CARLO GAVAZZI

Photoelectric amplifier for MOFx sensors

PAM03

User manual

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1. Introduction

This manual is a reference guide for Carlo Gavazzi photoelectric amplifier PAM03DB1RAU24. It describes how to install, setup and use the product for its intended use.

1.1. Description

The Carlo Gavazzi photoelectric amplifier is a device designed and manufactured in accordance with IEC international standards and is subject to the Low Voltage (2014/35/EU) and Electromagnetic Compatibility (2014/30/EU) EU directives.
The amplifier and its connected through beam photoelectric sensors are designed for presence detection (Safeguard Type D according to EN12453) and can be used in industrial doors and gates or similar applications that require detection of objects interrupting the light beam between emitter and receiver.
For a single module installation to fulfill the UL325 requirements or for several connected modules to fulfill the UL508 requirements they must be installed with a class 2 power supply and with the cables specified in the norm description.

Please do not hesitate to make any suggestions for improving this document.

1.2. Validity of documentation

This manual is valid only for PAM03DB1RAU24 photoelectric amplifier and until new documentation is published.
This instruction manual describes the function, operation and installation of the product for its intended use.

1.3. Who should use this documentation

This manual contains important information regarding installation and must be read and completely understood by specialized personnel dealing with photoelectric sensor installation.
Save the manual for future use.

1.4. Intended use of the product

This photoelectric amplifier is designed for use with the MOFx series through beam sensors consisting of a transmitter and a receiver. The combination of MOFx sensors and PAM03 amplifier works very well in environments with poor visibility due to flying dust, water spray or hoarfrost, like car washes, wood working or stone crushing machinery as well as industrial freezer doors.

1.5. Safety precautions

The PAM03 module is designed to perform according to the safety requirements set by the door regulative in Europe and North America, and as such, it is highly reliable. It should only be used in situations with moderate risks.
Installation and use must be carried out by trained technical personnel with basic electrical installation knowledge.
The installer is responsible for correct installation according to local safety regulations and must ensure that a defective installation will not result in any hazard to people or equipment. If the amplifier module or sensor is defective, it must be replaced and secured against unauthorised use.
The PAM03 module must only be used for its intended purpose. Do not change or modify any components unless specified in the manual.
Make sure that the power supply and load currents as well as other parameters are within the specifications, and install the module in an appropriate enclosure, that protects against fire, electrical and mechanical damage.

1.6. Other documents

Please find the datasheet on the Internet at http://gavazziautomation.com

1.7. Acronyms

PLC	Programmable Logic Controller
IEC	International Electrotechnical Commission
NO	Normally Open contact
NC	Normally Closed contact
NPN	Pull load to ground
PNP	Pull load to V+
Push-Pull	Pull load to ground or V+

2. Product

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2.1. Main features

The Carlo Gavazzi PAM03 amplification module can operate alone, controlling 3 MOF... sensor sets. Up to 10 amplifiers can also be connected in a master/slave setup via the built-in communication port sharing power and controlling up to 30 MOF... sensor sets. All connected MOF... sensors are multiplexed, eliminating crosstalk.
Due to their signal strength, the combination of MOF... sensor sets and PAM03 amplifiers are suitable for environments with high amounts of dust or fog like wood working and stone crushing machinery, car washes, automatic industrial doors or other applications where a photoelectric sensor must work despite a build-up of dust or dirt or sense through fog or mist or similar visibility hindrances.
The PAM03 module is very versatile thanks to the options of potentiometer or automatic gain adjustment, and the dip switch controlling the long/short range setting. This allows for optimal hysteresis and dust reserve settings for a wide variety of applications. On-delay and Off-delay settings make compensating for unstable signals easier.
The amplifier offers a test input, that is commonly used in industrial door applications, as well as an alarm function that alerts for both faulty sensors or connections, as well as decreased sensing performance due to dirt or misalignment.
The Carlo Gavazzi photoelectric PAM03 amplifiers are available in a plastic (PC/ABS) IP20 approved housing material.

2.2. Identification number

	Description
P	Photoelectric
AM	Amplifier relay
M	Multiplexed sensors
03	Number of channels/ sensor sets
D	Housing DIN-rail
B	Inter bus connection
1	Spring terminal connectors
R	Relay output
A	SPDT N.O. & N.C. contacts
U24	24 ... 42 VAC/DC power supply

Additional characters can be used for customized versions.

2.3. Operating mode

The PAM03 can operate alone, multiplexing 3 MOFT.../MOFR... sensor sets, and up to 10 PAM modules can stack to multiplex up 30 sensor sets. The PAM module automatically detects if it should be master or slave in a stacked setup, making installation and commissioning easy.

