CECS 347 Spring 2025

# Project # 3

By

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Date: May 01, 2025

**Summary:**

This project involves developing a space invaders style game using embedded systems components, we use the Texas launchpad microcontroller, nokia5110 lcd display, potentiometer for the analog input, tactical switches for user control and a speaker for audio feedback. The implementation required modular software design, real time system timing, peripheral interfacing, and basic games physics. The key technical achievements included analog to digital conversion for player input, a bitmap graphics rendering which is on a low resolution, interrupt driven control and pulse width modulation for sounds

## Introduction:

The space invades project primary objectives were to, interface with multiple hardware peripherals.(LCD, ADC, GP, IO, timers), Implement real-time game mechanisms using systick interrupts, develop modular firmware architecture, firm main ability, create user interaction through analog and digital inputs, and generate basic audio feedback for game play. This implementation demonstrates core components and embedded C programming for hardware and software integration while using real time system designs the approach V1 to V4 allowed for systematic testing and integration of subsystems.

## Operation:

For the system operation, we have the initialization phase which consisted of a system clocks configured via PLL at 80 megahertz the peripherals initialized for,

- SSI 2 communication Nokia5110 LCD communication

-ADC1 sequencer 3 For potentiometer input PE5/ AIN8

- GP IO interrupts for switch inputs (PF0, PF4)

- Timer1 for sound effect timing.

We have the gameplay loop, so the player controls the potentiometer voltage 0-3.3 volts. Which is mapped to spaceship x – pos (0-83 pix) and 10 Hz systick interrupt updates position. for the enemy AI. We have 3 distinct enemies' spirits that move right at 10 PX/ second, and the boundary detection removes enemies at x>83. For the combat system we have SW1 triggers bullet firing which is an edge triggered interrupt, collision detection via bounding box comparison, and explosion sprite renders for 100 MS upon hit. For the audio feedback we have a 4-bit R-2R DAC generate 2kHz pulse wave(shooting) and 500Hz decaying tone (explosion). For the termination condition you know the game has ended when you see game over, try again and it will display your score with a three second delay before reset which is Systick timeout.

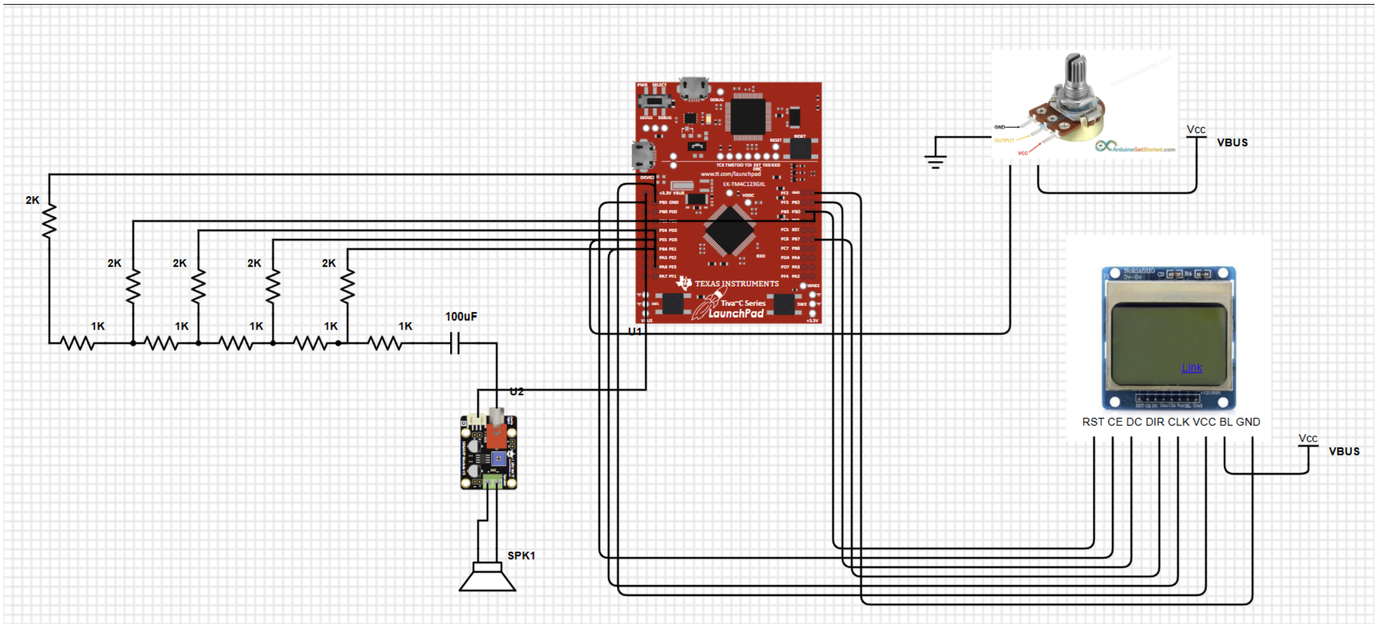
- Video:

https://drive.google.com/file/d/114w0dZOGghaaoO64nc6jKfw9tsGGQwiB/view?usp=sharing

