M-1

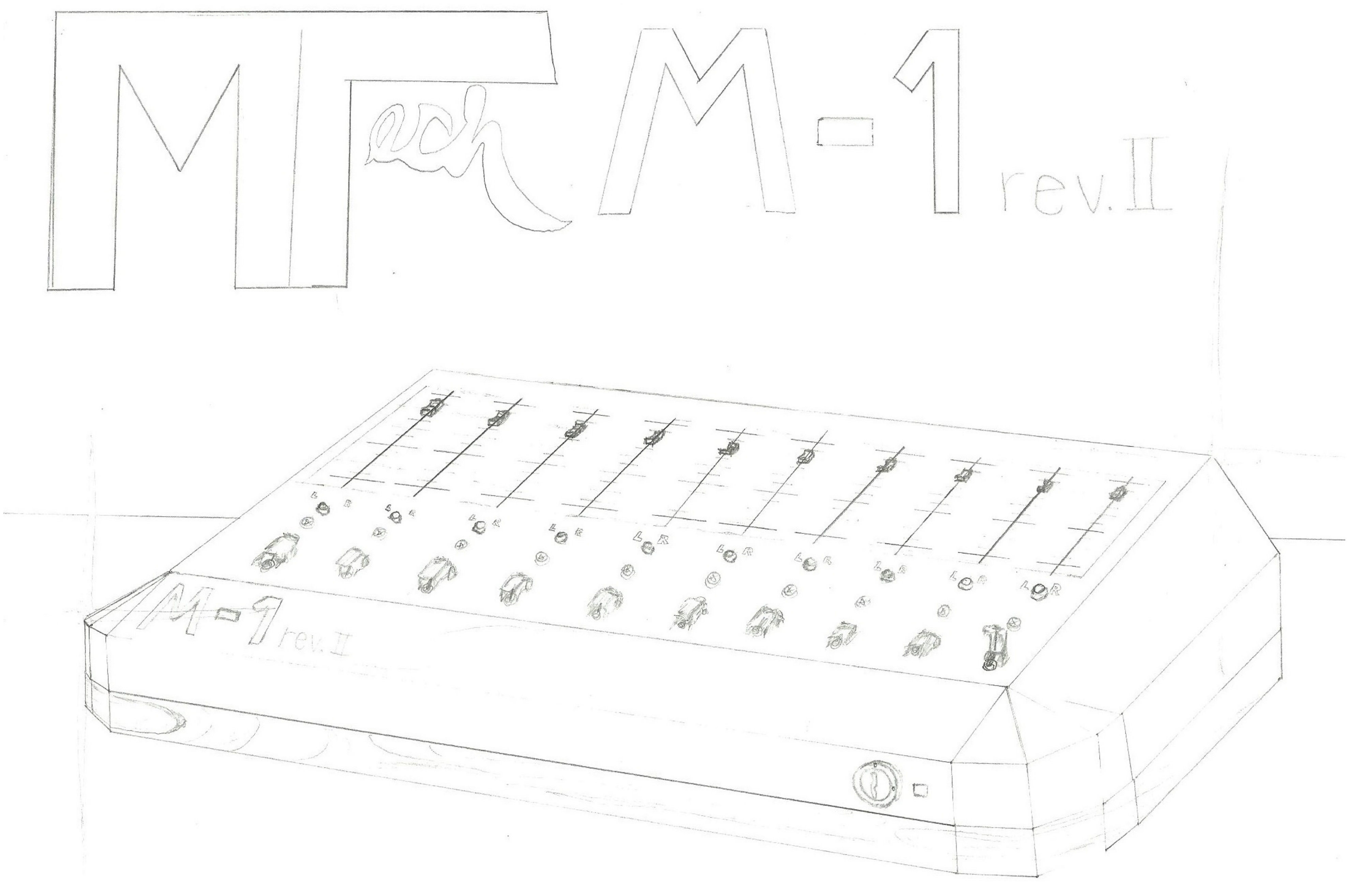
The Mealy Open Source Custom MIDI Controller

Computer Engineering
CALIFORNIA POLYTECHNIC STATE UNIVERSITY, SAN LUIS OBISPO

Advisor
Bryan Mealy

Garrett Leung, *EE*
Darren Mistica, *CPE*

June 2015



06.04.2015.1603

ABSTRACT

With the high price of large mixing consoles, aspiring artists are restricted to using a mouse to control digital facsimiles of knobs, faders, switches, and buttons. Though using the software controls is considered a simple task, dedicated hardware allows for tactile, visual, and utility. At a low cost, the heart of the MTech M-1 can be customized and placed into any shell with any combination of controls as possible with the underlying platform.

Modern MIDI controllers require significant physical space due to their preset button layout and space consuming setups. Despite their high price, modern MIDI controllers have only one setup. With one setup, music producers or artists have a hard time carrying their MIDI controllers around for concerts or other performances. The M-1 MIDI controller addresses the high cost that physical MIDI controllers currently hold on the market by allowing users to make/create their own specific MIDI control board using any combination of knobs, dials, buttons, and sliders. This customization of the controller allows the user to save space and money, while also accommodating for their style or a specific performance.

The M-1 controller is an affordable and fully customizable mechanical system. The fully customizable MIDI controller represents a digital MIDI controller while allowing the user to fully customize the physical layout of the controller. Users can place the buttons for the delay, reverb, compression, distortion, etc. in different areas of the device according to their needs. Being customizable allows the user to truly personalize the controller for their specific needs depending on the type of song being produced. Another feature of the M-1 controller is its plug-and-play capability through USB 3.0/2.0. Owning a cheap MIDI controller with plug-and-play capability allows the user to connect multiple setups of the MIDI controller because of its low price.

TABLE OF CONTENTS

List of Figures and Tables

Figures

Tables

CHAPTER I

INTRODUCTION

At the beginning of the recording industry, everything was custom built and everything was analog. This made professional recording equipment incredibly expensive and required a high level of technical expertise to develop. This applied a segment of Electrical Engineering known as signals processing to create amplifiers, speaker drivers, and recording equipment.

When time is taken into consideration, higher price tends to be associated with older music releases due to the associated technology (Mixon 469). As any budding technology, the beginning of an industry is not so refined. Sound recording made history in 1876 when Alexander Graham Bell and Thomas Watson developed a way to reproduce sound in wax (Pras 613).

Before 1894 when the 78 rpm disc was released, there was no way to duplicate records (Pras 615).
In 1892, the total output of original music was 320 minutes; 1000 in 1894. Technology didn't really change much until 1950 with the introduction of magnetic tape (Alexander 116). Over time, the music recording industry has been in the shape of a W—technology ever improving (Mixon 465).

Music formats have changed over time from records, to magnetic tape, the compact disc, and now fully digital mediums (Mixon 466). Irrespective of the medium, recordings have the ability to take music out of the time and put it in space. The advent of recording mediums have allowed artists to adapt their interpretation after witnessing their performances. This played a huge role in a musician's development. As the industry grew, performers would try to emulate the artists that came before them to gain experience (Pras 613).

Between the 1920s and 1930s was the first time engineers could mix multiple channels via mixing console (Jacobs 7). Separate tracks started being used for purposes such as narration, background noise, background music, and sound effects (Jacobs 14). From 1928 to 1931, the rational with sound recording was that once it was made, the product was complete (Jacobs 5).

In 1931, "dubbing" became a new tool for composition. Though it wasn't a new concept, it had become acceptable for creative use (Jacobs 6). Hearing sounds taken in different times and places had no precedent prior to this time period (Jacobs 7). The second half of the 1910s-1950s brought upon a change in the music recording industry (Alexander 115).

Magnetic tape was much more forgiving than the old glass-based master recordings (Alexander 120). This allowed for more takes at a reduced cost. However, as tape is reused, it loses fidelity over time. Fresh tape is preferred.

After the 1950s, there were generations of artists and producers that were more sterile in their tactics and really turned the industry into a money generating machine (Pras 615). From the 1900s to the 1970s, artists were generally selected, managed, and promoted by managers. Digital technology threatened the industry's ways in the 1980s and again in the late 1990's due to the common usage of the Internet. This caused another shift in business tactics (Pras 612).

As microphone technology improved, so have placement strategies and acoustic room treatments. Recording had turned into an art (Pras 614). In the 1980s, music sales had another resurgence with the introduction of the Compact Disc (Pras 616). Strangely enough, this decade was known as a period of time where mainstream music sounded all very similar. This is due mostly to the widespread use of MIDI and the bank of sounds that artists had during the time period (Pras 616).

