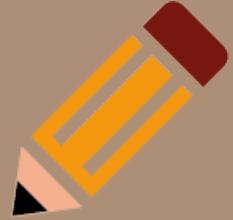


STEMStar II



Designed by: Jim Windgassen
REV - 21 April 2019

Special Thanks



For their kind donation of SIPAD Solid Solder Deposit Service on
the STEMStar II Printed Circuit Boards

What is STEMStar II ?



- STEMStar II is a fun star shaped circuit board that introduces students to:
 - Fundamental electronic components - resistors, capacitors, transistors, and LED's.
 - Modern surface mount circuit boards
 - Circuit simulation using LTSpice

The Kit



The kit consists of a printed wiring board (PWB) covered with protective paper and a small bag of parts

Step 1 - Preparation



- 1) Place the Printed Wiring Board (PWB) onto the assembly tray as shown and remove the protective paper.
- 2) Remove the parts from the bag and place them in the following order above the tray from left to right:

FIND NO.	QTY	DESCRIPTION
1	5	RESISTOR, CHIP, 750 OHMS, 250MW, 1206
2	5	RESISTOR, CHIP, 100K OHMS, 250MW, 1206
3	5	CAPACITOR, CHIP, 1UF, 16V, 10%, 1206
4	5	LED, RED, SOT-23
5	5	TRANSISTOR, MOSFET, N-CH, 60V, 115MA
6	1	SWITCH, SLIDE, DPDT, 100MA
7	1	BATTERY RETAINER COIN 20MM 2CELL SMD
8	2	BATTERY, LITHIUM MANGANESE, 20MM

- Find No. 1, 2, 3 are labeled
- Find No 4 are the red colored parts
- Find No. 5 is the black colored strip
- Find No 6 looks like a tiny little switch
- Find No. 7 is the large metallic part



Take the time to set yourself up for success !

Electronics – Resistor

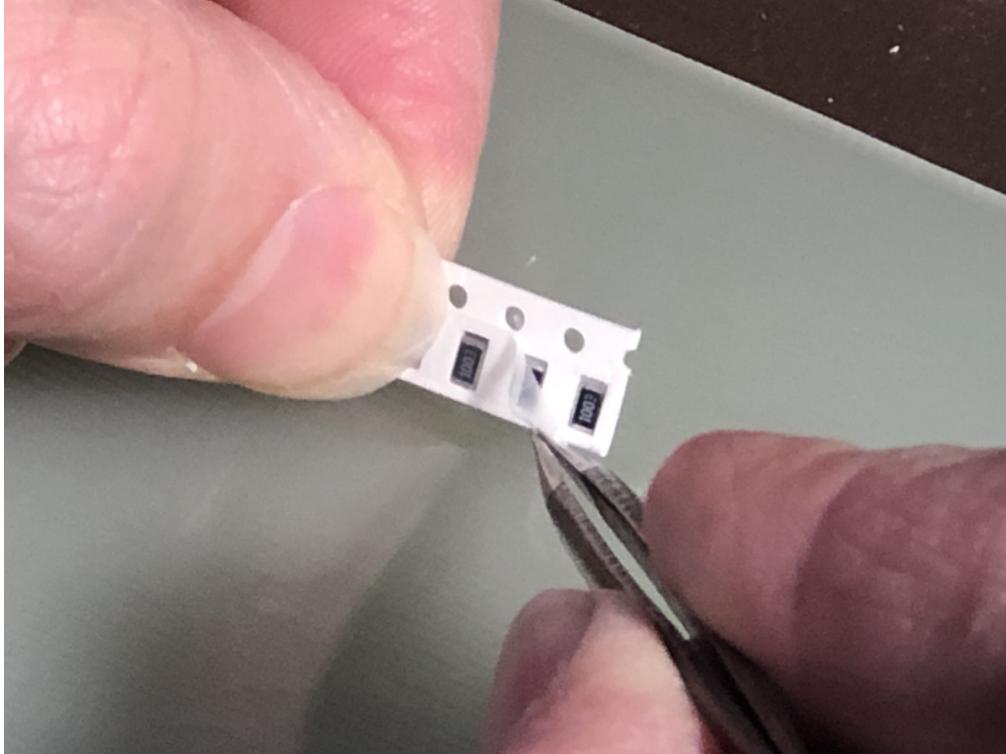
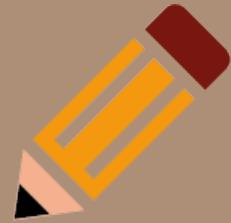


- Resistor – Measured in Ohms – Abbreviated as **R**
 - Resists the flow of electricity
 - Think of it kind of like a kink in a garden hose
 - A 1 ohm resistor will flow 1 amp when 1 volt is put across it
 - Relationship between voltage, current & resistance is Ohm's Law $V = I * R$



