

General Specifications

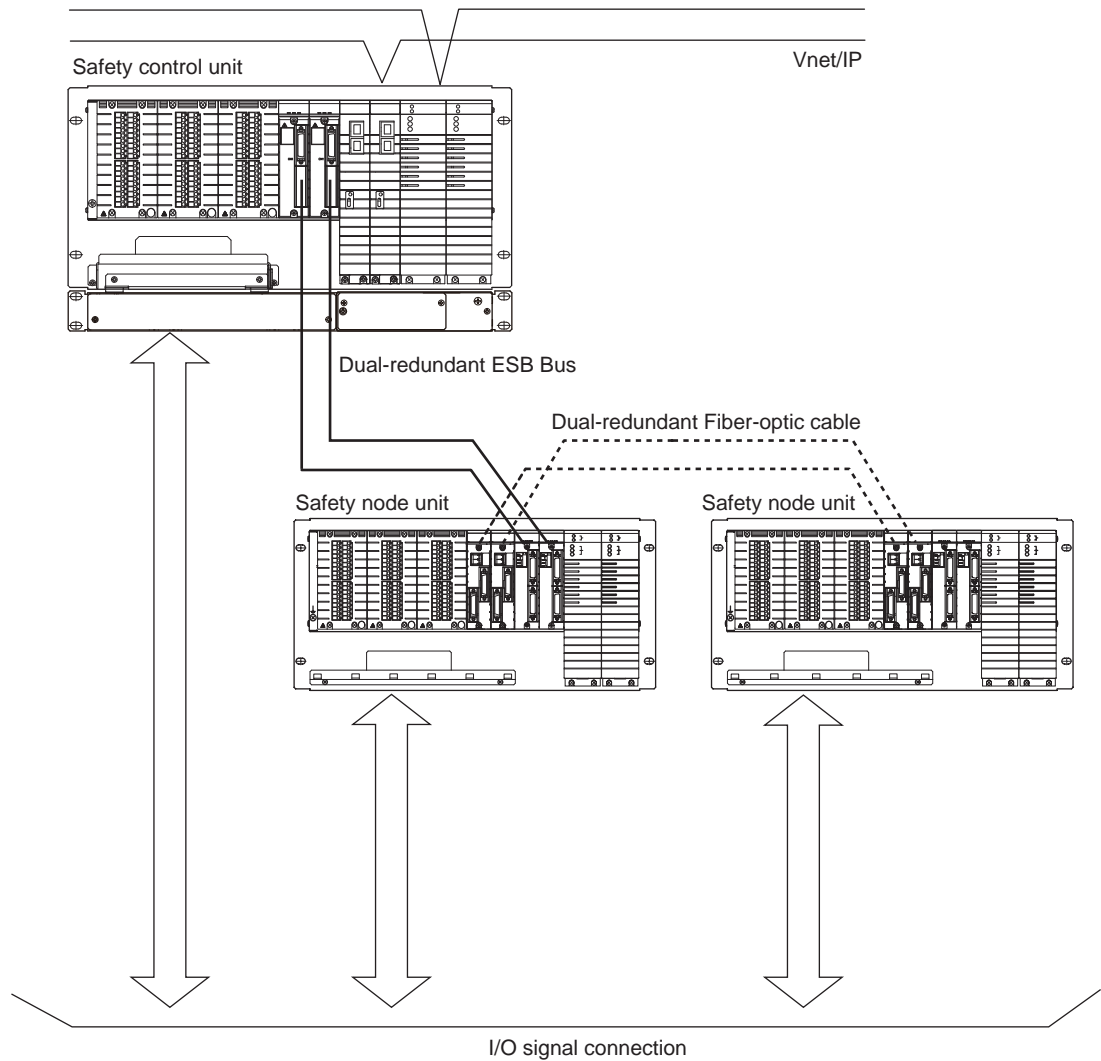
ProSafe-RS Lite Outline of I/O Modules

GS 32P56K60-01EN

■ GENERAL

This GS provides the outline of I/O modules to be mounted on the safety control unit or the safety node unit of the ProSafe-RS Lite system.

An example of a system configuration is shown below.



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Figure System Configuration

■ COMMON SPECIFICATIONS

● Installation Environment

Refer to the GS "ProSafe-RS Lite Safety Instrumented System Overview (for Vnet/IP)" (GS 32P51B10-01EN).

● Conformity Standards

Refer to "Standards Compliant Models" (GS 32P01B60-01EN).

■ STANDARD SPECIFICATIONS

● Safety Control Unit

A CPU module, two power supply modules, and two ESB Bus coupler modules, along with I/O modules, are mounted on the safety control unit.

There are 4 types of safety control units:

L1SC70S-S: Safety control unit (standard (-20 to 40 °C) type)

L1SC70S-F: Safety control unit (wide range temperature (-20 to 70 °C) type)

L1SC70D-S: Duplexed safety control unit (standard (-20 to 40 °C) type)

L1SC70D-F: Duplexed safety control unit (wide range temperature (-20 to 70 °C) type)

For more details, refer to Safety Control Unit (GS 32P56D10-01EN).

● Safety Node Unit

Two power supply modules, two ESB Bus interface modules, and I/O modules are mounted on the safety node unit.

L1NB10D: Safety node unit (wide range temperature (-20 to 70 °C) type)

For more details, refer to Safety Node Unit (GS 32P56K10-01EN).

● Unit for Optical Bus Repeater Module

Optical ESB Bus Repeater Modules are installed in Unit for Optical Bus Repeater Module.

L1NT10D: Unit for Optical Bus Repeater Module (wide range temperature (-20 to 70 °C) type)

For details, refer to Unit for Optical Bus Repeater Module (GS 32P56K11-01EN).

● I/O Module

There are three types of I/O modules: an analog I/O module, a digital I/O module, and a communication module.

Table Mountability of I/O Module on Node Unit

Model	Module type	L1SC70D L1SD70S	L1NB10D	L1NT10D	Redundancy	Temperature adaptability (*1) and G3 compatibility
—	Analog I/O modules					
L1AI143	Analog Input Module (4 to 20 mA, 16 channels, Module Isolation)	X	X	—	X	X
L1AV144	Analog Input Module (1-5V/1-10 V, 16 channels, Module Isolation)	X	X	—	X	X
L1AI533	Analog Output Module (4 to 20 mA, 8 channels, Module Isolation)	X	X	—	X	X
L1AT145	TC/mV Input Module (16-channel, Isolated Channels)	X	X	—	X	X
L1AR145	RTD Input Module (16-channel, Isolated Channels)	X	X	—	X	X
—	Digital I/O modules					
L1DV144	Digital Input Module (24 V DC, 16 channels, Module Isolation) (*2)	X	X	—	X	X
L1DV521	Digital Output Module (24 V DC/2A, 4 channels, Module Isolation) (*3)	X	X	—	X	X
L1DV526	Digital Output Module (100-120 V AC, 4 channels, Module Isolation)	X	X	—	X	X
L1DV531	Digital Output Module (24 V DC/0.6 A, 8 channels, Module Isolation) (*3)	X	X	—	X	X
L1DV53A	Digital Output Module (48 V DC, 8 channels, Module Isolation) (*3)	X	X	—	X	X
L1DV541	Digital Output Module (24 V DC/0.2 A, 16 channels, Module Isolation) (*3)	X	X	—	X	X
—	Communication modules					
ALR111	Serial Communications Module (RS-232C) (*4)	X	X	—	X	G3 compatibility only
ALR121	Serial Communications Module (RS-422/RS-485) (*4)	X	X	—	X	X
ALE111	Ethernet Communication Module (*4) (*5)	X	X	—	X	X
—	Bus interface modules					
L1EC402	ESB Bus Coupler Module (for 2-port)	X	—	—	X (*6)	X
L1EC401	ESB Bus Coupler Module (for 1-port)	X	—	—	X (*6)	X
L1NT401	Optical ESB Bus Repeater Master Module 5 km	X	X	X	X (*6)	X
L1NT501	Optical ESB Bus Repeater Slave Module 5 km	—	X	X	X (*6)	X
L1NT411	Optical ESB Bus Repeater Master Module 5 to 50 km	X	X	X	X (*6)	X
L1NT511	Optical ESB Bus Repeater Slave Module 5 to 50 km	—	X	X	X (*6)	X

X: Acceptable —: Not acceptable

*1: Temperature-adaptability is possible only when the I/O module is mounted on L1SC70□-F or L1NB10D.

*2: Where "Pulse Test" is enabled for field wiring diagnostic functions, diagnostic pulse (ON pulse) are generated on the input channel periodically.

Pulse Interval: about 0.5 s, Pulse width: about 400 μs

Use a device that works properly with diagnostic pulses.

*3: Where "Pulse Test (ON or OFF)" is enabled for field wiring diagnostic functions, diagnostic pulses (ON or OFF pulse) are generated on the output channel periodically.

Pulse Interval: about 0.5 s, Pulse width: about 200 μs

Use a device that works properly with diagnostic pulses.

*4: Interference-free module.

*5: ALE111 style code S1 and unit revision U:2 or later must be used.

*6: Applicable to dual redundancy only.

For more details on the I/O module specifications, refer to the I/O module specifications.

● Terminal Blocks

For wiring between an I/O module and field equipment, a signal cable interface adapter or a pressure clamp terminal block is available. MIL cables provided by the user may be used with a connector cover for MIL cable.

For a signal interface adapter, dedicated signal cable is used to connect with terminal board or relay board. There is option to prevent wrong type I/O module insertion. Option codes for this mechanism must be specified for I/O module and signal cables respectively. The I/O module and the signal interface adapter is the set purchase.

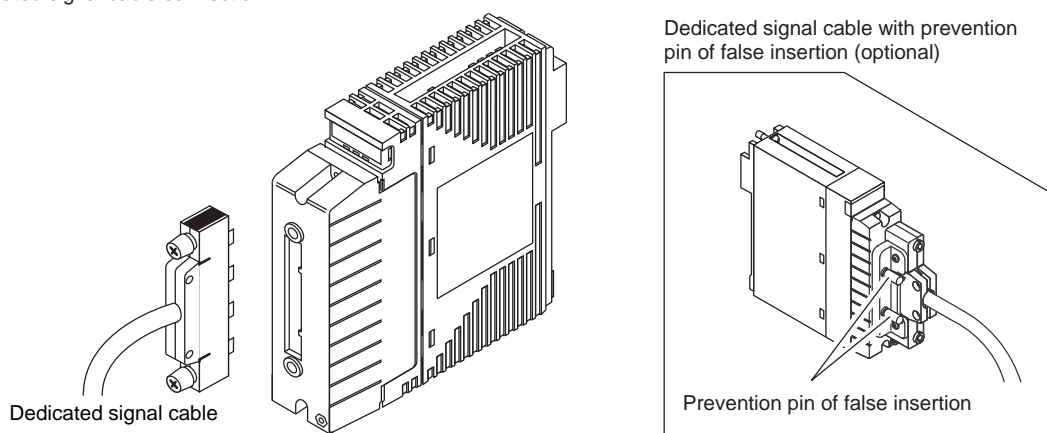
A pressure clamp terminal can be directly wired to field equipment. A signal cable interface adapter can be wired to field equipment via a terminal board.

There are two types of pressure clamp terminal blocks: a single configuration type and a dual-redundant configuration type. An I/O module can be made dual redundant on the terminal block.

An MIL cable can be directly connected to an I/O module without a terminal block. This cable is provided to customers by option. To prevent it from being disconnected from the I/O module, cable connector covers (L1CCC01 and L1CCC02) are available for the use with the MIL cable.

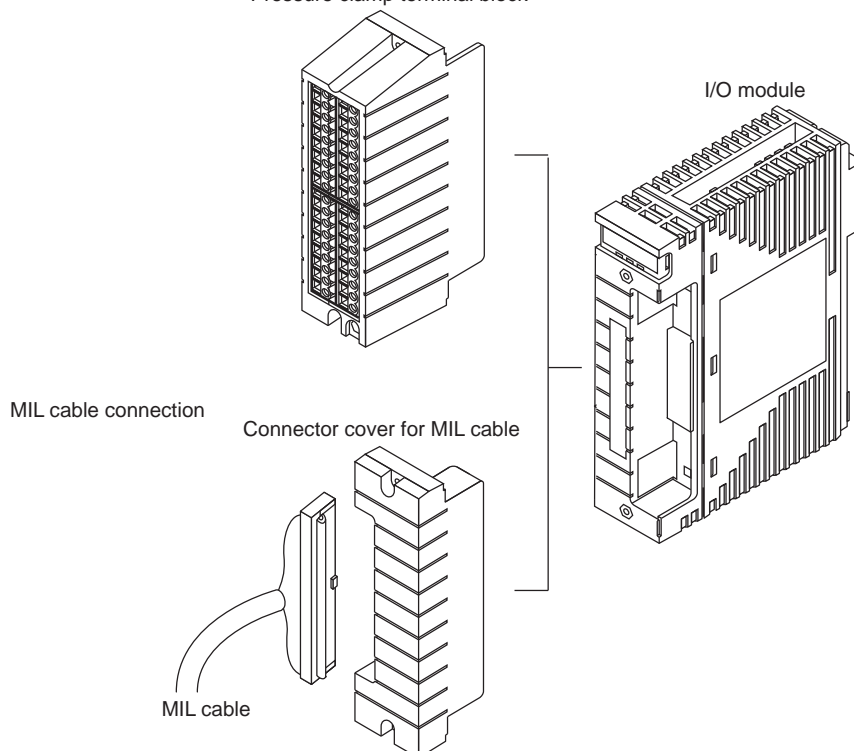
Table "Connection between I/O Module and Terminal Block" presents how an I/O module is connected with a terminal block and a connector cable.

Dedicated signal cable connection



Pressure clamp terminal connection

Pressure clamp terminal block



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Table I/O Module and Signal Connection

Model	Module type	Number of I/O points channels per module	Signal connection		
			Pressure clamp terminal	Dedicated cable (*1)	MIL cable
—	Analog I/O modules				
L1AI143	Analog Input Module (4 to 20 mA, 16 channels, Module Isolation)	16	X	X	X
L1AV144	Analog Input Module (1 - 5V/1-10 V, 16 channels, Module Isolation)	16	X	X	X
L1AI533	Analog Output Module (4 to 20 mA, 8 channels, Module Isolation)	8	X	X	X
L1AT145	TC/mV Input Module (isolated channels)	16	—	X	—
L1AR145	RTD Input Module (isolated channels)	16	—	X	—
—	Digital I/O modules				
L1DV144	Digital Input Module (24 V DC, 16 channels, Module Isolation) (*2)	16	X	X	X
L1DV521	Digital Output Module (24 V DC/2A, 4 channels, Module Isolation) (*2)	4	—	X	—
L1DV526	Digital Output Module (100-120 V AC, 4 channels, Module Isolation) (*2)	4	—	X	—
L1DV531	Digital Output Module (24 V DC/0.6 A, 8 channels, Module Isolation) (*2)	8	X	X	X
L1DV53A	Digital Output Module (48 V DC, 8 channels, Module Isolation) (*2)	8	—	X	—
L1DV541	Digital Output Module (24 V DC/0.2 A, 16 channels, Module Isolation) (*2)	16	X	X	X
—	Communication modules				
ALR111	Serial Communication Module	2 ports	—	X (D-sub 9-pin) (*3)	—
ALR121	Serial Communication Module	2 ports	—	X (M4 terminal block 10-pole) (*3)	—
ALE111	Ethernet Communication Module	1 port	—	—	—

X: Connectable —: Not connectable

*1: This cable for connecting I/O modules with terminal boards, and relay boards, is a Yokogawa Electric Corporation dedicated cable.

