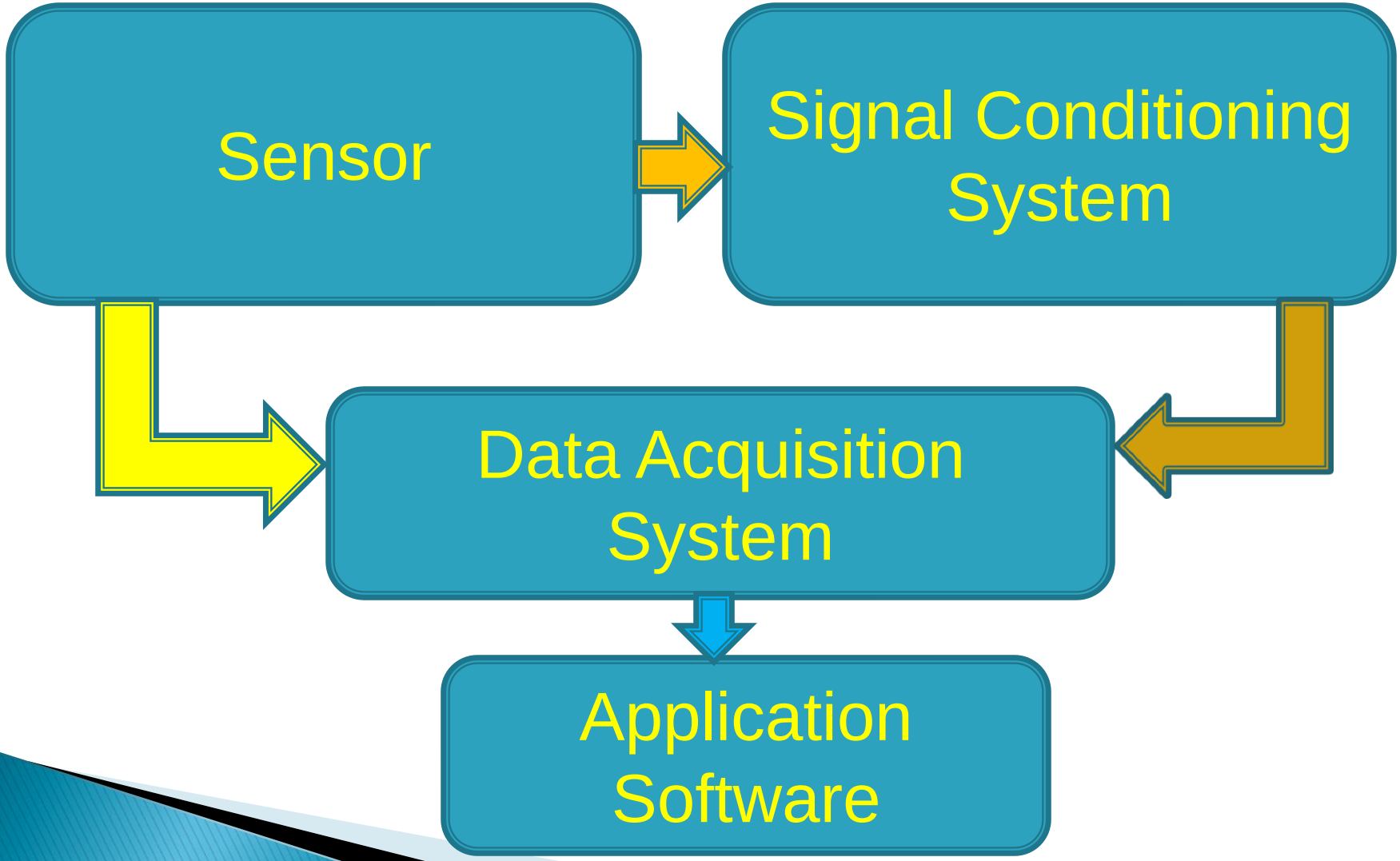
Design, Test and Integration of Force Sensor and Strain Gage

Presented by
Firdous Saleheen
firdous.saleheen@temple.edu
Date: November 30, 2011

Outline

- Basic Sensor System Building Blocks
- Force Sensing System Design
- Strain Gage System Design
- Application Software
- Application to Tactile Imaging System

