7 Poster

The World of Ride Simulators

A Servotest 7 Poster Ride Simulator System will enable automotive manufacturers and race teams to conduct high performance tests on a range of vehicles.
After recording performance data from service environment trials or circuit driving, this equipment can be used to recreate the required road and/ or aerodynamic inputs to allow for accurate in laboratory testing of vehicle performance.
Our customers are wide ranging and we are proud to have been involved in many prestigious programmes with various vehicle manufacturers and race teams. The Servotest 7 Poster Ride Simulator is ahead of the field in many respects including overall simulation accuracy and reliability. We look forward to working with you in ensuring the entire project is a success.
SVT "Tyre Coupled" Road Simulator will be used to develop past, present and future vehicles. The simulator is designed to reproduce the vertical tyre motions experienced by vehicles on the road surface and also to reproduce the correct weight distribution of the vehicle in test via the 3 Aero-loading actuators. The simulators can be used for development testing of road going and race vehicles to increase quality and performance whilst reducing track testing and model development time.

ISO 9001 - 2000 Reg. No. 059-A

ISO 14001 Reg. No. 059-C

A world of experience…

Servotest is a World Class Test and Motion Simulation Company, with experience of operating around the globe, for multi national corporations, smaller specialist companies and Government Departments. Since the 1950's our engineers and equipment have been at the forefront of our industry. Product and Service quality is maintained by a program of continuous training and development of our engineers and equipment.
We operate in all of the key industry sectors for our marketplace, including Automotive, Marine, Civil Engineering, Aviation, Defence,Aerospace and Traction. The company holds both ISO14001and 9001 Quality accreditation marks and is a member of many national & international trade organizations.

Motor Sport Heritage

During the 1980s, a rapid advance in technology occurred within the high-level motorsport industry. With the introduction of active suspension systems and high downforce aerodynamics, new sophisticated techniques were required for analysing the effects on vehicle handling. Traditionally, 4 post road ride simulators had been used, but these were proving less realistic for race car use. Also, they do not simulate lateral and longitudinal forces generated by the vehicle during cornering or acceleration/ braking.

In 1991, Servotest were approached by Williams Grand Prix Engineering to develop a simulator that could more accurately simulate the suspension forces seen on its F1 cars. Three additional vertical aeroloader actuators were added to our 4 post system, complete with compliant links and very high response servovalves. This is necessary to (i.) Allow the chassis to pitch and roll as freely as possible, and (ii.) To simulate the rapidly changing suspension forces due to aerodynamic load changing with weight transfer induced body motion. This system was delivered in 1992, and gave Williams the opportunity to develop their now infamous FW14B chassis in to the dominant winner in the 1990s, with Constructors Championship wins in 1992-94 and 1996-98.

Servotest have now delivered some sixteen 7 post race car simulators, eleven of which were destined for F1 GP teams. A recent major step forward was replacing the DCS2000 control system with the latest state-of-the-art fibre-optic linked PULSAR controller. A very comprehensive RACECAR software suite has been developed, with continual feedback from our customers to push the performance envelope of the rig.

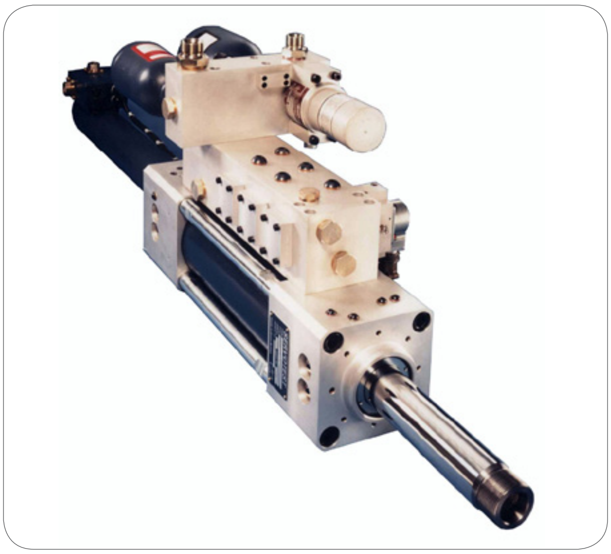
With VIRTUAL ICS ANALYSIS, customers can now integrate computer-generated models, such as the rotating tyre stiffness characteristics, in to a virtual 7 poster environment to enhance the results obtained from the rig.

Actuators and Types of Wheel Pans

Servotest 080 linear actuators are robust fatigue-rated double-ended actuators designed for dynamic thrust of 10-1000 with stroke lengths of 50-500mm, and are able to operate at pressures up to 28 Mpa (280 bar).

