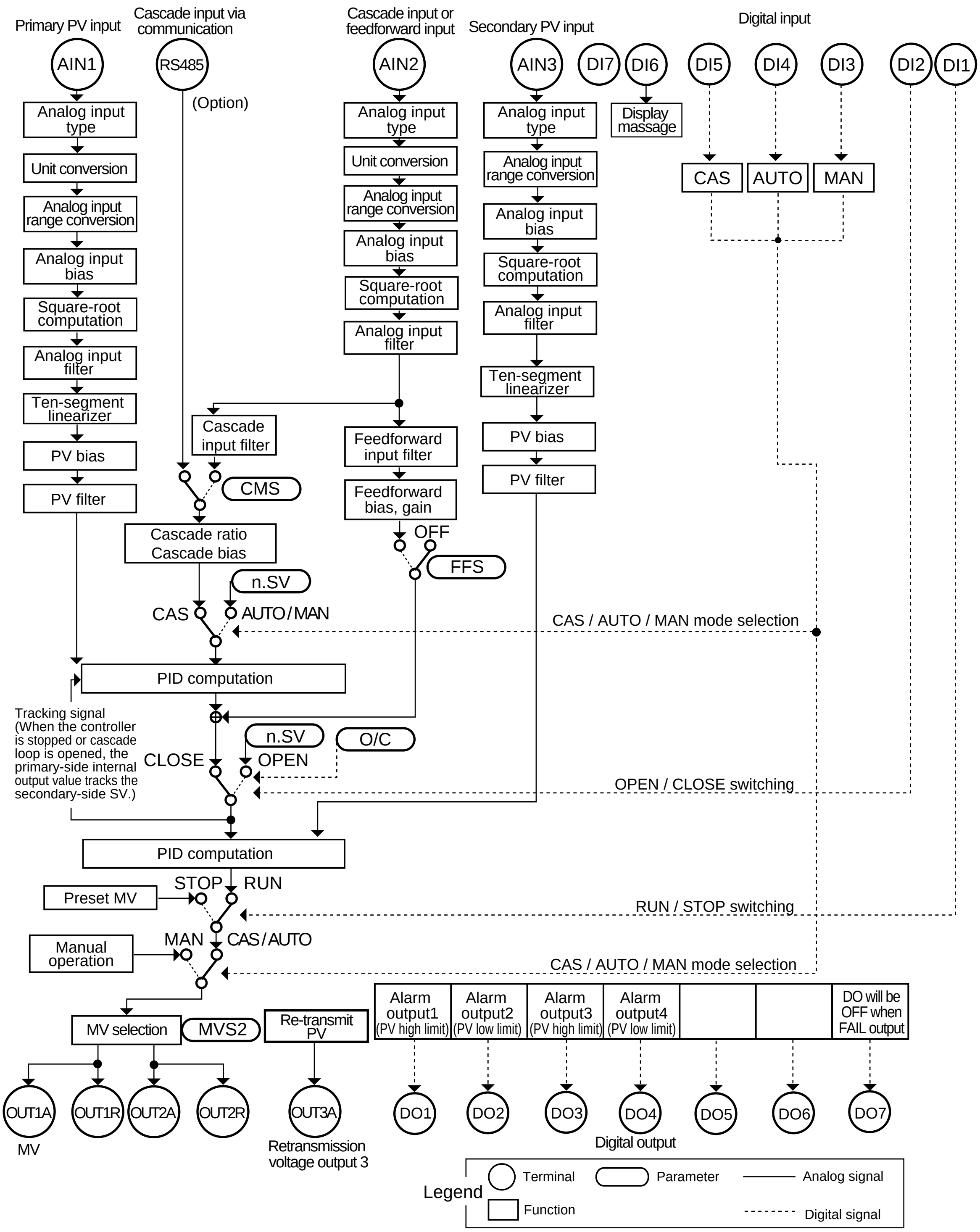
■ Cascade Control (US1000-00)

One universal input terminal (AIN1) is provided. Voltage pulse or current output can be selected for the MV output by setting the MVS2 parameter (OUT1A terminal).



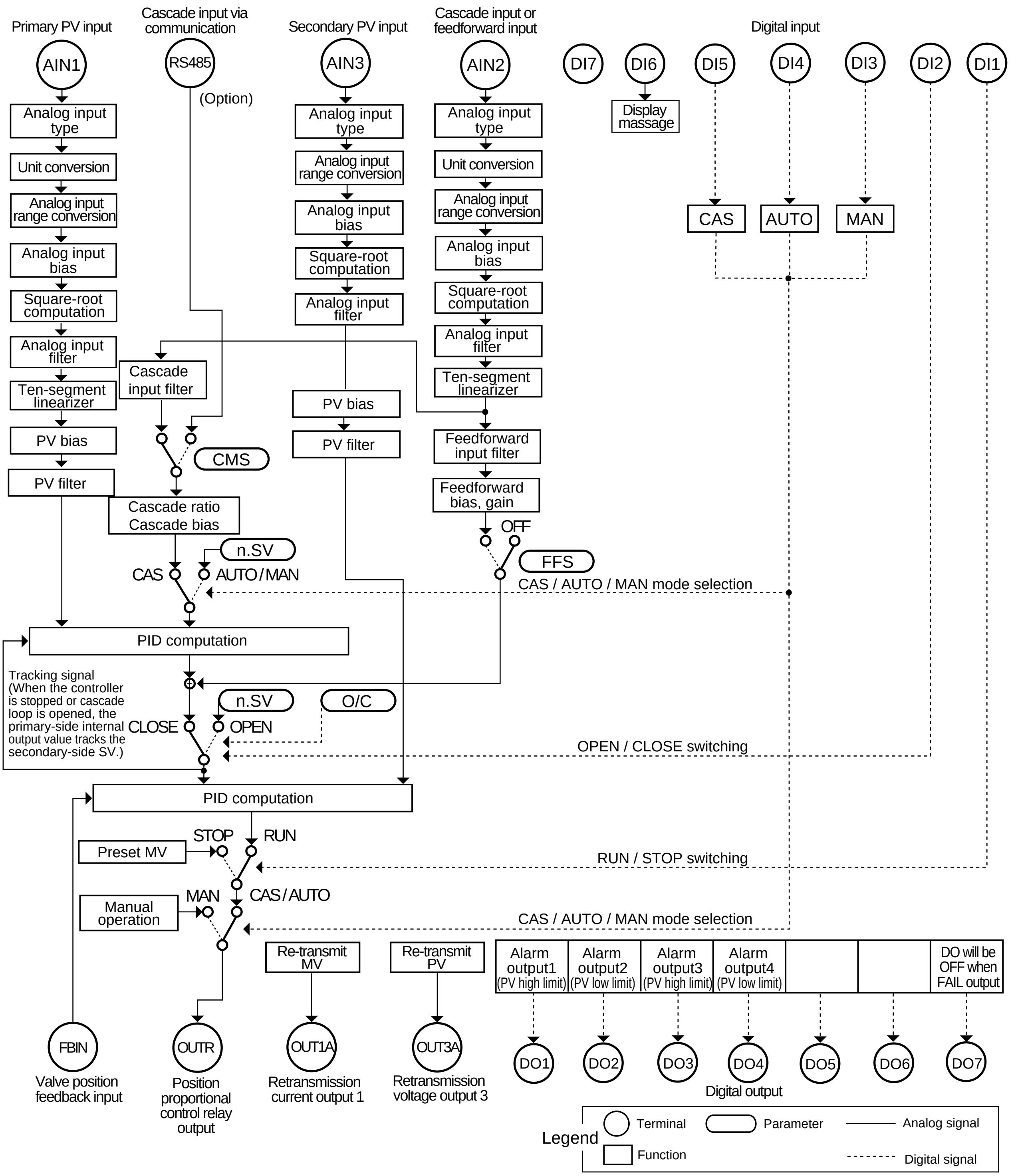
■ Cascade Control (US1000-11)

Two universal input terminals (AIN1 and AIN2) are provided. The type of MV output can be selected from those in Table 2.4 in Section 2.1 by setting the MVS2 parameter.



■ Cascade Control (US1000-21)

Control is performed based on a position-proportional PID computation so as to ensure that the MV output and control valve opening always match. Two universal input terminals (AIN1 and AIN2) are provided. The MV output is a position-proportional control relay output (OUTR terminal). A valve position feedback input is provided.

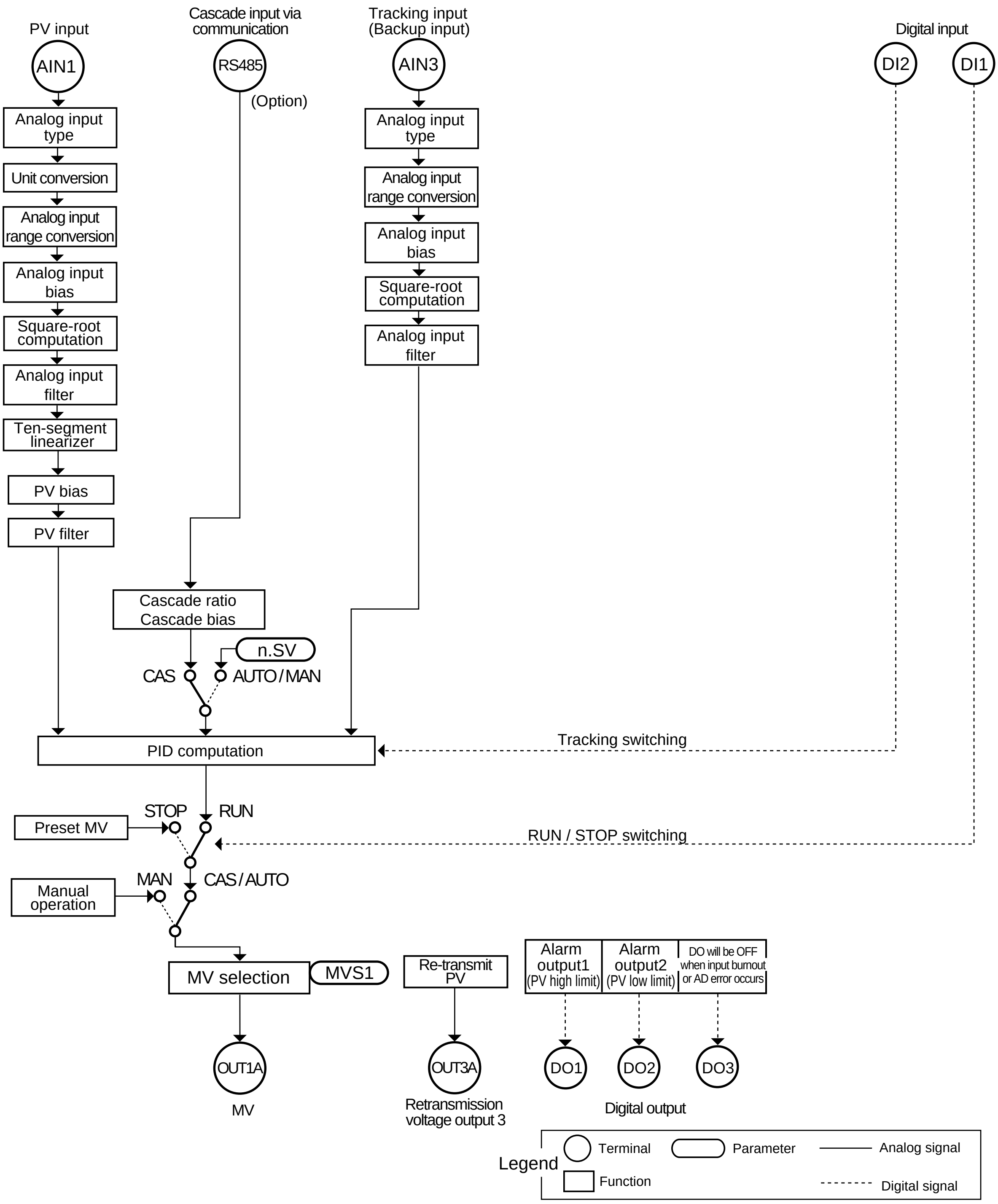


2.5 Loop Control for Backup (US mode 5)

This US mode provides a control function that is used in combination with higher-level control equipment (such as another controller or a programmable controller). Normally, the controller outputs the MV output received from the higher-level equipment (tracking the input from an AIN3 terminal). On receiving a FAIL signal from the higher-level equipment, the controller starts controlling the equipment instead.

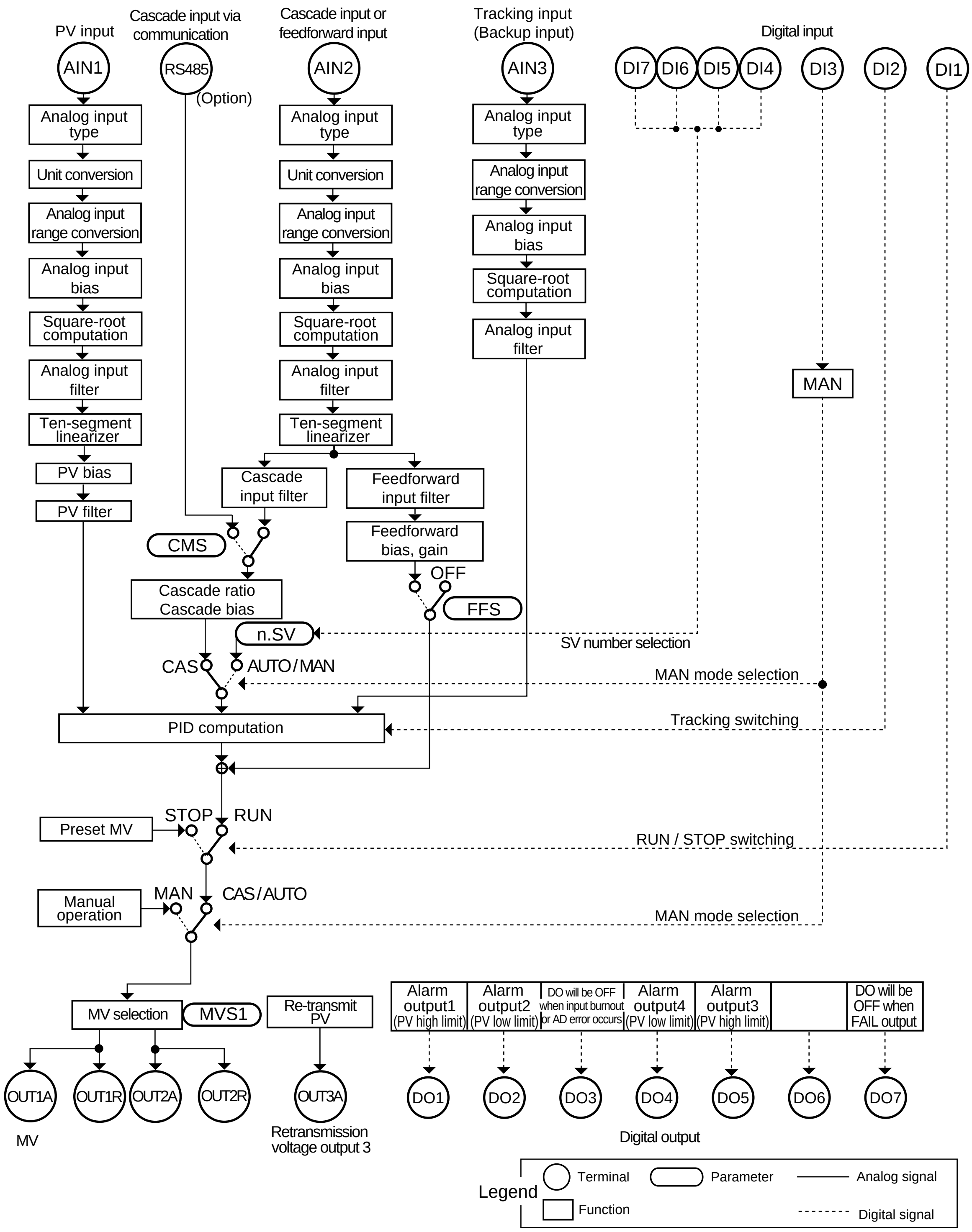
■ Loop Control for Backup (US1000-00)

One universal input terminal (AIN1) is provided. Voltage pulse or current output can be selected for the MV output by setting the MVS1 parameter (OUT1A terminal).



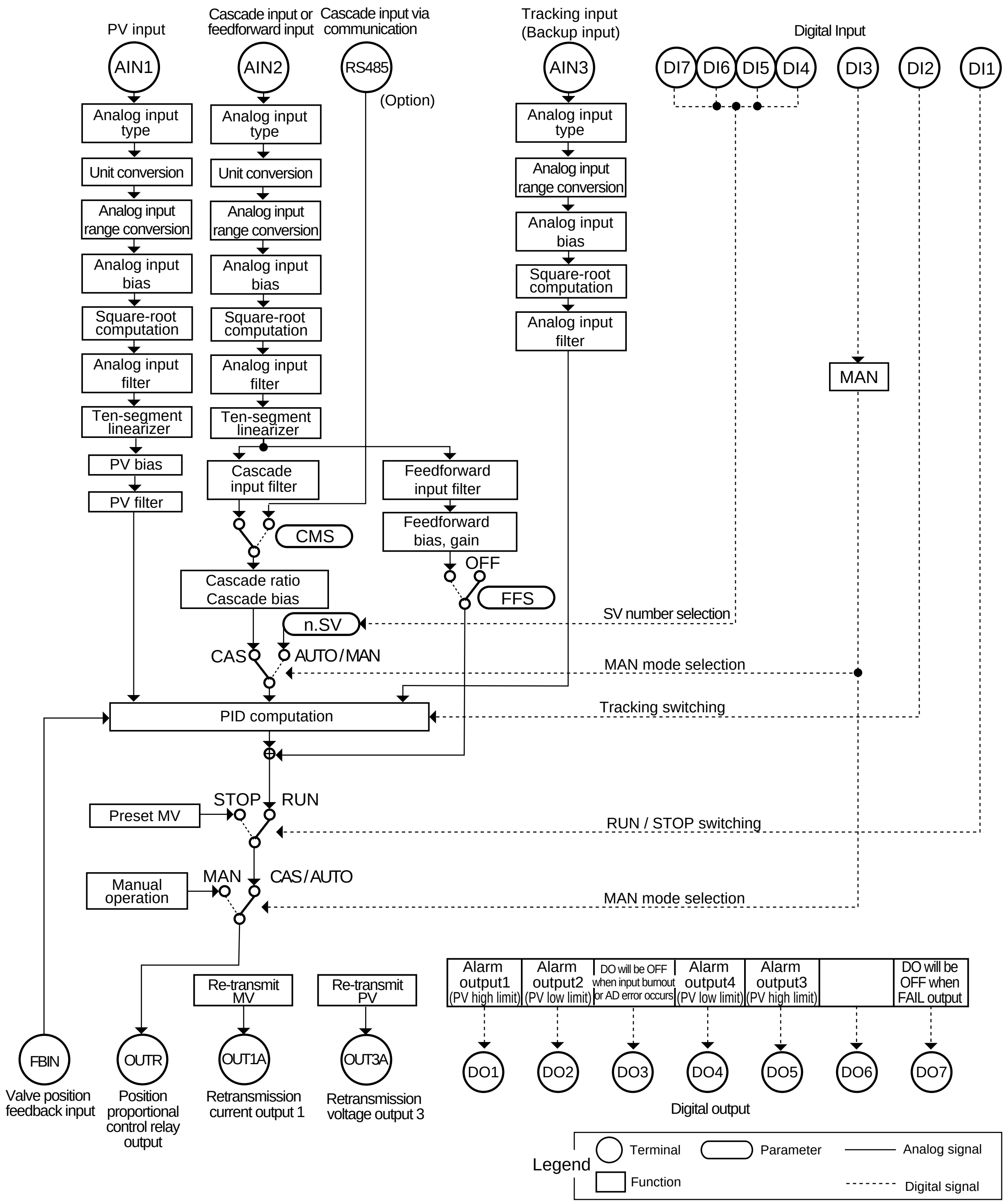
■ Loop Control for Backup (US1000-11)

Two universal input terminals (AIN1 and AIN2) are provided. The type of MV output can be selected from those in Table 2.4 in Section 2.1 by setting the MVS1 parameter.



■ Loop Control for Backup (US1000-21)

Control is performed based on a position-proportional PID computation so as to ensure that the MV output and control valve opening always match. Two universal input terminals (AIN1 and AIN2) are provided. The MV output is a position-proportional control relay output (OUTR terminal). A valve position feedback input is provided.



2.6 Loop Control with PV Switching (US mode 6)

This US mode provides a control function that switches between two PV inputs by a contact input signal or according to a PV range. The method of PV switching is specified by USER parameter 3 (U3) as shown in the table below, and the range for PV switching is specified by USER parameters 1 and 2 (U1, U2).

Table 2.5 USER Parameters for Loop Control with PV Switching

Main menu	Submenu	Parameter	Description	Range of setting	Default
USR	–	U1	USER parameter 1	PV upper limit for PV switching	0
		U2	USER parameter 2	PV lower limit for PV switching	0
		U3	USER parameter 3	Switching condition 0: Switching within the PV range specified by U1 and U2 1: Switching at the PV upper limit specified by U1 2: Switching by contact input	0

The following are the description of the switching methods specified by USER parameter 3.

(1) Switching within the PV range specified by U1 and U2 (U3 = 0)

This method should be selected in cases where, for example, two thermocouples are used æ one for higher temperatures and the other for lower temperatures — and a sudden change in PV must be avoided when switching the thermocouple.

In a PV rising process, input switching starts when input 1 reaches the lower limit for PV switching. The PV gradually becomes closer to input 2 and when it exceeds the upper limit for PV switching, the PV completely transfers to input 2. (Figure 2.6.1 (1))

Conversely, in a PV falling process, input switching starts when input 2 reaches the upper limit for PV switching. The PV gradually becomes closer to input 1 and when it falls below the lower limit, the PV completely transfers to input 1. (Figure 2.6.1 (2))

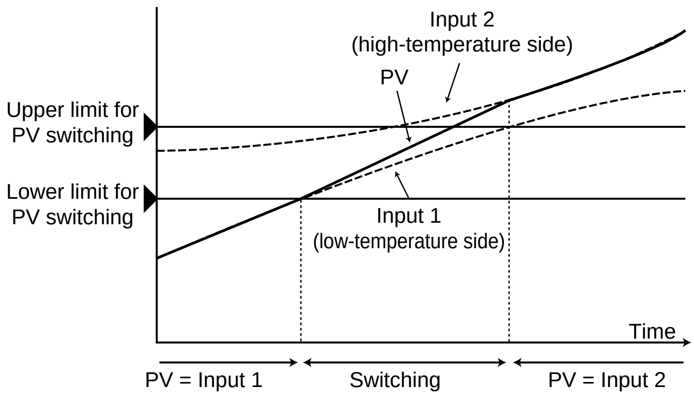


Figure 2.6.1 (1) Switching within Specified PV Range (Rising PV)

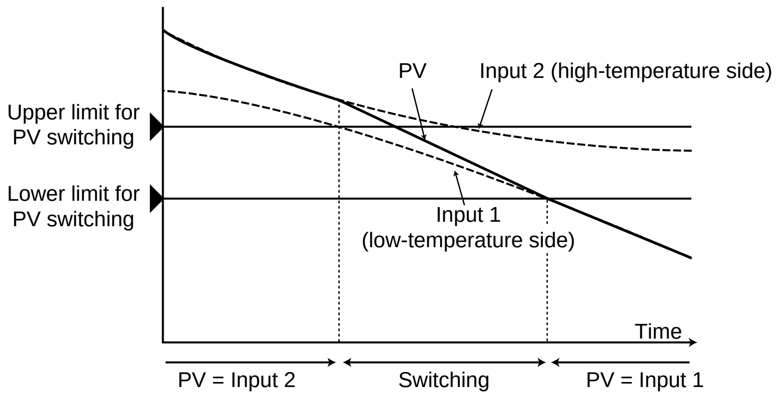


Figure 2.6.1 (2) Switching within Specified PV Range (Falling PV)

(2) Switching at the PV upper limit specified with U1 (U3 = 1)

This method should be selected in cases where, for example, two thermocouples are used æ one for higher temperatures and the other for lower temperatures æ and a sudden change in PV is allowed when switching the thermocouple. MV will change smoothly (i.e., without any bumps) however, even when PV changes suddenly.

As shown in the figure below, PV = input 1 when input 1 is less than the upper limit for PV switching, and PV = input 2 when input 1 is no less than the upper limit for PV switching. Hysteresis (0.5% of PV range) is provided around the switching point.

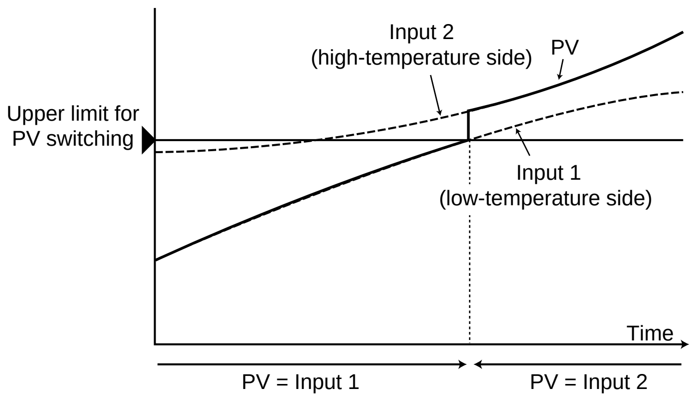


Figure 2.6.2 Switching at the Upper Limit for PV Switching

(3) Switching by contact input (U3 = 2)

The PV switching function is assigned to the contact input DI2.

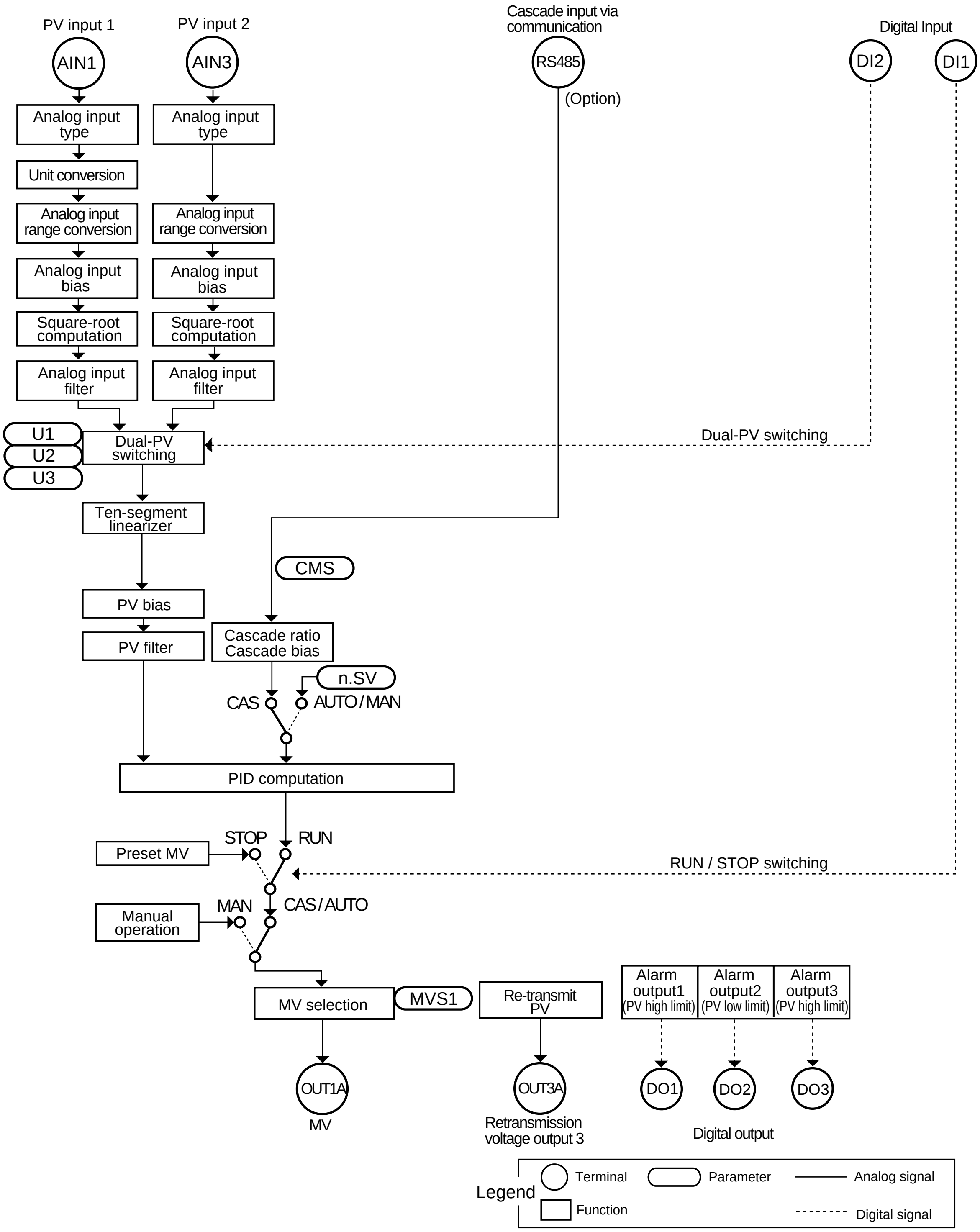
- PV = Input 1 when DI2 = OFF
- PV = Input 2 when DI2 = ON

■ Use of Tracking Input

When using a tracking input with US1000-11 or US1000-21, a tracking flag function must be assigned to a contact input (DI). For information about contact input assignment, refer to Section 3.15, “Parameters for Contact Input.”

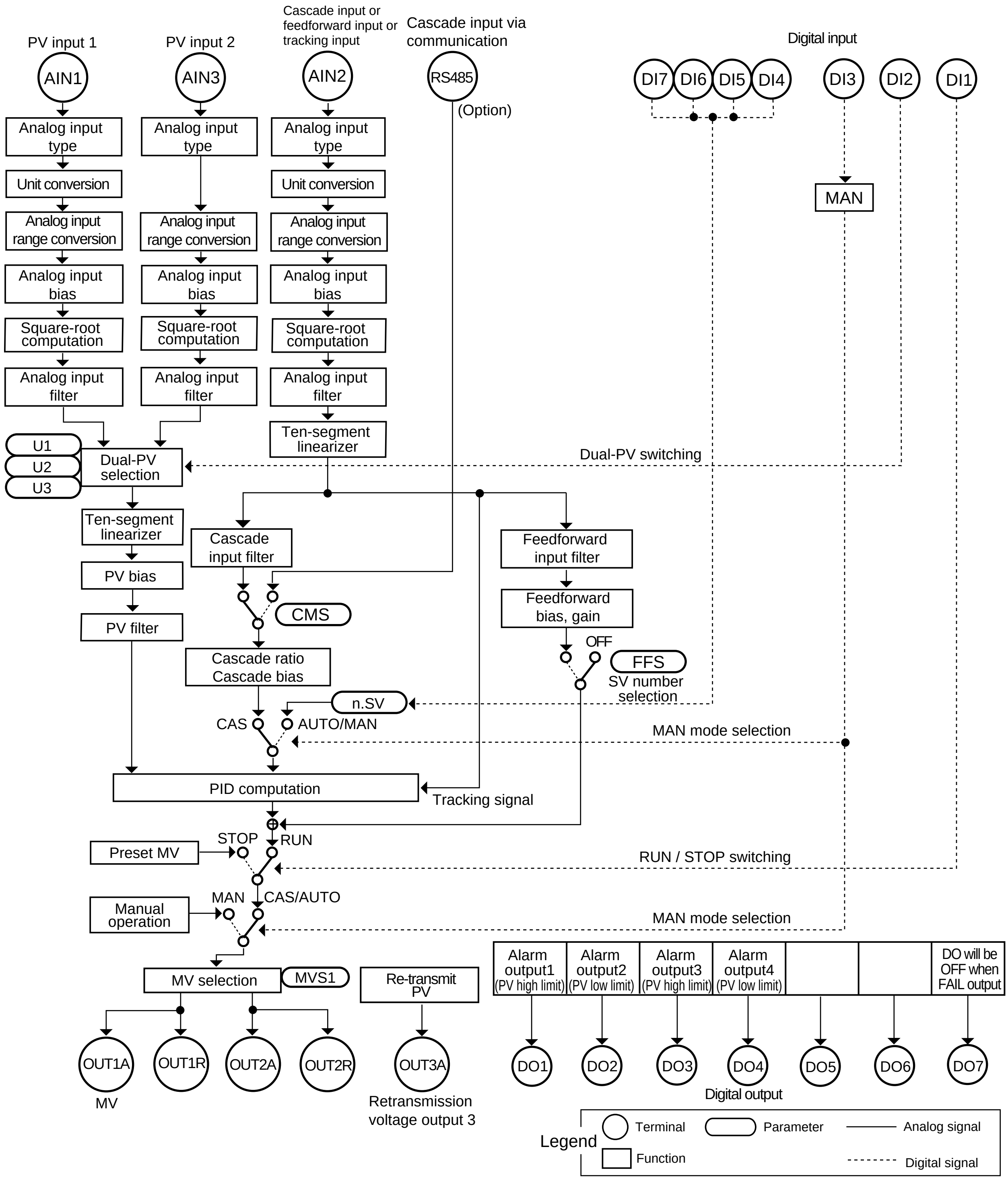
■ Loop Control with PV Switching (US1000-00)

One universal input terminal (AIN1) is provided. Voltage pulse or current output can be selected for the MV output by setting the MVS1 parameter (OUT1A terminal).



