samlexsolar
A Division of Samlex America Inc.

30 Amp Solar Charge Controller

SCC-30AB

Owner's Manual

Please read this manual before operating your charge controller.

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Please read these instructions before installing or operating the Charge Controller to prevent personal injury or damage to the Charge Controller.

General

Installation and wiring compliance

- Installation and wiring must comply with the local and National Electrical Codes and must be done by a certified electrician.

Preventing electrical shock

- The negative system conductor should be properly grounded. Grounding should comply with local codes.
- Disassembly / repair should be carried out by qualified personnel only.
- Disconnect all input and output side connections before working on any circuits associated with the Charge Controller. Turning the on/off control on the Charge Controller to off position may not entirely remove dangerous voltages.
- Be careful when touching bare terminals of capacitors. The capacitors may retain high lethal voltages even after the power has been removed. Discharge the capacitors before working on the circuits.

Installation environment

- The Charge Controller should be installed indoor only in a well ventilated, cool, dry environment
- Do not expose to moisture, rain, snow or liquids of any type.

Preventing fire and explosion hazards

- Working with the Charge Controller may produce arcs or sparks. Thus, the Charge Controller should not be used in areas where there are inflammable materials or gases requiring ignition protected equipment. These areas may include spaces containing gasoline powered machinery, fuel tanks, battery compartments.

Precautions when working with batteries

- Batteries contain very corrosive diluted sulphuric acid as electrolyte. Precautions should be taken to prevent contact with skin, eyes or clothing.
- Batteries generate hydrogen and oxygen during charging resulting in evolution of explosive gas mixture. Care should be taken to ventilate the battery area and follow the battery manufacturer's recommendations.
- Never smoke or allow a spark or flame near the batteries.

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SAFETY INSTRUCTIONS

- Use caution to reduce the risk of dropping a metal tool on the battery. It could spark or short circuit the battery or other electrical parts and could cause an explosion.
- Remove metal items like rings, bracelets and watches when working with batteries. The batteries can produce a short circuit current high enough to weld a ring or the like to metal and thus cause a severe burn.
- If you need to remove a battery, always remove the ground terminal from the battery first. Make sure that all the accessories are off so that you do not cause a spark.

Charge Controller related

- It is to be ensured that the input voltage fed to the Charge Controller does not exceed 50 VDC to prevent permanent damage to the Charge Controller. Ensure that the maximum Open Circuit Voltage Voc of the 12 V nominal Solar Panel / the Solar Array is less than 50 V. If two 12 V nominal Solar Panels are being used in series to make a 24 V nominal Solar Array, make sure that the maximum Open Circuit Voltage Voc of each of the 12 V Panels is less than 25 V.
- Do not exceed the maximum current rating of 30 A. The Short Circuit Current of the Solar Array should be less than 30 A
- Do not exceed a battery voltage of 24V (nominal) . Do not use a battery less than 12V.
- Charge only 12, or 24 volt Lead-Acid batteries when using the standard battery charging programs or Ni-Cd batteries when DIP Switch number 2~4 is in the ON position.
- DO NOT short circuit the PV array or load while connected to the controller. This will damage the controller.
- The controller should be protected from direct sunlight. Ensure adequate space for air flow around the controller’s face plate.
- Do not install in a sealed compartment with batteries.
- Never allow the solar array to be connected to the controller with the battery disconnected. This can be a dangerous condition with high open-circuit solar voltage present at the terminals.
- Use only copper wire with minimum 75°C insulation rating and between 10 AWG (5.2 mm^2) and 14 AWG (2.1 mm^2) gauge.
- The Negative system conductor should be properly grounded. Grounding should comply with local codes.

GENERAL DESCRIPTION OF PV / SOLAR SYSTEM

What is Photovoltaic (PV)?

The word 'photo-voltaic' is derived from two different words; the word 'photos', from the Greek, meaning light and the word 'voltaic' developed from the name of the Italian scientist, Volta, who studied electricity. This explains what a PV system does: it converts light energy from the sun into electrical energy.

What is in a Photovoltaic (PV) system?

Non Grid-tied PV / Solar System

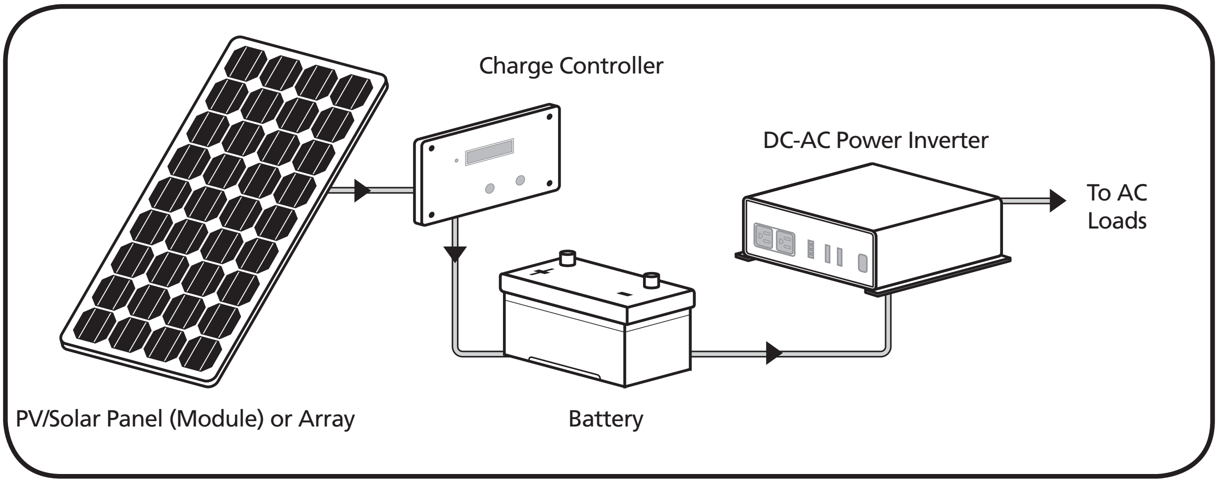

Fig. 2.1. Non Grid-tied PV System–Block Diagram

Fig. 2.1 shows a Block Diagram of a typical non-grid tied Photovoltaic (PV) System with its main components. It consists of a PV / Solar Panel (Module), Charge Controller, Batteries and Power Inverter. The PV / Solar Panel (Module) or Array converts the solar light energy into DC electrical energy. The Charge Controller conditions the DC electrical voltage and current produced by the PV / Solar Panel (Module) or Array to charge a battery. The battery stores the DC electrical energy so that it can be used when there is no solar energy available (night time, cloudy days etc). DC loads can be powered directly from the PV / Solar Panel (Module) / Battery. The inverter converts the DC power produced by the PV / Solar Panel (Module) / stored in the battery into AC power to enable powering of AC loads.

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GENERAL DESCRIPTION OF PV / SOLAR SYSTEM

Grid-tied PV / Solar System

Fig. 2.2 shows a Block Diagram of a typical Grid-tied PV / Solar System. In this system, the Solar Panels (Modules) / Arrays directly feed to an inverter and the inverter is connected to an Electricity Transmission and Distribution System (referred to as the Electricity Grid) such that the system can draw on the Grid's reserve capacity in times of need, and feed electricity back into the Grid during times of excess production.

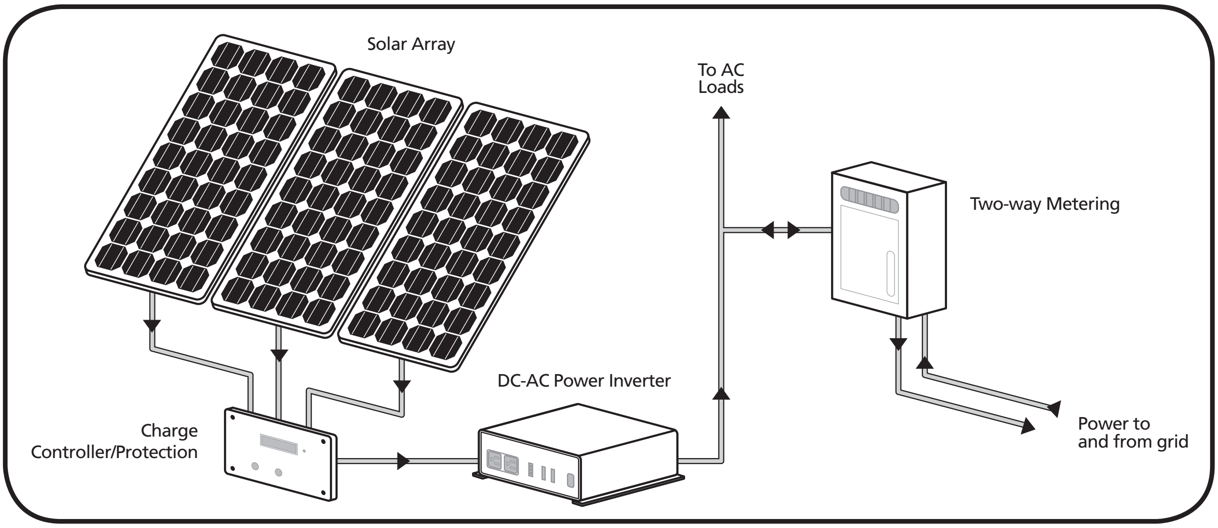

Fig. 2.2 Grid-tied PV / Solar System – Block Diagram

In order to safely transmit electricity to your loads and to comply with your power provider's grid-connection requirements, you may need the following additional items:

- Power conditioning equipment
- Safety equipment
- Meters and instrumentation.

PV / Solar Cell

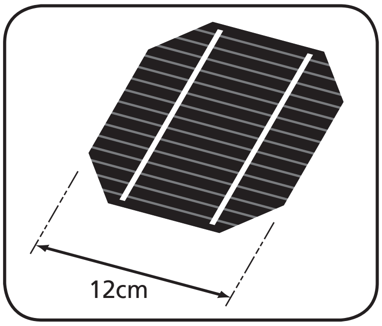

Fig. 2.3. PV / Solar Cell

The basic element of a PV System is the photovoltaic (PV) cell, also called a Solar Cell. An example of a PV / Solar Cell made of Mono-crystalline Silicon is shown in Fig. 2.3. This single PV / Solar Cell is like a square but with its four corners missing (it is made this way!).

