



**INDUSTRIAL  
CONTROL DIRECT**  
A BSD Industrial Company



# Solar Cube

## Precision Solar Tracking & Measurement

### Setup and Installation

SCSIM-REV01121212



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## Welcome to Solar Cube!

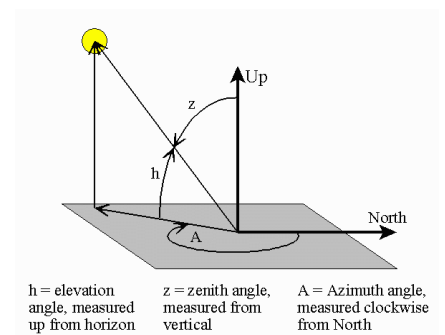
There is a requirement to optimise the amount of energy produced by a solar panel, assuming the solar panel can be positioned. This can be achieved by tracking the sun across the sky, positioning the solar panel to face it. The **Solar Cube** Controller will be used to control one or two motors to angle the solar panel correctly, depending on number of axis required.

The sun position calculation depends on the current time and date as well as the longitude and latitude giving the location of the solar panel. The results of this calculation are the 'zenith angle' and the 'azimuth angle', which together exactly specifies the current position of the sun in the sky.

**Solar Cube** is an off the shelf product which can perform this calculation. To position the solar panel the unit uses feedback from an electronic compass device connected on RS485 to power motors until the correct position is reached. The compass would simply be mounted on the solar panel frame.

No expensive encoders are required for position control. We simply fire the outputs until the array is motored to the correct position. The compass tells us where we are facing.

**Solar Cube** also offers data logging facilities using its own internal Micro SD card. Power output can be logged continually to produce daily, monthly and yearly figures. Revenues can be calculated along with CO2 avoidance figures.



## Warranty and Limitation of Liability



IMO Precision Controls Ltd. warrants to the original purchaser that the *Solar Cube* module is free from defects in material and workmanship under normal use and service. The obligation of IMO under this warranty shall be limited to the repair or exchange of any part or parts which may prove defective under normal use and service within three (3) years from the date of purchase, such defect to be disclosed to the satisfaction of IMO after examination by IMO of the allegedly defective part or parts. THIS WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED INCLUDING THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR USE AND OF ALL OTHER OBLIGATIONS OR LIABILITIES AND IMO NEITHER ASSUMES, NOR AUTHORIZES ANY OTHER PERSON TO ASSUME FOR IMO, ANY OTHER LIABILITY IN CONNECTION WITH THE SALE OF THIS *Solar Cube* MODULE. THIS WARRANTY SHALL NOT APPLY TO THIS *Solar Cube* MODULE OR ANY PART THEREOF WHICH HAS BEEN SUBJECT TO ACCIDENT, NEGLIGENCE, ALTERATION, ABUSE, OR MISUSE. IMO MAKES NO WARRANTY WHATSOEVER IN RESPECT TO ACCESSORIES OR PARTS NOT SUPPLIED BY IMO. THE TERM "ORIGINAL PURCHASER", AS USED IN THIS WARRANTY, SHALL BE DEEMED TO MEAN THAT PERSON FOR WHOM THE *Solar Cube* MODULE IS ORIGINALLY INSTALLED. In no event, whether as a result of breach of contract, warranty, tort (including negligence) or otherwise, shall or its suppliers be liable of any special, consequential, incidental or penal damages including, but not limited to, loss of profit or revenues, loss of use of the products or any associated equipment, damage to associated equipment, cost of capital, cost of substitute products, facilities, services or replacement power, down time costs, or claims of original purchaser's customers for such damages.

**To obtain warranty service, return the product to your distributor with a description of the problem, proof of purchase, post paid, insured and in a suitable package.**

## Use of Pre-Installed Software

Due to the many variables and requirements associated with any particular installation, IMO Precision Controls Ltd. cannot assume responsibility or liability for actual use based on the pre-installed software in the *Solar Cube* module. It is the sole responsibility of the system designer utilizing the *Solar Cube* module to appropriately design the end system, to appropriately integrate the *Solar Cube* module and to make safety provisions for the end equipment as is usual and customary in industrial applications as defined in any codes or standards which apply.

## Safety / Compliance

### Safety Warnings and Guidelines

When found on the product, the following symbols specify:

- All applicable codes and standards need to be followed in the installation of this product.
- For I/O wiring (discrete), use the following wire type or equivalent: Belden 9918, 18 AWG or larger.

Adhere to the following safety precautions whenever any type of connection is made to the module.

- Connect the green safety (earth) ground first before making any other connections.
- When connecting to electric circuits or pulse-initiating equipment, open their related breakers. Do not make connections to live power lines.
- Make connections to the module first; then connect to the circuit to be monitored.
- Route power wires in a safe manner in accordance with good practice and local codes.
- Wear proper personal protective equipment including safety glasses and insulated gloves when making connections to power circuits.
- Ensure hands, shoes, and floor is dry before making any connection to a power line.
- Make sure the unit is turned OFF before making connection to terminals. Make sure all circuits are de-energized before making connections.
- Before each use, inspect all cables for breaks or cracks in the insulation. Replace immediately if defective.

### Grounding

Grounding is covered in various chapters within this manual.

### CE Compliance

To check for compliance and updates, visit our website at: [www.imopc.com](http://www.imopc.com)



**Warning:** Consult user documentation.



**Warning:** Electrical Shock Hazard.

**WARNING:** To avoid the risk of electric shock or burns, always connect the safety (or earth) ground before making any other connections.

**WARNING:** To reduce the risk of fire, electrical shock, or physical injury it is strongly recommended to fuse the voltage measurement inputs. Be sure to locate fuses as close to the source as possible.

**WARNING:** Replace fuse with the same type and rating to provide protection against risk of fire and shock hazards.

**WARNING:** In the event of repeated failure, do not replace the fuse again as a repeated failure indicates a defective condition that will not clear by replacing the fuse.

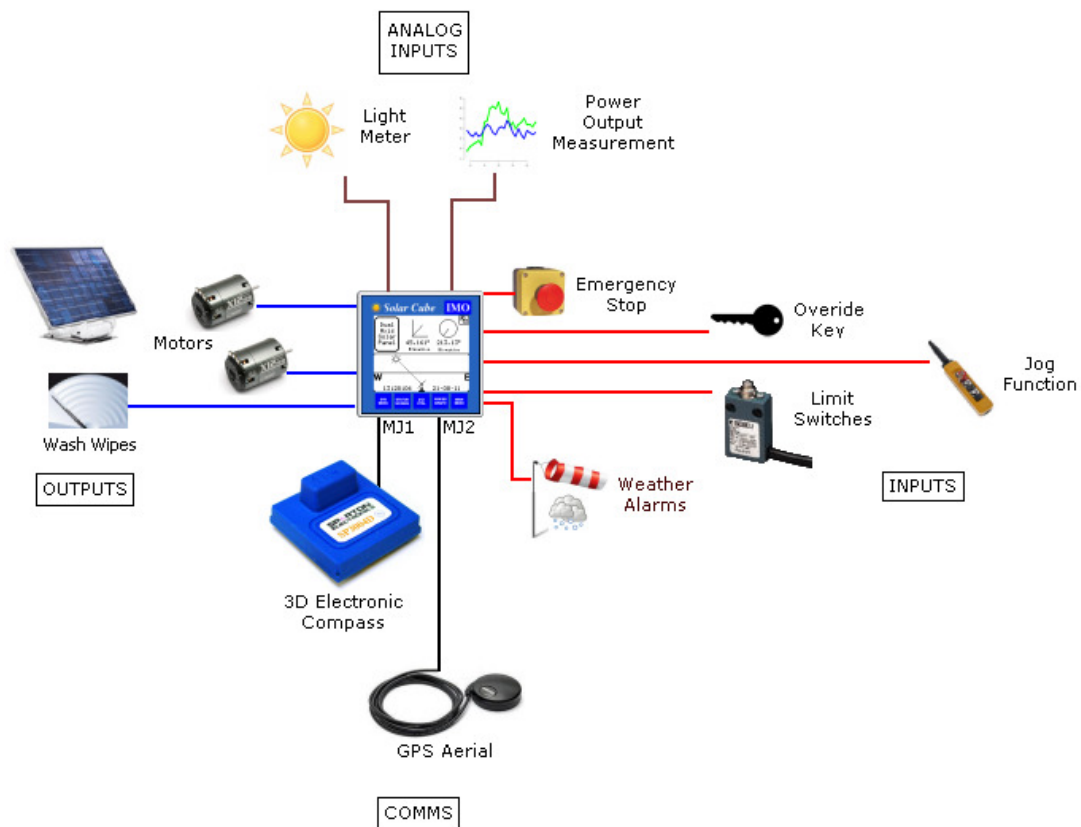
**WARNING:** Only qualified electrical personnel familiar with the construction and operation of this equipment and the hazards involved should install, adjust, operate, or service this equipment. Read and understand this manual and other applicable manuals in their entirety before proceeding. Failure to observe this precaution could result in severe bodily injury or loss of life.



## System Components

Solar Cube is a standalone controller which can be wired to the motors of a single or dual axis solar panel using four of its relay outputs. The only additional item which is required for a basic system is the electronic compass, part number **COMPASS-485**, available from IMO.

The other items shown in the diagram below are optional enhancements, many of which can be supplied by IMO also.



The following pages introduce each of these peripherals in turn:

## ***Electronic Compass***

The electronic compass connects to the Solar Cube using RS485 serial communications. RS485 is used rather than RS232 to allow the system control box to be further away from the solar array if required. RS232 would be limited to 15m, but RS485 allows the compass to be up to 1500m away!

The compass is contained within a small plastic box, which mounts on the frame of the solar array. The mounting position is discussed later, but is required to be mounted on a movable part of the frame.

The compass requires a 5V DC supply and a communications feed using two wire twisted pair shielded cable. This cable must be weather proof. It is recommended that the power supply for the compass is mounted within a weather proof enclosure and that the cable run from the main control box joins with the compass wiring in the enclosure also.

The compass is not optional and is an integral part of the *Solar Cube* system.

Request part number **COMPASS-485** from IMO.



## ***GPS Aerial***

The GPS aerial can be mounted near to the *Solar Cube* unit, perhaps on top of the control panel. It connects via RS232 to the *Solar Cube*. The cable attached to it has an RJ-45 connector which plugs directly in to the MJ2 serial port on the *Solar Cube* unit.

