D.I.Y. Automatic Nightlight Kit

Part Number: KIT-ABRA-102

Level: Beginner

- *Adjust your nightlight to turn on when you consider it dark.*
- *Control the brightness.*
- *Learn how a Light Dependent Resistor works.*
- *Learn how a transistor works.*
- *Learn how to use a LED light with current limiting resistor.*
- *Battery powered.*
- *Dual white LEDs.*

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1. Description:

This is the upgraded version of our popular Automatic Nightlight with a well thought-out PCB layout with ENIG gold-plated pads and blue soldermask on both sides.

This module uses a Light Dependent Resistor (LDR) also known as photocell which controls a pair of white 5mm LEDs. A variable resistor (potentiometer) is used to adjust the sensitivity and the brightness. The module can be powered by a 9V battery or an external AC-DC power supply. (battery/power supply is not included in the kit)

This is a D.I.Y. kit that requires soldering through-hole components on the double-sided printed circuit board. Users with minimal soldering tools can easily assemble this module.

2. Specifications:

- **Operating Voltage Range:** 4.5 – 12VDC (9VDC recommended)
- **PCB Dimensions:** 39 x 36 x 1.2 mm / 1.53 x 1.42 x 0.05 ”

3. Advantages:

- Adjust your nightlight to turn on when you consider it dark.
- Control the brightness.
- Learn how a Light Dependent Resistor works.
- Learn how a transistor works.
- Learn how to use a LED light with current limiting resistor.
- Battery powered.
- Dual white LEDs.

4. Bill of Materials

Component	Label	Value / Type	ABRA Part Number	Quantity
Resistors And Potentiometer	**P1**	**3386 100KΩ Potentiometer**	**3386F-1-104**	**1**
	R2	**1/4 Watt 4-band 22KΩ ±5%**	**R1/4-22K**	**1**
	R3	**1/4 Watt 4-band 470Ω ±5%**	**R1/4-470**	**1**
Diodes	**D1**	**1N4001 Silicone Diode**	**1N4001**	**1**
	LED1, LED2	**5mm White Light-Emitting Diode**	**LED-5W**	**2**
Transistor	**Q1**	**2N3904 NPN Transistor**	**2N3904**	**1**
Photocell	**LDR1**	**5mm Photo Resistor**	**PHOTO-310**	**1**
Connectors	**----**	**9V Battery Connector**	**29-130**	**1**
PCB	**----**	**Double-sided Printed Circuit Board**	**KIT-ABRA-102-BRD**	**1**

5. Assembly:

1) In order to assemble the module, you need the following tools:

Must Have

Soldering Station

60/40 or 63/37 Tin-Lead Solder

Flush Cutters

Tweezers/Pliers

Wire Stripper

Vice

Recommended

Isopropyl Alcohol

Rosin Flux/Pen

Soldering Brush

Lint Free Wipers

***It is recommended to have some isopropyl alcohol and a fine soldering brush handy to clean off the excess flux on the circuit board when the soldering is done.**

***ATTENTION* DO NOT USE RUBBING ALCOHOL, IT WILL DAMAGE THE COMPONENTS.**

2) Open the package and verify the components. (refer to section **4. Bill of Materials** on **page 2**)
3) Lay down all the components on your workbench and proceed to the next step.
4) Prepare your soldering tools.
    a) Use an appropriate tip for the application. Also, make sure the soldering tip is clean. Gently use a brass wool or a brush to clean the tip when needed. Another way of cleaning the soldering tip by using a wet sponge.

b) The soldering iron temperature depends on the type of solder used. If you are using a typical **60/40 lead solder**, depending on the thickness the temperature should be set anywhere between **370 to 500 °F (187 to 260 °C)**. If you are using a lead-free solder, increase above temperatures **by 40 to 70 °F (5 to 20 °C)**.

***ATTENTION* HIGHER TEMPERATURES WILL DAMAGE THE COMPONENTS AND THE PRINTED CIRCUIT BOARD.**

***ATTENTION* DO NOT TOUCH THE SOLDERING IRON WHEN IT IS HOT.**

c) It is recommended that you clean the board with a fine brush, isopropyl alcohol and lint-free cloth to get rid of any pre-existing residue, glue or dirt. This way the solder will create a better joint with the pad surface.

d) Have your flush cutter, needle nose plier or tweezers handy.

