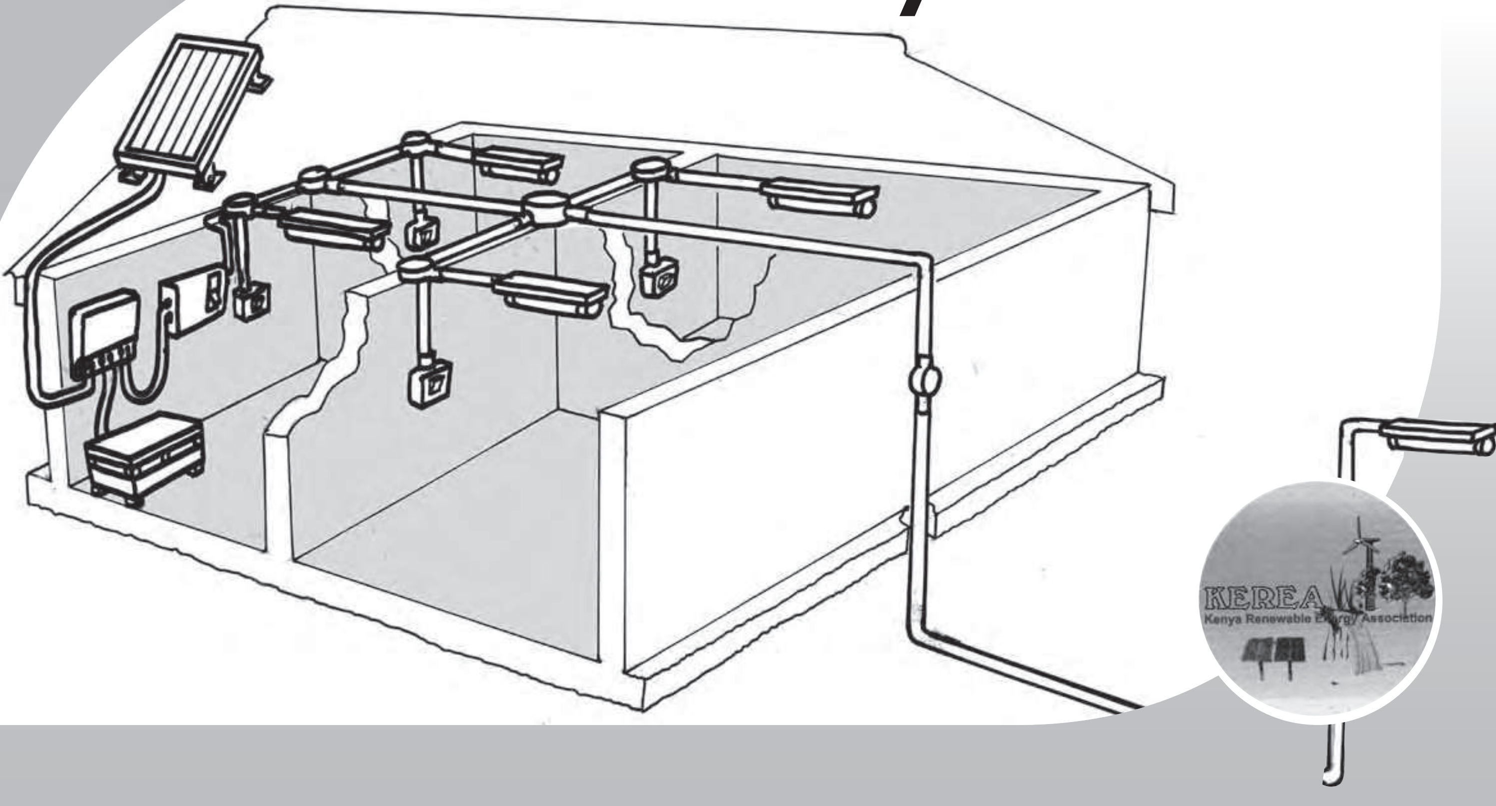
Installers Manual for Solar PV Systems



Installers Manual
Technical guide for Installers of Solar Home Systems

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Introduction

This manual was produced for the Kenya Photovolatic Capacity Building Project under the IFC/GEF funded Photovolatic Market Transformation Initiative. It has been developed by Energy for Sustainable Development Africa who also co-financed it, and is the result of a consultative process involving members of the Kenya Renewable Energy Association and other Kenyan PV stake holders.

Two key factors contribute to a properly functioning solar PV system; these are a proper sizing and a correct installation. Installations are site specific and the challenges faced during installation will vary from site to site. The purpose of this manual is to guide technicians through the basic steps they have to go through to correctly install and commission a solar PV system.

The installation and commissioning of a solar PV system can be broken down into the following activities:

- **Pre-installation site visit:** Determination of the location of various system components, determination of wire runs, determination installation material and tools that may be required any envisioning difficulties that may arise.
- **Assembly of installation equipment and tools and transport to site:** Establishing and sourcing that the installation materials and tools required and arranging for their transportation to the site.
- **Installation:** Installing the system components and connecting them in the required order.
- **Checking the System (Commissioning):** Checking the system components to ensure they have been properly connected and are working as required. Checking that all the appliances to be powered by the system are working properly.
- **Educating the End-User:** Training the user on how to operate and maintain the system.

Proper planning requires that, before commencing an installation the technician should consider the activities above and what is required in terms of equipment and how much is required in terms of time, labor and cost.

This manual is designed for single module 12V PV systems from 12-150Wp installations. For larger installations or installations involving 2 or more modules contact your PV supplier for assistance.

Disclaimer:

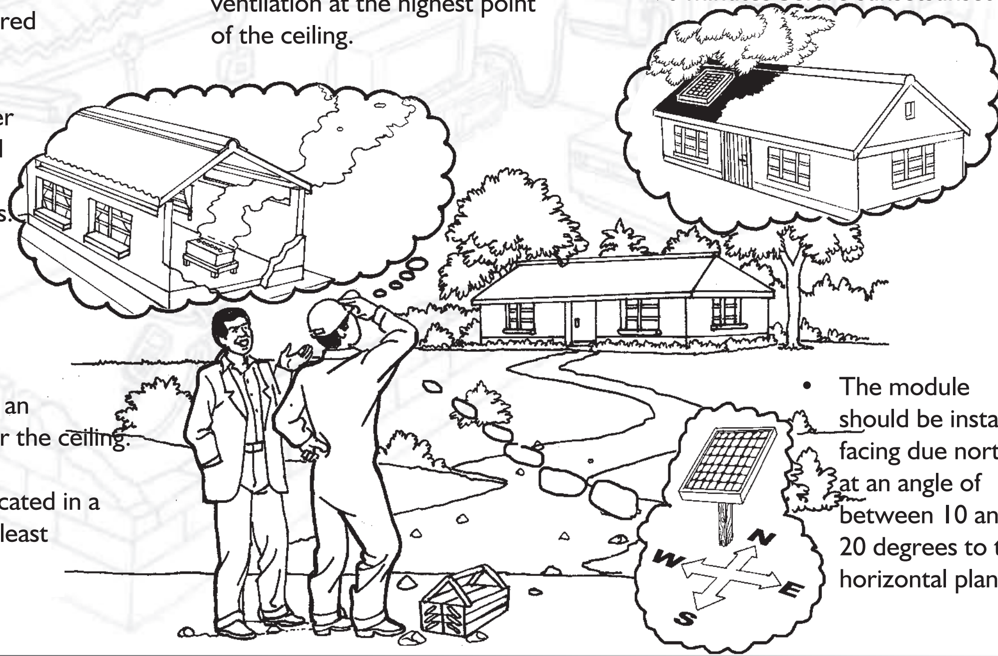
This manual was initially designed for Kenya and has been adapted for Uganda. Where possible this manual attempts to adhere to the Kenyan and Ugandan PV standards but is not intended to be a reflection of neither the Kenyan nor the Ugandan PV standard.

