## Wireless programmable keypad with LCD display

ECE 445 Design Review

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### 1) Power System

A consistent power supply is necessary in order to power all of the components in our circuit. We choose to use a standard 9V battery, which benefits the user in the sense that they are easily replaceable and are not hard to find. In order to maintain a stable power supply, we will also built 2 voltage regulator/divider circuits to satisfy the input voltage requirements of our circuit components. One regulator supplies the required 3.3V for the bluetooth and 5 V for the LCD screen.

### 1.1) Battery

A 9-volt alkaline battery is select to power the whole device, as it benefits the user in the sense that they are easily replaceable and are not hard to find. The battery is capable of providing a regulated 5V to the LCD screen, much less the 3.3V required for powering microcontroller, BLE module, and miscellaneous LEDs.

### **1.2) Power Supply**

The circuit consists of two LM317T adjustable voltage regulator, whose functionality is to step down the varying input voltage and generate stable outputs for the rest of the device. The regulator features a wide range of input voltage and a maximum output current of 1.5A, both of which exceed our requirement significantly. Aside from the two resistors necessary for adjusting the output voltage, extra components are added to protect the device and improve the performance.

### **1.3) Voltage Divider**

This simple resistive voltage divider is essentially two resistors connected in series, producing the output fractional to the battery voltage, which otherwise too high for the ADC port of the microcontroller.

### **1.4) Power Level Indicator**

One green LED and one red LED are used to indicate the power level of the battery. Only the green LED will be lighted if the power is turned on and battery voltage is higher than 7 volts. Once the voltage drops below the level, the red LED instead is set on, reminding the user to change battery.

# 2) Diagrams



Figure 1: The power source diagram

### 3) Circuit Schematic





Aside from the two resistors (**R1**, **R2**) for setting output voltage, we also added some capacitors and diodes to improve the circuit overall performance.  $C_2$  is used to improve ripple rejection[1]. This helps avoid amplification of the ripple when a higher output voltage is used.

 $C_1$  is used when the regulator is not in close proximity to the power-supply filter capacitors. [2]

 $C_3$  improves transient response. The protection diode  $D_1$ ,  $D_2$  is used to provides a low-impedance discharge path to prevent the capacitor from discharging into the output of the regulator.[3]

### 4) Calculation

### 4.1) Power Supply Resistor Selection

The output voltage of LM317T is given by its datasheet as [4]they

$$\mathbf{V}_{\text{out}} = \mathbf{V}_{\text{ref}} \left(1 + \frac{R_2}{R_1}\right) + I_{adj} R_2$$

 $V_{ref}$  is the voltage between the output and adjustment terminals and is fixed at 1.25V  $I_{adj}$  is designed to be minimized and to maintain constant with line and load changes. Since  $I_{adj}$  is relatively small (100  $\mu$  A max), the error term  $I_{adj} \times R_2$  can be neglected for simplifying calculation. Furthermore, the datasheet also suggests a resistance of 240  $\Omega$  for  $R_1$ .[5] As a result, in order to acquire the desired voltage, the value of  $R_2$  can be determined by the equation

$$V_{\text{out}} = 1.25 \left(1 + \frac{R_2}{240}\right)$$

The resistance of  $R_2$  is 393.6  $\Omega$  and 720  $\Omega$  for output voltage of 3.3V and 5V, respectively.





**Figure 3**: The output voltage for 3.3V regulator ( $R_2 = 393.6 \Omega$ )



**Figure 4**: The output voltage for 5V regulator ( $R_2 = 720 \ \Omega$ )



Figure 5: Output Voltage over Time for a standard Duracell Ultra Power 9V Battery [6]6) Requirement and Validation

Table 1: The requirement and validation of the power source

Requirement	Validation
<ol> <li>The voltage regulator must provide 3.3V, 5V from the battery (9V) consistently to maintain the circuit functional.</li> </ol>	<ol> <li>A. Measure the output voltage using an oscilloscope, ensuring that the output voltage stays within 5% of 3.3V or 5V</li> <li>B. The output is stable even when the battery voltage is as low as 6.5 Volts, which ensures the function of the device over a long period of time.</li> <li>2.</li> </ol>

2. The power level indicator must indicate the right value of voltage coming from the power source

A. Connect the circuit to a power source. When the voltage is logic high, the green is on and red is off. When the voltage is logic low, green is off and red is on.

### VII) Ethics and Safety

We will put our best effort to keep our ethics in accordance with IEEE Code of Ethics #1,5 and 7[7]. Our project involves in complex hardware and software design therefore in order to fulfill IEEE Code Ethics #5, we need sufficient background knowledge to ensure we not only successfully implement the system but also produce a quality product. Under IEEE code of ethics #7, we will openly listen to TA's criticism and advice since they are useful in making sure we are on the right track. As we're aware of, there are existing products on the market that offers similar functionalities to our project, and very likely patented for their design. Although we have no intentions thus far to market this project commercially, we have to credit sources properly and avoid plagiarism to the best of our abilities. Although we only making a keypad, a harmless device, we realize that there could be unexpected dangers of using the power, and we will do our best to minimize the potential power and circuit failure with in accordance with IEEE code of ethics #1 by optimizing the both hardware and software component.

### Reference

[1],[2],[3],[4],[5] Texas Instrument "LM317 3-Terminal Adjustable Regulator", 2017. [Online] Available :

http://www.ti.com/lit/ds/symlink/lm317.pdf . Accessed 1 Oct 2017

[6] Batterysales, "Duracell MX1604 Alkaline-Manganese Dioxide Battery", 2017. [Online]. Available:

<u>http://www.batterysales.nl/files/downloads/Battery\_Sales\_Europe\_Ultra\_Power\_9V\_MX1604.p</u> <u>df</u>. Accessed 1 Oct. 2017.

[7] IEEE.org, "IEEE IEEE Code of Ethics", 2017. [Online]. Available:

http://www.ieee.org/about/corporate/governance/p7-8.html. Accessed 30 Sept. 2017.