Apple iPhone/iPod Touch - iEffect

Mobile Guitar Effect Accessory & Application

Final Report

EEL4924 - Electrical Engineering Design 2

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Project Abstract:

We designed an accessory for Apple iPhone. Our accessory, the iEffect, will be a mobile guitar effect pedal add-on to the iPhone. It will allow the users to simply plug in the device to the audio port. The user will interact through the iPhone touch screen interface with an effect pedal type structure that will change depending on the effect he/she has chosen. The interface will have a menu system to allow the user to choose what effect to control, whether it is a distortion, delay or other effects.

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Introduction:

The iEffect is an external guitar effect module to modify a guitar's unamplified signal and provide a ¼" jack to output to an amplifier. An MSP430 is used to modify the waveform after the pre-amplification circuit. The iPhone will be used to choose and control the effects that the user wants to implement. For example, if distortion is selected, the user could control the volume and gain through a custom touch screen interface. In addition to digital effects modified by MSP430, 3-band equalizer is implemented in analog circuits.

Guitar effect pedal is a popular tool for guitar players to add effects to the sounds generated by a guitar. Common guitar effects include the following:

- **Distortion** – A simple effect that "clips" or flattens the signal at assigned limit values.
- **Noise Gate** – This effect completely cuts the signal down to the center value at assigned limit values.
- **High Boost –** This effect simply increases the amplitude only above assigned limit values to simulate a high boost.
- **Waveform Overlap –** This effect overlaps (averages) a waveform stored in memory with the signal. With a faster processor, this could be implemented to use a potentiometer to control the averaged waveform and use better averaging algorithms.
- **Delay –** Simple delay, storing the current value in the current location within a circular buffer and retrieving the oldest value and averaging it with the current signal.
- **Tremolo –** This effect oscillates the volume by multiplying the signal by a fraction that's proportional to a varying (sequentially incrementing then decrementing) multiplier value from three to nine. The volume never exceeds the original level of the signal to maintain controlled gain.

Competitive Products:

In the market, there are varieties of guitar effects pedals from several tens of dollars to several hundreds of dollars. Interfaces for the guitar effect pedals are knobs and buttons. The Interface to the iPhone touch screen will allow the user to control the effect easily while playing guitar. Also the iPhone interface will reduce the size of the pedal and manufacturing process. One major benefit of this device is that it will be sold as iPhone application device in the huge iPhone market.

Figure 1 -- iPhone (left) and Boss Effect Pedal DD-6 (right)

Features:

Users of the iEffect will be able to

1. Carry around a handy iEffect
   All of the electronics are fit into a small enclosure. The iEffect does not affect the mobility of the iPhone.

2. Turn the iPhone to the guitar effect pedal simply by plugging a iEffect into an audio port
   The iPhone sends signals to the MSP430 to control it through the iPhone audio port. Users do not need to have any engineering knowledge to install the iEffect to the iPhone.

3. Select and adjust the digital effects using the iPhone touch screen interface
   The iEffect has three digital effects in the followings.
   a) **Delay –** Simple delay, storing the current value in the current location within a circular buffer and retrieving the oldest value and averaging it with the current signal. Users can adjust a level of the delay and a delay time.
   b) **Distortion** – A simple effect that "clips" or flattens the signal at assigned limit values. Users can adjust a distortion level and a distortion value.
   c) **Tremolo** – This effect envelops the original signals at a certain message frequency. Users can adjust a level of tremolo and a message frequency.

4. Change orders of the digital effects
   The digital effects above can modify the signals in total of six different orders. This feature expands variations of the digital effects. Users change the effects orders with the iPhone interface.

5. Bypass the digital effects
   If the users prefer pure analog signals to digital signals, they can choose to bypass any digital processing.

6. Control 3-band equalizer with potentiometer knobs
   An analog 3 band equalizer circuits allows the users to boost the signal up to 9.5dB at the three ranges of frequencies; low frequency (80Hz), middle frequency (1KHz) and high frequency (8kHz).

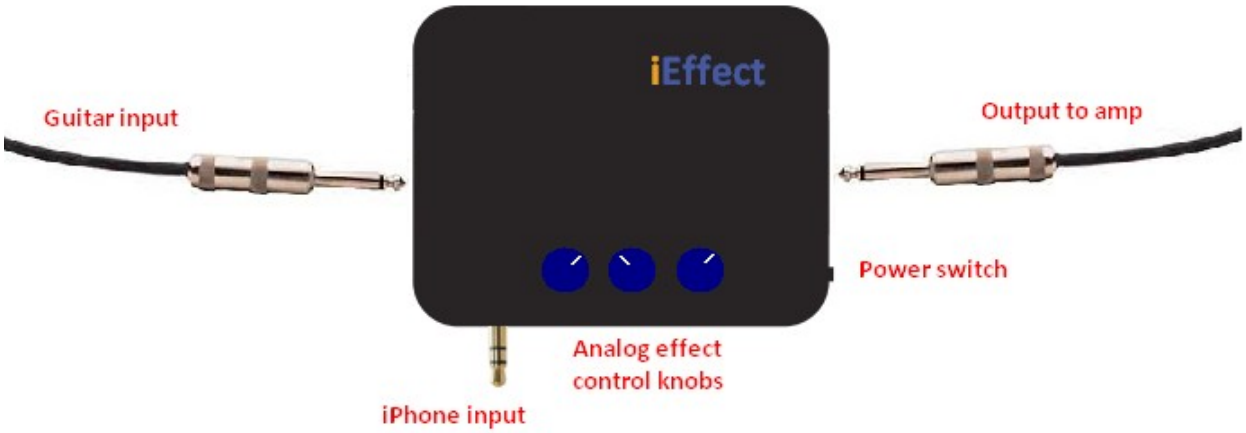


Figure 2 -- Image of iEffect

Concept/Technology Selection

This project consists of three parts: Hardware Digital Components, Hardware Analog Components and iPhone components. Hardware Digital Components receive the signals from iPhone and modify the guitar signals. The Hardware Analog Components adjust the input signals for the digital

component and also add the analog effects to the input signals. iPhone components allow the users to control the effect pedal intuitively. Details of each component are discussed below.

