Remote Controlled Smart Socket

ECE445 Mock Design Review
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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.

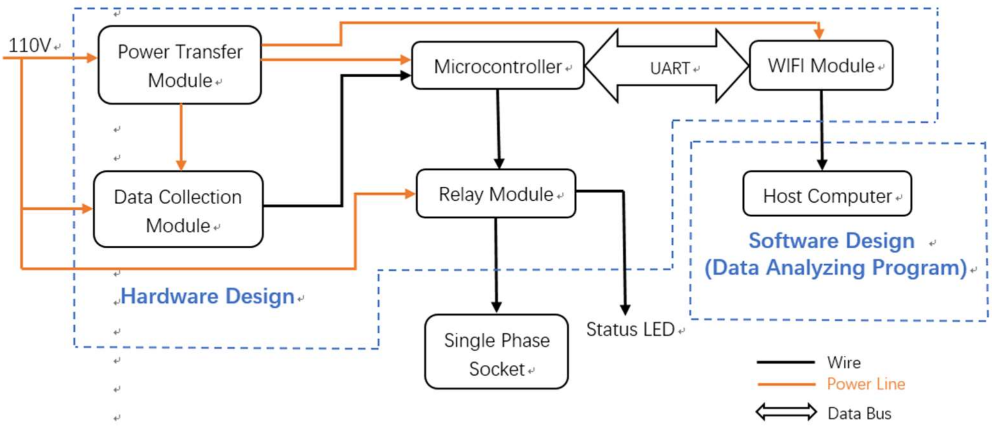


Figure 1 Block Diagram

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.

By CS5463 datasheet [5], we know that due to the input voltage limitation, the chip cannot connect to 110V circuit directly, so we need sample circuit first.

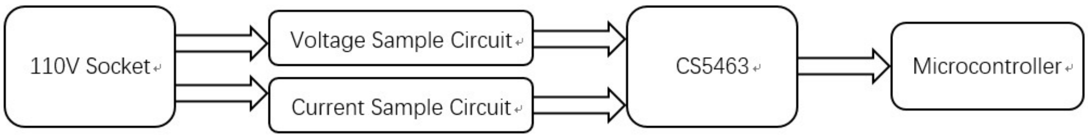


Figure 2 Data Collection Block Diagram

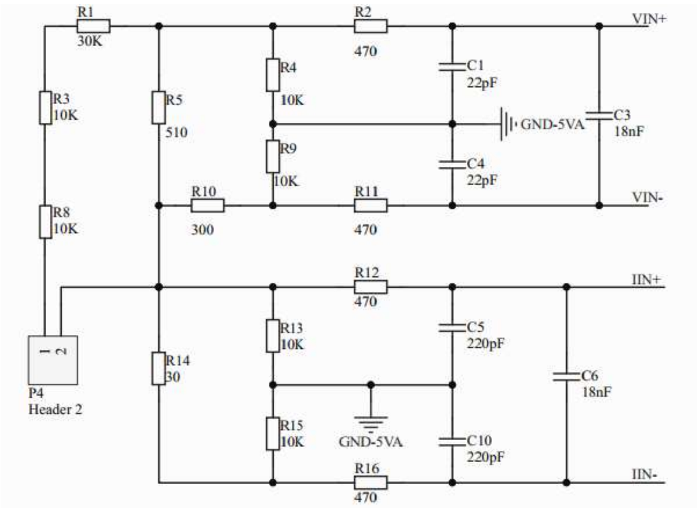


Figure 3 Sample Circuit Schematic

Voltage sample circuit is the top part of the schematic. R1, R3, R5 and R8 build the voltage divider circuit. R5 is the sampling resistor. R10 is to limit current. R4 and R9 are to control the differential voltage signal. R2, C1, R11 and C4 build a simple low pass filter. Then C3 filters the differential voltage signal again.

The full-scale differential input voltage for the voltage channel is $\pm$250mV[],

so the maximum RMS voltage is $250\text{mv} \div \sqrt{2} = 176.78\text{mv}$. In our circuit, the output voltage after voltage divider is

$\frac{1k\Omega}{300k\Omega*3+1k\Omega} * 110V = 122mV$. So it is not beyond the voltage range. But we have a gain factor K, where K=$\frac{1k\Omega}{300k\Omega*3+1k\Omega} = \frac{1}{901}$.

The bottom part of the schematic is current sampling circuit, which is similar to voltage part. We use a shunt resistor to get the sampling voltage and calculate the current.

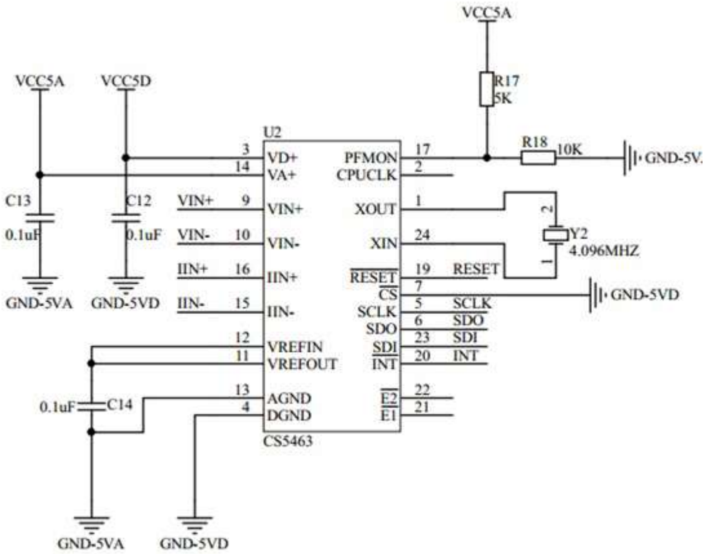


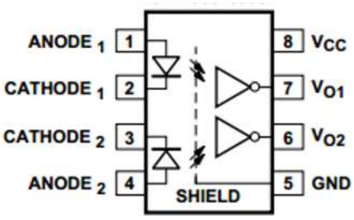
Figure 4 CS5463 Connection Diagram

VIN+/VIN- and IIN+/IIN- are connected to the output of the sampling circuit respectively. RESET, SCLK, SDI, SDO and INT are used to communicate with microcontroller.

Risk Analyse

CS5463's input signal is operated on the 110V voltage and this will result in that the common-mode level of the CS5463 is referenced to the line side of the power line [5]. 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 an isolation circuit.

We choose HCPL2631 to build the isolation circuit. It is LSTTL/TTL compatible and has very superior common-mode rejection so it can provide maximum ac and dc circuit isolation [6].



LED	OUTPUT
ON	L
OFF	H

Figure 5 HCPL2631 Functional Diagram and Truth Table

References

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