WHAT IS THE SPMM?

The standard version of the Suspension Parameter Measuring Machine (SPMM) is designed to measure the quasi-static suspension characteristics that are important to a vehicle's ride and handling. The machine applies forces slowly, so as not to excite any dynamic forces emanating from inertias, dampers or elastomers. The optional dynamic upgrade enables some tests to be performed at higher frequencies.

The SPMM is a moving body, fixed ground plane Kinematics and Compliance test machine with electro-mechanical actuators. It is designed to subject a vehicle to a variety of forces and displacements and measure the kinematic characteristics due to the suspension and steering system geometries, and compliances due to the suspension springs, anti-roll bars, elastomeric bushes and component deformations.

A wide range of parameters may be evaluated, the principal ones being suspension stiffness and hysteresis, bump-steer, roll-steer, roll stiffness distribution, longitudinal and lateral compliance, steer, and steering system characteristics. Knowledge of these parameter values and characteristics is an essential tool to a thorough understanding of a vehicle's performance in terms of ride, impact isolation, steering and handling.

The SPMM is an accurate, easy to use, reliable and safe test machine. It is available in either a 4 wheel station (twin-axle) version, or a two wheel station (single-axle) version.

The optional MIMS upgrade adds the capability to measure the Moments of Inertia and Centre of Gravity height of a vehicle.
TESTING CAPABILITIES

The rig can impart a wide variety of displacements, forces and moments to the suspension system and can quantify a wide range of suspension characteristics. Any of the rig’s axes can be moved in combination with any other axis, either in phase or in anti-phase. In this way complex combined loadings can be generated. Axes may be moved under servo control to maintain the relevant forces or moments at the required test values.

During the tests described below, displacement and angular measurements are made (at the wheel centre) of steer (toe) angle, camber angle, vertical displacement, longitudinal displacement and lateral displacement. Measurements of the six force and moment components at the tyre contact patch are also made.

**Vertical motion of the vehicle body (input)**
To determine:
- Ride toe (steer).
- Ride camber.
- Ride castor.
- Change in wheel position vs. ride position.
- Wheel rate (measured at wheel centre).
- Ride rate (measured at tyre contact patch).
- Tyre radial rate.
- Virtual swing arm lengths and centres.
- Kinematic anti-lift and anti-dive angles.

**Longitudinal force at tyre contact patch (input)**
To determine:
- Steer (toe) change
- Axle steer
- Camber change
- Castor change
- Wheelbase change
- Longitudinal stiffness
- Anti-lift and anti-dive coefficients (SVSA)
- Tyre tangential rate

**Roll motion of the vehicle body (input)**
To determine:
- Roll steer.
- Axle roll steer.
- Roll camber.
- Roll moment.
- Body and axle roll moments (vs. roll angle).
- Roll stiffness.
- Roll moment distribution.
- Roll centre location and migration with roll angle.
- Change in wheel loads (vs roll angle).
- Virtual swing-arm lengths and angles.

**Lateral force at tyre contact patch (input)**
To determine:
- Steer (toe) change
- Axle steer
- Camber change
- Castor change
- Wheelbase change
- Longitudinal stiffness
- Anti-lift and anti-dive coefficients (SVSA)
- Tyre tangential rate

**Handwheel steer motion (input)**
To determine:
- Instantaneous steering ratio.
- Ackerman error curve.
- Scrub radius.
- Castor trail.
- Lateral offset.
- Steering system hysteresis.
- Castor angle and change.
- King-pin inclination and change.

**Aligning Torque (input)**
To determine:
- Steer (toe) change
- Axle steer
- Camber change

The SPMM's design, (moving body and fixed co-planar ground plane) enables driving situations that result in horizontal plane accelerations, (eg. steady state cornering, acceleration and braking) to be faithfully simulated. Special software for these simulation tests has been developed by ABD at the request of its customers.

**OUTPUT**

An interactive graph-plotting facility, *SPMM Grapher*, is supplied with the SPMM. This enables the results from a test to be viewed as soon as it is completed and provides automatic calculation of loop gradients and hysteresis. Multiple plots can be displayed and data from one test can be laid-over data from a previous test.

ABD also supply an optional MATLAB® based *Post Processing* package. This can automatically process the results from a series of tests to produce a results report. The report format can be customised to meet the customer’s specific requirements.
The SPMM is a moving body, fixed ground plane machine. This design has a number of advantages including the ability to produce roll and pitch inputs that replicate the behaviour of a vehicle on the road.

