MIX Masters

Remote Controlled KitchenAid Mixer for the Clients at ADEC

Documentation and User Manual

Arnaud Bacye
Karina Dubé
Justin Erman
Matthew Martin

Table of Contents

1 Introduction

Technology today is produced for a mass market. Machines have been created to manufacture hundreds of thousands of goods in specific, predefined ways. As a result, consumer products are often created with the “average” user in mind. In some cases, however, this may make the product more difficult for other users, such as those with disabilities. Since it’s impossible to make a product that satisfies *everyone*, these other users may need to look into other technologies — assistive technologies. Assistive technologies refer to items or pieces of equipment that have been bought or modified for use by individuals with disabilities.

We have decided to work with ADEC, a local community for the disabled that works with them to improve their lives. This includes helping them become more independent and employing them in various day tasks to give them meaningful work. Harnessing assistive technologies allows users to achieve the independence ADEC is hoping to instill. This area, however, is still growing and there are some devices that have not yet been made adaptive, limiting the freedom of the disabled community.

Aside from researching and developing adaptive technologies, ADEC offers a variety of activities for those with disabilities. One such activity is making dog biscuits, which involves the use of a KitchenAid mixer. In order to promote a stronger sense of independence for these individuals, ADEC hopes to implement ways to make this process easier and more accessible. Our goal is to modify and improve the mixer used in this process.

To do so, the speed control of the mixer will be changed such that only speeds two through six and off will be used. The biscuit making process does not require any faster speeds than two or three, but according to the clients, the mixer is used for other functions that may require more speeds. Additionally, the speed will no longer be changed with the slider on the body of the mixer, but with a remote separate from the mixer with buttons for all speeds needed, allowing for easier control for our users.

The design appears to be well suited for our users, with lights, tactile feedback, and large buttons on the remote side. The mixer side does have its design challenges, such as having the lever be left on speed 10 for the sake of the speed governor and the inability for the motor to work manually once the remote system is installed. We had a fully operational system as of Design Review 2, but a few catastrophic failures led to major setbacks to having a complete prototype by the final demonstration.

2 Detailed System Requirements

In order to ensure that the modified mixer product fulfills the needs of our clients, it must meet several requirements. The product must be capable of changing the operating speed of the mixer through the use of push buttons, which are located on a remote. The remote must also have the ability to show the user the current speed of the mixer, as well as indicate the status of its battery and whether the remote is in an on or off state. Additionally, the remote must be portable, such that it can be moved easily around the operating space of the device. Cleaning of the device and remote should be an easily accomplished task, as the remote will become dirty from frequent use.

The remote will need to communicate with the mixer wirelessly, and must do so from a reasonable operating distance. Furthermore, the remote must be able to transmit different information corresponding to varying speeds of the mixer, as well as setting the mixer to an inactive state. Safety features will also need to be implemented in the device. For example, if the remote is shut off due to a loss of power, or the remote is removed from the operating range of the mixer, the receiver must recognize the absence of the remote in an appropriate amount of time, and set the mixer to an idle state.

The mixer must operate on a separate circuit that will enable wireless control. It is desired that the mixer retain its original, manual function, as well as be controlled with the remote. The two methods of operation must be mutually exclusive; manual operation should not be possible while the mixer is being controlled by the remote. This task may be accomplished through the use of a physical switch, or through the use of a relay. The new circuit that will be used to remotely control the mixer must be sufficiently small enough such that the circuit board will be able to fit within the housing of the mixer, or be affixed to the mixer in separate housing.

This added circuit will draw its power to operate from the mains voltage, and must be able to safely interact with it. Because the circuit will rely on mains to power its microcontroller, and the circuit must be small enough to be placed on the mixer, the circuit must also include a power supply circuit. The 120V AC mains voltage must be supplied to the circuit, and stepped down to provide a 5V DC source. The circuit components used here must be small in order to keep the size of the circuit as small as possible, and the circuit must not introduce any safety concerns, as it will be interfacing with mains voltage.

Summary of Requirements

1) Control the speed of the mixer motor using push buttons.
2) Has indicators of current speed and other status measures, including but not limited to:
    a) battery life
    b) on/off indicator

3) Portable to a degree. It will largely remain in one spot, so it’s not necessary to be able to walk around while using it. It should, however, be easily moved especially if it needs a charging station.
4) Easily cleaned. We don’t want damage if the remote gets spilled on.
5) The mixer and remote need to be able to interface via long range, over the air communication means.
6) The devices need at least a range of 10 feet.
7) At least 6 discrete commands need to be available for transmitting speed settings, as well as the ability to transmit an idle state to confirm no change within the system.
8) If power is cut to the remote, disabling the signal transmitter, the mixer receiver must recognize the loss of a signal within a reasonable amount of time and disable.
9) The motor will need to be controlled via a separate circuit, such that the mixer can operate using the slide on the body, and the remote.
10) The added circuitry will need to be electrically isolated from existing circuitry, and the new circuit will need to fit within or near the housing of the mixer.
11) The new circuit will need to safely interact with the mains voltage, and the it must be ensured that the circuit will not result in unsafe operation.
12) Convert AC voltage at the wall into a small DC voltage (5VDC) required by low-current devices (microcontrollers)
13) Minimize total cost for overall system
14) Minimize space used for complete circuitry
15) None to minimal safety issues

3 Detailed project description

3.1 System Theory of Operation

From a high level perspective, a remote sitting on the counter will control the speed of a standing mixer via radio frequencies (RF).

The remote will be the interface between machine and man, having large buttons which set distinct speeds. When the button is pressed, the microcontroller pin will be pulled high. This will set the appropriate LED on, all other LEDs off, and activate the RF device to transmit the signal via RF to the mixer.

A receive device will decode this transmission which is used to set a data variable. Setting the speed of the mixer involves powering the mixer in short bursts. This uses a zero cross detector and then waits a specific amount of time (determined by data variable) after the zero cross, allowing the motor to receive only a certain part of the power signal’s sine wave.

