Damping Tab

Two pages are included on the Damping Tab, **Dynamic Response** and **Damping Ratio.**

Before getting into program functional details an understanding of **Damping Coefficients** and **Damping Ratio** is required. **Damping Ratio** is the ratio of the actual shock damping coefficient to what is called the critical damping coefficient. Critical Damping Coefficient is a function of the unsprung mass and the spring rate calculated at the wheel. The equation is:

$$C_{crit} = 2\sqrt{m_{us} k_w}$$

$$Where$$

$$m_{us} \; = unsprung\ mass\ on\ one\ wheel$$

$$k_w = effective\ spring\ rate\ at\ wheel$$

The Damping Coefficient (C) for the system is a function of the shock piston geometry, oil viscosity, temperature, friction, wheel to shock motion ratio, and piston velocity. The program calculates the system damping coefficient based on the user entered variables.

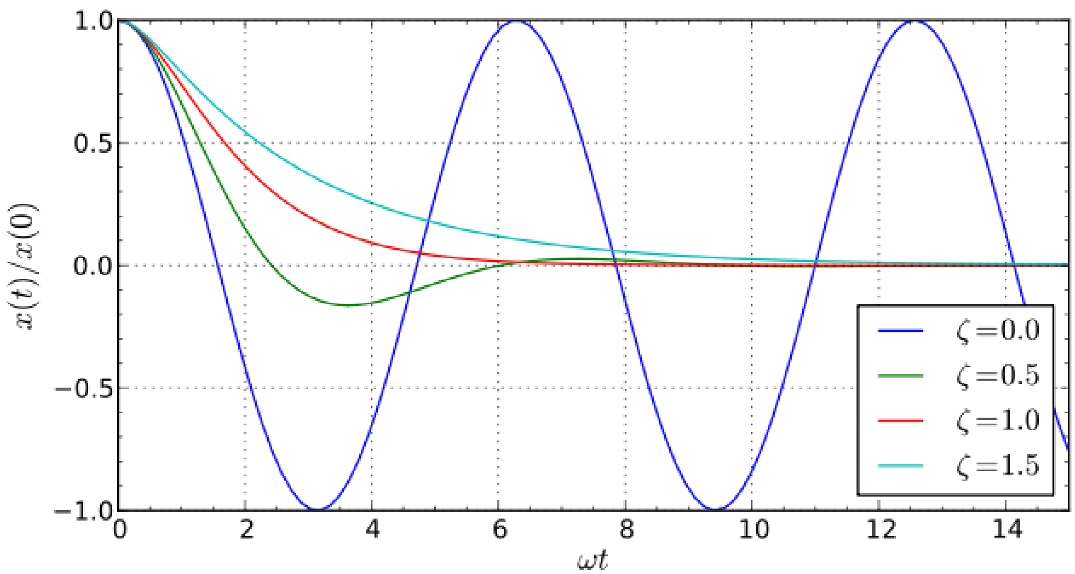
The Damping Ratio (zeta or ζ) is then:

$$\zeta = C/C_{crit}$$

The Step Response test is a standard test that provides valuable insights into the level of damping in the system. Response can be zero damped, underdamped, critically damped or overdamped. Damping Ratio (zeta or ζ) is an indicator of how light/heavy the damping is for the current shock oil/piston combination. There are four terms generally used to describe the level of Damping:

Zero Damped ζ =0 System will oscillate indefinitely (impossible in real world conditions)
Under Damped ζ < 1, System responds with decaying oscillations
Critically Damped ζ = 1, System responds with no oscillations.
Over Damped ζ >1 System responds slowly without oscillating.

