Automatic battery charging system on android smartphones

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Abstract. A smartphone needs a battery source to work well. During the battery charging process, the state of charge can be increased by up to 100%. One habit of charging batteries is to leave the smartphone connected to the charger all night long. Batteries that are already 100% but still connected to the charger will continue to receive an electric current even though a small value can cause a decrease in battery life and durability. This final project aims to create an automatic battery charging system based on the Android operating system. The result of this system is when the percentage limit that we have set is the same as the percentage of the battery on the smartphone, the system will automatically cut off the incoming current so that the charging process will stop. This system is designed using a microcontroller, Bluetooth module, relay module, Android apps, and smartphone with an Android operating system. The tests are the suitability of the apps with the smartphone, the charging and discharging conditions on the system, and automatic battery charging. From the results of the tests, the system can cut the current to a value of 0 amperes from the charger manually and automatically controlled through the apps, the apps can be used on smartphones that have Android version 2.1 or higher.

1. Introduction
Along with the development of technology, humans are increasingly inseparable from electronic devices, every device requires a power supply or energy source to function properly. On smartphone devices, the energy source comes from the battery. The battery is one of the storage media that can be charged by the charging process. The way users use smartphones especially in the charging process will affect the battery life and durability of the smartphone.

State of Charge (SoC) is the percentage of the total energy stored in batteries whose value will decrease with use. One of the habits of smartphone users is to do the charging process which is left asleep from night to morning, since the overnight charging duration is unnecessarily long, the battery is subjected to a high average state of charge (SOC), which accelerates battery aging [1].

Recent applications that are used by smartphone users only help users by informing and monitoring battery conditions such as battery condition, incoming current, and battery percentage [2]. To provide choices in managing batteries on smartphones, this final project will design and create a battery charging system for smartphones that can monitor and also control charging on smartphones so that battery life and durability can be maintained and remain optimal.

1.1. Battery
A battery is a device that can be used to store energy. The way the battery works is when the battery is in the process of charging, the battery will convert electrical energy into chemical energy and when used the battery will convert the stored chemical energy into electrical energy. The battery is used as a source...
of voltage from the electrical devices used, the types of batteries that are generally used by smartphones are Lithium-Ion (Li-Ion) and Lithium Polymer (Li-Po) batteries. Some of the factors that affect battery life are temperature, work cycles, and charging conditions, those factors will decrease Full Charge Capacity (FCC) or the maximum amount of charge that a battery can hold [3].

1.2. State of Charge (SoC)
State of Charge (SoC) is the ratio of total energy capacity that can be used from batteries to total battery capacity. SOC is the amount of energy available and written in percentages with a value of 0 to 100%. This percentage is used on smartphones to help users monitor battery conditions. In the filling process, there are 3 types of Integrated Circuits (ICs) that used to regulate the filling process, the ICs are the fuel gauge, the filling controller, and the protection IC [4]. The fuel gauge is used to measure the SoC on a smartphone by looking at the battery voltage, battery temperature, and current from the charger to the smartphone, the results obtained are sent to the charging controller IC to control the voltage and current in the charging process. IC protection has to protect batteries from exceeding the current-voltage and current limit [5].

1.3. Microcontroller
The microcontroller is an IC that is used to perform a specific command on a system. The main components in a microcontroller are the Central Processing Unit (CPU), memory and I/O system (input and output). The CPU is responsible for managing the system created by the user. Arduino memory consists of 3 parts, namely: Electrically Erasable Programmable Read-Only Memory (EEPROM) which functions as a storage of data that is stored even if it is turned off, Static Random Access Memory (SRAM) which is used to regulate variables when the program is running, and Flash Memory which serves to store the Arduino code. I/O system is used to connect Arduino with other devices [6].

1.4. Relay
Relay is a switch that serves to inflate and cut off the electric current. Relays consist of Electromagnet (Coil), Armature, Switch Contact Point (Switch), and Spring. The way relay works is when an electric current is flowing through the coil, the coil will become a magnet and pull the relay contacts so that it can deliver high voltage electricity [7]. Relay has 2 contact points, namely:

- Normally Closed (NC) when the initial conditions are in a closed condition.
- Normally Open (NO) when the initial conditions are open.

The types of relays can be classified based on the number of contacts and conditions they have, namely:

- Single Pole Single Throw (SPST).
- Single Pole Double Throw (SPDT).
- Double Pole Single Throw (DPST).
- Double Pole Double Throw (DPDT) [8].

