Microprocessor-Controlled Capacitor Switching Thyristor Modules

Technical User's Manual

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WARNINGS & SAFETY PRECAUTIONS

- Check your power cables and connections for damage before powering up the module. If the cables are damaged, do not power it up.
- Power cables should not pass over the module.
- To replace the module, the power must be switched off and capacitors must be completely discharged.
- Do not exceed the nominal ratings specified in the technical specifications.
- Do not touch the modules with bare and/or wet hands while it is on.
- Make sure that the power is turned off when cleaning. Use a dry cloth to clean the module.
- Do not operate the module under or above the specified voltage ratings.
- The module must be vertically mounted on the mounting plate.
- Check cabling and connections before powering up.

Caution: Life-threathening voltage levels may remain in the capacitors long after the power is switched off. Make sure capacitors are completely discharged before touching the module.

Table of Contents

1 – Introduction

1.1 General Description

Thyristor modules are designed to switch capacitive loads up to 80kVAr in power factor correction (PFC) applications. The modules can switch capacitive loads within 10ms of receiving a triggering signal. The microprocessor-based architecture and its algorithm senses the voltage zero crossing, thereby avoiding capacitor abrasion. The modules can switch up to 480V, star- or delta-connected symmetrical or asymmetrical, resistive, inductive and capacitive loads during the voltage-zero crossing. Triggering is easily performed through power factor correction relays, or PLCs. The advantages of the thyristor modules over state-of-the-art mechanical contactors include: (1) longer life expectancy, (2) fast switching performance, (3) guaranteed minimal voltage or current transients during switching which (4) extends the capacitor lifetime. Thyristor modules monitor voltage, status and, temperature. Detected faults are displayed on the four LEDs on the front panel and recorded in the module internal memory. The modules can operate with or without a detuned filter reactor. The modules protect detuned filter reactors against overheating through their external thermostat connections. Thyristor modules are maintenance free and quiet.

1.2 Application Areas

Thyristor modules are designed for dynamic power factor correction applications requiring extremely fast and frequent switching actions. Applications include, but are not limited to, welding, presses, elevators, cranes, arc furnaces, wind turbines and similar areas with dynamically varying loads.

2 – Technical Specifications

Technical specifications of the 12kVAr, 25kVAr, 50kVAr and 80kVAr thyristor modules are listed in Table 2.1. This table gives guaranteed ratings and exceeding these guaranteed ratings will significantly reduce module life expectancy.

Table 2.1: Technical specifications for 12kVAr, 25kVAr, 50kVAr, and 80kVAr

Parameter	Units	12kVAr	25kVAr	50kVAr	80kVAr
Nominal Voltage	V	400 ±%14	400 ±%14	400 ±%14	400 ±%14
Maximum Blocking Voltage	V	1600	1600	1600	1600
Maximum Operating Current	A	20	40	80	115
Maximum *di/dt*	A/µs	50	100	140	140
Conductor Cross Section	mm^2	16	16	35	35
Number of Semicoductor Modules	-	2	2	2	2
Auxiliary Supply Voltage	V	-	-	230±%10	230±%10
Fan Power Rating	VA	-	-	32	32

Auxiliary Supply Conductor Cross Section	mm^2	-	-	2.5	2.5
Fan Activation Temperature	ºC	-	-	50	50
Triggering Voltage/Current	V/mA	24/10	24/10	24/10	24/10
Triggering Conductor Cross Section	mm^2	2.5	2.5	2.5	2.5
Overheating Protection	ºC	90±5	90±5	90±5	90±5
IP Class	-	20	20	20	20
Ambient Temperature -Operating (Full Load) -Operating (%75 Load) -Storage	 ºC ºC ºC	 -20~45 -20~60 -40~100	 -20~45 -20~60 -40~100	 -20~45 -20~60 -40~100	 -20~45 -20~60 -40~100
Relative Humidity	%	5~95	5~95	5~95	5~95
Size (W x D x H)	mm	158x154x115	158x154x115	161x229x197.5	161x229x197.5
Weight	kg / lb	2.2 / 4.9	2.2 / 4.9	5.9 / 13.0	5.9 / 13.0

3 – Setup

3.1 Prerequisites for Setup

Modules should be mounted on the mounting plate through the mounting holes provided on the enclosure. **Modules must be mounted vertically! A minimum of 150mm clearance is imperative** above and below to dissipate heat efficiently! **Do not drill additional mounting holes on the device!** Modules should be grounded through the mounting holes. 50kVAr and 80kVAr modules may also be grounded through connecting the ground cable to the auxiliary power supply connector.

Electrical connections should follow the wiring diagrams provided in Figures 3.3-3.6 in the Wiring Diagrams section. **“Superfast” electronic branch fuses must be used to protect the thyristor modules!**

12kVAr and 25kVAr modules do not require an auxiliary voltage connection. These modules are powered internally. The 50kVAr and 80kVAr modules are equipped with a fan and are designed for forced cooling. **Therefore, 50kVAr and 80kVAr modules require an auxiliary voltage (220V 50Hz) supply to power internal circuits and the cooling fan!**

Modules can be instantaneously activated through a power factor correction relay, or any other compatible system, by applying a 10-24VDC trigger signal. Internal circuits are galvanically isolated from the trigger signal.

Thyristor modules are equipped with an external thermostat terminal. If a detuned filter reactor is used in the system, the user may attach its thermostat to the external thermostat terminal on the module. This allows the module to protect the detuned filter reactor from overheating. **If this external thermostat connection is not used, user must short the thermostat connection terminals for the system to function properly!**

3.2 Installation

CAPACITOR AND DISCHARGE MECHANISM: The recommended capacitor voltages for a 400V PFC system with and without a detuned filter reactor are listed in Table 3.1. A suitable detuned filter reactor is recommended to avoid the risk of resonance and reactor acoustic noise.

