Asia-Pacific Economic Cooperation

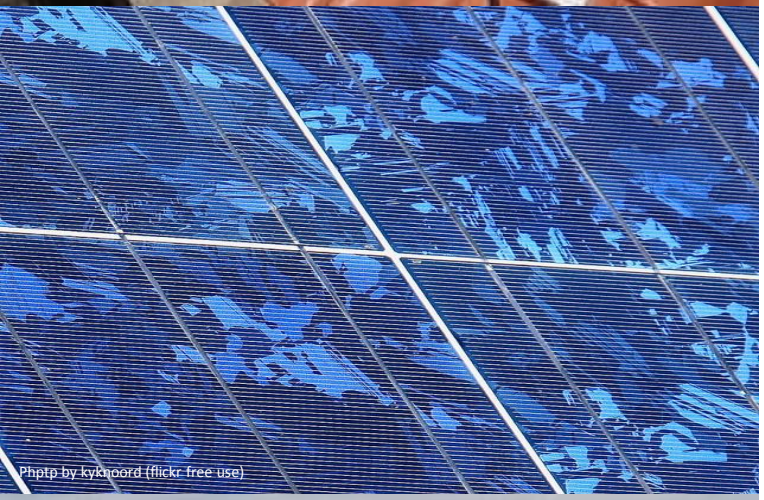
Rooftop Solar PV System Designers and Installers

Training Curriculum

APEC Secretariat

March 2015


Phptp by marufish (flickr free use)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COMMON ELECTRICAL DRAWING SYMBOLS

Training of PV Designer and Installer

APEC
Asia-Pacific Economic Cooperation

Cu International Copper Association
Copper Alliance

castlerock consulting

Purpose

To understand the commonly used electrical symbols in drawings especially pertaining to installation drawings and electrical drawings.

General Drafting Practices

- Electrical systems should be drawn separate from other drawings such as architectural, structural, mechanical.
- Electrical symbols should be drawn darker than the background drawing showing other systems and/or building structure
- It is preferable that the solar PV electrical system drawing is done separately from other electrical systems but referencing them if it helps with clarity
- Electrical plans are generally drawn to scale, but graphic symbols only indicate the approximate locations of electrical equipment

General Drafting Practices

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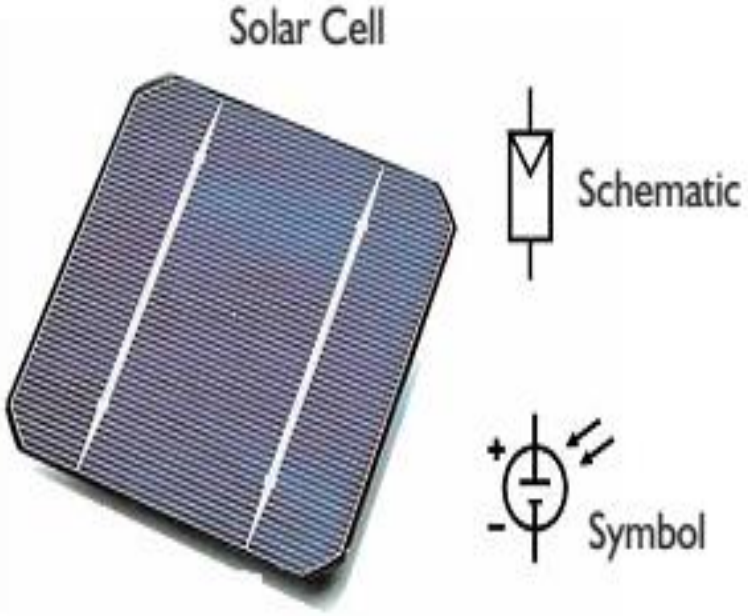
- CAD electrical construction drawings should be created at full scale as this will help to make the scale and print size uniform when printed with other drawings
- Use locally accepted standard practices when possible, otherwise a good standard to use is *CAD Layer Guidelines* published by the American Institute of Architects
- A complete set of electrical construction drawings include the following:
  - Plan for each structure and location/site with electrical installation
  - Site plan(s) showing incoming utility services and substations, exterior transformers, feeders, trunk lines, cables between buildings, etc
  - Symbol list and abbreviation list
  - Bill of materials for electrical systems
  - One line diagram for the solar PV system

