

The Crops

A Tower Defense Game

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Project Overview

- Classic strategy video tower defense game
- Storyline:

You are the owner of the farm, grow your crops to resist pests invasion.

Don't let the pests to get in your barn!

- The game is ultimate mode, the more rounds you survive the stronger pest you will face.
- Tip to save your farm: Build crops next to the invasion route, and be smart to use your coins!

Hardware Design

Graphics Processing

- Use matlab code to preprocess .png images to .mif files
- Single-port ROM memory blocks for every image
- RGB colors 24-bit color data, containing R, G, and B, 8 bit each

VGA Display Module



VGA Display

- Two Displaying method:

- Sprite Display

32-bit write data: [9:0] - pos_x, [19:10] - pos_y, [31:20] - id

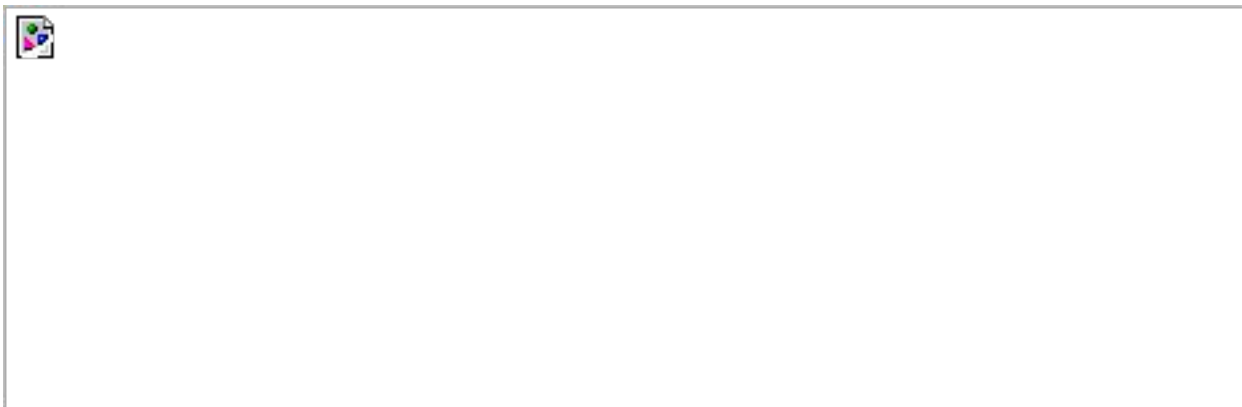
- Bullets: Sprite1 ~ Sprite50
 - Monsters: Sprite51 ~ Sprite 60
 - Tower with blur effect: Sprite61

- Tiles Display



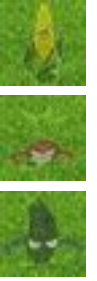
- Cursor: Display logic in 20x13 grids
 - Towers: Two-port memory to store grids and flag for display logic
 - Score and coins: 4-bit mapping of digits
 - Other game elements including barn, trash, life, titles, brands, and brands

