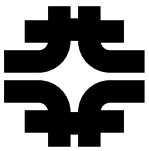

Fermi National Accelerator Laboratory

FERMILAB-TM-2034

Rack Protection Monitor - A Simple System

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December 1997

Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy

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Fermilab TM#2034
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5 November 97

Rack Protection Monitor - A Simple System

1. General

Typically, in many research facilities, relay racks house the 'electronics of research'. As the research and experiments change, the relay rack becomes the protective enclosure for new and expensive electronics systems. The Rack Protection Monitor protects these systems.

The Rack Protection Monitor is a simple, fail-safe device to monitor smoke, temperature and ventilation sensors. It accepts inputs from redundant sensors and has a hardwired algorithm to prevent nuisance power trips due to random sensor failures. When a sensor 'goes off' the Rack Protection Monitor latches and annunciates the alarm. If another, a second sensor 'goes off', the Rack Protection Monitor locally (and without external input) shuts down the power to the relay rack and sends alarm information to central control.

2.0 Operation

2.1 The instrument has three channels - designated for Smoke, Temperature and Ventilation. Each channel is redundant, with two sensors each (six total). The channels are wired to accept 'closed-contacts-when-normal' and 'opening-on-alarm'. The sensors are placed strategically in the rack volume.

2.2 When the sensors are operational, at startup, a Reset command will enable each channel. The green light on the chassis indicates that the channel is armed.

2.3 When an alarm occurs the 'sealed-in' relay for the channel in alarm drops out and the green light changes to red. A 'system flashing light' and a buzzer indicate a chassis alarm. The sensor itself may then become intermittent or reset. The channel, however, will remain latched until the alarm condition clears and the system is reset. The Rack Protection Monitor has the capability of shutting off power. In order to prevent nuisance trips, power shutdown does not happen 'automatically' upon receipt of a 'first alarm'.

2.4 When a 'second alarm' is received - if the first alarm has not been acknowledged - that channel will go into alarm and will initiate a power shutdown. Any combination of channels - either smoke, temperature, or air movement - will create a "second alarm". This "second alarm" will also send an alarm to central control. (FIRUS)

2.5 The Reset button will silence the chassis buzzer when the system is in alarm. It will also rearm the channel that alarmed if the sensor reset itself. If a 'first alarm' does not clear after a reset attempt, the channel red light will remain 'on', and the chassis flasher will remain 'on' - only the buzzer will go quiet. When a second alarm occurs , the chassis will 're-alarm' and the buzzer will go on again.

3.0 Construction

3.1 The Rack Protection Monitor is fail-safe. It is implemented with electromechanical relays that are 'picked up' on normal (reset) condition. They 'drop out' when an alarm occurs. A power failure to the Rack Protection Monitor will initiate a power shutdown. (An optional battery is intended to maintain the audible alarm for the 'second alarm' condition)

3.2 Each channel has an independent latching relay. When a 'reset contact' from the 'Reset' relay closes, each channel picks up. The algorithm for 'first' and 'second' alarm outputs is hardwired to keep relays A1 and A2 picked up. A1 is the simple summation of the first alarm string. A2 is the implementation of the Boolean condition for 'second alarm' output. No software issues exist. On installation, the instrument is tested and checked and commissioned.

3.3 The Rack Protection Monitor is built typically in a rack mounted box, 19" wide and 2U high. The channel alarms and controls are mounted on the front panel. The larger box allows for the installation of the smoke detection right in the box. (Box with screen top and bottom is used). The RPM uses small control relays, each with four 'Form C' contacts. A version was built with all 120Volt control to eliminate the power supply. The usual practice is to install a high MTBF power supply for 120Vac to 24Vdc. A compact model was built in a $3^1/_2$in. by 6in. box. Various packaging options have been tried.

3.4 Under-voltage release - The power shutdown is designed into the Rack Protection Monitor for use with Circuit Breakers with undervoltage release mechanism. This method is more appropriate to the fail safe requirement than the traditional 'shunt trip' breaker mechanism. The Square D "MULTI 9 NC100H" series is compatible with this application. The circuit breaker can be mounted in the box with the RPM or in a separate enclosure.

3.5 The Rack Protection Monitors in service were buit with point-to-point wiring of relay bases. An improvement for larger production quantities would be the layout of a printed circuit 'motherboard' for the relay sockets. This would cut down significantly on the construction labor.

3.6 The prototype material cost for a full RPM was approx. $600 and required one man-week for construction. Our assembly experience and equipment cost reduction have shown that it is possible to cut the material cost and labor by one half.

4.0 Features

The following features may be mentioned elsewhere, and are collected here.

4.1 Redundant inputs
4.2 Fail-safe wiring
4.3 Hardwired logic
4.4 Nuisance trip avoidance
4.5 Local control for Electrical shutdown
4.6 Ungrounded signal output (dry contacts)
4.7 Stand-alone - can be integrated into monitoring systems or it can functions by itself.

5.0 Sensors

These following sensors have demonstrated field reliability in this application :

5.1 Pyrotronics Smoke detectors (Ionization type)

5.2 Temperature Switches - Bimetalic Snap Action Thermostats (Klixon)

5.3 Air Movement Switches (Effector Model# SL 5101)

6.0 Options

Certain field conditions have required 'nonstandard' application of the Rack Protection Monitor. Here are some of the variations used.

6.1 Water Detector - replacement of one 'Temperature' or 'Ventilation' channel with a drip sensor.

6.2 Remote 'Second Alarm' - remote crash button

6.3 Remote readout

6.3.1 Contacts and multiconductor - for connection to local control rooms.

6.3.2 Summing of Rack Protection Monitors

6.3.2 RS232 adapter for serial communication

6.4 A 'Four Channel' model

Where only Smoke and Temperature need to be monitored, a four channel instrument can be used. This cuts down substantially the number of relays needed.

7.0 Conclusion

The 'Simple Rack Protection Monitor' was designed and built to meet an immediate need in the Fixed Target program for high energy physics research at Fermilab. It relies on 'old and proven' technology. Only hardware 'on hand' or readily available was used. No active electronics or software were allowed. It was deployed successfully and debugged in the field. The simple logic of the Rack Protection Monitor can easily be implemented in a PLC. We are presently experimenting with the minimal code that would preserve the essential fail-safe feature of the electromechanical version.

During the installation and commissioning of experiments the RPM is very handy because it can easily provide system protection before any central monitoring system is in service. Since it is portable, it can be taken out and used again.

It may be desirable to use the RPM in conjunction with the newer PLC monitoring systems. The local active power shutdown would be done by the RPM and the PLC would monitor the rack (and RPM) with its attractive GUI interface.

Steve Morrison built and tested the versions of the RPM. He did a great job.

Dongning Mao provided valuable field test data for the selection of the thermostat range in the Fastbus environment.

8.0 Exhibits

Drawing # SGO 5NOV95 - Rack Protection Monitor

Engineering Note " FastBus Protection Chassis"

Drawing # SGO 1NOV95 - FastBus Protection Chassis - Functional Schematic

Drawing # SGO 1OCT97 - Rack Protection Chassis - Heat & Smoke Detector