ACOUSTIC NAVIGATION FOR MOBILE ROBOTS

Bi-Weekly Report

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Introduction

Our design project is going according to plan. We have already received all of the major parts and are working diligently on the final aspects of our design. We have passed some of our troubles and are working to complete the design. Below is on outline of our status concerning different aspects of the design, as well as an update of our scheduling and new issues with our design.

Current Design

Figures 1 and 2 illustrate our current design. We have decided to fabricate two separate printed circuit boards: one for the microphone array itself and one for the microcontroller. This will allow us more modularity and ease of maintenance and fabrication. The microphone array board will consist of the 8 microphones patterned in such a way that each microphone has 45^{o} of coverage. Further, the board will have a resistor pack that will develop the output signal for each microphone. We will route the signals to the microcontroller board via a 10-pin connector. The microcontroller prepares the microphone signal to be presented to the microprocessor of the Mark III. This board will accept the eight microphones data into an 8:1 multiplexer that is controlled by the Mark III's processor. Once a microphone is selected, it will be sent to the filter (LMF100). The filter has two inputs, one for the microphone data and one from the crystal and 4-bit counter (74LS191) circuit, which will provide 8 center frequencies through a processor controlled 8:1 multiplexer. After the filter, the signal will be converted to DC and be sent to the A/D converter (ADC0801). This will then convert the signal into an 8-bit value that will be sent to the processor. In all, we will be using 17 pins on the Mark III. Six bits will be used for the multiplexers, and eight bits will be used for the microphone signal. However, we also have the capability to send the microphone signal to the processor in analog format, as the processor has analog capabilities.

Microphone Directionality

Our microphones, although described as unidirectional on the Panasonic datasheet, do not appear to be very directional. We have tested the microphone's signal strength at varying levels and distances and although there is slight directionality, it is hardly practical. We will ultimately need to implement a sound-dampening fixture, which is described in the following section. This will give us the directionality that we need to really apply this design to real-world environments. Figure 5 and Table 1 show a graph and table of the measured directionality readings.

Microphone Fixture

Our microphone fixture has been designed and manufactured. We created it using plexi-glass, super glue, and a rubberized aluminum cylindrical shaft to support the dividing walls. This fixture will be mounted on our microphone array board, and surround the microphones. It will be covered in the sound dampening material and will provide 3–6 dB of attenuation. We feel this will provide ample sound absorption and give us the directionality in the microphones we are seeking.

RMS-to-DC Conversion

Our main focus on our project is rectification. We are having difficulty in solving this aspect of our design, as previous attempts have failed. We have been in contact with an EE professor that has been providing advice, however, we have not concluded on a design at this time. First, our objective is to turn our AC signal into a DC signal that demonstrates the AC signal's amplitude. We have tried using a circuit of capacitors, diodes, and even superdiodes, but that has given us poor results. We have not been able to remove the DC offset from our signal, to operate the diodes properly. We have found an IC that hopefully will solve our problems (Figure 3). We have ordered some samples and expect them to arrive shortly.

Our team spoke with several engineers at Analog Devices, the company that produces the RMS-to-DC converter. They confirmed that a capacitor, in the range of 0.1–3.3 μF, would remove the DC offset in our AC signal. They also confirmed, to the best of their ability, that this IC would operate on a single 5 Volt supply. The resolution of the RMS-to-DC converter is quite great, achieving an accuracy of ± 0.2 mV, which is greater than the accuracy of our analog-to-digital converter. The addition of this chip greatly reduces the number of resistors on the final board, reduces the complexity of our overall circuit, as we no longer have to rectify and smooth the filtered signal in discrete components, and reduces the complexity of our PCB design. This chip was chosen because it provides a true RMS value, in the form of a DC signal, which is exactly what our design requires, can operate with either an AC or DC signal, and requires little power.

PCB Generation

After attempting to complete our first printed control board in EAGLE 4.0 software, we decided to change to the PROTEL software, mainly because we have a fully licensed version in the labs. Second, the EE department will etch our boards, and they only use PROTEL. However, we are not using the EE unless we are under a great time constraint, as the EE department does not perform the drill-thru technique that would require the use of vias. This would make our assembly much more time consuming and subject to failure. We have found a site, http://www.apcircuits.com that will manufacture our boards fairly cheaply at around $75. They allow PROTEL designs and perform all the professional services such as drill-thru, silk screening, etc. Once our design is completed, we will send off for both boards to be etched.