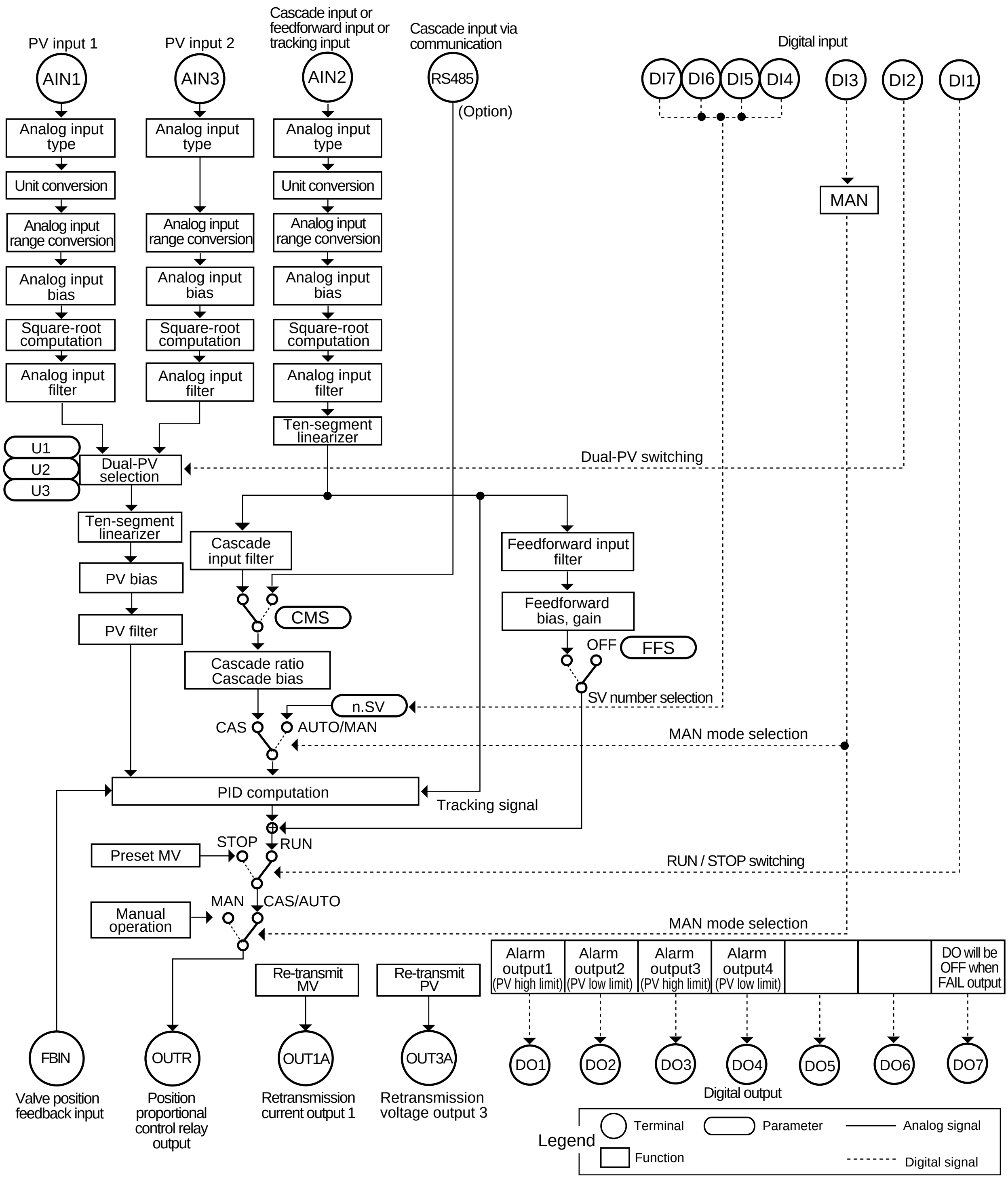
■ Loop Control with PV Switching (US1000-11)

Two universal input terminals (AIN1 and AIN2) are provided. The type of MV output can be selected from those in Table 2.4 in Section 2.1 by setting the MVS1 parameter.



■ Loop Control with PV Switching (US1000-21)

Control is performed based on a position-proportional PID computation so as to ensure that the MV output and control valve opening always match. Two universal input terminals (AIN1 and AIN2) are provided. The MV output is a position-proportional control relay output (OUTR terminal). A valve position feedback input is provided.



2.7 Loop Control with PV Auto-selector (US mode 7)

This US mode provides a control function that automatically selects either the larger or smaller value or sets the average value or difference of two PV input values as the PV input. The selection of input is specified by USER parameter 1 (U1).

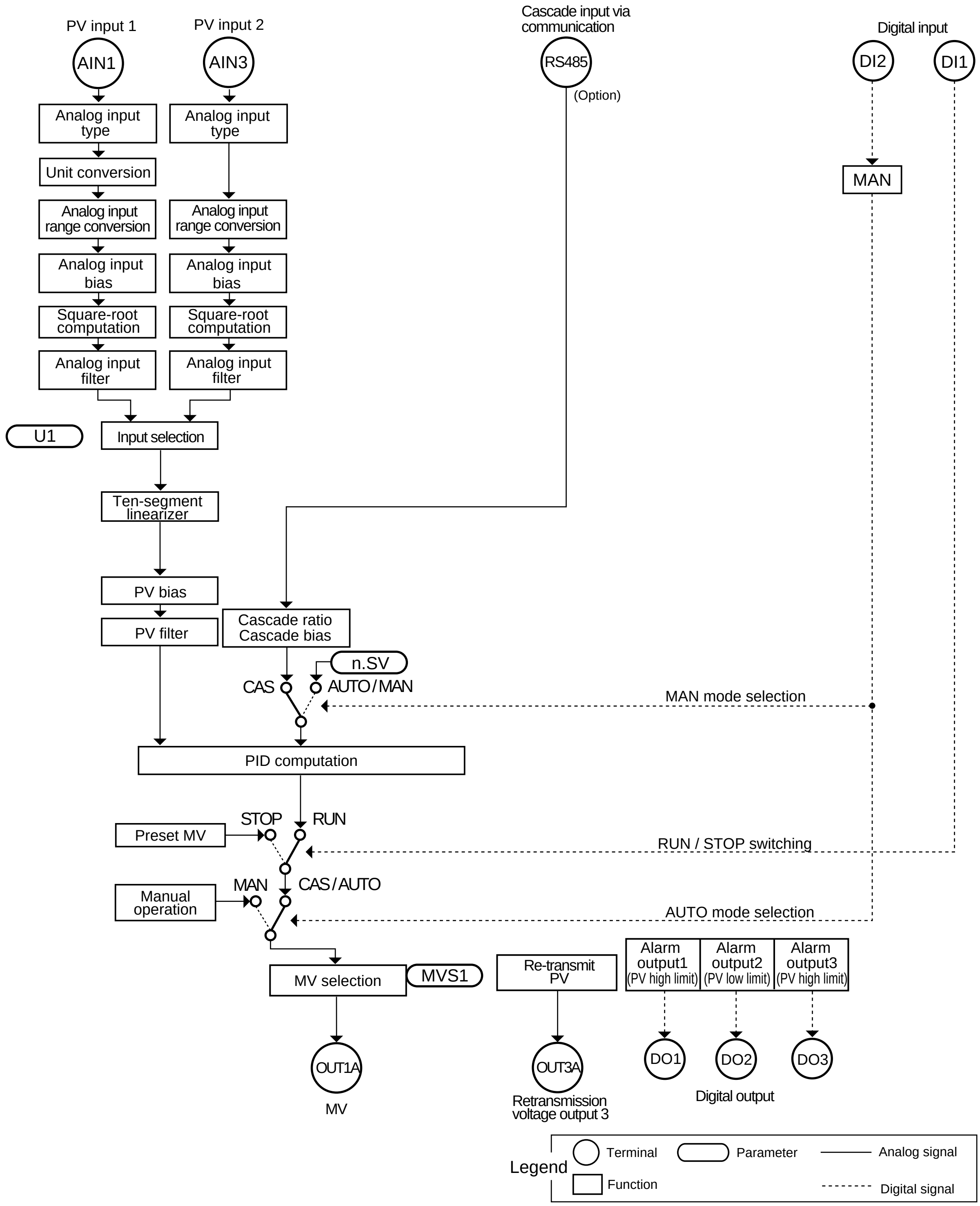
Table 2.6 USER Parameters for Loop Control with PV Auto-selector

Main menu	Submenu	Parameter	Description	Range of setting	Default
USR	–	U1	USER parameter 1	Input selection 0: Accepts the maximum value between input 1 and input 2 1: Accepts the minimum value between input 1 and input 2 2: Accepts average value of input 1 and input 2 3: Accepts the difference between input 1 and input 2 (i.e., input 2 - input 1)	2

When using the tracking input with US1000-11 or US1000-21, a tracking flag function must be assigned to a contact input (DI). For information about contact input assignment, refer to Section 3.15, "Parameters for Contact Input."

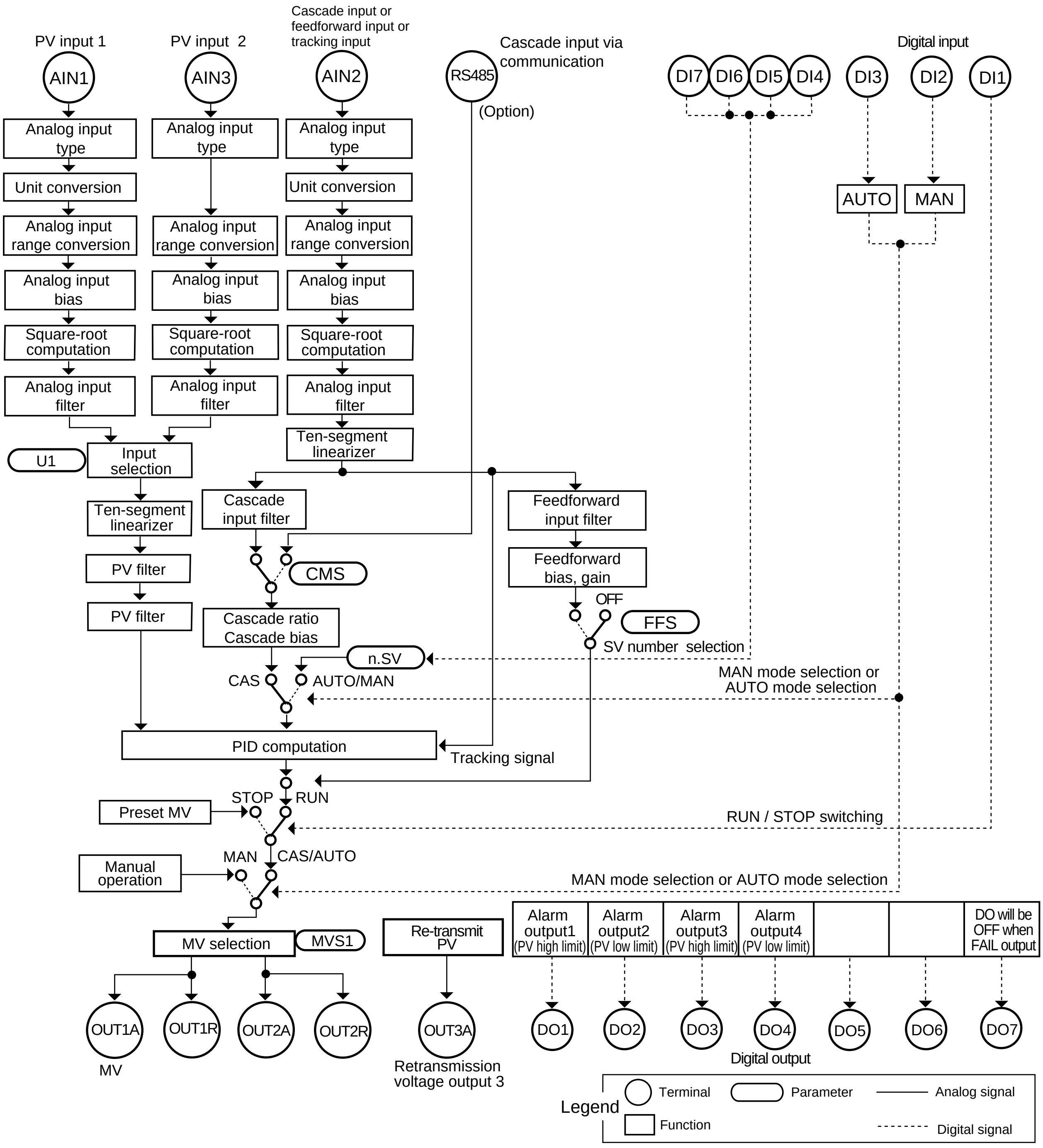
■ Loop Control with PV Auto-selector (US1000-00)

One universal input terminal (AIN1) is provided. Voltage pulse or current output can be selected for the MV output by setting the MVS1 parameter (OUT1A terminal).



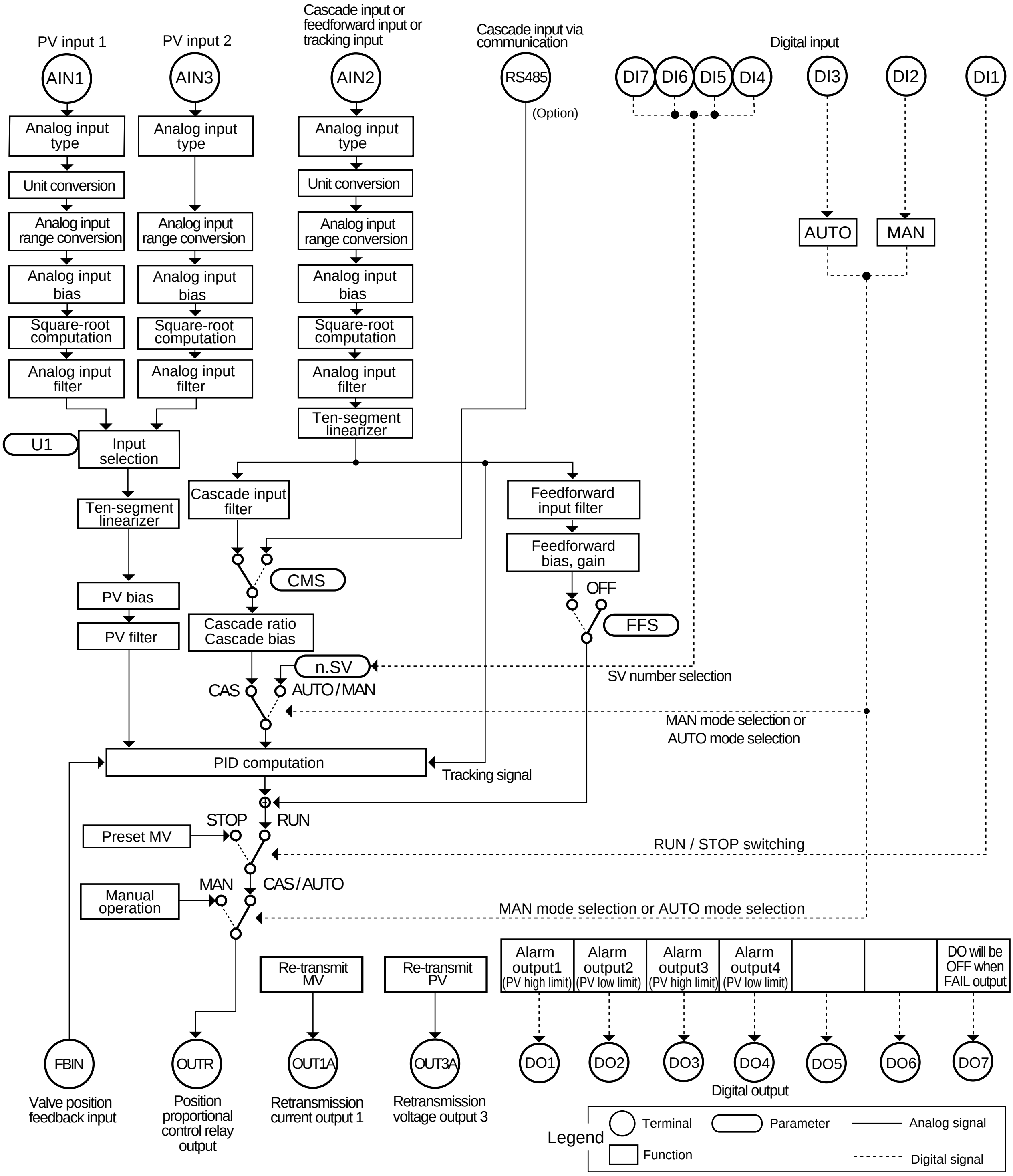
■ Loop Control with PV Auto-selector (US1000-11)

Two universal input terminals (AIN1 and AIN2) are provided. The type of MV output can be selected from those in Table 2.4 in Section 2.1 by setting the MVS1 parameter.



■ Loop Control with PV Auto-selector (US1000-21)

Control is performed based on a position-proportional PID computation so as to ensure that the MV output and control valve opening always match. Two universal input terminals (AIN1 and AIN2) are provided. The MV output is a position-proportional control relay output (OUTR terminal). A valve position feedback input is provided.



2.8 Loop Control with PV-hold Function (US mode 8)

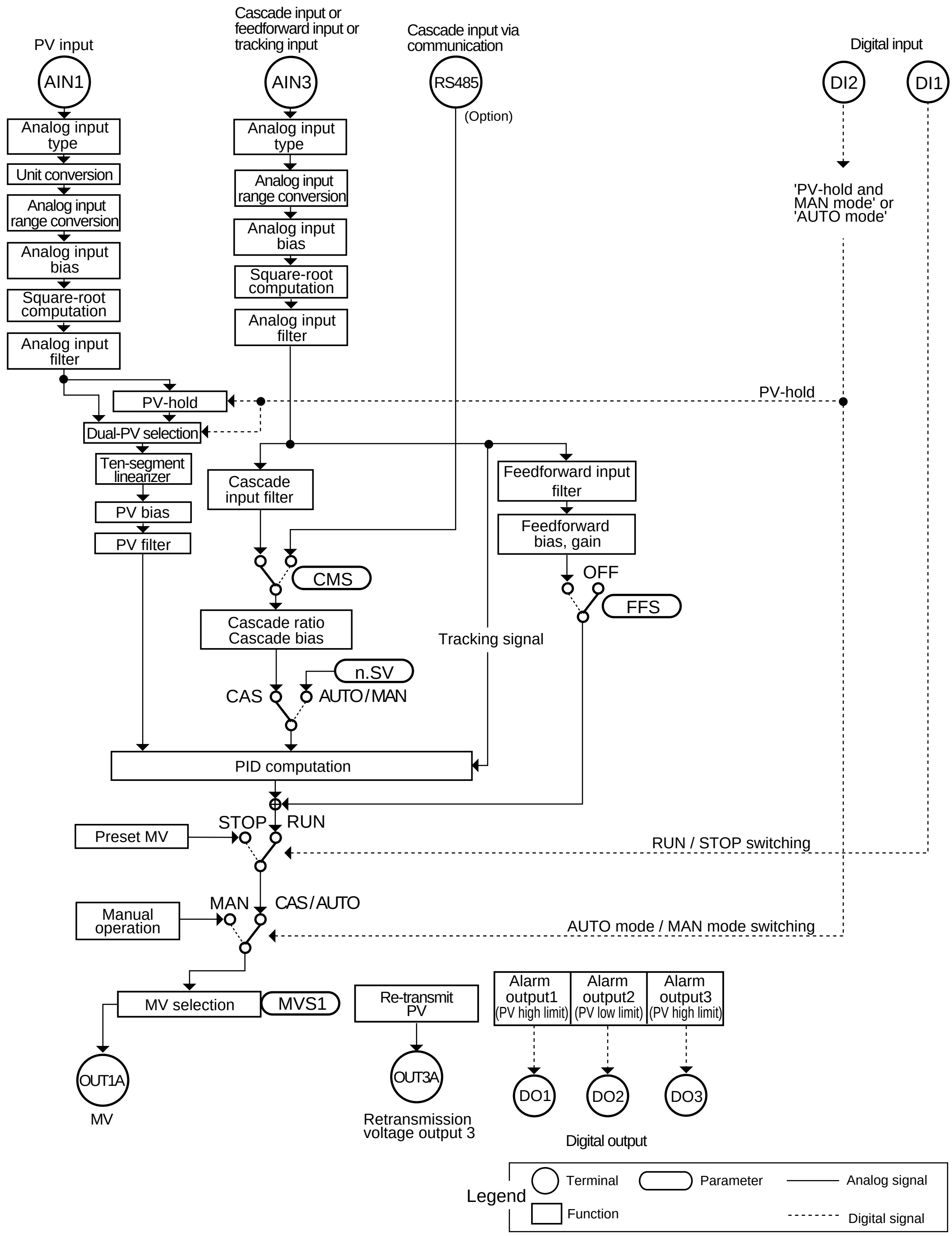
This US mode provides a control function that switches the operation mode and holds the PV input and MV output values upon receiving a contact input signal when the PV input and MV output become erratic due to external disturbance.

When the contact input DI2 is on, the controller holds the PV and MV output values and switches to MAN mode. When the DI2 turns off, the controller continues the operation at the held PV and MV output and switches smoothly (i.e., without any bumps) to AUTO mode.

When using the tracking input with US1000-11 or US1000-21, a tracking flag function must be assigned to a contact input (DI). For information about contact input assignment, refer to Section 3.15, “Parameters for Contact Input.”

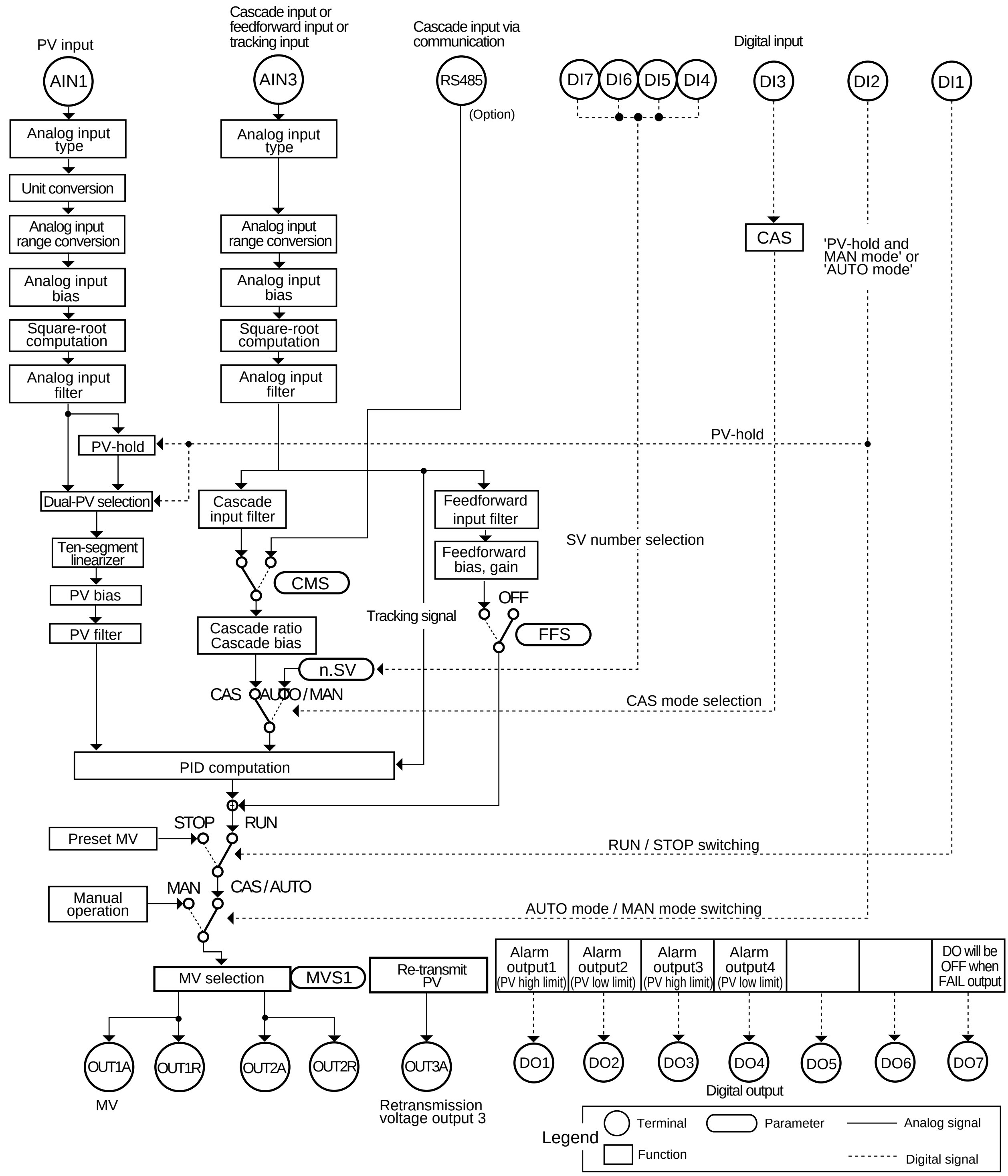
■ Loop Control with PV-hold Function (US1000-00)

One universal input terminal (AIN1) is provided. Voltage pulse or current output can be selected for the MV output by setting the MVS1 parameter (OUT1A terminal).



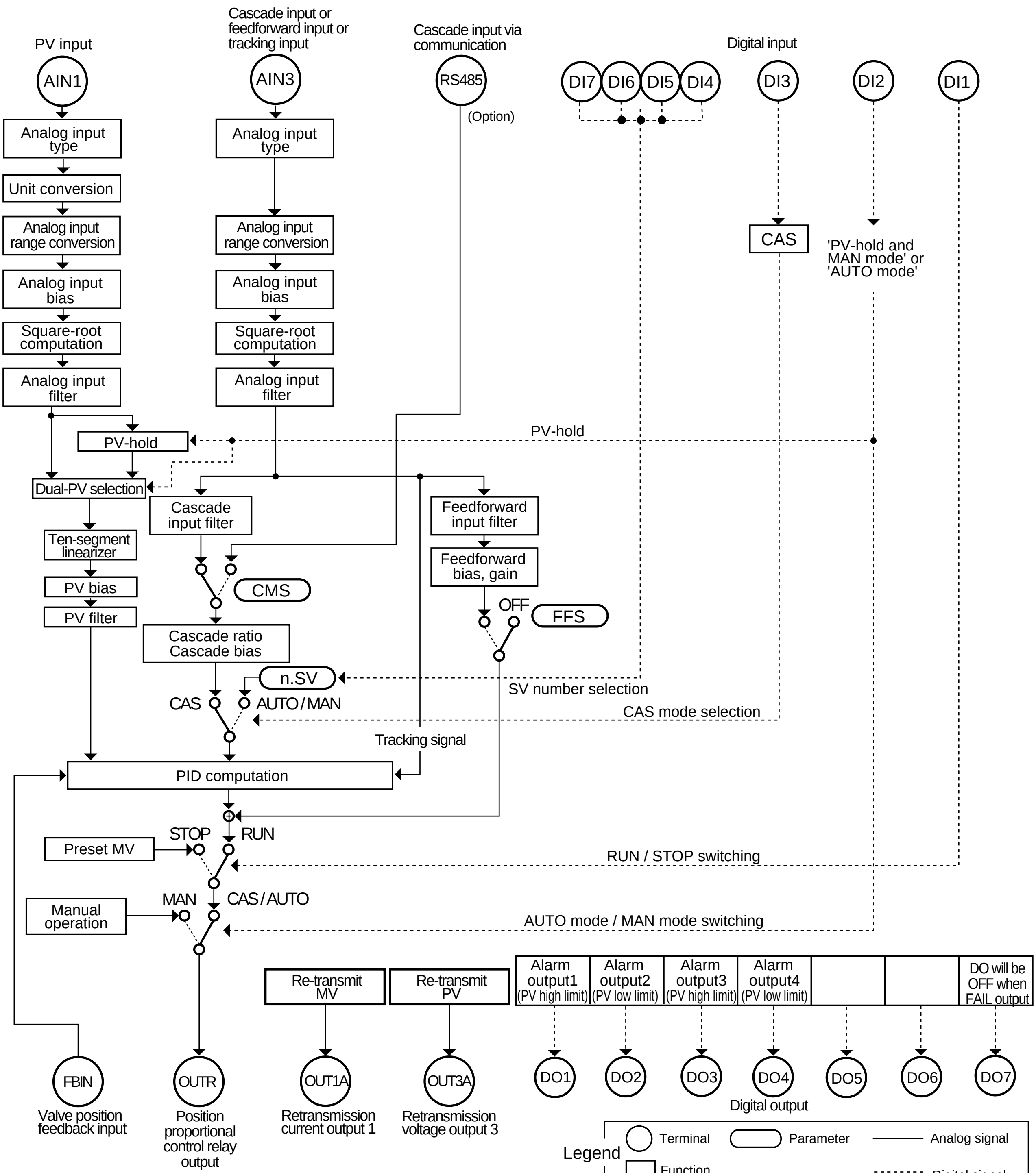
■ Loop Control with PV-hold Function (US1000-11)

One universal input terminal (AIN1) is provided. The type of MV output can be selected from those in Table 2.4 in Section 2.1 by setting the MVS1 parameter.



■ Loop Control with PV-hold Function (US1000-21)

Control is performed based on a position-proportional PID computation so as to ensure that the MV output and control valve opening always match. One universal input terminal (AIN1) is provided. The MV output is a position-proportional control relay output (OUTR terminal). A valve position feedback input is provided.



2.9 Dual-loop Control (US mode 11)

This US mode provides two control computation units to allow control of two loops using just a single controller. Loops 1 and 2 can be operated and monitored separately.
When using the tracking input, a tracking flag function must be assigned to a contact input (DI). For information about contact input assignment, refer to Section 3.15, “Parameters for Contact Input.”

■ Dual-loop Control (US1000-11)

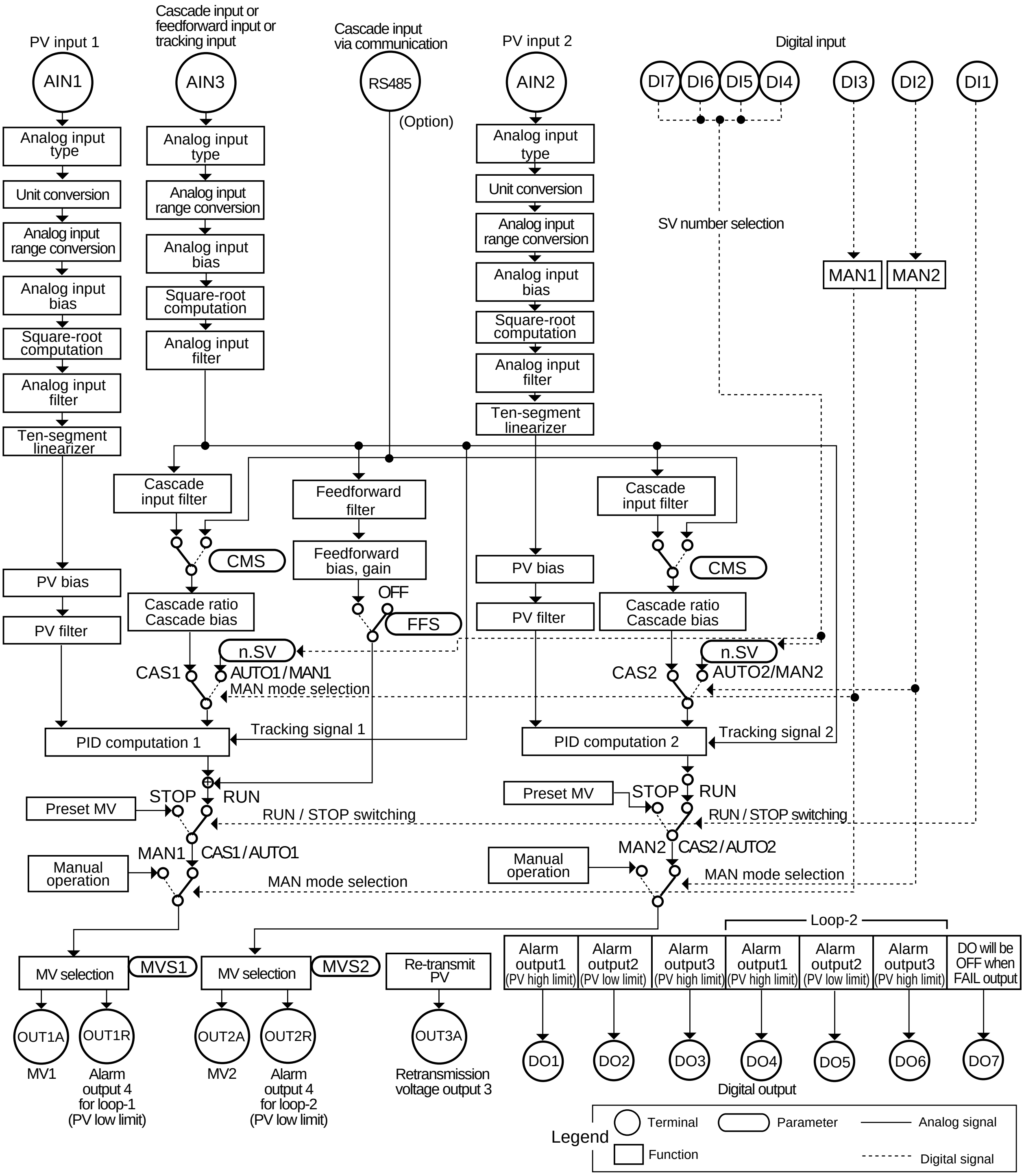
Two universal input terminals (AIN1 and AIN2) are provided. The types of MV output for loop 1 and loop 2 can be selected by setting the MVS1 and MVS2 parameters, respectively.