--Hardware Digital Component

a) Microprocessor
MSP430 is used to generate guitar pedal effects. Particularly, MSP430F2619 is chosen for this project. This microprocessor has the largest memory (120KB) of the varieties of 16MHz MSP430s. This large memory theoretically allows to store 1 second signals in the memory to implement a delay effect. The MSP430 12-bits A/D capabilities are also important to capture the guitar signals and send the digital signals to D/A converter. 16MHz MSP430 is chosen for real time effects.

b) D/A converter TLV5619
This chip is a parallel 12-bits D/A converter. Since D/A converter on MSP430F2619 is not able to function while A/D converter on the MSP430 is running. So this Ti parallel D/A converter processes the data fast enough to output real time D/A conversion.

--Hardware Analog Component

a) Guitar pre-amp
Output signals from guitars are usually 300mV peak to peak maximum. The signals first come through the equalizer circuit. This equalizer circuit adds the equalizer effects to the original signals as well as adjust the original signals to feed it into MSP A/D converter pin. The signals into MSP A/D converter have to be between 3.3V and 0V for digital processing.

b) 3-Band Equalizer
The 3-band equalizer is implemented with three active band pass filters. Before the guitar signals go to the band pass filters, the signals pass the op-amp follower and are amplified with a gain of three, which makes a maximum 9.5dB boost. The specs of each band pass filer are the followings.

Low Frequency: Center Frequency = 78Hz, Q = 4;
Middle Frequency: Center Frequency = 1.15kHz, Q = 3;
High Frequency: Center Frequency = 7.8kHz, Q = 2;

A potentiometer adjusts the boost of the signals at each frequency range. The potentiometer simply works as a voltage divider. The boosted signals are added to the original guitar signals.

The other analog part is a low pass filter for output signals from MSP430. The output from MSP430 is a digitized signal with very high frequency components, so a low pass filter will smooth-out the signal.

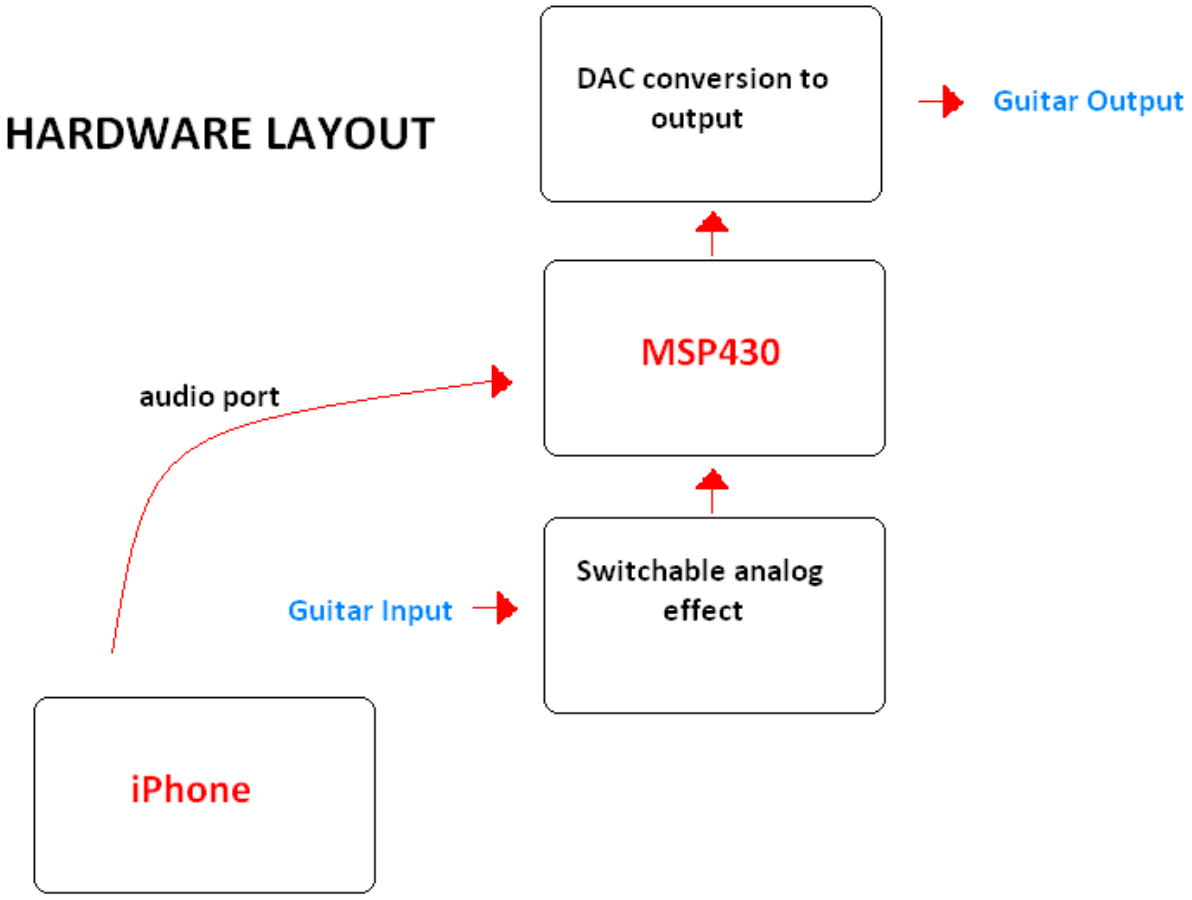


Figure 3-- iEffect Hardware Diagram

--iPhone Component:

The iPhone component is quite complex. iPhone programming is written in objective-c with the XCode program in the iPhone SDK. Various object class source files (.m/.h files) are created to accommodate:

- Audio signal generation (manually created waveforms)
- Interface controllers for each “screen”
- Timer control for button queues

The interface builder SDK tool is used to design the user interface for each screen and connecting the interface objects to the main source controller methods.

