

USB Audio Output Transmitter

Electrical Engineering Senior Design

Submitted to:

**Department of Electrical Engineering
University of San Diego**

Prepared by:

**Chris Robinson
Nick Moiseff
Veronika Rice
ELEC 492 – Fall 2005**

Wednesday, December 15, 2005

Table of Contents

Executive Summary	3
Introduction	3
Problem Statement	3
Market and Background Survey	3
Functional Requirements	4
Technical Survey	4
Block Diagram	5
Bill of Materials	7
Work Tasks	7
Test Plan/Results	7
Review of Constraints	8
Timeline	8
Description of Product Results	9
Budget	9
Personnel	9
References	11
Resources	11
Figure 4 – Schematic of Radio Transmitter Circuit	12
Figure 5 – PCB Layout of Radio Transmitter Circuit	12
Figure 6 – PCB Layout of Audio Filter Circuit	13
Figure 7 – Schematic of USB Hub Circuit	14
Figure 8 – Hub PCB Board Layout	15
Figure 9 – Schematic of PIC Layout	16
Figure 10 – PCB Layout of Transmitter with PIC circuit	17

Executive Summary

Audio technology has grown tremendously over the last five years. Because of the digitizing of music into MP3 format, much of today's music is downloaded and played on personal computers. Often times, the computers do not have an adequate speaker system, or the user desires to listen to audio signals within a certain area away from the computer. A simple solution to playing the audio file over stereo speakers is to wire the speakers to the computer. However, wiring is a large inconvenience and can be very costly if the consumer wants to wire speakers a far distance away from the computer. A solution to this problem is a USB Audio Output Radio Transmitter. The audio output transmitter will transmit the audio signal over a desired, programmable FM radio frequency, thus allowing a receiver to pick up and play the audio file over stereo speakers.

USB audio output radio transmitters are "a new way of allowing people the capability of taking advantage of MP3 files stored on the computer, and I do believe there's a market for it. People have this whole library on their computer and they want to listen to it in another room,"¹ said Connie Wong, an analyst at Semico Research in Phoenix, Ariz. According to Semico Research, the MP3 portable player market will see an annual compound growth rate of 30.4% between 2002 and 2007. Now that it is 2005, and iTunes as well as iPods are dominating the market, the power curve is here. The demand for USB audio radio transmitters is greater than ever.

Introduction

Due to the extensive research that we have done for actually implementing a design to address the problem of eliminating wires and creating a wireless network in which music files can be played we have come up with the following report. In this report we have documented everything that we have done to create our USB audio transmitter. This report provides an outline to the steps that we have taken over the last year to create a working audio transmitter. Following this report will allow anyone to recreate as well as understand primarily why and how we went through the engineering process, ultimately creating our final project.

Problem Statement

To research, develop, and build a device that will interact with a PC using Windows XP, take control of its audio output, and transmit that output over the FM radio frequency designated by the user.

Market and Background Survey

Audio output radio transmitters have started to develop over the last two years. The largest breakthrough with audio output radio transmitters has been by companies such as Griffin, Belkin, and Monster; all who have developed audio output radio transmitters that can be incorporated with Apple Computer's iPods. These audio transmitters are plugged into the iPod and use the iPod's battery power to transmit the audio signal from the iPod. However, these transmitters are not very effective because the signal is not very clear and the power needed to

¹ http://www.forbes.com/2003/07/18/cx_aw_0718tentech.html

transmit the audio signal consumes three times the amount of normal iPod battery consumption. While the product works, the sound quality fails with static. It also is affected by where the iPod is in relation to the receiver.

USB audio output radio transmitters are “a new way of allowing people the capability of taking advantage of MP3 files stored on the computer, and I do believe there's a market for it. People have this whole library on their computer and they want to listen to it in another room,²” said Connie Wong, an analyst at Semico Research in Phoenix, Ariz. According to Semico Research, the MP3 portable player market will see an annual compound growth rate of 30.4% between 2002 and 2007.

When the Aurius came out, towards the end of 2003, "a lot of online Internet connected audio products, which are capable of moving the audio portion signal across the house, haven't really caught on yet," In-Stat/MDR's Mike Paxton said. "It's not to say they aren't coming, but they might be a little bit ahead of the power curve."

Now that it is 2005, and iTunes as well as iPods are dominating the market, the power curve is here. The need for USB audio radio transmitters is greater than ever.

Functional Requirements

Our device is compatible with personal computers using Windows XP. The device is powered from a single USB port and is installed by the computer as an audio device as soon as it is plugged in. When opened, audio files are automatically sent to the hub and then the radio transmitting device. A graphical user interface (GUI), allows the user to input a desired FM frequency from a drop down menu. When the frequency is selected from the GUI it is sent to the USB Audio device where the music is modulated with the frequency for transmission. The 18F2550 microchip microcontroller will control the output signal modulation and send the finished signal to the transmitter. The transmitter will begin transmitting automatically through an attached quarter wave antenna, so that high quality audio output can be immediately listened to with the use of any FM radio within a limited radius.

We are powering our design solely on a 5V, USB, power supply. The amount of hardware that we are running from one 5V (100 mA) power supply is a large amount. We have decided to relinquish some range in order to give more functionality to one power supply.

