GreenSense Systems

ENSC 440 Capstone Project
Spring 2012

Wireless Ultrasonic Waterflow Monitoring System

Timbo Yuen, James Lin, Ehsan Arman, Eric Lo, Babak Razzaghi

Roadmap

- Background
- Motivation
- Project Overview
  - Hardware
  - Software
- Budget & Schedule
- Future Development
- Business Plan
- Questions

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Background

CEO:	Timbo Yuen -Oversee of Design Process
Product Manager:	Timbo Yuen - Electronics Design, Software Design, Systems Design
Hardware Engineer:	James Lin - Electronics Design, Circuit Design
Project Manager:	Babak Razzaghi, Eric Lo - Coordination of software&Hardware Design
Software Engineer:	Babak Razzaghi, Ehsan Arman - Software Design

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Background

Company Goals:

1) Make Safe Useful Devices
2) Measure Waterflow in Standard Range
3) Create eco-friendly System
4) Detect Leakage in Piping System
5) Conserve Water

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Motivation

- Reduce Water Loss Due To Leakage
- Accurately Monitor Water Flow
- Transit Wirelessly Using Wi-Fi
- Measure Flow Rate With Ultrasonic Transducers

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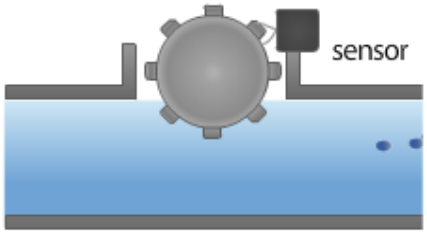
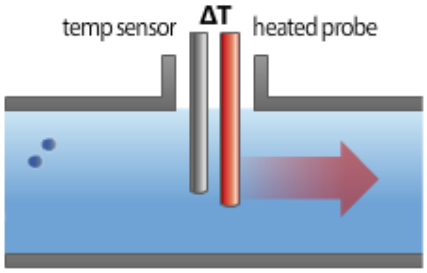
Project Overview

- Existing Solutions

Paddle Wheel



Thermal for Compressed Air



Variable Area (Float Style) for Water, DI Water, Corrosives or Compressed Air

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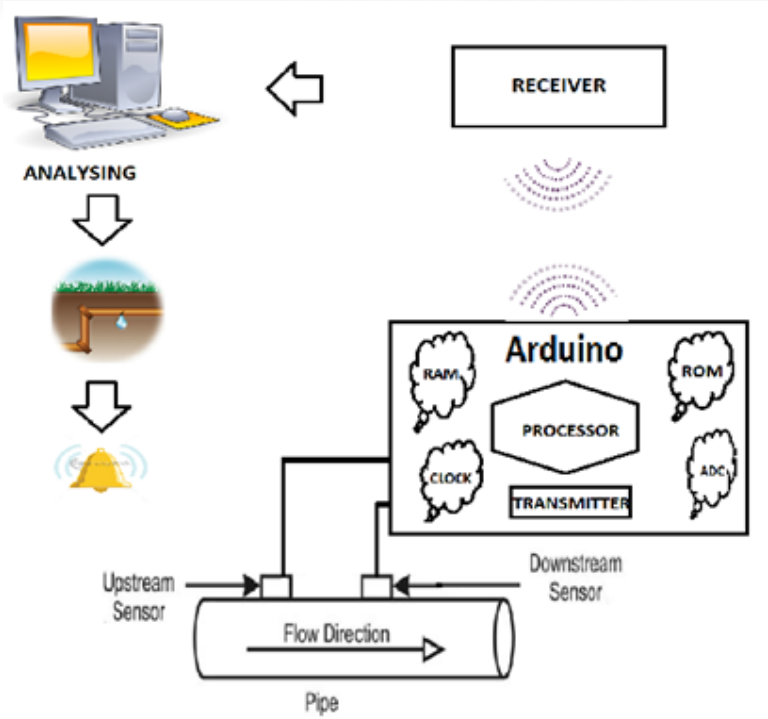
Project Overview

System Overview

1. Ultrasonic Sensor
2. Sensor Driver
3. Microcontroller
4. Transceiver
5. Computer
6. Leakage?



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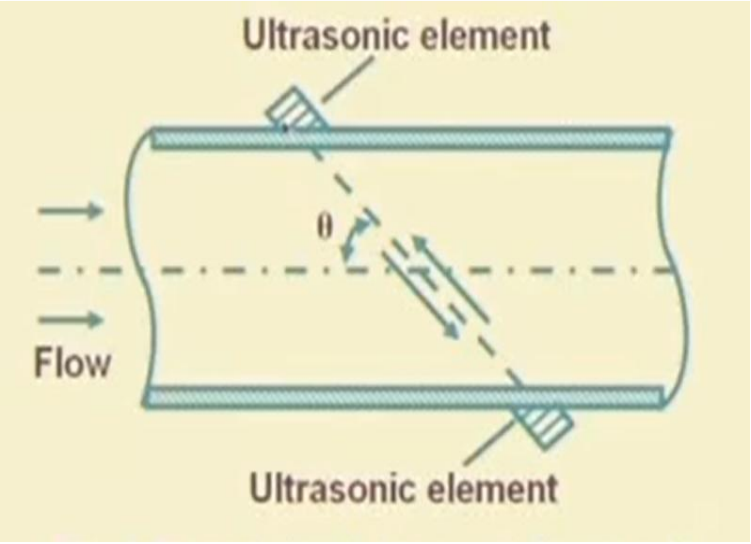
Project Overview

