APPLICATION NOTE | AN-General-0012v101EN

Additional information for connecting PTC-Sensors

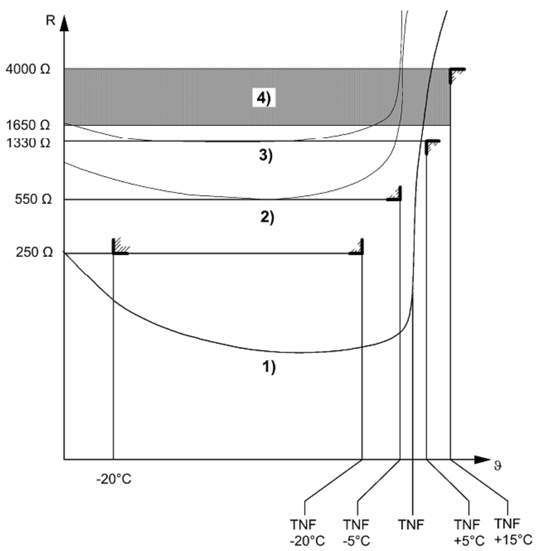
Inverter type	FRENIC Series
Software version	All versions
Required options	None (FRENIC Mini: 1kΩ resistor)
Related documentation	
Author	Martin Fuchs
Use	Public, Web
Date	20/03/2014
Version	1.0.1
Languages	English

1. Introduction.

This document describes important points about motor temperature protection in case those PTC-sensors are directly connected to Fuji Electric FRENIC series.

2. General considerations.

According to EN 60947-8/VDE 0660-302 or DIN 44081/44082 PTC-sensors, depending on the connection, and monitoring devices should comply with following specification. In addition the measuring voltage for each sensor should not exceed 2,5 V in normal operation or 7,5 V under fault conditions. PTC-monitoring devices should issue an alarm in the range of 1650 Ω to 4000 Ω.



Temperature	Resistance	Voltage
-20 °C … TNF -20°C	≤ 250 Ω	≤ 2,5 V
TNF -5°C	≤ 550 Ω	≤ 2,5 V
TNF +5°C …	≥ 1330 Ω	≤ 2,5 V
TNF +15°C	≥ 4000 Ω	≤ 7,5 V

1) One single PTC sensor is connected
2) 3 PTC sensors are connected in series
3) 6 PTC sensors are connected in series
4) Tripping area for monitoring devices

Figure 2.1 Switching ranges / resistance curve *1

*1:TNF = rated operating temperature in°C

The goal of this document is to show how sensors can be connected to FRENIC inverters to have the correct sole protection for the motors. In many applications the current input [C1] is needed for control signals, therefore the [C1] terminal cannot be used for PTC monitoring. This application note should show an alternative how to use analog 4…20 mA signals and motor protection by means of the inverter at the same time without using additional analog extension cards. It is important to state that the internal detection circuits and algorithms do **NOT** comply with safety standards or others like ATEX directive etc.

3. Connection methods

Following connections should be investigated:

a) Connection of PTC-Sensor to [C1]/ [V2] terminal of FRENIC inverters (dedicated functions example FRENIC MEGA/HVAC/AQUA)
b) Connection of PTC-Sensor to digital input terminals of FRENIC inverters. There are two connection methods investigated (b1,b2).

a) Connection of PTC-Sensor to [C1] terminal of FRENIC inverters

A basic circuit for the PTC function is displayed in Figure 3.1. It can be seen from this figure that the detection circuit is fed by the internal 10 VDC supply with a pre-resistor of 27 kΩ. In general it is necessary to activate the PTC-monitoring by a switch (SW5) and by parameter H26. The Threshold level is set via parameter H27. The alarm issued at this level is OH4.