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3. Operation

3.1. User interface of PAM03

The PAM03 amplifier connects up to 3 sets of photoelectric MOFT.../MOFR... sensors with their corresponding relays. Each of these channels has a separate trimmer that controls the signal strength of the sensor set.
Each trimmer has two LEDs: One yellow and one tri-color, that indicate output status and the health of the connected sensor sets. (see section 3.2 LED indication)

The On-delay/OFF-delay trimmers are located below the 3 sensor channel trimmers. (see section 4.1.5 Time delays)

A green LED, located below the Delay trimmers and above the dip switches, shows Power/ Multiplex/Error status (See section 3.2.2. LED indication)

The dip switches at the bottom of the user interface are described in section 6.1 Functions

3.2. LED indication

Each channel has 2 LEDs: One yellow and one tri-color. The user interface also has a green LED, that indicates the power status of the single module, or the communication between connected modules.

Please also refer to section 3.4 for a schematic view of the LEDs and their meaning.

3.2.1. Output indication, yellow LED

Each channel has a yellow LED, that indicates the relay status

When no object is detected between the emitter (target) and the receiver, the relay is active, and the yellow LED is ON.

3.2.2. Tri-color LED

The channel also has a tri-color LED that indicates channel adjustment status and is used for diagnostic purposes:

- Steady green light means the channel is in Automatic sensitivity adjustment mode. This is activated by turning the trimmer all the way counter clockwise.
- Steady red light means the automatic channel sensitivity adjustment has reached maximum, cleaning is needed.
- Flashing yellow LED means the module is in alignment mode. The faster the LED flashes, the stronger the received signal is. Alignment mode is activated by moving one of the dip switches into the alignment setting. (see section 6.1.3.)
- LED is off means the sensitivity is adjusted by trimmer.

The tri-color LED also carries diagnostic information. Please refer to section 3.3

3.2.3. Power/multiplex, Green LED

The green LED light located just above the dip switches indicates the status of the communication of the interconnected modules.

A constant light means the power is on, and there is no bus connection with other modules.
When several modules are connected, flashing green LEDs means the bus connection is working correctly. However, if the LED flashes with a duty cycle of 50% off, 50% on, then it indicates an error in the communication.

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3.3. Diagnostic functions

3.3.1. Error types and their LED indications

The LEDs carry diagnostic information when their lighting patterns change.

If the tri-color LED alternates between two colors, it means there is an error on either the emitter or the receiver. The speed and color of the lights indicate whether the error lies with the emitter or the receiver as well as the type of error: Slowly alternating lights means a short circuit, while faster alternating lights means one of the wires has broken.
Alternating yellow and red means receiver error.
Alternating green and red lights means emitter error.

If the green communication LED flashes at 1 Hz equal time on and off, the communication between the modules failed.

3.4. LED indications at a glance

Status indications			
LED	**LED steady ON**	**LED OFF**	**LED flashing**
Yellow LED	Relay active, target detected, no object interrupts light beam	Relay inactive, object interrupts light beam, target not detected	
Tri-color LED	LED steady green: Automatic sensitivity adjustment LED steady red: Automatic sensitivity adjustment at maximum	Sensitivity adjustment by trimmer	Yellow: Channel in alignment mode - Slow flashes = weak signal Fast flashes = strong signal Constant light = max signal Sensitivity trimmer adjusted: Flashing at 1 Hz, 50% off, weak signal
Green LED	Stand alone mode, power ON		Flashes 1 Hz, 10% off, 90% on: interconnected mode, communication OK
Diagnostic indications			
Receiver faults, Tri-color LED			Alternating red and yellow at 2 Hz: Short circuit on wires
			Alternating red and yellow at 4 Hz: Broken wire
Emitter faults, Tri-color LED			Alternating green and red at 2 Hz: Short circuit on wires
			Alternating green and red at 4 Hz: Broken wire
Green LED			Flashes 1 Hz, 50% of duty cycle off = interconnected mode, communication failed

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4. Output parameters

Each PAM03 has 3 relays corresponding to the 3 sensor sets. As the sensor sets are through-beam sensors, it is important to keep the following in mind:

When the light beam between emitter and the receiver is uninterrupted, then the corresponding relay is active, meaning it carries a current. The emitter is the target of the receiver.

Whenever an object breaks the light beam, the target (emitter) is no longer visible, and the relay breaks, no longer carrying any current.

4.1. Output relays

The PAM03 module has two types of relays:
3 standard output relays and 1 warning relay.

4.1.1. Warning relay

As long as there are no errors on the module, the warning relay is active and carries a current. If for some reason an error occurs, the warning relay is dropped, meaning the installation should stop for maintenance.

The warning relay has two settings, selectable by dip switch:

- !
- Common

If the dip switch is set to "!", then the warning relay only warns about the specific module. The warning relay of that module must be connected.

If the dip switch is set to "Common", then the warning relay handles errors from all connected modules. Only the warning relay of the module that is set to "Common" needs to be connected. The other connected modules do not need their warning relays connected, and may be left in the "!" setting. It does not matter which of the connected modules handles the warning relay.

