PROTOTYPE OF SOLAR CELL AUTOMATIC CHARGING HANDPHONE AS ALTERNATIVE SOURCES OF ELECTRICITY

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ABSTRACT

Electrical energy has not been able to adequately meet the needs of communication equipment in the remote areas, especially at a location far from electrical energy sources such as when conducting natural tourism, traveling to the beach or doing mountain climbing. Utilizing solar cell as an alternative source of electrical energy will support the manufacture of automatic charger equipment that will be supplied to the load of handphone where the method used in the charging process is constant current and constant voltage.This method uses LM317 as its main component. The design of this tool uses two 3000 mAh capacity batteries that are assembled in parallel.Where the battery is flowing current and voltage constantly so as not to happen overcharging.The circuit is controlled automatically using the Arduino nano and is monitored via LCD.

Keywords: *Solar Cell, Battery, LM317, Overcharging*

1. INTRODUCTION

The need for communication equipment, especially during an emergency and there is no supply of electrical energy, it is necessary to create a battery charging device or charger with a solar cell source. Electrical energy in the use of technology has not been able to meet the needs of community communication equipment in remote areas, especially in locations far from sources of electrical energy such as when doing nature tours, traveling to the beach or mountain climbing. In this problem, there are several chargers that have been made by researchers such as a battery charger circuit using LM338 as an output voltage regulator, TIP 122 and a diode as an automatic circuit breaker [1]. The researcher [2] made an automatic battery charger circuit using an op-amp to cut off the maximum voltage, while the researcher [3] monitored the voltage and current on the battery charger automatically. Researchers [4] made a voltage regulator circuit LM317 as a voltage stabilizer for battery charging so that overcharging and over voltage did not occur, while researchers [5] made a handphone battery charger circuit using LM7805.

From several tools that have been made by other researchers, this time the researcher will offer an automatic battery charging device using LM317 as a voltage regulator and a constant current and constant voltage charging circuit as a battery charging method, which did not exist in the battery charging system of previous researchers. The researchers focused on the automated system only. The reason for using the LM317 compared to other LM regulators is that the first one is based on the datasheets, the LM317 is a type of adjustable regulator where the output voltage can be adjusted. Second, based on the need for a control charger in this study with a maximum specification of 0.5A and 12V, the selection of using LM317 is more effective because of the sufficient specifications of the LM317, namely a maximum current of 1.5A and a voltage variation between 1.25V to 37V. Third, to change the output only required 2 external resistors. Fourth, the LM317 is equipped with a current limiting function, making it suitable for use as a controller of the "Constant Current" method of charging by connecting 1 resistor as shown in the datasheet, the LM317 can be used as a current limiting device. Fifth, compared to the use of regulators such as the LM7805, the LM317 can be adjusted for output and is also more efficient in conversion because the LM7805 voltage is converted to a fixed voltage of 5V. In this constant current and constant voltage method, the current and voltage are regulated constantly so that when charging the battery is more efficient and more real when the battery is full. This system will be controlled using the Arduino Nano microcontroller. The condition of the battery affects the time of discharging where the load to be used on this charger is in the form of a cellphone. Thus, it is necessary to make a more efficient battery charging device or cellphone charger with the title Prototype Solar Cell Automatic Charging Cellphone as an Alternative Source of Electrical Energy.

2. RESEARCH METHOD

2.1 Design of System

Figure 1 shows a block diagram of an automatic charging application system with a solar cell system. The power source that will be used is solar cell. Solar cells are useful for converting sunlight energy into electrical energy. The energy generated by the source will be forwarded to the switching section. In this section there will be two processes in the battery, namely charge and discharge.

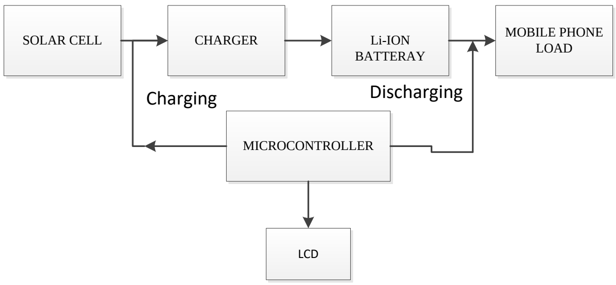

Figure 1. Block Diagram System

The charging process is the process of charging the battery with energy generated by the source, while the discharging process is the process of using the battery where the energy stored in the battery will be transferred to the load of the handphone. The entire process in the switching section will be controlled by the Arduino Nano microcontroller, where as input commands use buttons and output is a display on the LCD. The next stage is to determine the method used during the charging process, at this stage the supplied voltage and current will be regulated constantly according to the method used in this research, namely Constant Current (CC)/Constant Voltage (CV). Figure 2 is a flow chart in this study, for the first stage, namely the design of the solar cell system. In this stage, the tool made will be tested whether it is able to produce the appropriate current and voltage.

