Application Guidance Notes: Technical Information from Cummins Generator Technologies

AGN 070 - Magnetizing Transformers

DESCRIPTION

Although very high inrush currents are quoted during transformer magnetisation, this situation really only occurs when the transformer is being powered by the very low source impedance of a **Mains supply**. When a **Generating Set** magnetises a transformer, the inrush current becomes limited by the high source impedance of the alternator.

Test data and experience suggests when an alternator of the same rating as the transformer is being used to magnetise a transformer with an unloaded secondary, the typical level of inrush current (kVA) is generally in line with the transformers rated current (kVA).

This 'general' rule is subject to tolerance of some +/- 25% because of the influence of the transformer's lamination steel's remanence level retained by the molecule level magnetic orientation prevailing from the moment the transformer was last switched off.

When the newly applied ac voltage sine wave is applied, depending on whether this 'new' flux aligns or opposes the remanence, will result in the inrush current typically varying by the advised rated kVA +/- 25%.

Any impact load applied to an alternator, such as a block-load (starting a motor or magnetising a transformer) subjects the stator winding to a sudden, step load change that results in sudden step change of magnetic conditions within the alternator's stator winding assembly. This sudden step change results in complex forces being suddenly applied to the winding assembly, which effectively imposes flex and leverage between adjacent conductors and the conductors against the stator core's lamination pack.

This means that such impact loads should always be identified and carefully considered in an attempt to clarify the overall situation of how great this impact load will be and therefore, what is the risk of stator winding being overwhelmed by such stressful events; resulting in premature failure? In the case of magnetising transformer's, this task is not usually a repeated task conducted repetitively through a typical working period.

When starting motors, the overall objective is to ensure the resulting transient voltage dip will not be too high, for reasons associated with ensuring that the motor will not be stalled…etc.

When magnetising transformers, the Transient Voltage Dip (TVD) situation is often not of prime concern as there is unlikely to be a substantial level of already established loads. This allows much higher levels of impact kVA to be considered acceptable to a Generating Set supplied electrical distribution system.

Experience suggests transformers typically require 5% of rated kVA to support the No-Load magnetisation requirement, with this being at a low lagging pf. Undeniably, the excitation system for the proposed alternator must be of the type which consists of a PMG + MX type AVR, or auxiliary winding excitation.

In practice, applications that introduce concerns regarding the ability of the proposed Generating Set to magnetise the proposed transformer often face the challenge of magnetising more than one transformer in the form of a high voltage (HV) ring.

Such applications introduce the need for a smart approach. The following describes a 'Proven Scheme', which has been employed on many sites where the ratio of connected transformer kVA to Generating Set kVA exceeds 1.5 : 1.

The Proven Scheme

Sometimes the best way to magnetise a transformer is to excite the alternator into the already connected transformer. This method of controlled 'excitation-build-up' will provide a soft approach to transformer magnetisation by a soft voltage build-up of the alternator and so in turn, the magnetisation process of the transformer.

It does require the alternator to be fitted with an excitation system that can support a steady state short circuit current - this means the separately excited (Series 3) excitation system of PMG + MX type AVR must be nominated, or an equally suitable excitation system with auxiliary winding.

Method

1. Ensure the alternator excitation is switched off. On an MX type AVR, terminals K1 and K2 must be open circuit. A 240V ac 10A single pole switch may be used for this purpose.
2. Connect the stationary Generating Set to the transformer.
3. Start the engine and allow the Generating Set to run up to speed.

4. When the Generating Set is at full speed, switch on the alternator's excitation.

The AVR will now excite the alternator and as the excitation builds, the Generating Set output current will also increase, which will flow through the transformer's windings. Initially this current will rise to steady state 3 phase fault current level, but as the transformer's magnetisation process begins to build, the current level will fall. Correspondingly, the system voltage level will begin to rise. Within a matter of seconds the Generating Set output voltage will reach the rated voltage and the system load will consist of only the transformer's required magnetisation current.

When a number of Generating Sets are operating in Parallel, they should all be allowed to run up to full speed before switching on, in unison, each Alternator's excitation.

Maximum inrush current

It is possible to calculate the maximum inrush current of an alternator. This is based on the alternator's maximum kVA output rating against the safe limit of Transient Voltage Dip (TVD). Calculations are best explained using the following examples:

PI734F Winding 312. Class H temp' rise rating is 2080kVA at 400V. FLC = 3002A. In the locked rotor condition, the safe limit of TVD is 25%. The maximum impact for a limit of 25% is 3550kVA. 3550kVA at 400V = a **maximum inrush current of 5124A.**

HVSI804R Winding 83. Class F temp' rise rating is 2168kVA at 10.5kV. FLC = 119.2A. In the locked rotor condition, the safe limit of TVD is 25%. The maximum impact for a limit of 25% is 2450kVA. 2450kVA at 10.5kV = a **maximum inrush current of 134.7A.**