INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY

ECAD LAB PROJECT

SOLAR POWERED BATTERY CHARGER

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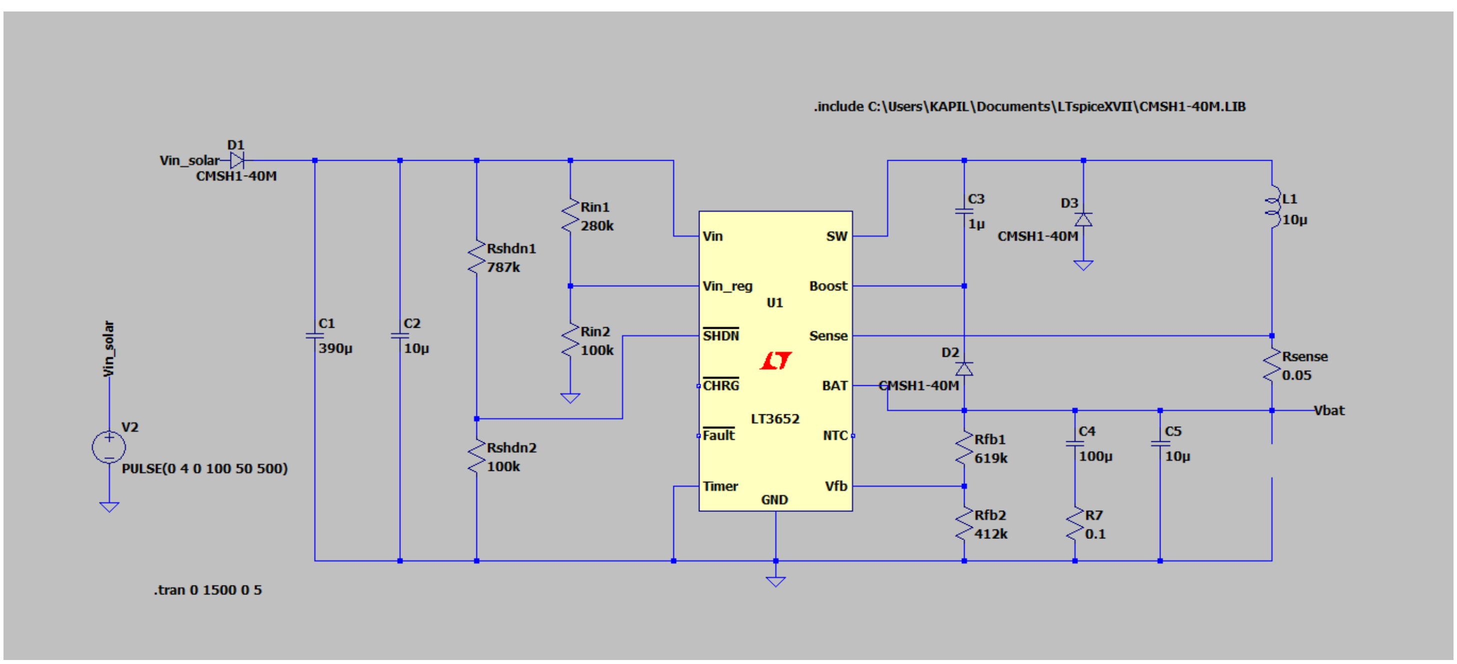
INTRODUCTION

The market for portable solar powered electronic devices continues to grow as consumers look for ways to reduce energy consumption and spend more time outdoors. Because solar power is a variable and unreliable, nearly all solar-powered devices feature rechargeable batteries. Solar cells are inherently inefficient devices, but they do have a point of maximum power output, so operating at that point seems an obvious design goal. A charger design that efficiently extracts power from a solar panel must be able to steer the panel's output voltage to the point of maximum power. The LT3652 is a multi-chemistry 2A battery charger designed for solar power applications. The LT3652 employs an input voltage regulation loop that reduces the charge current if the input voltage falls below a programmed level set by a simple voltage divider network. When powered by a solar panel, the input voltage regulation loop is used to maintain the panel at near peak power output.

