Dedan Kimathi University of technology

Department of Electrical and Electronic Engineering

EEE2406: Instrumentation

Lab 2

Title: Real-time Remote Force measurement and Recording

July 13, 2015

1 Remote Force measurement

1.1 Objectives

The aim of this laboratory practice is to

- Introduce the student to remote sensing in instrumentation systems
- Introduce the student to microprocessor application in instrumentation.
- Demonstrate real time remote force measurement, signal processing, display and Recording in instrumentation systems

1.2 Requirements

1. AD620 chip (operational amplifier)
2. MCP3008 chip (analogue to digital converter)
3. Load cell (3133 Micro Load Cell - (0-5 kg) - CZL635)
4. Weights (0.25 kg, 0.5 kg, 1 kg)
5. Raspberry Pi with necessary accessories
6. WiFi network dongles
7. Breadboard and connectors

2 Theory

2.1 Introduction

Instrumentation and measurements is a key area in the field of Electrical and Electronic Engineering. This is carried out with the use of sensors and transducers. Sensors detect the quantities to be measured while transducers convert non electrical quantities into electrical ones, mainly voltage or current [1].

Telemetry is important in instrumentation as it enables collection of data from several measurement points at inconvenient locations or inaccessible areas transmit that data to a convenient location and present the several individual measurements in a usable form [2].

Microprocessor based systems are suitable for dedicated and complicated measurement systems available in modern day industries and hospitals. These microprocessors perform complicated signal processing operations [2].

In measurement systems, the last stage is often the data presentation stage. This consists of display devices and recorders. The significance of these devices is that they make the result of measurement meaningful through display of instant observation or storage for observation at a later stage [2].

2.2 Force Measurement using the Strain gauge

The stain gauge on the principle that a resistance of a wire of a semiconductor is changed by elongation or compression due to externally applied stress. It is commonly used in the measurement of force , torque and displacement [1].

In this case the measurand is a force and is applied in a column therefore producing strain. The force is first detected converted into strain which is a mechanical displacement. This strain changes the resistance of the strain gauge. Hence we have an output which is a change in the value of resistance. The measurement of force is a 2-stage process i.e first conversion of force into strain and second conversion of strain into a change in electrical resistance.

It is common phenomena that when a metal conductor is stretched or compressed, its resistance changes on account of the fact that both length and diameter of the conductor change. Also there is a change in the value of resistivity of the conductor when it is strained and this property is called piezo-resistive effect.

Hence resistance strain gauges are also known as piezo resistive gauges. The resistance change in strain gauges is small and requires the use of a bridge circuit for measurement, as shown in Figure 1. The strain gauge elements are mounted in two arms of the bridge, and two resistors, R_1 and R_2, form the other two arms. The output signal from the bridge is amplified and impedance matched.

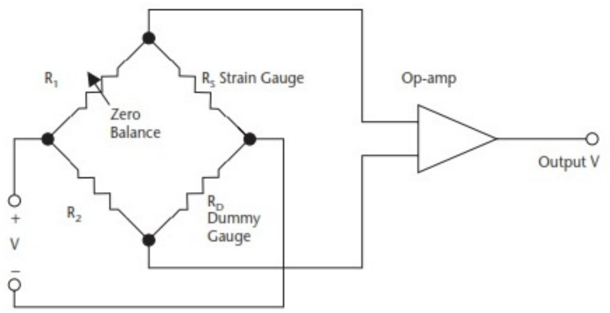

Figure 1: Strain gauge bridge circuit

2.3 Analog to Digital Conversion

The Raspberry Pi computer does not have a way to read analog inputs. It' s a digital-only computer. Analog inputs are handy because many sensors are analog outputs, so we need a way to make the Pi analog-friendly [3].

