Utility Interconnections & the *NEC*

by John Wiles

Section 690.64 of the *National Electrical Code (NEC)* continues to puzzle inspectors and installers with the requirements that apply to the connection of grid-tied inverters to the premises wiring and to the utility. This article should clarify some of those requirements. For details, refer to previous *Code Corner* articles (see Access).

A Diagram is Worth 1,000 Words

This diagram applies to several types of grid-tied PV systems. These systems all start with a meter connected to the utility. Next to that may be an existing service disconnect and the connected existing load center or a PV supply-side connection, which is just a second service entrance on the existing premises wiring system.

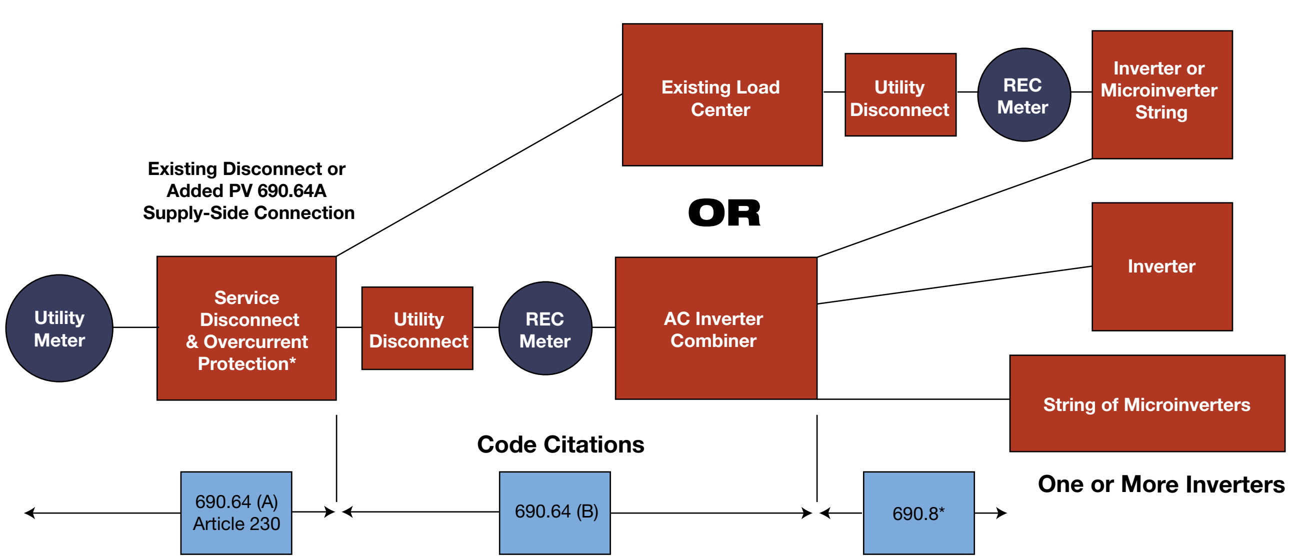
In either case, *NEC* Article 230 (which covers service conductors and equipment) requirements apply (as noted at the bottom of the diagram). In most jurisdictions, the utility will require a PV disconnect on the AC output of the PV system. In many cases, a renewable energy credit (REC) meter is used to measure the PV system output. There are many different scenarios to consider, such connecting one or more inverters or strings of microinverters or AC PV modules to the added combining panel. Alternatively, a single inverter could be connected to an existing load center. In some cases, multiple inverters might be connected through an AC combining panel and then back-feed an existing load center. Another scenario might use a microinverter string connected through an AC disconnect and then back-fed to the existing load center.

Inverter Output Circuit

All grid-tied inverters have a rated output current that cannot be exceeded. There are no surge currents in these output circuits and *NEC* 690.8 requires that the circuit and the overcurrent protective device (OCPD) be rated at 125% of that rated output current. When the calculated OCPD value is a nonstandard value, the next standard higher value should be used, but this should not exceed the maximum overcurrent value given in the inverter's technical specifications. Conductor size should be selected so that it is protected by the OCPD rating.

