LabVIEW Generator Controls Workshop

Learning Objectives

The objective of the LabVIEW Powerplant Controls Workshop is to develop understanding of a control system and how to develop, implement, and fine-tune it. Through interactive, hands-on lessons, participants will focus on:

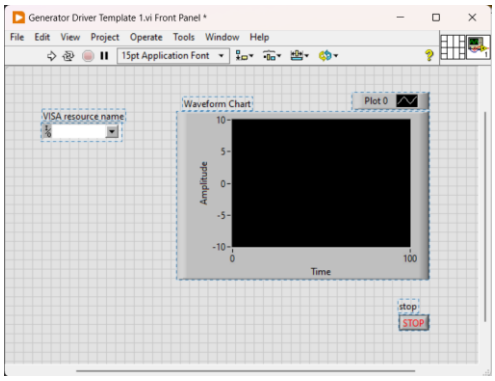
- **Achieving Precision through Closed-Loop Control:**
  - Explore and implement PID (Proportional-Integral-Derivative) control strategies to stabilize system outputs and fine-tune motor and load levels under varying conditions.
  - **Tuning Control Parameters for Optimal Performance:**
    - Adjust and refine control parameters to achieve desired system responses, minimize oscillations, and enhance system stability and accuracy.
- **Implementing System Operations with LabVIEW:**
  - Develop routines to initialize, operate, and collect performance data from a physical generator model, creating a foundation for real-world control applications.
- **Executing Instrument Drivers to for Device Control:**
  - Apply an instrument driver to initialize and control devices, facilitating seamless interaction with supervisory system control.
- **Building a Functional Control System:**
  - Learn to create control system logic, applying structures like loops and conditionals to effectively manage system behavior.
  - Experience intuitive user interfaces for monitoring and adjustment, using real-time charts and control elements.

Each lesson builds toward mastery in developing, executing, tuning and understanding dynamic control systems. By the end, participants will be prepared to design, implement, and optimize control systems, integrating practical programming skills with control engineering principles to address real-world challenges.

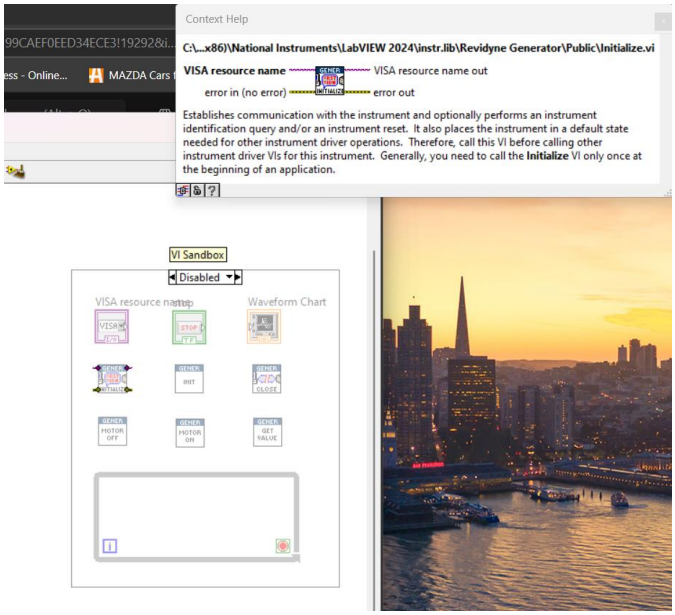
Power Generator Mini-System Plant

Lesson 1: Opening the serial port and reading data

1. **Open the Generator Driver Template 1 VI**

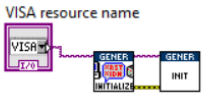


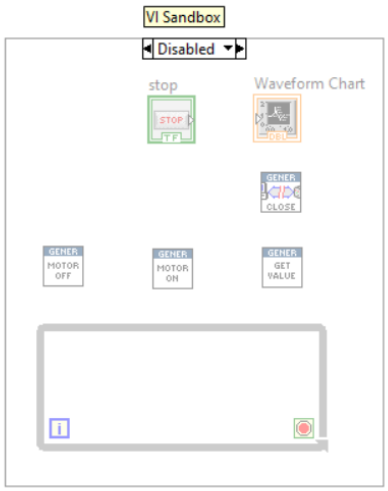
2. **Review all the VIs needed to build the program**
    a. Go to diagram
    b. Press ctrl+h to bring up the context help window
    c. The Disabled structure holds all the VIs needed to build the program
    d. Hover over each of the VIs and examine their functionality