Table 2.7 Loop-1 MV Output for US1000-11 Set Up in Dual-loop Control or Temperature and Humidity Control

Terminal code	Terminal No.	Type of control computation (Value of MVS1)		
		Time proportional PID (0, 1) Continuous PID (2) ON/OFF computation (3)	Heating/cooling computation (4, 5)	Heating/cooling computation (6, 7)
OUT1A	16, 18	Loop 1 Retransmission output (0, 3) Voltage pulse output (1) Current output (2)	Loop 1 Heating pulse output (4) Cooling pulse output (5)	Loop 1 Heating current output (6) Cooling current output (7)
OUT1R	55 to 57	Loop 1 Control relay output (0, 3) Alarm output 4 (1, 2)	Loop 1 Cooling control relay output (4) Heating control relay output (5)	Loop 1 Cooling control relay output (6) Heating control relay output (7)

Table 2.8 Loop-2 MV Output for US1000-11 Set Up in Dual-loop Control or Temperature and Humidity Control

Terminal code	Terminal No.	Type of control computation (Value of MVS2)		
		Time proportional PID (0, 1) Continuous PID (2) ON/OFF computation (3)	Heating/cooling computation (4, 5)	Heating/cooling computation (6, 7)
OUT2A	49, 50	Loop 2 Retransmission output (0, 3) Voltage pulse output (1) Current output (2)	Loop 2 Heating pulse output (4) Cooling pulse output (5)	Loop 2 Heating current output (6) Cooling current output (7)
OUT2R	58 to 60	Loop 2 Control relay output (0, 3) Alarm output 4 (1, 2)	Loop 2 Cooling control relay output (4) Heating control relay output (5)	Loop 2 Cooling control relay output (6) Heating control relay output (7)


PV input 1
AIN1
Analog input type
Unit conversion
Analog input range conversion
Analog input bias
Square-root computation
Analog input filter
Ten-segment linearizer
PV bias
PV filter
Cascade input or feedforward input or tracking input
AIN3
Analog input type
Analog input range conversion
Analog input bias
Square-root computation
Analog input filter
Cascade input via communication
RS485
(Option)
PV input 2
AIN2
Analog input type
Unit conversion
Analog input range conversion
Analog input bias
Square-root computation
Analog input filter
Ten-segment linearizer
Digital input
DI7
DI6
DI5
DI4
DI3
DI2
DI1
SV number selection
MAN1
MAN2
Cascade input filter
CMS
Cascade ratio Cascade bias
Feedforward filter
Feedforward bias, gain
OFF
FFS
n.SV
CAS1
AUTO1 / MAN1
MAN mode selection
PID computation 1
Tracking signal 1
Preset MV
STOP
RUN
RUN / STOP switching
MAN1
CAS1 / AUTO1
Manual operation
MAN mode selection
PV bias
PV filter
Cascade input filter
CMS
Cascade ratio Cascade bias
n.SV
CAS2
AUTO2/MAN2
PID computation 2
Tracking signal 2
Preset MV
STOP
RUN
RUN / STOP switching
MAN2
CAS2 / AUTO2
Manual operation
MAN mode selection
Loop-2
MV selection
MVS1
MV selection
MVS2
Re-transmit PV
Alarm output1 (PV high limit)
Alarm output2 (PV low limit)
Alarm output3 (PV high limit)
Alarm output1 (PV high limit)
Alarm output2 (PV low limit)
Alarm output3 (PV high limit)
DO will be OFF when FAIL output
OUT1A
OUT1R
OUT2A
OUT2R
OUT3A
MV1
Alarm output 4 for loop-1 (PV low limit)
MV2
Alarm output 4 for loop-2 (PV low limit)
Retransmission voltage output 3
DO1
DO2
DO3
DO4
DO5
DO6
DO7
Digital output
Legend
Terminal
Parameter
Analog signal
Function
Digital signal

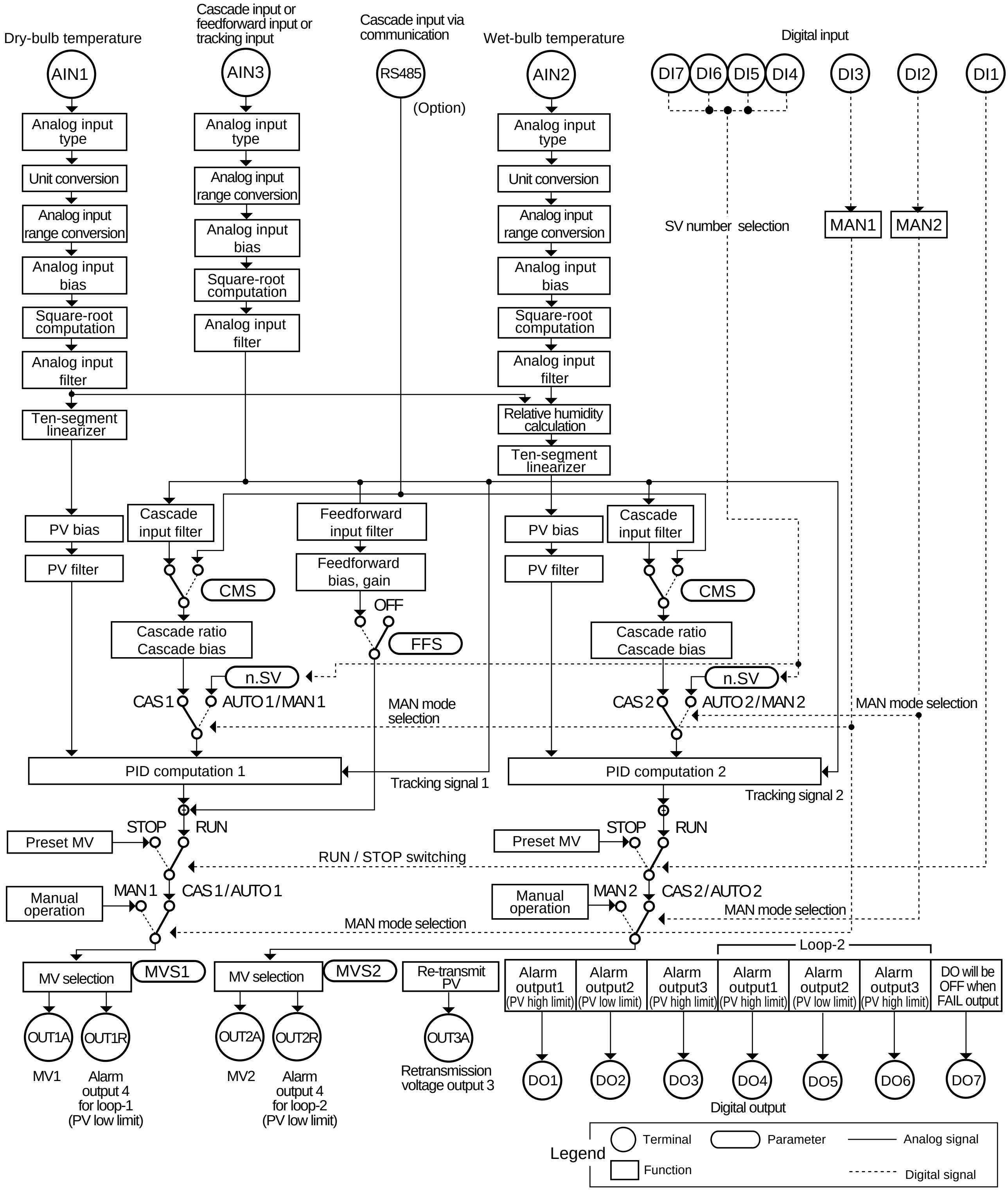
2.10 Temperature and Humidity Control (US mode 12)

This US mode provides a control function that controls the temperature and relative humidity in parallel. The temperature control uses dry-bulb temperature, and the relative humidity control uses both dry- and wet-bulb temperatures for control computation.

When using a tracking input, a tracking flag function must be assigned to a contact input (DI). For information about contact input assignment, refer to Section 3.15, “Parameters for Contact Input.”

■ Temperature and Humidity Control (US1000-11)

Two universal input terminals are provided: AIN1 terminal is for dry-bulb temperatures and AIN2 for wet-bulb temperatures. The types of MV output for loop 1 and loop 2 can be selected from those in Tables 2.7 and 2.8 in Section 2.9 by setting the MVS1 and MVS2 parameters, respectively.



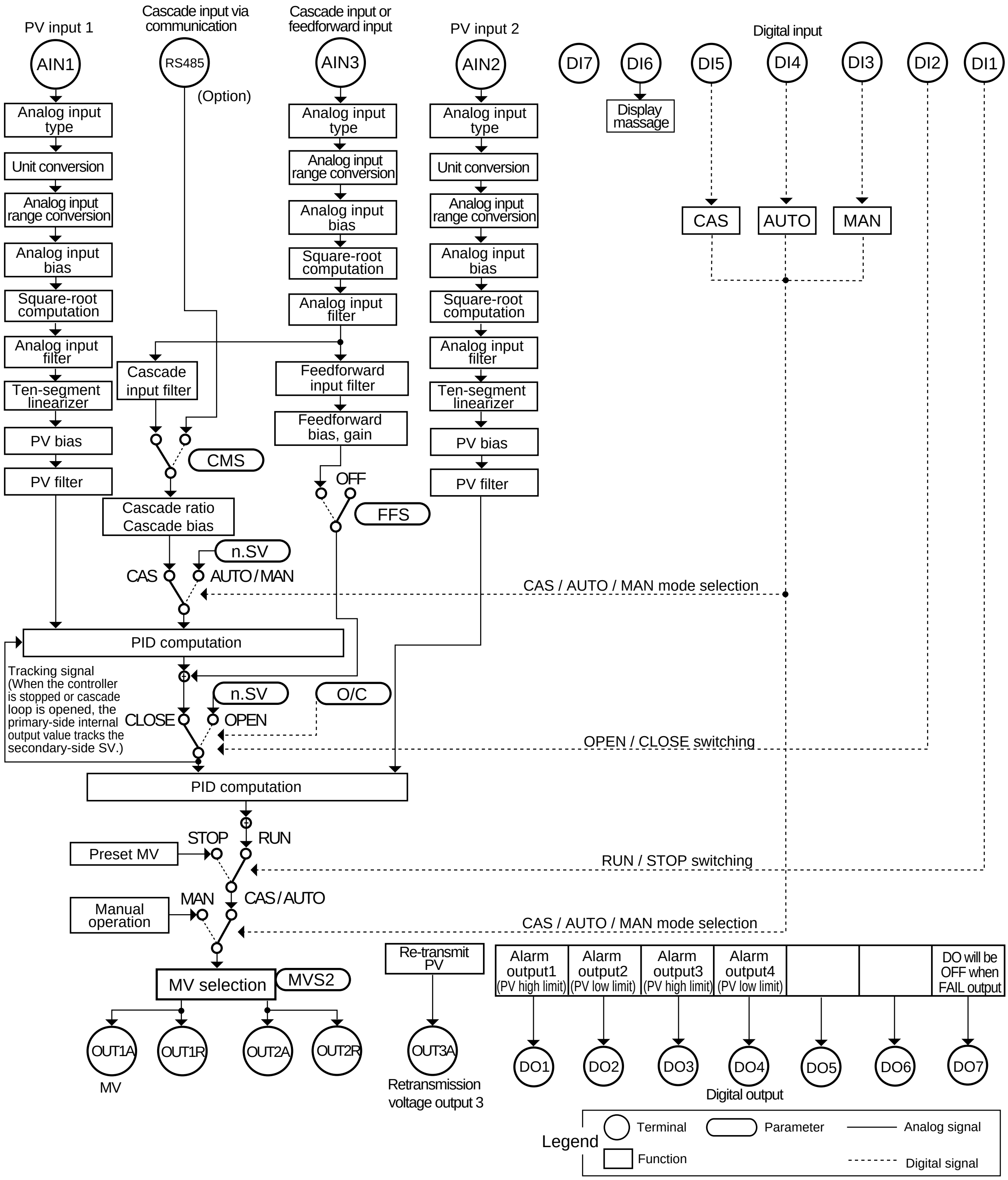
2.11 Cascade Control with Two Universal Inputs (US mode 13)

This US mode provides two control computation units and enables cascade control using just a single controller. This function is the same as that of cascade control (US mode 4), except for the following two points:

- Analog input 2 (terminal AIN2) that allows the universal input is used for the secondary loop PV input.
- Analog input 3 (terminal AIN3) can be used for the cascade input or the feedforward input of the primary loop.

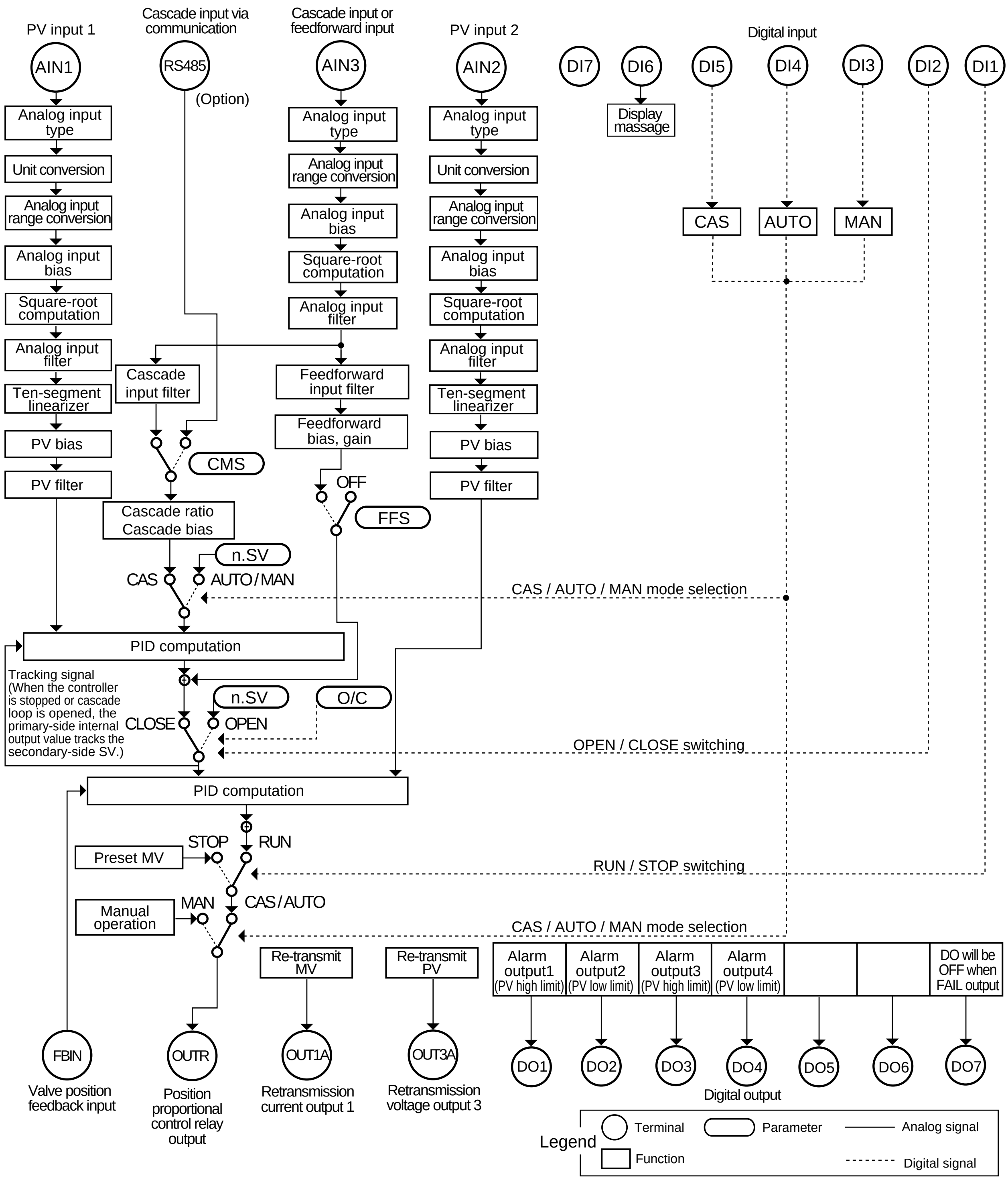
■ Cascade Control with Two Universal Inputs (US1000-11)

Two universal input terminals (AIN1 and AIN2) are provided. The type of MV output can be selected from those in Table 2.4 in Section 2.1 by setting the MVS2 parameter.



■ Cascade Control with Two Universal Inputs (US1000-21)

Control is performed based on a position-proportional PID computation so as to ensure that the MV output and control valve opening always match. Two universal input terminals (AIN1 and AIN2) are provided. The MV output is a position-proportional control relay output (OUTR terminal). A valve position feedback input is provided.



2.12 Loop Control with PV Switching and Two Universal Inputs (US mode 14)

This US mode provides a control function that switches between two PV inputs by either a contact input signal or according to a PV range. The function is the same as that of loop control with PV switching (US mode 6), except for the following two points:

- Analog input 2 (terminal AIN2) that allows the universal input is used for PV input 2.
- Analog input 3 (terminal AIN3) can be used for cascade input, feedforward input, or tracking input.

When using a tracking input, a tracking flag function must be assigned to a contact input (DI). For information about contact input assignment, refer to Section 3.15, “Parameters for Contact Input.”

The method of PV switching and the PV range for switching are specified with the following USER parameters.

Table 2.9 USER Parameters for Loop Control with PV Switching and Two Universal Inputs

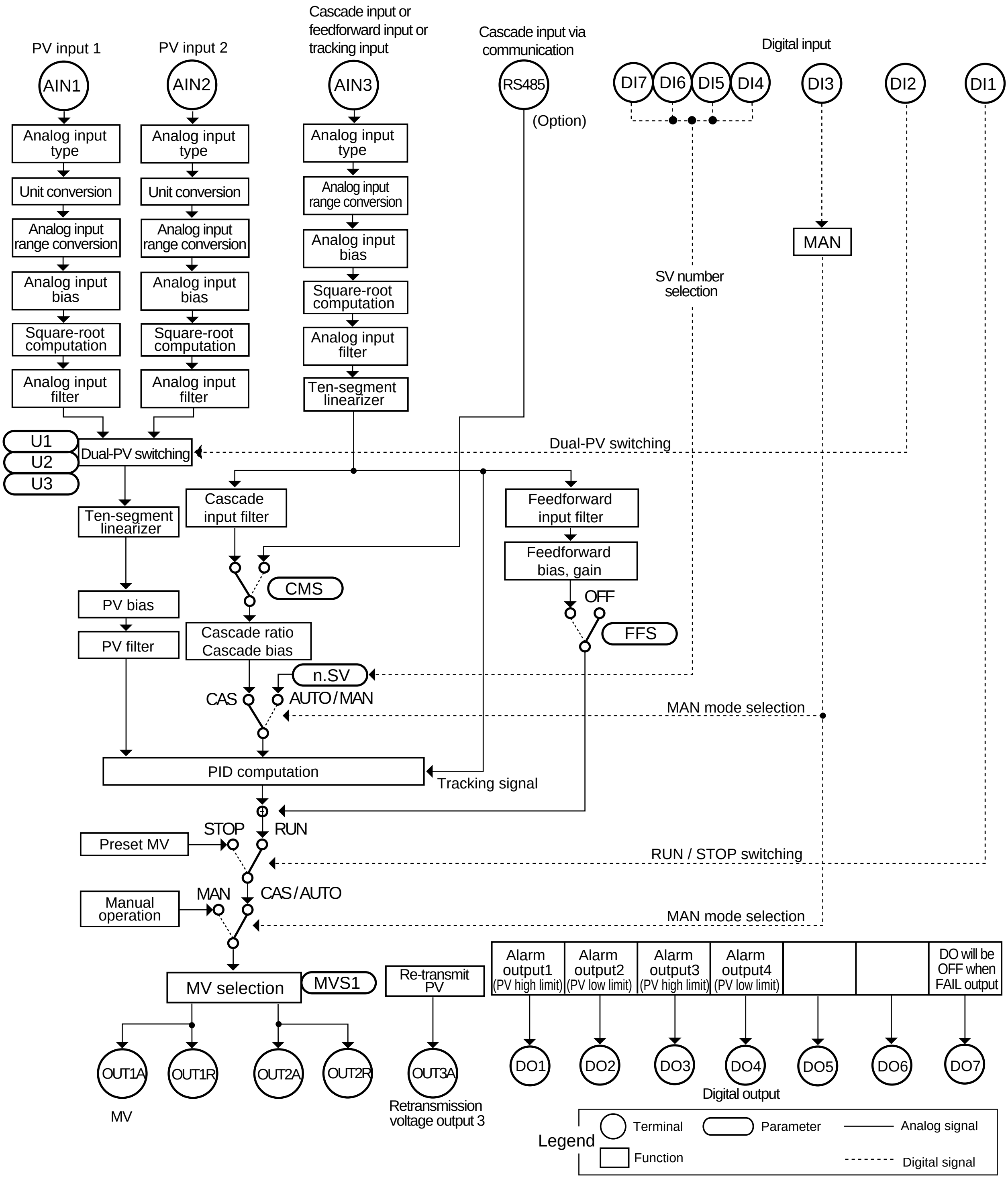
Main menu	Submenu	Parameter	Description	Range of setting	Default
USR	–	U1	USER parameter 1	PV upper limit for PV switching	0
		U2	USER parameter 2	PV lower limit for PV switching	0
		U3	USER parameter 3	Switching condition 0: Switching within the PV range specified by U1 and U2 1: Switching at the PV upper limit specified by U1 2: Switching by contact input	0

See Also

Section 2.6, “Loop Control with PV Switching,” for information about the USER parameter 3.

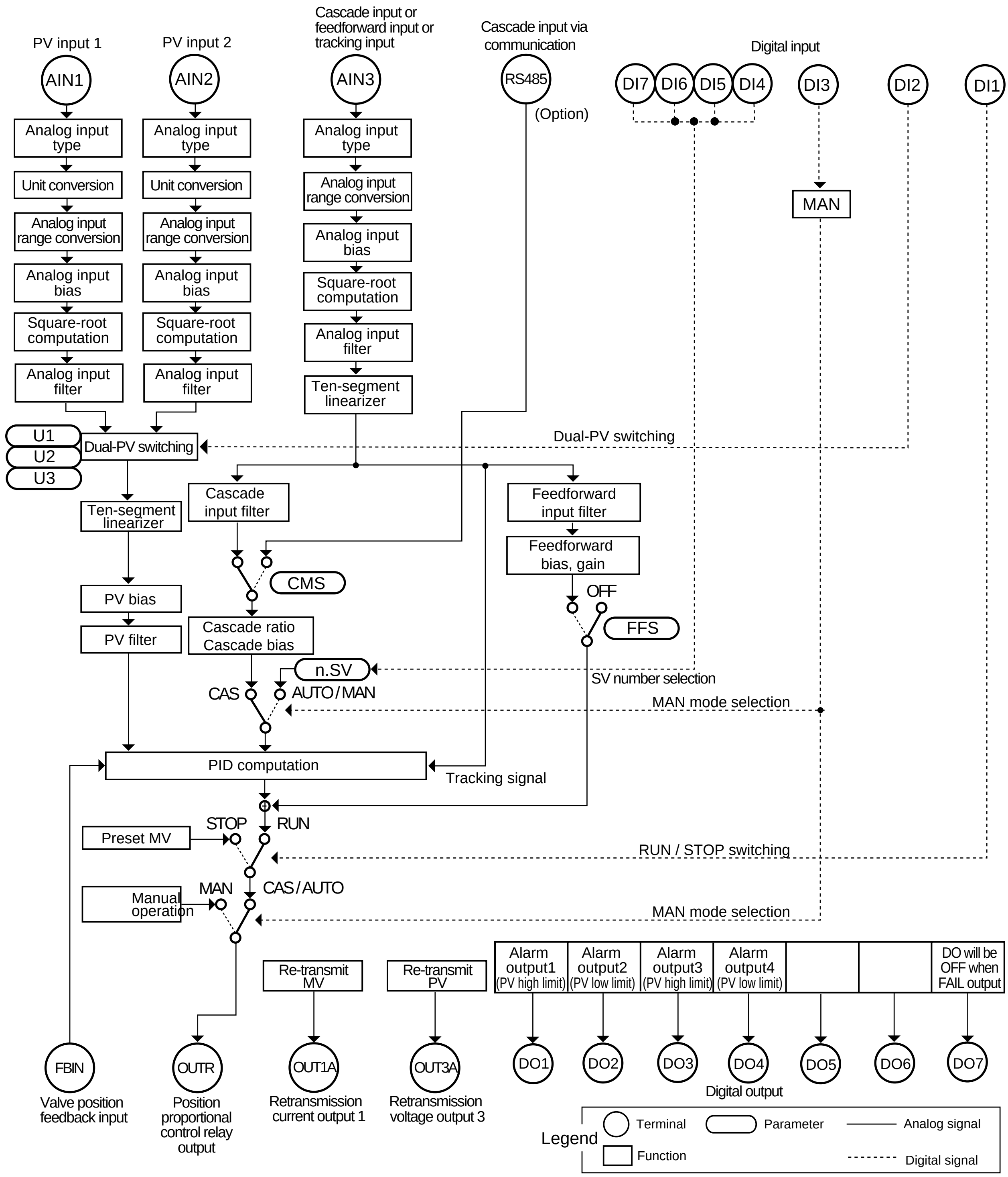
■ Loop Control with PV Switching and Two Universal Inputs (US1000-11)

Two universal input terminals (AIN1 and AIN2) are provided. The type of MV output can be selected from those in Table 2.4 in Section 2.1 by setting the MVS1 parameter.



■ Loop Control with PV Switching and Two Universal Inputs (US1000-21)

Control is performed based on a position-proportional PID computation so as to ensure that the MV output and control valve opening always match. Two universal input terminals (AIN1 and AIN2) are provided. The MV output is a position-proportional control relay output (OUTR terminal). A valve position feedback input is provided.



2.13 Loop Control with PV Auto-selector and Two Universal Inputs (US mode 15)

This US mode allows a total of three PV inputs to be used æ two universal inputs and one analog input. It provides a control function that automatically selects either the largest or smallest value or sets the average value of two or three PV input values, or difference between the PV input values, as the PV input.

The function is the same as that of loop control with PV auto-selector (US mode 7), except for the following two points:

- Analog input 2 (terminal AIN2) that allows the universal input is used for PV input 2.
- Analog input 3 (terminal AIN3) can be used for PV input 3, cascade input, feedforward input, or tracking input. To use this terminal for PV input 3, set USER parameter 2 (U2) to 1.

When using a tracking input, a tracking flag function must be assigned to a contact input (DI). For information about contact input assignment, refer to Section 3.15, “Parameters for Contact Input.”

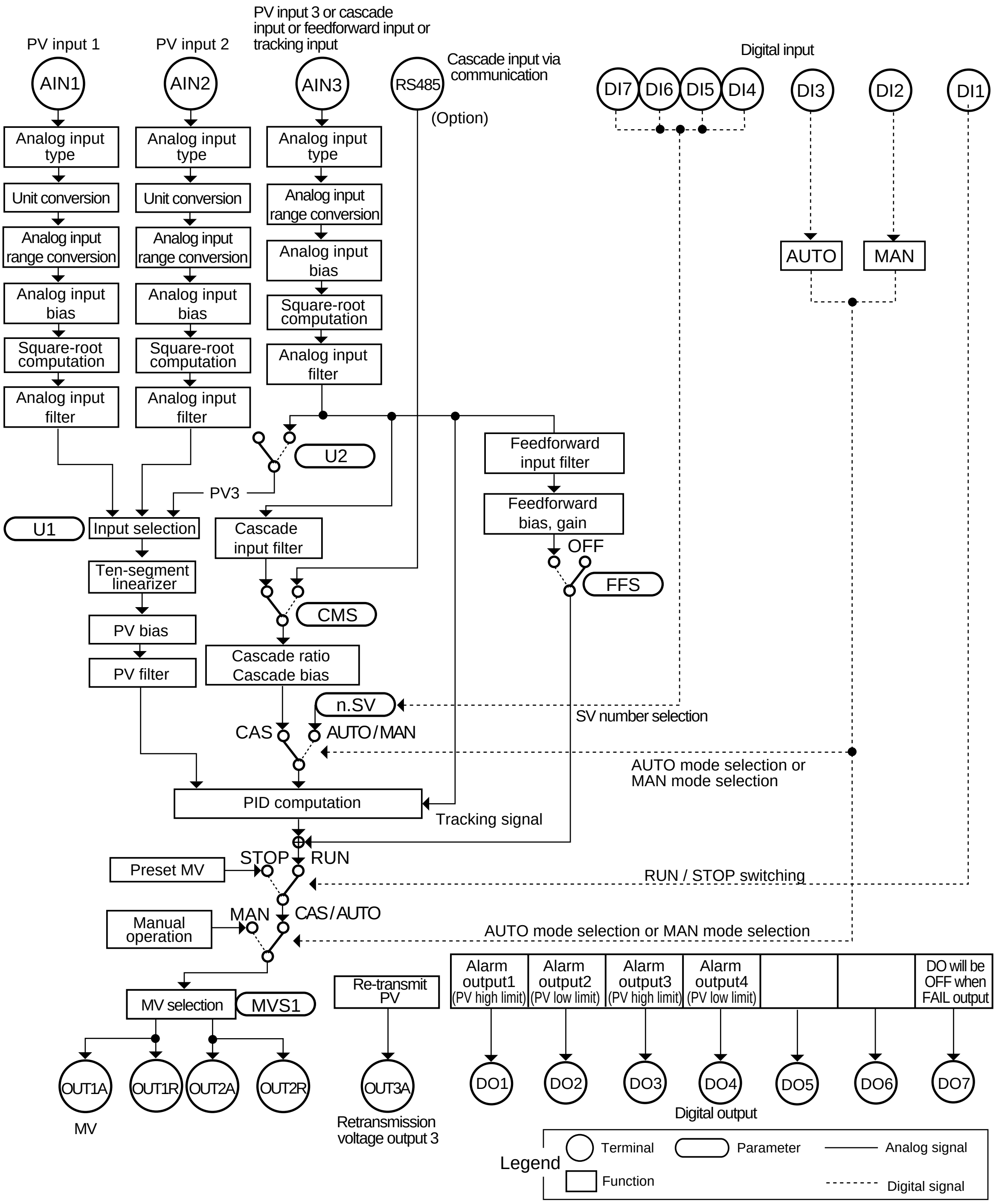
The selection of PV is carried out according to the following USER parameters.