*2: Depending on the I/O module's connection configuration, there are restrictions regarding current, cable length, and the like.

*3: The dedicated signal cable can be connected directly to the I/O module without the terminal block.

Table Connection between I/O Module and Terminal Block

Model	Module type	Field wiring Connection connection means for field wiring					
		Pressure clamp terminal (pressure clamp terminal block)		Terminal board/Relay board, dedicated cable Upper : 19-inch Rack Mountable Type Lower : DIN Rail Mount Type		MIL cable	
		Single	Dual-redundant	Single	Dual-redundant	Single	Dual-redundant
L1AI143	Analog input	L1TA4S	L1TA4D	SEA4D (1 port), KS1 (1 unit) SBA4D/S1BB4D (1 port), KS1 (1 unit)	SEA4D (2 ports), KS1 (2 units) SBA4D/S1BB4D (2 ports), KS1 (2 units)	MIL connector	MIL connector (2 units)
L1AV144		L1TA4S	L1TA4D	SEA4D (1 port), KS1 (1 unit) SBA4D (1 port), KS1 (1 unit)	SEA4D (2 ports), KS1 (2 units) SBA4D (2 ports), KS1 (2 units)	MIL connector	MIL connector (2 units)
L1AI533	Analog output	L1TA4S	L1TA4D	SEA4D (1 port), KS1 (1 unit) SBA4D (1 port), KS1 (1 unit)	SEA4D (2 ports), KS1 (2 units) SBA4D (2 ports), KS1 (2 units)	MIL connector	MIL connector (2 units)
L1AT145	TC/mV input	—	—	— SBT4D (1 port), AKB331 (1 unit) (*2)	— SBT4D (2 ports), AKB331 (2 units) (*2)	—	—
L1AR145	RTD input	—	—	— SBR4D (1 port), AKB611 (1 unit)	— SBR4D (2 ports), AKB611 (2 units)	—	—
L1DV144	Digital input	L1TB4S	L1TB4D	SED4D/SRM53D (*1)/ SRM54D (1 port), AKB331 (1 unit) (*2) SBD4D (1 port), AKB331 (1 unit) (*2)	SED4D/SRM53D (*1)/ SRM54D (2 ports), AKB331 (2 units) (*2) SBD4D (2 ports), AKB331 (2 units) (*2)	MIL connector	MIL connector (2 units)
L1DV521	Digital output	—	—	SED2D (1 port), AKB651 (1 unit) (*3) SBD2D (1 port), AKB651 (1 unit) (*3)	SED2D (2 ports), AKB651 (2 units) (*3) SBD2D (2 ports), AKB651 (2 units) (*3)	—	—
L1DV526		—	—	SWD2D (1 port), AKB652 (1 unit) —	SWD2D (2 ports), AKB652 (2 units) —	—	—
L1DV531		L1TB4S	L1TB4D	SED4D/SRM53D (1 port), AKB331 (1 unit) (*2) SBD3D (1 port), AKB331/AKB651 (1 unit) (*2) (*3)	SED4D/SRM53D (2 ports), AKB331 (2 units) (*2) SBD3D (2 ports), AKB331/AKB651 (2 units) (*2) (*3)	MIL connector	MIL connector (2 units)
L1DV53A		—	—	SED3D (1 port), AKB331 (1 unit) (*2) SBD3D (1 port), AKB331/AKB651 (1 unit) (*2) (*3)	SED3D (2 ports), AKB331 (2 units) (*2) SBD3D (2 ports), AKB331/AKB651 (2 units) (*2) (*3)	—	—
L1DV541 (*3)		L1TB4S	L1TB4D	SED4D/SRM54D (1 port), AKB331 (1 unit) (*2) SBD4D/SBM54D (1 port), AKB331/AKB651 (1 unit) (*2) (*3)	SED4D/SRM54D (2 ports), AKB331 (2 units) (*2) SBD4D/SBM54D (2 ports), AKB331/AKB651 (2 units) (*2) (*3)	MIL connector	MIL connector (2 units)

Note: A dual-redundant terminal block is used for connecting two adjacent I/O modules.

Note: Cable connection covers (L1CCC01 and L1CCC02) are available for MIL connector connection.

*1: L1DV144 to be connected with SRM53D or SRM54D is for relay read back.

*2: Use AKB331 style code S3 or later when connecting to SED3D, SBD3D or SBD4D.

*3: AKB651 can be used for connecting with SED2D, SBD2D, SBD3D or SBD4D.

Table Connection between Communication Module, Bus Interface, and Communication Cable

Module type	Model	Communication cable
Communication module	ALR111	AKB131 AKB132 AKB135 AKB136 Other (prepared by customers)
	ALR121	AKB161 AKB162 Other (prepared by customers)
	ALE111	Ethernet Cable (*2) (prepared by customers)
Bus Interface	SNT401	Fiber-optic Cable (prepared by customers) (*1)
	SNT501	Fiber-optic Cable (prepared by customers) (*1)
	SNT411	Fiber-optic Cable (prepared by customers) (*1)
	SNT511	Fiber-optic Cable (prepared by customers) (*1)

*1: For a fiber-optic cable, refer to ProSafe-RS Lite Safety Instrumented System Overview (GS 32P51B10-01EN).

*2: Refer to Ethernet Communication Module (GS 32P06K51-01EN).

● Current Consumption of I/O Modules

Table Current Consumption of I/O Modules

Model	Module type	Maximum current consumption at 5 V DC (mA)	Maximum current consumption at 24 V DC (mA)
—	Analog I/O modules		
L1AI143	Analog Input Module (4 to 20 mA, 16 channels, Module Isolation)	320	550
L1AV144	Analog Input Module (1 - 5V/1-10 V, 16 channels, Module Isolation)	300	140
L1AI533	Analog Output Module (4 to 20 mA, 8 channels, Module Isolation)	320	300
L1AT145	TC/mV Input Module (16-channel, Isolated Channels)	400	200
L1AR145	RTD Input Module (16-channel, Isolated Channels)	500	200
—	Digital I/O modules		
L1DV144	Digital Input Module (24 V DC, 16 channels, Module Isolation)	290	140
L1DV521	Digital Output Module (24 V DC/2A, 4 channels, Module Isolation)	280	140
L1DV526	Digital Output Module (100 - 120 V AC, 4 channels, Module Isolation)	500	50
L1DV531	Digital Output Module (24 V DC/0.6 A, 8 channels, Module Isolation)	280	140
L1DV53A	Digital Output Module (48 V DC, 8 channels, Module Isolation)	290	150
L1DV541	Digital Output Module (24 V DC/0.2 A, 16 channels, Module Isolation)	300	150
—	Communication modules		
ALR111	Serial Communication Module (RS-232C, 2-port)	500	—
ALR121	Serial Communication Module (RS-422/RS-485, 2-port)	500	—
ALE111	Ethernet Communication Module (1-port)	500	—
—	Bus interface module		
L1EC402	ESB Bus Coupler Module	500	—
L1EC401	ESB Bus Coupler Module	500	—
L1NT401	Optical ESB Bus Repeater Master Module 5 km	500	—
L1NT501	Optical ESB Bus Repeater Slave Module 5 km	500	—
L1NT411	Optical ESB Bus Repeater Master Module 5 km to 50 km	500	—
L1NT511	Optical ESB Bus Repeater Slave Module 5 km to 50 km	500	—

■ NODE UNIT MOUNTING RESTRICTIONS (FOR AMBIENT TEMPERATURE 60 °C OR LOWER)

Power supply capacity limitation

Up to eight modules per unit can be mounted on L1NB10D safety node unit and L1SC70□ safety control unit; however, the number differs by power supply capacity. Use the Table "Coefficients of Module (temperature type)" to calculate the sum of Coefficient A and B, and figure out the number that both $\Sigma(\text{coefficient A}) + \Sigma(\text{coefficient B})$ and $\Sigma(\text{coefficient B})$ are satisfied within the value shown in the Table "Power Supply Capacity Limitation (temperature type, 60°C or lower)". The values shown in the Table "Power Supply Capacity Limitation (temperature type, 60°C or lower)" differ by the installation environments such as for standard installation and explosion protection.

Table Coefficients of Module (temperature type)

Model	Coefficient A		Coefficient B	
	Single	Dual redundant	Single	Dual redundant
L1AI143-H□3 (2-wire setting)	3	6	25	29
L1AI143-H□3 (4-wire setting)	3	6	5	10
L1AI143-S□3 (2-wire setting)	3	5	22	25
L1AI143-S□3 (4-wire setting)	3	5	4	7
L1AI533-H□3	3	6	12	23
L1AV144-S□3	3	5	2	4
L1AT145-S□3	5	8	8	16
L1AR145-S□3	5	9	8	16
L1DV144-S□3	2	4	2	4
L1DV521-S□3	2	4	2	4
L1DV526-S□3	5	10	3	5
L1DV531-L□3	2	4	2	4
L1DV53A-S□3	2	4	3	5
L1DV541-S□3	3	6	5	7
Other (*1)	5	10	0	0

—: Not available

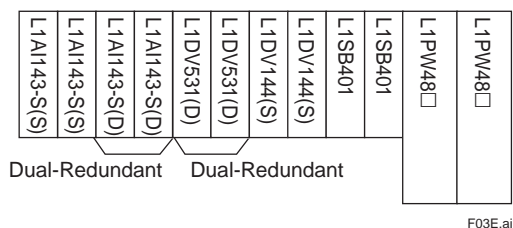
*1: L1EC401, L1EC402, L1NT401, L1NT501, L1NT411, L1NT511, ALR111, ALR121, ALE111

Table Power Supply Capacity Limitation (temperature type, 60°C or lower)

Model	Installation environment	Ambient temperature (°C)	$\Sigma(\text{coefficient A}) + \Sigma(\text{coefficient B})$	$\Sigma(\text{coefficient B})$
L1NB10D	Standard installations	$-20 \leq T_a \leq 60$	—	≤ 100
	For FM NI and EX "ec" installation in Class I, Division 2/Zone 2 area	$-20 \leq T_a \leq 50$	—	≤ 100
		$-20 \leq T_a \leq 60$	—	≤ 88
L1SC70S	Standard installations	$-20 \leq T_a \leq 60$	≤ 121	≤ 85
	For FM NI and EX "ec" installation in Class I, Division 2/Zone 2 area	$-20 \leq T_a \leq 60$	≤ 121	≤ 85
L1SC70D	Standard installations	$-20 \leq T_a \leq 60$	≤ 97	≤ 85
	For FM NI and EX "ec" installation in Class I, Division 2/Zone 2 area	$-20 \leq T_a \leq 60$	≤ 97	≤ 85

Example)

When the following I/O modules are mounted on L1NB10D.
(Standard installation, ambient temperature 40°C)

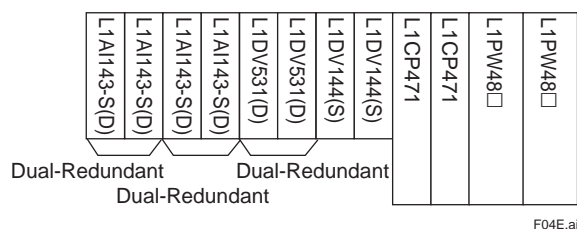


< Calculation method >

$$\begin{aligned} & \Sigma (\text{coefficient B}) \\ &= 22+22+25+4+2+2 \\ &= 77 \text{ (mountable because } \leq 100 \text{ is satisfied)} \end{aligned}$$

Example)

When the following I/O modules are mounted on L1SC70D.
(Standard installation, ambient temperature 40°C)



< Calculation method >

$$\begin{aligned} & \Sigma (\text{coefficient A}) + \Sigma (\text{coefficient B}) \\ &= (5+5+4+2+2) + (25+25+4+2+2) \\ &= 18+58 \\ &= 76 \text{ (mountable because the sum of the coefficient A and the coefficient B } \leq 97 \text{ and the coefficient B } \leq 85 \text{ are} \\ & \text{satisfied)} \end{aligned}$$

Channel availability maximum load current, and external power supply voltage

No specific conditions. Also refer to the I/O module specifications.

Mounting rules

No specific conditions.

■ NODE UNIT MOUNTING RESTRICTIONS (FOR AMBIENT TEMPERATURE MORE THAN 60 °C)

When L1NB10D safety node unit and L1SC70□-F safety control unit for wide range temperature type are used in the ambient temperature of more than 60 °C, available channel of I/O module, maximum load current, external power supply voltage, and mounting location are also restricted as shown below, in addition to the power supply capacity.

There are two types I/O module available - "ISA Standard G3 and wide range temperature" type and "ISA Standard G3 and high-density installation" type. For example, the maximum of eight modules can be mounted on a safety node unit for ISA Standard G3 and high-density installation type and four for ISA Standard G3 and wide range temperature type per unit. ISA Standard G3 and high-density installation type improves the installation efficiency.

● For ISA Standard G3 and High-density Installation Type

By selecting the ISA Standard G3 and high-density installation type listed on the Table "Coefficients of Module (high-density installation type)", I/O module can be installed side by side without leaving an empty slot. L1AI143-S□3, L1AI533-H□3, ALR121-S□3 and ALE111-S□3 allow usages of ISA Standard G3 and wide range temperature type in the same situation as ISA Standard G3 and high-density installation type. Do not mixedly install I/O modules other than listed on the Table "Coefficients of Module (high-density installation type)" on the same node unit. If different types of modules are mounted together, apply the installation conditions of the ISA Standard G3 and wide range temperature type.

Power supply capacity limitation

When ISA Standard G3 and high-density installation type is used at the ambient temperature of more than 60 °C, make sure that Σ (coefficient A) + Σ (coefficient B), Σ (coefficient A) and Σ (coefficient B) must fall within the value shown on the Table "Power Supply Capacity Limitation (high-density installation type)".

Table Coefficients of Module (high-density installation type)

Model	Coefficient A		Coefficient B	
	Single	Dual redundant	Single	Dual redundant
L1AI143-H□C (2-wire setting)	3	6	25	29
L1AI143-H□C (4-wire setting)	3	6	5	10
L1AI143-S□3 (*1) (2-wire setting)	3	5	22	25
L1AI143-S□3 (*1) (4-wire setting)	3	5	4	7
L1AI533-H□3 (*1)	3	6	12	23
L1DV144-S□C	2	4	2	4
L1DV521-S□C	2	4	2	4
L1DV531-L□C	2	4	2	4
L1DV541-S□C	3	6	5	7
ALR121-S□3 (*1)	5	10	0	0
ALE111-S□3 (*1)	5	10	0	0
Other (*2)	5	10	0	0

*1: The usage of ISA Standard G3 and wide range temperature type is allowed in the same situation as ISA Standard G3 and high-density installation type.