Technical Survey

We purchased all of our demo boards and components from the Internet. We acquired the PIC from Microchip.com. We purchased another development kit that we thought would help us further understand how to interface a USB component with a computer, however, it helped very little. We acquired a USB hub device from Texas instruments as a free sample for 180 days. We had originally planned on using a design like this one but now we have modified the design. We are using a hub similar to the TUSB2036EVM however; our main modification is the elimination of the external power source jack. We plan on powering the device from the sole USB power supply. We will be using the BH1415F Wireless Audio link IC which is a very cost effective

² http://www.forbes.com/2003/07/18/cx_aw_0718tentech.html

chip to modulate the signal with the sound file. We have also used the Aurius USB Audio transmitter, as well as the FM-25B Ramsey Development Kit in order to further our understanding of USB Audio integration.

Block Diagram

During the Spring 2005 semester, most of our construction will consist of kits used to further our understanding of the incorporation of all of the parts of our proposed design. (see Figure 1)

The USB Hub will be connected to a personal computer via a single USB port. This hub will incorporate Dr.Paturo's Audio interface board with the microcontroller development kit. The microcontroller will allow for proper modulation of the audio signal at the chosen FM frequency. This output signal will be transmitted using the Ramsey Kit which includes a transmitter and antenna. The Ramsey Kit is connected to a 12V power source, which we plan to extinguish the need for by including a power boost from the 5V USB power source.

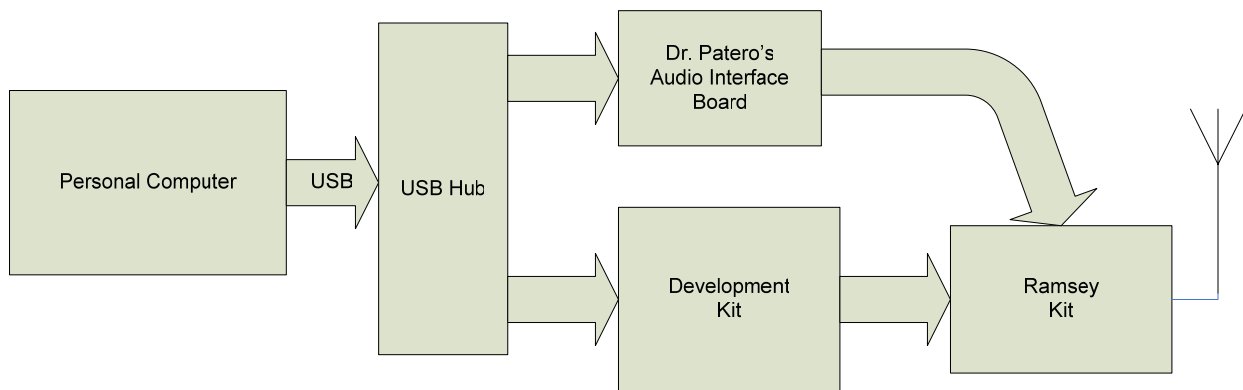


Figure 1: Block Diagram of USB Audio Output Radio Transmitter (completed SPR '05)

During the Fall 2005 semester, we will continue where our research has left off from the Spring 2005 semester. By the conclusion of the Fall 2005 semester, our team will have designed, tested and built a our own product with components mocked in function by the previous diagram. (see Figure 2)

The USB Hub is connected to a personal computer via a single USB port. This hub incorporates an Audio interface board with the microcontroller development kit. The microcontroller will allow for proper modulation of the audio signal at the chosen FM frequency. This output signal is then transmitted through the transmitter circuit and a quarter wave transmission antenna.