High level system layout

1. Theory behind Sensor
   -Angle
   -Time Interval
   -How to sense waterflow
2. Time difference of Transmitting and Receiving Sensors for V Measurement



$$t_R = \frac{L}{c - V\cos\theta} \qquad t_F = \frac{L}{c + V\cos\theta}$$

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Project Overview

- Most Common Solution(Doppler)- based on frequency shift
- Enginuity Consulting Ltd. Provides the Ultrasonic Sensor Solution
- Advantages:
  1. less leakage
  2. less maintenance/Longer operating time

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Hardware Design

Challenges for Transmitter Circuit

- Need to drive the transducer at 40 kHz
  - At 40 kHz frequency, the sound pressure is highest
- Arduino Uno will provide the 40 kHz square pulse, so we will just amplify it to desired levels
- Arduino Uno needs to control when to send the signal
  - CMOS analog switch can use voltage level as control
- Operational amplifier circuits all used the LM6171, a VFA type op amp

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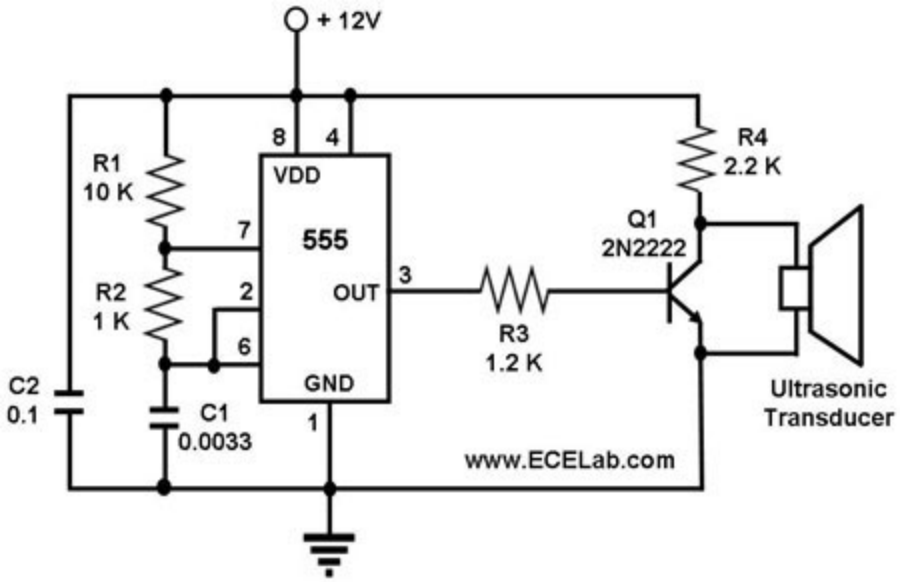
The original circuit (Tranmitting circuit)



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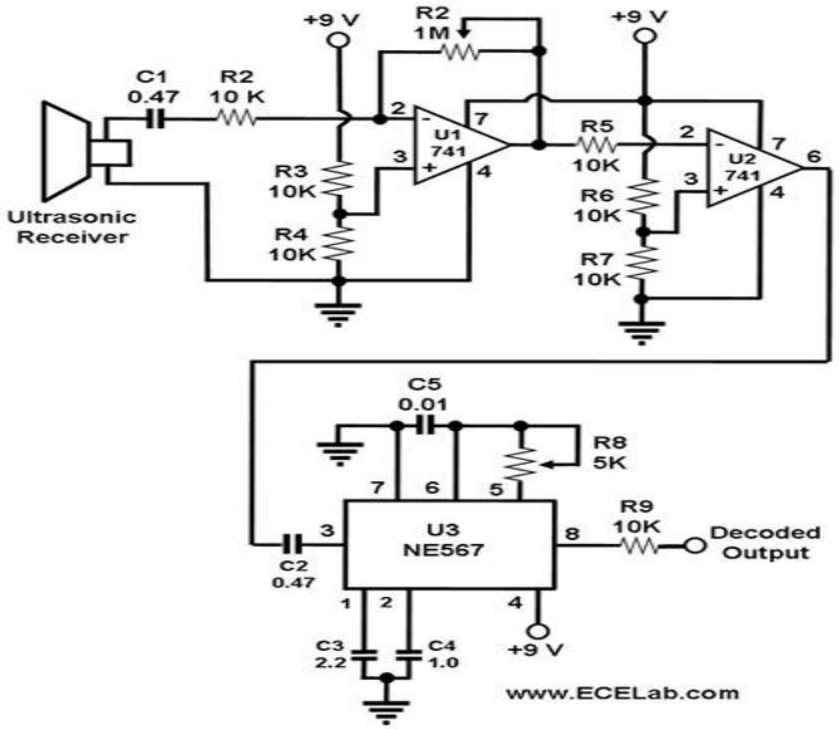
The original circuit (receiving circuit)



