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Characteristics of Input Signals of Protection of Alternating Current Electric Motor in Transient and Steady States

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1 INTRODUCTION

The active Rules of the power plants device (RPD) specify winds of the stator of the electric motor (EM) of alternating current of voltage for protection above than 1 kV from multiphase short circuits (SC) installation only of current protection performed as current cutting or longitudinal differential current protection. Use of relay protection (RP) realising other principles and functioning algorithms, and so as the installation of back-up protection on EM, including high-power capacity, active Norms and Standards is not provided at present (in spite of ample opportunities of digital equipment in practical realisation of any algorithm of functioning of RP).

Pleasantly to note that in actual practice the manufacturers of microprocessor RP (MPRP) are advanced, offering, for example, expansion of functionalities of current protection regulated by RPD. So, for example, scientific and technical centre “Mekhanotronika” in its terminals of digital protection for EM of voltage 6-10 kV series give chancey is granted to the users of digital protection to execute the steps of current EM protection by directed. Use the devices of RP for protection of stator winding of EM from multiphase SC realising other algorithms, is not provided. Authors believe that in digital EM protection terminals realisation and some other algorithms of revealing of inside SC in EM, for example is expedient, with the aid of the devices of remote protection.

As well as any other apparatuses traditionally used in RP outlines electromagnetic current transformers (CT) and voltage transformers (VT) introduce errors to measured signals influencing determined to work of RP even with their insignificant and admissible values [1].

During passing of primary signals of RP through electromagnetic SC being [2] the key pathes elements of transformation of these signals, the last can be deformed substantially both in size, and in phase. Present work is devoted to research of characteristics of mentioned RP devices signals of stator winding of EM of voltage above than 1 kV in transient and steady-state modes of their work, as distortions of these signals have essential influence stability of RP functioning.

2 MAIN PART

At the evaluation of behaviour of RP devices, as well as at execution of necessary calculations, as known, errors, introduced by primary detector mounts to measured sizes should be taken into account. The RPD is specified for current protection to take into account the values of current or total errors, for current directed and distance protection - current and angular.

Errors of electromagnetic CT used in outlines of RP of high-voltage EM, depend on substantially processes proceeding in primary EM circuits. In steady-state EM operating mode these errors do not exceed admissible values determined by Norms and Standards what it is impossible to say about transient conditions. The transients in EM phenomenones have determined features as compared with transient phenomenones in other elements of power plants, for example, generators or synchronous compensator. It concerns, primarily, processes of EM starting up, as exactly in these modes on the phases of stator winding not only periodic and aperiodic components of starting EM current, but also the currents of variable frequency influencing specifications essential to magnetic condition of cores of transformers.

A duration of batching of aperiodic components of starting current, as rule, is insignificant, what it is impossible to say existence of components of variable frequency of the time (for EM high-capacity is up to 1 and more seconds). The currents of variable frequency long by magnetized cores of the transformers, causing their deep saturation, resulting in significant errors in secondary signals. Batching of currents of variable frequency on the phases of stator winding of EM is characteristic for the modes of starting up not only asynchronous electric motors (AM), but also synchronous electric motors (SM) [3,4].

On the fig. 1 experimental time-dependent change oscillogram of starting up non-loaded SM of the type STD-3150 of secondary current of transformer of type TLM -10 installed in the phase A protection on the part of linear conclusions of stator winding of SM, secondary current of a transformer of type TPOL -10 installed in the same phase of DP on the part of zero conclusions of stator winding of SM, as well as the current of unbalance proceeding in current circuit of the same phase of DP is presented. Characteristic of given case is that secondary winds of the classes 0,5 and 10P CT of type TPOL -10 installed in zero conclusions of stator winding of SM, for reduction of the load on CT, are included consistently.

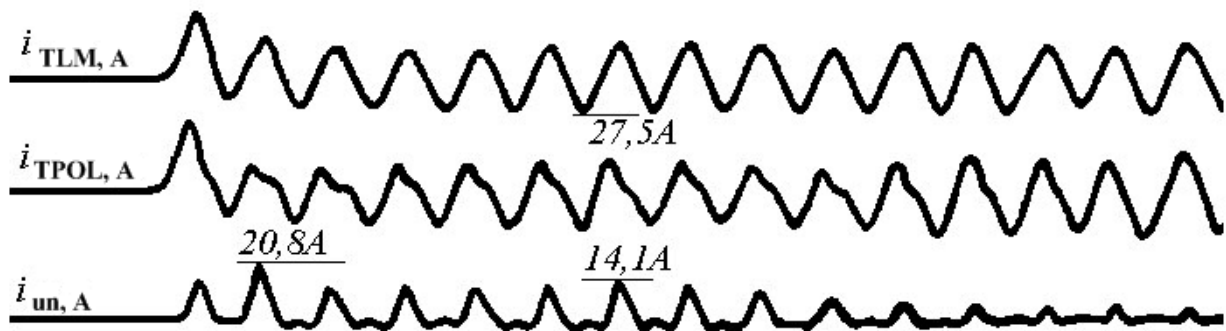


Fig. 1: An oscillogram of secondary currents of transformer and the current of unbalance in the phase And protection at start-up of SM of capacity 3150 kWt

