ACOUSTIC NAVIGATION FOR MOBILE ROBOTS

Bi-Weekly Report

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Table of Contents

Introduction

Our design project is going according to plan. We have already ordered a majority of the major parts and are working diligently on the final aspects of our design. Pending the arrival of our parts, we hope to begin modeling and building our circuits soon. Below is on outline of our status concerning different aspects of the design, as well as an update on our scheduling, cost, and new implementations that differ from our original proposal.

Microphone Array

We have decided on the Panasonic microphone WM-65A103 (Figure 1). This microphone is unidirectional, very small, and accurate. The cost also played a part in our decision, as they are only $1.83 each. Further the output seems to be impedance related, based on the load resister we wish to implement. We are hoping/thinking that this will allow us to bypass the original design of pre-amplification in our circuit. Our group has also considered the possibility of designing the microphone array on a separate PCB, allowing for more modularity and ease of construction. This would allow us to not worry about mounting the microphones on the controller, possibly causing more aggravation due to the size of the microphones as well as implementing the sound dampening ideas. We could utilize a 9-pin connector with a ribbon cable so connecting the two boards would be easy and trouble-free. This is also a very critical aspect of our current design stage, as we need the microphones to physically model and see the output on our O-Scope. This would answer a lot of questions on amplification, rectification, etc. Although we have a good idea of our other design theories, having the microphones physically modeled will assure us that our design is working smoothly.

Filter Solution

While talking to Avens Signal, two options were presented for digitally programmable, tunable, single supply filters. The first option was their $100 Frequency Filter Module. It represented all of the requested functionality, but at a premium price. The vendor mentioned using a switched capacitor, which could offer similar functionality at a fraction of the cost. A switched-capacitor filter has a tunable center frequency, adjustable through a clock input. The center frequency is then proportional to that inputted frequency. The filter that our team chose is the LMF100 from National Semiconductor (Figure 2). It is operable with a single power supply and offers many modes of simultaneous filtering. Our design mainly calls for the use of an adjustable band-pass filter. The LMF100 datasheet details how to configure the device for our needs. With this change in filtering design from our proposed design, a clock, counter, and 8:1 digital multiplexer will be additionally required. The clock will drive the counter, so that the clock signal will be halved at each bit, granting lower frequencies. These frequencies from the clock will then be multiplexed to be the clock input to the LMF100 filter. The multiplexer will be controlled via the microcontroller. This is also a design change, as the proposed design called for one bit output from our PCB to the microcontroller, but is now 3 bits input from the microcontroller to the PCB.

Sinusoidal Signal Rectification

In order to aid in the design of the rectifier, we modeled both a half-wave and full-wave rectifier coupled with a low-pass filter using PSpice. We started with the simplest forms of each of these rectifiers, tweaked resistance and capacitance values, and attempted to model the behavior of the input signal as close to that of our microphones output. The following is an overview of what we encountered during the process.

Problems

Two problems/questions we ran into during the simulations were:

1. What exactly is the behavior of the microphone signal going to resemble?
2. How can we simulate this behavior in PSpice?

For the first issue, we decided that in order to get a better idea of the signal, we would need to physically test our microphones with an oscilloscope. We were assuming that the signal generated would be a sinusoid around a constant dc voltage (V_{ref}), oscillating anywhere between ground and 2*V_{ref}. Once we receive our microphones, we will be able to get a better understanding of this behavior.

Concerning how to simulate this signal, we used a sinusoidal frequency modulating voltage source and altered its parameters to test different frequencies and signal levels. This could be a valid method depending on whether our assumptions about the microphone signal above are correct. Otherwise, we will have to derive other methods to simulate the behavior.

Half wave rectifier

The half wave rectifier proved to be the most feasible solution. It is a very simple design and it accomplishes what we need. Figure 3 shows our half-wave rectifier model. Figure 4 shows the voltage relationships between the input and output signals with a constant 4V signal around 400 Hz. The green line is the rectified output, and the red line is the simulated microphone input signal. Figure 5 shows the voltage relationships between the input and output signals with a smaller input frequency of 70 Hz. The smaller frequencies demonstrate the worst case for rectification purposes since the capacitor has more time to lose its charge. Again, the green line is the rectified output, and the red line is the simulated microphone input signal.

Full wave rectifier

Our full wave rectifier design proved to be an illegitimate solution since it requires an AC voltage input around oscillating around ground. Figure 6 shows our full-wave rectifier model.

