Bouncing a ball on a balance

Tsienza Smith , Prof : Veiko Vunder
Institute of Technology, Robotics and Computer Engineering
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Abstract— **To measure the state of stress on the surface of a workpiece, a strain gauge can be glued on. A strain gauge is an electrical dipole, whose resistance varies with its elongation in one direction. It can be a very thin, very long conducting wire.**

The measurement cannot be made directly because the variations in conductivity of the gauge are too small to be measured directly with an ohmmeter. Direct measurement of signals makes it difficult to draw meaningful conclusions. Addition of noise makes the task more cumbersome. It is necessary to use a Wheatstone bridge circuit with an electronic amplifier.

Due to its sensitivity, the Wheatstone bridge circuit is a commonly used circuit for the measurement of small changes in electrical resistance, particularly for strain gauges. It comprises four resistive elements and can be excited by either a voltage or current source.

I. INTRODUCTION

In this work, we implement a device capable of amplifying the differential signal of a Wheatstone bridge simulating a load cell consisting of four resistors and a potentiometer and automatically correct its offset at start-up.

We use reference triggering to capture force changes on a digital balance when a lightweight object is bounced to the scale's plate and register the force readings of the digital balance together with the video frames describing the falling object's trajectory.

II. EQUIPMENT USED

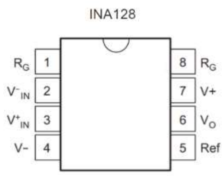
To perform this task, the following components are used:

1 - NI-DAQ 6211
2 - Breadboard + jumper cables
3 - 5v Battery pack with bi-polar power outlets
4 - INA128 instrumental amplifier with 100 Ω gain resistor (gain 501, no filter)
5 - LM293P comparator chip (for creating a digital trigger signal)
6 - 22 kΩ resistor for level shifting
7 - A ball to drop on the scale
8 - Camera
9 - LabView 2021

a)

b)

c)



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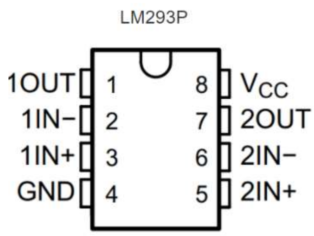
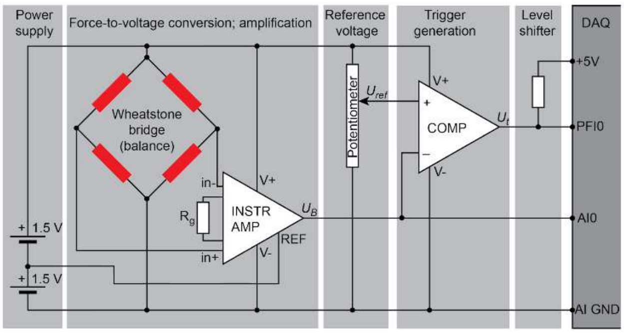


Figure 1: Components illustration. (a) Shows NI-DAQ 6211, device which is used to measure and analyze real-world signals [1]. (b) scale with orange ball on it. (c) INA128, instrumentation amplifier [2]. (d) LM293P [3].

III. NI MYDAQ CONNECTION PROCEDURE

The components are connected as follows (Fig 2):



Data Acquisition and Signal Processing (LOTI.05.052), Lab 4.

Figure 2: Wiring diagram of the implemented system

The circuit (Fig 2) consists of a Wheatstone bridge supplied by a DC power source simulating a real force sensor. The output signal is amplified by INA128 and connected to DAQ device (pin AI0). To function, this component must be powered by + 3 V on V + and 0 V (ground) on V-. The output voltage is not referenced against ground, but against the 5 Vref pin called "reference". this pin is connected to a voltage equal to half of the reference voltage of the converter. LM293P is responsible for trigger generation.

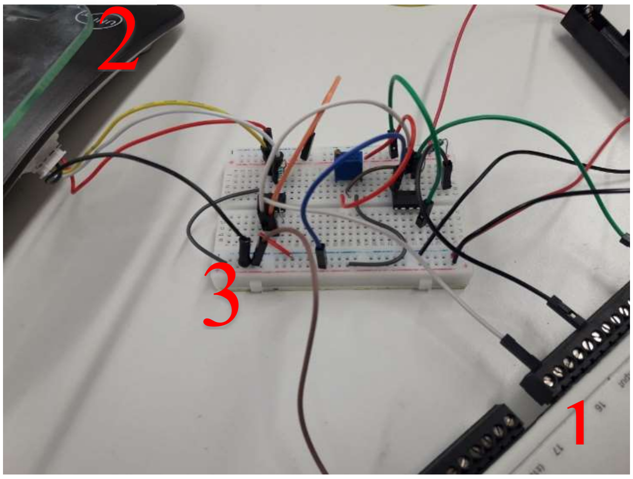


Figure 3: Experimental setup

Figure 3. depicts the hardware implementation of the proposed system with DAQ device (1), balance (2), breadboard circuitry (3). Programming and analysis is done Labview Software (DAQ device programming language).