Thru Hole, Surface Mount, and Power Resistors

Step 2 – Install Find No. 1



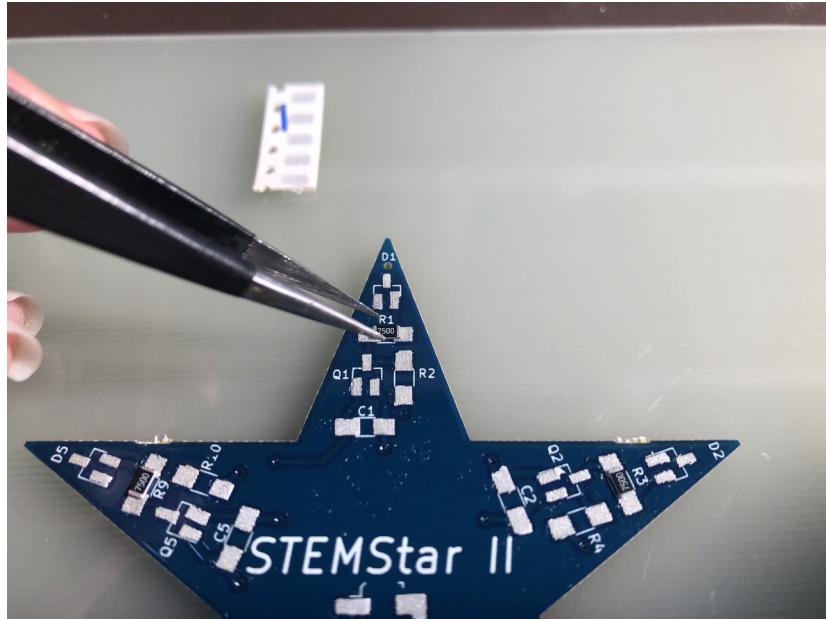
Double check that you have the resistors marked with the “1” on the paper tape. They will also have the number “7500” on each part in the tape to indicate that they are 750 ohms.

Hold the strip of parts just above the tray and use the tweezers to pull back the film covering the resistors and dump them on the tray.



Put the parts in a row above the PWB. There is no direction for resistors.

Step 2 (ctd) – Install Find No. 1

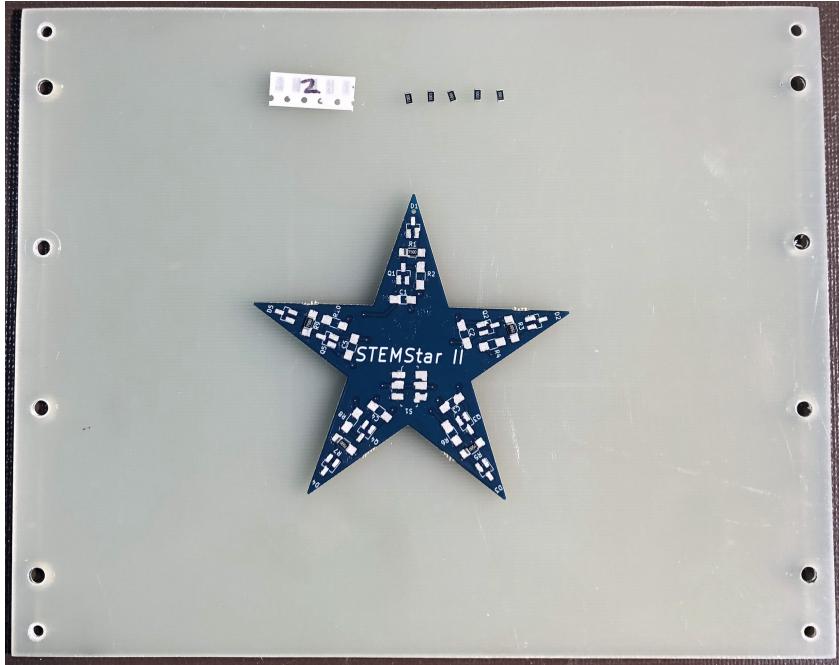


Pick up one of the 750 ohm resistors using tweezers, and place it on the pads for R1 as shown above. Gently press the resistor down with the tweezers.



Install 4 more 750 ohm resistors at R3, R5, R7, R9 as shown above.

Step 3 – Install Find No. 2



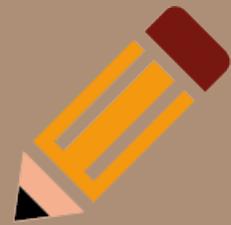
Double check that you have the resistors marked with the “2” on the paper tape. They will also have the number “1003” on each part in the tape to indicate that they are 100k (100,000) ohms.

Place the parts on the tray as you did before for Find No. 1.

