Study of Auto Cut off Electricity Power Supply on Full Charge of Battery Using Microcontroller

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***Abstract*- The main objective of the project is to propose a system where we will monitor the battery charging percentage/battery charging status by using a current sensor and 8051 microcontrollers.**

Now-a-days, there is a tremendous demand for energy and similarly demand for portable energy sources. As a result, it becomes very important to save energy. The portable devices which stores energy such as mobile phone's battery, laptop's battery, power bank, etc., uses rechargeable cells. These cells can be charged again and again.

But many-a-times this thing happens that people put their phone/laptop etc., on charging and forgets to unplug the charger once battery is fully charged. Under such circumstances there is possibility that the device by get heated. Also due to excessive heat the device may explode. Excessive charging and excessive heating of the device may lower down the complete performance of the device in long run. It can be concluded that the energy is flowing through the mains towards the charger but the device is not accepting the charge. So, we can conclude that the energy is being wasted.

To stop such wastage of energy our circuit is introduced. We have used a current sensor and a relay switch in our system which will break the supply coming directly from the mains. This system will be placed in the supply box/switchboard and then the adapter of phones/laptop will be attached to it.

***Index terms*- Current Sensor (ACS712), Relay (SPDT)**

I.INTRODUCTION

Now a day's, many applications are simply performed by various electronic appliances. Thus, in numerous electronic appliances are emerging day by day. The overnight charging of mobile phone, it may degrade the battery life and performance of the device. The device should regularly monitor the battery level, so that the power off has to be done after the completed charging. The devices are integrated with current sensor ACS712 to get the real time status of charging, primary current of the transformer. Based on charging current automatic power cut off to the devices. The charging current of devices is paired with the measured values in the microcontroller, based on that charging of the circuits is performed.

A device that could monitor the power consumption and control it, will help vastly in reducing the wastage of energy. This system would be capable of turning on and off only when the device is connected and charge only when needed, and can be further improved to monitor other appliances.

Objectives:

In this project, we are designing a system using which auto power off will happen when the gadgets get full charged. As the primary current of the transformer is solely dependent on the secondary current the transformer. Here we will monitor the same with ACS712 current sensor which will continuously compared with the values measured using 8051microcontrollers. On achieving the full charge condition i.e. secondary current goes to zero (ideally),our circuit will detect the same to provide auto cut off and hence overcharging protection. The system is based on the Automation.

Advantages:

- This circuit reduces power loss and continues heat production in the device and provides long life of the devices connected.
- This circuit reduces the electricity bill at the user end.
- Continuous detection of change in primary current.

- The circuit can handle large current as Sensor ACS712 is having large current detection capability up to 30Ampere.
- Simple, compact, easy to handle and portable.
- Circuit is less costly.

II. PROPOSED WORK:

The project mainly focuses on reducing the damage caused by excessive charging. Also, it primarily focuses on saving the energy The main objective of the project is to propose a system where we will monitor the battery charging percentage/battery charging status by using a current sensor and 8051 micro-controllers.

Now-a-days, there is a tremendous demand for energy and similarly demand for portable energy sources. As a result, it becomes very important to save energy. The portable devices which stores energy such as mobile phone’s battery, laptop’s battery, power bank, etc., uses rechargeable cells. These cells can be charged again and again.

But many-a-times this thing happens that people put their phone/laptop etc., on charging and forgets to unplug the charger once battery is fully charged. Under such circumstances there is possibility that the device by get heated. Also due to excessive heat the device may explode. Excessive charging and excessive heating of the device may lower down the complete performance of the device in long run. It can be concluded that the energy is flowing through the mains towards the charger but the device is not accepting the charge. So, we can conclude that the energy is being wasted.

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In our project current sensor, 8051 microcontroller and relay are used for detecting, processing and acting upon the situation is done respectively. This project will save the performance of the battery as well as the device.

Components Used:

1. Transformer.
2. Diodes.
3. Capacitor
4. 7805 voltage regulator IC.
5. Current Sensor (ACS712)
6. Analog to digital converter
7. 8051 Microcontroller.
8. SPDT Relay.