As witnessed with even Michael Jackson, artists often do not meet deadlines (Strasser 45). Likewise, when new technology gets created, it does not instantly take the world by storm. It took 25 years for the VCR to become a fixture in a home while DVD only took 5 (Strasser 42). Unlike music genres, recording technology is not bound to such a constraint (Ryan 188).

Turbulent technology creates opportunities for new innovation (Alexander 113). With the internet, it was possible for artists to digitally interact with industry managers without any face-to-face meetings. This allowed for musicians to have more control over their work (Pras 616). The internet age may possibly lead to a structural disturbance and innovative, diverse products (Alexander 122). If one takes a look at what is possible with the internet, we find ourselves living at the cusp of an era ruled by it.

Previous research shows that artists involved in production are better able create more diverse music than those that are not (Laat 679). With the post 2000 emergence of more rap subgenres, this possibly indicates that there are fewer institutional barriers for minorities (Laat 675). Since CD sales dropped after the year 2000, record companies have started creating shorter contracts with artists (Laat 678).

The artists that can deliver the most profits are the ones that thrive in the sparse rosters held by recording companies in the present day (Strasser 46). Artists are judged not only on their musical ability but also how they look and for their ability to enter other forms of commerce (Strasser 46). In the early 2000s, companies started releasing music digitally, putting more focus on singles rather than whole albums (Pras 617).

File-Swapping sites and economic downturn put a burden on the record industry in 2001 (Strasser 44). It is estimated that more than 1 million jobs will be lost in the creative industry due to Piracy by 2015 (Pras 612). There has been a decline in production quality due to low budgets and time constraints (Pras 610).

Conversely, the accessibility to affordable recording equipment has given rise to music production in emerging countries (Pras 614).

Classical music recording has unfortunately transformed into a mostly outsourced venture (Pras 610). It is a difficult time for new producers in this era since it is difficult to get into the industry (Pras 611). With this in mind, many artists decided to take things into their own hands. The do-it-yourself philosophy with music has helped give birth to new genres and subcultures (Homer 86).

John Frusciante states that for the amount of money spent on getting one album produced, he could have purchased his own equipment and kept it forever (Homer 89). As artists continue to push the boundaries of the availible technology, the creative genius can be measured by their innovation (Homer 87). Artists, now with the ability to self-record end up forgoing the assistance of experienced sound engineers. Technology has made it possible to place a desktop studio in the right hands challenge an established industry (Homer 90).

Digital Audio Workstation Software allows artists to record full albums from their bedrooms and if they have a good product, sell multi-million album copies (Homer 92). However, having an ear for mastering along with the specialized, acoustically flat audio equipment to listen upon, is something many home-studio artists lack (Homer 94).

The professional studio is losing its foothold in their own industry with artists instead using it as the final touches to their masterpiece (Homer 95). Mastering is the art of balancing, equalizing, and compressing to improve the audio quality of a recording. It is learned best only through experience (Homer 96).

Five producers commented on the future of music and stated that it will: include live music videos where the audio is mastered then dubbed back onto the video, selling songs title by title rather than by album,

and the ability to record from anywhere at a far cheaper cost than in the analog era (Pras 612). They speculate that the usage of live video may replace polished audio production (Pras 613). With the ability to stream MIDI via USB, computers come pre-equipped to work with any USB-MIDI compliant device (Ashour 8). Audience members have a presence in online communities and can actively influence the fan base (Baym 178).

Technologies such as music streaming services allow for the tracking of metadata as well as an organized spreading of music through a browser (Baym 179). The internet has changed the way artists can interact with their audience (Homer 88). The limit is as it always has been: creativity given the available tools. A tool such as M-1 can help level the playing field between professional studios and home studios.

Chapter II

Customer Needs

The design requirements for the MTech M-1 MIDI Controller consist of customer needs that allow this midi controller to stand out among its competitors. The M-1 Controller is powered through USB 3.0/2.0 so a computer can conveniently power it if an AC outlet cannot be reached. The product's lightweight and portable features allow users to easily transport it to different performances or studios. Specific and customizable labels allow customers to recognize each slider, button, and knob. The product's affordability allows the customer to purchase more knobs and sliders to enhance their controller to their specifications and playing style. Customers have the convenience of customizing the controller to have specific setups for specific songs or performances. The product's completely enclosed and stylish casing prevents electrocution, damage to specific parts of the device, and customers from shocking themselves. These requirements outline the project's design and implementation standards.

Requirements and Specifications

The M-1 MIDI Controller improves features of current existing midi controllers currently out in the market. Table 1 shows the project's marketing requirements guide and the product's specifications. These requirements include viable marketing strategies while highlighting the M-1 controller's portability and low-cost, yet also maintaining the appropriate safety standards at an inexpensive overall cost. The project's requirements ensure a stylish and safe enclosure design, improves the accuracy of the controllers, and improves on the ergonomics of MIDI controllers. An overview of the engineering specifications includes various component operation ratings, average device size, and total ideal product cost.

The M-1 controller improves many features of existing MIDI controllers. The project's marketing requirements guides the product specifications shown in Table 1. The project's requirements ensure safe design, improve device utility, and decrease harmful environmental impact. An overview of the engineering specifications includes component operation ratings, device size, and total ideal product cost.

TABLE 1
M-1 MIDI CONTROLLER REQUIREMENTS AND SPECIFICATIONS

Marketing Requirements	Engineering Specifications	Justification
1	Microcontroller powered with 5V DC	USB power by 5V
2, 6	System cannot exceed 20 pounds	Maximum weight limit that allows the midi controller's portability
2, 4, 6	Size of controller less than 10" x 5" x 3"	Small form factor for portability
3	Product cannot cost over $300	Marketability and competitive pricing against competitors in the same field [6]
4	Concealed internals after assembly per IEEE standards	Safety purposes while having a design and stylish look
4, 5, 8	Operates in any 45^{o} to 90^{o} orientation	Good for small space or space limiting situations. Ergonomics in mind for special needs
5, 6	Expandable assembly with 6-pin connectors	Freedom of customization
7	"At-a-glance" identification with 3.45V green LEDs on each module with 125^{o} viewing angle	Ease of use and easy to recognize specific modules for simplicity
8	Large swing potentiometers from -2.5V to 2.5V with a full MIDI signal range from 0-127 [5]	Large ranges allow for more accuracy and flexibility

Marketing Requirements

1. USB Powered
2. Lightweight system
3. Affordable and low-cost
4. Stylish, modern design
5. Modular and customizable design
6. Portable system
7. Easy-identification design
8. Flexible and precise ranges

CHAPTER III

FUNCTIONAL DECOMPOSITION

The level 0 block diagram depicted in Figure 1 below highlights the main input and output of the entire system. The system takes in an input signal and outputs USB data shown in Table 2. Project “M-1 rev. I” uses ATmega328p MIDI Controller firmware. The serial output is wired into the Cypress CY8C5KIT, which converts it using Cypress Libraries. The resulting output is a USB-MIDI compliant data stream compatible with all Digital Audio Workstations and personal computers equipped with at least one USB 2.0 compliant port.