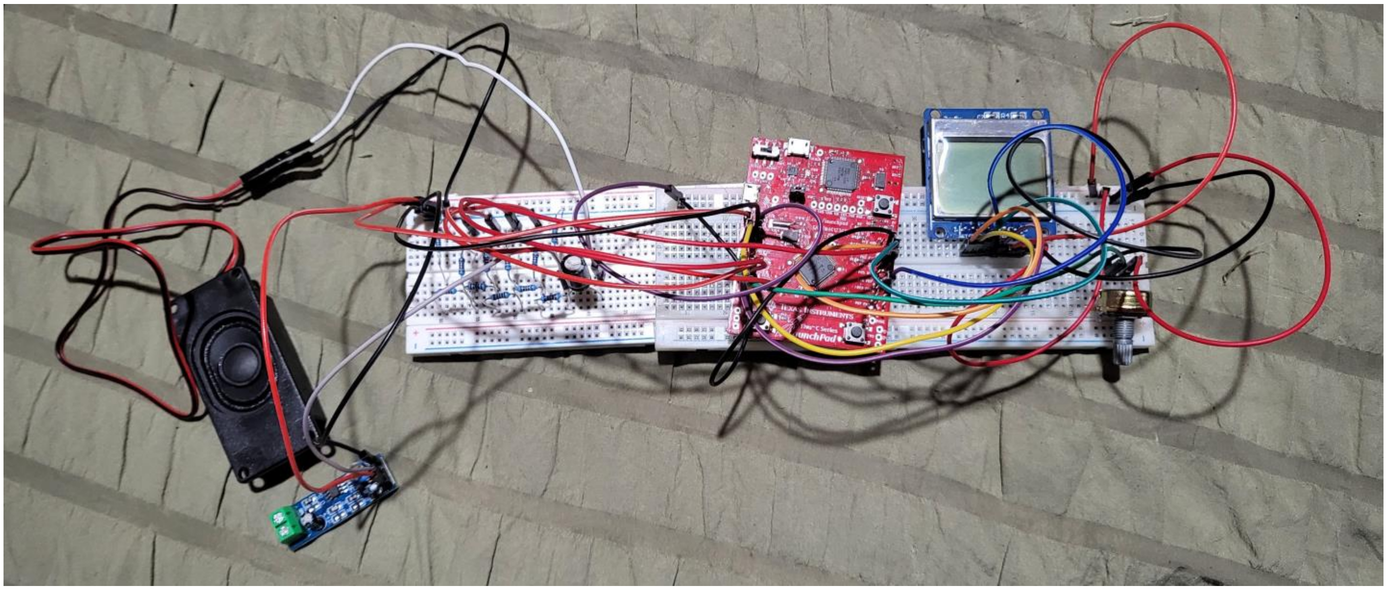
## Theory:

The Space Invaders game was built using embedded system principles, combining both hardware interfacing and real time software controls. The Nokia 5110 LCD display was driven via SPI (SSI2) to Render bitmap graphics, including spirits for the player, enemies, bullets, and explosions. Player movement was controlled by a point to meter connected to ADC-1, Converting analog voltage into a digital position value scaled to the screen width. Two GPIO switches provided digital inputs, one to start the game and the other to file the bullets, with debouncing implemented in the interrupt service routines to prevent false triggers. Enemy movement and bullets physics were handled by a 10Hz systick timer interrupt, insuring smooth gameplay. Collision detection used axis-aligned bounding boxes for computational efficiency, while a 4-bit R-2R DAC Generated sound effects for shooting and explosions via Timer 1 PWM. The system prioritizes interrupts to maintain responsiveness with GPIO buttons at the highest priority and ADC potentiometer at the lowest. Some problems. Included simplified sound generations for the square waves instead of PCM and basic collision detection aabb Instead of pixel perfect to balance performance and resource constraints on the microcontroller.