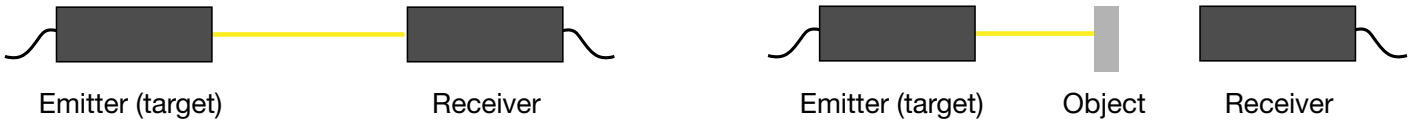
Any type of error will cause the warning relay to open and stop carrying a current: Short circuits in the receiver or the emitter, broken wires in the receiver or the emitter, or if the automatic sensitivity adjustment is maxed out. This usually means the sensor sets need cleaning because of a build up of dust or moisture.
If several modules are connected and the communication between the modules is interrupted, then the warning relay also opens.
To see more, go to 6.1.5.

4.1.2. Output relays

The 3-wire output relays are SPDT gold contacts. Thanks to the gold contacts, PAM module can handle very small operational currents ≥ 1mA @ 5V. If higher currents are applied to a contact, the gold layer will burn away, and the relay will no longer work at the low operational currents of a signal relay.

4.1.3. Time delays

The PAM03 amplification module has two trimmers to control ON-delay and OFF-delay respectively. The time delay setting affects all relays equally. If the trimmer is set all the way counterclockwise, the timer is disabled.



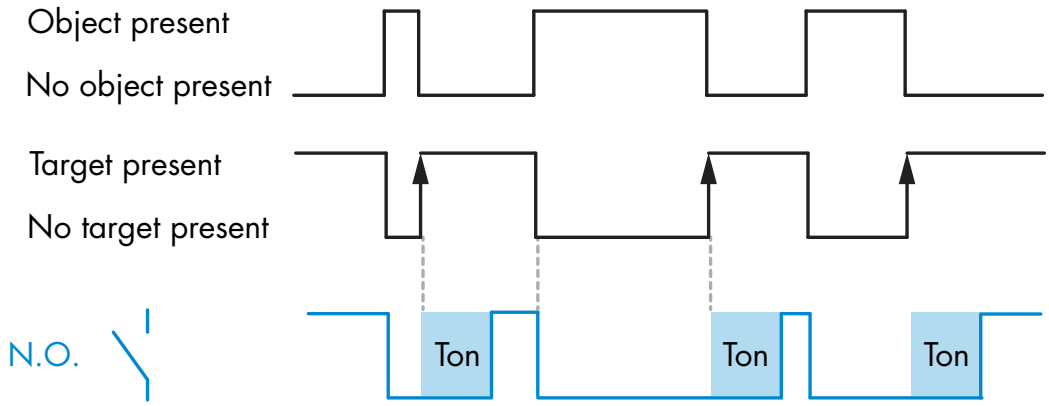
The relays are configured as positive safety, which means that:

- The relay is powered and current flows through the Normally Open contact when the receiver sees light from the emitter (the target). No object is present.
- The ON-delay is activated when the receiver changes from not receiving any light to receiving light from the emitter (the target), when the object stops blocking the light beam.
- The OFF-delay is activated when the receiver changes from receiving light to not receiving any light, i.e. when an object blocks the light beam.

Please bear in mind, that the timer settings (ON-delay and OFF-delay) affect all the relay outputs. The trimmers select how much of which type of timer function is introduced on the relay. Any one of the following is possible:

4.1.3.1. ON-delay

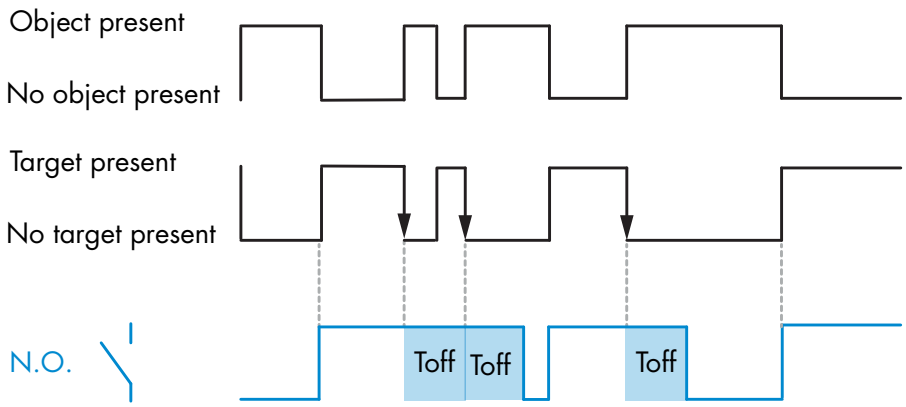
ON-delay means that the activation of the relay is delayed after the object leaves the light beam, as shown in the figure below:



