Electrical Overview

Year: 2023 Semester: Spring Team: 8 Project: Engineer’s Chess

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1.0 Electrical Overview

Computation regarding the game itself and the peripherals (minus the microphone) will be handled by a 32-bit STM microcontroller. The STM32 will interface with the main display, the two secondary OLED displays, the buttons, and the secondary computer (Jetson Nano) for user voice-commands. The main display is a 64x64 LED matrix that is multiplexed on two rows at the same time. The two OLED displays are interfaced using SPI, and the buttons will be attached to the GPIO pins on the STM32 directly. The Jetson Nano will be in charge of all signal processing, and will take in data from an ADC and communicate with the STM32 on what command was heard. The ADC will be attached to an amplified microphone which will perform analog-to-digital conversion for the Jetson Nano and relay this information over a serial connection. The secondary-computer will be handling various algorithms such as FFT and machine learning algorithms for classification which will be accelerated by the GPU. The STM microcontroller will be used for game logic as well as communicating with most of the peripherals.

2.0 Electrical Considerations

2.1 Operating Frequencies

The internal operating frequencies of the STM32 and Jetson Nano are 48 MHz [1] and 1.43 GHz [2] respectfully. The ADC will sample at around 10 kHz [3] because the highest frequency of the human voice is 4 kHz and we need to sample at 2 times the maximum frequency. The main display will have a refresh rate of at least 30 Hz because most low-end monitors operate at that frequency.

2.2 Power Consumption

The STM32 operates at around 3.3 V and 120 mA [1], resulting in a 396 mW power draw. The two OLED displays will run at the same voltage (3.3 V) to simplify the interface and will draw 24 mA of current each with 79.3 mW of power [4]. The Jetson Nano operates at 5-10 W on a 5 V supply [2]. The ADC used will also operate at 5 V with a current of 550 uA [3], resulting in 2.75 mW of power. The main display draws a significant amount of power depending on how many LEDs are on at any given time and operates at 5 V. In total, the board will need 1.56 A of current at 5 V.

2.3 Power Supply

The board itself will receive power from a barrel jack with a constant 5 V that can deliver up to 2 A. This 5 V will be used to directly power the Jetson Nano, ADC, and the LED matrix. A voltage regulator will be used to power the STM32, buttons, and OLED displays.

3.0 Interface Considerations

3.1 Inter-Computer Interface

There will be a full-duplex (Tx and Rx) 115200 baud UART communication link between the Jetson Nano and STM32. The Jetson Nano will send a few bytes of data to inform the STM32 of what command it thinks it heard the player say. The STM32 will inform the Jetson Nano if it needs to recompute what was said or if the predicted command was correct.

3.2 ADC Interface

The Jetson Nano will communicate with the ADC IC through a typical SPI interface. SCLK will need to run 180 kHz (18\*sample rate according to the datasheet [3]).

3.3 OLED Interface

The interface between the STM32 and the two secondary displays will consist of a single SPI interface, shared between the two displays (which means they will both display the same information). The operating frequency of this link will be 187.5 kHz [4], which is fine, because the STM32 only needs to issue commands to change the display and not to continuously display text.

3.4 Main Display Interface

The 64x64 LED Matrix uses a custom-interface that involves communicating with a display driver. This will be done via GPIO since there are no peripherals that map directly to this vendor-specific protocol. The protocol involves multiplexing two rows of LED’s at the same time and bit-banging color patterns on the lines. The operating frequency of this link will be 960 Hz. The outputs of the STM32 will have to be level-shifted to match the levels of the display.

4.0 Sources Cited:

* [1] STM32F091xB/STM32F091xC Datasheet [Online] Available: <https://engineering.purdue.edu/477grp8/Files/refs/STM32F091xB_STM32F091xC%20Datasheet.pdf>
* [2] Jetson Modules [Online] Available: <https://developer.nvidia.com/embedded/jetson-modules>
* [3] MCP3004/MCP3008 Datasheet [Online] Available: <https://ww1.microchip.com/downloads/aemDocuments/documents/MSLD/ProductDocuments/DataSheets/MCP3004-MCP3008-Data-Sheet-DS20001295.pdf>
* [4] 1602A OLED Display [Online] Available: <https://engineering.purdue.edu/477grp8/Files/refs/1602A%20OLED%20Manual.pdf>

Appendix 1: System Block Diagram

Graphical user interface

Description automatically generated

**Interfaces**

* The secondary computer (Jetson Nano) receives speech data from the ADC via SPI
* The microcontroller (STM32) and secondary computer exchange movement data for the pieces, as well as commands to shut-down the system
* The LCD screens receive time and move information from the microcontroller
* The LED matrix is driven by the microcontroller to display the chessboard itself