SM

COOK ENGINEERING, INC.

SKY12032011

Lecture 2: PV Design Consideration

Dec 03 2011

Agenda

- **Design Consideration**
- 2.1 A Peek inside a PV SYSTEM
- 2.2 PHOTOVOLTAIC RELATED GREEN BUILDING CREDIT
- 2.3 NEC CODE REQUIREMENT
- 2.4 SHADING CONSIDERATION IN STRING LAYOUT
- 2.4 RESIDENTIAL DESIGN EXAMPLE
- 2.5 COMMERCIAL DESIGN CONSIDERATION
- 2.6 MICROINVERTER

2.1 A Peek inside a PV cell

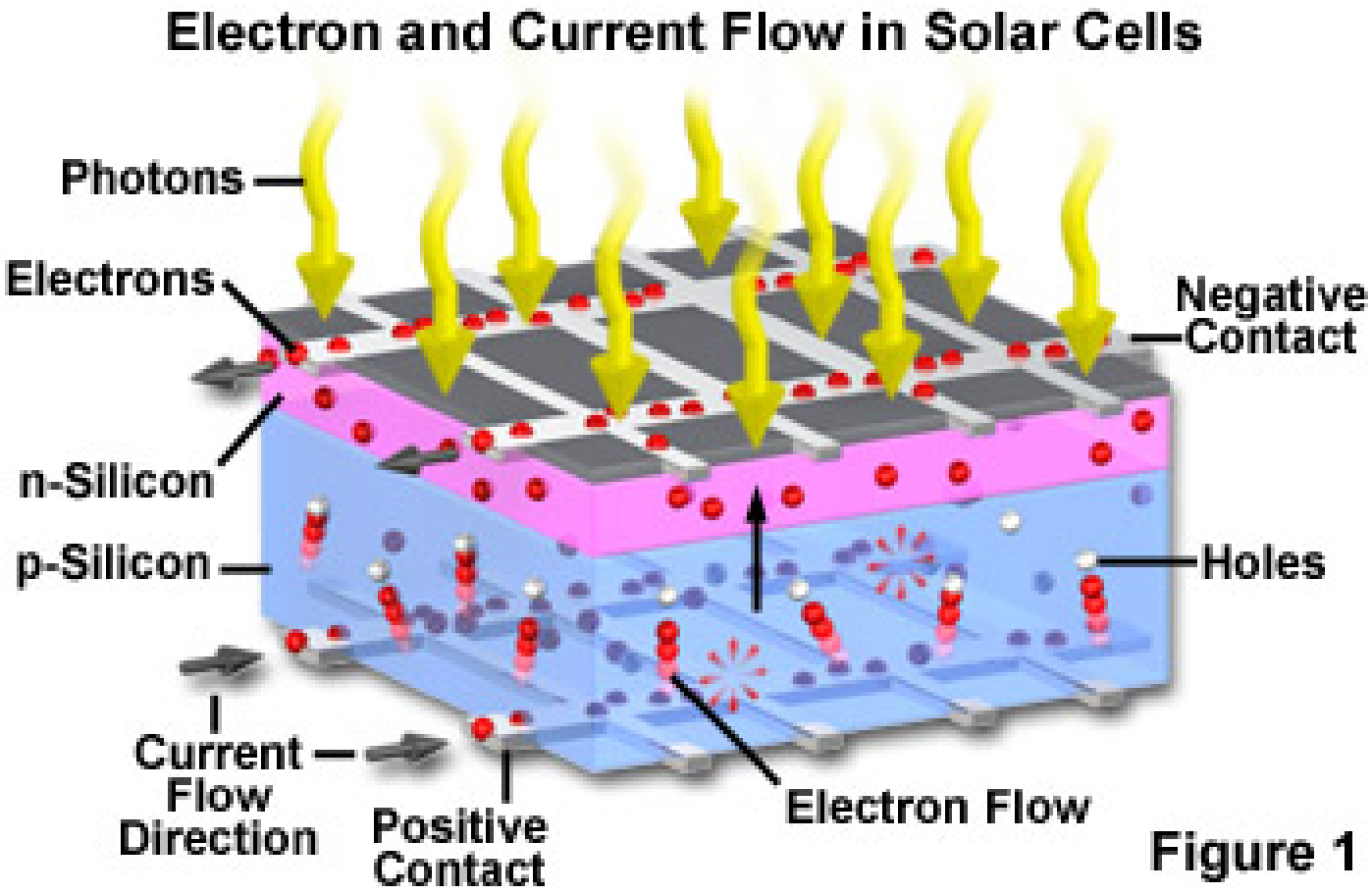
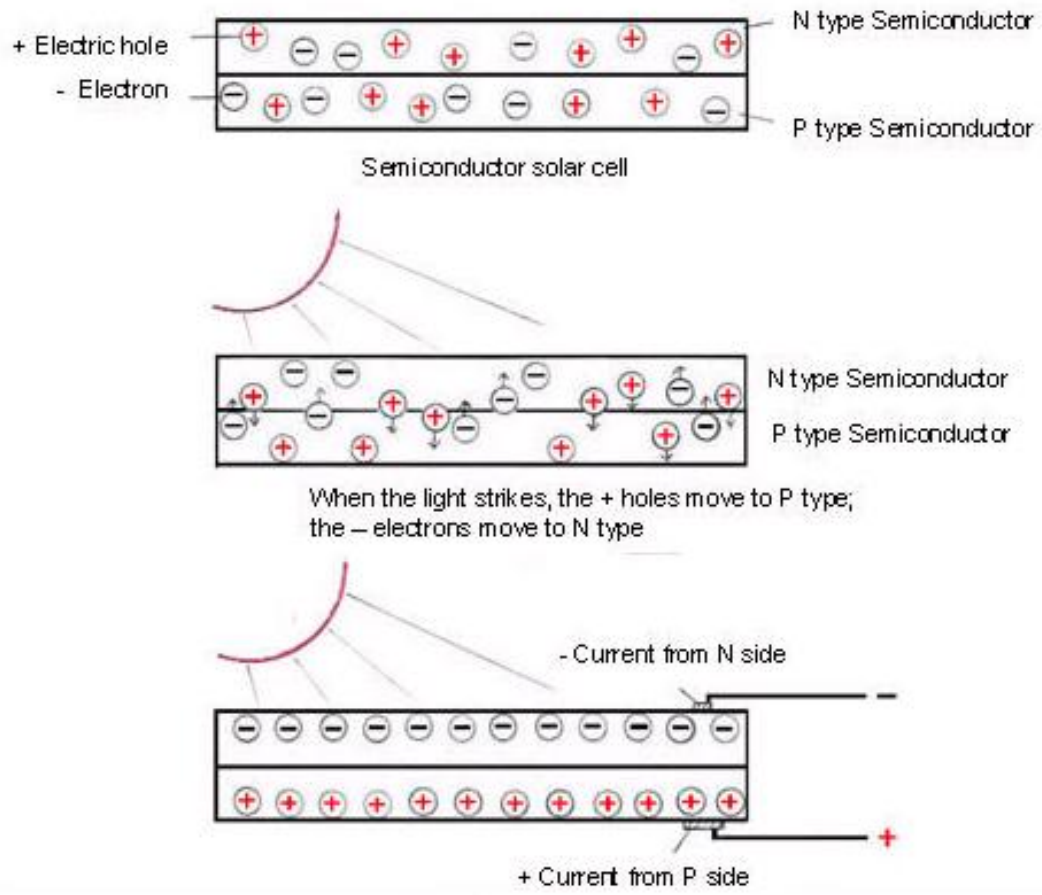
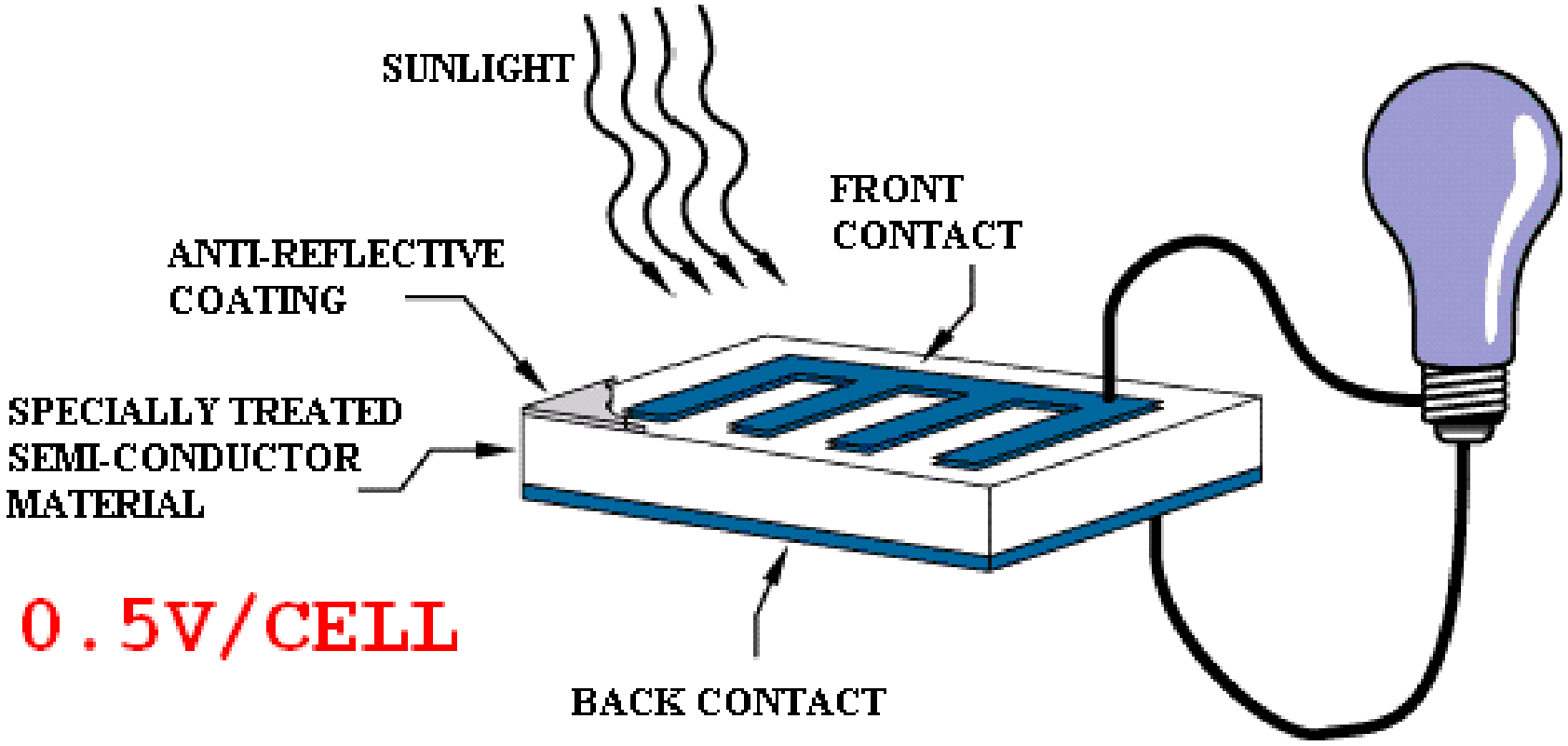


