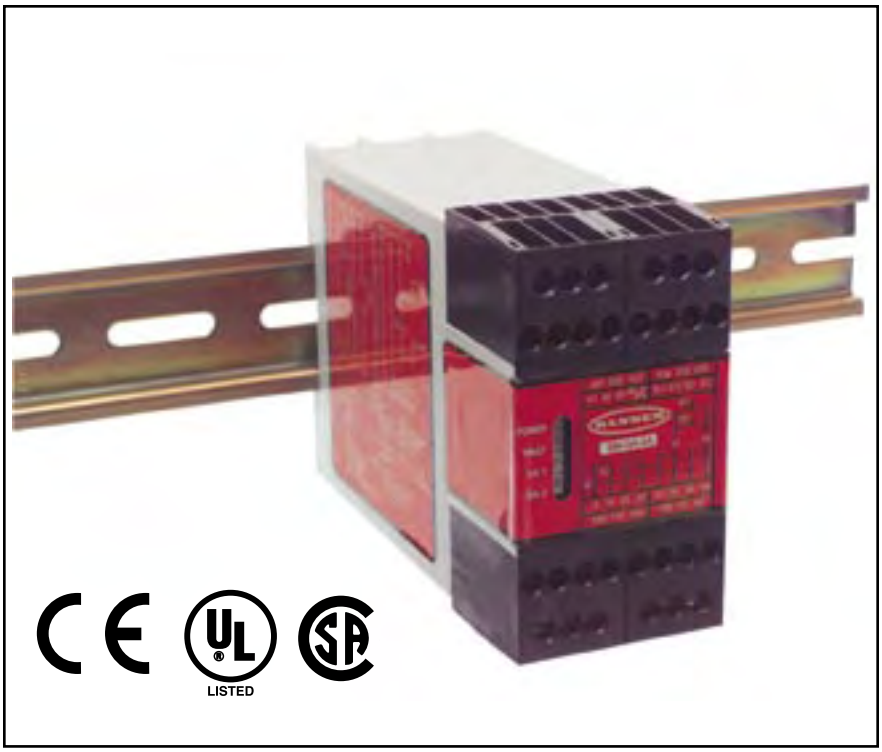
BANNER®
the machine safety specialist

# Safety Mat Monitor Module

*Models SM-GA-5A (24V dc/115V ac) and SM-HA-5A (24V dc/230V ac)*




## Features

- Monitors one (or multiple in series) 4-wire safety mat
- Selectable Auto-Reset or Monitored Manual Reset
- Input monitoring circuit incorporates diverse-redundant microprocessors
- Plug-in terminal blocks
- Four redundant, forced-guided (positive-guided) output contacts rated at 6A
- One normally closed output for status monitoring
- Two auxiliary solid-state outputs indicate state of internal relays K1 and K2, and state of internal power supply.
- DIN-rail-mountable 45 mm-wide housing
- External device monitoring (one-channel EDM)
- Design complies with UL 991, ISO 13856-1, EN 954-1 (Category 4)

# Safety Mat Monitor Module — Models SM-GA-5A and SM-HA-5A

## Important … read this page before proceeding!

Banner Engineering Corp. has made every effort to provide complete application, installation, operation, and maintenance instructions. In addition, any questions regarding the use or installation of this Banner Safety Mat Monitor Module should be directed to the factory applications department at the telephone numbers or address shown on back cover.

The user shall ensure that all machine operators, maintenance personnel, electricians, and supervisors are thoroughly familiar with and understand all instructions regarding the installation, maintenance, and use of this Safety Mat Monitor Module, and with the machinery it controls.

The user and any personnel involved with the installation and use of this model Safety Mat Monitor Module must be thoroughly familiar with all applicable standards. The standards, some of which are listed below, directly address the use of safety mat systems. Banner Engineering Corp. makes no claim regarding a specific recommendation of any organization, the accuracy or effectiveness of any information provided, or the appropriateness of the provided information for a specific application.

The user has the responsibility to ensure that all local, state, and national laws, rules, codes, and regulations relating to the use of this Safety Mat Monitor Module in any particular application are satisfied. Extreme care is urged that all legal requirements have been met and that all installation and maintenance instructions contained in this manual are followed.

**U. S. Standards Applicable to Use of Safety Mats and Controllers**

ANSI B11 — Standards for Machine Tools "Safety Requirements for the Construction, Care and Use"
Available from: Safety Director
AMT – The Association for Manufacturing Technology
7901 Westpark Drive
McLean, VA 22102
Tel.: 703-893-2900

NFPA 79 — "Electrical Standard for Industrial Machinery"
Available from: National Fire Protection Association
1 Batterymarch Park, P.O. Box 9101
Quincy, MA 02269-9101
Tel.: 800-344-3555

ANSI/RIA R15.06 — "Safety Requirements for Industrial Robots and Robot Systems"
Available from: Robotic Industries Association
900 Victors Way, P.O. Box 3724
Ann Arbor, MI 48106
Tel.: 734-994-6088

**International Standards Applicable to Use of Safety Mats and Controllers**

ISO 12100-1 (EN 292-1) — "Safety of Machinery – Basic Concepts, General Principles for Design
Part 1: Basic Terminology, Methodology"

ISO 12100-2 (EN 292-2) — "Safety of Machinery – Basic Concepts, General Principles for Design
Part 2: Technical Principals and Specifications"

IEC/EN 60204-1 — "Electrical Equipment of Machines: Part 1: General Requirements"
Also, request a type "C" standard for your specific machinery.

EN 954-1 — "Safety of Machinery – Related Parts of Control Systems: Part 1 General Principles for Design

ISO 13856-1 (EN 1760-1) — "Safety of Machinery – Pressure-Sensitive Protective Devices: General Principles for Design and Testing

Available from: Global Engineering Documents
15 Inverness Way East
Englewood, CO 80112-5704
Tel.: 800-854-7179

## Overview

The purpose of Safety Mat Monitor Modules SM-GA-5A and SM-HA-5A is to verify the proper operation of 4-wire presence-sensing switching mats (sensors). Multiple mats may be switched in series to one Module (see Figure 3, page 9). The Module provides the redundant safety outputs required for creating a control-reliable safety circuit.

