

ADAPTIVE BABY MONITORING SYSTEM

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Abstract

The project focuses on designing a system that can assist parents with hearing disorders in taking care of their babies. The system includes a cry detector, which listens for a cry from the baby. This is achieved by extracting the Mel-Frequency Cepstrum Coefficients and then training a Support Vector Machine classifier, which determines whether or not the baby is crying.

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1. Introduction

1.1 Purpose

A baby's cry is an important signal that they are in need of care. For parents or caretakers with hearing disorders, it is sometimes hard for them to tell when a baby is crying. Our product will aid them and let them know when their baby is crying immediately so that they will know immediately and be able to provide assistance to the baby.

1.2 Objectives

Goals:

- Ensure that parents with hearing disorders are always aware of whenever the baby is crying and in need of care promptly.
- Optimize adaptability by providing immediate solution to alleviate stress from the baby.
- Functions and Features:
- Cry detector which will be trained using machine learning to adapt to a baby's individual cry.
- Notify parents or caretakers whenever the baby starts to cry through mobile app.
- Upon detection of cry, playback device will play music.
- Playback device, which is powered through a wall plug, contains a power routing system that powers all the different components of the playback device.

1.3 Block Diagram

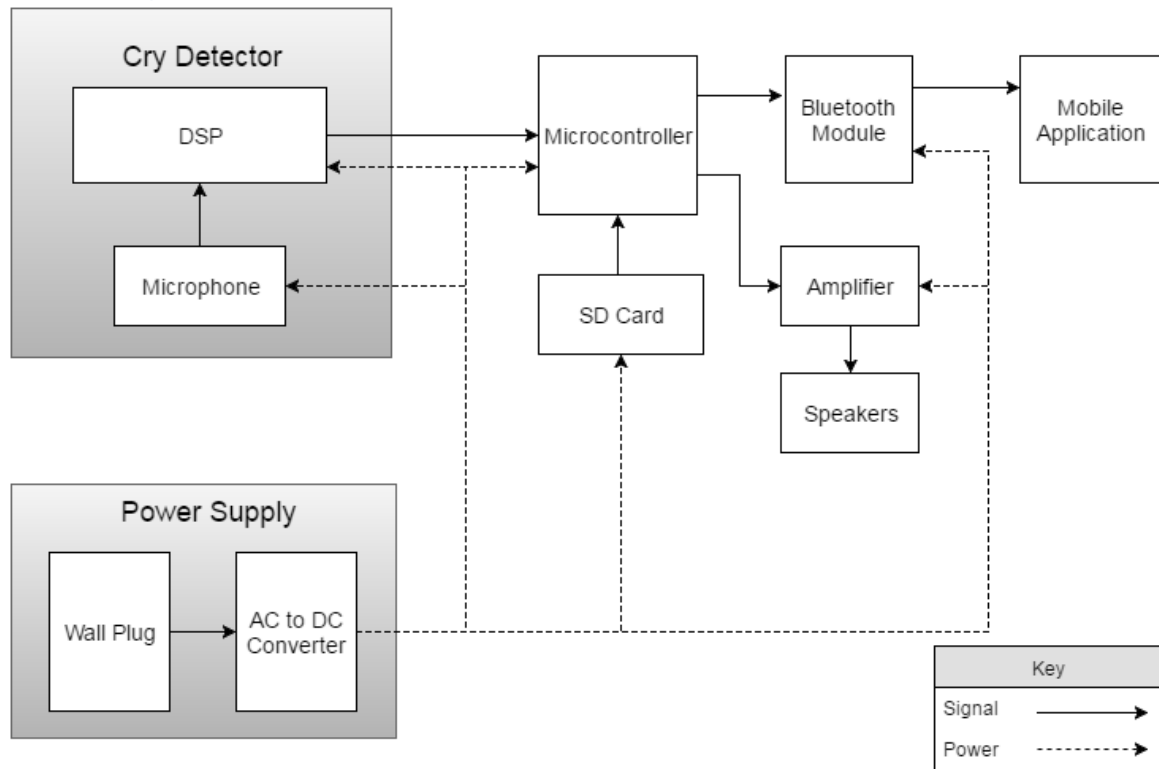


Figure 1: Block Diagram

2 Design

2.1 Cry Detector

2.1.1 Design Procedures

The first major design decision was the type of classifier to use. For the purposes of this project, the classifier must be able to perform fast enough in order to support real-time cry detection. We decided to use Support Vector Machines. While SVM classifiers take a long time to train, the time it takes to classify incoming audio signals is trivial.

The second design decision was what features to use in the classifier. Human vocalizations are distinguished primarily by the frequency components and power spectrum of the signal. Hence, we decided to use Mel-Frequency Cepstrum Coefficients as features.

