BY **RICHARD CADENA**

Do GFCIs work with dimmers?

EVERYBODY KNOWS THAT water and electricity don't mix, but not everyone knows why. The simple answer is that wet skin has lower resistance to the flow of electricity than dry skin does, and according to Ohm's Law, if you are shocked, the current that flows through your body is controlled by the voltage divided by the resistance of your body. That means that if your skin is wet, more current will flow for a given amount of voltage, making you more vulnerable to a fatal shock. So, any time you are using electricity in the proximity of water, it should have Ground-Fault Circuit Interrupter (GFCI) protection, including those shows that have dimmers. But, using GFCIs with dimmers can be tricky. Is it even possible? The answer is yes, if it is set up correctly.

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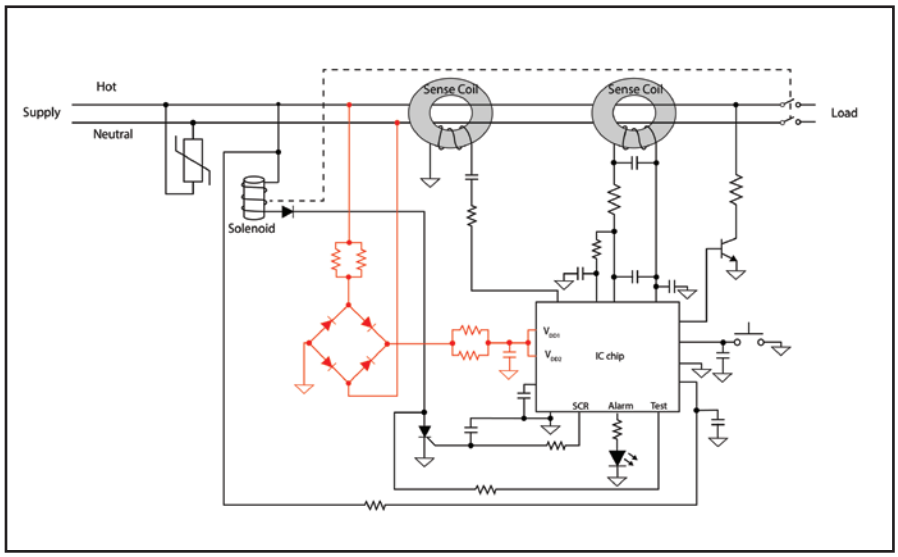
A GFCI will interrupt the circuit if someone is being shocked with electricity flowing through them to ground. When that happens, the current is diverted from the circuit, and a sensor in the GFCI detects this "leakage current." If it exceeds the threshold, then it activates a solenoid that opens the switching contacts and interrupts the circuit. GFCIs are extremely sensitive to leakage current and can save lives, but they have their Achilles' heel.

The GFCIs that we are most familiar with—the ones in our bathrooms, kitchens, garages, outside of our homes, and most of the ones we should use for entertainment lighting—are class A devices, meaning that they must trip if there is 6 mA of leakage or more, and it must trip within 5.59 seconds. Most manufacturers exceed this requirement by about 50%, so they might actually trip within about 2.75 seconds when the threshold leakage current is reached. This is fast enough at a low enough current to protect 99% of the world's population from a fatal shock. The unfortunate other 1% would be the more vulnerable population including infants, the very elderly, and certain people with compromised health.

It stands to reason that, for certain situations where electrical circuits are needed in the proximity of moisture or water, those circuits should have GFCI protection. That would include outdoor events where the cables could be exposed to rain, ice, or snow, as well as shows with water effects, ice shows, or similar. (Refer to *ANSI E1.19 – 2015: Recommended Practice for the Use of Class A Ground-Fault Interrupters Intended for Personnel Protection in the Entertainment Industry*.)

The output of the sense coil in a GFCI is connected to an integrated circuit (IC) chip, and when there is enough leakage current, the sense coil generates voltage that is applied to the input of the IC chip. That voltage turns on the output of the chip, which energizes the solenoid and opens the switching contacts.

But the IC chip requires low-voltage DC



A schematic diagram of a GFCI shows the components, including an integrated circuit chip, which requires a supply voltage to operate (shown in red). If the GFCI is connected to the output of a dimmer, the supply voltage can be dimmed to the point that it drops low enough that the IC chip stops working. If the dimmer is connected to the output of the GFCI, the supply voltage for the GFCI is maintained throughout the dimming curve.

to operate, and in a GFCI, that voltage is supplied through a bridge rectifier (which converts AC to pulsing DC) that gets its power from the line voltage. If you place a dimmer ahead of the GFCI and start dimming the load, the supply voltage is also dimmed, so the IC chip supply voltage starts dropping. At some point in the dimming curve, the voltage will drop low enough that it can no longer power the IC chip, and it will stop working. That's when the protection of the GFCI is lost.

A portable GFCI (right) can supply enough power to protect single-channel dimmers, like the Lex Slimmer Dimmer, and smaller dimmer packs, like the Leprecon ULD series dimmers.

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But what if we put the GFCI upstream of the dimmer? In that case, the power to the GFCI is never dimmed and it works well throughout the entire dimming curve while still dimming the load. The trick is finding a way to power the dimmers through a GFCI.

Until recently, you could buy an ETC Sensor dimmer rack and populate it with GFCI dimmer modules. But in 2015, changes to *UL 943*, the standard for GFCIs, created much higher hurdles for manufacturers like ETC to meet the requirements, so they discontinued them. Likewise, Leviton used to manufacture a GFCI with a separate power terminal for the sole purpose of powering the electronics inside the device. That would allow you to dim a load through the GFCI without affecting the supply voltage for the IC chip. Leviton stopped manufacturing them a few years ago.

The new UL requirements include automatic self-testing and, in the event that a GFCI cannot pass a self-test, it must not pass power to the output receptacle. These measures were imposed because few consumers take the time or effort to use the manual test buttons to confirm that a GFCI is actually working. A GFCI has many parts that can fail, yet, under the old standard, they could still provide unprotected power to the receptacles.

Class A GFCIs are available up to 100 A, but a 96-channel, 2400 W per channel dimmer rack at full load could draw up to 1,920 A or 640 A per phase. Even with 50% diversity (meaning only 50% of the connected load is turned on at any point in time), it would require a lot more than 100 A per phase. So, it may not be practical to put GFCI protection upstream of a large dimmer system, but it is possible to do it with smaller dimmer systems.

The Lex Slimmer Dimmer, for example, is a single-channel 1800 W dimmer, and I have successfully used it to dim a 575 W Source Four Par through the full dimming curve, all while it was powered through a Yellow Jacket portable GFCI. The GFCI is a 15 A, 120 V device, and it can be placed anywhere in the branch circuit, including at the input to the Slimmer Dimmer. The same setup could be used with any other dimmer that works with a 15 A circuit, like the Doug Fleenor Design DMX12DIM-ELV (a 12-channel, 100 W per channel dimmer pack), or the Leprecon ULD Series 1800 W or 3600 W tree-mount dimmers. The 3600 W version has two 15 A power cords, so it would require two portable GFCIs.

Granted, it would be challenging to provide GFCI protection like this for a Rolling Stones show or a U2 show. In those cases, it's might be more practical to isolate those circuits to make sure unqualified personnel can't reach them. However, powering dimmer circuits through GFCIs is a practical solution for many events like those held outdoors in tents, small stages, and maybe even medium-sized stages. And that's a very important safety protection that is too often ignored in live event production, even though, as we all know, water and electricity don't mix. ■

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.