Visiting the site

Battery and Module Location

A site visit is required before the installation to consult with the end-user and determine the most appropriate location for the installing the solar PV module(s) and the battery. Things to be considered when making this decision are:

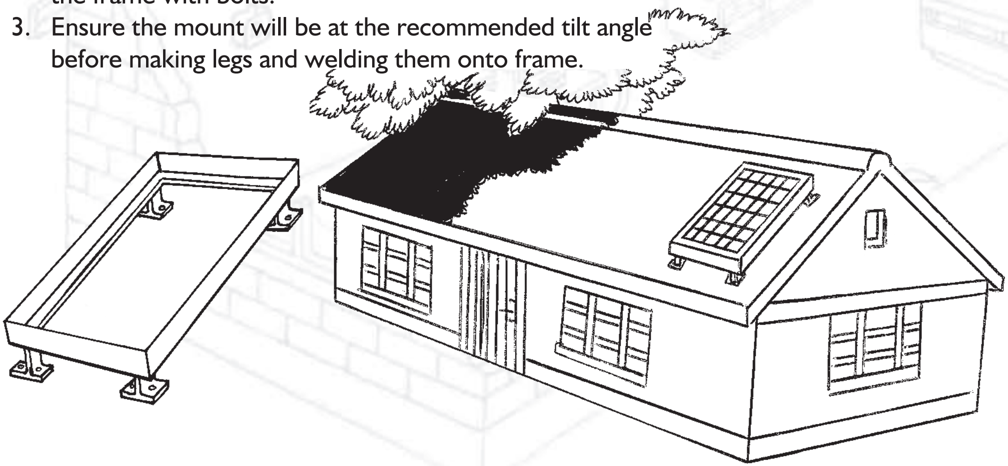
- The module, charge controller and battery should be located as close to each other as possible to reduce power loss.
- Potentially explosive gases are released from the battery during charging, these gases are lighter than air and hence tend to causing an accumulation of this gas under the ceiling.
- The battery should also be located in a secure place where it will be least interfered with.
- Batteries should therefore be placed in a room with good ventilation at the highest point of the ceiling.
- No object (trees, buildings etc. should shade any part of the PV-panel at any time of the year between 90 minutes after sunrise and 90 minutes before sunsetsunset



- The module should be installed facing due north at an angle of between 10 and 20 degrees to the horizontal plane.

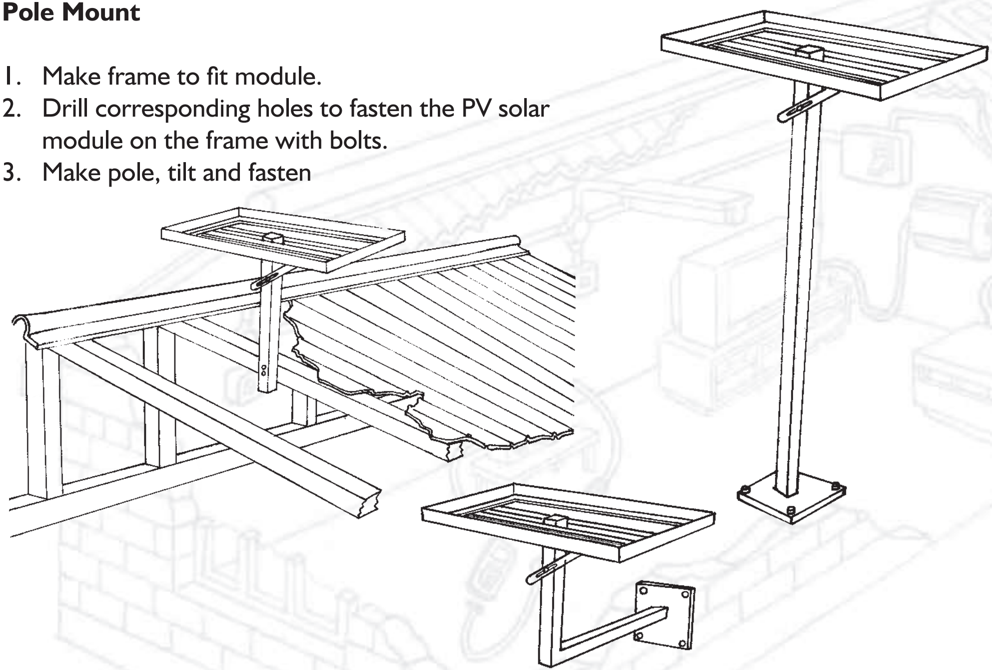
Choosing the Type of Module Mount

The decision on the type of module mount to use is also made during the site visit. There are two main types of module mount, the leg mount and the pole mount. Support structures for panels shall be made with permanent materials and be strong enough to withstand all climatic conditions. They should be securely braced and fixed to the roof or the wall of a building or the ground such that they are without deflection or vibration.

Mounts Type	Pros and Cons
Leg Mount 1. Make frame to fit module. 2. Drill corresponding holes to fasten the PV solar module on the frame with bolts. 3. Ensure the mount will be at the recommended tilt angle before making legs and welding them onto frame. 	• Ideal for mounting on corrugated roof. • Cheap and simple to make • Legs should be fastened to rafters or roofing beams making them difficult to install in when the distance between rafters is wide. • Requires one to make holes in the roof, therefore difficult to mount on tiled roof. • Difficult to orient and tilt – Depends the direction the roof is facing and the angle of the roof.

Pole Mount

1. Make frame to fit module.
2. Drill corresponding holes to fasten the PV solar module on the frame with bolts.
3. Make pole, tilt and fasten



- Can be mounted on roof, side of the wall or on the ground.
- Expensive to make – requires more material.
- Simple to orient and tilt.

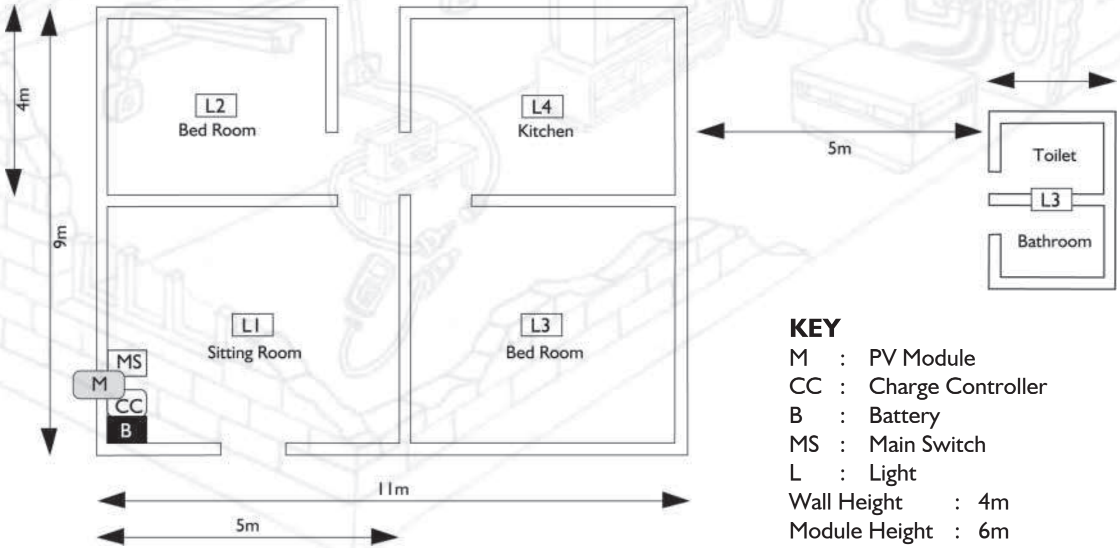
It is important to ensure that no part of the mount frame covers any of the cells of the module.
Discuss with the end-user the implications of using the different types of mounts and recommend the best option.

Planning

Determining Wire runs and Installation materials

Floor Plan
Sketch a plan of the installation site showing the layout of the building(s) and dimensions. Also note the height of the walls and the anticipated module height.

Discuss with the end-user the proposed locations for the lights and power outlets/sockets. Indicate the locations of the lights, sockets, solar PV module, battery and charge controller on the floor plan as shown below.