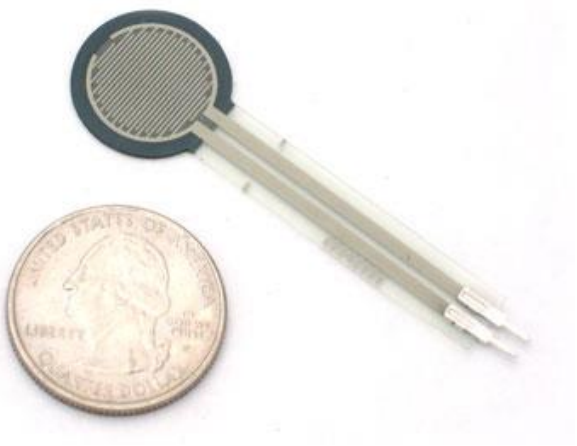
Overview

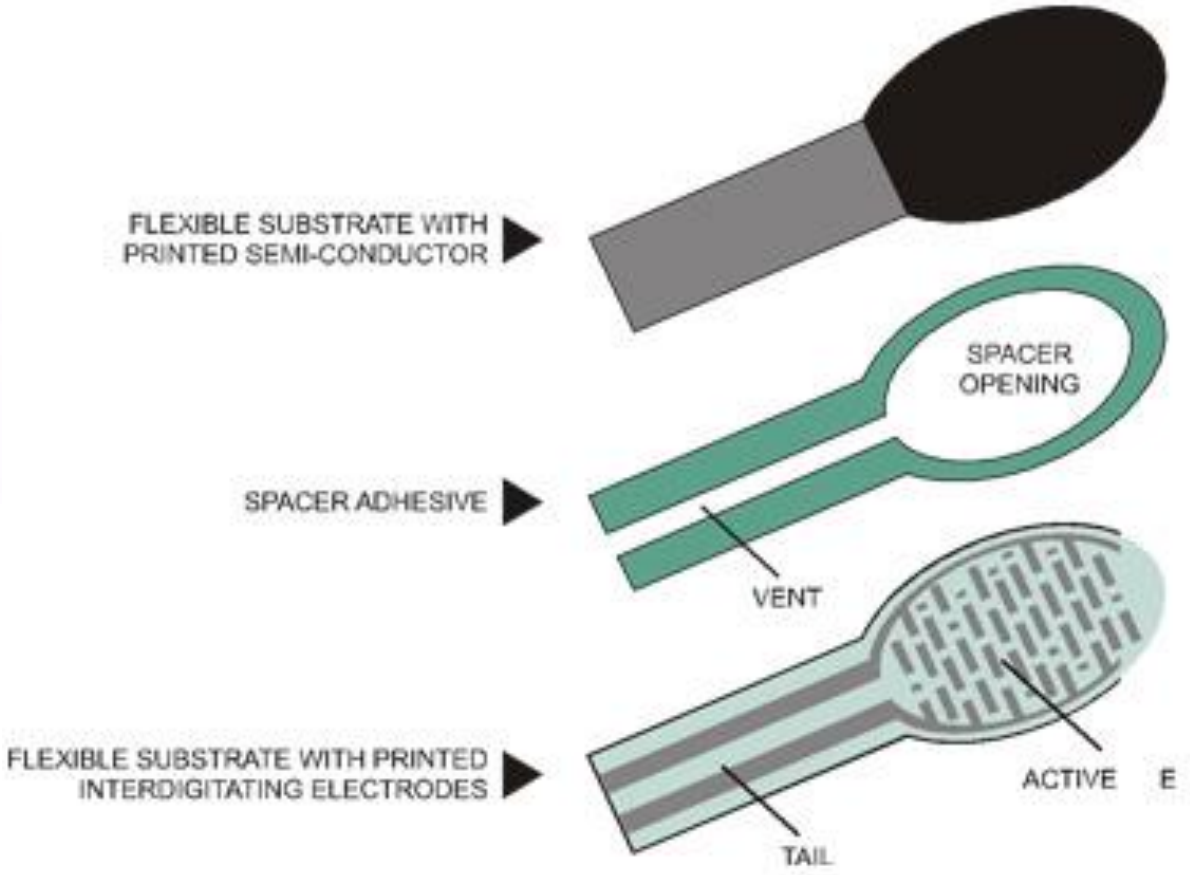

Sensor
Signal Conditioning System
Data Acquisition System
Application Software

Force Sensing System

- Force Sensing Resistor as Force Sensor
- Measurement Circuit for Force Sensor
- Arduino Uno board and Matlab script as Data Acquisition System
- Application Software written in Matlab R2010b

Force Sensing Resistor (FSR)