Figure 1

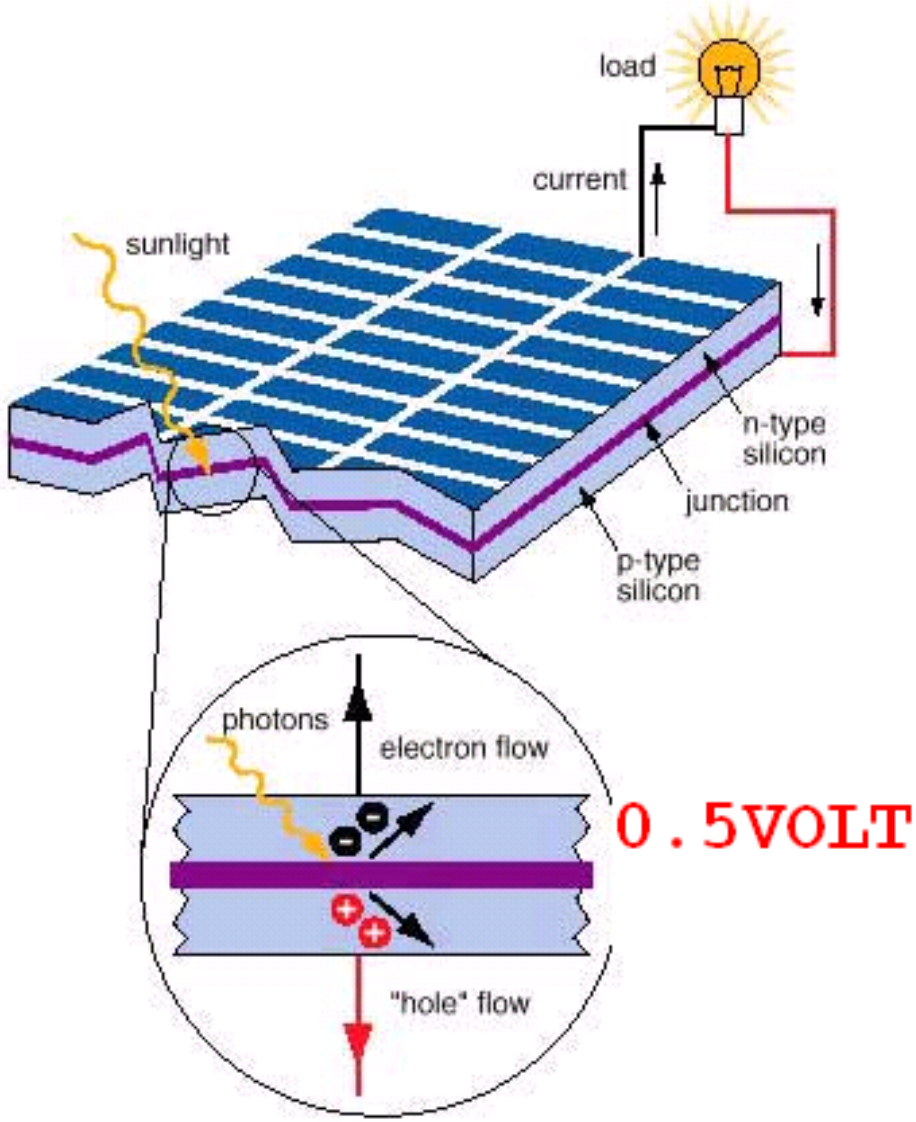
PHOTOVOLTAIC



PV CELL

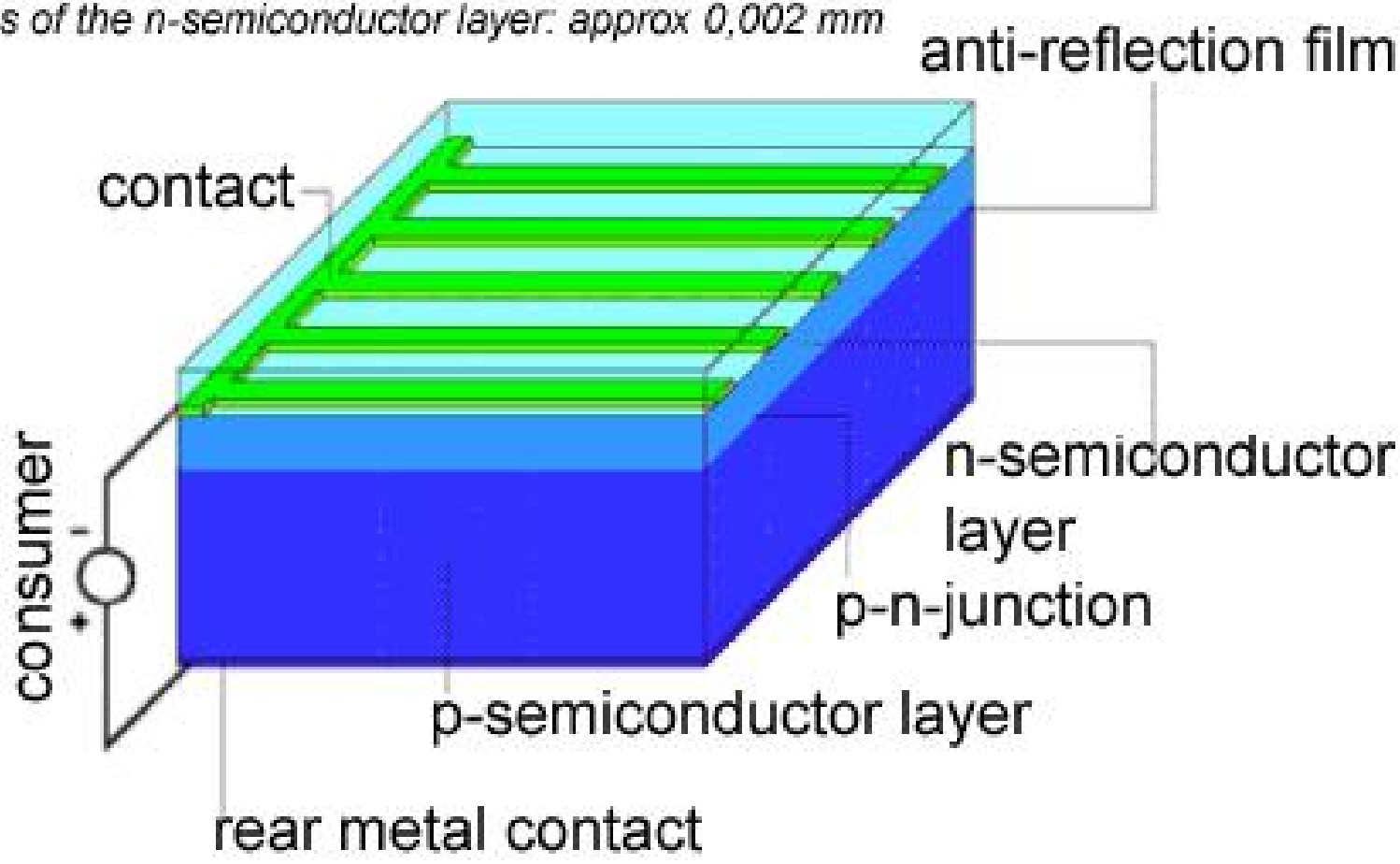

SUNLIGHT
FRONT CONTACT
ANTI-REFLECTIVE COATING
SPECIALLY TREATED SEMI-CONDUCTOR MATERIAL
0.5V/CELL
BACK CONTACT

ELECTRICITY FROM CELL

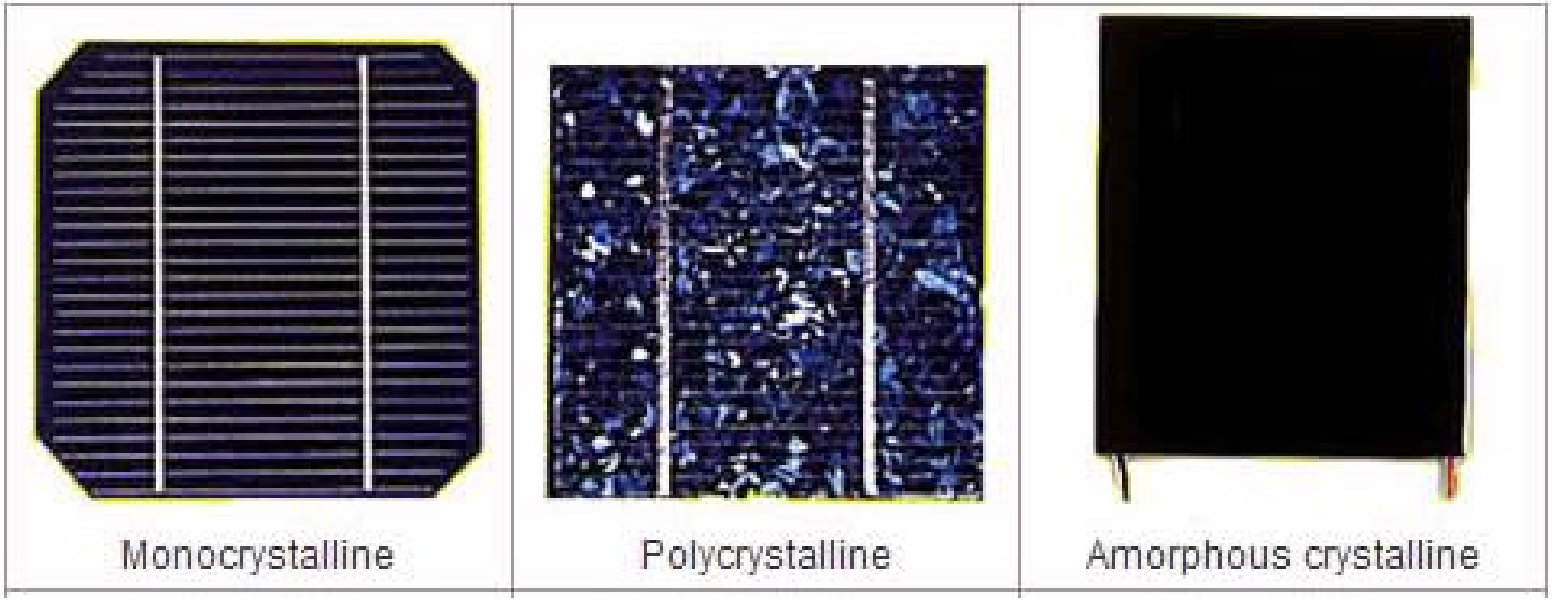


CRYSTALLINE

thickness of the solar cell: approx 0,3 mm
thickness of the n-semiconductor layer: approx 0,002 mm



