

# Power Master Budget SERIES

## SOLAR CHARGE CONTROLLER 6Amp/10Amp/20Amp/30Amp Installation and Operation Manual



## USER MANUAL

### Solar Battery Charging

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# Chapter 1 Budget series Installation

## 1.1 Introduction

The Budget is an advanced design using a microcontroller for digital accuracy and fully automatic operation. PM-SCC-6AB can be used for 12V and PM-SCC-10AB, PM-SCC-20AB, PM-SCC-30AB can be used for 12V and 24V system for solar charging. The PWM battery charging has been optimized for longer battery life. Budget is designed for user-friendly operation. Please take the time to read this operator's manual and follow the instruction step by step to help you make full use of the charging system.

## 1.2 Safety Instruction

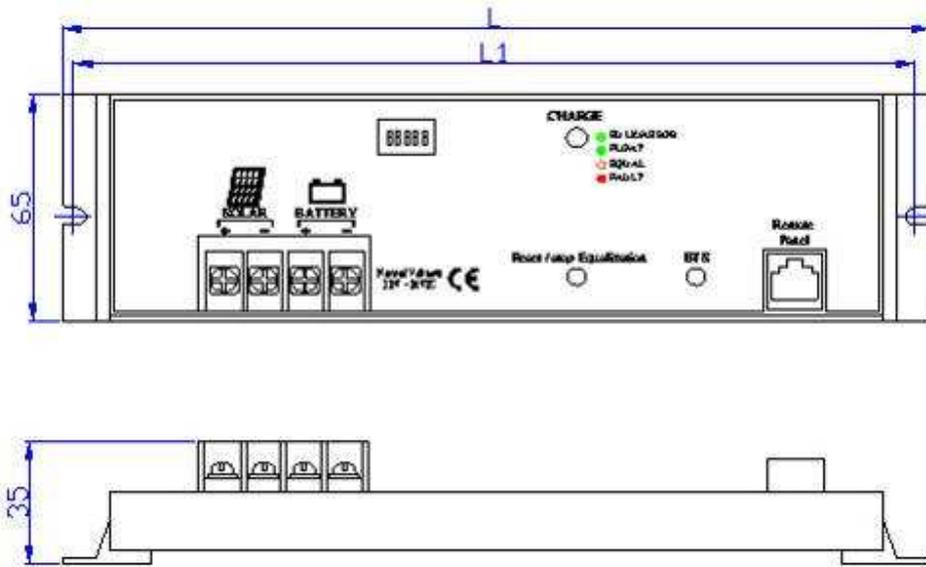
- This manual contains important instructions that should be followed during installation and maintenance of the Budget controller.
- Be very careful when working with batteries. Lead acid batteries can generate explosive gases, and short circuits can draw thousands of amps from the battery. Read all instructions provided with the battery.
- Do not exceed the rated current ratings of the controller.
- Do not exceed a battery voltage of 24V (nominal) for PM-SCC-10AB, PM-SCC-20AB, PM-SCC-30AB and 12V for PM-SCC-6AB. 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-CAD batteries when DIP Switch number 2~4 is in the ON position in the Budget.
- 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.
- Do not install a Budget in a sealed compartment with batteries.
- Never allow the solar array to be connected to the Budget with the battery disconnected. This can be a dangerous condition with high open-circuit solar voltage present at the terminals.
- Pressure terminal connectors are not required. Use only copperwire with minimum 75°C insulation rating and between 10 AWG (5.2 mm<sup>2</sup>) and 14 AWG (2.1 mm<sup>2</sup>) gage.
- The negative system conductor should be properly grounded. Grounding should comply with local codes.