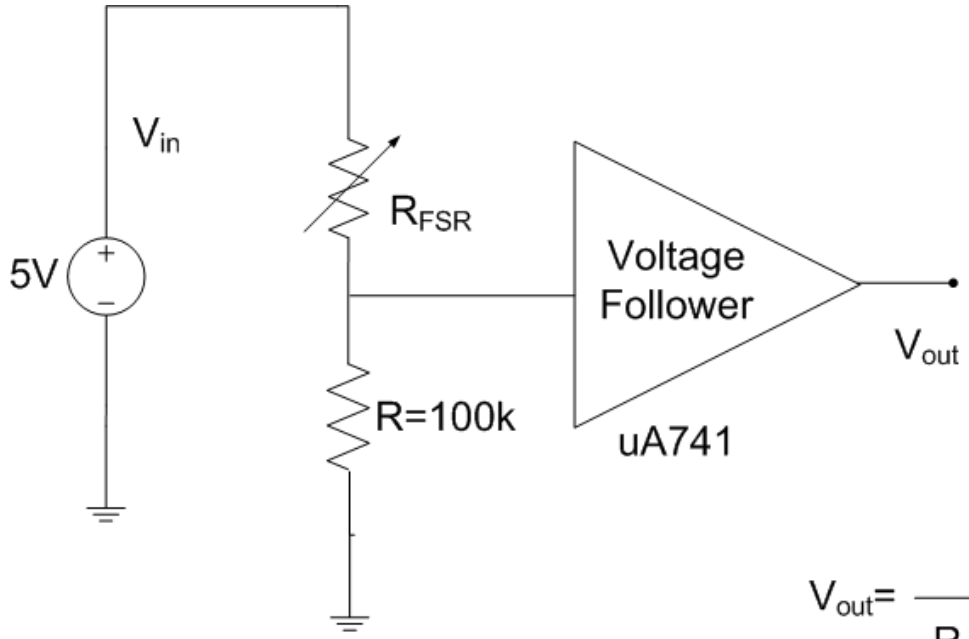


- FSR is a material whose resistance changes when a force is applied.
- Small size, low cost and easy to use.

Interlink Model 402

Sensing area diameter 12.7mm

Measurement Circuit



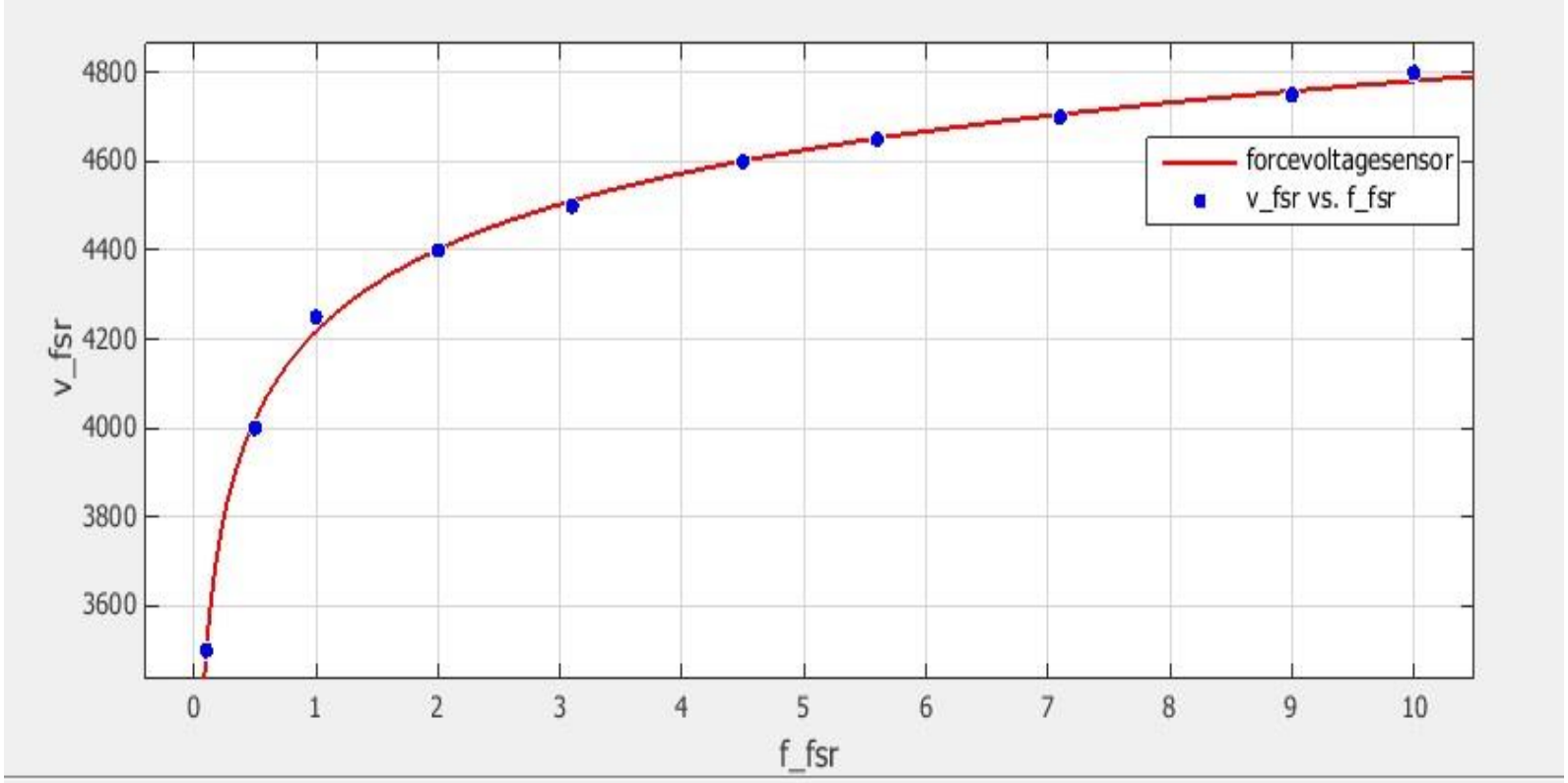
$$V_{out} = \frac{R}{R + R_{FSR}} \times V_{in}$$

