Date：2016.08.03

Safety Laser Scanner
UAM-05LP-T301C
Specification

FUNCTIONAL SAFETY

c UL us LISTED

CE

RoHS

Symbol	Amended Reason	Pages	Date	Amended by	Number
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M.Hino	M.Hino	東	Higashi	Drawing No.	C-62-00044	1／38

1.Applicable directives and standards

UAM is certified by TUV SUD Product Service GmbH and UL/c-UL, FDA (CDRH) as a safety sensor defined in EU Machine Directive (2006/42/EC).

Table1-1 Applicable directives and standards

Certification authority	Directives/Standard	Details	
TUV SUD	EU directives	Machinery Directive: Directive 2006/42/EC	
		EMC Directive: Directive 2014/30/EU	
	EN standards IEC standards ISO standards	IEC 61496-1:2012 EN 61496-1:2013	Type 3
		IEC 61496-3:2008	Type 3
		IEC 61508 Part1-7:2010	SIL2
		EN62061:2005/A2:2015 △2	SIL2
		EN ISO13849-1:2015	Category 3, PLd
		IEC60825-1:2014 △2	Safety of laser products Class 1
UL/c-UL	UL standards IEC standards ISO standards CSA standards	UL 508:2010	
		ANSI/UL 1998:2013	
		IEC 61496-1:2012	Type 3
		IEC 61496-3:2008	Type 3
		IEC 61508 Part1-7:2010	SIL2
		ISO13849-1:2006	Category 3, PLd
		CSA C22.2 No.14-13:2013	
FDA (CDRH)		21 CFR Part 1040.10 and 1040.11	Safety of laser products Class 1

2. Specification

Table 2-1 UAM-05LP specification

Subject	Specifications		
Model	UAM-05LP-T301C		
Detection property	Protection Range Warning Range	Max: 5m	
		Max: 20m (Non-safety) *1	
	Distance tolerance*2	+100 mm	
	Detection capability	From Black-Reflector Sheet（1.8%）to Retro-Reflector Sheet	
	Angular Range	270 °	
	Minimum Detectable Width	φ30 mm (Max: 1.8m) φ40 mm (Max: 2.5m) 2 φ50 mm (Max: 3.0 m) φ70 mm (Max: 5.0 m)	
	Scan Frequency	30ms (Rotational Speed: 2000 rpm)	
	Area pattern	Max 32 patterns(128 when encoder input function is used) 3	
	Response time	OFF	60 ms~2010 ms 3
		ON	270 ms~2010 ms 3
Optics	Element	Pulsed Laser Diode	
	Wave Length	905 nm	
	Safety Class	Laser Class 1	
Type	Type 3 (IEC61496-1, IEC61496-3)		
Functional Safety	SIL 2 (Type B, HFT=1) (IEC61508)		
PFH_d	7.8×10^{-8} （T1=20 year）: When master slave function is not in use. 1.6×10^{-7} （T1=20 year）: When master slave function is in use.		
Housing	Size	80mm (W)×80mm (D)×95mm (H) (without cable)	
	Weight	0.5Kg	
	Protection	IP65	
	Case Material	Body: Aluminum Optical Window: Polycarbonate	
	Connection Cable	Waterproof connector : 0.3m	
Power supply	DC 24V ±10%: when operation using converter power supply DC 24V -30%/+20%: when operation using battery		
Supply current	Normal (without load)	6W	
	Max. (with load)	50W	

*1.Distance when reflectance of the object is 90% or above.
*2. Additional distance of 200mm is needed when the UAM is working under high reflective background.

Subject	Specifications	
Output	OSSD 1/2 (Safety)	Output type (High side SW)
		Output current:(Max:500mA) *3
		Leak current (Max:1mA)
		AWG 26
		Load tolerance (L/R=25ms, C=1μF)
	OSSD3/4 (Safety)/ WARNING 1/ 2 (Non-Safety)	Output type (High side SW)
		Output current:(Max:250mA) *3
		Leak current (Max:1mA)
		AWG 28
		Load tolerance (L/R=25ms, C=1μF)
	RES_REQ 1, RES_REQ 2, MUT_OUT 1, MUT _OUT 2, AUX_OUT1△3, AUX_OUT2△3	Output types (PNP Transistor)
		Output current (Max: 200mA)
		Leak current (Max: 1mA)
		AWG 28
Input	Area pattern 32 (5 Inputs x 2 Channels) EDM1, EDM2, MUTING1, MUTING2, MUTING3, MUTING4, OVERRIDE1, OVERRIDE2, RESET1, RESET2	Input Impedance 4.7 kΩ AWG 28
	ENC_A1, ENC_A2, ENC_B1, ENC_B2	Input Impedance 4.7 kΩ
		AWG 28
Interface	Configuration	USB2.0 (USB micro type-B connector)
		RS-485
		Ethernet 100BASE-TX (Water proof connector)
Environmental resistance	Temperature	-10ºC to +50ºC (No freezing)
	Storage Temperature	-25ºC to +70ºC (No freezing)
	Humidity	95% RH with no condensation
	Storage Humidity	95% RH with no condensation
	Surrounding Intensity*4	Less than 1500 lx
	Vibration	Frequency range: 10~55 Hz Sweep rate: 1 octave/min Amplitude: 0.35 mm ±0.05 mm
	Bump	Acceleraction: 98m/s ^{2} (10G) Pulse duration: 16 ms
	Outdoor Operation	Not permitted
	Altitude	Below 2000m

*3.Total current supply of OSSD output and Warning output should be below 1.0A.
*4.When the light sources are located at ≥5º from the detection plane of UAM.

3. Components of UAM-05LP

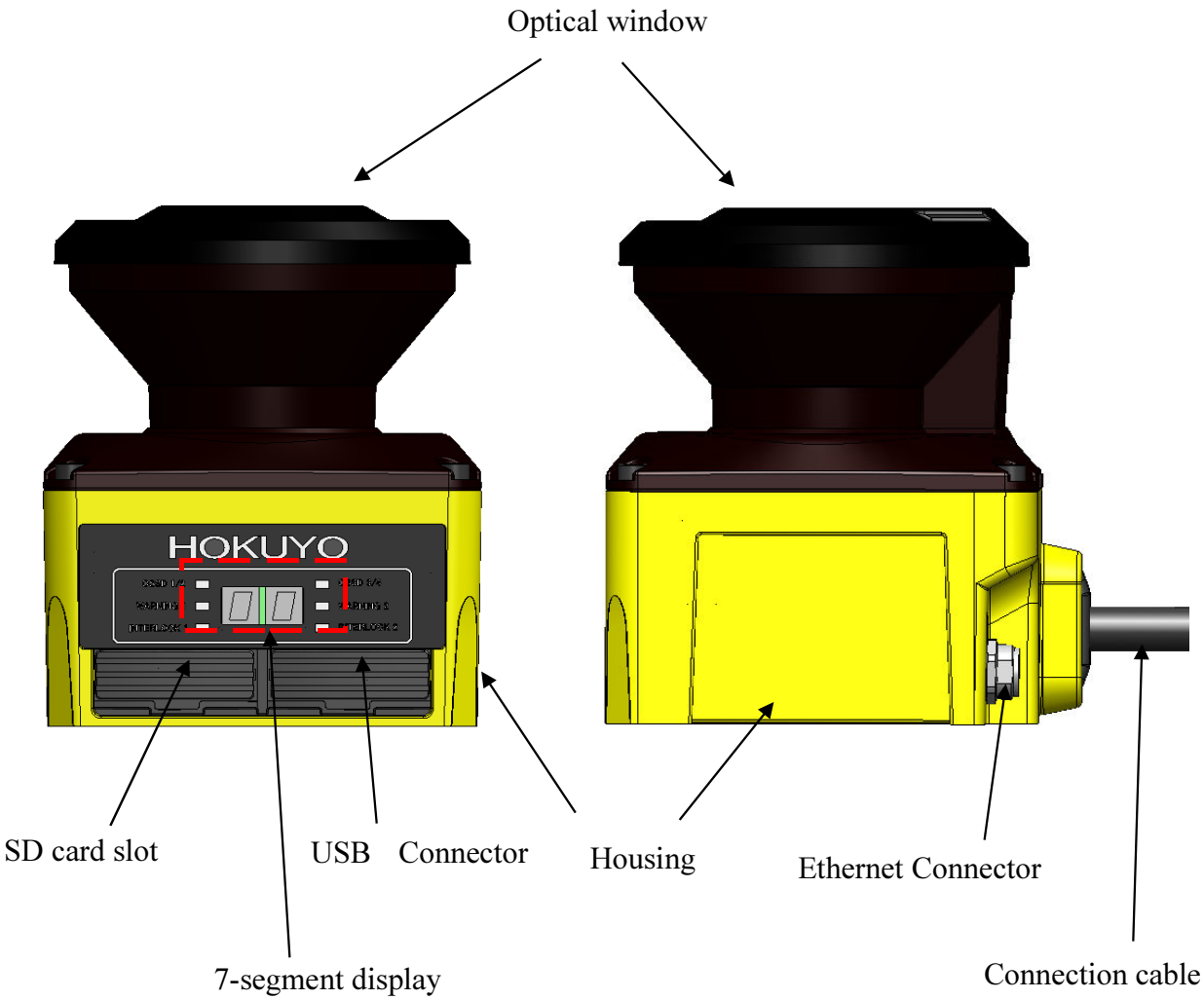


Figure 3-1 UAM-05LP components

4. Function

4.1 Scanning area

Scanning area of UAM consists of protection zone and warning zones. Maximum 32 sets of area can be configured. Further, two combinations for protection and warning zones can be selected for the operation.

Combination 1: Protection zone, Warning zone 1 and Warning zone 2
Combination 2: 2 Protection zones (Dual Protection)

In dual protection mode, two protection areas can be configured but it is not possible to configure the warning zones Protection and warning zones can be configured by using UAM Project Designer. Refer to User's Manual for configuration details.

4.1.1 Protection zone

Protection zone is safety-critical and directly connected to the OSSD signal. When an obstacle is detected in the protection zone, UAM will switch the OSSD to OFF-state (which should trigger a switch to stop a machine or AGV). For mobile applications, the OSSD signal can be used as the emergency stop signal. Figure 4-1 and 4-2 show the examples of protection zone configured using manual mode and teaching mode respectively. User can configure these zones accordingly to ensure hazardous area is completely protected.

