ATEX THERMISTOR MOTOR PROTECTION RELAYS IN ON BOARD ELECTRICAL INSTALLATIONS

LEON PANĂ[1], FLORIN GABRIEL POPESCU[2], SEBASTIAN DANIEL ROSCA[3]

Abstract: Protecting electric motors in ATEX areas is very important to prevent the risk of explosion and ensure the safety of personnel and equipment in the area. To ensure adequate protection, a number of safety factors must be considered, including the design and construction of electric motors, electrical connections, and the qualification and training of personnel who install and maintain them. In this context, the protection of the electric motors within these on board installations is necessary, even mandatory, as the ships have potentially explosive areas. Most protection relays protect electrical motors against overheating in the windings and overloads or inadequate cooling and the basic size is determined by the intensity of the electric current. The disadvantage of these relays is that they do not detect the real temperature of the motor windings. Along with the evolution of electronics, ATEX certified protection relays have also developed significantly. This paper aims to present the technical solution of the protection of electric motors in HVAC installations on board ships with explosive potential. At the end of the paper a CAD application is presented to simulate the operation of the ATEX thermistor motor protection relay.

Key words: ATEX, CAD, PTC thermistor relay, overload, short-circuits.

1. INTRODUCTION

A multitude of electric motors, of different sizes and types, are found on board ships. No ship, whether commercial or military, is without HVAC installations. In this context, the protection of electric motors within these installations is necessary, even mandatory, as ships have potentially explosive areas [1], [3], [12], [14], [17], [20].

Protecting electric motors in ATEX areas is extremely important to prevent the risk of explosion and ensure the safety of personnel and equipment in the area. [5], [9], [25]. To ensure adequate protection, a number of safety factors must be taken into account, including the design and construction of the electric motors, the electrical

[1] *Ph.D., Lecturer, Eng., Mircea cel Batran Naval Academy, leon_pana@yahoo.com*
[2] *Ph.D., Associate Prof. Eng.,University of Petroșani, floringabriel82@yahoo.com*
[3] *Ph.D Student Eng., at the University of Petrosani, sebastianrosca91@gmail.com*

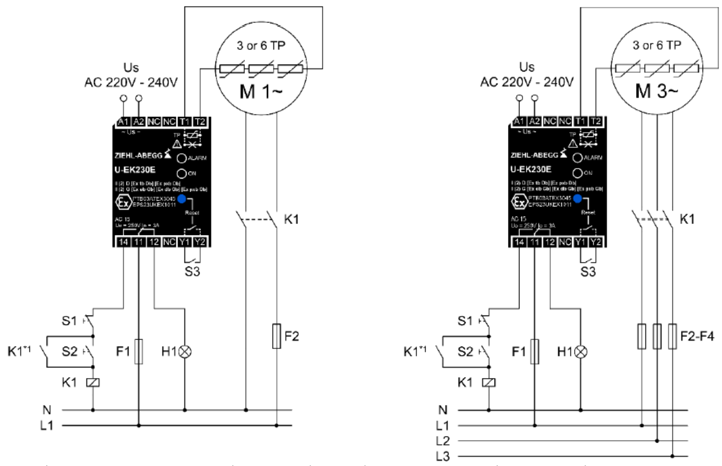
connections and the qualification and training of the personnel who install and maintain them [2], [8], [11], [13], [15], [16], [19].

2. PTC-THERMISTOR RELAY TYPE U-EK230E FOR ATEX ELECTRIC MOTOR PROTECTION

The relay protects electrical equipment against excessive warming and thermal overload. If this is used in combination with adequate temperature sensors (e.g. thermistors) tripping temperatures from 60 °C up to 180 °C can be realized [7]. The relay is conform to EN 60947-8 and temperature sensors (thermistors) according to DIN VDE V 0898-1-401 (ATEX) or equivalent detail specification (UKEX) shall be connected. The temperature sensors are suitable for mounting into windings of electric motors or power transformers, bearings and heatsinks as well as to monitor the temperature of liquid media, airflow and gases. With ATEX approval, equipment in explosive gas atmospheres Zone 1 and 2 (marking G: gas) or in areas with combustible dust Zone 21 and 22 (marking D: dust) can be protected.

All protection functions of this thermistor relay serve to protect non-explosive-protected equipment and explosive-protected equipment in regular operation and in case of failure [4], [6], [10], [18], [21], [24].