Example with normally open output

4.1.3.2. OFF-delay

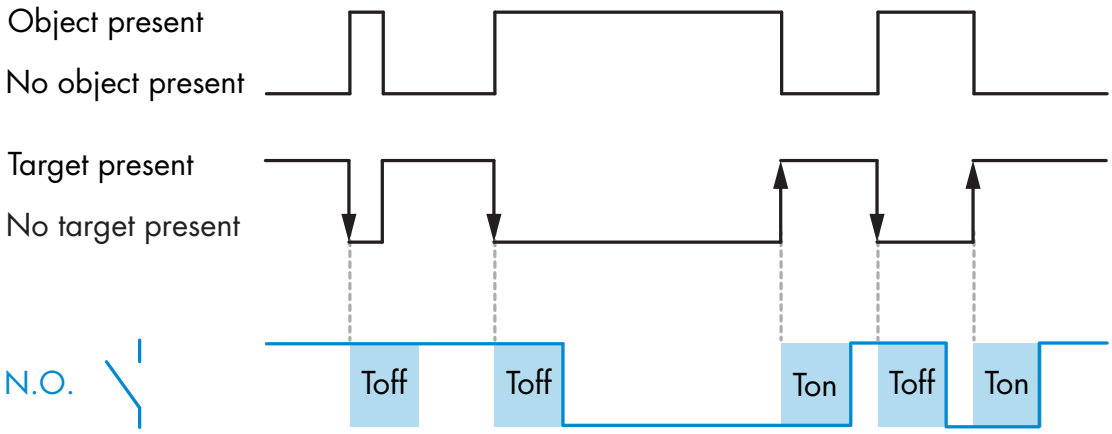
The deactivation of the relay is delayed by the specified amount of time after the object has moved into the light beam as shown in the figure below. This means that the relay only deactivates if the object remains within the light beam longer than the off delay.



Example with normally open output

4.1.3.3. ON and Off delay

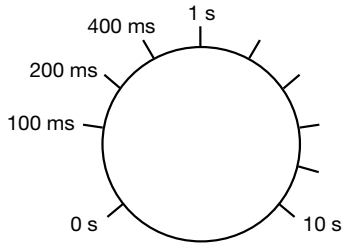
When selected, both the Ton and the Toff delays are applied to the relay switching.



Example with normally open output

4.1.3.4. Time delay scale

The time delay trimmers may be set from 0 to 10 seconds.
For maximum versatility, the delay trimmer scale has short time intervals for the first half turn, and larger time intervals for the second half. The scale is the same for both trimmers. The time delays are as follows:



4.2. Connecting several PAM03 modules

When several PAM03 are connected via the communication port on the side of the module, an automatic process of connection and role assignment takes place. The first of the modules automatically takes on the role of master, while the following modules are set up as slaves.

Only the master module needs to be connected to the power supply, it supplies the rest of the connected modules. This sharing of the power supply is an additional safety feature, ensuring that any loss of communication between modules is handled immediately, as the following modules will also lose their power supply.

The master module controls the pulse order of all multiplexed sensors of all connected modules.

4.2.1 Multiplexing

Multiplexing means, that the master module controls when each emitter is active, and does not allow the next emitter in the application to pulse until the corresponding receiver has received a signal. This means that no two sensors pulse at the same time, eliminating the risk of cross talk between sensors.

However, the more sensors in the application, the longer it takes for them to pulse one after another.

5. Inputs

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Besides the parameters directly related to output configuration, the sensor also has various internal parameters useful for setup and diagnostics.

5.1. Inputs from 3 sensor sets

The PAM03 module works with the MOFT.../MOFR... sensor sets, that consist of one emitter and one receiver. Each transmitter and receiver has two wires: Signal and ground. The wires of one emitter and receiver set are connected to a spring terminal block and clicked into place in the appropriate port in the amplifier module. One PAM03 module can handle 3 sensor sets. Please refer to section 8 for connection and wiring diagrams.

The connected sensor sets are multiplexed, meaning the master module controls when which emitter is active, and does not allow the next sensor in the application to activate until the signal is received. This prevents crosstalk among all the connected sensor sets.

5.1.1. Sensing range

Depending on which sensor set is connected to the PAM03 module, the maximum sensing range will be:

- MOFT20 - 20 m
- MOFT50 - 50 m

However, this sensing range is dependent on the environment, and will be shorter in a very dusty and dirty environment, as a certain amount of dust reserve is needed to overcome the signal loss caused by flying dirt, dust or moisture.

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6. Functions

6.1 Functions

Besides the trimmers for sensitivity adjustment and time delays, the PAM03 module has 4 dip switches controlling other useful features. The settings of the dip switches is common to all sensor sets connected to the PAM module.