*2: L1EC401, L1EC402

Table Power Supply Capacity Limitation (high-density installation type)

Model	Installation environment	Ambient temperature	$\Sigma(\text{coefficient A}) + \Sigma(\text{coefficient B})$	$\Sigma(\text{coefficient A})$	$\Sigma(\text{coefficient B})$
L1NB10D	Standard installations	$-20 \leq T_a \leq 65$	≤ 112	—	≤ 84
		$-20 \leq T_a \leq 70$	≤ 102	—	≤ 80
	For FM NI and EX "ec" installation in Class I, Division 2/Zone 2 area	$-20 \leq T_a \leq 65$	≤ 112	—	≤ 84
		$-20 \leq T_a \leq 70$	≤ 102	—	≤ 80
L1SC70S	Standard installations	$-20 \leq T_a \leq 65$	—	≤ 40	≤ 68
		$-20 \leq T_a \leq 70$	—	≤ 40	≤ 61
	For FM NI and EX "ec" installation in Class I, Division 2/Zone 2 area	$-20 \leq T_a \leq 65$	—	≤ 40	≤ 68
		$-20 \leq T_a \leq 70$	—	≤ 40	≤ 61
L1SC70D	Standard installations	$-20 \leq T_a \leq 65$	—	≤ 25	≤ 68
		$-20 \leq T_a \leq 70$	—	≤ 25	≤ 61
	For FM NI and EX "ec" installation in Class I, Division 2/Zone 2 area	$-20 \leq T_a \leq 65$	—	≤ 25	≤ 68
		$-20 \leq T_a \leq 70$	—	≤ 25	≤ 61

Channel availability, maximum load current, and external power supply voltage

When ISA Standard G3 and high-density installation type is used at the ambient temperature of more than 60 °C, the channel availability, maximum load current, and external power supply voltage are restricted as in the tables below.

•L1AI143-H□C

Model	Ambient temperature	Channel Numbers															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
L1AI143-H□C 2-wired setting	$-20 \text{ }^{\circ}\text{C} \leq T_a \leq 65 \text{ }^{\circ}\text{C}$	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	—
	$-20 \text{ }^{\circ}\text{C} \leq T_a \leq 70 \text{ }^{\circ}\text{C}$	X	X	X	X	X	X	X	X	—	—	—	—	—	—	—	—
L1AI143-H□C 4-wired setting	$-20 \text{ }^{\circ}\text{C} \leq T_a \leq 65 \text{ }^{\circ}\text{C}$	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	$-20 \text{ }^{\circ}\text{C} \leq T_a \leq 70 \text{ }^{\circ}\text{C}$	X	X	X	X	X	X	X	X	X	X	X	X	—	—	—	—

X: Connectable

—: Not connectable

•L1AI143-S□3

Model	Ambient temperature	Channel Numbers															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
L1AI143-S□3 2-wired setting	$-20 \text{ }^{\circ}\text{C} \leq T_a \leq 65 \text{ }^{\circ}\text{C}$	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	—
	$-20 \text{ }^{\circ}\text{C} \leq T_a \leq 70 \text{ }^{\circ}\text{C}$	X	X	X	X	X	X	X	X	X	X	—	—	—	—	—	—
L1AI143-S□3 4-wired setting	$-20 \text{ }^{\circ}\text{C} \leq T_a \leq 70 \text{ }^{\circ}\text{C}$	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

X: Connectable

—: Not connectable

Note: The usage of ISA Standard G3 and wide range temperature type is allowed in the same situation as ISA Standard G3 and high-density installation type. When the ambient temperature is 60 °C or lower, all channels are connectable.

•L1AI533-H□3

Model	Ambient temperature	Channel Numbers							
		1	2	3	4	5	6	7	8
L1AI533-H□3	$-20 \text{ }^{\circ}\text{C} \leq T_a \leq 65 \text{ }^{\circ}\text{C}$	X	X	X	X	X	X	—	—
	$-20 \text{ }^{\circ}\text{C} \leq T_a \leq 70 \text{ }^{\circ}\text{C}$	X	X	X	X	—	—	—	—

X: Connectable

—: Not connectable

Note: The usage of ISA Standard G3 and wide range temperature type is allowed in the same situation as ISA Standard G3 and high-density installation type. When the ambient temperature is 60 °C or lower, all channels are connectable.

•L1DV144-S□C

Model	Ambient temperature	Channel Numbers																24 V DC External power supply
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
L1DV144-S□C	-20 °C ≤ Ta ≤ 65 °C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	+10%, - 10%
	-20 °C ≤ Ta ≤ 70 °C	X	X	X	X	X	X	X	X	X	X	X	X	—	—	—	—	

X: Connectable

—: Not connectable

•L1DV521-S□C

Model (Maximum load current)	Ambient temperature	Channel Numbers				24 V DC External power supply
		1	2	3	4	
L1DV521-S□C (2 A/CH)	-20 °C ≤ Ta ≤ 65 °C	X	X	X	—	+20%, - 10%
	-20 °C ≤ Ta ≤ 70 °C	—	—	—	—	
L1DV521-S□C (1.5 A/CH)	-20 °C ≤ Ta ≤ 65 °C	X	X	X	X	
	-20 °C ≤ Ta ≤ 70 °C	X	X	—	—	
L1DV521-S□C (1 A/CH)	-20 °C ≤ Ta ≤ 70 °C	X	X	X	X	
	-20 °C ≤ Ta ≤ 70 °C	X	X	X	X	

X: Connectable

—: Not connectable

•L1DV531-L□C

Model (Maximum load current)	Ambient temperature	Channel Numbers								24 V DC External power supply
		1	2	3	4	5	6	7	8	
L1DV531-L□C (0.6 A/CH)	-20 °C ≤ Ta ≤ 65 °C	X	X	X	X	X	X	—	—	+20%, - 10%
	-20 °C ≤ Ta ≤ 70 °C	X	X	X	X	—	—	—	—	
L1DV531-L□C (0.45 A/CH)	-20 °C ≤ Ta ≤ 65 °C	X	X	X	X	X	X	X	X	
	-20 °C ≤ Ta ≤ 70 °C	X	X	X	X	—	—	—	—	
L1DV531-L□C (0.4 A/CH)	-20 °C ≤ Ta ≤ 70 °C	X	X	X	X	X	X	X	X	
	-20 °C ≤ Ta ≤ 70 °C	X	X	X	X	X	X	X	X	

X: Connectable

—: Not connectable

•L1DV541-S□C

Model (Maximum load current)	Ambient temperature	Channel Numbers																24 V DC External power supply
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
L1DV541-S□C (0.2 A/CH)	-20 °C ≤ Ta ≤ 65 °C	X	X	X	X	X	X	X	X	X	X	X	X	—	—	—	—	+20%, - 10%
	-20 °C ≤ Ta ≤ 70 °C	X	X	X	X	X	X	X	X	X	X	—	—	—	—	—	—	
L1DV541-S□C (0.15 A/CH)	-20 °C ≤ Ta ≤ 70 °C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

X: Connectable

—: Not connectable

Mounting rules

Modules can be mounted on Slots No. 1 to 8 of L1NB10D Safety Node Unit.

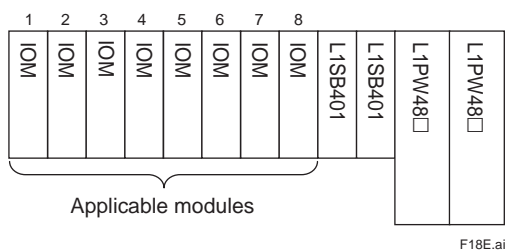


Figure Mounting examples on a safety node unit

Modules can be mounted on the slots No. 1 to 7 of L1SC70□-F Safety Control Unit where ESB bus coupler module is not mounted.

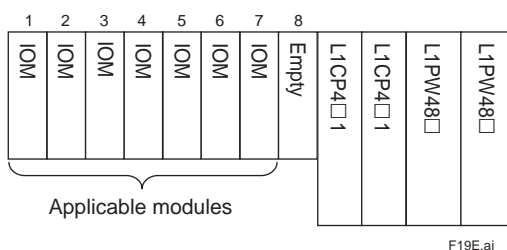


Figure Mounting examples of a safety control unit (without ESB bus coupler)

Modules can be mounted on the slots No. 1 to 6 of L1SC70□-F Safety Control Unit with ESB bus coupler.

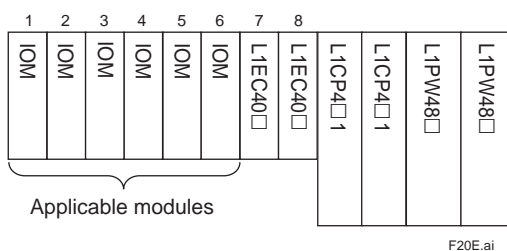


Figure Mounting examples of a safety control unit (with ESB bus coupler)

When mounting I/O modules (ISA Standard G3 and high-density installation type) to a Safety Node Unit or a Safety Control unit at the ambient temperature more than 60 °C, mount them in order of DIO (Digital Input/Output module) → AI (Analog Input module) → AO (Analog Output module) from left to right. (Example 1)

In Addition, the following conditions must be met:

- AI cannot be mounted on the immediate right slot of AO. (Example 2)
(When an empty slot or communication module such as ALR is inserted between AO and AI, the order of the modules is acceptable.) (Example 3)
- DIO cannot be mounted on the immediate right slot of AI or AO. (Example 4)
(When an empty slot or communication module such as ALR is inserted between AI and DIO, or between AO and DIO, the order of the modules is acceptable.) (Example 5)

See the following examples.

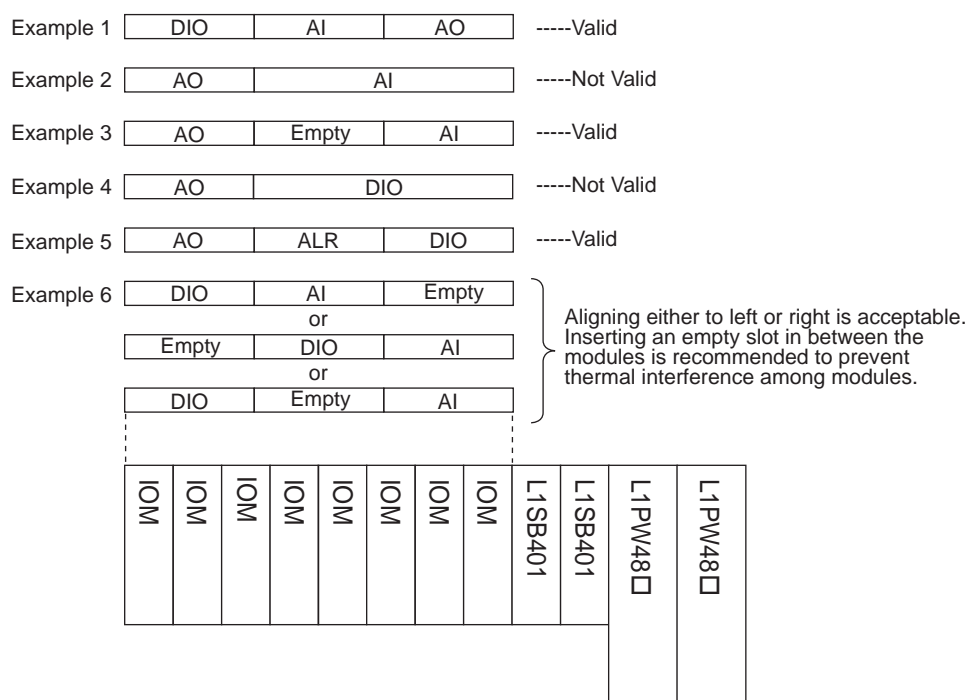


Figure Examples of L1NB10D

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● For ISA Standard G3 and Wide Range Temperature Type

When using I/O modules other than the ones listed on the Table “Coefficients of Module (high-density installation type)”, select ISA Standard G3 and wide range temperature type which meets the following conditions.

Power supply capacity limitation

Refer to the Table “Coefficients of Module (wide range temperature type)” to find the sum of Coefficient A and B assigned to the module and then make sure that Σ (coefficient A) + Σ (coefficient B) and Σ (coefficient B) satisfy the value on the Table “Power Supply Capacity Limitation (wide range temperature type, more than 60°C)”.

Table Power Supply Capacity Limitation (wide range temperature type, more than 60°C)

Model	Installation environment	Ambient temperature (°C)	Σ (coefficient A) + Σ (coefficient B)	Σ (coefficient B)
L1NB10D	Standard installations	$-20 \leq T_a \leq 70$	—	≤ 100
	For FM NI and EX "ec" installation in Class I, Division 2/Zone 2 area	$-20 \leq T_a \leq 70$	—	≤ 80
L1SC70S	Standard installations	$-20 \leq T_a \leq 70$	≤ 121	≤ 85
	For FM NI and EX "ec" installation in Class I, Division 2/Zone 2 area	$-20 \leq T_a \leq 70$	≤ 121	≤ 80
L1SC70D	Standard installations	$-20 \leq T_a \leq 70$	≤ 97	≤ 85
	For FM NI and EX "ec" installation in Class I, Division 2/Zone 2 area	$-20 \leq T_a \leq 70$	≤ 97	≤ 80

Channel availability, maximum load current, and external power supply voltage

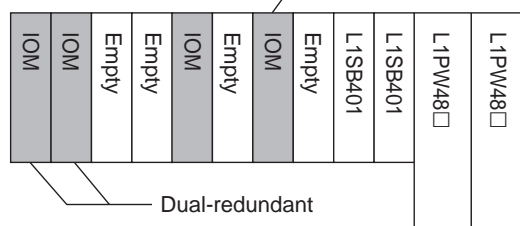
No specific conditions. Also refer to the I/O module specifications.

Mounting rules

When using L1NB10D safety node unit or L1SC70□-F wide range temperature type of safety control unit at the ambient temperature more than 60°C, the following rules must be met:

- The maximum of four I/O modules per unit can be mounted. However, it of the safety control unit becomes three per unit when the safety node is extended with L1SC70□-F, because L1EC40□ are mounted on slots 7 and 8.
- Leave at least one slot empty in between an I/O module and L1EC40□, L1NT□□1, L1SB401, and L1CP471.
- Leave at least one slot empty between I/O modules.
Leave the slots annexed to the dual-redundant modules empty.
- As for L1NT□□1, leave two slots empty for every dual-redundant module between the modules such as L1EC40□, L1NT□□1, L1SB401, and L1PW48□.

At least one empty slot is required between L1SB401 and I/O module



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Figure Example Mounting of I/O Module on Safety Node Unit

■ NODE UNIT MOUNTING RESTRICTIONS (MISCELLANEOUS)

● For ALR111, ALR121 and ALE111

The maximum number of ALR111, ALR121 and ALE111 modules mountable:

6 modules per SCS (4 units for master and 2 units for slave)

(When using the DNP3 slave function, two more ALE111 modules can be mounted.)

● For L1EC402 and L1EC401

L1EC402 or L1EC401 can be mounted on slots No. 7 and 8 of the safety control unit.

