Asia-Pacific Economic Cooperation

Rooftop Solar PV System Designers and Installers

Training Curriculum

APEC Secretariat

March 2015


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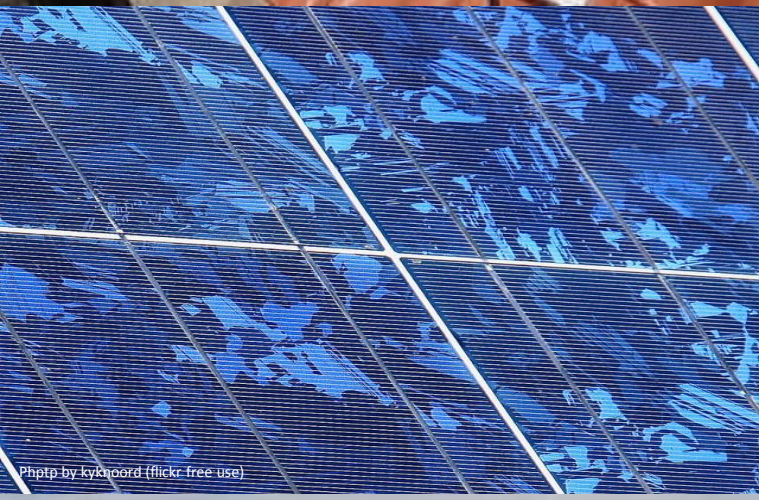
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Solar Charge Controller

Training of PV Designer and Installer

APEC
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Cu International Copper Association
Copper Alliance

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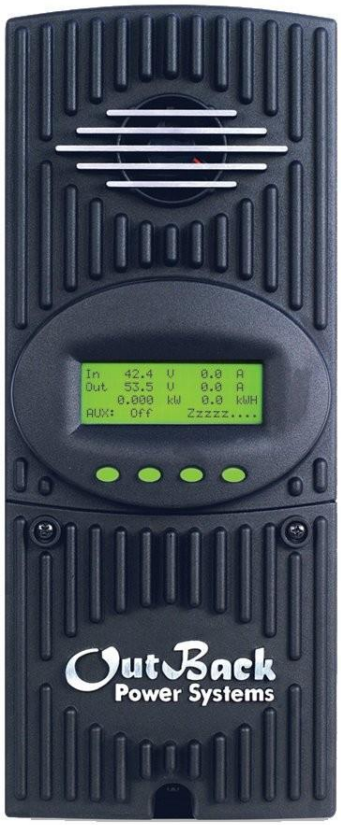
Contents

What is it?



Detects the "state of charge" of the battery(ies)

- Simplest method by detecting the voltage
- More complicated methods include current detection and counting incoming and outgoing energy

Once it detects that the batteries are full, stops the charging circuit

What is it?

Many also incorporate a load controller that stops the load from taking energy from the batteries once the voltage is too low

- Also called “Low Voltage Disconnect” circuitry

More advanced controllers also have different charging stages

Charging stages

- Controller with multiple charging stages can prolong the life of the batteries

Charging stages

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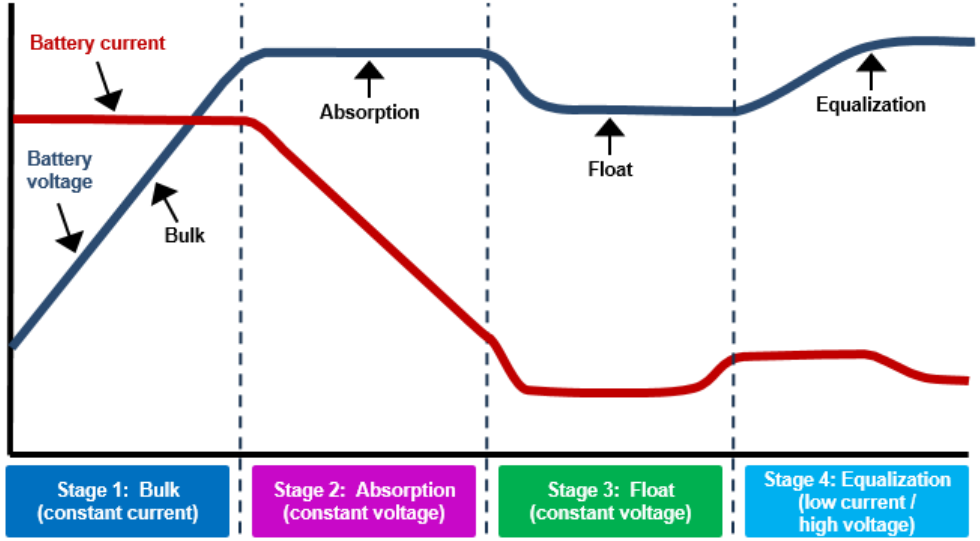
- Common stages are:



Bulk – up to 80% full.