The final design decision was where to implement the classification and feature extraction on. Initially, the plan was to implement everything on a Microchip Digital Signal Processor. However, we found out that it was very difficult to fit the parameters of a robust classifier into the very small RAM space of most commercial DSP's. Additionally, the DSP that we experimented on had a very limited set of instructions, so it was very difficult to implement both the classifier and the MFCC without prebuilt routines. For this reason, we substituted the DSP with a computer that ran MATLAB, as its processing speed and libraries for Digital Signal Processing and Machine Learning proved very helpful.

2.1.2 Design Details

Mel-Frequency Cepstrum Coefficients contain information about a signal's power spectrum distributed across multiple frequency regions in very compact form. The process of obtaining these coefficients is illustrated below [1].

1. Divide the signal into 25ms frames

This is done because we want to analyze the signal in a short time scale. Audio signals tend to vary greatly over long periods of time, so we want to shrink to a scale in which there is less variation in the signal.

2. Take Discrete Fourier Transform of windowed excerpt of signal

We then perform a windowing function, in this case a Hamming Window, and take the DFT of each windowed frame. The equation for DFT is shown in (1).

$$S_i(k) = \sum_{n=1}^N s_i(n)h(n)e^{-j2\pi kn/N}, 1 \leq k \leq K \quad (1)$$

3. Obtain power spectral estimate

We then obtain the average power spectral estimate as shown in (2)

$$P_i(k) = \frac{1}{N} |S_i(k)|^2 \quad (2)$$

4. Compute Mel-spaced Filterbank and filterbank energies

Then, we calculate the filterbank, which is a series of triangular filters that correspond to the different frequency regions of a signal. We decided to use 26 filterbanks. The filterbank is calculated by converting to the Mel-scale, which is shown in (3). Once we obtain the filterbank, as shown in (a) of Figure 2, we can calculate the filterbank energies simply by applying the filterbank to the average power spectral estimate obtained in the previous step, also shown in Figure 2. The filterbank energies represent the power of a signal distributed across different frequency components, represented by the filterbanks.

$$M(f) = 1125 \ln(1 + f / 700) \quad (3)$$

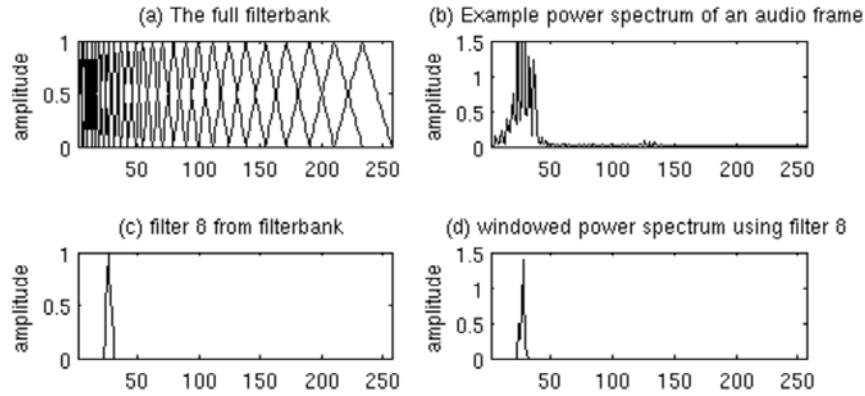


Figure 2: Illustration of Mel Filterbank

5. Take Discrete Cosine Transform of log filterbank energies to obtain cepstral coefficients

Then, we take the log of the filterbank energies and take the Discrete Cosine Transform. The resulting amplitudes of the DCT become the cepstral coefficients that we use in the classification. We decided to use 13 of the 26 coefficients.

The result of the MFCC process described above is then used as training data for the SVM classifier [2]. The coefficients for each frame will be used as feature vectors in the classifier. The algorithm for classification is illustrated in the flowchart in Figure 3 [3].