Two functions of the Safety Module are:

- To monitor the contacts (contact plates) and the wiring of one or more safety mat(s) for failures and prevent the machine from restarting if any mat or the Module fails, and
- To provide a reset routine after the operator steps off of the safety mat. This prevents the controlled machinery from restarting automatically after the mat is cleared. This necessary reset/restart function is required by ANSI B11 and NFPA 79 machine safety standards. If the Module is used in auto-reset mode, the reset/restart function must be provided by the machine control system.

**NOTE: The Module is not designed to monitor 2-wire mats, bumpers, or edges (with or without sensing resistors).**

In operation, the internal power supply from the Module is provided to the switching elements in the sensor(s), +V to one conductor, -V to the other conductor, and back to the Module where it supplies power to the Module's output relays. The output relays are energized when all the sensors in the system are clear. When one or more sensor(s) is actuated, the power supply to the output relays is shorted, causing the outputs to de-energize. They also de-energize if the power supply to the output relays is interrupted, opened, or shorted by a fault in the sensor wiring or in the switch element.

The output relays will energize automatically if the Module is wired for Auto Reset mode (see Figure 3) and all sensors are clear and all faults are removed or corrected and power is applied. The Module will require a manual reset if wired for Manual Reset mode.

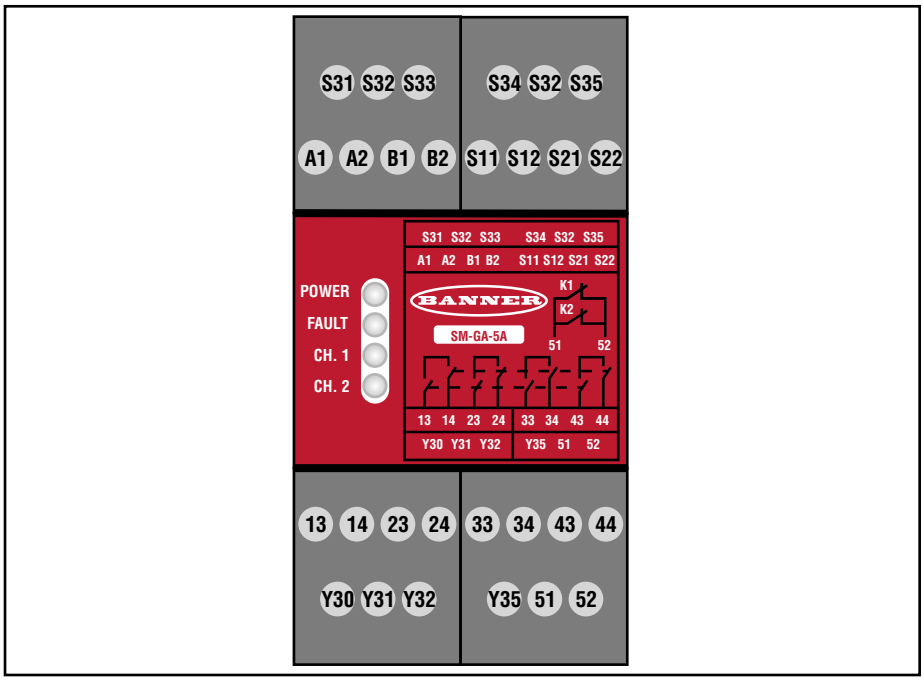



**Figure 1. SM-GA-5A and SM-HA-5A features and terminal locations**

### WARNING . . .
**Application of Safety Mats**

Requirements vary widely for the level of control reliability or safety category (per EN 954-1) in the application of safety mats. While Banner Engineering always recommends the highest level of safety in any application, **it is the responsibility of the user to safely install, operate, and maintain each safety system per the manufacturer's recommendations and comply with all relevant laws and regulations.**

Do not use safety mats or the SM-..A-**5A Monitoring Module as a tripping device to initiate machine motion** (such as in a presence-sensing device initiation application), due to the possibility of unexpected start or re-start of the machine cycle resulting from failure(s) within the mat and the interconnect cabling.

**Do not use a safety mat or the SM-..A-5A Monitoring Module to enable or provide the means to allow the machine control to start hazardous motion by simply standing on the safety mat** (e.g., at a control station). This type of application uses reverse/negative logic and certain failures (e.g., loss of power to the Module) can result in a "false" enable signal.

**Categories for Safety-Related Parts of Control Systems**
Pressure-sensitive mats and pressure-sensitive floors must meet the requirements of the category for which they are specified and marked. These categories are defined in EN 954-1.

The safety mat, its Safety Module and any output signal switching devices must meet the requirements of Safety Category 1 as a minimum. To meet these requirements, the system must at minimum meet the requirements of ISO 13856-1 (EN 1760-1) and the relevant requirements of EN 954-1.

The SM-GA-5A and SM-HA-5A Modules are designed to monitor 4-wire safety mats; it is not recommended to use two-wire devices (mats, sensing edges, etc., with two wires and a "sensing" resistor). While the Module internally meets or exceeds EN 954-1 Category 4 requirements, **the overall safety circuit performance is determined by the mat(s) or other sensor(s) connected to the Module.**

## Safety Mat Requirements

The following are minimum requirements for the design, construction, and installation of four-wire safety mat sensor(s) to be interfaced with the SM-..A-5A Module. These requirements are a summary of standards ISO 13856-1, ANSI/RIA R15.06 and ANSI/B11.19. The user must review all relevant applicable regulations and standards and apply the Module and any sensors in full compliance.