6.1.1. Automatic sensitivity adjustment

If the channel trimmers are turned all the way counterclockwise to the A setting, then the channel is set to automatic sensitivity adjustment.

Automatic sensitivity adjustment means that the PAM03 modules constantly monitors the signal strength of the channel and increases the signal strength as needed. If the signal reaches maximum, the tri-color LED will be constantly red, and the warning relay will be triggered, if it is connected.

NB: The automatic sensitivity adjustment adjusts according to the selected Excess gain settings.

6.1.2. Alignment mode settings

The dip switch has two settings: OFF or Align. The standard working setting is OFF.
When installing or maintaining the application move the dip switch to the Alignment setting. In this mode the tri-color LED will start flashing yellow. The faster the flashes, the stronger the signal.
The setting is common to all 3 sensor sets connected to the module.

When the signal reaches maximum, the tri-color LED will be steady on.

For the best alignment result:
1. Turn the trimmer to maximum signal strength, and align the sensor physically until the tri-color LED shows yellow light, steady on.
2. Turn the trimmer slightly back until the tri-color LED starts flashing and the relay is still active.
3. Re-adjust the sensor physically until the tri-color LED starts flashing fast or is steady on.
4. Turn the trimmer further back until the tri-color LED flashes again and the relay is still active.
5. Repeat the process until the sensor alignment can no longer be improved.
6. Return the dip switch to the Off position

6.1.3. Excess gain settings (dust reserve)

The excess gain dipswitch controls how much extra signal strenght should be available over the level necessary to activate the output relay. The excess gain is necessary to compensate for signal loss due to low visibility or dirt build up on the sensor sets.
The setting is common to all 3 sensor sets connected to the module.

The excess gain dip switch has two settings: Low and High. The factory setting is High.
- High: Use this setting when operating in environments with high amounts of airborne pollution.
- Low: This setting is used when detecting semitransparent objects like windscreens in car washes.

If the trimmer controls the sensitivity of the channel, then the excess gain setting will affect when the tri-color LED starts flashing yellow to warn of a weak signal. The high excess gain setting will activate the warning flashes later than the low setting.

If the tri-color LED starts flashing yellow, either clean the sensor environment or increase the signal strength.

If the channel sensitivity is adjusted automatically, the excess gain setting will not have an immediately visible impact on in the tri-color LED. It will be steady green to show the auto adjustment is on and working. The excess gain is recalibrated automatically. If the maximum signal strenght is reached, meaning that the system can adjust automatically no longer but still has a weak signal, then the tri-color LED will change to red, and the warning relay will open and drop its current, if it is connected.

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6.1.4. Sensing range settings

The sensing range setting affects the maximum setting of the sensing range trimmer of the signal channels. It is common to all 3 channels.

The sensing range dip switch has two settings:
- 50% of the maximum sensing range
- 100 % of the maximum sensing range

If the dip switch is set to 50%, the strength of the emitted light is lowered, and so the sensing range is half the maximum sensing range. This also means that at the 50% setting, the trimmer maximum is half the signal strength of the 100% setting. The lower setting is applicable when detecting semi-transparent materials, or to avoid saturation if the application requires a short distance between receiver and transmitter.
The factory setting is 100%.

6.1.5. Warning relay settings

The warning relay is part of the safety function of the PAM module.
The warning relay is active and carries a current when all sensors are connected and function as expected, and no other errors are found. This means that the N.O. relay will release and stop carrying a current under the following circumstances:
- Communication error between connected PAM modules
- Short circuit in either transmitter or receiver
- Broken wire in either transmitter or receiver
- If maximum sensitivity adjustment is reached, and the signal still is weak for 5 seconds or longer.

The warning relay dip switch sets the warning relay to either common for all connected PAM03 modules, or ! for the stand alone setting. If several modules are connected, only one of them needs to be in the 'Common' setting, the rest may remain in the '!' setting. Only the one module with the 'Common' setting needs to have its warning relay connected. It does not matter which of the connected modules handles the warning relay.
The factory setting is '!'.

When several PAM03 modules are connected, then the common warning relay is recommended. All warnings from all modules are routed to the one module that is set to 'Common'.

Please refer to sections 7.2. and 8 for test procedures and suggested settings.

7. Installation and test procedure for automated industrial doors

7.1 Installation procedure

During installation the PLC or door control system must be disconnected from the main power supply.

