

SFWR ENG 4A03 Lab 1: Introduction to Labview and Review of Continuous Control Systems

Due: 1730 Monday October 7, 2004

Introduction to Labview

You will find an introductory handout on Labview at:

<https://websvn.mcmaster.ca/trunk/se4a03/ref/labview/labview1.pdf>

A hardcopy will also be available in the lab. More information on Labview is available at:

<http://www.ni.com>.

Prelab

Before the lab checkout your lab group working directory from the subversion repository:

```
svn checkout https://websvn.mcmaster.ca/trunk/se4a03/groups/groupX
```

where *X* is your lab group number. First group member to check it out, please create a revision controlled subdirectory for lab1 with the following commands:

```
cd groupX
svn mkdir lab1
```

Next create a file in the `lab1` subdirectory called `readme.txt` using your favourite text editor. In the file put your name and the date, then put it under revision control, e.g. on the Linux systems you could do:

```
cd lab1
vi readme.txt
svn add readme.txt
svn commit -m "Created lab1 directory and readme.txt for groupX"
```

All other groups members should checkout their group's subdirectory and edit the `readme.txt` file to add a new line with your name and the date on it. Commit the updated file to subversion with a meaningful log message. You can then use space below these lines in the file to tell other group members what you have put in the directory and what needs to be done to complete the lab.

In the Lab

As you complete each of the sections, demonstrate the working instrument to one of the TAs.

1. Do the Labview exercises 1 from the handout.
2. Do exercise 2(a) from the handout.
3. Once you have completed Exercise 2(a) from the handout, go back to your exercise 1 virtual instrument (VI) and replace the Input knob with the temperature sensor reading from the DAQ (ask the TA for help if you need it). Set the upper and lower limits so that you can move the temperature value in and out of the safe range by putting a finger on the temperature sensor. Save this new vi as `Exercise 1b.vi`.

- Go to <http://www.ni.com> and search for information on the BNC-2120 encoder. You should find a document that describes the connections required on the connector board and provides a downloadable VI titled:

Measure the Rotation of a Quadrature Encoder Using a BNC-2120

as well as a short overview document titled:

How Do I Use a Quadrature Encoder with My Data Acquisition Board?

Download the VI and configure it to work with your board. Make sure that the encoder connections are properly wired.

- Modify the BNC-2120 Encoder instrument to add an “angular odometer”, i.e. a readout of the total angular distance traveled by the knob (regardless of direction) since the time the VI was last restarted.

Make sure that all of the VIs you created are added to the subversion revision control system directory for your groups lab1. Commit the files with a suitable log message.

Finally, to submit the files for marking, you must “tag” your lab 1 submission either from, for example, a unix command line with:

```
svn copy https://websvn.mcmaster.ca/trunk/se4a03/groups/groupX/lab1 \
https://websvn.mcmaster.ca/tags/se4a03/groups/groupX/lab1 \
-m "Tagging lab1 for marking."
```

(where X is again replaced by your group number) or using the subversion Windows Explorer interface. This is the submission that will be marked by the TAs!

Review of Continuous Control

The answers to all of the following sections should be created in a PDF file called `lab1-report.pdf` that you put in your group’s lab1 subdirectory. You can use LaTeX, OpenOffice, or some other system, as long as it generates PDF.

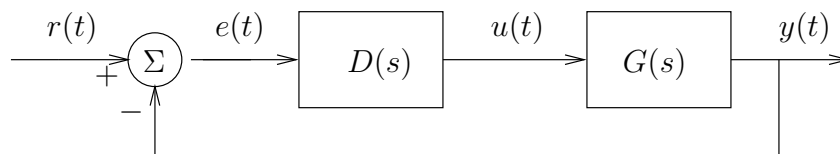
For an example latex source for this lab see:

<https://websvn.mcmaster.ca/trunk/se4a03/labs/lab1/>

Consider the unstable system:

$$G(s) = \frac{Y(s)}{U(s)} = \frac{1}{s - 1}$$

in the feedback loop:



- Sketch the root locus for the system where:

$$D(s)G(s) = \frac{K(s + 3)}{s(s + 2)(s + 1)^2}$$

Confirm your sketch using Matlab.

