Equipment and Software Familiarization

EXERCISE OBJECTIVE

When you have completed this exercise, you will be familiar with the hardware and software components of the Digital Servo Controller module. You will know how to use the Human Machine Interface (HMI) and its various functions. You will be able to acquire and plot the data generated by the servo system using a spread sheet.

DISCUSSION OUTLINE

The Discussion of this exercise covers the following points:

- Servo system hardware
- Servo system software

DISCUSSION

Servo system hardware

The hardware of the servo system consists of:

- The mechanical unit containing the dc brush-type **servo motor**, **motor shaft encoder** and **rail encoder**, **platform**, belt drives and pulleys for moving the platform, **flywheel**, and friction brake.
- The Digital Servo **controller** module, which itself contains:
  - A dc motor **power amplifier**
  - A microcontroller
  - A/D and D/A converters
  - A **USB** interface

Servo system software

The Human Machine Interface or **HMI** necessary for the servo system operation runs on a computer. The HMI allows selection of control system, signal generator, and data display functions.

The servo system can be controlled using either a device-based control system where the actual controller algorithms are executed in a dedicated microcontroller-based system or host-controlled. In this last instance, the controller algorithms are executed directly on the computer. With device-based execution, the algorithms can be executed in a shorter time. In the exercises, device control will be used.

To test the servo system, it is necessary to capture and plot the data that it generates. The Digital Servo has a function that allows it to capture and plot the acquired data. Following is a list of the various measured and adjustable parameters:

- Reference (or set point): The reference is either the desired position (in position-control mode) or the reference speed (in speed-control mode).
- Position: The position is either the rail position or the **angular position** of the motor shaft.
- Speed: The speed of the motor shaft.
- Current: The dc servo motor current supplied by the power amplifier.
- Voltage: The dc servo motor voltage supplied by the power amplifier.
- Error: The error is the difference between the actual speed or position value and the reference speed or position value.
- K_p x Error: The product of the **proportional** gain K_p and the error value.
- Error Sum/t_i: The error integration over time.
- t_d x Delta Error: The error derivative (or negative of process) in relation to time.
- Total controller output: The total controller output is the sum of the error product, integration error, and error derivative.

This data can be displayed on the HMI or captured to a file where it can be manipulated by a spread sheet.

PROCEDURE OUTLINE

The Procedure is divided into the following sections:

- Basic setup
- Hardware familiarization
- Software familiarization

PROCEDURE

Basic setup

In this section, you will setup the Digital Servo.

1. Setup the Digital Servo system as shown in Figure 1. The system consists of the mechanical unit, the servo controller and the computer.

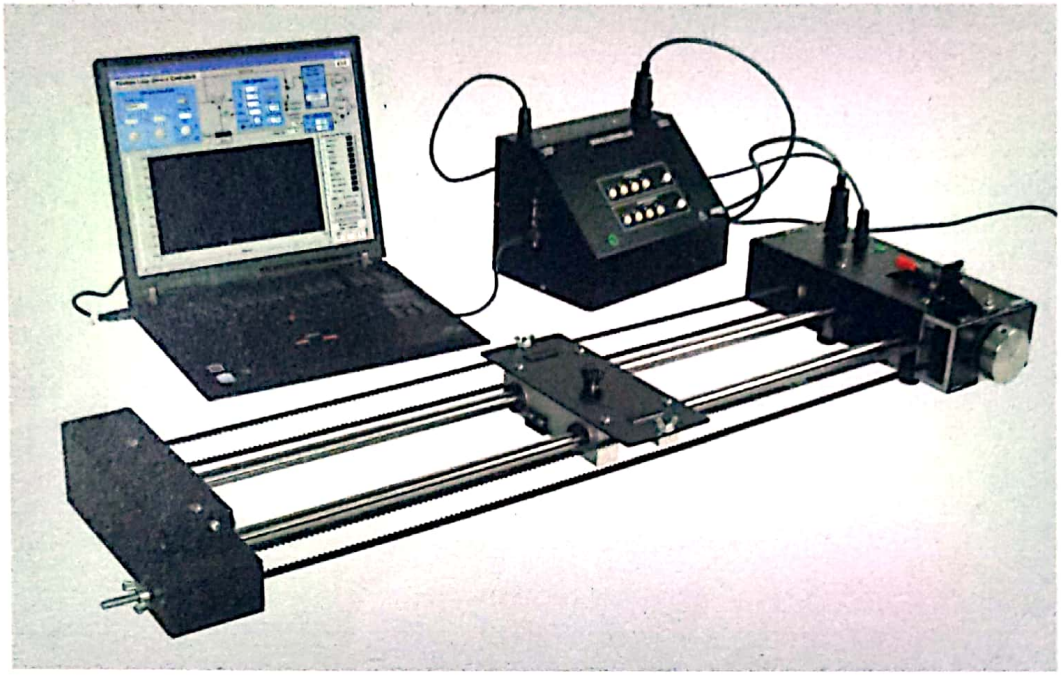


Figure 1. Digital Servo complete setup.

Hardware familiarization

In this section, you will familiarize yourself with the servo motor hardware.

2. Connect the servo motor power and incremental encoders cables used to communicate between the servo controller and the mechanical unit.

3. Connect the USB cable to the servo controller and the computer.

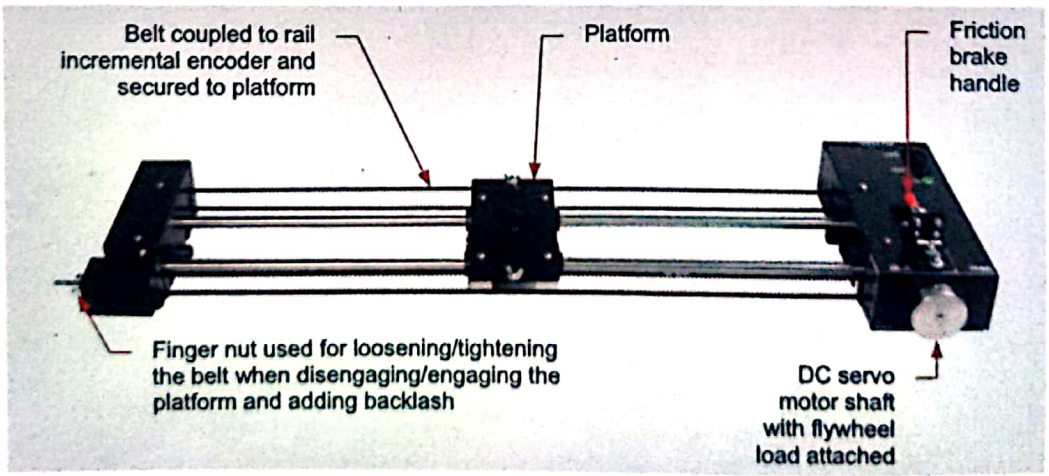


Figure 2. The mechanical unit.