Servotest 80mm rod dia. type actuators are of low aspect ratio design to give high flexural rigidity and low stress levels. Making it an ideal choice for 4 Poster applications. It consists of a hollow, hardchromed precision-ground steel piston rod, a bronze piston, and steel cylinder, front and rear bearing heads incorporating hydrostatic bearing pads, a dual coaxial displacement transducer, two servo valves manifold with pressure and exhaust accumulators, an oil filter, and a low pressure interlock switch.

The piston and cylinder are machined with a finite clearance and no piston seals are fitted. The piston rod supported in hydrostatic bearings, prevents metal-tometal contact so that coulomb friction and 'stick-slip' are eliminated. The hydrostatic bearings provide a very strong selfcentring effect on the rod which gives the actuator a very high side-load capacity. Pressure equalising grooves are machined in the piston.



A pressure accumulator is fitted close to the servo valve pressure port to provide instantaneous flow to meet peak demands. There is also an exhaust accumulator close to the servo valve exhaust port to smooth pulsations in the return line.

Pressure controlled snubbers will be incorporated at each end of the stroke to dissipate kinetic energy within a controlled acceleration profile.

The static force required to support the vehicle mass (up to 6,000 kg per axle) can be provided by a conventional actuator or one with an additional servo-controlled preload section. This in turn acts as an enrgy saving device, used particularly with large vehicle "truck" simulators.

The major advantage of a separate pre-load section is that it reduces the hydraulic power requirement.

In application where the actuators are required to accelerate the unsprung mass at (say) 30 g, the actuator has a significant dynamic performance compared to the static support force requirement. For these reasons a conventional actuator is offered with the static support force provided by the dynamic piston.

Wheel Pans

The actuator/wheel-pan assemblies are a proven design specifically for high cycle, long life, and low maintenance applications. Servotest Wheel pan design have proven to be extremely reliable in many similar tough applications world-wide.

Servotest offers a range of wheel pan designs to secure and restrain the wheel. Wheel-pan design for commercial car 4 poster consists of an aluminium alloy platform (weighing 30 kg) attached directly to the piston rod to apply road profile inputs through the tire patch.

To accommodate a 178 mm (7 inch) variation in track and 356 mm (14 inch) variation in wheelbase, the platform measures up to 637mm (26 inches) wide x 417mm (17 inches long). Front and rear restraint protruding 3 cm above the surface of the platform provide the driver with feedback regarding the positions of the car on the wheel-pan in the fore and aft direction. In addition, proximity detectors mounted off the actuator body provide a visual indication on the local console regarding correct fore and aft positioning of the car. These proximity detectors provide an interlock signal to inhibit operation of the ride simulator if the car is not correctly positioned.

The car is guided laterally by approach rails to ensure the car is situated within the tolerance band of +/- 7” regarding wheelbase variation.

Race car Wheel-pan differs slightly in design and material, made from lightweight aluminium alloy the platform is smaller in size 430 x 430 x 25 mm. 7 Poster wheel-pan design also incorporates low friction contact surface to prevent suspension bind, and Anti-rotation mechanism.

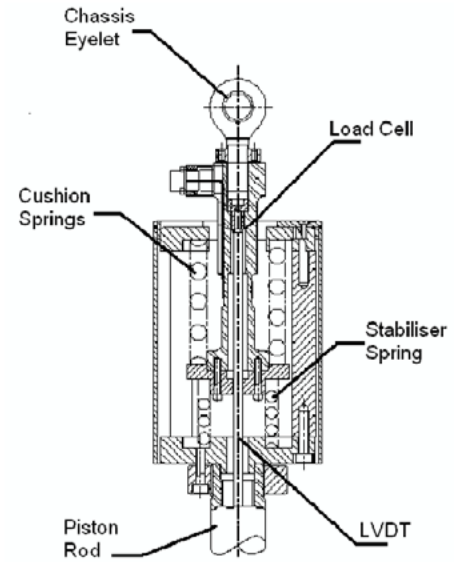
Each actuator is equipped with a magnetic base, allowing for quick and effortless movement of actuators to encompass a variety of wheel pan configurations.

