

SOLAR PHOTOVOLTAIC (PV) SYSTEMS

ELECTRICAL CODE COMPLIANCE AND INSPECTION CHECKLIST

This checklist contains common electrical code requirements for PV systems, based on the 2008 National Electrical Code® and industry standards, and is intended as a guide for PV system inspectors, designers, and installers. The organization of this checklist is aligned with the major sections of Article 690 on Solar Photovoltaic Systems, including circuit requirements, disconnecting means, wiring methods, grounding, marking, connections to other sources and storage batteries. While the items on this checklist provide an overview of the common electrical system requirements, it should not be considered a complete or exhaustive list of all requirements for documentation or code compliance. In particular, this checklist does not address system performance, manufacturer-specific installation instructions, structural loading issues, special fire codes or other local requirements established by the Authority Having Jurisdiction (AHJ).

This checklist is intended for use by qualified persons having a thorough understanding of the building codes and PV systems design and installation practices, and it is not intended as a design guide. System designers and integrators may find this checklist helpful in preparing permit applications and plan review documents, and local officials may also use this as a guide for reviewing plans and issuing building permits. Contractors and installers may use this checklist as part of conducting final checkouts and system commissioning, and field inspectors may use this checklist as part of their final inspection and approval process.

SYSTEM INFORMATION

Customer _____
 Site Address _____
 Contact Name _____
 Phone _____ Fax _____ Email _____

Permitting Authority _____
 Contact Name _____
 Phone _____ Fax _____ Email _____

Type of System _____
 Module (qty) _____ System Output (kWdc) _____
 Inverter (qty) _____ System Output (kWac) _____
 Charge Controller _____ Battery _____

GENERAL PRACTICES AND COMPONENTS	REFERENCE	COMPLIANCE / NOTES
1. Equipment Approval. All equipment is identified and listed for the application (includes UL 1703 listing for modules and UL 1741 listing for inverters and charge controllers).	NEC 110.2; 690.4(D); 690.60	
2. Manufacturer's Instructions. Equipment is installed and used in accordance with any instructions included in the listing or labeling.	110.3(B)	
3. Site Drawings. Site drawings include descriptions and locations of major components.		
4. Electrical Diagram. Electrical diagram includes component interconnects, conductor types and sizes, conduit types and sizes, disconnects, and point of interconnection.		
5. Array Mounting Information. Mounting detail drawing includes roof type and age, mounting system, fastener spacing, and penetration weather sealing method.		

6. Owner's Documentation. Documentation includes system warranty, component warranties, owner's manuals, utility interconnection agreement, and instructions for operation and maintenance.		
7. AC Modules. AC modules have appropriate markings, overcurrent protection, disconnects, and ground fault protection.	690.6; 690.52	
8. Stand-Alone Inverter Output. Inverter output rating is equal to or greater than the largest single load on the system, but is permitted to be less than the sum of every load on the system.	690.10(A)	
9. Local Building Permit. Permits are obtained and displayed as required.		

CIRCUIT VOLTAGE AND CURRENT REQUIREMENTS	REFERENCE	COMPLIANCE / NOTES
1. Maximum System Voltage. Maximum system voltage is calculated based on module open-circuit voltage at the lowest expected ambient temperature. Module manufacturer's temperature coefficients are used when available.	NEC 690.7(A)	
2. 600 V Limit. Maximum system voltage is less than 600 V for dwellings. Circuits over 150 V accessible only to qualified persons.	690.7(C); 690.7(D)	
3. Maximum PV Current. The maximum PV source- and output-circuit currents (used for sizing conductors and overcurrent protection devices) are based on 125% of the module short-circuit current.	690.8(A)(1); 690.8(A)(2)	
4. Inverter Current. Maximum inverter input and output circuit currents are based on inverter ratings.	690.8(A)(3); 690.8(A)(4)	
5. Equipment Maximum Voltage. Equipment and devices are rated for maximum system voltage at lowest temperature.	690.7; 110.4	

