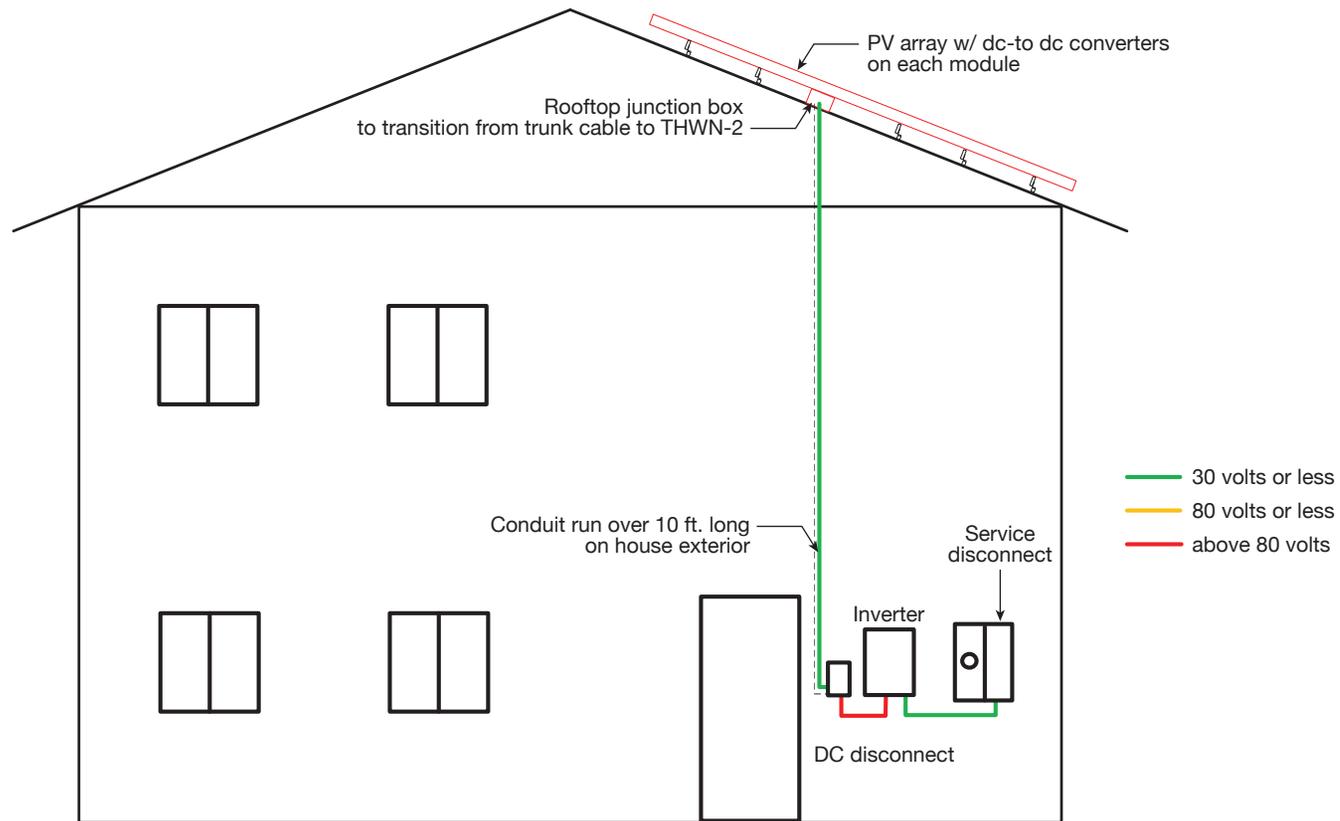
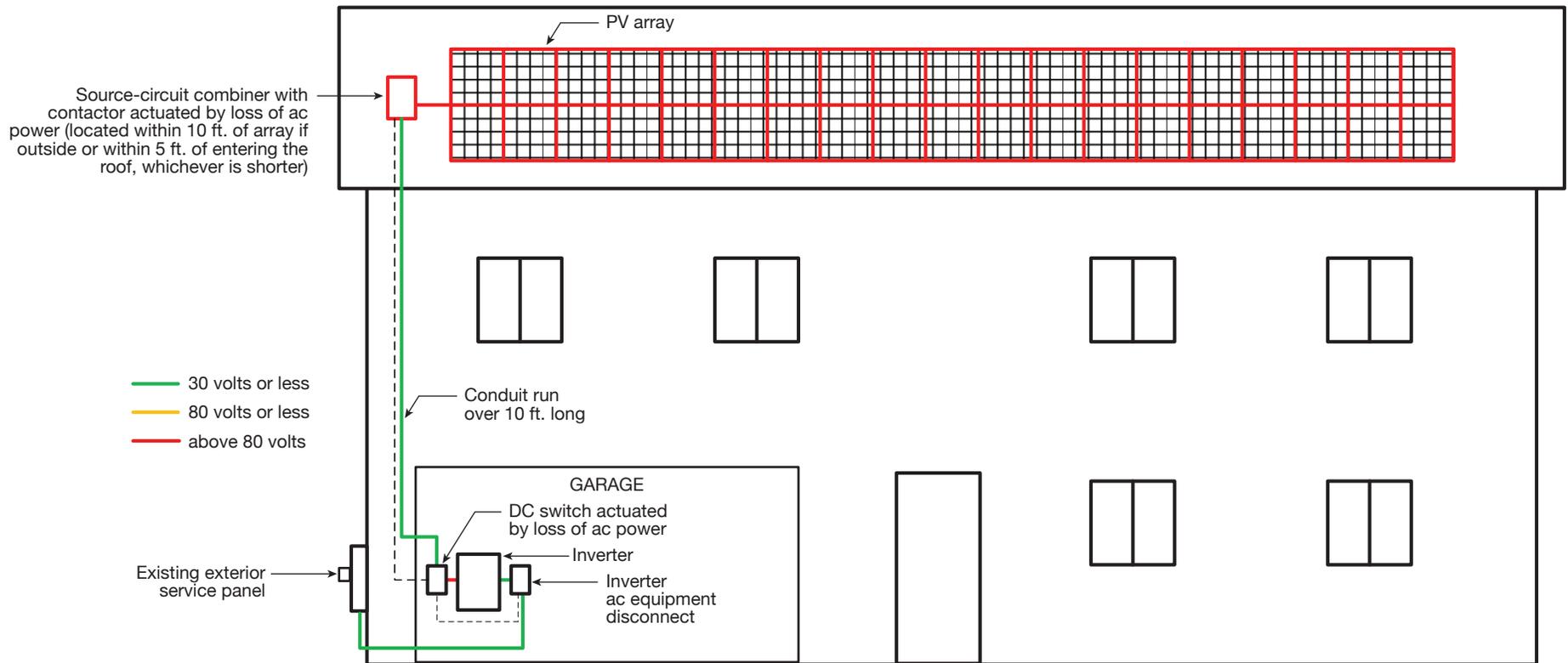


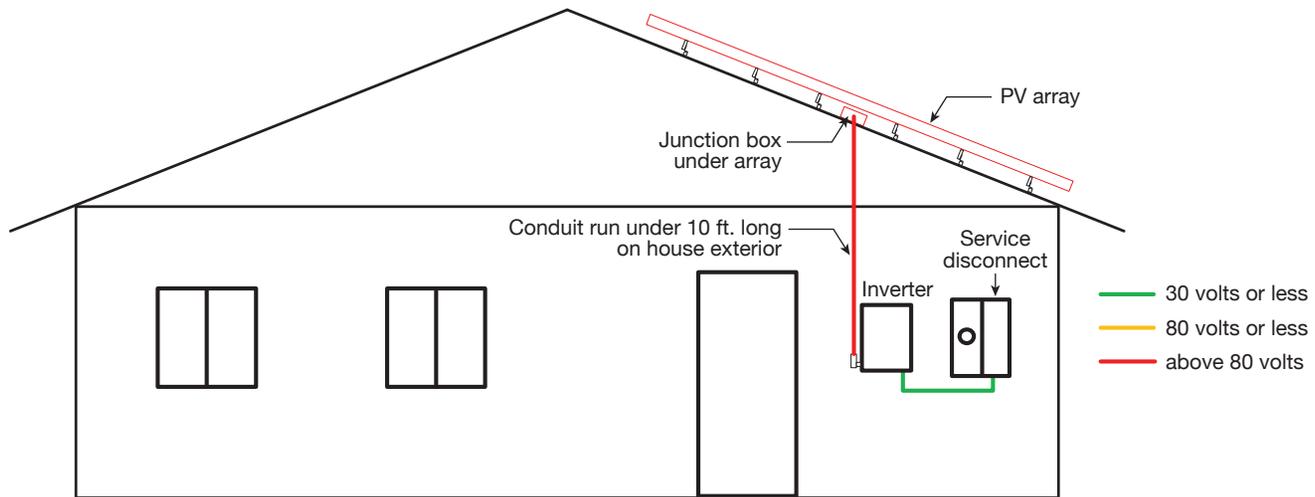
Residential microinverter system If an inverter is dedicated to every module, whether externally or as part of a listed ac module assembly, the PV system shuts down completely upon loss of utility power without additional remotely activated switches. For load-side connected PV systems, the service disconnecting means can be the rapid-shutdown initiator. For supply-side