Introduction

Released in 1978 by Taito, Space invaders was one of the earliest “shooting” video games. The goal is to defeat waves of alien invaders that zig-zag towards Earth with a laser cannon, and of course, to score as many points as possible doing it. The invaders have lasers too and they shoot them, more or less at random, at the laser cannon and the shields that have been deployed for the player’s defense. If the invaders reach Earth, the player loses. If the laser cannon is destroyed (either by laser fire or by contact), the aliens regroup and attack the next laser cannon. If all the aliens are destroyed, the player must face a new wave of aliens that starts closer and moves faster.

![Space Invaders](image)

Figure 1. Space Invaders™

For this project, we use the LCD to display the laser cannon, the aliens and the score. Shields are optional. One pushbutton is used to start the game and the other is used to fire the laser cannon. The position of the laser cannon is controlled by a potentiometer mounted near the display. Game parameters are configured with a DIP switch.
Design.

Any product such as Space Invaders will have hardware, software and mechanical designs. You will need only to document the (electrical) hardware and software designs, but be aware that there are circuit boards that need to be laid out, plastics to mold, connectors to fit, etc. All these things are covered by the mechanical design but are beyond the scope of this class.

Often, engineers buy a development kit such as the C8051F020DK to build a prototype so that hardware can be tested before it is rendered to a circuit board and so that software can be written while the physical parts are in fabrication. The development kit itself is not part of the design, but designers borrow liberally from it for their designs. For example, an engineer may use the power supply from the evaluation board for his design. See Figure 2.

![Figure 2. Power Supply from the C8051F020DK](image)

Your design will need to include the power supply, crystal oscillator, reset circuit, etc. You can get that part of the design from the development kit schematic (don’t just copy the images, use a schematic capture program an incorporate the parts you need). You won’t need, for example, the serial port or any of the LEDs, so you should not include those parts in your design.

Remember, the design document describes the design of the finished product, not the evaluation kit and not the experiences you had while developing it. Be as clear, complete and concise as possible, and remember that your audience consists of engineers with similar technical background to your own.

For reference, the design document guidelines are on the course website:


The project must be demonstrated to your lab instructor, who will verify that it meets the requirements. The demonstration and documentation are due at the time scheduled for the final exam.
Requirements.

1. The system shall run on an external 9v DC supply.
2. The system shall use a 64x128 pixel LCD.
3. The system shall have a reset button, a start button and a fire button.
4. The system shall have a potentiometer located near the bottom of the LCD to control the position of the laser cannon.
5. The laser cannon shall be seven pixels high. The width shall be to 7, 9, 11 or 13 pixels depending on the DIP switch.
6. Invaders shall be 6-8 pixels high. Those on the front row shall be 10 pixels wide with 3 pixels between them. Those on the back row may be narrower.
7. The system shall keep a 4-digit score that tallies the number of aliens destroyed by the current player.
8. When the start button is pressed, the score shall be set to zero and the number of extra lives (laser cannons) shall be set to 3.
9. The display shall always show the score and the number of lives (laser cannons) remaining.
10. At the beginning of each wave, the display shall show (a) the laser cannon (at the bottom of the screen), and (b) 2 rows of 8 alien space invaders (arrayed on the left side of the screen as far from the laser cannon as possible).
11. Once the battle begins, the formation of invaders shall move to the right, firing lasers at random. When the invaders reach the side of the display, they shall move 8 pixels closer to the laser cannon and reverse direction.
12. The invaders shall move left or right one pixel at a time. The movement speed of the invaders shall be roughly inversely proportional to the number of invaders on the screen.
13. The system must be able to display up to 8 simultaneous laser bursts (i.e. projectiles) from the invaders and up to 4 simultaneous laser bursts from the player’s laser cannon. All laser bursts are one pixel in size and move at a uniform speed. To improve visibility, trailing pixels (up to 7) shall be displayed.
14. If a laser burst hits an invader, the invader shall be destroyed. If all invaders are destroyed, two new rows of aliens shall be arrayed 8 pixels closer than before (but no more than 16 pixels total), and the battle continues with the movement speed of the aliens increased.
15. If a laser burst hits the laser cannon or if an invader reaches the bottom row, the laser cannon shall be destroyed. If there are lives remaining, the invaders regroup as they were at the beginning of the wave, and the battle restarts with a new laser cannon. If no lives remain, the game is over.
16. A sound shall be generated each time the laser cannon fires, each time an invader is destroyed or when the laser cannon is destroyed. The sound for each of these three events shall be different and shall not exceed 250 milliseconds.
17. If, when the game is over, the words GAME OVER shall appear until the start button is pressed.
Optional Features (not required, but more fun)

18. At the beginning of each wave, the display may also show four equally spaced 14x8 pixel shields. If a laser burst hits a shield, one pixel of that shield should be removed.
19. If the front row of space invaders ever overlaps the shields, the shields are removed.
20. At random times, a flying saucer may cross the screen behind the array of invaders. Hitting the saucer with a laser burst scores 50 points.
21. Use three or four rows of invaders instead of two.
22. Use two images for the invaders and alternate (animate) them each time the invaders move (See below).