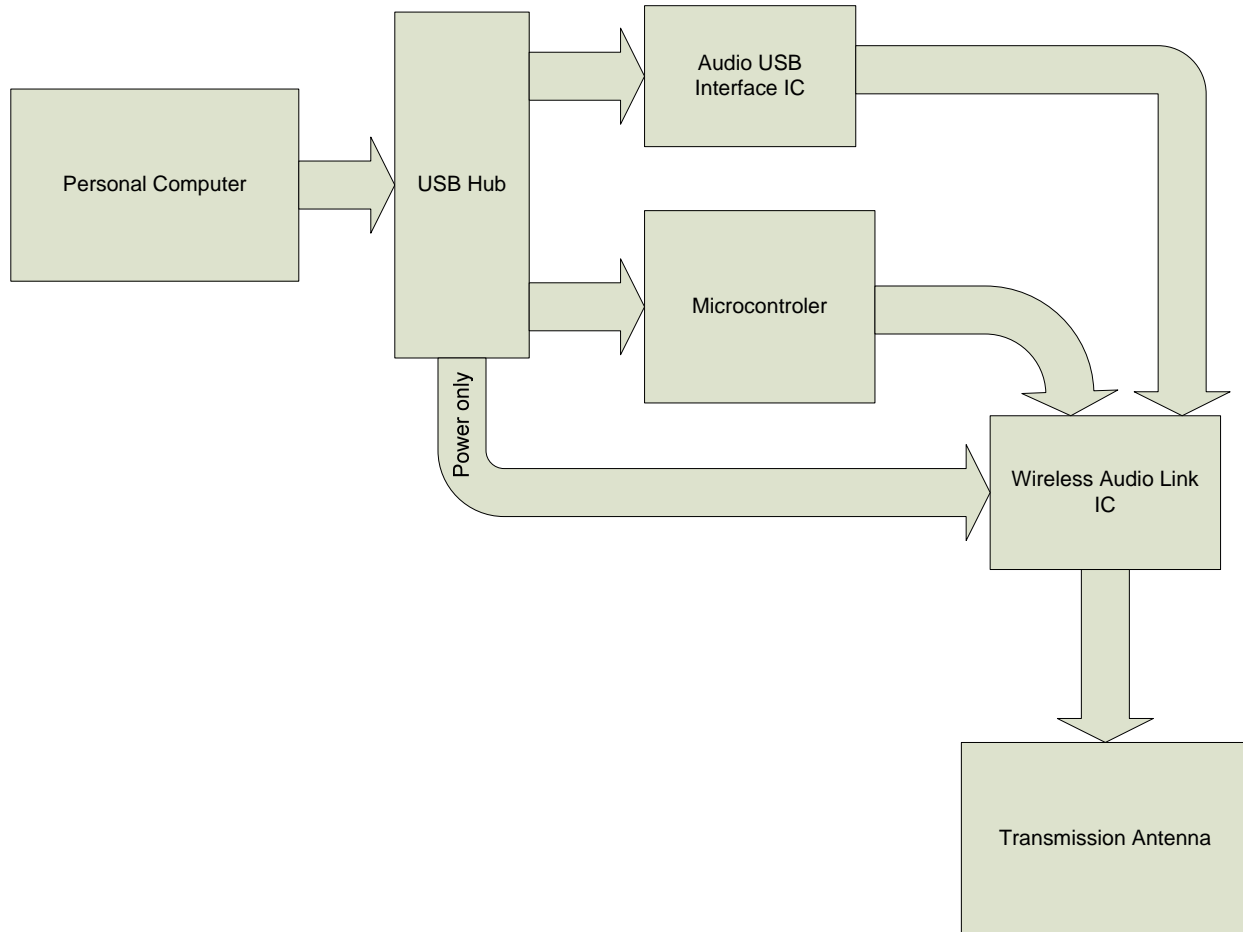


Figure 2: Block Diagram of USB Audio Output Radio Transmitter (12/8/05)

Where as our previous design included other components to create a larger transmission range, our final design incorporates a less power consumption approach; giving up transmission range for the need for only one power source. The microcontroller (18F2550) sends the desired frequency (at which the audio files are to be modulated) to the Wireless Audio Link IC and the wireless audio link actually modulates the frequency, sending the modulated signal to the transmission antenna.

The main sales appeal of our project is the reduction of wires and the use of just one power supply. Throughout the design process we constantly analyzed power consumption as well as the rest of our circuit. By being willing to sacrifice a larger transmission range we were able to compensate by using just one power supply. Originally we had intended on using a boost circuit but after a complete analysis of our circuit we have decided not to use a boost and drive our circuit solely from a 5V power supply through the USB port.

At this point we believe that we have engineered our product to meet our technical desires, as stated in previous statements.

Bill of Materials

1. Microcontroller (USB Development Kit)
2. USB Hub (TUSB2036 – Samples from Texas Instruments)
3. Audio USB Interface IC (Stereo-audio codec with USB interface – converts USB into audio signal) PCM2902E
4. Wireless Audio link IC (BH1415F)
5. FM Amplifier Circuit
6. Transmission Antenna
7. Computer with USB port
8. Board
9. Casing

Work Tasks

This project works for a three person team.

1. Design audio interface circuit required to interface computer and USB
2. Design FM transmitter with controller
3. Design and program controller
4. Design and Construct circuit board using USB power
5. Test and demonstrate working USB audio output radio
6. Publish Results to the Web

Test Plan/Results

As of October 13, 2005 we have completed numerous tasks while having more in front of us as well. We completed a Synthesized FM Stereo Transmitter kit. The kit modulates an input signal with a high frequency carrier signal. It outputs the signal at a desired frequency. This kit helps us to understand the Microcontroller as well as the Wireless Audio Link IC.

The second kit is the PICDEM FS USB Demo Board. The board is centered around a PIC that we are planning on using to convert the user selected into a string that will be recognized by the transmission IC as a particular frequency. The programming language is something that we are struggling with, in particular, trying to find the correct language to send to the PIC as well as outputting through the USB portion of the board.

We have utilized ExpressPCB to create the USB Hub device as well as our USB audio interface. We plan on populating a board with our final product making it an easy to use portable device.

The main sales appeal of our project is the reduction of wires. We analyzed the power consumption of all the used elements; we came to the conclusion that a 5V power supply is sufficient for a desired response range. Originally we had intended on using a boost but after a complete analysis of our circuit we have decided not to use a boost and drive our circuit solely from a 5V power supply through the USB port.

We calculated the power at different points within our finished product from last semester. By doing so we were able to eliminate many stages and modify others. At this point we believe that we have engineered our product to meet our technical desires, as stated in previous statements.

Review of Constraints

Our group is considering the following Non-Technical Restraints while researching the various parts of our design:

- (1) *Economic* – The closest product available on the market to our final project is the Aurius FM transmitter. This product achieves a transmitting radius of 30-50ft, is powered from the USB port of a personal computer, has programmable FM frequencies, and costs about \$50 per unit. To be competitive, our design will have to match or beat this range for this price.
- (2) *Environmental* – Our unit is intended to transmit to all of the rooms of in a home. Our transmitter will have a strong enough signal to be received on multiple levels through walls. There will also be competing radio signals that will limit the functional range of our transmitter. We are planning to use about six different possible user selected frequencies.
- (3) *Social* – Our product will be easy to use. Essentially it will be a USB plug and play component. This versatility will allow a wide range of users, targeting those with no background computers or electronic interfacing.
- (4) *Political* – The FCC limits the power output and field strength of personal transmitters. Our unit will comply with these regulations.
- (5) *Ethical* – Not abiding FCC regulations would be unethical and thus not an option. If we do produce a product that is capable of exceeding those limitations, adequate warnings will be issued to all consumers. If our product is going to be mass produced then modifications will be made to the signal strength.
- (6) *Health & Safety* – The casing of our unit should adequately protect consumers from exposed circuits. The goal to reduce wiring by having the unit powered solely from a single USB port reduces the risk of excessive dangerous wiring.
- (7) *Manufacturability* – Our overall aim is to produce a unit that is most effective as well as easy to use. The compact casing of our product and reduction of overall wiring will be beneficial once we enter the manufacturing process.
- (8) *Sustainability* – We are taking multiple precautions to protect our unit from possible malfunctioning of parts. In addition it is unethical to sell a product that is likely to stop working.

