AMERICAN RIVER COLLEGE

System Components

Lesson Plan

- Safety Review – Any Questions?
- NABCEP Learning Objectives Review: System Components

Category	Course Time By %	Exam Items	Level of Testing
1. PV Markets & Applications	5%	3	Comprehension
2. Safety Basics	5%	3	Comprehension Application
3. Electricity Basics	10%	6	Comprehension Problem Solving
4. Solar Energy Fundamentals	10%	6	Comprehension Application Problem Solving
5. PV Module Fundamentals	10%	6	Comprehension Application Problem Solving
6. System Components	15%	9	Comprehension Application Problem Solving
7. PV System Sizing Principles	10%	6	Application Problem Solving Design
8. PV System Electrical Design	15%	9	Application Problem Solving Design
9. PV System Mechanical Design	10%	6	Application Problem Solving Design
10. Performance Analysis, Maintenance and Troubleshooting	10%	6	Analysis Problem Solving
Totals	100%	60	

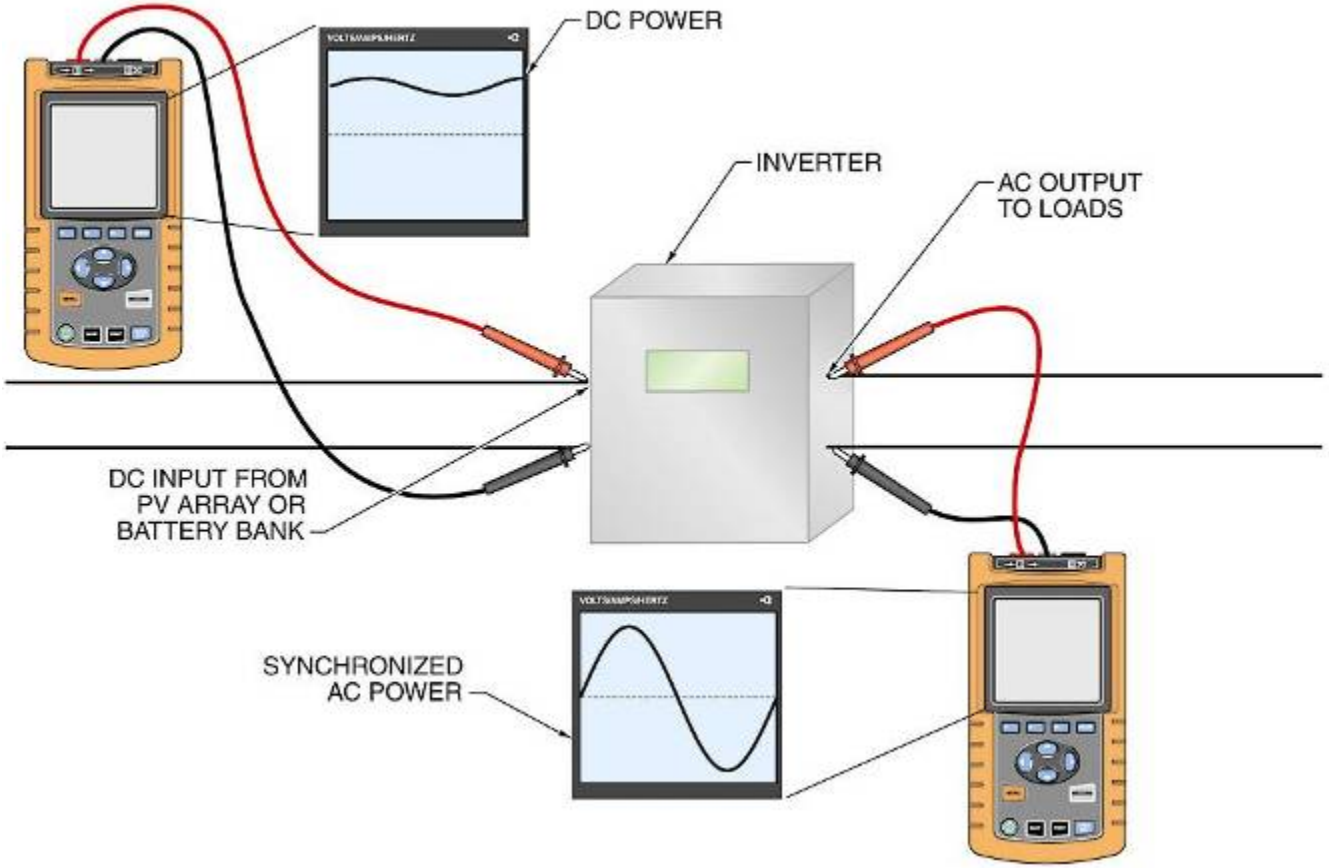
6.	**System Components** *Suggested Percentage Time Allotment: 15%*	**Learning Priority**
6.1	Describe the purpose and principles of operation for major PV system components, including PV modules and arrays, inverters and chargers, charge controllers, energy storage and other sources.	Critical
6.2	List the types of PV system balance of system components, and describe their functions and specifications, including conductors, conduit and raceway systems, overcurrent protection, switchgear, junction and combiner boxes, terminations and connectors.	Important
6.3	Identify the primary types, functions, features, specifications, settings and performance indicators associated with PV system power processing equipment, including inverters, chargers, charge controllers, and maximum power point trackers.	Important
6.4	Understand the basic types of PV systems, their major subsystems and components, and the electrical and mechanical BOS components required.	Important

Modules and Arrays

Schott Solar

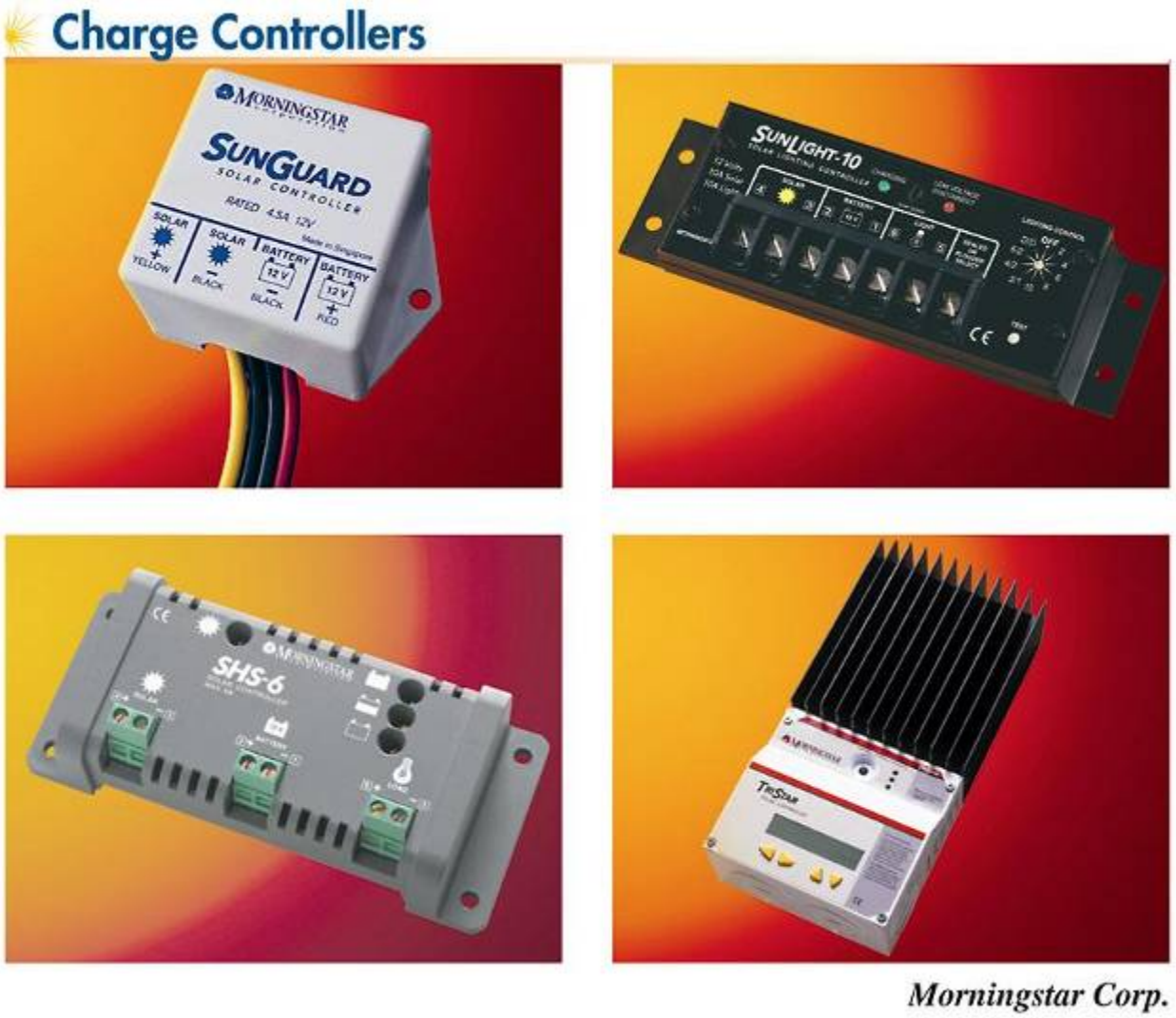
- PV modules are connected together to form an array, which is the primary power- generating source and principal component in any PV system.

Inverters



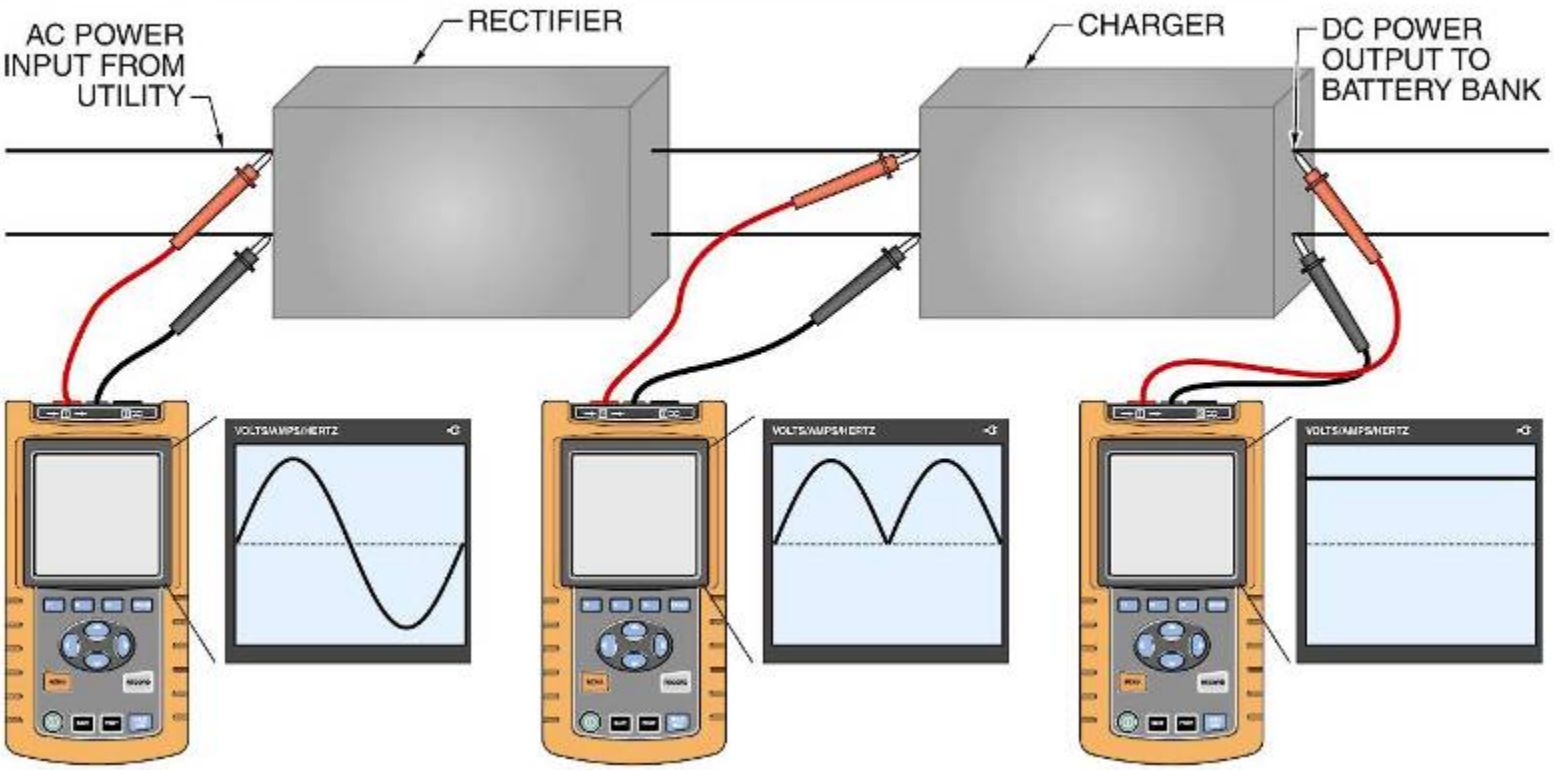
- Inverters convert DC power from batteries or arrays into utility-grade AC power.

