

2.737 Mechatronics

Laboratory Assignment 4: AC-Driven and Demodulated Electronic Scale

Assigned: 10/28/14

Pre-lab due: No prelab

Reports due: Monday 11/3 in checkoffs; no lecture that day

1 Overview

In this lab you will implement an electronic scale using AC excitation and demodulation. That is, you will use the myRIO to generate a sine wave which provides the reference voltage for the strain gage bridge. With this sinusoidal drive, the bridge common-mode and differential voltages are also sinusoidal; the bridge imbalance which represents weight is then reflected in the sinusoidal differential bridge output voltage. The configuration for this experiment is shown below in Fig. 1.

As shown in the figure, the myRIO is used to generate a sinusoidal drive at about 50 Hz and outputs this sine wave through a D/A converter to drive the bridge reference voltage. A 741 op amp is used as a buffer to drive the bridge current. Note that no precision DC reference is required, since the bridge is directly driven by the D/A, which provides the AC signal. Note that all the circuit elements are referenced to a single common S ; there is no common disturbance in this circuit as there was in Lab 3.

As before, an LT1167 differential amplifier is used to amplify the sinusoidal bridge output. You may *optionally* design an offset adjustment circuit to null this imbalance in the modulated domain. The amplified bridge output is input to the myRIO A/D converter to yield a measurement in the modulated domain. This measurement is then demodulated to yield estimates of the signal magnitude \hat{M} , the signal phase $\hat{\phi}$, and the corresponding weight \hat{W} .

2 Prelab and Lab Reports

Note that no prelab is required. The lab report is due at the time of your checkoffs on Monday 11/3. This lab is not tightly specified as to how you solve the demodulation problem. Also, you will need to write your own Labview code to implement the required functions. Be sure to document your approach, including relevant calculations.

3 Lab exercises

1. **System operating theory:** Construct a model for the propagation of signals through the system. Use any relevant results from Lab 3 to help with this analysis. Choose A such that the bridge is driven with a ± 10 V sine wave. What gain do you select for the differential amplifier? Why? This model should represent the bridge as a resistive imbalance which

