

DIN RAIL SMART PROTECTION: RACPRO1 E-FUSE MODULES



The RACPRO1 e-Fuse series offers advanced DC protection with intelligent load current limiting, overload and fault detection, and simplified installation. Unlike traditional fuses, the modules integrate advanced logic for reliable fault handling in industrial automation systems.

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ABSTRACT

The RACPRO1 e-Fuse series represents a breakthrough in DC power protection, offering intelligent load current limiting and prioritization, enhanced overload and fault detection, and simplified installation and wiring. Unlike traditional fuses or circuit breakers, RACPRO1-4SP modules integrate advanced logic for seamless fault handling, enabling reliable and efficient system assembly and operation in industrial automation applications. This paper discusses the key features, advantages, and technical specifications of RACPRO1-4SP e-Fuses, highlighting their role in advanced automation power supply systems.

INTRODUCTION

Electrical systems rely on dependable protection mechanisms to ensure operational continuity and safeguard components against electrical faults. Conventional fuses and circuit breakers have served this purpose but come with inherent limitations such as the need for manual replacement, slow fault response, or changing performance with age, load and temperature.

The RACPRO1-4SP series are 4-channel electronic fuse (e-Fuse) load switches with independent overcurrent limit control and real-time output current indication. Each channel is separately protected so that overload or fault conditions on an individual load do not affect overall system reliability or function. The useful LED indicators show the output current and change from green to yellow (current within limit) to orange (current at limit) to red (overcurrent or short-circuit). A volt-free DC-OK output can be used to monitor system function. Each channel can also be switched ON or OFF to ease fault diagnostics or for maintenance. The RECOM e-Fuses RACPRO1-4SP/24V/5A are available with 5A maximum channel current and 150% power boost for 5s but can handle >150% overload for up to 100ms to avoid nuisance tripping. The channels power up in sequence to reduce the input inrush current with a pre-settable delay time. Under system overload hiccup or tripping mode is adjustable by a switch and the 5A modules can also be set to limit the available power to below 100W per channel for LPS installations. The e-Fuses have a high lifetime expectancy >80,000h/40°C and easy wiring with tool-less push-in and lever-release terminals. The input and output terminals are also paired to allow easy daisy-chaining between modules.

There are currently two 4-Channel 24V modules available, the RACPRO1-4SP/24V/10A with four outputs of up to 10A each and the RACPRO1-4SP/24V/5A with four outputs of up to 5A (or 3.75A in LPS mode). More variations will be developed in due course.

Why e-Fuses? Compared to traditional fuses or circuit breakers:

- E-Fuses offer fast fault detection and either latching or automatic reset. Each channel's current limit is independently adjustable with up to 150%/5s power boost.
- They handle overcurrent, undervoltage, and short circuit conditions in a controlled and repeatable way under all operating conditions.
- E-Fuses allow for load prioritization and sequential startup and shutdown to reduce inrush currents, making them ideal for complex electrical systems.

KEY BENEFITS AND FEATURES

Fast and Intelligent Fault Reaction

Traditional protection devices like fuses react quickly to overcurrent events but lack reset functionality, while electromechanical circuit breakers (RCD) or polymer PTCs are resettable but are slow to respond.

- RACPRO1 e-Fuses integrate the best of both worlds:
 - Quick load disconnection during severe overload or short circuit conditions with automatic recovery after fault resolution.
 - Overcurrent tolerance of up to 150% for 5 seconds to eliminate false triggering.
 - Programmable fault response modes (e.g., latching with remote reset or automatic restart).



Priority Load Management

- Sequential start-up minimizes inrush currents. Each channel is switched on in sequence at power up, spreading the inrush current over time to protect the main power supply (Fig.1).
- On power-down, the sequence is reversed, ensuring that the channel with the highest priority (Ch.1 typically the system controller power supply) always starts up first and shuts down last.
- Under system overload conditions, the modules also offer sequential load shedding.
- This ensures that critical loads are maintained while non-essential devices are temporarily disconnected under overload conditions.