The mixer will be powered by a wall outlet running at the usual 120 volts AC. To power the receiver side microcontroller, a transformerless power supply will step down the voltage from 120 volts AC to 5 Volts DC. On the remote side, powering is performed by a 9 volt battery that goes through a voltage regulator to step it down to 5V.

3.2 System Block Diagram

Figure 3.2.1 (below) is a block diagram detailing the full system from end to end.

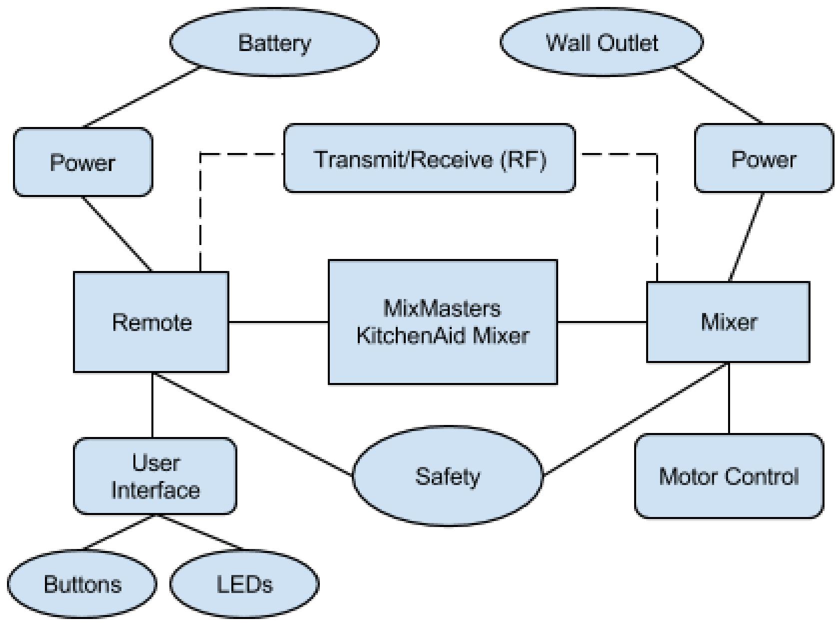

Figure 3.2.1: System Block Diagram

3.3 Remote Interface

Requirements:

1. Control the speed of the mixer motor using push buttons.
2. Has indicators of current speed and other status measures, including but not limited to:
    a. battery life
    b. on/off indicator
3. Portable to a degree. It will largely remain in one spot, so it's not necessary to be able to walk around while using it. It should, however, be easily moved especially if it needs a charging station.
4. Easily cleaned. We don't want damage if the remote gets spilled on.

This subsystem is the interface for the user to control the mixer. The user will have a series of buttons that will control the speed of the mixer wirelessly with an RF signal and should be well interfaced with the communications subsystem. The system will also interact with the power subsystem; since our remote will be wireless, it's necessary for it to have its own power supply.

Design Review 1

The original solution for this interface was to use external interrupt pins. When the user presses a button, an interrupt service routine is run that will call the appropriate functions for sending a signal to the mixer and turning the correct LED on and all others off. (Figure 3.3.1)

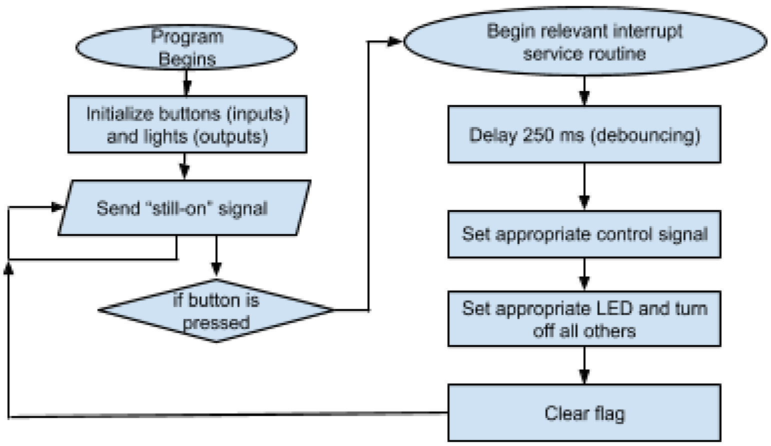

Figure 3.3.1: Flow chart for Mixer Interface

For our test and Design Review 1, we have the program increment a counter that is displayed in binary with the board LEDs, to prove the debouncing of our buttons, and chooses which of the last two lights to turn on, to prove our ability to turn an individual light on and the rest of the lights off. (Figure 3.3.2)

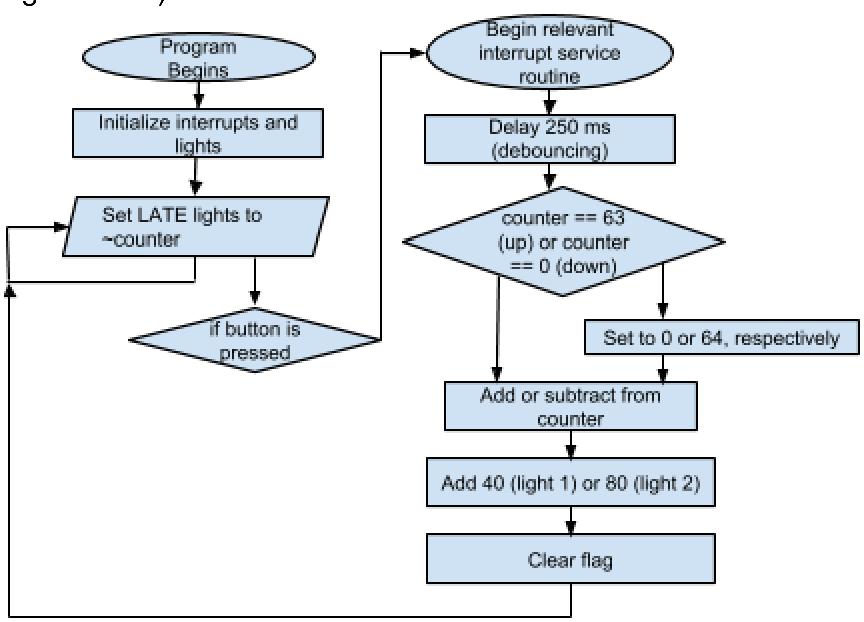

Figure 3.3.2: Flow chart for subsystem test program for Design Review 1

The decision to use interrupt pins was made because we do not want the system constantly sending a signal of the speed. This means the last received signal for the mixer will be the speed at which the mixer is set. We do want the system to be constantly sending a “still-on” routine (i.e. the remote has not lost power) and so, the interrupt will allow sporadic sending of actual instructions.