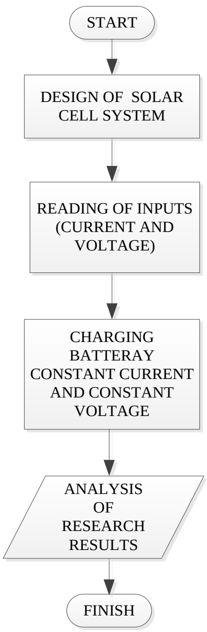

Figure 2. Flowchart of System

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If it is not appropriate, the system will be repaired, then it will be continued with the next step, namely the charging process. In this stage the current and voltage will be regulated constantly according to the method used, namely constant current and constant voltage. With this method, charging the battery becomes more efficient and does not damage the battery. After going through this process, the results and analysis of this research are presented in the form of graphs and tables.

2.2 Prototype Solar Cell Automatic Charging Handphone

Figure 3. Prototype Solar Cell Automatic Charging Handphone

Figure 3 is a Prototype of Solar Cell Automatic Charging handphone, it can be explained for each part as follows :

A. *Solar Cell*
Solar cell as a device to generate electricity that utilizes solar power as its energy source. Here the solar cell used with a capacity of 10 WP, can be seen in Figure 4.

Figure 4. Solar Cell

B. *Voltage Regulator*
Voltage regulator is to maintain the voltage at a certain level constantly. That is, the DC output voltage on the voltage regulator is not affected by changes in input voltage, output load and temperature. The voltage regulator uses IC LM317 which has a voltage range from 1.2 Volt DC to 37 Volt DC and the maximum output current can reach 1.5 Ampere. The voltage regulator circuit is shown in Figure 5 and the assembly results are shown in Figure 6.

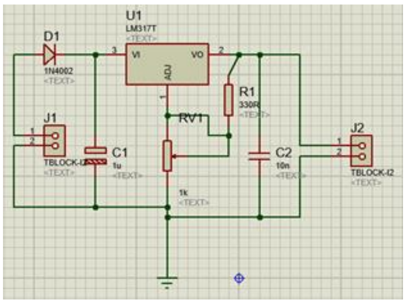

Figure 5. Voltage Regulator Circuit

Figure 6. Voltage Regulator

C. Constant Current (CC) and Constant Voltage (CV)

The charging method is Two Step Charger, meaning that this circuit has two charging modes, namely constant current (CC) and Constant Voltage (CV). By combining these two modes, it can extend battery life. The battery used in this circuit has a voltage of 4.2 Volts. Furthermore, the current to be used in Constant Current (CC) mode is 400mA. Constant Current (CC) charging mode runs until the battery is 4.2 Volts. When the battery reaches a voltage of 4.2 Volts the mode changes to Constant Voltage (CV), where the charging will flow constant to 4.2 Volts. Then monitor the charging current as the current will drop until the battery is full. At that time the relay will automatically disconnect from the solar cell charging source when the battery is full. The following Figure 7 is a series of Constant Current (CC) and Constant Voltage (CV) and the assembly results are shown in Figure 8

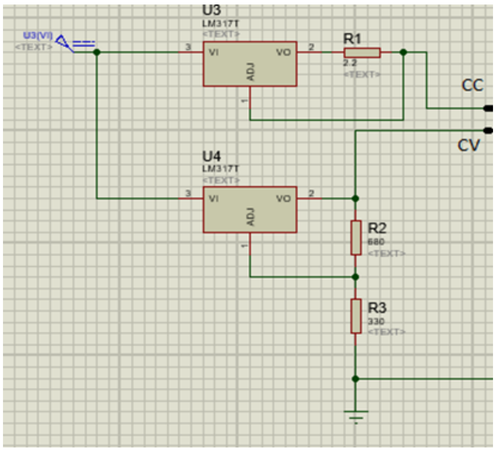

Figure 7. Constant Current (CC)/Constant Voltage (CV) circuit

Figure 8. Constant Current (CC)/Constant Voltage (CV)