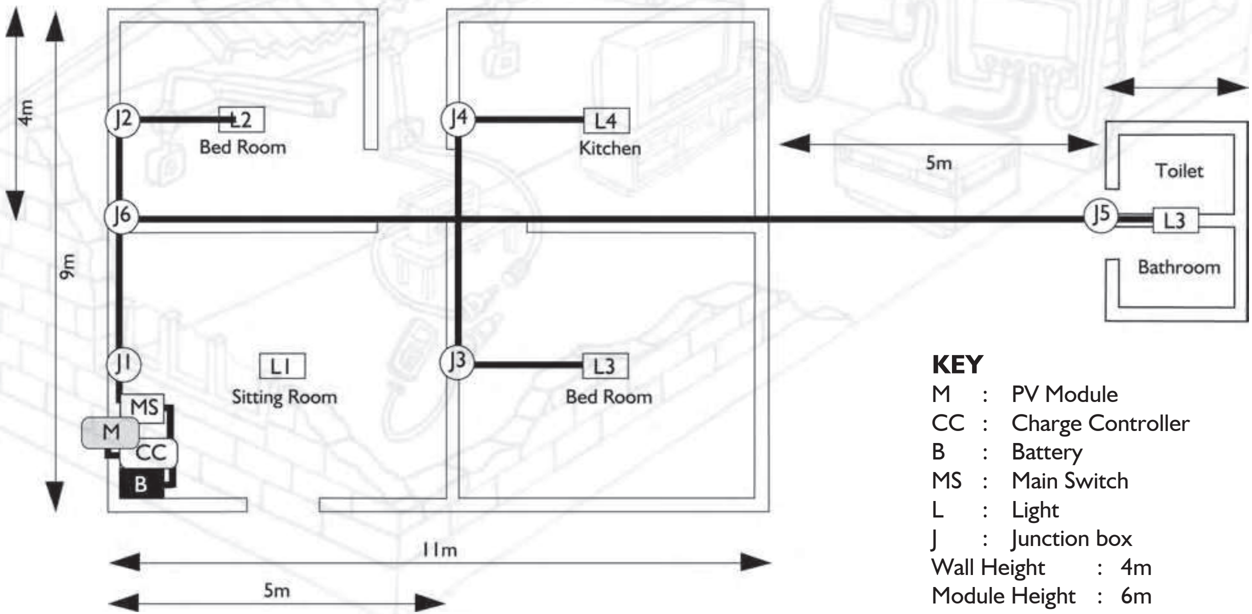
KEY

M : PV Module
CC : Charge Controller
B : Battery
MS : Main Switch
L : Light
Wall Height : 4m
Module Height : 6m

Cable Plan

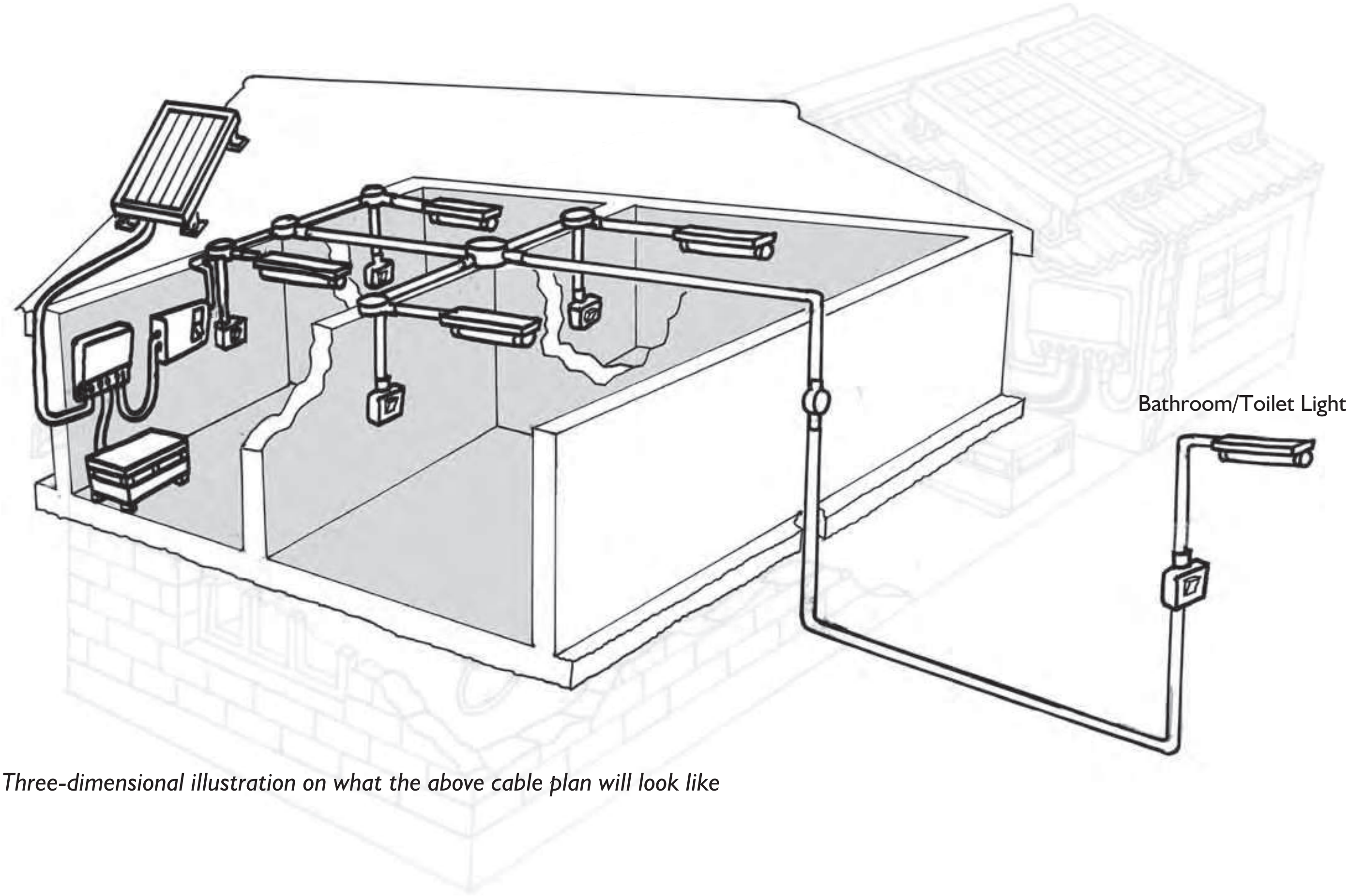
Design a cable plan based on the floor plan and the agreed upon locations of the system components. The cable plan is used to determine:

- Length and thickness of cable required
- Number of junction boxes
- Number of switches
- Number of pattrice boxes
- Cable clips required
- If outdoor wiring (overhead or underground) is required



KEY

M : PV Module
CC : Charge Controller
B : Battery
MS : Main Switch
L : Light
J : Junction box
Wall Height : 4m
Module Height : 6m



Three-dimensional illustration on what the above cable plan will look like

Wire Runs and Voltage Drop

Solar PV systems are low voltage DC systems and therefore differ from conventional grid electricity which is high voltage AC. Because of this, wiring for solar PV systems differs from conventional AC wiring.

Low voltage systems require a higher current to carry the same power as high voltage systems. If the wire cross-section is not large enough to support the current, a voltage drop will occur over the length of the cable which will cause poor performance of lamps or appliances i.e. dim lights, blackening of fluorescent lights and running lines on the TV. Therefore cables used in solar PV systems should be of thicker gauge than those used in AC systems.

To reduce voltage drop, the following are useful criteria to considered when determining wire runs:

- As a rule of thumb the gauge used for the different wire runs in a 12V system is as follows
  - Module to Charge controller – 6mm^2 (for systems below 50Wp, 4mm^2 can be used)
  - Battery to Charge controller – 6mm^2 (for systems below 50Wp, 4mm^2 can be used)
  - Between junction boxes – 4mm^2
  - Junction box to switch – 2.5mm^2
  - Junction box to light – 2.5mm^2
- Wires of cross section area less than 2.5mm2 are not recommended for use with photovoltaic systems. After completing the installation, voltage drop must be measured at each appliance. The voltage drop should not exceed 0.6V (see the section on commissioning for instructions on how to determine voltage drop). Under no conditions is a voltage of less than 10.5V permissible across an appliance.
- Maximum wire run tables can also be used to give the maximum run of cable that can be used between modules, batteries, and loads in 12V systems. For systems with wire runs longer than 16m, wire run tables should be used to determine the most appropriate cable gauge (see Annex).

Other useful criteria to consider when determining wire runs are:

- Switches should be mounted not less than 1.2m from the floor
- Wiring can be done using cable clips, mini-trunking or PVC conduit.
  - Surface mounted cables will be installed using appropriate fasteners at suitable intervals (e.g. 20-30cm) to prevent sagging
  - Mini-trunking can be used for visible wiring for a neater appearance
  - PVC conduits are recommended for outdoor wiring

- In cases where wiring across buildings is required, underground wiring is advised. Underground cables shall be at least 0.6m below the surface in PVC conduit and be indicated with markers (colored tape or brick lining 0.2m above the surface). They shall be used across all areas with vehicular traffic and the conduit must be able to withstand the loads of the vehicles expected to cross over them.