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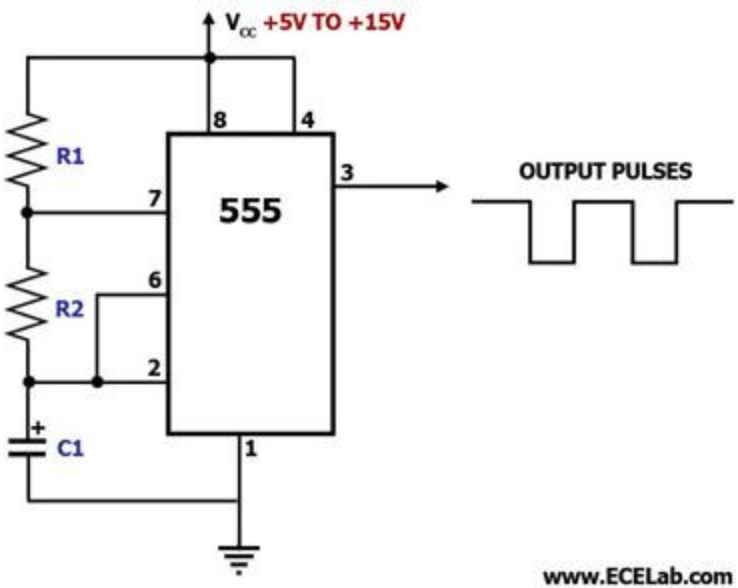
The original circuit

555 timer is able to generate train pulse



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The original circuit (receiving circuit)

Our original designed transmitting and receiving circuit does not work properly.

The reason for that is our frequency is high, thus the component s in the circuit are not able to work properly.

We redesigned our transmitting and receiving circuit in later days.

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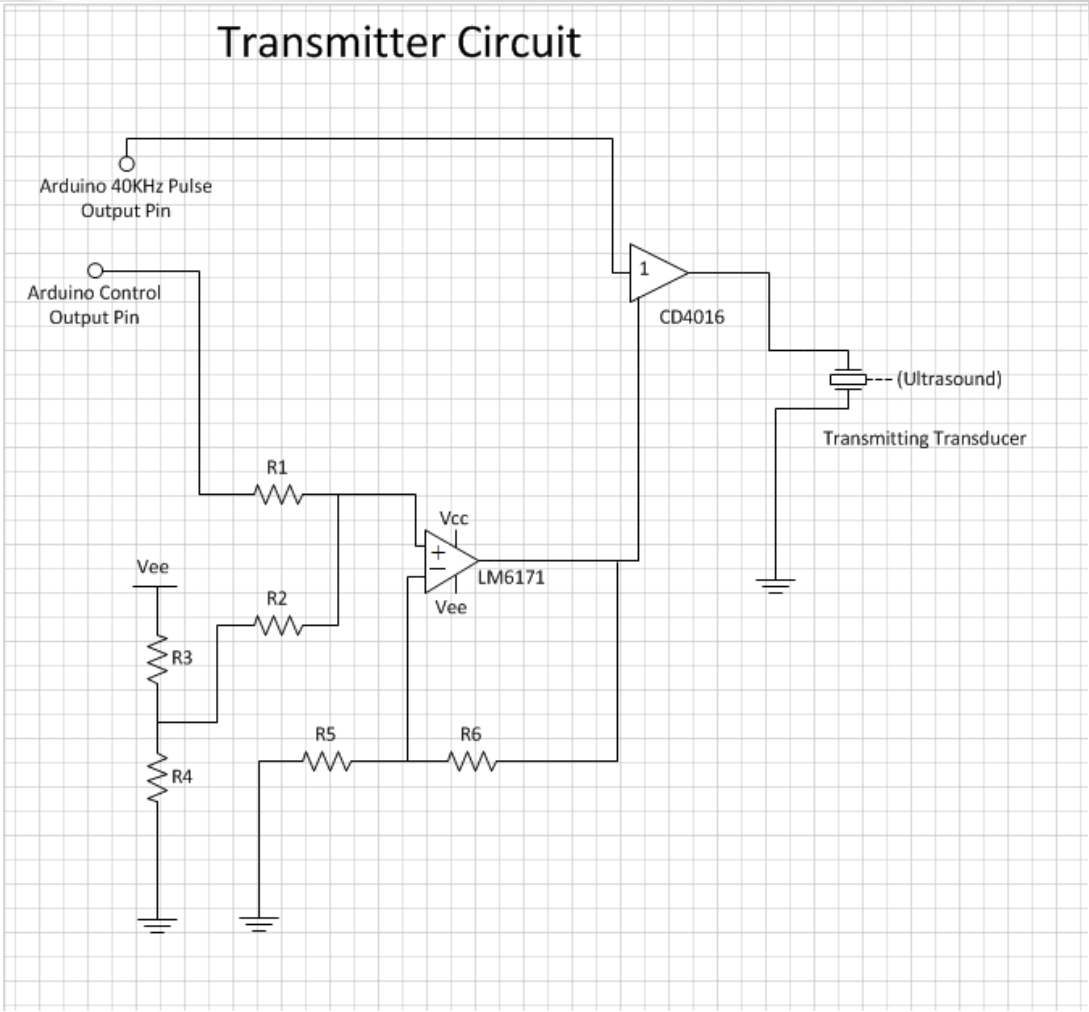
Hardware Design



