Game Console Starter Kit 2.0

Lesson Plan

Introduction

Thank you for purchasing the Game Console Starter Kit 2.0. On this CD you will find an entire course created around learning how to build and create your very own video game consoles. These lessons are given as a self-paced 12 step course covering the entire gauntlet from analog electronics all the way to microcontroller programming. This document serves as a suggested lesson plan.

The layout of the CD is as follows. There are 12 lessons, a majority of which include experiments meant to be performed on a solderless breadboard. Each lesson is given its own folder with all associated files beneath it. For example:

CDROM_ROOT:\Lesson1 - Root folder of lesson 1 (this is where you will begin)

CDROM_ROOT:\Lesson1\Experiments - Experiments for lesson 1 (some lessons won't have experiments)

CDROM_ROOT:\Lesson1\Questions - Quiz questions and answers after you have completed lesson 1

CDROM_ROOT:\Lesson1\Slides - Power Point and Adobe PDF lesson slides (includes audio voiceovers)

CDROM_ROOT:\Lesson1\Videos - In some lessons you can also watch a supporting video

NOTE 1: *Additional source code, datasheets, tools, etc. are located on the XGS Pico Edition 2.0 CD that comes with the kit, so if you can't find something on the LESSON CD, then look in the Pico 2.0 CD.*

NOTE 2: *You will need Adobe PDF reader and the Microsoft Power Point Reader to view the media in the lessons. If you don't have these loaded on your computer, you can install them from the CD, they are located in the* ***\Tools*** *sub-directory from the root of the CD.*

How to Start

The linear approach to completing this course is to follow the lessons 1 through 12. However if you would like you can skip around, this isn't recommend. When you start each lesson you will have an assigned reading section that is laid out for you below. For example Lesson 1 requires that you read the ***Black Art of Video Game Console Design*** Pages 1-90 BEFORE starting in the slides. This will give you a very in depth coverage of the material before you watch any slide show or begin on the experiments.

Once you have finished reading you can open up the slide show located under the lessons folder in the /slides/ folder. If you have an application that can play Microsoft power point slides you may step through the slides with that. If you do not have power point, you can page through each slide in a PDF viewer program. Each slide has an audio mp3 file that you may listen to, that emulates a classroom setting. If watching the power point slides as a slide show you may click on the sound icon in the top right hand corner of each slide. This will automatically begin playing the voice over for this particular slide.

After you have finished the slides for the lesson you can then begin on the experiments. The experiments have a PDF manual that you will read through that gives step by step instructions on how to complete them. Some experiments may have supporting files, for example source code. If they do have supporting files they will be located in the same folder as the experiment manual. All of the experiments require hardware that is completely self-contained in the lesson kit you purchased. This will be the physical building portion of the class, where a lot of experienced is gained. Try your hardest to get through the experiments. If you get stuck on them, visit the XGameStation forums located at http://www.xgamestation.com/phpbb/

After the experiments are completed you may then test your knowledge by taking a 10 question quiz located in the quiz folder under the lesson subfolder. The answers to each quiz are given at the bottom of the file.

There is a final exam for those who like to make sure they have all the subject course matter understood. This final exam is located in the **CDROM_ROOT:\FinalExam** folder.

Lesson 1: Introduction to analog circuitry

Text Book: Pages 1-90

Goals:

Electrical Engineering is a discipline that requires knowledge from various backgrounds including: math, chemistry, physics, and computer science. One of the more difficult areas of electrical engineering deals with analog circuits. Analog circuitry is the study of circuit design where voltages and currents are based on signals that change with a function of time. Students can expect to learn some of the basic fundamentals of electronics including: electron motion, Ohm's law, Kirchoff's laws, and common circuit solving techniques.

Using the knowledge gained from the book and lecture notes students will begin experimenting with actual hardware components. Experiments include creating a 5 Volt regulator that will be used for all additional hardware experiments, and blinking lights (LEDs) on and off with a few simple components. Students will be given an introduction to some of the common engineering tools such as solderless breadboards, digital multi-meters, and more.

Key Topics:

- Understanding electronic signals (analog vs. digital)
- Voltage and current definitions
- Ohms Law
- Power Equations
- Resistors, Capacitors, Inductors, Transformers
- Testing Equipment
- Kirchoff's Laws
- Voltage Dividers
- 5 Volt Regulator

Experiments:

- Creating the 5 Volt Regulator
- Power LED
- Measuring with the Multimeter
- Voltage Divider Circuit
- Introduction to the Potentiometer

Quizzes:

10 Question Quiz (true/false, multiple choice)

Covers select topics from Text/Lesson One

Recommended Study Time: 5-7 hours

Lesson 2: Advanced analog circuitry

Text Book: Pages 91-194

Goals:

Armed with the knowledge from the previous lesson as building blocks, students will continue studying some advanced uses of analog components. Students will learn about the relationships between capacitors, inductors, transformers, and one of the most important inventions in electronics - transistors. Circuit simulators such as SPICE engines will be covered thoroughly so students can test designs in software before implementing in the real world.