Robot Progress

We have assembled the Mark III Robot and it is functioning properly. We carefully soldered the circuit board together and did not have many problems with it. After it was constructed, we confirmed its ability to receive data from the computer via its serial port. At first, we could not get the Mark III to connect. We found a Yahoo! Group forum, which posts questions and answers about common problems with the robot. We found that we were using the connection software for an older version of the robot, and all that was required that we use software compatible with our robot. Once connection was established with the computer, we located and ran a sample program to test it. This sample program controls the Mark III to line follow. The test was successful and our Mark III is complete.

Algorithm Design for Mark III

We have begun to learn how to program the Mark III. We must now modify the existing programs to achieve our own design goals. We have looked at several examples and we are looking into how to actually control the servos of the robot. Once this is completed, we will then be able to move the servos according to data received from the microphones. However, we are only in the early stages of designing the algorithm.

Order Status

We have received all our parts that we have ordered except the RMS-to-DC converter. One problem we noticed is that soldering the leads on the microphones is a difficult process and the leads that we have attached our very brittle and are not easily handled. We may need to order another batch in the future, to ensure we will have eight working microphones. The only currently pending transactions are the actual etching of our microphone array and controller boards.

Schedule/Future Plans

We have finally worked out our entire microphone and filter issues, leaving us with just completing the rectifier and the analog-to-digital conversion. We believe the new part we ordered will solve these issues. After this, we will get the controller board designed and sent off for etching, leaving us only the OOPIC programming to complete and testing

With only about 4 weeks left to go in the semester, we are slightly behind our original planned schedule. With the many problems we have experienced with our microprocessor and microphone array, it has pushed back many of the things we still need to do to complete this project. Hopefully, we will complete our designs of our microphone array and PCB soon and get them etched. The coming weeks will be very busy for all of us in order to meet our deadline and have a working demo of our project. Please refer to Figure 4 for our Gantt chart.