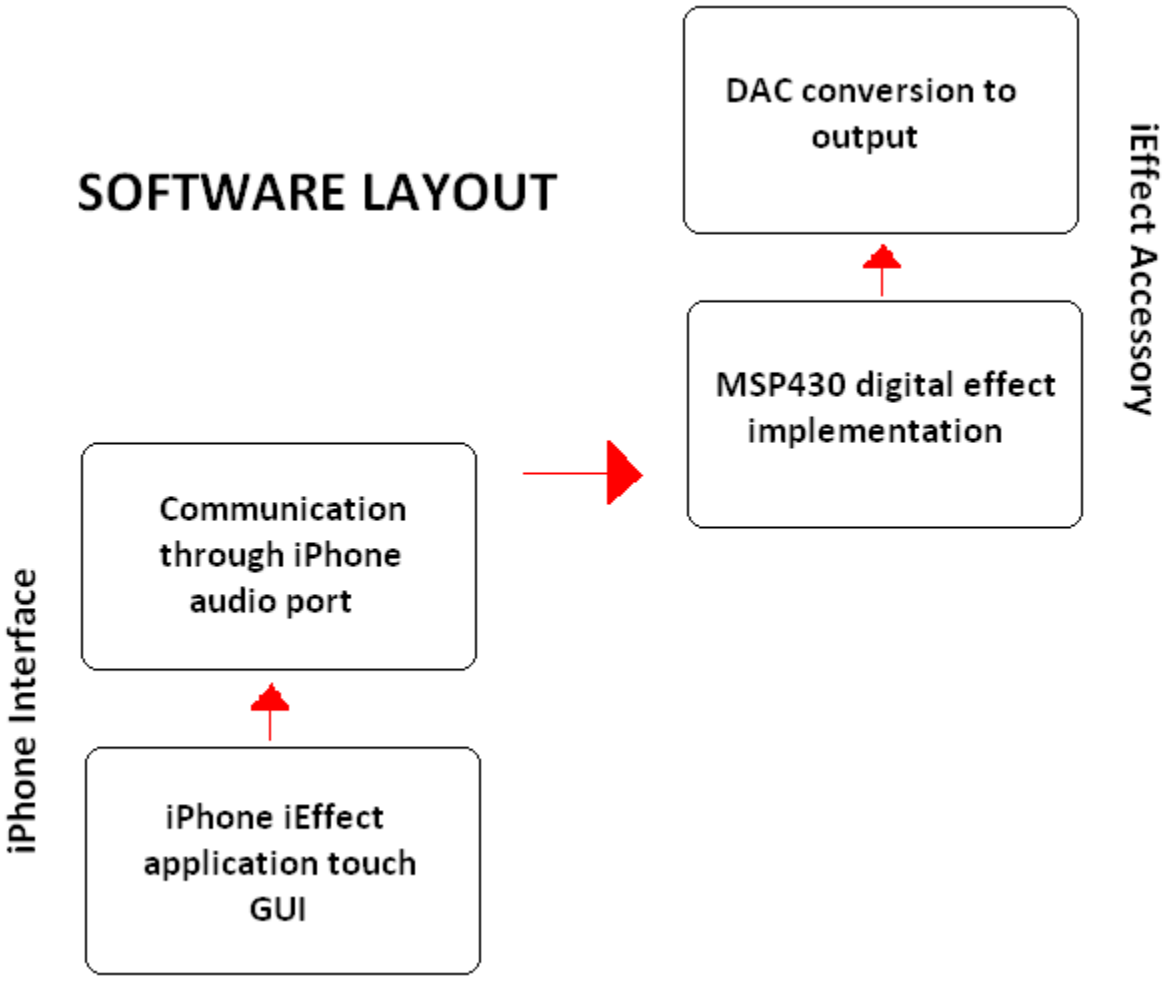


Figure 4 -- iEffect Software Diagram

Project Archtecture:

Input signals, guitar signals will flow the iEffect hardware shown in the block diagram below.

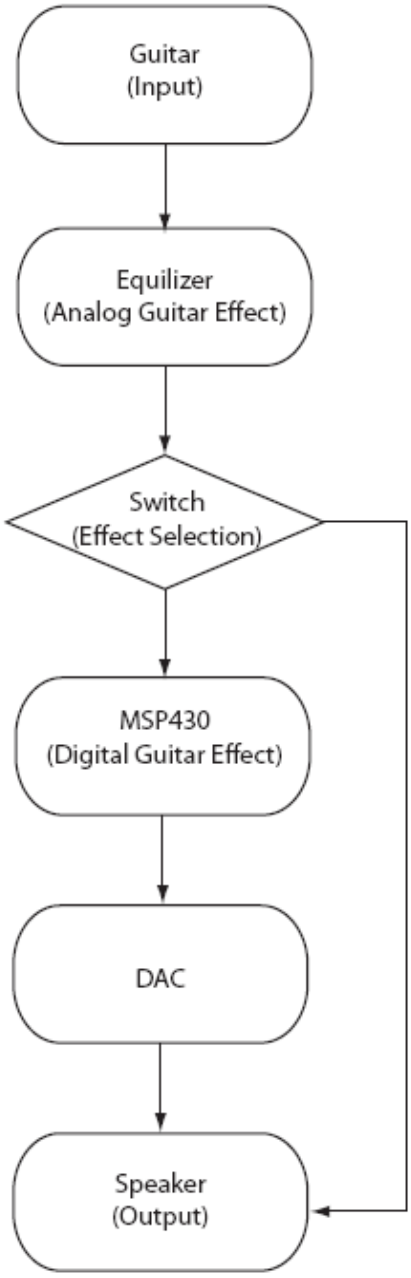
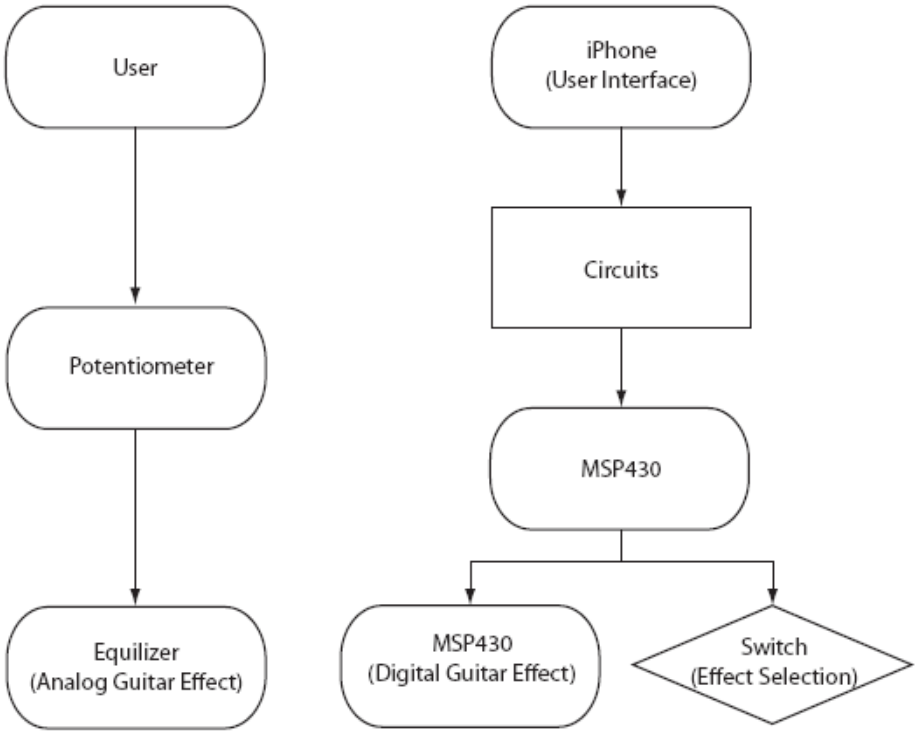