Theory of Operation of PV / Solar Cell

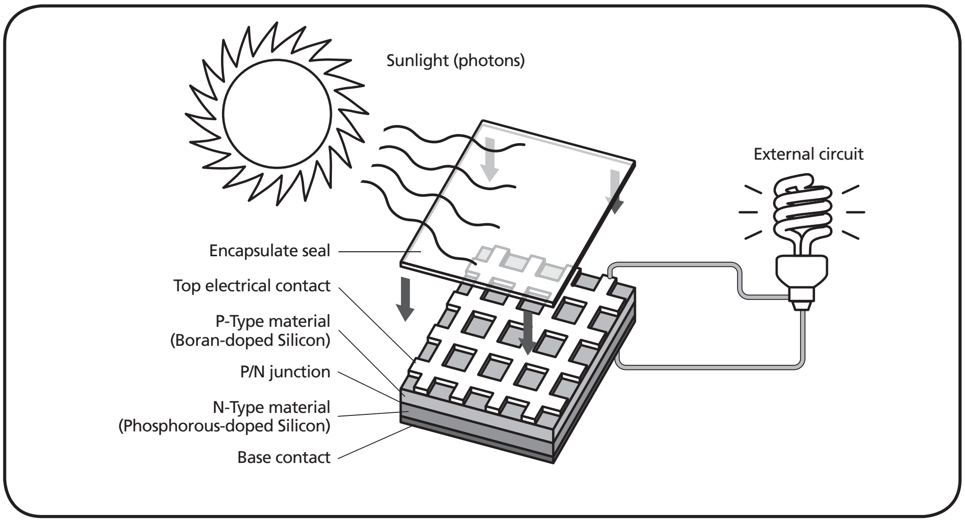

Figure 2.4: Construction and Working of PV / Solar Cell

A PV / Solar Cell is a semiconductor device that can convert solar energy into DC electricity through the "Photovoltaic Effect" (Conversion of solar light energy into electrical energy). When light shines on a PV / Solar Cell, it may be reflected, absorbed, or passes right through. But only the absorbed light generates electricity.

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GENERAL DESCRIPTION OF PV / SOLAR SYSTEM

When light enters the PV / Solar Cell, some of the “Photons” (packets of electro-magnetic wave energy) from the light energy are absorbed by the semiconductor atoms. The energy of the absorbed light is transferred to the negatively charged electrons in the atoms of the solar cell. With their newfound energy, these electrons escape from their normal positions in the atoms of the semiconductor photovoltaic material and become part of the electrical flow, or current, in an electrical circuit. A special electrical property of the PV / Solar Cell – a built-in electric field – provides the force, or voltage, needed to drive the current through an external load, such as a light bulb.

To induce the built-in electric field within a PV / Solar Cell, two layers of somewhat differing semiconductor materials are placed in contact with one another (See Fig. 2.4). One layer is an N-type semiconductor (e.g. Phosphorus doped Silicon) with an abundance of “Electrons”, which have a Negative electrical charge. The other layer is a P-type semiconductor (e.g. Boron doped Silicon) with an abundance of” Holes”, which have a Positive electrical charge.

Although both materials are electrically neutral, N-type silicon has excess Electrons and P-type silicon has excess Holes. Sandwiching these together creates a P-N Junction at their interface, thereby creating an electric field.

When N-type and P-type silicon come into contact, excess electrons move from the N-type side to the P-type side. The result is a buildup of Positive charge along the N-type side of the interface and a buildup of Negative charge along the P-type side.

Because of the flow of electrons and holes, the two semiconductors behave like a battery, creating an electric field at the surface where they meet – the P/N Junction. The electrical field causes the electrons to move from the semiconductor toward the Negative surface, where they become available to the electrical circuit. At the same time, the Holes move in the opposite direction, toward the positive surface, where they await incoming electrons. The electrical current is fed to the external load through the top electrical contact surface (normally in the form of a grid) and the bottom base contact.

The Open Circuit Voltage $\mathbf{V_{oc}}$ of a PV /Solar Cell is just under 0.6 V

Factors Affecting Voltage and Current Output of the PV / Solar Cell

The amount of electric current generated by photon excitation in a PV / Solar Cell at a given temperature is affected by the incident light in two ways:

- By the intensity of the incident light.
- By the wavelength of the incident rays.

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GENERAL DESCRIPTION OF PV / SOLAR SYSTEM

The materials used in PV / Solar Cells have different spectral responses to incident light, and exhibit a varying sensitivity with respect to the absorption of photons at given wavelengths. Each semiconductor material will have an incident radiation threshold frequency, below which no electrons will be subjected to the photovoltaic effect. Above the threshold frequency, the kinetic energy of the emitted photoelectron varies according to the wavelength of the incident radiation, but has no relation to the light intensity. Increasing light intensity will proportionally increase the rate of photoelectron emission in the photovoltaic material. In actual applications, the light absorbed by a PV cell will be a combination of direct solar radiation, as well as diffused light bounced off of surrounding surfaces. PV / Solar Cells are usually coated with anti-reflective material so that they absorb the maximum amount of radiation possible.

The output current of the PV / Solar Panel (Module) can increase due to what is known as the **"Edge of the Cloud Effect"**. As the sun moves into a hole between the clouds, your solar panels will see full direct sunlight combined with reflected light from the clouds! They will absorb more energy than they could on a cloudless day! Thus, a factor of 1.25 times the Short Circuit Current Isc is recommended when sizing the current capacity of the Charge Controller

The output current of the PV / Solar Cell has a positive Temperature Coefficient – The output current increases with the rise of temperature. However, it is negligible – less than 0.1 % / °C of the Short Circuit Current **Isc**

The output voltage of the PV / Solar Cell has a Negative Temperature Coefficient – The output voltage increases with decrease in temperature. For example, a Silicon Cell has a Temperature Coefficient of – 2.3 mV / °C / Cell. Hence, during cold winter days, the voltage will rise. Hence, as a Thumb Rule, the voltage rating of the Charge Controller should be sized as 1.25 times the Open Circuit Voltage rating **Voc** of the PV / Solar Panel (Module) to ensure that the Charge Controller is not damaged due to over-voltage.

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GENERAL DESCRIPTION OF PV / SOLAR SYSTEM

PV Cell Types

PV cells are most commonly made of Silicon, and come in two varieties, crystalline and thin-film type, as detailed in Table 2.1

Cell types include Mono-crystalline Silicon, Poly-crystalline Silicon, Amorphous Silicon (a-Si), Gallium Arsenide (GaAs), Copper Indium Diselenide (CuInSe2, „CIS“), Cadmium Telluride, or a combination of two materials in a tandem cell.

	Bulk type / Wafer-based (Crystalline)			
	Mono Crystalline Si	Poly Crystalline Si		Poly Crystalline Band
Pros	High efficiency	High efficiency with respect to price		-
Cons	Increased manufacturing cost caused by the supply shortage of silicon			-
	Thin film type			
	Amorphous Si	CIGS	CdTe	Polymer organic
Pros	Low price	Low price Able to automate all manufacturing process		Low manufacturing Can be more efficient (still in research)
Cons	Low efficiency	Low efficiency		

Table 2.1 PV Cell Types

PV Module / Panel and PV Array

To increase their utility, a number of individual PV cells are interconnected together in a sealed, weatherproof package called a Panel (Module). For example, a 12 V Panel (Module) will have 36 cells connected in series and a 24 V Panel (Module) will have 72 PV Cells connected in series

To achieve the desired voltage and current, Modules are wired in series and parallel into what is called a PV Array. The flexibility of the modular PV system allows designers to create solar power systems that can meet a wide variety of electrical needs. Fig. 2.5 shows PV cell, Panel (Module) and Array.

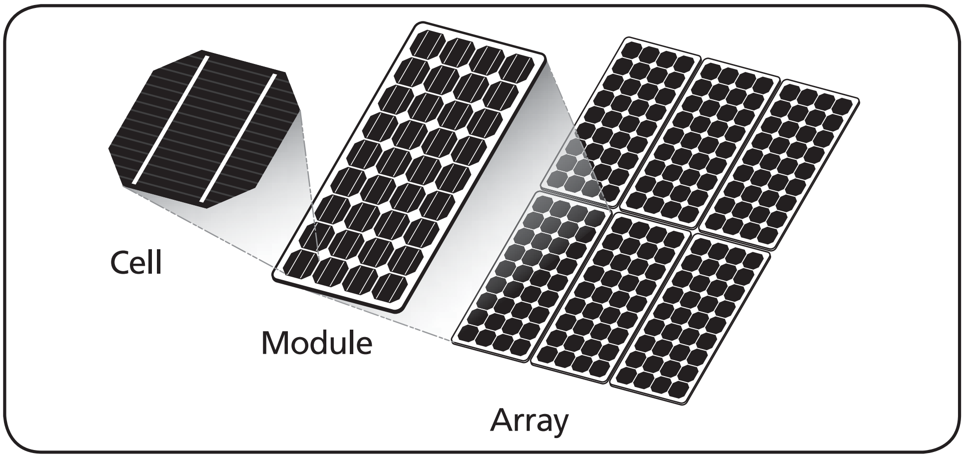

Figure 2.5. PV cell, Module and Array

The cells are very thin and fragile so they are sandwiched between a transparent front sheet, usually glass, and a backing sheet, usually glass or a type of tough plastic. This protects them from breakage and from the weather. An aluminum frame is fitted around the module to enable easy fixing to a support structure.

The picture in Fig. 2.6 shows a small part of a Module with cells in it. It has a glass front, a backing plate and a frame around it.

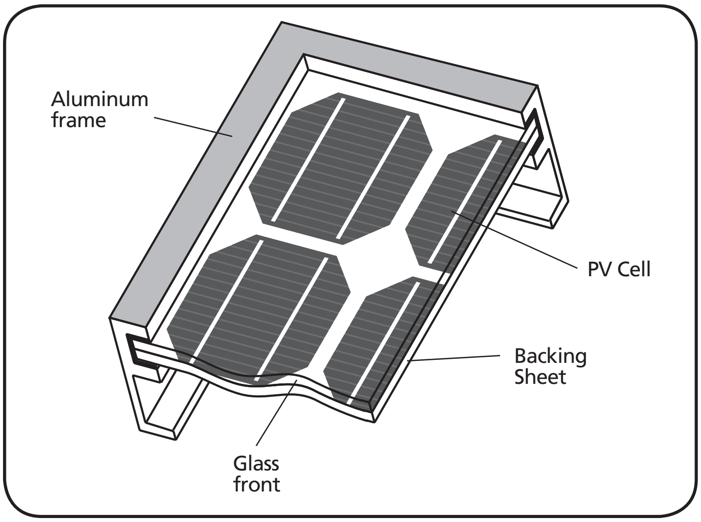

Fig. 2.6. Construction of a typical Mono-crystalline PV / Solar Panel

Bypass Diodes

As mentioned, PV / Solar cells are wired in series and in parallel to form a PV / Solar Panel (Module). The number of series cells indicates the voltage of the Panel (Module), whereas the number of parallel cells indicates the current. If many cells are connected in series, shading of individual cells can lead to the destruction of the shaded cell or of the lamination material, so the Panel (Module) may blister and burst. To avoid such an operational condition, Bypass Diodes are connected anti-parallel to the solar cells as in Fig. 2.7. As a consequence, larger voltage differences cannot arise in the reverse-current direction of the solar cells. In practice, it is sufficient to connect one bypass diode for every 15-20 cells. Bypass diodes also allow current to flow through the PV module when it is partially shaded, even if at a reduced voltage and power. Bypass diodes do not cause any losses, because under normal operation, current does not flow through them.