In this stage the charge controller gives the maximum current to the batteries and the voltage is allowed to rise up to a preset limit. If there is a temperature sensor, the controller will also guard against over temperature

Absorption – Up to 100% full.

In this stage, the charge controller will hold the voltage constant at a preset limit and decrease the current until the battery is fully charged

Float

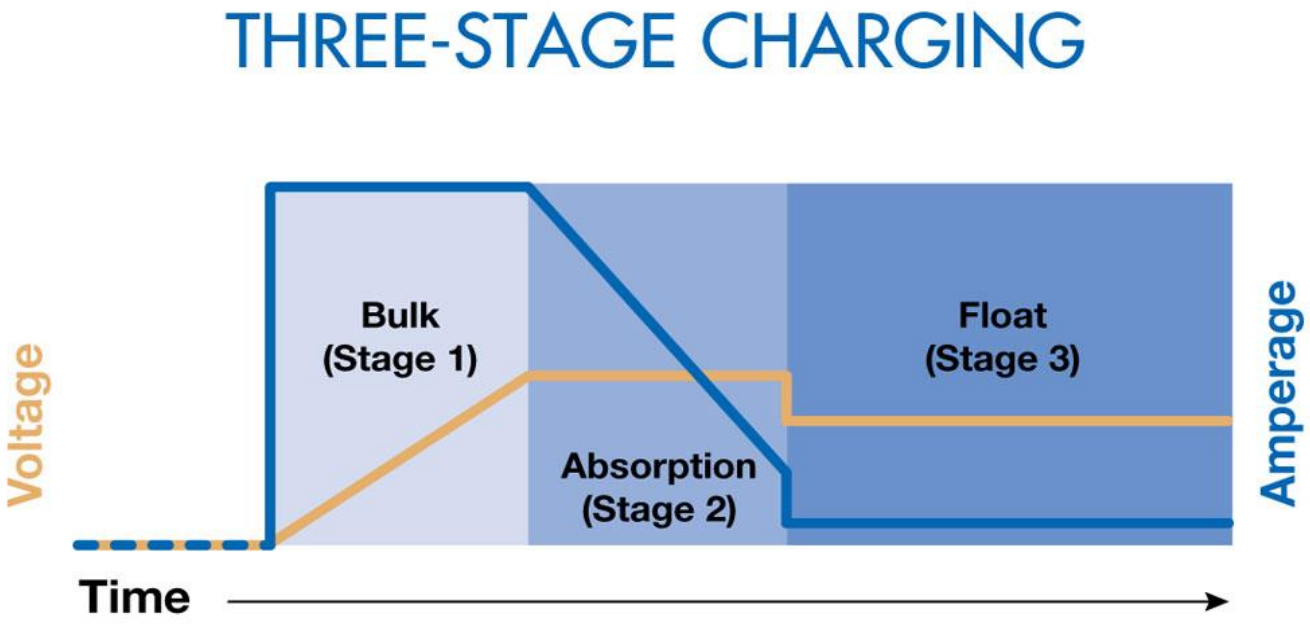
Used to maintain a charge. In this stage the charge controller will hold the voltage constant at a preset limit and keep the current at no more than 1% of the battery capacity

Equalization

Not required (not recommended either) for most brands of AGM or Gel sealed batteries.

This stage is critical to prevent premature damage to flooded cells, especially physically tall batteries