In Constant Current (CC) charging, it is necessary to set the current to remain constant at 400 mA, the following calculations are required:

Resistor (R)=1.25/I=1.25/0.40 = 3.1 Ohm (1)

the resistance needed to produce a constant current of 400 mA is 2.2 Ohm because there is no 3.1 Ohm resistor resistor For Constant Voltage (CV) mode, the battery must be set to constant voltage to 4.2 V. The LM317 IC can do this with the help of just two resistors. This is shown in the following calculation:

Vout = 1.25 x (1 + R2/R1) (2)

4.2 = 1.25 x (1 + R2/330)

R2 = 778 Ohm

The output voltage must be 4.2V, and the value of R1 must be less than 1000 Ohms so 330 Ohms is determined. The value of R2 is used 750 Ohms because there is no resistance that is worth 778 Ohms or can use any value of the resistor combination as long as the output voltage is 4.2V.

D. *Design of Arduino Nano*

This microcontroller is designed to control the automatic system on the relay to run as desired by the researcher. Figure 9 is the design of Arduino.

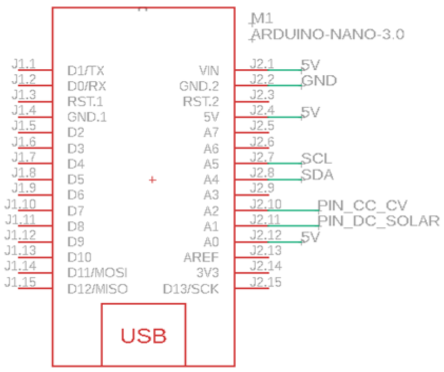

Figure 9. Design of Arduino

Where :

- Pin Vin as input of arduino is 5V
- Pin GND.2 as ground
- Pin 5V as output load
- Pin A5 as SCL (Serial Clock)
- Pin A4 as SDA (Serial Data)
- Pin A2 as input of relay 1
- Pin A1 as input of relay 2

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E. Design of Current Sensor

The current sensor used in this study is INA219. This sensor is able to read currents up to 3 Ampere and is also able to read voltages up to 36.Volts. Figure 10 is design of INA219.

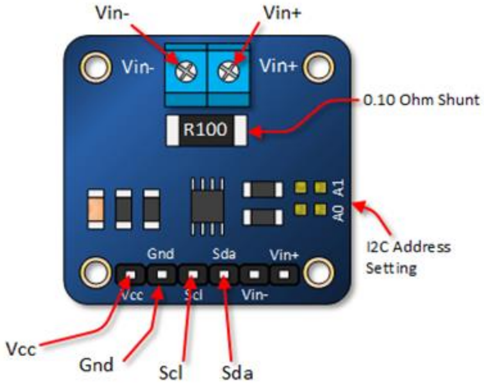

Figure 10. Design of INA219

F. Design of Driver Relay

The relay used for this research is a 2 channel relay where relay 1 is to control the Constant Current (CC)/Constant Voltage (CV) circuit and relay 2 is to control battery charging from the solar cell. Figure 11 merupakan skema modul relay 2 channel.

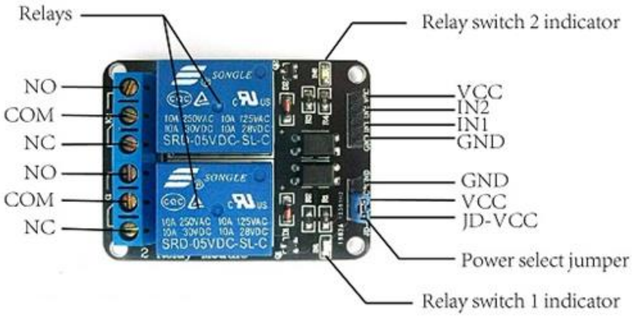

Figure 11. is a 2 Channel Relay.