3. **Open the Serial Port**
    a. Drag the Visa resource name control, Initialize and Init functions onto the diagram

b. Wire the Visa resource name and error info to the VIs



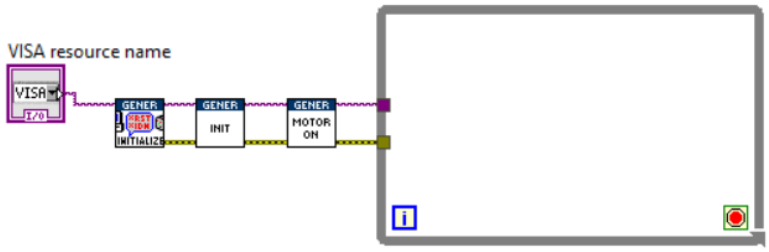


4. Turn on the Powerplant Motor

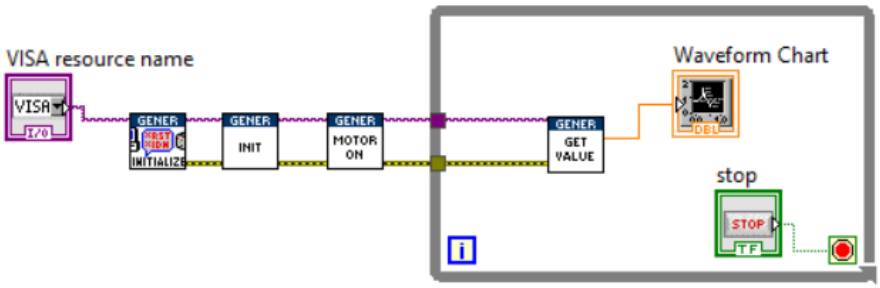
a. Drag the Motor On VI onto the diagram

b. Wire the Visa name resource and error info to the VI

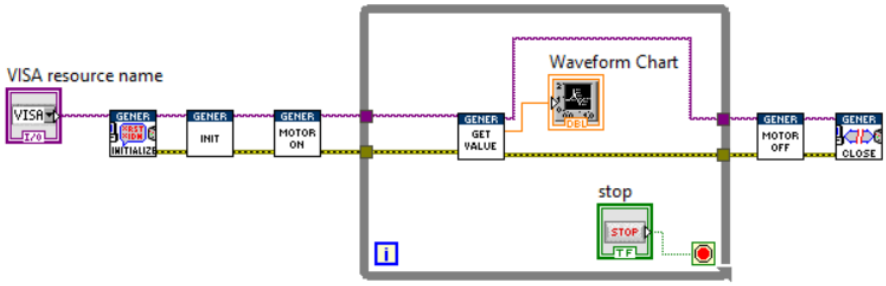
5. **Add a While loop**
    a. Drag the While Loop to the diagram
    b. Wire the Visa resource name and error info the loop's edge



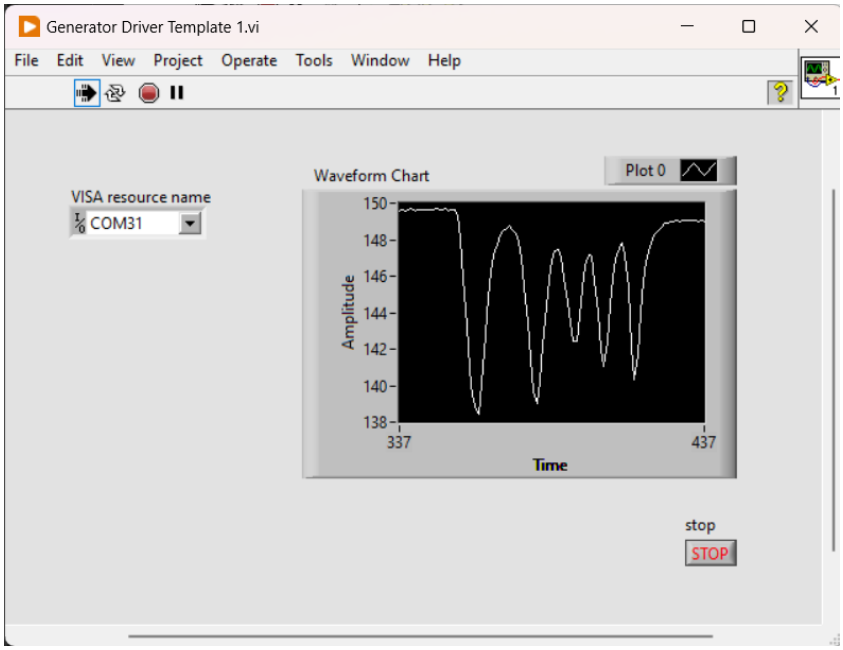
6. **Read the Generator's voltage value and plot**
    a. Drag the Get Value VI and Waveform Chart and Stop Button onto the diagram
    b. Wire the Visa resource name and error info to the Get Value VI
    c. Wire the Value Terminal of the Get Value VI to the Waveform Chart
    d. Wire the Stop Button to the Loop terminal