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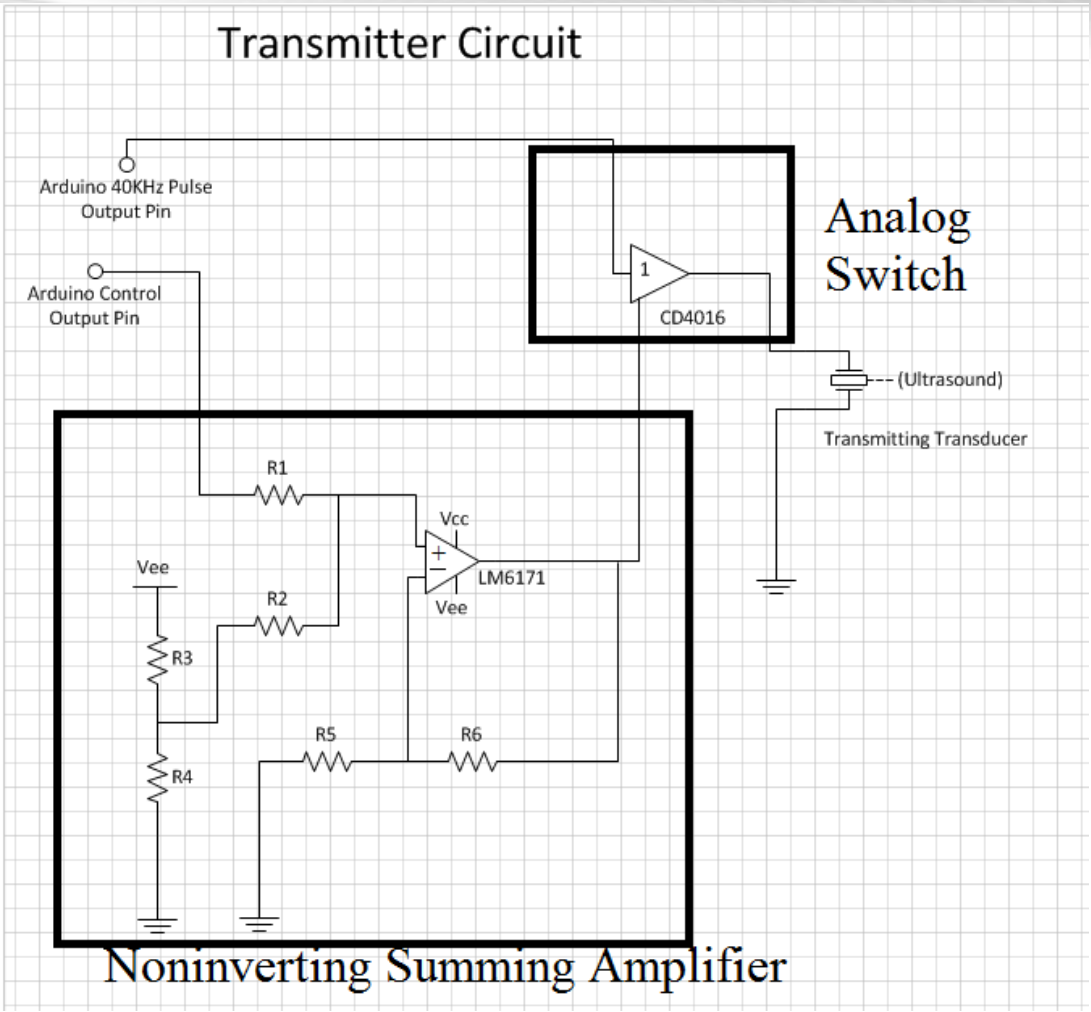
Hardware Design



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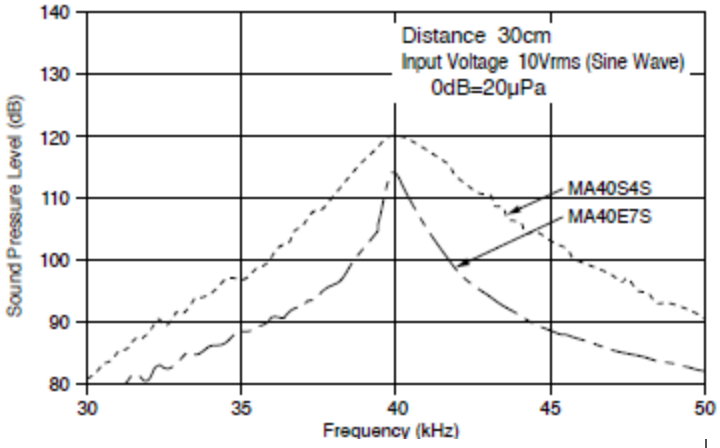
Hardware Design

Challenges for Receiver Circuit

- Lots of noise from receiving transducer
  - Bandpass Filter used
  - Clamper circuit used
- Low signal level
  - Noninverting Amplifier circuit used
- Easy level detection needed for MCU
  - Process signal to appear as digital
    - Full Wave Rectifier circuit used
    - Comparator circuit used