Table 3.1: Capacitor voltages for PFC with and without a detuned filter reactor

PFC type	Recommended Capacitor Voltage Rating (V)
No detuned filter reactor	400
7%	440
14%	480

Switching action takes place within 10ms upon receiving the 24VDC trigger signal given that the capacitors were appropriately discharged. If the capacitors remain charged, switching action might be delayed. In point welding and similar applications where capacitors are required to be switched on and off frequently, the capacitors must be equipped with a discharging. High power resistors or discharge reactors are recommended to increase switching speed and frequency.

Discharge resistors need to be selected carefully to achieve desired discharge rate. Figures 3.1 and 3.2 show the relationship between the discharge resistance and discharge time for 12.5kVAr, 25kVAr, 50kVAr and 80kVAr PFC systems employing two and three discharge resistors, respectively. The discharge rates are almost identical for systems with a 7% detuned filter reactor and without a detuned filter reactor. If a detuned filter reactor is not used, the discharge may be obtained from 7% curves on Figures 3.1 and 3.2.

The recommended power ratings for common discharge resistor values are listed in Table 3.2. These power ratings allow for safety margins. Avoid use of power resistors lower than the given ratings. Avoid thermal coupling between the modules and power resistors by keeping a clearance distance of 150 mm in all directions. **Do not place discharge resistors directly underneath the modules!**

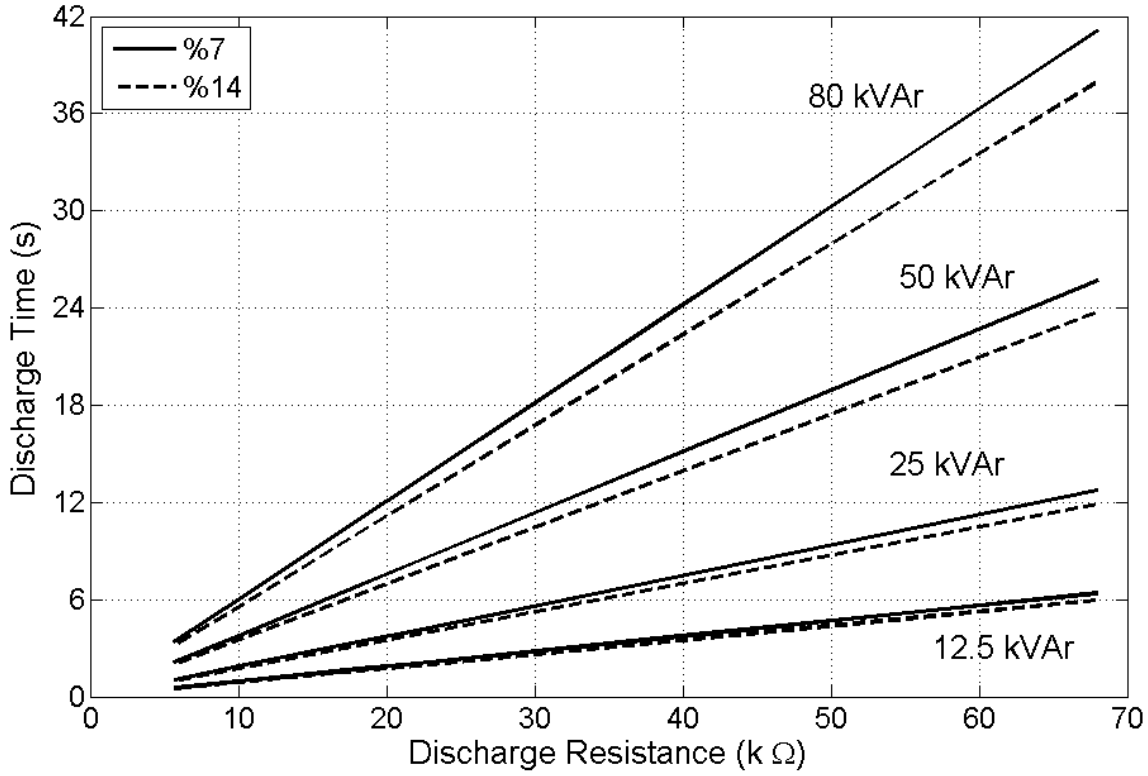

Figure 3.1: The effect of discharge resistance on discharge time for 7% (189Hz) and 14% (134Hz) detuned reactor PFC with three discharge resistors. 7% rates may be used if no reactor is employed.