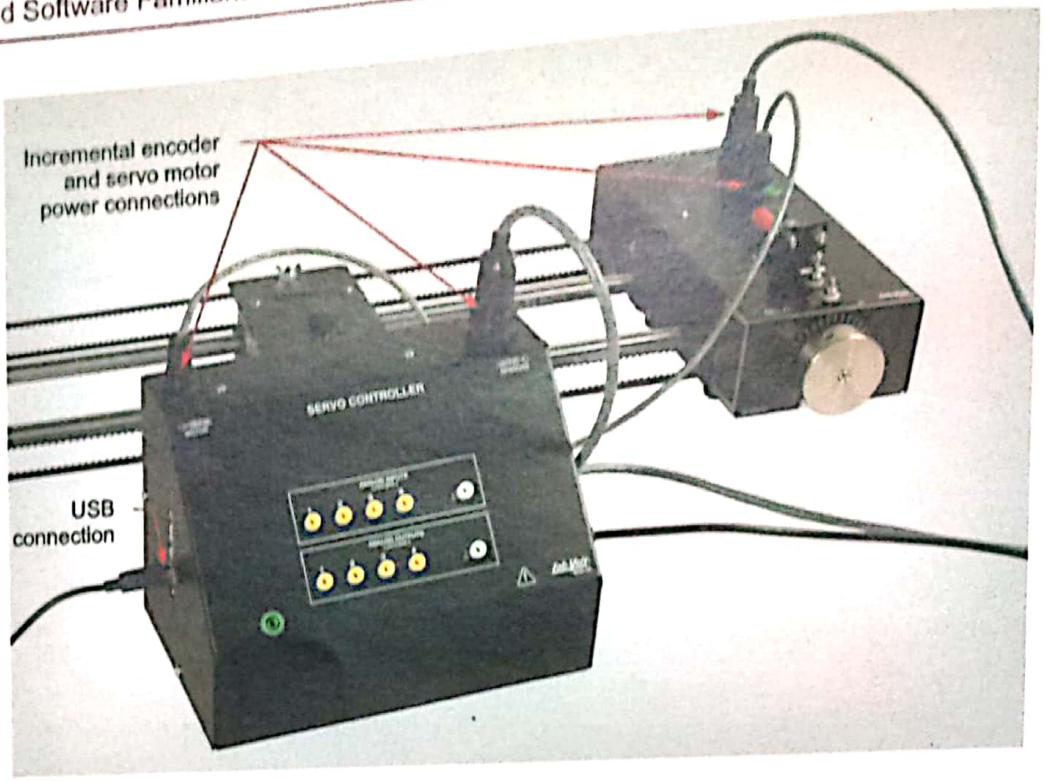


Figure 3. The servo controller.

4. Move the platform back and forth along the rail. Try to center the platform between the right- and left-end stops.

5. Gently couple the flywheel to the shaft (see Figure 4) if it is not already so. A set screw mated to a hex key can be used to tighten the flywheel to the shaft.

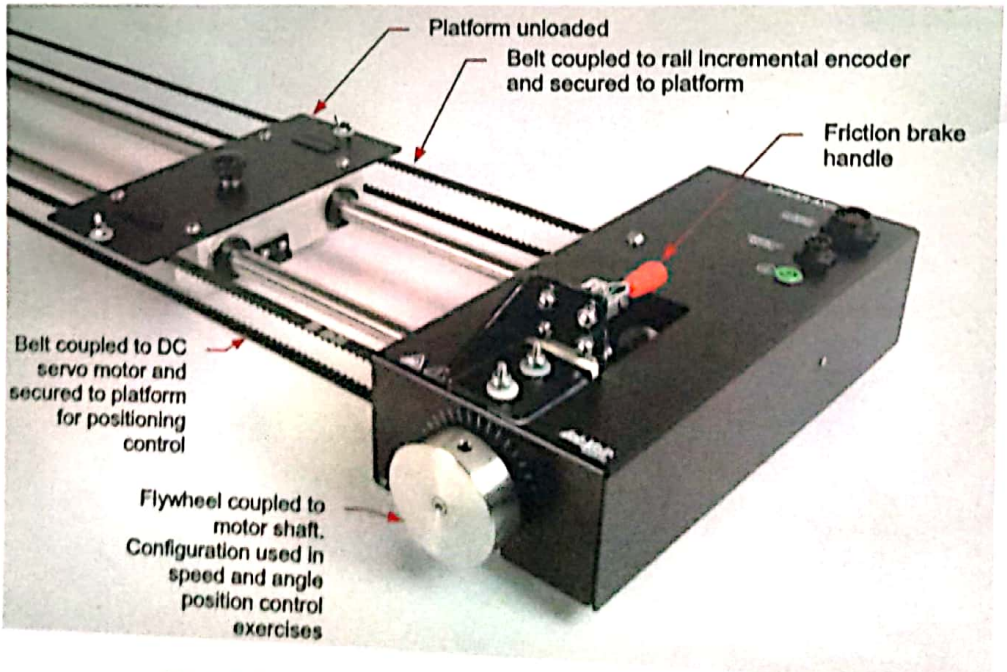


Figure 4. Flywheel coupled to motor shaft, platform unloaded.

6. Referring to Figure 2 and Figure 5, loosen the finger nut at the extreme right-hand side of the mechanical unit. When the belt is loose, lift it off the pulley and onto the two steel pins, effectively disengaging the platform.

The platform must be disengaged when implementing the speed-control experiments using the controller. Attempting speed-control experiments while the belt is still in the engaged position may damage the unit.

7. Tighten the finger nut to ensure the belt remains in place while performing exercises that require platform disengagement.

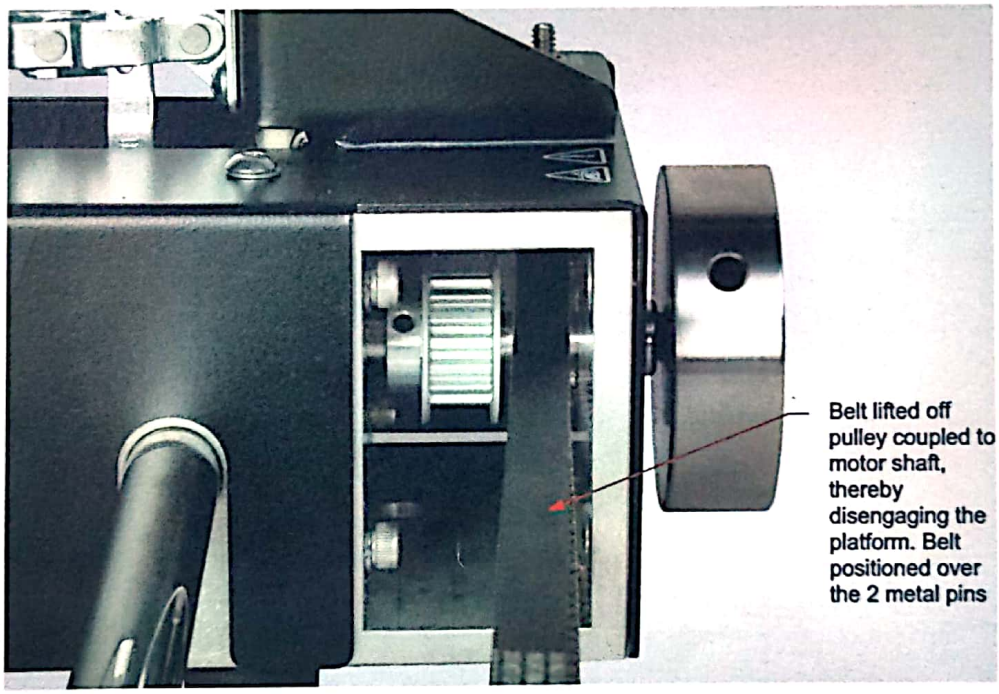


Figure 5. Belt in the disengaged position.