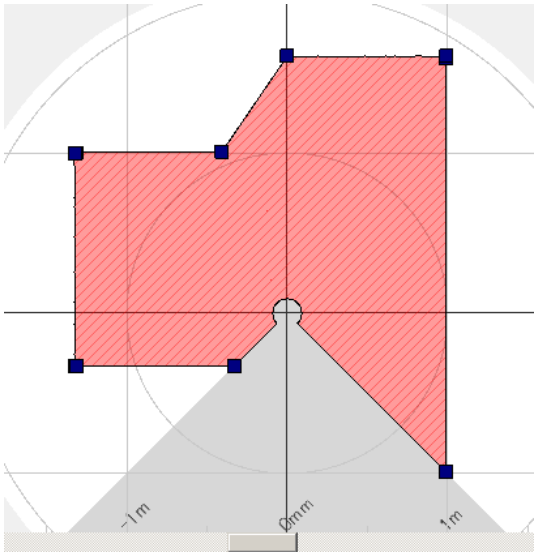


Figure 4-1 Protection zone configured using manual mode

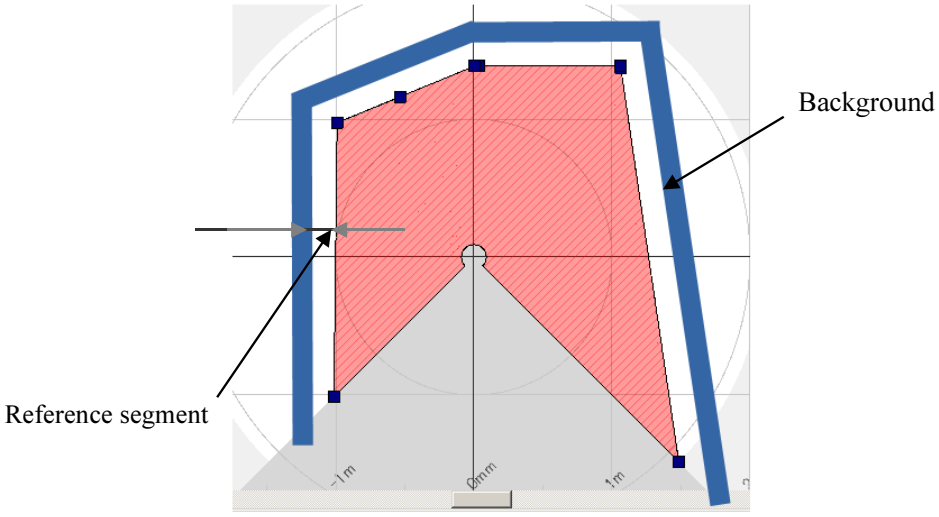


Figure 4-2 Protection zone configured using teaching mode

In dual protection mode, two protection zones can be configured independently. UAM will monitor these zones simultaneously. OSSD1 and OSSD2 are dedicated to protection zone1 and OSSD3 and OSSD4 are dedicated to protection zone2.

Figure 4-3 shows an example of the dual protection zone configuration. Warning zones cannot be configured in dual protection mode.

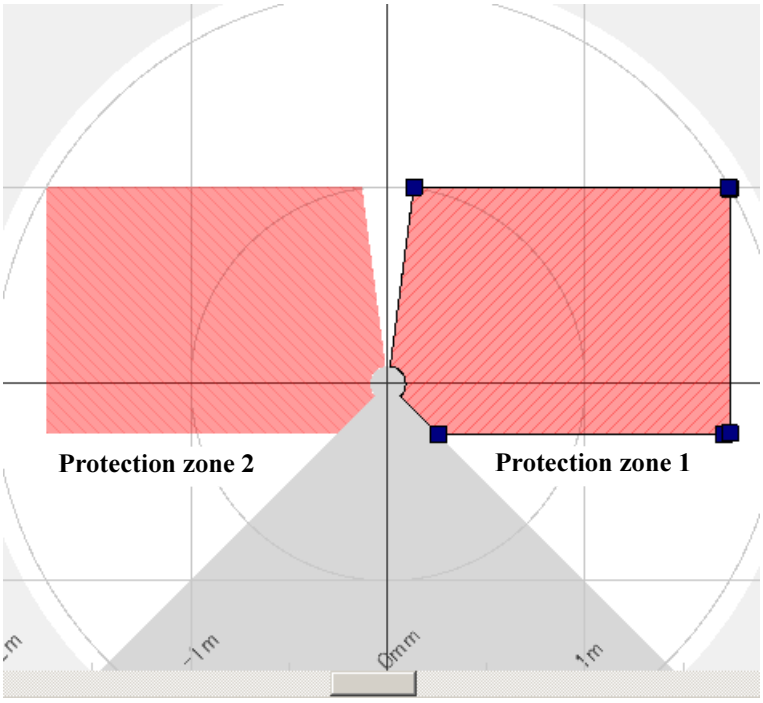


Figure 4-3 Example of Dual protection zone configuration

4.1.2 Warning zone

Warning zones are non-safety zones and are connected to Warning1 and Warning2 outputs. When the obstacle is detected in the warning zones, UAM will switch the respective warning signal from ON-state to OFF-state.

Warning signals can be used as an alert signal to avoid human beings or objects from approaching near the protection zone. For mobile applications, warning signals can be used for reducing the speed of automatic guided vehicle (AGV) to avoid collision. Figure 4-4 shows an example of warning zone configuration.

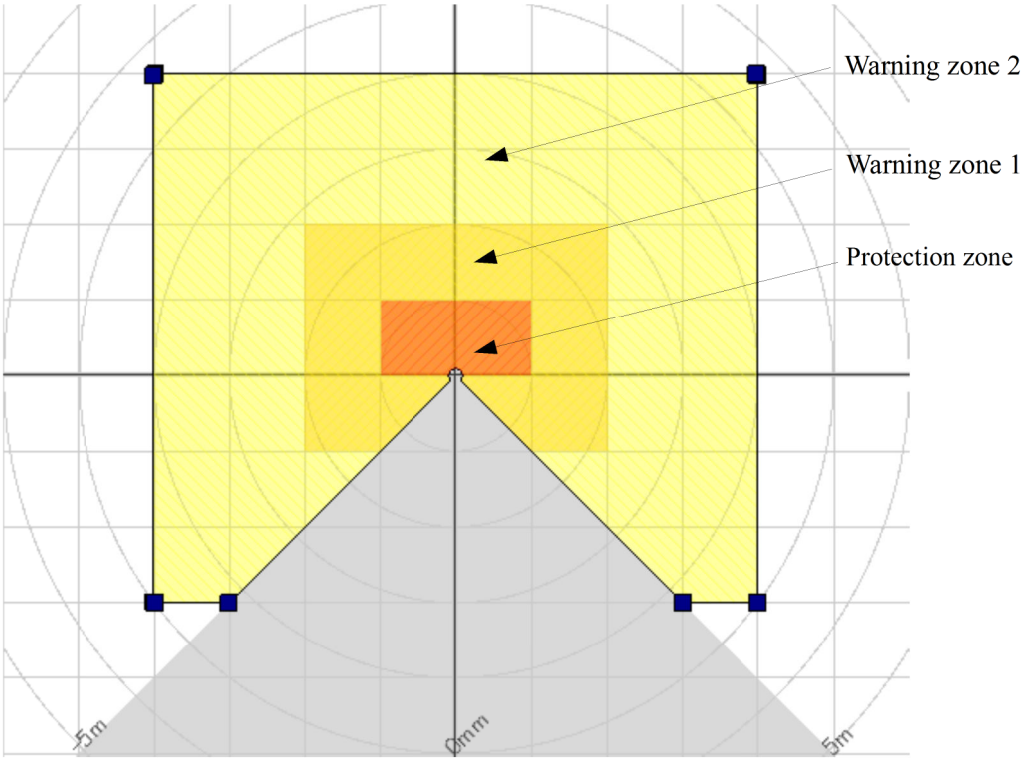


Figure 4-4 Warning zones

4.2 OSSD

OSSD is safety-related signal. When humans or objects are detected in the protection zone, the OSSD signal will switch to OFF state from ON-state. OSSD signal has the self- diagnostic function which tests the signal periodically by switching it to OFF state for a brief period. Signal is continuously switched to OFF-state when an error is detected during the diagnostic.

Output states of OSSD1 and OSSD2 signal are identical. Both signals should be connected to the safety related machines or control system to fulfill the required safety level. If OSSD3 and OSSD4 are used they must be connected in the same manner.

4.2.1 Self-diagnostic function of OSSD

Self-diagnostic is a function to detect the malfunction in the output circuit by switching OFF the OSSD1 to OSSD4 for an interval of 300μs. Therefore, safety-relay or power converter used must not response to this diagnostic function. Figure 4-5 below shows the timing chart of the self diagnostic function of the OSSD during dual protection mode.

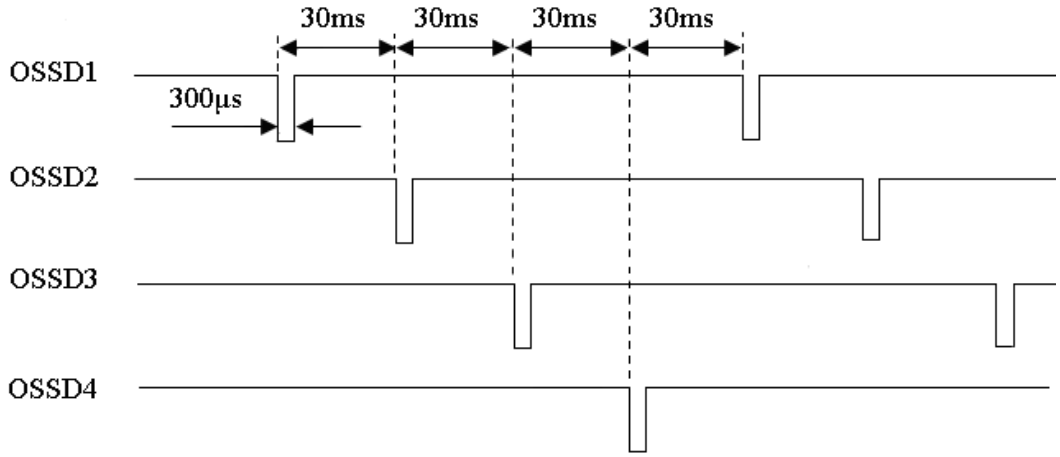


Figure 4-5 Timing chart of the OSSD's self-diagnostic function

In single protection mode, self-diagnostic function is done for OSSD1 and OSSD2 only.

4.3 Interlock function

Interlock is a function to prevent automatic restart of the OSSD signal switching from OFF-state to ON-state. Automatic restart, manual restart and manual start interlock functions are configurable using the UAM Project Designer.

4.3.1 Automatic restart

UAM will restart automatically when interlock function is disabled or only the start interlock function is enabled. When obstacle from the protection zone is removed, OSSD signals switch from OFF-state to ON-state automatically. OSSD response times for ON and OFF states are configurable. However, if UAM is in the lockout state due to error, OSSDs will remain in OFF-state even if the interlock function is disabled.

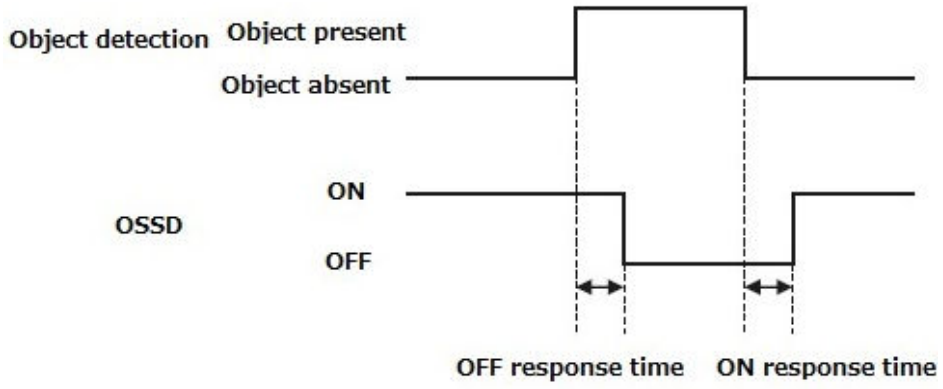


Figure 4-6 Timing chart of automatic restart

4.3.2 Manual restart (Interlock enabled)

UAM operates in manual restart mode when interlock function is set to manual mode. The OSSD signal switches from ON-state to OFF-state, if UAM detects any obstacle within the protection zone or detects any system error. In this mode, even if the detected obstacles or system error is removed, OSSD signals will remain in OFF-state. An external reset input signal is required to release the interlock which allows the UAM to switch to normal operation.