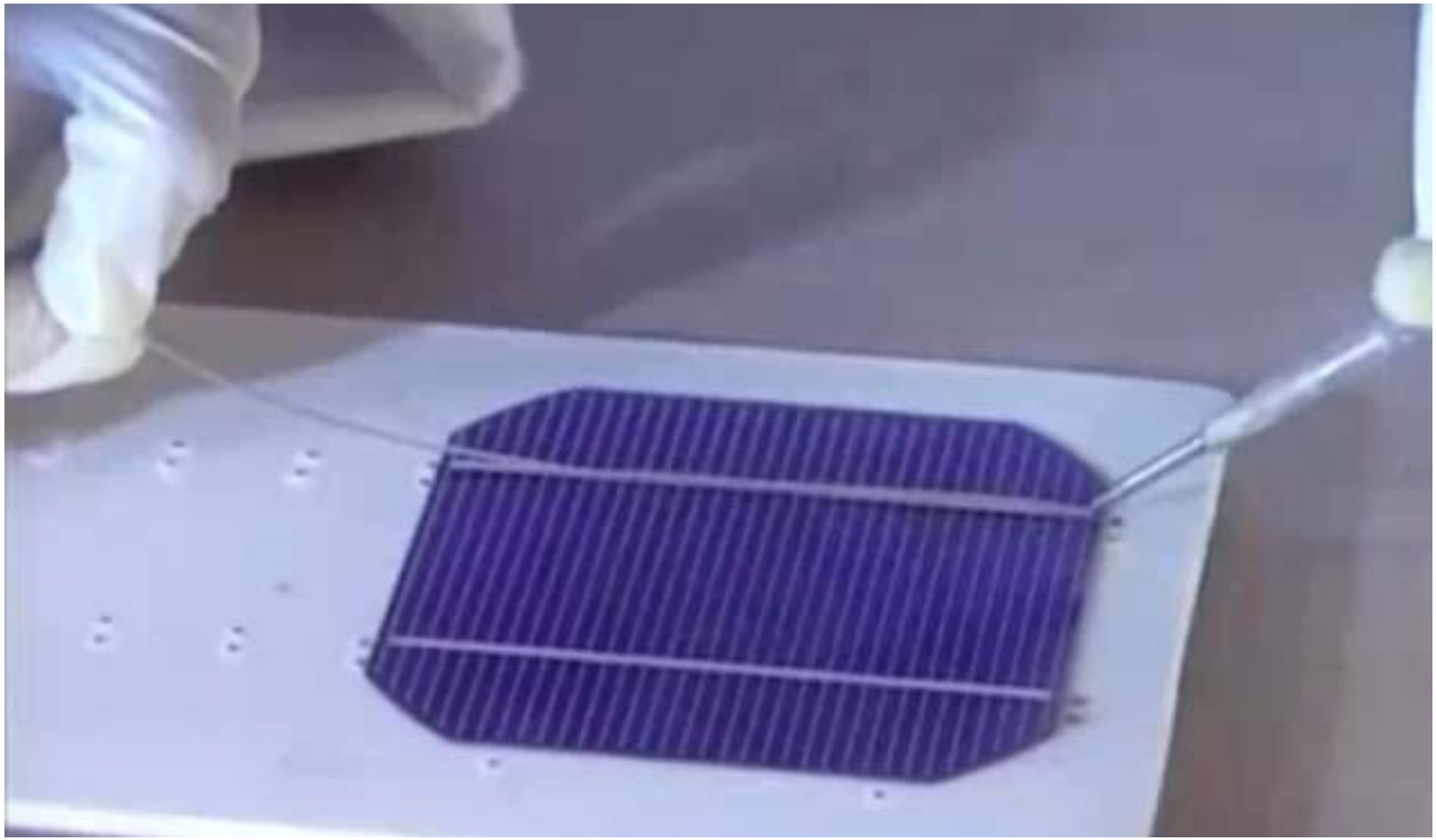
MONO， POLY CRYSTALLINE， THIN FILM



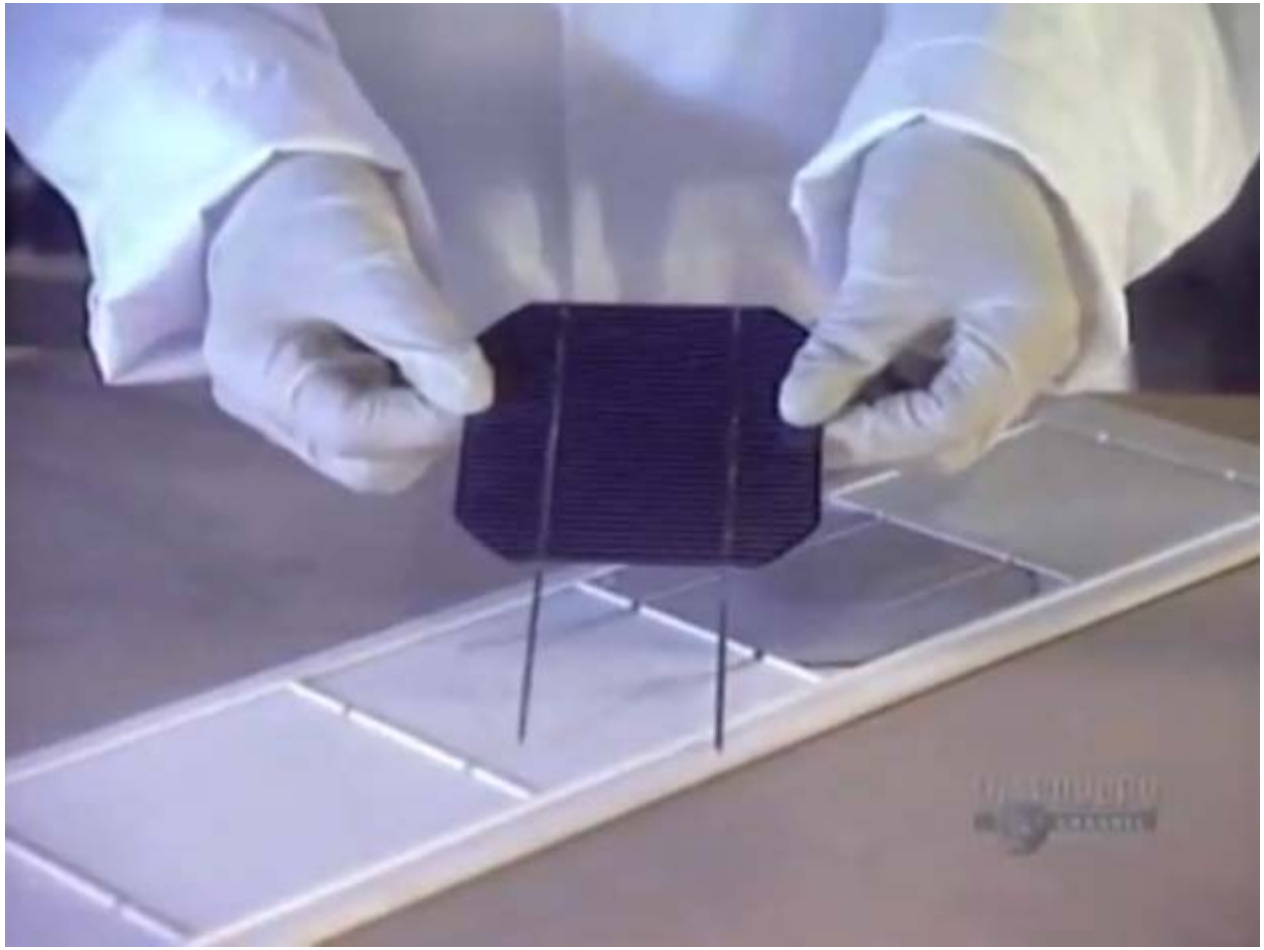
2.2 Cell, Module, Panel, Array

- CELL

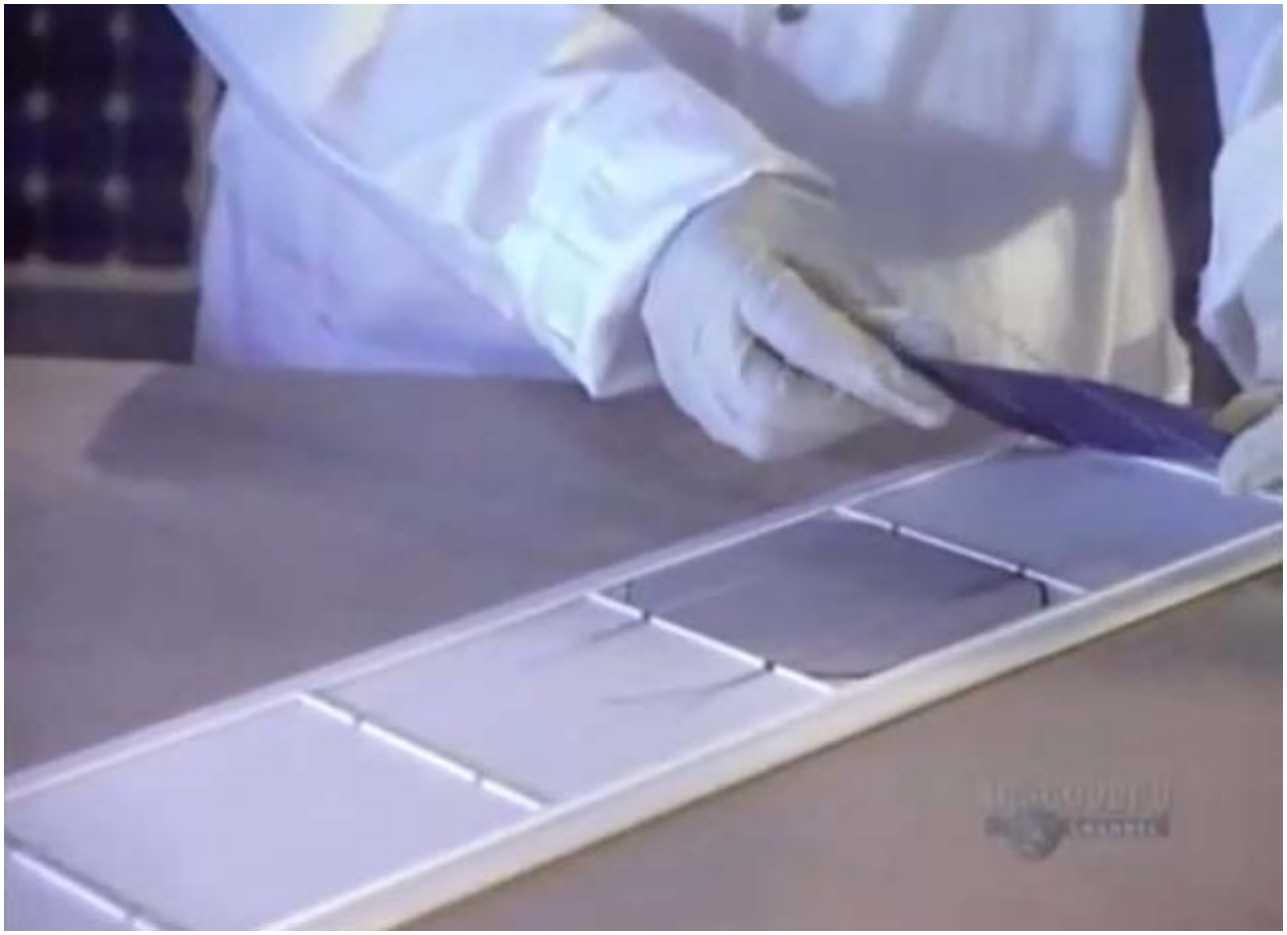
SOLDERING SINGLE CELL FRONT SIDE



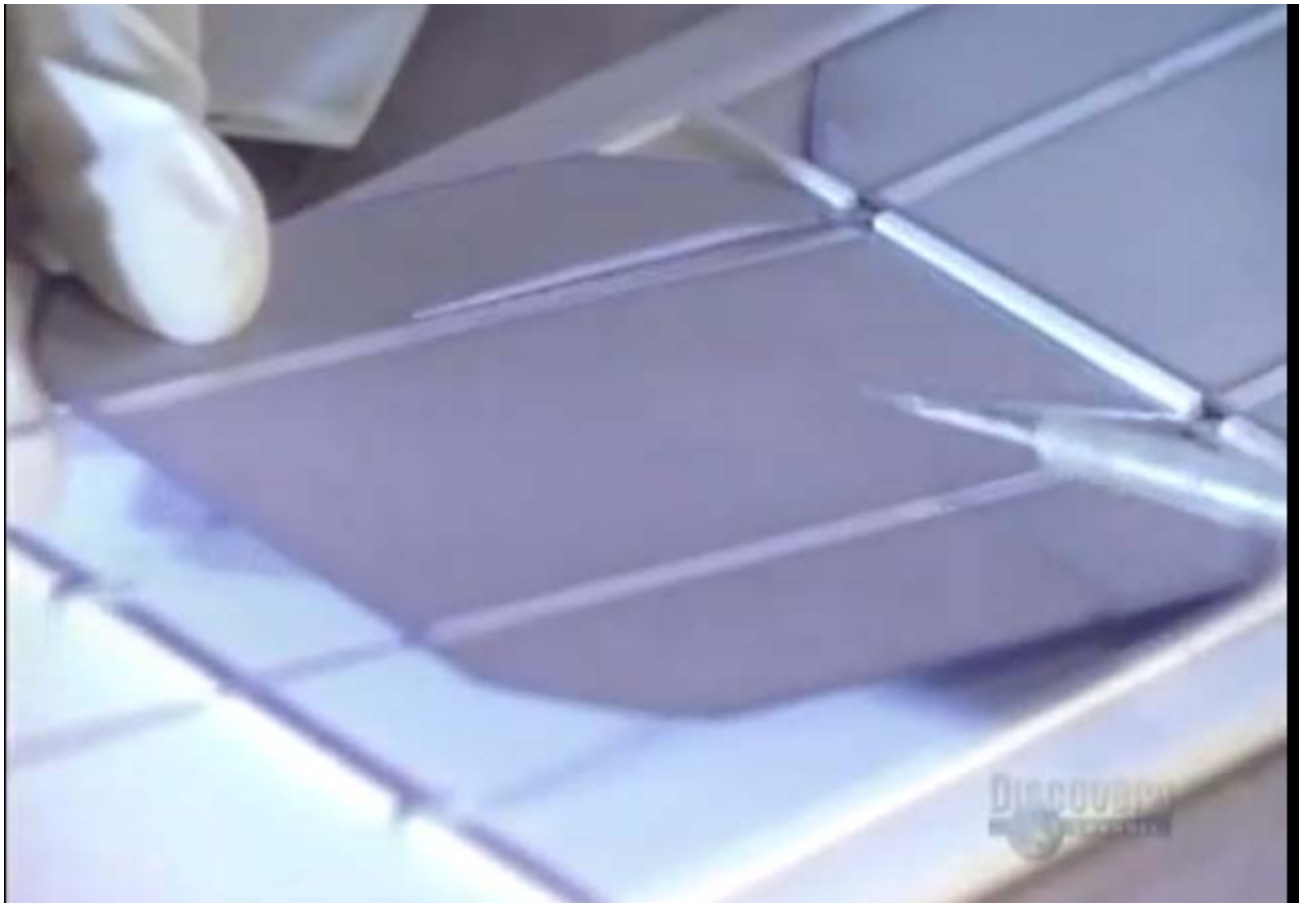
BEFORE SOLDERING ON BACKSIDE



LAYOUT CELLS ON MODULE

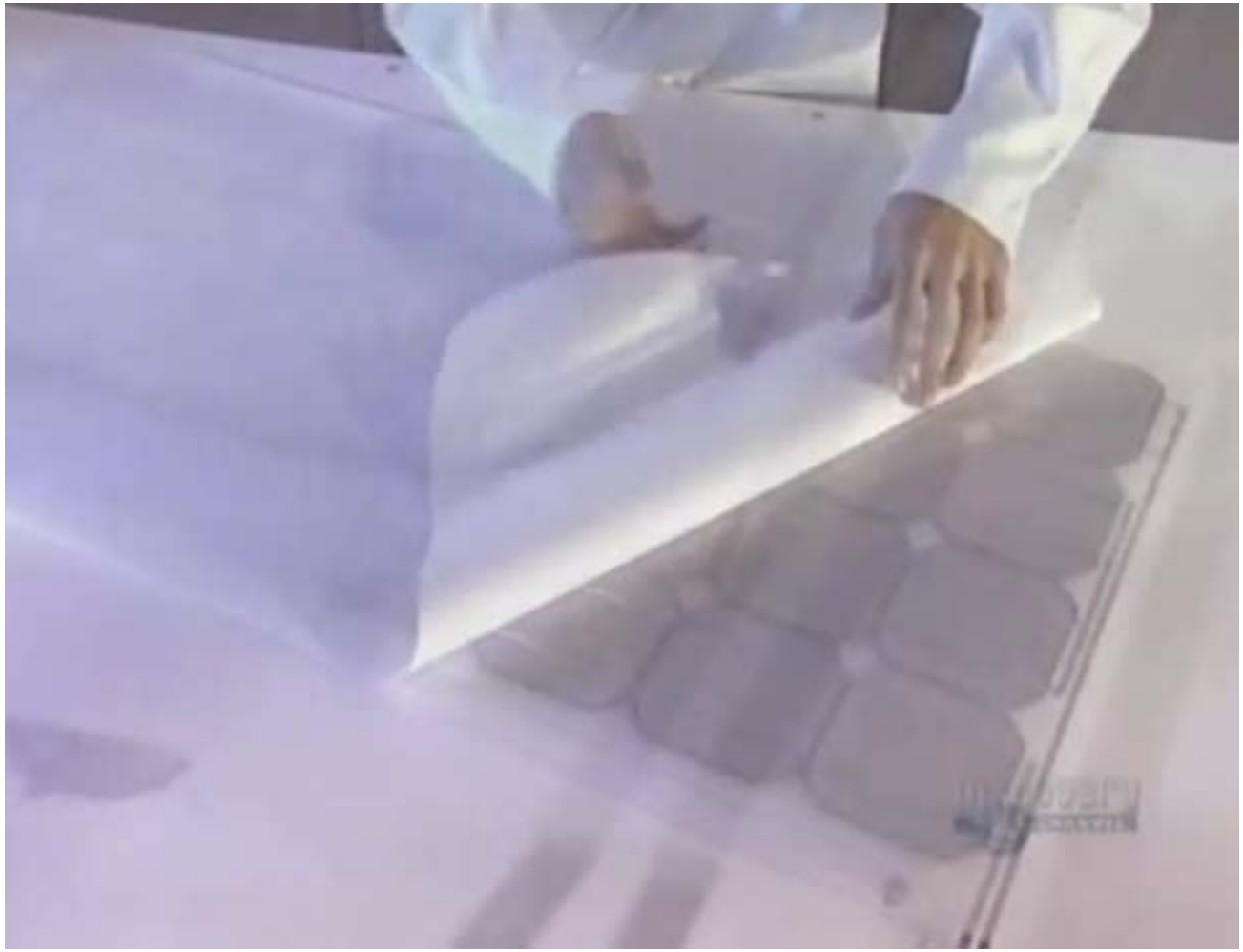


SOLDERING BACK SIDE OF CELL

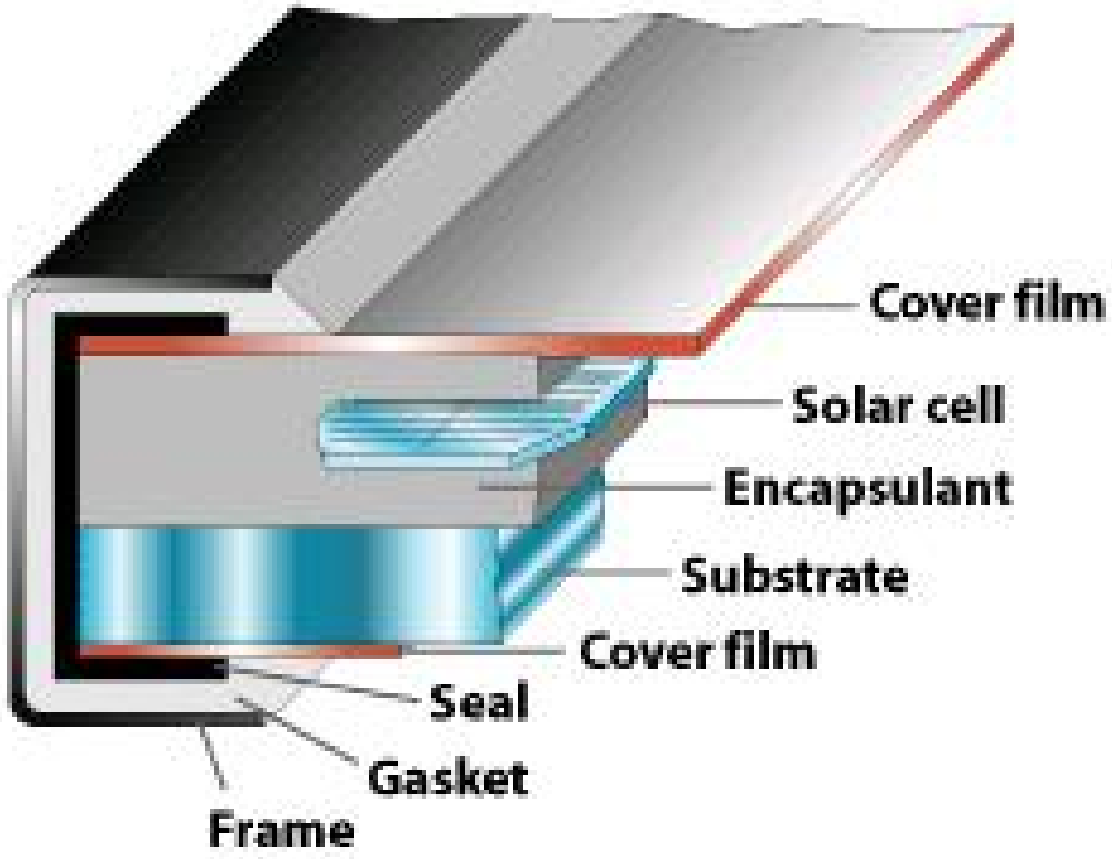


POWER STIP LINK THE MODULE

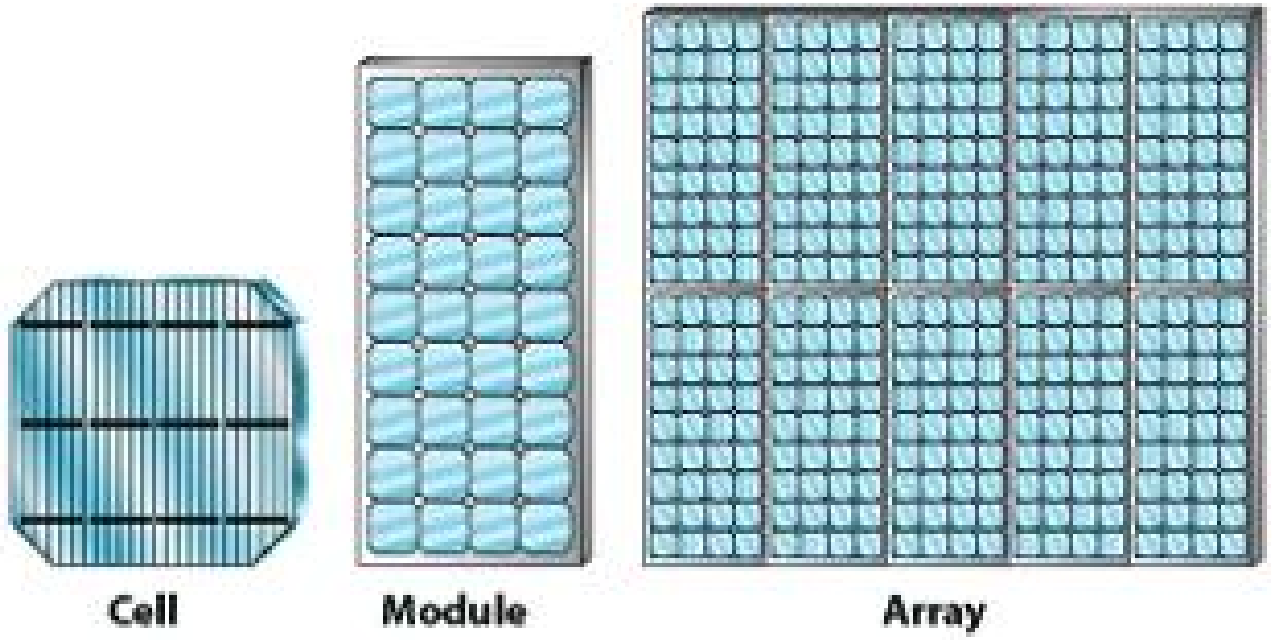
FORM AND LAMINAR



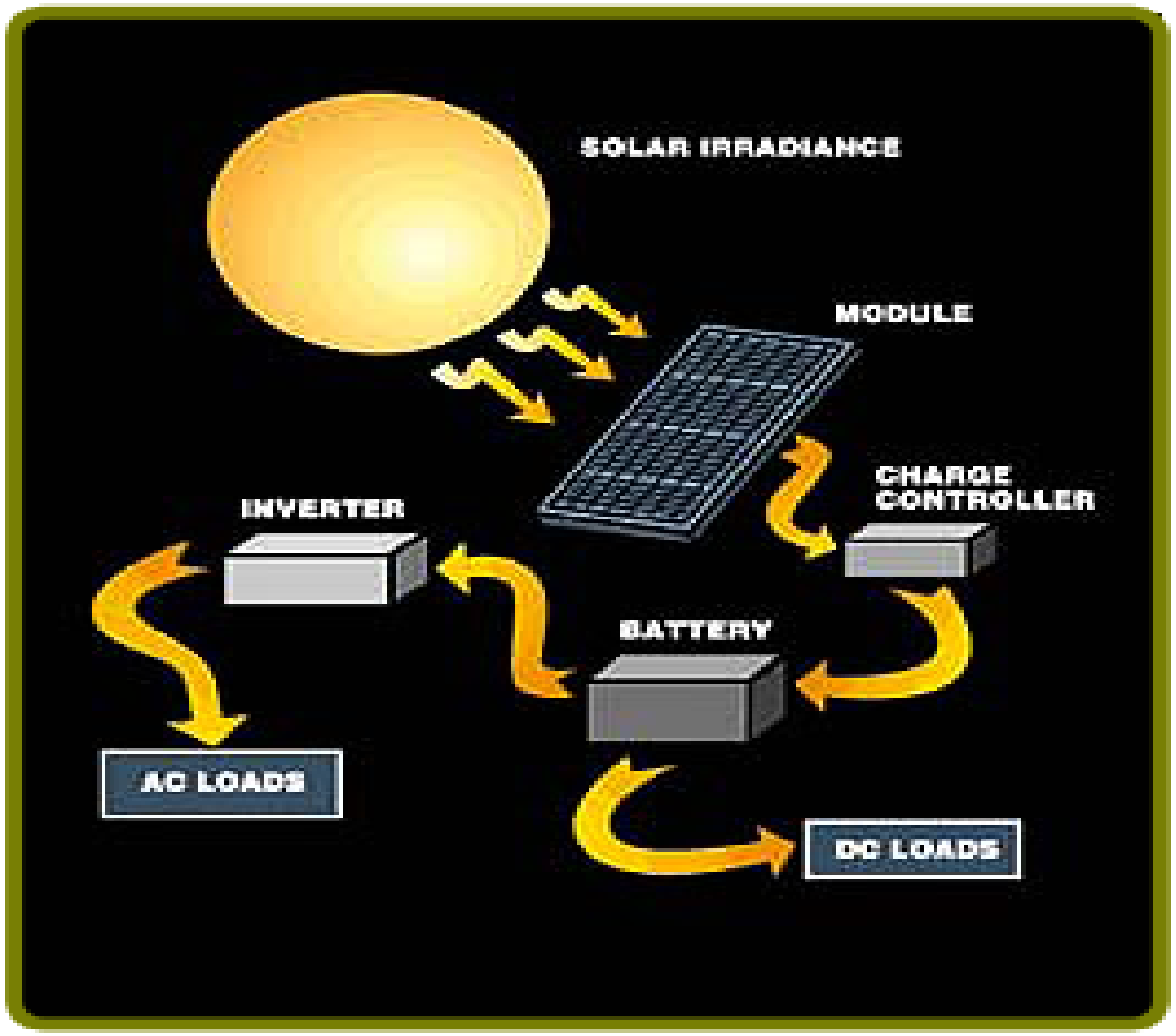
FRAME


Cover film
Solar cell
Encapsulant
Substrate
Cover film
Seal
Gasket
Frame

CELL, MODULE, ARRAY

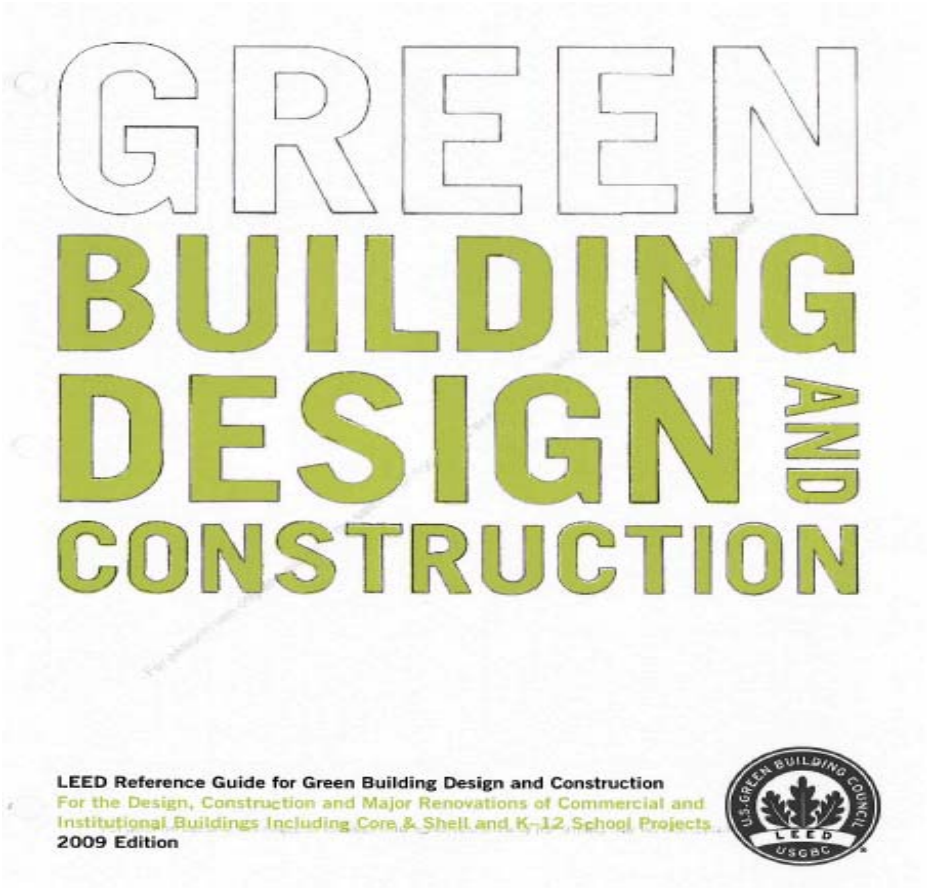


OFF GRID SYSTEM



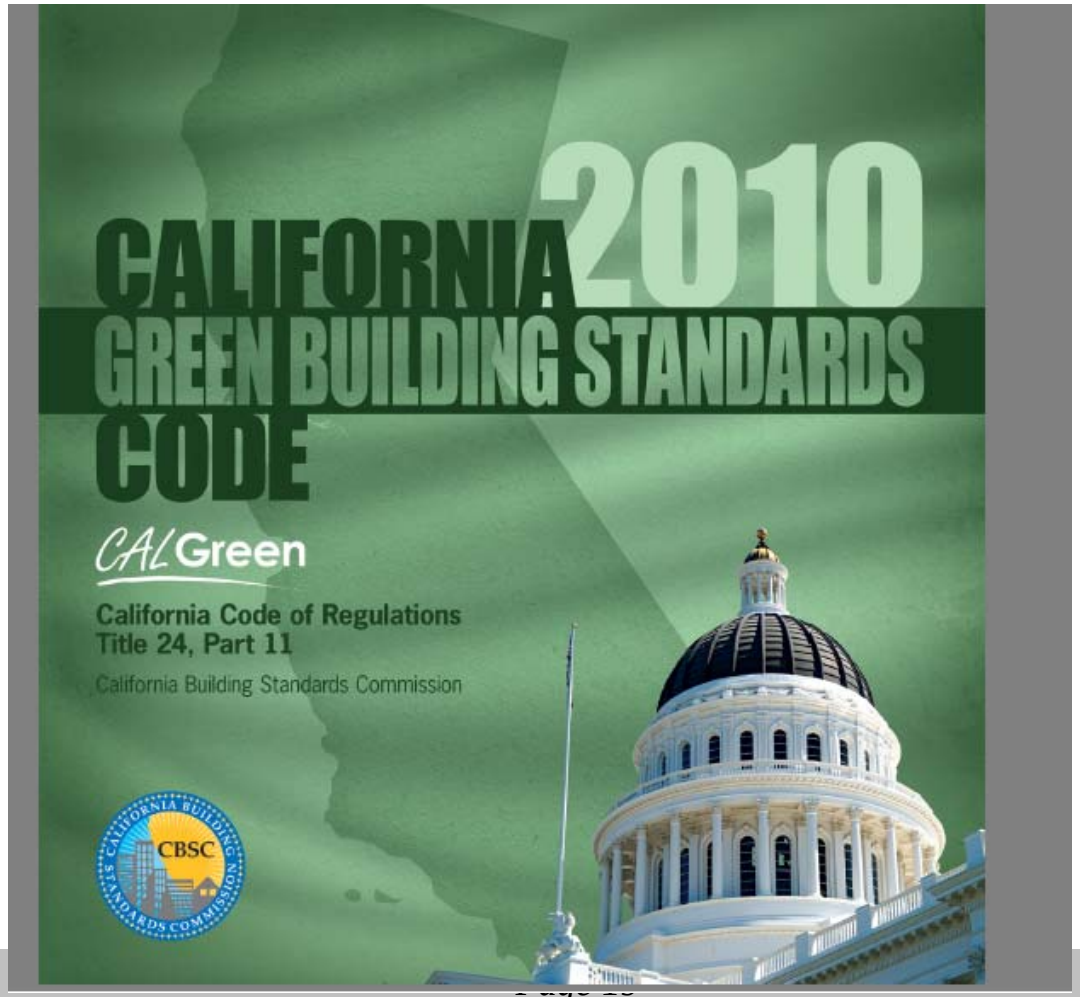
WHAT IS GREEN BUILDING STANDARD?