G. Design of Boost Converter

The boost converter functions to distribute the power source from the battery with a minimum voltage of 3 Volts and step up to 5 Volt output. It can be seen in Figure 12 that this module will flow the Arduino and handphone.

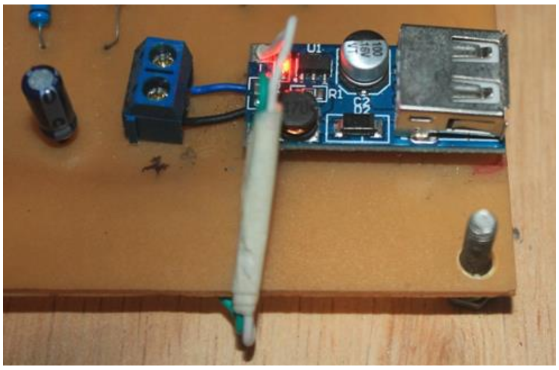

Figure 12. Design of Boost Converter

H. Design of LCD 16 x 2

The LCD used in this research uses a 16 x 2 type LCD (16 columns arranged in 2 rows). LCD is one of the devices used as output, Figure 13 is LCD

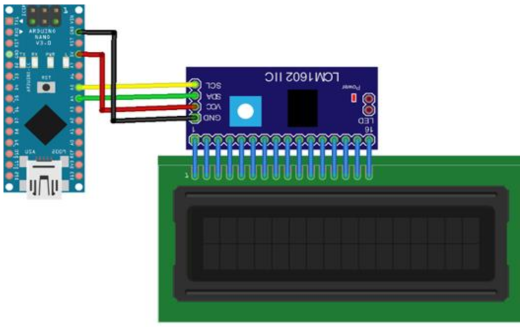

Figure 13. Design of LCD Circuit

3. RESULT AND DISCUSSION

A. Solar Cell Test

This test is carried out to determine the output voltage produced by the solar cell for charging the battery of 19 Volts. For the test shown in Figure 14

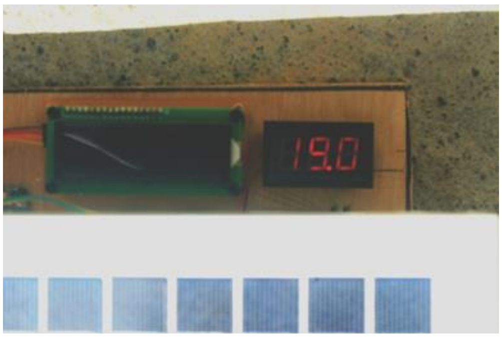

Figure 14. Solar Cell Test

From Figure 14, the resulting output is in accordance with the datasheet of the solar cell which indicates the solar cell is functioning properly.

B. Voltage Regulator Test

This test is to adjust the output voltage produced by the solar cell to remain stable as desired. On this occasion the required voltage is 12 Volts.

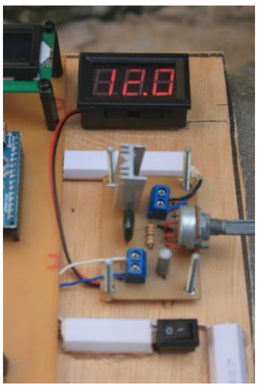

Figure 15. Voltage Regulator Test

From Figure 15, the output voltage generated from the solar cell can be adjusted as needed, namely 12 Volts, so that the circuit functions properly.

C. Constant Current and Constant Voltage Circuit Testing

This test is to regulate the charging current and voltage from the solar cell to the li-ion battery constantly for more efficient battery charging

Figure 16. Monitoring of Constant Current Charging

From Figure 16, it can be seen that the current flows constantly with a value of 400mA. This charging mode works when the li-ion battery voltage is between 3 Volts to 4.2 Volts. After the li-ion battery reaches a voltage of 4.2 Volts, the charging will change to the constant voltage shown in Figure 17.