- Charge controllers protect batteries in PV systems from overcharge or excessive discharge.



Morningstar Corp.

Rectifiers and Chargers



- Rectifiers and chargers make AC power from sources such as the utility or engine generators available for charging batteries or other DC loads.

- PV systems with battery storage usually require more than one battery. A battery bank is a group of batteries connected together to provide a specific voltage and capacity.

East Penn Manufacturing Co., Inc.

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System Components

- Balance-of-system (BOS) components include all the mechanical and electrical parts to connect and secure the major components.

- Junction Box
- Combiner Box
- Conduit
- GFI
- Switchgear
- Bonding
- Grounding

SolarWorld Industries America

MECHANICAL

Schott Solar

ELECTRICAL

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Inverters

SMA America, Inc.

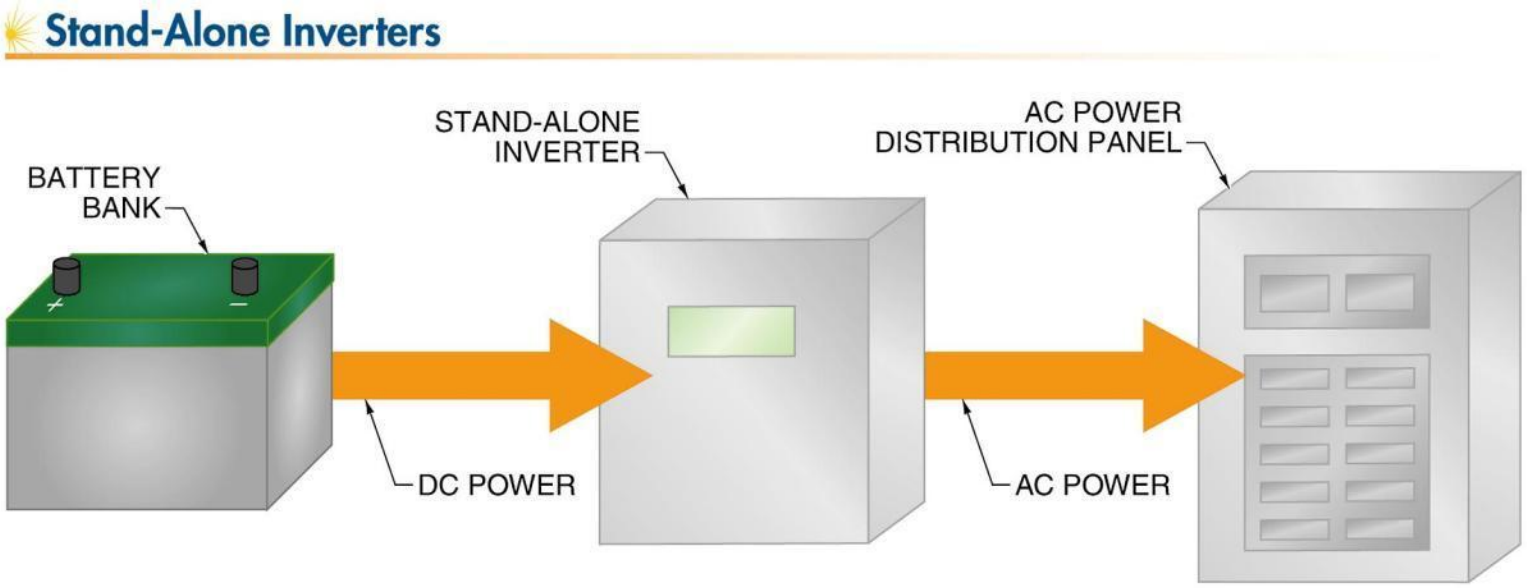
Xantrex Technology Inc.

Sharp Electronics Corp.

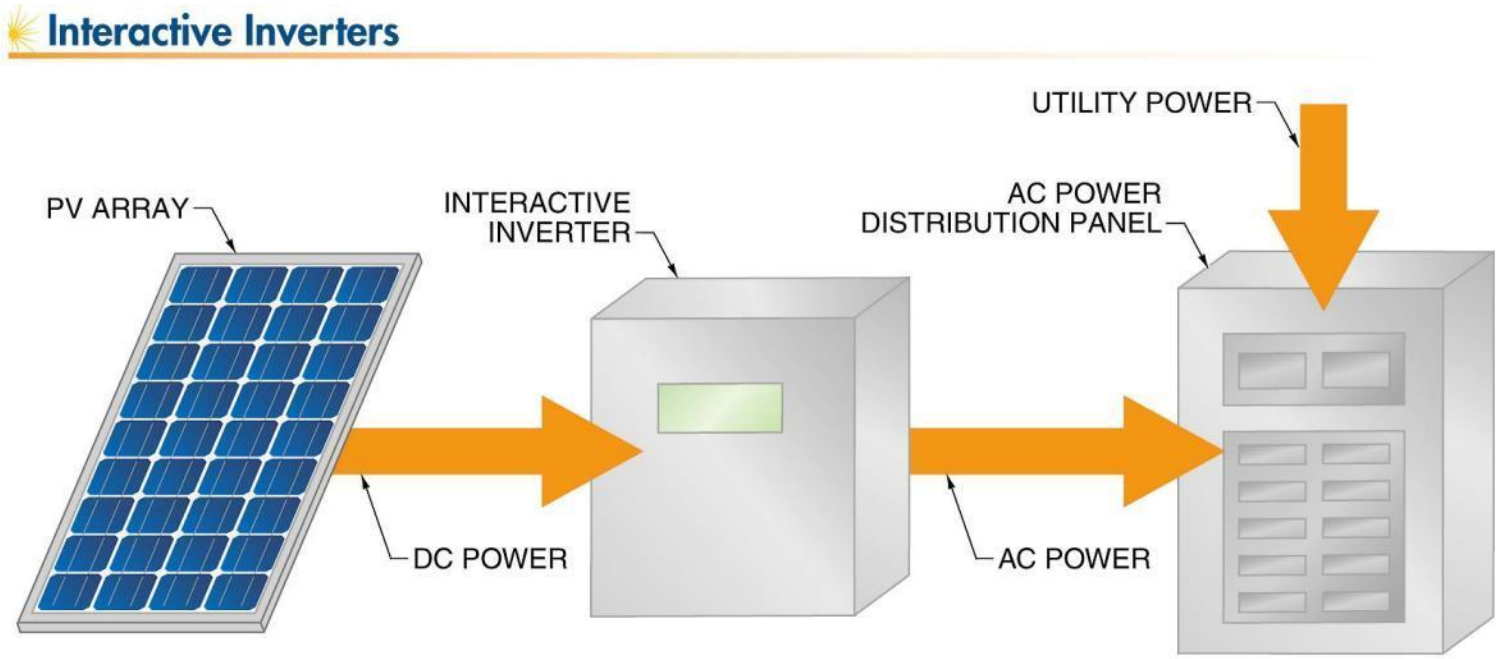
Fronius USA LLC

- Inverters are available in many different configurations and ratings.

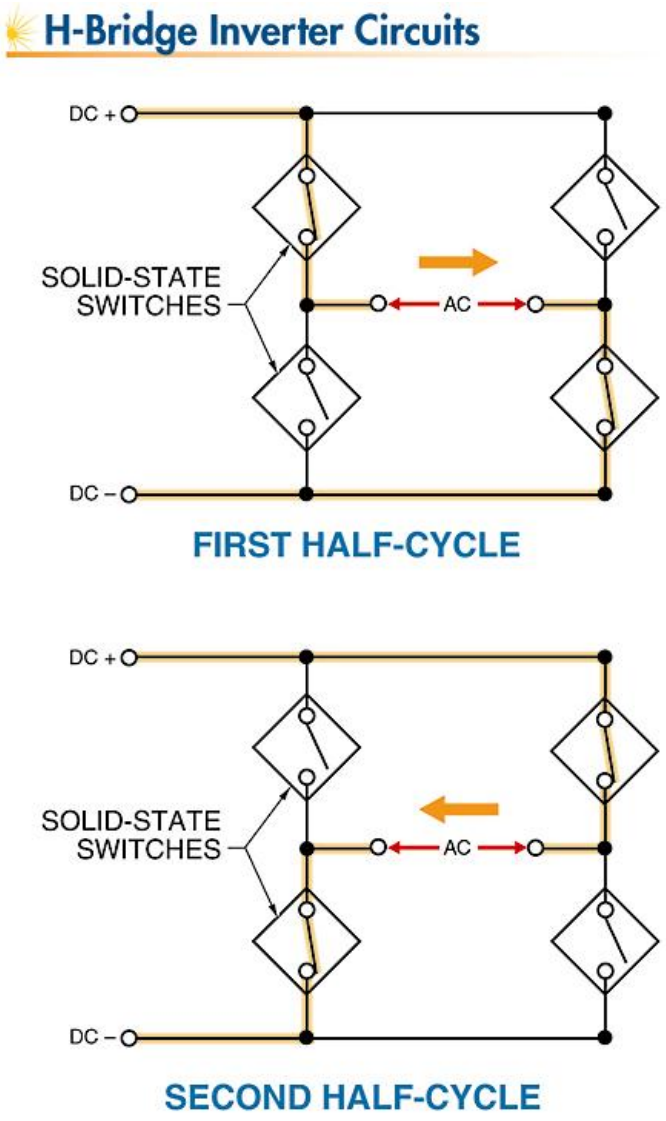
- Stand-alone inverters are connected to the battery bank.



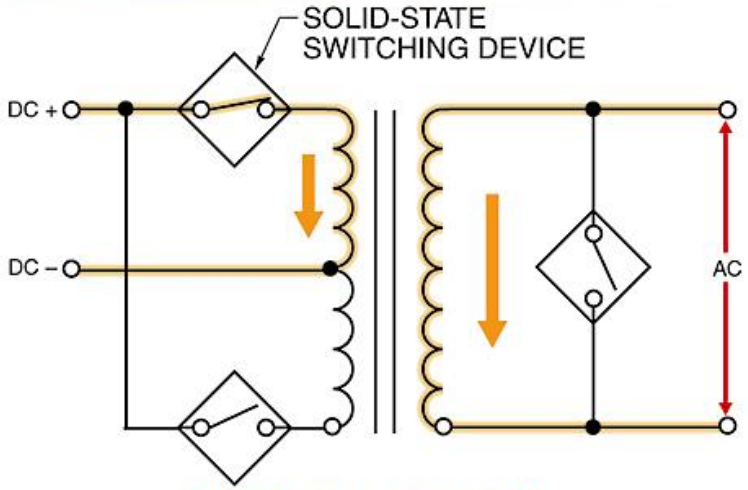
- Interactive inverters are connected to the PV array.