Precision Equipment

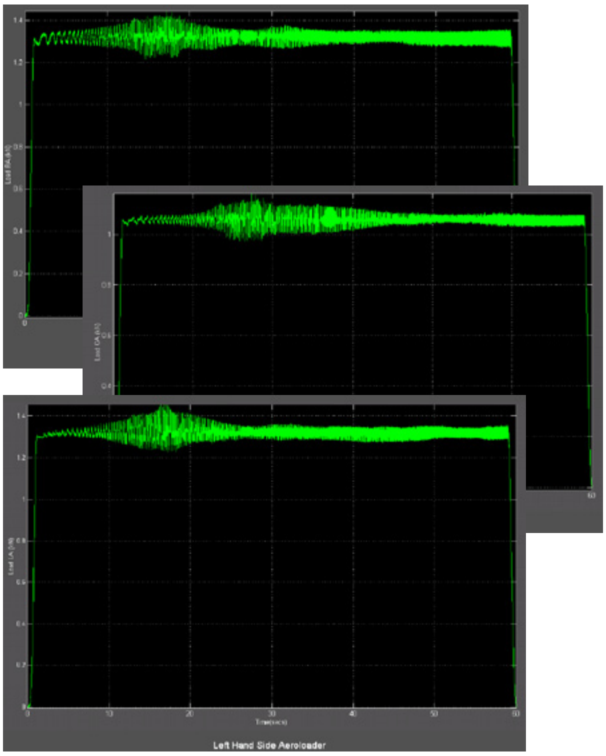
Compliant Links – Aeroloaders

Aeroloader actuators allow realistic motion control of chassis, thus need to respond very rapidly, as they combine changes in the weight transfer (pitch and roll) with the resultant changes in aerodynamic downforce.

Even a small change in the ride height across the car due to weight transfer, creates a very rapid and significant change in downforce. However, on the car, the chassis is connected to the ground through the springs and tyres, which are fairly low stiffness compared to the actuator. If the undamped actuator were connected directly to the chassis, it would respond too rapidly, resulting in a higher force and overshoot in displacement. This would make aerodynamic map verification almost impossible.



Servotest's solution to this problem consists of an aluminium cylinder, containing a link assembly suspended by two preloaded coil springs, each of different stiffness. The cushion spring helps to simulate the progressive effect of the car suspension under compression, whilst the stabiliser spring simulates extension and provides pre-load.



The key to good 7 post performance is in the aeroloaders, and we use custom made very high response servovalves (with 33% less lag than a standard high-response servovalve), special compliant links, and velocity feedforward algorithms to achieve the highest accuracy of all of our competitors (i.e. lowest residual loads). To minimise the unwanted residual forces applied by the earoloaders on the car we use a velocity feed-forward "VFF" optimization scheme which is based on the measurement of the car body velocity (using three velocity transducers).

By using EFB Two-stage servovalves (Rated at 75 L/min ±10% @ 70 bar pressure drop), the VFF filters can work better without introducing high frequency instability. Thanks to our unique optimisation scheme, Servotest 7 poster can reduce the residual loads up to10 times less than completive 7 poster rigs. Generally the target is 0.2 N/mm/s up to 10 Hz, rising to 1 N/mm/s at 20 Hz.

The LVDT connects from the actuator base to the link (i.e. through the piston rod), so it is not affected by the compliance. Likewise, the link is strain-gauged to provide load feedback from the eyelet. If required an accelerometer can be attached to the top of the link.

Typical Servotest 7 Poster – Performance

WHEELPAN	
Displacement	250mm
Maximum Velocity	2.5m/s
Response Accuracy	±1% gain up to 40Hz
	±1% phase up to 40Hz
AEROLOADER	
Displacement	300mm
Maximum Velocity	2.0m/s
Residual Load	0.2N/mm/s up to 10Hz
	1.0N/mm/s between 10-20Hz

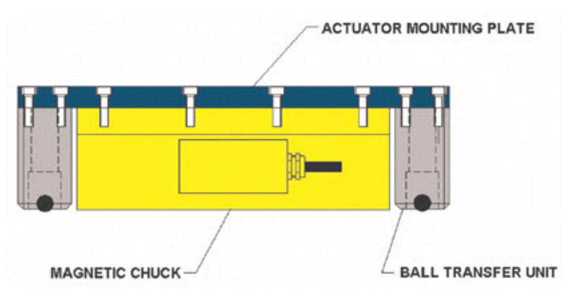
Magnetic Bases – Aeroloader Actuators

Allows quick and effortless movement of actuators to encompass a variety of configurations. This is important for aeroloaders as they need to be attached at the most convenient point on the chassis, which is different for every vehicle.

Due to the space constraints and flexibility required by the aeroloaders, Servotest developed a unique and invovative design to adjust the position of the actuators. Servotest magnetic bases (which operate on a flat section of the bedplate) has proven so successful that we now offer the magnetic bases for the wheelpan actuators as well, and we have delivered two such 4 post systems recently. Not only are they much quicker and easier to reposition, because you do not have to unbolt the X-Y clamps, but they are cheaper, lighter, and offer more position flexibility.