Figure 1: Sequential start-up

Overload and Short-Circuit Protection

- Temporarily accommodates overloads without immediate disconnection.
- Automatically isolates severe faults to protect power supplies and connected loads, while ensuring that the remaining loads remain powered up (Fig.2).



Figure 2: Short circuit (e.g. on Channel 2) does not affect the operation of the other outputs



Under Voltage Lockout Protection

The input voltage is constantly monitored. If the DC supply voltage starts to dip because the main power supply is overloaded or the AC line suffers a Brown Out, then the e-Fuse starts sequentially shedding loads to ensure that the priority load always stays powered up (Fig.3).



Figure 3: Load shedding with priority during a supply under voltage condition

If the input voltage falls below the under voltage lockout limit (UVLO), then the e-Fuse disconnects all the load channels. This function avoids operational problems caused by insufficient supply voltage during start-up and operational dips/brown-out conditions such as:

- Signal corruption
- Weak transistor gate drive
- Latch-up

A hysteresis ensures clean UVLO function to increase overall system stability (Fig 4).







Intelligent Hiccup Protection (When in Hiccup Mode)

- In the event of a sustained short circuit or overload, the hiccup function will check if the condition still exists in ever increasing time intervals (100ms, 200ms, 400ms, 800ms, etc.) up to 6.4s (Fig.5). The DC-OK contact opens to indicate a fault condition.
- This unique intelligent hiccup function significantly reduces the hiccup stress on the power supply, system components and wiring and makes fault diagnosis easier by reducing the interference due to repetitive hiccup spikes, yet still offers an acceptable automatic reset time once the fault has been cleared.
- After the fault has been cleared, the channel is automatically enabled and the DC-OK contact closed to indicate normal operation.



Figure 5: Intelligent Hiccup Interval Control

Intelligent Latch Protection (When in Latching mode)

- In the event of a sustained short circuit or overload lasting more than 100ms, the latching mode will disable the affected output and open the DC-OK contact to indicate a fault condition.
- After the fault has been cleared, the latched output can be reset remotely using the remote reset input or by manually turning off and on the affected channel or by powering down the module.
- The DC-OK contact is then closed to indicate normal operation.

Load Monitoring

- In industrial automation environments, the loads are often highly inductive with large inrush currents in comparison to their continuous rated current. These high inrush currents can cause nuisance tripping in fuses or RCDs. Therefore, the RECOM e-Fuse allows temporary over-current conditions of up to 150% of the set limit current for up to 5 seconds, ensuring that industrial loads have sufficient power during start up or short-term overload conditions.
- Nevertheless, a severe overload or short circuit will bypass the overload delay and cause the channel to disconnect within 100ms (Fig.7).



Figure 6: Overload and short circuit behavior with soft restart



- The soft-start feature ensures a defined and predictable ramp-up of the output voltage when switching on (Fig. 7), which:
 - Ensures that the inrush current remains within acceptable limits.
 - Protects both the load and the power supply from power transients.
- The soft-start also means that the e-Fuse outputs are hot-plug capable and hot-swap compatible (as long as the total current remains under limit).
- Each output channel has its own soft-start circuit to protect each load separately.



Figure 7: Soft-start function

Secure Start-Up for Highly Capacitive Loads

- Some industrial automation loads are highly capacitive. The e-Fuse module delivers a smooth voltage ramp-up even with highly capacitive loads (up to 20,000μF) because each output has its own buck converter output stage (Fig. 8).
- Competitor solutions often use a low cost PWM output to control the average output current which results in a noisy pulsating start up ramp with highly capacitive loads.
- If the load is both highly capacitive and draws the full rated resistive load current, then the competitor solution often fails completely to start up and goes into premature short circuit protection (Fig. 9).
- The start-up uncertainty with the competitor solution is often poorly documented or not even mentioned but will seriously adversely affect the operation in real-life installations.







Figure 8: Start up ramp of the RECOM e-Fuse in comparison with a competitor's solution for highly capacitive load (20,000µF)









Figure 9: Start up ramp of the RECOM e-Fuse in comparison with a competitor's solution for highly capacitive load (20,000µF) and full load (5A). The competitor solution fails to start.