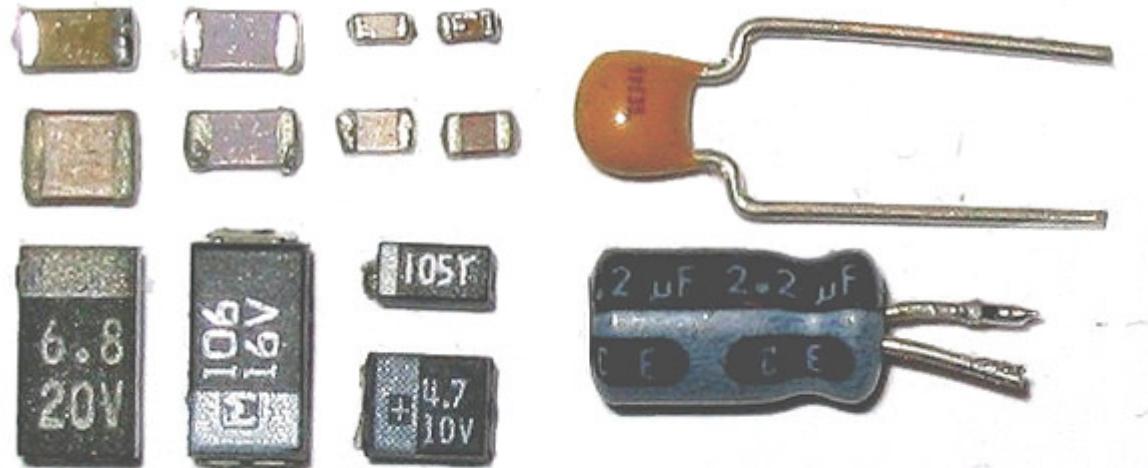


Install the 100k resistors at locations R2, R4, R6, R8, R10 as shown above.

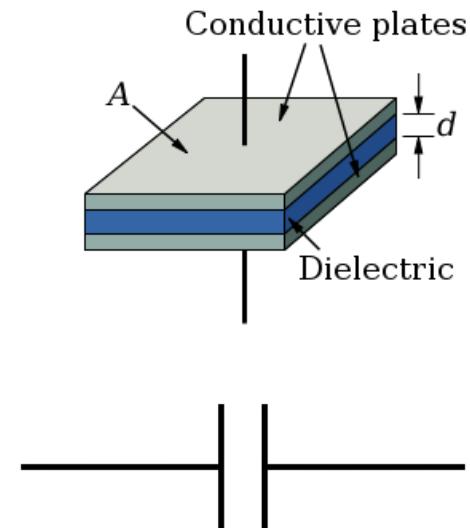
Electronics - Capacitor



- Capacitor – Measured in Farads – Abbreviated as **C**
 - We usually speak of capacitors in microfarads (μF) or picofarads (pF)
 - 1 μF is 1 millionth of a Farad and 1 pF is 1 trillionth of a Farad
 - DC (constant) currents cannot flow through a capacitor, but AC (alternating) currents can flow through them.
 - A capacitor consists of two plates of metal separated by a dielectric (insulator).



Surface Mount and Through Hole Capacitors

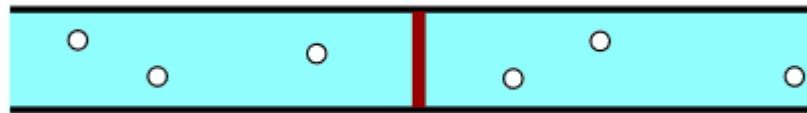


Schematic Symbol for a Capacitor

Electronics - Capacitor



- Capacitors Store Energy in Electric Fields
 - Similar to the way that a spring stores energy by being compressed
 - Acts like an energy storage unit that can be charged and discharged very quickly
- Two Ways to Visualize a Capacitor in Your Mind



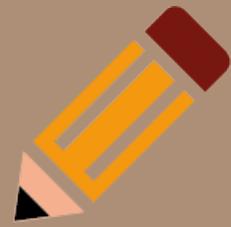
A Rubber Membrane Between Two Sides of a Pipe



A Spring

It may be easier to use one or the other of these visualizations of a capacitor depending on how it is being used in a circuit.

