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New Fuse Servicing Disconnect Switch Requirement

The 2011 edition of The National Electric Code (NEC) contains additional requirements within Article 690 pertaining to fuse servicing. Currently, 19 States have adopted and implemented NEC 2011 including Massachusetts, New Jersey, Texas, and Colorado.[i] One of these new requirements, Article 690.16(B), is a corollary of safety concerns during servicing of fuses in photovoltaic (PV) systems.

Fuses that are integral to the inverter or part of a string combiner may be energized from multiple sources. Shutting down the inverter does not always remove all sources of energy from all DC fuses. For example, when the inverter is off and the fuse is no longer carrying current, the PV modules will still energize the PV circuits during sunlight hours. If a fuse is in need of replacement while the PV array is still connected to the combiner, that fuse will remain live and presents an electrical shock risk and arc flash hazard. It is imperative that the fuse be completely de-energized from all sources before attempting to replace the fuse. This can be seen in Figure 1.

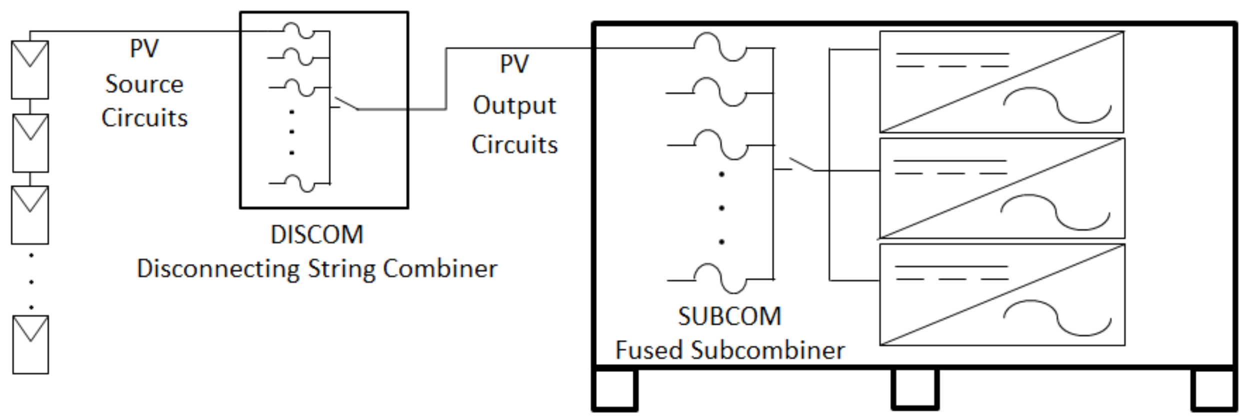

Figure 1. Typical DC Combiner Fusing in Solectria Renewables' SGI 500

String Combiner Boxes

For string combiner boxes, satisfying the new requirement NEC 690.16(B) is simple. The "touch safe" fuse holders enable the safe removal of the fuse from all energy sources. However, these fuse holders are not load break rated and are explicitly labeled "Do not open under load." Opening a fuse holder under load presents a dangerous arc flash hazard. Solectria Renewables' DISCOM disconnecting string combiner has an integrated DC disconnect. To service the fuse simply turn off the DC disconnect on the front of the string combiner and, after the absence of current is verified with a DC clamp meter, open the fuse holder and remove the fuse. The combination of a DC disconnect and "touch safe" fuse holders in DISCOM disconnecting string combiners provide a convenient method for quickly maintaining the fuses within the combiner box and meeting NEC 690.16(B).

NEC 690.16(B) Challenges

The requirement for providing satisfactory fuse servicing disconnects for a DC combiner internal to the inverter can be ambiguous. It is important to review NEC 690.16 to ensure that all fuse servicing requirements are met. Project specific questions should be directed to the authority having jurisdiction (AHJ).

The fused subcombiner integral to the inverter has one disconnect located inside the inverter after the DC fuses have been combined on the DC bus. This singular disconnect does not de-energize the fuses from all sources and alone does not meet the requirement of NEC 690.16(B). Therefore, an additional disconnecting means may be required for each subcombiner fuse (i.e. PV output circuit).

Requirement 690.16(B) specifies that these disconnects must be located within sight of the fuse location. Article 100 defines "within sight from" as no more than 15m (50 ft). Even though 690.16(B) requires a directory for disconnects more than 1.8m (6 ft) away, the circuit must still have disconnects installed within 15m (50 ft) of the fuse.

Alternate Solutions to Costly Disconnect Switches

At first glance it appears that the simplest solution is to install multiple disconnects or an assembly of DC disconnects next to the inverter. Installing multiple visible blade disconnects next to the inverter is extremely labor intensive and occupies a lot of space. A "multiple disconnect safety system" has a smaller footprint but for a 500kW inverter can cost $10,000-$12,000, not including delivery, additional foundations, and labor.

An alternative solution is to position all DISCOM disconnecting string combiners within 50 feet of the inverter. The disconnect in the DISCOM now serves a dual purpose. It breaks the load for the touch safe fuse holders in the string combiner box as well as de-energizes the associated subcombiner fuse when used in conjunction with the main inverter DC disconnect. Routing each PV source circuit conductor from the array to a string combiner within 50 feet of the inverter is physically and financially impractical on large scale systems.

DC Subcombiner Circuit Breakers

The most cost-effective and simplest way to resolve requirements for fuse servicing disconnects is to remove fuses and the service disconnects at the inverter's subcombiner altogether. NEC 690.16(B) only requires disconnects to be present in the circuit when there are fuses. If there are no fuses, there is no need to provide DC disconnects adjacent to the inverter just to service fuses.