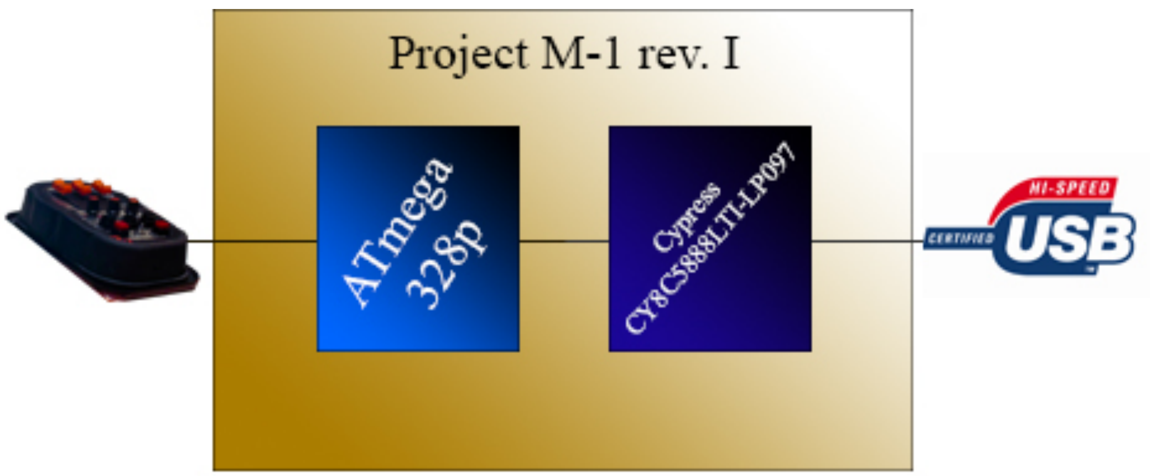


FIGURE 1: LEVEL 0 BLACK BOX DIAGRAM

TABLE 2
M-1 MIDI CONTROLLER FUNCTIONALITY TABLE WITH INPUTS AND OUTPUTS

Module	M-1 MIDI Controller
Inputs	Power: 5V DC (from USB) Physical Inputs: • Knobs • Sliders
Outputs	USB Data
Functionality	To take in a digital signal from a specific physical input from the USB and change the signal according to the specified controller/physical input [7]. The controller modifies the input signal and changes it into the USB data output signal.

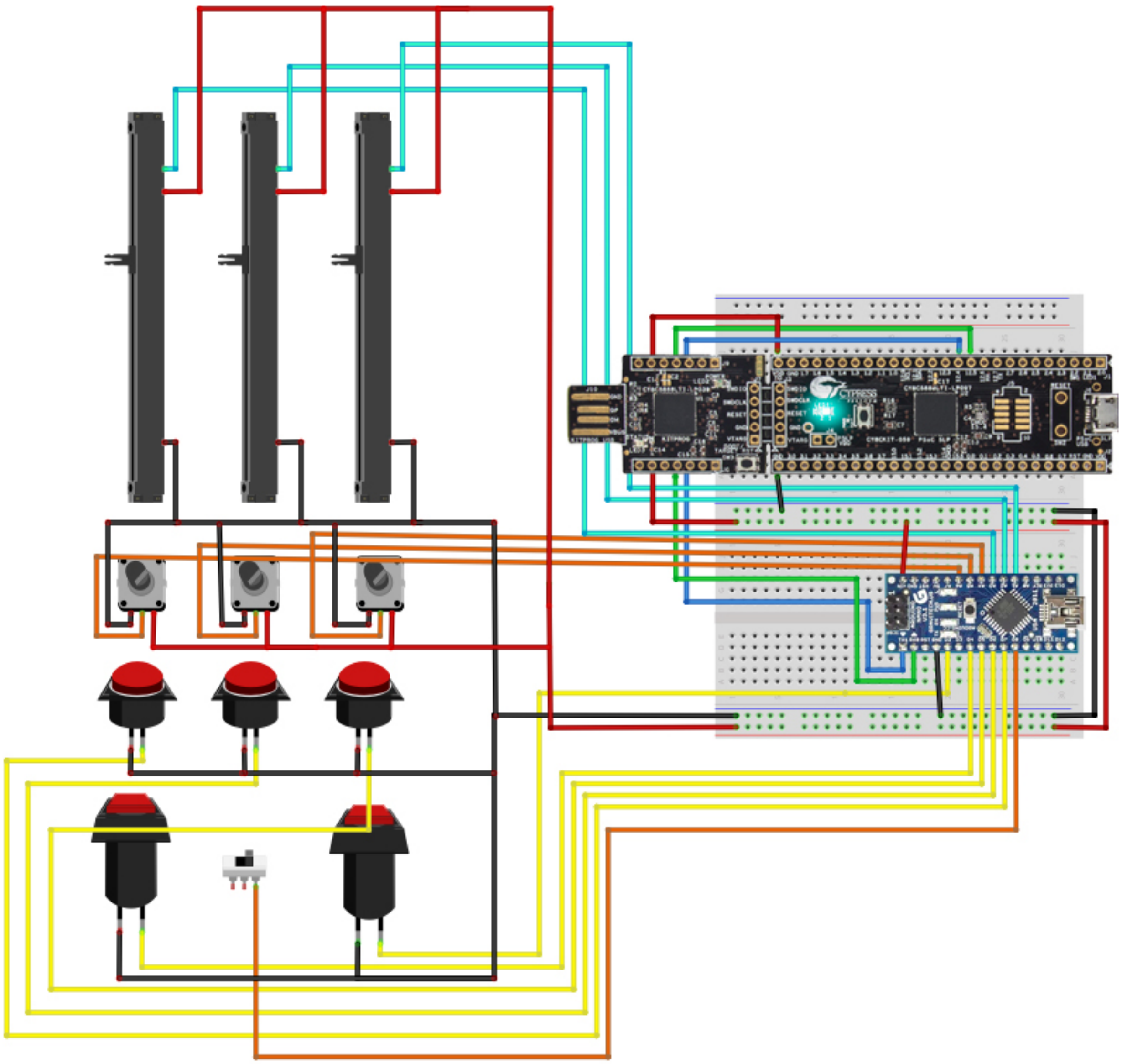


FIGURE 2: LEVEL 1 WIRING DIAGRAM

As seen in Figure 2, the Arduino Nano is hooked up to the serial ports of the Cypress Kit. All inputs are routed into the Nano with the Nano running the MIDI protocol on the incoming bit stream, and then outputting the data. The power from the Cypress Kit is also fed into the Nano as well, completing the circuit. The USB Micro-B port on the Cypress Kit then plugs into the user's computer where it will automatically be recognized as a MIDI Device.

TABLE 3
M-1 MIDI CONTROLLER BUTTON FUNCTIONALITY TABLE

Module	Button
Inputs	Power: 5V DC (from USB)
Outputs	On/Off signal
Functionality	To take in a digital signal from a specific input from the USB and change the signal by letting it pass or not pass. The input signal turns “on” or turns “off” to do this.

TABLE 4
M-1 MIDI CONTROLLER TOGGLE SWITCH FUNCTIONALITY TABLE

Module	Toggle switch
Inputs	Power: 5V DC (from USB)
Outputs	Toggled signal
Functionality	To take in a digital signal from a specific input from the USB and change the signal by toggling it to pass or not pass. The input signal toggles another signal, or does not toggle the signal at all, to do this.

TABLE 5
M-1 MIDI CONTROLLER POTENTIOMETER FUNCTIONALITY TABLE

Module	Potentiometer
Inputs	Power: 5V DC (from USB)
Outputs	-2.5V to 2.5V signal
Functionality	To take in a digital signal from a specific input from the USB and change the signal by sliding the potentiometer. The amount of resistance controls the amount of voltage allowed. This affects the input signal coming in.

TABLE 6
M-1 MIDI CONTROLLER SLIDER POTENTIOMETER FUNCTIONALITY TABLE

Module	Slider potentiometer
Inputs	Power: 5V DC (from USB)
Outputs	-2.5V to 2.5V signal
Functionality	To take in a digital signal from a specific input from the USB and change the signal by sliding the potentiometer. The amount of resistance controls the amount of voltage allowed. This affects the input signal coming in.

TABLE 7
M-1 MIDI CONTROLLER ATMEGA328P FUNCTIONALITY TABLE

Module	ATmega328p
Inputs	• Button (On/Off signal) • Toggle Switch (Toggled signal) • Potentiometer (-2.5V to 2.5V signal) • Slide Potentiometer (-2.5V to 2.5V signal)
Outputs	USB data
Functionality	To take in digital signals from the button, toggle switch, potentiometer, and slide potentiometer so it can decode/encode the signals and output the new generated USB output signal.

TABLE 8
M-1 MIDI CONTROLLER CYPRESS CY8C5KIT FUNCTIONALITY TABLE

Module	Cypress CY8C5KIT
Inputs	ATmega328p
Outputs	USB data
Functionality	To take in digital signals from the ATmega328p so it can decode/encode the signals and output the new generated USB output signal.