LT3652 Input Voltage Regulation Loop

The input voltage regulation loop of the LT3652 acts over a specific input voltage range. When V_{IN}, as measured via a resistor divider at the V_{IN_REG} pin, falls below a certain set point, the charge current is reduced. This action causes the voltage from the solar panel to increase along its characteristic V-I curve until a new peak power operating point is found. If the solar panel is illuminated enough to provide more power than is required by the LT3652 charging circuit, the voltage from the solar panel increases beyond the control range of the voltage regulation loop, the charging current is set to its maximum value and a new operation point is found.

CIRCUIT (LTSPICE)



CALCULATIONS

1. The expression for the input voltage control range is:

$$(2.67*(R_{in1}+R_{in2}))/R_{in2} < V_{in} \text{ Control Range } < (2.74*(R_{in1}+R_{in2}))/R_{in2}$$

2. Following expression describes the current sensing voltage $V_{SENSE} – V_{BAT}$:

$$1.43 * (V_{IN\_REG} – 2.67 \text{ V})$$

3. We put the value of V_{IN_REG} from 1, then the charging current for the battery would then be :

$$(1.43/R_{sense})* (((V_{in}*R_{in2})/ (R_{in1}+R_{in2})) – 2.67 \text{ V})$$

4. The current sensing resistor, R_{SENSE}, is determined from the maximum $V_{SENSE} – V_{BAT}$ of 100mV divided by the maximum charging current of 2A :

$$R_{SENSE} = 0.05\Omega$$

5. The voltage divider network must have a Thevenin's equivalent resistance of 250k to compensate for input bias current error. The V_{FB} pin reference voltage is 3.3V. Calculating feedback voltage divider network (assuming $V_{BAT(FLOAT)}$ = 8.2V)

$$R_{FB1} = (V_{BAT(FLOAT)} \text{ x } 250 \text{ k})/ 3.3 \text{ V} = 621.2 \text{ k}$$

$$\text{Let } R_{FB1} = 619 \text{ k}$$

$$R_{FB2} = (R_{FB2} * 250 \text{ k})/(R_{FB2} – 250 \text{ k})$$

$$R_{FB2} = 419.2 \text{ k}$$

$$\text{Let } R_{FB2} = 412 \text{ k}$$

6. Voltage divider network of R_{IN1} and R_{IN2} connected between the V_{IN} and the V_{IN_REG} pins (assuming $V_{P(MAX)}$ = 10.9 V and $V_{FORWARD (D1)}$ = 0.5 V) :

$$\text{Let } R_{IN2} = 100 \text{ k}$$

$$\text{Then, } R_{IN1} = ((V_{P(MAX)} – V_{FORWARD (D1)} -2.74) / 2.74) * R_{IN2}$$