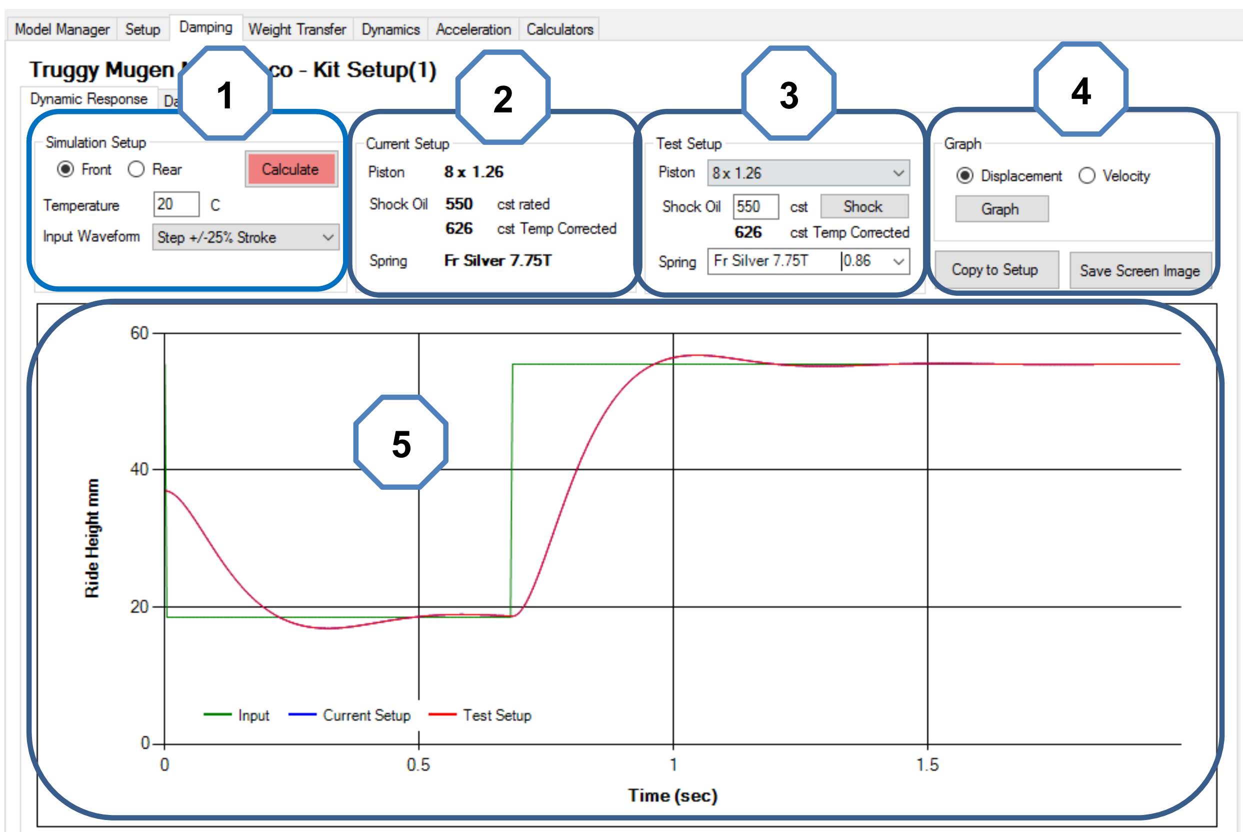
The graph below represents the system response to a step input for the four different damping levels.



Since the the Damping Coefficient varies depending on the variables noted above some valuable insights into the effects on the Damping Ratio can be extracted. The two Damping Tabs provide different methods of evaluating damping in the system.

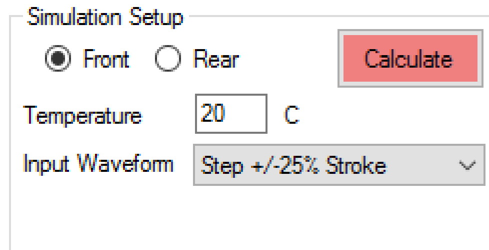
Dynamic Response Page

The **Dynamic Response** model used in Engineering Terms is a 1 degree of freedom mass-spring-damper simulation. Essentially it allows the response of one wheel to be studied for variety of inputs and takes into account Internal Shock Geometry, Piston hole size, number of holes, leakage flow, oil viscosity, temperature and shock to wheel motion ratio. The simulation allows a Test Shock with a different Piston, Shock Oil, Shock position and spring to be compared with the current setup values.