1. USGBC – U.S.GREEN BUILDING COUNCIL



WHAT IS GREEN BUILDING STANDARD?

2. CALIFRONIA GREEN BUILDING CODE



PV CREDITS ON GREEN BUILDING CODE

1. PERFORMANCE MODELING 15% - ENERGYPRO
2. ON SITE RENEWABLE ENERGY(USGBC)
3. MINIMUM ENERGY PERFORMANCE
4. COOL ROOF

PV CREDITS ON GREEN BUILDING CODE

			3	**Water Efficiency**		Possible Points:	10										
	Y			Prereq 1	Water Use Reduction—20% Reduction												
	Y		2	Credit 1	Water Efficient Landscaping		2 to 4										
				Credit 2	Innovative Wastewater Technologies		2										
	Y		1	Credit 3	Water Use Reduction		2 to 4										
			21	**Energy and Atmosphere**		Possible Points:	35										
	Y			Prereq 1	Fundamental Commissioning of Building Energy Systems												
	Y			Prereq 2	Minimum Energy Performance												
	Y			Prereq 3	Fundamental Refrigerant Management												
	Y		15	Credit 1	Optimize Energy Performance		1 to 19										
				Credit 2	On-Site Renewable Energy		1 to 7										
	Y		2	Credit 3	Enhanced Commissioning		2										
	Y		1	Credit 4	Enhanced Refrigerant Management		2										
	Y		3	Credit 5	Measurement and Verification		3										
				Credit 6	Green Power		2										
			8	**Materials and Resources**		Possible Points:	14										
	Y			Prereq 1	Storage and Collection of Recyclables												
				Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof		1 to 3										
				Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Element		1										
	Y		2	Credit 2	Construction Waste Management		1 to 2										
	Y		2	Credit 3	Materials Reuse		1 to 2										
	Y			Credit 4.3	Low-Emitting Materials—Flooring Systems												1
	Y			Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Product												1
				Credit 5	Indoor Chemical and Pollutant Source Control												1
	Y			Credit 6.1	Controllability of Systems—Lighting												1
	Y			Credit 6.2	Controllability of Systems—Thermal Comfort												1
	Y			Credit 7.1	Thermal Comfort—Design												1
	Y			Credit 7.2	Thermal Comfort—Verification												1
	Y			Credit 8.1	Daylight and Views—Daylight												1
	Y			Credit 8.2	Daylight and Views—Views												1
			3	**Innovation and Design Process**		Possible Points:	6										
	Y			Credit 1.1	Innovation in Design: Specific Title												1
	Y			Credit 1.2	Innovation in Design: Specific Title												1
				Credit 1.3	Innovation in Design: Specific Title												1
				Credit 1.4	Innovation in Design: Specific Title												1
				Credit 1.5	Innovation in Design: Specific Title												1
	Y			Credit 2	LEED Accredited Professional												1
				Regional Priority Credits		Possible Points:	4										
				Credit 1.1	Regional Priority: Specific Credit												1
				Credit 1.2	Regional Priority: Specific Credit												1
				Credit 1.3	Regional Priority: Specific Credit												1
				Credit 1.4	Regional Priority: Specific Credit												1
			63	**Total**		Possible Points:	110										
				Certified 40 to 49 points		**Silver 50 to 59 points**											
				Gold 60 to 79 points		**Platinum 80 to 110**											

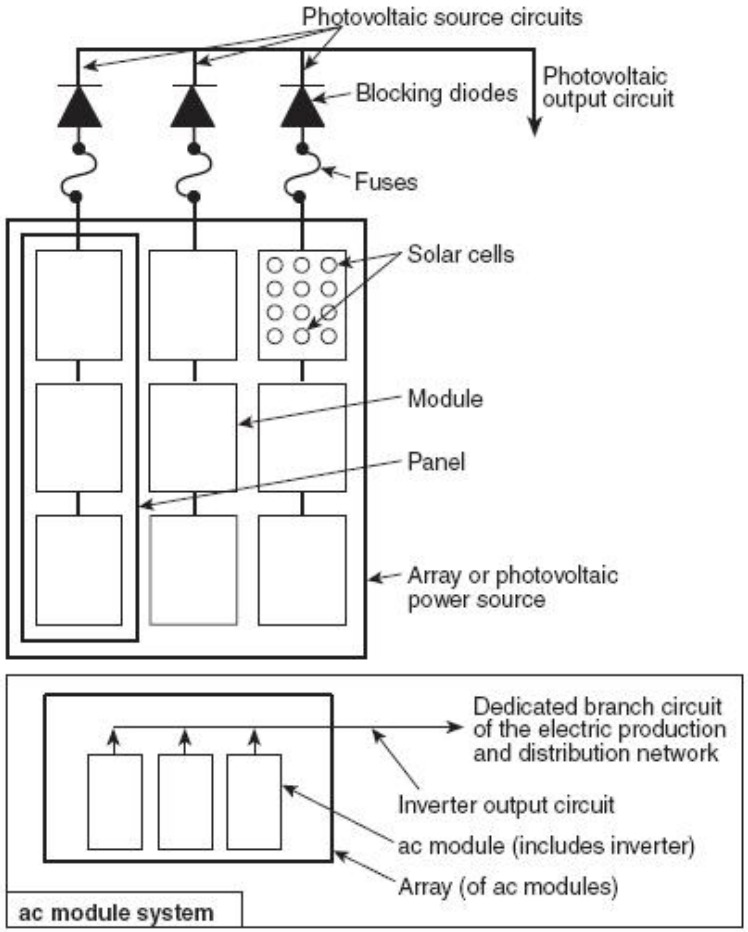
NEC DEFINITION – MODULE , PANEL , ARRAY

Module. A complete, environmentally protected unit consisting of solar cells, optics, and other components, exclusive of tracker, designed to generate dc power when exposed to sunlight.

Panel. A collection of modules mechanically fastened together, wired, and designed to provide a field-installable unit.

Array. A mechanically integrated assembly of modules or panels with a support structure and foundation, tracker, and other components, as required, to form a direct-current power-producing unit.

MODULE， PANEL， ARRAY



Notes:
1. These diagrams are intended to be a means of identification for photovoltaic system components, circuits, and connections.
2. Disconnecting means required by Article 690, Part III, are not shown.
3. System grounding and equipment grounding are not shown. See Article 690, Part V.

STRING

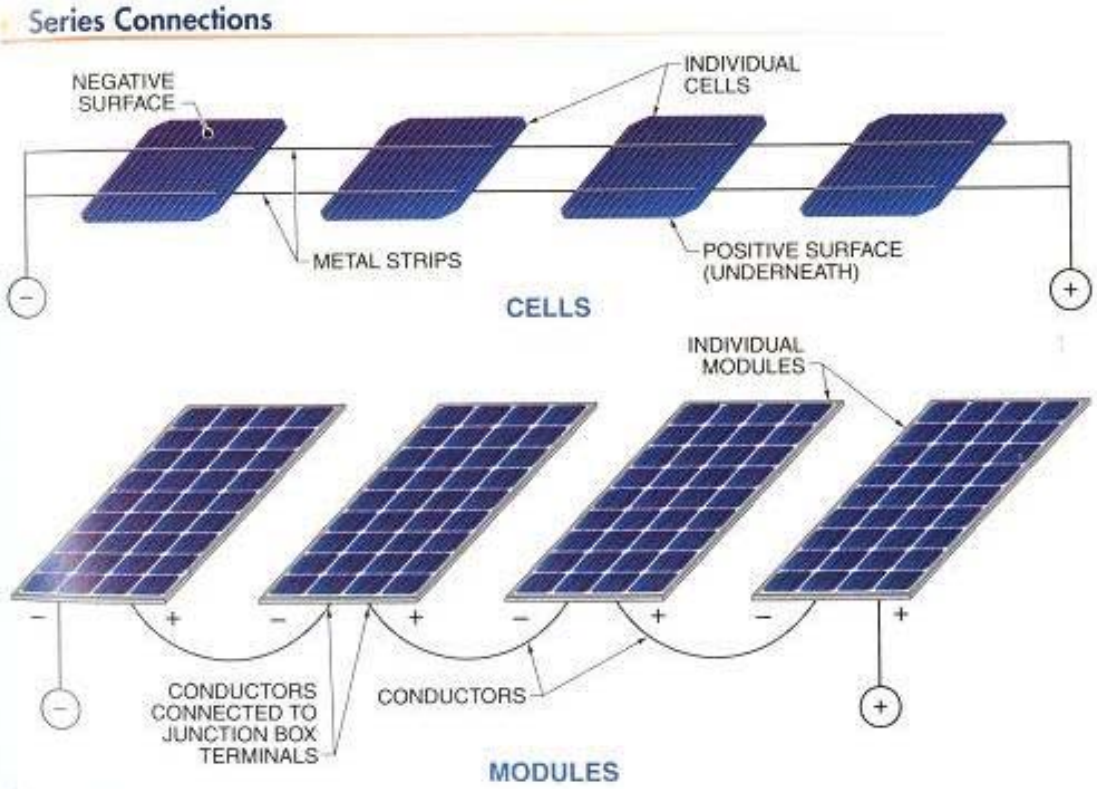
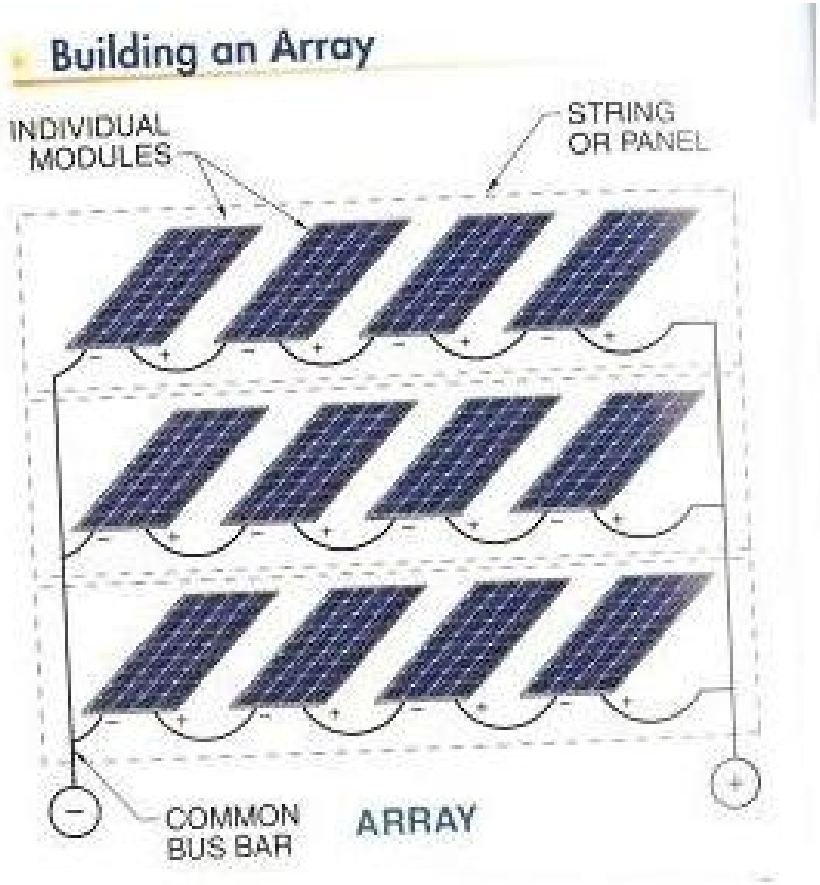
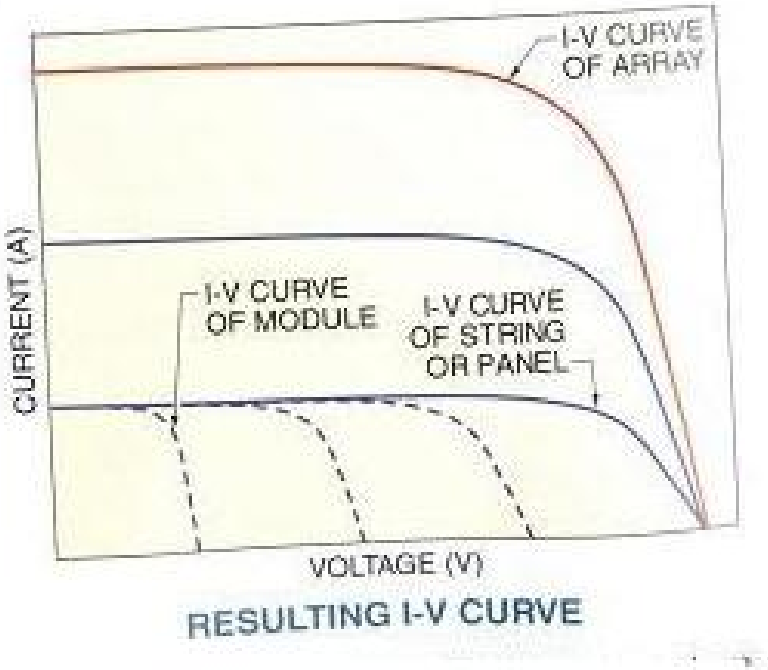


Figure 5-25. *PV cells or modules are connected in series strings to build voltage.*

PANEL

ARRAY


Building an Array
INDIVIDUAL MODULES
STRING OR PANEL
COMMON BUS BAR
ARRAY


I-V CURVE OF ARRAY
I-V CURVE OF MODULE
I-V CURVE OF STRING OR PANEL
CURRENT (A)
VOLTAGE (V)
RESULTING I-V CURVE

2.3 Orientation, Tilt, PV Temp. vs. Output Voltage

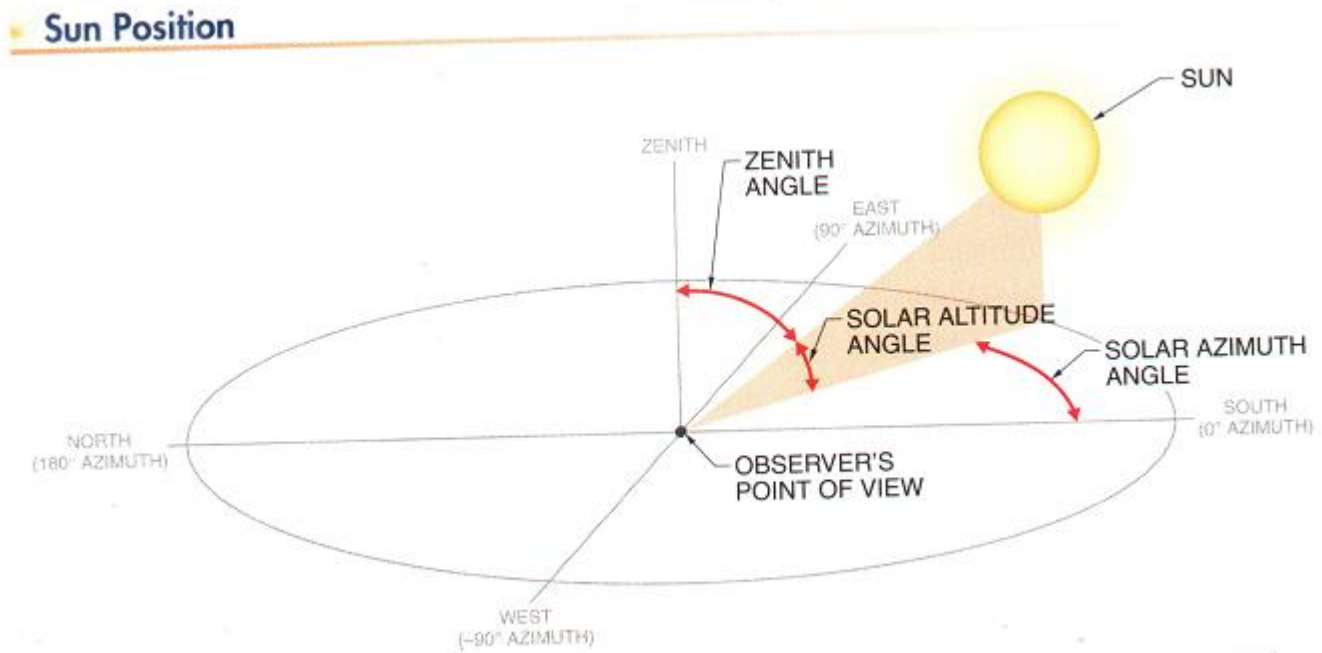
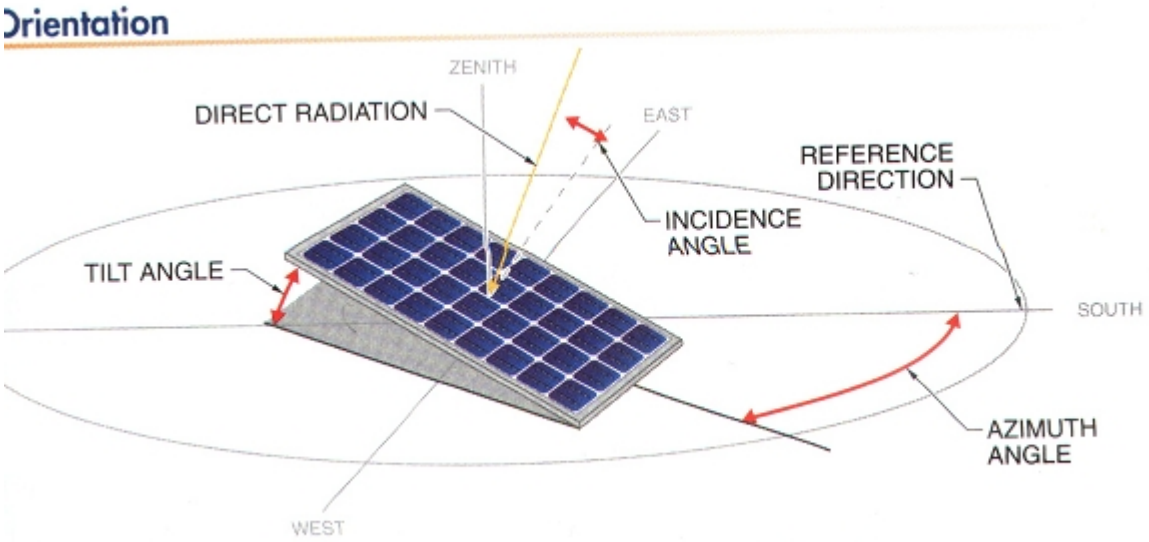