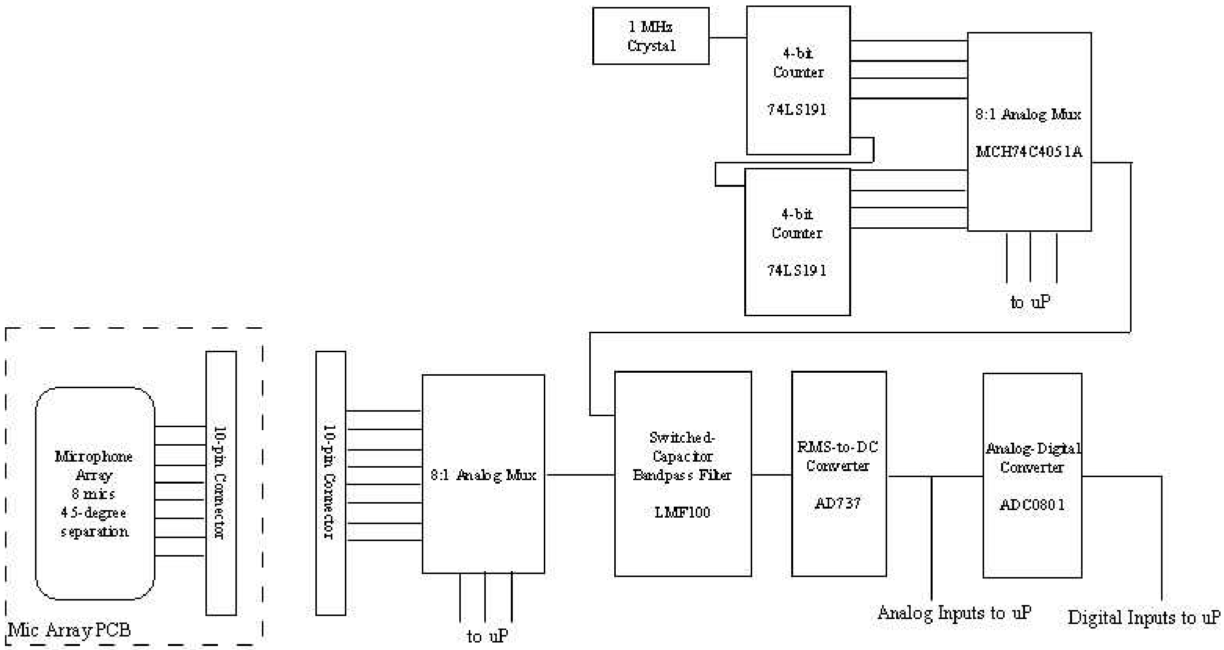


Figure 1 — Design Diagram

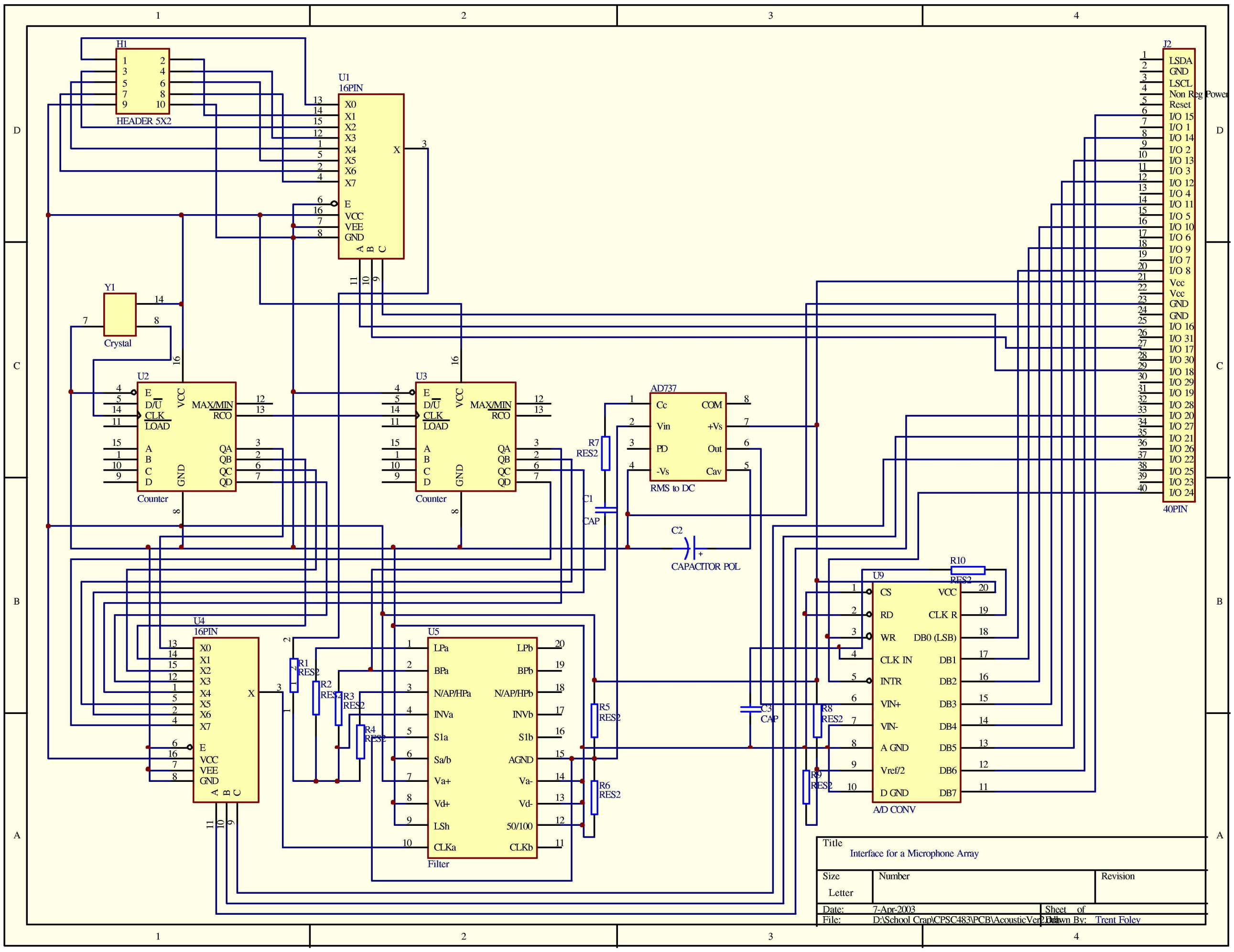


Figure 2 — Schematic

ANALOG DEVICES

Low Cost, Low Power, True RMS-to-DC Converter

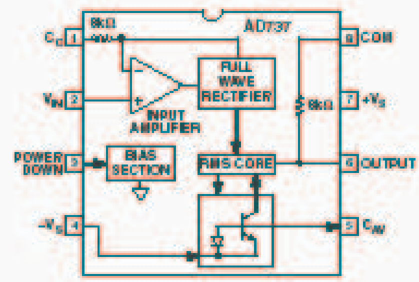
AD737*

FEATURES

Computes:
- True rms Value
- Average Rectified Value
- Absolute Value

Provides:
- 200 mV Full-Scale Input Range (Larger Inputs with Input Attenuator)
- Direct Interfacing with 3 1/2 Digit CMOS A/D Converters
- High Input Impedance of 10^{12} Ω
- Low Input Bias Current: 25 pA Max
- High Accuracy: ±0.2 mV ±0.3% of Reading
- RMS Conversion with Signal Crest Factors up to 5
- Wide Power Supply Range: +2.8 V, –3.2 V to ±16.5 V
- Low Power: 160 µA Max Supply Current
- No External Trims Needed for Specified Accuracy
- AD736—A General-Purpose, Buffered Voltage Output Version also Available

FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

The AD737 is a low power, precision, monolithic true rms-to-dc converter. It is laser trimmed to provide a maximum error of ±0.2 mV ±0.3% of reading with sine wave inputs. Furthermore, it maintains high accuracy while measuring a wide range of input waveforms, including variable duty cycle pulses and triac (phase) controlled sine waves. The low cost and small physical size of this converter make it suitable for upgrading the performance of non-rms precision rectifiers in many applications. Compared to these circuits, the AD737 offers higher accuracy at equal or lower cost.

The AD737 can compute the rms value of both ac and dc input voltages. It can also be operated ac-coupled by adding one external capacitor. In this mode, the AD737 can resolve input signal levels of 100 µV rms or less, despite variations in temperature or supply voltage. High accuracy is also maintained for input waveforms with crest factors of 1 to 3. In addition, crest factors as high as 5 can be measured (while introducing only 2.5% additional error) at the 200 mV full-scale input level.

