MOTOR CHOKES

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Thyristor converters are the most frequently applied supply and electric motor regulation systems. In order to improve the mechanical characteristics and dynamic properties of thyristor power transmission systems, the motor chokes are quite often placed between a motor and converter system.
The single-phase ED1S and three-phase ED3S motor chokes are manufactured by the ELHAND TRANSFORMATORY Company in Lubliniec.

The motor chokes are widely applied in converting power transmission systems with both direct and alternating current. Depending on the type of power transmission system with which they operate, they have many tasks do fulfil, e.g. ensuring continuity and smoothing the pulsation of the motor current, minimising the short circuit current in the converter load circuit, as well as decreasing commutation overvoltages and compensating the supply line capacity.

Motor chokes tasks in controlled rectifying systems

The pulsation of the rectified current in the circuit of the motor, supplied by a controlled rectifier, creates sparkling under brushes and hinders the commutation process. When properly selected, the ED1S motor choke, placed within the rectifier load circuit, enables limiting the effective value of the current first harmonic to the permissible level (2-15%) of the rated current, dependant on power and the motor angular velocity regulation range. The circuit induction, necessary for maintaining the permissible value of k^{th} current harmonic ΔI_k (%) in the circuit and by knowing component amplitude of the rectified supply voltage variable $Ud_{Z,}$ is determined from the dependency (1) [2,3]

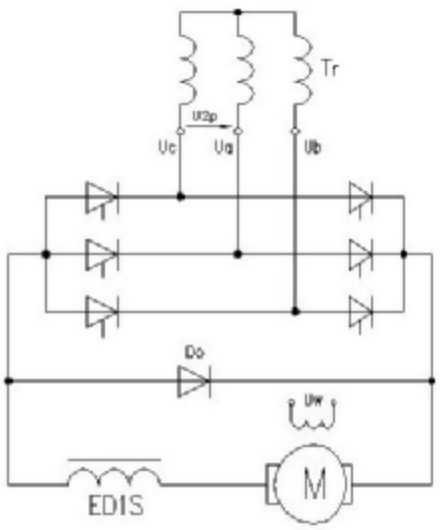
$$L_{ob} = \frac{Ud_z \cdot 100}{wkm\Delta I_k(\%)Id_n}, \quad (1)$$

where: w -pulsation, m – phases number, k – harmonic multiplication factor, Id_n – rectifier's current rated value, $DI_k(\%)$ – permissible value of the respective current harmonic.

By knowing the essential circuit induction L_{ob} and the machine armature induction L_t, the induction of the ED1S motor choke, limiting the current pulsation in the rectifier load circuit, may be determined (2) (drawing 1)

$$L_{ED1S} = L_{ob} - L_t, \quad (2)$$

However, one should bear in mind that the magnetic material of the core and the motor choke structure ought to make it possible to maintain constant induction with the armature current equalling the double value of rated current. This condition results from the converter current overload capacity [2,1,5].



Drawing 1 Simplified diagram for three-phase symmetric bridge [2]

The lack of continuity in the current course within the circuit supplying the motor makes unfavourable changes in the course of the

motor mechanical characteristics and leads to worsening the power transmission dynamic properties. For this reason, one of the most important tasks of the ED1S motor choke is to assure the wide range of the current continuous conduction within the converter output circuit. This current becomes non-continuous when the current and load induction values are smaller. By determining the load current boundary value I_{dgr} in the manner presented in [2] and by knowing the converter type and parameters, it is possible to define the lowest circuit induction value L_{ob}, that will ensure the converter continuous load current flow. For the three-phase converting bridge system (drawing 1), it equals (3) [2,3].

$$L_{ob} = \frac{1}{w}\left(0.126\frac{U_{2p}}{I_{dgr}}\sin a - 2X_a\right), \quad (3)$$

where I_{dgr} – converter load current boundary value, at which the change in the current character takes place, X_a – anodic circuit phase reactance, U_{2p} - e inter-conductor voltage supplying the converter

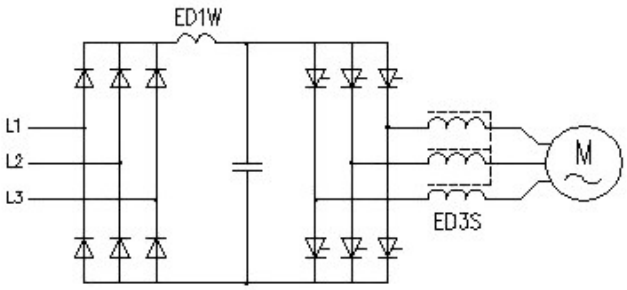
On the basis of the circuit induction and parameters of the machine supplied, it is easy to determine the ED1S (4) motor choke induction that, when installed in the circuit, ensures the motor current continuous character [2,5].

$$L_{ED1S} = L_{ob} - L_t, \quad (4)$$

where: L_{ob} – circuit induction determined from dependency (3), L_t – armature induction set out on the basis of the machine type and technical parameters.

The role of motor chokes in the alternating current power transmission systems

Inverters output voltages are the series of rectangular impulses with regulated widths and frequency. The speed of the voltage course impulse accrual is very high and poses a threat for the machine-supplied insulations. Limiting the speed of the voltage accrual and, consequently, the risk of damaging the motor insulation is possible by placing the ED3S (drawing 2) [1,3] motor choke between the motor and the inverter.



Drawing 2 Simplified diagram for the converter supplying a squirrel-cage motor

The ED3S motor chokes are also used to limit short-circuit currents by the time protections work and the current in the circuit is switched off. The selection of suitable induction for the motor choke is usually the only possibility to protect thyristors (power transistors) of the converting systems (drawing 2). The selection of the ED3S motor choke induction is dependant on the maximum value of the short-circuit current in the system. This current may not exceed the thyristor current non-repeatable peak value I_{TSM} [2,1,3].

In practice, it is often necessary to lead the voltage to the power transmissions at a distance from the supply source. Long supply lines have large capacities, due to which the increase of power loss in the circuit is observed. [6]. The ED3S motor choke, apart from protecting the machine insulation, compensates the supply line capacity and limits the harmonics and commutation overvoltages in the motor circuit. The ED1W choke is placed in the converter mediating circuit in order to smooth pulsation and to ensure the continuity of the rectified current. The optimum selection of its induction has a considerable impact on the entire power transmission system operation.

Motor chokes structure

Motor chokes, depending on the power transmission system type and operating conditions, are manufactured in single-phase and three-phase versions, for naval and land use. Rated currents of such chokes reach hundreds of amperes and their inductions are within the range of tens of millihenries. The application requirements and technical parameters resulting from this lead to significant dimensions of ready-made magnetic devices.

Motor choke windings are usually coiled with copper round winding wire and, for greater current loads, with rolled formed wire or a band.

The core is manufactured from silicon sheet, of a thickness between 0.25 and 0.5 mm. After the windings and cores assembly, the chokes undergo a vacuous impregnation process, which ensures the reliability of the line chokes produced in hard environmental conditions and also results in lowering the power losses. Furthermore, the chokes are equipped with terminals and cable tips, angle plates and transportation grips.

The final production stage of the motor chokes consists of the tests carried out at the electrical test station on the basis of the norms currently in force.

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