

Safety Monitoring Relays

G9SX-LM

SpeedSPEC

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G9SXL

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Low-speed Monitoring Unit

- Low-speed monitoring function ensures safety for maintenance work
- Motor rotation speed detected by proximity sensor
- Monitors and confirms that speed does not exceed the preset level
- Includes an enabling switch input for maintenance work
- Detailed LED indications enable easy fault diagnosis
- Safety Category 3 (EN954-1), PLd(ISO13849-1), SIL 3 (IEC/EN 62061) certified.
- A Rapid Delivery Product: Select models are available for shipment today or within 3 to 5 days



Note: Proper use of this Low-speed Monitoring Unit requires the design and fabrication of a Cogwheel specific to the application.

Specifications



Ratings

Power Input

	G9SX-LM224-□	G9SX-EX401-□
Rated supply voltage	24 VDC	
Operating voltage range	-15% to 10% of rated supply voltage	
Rated power consumption*	5 W max.	2 W max.

*Power consumption of loads not included.

Inputs

	G9SX-LM224-□
Safety input Enabling input Feedback/reset input Mode selector input	Operating voltage: 20.4 VDC to 26.4 VDC Internal impedance: Approx. 2.8 kΩ*
Rotation detection input	Operating voltage: 20.4 VDC to 26.4 VDC Internal impedance: Approx. 2.8 kΩ* Frequency input range: 1 kHz max.

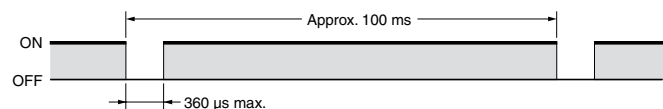
*Provide a current equal to or higher than that of the minimum applicable load of the connected input control device.

Outputs

	G9SX-LM224-□
Safety instantaneous output *1	Source output (PNP compatible) Load current: 0.8 A DC max.*2
Safety speed detection output *1	Source output (PNP compatible) Load current: 0.3 A DC max.
Auxiliary output	Source output (PNP compatible) Load current: 100 mA DC max.

*1. While safety standstill detection outputs are in the ON state, the following pulse signal is output continuously for output circuit diagnosis. When using these safety outputs as input signals to control devices (i.e. Programmable Controllers), consider the pulse signal shown at right.

*2. The following derating is required when Units are mounted side-by-side.
G9SX-LM□: 0.4 A max. load current



Expansion Unit

	G9SX-EX-□
Rated load	250 VAC, 3 A/30 VDC, 3 A (resistive load)
Rated carry current	3 A
Maximum switching voltage	250 VAC, 125 VDC

Functions

Operation Mode

The relationship between safety inputs/ enabling inputs and safety instantaneous outputs of the G9SX-LM□ differs depending on the status of the selector switch as shown below.

Selector switch = Normal operating mode (M1 = ON, M2 = OFF)

Enabling input	—	—
Safety input	ON	OFF
Rotation detection input (low speed detection frequency)	—	—
Safety instantaneous outputs	ON	OFF

Selector switch = Maintenance mode (M1 = OFF, M2 = ON)

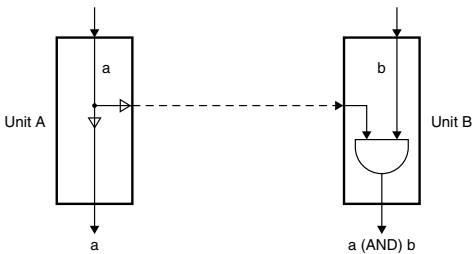
Enabling input	ON	ON	OFF	OFF
Safety input	—	—	—	—
Rotation detection input (low speed detection frequency)	Less than the preset value	Equal to or more than the preset value	Equal to or less than the preset value	Equal to or more than the preset value
Safety instantaneous outputs	ON	OFF	OFF	OFF

Notes:

- For Maintenance mode, the low-speed detection frequency must be less than the preset value. If the frequency input equals or exceeds the preset value, the safety instantaneous outputs are turned OFF.
- When the logical AND connection preset switch is set to AND (enabled), the logical AND connection input must be ON to set Safety instantaneous outputs in the ON state.
- For reset mode, take the operation of the application into account to select auto reset or manual reset.