CHAPTER IV

GANTT CHARTS

TABLE 9
MEMBER LEGEND FOR GANTT CHART

Member	Corresponding Color
Garrett Leung	
Darren Mistica	
Group	

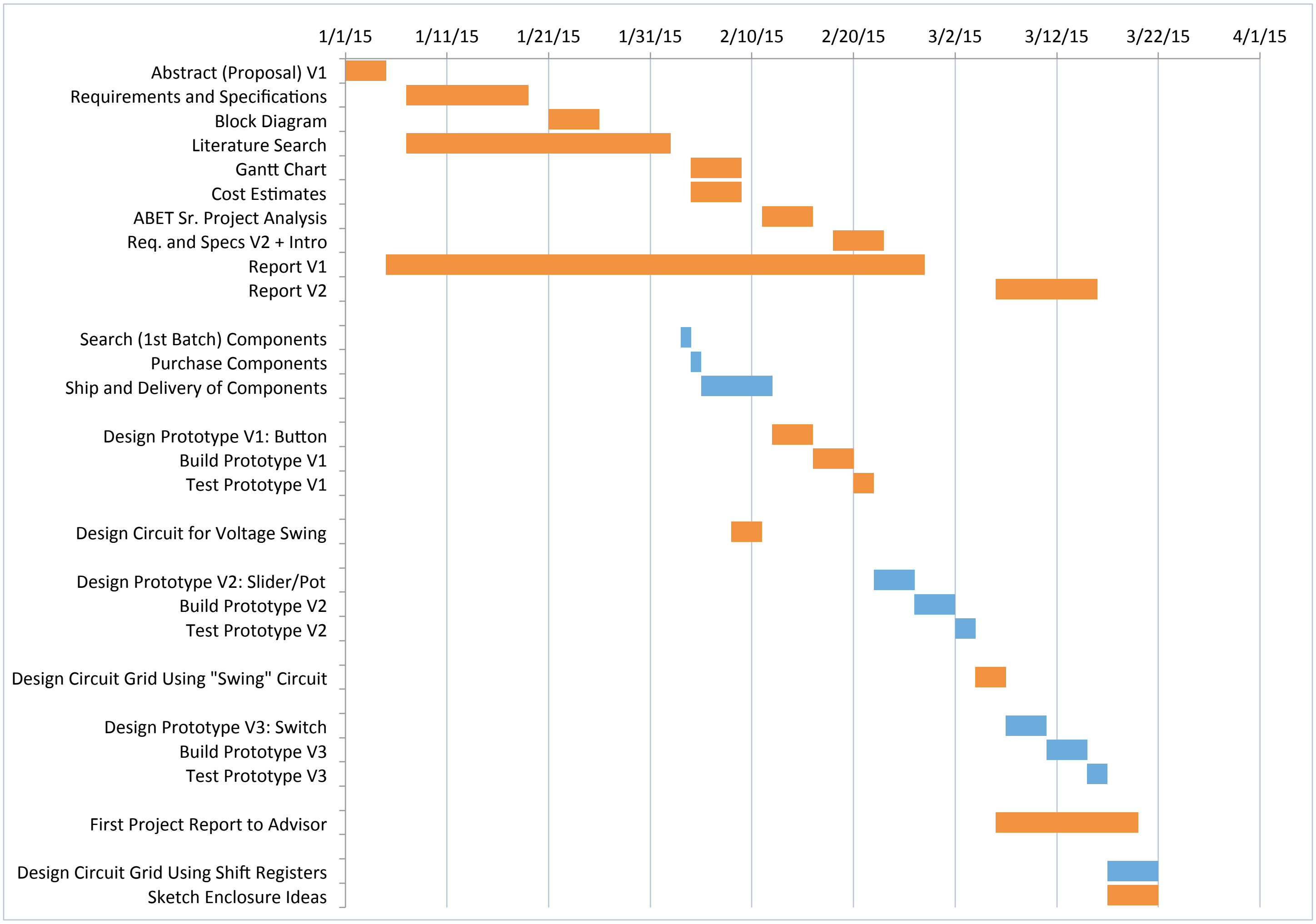


FIGURE 3: WINTER 2015 M-1 CONTROLLER GANTT CHART

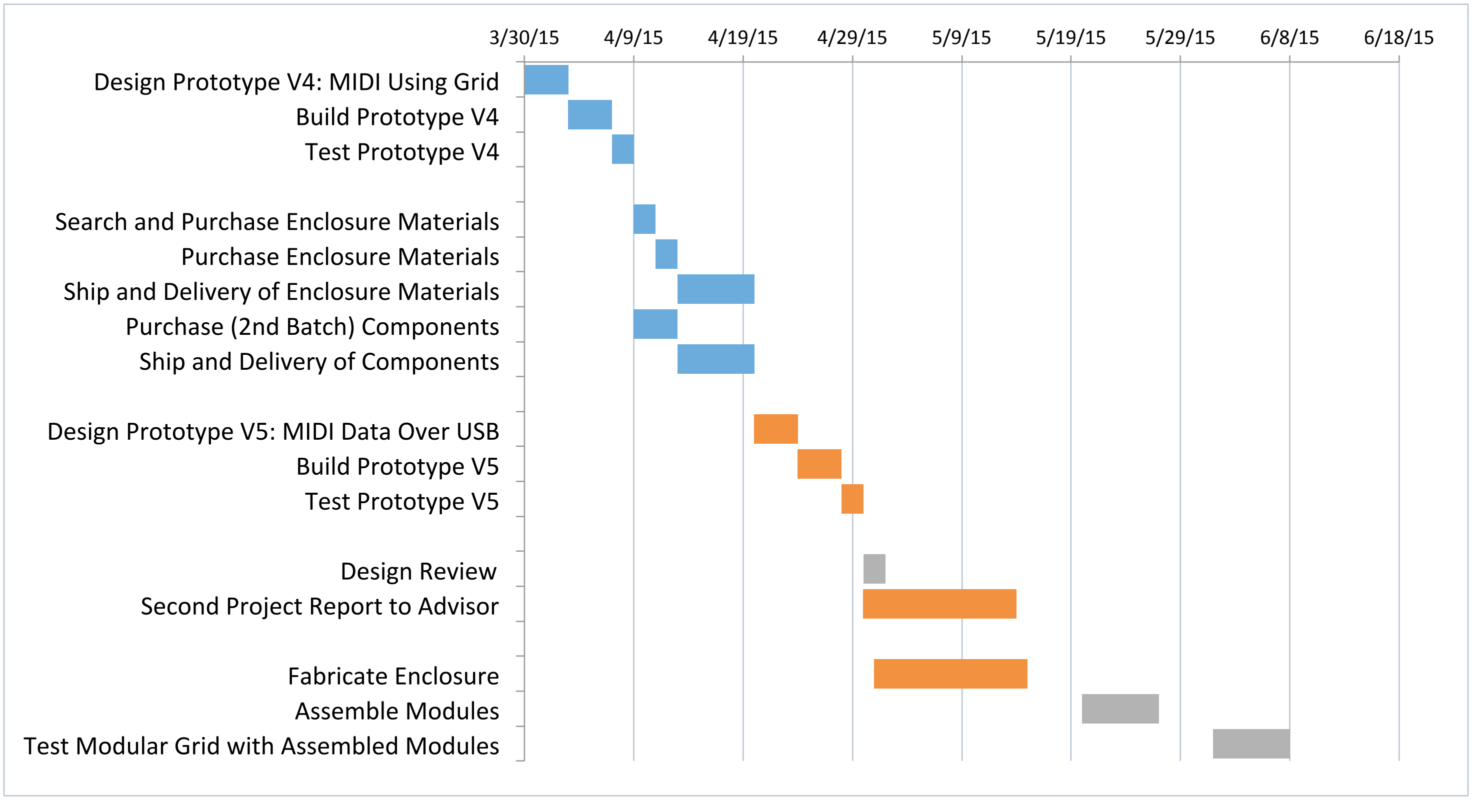


FIGURE 4: SPRING 2015 M-1 CONTROLLER GANTT CHART

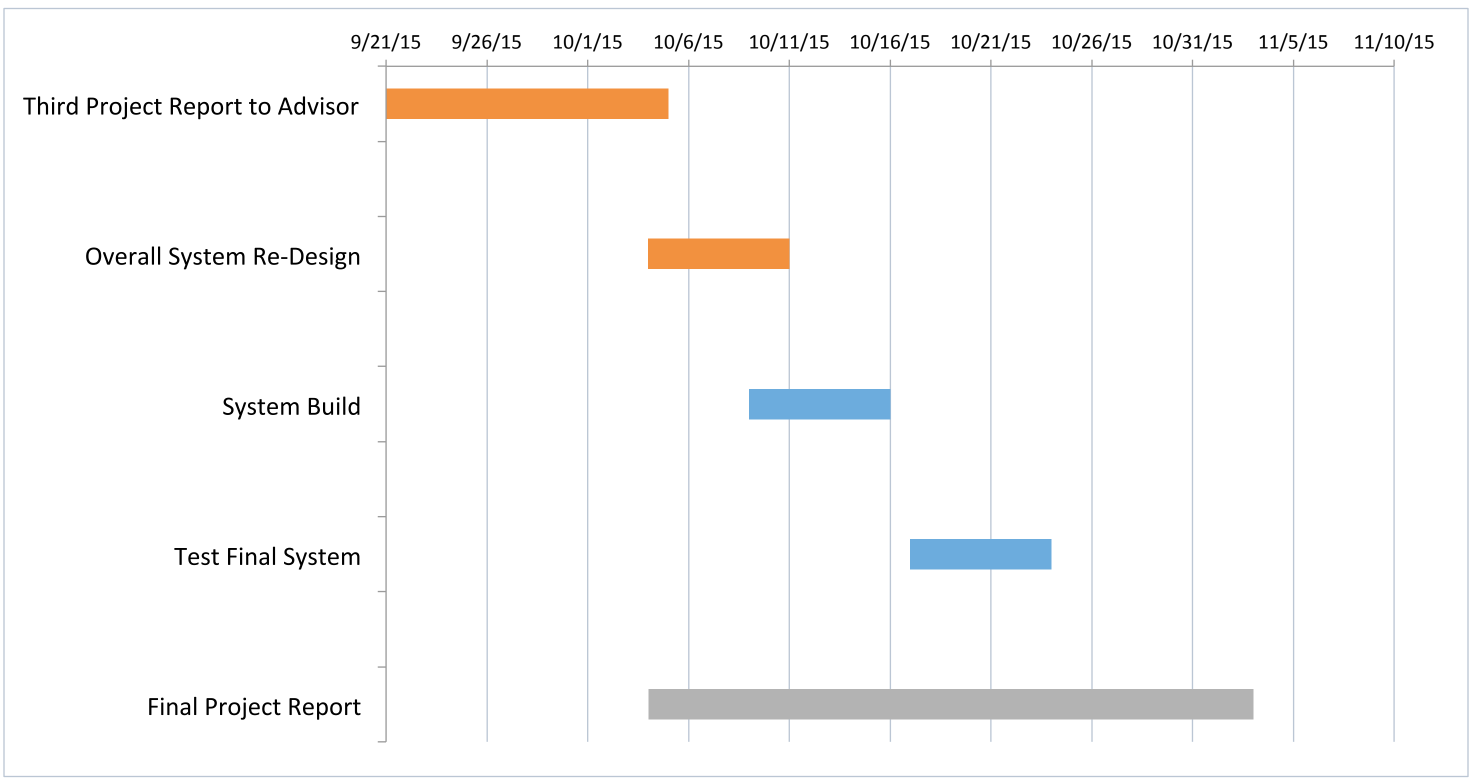


FIGURE 5: FALL 2015 M-1 CONTROLLER GANTT CHART

Cost Estimates

Professional level audio equipment normally commands a high entry-level price. Furthermore, the cheapest ready-made kits on the market are in the $40 range to build a custom MIDI Controller. Using any available libraries and utilizing premade PCB kits will cut down the overall cost for a hand-wired prototype.

Table 10
Alpha Prototype Bill of Materials

Item	Website	Unit Price	Quantity	Sub-Total
1k Linear Slide Potentiometer	http://ww	$1.14	1	$1.14
1k Linear Potentiometer	http://ww	$1.13	1	$1.13
SPDT Toggle Switch	http://ww	$1.90	1	$1.90
Red Pushbutton	http://ww	$1.50	1	$1.50
Arduino Uno	http://ww	$26.39	1	$26.39
			Grand Total:	**$32.06**

At the start of the project, the initial prototype equaled a pre-shipping total of $32.06. Parts for this project were purchased from either Mouser Electronics or from an Amazon Prime account.

Table 11
Beta Prototype Bill of Materials

Item	Website	Unit Price	Quantity	Sub-Total
1k Linear Slide Potentiometer	http://ww	$1.14	1	$1.14
Hillshire Farm Honey Ham	http://ww	$3.48	2	$6.96
1k Linear Potentiometer	http://ww	$1.13	1	$1.13
Arduino Nano Clone	http://ww	$5.90	1	$5.90