- Measurement based on simple voltage divider rule
- Output voltage changes as resistance of FSR varies by above formula
- A voltage follower is used to match the upstream high impedance circuit.

Data Acquisition from Force Sensor

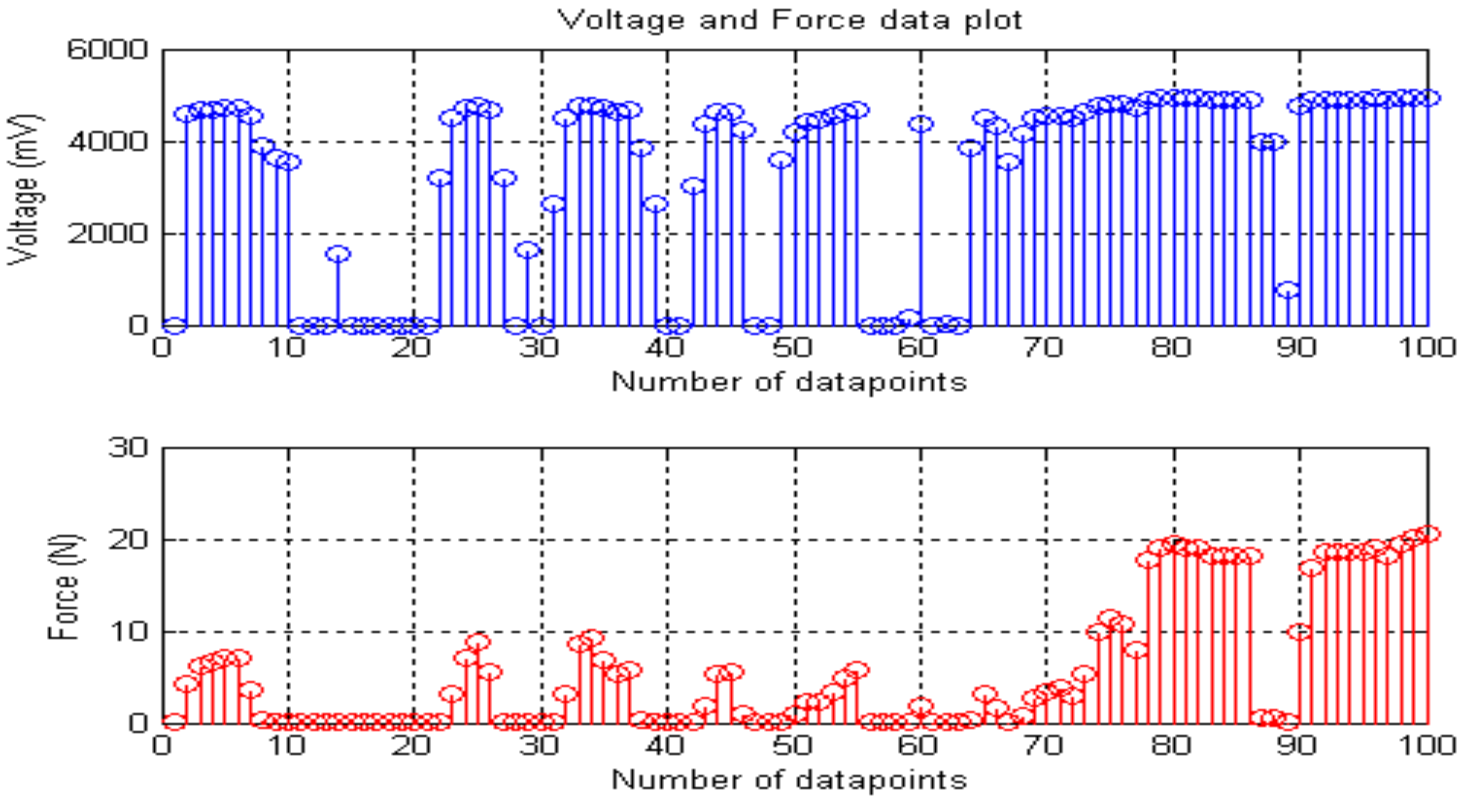
- Divided into two parts:
  - Hardware for data acquisition
  - Software for data acquisition
- Hardware – Output of measurement circuit is connected to analog pin Arduino UNO board
- Software –
  - Matlab package to support Arduino IDE.
  - Upload matlab written srv.pde file into board
  - Run a script to read the analog pin of Arduino in Matlab