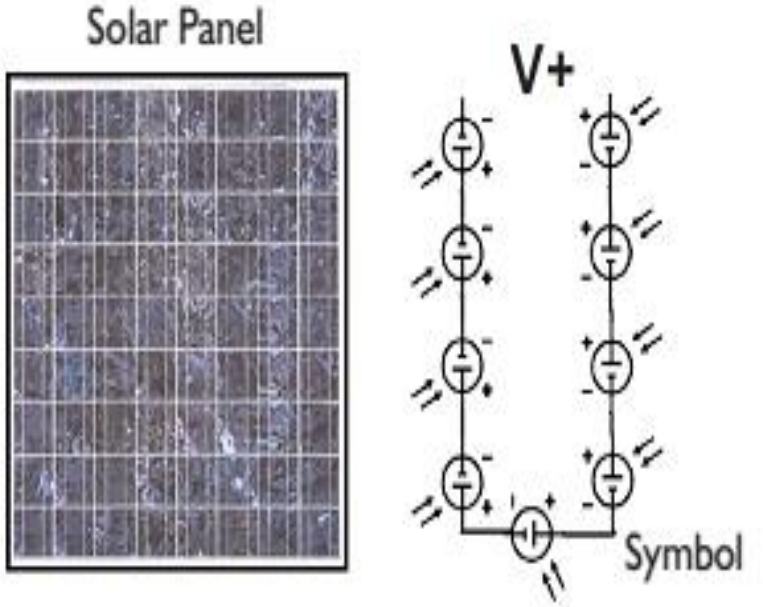
Electrical Symbols

While there are common electrical symbols used in the industry, it is more important that locally accepted symbols are used so other people involved can also understand the information conveyed in the drawings

Electrical Symbols



This is a solar cell and the common symbols for it. A solar panel usually consists of many solar cells wired in series and 2-3 of those in parallel. The upper symbol is normally used to denote a solar panel in a system diagram



This is what the solar panels' simplified internal circuits look like. In reality, the solar panels have blocking diodes and usually have more than 1 set of cells in series