For the circuit portion, the pin is constantly low until it is pulled high by the button and the Vcc voltage attached to it. Since the input pin is 1 when the voltage is high, this configuration will trigger the pin when the button is closed (Figure 3.3.3).

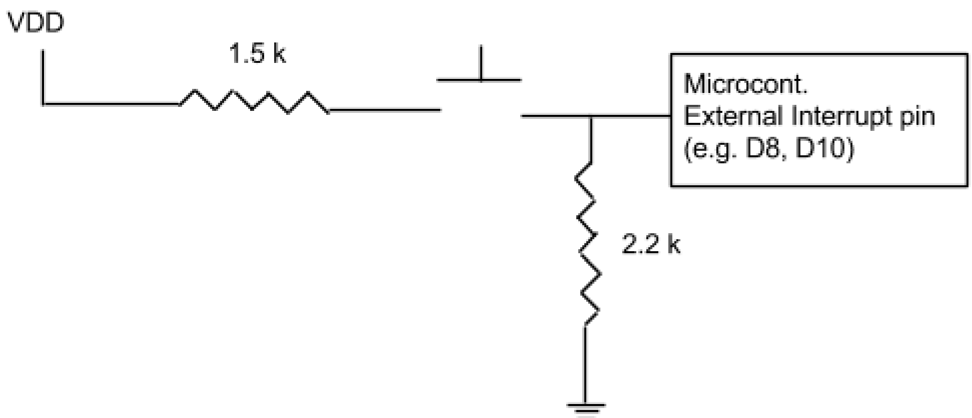

Figure 3.3.3: Hardware Schematic with Interrupt for Design Review 1

This system was tested with the software and hardware as described using the Senior Design boards. The results of the test were successful, creating a functioning button interface that controls a set of LEDs that count in binary and light up two particular LEDs according to which button was pressed.

Design Review 2 and Beyond

After Design Review 1, the decision was made to switch to a polling program for control of the switches for the entire program. This decision was made based on ease-of-use with a microcontroller, since it was much simpler to use six or seven standard I/O pins versus six or seven interrupt pins (Figure 3.3.4). The system now constantly sends the speed signal which is also used as a safety function, as discussed in section 3.4. It is state driven in that pressing a button sets the particular signal to be sent.

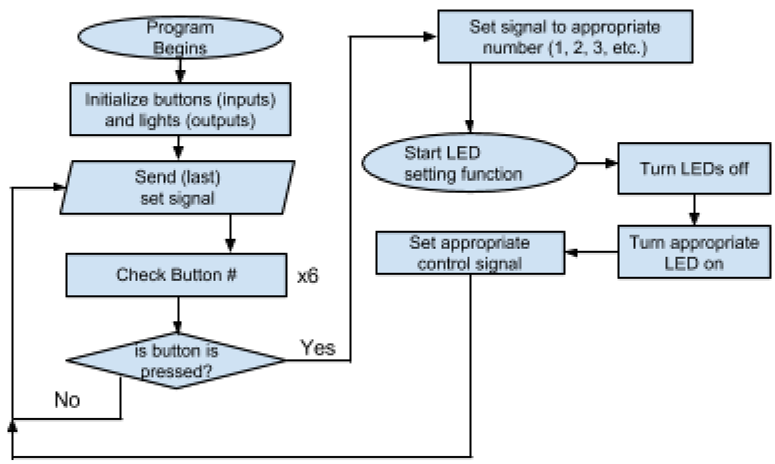

Figure 3.3.4: Flowchart of final Button Routine

The hardware of the buttons changed very little with the exception of changing the order of the button and the resistor on the pull up side as well as increasing the resistance on both sides to 10k ohms and 22k ohms (Figure 3.3.5). The order was switched on account of making the board arrangement cleaner. Additionally, hardware for the LED needed to be included on the custom PCB (Figure 3.3.6).