Key Topics:

- Mechanical Switches
- Potentiometers
- Capacitor Equations
- Low and High Pass Filters
- Inductor Equations
- Rectifiers
- Transistor Switching
- Building Inverters
- Clock Generation
- SPICE simulations

Experiments:

- Playing with Switches
- Simulation and Hardware Verification
- Diode Experiment
- Capacitor Charging and Discharging
- Playing with Transistors

Quizzes:

10 Question Quiz (true/false, multiple choice)
Covers select topics from Text/Lesson Two

Recommended Study Time: 5-7 hours

Lesson 3: Introduction to the Digital Realm

Text Book: Pages 195-247

Goals:

Once students have grown an appreciation for analog circuitry and its complexities, they will be introduced to the digital side of electronics where many generalizations can be made making circuit design a magnitude easier. Concepts such as Boolean logic, truth tables, logic voltage levels, and basic gates will be explored. Also binary math will be introduced.

Key Topics:

- Logic Symbols
- Truth Tables
- Boolean Algebra
- DeMorgan's Theorem
- Datasheets
- Loading Concepts
- DIP Packages
- Half/Full Bit Adders

Experiments:

- Introduction to the AND Gate
- Introduction to the OR Gate
- More Complex Circuit
- Playing with the XOR Gate
- Building a Half Bit Adder
- 555 Timer and Binary Counter

Quizzes:

10 Question Quiz (true/false, multiple choice)
Covers select topics from Text/Lesson Three

Recommended Study Time: 5-7 hours

Lesson 4: Advanced Digital Design

Text Book: Pages 309-380

Goals:

This lesson will focus on advanced digital design concepts that are required for building game consoles. Students will learn about glue logic and logic simplification through techniques like K-maps and ones looping. Also, students will learn about more complicated digital chips like shift registers that are used on the XGS micro-edition for reading joysticks and the SRAM.

The concept of state machines will be introduced to students. By the end of the lesson students will design, on paper, a full state machine with inputs and outputs and then finish the design in hardware with LEDs and switches.

Key Topics:

- Logic Simplification
- Bubble Pushing
- Minterms/Maxterms
- K-Maps
- Decoders, 7 Segment Displays, Muxes
- Flip Flops
- State Machine Design

Experiments:

- 7 Segment Display
- LED State Machine Design
- Pattern Detector Design

Quizzes:

10 Question Quiz (true/false, multiple choice)
Covers select topics from Text/Lesson Four

Recommended Study Time: 5-7 hours

Lesson 5: Computer Architecture

Text Book: Pages 382-510

Goals:

Students will be introduced to the wonderful world of microprocessors and microcontrollers. By the end of the lesson students will understand the general idea behind building their own simple computer. They will know the inner workings of a processor including how assembly language and machine code comes together to control inputs and outputs.

One experiment included with this lesson has the students working with a microprocessor entirely in simulation. By writing some basic code students are able to run and save their programs without having to touch a single piece of hardware. Additional experiments are performed with the sx-28 microcontroller (the heart of the Pico XGS).

Key Topics:

- Microprocessors and examples
- Microcontrollers and examples
- Von Neumann vs. Harvard
- Endianess
- External/Internal Architecture
- Pipelining
- Addressing Modes
- Interrupts
- Memory Types
- Intro to the SX-28 Microcontroller

Experiments:

- Microprocessor Simulators
- Intro to the SX-28
- SX-28 Controlling the 7 Segment LED
- SX Pong

Quizzes:

10 Question Quiz (true/false, multiple choice)
Covers select topics from Text/Lesson Five

Recommended Study Time: 5-7 hours

Lesson 6: Designing Game Systems I

Text Book: Pages 511-600, 639-651

Goals:

This lesson is part of a two lesson introduction to designing game systems. Students will start by covering some of the early generation game consoles. By examining ideas implemented by other video game console designers, students will begin to understand how all the pieces fit together. Sound experiments will be the focus for this lesson.

Key Topics:

- SX-28 Overview
- Jump Tables
- Accessing RAM
- SX Registers
- Assembly Programming the SX-28
- XGameStation Prototypes
- D/A Converters
- Game Console Sound
- PWM Signals

Experiments:

- Digital Organ
- PWM Generated Sound
- PCM Digitized Sound

Quizzes:

10 Question Quiz (true/false, multiple choice)
Covers select topics from Text/Lesson Six

Recommended Study Time: 6-8 hours

Lesson 7: Designing Game Systems II

Text Book: Pages 600-639, 652-696

Goals:

This lesson continues with the game system design process. Topics such as input devices and one of the hardest topics - video generation will be covered in depth. Experiments such as reading a Nintendo controller and drawing video to a TV screen are provided in this lesson.