UAM will resume normal operation only after confirming the reset signal (RESET). The duration of the reset signal should be more than 500ms. Figure 4-7 shows the timing chart of the manual restart. After reset signal is confirmed, the OSSD signal will switch to ON-state after the lapse of the configured delay time. . If OSSD's OFF-state is due to an internal fault, it will remain in OFF-state even when reset signal is provided. Reset delay is configurable in the range of 1s to 6s.

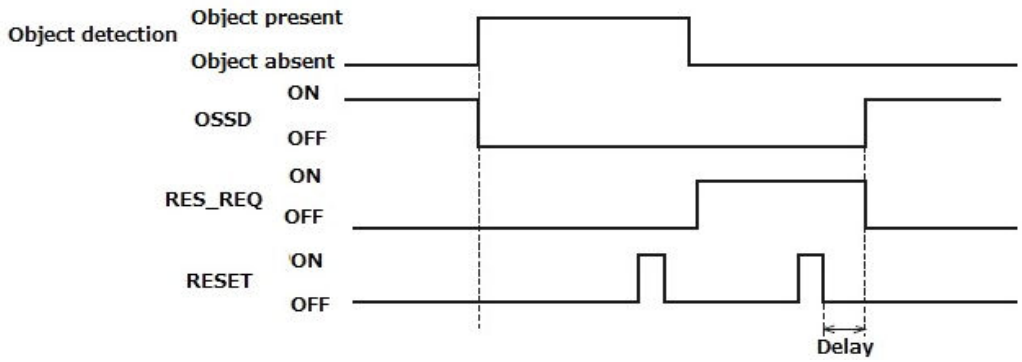


Figure 4-7 Timing chart of manual restart

4.3.3 Manual start (Interlock enabled)

Start interlock is a function which keeps the OSSD in OFF-state during the start-up until an external reset input is applied. Start interlock setting has only manual mode. The RES_REQ signal switches to ON-state after the UAM completes initial routines and ready to accept the RESET input. When RESET input is applied, OSSD will switch to ON state if no object is detected in the protection zone. The duration of the reset input should be more than 500ms. Figure 4-8 shows the sequence of start interlock. Delay can be configured in the range of 1s to 6s.

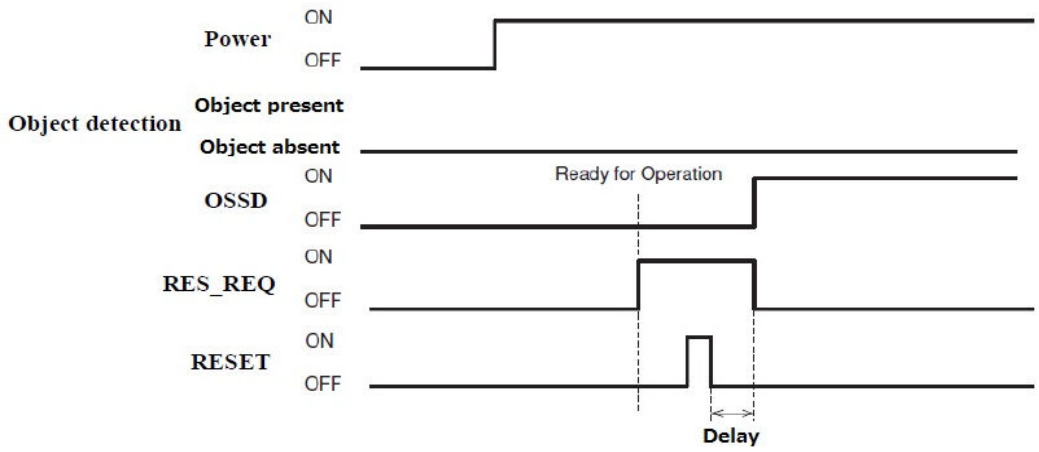


Figure 4-8 Manual start sequence

4.4 External device monitoring (EDM) function

EDM is a function that monitors the state of the input signal from the controlled machine or automated guided vehicle (AGV). EDM is configured using the UAM project designer. When EDM function is enabled, any fault detected in EDM signal will switch the OSSD signal to OFF-state. Logic of EDM signal should be always inverse of the OSSD signal. EDM input signal ON/OFF delay is configurable to match the user's system. Figure 4-9 and 4-10 below shows the EDM circuit and EDM timing chart respectively.

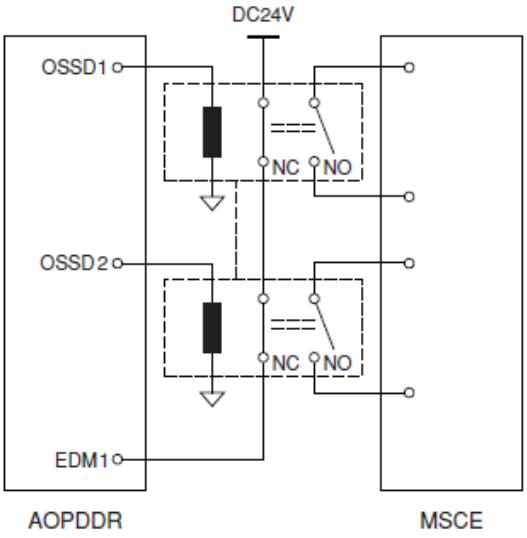
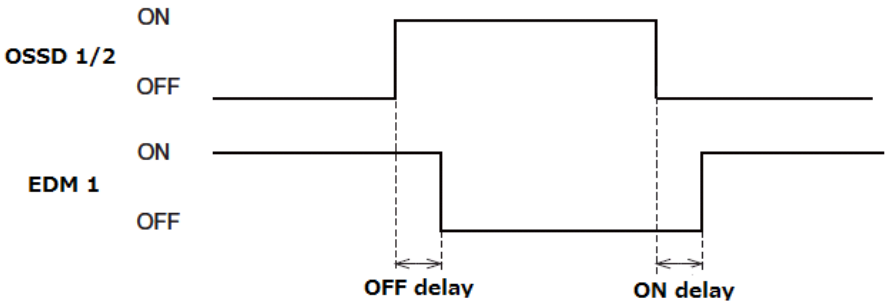


Figure 4-9 EDM circuit



In dual protection mode, EDM2 circuit and timing chart for OSSD3 and OSSD4 are same as above.

4.5 Muting function

Muting function temporarily suspends the safety function in the configured zone of UAM when the specified conditions are fulfilled. In the muting state OSSD remains in the ON-state even when an object is detected in the configured muting zone. Two independent hard wired input signals are provided to start and end the muting function. Muting zone is configured using the UAM project designer. When muting inputs fulfill the muting start conditions, UAM will suspend the safety function within 60ms and resume the safety function if they fulfill the muting stop conditions.

4.5.1 Muting start condition

Muting function will start when the following conditions are fulfilled:

a) There are no objects in the protection zone and the OSSD is in ON-state.
b) The two independent hard wired muting input signals are switched to ON state in the predefined sequence within the pre-set time interval. However, the switching interval between two input signals should not be 0 (Refer to figure 4-11).

The following configurations are necessary for the muting function. User can configure these by using the UAM project designer.

- Muting inputs sequence
  - ▸ Muting 1 → Muting 2
  - ▸ Muting 2 → Muting 1

- Time interval between two inputs (T1)
  - ▸ 1second
  - ▸ 3seconds
  - ▸ 5seconds
  - ▸ 10seconds

When using muting function in dual protection mode, Muting 3 and Muting 4 are configured in the similar way.

4.5.2 Muting stop condition

Muting function will stop when any one of the condition below is fulfilled:

a) One of the muting inputs switches to OFF-state.
b) When the predefined (preset) maximum muting time T2 exceeds (1 minute and above) (Figure 4-11).
c) Objects are detected in the protection zone which is not covered by the muting zone.
d) Error is detected by the self-diagnostics function.
e) During muting state when the area is switched to other area.

Figure 4-11 shows the muting sequence.

- Maximum muting period (T2)
  Maximum muting period can be selected from one of these values
  - 1 minute
  - 6 minutes
  - 12 minutes
  - Unlimited

When using the muting function in dual protection mode, Muting 3 and Muting 4 are configured in the similar way. Same applies for muting input sequence, time interval between inputs and maximum muting period.

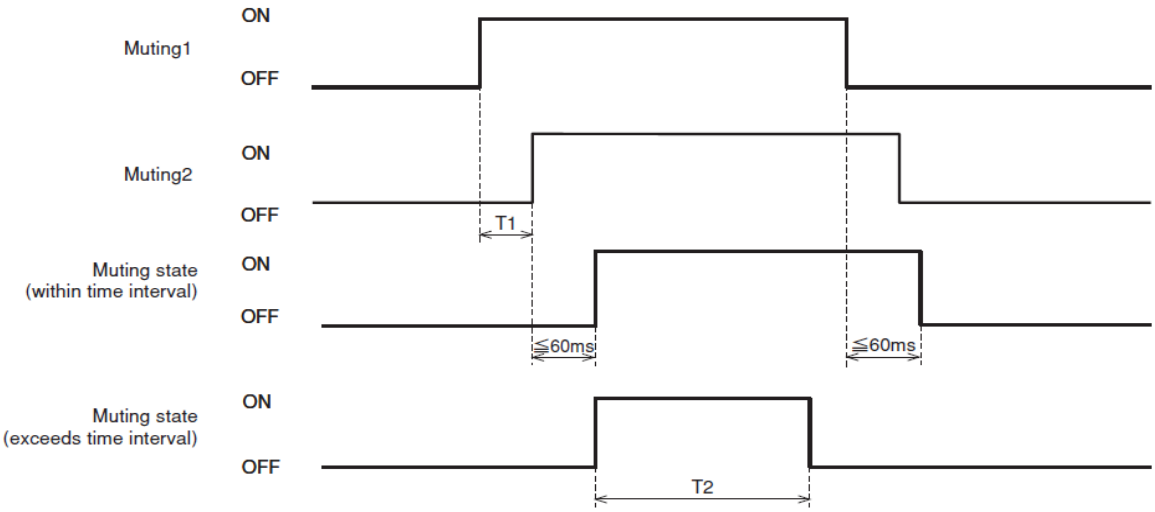


Figure 4-11 Muting sequence

4.5.3 Muting override function

Muting override is a function to recover UAM when the OSSD is switched to OFF state due to muting related errors by temporarily suspending the safety function. Override function is active when the override input (OVERRIDE 1/2) and the reset input (RESET 1/2) are switched in a sequence. Figure 4-12 shows the override sequence.