### 1.3 Specifications

MODEL	PM-SCC-6AB	PM-SCC-10AB	PM-SCC-20AB	PM-SCC-30AB
<b>ELECTRICAL</b>				
System voltage ratings	12 Vdc	12, 24 Vdc		
Current ratings- <b>Battery Charge Control</b>	6A	10A	20A	30A
Accuracy	± 60 mV	12/24V: ≤0.1 % ± 50 mV		
Min. voltage to operate	6 V	9 V		
Max. solar array Voc	30 V	50 V		
Max. operating voltage	16 V	34 V		
Total current consumption	6 mA	9 mA		
High temp shutdown	N/A	90°C disconnect solar 70°C reconnect solar		
<b>BATTERY CHARGING / Built-in BTS</b>				
Charge algorithm	PWM, constant voltage			
Temp comp. coefficient	-5mV/°C / cell (25°C ref)	12V:-5mV/°C / cell (25°C ref) 24V:-10mV/°C / cell (25°C ref)		
Temp comp. range	0°C to +50°C			
Temp comp. setpoints	PWM setpoint: 14.1V	PWM, float, equalize (with BTS)		
<b>MECHANICAL</b>				
Weight	0.2 Kgs	0.3 Kgs	0.4 Kgs	
Power terminals	6A Rated	10A Rated	20A Rated	30A Rated
<b>ENVIRONMENTAL</b>				
Ambient temperature	-40 to +45°C			
Storage temperature	-55 to +85°C			
Humidity	100% (NC)			
Enclosure	Indoor & vented, (powder coated steel)			
<b>OPTIONS</b>				
Remote Panel	Optional LCD display for PM-SCC-30AB only			
Specifications subject to change without notice				

## 1.4 Mounting Dimension

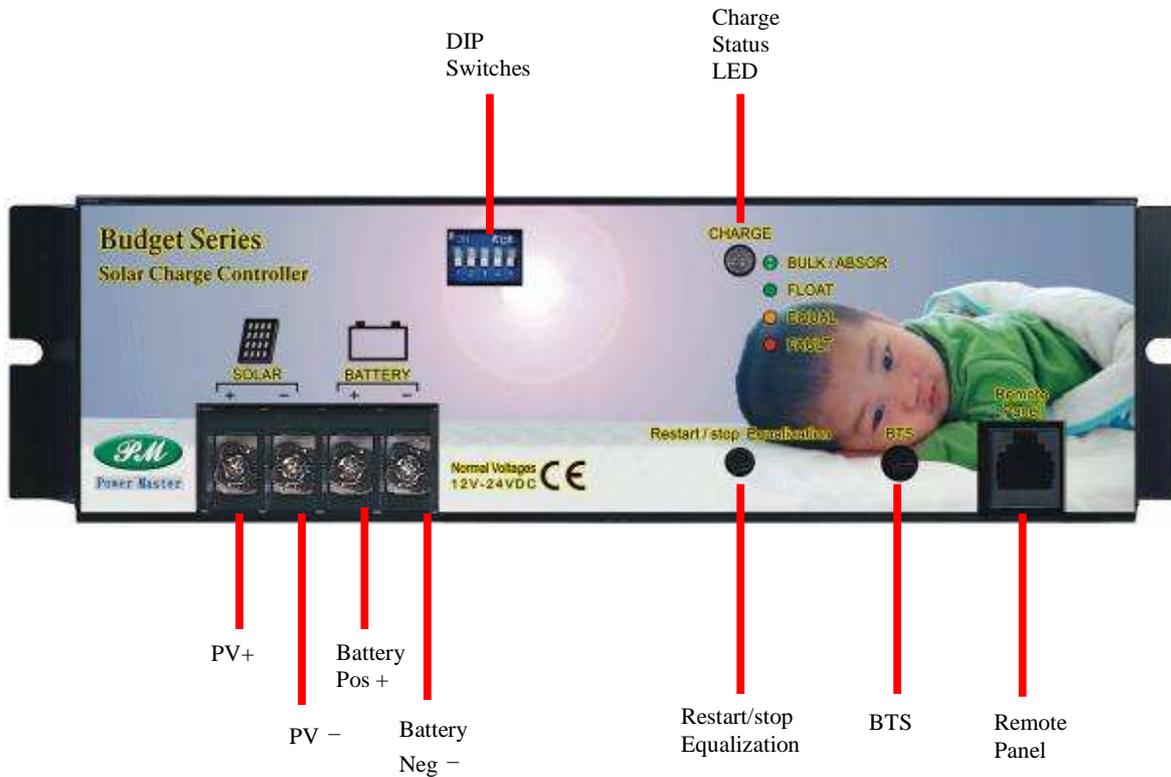
Unit: mm



Model \ Length	L	L1
PM-SCC-6AB	106 mm	99 mm
PM-SCC-10AB PM-SCC-20AB	168 mm	161 mm
PM-SCC-30AB	236 mm	229 mm

## 1.5 Installation Overview

The installation is straight forward but it is important that each step is done correctly and safely. A mistake can lead to dangerous voltage and current levels. Be sure to carefully follow the following instructions for all the terminal connection.