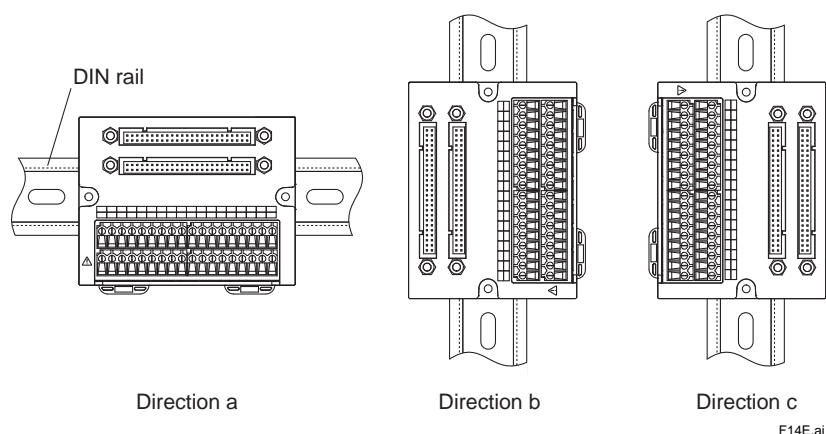
■ CAUTIONS FOR MOUNTING

● Terminal board and relay board mounting directions

Mount a terminal board and a relay board in the directions as shown in the below figure.

When mounting SBD2D in the direction of b or c, the following conditions must be met.

- When the ambient temperature is 60 °C or lower, the total load current of the SBD2D must be kept within the specified value of 8 A or lower.
- When the ambient temperature is at 70 °C, the total load current must be 6 A or less.
- In case the ambient temperature is in between 60 and 70 °C, reduce the total load current from 8 A maximum by the rate of 0.2 A/°C.



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● Mounting an L1AT145 module with SBT4D terminal board

Prevent the terminal board from being influenced by the ambient temperature in order to keep the reference junction compensation accuracy, as detailed conditions are shown below.

The reference junction compensation accuracy is specified when the ambient temperature is stable.

When the temperature fluctuates, the accuracy may vary until it becomes stable.

Mounting a terminal board by itself

Install all the heat sources above the terminal board or terminal board wiring.

Provide a heat shield in case installation of the heat sources below or sideways of the terminal board is unavoidable.

Installing terminal board in a cabinet

Install all the heat sources above the terminal board or terminal board wiring when those are mounted in a cabinet.

Provide a heat shield in case installation of the heat sources below or sideways of the terminal board is unavoidable.

● Cautions of the power source for the loads of SBM54D

In the case of using multiple power sources for the loads of SBM54D, there are cautions of the load voltage.

When the load voltage is different between loads.

All of the load voltages must be in either the range below.

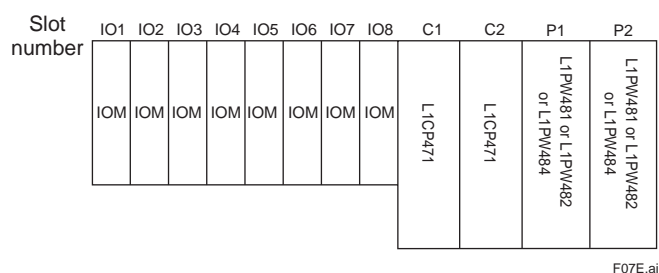
- Load voltages ≤ 100 V
- 50 V < Load voltages ≤ 150 V

● Cautions of the Digital I/O module when SBM54D is used.

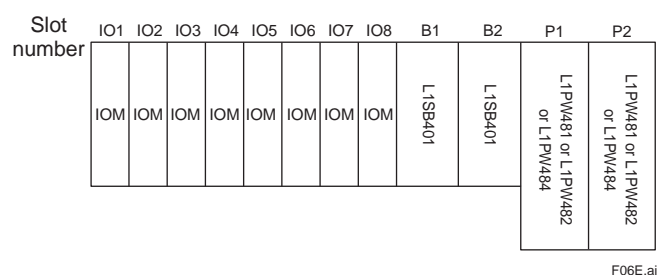
The functions of Disconnection diagnosis, ON Pulse diagnosis and OFF Pulse diagnosis for L1DV541 must be disabled when SBM54D is used.

● Mounting I/O Modules for Dual Redundancy

For dual redundancy, I/O modules should be mounted on Slot No. IO1-IO2, IO3-IO4, IO5-IO6, or IO7-IO8, as shown in the figure below.



For the Safety Control Unit



For the Safety Node Unit

● Empty Slot Protection

Be sure to mount a dummy cover (L1DCV01) on an empty slot on which an I/O module is not mounted.

■ LIMITATIONS ON DIGITAL INPUT MODULE CONNECTIONS

Digital input incorporates input wiring diagnostic functions. Where a pulse test is enabled, it is necessary to take into account the following conditions for the length of the field wiring cable.

● If Pulse Test is Used

The total value of the capacitance of the field devices connected to the digital input modules and their wiring cable capacitance should be:

Total capacitance < 0.1 μ F (100000 pF)

Note: Wiring capacitance from pressure clamp terminal block or terminal board to the field device depends on the cable type such as Discrete wire or Multi-core cable. Make sure the specification of cable.

Note: Calculate the total capacitance of an AKB331 cable with a capacitance of 60 pF/m.

Note: It is not necessary to take into account the capacitance of pressure clamp terminal block, terminal boards, or signal cable adapters.

[References]

For terminal board connections, if the AKB331 cable is 15 m long, the distance between the terminal board and field device is 500 m, the capacitance of the cables is 100 pF/m, and the capacitance of the field devices is 0 pF then

$$\begin{aligned}\text{The total wiring capacitance} &= 15 \text{ (m)} \times 60 \text{ (pF/m)} + 500 \text{ (m)} \times 100 \text{ (pF/m)} + 0 \text{ (pF)} \\ &= 50900 \text{ (pF)} < 100000 \text{ (pF)}\end{aligned}$$

From this calculation, pulse test can work properly.

● When a short circuit detection during input ON is enabled with SCB110 wiring check adapters

The total resistance of field devices and their wiring cables must meet the following condition so that the short circuit of the wiring can be correctly detected.

The total resistance of field devices and their wiring cables < 132 Ω

Note: It is not necessary to take into account the resistance of pressure clamp terminals, terminal boards, signal cable adapters, and wiring check adapters (SCB100/SCB110).

The following table shows AKB331 cable lengths and allowable resistance on the field side if AKB331 cables are used.

AKB331 cable length, m	Resistance allowed on the field side, Ω
0	132
10	120
20	109
30	98
40	87
50	75

[References]

For example, if the AKB331 cable length is 10 meters and the resistance of field device ON is 20 Ω , the allowable wiring resistance is then:

$$120 \Omega - 20 \Omega = 100 \Omega$$

The cable length, both from and to field devices if the cables have a wiring resistance of 58 Ω /km (AWG22 equivalent), is:

$$100 \Omega / 0.058 \Omega/\text{m} \approx 1724 \text{ (m)}$$

Hence, the distance to the field devices is:

$$1724 \text{ (m)} / 2 = 862 \text{ (m)}$$

Note: For cable resistances, refer to the cable manufacturer's specifications.

● When an open circuit detection during input OFF is enabled with SCB100 wiring check adapters

The open circuit can be detected when input signal is 800 k Ω or more.

Please note that the input signal must be 800 k Ω or more when a fuse with LED indicator is used and the current flows after the fuse blown.

■ LIMITATIONS ON DIGITAL OUTPUT MODULE CONNECTIONS

Digital output modules incorporate output wiring diagnostic functions. Where a pulse test is enabled, it is necessary to take into account the following conditions for the length of the field wiring cable.

The total value of the capacitance of the field devices connected to the digital input and output modules and their wiring cable capacitance should be:

Total capacitance < 0.1 μ F (100000 pF)

Note: Wiring capacitance from pressure clamp terminal block or terminal board to the field device depends on the cable type such as Discrete wire or Multi-core cable. Make sure the specification of cable.

Note: Calculate the total capacitance of an AKB331 cable with a capacitance of 60 pF/m.

Note: Calculate the total capacitance of an AKB651 cable with a capacitance of 200 pF/m.

Note: It is not necessary to take into account the capacitance of pressure clamp terminal block, terminal boards, or signal cable adapters.

[References]

For terminal board connections, if the AKB331 cable is 15 m long, the distance between the terminal board and field device is 500 m, the capacitance of the cables is 100 pF/m, and the capacitance of the field devices is 0 pF then

$$\begin{aligned}\text{the total wiring capacitance} &= 15 \text{ (m)} \times 60 \text{ (pF/m)} + 500 \text{ (m)} \times 100 \text{ (pF/m)} + 0 \text{ (pF)} \\ &= 50900 \text{ (pF)} < 100000 \text{ (pF)}\end{aligned}$$

From this calculation, pulse test can work properly.

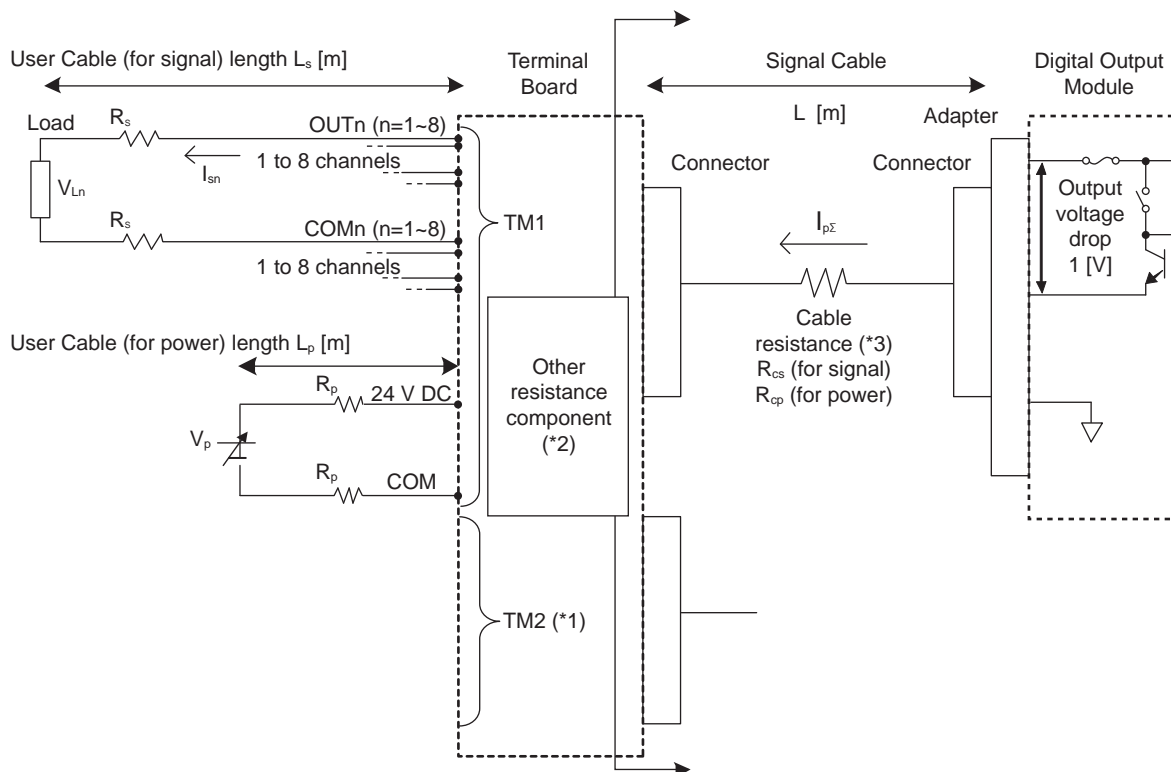
When digital output modules are connected with terminal boards, MIL connectors or pressure clamp terminals, due to the voltage drop on the field wirings, the length of field wirings have restrictions as follows.

● L1DV531

Terminal Board is Connected

The L1DV531 digital output module can respectively handle a maximum of 0.6 A load currents per channel. However, this can cause the generation of a voltage drop due to connected cable and adapter resistance components, etc. Therefore, it is necessary to take account of the limitations on the magnitude of load current and connected cable length as given below.

In case of short circuits detection is enabled, the possible cable length may be limited.



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*1: TM1 only for SBD3D

*2: Other resistance component is given below:

Table Other resistance component vs. Terminal board

Terminal board model No.	Connectionmodule model No.	Other resistance component [mΩ] (By 1 channel)	
		Signal	Power
SED4D	L1DV531	202.8	56.36
SBD3D	L1DV531	222.1	34.72

*3: Cable resistance is given below:

Table Signal cable vs. Cable resistance

Signal cable model No.	Cable resistance [mΩ/m]	
	R_{cs} (for signal)	R_{cp} (for power)
AKB331	446.0	63.71
AKB651	118.6	16.94

If the digital output module connection is configured with a terminal board, signal cable, and adapter for signal cable, observe the following preconditions:

the external power supply voltage is expressed as V_p [V],
 user cable (power) length as L_p [m],
 user cable (power) resistance value as R_p [Ω /m],
 user cable (signal) length as L_s [m],
 user cable (signal) resistance value as R_s [Ω /m],
 signal cable length as L [m],
 signal cable (signal) resistance value as R_{cs} [Ω /m],
 signal cable (power) resistance value as R_{cp} [Ω /m],
 total value of current flowing through channel 1 to channel 8 as $I_{p\Sigma}$ [A],
 current flowing through n-channel as I_{sn} [A] and
 voltage supplied to loads connected to n-channel as V_{Ln} [V].

For SED4D

The voltage drop from the external power supply (V_p) to the output channel load is a total voltage drop of $\Delta V1$ in the power line, $\Delta V2$ in the signal line and $\Delta V3$ in the circuit inside Digital Output Module. Therefore, the voltage supplied to the load connected to a channel is expressed by:

$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3) \\ = V_p - (R_p \times L_p \times 2 + R_{cp} \times L + 0.05636) \times I_{p\Sigma} - (R_s \times L_s \times 2 + R_{cs} \times L + 0.2028) \times I_{sn} - 1$$

[References]

The following shows a possible user signal cable length L_s [m] when changing the length, L [m], of a AKB331 signal cable and the current, I_{sn} [A], flowing through n-channel as in the table below.

Other parameters are given below:

L_p [m] 0.5 User cable (power) length
 R_p [Ω /m] 0.0096 User cable (power) resistance value (when using AWG14)
 R_s [Ω /m] 0.0096 User cable (signal) resistance value (when using AWG14)
 V_{Ln} [V] 21.6 Voltage supplied to loads connected to n-channel
 $I_{p\Sigma}$ [A] ($I_{sn} \times 8$) Total value of current flowing through channel 1 to channel 8
 The capacitance of an AKB331 cable 60 [pF/m]

Wiring capacitance of User cable is calculated with the parameters given below:

User cable (signal) wiring capacitance 50 [pF/m]
 Field devices capacitance 0 [pF]

- In case the external power supply voltage (V_p [V]) is 28.8 V.