PCB Generation

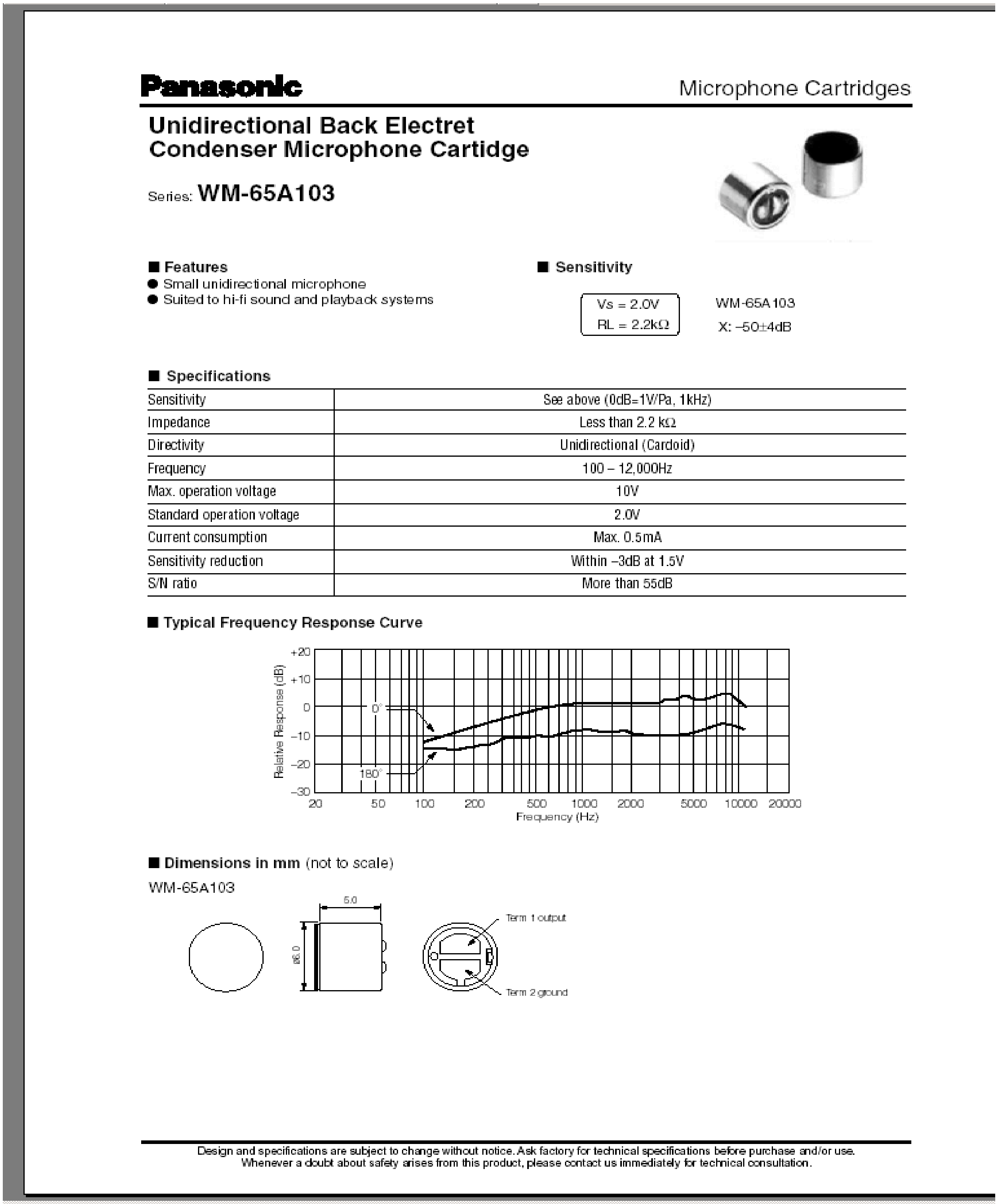
We have decided on the PureSoft's EAGLE 4.0 (http://www.puresoft.co.uk/eagle/) printed circuit board design software. This software appears to be easy to use. Powerful, and allows for a free trial version to download. We believe the trial version will allow us to design our board, without the need for purchasing the full version. Once this is accomplished, we will use the resources Prof. Gutierrez-Osuna has provided us to get it built.