7. **Turn off motor and close the serial port**
    a. Drag the Motor Off and Close VI to the diagram
    b. Wire the Visa resource and error info to the Motor Off and Close VIs



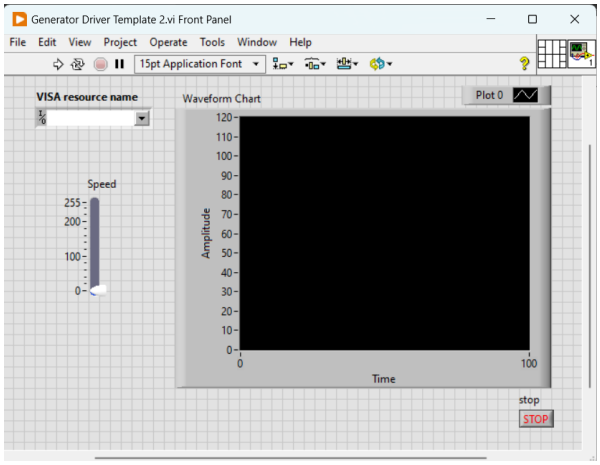
8. **Run the VI**
    a. Go to the front panel
    b. Select the Com Port connected to the Generator model
    c. Click the run arrow
    d. Observe the Generator output (scaled to AC volts)
    e. Press the manual damper button on the generator to affect the output



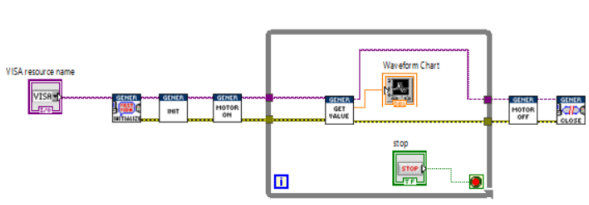
End of Lesson 1

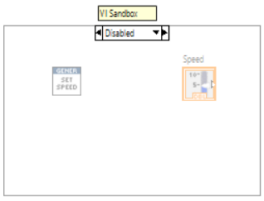
Lesson 2: Control the Powerplant Motor Speed

1. **Open the Generator Driver Template 2 VI**

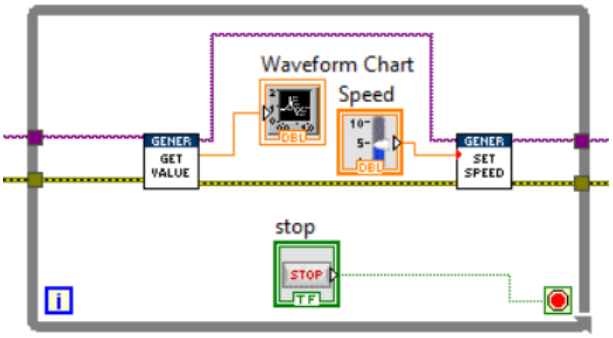


2. **Start with the diagram from Lesson 1**
    a. Review the VIs in the VI Sandbox
    b. Go to the diagram
    c. Press ctrl+h
    d. Hover over each new VI in the VI Sandbox and review its functionality

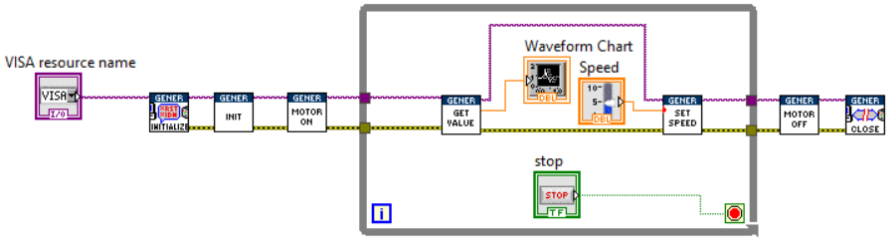




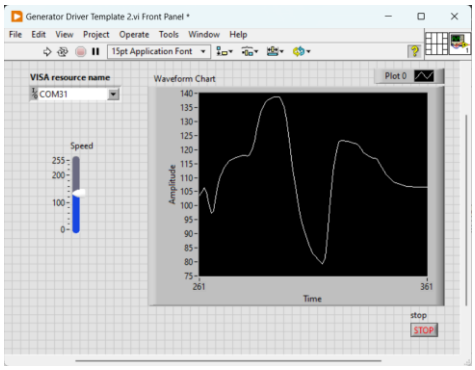
3. **Add Power Plant Motor Speed Control**
    a. Drag the Set Speed and Speed Slide control onto the diagram
    b. Wire the Visa resource name and error info to the Set Speed VI and the outputs to the Loop edge tunnels
    c. Wire the Speed slide control to the speed input terminal of the Set Speed VI