Figure 1 shows the circuit diagram for the single-phase or three-phase connection [11].



Us	Supply voltage	S1	Off switch	
TP	PTC thermistor	S2	Push button on (manual reset)	1) external interlock, see chapter 15.11 Manual reset
F1 – F4	Fuses	S3	Remote reset	
H1	Indicator lamp fault	K1	Contactor	

Fig.1. Single phase and three phase circuit diagram

The principal features of relay are:

- 1 thermistor circuit for 1 (not allowed for explosive atmospheres), 3 or 6 PTC thermistors “TP” connected in series.
- Short-circuit detection within the thermistor circuit.

• Output relay with 1 change-over contact (co).

• Operating status display

The principle of the relay operation is simple. A current monitors continuously the resistance of the thermistor circuit. In cold state, the resistance is ≤ 250 Ω per thermistor (thermistor circuit ≤ 1.5 kΩ). The relay is switched on his contacts 11, 14 are closed. The resistance of the thermistors rises rapidly at sensor operating temperature TNF. The relay switches off at a resistance of 3…4 kΩ and his contacts 11, 12 close. The relay also switches off in the case of detector or line short-circuit (< approx. 20 Ω) or detector or line interruption. The relay remains switched off until the build in or an external reset button is pressed. Power-on is recognized as reset action. With bridged terminals Y1, Y2, the reclosing lock function is disabled [22], [23], [26].

Function diagram of the relay is presented in fig.2. The device switches on automatically in case of a supply voltage dip

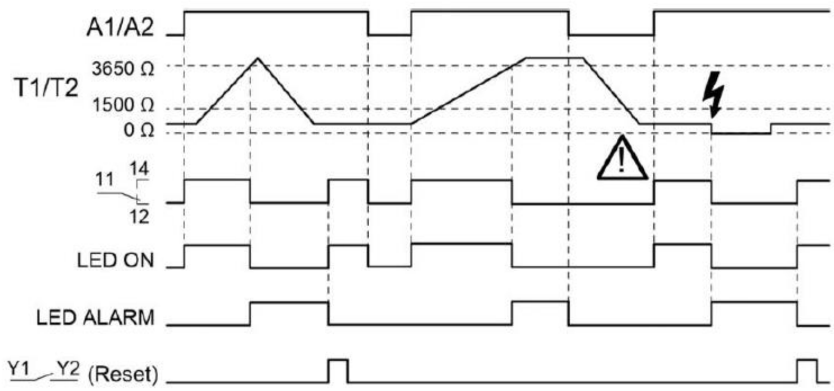


Fig.2. Basic function diagram

Figure 3 shows the connection mode with a bridge at the reset input relay (Y1/Y2) the reclosing lock is out of operation. In this case the relay switches back automatically, when the temperature of the thermistor circuit has fallen below the switchback value.

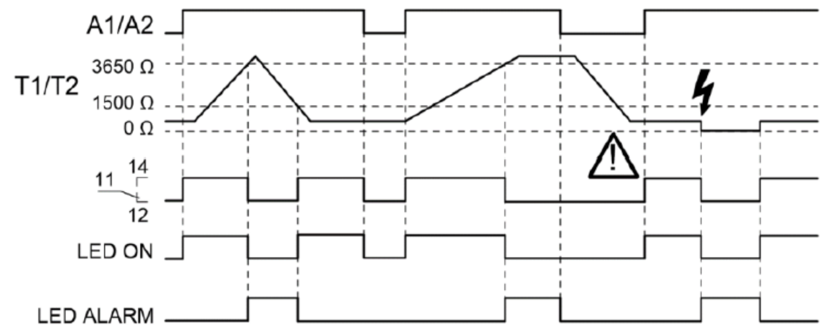


Fig.3 Inputs (Y1 and Y2) bridge connection mode

The relay must be installed outside ATEX area (gas area Zone 0, 1 and 2) unless the device is protected by a suitable ignition protection type (pressurized enclosures or flameproof enclosures).

3. CAD SIMULATION

The CAD simulation created in Matlab, using App Designer, aims to present a simplified simulation of the principle operation of the U-EK230E PTC Thermistor assembly. The application has two components: the code and the design. Both can be easily accessed from the main App designer window.

Initially, the design was created, according to fig. 4. It contains the following elements: the system tripping device, an integrated circuit breaker (motor starter) and the electric motor.