We will analyse oscillogram. An aperiodic component of starting current proceeding in phase A stator winding of SM, in the first period causes saturation only of core of transformer installed on the part of zero conclusions of stator winding and having significant load from connecting wires. The core of transformer installed on the part of linear conclusions of stator winding having considerably smaller load, enters the mode of saturation, beginning from the second period. Condition of deep saturation of cores of both CT is supported by the current of variable frequency and after attenuation of aperiodic component of starting current.

On the fig. 2 phase voltage time-dependent change oscillogram A on feeding buses, secondary type TWLM -10 specifications currents installed on the part of linear conclusions, (shoulder 1) type TPOL -10 specifications - on the part of zero conclusions of winding of the stator, (shoulder 2) as well as the current of unbalance in given DP phase received under conditions of experimental starting up non-loaded AM of type 2AZM-4000/6000 is presented.

We will analyse oscillogram. Voltage in initial moment of starting up is lowered accounts for $0,83U_{nom}$, remaining on form sine wave. An aperiodic component of starting current transformer in phase A stator winding of EM, in the first period causes saturation core of a transformer installed on the part of zero conclusions of stator winding and having significant load from connecting wires. Core of a current transformer installed on the part of linear conclusions of stator winding having

considerably smaller load, enters the mode of saturation beginning from the second period. After champing of aperiodic component of starting current in the phase C from stator winding of AM core of CT gradually leave a deep saturation. Repeat deep saturation of core of CT is caused by magnetized action to the cores of CT of variable frequency proceeding on given phase of stator winding of EM. Duration of the second stage of finding of cores of CT installed in the circuits of the phase C from stator winding of AM, under conditions of deep saturation exceeds 0,3 s. (at start-up of EM with shaft load duration of the second stage is considerably more).

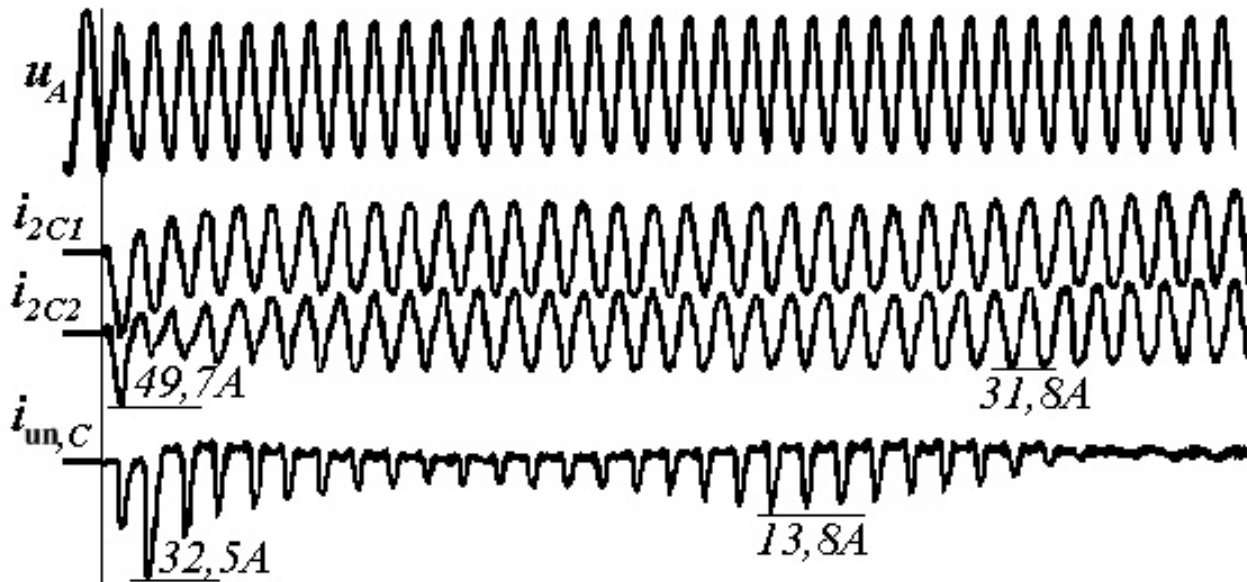


Fig. 2: An oscillogram of time-dependent change of phase voltage, secondary currents of transformer and the current of unbalance in the phase A protection at start-up of AM of capacity 4000 kWt