Resistance vs Force Curve



- **Used matlab curve fitting tool logarithmic fitting**
- **f_fsr = exp(log((v_fsr-6835)/(-2617))/(-0.1054))**

Force Sensing Graph

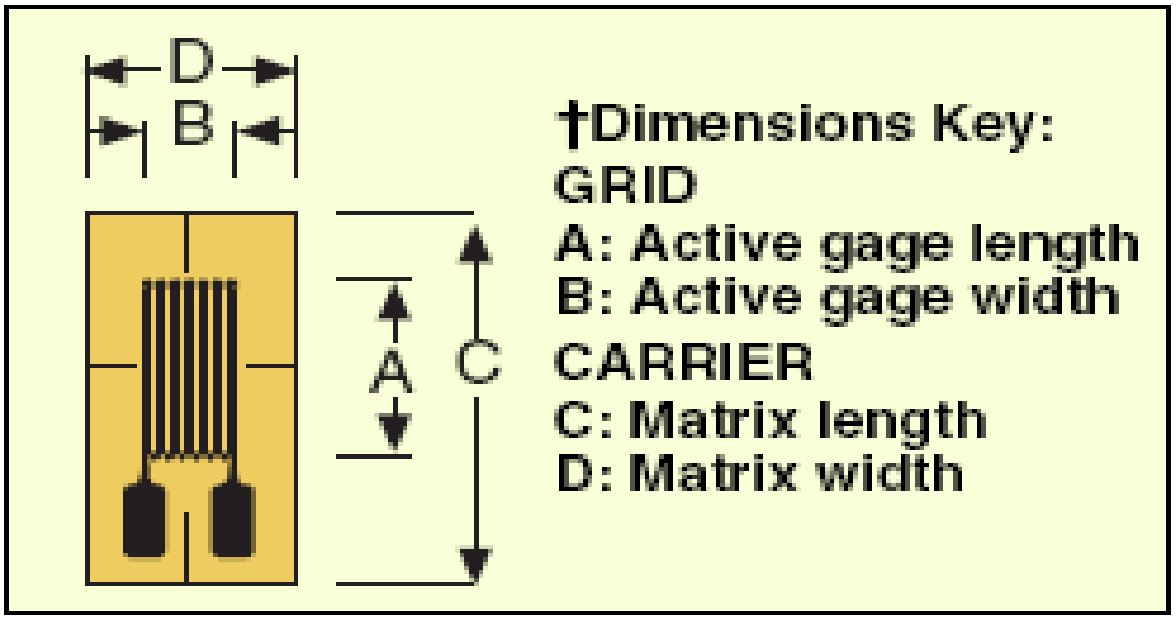


Strain Gage System

- Strain Gage
- Signal Conditioning Circuit
- Arduino Uno board and Matlab script as Data Acquisition System
- Application Software written in Matlab R2010b

