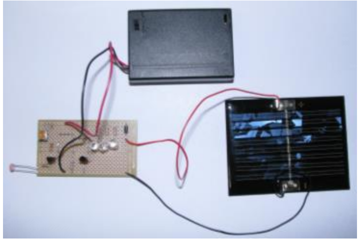
SOLAR NIGHT LIGHT – PROTOBOARD PROJECT

DESCRIPTION

The *SOLAR NIGHT LIGHT* is a simple project that turns on 3 LEDs when it gets dark. It consists of 3 parts, the light sensing protoboard circuit, 3 x AA rechargeable Nickel Metal Hydride Batteries to power the protoboard and a 4 volt Solar Panel to charge the batteries during the day.



SECTION 1: COMPONENTS REQUIRED

1.1 COMPONENTS REQUIRED

The following components are required and are available from Scorpio Technology (item codes in brackets). If you wish to order a pack of 10 sets of components you can do so by ordering ***NIGHTLIGHT10***

Before starting we suggest that you check you have all the components using the checklist below – tick off each component as you identify it.

☐ 1 x Protoboard	(PCB-PROTO)
☐ 1 x 3 x AA Battery Holder with switch	(BH3AAF)
☐ 3 x LED White clear	(LEDSCW5)
☐ 1 x Diode – 1N5817	(DIO1N5817)
☐ 1 x Transistor – S9011	(TRAN9011)
☐ 1 x Transistor – SS8050	(TRANSS8050P)
☐ 1 x Trimpot 100K Ohm	(TRIM100)
☐ 1 x Resistor – 680 Ohm (Bl-Gy-Br-G)	(RES680)
☐ 2 x Resistor – 1K Ohm (Br-Blk-R-G)	(RES1K)
☐ 3 x Resistor – 18 Ohm (Br-Gy-Blk-G)	(RES18)
☐ 1 x Light Dependent Resistor	(LDR)
☐ 1 x Solar panel No. 17	(SOLAR17)

1.2 ADDITIONAL REQUIREMENTS

The following material is to be supplied by the student / designer:

- ☐ Hookup wire in red and black (WIREHU10R and WIREHU10BL)
- ☐ Length Tinned copper wire (for wire links) (TCW)
- ☐ The Nickel Metal Hydride Batteries suited to solar panel charging are available from Bunnings: Solar Magic AA 2000maAh Ni-MH Rechargeable Batteries - 4 Pack I/N:4352433
- ☐ Material / parts for the housing and mounting of the circuit and battery holder.

WARNING: Do NOT use Lithium Rechargeable batteries

1.3 TOOLS REQUIRED

The following tools are required. A number of these are available from Scorpio Technology, and can be ordered separately if required (item codes in brackets):

- ☐ Soldering Iron: a good quality soldering iron, with a fine tip (SOLDIRN) and Soldering Iron Stand (SOLDIRNSTD) or Soldering Station (SOLDSTN)
- ☐ Solder: the use of 0.71mm 60/40 solder is recommended (SOLD500)
- ☐ Assorted hand tools – depending on the choice of materials to be used

SECTION 2: DESIGN

The designer has to make a variety of decisions and determine the following:

- ☐ How the *SOLAR NIGHT LIGHT* will be used.
- ☐ The size, design and shape of the housing
- ☐ The type of material to be used for the project.
- ☐ Draw up a picture of the design with all measurements shown and materials identified.

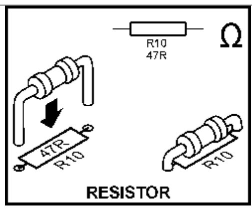
SECTION3: THE ELECTRONIC COMPONENTS

The components required are:

Mount the Resistors (R1 to R6) in place.

- ☐ *Resistor – 1K Ohm (Brown-Black-Red-Gold) R1 and R2*
- ☐ *Resistor – 680 Ohm (Blue-Grey-Brown-Gold) R3*
- ☐ *Resistor – 18 Ohm (Brown-Grey-Black-Gold) R4, R5 and R6*

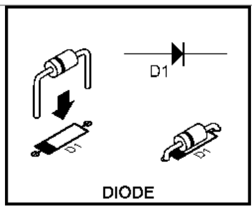
Resistors are non-polarised components and do not need to be placed in any particular direction. However, the convention is that horizontal resistors are mounted with the tolerance band to the right or to the bottom of the board.