- Override start conditions
  - At least one of the muting inputs is in ON-state.
  - Object is present in the protection zone.
  - Time interval between override input and reset input is within 0.03s to 1s (T3).
- Override stop conditions
  - Both muting inputs are in OFF-state.
  - Override input or reset input is in OFF-state.
  - When predefined maximum override time T4 exceeds.
  - Error is detected by self-diagnostic function of the UAM.
  - During override state when area is switched to the other area.
- Maximum override period (T4)

  Maximum override period can be selected from one of these values
  - 1 minute
  - 6 minutes
  - 12 minutes

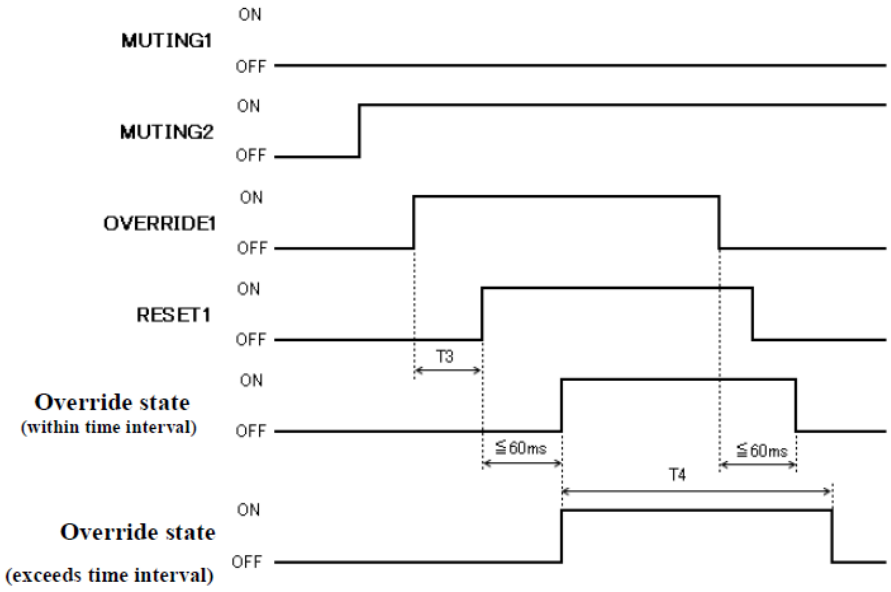


Figure 4-12 Override Sequence

When using muting override in dual protection mode, Muting 3, Muting 4, Override input 2 and Reset input 2 are configured in the similar way.

4.6 Reference monitoring function

Reference monitoring is a function to monitor the displacement of the UAM or the structure used as reference boundary.

4.6.1 Area protection

An example of reference monitor function used for area protection is shown in figure 4-13. If reference segments are configured on moveable objects (example: door) the OSSD will switch to OFF-state when the door position is changed.

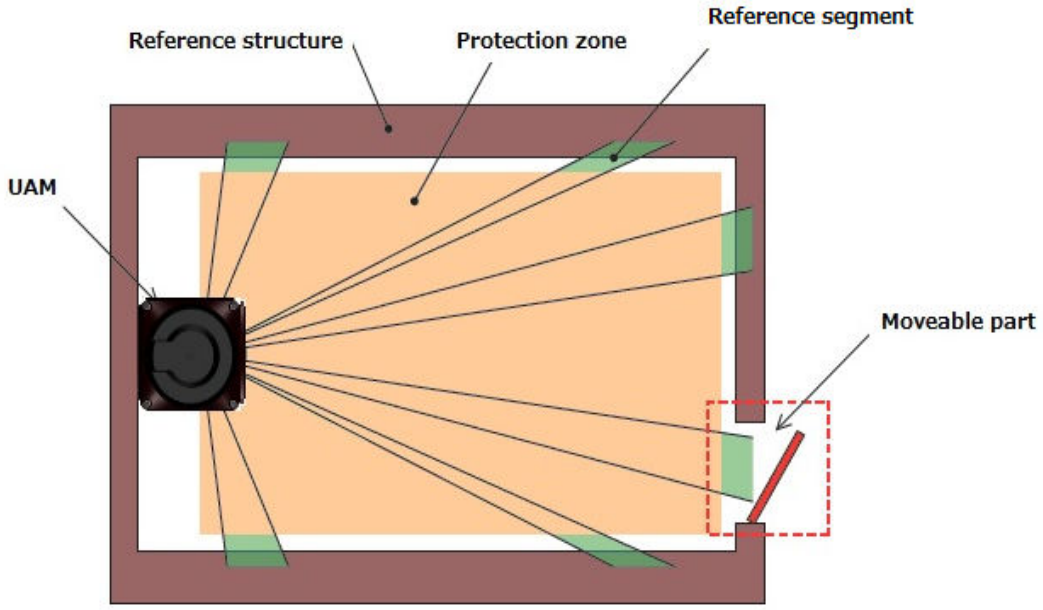


Figure 4-13 Top view of the area protection using reference monitor function

4.6.2 Access protection

An example of reference monitor function used for access protection is shown in figure 4-14(a), (b). Reference segments should be configured on each surface for displacement detection. Reference segments should be configured such that displacement can be easily detected. The OSSD will switch to OFF-state when access penetration is detected, and also if the distance between UAM and the reference structure changes. This function is compulsory for vertical applications.

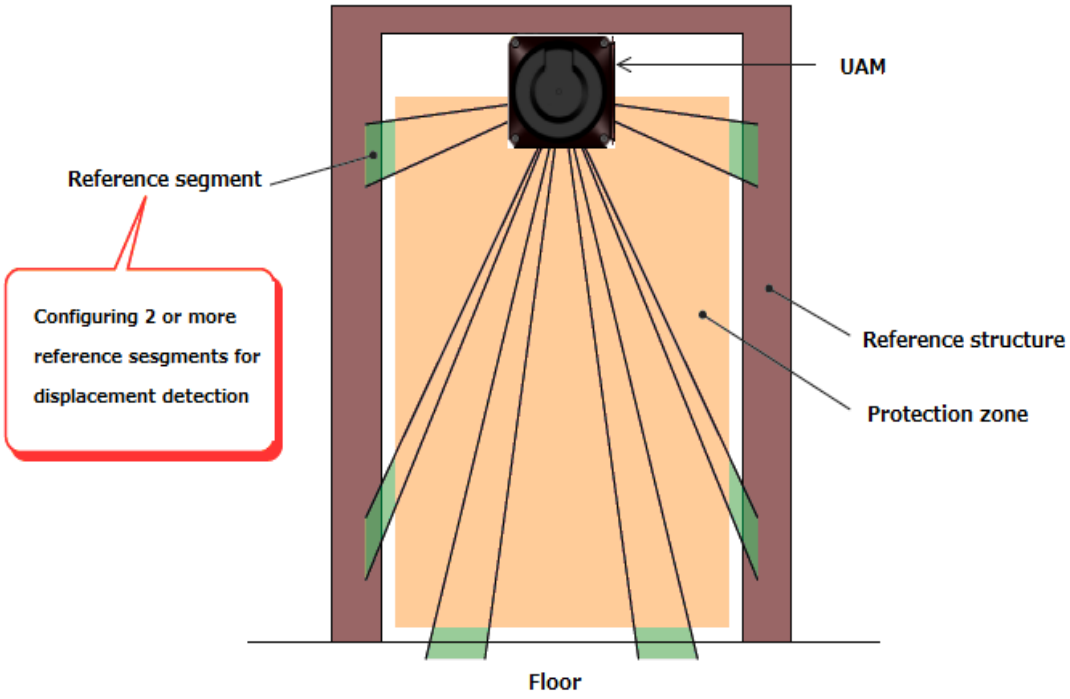


Figure 4-14(a) Front view of the access detection using reference monitor function

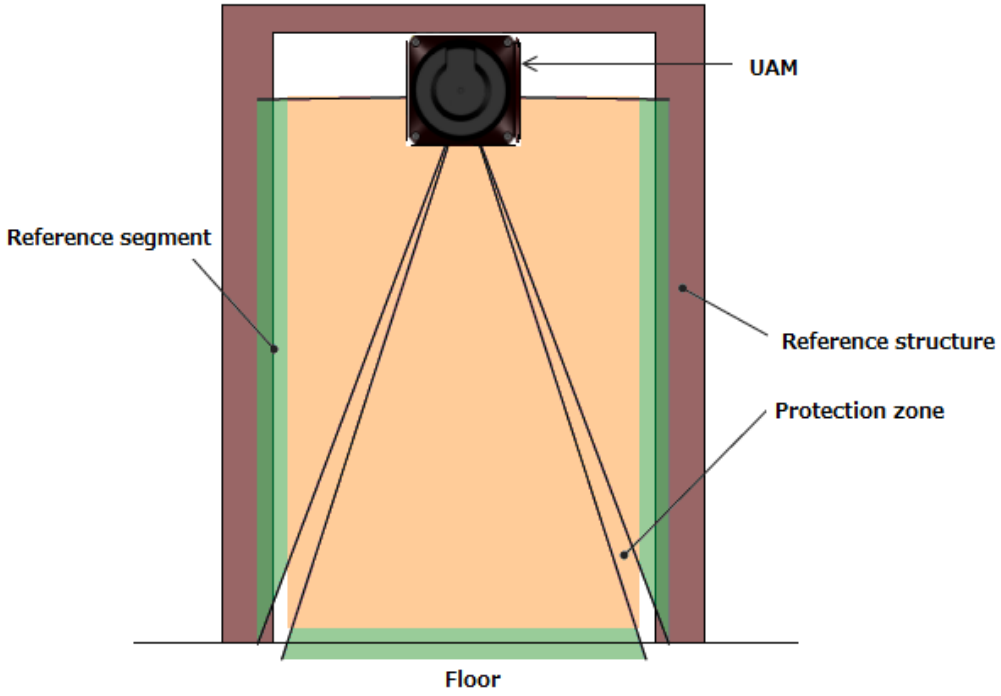


Figure 4-14(b) Front view of the access detection using reference monitor function

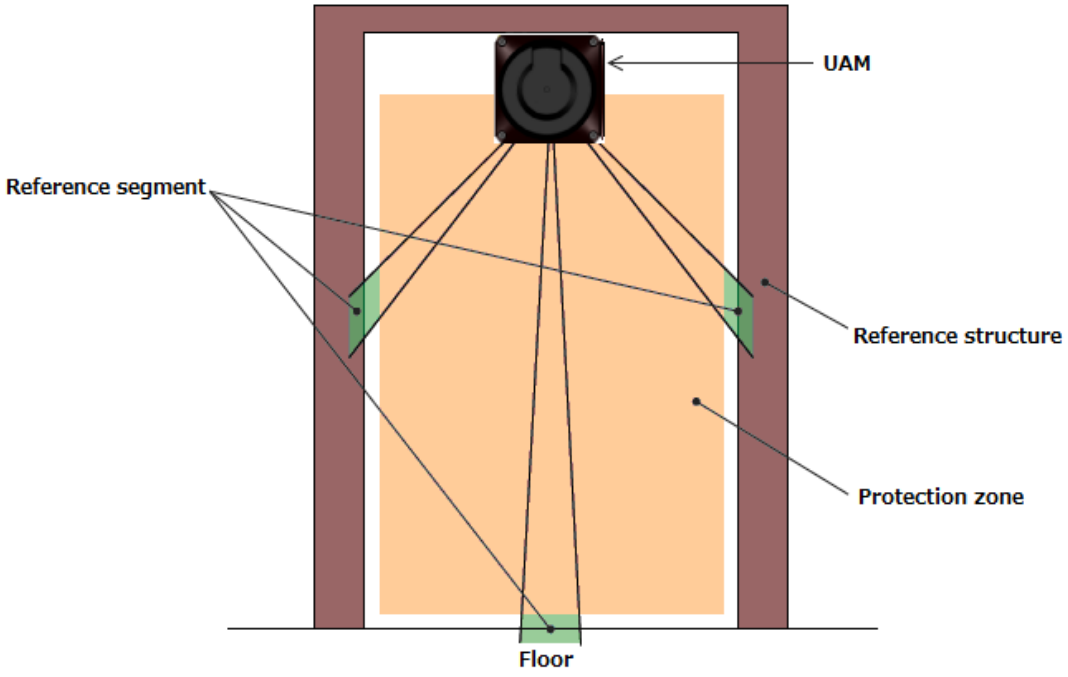


Figure 4-14(c) Incorrect configuration of reference segment

4.7 Area sequence function

Area sequence is a function to monitor sequences of area switching. When this function is activated, OSSD signal will switch to OFF-state if the switching pattern is other than the configured sequence. This function prevents the machine to operate with random protection zone.
From each area, switching selection to maximum 31 other areas is possible when configuring the area sequence. And, it is necessary to specify 1 or more areas to avoid error.