It has two functions; the first is to accurately set the longitude and latitude of the installation. This is a fundamental part of the system configuration and is a one-time operation during commissioning. The second is to keep the *Solar Cube* internal clock accurately set on a daily update.

Request part number **i3GPS** from IMO





### **Override Key and Jog Function**

It is possible to move the position of the solar array manually using either the touch screen and software buttons, or hardwired push buttons. Four buttons to motor the array up, down, left or right can be wired to inputs 2 to 5 respectively. The override key is used to enable the use of the buttons and overrides the automatic operation of the array. The buttons could be mounted on the control cabinet or on a pendant control.

The override key and jog buttons are optional and if not wired the inputs will be in an OFF state.

IMO have a range of enclosures, key switches and contacts. Recommended are Enclosure **BG1**, Contact **B4TU20** and Key Switch **B3SAR0**.



For the jog push buttons use part number **BS3DT-WHITE/BLACK** with contacts **B4TU20**.



### **Emergency Stop**

An emergency stop push button can be wired in to an input. When the input is powered the system will stop instantly, all four outputs which motor the array will be held off until the emergency stop button is reset.

The emergency stop button is optional. If not present the input will be in an OFF state.

IMO have a range of enclosures, emergency stop buttons and contacts. Recommended are Enclosure **BG1**, Contact **B4TU20** and Emergency Stop Push Button **BS3P45RED**.



## **Limit Switches**

Limit switches provide a safety cut out if the array has motored beyond its physical limits in any one particular direction. Four limit switches can be installed, one for each direction if required. When a limit switch is activated then the associated direction output will be held off until the limit switch is turned off, meaning the Array will cease to motor in that direction.

If a single axis system is being installed only the UP and DOWN limit switches will be required.

The limit switches are optional and if not connected the inputs will be in an OFF state.

IMO have a range of compact and heavy duty limit switches, types FM/FR/FZ/FX. Please ask IMO for details.



## **Weather Alarms**

Two digital inputs are available for weather alarms. These are for windy and icy conditions. In both cases it is assumed a digital sensor is used which is ON for an alarm condition and OFF in the normal case.

When icy conditions are detected the panel will be tipped up to a vertical position and held there until the alarm condition has gone away. If the system is dual axis then the panel will continue to motor LEFT and RIGHT and track the sun as best it can. The idea here is to stop snow settling on to the panel and the weight causing damage.

When windy conditions are detected then the panel will move to a horizontal position and held there until the alarm condition has gone away. The panel will not continue to move LEFT and RIGHT in the case of a dual axis system as there would be little point to this movement.

The sensors are optional, if not wired then the two inputs will be OFF and not in alarm.

## **Current Transformer Input**

The first analog input on the *Solar Cube* unit is used to measure the power output signal from the Solar Array. This allows the system to display and log the power produced. The input is 0-10V from a Current Transformer (CT) mounted around the Solar Inverter AC output. The Current Transformer would need to feed into a signal conditioner to create a steady 0-10V signal. Assuming a fixed current, the input provides a reading in Watts of power being produced at that instant.

Other options are available from IMO on request. *Solar Cube* can support a 4-20mA or 0-20mA signal if required. Alternatively, if the Solar Inverter used by the Array supports serial communications, then a serial protocol option could be developed. Please ask IMO for further details.

The input is optional, but if not present it is not possible for the *Solar Cube* to log or monitor the power produced by the Array.

The Current Transformer (CT) used depends on the current and voltage produced by the Array's Inverter. Please ask IMO for a recommended part depending on your requirements.

IMO recommend Signal Conditioner **Voltcon – FC**. Again please ask IMO for further details.



### **Light Meter Input**

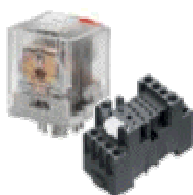
The second analog input on the *Solar Cube* again is 0-10V, and allows input from a light meter. This is used by the *Solar Cube* to automatically adjust the solar tracking algorithm according to current lighting conditions. The Solar Array needs to move less when it is cloudy and more when it is sunny.

The input is optional, if not installed the *Solar Cube* will employ a fixed light level tracking algorithm. The error factor used by the algorithm could be seasonally adjusted manually.

### **Motor Outputs**

There are four outputs from the *Solar Cube* which power motors for UP, DOWN, LEFT and RIGHT. All four outputs are used for a dual axis system, only UP and DOWN are used for a single axis system. The outputs must be wired to relays and should not be directly connected to the Array motors. It is cheaper to replace a relay if a problem should occur than repair the *Solar Cube* controller itself.

IMO recommend Relay RS2PN and Base SRR8 for this application. However the relay used will depend on the current rating of your motors. Please ask IMO for further details.

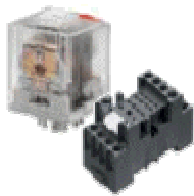


## ***Washer Outputs***

Solar Cube has a single output which can be used to power a washer pump to clean the Solar Array daily. The hour which this is activated is configurable along with the length of time the washer powers for. It is desirable to clean the solar array daily for maximum power production, especially in a dusty environment. The washer output is however optional.

Like the motor outputs, the washer output should be wired to a relay and not directly connected to the washer pump motor.

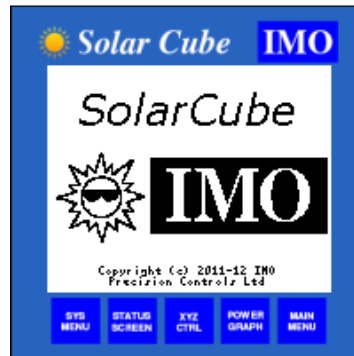
IMO recommend Relay RS2PN and Base SRR8 for this application. However the relay used will depend on the current rating of your washer pump. Please ask IMO for further details.



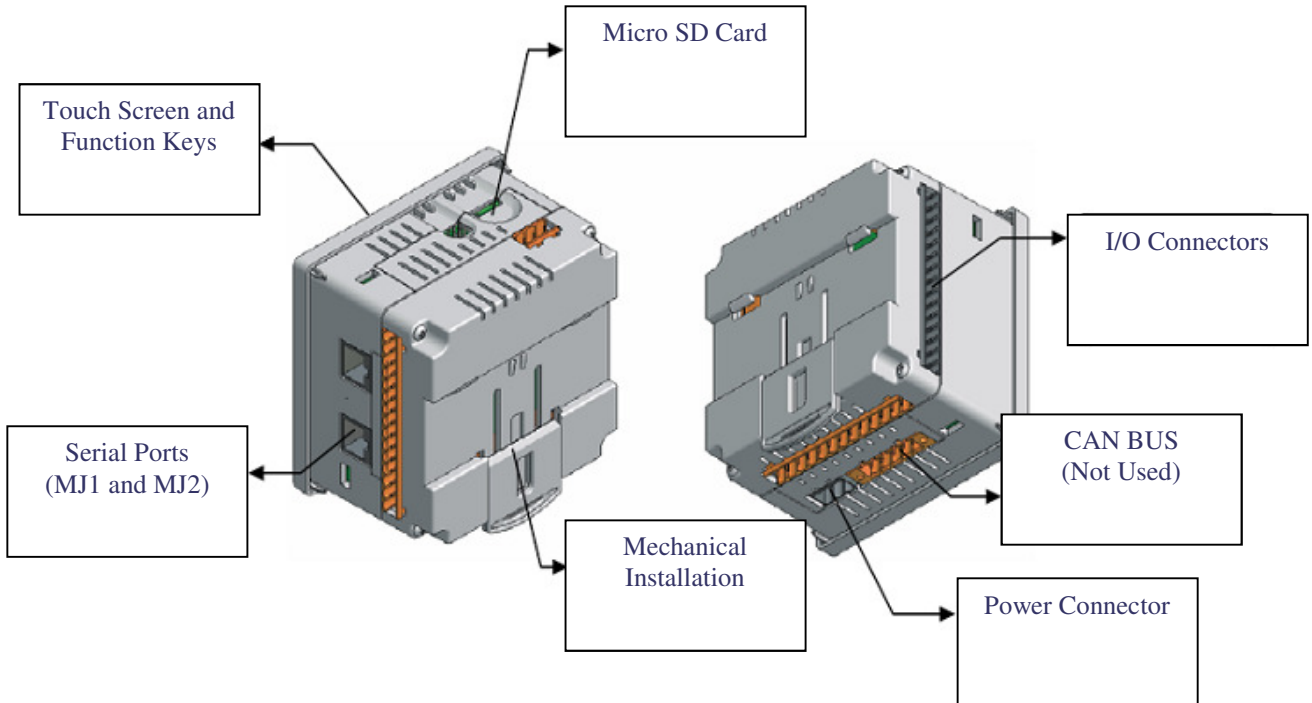
# Solar Cube Installation

## Visual Overview

Front View:

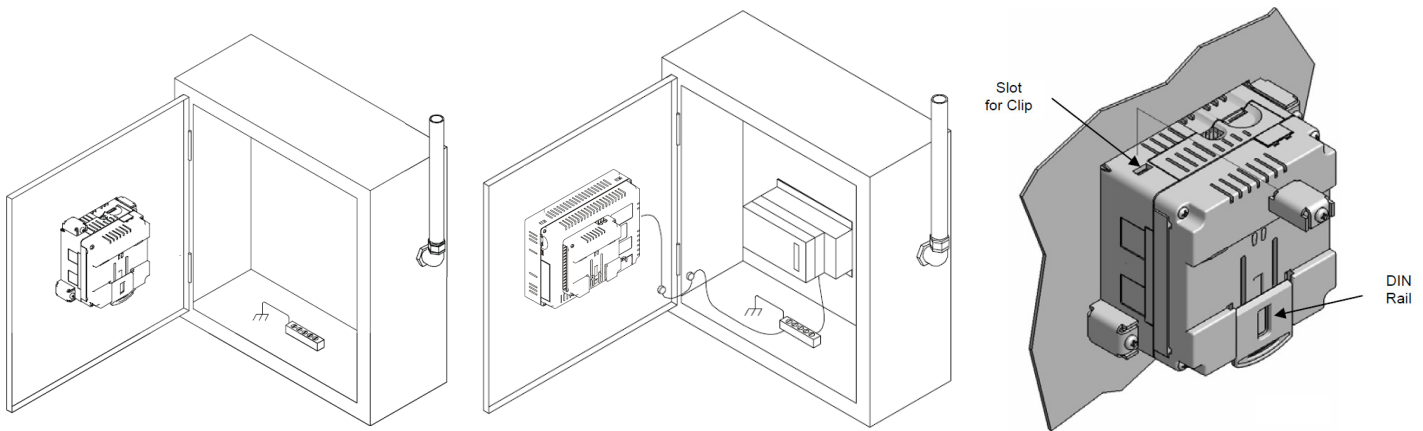


Side and Rear Views:



## Mechanical Installation

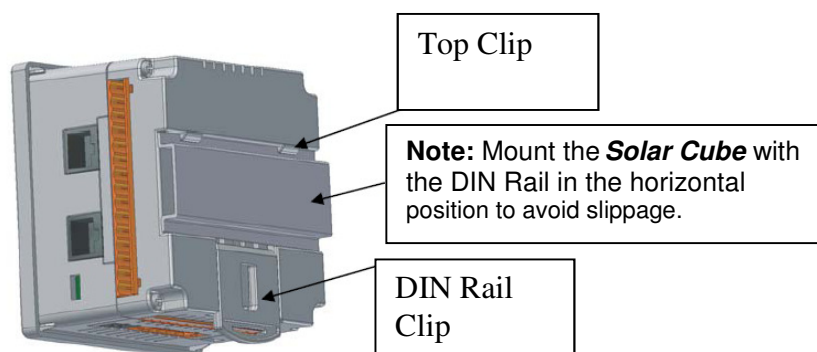
### Mounting Procedures (Installed in a Panel Door):



Once the panel design has been completed using the criteria and suggestions in the following sections, use the following steps to panel mount the **Solar Cube**:

1. Remove all connectors from the **Solar Cube** unit.
2. Make sure the gasket is installed on the **Solar Cube** and is free from dust and debris. Check that the corners of the gasket are secure.
3. Pass the unit through the panel.
4. Insert the each of the four (4) mounting clips into the slots in the **Solar Cube** case. One clip should be installed on each corner. Lightly tighten each screw so the clip is held in place.
5. Tighten the screws on the clips such that the gasket is compressed against the panel.

### Mounting Procedures (Installed on DIN Rail):



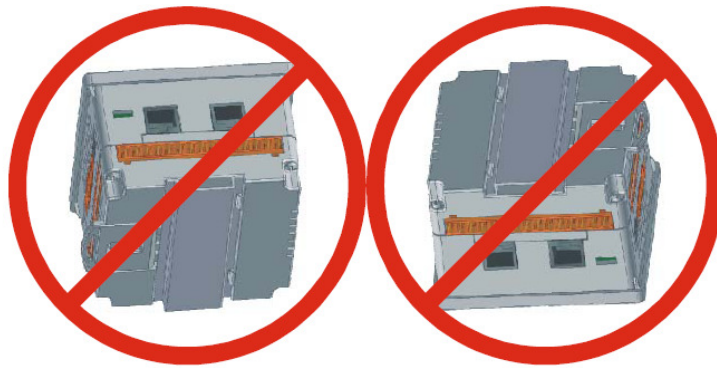
The **Solar Cube** is designed to clip onto standard 35 millimeter DIN rail. If your installation requires liquid or dust protection, make sure the **Solar Cube** is placed in an appropriate sealed panel when mounting on DIN rail. Use the following steps to mount the **Solar Cube** on DIN rail.

1. Move the DIN rail clip to the lower position.



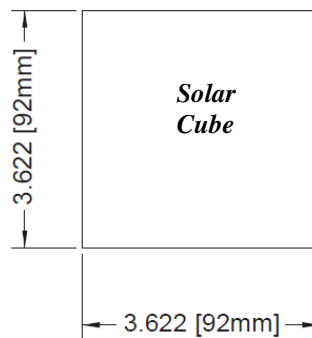
2. Clip the “Top Clips” on the top of the DIN rail.
3. Press the unit into place and press the DIN rail clip up. A small flat-head screwdriver can be used in the slot of the DIN rail clip if clearance is an issue.

**Mounting Orientation:**

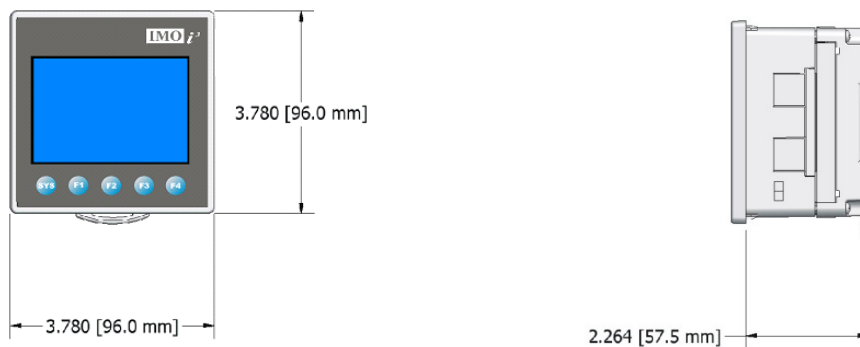


**NOTE:** There are NO orientation restrictions on the *Solar Cube*. However, the above orientation provides for optimum readability of the screen and ease of use of the keypad.

**Panel Cut Out:**



**Dimensions:**



## ***Factors Affecting Panel Layout Design and Clearances***

The designer of a panel layout needs to assess the requirements of a particular system and to consider the following design factors.

### ***Clearance / Adequate Space***

Install devices to allow sufficient clearance to open and close the panel door.

<b>Minimum Clearance Requirements for Panel Box and Door</b>	
Minimum Distance between base of device and sides of cabinet	2 inches (50.80mm)
Minimum Distance between base of device and wiring ducts	1.5 inches (38.10mm)
If more than one device installed in panel box (or on door): Minimum Distance between bases of each device.	4 inches between bases of each device (101.60mm)
When door is closed: Minimum distance between device and closed door (Be sure to allow enough depth for the <i>Solar Cube</i> .)	2 inches (50.80mm)

### ***Grounding***

Panel box: The panel box needs to be properly connected to earth ground to provide a good common ground reference.

Panel door: Tie a low impedance ground strap between the panel box and the panel door to ensure that they have the same ground reference.

### ***Temperature / Ventilation***

Ensure that the panel layout design allows for adequate ventilation and maintains the specified ambient temperature range. Consider the impact on the design of the panel layout if operating at the extreme ends of the ambient temperature range. For example, if it is determined that a cooling device is required, allow adequate space and clearances for the device in the panel box or on the panel door.

**WARNING: It is important to follow the requirements of the panel manufacturer and to follow all applicable electrical codes and standards.**

**WARNING: Be sure to meet the ground requirements of the panel manufacturer and also meet applicable electrical codes and standards.**

### ***Orientation***

When panel-mounted, there are no orientation restrictions on the *Solar Cube*.

### ***Noise***

Consider the impact on the panel layout design and clearance requirements if noise suppression devices are needed. Be sure to maintain an adequate distance between the *Solar Cube* and noisy devices such as relays, motor starters, etc.

### ***Shock and Vibration***

The ***Solar Cube*** has been designed to operate in typical industrial environments that may inflict some shock and vibration on the unit. For applications that may inflict excessive shock and vibration please use proper dampening techniques or relocate the ***Solar Cube*** to a location that minimizes shock and/or vibration.

### ***Panel Layout Design and Clearance Checklist***

The following list provides highlights of panel layout design factors:

- ✓ Meets the electrical code and applicable standards for proper grounding, etc.?
- ✓ Meets the panel manufacturer's requirements for grounding, etc.?
- ✓ Is the panel box properly connected to earth ground? Is the panel door properly grounded? Has the appropriate procedure been followed to properly ground the devices in the panel box and on the panel door?
- ✓ Are minimum clearance requirements met? Can the panel door be easily opened and closed? Is there adequate space between device bases as well as the sides of the panel and wiring ducts?
- ✓ Is the panel box deep enough to accommodate the ***Solar Cube***?
- ✓ Is there adequate ventilation? Is the ambient temperature range maintained? Are cooling or heating devices required?
- ✓ Are noise suppression devices or isolation transformers required? Is there adequate distance between the base of the ***Solar Cube*** and noisy devices such as relays or motor starters? Ensure that power and signal wires are not routed in the same conduit.
- ✓ Are there other requirements that impact the particular system, which need to be considered?

## Electrical Installation

**Note:** Each *Solar Cube* unit is sent with a datasheet in the box. **The datasheet is the first document you need to refer to for model-specific information related to *Solar Cube* models such as pin-outs, jumper settings, and other key installation information.** The web version of this manual has all of the *Solar Cube* datasheets attached to it. Visit our website to obtain datasheets, user documentation, and updates.

### Grounding Definition

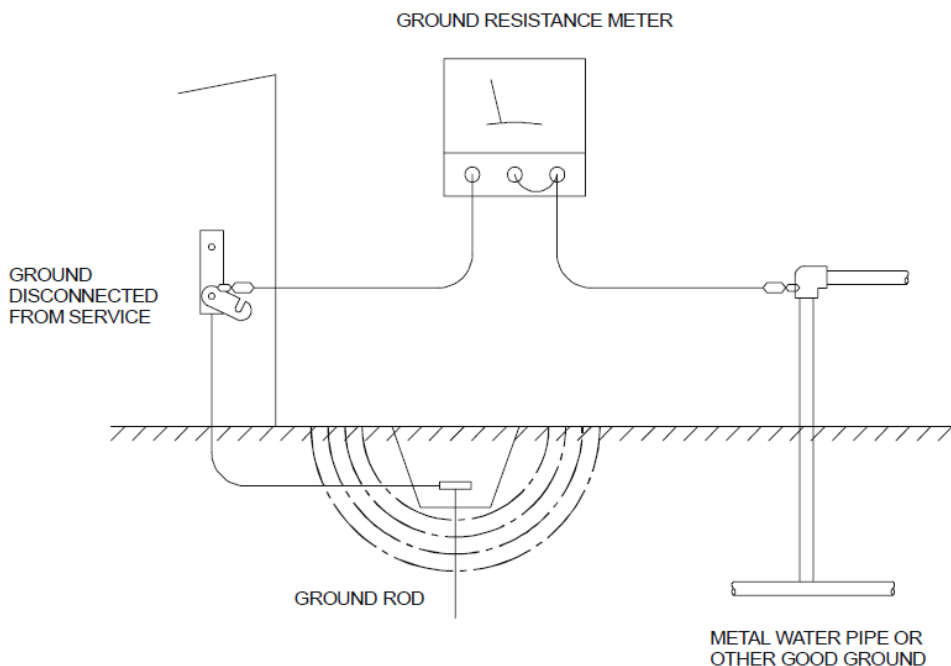
**Ground:** The term *Ground* is defined as a conductive connection between a circuit or piece of equipment and the earth. Grounds are fundamentally used to protect an application from harmful interference causing either physical damage such as by lightning or voltage transients or from circuit disruption often caused by radio frequency interference (RFI).