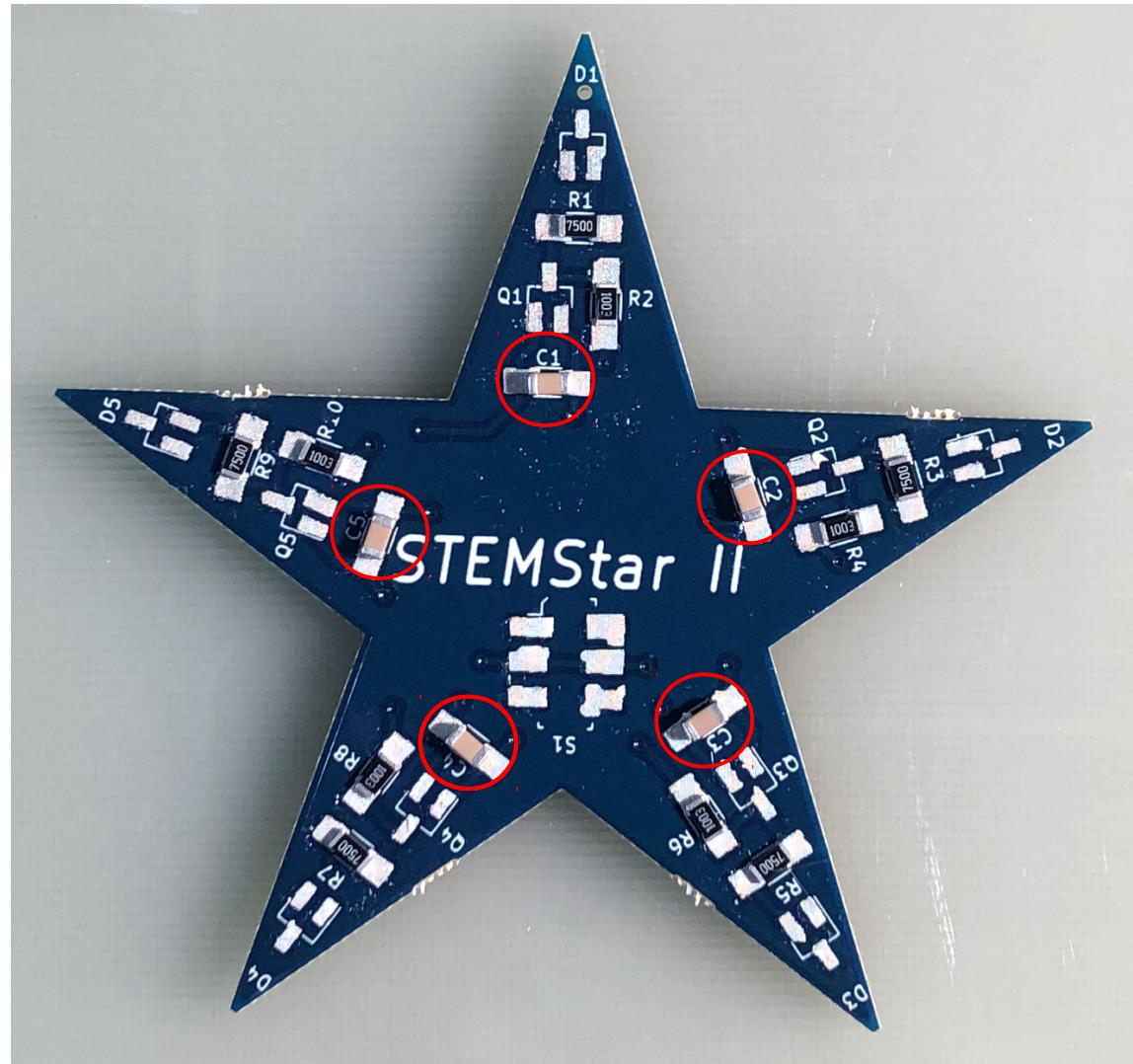
Step 4 – Install Find No. 3



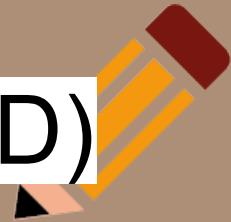
Get Find No 3, 1 micro-farad ($1\mu\text{F}$) capacitors

Place the parts on the tray as you did before for Find No. 1.

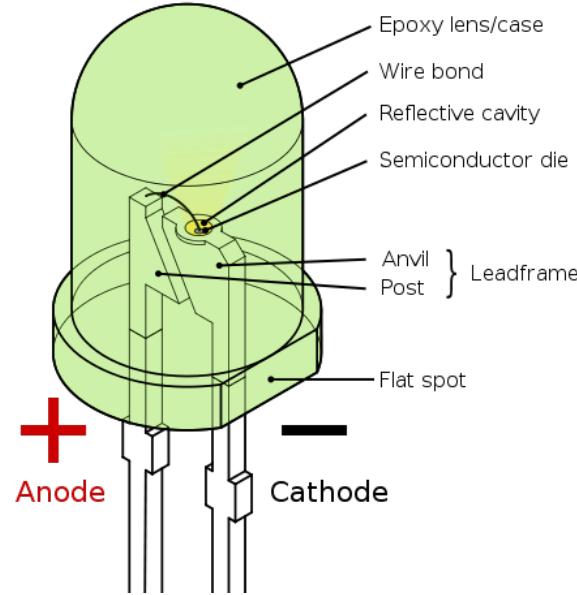
Install the $1\mu\text{F}$ capacitors at locations C1, C2, C3, C4, C5 as shown.
There is no direction for these type of capacitors.



