SOLAR PV STANDARD ELECTRICAL PLAN

Microinverter Systems for Single Family Dwellings

***** Provide this document to the inspector along with ALL system installation instructions *****

Project Address:_____

Permit Number: _____

Scope: Standard plan for the installation of grounded microinverter solar PV systems, not exceeding a total AC output of 10kW, in single family dwellings having a 3 wire electrical service not larger than 225 amps at a voltage of 120/240. This plan covers dedicated crystalline and multicrystalline type module, having one microinverter per module, and where all the modules and microinverters are mounted on the roof of the single family dwelling.

Note: This plan is not intended for systems containing batteries or hybrid systems. This document addresses only the requirements of the 2011 Los Angeles Electrical Code (LAEC). Refer to Information Bulletin P/GI 2011-027, for building code requirements.

NOTE: Calculate the total AC output of the system.

# of Microinverters ____ x Inverter AC Output Current ____A x 240 V = _____ W divided by 1,000 ≤ _____≤ 10 kW

Installer information:

Name:	Phone Number: ( ) -
Address: _____ City: _____ State: _____ Zip _____	Homeowner: ☐ Contractor: ☐ Contractor License # _____ License type _____ Signature _____

A) Microinverter information:

Each microinverter shall have factory installed Ground Fault protection, be identified as "Utility-Interactive", and be approved by the Electrical Testing Laboratory.

Provide the following information from the microinverter installation manual.

1) Manufacturer _____

2) Model number _____

Note: Must use microinverters that are approved by L.A. City under a research report and must comply with the conditions of approval stated in the research report. Check our website at http://ladbs.org/LADBSWeb/electrical-test-lab.jsf for approved products.

(Rev. 2- 10/2013)

3) Minimum mounting height above the roof surface _____ **inches**

4) Maximum DC input open circuit voltage _____ **Volts**

5) Maximum DC input short circuit current _____ **Amps**

6) Maximum AC output current _____ **Amps**

7) Maximum size branch circuit breaker permitted _____ **Amps**

8) Maximum number of inverters permitted per branch circuit _____

Note: The number of microinverters installed per branch circuit may be less than the maximum number permitted by the manufacturer, but shall not be more.

B) Module information:

9) Manufacturer _____

10) Model number _____

11) Total number of modules being installed _____

12) Maximum DC output voltage (Voc) _____ Volts x temperature correction factor 1.14 **= _____volts.** (Shall not exceed the microinverter maximum DC input open circuit voltage)

13) Maximum DC current output (Isc) _____ **Amps** x 1.25 = _____ **Amps** (Shall not exceed the microinverter maximum DC input short circuit current rating.)

Important: Not all modules are suitable for use with microinverter systems. Review the microinverter installation manual prior to beginning any installation to avoid costly errors.

C) Manufacturer "Trunk" cable (if supplied):

Some microinverter manufacturers include as part of their installation kit a "Trunk" cable that each microinverter of the branch circuit plugs into. These cables must be approved by City of Los Angeles Electrical Testing Laboratory, have a wet location insulation temperature rating of at least 90 degrees Celsius, be provided with an equipment grounding conductor inside of the overall cable sheath and contain no more than three current carrying conductors. Cables that will be exposed to sunlight must be listed as such. This cable will typically be run underneath the array where it will not be subject to physical damage. This cable, if provided, must be used. Non-manufacturer supplied cables or installer fabricated assemblies are not approved. Where the cable is exposed to physical damage, the cable shall be protected.

14) Provide the conductor size of the manufacturer supplied "Trunk" cable _____ **AWG (From cable jacket)**

15) Provide the MINIMUM INSTALLATION spacing above the roof surface to the bottom of the "Trunk" cable per the installation instructions _____ **inches** (If no dimension specified, write "None specified").

16) Provide the MINIMUM INSTALLATION spacing below the array modules to the top of the "Trunk" cable per the installation instructions _____ **inches** (If no dimension specified write "None specified").

D) Temperature compensation for roof mounted cables under the array:

17) Depending on the mounting method of the array, temperatures under the array may be higher than the surrounding ambient air.