### Ground Specifications

Ideally, a ground resistance measurement from equipment to earth ground is 0 ohms. In reality it typically is higher. IMO recommends *less than fifteen (15) ohms* resistance from our equipment to ground. Resistance *greater than twenty-five (25) ohms* can cause undesirable or harmful interference to the device.

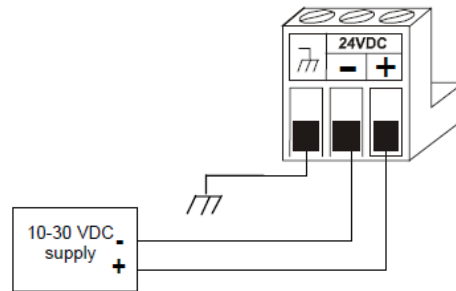
### How to Test for Acceptable Ground

In order to test ground resistance, a Ground Resistance Tester must be used. A typical Ground Resistance Meter Kit contains a meter, two or three wire leads, and two ground rods. Instructions are supplied for either a two-point or three-point ground test. The figure below shows a two-point ground connection test:



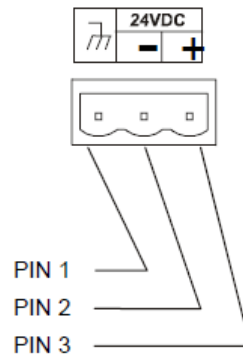
**Primary Power Port**

Primary Power Port Pins		
Pin	Signal	Description
1	GND	Frame Ground
2	0V	Input power supply ground
3	+24V	Input power supply positive voltage



**Power Connector**

**Power Up:**  
Connect to Earth Ground.  
Apply 10 – 30 VDC.  
Screen lights up.  
Torque rating 4.5 - 7 Lb-In  
(0.50 – 0.78 N-m)



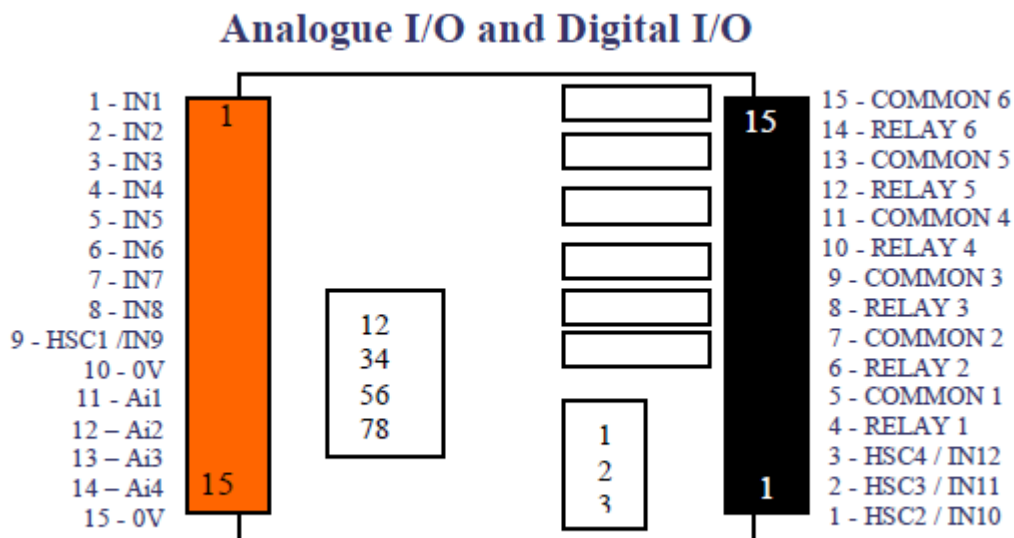
### Inputs and Outputs

The *Solar Cube* is a compact unit that contains high density, very versatile I/O. Using the I/O properly requires wiring to the proper terminals. This section will offer some tips and suggestions to help you accomplish this.

The Solar Cube unit has a total of 12 digital inputs, 6 relay outputs and 4 analog inputs. These are allocated as follows:

Input	Function	Output	Function
I1	Override Key	Q1	Motor Up
I2	Jog Up	Q2	Motor Down
I3	Jog Down	Q3	Motor Left
I4	Jog Left	Q4	Motor Right
I5	Jog Right	Q5	Washer
I6	Emergency Stop	Q6	Compass Control
I7	Limit Switch Up		
I8	Limit Switch Down		
I9	Limit Switch Left		
I10	Limit Switch Right		
I11	Wind Alarm		
I12	Ice Alarm		
A11	Current Transformer Input (0-10V)		
A12	Light Meter Input (0-10V)		
A13	Not Used		
A14	Not Used		

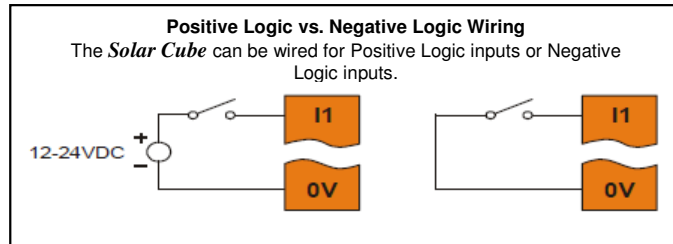
The following shows the locations of these inputs and outputs on the unit itself:





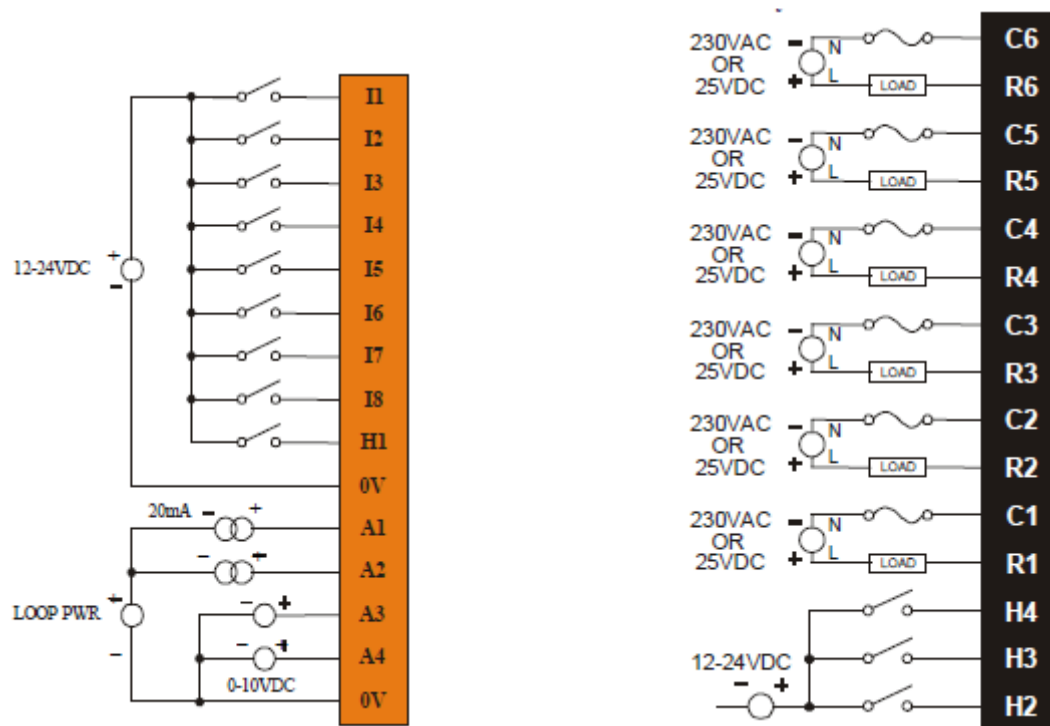
## Wiring Digital Inputs

**Note:** The digital inputs on the *Solar Cube* are designed for low voltage DC inputs. The inputs are designed to support both positive and negative input modes; however the software is configured for only positive logic. If you require negative logic inputs then please contact IMO for further details.



In positive logic mode a positive voltage applied to the input will turn the input. The internal design of this mode is basically a resistor from the input to I/O ground. This mode is sometimes called sourcing. In negative logic mode, connecting the input to the I/O ground or zero volts will turn the input on. The internal design of this mode is basically a resistor from the input to the positive I/O voltage (usually 12 or 24 volts). This mode is sometime called sinking. Some of the digital inputs may support high-speed input functional such as counting or frequency measurement.

The following shows the wiring for the inputs:



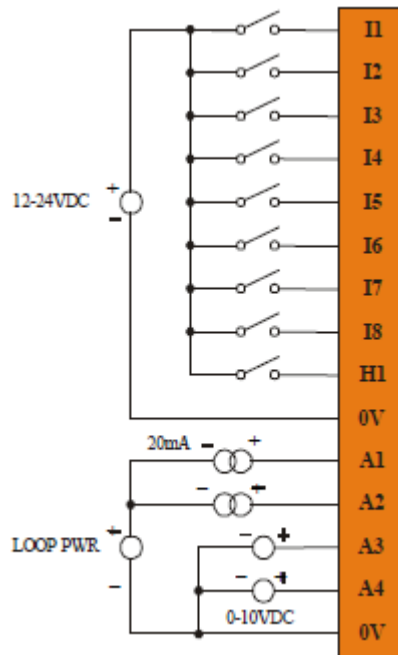
Inputs 1-8 are marked I1-I8. Input 9 is marked 'H1' on the orange connector, this is because it can also be used as a high speed counter in other applications. Inputs 10-12 are on the black

connector at the bottom and are labelled H2-H4. Again, this is because they can also be high speed counters in other applications.

### Wiring Analog Inputs

The analogue inputs on the *Solar Cube* allow voltage or current measurement from a Current Transformer on input 1 and a Light Meter on input 2. Both the software and the unit are initially configured for 0-10V inputs on both devices. If you require either of these devices to be current based then please contact IMO for assistance.