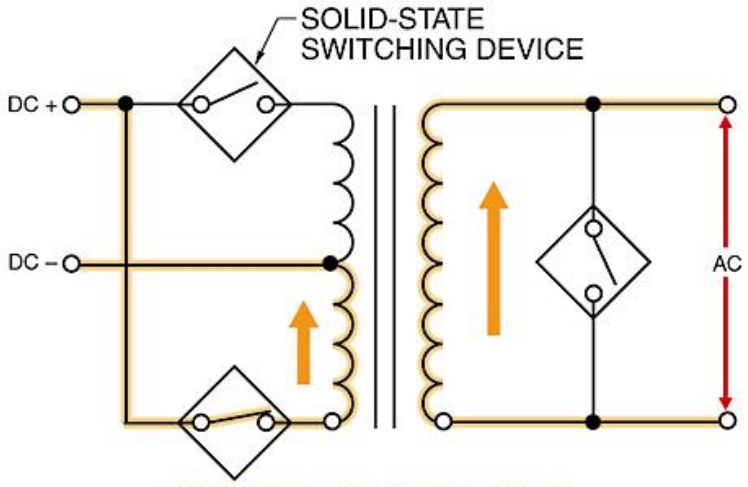
- H-bridge inverter circuits use two pairs of switching devices to direct a DC input to the output in both directions.



Push-Pull Inverter Circuits



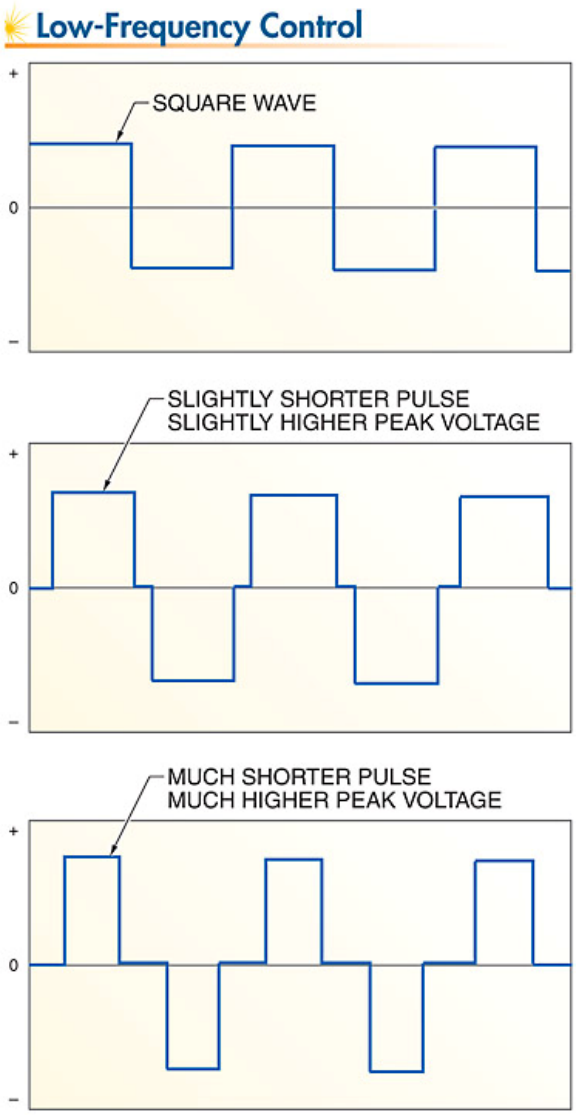
FIRST HALF-CYCLE



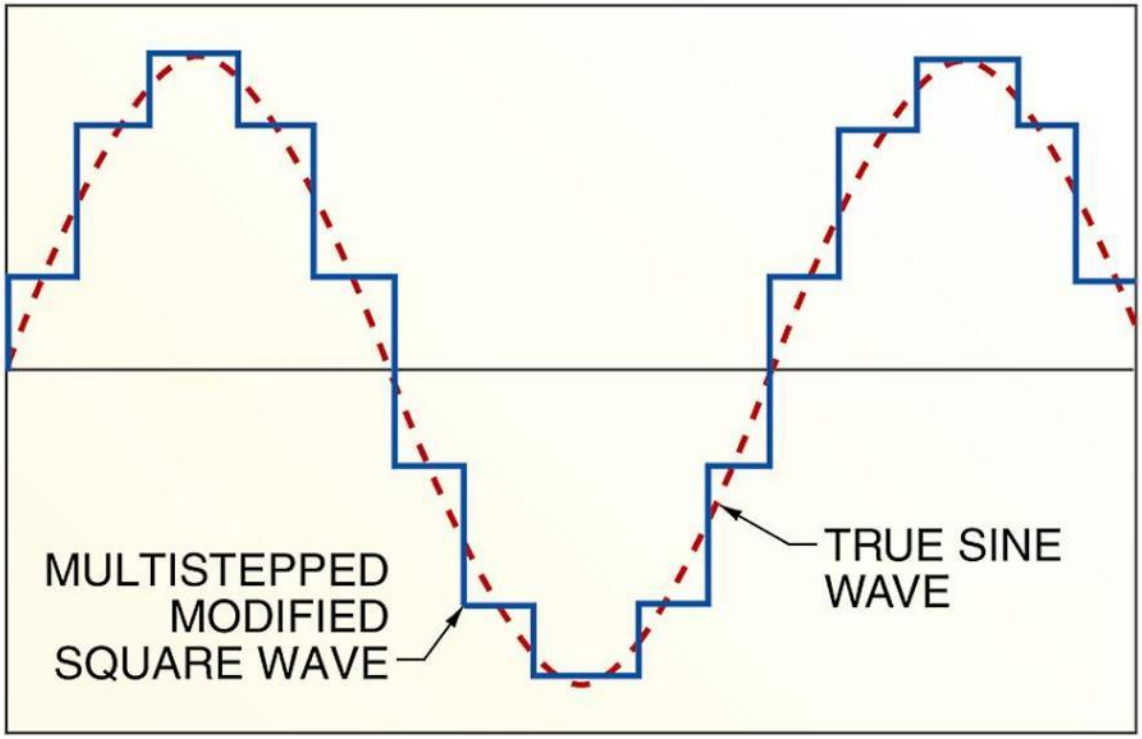
SECOND HALF-CYCLE

- Push-pull inverter circuits use one pair of switching devices and a transformer to alternate the direction of direct current.

- Square waves can be modified by adjusting the duration and magnitude of the pulses.

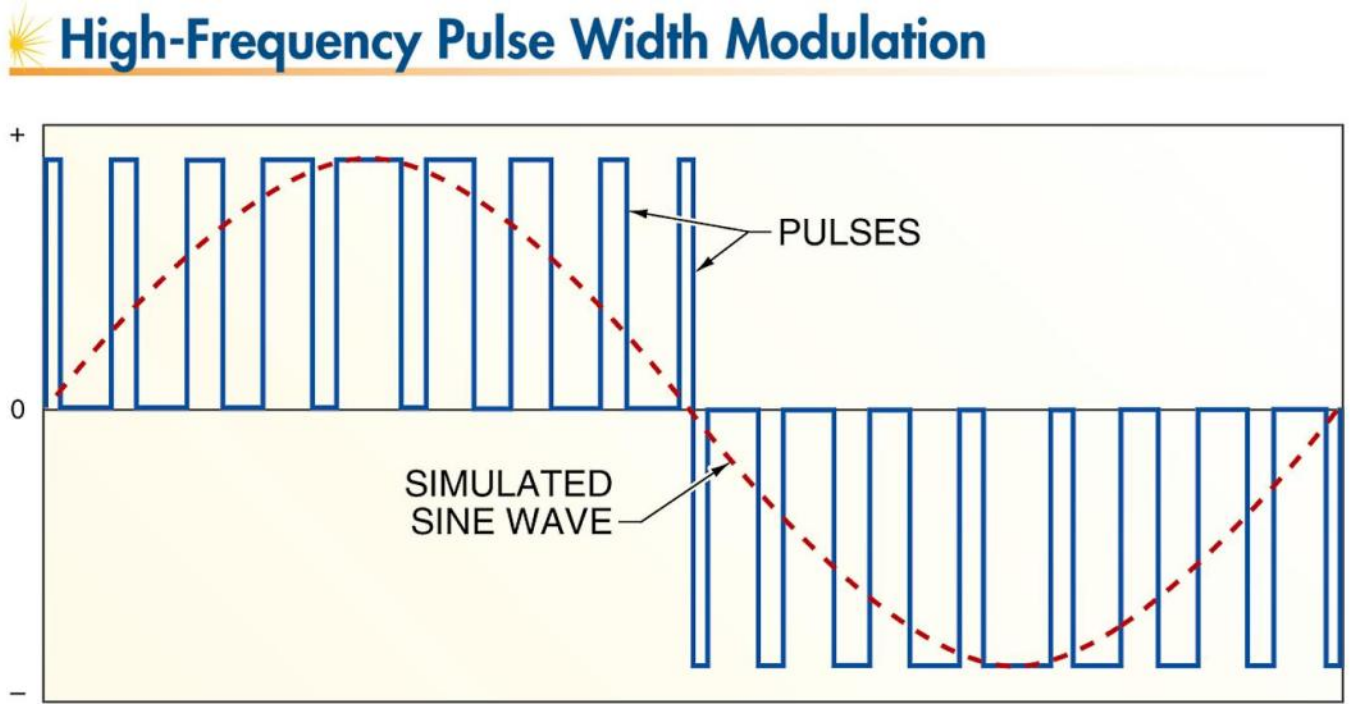


Multistepped Modified Square Waves



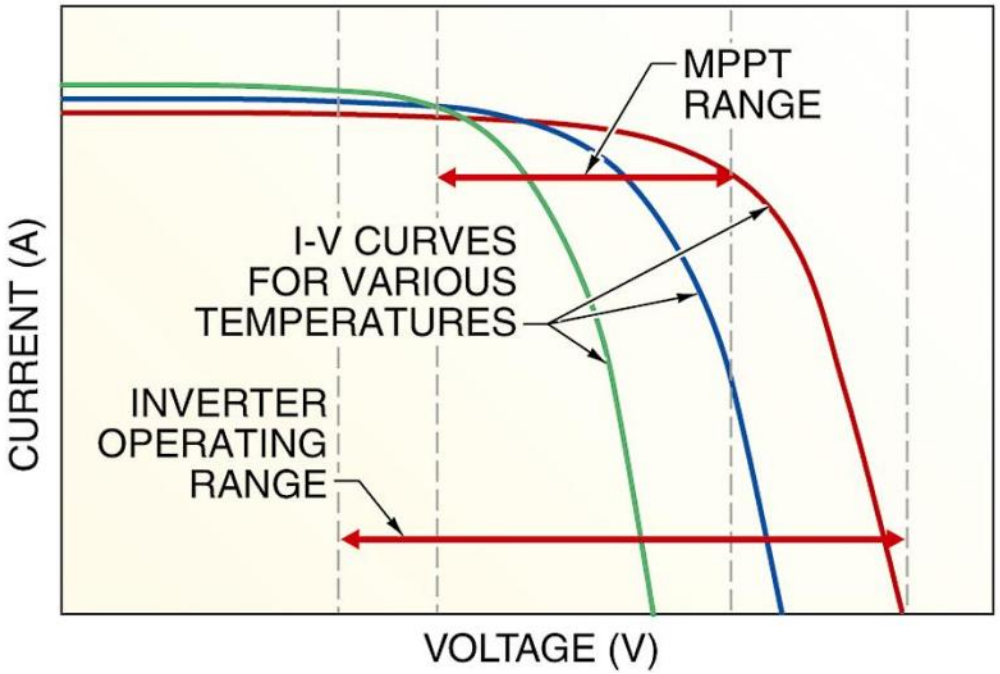
- Combining multiple modified square waves with different magnitudes and durations results in a multistepped modified square wave that more closely approximates a sine wave.