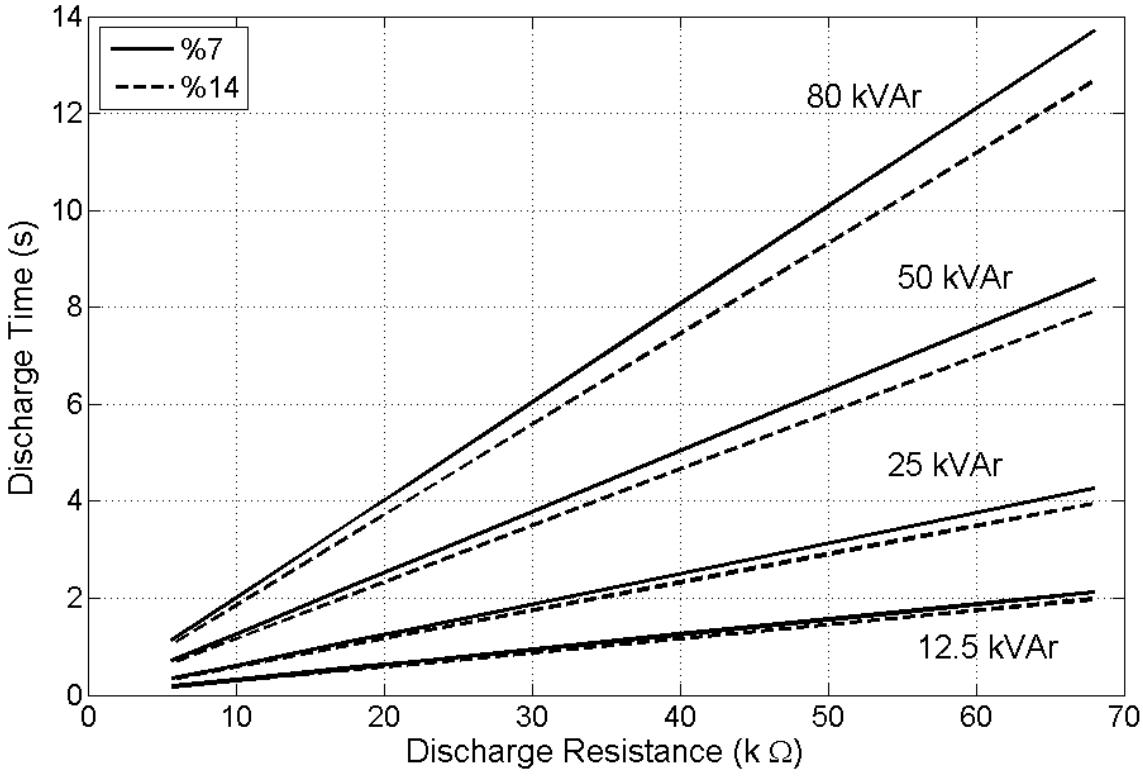

Figure 3.2: The effect of discharge resistance on discharge time for 7% (189Hz) and 14% (134Hz) detuned reactor PFC with two discharge resistors. 7% rates may be used if no reactor is employed.

Table 3.2: Recommended power ratings for discharge resistors

Resistance (kΩ)	Resistor Power (W)
5.6	100
10	50
18	25
22	25
39	10
56	10
69	5

SUPERFAST FUSE SELECTION: Each thyristor module should be connected to the line through a "superfast" branch fuse. Depending on the module type, recommended fuse current and voltage ratings are listed in Table 3.3.

Table 3.3: "Superfast" fuse ratings for each thyristor module

Model	Current (A)	Voltage (V)	Power (kVAr)
12kVAr	35	NH AC 690	12.5
25kVAr	63	NH AC 690	25
50kVAr	125	NH AC 690	50
80kVAr	200	NH AC 690	80

MITIGATING HIGH *di/dt*: When the thyristors are triggered, the current is initiated at the gate-cathode junction. The current spreads to the entire junction area as it increases. If the current time rate of change (*di/dt*) during this process is faster than the charge carriers in the junction, then the thyristor may get damaged. Absolute maximum *di/dt* ratings for thyristor modules are presented in Table 3.4. If these values are exceeded, the thyristor modules might be permanently damaged. Detuned filter reactors limit the *di/dt*. If a detuned filter reactor is not used, then a current limiting reactor with a minimum of 20µH inductance is recommended to protect the module and maintain a long life expectancy.

Table 3.4: Absolute maximum *di/dt* ratings for module types

Model	*di/dt* (A/µs)
12kVAr	50
25kVAr	100
50kVAr	140
80kVAr	140

3.3 Wiring Diagrams

Wiring diagrams with or without detuned filter reactors for 12kVAr, 25kVAr, 50kVAr and 80kVAr modules are presented in Figures 3.3-3.6.