Connection of AI1 and AI2 is shown below:



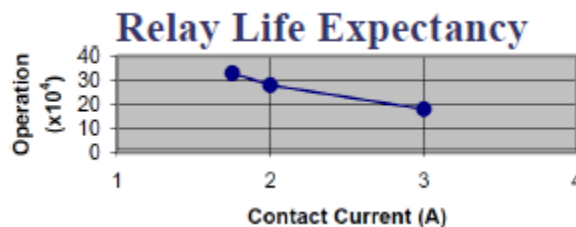
## Wiring Relay Outputs

Relay outputs are designed to switch loads that typically have high voltage or current requirements or require isolation that relays provide.

*Note: The design of the **Solar Cube** does not require external coil power for the relays to function. The relays will activate anytime the **Solar Cube** is powered.*

There are several factors that should be considered when using relays.

**Relay Life** – Relays are mechanical devices that have a long but limited life. Typically, switching more current limits the life of relays.



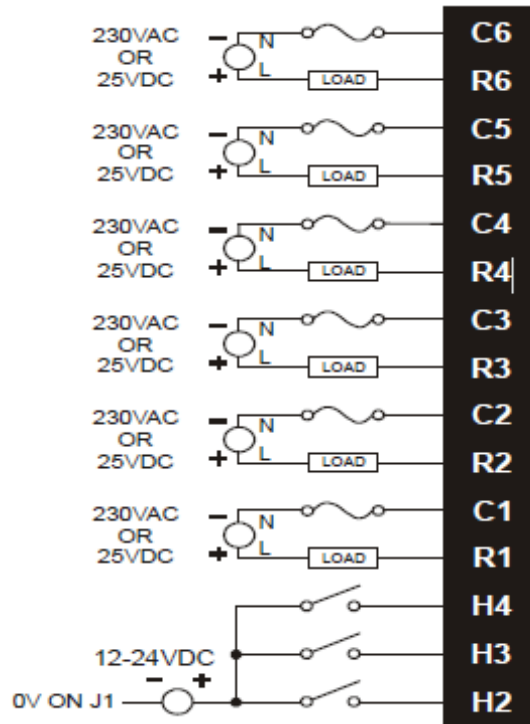
**Current / Temperature De-Rating** – Products containing relays often have total current limits based on the ambient temperature of the application.

**Fusing** – External fusing is generally required to protect the relays, devices and wiring from shorts or overloads.

**WARNING:** To protect the module and associated wiring from load faults, use external (**5 A**) fuse(s) as shown. Fuses of lower current or fusing for the entire system need to be in place to assure the maximum current rating of the unit is not exceeded.

**WARNING:** Connecting high voltage to any I/O pin can cause high voltage to appear at other I/O pins.

## Solar Cube Setup and Installation



Output 1 is wired to R1 (relay) and C1 (common), and so on for the other 5 outputs.

**Protection for Inductive Loads** – Inductive loads can cause reverse currents when they shut off that can shorten the life of relay contacts. Some protective measures need to be determined by an engineer. Below you will find recommendations that will work for many applications. If you have additional questions on protection from inductive load, consult an application engineer or IMO Technical Support.

**DC Loads** – General purpose diode (IN4004) in reverse bias across the load.

**AC Load** – MOV (Harris V140xxx for 120V, V275xx for 220V).

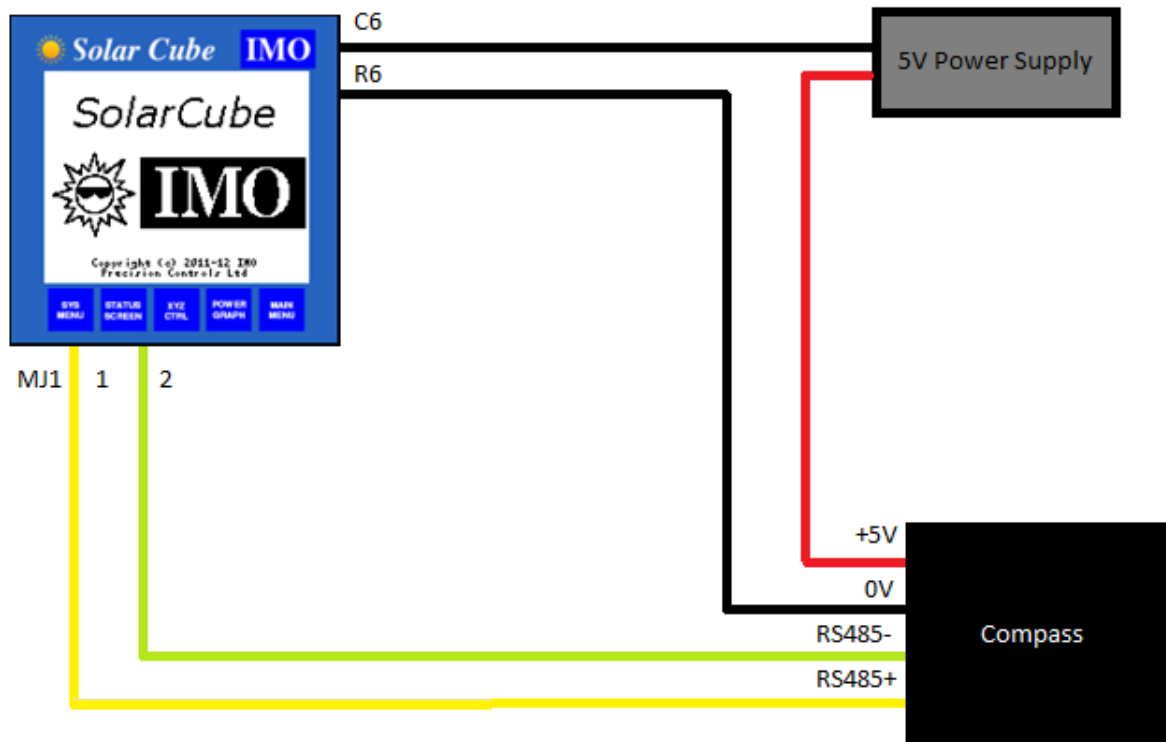
## Connecting the Digital Compass

The digital compass connects to the *Solar Cube* using RS485 communications and plugs into port MJ1. It also requires connection to relay output 6, this is listed as *Compass Control* on the I/O listing earlier in the document. This will require connection to the terminals R6 and C6 as described in the previous section. A compass control output is required so that the unit has control over when the compass is powered on.



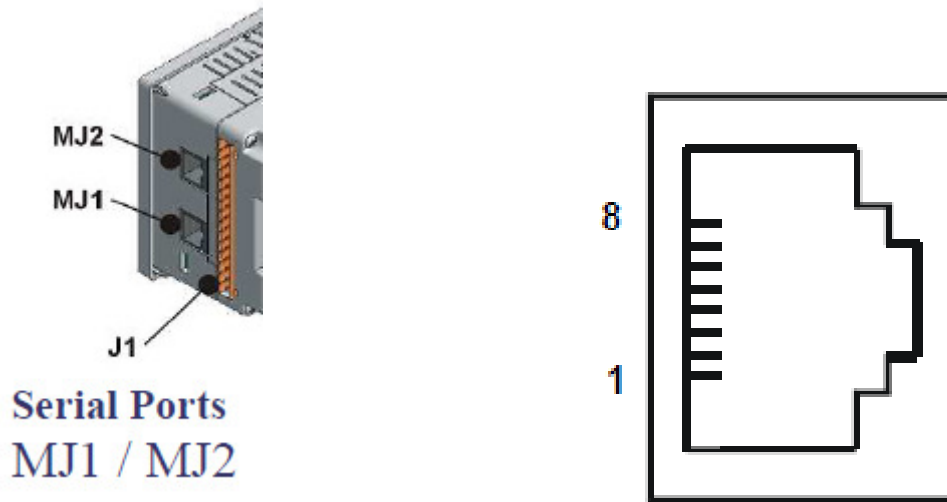
### Cable Assembly

The cable which is supplied with the compass has four wires; red, black, yellow and green. Red is connected to a +5V power supply, mounted in the control box. Black is connected to output 6 on the *Solar Cube* as shown below. The yellow and green wires need to be connected to a twisted pair comms cable which is run back to the *Solar Cube* and connected to the serial port MJ1. Twisted pair shielded cable should be used for this, which should also be weatherproof.



**MJ1 Connection**

A crimping tool will be required to attach an RJ45 connector to the end of the comms cable you have made. The diagram below shows the MJ1 socket and its pin number assignment. The yellow cable connects to pin 1 (RX/TX+) and the green to pin 2 (RX/TX-) as shown in the diagram on the previous page.



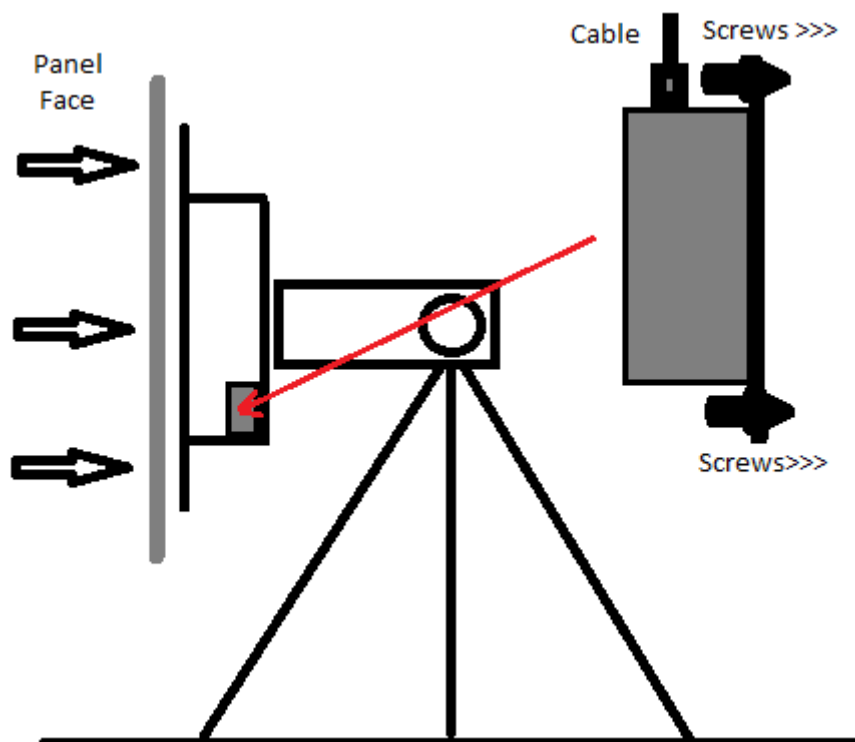
**Serial Ports  
MJ1 / MJ2**

<b>MJ1 Serial Port Pin Assignments</b>			
<b>Pin</b>	<b>Signal</b>	<b>Signal Description</b>	<b>Direction</b>
1	RX/TX+	RS-485 Receive/Transmit Positive	In/Out
2	RX/TX-	Receive/Transmit Negative	In/Out
3	CTS <sup>1</sup>	RS-232 Clear to Send	Out
4	RTS <sup>1</sup>	RS-232 Request to Send	In
5	+5*	+5 VDC 60mA max	Out
6	0V	Ground	-
7	RD <sup>1</sup>	RS-232 Receive Data	In
8	TD <sup>1</sup>	RS-232 Transmit Data	Out



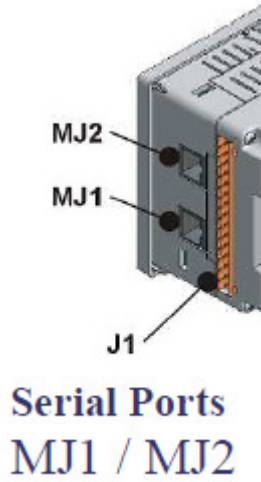
### *Mounting the Compass*

- The compass must be mounted on a movable part of the Solar Panel frame.
- That part of the frame must be vertical when the panel is vertical and must move with it as its elevation changes.
- The compass box must have the connected wire pointing upwards when the panel is vertical.
- The face of the compass (the side with the writing) must face in the same direction as the face of the solar panel.
- The compass should be mounted away from motors, transformers and anything which generates a magnetic field.