1. Transformer:

A transformer is a passive electrical device that transfers electrical energy from one electrical circuit to another, or multiple circuits. A varying current in any one coil of the transformer produces a varying magnetic flux in the transformer's core, which induces a varying electromotive force across any other coils wound around the same core.

In our project a 12Volt, 1 Ampere Transformer is used.

2. Diodes:

A diode is a two-terminal electronic component that conducts current primarily in one direction (asymmetric conductance); it has low (ideally zero) resistance in one direction, and high (ideally infinite) resistance in the other. A semiconductor diode, the most commonly used type today, is a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals.

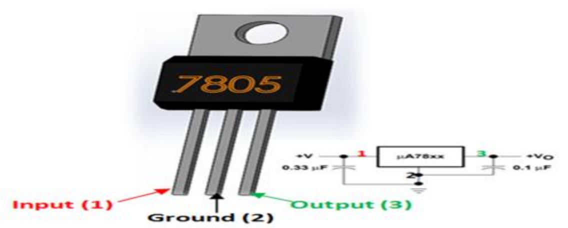
In our project 1N4007 diode is used.

3. Capacitor:

A capacitor is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals. The effect of a capacitor is known as capacitance. No current actually flows through the dielectric. However, there is a flow of charge through the source circuit.

In our project a 40000micro farad 35V as C1 capacitor and 0.1 uF as C2 after 7805 IC is used.

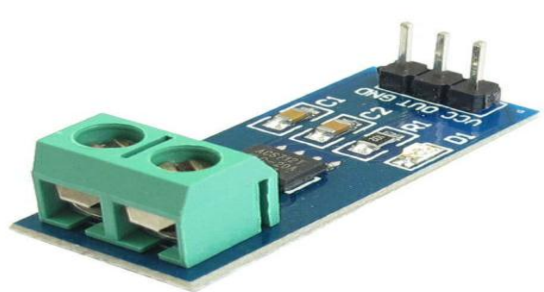
4. Voltage Regulator:



A voltage regulator is a system designed to automatically maintain a constant voltage level. Depending on the design, it may be used to regulate one or more AC or DC voltages.

In our project 7805 voltage regulator is used.

5. Current Sensor:



Sensing and controlling current flow are a fundamental requirement in a wide variety of applications including, over-current protection circuits, battery chargers, switching mode power supplies, digital watt meters, programmable current sources, typical applications include motor control, load detection and management, switched-mode power supplies, and overcurrent fault protection. etc.

This ACS721 current module is based on ACS712 sensor, which can accurately detect AC or DC current.

The sensed current and the output signal can be
1.Alternating current input,

- Analog output, which duplicates the wave shape of the sensed current.
- Bipolar output, which duplicates the wave shape of the sensed current.
- Unipolar output, which is proportional to the average or RMS value of the sensed current.

2. Direct current input,
Unipolar, with a unipolar output, which duplicates the wave shape of the sensed current, digital output, which switches when the sensed current exceeds a certain threshold

In our project we have used ACS 712 as the current sensor.

6. Relay:

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal.

In our project 5V, 15A relay is used.

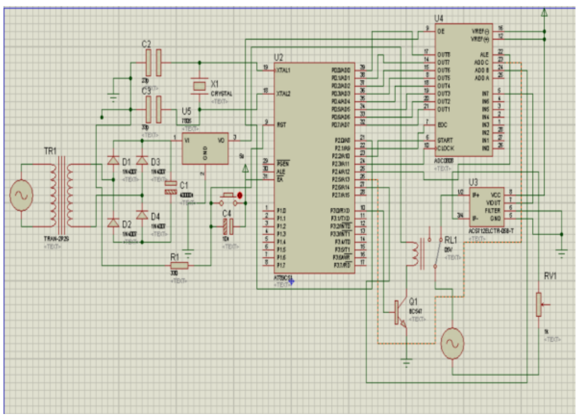
III. ANALYSIS AND DESIGN

Considering todays criteria of the compact things available in the market, we also have tried to make this project as compact and portable as possible.

- The circuit mainly consists of the relay, current sensor, power supply unit, ADC etc., depending upon the size of these components we have designed the circuit diagram.

- As our project is mainly focused to be used in residential sector, we have designed it in the same manner as other home equipment are made.
- As this project is made to stop the wastage of power and increase the battery health of the mobile phones, laptops etc., the power requirement of the project is also very low.