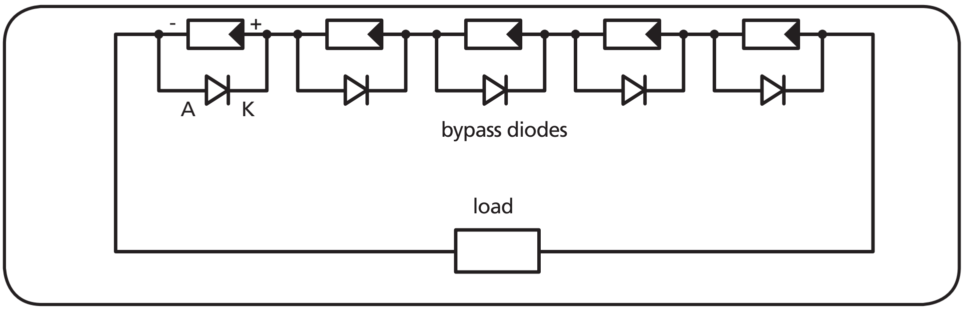

Figure 2.7: Parallel PV cell with bypass diodes

Current (I), Voltage (V) and Power (P) Curves of a PV / Solar Panel (Module) and how the PV / Solar Panel (Module) is rated - V_{oc} , Vmp , I_{sc} , Imp , Pmax

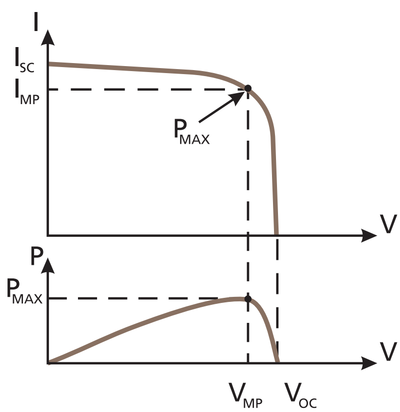

Fig. 2.8 Current (I), Voltage (V) and Power (P) Curves

A Current (I) versus Voltage (V) Curve of a PV / Solar Module ("I-V" Curve) shows the possible combinations of its current and voltage outputs. A typical I-V curve for a 12 V Module is shown at Fig. 2.8.

The power in a DC electrical circuit is the product of the voltage and the current. Mathematically,

- Power (P) in Watts (W) = The Current (I) in Amperes (A) X the Voltage (V) in Volts (V) i.e. W = V X A

A PV / Solar Cell or a Panel (Module) produces its maximum current when there is no resistance in the circuit, i.e. when there is a short circuit between its Positive and Negative terminals. This maximum current is known as the Short Circuit Current and is abbreviated as I_{sc}. When the Cell / Panel (Module) is shorted, the voltage in the circuit is zero.

Conversely, the maximum voltage occurs when there is a break in the circuit. This is called the Open Circuit Voltage (V_{oc}). Under this condition, the resistance is infinitely high and there is no current, since the circuit is incomplete. **Typical value of the open-circuit voltage is located about 0.5 – 0.6 V for Crystalline Cells and 0.6 – 0.9 V for Amorphous Cells.**

These two extremes in load resistance, and the whole range of conditions in between them, are depicted on the I-V Curve. Current, expressed in Amps, is on the vertical Y-axis. Voltage, in Volts, is on the horizontal X-axis.
The power available from a photovoltaic device at any point along the curve is just the product of Current (I) in Amps (A) and Voltage (V) in Volts (V) at that point and is expressed in Watts. At the short circuit current point, the power output is zero, since the voltage is zero. At the open circuit voltage point, the power output is also zero, but this time it is because the current is zero.

Maximum Power Point and Rated Power of PV / Solar Panel (Module)

There is a point on the knee of the I-V Curve where the maximum power output is located and this point is called the Maximum Power Point (MPP). The voltage and current at this Maximum Power Point are designated as Vmp and Imp.

The values of Vmp and Imp can be estimated from V_{oc} and I_{sc} as follows:

Vmp ≈ (0.75 – 0.9) V_{oc}

Imp ≈ (0.85 – 0.95) I_{sc}

The rated power of the PV / Solar Module in Watts (Pmax) is derived from the above values of voltage Vmp and current Imp at this Maximum Power Point (MPP):

- Rated power in Watts, Pmax = Vmp X Imp

Example of I-V Curve and Ratings of a 12 V PV / Solar Panel

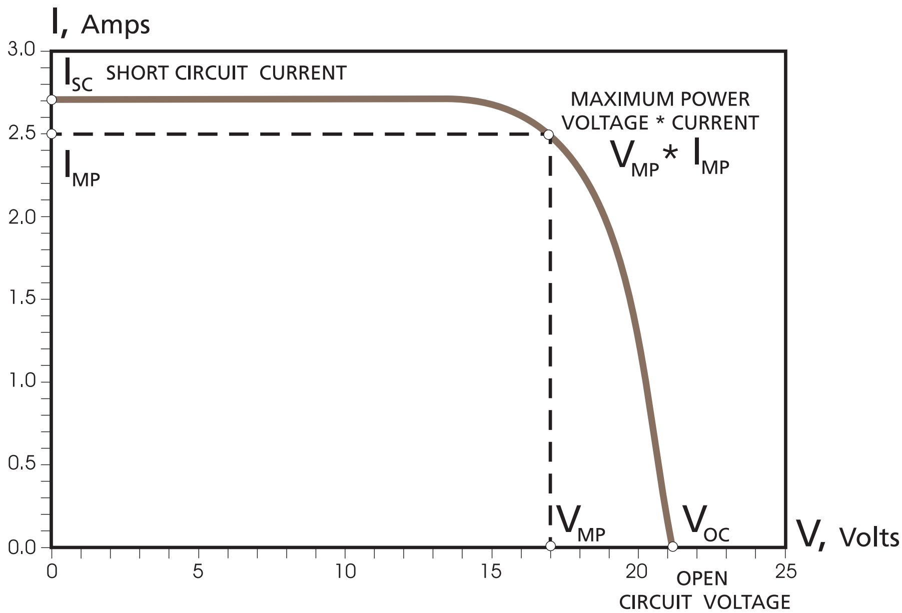

Fig. 2.9. Example of I-V Curve and Ratings of a 12 V PV / Solar Panel

The I-V Curve for a typical 12 Volt PV / Solar Panel is shown in Fig. 2.9.

This Maximum Power Point in the example curve given above is where Vmp is 17 Volts, and the current Imp is 2.5 amps. Therefore, the rated or the maximum power Wmax in watts is 17 Volts times 2.5 Amps, or 42.5 Watts.

Standard Test Conditions (STC) for Specifying PV / Solar Modules

The I-V curve is also used to compare the performance of PV / Solar Modules. The curve is, therefore, generated based on the performance under Standard Test Conditions (STC) of sunlight and device temperature of 25 °C. It assumes there is no shading on the device. Standard sunlight conditions on a clear day are assumed to be 1,000 Watts of solar energy per square meter (1000 W/m^2 or 1 kW/m^2). This is sometimes called one sun, or a peak sun. Less than one sun will reduce the current output of the PV device by a proportional amount. For example, if only one-half sun (500 W/m^2) is available, the amount of output current is roughly cut in half.

Types of Batteries

There are several different types of battery chemistry including liquid Lead-Acid, Nickel-Iron (NiFe), Nickel-Cadmium (Ni-Cd), alkaline, and gel-cell. Batteries are either sealed or vented. Simply, there are only two principal types of batteries: starting and deep-cycle.

Starting batteries are designed for high cranking power, but not for deep cycling. Used as energy storage, they will not last long in a deep cycle application. Starting batteries use lots of thin plates to maximize the surface area of the battery. This allows very high starting current but lets the plates warp when the battery is cycled. This type of battery is not recommended for the storage of energy in solar applications. However, they are recommended as starting battery for the back-up generator.

Deep cycle batteries are the type of battery best suited for use with inverters. The physical dimension of the plates is thicker and the active material that holds the charge is denser to increase cycle life. The "deep cycle" type of battery is designed to have the majority of their capacity used before being recharged. They are available in many sizes and in either "non-sealed" or "sealed" types.

Usual battery inverters are optimized for use with lead acid batteries that have a nominal voltage of 2.0 volts per cell. Ni-Cd/NiFe batteries (also called alkaline batteries) have a nominal cell voltage of 1.2 volts per cell. The nominal voltage of a Ni-Cd / NiFe battery bank can be made the same as a lead acid bank just by juggling the number of cells (10 cells for 12 volts, 20 cells for 24 volts and 40 cells for 48 volt systems). However, the Ni-Cd/NiFe battery bank must be charged to a higher voltage to fully recharge and will drop to a lower voltage during discharging compared to a similarly sized lead acid type battery.

State of Charge (SOC) of the Battery

One important parameter that defines the energy content of the battery is the State of Charge (SOC). This parameter indicates how much charge is available in the battery referring to its capacity. It is the ratio of the difference of the rated capacity in Ampere Hours (Ah) and the net Ah discharged or charged since the last full SOC. For example, in a 100Ah capacity battery, if the net Ah discharged is 20 Ah, then the SOC is 80% ie (100 Ah – 20 Ah) divided by 100 Ah. SOC is also called Residual Capacity.

Generally, the voltage of the battery cell is taken as the basis for calculating SOC or the remaining capacity. Results can vary widely depending on actual voltage level, temperature, discharge rate and the age of the cell and compensation for these factors must be provided to achieve a reasonable accuracy. Fig 3.1 shows the relationship between the Open Circuit Voltage and the Residual Capacity at constant temperature and discharge rate for a high capacity Lead Acid cell. Note that the cell voltage diminishes in direct proportion to the remaining capacity.

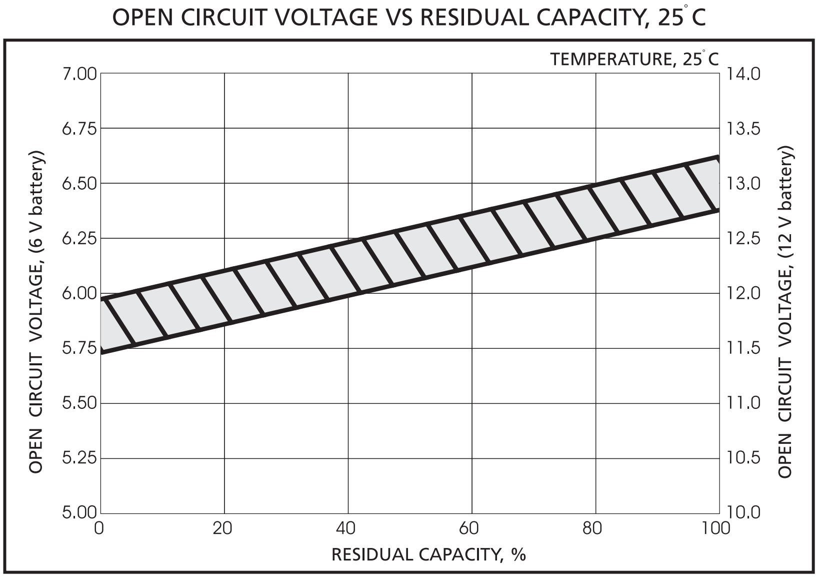

Fig 3.1 SOC versus Open Circuit voltage

The Lead-Acid Batteries

A basic equivalent circuit of the Lead-Acid battery is modeled by a voltage source with an equilibrium voltage (V_E) in series with an internal resistor (R_{in}) (see Fig 3.2). It must be noted here that this configuration can describe only a current state because the magnitude of V_E and R_{in} are not actually constant, but is function of many parameters such as state of charge (SOC), temperature, current density, and aging of the battery.