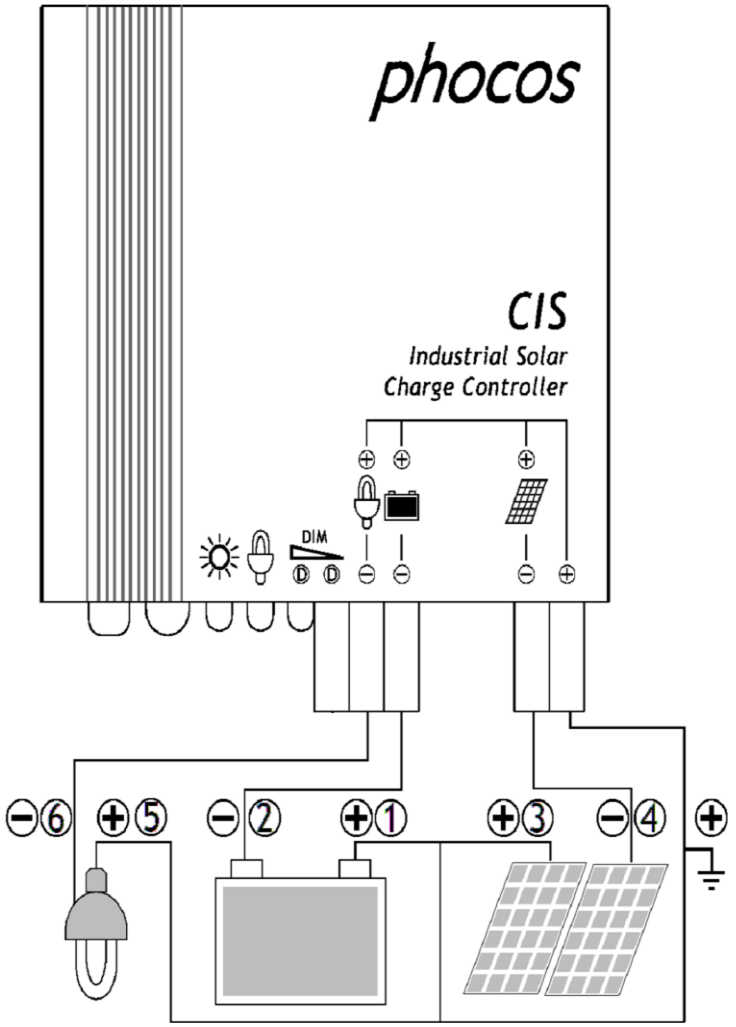
Charging stages



Charge Controller with Load Control

Example charge controller – Phocos CIS:

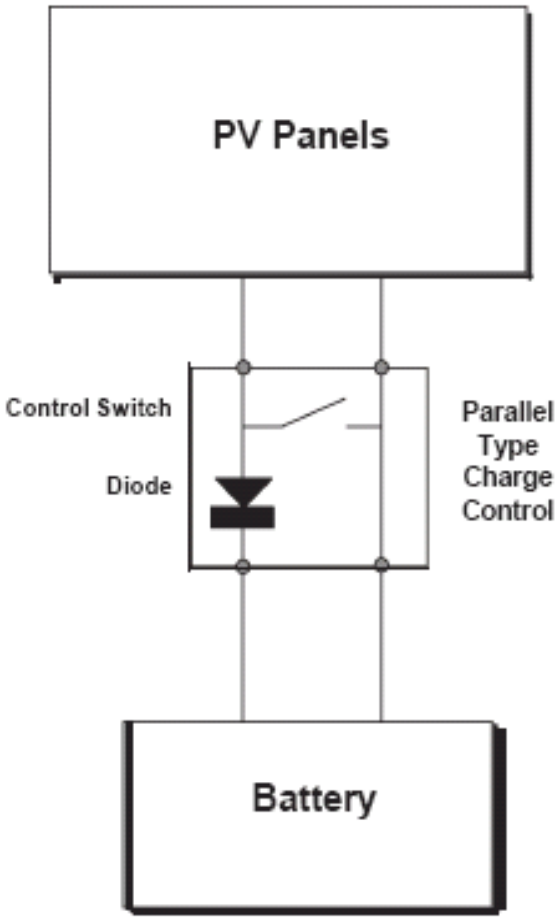
- Programmable load timer on/off depending on solar PV input voltage
- Low Voltage Disconnect Circuitry
- 3-stage charging plus equalization stage (Bulk/Absorption/Float + Equalize)
- 12/24VDC system, autoselect
- 5/10/20A maximum current capacity
- Dimming capability (if the lamp supports it)