SPDT Toggle Switch	http://ww	$1.90	1	$1.90
Red Pushbutton	http://ww	$1.50	1	$1.50
			Grand Total:	**$18.53**

The second prototype used the same peripherals as the Alpha Prototype, but using a different base platform to reduce costs. This resulted in a 42.2% decrease in cost. In the end, the project totaled $272.81 total for the price of creating several prototypes and keeping them.

TABLE 12
M-1 REV. I TOTALS

M-1 rev. I Subtotal:	80.59
M-1 rev. I Core Price:	$15.28

TABLE 13
M-1 REV. II TOTALS

M-1 rev. II Subtotal:	128.16
M-1 rev. II Core Price:	$9.38

TABLE 14
PROJECT TOTAL

S&H + Tax:	$36.98
Project Sub:	235.83
Grand Total:	$272.81

TABLE 15
TOTAL BILL OF MATERIALS

Item	Website	Price Per Unit	Quantity
x5 Red LED Self-Locking Buttons	http://ww	$6.97	2
1k Linear Slide Potentiometer	http://ww	$1.14	10
10"x10' Aluminum Flashing	http://ww	$13.52	1
x50 6mm Black/Red Knobs	http://ww	$6.55	1
Rust-Oleum Black FlexiDip	http://ww	$5.98	1
Double Sided Scotch Tape	http://ww	$2.39	1
Hillshire Farm Honey Ham	http://ww	$3.48	2
x5 Red LED Toggle Switch	http://ww	$13.59	2
x15 40 Pin Male Headers	http://ww	$4.90	1
Cypress ARM 5LP Dev Kit	http://ww	$9.38	2
1k Linear Potentiometer	http://ww	$1.13	10
0.75"x5.5" Alder Board	http://ww	$3.92	5
Arduino Nano Clone	http://ww	$5.90	1
400 Pin Breadboard	http://ww	$5.95	2
x5 Red Fader Knobs	http://ww	$5.33	2
SPDT Toggle Switch	http://ww	$1.90	1
Electronic Keylock	http://ww	$4.63	1
Black Pushbutton	http://ww	$1.40	10
Red Pushbutton	http://ww	$1.50	10
Aluminum Foil	http://ww	$2.97	1
Arduino Uno	http://ww	$26.39	1