The magnetic chuck contains a series of rare earth neodymium permanent magnets. A controller creates an electrical field to de-magnetise the chuck, at which point the chuck is free to move with little force. When the controller is switched off, the chuck re-energises and clamps to the bedplate with a pressure of 1600kN/m2. Thus, no hydraulic clamping is needed and it is inherently safe in the event of a power failure. In addition, no hydraulic clamping is necessary, as the magnetic bases provide this when energised. Four sprung-loaded ball transfer units allow low effort movement of the actuator when the chuck is de-energised. When the chuck is reenergised, the roller balls retract under the attraction force, to allow full magnet contact with the ground steel bedplate.

By using the low friction magnetic bases, a dramatic reduction can be made in drive motor size, thus reducing complexity, bulk, and costs. Our simple x-y adjust uses a parallel drive, via a ball-screw or toothed belt, for setting the wheelbase, and a sliding crossmember to adjust the track width. All four actuators are adjustable in equal displacements in either direction, to minimise travel and thus increase.



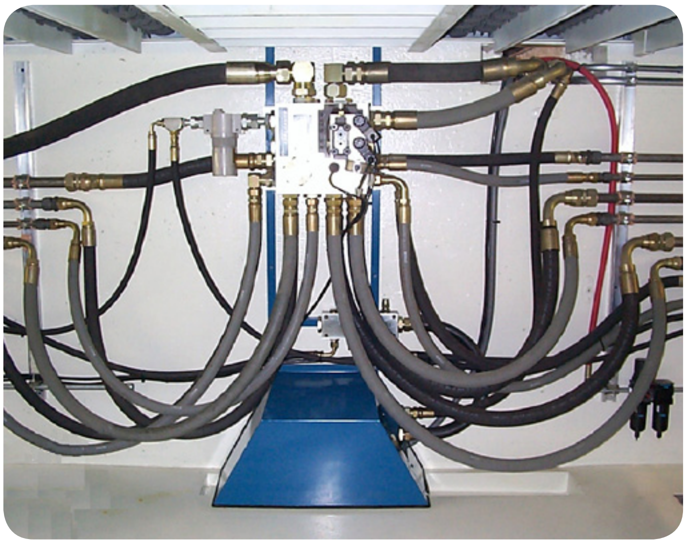
Hydraulic Power Distribution

The hydraulic circuit consists of four main components: hydraulic power supply (HPS), ring main, solenoid control manifold (SCM), and distribution hoses.

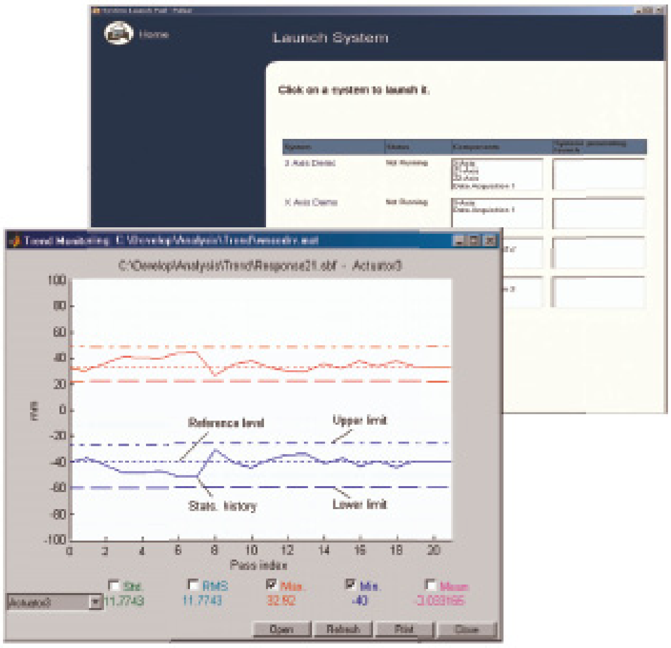
For 7 post applications, normally, either a 90kW (125hp) or a 180kW (250hp) HPS will be required. If there is intention to create a dynamic test lab, with additional test equipment, then it is more cost effective to go for a larger HPS with a comprehensive ring main.

The pumps feature an integral oil tank with a low pressure high flow boost pump to keep the oil circulating through the filter and cooler. This maintains oil temperature during low demand and makes sure the oil is clean before it leaves the pump. Starting is done off load using a star-delta system.