Key Topics:

- Display Technologies
- Raster Graphics
- NTSC Basics
- Adding Color
- RGB/VGA Basics
- Vector Graphics
- Game Controller Inputs
- Atari, Sega, NES Controllers Examined
- Serial Communications
- RS-232 Communications
- Game Cartridges
- Assembly Overview of Video Generation on the SX chip

Experiments:

- Read Nintendo Controller
- Mono Color Bar Demo
- Color Bar Demo
- Drawing a Star Field

Quizzes:

10 Question Quiz (true/false, multiple choice)
Covers select topics from Text/Lesson Seven

Recommended Study Time: 6-8 hours

Lesson 8: Game Console on a Breadboard

Text Book: Pages 803-898

Goals:

Taking into account all the past lessons, students will begin to assemble their very first working video game console. Thorough coverage is given to help with the assembly process including step by step slides and very detailed book instructions. By the end of this lesson students will be playing their first games on a TV with sound and input.

Key Topics:

- Game Console Schematic
- 5 Volt Regulator Construction
- SX-28 Circuit
- Clock Circuit
- LED Output Port
- Video Out Circuit
- Audio Out Circuit
- Joystick Port

Experiments:

- Assembly of the Game Console onto a Breadboard
- Running Numerous Demos to Verify Working Console

Quizzes:

10 Question Quiz (true/false, multiple choice)
Covers select topics from Text/Lesson Eight

Recommended Study Time: 3-4 hours

Lesson 9: Game Console on a PCB

Text Book: Pages 249-307

Goals:

In this lesson the Pico edition will become a more permanent game console by soldering it onto a prefabricated printed circuit board (PCB). Students will learn about the different components of a PCB: silk screen, solder mask, copper traces, through holes, and more. Soldering techniques will be covered with real time video demonstrations illustrating the entire assembly processes from beginning to end.

Key Topics:

- Soldering Iron Usage
- 5 Volt Power Supply
- Filtering and Pull Up Resistors
- Current Limiting Resistors
- Directional Pad and LEDs
- 7 Segment LEDs
- Audio and Video R2R Ladders
- DIP Socket Headers
- Expansion, RCA, and Joystick Headers

Experiments:

- Assembly of the Game Console onto a PCB
- Running Numerous Demos to Verify Working Console

Quizzes:

10 Question Quiz (true/false, multiple choice)
Covers select topics from Text/Lesson Nine

Recommended Study Time: 3-4 hours

Lesson 10: Hacking Demos

Text Book: None

Goals:

There are a number of demos that come shipped with the Pico edition game console. A majority of these demos are coded in assembly. The best way to gain confidence in programming the game console is by making small changes (hacks) to existing demos. Therefore, hacking demos is the primary focus for this lesson. Each hack is described in detail along with the source code changes required to modify the program.

Key Topics:

- Starfield Hack
- Character Tiles Hack
- Game Text Hack
- Racer Hack
- Sound Hack

Experiments:

- Modifying Original Source Code with Hacks and Running on Game Console

Quizzes:

10 Question Quiz (true/false, multiple choice)
Covers select topics from Text/Lesson Ten

Recommended Study Time: 3-4 hours

Lesson 11: Creating Games for the Console

Text Book: None

Goals:

This lesson covers the process behind developing games for the console built in previous lessons. Tile engines will be used to build the game world. All sections of the game will be covered thoroughly through the lesson slides. Students will be able to add their own special customizations to show off their new game to friends and family.

Key Topics:

- Game Components Required
- Organizing Code and Art into System ROM Space
- Organizing RAM
- Using the Real Time Clock Counter
- Creating the Title Screen
- Creating the Game Boards
- Game Screen Layout
- Creating the Game Screen
- Final Thoughts

Experiments:

- Programming Game Console with Final Course Game

Quizzes:

10 Question Quiz (true/false, multiple choice)
Covers select topics from Text/Lesson Eleven

Recommended Study Time: 3-4 hours

Lesson 12: Emulators and Simulators

Text Book: None

Goals:

Programming hardware systems can take an enormous amount of time. This time includes time for assembling the code into machine code and transferring the machine code to the onboard flash. Programs could take up to a minute just to test a single line of code change. Emulators will be covered in this lesson that can help eliminate a majority of the game development time.

Key Topics:

- Definition of Emulators and Simulators
- XGS Emu Overview
- SXSim Overview
- Launching the SXSim
- Breakpoints
- Measuring Clock Cycles
- Code Organizing
- Macro Expansion

Experiments:

- None

Quizzes:

10 Question Quiz (true/false, multiple choice)
Covers select topics from Text/Lesson Twelve

Recommended Study Time: 1-2 hours

Final Exam

- 50 multiple questions