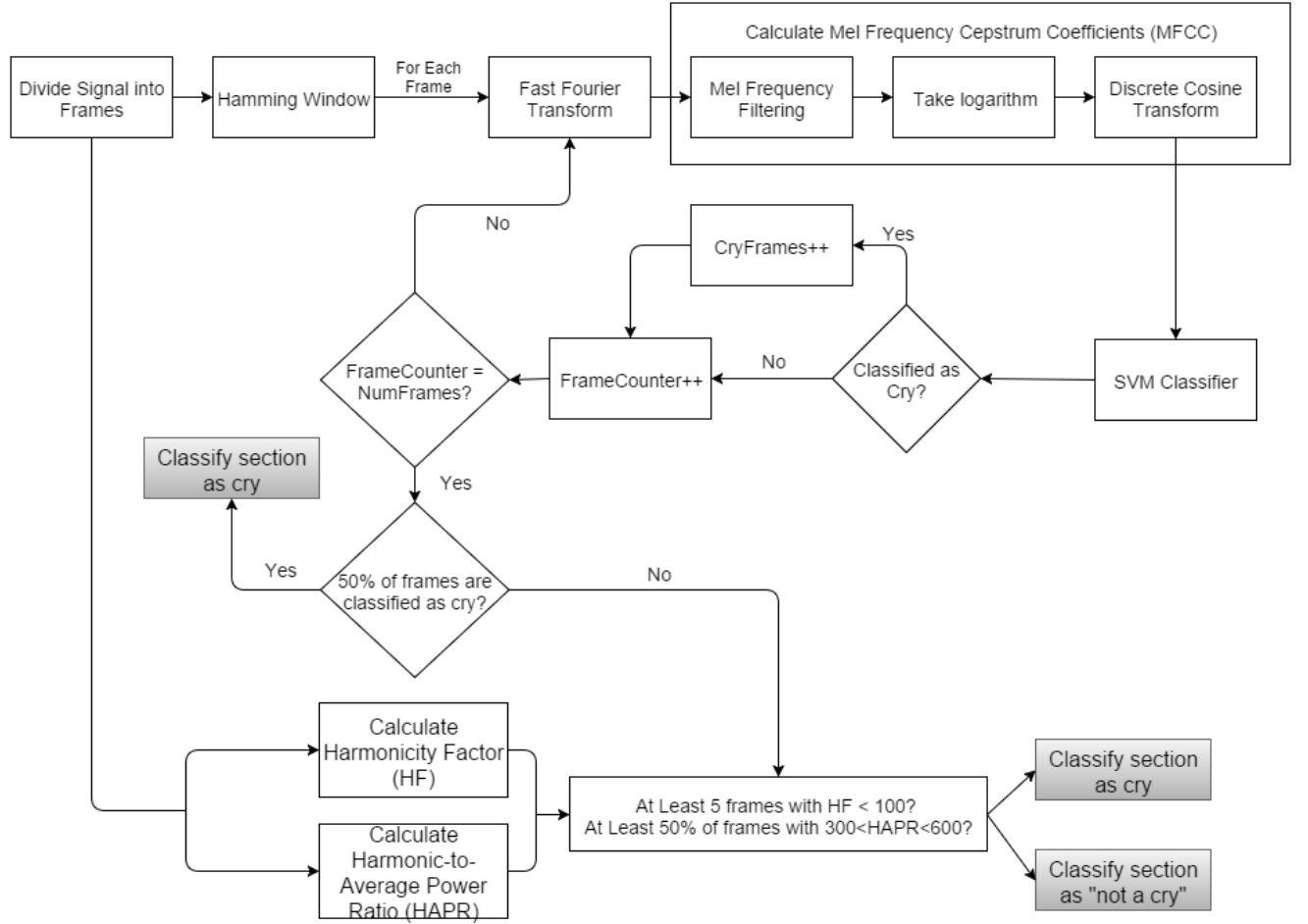


Figure 3: Flowchart of Cry Detection Algorithm

For the purposes of this project, we are using Binary SVM Classification, as each frame is classified as either cry or no cry. We perform MFCC on all the training data to obtain the feature vectors, and we label each of these feature vectors with a 0 or 1, with 0 being a no-cry and 1 being a cry.

The model is trained by minimizing the expression (4) with respect to $\alpha_1, \dots, \alpha_n$ and $0 \leq \alpha_j \leq 1$ for $j=1, \dots, n$. $G(x_j, x_k)$ is the j -kth element of the Gram matrix, whose kernel is a Gaussian, as shown in (5) [4].

$$0.5 \sum_{jk} \alpha_j \alpha_k G(x_j, x_k) \quad (4)$$

$$G(x, y) = \exp(-(x-y)'(x-y)/(2\sigma^2)). \quad (5)$$

In the testing phase, we calculate a score based on the score function. If the score is negative or zero, then we classify the frame as a no-cry. Otherwise, if the score is positive, we classify the frame as a cry.

2.2 Microcontroller

2.2.1 Design Procedures

This was implemented by an Arduino built on top of an ATmega328p microcontroller. The microcontroller will receive input signal from the DSP, which will be high when a cry is detected and low otherwise. The microcontroller also interfaces with a SD card to play WAV files from it. Using libraries on the Arduino, the microcontroller was programmed to output the audio signal as PWM to the amplifier [5].

The ATmega328p also facilitates interaction between the DSP and Bluetooth module, as it sends a signal to the Bluetooth module whenever a cry is detected [7]. That way, the mobile application, which interfaces with the Bluetooth module, knows when a cry is detected based on the input from the DSP, and it will send a notification accordingly. The ATmega328p send data to the Bluetooth module using serial communication to send the notification.