The SCM controls flow of oil to the rig from the ring main. It is controlled by the PULSAR software in off/low/high pressure mode, with a safety pressure switch to shut the rig down if sudden unexpected pressure changes are detected. From here, the oil is distributed to the individual servovalve manifolds through flexible hoses.



7 Poster PULSAR Digital Controller

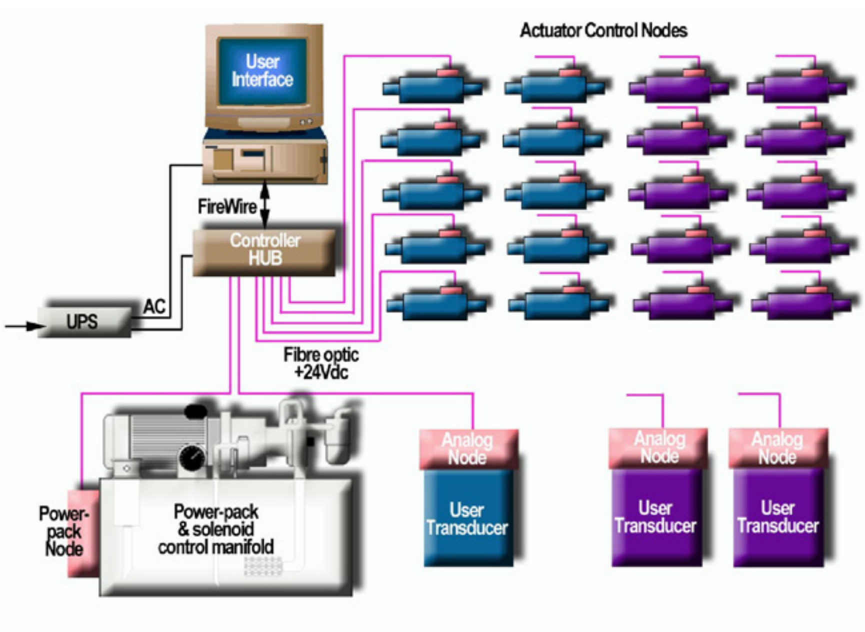


The Servotest Pulsar control system offers users the very latest in digital control for servohydraulic test and simulation systems. It employs state-ofthe- art real-time control techniques to ensure optimum accuracy.

The system is based on a revolutionary I/O system, using distributed fibre-optic technology. Building on the success and popularity of its predecessor, DCS2000, the Pulsar control system provides a powerful, reliable and flexible total control solution.

7 Poster PULSAR consists of 7 control nodes mounted on each actuator, in turn controlled by a PC. Typically, there will be one hydraulic (powerpack) node, additional nodes can be configured as analogue nodes for analogue input and output signals.

Each actuator control node box can contain up to six transducer modules, in addition to the standard motherboard and FPGA board. Some feature an integral carrier module for transducer excitation.



Pulsar System Features

- **Synchronised sampling, modelling and control:**
  All signals are synchronised and each can be data logged.
- **Data Acquisition:**
  User transducers sampled in-sync with control loop.
- **Optical Fibre Long Line Cabling:**
  No signal degradation.
- **Short Analogue Line:**
  Maximise Signal / Noise ratio.
- **Versatility:**
  System sizes from 1-16 nodes, each with wide choice of I/O and applications.
- **Servo Control Orientated Architecture:**
  High power time coherent DSP maths engine specifically designed by Servotest Systems Ltd.

The Servotest Control System PULSAR Incorporating OptoStar Technology

PULSAR

The Race Car software provides a complete integrated test package, from geometry set-up to analysis of the results. Over 10 years experience in working with top race car teams and manufacturers has been incorporated into this latest generation of software. Pulsar Race Car software uses the latest and most advanced tools and techniques in software engineering to create an intuitive environment in which the race car test engineer can concentrate on testing rather than the test rig.

The Pulsar software uses the latest and most advanced tools and techniques in software engineering, with extensive use being made of object-oriented design and programming to ensure a solid base for future development. Throughout its design, great emphasis has been placed on ease of use, without compromising the power and flexibility of the system. The system configuration is stored within industry standard database files, which are created and updated using a set of simple configuration screens.