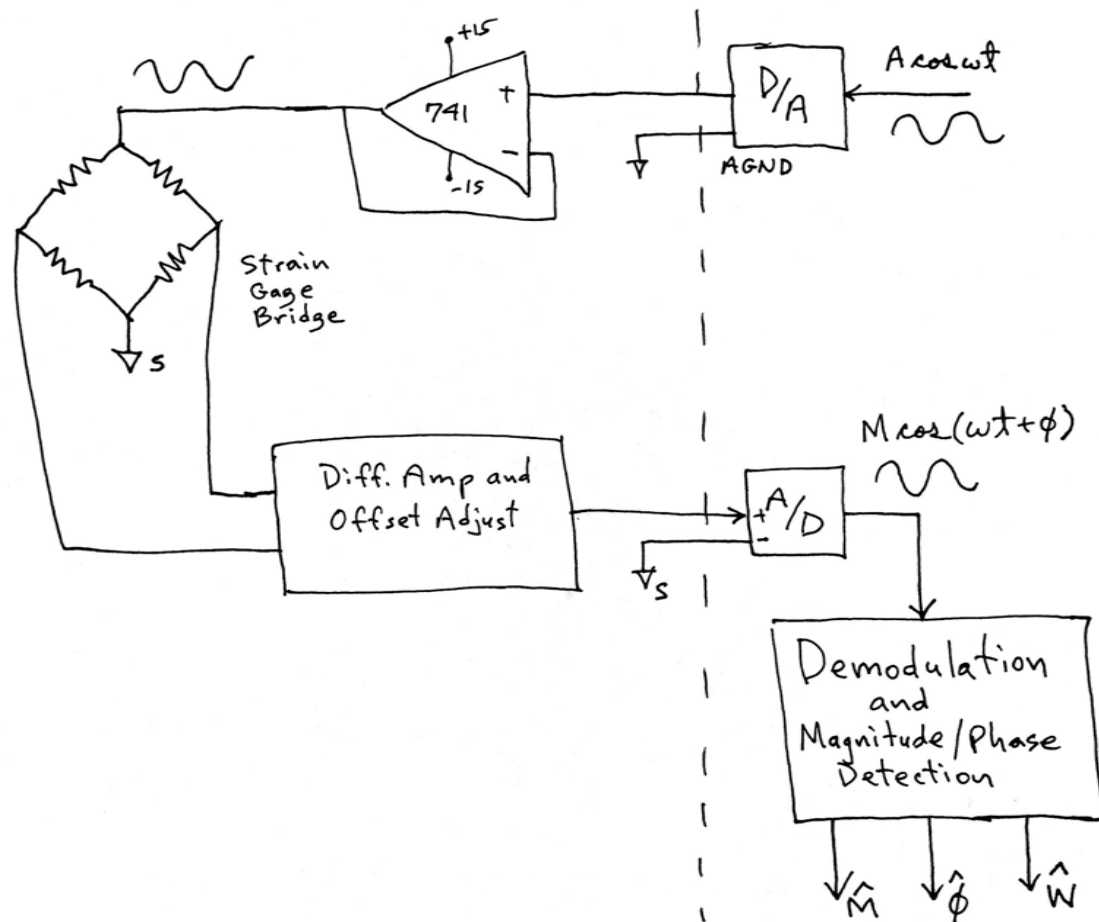


Figure 1: AC-driven and demodulated electronic scale circuit configuration.

depends upon the applied weight. Show how this imbalance propagates into the measured signal $M \cos(\omega t + \phi)$. Stray circuit elements and the effect of sampling will result in a non-zero phase shift ϕ . You will not be able to predict this value ahead of time, but will need to be able to accommodate such a phase shift, which will be determined experimentally. Also recognize that each scale has a different amount of imbalance at zero weight. You will need to include this imbalance in your model. Note that this imbalance results in a non-zero sinusoidal component of the output at zero weight.

2. **Offset correction circuit (optional):** You may optionally design a circuit to allow adjustment of the scale zero-weight offset. That is, come up with a circuit connection which allows nulling of the zero-weight offset while still in the modulated domain. That is, you will need to null the sinusoidal output associated with zero weight. Explain your approach and present an analysis of how it operates. Plan to demonstrate for the staff that you can adjust the offset to positive and negative values around zero, and to explain your approach. If you choose *not* to design this nulling circuit, you will at least need to subtract the scale offset

with an adjustment within Labview in the demodulated domain.

3. **Demodulation and Estimates:** Design a demodulation algorithm to be implemented on the myRIO, and which yields estimates of the signal magnitude \hat{M} , the signal phase $\hat{\phi}$, and the corresponding weight \hat{W} . Create an analysis which explains the theory for how this demodulation works, and how you develop the relevant estimates. Show how the weight reflects through the bridge imbalance into the estimates, and how you will make the weight estimate accurate. Note that you may not assume that $\phi = 0$, but must handle the general case where $\phi \neq 0$. You must also provide an adjustable weight offset to allow nulling of the zero-load weight estimate (tare).
4. **Experimental Implementation:** Create a Labview VI to run on the myRIO and which implements the AC system. We suggest that you run at a carrier frequency of 50 Hz, and a sampling rate as high as allowed by the numerical capability of the myRIO. You are free to try other frequencies to see the effect on the circuit operation. Your VI should include graphical displays of interesting relevant waveforms including the three estimates, as well as numerical displays of the three estimates. Run this system in the lab, and measure the scale output for a number of different weights. What is the linearity of your measurement? Note that linearity is defined in terms of the error as a percent of *full-scale reading*.
5. **Challenge question:** Can your system measure the scale dynamic resonant response as we did in Lab 3? Why or why not? How could this be measured?

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