- Pulse-width modulation at high frequencies generates the truest approximation of a sine wave.

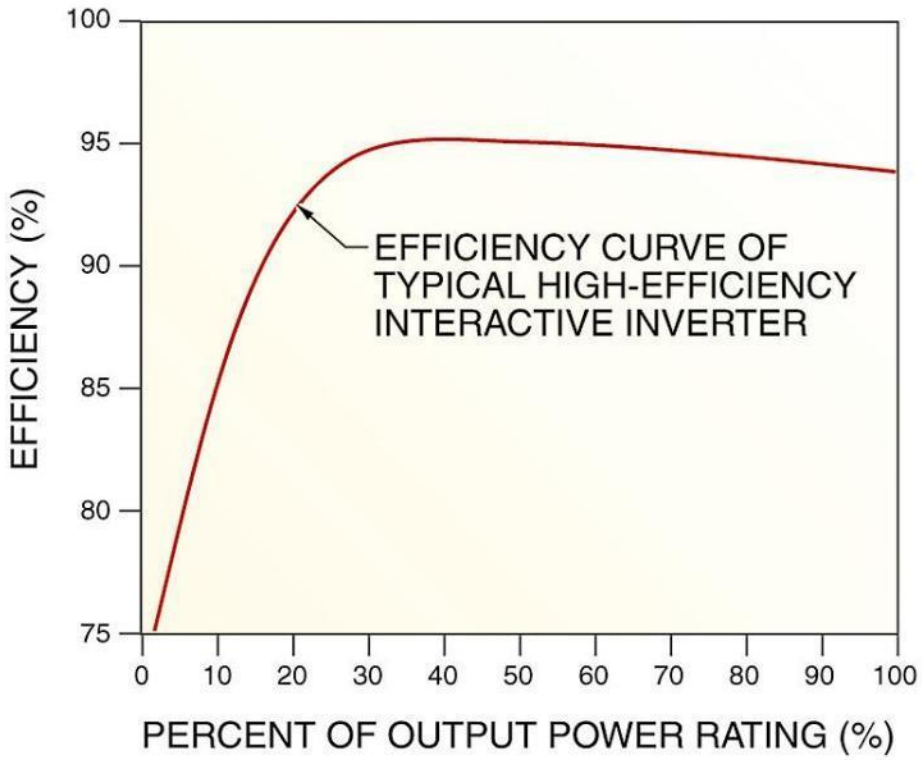


- Most inverters operate from a relatively wide range of input voltages, but the range for MPPT operation is smaller.

DC Input Voltage Ranges

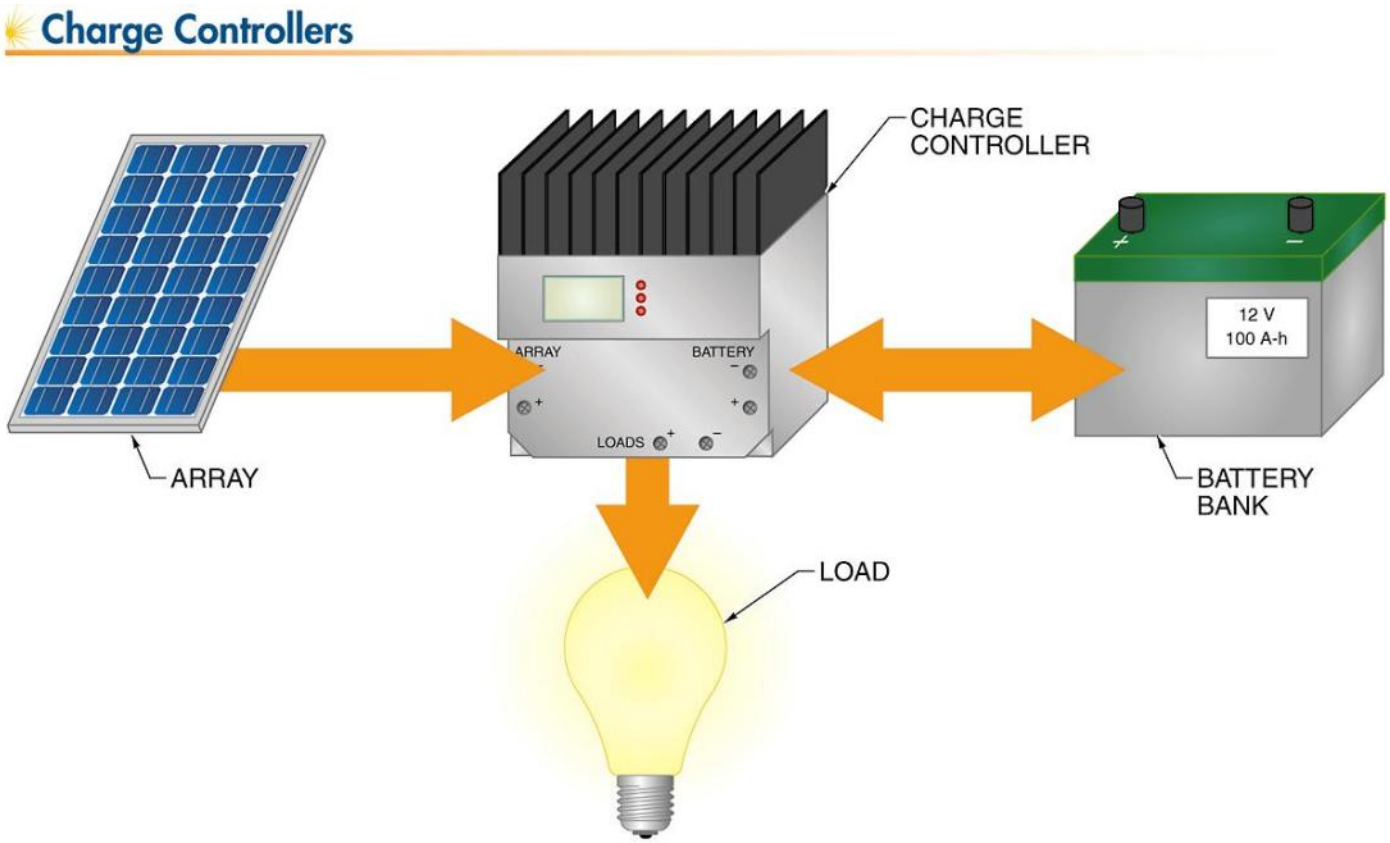


Inverter Efficiencies

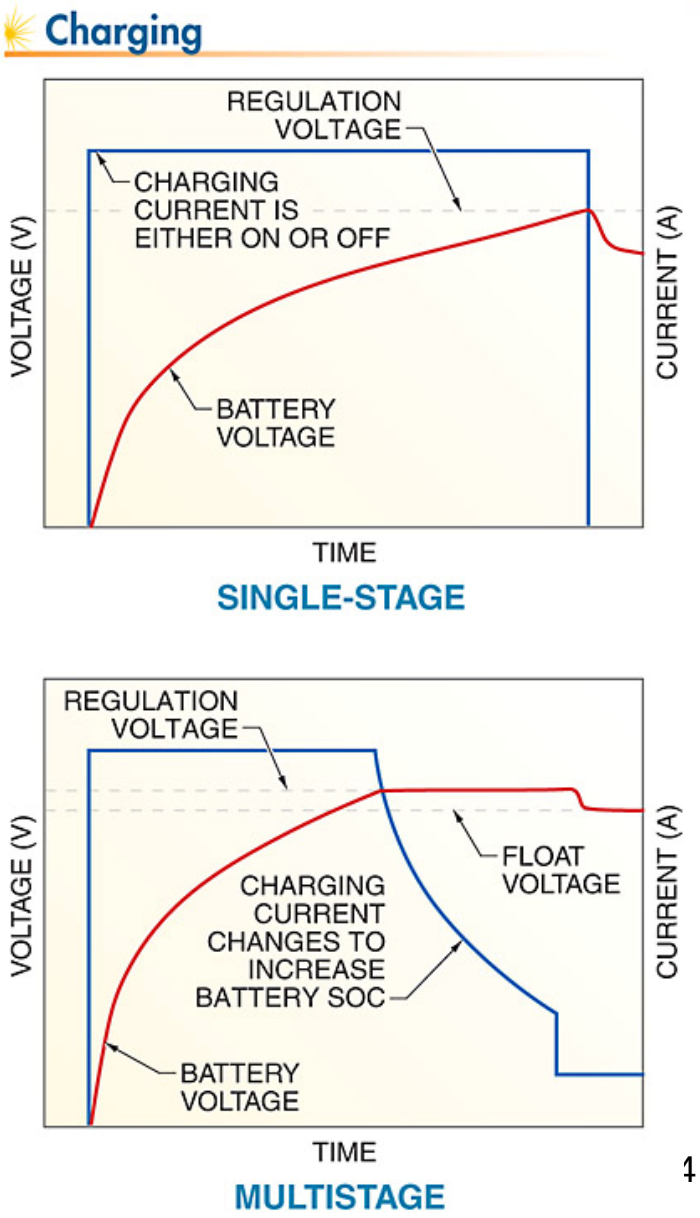


- Most sine wave inverters maintain high efficiency over a wide operating-power range.

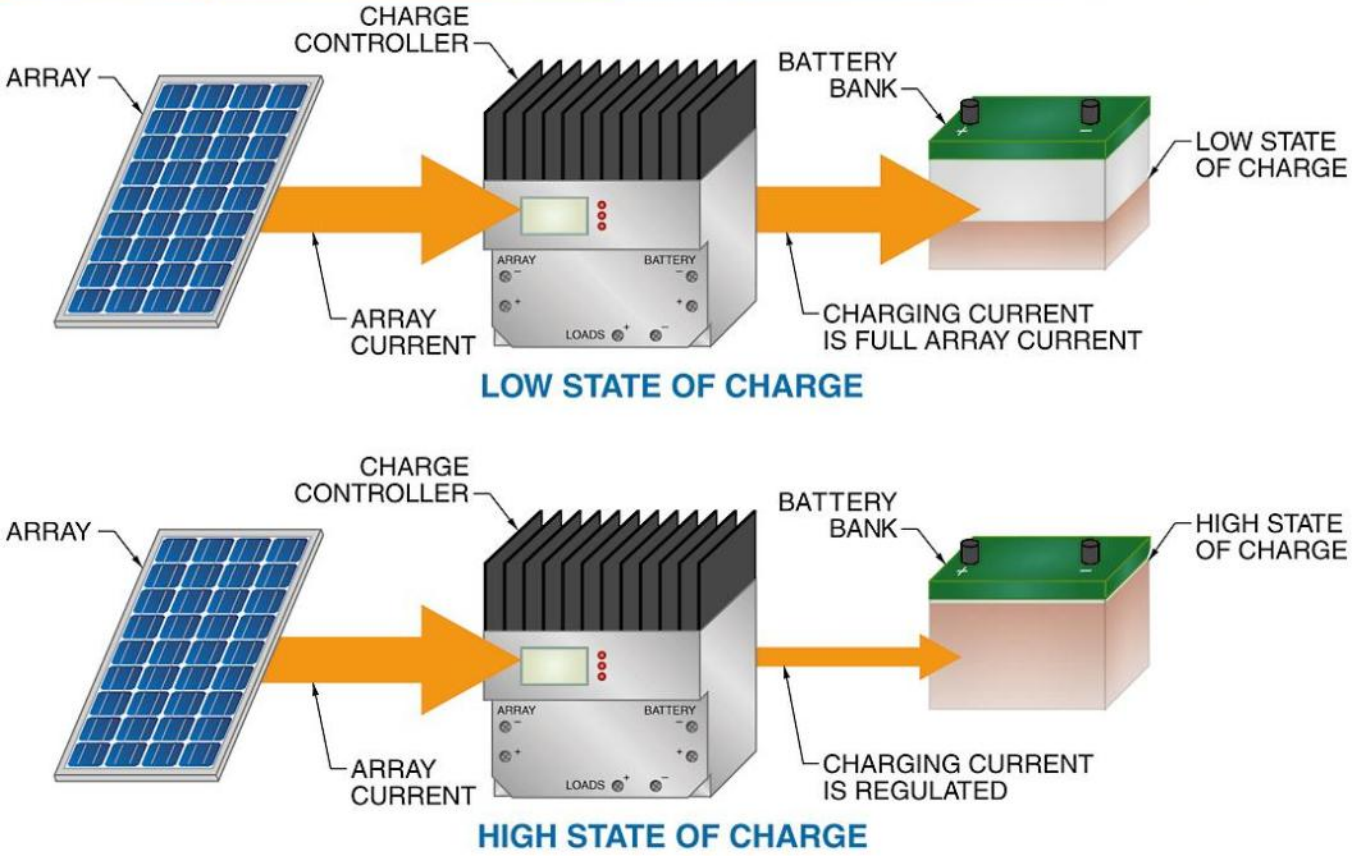
- Charge controllers manage interactions and energy flows between a PV array, battery, and electrical load.



