

Inverter

Supply-Side Connections

by John Wiles

Supply-side (of the service disconnect) connections must be used for many larger PV systems, which cannot meet the requirements for a load-side connection to the premises wiring system.

Code Considerations

A supply-side connection (a.k.a. service-entrance connection) is allowed by the *National Electrical Code (NEC)* and is addressed in a number of sections in the *Code*.

Section 690.64(A)—moving to 705.12(A) in the 2008-2011 *NEC*—allows a supply (utility) side connection as permitted in 230.82(6).

Section 240.21(D) indicates where service-entrance conductors shall be protected and refers to 230.91. In general, the other “tap rules” of Section 240 do not apply—they were not developed to address two sources of power in a tap circuit, nor were they developed to assure safe operation when one source is an unprotected utility power source.

Section 230.91 requires that the service overcurrent device be co-located with the service disconnect. A circuit breaker or a fused disconnect would meet these requirements. A utility-accessible, visible-break, lockable fused disconnect (a.k.a. safety switch) used as the new PV service disconnect may also meet utility requirements for an external PV AC disconnect if utilities require such an additional disconnect.

Section 230.71 specifies that the service disconnecting means for each set of service-entrance conductors shall be a combination of no more than six switches and sets of circuit breakers mounted in a single enclosure or in a group of enclosures. The PV system may be counted as a separate service (230.2) and could have up to six disconnects of its own.

Section 230.70(A) establishes the location requirements for the service disconnect. This requires the service disconnect to be installed at a readily accessible location, either outside the building or inside the building, nearest the point of entrance of the service conductors.

Section 705.10 requires that a permanent sign or directory, showing the location of all power sources for the building, be placed at each service-equipment location. Locating the PV AC disconnect adjacent to or near the existing service disconnect may facilitate the installation, inspection, and operation of the system, since one simple Power Source plaque can be used at a central location, rather than having to create a directory and map out where all the other service-entrance equipment is located.

Sizing

The new PV service disconnect will normally be sized at 125% of the rated output current of the inverter(s). But for small systems, how small can the service disconnect be? Section 230.79 addresses the rating issue. Some inspectors interpret 230.79(A) to allow a disconnect rated at 15 amps—if that value is at or above the inverter output circuit’s rating.

However, caution is advised, since the PV system is connected to service-entrance conductors rated at 100 A and above. In this application, a typical 15 A circuit breaker with 10,000 A of interrupt capability may not be able to withstand the potential fault current since it is not protected and coordinated with any main breaker typically rated at 22,000 A. Of course, section 110.9 should be followed and fault current calculated (see below). A service-entrance-rated 30 A fused disconnect can be used, since the proper fuses will have sufficiently high interrupt ratings.

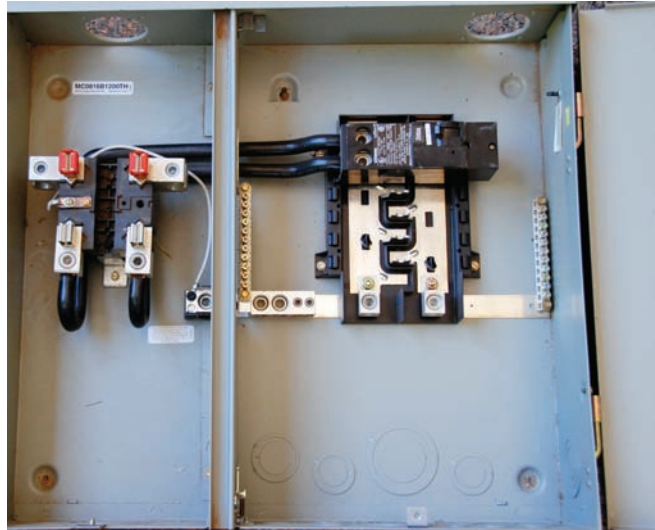
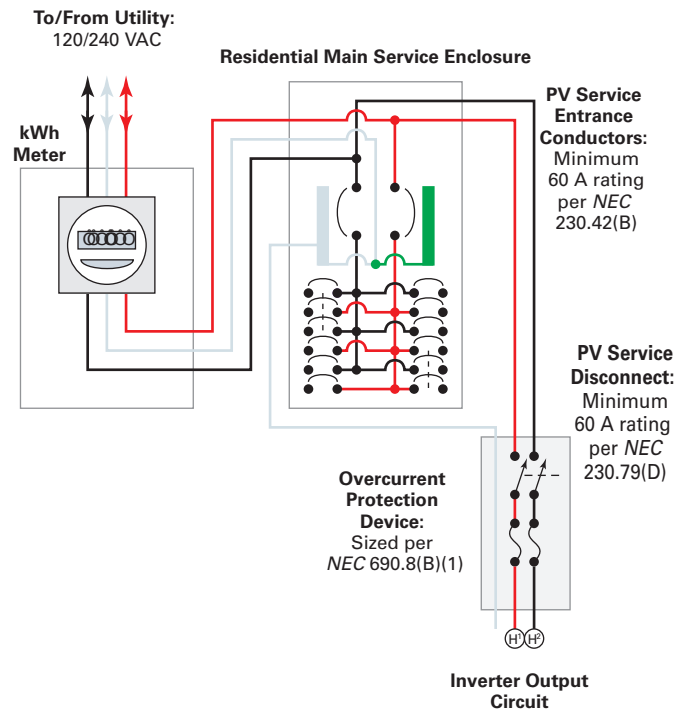
Another consideration is the size of the service-entrance conductors, the new PV connection conductors, and the terminals on available switchgear likely rated at 30 or 60 A. The added conductors between the existing service-entrance conductors and the new service disconnect may be subjected to available fault currents and will have no protection except that provided by the fuse on the utility transformer’s primary side input. Sizing these conductors as large as possible with an upper limit of the existing service-entrance conductor size would seem prudent, but small disconnects will not accept very large conductors.