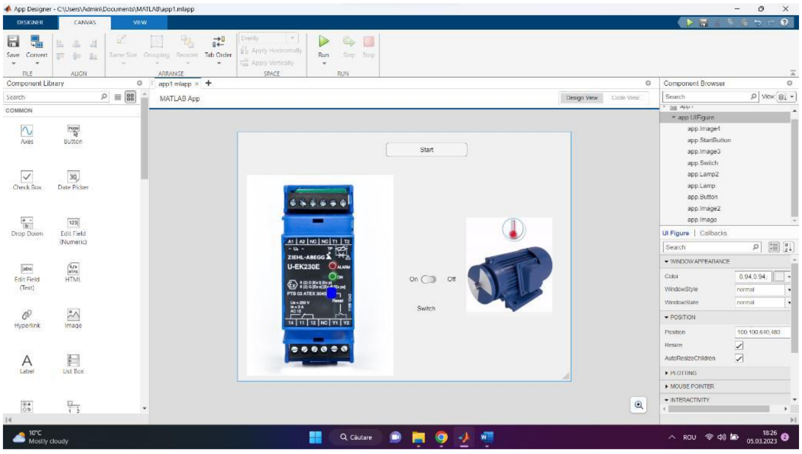


Fig.4. Graphical components of the CAD application

After finalizing the CAD configuration, the code was written, using callbacks for each element, as can be seen in fig.5.

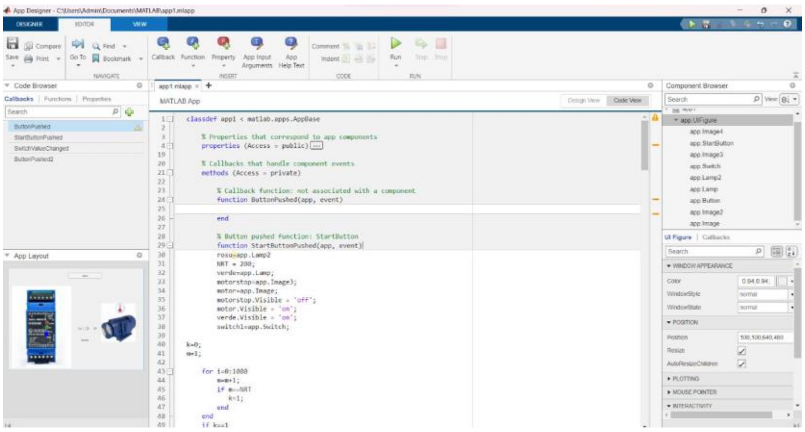


Fig.5. Graphical simulation code program

The steps to simulate the application are:

1. Press the START button. The electric motor starts and a green LED comes on to indicate this (fig.6).
2. Using the temperature sensor that is mounted on the stator windings of the motor, the temperature is monitored, and when it reaches the preset value (insulation class temperature), an integrated switch opens, thus stopping the motor. and the red LED of the relay lights up (fig.7).