connected PV systems, the PV system disconnecting means, adjacent to the service disconnecting means, can be the rapid-shutdown initiator.



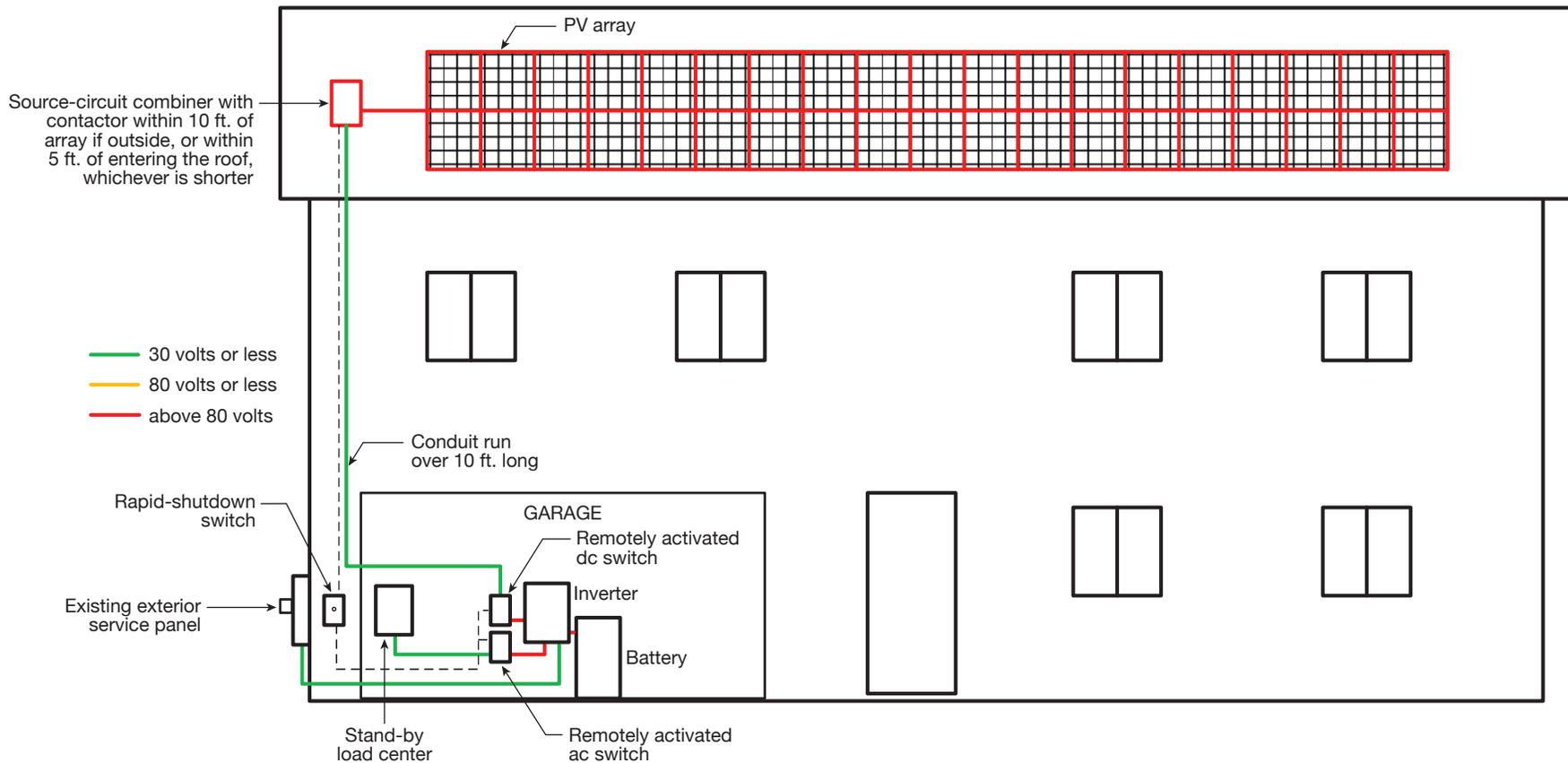
String inverter with roof-mounted dc-to-dc converters While module-level dc-to-dc optimizers are well suited for controlling voltage in the PV source circuits, system designers must verify that the voltage from the inverter capacitor bank is controlled to less than 30 volts within 10 seconds. In scenario