Logical AND Connection

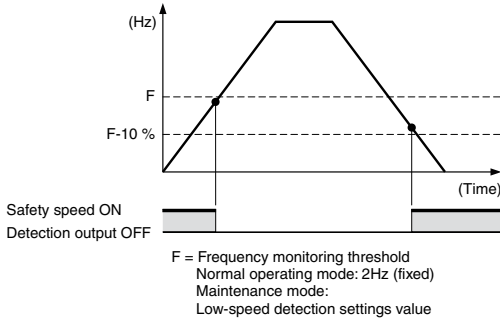
The logical AND connection means that the Basic Unit (or Advanced Unit) outputs a safety signal "a" to an Advanced Unit, and the Advanced Unit calculates the logical multiplication (AND) of the safety signal "a" and safety signal "b." The safety output of an Advanced Unit with the logical AND connection shown in the following diagram is "a" AND "b"



Low-speed Detection Function

Converts the pulse signals from two proximity sensors that monitor the rotation status of hazards to frequency to control the safety speed detection outputs.

- The diagram below shows the relationship between the Low-speed detection frequency and Safety speed detection outputs. The frequency (F) has a tolerance of - 10%.
- This accuracy tolerance does not include any characteristics of proximity sensors.

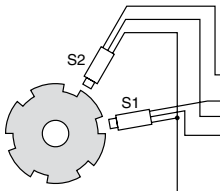


Use the following OMRON E2E series three-wire DC sensors (PNP).

E2E-X1R5F1
 E2E-X2F1
 E2E-X5F1
 E2E-X2MF1
 E2E-X5MF1
 E2E-X10MF1

Notes

- To monitor the rotation status of hazards, install a cogwheel for proximity sensors linked to hazards as follows. For design of cogwheel and installation of proximity sensors, see "Shape of Cogwheel and Setting of Proximity Sensors".



- If G9SX-LM□ is operated without proximity sensors being connected, G9SX-LM□ will detect it as an error.
- If both sensors do not detect the cogwheel, G9SX-LM□ will detect it as an error

Auxiliary Outputs

Auxiliary outputs X1 to X4 can be used to notify outputs, error status, and operation mode.

Terminal name	Signal name	Output ON requirement
X1	Safety instantaneous outputs monitor	X1 is turned ON when Safety instantaneous output is ON.
X2	Error monitor	X2 is turned ON when an error LED indicator is lit or blinking.
X3	Safety speed detection outputs monitor	X3 is turned ON when Safety speed detection output is ON.
X4	Operation mode monitor	X4 is turned ON when in the Maintenance mode.

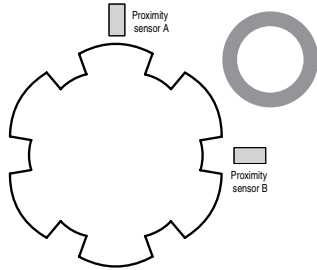
Functions (continued)

Shape of Cogwheel and Setting of Proximity Sensors

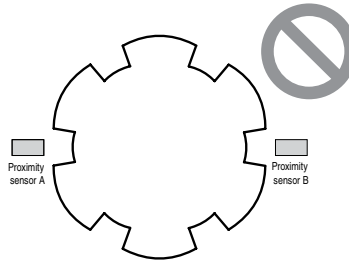
1. Installation of proximity sensors

For safe and stable detection of a rotating cogwheel, install proximity sensors according to the following description:

- To avoid interference from surrounding metal and mutual interference, specified proximity sensors should be correctly installed.
- For handling of proximity sensors, see the instruction manual for the E2E.
- Connect two proximity sensors of the same type.
- Install proximity sensors so that one of them is turned ON when the rotation of cogwheel stops.
If neither sensor has detected any movement for a certain period of time, G9SX-LM□ will detect it as an error



Install proximity sensors so that one of them is turned ON when the rotation of cogwheel stops.
Install one proximity sensor on the center line of the concavity width, and the other on the center of the convexity width so that one of the proximity sensors will be turned ON when the rotation of the cogwheel stops.



With this installation, both proximity sensors are turned OFF when the rotation of the cogwheel stops.
If both sensors are turned OFF for a certain period of time, G9SX-LM□ will detect it as an error.