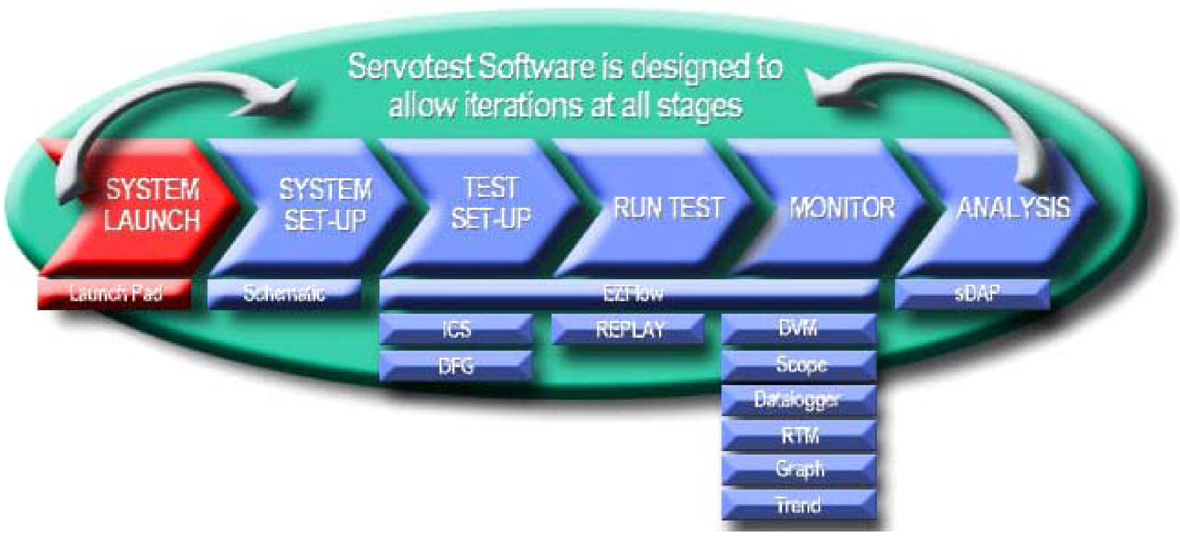
The Pulsar software runs within the Microsoft Windows™ environment, providing the user with a powerful, easy to use interface. The software revolves around the concept of signals which are arranged into groups for ease of selection.

Command signals to the actuators can have Cycle Counter and multiple Function Generator inputs applied to them. Signals can be Monitored, displayed on software Oscilloscopes, sent to the Analogue Outputs or the Data Logger which allows triggering and user-defined acquisition rates. Monitored signals can be displayed as Maximum, Minimum, Average and RMS or Instantaneous values, and have a user selectable averaging period. Multiple Safety Limits can be set on any signal with the Limit action selectable between Indicate, Trip or Shut.

A large high resolution colour monitor will be supplied with the control system providing the user with a large screen area to display signals, configure tests and analyse data.

The following sub-modules make up the recommended Pulsar Race Car Software Suite:

- Launch Pad
- Schematic (including signal generator, hydraulic control, cycles counters and others)
- Race Car Configuration
- Replay
- Data Logger



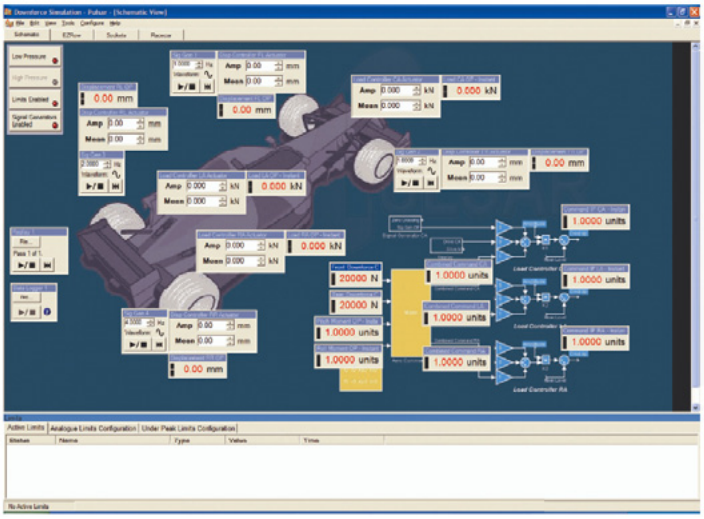
User Interface

The main user interface screen shown opposite offers the user easy point-and-click operation of all the main test options:

The background images for the Schematic Front Panel are user configurable and can contain any image or photograph.