The following table determines the wire run lengths and cable gauges for the example used in this manual

Wire Run	Vertical Distance (m)	Horizontal Distance (m)	Cable gauge (mm^2)
Module to Charge Controller	4m	1m	6
Battery to Charge Controller	2m	1m	6
Charge Controller to Main Switch	-	0.5m	4
Main Switch to J1	2.5m	-	4
J1 to Switch 1	2.5m	-	2.5
J1 to Light 1	-	2.5m	2.5
J1 to J6	-	2.5m	4
J6 to J2	-	2.5m	4
J2 to Switch 2	2.5m	-	2.5
J2 to Light 2	-	2.5m	2.5
J6 to J7	-	5m	4
J7 to J3	-	2.5m	4
J3 to Switch 3	2.5m	-	2.5
J3 to Light 3	-	3m	2.5
J7 to J4	-	2m	4
J4 to Switch 4	2.5m	-	2.5
J4 to Light 4	-	3m	2.5
J7 to J5	5m	11m	4
J5 to Switch 5	2.5m	-	2.5
J5 to Light 5	-	1m	2.5

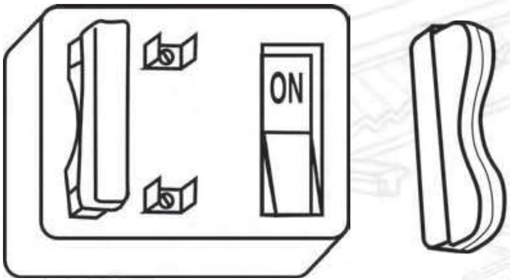
Fuses

Fuses are placed in the circuit between the battery and the charge controller and between the charge controller and the load to protect the components of the system.

To calculate the required fuse size for a given circuit:

- Determine the maximum possible power required by adding the power in watts of all loads
- Divide the power by the system voltage to get current in amps. This is the maximum rated current in the circuit
- Increase this figure by 1.2 and select a fuse close this figure.

In the example used in this manual, the system powers five 10W lights a total load of 50W. The system voltage is 12V giving a maximum current of about 4amps. The required fuse size for this system is 5amps.



The main switch contains the fuse between the loads and the charge controller. A common practice is to use a splitter switch designed for AC systems as a main switch. The splitter switch offers two fused outlets which can be used separately, one for supplying the lights and the other for supplying sockets. Fuse wire is used in the splitter switch and the correct size of fuse wire should be put in before the switch is used.

Fuses should be designed in such a way that the fuse nearest to the fault is the first to blow. Therefore the size of the main switch fuse and the battery in-line fuse should always be smaller than the charge regulator fuses between the load and regulator and the regulator and battery respectively.

Tools and Materials

Technicians need to prepare the tools and installation materials before leaving for the site. The tools and materials required for any installation depend on the site and the system being installed.

The lists used here are based on the example used in this manual and does not exhaustively cover all the tools and materials required for an installation, it is meant only to be used as a guide.

List of Tools

Tools	Function
Digital Multi-meter	Testing and commissioning
2 flat screwdrivers (large and small) 2 star screwdrivers (large and small)	For fitting pattrice and junction boxes and charge controller terminals and fastening screws where necessary.
Electricians' pliers (large type) Adjustable spanner	For tightening bolts on battery terminals, for fitting module bolts
Ball pien hammer	For fitting cable clips
Clear plastic goggles and rubber gloves	To protect eyes when filling battery with acid.
Knife or wire stripper	For cutting and stripping wire
Basic compass.	To assist in orienting module
Connector strips	For connecting wires
Rolls of insulating tape - black and red	For color-coding wires when necessary.
Tape measure	For measuring distances
Writing material	To take notes where necessary
Hydrometer	For measuring specific gravity of battery
Drill (battery powered or hand drill)	For drilling holes where necessary
Silicon sealant or plasticine	For sealing holes made in the roof during module installation
Ladder	For working at heights
Test and completion certificate	To be filled after installation and copy left with the end user.

List of Materials

Item		Amount
Lights	• As per the initial system design	5
Junction boxes	• As per the cabling diagram. • Each light should have it's own junction box • A junction box should not have more than 4 cables • Junction boxes designed for 240VAC lighting circuits are not suitable as they are designed for $1.5mm^2$ conductors. If DC junction boxes are unavailable, one can improvise by using a box with connector strips.	7
Switches	• Each light should have it's own switch. Selected switches should be rated at twice the expected current capacity of their load.	5
Pattress boxes	• Each light or socket should have it's own pattrice box.	5
Wood screws	• For surface mounting pattrice and junction boxes. • Approximately 4 per box and 20% surplus for emergency	60
$2.5mm^2$ cable	• As per the wire run calculations • Add 20% surplus for emergency	30m
$4mm^2$ cable		40m
$6mm^2$ cable		10m
Main switch (splitter switch)	•	1
Battery in-line fuse holder	•	1
Connector strip	• For connecting wires.	
Fuse wire	• Fuse wire for splitter switch. As per calculation	1 (5 amps)
Glass fuse	• For in-line fuse	1 (5 amps)
Cable Clips $2.5mm^2$	• For every 20-30cm of cable	100-150

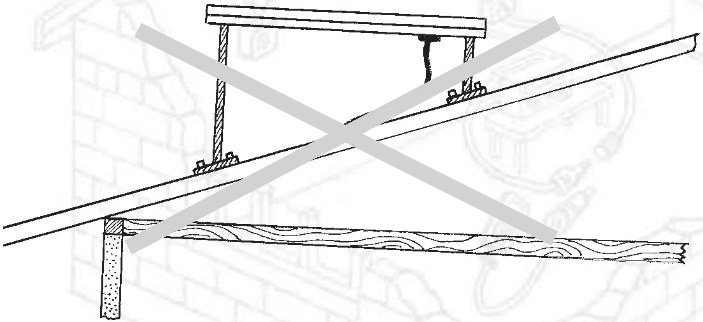
Cable Clips $4mm^2$	• For every 20-30cm of cable. • Less the length of cable used with the PVC conduits	80-120
Cable Clips $6mm^2$	• For every 20-30cm of cable	35-50
PVC conduit and installation accessories	• For outdoor length of wiring and 20% surplus for emergency • PVC junction boxes, PVC glue, bending spring, draw wire, couplers and spacer bar saddles	20m As required
Mini-trunking	• As per end-user request	1

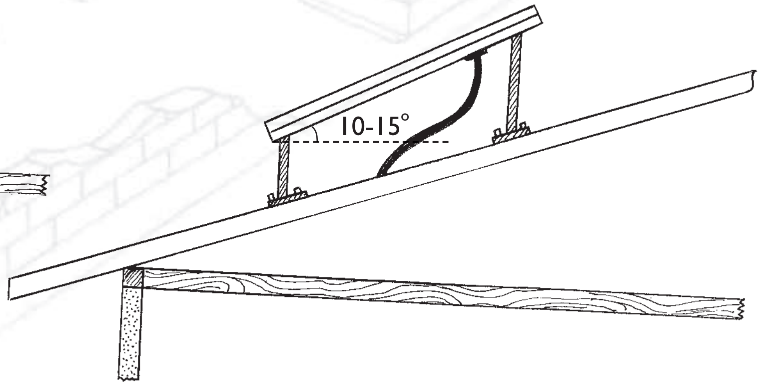
Module mount and accessories	• Include nuts and bolts required for module and mount installation	1
Battery box	• To store battery and battery maintenance materials	2 bottles
Distilled water and petroleum jelly	• To leave with end-user for battery maintenance	1 small jar
Spare light tubes	• To leave with end-user for replacement	2

Installing the System

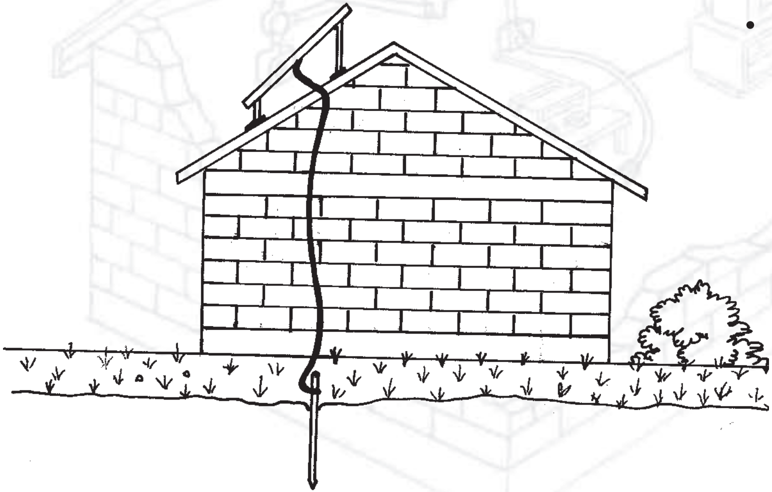
Module installation
The most challenging part of a solar PV system installation is mounting the module. Module installation will vary based on the location, the type of building and the type of mount used. However, the principles remain the same.