2. Relationship between the cogwheel shape and the setting of proximity sensors

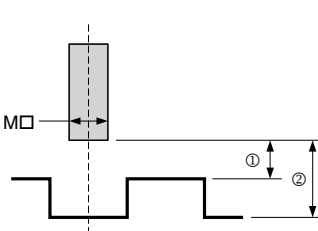
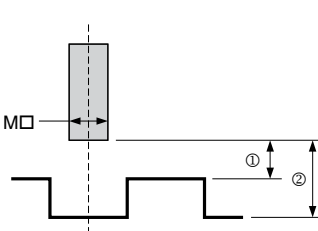
Design the cogwheel shape according to types of proximity sensors. Use the following provisions as a reference.

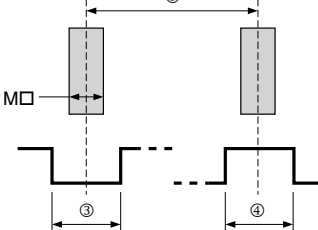
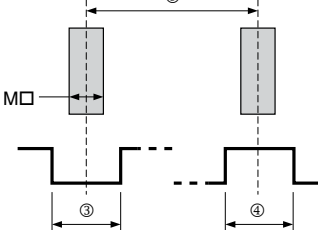
- Proximity sensors to be used should be selected based on the max. number of revolutions during normal operation and the number of cogwheel teeth.
See the equation below.

$$R \times 1 / 60 \times N < F$$

R : Max. number of revolutions during normal operation (rpm)
N : Number of cogwheel teeth
F : Response frequency of proximity sensor (Hz)
- Install one proximity sensor on the center line of the concavity width, and the other on the center of the convexity width so that one of the proximity sensors will be turned ON when the rotation of the cogwheel stops.
- All cogwheel teeth should be identically shaped.

The following tables show data for iron cogwheels. Use of other material will show different characteristics of operating range.
"Sensing distance" on the table below shows a size when the proximity sensors are arranged in parallel.

	Shielded	Size	M8	M12	M18
		Model	E2E-X1R5F1□	E2E-X2F1□	E2E-X5F1□
		Sensing distance	1.5 mm	2 mm	5 mm
①	Distance of convexity		1.2 mm max.	1.6 mm max.	4 mm max.
②	Distance of concavity		4.5 mm min.	8 mm min.	20 mm min.
	Unshielded	Size	M8	M12	M18
		Model	E2E-X2MF1□	E2E-X5MF1□	E2E-X10MF1□
		Sensing distance	2 mm	5 mm	10 mm
①	Distance of convexity		1.6 mm max.	4 mm max.	8 mm max.
②	Distance of concavity		8 mm min.	20 mm min.	40 mm min.

	Shielded	Size	M8	M12	M18
		Model	E2E-X1R5F1□	E2E-X2F1□	E2E-X5F1□
		Sensing distance	15 mm min.	20 mm min.	35 mm min.
③	Concavity width		16 mm min.	24 mm min.	36 mm min.
④	Convexity width		Concavity width X 2 min. / Concavity width X 6 max.		
⑤	Sensing distance		15 mm min.	20 mm min.	35 mm min.
	Unshielded	Size	M8	M12	M18
		Model	E2E-X2MF1□	E2E-X5MF1□	E2E-X10MF1□
		Sensing distance	60 mm min.	100 mm min.	110 mm min.
③	Concavity width		24 mm min.	30 mm min.	60 mm min.
④	Convexity width		Concavity width X 2 min. / Concavity width X 6 max.		
⑤	Sensing distance		60 mm min.	100 mm min.	110 mm min.

Functions (continued)

3. Design examples

This example shows a design of cogwheel and proximity sensors when the number of motor revolutions of hazards is 3000 rpm at normal operation (high speed), and 60 rpm at low speed.

Step 1: Calculating the number of cogwheel teeth

"Input frequency range" and "Low speed detection settings" of G9SX-LM□ should be considered.

Input frequency range: 1000 max.	Set the number of cogwheel teeth such that the value of the number of rotations at normal operation (high speed) $\times 1 / 60 \times$ value of the number of cogwheel teeth becomes 1000 max.
Low speed detection settings: 2 to 10 Hz	Set the number of cogwheel teeth such that the value of the number of rotations at low speed $\times 1 / 60 \times$ value of the number of cogwheel teeth becomes within the range of 2 to 10.