$$R_{IN1} = 279.6 \text{ k}$$

$$\text{Let } R_{IN1} = 280 \text{ k}$$

7. The values of resistors in V_{SHDN} voltage divider network are found by backhand calculations to be:

$$R_{SHDN1} = 798.2 \text{ k}$$

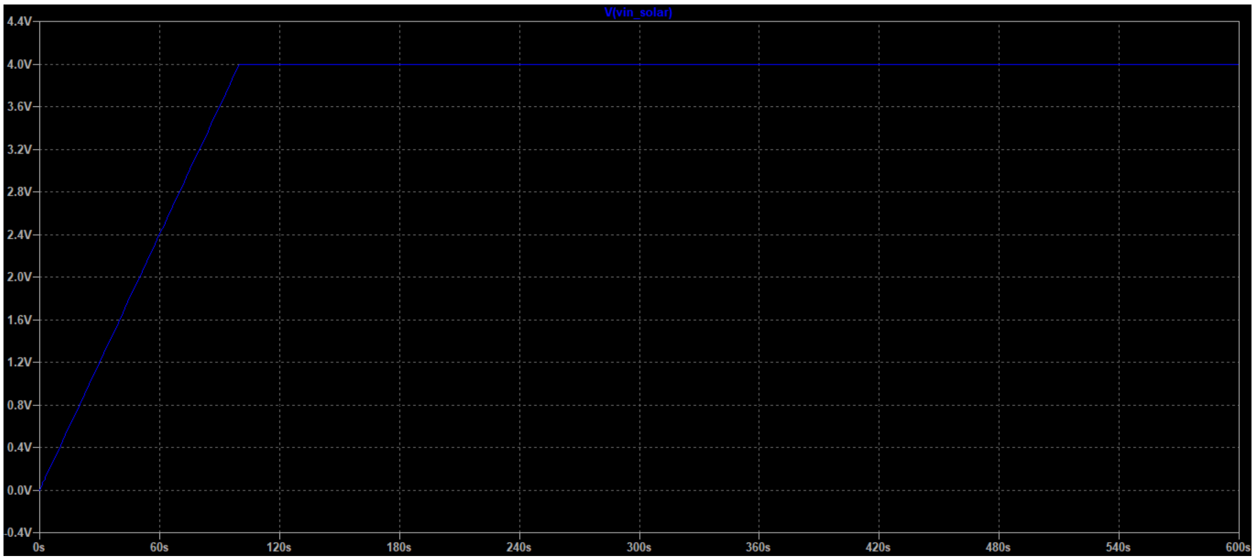
$$R_{SHDN2} = 100 \text{ k}$$

$$\text{We choose } R_{SHDN1} = 787 \text{ k}$$

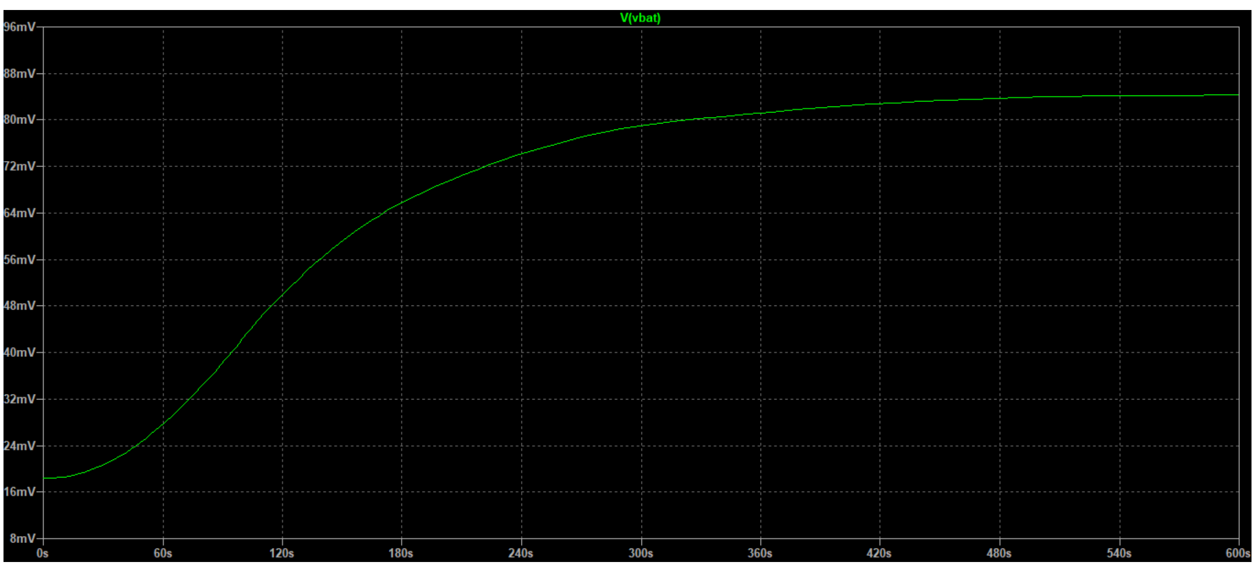
SIMULATION RESULTS (LTSPICE)