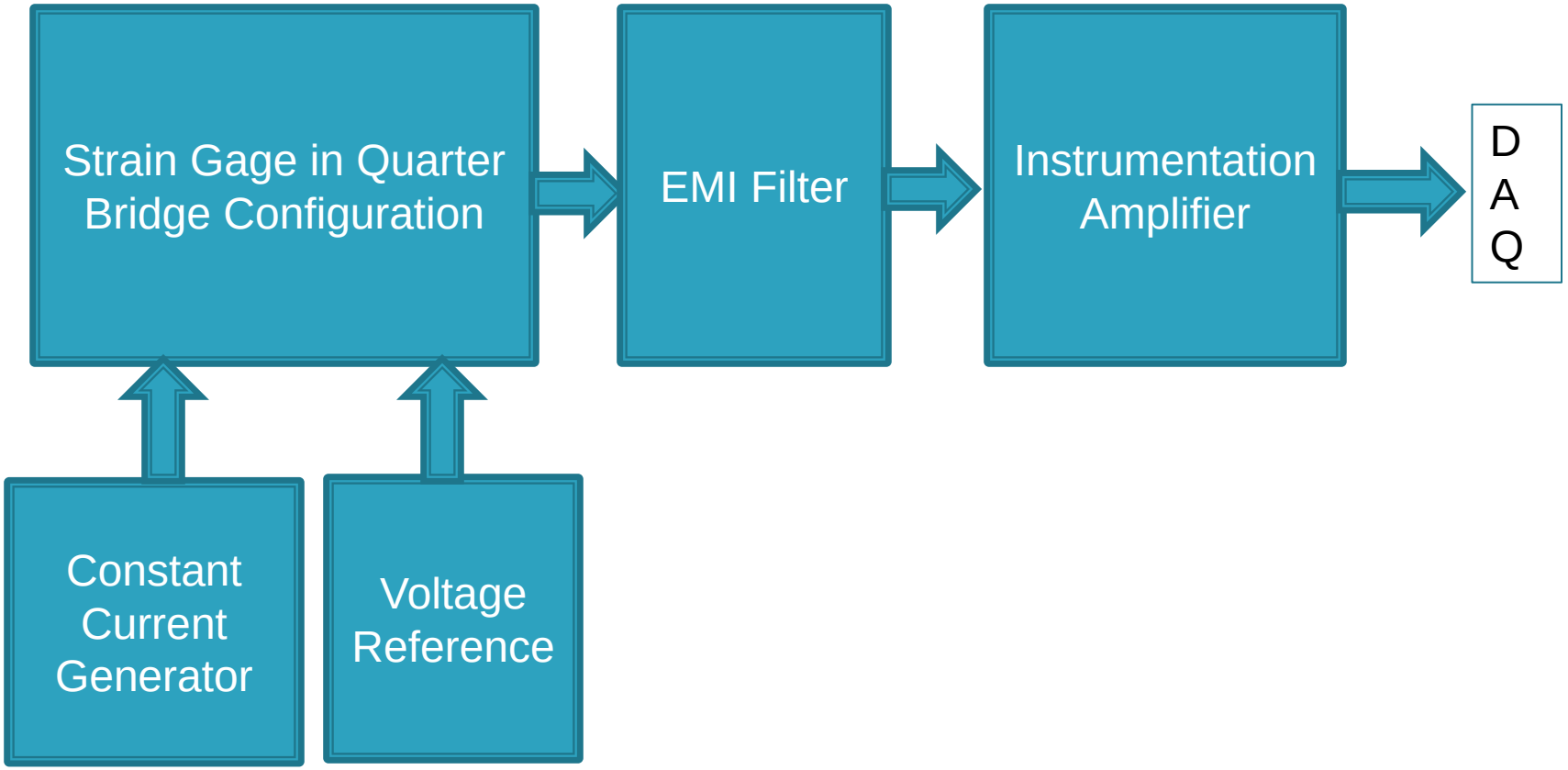
Strain Gage

- SGT-2C/350-TY11 used as strain gage.
- Nominal resistance value is 350 ohms



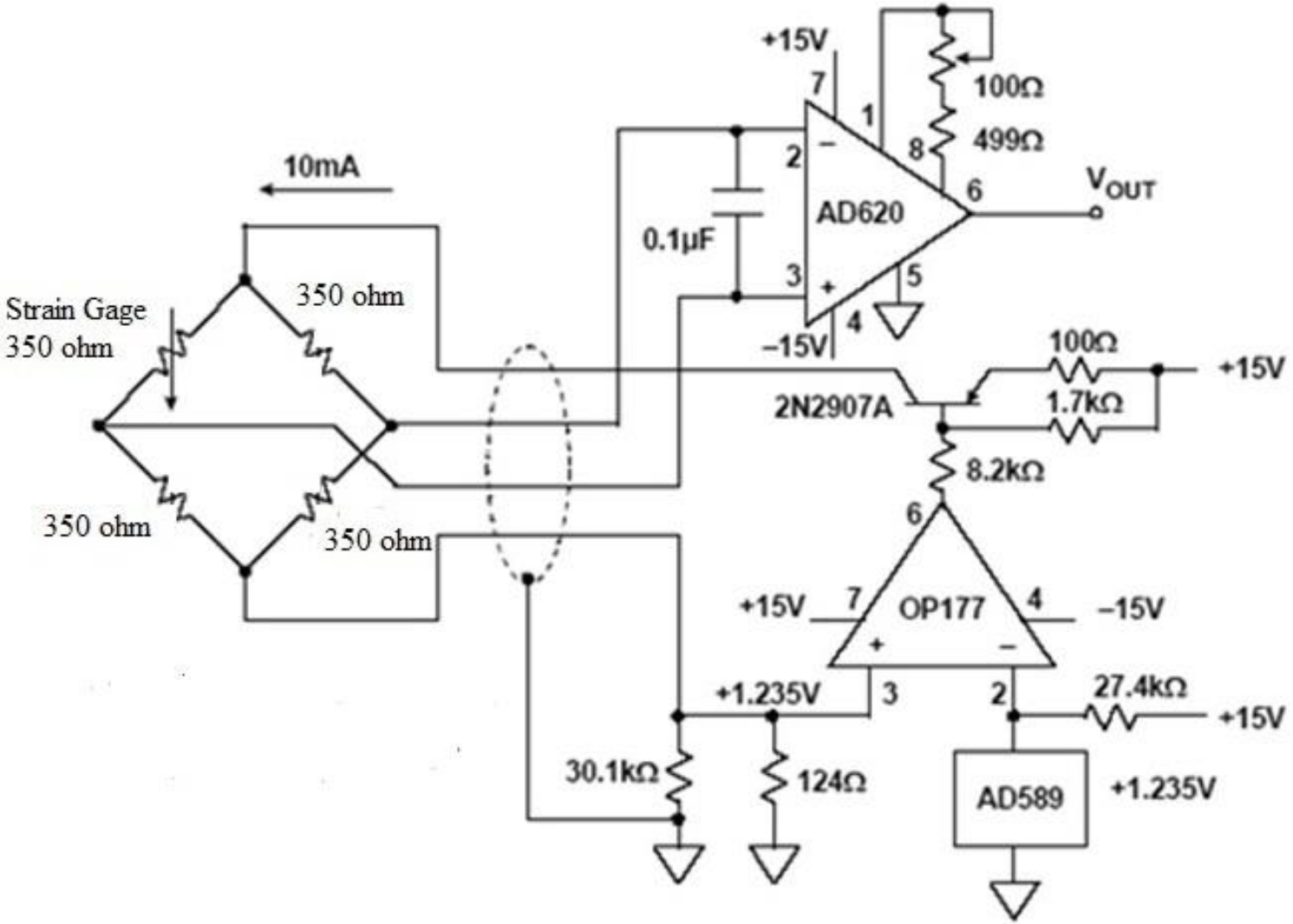
A = 1.5mm, B = 4.6mm, C = 6.4mm and D = 4.6mm.

Basic Building Block for Signal Conditioning



DAQ- Data Acquisition System

Signal Conditioning Circuit



Data Acquisition from Strain Gage

- Divided into two parts:
  - Hardware for data acquisition
