MEMORANDUM

Date: August 2, 2001

To: Whom it may concern

From: John Berdner – President, SMA America, Inc.

Regarding: PV over current protection with Sunny Boy 2500U

The inherently current limited nature of PV modules means it is possible to eliminate the UL series fuses under certain conditions without sacrificing system safety. NEC Article 690-9, Exception b (shown below), permits PV systems to be installed without over current protection for the DC conductors if the maximum fault current from all sources is less than the ampacity of all the dc conductors. For purposes of fault analysis, UL considers the module's UL series fuse rating to be the "ampacity" of the PV module and it's internal conductors.

Exception: An overcurrent device shall not be required for circuit conductors sized in accordance with Section 690-8 (b) and located where:

(a) There are no external sources such as parallel connected source circuits, batteries, or backfeed from inverters , or

(b) The short-circuit currents from all sources do not exceed the ampacity of the conductors.

FPN: Possible backfeed of current from any source of supply, including a supply through an inverter into the photovoltaic output circuit and photovoltaic source circuits, is a consideration in determining whether adequate overcurrent protection from all sources is provided for conductors and modules.

Figure 1 below illustrates a typical system with a utility interactive inverter. A fused disconnect is shown to represent the most general case. For the general case the maximum fault current at fault A-A' is given by Equation 1:

Equation 1: $I_{fault} = [(n-1) * 1.56 * I_{sc}] + I_{out}$

If the inverter does not contribute reverse fault current during array faults, then the term (Iout) is zero. The Sunny Boy 2500 U inverter includes electronic current limiting functions to prevent reverse current flow from the inverter to the array. The functionality of this feature been verified by in-field testing of all possible array fault conditions at New Mexico State University's Southwest Technology Development Institute (SWTDI). The test protocol used for the SWTDI tests was developed by Sandia PV Design Assistance Center and Underwriters Laboratories.

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When Iinv_rev ~ 0, the condition where fuses can be eliminated is shown by Equation 2.

Equation 2:	Isf > Ifault, or: Isf > [(n-1) * 1.56 * Isc]	
If Iinv_rev ~ 0, then:	Isf > 2 * 1.56 * Isc	(for three strings)
	Isf > 1 * 1.56 * Isc	(for two strings)
	Isf > 0 * 1.56 * Isc	(for one string)

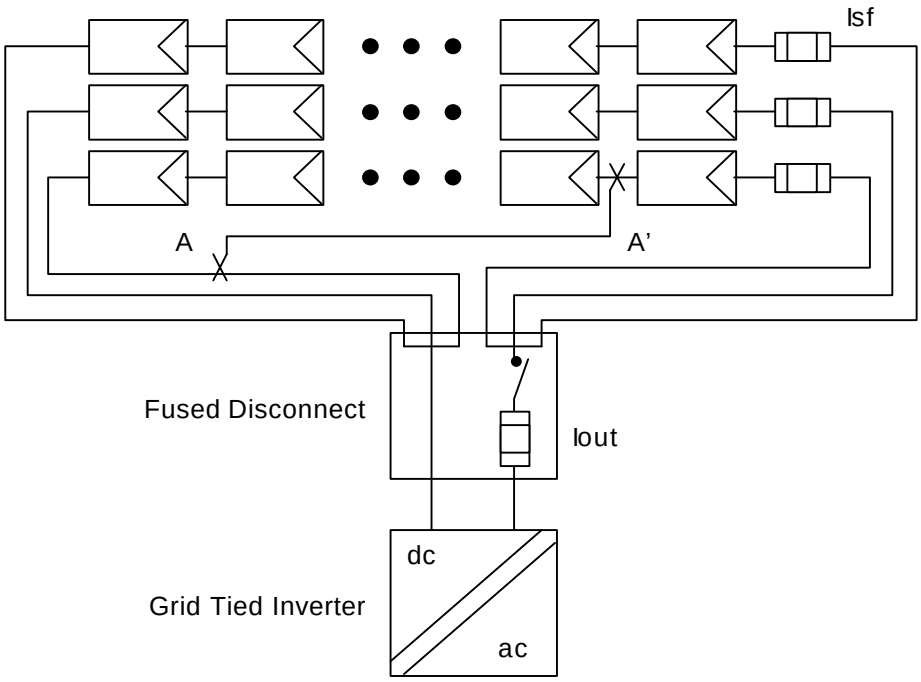

Figure 1 - Typical Utility Interactive PV System

In systems where all wiring is appropriately sized and Iinv_rev = 0 it is clear that series fuses can be eliminated in PV arrays with one or two series strings. For three or more strings, fuses are not required when the relationship between array short circuit current (Isc) and UL series fuse rating (Isf) meets the constraints outlined in Equation 2 above.

If you have any questions , or if I can be of additional assistance, please contact me directly.

Best regards,

John Berdner

President – SMA America, Inc.