INCREASING INPUT VOLTAGE

V_{IN_SOLAR} = 0 at T=0 and starts increasing and rises upto 4 V at T=100s



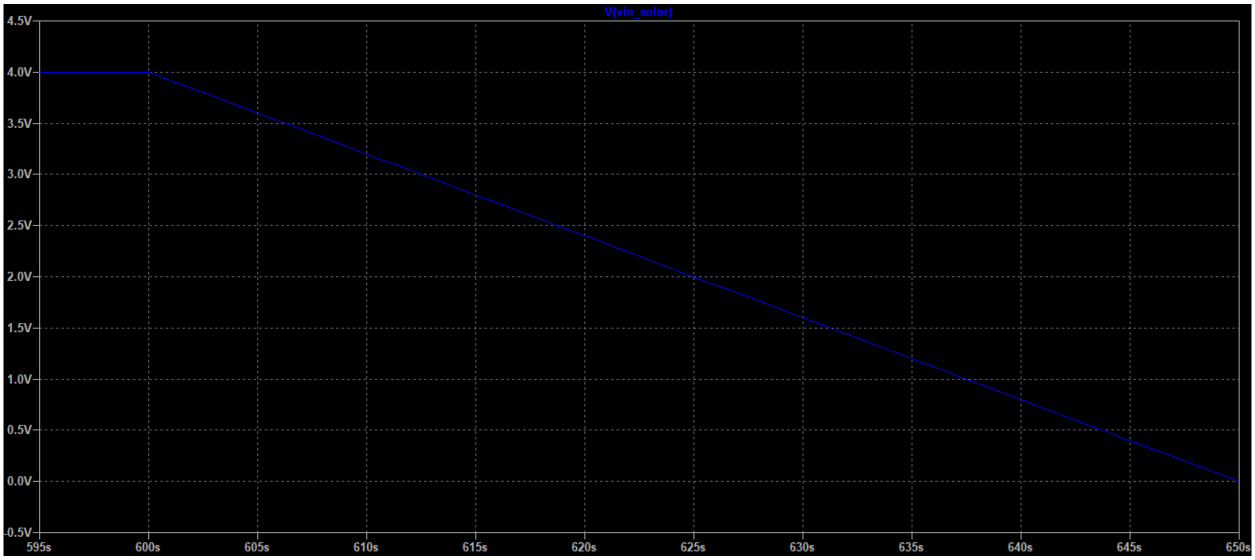
Input Voltage (V_{IN_SOLAR})



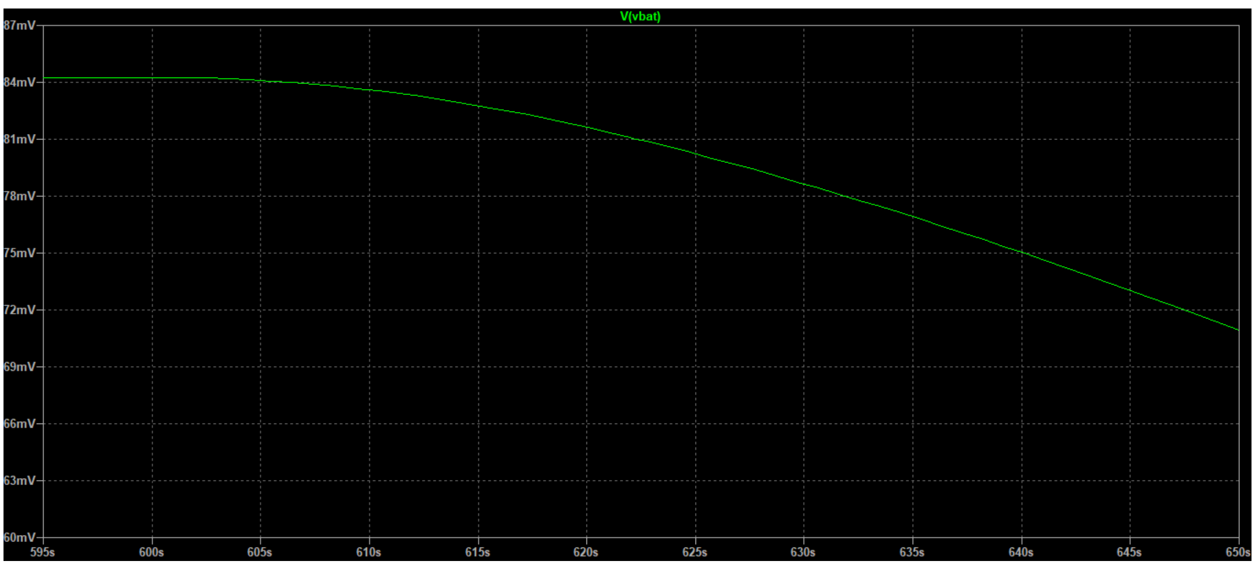
Output Voltage (V_{BAT})