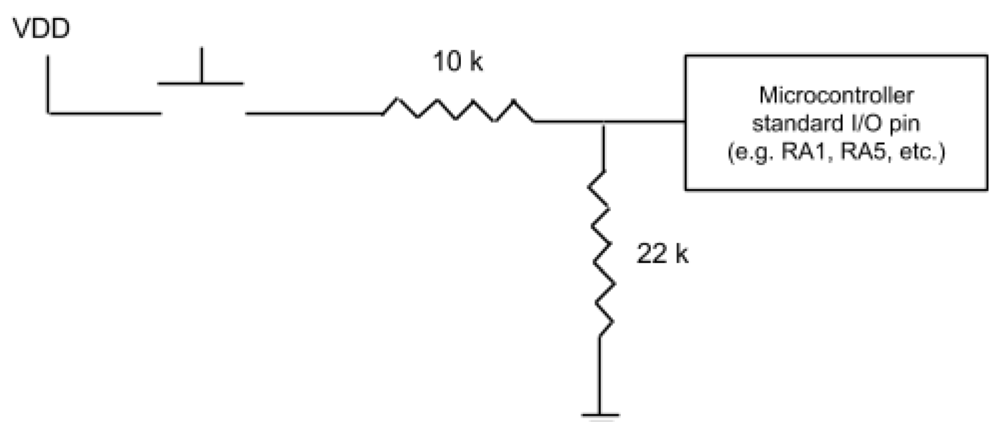

Figure 3.3.5: Hardware schematic for final Button Interface

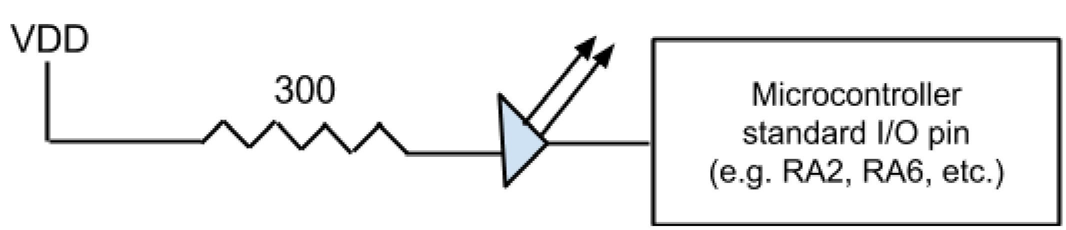

Figure 3.3.6: Hardware schematic for final LED Interface

This system was tested during Design Review 2 using only two buttons and then expanded in the final product to six buttons. The working system uses a 8.5” x 5” x 3”

Polycase enclosure as the casing, six (normally-off) arcade buttons, six green LEDs, and epoxy as the seal to make the buttons and LEDs watertight. The particular, smooth-faced Polycase was chosen because the smooth surface would be easier to clean flour off of than a ridged surface. At the Final Demonstration, we could successfully press each of the six buttons and light up the correct LED and send the correct signal, tested using the USBee Logic Analyzer.

3.4 Wireless Communication

Requirements:

1. The mixer and remote need to be able to interface via long range, over the air communication means.
2. The devices need at least a range of 10 feet.
3. At least 6 discrete commands need to be available for transmitting speed settings, as well as the ability to transmit an idle state to confirm no change within the system.
4. If power is cut to the remote, disabling the signal transmitter, the mixer receiver must recognize the loss of a signal within a reasonable amount of time and disable.

To accomplish these tasks, infrared communication was originally selected as the signal medium. The choice came down to a few key points. Infrared is cheap in terms of cost and requires only a small amount of power. Furthermore, implementation is fairly simple. As an alternative, Bluetooth would have been low power, but would have cost a larger chunk of the budget. Given the cost of the KitchenAid Mixer, a slight increase in cost puts the entire budget at risk. Furthermore, Bluetooth seems like overkill when the data being transmitted is only meant to communicate one of one of six possible states. Meanwhile, directly linking the remote to the mixer via long cables or some other means could pose risks to the client: if the controller were powered by the mixer, potentially dangerous voltages and currents could be shorted through the controller under the wrong circumstances or the wires could come break, causing hassle for the user. Furthermore, unwieldy cables on a kitchen counter would become problematic during the ingredient gathering stage, or if the cord is accidentally pulled the mixer could topple, damaging it and, potentially, the client. As such, infrared seemed to be the best choice. However, after experimentation with infrared, the directionality of infrared as well as the inconsistency due to background radiation makes infrared seem like an unviable option.Therefore RF frequency communications were chosen as an alternative to infrared.

Although there is no official upper or lower limits for the range, the remote must be able to transmit clearly up to at least 10 feet. 6 feet is a distance, at which a user can only barely see the contents of the bowl, so it would be useless to extend range much beyond that distance. RF communication systems have no issues at such short, unobstructed ranges, so RF will meet this requirement soundly. During the final testing of the product, just prior to the first catastrophic board failure, the RF receiver was picking up accurate data from over 20 feet away, but there were no output devices connected to show the data was being properly received by the universal synchronous/asynchronous receiver/transmitter (USART) on the receive board. Connecting such output was going to be the first thing we tried after we checked the receiver's ability to control the mixer, but when the board died we were set back. Until the board was reconstructed, testing was impossible, and the second board broke within minutes of its reconstruction (hindering any testing). We attempted to use the 32 bit microcontroller on the kit-boards from Senior Design I to replace the broken PIC12, a 8-bit microcontroller with limited success. Although we could still receive data, we were incapable of devising a code to parse the information as the PIC32 continuously received data but the PIC18 could only send data in 8-bit increments, with a leading start bit and trailing zeros representing the inherent delay of the PIC18's clock. Given more time, it is possible a mechanism for translation could have been devised.

The remote must be able to send a turn off command, 5 discrete speed states, and also a reset signal. The reset signal will return both devices to their initial settings (the mixer turns off and the remote ceases sending signals after sending reset a few times). Then each of the speeds will be sent by sending a single byte representing the speed: each encoded speed needs to be more than a shift different from each other in case the USART misses a single character. Further, a leading theory with RF signals is that it is important to send an equal number of 1's and 0's to ensure that the auto-gain doesn't begin affecting the receiver (among other reasons). For this reason, each of the signals has four 1s and four 0s and are distinct enough that a framing error will not affect the received signal. After any button is pressed, the other transmitter will continue sending that signal for a period of time

Furthermore, due to the risk that the remote becomes nonfunctional for some reason or another (e.g. battery dies, transmitter ceases function, etc.), the receiver must recognize that it hasn't received a signal in a few seconds. Currently the recognition time is planned for three seconds, but that number could be modified as the client needs. To perform this task, the mixer will keep a lookout for signals from the receive device. Meanwhile, the receive device will be receiving signals from the transmitter. Every time that a signal is received it will modify an internal variable within the microcontroller. A period will be defined by the microcontroller (for instance, three seconds), and if that time has passed without receiving any signal then the mixer will begin shutdown. However, if the mixer receives any signal from the remote, it will reset the stop countdown back to 0, so that another three seconds must pass.

On the transmit side, the microcontroller will also be counting. When about ten minutes (to be experimented with) have passed, the remote will cease action and will begin shutdown of the mixer by sending the stop command. At this point, the mixer will cut power to itself. This is necessary in case the machine is accidentally left on.