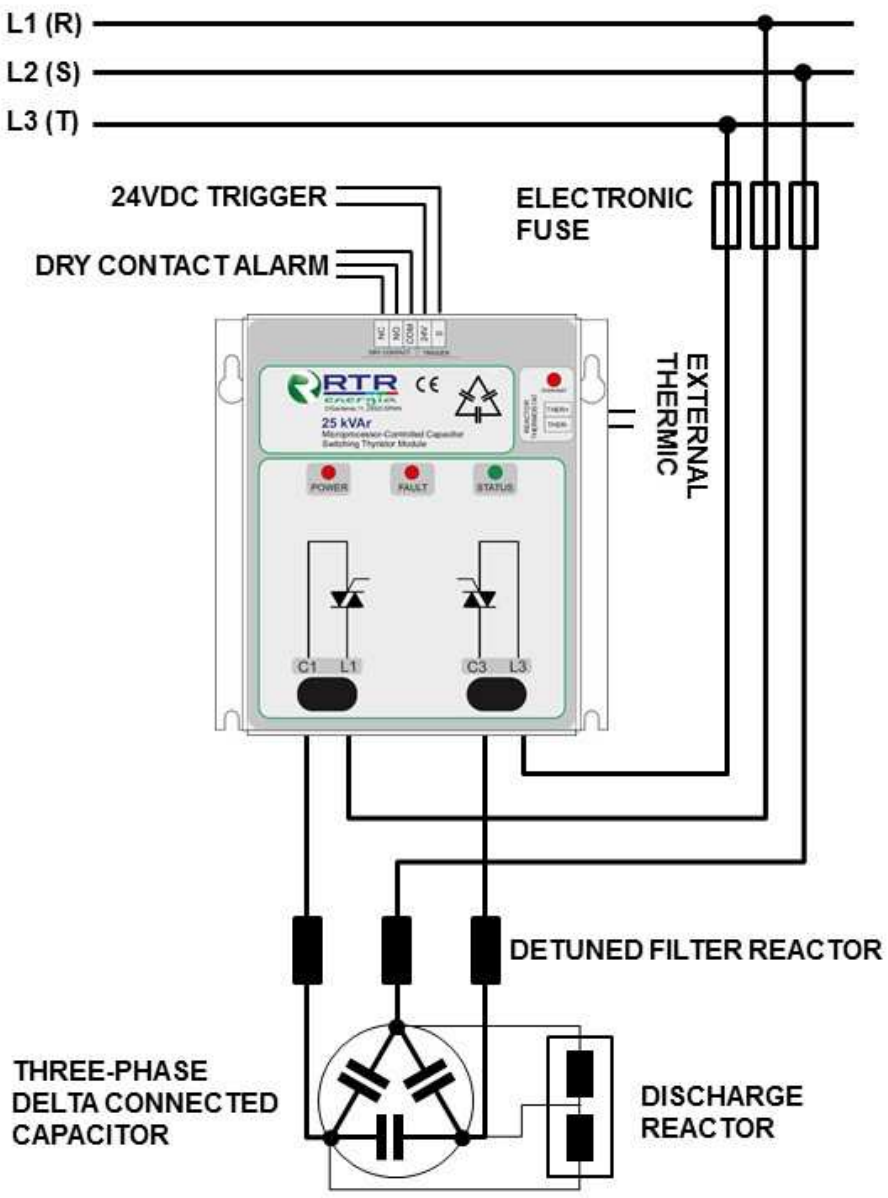

Figure 3.3: Recommended wiring diagram for 12kVAr and 25kVAr modules with a detuned filter reactor and a discharge reactor. Connection terminals, wiring diagrams and structures of 12kVAr and 25kVAr modules are identical.

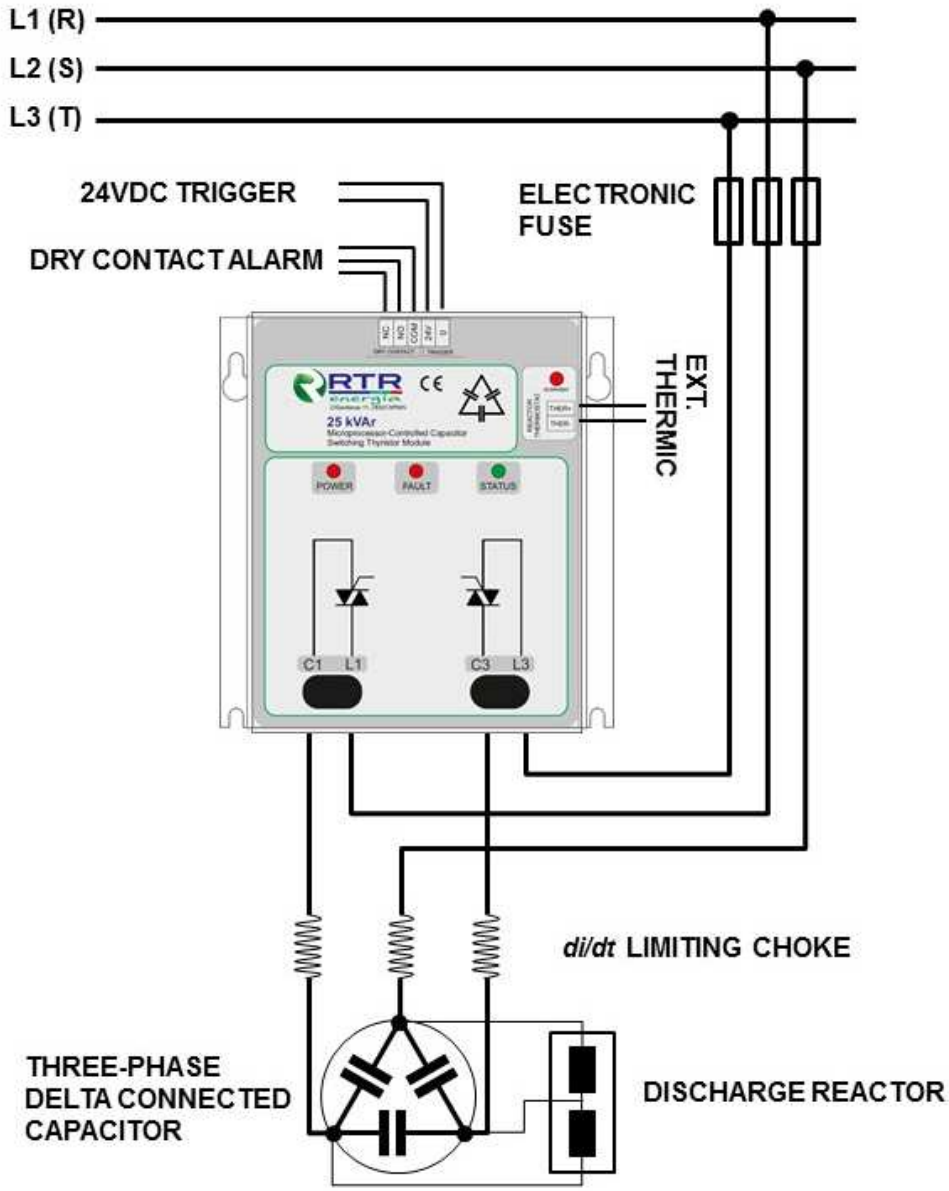

Figure 3.4: Recommended wiring diagram for 12kVAr and 25kVAr modules without a detuned filter reactor and with a discharge reactor. Connection terminals, wiring diagrams and structures of 12kVAr and 25kVAr modules are identical.