  - Software for data acquisition
- Hardware – Output of measurement circuit is connected to analog pin Arduino UNO board
- Software –
  - Matlab package to support Arduino IDE.
  - Upload matlab written srv.pde file into board
  - Run a script to read the analog pin of Arduino in Matlab

Strain Calculation from Signal Conditioning Output

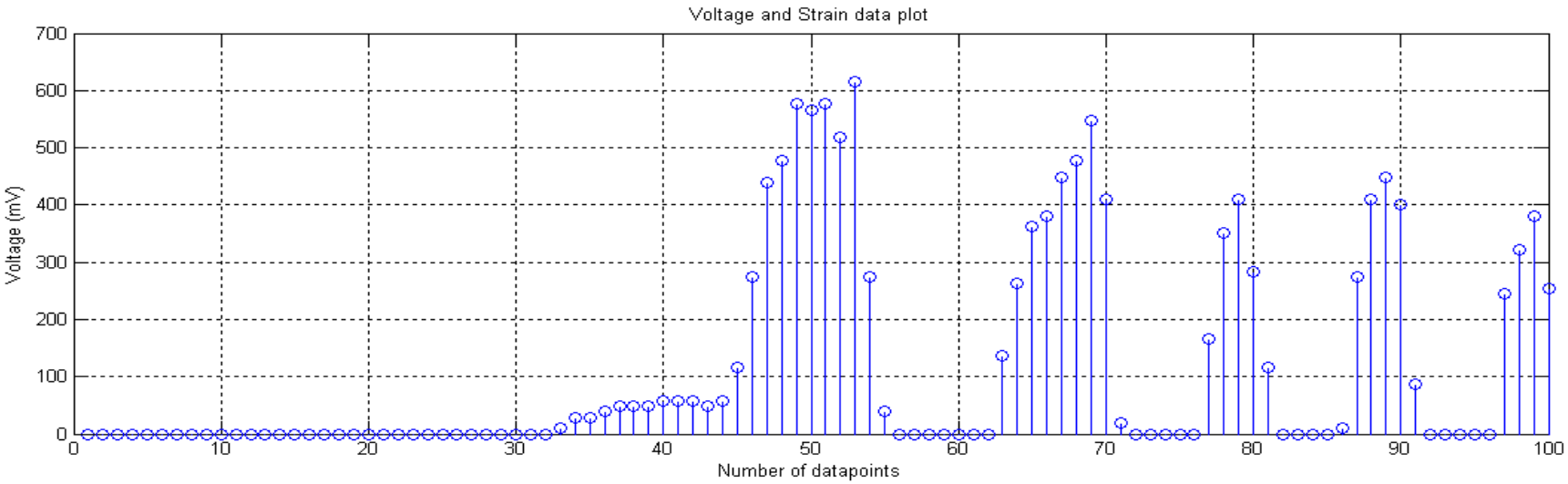
$$strain = \frac{4 * Vout}{GF * (Vex - 2 * Vout)}$$