Table 2.10 USER Parameters for Loop Control with PV Auto-selector and Two Universal Inputs

Main menu	Submenu	Parameter	Description	Range of setting	Default
USR	–	U1	USER parameter 1	Input selection 0: Accepts the maximum value between inputs 1, 2 (and 3) 1: Accepts the minimum value between inputs 1, 2 (and 3) 2: Accepts the average value of inputs 1, 2 (and 3) 3: Accepts the difference between input 1 and input 2 (i.e., input 2 - input 1)	2
		U2	USER parameter 2	0: Uses two points (inputs 1 and 2) 1: Uses three points (inputs 1, 2 and 3)	0

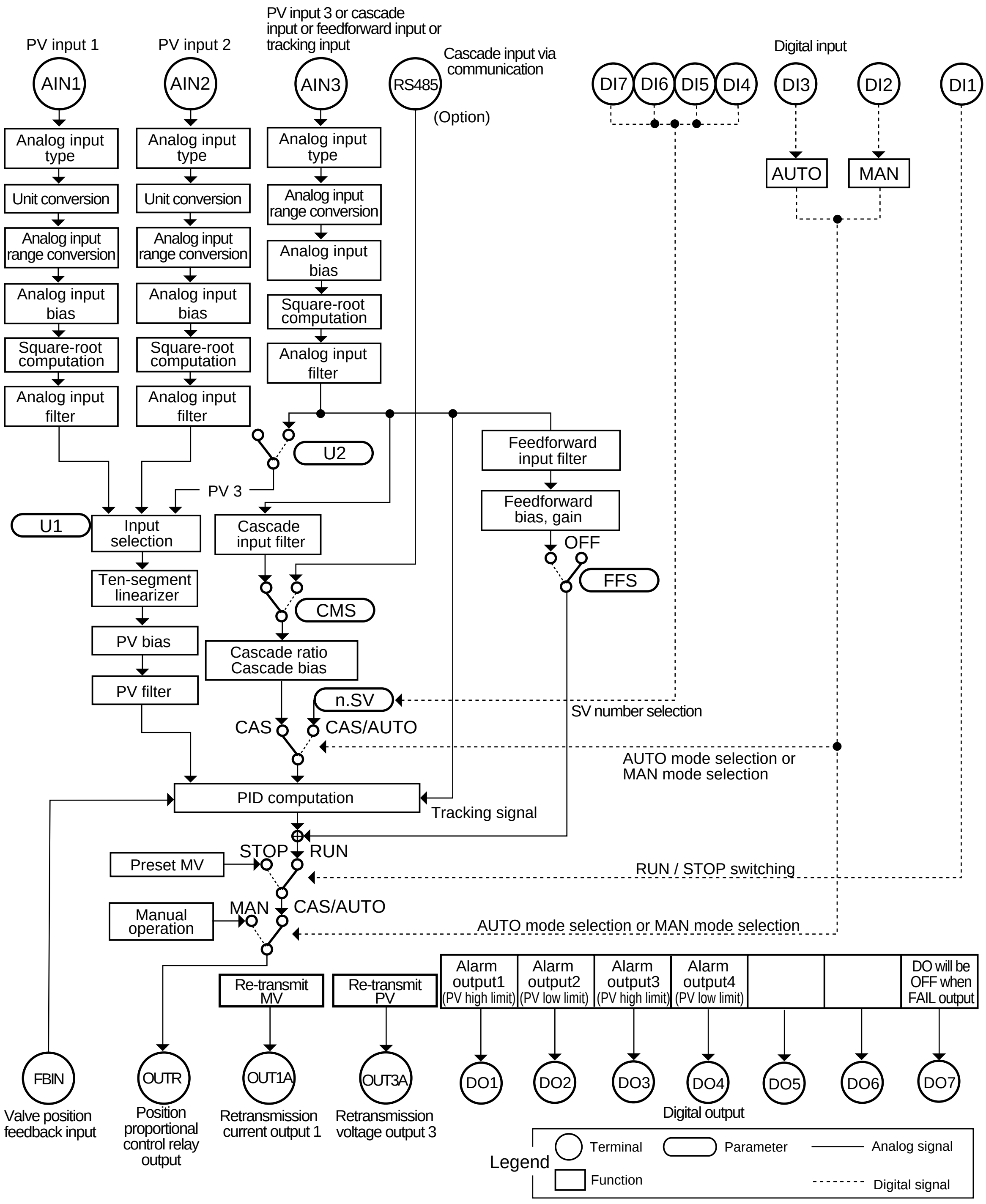
■ Loop Control with PV Auto-selector and Two Universal Inputs (US1000-11)

Two universal input terminals (AIN1 and AIN2) are provided. The type of MV output can be selected from those in Table 2.4 in Section 2.1 by setting the MVS1 parameter.



■ Loop Control with PV Auto-selector and Two Universal Inputs (US1000-21)

Control is performed based on a position-proportional PID computation so as to ensure that the MV output and control valve opening always match. Two universal input terminals (AIN1 and AIN2) are provided. The MV output is a position-proportional control relay output (OUTR terminal). A valve position feedback input is provided.



2.14 Custom Computation Control (US mode 21)

This US mode allows users to customize input and output computations, signal assignments, and operation displays. To use the custom computation function, the optional LL1200 PC-based Custom Computation Building Tool is necessary. The tool includes the LL1100 PC-based Parameters Setting Tool, which is used to set the parameters of the US1000 controller from a personal computer.

● Main Specifications of Custom Computation Function

Provided computation modules:

Basic four arithmetical operations, logical operations, ten-segment linearizer approximation, temperature and humidity calculation, temperature compensation, pressure compensation, and others.

Customization of operation displays:

Customizing display types, the display sequence, and display conditions, is possible.

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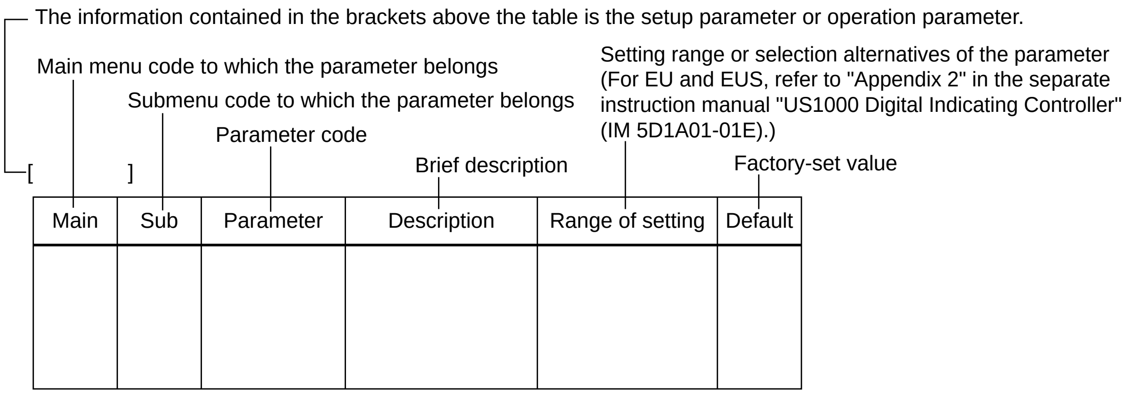
3. Parameters

The US1000 controller has two kinds of parameters: “Setup Parameters,” which are used to configure functions, and “Operation Parameters,” which are used for operation.
This chapter describes all of these parameters. (However, refer to Chapter 2 for USM parameters.)

●Regarding Tables in This Chapter



Parameters of the same function are distinguished by the number in their parameter codes.
For example: RH1, RH2, RH3
In this chapter, these parameters are expressed by one code with the numbers represented as “n” for convenience sake.
For example: RHn

See Also

- Some parameters are not displayed depending on the controller model and controller mode (US mode).
- For information on parameter call-up and setting operations, refer to the separate instruction manual “US1000 Digital Indicating Controller” (IM 5D1A01-01E).

3.1 Parameters that Determine the Action at Power-on and Power Recovery

A momentary power failure of less than 20 ms has no effect on the controller action. (The controller continues to operate normally.)
Following a power failure that lasts for 20 ms or longer however, the controller will operate as described below upon a power recovery (see Figure 3.1.1).

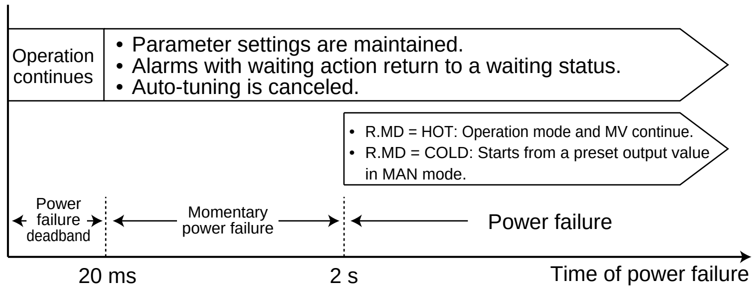


Figure 3.1.1 Time of Power Failure and Operation Upon Power Recovery

- Alarm action: Continues. But the alarms with waiting action immediately return to waiting status (Refer to subsection 3.14.1, "Alarm Types.")
- Parameter settings: Maintained.
- Auto-tuning: Canceled.
- Control action: The operation prior to the power failure continues when the power failure is less than 2 seconds. The operation varies according to the parameter R.MD setting when the failure lasts for 2 seconds or longer.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMLP	C.CTL	R.MD	Restart mode	HOT: Continues the operation prior to power failure COLD: Starts in MAN mode	COLD
		R.TM	Restart timer	0 to 60 s	0 s

R.MD setpoint	Control action after recovery
HOT	Operation mode and MV continue after recovery.
COLD	Starts in MAN (manual operation) after recovery. MV is reset to the preset MV value ('n.PM' of operation parameters).

Parameter R.TM is used to delay the start of the controller's operation by a specified period of time, after the power is turned on. R.TM is used in cases where the controller should start up after the other equipment.

3.2 Parameters for Analog Input

The US1000 controller can use a maximum of three analog inputs according to its model and suffix code*1. The input type and range can be set for each parameter.

●Example 1: For setting the type T thermocouple input, a measurement range of 0.0 to 300.0˚C, and burnout action for analog input 1.
Parameter menu: [Setup parameter] - [USMD] - [IN]
TYP1 = 6
UNI1 =˚C
RH1 = 300.0
RL1 = 0.0
A.BO2 = DNS

●Example 2: For setting the voltage input range of 1 to 5 V, a display scale of 0.0 to 500.0 m^3/H, and square-root extraction for analog input 3.
Parameter menu: [Setup parameter] - [USMD] - [IN]
TYP3 = 41
RH3 = 5.000
RL3 = 1.000
SDP3 = _ _ _ _. _
SH3 = 500.0
SL3 = 0.0
A. FL3 = 2 (Two-second filtering)
A.SR3 = ON
A.LC3 = 3.0%

In the following pages, each analog-input parameter is described.

*1 US1000-00 can use two analog inputs, and US1000-11 and US1000-21 can use three.

3.2.1 Analog Input Type and Unit

Analog input 1 and analog input 2 are universal and can be defined as either thermocouple, RTD, or DC voltage-signal type. Analog input 3 can receive either standard signals or DC voltage signals. Select an analog input type from the analog-input type list on the next page. Units for analog input 1 and 2 are set using parameters UNI1 and UNI2, respectively.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
USMD	IN	TYP1	Analog input-1 type for AIN1 terminal	See section 4.4	41
		UNI1	Analog input-1 unit	°C: Celsius; °F: Fahrenheit	°C
		TYP2	Analog input-2 type for AIN2 terminal	See section 4.4	41
		UNI2	Analog input-2 unit	°C: Celsius; °F: Fahrenheit	°C
		TYP3	Analog input-3 type for AIN3 terminal	See section 4.4	41

Table Analog Input Types

Input type		Setting	Range (°C)	Range (°F)	Accuracy
Thermocouple	K	1	-270.0 to 1370.0°C	-450.0 to 2500.0°F	0°C and over: ±0.1% of F.S. Below 0°C : ±0.2% of F.S. K (below -200°C) : ±2% of F.S. T (below -200°C) : ±1% of F.S.
		2	-270.0 to 1000.0°C	-450.0 to 2300.0°F	
		3	-200.0 to 500.0°C	-200.0 to 1000.0°F	
	J	4	-200.0 to 1200.0°C	-300.0 to 2300.0°F	
	T	5	-270.0 to 400.0°C	-450.0 to 750.0°F	
		6	0.0 to 400.0°C	-200.0 to 750.0°F	
	B	7	0.0 to 1800.0°C	32 to 3300°F	400°C and over: ±0.1% of F.S. Below 400°C : ±5% of F.S.
	S	8	0.0 to 1700.0°C	32 to 3100°F	±0.15% of F.S.
	R	9	0.0 to 1700.0°C	32 to 3100°F	
	N	10	-200.0 to 1300.0°C	-300.0 to 2400.0°F	±0.1% of F.S.
	E	11	-270.0 to 1000.0°C	-450.0 to 1800.0°F	0°C and over: ±0.1% of F.S. Below 0°C : ±0.2% of F.S. E (below -200°C) : ±1.5% of F.S.
	L	12	-200.0 to 900.0°C	-300.0 to 1600.0°F	
	U	13	-200.0 to 400.0°C	-300.0 to 750.0°F	
		14	0.0 to 400.0°C	-200.0 to 1000.0°F	±0.2% of F.S.
	W	15	0.0 to 2300.0°C	32 to 4200°F	±0.2% of F.S.
	Platinel 2	16	0.0 to 1390.0°C	32.0 to 2500.0°F	±0.1% of F.S.
	PR20-40	17	0.0 to 1900.0°C	32 to 3400°F	800°C and over: ±0.5% of F.S. Below 800°C : Accuracy not guaranteed
	W97Re3 W75Re25	18	0.0 to 2000.0°C	32 to 3600°F	±0.2% of F.S.
RTD	JPt100	30	-200.0 to 500.0°C	-300.0 to 1000.0°F	±0.1% of F.S.
		31	-150.00 to 150.00°C	-200.0 to 300.0°F	±0.2% of F.S.
	Pt100 (ITS90)	35	-200.0 to 850.0°C	-300.0 to 1560.0°F	±0.1% of F.S.
		36	-200.0 to 500.0°C	-300.0 to 1000.0°F	
		37	-150.00 to 150.00°C	-200.0 to 300.0°F	±0.2% of F.S.
Standard signal	0.4 to 2.0 V	40	0.400 to 2.000		±0.1% of F.S.
	1 to 5 V	41	1.000 to 5.000		
DC voltage	0 to 2 V	50	0.000 to 2.000		
	0 to 10 V	51	0.00 to 10.00		
	-10 to 20mV	55	-10.00 to 20.00		
	0 to 100mV	56	0.0 to 100.0		

3.2.2 Analog Input Range and PV Range

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
USMD	IN	RH1	Maximum value of analog input-1 range	Within instrument input range	Maximum level of instrument range
		RL1	Minimum value of analog input-1 range	Within instrument input range	Minimum level of instrument range
		RH2	Maximum value of analog input-2 range	Within instrument input range	Maximum level of instrument range
		RL2	Minimum value of analog input-2 range	Within instrument input range	Minimum level of instrument range
		RH3	Maximum value of analog input-3 range	Within instrument input range	5.000
		RL3	Minimum value of analog input-3 range	Within instrument input range	1.000
		P.RH1	Maximum value of PV1 range	-19999 to 30000, 0<P.RH1-P.RL1≤30000	Thermocouple, RTD: RH1 value; voltage input: 100.0
		P.RL1	Minimum value of PV1 range	-19999 to 30000, 0<P.RH1-P.RL1≤30000	Thermocouple, RTD: RL1 value; voltage input: 0.0
		P.RH2	Maximum value of PV2 range	-19999 to 30000, 0<P.RH2-P.RL2≤30000	Thermocouple, RTD: RH2 value; voltage input: 100.0
		P.RL2	Minimum value of PV2 range	-19999 to 30000, 0<P.RH2-P.RL2≤30000	Thermocouple, RTD: RL2 value; voltage input: 0.0

Parameters RH1 to RL3 are used to set the range used for control within the instrument range shown in the analog-input type list on the previous page.

Parameters P.RH1 to P.RL2 (PV range) are used to set the PV ranges used for the controller's internal computation when the controller performs loop control with PV switching or loop control with PV auto-selector which receives two inputs of different measurement ranges (see Figure 3.2.1). The parameters are also used to set the PV range for relative humidity data obtained from dry- and wet-bulb calculations in temperature and humidity control (see Figure 3.2.2).
The decimal point position of the PV range can be set with parameters P.DP1 and P.DP2 (refer to subsection 3.2.3).

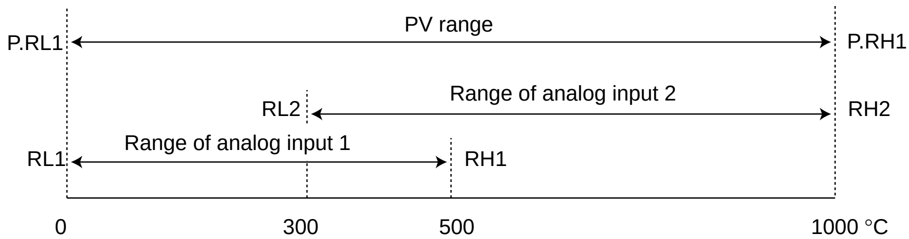


Figure 3.2.1 PV Range for a Control Having More than One Input

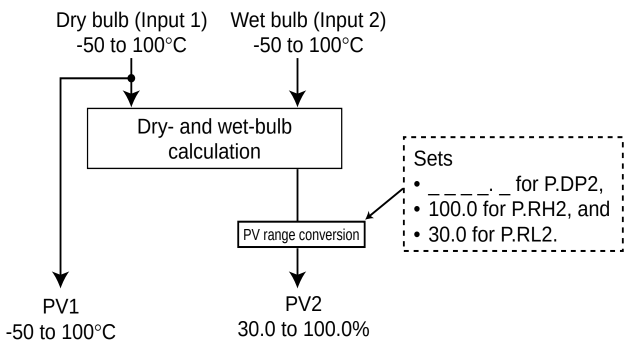


Figure 3.2.2 PV Range for Temperature and Humidity Control

3.2.3 Decimal Point Position of Analog Input

Parameters SDP1 to SDP3 are used to set the decimal point positions of analog inputs. These parameters can be set only for standard signal and DC voltage-signal inputs. As for thermocouple and RTD inputs, the decimal point positions of the instrument ranges listed in the analog-input type table in subsection 3.2.1 apply.

P.DP1 and P.DP2 are the parameters that set the decimal point positions of PV1 and PV2, which are used in the internal computation of the controller. (Refer to subsection 3.2.2, "Analog Input Range and PV Range.")

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
USMD	IN	SDP1	Analog input-1 decimal point position	0 to 4 *1	1
		SDP2	Analog input-2 decimal point position	0 to 4 *1	1
		SDP3	Analog input-3 decimal point position	0 to 4 *1	1
		P.DP1	PV1 decimal point position	0 to 4 *1	1
		P.DP2	PV2 decimal point position	0 to 4 *1	1

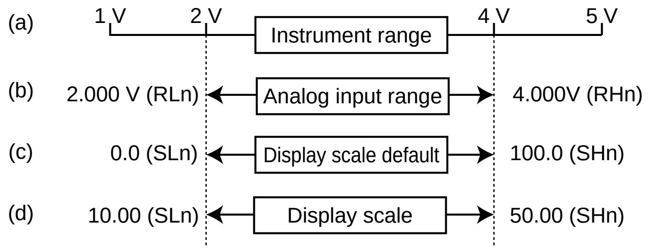
* The parameter settings in the table above are displayed with under bars "_" and a period ".". For example, "_ _ _ _. _" is the display shown when the setting of SDP1 is 1.

3.2.4 Display Scale of Analog Input

When the analog input type is specified as a standard signal or DC voltage signal, the PV input signal is in voltage. In this case, the range of the voltage signal can be prescribed with parameters RHn and RLn (Refer to subsection 3.2.2, "Analog Input Range and PV Range."). However, the signal still needs to be converted to the physical quantity unit of the controlled object. SHn and SLn are the parameters used to carry out this conversion. The signal is converted into the physical quantity unit of the controlled object, which is a display scale. The number of decimal places can be set with parameter SDPn (Figure 3.2.3). (Refer to subsection 3.2.3, "Decimal Point Position of Analog Input.")

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
USMD	IN	SH1	Maximum value of analog input-1 scale	-19999 to 30000, SL1<SH1	100.0
		SL1	Minimum value of analog input-1 scale	-19999 to 30000, SL1<SH1	0.0
		SH2	Maximum value of analog input-2 scale	-19999 to 30000, SL2<SH2	100.0
		SL2	Minimum value of analog input-2 scale	-19999 to 30000, SL2<SH2	0.0
		SH3	Maximum value of analog input-3 scale	-19999 to 30000, SL3<SH3	100.0
		SL3	Minimum value of analog input-3 scale	-19999 to 30000, SL3<SH3	0.0



(a) When the input type is set at "41," the instrument range is 1.000 to 5.000 V.
(b) In this example, the analog input range is set as 2.000 to 4.000 V using parameters RLn and RHn.
(c) The default of the display scale is 0.0 to 100.0.
(d) Parameters SDPn, SHn, and SLn have been set to _ _ _. _ _, 50.00, and 10.00, respectively.

Figure 3.2.3 Setting Input Scale

3.2.5 Analog Input Bias (Normally used at default)

This biasing is used to correct sensor-input characteristics, compensating lead wire errors, and so on. The analog input biasing is similar to the PV biasing described in subsection 3.3.1.

Corrected analog input value = Analog input value + Analog input bias

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMPL	AIN	A.BS1	Analog input-1 bias	EUS (-100.0 to 100.0%)	EUS (0%)
		A.BS2	Analog input-2 bias	EUS (-100.0 to 100.0%)	EUS (0%)
		A.BS3	Analog input-3 bias	EUS (-100.0 to 100.0%)	EUS (0%)

3.2.6 Analog Input Filter (Normally used at default)

The analog input filter is used to remove noise from a PV input signal that contains high frequency noises such as flow rate and pressure signals. The filter provides a first-order-lag calculation, which can remove more noise the larger time constant becomes (see Figure 3.2.4). However, an excessively large time constant will distort the waveform.
The analog input filter is similar to the PV filter described in subsection 3.3.2. Normally, the PV input filter is used, but in cases where a constant level of correction is required, such as in an environment that contains a lot of noise, the analog input filter should be used.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMPL	AIN	A.FL1	Analog input-1 filter	OFF, 1 to 120 s	OFF
		A.FL2	Analog input-2 filter	OFF, 1 to 120 s	OFF
		A.FL3	Analog input-3 filter	OFF, 1 to 120 s	OFF

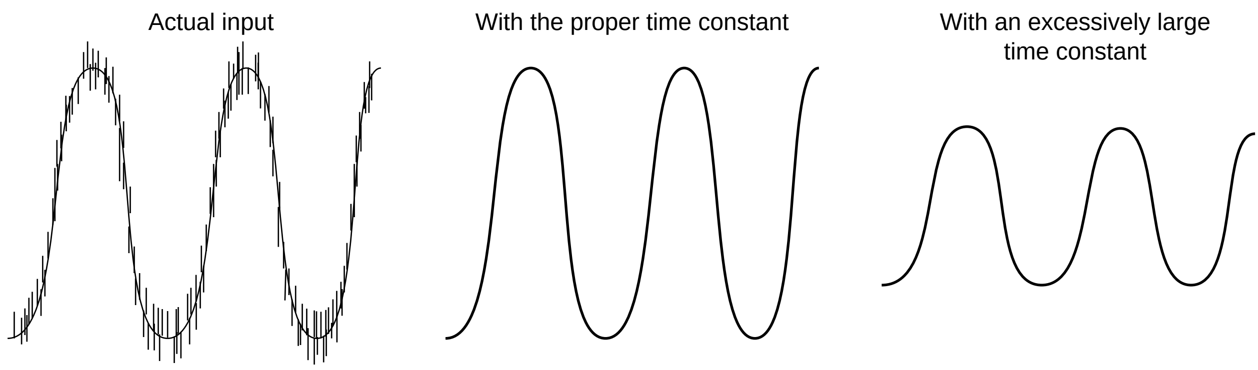


Figure 3.2.4 Image of Measured Signal Correction by Analog Input Filters

3.2.7 Square-root Extraction

This calculation is used to convert a differential pressure signal from a throttling flow meter such as an orifice and nozzle. Low signals are cut off at the point specified by parameter A.LCn.
The slope below the lowcut point is fixed at 1.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMPL	AIN	A.SR1	Analog input-1 square-root computation	OFF, ON	OFF
		A.LC1	Analog input-1 square-root low signal cut off	0.0 to 5.0%	1.0%
		A.SR2	Analog input-2 square-root computation	OFF, ON	OFF
		A.LC2	Analog input-2 square-root low signal cut off	0.0 to 5.0%	1.0%
		A.SR3	Analog input-3 square-root computation	OFF, ON	OFF
		A.LC3	Analog input-3 square-root low signal cut off	0.0 to 5.0%	1.0%

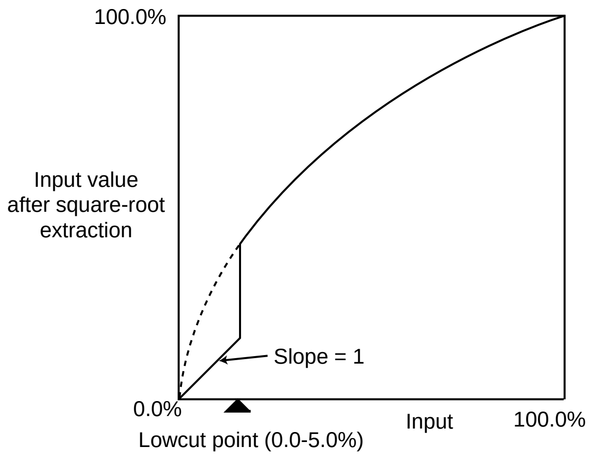


Figure 3.2.5 Square-root Extraction

3.2.8 Action at a Burnout

For thermocouple, RTD, and standard signal inputs, the action at a burnout can be specified to each input.
When upscale is specified, PV = 105.0% and MV = preset MV value (operation parameter n.PM).
When downscale is specified, PV = -5.0% and MV = preset MV value (operation parameter n.PM).

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMPL	AIN	A.BO1	Analog input-1 burnout action	OFF: Disabled UPS: Upscale DNS: Downscale	OFF
		A.BO2	Analog input-2 burnout action	OFF: Disabled UPS: Upscale DNS: Downscale	OFF
		A.BO3	Analog input-3 burnout action	OFF: Disabled UPS: Upscale DNS: Downscale	OFF

3.2.9 Reference Junction Compensation for Analog Input

The US1000 controller has a reference junction compensation function for the thermocouple inputs of analog input 1 and 2. When an external device is used for reference junction compensation (0 °C), set parameter A.RJn to OFF.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMPL	AIN	A.RI1	Analog input-1 reference junction compensation	OFF, ON	ON
		A.RJ2	Analog input-2 reference junction compensation	OFF, ON	ON

3.3 Parameters for PV Computation (Normally used at defaults)

The computation on measured values carried out after a series of computations on the analog input signal is called PV computation. The PV computations contain the PV biasing and PV filtering.

3.3.1 PV Bias

In some cases, the obtained PV value is smaller than the actual value by a constant quantity due to the physical circumstances of the detecting element. For example, the ambient temperature inside a furnace is often measured to substitute it for a material's temperature. In such cases, add a constant value for biasing.
When there is a dispersion in PV values between other equipment, a fine adjustment is possible using this function.
The PV biasing and analog biasing are similar functions (refer to subsection 3.2.5). However, PV bias should be used normally because it is given as an operation parameter and its value can be changed during operation.

PV value inside the controller = PV input value + PV bias

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	PAR	BS	PV bias	EUS (-100.0 to 100.0%)	EUS (0%)

3.3.2 PV Filter

This filter is used to improve controllability or to correct the phase of an input signal. The filter provides first-order-lag calculation. The PV filter and the analog input filter have similar functions (refer to subsection 3.2.6). However, the PV filter should be normally used because its time constant is given as an operation parameter and can be changed during operation.

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	PAR	FL	PV filter	OFF, 1 to 120 s	OFF

3.4 Parameters for Cascade Input

3.4.1 Selection of Cascade Input

The destination of cascade input can be specified using the CMS parameter. The signal from the cascade input destination is taken for the target setpoint (cascade setpoint) when the controller is in CAS mode.
When the CMS parameter is set at AIN, the cascade input is the signal from the analog input terminal (AIN2 or AIN3). When it is set at CPT, the cascade input is the signal from RS-485 terminal.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
S.LP1 S.LP2	SV	CMS	Cascade input selection	AIN: Analog input CPT: Communication	AIN

3.4.2 Cascade Input Filter

This filter performs a first-order-lag calculation on the cascade setpoint value from the analog input terminal when the CMS parameter described in subsection 3.4.1 is set at AIN.
This calculation is not performed on the cascade setpoint transmitted via RS-485 communication.

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	PAR	CFL	Cascade input filter	OFF, 1 to 120 s	OFF

3.4.3 Cascade Ratio and Cascade Bias

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	PAR	CRT	Cascade ratio	0.001 to 9.999	1.000
		CBS	Cascade bias	EUS (-100.0 to 100.0%)	EUS (0%)

The ratio multiplication and bias addition given by the following expression can be performed on the cascade setpoint.

Cascade setpoint after computation = Cascade setpoint×(CRT) + (CBS),
where CRT represents the cascade ratio and CBS the cascade bias.

3.4.4 OPEN/CLOSE Switchover for Internal Cascade Control

Cascade OPEN: The internal cascade loop (the primary and secondary loops inside a controller) is disconnected.

Cascade CLOSE: The internal cascade loop (the primary and secondary loops inside a controller) is connected.

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
MODE	—	O/C	OPEN/CLOSE switchover	CLOSE/OPEN	CLOSE

OPEN/CLOSE switchover of an internal cascade loop is also possible using a contact input. For information about this method, refer to Section 6.6 “OPEN/CLOSE Switchover of Cascade Loop” in the separate instruction manual “US1000 Digital Indicating Controller” (IM 5D1A01-01E).

Note that the OPEN/CLOSE switchover by contact input takes priority over the switching by the O/C setting parameter.

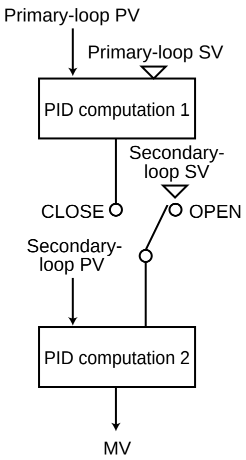


Figure 3.4.1 Switching between Cascade OPEN and Cascade CLOSE

3.5 Parameters for Feedforward Input

■ Feedforward Control

In the feedback control generally performed, the PID action works only after the effect of the disturbance appears in PV. This delays the recovery to the normal state. When the disturbance can be measured however, the effect of the disturbance can be nullified by adding a corrective signal that corresponds to the degree of that disturbance, to the controller's MV before the effect appears in the controlled process. This operation is called feedforward control.

For example, in the pH control illustrated in Figure 3.5.1, the flow of waste water is measured as the feedforward input and added to the controller's MV after passing through the feedforward gain and biasing operation. This means that the quantity of the neutralizing solution can be controlled so as to nullify the effect of the waste water.

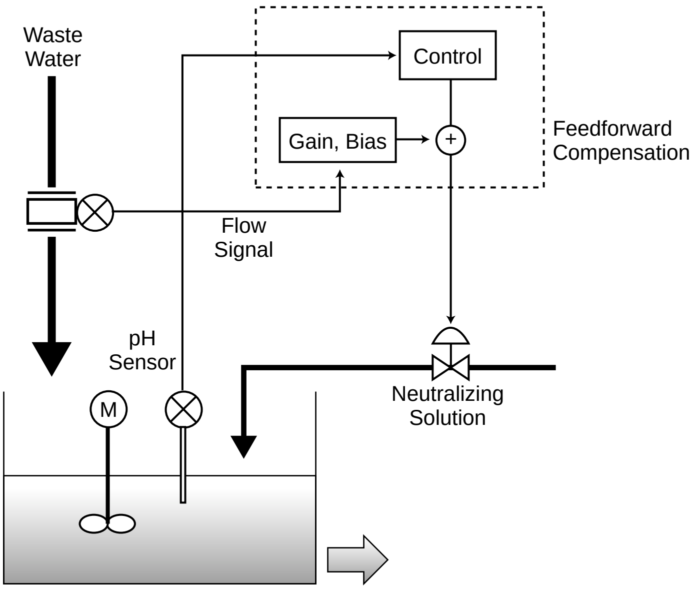


Figure 3.5.1 Feedforward Control

3.5.1 Selection of Feedforward Input

NOTE

When the FFS parameter is set at AIN, always set the CMS parameter (refer to subsection 3.4.1) to CPT in order to prevent the feedforward input from being acquired by the controller as a cascade input when the key is pressed by mistake.
Set the above even when the RS-485 communication function will not be used.