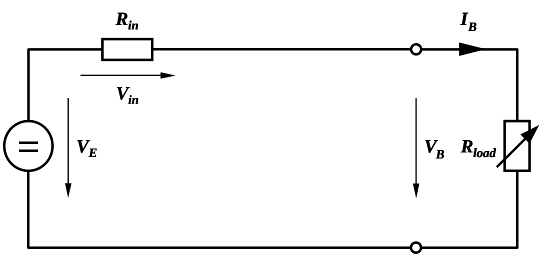

Fig 3.2. Basic equivalent circuit of the Lead-Acid battery for a current state

Furthermore, it is to consider that these parameters depend also on the current direction (charging or discharge). When the battery were at rest or under open-circuit condition $V_B = V_E$. When current is drawn from the battery, the voltage will be lower than V_E. When current is flowing into the battery, the terminal voltage will be higher than V_E. For example, at each moment during discharge phase the terminal voltage can be derived as follow:

$$V_B = V_E - V_{in} \quad (3.1)$$

$$= V_E - R_{in} \times I_B \quad (3.2)$$

where:
V_B = terminal voltage [V]
V_E = equilibrium voltage [V]

V_{in} =internal loss voltage [V]
R_{in} =internal resistance [Ω]
I_B =discharge current [A]

Obviously, higher discharge current results in reduction of the terminal voltage. Therefore, to specify the state of the battery by the battery voltage, discharge current should be also measured.

In case of discharge, the minimum voltage level acceptable for a Lead-Acid battery is defined as ***discharge voltage threshold***. Falling below this threshold is called ***deep discharge***, with which the battery may suffer damage. In case that the battery is left longer after deep discharge, lead of the support structure is converted to lead-sulphate in rough-crystalline form, which during charging can be only bad or cannot be converted again anymore. As a result, the battery loses a part of its storage capacity; besides loss of support structure arises as well.

In practice, harmful deep discharge is to be prevented: the loads will be compulsory disconnected from battery as soon as the discharge voltage threshold is reached i.e. with the help of a so-called ***deep discharge protection*** (DDP). This threshold is basically given in the data sheets by the manufacturer for different discharge currents. Preferably, the value of this threshold should depend on the discharge current. The relation between the discharge current and the voltage during discharge for the Lead-Acid battery is presented in Figure 3.3.

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GENERAL INFORMATION: BATTERIES

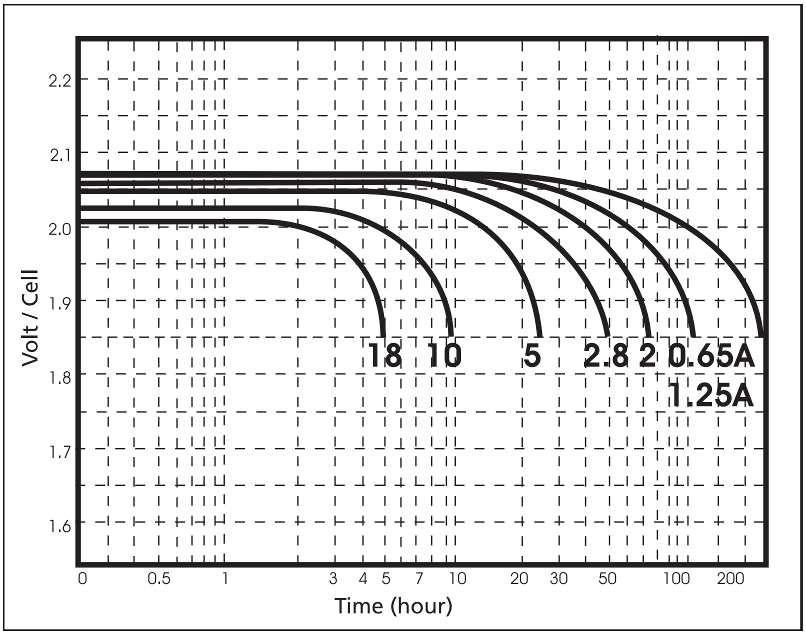


Fig 3.3: Discharge characteristic curves

Figure 3.3 shows the discharge profile of a typical battery type at several constant current rates. The typical end-of-discharge voltage at these discharge rates can also be noticed where the voltage starts to drop steeply. Moreover, the end-of-discharge voltage varies between 1.75-1.9 V, depending on the battery type and the discharge current. Higher service capacity is obtained at the lower discharge rates. At higher discharge rates, the electrolyte in the pore structure of the plate becomes depleted, and it cannot diffuse rapidly enough to maintain the cell voltage. However, intermittent discharge, which allows time for electrolyte diffusion will improve the performance under high discharge rates

Gassing

With 2.3 V – 2.4 V, namely the so-called ***Gassing Voltage***, gas is developed at the electrodes in the battery, by which the water is decomposed into hydrogen (H_2) and oxygen(O_2). Both gases mix together in the battery providing detonating gas (explosive!) and escape through ventilation opening in the vent plug. With the gassing, the battery also loses water, which must be refilled according to maintenance within regular intervals. The gas is the unwelcome secondary reaction of the chemical conversion during charging because current is consumed for the electrolysis and, therefore, the storage efficiency of the battery is made worse unnecessarily.

After the gassing voltage is exceeded, voltage stays approximately constant. The whole charging current during this period results in H_2 and O_2, which is defined as loss.

Freezing of electrolyte

For applications with low ambient temperature, the Lead-Acid battery must also be protected against freezing of electrolyte. The risk of freezing depends on the state of charge. Figure 3-4 illustrates the freezing limit as a function of the state of charge.

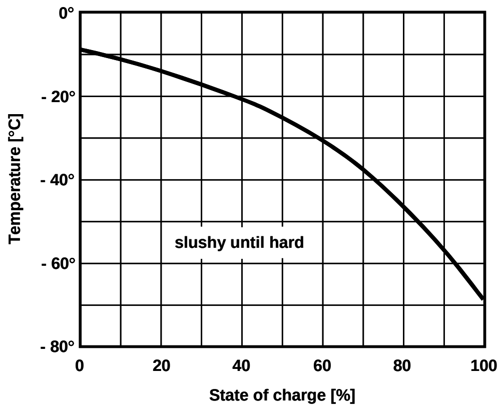


Figure 3-4: Freezing limit of a Lead-Acid battery dependent on the State of Charge

Cycle life of Lead-Acid batteries

The cycle life refers to a capability of the battery to withstand a certain number of charge/discharge cycles of given Depth of Discharge (DOD). Since the lifetime of the battery also depends on the average depth of discharge during cycling (expressed in percentage (%) of rated capacity), the cycling capability may be more conveniently expressed by multiplying this average depth of discharge by the battery lifetime expressed in number of cycles. The result is called the Nominal Cycling Capability, which is expressed as the number of equivalent 100 % nominal capacity cycles.

The starter battery typically has a low cycling capability of less than 100 nominal cycles, which means that it is able to withstand for example 500 cycles of maximally 20 % depth of discharge. The battery appropriate for PV application requires a good cycling capability of at least 500 nominal cycles, which means that it should be able to withstand for example 1000 cycles of 50 % depth of discharge (Fig. 3-5).

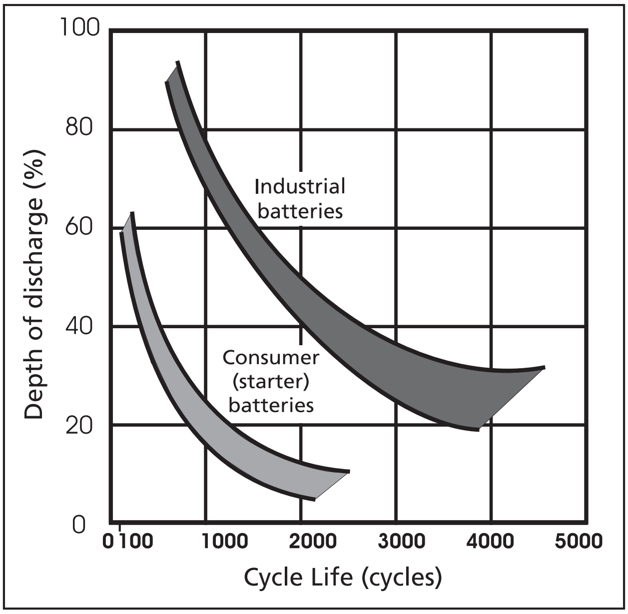


Figure 3-5: Cycle life as a function of deep of discharge

Battery capacity

Previously, the storage capacity of a battery is expressed in Ah (Ampere-hours) showing how many hours a certain current can be taken from the charged battery until the battery is discharged, i.e. until the battery voltage drops to the discharge voltage threshold.

Nowadays, it might be more favorable to express a battery capacity in dischargeable energy, namely Wh (Watt-hours) or kWh (kilowatt-hours). However, these two ways of expressing the battery capacity are equivalent because they are related via the battery voltage, i.e. Ah × V = Wh.

Unfortunately, the capacity of a battery is not a constant quantity, but depends on the amount of discharge current. The manufacturers, therefore, give the rated capacity of their batteries always with regard to a certain discharge current.

The so-called ***Rated Battery Capacity*** refers to the capacity of the battery under given standard conditions: it is common practical to define the rated capacity at 20 °C by discharging the battery with a ***Rated Battery Current*** (I_{20}), which refers usually to a constant current, with which the battery will be completely discharged in 20 hours. Some battery manufacturers indicate the 100-hour discharge capacity for batteries intended for PV applications. When comparing such capacity, it should be remembered that, for a given battery, the 100-hour capacity is always at least 15 % higher than the 20-hour capacity .

Besides, battery capacity is also affected by the temperature: it falls by about 1 % per degree below about 20 °C. Moreover, extreme high temperatures accelerate aging, self-discharge and electrolyte usage.