The physical transmitter and receiver will be the 434MHz RF Link Transmitter and Receiver from Sparkfun. The receiver can operate at up to 4800 bits per second which is still way faster of a speed than necessary for the mixer. We limited it to a baud rate of 2400 so that the device would be fine. For the original prototype, the communication occurs between microcontrollers via these RF devices using the Universal Asynchronous Receiver/Transmitter (UART) on each microcontroller initialized to 2400 baud. For the final product, the devices would have used the asynchronous mode of the USART of the microcontrollers initialized to slightly higher than 2400 baud to best optimize the low clock speed of the transmission microcontroller.

3.5 Secondary Circuit and Motor Control

Requirements:

1. The motor will need to be controlled via a separate circuit, such that the mixer can operate using the slide on the body, and the remote.
2. The added circuitry will need to be electrically isolated from existing circuitry, and the new circuit will need to fit within the housing of the mixer.
3. The new circuit will need to safely interact with the mains voltage, and the it must be ensured that the circuit will not result in unsafe operation.

The Kitchenaid Mixer is a variable speed stand mixer. The mixer's speed is controlled using a slide on the side of the mixer body. This slide moves a control plate within the mixer housing. As the speed of the motor increases, a governor, which is attached to the motor, flies out and interacts with the plate in order to regulate the speed of the mixer, which is accomplished by quickly altering connections within the plate.

For the final product, it is desired that the manual method of changing the speed of the mixer be functional, so it will be necessary to retain existing circuitry. Therefore, the decision was made to add a separate circuit to the mixer, such that it can be controlled remotely, and the active circuit could be switched depending on the desired method of use during each use.

The secondary circuit will primarily make use of a TRIAC to regulate the speed of the motor in the mixer. The TRIAC will be driven by a microcontroller (PIC12F1822) by applying a pulse to its gate, which will send the mains voltage signal to the motor of the mixer. To accomplish this, the circuit and microcontroller must be capable of detecting the zero crossing of the AC mains sine wave signal. This is done by sending the mains voltage through a bridge rectifier to produce a DC signal. This DC signal is used to drive an optoisolator, which is a device that uses an input to drive an LED, which when fired operates a device on the output side of the device, such as a transistor or a DIAC. This optoisolator uses an LED to operate a transistor. When the DC signal produced from the bridge rectifier is at a high enough voltage to forward bias the LED, the transistor on the output end will sink a signal from VDD (which is at the collector) through a resistor to GND (the emitter). When the AC signal nears zero, and as it crosses zero, however, the DC signal that is produced is not sufficient to drive the LED, and therefore, the transistor at the output is turned off. The signal from VDD no longer goes through the transistor, but instead into a pin on the the microcontroller, which triggers an external interrupt. This is the way in which the microcontroller detects the zero crossing of the mains voltage signal.

Once the microcontroller has detected the zero crossing, it waits a determined amount a time of time before a pulse is sent from another pin into a separate optoisolator. This optoisolator uses the LED at the input to turn on a DIAC (diode for alternating current) at the output of the optoisolator. The DIAC acts as an open circuit when off, and when turned on by the LED, it briefly sends a signal from mains through resistors to the gate of the TRIAC, which turns on the TRIAC. The TRIAC then sends the remainder of the mains voltage signal to the motor of the mixer. Depending on the delay between detecting the zero crossing and the firing of the pulse, the mixer will rotate at a certain speed. By varying the length of the delay after the zero crossing, the microcontroller can cause the motor to run at different speeds, allowing for speed control of the mixer. Below is the circuit used for the motor control (Figure 3.5.1), as well as an image of the first prototype used (Figure 3.5.2). In the prototype, the microcontroller is not shown; jumper cables were used between the PIC32 board and prototype board for the detection of zero crossing and for firing the output pulse.

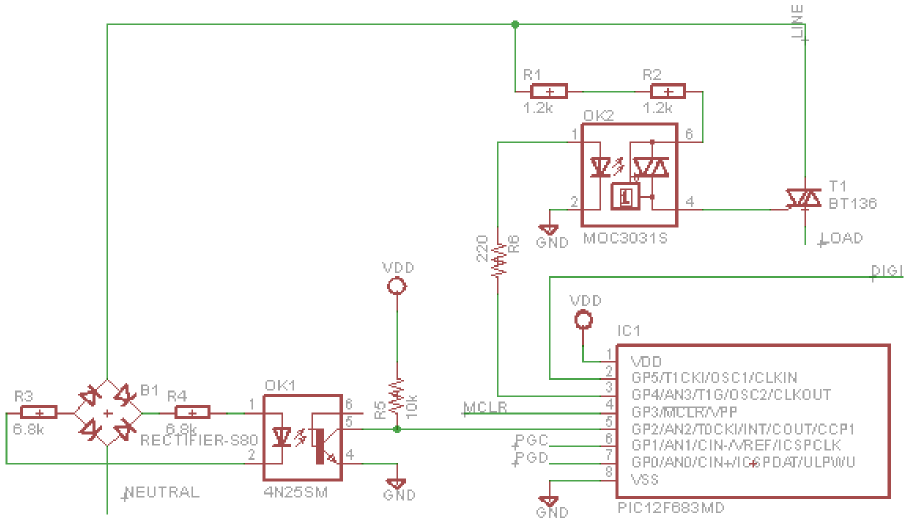

Figure 3.5.1. Schematic for motor control circuit.