Figure 5 – Guitar Signal Diagram

The control signals for the guitar effects flow as shown below.



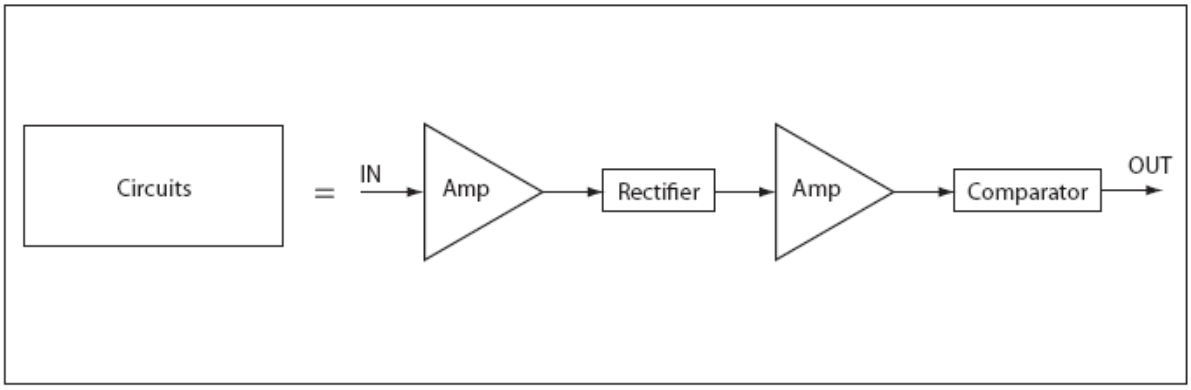


Figure 6 – Control Signal Diagram

The hardware signal flows above are implemented as shown in the schematics below.

