BY RICHARD CADENA

Practice problem perplexes aplenty

IF YOU ARE PREPARING to take the ETCP Entertainment Electrician Certification exam, or if you have taken it in the past, you might have tried taking the practice exam at http://etcp.plasa.org/practiceexams. If not, then you really, really should, because it's one of the best ways to prepare for the real exam. If you have, then you might have come across a question about portable generators, in which case you were likely stumped. I was.

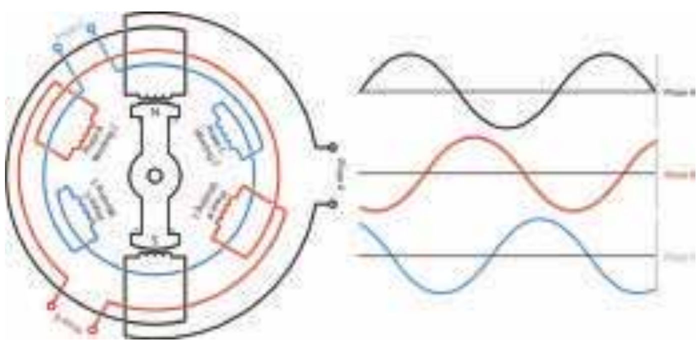
> *On a film set, an entertainment electrician has a sustained load of three - 24 kW fresnels (240 V) powered by a three-phase generator set to single-phase. Which of the following generators is the MINIMUM size required to power the luminaires?*
> *A. 50 kW*
> *B. 75 kW*
> *C. 100 kW*
> *D. 125 kW*

It took me a long time, perhaps a year or more, to understand the solution to the question. I know a lot of you have struggled with the answer, because I get a lot of email asking about the same question. It's a question that requires some knowledge of how portable generators are built and how they operate.

I could just give you the answer, but that would not help you in the long run. Instead, let's deconstruct the portable generator on paper and see how it works and why the solution to this problem is what it is.

The part of the generator that rotates is called the rotor. The part that is stationary is called the stator. It's complicated, I know. The generators we typically use in the live event production industry typically have four poles, which makes the rotor look sort of like a spinning cross or "+" sign. Each pole is wound with copper wire, and an exciter current is run through the winding in order to create a magnetic field. When the magnetic field passes by the stator coil, it generates a voltage. Since the magnetic field is rotating, the voltage it generates is a sine wave. That's how we get the output waveform.

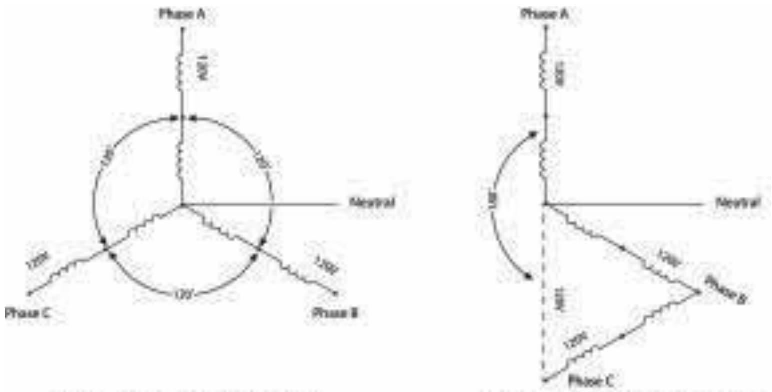
Most portable generators used in the live event production industry are of the three-phase, as opposed to the single-phase, variety. In a three-phase generator, there are three pairs of windings in the stator, one pair for each electrical phase. Each phase winding is physically located one-third of the way around the outside of the stator. As the magnetic field rotates, it generates a separate voltage waveform in each phase winding, and they are electrically timed so that the waveform in phase A is 120° ahead of phase B, which is 120° ahead of phase C. Not only are the phase windings physically spaced 120° apart from each other, but their voltage waveforms are also 120° apart from each other.



As long as a three-phase generator is operated in three-phase mode, then there are three independent waveforms, each providing its own voltage and current. This is the typical four-wire-plus-ground-power distro scheme with green, white, black, red, and blue conductors which we see in the live event production industry almost every day.

But if a three-phase generator has the ability to run in single-phase mode, then there's a switch that allows you to reconfigure the windings so that they are connected in series rather than being wired with one common node, as shown in the illustration on page 75. When you change the configuration from three-phase to single-phase, you are rewiring the generator internally so that the output of phase A is fed to the output of phase B, and the output of phase B is fed to the output of phase C. The neutral is the center tap between phase A and phase B. The generator windings then act as two sets of windings instead of three. One winding is for phase A, and the other is the combination of phase B and phase C. The effective number of windings has been reduced from three to two.

In any generator, the limiting factor for output current is the melting temperature of the insulation on the conductors. If the generator tries to output too much current, the conductors get too hot and the insulation will start to melt. In single-phase configuration, phase B and phase C are connected in series, so, instead of being able to provide the full output current through phase B and the full output current through



Three-phase Configuration   Single-phase Configuration

phase C, the effective output current is halved for those two conductors. Now, instead of the three-phase generator being able to output the current of one of the phases times three, it can only output the current of one of the phases times two. That effectively reduces the output of the entire generator by one-third, so its output goes from X to 2/3X.

For example, in a three-phase, 150 kVA generator, the total number of amps it can output at 120 V is 1,250 (150,000 VA ÷ 120 V = 1,250 A) or 417 A three-phase (416.7 x 3 = 1,250). If the same generator is switched to single-phase operation, then the total number of amps is reduced by one-third, making the total number of amps go from 1,250 to 833 (1,250 x 2/3 = 833.3).

With that information, you should be able to correctly answer the following question:

If you have a portable lighting system with a total power requirement of 1,000 A at 120 V, and you are to power it with a three-phase generator set for single-phase operation, what is the smallest sized generator that you could use for the job?

Email your answer to me (rcadena@APTxl.com) and one correct answer will be chosen from a random drawing to receive an Academy of Production Technology coffee mug. ■

Richard Cadena is Technical Editor of *Protocol*, *Lighting&Sound America*, and *Lighting&Sound International* and serves as PLASA's Assistant Technical Standards Manager. He is also an ETCP Certified Entertainment Electrician and an ETCP Recognized Trainer. Richard is the author of *Electricity for the Entertainment Electrician & Technician*, *Automated Lighting: the Art and Science of Moving Light*, and *Lighting Design for Modern Houses of Worship*.

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