- Single-stage battery charging is simpler to manage, but multistage battery charging brings batteries to a higher state of charge.

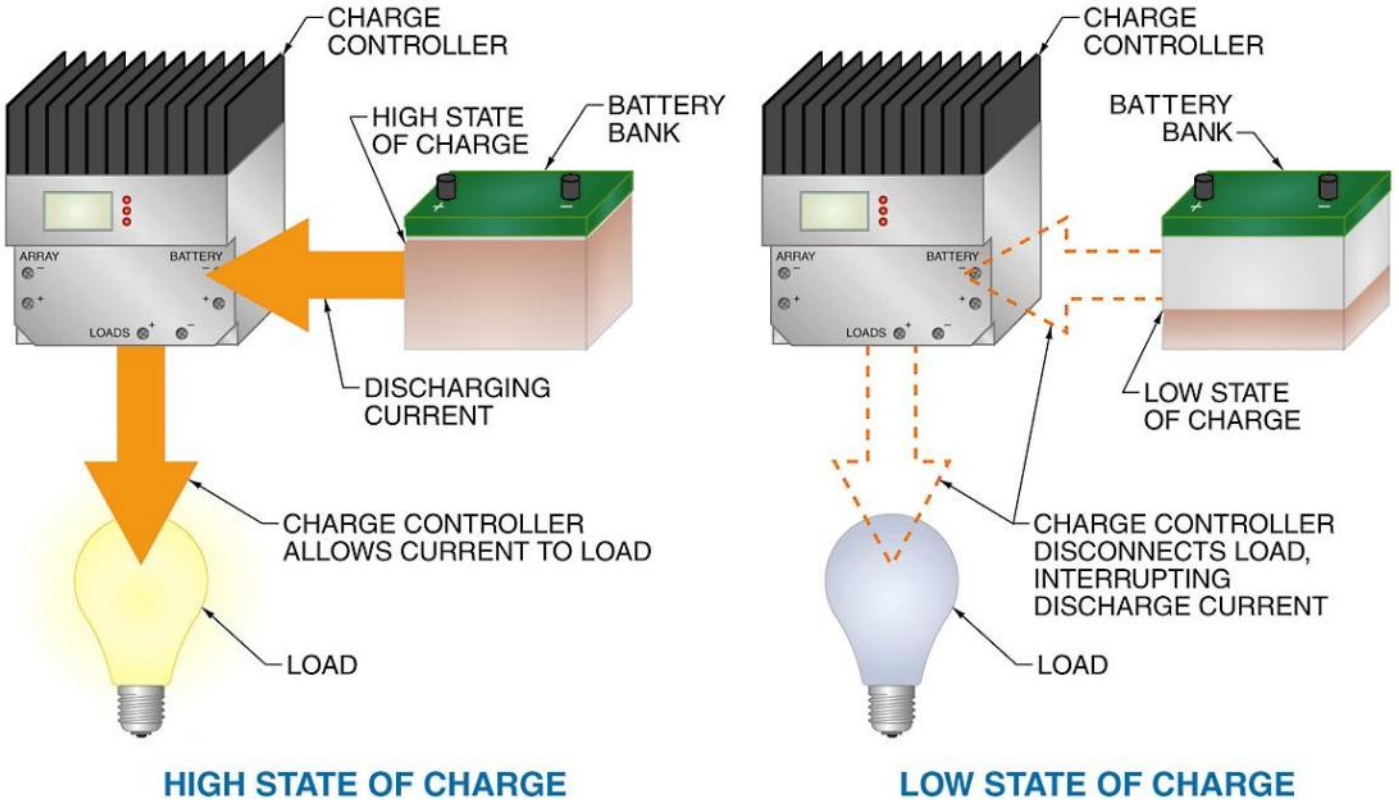


Overcharge Protection



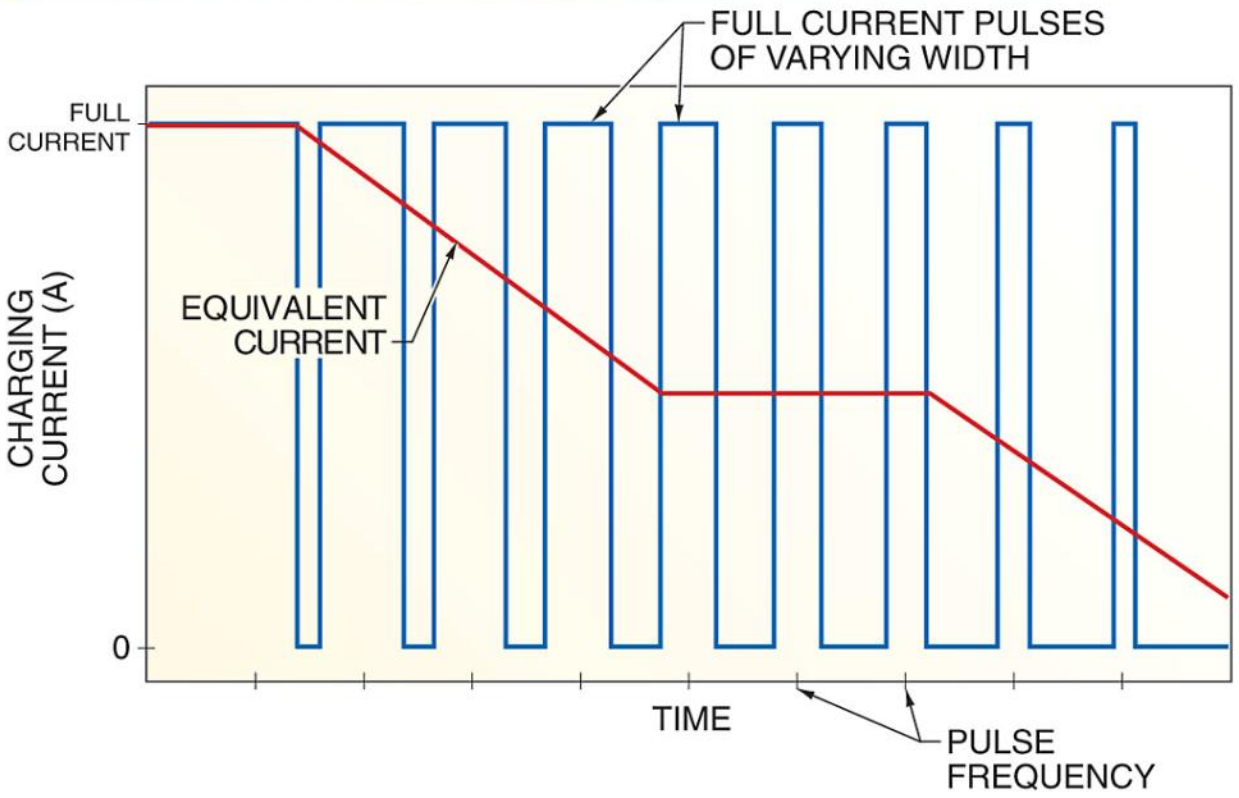
- Charge controllers protect batteries from overcharge by terminating or limiting charging current.

Overdischarge Protection



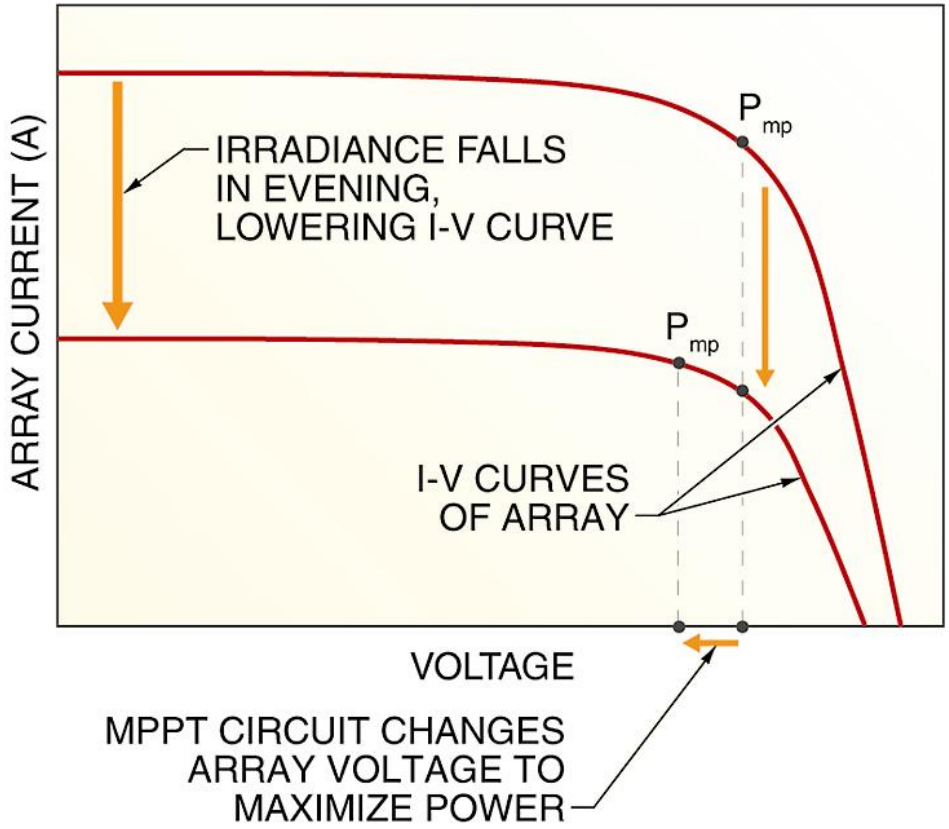
- Charge controllers protect batteries from overdischarge by controlling discharging current.

