Lab # 8 Parallel Port Interface with LabView & Root Locus Design

Introduction:
In this lab, we will learn two basic things: the first is how to use the parallel printer port to interface some circuits with the PC, and the second is how to design systems using Root Locus technique.

Parallel port acts as an interface between the external control measurement circuitry with the internal software of the computer. In the first part of this experiment we will learn how to interface some circuits with the parallel printer port using LabView software.

Root locus is the locus of the roots of the characteristic equation of the closed loop transfer function as the loop gain of the feedback system is increased from zero to infinity. The root locus is a useful tool for analyzing the transient response, as well as the stability of a single input single output dynamic systems.

Part (I): Parallel Printer Port Interface
Every PC has one or more parallel printer ports (LPT's). In addition, each port contains three different input/output ports as following:
DP refers to printer Data Port, PC refers to Printer Control and PS refers to Printer Status.

<table>
<thead>
<tr>
<th>LPT 0</th>
<th>LPT 1</th>
<th>LPT 2</th>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3BC Hex</td>
<td>378 Hex</td>
<td>278 Hex</td>
<td>Read/Write</td>
<td>Data Port (DP), 8 bits</td>
</tr>
<tr>
<td>3BD Hex</td>
<td>379 Hex</td>
<td>279 Hex</td>
<td>Read only</td>
<td>Printer Status (PS), 5(6) bits</td>
</tr>
<tr>
<td>3BE Hex</td>
<td>37A Hex</td>
<td>27A Hex</td>
<td>Read/Write</td>
<td>Printer Control (PC), 4(6) bits</td>
</tr>
</tbody>
</table>

The original IBM-PC's Parallel Printer Port had a total of 12 digital outputs and 5 digital inputs accessed via 3 consecutive 8-bit ports in the processor's I/O space.

The parallel Port has 25 pins can be classified as the following:
- 8 Output Pins accessed via the DATA Port
- 4 Output Pins (three inverted) accessed via the CONTROL Port
- 5 Input Pins (one inverted) accessed via the STATUS Port
- The remaining 8 pins are grounded

![Diagram of parallel port connections]
Examples

1) (From LabView to Outside World):
   Connect the following circuit in the block diagram window, and connect the parallel port cable with the input/output circuit board to your PC, and then run the project to realize the results on the circuit?

Output:
   Control Panel:

   ![Control Panel Diagram]

   Front Panel:

   ![Front Panel Diagram]

2) (From Outside World to LabView):
   Connect the following circuit in the block diagram window, and connect the parallel port cable with the input/output circuit board to your PC, and then run the project to realize the results on the LabView?

Output:
   Control Panel:

   ![Control Panel Diagram]

   Front Panel:

   ![Front Panel Diagram]

Note:
We note that the input from the outside world is high unless it is made low because there are pull up resistors inside.
3) Make a flasher using the input/output circuit board and then control it using LabView software?

**Output:**
Control Panel:

![Control Panel Diagram]

Front Panel:

![Front Panel Diagram]
Part (II): Root Locus Design

Rules for Making Root Locus Plots

The closed loop transfer function of the system shown is
\[ T(s) = \frac{KG(s)}{1 + KG(s)H(s)} \]

So the characteristic equation is
\[ 1 + KG(s)H(s) = 1 + K \frac{N(s)}{D(s)} = 0, \text{ or } D(s) + KN(s) = 0 \]

As \( K \) changes, so do locations of closed loop poles. The table below gives rules for sketching the location of these poles for \( K=0 \rightarrow \infty \) (i.e., \( K \geq 0 \)).

<table>
<thead>
<tr>
<th>Rule Name</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Definitions**            | - The loop gain is \( KG(s)H(s) \) or \( K \cdot (N(s)/D(s)) \).  
                           - \( N(s), \) the numerator, is an \( m \)-th order polynomial; \( D(s), \) is \( n \)-th order.  
                           - \( N(s) \) has zeros at \( z_i \) (\( i=1..m \)); \( D(s) \) has them at \( p_i \) (\( i=1..n \)).  
                           - The difference between \( n \) and \( m \) is \( q \), so \( q=n-m \). (\( q \geq 0 \))  
                           - Mark zeros as " O " and poles as " X ". |
| **Symmetry**               | The locus is symmetric about real axis (i.e., complex poles appear as conjugate pairs). |
| **Starting and Ending Points** | The locus starts (\( K=0 \)) at poles of loop gain, and ends (\( K \rightarrow \infty \)) at zeros. Note: this means that there will be \( q \) roots that will go to infinity as \( K \rightarrow \infty \). |
| **Locus on Real Axis**     | The locus exists on real axis to the left of an odd number of poles and zeros (goes from an Odd zero or pole to an even zero or pole). |
| **Asymptotes as \(|s| \rightarrow \infty|** | If \( q>0 \) there are asymptotes of the root locus that intersect the real axis at \( \sigma \) and radiate out with angles \( \theta \) where \( r=1, 3, 5… \)
\[
\sigma = \sum_{i=1}^{m} p_i - \sum_{i=1}^{n} z_i \frac{q}{q} \quad \theta = \pm r \frac{180}{q}
\]
| **Break-Away/-In Points on Real Axis** | Break-away or -in points of the locus exist where:
\[ N(s)D'(s)-N'(s)D(s)=0. \] |
Examples

Draw root locus for the following open loop transfer functions with a unity feedback ($H(s) = 1$).

1) $G(s) = \frac{s+3}{s^2+3s+2}$
2) \[ G(s) = \frac{2}{s^2 + s} \]
3) \[ G(s) = \frac{s+3}{s^2+2s+3} \]
4) \[ G(s) = \frac{2(s+3)}{s(s+1)} \]

**Using MATLAB**

```matlab
clear all
clc
figure
G1 = tf([2 6],[1 1 0])
rlocus(G1)
```

**Using LabView**

Output
Exercise:

Build a MATLAB GUI project to draw the root locus graph of a system with a unity feedback. The project will work as the following:

- The user must enter the open loop transfer function as num and den.
- Then the GUI will construct the transfer function using these values and then show the result to the user.
- The GUI will find the poles of the transfer function and then show them to the user.
- Also the GUI will find the roots of the transfer function and then show them to the user.
- After that the GUI will draw the root locus graph of the open loop transfer function.
- Your GUI must give a help for a new user if he/she needs a help.
- The user must be able to exit from the GUI using a push button.