The note in the diagram indicates that *if* there is an

Grid-Tied Inverter Connections & Their *NEC* Code Sections



*Note: If OCPD is installed at inverter, then 690.64(B) applies.

overcurrent device mounted at the inverter, then the requirements of 690.64(B)—and *not* 690.8—will apply. Some installers and manufacturers use a circuit breaker or fused disconnect at the inverter to meet the 690.15 requirements for a maintenance disconnect at the inverter. The inclusion of an overcurrent device at this location generally necessitates that the output conductors from the inverter be larger—as required by 690.64(B)—than would otherwise required by 690.8.

After the First Inverter Overcurrent Device

Any conductor or bus bar that can have power flowing from more than one source (under normal or fault conditions), such as the utility and an inverter, and where the conductor is protected by an overcurrent device on each source, must meet 690.64(B) requirements. This is the long-standing 120% allowance for when 690.64(B)(7) conditions can be met. Section 690.64(B) applies to all conductors and bus bars from the first overcurrent device connected to the inverter output all the way to the service disconnect.

These bus bars and conductors would include the bus bars of any back-fed main panel boards connected to one or two inverters, or sets of microinverters, and any bus bars in AC inverter combiner panels. The conductors or feeders between the panel boards or load centers and the main service disconnects are also subject to the requirements of 690.64(B)(2).

In general, the ratings of all of the breakers *supplying* a bus bar or conductor are *added* together and the sum is divided by 1.2 (for the 120% allowance) to calculate minimum required bus bar and conductor ratings. If the location requirements of 690.64(B)(7) cannot be met (PV breaker located at the opposite end of the bus bar or conductor from the utility breaker), then the sum is divided by 1, and the bus bar rating or cable ampacity goes even higher.

For example: Two inverters each require a 50 A back-fed breaker in a main lug inverter combining load center to meet 690.8 requirements. A supply-side connection is going to be made with a 100 A fused disconnect. The rating of the combining load center and the ampacity of the conductor to the 100 A fused disconnect must follow the 690.64(B)(2) requirements. As noted, even with a supply-side connection, as soon as the circuit passes through the service entrance disconnect/overcurrent device, all load-side requirements apply, because the PC circuit is now on the load side of the service disconnect.

(50 A + 50 A +100 A) ÷ 1.2 = 200 A ÷ 1.2 = 166.7 A

The numbers indicate that a 200 A inverter load center/panel would be needed because there is no 175 A option available. Assuming a 75°C rated conductor, a 2/0 AWG conductor should be used between that panel and the 100 A fused disconnect.

Now suppose that the two inverters are back-feeding into an existing load center (switchgear) with a 200 A main breaker, and positioning the two back-fed inverter breakers at the opposite end of the switchgear bus bar from the main breaker isn't possible. The requirements of 690.64(B)(7) are not met and the 120% allowance cannot be used. The equation becomes:

(50 + 50 + main breaker) ≤ Bus bar rating

If the main breaker were rated at 200 A, then the bus bar would have to be rated at 300 A.

As the diagram shows, 690.64(B) applies to any panel or load center that has connections to the utility and to the inverter. It can be an existing load center or an added inverter combining panel.

The Main Disconnect & On to the Meter

Any circuit between the utility revenue meter and the service disconnect would be considered a service entrance circuit and be governed by the requirements of Article 230. This would be true if the circuit was an existing service entrance conductor or a new 690.64(A) supply-side connection. The conductor size, type, and routing, as well as the size and location of the service disconnect, would have to meet Article 230 requirements. However, after passing through the overcurrent device on either an existing service disconnect or through the overcurrent device on an added PV supply-side connection, the requirements of 690.64(B) apply all the way to the first overcurrent device connected to the inverter output.

A diagram can simplify understanding of the requirements of *NEC* 690.64. While the PV industry had hopes of getting additional clarity into this section of the *Code*, those hopes were not realized for the *2011 NEC*, and we must continue to work with the existing language.

Access

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Southwest Technology Development Institute • www.nmsu.edu/~tdi/Photovoltaics/Codes-Stds/Codes-Stds.html • PV systems inspector/installer checklist, previous "Perspectives on PV" and *Code Corner* articles, and *Photovoltaic Power Systems & the 2005 National Electrical Code: Suggested Practices*, by John Wiles.

Further Reading:

"Inverter Ins & Outs," *Code Corner, HP132*

"Connecting Inverters to the Grid, Part 1: Load-Side Connections," *Code Corner, HP134*

"Inverter Supply-Side Connections," *Code Corner, HP135*

"Common Questions about Grid-Tied Systems," *Code Corner, HP138*