The AD737 has no output buffer amplifier, thereby significantly reducing dc offset errors occurring at the output. This allows the device to be highly compatible with high input impedance A/D converters.

Requiring only 160 µA of power supply current, the AD737 is optimized for use in portable multimeters and other battery-powered applications. This converter also provides a power-down feature that reduces the power supply standby current to less than 30 µA.

The AD737 allows the choice of two signal input terminals: a high impedance (10^{12} Ω) FET input that directly interfaces with high Z input attenuators and a low impedance (8 kΩ) input that allows the measurement of 300 mV input levels while operating from the minimum power supply voltage of +2.8 V, –3.2 V. The two inputs may be used either singly or differentially.

The AD737 achieves a 1% of reading error bandwidth exceeding 10 kHz for input amplitudes from 20 mV rms to 200 mV rms while consuming only 0.72 mW.

The AD737 is available in four performance grades. The AD737J and AD737K grades are rated over the commercial temperature range of 0°C to +70°C. The AD737A and AD737B grades are rated over the industrial temperature range of –40°C to +85°C.

The AD737 is available in three low cost, 8-lead packages: plastic DIP, plastic SOIC, and hermetic CERDIP.

PRODUCT HIGHLIGHTS

1. The AD737 is capable of computing the average rectified value, absolute value, or true rms value of various input signals.
2. Only one external component, an averaging capacitor, is required for the AD737 to perform true rms measurement.
3. The low power consumption of 0.72 mW makes the AD737 suitable for many battery-powered applications.

*Protected under U.S. Patent Number 5,495,245.

REV. D

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Figure 3 — RMS-to-DC Conversion