MCP3008 (analog to digital converter chip) is such a converter. It has 8 analog inputs and the Pi can query it using 4 digital pins. That makes it a perfect addition to the Pi for integrating simple sensors like photocells or potentiometers, thermistors [3]

Figure shows the schematic diagram of MCP3008 chip

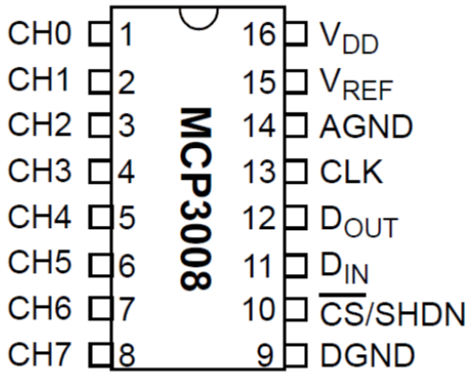

Figure 2: MCP3008 Schematic

2.4 Wireless Communication

Using wireless technologies in industrial and factory automation is very attractive for many reasons. The wireless way of communicating makes plant setup and modification easier, cheaper, and more flexible [4]. In [4], Bluetooth, Zigbee and WiFi protocols are compared in terms of power consumption, range of coverage, throughput and number of nodes that can be supported. The conclusion is that for development of control of wireless networked systems using personal computers, WiFi network is the most effective.

3 Procedure

The laboratory exercise will involve the following tasks

- Force measurement using the strain gauge
- Transmission of the measured value from the remote location to the control room using WiFi wireless network
- Real time data display and recording section on the Raspberry Pi

3.1 Force measurement

This includes the transducer and the signal conditioning section. The force signal is detected using sensor. An amplifier network is used for amplifying the detected signal.The signal which is an analog voltage is then converted to digital format before being read into the Raspberry Pi

3.1.1 Signal detection

The sensor used is a load cell (3133 - Micro Load Cell - CZL635, Figure 3)
The sensor has four pins (red-power, black-ground, blue and white-outputs). The red pin is connected to 5 V (pin 2 on Pi) and the black pin grounded (pin 39 on pi). The output is taken between the blue and white pins to the signal conditioning section. Figure 4 shows the Raspberry Pi pin configuration

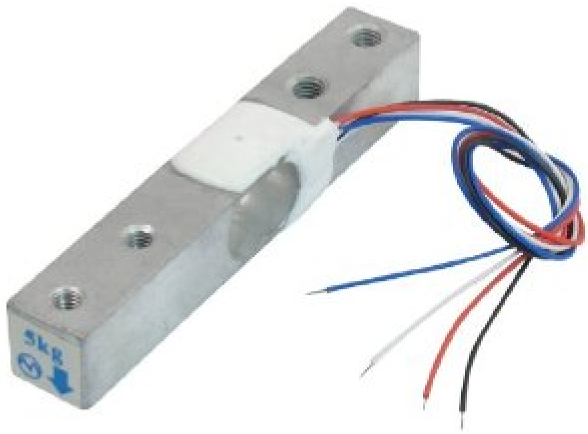

Figure 3: Load Cell

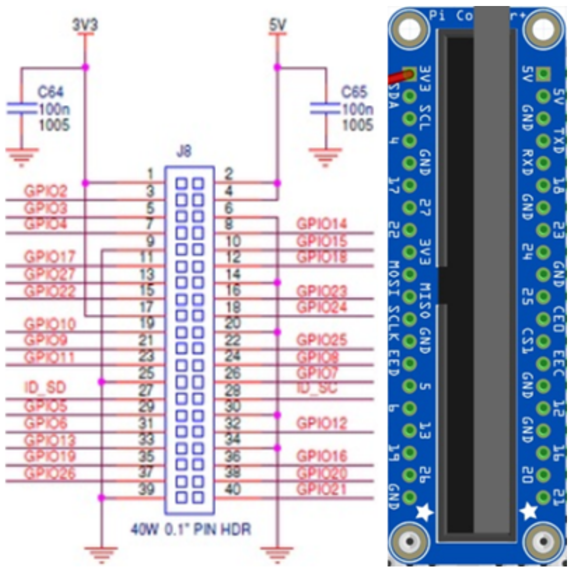

Figure 4: Raspberry Pi Pin Configuration

3.1.2 Signal conditioning

This consists of the amplifying section and the analog to digital conversion stage.