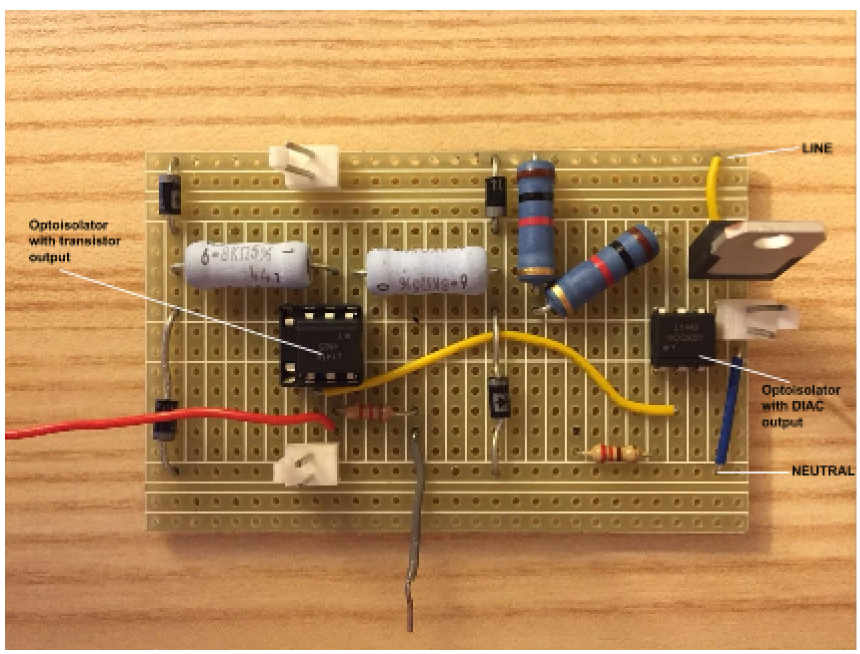

Figure 3.5.2. First prototype of motor control circuit.

Once the mixer was tested with the mixer control circuit, it was discovered that the governor attached to the motor of the mixer continued to fly out as the motor increased in speed while the motor was being controlled with the new circuit. The control plate, however, remained in its initial position. The governor would then make contact with the control plate as it extended, with the plate remaining motionless. This presented an issue, as the intended function had the control plate moving back as the speed increased. As a result, when the mixer was to be operated using the new circuit, the governor would make excessive contact with the control plate, causing unwanted noise and damaging the contact point of the plate. The issue could only be resolved if the control plate was put in the position such that it was furthest from the governor, i.e. speed 10 of the mixer, using the slide control. Because this would temporarily involve running the mixer at full speed when switching to the added circuit, the decision was made to remove the manual functionality of the mixer. Manual operation using the slide can be restored by placing connections back to the control plate, but for use of the mixer with the remote and added circuit, the control plate will be set furthest from the governor, and will only be usable with the remote.

3.6 Power Supply Circuit

Requirements:

1. Convert AC voltage at the wall into a small DC voltage (5VDC) required by low-current devices (microcontrollers here)
2. Minimize total cost for overall system
3. Minimize space used for complete circuitry
4. None to minimal safety issues

Traditionally, converting an AC voltage to a wall receptacle into the DC voltage required by low current devices such as micro controllers has been done with transformer, rectifier or switch-based circuit. However, these power supply solutions are not very cost effective, mainly because the transformers in transformer-based solutions, and the inductor/controller in switch-based power sources are expensive and take up a considerable amount of space. Taking into account our initial plan to have a small power system attached to the mixer, we opted for a transformerless power supply. Transformerless power supplies, mainly divided in two categories: resistive and capacitive, provide a low-cost alternative to transformer-based and switcher-based power supplies, and with proper considerations can be relatively safe.

For this project, we decided to use a resistive transformerless power supply to power the microcontroller on the mixer side with 5VDC. A resistive power supply uses resistance to limit current instead of reactance (for capacitive power supply). There are several advantages for using a resistive power supply including that it is significantly smaller than a transformer-based power supply and has lower cost than a capacitive and a transformer-based power supply. As shown in Figure 3.6.1, our circuitry includes the following components:

* a zener diode D1 (10V) and a typical p-n junction diode D2.

* 4 capacitors (of 100 microfarads each) , all in parallel with the diodes

* a fuse S1 and a 110V metal-oxide varistor Z1 (in parallel with the input voltage) to provide over current and transient protection respectively.

* two 1 kilo-ohms in-series resistors R2 and R3 rated at 2W each to reduce the possibility of arcing and to ensure that a high voltage transient doesn't bypass the resistor

* a 0.047 microfarad capacitor C2 and a 3 mega-ohms resistor R1 to prevent electromagnetic interference created by the circuit from migrating onto the line or neutral busses.

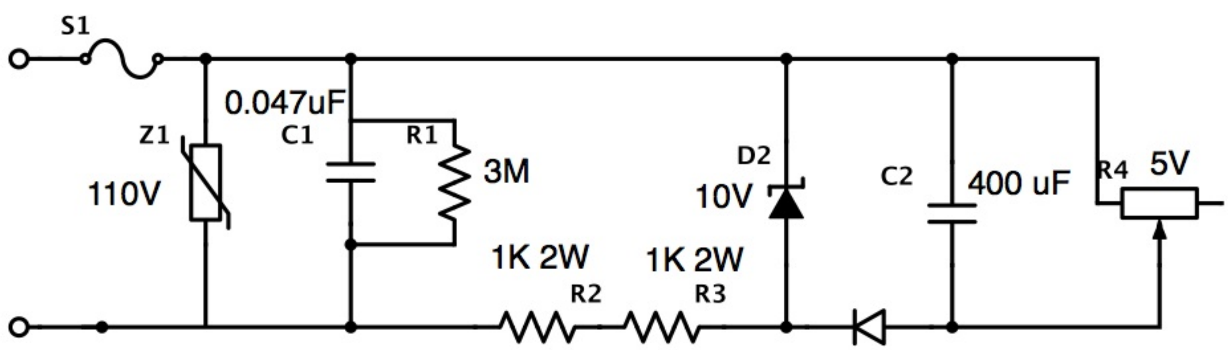

Figure 3.6.1: Transformerless Power Supply Circuit Diagram

As for the remote side, it is powered using a 9V alkaline battery connected to a voltage regulator to provide 5V to the microcontroller. We also established a battery level indicator which will let the client/user know when the battery is below a specific threshold voltage (3V) and needs some recharge/change. This is accomplished by connecting the output voltage from a voltage divider to the ADC input pin of the microcontroller and proceeding with an Analog-to-Digital conversion to read the voltage from the battery.