CHAPTER IV

REVISION HISTORY

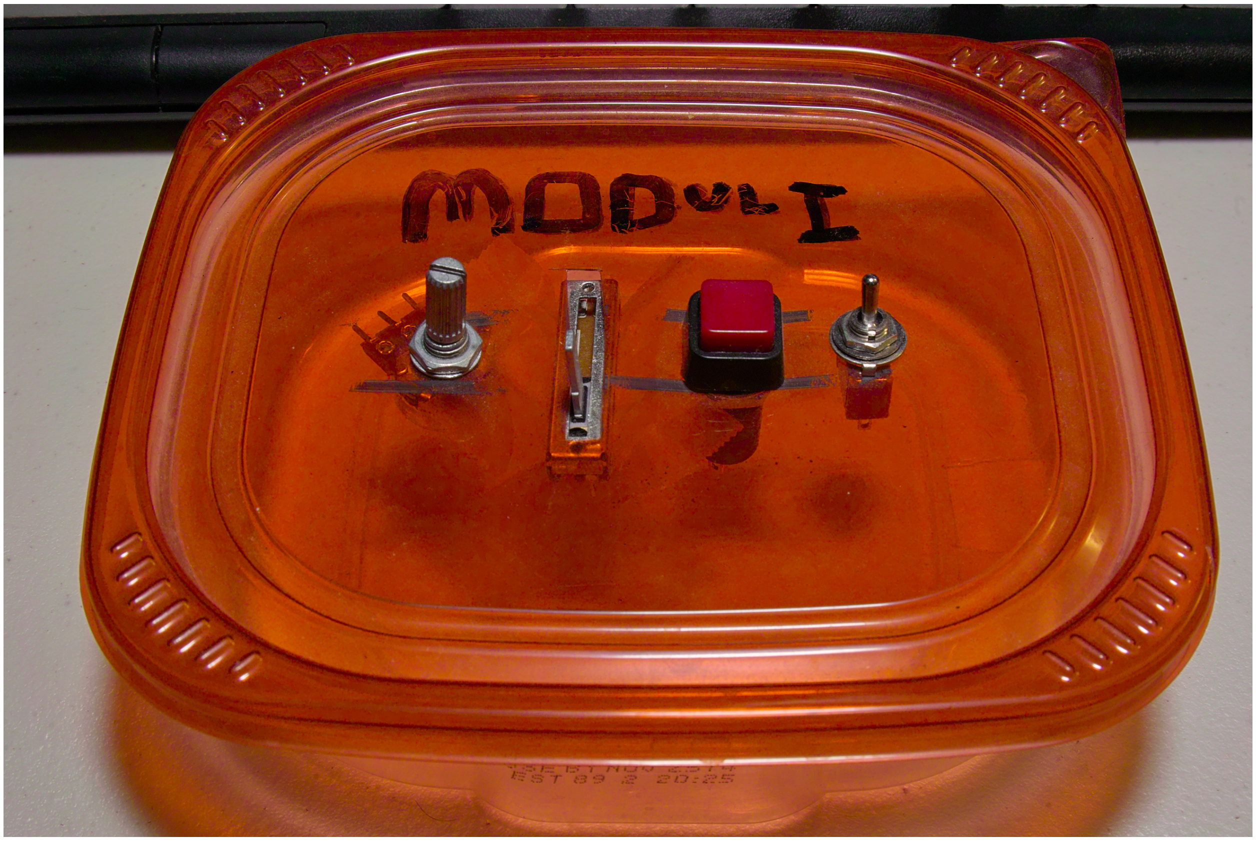


FIGURE 6: ALPHA PROTOTYPE ENCLOSURE DESIGN

The Alpha Prototype consisted of one potentiometer, one slide potentiometer, one momentary pushbutton, and one toggle switch housed in a re-sealable plastic container. It used an Arduino Uno board that has an ATmega328p in the 28-pin PDIP 28P3 28 Packaging. The Beta Prototype called for a clone of the Arduino Nano. The Nano is equipped with the same ATmega328p but instead in the much smaller TQFP 32A 32 Packaging.

As seen on the next page in Figure 7, the “M-1 rev. I” features a three band-mixing console with pan control, solo cueing, and recording triggers. The microcontroller platform was switched to the Cypress

ARM 5LP CY8CKIT-059. This allows for onboard USB-MIDI communication without the need for external ports to be soldered and set up.

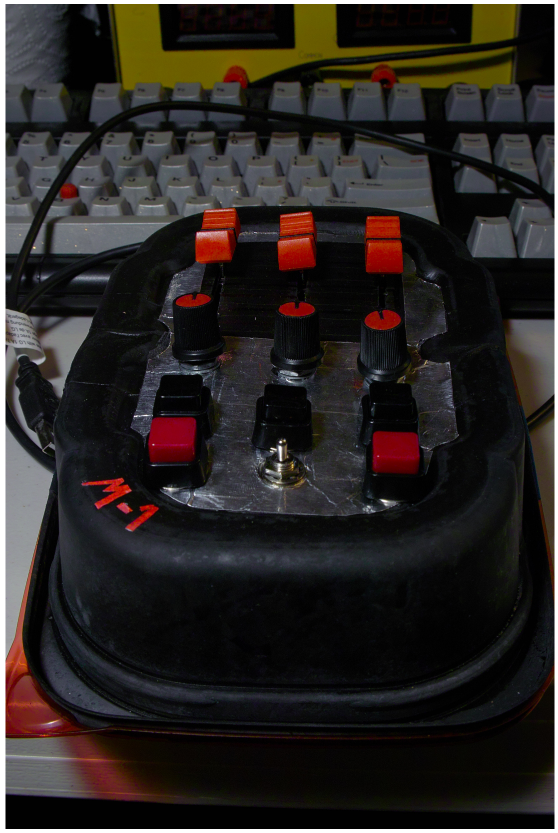


FIGURE 7: M-1 REV. I ENCLOSURE DESIGN

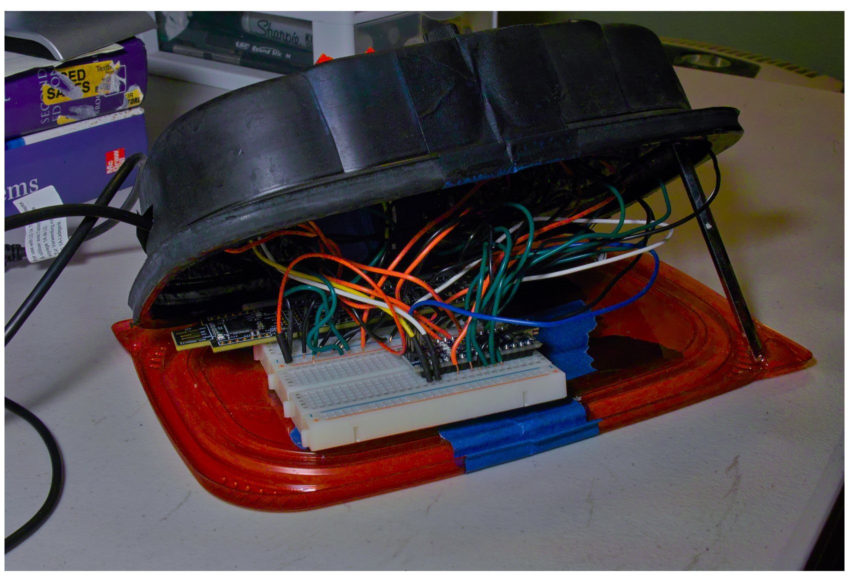


FIGURE 8: M-1 REV. I PLUGGED INTO BREADBOARD

DEVELOPER'S GUIDE

I. ARDUINO IDE

As of the current writing, Arduino IDE is on version 1.6.4. Keep this in mind if the layout in future versions changes.

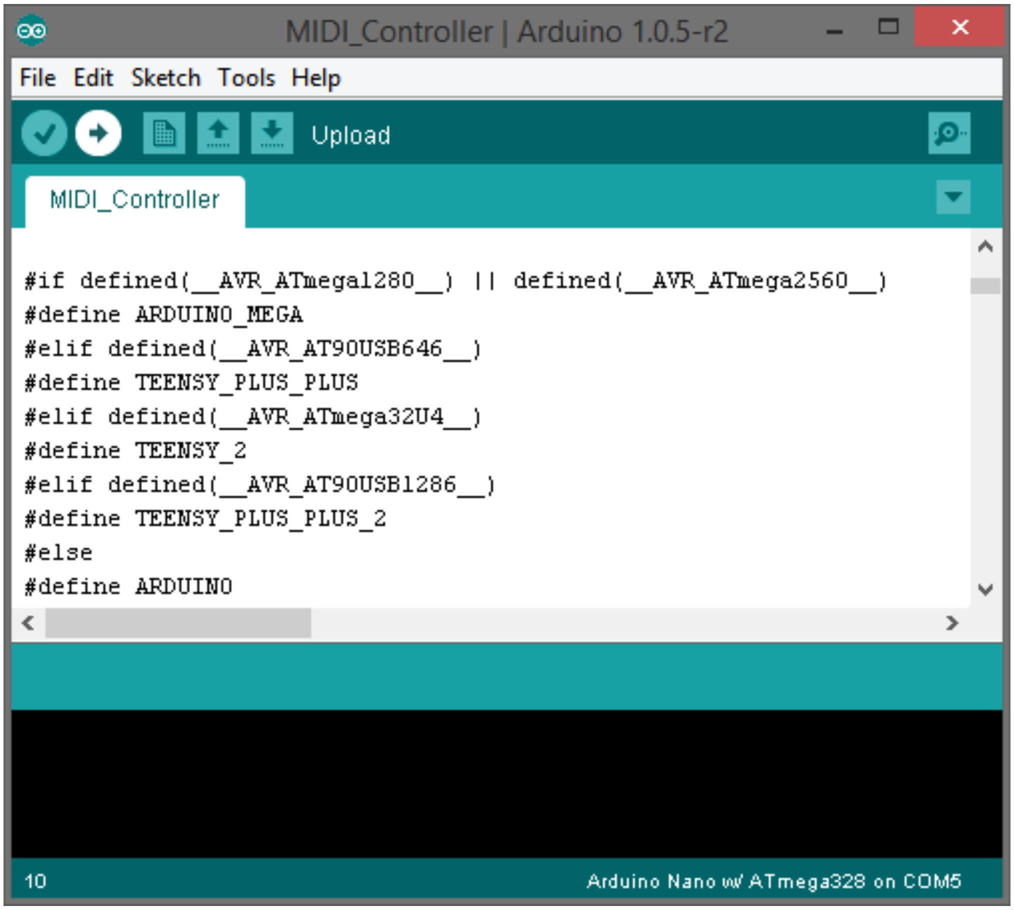


FIGURE 9: FLASHING CODE TO THE ARDUINO NANO

Flashing the Arduino Nano from within the Arduino IDE is quite simple. Once the platform and port is selected from the "Tools" dropdown menu, to flash, press the "Upload" button. This will be done with the "MIDI Controller" code found in Appendix A.