Table 1

Mounting Method of Array	Temperature
1. PV Panels installed parallel to the roof and there is a clear unobstructed space between the roof and the back of the panels:	
a. The clear space between the roof and the back of the panels is no more than 1”	60˚C (140˚F)
b. The clear space between the roof and the back of the panels is no more than 3”	56˚C (133˚F)
c. The clear space between the roof and the back of the panels is no more than 6”	55˚C (131˚F)
d. The clear space between the roof and the back of the panels is over 6”	39˚C (102˚F)
2. PV Panels installed parallel to the roof and using channels (rails) spaced in a manner that obstructs the air flow below the panels:	
a. The space between the roof and the back of the panels is no more than 1”	64˚C (147˚F)
b. The space between the roof and the back of the panels is no more than 3”	60˚C (140˚F)
c. The space between the roof and the back of the panels is no more than 6”	59˚C (138˚F)
d. The space between the roof and the back of the panels is over 6”	43˚C (109˚F)
3. PV Panels are installed at an angle to the roof	
a. The clear space between the roof and the back of the panels is no more than 1”	54˚C (129˚F)
b. The clear space between the roof and the back of the panels is over 1”	39˚C (102˚F)
4. Panels are directly mounted on the roof with no air circulation underneath	63˚C (145˚F)

Array Mounting Method (e.g.1a): _____ (from Table 1) Temperature (e.g.60˚): _____ **°C** (from Table 1)

E) Sizing the conductors for the microinverter branch circuit:

Where the manufacturer supplied cable transitions to regular building conductor installed inside of a raceway, a reduction in the amount of current these conductors can carry may be required based on the temperature and number of conductors in the raceway.

18) The amount of current that will be carried by the conductors per raceway shall be calculated as follows:

a. Number of inverters installed on branch circuit #1 _____ **x** Maximum inverter AC output (Step #6) _____ Amps **x** 1.25 (for long continuous load) **=** _____ **Amps.**

b. Number of inverters installed on branch circuit #2 _____ **x** Maximum inverter AC output (Step #6) _____ Amps **x** 1.25 (for long continuous load) **=** _____ **Amps.**

c. Number of inverters installed on branch circuit #3 _____ **x** Maximum inverter AC output (Step #6) _____ Amps **x** 1.25 (for long continuous load) **=** _____ **Amps.**

d. Number of inverters installed on branch circuit #4 _____ **x** Maximum inverter AC output (Step #6) _____ Amps **x** 1.25 (for long continuous load) **=** _____ **Amps.**

e. Max current in any branch circuit (Largest of 18a, 18b, 18c or 18d) = _____ **Amps**

f. Height of raceway installed above the rooftop _____ **inches**

g. Number of current carrying conductors in a raceway _____

h. Select a conductor size (from Table 2, page 4) that can carry the maximum current in step #18e. Your selected conductor size is permitted to have a higher ampacity than the number in step #18e, but it shall not be less**.** Use approved cable/conductor reducer at the terminal when needed (i.e. #8 AWG to #12 AWG).
Conductor Size _____ **AWG** (minimum # 12AWG)

Table 2

Table 2 is based on the following:

- Table 310.16 - Allowable Ampacity of Insulated Conductors, 90 C rated conductors.
- Table 310.16 - Correction Factors based on temperature ranges.
- Table 310.15(B)(2)(c) - Temperature Adjustments for Conduits Exposed to Sunlight On or Above Rooftops.
- Table 310.15(B)(2)(a) Adjustment Factors for More Than Three Current-Carrying Conductors in a Raceway or Cable.
- Sections 240.4(D)(5) and 240.4(D)(7) for 10 AWG and 12 AWG conductors.