Electrical Symbols

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Fuse

Over voltage protection

Diode

Converter DC / DC
Converting DC to DC

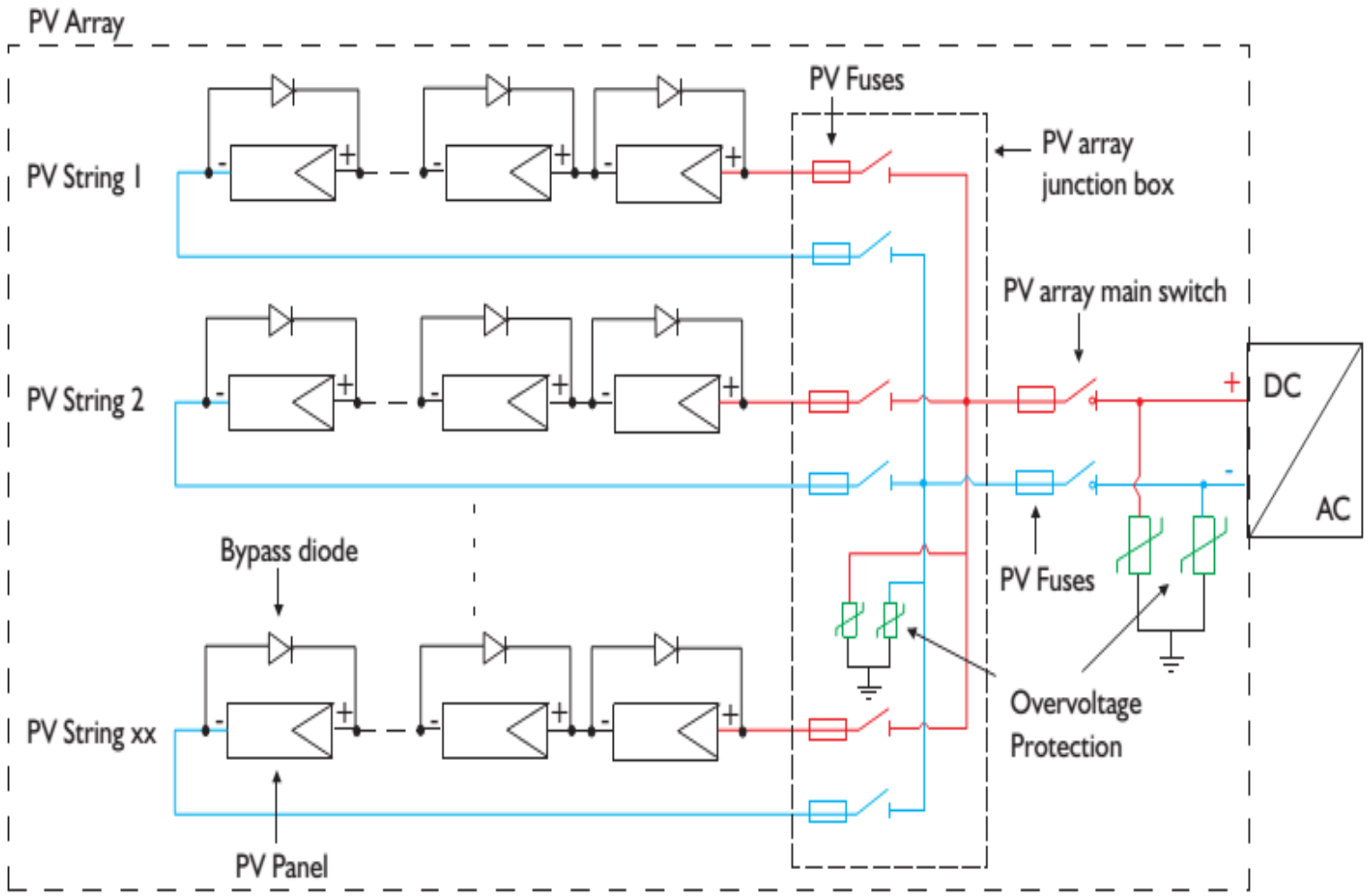
Inverter
DC to AC Converter

Representation battery

Watt hour meter
energy meter

Switch
Contact closure or work

Example


PV Array
PV Fuses
PV String 1
PV array
junction box
PV array main switch
PV String 2
DC
AC
Bypass diode
PV Fuses
PV String xx
Overvoltage
Protection
PV Panel

Common Symbols

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Lighting outlets

- Ceiling outlet
- Drop cord
- Fan outlet
- Junction box
- Lamp holder with pull switch
- Exit light outlet
- Outlet controlled by low voltage switching when relay is installed in outlet box
- Surface or pendant individual fluorescent fixture
- Recessed individual fluorescent fixture
- Recessed incandescent

Signaling system outlets residential occupancies

- Push button
- Buzzer
- Bell
- Telephone
- Intercom
- Electric door opener
- Chime
- Television outlet
- Thermostat

Receptacle outlets

- Duplex receptacle outlet
- Duplex receptacle ground fault circuit interrupter
- Weatherproof receptacle outlet
- Triplex receptacle outlet
- Quadruplex receptacle outlet
- Duplex receptacle outlet—split wired
- Single special-purpose receptacle outlet
- Range outlet
- Special purpose connection
- Clock hanger receptacle
- Floor single receptacle outlet
- Underfloor duct and junction box for triple, double, or single duct system as indicated by number of parallel lines