Figure 2-25. *Solar azimuth and altitude angles are used to describe the sun's location in the sky.*

ORIENTATION AND TILT ANGLE



28. *Array orientation can be described using azimuth and tilt angles.*

MAGNETIC DECLINATION

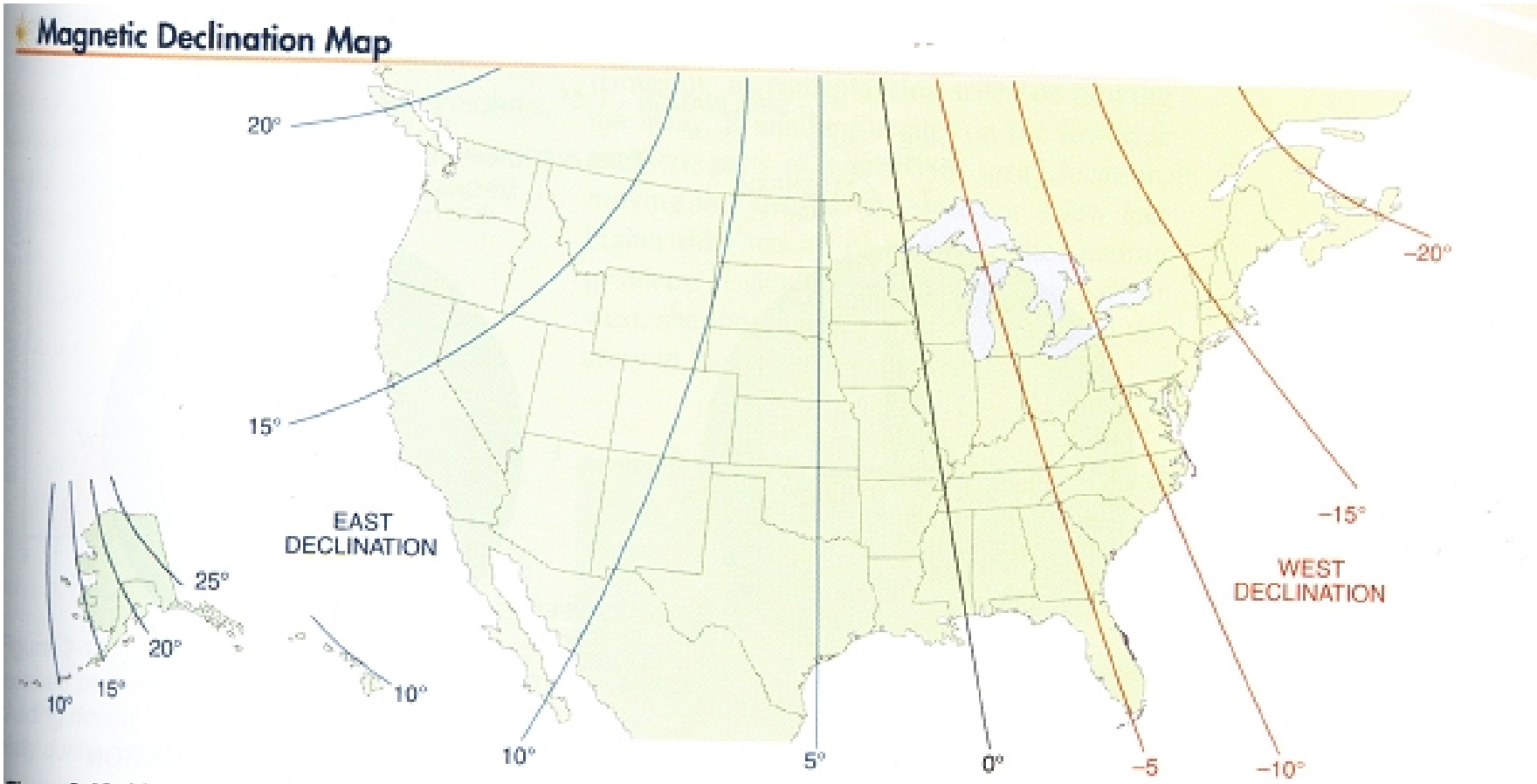


Figure 3-13. *Magnetic declination varies by location and changes slightly over time. Up-to-date maps are used to determine the necessary adjustment to magnetic compass readings.*

TRUE SOUTH AND MAGNETIC SOUTH

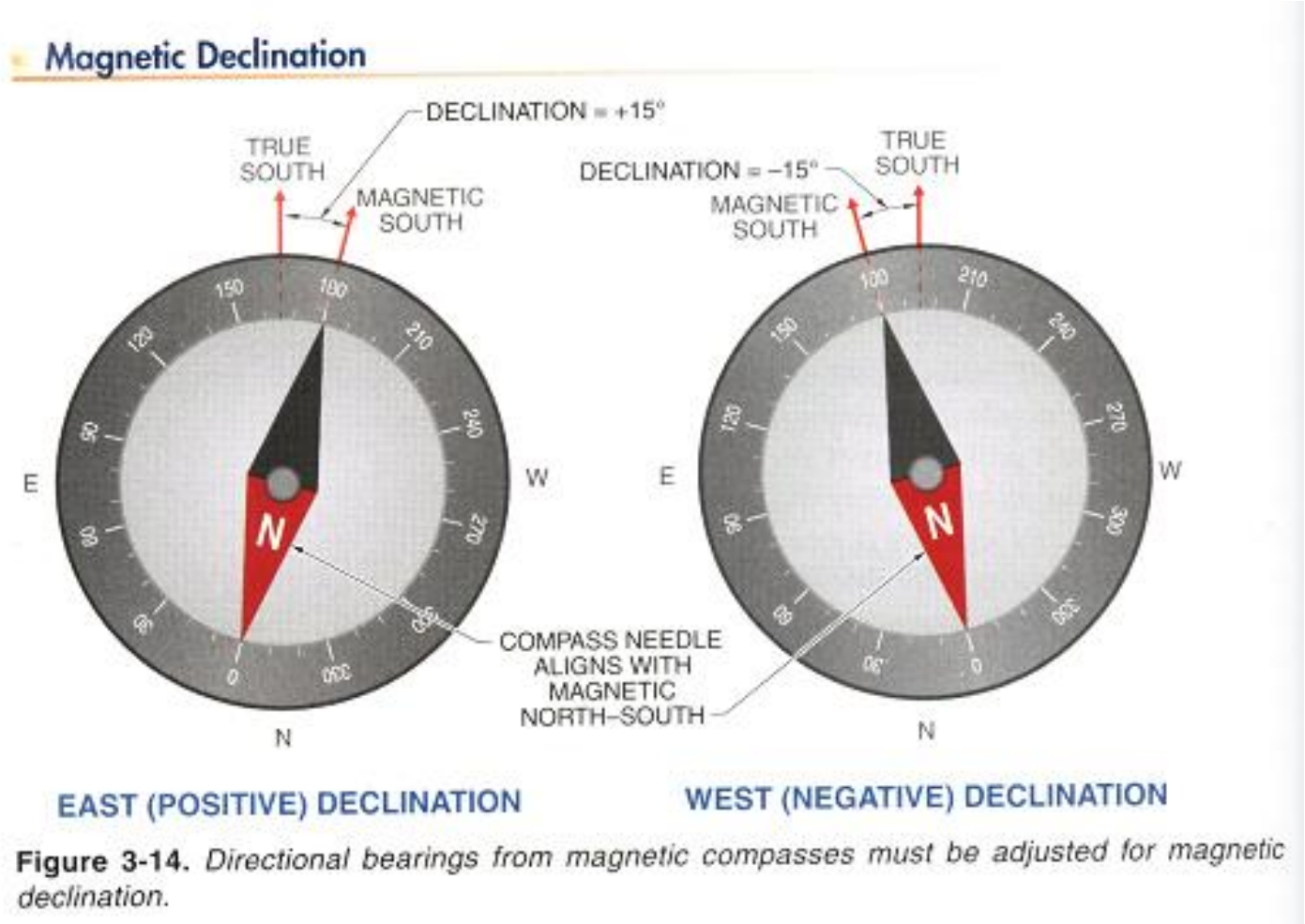


Figure 3-14. *Directional bearings from magnetic compasses must be adjusted for magnetic declination.*

TEMPERATURE EFFECT - CRYSTALLINE

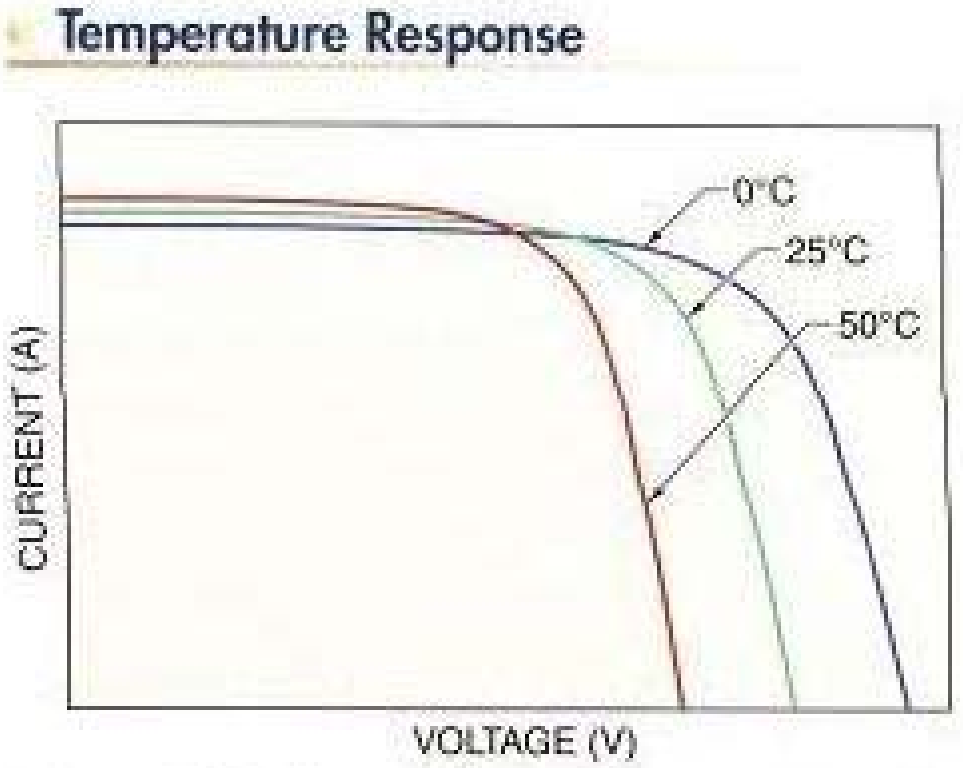
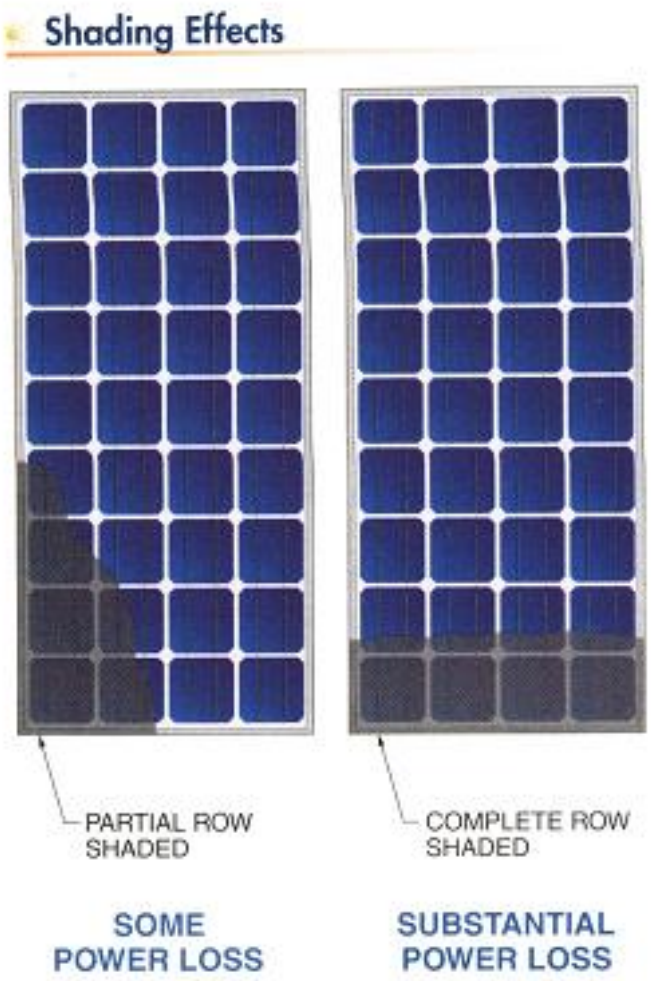


Figure 5-20. *Increasing cell temperature decreases voltage, slightly increases current, and results in a net decrease in power.*

2.4 Partial Shading and dead cells



PARTIAL SHADING

Sharp Electronics Corp.

Even shading from small obstructions, such as a rooftop vent, may be a significant issue.

DISTANCE BETWEEN ROWS

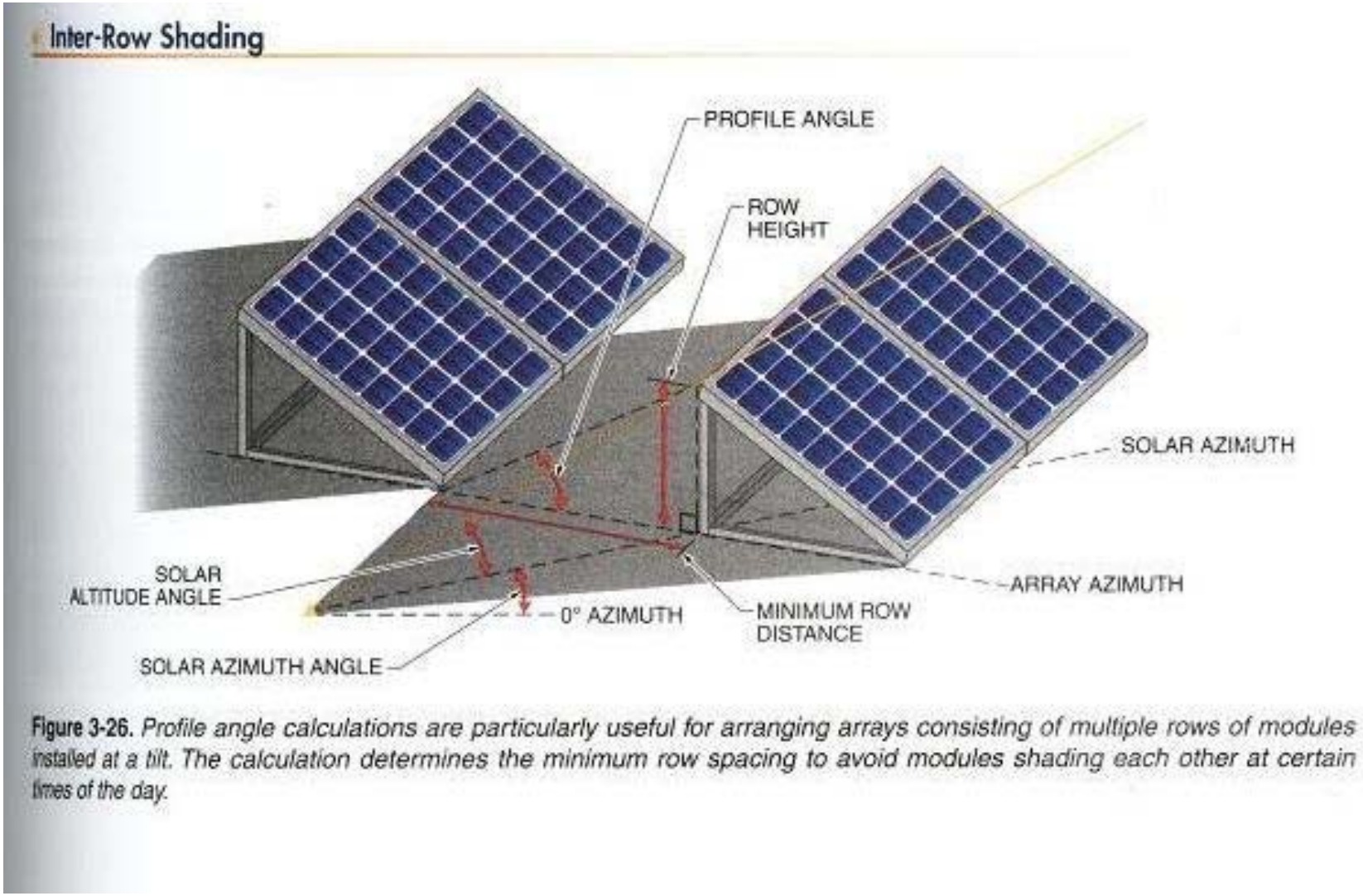


Figure 3-26. *Profile angle calculations are particularly useful for arranging arrays consisting of multiple rows of modules installed at a tilt. The calculation determines the minimum row spacing to avoid modules shading each other at certain times of the day.*