Types of Charge Controllers

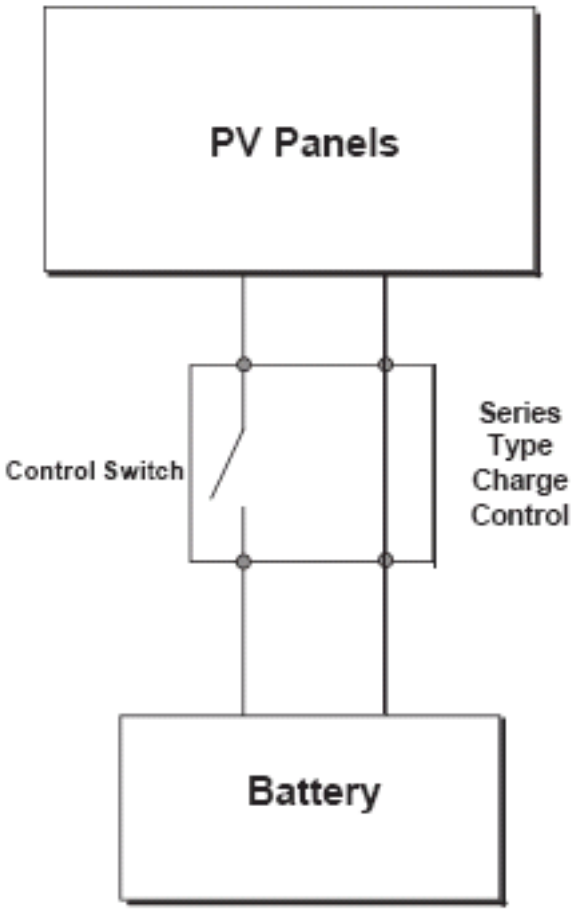
- Simple (Able to be assembled by most home industries)
  - ➢Shunt Controller
  - ➢Switching Controller
    - Transistor Switching
    - Relay Switching
- Commercial
  - ➢Pulse Width Modulated
  - ➢Maximum Power Point Tracking

Shunt Controller



- Placed between the panels and the battery
- To prevent overcharge, the output from the panel is shorted by the controller using a semiconductor switch
- Because the panel wires go to the battery, a blocking diode has to be installed or shorting the panel output would also short the battery
- Disadvantages:
  - Excess power turned to heat, good for up to 50Wp panels
  - Sensitive to lightning
  - Requires a blocking diode (adds losses)
- Advantages:
  - Cheap and simple, lends itself to home industry

Switching/Series Controller



- Placed between the panels and the battery
- To prevent overcharging, a transistor switch or a relay is used to disconnect the panel from the battery
- Disadvantages (Relay):
  - Usually more expensive than transistor type
  - Can only do on/off type of control
- Advantages (Relay):
  - Very robust, resists lightning strike pretty well
  - Low losses and voltage drop
  - Can be used on larger systems
  - Simple circuitry that may be repaired locally

Relay Switching Controller

High reliability relay type controller circuitry designed by S.P.I.R.E. and constructed in Kiribati by the Kiribati Solar Energy Co.

Semiconductor Switching Controller

- Sensitive to lightning damage
- Easy to damage if there's excess current
- Higher internal voltage drop
- Relay controllers are usually more robust