According to the information above, when setting the number of cogwheel teeth at "6," the values will be as mentioned below. These values are frequencies input to rotation detection input of G9SX-LM□, falling within the ranges of "Input frequency range" and "Low speed detection settings".

At normal operation (high speed): $3000 \text{ rpm} \times 1 / 60 \times 6 = 300 \text{ Hz}$
At low speed: $60 \text{ rpm} \times 1 / 60 \times 6 = 6 \text{ Hz}$

Note: When the number of rotations between cogwheel and motor differs due to gear attachment, etc., take its rotation ratio into account.

Step 2: Selecting proximity sensors

Select proximity sensors according to the frequencies obtained in Step 1. Since the input frequency to G9SX-LM□ at normal operation (high speed) is 300 Hz, select proximity sensors with higher response frequency performance than this value. E2E-X2F1□ (M12 shielded type, Response frequency: 1.5 kHz) is used in this example.

Step 3: Determining the arrangement of proximity sensors for cogwheel

In this example, proximity sensors are installed in the horizontal direction to the cogwheel surface.

Step 4: Determining the distance between cogwheel and proximity sensors

Determine the distance between cogwheel and proximity sensors, and the height of the cogwheel teeth according to "2. Relationship between the cogwheel shape and the setting of proximity sensors".

- Distance of convexity: Design it to be 1.6 mm or less according to the table. In this example, a distance is set to 1 mm (50% of operating range).
- Distance of concavity: Design it to be 8 mm or more according to the table. In this example, the height of the cogwheel is set to 20 mm, making it 21 mm by adding 1 according to "1. Distance of convexity".

Step 5: Determining the widths of convexity and concavity

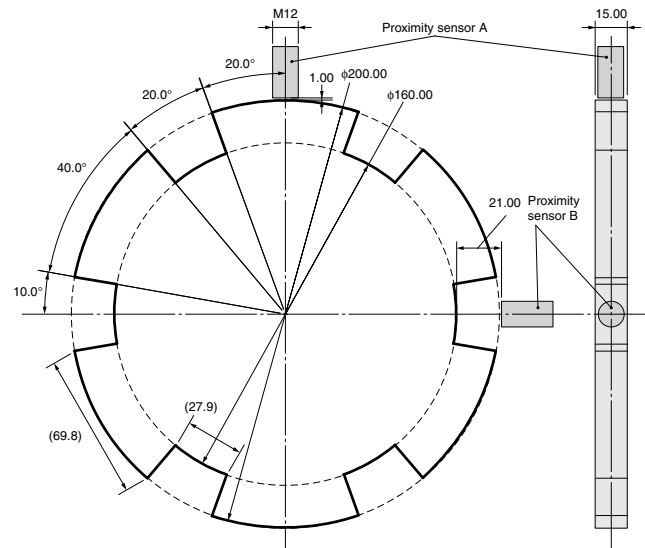
- Because the number of cogwheel teeth obtained from Step 1 is 6, the angle of the combination of convexity and concavity is: $360^\circ / \text{number of cogwheel teeth} = 6^\circ$.
According to the table of "2. Relationship between the cogwheel shape and the setting of proximity sensors", design the width of convexity as twice as the width of concavity.
Therefore, ratio of an angle of convexity and angle of concavity is set to 2:1 = $40^\circ : 20^\circ$.
- Determine the diameter when concavity is assumed to be a circle.
In this example, set the diameter to 160 mm and verify if it satisfy the provisions of the table in "2. Relationship between the cogwheel shape and the setting of proximity sensors".
According to a. in Step 5, the concavity width is $160 \text{ mm} \times p \times 20^\circ / 360^\circ = 27.9 \text{ mm}$, satisfying the concavity width of E2E-X2F1□: 24 mm or more.
- Since the height of the cogwheel teeth is set to 20 mm according to Step 4, the diameter of the cogwheel at convexity is to be $160 \text{ mm} + 20 \text{ mm} \times 2 = 200 \text{ mm}$. Verify that it satisfies the provisions of the table in "2. Relationship between the cogwheel shape and the setting of proximity sensors".

According to a. in Step 5, the convexity width is $200 \text{ mm} \times p \times 40^\circ / 360^\circ = 69.8 \text{ mm}$, satisfying twice or more of the concavity width obtained in b. in Step 5.