### Control Terminal Connection

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
There is no DIP switches for PM-SCC-6AB model.		
Remote Panel	Connecting port for the optional LCD remote panel for PM-SCC-30AB model	
BTS	Battery Temperature Sensor is built-in Budget for temperature compensation	

### LED Status Indicators

Charge Status LED	<b>Blinking Green:</b> Charging is in the state of Bulk or Absorption <b>Solid Green:</b> Charging is in the state of Float <b>Solid Orange:</b> Charging in the state of Equalization <b>Solid Red:</b> Charging in the state of fault: Over Current <b>Blinking Red:</b> Charging in the state of fault: Over Temp.
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**Push Buttons**

<i>PUSH</i> Restart/Stop Equalization	When there is a fault occurring, push Restart/Stop Equalization to reset it.
<i>HOLD</i> Restart/Stop Equalization	When DIP Switch 5 is set at OFF, hold Restart/Stop Equalization to manually start equalization and press it again to stop equalization.

❖ **Optional Remote LCD Meter for PM-SCC-30AB**

One Remote LCD Meter can be added to the PM-SCC-30AB at any time during or after installation. The display is a 2x16 LCD meter with backlighting. One pushbutton is used to scroll through the displays function.

There are a series of display screens that provide information such as:

- Operating information and data
- Reset Amp-Hours



## Chapter 2 Budget series Operation

### 2.1 Installation Steps

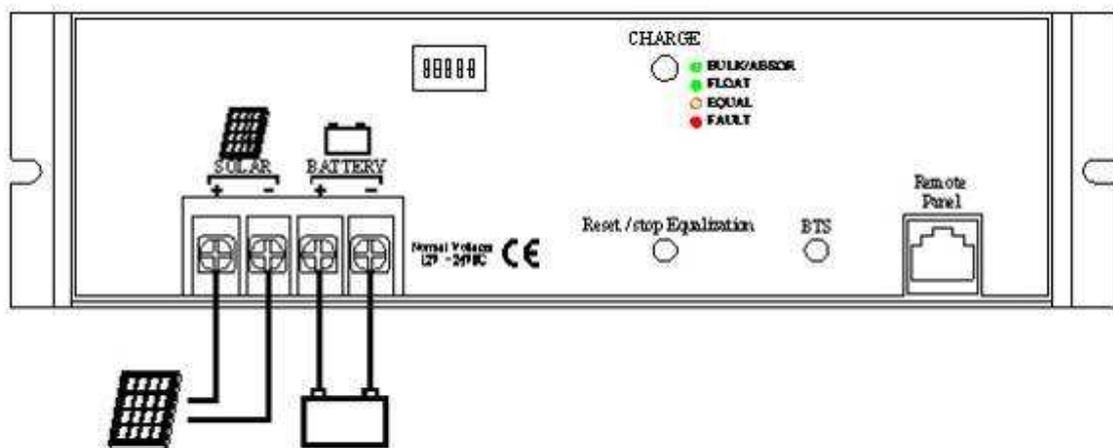
This section provides a brief overview of how to get started using the Budget controller. However, please review the entire manual to ensure best performance and years of trouble-free service.

#### NOTES:

- The Budget prevents reverse current leakage at night, so a blocking diode is not required in the system.
- The connector terminals will accept a maximum wire size of AWG #10 (up to 5.2 mm<sup>2</sup>). A flathead screwdriver is required. (Some #10 spade connectors may not fit in this terminal.)
- Tighten each terminal clamping screw to 20 inch-pounds of torque.
- The Budget is designed to regulate power from a PV array. Other generators can be connected directly to the battery, however, with no effect on the Budget.

#### STEPS:

1. Mount the Budget on to a vertical surface. Allow a minimum of 5 cm (2 inches) space above and below the controller for air flow.
2. Make sure the PV currents will not exceed the ratings of the Budget model being installed.
3. The connections to the Budget terminals are shown in the panel drawing.