<Area switching sequence>

When area sequence is disabled, UAM can switch from an area to any other areas (Figure 4-15(a) whereas it can only switch to specified areas if area sequence is enabled. (Figure 4-15(b)).

Area sequence function is recommended for control systems where switching area sequences can be configured.

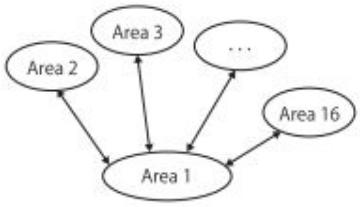


Figure 4-15(a) Operation without area sequence

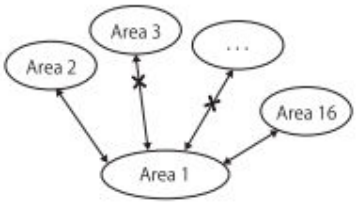


Figure4-15(b) Operation with area sequence

4.8 Response time

Response times of OSSD signal (Figure 4-16), OFF response time (Default 60ms) and ON response time (Default 270ms) are configurable individually for each area using the UAM project designer. Response time of the Warning 1 and Warning 2 will be same as the OSSD response time. Table 4-1 shows the possible configurable values. In the dual protection mode, it is possible to set a separate response time for each protection area.

When longer response time is configured, the stability of UAM can be increased. However, longer response time requires longer safety distance. User must perform risk assessment before configuring the response time. Addition of maximum 1 cycle (30ms) has to be taken into account for the area switching.

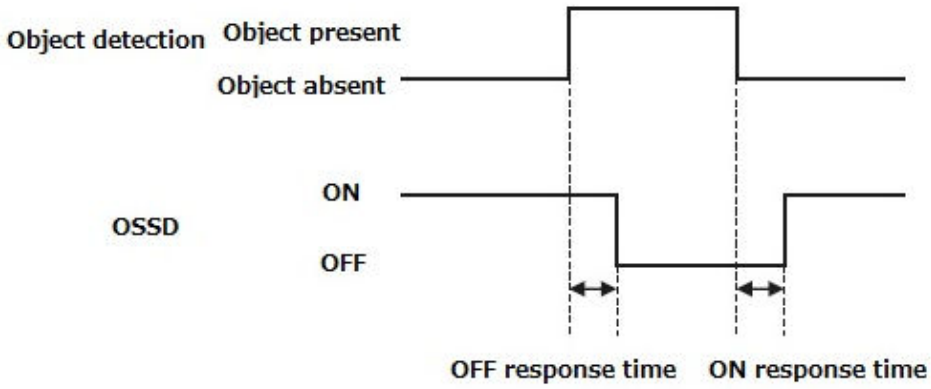


Figure 4-16 Response time

Table 4-1 Response time of UAM △3

	Response time (ms)							
OFF	60	90	120	150	180	210	240	270
	300	330	360	390	420	450	480	510
	540	570	600	630	660	690	720	750
	780	810	840	870	900	930	960	990
	1020	1050	1080	1110	1140	1170	1200	1230
	1260	1290	1320	1350	1380	1410	1440	1470
	1500	1530	1560	1590	1620	1650	1680	1710
	1740	1770	1800	1830	1860	1890	1920	1950
	1980	2010						

	Response time (ms)							
ON								270
	300	330	360	390	420	450	480	510
	540	570	600	630	660	690	720	750
	780	810	840	870	900	930	960	990
	1020	1050	1080	1110	1140	1170	1200	1230
	1260	1290	1320	1350	1380	1410	1440	1470
	1500	1530	1560	1590	1620	1650	1680	1710
	1740	1770	1800	1830	1860	1890	1920	1950
	1980	2010						

* Default value
* Default value of OFF response time varies depending on the selected application when creating a “New” project. Refer to User's Manual for details.
* Minimum configurable response time in Master/Slave mode is,
a) 120ms for OFF and 300ms for ON when the OSSDs of the slave units are not used.
b) 60ms for OFF and 300ms for ON when the OSSDs of all the slave units are used.

4.9 Other outputs ⚠3

UAM consist of 8 non-safety outputs, WARNING1, WARNING2, MUT_OUT1, MUT_OUT2, RES_REQ1, RES_REQ2, AUX_OUT1 and AUX_OUT2. WARNING1/OSSD3, WARNING2/OSSD4, RES_REQ1/MUT_OUT1/AUX_OUT1 and RES_REQ2/MUT_OUT2/AUX_OUT2 are configurable outputs that share the same terminal. When the functions are selected using UAM project designer, outputs are configured automatically.

4.9.1 Warning output 1 (WARNING 1)

This signal will switch to OFF-state when an obstacle is detected in the configured warning zone 1.

4.9.2 Warning output 2 (WARNING 2)

This signal will switch to OFF-state when an obstacle is detected in the configured warning zone 2.

4.9.3 Muting output 1 (MUT_OUT 1)

MUT_OUT1 indicates the muting/override status of the protection zone 1. When the muting function is activated, MUT_OUT1 will switch to ON-state. At the same time, number 37 is displayed on the 7-segment LED. This signal should be used to indicate that protection zone 1 is in muting state or override state.

4.9.4 Muting output 2 (MUT_OUT 2)

MUT_OUT2 indicates the muting/override status of the protection zone 2.When the muting function is activated, MUT_OU2 will switch to ON-state. At the same time, number 38 is displayed on the 7-segment LED. This signal should be used to indicate that protection zone 2 is in muting state or override state.

When both protection zone 1 and protection zone 2 are in muting or override state, number 39 is displayed on the 7-segment LED.

4.9.5 Reset Request 1 (RES _ REQ1)

This signal will switch to ON-state when the protection zone 1 of the UAM is ready to receive reset signal.

4.9.6 Reset Request 2 (RES _ REQ2)

This signal will switch to ON-state when the protection zone 2 of the UAM is ready to receive reset signal.

4.9.7 Auxiliary Output 1 (AUX_OUT1)

See section 4.18 for the details.

4.9.8 Auxiliary Output 2 (AUX_OUT2)

See section 4.18 for the details.

4.10 Area switching

A maximum of 32 sets of area can be configured in UAM. However the maximum configurable area number differs depending on the selected function such as, muting and dual protection. Table 4-2 shows the maximum configurable area number according to the used mode.

External input signals are provided in UAM for switching the area. Each signal has a pair of normal and inverted signal. For example, it is necessary to provide both input signal IN_A and inverse IN_A signal to switch the area. Error will occur if IN_A and inverse IN_A signals do not complement each other. Table 4-3 below shows the combination of input signal to switch the area. Area in use will be displayed in the 7 segment LED of UAM.

It is also possible to configure area input delay. Configure the necessary delay required for the system to provide stable input signals to UAM. The default value is 30ms.

There are maximum 5 input pairs (a pair is combination of normal and inverted signal) in UAM therefore, it can operate with maximum 32 sets of area. Further, it is also possible to switch the area through the speed monitoring of incremental encoder signal connected to UAM. Maximum configurable area in encoder input mode is 128.

Table 4-2 Input combination for area switching

Mode	Protection	Max internal input	Max Area	Max encoder area
Standard	1	5	32	－
	2	5	32	－
EDM	1	4	16	－
	2	4	16	－
MUTING / EDM	1	2	4	－
	2	1	2	－
Encoder *1	1	3	7	128*2
	2	3	7	128*2

*1: Muting function cannot be used if encoder input mode is selected.

*2: Among the 8 input patters, at least one pattern must be used for encoder input. Other 7 remaining patterns can be selected to be used as static input or not in use. A pattern with encoder input mode can have maximum 128 sets of area.

Table 4-3 Input combination for area switching

a) In the case of 5 Input

Area	IN_A	IN_B	IN_C	IN_D	IN_E	IN_$\overline{A}$	IN_$\overline{B}$	IN_$\overline{C}$	IN_$\overline{D}$	IN_$\overline{E}$
Area 1	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
Area 2	OFF	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF
Area 3	ON	OFF	ON	ON	ON	OFF	ON	OFF	OFF	OFF
Area 4	OFF	OFF	ON	ON	ON	ON	ON	OFF	OFF	OFF
Area 5	ON	ON	OFF	ON	ON	OFF	OFF	ON	OFF	OFF
Area 6	OFF	ON	OFF	ON	ON	ON	OFF	ON	OFF	OFF
Area 7	ON	OFF	OFF	ON	ON	OFF	ON	ON	OFF	OFF
Area 8	OFF	OFF	OFF	ON	ON	ON	ON	ON	OFF	OFF
Area 9	ON	ON	ON	OFF	ON	OFF	OFF	OFF	ON	OFF
Area 10	OFF	ON	ON	OFF	ON	ON	OFF	OFF	ON	OFF
Area 11	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
Area 12	OFF	OFF	ON	OFF	ON	ON	ON	OFF	ON	OFF
Area 13	ON	ON	OFF	OFF	ON	OFF	OFF	ON	ON	OFF
Area 14	OFF	ON	OFF	OFF	ON	ON	OFF	ON	ON	OFF
Area 15	ON	OFF	OFF	OFF	ON	OFF	ON	ON	ON	OFF
Area 16	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	OFF
Area 17	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	ON
Area 18	OFF	ON	ON	ON	OFF	ON	OFF	OFF	OFF	ON
Area 19	ON	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	ON
Area 20	OFF	OFF	ON	ON	OFF	ON	ON	OFF	OFF	ON
Area 21	ON	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	ON
Area 22	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON
Area 23	ON	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	ON
Area 24	OFF	OFF	OFF	ON	OFF	ON	ON	ON	OFF	ON
Area 25	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	ON
Area 26	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	ON	ON
Area 27	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	ON
Area 28	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	ON	ON
Area 29	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	ON
Area 30	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	ON	ON
Area 31	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON
Area 32	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON

b) In the case of 4 Input number

Area	IN_A	IN_B	IN_C	IN_D	IN_$\overline{A}$	IN_$\overline{B}$	IN_$\overline{C}$	IN_$\overline{D}$
Area 1	ON	ON	ON	ON	OFF	OFF	OFF	OFF
Area 2	OFF	ON	ON	ON	ON	OFF	OFF	OFF
Area 3	ON	OFF	ON	ON	OFF	ON	OFF	OFF
Area 4	OFF	OFF	ON	ON	ON	ON	OFF	OFF
Area 5	ON	ON	OFF	ON	OFF	OFF	ON	OFF
Area 6	OFF	ON	OFF	ON	ON	OFF	ON	OFF
Area 7	ON	OFF	OFF	ON	OFF	ON	ON	OFF
Area 8	OFF	OFF	OFF	ON	ON	ON	ON	OFF
Area 9	ON	ON	ON	OFF	OFF	OFF	OFF	ON
Area 10	OFF	ON	ON	OFF	ON	OFF	OFF	ON
Area 11	ON	OFF	ON	OFF	OFF	ON	OFF	ON
Area 12	OFF	OFF	ON	OFF	ON	ON	OFF	ON
Area 13	ON	ON	OFF	OFF	OFF	OFF	ON	ON
Area 14	OFF	ON	OFF	OFF	ON	OFF	ON	ON
Area 15	ON	OFF	OFF	OFF	OFF	ON	ON	ON
Area 16	OFF	OFF	OFF	OFF	ON	ON	ON	ON

