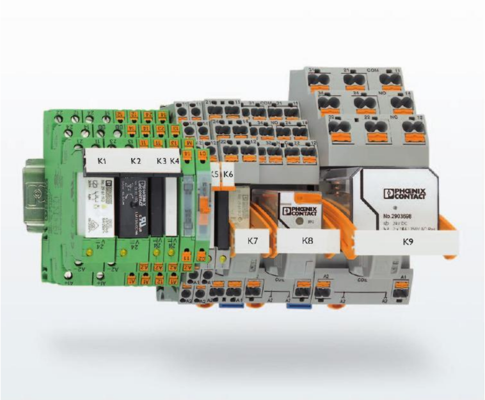
Electromechanical relays and relay modules

Electromechanical relays and relay modules for use in switchgear assemblies in accordance with DIN EN 61439, temperature rise verification



Application note
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1 Description

With the introduction of the new standard "Low-voltage switchgear assemblies - Part 1: General specifications" DIN EN 61439: 2010-06, new tasks have arisen for planners, switchgear manufacturers and electricians. This document describes how, when necessary, electromechanical relays and relay modules installed in switchgear assemblies can be taken into account in a practical manner when calculating the temperature increase. Section 5 „Recommendation" provides easily workable recommendations for the respective Phoenix Contact products derived from a practical sample calculation.

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2 The new DIN EN 61439 at a glance

The standard for "Low-voltage switchgear assemblies - Part 1: General specifications" DIN EN 61439: 2010-06 is binding for switchgear assemblies as of the withdrawal of the previous version on September 23, 2014. This basic standard is expanded by applicable switchgear assembly standards (from Part 2 onward), which for their part define specific requirements for e.g. switchgear assemblies, installation distributors, electricity distributors in buildings and cable distribution boards. The scope of application of this standard covers switchgear assemblies

- whose rated voltage does not exceed 1000 V AC or 1500 V DC
- which are stationary or mobile and designed with or without housing
- which are used in the generation, transmission, distribution or conversion of electrical energy and for the control of operating equipment which consumes electrical energy
- which are intended for the electrical equipment of machines
- which are intended for use under special operating conditions, e.g. on ships or rail vehicles.

The new series of standards defines clear rules for switchgear assemblies. It specifies the safety requirements for the electrical operating equipment of planners, systems manufacturers, electricians and end users in order to define protection objectives for people and systems.

A switchgear assembly is defined as one or more low-voltage switching devices with the associated modules and equipment for controlling, measuring, protecting and regulating the required line and rail distributions. Switchgear assemblies include the following electrical equipment and modules: circuit breakers, miniature circuit breakers, motor starters, electronic modules, residual current safety equipment, relay modules, modular terminal blocks etc.

Point 1 of the "Scope of application" standard expressly declares that the standard and thus also its design verification applies not only to individual equipment and modules which can be used by themselves, but also that these must conform entirely with the applicable product standard. For relays this is DIN EN 61810.

3 Temperature rise verification as part of the design verification

Point 10 of the standard describes the design verification of a switchgear assembly. It serves as a verification from the manufacturer that the switchgear assembly is in accordance with the requirements of this series of standards. The results are to be documented in a test report. According to point 10.10, compliance the temperature rise limits of a switchgear assembly must also be verified. If these limits are exceeded, measures for additional cooling or ventilation may arise in practice. The standard allows various procedures for temperature rise verification: In addition to practical testing or the derivation of similar variants from measurement, 10.10.1 c) also provides for calculation.

According to 10.10.4, the procedure of calculating the temperature rise of a switchgear must always take into account the power dissipation of all installed equipment. This requires that the manufacturers of the equipment provide the corresponding values. In practice, it is difficult and only possible with great effort to determine the power dissipation of certain equipment with sufficient precision. This also includes electromechanical relays and relay modules.

4 Practical handling of power dissipation data for relays and relay modules

The power dissipation of an electromechanical relay or relay module always consists of the input power dissipation or coil power dissipation P_1 and the contact-side power dissipation P_2. The first partial value P_1 can be precisely calculated from the rated values input or coil voltage U and input or coil nominal current I through multiplication ($P_1 = U * I$).

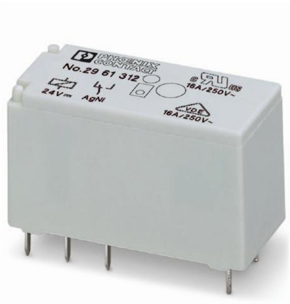
The contact-side partial value of the power dissipation P_2 can in principle be calculated with the load current I and the contact resistance R through $P_2 = I^2 * R$. Unfortunately, the power dissipation depends very heavily on the application, specifically from the square of the load current. In actual applications of relays in switchgear assemblies, it can reach over 3 to 4 powers of ten (mA range up to 2-digit A range). The square of the current and the resulting mathematical power dissipation value thus already extends to 6 to 8 powers of ten.