Mount the Diode (D1).

- ☐ *Diode – 1N5817 (DIO1N5817)*

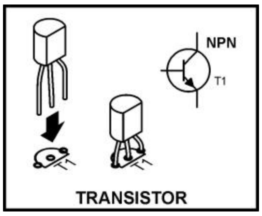
When mounting diodes ensure that the negative end, with the band, is facing in the correct direction as shown on the PCB.
WARNING: if diodes are inserted in the wrong direction the circuit will NOT work.



Insert the Transistors T1 and T2

It is very important to ensure that they are mounted in the correct direction (as shown on the layout drawing). The flat side of the Transistor MUST face the same direction as shown in the Protoboard layout.

- ☐ *T1 Transistor 9011*
- ☐ *T2 Transistor SS8050*



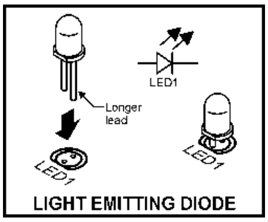
You must ensure that each transistor is mounted in the correct location. Swapping them over will either lead to degraded performance or failure for the circuit to work.

If a transistor faces in the wrong direction and power id connected to the Protoboard the Transistor is likely to be damaged.
The transistor has 3 leads (legs): the Emitter (E), Base (B) and the Collector (C).

☐ **Mount the White Super Bright LED (Clear body) L1,L2, and L3**

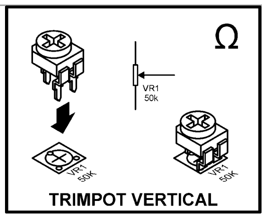
LEDs are polarised components and must be mounted correctly. If mounted the wrong way round the LED will never operate. The negative lead can be identified in different ways:

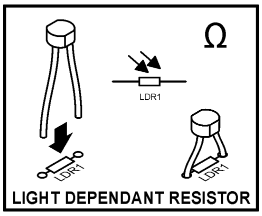
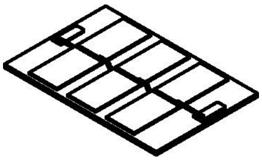
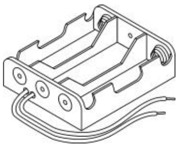
1. The flag (the larger connection inside the body) identifies the negative lead. This is visible when the LED is held up to the light
2. The short leg is negative
3. A flat on the ridge, around the base of the LED is on the negative side.
The lengths of wire used to connect the LEDs will be determined by how far away from the Protoboard the LEDs will be mounted.



☐ **Mount the Trimpot**

This is a special type of resistor. It is called a variable resistor and its resistance can be varied anywhere between zero and 1000,000 Ohms. It has three leads and must be mounted as shown. You can adjust the circuits sensitivity to light.



☐ **Mount the Light Dependant Resistor (LDR)** *This type of resistor's, resistance is controlled by light intensity. Bright light gives low resistance while darkness gives very high resistance. The LDR is the sensor that uses light intensity to control the operation of the circuit.* *The lengths of wire used to connect the LDR will be determined by how far away from the Protoboard the LDR will be mounted.* *The positioning of the LDR should be carefully considered. Light must be able fall onto the face of the LDR. Light from the LEDs should not allowed to fall onto the LDR or erratic operation of the circuit will occur.*	
☐ **Solar Panel** *Solder wires the appropriate length to the Solar Panel. The length of the wires will be determined by the how far away from the Protoboard the Solar Panel will be when mounted in position. Use a RED wire for Positive (+) and a BLACK wire for Negative (-)*	
☐ **Battery Pack** *The Battery Pack MUST be mounted with the Positive (+) RED wire and the Negative (-) BLACK wire in the correct position. Check that you have done this correctly, because if the wires are reversed and you insert the batteries when you turn on the Battery Pack it is likely that the Transistors in the circuit will be permanently damaged and will have to be replaced. Depending on where the Battery Pack will be positioned, you may need to increase the length of the wires.*	

SECTION 4: ASSEMBLING THE PROTOBOARD

4.1 MOUNTING THE COMPONENTS

☐ Face the Protoboard so that you can see the component side.

Begin with the components that sit lowest on the Protoboard. In this case it will be the wire links, resistors, trimpot and lastly the transistor.

Refer to Section 4.4 for detailed information on locating component mounting positions.