**Design and Construction**
The safety mat system [sensor(s), safety module, and any additional devices] must have a response time that is fast enough to reduce the possibility of an individual stepping lightly and quickly over the mat's sensing surface (less than 100 to 200 ms, depending on the relevant standard).

For a safety mat system, the minimum object sensitivity of the sensor must detect, at a minimum, a 30 kg (66 lb.) weight on an 80 mm (3.125") diameter circular disk test piece, anywhere on the mat's sensing surface, including joints and junctions. The effective sensing surface or area must be identifiable and can comprise one or more sensors. The safety mat supplier should state this minimum weight and diameter as the minimum object sensitivity of the sensor.

User adjustments to actuating force and response time are not allowed (ISO 13856-1). The sensor should be manufactured to prevent any reasonably foreseeable failures (e.g., oxidation of the contact elements) which could cause a loss in sensitivity.

The environmental rating of the sensor must meet a minimum of IP54. When the sensor is specified for immersion in water, the sensor's minimum enclosure level must be IP67. Special attention may be required to the interconnect cabling. A wicking action may result in the ingress of liquid into the mat, possibly causing loss of sensor sensitivity. The termination of the interconnect cabling may need to be located in an enclosure that has an appropriate environmental rating.

The sensor must not be adversely affected by the environmental conditions for which the system is intended. The effects on the sensor of liquids and other substances which can be expected must be taken into account. For example, long-term exposure to some liquids can cause degradation or swelling of the sensor's housing material, resulting in an unsafe condition.

The sensor's top surface should be a lifetime non-slip design, or otherwise minimize the possibility of slipping under the expected operating conditions.

The four-wire connection between the interconnect cables and the sensor must withstand dragging or carrying the sensor by its cable without failing in an unsafe manner (e.g., broken connections due to sharp pulls, steady pulls, or continuous flexing). If not, an alternate means must be employed to avoid such a failure, for example, a cable which disconnects without damage and results in a safe situation.

**Installation**

The mounting surface quality and preparation for the sensor must meet the requirements stated by the sensor's manufacturer. Irregularities in the floor (or other mounting surfaces) may impair the function of the sensor and therefore should be reduced to an acceptable minimum.

The mounting surface should be level and clean. The collection of fluids under or around the sensor should be avoided. The risk of failure due to build-up of dirt, turning-chips, or other material under the sensor(s) or the associated hardware must be prevented. Special consideration should be given to joints between sensors to ensure that foreign material does not migrate under or into the sensor.

Any damage (e.g., cuts, tears, wear, or punctures) to the outer insulating jacket of the interconnect cable (in the presence of fluids) or to any part of the exterior of the sensor must be immediately repaired or replaced. Ingress of material (including dirt particles, insects, fluid, moisture, or turning-chips) which may be present near the mat can cause the sensor to corrode or to lose its sensitivity.

The sensor(s) must be routinely inspected and tested per the manufacturer's recommendations. Care must be taken not to exceed operational specifications (e.g., the maximum number of switching operations).

The sensor(s) must be securely mounted to prevent inadvertent movement (creeping) or unauthorized removal. Methods include, but are not limited to, secured edging or trim, tamper-resistant or one-way fasteners, and recessed flooring or mounting surface, in addition to the size and weight of large mats.

The sensor(s) must be installed to minimize tripping hazards (particularly towards the hazard). A tripping hazard may exist when the difference in height of an adjacent horizontal surface is 4 mm (1/8") or more. Tripping hazards must be minimized at joints, junctions, edges, and when additional coverings are used. Methods include a ground-flush installation of the sensor, or a ramp that does not exceed 20° from horizontal. Use contrasting colors or markings to identify ramps and edges.

The safety mat system must be sized and positioned so that persons cannot enter the hazardous area without being detected, and can not reach the hazard before the hazardous conditions have ceased. Additional guards or safeguarding devices may be required to ensure that exposure to the hazard(s) is not possible by reaching over, under or around the device's sensing surface.

A safety mat installation must take into account the possibility of easily stepping over the sensing surface and not being detected. ANSI and international standards require a minimum depth of field of the sensor surface (the smallest distance between the edge of the mat and hazard) to be between 750 mm to 1200 mm (30" to 48"), depending on the application and the relevant standard. The possibility of stepping on machine supports or other physical objects to bypass or climb over the sensor also must be prevented.

### Separation Distance

As a stand-alone safeguard, the sensor must be installed at a separation distance (safety distance) such that the exterior edge of the sensing surface is at or beyond the safety distance, unless used solely used to prevent start/restart or solely used for clearance safeguarding (see ANSI/RIA R15.06).

The separation distance required for an application depends upon several factors, including the speed of the hand (or individual), the total system stopping time (which includes several response time components), and the depth penetration factor. The user must refer to the relevant standard to determine the appropriate distance or means to ensure that individuals can not be exposed to the hazard(s).

One formula used to calculate separation distance (**Ds**) is:

$$Ds = K \times (Ts + Tr) + Dpf$$

where:

**K** = the OSHA-recommended hand speed constant of 63" per second (NOTE below);

**Ts** = the overall stop time of the machine, measured from the application of the "stop" signal to the final ceasing of all motion (including stop times of all relevant control elements, and measured at maximum machine velocity).

**Tr** = the response time of the safety mat system: Module response time plus the response time of the sensor(s), as stated by the manufacturer.

**Dpf** = the added distance due to depth penetration factor: 1.2 m (48")

NOTE: The OSHA-recommended hand-speed constant (K) has been determined by various studies, and although these studies indicate speeds of 63"/second to more than 100"/second, they are not conclusive determinations. The employer should consider all factors, including the physical ability of the operator, when determining the value of K to be used.

If an individual can cross completely over the sensor and be no longer detected, supplemental safeguarding or other means should be used to prevent unexpected startup and exposure to a hazard. At a minimum, the safety mat system (or the machine control) must be manually reset and require re-initiation of the normal actuating means prior to the start or re-start of the machine cycle.