shown here, the dc disconnect at the string inverter can be used to initiate rapid shutdown. Since most residential-sized string inverters have integrated dc disconnect wiring centers, the energized conductors from the capacitor bank are protected inside the listed device instead of outside the unit as shown here.



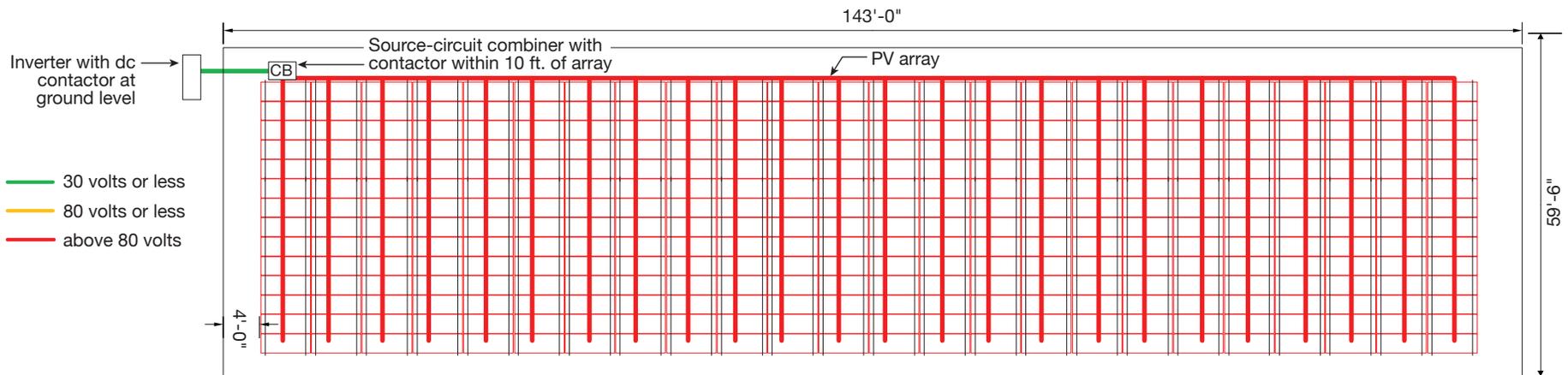
String inverter with remote switches If an inverter cannot meet the 30-volt and 10-second limits in 690.12, you must install a switch to isolate the capacitor bank. In this scenario, loss of ac power actuates both the dc switch in the garage and the source-circuit contactor combiner near the array. In order to use the dc disconnect as the rapid-shutdown initiator, this device would also have to remotely activate the switch in the attic. (Note that rapid shutdown is relatively simpler using string inverters that meet the 30-volt and 10-second limits, as is the case with many non-isolated [transformerless] string inverters.)