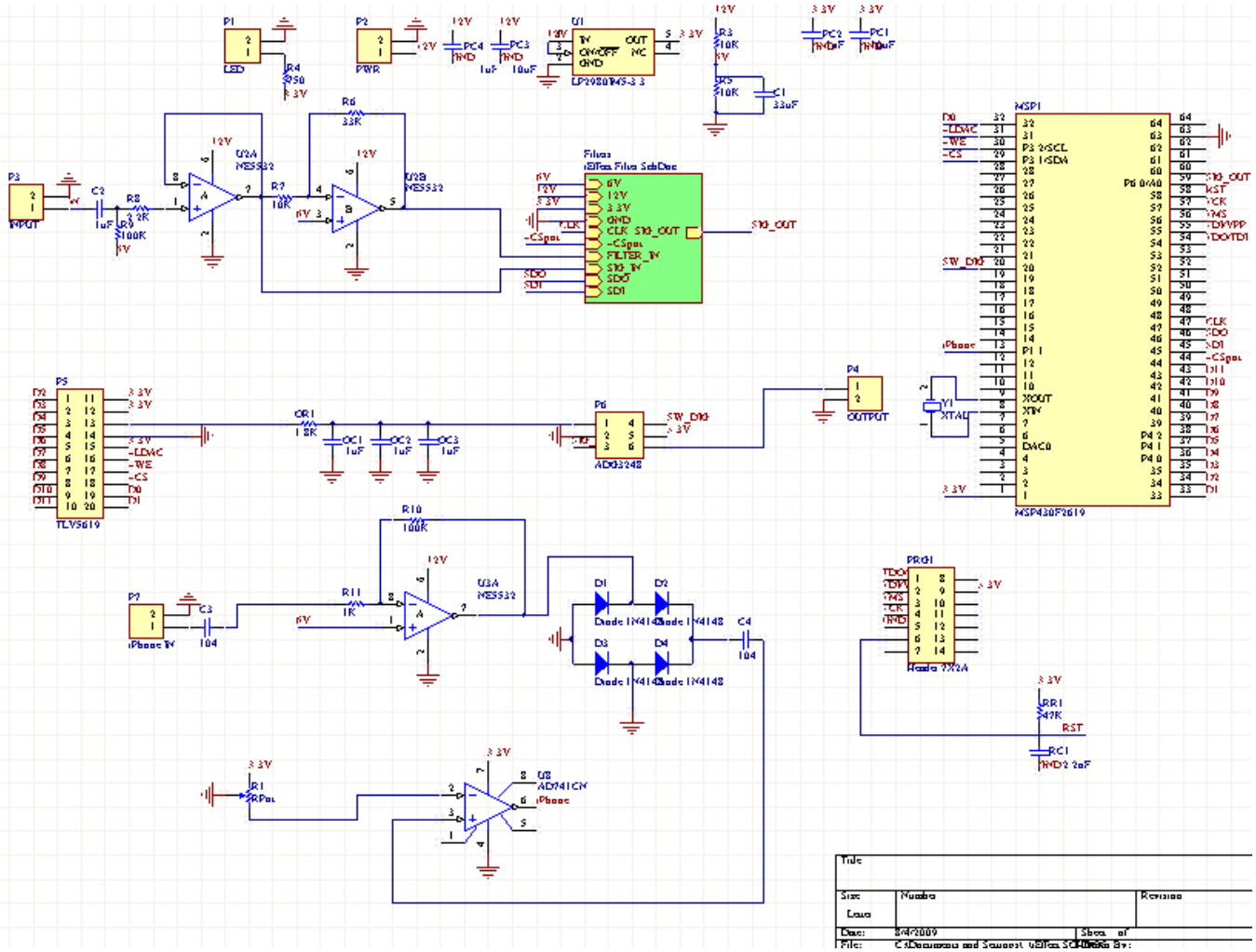


Figure 7 – iEffect Schematics

The next figure below shows the schematics of iEffect Equalizer. How it works is discussed in previous section.