Pulse-Width Modulation



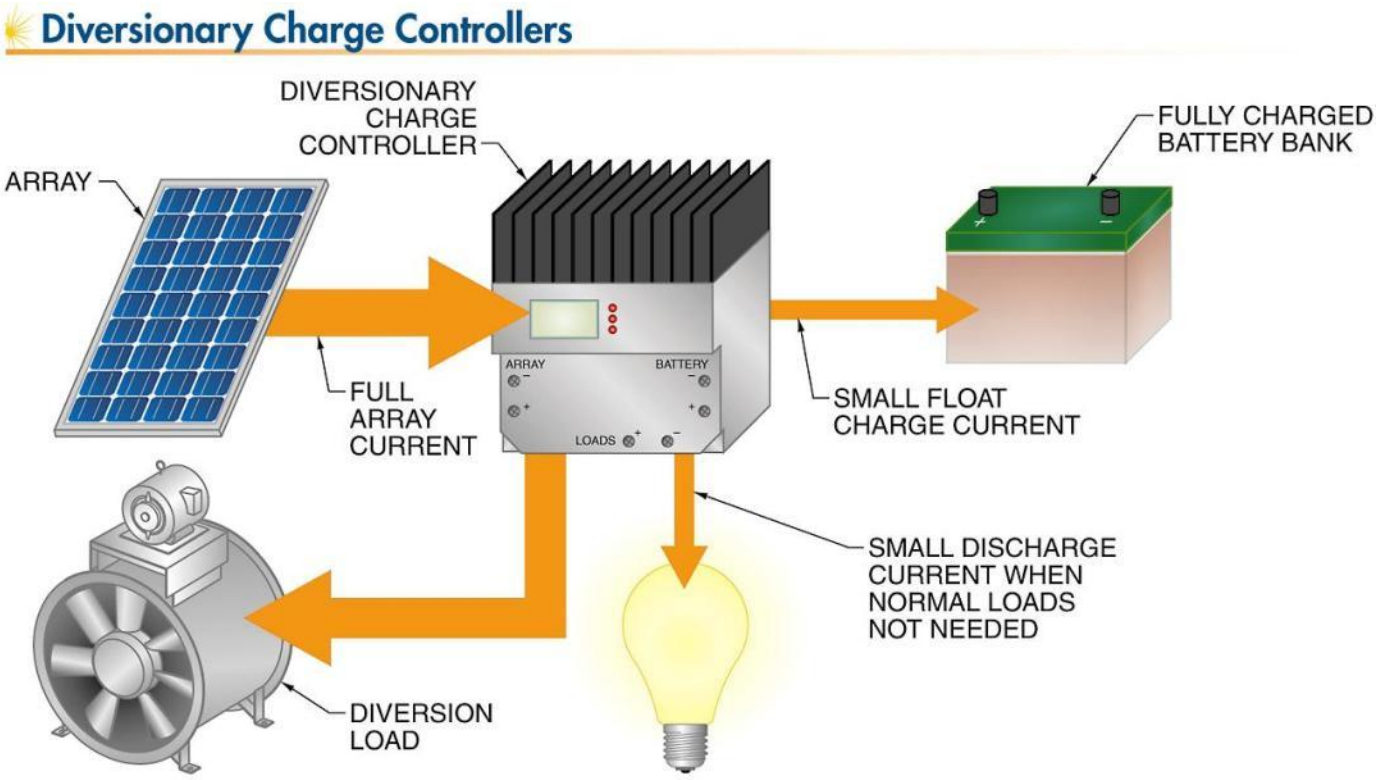
- Pulse-width modulation (PWM) simulates a lower current level by pulsing a higher current level ON and OFF for short intervals.

Maximum Power Point Tracking

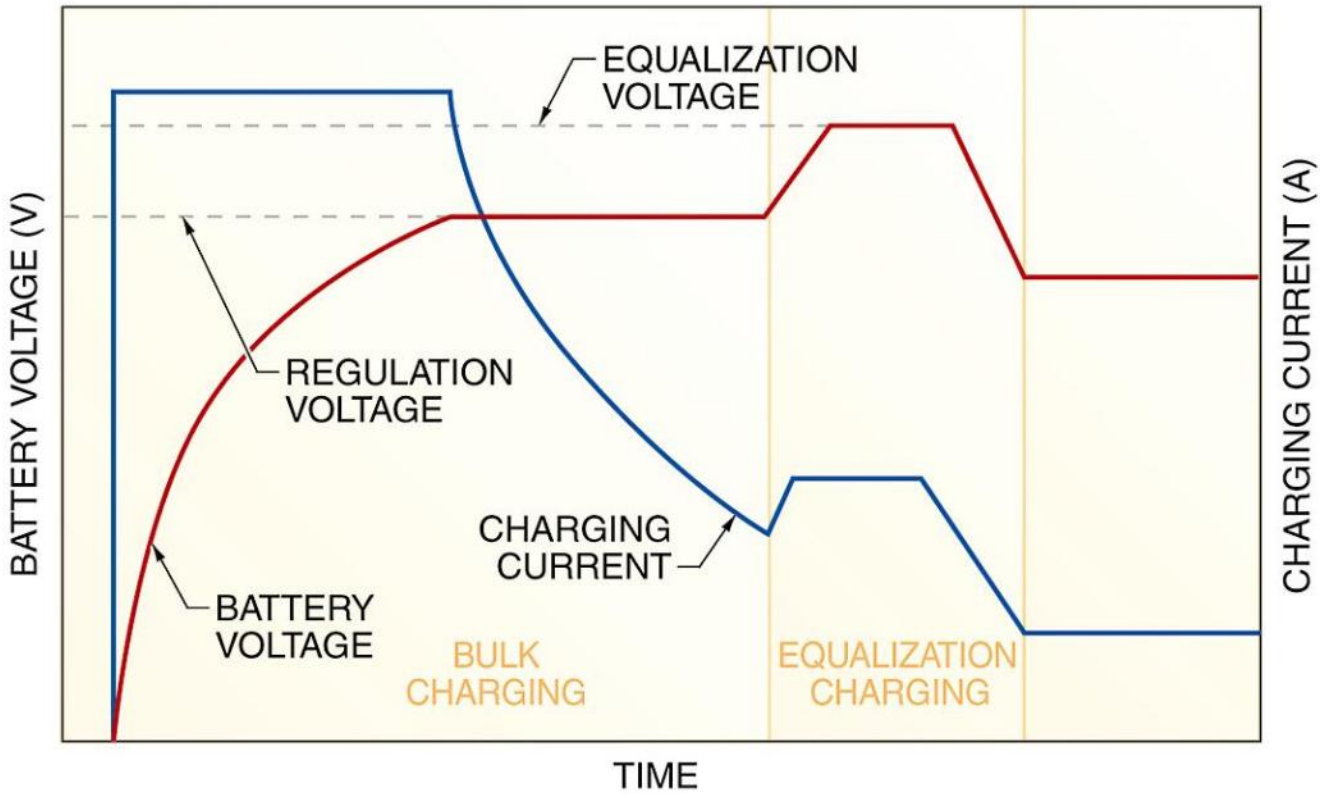


- Maximum power point tracking manipulates the load or output voltage of an array in order to maintain operation at or near the maximum power point under changing temperature and irradiance conditions.

- Diversionary charge controllers regulate charging current by diverting excess power to an auxiliary load when batteries are fully charged.



Equalization Charge



- The equalization setpoint brings the battery voltage to a level that is higher than the normal charge regulation voltage.

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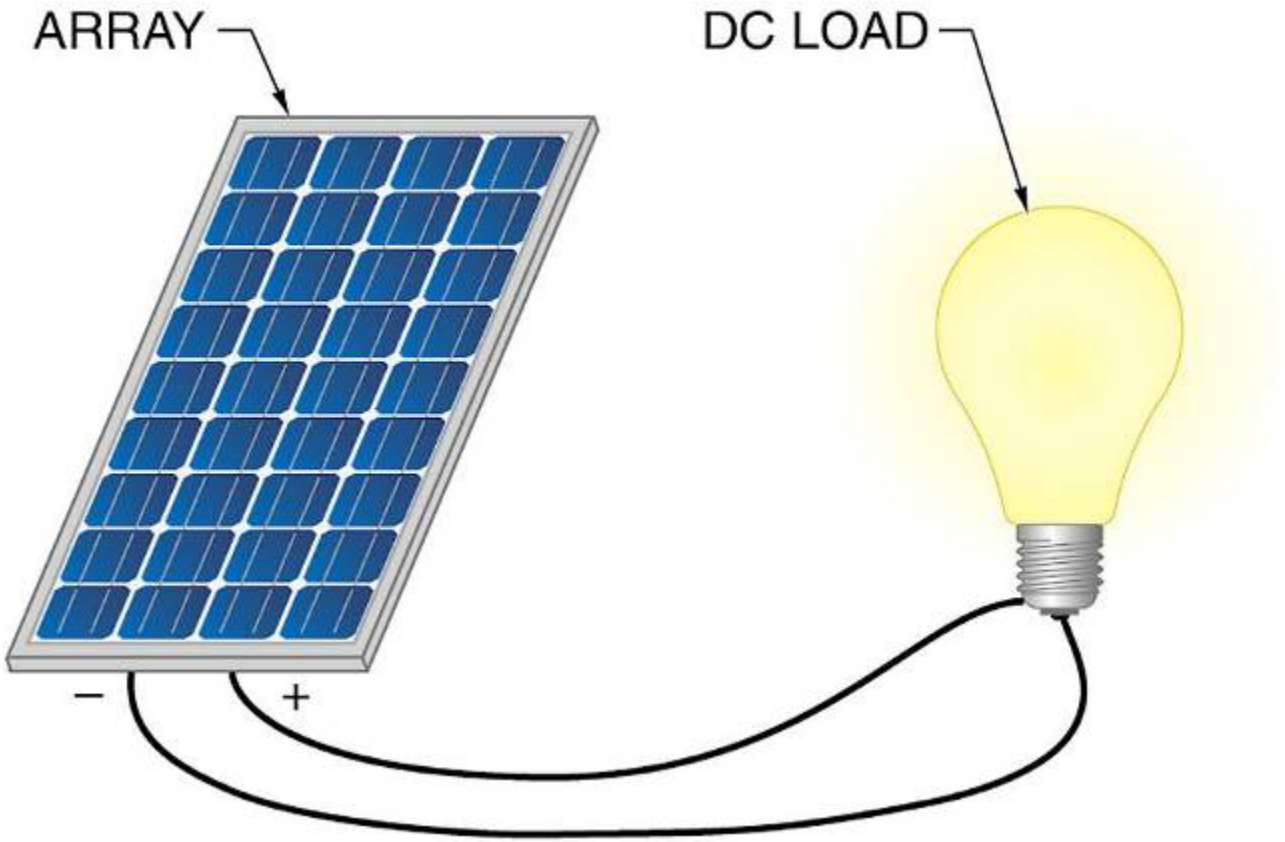
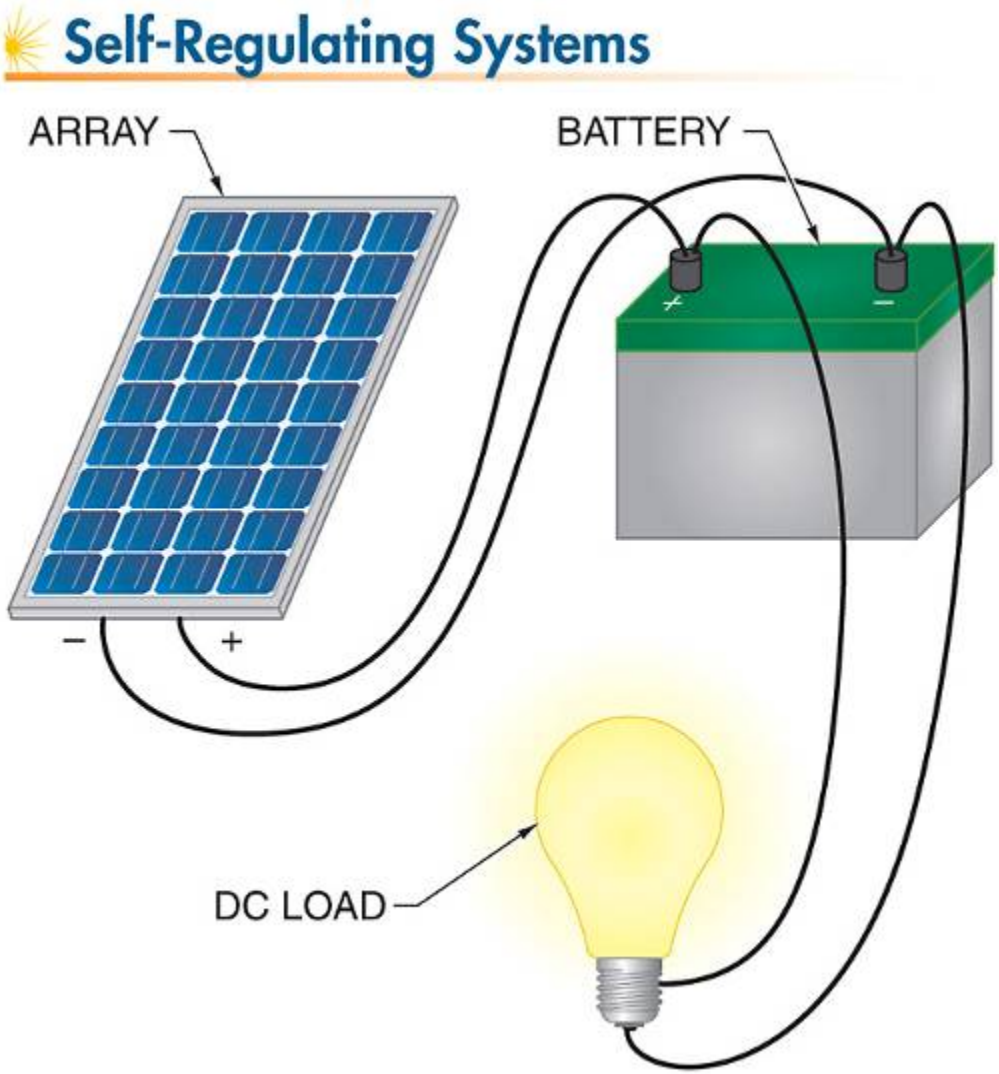
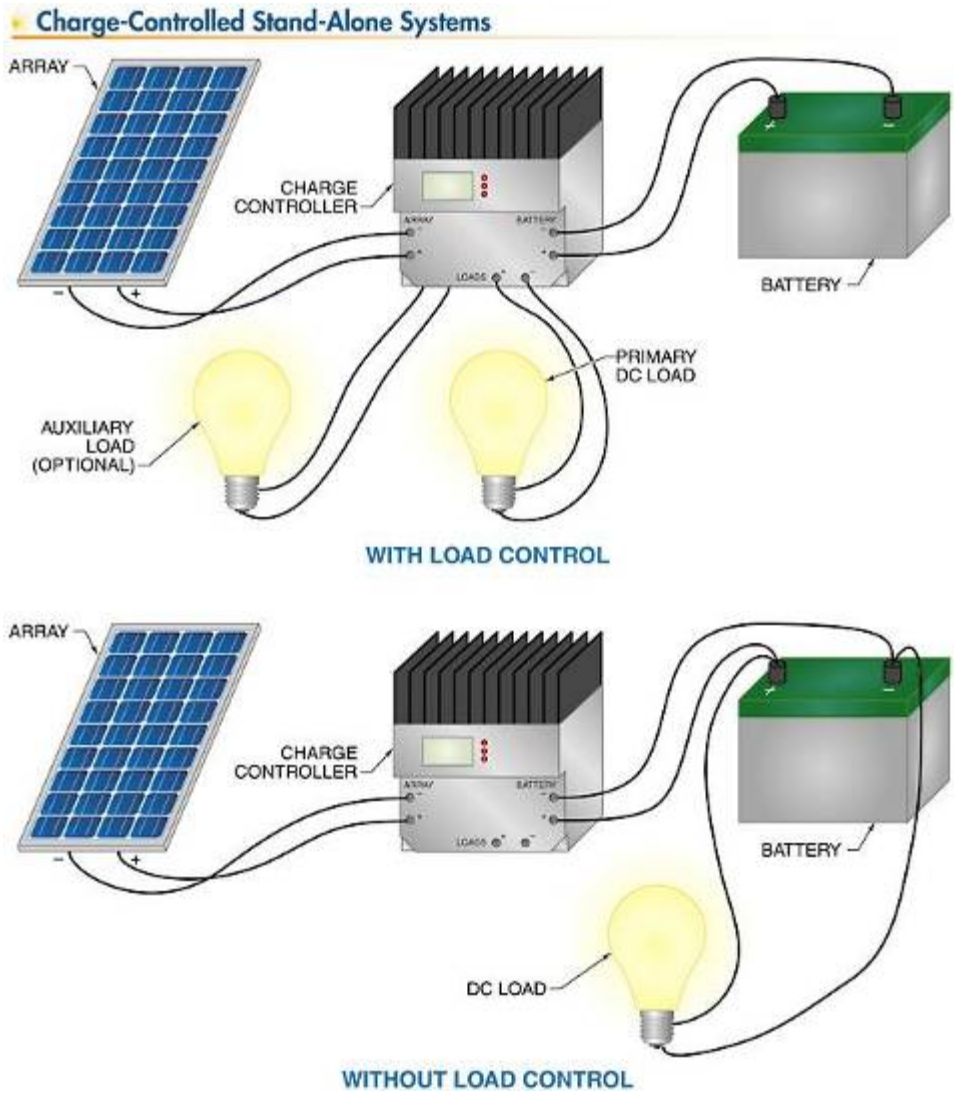
Direct-Coupled Systems