To use a feedforward input, set the FFS parameter at AIN. The use of feedforward input is however limited by the model of the controller and controller mode (US mode). Check if a feedforward input can be assigned to any terminal referring to the function block diagrams in Chapter 2.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
S.LP1	CTL	FFS	Feedforward input selection	OFF = Disabled; AIN: Analog input	OFF

3.5.2 Feedforward Input Filter, Bias, and Gain

The gain, filtering, and biasing calculation given by the following expression can be provided on the feedforward input.

$$MV = MV_C + FF$$
$$FF = F_{GN} \{1 / (1 + F_{FL} \bullet S) FI_N + F_{BI}\} + F_{BO}$$

where,

FF: Feedforward input after gain, filtering, and biasing calculation
MV_C: MV obtained by feedback control
F_{GN}: Feedforward gain
F_{FL}: Feedforward input filter
F_{IN}: Feedforward input
F_{BI}: Feedforward input bias
F_{BO}: Feedforward output bias

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1	PAR	FGN	Feedforward gain	-9.999 to 9.999	1.000
		FBI	Feedforward input bias	-100.0 to 100.0%	0.0%
		FBO	Feedforward output bias	-999.9 to 999.9%	0.0%
		FFL	Feedforward input filter	OFF, 1 to 120 s	OFF

3.6 Parameters for Ten-segment Linearizer

The two functions described below are possible using a ten-segment linearizer. Which function to use is specified by the parameter n.PMD (refer to subsection 3.6.2), whose default is set to ten-segment linearizer biasing.

●Ten-segment linearizer biasing

This function is used to correct the input signal affected by sensor deterioration. Corrected values are output by adding the corresponding output values (Y) to each of the 11 points of optionally set input values (X). The values on the X-axis of a ten-segment linearizer for biasing are set with parameters n.X1 to n.X11, and the values on the Y-axis are set with parameters n.Y1 to n.Y11.

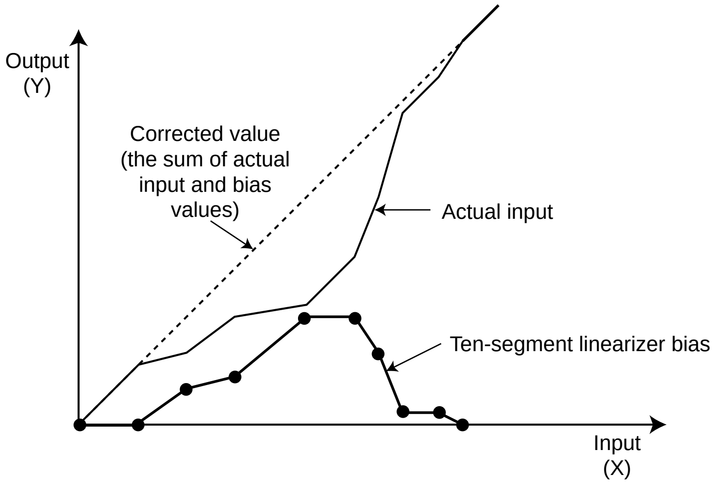


Figure 3.6.1 Ten-segment Linearizer Biasing

●Ten-segment Linearizer Approximation

This function is used when the input signal and the required measurement signal have a non-linear relationship æ for example, when trying to obtain the volume from a sphere tank level. Output values (Y) can be set optionally according to the 11 points of optionally set input values (X). The values on the X-axis of a ten-segment linearizer for approximation are set with parameters n.X1 to n.X11, and the values on the Y-axis are set with parameters n.Y1 to n.Y11.

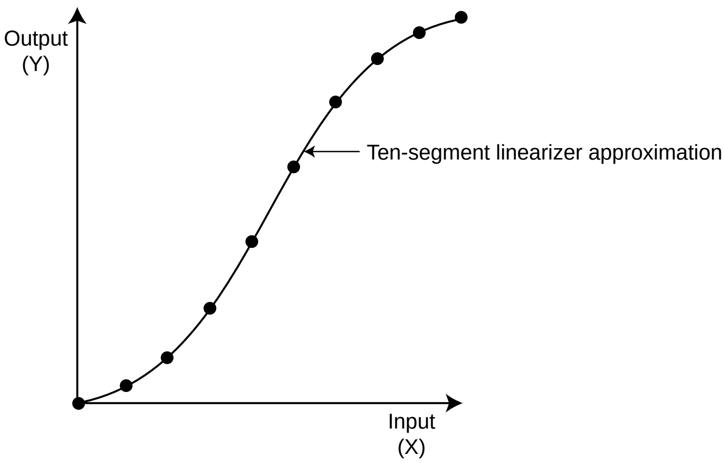


Figure 3.6.2 Ten-segment Linearizer Approximation

3.6.1 Unit of Ten-segment Linearizer

Ten-segment linearizer 1 and 2 are used for loop-1 and loop-2, respectively.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CONF	C. PYS	PY1X	Ten-segment linearizer-1 input unit	0: %, 1: ABS0, 2:ABS1, 3: ABS2, 4: ABS3, 5: ABS4, 6: EU (AIN1), 7: EUS (AIN1), 8: EU (AIN2), 9: EUS (AIN2), 10: EU (AIN3), 11: EUS (AIN3), 12: EU (PV1), 13: EUS (PV1), 14: EU (PV2), 15: EUS (PV2)	12
		PY1Y	Ten-segment linearizer-1 output unit		13
		PY2X	Ten-segment linearizer-2 input unit		14
		PY2Y	Ten-segment linearizer-2 output unit		15

12: EU (PV1): The same engineering unit specified for loop-1 PV.
13: EUS (PV1): The engineering unit that corresponds to the loop-1 PV range span.
14: EU (PV2): The same engineering unit specified for loop-2 PV.
15: EUS (PV2): The engineering unit that corresponds to the loop-2 PV range span.

For general use, use the defaults of the parameters for ten-segment linearizer biasing, and change the settings of the parameters as follows for ten-segment linearizer approximation.
PY1X: 12, PY1Y: 12, PY2X: 14, PY2Y: 14
The values from 0 to 11 are used for the custom computation function. Do not set these values for general use.

See Also

Appendix 2 of the separate instruction manual “US1000 Digital Indicating Controller” (IM 5D1A01-01E), for the meanings of EU and EUS.

3.6.2 Parameters to Set Ten-segment Linearizer

These parameters set the inputs and outputs of a ten-segment linearizer for both biasing and approximation. The parameters with n = 1 are for loop-1, and those with n = 2 are for loop-2. Parameter n.PMD specifies the type of ten-segment linearizer.

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
PYSn (n=1, 2)	—	n. X1	Ten-segment linearizer-n input 1	EU (-66.7 to 105.0%)	EU (0.0%)
		n. Y1	Ten-segment linearizer-n output 1	EUS (-66.7 to 105.0%)	EUS (0.0%)
		n. X2	Ten-segment linearizer-n input 2	EU (-66.7 to 105.0%)	EU (0.0%)
		n. Y2	Ten-segment linearizer-n output 2	EUS (-66.7 to 105.0%)	EUS (0.0%)
		n. X3	Ten-segment linearizer-n input 3	EU (-66.7 to 105.0%)	EU (0.0%)
		n. Y3	Ten-segment linearizer-n output 3	EUS (-66.7 to 105.0%)	EUS (0.0%)
		n. X4	Ten-segment linearizer-n input 4	EU (-66.7 to 105.0%)	EU (0.0%)
		n. Y4	Ten-segment linearizer-n output 4	EUS (-66.7 to 105.0%)	EUS (0.0%)
		n. X5	Ten-segment linearizer-n input 5	EU (-66.7 to 105.0%)	EU (0.0%)
		n. Y5	Ten-segment linearizer-n output 5	EUS (-66.7 to 105.0%)	EUS (0.0%)
		n. X6	Ten-segment linearizer-n input 6	EU (-66.7 to 105.0%)	EU (0.0%)
		n. Y6	Ten-segment linearizer-n output 6	EUS (-66.7 to 105.0%)	EUS (0.0%)
		n. X7	Ten-segment linearizer-n input 7	EU (-66.7 to 105.0%)	EU (0.0%)
		n. Y7	Ten-segment linearizer-n output 7	EUS (-66.7 to 105.0%)	EUS (0.0%)
		n. X8	Ten-segment linearizer-n input 8	EU (-66.7 to 105.0%)	EU (0.0%)
		n. Y8	Ten-segment linearizer-n output 8	EUS (-66.7 to 105.0%)	EUS (0.0%)
		n. X9	Ten-segment linearizer-n input 9	EU (-66.7 to 105.0%)	EU (0.0%)
		n. Y9	Ten-segment linearizer-n output 9	EUS (-66.7 to 105.0%)	EUS (0.0%)
		n. X10	Ten-segment linearizer-n input 10	EU (-66.7 to 105.0%)	EU (0.0%)
		n. Y10	Ten-segment linearizer-n output 10	EUS (-66.7 to 105.0%)	EUS (0.0%)
		n. X11	Ten-segment linearizer-n input 11	EU (-66.7 to 105.0%)	EU (0.0%)
		n. Y11	Ten-segment linearizer-n output 11	EUS (-66.7 to 105.0%)	EUS (0.0%)
		n. PMD	Ten-segment linearizer-n mode	0: Biasing; 1: Approximation	0

3.7 Parameters Related to Target Setpoint and SUPER Function

A maximum of 8 target setpoint values (SV) can be set for each loop of the US1000 controller. It is possible to improve controllability by setting the SUPER function, time for ramp-rate setting, and other functions to each SV.

3.7.1 Target Setpoint (SV)

A maximum of 8 target setpoint values (1.SV to 8.SV) can be set for each loop, however, use 1.SV only for simple single-loop control. For information on how to use the controller switching between multiple SVs, refer to subsection 3.10.2, “SV Number Selection for Preset PID.”
The SV set with parameter n.SV can also be changed using the ▽ and △ keys on the front panel. (Doing this will also change the setting of the n.SV parameter itself.)

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	n.PID (n=1-8)	n.SV	Target setpoint	EU (0.0 to 100.0%)	EU (0%)

3.7.2 SUPER Function

The SUPER function is an overshoot-suppressing function based on fuzzy inference. This function is highly effective in the following cases when used together with the auto-tuning function. (Refer to Section 3.11, “Parameters for Auto-tuning,”)

- An overshoot must be suppressed.
- Rise-up time needs to be shortened.
- Load varies often.
- SV is changed frequently.

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	PAR	SC	SUPER function selection	OFF, ON	OFF

NOTE

The SUPER function operates using the PID parameters. All of the parameters for PID computation — P (proportional band), I (integral time), and D (derivative time) — must therefore be set to their appropriate values. The SUPER function will not operate when I or D is set to OFF.

When the SUPER function is set on, the controller monitors deviations in order to detect the possibility of an overshoot. When the possibility of an overshoot is detected, the controller changes the target setpoint to a virtual value somewhat smaller than the actual value (auxiliary SV) and continues control. Then, when there is no longer the possibility of an overshoot, the target setpoint is gradually reset to its original value. (See Figure 3.7.1.)
The SUPER function operates using the PID parameters. Be sure to set the PID parameters to their appropriate values by the auto-tuning function before activating the SUPER function.

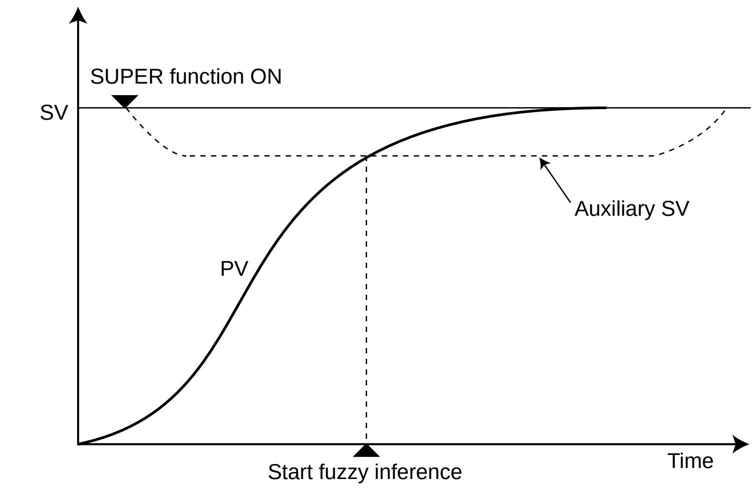


Figure 3.7.1 SUPER Function

3.7.3 PV Tracking

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
S.LP1 S.LP2	SV	PVT	PV tracking selection	OFF, ON	OFF

PV tracking is the function that sets the SV equal to PV temporarily to prevent a sudden change in PV during any of the following events: (1) power-on, (2) switching from MAN to AUTO mode, (3) switching from STOP to RUN. After SV is made equal to PV, the SV is gradually changed to the preset SV value at a constant rate-of-change (ramp rate) that is determined by parameters TMU, UPR, and DNR (refer to subsection 3.7.4, “SV Rate-of-Change (Ramp Rate)”). Since setting UPR and DNR to OFF reduces the ramp rate to 0, be sure to set the appropriate values to parameters TMU, UPR, and DNR.

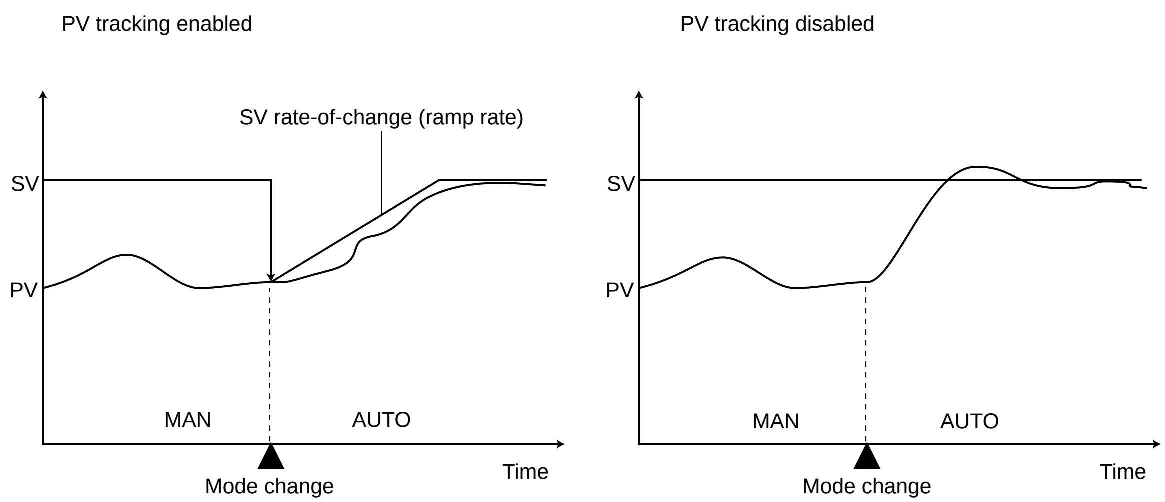


Figure 3.7.2 PV Tracking

3.7.4 SV Rate-of-change (Ramp Rate)

In order to prevent a sudden change in the SV changing operation, the US1000 controller has a function to change SV at a constant rate. This rate is specified by setting the amount of change per hour or per minute. Positive and negative rates can be set with separate parameters UPR and DNR, respectively.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
S.LP1 S.LP2	SV	TMU	Time unit for ramp-rate setting	0: 1 h; 1: 1 min	0

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	PAR	UPR	Setpoint ramp-up	OFF, EUS (0.1 to 100.0%)	OFF
		DNR	Setpoint ramp-down	OFF, EUS (0.1 to 100.0%)	OFF

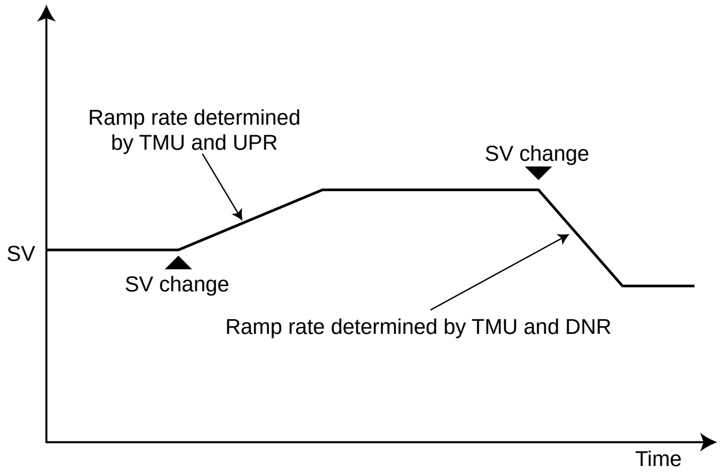


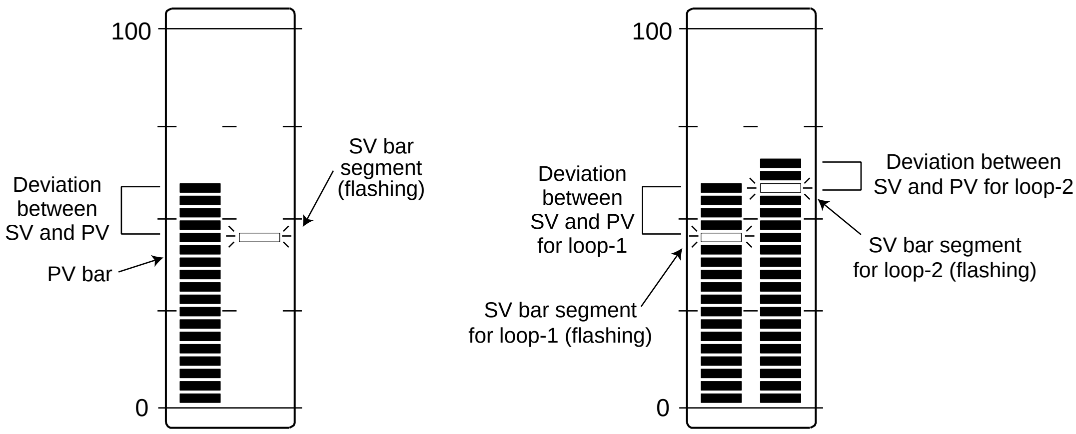
Figure 3.7.3 SV Rate of Change

3.7.5 Deviation Display Range and SV Bar Segment

When the deviation between SV and PV exceeds the value of parameter DVB, the bar segment that indicates SV flashes.
Upon default setting, the SV bar segment flashes when PV deviates from SV by one or more bar segments.
Since PV and SV are both displayed on a single bar when the cascade loop is open or during dual-loop control, for example, it is difficult to find the SV position when it is smaller than PV. To avoid this problem, set DVB at EUS (0.0%) to make the SV bar segment continually flash. Alternatively, set DVB at EUS (100%) to make the SV bar segment always lit.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
S.LP1 S.LP2	SV	DVB	Deviation display range	EUS (0.0 to 100.0%)	EUS (1.65%)



SV display for single-loop control   SV display for dual-loop control

Figure 3.7.4 Deviation Display Range and SV Bar Segment

3.8 Parameters for Control Computation

The type of control computation can be selected for each control loop. Selecting the control computation type also determines the MV output type (relay, current, etc.).
This section describes each type of control computation and the settings specific to the control computation.

The control computation types that can be selected for each controller model are shown below. Since the control computation of the US1000-21 (the position-proportional model) is fixed at position-proportional PID computation with relay output, it does not need the computation type to be set.

●Applicable Control Computation Types for Each Controller Model

US1000-00:	Time-proportional PID computation with voltage pulse output, continuous PID computation
US1000-11:	Time-proportional PID computation with relay output or voltage pulse output, continuous PID computation, ON/OFF computation, heating/cooling computation
US1000-21:	Position-proportional PID computation

3.8.1 Control Computation Type and MV Output Type

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
USMD	OUT	MVS1	MV1 selection	0: Control relay output, 1: Voltage pulse output, 2: Current output, 3: Control relay output for ON/OFF computation, 4 to 12: Output for heating/cooling computation (see the next page)	2
		MVS2	MV2 selection		2

●MVS1 and MVS2

Parameters MVS1 and MVS2 are used to set the MV output type. Either or both of them must be set according to the controller mode (US mode). (The controller does not display parameters that do not need to be set.)

- Set MVS1 except the following cases.
- Cascade control (US mode 4), cascade control with two universal inputs (US mode 13):
  Set MVS2.
- Dual-loop control (US mode 11), temperature and humidity control (US mode 12):
  Set both MVS1 and MVS2.
- US1000-21 (the position-proportional model):
  Set neither MVS1 nor MVS2, regardless of controller mode (US mode).

TIP

●When the controller mode is cascade primary loop control (US mode 2), leave the MVS1 setting at the default value (2).

●When the controller mode is dual-loop control (US mode 11) or temperature and humidity control (US mode 12), the setting range of MVS1 and MVS2 is 0 to 7.

The control computation types and MV output types are summarized in the following table.

Control Computation Type	Setting of MVSn	Description	MV Output Type
Time-proportional PID computation with relay output	0	PID computation result is output in the pulse width of a time-proportional on/off signal.	Control relay output
Time-proportional PID computation with voltage pulse output	1	PID computation result is output in the pulse width of a time-proportional on/off signal.	Voltage pulse output
Continuous PID computation	2	PID computation result is output as an analog signal.	Current output
ON/OFF computation	3	SV and PV are compared and an ON or OFF signal is output according to the sign of the deviation.	Control relay output
Heating/cooling computation	4 to 12*1	The PID or ON/OFF computation*2 result is output as two types of signals for the heating and cooling output.	Control relay*2, voltage pulse*2, or current output can be selected for each of heating-side and cooling- side outputs
Position-proportional PID computation	None	Control is performed so as to maintain the MV output in accordance with the control valve opening.	Position-proportional control relay output

*1 The MV output types for the heating/cooling computation are as follows.

●Single-loop control or cascade control

4: Heating control relay output / cooling control relay output
5: Heating pulse output / cooling control relay output
6: Heating current output / cooling control relay output
7: Heating control relay output / cooling pulse output
8: Heating pulse output / cooling pulse output
9: Heating current output / cooling pulse output
10: Heating control relay output / cooling current output
11: Heating pulse output / cooling current output
12: Heating current output / cooling current output

●Dual-loop control or temperature and humidity control
(Both of the loop-1 and loop-2 have the same output combinations.)

4: Heating pulse output / cooling control relay output
5: Heating control relay output / cooling pulse output
6: Heating current output / cooling control relay output
7: Heating control relay output / cooling current output

*2 Setting the proportional band (n.P or n.Pc) at 0 enables ON/OFF signal resulting from ON/OFF computation to be output.

3.8.2 Time-proportional PID Computation and Cycle Time of MV Output

The cycle time of an MV output must be set for time-proportional PID computation.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMLP	C.CTL	CT1	Cycle time of MV1	1 to 1000 s	30 s
		CT2	Cycle time of MV2	1 to 1000 s	30 s

In time-proportional PID computation, the fundamental period of time at which the relay or voltage pulse output turns ON and OFF is called the “cycle time.” The type of output used – relay or voltage pulse – is set using parameter MVS1 or MVS2. The cycle time of MV output can be set in seconds using parameter CT1 or CT2. The proportion of ON time within the cycle time is proportional to the MV output.

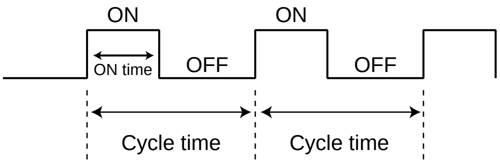


Figure 3.8.1 Cycle Time of MV Output

A short cycle time enables fine control, but may reduce the service life time of the controller’s output relay and the input contact of the final control element due to the fact that the number of ON/OFF switchings is increased. Generally, the cycle time of MV output is set between 10 and 30 seconds for relay contact output.
The following figure compares the actions of different cycle times when MV output = 50%.

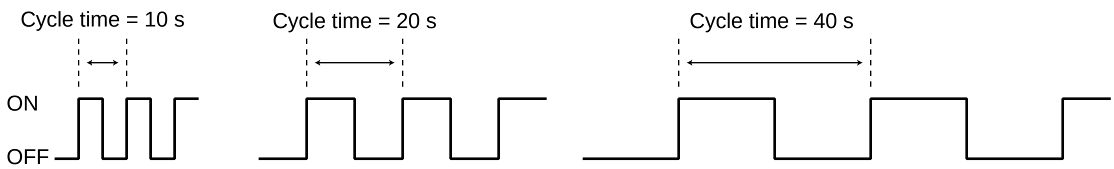


Figure 3.8.2 Comparing ON/OFF Actions of Different Cycle Times

3.8.3 Continuous PID Computation

With continuous PID computation, the result of the PID computation is output in a current signal (analog outp ut) in proportion to the result.

See Also

Section 3.9, “Parameters for PID Computation,” for information on PID computation; and subsection 3.12.1, “Analog Output Type,” for information about analog output types.

3.8.4 ON/OFF Computation and Hysteresis

The output type of ON/OFF computation is relay contact. A hysteresis band can be set around the ON/OFF switching point (SV).

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	n.PID (n=1-8)	n.H	Hysteresis	ON/OFF computation: EUS (0.0 to 100.0%), Position proportional PID or heating/cooling computation: 0.0 to 100.0%	ON/OFF computation: EUS (0.5%), Position proportional PID or heating/cooling computation: 0.5%

NOTE

When the relay is expected to be turned on and off frequently, set a somewhat wider hysteresis in consideration of the fact that the service life of the output relay will be significantly reduced.

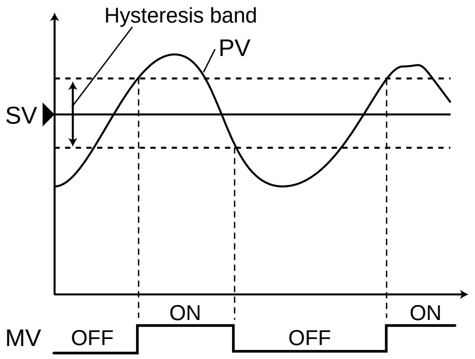


Figure 3.8.3 Hysteresis for ON/OFF Computation

3.8.5 Heating/Cooling Computation and Cycle Time, Hysteresis, and Deadband

In heating/cooling computation, the PID computation result is output as two signals for heating and cooling.

See Also

Subsection 3.9.2, "Cooling-side PID Parameters for Heating/Cooling Computation," for information on the PID computation for heating/cooling computation.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMLP	C.CTL	CTcl	Cycle time of cooling side MV1	1 to 1000 s	30 s
		CTc2	Cycle time of cooling side MV2	1 to 1000 s	30 s

When the cooling-side output is relay contact or voltage pulse (that is, parameter MVS1 or MVS2 has been set between 4 and 9), the cycle time of the cooling-side MV output (CTc1 or CTc2) must be set. For a description of the cycle time, refer to subsection 3.8.2, "Time-proportional PID Computation and Cycle Time of MV Output."

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	n.PID (n=1-8)	n.Hc	Cooling-side relay hysteresis	0.0 to 100.0%	0.5%

When the cooling-side output is relay contact (that is, parameter MVS1 or MVS2 has been set between 4 and 6), a hysteresis band can be set around the ON/OFF switching point (SV). For a description of the hysteresis, refer to subsection 3.8.4, "ON/OFF Computation and Hysteresis."

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	n.PID (n=1-8)	n.DB	Deadband	Heating/cooling computation: -100.0 to 50.0% Position proportional PID computation: 1.0 to 10.0%	3.0%

A deadband (positive) is the area where no MV is output for the heating-side or cooling-side. A deadband is set as a proportion of the output span (%). For a negative deadband, the MV output overlaps both the heating-side and cooling-side.

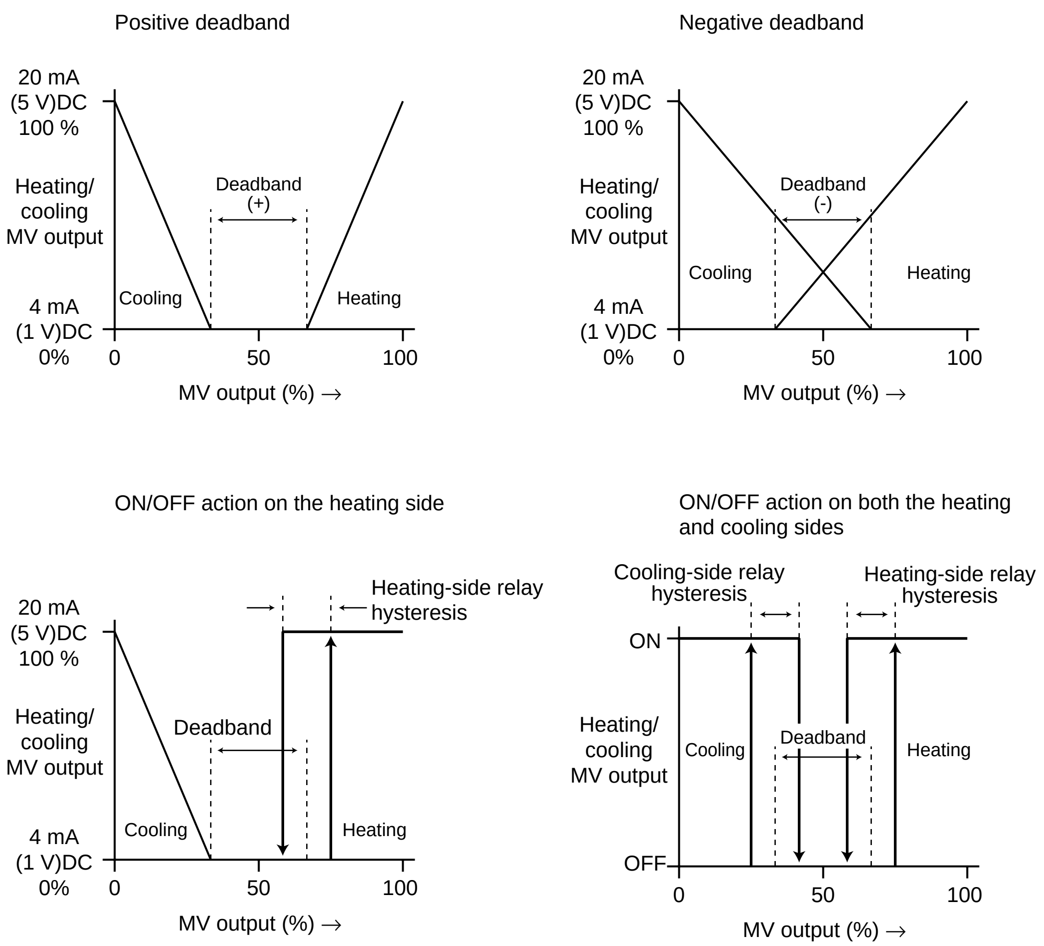


Figure 3.8.4 Deadbands

3.8.6 Position-proportional PID Computation and Valve Position

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
USMD	VALV	V.RS	Reset valve position	0, 1; Setting 1 clears valve position data.	0
		V.L	Valve in fully-closed position	The position data of a fully-closed valve is saved when the SET/ENT key is pressed after a valve is fully closed using the ▽ key.	Indefinite
		V.H	Valve in fully-opened position	The position data of a fully-opened valve is saved when the SET/ENT key is pressed after a valve is fully opened using the △ key.	Indefinite
		V.AT	Automatic calibration for valve positioning	OFF, ON	OFF

Position-proportional PID control is the control method that maintains the valve position to achieve MV by monitoring MV and the feedback input from the valve.
The feedback input from the valve is sent by a feedback slide (slide rheostat) attached to the valve stem. The relay is controlled to make the valve position correspond to the MV using both the feedback input and control computation result (position-proportional PID control).

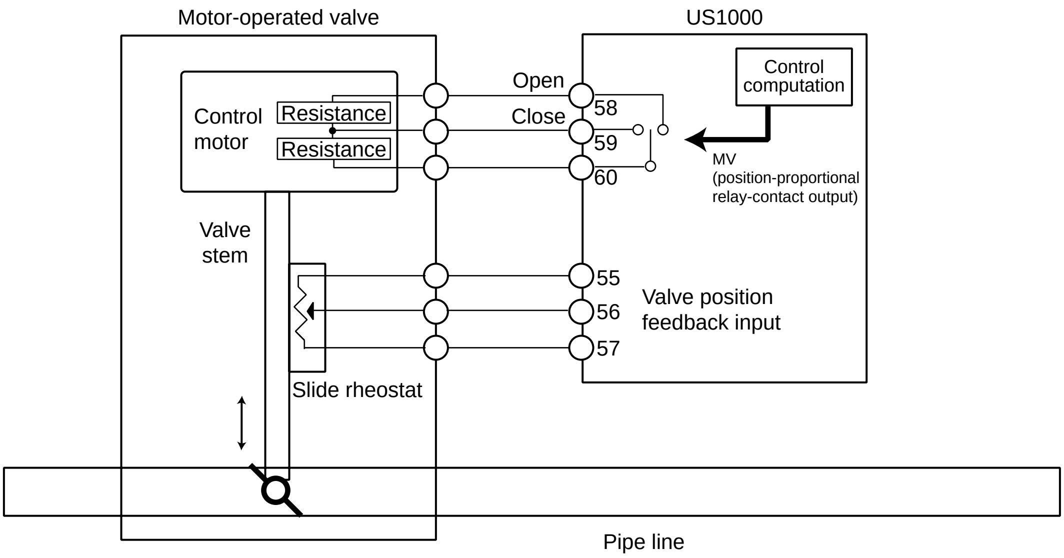


Figure 3.8.5 Controlling the Motor-operated Valve by Position-proportional PID Control

See Also

See section 4.9 "(17) Calibration of valve position (US1000-21 only)" of the separate 'US1000 Digital Indicating Controller' manual, for the operations.