Hierarchy of Display

- Sprites on top of Tiles



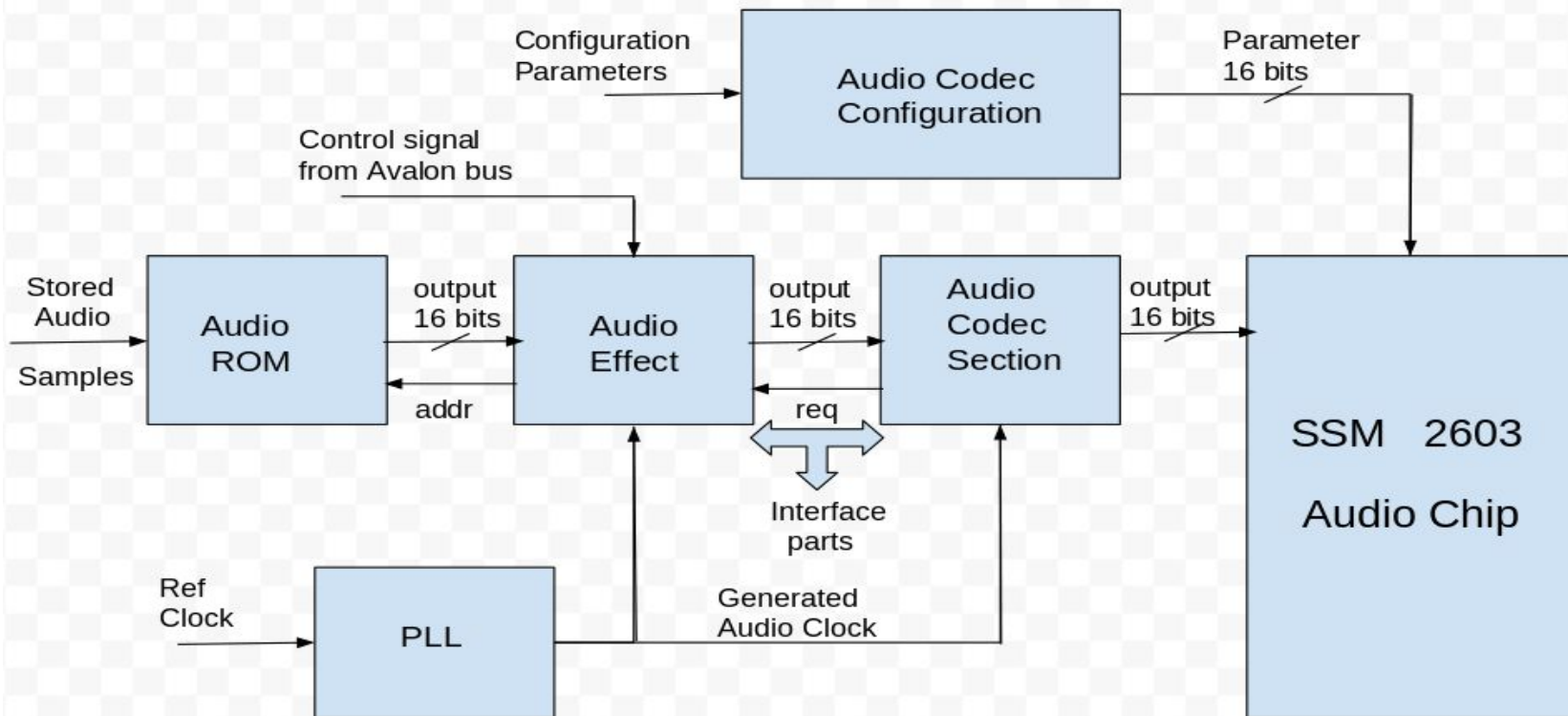
Sprites

Type	Monsters	Bullets	Plants (blur)
Numbers	10	50	1
Pixels	32*32	32*32 (16*16)	32*32
ROM Size(KB)	14.8	14.8	14.8
Images			

Tiles

Type	Numbers	Pixels	ROM Size (KB)	Images
Barn	1	64*64	59.8	
Trash	1	32*32	14.8	
Plants	(20*13)	32*32	14.8	
Cursor	1	32*32	14.8	
Heart	5	32*32	14.8	
Digits	10	16*32	7.3	0 1 2 3 4 5 6 7 8 9
Titles	4	64*32	29.8	Coins: Life: Score: Round
Brands	2	256*32 / 256*64	123.8 / 251.8	FARM TD GAMEOVER Press START to begin! Press START to retry!

Audio Processing



Audio Processing

SSM 2603 sampling rate range is varying from 8KHz to 96KHz.

We have to generate own clock sampling rate to match with audio file we using.

One background music and another alarm music is being used as warning.

Converting audio file into MIF file properly. (Only format supported for ROM storing).

Audio Processing Block Details

1. Audio ROM Block
2. Audio Effect Block
3. Audio Codec Block
4. Audio Codec Configuration

Initializing no audio files playing since we have passed four bits '0' to effect block.