Table Possible Cable Length, L_s [m], (when Using AWG14) from the Terminal Board to Loads

Current value (I_{sn}) per channel, [A]	AKB331 cable length							
	15 m	10 m	7 m	5 m	3 m	2 m	1 m	0.6 m
0.1	415.0	555.0	639.0	695.0	751.0	779.0	807.0	818.2
0.2	391.8	539.0	627.4	686.3	745.2	774.6	804.1	815.8
0.3	291.7	523.0	615.7	677.5	739.3	770.2	801.1	813.5
0.4	22.6	271.5	420.8	520.4	619.9	669.7	719.5	739.4
0.5	Not applicable	110.0	259.4	358.9	458.5	508.2	558.0	577.9
0.6	Not applicable	2.4	151.7	251.3	350.8	400.6	450.4	470.3

Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection during output OFF is needed. The above table shows the case that short circuit detection is taken into account. Columns grey in the above table are the area influenced by the short circuit detection.

For SBD3D

SBD3D has parallel diode inside in order to use dual-redundant configuration power supply.

The voltage drop of this diode shows 0.55 V. An external power supply shall be specified as additional 0.55 V within the applicable voltage range 28.8 V maximum of the SBD3D.

The voltage drop from the external power supply (V_p) to the output channel load is a total voltage drop of $\Delta V1$ in the power line, $\Delta V2$ in the signal line and $\Delta V3$ in the circuit inside Digital Output Module. Therefore, the voltage supplied to the load connected to a channel is expressed by:

$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3) \\ = V_p - (R_p \times L_p \times 2 + R_{cp} \times L + 0.03472) \times I_{p\Sigma} - 0.55 - (R_s \times L_s \times 2 + R_{cs} \times L + 0.22212) \times I_{sn} - 1$$

[References]

The following shows a possible user signal cable length L_s [m] when changing the length, L [m], of a signal cable and the current, I_{sn} [A], flowing through n-channel as in the table below.

Other parameters are given below:

L_p [m]	0.5	User cable (power) length
R_p [Ω /m]	0.00798	User cable (power) resistance value (when using 2.5 mm ²)
R_s [Ω /m]	0.00798	User cable (signal) resistance value (when using 2.5 mm ²)
V_{Ln} [V]	21.6	Voltage supplied to loads connected to n-channel
$I_{p\Sigma}$ [A]	($I_{sn} \times 8$)	Total value of current flowing through channel 1 to channel 8
The capacitance of an AKB331 cable	60 [pF/m]	
The capacitance of an AKB651 cable	200 [pF/m]	

Wiring capacitance of User cable is calculated with the parameters given below:

User cable (signal) wiring capacitance	50 [pF/m]
Field devices capacitance	0 [pF]

- In case AKB331 cable is used at the external power supply voltage (V_p [V]) of 28.8 V.

Table Possible cable Length, L_s [m], (when Using 2.5 mm²) from the Terminal Board to Loads

Current value (I_{sn}) per channel, [A]	AKB331 cable length							
	15 m	10 m	7 m	5 m	3 m	2 m	1 m	0.6 m
0.1	478.6	647.0	748.1	815.5	882.8	916.5	950.2	963.7
0.2	451.3	628.4	734.7	805.6	876.4	911.9	947.3	961.5
0.3	246.5	545.9	721.3	795.7	870.0	907.2	944.4	959.2
0.4	Not applicable	250.9	430.5	550.3	670.1	729.9	789.8	813.8
0.5	Not applicable	73.9	253.5	373.3	493.1	552.9	612.8	636.8
0.6	Not applicable	Not applicable	135.5	255.3	375.1	434.9	494.8	518.8

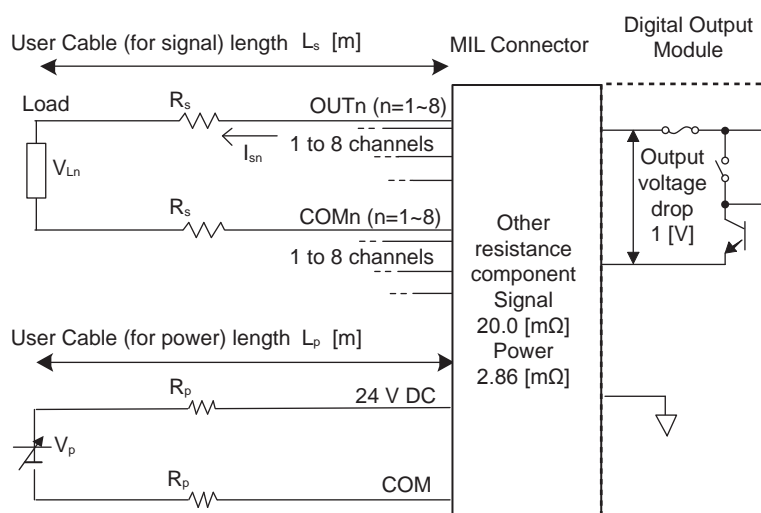
Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection during output OFF is needed. The above table shows the case that short circuit detection is taken into account. Columns grey in the above table are the area influenced by the short circuit detection.

- In case AKB651 cable is used at the external power supply voltage (V_p [V]) of 28.8 V.

Table Possible cable Length, L_s [m], (when Using 2.5 mm²) from the Terminal Board to Loads

Current value (I_{sn}) per channel, [A]	AKB651 cable length								
	30 m	25 m	20 m	15 m	10 m	7 m	5 m	3 m	2 m
0.1	715.2	760.0	804.7	849.5	894.3	921.2	939.1	957.0	966.0
0.2	700.1	747.2	794.3	841.4	888.5	916.8	935.6	954.4	963.9
0.3	667.0	734.4	783.8	833.3	882.7	912.3	932.1	951.9	961.8
0.4	372.0	451.6	531.3	610.9	690.5	738.2	770.1	801.9	817.9
0.5	195.0	274.6	354.3	433.9	513.5	561.2	593.1	624.9	640.9
0.6	77.0	156.6	236.2	315.9	395.5	443.2	475.1	506.9	522.9

Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection during output OFF is needed. The above table shows the case that short circuit detection is taken into account. Columns grey in the above table are the area influenced by the short circuit detection.

MIL Connector is Connected

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Where a MIL connector is used, assuming that:

- the external power supply voltage is expressed as V_p [V],
- user cable (power) length as L_p [m],
- user cable (power) resistance value as R_p [Ω /m],
- user cable (signal) length as L_s [m],
- user cable (signal) resistance value R_s [Ω /m],
- total value of current flowing through channel 1 to channel 8 as $I_{p\Sigma}$,
- current flowing through n-channel as I_{sn} [A], and
- voltage supplied to loads connected to n-channel as V_{Ln} [V].

The voltage drop from the external power supply (V_p) to the output channel load is a total voltage drop of $\Delta V1$ in the power line, $\Delta V2$ in the signal line and $\Delta V3$ in the circuit inside Digital Output Module. Therefore, the voltage supplied to the load connected to a channel is expressed by:

$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3)$$

$$= V_p - (R_p \times L_p \div 7 \times 2 + 0.00286) \times I_{p\Sigma} - (R_s \times L_s \times 2 + 0.0200) \times I_{sn} - 1$$

[References]

The following shows a possible user signal cable length L_s [m] when changing the length, L_p [m], of the power supply cable and the value of the current, I_{sn} [A], flowing through n-channel as in the table below.

Other parameters are given below:

R_p [Ω /m]	0.058	User cable (power) resistance value (when using AWG22)
R_s [Ω /m]	0.058	User cable (signal) resistance value (when using AWG22)
V_{Ln} [V]	21.6	Voltage supplied to loads connected to n-channel
$I_{p\Sigma}$ [A]	$(I_{sn} \times 8)$	Total value of current flowing through channel 1 to channel 8

Wiring capacitance of User cable is calculated with the parameters given below:

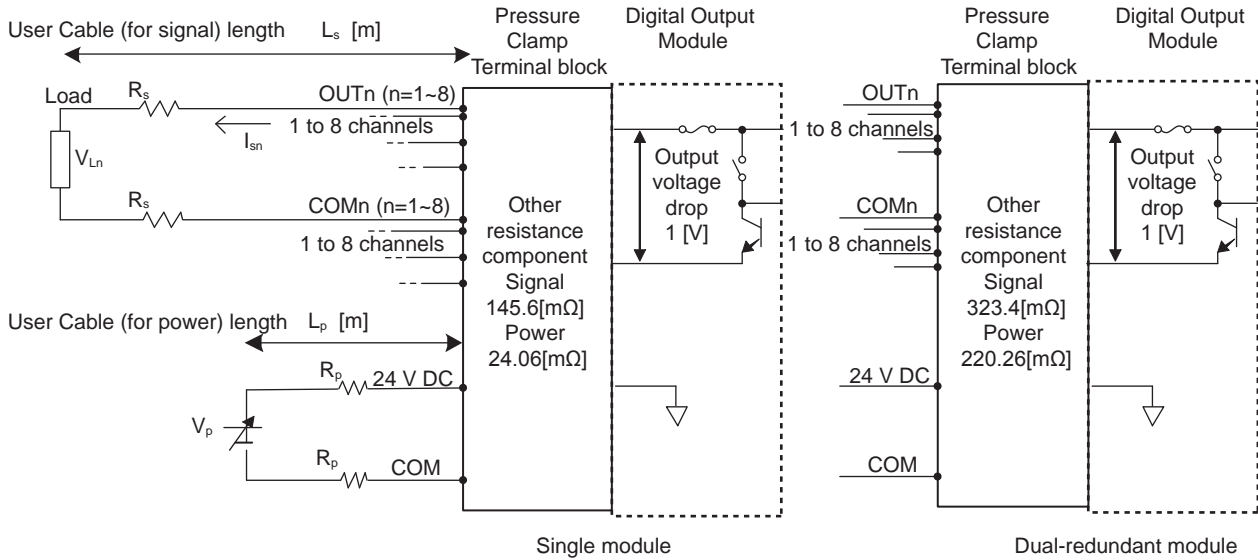
User cable (signal) wiring capacitance	50 [pF/m]
Field devices capacitance	0 [pF]

- In case the external power supply voltage (V_p [V]) is 28.8 V.

Table Possible Cable Length, L_s [m], (when Using AWG22) from MIL Connector to Loads

Current value (I_{sn}) per channel, [A]	Power Supply cable length L_p							
	15 m	10 m	7 m	5 m	3 m	2 m	1 m	0.6 m
0.1	137.5	138.5	139.1	139.5	140.0	140.2	140.4	140.4
0.2	136.5	137.9	138.7	139.2	139.8	140.0	140.3	140.4
0.3	135.6	137.2	138.2	138.9	139.6	139.9	140.2	140.3
0.4	116.1	121.8	125.3	127.5	129.8	131.0	132.1	132.6
0.5	89.4	95.1	98.5	100.8	103.1	104.2	105.4	105.8
0.6	71.6	77.3	80.7	83.0	85.3	86.4	87.6	88.0

Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection during output OFF is needed. The above table shows the case that short circuit detection is taken into account. Columns grey in the above table are the area influenced by the short circuit detection.

Pressure Clamp Terminal Block is Connected

F09E.ai

If the digital output module connection is configured with a pressure clamp terminal block, observe the following preconditions:

- the external power supply voltage is expressed as V_p [V],
- user cable (power) length as L_p [m],
- user cable (power) resistance value as R_p [Ω/m],
- user cable (signal) length as L_s [m],
- user cable (signal) resistance value R_s [Ω/m],
- total value of current flowing through channel 1 to channel 8 as $I_{p\Sigma}$
- current flowing through n-channel as I_{sn} [A], and
- voltage supplied to loads connected to n-channel as V_{Ln} [V].

The voltage drop from the external power supply (V_p) to the output channel load is a total voltage drop of $\Delta V1$ in the power line, $\Delta V2$ in the signal line and $\Delta V3$ in the circuit inside Digital Output Module. Therefore, the voltage supplied to the load connected to a channel is expressed by:

- **Single Module**

$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3)$$

$$= V_p - (R_p \times L_p \times 2 + 0.02406) \times I_{p\Sigma} - (R_s \times L_s \times 2 + 0.1456) \times I_{sn} - 1$$

- **Dual-redundant Module**

$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3)$$

$$= V_p - (R_p \times L_p \times 2 + 0.22026) \times I_{p\Sigma} - (R_s \times L_s \times 2 + 0.3234) \times I_{sn} - 1$$

[References]

The following shows a possible user signal cable length L_s [m] when changing the length, L_p [m], of a power supply cable and the current, I_{sn} [A], flowing through n-channel as in the table below.

Other parameters are given below:

R_p [Ω /m]	0.0096	User cable (power) resistance value (when using AWG14)
R_s [Ω /m]	0.0096	User cable (signal) resistance value (when using AWG14)
V_{Ln} [V]	21.6	Voltage supplied to loads connected to n-channel
$I_{p\Sigma}$ [A]	$(I_{sn} \times 8)$	Total value of current flowing through channel 1 to channel 8

Wiring capacitance of User cable is calculated with the parameters given below:

User cable (signal) wiring capacitance	50 [pF/m]
Field devices capacitance	0 [pF]

- In case the single module is used at the external power supply voltage (V_p [V]) of 28.8 V.

Table Possible Cable Length, L_s [m], (when Using AWG14) from Pressure Clamp Terminal Block to Loads

Current value (I_{sn}) per channel, [A]	Power Supply cable length L_p							
	15 m	10 m	7 m	5 m	3 m	2 m	1 m	0.6 m
0.1	819.6	826.8	831.1	833.9	836.8	838.3	839.7	840.3
0.2	812.5	821.8	827.5	831.2	835.0	836.8	838.7	839.5
0.3	805.4	816.9	823.9	828.5	833.1	835.4	837.7	838.7
0.4	669.7	709.7	733.7	749.7	765.7	773.7	781.7	784.9
0.5	508.2	548.2	572.2	588.2	604.2	612.2	620.2	623.4
0.6	400.6	440.6	464.6	480.6	496.6	504.6	512.6	515.8

Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection during output OFF is needed. The above table shows the case that short circuit detection is taken into account. Columns grey in the above table are the area influenced by the short circuit detection.

- In case the dual-redundant module is used at the external power supply voltage (V_p [V]) of 28.8 V.

