**Creation of Gamebox portable gaming system**

**using STM32F407**

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Abstract

The goal of this project is to design a handheld gaming system. The system is designed to take a STM32F407 processor and build peripherals around it to allow interactive gameplay. The processor and peripherals were selected to meet project specifications, allow ease of creation, and be under a certain budget. To accomplish this goal, we will include peripherals such as sound, user button inputs, an LCD color display, and a power supply unit with a power switch that will last at least one hour on new batteries. This project will teach us about taking user input in through a set of peripherals, and use this input in responsive manner to meet the needs of the user. This is a relevant project as engineers to aim to supply a source of education for game design and engineer hobby enthusiasts on how gaming console are designed and created, as well as bringing an enjoyable experience to our users.

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Scope of Project

A gaming system is needed to allow integration of hardware and software to gaming and engineering enthusiasts. The system must operate using the ARM STM32F407VGT6 process and be smaller than 6inx6inx3in. The system must also be handheld, portable, and ergonomic. In order to operate portably and reasonably, the system must have a battery life of at least 1 hour and include a mechanical power switch. The system must also have an LED to indicate the power status. In order to play complex games, the system must include a tactile button interface with at least a button and a D-pad. The system must have a color LCD graphical display of a size at least 2.9in diagonal. In order to provide feedback the system must have audio capability. That being said, due to the time and cost constraints the game design on the LCD and the game’s audio will be very basic. For durability the system must remain in operation with a 1-foot drop test. This project will consist of creating a function, interactive, and relatively fast portably gaming system. Due to the limited cost and time the system probably will not be fully optimized, but given the constraints it should be quite close to what is required. As an additional note, the state of the game itself will be quite basic because of the time and audio constraints.

Plan

*Technical Challenges:*

There are several technical challenges for this project. The biggest challenge will be interfacing the LCD display to our board. The LCD display is a completely foreign peripheral to our team, and to connect to it we need to create a PCB breakout board. Another major concern involving the LCD will be the graphics. The team will have to write individual pixels to the LCD using 30+ pins to dictate color and other signals. To address this challenge we will utilize coding to create different matrices to write pixels. Another concern is the power required by the LCD. We currently are trying to utilize a battery pack, but since the power the display requires is so much greater than the batteries we intend on using, we will use a DC to DC converter to amplify the power supply.

Another big anticipated challenge is a lack of time and experience. Our team has never seen some of these peripherals so interfacing with them will definitely take large amounts of time. To combat this we will try to use prior labs and experiences to reduce the time it takes learning the new components. The main part of this inexperience also involves the graphics and complex user input interfacing. To compensate for this inexperience our team will have deadlines and time constraints for learning the components to keep us on pace.

*Inputs:*

The gaming system will need only one type of input: buttons. Using 5-6 buttons we can create the needed interface for gameplay. The team will save costs on the buttons by taking them from the available buttons in the Tool Crib, however the cost of these buttons are relatively inexpensive. We felt that more expensive buttons would not improve the overall quality of input for the system, and thus we decided to use these buttons based on their ease of access and free price. There will be two main challenges with the buttons. Firstly we will need to de-bounce each button input in order to create an accurate signal. Without de-bouncing the gameplay could erratic and inconsistent. The second challenge with the buttons will be laying out the buttons in an intuitive way. The buttons will have to be ergonomic and easy to use. To combat these problems we will de-bounce the buttons through software, and take the directional pad (D-pad) and A and B layout from similar gaming systems like the Gameboy. The D-pad will be created with 4 buttons in a symmetric cross shape and allow the user to intuitively control directional components of gaming. To house both the D-pad and the other two input buttons, we will cut holes for them in the case of the device and mount the button systems on the case so that they protrude out for easy access by the user. The buttons will be connected to a voltage supply so that when they are pressed a circuit will be created to the GPIO pins, set to pull down floating signals, that they are connected to so that inputs can recognized by the system very fast.

*Display:*

The display on our system will be very similar to the LCD we used in lab, but a little more complicated. This is in part, why we chose this display. Another reason we chose this display was due to the low cost, size, and resolution it offers. The LCD is 2.9in diagonally, which is more than large enough when compared to similar systems. The color display uses 24-bits to describe each pixel’s individual color. Using this we can write to each pixel and make images according to our design. However, this has caused certain challenges for us. Initially we thought we could solder the connector and the pins of the LCD, however since the color LCD requires so many pins they are created with spacing that is very compact. To combat this are creating a breakout PCB to bridge the connection between the LCD and our STM32F407 processor. The display is also tricky because it needs to be powered by up to 20 volts. Our battery pack is significantly less, so we will be using a DC-DC converter to step up the voltage to power our display.