### ***Connecting the GPS Aerial***

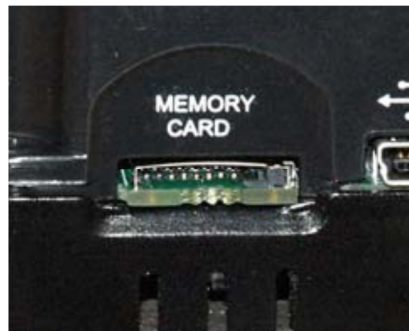
The GPS aerial can be mounted near to the *Solar Cube* unit, perhaps on top of the control panel. It connects via RS232 to the *Solar Cube*. The cable attached to it has an RJ-45 connector which plugs directly in to the **MJ2** serial port on the *Solar Cube* unit.



## Installing the Micro SD Card

### Overview

The *Solar Cube* unit provides a Removable Media slot, labeled **Memory Card**, which supports standard Micro SD (IMO Recommends using SanDisk™ media only) Flash memory cards. Micro SD cards are used log data for later retrieval. Use of a card is optional, but without it the data recorded by the unit is not saved.

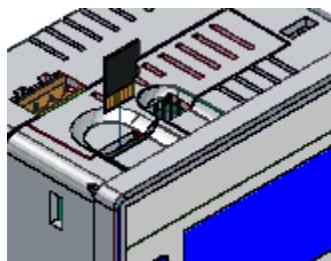


### Micro SD Cards

When the Micro SD card format was introduced, it was originally called TransFlash. Cards labeled either Micro SD or TransFlash from SanDisk™, with up to 2 GB of Flash memory are compatible with the *Solar Cube* Memory slot. The Memory slot is equipped with a “push-in, push-out” connector and a Micro SD card can be safely inserted into the Memory slot whether the *Solar Cube* power is On or Off. *To install a Micro SD card:* Align its 8-pin gold edge connector down, facing the front of the *Solar Cube* unit as shown below then carefully push it all the way into the Memory slot. Ensure that it clicks into place.

*To remove the Micro SD card:* Push down on the top of the card gently to release the spring.

The card pops up for removal.



**Note:** Please use only SanDisk™ removable media in the *Solar Cube*.

(Cards from other manufacturers are used at the customer's risk.)

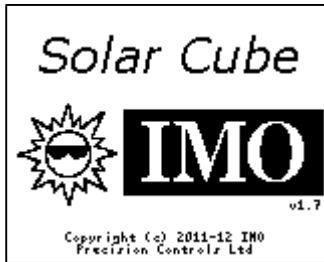
### Micro SD File System

The Micro SD Memory slot uses the PC-compatible FAT16 File System. This means that a PC, with a Micro SD-compatible card reader, can read files that have been written by the *Solar Cube* unit.

When a new card is inserted into the unit it will need to be formatted. Please see the section *Program Settings 4* later for information on formatting the card.

## Software Configuration

### Powering Up the Unit



When the unit is powered for the first time the splash screen above is displayed. Note that the software version is displayed in the bottom right corner below the IMO logo. It is important to note this if contacting IMO for technical support.

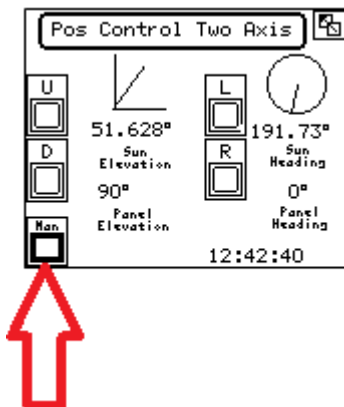
### Initial Manual Control

The first task in commissioning is to isolate, for now, the motor outputs on the unit. It is not a good idea for the system to start running while we are configuring the settings.

Press the button marked *XYZ Control* on the front of the unit to go to the position control screen:



Once on the screen touch the *Man* button to enable manual control:



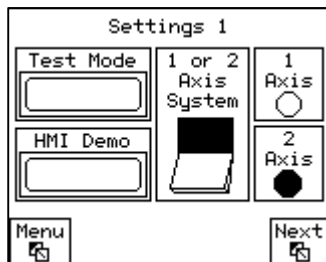
## Navigation

The function keys on the front of the unit have the following functions:

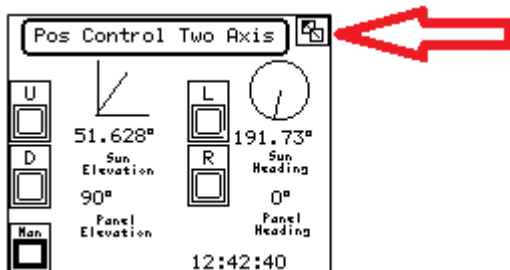


SYS MENU	Displays the first of the <i>Program Settings</i> screens. Also can be used to display the system menu, if instructed by IMO Technical Support.
STATUS SCREEN	This displays the main operational screen, the screen which is shown usually once the system is configured and running. See the section <i>The Main Screen</i> .
XYZ CONTROL	Displays the position control screen where the motor control gear can be tested. See the section <i>Testing the Motor Control</i> .
POWER GRAPH	The first of several screens which show statistical information about the power produced by the Solar Array. See the section <i>Live Power Output Graph</i> .
MAIN MENU	Allows selection of configuration and test screens. See the section <i>The Main Menu</i> below.

Many screens have further screens which continue on from them. A 'next' option is always provided in the bottom right corner to access further screens. The touch button in the bottom left corner always goes to the menu screen. For example:



Some screens have a return touch button in the top right corner which takes you back to the main menu as follows:



### Entering Values

Some configuration screens require values to be entered. When the parameter you wish to set is touched, a keypad screen appears allowing you to enter the value:

Settings 2			
Elevation			
Max	Min	Error	Timer
85°	5°	2°	30 s
Direction			
Max	Min	Error	Timer
350°	10°	2°	30 s
Menu	Twilight 0°	C/O Tim 5s	Next



002			
_QZ 1	ABC 2	DEF 3	▲
GHI 4	JKL 5	MNO 6	▼
PRS 7	TUV 8	WXYZ 9	Esc
0	Enter		

Type the value as required and press **Enter**. If you wish to return without changing the value simply press **Esc**.

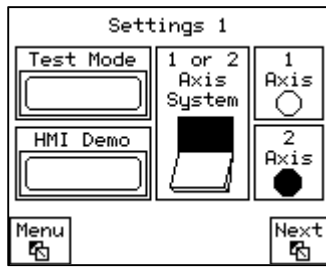
## The Main Menu

Main Menu	
Output Graph	Sun Pos
GPS	3D Compass
Time Settings	Program Settings
Position Control	Main Screen

The main menu provides touch buttons for the following functions:

Output Graph	The first of several screens which show statistical information about the power produced by the Solar Array. See the section <i>Live Power Output Graph</i> .
GPS	Allows configuration of the Longitude and Latitude of the installation, either manually or via a GPS aerial. See the section <i>Setting Longitude and Latitude</i> .
Time Settings	Allows setting of the system clock and configuration of the time zone. See the section <i>Setting the Time</i> .
Position Control	Displays the position control screen where the motor control gear can be tested. See the section <i>Testing the Motor Control</i> .
Sun Pos	Allows the sun tracking to be tested. See the section <i>Testing the Sun Tracking</i> .
3D Compass	Allows the 3D Compass to be tested. See the section <i>Testing the Compass Input</i> .
Program Settings	Accesses the first of a series of configuration screens. See the section <i>Program Settings 1</i> .
Main Screen	This displays the main operational screen, the screen which is shown usually once the system is configured and running. See the section <i>The Main Screen</i> .

## Program Settings 1



The number of axis setting allows the choice of a 1 or 2 axis system; Otherwise, known as 'single' or 'dual' axis system.

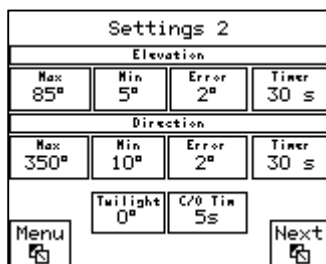
**Settings Screen 2**, the **Position Control Screen** and the **Main Screen** are presented differently based on this setting.

To change the setting touch the switch labelled **1 or 2 Axis System**. You will see the lamps on the right of the switch reflect the new selection.

**Test Mode** quickly moves the array through a complete day, every second which passes will advance the time by 7 minutes. During the night the time moves on much faster. This allows an engineer to test the movement of the array through a whole day. It is also a feature which allows the software to be demonstrated at a show or presentation. To change this setting press the touch button provided.

The **HMI Demo** option is only used for software demonstration. It cycles the unit through all of the available screens.

## Program Settings 2 – Dual Axis System



The min/max elevation and direction angles allow the minimum and maximum physical positions of the solar array to be configured. The **Solar Cube** will not try to move the array beyond these angles regardless of the position of the sun. These angles can be calculated by going to the **Position Control** screen from the main menu and motoring the Array to its minimum and maximum positions in both directions. The electronic compass needs to be working before this can be achieved. The values for the angles may be known already from the design of the array. Elevation angles can be configured from 0-90 degrees, direction angles are configured from 0-360 degrees.