4.2 SOLDERING THE COMPONENTS IN PLACE

NOTE: Check that all the components are in their correct positions: it pays to spend some time doing this before soldering components in place. It can prevent wasted time later on, trying to find out why the circuit is not working and unsoldering and replacing damaged or wrongly positioned components.

4.3 GENERAL PRINCIPLES

- ☐ Turn over the Protoboard to the side that has the copper tracks and slightly bend the leads of the components outwards, to prevent the components slipping out.
- ☐ Apply the soldering iron's tip to the lead and track pad at the same time. Heat the joint for 2-3 seconds and then apply the solder to the heated lead and pad on the opposite side to the soldering iron tip. Melt the solder onto the hot pad and lead, not onto the soldering iron.
- ☐ Once all the components have been soldered, use a pair of side cutters to cut off the ends of the leads – as close as possible to the solder

4.4 MOUNTING COMPONENTS TO THE PROTOBOARD

The picture shown later in Section 4.4 shows the location of the components on the Protoboard.

Begin with the components that sit lowest on the Protoboard. In this case begin with the wire links.

4.5 PROTOBOARD LAYOUT

Carefully follow the layout of the following picture:

- ☐ Every component and wire MUST be in the exact location shown.
- ☐ Any variations will prevent the circuit from working.

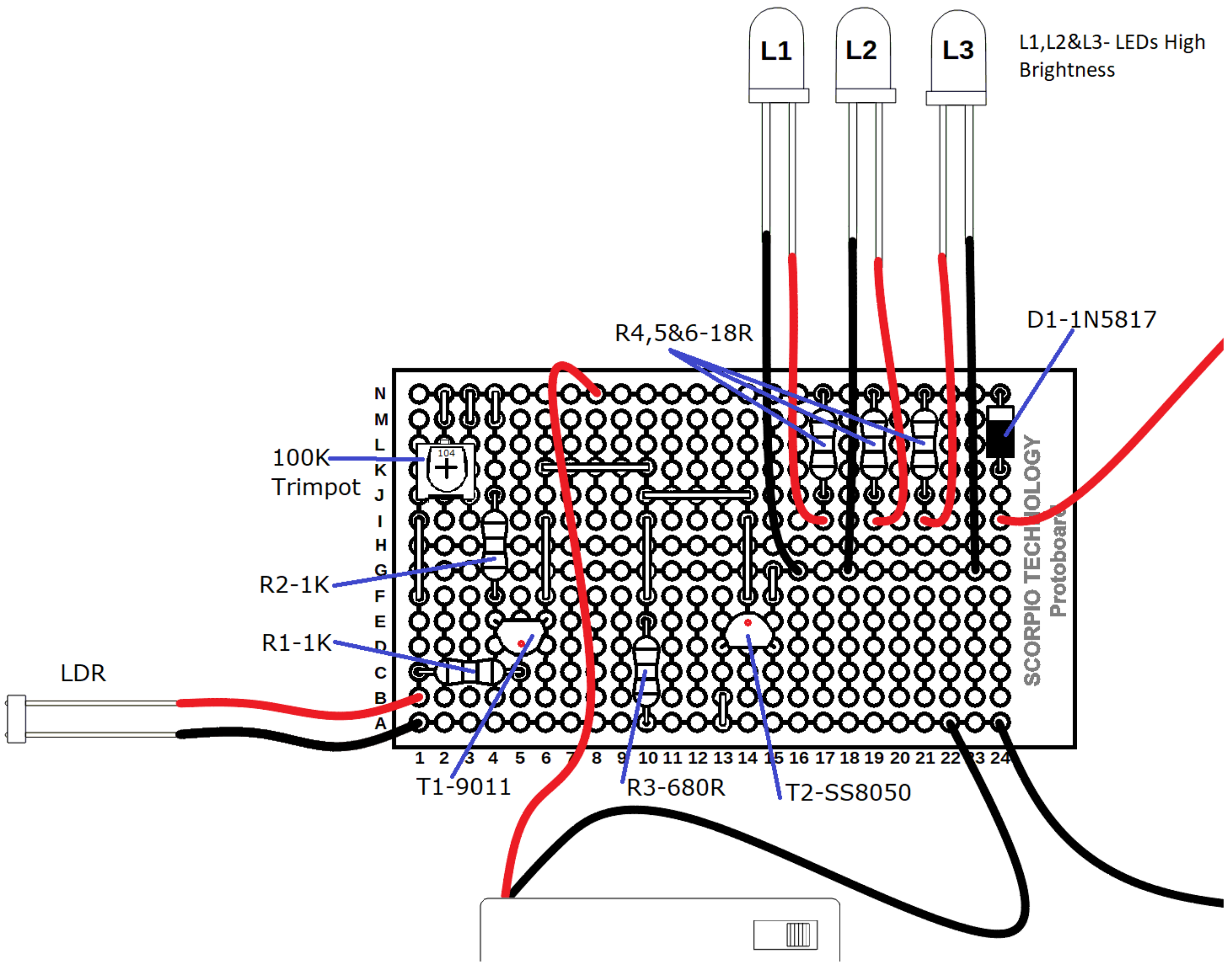
If your circuit does not work make sure the components and wires are connected as shown.