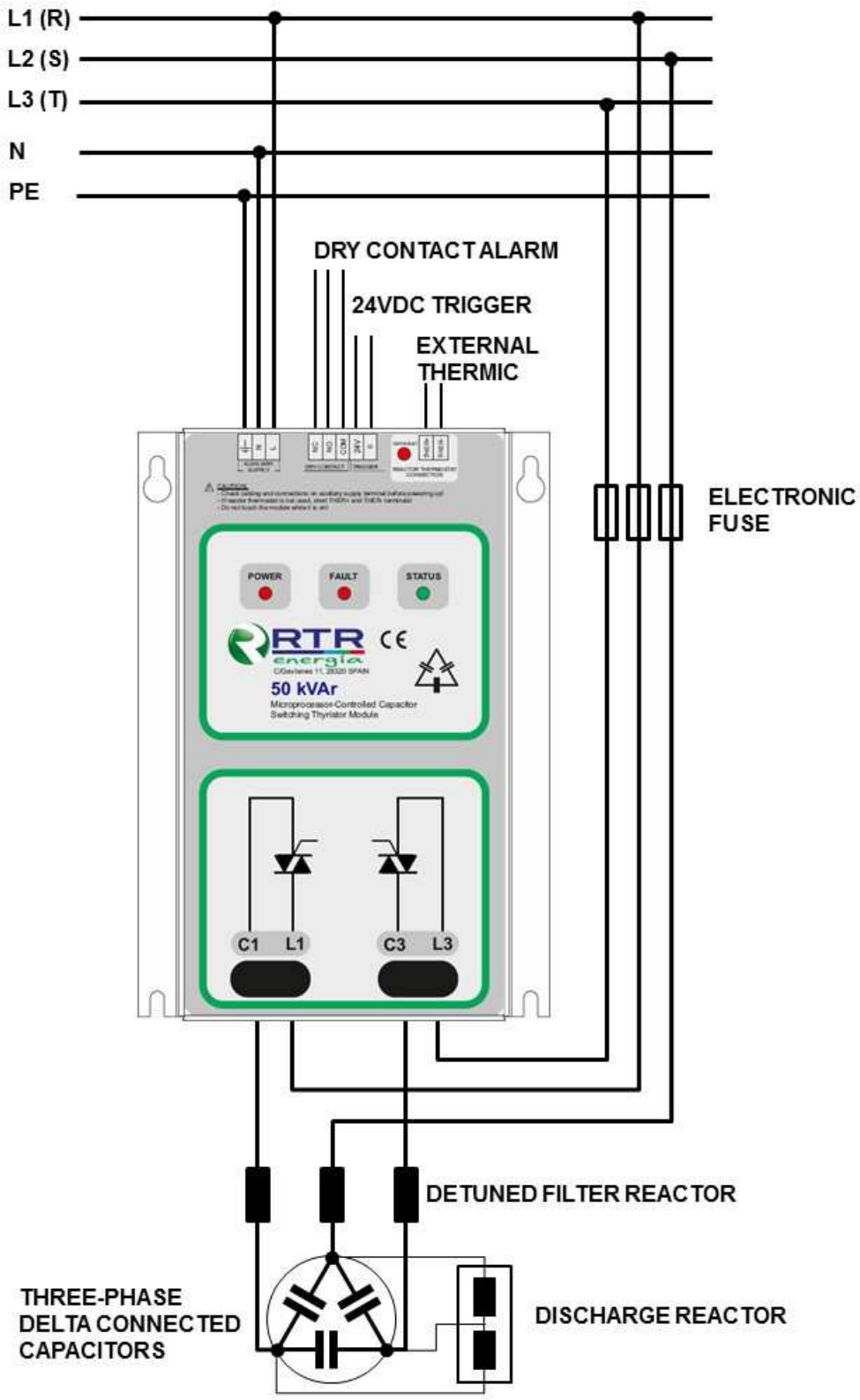

Figure 3.5: Recommended wiring diagram for 50kVAr and 80kVAr modules with a detuned filter reactor and a discharge reactor. Connection terminals, wiring diagrams and structures of 50kVAr and 80kVAr modules are identical.