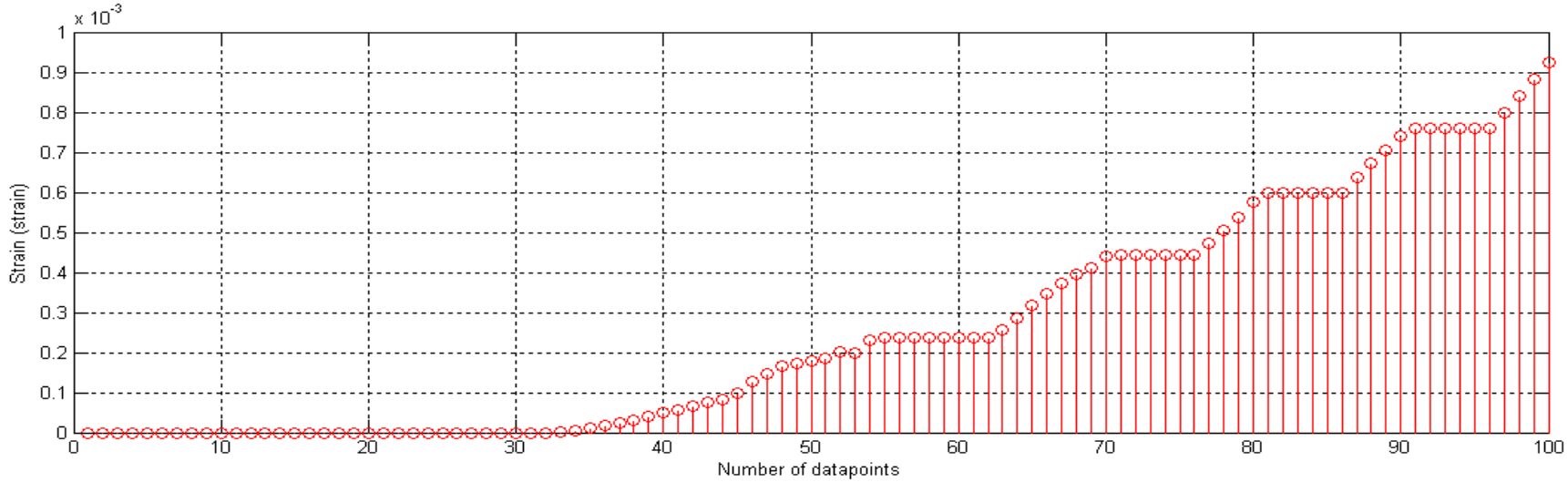
Vout = Output voltage of signal conditioning circuit

GF = Gage factor = 2

Vex = Excitation voltage = 1200mV

Strain Gage Graph





Application Software

- Fruit ripeness checker, rubber ball hardness test

Simple Algorithm

1. Start of Program
2. Take user input of force and strain data
3. Make force data into stress data by dividing the force with area
4. Find Young's modulus for each datapoint
5. Take the mean of Young's modulus
6. Design a look up table of Young's modulus vs Ripeness rating
7. Check the look up table for decision
8. Display a decision
9. End of Program

Application to Tactile Imaging System

- Force sensor can be put around TIS probe to get the force applied in the neighboring region of tumor
- Instead of a single FSR, four sensors might be used to get an improved force estimation, essentially hardness of tumor estimation
- Improvement of force estimation will cost less than $100
- Strain gage senses the dimension change of the surface it is mounted on. So it may give an indirect estimation of strain of tumor when force is applied.