Remote Controlled Smart Socket

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1 Introduction

1.1 Objective

Nowadays, with the development of science and technology, electricity becomes such an essential part that we cannot live without it and thus there are many accompanied problems being induced. For example, many people get annoyed at work when they realize they forget to turn off the household appliances. It is not only money-consuming and wasting energy but also dangerous if the appliance is overheated by long time power-on. Only from January 2017 to September 2017, there are 32 civilian home fire fatalities reported by U.S. news media, which are caused by electrical malfunction or appliances[1]. Moreover, in many laboratories or hospitals electric security is a really important part. Many equipment is precision and has very strict requirements for the power supply system. Uncautious using electricity may cause a lot of problems such as damage of equipment, fire and hurt people. On January 22, 2017, an electrical worker died in Lubbock Hospital when he tested the new equipments because of the overflow current[2]. If we can monitor the power supply of the socket and alert the user in advance, we can avoid these accidents.

Our goal is to build a smart socket, which can protect the equipment by checking the power supply automatically or remote controlling by people. It can be analyzed by the core microcontroller in power and other parameters and send these data to the computer. Depending on the value of the parameters, the computer would send the signal back if something goes wrong and shut down the power to protect the socket and devices. In addition, user can manually send back the signal by computer if they want to turn off an appliance when they are absence.

1.2 Background

Internet of Things develops based on the computer and Internet, which utilize sensor, RFID and other technologies to realize the communication between physical objects. Nowadays, people’s lives are already around by electronic devices and with more focus on the daily life’s quality and detail, Internet of Things gets more and more attention. Based on this technology, we put almost everything in our pocket and construct a smart world[3]. Among it, smart home is a very important field and there are already series of products which can control the power supply system. But most of those products’

functionality is simplex and does not fit industrial demands. Also, the smart socket will become more popular and necessary in the future. “Coming era of smart grids has implications for domestic DC distribution concepts with smarts sockets” [4].
Our goal is to fit for both household and industry use. Therefore, our socket must overcome the problems and implement multiple functions including control system, monitoring system and protection system. Also, taking account of universal practicability, the socket needs to be portable and not too expensive.

1.3 High-level Requirements

- The data of voltage and current can be send to the microcontroller once per second.
- At least two abnormal data have to be detected before send a warning message. At least five abnormal data have to be detected before automatically shut down the device.
- Switch of the socket can be controlled by computer, in order to turn on and off remotely.

2 Design

The whole system needs five sections: power transformation, data collection, control system, wifi module and the software feedback system.
In United States, the wall power is 110v. In our design, we want a small, stable DC voltage, so we design a power transfer module to transfer the 110v AC to 5v DC or smaller. For data collection, we focus on measuring the voltage and current and send the data to the microcontroller and then the microcontroller will send the data through wifi module to the computer. The control system contains one microcontroller to analyze the data and transfer them to the computer. For the wifi module, we will use ESP8266 to connect the microcontroller to a standard wifi network. For software part, we will use C language to modify the program based on Linux or Windows.

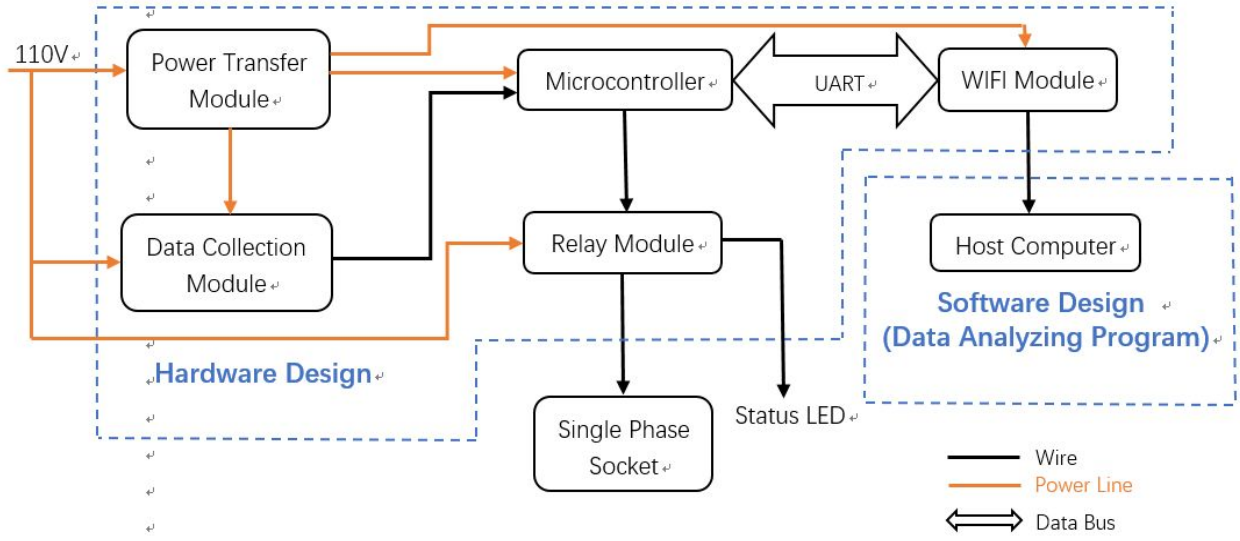

Figure 1. Block Diagram

2.1 Power Transfer

Our power will be used to power 5 modules. For microcontroller and data collection module, the power is 5V. For the relay and the WIFI module, the voltage should be 3.3V. We will use the wall power 110V AC and build a resistor circuit to transfer the wall power to DC voltage and use the transferred DC voltage to supply the modules and the chips. We will use a transformer chip and several resistors to achieve this task.
Requirement: Able to deliver 5V to the microcontroller and data collection module and 3.3 V to the relay and WIFI module. The error should be less than +/- 1 V.