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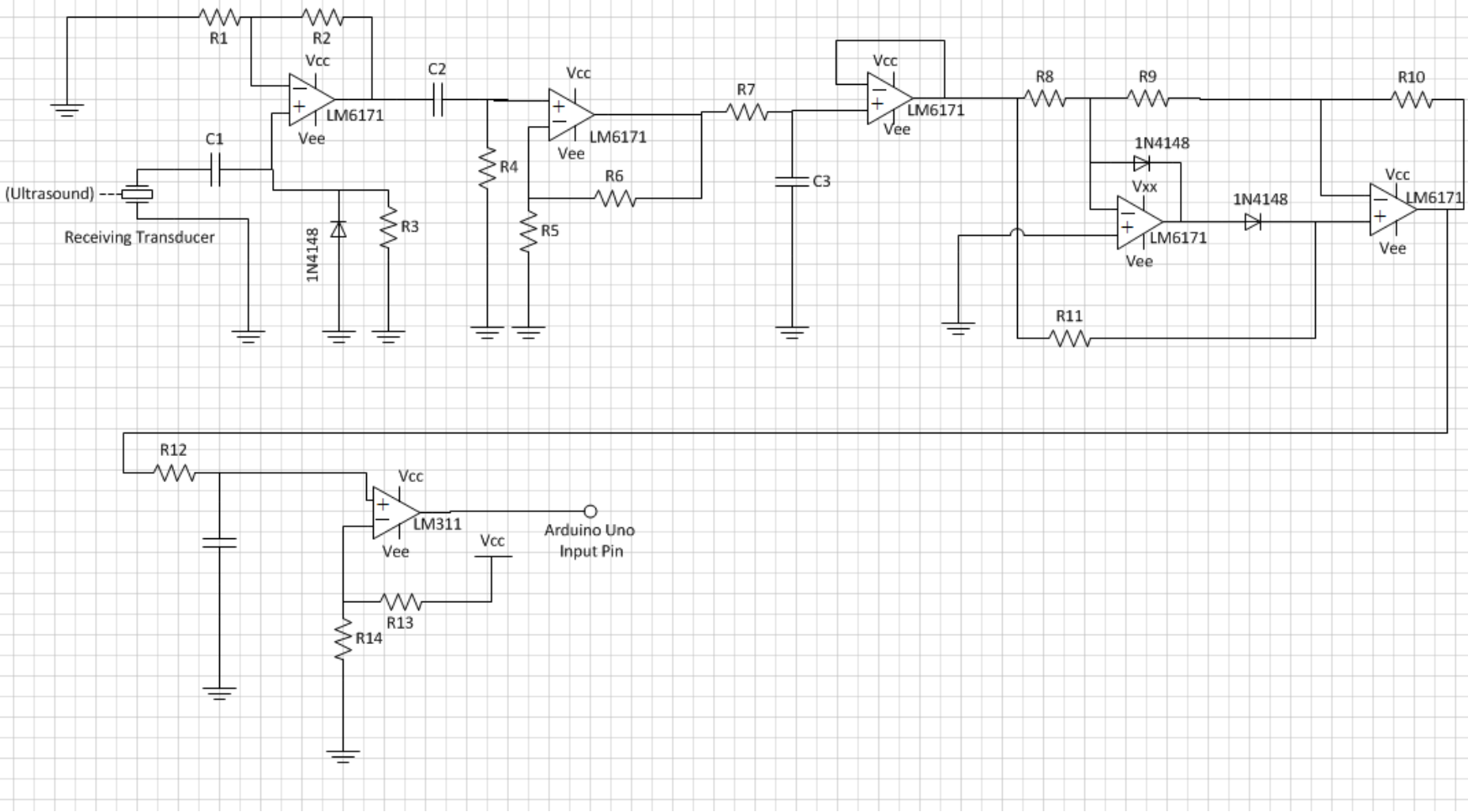
Receiver Circuit



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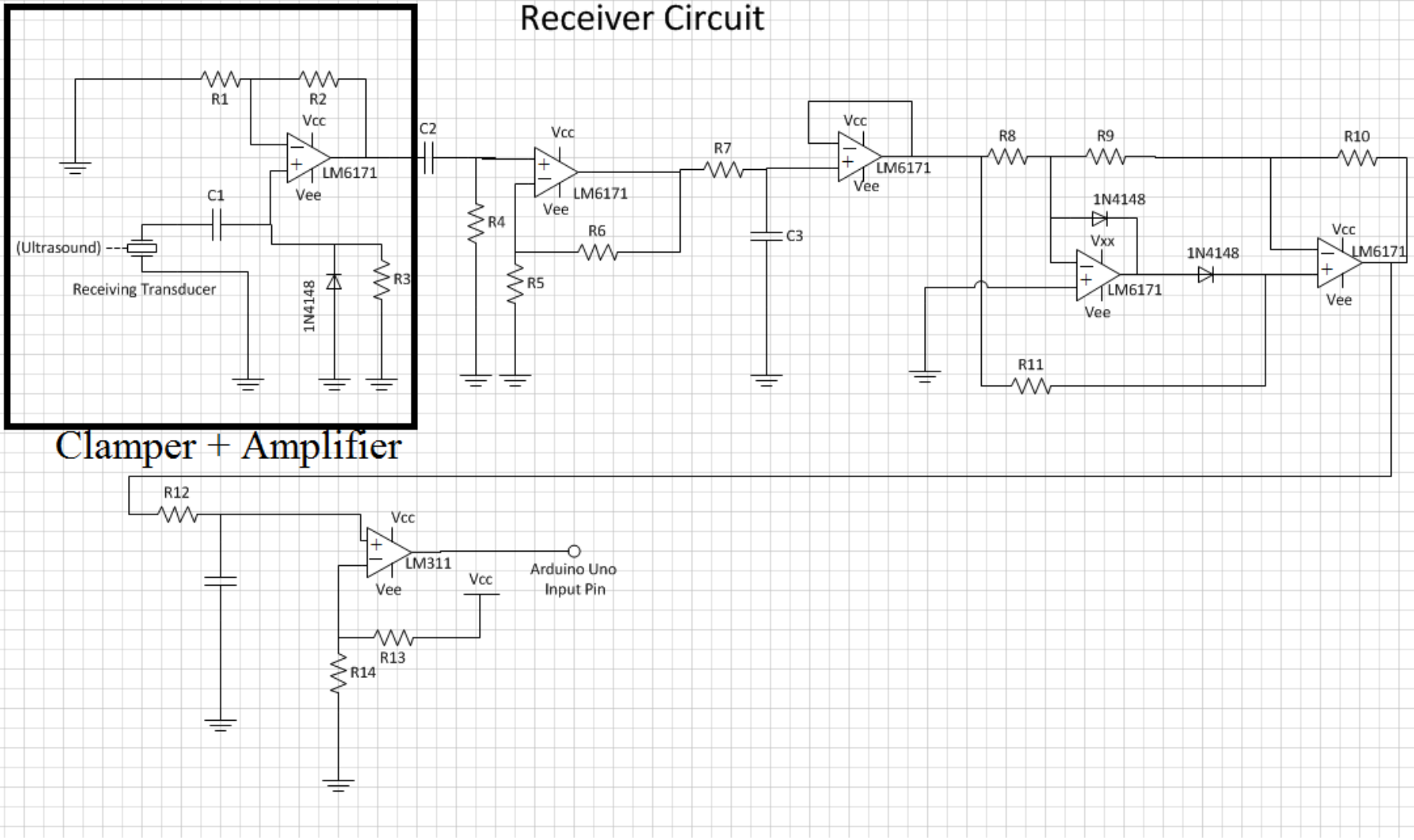
Receiver Circuit