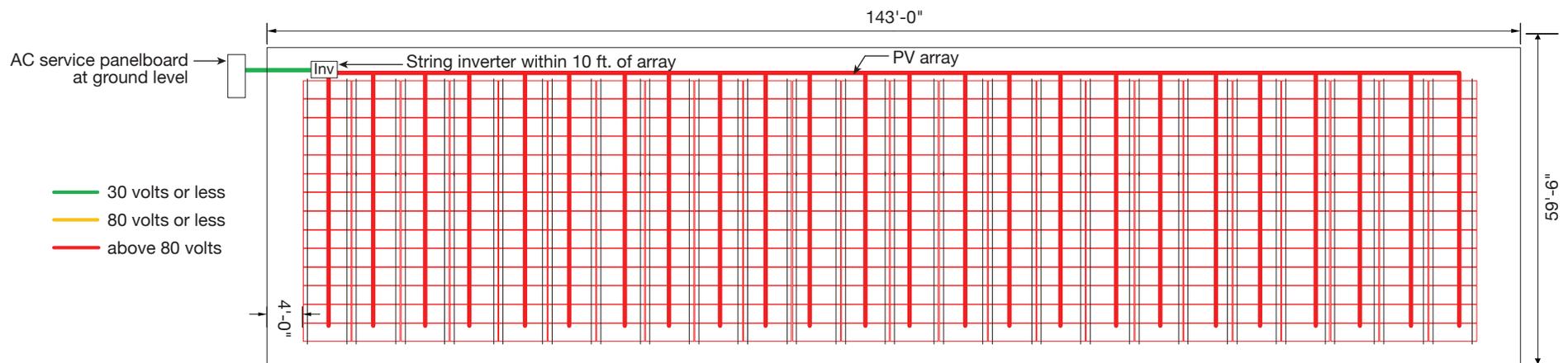
No remotely-actuated switches required If you can install a string inverter within 10 feet of the PV array, as shown here, you do not need to install any remote switches to comply with 690.12.



Utility-interactive system with battery storage and remote switches If the battery cables are less than 5 feet long, subsection 690.71(H) does not require a remotely-actuated switch on the battery cables. In this scenario, installers could use a remotely-actuated ac switch to shut down the backup power circuits. As shown here, a rapid-shutdown controller switch initiates rapid shutdown; this switch actuates contactors in a rooftop combiner as well as contactors in ac and dc switches at the inverter. Note that the remotely actuated dc switch is not required where the inverter complies with the 30-volt and 10-second limits. Further, where the battery cables are more than 5 feet long, the battery cables and backup power circuits need to be controlled using a remotely actuated dc switch between the battery and the inverter that complies with 690.71(H).



Commercial roof-mounted PV system with central inverter and remotely-actuated switches Some large central inverters have dc input contactors that will open and isolate their input capacitors within 10 seconds of loss of dc power or loss of ac power. The most commonly used remotely actuated switches in PV systems today are contactors that operate from a 24 V power supply. Since these normally open contactors require 24 V power to stay closed, interrupting the 24 V power supply will remotely open these contactors. For those inverters that do not have dc input contactors, you must install additional remotely actuated switch(es) in order to isolate in the dc capacitor bank during rapid shutdown.



Commercial roof-mounted PV system with rooftop string inverters Currently, one of the most common methods of PV system design for large commercial rooftop systems uses 15 to 50 kW 1,000 Vdc string inverters that output 3-phase 480 Vac power to the building. If you place these string inverters within 10 feet of the array that they are connected to, as shown here, the PV system can meet the requirements of 690.12. In this scenario, rapid shutdown can be initiated upon loss of utility power without any remotely activated switches.