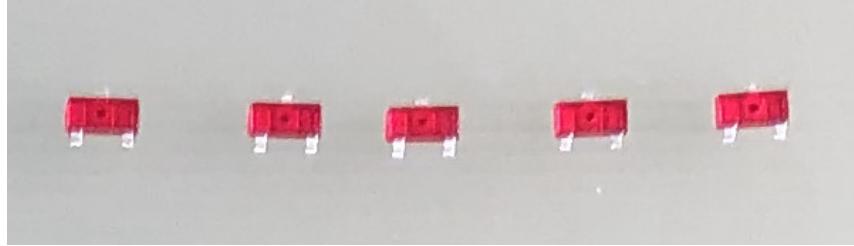
Electronics – Light Emitting Diode (LED)



- Light Emitting Diodes (LED's)
 - The LED is a special kind of diode that can emit light
 - A diode is an electronic component which only allows current to flow in one direction
 - LED's are available that make almost any color of light
 - The color of the LED is determined by the kind of semiconductor material used to make the LED.



Step 5 – Install Find No. 4



Get Find No 4, red light emitting diodes (LED).

Place the parts on the tray with the leads facing down towards the tray and the side with two leads towards you as shown above.

Install the LED's at locations

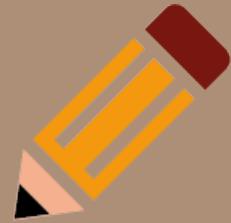
D1, D2, D3, D4, D5

Ensure that the 3 leads on each part are on the pads.

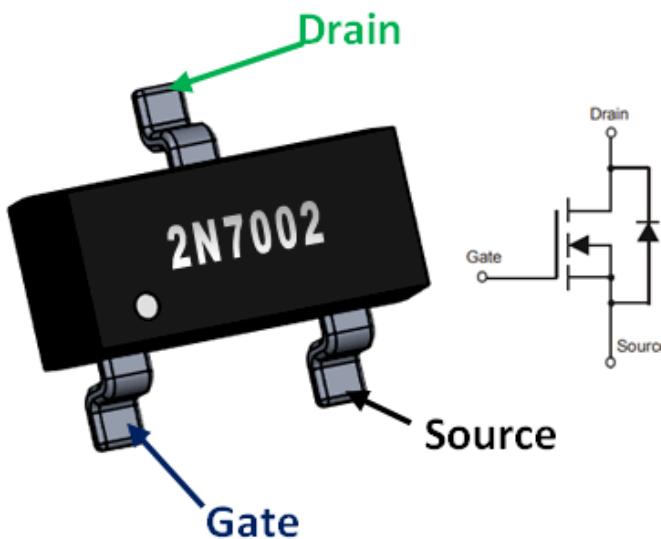
Note – The LED's are in a 3 leaded package so that they will only fit on the board one way – only 2 of the 3 leads are electrically connected.



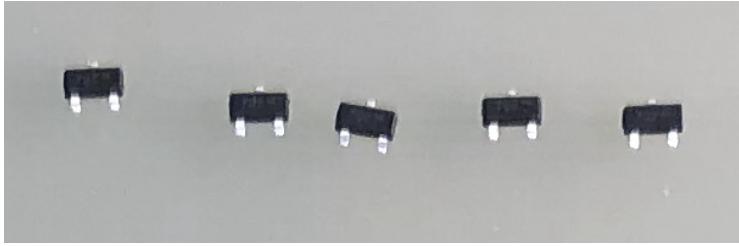
Electronics - MOSFET



- A MOSFET is a kind of transistor – a device that acts as an electronic switch
- MOSFET is an acronym for Metal Oxide Shielded Field Effect Transistor
- The MOSFET has three terminals called Drain, Gate, and Source
- When the part is on, current can flow between the Drain and the Source
- Turns on when the voltage at the gate is higher than the voltage at the source.



Step 6 – Install Find No. 5



Get Find No 5, MOSFET transistors

Place the parts on the tray with the leads facing down towards the tray and the side with two leads towards you as shown above.

Install the transistors at locations

Q1, Q2, Q3, Q4, Q5

Ensure that the 3 leads on each part are on the pads.