CONDUCTORS AND WIRING METHODS	REFERENCE	COMPLIANCE / NOTES
1. Conductors and Wiring Methods. Standard building-wire conductors and appropriate wiring methods are used. Conductors are rated for conditions of use.	NEC 300; 690.31(A)	
2. Conduit. PV source- and output-circuit conductors operating at more than 30 V and installed in readily accessible locations are in conduit.	690.31(A)	
3. PV Source-Circuit Wiring. Conductors have 90°C, sunlight, and wet service resistances. Single conductor type USE-2 and specifically listed and labeled PV wire is permitted in PV source circuits.	690.31(B)	
4. PV Conductors Alone. PV source- and output-circuit conductors are not run together with conductors of other systems.	690.4(B)	
5. Ampacity. Conductors are sized for a de-rated ampacity of at least 125% of the maximum currents calculated or determined in 690.8(A). De-rating factors include high ambient temperatures, location on or above rooftops, and number of conductors run together within a conduit or cable.	690.8(B); 310.15(B); 310.16	
6. Flexible Conductors. Tracking or movable array mounts use flexible conductors identified for hard service and outdoor use. Ampacities calculated according to 400.5.	690.31(C); 400.5	N/A
7. Small Conductors. Single-conductor cables in sizes 16 AWG and 18 AWG are permitted for module interconnections if they meet the ampacity requirements of 690.8.	690.31(D); 310.15	N/A
8. PV Source-Circuit Conduit. Where DC PV source circuits are run inside a building, they are in <i>metal conduit</i> from the point of penetration into the building to first accessible disconnect.	690.31(E)	
9. Connectors. Connectors are polarized, noninterchangeable, guarded, latching or locking, have "first-to-make/last-to-break" contact for grounded conductor, and either are rated for interrupting current or require a tool to open.	690.33	
10. Wiring Connectors. Connectors are listed for the intended use and environment. Screw terminals are tightened to recommended torque. Crimp-on terminals are used with appropriate crimping tool.	110.14	
11. Junction Boxes. Junction boxes are of appropriate type and size and allow the conductors within to be accessible.	690.34; 314	

12. Color Codes. Grounded conductors are marked white or gray and grounding conductors shall be green, green/yellow, or bare.	310.12	
13. Strain Relief. Strain relief or conduit is used with all conductors.	300.4	
14. Multiwire Branch Circuits. No multiwire branch circuits are allowed on stand-alone 120 V inverter output circuit or panels.	690.10(C)	N/A

OVERCURRENT PROTECTION	REFERENCE	COMPLIANCE / NOTES
1. Protected Circuits. PV source circuit, PV output circuit, inverter output circuit, and battery circuit conductors and equipment are protected in accordance with Article 240.	NEC 690.9(A); 240	
2. Multiple Power Sources. Circuits connected to multiple power sources are provided overcurrent protection from each source.	690.9(A)	
3. Ratings. Overcurrent protection devices are rated for not less than 125% of the maximum currents calculated or determined in 690.8(A).	690.8(B); 240.4;	
4. Transformers. Overcurrent protection is provided for power transformers in accordance with Section 450.3.	690.9(B); 450.3	
5. Supplementary Overcurrent Protection. Branch-circuit or supplementary-type overcurrent protection devices are permitted on PV source circuits.	690.9(C)	
6. Listed for DC. Overcurrent protection devices in DC circuits are listed for such use and have the appropriate voltage, current, and interrupt ratings.	690.9(D)	

