Digi Systems
DSS S1

Group #9
Friday, December 10, 1999

Josh– Group Leader
Introduction & Appendices
Erik–
Prototype Description &
Principals of Operation
Mark–
Analysis and Testing
Brett–
Project Management
Rich–
Summary and Recommendations

Executive Summary

Our digital postal scale, the DSS S1, is created to be an effective and efficient product for the home/office market. With a three point bending system, the scale resembles a diving board to maximize accuracy from the enhanced leverage. The end of the beam is attached to a platform that supports the object to be weighed. The other end goes into the body of the scale and over a knife-edge where it attaches to a lead weight to secure it. The inside of the body is concealed by a cover, which contains an on/off switch and digital display for the readout.

The testing of our scale came to be inaccurate due to some troubles that we encountered in the circuit and we were unable to find the resolution required. But enclosed you will find our data none-the-less in a chart and a graph. The various tasks that were needed to accomplish this project were many, so they had to be split up in order to be productive and efficient and keep our deadlines. You will find the jobs assigned to each person along with a timeline for our scale and some recommendations for a future project.

Introduction

This is a final report on our digital postal scale, the DSS S1. Contained within these pages you will find detailed descriptions on what we did in order to create a prototype scale that is fully functional and within the required specifications: must hold a capacity of 0-4 lbs.; have a resolution of 0.5 oz; an accuracy of 0.5% over the full range; have an output readable from 2 feet away; have a platform large enough to accommodate a standard envelope; be powered by 9V batteries; must fit into a shoe box (15"x 8"x 5"). Each group must also stay under their budget which was $25 per team member in the group.

Prototype description and principles of operation

When our group designed our scale we had the idea in mind that three point-bending and minimal moving parts would minimize the error in our scale. With that in mind we had chosen to go to a diving board flex system, and with this we would gain both three point-bending and also minimal moving parts (see Figure 1).

To account for the torque that would be made with the beam (tipping forward) we put a five pound lead weight to the back of our scale, which kept the scale steady up to and including four pounds and then the scale would slightly tip. With this type of teeter-totter system, not only the beam would keep from deforming but also the strain gage would not be affected by large amounts of weight.

We had visually placed the strain gage exactly over our knife-edge, (which was made out of steel, and the edge was cut at 60° from the horizontal) where we were able to a get maximum flex. We had tested this on the diving boards in the Lombardi Pool, on the University campus. When weight was placed on the scale platform the strain gage would then cause a change in the resistance in the wheatstone bridge, this voltage would then in turn go into the op-amp, which would increase this voltage and would read out on the voltmeter.

The casing and platform of our scale was made out of sheet metal, which we had to have sent out of town to have fabricated because the prices in town were too overpriced. The beam for our scale was made out of 1/8" aluminum, (see Figure 2), we chose to go with a 1/8" piece because of the way that our scale was designed. We were afraid that if we were to go with a thinner beam then it would have been permanently deformed if too much weight was placed on the platform. The electrical part of our scale consisted of the following parts: three 9 volt batteries, one to power the voltmeter and two to power our circuit; three 100 ohm and six 10 ohm resistors, which made up three sides of the wheatstone bridge; three 20k ohm resistors, one 6.8M ohm resistors, a 741 operational amplifier, that in combination amplified the output signal; one 120 ohm strain gage, one solder able bread board, and a digital multi-meter. (see Figure 3).

After we had all of the parts, we had to put it all together. First of all we knew that the lead weight had to be placed in the back, so we drilled two holes through the beam, the lead weight, and the base of our scale. We attached all three parts with two bolts equipped with washers and nuts. The knife-edge, platform, and rubber stoppers all were adhered with epoxy, which proved to be very strong. The digital multi-meter itself was put on with lead tape. A complete detailed drawing of the scale mechanics, electrical, and assembly can be found in the appendices (see Figures 1,2,3,4,6) found in the back of the report.

Analysis and Testing

Testing our scale was a frustrating process to say the least. Our very first circuit gave us the best results. However, when we tried to implement it as a working part of the scale, it never worked again. Unable to test this circuit, we built another. This time we decided to take our time and build a nice looking and hopefully a working circuit. I guess this is why we choose to be Mechanical Engineers instead of Electrical Engineers, because the circuit never worked correctly.