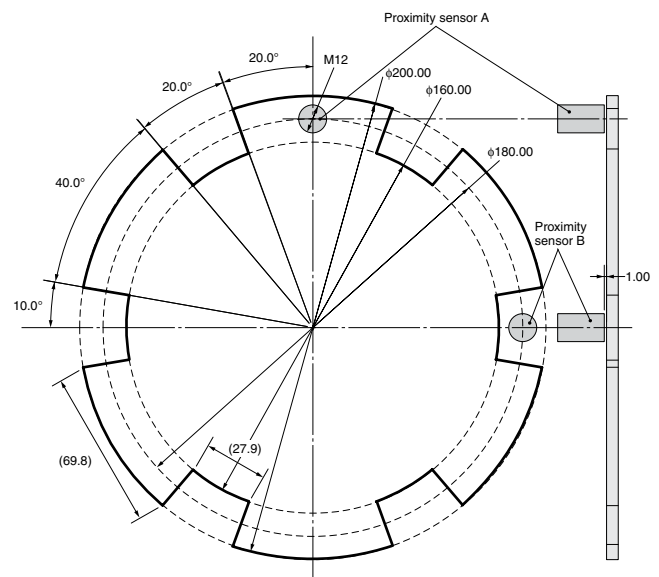
Step 6: Determining the thickness of the cogwheel teeth

Determine the thickness according to the shape of the selected proximity sensors. Since the size of E2E-X2F1□ is M12, the thickness of the cogwheel teeth should be 15 mm (standard object width of E2E-X2F1□) to install proximity sensors in the horizontal direction according to Step 3.

According to the process above, an example of shape of cogwheel and arrangement of proximity sensors are shown in the diagram below. Proximity sensors are arranged to be intersecting each other. Note that the distance between proximity sensors defined in the table of "2. Relationship between the cogwheel shape and the setting of proximity sensors" must be satisfied.



The diagram below shows a design when proximity sensors are installed in the vertical direction to the cogwheel surface.



When installing proximity sensors in the vertical direction to the cogwheel surface, note that the height of cogwheel teeth should not be affected by surrounding metal products.

Functions (continued)

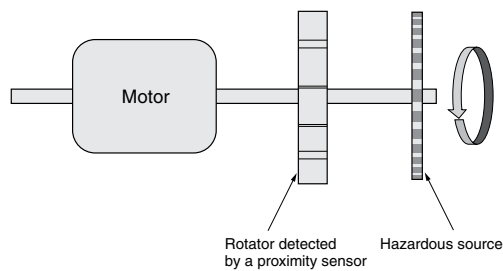
4. Example of low speed detection settings

When the number of rotations at low speed is 50 rpm and the number of cogwheel teeth detected by proximity sensors is 6, the frequency at low speed is $50 \text{ rpm} \times 1 / 60 \times 6 = 5 \text{ Hz}$.
Consider the low-speed detection frequency accuracy (tolerance of -10%) such that low speed detection frequency setting is 6.0 Hz or higher.

(1)	(2)	(3)-1	(3)-2
Low speed detection settings (Hz)	Low-speed detection frequency accuracy: Hz (1) - (1) x 10%)	Safety speed detection outputs are turned ON. No. of revolutions: rpm * No. of cogwheel teeth: 6 ((2) x 60 / 6)	Safety speed detection outputs are turned ON. No. of revolutions: rpm * No. of cogwheel teeth: 3 ((2) x 60 / 3)
2	1.8	18	36
2.2	1.9	19	38
2.4	2.1	21	42
2.8	2.5	25	50
3.0	2.7	27	54
3.2	2.8	28	56
3.6	3.2	32	64
4.2	3.7	37	74
4.7	4.2	42	84
5.3	4.7	47	94
6.0	5.4	54	108
6.6	5.9	59	118
7.3	6.5	65	130
8.4	7.5	75	150
9.3	8.3	83	166
10	9	90	180

5. Relationship between motor, cogwheel, and hazards

Install the cogwheel between the motor and a hazardous source.