THIN FILM vs CRYSTALLINE

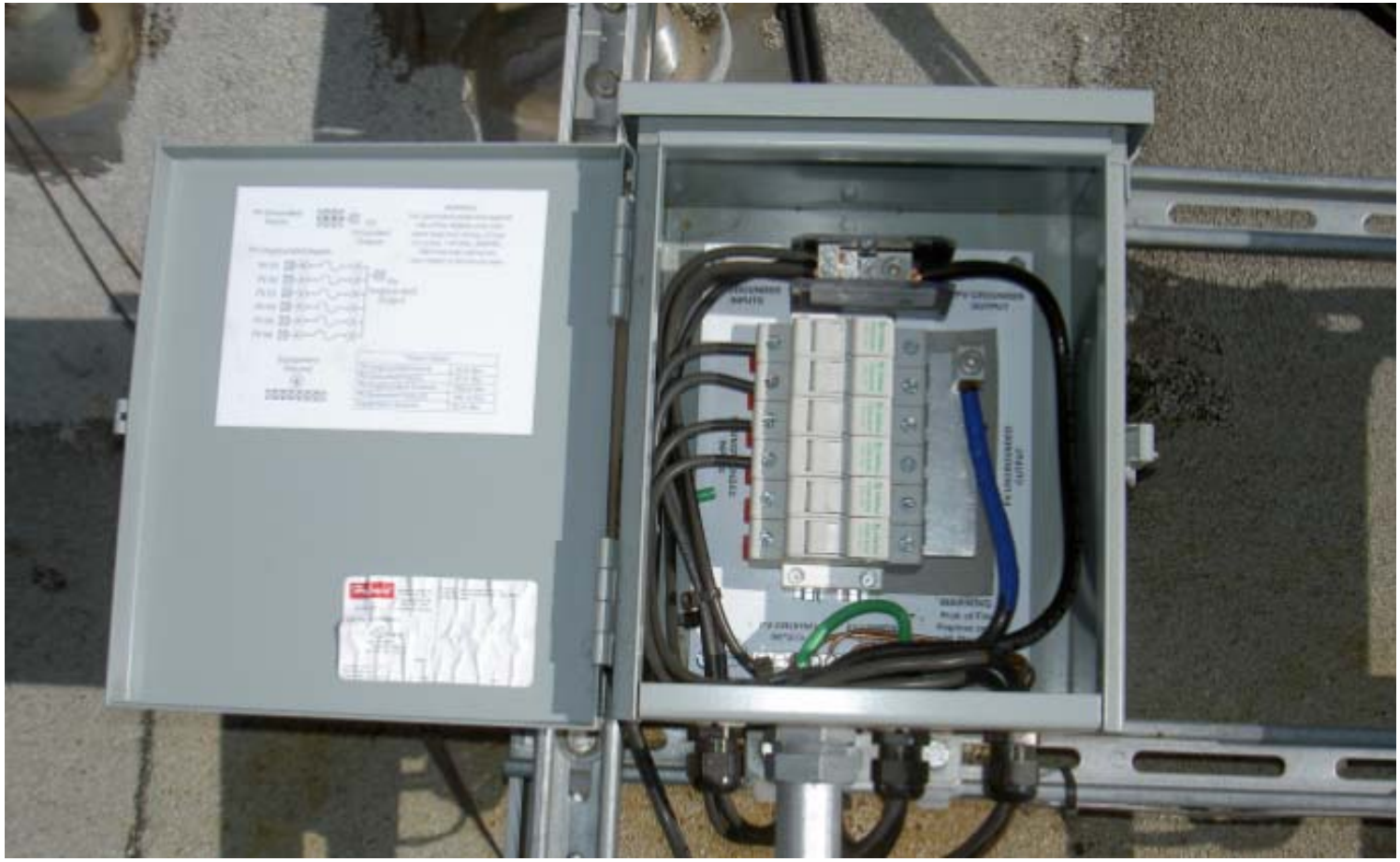
ARRAY LAYOUT

ARRAY LAYOUT

ARRAY LAYOUT

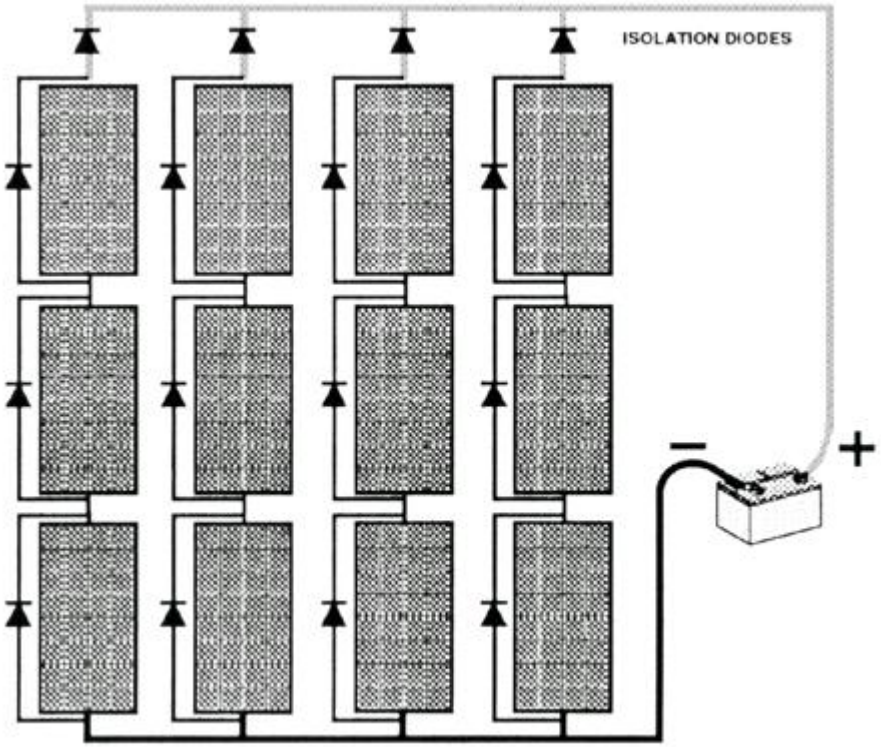
COMBINER BOX

COMBINER BOX



INVERTER CONNECTION

2.5 Fuse and Diodes



MANUFACTURER'S INFORMATION

BYPASS DIODE

BYPASS DIODE — SHADED CELL

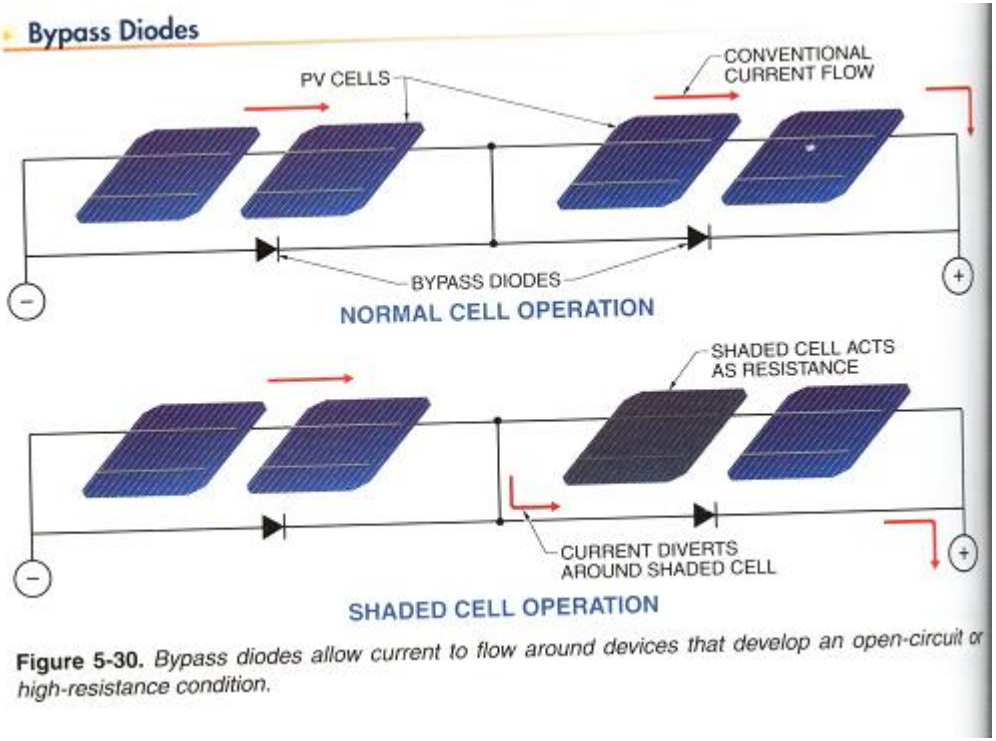


Figure 5-30. *Bypass diodes allow current to flow around devices that develop an open-circuit or high-resistance condition.*

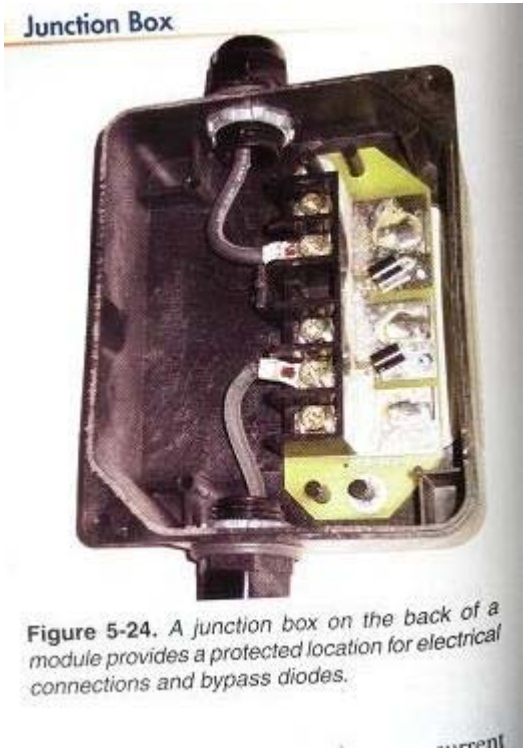
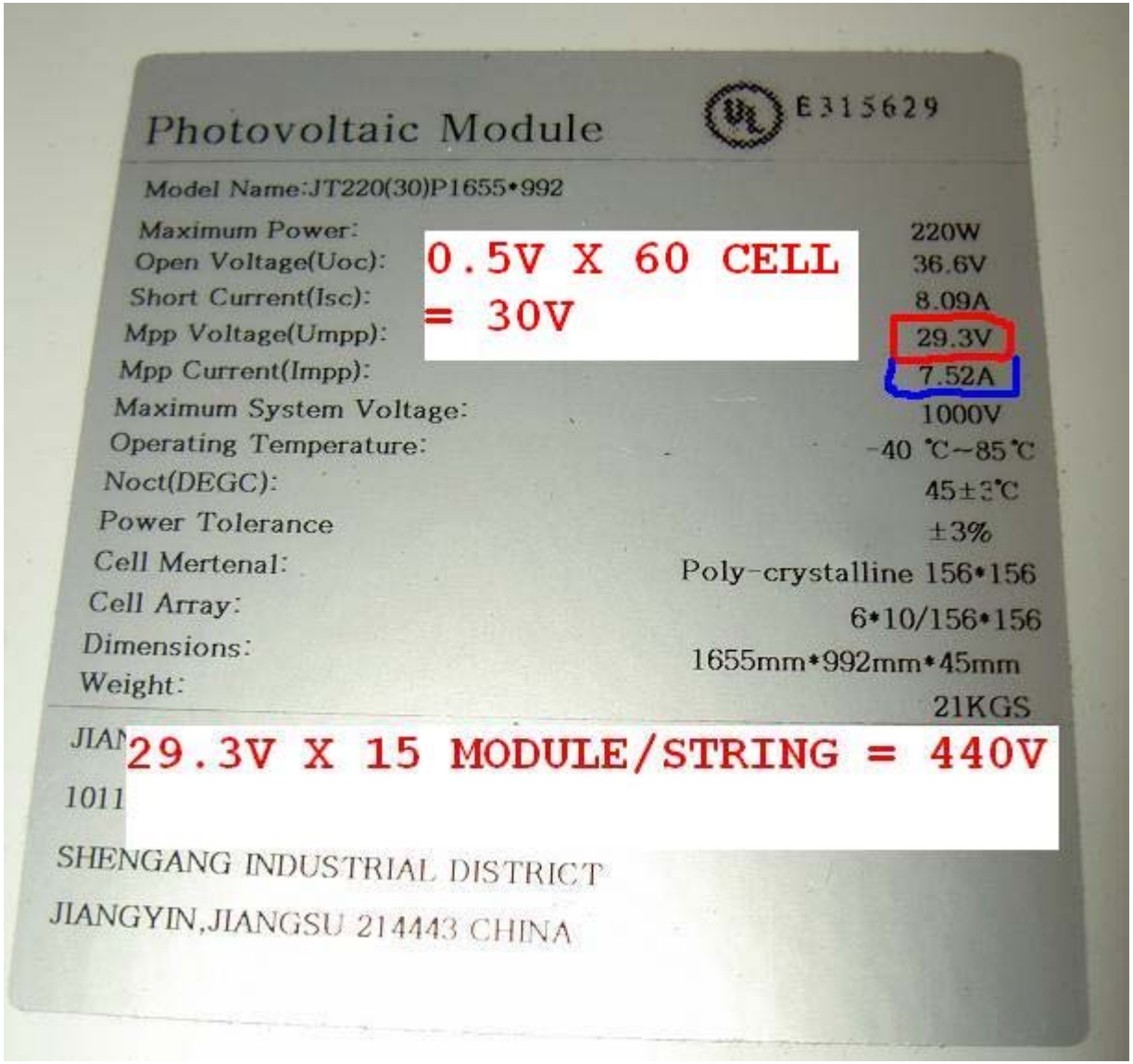
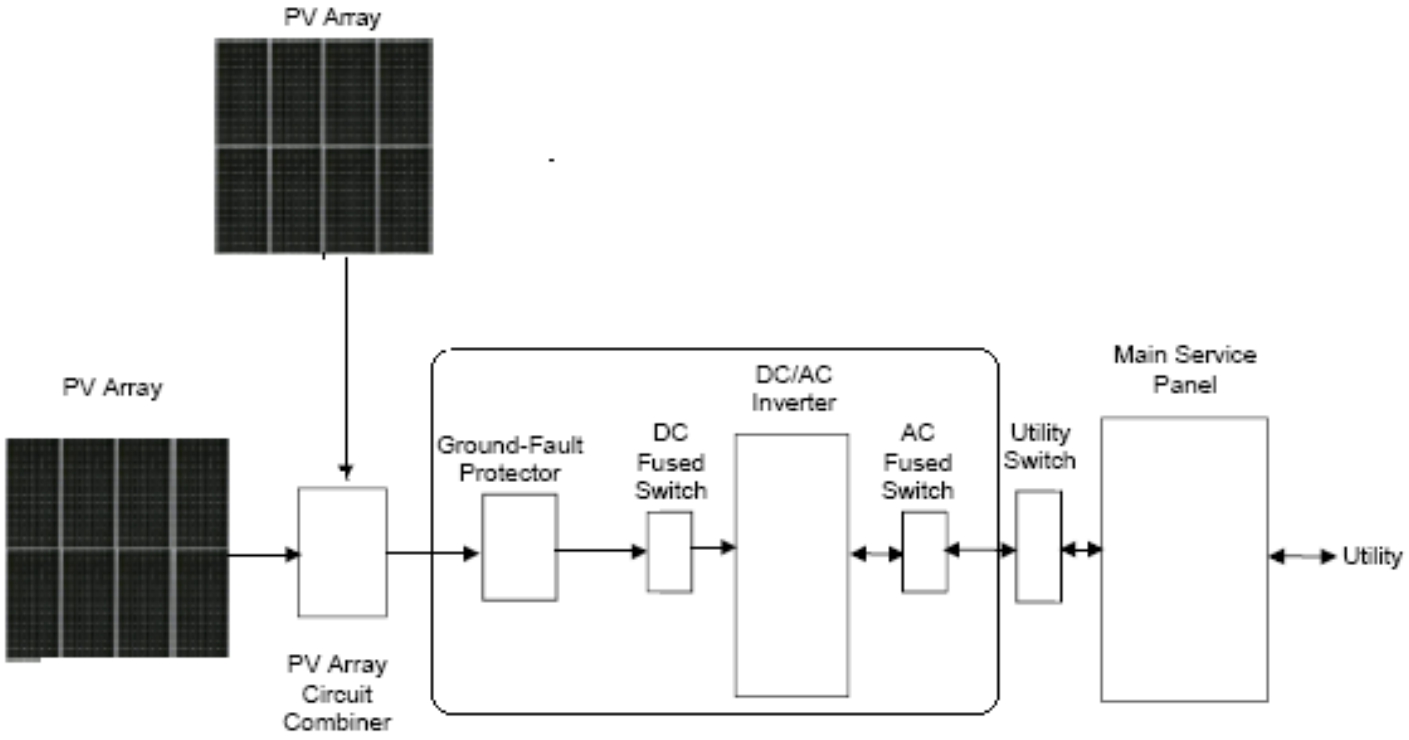


Figure 5-24. *A junction box on the back of a module provides a protected location for electrical connections and bypass diodes.*

HIGH VOLTAGE ON ROOF



2.7 ON GRID *PV SYSTEM*



Grid-Interactive PV System
w/o Battery Backup

BE AWARE OF TREE

SYSTEM DESIGN CONSIDERATON

BE AWARE OF TREE

2.8 National Electrical Code on PV systems

690.47 Grounding Electrode System

(A) Alternating-Current Systems If installing an ac system, a grounding electrode system shall be provided in accordance with 250.50 through 250.60. The grounding electrode conductor shall be installed in accordance with 250.64.