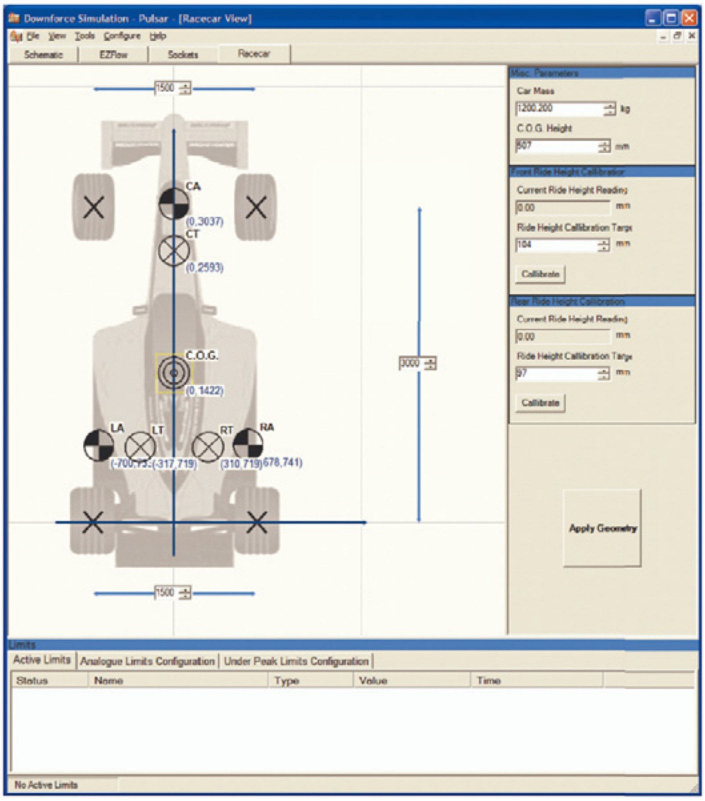
From this main screen the test system can be set-up and monitors of signals can be displayed. Other applications such as EZ Flow and Sockets can be accessed from the tabs at the top of the screen.

Incuded in the schematic view are the following standard sub-modules: Hydraulic Control, Actuator Control, Signal Generators, Cycle Couters, Limits, Monitors, Scope – each of which is described in more detail on the following pages.



Race Car Configuration

The geometry of the test system can be input using the graphical interface included in the Race Car Configuration panel. This interface allows for flexible placement of the actuators and velocity transducers.



PULSAR Software

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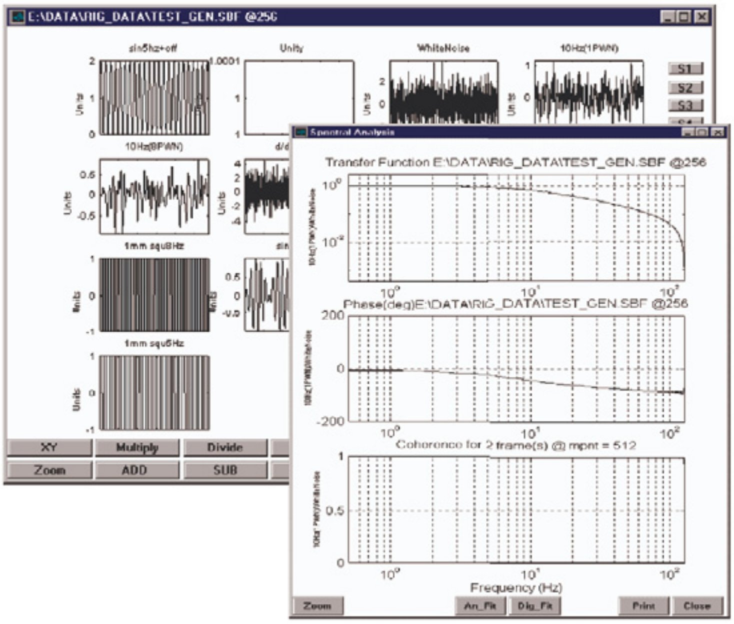
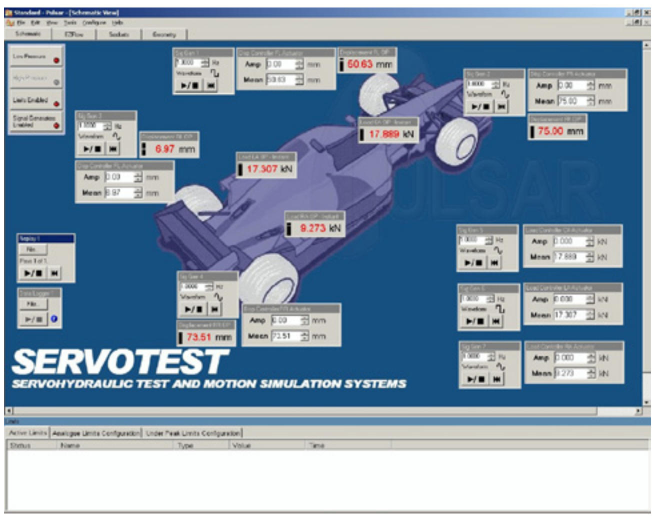
sDAP

The Servotest Data Analysis Package (SDAP) allows the user to turn test rig data into useful information through editing and analysis.

sDAP can be used at any time during the test cycle from editing raw data to plotting histograms to performing frequency analysis.