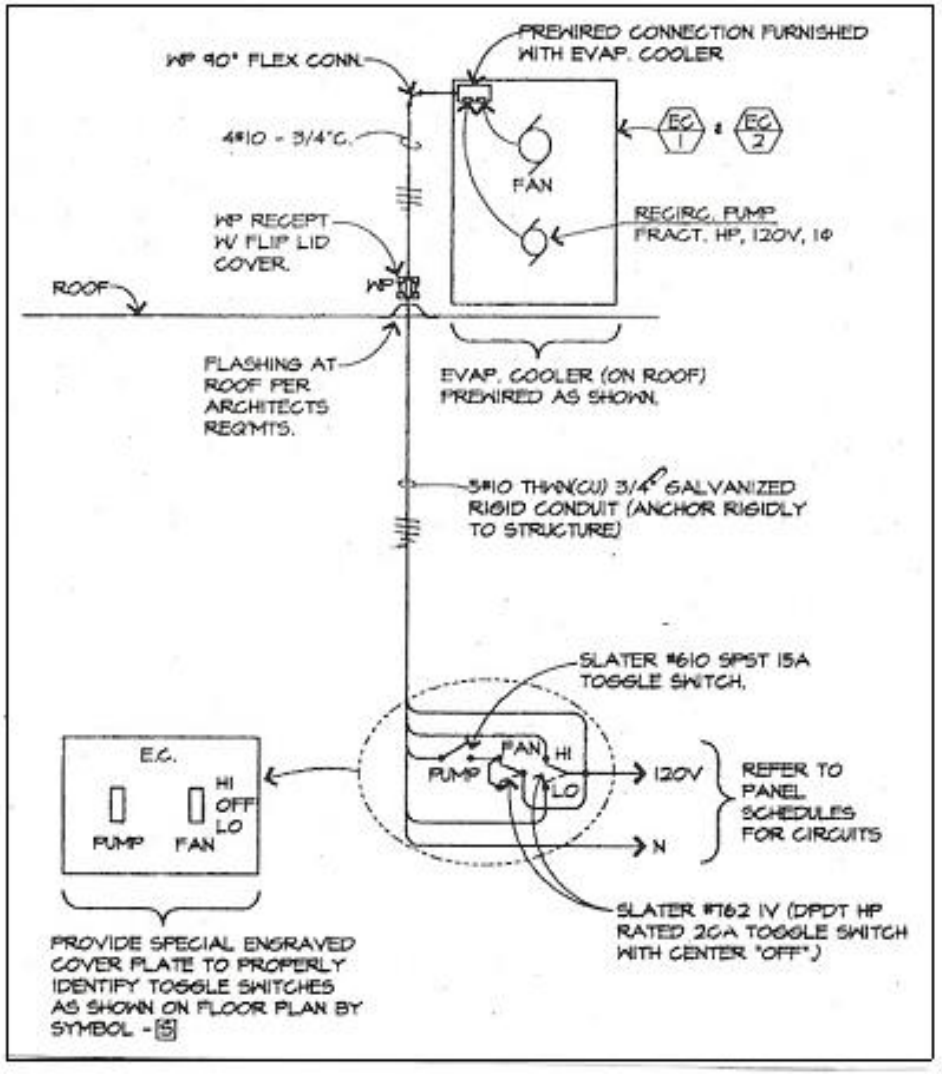
Panels, circuits, and miscellaneous

- Ground
- Lighting panel
- Power panel
- Wiring, concealed in ceiling or wall
- Wiring, concealed in floor
- Conduit run to panel board
- *Indicates number of conductors
- Externally operated disconnect switch

Switch outlets

- Single pole switch
- Double pole switch
- Three way switch
- Four way switch
- Key operated switch
- Switch and pilot lamp
- Weatherproof circuit breaker
- Weatherproof switch
- Switch for low voltage switching system
- Time switch
- Ceiling pull switch
- Switch and single receptacle
- Switch and double receptacle
- Circuit breaker
- Remote control switch
- Fused switch
- Master switch for low voltage switching system
- Automatic door switch

*Indicates number of conductors (in this case, 4). Any circuit without cross hatches indicates two-conductor circuit. Some electrical engineers show number of hot conductors with full marks; neutral conductors with half marks (—|||— = 3 hot conductors, 1 neutral).



Common Symbols

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	Electrical switchbox	S	Single Pole Switch
S_3	Three-Way Switch		SinglePlex Receptacle
	Duplex Receptacle	WP	Duplex Receptacle WP= Waterproof
GFCI	GFCI Duplex Receptacle	*	Isolated Ground Receptacle
	Switched Receptacle		FourPlex Four Gang Receptacle
	240-Volt Receptacle	PC	Ceiling Mounted Light Fixture PC= Pullchain
	Wall-Mounted Light Fixture	R	Recessed Light Fixture
WP	Weatherproof Light Fixture		Fluorescent Light Fixture
CF	Ceiling Fan		Combination Light & Fan
VF	Power Vent Fan	2	Electric Motor Number=HP
SD	Smoke Detector		Circuit Breaker
	Telephone Jack	T	Doorbell Transformer
	Doorbell Pushbutton		Ground