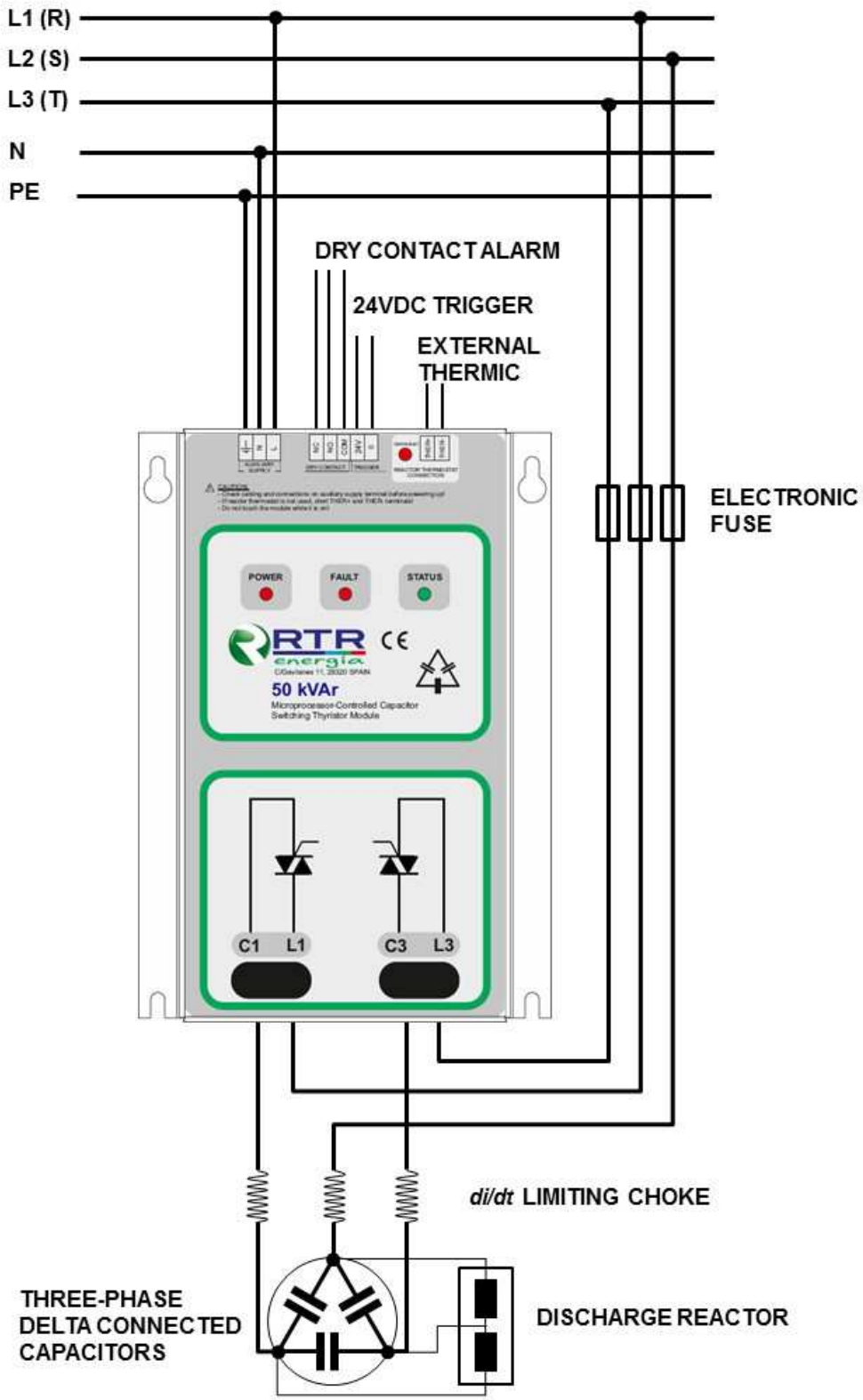

Figure 3.6: Recommended wiring diagram for 50kVAr and 80kVAr modules without a detuned filter reactor and with a discharge reactor. Connection terminals, wiring diagrams and structures of 50kVAr and 80kVAr modules are identical.

3.4 Ready for Start-Up

Module is ready to start up as soon as power and capacitor connections on L1-C1 and L3-C3 terminals are completed. When the module is turned on (including the auxiliary supply voltage for 50kVAr and 80kVAr), it will be waiting for a trigger signal. As soon as a trigger signal is detected, the green status LED will light up indicating that the thyristors are triggered and the capacitors are switched on. The module is equipped with fault detection and a respective LED. Each is described in the following section.

3.5 Alarms and Indicators

Thyristor modules have four LEDs on the front panel dedicated for alarms, status feedback and faults. The function of each LED is described as follows:

POWER LED (red): Informs the user that the module is powered up.

FAULT LED (red): Informs the user of internal faults. If the module detects a misconnection on L1-C1 or L3-C3 terminals, a fault on the discharge mechanism or any other error which must be cleared before the system is enabled, this LED blinks until the fault is cleared. In case of overheating, this LED will light up and stay lit until the modules are cooled below 70ºC.

REACTOR FAULT DETECTION LED (red): This LED will light if reactor overheats.

STATUS LED (green): Informs the user that the modules are activated and capacitors are switched on.

4 – Technical Drawings

Technical drawings for 12kVAr, 25kVAr, 50kVAr and 80kVAr modules are presented in this section. The frames and dimensions of 12kVAr and 25kVAr are identical. Similarly, frames and dimensions of 50kVAr and 80kVAr are identical as well.