4. 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** to properly start the microcontroller.
  - ✘ A battery below 10 volts may not start the microcontroller properly. Make sure the battery is charged before installing the system.
5. Connect the **SOLAR** (PV array) next. The green LED indicator will light if the array is connected during the daytime and the array is wired correctly.
  - ✘ Remember that the Solar array will generate power whenever in sunlight. Also, be

careful not to shortcircuit the PV array while connected to the controller, since this will damage the controller.

6. Set the DIP Switch 1 for the voltage system, set the DIP Switch 2, 3, 4 for battery charging algorithm.
7. For most effective surge protection, it is recommended that the negative system conductor be properly grounded.

### **Solar Battery Charging**

The energy output of a solar array is used for recharging the system battery.

The Budget manages the charging process to be efficient and to maximize the life of the battery. Charging includes a bulk charging stage, PWM absorption, float and equalization for **PM-SCC-10AB, PM-SCC-20AB and PM-SCC-30AB**.

## **2.2 Adjustability of Solar Battery Charging**

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

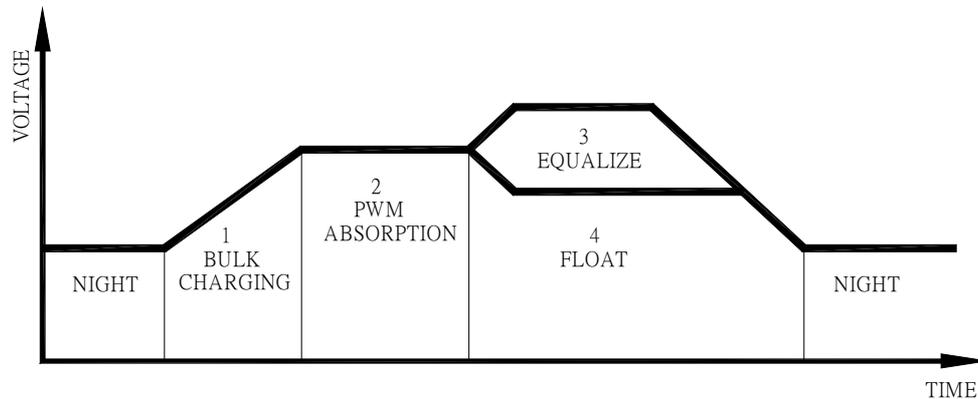
<b>DIP Switch</b>	<b>Solar battery charging</b>
1	Select Battery Voltage
ON	12V system
OFF	24V system
2~4	Standard battery charging programs
5	Select Auto/Manual Equalization
ON	Auto Equalization
OFF	Manual Equalization

### **PWM Battery Charging**

PWM (Pulse Width Modulation) battery charging is the most efficient and effective method for recharging a battery in a solar system.

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 Budget's battery charging is fully automatic, the following information is important for getting the best performance from your Budget controller and battery.

## Four Stages of Solar Charging



*Solar Charging Stages*

- 1. Bulk Charging:** In this stage, the battery will accept all the current provided by the solar system.
- 2. PWM Absorption:** When the battery reaches the regulation 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, level the cell voltages, and complete the chemical reactions.
- 4. Float:** When the battery is fully recharged, the charging voltage is reduced to prevent further heating or gassing of the battery.

### Battery Charging Notes

The Budget manages many different charging conditions and system configurations. Some useful functions to know follow 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 Temperature Compensation:** All charging setpoints are based on 25°C (77°F). If the battery temperature varies by 5°C, the charging will change by 0.15 volts for a 12 volt battery. This is a substantial change in the charging of the battery.

**Battery Types:** The Budget’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 Budget 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-cad etc.

The table below summarizes the major parameters of the standard charging algorithms. Note that all the voltages are for 12V systems (24V = 2X).

**All values are 25°C (77°F).**

<b>DIP Switches (2-3-4)</b>	<b>A Battery Type</b>	<b>B Bulk Voltage</b>	<b>C Float Voltage</b>	<b>D Equalize Voltage</b>	<b>E Equalize Time (hours)</b>	<b>F Equalize Interval (days)</b>
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-NiCad	16.0	14.5	None	-	-

***Standard Battery Charging Programs***

**A. Battery Type**– These are generic lead-acid and Ni-cad battery types.

**B. BULK Voltage**–This is the PWM Absorption stage with constant voltage charging. The “PWM 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.