- The simplest type of PV system is the direct-coupled system, consisting of only an array and a DC load.

- Self-regulating systems avoid the complexity of adding charge control components by precisely sizing the battery and array.

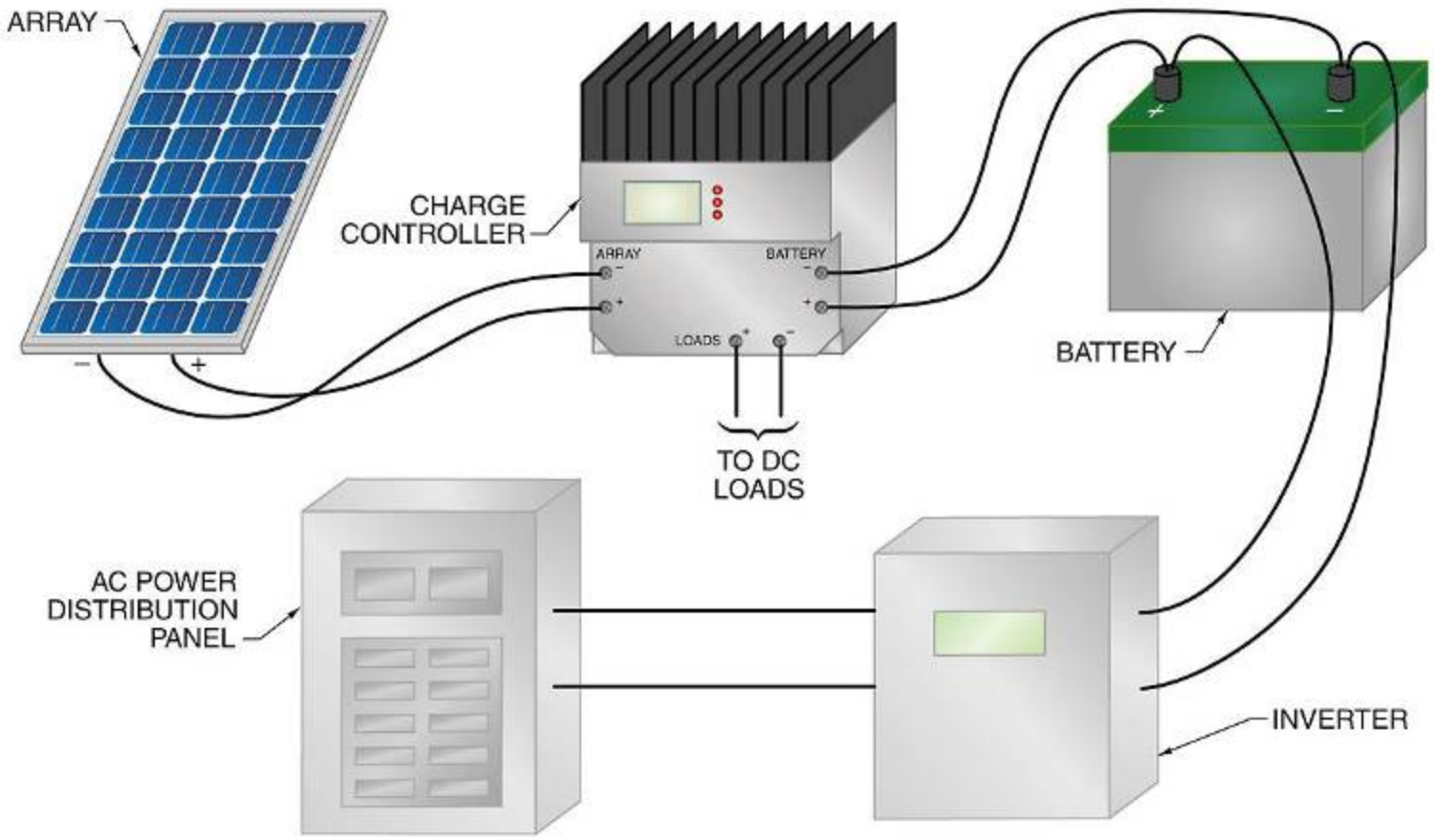




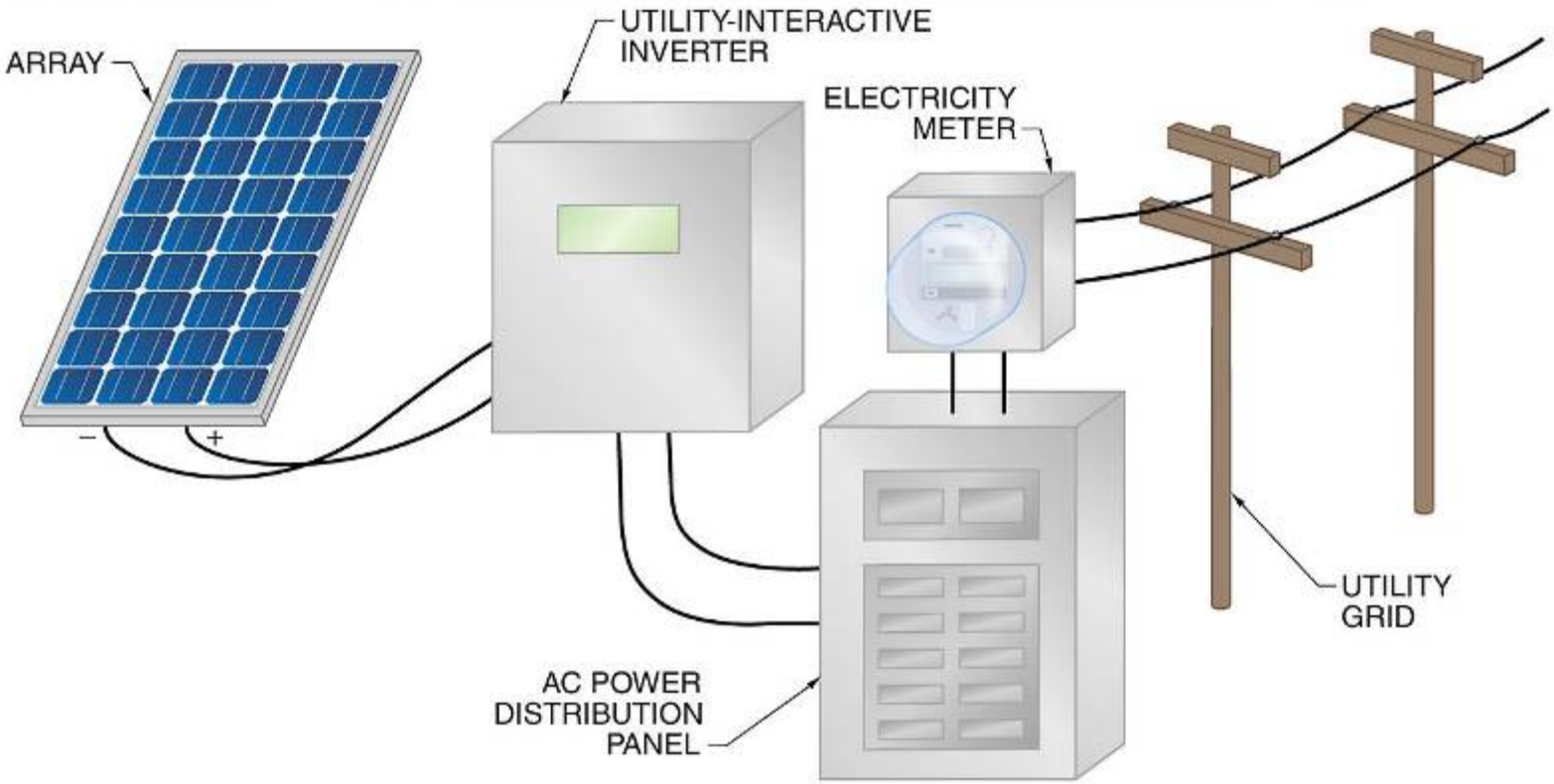
- Systems with charge control regulate the charging current into the battery. Regulation may involve disconnecting or dissipating the current inside the controller or diverting the excess current into an auxiliary load.