ITEMS	SYMBOL	IN WORDS	OPERATION FUNCTIONS
RELAY		RELAY COIL	
		NORMALLY OPEN CONTACT	CLOSES INSTANTANEOUSLY WHEN COIL IS ENERGIZED
		NORMALLY CLOSED CONTACT	OPENS INSTANTANEOUSLY WHEN COIL IS ENERGIZED
TIME DELAY RELAY		RELAY COIL	ENERGIZED / DE-ENERGIZED; DELAY; CLOSE OPEN; T
		ON-DELAY: NORMALLY OPEN TIMED CLOSED	
		ON-DELAY: NORMALLY CLOSED TIMED OPEN	
		OFF-DELAY: NORMALLY OPEN TIMED OPEN	
		OFF-DELAY: NORMALLY CLOSED TIMED CLOSED	
LIMIT SWITCH		NORMALLY OPEN	CLOSES WHEN ACTUATED BY MECHANICAL FORCE
FLOW SWITCH	0-100	NORMALLY OPEN	CLOSES WHEN WATER STARTS TO FLOW
	0-200	NORMALLY CLOSED	OPENS WHEN WATER STARTS TO FLOW
PRESSURE SWITCH		NORMALLY OPEN	CLOSES AS THE PRESSURE INCREASES TO A SPECIFIC RANGE (IN PSI)
		NORMALLY CLOSED	OPENS AS THE PRESSURE INCREASES TO A SPECIFIC RANGE (IN PSI)
FLOAT SWITCH		PUMP UP OPERATOR	CLOSES AS THE WATER LEVER FALLS TO A SPECIFIC DEPTH
		PUMP DOWN OPERATOR	OPENS AS THE WATER LEVER FALLS TO A SPECIFIC DEPTH
PUSH BUTTON SWITCH		NORMALLY OPEN	PUSH TO CLOSE, RELEASE TO OPEN
		NORMALLY CLOSED	PUSH TO OPEN, RELEASE TO CLOSE

SOLENOID VALVE CONTROL	
SELECTOR SWITCH	OFF, AUTO, HAND
TIME METER	TM
CONNECTED WIRES	
NON-CONNECTED WIRES	
OUT-GOING TERMINAL	
PROBE	P
STARTER COIL	OL

FOR FLOOR PLANS

- LIGHTING FIXTURE, CEILING MOUNTED
- LIGHTING FIXTURE, WALL MOUNTED AT HEIGHT SHOWN
- FLOODLIGHT FIXTURE, WALL MOUNTED
- FLOODLIGHT FIXTURE MOUNTED ON POLE TOP
- FLOURESCENT LIGHTING FIXTURE
- LIGHTING FIXTURE DESIGNATIONS (LOCATED ADJACENT TO FIXTURES). "A" INDICATES FIXTURE TYPE. (SEE FIXTURE SCHEDULE FOR ALL TYPES). "2/40" = TWO 40 WATTS LAMPS
- DUPLEX OUTLET, + 16"
- DUPLEX OUTLET WITH BUILT-IN GROUND FAULT CIRCUIT INTERRUPTER, + 16"