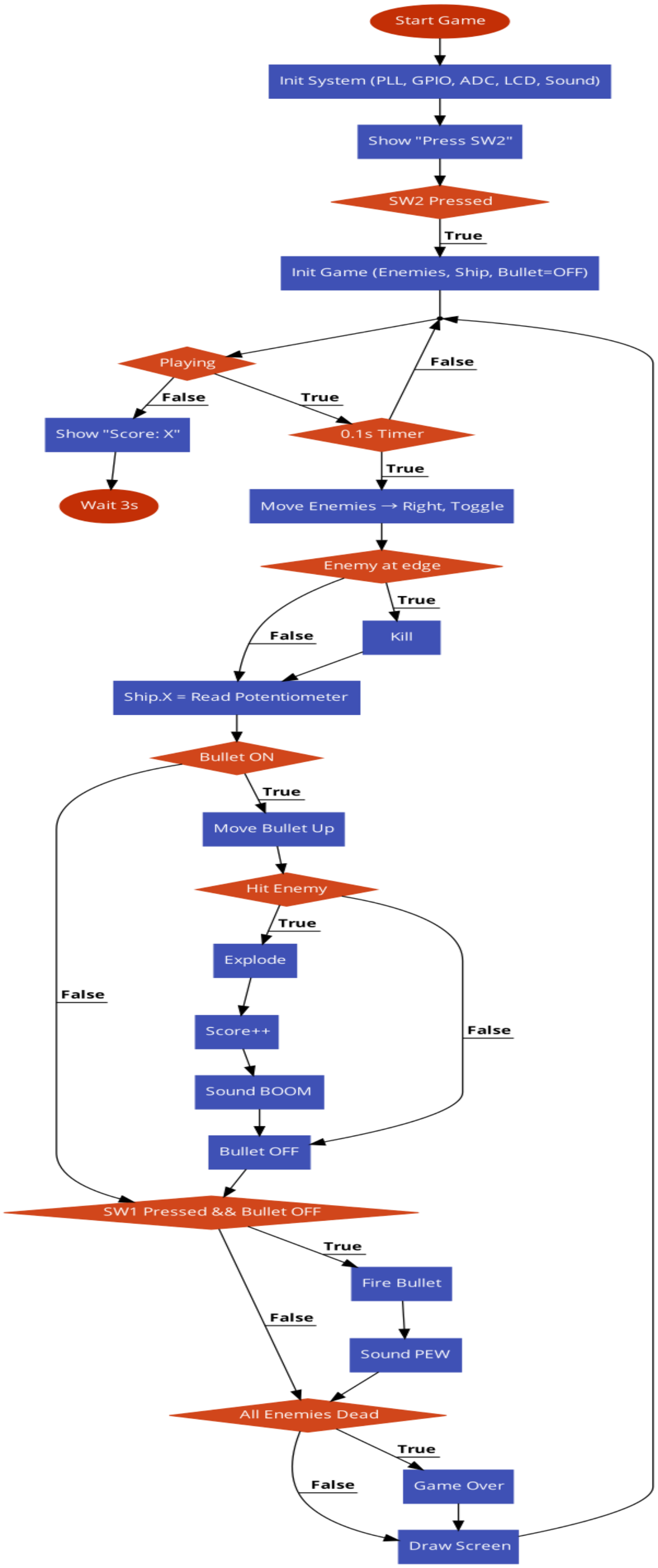
**Hardware Design:**



- Picture :



## Software Design:


Start Game
Init System (PLL, GPIO, ADC, LCD, Sound)
Show "Press SW2"
SW2 Pressed
True
Init Game (Enemies, Ship, Bullet=OFF)
Playing
False
True
Show "Score: X"
Wait 3s
0.1s Timer
False
True
Move Enemies → Right, Toggle
Enemy at edge
True
False
Kill
Ship.X = Read Potentiometer
Bullet ON
True
Move Bullet Up
Hit Enemy
True
Explode
False
Score++
False
Sound BOOM
Bullet OFF
SW1 Pressed && Bullet OFF
True
Fire Bullet
False
Sound PEW
All Enemies Dead
True
Game Over
False
Draw Screen

**Code Listing:**

ZIP file attached.

**Conclusion:**

The Space Invaders game projects successfully demonstrated the integration of embedded systems principle to create a functional and interactive gaming experience. By leveraging the microcontrollers peripherals including the Nokia 5110 LCD for display, ADC for analog input processes and GPIO for digital controls, we developed a responsive system capable of real time gameplay. While the project successfully met its core requirements, there were several challenges that we experienced during development. One major issue was the LCD display flickering during rapid updates, which was mitigated by optimizing the frame buffer refresh rate. Another challenge was inconsistent bun response due to the. Insufficient deep bouncing which required additional delay logic and the GPIO ISR. The potentiometer input occasionally produced jitter which led to unstable spaceship movements which was developed by adding software or filtering moving average. The 4-bit DAC audio quality was limited to producing harsh square wave tones due to the hardware constraint.