DECREASING INPUT VOLTAGE

V_{IN_SOLAR} = 4V at T=600s and starts decreasing upto 0 V at T=650s and remains 0



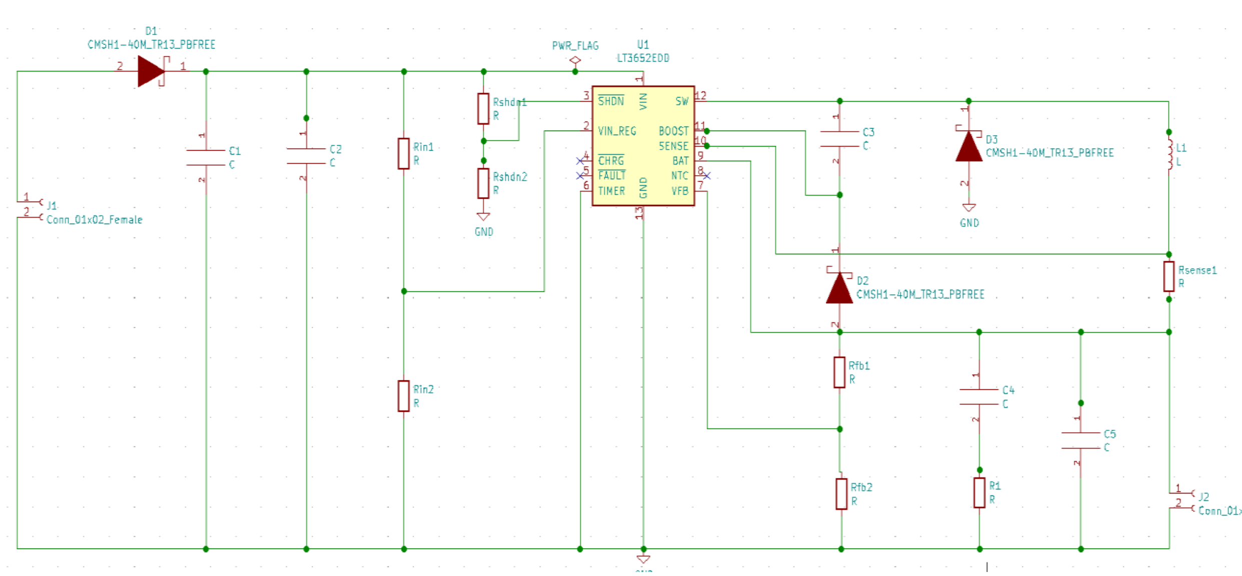
INPUT VOLTAGE (V_{IN_SOLAR})