Common Symbols

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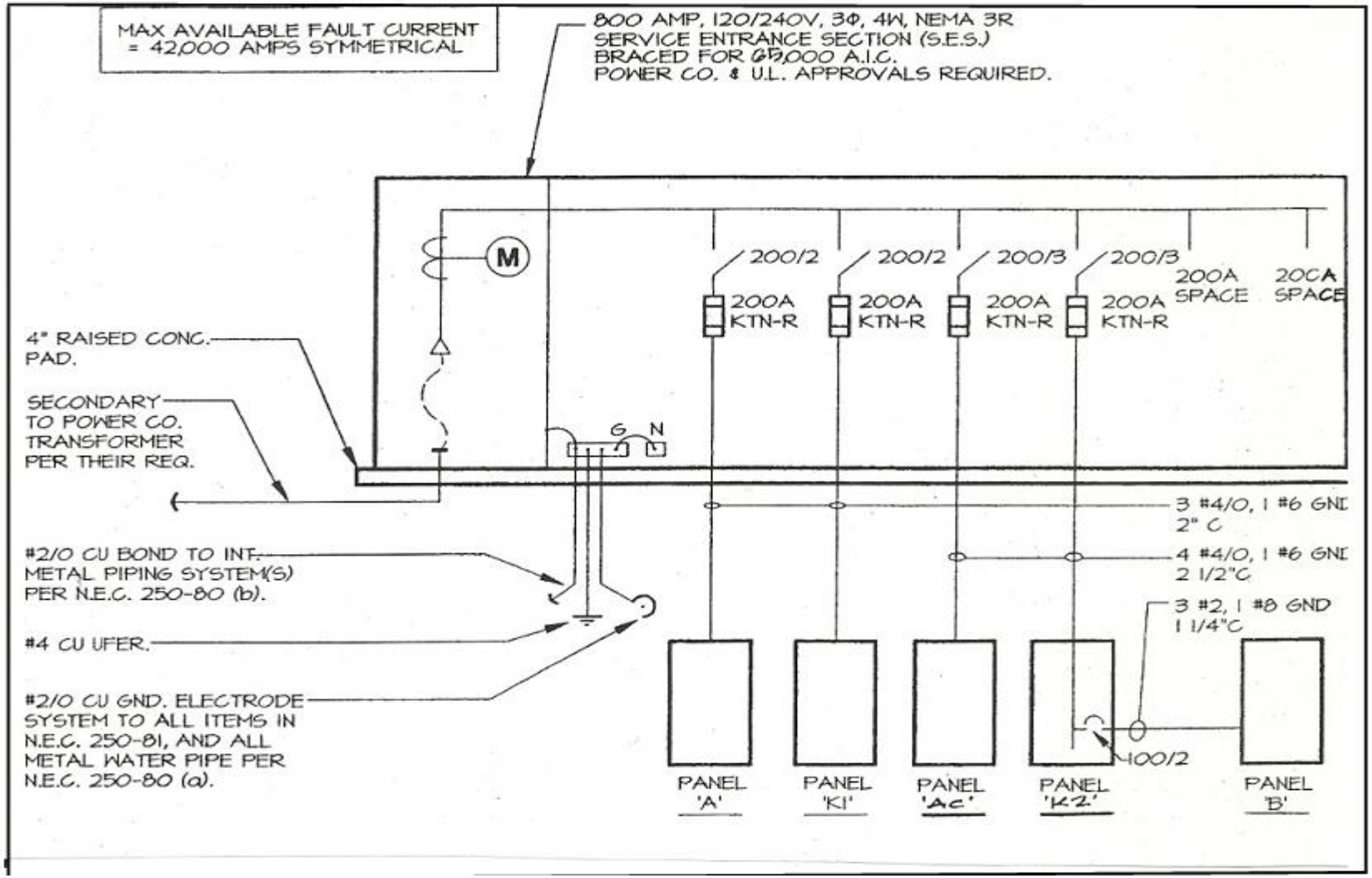
S_F	Fused switch, wall mounted
F	Fused safety switch xxAF= frame size xxAT= trip size
S_K	Key controlled switch, wall mounted
S_{LV} S_L	Low voltage switch, wall mounted
S_{LM}	Low voltage master switch, wall mounted
S_M	Manual motor switch, wall mounted
S_{MTO}	Manual motor switch, with thermal overloads wall mounted
S_{MC} S_B	Momentary contact Intermittent switch, wall mounted
	Motion detector sensor
P	
PE PES	Photoelectric switch
S_{PO}	Pilot/remote light switch load off, wall mounted
S_P	Pilot/remote light switch load on, wall mounted
S_{RC}	Remote control switch receiver, wall mounted
S	Ceiling pull switch ceiling mounted
S_{CP}	Chain pull switch

S	Single pole switch, wall mounted
S_L	Switch with locator lamp glow, wall mounted
S_{TH}	Thermal rated motor switch
T	Thermostat
S_3	Three-way switch, wall mounted
S_T	Timer or motor switch with thermal overload wall mounted
TC	Time clock switch
S_V	Variable speed or volume control switch, wall mounted
S	Wall bracket pull switch
S_{WCB}	Weather proof circuit breaker, wall mounted
S_{WP}	Weather proof switch, wall mounted
	Cable tray
	Conduit turning up
	Conduit turning down
	Conduit with capped end
E	Emergency circuit
	Exposed circuit
LA5-2,6	Homerun to panel letters indicate panel numbers indicate circuits

