

Design Review

Goin' Postal (team XXX) October 18, 1999

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OVERVIEW

It is the goal of team 14 to manufacture a prototype of a digital postal scale. This scale will accurately measure the weight of a package from any point on its platform, while meeting all pre-determined specifications (*see Table 1*). This design review will describe our scale concept and its three major subsystems: 1) platform; 2) sensing beam assembly; 3) electrical assembly. It will also discuss its features and principles of operation, as well as assess our progress, and what we deem to be potential problems.

Table 1 - SPECIFICATIONS	
Fabrication cost	Less than \$125.00
Platform size	Standard envelope
Capacity	4 lbs
Readability	2 ft
Kit size	Shoe box
Assembly time	Less than 50 min.
Disassembly time	Less than 15 min.
Resolution	0.5 oz
Accuracy	+/- 0.5% full range
Power supply	Two 9-volt batteries

PLATFORM

The platform is a flat rectangular plate that measures 5-1/2" x 5-3/16" to accommodate a standard envelope, and is made of 0.125" thick 6061-t6 aluminum so that it can support a 4 pound parcel weight with minimal stress. Attached to the underside of the plate are two limiting bars that will each carry two pins. These pins will ride in slots on the vertical legs of a u-shaped rigid steel base. The primary purpose of these bars, and pins is to restrict the movement of the platform in all directions but down. It will also serve to add rigidity to the platform, stabilize the scale, and give more accurate readings, by preventing an unbalanced load from tilting the platform (*see Fig. 1*). We have not had any problems with the platform, nor do we foresee any. Cost of the materials for the platform, limiters, and base will be approximately \$19.00.

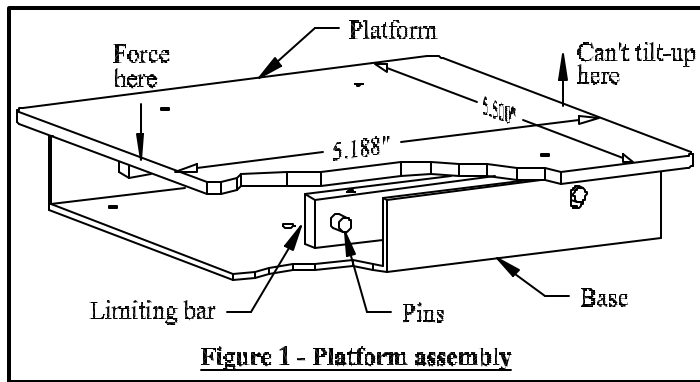


Figure 1 - Platform assembly

SENSING BEAM ASSEMBLY

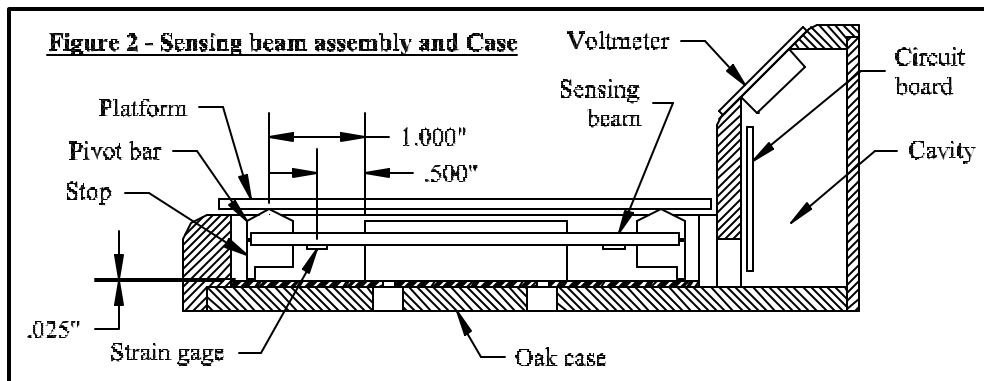
The platform rests directly on the sensing beam assembly. This assembly converts the applied force to a measurement of strain. Its primary component is a centrally mounted dual-arm sensing beam, which functions as two separate cantilever beams (*see Fig. 2*).

We selected 6061-T6 aluminum for the beam primarily because of its availability, low cost, and favorable properties for this application. We selected an initial span across which the strain is measured of 1". After thorough analysis of various bases and heights, we decided to utilize standard 1/8" thick material cut to a width of 0.340". This beam size will give us a strain of 1954 micro-strain with an applied weight of 4lbs (*see Table 2*) which should be ideal for this system. The stress for this size beam with 4lbs applied is 19,540-psi. With the yield strength of 6061-T6 averaging 42,000-psi, this gives us a safety factor of roughly 2.

We determined a need to ensure that the sensing beam will not over-stress with the application of excessive weight. To accomplish this we calculated the deflection of the beam with various applied weights, and determined that we should limit the vertical travel of the platform to 0.025" (see Table 2). We then incorporated a stop on the underside of each end of the beam utilizing that dimension.

WEIGHT	MICRO-STRAIN	DEFLECTION
1	488.5	0.0052 in
4	1954	0.0208 in
5	2442.5	0.0260 in

Attached to each end of the sensing beam is a pivot bar upon which the platform rests. The function of the pivot bars is to transfer force from the platform to each arm of the sensing beam (see Fig. 2). Having the pivot bars attached to the sensing beam will ensure that the force transferred from the platform will always be applied at the same point on the beam, which is



essential to accuracy, and repeatability. We have also incorporated a step on the underside of the pivot bars to positively locate them, and prevent them from

rotating on the sensing beam. The pivot bars will be spaced apart sufficiently to provide balance front-to-rear and they will be long enough to provide balance side-to-side. The pivot bars will be lubricated at the points with lithium grease to minimize friction.