Table 2: Maximum Allowable Ampacity of Conductors Installed in a Circular Raceway, Exposed to Sunlight, On or Above Rooftops

Number of Current Carrying Conductors in a Raceway	Height Above Rooftop	Highest Ambient Temp									
		Up to 40˚C					41˚C - 45˚C				
		12 AWG	10 AWG	8 AWG	6 AWG	4 AWG	12 AWG	10 AWG	8 AWG	6 AWG	4 AWG
Up to 3 Conductors	0 to 0.5"	12	16	23	31	39	12	16	23	31	39
	above 0.5" to 3.5"	17	23	32	44	55	17	23	32	44	55
	above 3.5" to 12"	20	28	39	53	67	17	23	32	44	55
	above 12"	20	30	42	57	72	20	28	39	53	67
4 to 6 Conductors	0 to 0.5"	10	13	18	25	31	10	13	18	25	31
	above 0.5" to 3.5"	14	19	26	35	44	14	19	26	35	44
	above 3.5" to 12"	17	23	31	43	54	14	19	26	35	44
	above 12"	18	24	33	46	58	17	23	31	43	54
7 to 9 Conductors	0 to 0.5"	9	11	19	22	27	9	11	16	22	27
	above 0.5" to 3.5"	12	16	22	30	39	12	16	22	30	39
	above 3.5" to 12"	15	20	27	37	47	12	16	22	30	39
	above 12"	16	21	29	40	51	15	20	27	37	47
		46˚C - 50˚C					51˚C - 55˚C				
Up to 3 Conductors	0 to 0.5"	0	0	0	0	0	0	0	0	0	0
	above 0.5" to 3.5"	12	16	23	31	39	12	16	23	31	39
	above 3.5" to 12"	17	23	32	44	55	12	16	23	31	39
	above 12"	17	23	32	44	55	17	23	32	44	55
4 to 6 Conductors	0 to 0.5"	0	0	0	0	0	0	0	0	0	0
	above 0.5" to 3.5"	10	13	18	25	31	10	13	18	25	31
	above 3.5" to 12"	14	19	26	35	44	10	13	18	25	31
	above 12"	14	19	26	35	44	14	19	26	35	44
7 to 9 Conductors	0 to 0.5"	0	0	0	0	0	0	0	0	0	0
	above 0.5" to 3.5"	9	11	16	22	27	9	11	16	22	27
	above 3.5" to 12"	12	16	22	30	39	9	11	16	22	27
	above 12"	12	16	22	30	39	12	16	22	30	39
		56˚C - 60˚C					61˚C - 65˚C				
Up to 3 Conductors	0 to 0.5"	0	0	0	0	0	0	0	0	0	0
	above 0.5" to 3.5"	0	0	0	0	0	0	0	0	0	0
	above 3.5" to 12"	12	16	23	31	39	0	0	0	0	0
	above 12"	12	16	23	31	39	12	16	23	31	39
4 to 6 Conductors	0 to 0.5"	0	0	0	0	0	0	0	0	0	0
	above 0.5" to 3.5"	0	0	0	0	0	0	0	0	0	0
	above 3.5" to 12"	10	13	18	25	31	0	0	0	0	0
	above 12"	10	13	18	25	31	10	13	18	25	31
7 to 9 Conductors	0 to 0.5"	0	0	0	0	0	0	0	0	0	0
	above 0.5" to 3.5"	0	0	0	0	0	0	0	0	0	0
	above 3.5" to 12"	9	11	16	22	27	0	0	0	0	0
	above 12"	9	16	16	22	27	9	11	16	22	27

F) Solar Load Center and circuit breakers, sizing information:

Regardless of the number of branch circuits, the Los Angeles Department of Water and Power (LADWP) always requires a performance meter and a safety disconnect switch to be installed between the PV power source and their equipment. Multiple microinverter branch circuits shall not connect directly into the main service panel of the house. They first go to a solar load center, which is a standard circuit breaker panel that collects together the individual branch circuits from the microinverters. Each branch circuit shall have its own dedicated circuit breaker. From this Solar Load Center one feeder will go to the performance meter, then to the safety disconnect switch, and finally to the point of interconnection at the house main service panel. Only PV system monitoring equipment/devices are permitted to be connected between the output of the inverter and the house main service panel. Contact LADWP for performance meter and AC utility disconnect switch requirements.

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19) Total number of microinverter branch circuits installed _____

20) List the current in Amps (from step 18) for each individual branch circuit outputs.