- Consider the system with dynamics given by the following equation

$$\frac{d^2y}{dt^2}(t) = -3\frac{dy}{dt}(t) - 2y(t) + u(t)$$

- a) What is the transfer function $G(s) = \frac{Y(s)}{U(s)}$?
- b) One definition of bandwidth ω_{BW} is that value of the frequency when the ratio of the amplitude of the transfer function at $j\omega_{BW}$ to that of the transfer function at DC (i.e. $j\omega = 0$) is reduced by a factor of $\frac{1}{\sqrt{2}}$. i.e.

$$\frac{G(j\omega_{BW})}{G(j0)} = \frac{1}{\sqrt{2}}$$

Using this definition, what is the bandwidth of the system?

- c) Assuming zero initial conditions, what is the time domain response of the system when $u(t) = \sin \omega_1 t$?
- d) Show that for t large, the system response is approximately:

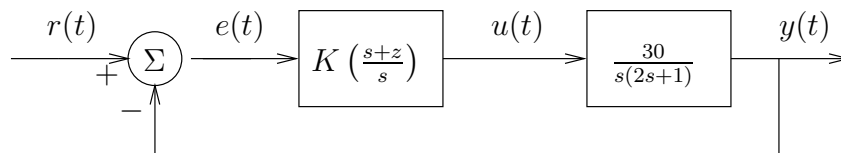
$$y(t) = AU_o \sin(\omega_1 t + \phi)$$

where

$$A = |G(j\omega_1)|$$

$$\phi = \angle G(j\omega_1) = \tan^{-1} \frac{\text{Im}[G(j\omega_1)]}{\text{Re}[G(j\omega_1)]}$$

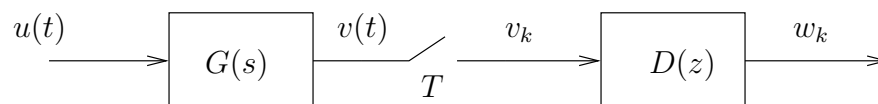
3. Consider the feedback control system below where the controller zero $z \in \mathbb{R}$ will be chosen by the system designer:



- a) Compute the closed loop transfer function $G_{cl}(s) = \frac{Y(s)}{R(s)}$.
- b) For what values of z is the closed loop systems stable for all values of $K > 0$? Justify your answer with Root Locus sketches. (Hint: Think asymptotes.)
- c) What is the steady state error $e(t)$ in response to a unit ramp input $r(t) = t$ when z and K are chosen so that $G_{cl}(s)$ is strictly stable?
- d) Find a difference equation to implement a digital version of the controller $D(s) = K \frac{s+z}{s}$ using the Trapezoid Rule with sampling period T .
- e) Assuming zero initial conditions, find the transfer function $D(z)$, for this difference equation.

4. Frequency Response

Consider the system shown below:



- a) Assume that $G(s)$ is a stable, strictly causal, linear, time invariant transfer function of a continuous system. Use the Final Value Theorem to prove that for a step input $u(t) = 1(t)$ then

$$\lim_{t \rightarrow \infty} v(t) = G(0)$$

b) Assume the sampling period $T = \frac{1}{2}$ second, input $u(t) = 1(t)$,

$$G(S) = \frac{1}{s + 3} \text{ and } D(z) = \frac{W(z)}{V(z)} = \frac{z}{z + 0.5}$$

Consider only the **steady state** behaviour of the system

- i) What is $v(t)$ in steady state?
 - ii) What is v_k in steady state?
 - iii) What is w_k in steady state?
- c) Repeat the previous question with $u(t) = 3 - 2 \sin(2\pi t)$.