II. Cypress Studio

As of the current writing, Cypress PSoC Creator is on version 3.2. The layout may subject to change.

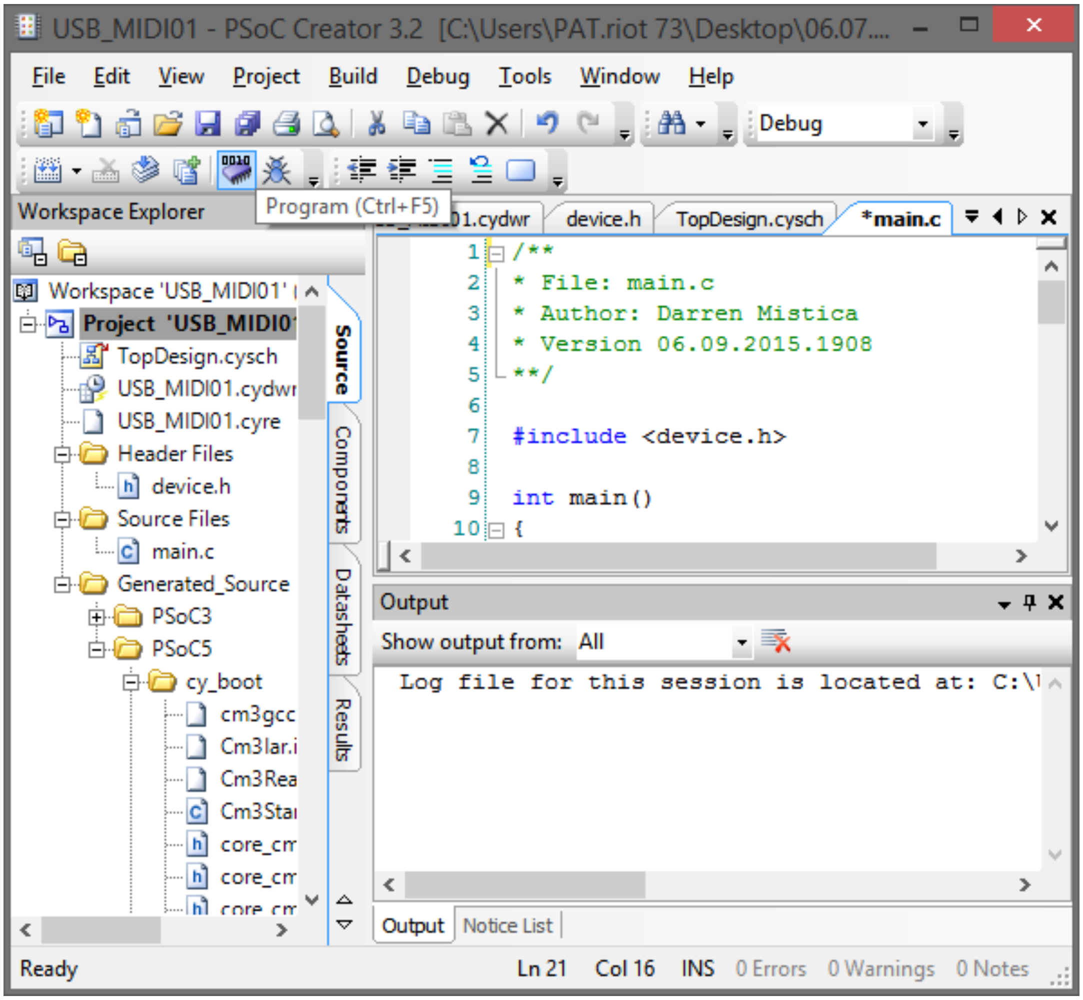


Figure 10: Flashing code to the Cypress CY8C5KIT-059

Flashing the CY8CKIT-059 from within the PSoC Creator is also very simple. Right click on the "Project" listing in the Workspace Explorer found on the left of the window. Once the platform has been selected, the port should automatically be recognized upon connection. Press the "Program" button after using the "MIDI Bridge" code found in Appendix A. After viewing the source code, it is clear that after doing the proper initializations, the main loop of the program will output USB-MIDI data as gathered from the two serial pins found on the CY8CKIT-059.

References

Alexander, Peter J. "New Technology and Market Structure: Evidence from the Music Recording Industry." *Journal of Cultural Economics* 18.2 (1994): 113-23. *Springer Link*. Web. 4 June 2015.

Ashour, Gal, Billy Brackenridge, Oren Tirosh, Mike Kent, and Geert Knapen. *Universal Serial Bus Device Class Definition for MIDI Devices*. N.p.: USB Implementers Forum, 1 Nov. 1999. PDF.

Baym, Nancy K. "Rethinking the Music Industry." *Popular Communication* 8.3 (2010): 177-80. *EBSCO Host*. Web. 4 June 2015.

Homer, Matthew. "Beyond the Studio: The Impact of Home Recording Technologies on Music Creation and Consumption." *Nebula* 6.3 (2009): 85-99. *Gale Academic OneFile*. Web. 4 June 2015.

Jacobs, Lea. "The Innovation of Re-Recording in the Hollywood Studios." *Film History: An International Journal* 24.1 (2012): 5-34. *Project MUSE [Johns Hopkins UP]*. Web. 4 June 2015.

Laat, Kim De. "Innovation and Diversity Redux: Analyzing Musical Form and Content in the American Recording Industry, 1990–2009." *Sociological Forum* 29.3 (2014): 673-97. *Wiley Online Library*. Web. 4 June 2015.

Mixon, Franklin G., Jr., and Rand W. Ressler. "A Note on Elasticity and Price Dispersions in the Music Recording Industry." *Review of Industrial Organization* 17.4 (2000): 465-70. *Springer Link*. Web. 4 June 2015.

Pras, Amandine, Cathrine Gustavino, and Maryse Lavoie. "The Impact of Technological Advances on Recording Studio Practices." *Journal of the American Society for Information Science and Technology* 64.3 (2013): 612-26. *Wiley Online Library*. Web. 4 June 2015.

Ryan, Jennifer. "Reviewed Work: Lost Sounds: Blacks and the Birth of the Recording Industry 1890-1919." *Popular Music* 26.1 (2007): 187-88. *JSTOR*. Web. 4 June 2015.

Strasser, Richard. "Restructuring the Recording Industry: Are EMI's Problems a Warning Sign for Others in the Music Industry?" *MEIEA Journal* 3.1 (2003): 37-53. *Academic OneFile [Gale]*. Web. 4 June 2015.

APPENDIX A

ANALYSIS OF SENIOR PROJECT DESIGN

Project Title: M-1: The Mealy Open Source Custom MIDI Controller
Student's Names: Garrett Leung, Darren Mistica
Advisor's Name: Bryan Mealy

I. SUMMARY FUNCTIONAL REQUIREMENTS

For this project to be worthwhile, it would have to be able to at the minimum be able to handle one potentiometer and one momentary switch. The minimum to be useful would be three slide potentiometers, two rotary potentiometers, and at least two buttons. Ideally, twenty slide potentiometers, twenty rotary potentiometers, and 120 momentary or toggle switches.

The primary communication must follow USB-MIDI protocol. Ideally it will have a USB-B port for durability and a removable cable. Since USB accessories that don't require a large current draw can run solely off the port, being self-powered would enable the equipment to be smaller and lighter. Live music performers tend to be in low light situations when performing at night; user controlled on-board illumination could be a nice feature. Finally, it should be user customizable after being briefed with no discrimination towards programming experience.