Circuit #1 _____ **Amps,** Circuit #2 _____ **Amps,** Circuit #3 _____ **Amps,** Circuit #4 _____ **Amps.**

21) Total PV current in Amps connected to the service panel (sum of the individual branch circuits from step 20)
= _____ Amps

NOTE: Skip steps 22 and 23, if only one branch circuit is installed.

22) Size of load center panel main breaker if installed (If no main breaker is installed, write NONE) _____ **Amps**

23) Solar load center (panel) bus bar:

a. Circuit #1 OCPD____**Amps,** Circuit #2 OCPD____**Amps**, Circuit #3 OCPD____**Amps**, Circuit #4OCPD____**Amps**

b. Main overcurrent protective device size: _____**Amps** (If no main breaker for load center panel, use solar OCPD from main service panel)

c. Solar load center bus size (from panel label): _____**Amps** (This figure must be larger than the number at step #21 or the panel will be undersized)

The sum of the values in (a) and (b) shall not exceed 120% of the value in (c)

24) To size the load center feeder (or branch circuit, if only one circuit is installed) conductors and its OCPD (from main service panel), use the result from step #21 and select the correct size conductor from Table 3 below for your installation.

a. Solar load center output conductor size _____ **AWG** (see Table 3)

b. OCPD Size _____**Amps** (see Table 3)

Table 3

AWG size	90˚C Copper Wire	Maximum OCPD
12	20 Amp per 240.4(D)	20 Amps
10	30 Amp per 240.4(D)	30 Amps
8	50 Amp	50 Amps

Note: This table is based on Table 310.16 using 90˚C and 0.91 correction factor, and OCPD is based on 75˚ C terminal rating.

G) LADWP "Performance" meter:

The output wiring from the microinverters shall always connect to the "LINE" side terminals at the top of the meter. The wiring from the meter to the main service panel will connect to the "LOAD" side terminals at the bottom.

H) LADWP "Safety Disconnect Switch":

Where the DWP disconnect switches (with or without fuses) are installed in the circuit(s) from the microinverters to the house main service panel, the wiring originating at the microinverters shall always connect to the "LOAD" side (bottom) terminals of ANY disconnect switch. The wiring originating at the electric service panel shall always connect to the "LINE" side (top) terminals of the disconnect switch. Check with the LADWP for specific requirements.

I) Connection to the main service panel:

The connection to the main service panel shall be through a dedicated circuit breaker that connects to the panel bus bars in an approved manner. "Load Side Taps" where the inverter AC wiring does not terminate to a dedicated breaker or set of fuses are prohibited under ANY condition by Section 690.64 (B).

Where the main breaker of the service panel that the PV system will interconnect to is located at either the top or bottom of the panel distribution bus bars and the PV interconnect breaker is located at the opposite end, the code permits the sum of the ratings of the main breaker and the PV breaker to exceed the rating of the panel bus bars. Per Section 690.64 (B)(2), the sum of the main service panel main breaker and the microinverter PV interconnect breaker shall not add up to more than 120% of the rating of the panel bus bars. For a 100 amp rated bus this means that both breakers together shall not add up to more than 120 amps. For a 200 amp rated bus, not more than 240 amps and for 225 amps, not more than 270 amps. In order to qualify for this additional allowance, the PV dedicated circuit breaker must be located at the opposite end of the breaker panel from the main breaker and shall have the warning label installed next to it per Section 690.64 (B)(7). "WARNING INVERTER OUTPUT CONNECTION. DO NOT RELOCATE THIS OVERCURRENT DEVICE".