4. **View the whole diagram**



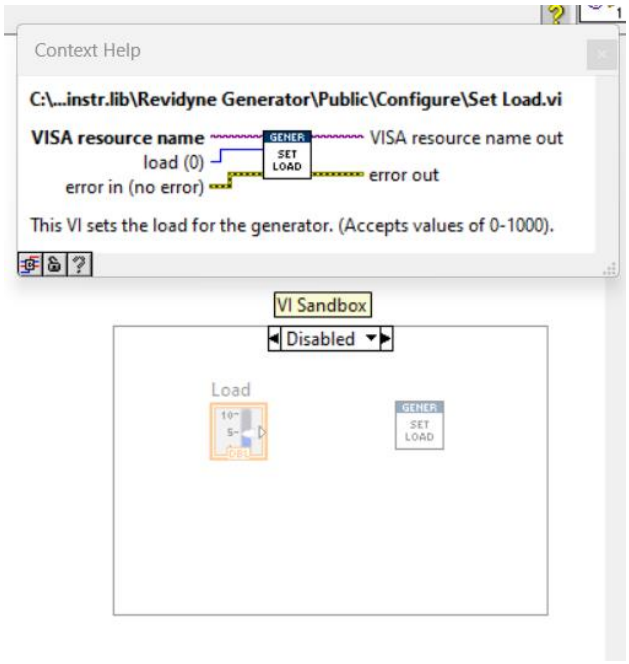
5. **Run the VI**
    a. Go to the front panel
    b. Select the Com port connected to the Powerplant model
    c. Click the Run arrow
    d. Adjust the slider and observe the voltage change from the generator



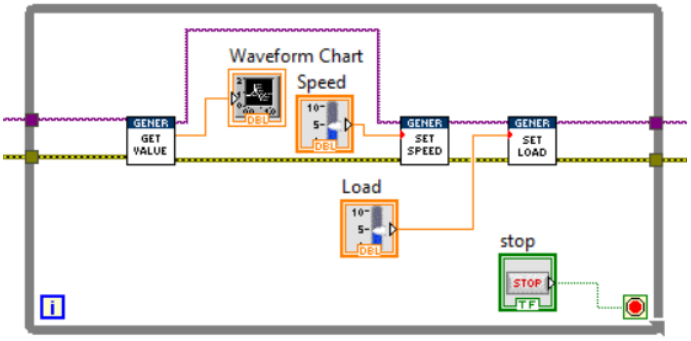
End of Lesson 2

Lesson 3: Control the Powerplant Motor Speed

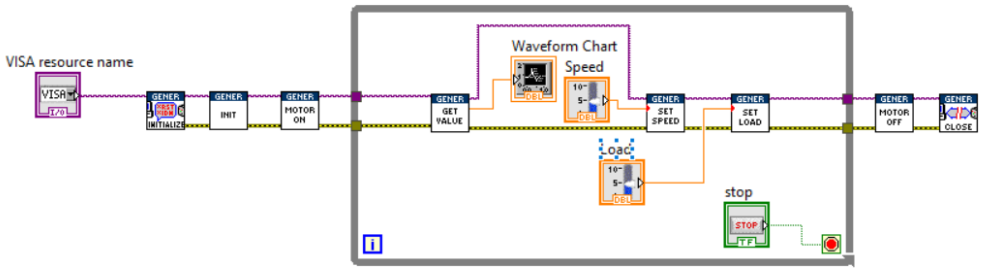
1. **Open the Generator Driver Template 3 VI**
    a. Review the new VIs in the VI Sandbox.
    b. Press ctrl+h and see the functionality of each new VI



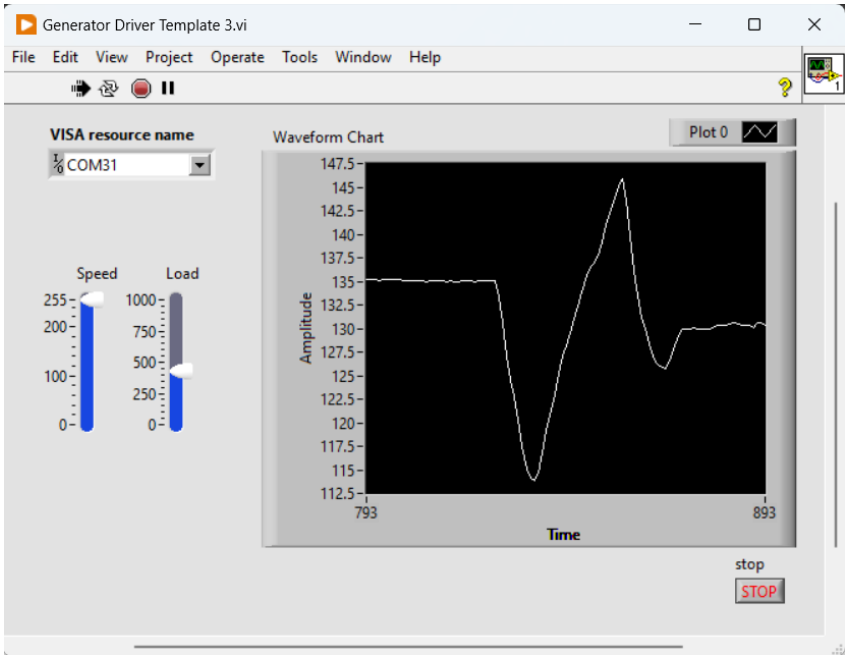
2. **Add the Powerplant generator load control**
    a. Drag the Set Load VI and the Load Slide to the diagram
    b. Wire the Visa resource name and error info to the Set Load VI and its outputs to the Loop tunnels
    c. Wire the Load slide output to the load input terminal of the Set Load VI