2.2 Data Collection

Data collection module is to measure and calculate the circuit parameters and send the data to microcontroller to analyze. In order to realize it, we will use the CS5463 power metering chip. This chip can measure small DC voltage and current accurately enough for this project. This sensor can collect the data from the current connected device. Combined with voltage divider and current divider, CS5463 can sample voltage and current and calculate the power. We will weld this chip on the PCB. Moreover, the data collected by the sensor will be sent to the microcontroller. The safety voltage for this sensor is 5V DC. Besides, CS5463 has an internal temperature sensor so it can also measure the temperature for future use.
Requirement: Able to collect the voltage and current values once per second and send the measured value to the microcontroller.

2.3 Microcontroller

Microcontroller is the core of the socket. It manages the main logic function; sends signals to other modules and communicates with computer. The power transfer module, relay module, WIFI module and the data collection module are all connected to the microcontroller. It will received the data from the data collection module and analyze them and then send them to the computer through the wifi module. The microcontroller will qualify the data from the data collection sensor. All the modules are related by the microcontroller. We decide to use SPI or I2C to do the communication part for microcontroller. Both SPI or I2C will be tested in the circuit and the better performance way will be kept for the project. Our microcontroller will be powered by 5V from the power transformation module and send signal to both wifi module and relay module. The wifi module will adopt the UART as the tube to transfer the information and the data. If the voltage and current value seems to be abnormal, the microcontroller is able to receive the command from the users through the wifi module and control the relay to shut down the power.

Requirement 1: The work voltage is 5V.
Requirement 2:Microcontroller can receive the data from the data collection module.
Requirement 3:Microcontroller is able to analyze the collecting data and send them through Wifi module.
Requirement 4:Microcontroller is able to control the relay module after receive the command from users.

2.4 Relay Module

Relay module is to control the socket power supply. The relay we choose is electromagnetic controlled. It can detect the abnormal behavior of the circuit and cut off automatically. It can also be controlled remotely by the users. The output current may not strong enough to control the Relay module directly, so we will build an amplifier to strength the output current. We will use an integrated circuit to connect between the relay and the microcontroller.

Requirement 1: When the current flow through the coil is larger than 50mA, relay turns on; When it's smaller than 50mA, relay turns off.
Requirement 2: The output current from the pin of microcontroller is strong enough to control the relay.
Requirement 3: The voltage is no larger than 3.3V.

2.5 Wifi Module

This module is to provide safe and stable communication between microcontroller and host computer. We choose ESP8266 to construct the data link. Compare to other chip in the market, ESP8266 is cheaper and consumes lower energy.
Requirement: It can send a stable signal between the computer and the microcontroller.

2.6 Risk Analyse

In our project, the hardest part is the connection between the data collection module and the microcontroller. First, the measurement of voltage and current maybe not accurate and could be stucked and it is hard to chase which part on the PCB goes wrong. Second, CS5463's input signal is operated on the 110V voltage and this will result in that the common mode input reference voltage is the live line voltage. It may lead to severe common mode interference, even destroy the devices. Thus, in order to ensure efficient communication between microcontroller and power metering IC, we are thinking about add a isolation circuit.
Also, we think that the power transfer module is another key part which would affect the whole system: if the voltage is not correct then the whole system would be down. The transfer circuit has to be stable and accurate and if it goes wrong, both the system and the user could be injured and thus we will also use a small voltage LED to connect to the power transfer module to detect the status of this module.

3.Safety and Ethics

3.1 Safety

Because our socket will deal with a high voltage of 110V, it is dangerous for us when we test our circuit. Especially for the power transfer module, the capacitors may not working or our circuit does not work very well as expect. At this time, some incautious acts could induce a serious outcome such as getting an electric shock. When we testing our project, we have to keep the circuit away from water, metal and anything which is conductive. Also, after every test, the connection should be turned off first before we modify our circuit. For the reason that our project is uncovered, the whole project could be dangerous as an electricity conductor, we need to wear an isolated glove every time and keep the other part of the body away from the circuit. Moreover, if the current is too large, the chips could be burned up. The best result is that the circuit is broken and we need to reconnect the whole system and the worst result is that something could be ignited. Therefore, we need to design the power transfer part first and make sure it is

working before every test and connect it first before we add on more. Also, we need to make sure the fire extinguisher is in the laboratory and do not use water to extinguish the fire because it may be still powered on.
The finished product supposed to be covered by some isolated material so that the circuit is not exposed to the users. However, the customers should be careful about the environment. First, they need to make sure that no wire is out of the cover. Second, they need to keep the place clean, for example, there is no water around the socket. Third, they have to make sure that the wall power is no larger than 110V.

3.2 Ethics

Our socket is a remoted controlled electric device which connects the wifi in the room and has other control utilities. Violation usage includes stealing data, hack the devices, shut down the devices with illegal purposes and break the whole electrical circuit. Unfortunately, these possible actions are against #7 and #9 of the IEEE Code of Ethics[5]. So we want to reiterate our principle in a note while packaging, which is people are not allowed to use our product to undermine the privacy of others or use them for malignant business competition or other criminal act. We are responsible for making human's lives more safety and convenient. The main function of our socket is to control the power supply and protect both appliance and people from potential electrical fault. It stresses the importance of electronic security so it is an implementation of the IEEE Code of Ethics, #1:" to accept responsibility in making decisions consistent with the safety, health, and welfare of the public and to disclose promptly factors that might endanger the public or the environment"[5]. We want to build a safe electric environment.

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