Circuit Diagram:

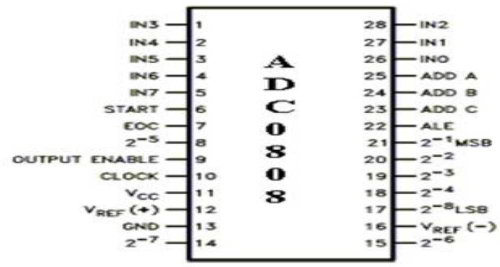


Circuit Diagram Description:

1. Microcontroller:-

- P2.0 is given to base of the Transistor
- Transistor collector terminalis connected to relay's common terminal.
- Transistor emitter Terminal connected to the ground.
- Relay coil first terminal are connected to the 5 v DC supply.
- NC (normally connected) pin is connected to the ACS 712 current Sensor.
- NO (normally open) pin is kept open until any switching happens.
- Micro controller pin 13 (oscillator 1) &14 (oscillator 2) connect to the crystal oscillator with 12 MHz frequency. Crystal X1 and capacitors C2, C3 are associated with the clock circuitry of the microcontroller.
- Micro controller Pin 1 MCLR / VPP connect to the 5 V dc.
- Thus on detection of full charge by ACS712, signal will be given to Microcontroller 8051 which further act to cut off the supply with relay used.

2. Analog to Digital Converter:-



- Data out pins (D0 to D7) of the ADC0808 are connected to the port pins P1.0 to P1.7 respectively
- Control signals for the ADC (INTR, WR, RD and CS) are available at port pins P3.4 to P3.7 respectively
- Resistor R9 and capacitor C1 are at port 19 and 4 are associated with the internal clock circuitry of the ADC.
- Preset resistor R10 forms a voltage divider which can be used to apply a particular input analogue voltage to the ADC.
- Push button S1, resistor R11 and capacitor C4 forms a debouncing reset mechanism.
- ADC0808 is responsible to convert the analog inputs from the ACS 712 into digital outputs which will be given to microcontroller continuously.

3. Current Sensor:-

- The current sensor IP1 is connected to the NC terminal of the relay and the IP2 terminal is connected to the input of the load.
- The output of the sensor is given to the ADC0808 IC.

Description: -

- Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage.
- The output of the device has a positive slope (>VIOUT(Q)) when an increasing current flow through the primary copper conduction path

(from pins 1 and 2, to pins 3 and 4), which is the path used for current sensing.

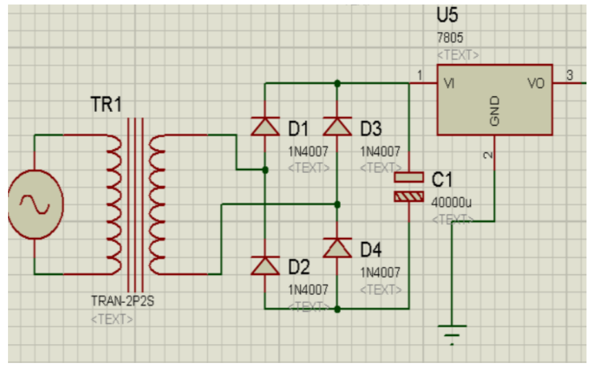
- The internal resistance of this conductive path is 1.2 mΩ typical, providing low powerloss.
- The terminals of the conductive path are electrically isolated from the sensor leads (pins 5 through 8). This allows the ACS712 current sensor to be used in applications requiring electrical isolation without the use of opto-isolators or other costly isolation techniques.
- The sole purpose of this sensor is to continuously check the current of the adpater connected as a load and provide the same details to the 8051 microcontroller via IC ADC0808.

4. Relay:

Description:

- Coil End 1
  Used to trigger (On/Off) the Relay, normally one end is connected to 5V and the other end to ground
- Coil End 2
  Used to trigger (On/Off) the Relay, normally one end is connected to 5V and the other end to ground
- Common (COM)
  Common is connected to one End of the Load that is to be controlled
- Normally Close (NC)
  The other end of the load is either connected to NO or NC. If connected to NC the load remains connected before trigger
- Normally Open (NO)
  The other end of the load is either connected to NO or NC. If connected to NO the load remains disconnected before trigger
- Relay acts according to instructions (signals) given by microcontroller via transistor BC547 to switch the supply.