3. **The entire diagram looks like this**



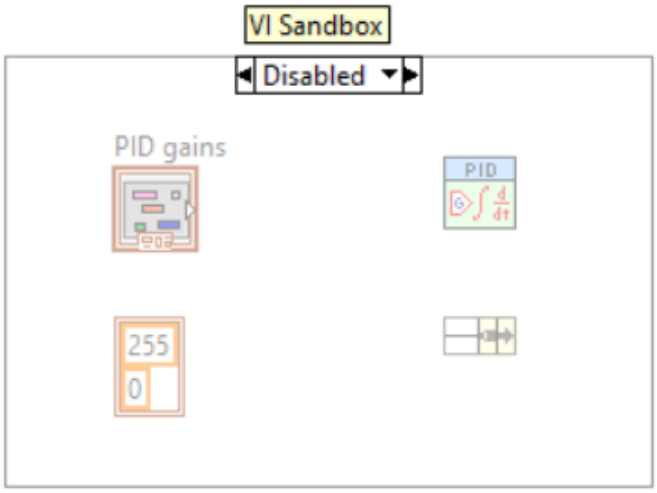
4. **Run the VI**
    a. Go to the front panel
    b. Select the Com port assigned to the Powerplant model
    c. Click the Run arrow
    d. Adjust the Speed and Load slide controls and observe the response



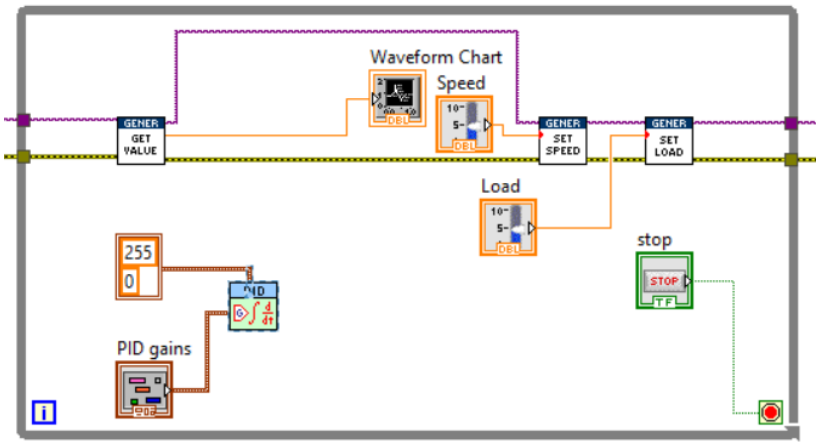
End of Lesson 3

Lesson 4: Use PID Closed Loop Control

1. **Open the Generator Driver Template 4 VI**
   a. Review the new VIs in the VI Sandbox.
   b. Press ctrl+h and see the functionality of each new VI

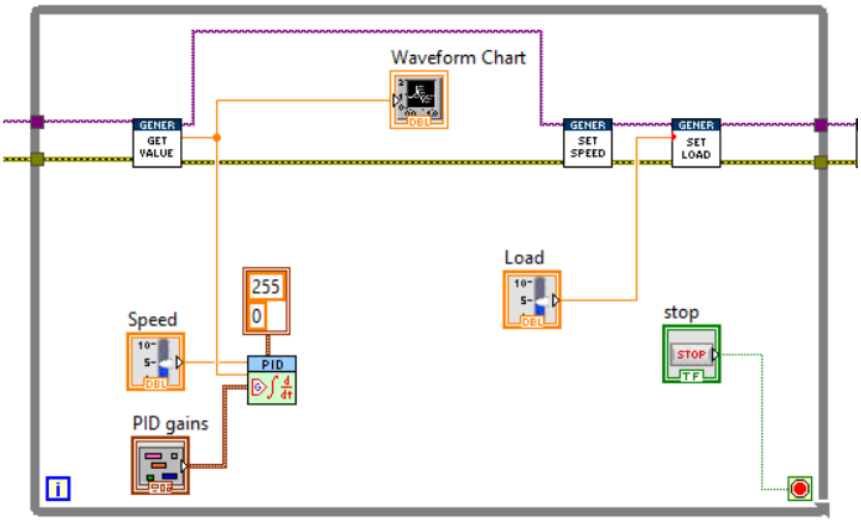


2. **Add PID control to the diagram**
   a. Drag the PID VI, PID gains control and the range constants to the diagram
   b. Wire the PID Gains control to PID gains terminal of the PID VI
   c. Wire the output range cluster to the output range terminal of the PID VI