Table Possible Cable Length, L_s [m], (when Using AWG14) from Pressure Clamp Terminal Block to Loads

Current value (I_{sn}) per channel, [A]	Power Supply cable length L_p							
	15 m	10 m	7 m	5 m	3 m	2 m	1 m	0.6 m
0.1	795.6	802.8	807.1	810.0	812.9	814.3	815.7	816.3
0.2	784.0	793.4	799.0	802.8	806.5	808.4	810.3	811.0
0.3	772.5	784.0	791.0	795.6	800.2	802.5	804.8	805.8
0.4	578.7	618.7	642.7	658.7	674.7	682.7	690.7	693.9
0.5	417.2	457.2	481.2	497.2	513.2	521.2	529.2	552.4
0.6	309.6	349.6	373.6	389.6	405.6	413.6	421.6	424.8

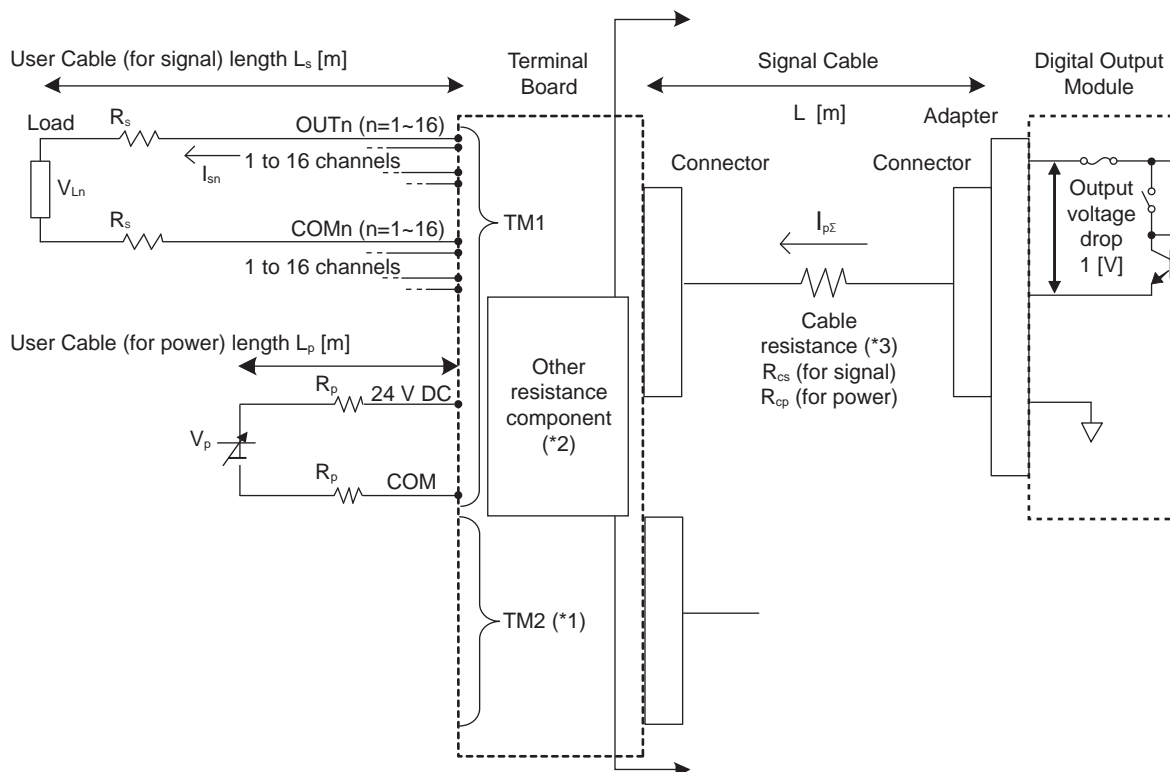
Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection during output OFF is needed. The above table shows the case that short circuit detection is taken into account. Columns grey in the above table are the area influenced by the short circuit detection.

● L1DV541

Terminal Board is Connected

The L1DV541 digital output module can respectively handle a maximum of 0.2 A load currents per channel. However, this can cause the generation of a voltage drop due to connected cable and adapter resistance components, etc. Therefore, it is necessary to take account of the limitations on the magnitude of load current and connected cable length as given below.

In case of short circuits detection is enabled, the possible cable length may be limited.



F15E.ai

*1: TM1 only for SBD4D

*2: Other resistance component is given below:

Table Other resistance component vs. Terminal board

Terminal board model No.	Connection module model No.	Other resistance component [mΩ] (By 1 channel)	
		Signal	Power
SED4D	L1DV541	202.8	56.36
SBD4D	L1DV541	222.1	34.72

*3: Cable resistance is given below:

Table Signal cable vs. Cable resistance

Signal cable model No.	Cable resistance [mΩ/m]	
	R_{cs} (for signal)	R_{cp} (for power)
AKB331	446.0	63.71
AKB651	118.6	16.94

If the digital output module connection is configured with a terminal board, signal cable, and adapter for signal cable, observe the following preconditions:

the external power supply voltage is expressed as V_p [V],
 user cable (power) length as L_p [m],
 user cable (power) resistance value as R_p [Ω /m],
 user cable (signal) length as L_s [m],
 user cable (signal) resistance value as R_s [Ω /m],
 signal cable length as L [m],
 signal cable (signal) resistance value as R_{cs} [Ω /m],
 signal cable (power) resistance value as R_{cp} [Ω /m],
 total value of current flowing through channel 1 to channel 16 as $I_{p\Sigma}$ [A],
 current flowing through n-channel as I_{sn} [A] and
 voltage supplied to loads connected to n-channel as V_{Ln} [V].

For SED4D

The voltage drop from the external power supply (V_p) to the output channel load is a total voltage drop of $\Delta V1$ in the power line, $\Delta V2$ in the signal line and $\Delta V3$ in the circuit inside Digital Output Module. Therefore, the voltage supplied to the load connected to a channel is expressed by:

$$\begin{aligned} V_{Ln} &= V_p - (\Delta V1 + \Delta V2 + \Delta V3) \\ &= V_p - (R_p \times L_p \times 2 + R_{cp} \times L + 0.05636) \times I_{p\Sigma} \\ &\quad - (R_s \times L_s \times 2 + R_{cs} \times L + 0.2028) \times I_{sn} - 1 \end{aligned}$$

[References]

The following shows a possible user signal cable length L_s [m] when changing the length, L [m], of a AKB331 signal cable and the current, I_{sn} [A], flowing through n-channel as in the table below.

Other parameters are given below:

L_p [m] 0.5 User cable (power) length
 R_p [Ω /m] 0.0096 User cable (power) resistance value (when using AWG14)
 R_s [Ω /m] 0.0096 User cable (signal) resistance value (when using AWG14)
 V_{Ln} [V] 21.6 Voltage supplied to loads connected to n-channel
 $I_{p\Sigma}$ [A] ($I_{sn} \times 16$) Total value of current flowing through channel 1 to channel 16
 The capacitance of an AKB331 cable 60 [pF/m]

Wiring capacitance of User cable is calculated with the parameters given below:

User cable (signal) wiring capacitance 50 [pF/m]
 Field devices capacitance 0 [pF]

- In case the external power supply voltage (V_p [V]) is 28.8 V.

Table Possible Cable Length, L_s [m], (when Using AWG14) from the Terminal Board to Loads

Current value (I_{sn}) per channel, [A]	AKB331 cable length							
	15 m	10 m	7 m	5 m	3 m	2 m	1 m	0.6 m
0.1	1694.4	1868.6	1973.1	1994.0	1996.4	1997.6	1998.8	1999.3
0.2	404.2	785.8	1014.8	1167.5	1320.1	1396.4	1472.7	1503.3

Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection during output OFF is needed. The above table shows the case that short circuit detection is taken into account.

AKB331 Cable length is from 0.6 to 5 m:

Columns grey in the above table are the area influenced by the wiring capacitance.

AKB331 Cable length is from 7 to 15 m:

Columns grey in the above table are the area influenced by the short circuit detection.

For SBD4D

SBD4D has parallel diode inside in order to use dual-redundant configuration power supply.

The voltage drop of this diode shows 0.55 V. An external power supply shall be specified as additional 0.55 V within the applicable voltage range 28.8 V maximum of the SBD4D.

The voltage drop from the external power supply (V_p) to the output channel load is a total voltage drop of $\Delta V1$ in the power line, $\Delta V2$ in the signal line and $\Delta V3$ in the circuit inside Digital Output Module. Therefore, the voltage supplied to the load connected to a channel is expressed by:

$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3) \\ = V_p - (R_p \times L_p \times 2 + R_{cp} \times L + 0.03472) \times I_{p\Sigma} - 0.55 - (R_s \times L_s \times 2 + R_{cs} \times L + 0.22212) \times I_{sn} - 1$$

[References]

The following shows a possible user signal cable length L_s [m] when changing the length, L [m], of a signal cable and the current, I_{sn} [A], flowing through n-channel as in the table below.

Other parameters are given below:

L_p [m]	0.5	User cable (power) length
R_p [Ω /m]	0.00798	User cable (power) resistance value (when using 2.5 mm ²)
R_s [Ω /m]	0.00798	User cable (signal) resistance value (when using 2.5 mm ²)
V_{Ln} [V]	21.6	Voltage supplied to loads connected to n-channel
$I_{p\Sigma}$ [A]	($I_{sn} \times 16$)	Total value of current flowing through channel 1 to channel 16
The capacitance of an AKB331 cable	60 [pF/m]	
The capacitance of an AKB651 cable	200 [pF/m]	

Wiring capacitance of User cable is calculated with the parameters given below:

User cable (signal) wiring capacitance	50 [pF/m]
Field devices capacitance	0 [pF]

- In case AKB331 cable is used at the external power supply voltage (V_p [V]) of 28.8 V.

Table Possible cable Length, L_s [m], (when Using 2.5 mm²) from the Terminal Board to Loads

Current value (I_{sn}) per channel, [A]	AKB331 cable length							
	15 m	10 m	7 m	5 m	3 m	2 m	1 m	0.6 m
0.1	1982.0	1988.0	1991.6	1994.0	1996.4	1997.6	1998.8	1999.3
0.2	336.1	795.2	1070.6	1254.3	1437.9	1529.7	1621.5	1658.2

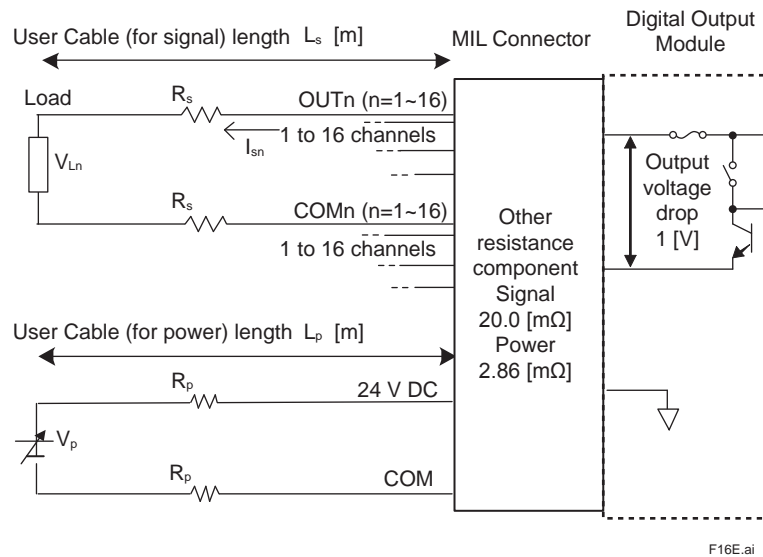
Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection during output OFF is needed. The above table shows the case that short circuit detection is taken into account. Columns grey in the above table are the area influenced by the wiring capacitance.

- In case AKB651 cable is used at the external power supply voltage (V_p [V]) of 28.8 V.

Table Possible cable Length, L_s [m], (when Using 2.5 mm²) from the Terminal Board to Loads

Current value (I_{sn}) per channel, [A]	AKB651 cable length								
	30 m	25 m	20 m	15 m	10 m	7 m	5 m	3 m	2 m
0.1	1880.0	1900.0	1920.0	1940.0	1960.0	1972.0	1980.0	1988.0	1992.0
0.2	980.9	1103.0	1225.1	1347.1	1469.2	1542.4	1591.3	1640.1	1664.5

Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection during output OFF is needed. The above table shows the case that short circuit detection is taken into account. Columns grey in the above table are the area influenced by the wiring capacitance.

MIL Connector is Connected

F16E.ai

Where a MIL connector is used, assuming that:

- the external power supply voltage is expressed as V_p [V],
- user cable (power) length as L_p [m],
- user cable (power) resistance value as R_p [Ω /m],
- user cable (signal) length as L_s [m],
- user cable (signal) resistance value R_s [Ω /m],
- total value of current flowing through channel 1 to channel 16 as $I_{p\Sigma}$,
- current flowing through n-channel as I_{sn} [A], and
- voltage supplied to loads connected to n-channel as V_{Ln} [V].

The voltage drop from the external power supply (V_p) to the output channel load is a total voltage drop of $\Delta V1$ in the power line, $\Delta V2$ in the signal line and $\Delta V3$ in the circuit inside Digital Output Module. Therefore, the voltage supplied to the load connected to a channel is expressed by:

$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3) \\ = V_p - (R_p \times L_p \div 7 \times 2 + 0.00286) \times I_{p\Sigma} - (R_s \times L_s \times 2 + 0.0200) \times I_{sn} - 1$$

[References]

The following shows a possible user signal cable length L_s [m] when changing the length, L_p [m], of the power supply cable and the value of the current, I_{sn} [A], flowing through n-channel as in the table below.

Other parameters are given below:

R_p [Ω /m]	0.058	User cable (power) resistance value (when using AWG22)
R_s [Ω /m]	0.058	User cable (signal) resistance value (when using AWG22)
V_{Ln} [V]	21.6	Voltage supplied to loads connected to n-channel
$I_{p\Sigma}$ [A]	$(I_{sn} \times 16)$	Total value of current flowing through channel 1 to channel 16

Wiring capacitance of User cable is calculated with the parameters given below:

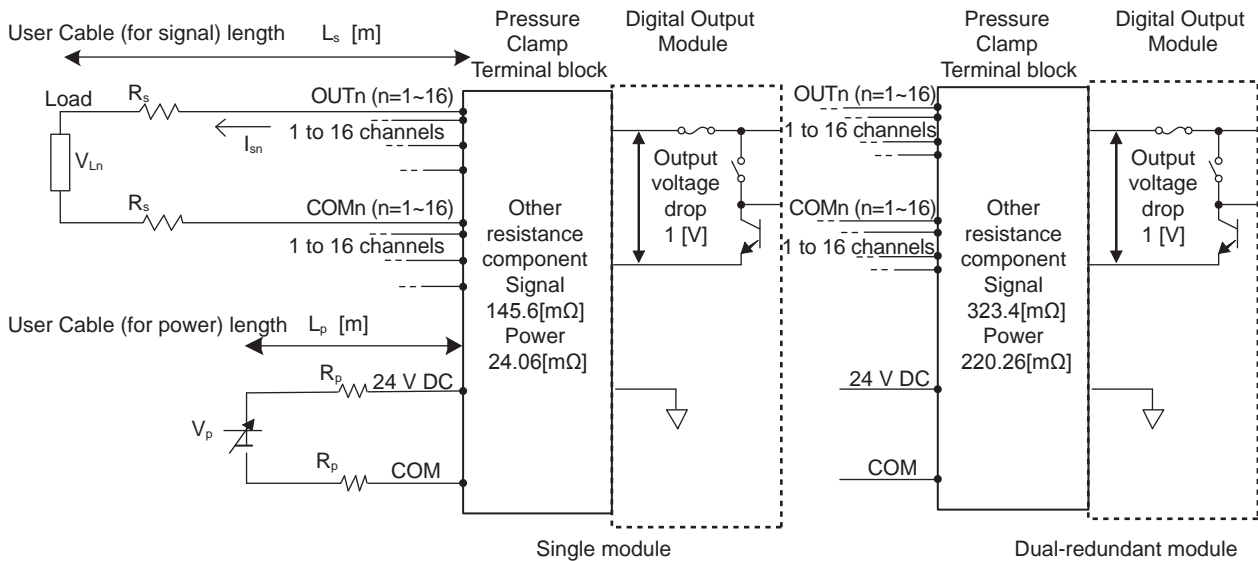
User cable (signal) wiring capacitance	50 [pF/m]
Field devices capacitance	0 [pF]

- In case the external power supply voltage (V_p [V]) of 28.8 V.