Requirements for solar batteries

Typical requirements for the battery to be used in long term storage are:

- low specific kWh-cost, i.e. the stored kWh during the whole life of the battery
- long lifetime
- high overall efficiency
- very low self-discharge
- low maintenance cost
- easy installation and operation
- high power

- Specific kWh-cost

Usually, it refers to a sum of investment and operation costs of the battery divided by the stored kWh (kWh_{Σ}) during its whole life. This cost is, thus, influenced by the battery's lifetime.

- Lifetime

The lifetime of the battery should be long, especially in order to keep the specific kWh-cost and the installation cost low, particularly in remote areas.

- Overall efficiency

The overall efficiency (η_{Σ}) is derived from charge or coulombic efficiency (η_I) and voltage efficiency (η_V):

$$\eta_{\Sigma}=\eta_I \times \eta_V \qquad (3.3)$$

The coulombic efficiency is usually measured at a constant discharge rate referring to the amount of charge able to be recalled from the battery (Q_D) relative to the amount put in during charging (Q_C). Self-discharge will affect columbic efficiency.

$$\eta_I=Q_D / Q_C \qquad (3.4)$$

The battery will usually need more charge than was taken out to fill it back up to its starting point. Typical average coulombic efficiencies are 80 – 85 % for stand-alone PV systems, with winter efficiencies increasing to 90 – 95 %, due to higher coulombic efficiencies when the battery is at a lower state of charge and most of the charge going straight to the load, rather than into the batteries.

3

GENERAL INFORMATION: BATTERIES

The voltage efficiency is determined by the average discharge voltage (V_D) and average charging voltage (V_C). V_C is lower than V_D particularly by internal resistance of the battery.

$$\eta_V = V_D / V_C \qquad (3.5)$$

The overall efficiency (η_Σ) should be as high as possible, to be able to pass the biggest proportion of the energy in the battery, which is generated by the PV generator system, further to consumers.

- Self-discharge

The battery discharges itself even without load connected. This effect is caused by secondary reactions at its electrodes and proceeds faster with higher temperature or in older batteries. Thermodynamic instability of the active materials and electrolytes as well as internal and external short-circuits lead to capacity losses, which are defined as self-discharge. This loss should be small, particularly in respect of annual storage.

- Maintenance cost

The maintenance, e.g. water refilling in case of Lead-Acid batteries, should be kept as low as possible.

- Easy installation and operation

Since batteries are often used also by non-experts, easy installation and operation are, therefore, favorable.

- Power

In special cases, battery must be highly loadable for a short time, e.g. at the start of diesel generators or in case of momentary power extension of PV systems.

There are many types of batteries potentially available for use in stand-alone PV systems. Useful data of available batteries given in Table 3.1 shows approximated values and are provided as a guideline.

Table 3-1: Comparison between selection criteria of available batteries

Type	Cycle life until 80 % DOD	Coulombic Efficiency η_I [%]	Self-discharge [%/month]	Temp. range [°C]
Lead Acid	500...1500	> 80	3…4	-15°...+50°
Ni-Cd	1500...3500	71	6…20	- 40°...+45°
Ni-Fe	3000	55	40	0°…+40°

Since many values are dependent on charge and discharge conditions, they have not been standardized for PV applications and for test purposes until now. Therefore, the comparison between batteries and selection of the most suitable one for each application are not easy. Due to particular operating conditions with PV applications in practical operation, the cycle life given by manufacturer (and in Table 3.1) for cycling load can be reduced more than half.

According to Table 3.1, it follows that in most cases, the Lead-Acid batteries would be the best choices for PV applications. The selection of suitable choices should be based on specific application.

Temperature Compensated Battery Charging

Temperature affects the rate of chemical reactions in the batteries as well as the rate of diffusion and the resistivity of the electrolyte. Therefore, the charging characteristics of the battery will vary with temperature. This is nearly linear and the Voltage Coefficient of the temperature change can vary from -3 mV / °C / Cell at 50 °C to -5 mV / °C / Cell at -10 °C. Please note that the Voltage Coefficient of the temperature change is negative which means that as the temperature rises, the charging voltage is required to be reduced and as the temperature is decreased, the charging voltage has to be increased

The Absorption Voltage set point is normally specified at 25 °C. Battery temperatures often vary up to 15 °C from the 25 °C reference in PV Systems. The Absorption Voltage for a 12 V sealed battery must then be adjusted as follows:

Battery Temperature	Absorption Voltage
40 °C	13.8V
25 °C (Reference)	14.1V (Reference)
10 °C	14.5V

In case temperature compensation is not provided, the warmer battery at 40 °C will begin to heat and outgas at 13.8 V and will continue to overcharge until the non-compensated Absorption Voltage set point is reached (14.1 V). In cooler temperatures, the 10 °C battery will experience severe undercharging resulting in sulfation.

4

INTRODUCTION & FEATURES

The SCC-30AB is a Series Type of PWM (Pulse Width Modulation) Charge Controller. It is based on an advanced design using a microcontroller for digital accuracy and fully automatic operation. It can be used for 12V or 24V systems for solar charging . The PWM battery charging has been optimized for longer battery life. The unit is designed for user-friendly operation. Please take the time to read this Owner's Manual and follow the instructions step by step to help you make full use of the charging system.

Features

- Advanced microcontroller based, high performance design for digital accuracy and fully automatic and intelligent operation
- Dual voltage capability – can be used with 12 V / 24 V Solar Systems
- 30 A charging capacity – enables use of up to 360 W of 12 V or 720 Watts of 24 V Solar Panels
- Series Mode PWM (Pulse Width Modulation) charging design for low loss higher efficiency charging and longer battery life
- 4 Stages of charging for 100% return of capacity and long battery life – Bulk, Absorption, Float and Equalization Stages
- Choice of 8 sets of Absorption / Float / Equalization voltage settings to enable complete and safe charging of a wide range of Lead Acid / Ni-Cd Batteries
- Convenient 2 X 16 character LCD Display with backlight for display of operating information and data. Additional LED indication for displaying the charging stages
- Optional remote Battery Temperature Sensor (BTS) for temperature compensation to ensure improved charging of batteries that experience wider temperature variations during the year
- MOSFET based reverse current blocking for night-time battery discharge prevention. This allows much lower losses as compared to Diode based blocking
- Specially designed for RVs, boats and trucks – allows convenient and aesthetic flush mounting on walls / panels
- Industry leading warranty

Requirements of Battery Charging in PV Systems

Batteries in PV Systems are commonly subject to abusive conditions that are generally due to:

- Under charging due to low sun peak hours
- Excessive charging in high sun peak hours
- Inappropriate or ineffective charge control for the battery technology

The individual or combined effects of sun peak hour changes, poor charge control and the daily load changes can be potentially damaging to the battery. Cheaper charge control strategies such as simple on/off PV array shedding (Non PWM control) will generally provide the battery with sufficient charging current to complete the Bulk Charge Phase which will return the battery to 80% State of Charge. After the Bulk Charge Phase, the Taper or Absorption Charge Phase is very important in preventing stratification, hard sulfation and pre-mature capacity loss.

PWM Battery Charging

PWM (Pulse Width Modulation) battery charging is the most efficient and effective method for recharging a battery in a solar system. The PV array is connected to the battery through a series or parallel (called Shunt) connected MOSFET Switch. The PWM control circuit switches on and switches off the MOSFET Switch at a frequency of several hundred cycles per second. Thus, instead of a steady output from the controller, it sends out a series of short charging pulses to the battery – like a very rapid "on-off" switch. The controller constantly checks the state of the battery to determine how long (wide) the pulses will be. In a fully charged battery with no load, it may just "tick" and send very short pulses to the battery. In a discharged battery, the pulses would be very long and almost continuous. The controller checks the state of charge on the battery between pulses and adjusts itself each time. This technique allows the current to be effectively "tapered" and the result is equivalent to "constant voltage" charging

Series and Shunt Type of Charge Controller

When the MOSFET Switch is connected in series with the PV Array and the battery, the Controller is called Series Type. When it is connected in parallel across the PV Array / the Battery, it is called Shunt Type. In Series Type, the MOSFET Switch is kept open when the battery is fully charged. The PV Array stops supplying current during this period. In the Shunt Type, when the battery is fully charged, the MOSFET Switch is kept closed to shunt (divert) the full Short Circuit Current of the PV Array away from the battery.

Advantages of Series Type of Charge Controller

A series Type of Charge Controller has the following advantages over a Shunt Type:

- Power systems experience temporary over voltage conditions. For example, when lightning strikes, extremely high electrostatic energy is discharged. This energy induces damaging high voltage transients in exposed and un-protected electrical circuit elements like cables etc and these high voltage transients are fed to the electrical devices and cause damage if the device is not adequately protected.

PV Systems and associated cabling are installed in exposed locations and hence, they are more prone to the damaging effects of high voltage transients. Large PV Systems employ numerous lightning protection devices like Lightning Rods, Surge Suppressors, shielded cables etc. However, in small PV systems, these protections are seldom incorporated. Because there is less system level protection, small PV Charge Controllers are more susceptible to damage by high voltage transients. Transient Voltage Surge Suppressors (TVSS) are used to protect the input and output sections of the Charge Controller. The TVSS clamps the high voltage of the transient to a safe level. The Clamping Voltage is seen by the MOSFET and temporarily stresses the MOSFET. In a Series Type of Charge Controller, the MOSFET Switch is located between the input terminals and the battery. Hence, the voltage seen across the MOSFET Switch during high voltage transient condition is lower and is equal to the Clamping Voltage of the TVSS minus the battery voltage. This produces lower stress. On the other hand, in a Shunt Type Charge Controller, the MOSFET Switch sees the full Clamping Voltage and, therefore, it is stressed to a higher degree.

- Lesser switching noise. During charging, the Shunt MOSFET Switch experiences higher level of stress because it is in a high temperature reverse bias standoff position
- The voltage applied across the Series MOSFET Switch is lesser and hence, it experiences lesser stress and is, therefore, more reliable

A Shunt Type requires a Schottky Diode in series with the battery to prevent short circuiting of the battery during the time the MOSFET switch shunts the PV Array. In a Series Type, this Schottky Diode is not required. Elimination of the Schottky Diode in the Series Type has the following associated advantages:

- Lower voltage drop, less heating and consequent lower losses
- Reverse leakage through the Schottky is eliminated

Battery Charging Algorithm

Selecting the best method for charging your battery together with a good maintenance program will ensure a healthy battery and long service life. Although the SCC-30AB's battery charging is fully automatic, the following information is important for getting the best performance from your SCC-30AB Charge Controller and battery.