1. Make sure the power supply to the PAM03 modules is within the specifications
2. According to the connection diagram in section 10, connect sensor set 1 ... 3 to each of the 4-wire spring terminal blocks, and click them into place in the corresponding input ports
3. Connect the output relay wires to the 3-wire spring terminal blocks, and click them into place
4. If used, connect the wires of the warning relay to the 3-wire spring terminal block, and click it into place. If several modules are connected, connect to the module whose warning relay dip switch is set to 'Common'
5. Connect the needed number of PAM modules via the communication port on the side of the module
6. Mount the modules on the DIN rail
7. Connect the power supply wires to the 2-wire spring terminal block and click it into place
8. Connect power supply and align the sensors' direction and sensitivity to obtain optimal signal between each transmitter and receiver as described in section 6.1.2
9. If needed: Connect test input wires to 2-wire spring terminal block and click it into place. Do so for each PAM03 module
10. Connect relays to PLC or door controller
11. Do a physical test with a hand or an object to make sure the relays turn off when an object interrupts the light beam
12. Run a safety test as described in section 7.2

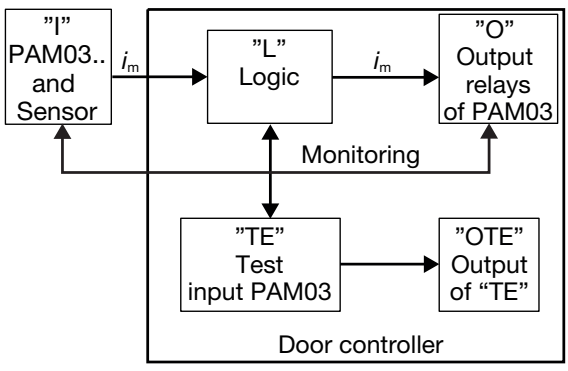
7.2 Testing

Testing is a verification check of the photoelectric sensors and amplifier module performed by the door controller. To verify that cables, response times, relay outputs and sensors are working correctly, we recommend testing the sensor before the gate or door opens or closes by using the PAM03 test function. After the initial approval of the installation, the door controller should run automatic tests of the door function.

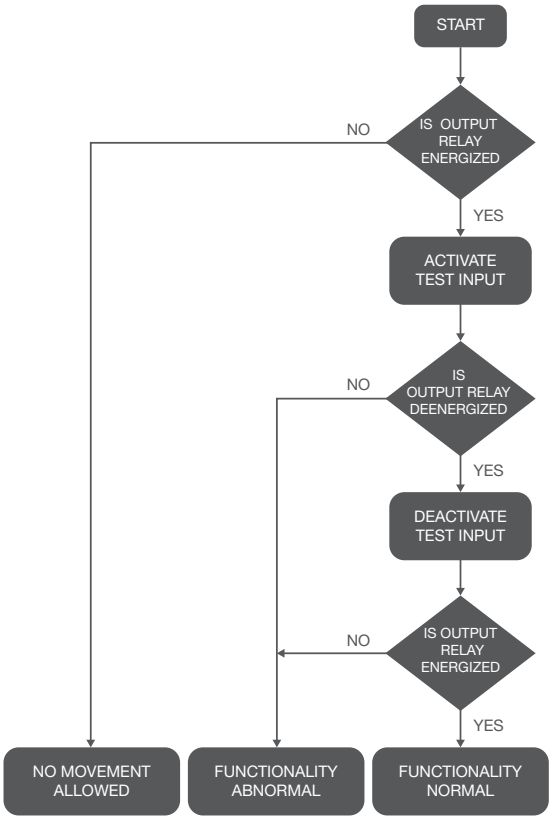
Please be aware, that the test must be run on each PAM03 module separately.

1. Make sure the sensors and modules are installed and connected according to the instructions in this manual, and correctly connected to the PLC/door controller. The test input of each PAM03 module should be connected to the door controller. The door controller initiates and controls the tests
2. The starting point is the state where no object blocks the light beam between transmitter and receiver. The output relay carries a current, so the status is OK
3. The door controller sends a test signal to the PAM03 module
4. The test signal deactivates the emitters, simulating an object blocking the light beam. The relays must drop
5. After a short while, the door controller allows the PAM03 module to return to normal function, meaning the emitter is reactivated allowing the relay to connect and carry a current again

The purpose of this procedure is to test that receiver, detection circuitry and the relays of the specific module are able to deactivate and re-activate, simulating the presence and absence of an object blocking the light beam. Any errors will be revealed by the test.