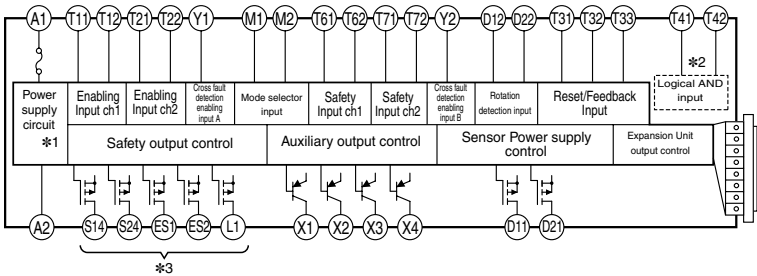
Perform a risk assessment for entire equipment including the conditions of use to implement safety measures.

(For example, attaching a protective cover around a cogwheel)

Wiring

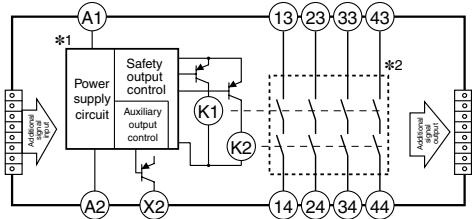
Internal Connection

G9SX-LM224-□ (Low-speed Monitoring Unit)



- *1. Internal power supply circuit is not isolated.
- *2. Logical AND input is isolated.
- *3. Outputs S14, S24, ES1, ES2 and L1 are internally redundant.

G9SX-EX401-□ (Expansion Unit)



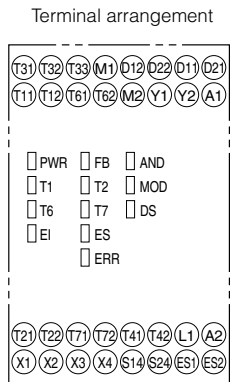
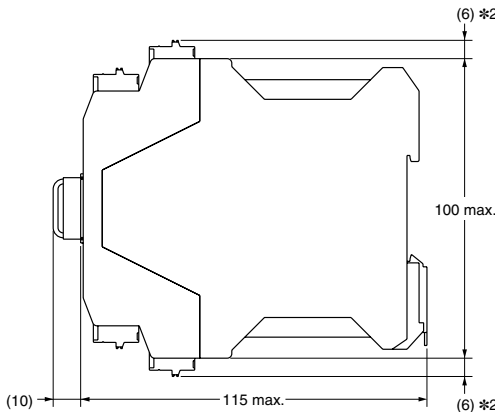
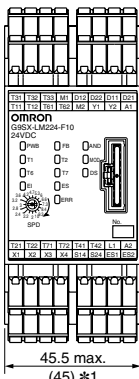
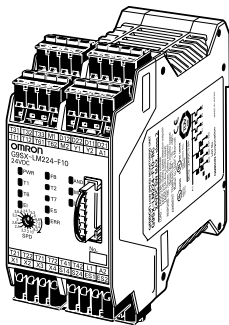
- *1. Internal power supply circuit is not isolated.
- *2. Relay outputs are isolated.

Dimensions and Terminal Arrangements

(mm)

Low-speed Monitoring Unit

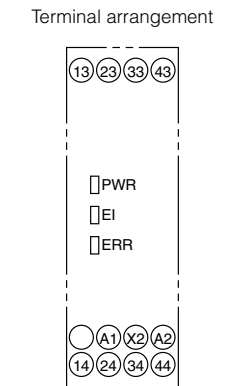
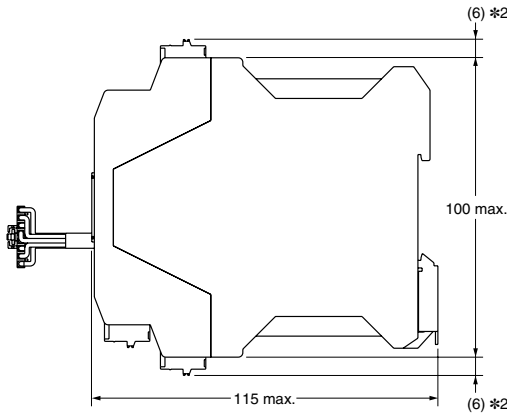
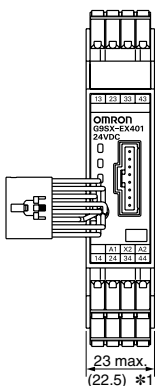
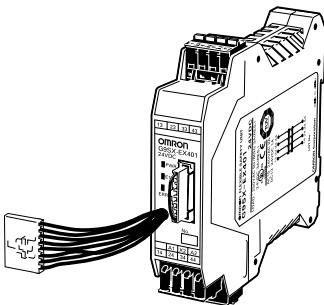
G9SX-LM224-F10-□



- *1 Typical dimension
- *2 For -RC terminal type only.