5. Power supply:



Power Supply Description:

Power supply:

1. At outputs we require 5V DC regulated that's why we need (5+3+1.4v diode drop) voltage at input 7805 IC regulator. Therefore, we need 9.4V DC at Input of 7805 IC.
2. From VLDC the Vm is calculated,
   VLDC = (2Vm/π)
   9.4 = (2Vm / π)
   Vm = [(9.4 × π)/2
   Vm. = 14.76 V.
3. From VM, VRMS of Transformer step down voltage can be calculated,
   VRMS = (Vm/ √2)
   VRMS = (14.76/√2)
   VRMS =10.44 volts

Because In market transformer with 12, 18,24 volts available. So, from them we are using 12 volts Transformer for safe side.

Therefore, VRMS = 12 Volts

4. From VRMS the Vm is calculate as follows:

During any given time, two diodes will be conducting, while the other two diodes will have a reverse voltage applied across them. This reverse voltage is the minimum voltage that the diodes should be able to withstand.

Our transformer output voltage is 12V. This voltage is RMS voltage, and not the peak output voltage of the transformer.

VRMS = (Vm/ √2)

12 = (Vm/√2)

Vm =16.97 volts

5. Transformer current rating:

We require ILDC = 1Amp as load

therefore

ILDC = (2√2× IRMS)/π
IRMS =(ILDC×π)/2√2
= (1Amp × π)/2√2
= 1.11 Amp
Hence, we choose transformer having 1 amp rating

6. Diode selection: -
As Iavg =ILDC = 1 Amp
But the diodes must withstand twice this voltage
Therefore, reverse voltage will be
VDR = Vm x 2
VDR = 16.97V x 2
VDR = 33.94V
This is the minimum reverse voltage. A good practice is to rate the diodes for at least twice the calculated rating:
PIV of diode = VDR x 2
PIV = 33.94V x 2
PIV of diode = 67.88
Current rating
The power supply is rated at ILDC= 1A continuous. This is the minimum current rating of the diodes. A good practice is to rate the diodes greater than 1 Amp which can be easily sustain by 1N4007 having current rating of 1 Amp with PIV rating as 1000 volt

7. From Vm, The VLDC is calculate as follows: -
VLDC = (2Vm/π)
VLDC = (2× 16.97/ π)
VLDC= 10.80 volt
8. so, the output of bridge VLDC is supplied to 7805 IC.
Maximum input Voltage of IC is 37 volts
So, it can sustain at 10.80 plus diode drops 1.4 = 12.2 volts.

At the same time Input to 7805 IC will be 12.2. volts which it can easily sustain
Thus, at output of 7805 IC we get 5 volts
Thus, we design 5 volts power supply

9. Selection of capacitor:
Lastly, capacitor C is used to filter out the 50Hz components present on the DC output.
Designing the Power Supply
For each application, the specifications will be different. We will need the following information to start with the design:
Normal output voltage
Maximum output current
Maximum output ripple (amount of change on the output voltage)
Line frequency (50Hz)
System voltage
Input Voltage: 220V 50Hz
Output Voltage: 5 volts from 7805
Output Current:
Assuming maximum conditions,
100mAmp - 5 volt, 15Amp relay
250mA - reset,
250mA - 8051Vcc,
22mAmp - 0808 IC,
10mA- ACS712 IC =1Amp (safe side)
SO total of 1 Amp load current will be required
Maximum Ripple: 5%
Calculations for Capacitor
Capacitor C needs to limit this ripple to 5% of the output voltage.
Calculating C
Vc x C = I x t
Where:
Vc = voltage change allowed on output (ripple, given as 5%)
I = maximum current (given as 1A)
t = time period between 2 peaks (50Hz given)
Vc = (% ripple / 100) x Voutput
Vc = (5 / 100) x 5V
Vc = 0.25V
I = 1A, given
t = 1 / (2 x frequency)
t = 1 / (2 x 50)
t = 0.01 second
Now:
Vc x C = I x t
0.25 x C = 1 x 0.01
C = (1 x 0.01) / 0.25
C = 0.04 Farad
C = 40 000 uF

Capacitor Specification:-
The capacitor voltage rating must be twice the maximum output voltage Vm=2× 16.97= 33.94 volt,
So, a good choice will be to use a 35V, 40000 uF capacitor

10. Power Consumption:

Transformers ratings are normally specified in VA, which is the amount of current the transformer can withstand.

