BY **RICHARD CADENA**

Protecting against dirty power

I RECEIVED A CALL FROM A FRIEND recently who said the program memory in a lighting controller had been completely wiped out. Otherwise, everything was fine. Another caller had a situation where some large venue video projectors would randomly freeze and display white noise. Both of these seemingly unrelated events could have been caused by power quality issues or what is commonly referred to as "dirty power."

Power quality is a catch-all term used to describe a number of different problems with a power distribution system, including voltage fluctuations, harmonic distortion, and disturbances that include loss of power—both short and long term—voltage sags and swells, and transient voltage spikes. If you happen to be in an area where these issues come along with the power feeding the building, there's not a lot that you can do to change that. You can, however, work to diagnose the issues and use some tools to keep them from creating problems.

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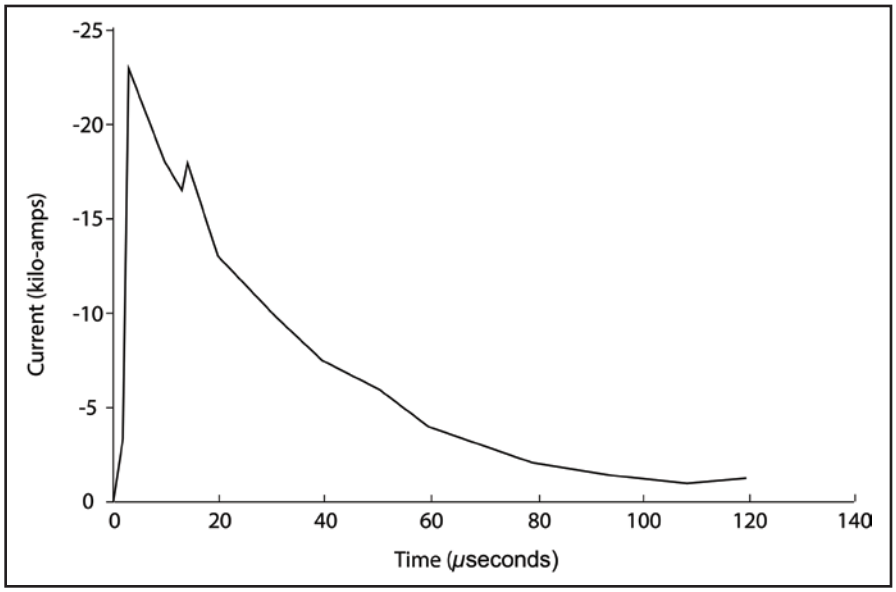
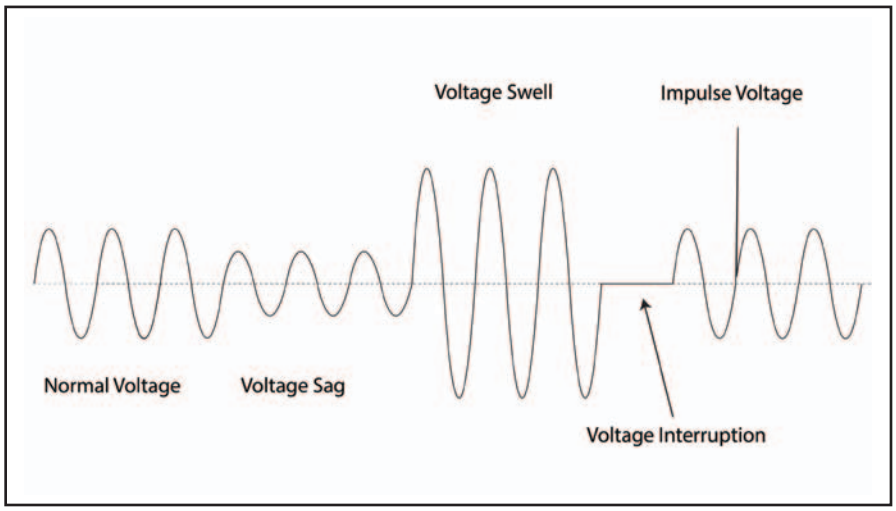
Power grid disturbances

When you meter power, you're typically looking at a snapshot over a very short time period using a very slow-reacting instrument such as a voltmeter or ammeter. The voltage appears to be very stable, changing very little, if at all, while you're metering. In reality, it is always changing, sometimes so slowly that you don't notice it, and sometimes so quickly that your meter doesn't register it. Using more sophisticated instruments over a longer period of time, you can see a lot more activity on the power grid. The voltage can droop or sag, it can swell, and those very short transient voltage spikes can cause the kind of headaches that will have you chasing intermittent problems for a while.



A lightning striking a building can cause thousands of amps to flow, potentially wreaking havoc on sensitive electronic equipment.



Power grid disturbances can include voltage sags or dips, swells, interruptions, and transient voltage spikes.