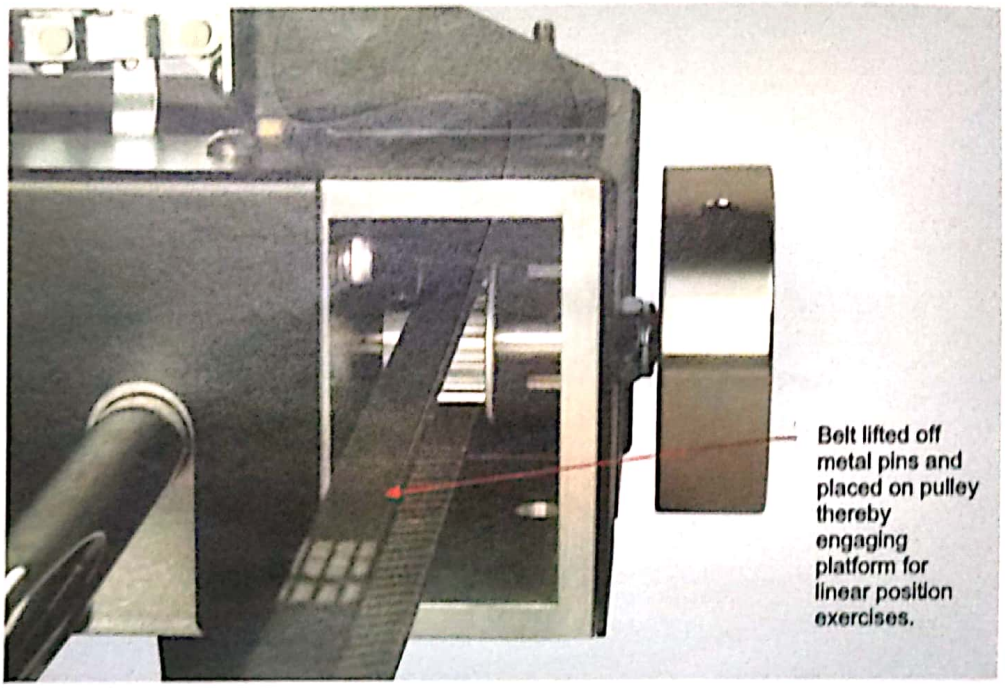


Figure 6. Belt in the engaged position.

Software familiarization

In this section, you will familiarize yourself with the servo motor software and with the use of a spread sheet for data collection and display.

8. Power up the servo controller and the computer and start the Digital Servo controller software by clicking on the servo controller icon located on the desktop. The **LVServo** screen appears as shown in Figure 7.

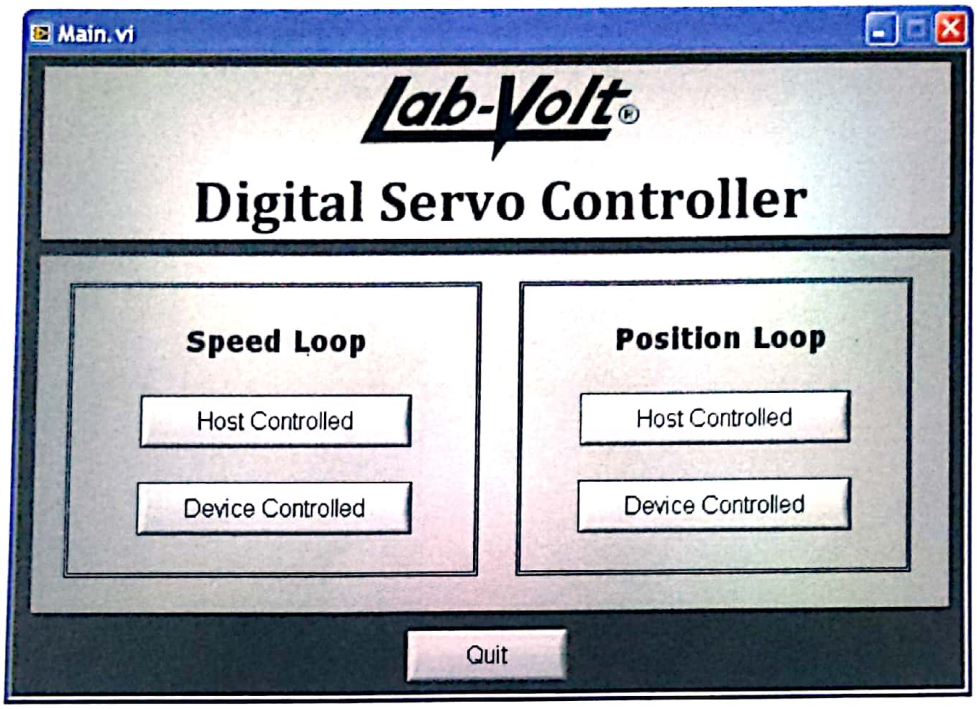


Figure 7. Digital Servo controller main screen.

9. Click on the **Device Controlled** command button in the **Position Loop** menu. The default position control screen appears as shown in Figure 8.

All the exercises in this document use the device controlled mode for Speed Loop and Position Loop. Host controlled mode is not used.

