

EE459Lx Project Description

Spring 2009

Power Controller for Energy Efficiency

Project Overview

The project this semester is a prototype for a device that can be used in a home to reduce the power consumption of electronic devices that are on to some degree all of the time. Most modern electronic devices such as audio and video equipment consume a small amount of power even when they have been turned off. If a device is controlled by a remote control, then it needs to always be operating enough to see if the remote is signaling it to turn on. The total amount of power consumed by these devices running 24 hours a day can be significant. This project is a power controller a user can program to completely shut off the power to devices during the hours they are normally not in use. For example, it might be programmed to turn off power to a TV between 1:00AM and 5:00PM Monday through Friday. This would reduce by almost 50% the amount of time the device is consuming some amount of power.

Design Requirements

The requirements stated below for the basic project can be implemented in a variety of ways. It is up to the design team to decide how to build their project. In all projects involving microcontrollers there are ways to build the project that requires more hardware and less software, and vice-versa. The design team must decide whether to implement the various parts of the design in hardware or software. Design trade-offs in areas such as reliability, manufacturability, ease of use, cost, etc., should also be analyzed to determine which is the best one to use. In addition to the baseline requirements, students are expected to think of other features that would add value to the product and if possible add some of these features to the project. Others features can be described in the final report as features that should be considered for inclusion if and when the device goes into production. Possible design options can be found by studying the features that other manufacturers have included in similar devices.

The power controller is to some extent a programmable clock with controllable power outlets on the back. Initially the user sets the time of day and day of the week into the clock. They can then set for each day of the week a time to turn on and turn off each of the outlets. The device must have the ability to control at least four devices. Each device must have at least one turn-on and one turn-off time for each day of the week. For each of the four devices there must be an override control that allows a user to turn on or turn off the device regardless of the programmed settings.

The project consists of several components that are all controlled by a microcontroller.

Inputs

The device needs inputs of some sort to allow the user to program it. Ease of use by a non-technical user must be taken into consideration. The design team should select the input controls based on the type and amount of information that needs to be stored. Some options are:

- Buttons
- Dials
- Keypad

- Remote control device such as used with a TV

The design teams should examine the relative merits (cost, ease-of-use, physical size, etc.) of the different types of input devices to determine which is the best one to use. One issue that needs to be addressed is how the input devices will interface to the microcontroller. Some types of input require more I/O lines to the micro than others and the micro only has a limited number of I/O lines.

Outputs

The device needs to have some sort of output in order to communicate its status and conditions to the user. The output also needs to provide the user with any pertinent information when the device is being programmed. The design team must decide what information needs to be displayed and how to present it in a way that makes it easy for the user to understand it. As with the inputs, the number of available microcontroller I/O lines will affect the choice of output display.

The device needs outputs that control the power outlets. These can be controlled by triacs or relays or some other device that can switch higher voltages and current.

Memory

The device should have the ability to retain the programming information if power is lost. The user should not have to re-enter all the programming data if the device loses power for some reason. The settings can be stored in some sort of non-volatile memory such as an EEPROM or the device can be provided with long-term battery backup.

Timing

Most clock-like devices keep track of time by counting the cycles of the 120 Volt, 60Hz AC power line. In the interest of safety, we do not want to have any 120 Volt power connected to our project boards. Projects teams should use some other method to keep track of time:

- a real-time clock (RTC) integrated circuit and oscillator
- use the microcontroller's internal timers to generate interrupts at known intervals
- install an oscillator such as an NE555 timer on the project board

For the purposes of this prototype, accuracy is not very important so any method that makes the clock run with less than about a 5% error is acceptable.

When testing the device it would be very useful to have the option to make it run much faster than normal. For example, the design might include a switch that makes the internal clock advance one minute for every second of actual time, or one day for every minute, etc.

Optional Features

The design team is free to add additional features to the device as they see fit. The additional features should add value to the project and hopefully will result in more people choosing to buy it. However the team must remember that each added feature will add to the product's cost so adding lots of interesting features may force the price above what many consumers would be willing to pay. Teams must remember that they are responsible for coming up with a design that they can build during the time scheduled. Teams must be careful to avoid "mission creep" where more and more features are added to the design until it becomes too bloated to be constructed. Do not allow optional features to get in the way of designing and constructing the baseline project.

Some optional feature that might be considered:

- Battery backup in case there is a power outage. When running off the battery it should continue to keep time not have to be reset when the power is restored. Since a display may consume a significant amount of power it is permissible to shut off the display while running on batteries in order to extend the time the clock can operate.
- Wireless connections. Some devices that might need to be controlled may not be near enough to the main controller to allow cables to be run to them. Consider a having a slave controller that receives wireless signals from the main controller to turn devices on and off. This feature only makes sense if the power consumption of the remote slave controller is less than that of the devices it controls since the slave controller would have to be on at all times.

Milestones

Each team is required to complete certain parts of the project and demonstrate that they have them working by specified dates. The purpose of this is to make sure no team gets too far along in the semester without having some very fundamental parts of the project working.

1. Power circuit. Install the connector for power and ground and confirm that you can hook your board to the lab power supply and apply power to it without shorting out the power source.
2. Timing circuit: Show that the logic board master clock is functioning and that any lower frequency clocks are being properly generated from the master clock. This can be shown using one of the oscilloscopes in the lab.
3. Microcontroller: Install the microcontroller and demonstrate that it is functioning and that you can program it. Write a small program that does something to confirm that the microcontroller is working. It is very important to get the micro working early in the project so it can then be used to test other parts of the project.
4. Display: Show that you can output something on your choice of display. Your display can be a very useful part of your debugging since once it is working you can use it to output information about what is happening with the rest of the system.
5. Inputs: Demonstrate that your input controls can be read by the microcontroller. For example, if you are using pushbuttons, show that each time the button is pressed something changes on the display
6. Outlets: Show that you can control the power outlets from your microcontroller.

Specifications

The following are some specifications as to how the project is to be constructed.

1. Most of the project circuitry must be built on a single prototyping board. These are provided in the class and are approximately 6 by 9 inches. If teams choose to build their project on some other board they must first get permission from the instructor.
2. All signal and power connections to the logic board must be made using connectors and wiring that make for a reliable connection. For example, using clip leads to attach to a pin of an IC socket should not be used for anything more than the very first test of the board. A person trying to use your board should be able to see immediately where the power and signals are connected. They shouldn't have to be told to "use a jumper to connect the +5 volts to this pin over here."
3. The design should be based on a Freescale MC68HC908JL16 microcontroller. Projects may use multiple microcontrollers if needed. The use of a different microcontroller must be approved by the instructor.
4. The microcontroller should be installed in a zero-insertion force (ZIF) socket in order to make it easy to remove it for reprogramming. When planning where to mount the various IC sockets on the board, make sure to leave extra room for the ZIF socket since it is longer and wider than a normal socket.