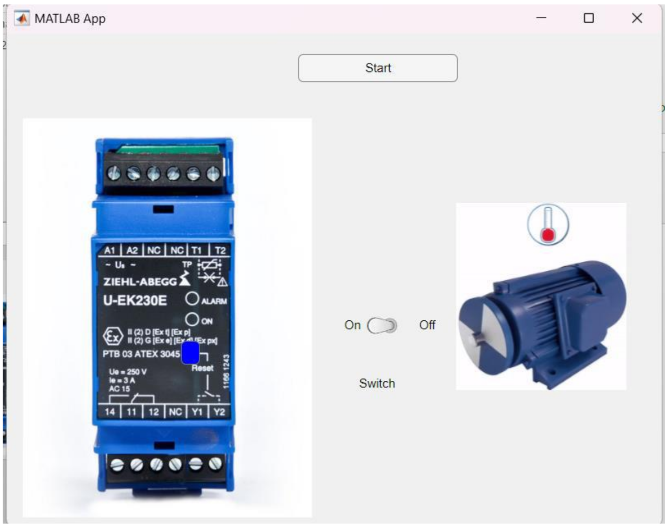


Fig.6. Start (run) electric motor

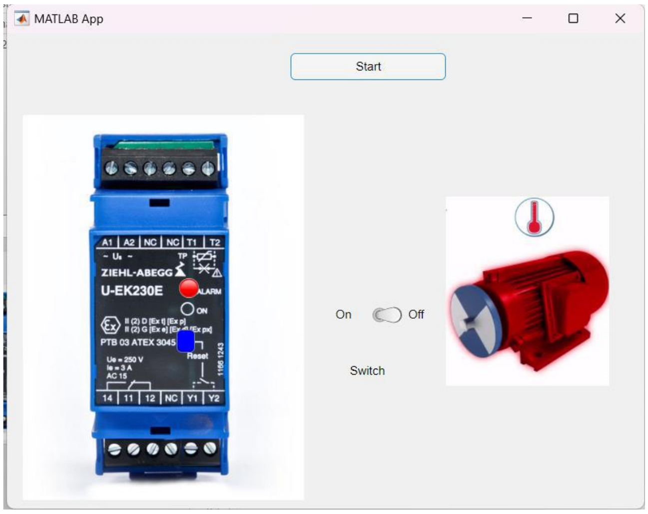


Fig.7. Protection tripping (motor stop)

3. When the temperature drops enough for the motor to operate safely, the red LED of the relay lights up. At this point, the RESET button can be pressed to restart the motor safely (fig.8).

Fig.8. Relay reset mode

4. CONCLUSIONS

PTC thermistors are used in a wide range of applications, such as temperature control, overload protection, liquid level detection, and more. For example, a PTC thermistor can be used to monitor the temperature of an electric motor. If the temperature exceeds a specified value, the thermistor's resistance increases sharply, which can trigger a protective device to stop the motor and prevent overheating.

Some of the advantages of the PTC thermistor include:

- High sensitivity to temperature changes: PTC thermistors are very sensitive to temperature variations, making them ideal for applications that require precise temperature monitoring.
- High electrical resistance at high temperatures: Once the temperature exceeds a specified value, the resistance of the PTC thermistor increases sharply, making it useful for protecting circuits from overloads.

• Reliable operation: PTC thermistors are reliable and robust, and because they have no moving or mechanical parts, they have a longer lifespan than other types of temperature sensors.
• Low cost: The cost of PTC thermistors is relatively low compared to other types of temperature sensors, making them a popular choice for industrial and commercial applications.
• Compact size: PTC thermistors are small and compact, making them ideal for applications where space is limited.

REFERENCES

[1]. Borstlap R., Katen H.T., *Ship Electrical Systems – 2nd Edition*, Dokmar Maritime Publisher B.V, 2022

[2]. Marcu M.D., Popescu F.G., Pana L., *Modeling and simulation of power active filter for reducing harmonic pollution using the instantaneous reactive power theory*. Environmental Engineering and Management Journal, June, Vol.13, No. 6, Pages: 1377-1382, 2014.

[3]. Pana L., Deliu F., Rosca S.D., *Measurement and analysis of vibrations of electric motors on board container ships*, Scientific Bulletin "Mircea cel Batran" Naval Academy Constanta, vol.24(1), pp. 145-156, 2021.

[4]. Pana L., Dobref V., Delhi F., *Simulation of protection functions in LV shipboard electrical power systems*, Scientific Bulletin "Mircea cel Batran" Naval Academy Constanta, vol.25, (1), pp. 8-15, 2022.

[5]. Pana L., Dragomir E., Eni M.., *ETAP simulation of short circuit currents in on board HV power plants*, Scientific Bulletin "Mircea Cel Batran" Naval Academy, vol. 27, (1), pp. 164-174,164A, 2024.

[6]. Pană L. Popescu F.G., *Analytical modeling of protection relays*, Annals of University of Petrosani, Electrical Engineering, Vol. 17, pag. 61-68, Petroşani, 2015.

[7]. Pană L. Popescu F.G., *Evaluation of the moments load and maximum allowable voltage drop for overhead and underground power lines*, Annals of University of Petrosani, Electrical Engineering, Vol. 19, pag.15-27, Petroşani, 2017.

[8]. Pana L., Stochitoiu M.D., *The influence of the deforming regime on the losses of power and energy in the electrical transformers on board the cruise ships*, Scientific Bulletin "Mircea Cel Batran" Naval Academy, vol. 24, (1), pp. 157-166, 2021.

[9]. Popescu F.G., **Marcu M.D.,** *Metode moderne de analiză şi reducere a armonicilor de curent şi tensiune*, Editura Universitas, Petroşani, 2016.

[10]. Popescu F.G., **Marcu M.D.,** *Electronică de putere*, Editura Universitas, Petroşani, 2021.