2.2.2 Design Details

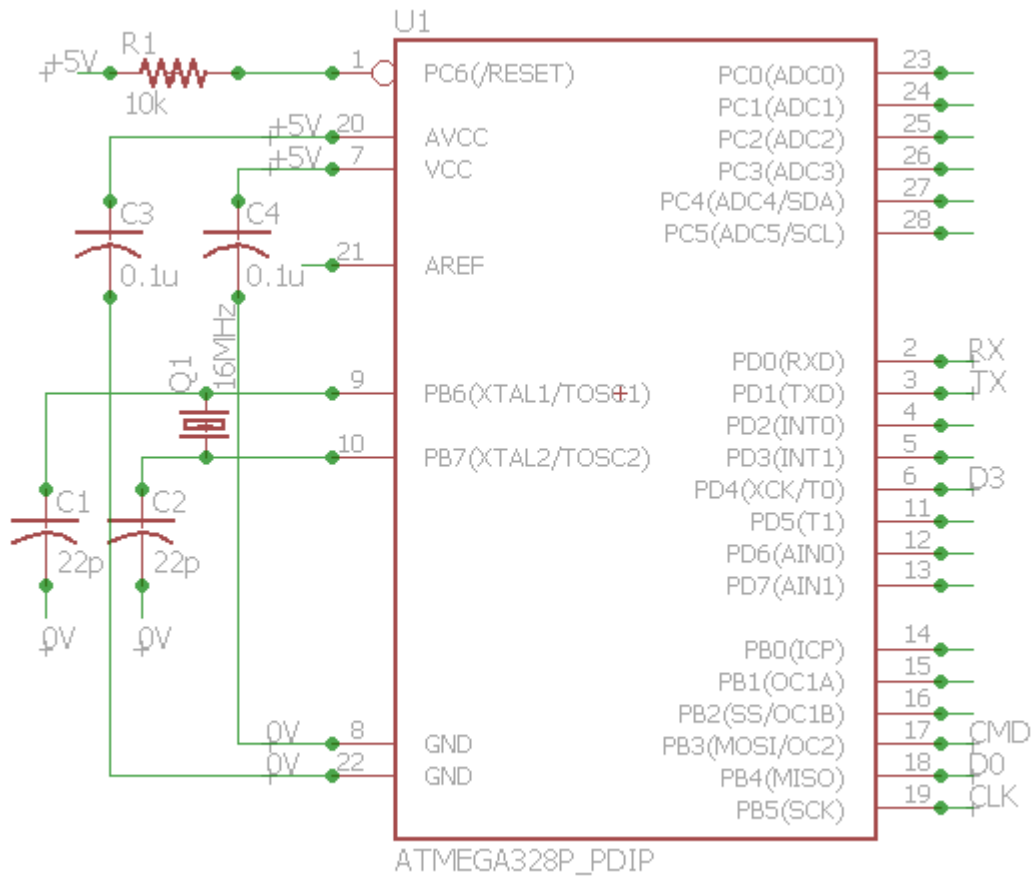


Figure 4: Schematic of Microcontroller [6]

2.3 Audio Output

2.3.1 Design Procedures

Amplifier

The amplifier acts as a amplification stage to connect the audio output from the microcontroller and the speaker. Since the speaker is a heavy current load, the direct output from the microcontroller will fail to drive it. The amplifier will be using a fully discrete design to ensure the flexibility and power to drive a low impedance and high current load. The amplifier will buffer (when gain is equal to 1) or increase the voltage and provide the current that will be able to drive the speaker. The amplifier have an a gain of 10 with adjustable volume by using a potentiometer. The amplifier is splitted into three basic parts: input stage, voltage amplification stage and output stage.

The input stage is implemented as a differential pair, so the gain is controllable with a negative feedback loop. Voltage amplification is implemented with a Class A common emitter topology.

Choosing class A instead of Class B or Class AB eliminates any crossover distortion at this stage. Since the role for voltage amplification stage is only amplifying the voltage, not much current is flowing in this stage, so the poor power efficiency of class A amplifier at this stage will not significantly affect the overall efficiency of the amplifier system. The trade off is power vs. distortion, and we pick better distortion for this stage.

The output stage is implemented with a Class AB stage, since the amplifier needs to provide several watts of output. Class A amplifier has efficiency less than 25% while class AB can go over 50%, so class AB is the choice for output stage. The amplifier is a audio amplifier so both half cycle of the signal needs to appear at the output, leading to the push-pull common collector topology for this stage.

Speaker

The speaker is a simple passive device that accepts audio signal and plays the WAV file from the SD card. It takes the output of the amplifier as an input.

2.3.2 Design Details

Amplifier:

The amplifier shown in Figure 5 is adapted from a basic three stage audio power amplifier [9]. It is implemented in the following stages.

Input network

R_{21} and C_5 forms a low pass filter to filter out some radio frequency signal.

$$f_{-3dB} = \frac{1}{2\pi RC} = \frac{1}{2\pi * 2200 * 330 * 10^{-12}} = 219kHz \quad (6)$$

R_{20} is picked to be the same value as R_{14} in the feedback network to balance out the differential.

Input stage

Q_3 , R_1 , R_2 and R_3 forms a 2mA current source. R_1 and R_2 is picked so that that the base of Q_1 is set to a known value. Then assume that V_{be} is 0.7V, we can pick R_3 to get the desired current. The output resistance is relatively high so we don't need to worry too much about the load.

$$\begin{aligned} V_b &= \frac{R_2}{R_1 + R_2} * V_{cc} = \frac{10k}{2k + 10k} * 12 = 10V \\ V_e &= 10 + 0.7 = 10.7V \\ R_3 &= \frac{V_{cc} - V_e}{I} = \frac{12 - 10.7}{2mA} = 650\Omega \end{aligned} \quad (7)$$

The 2mA current will be used to biasing the input differential pair which acts as first stage gain and also the comparator for the negative feedback network.