Four Stages of Solar Charging

Fig. 4.1 represents the 4 stages of charging used in the SCC-30AB

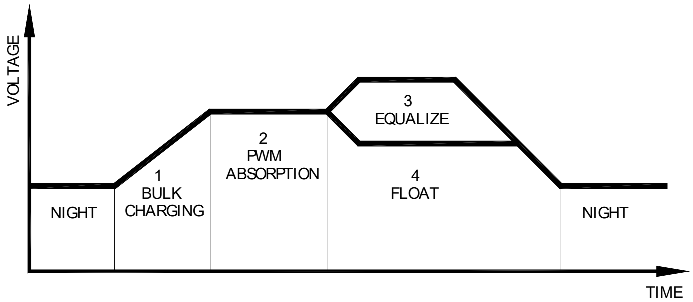


Fig. 4.1   Solar Charging Stages

1. ***Bulk Charging:*** In this stage, the battery will accept all the current provided by the solar array. The value of this current will be equal to the Short Circuit Current Isc of the solar array

2. ***PWM Absorption:*** When the battery reaches the Absorption Voltage, the PWM begins to hold the voltage constant. This is to avoid over-heating and over-gassing the battery. The current will taper off to safe levels as the battery becomes more fully charged.

3. ***Equalization***: Many batteries benefit from a periodic boost charge to stir the electrolyte, equalize the cell voltages, and complete the chemical reactions (See additional details on Equalization given below)

4. ***Float***: When a battery becomes fully charged, dropping down to the float stage will provide a very low rate of maintenance charging while reducing the heating and gassing of a fully charged battery. When the battery is fully recharged, there can be no more chemical reactions and all the charging current is turned into heat and gassing. The purpose of float is to protect the battery from long-term overcharge. From the PWM absorption stage, charging is dropped to the float voltage. This is typically 13.4V.

Equalization

Routine equalization cycles are often vital to the performance and life of a battery — particularly in a solar system. During battery discharge, sulfuric acid is consumed and soft lead sulfate crystals form on the plates. If the battery remains in a partially discharged condition, the soft crystals will turn into hard crystals over time. This process, called "lead sulfation," causes the crystals to become harder over time and more difficult to convert back to soft active materials.

Sulfation from chronic undercharging of the battery is the leading cause of battery failures in solar systems. In addition to reducing the battery capacity, sulfate build-up is the most common cause of buckling plates and cracked grids. Deep cycle batteries are particularly susceptible to lead sulfation.

Normal charging of the battery can convert the sulfate back to the soft active material if the battery is fully recharged. However, a solar battery is seldom completely recharged, so the soft lead sulfate crystals harden over a period of time. Only a long controlled overcharge, or equalization, at a higher voltage can reverse the hardening sulfate crystals.

In addition to slowing or preventing lead sulfation, there are also other benefits of equalization of the solar system battery. These include:

*-**Balance the individual cell voltages***

Over time, individual cell voltages can drift apart due to slight differences in the cells. For example, in a 12 cell (24V) battery, one cell is less efficient in recharging to a final battery voltage of 28.8 volts (2.4 V/c). Over time, that cell only reaches 1.85 volts, while the other 11 cells charge to 2.45 volts per cell. The overall battery voltage is 28.8V, but the individual cells are higher or lower due to cell drift. Equalization cycles help to bring all the cells to the same voltage.

*-**Mix the electrolyte***

In flooded batteries, especially tall cells, the heavier acid will fall to the bottom of the cell over time. This stratification of the electrolyte causes loss of capacity and corrosion of the lower portion of the plates. Gassing of the electrolyte from a controlled overcharging (equalization) will stir and remix the acid into the battery electrolyte.

NOTE: Excessive overcharging and gassing too vigorously can damage the battery plates and cause shedding of active material from the plates. An equalization that is too high or for too long can be damaging. Review the requirements for the particular battery being used in your system.

When to Equalize

The ideal frequency of equalizations depends on the battery type (Lead Calcium, Lead-Antimony, etc.), the depth of discharging, battery age, temperature, and other factors.

One very broad guide is to equalize flooded batteries every 1 to 3 months or every 5 to 10 deep discharges. Some batteries, such as the L-16 group, will need more frequent equalizations.

The difference between the highest cell and lowest cell in a battery can also indicate the need for equalization. Either the specific gravity or the cell voltage can be measured. The battery manufacturer can recommend the specific gravity or voltage values for your particular battery.

5

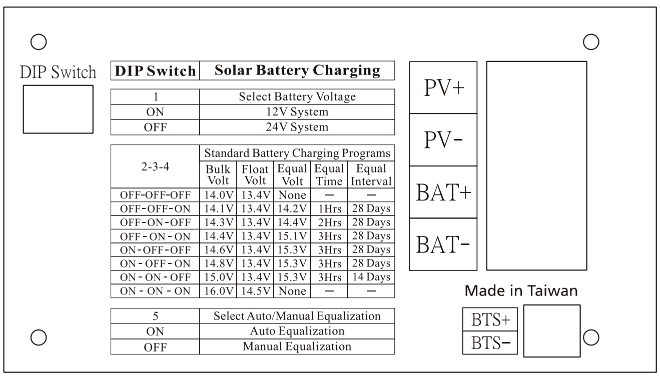
CONSTRUCTION, LAYOUT & CONTROLS

General

SCC-30AB is designed for flush mounting on a wall / panel. The controls and indications are built on the Front Panel face plate that has 4 countersunk holes for flush mounting (Fig. 5.1). All the electronics, DIP switches for settings, terminal strip for connections for the PV Array and the Battery and terminal for the optional Battery Temperature Sensor (BTS) are mounted on a PCB that is in turn mounted at the back of the face plate (Fig. 5.2). For flush mounting on the wall / panel, a suitable cutout is required to be made in the wall / panel to accommodate the PCB at the back of the unit. As the components at the back of the unit will be hidden and protected behind the wall / panel, the components at the back of the unit are exposed and do not have a protective cover. **PLEASE HANDLE THE UNIT CAREFULLY TO PREVENT ANY DAMAGE TO THE EXPOSED COMPONENTS AT THE BACK OF THE UNIT.**

NOTE: As the unit will be connected to 12 V / 24 V Nominal Solar Array / battery system, there is no likelihood of electrical shock.

Fig. 5.1 Front Panel of SCC-30AB



DIP Switch	Solar Battery Charging
1	Select Battery Voltage
ON	12V System
OFF	24V System

2-3-4	Standard Battery Charging Programs				
	Bulk Volt	Float Volt	Equal Volt	Equal Time	Equal Interval
OFF-OFF-OFF	14.0V	13.4V	None	—	—
OFF-OFF-ON	14.1V	13.4V	14.2V	1Hrs	28 Days
OFF-ON-OFF	14.3V	13.4V	14.4V	2Hrs	28 Days
OFF-ON-ON	14.4V	13.4V	15.1V	3Hrs	28 Days
ON-OFF-OFF	14.6V	13.4V	15.3V	3Hrs	28 Days
ON-OFF-ON	14.8V	13.4V	15.3V	3Hrs	28 Days
ON-ON-OFF	15.0V	13.4V	15.3V	3Hrs	14 Days
ON-ON-ON	16.0V	14.5V	None	—	—

5	Select Auto/Manual Equalization
ON	Auto Equalization
OFF	Manual Equalization

Fig. 5.2. Back view of SCC-30AB

Controls & Indications

The description and the functions of the controls and indications are given below:

Front Panel

Charge Status LED Indications

LED State	Indication
Blinking Green	Charging is in the state of Bulk or Absorption
Solid Green	Charging is in the state of Float
Solid Orange	Charging in the state of Equalization
Solid Red	Charging in the state of fault: Over Current
Blinking Red	Charging in the state of fault: Over Temp.

Push Buttons

Display **Reset Amp-Hours**	Push to change the display as in Fig. 5.3. Push and hold to reset Amp-Hours.
Equalization **Start/Stop**	When DIP Switch 5 is set at OFF, hold Restart/Stop Equalization for 5 sec to manually start equalization. Press it for 2 sec to stop equalization.

LCD Display

The LCD Display is a 2 Line, 16 character display with backlighting. The Push Switch marked "PUSH Select Display" and "HOLD – Reset Amp Hours" is used to manipulate the LCD functions. Every time the Push Switch is pressed, the screen display scrolls. The scrolling sequence is shown in Fig. 5.3.

- The LCD provides the following information:
- Solar PV Array 0~30 Amps DC
- Battery Voltage: 4 to 80 Volts DC
- Watts: 0 to 3600 Watts (Volts time Amps)
- Amp-hours: 0 to 655536Ah; can be reset to 0
- Totalizing Amp-Hours: 0 to 65536 Ah; reset to 0 when power is disconnected
- Control mode and battery charging status

- Display of BULK and FLOAT voltage setting value
- Display of Equalization Voltage, Equalization Time and Equalization Interval
- Display of heat sink (the front panel metal plate acts as the heat sink) temperature and battery temperature through the optional Battery Temperature Sensor (BTS).

  * **NOTE**: As the display is not capable of showing negative values, battery temperature below 0 °C will not be displayed. Voltage compensation will, however, be carried out even below 0 °C.
- Fault Messages

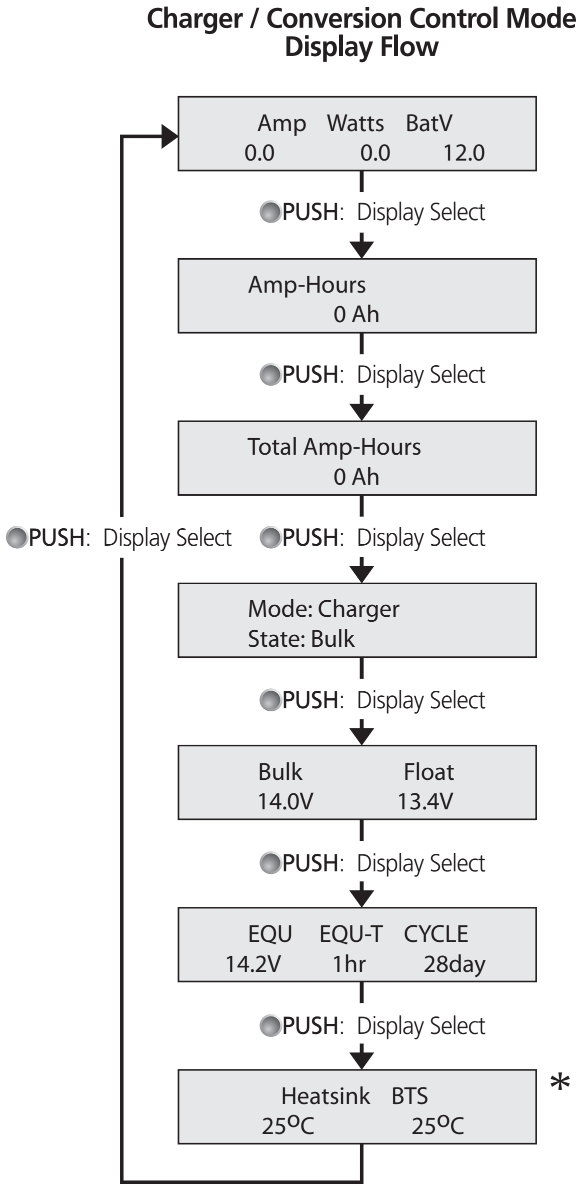


Fig. 5.3. LCD Display Flow

Fault Messages

The LCD displays might have the following fault messages when SCC-30AB stops operating.

