SMOOTHING CHOKES

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In the load circuit of each rectifying system, output voltages are received, being the sum of two components: constant and variable. For the purpose of ripple reduction, usually unfavourable for the receiver, a rectifying filter is switched on, between the rectifier outlet and load.

The ELHAND TRANSFORMATORY Company from Lubliniec is the manufacturer of ED1W smoothing chokes that are used in rectifying filters.

SMOOTHING FILTERS

The task of smoothing filters is the correction of the voltage and rectifier current time course shape. The filter arrangement has little impact on the constant component value; however, it limits the component variable and thus the pulsation ratio.

The properties and operational effectiveness of the rectifying filter are determined by the smoothing ratio:

$$b_s = \frac{k_{t1}}{k_{t2}}, \qquad (1)$$

where: k_{t1} i k_{t2} are the pulsation ratios (voltage or current) at the rectifier outlet and inlet, respectively.

It is the ED1W smoothing choke, switched on to the series, that plays the function of the filter (Drawing 1a). With the induction of the smoothing choke operating in the rectifier output circuit m – pulse type, supplying the receiver with the resistance R and the given voltage and output current b_s the smoothing ratio is expressed on the basis of the following dependency:

$$L_{ED1W} = \frac{(1 - b_s)(R + r)}{2pfmb_s}, (2)$$

where: R- receiver's resistance; r- rectifier circuit internal resistance; m- ratio dependant on the rectifier's type; b_s- smoothing ratio; f – frequency of the voltage supplying the rectifier.
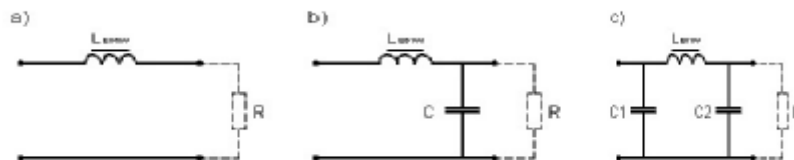

Drawing 1 The most common smoothing filters systems: a) induction-type, b) G-type: induction & capacitive, c) P-type: induction & capacitive.

In the single-phase one-pulse rectifiers with induction filter, it is difficult to obtain a continuous character of the current in the load circuit, for the current impulses occur every second half-

period. For this reason, the induction filters rarely operate with one-pulse rectifiers. More frequently, it is the single-phase two-pulse rectifiers with a filter in the form of an induction choke that are used (Drawing 2). In this system, even with relatively small load currents, the continuous flow of the current without large ripples occurs.
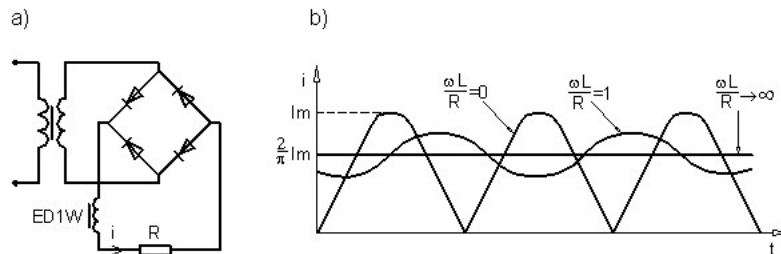
Drawing 2 Two-pulse bridge rectifier with induction filter. A) system diagram, b) currents time courses.

If the choke reactance >>R, then there is a very good current ripple filtration in the circuit. An additional advantage of this system is the fact that the current average value $2/pI_m$ does not depend on induction. Limiting the current ripples by increasing the choke induction does not result in voltage losses.

The rectifying filter in the form of the ED1W smoothing choke will do its task more effectively when operating with the rectifier, in which the frequency of the component variable is a few times higher (e.g. in the impulse rectifiers). In rectifying systems supplied with industrial frequency voltage, voltage and current smoothing by means of the choke only would require the use of elements with very large inductions. That is why, in practice, the induction filters are usually used in three-phase systems with higher power [2].

By combining the smoothing choke with the condenser, one gets the LC filter structure (Drawing 1b, 1c) with parameters advantageous both for low and high load currents. The choke in the system is a series impedance and the condenser additionally shunts the load for the component variables. It is quite often the case that the ED2W chokes are used as the smoothing chokes variation. They have two independent windings placed in the core in a U shape. They are used in the systems co-operating with multi-pulse rectifiers of great powers.

Drawing 3 ED2W smoothing choke diagram

If the effectiveness of a single filter is too low, further limitation of the component variable can be obtained by building a multi-stage filter, comprising a few links combined in the form of cascade. The resultant smoothing ratio equals:

$$b = b_1 \cdot b_2 \cdot \mathbf{K} \qquad (3)$$

where: b – multi-stage filter smoothing ratio; b_1 ,b_2 – smoothing ratios of the filter subsequent stages.

It is important to remember that the smoothing filter application considerably affects the output characteristics of the entire rectifying system. In non-stationary states arising while switching the rectifier in the circuit on and off, significant current or voltage oscillation may occur, caused by the resonance nature of LC system and the quality factor [3,4].

Smoothing choke structure

The ED1W and ED2W smoothing chokes are manufactured in the single-phase version. It is the current and induction that are the basic parameters of these chokes. To great extent,

these values depend on the type of the rectifier with which the choke operates and on the power of the supplied receiver.

The choke windings are coiled with copper round winding wire or rolled formed wire. The core is manufactured from electromagnetic silicon sheet (El or U shape), of a thickness between 0.25 and 0.5 mm.

After the windings and cores assembly, the chokes undergo the process of vacuous impregnation, which ensures the reliability of the smoothing chokes produced in hard environmental conditions and also results in lowering the power losses. Furthermore, the chokes are equipped with terminals and cable tips, as well as mechanical instrumentation. Finally, the completed chokes are directed to the electrical test station, which is the final production stage.

All the activities, from material purchasing to packing the completed product, are carried out in accordance with the procedure for quality assurance system ISO 9002.

Bibliography

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