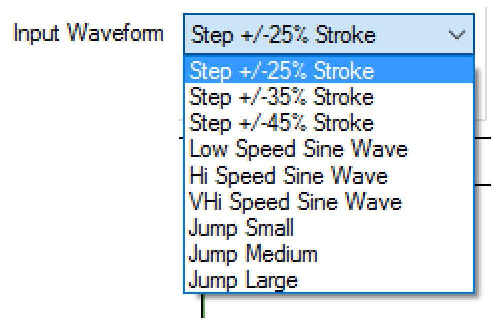
Area 1 – Simulation Setup

Select the Front or Rear radio button to run the simulation using the current setup values, suspension geometry and sprung mass for that end.



Enter the track air temperature or the anticipated temperature of the shock oil. This allows the effect of temperature on the oil viscosity to be included.

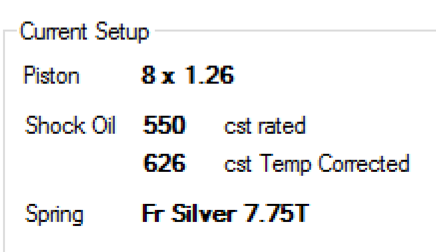
The Input Waveform dropdown allows the response to three different inputs to be studied. The first three are step inputs of different magnitudes which simulate the wheel hitting a sharp bump followed immediately by a hole.



The second group are sine wave inputs. Simulating slow to very high frequency inputs to the wheel. Slow inputs being in the handling range and the higher frequency simulating bumps or wash boards

The last group will be of the most interest to the off-road crowd as this simulates the landing off a jump. The shock is initially at full droop and the velocity input to the wheel is varied for a small, medium and large jump.

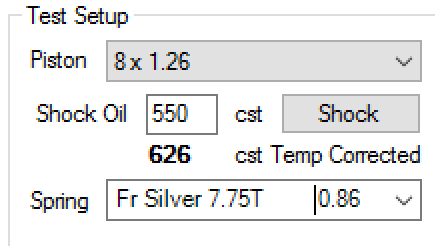
Area 2 – Current Setup



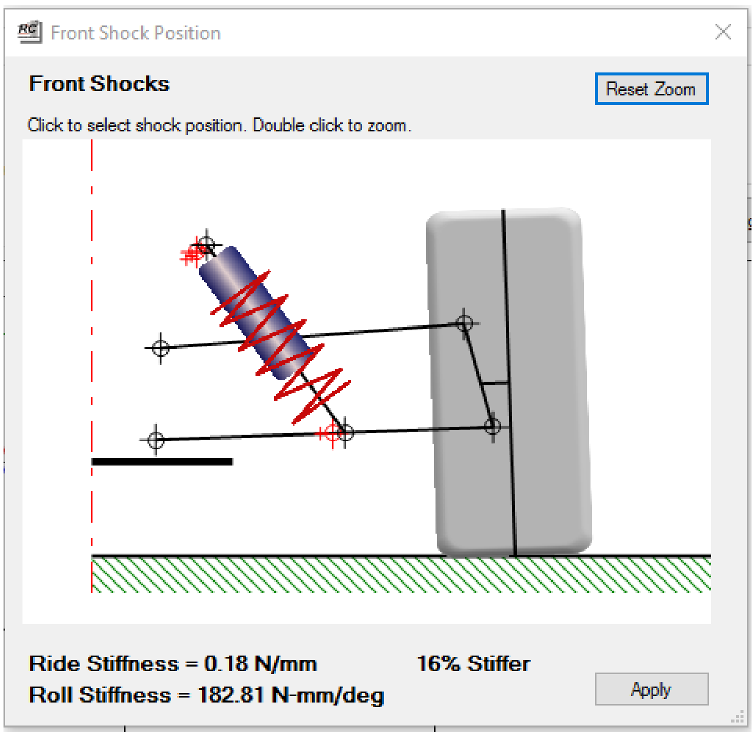
Current Piston, Shock Oil and Spring for the current setup are displayed for reference. The Oil Viscosity value corrected for temperature is also displayed.

