Overview

➢ Product Description

➢ Objectives

➢ Block Diagram
Product Description

- **Weighing Scale**
  - 0 – 5 lbs
  - 1 decimal place accuracy

- **Clock Function**
  - 3 switches

- **Implemented with M68HC11 Microprocessor**
Objectives

DIGITAL WEIGHING SCALE

Primary Functionality
- Continuously display weight
  - Updated weight on LCD once per second
  - Accurate
  - Accurate to one decimal place

Secondary Functionality
- Digital clock
  - Continuous display of standard time on LCD
  - Ability for time to be set
  - Product should have switches to allow user to set time

Affordable
- Inexpensive components
- Minimal number of components
- Efficient design
- Efficient assembly
- Strategic placement of components to maximize the use of space on breadboard

Safe
- Stable
- Good electrical design
- Wires color-coded
- Neatly assembled
Background

- Prior Work
- OSHA
- FCC
Patent application 20020050412
“A lever system (1, 7) for a weighing scale has an electrical transducer, particularly a strain gauge (14), producing signals corresponding to the amount of the weighing load. The transducer is attached to a body (1) that is coupled to the lever system (1, 7). The lever system (1, 7) includes a means (17) for receiving a calibration weight (18) in an arrangement where the forces generated by the calibration weight (18) and/or a damper element (5, 6) are magnified.”

Patent application 20020082802
“An apparatus and method for weighing and non-contact measuring of dimensions of a stationary object, wherein the platen on which the object is placed for weighing and measuring is isolated from the support assembly for the dimension measuring sensors for greater sensitivity and accuracy in weight determination. A method of determining object speed of linearly in-motion object, useful for determining object dimensions, is also disclosed.”
1910.303(c)
Splices. Conductors shall be spliced or joined with splicing devices suitable for the use or by brazing, welding, or soldering with a fusible metal or alloy. Soldered splices shall first be so spliced or joined as to be mechanically and electrically secure without solder and then soldered. All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors or with an insulating device suitable for the purpose.

1910.303(g)(1)
Working space about electric equipment. Sufficient access and working space shall be provided and maintained about all electric equipment to permit ready and safe operation and maintenance of such equipment.
1910.305(f)

All conductors used for general wiring shall be insulated unless otherwise permitted in this Subpart. The conductor insulation shall be of a type that is approved for the voltage, operating temperature, and location of use. Insulated conductors shall be distinguishable by appropriate color or other suitable means as being grounded conductors, ungrounded conductors, or equipment grounding conductors.
This is a class B digital device, pursuant to Part 15 of the FCC Rules

- The device can not cause harmful interference
- The device must accept any interference received
- These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.
Mechanical Design

- Overview
- Parts List
- Design Alternatives
Overview

- **Final Design**
  - Object is placed on the tray
  - Force is measured through the dowel rod on the pressure sensor
  - The voltage from the sensor is converted to the weight value
Parts List

- Plastic Project Box
- 2-Metal Bushings
- 4-screws
- 2-9V battery clips
- Wood Dowel Rod
- Plastic End Cap
- 16-Gauge Sheet Metal
- M-Type Power Plug
- M-Type Power Jack
Design Alternatives

- Use of Spring / Lever Mechanism
- Using 4 Sensors
Use of Spring / Lever Mechanism

- One possible design involved using a lever and spring mechanism to turn a potentiometer with changes in weight.

- This design was rejected because of its non-linear response due to the spring’s behavior.
Using 4 Sensors

- Another possible design involved using a plate with 1 leg/sensor in each corner.

- The data from each sensor would be added to achieve a more accurate reading.

- This idea was rejected because of the expensive nature of the sensors.
Hardware

- Components Utilized
- Schematics
Components Utilized

- MC68HC11 microprocessor
- Evaluation Board
- Flexi-force
- Pressure Sensor
- LM 741 Op-Amp
- Potentiometer

- Resistors
- 3-Switches
- 9 volt batteries
- LCD
- Wires
The Flexi-force single element sensor acts as a resistor in an electrical circuit. When the sensor is unloaded, its resistance is very high. When a force is applied to the sensor, this resistance decreases.

**Physical Properties:**
- **Thickness:** 0.005" (0.127 mm)
- **Length:** 8.000" (203 mm) - End of connector to tip of sensor
- **Width:** 0.55" (14 mm)
- **Active Sensing Area:** 0.375" (10 mm) diameter
- **Connector:** 3 pin Berg Clincher
The op-amp is used to convert the varying resistance from the pressure sensor to a voltage that can be read by the A/D converter.
Sensor / Op-amp circuit

Schematics

- Op Amp / Sensor Circuit Output
- +5V
- SET Switch
- MODE Switch
- INCR Switch

December 10, 2002 Group 1
Software

- Overview Chart
- A/D
- Look-Up Table
- Real Time Clock
- Displaying & Processing Data
  - Whole Number
  - Decimal Number
Overview Chart

Configure A/D Converter

Check If CCF Is set

Collect 4 samples from AN2/PE2

Average the samples

Look up corresponding weight in table

Separate weight into whole and decimal part

Save whole and decimal parts

NOTE: The weight is displayed in the ‘second’ routine
A/D Conversion

- Bit pattern to written into ADCTL
  - Bit-7 = Don't care because it's a read only bit
  - Bit-5 = 0 for Non-scan mode
  - Bit-4 = 0 for Single-channel mode
  - Bit-3, Bit-2, Bit-1 and Bit-0 = 0 0 1 0 (to select AN2)
Look-Up Table

Data from A/D conversion is used to find the weight that corresponds to the voltage read from the sensor circuit.