- The module must be oriented North-South
- The module should be tilted at an angle to face the equator. One of the reasons for this is done is to allow rainwater to run off the module and clean dust off the surface of the module. The angle of tilt varies depending on location of the module in relation to the equator. In Kenya and Uganda a 10-20° tilt is recommended.

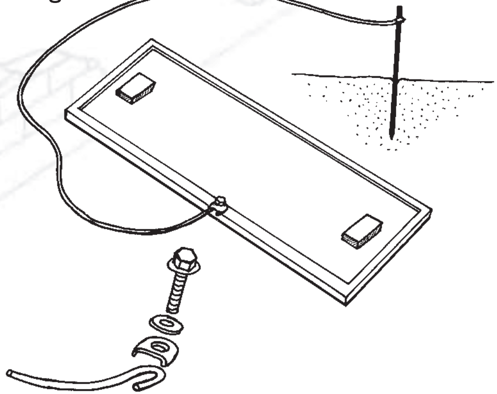




- There should be no shading on the module at any time of the day between 90 minutes after sunrise and 90 minutes before sunset.
- Where possible modules should be installed lower than the highest point of the building. If installed at the highest point the frame should be grounded. This should be done with a 16mm2 cable connected to a 1.5m earth spike.



- The module and mount must be tightly fastened to avoid deflections or vibrations when there are strong winds.
- If holes are made on the roof during installation these should be properly sealed. Cables through roofing shall be contained in roof entry boxes which also shall form a waterproof seal to avoid leakage.
- If the module is to be installed on a corrugated/metal roof, the module should be installed a distance of at least 1m from the roof. Metal roofs heat up when there is sunshine, and if this heat is transferred to the module it will reduce its power output.
- The module should be installed in such a way as to make it accessible for cleaning when necessary. If installed on the roof, it should be as close as possible to the side of the building.



Battery Installation

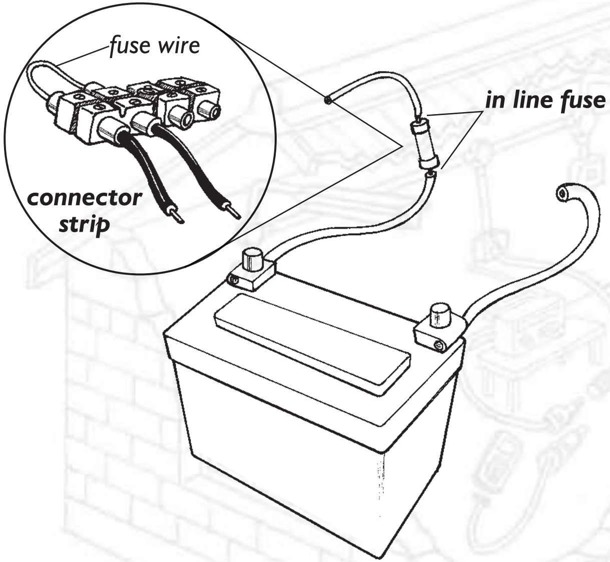
Flooded lead acid batteries are usually dry when purchased with their battery acid packaged separately. Before installation the new battery should be filled with acid and then fully charged before use.

The battery should be taken to the nearest battery charging station and charged until it is fully charged. If there no access to a battery charging station the battery can be connected to the installed system until it is fully charged. This should only be done as a last resort. If it is to be charged from the installed system the user must be instructed not to use his/her system until the charge controller indicates the battery is fully charged.

Battery should be filled outdoors using a jug and funnel. A plastic bucket of water should be close by in case of spills and to wash the jug and funnel after use. Add baking soda to this water before disposing it.

Fill battery acid cell by cell to between the max and min levels indicated on battery. Take precaution when filling the battery use gloves and goggles. Take care not to over fill the battery. Use baking powder to dilute spilt acid. Use insulated tools to avoid accidental shorting when working with batteries. Insulating tape can be used to insulate tools.

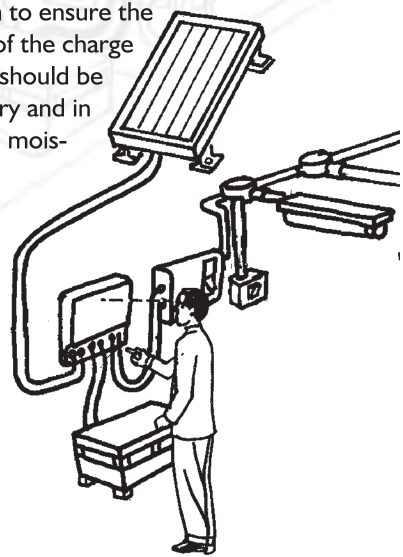
Always use battery terminals to connect cables to the battery. Connect the battery in-line fuse in the positive battery cable. If unavailable a battery in-line fuse can be made using a connecter strip and appropriate fuse wire.



Do not connect the battery to the charge regulator at this point but wrap insulating tape at the end of the battery cable to avoid short circuits. Batteries should be installed in boxes to protect against accidental short circuiting of the terminals while still being accessible for checking. The battery enclosure should have sufficient ventilation to avoid build up of gases during charging. At least 20mm free space should be left between the battery, the wall, and the top of the box. The box should be made of durable material, if made of wood it should be preserved against termites, rot and acid. See annex for a sample battery box design.

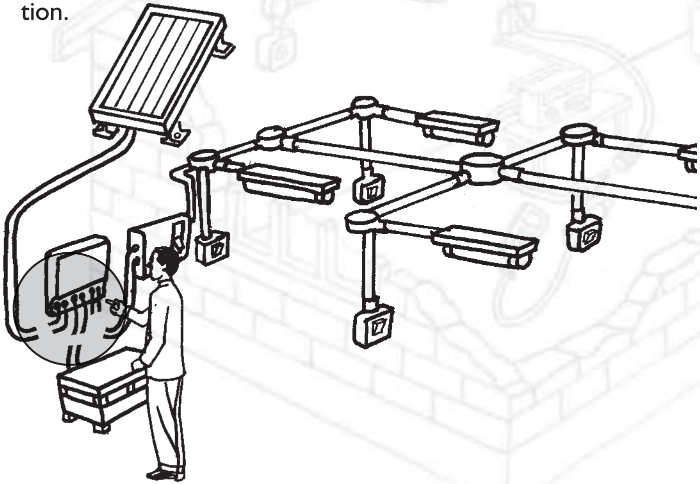
Installing the Charge Regulator

For easy readability the charge regulator should be mounted at eye level. Wherever possible it should be wall mounted, however care should be taken to ensure the wall can hold the weight of the charge controller. The regulator should be located close to the battery and in a location protected from moisture and dust.



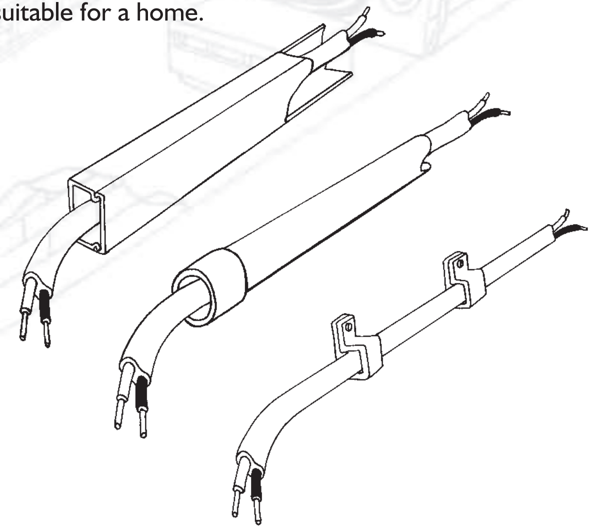
Charge controller configurations and indicators vary depending on the type and model of controller. Charge controller configurations also vary with battery type i.e. flooded or sealed lead acid battery. Read through the charge controller manual carefully and follow the instructions when installing and configuring the charge controller. Keep in mind that you have to educate the user on how to use the charge controller to check the performance of the system.

Cables from the battery, load and module are connected to the regulator during the commissioning stage of the installation.



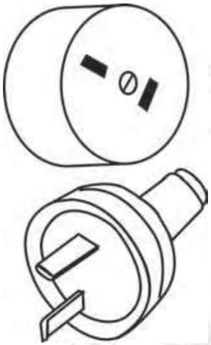
Wiring

Wiring can be divided into indoor and outdoor wiring. Indoor wiring can be further divided into visible wiring and concealed wiring. Wiring can be done through conduit, mounted in mini-trunking or surface mounted. PVC conduits are recommended for outdoor wiring, mini-trunking can be used for visible wiring to give a neat finish and surface mounting can be used for all indoor wiring. Since a large portion of solar PV installations will be on domestic premises, due consideration must be given to the aesthetic appearance of the installation. An installation that may be acceptable for use in a school or factory may be unsuitable for a home.