(a) Main service overcurrent protective device size: _____**Amps**

(b) Solar OCPD size (from 24b): _____**Amps**

(c) Main panel bus size (from panel label): _____

The sum of the values in (a) and (b) shall not exceed 120% of the value in (c)

Note: Certain "All-in-One" service panels have the factory installed main breaker in the center of the distribution section. Because of the possibility of overloading the bus bars, this type of service is not able to take advantage of the 120% overage permitted for top or bottom fed bussing. For this type of installation the sum of the main circuit breaker and the PV breaker may not exceed 100% of the rating of the factory bussing. For example, if the main service panel label states that the bus bars are rated for 200 amps you cannot exceed that figure. In some cases it may be possible to reduce the size of the main circuit breaker to accommodate the addition of a PV breaker and still not exceed the bus bar rating. This requires that a "load calculation" of the house electrical power consumption be made in order to see if this is an acceptable solution. Where it is necessary to install the PV interconnection as a "Line Side Tap" and where the main service panel at the dwelling is an "All-in-One" type, the service shall be provided with factory installed terminals designed specifically to accommodate this type of connection. Where these terminals are not provided there shall be NO PV connection between the load side of the meter and the line side of the main circuit breaker.

J) Grounding the photovoltaic system:

A Grounding Electrode Conductor sized not less than #6 AWG solid copper, shall be run UNSPLICED from the factory identified grounding terminal of each microinverter to the grounding electrode system of the house, (i.e. ground rod, Ufer ground, or metallic water pipe with a minimum of 10 feet in the ground).

Note: The Grounding Electrode Conductor is permitted to be spliced per Section 250.64 (C) using an irreversible means or by the installation of a "Ground Plate". (A Ground Plate is defined as a copper bus bar ¼" thick by 2" wide by whatever length is needed to terminate the conductors). This conductor may also be used as the required equipment grounding conductor for the modules and the frame rails of the array. (Equipment grounding conductors may be connected to the Grounding Electrode Conductor by non-irreversible means such as listed split bolts).

K) Disconnection of photovoltaic equipment:

Section 690.15 requires that means are provided to disconnect equipment from all ungrounded conductors of all sources. Such disconnecting means shall comply with Sections 690.16 and 690.17.

Note: Section 690.17 contains an exception which states "A connector shall be permitted to be used as an ac or a dc disconnecting means, provided that it complies with the requirements of 690.33 and is listed and identified for the use."

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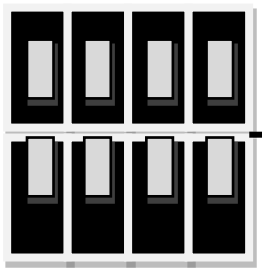
L) Signage:

Per Section 690.54, a permanent label for the microinverter AC power source shall be installed at the point of interconnection at an accessible location. This label shall show that it is a PV source and additionally, the rated AC output current and the nominal operating AC voltage.



Array (Modules and Microinverters)

J/B

Solar Load Center

PV SYSTEM AC DISCONNECT
RATED AC OUTPUT CURRENT##AMPS
AC NORMAL OPERATING
VOLTAGE _____ VOLTS
690.54

M

LADWP PERFORMANCE METER

A C

PHOTOVOLTAIC SYSTEM LADWP SAFETY DISCONNECT SWITCH

M

WARNING
DUAL POWER SOURCES
SECOND SOURCE IS PHOTOVOLTAIC SYSTEM
RATED AC OUTPUT CURRENT _____ AMPS
AC NORMAL OPERATING
VOLTAGE ____ VOLTS
690.54

INSTALL PERMANENT PLAQUE OR DIRECTORY PROVIDING THE LOCATION OF THE SERVICE DISCONNECTING MEANS, AND PHOTOVOLTAIC SYSTEM DISCONNECTING MEANS IF NOT INSTALLED AT THE SAME LOCATION. PLAQUE SHALL BE MOUNTED ON THE EXTERIOR OF THE BUILDING

Minimum 20 point type on a sharply contrasting background

690.56-(B), 705.10

WARNING
INVERTER OUTPUT CONNECTION DO NOT RELOCATE THIS OVERCURRENT DEVICE
(UNLESS BUSBAR IS FULLY RATED)
690.64(B)(7), 705.12(D)(7)

Note: Italicized text shown inside the boxes is not required to be part of the sign, it is only for reference