Table Possible Cable Length, L_s [m], (when Using AWG22) from MIL Connector to Loads

Current value (I_{sn}) per channel, [A]	Power Supply cable length L_p							
	15 m	10 m	7 m	5 m	3 m	2 m	1 m	0.6 m
0.1	362.9	365.4	366.9	367.9	368.9	369.4	369.9	370.1
0.2	232.4	243.8	250.7	255.2	259.8	262.1	264.4	265.3

Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection during output OFF is needed. The above table shows the case that short circuit detection is taken into account. Columns grey in the above table are the area influenced by the short circuit detection.

Pressure Clamp Terminal Block is Connected

F17E.ai

If the digital output module connection is configured with a pressure clamp terminal block, observe the following preconditions:

- the external power supply voltage is expressed as V_p [V],
- user cable (power) length as L_p [m],
- user cable (power) resistance value as R_p [Ω/m],
- user cable (signal) length as L_s [m],
- user cable (signal) resistance value R_s [Ω/m],
- total value of current flowing through channel 1 to channel 16 as $I_{p\Sigma}$,
- current flowing through n-channel as I_{sn} [A], and
- voltage supplied to loads connected to n-channel as V_{Ln} [V].

The voltage drop from the external power supply (V_p) to the output channel load is a total voltage drop of $\Delta V1$ in the power line, $\Delta V2$ in the signal line and $\Delta V3$ in the circuit inside Digital Output Module. Therefore, the voltage supplied to the load connected to a channel is expressed by:

• Single Module

The calculation formula is different between channels 1 to 8 and channels 9 to 16 of the L1DV541 module; possible cable lengths in channels 9 to 16 are shorter than those in channels 1 to 8.

Channels 1 to 8

The same calculation formula is given below:

$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3) \\ = V_p - (R_p \times L_p \times 2 + 0.02406) \times I_{p\Sigma} - (R_s \times L_s \times 2 + 0.1456) \times I_{sn} - 1$$

However in this case, it is recommended that channels 1 to 8 be used following the specifications for channels 9 to 16.

Channels 9 to 16

The calculation formula is given below:

$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3) \\ = V_p - (R_p \times L_p \times 2 + 0.02406) \times I_{p\Sigma} - (R_s \times L_s \times 2 + 0.9584) \times I_{sn} - 1$$

• Dual-redundant Module

$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3) \\ = V_p - (R_p \times L_p \times 2 + 0.22026) \times I_{p\Sigma} - (R_s \times L_s \times 2 + 0.3234) \times I_{sn} - 1$$

[References]

The following shows a possible user signal cable length L_s [m] when changing the length, L_p [m], of a power supply cable and the current, I_{sn} [A], flowing through n-channel as in the table below.

Other parameters are given below:

R_p [Ω /m]	0.0096	User cable (power) resistance value (when using AWG14)
R_s [Ω /m]	0.0096	User cable (signal) resistance value (when using AWG14)
V_{Ln} [V]	21.6	Voltage supplied to loads connected to n-channel
$I_{p\Sigma}$ [A]	$(I_{sn} \times 16)$	Total value of current flowing through channel 1 to channel 16

Wiring capacitance of User cable is calculated with the parameters given below:

User cable (signal) wiring capacitance	50 [pF/m]
Field devices capacitance	0 [pF]

- In case the single module is used at the external power supply voltage (V_p [V]) of 28.8 V.

Table Possible Cable Length, L_s [m], (when Using AWG14) from Pressure Clamp Terminal Block to Loads

Current value (I_{sn}) per channel, [A]	Power Supply cable length L_p							
	15 m	10 m	7 m	5 m	3 m	2 m	1 m	0.6 m
0.1	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0
0.2	1304.6	1384.6	1432.6	1464.6	1496.6	1512.6	1528.6	1535.0

Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection during output OFF is needed. The above table shows the case that short circuit detection is taken into account. Columns grey in the above table are the area influenced by the wiring capacitance.

- In case the dual-redundant module is used at the external power supply voltage (V_p [V]) of 28.8 V.

Table Possible Cable Length, L_s [m], (when Using AWG14) from Pressure Clamp Terminal Block to Loads

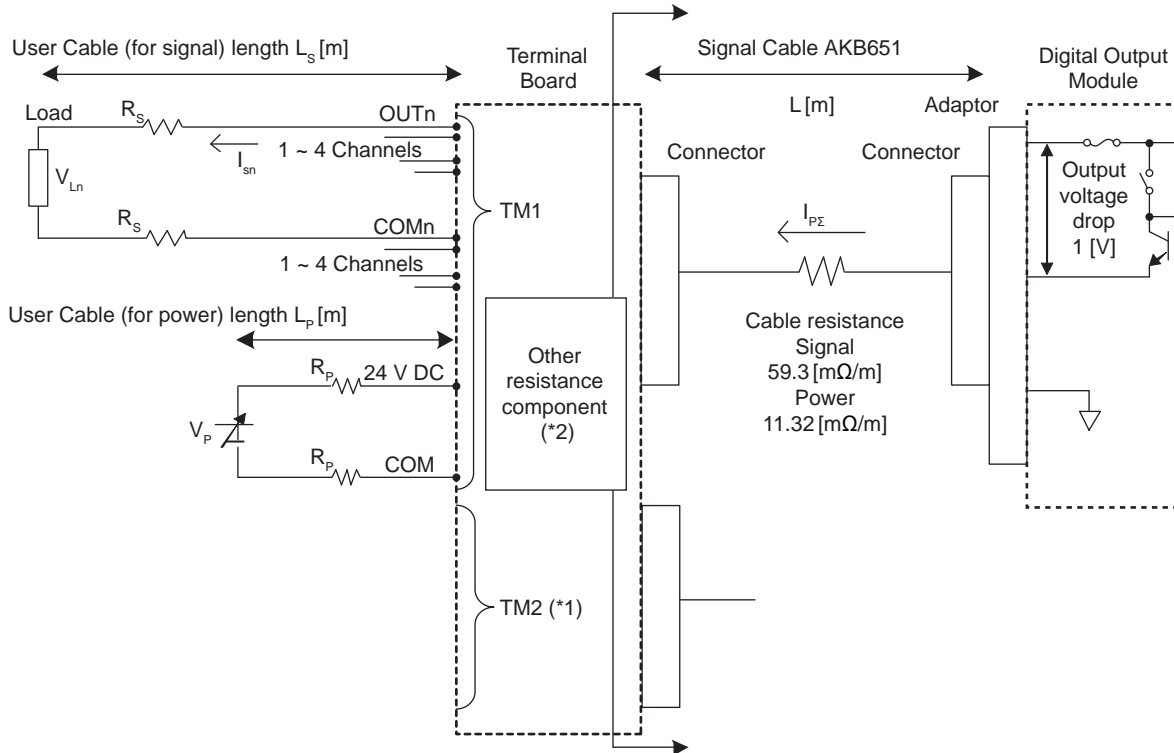
Current value (I_{sn}) per channel, [A]	Power Supply cable length L_p							
	15 m	10 m	7 m	5 m	3 m	2 m	1 m	0.6 m
0.1	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0
0.2	1174.2	1254.2	1302.2	1334.2	1366.2	1382.2	1398.2	1404.6

Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection during output OFF is needed. The above table shows the case that short circuit detection is taken into account. Columns grey in the above table are the area influenced by the wiring capacitance.

● L1DV521

Terminal Board is Connected

The L1DV521 digital output module can be connected only to terminal board via signal cable (AKB651). In this configuration, the generation of a voltage drop which is commensurate with load current depending on the ohmic value. Therefore, it is necessary to take account of the following limitations.



F10E.ai

*1: TM1 only for SBD2D

*2: Other resistance component is given below:

Table Other resistance component vs. Terminal board

Terminal board model No.	Connectionmodule model No.	Other resistance component [mΩ] (By 1 channel)	
		Signal	Power
SED2D	L1DV521	60.0	42.64
SBD2D	L1DV521	57.7	20.59

Terminal Board is Connected

Observe the following preconditions:

the external power supply voltage is expressed as V_p [V],
 user cable (power) length as L_p [m],
 user cable (power) resistance value as R_p [Ω/m],
 user cable (signal) length as L_s [m],
 user cable (signal) resistance value as R_s [Ω/m],
 signal cable (AKB651) length as L [m],
 total value of current flowing through channel 1 to channel 4 as $I_{p\Sigma}$ [A],
 current flowing through n-channel as I_{sn} [A], and
 voltage supplied to loads connected to n-channel as V_{Ln} [V].

In case of short circuit detection is enabled, the possible cable length may be limited.

For SED2D

The voltage drop from the external power supply (V_p) to the output channel load is a total of a voltage drop of $\Delta V1$ in the power line, $\Delta V2$ in the signal line and $\Delta V3$ in the circuit inside Digital Output Module. Therefore, the voltage supplied to the load connected to a channel is expressed by:

$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3) \\ = V_p - (R_p \times L_p \times 2 + 0.01132 \times L + 0.04264) \times I_{p\Sigma} - (R_s \times L_s \times 2 + 0.0593 \times L + 0.0600) \times I_{sn} - 1$$

[References]

The following shows a possible user signal cable length L_s [m] when changing the length, L [m], of the power cable (AKB651 cable) and the value of the current, I_{sn} [A], flowing through n-channel as in the table below.

Other parameters are given below:

L_p [m]	3.0	User cable (power) length
R_p [Ω /m]	0.0038	User cable (power) resistance value (when using AWG10)
R_s [Ω /m]	0.0038	User cable (signal) resistance value (when using AWG10)
V_{Ln} [V]	21.6	Voltage supplied to loads connected to n-channel
$I_{p\Sigma}$ [A]	($I_{sn} \times 4$)	Total value of current flowing through channel 1 to channel 4
The capacitance of an AKB651 cable	200 [pF/m]	

Wiring capacitance of User cable is calculated with the parameters given below:

User cable (signal) wiring capacitance	50 [pF/m]
Field devices capacitance	0 [pF]

- In case the external power supply voltage (V_p [V]) is 28.8 V.

Table Possible cable Length, L_s [m], (when Using AWG10) from the Terminal Board to Load

Current value (I_{sn}) per channel, [A]	AKB651 cable length							
	20 m	15 m	10 m	7 m	5 m	3 m	2 m	1 m
0.1	1920.0	1940.0	1960.0	1972.0	1980.0	1988.0	1992.0	1996.0
0.2	1920.0	1940.0	1960.0	1972.0	1980.0	1988.0	1992.0	1996.0
0.3	1920.0	1940.0	1960.0	1972.0	1980.0	1988.0	1992.0	1996.0
0.4	1721.9	1790.7	1859.5	1900.8	1928.3	1955.9	1969.6	1983.4
0.5	1314.0	1382.8	1451.6	1492.9	1520.4	1548.0	1561.7	1575.5
0.6	1042.1	1110.9	1179.7	1221.0	1248.5	1276.0	1289.8	1303.6
0.8	702.2	771.0	839.8	881.1	908.6	936.1	949.9	936.6
1.0	498.2	567.0	635.8	677.1	704.7	732.2	745.9	759.7
1.5	226.3	295.1	363.9	405.2	432.7	460.2	474.0	487.8
2.0	90.3	159.2	228.0	269.2	296.8	324.3	338.0	351.8

Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection of the field wiring during output OFF is needed. Maximum cable length which the short circuit of the field wiring can be detected during output OFF varies with the characteristics of the equipment's inrush current value at on-pulse test. The above table shows the case that short circuit detection is taken into account with the inrush current value of 0.5A or less. Columns grey in the above table are the area influenced by the wiring capacitance.

For SBD2D

SBD2D has parallel diode inside in order to use dual-redundant configuration power supply.

The voltage drop of this diode shows 0.55 V. An external power supply shall be specified as additional 0.55 V within the applicable voltage range 28.8 V maximum of the SBD2D.

The voltage drop from the external power supply (V_p) to the output channel load is a total of a voltage drop of $\Delta V1$ in the power line, $\Delta V2$ in the signal line and $\Delta V3$ in the circuit inside Digital Output Module. Therefore, the voltage supplied to the load connected to a channel is expressed by:

$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3) \\ = V_p - (R_p \times L_p \times 2 + 0.01132 \times L + 0.02059) \times I_{p\Sigma} - 0.55 - (R_s \times L_s \times 2 + 0.0593 \times L + 0.05774) \times I_{sn} - 1$$

[References]

The following shows a possible user signal cable length L_s [m] when changing the length, L [m], of the power cable (AKB651 cable) and the value of the current, I_{sn} [A], flowing through n-channel as in the table below.

Other parameters are given below:

L_p [m]	3.0	User cable (power) length
R_p [Ω /m]	0.00798	User cable (power) resistance value (when using 2.5 mm ²)
R_s [Ω /m]	0.00798	User cable (signal) resistance value (when using 2.5 mm ²)
V_{Ln} [V]	21.6	Voltage supplied to loads connected to n-channel
$I_{p\Sigma}$ [A]	($I_{sn} \times 4$)	Total value of current flowing through channel 1 to channel 4
The capacitance of an AKB651 cable	200 [pF/m]	

Wiring capacitance of User cable is calculated with the parameters given below:

User cable (signal) wiring capacitance	50 [pF/m]
Field devices capacitance	0 [pF]

- In case the external power supply voltage (V_p [V]) is 28.8 V.