Voltage amplification stage

R_5 , R_6 , R_7 and Q_4 are used to form another current source. This time 10mA is needed for the voltage amplification stage.

$$R_7 = \frac{V_{cc} - V_e}{I} = \frac{12 - 10.7}{10mA} = 130\Omega \quad (8)$$

Q_6 is used in the voltage amplification stage configured as a common emitter amplifier with emitter degeneration.

R_4 is used to bias the base of Q_6 . Assume that Q_6 has V_{be} of 0.7V and also an emitter voltage at 0.3V+V_{ee} resulting from the biasing current and the emitter resistance. Also the current across R_4 is approximately 1mA from the differential pair. We can calculate the value needed for R_4 .

$$R_4 = \frac{V_e + V_{be}}{I_4} = \frac{0.3 + 0.7}{1mA} = 1k\Omega \quad (9)$$

R_{10} is the degeneration resistor to boost the bandwidth and linearity for the amplifier. C_1 is the miller effect capacitance added to stabilize the amplifier.

Output stage

The output stage is formed by using a push-pull network to form a class AB emitter follower. It is implemented by two complementary Darlington pairs that is capable of very high current gain. TIP41C and TIP42C which are complementary power BJTs are used here to make sure it can handle large current. The output stage is biased using a V_{be} multiplier consists of Q_5 , R_8 and R_9 . We need at least $4 * V_{be}$ between the base of Q_3 and Q_9 to ensure the output stage is active.

$$4 * V_{be} = \frac{R_8 + R_9}{R_9} * V_{be}$$
$$\frac{R_8}{R_9} = 3 \quad (10)$$

In practical, R_8 is set to 2k and R_9 uses a potentiometer so we can balance the distortion and power of the output stage.

Feedback network

The previous stages provides a very large open loop gain of at least several thousand. We don't need that much gain since the input is a typical 1Vrms signal from the DAC. We want the output voltage in the range of +10V to -10V, leaving some headroom to the current source and transistors. The actual gain needed depends on the input signal. R_{13} and R_{14} forms the feedback network. It is basically a voltage divider that feed a portion of the output to the differential stage. The gain is:

$$G_v = \frac{20k + 2k}{2k} = 11 \quad (11)$$

The overall gain considering the input stage is:

$$A_v = \frac{20k + 2k}{2k} \cdot \frac{2.2k}{20k + 2.2k} = 9.9 \quad (12)$$

Load

The load will be an 8 Ohm speaker. The actual load will be reactive and have different impedance at different frequency.