LPS Power Limit

The 5A version RACPRO1-4SP/24V/5A has a dip switch setting that will limit the output current of each channel to a maximum of 3.75A. This feature is designed for LPS installations requiring a limited power output of 100W per channel.

ADVANCED CONTROL FEATURES

Individual Current Limits

- Each output channel current limit can be individually set via a trimmer to match specific load requirements (Fig.10).
- This provides flexibility for mixed-load environments, protecting both high and low current devices when powered from a single high current supply.
- The load current is shown by multicolor LED bar displays allowing a quick visual check.



Figure 10: Independent channel current limit setting via trimmers

Load Indicators

LED indicators allow real-time load monitoring (Fig.11):

- Green: Low load (0–60% of maximum)
- Yellow: Medium load (60–80% of maximum)
- Orange: High load (80–100% of maximum)
- Red: Full load (100% of maximum)
- Red (all LEDs flashing): Overload condition (>115%)
- Middle LEDs Red: Channel in shutdown due to overload



Figure 11: Multicolor LED load / channel status indicators



Pushbutton Channel Control

- Each channel can be toggled on and off by a short press on the pushbutton above each channel display. This function is ideal for system set up, maintenance and troubleshooting as the remaining channels are not affected.
- A long press on the pushbutton enables the pushbutton lock to prevent tampering or accidental load disconnection. Another long press re-enables the pushbutton function.
- LED display (Fig. 12):
 - Middle two LEDs flashing orange: Channel manually switched off
 - Four center LEDs flash white briefly: Channel push button control locked/unlocked
 - Upper white LED lights up: Channel is in normal operation (position of lit LED indicates set current limit)



Figure 12: Channel pushbutton control indicators



SYSTEM INTEGRATION

Daisy-Chaining and Load Wiring

- Simplifies configuration for systems with multiple loads. The push-in input connectors are paired to allow easy daisy-chaining of several e-Fuse modules from a central power supply (Fig 13, top).
- The output load terminals have both +/- push-in terminals for easy wiring. Many competitor solutions use an external common minus connector. (Fig. 13, bottom) which increases the cost by requiring external connector blocks.
- These connector blocks also take up valuable space on the DIN-rail (Fig. 14) and raises the risk of a wiring error as the terminal block needs either looped wire connections or internal bus links to function correctly.
- Thus, integrated paired input connections and +/- load wiring saves time and greatly simplifies installation.



Figure 13: Easy daisy-chaining with the RECOM solution (Top)



Figure 14: RECOM solution avoids the need for external connector blocks



Tool-less wiring

- The RACPRO1 e-Fuse module features cage clamp connectors so that input and output wires can be simply pushed in for a reliable, vibration resistant connection.
- The input connectors have a release lever to allow tool-less release. The output connectors can be released by pressing down on the white release lever.

DC-OK and Remote Reset

- Voltage-free relay contacts allow remote monitoring of system health and are compatible with all SCADA systems.
- The DC-OK contacts will close in the case of a fault condition such as:
 - Any output channel is in overload protection.
 - The input voltage is below the UVLO limit.
- The latching fault mode supports a remote external reset once the cause of the overcurrent or fault condition has been investigated and cleared.



Figure 15: DC-OK and remote reset connector

SUMMARY

RACPRO1 e-Fuses are engineered to provide advanced protection, simplify system design, and reduce maintenance. The long life expectancy of 80,000 hours operational lifetime at 40°C and full load and intelligent design eliminates the need for frequent fuse changes or regular testing of electromechanical RCDs.

The modular construction allows upgrading from 5A to 10A versions without requiring more space on the rail, and the modules can be easily daisy-chained to protect as many loads as may be required. The sequential start up and individual output soft start reduces inrush currents in large installations.

Finally, the flexible system design accommodates diverse load profiles with individual channel settings, making them ideal for distributed power architectures where reliability and safety are critical.

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