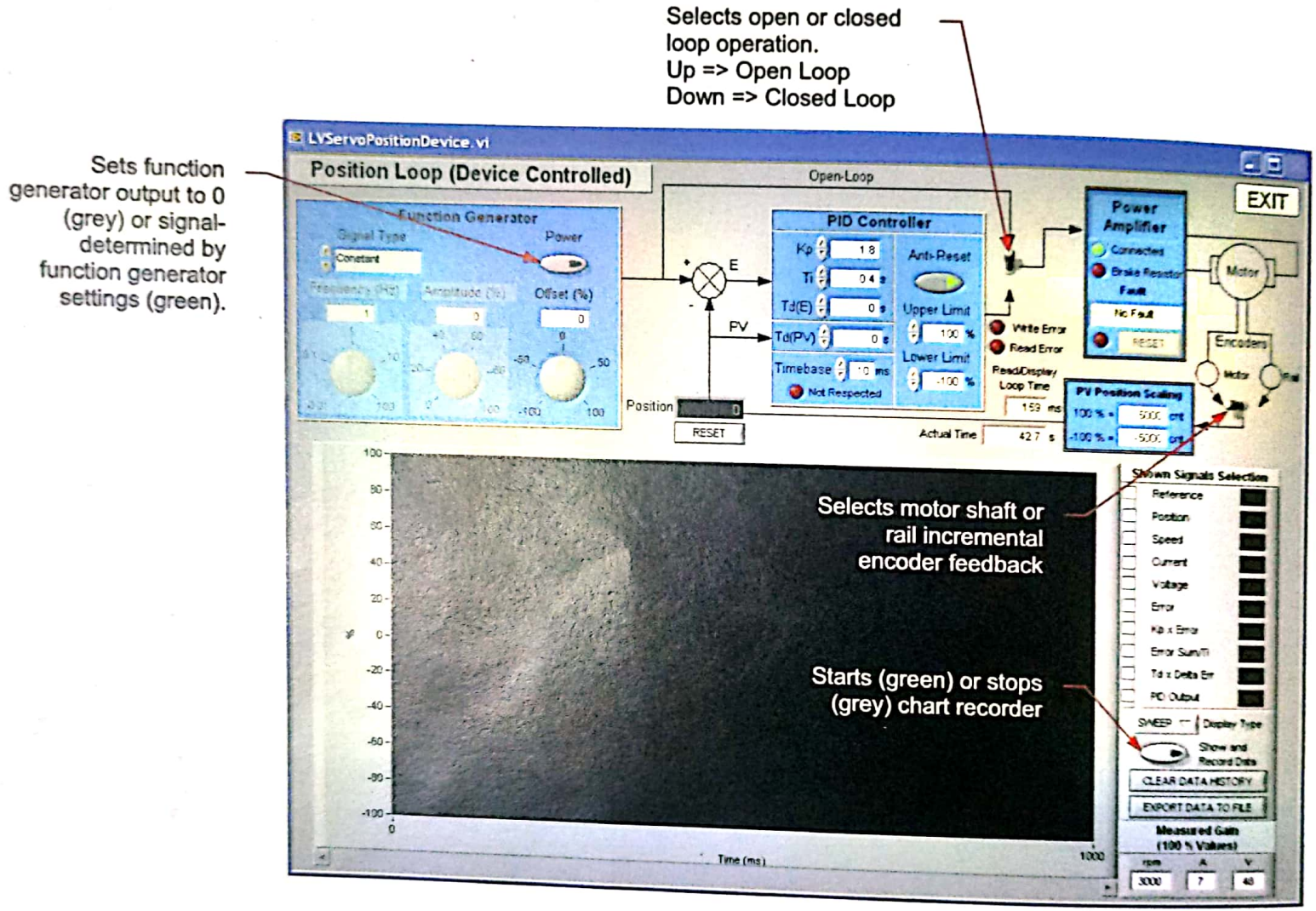


Figure 8. Default-position control screen.

10. Click on the **Exit** button to return to the screen shown in Figure 7.

11. Click on the **Device Controlled** command button in the **Speed Loop** menu. The default speed-control screen appears as shown in Figure 9. Notice that only one encoder can be used in speed-control mode, i.e., the motor shaft incremental encoder.

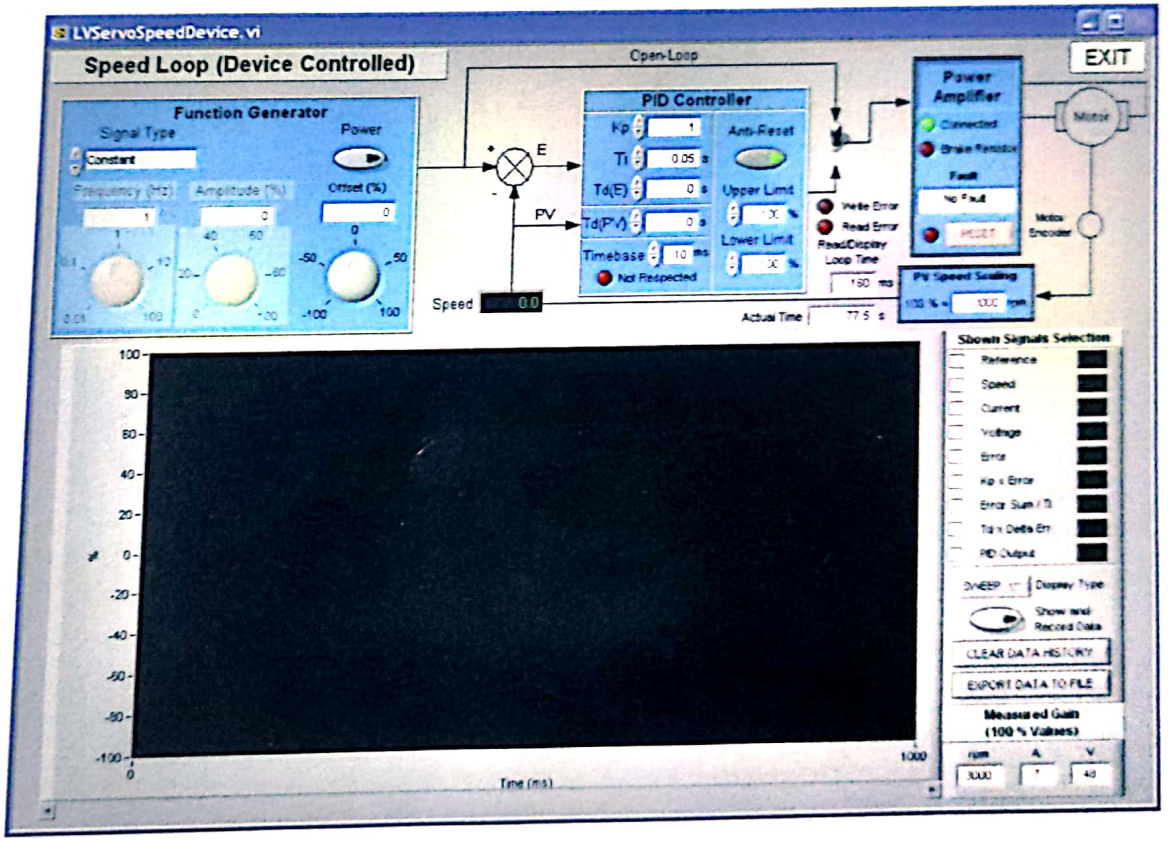


Figure 9. Default speed-control screen.

12. Modify the settings shown in the default screen (Figure 9) to those shown in Figure 10. These modified settings are summarized in Table 1.

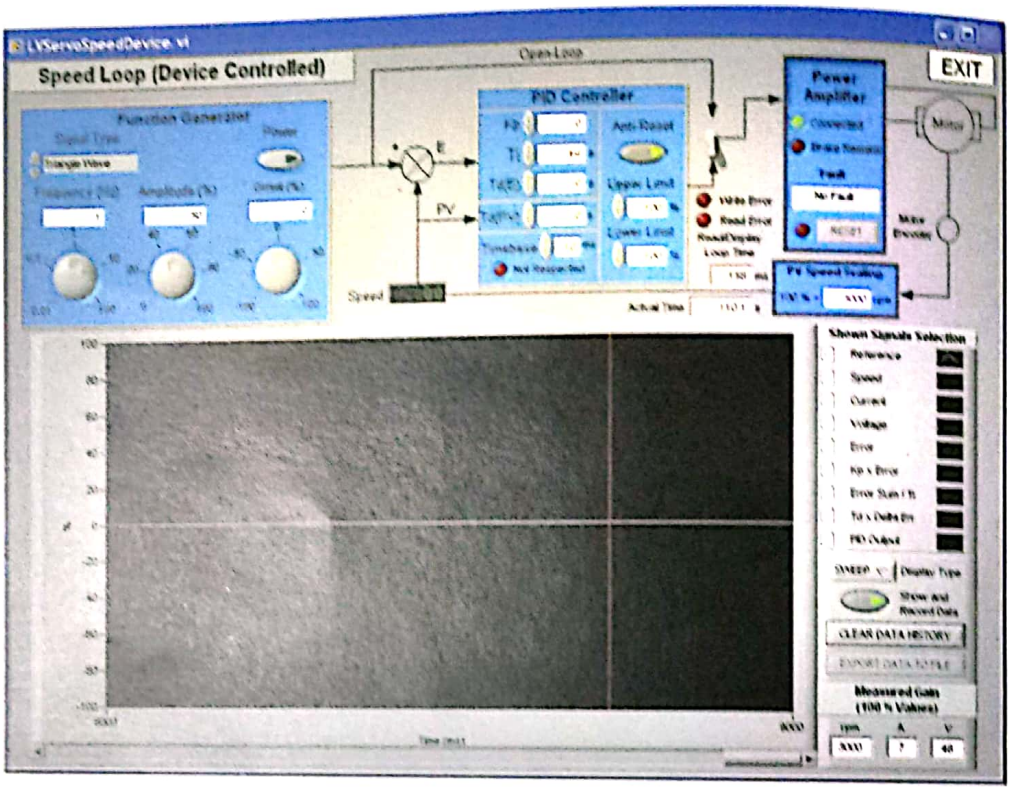


Figure 10. Modified speed-control screen settings.