3.9 Parameters for PID Computation

This section describes PID computation and the parameters related to PID computation.

3.9.1 PID Parameters

When the controller uses the zone PID or preset PID function (see Section 3.10, "Parameters for Preset PID and Zone PID"), a maximum of 8 sets of PID parameters can be set. When the controller does not use either of these, only 1.P, 1.I, and 1.D are used.
For heating/cooling computation, parameters n.P, n.I, and n.D, which are described here, are used for the heating-side PID parameters. For the cooling-side PID parameters, n.Pc, n.Ic, and n.Dc are used. These are described in subsection 3.9.2, "Cooling-side PID Parameters for Heating/Cooling Computation."
Individual PID parameters are described here.

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	n.PID (n=1-8)	n.P	Proportional band	0.1 to 999.9%, 0.0 to 999.9% for heating/cooling computation	999.9%
		n.I	Integral time	OFF, 1 to 6000 s	1000 s
		n.D	Derivative time	OFF, 1 to 6000 s	OFF

(1) Proportional Band (n.P)

The control method in which the control output magnitude is proportional to the deviation is called proportional action (P-action). The PV variation span (or deviation), which is expressed as a percentage (%) and is required to change the control output (control computation output) from 0 to 100%, is called the "proportional band." Generally, the output becomes 50% when PV matches SV. The proportional action can remove the vibration from the output, the demerit of ON/OFF action.

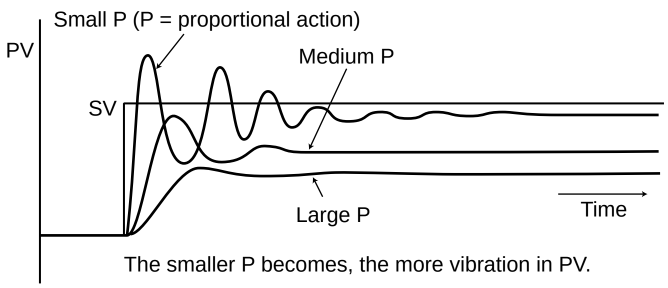


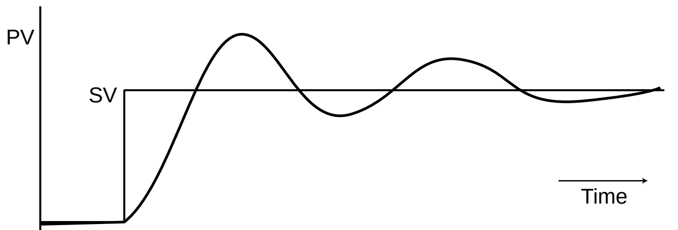
Figure 3.9.1 Proportional Action

TIP

Keep the following points in mind when performing fine adjustment on the proportional band obtained from the auto-tuning function or when you tune the proportional band manually.
- Change the proportional band from a larger to smaller value.
- If cycling appears, it means the proportional band is too small.
- An offset (steady-state deviation) cannot be removed by tuning the proportional band.

(2) Integral Time (n.I)

The function that automatically reduces offsets, that cannot be avoided in principle, using the proportional action, is called an “integral action” (I-action). An integral action continually increases and decreases the output in proportion to the integrated deviation (the product of the deviation span and the deviation duration time). Integral action is generally used in combination with the proportional action. This is referred to as a proportional-plus-integral action (PI-action).
Like a small proportional band, a short integral time results in a vibrational PV.
The vibration derived from an integral action however, has a longer period than that derived from a small proportional band.



An integral time that is too short results in a long period of vibration in PV.

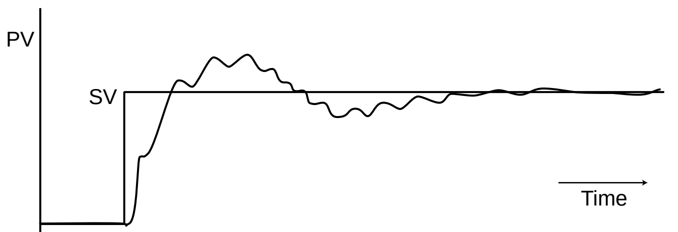
Figure 3.9.2 Integral Action

TIP

Keep the following points in mind when performing fine adjustment on the integral time obtained from the auto-tuning function or when you tune the integral time manually.
- The main purpose is to reduce the offset.
- Change the integral time from a larger to smaller value.
- If the vibration lasts longer than that observed when a small proportional band is used, it means the integral time is too small.

(3) Derivative Time (n.D)

In cases where the controlled process has a large time constant or a long dead time, control based on only the proportional action or proportional-plus-integral action may require a late or excessive corrective action. If attention is paid on whether the deviation is increasing or decreasing and a corrective action is taken earlier, the controllability will improve. Derivative action changes the output in proportion to the differential value (rate of change) of deviation, and the derivative time parameter sets the intensity of the derivative action.
Setting the derivative time parameter n.D at OFF corresponds to derivative time = 0, during which the derivative action does not work. The n.D parameter must be set off for the control of inputs that originally have vibrational characteristics — for example, inputs for prompt response such as pressure and flow rate, and inputs from optical sensors.



A derivative time that is too long results in a short period of vibration in PV.

Figure 3.9.3 Derivative Action

■ Bumpless Tuning

To prevent a bump in MV when the parameter n.P is changed during manual tuning of the PID parameters, the US1000 controller is provided with a function to absorb the effect of n.P changes by an integral action. This function allows for bumpless tuning and is always available regardless of whether there is any parameter setting.

■ Balance-less and Bumpless Operation

To prevent a bump in MV when the operation mode is changed from MAN to AUTO mode, the US1000 controller is provided with a function that absorbs the effects of operation mode changes made by the integral action. A balance-less and bumpless operation is allowed owing to this function and is always available regardless of whether there is any parameter setting.

3.9.2 Cooling-side PID Parameters for Heating/Cooling Computation

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1	n.PID (n=1-8)	n.Pc	Cooling-side proportional band	0.0 to 999.9%	999.9%
		n.Ic	Cooling-side integral time	OFF, 1 to 6000 s	1000 s
		n.Dc	Cooling-side derivative time	OFF, 1 to 6000 s	OFF

For heating/cooling computation, parameters n.P, n.I, and n.D, which are described in subsection 3.9.1, “PID Parameters,” are used for the heating-side PID parameters. The parameters n.Pc, n.Ic, and n.Dc are used for the cooling-side PID parameters.

See Also

Subsection 3.9.1, “PID Parameters,” and note that the functions of n.Pc, n.Ic, and n.Dc are identical to those of n.P, n.I, and n.D.

3.9.3 PID Control Mode

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
S.LP1 S.LP2	CTL	MOD	PID control mode	0: Batch control; 1: Fixed point control	1

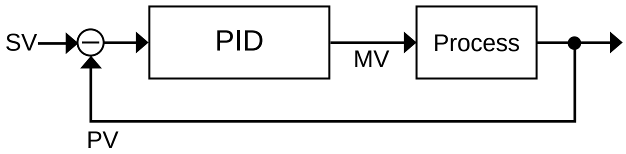
The US1000 controller has two modes of PID control: batch control mode and fixed-point control mode. In these control modes, the controller uses different PID control equations for both the CAS and AUTO operation modes

●Batch Control Mode (follow-up control)
- In CAS mode: Derivative-of-deviation PID control (Good follow-up capability at SV change)
- In AUTO mode: PV-derivative PID control (Follow-up capability at SV change and good stability)

●Fixed-point Control Mode
- In CAS mode: PV-derivative PID control (Follow-up capability at SV change and good stability)
- In AUTO mode: Proportional-plus-derivative PID control (Good stability because of small MV variation at SV change)

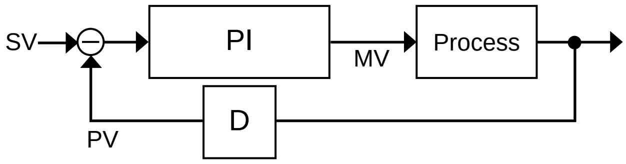
■ Block Diagram for Each PID Control Equation

Derivative-of-deviation PID control



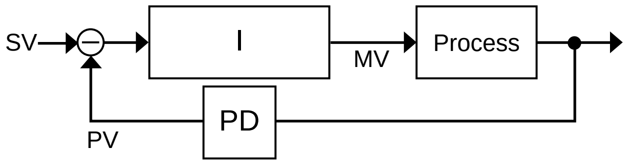
Since derivation is performed on deviation, a better follow-up capability for the SV change is obtained.

PV-derivative PID control (D-PI control)



Since derivation is performed on PV, a smaller variation in the output resulting from the SV change is obtained.
This method is suitable in situations where SV is not changed very often.

Proportional-plus-derivative PID control (PD-I control)



Since only the integral action works at the SV change, there is no sudden change in MV even when SV is changed in steps from a personal computer or other device. This control method produces stable control, but its follow-up capability is not so good. This method is used for general fixed-point control.

3.9.4 Anti-reset Windup

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
S.LP1 S.LP2	CTL	AR	Anti-reset windup	AUTO; 50.0 to 200.0%	AUTO

If a large deviation lasts for a long time, MV will reach its maximum level because the integral action increases MV to its high limit. If MV stays at this level even after PV reaches SV, an overshoot may result. To prevent this, the controller stops the PID computation and holds MV when it reaches its limit. This function is called “anti-reset windup.”

PID computation is resumed when the deviation ratio obtained by the following expression has fallen below the value of the parameter AR.

Deviation ratio = | PV - SV |/Proportional band (n.P)×100

When parameter AR is set at AUTO, the US1000 automatically determines the point at which to resume PID computation.

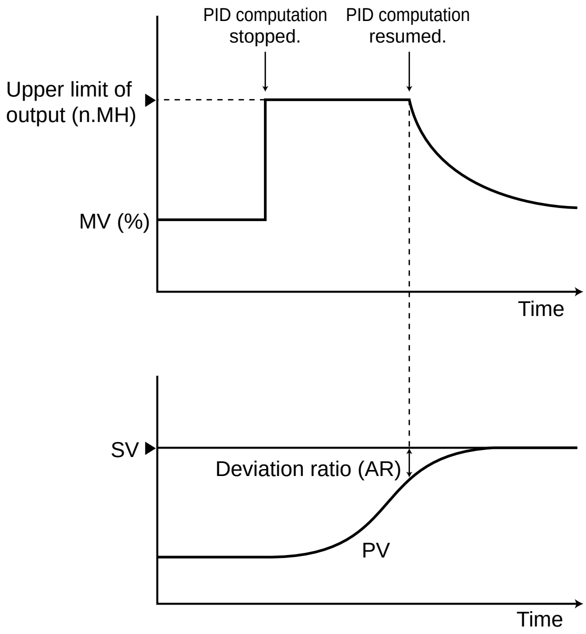


Figure 3.9.5 Anti-reset Windup Action

3.9.5 Manual Reset

The manual reset parameter n.MR can be set only when the integral time (n.I) is set off. When the integral time is set off and control is performed by only a proportional action or a proportional-plus-derivative action, there will be an offset (steady-state deviation) — a phenomenon in which the deviation between PV and SV remains the same every time the process status changes. The parameter used to reduce (reset) this offset manually is the manual reset parameter n.MR. (The function that resets offsets automatically is the integral action.)
The manual reset parameters available are 1.MR to 8.MR, but the controller uses 1.MR only except when the preset PID or zone PID function is used.

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	n.PID (n=1-8)	n.MR	Manual reset	-5.0 to 105.0%	50%

3.9.6 Direct/Reverse Action of Control

Direct action: Control action that increases MV to achieve a positive deviation (PV > SV) and reduces MV to achieve a negative deviation (PV < SV)

Reverse action: Control action that reduces MV to achieve a positive deviation and increases MV to achieve a negative deviation

Parameters to switch between the direct or reverse action are provided as 1.DR to 8.DR, but the controller uses only 1.DR except when the preset PID or zone PID function is used.

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	n.PID (n=1-8)	n.DR	Direct/reverse action switchover	0: Reverse action; 1: Direct action	0

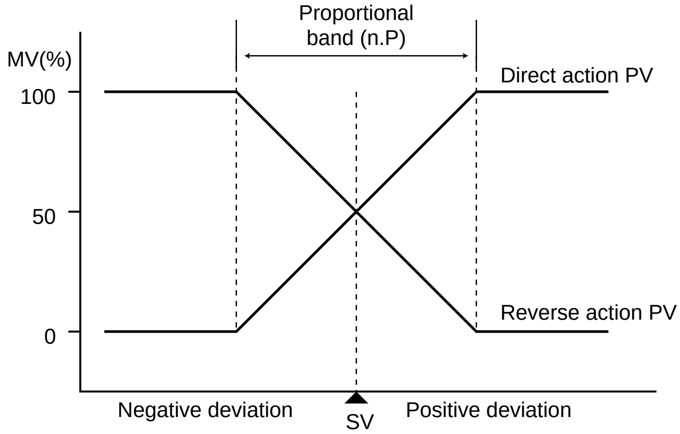


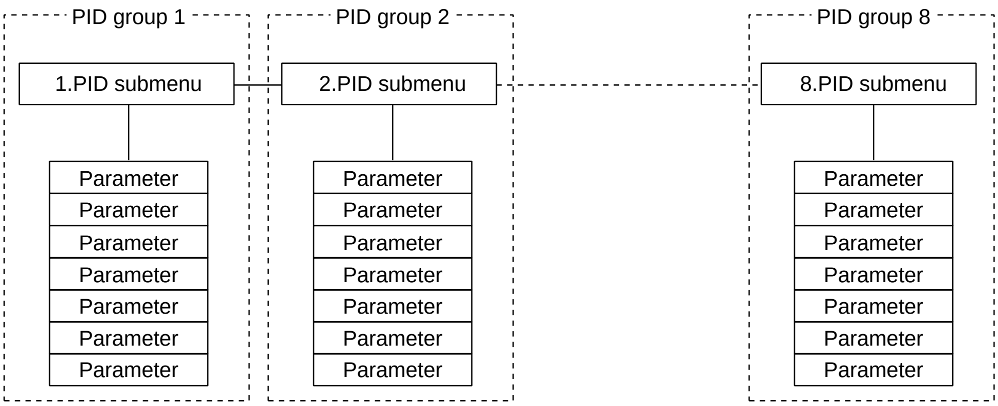
Figure 3.9.5 Direct Action and Reverse Action

3.10 Parameters for Preset PID and Zone PID

The US1000 controller can have multiple groups of preset PID parameters and switches between these parameter groups according to the controlled process condition. This function is called a "preset PID" or "zone PID" depending on the switching method.
Preset PID is a function in which the operator switches PID groups by setting the parameter SVNO (SV number selection).
Zone PID is a function in which PID groups are switched automatically corresponding to the PV ranges set by the zone PID reference point parameters n.RP.

TIP

A PID group denotes a set of parameters that belong to the operation parameter submenus 1.PID to 8.PID. Each PID group has one target setpoint (SV), four alarm setpoints, and one of each PID parameter and other parameters. A maximum of 8 sets of PID groups can be used per control loop, and each parameter is numbered from 1 to 8. These numbers are called either a "PID group number" or an "SV number."



3.10.1 Preset PID

Select either the preset PID or zone PID by setting the parameter PPID. To select neither of them for use, set 0.

0: Selects neither the preset PID nor the zone PID for use. With this setting, the controller displays only one PID group (the parameters under 1.PID submenu) and performs control computation using one set of PID parameters for any SV value.
1: Selects the preset PID for use. In this case, the PID group number is specified by setting parameter SVNO (SV number selection). Refer to subsection 3.10.2, "SV Number Selection for Preset PID."
2: Selects the zone PID for use. In this case, set the zone PID reference point parameters n.RP prior to operation. Refer to subsection 3.10.3, "Zone PID."

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMLP	C.CTL	PPID	Preset PID function selection	0: Disabled Preset PID 1: SV number selection 2: Zone PID	0

3.10.2 SV Number Selection for Preset PID

Parameter SVNO is used for switching PID group numbers (“SV number” hereafter) when the preset PID function is used. The SV number can also be switched by contact inputs. (Refer to Section 3.15, “Parameters for Contact Input.”) The switching by contact inputs takes priority over switching by parameter setting. The SV number can be switched any time during operation. When the SV number is switched, SV changes at the preset SV rate-of-change. (Refer to subsection 3.7.4, “SV Rate-of-Change (Ramp Rate).”)

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
MODE	—	SVNO	SV number selection	1 to 8	1

NOTE

To specify a PID group number (SV number) with parameter SVNO, be sure to turn off all the contact inputs registered to parameters SV.B0 to SV.B3. (Refer to Section 3.15, “Parameters for Contact Input.”)

See Also

Set USER display parameter U.SVN to ON for displaying the selected SV number during operations. See section 5.1 of the separate ‘US1000 Digital Indicating Controller’ manual for information about the USER display.

3.10.3 Zone PID

To use the zone PID function, set the PV ranges for PID group switching using the zone PID reference point parameters beforehand. Hysteresis at switching can also be set. It is also possible to combine switching over PV ranges and switching according to deviation.

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	n.PID n=1-6	n.RP	Zone PID reference point	EU (0.0 to 100.0%) provided that 1.RP≤2.RP≤3.RP≤ 4.RP≤5.RP≤6.RP	EU (100.0%)
	7.PID	RHY	Zone PID hysteresis	EUS (0.0 to 10.0%)	EUS (0.5%)
	8.PID	RDV	Zone PID reference deviation	OFF, EUS (0.0 to 100.0%)	OFF

(1) Zone PID Reference Point

Up to 6 reference points for zone PID can be set within a measurement range. As shown in the figure below, 7 zones are created by setting 6 reference points between the minimum value (EU (0%)) and the maximum value (EU (100%)) of the PV range. A PID group is assigned to each zone.

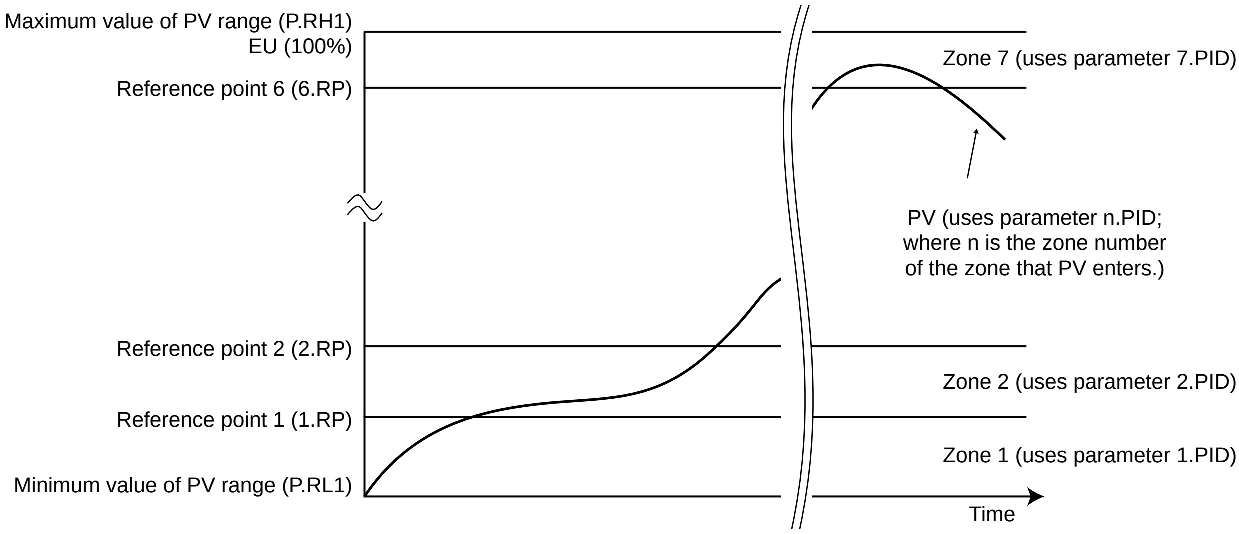


Figure 3.10.1 Zone PID Reference Points

(2) Zone PID Hysteresis

Hysteresis for zone switching can be set around reference points. The hysteresis is set using the parameter RHY under the 7.PID submenu and is applied, in common, to all of the reference points. The range of setting is 0.0 to 10.0% of the instrument range span.

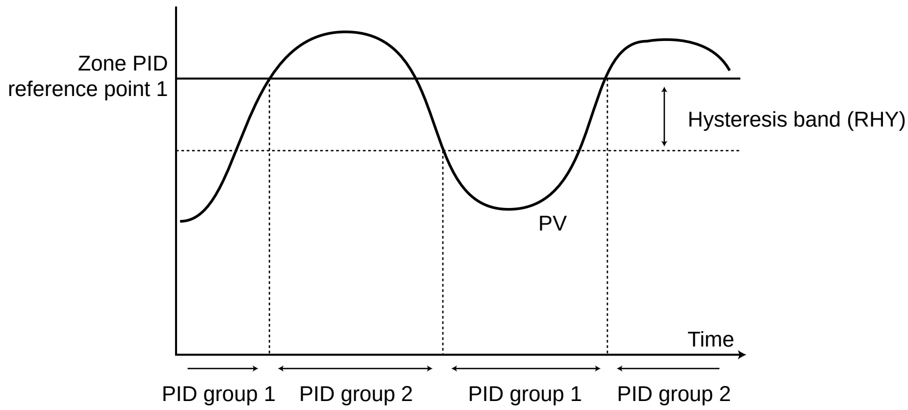


Figure 3.10.2 Zone PID Hysteresis

(3) Zone PID Reference Deviation

If the deviation (|PV - SV|) grows larger than the reference deviation during the zone PID operation, the controller stops using the PID group being used at that time (corresponding to the zone) and restarts operation using the parameters under the 8.PID submenu.

For example, by setting the proportional band parameter of 8.PID to a small value (large proportional gain), PV will be able to reach SV quickly because the PID group automatically switches to 8.PID when deviation grows large.
When the deviation is reduced to a smaller value than the reference deviation, the controller changes back to the operation with the PID group of the zone that corresponds to the current PV value.
For example, assume that the controller's measurement range is 0 to 1000°C. An RDV setting of 1% will make a reference deviation of 10°C.
Assuming that SV is 500°C, which is in zone 2, the RDV upper limit will be 510°C and the RDV lower limit, 490°C. When PV goes out of this reference deviation range, the controller stops using parameter 2.PID and starts using parameter 8.PID.

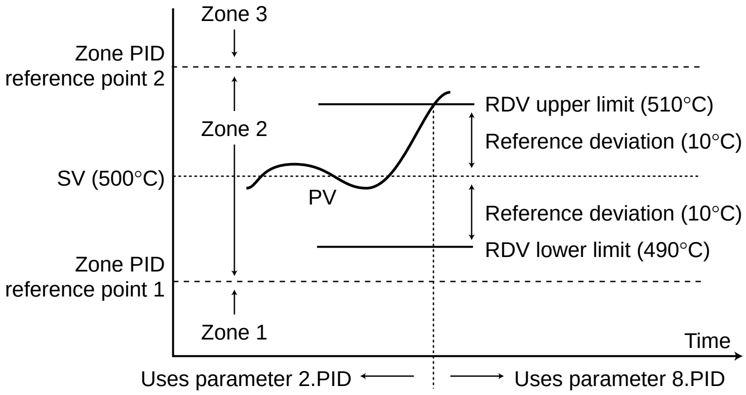


Figure 3.10.3 Zone PID Reference Deviation

See Also

Set USER display parameter U.1PI or U.2PI to ON for displaying the used PID group number during operations.
See section 5.1 of the separate 'US1000 Digital Indicating Controller' manual for information about the USER display.

3.11 Parameters for Auto-tuning

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	PAR	AT	Auto-tuning selection	OFF, 1 to 8: Individual execution among PID groups, 9: Collective execution for 1 to 8 PID groups. When PPID parameter is set at 0: OFF or 1.	OFF

WARNING

Do not use the auto-tuning function for the following processes.

- Fast-response processes such as flowrate and pressure.
- Processes in which a severe change in output, even if temporary, is undesirable.
- Processes in which any severe stress on the operating terminal is undesirable.
- Processes in which product quality can be adversely affected if PV fluctuates beyond its allowable range.

Auto-tuning is a function in which the US1000 controller itself obtains and sets PID parameter values automatically. Auto-tuning is unavailable in ON/OFF control.
The US1000 controller's auto-tuning is based on a step response method.
Setting the operation parameter AT to 1 starts auto-tuning. The controller turns MV on and off in steps three times and calculates suitable values of proportional band, integral time, and derivative time from the response.
When auto-tuning is running, the controller shows an operation display with the LED lamps at both ends of the MV bar flashing (see Figure 3.11.2).

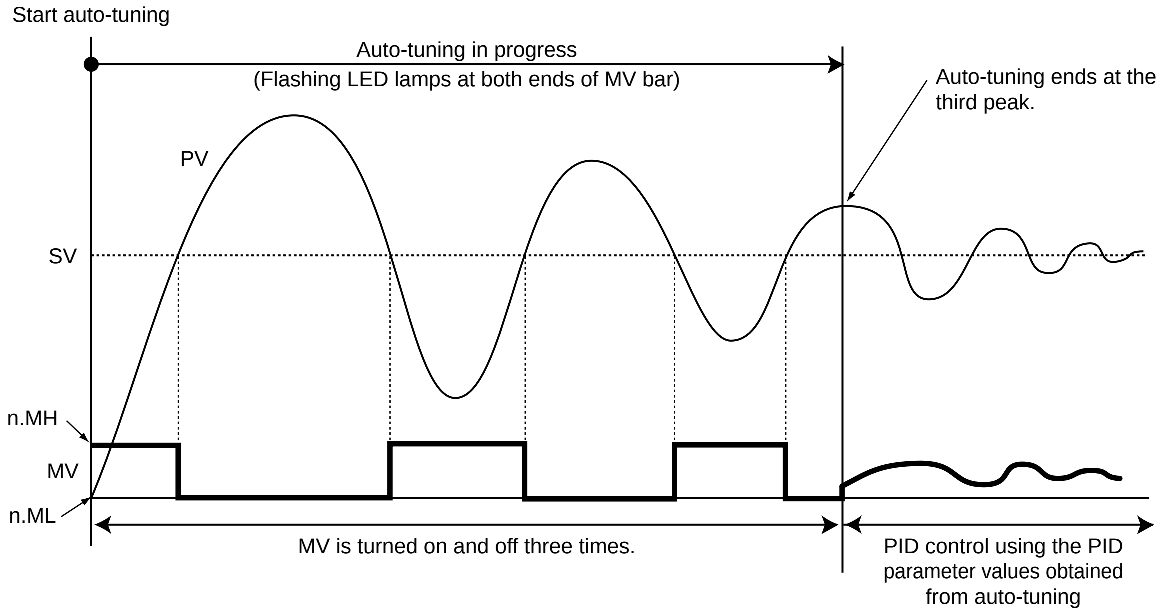


Figure 3.11.1 Operation of Auto-tuning

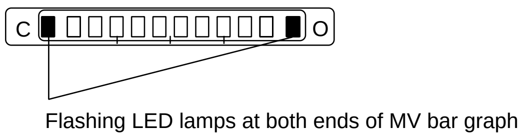


Figure 3.11.2   Display during Auto-tuning

The step MV variation of auto-tuning is regulated within the upper and lower limits of output (operation parameters n.MH and n.ML). The SV change made during auto-tuning will be ignored and the SV at the start of auto-tuning is maintained. The SV rate-of-change function (operation parameters UPR and DNR) does not work while auto-tuning is running.

■ Auto-tuning Operations under Preset PID and Zone PID

Operation of auto-tuning differs as described below depending on the setting of setup parameter PPID. (Refer to Section 3.10, “Parameters for Preset PID and Zone PID.”)

(1) When only one set of PID parameters is used (PPID = 0)

- Auto-tuning can be executed only for PID group 1.
- The setting of parameter AT is either OFF or 1.
- The SV at the start of auto-tuning is used for auto-tuning.
- The PID values obtained from auto-tuning will be stored to 1.P, 1.I, and 1.D.

(2) When preset PID is being executed (PPID = 1)

- Auto-tuning is executed for the PID group of the number specified to parameter AT, regardless of the PID group number set with parameter SVNO.
- The SVs set for each PID group with parameter n.SV are used for auto-tuning.
- The PID values obtained from auto-tuning will be stored to the PID parameters of the PID group number specified to parameter AT. (For example, when AT is set at 3, the values of 3.P, 3.I, and 3.D will be obtained.)
- When parameter AT is set at 9, auto-tuning is executed for PID groups 1 to 8 in succession, and the PID values obtained are stored to the PID parameters of the respective groups.

(3) When zone PID is being executed (PPID = 2)

WARNING

There is a possibility that the controlled process will be damaged when PV reaches the limit of the process. To prevent this, set the reference points and the maximum value of the PV range (P.RHn) so that the PV does not exceed the limit of the controlled process, before starting auto-tuning with AT set at 9 under zone PID.

- Regardless of the current zone number, auto-tuning is executed for the PID group of the number specified to the AT parameter.
- The SV at the start of auto-tuning is used for auto-tuning. However, when parameter AT is set at 9, the SV used for auto-tuning will be as shown in Figure 3.11.3. For PID groups 1 to 7, auto-tuning is performed taking the intermediate value of each zone for SV. For PID group 8, auto-tuning is performed taking the intermediate value of the maximum and minimum values of the PV range for SV.
- The PID values obtained through auto-tuning will be stored to the PID parameters of the PID group number specified to parameter AT. (For example, when AT has been set at 3, the values of 3.P, 3.I, and 3.D will be obtained.) When parameter AT is set at 9, the obtained PID values will be stored to the PID parameters of PID groups 1 to 8.
- When the controller is set up for heating/cooling computation, auto-tuning will not be performed for the zone where on/off control is specified (when the proportional band n.P or n.Pc is set at 0) but transfer to the next zone.

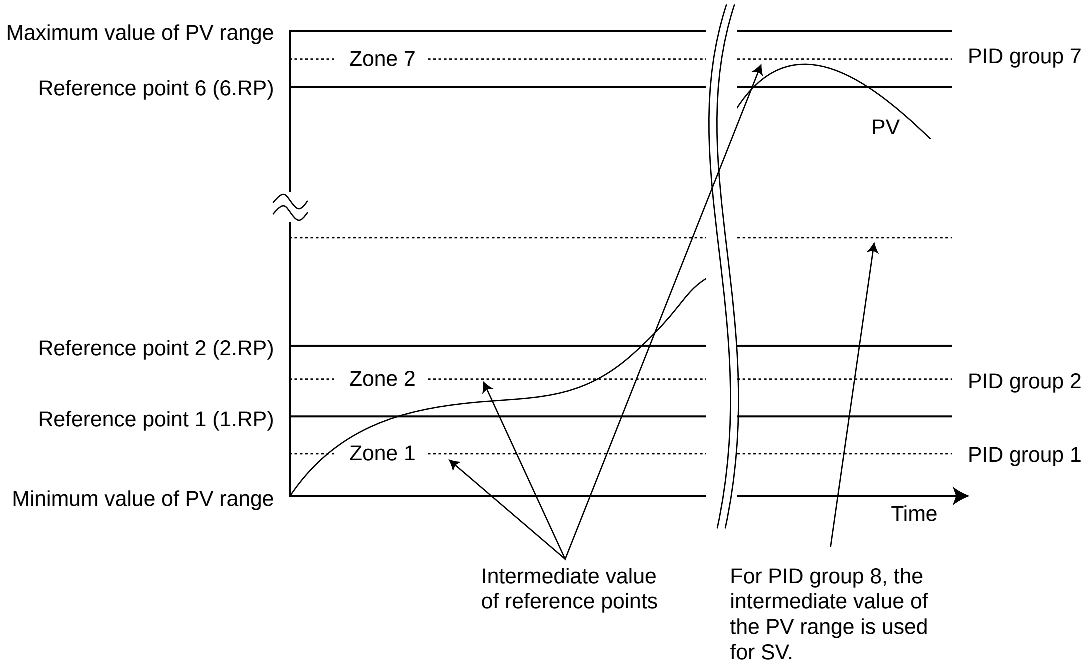


Figure 3.11.3 Auto-tuning When Setting AT to 9 under Zone PID

TIP

- At the time of shipping, the reference points are set at the same value as the maximum value of the PV range (EU (100%)). To execute auto-tuning under zone PID, change the reference point settings to proper values.
- In either of the following cases, set the maximum and minimum values of the PV range so that the intermediate value of each zone will be appropriate for auto-tuning — for example, set the minimum value of the PV range to room temperature.
  - Reference point 1 and the minimum value of the PV range differ greatly.
  - The uppermost reference point and the maximum value of the PV range differ greatly.