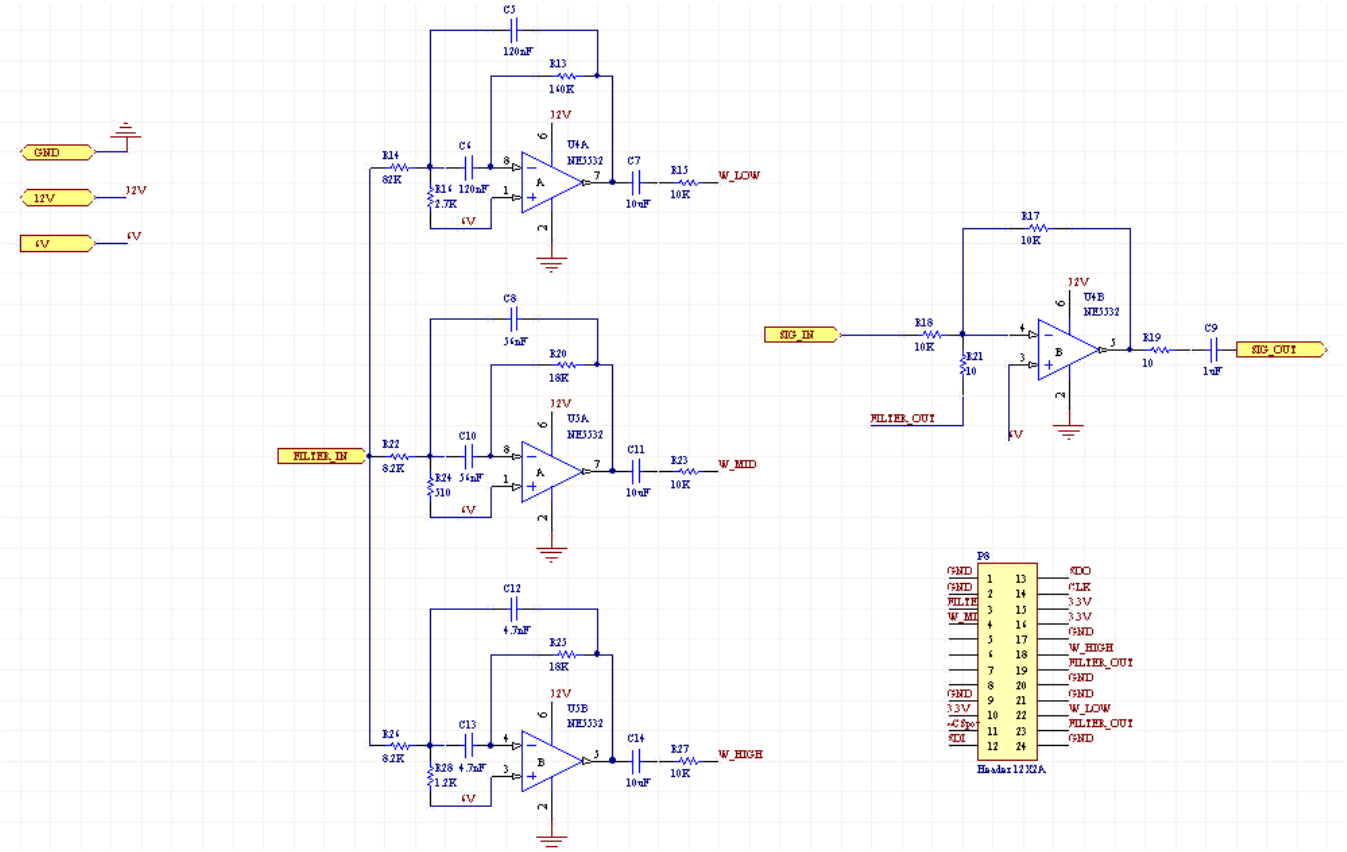
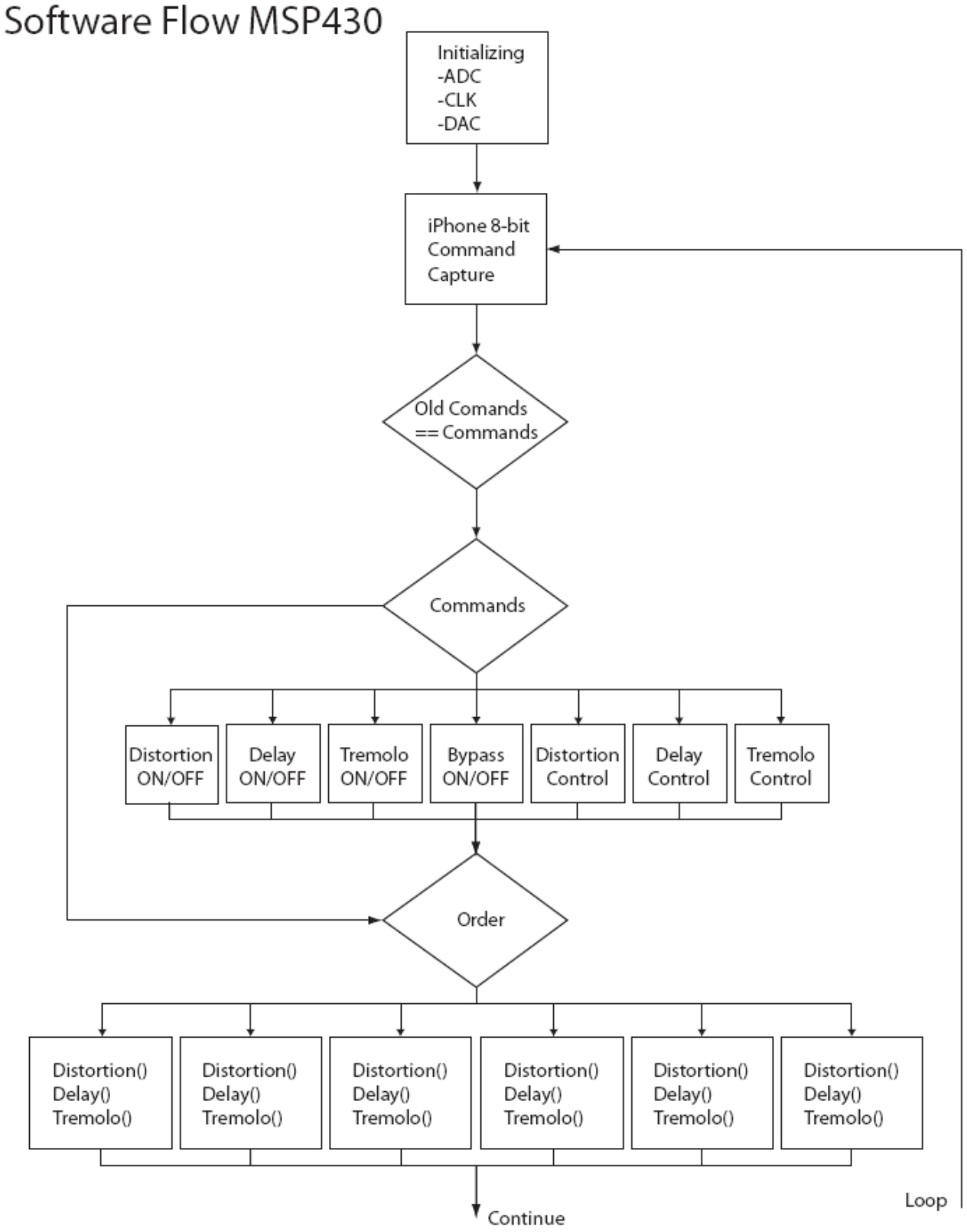
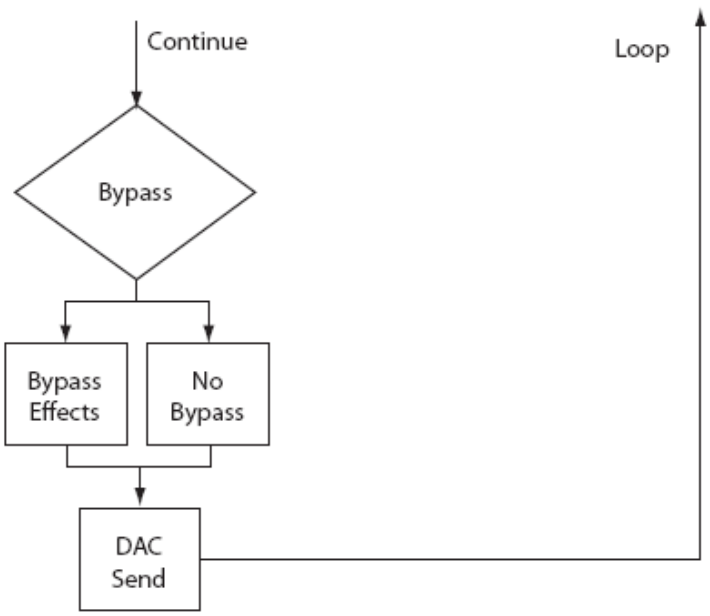


Figure 8 – iEffect 3-band Equalizer Schematics

The PCB layout of circuit diagrams in Figure 6 and 7 is shown in the Appendix section.

The software flow for the iEffect digital effects is described in the block diagram below.





Software Flow: Effects

(Equalizer effect is implemented in analog circuits)