Figure 17. Monitoring of Constant Voltage Charging

In Figure 17 it can be seen that the charging current is 3.4 mA, the li-ion battery is almost fully charged and can be shown in Figure 18

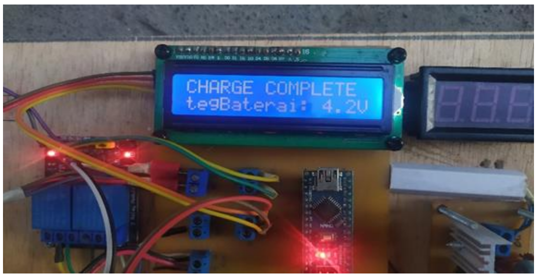

Figure 18. Monitoring Charger Complete

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D. Relay Driver Test

This test is to determine the performance of the sensor against changes in charging current and voltage to the li-ion battery, so that it can be seen whether the battery is charged as desired. Relay testing based on current and voltage values at charging time can be seen in Table 1.

Table 1 Result Data from Relay Driver Test

BATTERAY (VOLT)	RELAY 1 (NC) CONSTANT CURRENT	RELAY 1 (NO) CONSTANT VOLTAGE	RELAY 2 (NO) CHARGING
3.0 Volt	AKTIVE	NON AKTIVE	AKTIVE
3.1 Volt	AKTIVE	NON AKTIVE	AKTIVE
3.2 Volt	AKTIVE	NON AKTIVE	AKTIVE
3.3 Volt	AKTIVE	NON AKTIVE	AKTIVE
3.4 Volt	AKTIVE	NON AKTIVE	AKTIVE
3.5 Volt	AKTIVE	NON AKTIVE	AKTIVE
3.6 Volt	AKTIVE	NON AKTIVE	AKTIVE
3.7 Volt	AKTIVE	NON AKTIVE	AKTIVE
3.8 Volt	AKTIVE	NON AKTIVE	AKTIVE
3.9 Volt	AKTIVE	NON AKTIVE	AKTIVE
4.0 Volt	AKTIVE	NON AKTIVE	AKTIVE
4.1 Volt	AKTIVE	NON AKTIVE	AKTIVE
4.2 Volt	NON AKTIVE	AKTIVE	AKTIVE
4.2 Volt Complete	NON AKTIVE	NON AKTIVE	NON AKTIVE

In Table 1 it is explained that relay 1 in the NC (Normally Close) position works at constant current while relay 1 NO (Normally Open) works at constant voltage. Relay 2 works at maximum and minimum li-ion battery conditions. The maximum is to disconnect the charging and the minimum is to open the charging of the solar cell.

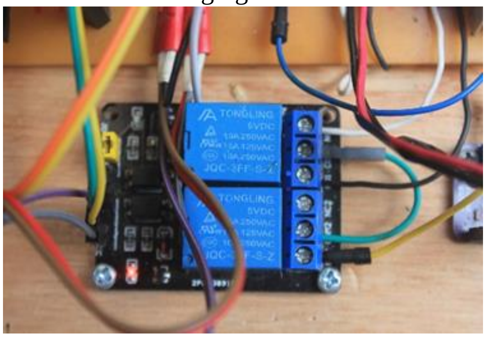

Figure 19. Relay Driver Test

In Figure 19 it is explained that the relay driver works well when charging, the relay 1 indicator light turns off indicating constant current charging, when the indicator light turns on shows constant voltage charging. In relay 2, when the indicator light is on, the charging source is flowing, when the relay indicator light is off, it stops charging the li-ion battery.

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E. *Testing Current and Voltage on Li-ion Batteries*

Testing sensors and relay drivers to determine system performance against changes in current and voltage when charging to a li-ion battery, so that when the battery is fully charged it will automatically stop charging the battery. Total during charging about 216 minutes or 3.5 hours. The following Table 2 shows the data from the charging results based on the current and voltage values.

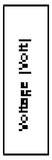

Table 2. Charging Result Data Based on Current and Voltage Values

Time (Minute)	V Original Batteray (Volt)		V Charging Batteray (Volt)		Current (mA)		
	LCD	AVO	LCD	AVO	LCD	AVO	CHARGING
0	3.6	3.78	4.0	3.92	400	460 - 470	Constant Current
30	3.7	3.87	4.0	3.96	400	450 - 440	Constant Current
60	3.8	3.91	4.1	3.99	400	450 - 440	Constant Current
90	3.8	3.95	4.1	4.04	400	470 - 480	Constant Current
120	3.9	3.99	4.1	4.07	400	460 - 480	Constant Current
150	3.9	4.04	4.2	4.12	400	460 - 470	Constant Current
180	3.9	4.08	4.2	4.16	400	460 - 470	Constant Current
210	4.0	4.12	4.2	4.19	400	450 - 440	Constant Current
215	4.1	4.17	4.2	4.2	3.5 - 0	3.5 - 0	Constant Voltage
216	42	4.2	4.2	4.2	0	0	Charge Complete

Figure 20 shows a graph of charging current showing the current value that goes up and down between 440 mA to 480 mAh at constant current. Furthermore, when the battery is close to full, in constant voltage mode, the current value drops to 3.5 mAh to 0, charge complete which indicates the battery is full.

