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THREE-PHASE MOTOR PROTECTION DEVICE

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Abstract: The work is devoted to analysis the reasons for electric motors are failure and motor protection device design. The algorithm of the protection device is considered and its structural diagram is drawn up. There was described the operation principle of the protection device based on its block diagram.
Keywords: asynchronous motor; motor lifetime; protection devices; block diagram; algorithm.

Asynchronous motor with a short-circuited rotor is designed for 15-20 years working life without major repairs in case of properly service in accordance with nominal parameters specified by manufacturer. In real life, there are significant deviations from the rated operating modes: low voltage quality, rules violation of technical operation (technological overloads, environmental conditions, reduction of insulation resistance, cooling problems). Emergency operating modes of the motor are following of such deviations. Up to 15-20% of motors that operates in agricultural industry get damaged annually.

When using reliable and effective protection devices it could be reduced power and operating costs, number of damages and extend the motor lifetime [1, p.15].

Electric motor accidents are divided into two main types: mechanical and electrical. Electrical accidents are associated with asymmetry or voltage deflection, open wire breakage of lines, breakage or short circuit the motor stator winding, current overloads during technological overloads and short circuits, reduced insulation resistance.

The most vulnerable in electric motor is stator winding and its insulation [1, p.12]. Most often, the windings fail due to the voltage asymmetry of the power supply and the operation with overload. In these cases, the current in the stator windings and their temperature increases significantly.

Despite the large number of existing motor protection devices, there is a need to improve and develop new devices on a more modern electronic basis. A feature of programmable microprocessors is that they run on a specific program, compiled for a specific protection device based on a mathematical model that analyzes the influence of factors on operation of the motor.

The researched three-phase protection device will disconnect the motor from power supply line in case of phase failure, phase voltage deviation by more than ±30 V and heating of stator winding more than 115 °C (according to insulation of class F) [2, p.16].

The protection device is supposed to be built on a microcontroller and a temperature sensor. In case of an emergency mode in any phase or temperature increase in the winding the corresponding motor is switched off and signal LED is switched on [3, p.232].

During motor is starting the voltage failure or surge may occur. It caused by the starting currents, so the device should be delayed after the motor has been switched on. Then phase voltages V_A, V_B, V_C are measured sequentially. If the voltage is zero, it corresponds to the non-phase mode, the protection device switches off the motor.

The phase voltage is then checked beyond the range of the accepted range of 190-250 V. If it goes beyond it, the error counter is activated, it is necessary to increase the noise stability of the device. If the next voltage measurement returns to normal, the counter is reset.

After comparing the linear voltages V_{AB}, V_{BC}, V_{CA} their difference is checked for exceeding the limit value ± 30 V. If it exceeds this value, then the error counter is switched on and the above algorithm of operation is repeated.

Temperature measurement begins with the initialization of the thermal sensor and the issuance of the command of the conversion permit.

On the basis of the described algorithm, a block diagram of the protection device is developed which is shown in Fig. 1. The block diagram consists of the following blocks: 1.1, 1.2, 1.3 – three-phase voltage rectification; 2.1, 2.2, 2.3 – voltage dividers; 3.1, 3.2, 3.3 – smoothing filters; 4 – primary phase temperature converter; 5 – temperature sensor; 6 – adjustment circuit; 7 – microcontroller; 8 – LED indication; 9 – galvanic isolation; 10 – executive relay; 11 – power supply of the protection device.

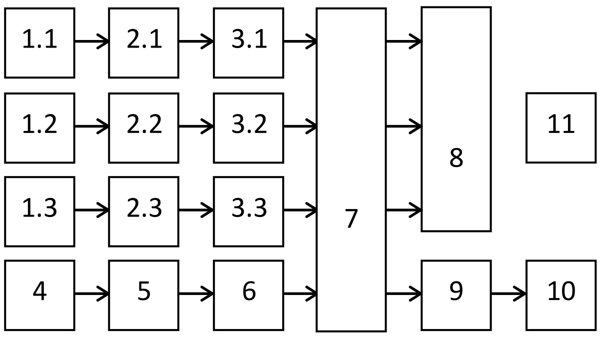

Fig. 1. The protection device block diagram

The measured phase voltage is rectified by the units 1.1, 1.2, 1.3 and then reduced by voltage dividers (units 2.1, 2.2, 2.3). Higher voltage harmonics are removed by the capacitor filter (units 3.1, 3.2, 3.3).

The voltages are fed to the microcontroller 7. It compares the voltages according to the algorithm. The signal unit 8 operates in the event of an emergency. The output of the microcontroller through the galvanic isolation 9 switches on the executive relay 10. Its contacts turn on and off the motor. The scheme provides for resetting the microcontroller and switching on the motor after elimination of an emergency situation. To control the temperature of the motor phases a temperature sensor 5 with primary converters 4, which are integrated into the windings, is provided. For trimming the temperature sensor unit 7 is used.

The developed protection device will reduce operating costs and increase the lifetime of the motor.

REFERENCES

1. Grundulis A.O. Zaschita elektrodvigatelej v sel’skom hozyaistve [Electric motor protection in agriculture]. Moscow: Agropromizdat, 1988. – 288 p. [in Russian].
2. Popova, I.O., Gryshenko O.K. (1998). Analiz vplyvu asymetrii naprugy na protses teplovogo iznosu izolyatsii asynkhronnykh elektrodvyguniv [The influence of voltage asymmetry on the process of heat dissipation in asynchronous electric motors isolation]. Melitopol, Ukraine: Scientific announcer of Tavria state agrotechnical academy, 1/8, Pp.14-18. [in Ukrainian].
3. Kurashkin S.F., Popova I.O. (2019) Prystrij zahystu grupy elektrodvyguniv [Protection device for asynchronous motors group]. Melitopol, Ukraine: Scientific announcer of Tavria state agrotechnological university, 2/8, Pp/ 229-236. [in Ukrainian].