Table 1. Modified speed-control settings summary.

Function Generator		Trend Recorder	
Signal Type	*Triangle*	Reference	*Checked*
Frequency	*1 Hz*	Speed	*Unchecked*
Amplitude	*50%*	Current	*Unchecked*
Offset	*0%*	Voltage	*Unchecked*
Power	*Off*	Error	*Unchecked*
PID Controller		K_p x Error	*Unchecked*
Gain (K_p)	*0*	Error Sum / t_i	*Unchecked*
Integral Time (t_i)	*Inf (Off)*	t_d x Delta Error	*Unchecked*
Derivative Time on E (t_d (E))	*0*	PID Output	*Unchecked*
Derivative Time on PV (t_d (PV))	*0*	Display Type	*Sweep*
Timebase	*10 ms*	Show and Record Data	*On*
Anti-Reset Windup	*On*	Measured Gain (rpm)	*3000*
Upper Limit	*100%*	Measured Gain (A)	*7*
Lower Limit	*-100%*	Measured Gain (V)	*48*
Open or Closed Loop	*Closed*		
PV Speed Scaling			
100% Value	*3000 rpm*		

13. Click on the function generator **Power** button.

14. A screen similar to Figure 11 appears. The triangular wave on the screen may be shifted to the right or left depending on when the screen capture was initiated.

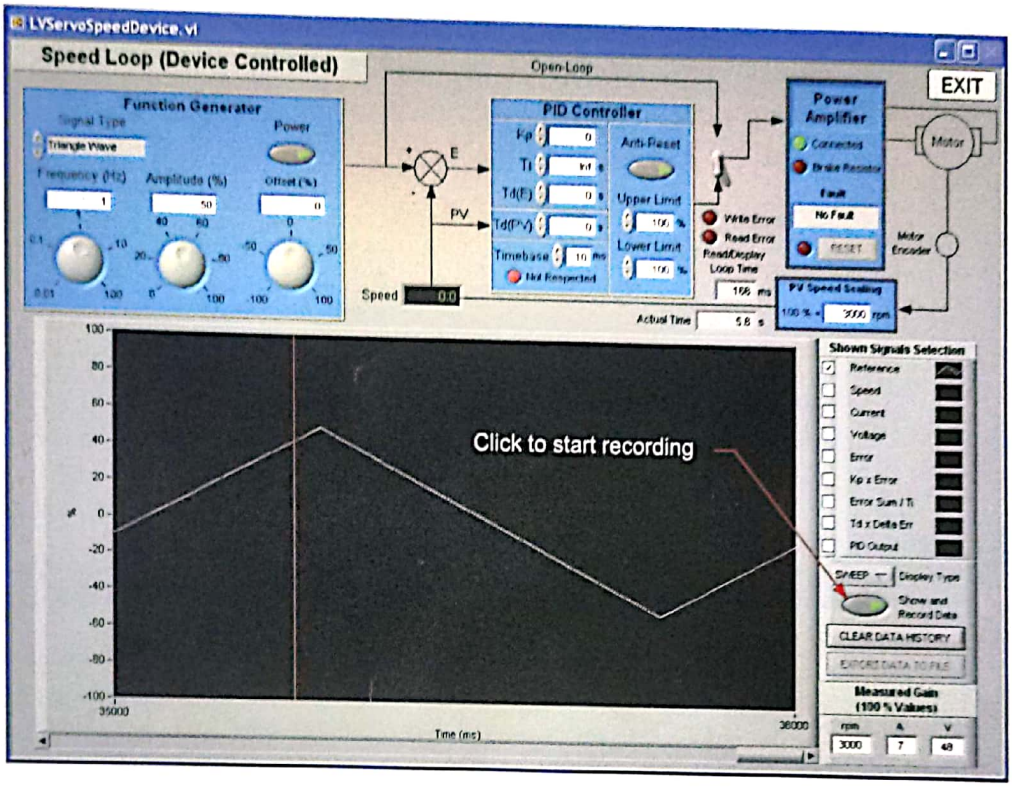


Figure 11. Triangle wave screen capture.

15. Export the data in the relevant file. Following is the complete data-export procedure (strip recorder running). The process is illustrated step-by-step in Figure 12.

    1. Begin by clearing the old data from memory by clicking on the **Clear Data History** button. This ensures that no previous data is exported at the same time as the new data.

    2. Wait until all the data to be exported has been viewed on the strip recorder, i.e., in this present exercise, wait until the triangle wave generator has produced a complete cycle of the triangle wave, and then click on the **Show and Record Data** switch to turn off the strip chart recorder.

    3. Click on the **Export Data to File** button. The data exported is the data that has been recorded since the last time the **Clear Data History** button was clicked on to when the **Show and Record Data** switch was set to OFF.

    4. Select an appropriate file name and file location for the saved data. The data is saved in a tab-delimited text file that can easily be exported to a spread sheet.