*Audio:*

The audio on our system will be very simplistic, driving on magnetic speaker on the device. The sounds we will use in the device are going to be created by varying frequency of triangle waves, and to keep audio creation simplistic, sound clips will not be very long before they are looped. The audio signal will be created using the STM32F407’s digital to analog (DAC) converter, and then will be interfaced with the external speaker module. The audio that is output will need to be in a frequency range around 350-600 hertz to make the noise generated on the speakers be within normal human hearing range. One challenge there will be with this correctly converting the analog signal that the DAC will output to the correct needs of the speaker system, and to account for this the analog output signal will be tested on an oscilloscope. Any transformations the output wave will need will be carefully tested and implemented on a circuit so that no damage to the speaker system or the STM microcontroller will be incurred. The audio speakers chosen were selected based upon their low cost and shape that is easy to fit into our design. The speakers space is advantageous as they take up a relatively small space, allowing for more room for other circuitry in the design, as their flat shape allows them to be easily mounted on the inside frame of the without protruding back too far. The speakers also meet the need of being able to being able to play frequencies within the desired range, so they are very ideal solution for our overall design.

*Power System:*

The power supply for the system will need to able to accommodate the varying electrical needs of the system, and also show on an LED when the power on the system is low. To implement the power switch on our system we will create a circuit that can break the circuit from the power supply to the components of the system. We will use a 4 AA battery holder to take in our power supply, and will use regulators to get our required 5V for the STM microcontroller which will power many other components in the system, and 20V for our LCD display. To show the power status of the system we will use an LED connected to a comparator circuit that will turn on the LED when the power drops below a certain threshold. To reduce the amount of components that will interface with the power supply, we will utilize the on board power supplies on the STM32F407 board after it has been powered from this system to power other components of the board. One concern is frying our board from an error in our power supply, so we will thoroughly test our power system to make sure it gives constant power that varies very little when it is in use. This design of our power supply system will be cheap as we will only need to acquire the cheap battery holder, and the rest we will implement with components that can be acquired in the Tool Crib for free.

*Block Diagram:*

*Diagram.png*

*Risk Assessment:*

One risk that our system will have is its usage of high voltages to power the display. These high voltages could potentially ruin other components if it comes into contact with them, so we will be careful to make sure our design keeps the 20V circuit away from other components of the system. Also this 20V circuit will be hazardous to work with, so we will make sure we as a group take necessary precautions so none of us are harmed when handling this circuit. We will thoroughly test the system before connecting it to other components so that items receive voltages in their desired ranges.

Another risk we have is that our LCD interfacing will not work. To try to minimize the impact of this potentially happening, we working on interfacing with the LCD as soon as possible so we can detect any potential problems in the system as soon as possible. When problems are encountered we will try to fix them if possible, but if interfacing with the LCD is holding back the design from being finished near the project due date, another more simplistic LCD may need to be purchased and used in place of our current LCD.

Budget

*Major Purchases:*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Component Name** | **Part Number** | **Price** | **Quantity** | **Total Cost** |
| Color LCD Display Module | NHD-3.5-320240MF-ATXL#-1 | $30.50 | 1 | $30.50 |
| PCB Breakout Board | N/A | 3 for ~$30\* | 3 | $30.00 |
| Audio Speaker | CLS0281MAE-L152 | $5.25 | 1 | $5.25 |
| LCD Connector | WM6472CT-ND | $2.82 | 1 | $2.82 |
| 50 Pin Socket Connector | S7128-ND | $3.05 | 1 | $3.05 |
| 4 AA Battery Holder | BH24AAW-ND | $1.46 | 1 | $1.46 |
| **Total:** | - | - | - | **$73.08** |

\*Price is an estimate on current design. Design may change before purchase, changing price.

Our group has already acquired the LCD display so the cost of the system that still needs to be purchased is $42.58, which most comes from the PCB cost estimate. We chose cheaper components as we feel that they will work just as optimally as any more expensive versions of the components, and we need to cut costs from an expensive LCD display interface whose components are estimated to cost $60.50.

*Miscellaneous Costs:*

Some miscellaneous costs on the project will potentially include materials such as adhesive glue to connect some components, such as speakers, to the case of the device. Fasteners be bought as well, as they will also be required to connect other components to the case in a stable way. Mount some systems inside the case of the system, some filler will also be required so the components cannot move around a lot, and thus wood could potentially be purchased and cut to keep components from shaking around too much within the case.

References

Display Datasheet:

<http://www.newhavendisplay.com/specs/NHD-3.5-320240MF-ATXL-1.pdf>

Display Driver Datasheet:

<http://www.newhavendisplay.com/app_notes/NV3035C.pdf>

Speaker Module Datasheet:

<http://www.cui.com/product/resource/cls0281mae-l152.pdf>

Online Tone Generator:

<http://onlinetonegenerator.com/>

LCD Connector:

<http://www.molex.com/pdm_docs/sd/512961894_sd.pdf>

AA Battery Holder Datasheet:

<http://www.memoryprotectiondevices.com/datasheets/BH24AAW-datasheet.pdf>