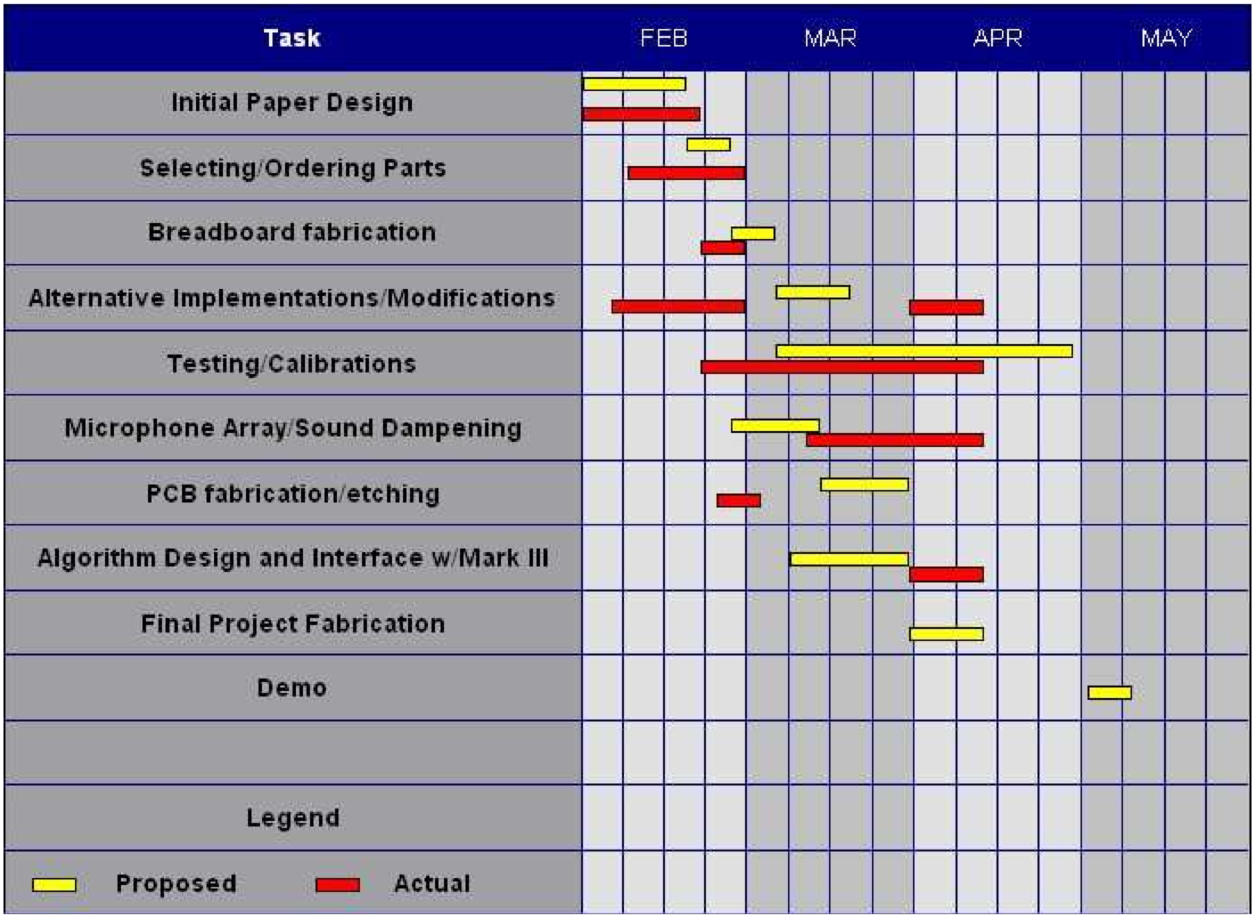

Figure 4 — Gantt Chart

Microphone Directionality Test

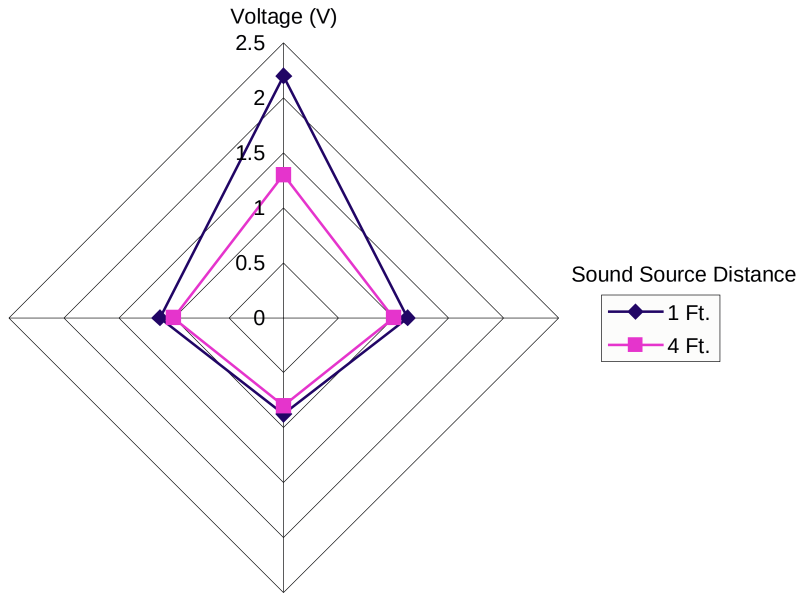

Figure 5

Microphone Directionality Testing		
Mic Position	Distance = 1 ft.	Distance = 4 ft.
Front	2.2 V	1.3 V
Left	1.125 V	1.0 V
Behind	875 mV	800 mV
Right	1.125 V	1.0 V

Table 1