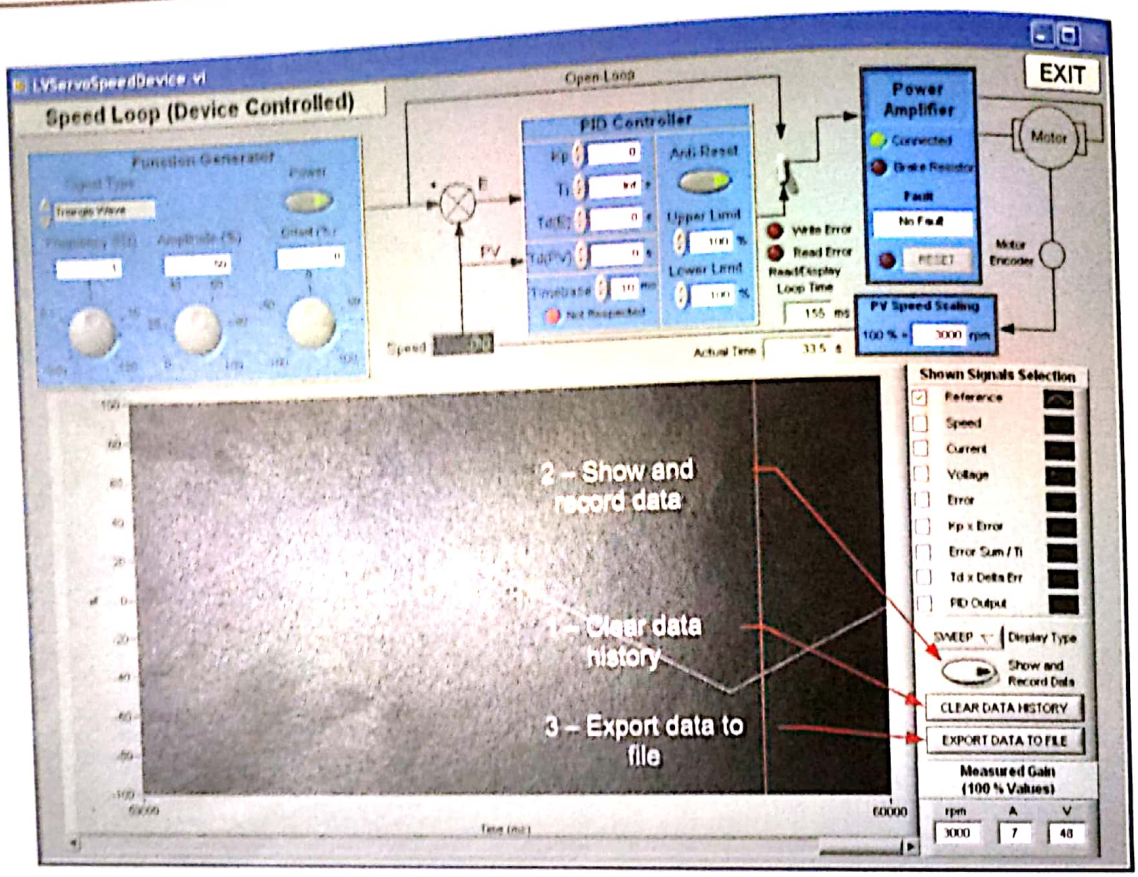


Figure 12. Data-export procedure.

16. Analyze the acquired data using a spread sheet like Microsoft Excel. Start the spread sheet application and open the file that contains the exported data. The following message may occur:

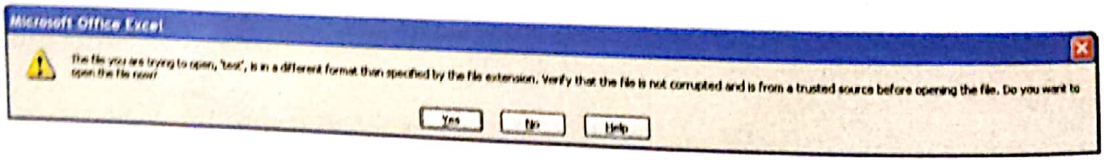
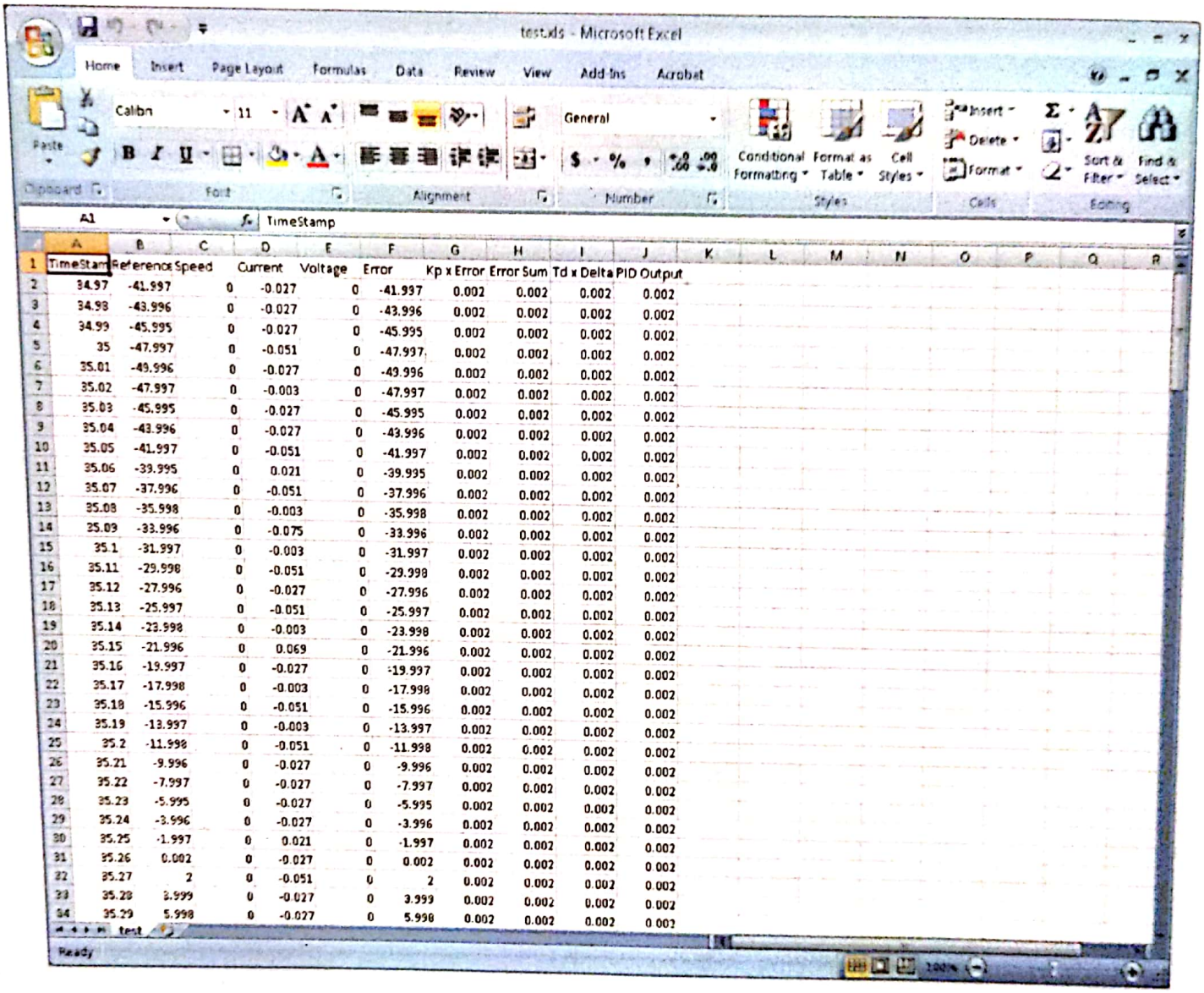


Figure 13. Microsoft Excel warning message.

17. Click on the **Yes** button. You will then be prompted to load the file using optional delimiters. Accept the default delimiter (tab) and follow the prompts. The file will be loaded into the spread sheet as shown in Figure 14.