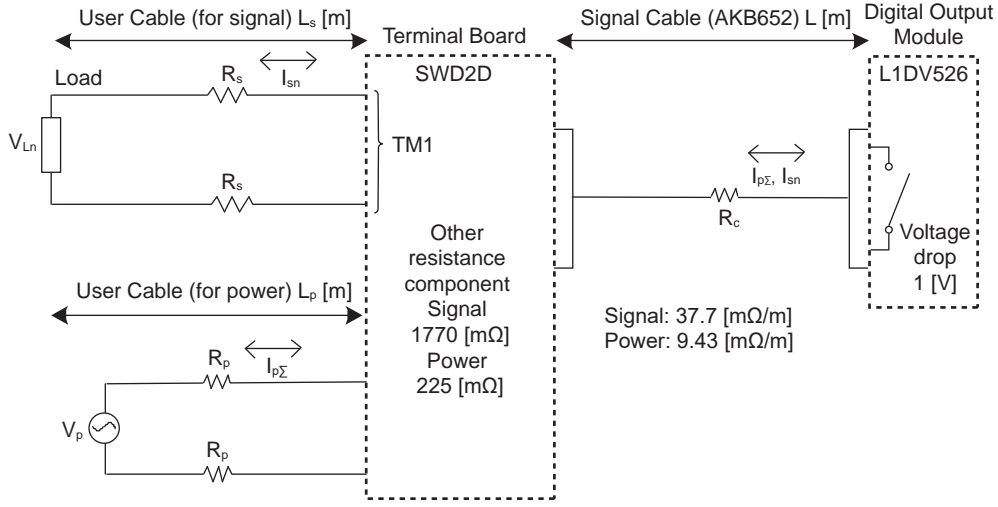
Table Possible cable Length, L_s [m], (when Using 2.5 mm²) from the Terminal Board to Load

Current value (I_{sn}) per channel, [A]	AKB651 cable length							
	20 m	15 m	10 m	7 m	5 m	3 m	2 m	1 m
0.1	1125.4	1147.5	1169.7	1182.9	1191.8	1200.6	1205.0	1209.5
0.2	1125.4	1147.5	1169.7	1182.9	1191.8	1200.6	1205.0	1209.5
0.3	1028.2	1061.0	1093.7	1113.4	1126.5	1139.6	1146.2	1152.7
0.4	733.2	766.0	798.7	818.4	831.5	844.6	851.1	857.7
0.5	556.2	589.0	621.7	641.4	654.5	667.6	674.1	680.7
0.6	438.2	471.0	503.7	523.4	536.5	549.6	556.1	562.7
0.8	290.7	323.4	356.2	375.9	389.0	402.1	408.6	415.2
1.0	202.2	234.9	267.7	287.4	300.5	313.6	320.1	326.7
1.5	84.2	116.9	149.7	169.4	182.5	195.6	202.1	208.7
2.0	25.2	57.9	90.7	110.4	123.5	136.6	143.1	149.7

Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection of the field wiring during output OFF is needed. Maximum cable length which the short circuit of the field wiring can be detected during output OFF varies with the characteristics of the equipment's inrush current value at on-pulse test. The above table shows the case that short circuit detection is taken into account with the inrush current value of 0.5A or less. Columns grey in the above table are the area influenced by the short circuit detection.

● L1DV526

Terminal Board is Connected



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Terminal Board is Connected

Observe the following preconditions:

- the external power supply voltage is expressed as V_p [V],
- user cable (power) length as L_p [m],
- user cable (power) resistance value as R_p [Ω/m],
- user cable (signal) length as L_s [m],
- user cable (signal) resistance value as R_s [Ω/m],
- signal cable (AKB652) length as L [m],
- total value of current flowing through channel 1 to channel 4 as $I_{p\Sigma}$ [A],
- current flowing through n-channel as I_{sn} [A], and
- voltage supplied to loads connected to n-channel as V_{Ln} [V].

The voltage drop from the external power supply (V_p) to the output channel load is a total voltage drop of $\Delta V1$ in the power line, $\Delta V2$ in the signal line and $\Delta V3$ in the circuit inside Digital Output Module. Therefore, the voltage supplied to load connected to a channel is expressed by:

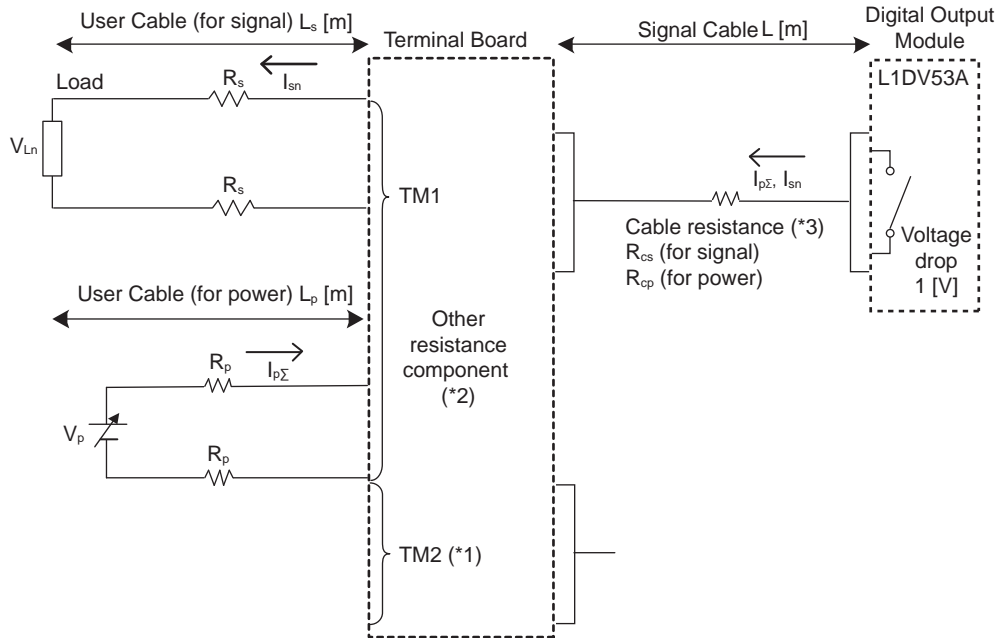
$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3)$$

$$= V_p - (R_p \times L_p \times 2 + 0.00943 \times L + 0.225) \times I_{p\Sigma} - (R_s \times L_s \times 2 + 0.0377 \times L + 1.77) \times I_{sn} - 1$$

● L1DV53A

Terminal Board is Connected

The L1DV53A digital output module can be connected only to terminal board via signal cable. In this configuration, the generation of a voltage drop which is commensurate with load current depending on the ohmic value. Therefore, it is necessary to take account of the following limitations.



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*1: TM1 only for SBD4D

*2: Other resistance component is given below:

Table Other resistance component vs. Terminal board

Terminal board model No.	Connection module model No.	Other resistance component [mΩ] (By 1 channel)	
		Signal	Power
SED3D	L1DV53A	222	89
SBD3D	L1DV53A	261	38

*3: Cable resistance is given below:

Table Signal cable vs. Cable resistance

Signal cable model No.	Cable resistance [mΩ/m]	
	R_{cs} (for signal)	R_{cp} (for power)
AKB331	446.0	63.71
AKB651	118.6	16.94

Terminal Board is Connected

Observe the following preconditions:

the external power supply voltage is expressed as V_p [V],
 user cable (power) length as L_p [m],
 user cable (power) resistance value as R_p [Ω /m],
 user cable (signal) length as L_s [m],
 user cable (signal) resistance value as R_s [Ω /m],
 signal cable length as L [m],
 signal cable (signal) resistance value as R_{cs} [Ω /m],
 signal cable (power) resistance value as R_{cp} [Ω /m],
 total value of current flowing through channel 1 to channel 8 as $I_{p\Sigma}$ [A],
 current flowing through n-channel as I_{sn} [A], and
 voltage supplied to loads connected to n-channel as V_{Ln} [V].

In case of short circuit detection is enabled, the possible cable length may be limited.

For SED3D

The voltage drop from the external power supply (V_p) to the output channel load is a total voltage drop of $\Delta V1$ in the power line, $\Delta V2$ in the signal line and $\Delta V3$ in the circuit inside Digital Output Module. Therefore, the voltage supplied to load connected to a channel is expressed by:

$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3) \\ = V_p - (R_p \times L_p \times 2 + R_{cp} \times L + 0.0890) \times I_{p\Sigma} - (R_s \times L_s \times 2 + R_{cs} \times L + 0.222) \times I_{sn} - 1$$

[References]

The following shows a possible user signal cable length L_s [m] when changing the length, L [m], of a AKB331 signal cable and the current, I_{sn} [A], flowing through n-channel as in the table below.

Other parameters are given below:

L_p [m]	0.5	User cable (power) length
R_p [Ω /m]	0.0096	User cable (power) resistance value (when using AWG14)
R_s [Ω /m]	0.0096	User cable (signal) resistance value (when using AWG14)
V_{Ln} [V]	43.2	Voltage supplied to loads connected to n-channel
$I_{p\Sigma}$ [A]	($I_{sn} \times 8$)	Total value of current flowing through channel 1 to channel 8
The capacitance of an AKB331 cable		60 [pF/m]

Wiring capacitance of User cable is calculated with the parameters given below:

User cable (signal) wiring capacitance	50 [pF/m]
Field devices capacitance	0 [pF]

- In case the external power supply voltage (V_p [V]) is 57.6 V.

Table Possible Cable Length, L_s [m], (when Using AWG14) from the Terminal Board to Loads

Current value (I_{sn}) per channel, [A]	AKB331 cable length								
	20 m	15 m	10 m	7 m	5 m	3 m	2 m	1 m	0.6 m
0.1	1976.0	1982.0	1988.0	1991.6	1994.0	1996.4	1997.6	1998.8	1999.3
0.2	1976.0	1982.0	1988.0	1991.6	1994.0	1996.4	1997.6	1998.8	1999.3
0.3	1278.2	1527.1	1776.0	1925.3	1994.0	1996.4	1997.6	1998.8	1999.3
0.4	696.6	945.5	1194.4	1343.7	1443.3	1542.8	1592.6	1642.4	1662.3
0.5	347.7	596.6	845.4	994.8	1094.3	1193.9	1243.6	1293.4	1313.3
0.6	115.0	363.9	612.8	762.1	861.7	961.2	1011.0	1060.8	1080.7

Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection of the field wiring during output OFF is needed. Maximum cable length which the short circuit of the field wiring can be detected during output OFF varies with the characteristics of the equipment's inrush current value at on-pulse test. The above table shows the case that short circuit detection is taken into account with the inrush current value of 0.6A or less. Columns grey in the above table are the area influenced by the wiring capacitance.

For SBD3D

SBD3D has parallel diode inside in order to use dual-redundant configuration power supply.

The voltage drop of this diode shows 0.6 V. An external power supply shall be specified as additional 0.6 V within the applicable voltage range 57.6 V maximum of the SBD3D.

The voltage drop from the external power supply (V_p) to the output channel load is a total voltage drop of $\Delta V1$ in the power line, $\Delta V2$ in the signal line and $\Delta V3$ in the circuit inside Digital Output Module. Therefore, the voltage supplied to load connected to a channel is expressed by:

$$V_{Ln} = V_p - (\Delta V1 + \Delta V2 + \Delta V3) \\ = V_p - (R_p \times L_p \times 2 + R_{cp} \times L + 0.03809) \times I_{p\sum} - 0.6 - (R_s \times L_s \times 2 + R_{cs} \times L + 0.2606) \times I_{sn} - 1$$

[References]

The following shows a possible user signal cable length L_s [m] when changing the length, L [m], of a signal cable and the current, I_{sn} [A], flowing through n-channel as in the table below.

Other parameters are given below:

L_p [m]	0.5	User cable (power) length
R_p [Ω /m]	0.00798	User cable (power) resistance value (when using 2.5 mm ²)
R_s [Ω /m]	0.00798	User cable (signal) resistance value (when using 2.5 mm ²)
V_{Ln} [V]	43.2	Voltage supplied to loads connected to n-channel
$I_{p\sum}$ [A]	($I_{sn} \times 8$)	Total value of current flowing through channel 1 to channel 8
The capacitance of an AKB331 cable	60 [pF/m]	
The capacitance of an AKB651 cable	200 [pF/m]	

Wiring capacitance of User cable is calculated with the parameters given below:

User cable (signal) wiring capacitance	50 [pF/m]
Field devices capacitance	0 [pF]

- In case AKB331 cable is used at the external power supply voltage (V_p [V]) is 57.6 V.

Table Possible cable Length, L_s [m], (when Using 2.5 mm²) from the Terminal Board to Load

Current value (I_{sn}) per channel, [A]	AKB331 cable length								
	20 m	15 m	10 m	7 m	5 m	3 m	2 m	1 m	0.6 m
0.1	1976.0	1982.0	1988.0	1991.6	1994.0	1996.4	1997.6	1998.8	1999.3
0.2	1976.0	1982.0	1988.0	1991.6	1994.0	1996.4	1997.6	1998.8	1999.3
0.3	1436.3	1735.7	1988.0	1991.6	1994.0	1996.4	1997.6	1998.8	1999.3
0.4	768.0	1067.4	1366.8	1546.4	1666.2	1786.0	1845.8	1905.7	1929.7
0.5	367.0	666.4	965.8	1145.4	1265.2	1384.9	1444.8	1504.7	1528.7
0.6	99.7	399.1	698.5	878.1	997.9	1117.6	1177.5	1237.4	1261.3

Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection of the field wiring during output OFF is needed. Maximum cable length which the short circuit of the field wiring can be detected during output OFF varies with the characteristics of the equipment's inrush current value at on-pulse test. The above table shows the case that short circuit detection is taken into account with the inrush current value of 0.6A or less. Columns grey in the above table are the area influenced by the wiring capacitance.

- In case AKB651 cable is used at the external power supply voltage (V_p [V]) is 57.6 V.

Table Possible cable Length, L_s [m], (when Using 2.5 mm²) from the Terminal Board to Loads

Current value (I_{sn}) per channel, [A]	AKB651 cable length							
	30 m	25 m	20 m	15 m	10 m	7 m	5 m	3 m
0.1	1880.0	1900.0	1920.0	1940.0	1960.0	1972.0	1980.0	1988.0
0.2	1880.0	1900.0	1920.0	1940.0	1960.0	1972.0	1980.0	1988.0
0.3	1880.0	1900.0	1920.0	1940.0	1960.0	1972.0	1980.0	1988.0
0.4	1487.9	1567.5	1647.1	1726.8	1806.4	1854.1	1886.0	1917.8
0.5	1086.9	1166.5	1246.1	1325.8	1405.4	1453.1	1485.0	1516.8
0.6	819.6	899.2	978.8	1058.4	1138.0	1185.8	1217.6	1249.5

Note: In addition to the influence of voltage drop and wiring capacitance, possible cable length may be shorter when the short circuit detection of the field wiring during output OFF is needed. Maximum cable length which the short circuit of the field wiring can be detected during output OFF varies with the characteristics of the equipment's inrush current value at on-pulse test. The above table shows the case that short circuit detection is taken into account with the inrush current value of 0.6A or less. Columns grey in the above table are the area influenced by the wiring capacitance.

● L1DV531 or L1DV541 is Used with Relay Board

When the digital output module (L1DV531, L1DV541) is used together with the relay board (SRM53D, SRM54D, SBM54D), the allowable tolerance of power supply voltage applied to the power terminals of the relay board varies with the length of the dedicated signal cable (AKB331), as in the Table below.

Table Allowable tolerance of power supply voltage to the relay boards

AKB331 cable length [m]	SRM53D (*1) Power supply voltage [V]		SRM54D (*2) Power supply voltage [V]		SBM54D (*2) Power supply voltage [V]	
	Lower limit	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit
1	22.92	25.2 (24 V + 5 %)	23.04	25.2 (24 V + 5 %)	22.19	28.8 (24 V + 20 %)
2	22.96		23.11		22.22	
3	23.00		23.19		22.24	
5	23.07		23.33		22.29	
7	23.14		23.48		22.34	
10	23.25		23.70		22.41	
15	23.44		24.07		22.54	
20	23.62		24.43		22.66	
25	Not applicable	Not applicable	Not applicable	Not applicable	22.78	
30					22.90	
35					23.03	
40					23.15	
45					23.27	
50					23.39	

Note: The maximum length of AKB331 used for connecting to SRM53D or SRM54D is 20 m.

*1: For connecting with L1DV531-□6□

*2: For connecting with L1DV541-S6□

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