One Line Diagram



Different Electrical Standards

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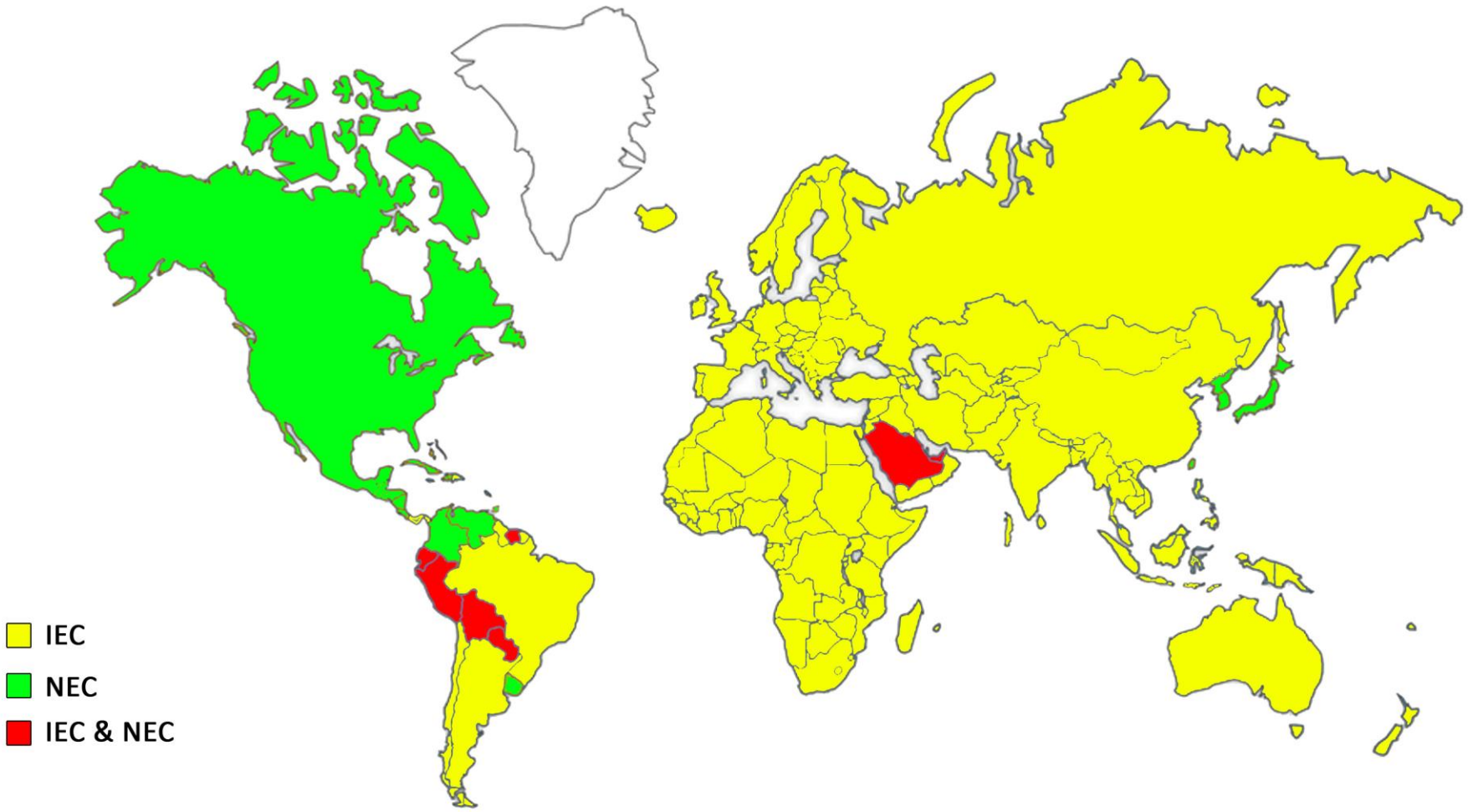

Different Electrical Standards

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IEC is one of the international standards that are widely used across the world. Another standard, which is regional to the North American countries, are also used as the basis for some countries' electrical code.

The map in the previous slide is only a guide to show which areas of the world use IEC or NEC as the basis of their electrical code. Many locally specific rules and regulations must be taken into account and researched individually in order for the solar PV installation to meet all required codes and regulations in the country of installation

Applicable Symbols

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Different standards may use different symbols. The following slides show the differences of some relevant symbols between IEC and NEMA symbol drawings. This is relevant as we create drawings, to be aware of the standard used by our peers in the country we are operating in.

Be aware of the current standards used at your location and find out which of the symbols available are applicable in the region and familiar to the local industry stake holders.

Applicable Symbols

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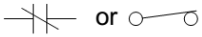
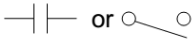
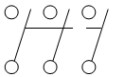
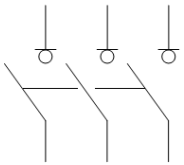
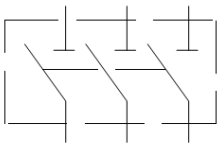
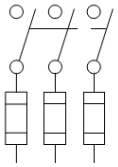
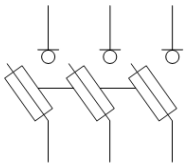
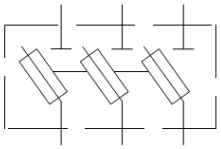
Description		US / Canadian	International / British	German
Basic Contacts	Normally Closed			
	Normally Open			
Disconnect Switch	Non-Fused			
	Fused			