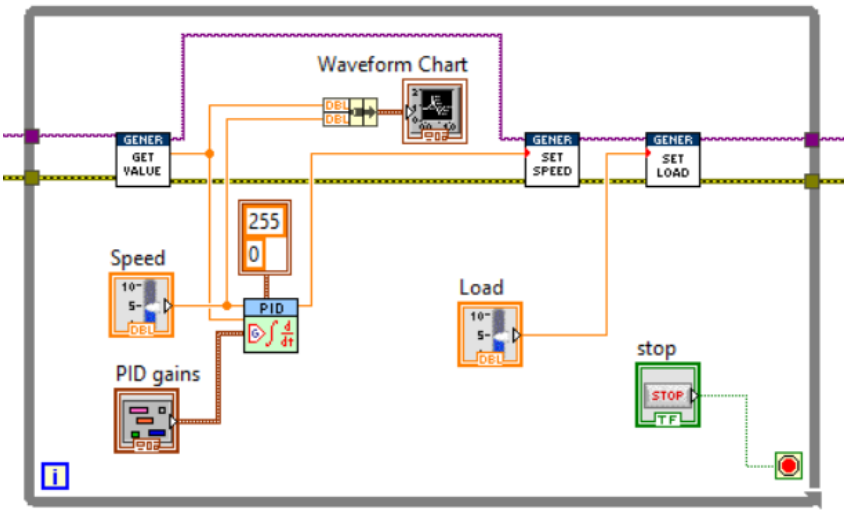
3. **Change the Speed slider from direct control to input to PID**

a. Unwire the Speed slide output and rewire to the PID Setpoint terminal
b. Wire the value output terminal from Get Value VI to the Process Variable input terminal of the PID VI