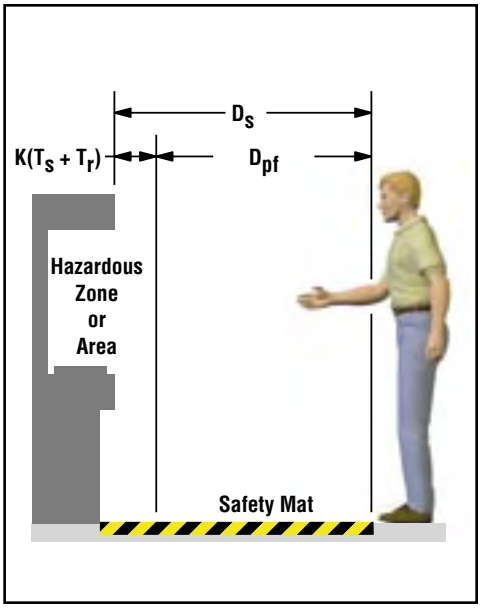



**Figure 2. Determining safety distance (Ds) for the safety mat**

## Safety Module Mechanical Installation

Route the mat cables to the Safety Module location. The Module must be installed inside an enclosure; it is not designed for exposed wiring. It is the user's responsibility to house the Module in an enclosure with a NEMA (or IEC) rating suitable for the operating environment. The Module may be mounted directly onto standard 35 mm DIN rail.

For reliable operation, the user must ensure that the operating specifications are not exceeded. The enclosure must provide adequate heat dissipation, so that the air closely surrounding the Module does not exceed its maximum operating temperature. Methods to reduce heat build-up include venting, forced air flow (e.g., exhaust fans), adequate enclosure exterior surface area, and spacing between Modules and other sources of heat. (See Safety Module Specifications, Operating Conditions: Temperature.)

**Caution . . .**

**Shock Hazard**

**Always disconnect power from the Safety Module and all power from the machine being controlled before making any wire connections.**

Electrical installation and wiring must be made by qualified personnel and must comply with the NEC (National Electrical Code), ISO/EN 60204-1 and -2, and all applicable local standards and codes.

**WARNING . . .**

**Resistance Values**

**Exceeding the maximum resistance between the monitoring channels (shorted) can result in the increase of response time or complete loss of the sensing function of the safety mat.**

Exceeding the maximum resistance within a contact monitoring channel will result in the Module issuing a stop command (opening the safety outputs).

**WARNING . . .**

**Multiple Safety Mats**

Whenever two or more safety mats are connected to the same Safety Mat Monitor Module, the corresponding contact plates of all mats must be connected together in series. This series combination is then wired to the respective Safety Mat Monitor Module input. **Never connect the contact plates of multiple safety mats in parallel to the Safety Mat Monitor Module inputs; this defeats the switch contact monitoring ability of the Safety Module, and creates an unsafe condition which could result in serious injury or death (e.g., a broken wire may not be detected).**

## Electrical Installation

The Safety Module is powered by either 24V dc/115V ac (model SM-GA-5A), or 24V dc/230V ac (model SM-HA-5A) at 7VA/4W. The sensor circuit, which monitors the contact plates of the safety mat, consists of two channels (A and B) that issue a stop command (i.e., open the safety outputs) when an individual steps onto the safety mat, shorting the two channels together.

Since the Safety Module functions by detecting the short circuit between the channels, resistance to electrical current flow in the contact monitoring circuit impacts the operation and the safety of the system. Total resistance includes contact resistance of the internal mat contacts, the number of mats in the circuit, and the wire resistance of the interconnect cables and connections.

The only limitation on the number of mats that can be connected in series is the amount of resistance. The total resistance within each channel can not exceed 34 ohms when the Module is supplied by an ac power supply, and no more than 54 ohms when the Module is supplied by a dc power supply.

The resistance between the channels when shorted together (i.e., when an individual steps on the mat) can not exceed 20 ohms under any circumstances (see warning at left).

To verify the installation does not exceed the maximum resistance specification, check with an ohmmeter that none of the following values are exceeded (before connection to the Module):

1. Test the total channel resistance for each channel (including all mats and interconnect wiring).

   - Connect the ohmmeter to the wires to be connected to S11 and S12 (Channel A), and note the resistance.

   - Connect the ohmmeter to the wires to be connected to S21 and S22 (Channel B), and note the resistance.

   None of the resistance values above may exceed 10 ohms (ac power supply) or 28 ohms (dc power supply).

2. Verify that the total resistance between the channels is less than 10 ohms.

   - Connect the ohmmeter to the wires to be connected to S11 and S21, actuate the sensor(s) in several locations (per manufacturer recommendation for testing the sensing capability) and note the resistance.

   - Connect the ohmmeter to the wires to be connected to S11 and S22, actuate the sensor(s) in several locations as described above and note the resistance.

   - Connect the ohmmeter to the wires to be connected to S12 and S21, actuate the sensor(s) in several locations as described above and note the resistance.

   - Connect the ohmmeter to the wires to be connected to S12 and S22, actuate the sensor(s) in several locations as described above and note the resistance.

   Typically, internal resistance values for a safety mat should be less than 10 ohms (20 ohms maximum). If greater, the mat may be damaged or suffer corrosion that could cause the loss of the sensing function. The user must refer to the mat manufacturer specifications or replace the sensor.

