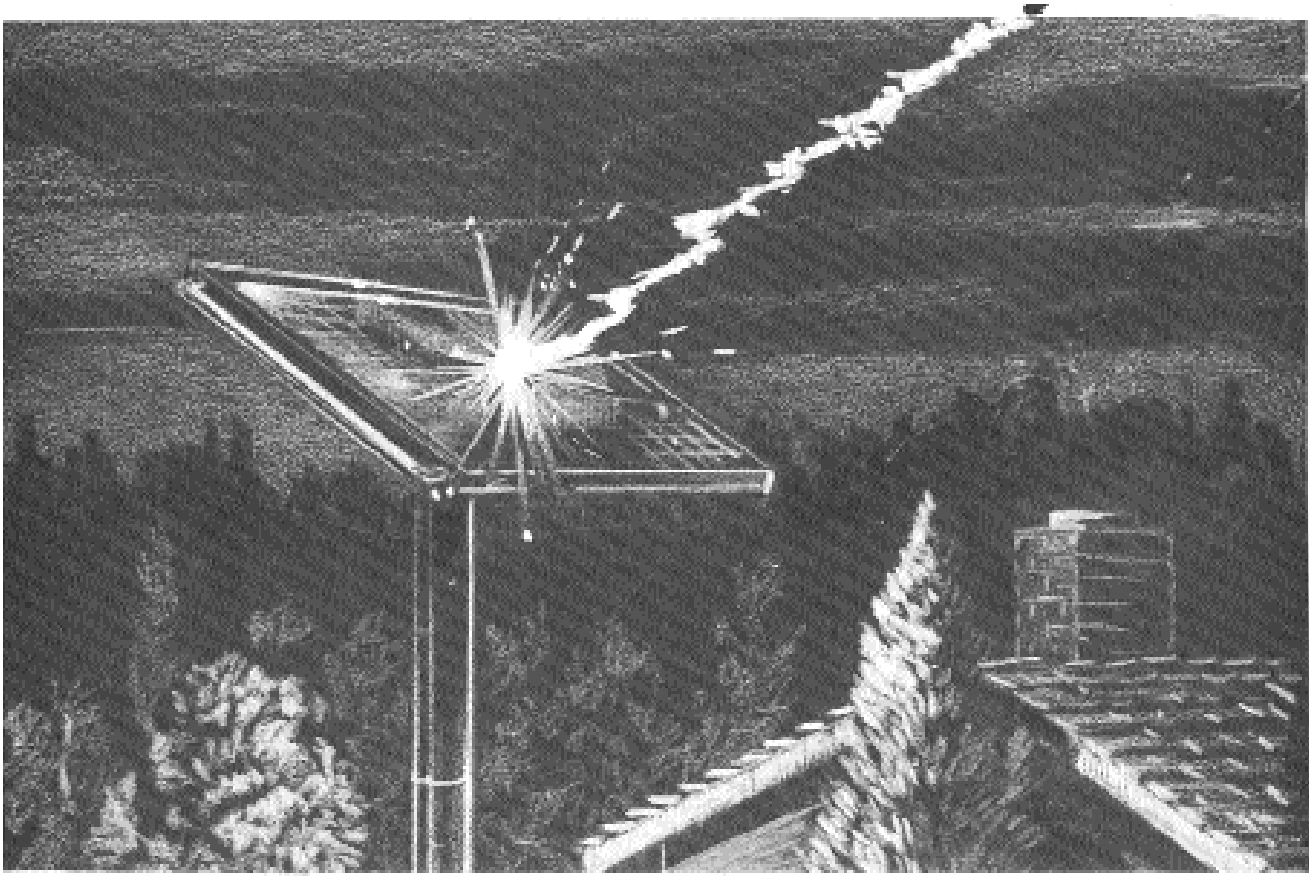
Grounding and lightning protection for solar-electric power systems



By Windy Dankoff

Lightning and related static discharge is the number one cause of sudden, unexpected failures in PV systems. Lightning does not have to strike directly to cause damage to sensitive electronic equipment, such as inverters, controls, radios, and entertainment equipment. It can be miles away and invisible, and still induce high voltage surges in wiring, especially in long lines.

Fortunately, almost all cases of lightning damage can be prevented by proper system grounding. Owners of independent power systems do not have grounding supplied by the utility company, and often overlook it until it is too late.

My own customers have reported damage to inverters, charge controllers, DC refrigerators, fluorescent light ballasts, TVs, pumps, and (rarely) photovoltaic panels. These damages cost many thousands of dollars, and all reports were from owner-installed systems that were **not grounded.**

Grounding

Grounding means connecting part of your system structure and/or wiring electrically to the earth. During lightning storms, the clouds build up a static electric charge. This causes accumulation of the opposite charge in objects to the ground. Objects that are insulated from the earth tend to accumulate the charge more strongly than the surrounding earth. If the potential difference (voltage) between sky and the objects is great enough, lightning will jump the gap.