4 System Integration Testing

4.1 Describe how the integrated set of subsystems was tested.

The different subsystems were combined through a series of tests. After getting each of the individual subsystems working on its own, we began to look into the combination of them.

The first system was to get the button to send a different signal according to which button was pressed and set the appropriate LED. This was tested by determining a series of signals that were not simply shifted versions of the other. A check was sent by sending the inverse of the signal. Using the USBee Logic Analyzer were measured the signal being sent when each individual button was pressed. This was successful when the signal produced matched the series of 1s and 0s we intended to send.

The second system was to get the received signal to appropriately change the speed of the mixer. First, however, we changed the speed with the button attached to the mixer circuit itself. Then we checked to make sure the receive signal was being properly received using the USBee Logic Analyzer. Finally, we listened for the speed changes in the motor.

It is worth noting that any time we tested the speed of the motor we actually had several options that were not the mixer motor itself. The first test was usually always with a lightbulb, checking the brightness of the bulb according to which button was pressed. This is because the motor control circuit also acts as a light dimmer when attached to a light. After the light test, we also had a second motor that was unattached to the mixer with which we could test our code. Our final testing occurred on the actual mixer itself.

For some of our final testing, the fuse on the power circuit had busted, so it was not included in the integrated set of subsystems test. The power supply was tested by using an AC power supply source (to simulate the power taken from the wall) that we connected to our circuitry on a breadboard. The voltage read from the digital multimeter was 3.4V, well enough in the range to power a 3.3 V microcontroller (as it was in our initial design). After noting that the system worked with the AC power supply, we used an extension cord to hook the circuitry to the wall socket, and got the same result. Later, we decided to operate all our devices at 5V. Thus, slight changes in our circuit configuration were made to account for the extra voltage needed. Among these changes, we used a different voltage regulator (a 5V low-dropout regulator instead of a 3.3V). Once these changes were implemented, the power supply was thus ready to be integrated with the other subsystems. However, to ensure full safety, we would only test that power system until we ensured a full isolation of our overall circuitry from mains voltage.

4.2 Show how the testing demonstrates that the overall system meets the design requirements

Remote:

1. Control the speed of the mixer motor using push buttons.
   Complete. The final remote uses 6 normally-off, arcade buttons in various colors with tactile feedback for the users to have many different senses involved for determining the mixer controls.

2. Has indicators of current speed and other status measures, including but not limited to:
   a. battery life
   b. on/off indicator

   Complete. The final system contains just the above listed features, but they are all effectively implemented with LEDs. Current speed is indicated with the LED that is above or below the button that is being pressed. Battery life and on/off indicator are located in the upper right hand corner.

3. Portable to a degree. It will largely remain in one spot, so it's not necessary to be able to walk around while using it. It should, however, be easily moved especially if it needs a charging station.
   Complete. The final system is enclosed in a Polycase container that is 8.5” x 5” x 3”, large enough to enclose the buttons and still light enough for easy carry.

4. Easily cleaned. We don't want damage if the remote gets spilled on.
   Possibly complete. The Polycase selected has a smooth top rather than a rough top, with the idea that the smooth top when spilled on by flour will be easily cleaned. However, the addition of epoxy, which is used for sealing the buttons and LEDs to prevent any liquid damage, roughens the surface and makes it more difficult to clean. The system still needs to undergo testing for this requirement.

5. The mixer and remote need to be able to interface via long range, over the air communication means.
   The subsystem design review 2 test used RF to communicate effectively and clearly. Although the final project could not properly parse the information, the RF receiver was picking up the signal from the

6. The devices need at least a range of 10 feet.
   Due to the breadboarding constraint it was impossible to test over more than a few inches during the integrated subsystem test. However, when prior to the first catastrophic board failure, we were able to see on the USBee logic analyzer that the signal was being received clearly and without error at distances exceeding 20 feet. No

further distance was tested due to how bad of an idea attempting to run the mixer from beyond 20 feet would be.

7. At least 6 discrete commands need to be available for transmitting speed settings, as well as the ability to transmit an idle state to confirm no change within the system.
   Only 3 distinct states were prepared for the subsystem design review, however, the other states have been written and tested independently.

8. If power is cut to the remote, disabling the signal transmitter, the mixer receiver must recognize the loss of a signal within a reasonable amount of time and disable.
   Complete. We were only given about 5 minutes during design review 2 so it has still not been demoed, however in the code if if the remote stops transmitting for 3 seconds continuously, the mixer will shut off. Likewise, if the remote remains in one state continuously for 10 minutes then the mixer will return to the ‘stop state,’ ceasing mixer functions.

9. The motor will need to be controlled via a separate circuit, such that the mixer can operate using the slide on the body, and the remote.
   A secondary circuit and board was designed to control the motor of the Kitchenaid mixer through the use of the remote. While the initial plan was to retain manual operation of the mixer, issues caused by the remaining governor and control plate complicated the function of the mixer when using the remote to control the mixer, and therefore operation of the mixer through the use of the slide was no able to be kept.

10. The added circuitry will need to be electrically isolated from existing circuitry, and the new circuit will need to fit within or near the housing of the mixer.
    The secondary circuit was designed to be placed in a case and attached to the side of the mixer. Necessary connections from the mixer, such as wires for line and neutral, and the leads of the mixer, will be made using insulated wires that run from the back of the mixer through the back of the circuit case and to the external circuit board.

11. The new circuit will need to safely interact with the mains voltage, and the it must be ensured that the circuit will not result in unsafe operation.
    The new circuit draws power from mains, and with the existing circuitry now disconnected, the mixer cannot be caused to function in the manual state through any unintentional means.

12. Ability to step down mains voltage down to operating voltage for low-current devices (microcontroller, RF transmitter and receiver, etc) using a transformerless power circuit
    Complete. We were able to scale 120VAC down to 5VDC through a voltage regulator. However, later in our testing, we encountered issues with the amount of voltage that was being outputted from the regulator. We ended up with about half the voltage we were expecting.