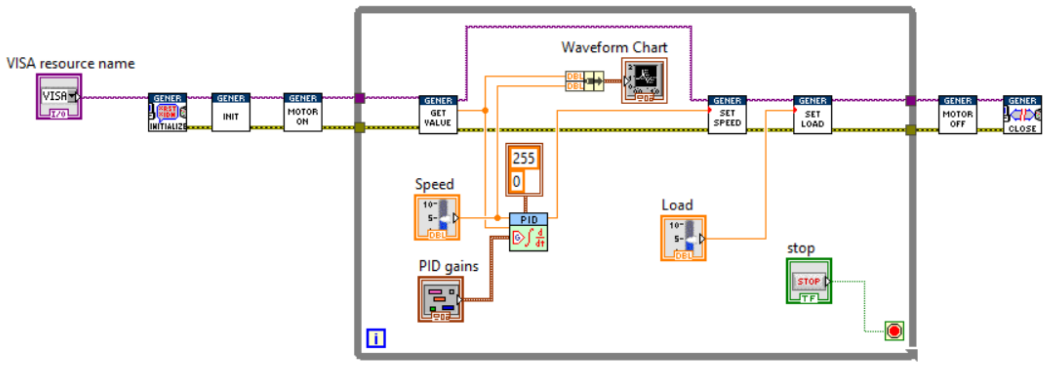


4. Send the PID output to Set Speed VI and combine with the Waveform Chart

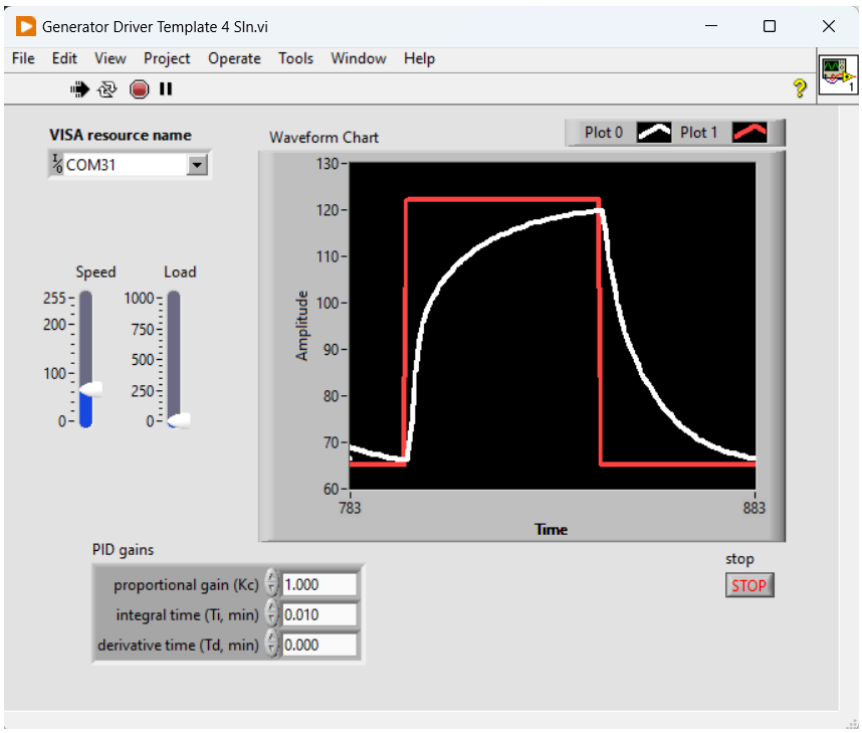
a. Wire the Speed slider and the Get Value output to the bundle VI
b. Wire the PID output terminal to the speed terminal of the Set Speed VI



5. **The entire diagram looks like this**



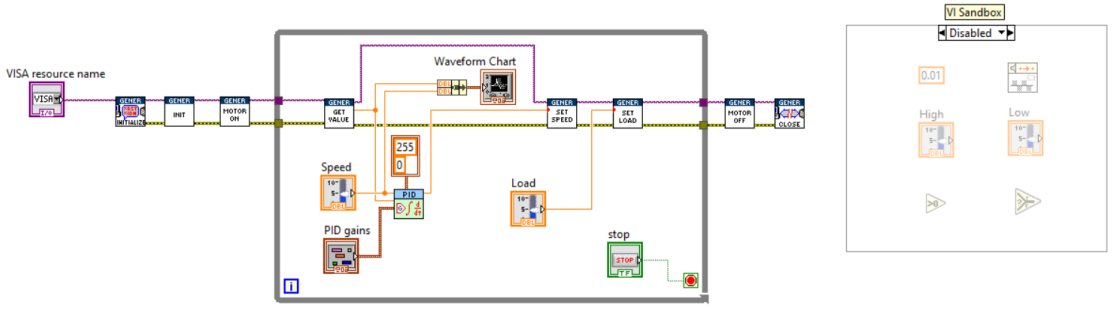
6. **Run the VI**
    a. Go to the front panel and select the Com port for the Powerplant model
    b. Click the Run arrow
    c. Adjust the Speed slider and observe the generator response
    d. Adjust the Load slider and observe the response
    e. Press the manual load button on top of the Powerplant model and observe the response



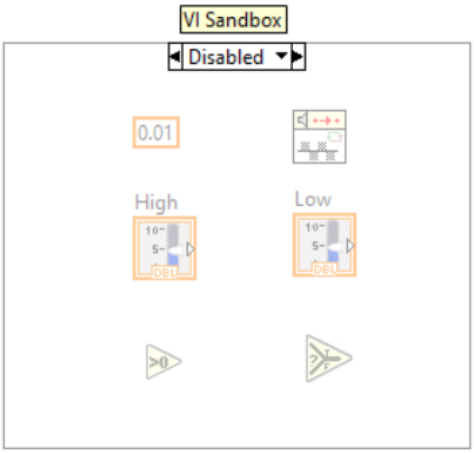
End Lesson 4

Lesson 5: Tuning the PID Controller

1. **Open the Generator Driver Template 4 VI**
    a. Review the new VIs in the VI Sandbox.
    b. Press ctrl+h and see the functionality of each new VI

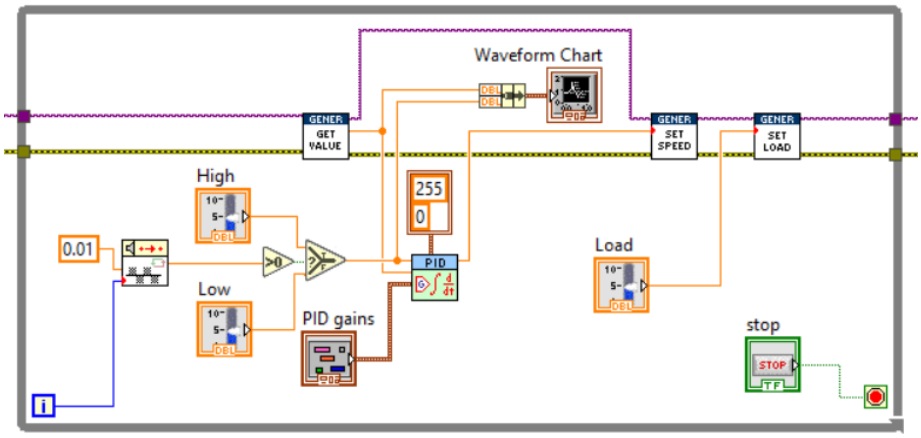


2. **Review the new VIs in the VI Sandbox.**
    a. Press ctrl+h and see the functionality of each new VI