TimeStamp	Reference Speed	Current	Voltage	Error	Kp x Error	Error Sum	Td x Delta	PID Output
34.97	-41.997	0	-0.027	0	-41.997	0.002	0.002	0.002	0.002
34.98	-43.996	0	-0.027	0	-43.996	0.002	0.002	0.002	0.002
34.99	-45.995	0	-0.027	0	-45.995	0.002	0.002	0.002	0.002
35	-47.997	0	-0.051	0	-47.997	0.002	0.002	0.002	0.002
35.01	-49.996	0	-0.027	0	-49.996	0.002	0.002	0.002	0.002
35.02	-47.997	0	-0.003	0	-47.997	0.002	0.002	0.002	0.002
35.03	-45.995	0	-0.027	0	-45.995	0.002	0.002	0.002	0.002
35.04	-43.996	0	-0.027	0	-43.996	0.002	0.002	0.002	0.002
35.05	-41.997	0	-0.051	0	-41.997	0.002	0.002	0.002	0.002
35.06	-39.995	0	0.021	0	-39.995	0.002	0.002	0.002	0.002
35.07	-37.996	0	-0.051	0	-37.996	0.002	0.002	0.002	0.002
35.08	-35.998	0	-0.003	0	-35.998	0.002	0.002	0.002	0.002
35.09	-33.996	0	-0.075	0	-33.996	0.002	0.002	0.002	0.002
35.1	-31.997	0	-0.003	0	-31.997	0.002	0.002	0.002	0.002
35.11	-29.998	0	-0.051	0	-29.998	0.002	0.002	0.002	0.002
35.12	-27.996	0	-0.027	0	-27.996	0.002	0.002	0.002	0.002
35.13	-25.997	0	-0.051	0	-25.997	0.002	0.002	0.002	0.002
35.14	-23.998	0	-0.003	0	-23.998	0.002	0.002	0.002	0.002
35.15	-21.996	0	0.069	0	-21.996	0.002	0.002	0.002	0.002
35.16	-19.997	0	-0.027	0	-19.997	0.002	0.002	0.002	0.002
35.17	-17.998	0	-0.003	0	-17.998	0.002	0.002	0.002	0.002
35.18	-15.996	0	-0.051	0	-15.996	0.002	0.002	0.002	0.002
35.19	-13.997	0	-0.003	0	-13.997	0.002	0.002	0.002	0.002
35.2	-11.998	0	-0.051	0	-11.998	0.002	0.002	0.002	0.002
35.21	-9.996	0	-0.027	0	-9.996	0.002	0.002	0.002	0.002
35.22	-7.997	0	-0.027	0	-7.997	0.002	0.002	0.002	0.002
35.23	-5.995	0	-0.027	0	-5.995	0.002	0.002	0.002	0.002
35.24	-3.996	0	-0.027	0	-3.996	0.002	0.002	0.002	0.002
35.25	-1.997	0	0.021	0	-1.997	0.002	0.002	0.002	0.002
35.26	0.002	0	-0.027	0	0.002	0.002	0.002	0.002	0.002
35.27	2	0	-0.051	0	2	0.002	0.002	0.002	0.002
35.28	3.999	0	-0.027	0	3.999	0.002	0.002	0.002	0.002
35.29	5.998	0	-0.027	0	5.998	0.002	0.002	0.002	0.002

Figure 14. Exported data file.

18. Select the data to be plotted. For this exercise, plot only the reference data, as shown in Figure 15.

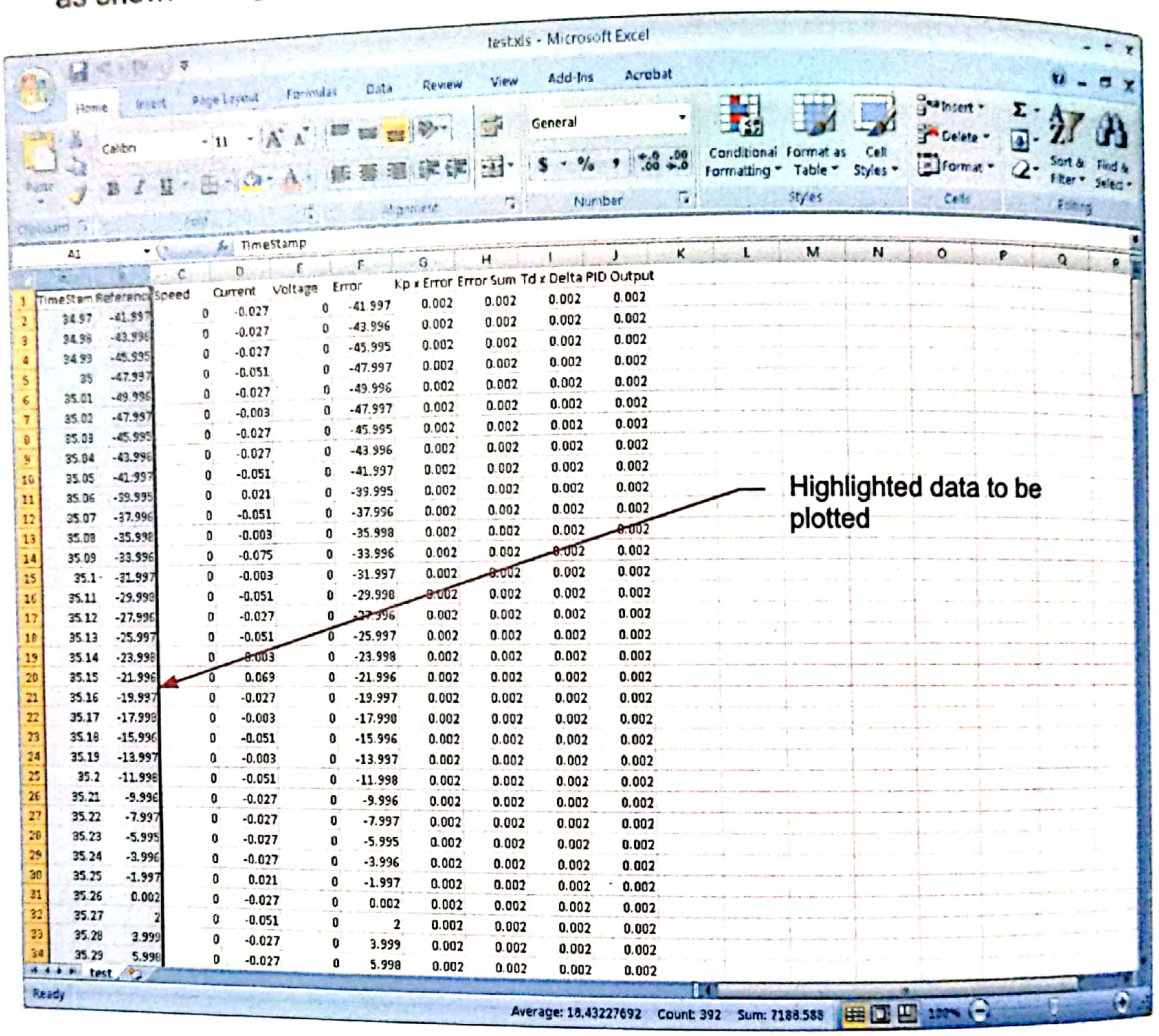


Figure 15. Reference data selected for plotting.