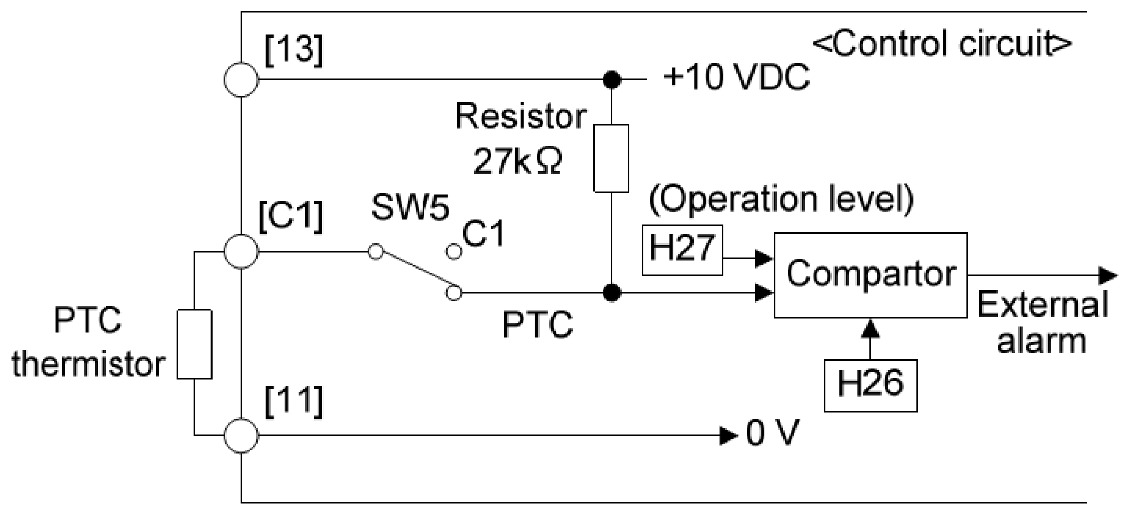


Figure 2.1 Internal Circuit Diagram
(SW5 Selecting PTC)

Figure 3.1: Detection-circuit for PTC-protection (FRN-G1, AR1, AQ1 Series)

As it can be seen the voltage on the PTC-voltage is the direct reference for the motor overload judgment. Therefore the measuring voltage will never be higher than the comparator level programmed in parameter H27. As long as the value in H27 is set below 2,5V the conditions for operating voltage of PTCs of chapter 2 are always fulfilled.

The threshold level of the function is activated when following condition is reached (example for G1, AR1 and AQ1 Series):

$$V_{PTC} \geq \mathrm{H27} = 10{,}5\mathrm{V} \cdot \frac{R_{PTC}}{R_{PTC} \cdot 27\mathrm{k}\Omega}$$

The theoretical tripping levels, considering the normative ratings of PTC monitoring devices, are calculated by the expressions of the related documentation of each inverter series. The results are displayed in Table 3.1.

Table 3.1: Tripping levels for Motor protection (parameter H27)

FRENIC Series	**Pre-resistor value in Ω**	**Tripping level in V (R_{PTC}=1650Ω)**	**Tripping level in V (R_{PTC}=4000Ω)**
MEGA (G1)	27k	0,60	1,35
HVAC/ AQUA (Ax1)	27k	0,60	1,35
LIFT (LM1)*2	27k	0,56	1,17
ECO (F1) *2	1k	1,77	1,88
MULTI (E1) *2	1k	1,87	2,00
MINI (C1) *2	1k (external)	1,87	2,00

*2 Circuit differs slightly from example in Figure 3.1

Conclusion:

The tripping resistance is in the regular range of DIN VDE 0660 (1,65 kΩ to 4 kΩ) when the detection voltage (H27) is set to correct values.
The measuring voltage on the PTC is below 2,5 V in normal operation and in tripped condition.

b1) Connection of PTC-Sensors to a digital input terminal of FRENIC inverters

The basic idea is to use a digital input programmed with ***THR*** (external alarm by assigning '9' to function codes E01… for terminal **[X1]** … etc.)
The characteristic increase of resistance of the PTC sensors will deactivate the digital input and cause an alarm **g1**. The supply should be the internal 24VDC (exactly 24,4 VDC). The diagram is shown in Figure 3.2.