Clamper + Amplifier

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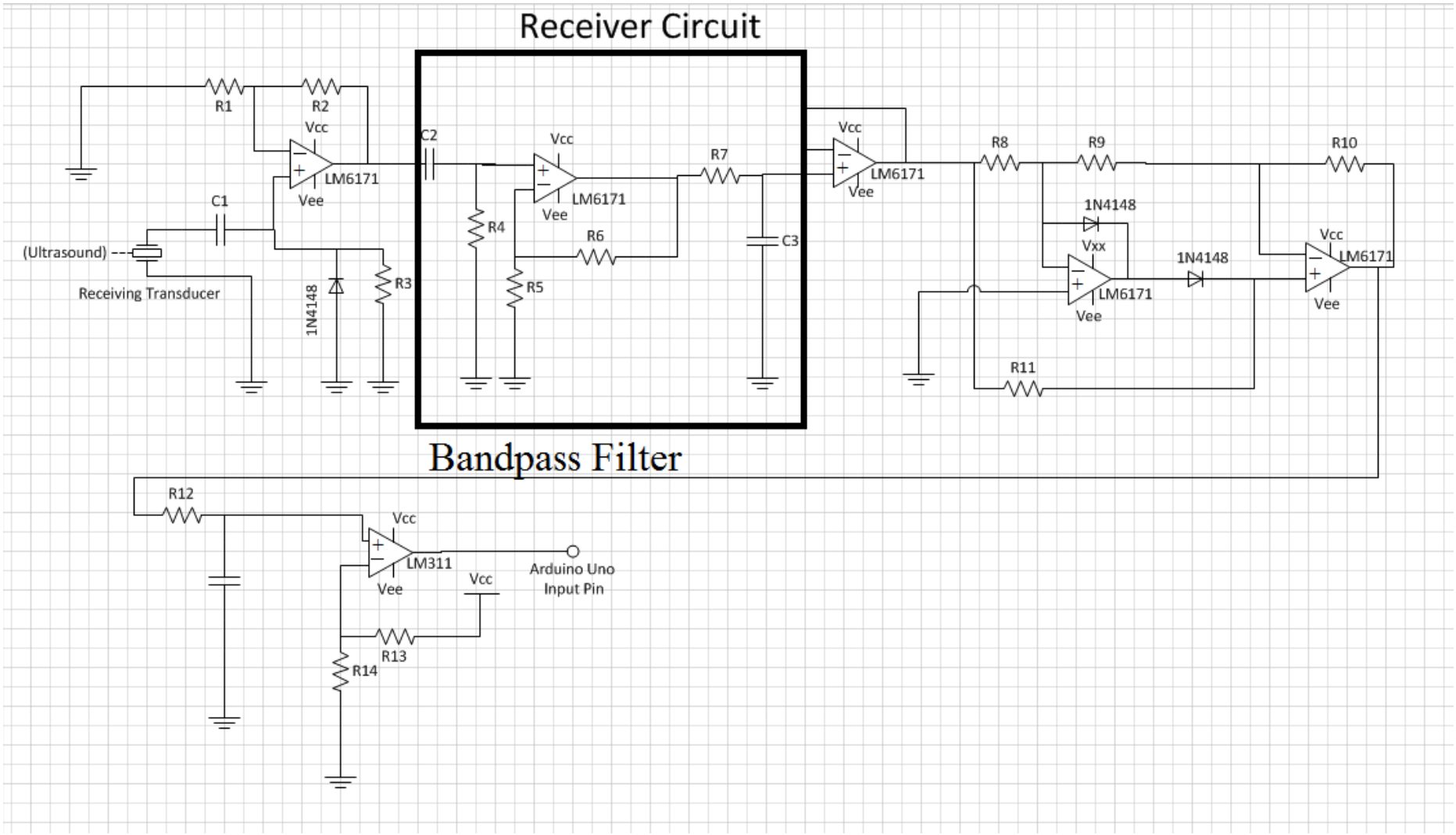