### External Device Monitoring

To satisfy the requirements of Safety Category 4 of EN 954-1, the master stop control elements must each offer a normally closed, forced-guided monitor contact. One normally closed monitor contact from each master stop control element is wired in series to the S31-S32 feedback input (see Figure 3). In operation, if one of the switching contacts of either master stop control element fails in the shorted condition, the associated monitor contact will remain open. Therefore, it will not be possible to reset the Safety Module. If no MSC-monitor contacts are monitored, a jumper must be installed between terminals S31 and S32 (see Figure 3). **It is the responsibility of the user to ensure that any single failure will not result in a hazardous condition and will prevent a successive machine cycle.**

### Connection to the Guarded Machine

The hookup diagrams (Figure 3) show a generic connection of the Safety Module's four redundant output circuits to master stop control elements MSC1 through MSC4. A master stop control element is defined as an electrically powered device, external to the Module, which stops the machinery being controlled by immediately removing electrical power to the machine and (when necessary) by applying braking to dangerous motion. This stopping action is accomplished by removing power to the actuator coil of either master stop control element.

### Connection of Reset Switch

The Reset switch can be any mechanical switch, such as a normally open momentary switch, or a two-position key switch. The Reset switch must be capable of reliably switching 12-30V dc at 5-50 mA. As shown in Figure 3, the Reset switch connects between terminals S33-S34 of the Safety Module. In addition, connect a jumper wire between terminals S32-S33. See Warning at right.

To perform a manual reset, close the normally open switch for at least 1/4 second, but no longer than 2 seconds, and then reopen the switch.

### Connection to Aux. Monitor Contact/Solid-State Monitor Outputs

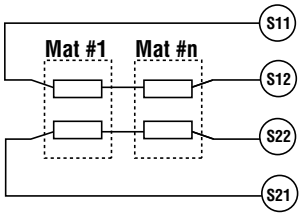
Auxiliary contact 51-52 contains two N.C. contacts from the positive-guided safety relays, switched in parallel. Contact 51-52 opens when safety contacts 13-14, 23-24, 33-34 and 43-44 close; it closes when the safety contacts open. The contact rating of this auxiliary contact is 250V ac/6A. It must be used only for non-safety-related control functions. A typical use is to communicate the status of the Safety Module output to a programmable logic controller (PLC).

There are two solid-state monitor outputs, each capable of switching up to 100 mA at 24V dc. One monitor output (terminal Y32) follows the action of the output circuits (K1 and K2); the other (terminal Y35) opens (low signal) when an internal power supply fault occurs. See Figure 3 for hookup information. External 24V dc power needs to be supplied to Y31 and Y30 to utilize the two solid-state monitor outputs.

**WARNING . . .**

**Reset Switch Location**

**Any Reset switch(es) used must be accessible only from outside, and in full view of, the hazardous area. Reset switches must also be out of reach from within the safeguarded space, and must be protected against unauthorized or inadvertent operation** (e.g., through the use of rings or guards). If any areas are not visible from the Reset switch(es), additional means of safeguarding must be provided.




**Series Connection of Multiple Safety Mats**
NOTE: The number of mats is limited by the total series resistance per input channel. See "Electrical Installation," and warning, page 7.

## WARNING . . .
### Wiring of Arc Suppressors

**If arc suppressors are used, they MUST be installed as shown** across the actuator coil of the Master Stop Control elements (MSC1 to MSC4). NEVER install suppressors directly **across the output contacts of the Safety Module.** It is possible for suppressors to fail as a short circuit. If installed directly across the output contacts of the Safety Module, a short-circuited suppressor will create an unsafe condition which could result in serious injury or death.

## WARNING . . .
### Interfacing MSCs

**NEVER wire an intermediate device(s) (e.g., PLC, PES, PC), between E-Stop Safety Module outputs and the Master Stop Control Element it switches in such a manner that in the event of a failure there is a loss of the safety stop command, OR in such a manner that the safety function can be suspended, overridden, or defeated, unless accomplished with the same or greater degree of safety.**

Whenever forced-guided, mechanically linked relays are added as intermediate switching devices, a normally closed forced-guided monitor contact from each relay must be added to the series feedback loop between Safety Module terminals S31 and S32.

