Pinball Capstone Design Project

Power Surge

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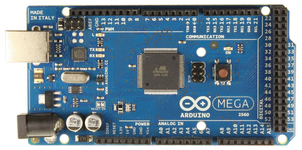
Abstract

The goal of our project was to design, construct and implement a pinball state machine using a wide range of electrical and computer engineering concepts. This project involved the use of many core concepts of Principles of Electrical Engineering I and II, digital logic design, electronic devices, digital electronics, digital system design and programming methodology I and II as well as many of the accompanying labs. The machine was achieved using an arduino programmable logic device, an array of different sensors, and a series of LED circuits.

The Arduino Mega 2560

The 'brain' of the machine is the logic board. It controls the rest of the components, receiving signals from the sensors, keeping track of points scored and balls remaining and controlling all the lights and most of the moving parts in the machine.

Arduino boards are open source microcontrollers that use a modified version of C and are easy to use and modify on the fly. This is especially useful for a project in progress where specifications and requirements change constantly.



The Arduino Mega 2560 has 54 i/o digital pins, 16 analog inputs, 256 KB of memory and a 16 MHz clock speed. It connects by USB cable to the computer and has an easy to use interface. After the code is downloaded to the board, the computer can be disconnected and the board will retain the programmed logic function, and will function as long as it's connected to a power source.

When connected to the rest of the components of the pinball machine, the board detects signals from the sensors hit by the ball and turns on the appropriate LED's. It keeps track of current score and balls remaining and outputs them to 7-segment digital displays.

Logic and Coding

Power Surge uses 45 pins from the arduino board with 15 input pins and 30 output pins. The inputs are controlled by the sensors and buttons the ball can trigger and the outputs control all the LED's, the score board and the selenoid.

Our program is designed as a constantly looping state machine that reacts to the input signals received from the machine itself. Each possible signal sets off logic that lights the appropriate LED's and adjusts the score and the number of balls remaining.

The scoreboard receives 4 binary bit signals from the arduino for each digit and has its own digital logic to control the decimal 7-segment display. With 3 digits for score and 1 for remaining balls, the scoreboard receives 16 1 bit lines from the board.

The selenoid is set off when the player loses his last ball. It is independently powered and controlled using an n-mosfet.

Inputs

Infrared sensor
Consists of an infrared emitter and a detector. When the detector senses the infrared light from the emitter, it acts as a short circuit. When the light is blocked by a pivot hit by ball, the detector acts as an open circuit.

Push button sensors
When pressed by the ball, the sensor connects to 5V briefly before returning to ground. There are 3 in the center and one the right side of the machine.

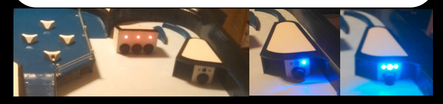
Detector/floor Switches
Open circuits that close to a short circuit when the ball rolls over the arm of the switch

Bumpers
The surfaces of the triangular bumpers that face the center of the deck are fitted with two springs. When the metallic ball hits the springs, it acts as a short circuit, allowing the springs to conduct electricity and signal the arduino.

Outputs

Push button LED's + Bonus
Above the 3 push buttons in the center are 3 LED's that start on. When a button is hit, the corresponding LED is shut off. Once all 3 buttons are hit and the LED's shut off, the bonus LED is turned on. Hitting the hole with the bonus LED on awards the player an extra ball.

Infra red bonus LED's
The points received for hitting the push button on the right depends on the number of times the infra red sensor is hit.
1 hit: 1 LED turns on and the push button is worth double points
2 hits: 2 LED's turn on and the push button is worth triple points
3+ hits: All 3 LED's turn on and the button returns 5 times the points.



Tunnel LED's
In the ski ball section, when the ball drops into one of the four holes, LED's illuminate the end of the tunnel the ball will come out of.

Bumper LED's
When either bumper is hit, the 4 LED's on that bumper are illuminated. They remain so for 2500 cycles of the arduino (less than a second).

Components

Flippers
The flippers are used by the player to launch the ball while it is in play. Pushing the buttons on the outside walls of the machine manually moves steel rods that push the outside lower corners of the flippers. This causes rotation around the outside upper corners where the flipper is bolted in place. In order to return the flipper to the resting position, a spring was added.

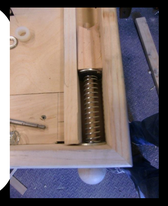
Ball Return
The ball may exit the game between the flippers, or to the far left and right of the deck in the lower half. All three of these places have a hole drilled in the deck which drops the ball down into the sub-deck. The three paths converge at the center and a floor switch is activated. If the player has balls remaining, the ball is dropped into a small PVC cup and the player can put it back into play with the ball launch.

Selenoid
Embedded in the wall of the ball return channel, the solenoid activates when the player loses his final ball. It extends a piston into the channel which prevents the ball from being returned the player. The solenoid must be independently powered though it is activated by the arduino using an n-mosfet.

Ski Ball Section
The ball enters this region by rolling up a ramp, roughly centered at the very back of the deck. It rolls along a raised plane that runs parallel to the deck. Four holes are cut into this plane, inspired by arcade style Ski-Ball games. The holes lead to tunnels that release the ball at various points. Built into the walls surrounding each channel is an LED which is activated by the ball crossing the corresponding floor sensor. Reflective foil tape was added to the mouth of each channel to reflect the light from the LED out of the channel onto the deck. This way the player can anticipate where the ball will come out.

Scoreboard
The scoreboard consists of the score display, the ball count display, and the 7447 bcd chips. The displays are each wired to a 50 ohm current limiting resistor, and then into the corresponding terminal of their own 7447 decoder chip. This network runs on its own power source due to the high current consumption. Once fully assembled, the display unit leaves 16 input lines for receiving binary data from the arduino, in addition to a grounding line and three power lines.

Ball Launch Channel
A wooden dowel is fed through a compression spring in the lower right corner of the machine. A ball was added to the end of the dowel to make for an easy grip when launching the ball. When pulled, the dowel compresses the spring and upon release launches the ball up the channel and into play.



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