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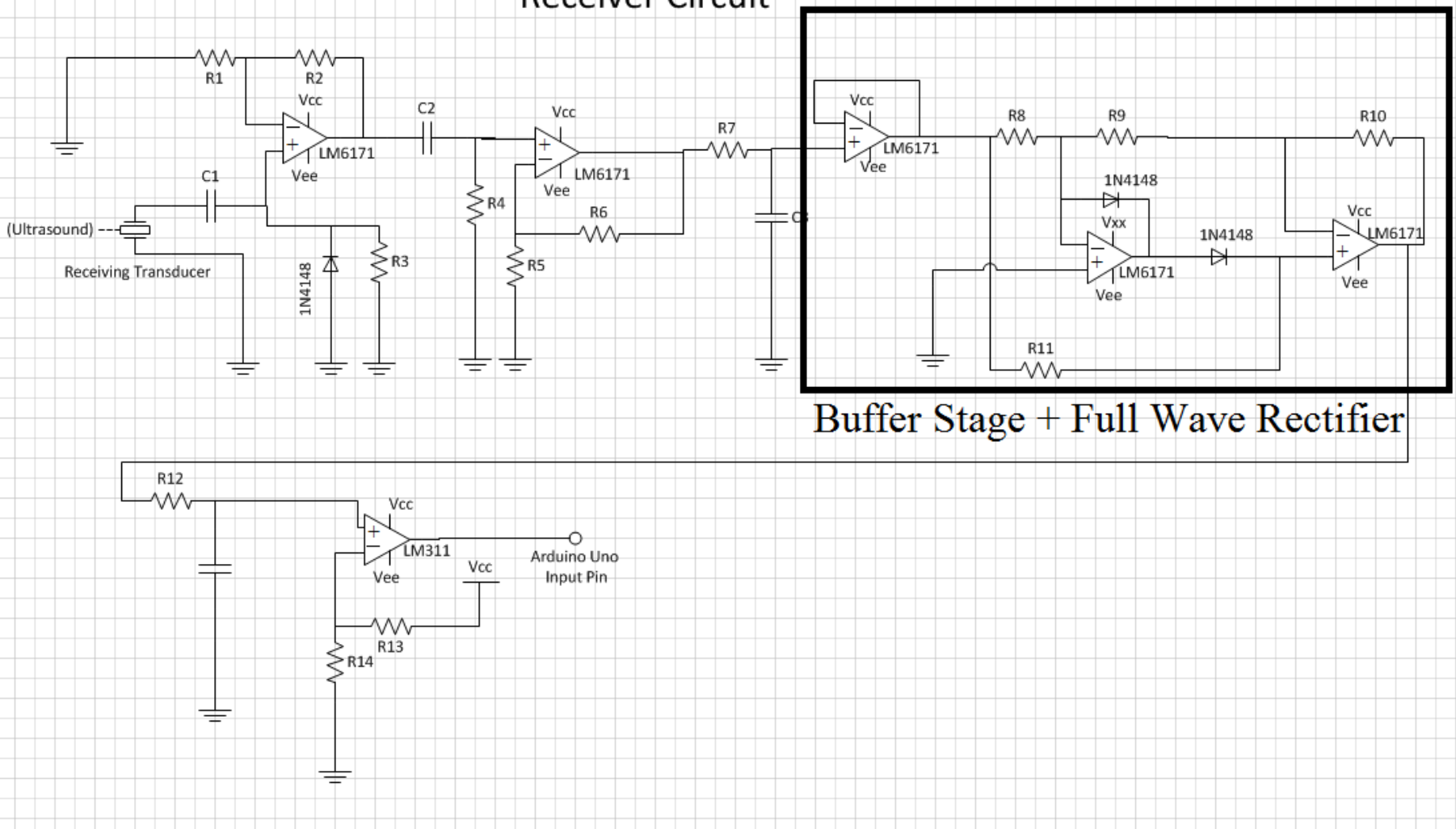
Receiver Circuit



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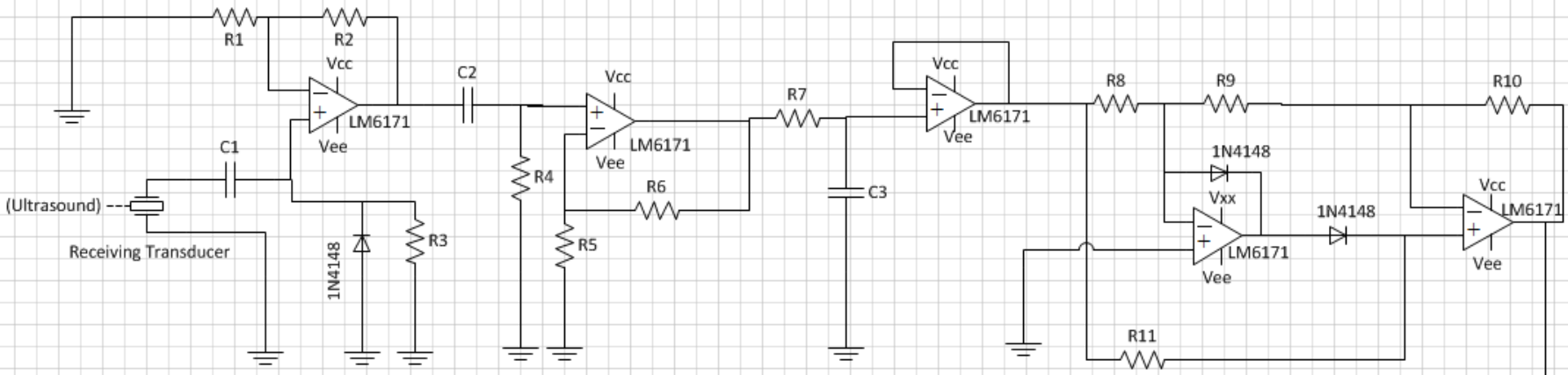
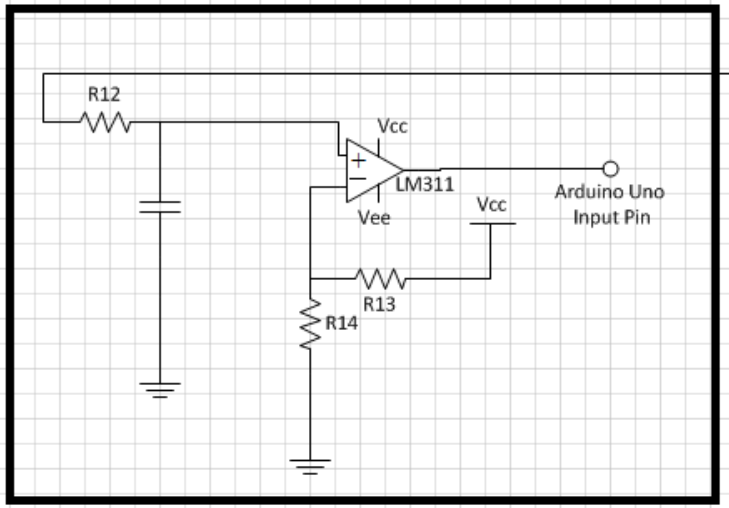
Receiver Circuit