Area 3 – Test Setup

This is where you enter changes to the shock setup. Select a new Piston, change the Shock Oil viscosity, or change the Spring. Note that you can add additional piston hole combinations in the **Shock** tab of the **Chassis Manager.**

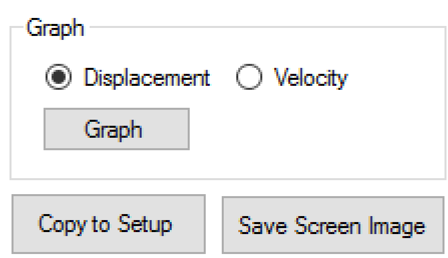


Clicking the Shock button will pop up the **Shock Position** form allowing the effect of changing the mounting position to be studied. Note that changing the shock position simulataneously affects both the damping and spring rate relative to the wheel. Changing shock oil and/or piston only changes the damping and changing the spring only affects the spring rate relative to the wheel.



Area 4 – Test Setup

Click the **Displacement** or **Velocity** radio button and then click the Graph button to update the graph. Displacement is graphed by default.



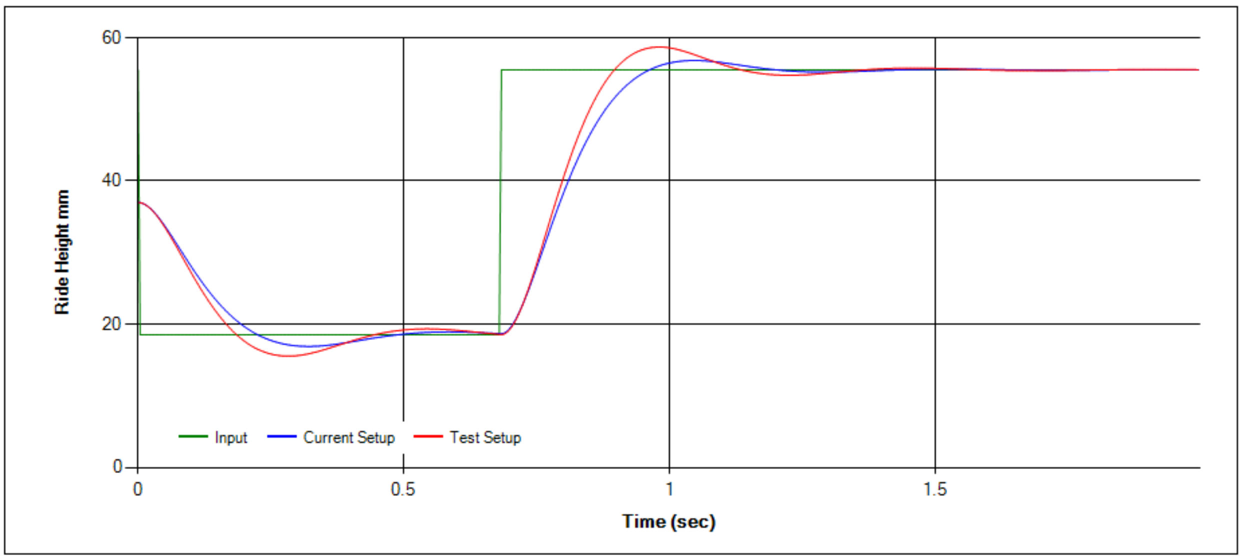
Click the **Copy to Setup** to either update the current setup or create a new setup using the currently entered Test Setup values.

Clicking the **Save Screen Image** button allows a screenshot of the entire Dynamic Response page to be saved and used as a reference or sent to other devices for later use.