Table 5.1. Fault messages

Display	Description	Cause of Fault
Alarm: OC Over Current	Over Current	The current exceeds 45 A
Alarm: OT	Heat Sink over temperature	Heat sink temperature exceeds 90 °C
Alarm: CPF00 Link Master error	Display Panel error	The CPU is not able to exchange data with the Display Panel

Back of the Unit

The back of the unit (Fig 5.2) has the following input / output connections and DIP Switches for various settings.

Table 5.2. Control Terminal Connection (At the back of the unit)

Name	Description	
PV+	Connecting terminal for Solar Array Positive	
PV–	Connecting terminal for Solar Array Negative	
Battery +	Connecting terminal for Battery cable Positive	
Battery–	Connecting terminal for Battery cable Negative	
DIP Switch 1	ON*	Selection of battery voltage for 12V system
	OFF	Selection of battery voltage for 24V system
DIP Switch 2,3, 4	Battery charge control mode: Battery charging algorithm	
DIP Switch 5	ON	Selection of Auto Equalization
	OFF*	Selection of Manual Equalization
BTS	Battery Temperature Sensor for temperature compensation	

***NOTE: Factory preset condition**

6

INSTALLATION & OPERATION

Warning!

This unit will be damaged if the battery is connected in reverse polarity.
ENSURE that the battery **+** and **-** wires are correctly connected before proceeding.
Damage due to reverse battery connection is not covered under warranty!

Installation Steps

This section provides a brief overview of how to get started using the SCC-30AB controller. However, please review the entire manual to ensure best performance and years of trouble-free service.

Notes:

- The SCC-30AB prevents reverse current leakage at night through an internal MOSFET Switch, so an external Blocking Diode is not required in the system.
- The connector terminals will accept a maximum wire size of AWG #10 (up to 5.2 mm2).
- Tighten each terminal clamping screw to 20 inch-pounds of torque.
- The SCC-30AB is designed to regulate power from a PV array. Other chargers can be connected directly to the battery, however, with no effect on the SCC-30AB.

Steps

1. As explained earlier in Chapter 4, SCC-30AB is designed for flush mounting on a wall panel. It has a face plate and a projecting part at the back consisting of the PCB with the Terminal Strip, connector for the Battery Temperature Sensor (BTS) and the DIP switches. The wall / panel will be required to be cut to accommodate the projections of the circuit board mounted on the back of the faceplate. All the wiring – 2 wires from the Solar Array, 2 wires to the battery and 2 wires to the Battery Temperature Sensor (if used) will be led to the connections at the back of the unit from behind the wall / panel. Make sure that the pocket created behind the cut-out in the wall / panel is clear so that the back portion carrying the PCB is not damaged when the unit is pushed back into the cut-out section of the wall / the panel for flush mounting.

The front face plate of the SCC-30AB acts as the heat sink for the heat dissipating components mounted on the PCB at the back of the Front Panel face plate. Hence, please ensure that the Front Panel face plate is not located near a heat generating source and that there is adequate cooling air flow across the face plate to remove the heat dissipated from its surface.

A drawing for making the cutout in the wall / panel is given at Fig 6.1 (not to scale). A full scale template is also included in the gift box to help direct marking the area to be cut out. 4 screws have been provided to fix the unit to the wall / panel.

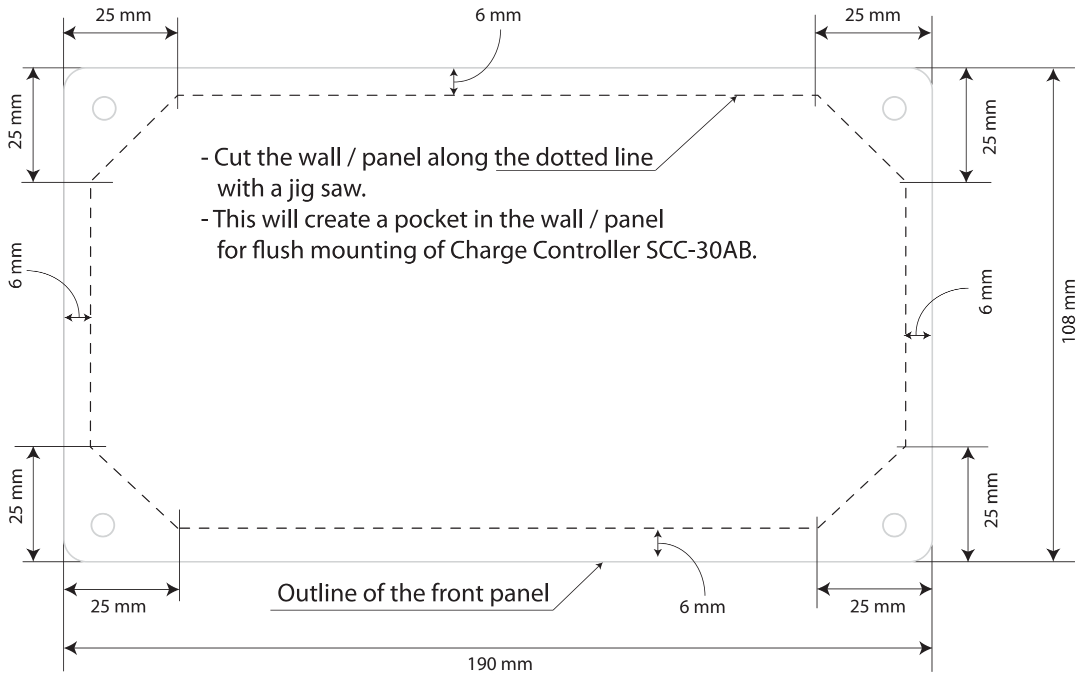


Fig. 6.1. Drawing for making the cut-out in the wall / panel

2. Make sure the PV currents will not exceed the ratings of the SCC-30AB.

3. The connections to the SCC-30AB terminals are shown in the drawing at Fig. 5.2. A barrier type of Terminal Strip has been provided for connecting the PV array and the battery. M-4 screws with clamping washers are used to make the connection. A flat or a #2 Philips head screw driver may be used to tighten these screws. Tighten each terminal clamping screw to 20 inch-pounds of torque. The distance between the barriers is 9 mm and a standard Spade Type of terminal lug meant for # 8 Stud and AWG #10 – AWG #12 wire may be used at the end of the wires to be connected to these terminals. 4 such terminal lugs are provided with the unit for ease of installation

4. Set the DIP Switch 1 for the voltage system, set the DIP Switch 2, 3, 4 for battery charging algorithm.

5. Connect the BATTERY first. Be careful that bare wires do not touch the metal case of the controller.

- The BATTERY must be connected before the Solar Panel (Module)/Array to properly start the microcontroller, activate protections & guide installation.
- A battery below 9 volts may not start the microcontroller properly. Make sure the battery is charged before installing the system.

6. Connect the Solar Panel (Module)/Array next. The green LED indicator will light if the Solar Panel (Module)/Array is connected during the daytime and the Solar Panel (Module)/Array is wired correctly.

- Remember that the Solar Panel (Module)/Array will generate power whenever in sunlight. Also, be careful not to short circuit the Solar Panel (Module)/Array while connected to the controller, since this will damage the controller.

7. For most effective surge protection, it is recommended that the Negative system conductor be properly grounded.

Dip Switch Settings

Five DIP Switches permit the following parameters to be adjusted at the installation site:

DIP Switch 1	ON*	Selection of battery voltage for 12V system
	OFF	Selection of battery voltage for 24V system
DIP Switch 2, 3, 4	Battery charge control mode: Battery charging algorithm (see Table 6.1)	
DIP Switch 5	ON	Selection of Auto Equalization
	OFF*	Selection of Manual Equalization

***NOTE: Factory preset condition**

Battery Charging Notes

The SCC-30AB manages many different charging conditions and system configurations. Some useful functions to know are given below.

Solar Overload: Enhanced radiation or “edge of cloud effect” conditions can generate more current than the controller’s rating. The Budget will reduce this overload up to 130% of rated current by regulating the current to safe levels. If the current from the solar array exceeds 150%, the controller will interrupt charging.

Battery Types: The SCC-30AB’s standard battery charging programs are suitable for a wide range of Lead-Acid battery types. These standard programs are select by DIP Switch 2~4.

Standard Battery Charging Programs

The SCC-30AB provides 8 standard battery charging algorithms (programs) that are selected with the DIP Switches. These standard algorithms are suitable for Lead-Acid batteries ranging from sealed (Gel, AGM, maintenance free) to flooded to L-16 cells and Ni-Cd etc.

Table 6.1 below summarizes the major parameters of the standard charging algorithms. Note that all the voltages are for 12V systems. For 24 V system, multiply the voltages by 2.

All values are 25°C (77°F).

Table 6.1. Standard Battery Charging Programs

Note: All the voltages given in the Table are for 12V Battery System. For 24V Battery Systems multiply the voltage values by 2.

DIP Switches (2-3-4)	A Battery Type	B PWM Absorption Voltage	C Float Voltage	D Equalize Voltage	E Equalize Time (hours)	F Equalize Interval (days)
Off-Off-Off	1 – Sealed	14.0	13.4	None	-	-
Off-Off-On	2 – Sealed	14.1	13.4	14.2	1	28
Off-On-Off	3 - Sealed	14.3	13.4	14.4	2	28
Off-On-On	4 - Flooded	14.4	13.4	15.1	3	28
On-Off-Off	5 - Flooded	14.6	13.4	15.3	3	28
On-Off-On	6 - Flooded	14.8	13.4	15.3	3	28
On-On-Off	7 - L-16	15.0	13.4	15.3	3	14
On-On-On	8-Ni-Cd	16.0	14.5	None	-	-

A. ***Battery Type***– These are generic Lead-Acid – wet cell (Lead Antimony, Lead Calcium), sealed AGM, sealed Gel Cell and Ni-Cd battery types.

B. ***Voltage***–This is the PWM Absorption Stage with constant voltage charging. The "PWM Absorption voltage" is the maximum battery voltage that will be held constant. As the battery becomes more charged, the charging current tapers off until the battery is fully charged.

C. ***Float Voltage***–When the battery is fully charged, the charging voltage will be reduced to 13.4 volts for all battery types. It will be 14.5V for Ni-Cd.

D. ***Equalization Voltage***–During an equalization cycle, the charging voltage will be held constant at this voltage.

E. ***Equalization Time***–The charging at the selected equalization voltage will continue for this number of hours.

F. ***Equalization Interval***–Equalizations are typically done once a month. Most of the cycles are 28 days so the equalization will begin on the same day of the month. It can be set by DIP Switch 2~4 for different interval days. Each new cycle will be reset as the equalization starts so that a setting day period will be maintained.

