Electrical Overview

Year: 2024 Semester: _Spring__ Team: _1___ Project: Dungeon Crawler____________
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Assignment Evaluation: See Rubric on Brightspace Assignment

1.0 Electrical Overview

For the Dungeon Crawler gameboard, a 32-bit controller will be used. The controller will be used to facilitate gameplay mechanics through the management of inputs and outputs of the board. Through an app based on a computer, a USB OTG will be used to port map and character data to the microcontroller. Map data is then displayed using data lines of neo pixels on the gameboard. The pixels are controlled via the DMA and PWM in order to allow multiple pixels to share a single data line. There are two types of other inputs managed. Keypad inputs and hall effect sensor inputs. The hall effect sensors, arranged in a matrix, are read by the controller to track character movement. The keypad is used to input gameplay values by a user such as dice rolls. Finally, custom output prompting and guiding gameplay is sent from the control to an LCD screen via SPI.

2.0 Electrical Considerations

2.1 Operating Voltage

The operating voltage of different components of the Dungeon Crawler Board will vary. We have chosen the STM32F405OEY6TR as our microcontroller. This microcontroller has an operating voltage of 1.8V to 3.6V[1]. The Hall Effect Sensors require 2.5V to 5.5V to operate [2]. Any I2C IO expanders will use the same logic level as the microcontroller [3]. This provides a range from 2.5V to 3.6V to supply voltage through the microcontroller if needed. Two components, the LCD screen and the WS2812B pixels, need higher voltage than the current operating voltages of the microcontroller. This prevents the usage of a single operating voltage for all systems. The LCD requires a voltage drive of 4.5V to 5.8V and the WS2812B pixel requires a supply voltage of 3.5V to 5.3V[4][5]. This creates a secondary margin of 4.5V to 5.3V to then supply separate from the microcontroller to the LCD and pixel lighting system.

2.2 Operating Frequency

The operating frequency of the microcontroller can run up to 168MHz[1]. However, it is necessary for the WS2812B pixels that comprise the lighting system that the timers run at 84MHz. The use of 84MHz is somewhat arbitrary but it allows for easy control of the PWM for sending data to the pixels. The WS2812B pixels receive data in series along a single data line. Using a PWM timer, the signal's duty cycle along the data line is controlled to read either 2/3 on or 2/3 off to signify a 1 or 0 bit. Groups of 24 bits are received by each pixel and the remaining bit signals are sent onward along the line. Data is read by the pixel groups at a rate of 800Kbps. Thus, 84MHz was chosen because this would give a prescaler of 1 and an ARR of 105. These both give way to easy computation and control of duty cycle ratios [5].

The LCD being used will be communicated with using SPI. The SPI on the STM32F405 controller can communicate at up to 42Mbits/s [1].

2.3 Power Supply

A 12V 8A wall adapter will supply the power for the Dungeon Crawler Board. Using a switching regulator, the output from the wall adaptor will be converted into the 2.5V-3.6V range for the microcontroller and hall effect sensors. The 12V will also be converted into the 4.5V-5.3V range needed for the LCD and WS2812B pixel lights. Of the 8A supplied, at most 7.173A will be used. This estimate is arrived at by assumed maximum usage of all components. For instance, it is highly improbable that all WS2812B pixels will be powered on at the same time and that all three LED inside each pixel will be turned on to max capacity. However, for freedom of use this is the estimate given for the pixels. It is to be noted that it has already been decided that full brightness is not desired, which is reflected in the estimate. The breakdown can be seen below:

The usage breakdown can be seen below:

- 256 x WS2812B * 60mA * .44(brightness control) = 6.83 A (This is assuming all three LEDs in each pixel are on)
- 256 x Hall Effect Sensor * 8uA = 2.048mA
- Microcontroller = 240mA
- LCD Display = 100mA
- TOTAL: 7.173A

3.0 Interface Considerations

3.1 USB OTG

The game board is initialized by utilizing an app on a PC. The data is set by the user and sent from the PC to the microcontroller. This is done using a USB OTG. The USB OTG is implemented in full-speed mode. The USB OTG is capable of 12Mbit/s full-speed. The USB OTG full-speed controller requires a dedicated 48 MHz clock. The clock is generated via a PLL connected to the HSE oscillator [1].

3.2WS2812B

As a previously mentioned, the light pixels will be controlled by using DMA and PWM. WS2812Bs can only read data at 800Kbps. The PWM modulates the duty cycle of the pixel data line to send 0s or 1s. Each pixel wired in series reads 24-bit signals on the line before letting the rest of the signal pass through to the next pixel in series. The 24-bit signal is comprised of 8 bits for each color, red, blue, and green. The data transfer time is 1.25µs. The ratio of the time the data line is high or low for this transfer time dictates whether a 0 or 1 bit is read by a pixel. 50µs of low time is used to reset the data line and pixels [5].

3.3 LCD

The LCD will be communicated with via SPI. There are 3 SPIs on the microcontroller that run at a rate of 42Mbits/s.

3.4 Hall Effect Sensors

The hall effect sensors will be paired with I2C to make use of I2C IO expanders. The use of these expanders is to create an easier design when creating the matrix of hall effect sensors to track player movements.

4.0 Sources Cited:

[1] "STM32F405OEY6TR," Buy STM32F405OEY6TR - ST Online Store, https://estore.st.com/en/stm32f405oey6tr-cpn.html (accessed Feb. 1, 2024).
[2] AH9246 N E W P R O D U C T description features pin ..., https://www.diodes.com/assets/Datasheets/AH9246.pdf (accessed Feb. 2, 2024).
[3] Adafruit MCP23017 I2C GPIO Expander, https://cdn-learn.adafruit.com/downloads/pdf/adafruit-mcp23017-i2c-gpio-expander.pdf (accessed Feb. 2, 2024).
[4] ILI9341, https://cdn-shop.adafruit.com/datasheets/ILI9341.pdf (accessed Feb. 2, 2024).
[5] WS2812B, https://cdn-shop.adafruit.com/datasheets/WS2812B.pdf (accessed Feb. 2, 2024).

Appendix 1: System Block Diagram