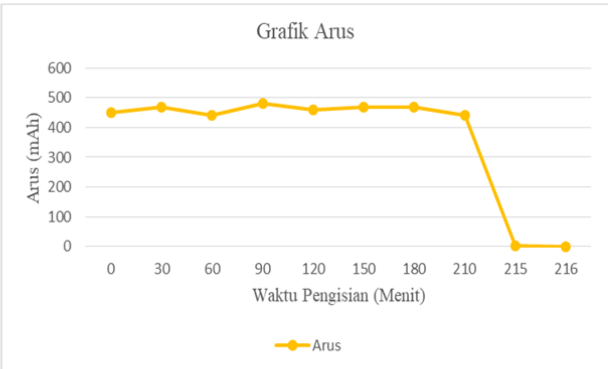

Figure 20. Graph of Li-ion Battery Charging Current

Figure 21 shows a graph of the voltage when charging the battery which shows the difference between the original voltage before charging and the charge voltage when charging, which is about 1 Volt.

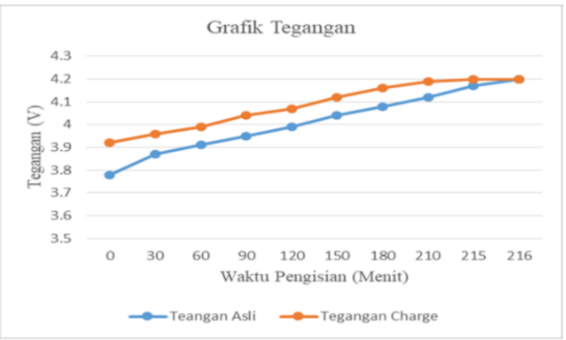

Figure 21. Graph of Li-ion Battery Charging Voltage

F. *Testing of Boost Converter*

This test is to supply the voltage from the li-ion battery to the Arduino microcontroller and the load of the handphone because it is able to increase the voltage from 3 Volts to 5 Volts DC. For this test, it is shown in Figure 22.

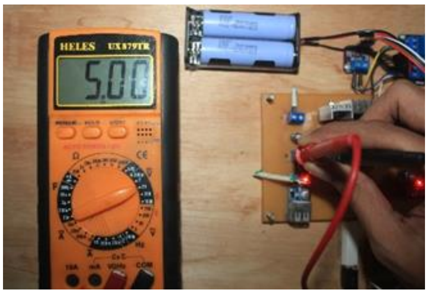

Figure 22. Testing of Boost Converter

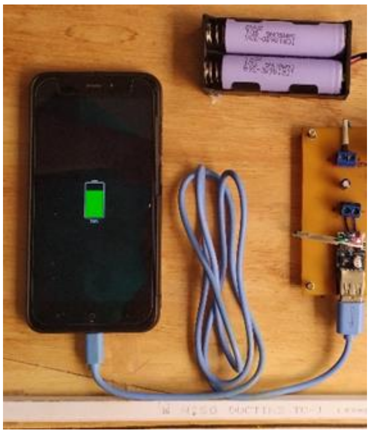

Figure 23. Mobile Charger Test

In Figure 23 it can be seen that the boost converter is able to charge the cellphone battery and runs well.

4. CONCLUSION

The results of the design of a prototype solar cell automatic charging for handphones as an alternative source of electrical energy can be concluded that the method used is constant current and constant voltage. When the battery voltage = < 3.0 volts, charging the li-ion battery is constant current, the charging current will run constant around 400mA until the li-ion battery shows a voltage of 4.2 volts. When the li-ion battery has a voltage of 4.2 volts then the charging moves to constant voltage, the charging current will drop to 3mA until the li-ion battery is fully charged. This circuit is controlled using an arduino nano microcontroller.

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