Step 7 – Install Find No. 6

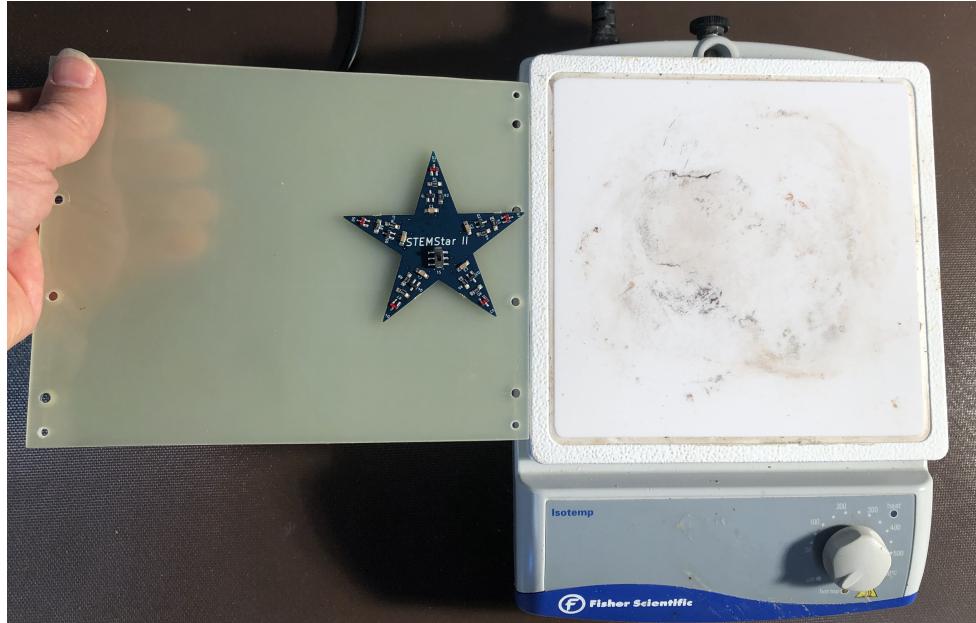
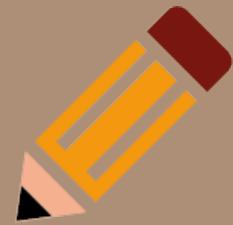


Get Find No 6, Switch.

Install the switch at location S1 as shown. The switch is symmetrical, so it will work correctly regardless of installation orientation



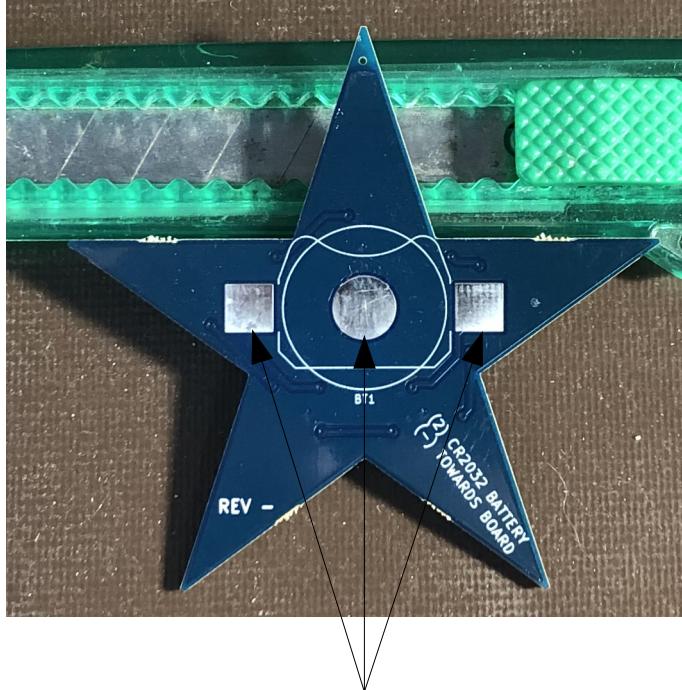
Step 8 – Reflow Time !



Raise your hand and ask for an adult to come over. The adult will help you bring your board over to the reflow station where your board will be placed onto a hot plate so that the solder on your board can melt and attach / connect the parts to your PWB.



Step 9 – Install Find No. 7



Using lead-free solder and a soldering iron, tin these 3 pads on the backside of the PWB. A stand will likely be required as the parts on the front prevent the board from lying flat. Tinning the center pad will make it easier for the battery to make good contact.



Apply a small amount of no-clean flux to the two outside pads.

Place the battery holder onto the pads, ensuring that the open side of the holder points towards the top of the board.

Solder the two tabs of the battery holder onto the PWB.

Step 10 – Install Find No. 8



Stack the two CR2032 batteries with their “+” side facing up.

Insert the two batteries into the holder as shown and push all the way in.