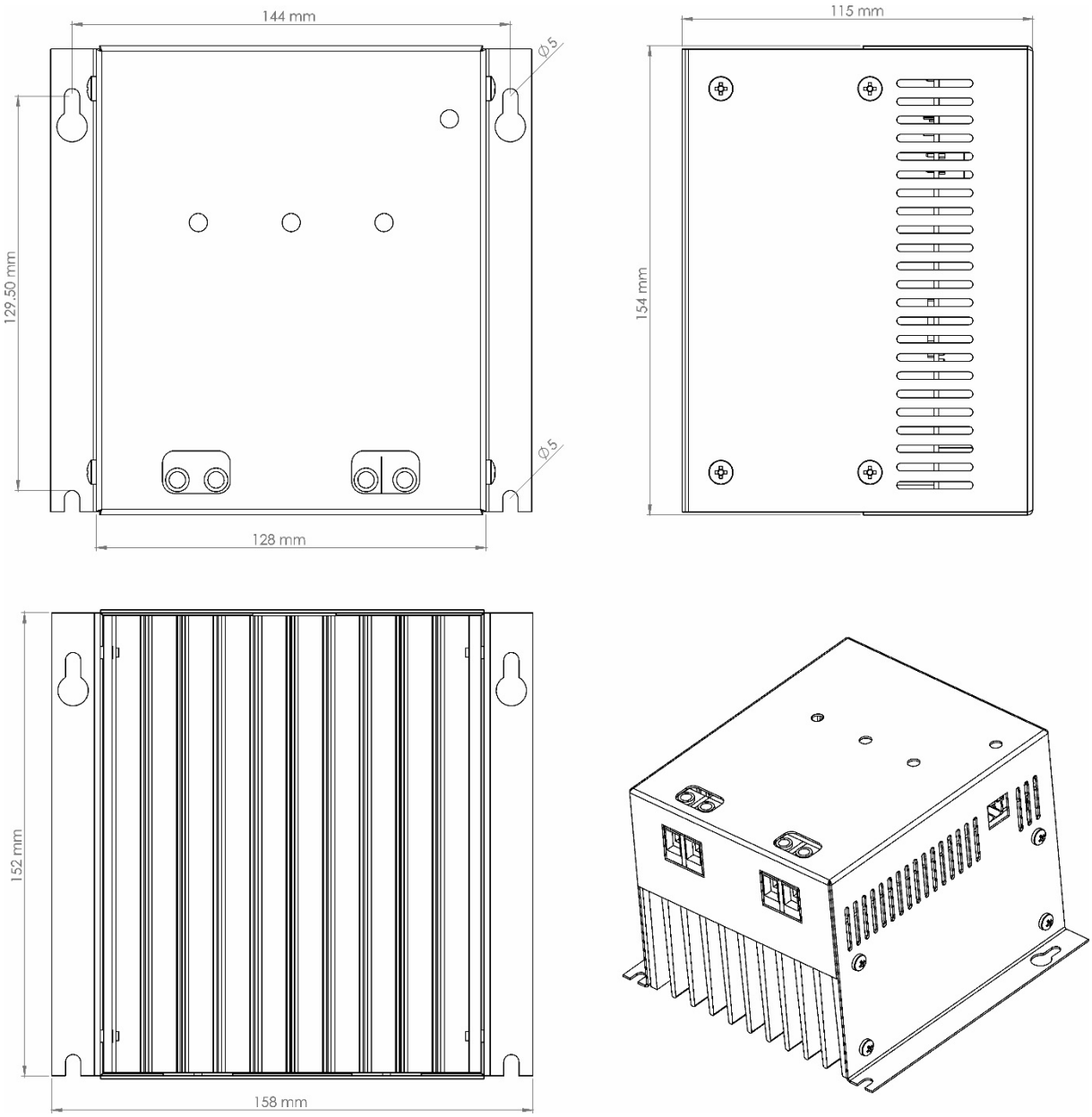

Figure 4.1: 12kVAr and 25kVAr modules technical drawings

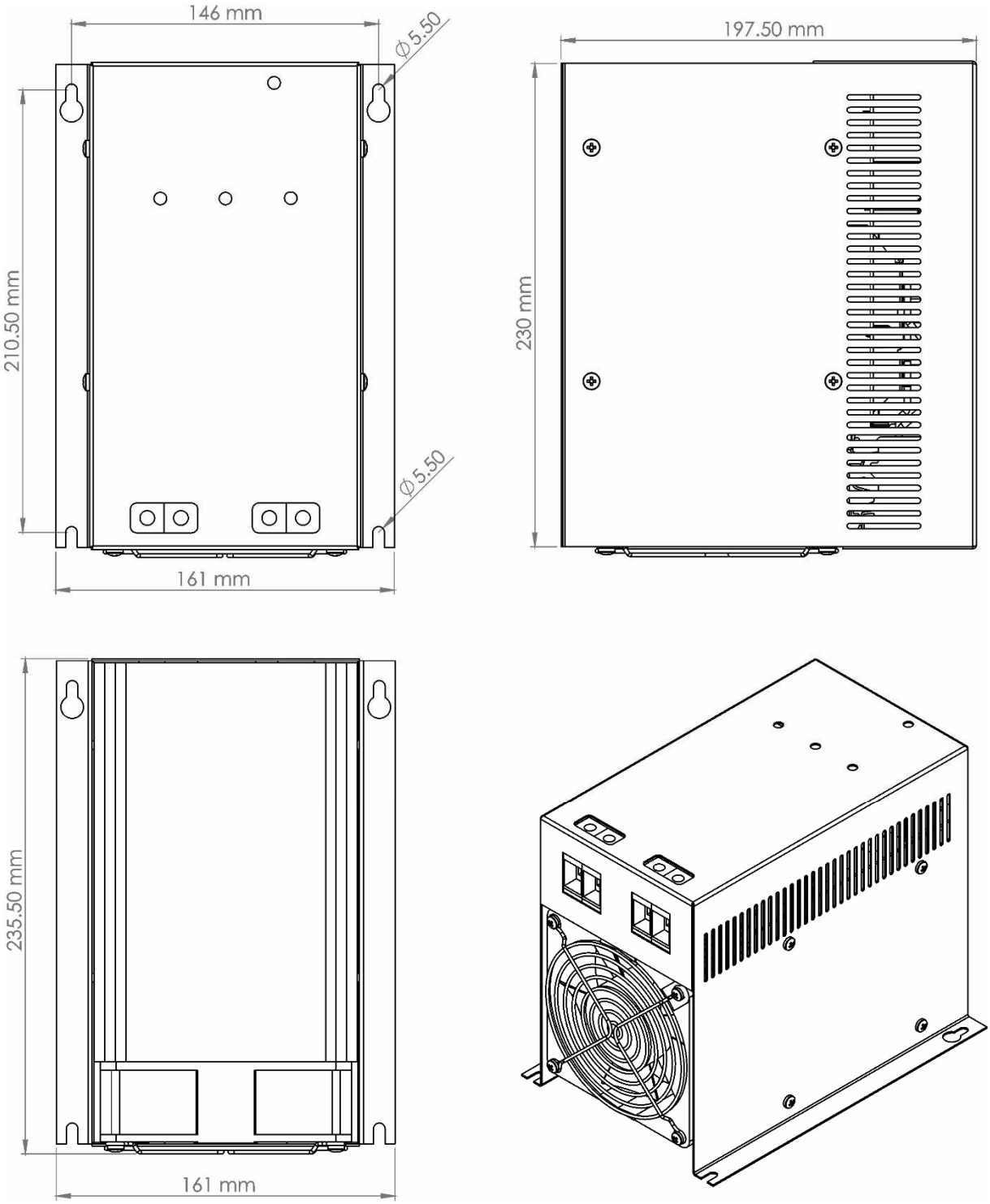

Figure 4.2: 50kVAr and 80kVAr modules technical drawings

5 – Troubleshooting

As explained in Section 3.5, thyristor modules inform the user of various faults and errors through the four LED indicators on the front panel. The troubleshooting procedures for various faults and alarms described as follows.

- ***Power is connected but POWER LED does not light up:***

  Please check the power connections and the STATUS and/or FAULT LEDs. If none of the LEDs is lit, then the internal circuitry is not powered. Make sure that power cables, superfast fuses and switches are all properly wired and power is received by the module.

  If any one of the STATUS or FAULT LEDs is lit, then the module is damaged and user should contact the technical service department at the number provided in Section 7.

- ***REACTOR FAULT DETECTION LED is lit:***

  Please check if the detuned filter reactor thermostat is connected to EXT+ and EXT- terminals. If a detuned reactor does not exist in the electrical system, then these terminals must be shorted. They must also be shorted if a detuned filter reactor is used without wiring the thermostat connections. Otherwise, the module will evaluate this situation as a reactor-thermal fault and will not let the user switch on the capacitors.

- ***FAULT LED is blinking:***

  If the module detects a misconnection on the L1-C1 and L3-C3 terminals, a fault on the discharge mechanism or any other error which must be cleared before the system is activated, this LED blinks continuously and prevents the system from activating until the fault is cleared.

  1. Make sure that L1 and L3 are connected to the line through the superfast fuses. If the connections are correct, then check to see if the fuses are blown.
  2. If L1 and L3 are properly connected and the fuses are not blown, then check to see if C1 and C3 are properly connected to the capacitors.
  3. If C1 and C3 are properly connected to the capacitors, then check to see if the discharge reactors or resistors are damaged, shorted or open-circuited.
  4. If the discharge mechanism is damaged, please replace the discharge mechanism and power up the modules.
  5. If a discharge reactor or a discharge resistor is not utilized, the capacitors will stay charged and the modules will not be able to switch capacitors. **Capacitors must be equipped with a proper discharging mechanism!**

- ***FAULT LED is lit:***

The module is in over-heating protection mode. Thermal protection is activated when the hottest spot of the heat sink is above 90±5ºC. The over-heating fault will not reset until the hot spot temperature is below 70±5ºC. **Make sure the modules are properly cooled.**

1. Make sure the 12kVAr and 25kVAr modules are vertically mounted on the mounting plates. If the modules are not mounted vertically, **they must not be powered up!**