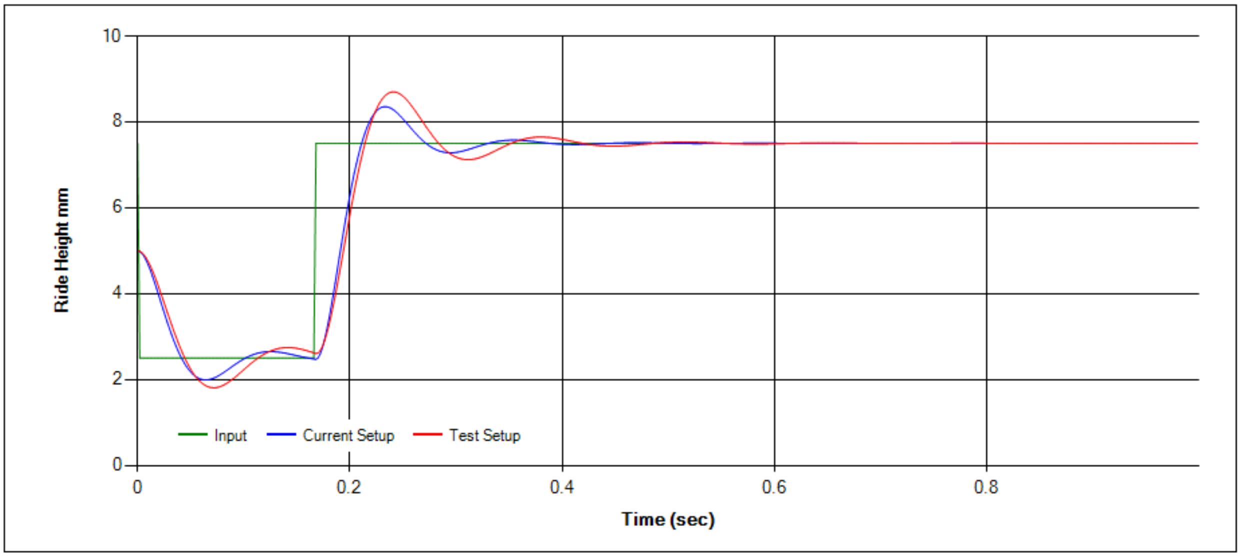
Area 4 – Graph

The results of the simulation are displayed in terms of either displacement or wheel compression/rebound velocity versus time.

In the graphs below the Red –Test Setup is slightly Underdamped and the Blue – Current Setup is close to Critically Damped for off-road applications higher levels of damping are required to allow jumps and bumps to be handled without bottoming the suspension.



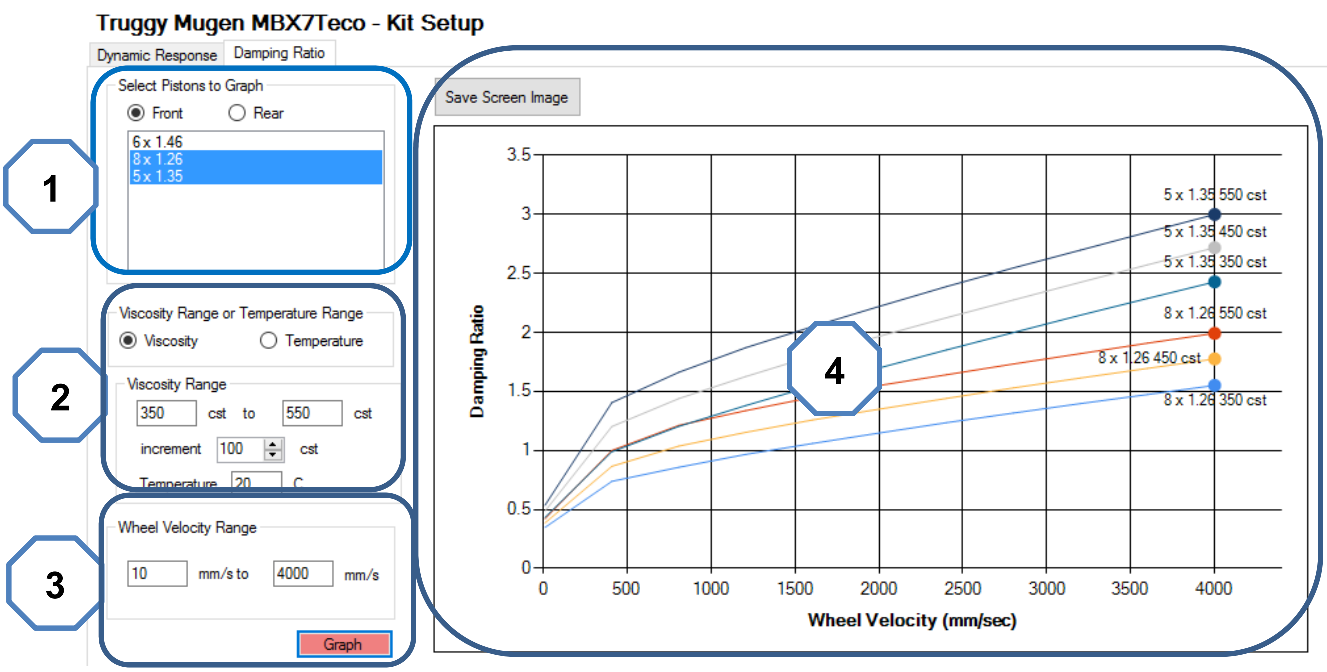
On-road setups will use settings which are more underdamped but still controlled such as that represented below.