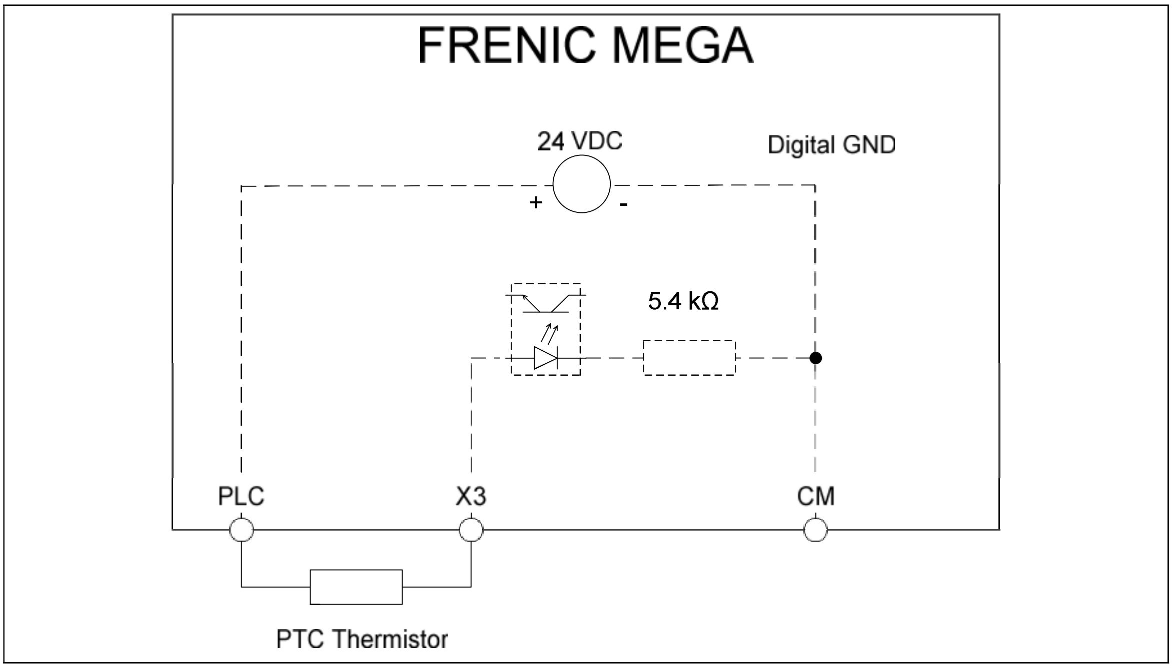


Figure 3.2 Connection of PTC-Sensors to a digital input terminal (24 VDC)

The digital inputs of FRENIC inverters have an input impedance of R_i=5,4 kΩ (except X7 of FRENIC MEGA). The Optocouplers have a following operating data:

I_F = 1,25 mA
U_F = 1,2 V

The Voltage on the PTC wires is therefore

$$V_{PTC} = V_{PLC} - V_F - (R_i \cdot I_F) = 24{,}4\text{V} - 1{,}2\text{V} - (5{,}4\text{k}\Omega \cdot 1{,}25\text{mA}) \cong 16\text{V}$$

The Ohmic value when the digital input is activated is determined as following:

$$R_{PTC} = \frac{V_{PTC}}{I_F} = \frac{16\text{V}}{1{,}25\text{mA}} \cong 13\text{k}\Omega$$

Comparing these results with chapter 2, it can be seen that the operating conditions are out of the permissible range. This circuit is **NOT** suitable for PTC monitoring.

b2) Connection of PTC-Sensors to a digital input terminal of FRENIC inverters by using the internal 10 VDC supply.

The idea is to use same philosophy as before but using a different voltage level for the senor supply. FRENIC inverters have a 10 VDC (10.3 VDC) supply connected to the terminals **[11]** and **[13]**. As the 10 VDC supply is isolated from the digital power supply (**[PLC]** and **[CM]**) it is necessary to connect the two GND by terminals **[11]** and **[CM]**.