Therefore, I suggest that Section 230.79(D) be used as the requirement for the smallest service disconnecting means for PV inverter supply-side taps. This section requires that the disconnect have a *minimum* rating of 60 A. This would apply to a service-entrance-rated circuit breaker or fused disconnect.

The service connection conductors (the conductors coming from the PV service disconnect that connect to the existing service entrance conductors) must have a minimum rating not less than the service disconnecting means per 230.42(B), which we have determined to be 60 A, as specified in 230.79(D). The rating for the conductors between the inverter and the PV service disconnect should be based on 125% of the rated output current for the utility-interactive PV inverter, as required by 690.8. Temperature and conduit-fill factors must be applied for sizing.

For a PV system with a 2,500 W, 240 V inverter that calls for a 15 A circuit and overcurrent protection, *Code* requirements

Typical Residential Supply-Side Connection



Even with all this room, putting a supply-side tap in this combined meter and service disconnect box would not fall within its listed use, and should not be done.

call for a minimum 60 A disconnect, with 15 A fuses; fuse adapters that allow the smaller-bodied 15-amp fuse to be installed in the larger 60-amp fuse holder would be needed. Conductors sized to handle 15 A could be used between the inverter and the 15 A fuses in the disconnect, provided these conductors are large enough to keep the voltage drop within the limits of the inverter AC output circuit. Section 230.42(B) requires that the conductors between the service connection and the disconnect be sized to handle not less than the rating of the disconnect—in this case, 60 A.

Section 110.9 requires that the interrupt capability of the new disconnect/overcurrent device be sufficient to handle the available fault current. In most cases, this means these interrupt ratings have to be at least equal to the interrupt rating of the existing service equipment. The utility service should be investigated to ensure that the available fault currents have not been increased above the rating of the existing equipment. Fused disconnects with RK-5 fuses are commonly available with interrupt ratings up to 200,000 A, which will exceed the interrupt requirements for nearly any PV installation.

Section 230.43 allows a number of different service-entrance wiring systems. Considering that the PV service connection conductors are unprotected from faults, it is suggested that the conductors be as short as possible, with the new PV service/disconnect mounted adjacent to the connection point. Making these PV conductors as large as the service-entrance conductors, while not a *Code* requirement, would also add a degree of safety. Of course, the added disconnect must accept the larger conductors. Conductors installed in rigid metal conduit would provide the highest level of fault protection.

All equipment must be properly grounded per Article 250 requirements. See 250.24(B) for bonding requirements. As a service disconnect, neutral-to-ground bonding would generally be required at the new disconnect, even though

the nearby existing service entrance has a similar neutral-to-ground bond. Any stray currents in the equipment grounding conductors are expected and accepted.

The actual location of the new service connection will depend on the configuration and location of the existing service-entrance equipment:

- On some residential and commercial systems there is sometimes room in the *main load center* to splice to the service conductors just before they are connected to the existing service disconnect.

In other installations, the *meter socket* has lugs that are listed for two conductors per lug. Of course, adding a new *junction box* (where the splice can be made) between the meter socket and the service disconnect is an option. Combined meter/service disconnects/load centers frequently have enough apparent interior space to make a connection between the meter socket and the service disconnect. However, tapping this internal conductor or bus bar in a listed device such as a meter/main combination would violate the listing and should not be done.

In situations where the service-entrance conductors are accessible, a new *meter base* (socket) could be added ahead of the combination device. A *splice box* would then be added between the new socket and the combination device. The meter would then be moved from the combination device to the new socket, jumper bars added to the old socket, and the old socket covered.



Besides not being code-compliant, tapping into the bus bar on this combination meter/service disconnect can violate the equipment's UL listing.

- In larger installations, the main service-entrance equipment will frequently have bus bars with holes that can be used for making additional connections. The addition of any terminals to the bus bar—and

sometimes the actual connection—can only be made by the organization supplying the service equipment, usually a UL508 panel shop. They can modify the equipment and still maintain the listing on the equipment. These organizations must control, by specification, labeling, instructions, or direct participation, any new connections made to the equipment.

In all cases, the utility service must be de-energized before any connections are made. Additional service-entrance disconnect requirements in Article 230 and other articles of the NEC will apply to this connection.

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