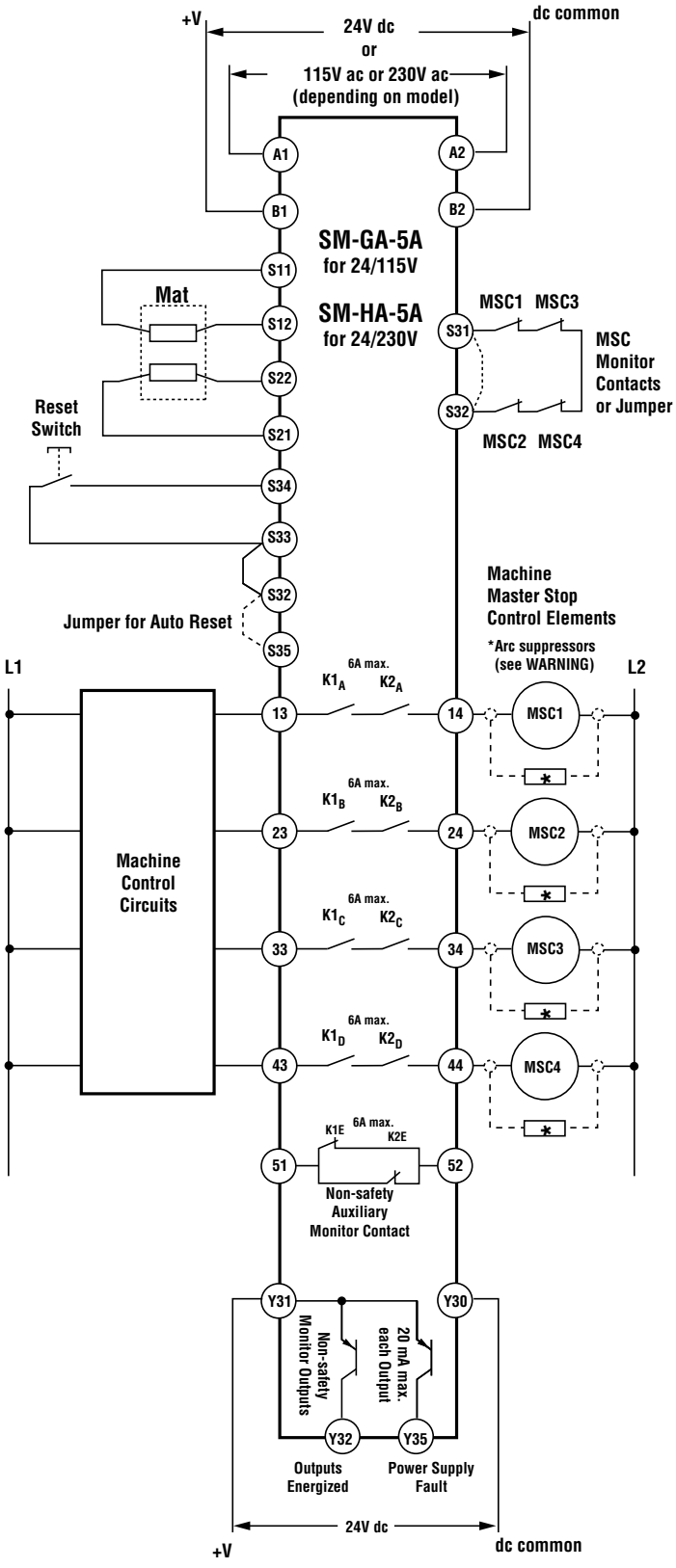



**Figure 3. Typical SM-GA-5A/SM-HA-5A Safety Mat Monitor Module hookup to a 4-wire safety mat**

# Safety Mat Monitor Module — Models SM-GA-5A and SM-HA-5A

## Configuration

**Automatic Reset**
The Module may be configured for Automatic Reset by removing the jumper between S32-S33 and connecting terminals S32 and S35 together (see Figure 3). In this case, no Reset switch is wired to terminals S34 and S33. The Safety Mat Monitor Module will reset (and its outputs energize) 250 ms after the operator steps off the safety mat. The 250 ms ON-Delay, in Automatic Reset mode, is intended to ensure that a reliable stop signal is issued if an individual steps lightly or quickly across the safety mat.

Automatic Reset mode is useful for some automated processes. **However, if Automatic Reset is used, it is necessary to provide a means of preventing resumption of hazardous machine motion, until an alternate reset procedure is performed.** The alternate procedure must include a Reset/Restart switch, located outside the area of dangerous motion, which is positioned so that any area of dangerous motion may be observed by the switch operator during the reset procedure.

NOTE: The minimum amount of time required for the Module to be in a STOP or OFF condition is 20 ms. This "recovery time" (OFF-state) is required for the internal circuitry of the Safety Module to normalize, allowing a reliable reset to occur. A lockout will occur if the Module is cycled too quickly. To clear the lockout, the Module must be re-cycled, meeting the minimum OFF time requirement.

**WARNING . . .**
**Reset Routine Required**

U.S. and international standards require that a reset routine be performed. When automatic reset is used, an alternate means must be established to require a reset routine, after stepping off the mat. **Allowing the machine to restart as soon as the mat is clear creates an unsafe condition which could result in serious injury or death.**

## Initial Checkout

**NOTE: If more than one safety mat is series-connected to one Safety Mat Monitor Module, this checkout procedure must be run individually *for each mat*.**

Procedure:

1. Remove power to the machine control elements.
2. Apply force to the mat's sensing area, using a test piece as outlined in the mat manufacturer's literature, or the appropiate standard.
3. Apply input power to the Safety Mat Monitor Module at terminals A1 and A2 or B1 and B2 (see Figure 3). Verify that only the Power indicator LED is ON (see Figure 1).
4. Remove the test piece from the safety mat (clear the mat sensing area).
5. **If using Manual Reset mode:**
   Close the Reset switch. Verify that the K1 and K2 indicators remain OFF.
   Open the Reset switch. Verify that the K1 and K2 indicators both come ON. If either indicator comes ON before the Reset switch is opened, disconnect the input power and check all wiring. Return to step 2 after correcting the problem.

   **If using Automatic Reset mode:**
   Verify that the K1 and K2 indicators both come ON.
   If both indicators do not come ON, disconnect the input power and check all wiring.
6. Apply force in several locations (using a test piece) to the mat's sensing area, per the mat manufacturer's recommendations. Verify that the K1 and K2 indicators turn OFF simultaneously.

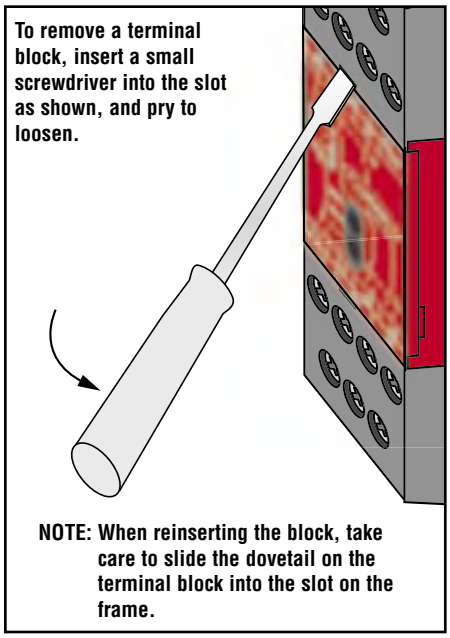
   If either indicator does not go OFF, disconnect the input power and check all wiring. Return to step 2 after correcting the problem.
7. Close and secure the enclosure. Apply power to the machine control elements and perform the following Periodic Checkout Procedure.