Functional verification procedure for the test input safety-related part of a control system (SRP/CS)

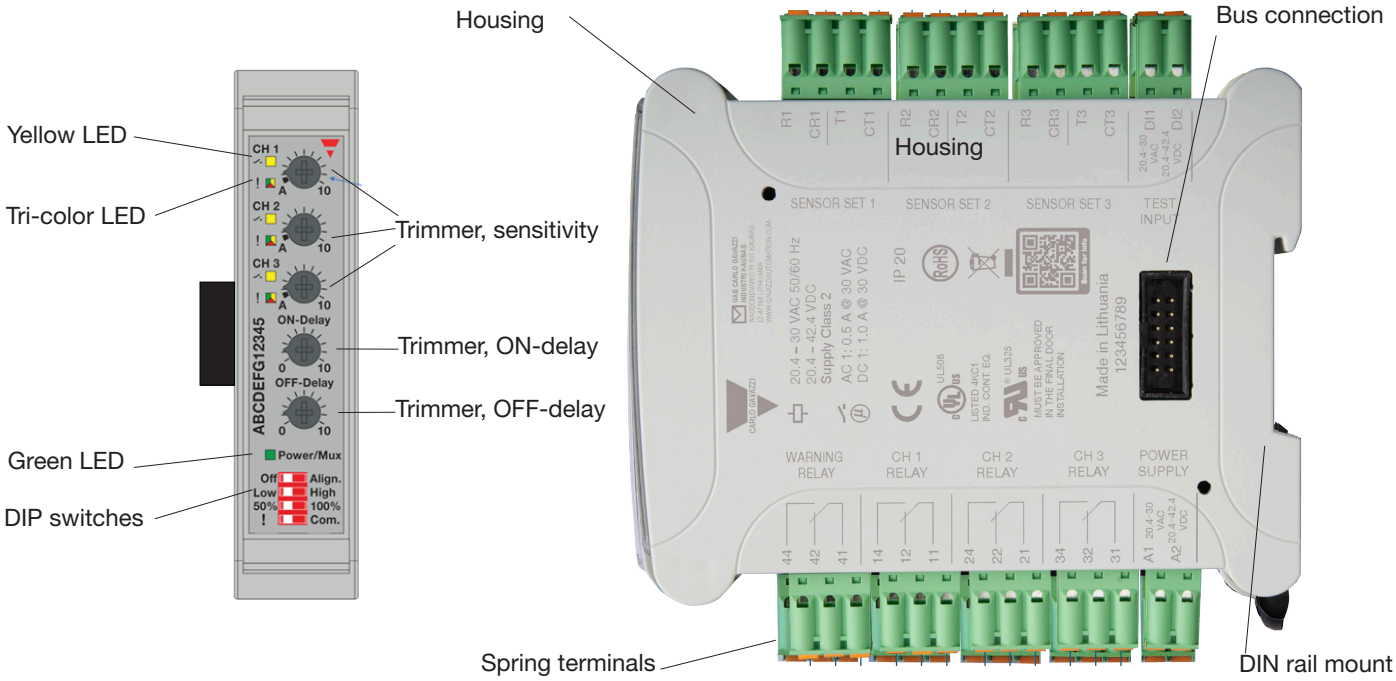


8. Recommended door settings

For use in a door application, best practice is to use these settings for the PAM03 module and MOFx sensors unless otherwise indicated by the specific circumstances of the installation:

- Sensitivity adjustment trimmers: Automatic
- ON-Delay trimmer: 0
- OFF-Delay trimmer: approximately 100 ms if the input reaction time of the PLC/door controller is slow
- Alignment mode: OFF
- Dust reserve setting: High
- Power setting: 100% unless the door is narrow (single person sized door)
- Warning relay settings: Connected PAM03 modules, set one of them to 'Common', the rest to '!' and connect the 'Common' one to PLC/door controller
- Connect the test input for all connected PAM03 modules