The error values are configured for each axis independently. These are angles in degrees which define the amount the current position can differ from the actual position by, before the array next moves. For a manual setting these are set between 1 and 20 degrees. If the Solar



Cube has a light meter fitted this setting will be the **maximum** error value used. The unit will calculate an error value between zero and this maximum depending on the current light level.

The error timers are configured for each axis independently in seconds. This is the period of time in which the error value is checked in seconds (5-60s). Although we are operating an error based tracking system, not a time based one; the array still needs a minimum movement period.

The no movement cut out timer (0-20s) is a safety system which will stop the array moving if something is preventing it from moving. If something is jammed in the mechanism for example. If the *Solar Cube* is trying to move the array and the electronic compass is not feeding back that movement for x seconds, then we stop moving. An alarm will be generated and manual intervention will be required.

The Twilight Zenith setting is the number of degrees above or below the horizon at which the sun is no longer producing power. This is configurable because it will be different from site to site. At this point we can return the solar panel to its datum point ready for the next day. As soon as the Zenith comes back above this setting then a new day has started, the panel will move to its dawn position.

### Program Settings 2 – Single Axis System

Settings 2			
Elevation			
Max	Min	Error	Timer
85°	5°	2°	30 s
Twilight		C/O Tim	
0°		5s	
Menu			Next

The min/max elevation angles allow the minimum and maximum physical positions of the solar array to be configured. The *Solar Cube* will not try to move the array beyond these angles regardless of the position of the sun. These angles can be calculated by going to the *Position Control* screen from the main menu and motoring the Array to its minimum and maximum positions. The electronic compass needs to be working before this can be achieved. The values for the angles may be known already from the design of the array. Elevation angles can be configured from 0-90 degrees.

The error value is an angle in degrees which define the amount the current position can differ from the actual position by, before the array next moves. For a manual setting this is set between 1 and 20 degrees. If the Solar Cube has a light meter fitted this setting will be the **maximum** error value used. The unit will calculate an error value between zero and this maximum depending on the current light level.

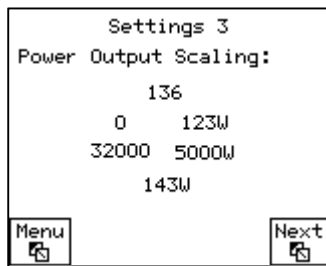
The error timer is configured for the single axis in seconds. This is the period of time in which the error value is checked in seconds (5-60s). Although we are operating an error

based tracking system, not a time based one; the array still needs a minimum movement period.

The no movement cut out timer (0-20s) is a safety system which will stop the array moving if something is preventing it from moving. If something is jammed in the mechanism for example. If the *Solar Cube* is trying to move the array and the electronic compass is not feeding back that movement for x seconds, then we stop moving. An alarm will be generated and manual intervention will be required.

The Twilight Zenith setting is the number of degrees above or below the horizon at which the sun is no longer producing power. This is configurable because it will be different from site to site. At this point we can return the solar panel to its datum point ready for the next day. As soon as the Zenith comes back above this setting then a new day has started, the panel will move to its dawn position.

### Program Settings 3



Power output logging will be based on a single analog input assumed to be in watts. The scaling for this input needs to be configured in order to calibrate the input. This input is used to log the current power production and also calculate daily kWh figures.

There are six values on the screen. The value at the top is the raw analog input value currently being received. This value will be between 0 and 32000, which represents 0-10V. The value will be 32000 when 10V is received on the input.

The value at the bottom is the scaled value in Watts which the input represents. The calibration should result in this value being correct for the current input value.

The numbers on the left are the minimum and maximum raw values which the Array can produce. Set these values as follows:

**Minimum Raw Value** – set this to zero initially.

**Maximum Raw Value** – with the array producing its maximum output set the maximum raw value to the input value. This may not be 32000, as the array may not be able to produce the maximum current which can be read by the CT.

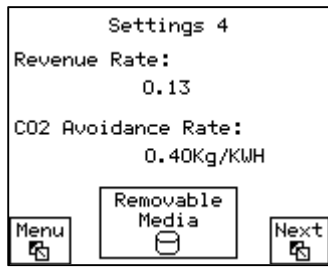
The numbers on the right are the minimum and maximum output values in Watts. Set these values as follows:

**Minimum Output Value** – set this to zero initially.

**Maximum Output Value** – set to the maximum output of the Array.

All four values can now be adjusted until a correct power output value is calibrated from the input received.

## Program Settings 4



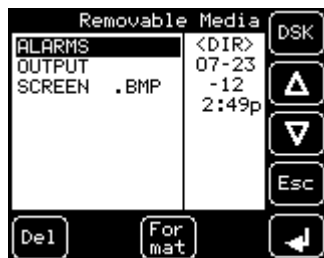
**Program Settings 4** contains settings relevant to the data logging functionality.

The revenue rate and the CO2 avoidance rate in Kg are also necessary for the data logging calculations.

Revenue rate does not have any units. It can be entered in whatever currency is used in the country of installation.

The CO2 avoidance rate is configured in Kg/KWH. This is the amount of CO2 avoided by each KWH generated by the Array. This figure can be provided by your energy provider for a domestic installation.

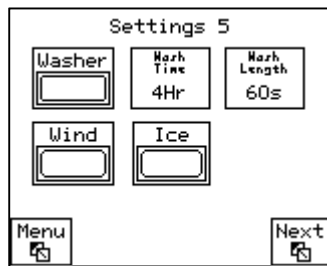
The **Removable Media** button will flash if there is a problem with the installed Micro SD card. This could be it is not inserted, it is full or it is not formatted correctly. Pressing the button will take you to the following screen which allows management of the card:



A new Micro SD card will need to be formatted in the unit. Press the **Format** button to begin this process and follow the on screen instructions.

Press **Esc** to return to the previous screen when complete.

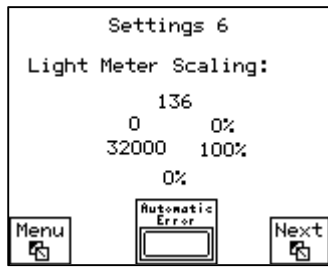
## Program Settings 5



The weather alarms are based on an ice sensor input and a wind sensor. If an alarm occurs the array is moved to a safe position where it cannot be damaged by the extreme conditions. The alarms can be enabled and disabled in the settings. Use the touch buttons provided to enable or disable the use of the sensors.

The automatic washer can be configured to activate at a particular time of day. First use the touch button to enable the use of the washer output. The time of day is configured between 0 and 23 hours. The length of the wash is configured in seconds between 0 and 120.

## Program Settings 6



If the light sensor program is enabled, the light level will be scaled to an error value for each axis. This will be used instead of the manual error setting, with the configured error value being the maximum error value. The error value will be much larger on a cloudy day so that the array moves less and lower on a sunny day so that the array moves more. The error value will also dynamically change throughout the day if the sun goes in and out.

Touch the **Automatic Error** button to enable the light sensor program.

Now the scaling for this input needs to be configured in order to calibrate it correctly. There are six values on the screen. The value at the top is the raw analog input value currently being received. This value will be between 0 and 32000, which represents 0-10V. The value will be 32000 when 10V is received on the input.

The value at the bottom is the scaled value as a percentage which the input represents. The calibration should result in this value being correct for the current input value.

The numbers on the left are the minimum and maximum raw values which the light sensor can produce. Set these values as follows:

**Minimum Raw Value** – set this to zero initially.

**Maximum Raw Value**– with the sensor producing its maximum output value set the maximum raw value to the input value. This may not be 32000, as the sensor may not be able to produce the maximum 10V even at the highest light level.

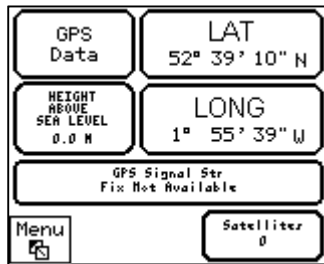
The numbers on the right are the minimum and maximum output values as a percentage. Set these values as follows:

**Minimum Raw Value** – set this to 0% initially.

**Maximum Raw Value**– set this to 100% initially

All four values can now be adjusted until a correct percentage output value is calibrated from the input received.

## Setting the Longitude and Latitude

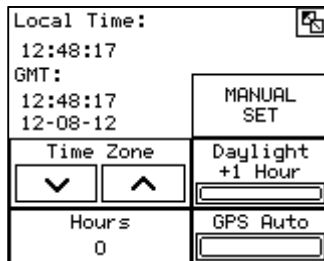


The longitude, latitude and current time signal can optionally be taken from a connected GPS aerial. If it is not connected the settings can be entered manually. The unit could be connected periodically to update the current time also.

With the GPS aerial connected, allow a few minutes for the satellites which are in view to be picked up. The number of satellites in view will be shown. The current latitude and longitude will then be set.

To set latitude and longitude manually touch each of the digits in turn and enter the values with the keypad. To set N/S, E/W value, touch the letter to toggle the setting. Your current position can easily be found on Google Maps!

## Setting the Time



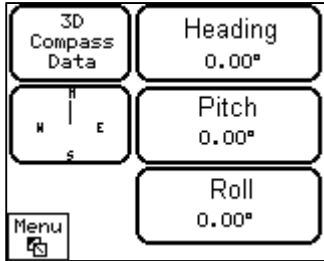
The setting 'GPS Auto' will enable the automatic update from a connected GPS aerial.

The time zone setting will be in plus or minus hours, and defines the hour difference from GMT for local time. The **Solar Cube** clock MUST be set to GMT, since GMT is necessary for the sun position calculations.

The unit calculates local time automatically based on the time zone and the 'daylight saving +1 hour' setting. Local time is used for display only. Data logging to the Micro SD card uses GMT for its time stamp records.

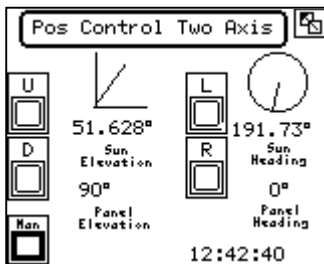
Pressing the **Manual Set** button moves to the system time screen where the time and date can be set on the unit manually.

### Testing the Compass Input



Once the compass is connected the heading, pitch and roll values will update as the compass is moved on this screen. Using the Position Control screen, motor the Array to various different positions and check back to this screen to check the compass values are correct. If the values are wrong the compass may not be mounted correctly. Please contact IMO if assistance is required.