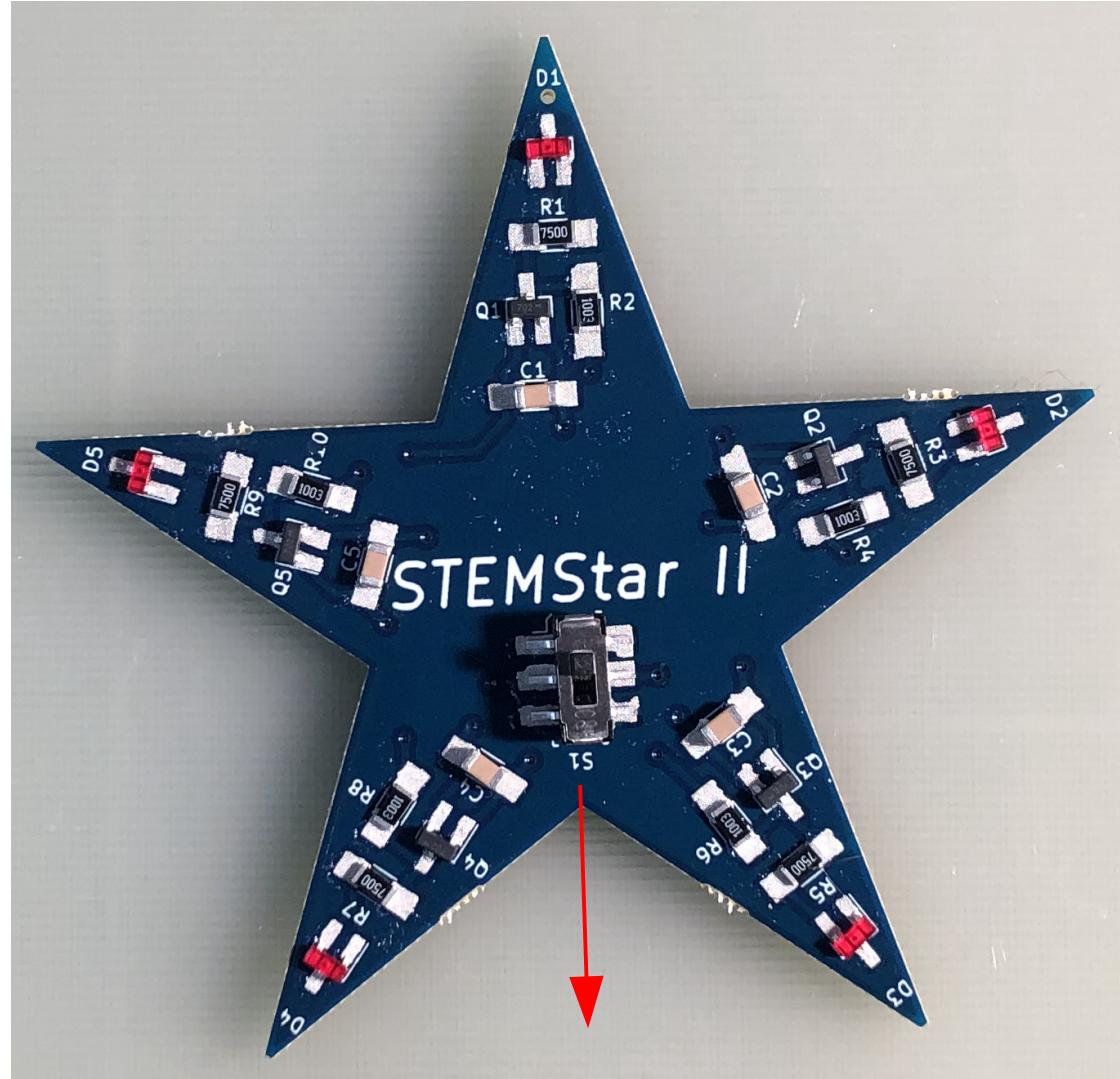


Step 11 – Test !

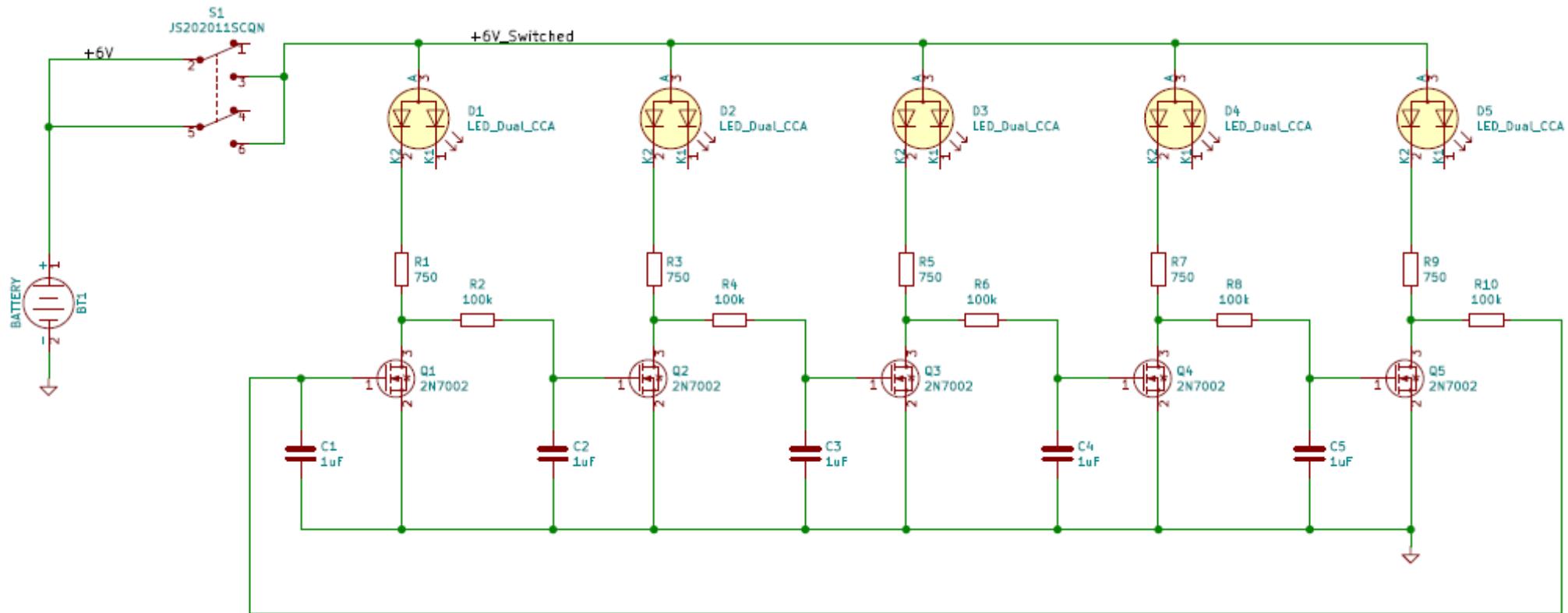
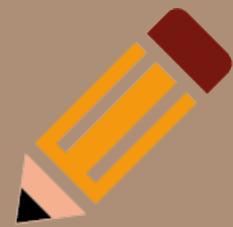