Timeline

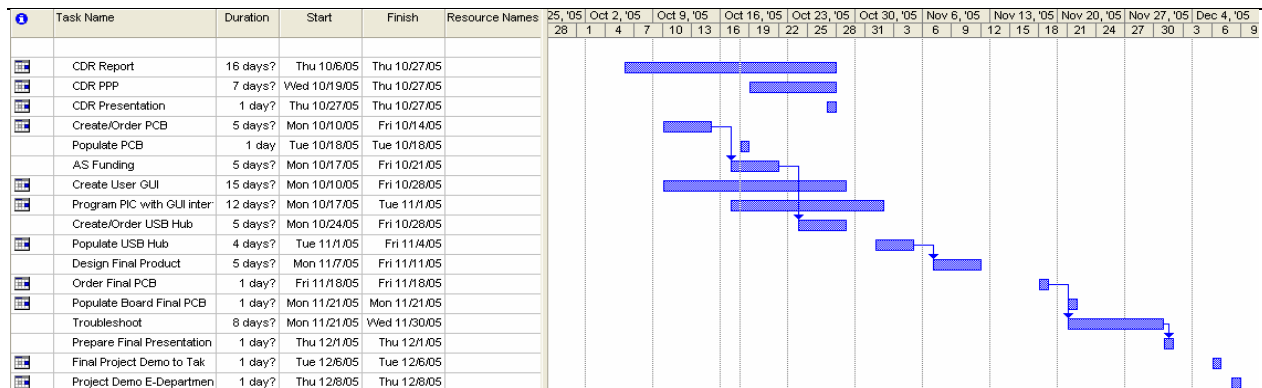


Figure 3: Timeline for Fall 2005 Semester

Description of Project results

Audio files are played from a digital audio player on the user's PC (iTunes, Music Match, etc). Since the computer recognizes the USB device as an Audio USB device, the audio files are transferred through the USB port. The digital files travel through the USB hub and then go to two different areas for two different functions. The microcontroller receives the desired frequency from the graphical user interface, then it takes this frequency and programs the wireless audio link IC using a program word. The program word is essentially entered by the user through from a drop down menu in the form of a possible frequency for reception. The digital file is converted from USB to audio signal within the USB Interface IC. The output from the Audio USB interface IC is modulated with the frequency set by the microcontroller. The Wireless Audio link IC's main job is to modulate the signal and send it to the quarter wave antenna transmission. When the modulated is transmitted by the quarter wave antenna the transmission can be received by any receiver by simply tuning to the frequency initially set by the user.

Budget

SPRING 2005:

USB Development Kit (\$119 for board without complier + \$7 for shipping and handling)	\$126.00
Aurius (\$40 + \$7 for shipping)	\$47.00
FM-25B Ramsey Development Kit (\$140 + \$10 Shipping)	\$150.00
Rohm BH1417f FM stereo modulator chip	\$2.00 each
Various Caps, Resistors, and Diodes	\$25.00 est.
Drivers and antenna	\$15.00 est.
Total Spring Budget	\$365.00

FALL 2005:

Custom PCB boards	\$210
Chips Parts	\$200
Presentation Supplies	\$10
Casing Units	\$20
Miscellaneous Supplies	\$20
Total Fall Budget	\$460.00

Personnel

Our team is made up of individuals that have different strengths. We have divided our group works tasks to allow each member of the team to contribute their strengths in order to create a well rounded expertise in Electrical Engineering.

(1) **Chris Robinson (RF Engineer)** has extensive skills with technical documents, compiling code, hardware assembly, circuit design, writing code (C++), control systems, programming and interfacing microprocessors, LAN design.

(2) **Nick Moiseff (Software Engineer)** has extensive skills with technical documents, software debugging, compiling code, telecommunications, website design, programming microcontrollers, circuit design, and memory upgrading.

(3) **Veronika Rice (Hardware Engineer)** has extensive skills with technical documents, hardware assembly, hardware organization, circuit design, circuit debugging, team organization, admin, and interfacing microprocessors.

The project leader is Veronika Rice. The team leader oversees company progress and is responsible to ensure that the company is meeting necessary deadlines.

Our individual work assignments are as follows:

WORK TASKS	CHRIS	NICK	VERONIKA
Project Preliminary Report	X	X	X
Component Search	X	X	
Budget Survey		X	X
Product Function Research	X		X
Documentation of Similar Product		X	X
Part Purchase		X	X
Microprocessor Research	X	X	
Microprocessor Code Invent	X	X	
Chip Research	X	X	
Board Layout			X
Board Construction	X		X
Product Testing/Debugging	X	X	X
Product Documentation	X	X	X
Initial Progress Report	X	X	X
Design Power Boost		X	
Design USB Hub	X		
Write Software		X	
Find Materials	X		X
Design/Order PCB			X
Build Prototype			X
Test, Debug Design		X	
CDR	X	X	X
Demo & Final Design Review	X	X	X
Portfolio	X	X	X

Conclusions and Recommendations

Upon completion of this system we have some various recommendations and conclusions. Over all our project works as expected. We were able to complete the overall goal of transmitting music over a user specified frequency at a desirable range. We ran into some problems along the way. The PIC was controlled using an oscillator and not a crystal. The crystal was incorrectly powered and thus the PIC relied on a counter from the same USB source. There was sufficient noise on the system that we would have liked to eliminate using a high pass filter thus making the signal more clear and distinct. A reason for so much interference could have been the location of the test sight being the University of San Diego, which is on top of a hill, thus allowing our system to accept most of the interference in the air. The amount of stations at which

we could transmit was limited as well. Instead of using eight different channels at which we could transmit music we were limited to just two. On the last day of testing our inductor created problems and allowed us to transmit on only one upper tier frequency and one lower tier frequency. With more time we would be able to replace the inductor and find out what was causing this hindrance.