The entire team put in many hours in an attempt to get our circuit to function within the parameters set by the class. Our circuit did work, just not to the specific regulations required. We did get a readout from the multi-meter, it just didn't read a amplified change in voltage from the strain gauge. We did however conduct some testing and analysis on our scale. We were going for a one to one resolution from pounds to voltage on our scale. That is how we came up with our theoretical voltage (see Figures 5a, 5b) for our data. As is visible, the graph shows a steady one to one line from actual weight to theoretical voltage. In this table (see Figure 5b) one pound of mass equals one volt displayed on the multi-meter.

We decided to go with the one to one ratio so the consumer would not have a problem reading the scale. Where as if the digital readout was not one to one with the actual weight, the consumer would have to refer to a chart in order to find the unit of weight desired. The experimental voltage, however, did not coincide with the theoretical voltage. The major reason for this fault is due to a decision to bypass the op-amp since we were able to obtain any kind of a reading through it. Without the op-amp we were unable to get a reading from weight under four pounds. And even after four pounds we could only obtain a reading in milivolts. Therefore the graph (see Figure 5a) seems to read an output of zero all the way across, however, once we reach four pounds we get a reading of one milivolt (0.001 V) thus giving a miniscule reading on the graph.

Project Management

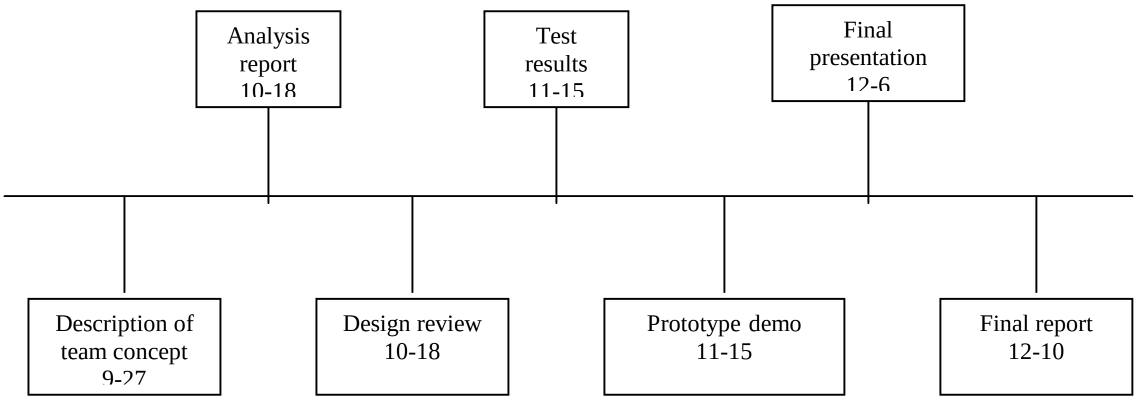
With a project of this elaboration it would be impossible for any one person to take on all of the responsibilities needed to complete this on time. And it would be inefficient for the whole group to work on the same thing together all of the time, so various tasks must be split up and assigned to different individuals. In order to properly relay the breakdown of our project tasks and the individuals who carried out these tasks we have presented you with the following:

Individual Responsibilities

Josh: Team leader, electrical, oral reports
Mark: Oral reports, mechanical
Erick: Electrical, mechanical

Brett: Written reports, mechanical
Rich: Written reports, electrical

Time Line



As a team we also were required to stay under our budget of $125 obtained from having five group members. Following is a detailed list of all of our purchases for the project:

Budgets and Expenditures

Materials	Quantity	Cost ($)
Digital Multi-meter	1	16.96
Batteries	2 packs	8.34
Aluminum bar	1	4.04
Rubber feet	3 packs	3.30
Various resisters		5.49
Strain gage	3	6.00
Potentiometers	2 packs	2.10
Lead weight	1	1.00
Aluminum platform	1	2.49
Wire	1 spool	2.55
Op-amp base	1	0.89
Op-amp	5	3.45
Aluminum body	1	45.00
Bread board	1	2.19
Nuts & bolts	1 pack	0.78
Epoxy	1	2.68
Subtotal		107.26
7.25% tax		7.78
TOTAL		115.04

Summary and Recommendations

We met almost all of the design specification requirements. The only specifications we did not achieve are getting the scale to readout a voltage within a half-ounce resolution, and we were not able to have the scale weigh within the half-ounce accuracy. The reasons why we could not achieve those specifications are because we had to bypass the operational amplifier. All the other specifications, such as size requirements, and digital output were achieved.

One key feature of our scale is that the mechanical aspects are based on those of a diving board. The reason why we chose to make our scale work on the same mechanics as a diving board, is because we wanted to use the three point bending system, and we wanted the scale to be unique. Another key feature is we used two potentiometers in our circuit. We used two because we wanted to be able to zero out the voltage readout, and we also wanted to be able to control the gain so we could control how sensitive the scale would be.