Robot

The robot our group decided on is the Mark III (Figure 7). It is small, expandable, and is serial port programmable. One of the main reasons that we chose this robot is that it is much cheaper than other robots we were considering. Also, our advisors had recommended we go with the Mark III because many of the other design groups were using Boebots. This robot also features both analog and digital inputs which could possible be used to bypass the need for A/D converters in our initial design. Unlike other robots we looked at, the Mark III is programmable in C. We also purchased an upgrade for the robot that includes OOPicII+ and more memory. The robot has already been ordered and we should receive it soon.

Schedule/Order Status

As far as our initial scheduling goes, we are right on time with our initial proposed work schedule (Figure 8). We have already ordered the robot, the microphones need for our microphone array, some sample IC's, the sound dampening foam, and other parts need for construction. The only parts we have yet to order are just resistors and capacitors needed for our filter and construction of the signal rectifier. We will get these parts either from the EE Lab on campus or purchase them at Radio Shack. Figure 9 shows our working parts list of what we have ordered and what we plan to get.



Panasonic — Microphone Cartridges

Unidirectional Back Electret Condenser Microphone Cartidge

Series: **WM-65A103**

■ **Features**

- Small unidirectional microphone
- Suited to hi-fi sound and playback systems

■ **Sensitivity**

Vs = 2.0V
RL = 2.2kΩ

WM-65A103
X: –50±4dB

■ **Specifications**

Sensitivity	See above (0dB=1V/Pa, 1kHz)
Impedance	Less than 2.2 kΩ
Directivity	Unidirectional (Cardoid)
Frequency	100 – 12,000Hz
Max. operation voltage	10V
Standard operation voltage	2.0V
Current consumption	Max. 0.5mA
Sensitivity reduction	Within –3dB at 1.5V
S/N ratio	More than 55dB

■ **Typical Frequency Response Curve**

■ **Dimensions in mm** (not to scale)

WM-65A103

Design and specifications are subject to change without notice. Ask factory for technical specifications before purchase and/or use.
Whenever a doubt about safety arises from this product, please contact us immediately for technical consultation.

Figure 1 – Panasonic Microphone

National Semiconductor

July 1999

LMF100
High Performance Dual Switched Capacitor Filter

General Description

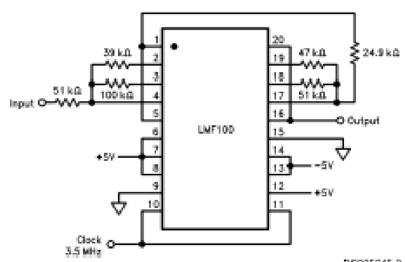
The LMF100 consists of two independent general purpose high performance switched capacitor filters. With an external clock and 2 to 4 resistors, various second-order and first-order filtering functions can be realized by each filter block. Each block has 3 outputs. One output can be configured to perform either an allpass, highpass, or notch function. The other two outputs perform bandpass and lowpass functions. The center frequency of each filter stage is tuned by using an external clock or a combination of a clock and resistor ratio. Up to a 4th-order biquadratic function can be realized with a single LMF100. Higher order filters are implemented by simply cascading additional packages, and all the classical filters (such as Butterworth, Bessel, Elliptic, and Chebyshev) can be realized.

The LMF100 is fabricated on National Semiconductor's high performance analog silicon gate CMOS process, LMCMOS™. This allows for the production of a very low offset, high frequency filter building block. The LMF100 is pin-compatible with the industry standard MF10, but provides greatly improved performance.

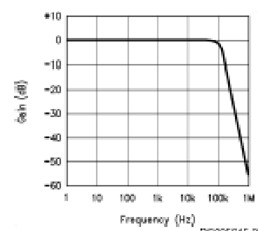
Features

- Wide 4V to 15V power supply range
- Operation up to 100 kHz
- Low offset voltage: typically (50:1 or 100:1 mode): Vos1 = ±5 mV, Vos2 = ±15 mV, Vos3 = ±15 mV
- Low crosstalk −60 dB
- Clock to center frequency ratio accuracy ±0.2% typical
- f_0 x Q range up to 1.8 MHz
- Pin-compatible with MF10

4th Order 100 kHz Butterworth Lowpass Filter



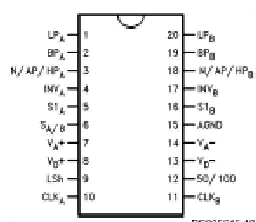
DS005645-2



DS005645-3

Connection Diagram

Surface Mount and Dual-In-Line Package



DS005645-18

Top View
Order Number
LMF100CCN or LMF100CIWM
See NS Package Number N20A or M20B

LMCMOS™ is a trademark of National Semiconductor Corporation.