The best advice is to experiment with the different inputs and setup options and observe the effects. Once you gain the understanding of what happens to the response you will be able to make better decisions to respond to different tracks and conditions. Enjoy!!!

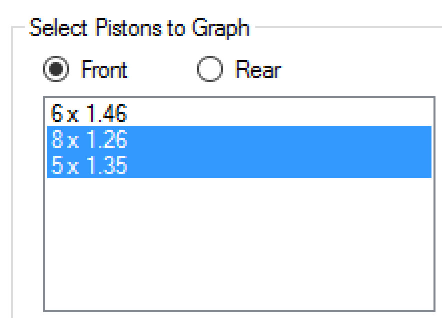
Damping Ratio Page

The **Damping Ratio** page uses the same shock model as the Dynamic Response Page and allows the effect of different piston hole geometries, oil viscosities, and temperature effects to be graphed over a range of wheel velocities. Lower wheel velocities generally in the 100-200mm/sec range represent the handling range. Higher velocities represent bumps and jumps.



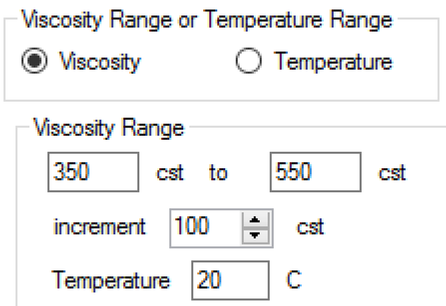
<u>Area 1 – Select Pistons to Graph</u>

Click the front or rear radio button and then click a piston displayed in the box. All the pistons that are currently entered for the chassis are displayed. Pressing ctrl-Click allows multiple pistons to be selected. Shift-Click allows selection of a range of pistons. Additional pistons can be entered using the Shock Page in the Chassis Manager.



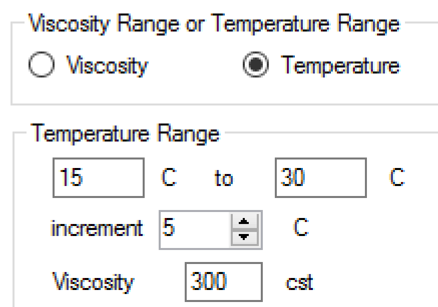
Area 2 – Graph Selection

Select either the Viscosity or Temperature radio button to graph that effect for the selected pistons.



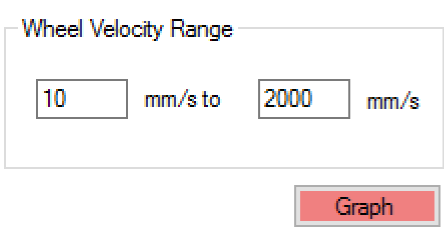
For Viscosity Range analysis enter the lower and upper viscosity range and increment to use generating the graphs. Entering too wide a range or too small a increment will result in a graph that will be cluttered and difficult to read so limit the number of graphs you request. Lastly enter the oil temperature you expect during race conditions. Normally this will be just the ambient air temperature.

If you wish to investigate the effect of oil temperature select the temperature radio button. Enter the Temperature Range of interest and termperature increment to use between graphs. Again limit the range and increment otherwise the graphs will cluttered and more difficult to interpret.



Area 3 – Wheel Velocity Range

The last step is to enter the wheel velocity range. The range for handling will generally be less than 200-300 mm/sec. Beyond the handling range is the region for bumps and jumps. A maximum value of 4000 mm/sec would represent landing off a very large jump.