Comparator Circuit

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Software Design

- 40KHz pulse generated on Microcontroller using PWM
- Timer set for transmitting ultrasonic transducer
- ISR issued for transmitting transducer and timer stopped
- Timer set for receiving ultrasonic transducer
- ISR issued for receiving transducer and timer stopped
- Measuring time difference for velocity calculations

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Software Issues

- Dealing with Timers and Interrupts
- Limited knowledge of Software Development in Arduino
- Difficulty transferring data to PC wirelessly

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Budget

Part Name	Qty	Cost
Arduino Uno	2	$80
USB printer cable	2	$16
9V DC adapter	1	$10
CuHead Wi-Fi Transceiver	1	$75
Capacitors	~100	$14
LM6171(6), LM311(1), CD4016(1), NE531(4), LM741(2), LM555(2), LM6181(2)	18	$81
Solderless Breadboard	3	$24
Transducers	4	$17
Water Pipes (2), Water Tank (2)	4	$40
Total Cost		$357

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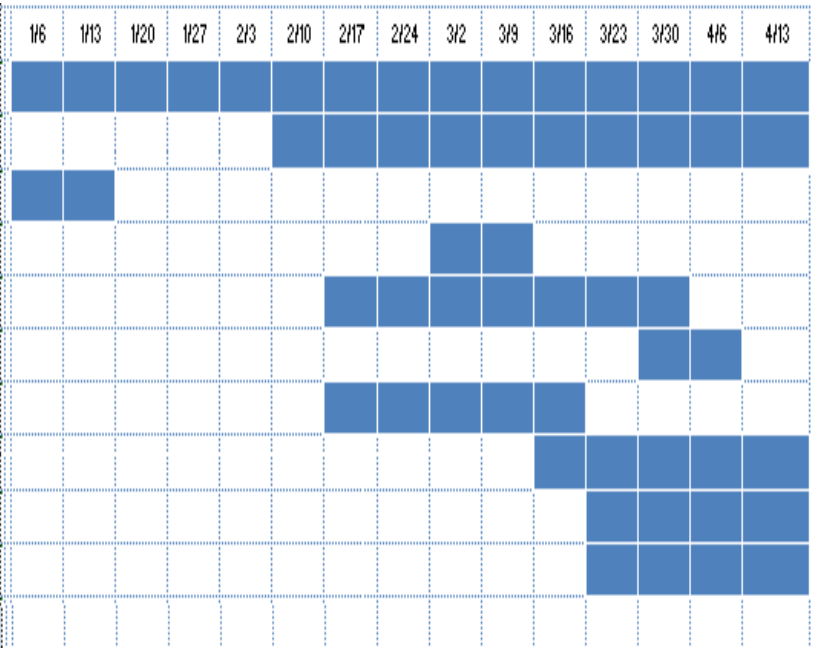
Timeline

Task Name	Duration	Start	Finish	owner
Reseach	90 days	06/01/2012	08/04/2012	All team members
Evaluate Design and optimize	60days	06/02/2012	08/04/2012	All team members
Project proposal	6 days	06/01/2012	12/01/2012	All team members
Design specification	10 days	25/02/2012	05/03/2012	All team members
Buying parts	45 days	15/02/2012	30/03/2012	All team members
Sensor module assembly	5 days	30/03/2012	05/04/2012	All team members
Transmitter and Reciver module assembly	30 days	15/02/2012	15/03/2012	All team members
PC and MCU module assembly	30 days	15/03/2012	15/04/2012	All team members
Microcontroller programing	25 days	20/03/2012	15/04/2012	All team members
GUI programming	19 days	20/03/2012	08/04/2012	All team members
Demo presentation	0.5 days	23/04/2012	23/04/2012	All team members



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Future Work

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Acknowledgements

- Thanks to Andrew and Steve for their guidance throughout the project
- Thanks to the TA's for their suggestion on documents

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Questions

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