- ☐ All components and links MUST be positioned correctly.
- ☐ The Transistor, Diode and Trimpot must face in the direction shown or the circuit will not work.

- ☐ Use the following picture to help you correctly locate the component leads and wire links.

The rows are marked by letters and columns are marked by numbers. A1 would identify the hole in the bottom left hand corner of the Protoboard. The information shown below works like this: "220 ohm Resistor, F7-J7" indicates that the 220 ohm resistor's leads fit into holes J7 and F7. For the wire links A3-B3 indicates a wire link that fits into holes A3 and B3.

- ☐ The connecting wires and components should be positioned according to the information shown in the following picture.



COMPONENTS

Resistor – 1K Ohm:	R1- (C1-C5), R2-(J4-F4)
Resistor – 680 Ohm:	R3-(E10-A10)
Resistor – 18 Ohm:	R4-(N17-J17), R5-(N19-J19), R6-(N21-K21)
Diode D1:	(N24-K24)
Trimpot:	(J1-L2-J3), T1-(E4-D5-E6), T2-(D13-E14-D15)

WIRE LINKS

N2-M2,	N3-M3,	N4-M4,	I1-F1,	I6-F6,	K6-K10,
I10-F10,	J10-J14,	I14-F14,	G15-F15,	B13-A13	

COMPONENT WIRES

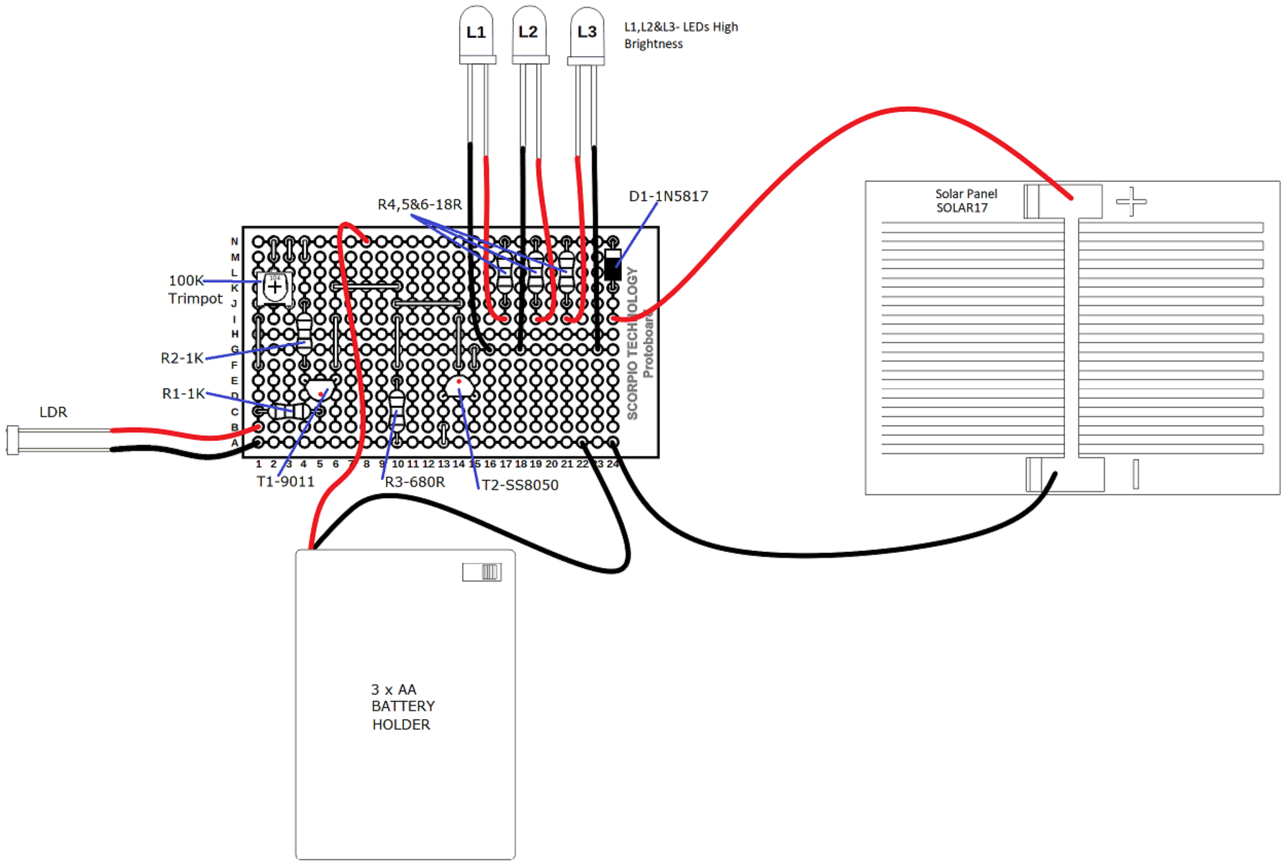
LDR wires: A1 and B1 to LDR's legs,

L1 wires: G16 neg and I17 pos, L2 wires G18 neg and I19 pos, L3 wires G23 neg and I21 pos,

Solar Panel: I24 pos and A24 neg,

Battery Pack: A22 and N8

☐ Complete the assembly of the protoboard and connect the Solar Panel and Battery Pack as shown in the following picture.



Wiring Diagram

☐ Give your Protoboard, Solar Panel and Battery Pack to a classmate and get them to check the positions and soldering of all links, components and wires.

☐ If everything is OK make sure the switch on the battery pack is turned off.

☐ Open the cover to the battery pack and insert the 3 x AA batteries. Make sure the negative end of each battery fits against the springs.

- ☐ Turn on the battery Pack.
- ☐ Cover the LDR to see if the LEDs operate.

If not try turning the trimpot setting to make the LEDs light.

SECTION 5: TROUBLESHOOTING

If any of the above are not achieved, turn off the power **immediately** and check the following:

- ☐ Check battery voltage. It should be around 3.6 Volts.
- ☐ Check the orientation of the Battery leads connected to the Protoboard. Red is positive and Black is Negative.
- ☐ Check the orientation of the Solar Panel leads connected to the Protoboard. Red is positive and Black is Negative.
- ☐ Check the position of components on the Protoboard against the drawing. Even one hole position different will probably mean it is a problem.
- ☐ Check that bare wire ends do not touch.
- ☐ Check for short circuits (solder bridges), these can occur more easily between close components.
- ☐ Make sure there are no dry joints (they can look "frosty") - the soldering may look dry or lumpy or you may notice the solder does not actually connect to the wire. This will look like a dark ring around the wire: try pulling the wire to see if the lead comes out or moves (a magnifying glass will help)
- ☐ Check that the Transistors are facing in the directions shown.
- ☐ Check that the leads from the LDR and the LEDs are not short circuited by a solder bridge or wires touching (shorting).
- ☐ Check that Transistors T1 and T2 are facing in the correct direction.
- ☐ Check the values of all resistors are correct.
- ☐ If the LEDs will not light. Check the orientation of the leads, LEDs have positive and negative leads. If connected the wrong way round they will never light up.
- ☐ If some LEDs light but another will not light, check the orientation of the non-working LED. If it mounted the wrong way round it will never light.
- ☐ Check the direction of diode, D1. Check that D1 has its positive and negative leads in the correct direction. If the diode is inserted the wrong way round the circuit will not work.
- ☐ Compare your project to a working one and look for differences in component placing, orientation, component values and soldering.
- ☐ Use a Transistor Tester to check that the Transistors are operating correctly. Replace the Transistor if the transistor Tester shows it is faulty.
- ☐ If this still does not enable the Solar Night Light to operate, check the charge of the batteries.