### Testing the Motor Control – Dual Axis System



This screen shows the current position of the Solar Array against the current position of the Sun in terms of angles.

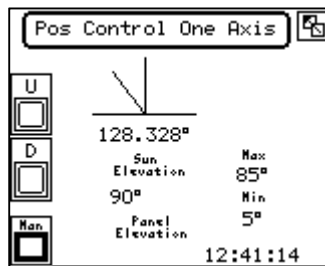
The *Man* button puts the *Solar Cube* into manual mode and prevents the sun tracking from moving the array. The UP, DOWN, LEFT and RIGHT buttons are now available. Hold a direction button to motor the array in that direction.

This screen can be used to test the motors and check the minimum and maximum angles which can be achieved.

**Once commissioning is complete remember to turn off the *Man* selection to enable automatic control of the motors by the tracking system.**



## Testing the Motor Control – Single Axis System



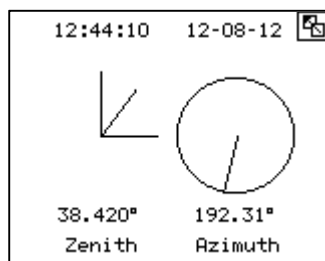
This screen shows the current position of the Solar Array against the current position of the Sun in terms of the elevation angle.

The *Man* button puts the *Solar Cube* into manual mode and prevents the sun tracking from moving the array. The UP and DOWN buttons are now available. Hold a direction button to motor the array in that direction.

This screen can be used to test the motors and check the minimum and maximum angles which can be achieved.

**Once commissioning is complete remember to turn off the *Man* selection to enable automatic control of the motors by the tracking system.**

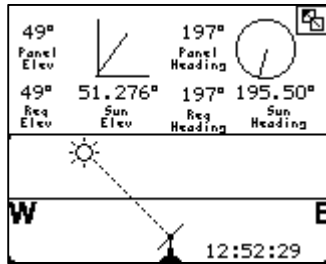
## Testing the Sun Tracking



This screen show the Zenith and Azimuth angles for the current time of day at the Longitude and Latitude configured. The time of the unit can be changed to check the Zenith and Azimuth are correct for sunrise and sunset. These times can be looked up on the internet for your current location.

## Running the System

### *The Main Screen – Dual Axis System*



The main screen shows the following information:

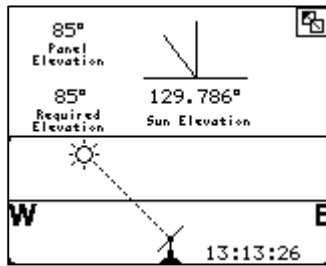
- The current position of the sun in terms of elevation and heading.
- The required position of the panel
- The current position of the panel
- A graphic of the current sun position
- The current local time

With an error value configured the current position of the panel must be out by the error value before the panel will move. The panel will then move by twice the error value in order for the panel to keep ahead of the sun in both directions. This allows for maximum generation as the sun moves across the panel.

The required positions will never exceed the minimum and maximum positions which have been configured for the Array.

After twilight the graphic will show a moon and stars until the sun rises again at dawn.

## The Main Screen – Single Axis System



The main screen shows the following information:

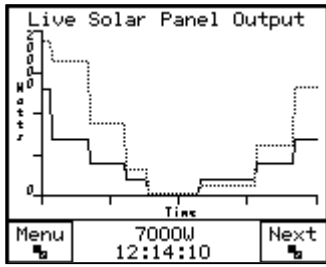
- The current position of the sun in terms of elevation
- The required position of the panel
- The current position of the panel
- A graphic of the current sun position
- The current local time

With an error value configured the current position of the panel must be out by the error value before the panel will move. The panel will then move by twice the error value in order for the panel to keep ahead of the sun. This allows for maximum generation as the sun moves across the panel.

The required positions will never exceed the minimum and maximum positions which have been configured for the Array.

After twilight the graphic will show a moon and stars until the sun rises again at dawn.

### Live Power Output Graph



This screen shows a live graph of the current power output being produced by the array. The trend shown extends for approximately 2 minutes. The power output is shown as a solid line. The current light level is also drawn as a dotted line for comparison.

The graph is set up for a maximum of 20,000 Watts of production.

### KWH Produced

Solar Panel Output	
Total KWH Produced 1611.95	Reset
KWH Produced Today 1.09	Reset
KWH Produced This Month 471.35	Reset
Menu	Next

*Solar Cube* records the number of KWH produced during the current day, for the month and the total produced ever. These values can be reset at any time by touching the reset buttons to the right.

The daily figure is reset at midnight every day. The monthly figure is reset on the first of every month.

### Revenue Screen

Solar Panel Output	
Total Revenue 211.35	
Revenue Today 1.93	
Revenue This Month 63.07	
Menu	Next

*Solar Cube* records the total revenue for the current day, for the month and the total revenue ever. These values can be reset at any time using the reset buttons on the *KWH Produced* screen.

The daily figure is reset at midnight every day. The monthly figure is reset on the first of every month.

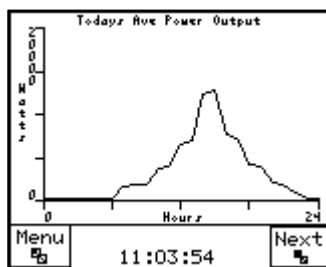
## CO2 Avoidance Screen

Solar Panel Output	
Total CO2 Avoided 651.11 Kg/KWH	
CO2 Avoided Today 0.49 Kg/KWH	
CO2 Avoided This Month 194.87 Kg/KWH	
Menu ⏮	Next ⏭

*Solar Cube* records the CO2 avoidance measured for the current day, for the month and the total avoidance ever. These values can be reset at any time using the reset buttons on the *KWH Produced* screen.

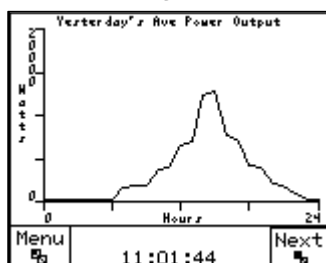
The daily figure is reset at midnight every day. The monthly figure is reset on the first of every month.

## Today's Average Hourly Production



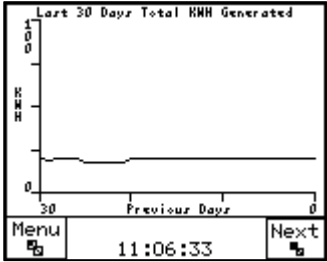
This screen shows a plot of the average Watts produced each hour for the current day. The graph is set up to plot a maximum of 20,000 Watts production.

## Yesterday's Average Hourly Production



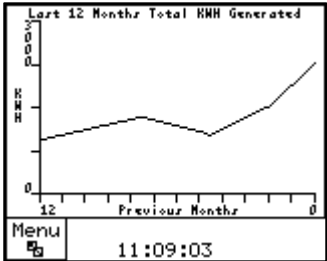
This screen shows a plot of the average Watts produced each hour for the previous day. The graph is set up to plot a maximum of 20,000 Watts production.

**Last 30 Days KWH Production**



The system stores the total KWH produced each day for the last 30 days and draws a graph. The graph is set up for a maximum production of 100 KWH per day.

**Last 12 Months KWH Production**



The system stores the total KWH produced each month for the last 12 months and draws a graph. The graph is set up for a maximum production of 3000 KWH per month.

## System Logs

### The Alarm Log



The alarm log is available by pressing *next* on the very last *Panel Settings* screen. The last few alarms are shown here along with the time the alarm occurred. The text *ALM* will be shown against the time at which the alarm occurred. A second log entry will show *RTN* against the time that the alarm was reset. These are known as *ALARM* and *RETURN*.

Touching the alarm log will open the alarm history screen, where the complete log can be scrolled through to look at past events. Use the arrow buttons to move up and down:



The following alarms can occur:

- Safety Break Alarm
- Limit Switch Up
- Limit Switch Down
- Limit Switch Left
- Limit Switch Right
- Wind Alarm
- Ice Alarm
- Washers Active
- Emergency Stop

## Micro SD Card Data Logging

There are two folders automatically produced on the Micro SD card. These are **Alarms** and **Output**. In order to access the files on the card the Micro SD can be inserted into a PC card reader. This will allow the files to periodically be inspected and data analysis to take place.

The alarm log will produce a file every month containing all of the alarms that have occurred. Each file is in **.csv** format which can be loaded into Excel. The file names have the month in them, for example **ALARM\_07.csv**.

	A	B	C	D	E
1	Date	Time	Event	Group	Alarm Name
2	23/07/2012	14:49:53	ALM		1 Safety Break Alarm
3	23/07/2012	14:49:54	RTN		1 Safety Break Alarm
4	23/07/2012	14:50:14	ALM		1 Safety Break Alarm
5	23/07/2012	14:50:17	RTN		1 Safety Break Alarm
6	23/07/2012	14:54:41	ALM		1 Safety Break Alarm
7	23/07/2012	14:54:43	RTN		1 Safety Break Alarm
8	23/07/2012	15:21:16	ALM		1 Safety Break Alarm
9	23/07/2012	15:22:17	RTN		1 Safety Break Alarm

The **Output Log** also contains **.csv** files, but this time a new file is created every day. An example file name is **120626.csv** which is data from 26/06/12. The following data is recorded every 10 minutes:

	A	B	C	D	E	F	G	H	I	J	K	L
1	Date	Time	KW	KWHoursToday	KWHoursTotal	RevenueToday	RevenueTotal	CO2Today	CO2Total	LightScaled	ElevationAngle2	PanelPosition
2	26/06/2012	10:07:43	0.922	13.753	754.315	593.442	32548.7	9.6271	528.02	0	48.9271	88
3	26/06/2012	10:17:43	0.755	13.9387	754.315	601.457	32548.7	9.75712	528.02	0	50.3457	62
4	26/06/2012	10:27:43	0.897	14.1247	754.367	609.482	32551	9.8873	528.057	0	51.7259	50
5	26/06/2012	10:37:43	1.153	14.3663	754.666	619.906	32563.8	10.0564	528.266	0	53.0625	53
6	26/06/2012	10:47:43	0.731	14.563	754.836	628.394	32571.2	10.1941	528.385	0	54.3492	53
7	26/06/2012	10:57:43	0.658	14.6953	754.836	634.104	32571.2	10.2867	528.385	0	55.5794	54



## Notes