A problem that we thought we were going to spend most of our time with was programming both the PIC18F2550/PIC18F4550 as well as the Graphical User Interface (GUI). Contrary to our primary belief, we successfully completed programming in less than two weeks. The programming works perfectly as the GUI interfaces perfectly with the PIC sending a user defined frequency at which the signal is modulated with.

References

<http://www.apple.com>

<http://www.belkin.com/index.asp>

<http://www.borland.com>

<http://www.engineeredaudio.com/products/aurius.html>

<http://focus.ti.com/docs/prod/folders/print/tusb2036.html>

<http://www.forbes.com>

<http://www.monstercable.com>

<http://www.ramseyelectronics.com>

Resources

Dr. Chuck Pateros

Microchip

MATLAB

MPLAB IDE v7.22

Borland C++ Programming

Ramsey FM25B Transmitter Kit

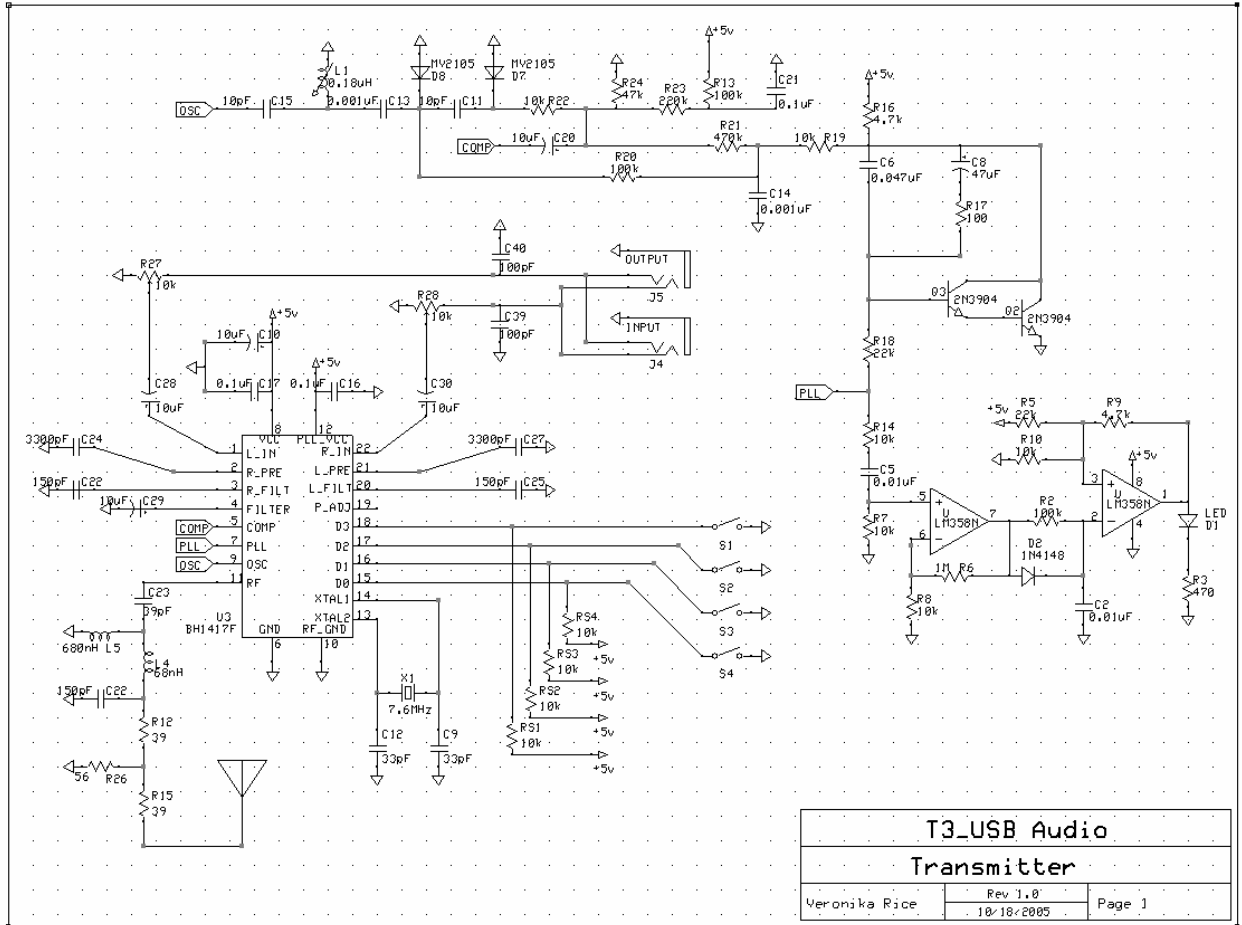


Figure 4 – Schematic of Radio Transmitter Circuit

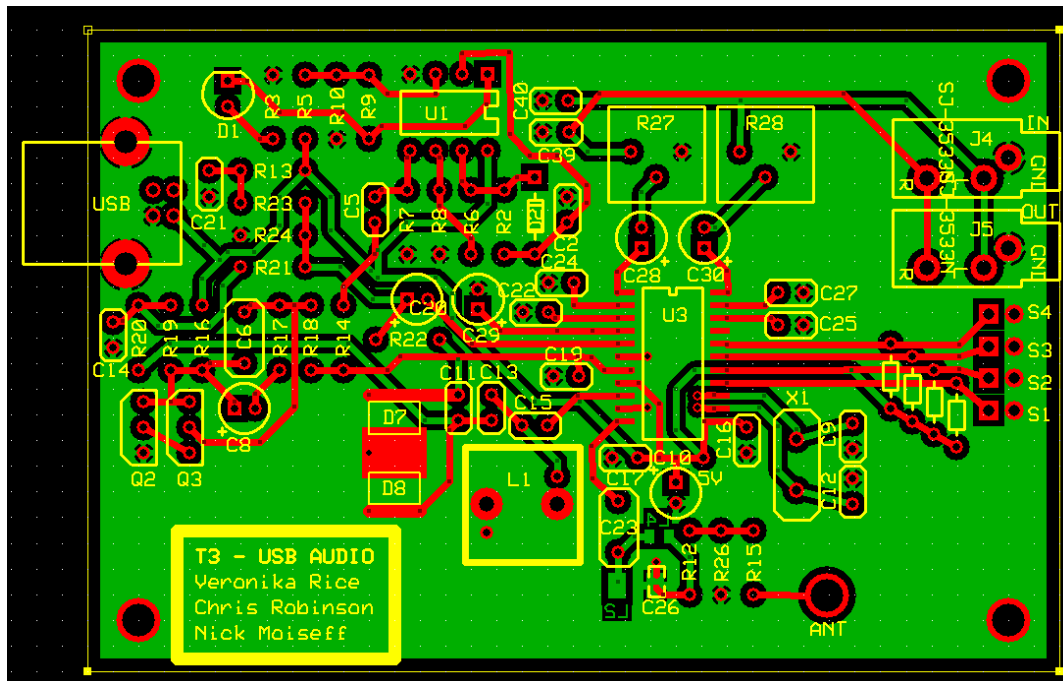


Figure 5 – PCB Layout of Radio Transmitter Circuit