Grounding your system does four things:

- It drains off accumulated charges so that lightning is not highly attracted to your system.
- If lightning does strike, or if a high charge does build up, your ground connection provides a safe path for discharge directly to the earth rather than through your wiring.

- It reduces shock hazard from the higher voltage (AC) parts of your system.
- It reduces electrical hum and radio caused by inverters, motors, fluorescent lights, and other devices.

Also, it is required by the National Electric Code. Photovoltaic systems are included in Article 690 of the Code. Low voltage systems are not exempt from grounding requirements or from the NEC.

To achieve effective grounding, follow these guidelines:

Install a proper grounding system

Minimal grounding is provided by a copper-plated ground rod, usually 8 ft. long, driven into the earth. This is a minimum procedure in an area where the ground is moist (electrically conductive).

Where the ground may be dry, especially sandy, or where lightning may be particularly severe, more rods should be installed, at least 10 feet apart. Connect or "bond" all ground rods together via bare copper wire (#6 or larger, see the NEC) and bury the wire. Use only approved clamps to connect wire to rods. If your photovoltaic array is some distance from the house, drive ground rod(s) near it, and bury bare wire in the trench with the power lines.

Metal water pipes that are buried in the ground are also good to ground to. Purchase connectors approved for the purpose, and connect **only** to cold water pipes, **never** to hot water or gas pipes. Beware of plastic fittings - bypass them with copper wire.

Iron well casings are super ground rods. Drill and tap a hole in the casing to get a good bolted connection. If you connect to more than one grounded object (the more the better) it is **essential to electrically bond (wire) them to each other**. Connections made in or near the ground are prone to corrosion, so use proper bronze or copper connectors. Your ground system is only as good as its weakest electrical connections.

If you have rocky soil

If your site is rocky and you cannot drive ground rods deeply, bury (as much as feasible) at least 150 feet of bare copper wire. Several pieces radiating outward is best. Try to bury them in areas that tend to be moist. If you are in a lightning-prone area, bury several hundred feet if you can. The idea is to make as much electrical contact with the earth as you can, over the broadest area feasible, preferably contacting moist soil.

You can save money by purchasing used copper wire (not aluminum) from a scrap metal dealer, and stripping off the insulation (use copper "split bolts" or crimped splices to tie odd pieces together.) If you need to run any power wiring over a distance of 30 feet or more, and are in a high-lightning, dry, or rocky area, run the ,wires in metal conduit and bond the conduit to your grounding system.

What to connect to your ground system

Ground the metallic framework of your PV array. (If your framework is wood, metallically bond the module frames together, and wire to ground.) Be sure to bolt your ground wires solidly to the metal so it will not come loose, and inspect it periodically. Also ground antenna masts and wind generator towers.

Ground the negative side of your power system, but first make the following test for leakage to ground: Obtain a common "multi-tester." Set it on the highest "milliamp" scale. Place the negative probe on battery neg. and the positive probe on your ground system. No reading? Good. Now switch it down to the lowest milli- or microamp scale and try again. If you get only a few microamps, or zero, **then ground your battery negative**. If you **did** read leakage to ground, check your system for something on the positive side that may be contacting earth somehow. (If you read a few microamps to ground, it is probably your meter detecting radio station signals.)

Connect your DC negative to ground **only in one place**, at a negative battery connection or other main negative junction nearby (at a disconnect switch or inverter, for instance.) Do **not** ground negative at the array or at any other points.

Ground your AC generator and inverter frames and AC neutral wires and conduits in the manner conventional for all AC systems. This protects from shock hazard as well as lightning damage.

PV array wiring should be done with minimum lengths of wire, tucked into the metal framework, then run through metal conduit. Positive and negative wires should be run together wherever possible, rather than being some distance apart. This will minimize induction of lightning surges. Bury long outdoor wire runs instead of running them overhead. Place them in grounded metal conduit if you feel you need maximum protection.

Surge protection devices bypass the high voltages induced by lightning. They are recommended for additional protection in lightning-prone areas or where good grounding is not feasible (such as on dry rocky mountain top), especially if long fines are being run to an array, pump, antenna, or between buildings. Surge protectors must be special for low voltage systems, so contact your PV dealer.

Safety first! If you are uncertain of your ability to wire your system properly, hire, an electrician!

(Windy Dankoff if the founder of Flowlight Solar Power, a leading manufacturer of solar water pumping systems. He says thee company grew up and Is no fun to play with anymore, so he's back to working at home, supplying solar. electric power systems to folks who live beyond the power lines.His phone: (505) 351-2100) Δ

A well-regulated militia, being necessary to the security of a free State, the right of the people to keep and bear arms, shall not be infringed.

The second amendment
to the Constitution
of the United States