As exemplified by presented oscillograms, saturation of cores of CT results in a long distortion of secondary currents CT that it is reflected on characteristics of input signals of RP. We will analyse with the aid of program [5] calculation of transient and steady-state processes in current RP circuits of characteristics of secondary currents of CT installed on the part of linear and zero conclusions of stator winding of AM, with reference to such as above experiment data - type 2AZM-4000/6000 AM starting up.

On the fig. 3 time-dependent change of the values of amplitude of the first harmonic component of secondary current (in % from amplitude of starting current of EM) and angular errors of CT type TPOL -10 (in electric degrees) on the main harmonic is shown. The cores of CT reach the largest saturation in the second period, at the same time amplitude of the first harmonic of secondary current accounts for 63,2% from amplitude of starting of AM current, and angular error for CT reaches $-29,4^\circ$. Saturation of core of CT by the current of variable frequency repeatedly results in reduction of amplitude of the first harmonic to 83,9% and increase of angular error on the first harmonic to $-16,8^\circ$. Be to be noted that to such as above values they are not the largest, as considerable influence render as well other factors on them, for example, the value of the resistance of control cables, spread of characteristics of magnetisation.

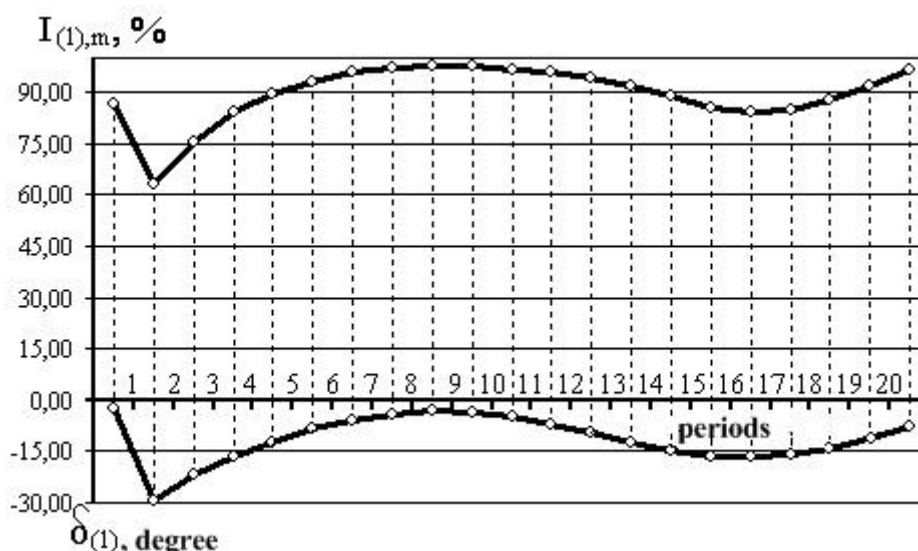


Fig. 3: Time-dependent change of amplitude of the first harmonic and angular type TPOL -10 specifications error at AM start-up of capacity 4000 kWt

For CT type TVLM -10 less loaded by specifications the appropriate errors is substantial below and values admissible by Norms and Standards are not exceeded.

The currents of variable frequency render a similar influence to specifications cores installed in other phases of winding of the stator of EM. Taking into account that the moments of approach of the maximum of the current of variable frequency in other phases turn out displaced in phase on (for natural frequency), we have the appropriate displacement of the time of the largest saturation of cores of CT from action of these components of starting current.

Deep saturation of cores of CT caused magnetized action to the cores of CT of aperiodic components of starting current EM, are characteristic as well for modes selflaunch [4], however their duration as well considerably less, than at saturation of cores of CT the currents of variable frequency in the modes of starting up EM.

The conditions inside damages in EM's winding are investigated to full extent and they published, for example, [4]. The errors of CT during passing through them of the signals of RP in steady-state modes of inside SC do not exceed values determined by Norms and Standards.

3 CONCLUSION

During passing of primary signals of RP through electromagnetic CT protection specifications of EM of alternating current enduring distortion of these signals significant in size and takes place.

Conducted researches of influence of distortion of input RP is signals of high-voltage EM can be used at development, research, choice of characteristics and parameters of operation of electric motors RP devices with two input signals.

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