3.12 Parameters for MV Output

This section describes the range of analog output used for MV or the retransmission output, the parameters that set the upper and lower limits of MV, and other items. The MV output type is determined by the MV selection parameter MVS1 or MVS2. (Refer to Section 3.8, “Parameters for Control Computation.”)

3.12.1 Analog Output Type

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
USMD	OUT	AO1	Analog output-1 type for OUT1A terminal	0: 4 to 20 mA; 1: 0 to 20 mA; 2: 20 to 4 mA; 3: 20 to 0 mA	0
		AO2	Analog output-2 type for OUT2A terminal		0
		AO3	Analog output-3 type for OUT3A terminal	0: 1 to 5 V; 1: 0 to 5V; 2: 5 to 1 V; 3: 5 to 0 V	0

These parameters are used to set the output ranges of the OUT1A, OUT2A, and OUT3A terminals. A setting of 2 or 3 makes the output have a negative relationship with the manual operation and control computation results, that is, the output decreases as the controller’s internal value increases. This differs from the reversed MV display and operation function, in which the MV bar display and the direction of increase/decrease of MV operation key remain normal. (Refer to subsection 3.12.5, “Reversed Display and Operation of MV.”)

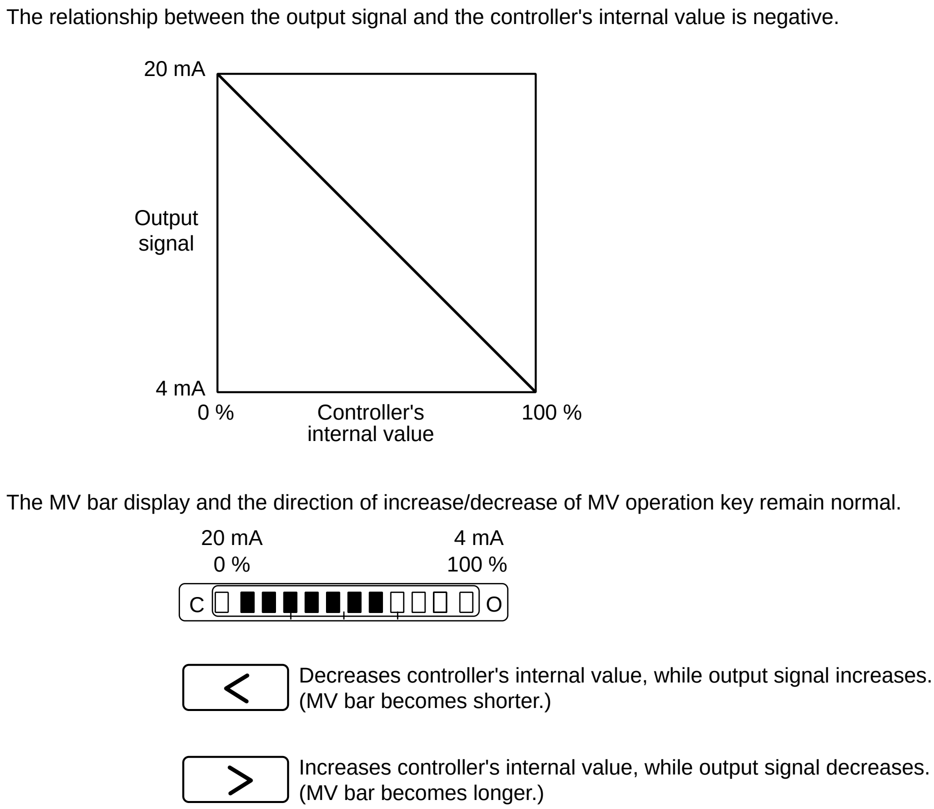


Figure 3.12.1 Operation of Reversed Output (when AO1 or AO2 is set to 2)

3.12.2 Output Limiter

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP2	n.PID (n=1-8)	n.MH	Upper limit of output	n.ML +0.1% to 105.0%; 0.0 to 105.0% for heating-side output limit in heating/cooling computation	100.0%
		n.ML	Lower limit of output	-5.0 % to n.MH - 0.1%; 0.0 to 105.0% for cooling-side output limit in heating/cooling computation	0.0%; heating/cooling computation: 100.0%

Upper and lower limits of MV can be set when operation mode is AUTO or CAS. Although parameters for output limiter are provided as 1.MH to 8.MH and 1.ML to 8.ML, use only 1.MH and 1.ML except when preset PID or zone PID is to be used.

NOTE

When the controller is set up for heating/cooling computation, the functions of n.MH and n.ML are as follows:

n.MH: Upper limit of heating-side output

n.ML: Upper limit of cooling-side output

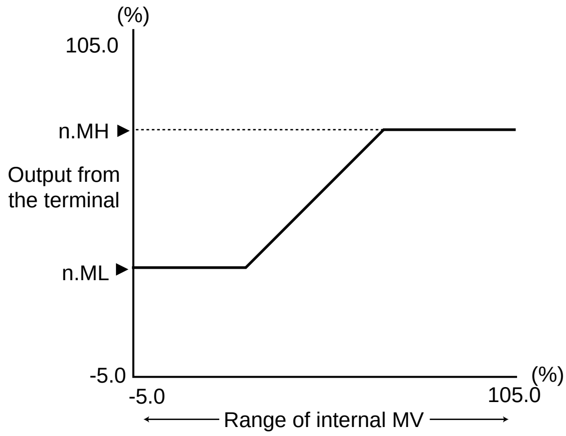


Figure 3.12.3 Output Limiter

■ Shutdown Function

This function fully closes a control valve beyond its positioner deadband. This function is available when the output type is current of 4 to 20 mA and the operation mode is MAN.

When output is reduced using the ▽ key until “SHUT” appears on the SV digital display, the shutdown function starts to operate and the output falls to approx. 0.0 mA.

3.12.3 Output Rate-of-change Limiter

The output rate-of-change limiter prevents a sudden change in MV.
While the output rate-of-change limiter is active, the derivative action is canceled. It is thus necessary to use this limiter considering the effect of the cancellation when the control involves a derivative action.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
S.LP1 S.LP2	CTL	MVR	Output velocity limiter	OFF, 0.1 to 100.0%/s	OFF

The following figure illustrates the change in MV when the output rate-of-change limiter is set at 2%/second. Output changes linearly at a rate of 2% per second.

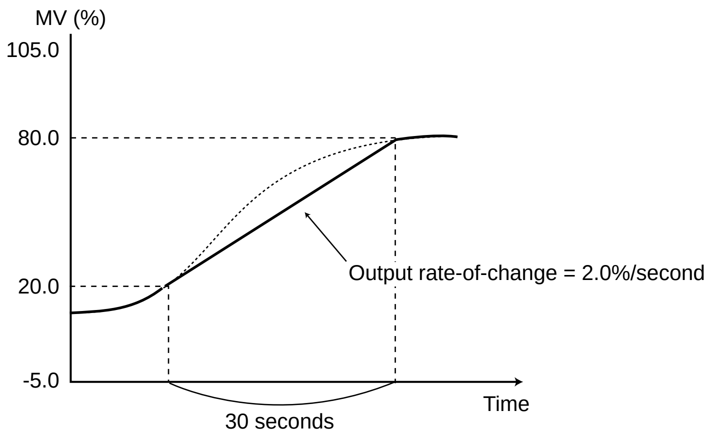


Figure 3.12.3 Output Rate-of-change Limiter

3.12.4 Preset MV

In the following situations, the controller outputs the preset MV value as MV.

- The contact input for the RUN/STOP switchover has switched to the STOP status and the operation mode is AUTO or CAS.
- An input burnout or an abnormality in an analog/digital conversion circuit has occurred during the AUTO mode or CAS mode operation.
- The controller has been powered on or recovered from a power failure when parameter R.MD is set at COLD. (Refer to Section 3.1, "Parameters that Determine the Action at Power-on and Power Recovery.")

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
0.LP1 0.LP1	n.PID (n=1-8)	n.PM	Preset MV	-5.0 to 105.0%	-5.0%
		n.PMc	Cooling-side preset MV	-5.0 to 105.0%	0.0%

NOTE

A preset output value is free from the limitations of the upper and lower limits of output. (Refer to subsection 3.12.2, "Output Limiter.")

3.12.5 Reversed Display and Operation of MV

This function is used to open/close a valve with a reverse key operation. Setting the parameter RVOP to ON reverses the MV bar's direction of increment when manually operated. As shown in Figure 3.12.4, the right end of the MV bar becomes the 0% position, and the left end, the 100% position. The [<] key (normally the MV decrease key) adopts the function of increasing MV, and the [>] key (normally the MV increase key) adopts the function of decreasing MV. The OC marks at the ends of the MV bar can be reversed using the spare OC mark labels supplied as necessary with the controller. As shown in Figure 3.12.5, when the parameter AOn (analog output type) is set at 2 or 3, the bar display and the direction of manual operation remain normal, and the correspondence between the controller's internal value and the output signal is reversed. On the other hand, when RVOP is set at ON, the bar display and the direction of manual operation are reversed, and the correspondence between controller's internal value and the output signal remains normal.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
USMD	OUT	RVOP	Reverse display and operation of MV	OFF, ON	OFF

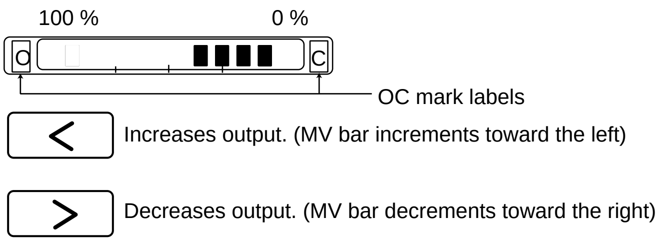


Figure 3.12.4 Display in Reversed Display and Operation of MV

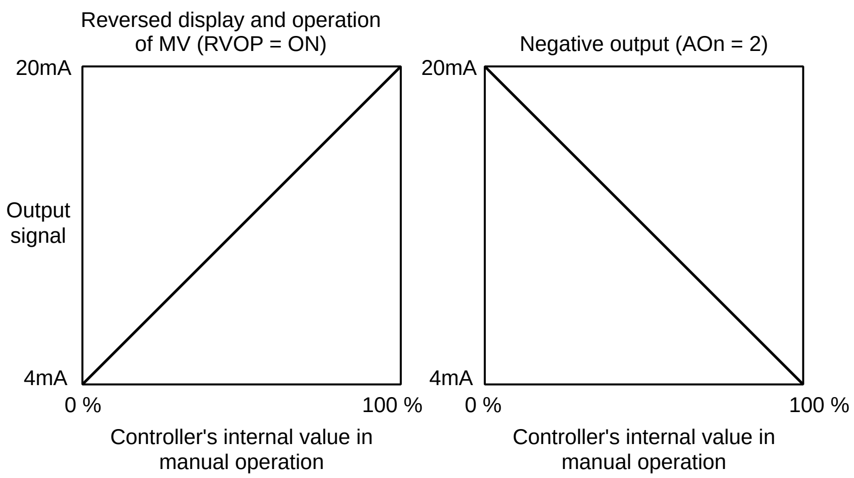


Figure 3.12.5 Difference between Reversed Display and Operation of MV and Reversed Output

3.13 Parameters for Retransmission Output

The retransmission output function is a function which outputs the controller's PV, SV, or MV in an analog signal (standard signal) to a device such as a recorder. The output range of the analog signal is set using parameter AOn. (Refer to subsection 3.12.1.)

3.13.1 Type of Retransmission Output

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMLP	RET	RET1	Retransmission output-1 type	OFF: Disabled; 1: PV1; 2: SV1; 3: MV1; 4: PV2; 5: SV2; 6: MV2	3
		RET2	Retransmission output-2 type	OFF: Disabled; 1: PV1; 2: SV1; 3: MV1; 4: PV2; 5: SV2; 6: MV2	2
		RET3	Retransmission output-3 type	OFF: Disabled; 1: PV1, 2: SV1, 3: MV1, 4: PV2, 5: SV2, 6: MV2	1

The terminal which can be used for retransmission output differs depending on the controller's model and suffix code and the type of control computation in use. Refer to the block diagrams in chapter 2 and confirm the code and number of the terminal that can be used for retransmission output. Then set the following parameters.

- To use the OUT1A terminal for the retransmission output: RET1, RTH1, RTL1
- To use the OUT2A terminal for the retransmission output: RET2, RTH2, RTL2
- To use the OUT3A terminal for the retransmission output: RET3, RTH3, RTL3

3.13.2 Scale of Retransmission Output

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMLP	RET	RTH1	Maximum value of retransmission output-1 scale	RET1 = 1/2/4/5: RTL1 + 1 digit to EU (100.0%) *1 RET1 = 3/6: RTL1 + 1 digit to 100.0%*1	100.0
		RTL1	Minimum value of retransmission output-1 scale	RET1 = 1/2/4/5: EU (0.0%) to RTH1 - 1 digit *1 RET1 = 3/6: 0.0% to RTH1 - 1 digit *1	0.0
		RTH2	Maximum value of retransmission output-2 scale	RET2 = 1/2/4/5: RTL2 + 1 digit to EU (100.0%) *1 RET2 = 3/6: RTL2 + 1 digit to 100.0% *1	P.RH1
		RTL2	Minimum value of retransmission output-2 scale	RET2 = 1/2/4/5: EU (0.0%) to RTH2 - 1 digit *1 RET2 = 3/6: 0.0% to RTH2 - 1 digit *1	P.RL1
		RTH3	Maximum value of retransmission output-3 scale	RET3 = 1/2/4/5: RTL3 + 1 digit to EU (100.0%) *1 RET3 = 3/6: RTL3 + 1 digit to 100.0% *1	P.RH1
		RTL3	Minimum value of retransmission output-3 scale	RET3 = 1/2/4/5: EU (0.0%) to RTH3 - 1 digit *1 RET3 = 3/6: 0.0% to RTH3 - 1 digit *1	P.RL1

*1 "+ 1 digit" means to add 1 digit to the least significant value of the engineering unit.
"- 1 digit" means to subtract 1 digit from the least significant value of the engineering unit.
For example, when RTL1 = 15°C, RTL1 + 1 digit makes 15.1°C.

The terminal which can be used for the retransmission output differs depending on the controller model and suffix code and the type of control computation in use. Set the necessary parameters by referring to subsection 3.13.1, "Type of Retransmission Output." Defaults are the maximum and minimum values of the PV range. (Refer to subsection 3.2.2, "Analog Input Range and PV Range.")

3.14 Parameters for Alarm Output

Alarm outputs have been already assigned to the contact outputs as factory-set defaults. (Refer to Chapter 2.) Normally, these assignments need not be changed.
The assigned alarm outputs can be set up in the following 3 steps.

(1) Set alarm type, hysteresis, and other parameters for each of alarm outputs 1 to 4.

Refer to subsection 3.14.1, "Alarm Types."
The factory-set defaults of alarm types are the following.

- Alarm type of alarm output 1: PV high limit
- Alarm type of alarm output 2: PV low limit
- Alarm type of alarm output 3: PV high limit
  (This alarm can be used as a high-high limit, or a secondary high-limit alarm.)
- Alarm type of alarm output 4: PV low limit
  (This alarm can be used as a low-low limit, or a secondary low-limit alarm.)

(2) Set an alarm setpoint for each of alarm outputs 1 to 4.

Refer to subsection 3.14.2, "Alarm Setpoint."

When an alarm occurs, the ALM lamp on the front panel lights up. To display the occurring alarm output numbers on the digital display on the front panel, make the following setting in step (3).

(3) Register the "loop-1 alarm" or "loop-2 alarm" to a USER display.

Refer to subsection 3.18.1, "USER Display" or Section 5.1, "Registering Auxiliary Operation Displays (USER Displays)" of the separate instruction manual "US1000 Digital Indicating Controller" (IM 5D1A01-01E).

3.14.1 Alarm Types

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
S.LP1 S.LP2	ALM	AL1	Alarm 1 type	OFF, 1 to 29 (see section 4.7)	1
		AL2	Alarm 2 type	OFF, 1 to 29 (see section 4.7)	2
		AL3	Alarm 3 type	OFF, 1 to 29 (see section 4.7)	1
		AL4	Alarm 4 type	OFF, 1 to 29 (see section 4.7)	2
		HY1	Alarm 1 hysteresis	EUS (0.0 to 100.0%), MV alarm: 0.0 to 100.0%	EUS (0.5%), MV alarm: 0.5%
		HY2	Alarm 2 hysteresis		
		HY3	Alarm 3 hysteresis		
		HY4	Alarm 4 hysteresis		
		PVR.T	PV velocity alarm duration time	1 to 9999 s	1 s
		AMD	Alarm mode*1	0: Always enabled 1: Disabled in STOP mode 2: Disabled in STOP or MAN mode 3: 8 alarms & always enabled 4: 8 alarms & disabled in STOP mode 5: 8 alarms & disabled in STOP or MAN mode	0

*1 The alarm mode parameter AMD under the S.LP2 main menu can only be set as 0, 1, or 2; it cannot be set to 3, 4, or 5.

Set the alarm type, hysteresis, and other parameters for each of alarm outputs 1 to 4.

The various alarm types are listed below.

Alarm type	Setting	Alarm type	Setting
PV high limit	1	PV high limit with waiting action	11
PV low limit	2	PV low limit with waiting action	12
High limit deviation	3	High limit deviation with waiting action	13
Low limit deviation	4	Low limit deviation with waiting action	14
Deviation of high limit passive	5	Deviation of high limit passive with waiting action	15
Deviation of low limit passive	6	Deviation of low limit passive with waiting action	16
Deviation of high and low limits	7	Deviation of high and low limits with waiting action	17
Deviation within high and low limits	8	Deviation within high and low limits with waiting action	18
PV high limit passive	9	PV high limit passive with waiting action	19
PV low limit passive	10	PV low limit passive with waiting action	20

Alarm type	Setting
SV high limit	21
SV low limit	22
MV high limit	23
MV low limit	24
PV velocity alarm	25
PV velocity alarm passive	26
Self-diagnostic alarm	27
Self-diagnostic alarm passive	28
FAIL passive	29

● "Passive" Alarms

Passive alarms turn the contact OFF when the alarm occurs, and ON when normal.
Other alarms (active alarms) turn the contact ON when the alarm occurs, and OFF when normal.

● Alarms "With Waiting Action"

Alarms numbered 11 to 20 are alarms "with a waiting action." These alarms do not issue alarms after the following events until the normal state is achieved.

- The power is turned on, the power is recovered from the power failure, SV is changed, the SV number is switched, or the alarm type is changed.

The following figure shows the operation of an alarm with the waiting action.

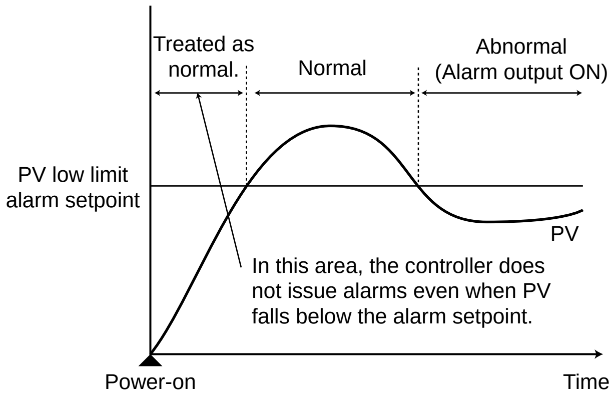
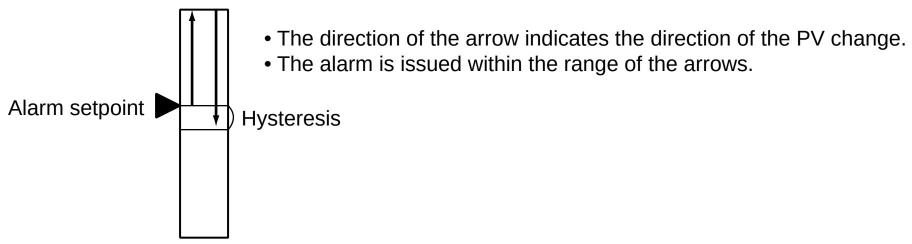


Figure 3.14.1 Alarm with Waiting Action

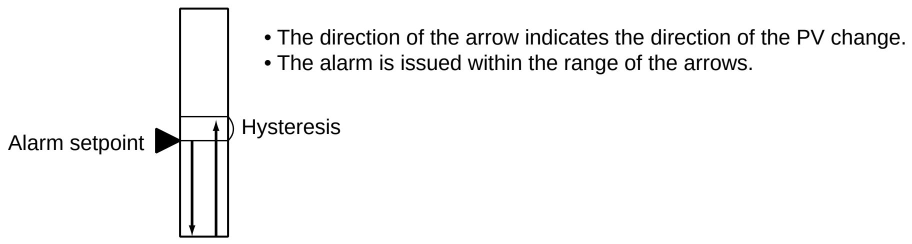
(1) PV high limit alarm (Setting: 1, 9, 11, 19)

This alarm is issued when PV rises to the alarm setpoint or above. The alarms numbered 9 and 19 are passive, and those numbered 11 and 19 have the waiting action.



(2) PV low limit alarm (Setting: 2, 10, 12, 20)

This alarm is issued when PV falls to the alarm setpoint or below. The alarms numbered 10 and 20 are passive, and those numbered 12 and 20 have the waiting action.



(3) High limit deviation alarm (Setting: 3, 5, 13, 15)

This alarm is issued when the deviation (PV - SV) increases to the alarm setpoint or more. The alarms numbered 5 and 15 are passive, and those numbered 13 and 15 have the waiting action.
(Figure 3.14.2)

(4) Low limit deviation alarm (Setting: 4, 6, 14, 16)

This alarm is issued when the deviation (SV - PV) increases to the alarm setpoint or more. The alarms numbered 6 and 16 are passive, and those numbered 14 and 16 have the waiting action.
(Figure 3.14.2)

(5) Deviation of high and low limits alarm (Setting: 7, 17)

This alarm is issued when the deviation (SV - PV or PV - SV) increases to the alarm setpoint or more. The alarm numbered 17 has the waiting action.
(Figure 3.14.2)

(6) Deviation within high and low limits alarm (Setting: 8, 18)

This alarm is issued when the deviation (SV - PV or PV - SV) is within the alarm setpoints. The alarm numbered 18 has the waiting action.
(Figure 3.14.2)

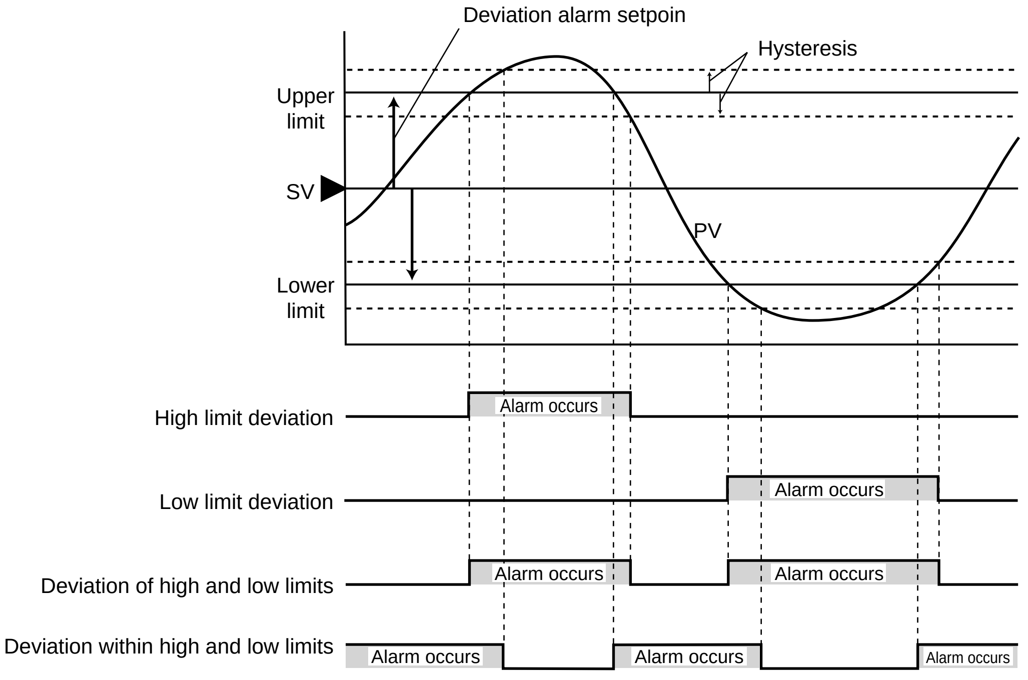
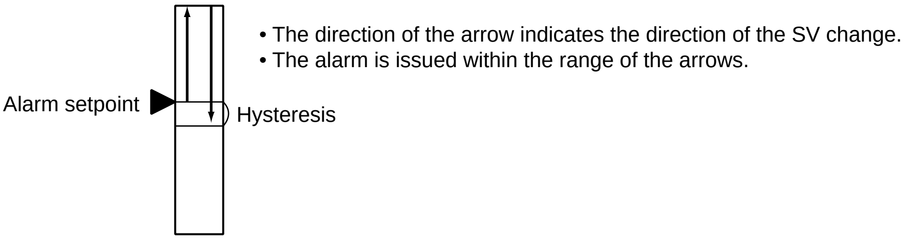


Figure 3.14.2 Deviation Alarms

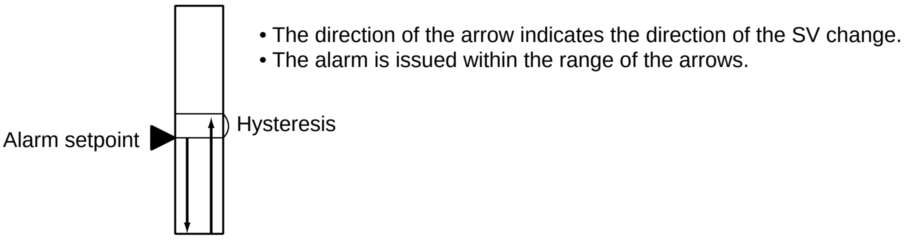
(7) SV high limit alarm (Setting: 21)

This alarm is issued when SV rises to the alarm setpoint or above.



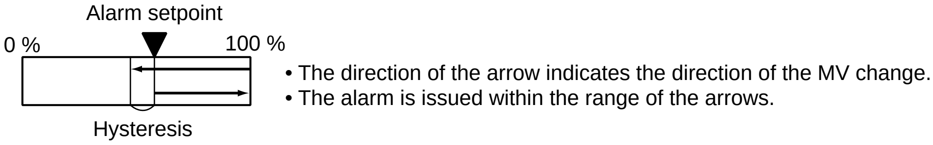
(8) SV low limit alarm (Setting: 22)

This alarm is issued when SV falls to the alarm setpoint or below.



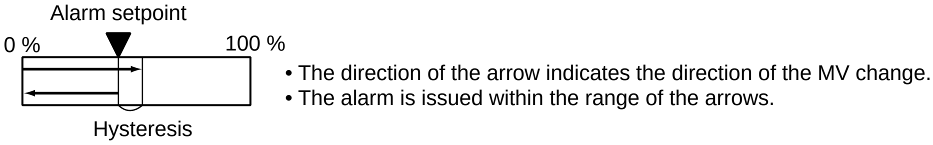
(9) MV high limit alarm (Setting: 23)

This alarm is issued when MV rises to the alarm setpoint or above.



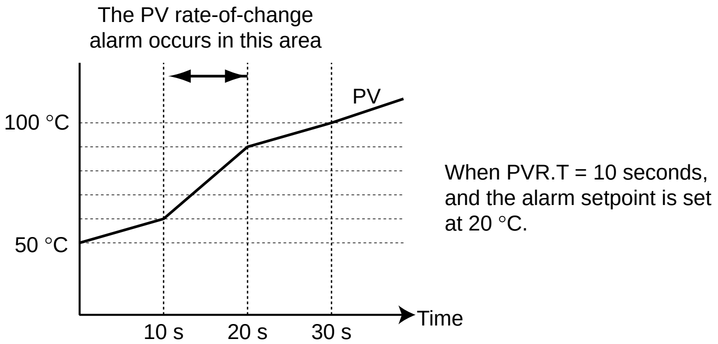
(10) MV low limit alarm (Setting: 24)

This alarm is issued when MV falls to the alarm setpoint or below.



(11) PV velocity alarm (Setting: 25, 26)

This alarm is issued when PV changes more than the alarm setpoint value within the period of time specified in the parameter PVR.T. Hysteresis does not function. The alarm numbered 26 is passive.



(12) Self-diagnostic alarm (Setting: 27, 28)

This alarm is issued upon the following events:
calibration value abnormal, reference junction compensation failure, analog/digital conversion circuit failure, EEPROM failure, and input burnout.
The alarm numbered 28 is passive.

(13) FAIL output (Setting: 29)

The FAIL output is passive and turns the contact ON in normal state, and OFF when FAIL conditions arise.
The FAIL conditions include RAM failure, ROM failure, system data abnormal, CPU failure, and power off.

TIP

The US1000 controller stops operation upon the FAIL conditions.
(There is no MV output, and alarm outputs are turned off.)

See Also

Subsection 8.5.2, “Error Code Description” of the separate instruction manual “US1000 Digital Indicating Controller” (IM 5D1A01-01E) for information about displays and what to do upon a self-diagnostic alarm or FAIL output

■ The 8-alarm Mode

The 8-alarm mode is the function that uses loop-2 alarm outputs 1 to 4 for loop-1 alarm outputs 5 to 8. This mode is unavailable with the controller mode (US mode) for cascade control, dual-loop control, temperature and humidity control, or cascade control with two universal inputs.
To use the 8-alarm mode, specify 3, 4, or 5 to the parameter AMD. The alarm outputs 5 to 8 for loop-1 can then be set up by setting the alarm type, alarm setpoint, and other alarm-related parameters for loop-2.
Alarm outputs 5 to 8 can be accessed by setting them as contact outputs or reading them via communication from an external device.
The alarm setpoint of loop-2 and the display scale of analog input-2 are interlocking.
Specify the same value to the display scale of analog input-1 and 2.

See Also

Section 3.16, “Parameters for Contact Output” of this manual, or the separate instruction manual “US1000 Digital Indicating Controller Communication Functions” (IM 5D1A01-10E)

3.14.2 Alarm Setpoint

Set an alarm setpoint for each of alarm outputs 1 to 4.
When the 8-alarm mode is specified, loop-2 alarm setpoints 1 to 4 are used for loop-1 alarm setpoints 5 to 8.

[Operation parameter]

<table>
<tr><th>Main</th><th>Sub</th><th>Parameter</th><th>Description</th><th>Setting Range</th><th>Default</th></tr>
<tr><td rowspan="4">0.LP1
0.LP2</td><td rowspan="4">n.PID
(n=1-8)</td><td>n.A1</td><td>Alarm 1 setpoint</td><td rowspan="4">PV alarm: EU (-100.0 to 100.0%)
Deviation alarm/PV-velocity alarm: EUS(-100.0 to 100.0%)
SV alarm: EU (0.0 to 100.0%)
MV alarm: -5.0 to 105.0%</td><td rowspan="4">PV high limit: EU (100.0%)
Deviation alarm: EUS (0.0%)
MV high limit: 100.0%
MV low limit: 0.0%
PV velocity: EUS (100.0%)
Other alarms: EU (0.0%)</td></tr>
<tr><td>n.A2</td><td>Alarm 2 setpoint</td></tr>
<tr><td>n.A3</td><td>Alarm 3 setpoint</td></tr>
<tr><td>n.A4</td><td>Alarm 4 setpoint</td></tr>
</table>

3.15 Parameters for Contact Input

At the time of shipping, the US1000 controller's contact inputs have already been assigned with the functions frequently used for each controller mode (US mode). (Refer to the function diagrams in Chapter 2.)

NOTE

Only personnel with a sufficient understanding of the US1000 controller and custom computation functions are qualified to change the settings of the following parameters as necessary. Those who are still beginners in regards to operating the US1000 controller or who do not thoroughly understand custom computation function should use the controller at the default value settings.
Changing the settings of these parameters may disable some of the functions assigned to each US1000 controller mode (US mode).