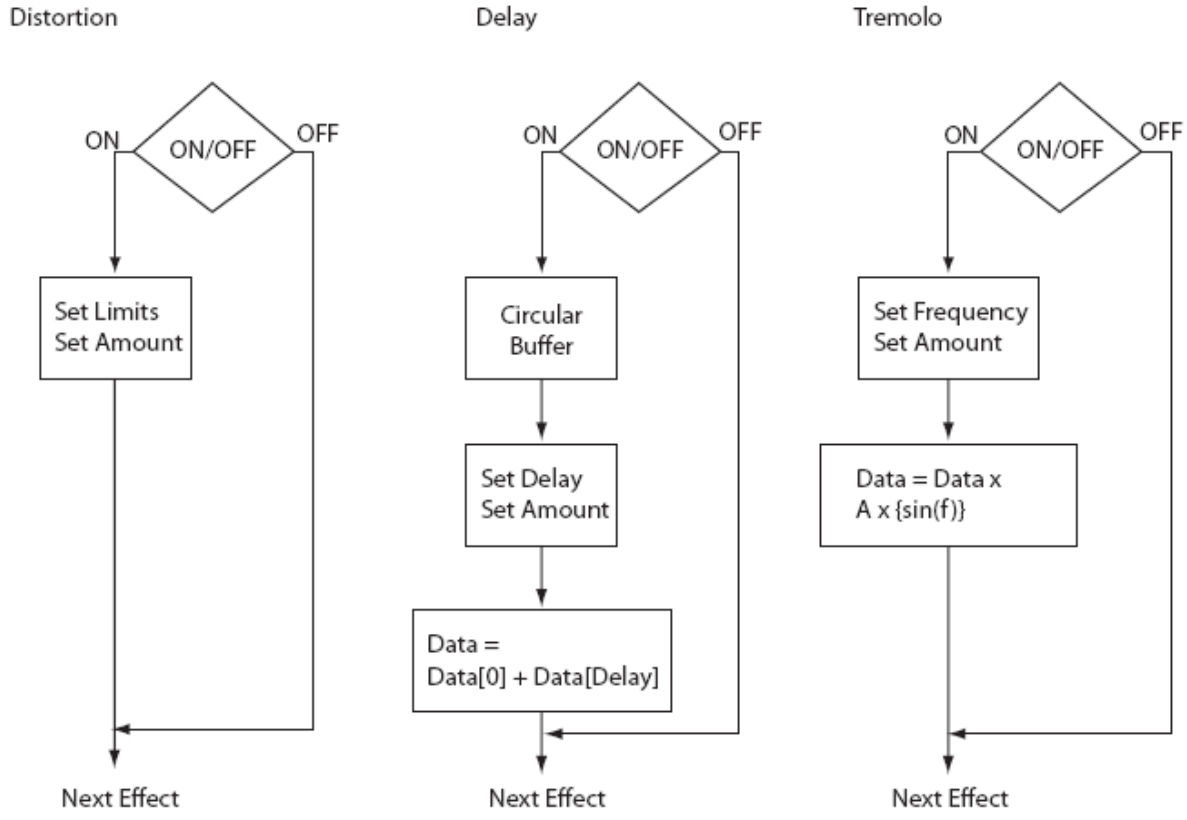


Figure 9 – iEffects MSP430 Code Flow

A diagram shown below describes the software flow of iPhone user interface.

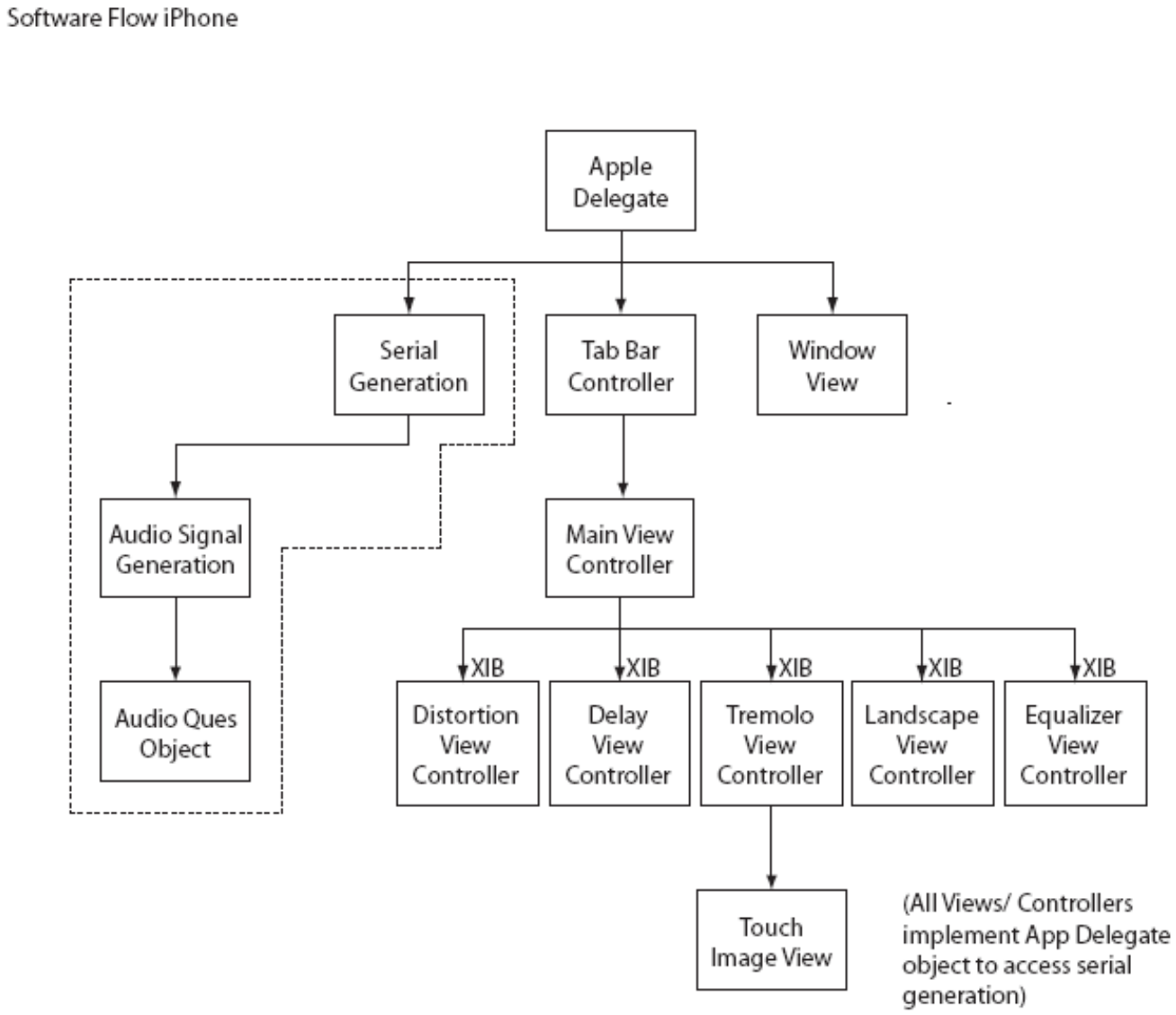


Figure 9 -- iEffects iPhone Code Flow

Cost Objectives:

Projected Price per iEffect Unit

Part #	Component	Price per Unit	Quantity	Cost
	PCB Board (4PCB - Barebones)	$ 63.00	1	$ 63.00
MSP430F2619	MSP430 Microcontroller	$ -	1	$ 9.35
TLV5619	D/A converter	$ -	1	$ 7.70
LT1013DDR	Operational Amplifier	$ 1.55	4	$ 6.20
NE5532	Operational Amplifier	$ 0.45	1	$ 0.45
	Resistors/Capacitors/Diodes	$ 0.10	~60	$ 6.00
	Switch	$ 3.00	1	$ 3.00
	Enclosure	$ 2.94	1	$ 2.94
	Audio Potermentiometer	$ 2.25	3	$ 6.75
	1/4" Jack	$ 3.00	2	$ 6.00
			TOTAL	$ 111.39

One Time Expenses	Cost
Apple iPhone OS 3.0 Development Tools (1 year license)	$ 100.00
MSP430 USB Programmer	$ 50.00

Table 1 – Cost Estimation

Division of Labor:

Below is each team member's responsibilities for this project.

-- Shuji Fujimaru is responsible for hardware design.

- Design equalizer effect circuit
- Design iPhone acquisition circuit
- Test and debug the analog circuitry
- Write MSP430 guitar effect codes

-- Ryan Nuzzaci is responsible for iPhone programming

- Build a guitar effect mode interface on iPhone
- Send a detectable signal to MSP430 from iPhone
- Design PCB boards for hardware components
- Write MSP430 'receive iPhone button data' code

Both of team members cooperated to seamlessly integrate guitar effect pedal accessory and iPhone.

Division of Labor

Item	Shuji Fujimaru	Ryan Nuzzaci
iPhone Programming (User Interface)	0%	100%
iPhone Programming (MSP430 Interface)	10%	90%
Analog Effects	80%	20%
MSP430 Programming (iPhone Interface)	40%	60%
MSP430 Programming (Digital Effects)	80%	20%
PCB Boards Design	30%	70%
PCB Boards Construction	50%	50%
Trouble Shooting	50%	50%

Table 2 – Division of Labor

Gantt Chart:

Our planned time line is shown in an attached Gant Chart. Numbers shown on the top of the chart represents a number of weeks. Available weeks in the summer 2009 are 12 weeks.

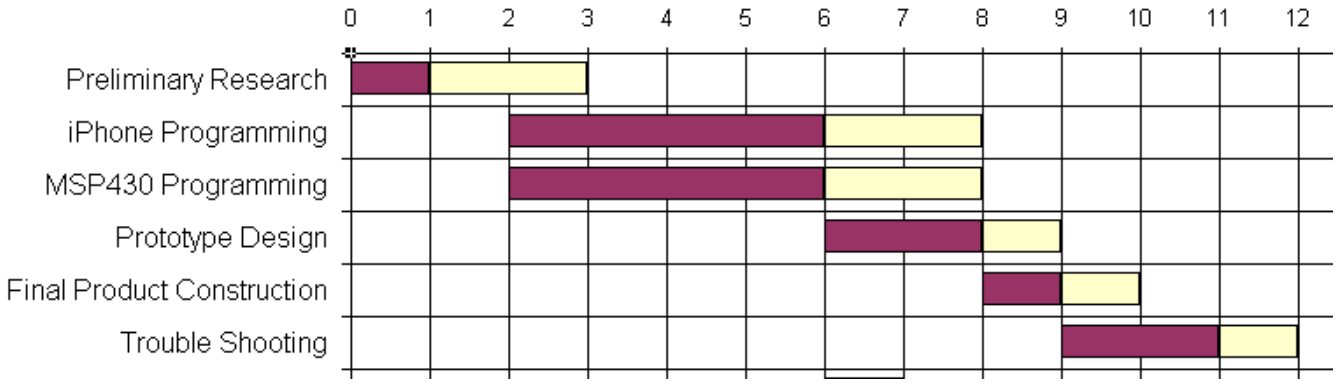


Figure 11 – Planned Gantt Chart

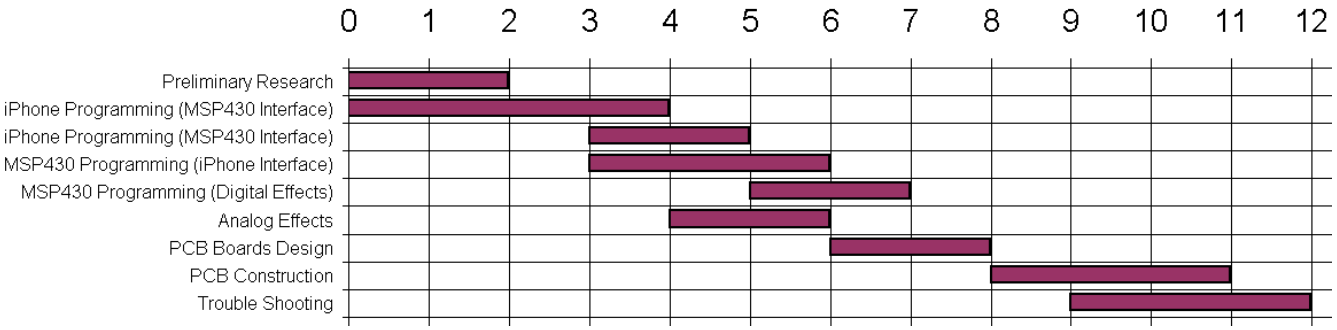


Figure 12 – Actual Gantt Chart

Appendix:

PCB Layout Design