Expansion Unit

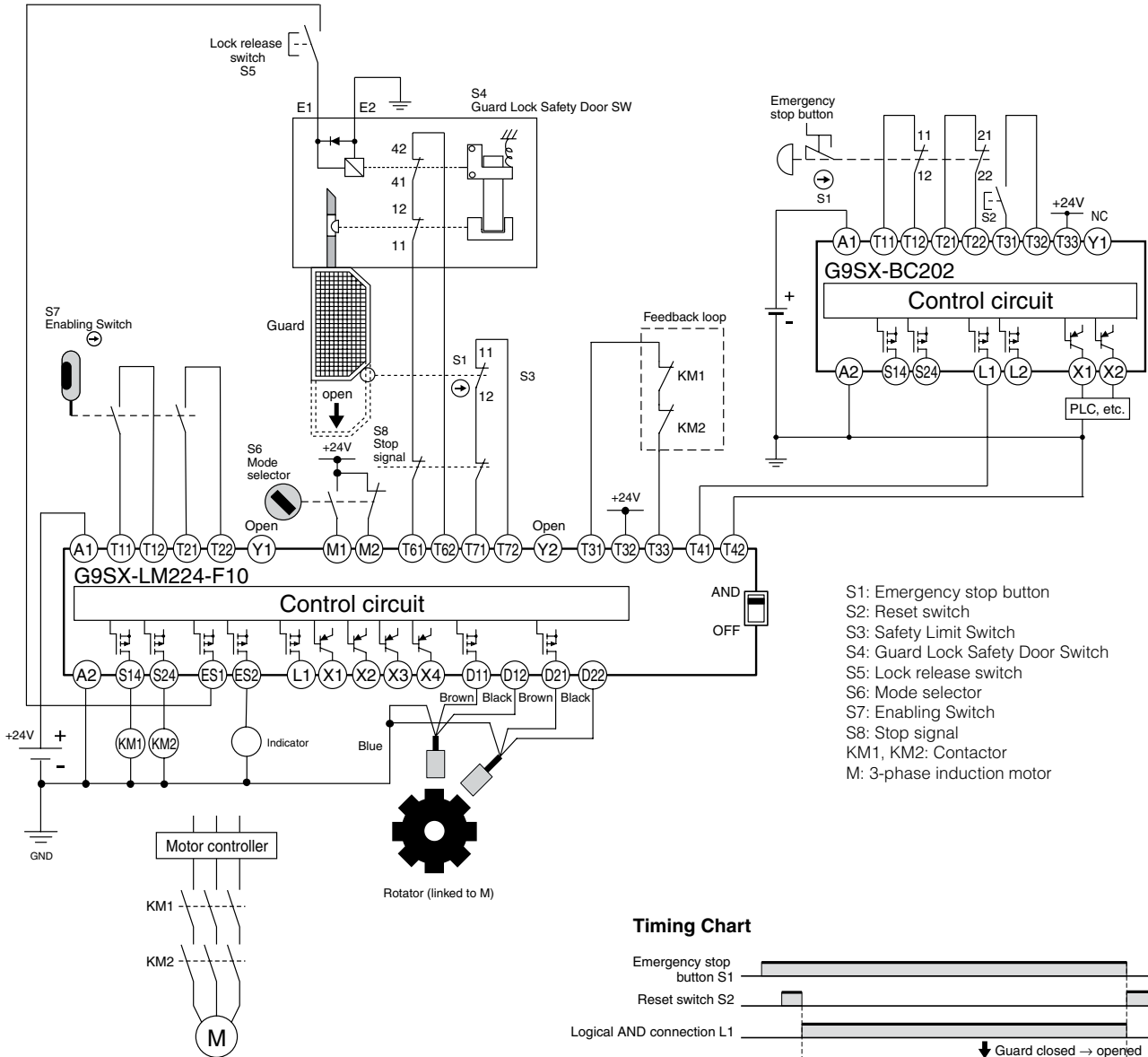
G9SX-EX401-□



- *1 Typical dimension
 - *2 For -RC terminal type only.
- Note: Above outline drawings are for -RC terminal type.