Equalization Procedure

Standard Equalization Programs

Both automatic and manual equalizations can be performed using the standard charging programs.

Manual Equalization

The SCC-30AB is shipped with the DIP Switch set for manual equalization only. This is to avoid an unexpected or unwanted automatic equalization. In the Manual Mode, the pushbutton is used to both start and stop a manual equalization. Hold the pushbutton down for 5 seconds to start and 3 seconds to stop an equalization (depending on whether an equalization is in progress or not).

There are no limits to how many times the pushbutton can be used to start and stop equalizations. Equalizations will be terminated automatically as per the charging program selected if the pushbutton is not used to manually stop the equalization.

Automatic Equalization

If the equalization DIP Switch 5 is moved to the ON position, the equalizations will begin automatically as per the charging program selected. Other than starting, the automatic and manual equalizations are the same and follow the standard charging program selected. The push button can be used to start and stop equalizations in both the manual and automatic mode.

Typical Equalization

The automatic equalizations will occur at the selected charging program from DIP Switch 2~4. When equalization begins (Auto or Manual), the battery charging voltage increases up to the Equalization Voltage **Veq**. The battery will remain at **Veq** for the time specified in the selected charging program.

The equalization process will continue until the voltage has been held above the bulk setting for a cumulative period of one, two or three hours. A second manual equalization cycle can be started with the pushbutton, if needed.

If the equalization cannot be completed in one day, it will continue the next day or days until finished. After equalization is completed, charging will return to PWM Absorption.

Temperature Compensated Battery Charging

An optional Battery Temperature Sensor (BTS) is available for temperature compensated battery charging. The BTS consists of a temperature sensing probe that is installed on the + battery post. A pair of 10 ft. wires (marked + & -) connect the temperature sensing probe to the 2 terminals marked BTS at the back of the unit. (Fig. 5.2).

As the battery gets warmer, the gassing increases. As the battery gets colder, it becomes more resistant to charging. Depending on how much the battery temperature varies, it is important to adjust the charging for temperature changes.

Various voltage set points given in the specifications are indicated at a reference temperature of 25 ºC / 77 ºF.

There are three battery charging parameters that are affected by temperature:

PWM Absorption

This is the most important part of charging that is affected by temperature because the charging may go into PWM absorption almost every day. If the battery temperature is colder, the charging will begin to regulate too soon and the battery may not be recharged with a limited solar resource. If the battery temperature rises, the battery may heat and gas too much.

Equalization

A colder battery will lose part of the benefit of the equalization. A warmer battery may heat and gas too much.

Float

Float is less affected by temperature changes, but it may also undercharge or gas too much depending on how much the temperature changes.

The Battery Temperature Sensor corrects the three charging set points noted above by the following values (reference temperature is 25 ºC / 75 ºF):

- 12 volt battery: –0.030 volts per °C (–0.017 volts per °F)
- 24 volt battery: –0.060 volts per °C (–0.033 volts per °F)

The temperature sensed by the BTS at the battery is displayed on the LCD screen under the screen display “Heatsink BTS” (see Fig. 5.3). As the LCD display is not capable of displaying negative values, battery temperature below 0 ºC will not be displayed. Voltage compensation will, however, be carried out below 0 ºC.

Variations in battery temperature can affect charging, battery capacity, and battery life. The greater the range of battery temperatures, the greater the impact on the battery. For example, if the temperature falls to 10°C (50°F) this 15°C (27°F) change in temperature will change the PWM Absorption, equalization and float set points by 0.90V in a 24V system.

Typical compensation is given in Table 6.2 below:

Temperature	12 Volt	24 Volt
50°C / 122°F	– 0.75 V	–1.50 V
45°C / 113°F	– 0.60 V	– 1.20 V
40°C / 104°F	– 0.45 V	– 0.90 V
35°C / 95°F	– 0.30 V	– 0.60 V
30°C / 86°F	– 0.15 V	– 0.30 V
25°C / 77°F (Reference)	0 V (Reference)	0 V (Reference)
20°C / 68°F	+ 0.15 V	+ 0.30 V
15°C / 59°F	+ 0.30 V	+ 0.60 V
10°C / 50°F	+ 0.45 V	+ 0.90 V
5°C / 41°F	+ 0.60 V	+ 1.20 V
0°C / 32°F	+ 0.75 V	+ 1.50 V

Table 6.2 Temperature Compensation

The SCC-30AB is very rugged and designed for the most extreme operating conditions. Most PV system problems will be caused by connections, voltage drops, and loads. Troubleshooting the SCC-30AB controller is simple. Some basic troubleshooting procedures are listed below.

Protections & Fault Messages on the LCD Display

The LCD displays might have the following fault messages when SCC-30AB stops operating due to protections/system error:

Display	Description	Cause of Fault
Alarm: OC Over Current	Over Current	The current exceeds 45 A
Alarm: OT	Heat Sink over temperature	Heat sink temperature exceeds 90° C
Alarm: CPF00 Link Master error	Display Panel error	The CPU is not able to exchange data with the Display Panel

SYMPTOM 1. BATTERY IS NOT CHARGING

- Check the green LED indicator. The green CHARGING LED should be on if it is daytime.
- Check that the proper battery charging algorithm (program) has been selected by DIP Switches.
- Check that all wire connections in the system are correct and tight. Check the polarity (+ and –) of the connections.
- Measure the PV array open-circuit voltage and confirm it is within normal limits. If the voltage is low or zero, check the connections at the PV array itself. Disconnect the PV array from the controller when working on the PV array.
- Check that the load is not drawing more energy than the PV array can provide.
- Check if there are excessive voltage drops between the controller and the battery. This will cause undercharging of the battery.
- Check the condition of the battery. Determine if the battery voltage declines at night with no load. If it is unable to maintain its voltage, the battery may be failing.
- Measure the PV voltage and the battery voltage at the SCC-30AB terminals. If the voltage at the terminals is the same (within a few tenths of volts) the PV array is charging the battery. If the PV voltage is close to the open circuit voltage of the panels and the battery voltage is low, the controller is not charging the batteries and may be damaged.

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TROUBLESHOOTING

SYMPTOM 2. BATTERY VOLTAGE IS TOO HIGH

- First check the operating conditions to confirm that the voltage is higher than specifications.
- Check that the proper battery charging algorithm (program) has been selected by DIP Switches.
- Check that all wire connections in the system are correct and tight.
- Disconnect the PV array and momentarily disconnect the lead from the BATTERY positive terminal BAT+. Reconnect the battery terminal and leave the PV array disconnected. The Green charging light should not be lit. Measure the voltage at the PV array terminals PV+ and PV- (with the array still disconnected). If the Green charging light is on or battery voltage is measured at the PV array terminals PV+ and PV- , the controller may be damaged.

SYSTEM	
Nominal system voltage	12 VDC or 24 VDC (Selected by DIP Switch)
Current rating	30 A
Set point accuracy	+ / - 50 mV
Minimum voltage to start the micro-controller, activate protections and guide operation	9 VDC
Total self consumption current	50 mA
INPUT SIDE (Solar panel / array)	
Maximum open circuit voltage Voc of the solar panel / array	50 VDC
Maximum operating voltage of the solar panel / array	34 VDC
Maximum short circuit current Isc of the solar panel / array	30 A
BATTERY CHARGING	
Charging algorithm	PWM
Charging stages	Bulk, Absorption, Float, Equalize (Selectable)
Battery Temperature Compensation	With optional Battery Temperature Sensor (BTS) supplied with 10 ft / 3 M of wire
Coefficient of temperature compensation when using optional Battery Temperature Sensor (BTS)	12 V: -5mV/ °C / cell (25 °C reference) 24 V: -10mV/ °C / cell (25 °C reference)
Temperature compensation range	0 °C to +50 °C
PROTECTIONS	
High temp shutdown (Temp of the face plate that is used as a heat sink)	90 °C - disconnect solar panel / array 70 °C - re-connect solar panel / array
Over current (overload) shut down	45 A
DISPLAY	
Backlit LCD	2 lines X 16 characters, alpha numeric
LED	1 LED for status display
ENVIRONMENTAL	
Ambient temperature	-10 °C to +45 °C
Storage temperature	-55 °C to +85 °C
Humidity	95% Non Condensing
MECHANICAL	
Dimensions (L X W X D)	7.48 X 4.25 X 1.38 inches / 190 X 108 X 35 mm
Weight (With gift box)	1.2 lbs / 0.55Kg
Net weight	0.8 lb / 0.36 Kg
Enclosure / face plate	Powder coated steel, for indoor use only
ACCESSORIES INCLUDED	
Insulated spade lugs for input / output connections	4 pieces For # 8 stud; AWG 12-10 wire size
Self tapping screws for fixing the face plate	4 pieces 7X19, 5/8”; Type 25 point; Flat head; Philips drive

Specifications subject to change without notice

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WARRANTY

5 YEAR Limited Warranty

SCC-30AB manufactured by Samlex America, Inc. (the "Warrantor") is warranted to be free from defects in workmanship and materials under normal use and service. This warranty is in effect for 5 years from the date of purchase by the user (the "Purchaser").

For a warranty claim, the Purchaser should contact the place of purchase to obtain a Return Authorization Number.

The defective part or unit should be returned at the Purchaser's expense to the authorized location. A written statement describing the nature of the defect, the date of purchase, the place of purchase, and the Purchaser's name, address and telephone number should also be included.

If upon the Warrantor's examination, the defect proves to be the result of defective material or workmanship, the equipment will be repaired or replaced at the Warrantor's option without charge, and returned to the Purchaser at the Warrantor's expense.

No refund of the purchase price will be granted to the Purchaser, unless the Warrantor is unable to remedy the defect after having a reasonable number of opportunities to do so.

Warranty service shall be performed only by the Warrantor. Any attempt to remedy the defect by anyone other than the Warrantor shall render this warranty void.

There shall be no warranty for defects or damages caused by faulty installation or hook-up, abuse or misuse of the equipment including exposure to excessive heat, salt or fresh water spray, or water immersion.

No other express warranty is hereby given and there are no warranties which extend beyond those described herein. This warranty is expressly in lieu of any other expressed or implied warranties, including any implied warranty of merchantability, fitness for the ordinary purposes for which such goods are used, or fitness for a particular purpose, or any other obligations on the part of the Warrantor or its employees and representatives.

There shall be no responsibility or liability whatsoever on the part of the Warrantor or its employees and representatives for injury to any persons, or damage to person or persons, or damage to property, or loss of income or profit, or any other consequential or resulting damage which may be claimed to have been incurred through the use or sale of the equipment, including any possible failure of malfunction of the equipment, or part thereof.

The Warrantor assumes no liability for incidental or consequential damages of any kind.

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NOTES

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152-2009_SCC-30AB_Charge_Controller_Manual_Jan2010