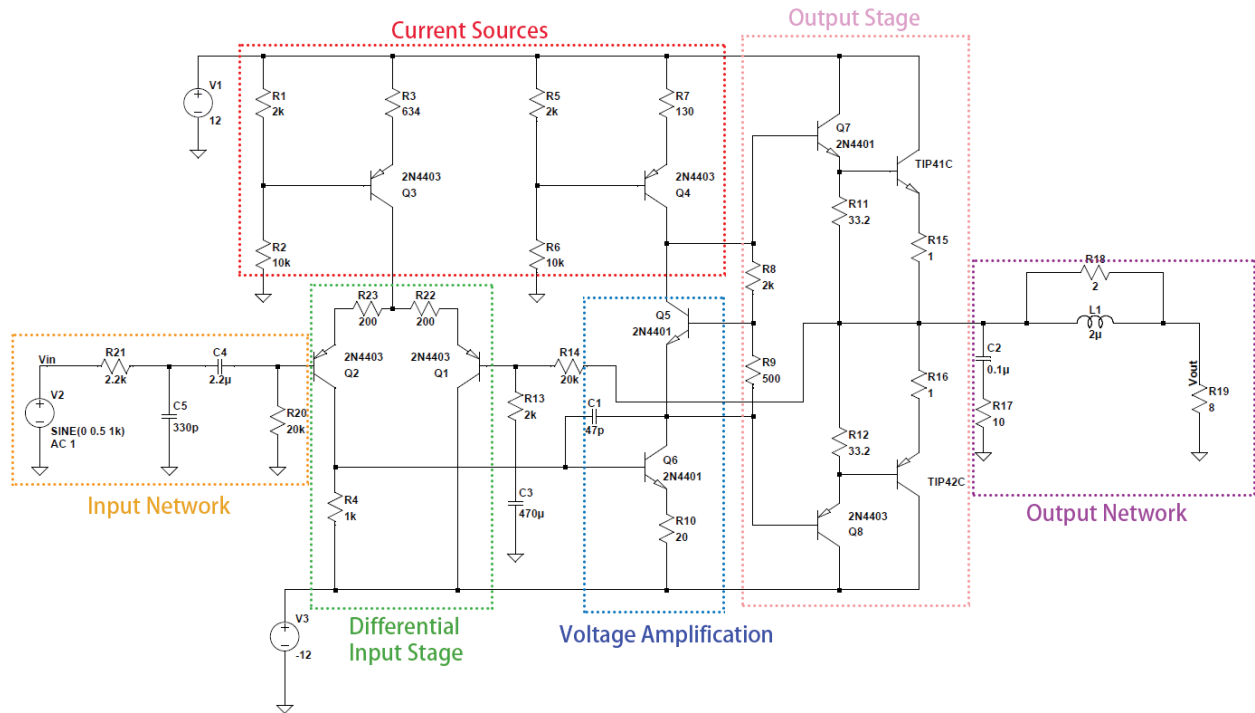


Figure 5: Schematic for the Amplifier

2.4 Power Supply

2.4.1 Design Procedures

The power supply will convert 120 VAC to +12V, +5V, +3.3V and -12V DC. It is used to power up the entire system. +/-12V rail will be used for the amplifier, +5V rail for all other IC chips and +3.3V for SD card module.

A transformer will be used to bring 120VAC down to approximately 12VAC. A bridged rectifier will be built from diodes to rectify the AC voltage. A capacitor will be used as a filter to reduce the ripple. Four LDO regulator ICs together with resistive network will be used to regulate the filter output and produce the four DC rails.

2.4.2 Design Details

The power supply will create four voltage rails.

Filter Capacitor

Assume maximum current load of 2A.

$$V_{ripple} = \frac{I}{fC} = \frac{2A}{60Hz * C}$$
$$V_{rectifier,out} = V_{transformer,out} - V_D = 12\sqrt{2} - 1 = 15.9V \quad (13)$$

We want the +12V voltage to stay above +10V at all time.

Then assume the highest output rail of 12V and highest dropout voltage of 3V, which results in the input of the regulator to be 15V.

$$V_{filter,min} = V_{rectifier,out} - V_{ripple} = 10V$$
$$V_{ripple} < 5.9V$$
$$C > 5650\mu F \quad (14)$$

To compensate for other voltage drop and stability, we picked a higher capacitor at 10000uF.

Output adjustment resistors

According to the datasheet of regulator [10].

$$V_{out} = 1.25(1 + \frac{R_2}{R_1}) \quad (15)$$

So in order to achieve 12V, 5V and 3.3V output, set R1 to 120ohm and calculate for R2.

$$R_2 = 120(\frac{V_{out}}{1.25} - 1) \quad (16)$$

$$R_{2,12V} = 120(\frac{12}{1.25} - 1) = 1032\Omega \quad (17)$$

$$R_{2,5V} = 120(\frac{5}{1.25} - 1) = 360\Omega \quad (18)$$

$$R_{2,3.3V} = 120(\frac{3.3}{1.25} - 1) = 197\Omega \quad (19)$$

3. Design Verification

3.1 Cry Detector

To verify that the classifier was accurate enough to meet our requirements, I performed a series of tests, namely 10-fold cross validation, resubstitution.

10-fold cross validation involves dividing the training data into 10 folds. We pick 9 of these folds to train a SVM classifier and 1 of these folds to test the classifier and compare its result to its given label, “cry” or “no cry”. This is repeated until all possible combinations have been fulfilled.

We received a classification accuracy of 94.8453%, which was well above our requirement for 80% as shown in the Requirements and Verification Table in Appendix A.

Resubstitution involves running the classifier on all the training data. The resubstitution loss was 4.9088%, meaning that the accuracy was 95.0912%, which was well above our requirement for 80% as shown in the Requirements and Verification Table.

Upon playing a cry sound, our system was able to detect a cry and send a signal to the microcontroller successfully in under 30 seconds, which was our listed requirement in the Requirements and Verification Table. Despite not implementing the classification on a Digital Signal Processor as originally desired and using a computer running MATLAB instead, the response time for our cry detector met the requirements.

3.2 Microcontroller

For the atmega328p, the requirement of being able to play music within 15 seconds of detection was needed to ensure that there was a quick response to a cry detection. This was measured by triggering a cry by setting a specific pin on the atmega328p and timing the time that it took for music to start playing. When tested the microcontroller had responded to the cry signal within 3 seconds of the pin being triggered and had sent a notification through Bluetooth, which had met the requirement for the audio playback from the microcontroller.

Another requirement was the speed of the audio played on the atmega328p in comparison to the actual audio speed when listened to on a computer. Using the audio file's track time, another timer could be used to time the audio playback from the microcontroller and compare it with the time of the actual audio file. Once tested the playback had shown to be 1:1 with the actual audio playback time which played for 30 seconds and had been matched by the microcontroller playing the audio for 30 seconds.

Lastly, there was a requirement for the audio playback to have less than 5 artifacts per minute. The issue was caused by audio track ending and was remedied by disabling the audio from playing completely before the song track finished. This requirement was met since the audio had no artifacts while it was playing.