19. Click on the **Insert** button and then select the line chart as shown in Figure 16.

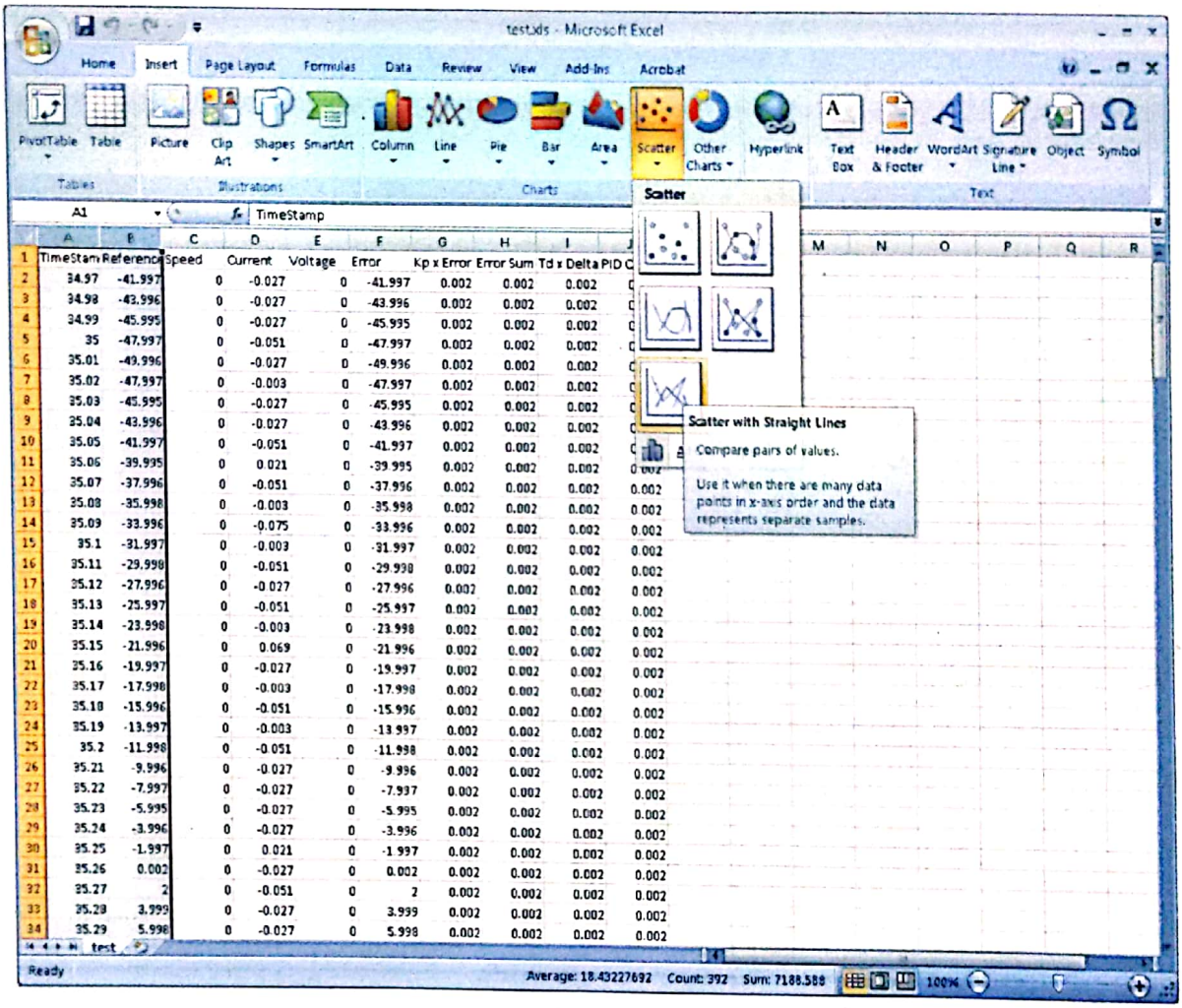


Figure 16. Line-chart selection.

20. Click on the **Chart** button. The plotted data appears as shown in Figure 17.

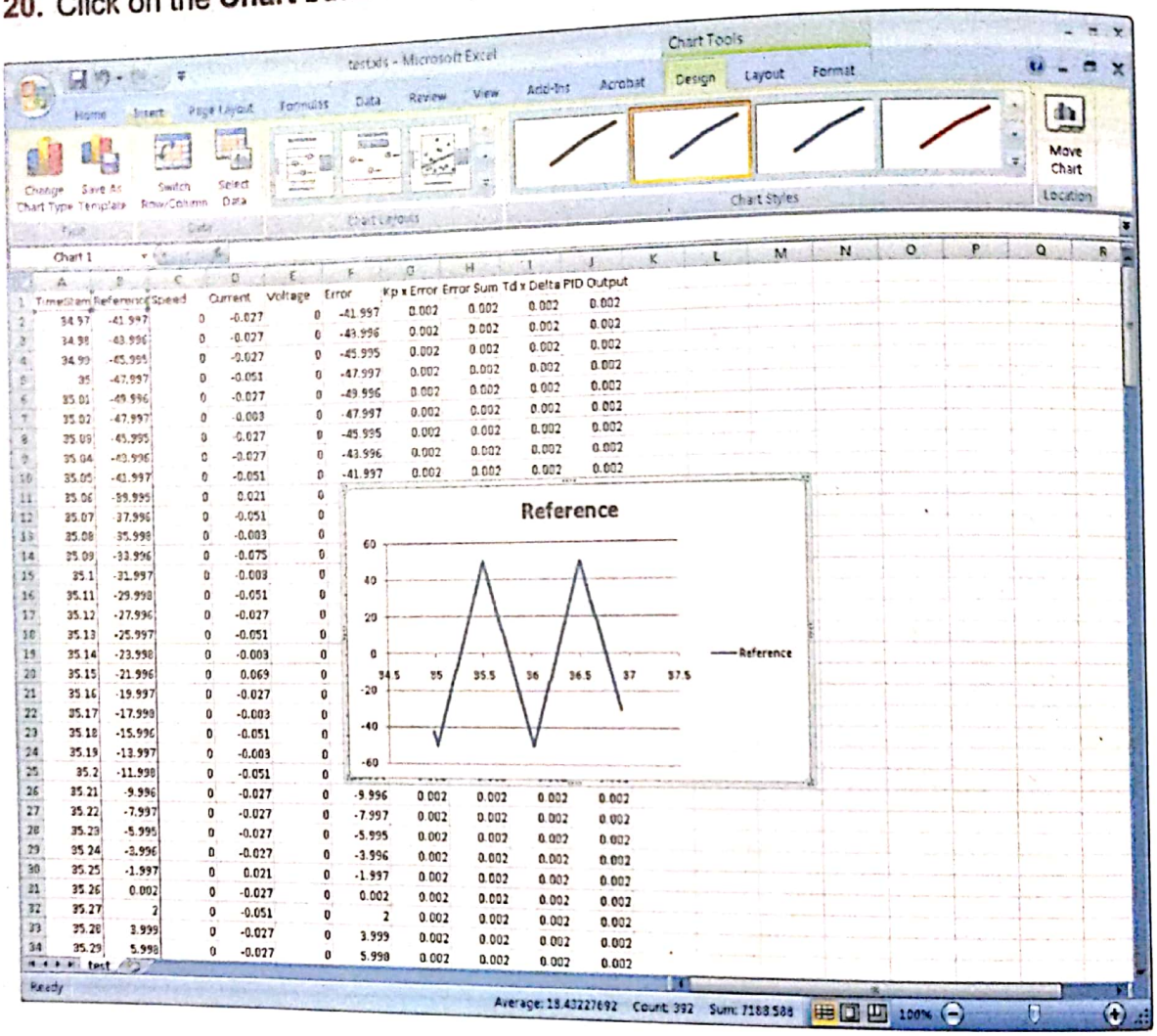


Figure 17. Plotted reference data.

21. Save the spread sheet as an Excel file if necessary. This saves the chart and maintains its format.

ON

In this exercise, you familiarized yourself with the hardware and software of the Digital Servo system. You learned how to engage the platform in order to perform position control exercises and how to disengage the platform for speed-control exercises. You also learned how to acquire data using the Digital Servo software and export the data to a spread sheet.

UESTIONS

1. What is the difference between host controlled mode and device controlled mode?

2. What is the difference between the rail incremental encoder and the motor shaft incremental coder as regards the physical mounting of the encoders and their control mode?

3. In which mode (Speed Control or Position Control) is it necessary for the platform to be disengaged at all times and why?