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CONF	DI	CAS1	Loop-1 mode switchover to CAS when the DI changes to on	Set the functions (D register or I relay number). 0: Not registered 1 to 1700: D register 5001 to 7048: I relay Example: DI1: 5161; DI2: 5162; DI3: 5163; DI4: 5164; DI5: 5165; DI6: 5166; DI7: 5167	Depends on USM parameter
		AUT1	Loop-1 mode switchover to AUTO when the DI changes to on		
		MAN1	Loop-1 mode switchover to MAN when the DI changes to on		
		CAS2	Loop-2 mode switchover to CAS when the DI changes to on		
		AUT2	Loop-2 mode switchover to AUTO when the DI changes to on		
		MAN2	Loop-2 mode switchover to MAN when the DI changes to on		
		O/C	OPEN(on)/CLOSE(off) switchover		
		R/S	RUN(off) /STOP(on) switchover		
		TRF1	Loop-1 tracking flag		
		TRF2	Loop-2 tracking flag		
		SV.B0	Bit-0 of SV number setting		
		SV.B1	Bit-1 of SV number setting		
		SV.B2	Bit-2 of SV number setting		
		SV.B3	Bit-3 of SV number setting		
		DP1	Operation display for interruption 1		
		DP2	Operation display for interruption 2		
		MG1	Interrupting message display 1		
		MG2	Interrupting message display 2		
		MG3	Interrupting message display 3		
		MG4	Interrupting message display 4		

3.15.1 Contact Input Functions

This subsection describes the controller actions when the following setting parameters have been set for the contact input function.

(1) CAS1, AUT1, MAN1, CAS2, AUT2, MAN2 (Operation mode switching)

These parameters set the operation mode switching functions. The operation mode changes to CAS, AUTO, or MAN when the contact status changes from off to on. The minimum on time is three times control period. The operation mode remains the same when the contact status changes from on to off.

(2) O/C (OPEN/CLOSE switchover)

This parameter sets a cascade OPEN/CLOSE switching function, which is effective only in cascade control or cascade control with two universal inputs.
“Cascade OPEN” denotes the status where the primary and secondary loops inside the controller are disconnected, and “cascade CLOSE” denotes the status where the loops are connected as a cascade loop (the control computation result of the primary loop is passed to the secondary loop as SV). For cascade OPEN, the contact is on, and for cascade CLOSE, it is off.

(3) R/S (RUN/STOP switchover)

The controller operation stops when the contact is switched from off to on, runs when the contact is switched from on to off.
When you power off the controller which is in stop status, the contact becomes off. Then you power on the controller, the controller will still be in stop status. In this case, once switch the contact to on and then off to run the controller.

See Also

For information on the stopping controller conditions, refer to section 6.13 of the separate ‘US1000 Digital Indicating Controller’ manual.

(4) TRF1, TRF2 (Tracking flag)

The tracking input from the AIN2 or AIN3 terminal is effective when the contact is on, and the controller outputs the tracking input as MV. The tracking input is not effective when the contact is off, and the controller outputs the control computation result as MV.
The tracking input is unavailable or assigned to the AIN2 or AIN3 terminal depending on the controller mode (US mode). For detailed information, see the function block diagrams in Chapter 2, “Controller Mode (US Mode).”

(5) SV.B0, SV.B1, SV.B2, SV.B3 (SV number selection)

These parameters are used to set an SV number selecting function under the preset PID. (Refer to subsection 3.10.2, “SV Number Selection for Preset PID.”)
SV numbers are 1 to 8 and are specified according to the patterns in the following table.

SV number	Contact statuses			
	Bit 0	**Bit 1**	**Bit 2**	**Bit 3**
1	**ON**	OFF	OFF	OFF
2	OFF	**ON**	OFF	OFF
3	**ON**	**ON**	OFF	OFF
4	OFF	OFF	**ON**	OFF
5	**ON**	OFF	**ON**	OFF
6	OFF	**ON**	**ON**	OFF
7	**ON**	**ON**	**ON**	OFF
8	OFF	OFF	OFF	**ON**

NOTE

To select an SV number by means of the parameter SVNO or communication, all the contacts registered to SV.B0 to SV.B3 must be turned off.

(6) DP1, DP2 (Operation display for interruption)

These parameters are used to set a function to display the “custom display” used in the custom computation function.
When the contact registered to parameter DP1 or DP2 is turned on, the custom display which has been registered to the custom display switching condition “DP1 = on” or “DP2 = on” will be displayed, interrupting the operation display at that time.

(7) MG1, MG2, MG3, MG4 (Interruptive message display)

These parameters are used to set a function which displays a pre-defined message on the PV digital display. Up to four messages can be defined. The optional LL1100 PC-based Parameters Setting Tool is necessary to define these messages.

3.15.2 Changing Contact Input Assignments

To change contact input assignments, register the I-relay number of the contact input to the parameter of the function to be assigned. For example, to assign the loop-1 tracking flag to DI7, register 5167 to parameter TRF1.

NOTE

In some controller modes (US modes), D-register or I-relay numbers which are not for the contact input are assigned to the parameters for contact input as default settings.
These settings should not be changed, because it will disable some functions of the controller mode.

3.16 Parameters for Contact Output

NOTE

Only personnel with a sufficient understanding of the US1000 controller and custom computation functions are qualified to change the settings of the following parameters as necessary. Those who are still beginners in regards to operating the US1000 controller or who do not thoroughly understand custom computation function should use the controller at the default value settings.
Changing the settings of these parameters may disable some of the functions assigned to each US1000 controller mode (US mode).

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
COMF	DO	DO1	Relay output flag registration for DO1	Set the functions (D register or I relay number). 0: Not registered 1 to 1700: D register 5001 to 7048: I relay Example: Loop-1 alarm output 1 = 5689 Loop-1 alarm output 2 = 5690 Loop-1 alarm output 3 = 5691 Loop-1 alarm output 4 = 5693 Loop-2 alarm output 1 = 5697 Loop-2 alarm output 2 = 5698 Loop-2 alarm output 3 = 5699 Loop-2 alarm output 4 = 5701	Depends on USM parameter
		DO2	Relay output flag registration for DO2		
		DO3	Relay output flag registration for DO3		
		DO4	Transistor output flag registration for DO4		
		DO5	Transistor output flag registration for DO5		
		DO6	Transistor output flag registration for DO6		
		DO7	Transistor output flag registration for DO7		

At the time of shipping, the US1000 controller’s contact outputs have already been assigned with the functions frequently used for each controller mode (US mode). (Refer to the function diagrams in Chapter 2.) Therefore, the contact output assignments need not be changed for general use.
To change the assignments, register a D-register or I-relay number of the flag to be output to a contact output parameter. For example, to assign the loop-2 alarm output 1 to the DO5 contact output, register 5697 to parameter DO5.
Note that the US1000-00 has only three contact output terminals: DO1, DO2, and DO3.

3.17 Parameter that Determines Control Period

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
USMD	MD	SMP	Control period	50, 100, 200, 500 ms	200

NOTE

Changing the control period clears the controller displays once and restarts the controller.

There are some restrictions as listed below on the use of the 50-ms, 100-ms, or 200-ms control period. If these conditions are not satisfied, the specified control period may not be achieved. There is no restriction when 500 ms is specified.

●Restrictions on the 50-ms control period
- Only applicable for the US1000-00 controller model.
- Only applicable for the controller mode (US mode) of single-loop control.
- SUPER function is disabled.
- The following alarm types cannot be specified: high limit deviation (setting: 3, 5, 13, 15), low limit deviation (setting: 4, 6, 14, 16), high and low limits deviation (setting: 7, 17), deviation within high and low limits (8, 18), self-diagnostic (setting: 27, 28), and FAIL output (setting: 29).

●Restrictions on the 100-ms control period
- Only applicable for the US1000-00 controller model.
- Cascade control cannot be specified as the controller mode (US mode).

●Restrictions on the 200-ms control period
- When custom computation is to be used, a maximum of 30 computation modules is permitted.

It is possible to check whether or not the specified control period is appropriate by the USER display of "sampling error counter." The sampling error counter counts up once when all the control processing cannot be executed within the specified control period.

See Also

Section 5.1, "Registering Auxiliary Operation Displays (USER Displays)" of the separate instruction manual "US1000 Digital Indicating Controller" (IM 5D1A01-01E) for information about the sampling error counter.

3.18 Parameters for Display Functions

3.18.1 USER Display

USER displays display data which are helpful during the controller operation.
For information about USER displays, refer to Section 5.1, "Registering Auxiliary Operation Displays (USER Displays)" of the separate instruction manual "US1000 Digital Indicating Controller" (IM 5D1A01-01E).

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CONF	U. OPE	U.1AL	USER display of loop-1 alarm	OFF, ON	OFF
		U.2AL	USER display of loop-2 alarm	OFF, ON	OFF
		U.SVN	USER display of SV number	OFF, ON	OFF
		U.1PI	USER display of loop-1 PID group number	OFF, ON	OFF
		U.2PI	USER display of loop-2 PID group number	OFF, ON	OFF
		U.AI1	USER display of AIN1 measured value	OFF, ON	OFF
		U.AI2	USER display of AIN2 measured value	OFF, ON	OFF
		U.AI3	USER display of AIN3 measured value	OFF, ON	OFF
		U.PV1	USER display of PV1	OFF, ON	OFF
		U.PV2	USER display of PV2	OFF, ON	OFF
		U.SMP	USER display of sampling error counter	OFF, ON	OFF

3.18.2 SELECT Display

SELECT displays permit easy callup of frequently accessed operation parameters from an operation display.
For information about SELECT displays, refer to Section 5.3, "Registering Quick Parameter Call-up Functions (SELECT Displays)" of the separate instruction manual "US1000 Digital Indicating Controller" (IM 5D1A01-01E).

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CONF	C. SEL	C.S1	Registration for the SELECT display 1	OFF, 201 to 773 (see section 5.3)	OFF
		C.S2	Registration for the SELECT display 2		
		C.S3	Registration for the SELECT display 3		
		C.S4	Registration for the SELECT display 4		
		C.S5	Registration for the SELECT display 5		

3.19 Parameters for Security Functions

The US1000 controller has the following security functions to prevent careless or accidental data changes.

- Key operation prohibiting function
- Menu display prohibiting function
- Password

3.19.1 Key Operation Prohibiting Function

This function is provided to disable (lock) specific operation keys.
For information about the function, refer to Section 4.9, “Setting Other Functions (as necessary)” of the separate instruction manual “US1000 Digital Indicating Controller” (IM 5D1A01-01E).

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMLP	KLCK	SVC	SV setting key lock on operation displays	OFF, ON	OFF
		△ / ▽	Data setting key lock	OFF, ON	OFF
		< / >	MV operation key lock	OFF, ON	OFF
		C	C mode key lock	OFF, ON	ON
		A	A mode key lock	OFF, ON	OFF
		M	M mode key lock	OFF, ON	OFF

3.19.2 Menu Display Prohibiting Function

This function is provided so that specific operation parameter menus will not be displayed as desired.
For information about the function, refer to Section 4.9, “Setting Other Functions (as necessary)” of the separate instruction manual “US1000 Digital Indicating Controller” (IM 5D1A01-01E).

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMLP	MLCK	MODE	Mode menu lock	OFF, ON	OFF
		O.LP1	O.LP1 menu lock	OFF, ON	OFF
		O.LP2	O.LP2 menu lock	OFF, ON	ON*1
		PID	PID menu lock	OFF, ON	OFF
		USR	USR menu lock	OFF, ON	ON*1
		PYS1	PYS1 menu lock	OFF, ON	OFF
		PYS2	PYS2 menu lock	OFF, ON	ON*1

*1 The default may be OFF or ON depending on the controller mode.

3.19.3 Password

Once a password is set, the controller requires the password to be input when transferring to a setup parameter display.
For information about password, refer to Section 4.9, “Setting Other Functions (as necessary)” of the separate instruction manual “US1000 Digital Indicating Controller” (IM 5D1A01-01E).

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMLP	MLCK	PWD	Password setting	0: No password, 1 to 30000	0

Main	Sub	Parameter	Description	Setting Range	Default
STUP	—	PS. IN	Password input	0 to 30000	0

3.20 Parameters for Communications Function

The US1000 controller can have an optional RS-485 communication interface. The RS-485 communication interface supports the Modbus communication protocol and PC link communication protocol, which is convenient for communicating with a Yokogawa PLC (sequencer).
For information about the RS-485 communication function, refer to the separate instruction manual "US1000 Digital Indicating Controller Communications Function" (IM 5D1A01-10E).

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
CMLP	R485	PSL	Protocol selection	0: Modbus (ASCII), 1: Modbus (RTU), 2: PC-link communication, 3: PC-link communication with sum check	0
		BPS	Baud rate	600, 1200, 2400,4800,9600, 19200, 38400 bps	9600
		PARI	Parity	N: None, E: Even, O: Odd	E
		STP	Stop bit	1, 2	1
		DLN	Data length	7, 8	8
		ADR	Controller address	1 to 99	1
		RSP.T	Minimum response time	0 to 10 (x 10 ms)	0

3.21 Other Parameters

This section introduces and briefly explains the following parameters.

- USER parameters
- Parameter initialization
- Test mode

3.21.1 USER Parameters

[Operation parameter]

Main	Sub	Parameter	Description	Setting Range	Default
USR	—	U1	USER parameter 1	-19999 to 31500	Refer to the following.
		U2	USER parameter 2	-19999 to 31500	0
		U3	USER parameter 3	-19999 to 31500	0
		U4	USER parameter 4	-19999 to 31500	0
		U5	USER parameter 5	-19999 to 31500	0
		U6	USER parameter 6	-19999 to 31500	0
		U7	USER parameter 7	-19999 to 31500	0
		U8	USER parameter 8	-19999 to 31500	0

USER parameters must be set in the following controller modes and can also be used for the custom computation function.

● **US mode = Loop control with PV switching (USM = 6), and**
US mode = Loop control with PV auto-selector and two universal inputs (USM = 14)

U1: PV upper limit for PV switching (Default = 0)
U2: PV lower limit for PV switching (Default = 0)
U3: Switching condition (Default = 0)
U3 = 0: Switching within specified PV range set in U1 and U2
U3 = 1: Switching at PV upper limit set in U1
U3 = 2: Switching by contact input

● **US mode = Loop control with PV auto-selector (USM = 7)**

U1: Input selection (Default = 2)
U1 = 0: Accepts the maximum value between inputs 1 and 2
U1 = 1: Accepts the minimum value between inputs 1 and 2
U1 = 2: Accepts the average value of inputs 1 and 2
U1 = 3: Accepts the difference between inputs 1 and 2 (input 2 - input 1)

● **US mode = Loop control with PV auto-selector and two universal inputs (USM = 15)**

U1: Input selection (Default = 2)
U1 = 0: Accepts the maximum value between input 1, input 2 (and input 3)
U1 = 1: Accepts the minimum value between input 1, input 2 (and input 3)
U1 = 2: Accepts the average value of input 1, input 2 (and input 3)
U1 = 3: Accepts the difference between inputs 1 and (input 2 - input 1)
U2: Number of inputs (Default = 0)
U2 = 0: Uses two points (inputs 1 and 2)
U2 = 1: Uses three points (inputs 1, 2 and 3)

3.21.2 Parameter Initialization

When the parameter INIT is set on, the controller initializes all parameters other than the US mode, input/output parameters, communication parameters, and valve calibration parameters. The controller also prepares to set related parameters in the ranges and scales specified by the input/output parameters.

For information about parameter initialization, refer to Section 4.6, "Writing the Data Defined So Far (Parameter Initialization)" of the separate instruction manual "US1000 Digital Indicating Controller" (IM 5D1A01-01E).

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
USMD	INIT	INIT	Parameter initialization	OFF, ON	OFF

3.21.3 Test Mode

NOTE

Do not change the following parameter.
Doing so may cause the US1000 controller to malfunction.

[Setup parameter]

Main	Sub	Parameter	Description	Setting Range	Default
USMD	TEST	TST	Test mode	Do not use this mode.	–

The test mode is for testing and adjusting the US1000 controller. Users must not access its parameter.

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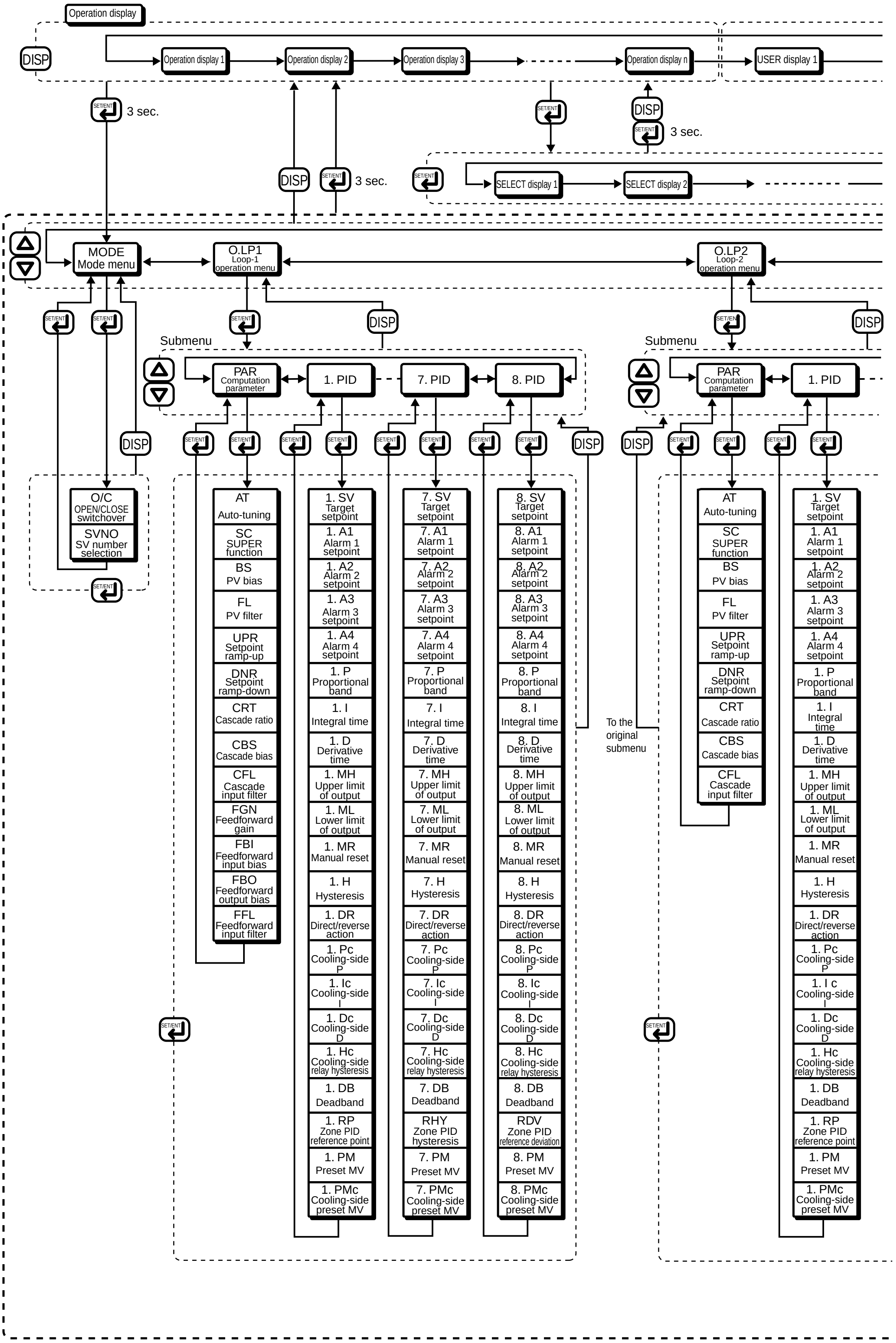
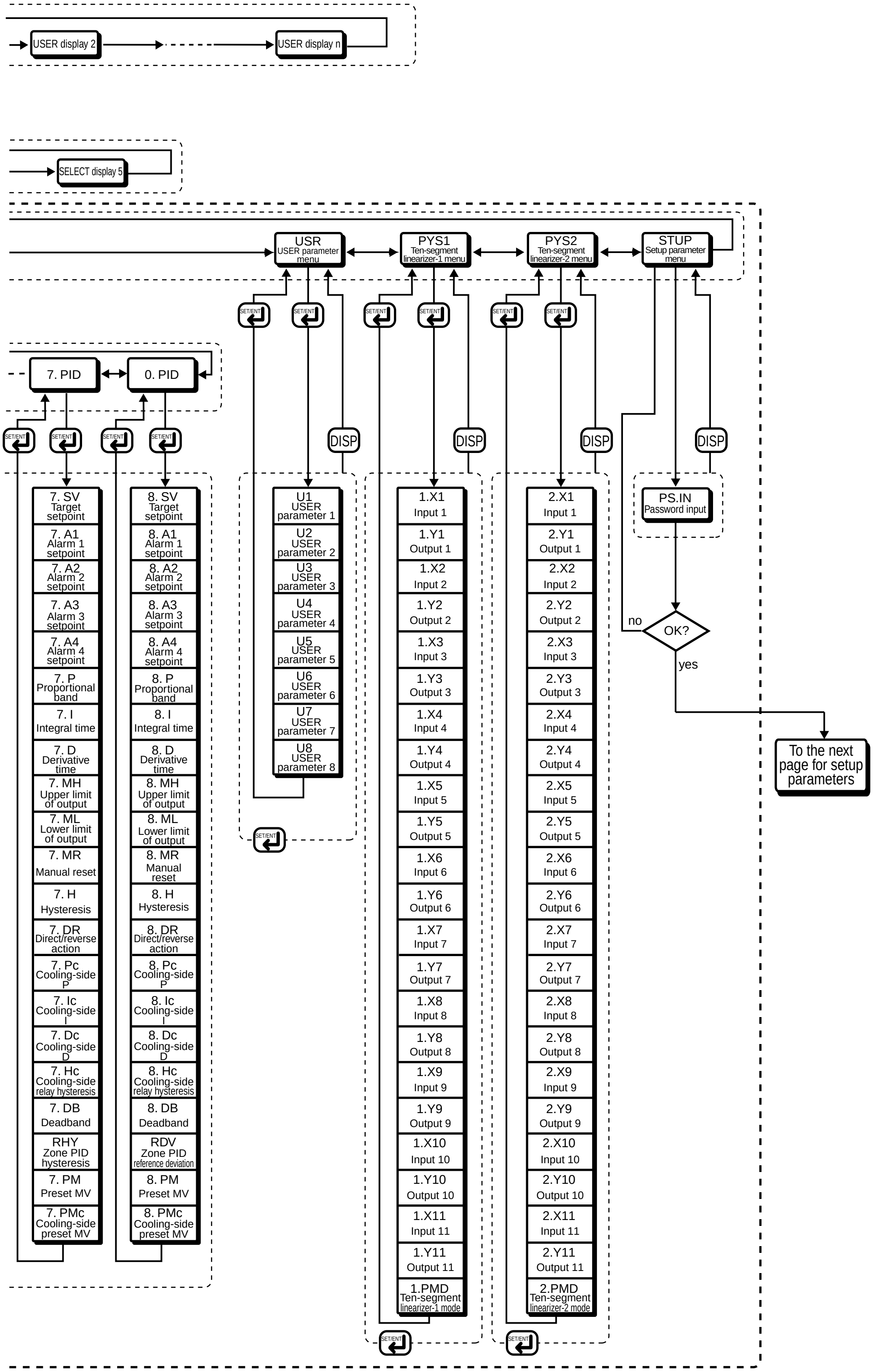
Appendix 1 Parameter Map

The parameter maps help you retrieve the desired parameters by showing the individual configuration diagrams for the operation and setup parameter groups. Make use of this appendix together with parameter tables given in chapter 3 when setting parameters.

Some parameters are hidden (i.e., unavailable) depending on the model names or controller modes (US modes).

■ Operating Parameters





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USER display n
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PYS2 Ten-segment linearizer-2 menu
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7. A2 Alarm 2 setpoint
7. A3 Alarm 3 setpoint
7. A4 Alarm 4 setpoint
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7. I Integral time
7. D Derivative time
7. MH Upper limit of output
7. ML Lower limit of output
7. MR Manual reset
7. H Hysteresis
7. DR Direct/reverse action
7. Pc Cooling-side P
7. Ic Cooling-side I
7. Dc Cooling-side D
7. Hc Cooling-side relay hysteresis
7. DB Deadband
RHY Zone PID hysteresis
7. PM Preset MV
7. PMc Cooling-side preset MV
8. SV Target setpoint
8. A1 Alarm 1 setpoint
8. A2 Alarm 2 setpoint
8. A3 Alarm 3 setpoint
8. A4 Alarm 4 setpoint
8. P Proportional band
8. I Integral time
8. D Derivative time
8. MH Upper limit of output
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2.Y4 Output 4
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2.Y5 Output 5
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2.Y6 Output 6
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2.Y7 Output 7
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2.Y9 Output 9
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2.X11 Input 11
2.Y11 Output 11
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PS.IN Password input
no
OK?
yes
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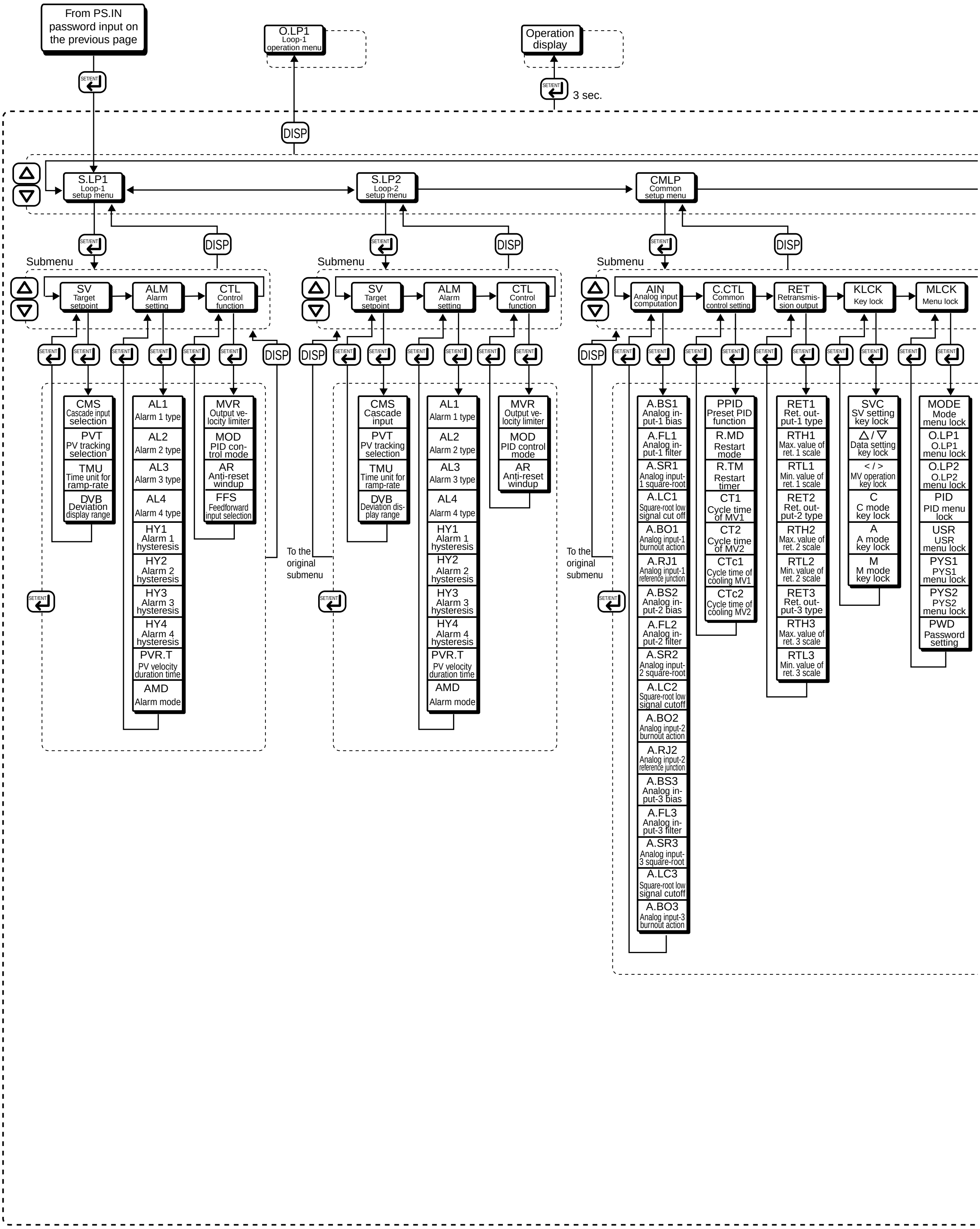
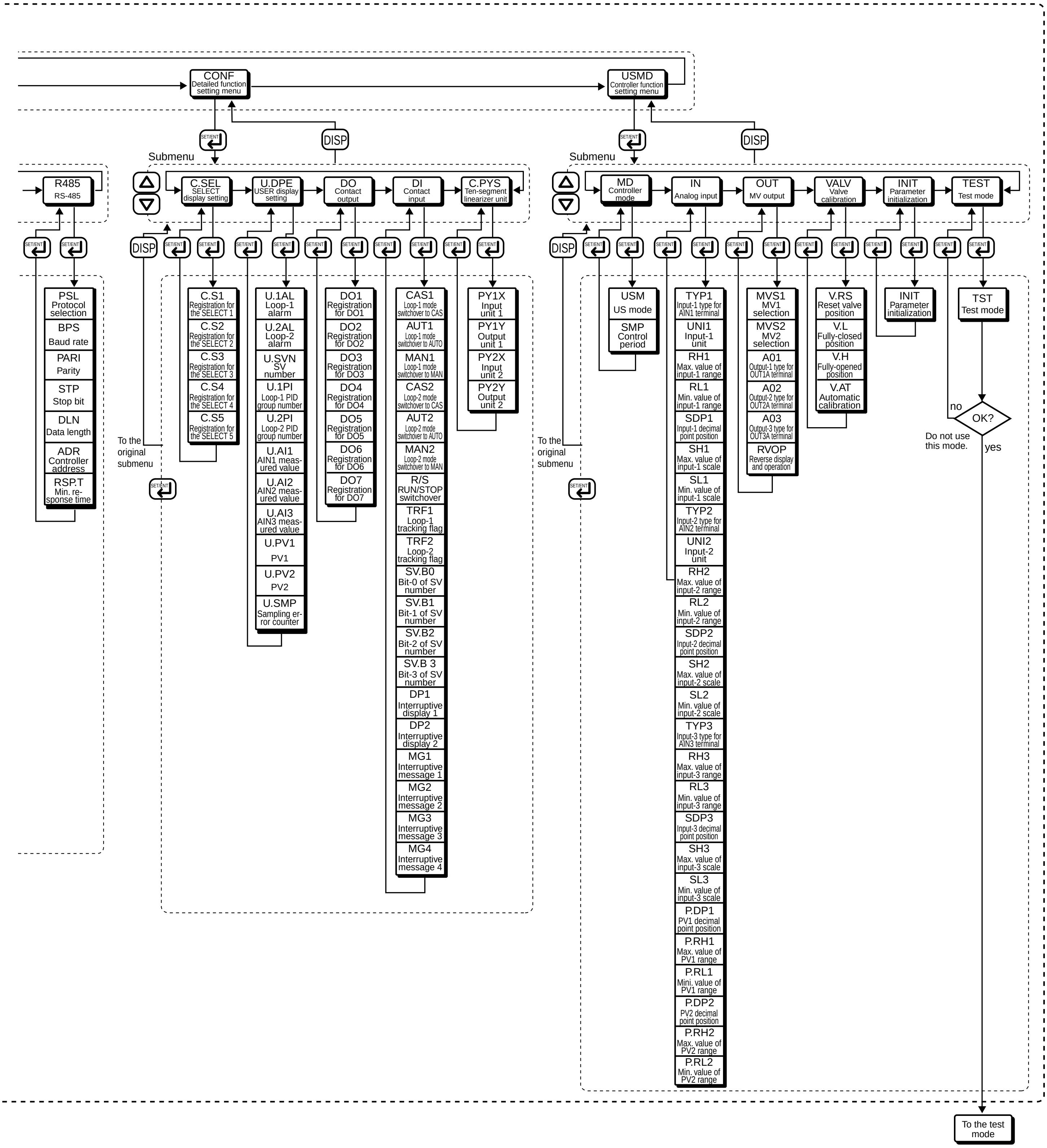
■ Setup Parameters

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Output unit 2
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UNI1
Input-1 unit
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RL1
Min. value of input-1 range
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P.RL2
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OK?
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yes
Do not use this mode.
To the test mode

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Numbers

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Revision Record

Manual Title: Model US1000 Digital Indicating Controller Functions
Manual number: IM 5D1A01-02E

Edition	Data	Revised Item
First	Aug., 1998	Newly published.
Second	Jun., 2004	Change of the company name.

Written by Yokogawa Electric Corporation

Published by Yokogawa Electric Corporation
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