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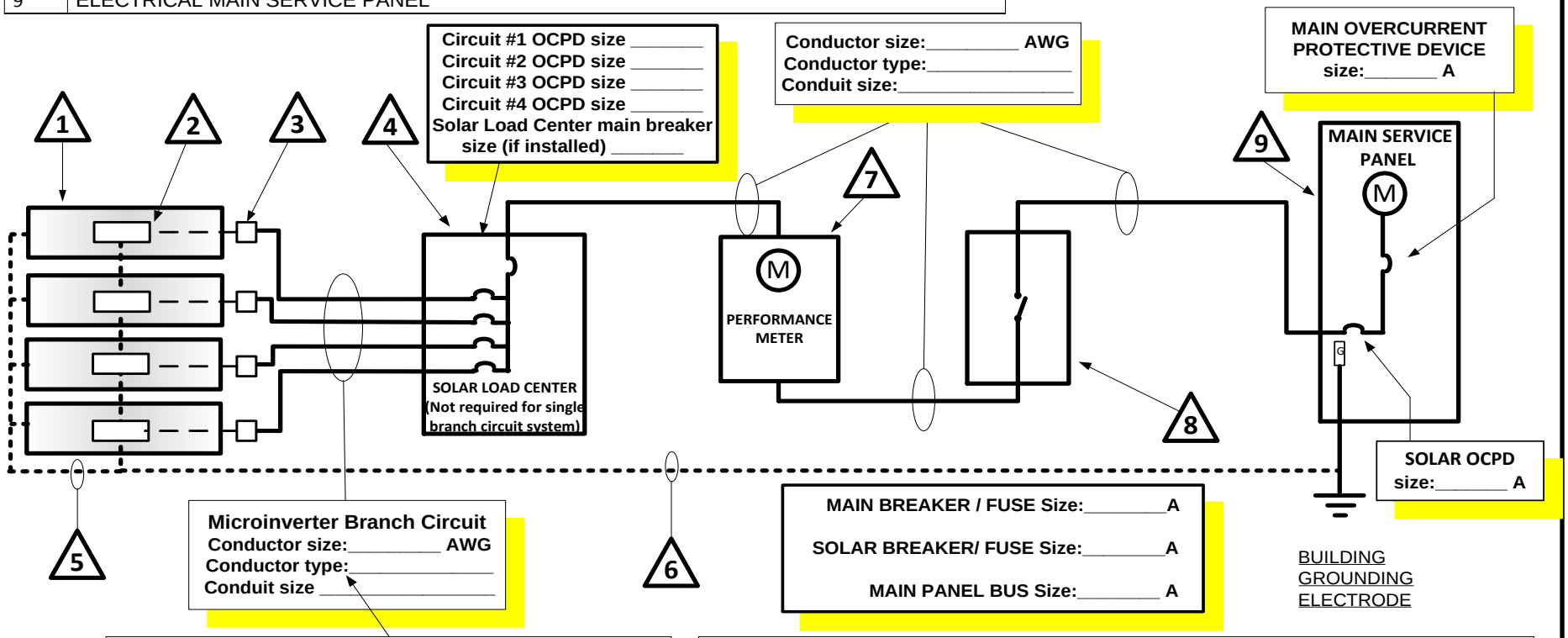
SOLAR PV STANDARD ELECTRICAL PLAN

Microinverter Systems for Single Family Dwellings

TAG	DESCRIPTION
1	SOLAR PV MODULE
2	MICROINVERTER
3	JUNCTION BOX FOR THE MANUFACTURER SUPPLIED CABLE TO RACEWAY TRANSITION
4	SOLAR LOAD CENTER
5	ARRAY EQUIPMENT GROUNDING CONDUCTOR
6	MICROINVERTER GROUNDING ELECTRODE CONDUCTOR (MIN #6 AWG COPPER)
7	LADWP PERFORMANCE METER
8	LADWP SAFETY DISCONNECT SWITCH
9	ELECTRICAL MAIN SERVICE PANEL

MAXIMUM 10 KW OUTPUT
MAXIMUM 225 AMP SERVICE
120/240 SINGLE PHASE

THIS PLAN MUST BE PROVIDED TO THE FIELD INSPECTOR



Provide required information in these boxes

Note: This plan is intended to be used ONLY with Microinverter Systems.