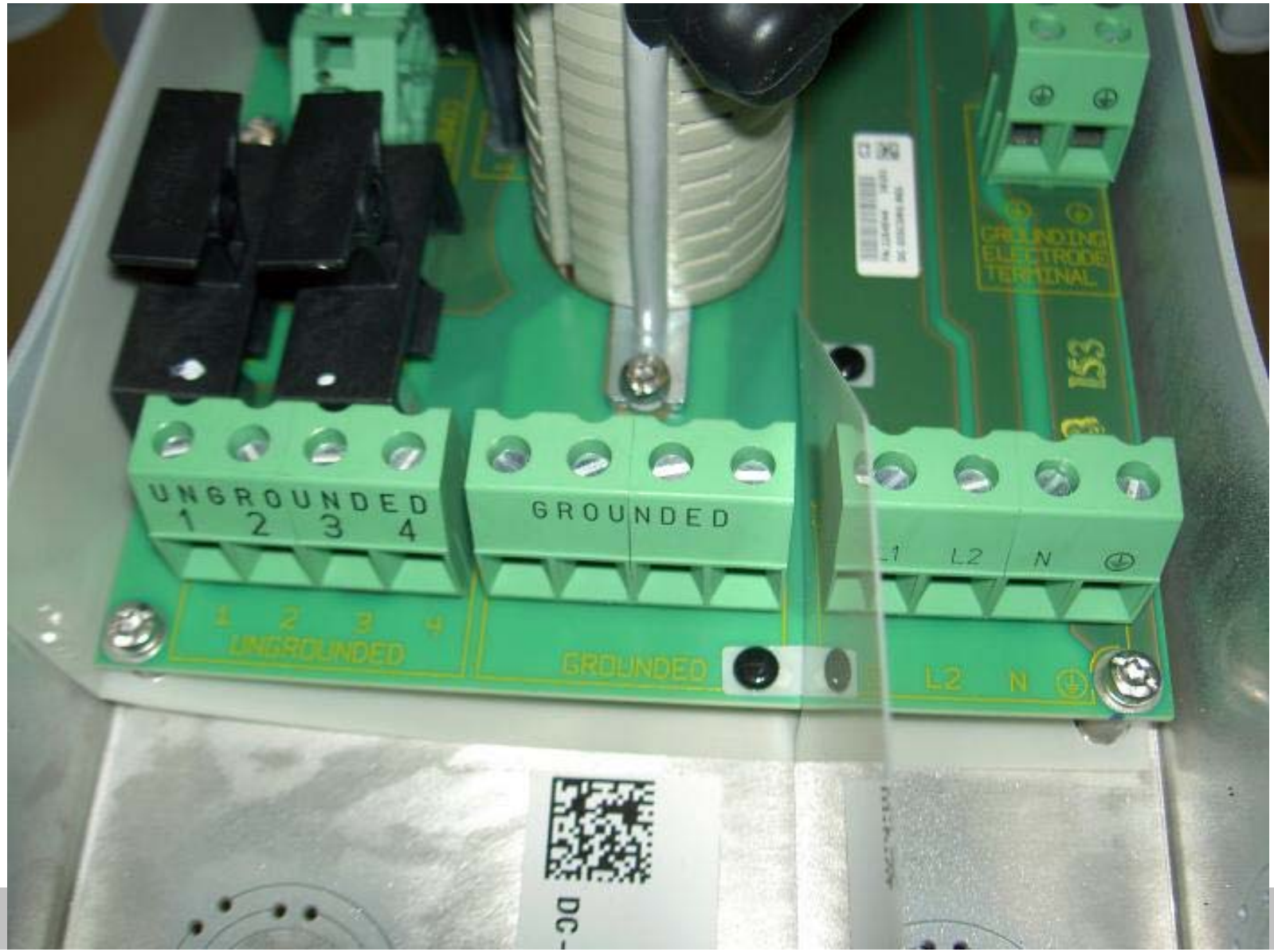
(B) Direct-Current Systems If installing a dc system, a grounding electrode system shall be provided in accordance with 250.166 for grounded systems or 250.169 for ungrounded systems. The grounding electrode conductor shall be installed in accordance with 250.64.

(C) Systems with Alternating-Current and Direct-Current Grounding Requirements Photovoltaic power systems with both alternating-current and direct-current (dc) grounding requirements shall be permitted to be grounded as described in (1) or (2):

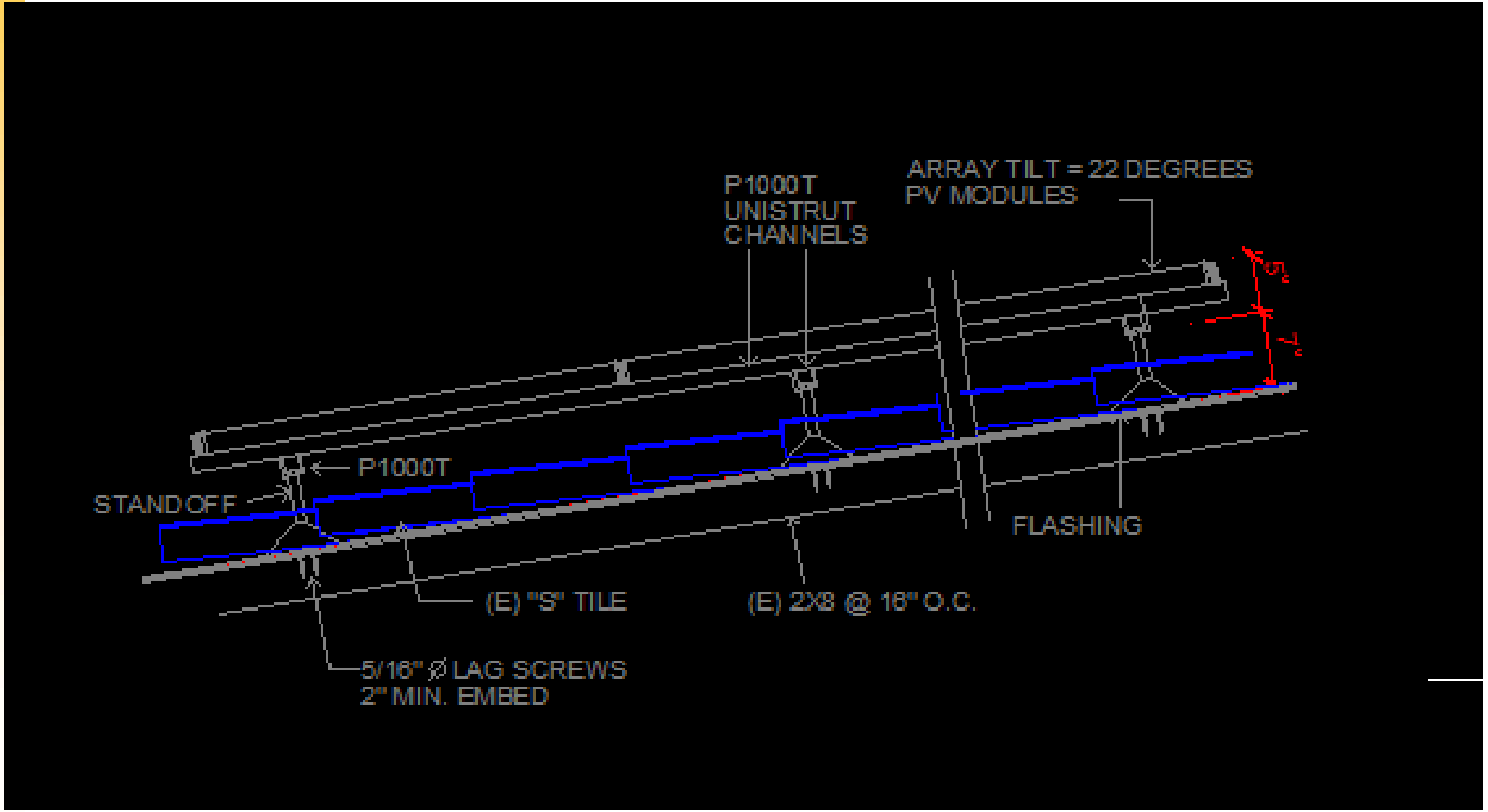
Inverters used in PV power systems usually contain a transformer that isolates the dc grounded circuit conductor from the ac grounded circuit conductor. This isolation necessitates that both a dc and an ac grounding system be installed. The two grounding systems are to be bonded together or have a common grounding electrode so that all ac and dc grounded

INVERTER - DC/AC BOUNDARY

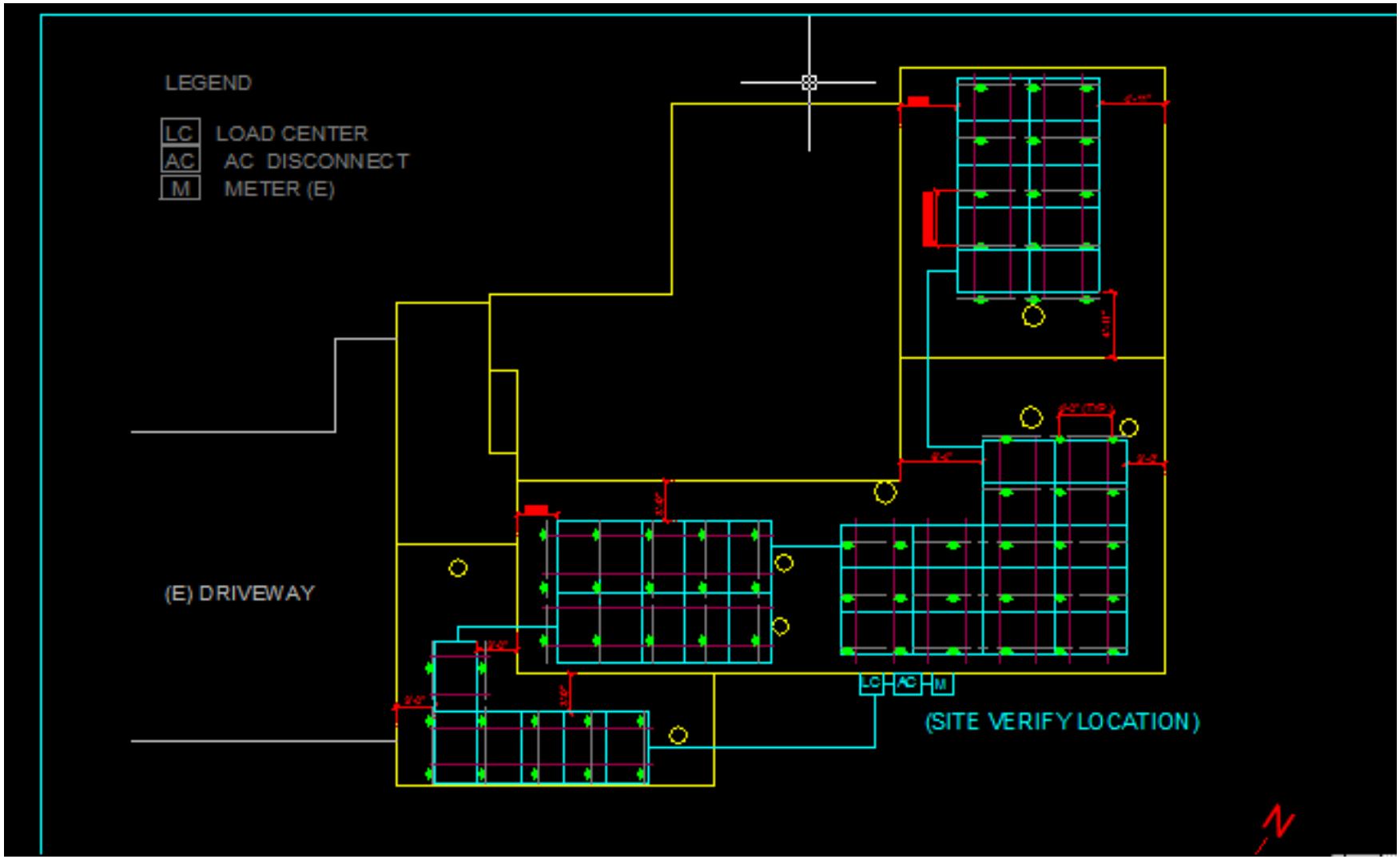
PV SYSTEM GROUNDING ELECTRODE



RESIDENTIAL DESIGN EXAMPLE



RESIDENTIAL DESIGN EXAMPLE LAYOUT



IF ONE CELL IS SHADED

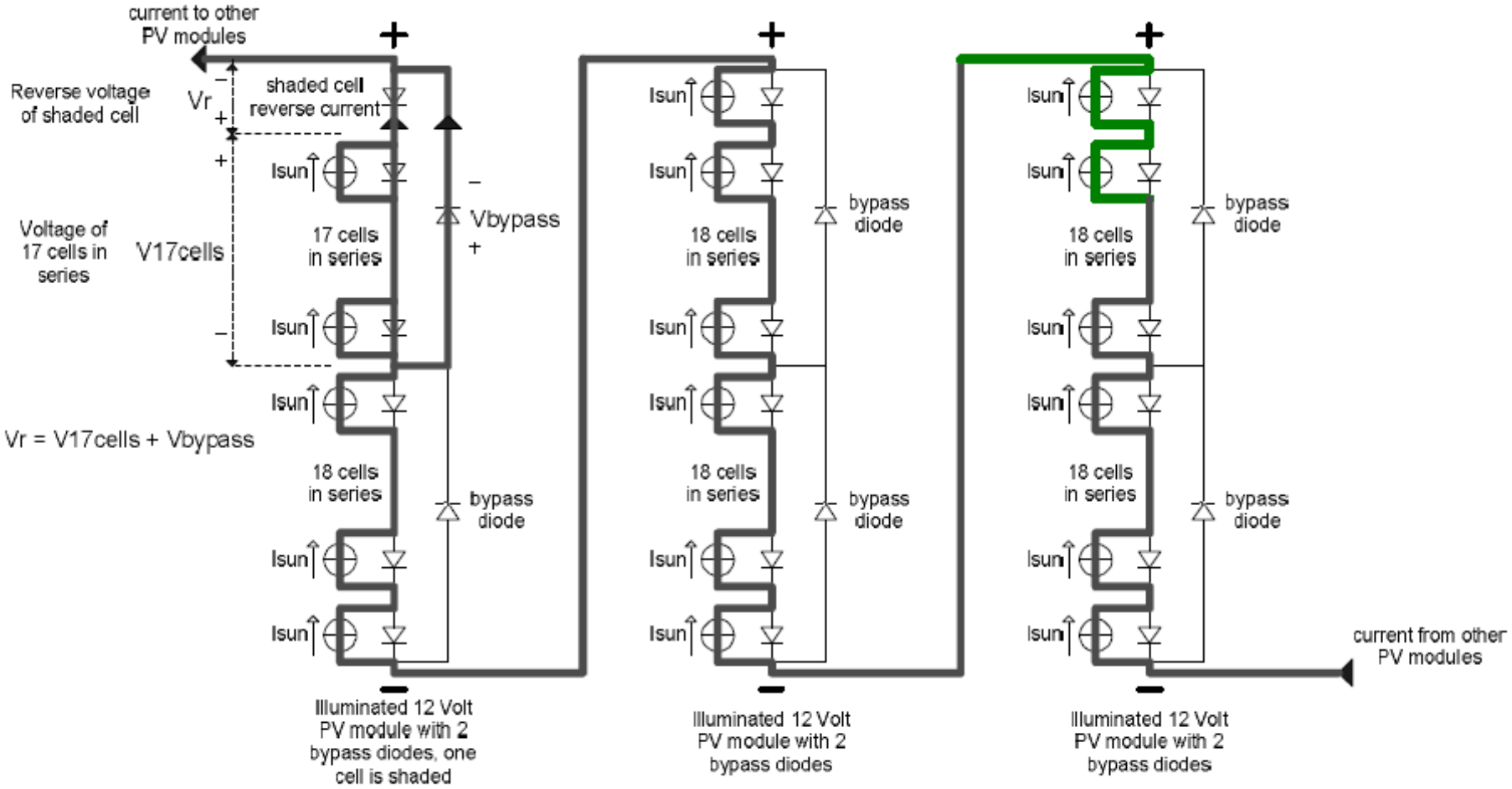


Figure 1: One shaded PV cell in a system of many illuminated PV modules connected in series