**CAUTION . . .**
**Disconnect Power Prior to Checkout**

Before performing the initial checkout **procedure, make certain all power is disconnected from the machine to be controlled.** Dangerous voltages may be present along the Safety Mat Monitor Module wiring barriers whenever power to the machine control elements is ON. **Exercise extreme caution whenever machine control power is or may be present. Always disconnect power to the machine control elements before opening the enclosure housing of the Safety Mat Monitor Module.**

**WARNING . . .**
**Multiple Safety Mats**

**When two or more safety mats are used, each mat must be individually actuated and deactuated, and the Safety Mat Monitor Module reset** (if Manual Reset mode is selected). This allows the monitoring circuits to check each mat and its wiring to detect faults. **Failure to test each mat individually in this manner could result in undetected faults and create an unsafe condition which could result in serious injury or death.**




**NOTE: When reinserting the block, take care to slide the dovetail on the terminal block into the slot on the frame.**

**Figure 4. Removal of terminal blocks**

**WARNING . . .**
**Abuse of Module After Failure**

If an internal fault has occurred and the Module will not reset, **do not tap, strike, or otherwise attempt to correct the fault by a physical impact to the housing.** An internal relay may have failed in such a manner that its replacement is required.

**If the Module is not immediately replaced or repaired, multiple simultaneous failures may accumulate such that the safety function can not be guaranteed.**

## Periodic Checkout Procedure

The functioning of the safety mat monitoring system must be verified periodically to ensure proper operation (see also the machine manufacturer's recommendations).

**NOTE: If more than one safety mat is series-connected to one Safety Mat Monitor Module, this checkout procedure must be run individually for each mat.**

Procedure:

1. With the machine running, apply force to the mat's sensing area, using a test piece as described inthe mat manufacturer's literature, or the appropriate standard. Verify that the machine stops within the expected time period.
2. Remove the test piece from the safety mat. Verify that the machine does not restart.
3. Close and then open the Reset switch (if using Manual Reset mode). Verify that the machine cycle can be restarted by normal initiation.

## Repairs

**NOTE: Do not attempt any repairs to the Safety Mat Control Module. It contains no field-replaceable components. Return the Safety Module to the factory for warranty repair or replacement.**

If it ever becomes necessary to return a Safety Module to the factory, please do the following:

1. Contact the Banner Factory Application Engineering Group at the address or at the numbers listed at the bottom of the back page. They will attempt to troubleshoot the system from your description of the problem. If they conclude that a component is defective, they will issue an RMA (Return Merchandise Authorization) number for your paperwork, and give you the proper shipping address.
2. Pack the Safety Module carefully. Damage which occurs in return shipping is not covered by warranty.

# Safety Mat Monitor Module — Models SM-GA-5A and SM-HA-5A

## Specifications

| | |
|---|---|
| **Supply Voltage and Current** | **SM-GA-5A:** 115V ac (A1-A2), 24V dc, ±15%, 10% max. ripple (B1-B2)<br>**SM-HA-5A:** 230V ac (A1-A2), 24V dc, ±15%, 10% max. ripple (B1-B2)<br>**Power consumption:** approx. 7VA/4 W |
| **Supply Protection Circuitry** | Protected against transient voltages and reverse polarity |
| **Output Configuration** | **Outputs (K1 & K2):** four redundant (total of eight) safety relay (forced-guided) contacts – AgNi, 5 µm gold-plated, plus 1 N/C Auxiliary Monitor output – AgNi, 5 µm gold-plated<br>**Low Current Rating:**<br>**Caution: The 5 µm gold-plated contacts allow the switching of low current/low voltage. In these low-power applications, multiple contacts can also be switched in series (e.g., "dry switching").**<br>To preserve the gold plating on the contacts, the following max. values should not be exceeded at any time:<br>**Min. voltage:** 1V ac/dc — **Max. voltage:** 60V<br>**Min. current:** 5 mA ac/dc — **Max. current:** 300 mA<br>**Min. power:** 5 mW (5 mVA) — **Max. power:** 7 W (7 VA)<br>**High Current Rating:**<br>If higher loads must be switched through one or more of the contacts, the minimum and maximum values of the contact(s) changes to:<br>**Min. voltage:** 15V ac/dc — **Max. voltage:** 250V ac/dc<br>**Min. current:** 250 mA ac/dc — **Max. current:** 6 A<br>**Min. power:** 5 W (5 VA) — **Max. power:** 200 W (1500 VA)<br>**Mechanical life:** 50,000,000 operations<br>**Electrical life:** 150,000 operations (typical, @ 1,500 VA switched power, resistive load)<br>150,000 operations (typical, @ 200 W switched power, resistive load)<br>**NOTE: Transient suppression is recommended when switching inductive loads. Install suppressors across load. Never install suppressors across output contacts (see Warning, page 9).**<br>**Solid-state Monitor Outputs:**<br>Two non-safety solid-state dc outputs<br>Output at Y32 monitors state of outputs – conducts (output high) when both K1 and K2 are energized<br>Output at Y35 conducts (output high) when internal power supply is OK<br>Output circuits require application of 24V dc ± 15% at terminal Y31; dc common at Y30<br>Maximum switching current: 100 mA at 24V dc<br>Both outputs are protected against short circuits |
| **Output Response Time** | 50 milliseconds typical |
| **Input Requirements** | Mat contacts must be capable of switching 12-30V dc @ 200 mA.<br>Resistance on inputs S11-S12 and S21-S22 must not exceed 0 ohms (ac supply) or 28 ohms (dc supply).<br>Resistance between mat layers must not exceed 10 ohms (see page 7).<br>Reset switch must have one normally open contact capable of switching 40 to 10 mA @ 7V dc. |
| **Status Indicators** | **3 green LED indicators:**<br>Power ON<br>K1 energized<br>K2 energized<br>**1 red LED indicator:**<br>Fault (internal power supply, ground fault, or cross-short of input channels) |
| **Housing** | Polycarbonate. Rated NEMA 1 (IEC IP20) |
| **Mounting** | Mounts to standard 35 mm DIN rail track. Safety Module must be installed inside an enclosure rated NEMA 3 (IEC IP54), or better. |
| **Vibration Resistance** | 10 to 55Hz @ 0.35 mm displacement per IEC 68-2-6 |
| **Operating Conditions** | **Operating Temperature:** 0° to +50° C (+32° to 122° F)<br>**Maximum Relative Humidity:** 90% @ +50° C (non-condensing) |
| **Dimensions** | See Figure 5. |
| **Certifications** | CE UL LISTED CSA |