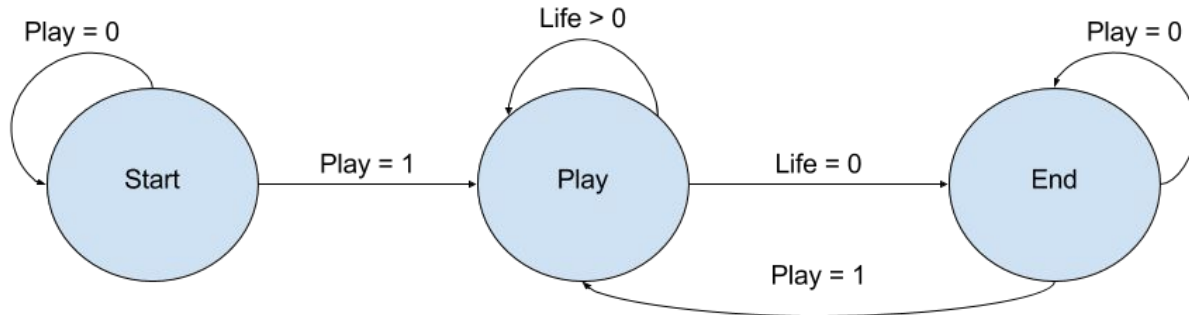
'0001' playing background music.

'0002' playing alarm music.

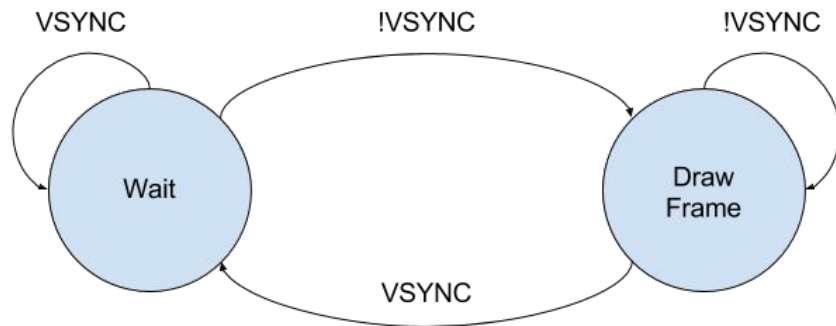
Software Design

Game Logic

- Two threads
 - Game logic for sprite movement and tiles display
 - Pest movement
 - Return logic
 - Bullet generator
 - Trajectory calculator
 - Cursor movement controlled by Xbox 360 controller key press



Game logic continue



Game logic function button

Buttons	Mode	Actions
Up	buildMode = 0	Move the cursor upwards
Down	buildMode = 0	Move the cursor downwards
Left	buildMode = 0	Move the cursor leftwards
	buildMode = 1	Choose the tower on the left
Right	buildMode = 0	Move the cursor rightwards
	buildMode = 1	Choose the tower on the right
A	buildMode = 0	Enter the build mode
	buildMode = 1	Build the tower
B	buildMode = 1	Exit the build mode
START	Play = 0	Enter the "play" state

Xbox 360 Controller



- ❑ The controller used in this project is a Xbox 360 wired controller.
- ❑ A userspace driver based on libusb-1.0 is implemented to drive the device.
- ❑ Input report and button mappings are:

<u>Offset</u>	<u>Length</u>	<u>Function</u>
0x02.0	1	D-Pad up
0x02.1	1	D-Pad down
0x02.2	1	D-Pad left
0x02.3	1	D-pad right
0x03.4	1	Button A
0x03.5	1	Button B
0x03.6	1	Button X
0x03.7	1	Button Y

Device Driver

Xbox 360 controller userspace driver

- ❑ Unlike normal HID device, Xbox 360 controller uses “Vendor Specific” DeviceClass.
- ❑ Use linux’s lsusb utility, detailed device descriptor can be obtained. The most important information is:

bDeviceClass	255 Vendor Specific Class
bDeviceProtocol	255 Vendor Specific Protocol
bInterfaceClass	255 Vendor Specific Class
bInterfaceProtocol	1
- ❑ Use a modified version of usekeyboard.c based on the specifications at <http://free60.org/wiki/GamePad>.

Experiences and Issues

- VGA display;
 - Wrong image display at the edges because RGB color information received was behind the sent address by one clock cycle:
 - Solved by adding 1 to the sent address
- Controller driver;
 - Using xbox 360 linux's kernel driver will raise issues when installing:
 - Solved by using userspace driver instead

Lessons Learned

- SoCKit board architecture
- Memory initialization file generation for memory block
- Coding experience in SystemVerilog and C
- Try out parameters for audio processing
- Debugging skill

DEMO