STAA AVG ; Save average
LDY #LISTST ; Load Y with $300
LDAB AVG ; Load ACCB with the value of the average
ABY ; Add ACCB with index Y and store in Y
LDAA $00,Y ; Load ACCA with the value in the address where
; Y is pointing to (this converts the voltage to the weight)
STAA WEIGHT ; store this value in location WEIGHT
The following code is used to divide the weight data into two parts, the whole number and fractional number. (assumes ACCA already contains the weight value)

```
ANDA #$F0 ; 'AND' ACCA with 11110000 to keep only the upper nibble
LSRA ; LOGICAL SHIFT ACCA to the Right
LSRA ; LOGICAL SHIFT ACCA to the Right
LSRA ; LOGICAL SHIFT ACCA to the Right
LSRA ; LOGICAL SHIFT ACCA to the Right
STAA WHLNUM ; store the shifted value in the location WHLNUM
LDAA WEIGHT ; Load ACCA with the value in WEIGHT
ANDA #$0F ; 'AND' ACCA with 00001111 to keep only the lower nibble
STAA DECNUM ; store this value in DECNUM (this is the tenths place)
```
Displaying Data

The weight data is displayed within the second routine to continuously show the user the most recent weight.

JSR ROW2  *Move the cursor to Row-2
LDX #MESS2  *message 2 is 'WEIGHT ='
JSR PRINT  *display 'WEIGHT ='
JSR DSPWGT  *display the weight, WHLNUM.DECNUM
LDX #MESS3  *message 3 is 'lbs'
JSR PRINT  *display ' lbs'
Calibration

- Hardware
- Software
Hardware Calibration

- The feedback resistor in the op-amp circuit must be adjusted to give a desired voltage output when a 5 lb weight is placed on the scale.

- Appropriate $V_{RH}$ and $V_{RL}$ levels must be applied to the A/D pins of the micro.
The look-up table must be adjusted so that the scale accurately display the weight from 0-5 lbs, given the A/D resolution determined by the Hardware Calibration.

The look-up table must be shifted so that 0 lbs is displayed when only the weight of the tray is present.
Operating Procedure

- Scale
  - Continuous Read-out

- RTC
  - 3 switches
## Cost Analysis

<table>
<thead>
<tr>
<th>Item</th>
<th>Total Cost</th>
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<tbody>
<tr>
<td><strong>Electrical Components</strong></td>
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<tr>
<td>Motorola M68HC11 – (1)</td>
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<tr>
<td>LM741 Op-Amp – (1)</td>
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<td>Switches – (3)</td>
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<td>Resistors (3-470 ohm) 5% tolerance – (3)</td>
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<td>Potentiometer – (1)</td>
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<td>Various length wires - (many)</td>
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<td>LCD – (1)</td>
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<td>9V batteries – (2)</td>
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<tr>
<td>Power supply – (1)</td>
<td>N/A</td>
</tr>
<tr>
<td>Serial cable – (1)</td>
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<tr>
<td>Flexi-force Pressure Sensor – (1)</td>
<td>$25.00</td>
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<tr>
<td><strong>Mechanical Assembly</strong></td>
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<tr>
<td>Plastic Project Box (including 4 screws)</td>
<td>$6.99</td>
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<td>Metal Bushings (2)</td>
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<td>9V battery clips (2)</td>
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<td>9V battery connectors (2)</td>
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<td>Wood dowel rod (1)</td>
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<td>Plastic end cap (1)</td>
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<td>16-gauge sheet metal (1)</td>
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<td>M-type power jack (1)</td>
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<td>M-type power plug (1)</td>
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<tr>
<td><strong>Total</strong></td>
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Problems Encountered

- Reselection of Project
- Calibration
- Mechanics
Reselection of Project

- Originally assigned to design current and voltage monitoring system for the WSU Solar Car Project
  - Unavailability of sensors
  - Unavailability of 150V – 5V DC/DC Converter

- This resulted in setting us back a few weeks for our weighing scale
Calibration

- Difficulty in determining an appropriate value for the feedback resistor
  - Used potentiometer

- Sensor conditioning required: leads to instability and non-linearity of sensor response
  - Currently conditioning sensor
Mechanics

- Use of metal rod creates a lot of friction in the bushing
  - Used wooden dowel rod instead

- Keeping the rod vertical
  - Used two 1-inch bushings to stabilize

- Keeping consistent contact with pressure sensor
  - Added flat end cap for bottom of dowel rod
## Work Breakdown

<table>
<thead>
<tr>
<th>Linear Responsibility Chart</th>
<th>Jen</th>
<th>Boban</th>
<th>Pierre</th>
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<tbody>
<tr>
<td>1. Understand Project Requirements</td>
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<tr>
<td>1.1 Abstract</td>
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<td>1.2 Executive Summary</td>
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<td>1.3 Purpose of Project</td>
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<td>1.4 Introduction &amp; Overview</td>
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<td>6. Problems Encountered</td>
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<td>7. Misc</td>
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<td>7.2 Cost Analysis</td>
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<td>8.2 Minutes</td>
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</tbody>
</table>

1: Primary Responsibility   2: Support/Work
Conclusion

- We are still working on calibrating the scale right now.

- The real time clock and all the other software works, we are just limited by the mechanical interface at this point.
Questions...