Power = V * I

Power = Voltage *Iload

Power = 12.2V * 1Amp

Power = 12.2VA

Transformer Specification:

Vprimary: 220V AC

Vsecondary: 12V AC

Irating: 1Amp

Frequency: 50Hz

Power: 12.2VA

6. Fuse Rating

To protect the power supply and load in the case of an fault, the HV (primary) side of the power supply is fitted with a protection fuse.

The power supply is designed for 1 Amps continuously, but there will be times when the current will exceed 1 Amp.

In these cases, we do not want the fuse to blow. A good rule is to allow for a 100% overload on the transformer;

Imax_secondary = Imax x 2

Imax_secondary = 1A x 2

Imax_secondary = 2A

But the fuse is on the HV side of the transformer, so

Imax_primary =

Imax_secondary x (V_secondary / V_primary)

Imax_primary = 2A x (12V / 230V)

Imax_primary = 0.104A, or 0.1Amp

Increasing the current rating of the fuse alone, will prevent it from blowing in most cases, However, some loads will take a couple of milliseconds to reduce their peak current. For this reason, the fuse must also have a timing element to allow for short periods of overload. For this reason, the fuse must be a slow-blow fuse, and not a fast-blow fuse.

This example is for a 230V power supply, so the fuse must be able to break the current at this voltage. The fuse rating is now:

230V, 0.1A slow-blow

7. Heat Sink

A heat sink is a piece of metal engineered to dissipate the maximum thermal energy into the ambient surroundings. It assists a component to remain below its maximum operating junction temperature by drawing this energy away, thereby preventing damage through excessive temperatures. All electronic components dissipate heat, and usually their package (body) is sufficient to dissipate it into the surroundings, however voltage regulators such as a 7805, 7812, LM317T, require assistance if they are to operate to their extreme limits.

Calculating Heat sink Rating :-

θJA(TOTAL),

θJA(TOTAL) =(Tj-Ta)/Pd

θJA(TOTAL) = Total junction-to-ambient thermal resistance

TJ = Junction Temperature

TA = Ambient Temperature

PD = Power Dissipation

Junction Temperature ,

The maximum operating junction temperature is usually 150 ºC for 7805 voltage regulators, and operating at the maximum will certainly affect the reliability of the device. The recommended operating junction temperature is usually 125 ºC. This figure tends to be the same for the majority of silicon based voltage regulators in a TO-220 package.

Ambient Temperature,

The ambient temperature is the maximum temperature of the surrounding area that the device will encounter. It is usually 25 ºC; however, you have to consider the worst-case scenario. In the summer, the temperature can go as high as 30 ºC, and if the airflow was poor then a figure as high as 60 ºC is more appropriate.

Power Dissipation,

The power dissipation of the regulator is very simple to calculate using the standard formula for current multiplied by voltage.

Pd= (Vin-Vout) × Iout

This formula describes the power dissipation, which is the difference in input voltage to the output voltage, multiplied by the output current. As you can see, increasing the input voltage increases power dissipation. In addition, increasing the amount of current drawn also increases dissipation.

Heat Sink Size,

$$\theta SA = \theta JA(ToTal) - \theta JC$$

The heat sink-to-ambient thermal resistance is θSA, which the following formula calculates, and since we have all the pertinent values, we can plug them in. This is the value you need when selecting a heat sink.

Rating,

It is a nice sunny day and the temperature is the hottest it has ever been at 27 ºC. Our power supply is providing 12.20 V DC. Load will draw no more than 1 mA current with all the peripherals attached thas why calculating if a heat sink for the voltage regulator would be required.

$$Pd = (Vin - Vout) \times Iout$$
$$= (12.20 - 5) \times 1$$
$$= 7.2W$$

Now,

$$\theta JA(TOTAL) = (Tj - Ta)/Pd$$
$$= (125 - 27)/7.2$$
$$= 13.61°C/W$$

Looking at the documentation sheet of the LM7805, you discover the values of the following parameters.