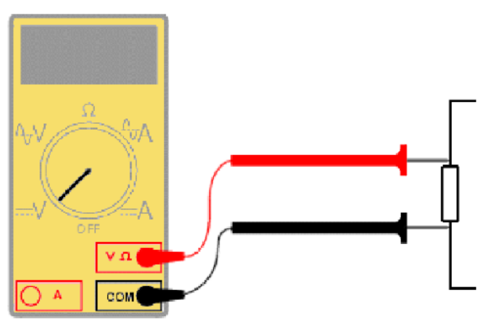
e) Having a roll of paper tape helps you to keep the components in place when soldering on the bottom side of the board.

f) Have a rosin flux pen or paste handy. Adding flux to the pads before soldering the components makes the wetting process easier by letting the melted solder flow better on the pad and create a better joint.

***ATTENTION* SOLDERING SHOULD BE DONE IN A VENTILATED AREA. BREATHING SOLDER FUMES WILL HARM YOU.**

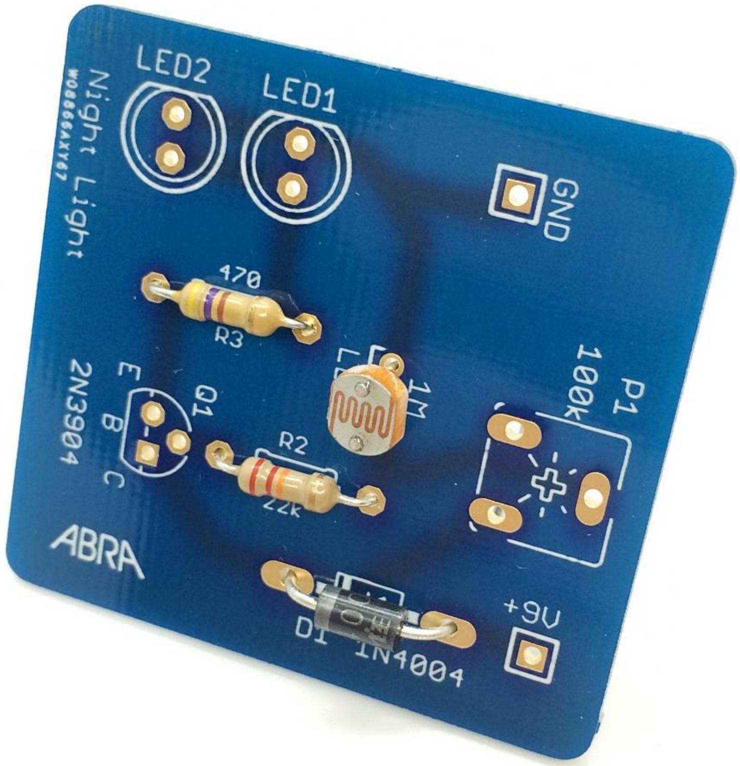
g) Always cut the excess leads with a flush cutter once a component is soldered on the PCB. At least 1mm of the lead should stick out from the solder joints.

Optional
Use a digital multimeter to measure the resistor values

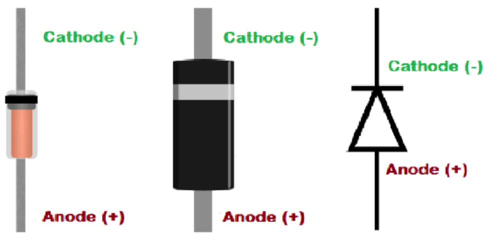


Step 1:

Insert the resistors (R2 and R3) along with the diode (D1) and the photocell (LDR) onto the board and solder them from the bottom.

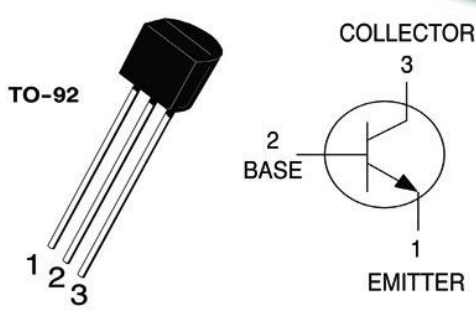


Pay attention to the polarity of the diodes.