DISCONNECTS	REFERENCE	COMPLIANCE / NOTES
1. Array Disconnect. A disconnect is provided between the PV power system output and other building conductors.	NEC 690.13	
2. Accessibility. Array disconnect is installed at a readily accessible location either on the outside of the building or structure or inside nearest the point of entrance of the system conductors.	690.14(C)(1); 690.31(E)	
3. Marking. Each PV system disconnect is marked as such, and suitable for the intended use.	690.14(C)(2); 690.14(C)(3)	
4. Grouping. There are no more than six disconnects for each source of power. Disconnects for each power source are grouped together.	690.14(C)(4); 690.14(C)(5)	
5. Equipment Disconnects. Disconnects are provided to disconnect equipment (inverters, batteries, charge controllers, etc.) from all ungrounded conductors of all power sources.	690.15	
6. Fuses. Disconnects are provided to independently disconnect a fuse from all sources of power if the fuse is energized from both directions.	690.16	
7. Features. Disconnects open all ungrounded conductors, are readily accessible, externally operated, have ON/OFF indication, and have appropriate interrupt rating. Manually operated switches and circuit breakers may fulfill these requirements.	690.17	

GROUNDING	REFERENCE	COMPLIANCE / NOTES
1. Ungrounded Systems. Ungrounded systems include disconnects, overcurrent protection, and ground-fault protection. Equipment is listed for use with ungrounded systems.	690.35	N/A
2. Module Grounding Continuity. Module connections are such that removal of a module does not interrupt a grounded conductor to another PV source circuit.	690.4(C)	
3. Ground-Fault Protection. Ground fault protection is provided for grounded arrays.	690.5	
4. PV System Grounding. One DC conductor is grounded for two-wire PV systems operating above 50 V.	690.41; 250.4(A)	
5. Single-Point. DC grounding is made at a single point on the PV output circuit.	690.42	
6. Equipment Grounding. Non-current-carrying metal components are grounded, including module frames, mounting structures, equipment, conduit, and boxes.	690.43	
7. Equipment Grounding Conductors. Equipment grounding conductors are routed with PV circuit conductors.	690.43	

8. Equipment Grounding Conductor Size. If array has GFP, the equipment grounding conductor is sized according to 250.122. If array does not have GFP, the equipment grounding conductor is sized for at least twice the de-rated circuit conductor ampacity.	690.45; 250.122	
9. Grounding Electrode Systems. The AC system is grounded according to 250.50 through 250.60. The DC system is grounded according to 250.166 or 250.169.	690.47(A); 690.47(B); 250	
10. Common Grounding. If system includes both AC and DC systems, the grounding electrode systems are bonded together. The bonding conductor is sized for the larger of the AC and DC requirements. Separate DC and AC grounding electrodes are permitted, or both grounding systems may use the premises AC grounding electrode. The grounding electrode conductor is sized to meet both AC and DC grounding requirements.	690.47(C); 250	
11. Array Grounding. Array is grounded with separate grounding electrode system, unless it would be within 6' of premises electrode.	690.47(D)	Not Required

MARKINGS AND LABELS	REFERENCE	COMPLIANCE / NOTES
1. Array Ground-Fault Protection. Interactive inverter, ground-fault indicator, and/or battery bank label warns of shock hazard during ground fault.	690.5(C)	
2. Modules. PV modules are labeled with open-circuit voltage, operating (maximum power) voltage, maximum permissible voltage, operating (maximum power) current, short-circuit current, and maximum power.	690.51	
3. System Info at DC Disconnect. PV power source is labeled with maximum power current, maximum power voltage, maximum system voltage, short-circuit current, and maximum rated output current of charge controller (if installed) at the DC disconnect.	690.53	
4. Inverter Info at AC Disconnect. Point of interconnection is labeled with inverter operating AC voltage and rated AC output current at the AC disconnect.	690.54	
5. Batteries. Battery bank is labeled with maximum operating voltage, equalization voltage, and polarity.	690.55	
6. Stand-Alone Systems. Exterior visible notice indicates the structure contains a stand-alone system and identifies the locations of disconnects.	690.56(A)	
7. Interactive Systems. Exterior visible notice indicates identifies the locations of array disconnect and utility service disconnect, if not located together.	690.56(B)	
8. Single 120 V Supplies. A stand-alone system supplied by a 120 V inverter includes a label warning against connecting multiwire branch circuits.	690.10(C)	
9. Ungrounded Systems. Ungrounded systems include a label warning of a shock hazard.	690.35(F)	
10. Disconnect Energized While Open. If all terminals of a disconnect are energized when open, a label warns as such.	690.17	
11. Marking. Panels containing overcurrent protection devices supplying power to busbar are marked to indicate all sources of supply.	690.64(B)(4)	
12. Back-Fed Breakers. Back-fed circuit breakers for load-side connections are labeled as inverter output connections with a warning not to relocate.	690.64(B)(7)	