3.3 Audio Output

The most important test of the amplifier is that it will reproduce the input waveform with the desired gain. The goal of the amplifier is set to approximately 10. The absolute minimum requirement is 8V/V when the input is 1V peak to peak at 1kHz and the load is 8Ω. This also ensures it outputs 1W into 8Ω load.

The required gain also needs to cover all audible frequency range from 20Hz to 20kHz. This should be at least above -3dB of the mid-band gain at 1kHz. Actual performance usually needs to be much better than this.

We don't want DC offset appears at the output since it will generate heat other than producing sound from the speaker, also it will displace the cone of the speaker leading to distortion. We decided on 1V maximum DC offset is allowed so that the displacement of the speaker cone is not significant, and the heat generated is not excessive.

Finally the idle power needs to be as low as possible since most of the idle power just turns to heat, which is a waste of power. The maximum allowed for idle power is 2W.

The test results are summarized in table 1.

Requirements	Test Results
With 1kHz 1Vp-p input, 8Ω load, the output should be at least 8Vp-p. This makes sure that overall gain is at least 8V/V and output power is at least 1W.	Vout=9.55V
With 20Hz and 20kHz, 1Vp-p input, 8Ω load, the output should not dropped by more than 3dB compared to 1kHz input.	Vout=9.40V (-0.14dB) @ 20Hz Vout=9.49V(-0.06dB) @ 20kHz
With 1kHz 1Vp-p input, 8Ω load, the output DC offset should not be greater than 1V.	Vdcoffset=-0.13V
Idle power dissipation should be less than 2W.	Pidle=1.76W

Table 1: Audio amplifier verification summary.

We can see all requirements are met as listed in the R&V table.

3.4 Power Supply

The power supply needs to provide stable output voltage with the required voltage level and enough power.

The detailed requirements for each component and the test results are listed in table 2.

Component	Voltage	Current	Power	Test Results
Amplifier	+12V	1A	12W	+11.8V
	-12V			-12.2V
Microcontroller	+5V	4mA	20mW	+5.04V
SD Card	+3.3V	100mA	330mW	+3.29V
Bluetooth	+5V	30mA	150mW	+5.04V
Total			>13W	

Table 2: Power supply verification summary

We can see all requirements are met as listed in the R&V table.

4. Costs

4.1 Parts

Description	Source	Part	Quantity	Cost/Unit	Total Cost
Microcontroller	Mouser	ATmega328p	1	\$3.37	\$3.37
Digital Signal Processor	Mouser	Microchip dsPIC30F2010	1	\$4.22	\$4.22
Full-range speaker	Parts Express	Dayton Audio CE32A-8	1	\$3.65	\$3.65
Bluetooth Module	Amazon	KEDSUM Arduino Wireless Bluetooth Transceiver Module	1	\$9.99	\$9.99
SD Cards	Amazon	SDSDB-016G-AFFP	1	\$5.99	\$11.98
Microphone	Digikey	I2S SPH0645LM4H-B	1	\$3.06	\$3.06
LDO Regulator	Mouser	LM338T/NOPB	3	\$1.90	\$5.70
Negative LDO Regulator	Mouser	LM337T/NOPB	1	\$1.59	\$1.59
AC/AC Adapter	Allied Electronics	Hammond Manufacturing BPE2G	1	\$21.25	\$21.25
Passive devices	ECE parts shop	/	/	/	/
Total					\$64.81

4.2 Labor

Name	Hourly Rate	Total Hours Invested	Total = Hourly Rate x 2.5 x Total Hours Invested
Michael Qiu	\$30	240	\$18,000
Luis Ramirez	\$30	240	\$18,000
Yueyang Lin	\$30	240	\$18,000
Total Labor Cost			\$54,000

4.3 Grand Total

Section	Total
Labor	\$54,000
Parts	\$64.81
Grand Total	\$54,064.81

5. Conclusion

5.1 Accomplishments

We succeeded in integrating the cry detector together with the notification system and the music player. Our verifications show that all the components of our project work effectively. Our demonstration showed that our cry detector was able to distinguish between baby cries and various other human vocalizations. The cry detector was able to communicate with the Bluetooth Module successfully, and it was able to trigger the music to start playing on detection of a cry. The music played at a sufficiently loud volume with very few popping sounds.

5.2 Ethical considerations

5.2.1 Ethics

In accordance with the IEEE Code of Ethics:

1. "To accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment[10]".

The design included some parts that operate with high voltage, which can potentially hurt people who touch the circuit while it is connected to wall plug. To ensure that no one will be harmed by the device, everyone operating with the device should follow the safety guidelines. The power supply should be enclosed with an insulating case to avoid been touched when exposed to consumers.

2. "To avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist [10]".

The device will collect voice signals nearby to perform the cry classification function. The data will be used locally and will not be distributed to any external network. The classification algorithm is based on real-time signals, meaning that no data of the collected voice will be left in storage after the classification is done. This ensures that the device will not harm the user's privacy.