Step 2:

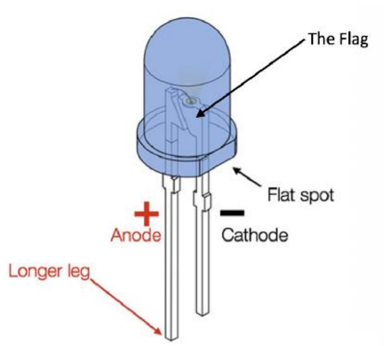
Insert the NPN transistor (Q1) and the potentiometer (P1) onto the board and solder them as you did in the previous step.



Step 3:

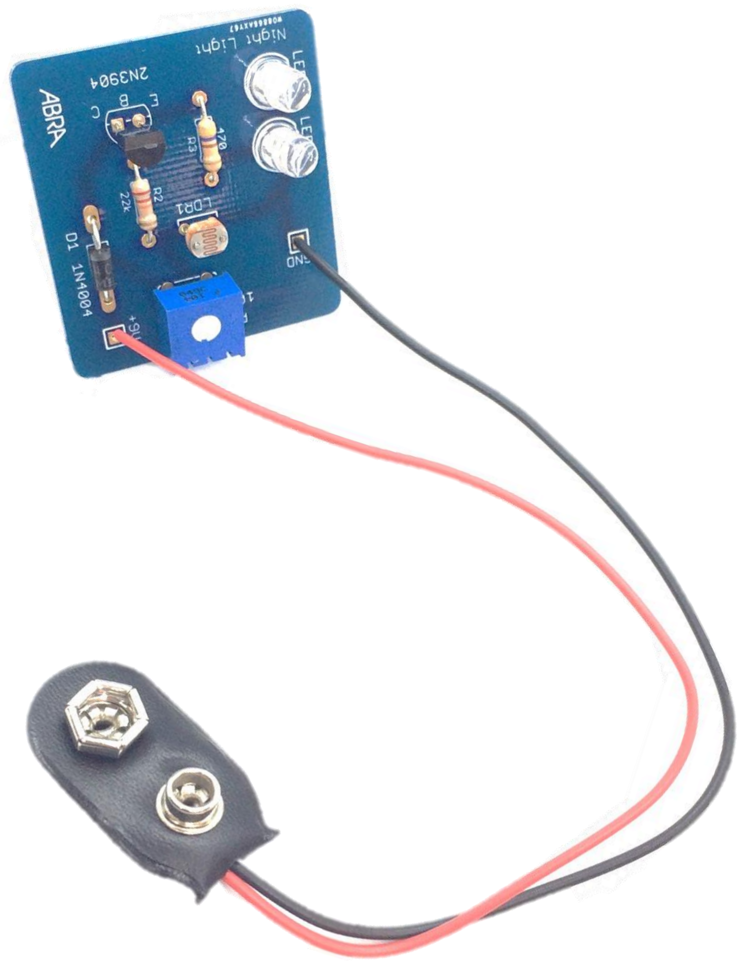
Solder both of the LEDs (LED1 and LED2). Refer the picture below for the correct orientation.

Pay attention to the LED polarity.



Step 4:

Insert the positive (red) wire and the negative (black) wire of the battery connector onto the board and solder them.

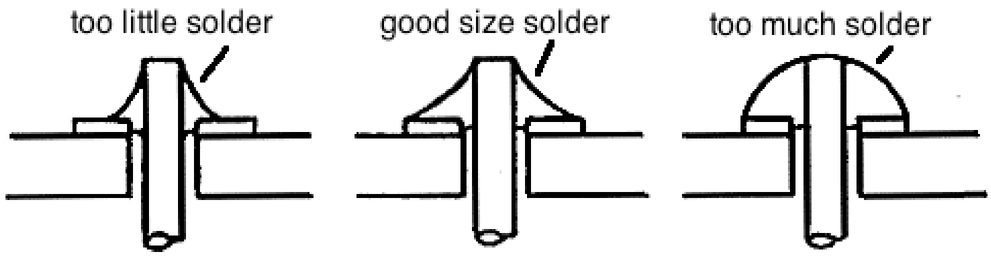


Insert your 9V battery, adjust the potentiometer to set the sensitivity and brightness.