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SOLAR PV STANDARD ELECTRICAL PLAN

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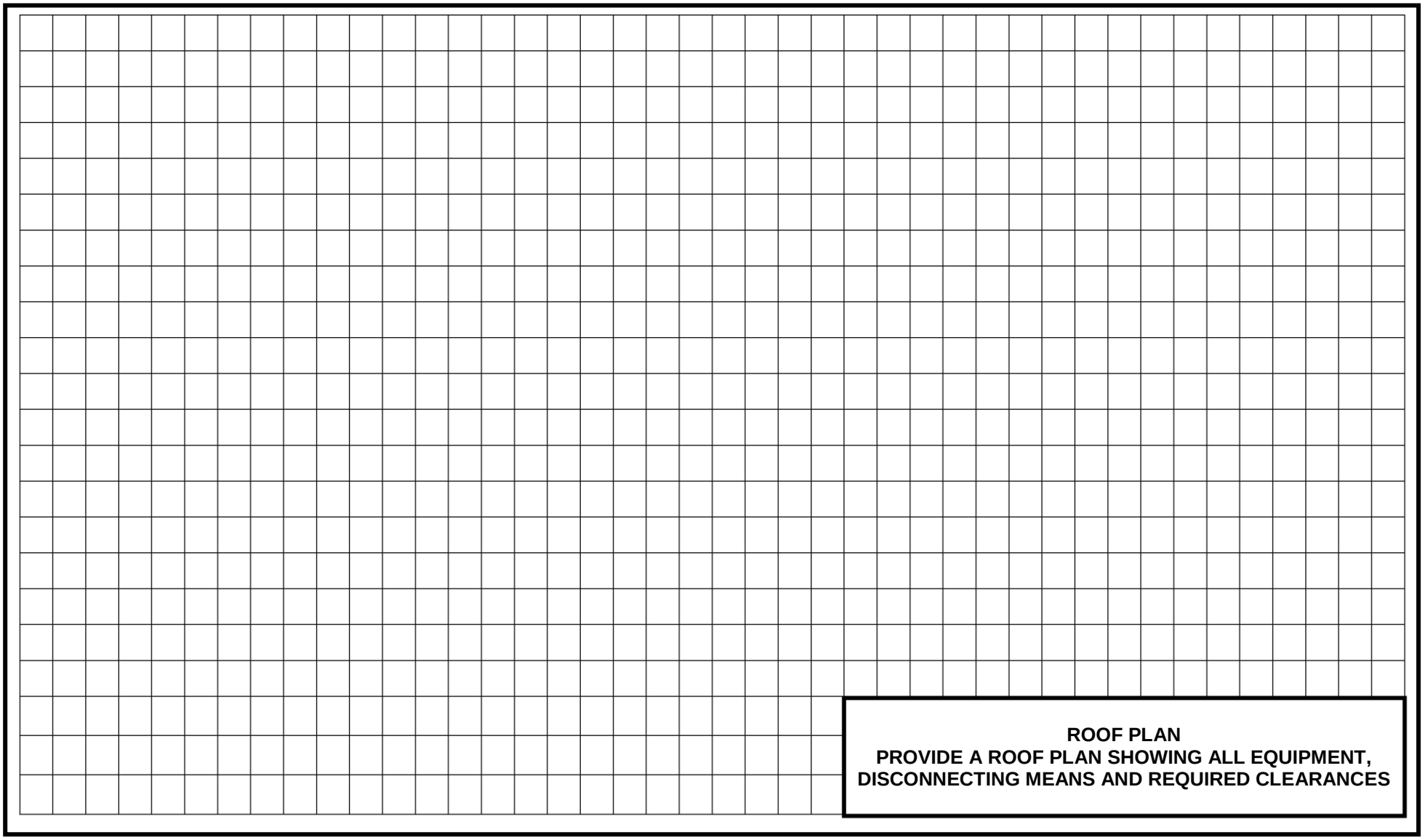

ROOF PLAN
PROVIDE A ROOF PLAN SHOWING ALL EQUIPMENT, DISCONNECTING MEANS AND REQUIRED CLEARANCES

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Permit Number: _____

Project Address: _____

Permit Number: _____