Figure 2 – Switched Capacitor Filter

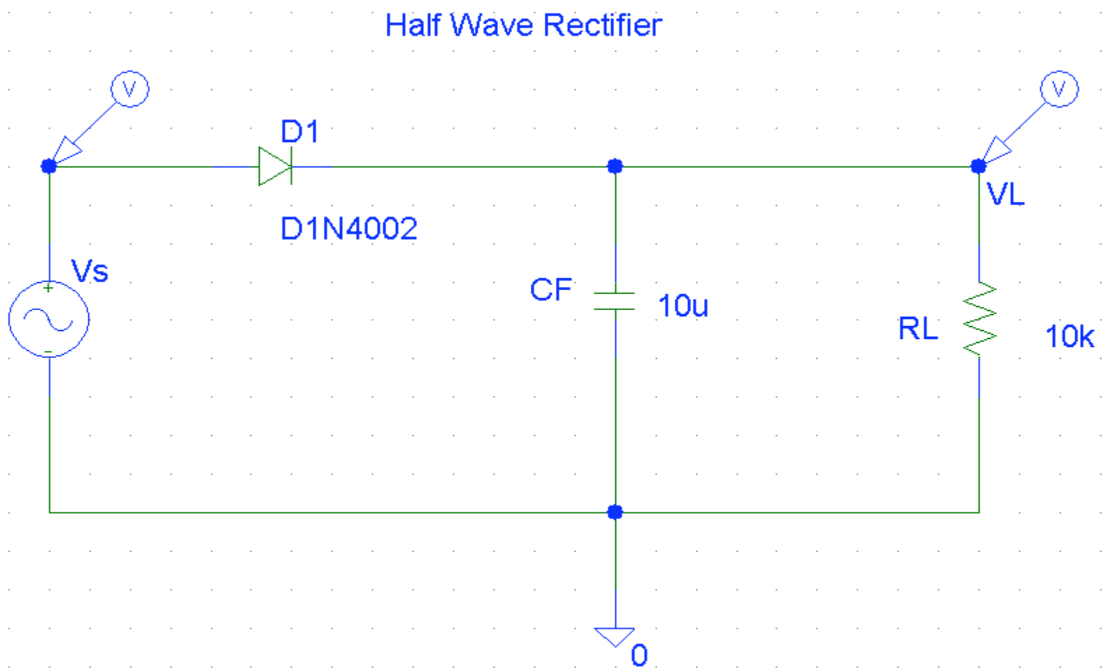


Figure 3

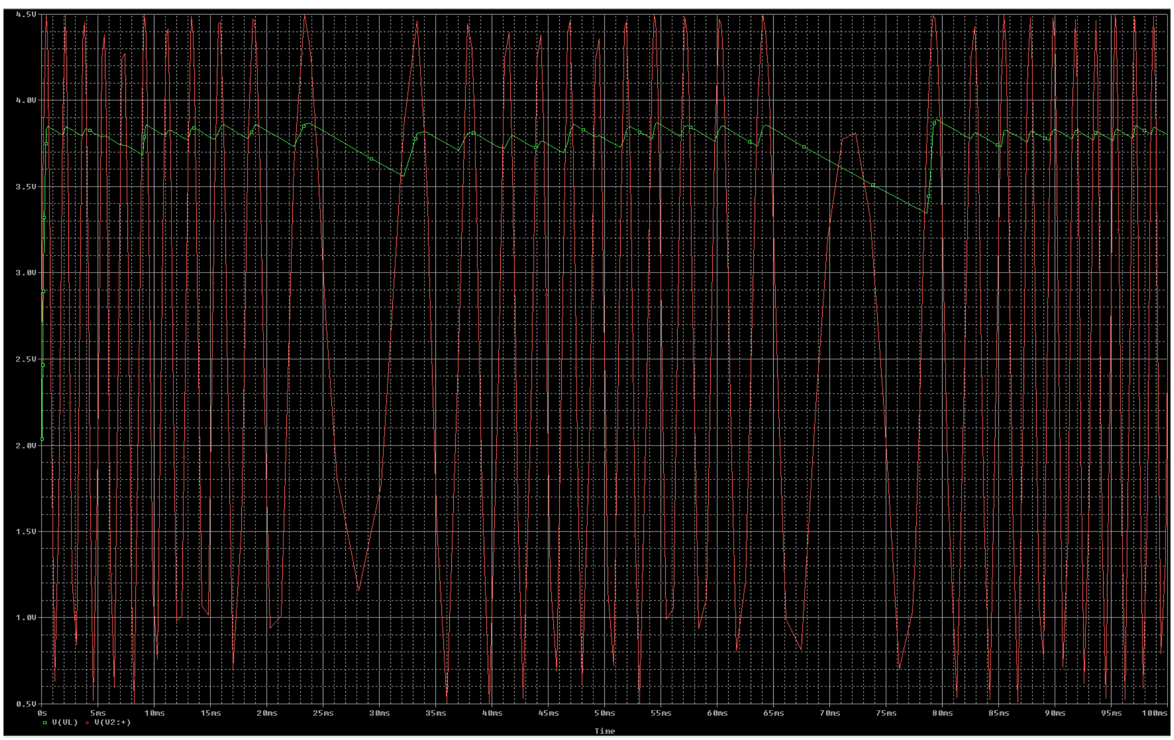


Figure 4

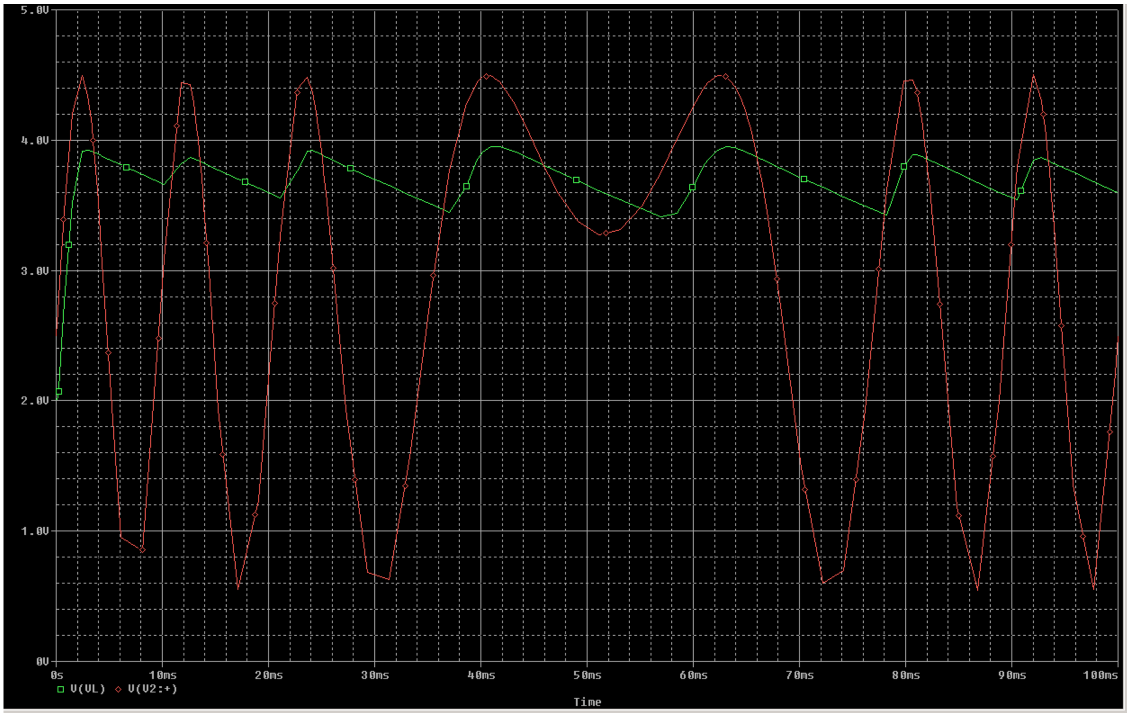


Figure 5

