Operating Dissimilar Alternators in Parallel

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MECHANICAL AND ELECTRICAL ENGINEERS

Although it is a relatively uncommon occurrence, every so often the question arises as to the feasibility of adding new generation equipment to an existing generator or generator system. The easy answer, and in most cases the best solution due to lack of maintenance, obsolete equipment, or lack of functionality, is to replace the entire plant with a new and larger system. On the flip side, there is always an economic advantage to expanding an existing standby power plant.

Older alternators and their associated governors, regulators, and excitation systems are rarely identical with new equipment, and these differences cause a host of both minor and major problems. Most can be resolved rather easily. Most new governors are easily retrofitted to old fuel systems (although actuators are not similar). Regulators are not necessarily compatible depending on the type of excitation system, and of course, the winding characteristics of different alternators cannot change.

The inability to equally share kilowatts or vars is the usual problem. In the worst cases, this type of problem causes a severe reduction in the overall capacity of the generation system. For example, in a system with four 1,000 kW generators, if one generator normally operates at 65 percent load, while the others operate at 50 percent load, the overall capacity of the plant is reduced by 18 percent. The owner who thinks he has 4,000 kW of capacity really has about 3,310 kW before the first generator will go into overload.

As mentioned, most problems relating to the sharing of kilowatts can usually be resolved with converting governors from droop-style to electronic. Of greater concern is the inability to share vars equally, and the end result of this type of problem is, once again, the reduction in plant capacity, but from a current standpoint and not a load standpoint.

The main problem with sharing vars is due to the different waveform shapes produced by the various alternator manufacturers. Every alternator produces an imperfect sinusoidal waveform which is again different from each other. When paralleled, these minor differences (i.e., distortion) are considered as a difference in potential. The only source of impedance in this circuit is the impedance of the lines and the impedance within the unit itself. As a result, a current will circulate between alternators.

The differences in waveform are due to the physical construction of the alternator windings, and the way they are placed in the armature slots. If one winding overlaps another of the same phase, then they will have a winding pitch value less than unity. The amount of overlap determines the degree of pitch. As the rotating field lines cut across the armature slots, the induced voltage is distorted because of the overlap of the windings, hence, the voltage wave is distorted with multiples of the 60 Hz fundamental.

In the interest of economy, no alternator manufactures winds their units at full pitch. A typical alternator would be approximately twice the physical size of another built at 2/3 pitch for example. Even with a full pitch alternator has some harmonic distortion simply due to the way they are placed in the armature slots as well as the shape of the slots. Regardless of the amount of distortion, if perfectly identical alternators are operated in parallel, there will be no circulating current. At any given moment, there will be no difference in voltage, including the voltage of the harmonics.

The amount of circulating current is also affected by the overall impedance of the lines between the generators, as well as the impedance within the alternators. The higher harmonics (5^{th}, 7^{th}, 9^{th}, etc.) are not normally a problem because the impedance of a particular system varies with the frequency of the system. The higher the frequency, the higher the impedance, thus more attenuation is available to dampen the high frequency current.

Third harmonics present a particular problem because the system impedance is usually low enough in typical installations to have minimal dampening effects. If the generators were very far apart, the line impedance would be high and the amount of current would be greatly reduced. An equivalent method of introducing such an impedance in the system is through the use of a line reactor.

Third harmonic voltages are present only across the phase-to-neutral circuit because they have the exact same angular displacement in relation to one another. The resulting current, therefore, travels along the neutral between two generators and then back through the phase lines. A simple means to eliminate nearly all the third harmonic current in a system is to merely disconnect the neutral lead of the generator that is the cause of the excessive current. The only condition that must be met with this fix is that the unit with the disconnected neutral must never be allowed to operate as the sole engine on line. This can easily be achieved through appropriate interlocking in the controlling switchgear.

If nothing is done, the measured current becomes a derating for the standby power plant. But keep in mind that the derating current is a reactive current. If your system operated at unity power factor, and the generators are rated at 0.8 power factor, the derating has no effect on the capacity of the plant until the harmonic current reduces the system power factor to 0.80. If the building system already operates at 80 perce4nt power factor, then the derating of the standby generator plant is immediate, and load planning must take this factor into account.

Without at least taking these factors into consideration, there is a risk that a system with old and new generators may not function as desired, or may not achieve the goals that were originally planned for the standby power plant.

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