[11]. *** Operating Instructions. Type U-EK230E Part.-No. *382008 Releasing unit for motors with temperature sensors "TP" (thermistors*).

[12]. Fita N.D., Obretenova M.I., Pasculescu D., Tatar A., Popescu F.G., Lazar T., *Structure and analysis of the power subsector within the national energy sector on ensuring and stability of energy security*, Annals of „Constantin Brâncuşi" University of Târgu Jiu, ENGINEERING SERIES, Issue 2/2022, pp.177-186, 2022.

[13]. **Marcu M., Niculescu T., Slusariuc R. I., Popescu, F. G.,** *Modeling and simulation of temperature effect in polycrystalline silicon PV cells*, IOP Conference Series: Materials Science and Engineering, Vol. 133, No. 1, pp. 012005, 2016.

[14]. **Handra A.D., Popescu F.G., Păsculescu D.,** *Utilizarea energiei electrice: lucrări de laborator*, Editura Universitas, 2020.

[15]. **Pasculescu D., Dobra R., Ahmad M.A.,** *Dosimetric Quantity System for Electromagnetic Fields Bio-effects*, International Journal of Scientific Research (IJSR) 5, no. 2, pp. 28-32, 2016.

[16]. **Popescu F.G., Păsculescu D., Păsculescu V.M.,** *Modern methods for analysis and reduction of current and voltage harmonics*, LAP LAMBERT Academic Publishing, ISBN 978-620-0-56941-7, pp. 233, 2020.

[17]. **Pasculescu D., Niculescu T.,** *Study of transient inductive-capacitive circuits using data acquisition systems*." International Multidisciplinary Scientific GeoConference: SGEM 2, no. 1, 323-329, 2015.

[18]. **Pana L., Janusz G., Pasculescu D., Pasculescu V. M., Moraru R. I.,** *Optimal quality management algorithm for assessing the usage capacity level of mining transformers*, Polish Journal of Management Studies 18, no. 2, 233-244, 2018.

[19]. **Dobra R., Buica G., Pasculescu D., Leba M.,.** *Safety management diagnostic method regarding work cost accidents from electrical power installations*. Proc. 1st Int. Conf. on Industrial and Manufacturing Technologies (INMAT), Vouliagmeni, Athens, Greece. 2013.

[20]. **Fîță N. D., Lazăr T., Popescu F. G., Pasculescu D., Pupăză C., Grigorie E.**, *400 kV power substation fire and explosion hazard assessment to prevent a power black-out*, International Conference on Electrical, Computer Communications and Mecatronics Engineering-ICECCME, pp. 16-18, 2022.

[21]. **Popescu F.G., Arad S., Marcu M.D., Pana L.,** *Reducing energy consumption by modernizing drives of high capacity equipment used to extract lignite*, Papers SGEM2013/Conference Proceedings, Vol. Energy and clean technologies, pp. 183 - 190, Albena., Bulgaria, 2013.

[22]. **Fîță N.D., Radu S.M., Păsculescu D., Popescu F.G.,** *Using the primary energetic resources or electrical energy as a possible energetical tool or pressure tool*, In International conference KNOWLEDGE-BASED ORGANIZATION, vol. 27, no. 3, pp. 21-26. 2021.

[23]. **Csaszar T., Pasculescu D., Darie M., Ionescu J., Burian S.,** *Method for assessing energy limited supply sources, designed for use in potentially explosive atmospheres*, Environmental Engineering and Management Journal 11, no. 7, 1281-1285, 2012.

[24]. **Andras A., Popescu F.D., Radu S.M., Pasculescu D., Brinas I., Radu M.A., Peagu D.,** *Numerical simulation and modeling of mechano–electro–thermal behavior of electrical contact using comsol multiphysics*. Applied Sciences, 14(10), 4026, 2024.

[25]. **Stepanescu, S., Rehtanz, C., Arad, S., Fotau, I., Marcu, M., Popescu, F**. *Implementation of small water power plants regarding future virtual power plants* 10th International Conference on Environment and Electrical Engineering, pp. 1-4, IEEE, 2011.

[26]. **Păsculescu D., Romanescu A., Păsculescu V., Tătar A., Fotău I., Vajai Gh.,** *Presentation and simulation of a modern distance protection from the national energy system*, 10th International Conference on Environment and Electrical Engineering, pp. 1-4. IEEE, 2011.