**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. This may take more than one day to complete.

**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.

**Temperature Effects**

**Battery Temperature Sensor (BTS)**

A sensor next to the remote panel is used for temperature compensated battery charging.

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 may be important to adjust the charging for temperature changes.

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 BTS corrects the three charging setpoints noted above by the following values:

- 12 volt battery:  $-0.030$  volts per  $^{\circ}\text{C}$  ( $-0.017$  volts per  $^{\circ}\text{F}$ )
- 24 volt battery:  $-0.060$  volts per  $^{\circ}\text{C}$  ( $-0.033$  volts per  $^{\circ}\text{F}$ )

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  $10^{\circ}\text{C}$  ( $50^{\circ}\text{F}$ ) this  $15^{\circ}\text{C}$  ( $27^{\circ}\text{F}$ ) change in temperature will change the PWM, equalization and float setpoints by  $0.90\text{V}$  in a  $24\text{V}$  system.

Temperature	12 Volt	24 Volt
$50^{\circ}\text{C} / 122^{\circ}\text{F}$	$-0.75\text{ V}$	$-1.50\text{ V}$
$45^{\circ}\text{C} / 113^{\circ}\text{F}$	$-0.60\text{ V}$	$-1.20\text{ V}$
$40^{\circ}\text{C} / 104^{\circ}\text{F}$	$-0.45\text{ V}$	$-0.90\text{ V}$
$35^{\circ}\text{C} / 95^{\circ}\text{F}$	$-0.30\text{ V}$	$-0.60\text{ V}$
$30^{\circ}\text{C} / 86^{\circ}\text{F}$	$-0.15\text{ V}$	$-0.30\text{ V}$
$25^{\circ}\text{C} / 77^{\circ}\text{F}$	$0\text{ V}$	$0\text{ V}$
$20^{\circ}\text{C} / 68^{\circ}\text{F}$	$+0.15\text{ V}$	$+0.30\text{ V}$
$15^{\circ}\text{C} / 59^{\circ}\text{F}$	$+0.30\text{ V}$	$+0.60\text{ V}$
$10^{\circ}\text{C} / 50^{\circ}\text{F}$	$+0.45\text{ V}$	$+0.90\text{ V}$
$5^{\circ}\text{C} / 41^{\circ}\text{F}$	$+0.60\text{ V}$	$+1.20\text{ V}$
$0^{\circ}\text{C} / 32^{\circ}\text{F}$	$+0.75\text{ V}$	$+1.50\text{ V}$

### ***Temperature Compensation***

### **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 from equalizations 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.**

**Standard Equalization Programs**

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

**Manual Equalization**

The Budget 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 or stop a manual equalization. Hold the pushbutton down for 5 seconds to start or 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 pushbutton can be used to start and stop equalizations in both the manual and automatic mode.

### **Typical Equalizations**

The automatic equalizations will occur at the selected charging program from DIP Switch 2~4. When an equalization begins (auto or manual), the battery charging voltage increases up to the equalization voltage ( $V_{eq}$ ). The battery will remain at  $V_{eq}$  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 two 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 an equalization is completed, charging will return to PWM absorption.

### **When to Equalize**

The ideal frequency of equalizations depends on the battery type (leadcalcium, 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 an 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.

### **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.

## **2.3 Troubleshooting**

The Budget 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 Budget controller is simple. Some basic troubleshooting procedures are listed below.

### **CAUTIONS:**

1. Troubleshooting should be done by qualified personnel only.
2. Remember that a battery can cause serious damage if shorted.
3. There are no user serviceable parts, fuses or circuit breakers inside the Budget.
4. Observe all normal precautions when working with energized circuitry.

### **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 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 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 unable to maintain its voltage, the battery may be failing.
- Measure the PV voltage and the battery voltage at the Budget 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.

### **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 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. Reconnect the battery terminal and leave the PV array disconnected. The Green charging light should not be lit. Measure the voltage at the SOLAR terminals (with the array still disconnected). If the Green charging light is on or battery voltage is measured at the SOLAR terminals, the controller may be damaged.