IF ONE MODULE IS SHADED

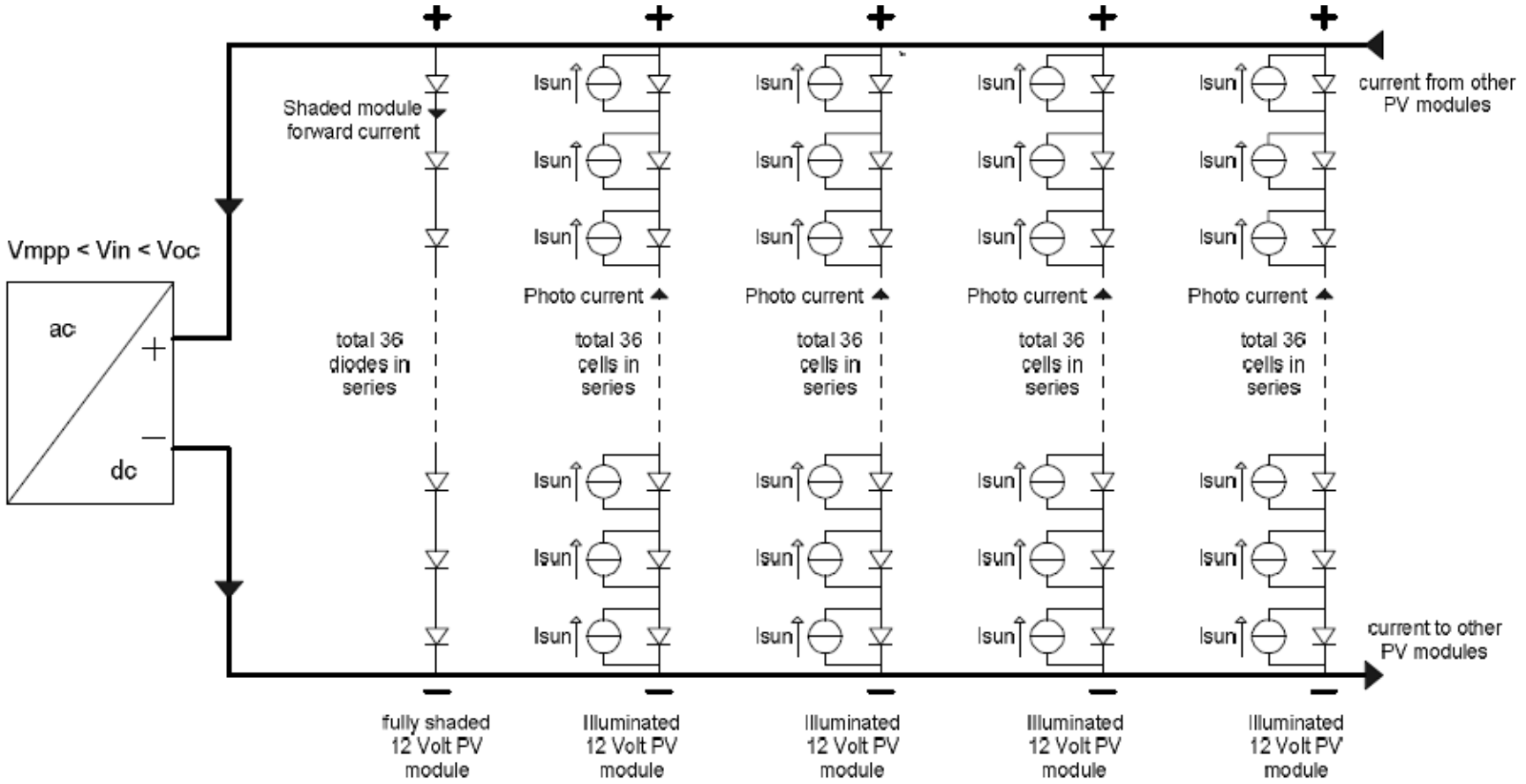
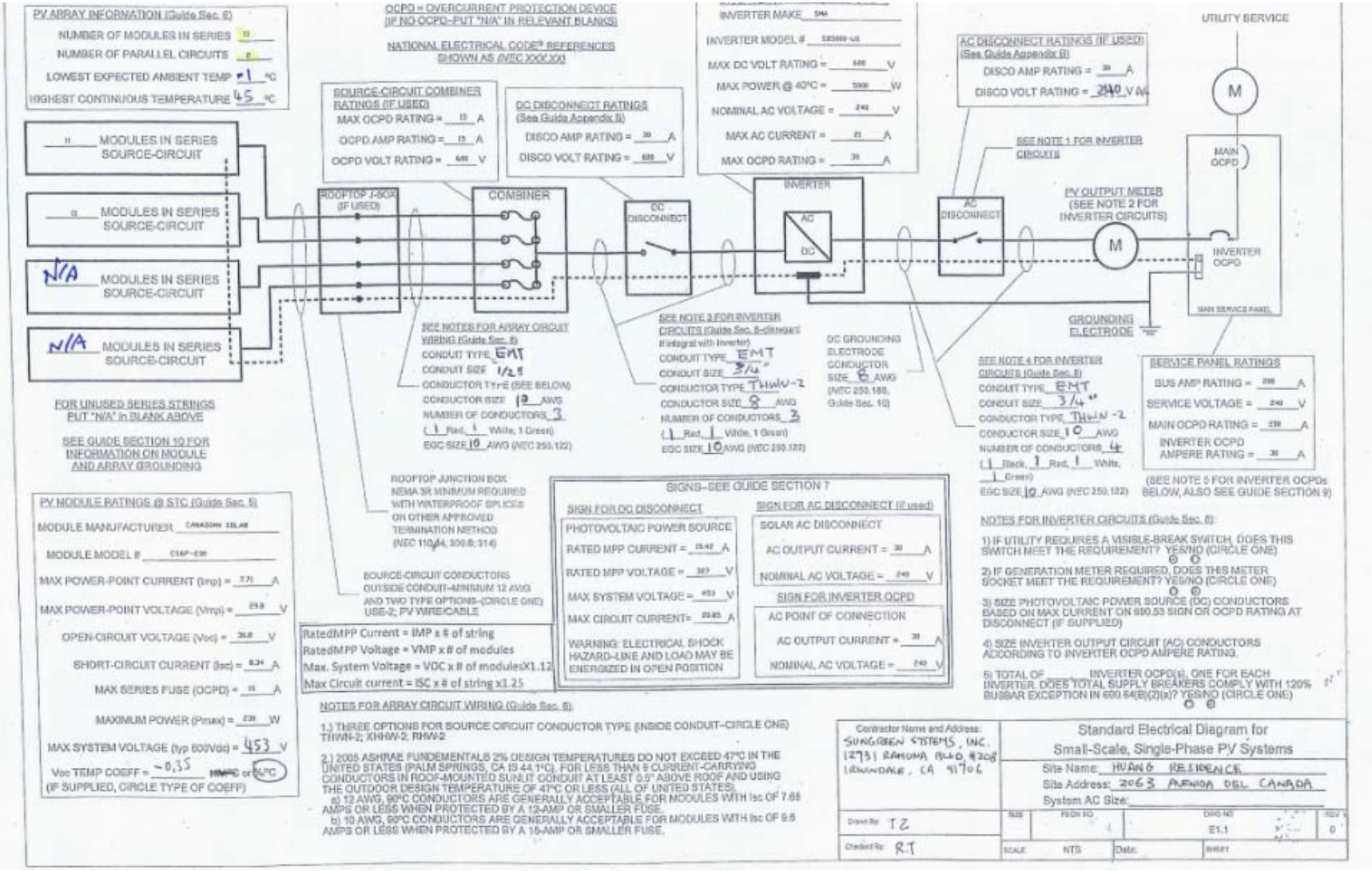


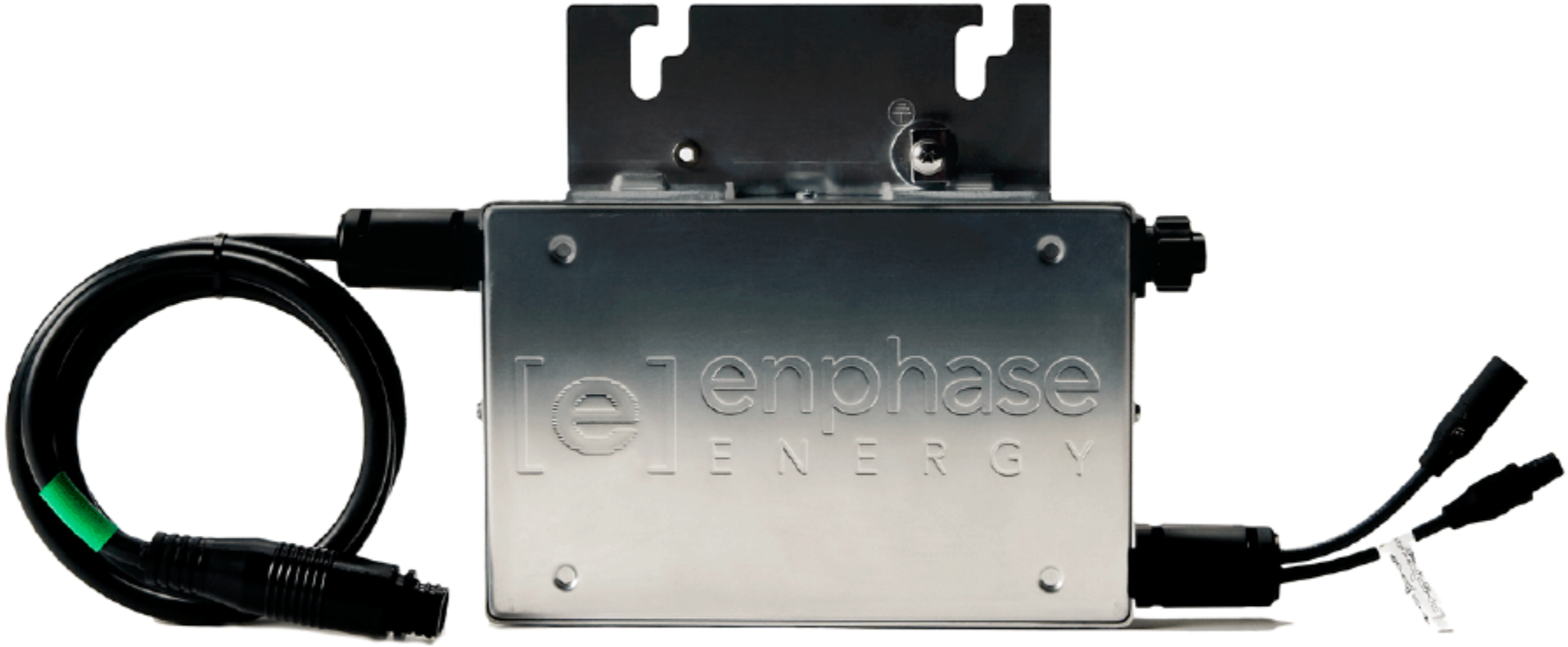
Figure 2: One shaded PV module is a system of many illuminated PV modules connected in parallel

RESIDENTIAL DESIGN
WITH REGULAR INVERTER

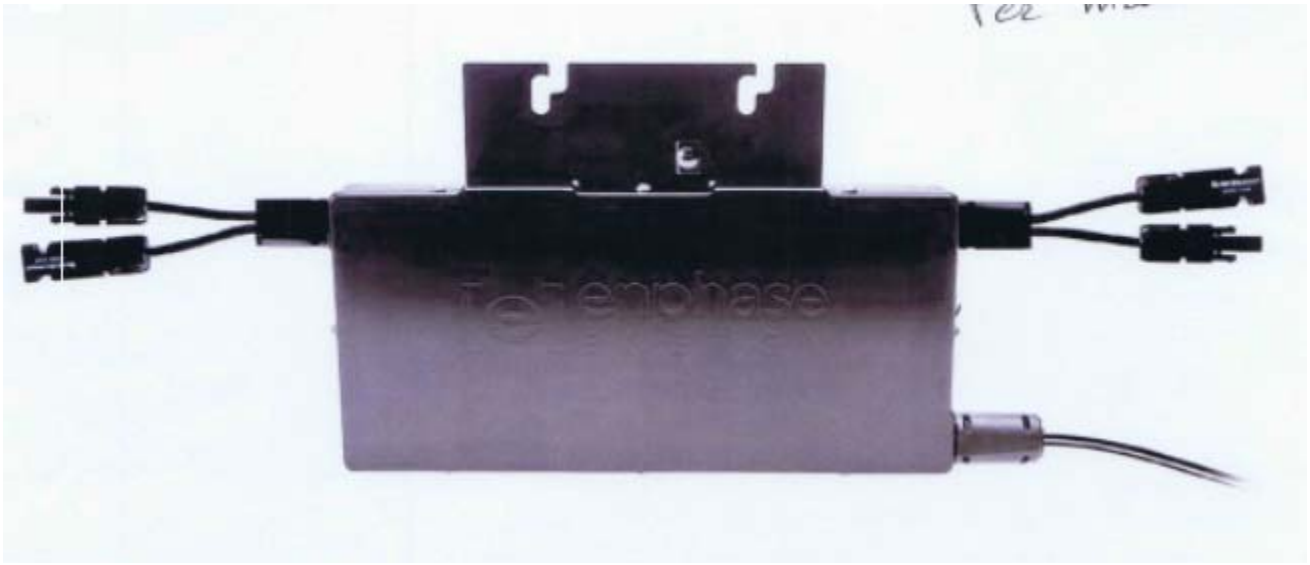
RESIDENTIAL DESIGN
TYPICAL EXAMPLE



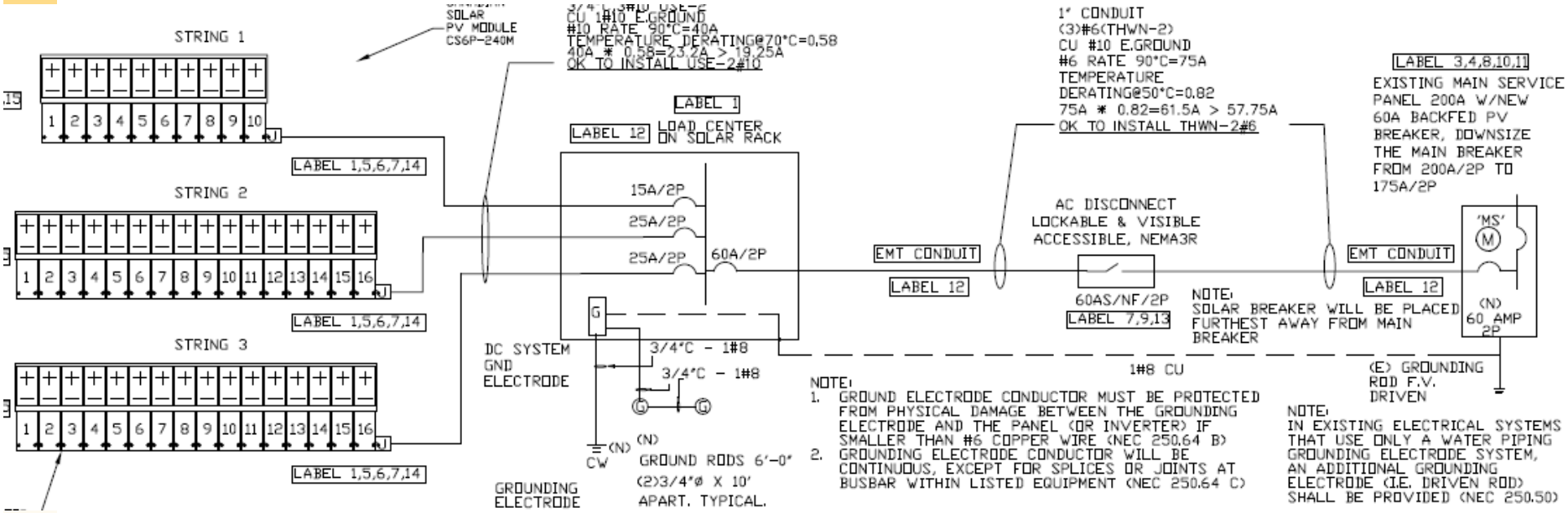
MICROINVERTER



MICROINVERTER – DOUBLE MODULE HALF-COST

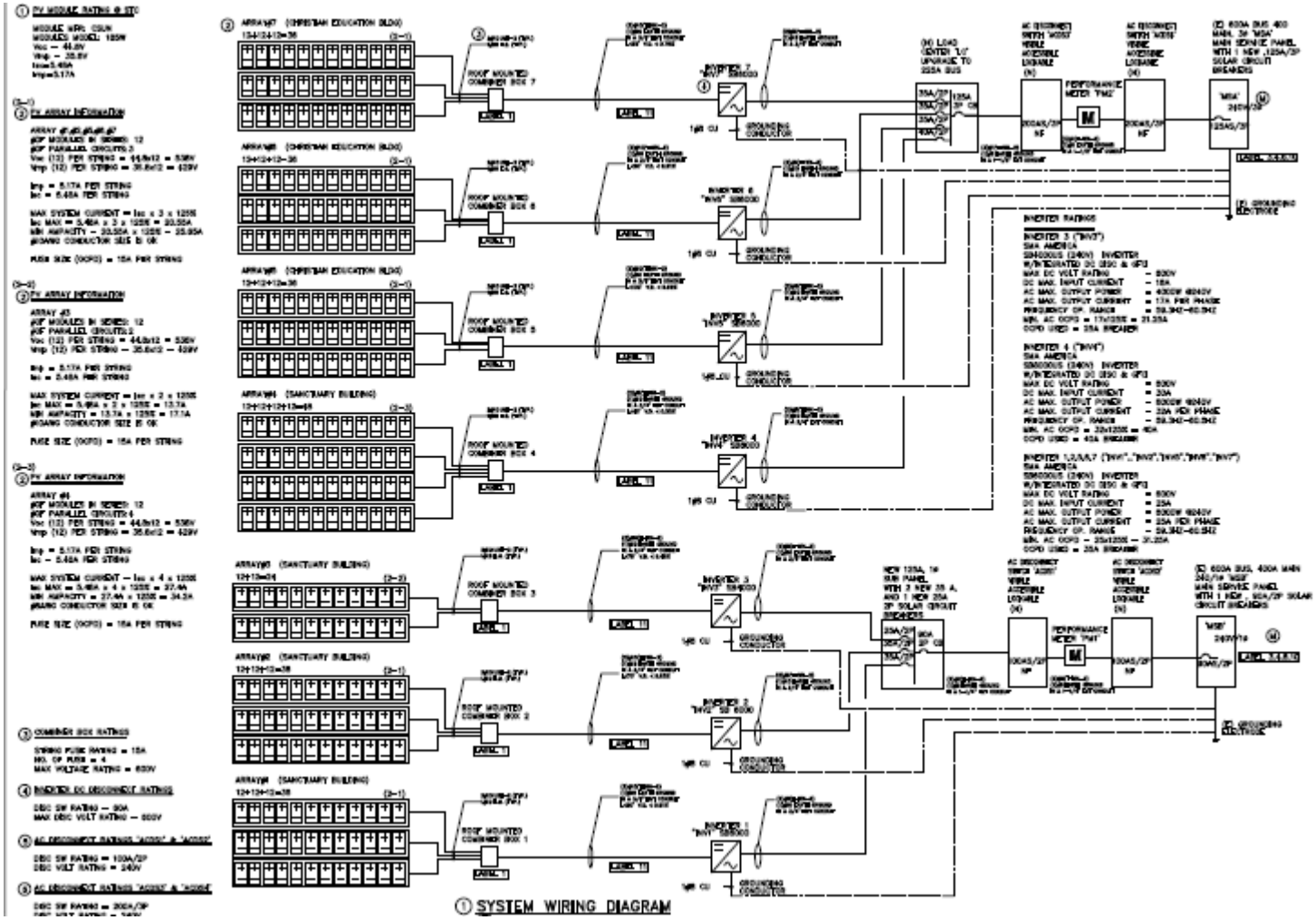


RESIDENTIAL DESIGN
MICROINVERTER



COMMERCIAL DESIGN

MULTIPLE METER & MULTIPLE INVERTER



COMMERCIAL EXAMPLE

COMMERCIAL EXAMPLE

Close-up Photo of Existing Garden

View of New Solar Trellis Looking Up from Garden Floor

Photo of Existing Garden Looking North

View of New Solar Trellis Looking Up Standing at Abbott Ave

View of New Solar Trellis Looking Up Standing at North-East Parking Surface

PROJECT:

Proposed New Solar Trellis over Garden above Banquet Room

San Gabriel Hilton Hotel
227 W. Valley Bl.
San Gabriel, CA 91776

OWNER:

Landwin Development

227 W. Valley Blvd.
San Gabriel, CA 91776

STRUCTURAL ENGINEER

TENG LI & ASSOCIATES

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ISSUE RECORDS

NO.	DATE	PURPOSES
1	12/16/15	Submittal for Planning and Building Departments for Approval

SHEET TITLE

New Solar Trellis Rendering

DATE: 12/16/2015 SHEET NUMBER
SCALE: 1/8" = 1'-0"
DRAWN BY: DL A-2
CHECKED BY: TL
SHEET 8 OF 8

FARM APPLICATION

COMMERCIAL EXAMPLE

BE AWARE OF UTILITYTY TRANSFORMER

COMMERCIAL EXAMPLE