Sags and swells

Like any circuit, a transmission line is subject to variations in voltage caused by faults or large loads coming on and off line, which can affect the operation of sensitive electronic equipment. If the venue in which you are working is in the proximity of heavy

A power quality meter can be used to capture voltage transients, sags and swells, and other power disturbances.

industry or a manufacturing operation that requires lots of power, like a bakery with large commercial electric ovens or a smelting plant, then the power grid can be greatly affected by those loads. The closer they are, the more it can affect your power.

A voltage sag or dip is defined as a 10% to 90% decrease in voltage for a period of half a cycle (8 ms in North America or 10 ms in Europe and Australia) up to one minute, and they are typically caused by faults or short circuits. If it lasts more than a minute, then it's considered a "long-duration" event.

The good news is that many newer switch-mode power supplies are very forgiving of the input voltage, and they typically work fine within a range of about 90 V up to 250 V, depending on the design. So, for example, if the panel voltage is 120 V and there is a 10% voltage sag, the voltage will momentarily drop to 108 V. But when you take into account the voltage drop due to the cable that supplies power, then, depending on the wire gauge and the length of the run, it could drop below the operating voltage of the device.

A switch-mode power outputs a pre-determined wattage regardless of the voltage input, as long as it's within the specified range. When the voltage drops, these power supplies compensate by increasing the current draw (remember, Power = Voltage x Current, so if the voltage drops, the current increases to maintain the same power), which exacerbates the voltage drop.

Online versus standby UPS

A good uninterruptable power supply (UPS) can help avoid problems related to voltage sags, if that is determined to be the issue. There are two main types of UPSs, but only one will guard against sagging voltage, and that's an online UPS. The other type is a standby UPS, which means it is ready to take over in the event of a power failure, but it takes a moment to kick into action. An online UPS constantly regenerates the voltage sinewave using an inverter supplied by either the mains power or the backup battery, depending on the condition of the input voltage. Since it's always online, it's constantly supplying the nominal voltage, and voltage sags do not affect its output, unlike a standby UPS.

Of course, an online UPS is more expensive than a standby UPS, so you'll want to make sure that's the issue before laying out the cash for one. You might also want to make sure that issue is not caused by excessive voltage drop. There are a couple of ways to find out. One way is to read the voltage at the power distribution panel, which might be a circuit breaker panel or a portable power distribution unit, and also read it at the load. The difference between the two is the voltage drop. You can convert it to a percentage by dividing the voltage drop by the voltage at the panel and multiplying by 100. For example, if you measure 208.6 volts at the panel and 201.2 volts at the load, then the voltage drop is 7.4 volts, which is a 3.5% drop in voltage.

Measuring the voltage at the load can be a bit tricky because you have to be able to access the circuit at the load, and if it is connected directly to a cable, you are not likely to be able to put your probes on the terminals. But you can use a line splitter that has voltage test ports (if it's a 120 V load) or a two-fer.

Another way to find the voltage drop is to use a circuit analyzer such as the Ideal 61-164 SureTest or the Extech CT70. They can measure the voltage and the impedance of the wiring at a location, and calculate the voltage drop based on hypothetical 10 A, 15 A, and 20 A loads without actually connecting any load at all. If you know how much current your load draws, you can quickly and easily ballpark your voltage drop.

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The *National Electrical Code* recommends no more than 3% voltage drop on branch circuits, or 3% on feeder circuits, but no more than 5% overall. (The International Electrotechnical Commission or IEC, recommends 3% to 8%, depending on the circumstances.) Anything above that is considered excessive, in which case the wire gauge should be increased, or the run should be shortened if possible.

Transients

A voltage transient is a temporary spike in voltage, typically caused by a nearby lightning strike or the energization of large, power-factor correcting capacitors that are commonly used by electrical utility companies. Measuring them requires that you have fairly expensive equipment and pretty good luck. Power quality meters that capture transients, such as a Fluke 434 or 435, are expensive, and it requires luck, because transient voltages are—well, transient. If a lightning storm caused a controller to reset last night, then by the time you are able to connect your meter, it is gone.

If transients are the suspected or known cause of an issue, then there are a number

of different types of transient voltage surge suppression devices that can be of help. But that's for the next installment of this column. In the meanwhile, I'll let you in on a little secret. The issue with the controller was actually not a loss of memory but an accidental change in the playback rate of a chase. Such is the nature of technology. ■

Richard Cadena has worked as a production electrician, lighting designer, and lighting consultant for more than 33 years in theatre, concert/touring, television, corporate events, sporting events, houses of worship, and more. He is the author of *Electricity for the Entertainment Electrician & Technician* (Second Edition, Focal Press, 2015) and *Automated Lighting: The Art and Science of Moving and Color-Changing Light* (Third Edition, Focal Press, 2018). Richard is also an ETCP Certified Entertainment Electrician and an ETCP Recognized Trainer. His websites include www.rcad.me, www.automatedlighting.pro, www.electrics.tech, and www.APTXL.com.