**Roll, Pitch and Bounce Mechanism**
The roll, pitch and bounce mechanism consists of a moving table to which the vehicle body is rigidly clamped. Precise control of the moving table is achieved by co-ordinating the motion of six linear, electro-mechanical actuators that restrain the six degrees of freedom of the table. The body of the vehicle can be made to roll, pitch or bounce, or combinations of these motions.

**Wheel Stations**
The wheel stations can move fore and aft and laterally, both to provide adjustment for different vehicle wheelbases and tracks and to apply horizontal loads to the wheels for simulation of braking, accelerating and cornering forces. They can also apply a torque to the wheel by rotation of the wheel pad about a vertical axis to enable aligning torques to be simulated.

**Wheel Position Measurement System**
The standard wheel position measurement system uses an array of digital draw wire encoders mounted on an encoder stand beside each wheel station, (shown above). These connect to a weighted plate which is attached to the wheel using wheel nuts and is pivoted so that it moves with the wheel in every sense except rotation about the axle. The front wheel measurement system can determine all 6 of the wheel’s degrees of freedom; X, Y, Z, steer, camber and spin. The rear wheel measurement system can determine 5 of the wheel’s degrees of freedom; X, Y, Z, steer and camber. Castor change can be measured using an inclinometer.

The optional *dynamic arm* wheel position measurement system contains 5 rotary encoders and one linear encoder. It provides a highly accurate and dynamic measurement of all 6 degrees of freedom of the wheel.

**Wheel Force Measurement System**
The standard wheel force measurement system uses multi-component piezo-electric load cells to measure the 3 orthogonal forces and 3 moments applied by the wheel as well as the X and Y position of the tyre’s centre of pressure.

**The Control and Integrated Software Suite**
The machine is driven entirely by DC servo motors. These are controlled using a programmable multi-axis controller which ensures smooth synchronised motion of the axes. The controller is interfaced to a computer which controls the overall operation of the machine and provides the user interface. The system is designed to be highly flexible and user-friendly with help screens and pop-up selection tables to allow new test sequences to be specified quickly and easily. Versatile post-processing of results includes graphs of any parameter against any other. A translator that enables data generated using the SPMM to be used directly within CARSIM can be provided.
SPECIFICATION

SPMM 4000 (other capacities are available on application)

4 Wheel Station SPMM Dimensions & Weights
Overall length including loading ramps: 7205 mm*
Length excluding loading ramps: 6410 mm*
Overall width: 3921 mm*
Overall Height, excluding vehicle: 2100 mm*
Ground plane height (or depth of pit installation): 1525 mm
Overall weight excluding vehicle: 14 tonnes
Maximum ground loading with 4 tonne vehicle: 1 N/mm²*

* Dimensions are for the 4 wheel station SPMM with draw wire encoder system, excluding control cabinet and walkways.

Applied Loads
Vertical per wheel: 0 to 40 kN
Fore and aft per wheel: ± 20 kN at ground plane
Lateral per wheel: ± 20 kN at ground plane
Aligning torque per wheel: ± 750 Nm
Maximum body roll moment: ± 80 kN/m
Maximum body pitch moment: ± 75 kN/m

4 Wheel Station Rig Capacity.
Nominal vehicle wheelbase range: 1960 - 4130 mm
Nominal vehicle track range: 1100 - 2082 mm
Nominal vehicle maximum weight: 4000 kg

Body Motions
Nominal Bounce: ± 150 mm*
Roll: ± 10º
Pitch: ± 8º

* An additional ± 40mm is available for adjusting the sill clamp height.

Tyre Contact Patch Motions
Nominal fore and aft: ± 150 mm*
Nominal lateral: ± 150 mm*
Powered rotational: ± 80º
Free rotational (with clutch option): ± 80º

* Note that these ranges are reduced if operating near the extremes of the wheelbase and track limits.

Wheel Deflections
Nominal wheel fore & aft: ± 75 mm
Nominal wheel lateral: ± 75 mm
Maximum wheel steer angle: ± 60º
Nominal camber angle: ± 20º

With the objective of continuous development and improvement, ABD reserve the right to change this specification without notice.

For more information contact:
Dr Steve Neads
Director, Suspension Test Systems
ANTHONY BEST DYNAMICS
Holt Road
Bradford on Avon
Wiltshire, BA15 1AJ    England
Tel: +44 (0) 1225 860200
Fax: +44 (0) 1225 860201
Email: sales@abd.uk.com