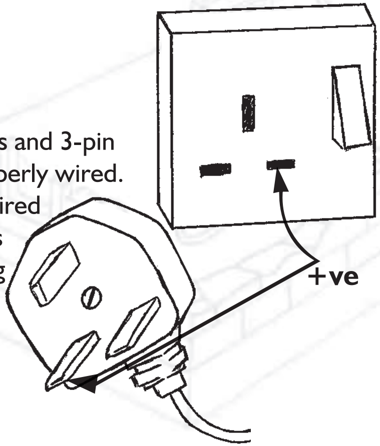
The following are key considerations when wiring:

- DC cables are two core with red and black wires. When wiring always use red for the positive wire and black for the negative. Reverse polarity damages most DC appliances and therefore extra care should be taken when wiring.



- To avoid reverse polarity in sockets specialized DC sockets and 2-pin plugs are often used for DC power outlets in solar PV systems. The pins are of different shapes so that they can only be inserted one way.

- If unavailable AC sockets and 3-pin plugs can be used if properly wired. The socket should be wired such the positive (live) is on the right and the plug should be wired such that the bottom left pin (when the plug is facing you) is the positive pin.



- Wiring routes should always follow horizontal and vertical lines and should be kept as short as possible.
- Surface mounted wires should be held firmly with cable clips every 20-30cm.
- Wire connections should be housed in junction boxes. If only two wires are being connected together, connector strips can be used and insulated with insulating tape.
- Out door cable runs should be laid underground in conduit at a depth of 50cm. Underground conduit runs should be continuous and not have junctions or connections.
- When working with PVC conduit the following accessories are necessary
  - PVC glue for joining conduits
  - PVC junction boxes
  - Bending spring for making the conduit bends
  - Draw wire for pulling cable through the conduit
  - Couplers and spacer bar saddles for surface mounting the conduit

During wiring lights should be mounted but not connected. Connection of lights and appliances is done only after the system has been tested.

Checking and Commissioning

After the system components have been installed and the wiring done the checks are performed before final connections and commissioning of the system.

Check Module Performance and Polarity

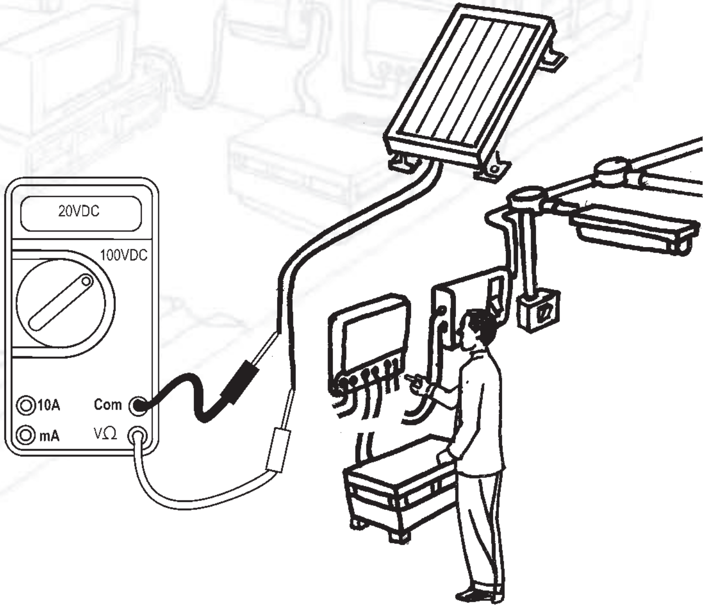
This is to check that the module is performing as per specifications. It also to confirm that the polarity conforms to the standard color-coding i.e. that the red cable is positive and the black cable is negative.

Module performance tests consist of measurement of open circuit voltage and short circuit current. These tests need to be carried out during the day under direct sunlight conditions, preferably around noon. Because of this, it is advisable to do them upon completion of the module installation, if the there is a possibility of not completing the installation before sundown.

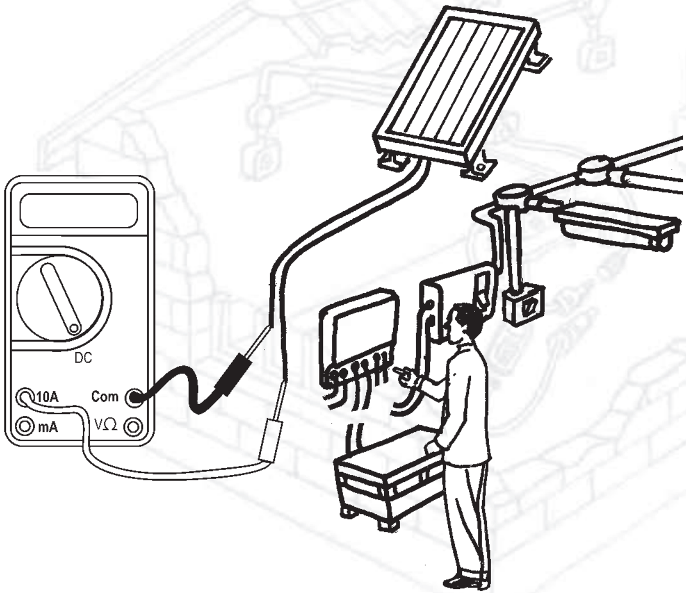
Measuring Open Circuit Voltage V_{OC} and Determining Polarity

Set multi-meter on measure DC voltage and set the range to 100VDC. Connect the red and black multi-meter leads to the red and black module cables respectively. The reading should be in the range of 19-22VDC. If the meter reading is positive it means that polarity is good.

If the reading is negative it means that the polarity has been reversed. If possible, reconnect the cables. If not, wrap red insulating tape on the black cable and black insulating tape on the red cable to code the cable.



Measuring Short Circuit Current I_{SC}
To measure short-circuit current the multi-meter used should be able to measure current up to 10Amps. Set the multi-meter to measure DC current and set the range to 10Amps. Note that the multi-meter leads are connected differently when measuring current and ensure they are connected correctly before proceeding.

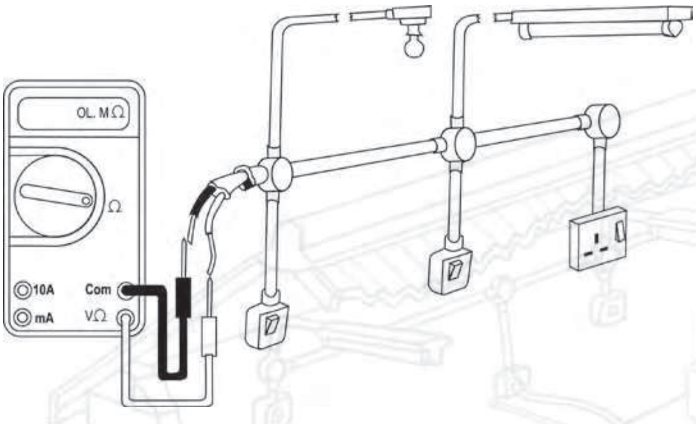


Connect the red and black multi-meter leads to the red and black module wires respectively. Compare the reading with the module's short circuit specification written at the back of the module. If the test is done at noon the readings should be comparable.

Check Insulation resistance
To ensure that cables are well insulated and at no point do the positive and negative cable come into contact i.e. no possibility short circuit due to faulty cable.

To perform the insulation resistance test turn all switches on and ensure that all cables terminating at lights are open.

Set the multi-meter to read resistance and set the range to MΩ. Connect the meter at the point of the cable to be connected to the charge controller. If the insulation is good, the meter should give an "OL." reading indicating an infinite resistance (very high resistance reading).



If the meter gives a resistance reading then the insulation is faulty. To find out where the fault is turn off the switches one by one starting with the furthest as you check for a change in the resistance reading. Once identified, the faulty cable should be repaired or replaced.

The multi-meter can also be set to the buzzer function to check insulation. If it buzzer does not sound when the measurement is taken then the insulation is good, if the meter buzzer sounds taken then the insulation is faulty.

Check Circuit Continuity and Switching
Circuit continuity and switching tests are carried out on the load side of each individual circuit to check:

- That all circuits are continuous when switched on i.e. cables are not broken/disconnected at any point.
- That Switches are working well

To perform this test, all cables at the light outlet points and sockets are short-circuited, all switches are turned off and the multi-meter is set to the buzzer function.