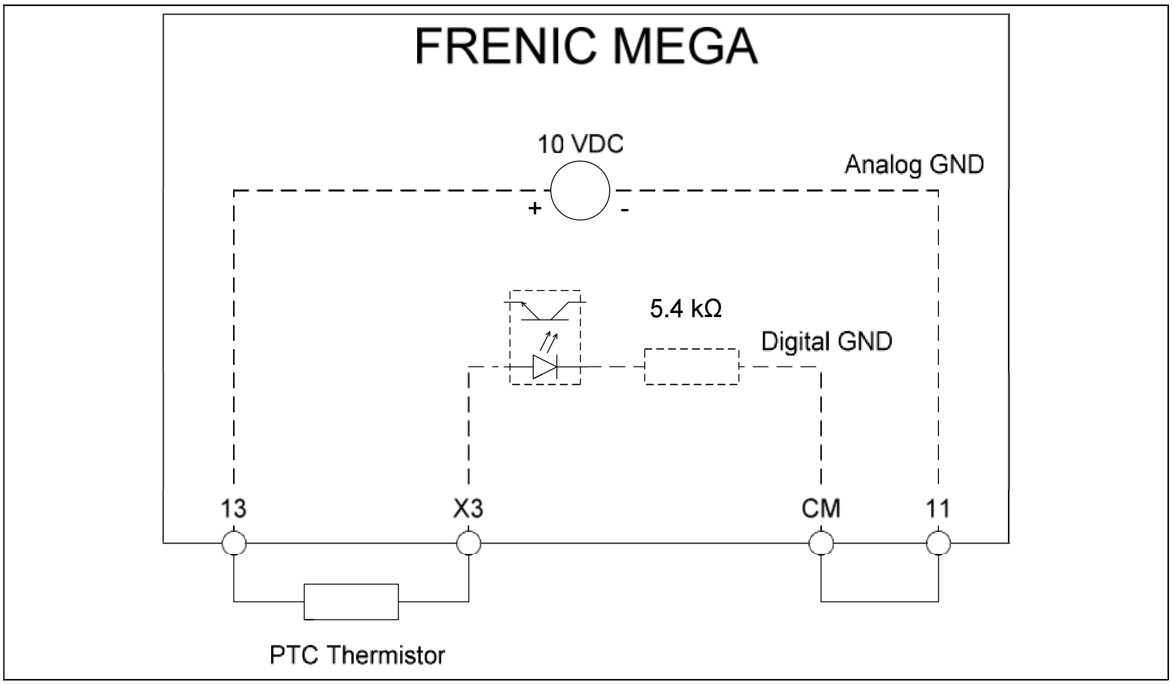


Figure 3.3 Connection of PTC-Sensors to a digital input terminal (10V)

With the same calculations as before the results are:

The Voltage on the PTC wires:

$$V_{PTC} = V_{13} - V_F - (R_i \cdot I_F) = 10{,}3\text{V} - 1{,}2\text{V} - (5{,}4\text{k}\Omega \cdot 1{,}25\text{mA}) \cong 2{,}35\text{V}$$

The Ohmic value during activation is:

$$R_{PTC} = \frac{V_{PTC}}{I_F} = \frac{2{,}35\text{V}}{1{,}25\text{mA}} \cong 1{,}88\text{k}\Omega$$

The tripping resistance is in the regular range of European standards (1,65 kΩ to 4 kΩ). The measuring voltage on the PTC is below 2,5 V in normal operation and in tripped condition.

3. Conclusion

This document shows how PTC-sensors can be connected to FRENIC inverters to have the correct sole protection for motors. It is possible to use a digital input programmed with ***THR*** as an alternative of the standard PTC function. But it is necessary to use 10 VDC supply for the detection circuit. A motor overheat is detected accurately and the conditions for the PTCs are matching within normative specification. By this an additional PTC monitoring device, additional option-cards or analog signal converters can be saved. A disadvantage is that the threshold level of the digital input is not adjustable like the dedicated parameter H27. In cases that safety standards like ATEX directive etc. are mandatory additional certified monitoring devices are necessary in any case.

4. Document history.

Version	Changes applied	Date	Written	Checked	Approved
1.0.0	First version	17/03/2014	M. Fuchs	J. Alonso	
1.0.1	Release with corrections	20/03/2014	M. Fuchs	J. Alonso	J. Català