9. Structure



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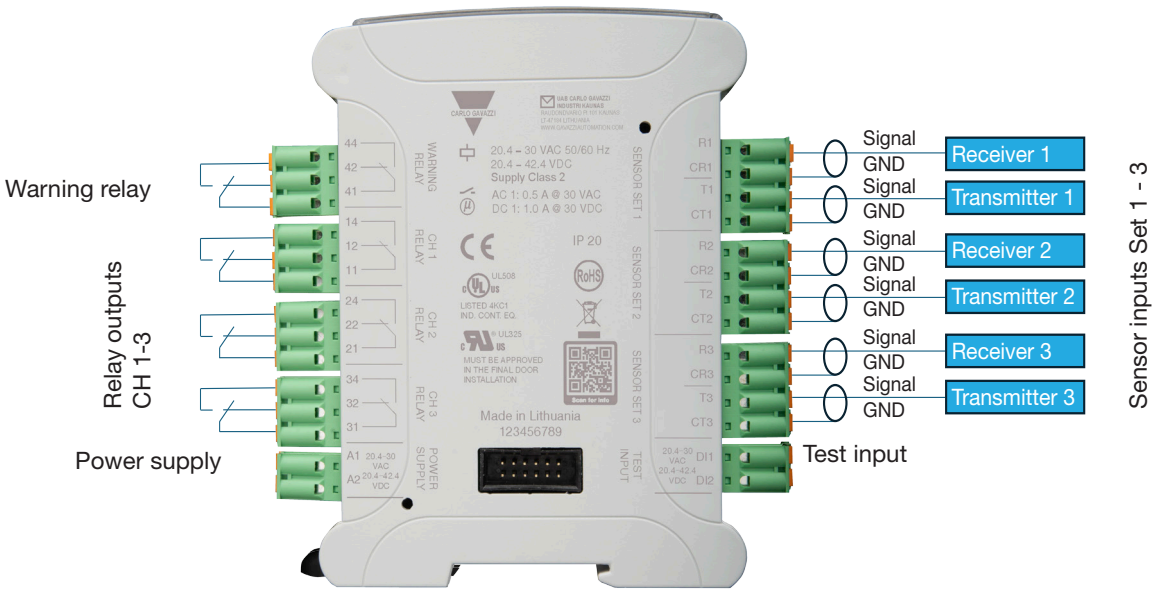
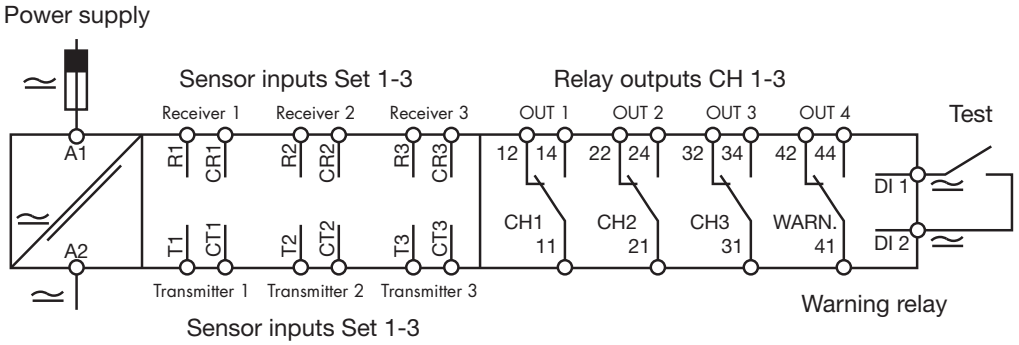
10. Connection and wiring diagrams

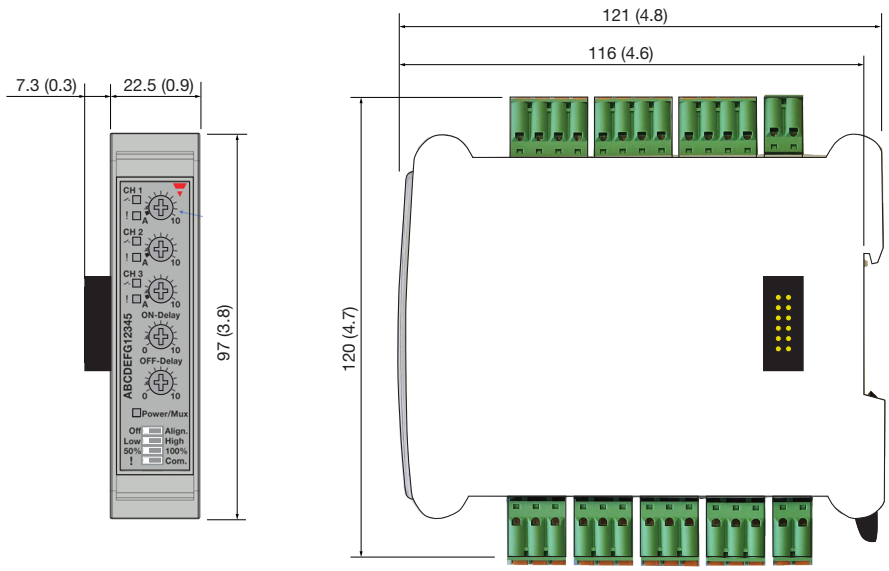




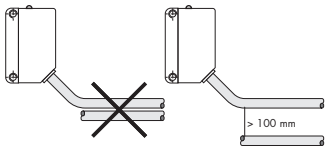
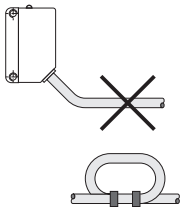
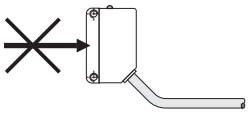
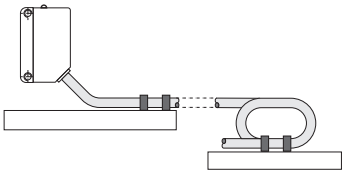
11. Commissioning

< 300 ms after the power supply is switched on, the module will be operational.

Dimensions



Installation Hints

			
To avoid interference from inductive voltage/ current peaks, separate the prox. switch power cables from any other power cables, e.g. motor, contactor or solenoid cables	*Relief of cable strain* The cable should not be pulled	*Protection of the sensing face* A proximity switch should not serve as mechanical stop	*Switch mounted on mobile carrier* Any repetitive flexing of the cable should be avoided

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Certified in accordance with ISO 9001

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