Furthermore, the contact resistance of a relay is not a constant and reproducible measurable variable. Its value varies from relay to relay, from switching cycle to switching cycle, with the load current and over time. Typically, contact resistance diminishes as contact current increases through the increase of the current-carrying contact area. With very small contact current in the lower mA-range the contact resistance can range from a few 100 mΩ to a few ohm, it is typically only a few mΩ. in the upper load range of a relay. Toward the end of the service life of a relay, the contact resistance increases due to the contact erosion/abrasion and the resulting low contact pressure.

It is therefore readily apparent that no generally valid power dissipation value covering all applications in switchgear assemblies can be meaningfully calculated by the manufacturer of the relay or relay module.

The following presents a sample calculation which can determine the power dissipation of a relay or relay module for most applications with sufficient precision using a practical, pragmatic approach. To this end, a power dissipation calculation with contact-side maximum data (worst case approach) is compared with a calculation using contact-side typical data (practical approach) and the results are evaluated.

The following sample calculation applies to a relay employed in high-volume quantities in the industry (REL-MR-24DC/21HC, Order No.: 2961312). With this type the differences between the two approaches become especially clear.



The following data from the data sheet is used as the basis for the calculation:

General data	
Permissible operating mode	100 % operating time (ED)
Input data	
Nominal coil voltage	24 V DC
Nominal input current	17 mA
Output data	
Contact type	1 changeover contact
Nominal contact current	16 A
Max. contact resistance	300 mΩ (in accordance with EN 61810-7, contact load category CC1)

4.1 Worst case approach with nominal/maximum values

Total power dissipation P = input/coil power dissipation + contact-side power dissipation

Input power dissipation = 24 V DC * 0.017 A = 0.408 W

Output power dissipation = 16 A * 16 A * 0.3 Ω = 76.8 W

Total power dissipation P = 77.2 W
(rounded to one decimal point)

Assessment

Even under optimal conditions (installation in the open air, 20 °C ambient temperature), the small relay, which measures only a few cubic centimeters, can only discharge power in the single-digit wattage range.

The theoretically (!) determined power dissipation does not correspond to reality and should never be used to calculate the power dissipation of a switchgear assembly. Possible consequences would be the implementation of an excessive but actually unnecessary cooling measure and the resulting decreased competitiveness of the manufacturer of the switchgear assembly.

4.2 Practical approach using standard applications with typical values

This approach starts from the premise that relays in switchgears are mostly used for switching binary switching signals in digital inputs (mA range) as well as for switching solenoid valves, contactor coils, servomotors, signal lamps and similar loads (mA range up to approximately 1 A). Selected calculation values: 10 mA, 100 mA and 1 A. Loads with higher continuous currents may occur but are generally not the rule. It is also assumed that currents are up to 1 A with an average contact resistance of 20 mΩ, which also includes standard bases for installation on DIN rails.

Total power dissipation P = input/coil power dissipation + contact-side power dissipation

Input power dissipation = 24 V DC * 0.017 A = 0.408 W

Output power dissipation (10 mA):
0.01 A * 0.01 A * 0.02 Ω = 0.000002 W

Output power dissipation (100 mA):
0.1 A * 0.1 A * 0.02 Ω = 0.0002 W

Output power dissipation (1 A):
1 A * 1 A * 0.02 Ω = 0.02 W

Total power dissipation P = 0.4080002 W to 0.428 W

When rounding to one decimal point, there is no difference between them, not even for pure input/coil power dissipation.

Assessment

In most applications, power dissipation values calculated on the basis of an approximately "real" contact resistance (very low, especially with higher currents) and contact currents that are typical in practice are greater than the input power dissipation by such a small amount that the **contact-side power dissipation can be disregarded up to contact-side currents of approximately 1 A in the first approximation.**

The values calculated above are valid for 100 % operating time (ED), i.e. for permanent activation of the coil. Since this is normally not the case in practice for all the relays used in a switchgear, the real power dissipation values in the actual applications are sometimes significantly lower. At 50 % ED, for example, the value is only half as high (in the sample calculation 0.214 W). In other words: Even disregarding the contact-side power dissipation, the use of full input/coil-side rated values for many real applications with an ED lower than 100 % still results in clear calculative reserves.

5 Recommendation

On the basis of the preceding observations, Phoenix Contact recommends the use of the coil and input-side power dissipation of electromechanical relays and relay modules with switching currents up to 1 A as a sufficiently precise basis for calculating the power dissipation balance of a switchgear in many applications. The coil-side and input-side power dissipation for the most important series is documented in the technical data at the address phoenixcontact.net/products.

6 Exceptions to this recommendation

Exceptions to this recommendation arise when relays are operated with load currents significantly higher than 1 A, especially at 100 % ED.

In these cases, or when you are otherwise unsure, please contact the Phoenix Contact sales organization and provide all the application data relevant to the power dissipation. On this basis, a sufficiently precise power dissipation value for the relay or relay module can be determined for the respective application.