1.5. MIT App Inventor
Massachusetts Institute of Technology (MIT) App Inventor is a website that can create applications for smartphones and tablets with Android Operating System (OS). Applications are made with block-based programming languages so that they are easy to make. The minimum Android OS to be able to run applications made is version 2.1 Eclair, this OS was published in 2009, so the majority of smartphones that exist today can use applications made by MIT App Inventor, also Android OS can be said as one of the most popular OS recently [9].
2. Method

2.1. System block diagram

![System block diagram](attachment:image1.png)

**Figure 1.** System block diagram.

In figure 1 the system uses a smartphone that has the Auto-Stop! application installed to read the battery percentage status, pair with a Bluetooth module, and send commands via a Bluetooth connection connected from a smartphone to Arduino Nano. Almost all smartphone has a built-in Bluetooth feature thus made this system available in almost every smartphone [10]. The power supply for the Arduino and buck converter comes from the AC-DC adapter which is boosted by the boost converter. The command is sent from the smartphone which then controls the relay condition and the smartphone charging condition.

2.2. Hardware design

![System schematic](attachment:image2.png)

**Figure 2.** System schematic.
2.3. Software design

Figure 3. System flowchart.

Figure 3 shows an automatic battery charging system flowchart whose working principle is to set the relay condition from the battery percentage limit that has been determined from the application, when the smartphone battery percentage is equal to the specified limit the relay condition will be disconnected, Bluetooth connection is disconnected, and a notification will appear on the screen.

Figure 4. Auto-Stop! application.

3. Results and discussion

3.1. Auto-Stop! application compatibility test on smartphone
Table 1. Compatibility test result.

| No | Smartphone Brands And Types   | Android Version | Error |
|----|-------------------------------|-----------------|-------|
| 1  | Luna V55C                     | 6               | No Error |
| 2  | Nokia 4.2                     | 9               | No Error |
| 3  | Oppo A3s                       | 8.1             | No Error |
| 4  | Samsung Galaxy J7             | 6.01            | No Error |
| 5  | Samsung Galaxy S8+            | 9               | No Error |
| 6  | Samsung J5 Prime              | 6               | No Error |
| 7  | Xiaomi Mi 5                   | 9               | No Error |
| 8  | Xiaomi Redmi 6A               | 8.1             | No Error |
| 9  | Xiaomi Redmi Note 5           | 9               | No Error |
| 10 | Xiaomi Redmi Note 7           | 9               | No Error |

Table 1 shows that every smartphone are capable of running our application without any error because we made the application with a minimum required version of 2.1 Android version.

3.2. Charging and discharging conditions test on the system

Table 2. Charging condition test result.

| No | Voltage (V) | Current (A) | Status On Application |
|----|-------------|-------------|-----------------------|
| 1  | 5.16        | 0.5         | Charging              |
| 2  | 5.13        | 0.5         | Charging              |
| 3  | 5.13        | 0.5         | Charging              |
| 4  | 5.08        | 0.5         | Charging              |
| 5  | 5.1         | 0.45        | Charging              |
| 6  | 5.13        | 0.45        | Charging              |
| 7  | 5.15        | 0.5         | Charging              |
| 8  | 5.16        | 0.43        | Charging              |
| 9  | 5.11        | 0.4         | Charging              |
| 10 | 5.12        | 0.5         | Charging              |

Table 2 shows that the measured current is around 0.5 Ampere, the current will shift according to user smartphone, battery percentage, charger type, etc. While the voltage value should be constant around 5.1 Volt because of charger tolerance value.

3.3. Automatic battery charging system test

Table 3. System test result.

| No | Limit (%) | Current (A) | Status On Application |
|----|-----------|-------------|-----------------------|
| 1  | 90%       | 0           | Discharging           |
| 2  | 91%       | 0           | Discharging           |
| 3  | 92%       | 0           | Discharging           |
| 4  | 93%       | 0           | Discharging           |
| 5  | 94%       | 0           | Discharging           |
| 6  | 95%       | 0           | Discharging           |
| 7  | 96%       | 0           | Discharging           |
| 8  | 97%       | 0           | Discharging           |
| 9  | 98%       | 0           | Discharging           |
| 10 | 100%      | 0           | Discharging           |
Table 3 shows that the system works on each limits from 90%-100%, the system also works on any other percentage chosen. Powers from charger won’t reach the smartphone as the current measured on USB cable are zero so the circuit is in open state.

4. Conclusion
Based on the system design, testing, and data retrieval on the automatic battery charging system on an Android smartphone we can conclude that Auto-Stop! the application will work on every Android smartphone that has more than version 2.1 Android, also system can disconnect and connect power from the charger according to percentage limit sets by the user with an accuracy rate of 100%.

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