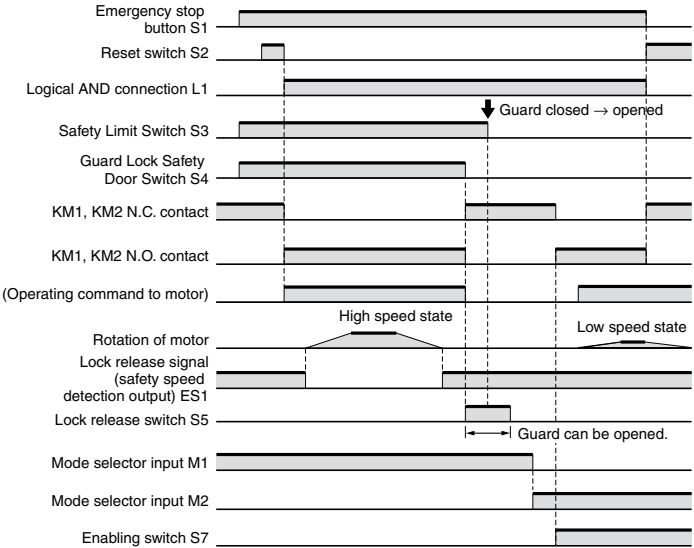
Application Example

**G9SX-LM224 (24 VDC) (Guard Lock Safety Door Switch (Mechanical Lock),
(2-channel Safety Limit Switch Inputs/2-channel Enabling Switch Inputs/Manual Reset)**
+ G9SX-BC202 (24 VDC) (2-channel Emergency Stop Button Inputs/Manual Reset)



Note: This example corresponds to category 3.
For details, see "Safety Category (EN954-1)".

Timing Chart



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Ordering

Model Number Legend

G9SX - □ □ □ □ - □ - □
1 2 3 4 5 6

- 1** Functions
 LM: Low-speed Monitoring Unit
 EX: Expansion Unit
- 2** Output Configuration (Safety Instantaneous Outputs)
 2: 2 outputs
 4: 4 outputs
- 3** Output Configuration (Safety Speed Detection Output)
 2: 2 outputs
- 4** Output Configuration (Auxiliary Output)
 1: 1 output
 4: 4 outputs
- 5** Maximum Preset Value
 Low-Speed Monitoring Unit
 F10: 10 Hz
 Expansion Unit
 No indicator: No OFF delay
- 6** Terminal Block Type
 RT: Screw terminals
 RC: Spring-cage terminals

List of Models

Low-speed Monitoring Unit

Safety instantaneous output	Safety slow-speed/stopping detection output	Auxiliary output	Maximum set threshold	Rated voltage	Terminal block type	Model
2 (Semiconductor)	2 (Semiconductor)	4 (Semiconductor)	10 Hz	24 VDC	Screw terminals	G9SX-LM224-F10-RT
					Spring-cage terminals	G9SX-LM224-F10-RC

Expansion Unit

Safety outputs		Auxiliary outputs	OFF-delay time	Rated voltage	Terminal block type	Model
Instantaneous	OFF-delayed					
4a (contact)	0	1 (Semiconductor)	--	24 VDC	Screw terminals	G9SX-EX401-RT
					Spring-cage terminals	G9SX-EX401-RC

Recommended Short Barrel Inductive Proximity Sensors

Type	Cable length	Barrel Size	Material	Protection	Indicator	Supply Voltage	Sensing Distance	Output	Model
Shielded	2 m	M8	Nickel plated brass	IP67	YES	12 to 24VDC	1.5mm	PNP	E2E-X1R5F1
		M12					2mm	PNP	E2E-X2F1
		M18					5mm	PNP	E2E-X5F1
Unshielded	2 m	M8					1.5mm	PNP	E2E-X2MF1
		M12					2mm	PNP	E2E-X5MF1
		M18					5mm	PNP	E2E-X10MF1

See the installation manual for detailed specifications on E2E proximity switches