Please note that when the potentiometer is set to its max value, the nightlight stays ON.

Assembly Check out:

- Before installing the 9V battery it is highly recommended to inspect the PCB carefully.
- Check for proper placement of components.
- Check that the LEDs, the transistor and the diodes are soldered in the correct orientation.
- Check that all connections are soldered with a shiny appearance.
- Redo any solder connection that is dull looking or in a ball.



- Check that there are no solder bridges touching adjacent connections together.

Operation:

- Install a 9V battery into the battery connector. (Battery is not included in this kit)
- With your room lights on, adjust P1 until the LEDs light up completely then go back until they are just barely on.
- Turn the room lights off, the LEDs should light up brightly.
- Adjust P1 to get the desired brightness in the dark.
- We suggest you to replace the 9 Volt Battery with an AC-DC adapter such as our **DC-950-2.5** or **DC-960-2.1** to avoid having to change batteries if you're planning to constantly use the module.

Troubleshooting:

- If the LEDs do not turn on throughout the range of adjustment of P1, repeat the Assembly Checkout.
- If the Assembly Checkout does not reveal any faults, replace the battery.

How Does the Circuit Work?

The Light Dependant Resistor (LDR1) resistance varies with the amount of light falling on it. LDR1 resistance varies from approximately 1 Meg Ohm in darkness to 100 Ohm in full light. This change in resistance in used to control the amount of current flowing through the NPN transistor (Q1) and the brightness of the LEDs. The potentiometer (P1) is adjusted in full light so that the LEDs are barely on. The LED brightness will increase as the light dims. When the light is completely off the LEDs will light up to their maximum brightness.

There are multiple lessons to be learned from this simple circuit:

- Why do we use a diode?
- What is a Light Dependent Resistor?
- How does the NPN transistor work in this circuit?
- How do you determine the ohmic value of the current limiting resistor for LEDs?

The diode (D1) is used to protect the circuit by only allowing the current to reach the circuit. A diode can only pass the electrical current one way. This prevents any damage caused by backfeeding of current to the battery or the power supply.

The light dependent resistor (LDR1) is made up off Cadmium Sulfide (CdS) that changes resistance with the amount of light falling on it. LDR1 is approximately 1 mega ohms (1M) in the dark and 100 ohms in the light.

The transistor (Q1) acts like a current valve. It has three leads, Emitter (E), Base (B) and Collector (C). It controls the amount of current passing between its Emitter (E) and Collector (C) depending on the amount of current flowing into its Base (B).

The potentiometer (P1) controls the voltage appearing at the base of Q1 (and current flowing into the base) by forming a voltage divider with LDR1. As the resistance of LDR1 increases with increased darkness, the voltage appearing at the junction of P1 and LDR1 increases which results in an increase in the current flow into the base. This increase in current is amplified by Q1 and results in a much larger increase in current flowing through the LEDs.

The voltage at the base of Q1 is determined by the formula:

V(base) = V(battery) x [LDR1 / (R1+LDR1)]

e.g. **When dark LDR1=1M ohm and V(base) = 9.0 x (1M/22K+1M) = 8.8 Volts**

When light LDR1=100 ohm and V(base) = 9.0 x (100/22K+100) = 0.04 Volts

When LDR1 sees no light with 8.8 Volts at the base, the transistor is fully turned on and acts as a switch with R2 limiting the maximum current into the LEDs; therefore, any voltage can be used to drive LEDs with the appropriate current limiting resistor. LEDs are usually specified to operate with a nominal 20mA (0.020A) current.

The value of a current limiting resistor can be determined by Ohm's Law:
R = V/I, where "R" is the required resistance, "V" the supplied voltage and "I" the max current allowed for the LED to function.

Note that the forward voltage-drop (VF) across the LEDs has to be subtracted from the total available voltage from the supply to correctly calculate the resistance.
So, the formula becomes: **R(limiting) = V – (VF/I(max))**.
For white LEDs VF is approximately 3.0V for a current limit of 20mA, the calculation for R2 would be: **R2 = 9.0-(3.0/.020) = 300 ohms**. In this kit a value of **470 ohms** was chosen to limit the current to **12mA** to prolong battery life.