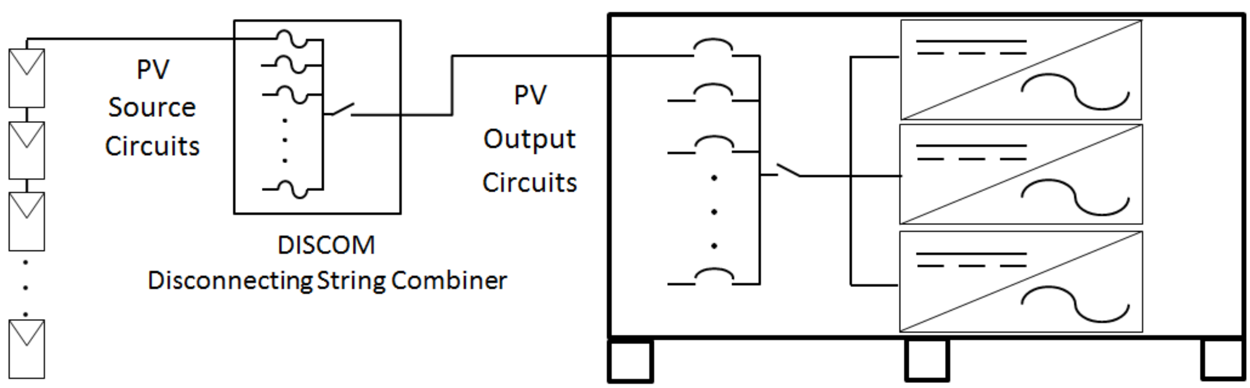

Figure 2. Inverter Subcombiner with DC Breakers

Even though fuses may be removed from the system design, overcurrent protection is still a requirement for PV Output Circuits. A subcombiner integral to the inverter that incorporates DC breakers provides the necessary overcurrent protection while eliminating the need for fuse servicing disconnects. A diagram of this can be seen in Figure 2.

DC subcombiner breakers eliminate additional components and labor ultimately minimizing installed cost compared to the installation of external disconnects. The PV Output Circuit conductors are terminated at the lugs installed on the circuit breakers inside the inverter. Purchasing an inverter with an integrated subcombiner with DC breakers simplifies system design and installation, increases safety and reliability, speeds installation, and minimizes cost.

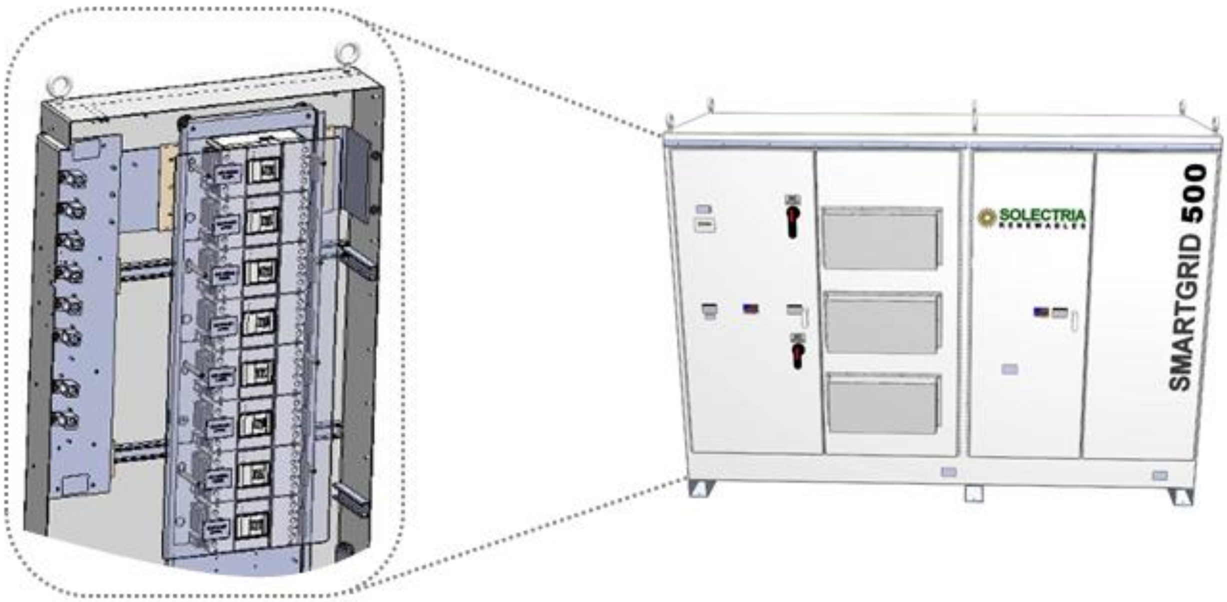

Figure 3. Solectria Renewables' SGI 500 Inverter 8 Position Subcombiner with DC Breakers

Solectria Renewables offers an optional factory installed DC breaker subcombiner in all SMARTGRID series inverters as seen in Figure 3. The DC subcombiner breakers are integral in the inverter and require no additional, external equipment. The subcombiner for a SGI 225-500KW inverter may include up to 16 DC breakers allowing for excellent flexibility with the array layout. The breakers are available with ampere ratings comparable to common fuse values.

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[i] National Electrical Manufacturers Association (NEMA) maintains a list of which NFPA 70 version each state has adopted. For a full list visit http://www.nema.org/Technical/FieldReps/Pages/National-Electrical-Code.aspx

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