CONNECTION TO OTHER SOURCES	REFERENCE	COMPLIANCE / NOTES
1. Inverters UL Listed. Inverter is listed and identified for interactive operation.	690.60, UL1741	
2. Islanding. Interactive inverters will de-energize if utility power is lost. Bimodal inverters may continue to operate if disconnected from utility power.	690.61	
3. Neutral Loading. If two-wire inverter is connected to system with multiple ungrounded conductors, sum of load and inverter's current rating does not exceed ampacity of grounded conductor.	690.62	

4. Unbalanced Interconnections. Loads are balanced on three-phase systems with interconnected single-phase inverters. Three-phase inverter automatically de-energizes if system becomes unbalanced.	690.63	
5. Point of Connection. The output of interactive inverter is connected to either the supply side or the load side of the utility service disconnect.	690.64	
6. Load-Side Connection. If load-side connection, the inverter output connection is made at dedicated circuit breaker or fusible disconnect.	690.64(B)(1)	
7. 120% of Busbar Rating. Sum of ampere ratings of all breakers supplying power to panel does not exceed 120% of the busbar rating.	690.64(B)(2)	
8. GFCI. Interconnection is on the line side of all ground-fault protection equipment.	690.64(B)(3)	
9. Suitable for Backfeed. Circuit breakers used for load-side connections are suitable for such operation.	690.64(B)(5)	
10. Back-Fed Breakers. Back-fed circuit breakers for load-side connections are positioned at the opposite end of the panel as the utility service disconnect.	690.64(B)(7)	

BATTERIES AND CHARGE CONTROL	REFERENCE	COMPLIANCE / NOTES
1. General. Battery bank is installed in accordance with Article 480.	690.71(A); 480	N/A
2. Voltage Limit for Dwellings. For dwellings, operating voltage is less than 50 V nominal (no more than 24 2 V lead-acid cells in series).	690.71(B)(1)	N/A
3. Covers/Access. Battery terminals and other live parts are guarded and adequate working space is provided.	690.71(B)(2); 480.9	N/A
4. Fuses. Current-limiting fuses are installed on battery output circuits.	690.71(C)	N/A
5. Cases and Racks. Batteries in banks of greater than 48 V nominal are in non-conductive cases. Conductive racks are permissible, if no materials within 6" from top of battery case. (Requirements do not apply to VRLA batteries.)	690.71(D)	N/A
6. Series Disconnects. Series disconnects are provided for battery strings over 48 V nominal.	690.71(E)	N/A
7. Maintenance Disconnect. A disconnect is provided for the grounded conductor of each string for battery systems over 48 V. Disconnect is accessible only to qualified persons.	690.71(F)	N/A
8. Charge Control. Charge control is used if charge rates are greater than 3% of battery capacity (C/33). Adjustment is accessible only to qualified persons.	690.72(A)	N/A
9. Diversion Charge Control. Systems using diversion charge controllers have a secondary independent means for charge control.	690.72(B)(1)	N/A
10. Diversion Loads. DC diversion load current rating is less than or equal to charge controller rating, load voltage rating is greater than maximum battery bank voltage, and load power rating is at least 150% of the array power rating.	690.72(B)(2)	N/A
11. Interactive Systems. Interactive systems with batteries need not comply with diversion load requirements, but must have a secondary independent means for charge control.	690.72(B)(3)	N/A
12. Battery Wiring. Battery interconnections are made with #2/0 AWG or larger flexible cables that are listed for hard-service use and identified as moisture-resistant.	690.74; 400	N/A