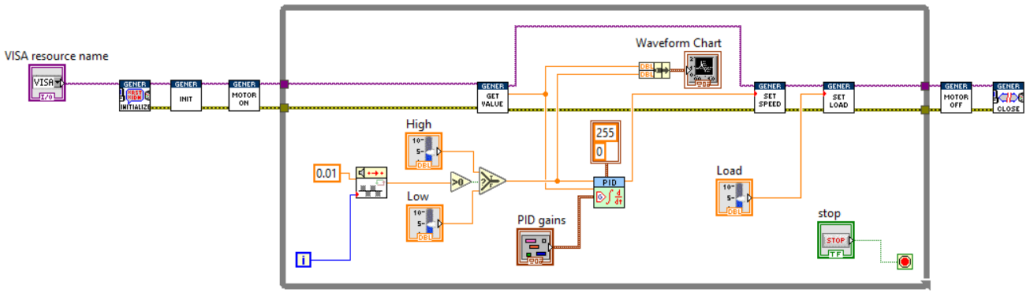


3. **Build a Square wave generator**
    a. Drag the High and Low slide controls, the >0, Select, 0.01 constant and the Square Wave VI to the diagram
    b. Delete the Speed slide control
    c. Wire the Loop counter (i) to the time input terminal of the Square Wave VI
    d. Wire the 0.01 constant to the frequency input terminal of the Square Wave VI
    e. Wire the Square Wave output to the Greater-than-0 VI

f. Wire the High and Low Slides into the Select VI
g. Wire the output of the Select VI to the Setpoint input of the PID VI



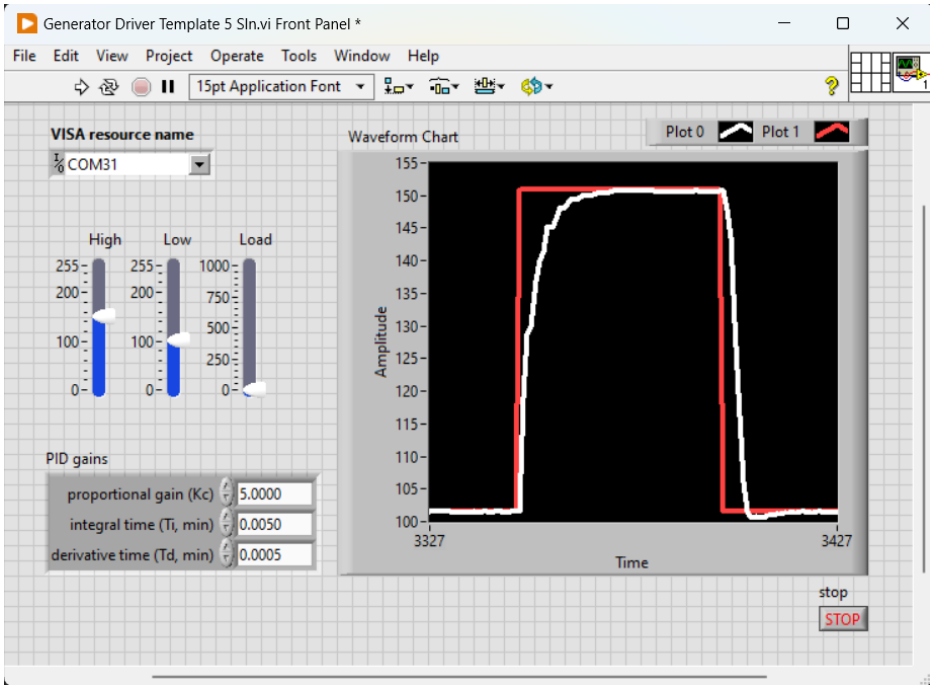
4. The entire diagram looks like this



5. Tune the PID Controller

a. Go to the front panel
b. Select the Com port for the Powerplant model
c. Click the Run arrow
d. Set the High slide to 150 and the Low slide to 100
e. Set the P, I and D values all to 0.
f. Adjust up the P value until you get a good-shaped waveform (It does not have to touch the setpoint waveform, just show a similar shape with little to no ringing.
g. Set the I value to 1 and adjust it down until the output from the Powerplant generator matches the Setpoint waveform with little or no ringing.

h. Set the D value to 1 and adjust it down until the waveform smooths out. (this will be a small number around 0.0005)
i. Set the load value and see how the system responds at different levels



End of Lesson 5