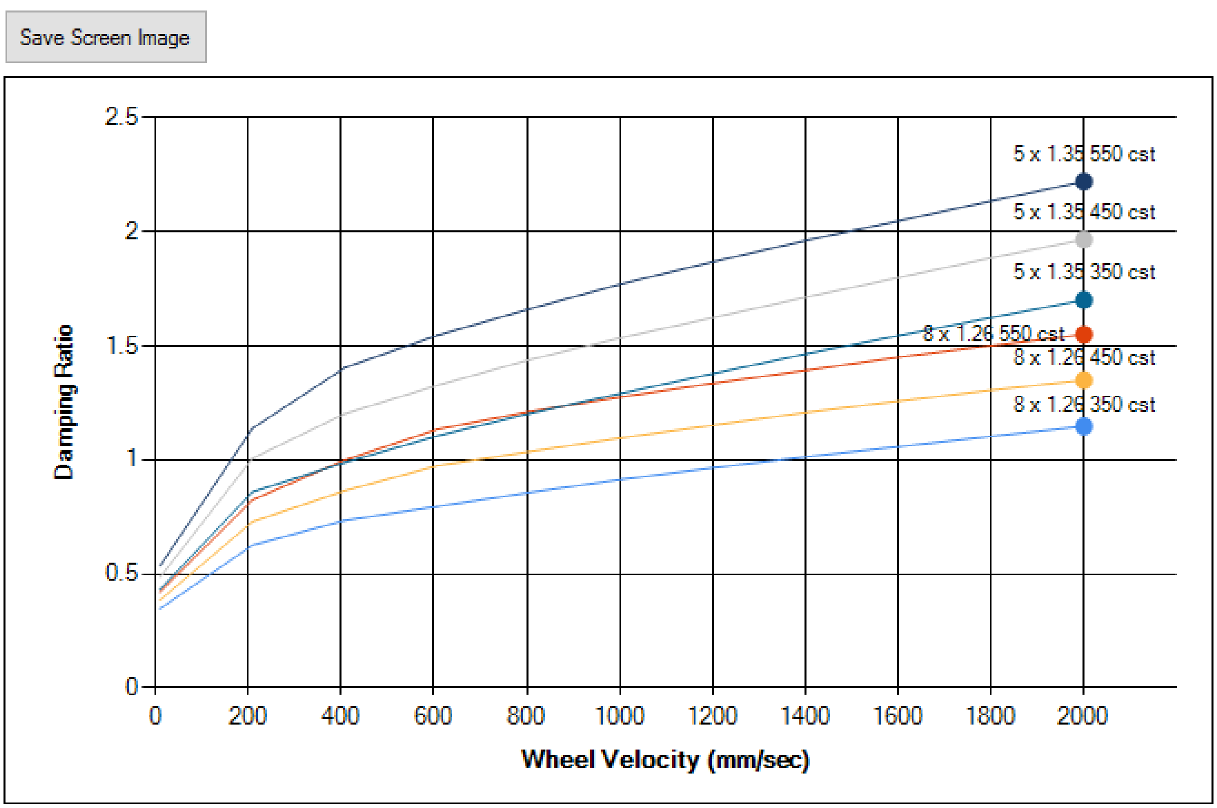


Lastly click the Graph button to generate the graphs.

Area 4 – Graphs

Results are presented in terms of Damping Ratio versus Wheel Velocity. Those with a technical background may ask why the results are presented in terms of Damping Ratio when an idealized damper the Damping Ratio would be constant over the entire piston velocity range. The model developed is not idealized and results in a damping coefficient that varies with piston velocity. This is primarily due to the orifice fluid flow. Since the objective of including damping in the program is to allow these effects to be studied over the entire operating range of the damper presenting the results in terms of damping ratio provides a simple way to rationalize and compare results.

The graph below compares the effect of viscosity changes on two different pistons a 5x1.35 and a 8x1.26. These piston sizes would typically be used in Truggies. What is of interest is looking at the 5x1.35 – 350cst and 8x1.26 – 550 cst graphs. Comparing the Damping Ratio at Wheel Velocities below 600 mm/sec the graphs are almost identical. However at higher velocities the 5x1.35-350cst piston produces a higher Damping Ratio which indicates this configuration would produce more “Pack” as it is called by the Offroad crowd.



Selecting the Temperature radio button graphs the effect of temperature on the selected pistons and entered oil viscosity.