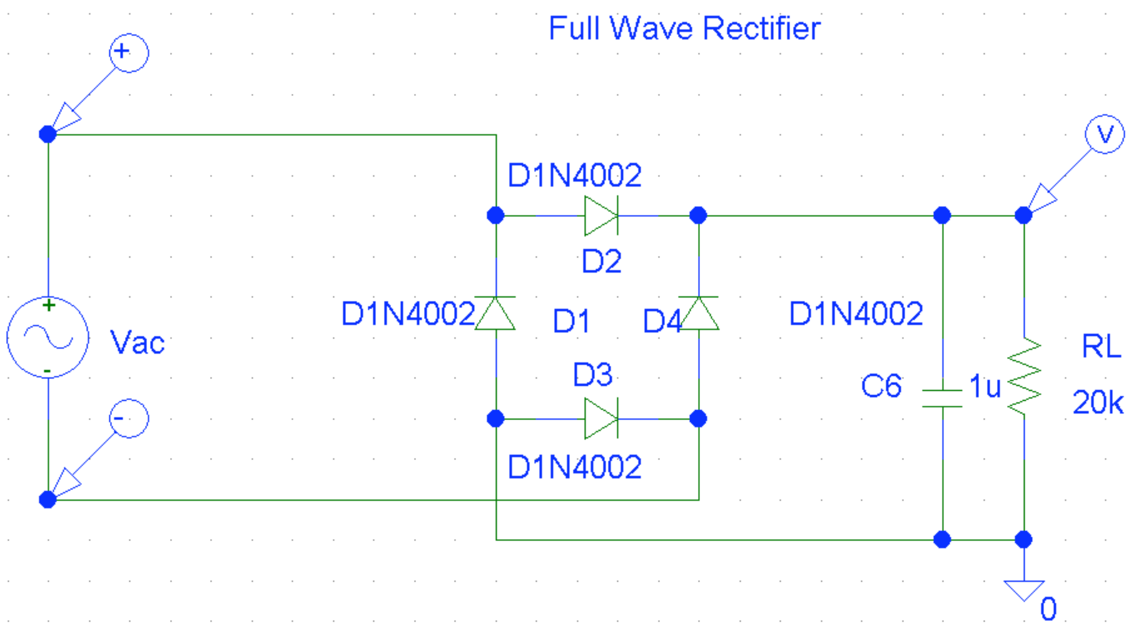


Figure 6

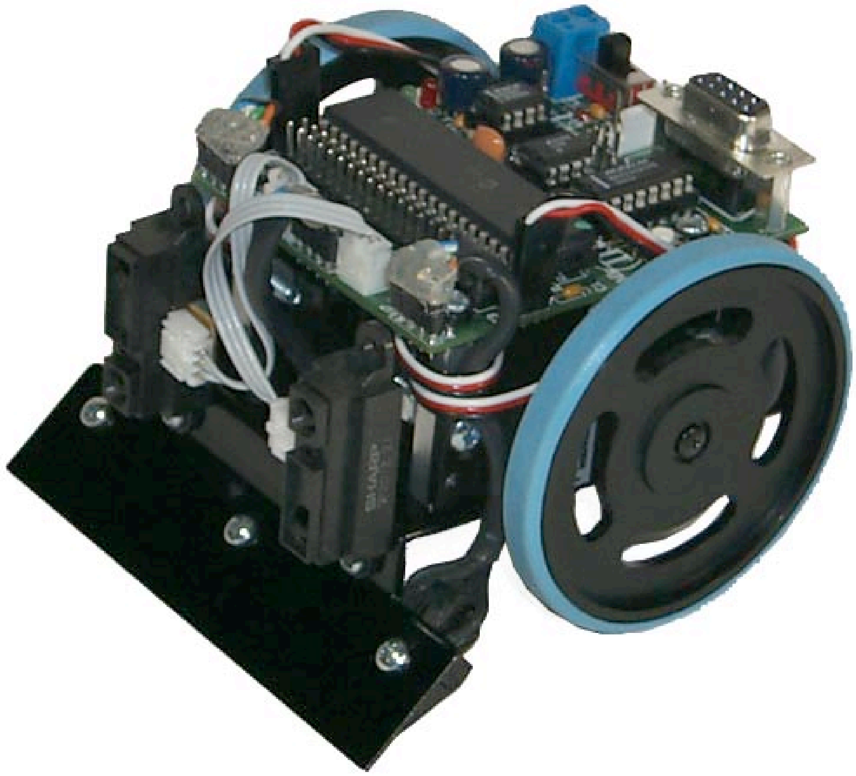


Figure 7 – Mark III Robot

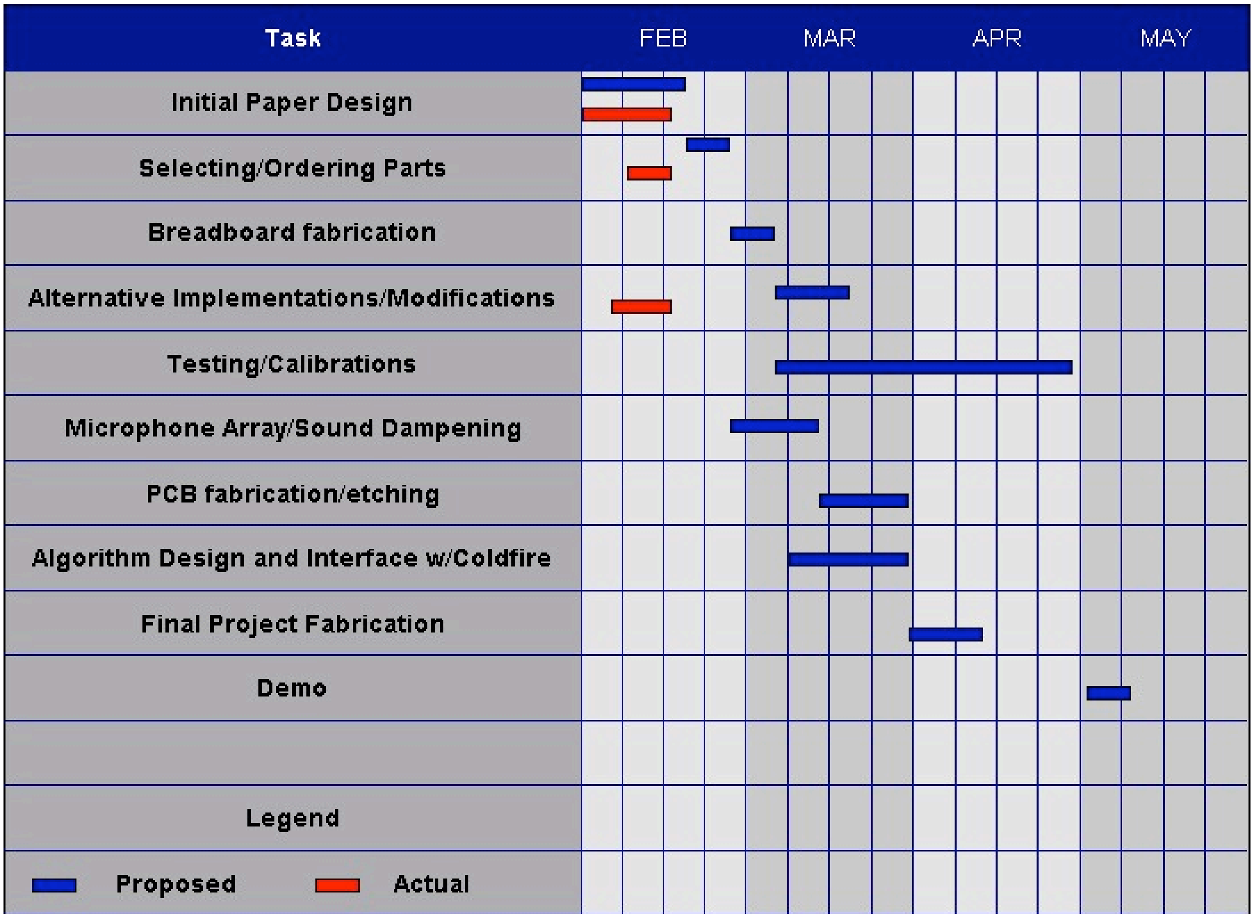


Figure 8 – Updated Gantt Chart

mber	Contact
03	www.digikey.com Navigate to online ordering and enter quantity and part number **Telephone:** 800-344-4539
051D	www.onsemi.com (Ordered already)
JS	www.onsemi.com (Ordered already)
	www.dynamat.com (Follow online store link and look for part number)
-50CIJM	www.national.com (Ordered already)
	www.national.com
	Junun.org
	Junun.org
S50	http://www.arcade-electronics.com/cgi-bin/webc.exe/st_prod.html?p_prodid=20494

Figure 9 – Working Parts List