## Dimensions

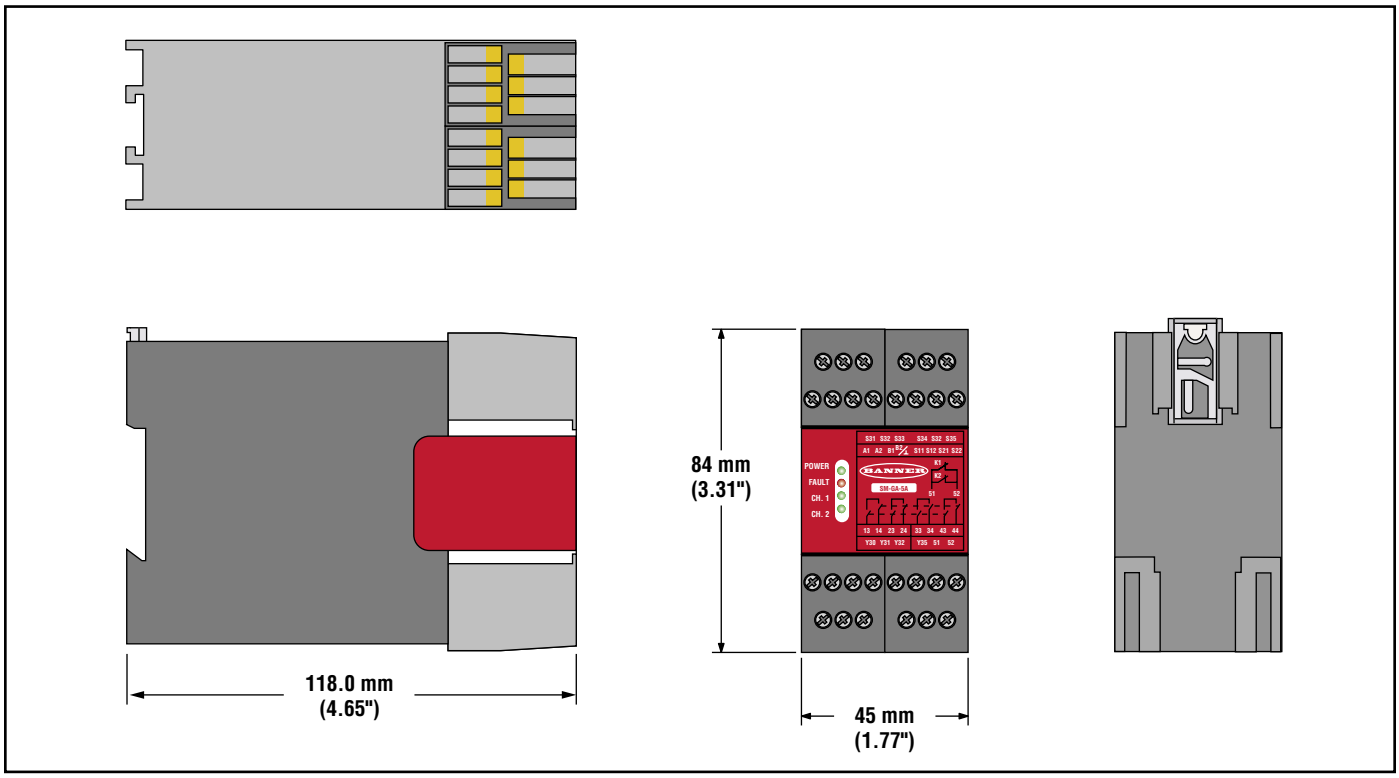



**Figure 5. Safety Mat Monitor Modules SM-GA-5A/SM-HA-5A enclosure dimensions**

## Troubleshooting

| Condition | Indicator Status | Possible Reasons/Solutions |
|---|---|---|
| Will not reset | Power LED ON<br>Fault LED OFF<br>Ch. 1 LED Flashing<br>Ch. 2 LED Flashing | **MSC Monitoring circuit open:**<br>• Check wiring at S31/S32. This must be a closed circuit before Module can be reset.<br>**Reset mode-select open:**<br>• Check jumper at S32/S35 (auto reset) or S32/S33 (manual reset).<br>**Connector(s) loose:**<br>• Ensure connector and wire termination is properly seated.<br>• Reset key connection. |
| | Power LED ON<br>Fault LED Flashing<br>Ch. 1 LED OFF<br>Ch. 2 LED OFF | **Internal fault**<br>• See “Repairs” on page 11. |
| | Power LED ON<br>Fault LED ON<br>Ch. 1 LED OFF<br>Ch. 2 LED OFF | **Safety mat actuated or incorrectly attached** |
| | All LEDs OFF | **Possible fault in machine control or wiring to the Module:**<br>• Check input power/ground.<br>• Ensure connector and wire termination is properly seated. |
| | All LEDs Dim | **Possible fault in machine control or input power:**<br>• Check input power and supply requirements of Module. |
| Intermittently drops out, able to reset | Power LED ON<br>Fault LED Flashing<br>Ch. 1 LED OFF<br>Ch. 2 LED OFF | **Momentary short between channels (e.g., S11 and S21):**<br>• Check for intermittent short between channels. |
| MSCs do not energize | Power LED ON<br>Fault LED OFF<br>Ch. 1 LED ON<br>Ch. 2 LED ON | **Possible fault in machine control, or an open circuit between machine control and MSCs:**<br>• Check continuity of safety outputs (e.g., between terminals 13 and 14).<br>• Check control wires.<br>• Check MSCs. |