SECTION 6: THEORY – HOW THE CIRCUIT WORKS

6.1 CIRCUIT OPERATION

If a special type of resistor, called a Light Dependant Resistor (LDR) is used, a circuit to sense light can be made.

An LDR is made from Cadnium Sulphide, which is a semiconductor material whose resistance changes according to the amount of light falling on it. The resistance of the LDR is about 10 Meg-ohms (Millions of Ohms) in total darkness and falls to about 150 ohms in bright light.

REMEMBER – Dark – High Resistance

Light – Low Resistance

The LDR is mounted in a clear resin block with 2 leads. Like most resistors, it does not matter which way round an LDR is mounted in a circuit.

If one of the resistors of the potential divider is replaced with an LDR, it is like having a variable resistor in the circuit, which alters its value when the light intensity changes.

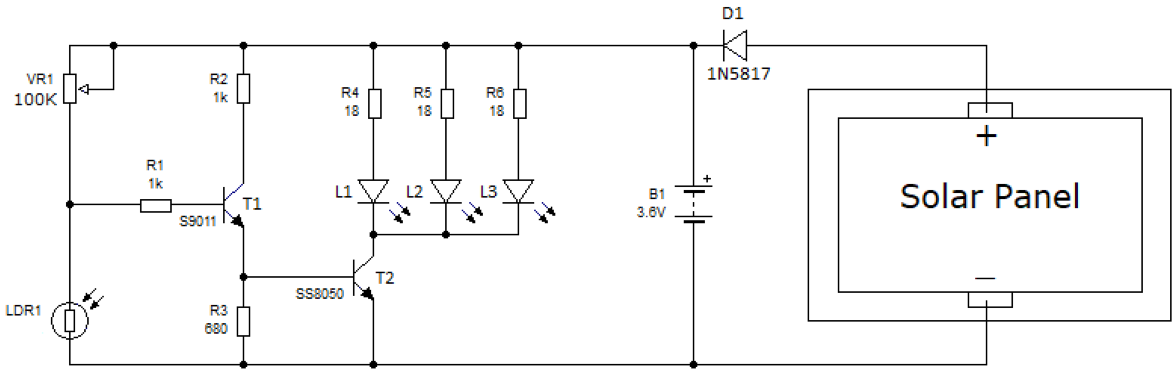
When the LDR is covered or placed in total darkness, its resistance increases, causing the voltage between the base and emitter of T1 to rise. The transistor begins to conduct and the LEDs lights up.

In practice it is necessary to adjust the Light Dependant resistor for different levels of light intensity, so the other resistor of the potential divider is replaced with a variable resistor.

This is the same method used to turn on street lights. The adjustment is made to turn on the street lights whenever the light intensity falls below the set value.

With the variable resistor, it is possible to adjust its value down to zero resistance. This would place a high voltage between the base and emitter of the transistor, causing excessive current.

To protect the transistor from damage by excessive current, R1, a 1k ohm resistor is placed in the base circuit.



LEDs turn on in the Dark Circuit Diagram

The circuit shown above will light when the LDR is in the dark. This is because its resistance will increase as the light level falls, causing the voltage across the LDR to increase.

Once there is sufficient voltage to the base of the transistor, it will turn on causing current to flow through R2, through the transistor and the through R3. Enough current will flow through R3 to cause a voltage across it. Once the voltage reaches 0.6 volts, Transistor 2 will turn on and the LEDs will light. Resistors R4, R5 and R6 limit the flow of current through the LEDs to a safe level. If the LEDs are too bright you can try changing resistors R4, R5 and R6 to a larger values. You could try any resistor greater than 18 ohm but below 150 ohm.

During the day and in light the Solar Panel will produce 4 volts. The Schottky Diode, D1 1N5817 needs 0.4 volts across to operate. This reduces the voltage to the batteries to the 3.6 volts needed to charge them. The speed the batteries charge is determined by light intensity. High light intensity will charge the batteries charge quicker than low light intensity.

With the LDR in the light, its resistance will be very low, this means the voltage across the LDR will also be very low. This voltage will not be enough to turn on Transistor T1, so the LEDs will not light.

The Nickel Metal Hydride Batteries from Bunnings are specially designed for charging from Solar Panels.

The connecting wires and components should be positioned according to the wiring diagram shown on page 5.