Connect the meter at the point of the cable to be connected to the charge controller and sequentially turn on and off each switch light and socket switch one by one. If the socket installed does not have a switch it will need to be short-circuited to simulate switching.

If continuity and switching is good, the buzzer will not sound when the meter is initially connected. It should sound each time a switch is turned on and stop when the same switch is turned off.

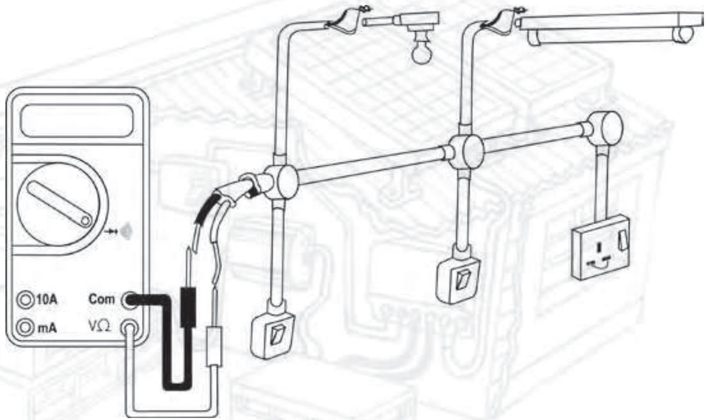
If continuity is faulty in a light or socket circuit the buzzer will not sound when the switch is turned on. This means that there is a broken cable or a faulty connection in the junction box, switch or socket. This fault needs to be corrected.

If the buzzer sounds before the switches are turned on then it means that one or more of the switches has been incorrectly installed. Switching on and off each switch until the buzzer stops will identify which switch this is.

It is important to note that if during the continuity test a broken conductor is found, the conductor has to be repaired, and tested again, but since it is impossible to do a proper insulation resistance test if the cables are not continuous, it is necessary to do the insulation resistance test again.

Ensure that all short circuits are disconnected after the continuity test.

If the multi-meter used does not have a buzzer function, the resistance function can be used. A low resistance reading (less than 1Ω) indicates continuity and a reading of “OL.” indicates no continuity.



Check Battery Voltage and Polarity

This test is done to ensure that the battery is charged and to ensure the polarity is correct before connecting to the charge controller.

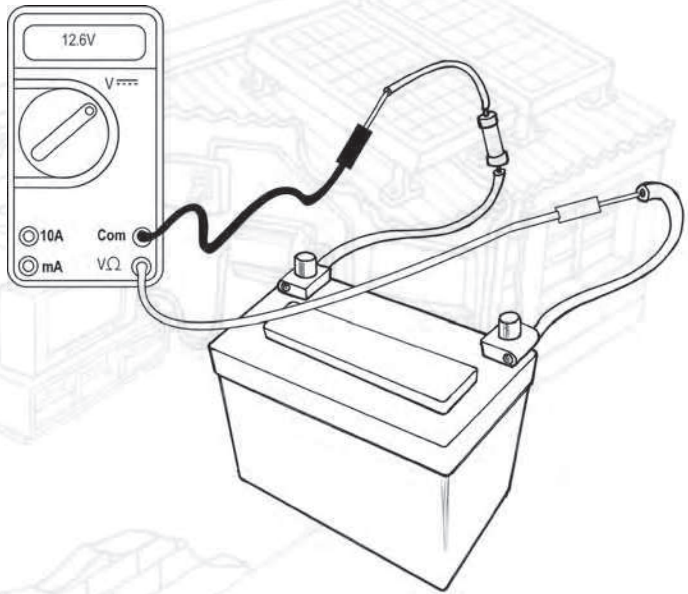
Set multi-meter on measure DC voltage and set the range to 20VDC. Connect the red and black multi-meter leads to the red and black module cables respectively. The reading for a charged battery should be in the range of 12.6 - 14VDC.

If the meter reading is positive it means that polarity is correct. If the meter gives a negative reading then battery cables should be switched.

After confirming the polarity is correct connect the battery to the charge controller as indicated in the charge controller manual. The connection point on the controller is usually indicated by a battery symbol. Connect the red cable to the positive and the black cable to the negative.

An indicator on the charge controller will show that the battery is connected and it's state of charge. If the battery state of charge is above 12.6VDC, connect the cable powering the loads to the charge controller and proceed with the checking and commissioning procedure.

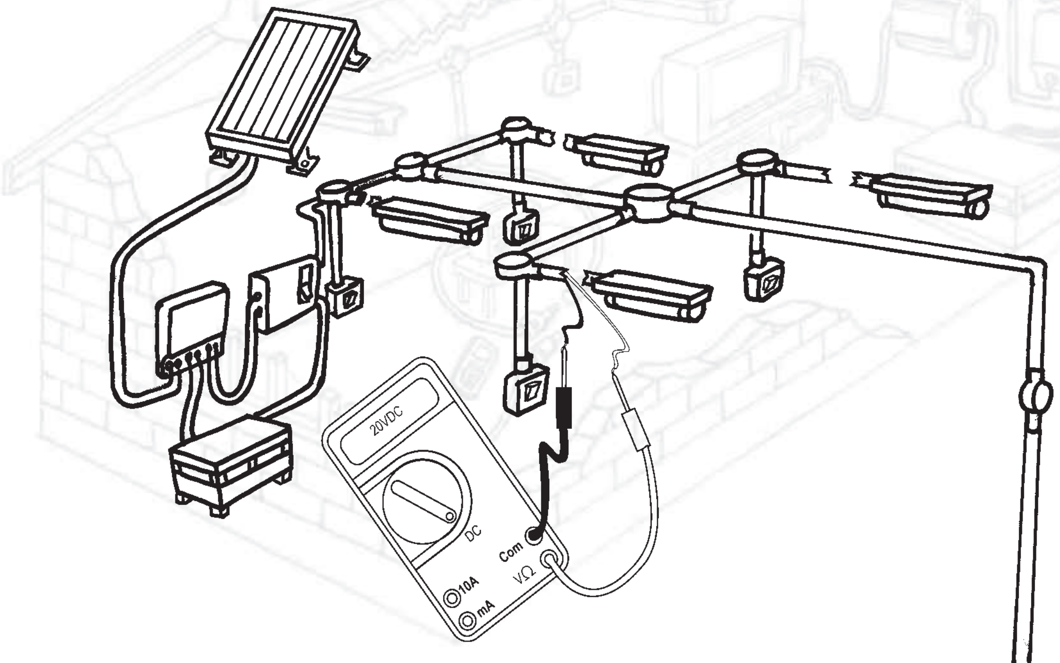
If the battery voltage is below 12-12.6V the charge controller will indicate it that the battery has a low state of charge and the low voltage load disconnect will prevent current flowing to the loads. If this happens connect the module to the charge controller (see controller manual for instructions) and leave the battery to charge until it is fully charged. When the battery has been charged disconnect the module before proceeding with the checking and commissioning procedure.



Check Polarity of Load Circuit Outlets and Connect Lights
Before connecting the lights or using the sockets it is important to ensure that all the polarity at all the outlets is correct. Unlike AC loads, reverse polarity can cause permanent damage to DC loads.

Connect the load cable to the charge controller and turn on all the switches. Set the multi-meter to the measure DC voltage and set the range to 20VDC. Measure the voltage at each power outlet connecting the red and black multi-meter leads to the red and black wires respectively. You should get a positive reading. A negative reading means the wiring has been reversed, in such a case correct the wiring or code the cables by wrapping red insulating tape on the black cable and black insulating tape on the red cable.