An advantage to our scale is its compact design. If you were to place the scale in a room, office, or anywhere, it could be put in a corner where it would be out of the way of everything. We do have some disadvantages to our scale however. We had to place a five-pound weight in the back of the scale to counterbalance it. Since the middle of the bending beam was the part of the beam that was supported, we had to anchor and weigh down the opposite end of the beam. When you look at the scale it is deceiving, with the compact small design you would not expect our scale to be as heavy as it is.

With having five members in the team were able to spend up to one hundred and twenty five dollars. We were able to keep the project under budget, only spending $115.04 dollars. Our main expenses were the cost of the metal for the outside case, and the voltmeter. The cost of the electronic components started to add up because we had to buy a few op amps, and extra strain gages.

Our biggest difficulty was the circuit. We used the circuit that was recommended to us by Jim Saxton and slightly modified it. The op-amp was the biggest problem with the circuit. We had built the circuit and put it into our scale. With the base of the scale being metal, we caused a short in the circuit and blew the op-amp when the power was on and the circuit touched the base. To fix the problem we placed four plastic offsets to hold the circuit up off the base. Another problem we had was the voltage readout would not stay steady. When we turned on the scale the readout would jump around quickly, and then would fluctuate less the longer we left the scale on. To fix this problem we put a 20k ohm resistor and ground connection before the op-amp. It helped with the problem, but didn’t fix it. A flaw in the design itself was that the center of gravity of the object being weighed had to consistently be in the same spot on the platform, otherwise the readout would be incorrectly modified by leverage.

Some recommendations we have are get as much help with the circuit as you can. The average mechanical engineer taking this course does not know enough about electronics to make them work perfectly. Go see electrical engineers, look up information on the Internet, and look for books in the library.