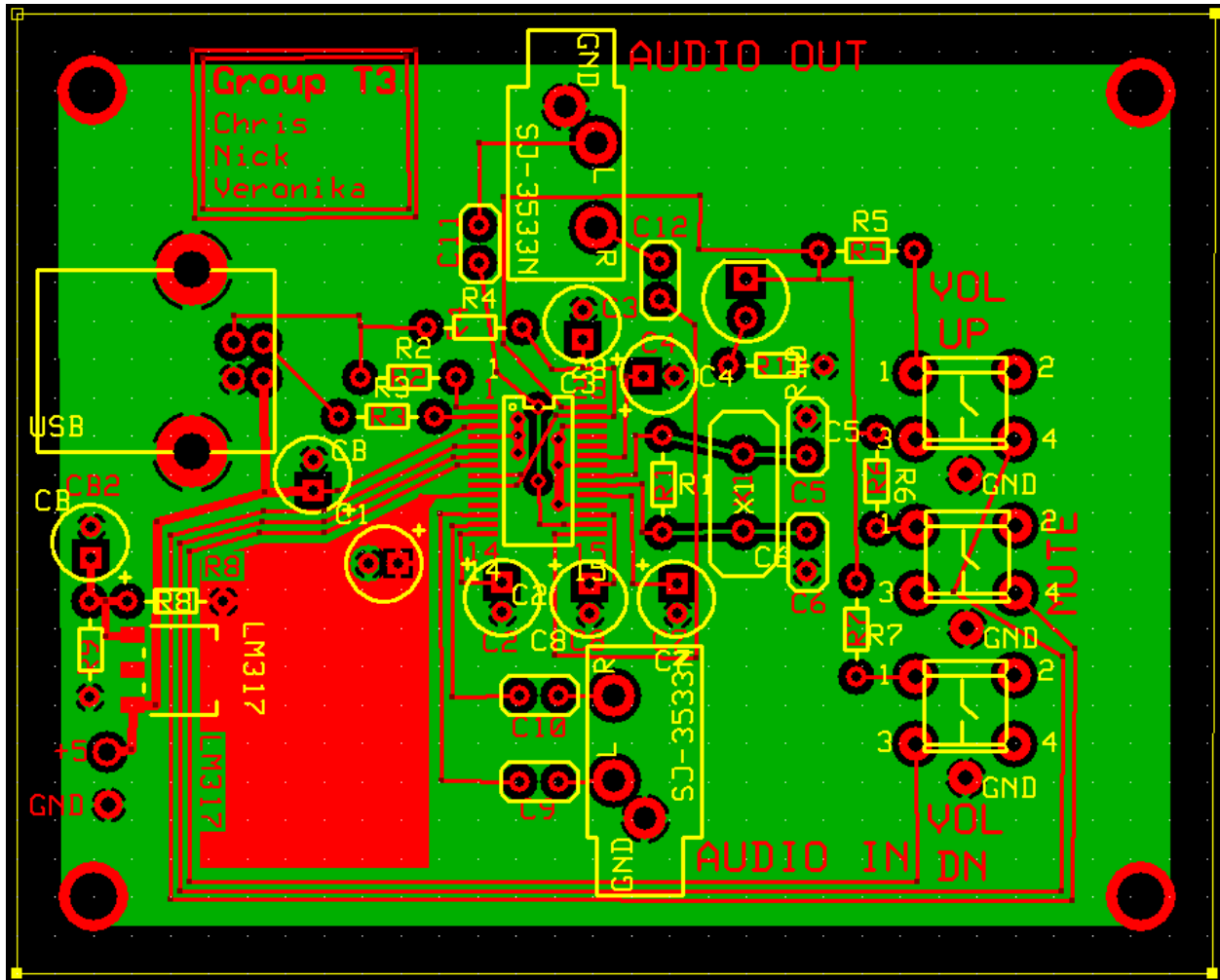


Figure 6 – PCB Layout of Audio Filter Circuit

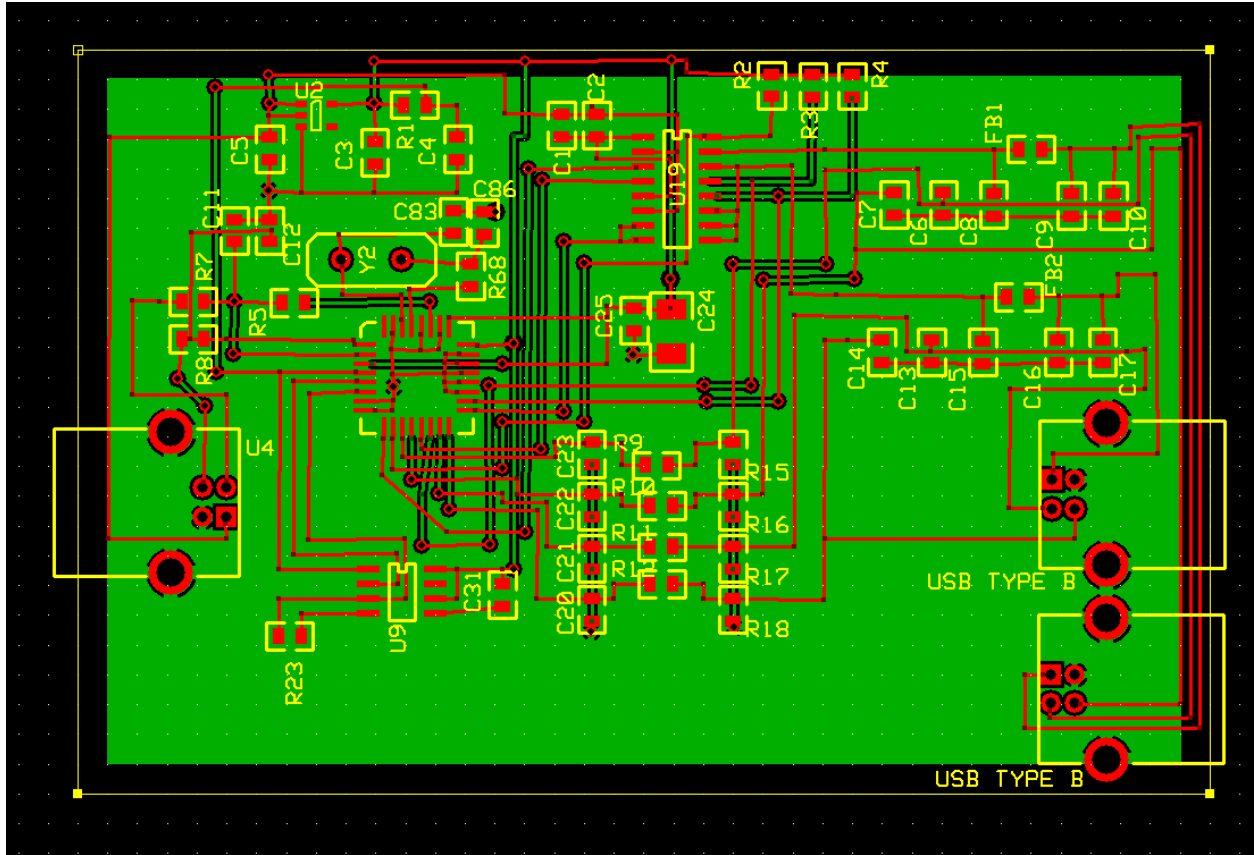


Figure 8 - Hub PCB Board Layout

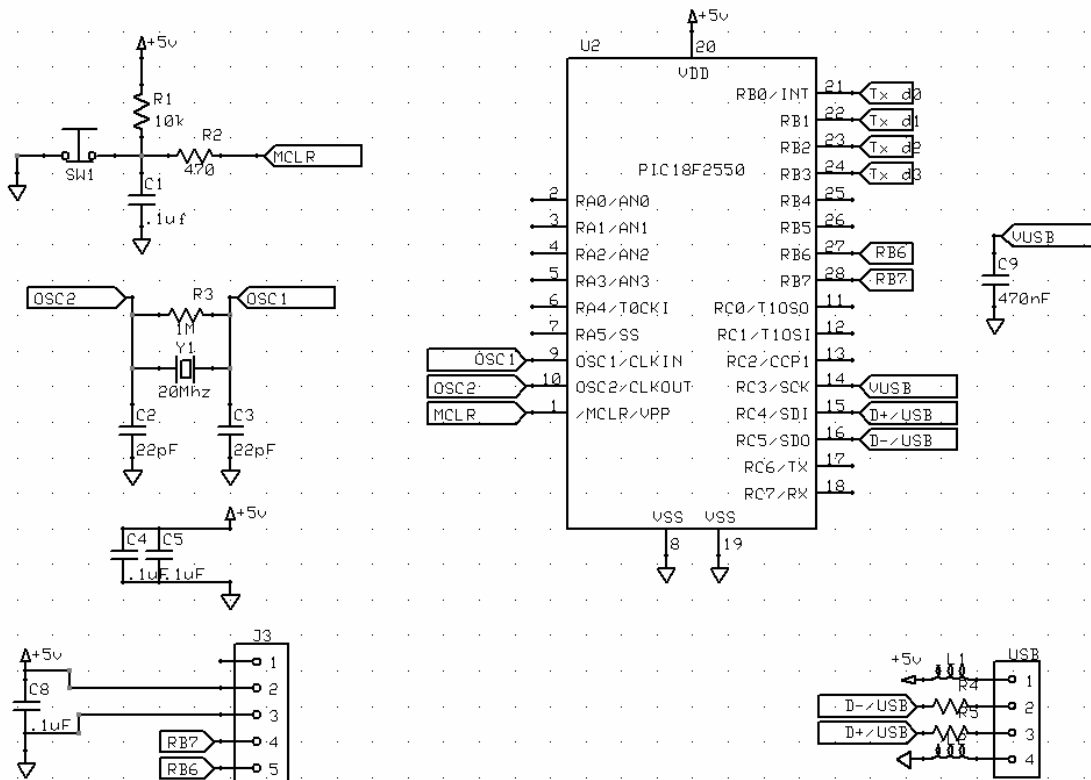


Figure 9 – Schematic of PIC layout

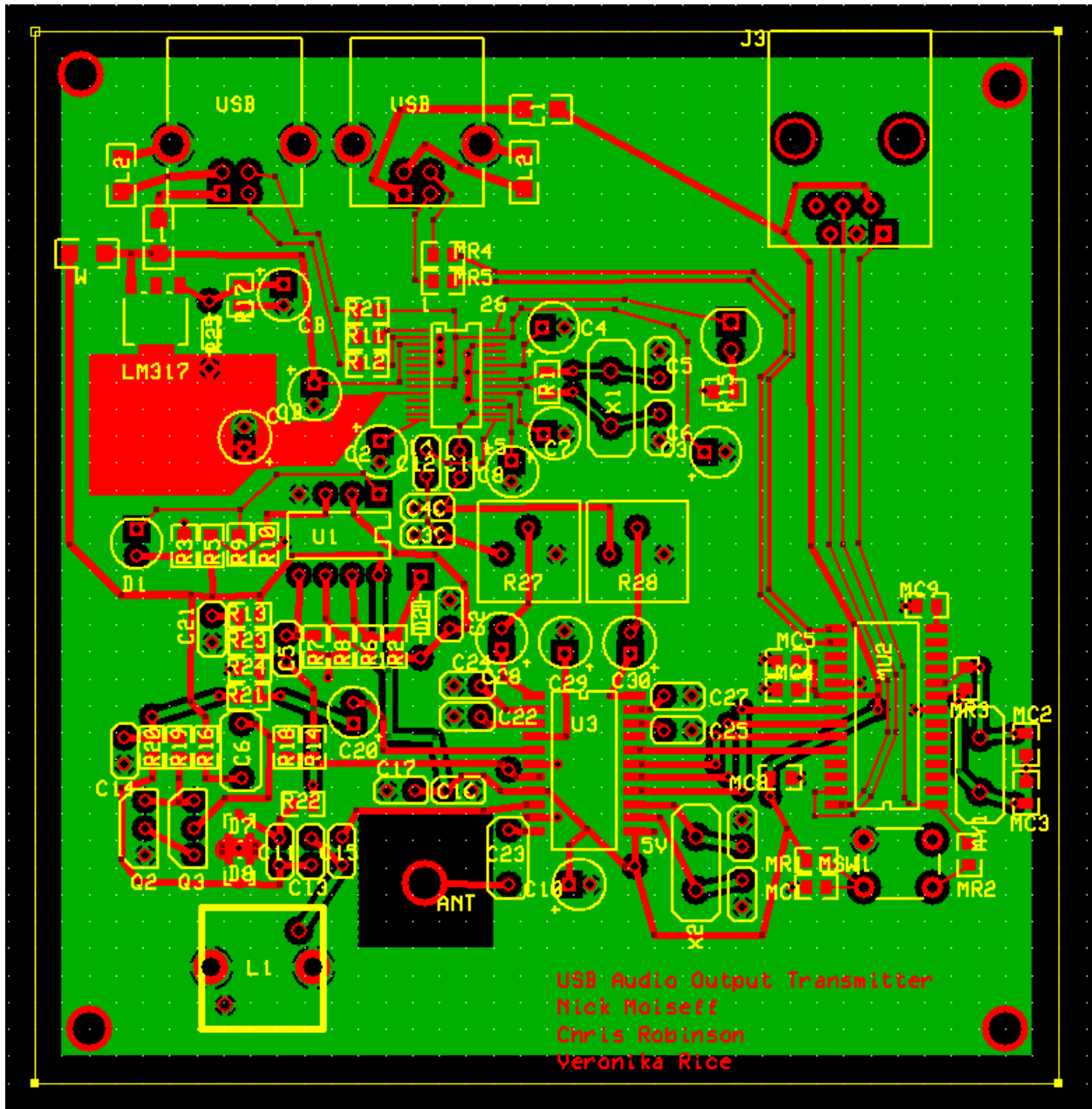


Figure 10 – PCB Layout of Transmitter with PIC circuit