This package provides powerful and comprehensive signal analysis, visualisation and processing features, with the ability to import files and export results in various formats.

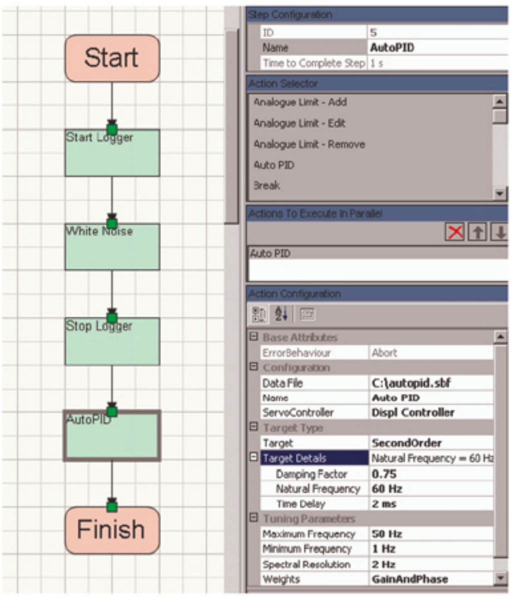




EzFlow

This powerful high level software tool allows sophisticated test sequences to be programmed simply and effectively. The programming sequence can incorporate logic functions and comprehensive test reports are automatically generated. In many cases this will become the main test set-up and run panel for customer tests. Once prepared and saved the test can be run by the operator by selecting the test and hitting the run button.

This block programming software enables sequences of various drive files (e.g. SBF, ADF, RPCII) to be created. Each sequence is made up in the form of a block diagram with each block being a signal generator, real time drive file, a synthesised drive file or an existing imported sequence. This way individual files can be concatenated, looped and nested to construct a durability schedule. Events can be triggered by EZFlow manually or by an external signal.

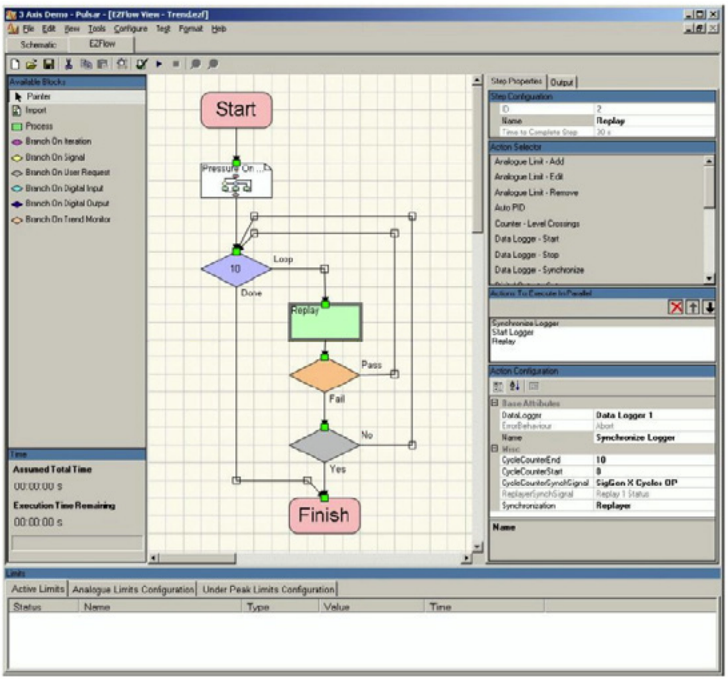


Auto PID

AutoPID allows quick and accurate optimisation of PID controllers, in the frequency domain, based on the system response to a sweep excitation. Once this response is collected, the PID optimisation takes place off-line. Most conventional PID tuning methods (Ziegler-Nichols,...) consider only one frequency when setting the PID terms. As a result, only around this particular frequency can the behaviour of the closed loop system be accurately controlled.

AutoPID on the other hand uses an optimisation algorithm that lets the user specify:

- A target frequency response for the closed loop system.
- The frequency range over which the optimisation takes place.
- The relative importance of gains and phases in this optimisation.



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