Appendices

Figure 1

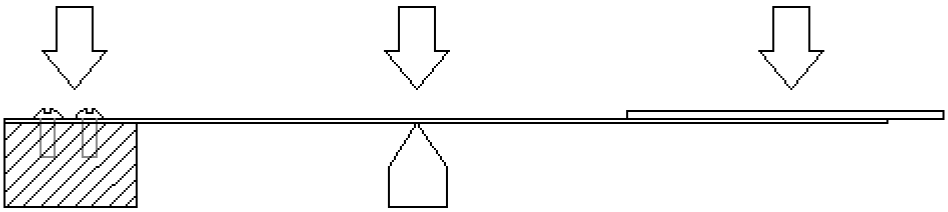


Figure 2

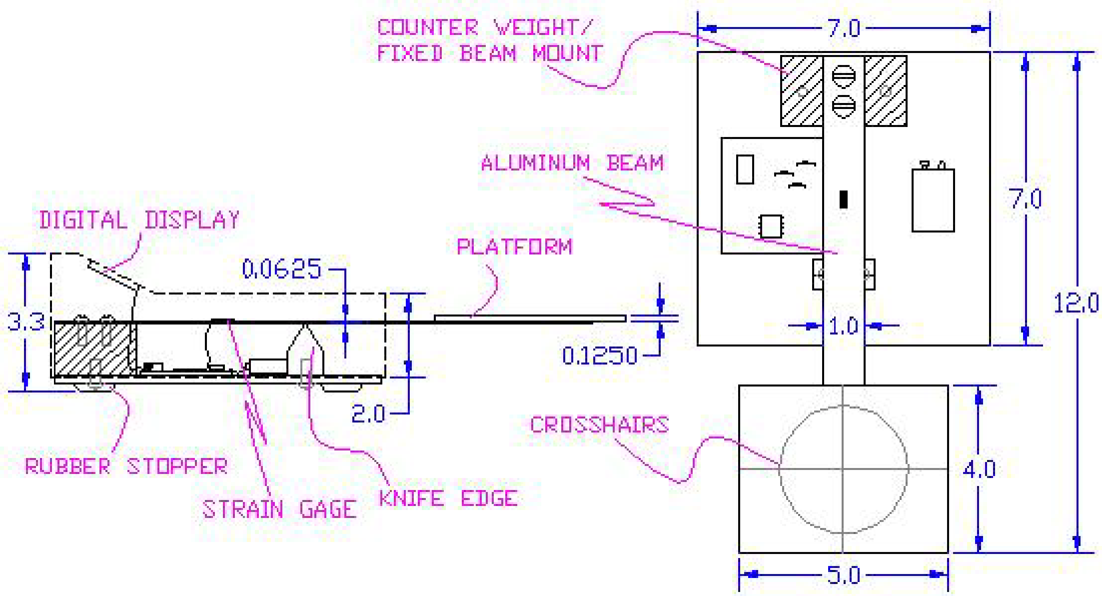


Figure 3

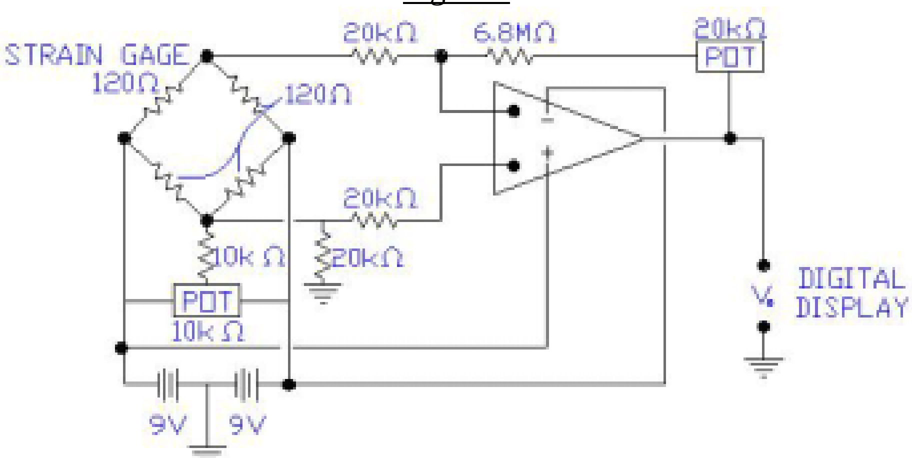


Figure 4

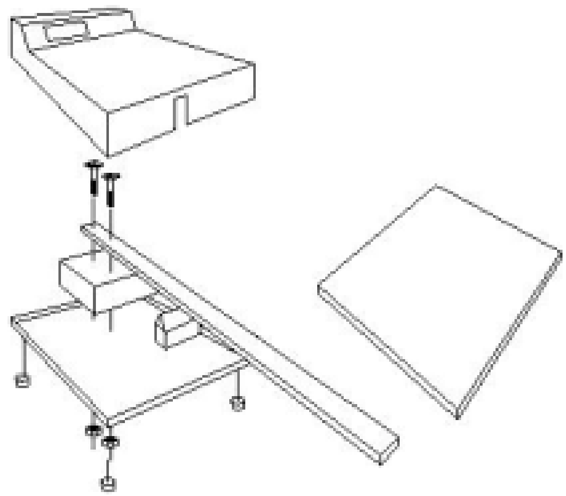


Figure 5a

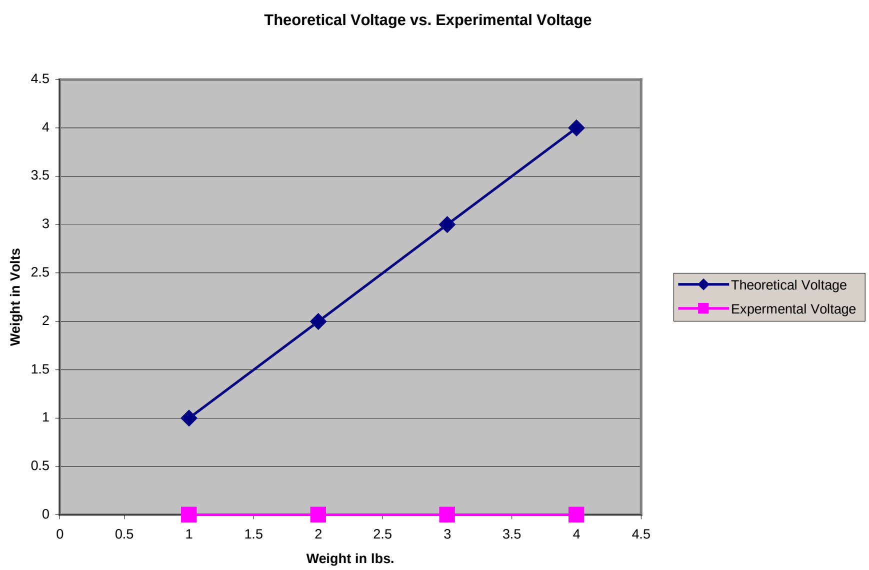


Figure 5b

Actual Weight In lbs.	Theoretical Voltage In Volts	Experimental Voltage In Volts
1	1	0
2	2	0
3	3	0
4	4	0.001

Figure 6