c) In the case of 3 Input number

Area	IN_A	IN_B	IN_C	IN_$\overline{A}$	IN_$\overline{B}$	IN_$\overline{C}$
Area 1	ON	ON	ON	OFF	OFF	OFF
Area 2	OFF	ON	ON	ON	OFF	OFF
Area 3	ON	OFF	ON	OFF	ON	OFF
Area 4	OFF	OFF	ON	ON	ON	OFF
Area 5	ON	ON	OFF	OFF	OFF	ON
Area 6	OFF	ON	OFF	ON	OFF	ON
Area 7	ON	OFF	OFF	OFF	ON	ON
Area 8	OFF	OFF	OFF	ON	ON	ON

d) In the case of 2 Input number

Area	IN_A	IN_B	IN_$\overline{A}$	IN_$\overline{B}$
Area 1	ON	ON	OFF	OFF
Area 2	OFF	ON	ON	OFF
Area 3	ON	OFF	OFF	ON
Area 4	OFF	OFF	ON	ON

e) In the case of 1 Input number

Area	IN_A	IN_$\overline{A}$
Area 1	ON	OFF
Area 2	OFF	ON

4.11 Incremental encoder

In UAM there are 2 pairs of encoder input terminals for connecting 2 units of dual channel incremental encoder signals. Area will be switched depending on the encoder speed. Direction of travel is detected by encoder's phase A and phase B signals having the phase difference of 90°. Speed and rotating direction of both encoders are constantly monitored to detect abnormal travel and stop the AGV.

Incremental encoder output signals should be connected to the respective input terminals of UAM. There are two patterns of signals generated by the combination of Phase A and Phase B of encoders depending on the direction of travel (Figure 4-17). In the first pattern, Phase B is 90 degrees ahead of Phase A wherein, at the rising edge of Phase A, state of Phase B is “H”. This pattern is considered as positive direction (forward motion). In the second pattern, Phase B lags behind Phase A by 90 degrees and the state of Phase B at the rising edge of Phase A is “L”. This is considered as negative direction (backward motion).

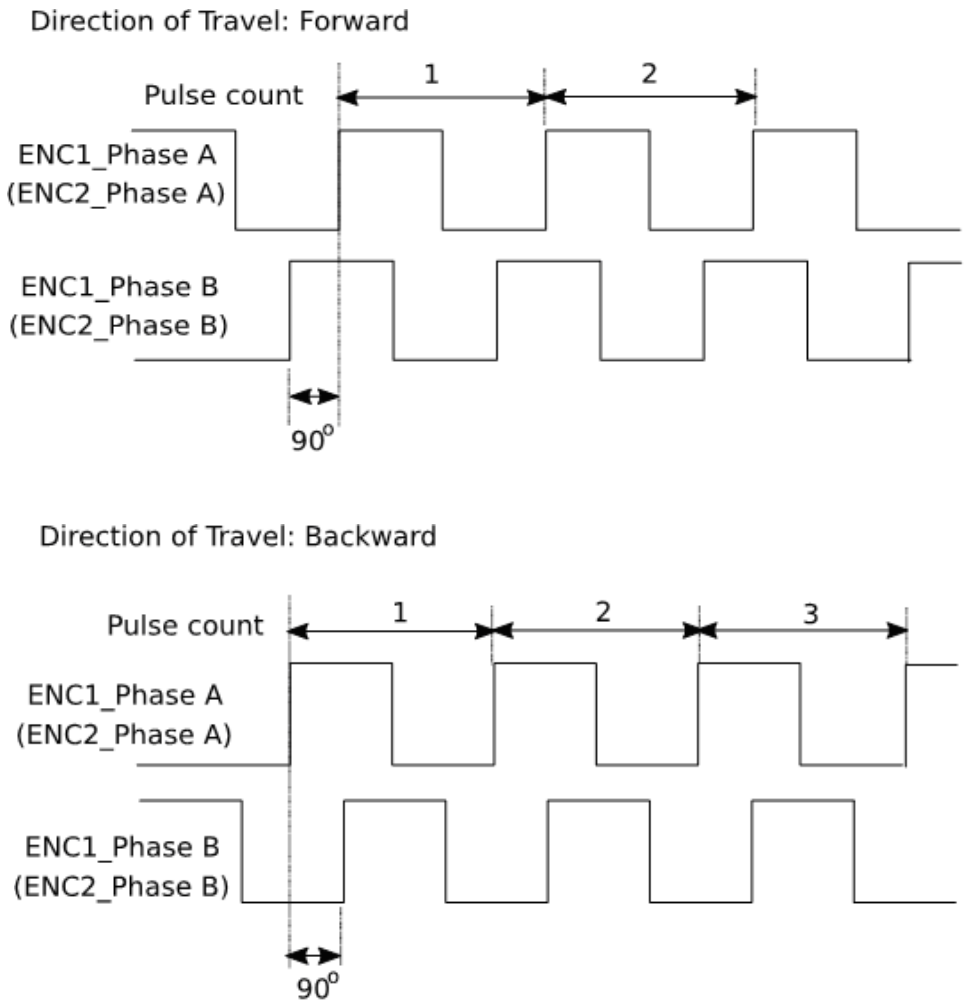


Figure 4-17 Input signal through Incremental encoder

4.11.1 Pulse per cm travel generated by incremental encoders

When AGV travels, incremental encoder generates pulses due to the transmission ratio between AVG tires and incremental encoder frictional wheel. Pulse count per cm depends on AGV's speed.

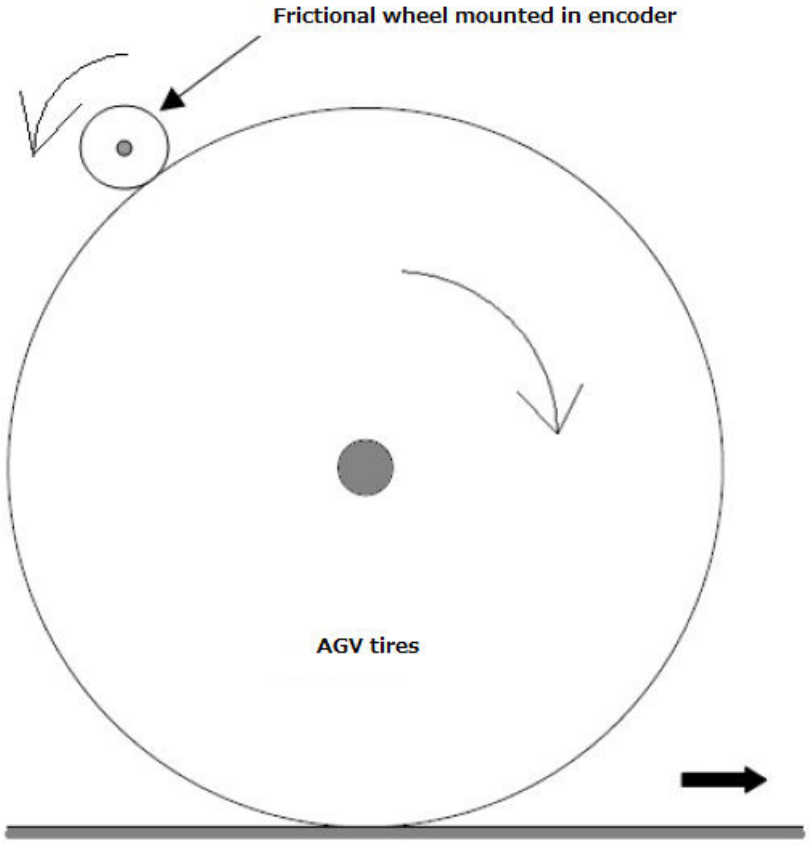


Figure 4-18 Calculation of pulse count for per centimeter travel

- AGV tire diameter : 40 cm
- Frictional wheel diameter mounted in incremental encoder: 5 cm
- Incremental encoder pulse number per revolution : 1000 pulse

AGV tire circumference = Diameter × Circumference ratio = 40 cm × 3.14 = 125.6 cm
AGV tire's one rotation is equivalent to 8 rotation of frictional wheel. This equals to the 8,000 pulse of incremental encoder.
From above, incremental encoder pulse count per cm is obtained as
8,000/125.6 = 63.7

While setting encoder parameters (Encoder Pulse1 and Encoder Pulse2) in UAM project Designer, set the encoder pulse count after rounding the calculated value to nearest whole number (64 in this case)
In the explanation above, the transfer method of the rotation was based on the frictional wheel. Same method can be applied for other cases to estimate the pulse count generated for one rotation of the wheel.

4.12 Ethernet Setting

● **Default setting**

Factory default value is shown below.

IP address : 192.168.0.10
Default gateway : 192.168.0.1
Subnet mask : 255.255.255.0
Port number : 10940

● **Changing the IP address**

IP address can be changed by using UAM project Designer. Refer to User's Manual for details.

● **IP address initialization**

Ethernet settings can be set to factory default by using IP initialization switch.

<Initialization steps>
a) Prepare a thin strong pin for IP initialization process. IP initialization switch is located exactly below the SD card Slot (Refer to figure 4-19)
b) When UAM is operating in normal state, press and hold the IP initialization switch for more than 3 seconds. After initialization process is complete 7-segment display status changes to “Fb”.
c) Sensor restarts with 7-segment display showing the status “00”.

Figure 4-19 IP initialization switch

4.13 Function to configure UAM by SD card

Configuration generated by UAM Project Designer can be saved in the SD card. It is possible to transfer the setting directly from the SD Card to UAM without connecting to a PC. Recommended specification of SD card is given below.

Create a project file with set the serial number and password of the UAM and save it on the SD card using UAM Project Designer. When the SD card is inserted to the specified UAM, settings are automatically transferred. It is possible to register multiple serial number and password in the SD card to simultaneously configure multiple devices. Setting will not be transferred to the unspecified UAM or if the password verification fails.

4.14 Master-Slave Function

Maximum 4 units of UAM can be interconnected using RS-485 for Master/slave operation. One unit will function as a master unit communicating with up to 3 units that function as slaves via safety communication channel. Use the UAM Project Designer to configure the devices. UAM will report error if the number of master and slave units is different than the configured settings.

Area switching of the slave unit is linked with the master unit while the slave units transmit the object detection information to the master which controls the OSSD. It is also possible to use each slave unit's OSSD. Figure 4-20 shows the connection example.