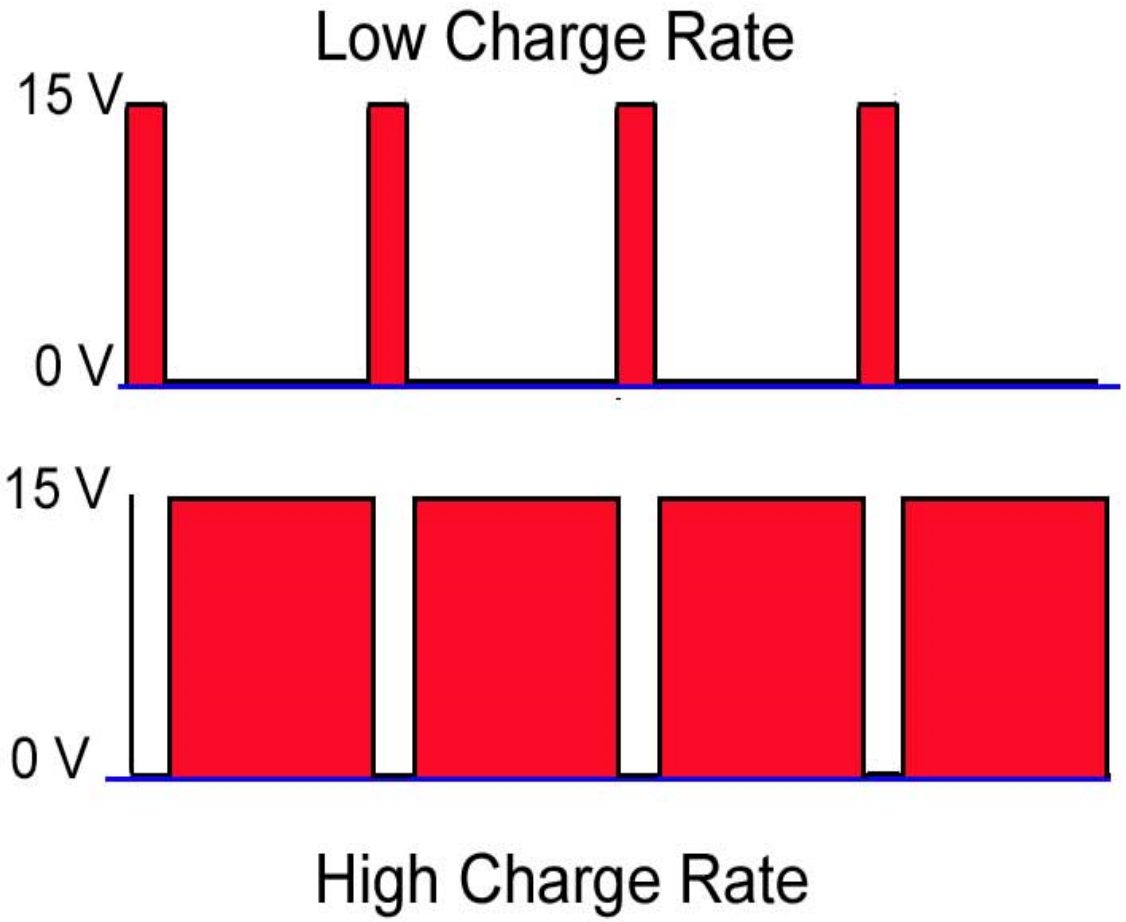
Semiconductor Switching Controller

- ProStar controller
- 12/20/40 Amperes
- Up to 48V battery
- Lightning protection included
- “On-Off” type controller

Pulse Width Modulated Controller

- Charging current and rate of charge is important for efficient charging
- Using pulses of energy, high current can be used without overheating the battery
- The ratio between the “on” pulse and the “off” pulse determines the rate of charging into the battery
- Wide pulses with little time between them provide high charging rate
- Narrow pulses with a lot of time between them provide low charging rate

Pulse Width Modulated Charging



Pulse Width Modulated Charge Controller

- Morningstar TS style semiconductor controller
- Remote data port
- Manually controlled equalization
- 12, 24 or 48V operation
- Up to 60A
- Both PWM and charge control available

Maximum Power Point Tracking Controller

- Cost efficient on larger systems (>1000Wp)
- Better at extracting more energy during non optimal sunlight (cloudy, morning/afternoon, etc)
- Not easy (just about impossible) to repair locally
- Require trained technician to troubleshoot
- Converts high voltage solar PV input to lower voltage at a higher current
- Biggest advantage: allows for a higher string voltage for lower losses and more flexibility in design

Maximum Power Point Tracking Controller

- Outback MX-60 MPPT controller
- Includes data logger and remote monitoring
- Programmable equalization
- Input voltage up to 140 DC to charge a battery ranging from 12V-60V
- Claims up to 30% more energy than non MPPT controllers but more likely 10%-15% if panel voltage is matched to that of batteries.

Different Charging Methods

- On/Off charging – full voltage and current from the panels are always allowed to charge the batteries. Shuts off the voltage and current when the batteries are sensed to be full by the controller.
- Controlled taper charging – When full charge is approached, current is reduced and a trickle charge to keep the batteries full are applied as long as the sun is shining.
- Pulse Width Modulated charging – Works the same as controlled taper charging but by modulating the pulse width.
- Maximum Power Point Tracking charging – Changes the input and voltage and current to the required voltage and current by measuring the maximum power produced rather than voltage or current.

How to Select a Charge Controller

- Consider all stake holders, if high reliability is required then purchase a commercially available charge controller. If community involvement is important, and the systems installed are small then consider a simple design charge controller that can be assembled and repaired locally.
- PWM or MPPT? For systems smaller than 1000Wp, PWM is more cost efficient. However, the solar panel selected must be compatible with the nominal voltage of the system.
- In remote areas, look at charge controllers that include a low voltage disconnect for the loads. This will prevent severe damage to the batteries.

Calculating your requirements

- Which voltage? For systems smaller than 250Wp, 12VDC can be used. Up to 500Wp, 24VDC should be used. Beyond 500Wp, 48VDC is highly recommended
- Which ampere? With controllers that include a load control circuit, the current rating of the controllers usually applies both to the input power and the load output power
- Which controller? Consider brand names that are widely used in the industry. Less expensive alternatives usually do not have a good reputation for reliability. When choosing a controller, just like any other piece of equipment, an honest lifetime cost calculation must be performed between the competing products

Charge Controller Notes

- Cable length between the controller and batteries needs to be a maximum 1.5m for proper operation
- Check the voltage and current running through the system during the design phase, installation phase and most importantly during the commissioning phase
- Is there adequate lightning protection?
- Check that the controller is programmed to charge the right type of battery (ie flooded vs sealed)
- Low quality controller brands are prone to corrosion, damage due to high humidity and heat, and tend to experience high component failure rate

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