THE BENEFITS AND RISKS OF THE DELAYED EXCITATION METHOD FOR PARALLELING GENERATOR SETS

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INTRODUCTION

Among other conditions, in order to connect the electrical outputs of two or more electrical AC power generating sources, their voltages, frequencies and phase angles should be closely matched. Automatic synchronizers are typically used throughout the electric power industry for this purpose. For applications where it is critical to expedite the paralleling of multiple generator sets onto a common bus, an alternate method called delayed excitation or dead-field paralleling is a viable approach, if properly implemented. Misuse of this method increases the risk of equipment damage.

DISCUSSION

The universally accepted method used to achieve parallel operation of multiple generator sets relies on an automatic synchronizer and load sharing unit(s). This combination is commonly referred to as conventional paralleling controls. The basic approach is to closely align the AC voltage waveforms of two or more generating sources prior to connecting them electrically (i.e., closing their circuit breakers onto a common electrical bus). There is also an alternate method known as Delayed Excitation Synchronization, or Dead-Field Paralleling. In an early rendition of this method, the generator breakers would be closed upon the generator set reaching full speed; the residual magnetism on the machine would induce partial voltage on the generators, which would drive them into synchronization (basically aligning the phase angles as the frequency was already at the nominal value). Then, the field excitation would be gradually increased until full voltage is reached, and the generators would be ready to accept load. Following this sequence, the risk of damaging the equipment was very low, but paralleling took a long time. With the advent of modern automatic synchronizers the original dead-field paralleling practice was nearly discontinued.

In a later rendition of dead-field paralleling, the long synchronization time problem was resolved by closing the breakers and turning the excitation on as the generators (two or more) are ramping up in speed. There are a number of subtle variations, but they're generally aligned with this common theme; some provide a measure of control through manipulation of the AVR (voltage regulator). Since the electric machines are driven by separately governed engines that are coming up in speed independently, any mismatch in their speeds would cause the electric machine running faster to act as a generator (putting braking torque on the engine, causing it to slow it down), and the electric machine running slower to act as a motor (assisting that engine to come up to speed). Through this torque producing/absorbing mechanism, the generator sets bootstrap themselves into synchronism as they ramp up in speed. Although this significantly reduces synchronization time, it increases the potential risk of damaging the equipment. If the excitation is too high at the lower speeds, the risk of damaging diode packs on self-excited generators increases. If the excitation is too high at the higher speeds, the risk of damaging the exciter increases. Given that generators have been neither designed/intended nor specifically tested for this mode of operation, the bounds of what is "too high" or "too low" are not well known. Caution should be used in system design to minimize the risk to equipment, and to implement safeguards for aborting the delayed excitation process (e.g., open the breakers, if the speed difference between prime movers is significant, or if large reverse currents are measured, etc.). Due to the potential risk to equipment, the use of dead-field paralleling was limited to special cases where the need for quick paralleling outweighed the potential risk to equipment and installation, and where an engineered system could be designed and implemented to ensure proper functionality and protection.

Given the market pull for systems with sub-10 second paralleling, the interest in dead-field paralleling has been growing. In spite that several third-party paralleling controls manufacturers now offer variants of dead-field paralleling as an option in their higher end controllers, and the evolution of delayed excitation technology, it is recommended that the application of dead-field paralleling only be considered for adoption in systems requiring paralleling times unachievable by more conventional means. It should also not be used as a mainstream paralleling solution. Careful selection of control logic and parameters is critical to ensure proper functionality, system protection, and reduce risk to equipment.

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