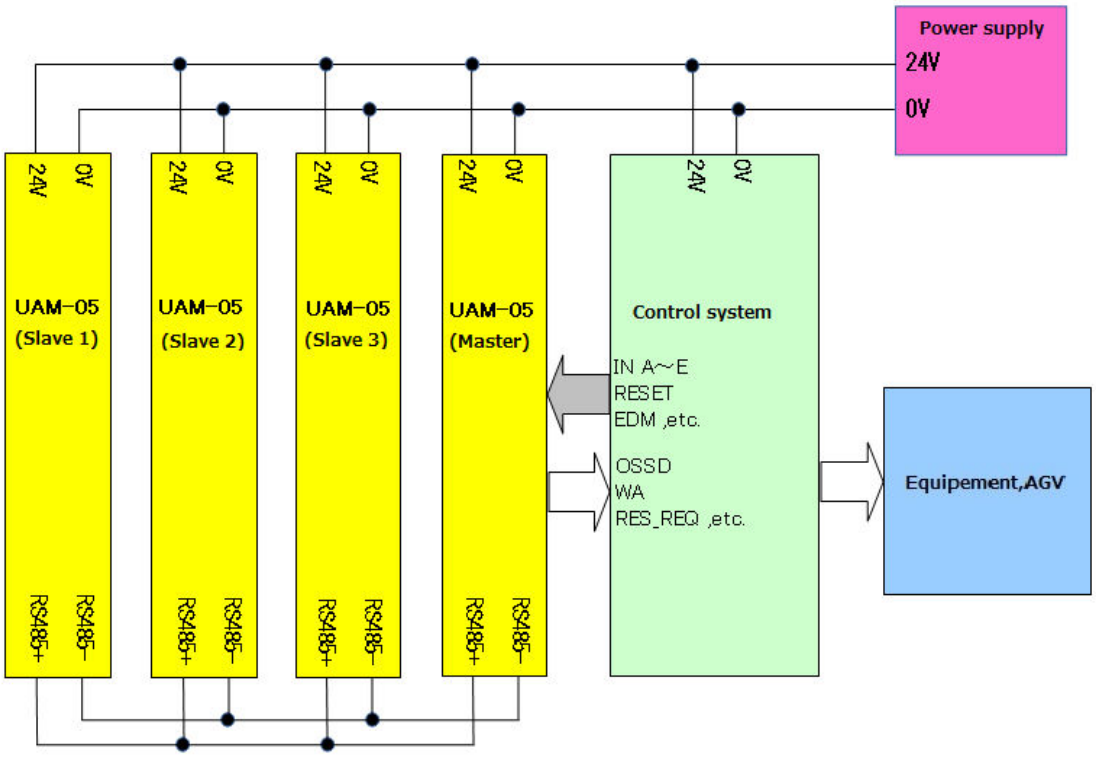


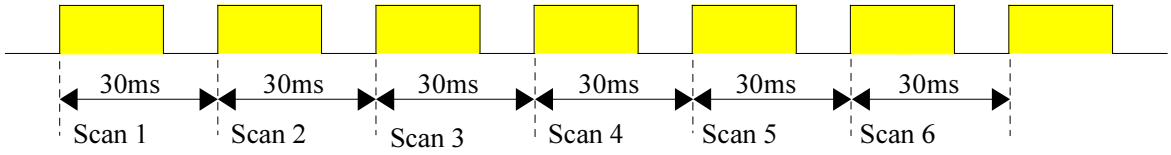
Figure 4-20 Connection example (When OSSD of slaves are not in use)

4.15 Laser Off Mode

Laser off mode is a function to completely stop the laser emission in the measurement region in order to prevent the interference to the surrounding equipment.
When this mode is enabled, Area1 is automatically assigned for laser off function. During the operation, UAM will stop the laser emission and switch the OSSD to OFF state whenever the area is switched to Area1.

4.16 Scan Skip Function

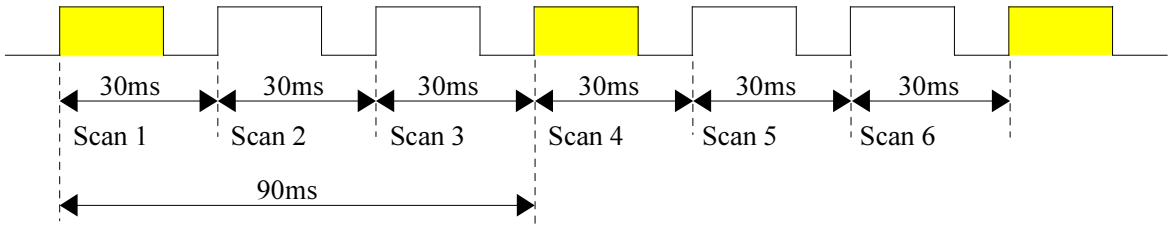
Scan skip is a function to stop the laser emission for a specified number of scan cycles in the measurement region in order to reduce the interference to the surrounding equipment.
When this function is enabled by specifying the skip count, UAM will operate by skipping the scan for the number of cycles. During the skipping cycle the laser is switched off in the measurement region. Configurable value for skip cycle is 0 ~ 3 count. Response time of UAM for the different settings is shown in Table 4-4.
Figure 4-21 shows the operating concept when the scan skip is 0. In this configuration the scan skip function is disabled and sensor operates normally.



* Laser emitted cycle is shown in yellow

Figure 4-21 Operation of UAM when scan skip count is 0

Figure 4-22 shows the operating concept when the scan skip is set to 2. In this configuration UAM will skip the measurement for every 2 cycles in between the normal measurement cycles. Outputs states just before the skipping cycle are retained during the skipping cycle.



* Laser emitted cycle is shown in yellow

Figure 4-22 Operation of UAM when scan skip count is 2

Table 4-4 Response time for different scan skip settings ※3

Master-Slave function disabled or when the slave OSSDs are used in master-slave mode.

Scan skip count	Off Response time (ms)							
1	90	150	210	270	330	390	450	510
	570	630	690	750	810	870	930	990
	1050	1110	1170	1230	1290	1350	1410	1470
	1530	1590	1650	1710	1770	1830	1890	1950
	2010							
2	120	210	300	390	480	570	660	750
	840	930	1020	1110	1200	1290	1380	1470
	1560	1650	1740	1830	1920	2010		
3	150	270	390	510	630	750	870	990
	1110	1230	1350	1470	1590	1710	1830	1950

Scan skip count	On Response time (ms)							
1	270	330	390	450	510	570	630	690
	750	810	870	930	990	1050	1110	1170
	1230	1290	1350	1410	1470	1530	1590	1650
	1710	1770	1830	1890	1950	2010		
2	300	390	480	570	660	750	840	930
	1020	1110	1200	1290	1380	1470	1560	1650
	1740	1830	1920	2010				
3	270	390	510	630	750	870	990	1110
	1230	1350	1470	1590	1710	1830	1950	

Master-Slave function enabled and slave OSSD outputs are not used

Scan skip count	Off Response time (ms)							
1	150	210	270	330	390	450	510	570
	630	690	750	810	870	930	990	1050
	1110	1170	1230	1290	1350	1410	1470	1530
	1590	1650	1710	1770	1830	1890	1950	2010
2	180	270	360	450	540	630	720	810
	900	990	1080	1170	1260	1350	1440	1530
	1620	1710	1800	1890	1980			
3	210	330	450	570	690	810	930	1050
	1170	1290	1410	1530	1650	1770	1890	2010

Scan skip count	On Response time (ms)							
1	330	390	450	510	570	630	690	750
	810	870	930	990	1050	1110	1170	1230
	1290	1350	1410	1470	1530	1590	1650	1710
	1770	1830	1890	1950	2010			
2	360	450	540	630	720	810	900	990
	1080	1170	1260	1350	1440	1530	1620	1710
	1800	1890	1980					
3	330	450	570	690	810	930	1050	1170
	1290	1410	1530	1650	1770	1890	2010	

4.17 Optical Window Contamination Warning Function ⚠2

This is a function to warn the optical window contamination by blinking the 7-segment display number before contamination level reaches the maximum limit causing the OSSD signals to switch to OFF state. Cleaning the optical window at the blinking stage will prevent the unnecessary stop due to contamination error. No specific configuration is necessary to activate this function.

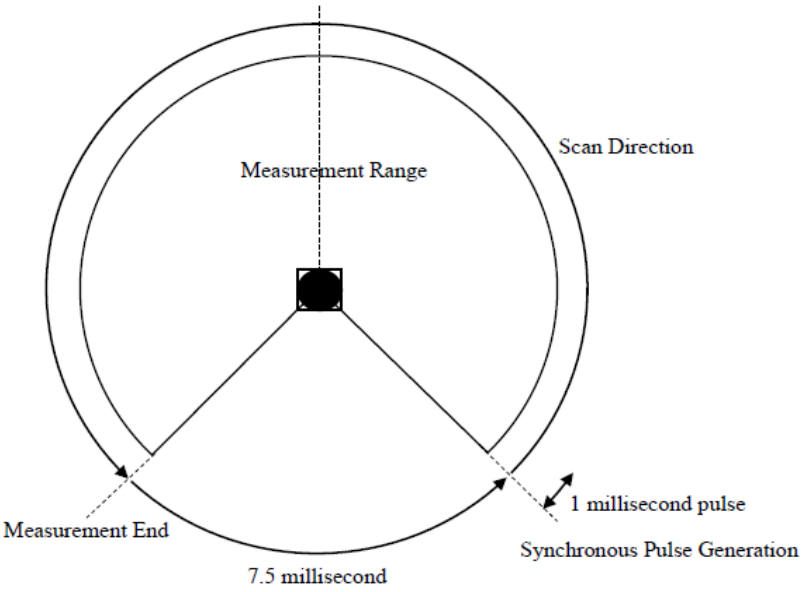
4.17 Auxiliary Output Function ⚠3

Auxiliary output signals, AUX_OUT1 and AUX_OUT2 can be assigned to one of the following functions shown on the table below. However, it will be automatically assigned to Reset Request signal if the interlock function is enabled or Muting output signal if the muting function is enabled.

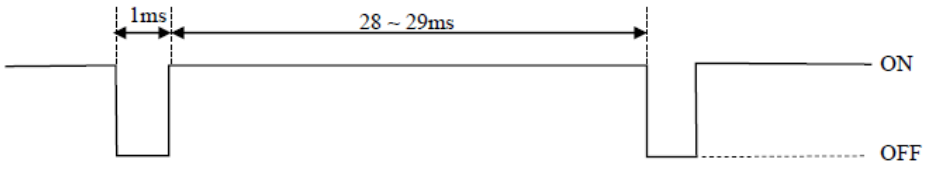
Output	Details
Synchronous signal	UAM generates 1ms pulse is in every scan.
Error	Signal goes to ON state when UAM is in error state.
Window contamination error	Signal goes to ON state when contamination on the optical window reaches the error level.
Window contamination warning	Signal goes to ON state when contamination on the optical window reaches the warning level.

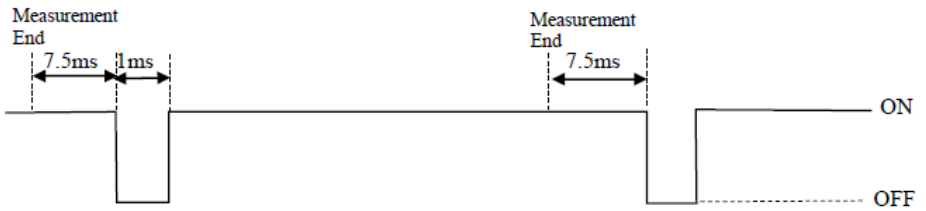
<Synchronous signal timing chart>

UAM outputs a signal synchronized with its scan at the time shown in the figure below.