II. PRIMARY CONSTRAINTS

The first obvious constraint is the inability to trigger software responses in order to compensate for loading a project and having a knob or toggle switch in a different position. Without the ability to motorize each control and sync the console to the software values upon project load, such a mixing console would only be good for single-run mixing sessions. This potentially can teach users to train their ears but for the sake of time, this "feature" has a negative impact.

Without adequate funding for the project, prototypes had to be disassembled to create their successors. The only way to counter-act the software constraint would be to have a custom suite of recording software. A Digital Audio Workstation that can communicate serially via USB to automate controls upon load. Furthermore, with plans in motion for a twenty band-mixing console, the project will slowly continue on.

III. Economic

Capital generated by this device encompasses system production, development, and shipping. Development and distribution affect the human builders, truck drivers, and delivery crew. Musicians, artists, and hobbyist benefit from a cheaper, modular, and space saving design. Consumers, as well as power plants, benefit from the low electricity usage due to the modular design of the MIDI controller. Costs incur during initial product production and assembly. Costs and benefits accrue after the first year of production.

Table 15 shows the full Bill of Materials for the M-1 Project along with Hyperlinks to each component. Furthermore, the tools used to create this project include: Personal Computer, Adjustable Soldering Station, Hand-Held Rotary Tool, Wire-Strippers, and various temporary fasteners.

With off-the-shelf PCBs, M-1 platform prices hold the top two ranks among product competitors found between 2005 and the present. In their designed forms, the Alpha, Beta, and "M-1 rev. I" all cost less than KORG's in-production MIDI Controller known as the NANOKONTROL 2.

The manufacturer of the M-1, MTech, wants to create custom enclosures to go with the open source hardware and software model. These enclosures will be hand crafted by Darren Mistica and sold at auction price with a reserve priced at the cost of the building material. This initially will be a slow

process. The musicians and hobbyists will be the ones that profit from this product. Its ease of use and low-cost design will allow many users to purchase more modules for their personal use.

IV. If manufactured on a commercial basis

As money comes into the project, a CNC Mill and 3D Printer can be created for rapid prototyping and production batch runs. Popular models can be voted on by the customer base and will become eligible for a limited time batch run of enclosures. These would be sold at a fixed price of \$300-\$400.

$$\text{Initial Investement} = -\$128.16$$

$$\text{Profit from First Sale} = \$271.84$$

$$n = 6 \text{ units a day} * 5 \text{ days a week} * 52 \text{ weeks} = 1560 \text{ units}$$

$$\Sigma = -\$128.16 + \$271.84(n)$$

$$= \$423{,}942 \text{ Total Profit after 1 year with Initial Investment}$$

In this phase, with the target cost of an “M-1 rev. II” platform at \$9.38, controls, and building material will be deducted from the fixed price. Using the rough estimate from the “M-1 rev. II” Bill of Materials, the project would come out at \$128.16 before shipping. Before shipping rates, the estimated profit could be in the range of \$271.84. A return that will almost double profit. User operating costs would be negligible since it would run off of only one USB Port on their machine. Finally, using manufacturing technology MTech could potentially net \$423, 942.24 in one year of selling 1560 units after the first initial investment of \$128.16.

V. Environmental

As with any hardware that requires silicon chips, there are highly hazardous chemicals used during the manufacturing of crystalline silicon, wafer slicing, die creation, and PCM manufacturing and assembly processes. These chemicals must be disposed of in the proper manner by the chip design and fabrication houses. It would be good interest to look into the background of chip manufacturers and discover what they are presently doing.

VI. Manufacturability

With the lack of ownership to machining tools, each enclosure would have to be made by hand. However, since they have to be handmade, each one can be unique and original, fetching a high price as art. Once there is enough product interest, CAD renderings of the most popular models can be drafted and reproduced in limited runs.

These runs would be cut from solid aluminum and the cost to make would be for the bulk aluminum. 3D Printers exist presently. However, if the cost of technology falls, this would enable MTech to only require a soldering station and a 3D Printer. The price and introduction of new technologies would be the only limit.

VII. Sustainability

Once the M-1 Platform has been hardwired and sealed in its chosen enclosure, the MIDI Controller functions as a plug-and-play USB Peripheral. There is no further action necessary by the user after the controller has been situated within the enclosure. The materials used for the creation of an M-1 MIDI Controller are made of components known to decompose slowly such as plastic, aluminum, silicon, and steel. This can be remedied by recycling a spent M-1 System at a reputable electronics recycling plant.

VIII. Ethical

MTech will not create custom controllers using third party branding nor create custom controllers in the likeness of any in-production products without expressed written consent. Ethical egoism applies to this product's ethical framework. Our company will act in self-interest utilizing electricity and other natural resources. This project composes its ethical validity using the IEEE code of ethics. Our group accepts responsibility to make decisions concerning the public using credible standards and produces products with no bias in all forms of discrimination and rejects all forms of bribery. Our honest policy maintains true to our claims and statistics while avoiding injury to the user, the user's property, the reputation and employment of our affiliates, and solving conflicts of involved parties.

IX. Health and Safety

M-1: The Mealy Open Source Custom MIDI Controller runs on USB power so there is a chance of electric shock during the event of a liquid spill or flood. Blunt edges of manufactured aluminum may be a liability in a loss of lateral motion control event. Also, these edges may be a liability if the controller is of adequate weight to cause bodily harm from a fall-height of one meter.

X. Social & Political

Socially, the M-1 Platform can potentially unleash affordable music production equipment for the masses. The software and hardware will remain open source allowing interested parties to craft their own enclosures if they so desire. Alternatively, sold at an artistic premium, the works of Darren Mistica will be functional and unique works of art. Cast, Machined, or Printed versions will be sold at a competitive price according to market value at the present time, allowing small limited production runs to be made as time progresses.

XI. DEVELOPMENT

In the development of Project M-1, several deep introspective journeys were undertaken before work could commence. While new facets of knowledge were pieced together as necessary, this idea for the project had been years in the making while at Cal Poly. A new microprocessor platform was to be learned in order to take advantage of its affordability and features. To know what sort of MIDI controls a music producer would actually wish to have could only be learned from firsthand experience. In the one quarter and 9 weeks prior to putting in the final sprint for this Senior Project, a musically creative endeavor was undertaken to learn how to produce music.

With that, it became obvious that the three main features desired in a hardware controller include: media transport control, a multi-band mixer, and modular or custom modules to represent commonly used effects and expression.

As a proof of concept, "M-1 rev. I" would be made to have a three-band mixer with pan control, solo, and track arming capabilities.

The "References" section shows the different mediums used in the development of our project. The research includes component datasheets, previous full-scale projects, and worldwide-published handbooks fundamental to the M-1 MIDI Controller.

Appendix B

Source Code

```
/**
* File: MIDI_Bridge.c
* Author: Darren Mistica
* Version 06.09.2015.1908
**/

#include <device.h>

int main()
{
    // Enable Global Interrupts
    CYGlobalIntEnable;

    // Start USBFS device 0 with VDD operation
    USB_Start(0u, USB_DWR_VDDD_OPERATION);

    while(1)
    {
        if(USB_IsConfigurationChanged() != 0u)
        {
            if(USB_GetConfiguration() != 0u)
            {
                  // Enable the output after receiving config req
                USB_MIDI_EP_Init();
            }
        }

        // Run USB MIDI if device is configured
        if(USB_GetConfiguration() != 0u)
        {
            USB_MIDI_IN_Service();
            USB_MIDI_OUT_EP_Service();

            if((USB_MIDI2_InqFlags & USB_INQ_IDENTITY_REQ_FLAG) != 0u)
            {
                USB_MIDI2_InqFlags &= ~USB_INQ_IDENTITY_REQ_FLAG;
            }
        }
    }

    return 0;
}
```

File: MIDI_Controller by Michael Balzer

Appendix C

Datasheets

[1] Cypress CY8CKIT-059 ARM Platform

[2] Atmel ATmega 328p Microcontroller

[3] Bourns 1K Linear Potentiometer PDB181-K420K-102B

[4] Bourns 1K Linear Slide Potentiometer PTA6043-2015CPB102

[5] Universal Serial Bus Revision 3.1 Specification