5.2.2 Safety

1. The output of the transformer will output a 18VAC voltage and feed into the AC-DC power supply. 18VAC has a peak voltage of approximately 25V relative to ground, it can go higher with no load condition. This is some significant amount of voltage and may cause severe current across human body if touched. So when dealing with the power supply module, one should never try to touch the components when the circuit is

operating. Always unplug the wall plug first before taking any operation on the circuit. This rule should be apply to everyone that is working or nearby the power supply circuit and throughout all phases of the project including implementation on breadboard and PCB.

2. The voltage to across most of the components are large. So double check the voltage, current and/or power ratings of the components used in the circuit to prevent any breakthrough. In case that a lower rating components is used in the circuit and start burning, unplug the wall plug first before taking any other measure.
3. The speaker may produce high volume. Don't try to get very close to the speaker to try to hear the sound if the volume is low. The speaker should produce audible sound if the operation of the circuit is correct. So always listen at a normal distance.

● 5.3 Future work

- On/Off command support from Bluetooth.
- Volume control command from Bluetooth.
- Full range of lullabies to pick and choose from.
- Using a DAC for better sound quality.
- Wider range of training data for classifier.
- Sending microphone audio through Bluetooth.

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Appendix A Requirement and Verification Table

Block	Requirement	Verification	Verification Status
Module 1: Cry Detector	SVM classifier must successfully classify testing tracks with false alarm rate plus missed detection rate less than $\frac{1}{5}$ of the total test samples.	Across 50 or more tracks of human vocalizations with class labels "cry" and "no cry", at least 80% of them must be classified correctly by the algorithm. Also, we will perform 10-fold cross validation on the training set. The resulting accuracy must also be at least 80%.	Yes
Module 1: Digital Signal Processor	(a) Upon detection of a cry, EMUD2 (the pin that goes to the output "CLASS") must be high. (b) If a human sound that is not a cry is played, EMUD2 (the pin that goes to the output "CLASS") must remain low.	Play a crying sound near the microphone. Open up the ICD2 debugger and look at a list of all the pins with their values. (a) If that sound is labeled as a cry, then check if the EMUD2 pin is high for at least one clock cycle. (b) Otherwise, if the sound is not labeled as a cry, EMUD2 should remain low. If EMUD2 is high in this case, then we have a false positive.	No
Module 2: Microcontroller for speakers	(a) Upon detection of a cry, music must start playing within 15 seconds. (b) There must be little to no slow down (playback is at a 1:1 speed with the actual audio file) or skipping. (c) Less than 5 pops or audio artifacts per	(a) A timer will track the time it takes for the microcontroller to process the track and play it through the speakers. (b) This can be tested by using a timer to time the length of the song compared to the audio file's actual playback time and (c) Record the amount of popping sounds that occur within a minute of audio playing.	Yes

	minute during playback.		
Module 3: Amplifier and Speaker	With 1kHz 1Vp-p input, 8Ω load, the output should be at least 8Vp-p. This makes sure that overall gain is at least 8V/V and output power is at least 1W.	Generate the input using signal generator, load the amplifier with 8Ω dummy load resistor and measure the output waveform using oscilloscope.	Yes
	With 20Hz and 20kHz, 1Vp-p input, 8Ω load, the output should not dropped by more than 3dB compared to 1kHz input.		Yes
	With 1kHz 1Vp-p input, 8Ω load, the output DC offset should not be greater than 1V.		Yes
	Idle power dissipation should be less than 2W.	With no input signal and 8Ω dummy load resistor, measure the DC current drawn from both rails and calculate the power.	Yes
	The amplifier module should have adjustable volume.	Generate the input using signal generator, monitor the output waveform on the oscilloscope while adjusting the position of the potentiometer.	Yes
Module 4: Android Application	The user must receive a notification on the mobile application within 15 seconds of a detected cry.	Play a crying sound near the microphone. Set a timer to 15 seconds. Before the timer reaches 0, the user should have received a notification saying that the baby is crying.	Yes

Module 5: Power Supply	+12V rail without load (0A load) should give at least +10V output but less than +20V. -12V rail without load (0A load) should give at least -10V output but less than -20V. +5V rail without load (0A load) should give +5V output with +/- 0.2V tolerance. -5V rail without load (0A load) should give -5V output with +/-0.2V tolerance. +3.3V rail without load (0A load) should give +3.3V output with +/- 0.2V tolerance.	Measure the open circuit output voltage with digital multi-meter without load.	Yes
	+12V rail with 1A load should give at least +10V output but less than +20V. -12V rail with 1A load should give at least -10V output but less than -20V.	Measure the output voltage with digital multimeter with 12Ω load.	Yes
			Yes
	+5V rail with 150mA load should give +5V	Measure the output voltage with digital multi-meter with 33Ω load.	Yes

	output with +/-0.2V tolerance. -5V rail with 150mA load should give -5V output with +/-0.2V tolerance. +3.3V rail with 100mA load should give +3.3V output with +/-0.2V tolerance.		
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