Synchronous Pulse Frequency





Note: Signal will be OFF when the device is in lockout state due to malfunction.

5. Wiring

5.1 Wire color and function

Table 5-1 shows the color of each lead wire, signal name and function. It is recommended to use the shielded cable for wiring.

Table 5-1 Wire color and function

Color	Signal	Function	Description	AWG
Brown	+ 24 DC	Power	Power Supply: DC 24V	22
Blue	0V DC	Power	Power Supply: DC 0V	22
Red	OSSD1	Output	Protection zone output 1	26
Yellow	OSSD2	Output	Protection zone output 2	26
Red/Black	WARNING 1/ OSSD3	Output	Warning zone output 1/Protection zone output 3	28
Yellow/Black	WARNING 2/ OSSD4	Output	Warning zone output 2/Protection zone output 4	28
Purple	IN_A	Input	Area switching Input A	28
Gray	IN_B/ MUTING 3	Input	Area switching Input B / Muting input 3	28
White	IN_C/OVERRIDE1/ ENC1_A	Input	Area switching Input C/Override input 1/ Encoder input 1_A	28
Pink	IN_D/ MUTING 1/ENC1_B	Input	Area switching Input D / Muting input 1/ Encoder input 1_B	28
Green	IN_E/EDM1	Input	Area switching Input E /External device monitoring 1	28
Purple/Black	IN_A	Input	Area switching Input A invert	28
Gray/Black	IN_B/ MUTING4	Input	Area switching Input B invert / Muting input 4	28
White/Black	IN_C/OVERRIDE2/ENC2_A	Input	Area switching Input C invert / Override input 2/Encoder input 2 A	28
Pink/Black	IN_D/ MUTING2/ENC2_B	Input	Area switching Input D invert / Muting input 2 / Encoder input 2 B	28
Green/Black	IN_E/EDM2	Input	Area switching Input E invert / External device monitoring 2	28
Yellow/Green	RESET 1	Input	Reset input 1	28
Yellow/Blue	RESET 2	Input	Reset input 2	28
Orange	RES_REQ1/MUT_OUT1/ AUX_OUT1 ※3	Output	RES_REQ1: Request output 1 MUT_OUT1: Muting state output 1 AUX_OUT1: Synchronous signal/Error/Window contamination error/Window contamination warning	28
Orange/Black	RES_REQ 2/MUT_OUT 2/ AUX_OUT2 ※3	Output	RES_REQ2: Request output2 MUT_OUT2: Muting state output2 AUX_OUT2: Synchronous signal/Error/Window contamination error/Window contamination warning	28
White/Blue（TP）	RS485+	Communication	Communication protocol RS485	28
White/Red（TP）	RS485-	Communication	Communication protocol RS485	28
Shield wire	FG	—	Frame ground	—

5.2 Wiring example

a) Standard (With maximum 32 sets of area)

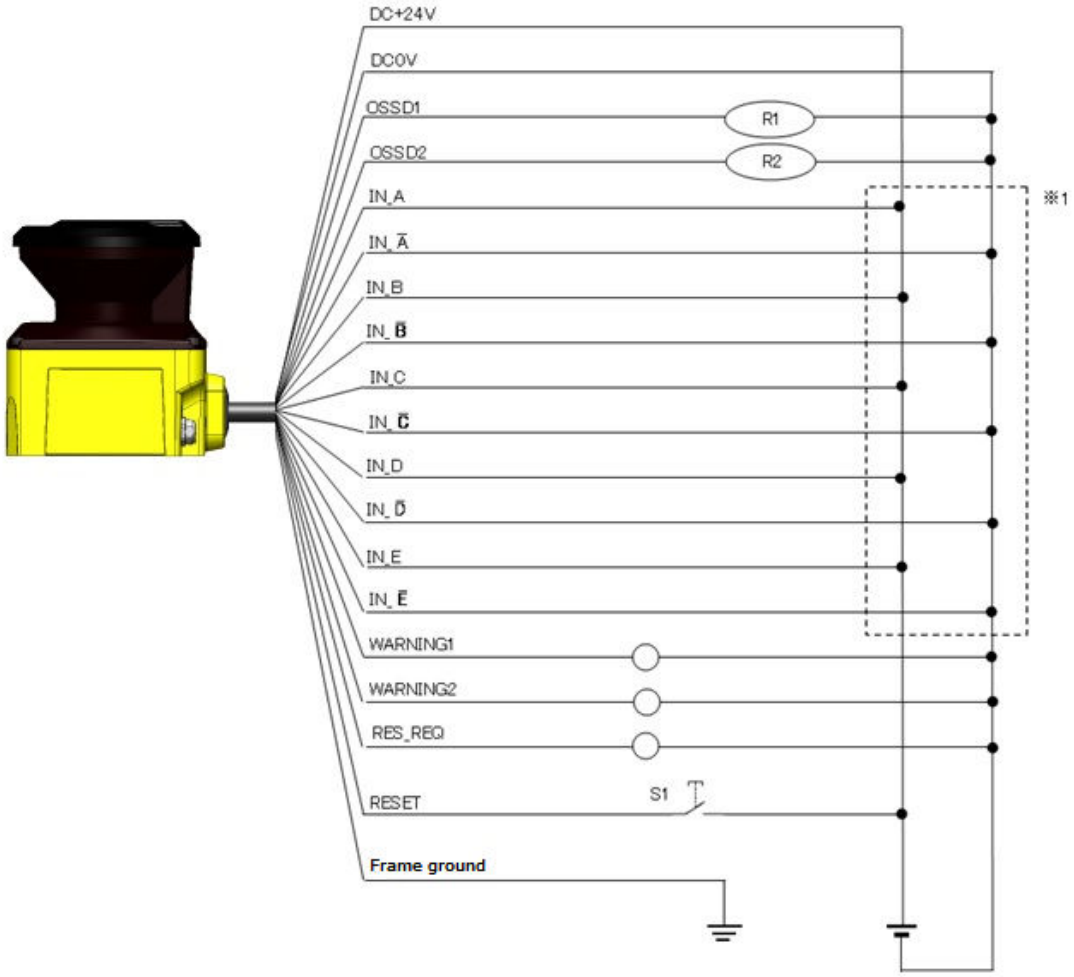


Figure 5-1 Wiring Example

R1 and R2: External equipment (Safety relay, Electromagnetic contactor)
S1: Interlock reset switch
*1: Refer to User's Manual for the detail on area switching.

6. Input/ Output circuit

6.1 OSSD/ Warning Output circuit

OSSD/Warning output is output source type

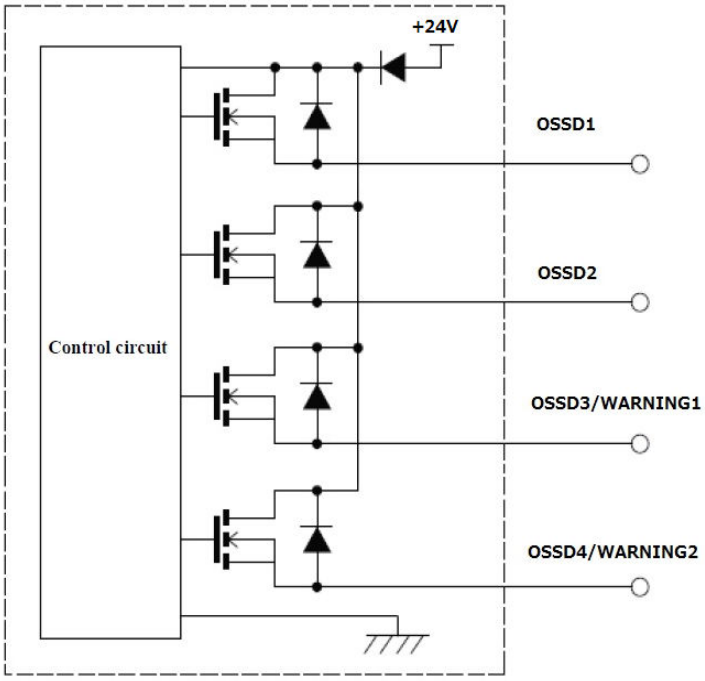


Figure 6-1 OSSD/WARNING Output circuit

6.2 Other output circuits ⚠3

RES_REQ1, RES_REQ2, MUT_OUT1, MUT_OUT2, AUX_OUT1, AUX_OUT2 outputs are PNP type.

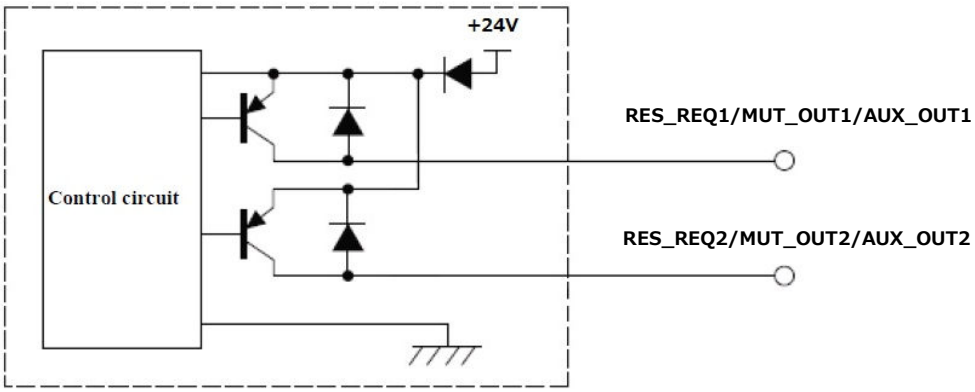


Figure 6-2 Output circuit

6.3 Input circuit

Figure 6-3 shows input circuit for Area input, EDM1, EDM2, RESET1, RESET2, MUTING 1, MUTING 2, MUTING 3, MUTING 4, OVERRIDE 1, and OVERRIDE 2 signals.

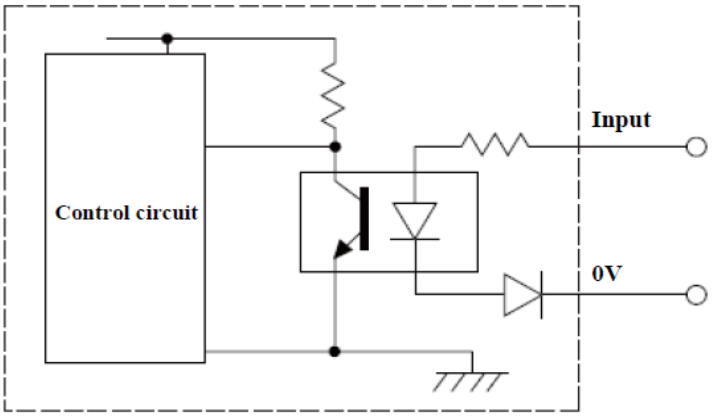


Figure 6-3 Input circuit

7. Revision history

Amended No.	Revision date	Details
-	August 2016	First Release
△1	January 2017	Standards updated Following sections added and/or modified ・Laser off mode added ・Scan skip function added ・Minimum detection width of 150mm added ・Other minor corrections
△2	November 2017	・Standards updated ・Minimum detection width of 40mm added ・Optical window contamination warning function added ・Other minor corrections
△3	May 2020	・Axillary output function added ・Extended master-slave response time ・Area added when encoder input function is used (up to 128) ・Other minor corrections