Amplifier Section
AD620 chip used for analog to digital conversion. It is an 8 pin chip, schematic shown in Figure 5
The blue pin of the sensor is connected to pin 2 of the AD620 while the white pin to pin 3. Pin 7 is connected to 5 V while pin 4 is grounded. A resistor of === is connected between pin 1 and 8. This resistor provides for the gain of the amplifier. The output is taken on pin 6

Analogue to Digital Conversion Section
The output of the amplifier (pin 6 of AD620) is connected to channel 0 (pin 1) of the

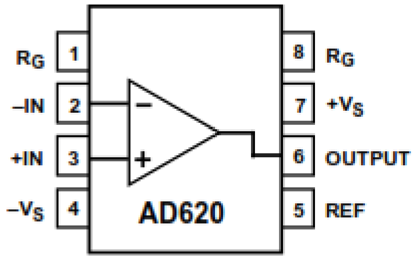

Figure 5: AD620 chip Schematic

MCP3008 chip. Other pins of the MCP3008 are connected as follows

- V_{DD} pin (pin 16) connected to 3.3 V (Raspberry Pi pin 1)
- V_{REF} pin (pin 15) connected to 3.3 V (Raspberry Pi pin 1)
- $AGND$ pin (pin 14) connected to ground (Raspberry Pi pin 39)
- CLK pin (pin 13) connected to General Purpose Input Output GPIO pin 18 (Raspberry Pi pin 12)
- D_{OUT} pin (pin 12) connected to General Purpose Input Output GPIO pin 23 (Raspberry Pi pin 16)
- D_{IN} pin (pin 11) connected to General Purpose Input Output GPIO pin 24 (Raspberry Pi pin 18)
- CS pin (pin 10) connected to General Purpose Input Output GPIO pin 25 (Raspberry Pi pin 22)
- $DGND$ pin (pin 9) connected to ground (Raspberry Pi pin 39)

A program to read the digital equivalent of the output of the sensor is written in python. See attached Appendix I.

3.2 Data transmission

This is achieved via WiFi network. A WiFi dongle is connected to each of the Raspberry Pi (one in the field and one in control room). The IP addresses of the two Pis are configured to suite that of the WiFi network.

A piece of code is written to read, on the Pi located in the control room, the data streaming on the Pi located in the field

See attached Appendix II

3.3 Data display and storage

This is achieved using mySQL database.

3.4 Circuit Diagram

4 Results

4.1 Amplified Output Voltage from Sensor

SR. No	Weight in (kg)	Output Voltage (V)
1	0	
2	0.25	
3	0.5	
4	0.75	
5	1.0	
6	1.5	
7	2	
8	2.5	
9	3	
10	3.5	
11	4	
12	4.5	
13	5	

4.2 Digital Equivalent of Output Voltage from Sensor

SR. No	Weight in (kg)	Digital Output
1	0	
2	0.25	
3	0.5	
4	0.75	
5	1.0	
6	1.5	
7	2	
8	2.5	
9	3	
10	3.5	
11	4	
12	4.5	
13	5	

4.3 Received values via WiFi network

Capture screen shots of the data streaming on the the Pi

4.4 Stored Data Files in MySQL

Take samples of data files from the MySQL database. The database will capture the following information

SR. No	Date	Time	Weight in (kg)	Digital Output
1				
2				
3				
4				
5				

5 Discussion

Discuss the results and carry out error analysis if necessary

6 Conclusion

Draw conclusions based on the outcome of the practical

References

[1] Blackburn J. A., *Modern Instrumentation for Scientists and Engineers.* Springer, 2001.

[2] Sawhney A. K., *Electrical and Electronic Measurement and Instrumentation.*

[3] M. Sklar, *Analog Inputs for Raspberry Pi using the MCP3008.* Adafruit Learning System.

[4] L. Benmabrouk. Zaineb, Ben Hamed. Mouna, ed., *Wireless Control of an Induction Motor*, International Journal of Electrical and Electronics Engineering, 2011.