There is at least one potential problem with this design. The scale will be well balanced, however, placing a weight to the extreme left or right sides will create some amount of torsional stress in the sensing beams. We are uncertain what effect this will have on the readings. The material cost for the pivot bars, sensing beam, and mounting will be approximately \$7.25.

The mechanism and display will be housed in a stained and varnished oak framework (see Fig. 2). Oak was selected for its inherent strengths, durability, ease of manufacture, and even its aesthetic qualities. We foresee no problems manufacturing the case, and the cost of materials will be approximately 10.00

ELECTRICAL ASSEMBLY

The electrical assembly is essentially a circuit that will sense a change in resistance, convert that to a change in voltage, amplify it, and then display it using a standard digital voltmeter. As previously discussed, the platform and sensing beam assemblies convert a force to a measurement of strain. To measure this strain we will utilize two strain gages. They will be mounted to the underside of the beams at the center of the strained area (see Fig. 2). The strain gage is effectively a variable resistor that changes resistance as it bends with the sensing beam. The change in resistance is not easily measured with any accuracy, so the resistance is converted to voltage by integrating the strain gages into positions R1, and R3 of a Wheatstone bridge. Positions R2 and R4 are 120-ohm resistors, which match the specified resistance of the strain gages (see Fig. 3). As long as the four legs of the bridge have the same resistance, there will be no voltage output. As soon as a load is applied, the resistance of the strain gages changes,

creating an output voltage. For example, a weight of one pound applied to our scale would create an output voltage of only 4.4mV.

This voltage is too small to be accurately measured so it is then routed through a differential amplifier circuit (see Fig. 3). This circuit consists of an LM471 operational amplifier (G) and four resistors to increase the voltage to a level that is easily measurable. The resistor labeled Rf is a potentiometer known as a feedback resistor. It provides us with the ability to adjust the gain of the amplifier circuit.

The ratio of Rf and Ra determines the gain. Since a weight of one pound creates an output voltage of 4.4mV, we will need a gain of approximately 227.5 to make one pound display one volt. With a 120-ohm resistor at Ra, and a 50k-ohm potentiometer at Rf we can easily achieve the correct gain.

The final piece of the circuit is a nulling potentiometer consisting of a potentiometer (POT1), and a resistor (R5). The weight of the platform will apply an initial load, and therefore create an output voltage. With the nulling potentiometer we will be able to zero out this initial reading. To complete the

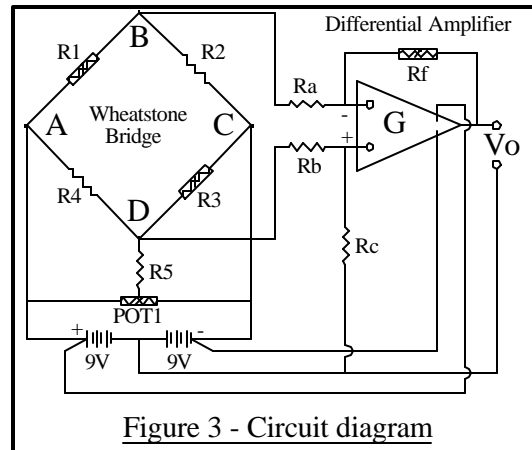


Figure 3 - Circuit diagram

scale we will attach a digital voltmeter at Vo to display the weight. Two 9-volt batteries power the bridge/amplifier circuit. All electronics, except the strain gages and the wires connecting them to the rest of the circuitry, will be housed in the rear cavity directly below the voltmeter (see Fig. 2). This will allow easy access for assembly, calibration, and battery replacement.

There are a couple of potential problems with the circuit. One is that after referencing a book on strain gages, we are unsure that the nulling potentiometer will work when there are two active strain gages. The second is that we have yet to find any reference material with guidelines for the selection of the values of the potentiometer, and resistor for the nulling potentiometer. We will continue to research this, and if we find nothing we will simply experiment. We have estimated the cost for components at around \$40.00.

PROJECT PROGRESS

Team 14 meets twice a week, and has a detailed schedule and task list. We are at this point right on schedule. Upcoming deadlines include: final release of plans by 10/18/99; purchase all required materials by 10/20/99; receive completed fabricated parts, and first article by 11/4/99; final assembly, test, and calibration by 11/8/99.

Table 3 shows a basic parts list (a detailed list is available including costs). All of the parts required should be very simple to acquire, or fabricate. We are using Reno Salvage as the source for our metals, and Sandy's Electronics and Radio Shack as the sources for our electronic components. Total estimated cost for all parts including hardware is approximately \$85.00, well below our \$125.00 budget. Our main operational concern at this point is being able to get parts fabricated in keeping with our tight schedule. We will most likely need to fabricate most of the parts ourselves.

DESCRIPTION	QTY
PLATFORM ASSEMBLY	1
SENSING BEAM ASSEMBLY	1
CIRCUIT ASSEMBLY	1
CASE	1
ON/OFF ROCKER SWITCH	1
STRAIN GAGES	2
DIGITAL VOLTMETER	1
HARDWARE	A/R