13. Minimize total cost for overall system
    The overall system cost for our power supply components was less than $10 dollars, which compared to transformer-based options is relative cheap. Thus, the expenditure requirement was met with our power configuration.

14. Minimize space used for complete circuitry
    The whole power supply (besides the extension cord) was able to fit in a 3.05 x 3.05 x 1.56 in. box, which definitely makes it easy for us to somehow attach the whole circuitry to the side of the mixer. Thus, this satisfies our efforts of minimizing the amount of space used for the power source.

15. None to minimal safety issues
    The power supply should not engender any safety issues. Besides the catastrophic board failure, mainly caused by conflicted grounds (between earth ground and our circuit ground), the circuit configuration presented no danger, as we had a fuse and a varistor to ensure overcurrent and transient protection.

5 User Manual/Installation Manual

5.1 How to install your product

How to Build a MixMasters KitchenAid

1) Build the two Circuit Boards according to the schematics and PCB specifications
2) Download the code to each board using a PICKit3: plug it into the appropriate header pins and program the devices. Ensure that the PICkit3 powers the mixer side board and ONLY program the board if the device is not being powered by the wall outlet. Do not plug in the PICkit3 while the mixer board is being powered by the wall under any circumstances. For the remote side board, no special caution or concerns need to be addressed.
3) Remote Side
    a) Buy appropriate casing for the remote (our tests use the Polycase shown here: http://www.polycase.com/dc-58p-gasket)
    b) Buy six different colored arcade buttons and 7 green and 1 red LEDs, as well as a power switch and a reset button if desired.
    c) Drill into the Polycase lid according to the map shown in the appendix, or design a new button layout for the remote, including holes for a power switch and the optional reset button.
    d) Attach the cables from each button and LED to the appropriate molex on the board
    e) Attach a 9V battery to the clip

4) Mixer Side
    a) Buy appropriate casing for the mixer circuitry to be mounted to the side of the mixer.
    b) Drill a hole or holes thick enough for four 12 gauge wires to fit through on the back corner closest to the back of the mixer. Mount the complete board into the casing, ensuring there is adequate room to fit the wires into the screw terminals.
    c) Ensure the mixer is not plugged in and remains unplugged.
    d) Disconnect line and neutral as well as the two motor leads from the mixer according to the mixer schematic and connect them to the 12 gauge wires, leaving a little slack to remove the back cover of the mixer. Send the 12 gauge wire through the existing holes in the mixer back cover so that the cover can be opened and closed still. Close the mixer cover before moving on to the next step.
    e) Take the leads of the 12 gauge wire and tighten them into the screw terminals so that they cannot come loose. Take the mains and motor wires and attach them to the board. Tighten the screw terminals until a tight connection is made prior to.
    f) Afterwards, attach the packaging to the side of the mixer, ensuring enough slack exists and that the packaging will not interfere with the operation of the mixer.
    g) Close up the mixer. Set the speed lever manually to max speed and leave it there. (The motor is unplugged, so it will not start up. This is to ensure the governor does not grind inside of the mixer).
    h) The entire system should now be ready for operation.

5.2 How to setup your product

Set up of the product is simple once it is completed. For any given use, place the remote within 10 feet of the mixer. Switch the power on and the the remote should be good to go if the specifications mentioned in section 5.3 are met.

5.3 How the user can tell if the product is working

The product is operational if upon turning on the switch for the remote two different green lights go on. The first is in the upper right corner to indicate power; the second is below the stop speed button (pink). If either of these buttons are not on, then the remote will not work. After these two lights are on, the next option will be to press one of the speed buttons (likely the green button for the slowest speed). If the mixer starts to spin, it will be operational.

5.4 How the user can troubleshoot the product

Battery removal/replacement:

If the red LED in the upper right hand corner turns on either during device operation or right after turning the remote power switch on, turn off device first, then carefully remove the drained battery from its snap connector and replace it with a new battery.

If only the power light turns on when power is switched on:

Repeatedly remove the battery from its case and set it back into position until both lights light up. This issue could be due in part to a bad connection between the battery and the board. Jiggling it will clear up the issue.

6 To-Market Design Changes

Keeping in mind the issues we encountered while testing our subsystems, it would be essential to ensure full safety of our clients when they are using the device. Thus, a key component would be the power source. The potentially safest options to power the mixer side would be to simply use a transformer-based power supply and/or a USB wall wart which is a fully isolated switched mode power supply. Those would ensure more stability of the output voltage needed to power the microcontroller and the RF components. In terms of load issues, it would be helpful to implement a test system to check whether during mixing operation the mixing hook hits anything and can't mix ingredients at the selected speed. Another mean for troubleshooting would be to implement a reset button, that would stop the current execution and restart the operation from the beginning.

As for the remote side, it would be very helpful to get feedback on our current interface design (such as color and arrangement of buttons), in order to enhance the usability of our device. Potential changes and areas of improvement could include the size of the remote, a graphical LCD display indicating the battery life status and which button is pressed. Also we would replace the epoxy used to glue the buttons to the holes with a material that is smoother and more water-proof. Furthermore, the battery snap connector would ideally be replaced with a more rigid connector to prevent potential power shortages. Additionally, we would have a shelf/battery holder attached to the side of the remote control which the user can access to without opening our circuitry casing. More modifications can certainly be done to enhance the ease of use of our device, because it is essential to remember the ultimate purpose for assistive technologies, which is to make appliances much simpler and more efficient to use.

7 Conclusions

We have proven that it is possible to create a remote controlled KitchenAid mixer powered by the wall outlet on the mixer side and a battery on the remote side. There is still much work to be completed before the product can go to market. First, we must design better safety features regarding the mixer power supply. Next, user testing with the clients of ADEC is necessary to determine if the configuration of buttons selected is ideal. With a few more iterations, we are confident that this product will be perfect for use by ADEC and similar companies.

8 Appendices

See Appendices document for relevant appendices