IV. EXPERIMENT AND RESULT

In this first part of the experiment, a ball was released on the scale to trigger the acquisition. In this configuration, the hardware starts acquiring data before the trigger signal is received. With this type of acquisition, the user can view the signal before the trigger event. In such applications, the hardware initiates data acquisition with a software function and stores the data in a circular buffer in the PC memory. The buffer is large enough to ensure that the required number of pretrigger samples are stored. When the buffer is full, it simply wraps around and stores each subsequent sample over the oldest sample in memory. The primary responsibility of the trigger mechanism is to stop the acquisition so that the samples left in memory represent the “slice-in-time” the user wants.

As the ball hits the balance, we observe a deflection of the scale followed by a series of mechanical oscillations (Fig 3). LabView was used to capture the output of the impact.

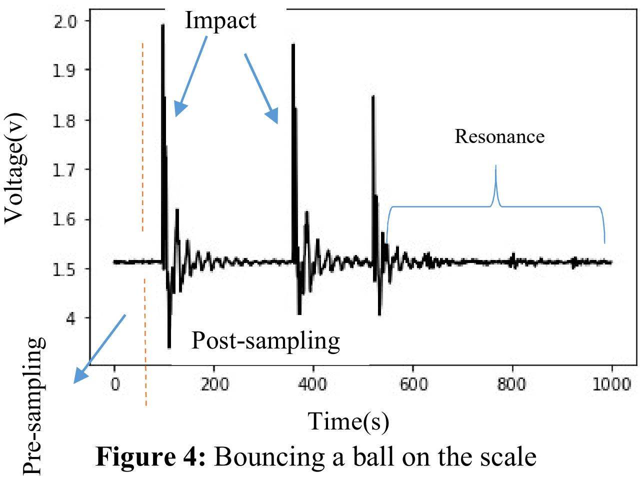


Figure 4: Bouncing a ball on the scale

Fig 4. Shows time series plot of the ball as captured with Labview

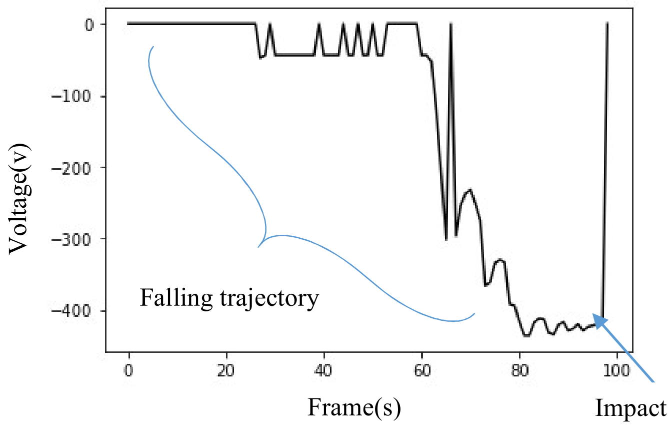


Figure 5: Bouncing a ball on the scale and triggered image acquisition.

In the second part of the experiment, the laptop's built-in camera was positioned in such a way that it could detect the vision range of the ball falling on the scale. The camera frames are continuously stored to ring buffer with constant FPS. The buffer is simply the space assigned to store image in PC's RAM (memory). Once a trigger event was detected on the PFI0 pin (DAQ device), the acquisition was stopped and the buffer was saved. We registered the force readings of the digital balance together with the video frames describing the falling object's trajectory. Fig 4. depicts the impact of the ball on the scale together with 100 frames captured.

V. CONCLUSION

During this manipulation we saw the main electronic and computer functions to be set up to use Wheatstone bridge sensor and strain gauge. The impact of the ball on a scale and triggered image acquisition were observed

VI. Reference

[1] NI-DAQ 6211 user manual for more information: https://www.ni.com/pdf/manuals/375195d.pdf

[2] INA128 datasheet, available: https://www.ti.com/lit/ds/symlink/ina128.pdf?ts=1641369840315&ref_url=https%253A%252F%252Fwww.google.com.tr%252F

[3] LM293P user manual: https://datasheet.octopart.com/LM293P-Texas-Instruments-datasheet-8209313.pdf

[4] J. Park, S. Mackay, practical data acquisition for instrumentation and control systems, 1st Ed - June 10, 2003

[5] Bouncing a ball on the scale: lab session. Data Acquisition and Signal Processing (LOTI.05.052)