- Stand-alone systems for AC loads must include an inverter, which draws DC power from the battery bank and changes it to AC power for distribution.

Stand-Alone Systems for AC Loads

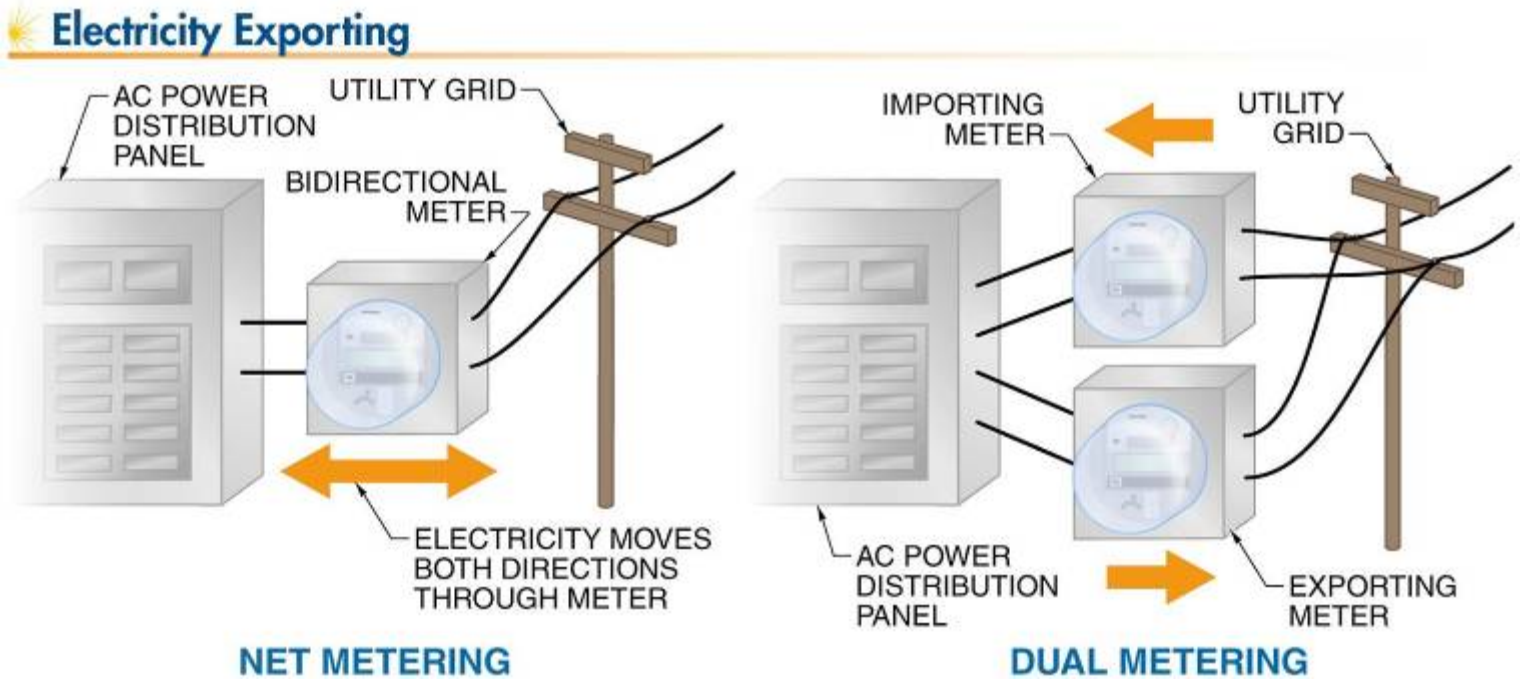


Utility-Interactive Systems

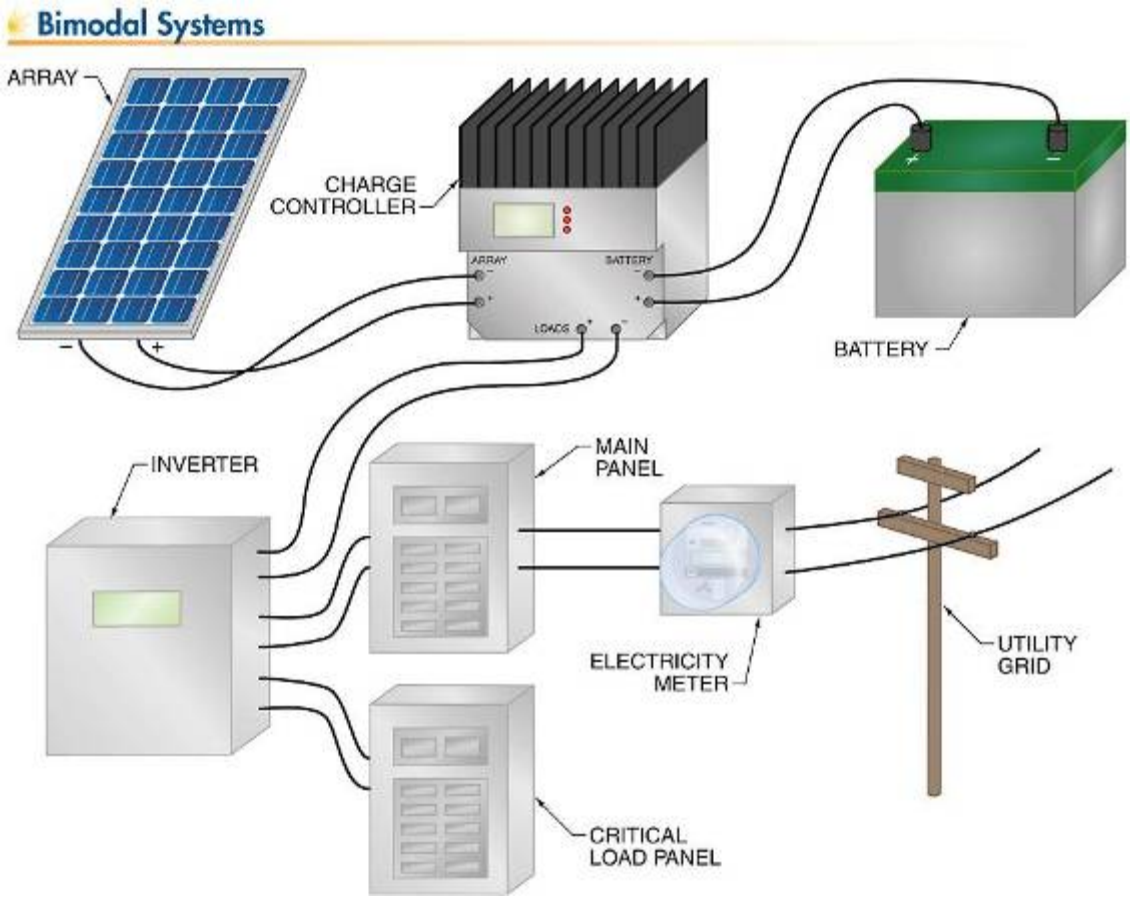


- A utility-interactive system is controlled by the inverter, which adds AC power converted from DC power to the utility grid power at the main AC power distribution panel.

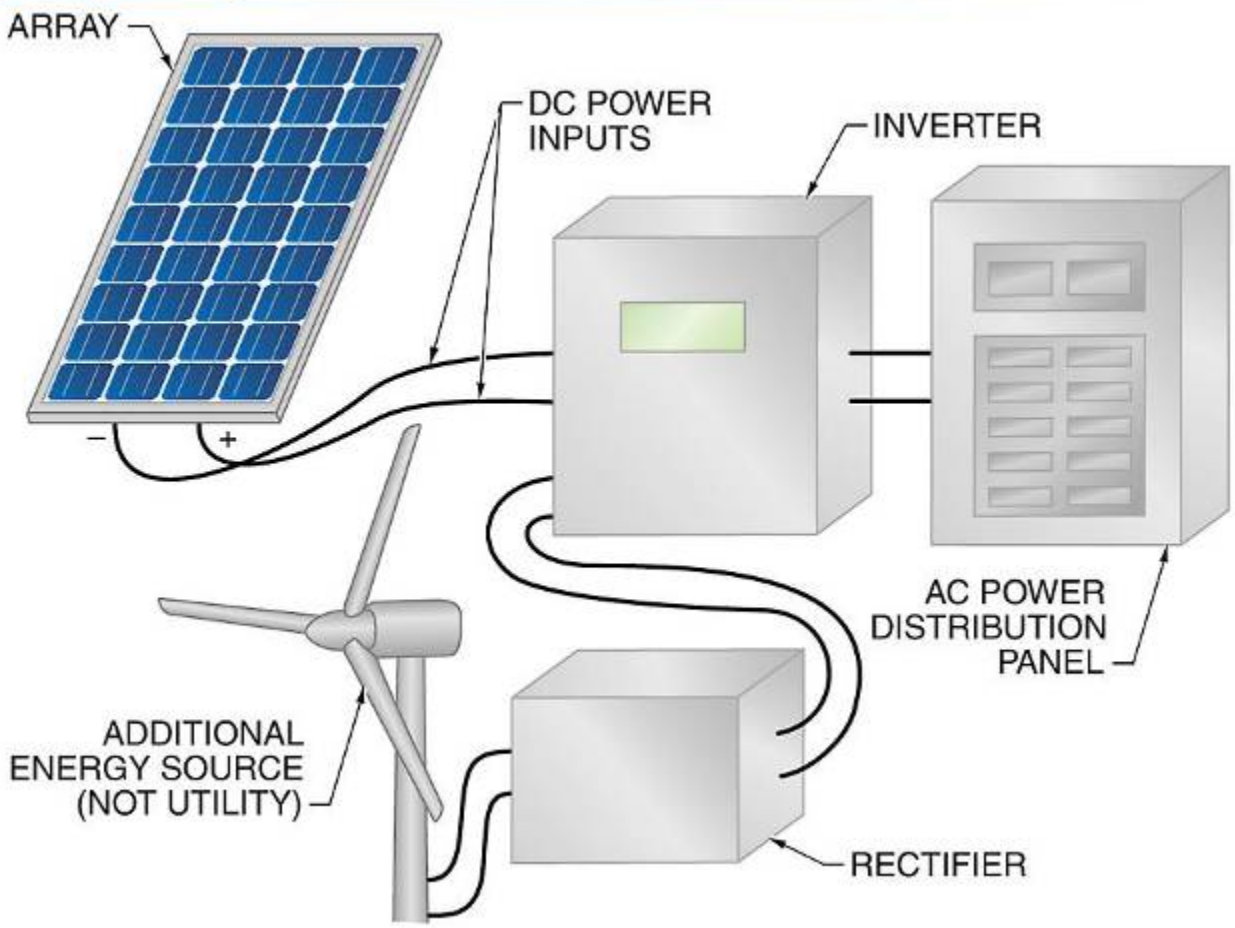
- Utility-interactive systems have either net-metering or dual-metering arrangements for exporting electricity to the utility grid.



- Bimodal systems can act like either a utility-interactive or a stand-alone system.



Hybrid Systems



- Hybrid systems include power sources other than the PV array and do not interact with the utility grid.