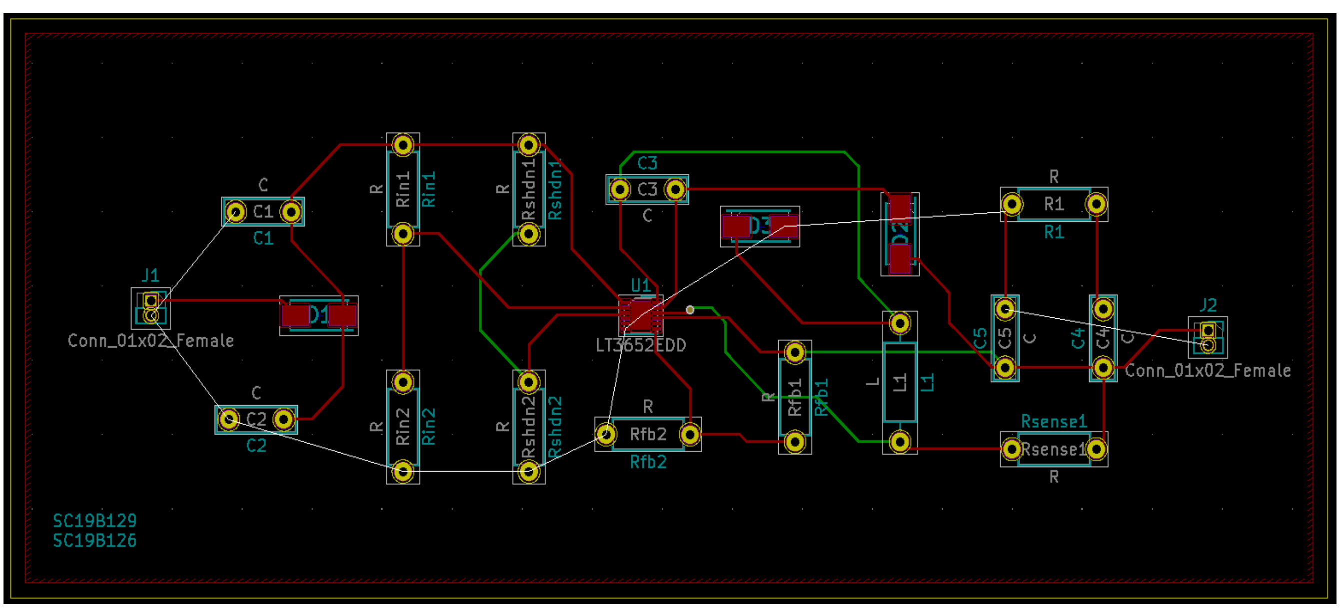
OUTPUT VOLTAGE (V_{BAT})