Applicable Symbols

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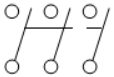
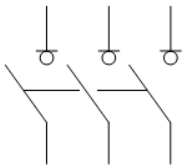
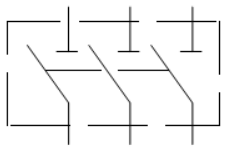
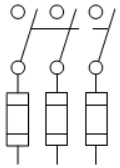
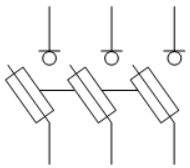
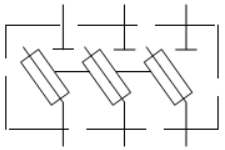
Description		US / Canadian	International / British	German
Fuse				
Ground				
Disconnect Switch	Non-Fused			
	Fused			

IEC (DIN) vs NEMA (IEEE/ANSI)

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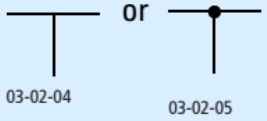
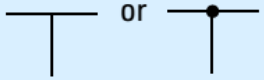
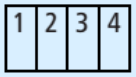
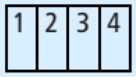
The following comparison of electrical circuit symbols is based on the following international/national specifications:

- IEC 60617 graphic symbol database (DIN EN 60617-2 to DIN EN 60617-12)
- NEMA ICS 19-2002 (R 2007), ANSI Y32.2/ IEEE 315/315 A, CSA Z99

Description	IEC (DIN EN)	NEMA ICS/ANSI/IEEE
Conductors, connectors		
Junction of conductors		
Connection of conductors (node)	 03-02-01	
Terminal	 03-02-02	
Terminal strip/block	 03-02-03	
Conductors	03-01-01	

IEC (DIN) vs NEMA (IEEE/ANSI)

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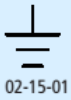
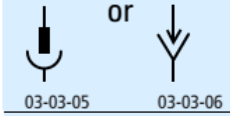
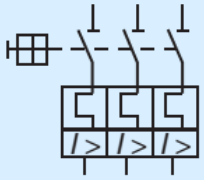
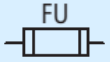
Description	IEC (DIN EN)	NEMA ICS/ANSI/IEEE
Earth, general symbol Ground, general symbol	 02-15-01	 GRD
Protective earth Protective ground	 02-15-03	
Connector with plug and socket	 03-03-05 or 03-03-06	
Three-pole breaker with switch mechanism with three thermoelectric overcurrent releases, three electromagnetic overcurrent releases, motor-protective circuit-breaker	 107-05-01	
Fuse, general symbol	 07-21-01	 FU

IEC (DIN) vs NEMA (IEEE/ANSI)

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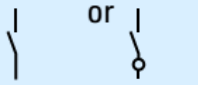
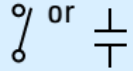
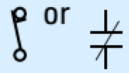
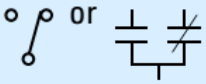
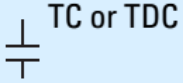
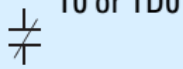
Description	IEC (DIN EN)	NEMA ICS/ANSI/IEEE
Contacts		
N/O contact		
N/C contact		
Changeover contact with interruption		
Early-make N/O contact of a contact assembly		
Late-break N/C contact of a contact assembly		

IEC (DIN) vs NEMA (IEEE/ANSI)

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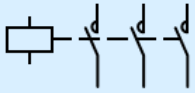
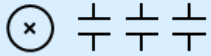
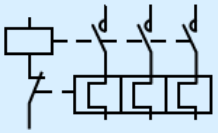
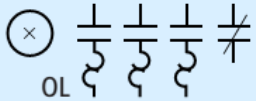
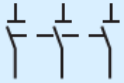
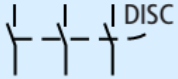
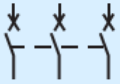
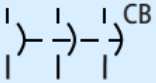
Description	IEC (DIN EN)	NEMA ICS/ANSI/IEEE
Switchgear		
Contactors (N/O contacts)	 07-13-02	 x code letter
Three-pole contactor with bimetal relay (3 thermal elements)		 x code letter
Three-pole switch-disconnector	 07-13-06	
Three-pole circuit-breaker	 07-13-05	

Note to trainers

Add the relevant standard symbols used in each country, feel free to remove the drawings and symbols here that are not used

Asia-Pacific
Economic Cooperation

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