Flip the switch to the “ON” position which is down – See figure.

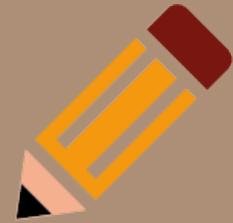
If everything is working, you will see the lights on the tips of the star “rotating”.



STEMStar II Schematic



LTspice Circuit Simulation Demo



- Engineers use circuit simulation software to check the behavior of their designs before making real hardware.
- Circuit simulation software is a great way to learn more about electronics !
- STEMStar II was simulated in LTspice which is freely available.
- LTSpice can be downloaded here:
 - <https://www.analog.com/en/design-center/design-tools-and-calculators/ltpice-simulator.html>
- STEMStar II LTspice file can be downloaded here:
 - <https://github.com/windgassen/StemStarII/tree/master/LTSpice>

STEMStar II Parts List



FIND NO.	QTY	MFR PART NO.	MFR	DIST PART NO.	DIST	DESCRIPTION	REF DESIGNATOR
1	5	CRCW1206750RFKEA	Vishay	61M5590	Newark	RESISTOR, CHIP, 750 OHMS, 250MW, 1206	R1,R3,R5,R7,R9
2	5	CRCW1206100KFKEA	Vishay	61M5538	Newark	RESISTOR, CHIP, 100K OHMS, 250MW, 1206	R2, R4, R6, R8, R10
3	5	MCSH31B105K160CT	Multicomp	23T7598	Newark	CAPACITOR, CHIP, 1UF, 16V, 10%, 1206	C1 – C5
4	5	KM-23SRD	Kingbright	25M9955	Newark	LED, RED, SOT-23	D1 – D5
5	5	2N7002	On Semi	04M7288	Newark	TRANSISTOR, MOSFET, N-CH, 60V, 115MA	Q1 – Q5
6	1	JS202011SCQN	C&K COMP	95W3256	Newark	SWITCH, SLIDE, DPDT, 100MA	S1
7	1	3024-2	Keystone	36-3024-2-N	Digikey	BATTERY RETAINER COIN 20MM 2CELL SMD	BT1
8	2	CR2032	Panasonic	13C1019	Amazon	BATTERY, LITHIUM MANGANESE, 20MM	BATTERY 1 – 2
9	1	StemStarII PWB	Amitron		Amitron	PWB, STEM STAR II	PWB1

All STEMStar II design files can be downloaded from my Github site:
<https://github.com/windgassen/StemStarII>

The PWB for STEMStar II was designed using KiCAD – a free PWB layout tool
<http://kicad-pcb.org/>

Source Credits for Images / Information



- Slide 6 - Electronics – Resistor
 - <https://openclipart.org/detail/19101/rsa-iec-resistor-symbol>
 - http://www.learnabout-electronics.org/Resistors/resistors_07.php
- Slide 10 & 11 – Electronics – Capacitor
 - <https://en.wikipedia.org/wiki/Capacitor>
 - [https://en.wikipedia.org/wiki/Spring_\(device\)](https://en.wikipedia.org/wiki/Spring_(device))
- Slide 13 – Light Emitting Diode (LED)
 - https://en.wikipedia.org/wiki/Light-emitting_diode
- Slide 15 – Electronics – MOSFET
 - <https://components101.com/mosfets/2n7002-datasheet-pinout-equivalent>