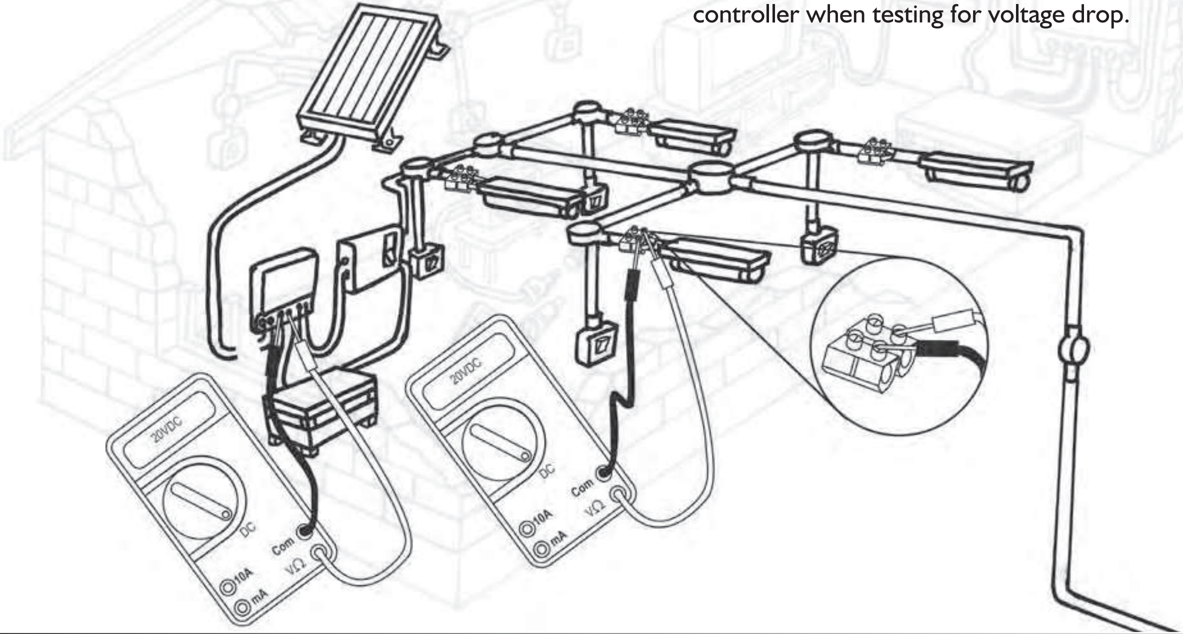
After confirming that the polarity is correct, turn off the switches and connect the lights. Turn on each light after connecting them to cross check.



Test for voltage drop
A voltage drop test is done to check that the appropriate cable gauge was used for the wire runs. Voltage drop is measured by comparing the voltage at the battery with the voltage at the power outlet.

To measure voltage drop turn on all the lights and appliances, and then measure the voltage at the battery and the voltage at each light or appliance. Start with the furthest light or appliance from the battery. The difference between the battery voltage and the voltage at the appliance is the voltage drop. This value should not exceed 0.6V. If the voltage drop exceeds 0.6V then the cable in that circuit needs to be replaced with a cable of larger gauge.

Note that the module should not be connected to the charge controller when testing for voltage drop.



Connect the Module

After performing all the tests connect the module to the charge controller as instructed in the manual. The module is always the last to be connected.

Finishing

Tidying up and completion of any work that is a direct result of the installation eg. repair of any damage caused to surface walls or fittings during the installation.

End-user education

After completing the installation spend sometime to educate the end-user on the user. Key issues the end-user should be educated on are

- How the system works
- Using the system efficiently
- Using the charge controller to check the system performance
- Maintaining the battery and module
- Replacing the battery
- Replacing fuses and lights

Test and Completion Certificate

After connecting all the system components fill a test and completion certificate. This is a record which gives details of the customer and installation location, the system components installed, the tests carried out and the spares left. The certificate is filled in triplicate and signed by the installer and the end user. Copies of the completion certificate are left with the customer, the technician and the PV supplier.

SAMPLE TEST & COMPLETION CERTIFICATE

This form should be completed by the technician in triplicate and countersigned by the system owner. Copies should be given to system owner, installer and PV dealer.

Technician's Name: ______________________________

Tel: ______________________________

Customer's details

Name: ______________________ Date: ____________

Address: ____________________ Tel: ____________

District: ______________ Location: ______________

Sub-location: ______________ Nearest Town: __________

Technical information

System voltage:

Solar Modules	Manufacturer	Model	Wattage	Serial No.
Lights	Manufacturer	Type	Wattage	Quantity
Charge controller	Manufacturer	Model	Rating (Amps)	Max Load Output current (Amps)
Battery	Manufacturer	Model	Capacity(Ah)	Quantity
Other Loads	Manufacturer	Model	Wattage	Serial No.

System Tests

Module(s) ISC: ______________ Amps   Continuity: ____________________

Module(s) VOC: ______________ VDC   Module(s) polarity: ______________

Polarity of outlets: ________________   Battery voltage: ____________ VDC

Voltage drop: ________________ VDC   Battery polarity: ________________

Final visual inspection: ____

Spares.

Item	Type /model	Quantity
Fluorescent Light tubes		
Battery water		
Fuses		

Guarantee card(s) signed: ☐ Yes ☐ No

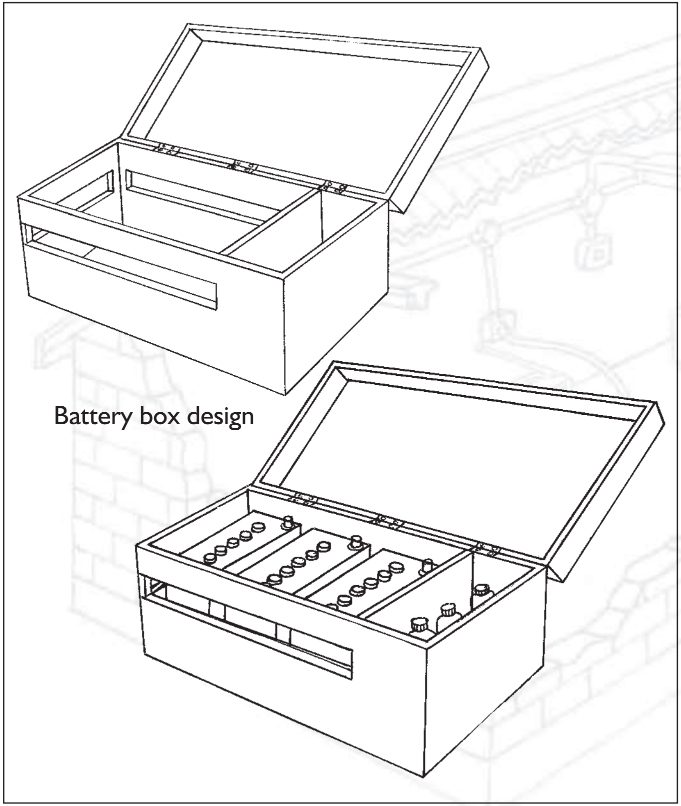
System explained: ☐ Yes ☐ No

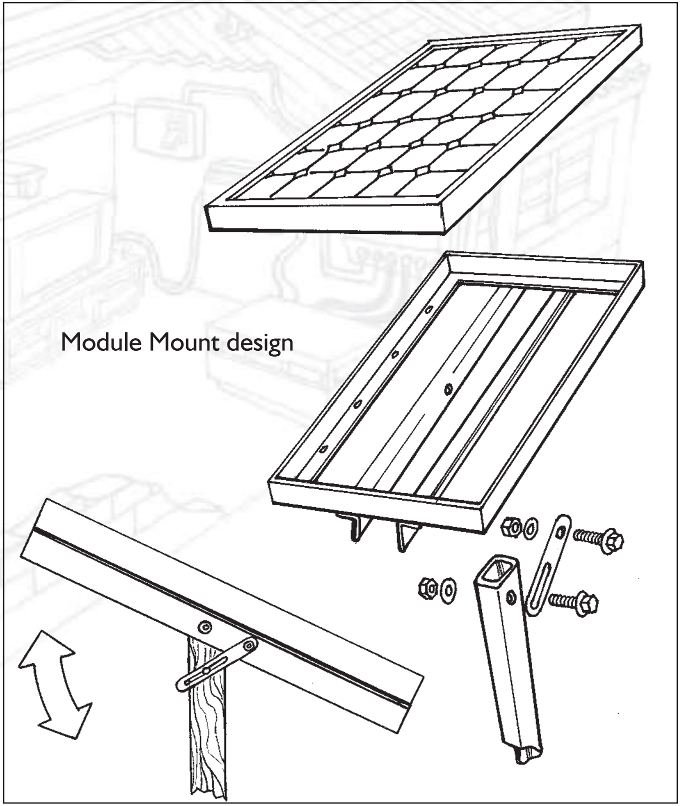
Comments: ____

Technician's signature: ____

Customer's signature: ____

Annex





Maximum Wiring Run Tables

Wire Size (mm^2)	Load Current								
	1 amp	2 amp	3 amp	4 amp	5 amp	6 amp	8 amp	10 amp	14 amp
1.5	22	11	7	6	4	4	3	2	2
2.5	38	19	13	9	8	6	5	4	3
4.0	60	30	20	15	12	10	8	6	4
6.0	88	44	29	22	18	15	11	9	6
10.0	150	75	50	38	30	25	19	15	11

How to Use Wire Run Table

1. Calculate the total load current flowing through the cable i.e. Add up the total loads (in Watts) at the end of the cable. Divide by the system voltage 12V.
2. Use the table above to determine maximum wire run for a given cable gauge carrying that load current.

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