2. If vertical mounting for 50kVAr and 80kVAr modules is not possible, then user needs to ensure that cooling air is circulating properly and warm air is removed from the panel. If the cooling fan is not activated while in over-heating status, then please check the auxiliary power connections and make sure the module is powered up properly. If the modules are powered up properly, then please contact the technical service number provided in Section 7.

- ***The module is triggered but the STATUS LED is not lit:***

STATUS LED displays operating status of the module. If this LED is not lit up, then one of the following four situations must be true:

1. System is not powered up
2. Trigger signal is not being received
3. Capacitors are charged but not discharging properly
4. System has a wiring error or is in overheating fault mode

First, make sure that the trigger signal is received by the module. To achieve this, disconnect the REACTOR FAULT DETECTION connections and check to see if the REACTOR FAULT DETECTION LED lights up when the trigger signal is applied. If the LED lights up, then the trigger signal is properly received. Then reconnect the REACTOR FAULT DETECTION connections. If the REACTOR FAULT DETECTION LED is lit, then the system is in reactor overheating fault protection mode. If the FAULT LED is lit, then the module is in overheating protection mode and user must wait until the temperature is below 70°C and take precautions to improve the cooling efficiency. If the FAULT LED is blinking, then please refer to the related topic under this section. If the POWER LED is on, but the FAULT and REACTOR FAULT DETECTION LEDs are off, then please contact the technical service department at the number in Section 7.

6 – Warranty, Terms and Conditions

These modules are warranted against manufacturing defects for 1 (one) year. The modules are out of warranty in case of user error, use not in accordance with recommended practice presented in this manual, internal circuits are tampered with and/or the cover is removed.

The manufacturer is not responsible for:

- Any costs resulting from a failure if the installation, setup, repair, alteration, or ambient conditions of the module do not follow the requirements specified in the documentation delivered with the module and other relevant documentation.
- Modules subjected to misuse, negligence, or accident.

In no event shall the manufacturer, its suppliers or subcontractors be liable for special, indirect, incidental, or consequential damages, losses or penalties. If you have any questions concerning your thyristor modules, please contact the local distributor or RTR Energía. The technical data, information and specifications are valid at the time of printing. The manufacturer reserves the right to make modifications without prior notice.

7 – Contact Information

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