KiCAD MODEL

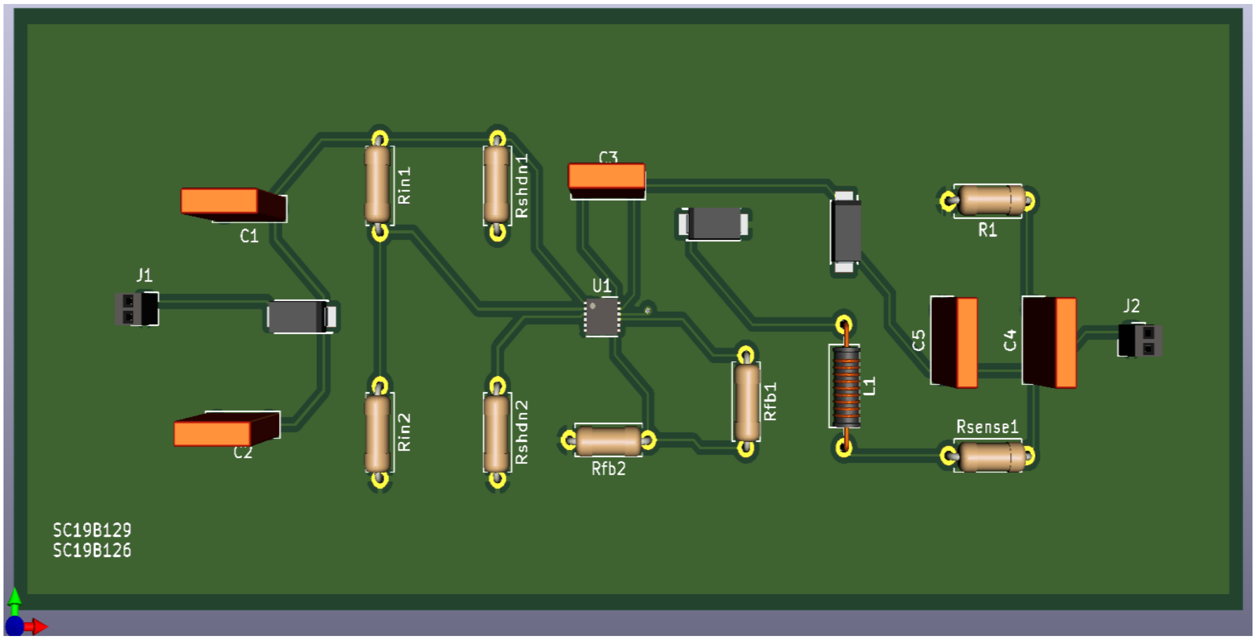
EESCHEMA



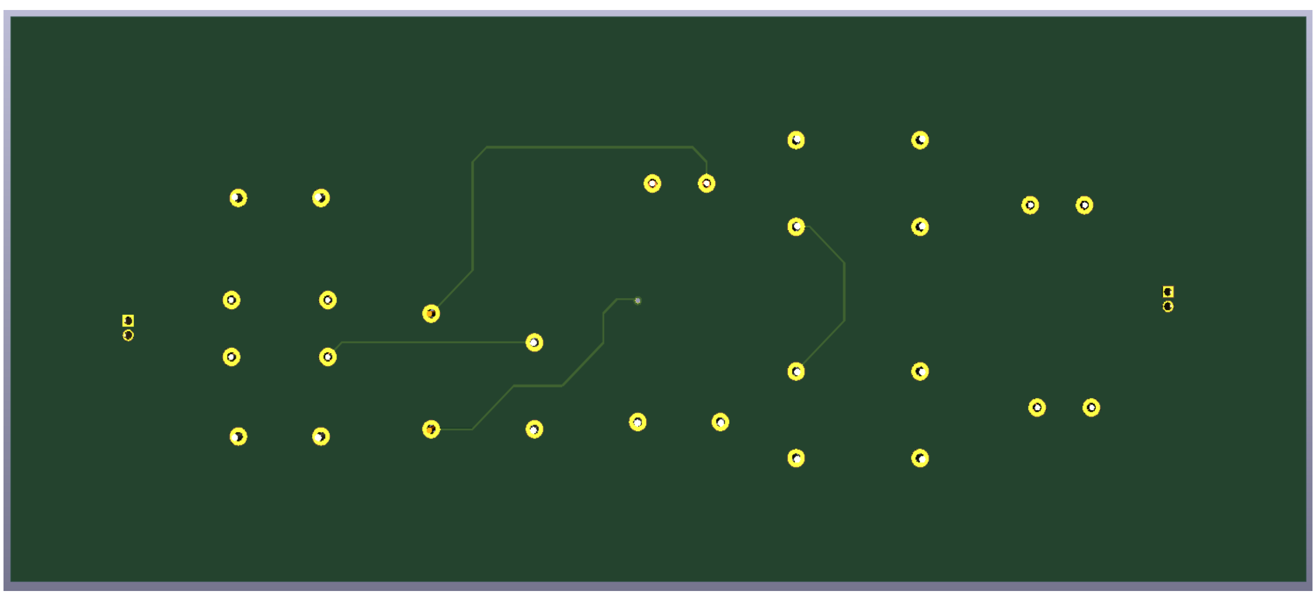
PCB DESIGN



3D VIEW (FRONT)



3D VIEW (BACK)



CONCLUSION

Thus, we have made an efficient battery charging circuit using the LT3652 IC and have shown the results for the same. The float voltage regulation loop and its adjustable charging current enable the LT3652 to be used with many battery chemistries, making it a versatile battery charger. The added features of a wide input voltage range, an auto-recharge cycle to maintain a fully charged battery.

REFERENCES

LT3652 Datasheet and Product Info | Analog Devices

https://greencoast.org/solar-battery-charging-basics

https://wikipedia.com

THANK YOU