θJC = 5 °C/W

θJA = 65 °C/W

Since θJA(TOTAL) > θJC, this voltage regulator will be sufficient for the purpose.

Since θJA(TOTAL) < θJA, a heat sink will definitely be required.

Calculating Heat Sink Size,

The heat sink-to-ambient thermal resistance is θSA, which the following formula finds, and since we have all the pertinent values, we can plug them in.

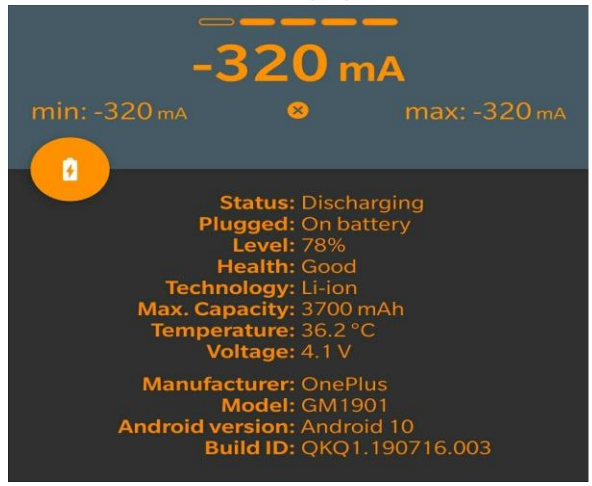
$$\theta SA = \theta JA(TOTAL) - \theta JC$$
$$= 13.61 - 5$$
$$= 8.61°C/W$$

Therefore, a heat sink with a rating close to 8.61ºC/W will be sufficient. Looking through catalogues, the Aavid Thermalloy model 6100BG has a rating of precisely 9 °C/W, which is sufficient.

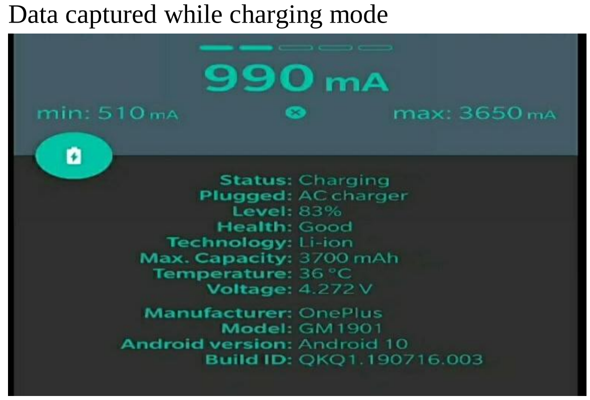
IV. CONCLUSION

As our project is made to detect the current of electronic gadgets connected via adapter. We knew the ideal value of current is zero when the device battery gets full and varies between the specified limits when it is in discharge condition. We need to know the practical current when mobile or laptop battery gets full or in discharge condition when connected to our circuit. Some experimental proofs when the device in discharging mode , charging mode and in full condition is shown below. From this data we able to find out the values of the currents in various mode of operation of battery of electronic gadgets while it is connected to supply via our circuit.

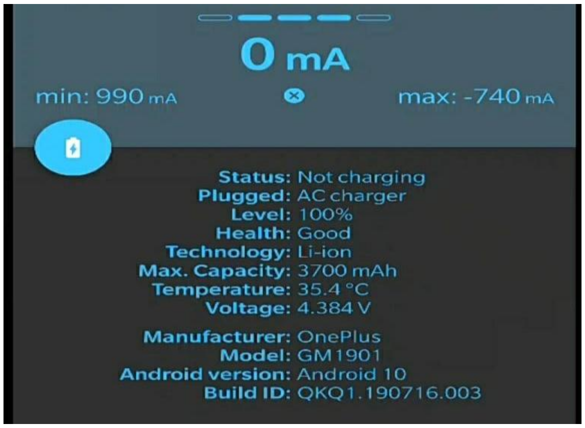
Data captured while discharging mode



Data captured while charging mode



Data captured on full charge condition



By using above data as experimental proofs we able to cut off the supply on detecting full charge and power on the supply when needed (discharging mode).

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